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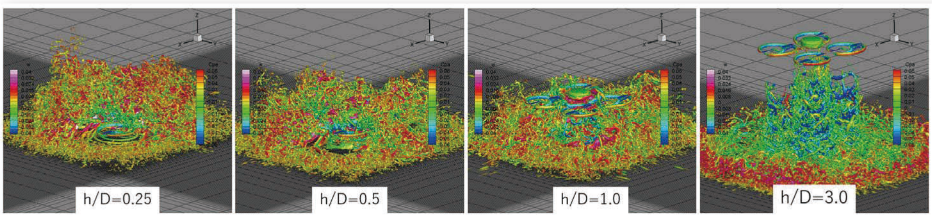
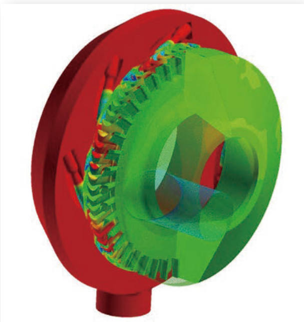
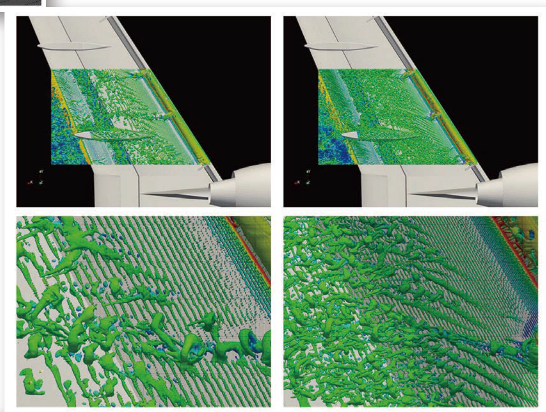
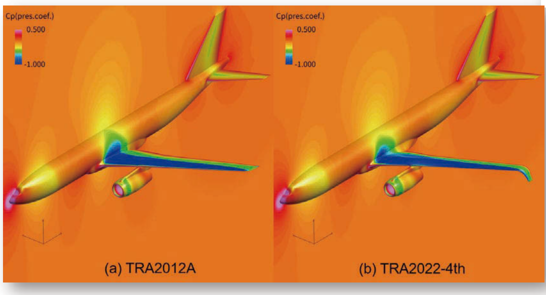
JAXA Supercomputer System Annual Report

(April 2019-March 2020)









Security and Information Systems Department
Japan Aerospace Exploration Agency (JAXA)

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Images of the front cover are derived from the reports listed below.

Report Number	Report Title
R19ECMP06	Post-K Priority Issue 8D: Research and development of core technology to innovate aircraft design and operation
R19ECMP17	Aerodynamic Investigation of a Multiple-Rotor Drone in Ground Effect
R19EG3214	Numerical Simulation of Rocket Turbopumps
R19EA0601	Environment Conscious Aircraft Systems Research in Eco-wing Technology:Aerodynamic System Design Technology

Aeronautical Technology

Active Flow Control using Plusma Actuators

Report Number: R19EA1477
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11520/

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Yoshihisa Aoki, Hikaru Aono

Abstract

Study of Separation Flow Control using Plasma Actuators

Reasons and benefits of using JAXA Supercomputer System

The reason for using a JAXA supercomputer is to understand the detailed flow field around the wings and flaps and to clarify the control effects in order to construct a flow control technology using a plasma actuator and improve its efficiency. Large-scale numerical simulations are required to realize them, and detailed analysis of the data has the potential to lead to new control methods and clarification of physical phenomena.

Achievements of the Year

The results of this fiscal year are as follows: (1) Knowledge on basic flow field characteristics of NACA0012 wing with flap and (2) Fundamental understanding on its control effect obtained from flow control simulations with a plasma actuator attached to the trailing edge of the main wing. The conditions for calculating the flow around the wing with the flap are a chord-based Reynolds number of 130,000 and angles of attack of 0 and -3 degrees. Under these conditions, the flow field separates on the upper and lower surfaces of the wing regardless of control. Separation occurs near the trailing edge of the main wing on the upper surface side, and near the half chord length of the main wing on the lower surface side, and vortices are released from the separated shear layer, causing the vortices to collapse. In the case with control, the vortex emitted from the separated shear layer on the upper surface side of the flap was affected by the control effect of the plasma actuator. In the future, we would like to investigate the effects of the operating conditions of the plasma actuator, such as the effects of the burst frequency, based on the results of this analysis.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1563
Elapsed Time per Case	200 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,245,586.03	0.15
SORA-PP	6,137.56	0.04
SORA-LM	235.98	0.10
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	51.66	0.04
/data	2,223.65	0.04
/ltmp	569.66	0.05

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.48	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Advanced simulation of internal flow in rotating machinery

Report Number: R19EA2111
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11522/

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Junichi Kazawa, Takahiro Kawahara

Abstract

Implement LES and DES in the rotating coordinate system to improve the aerodynamic performance prediction accuracy of rotating machine like fan, compressor, and so on, flows by numerical simulation.

Reasons and benefits of using JAXA Supercomputer System

LES and DES for rotating machines have a huge number of grid points and a high computational load. For this reason, calculations cannot be performed without JSS2.

Achievements of the Year

DES analysis was performed on the centrifugal compressor. It was confirmed that fine vortices can be captured by using a scheme with weak numerical viscosity.

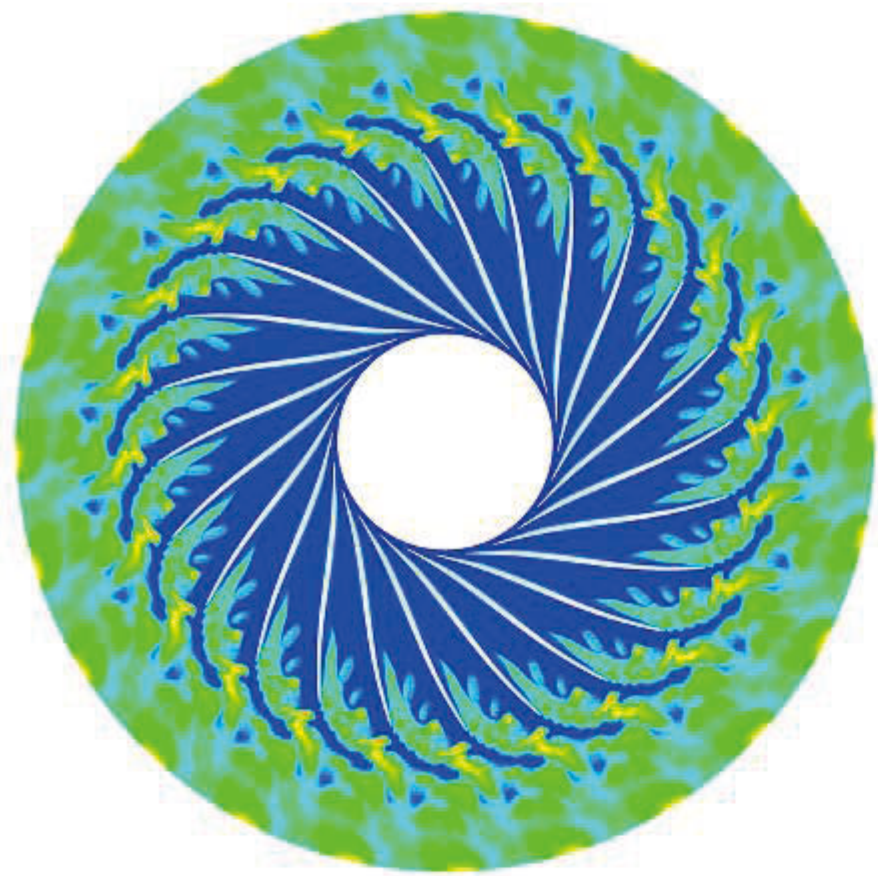

Fig. 1: Centrifugal compressor internal flow (entropy distribution)

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64 - 106
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	85,292.20	0.55
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	10.04	0.01
/data	958.69	0.02
/ltmp	2,055.92	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Aerodynamic Simulations on Airframe Noise Reduction Technology (FQUROH+)

Report Number: R19EDA101R20
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11577/

Responsible Representative

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Abstract

The FQUROH (Flight Demonstration of Quiet Technology to Reduce Noise from High-Lift Configurations) project aims at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear, which draws international attention to reduce noise in areas around airports, to a level applicable to future development of aircraft and related equipment. This contributes to reduction of aircraft noise in local communities around the airport and airline operating costs by reducing landing fee. One of the objectives of the FQUROH project is to verify the feasibility of practical noise reduction concepts and design methods based on advanced computational simulations through modification of aircraft. Computational simulations were performed as part of the FQUROH project to investigate Reynolds number effects, wind tunnel wall interference effects, and time-mean flow features around major aeroacoustic noise sources, such as slats.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

Reasons and benefits of using JAXA Supercomputer System

The JSS2 enabled a large number of high-fidelity Reynolds-averaged Navier-Stokes (RANS) simulations with aerodynamically-important details in several flight configurations in the expected flight envelop to be conducted in a timely manner. The aerodynamic effect of low-noise devices can be evaluated and quantified, which is difficult to obtain only with wind tunnel tests.

Achievements of the Year

RANS simulations were conducted for the JAXA high-lift configuration standard model (JSM) to improve our computational techniques for half-span wind tunnel models and to deepen our understanding on wind tunnel wall effects (Fig. 1).

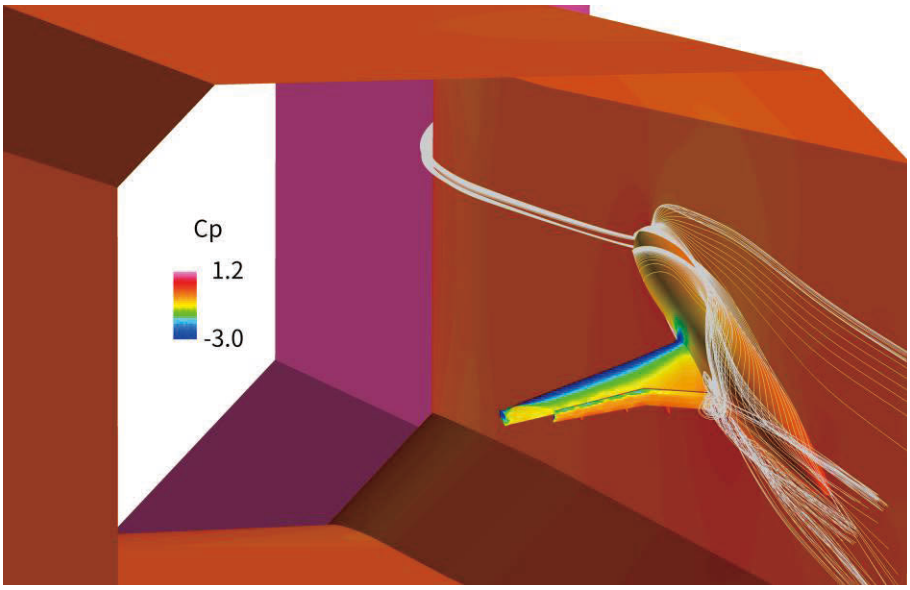

Fig. 1: JSM half-span model at an angle of attack of 20 degrees in the JAXA 6.5 m x 5.5 m Low Speed Wind Tunnel (LWT1)

Publications

- Peer-reviewed papers

1) Ito, Y., Murayama, M., Yokokawa, Y., Yamamoto, K., Tanaka, K., Hirai, T., Yasuda, H., Tajima, A., and Ochi, A., "JAXA's and KHI's Contribution to the Third High Lift Prediction Workshop," Journal of Aircraft, Vol. 56, No. 3, May-June 2019, pp. 1080-1098, DOI: 10.2514/1.C035131.

- Invited Presentations

1) Ito, Y., "Automatic Local Remeshing Method for High-Fidelity Computational Fluid Dynamics Simulations," 6th Workshop on Grid Generation for Numerical Computations (Tetrahedron Workshop VI), INRIA Saclay Ile-de-France, Palaiseau, France, October 2019.

2) Yamamoto, K., "A Flight Demonstration Project for Airframe Noise Reduction Technologies, FQUROH," Asia Pacific International Symposium on Aerospace Technology (APISAT) 2019, Gold Coast, Australia, December 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	216
Elapsed Time per Case	40 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.41

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	3,456,068.94	0.42
SORA-PP	138.15	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	66.10	0.06
/data	9,047.16	0.15
/ltmp	2,021.15	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	280.18	7.05

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Aerodynamic testing technology for reentering capsules

Report Number: R19EA1403
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11519/

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Abstract

To enhance hypersonic aerodynamic testing technology especially for reentering vehicles through developing understanding about the hypersonic wind tunnel nozzle flow which affects a lot estimation error to the flight characteristics and through defining the ability in predicting RCS jet interaction.

Reasons and benefits of using JAXA Supercomputer System

Since it perfectly suits the requirement in calculating heavy RCS jet interaction flow field and the hypersonic nozzle flow. Useful tools such as Fastar is another.

Achievements of the Year

JAXA1.27m hypersonic wind tunnel was numerically solved. The numerical result of p02/p0 at the nozzle exit was compared with the experimental data (p0:reservoir pressure, p02:pitot pressure). As shown in Figs.1 and 2., the quatitative tendency was successfully observed.

Also, predicting ability in the RCS jet interaction has been evaluated with the hypersonic wind tunnel tests.

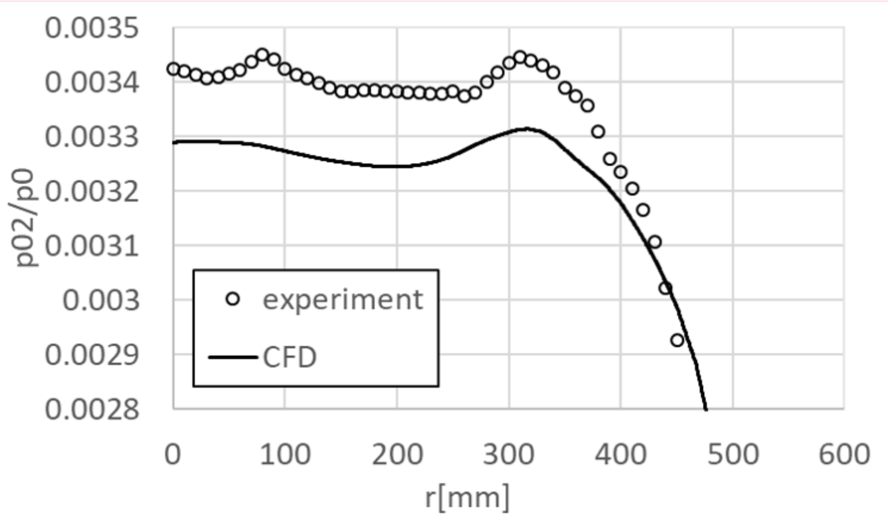

Fig. 1: Comparison of p02/p0 at the nozzle exit between experiment and calculation

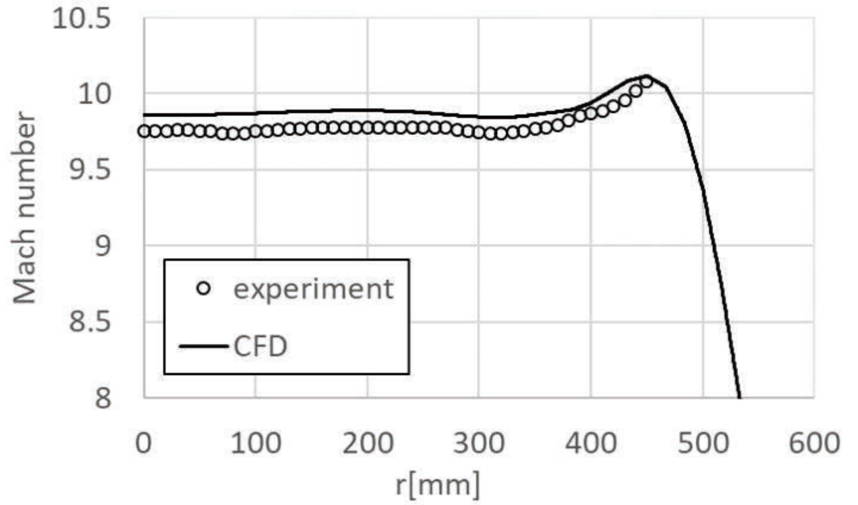

Fig. 2: Comparison of Mach number at the nozzle exit between experiment and calculation

- **Publications**

N/A

- **Usage of JSS2**
- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 128
Elapsed Time per Case	50 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.09

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	767,913.67	0.09
SORA-PP	283.26	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	79.75	0.07
/data	3,050.09	0.05
/ltmp	2,525.11	0.21

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	2.70	0.07

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

An attempt to develop a method for modeling holistic phenomena without a prerequisite knowledge

Report Number: R19EDA201N09
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11592/

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Members

Masashi Kanamori, Shogo Goto

Abstract

It is important to gain a fast and accurate feedback from computational results in a design process. A traditional way of Computational Fluid Dynamics (CFD) gives physically acceptable results at the costs of tremendous amount of computational resources and time. Our research group is therefore working on a machine-learning-based approach aimed at an innovative design tool.

Reasons and benefits of using JAXA Supercomputer System

High acurracy prediction by machine learning requires a wide variety of data the amount of which should be as large as possible. This conversely indicates poorly predicted results as a consequence of a shortage of data. The combination of the processing capability of JSS2 and a fast algorithm implemented in our CFD code, FaSTAR can serve us a plenty of data within a short period of time and its data productivity is necessary for the success of our research.

Achievements of the Year

We prepared a large number of computational results mainly for two-dimensional NACA airfoils using JSS2(Fig. 1).

We trained a neural network by the results and predicted the flow field around the two-dimensional airfoil by the network.

The prediction of the trained data succeeded to reproduce the original distribution correctly(Fig. 2). And a reproducibility was confirmed in the prediction of untrained data(Fig. 3).

In the future, we aim to improve the reproducibility for machine learning prediction by training the wider variety of data.

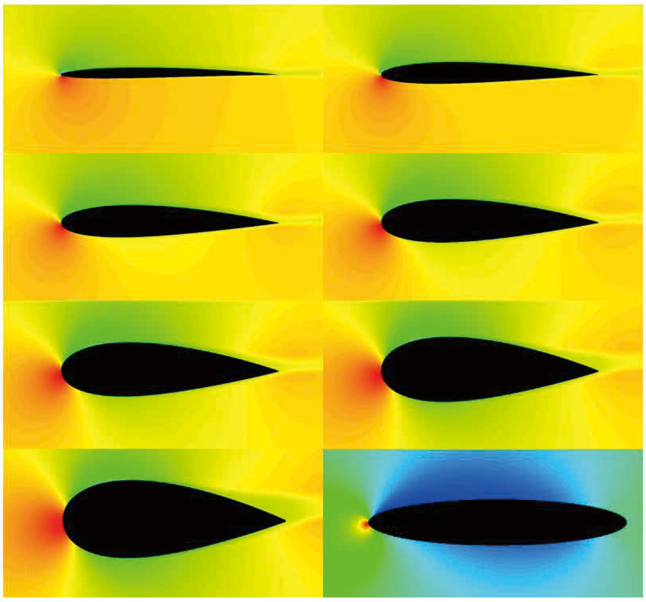

Fig. 1: List of training data made by JSS2

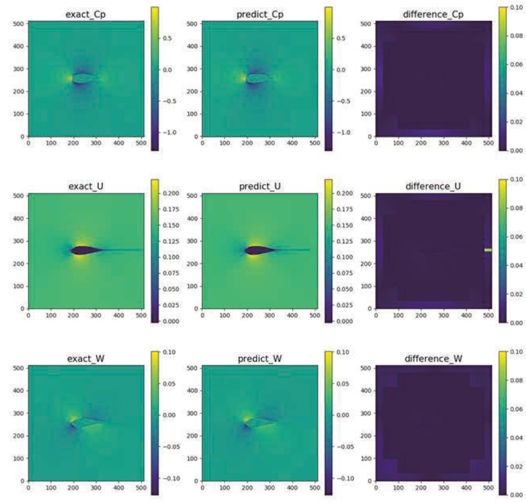

Fig. 2: Prediction result for trained data

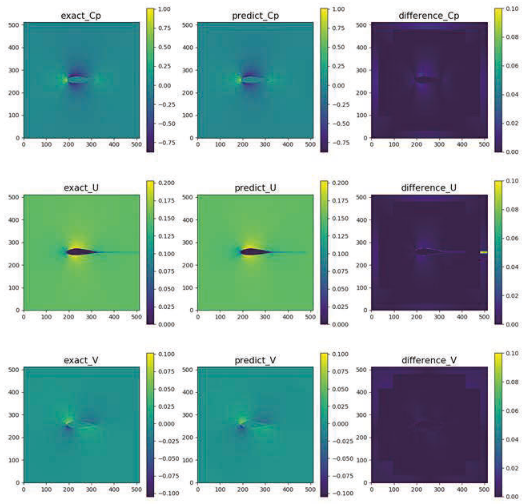

Fig. 3: Prediction result for untrained data

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	2 - 64
Elapsed Time per Case	6 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.04

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	208,418.77	0.03
SORA-PP	29,811.71	0.19
SORA-LM	1,180.57	0.49
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	5.96	0.00
/data	6,103.52	0.10
/ltmp	1,220.70	0.10

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Cooperative Research on Airframe Noise Reduction Technology (FQUROH+) #1

Report Number: R19EDA101R25
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11579/

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Abstract

This collaborative research is being carried out as part of the FQUROH (Flight Demonstration of Quiet Technology to Reduce Noise from High-Lift Configurations) project aimed at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear, which draws international attention to reduce noise in areas around airports, to a level applicable to future development of aircraft and related equipment. This contributes to reduction of aircraft noise in local communities around the airport and airline operating costs by reducing landing fee.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

Reasons and benefits of using JAXA Supercomputer System

The JSS2 enabled low-noise devices to be designed based on Reynolds-averaged Navier-Stokes simulations and more advanced computational simulations, such as large eddy simulations, using the Kawasaki Heavy Industries (KHI)-developed unsteady computational fluid dynamics software, "Cflow." Computational simulations using the JSS2 made it possible to design low-noise devices by understanding detailed physical phenomena, which were difficult only with wind tunnel tests.

Achievements of the Year

In order to design noise reduction devices for passenger aircraft in the FQUROH project, CFD simulations of the "OTOMO2" high-lift model were carried out using the KHI in-house unsteady CFD software called "Cflow." The focus here is on slat side edge noise; the computational result for the baseline configuration helped us come up with noise reduction concepts as well as understand noise generation mechanisms. The effect of noise reduction devices was also evaluated by unsteady CFD analyses.

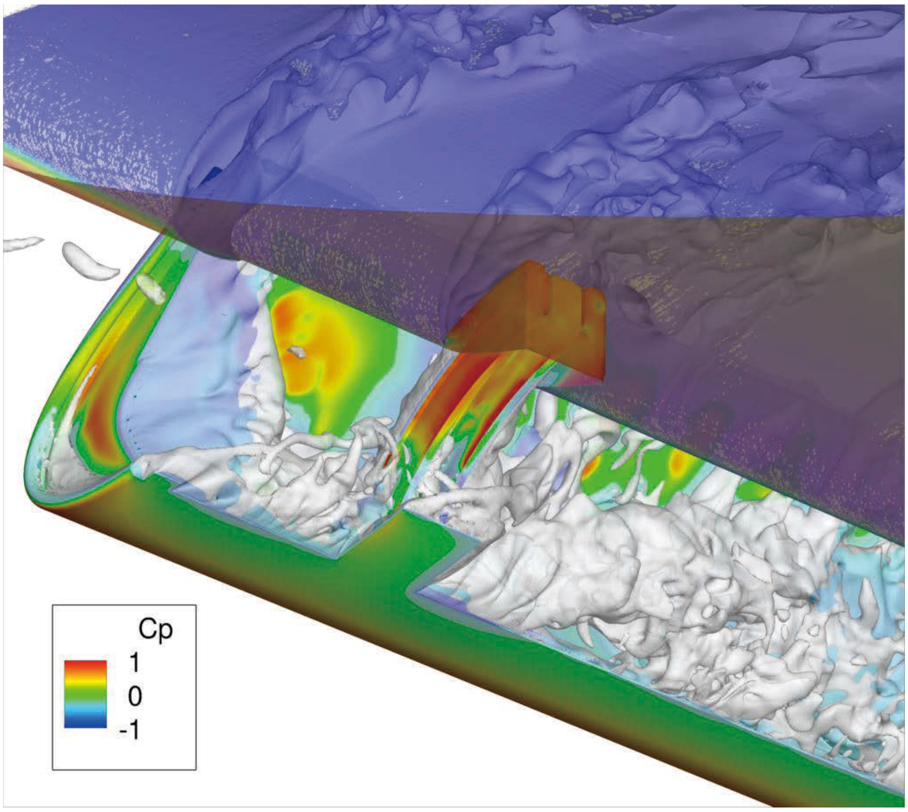

Fig. 1: Unsteady CFD analysis around slat side edge of OTOMO2 high-lift model

Publications

- Non peer-reviewed papers

1) Ueno, Y., Isotani, K., Hayama, K., Takaishi, T., Ito, Y., Yokokawa, Y., Murayama, M., and Yamamoto, K., "Validation of Noise Reduction Design for Landing Gear in the FQUROH Flight Demonstration Project," AIAA Paper 2019-2506, 25th AIAA/CEAS Aeroacoustics Conference, Delft, the Netherlands, May 2019, DOI: 10.2514/6.2019-2506.

- Invited Presentations

1) Yamamoto, K., "A Flight Demonstration Project for Airframe Noise Reduction Technologies, FQUROH," Asia Pacific International Symposium on Aerospace Technology (APISAT) 2019, Gold Coast, Australia, December 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	4096
Elapsed Time per Case	120 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.50

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	4,398,168.75	0.53
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	70.36	0.06
/data	13,093.87	0.22
/ltmp	7,322.00	0.62

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	109.78	2.76

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Cooperative Research on Airframe Noise Reduction Technology (FQUROH+) #2

Report Number: R19EDA101R26
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11580/

Responsible Representative

Kazuomi Yamamoto, FQUROH+ Team, Aviation Systems Research Unit, Aeronautical Technology Directorate

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Kazuomi Yamamoto(yamamoto.kazuomi@jaxa.jp)

Members

Shinsuke Nishimura, Yuki Morisaki, Kazuomi Yamamoto, Yasushi Ito, Mitsuhiro Murayama, Ryotaro Sakai

Abstract

This collaborative research is being carried out as part of the FQUROH (Flight Demonstration of Quiet Technology to Reduce Noise from High-Lift Configurations) project aimed at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear, which draws international attention to reduce noise in areas around airports, to a level applicable to future development of aircraft and related equipment. This contributes to reduction of aircraft noise in local communities around the airport and airline operating costs by reducing landing fee.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

Reasons and benefits of using JAXA Supercomputer System

It is necessary to carry out large-eddy simulations (LES) with hundred-million-node meshes, and large computing resources are essential to achieve the target resolution.

Achievements of the Year

LES analyses of the landing configuration of commercial aircraft were carried out, and important knowledge on the noise generation mechanism was obtained.

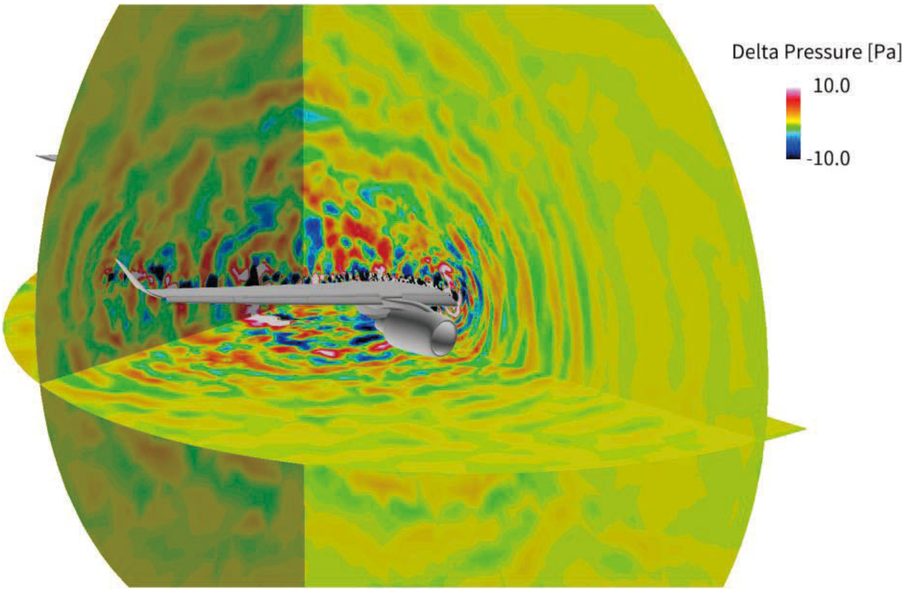

Fig. 1: LES analysis of the landing configuration of commercial aircraft (pressure distribution)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	120
Elapsed Time per Case	50 Hour(s)

Resources Used

Fraction of Usage in Total Resources[*1](%): 0.21

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,860,167.29	0.23
SORA-PP	13.52	0.00
SORA-LM	45.78	0.02
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	42.95	0.04
/data	4,602.35	0.08
/ltmp	1,706.77	0.15

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	109.78	2.76

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Cooperative Research: unsteady flow simulation with unstructured-grid CFD code

Report Number: R19EA3210
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11532/

Responsible Representative

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Members

Atsushi Hashimoto, Takashi Ishida, Hideaki Sugawara, Keiji Ueshima, Minoru Yoshimoto, Takuya Ogura, Shinsuke Nishimura, Yukinori Morita, Kazuhiro Imai, Kei Nakanishi, Shigeru Kuchiishi, Takashi Aoyama, Kanako Yasue

Abstract

In order to simulate unsteady separated flow phenomena, we validate an unstructured-grid CFD code for practical problems and identify problems that have to be solved.

Reasons and benefits of using JAXA Supercomputer System

JSS2 is indespensable to accelerate the validation of unsteady flow simulations.

Achievements of the Year

A separated flow at the leading edge of delta wing is simulated with steady and unsteady computaion of FaSTAR and compared with experimental data (Chu&Lucking, NASA-TM-4645, 1996). Figure 1 shows a steady computation result as an example, which is computed at Mach number of 0.85, Reynolds number of 6x10^6, angle of attack of 20.6deg. The pressure distributions on the upper surface of delta wing agree well with the experimental data.

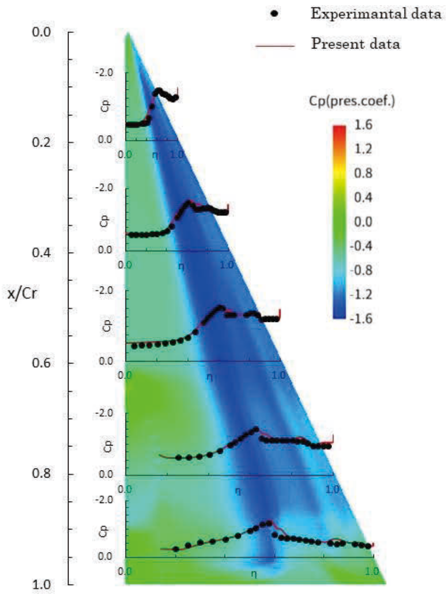

Fig. 1: Pressure distribution on upper surface of delta wing

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	256 - 512
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.10

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	811,012.37	0.10
SORA-PP	224.65	0.00
SORA-LM	2,468.31	1.03
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	295.53	0.25
/data	26,925.10	0.46
/ltmp	4,075.53	0.35

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.52	0.01

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Detection of origination for 3D unsteady aerodynamic phenomena

Report Number: R19EDA201N07
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11590/

Responsible Representative

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Members

Shigeru Kuchiishi, Kohji Suzuki, Kanako Yasue, Mami Hayakawa

Abstract

Unsteady CFD analysis will be performed in order to detect the starting point of buffet phnomena utilizing data mining techniques.

Reasons and benefits of using JAXA Supercomputer System

A large-scale parallel computer such as JSS2 is indispensable for large-scale analysis to acquire unsteady numerical simulations.

Achievements of the Year

Zonal DES (ZDES) analysis around OAT15A wing have been additionally performed for preparing a journal paper.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512
Elapsed Time per Case	120 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	57,184.28	0.01
SORA-PP	2,950.60	0.02
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	205.71	0.17
/data	4,898.30	0.08
/ltmp	1,946.69	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.07	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of 3D CFD core-software of automotive engine combustion chamber

Report Number: R19EDA201N11
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11594/

Responsible Representative

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Members

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Abstract

Enhancement of CAE utilization in automotive engine research by developing an engine combustion simulation software that is sharable in Japan automotive research community

Reasons and benefits of using JAXA Supercomputer System

Massive-parallel large scale simulation, Large number of simulations fo software validation

Achievements of the Year

Computational time of mortoring simulation(Fig.1) has been reduced to 1/3 by the improvement of BAMR(Block-based Adaptive Mesh Refinement) procedure, the acceleration of gas property calculation and the enhancement of inner iteration convergency of implicit time integration. Figure 2 shows the flame structure in combusiton simulation with BAMR.

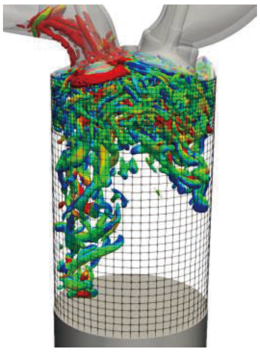

Fig. 1: Mortoring simulation with BAMR(Vortex structure).

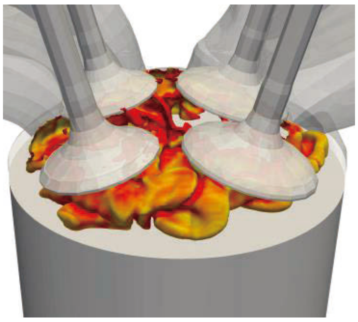

Fig. 2: Firing simulation with BAMR(Flame structure).

Publications

- Invited Presentations

Functional design and platform: "Introduction and recent methodological progress," 2019 JSAE Annual Congress(Spring).

Yasuhiro Mizobuchi, Taisuke Nambu, Hiroki Yao, "Platform of Combustion Simulation Software HINOCA," ICFD2019.

- Oral Presentations

Hiroki Yao, Taisuke Nambu, Yasuhiro Mizobuchi, "Improvement for the immersed boundary method toward accurate internal flow simulations," ANSS2019.

Hiroki Yao, Taisuke Nambu, Yasuhiro Mizobuchi, "Improvements of the Immersed Boundary Method for High Reynolds Number Flow with Complex Geometries and its Application to Internal Flow Simulations," 33rd CFD Symposium.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 256
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 1.31

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	10,061,932.97	1.22
SORA-PP	85,300.30	0.55
SORA-LM	2,774.84	1.16
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	4,679.09	3.90
/data	496,445.70	8.50
/ltmp	32,704.40	2.78

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	69.88	1.76

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of Aerodynamic Optimization Library: Harmonee

Report Number: R19EA3202
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11530/

Responsible Representative

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Members

Shigeru Kuchiishi, Takashi Ishida, Atsushi Hashimoto, Masahiro Kanazaki, Kohji Suzuki, Minoru Yoshimoto, Shinsuke Nishimura, Kei Nakanishi, Yukinori Morita, Takuya Ogura, Kyohei Sawada, Kazufumi Uwatoko, Tetsuji Ogawa, Mami Hayakawa

Abstract

An aerodynamic optimization library "Harmonee," which uses the unstructured CFD code FaSTAR, is develped and its validity and efficiency are examined. A Multi-Objective Evolutionary Algorithm (MOEA) is employed as an aerodynamic optimization method. This tool is aimed to enable the direct evolutionary computing to perform within a practical computational time by utilizing the high speed performance of FaSTAR. In the present project, basic programs are developed and validated using JSS2.

Reasons and benefits of using JAXA Supercomputer System

Aerodynamic optimization using an evolutionary algorithm requires a number of high-fidelity and large-scaled computations (3D RANS analysis) and needs to use the supercomputer.

Achievements of the Year

We validated our Harmonee module by applying it to a coupled aero-structure optimization problem which satisfies three objectives and two constraints shown in Fig.2, according to the flowchart shown in Fig. 1.

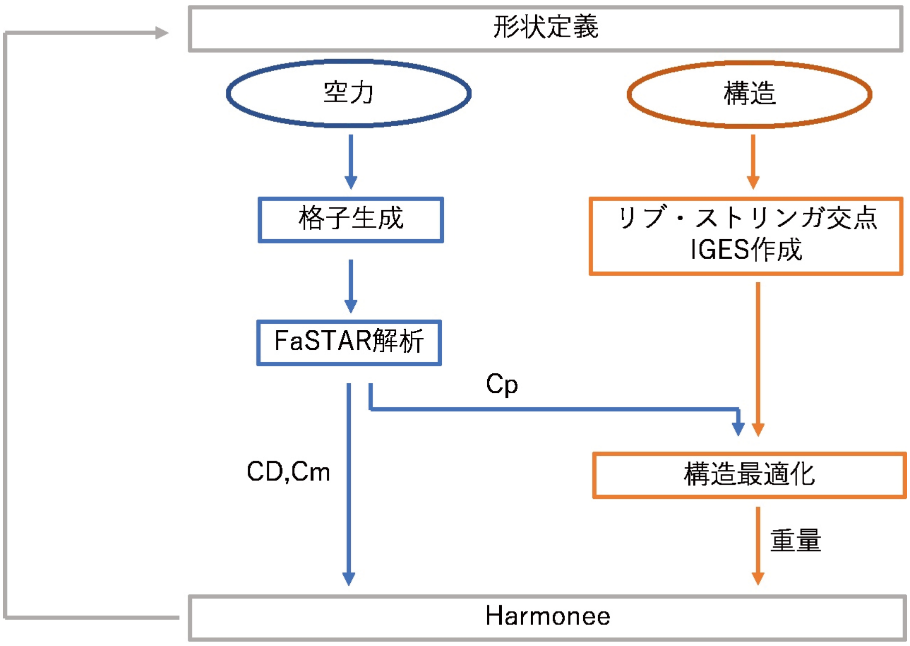

Fig. 1: Flowchart of coupled aero-structure optimization problem

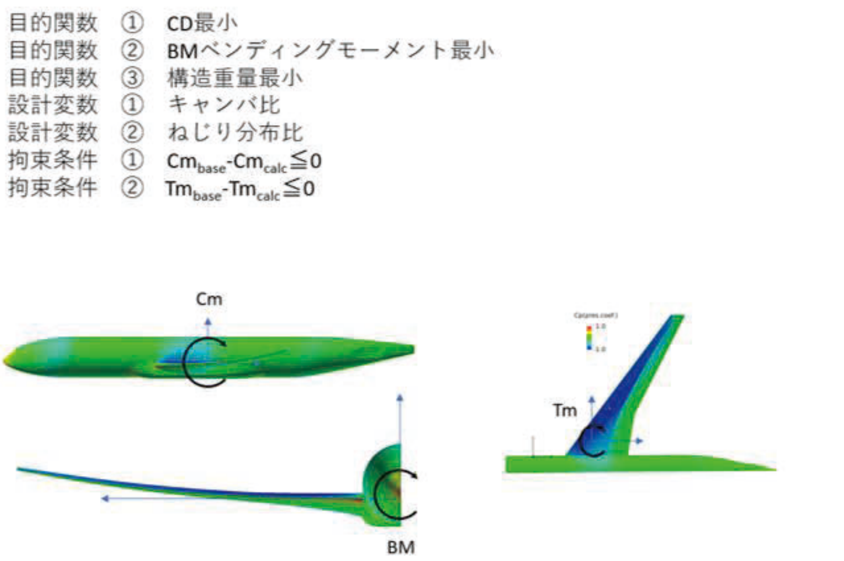

Fig. 2: Optimization problem for NASA Common Research Model

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	128
Elapsed Time per Case	2 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.20

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,482,708.63	0.18
SORA-PP	26,609.96	0.17
SORA-LM	12,495.92	5.22
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	865.85	0.72
/data	63,084.64	1.08
/ltmp	9,528.06	0.81

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.33	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of Aeroelastic Simulation Tool based on FaSTAR-Move

Report Number: R19EDA201N02
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11585/

Responsible Representative

Hitoshi Arizono, Aeronautical Technology Directorate, Numerical Simulation Research Unit

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Members

Hitoshi Arizono, Takashi Ishida, Hamidreza Kheirandish

Abstract

Development of Aeroelastic Simulation Tool based on FaSTAR-Move

Reasons and benefits of using JAXA Supercomputer System

Aeroelastic analysis requires unsteady analysis. Therefore, it is necessary to use JSS2 because the simulation cost is high.

Achievements of the Year

Inplemented the function of the aeroelastic simulation and conducted validation analysis.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	8 - 64
Elapsed Time per Case	5 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	532.92	0.00
SORA-PP	166.41	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	3.33	0.00
/data	1,796.25	0.03
/ltmp	672.46	0.06

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of CFD technology to support design of aircraft combustor with real configuration.

Report Number: R19EA2117
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11523/

Responsible Representative
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Members
Mitsumasa Makida, Naoki Nakamura

Abstract
In this research, we aim to obtain design methods for development of aircraft combustors with real configuration, which estimate dispersion of the fuel droplets, evaporation, and combustion processes.

Reasons and benefits of using JAXA Supercomputer System

It is important to do parametric case study with slightly different geometry, and each case with spray and combustion needs large scale simulation. To conduct such simulation and visualization effectively, we use the super computer with high parallelization efficiency.

Achievements of the Year

In this fiscal year, we added chemical reaction models into the base solver, which enabled to simulate the distribution of fuel spray, fuel vapor and chemical reaction rate near the fuel nozzle with realistically complicated configuration.Fig.1 shows calculation grids around the fuel nozzle, and as examples of calculation result, Fig.2 shows contour of fuel gas mass fraction and gas temperature.

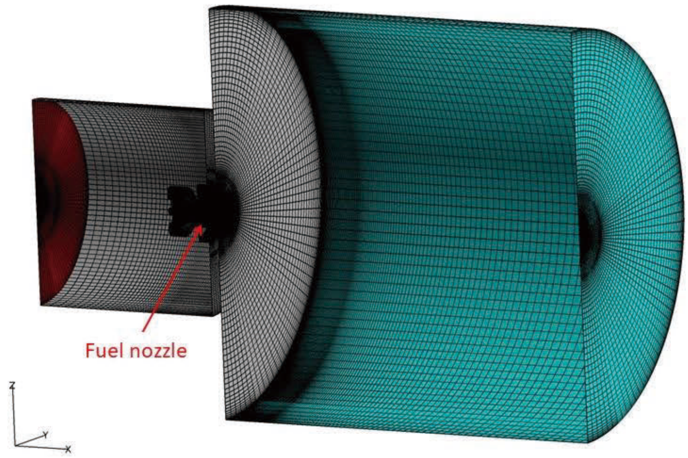

Fig. 1: Calculation grids around fuel nozzle

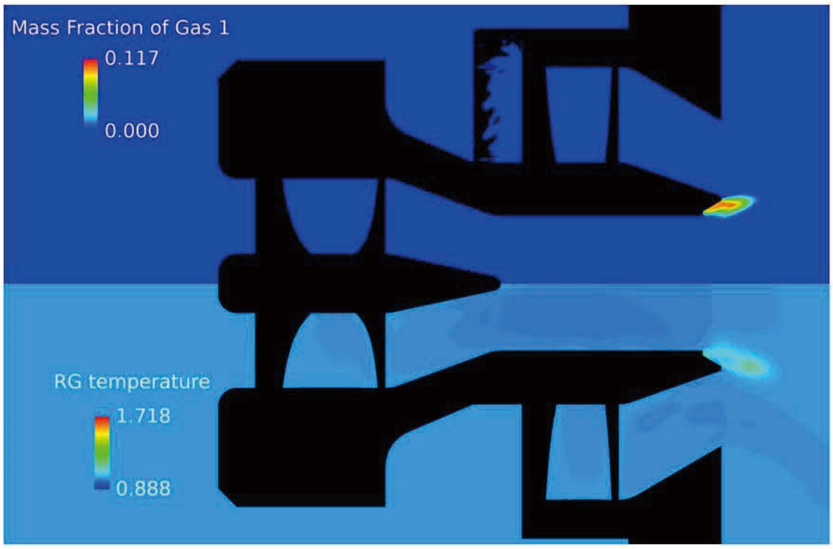

Fig. 2: Contour of fuel gas mass fraction and gas temperature.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	120
Elapsed Time per Case	300 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.20

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,722,316.00	0.21
SORA-PP	4,938.16	0.03
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	182.16	0.15
/data	14,019.68	0.24
/ltmp	2,736.70	0.23

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.11	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of combustor simulation system based on physics understanding and modelling

Report Number: R19EDA201N06
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11589/

Responsible Representative

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Members

HISHIDA Manabu, NAMBU Taisuke, YAO Hiroki, YASUDA Shogo, MATSUO Yuichi, MIZOBUCHI Yasuhiro, ABE Hiroyuki, OKABE Takeshi, MATSUYAMA Shingo, MOTOE Mikiroh, UCHIYAMA Kazuya, SHIMURA Kei

Abstract

Development of simulation technology applicable to combustor design based on physics understanding and modelling by detailed and high-fidelity simulations

Ref. URL: http://www.aero.jaxa.jp/eng/research/basic/numerical/comb/index.html

Reasons and benefits of using JAXA Supercomputer System

World-level research in this field requires massively parallel huge computational resource and only so-called supercomputer system can provide it.

Achievements of the Year

A skewed turbulent boundary layer is one of the key phenomena in aeronautical applications such as combustors and airfoils. In the present study, we have performed a series of direct numerical simulations (DNSs) of a shear-driven three-dimensional turbulent boundary layer up to the momentum thickness Reynolds number Re_θ=900. The latter $Re_\theta$is the largest Reynolds number ever performed in this configuration. Number of grid points used for Re_θ=900 are 1.5 billion to resolve the essential motions. Figure 1 shows visualization of tubulence structures for Re_θ= 900, which highlights that hierarchical turbulence structures appear clearly when the large spanwise surface veclotiy is imposed.

Under gas turbine engine conditions, an analysis of cross-flow type primary atomization was conducted using a sufficient grid density that can resolve even droplets after atomization(Fig.2). Details of the breakup mechanism from a liquid column to liquid droplets, which has been difficult to measure experimentally, were confirmed.

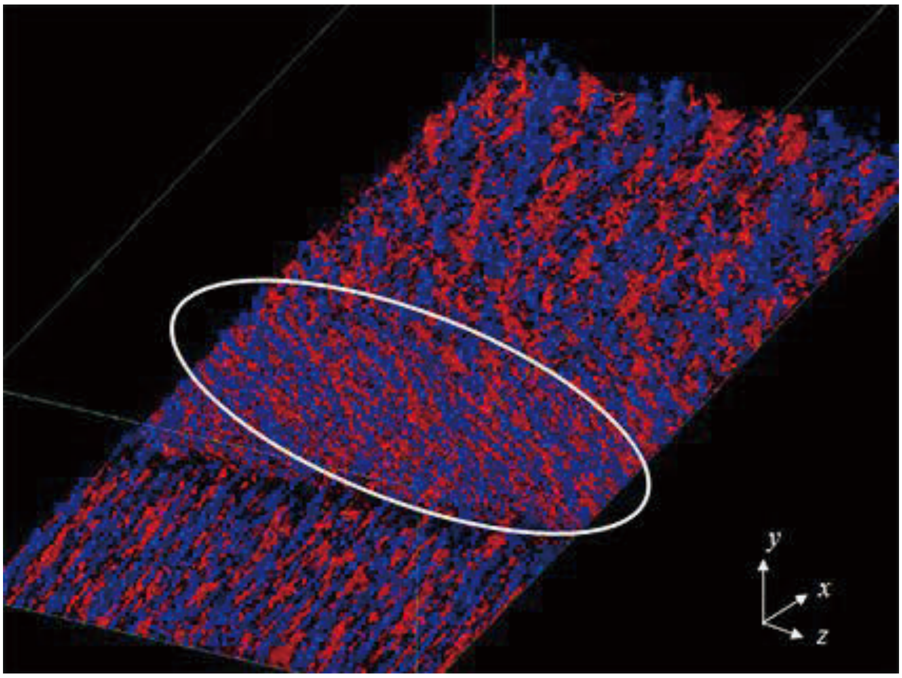

Fig. 1: Turbulence structures observed in the DNS for Re_θ=900 (blue: negative streamwise velocity fluctuation; red: positive streamwise velocity fluctuation).

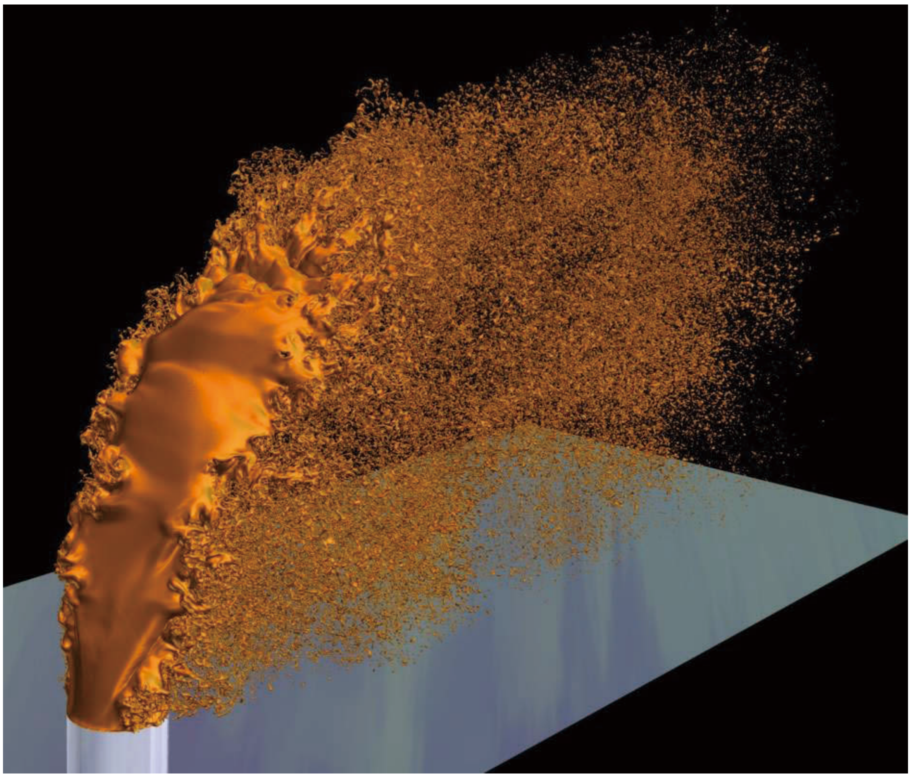

Fig. 2: Distribution of the liquid-gas interface.

Publications

- Invited Presentations

Hiroyuki Abe, "DNS study of a turbulent separation bubble with emphasis on low-frequency unsteadiness," AIAA SciTech (Orlando, FL, USA, Jan. 6-10, 2020).

- Oral Presentations

Hiroyuki Abe, Yasuhiro Mizobuchi and Yuichi Matsuo, "Prediction of turbulent flow around an airfoil with a nonlinear k-ε model," 51th FDC/37th ANSS, July, 2019.

Hiroyuki Abe, Yasuhiro Mizobuchi and Yuichi Matsuo, "DNS and RANS modeling of a turbulent boundary layer with separation and reattachment," AIAA Aviation Turbulence Model Benchmarking Working Group meeting (Dallas, USA, June 17, 2019).

Hiroyuki Abe, "DNS study on Reynolds stress anisotropy in a turbulent boundary layer with separation and reattachment," Proc. of 17th European Turbulence Conference (Turin, Italy, Sept. 3-6, 2019).

Hiroyuki Abe, "A DNS study of a shear-driven three-dimensional turbulent boundary layer with emphasis on momentum transport," American Physical Society 72nd Annual Meeting of the APS Division of Fluid Dynamics (Seattle, WA, USA, Nov. 23-26, 2019).

Taisuke Nambu, Yasuhiro Mizobuchi, "Detailed numerical simulation of primary atomization by crossflow in a flow condition of gas turbine combustor," The Fifty-Seventh Symposium (Japanese) on Combustion

Taisuke Nambu, Yasuhiro Mizobuchi, "Investigation of the Grid Density Effect on a VoF-based Numerical Analysis of Primary Atomization by Crossflow," ILASS-Asia 2019.

- Poster Presentations

Hiroyuki Abe, Yasuhiro Mizobuchi and Yuichi Matsuo, Prediction of turbulent flow around NASA CRM with a nonlinear k-ε model, JSME Fluids Engineering Conference, November, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	256 - 7712
Elapsed Time per Case	2000 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 8.88

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	79,926,448.43	9.71
SORA-PP	20,652.48	0.13
SORA-LM	34,526.54	14.42
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,660.61	1.38
/data	35,053.45	0.60
/ltmp	5,504.79	0.47

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	45.27	1.14

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of FaSTAR-Move

Report Number: R19EA3201
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11529/

Responsible Representative

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Members

Keiji Ueshima, Atsushi Hashimoto, Takashi Ishida, Shigeru Kuchiishi, Kanako Yasue, Hitoshi Arizono, Ryosuke Fuse, Toru Yada, Mami Hayakawa

Abstract

FaSTAR-Move, an extended version of the fast unstructured-grid flow solver FaSTAR, is developed to analyse flow field around moving/deforming objects such as external store separation, flutter, rotor, and compressor/turbine of aero-engines.

Reasons and benefits of using JAXA Supercomputer System

JSS is necessary to complete numerical simulations of unsteady phenomena and to understand it in short time span.

Achievements of the Year

FaSTAR-Move have been extended to enable rotor-stator analysis for turbine and rotor/body interaction analysis for helicopter. It was comfirmed that FaSTAR-Move can reasonably simulate the flow field around them.

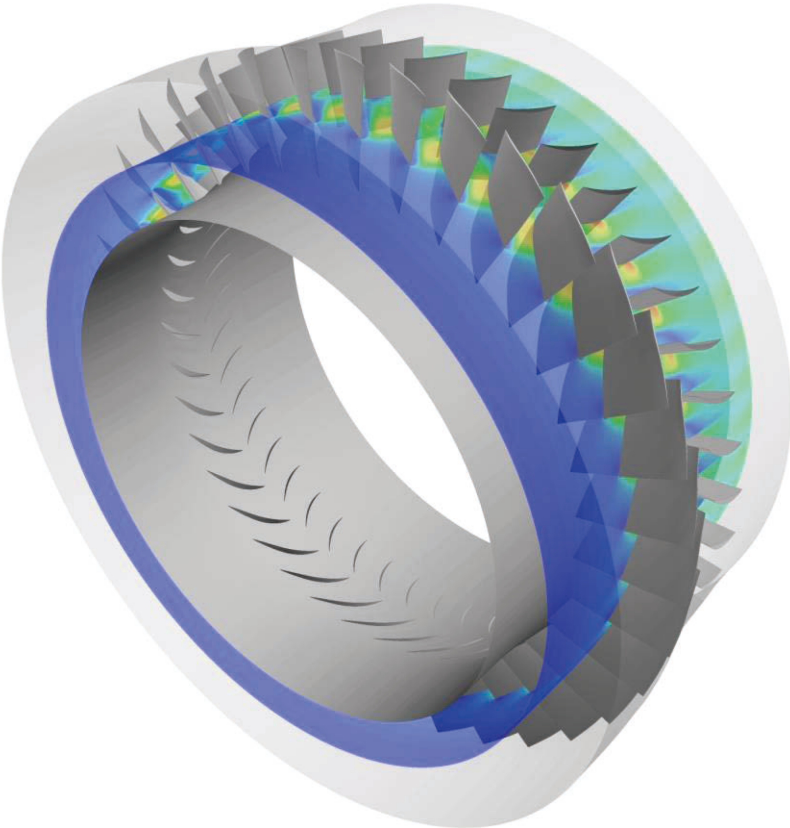

Fig. 1: Mach number contours for flow around Stage 37.

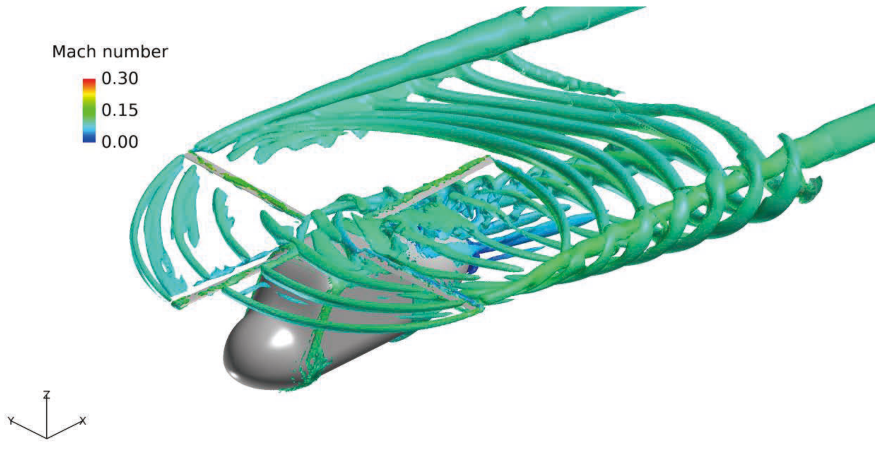

Fig. 2: Q-criteria of the rotor/body interaction analysis for helicopter.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	256 - 2048
Elapsed Time per Case	200 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.95

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	7,875,523.31	0.96
SORA-PP	74,469.64	0.48
SORA-LM	4,700.01	1.96
SORA-TPP	2,972.28	0.18

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	979.70	0.82
/data	79,206.55	1.36
/ltmp	5,732.20	0.49

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	5.74	0.14

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Digital tuft; measurement system of surface phisycal quantity for aircraft

Report Number: R19EDA102F00
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11582/

Responsible Representative

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Members

Masaru Naruoka, Hiroya Toriida

Abstract

Development of measurement system of surface phisycal quantity for aircraft

Reasons and benefits of using JAXA Supercomputer System

The puropose is to perform CFD analyses for estimation of aerodynamic penalty of aircraft equipped with the developed sensor system. The advantage of JSS2 is its speed and preciseness of calculation.

Achievements of the Year

The calculation results show that the additional sensor susyem equipped on the surface of a target aircraft does not significantly affect the original aerodynamic features.

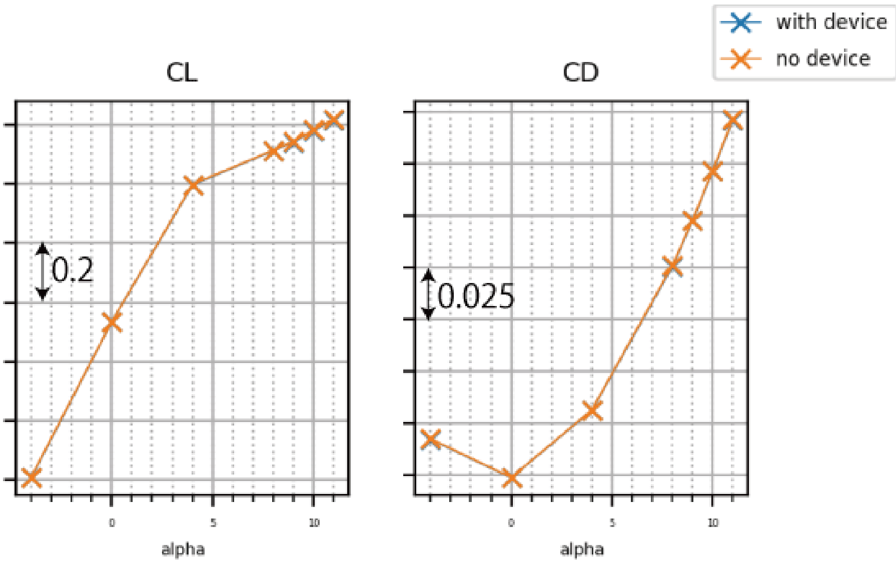

Fig. 1: CL and CD comparisons between with and without the sensor system

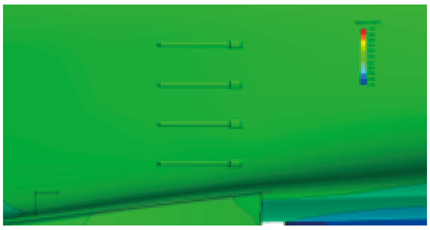

Fig. 2: Cp when the sensor system is equipped

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512
Elapsed Time per Case	5 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.15

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,358,574.08	0.17
SORA-PP	2,891.98	0.02
SORA-LM	21.82	0.01
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	3.97	0.00
/data	4,092.85	0.07
/ltmp	813.80	0.07

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Environment Conscious Aircraft Systems Research in Eco-wing Technology: CFD Code Modifications

Report Number: R19EA0621
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11515/

Responsible Representative

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Abstract

In a research of environment-conscious aircraft systems resarch for environmental conscious aircraft technology named "Research for Eco-Wing technology", innovative drag reduction technologies are investigated to reduce the fuel consumption for a conventional aircraft configuration. Aircraft noise prediction technologies and the conceptual design technologies are also developed for future aircraft which achieve low noise and high efficiency.

As part of research, an overset grid method with higher order interpolation is introduced into a CFD code to reduce time-consuming work for grid generation around complicated aircraft configurations, while achieving high resolution of noise sources with higher-oder numerical scheme. In this work, operation check and debug of the modified CFD code on JSS2 is conducted.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/ecowing/

Reasons and benefits of using JAXA Supercomputer System

The JSS2 is used to develop the airframe, engine, and interference noise prediction tools that have high or middle fidelities for applicable to MDO design with high fidelity CFD and FEM analysis. The airframe-engine installation and/or shielding effects are one of important key issues for the future aircraft. The accuracy of current low fidelity analysis for the airframe, engine, and interference noise prediction is not good enough for application to MDO design with high fidelity CFD and FEM analysis toward the future low-noise aircrafts. The JSS2 is required for development of high or middle fidelity noise prediction tools for competitiveness in technology.

Achievements of the Year

The pre-processing in the CFD code was modified with debuging through application to a large scale practical problem on JSS2 SORA-PP system.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	300
Elapsed Time per Case	10 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	19,749.72	0.00
SORA-PP	19,338.99	0.13
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	40.16	0.03
/data	50,682.91	0.87
/ltmp	1,360.64	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Environment Conscious Aircraft Systems Research in Eco-wing Technology:Aerodynamic System Design Technology

Report Number: R19EA0601
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11512/

Responsible Representative

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Abstract

Innovative drag reduction technologies are investigated to reduce the fuel consumption for a conventional aircraft configuration. Aircraft noise prediction technologies and the conceptual design technologies are also developed for future aircraft which achieve low noise and high efficiency.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/ecowing/

Reasons and benefits of using JAXA Supercomputer System

CFD analysis are used for the understanding of aerodynamic characteristics and evaluation of the performance in the aircraft design phase. Huge calculation resources and costs were required for the high fidelity and quick response CFD analysis for the optimum aerodynamic design process on complex aircraft geometry. JSS2 can achieve those requirements, the cost and time are drastically saved on the CFD analysis.

Achievements of the Year

Aerodynamic design was performed on the wing geometry of TRA2022-4 configuration to reduce the drag on cruise flight condition. Comparing with TRA2022-3 configuration designed on 2018, further drag reduction was obtained by design of the wing-body fairing geometry and modification of the main wing area.

The TRA2022-4 configuration which were applied drag reduction aerodynamic technologies and light-weight structual technologies can be acieved 15% saving of the fuel consumption comparing with a reference aircraft TRA2012A.

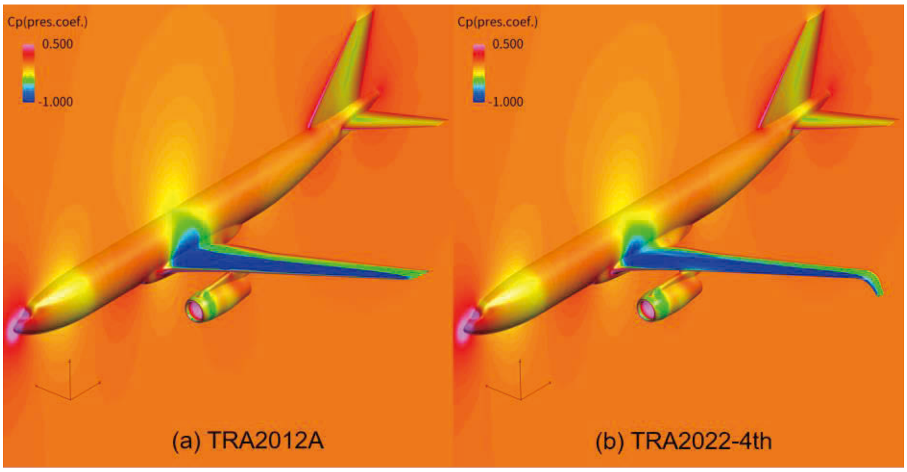

Fig. 1: Surface pressure distributions and surface flow patterns on TRA2022-4 and TRA2012A configurations(M=0.78, CL=0.52)

Publications

- Oral Presentations

1. K. Kubota, T. Yuhara and K. Rinoie, A Study on the Effects of Wingtip Geometries on the Aircraft Performance-Comparisons of Upward and Downward Pointing Winglets-, 57th Aircraft Symposium, 2019.(in Japanese)

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	15 - 1200
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 3.38

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	29,970,086.68	3.64
SORA-PP	107,862.42	0.70
SORA-LM	78.00	0.03
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	297.64	0.25
/data	75,301.37	1.29
/ltmp	11,612.22	0.99

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	15.27	0.38

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Environment Conscious Aircraft Systems Research in Eco-wing Technology:Airframe-Engine Noise Reduction Technology

Report Number: R19EA0602
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11513/

Responsible Representative

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Members

Ryotaro Sakai, Ryutaro Furuya, Mitsuhiro Murayama, Yasushi Ito, Takehisa Takaishi, Tohru Hirai, Kentaro Tanaka, Kazuhisa Amemiya, Gen Nakano, Tomoaki Ikeda, Fumitake Kuroda, Keisuke Ohira, Dongyoun Kwak, Junichi Kazawa

Abstract

Innovative drag reduction technologies are investigated to reduce the fuel consumption for a conventional aircraft configuration. Aircraft noise prediction technologies and the conceptual design technologies are also developed for future aircraft which achieve low noise and high efficiency.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/ecowing/

Reasons and benefits of using JAXA Supercomputer System

The JSS2 is used to develop the airframe, engine, and interference noise prediction tools that have high or middle fidelities for applicable to MDO design with high fidelity CFD and FEM analysis. The airframe-engine installation and/or shielding effects are one of important key issues for the future aircraft. The accuracy of current low fidelity analysis for the airframe, engine, and interference noise prediction is not good enough for application to MDO design with high fidelity CFD and FEM analysis toward the future low-noise aircrafts. The JSS2 is required for development of high or middle fidelity noise prediction tools for competitiveness in technology.

Achievements of the Year

A high-fildelity noise propagation prediction method has been developed to simulate engine fan noise shielding effect by airframe. By utilizing linearized Euler equation on Building-Cube Cartesian Grid, the method has several advantages to efficiently simulate the noise propagation around comlicated geometries in the flowfield. The accuracy has been validated and improved through comparison with the wind tunnel test results using a fan noise simulator to investigate the fan noise shielding effect (Fig.1).

In addition, aerodynamic and aeroacoustic performances of a Krueger flap were evaluated. A Krueger flap is a leading-edge high-lift device which works similarly to a conventional slat but deployed from the lower surface of the leading edge of the wing. In contrast to a conventional slat, a Krueger flap can keep the smoothed upper surface, thus it is considered as a high-lift device for future aircraft with drag reduction technologies associated with laminar flow control. The comparision of unsteady flow simulations around a conventional slat and a Krueger flap indicated a Krueger flap concept that provides comparable aerodynamic performance to a conventional slat with reduced noise levels (Fig.2).

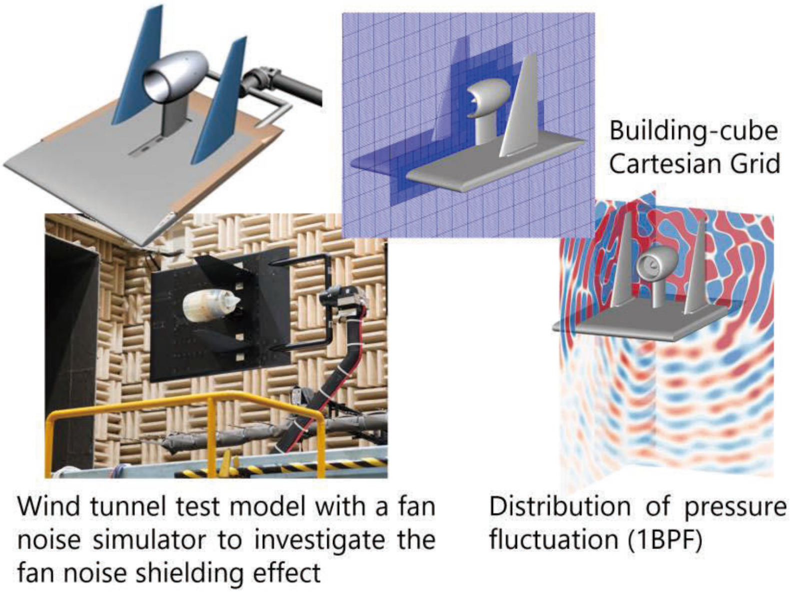

Fig. 1: Fan noise propagation simulation around a wind tunnel test model with a fan noise simulator to investigate the fan noise shielding effect

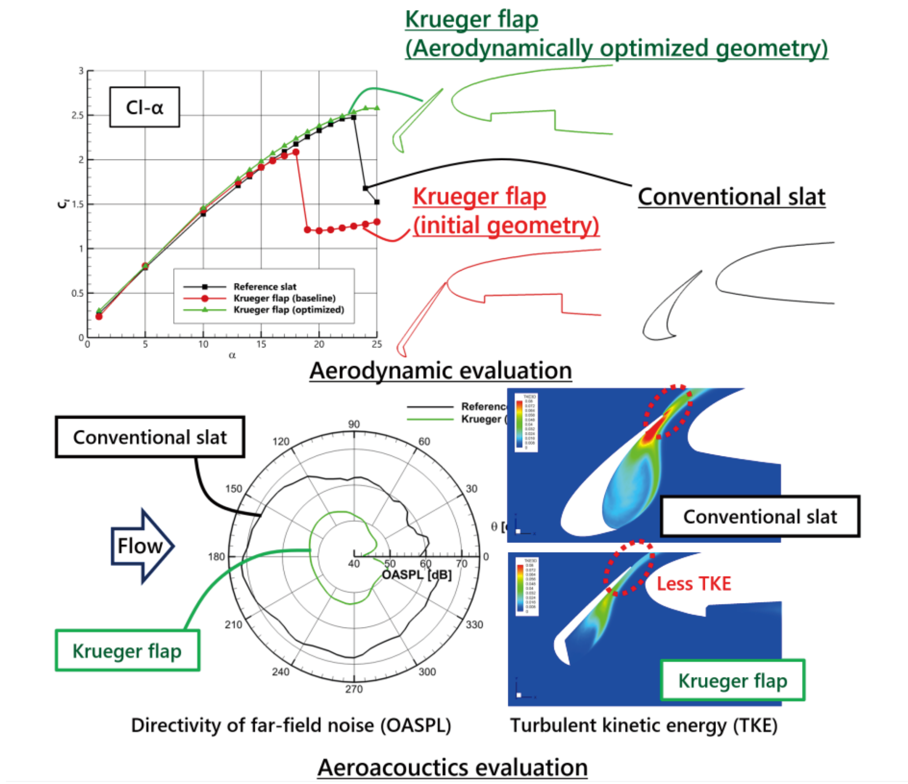

Fig. 2: Comparison of aerodynamic and aeroacoustic computational results around a conventional slat and a Krueger flap

Publications

- Poster Presentations

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	128 - 1600
Elapsed Time per Case	48 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.87

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	7,624,342.03	0.93
SORA-PP	6,534.87	0.04
SORA-LM	1,050.36	0.44
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	242.35	0.20
/data	14,656.28	0.25
/ltmp	4,075.74	0.35

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	177.19	4.46

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

FINE (Flight Investigation of skiN-friction reducing Eco-coating)

Report Number: R19EA0603
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11514/

Responsible Representative

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Members

Mitsuru Kurita, Fumitake Kuroda

Abstract

By developing a particular riblet pattern that is effective at reducing the turbulence frictional resistance, and by producing and applying an easy-to-coat method that can create an optimum riblet surface on the airframe, reduce friction drag in the turbulence boundary layer.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/ecowing/

Reasons and benefits of using JAXA Supercomputer System

CFD analysis are used for developing a particular riblet pattern that is effective at reducing the turbulence frictional resistance. Huge calculation resources and costs are required for the high fidelity and quick response CFD analysis for obtaining the optimum riblet pattern. Use of JSS2 is indispensable for these requirements; the cost and time on the CFD analysis are drastically saved.

Achievements of the Year

We have performed a series of direct numerical simulations of a turbulent channel flow over riblets in order to understand the basic characteristics regarding the riblets for the flight testing in the 'FINE' project. Consequently, the performance of the riblets, i.e. the effect of shrinking the streamwise extent of sinusoidal riblets, have been successfully clarified.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64 - 512
Elapsed Time per Case	500 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 1.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	11,614,271.43	1.41
SORA-PP	13.38	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	5.68	0.00
/data	9,847.38	0.17
/ltmp	813.80	0.07

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.82	0.02

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Flight Demonstration of Gust Alleviation Technologies

Report Number: R19EDA102H00
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11583/

Responsible Representative

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Members

Manabu Hishida

Abstract

Flight demonstration of gust alleviation control technologies using JAXA doppler lidar

Reasons and benefits of using JAXA Supercomputer System

Database construction of aerodynamics of a demonstration aircraft

Achievements of the Year

We calculate aerodynamic characteristics with jet engine exhaust conditions for a demonstration aircraft.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	256
Elapsed Time per Case	6 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	99,639.47	0.01
SORA-PP	187.55	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	0.66	0.00
/data	610.35	0.01
/ltmp	122.07	0.01

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

High-Resolution, Efficient CFD Methods by Second Slope Limiter for Transonic Speeds

Report Number: R19EDA201N10
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11593/

Responsible Representative

Keiichi Kitamura, Yokohama National University, Faculty of Engineering, Division of Systems Research

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Atsushi Hashimoto, Keiichi Kitamura, Suguru Ogawa, Yuuya Takagi, Hiroyuki Takimoto, Hiroto Yaginuma, Masashi Kanamori, Naoya Hase, Hayato Kawashima, Yoshikatsu Furusawa, Takuma Yamaguchi, Fumiya Tsutsui, Yuya Yasumura, Tomohiro Mamashita, Hironari Toriumi

Abstract

A high-resolution, Delayed DES has been conducted around whole the aircraft under the low-speed buffet condition. This numerical case is known as a tough problem, since it is difficult to obtain good numerical solutions that agree well with the corresponding experimental data. In this study, we introduced a new, unsteady-preconditioning function which controls the numerical dissipation to control grid-dependent, unsteady numerical oscillations. Its effect has been confirmed by the numerical test without undesirable influences on the surface pressure coefficient.

Reasons and benefits of using JAXA Supercomputer System

1) Expensive, unsteady CFD around whole the aircraft; 2) Many numerical cases (aerodynamic problems) in which our proposed schemes are verified.

Achievements of the Year

For high resolution SLAU2 (HR-SLAU2) which generated slight numerical oscillations, we incorporated a new, unsteady-preconditioning function to control the oscillations ("unsteady05", "unsteady005"). As a result, we succeeded in changing the amplitude of the numerical oscillations by changing the preconditioning constant. According to the pressure coefficients, it was also confirmed that the solution was not deteriorated by the dissipation control. In the future, we will establish a new function that can suppress numerical oscillations under various conditions by incorporating a variable threshold value instead of the constant.

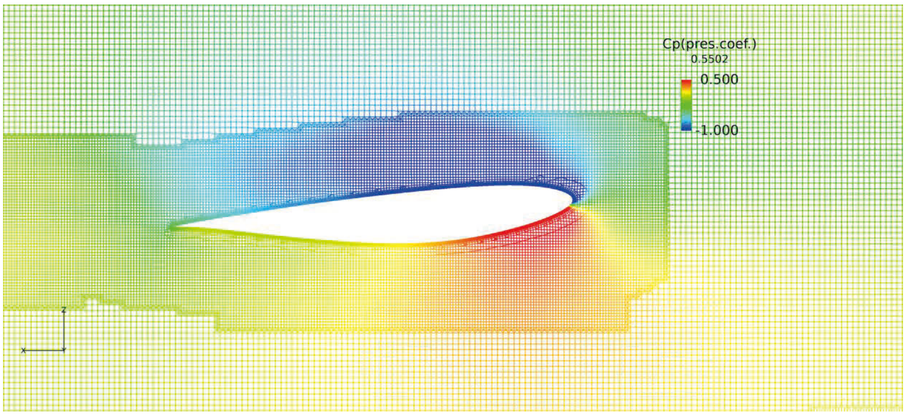

Fig. 1: Flowfield around main wing (13.1% cross-section). High Resolution SLAU2

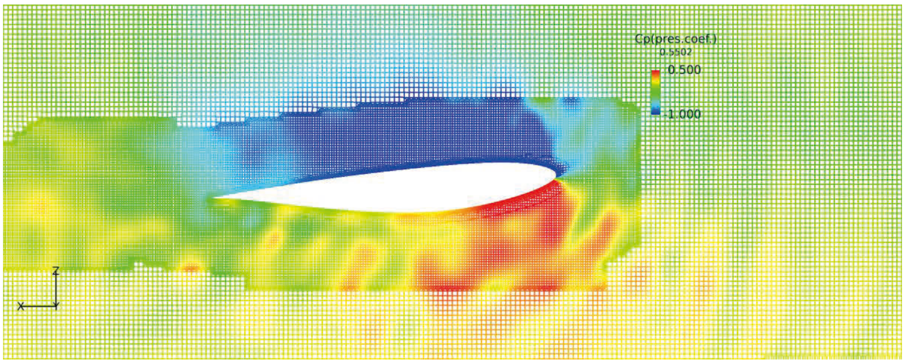

Fig. 2: Flowfield around main wing (13.1% cross-section). Unsteady05

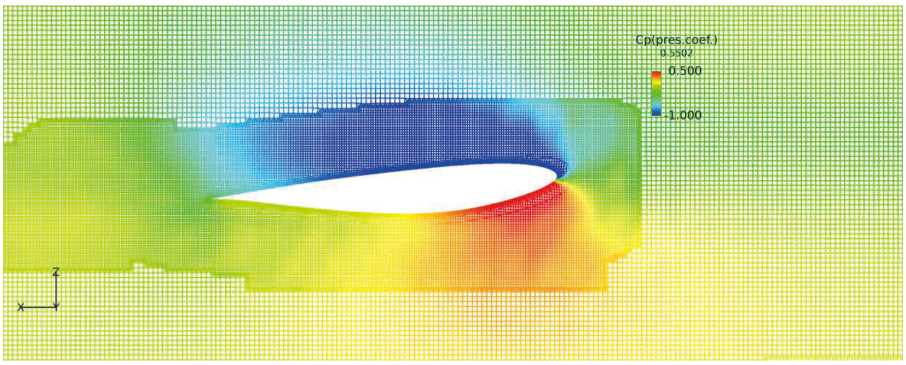

Fig. 3: Flowfield around main wing (13.1% cross-section). Unsteady005

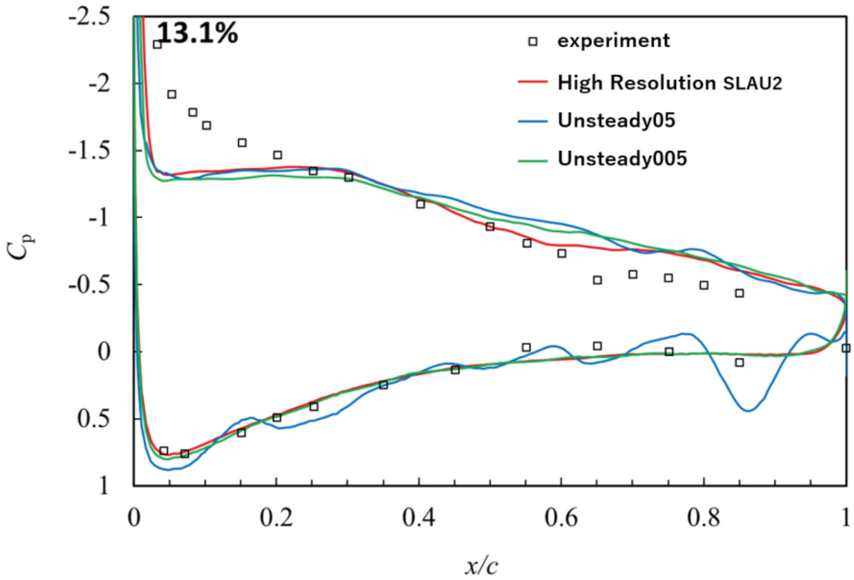

Fig. 4: Pressure distributions on 13.1% cross-section.

Publications

- Oral Presentations

- K. Kitamura, S. Ogawa, H. Takimoto, M. Kanamori, A. Hashimoto: Low Speed Buffet Simulation using High-Resolution Delayed-DES with Improved LES/RANS Transition, Asia Pacific International Symposium on Aerospace Technology (APISAT) 2019, Surfers Paradise Marriott Resort, Gold Coast, 4-6 December 2019.

- K. Kitamura, S. Ogawa, H. Takimoto, M. Kanamori, A. Hashimoto: High-Resolution Delayed-Detached-Eddy-Simulation (HR-DDES) on Low Speed Buffet, 51st FDC/37thANSS, 2E02, July 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	512
Elapsed Time per Case	50 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 2.17

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	16,511,937.74	2.01
SORA-PP	273,095.77	1.77
SORA-LM	30,795.18	12.86
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,109.86	0.92
/data	90,682.66	1.55
/ltmp	27,094.97	2.30

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	84.78	2.13

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Improvement of numerical analysis for internal flow with complicated configuration inside aero-engine

Report Number: R19EA2120
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11524/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

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Members

Shunji Enomoto, Junichi Kazawa, Atsushi Hashimoto, Takashi Ishida, Shigeru Kuchiishi, Mitsumasa Makida, Hiroki Ugajin, Taisuke Nambu, Keiji Ueshima, Kanako Yasue, Takashi Aoyama

Abstract

Unstructured-grid flow solver FaSTAR-Move and grid generator BOXFUN are applied to aero-engine elements with complicated configuration. Through the calculation, these programs are tested and investigated for the deficiency and future issue for improvement of accuracy.

Reasons and benefits of using JAXA Supercomputer System

For large scale computations in the future, programs should be tested under the same computational environment.

Achievements of the Year

The linear cascade (T106A) with cooling holes was analyzed using the FaSTAR-Move, and the computational results were compared with the experimental ones.

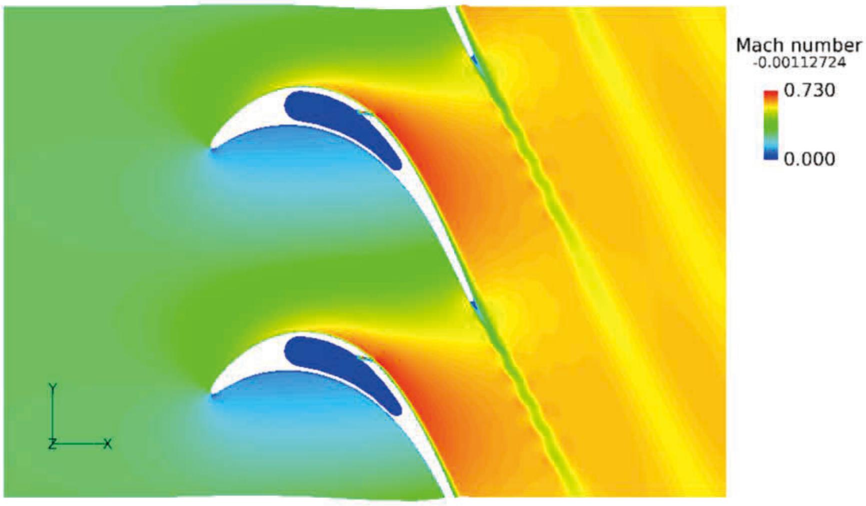

Fig. 1: Mach number distribution of the linear cascade (T106A) with cooling holes.

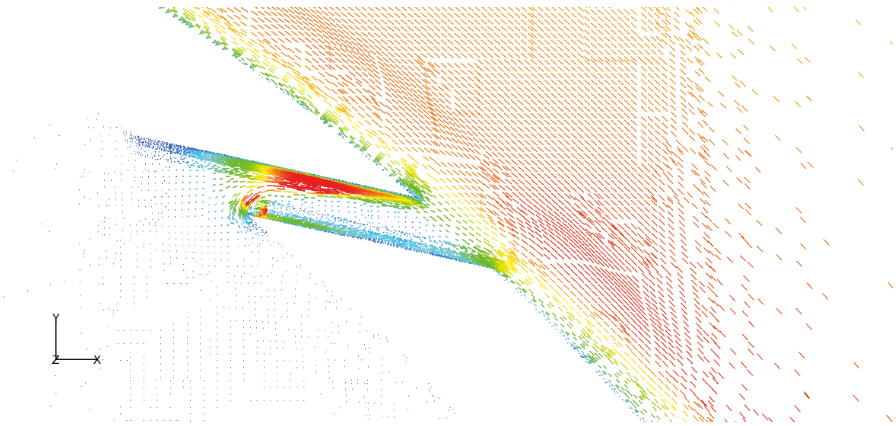

Fig. 2: Velocity vector distribution near the cooling hole.

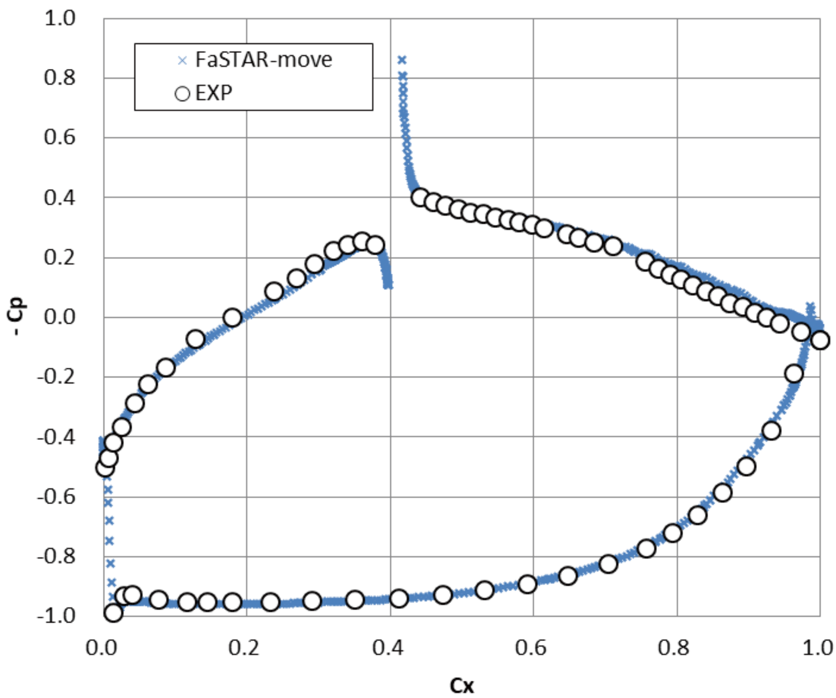

Fig. 3: Static pressure distribution on the blade surface

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	64
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.36

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	2,976,884.96	0.36
SORA-PP	31,404.87	0.20
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	181.18	0.15
/data	21,530.18	0.37
/ltmp	4,365.50	0.37

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	10.59	0.27

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Investigation of Indirect Reynolds Number Effect

Report Number: R19EDA201N08
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11591/

Responsible Representative

Takashi Aoyama, Associate Senior Researcher, Aeronautical Technology Directorate, Numerial Simulation Research Unit

Contact Information

Makoto Ueno, JAXA(ueno.makoto@jaxa.jp)

Members

Wataru Yamazaki, Jun Sakamoto, Hiroki Ichihashi, Makoto Ueno

Abstract

This research analizes the influence of total pressure loss due to boundary layer tripping roughness on flow around an airplane wind tunnel model using computational fluid dynamics (CFD). It is objected to realize, especially, pressure distribution variation due to Reynolds number variation, which is known as the indirect effect.

Reasons and benefits of using JAXA Supercomputer System

It is necessary to perform CFD computation including flow around a whole aircraft because it requires highly parallelized computation. Additionally, the JSS2 was chosen because the FaSTAR CFD solver is optimized, as well.

Achievements of the Year

In airplane development, it is known that the equivalent flow around the airplane in flight is able to be reqlized even with a scaled wind tunnel model in the case of surrounding gas with the same specific heat ratio, the Mach number, and the Reynolds number, while it is very expensive to achieve such high Reynolds number as in flight, in wind tunnel tests. Usual wind tunnel tests are, therefore, performed in relatively low Reynolds number conditions in many cases, and the difference between the wind tunnel and the flight conditions sometimes brings severe aerodynamic problems in development. For example, the C-141 airlifter development program delayed due to shock wave position difference between wind tunnel test and flight test. This kind of catastrophic change with pressure distribution difference brought by Reynolds number effect is called as "indirect effect".

We have been performed CFD simulations for the flow around the C-141 to reproduce indirect effect by varying Reynolds numbers with little success. It is assumed in a literature that the shock wave position difference was caused by excessive loss due to the boundary layer transition roughness position located at too upstream than the ideal. To simulate this condition, artificial momentums loss are focibly placed in the boundary layer in the CFD simulation.

The computation was performed as 2-dimensional CFD simulation around the C-141 airfoil at the 38.9% half-span position. The momuntum was located at 5% downstream from the leading edge of the airfoil as the region which has a width of 0.1 chord length both in the x-, and the y-direction. The sign of the added momentum is negative for flow direction and positive for upward. The strength of the added momentum has a unit of N/m^3. As the result, it is shown that the artificial momentum loss addition in the boundary layer brings shock wave location displacement similar to the phenomenon of the C-141. The figure is shown in Fig.1.

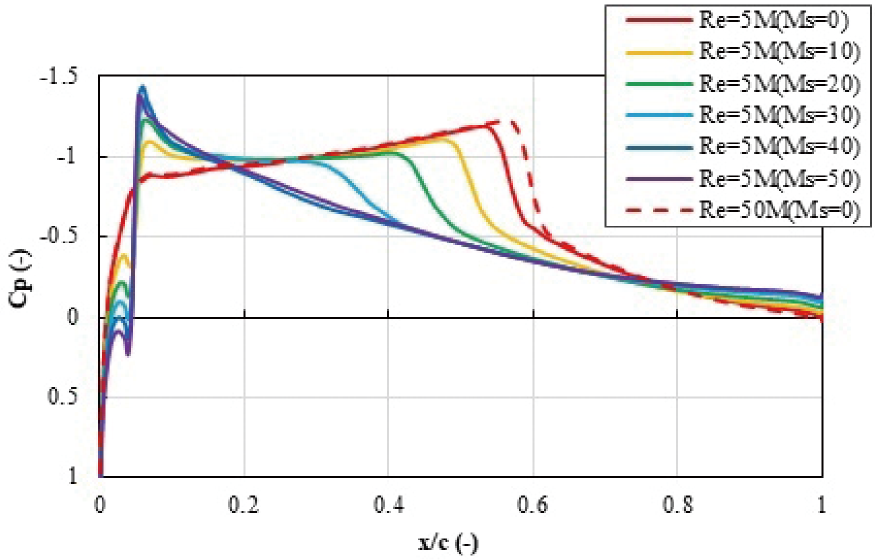

Fig. 1: Cp distributions on the upper surface of C141 airfoil

Publications

- Non peer-reviewed papers

Jun Sakamoto, Hiroki Ichihashi, Wataru Yamazaki, Makoto Ueno, Investigation of Reynolds Number Effect of C-141 Aircraft, Seventeenth International Conference on Flow Dynamics, Sendai, Miyagi, Oct., 2020.

Hiroki ICHIHASHI, Wataru YAMAZAKI and Makoto UENO, Investigation of indirect Reynolds number effect around airfoil considering influence of roughness, JSME, Hokuriku Shin-etsu Branch, 57th Annual Meeting, Nagaoka, Niigata, Mar., 2020.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	216
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.39

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	3,507,969.12	0.43
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	95.37	0.00
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Investigation of internal flow of aircraft combustor for En-Core Project.

Report Number: R19EA0714
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11517/

Responsible Representative

Mitsumasa Makida(JAXA, Aeronautical Technology Directorate)

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Members

Mitsumasa Makida, Naoki Nakamura, Takashi Ishiyama

Abstract

In the development process of aircraft combustors, air mass flow distribution between fuel nozzles, dilution and cooling air holes on the liner effects performances of combustors. So it is important to understand the internal flow and estimate the mass flow distribution. In this research, we conduct cold-flow simulations of internal flow inside the combustor which faithfully simulates the configuration of practical combustor. Then we aim to develop methods to analyze aerodynamic performance of combustors such as air mass flow distribution with high accuracy.

Reasons and benefits of using JAXA Supercomputer System

It is important to do parametric case study with slightly different geometry, and each case needs large scale simulation. To conduct such simulation effectively, we need the super computer with high parallelization efficiency.

Achievements of the Year

In this fiscal year, we conducted cold-flow simulations for a single-sector combustor. These simulations aimed to estimate the effect of the angle of pilot swirlers on the internal flow of the combustor. Fig.1 shows the total view of the combustor, Fig.2 shows the geometry of the fuel nozzle and pilot swirlers (angles of pilot1 and pilot2 are 55- and 45-degree respectively), and Fig.3 shows calculation grids of the combustion chamber and the fuel nozzle. And also, as examples of calculation result, Fig.4 shows contour of y-momentum on y=0 cross section. Calculations were also conducted for angles of pilot1 and pilot2 of 50- and 40-degree cases. To do parametric studies by changing minimum parts of combustor configuration, the overset boundary method, in which corresponding parts can be changed, is effective.

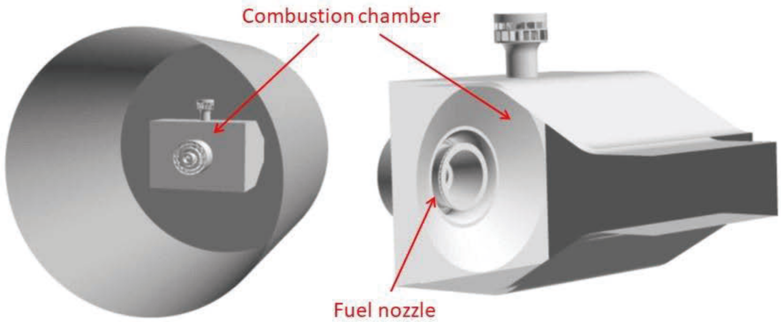

Fig. 1: Total view of combustor

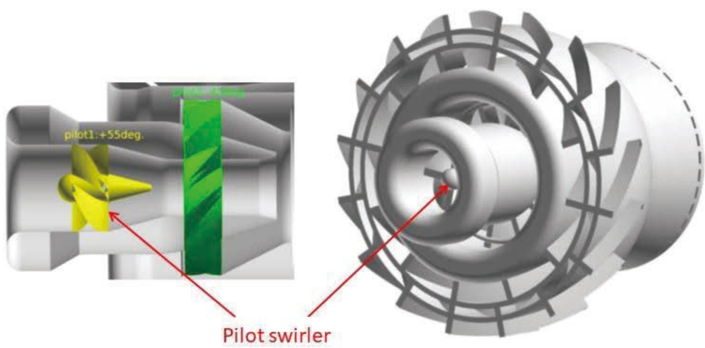

Fig. 2: Geometry of fuel nozzle and pilot swirlers

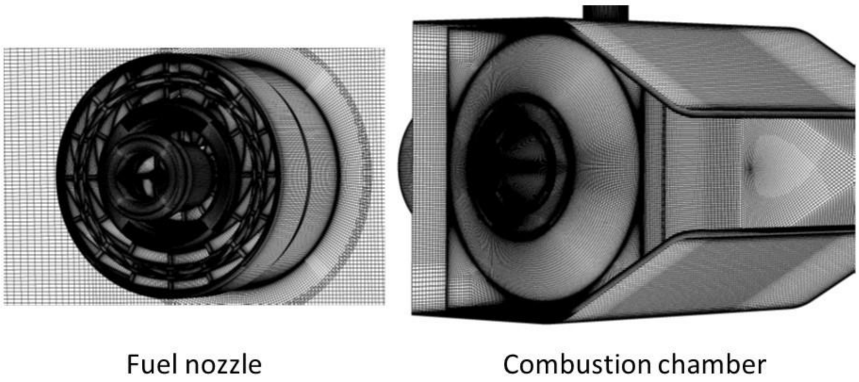

Fig. 3: Calculation grids of combustion chamber and fuel nozzle

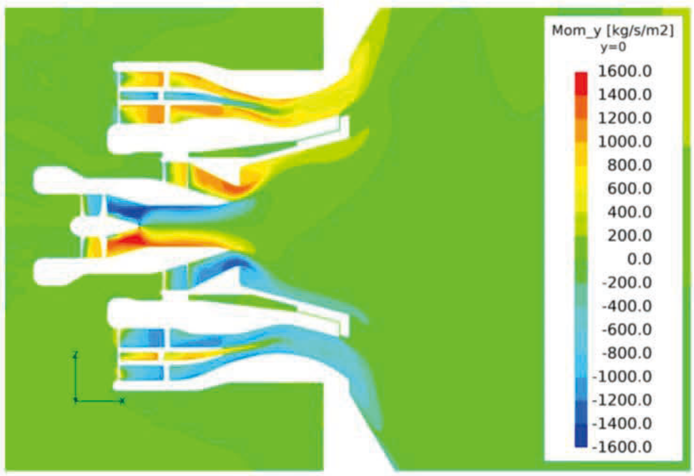

Fig. 4: Contour of y-momentum on y=0 cross section

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64
Elapsed Time per Case	250 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.09

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	655,339.74	0.08
SORA-PP	26,183.96	0.17
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	82.81	0.07
/data	7,402.33	0.13
/ltmp	1,450.89	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.85	0.05

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Laminar-turbulent transition simulation in aFJR High efficiency fan technology development

Report Number: R19EA2180
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11527/

Responsible Representative

Tatsuya Ishii, Aeronautical Technology Directorate, Propulsion Research Unit

Contact Information

Shunji ENOMOTO(enomoto.shunji@jaxa.jp)

Members

Shunji Enomoto

Abstract

With one of the goals of reducing the fuel consumption of aero engines, the High Efficiency and Lightweight Fan Turbine Technology Demonstration (aFJR) project studied the technologies required to increase the bypass ratio of aero engines. In a high bypass ratio fan, a larger fan rotates at a lower speed than a conventional fan, so that the Reynolds number of the fan flow decreases. By taking advantage of this fact, it is possible to design the laminar flow region of the fan blade surface boundary layer as wide as possible. In this study, we tried to estimate the presence or absence of the transition of the fan blade boundary layer by LES analysis without using a turbulence model or transition model.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/afjr/

Reasons and benefits of using JAXA Supercomputer System

The numerical simulation for predicting the turbulent flow transition is difficult to execute without a supercomputer due to the large amount of calculation.

Achievements of the Year

Fig. 1 shows the Mach number distribution of the entire calculation area. The computational grid simulates the shape of the TWT-2 wind tunnel in which the experiment was performed, and the mainstream Mach number is 1.1. A vertical shock wave exists slightly upstream of the fan blade, and the flow flowing into the fan blade is subsonic. Fig.2 shows the instantaneous Mach number distribution. The range of X<25mm is a clean laminar boundary layer without separation, and transition occurs around X=27mm, which is a natural transition. Figure 3 shows the instantaneous value of the v' component of the velocity fluctuation to see what is happening from the leading edge to the transition. A vortex street occurs around X=10mm, grows while traveling in the boundary layer, and reaches a transition at X=27mm. Fig. 4 is a view looking down from 0.02mm above the fan blade surface from above the Y axis. It is doubled in the Z direction. Looking at this figure, oblique waves are generated in the range of $12 < X < 23$mm. Since the periodic boundary condition is used in the Z direction, those oblique waves that match the periodic boundary grow selectively. For this reason, it is considered that the width in the Z direction needs to be set to be several times larger than the calculation for accurate calculation.

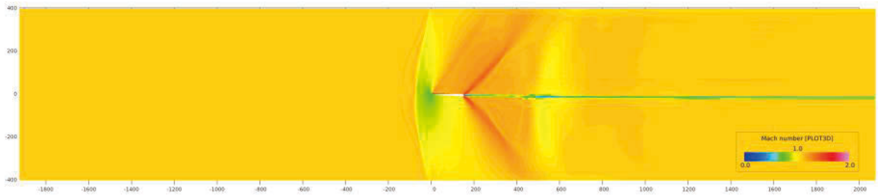

Fig. 1: Mach number distribution over the entire calculation domain

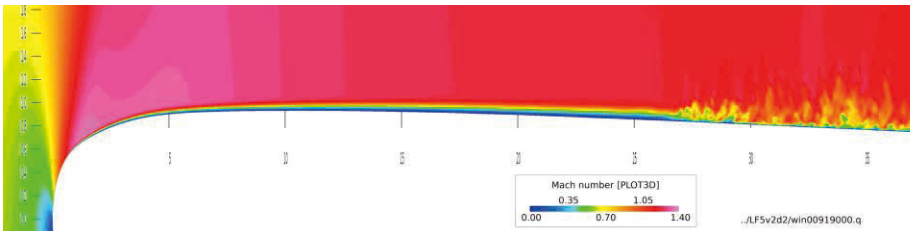

Fig. 2: Mach number distribution of wing cross section (5 times enlarged in Y direction) (Video. Video is available on the web.)

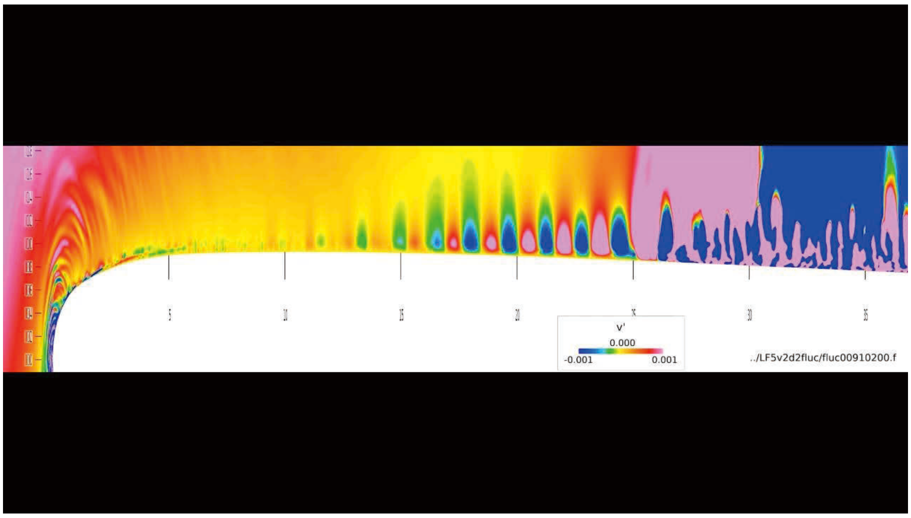

Fig. 3: Velocity fluctuation of wing section (v') (Video. Video is available on the web.)

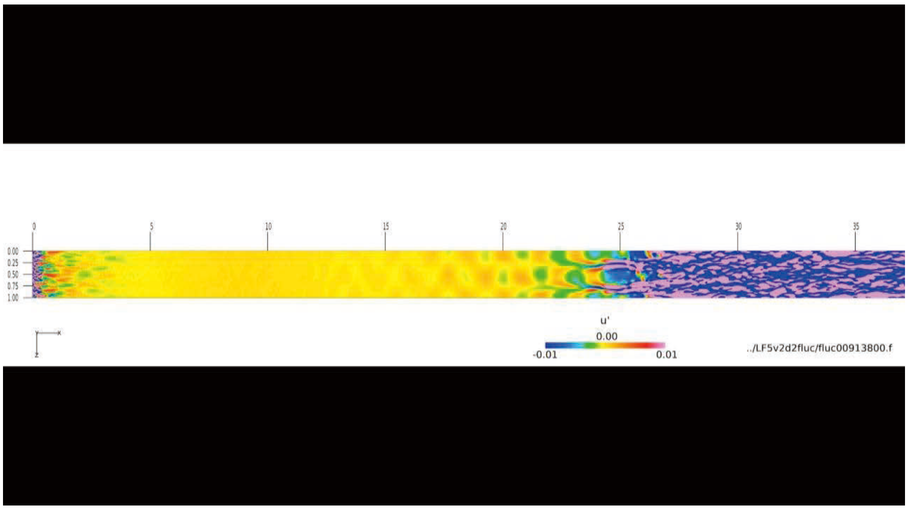

Fig. 4: Velocity fluctuation at the surface 0.02 mm away from the wing surface (u') (2 times enlarged in Z direction) (Video. Video is available on the web.)

Publications

- Non peer-reviewed papers

Shunji ENOMOTO, Junichi KAZAWA, LES of boundary layer transition of a transonic fan blade, Proceedings of the 33rd symposium on computational fluid dynamics

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	72
Elapsed Time per Case	500 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.10

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	39,440.18	0.26
SORA-LM	0.00	0.00
SORA-TPP	130,380.18	7.87

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	11.05	0.01
/data	3,329.19	0.06
/ltmp	665.84	0.06

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	10.48	0.26

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Next generation jet engine technology - development of high efficiency compressor design tecnology and aerodynamic performance prediciton -

Report Number: R19EA0711
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11516/

Responsible Representative

Tatsuya Ishii, Aeronautical Technology Directorate, Propulsion Research Unit

Contact Information

Junichi Kazawa, Aeronautical Technology Directorate, Propulsion Research Unit(kazawa.junichi@jaxa.jp)

Members

Junichi Kazawa, Yuntae Lee, Takafumi Kanayama, Kenshi Yamashita

Abstract

We will develop aerodynamic performance improvement technology and high precision aerodynamic performance prediction technology for multistage-compressore assuming an increase in relative tip clearance, corresponding to a small core engine applied to an ultra-high bypass ratio engine.

Reasons and benefits of using JAXA Supercomputer System

The number of cases of aerodynamic performance prediction of a multi-stage compressor will be very large for satisfactory results. So we can not be calculated in a realistic time using anything other than JSS2.

Achievements of the Year

The analysis including non-design points was performed for the two-stage compressor rig, and the accuracy of the numerical analysis program was confirmed. In addition, the effect of enlarging the operating range by casing treatment was confirmed using a overset grid method.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64 - 128
Elapsed Time per Case	100 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.89

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	4,029,838.62	0.49
SORA-PP	1,230,490.53	7.97
SORA-LM	36.46	0.02
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	22.75	0.02
/data	11,773.37	0.20
/ltmp	4,660.09	0.40

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.83	0.05

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Noise suppression technology for aircraft jet engines

Report Number: R19EA0716
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11518/

Responsible Representative

Tatsuya Ishii, Aeronautical Technology Directorate, Propulsion Research Unit

Contact Information

Shunji ENOMOTO(enomoto.shunji@jaxa.jp)

Members

Shunji Enomoto, Tatsuya Ishii

Abstract

Ultra high bypass ratio aviation jet engines have a smaller sound absorbing liner area than conventional engines. In this project, we will develop sound-absorbing device technology that provides high noise reduction performance even with a small-sized sound-absorbing liner.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/greenengine/

Reasons and benefits of using JAXA Supercomputer System

To perform many LES calculations by changing the shape of the sound absorbing liner and the incident sound frequency, the calculation performance of SORA-PP and TPP and the storage capacity of SORA-FS and J-Space were required.

Achievements of the Year

The purpose of this study was to evaluate the sound absorbing performance of a sound absorbing liner with glazing flow by numerical analysis. The calculation model of the sound absorbing liner greatly simplified the actual flow duct device, and used only one hole in two-dimensional laminar flow. Fig. 1 shows the sound pressure and the velocity vector around the hole of the sound absorbing liner. In the upper part of the figure, the flow of M = 0.3 flows from left to right, and only the boundary layer portion is shown in the figure. The incident sound also proceeds from left to right in the figure. A vortex is generated in the hole of the sound absorbing liner by the glazing flow, and the shape of the vortex is changed by the incident sound. Fig. 2 shows the fluctuation component of the velocity due to the incident sound. It can be seen that the velocity fluctuation is large near the corner on the downstream side of the hole, and almost no sound passes through the other part of the entrance of the hole. Fig. 3 is divergence of time-averaged sound intensity calculated from numerical calculation data. A negative sound intensity divergence (blue in the figure) may indicate a location where sound is diminishing. Accordingly, it has been clarified that the sound absorbing liner in the case where the glazing flow exists has a different sound absorption mechanism from the sound absorbing liner having no glazing flow.

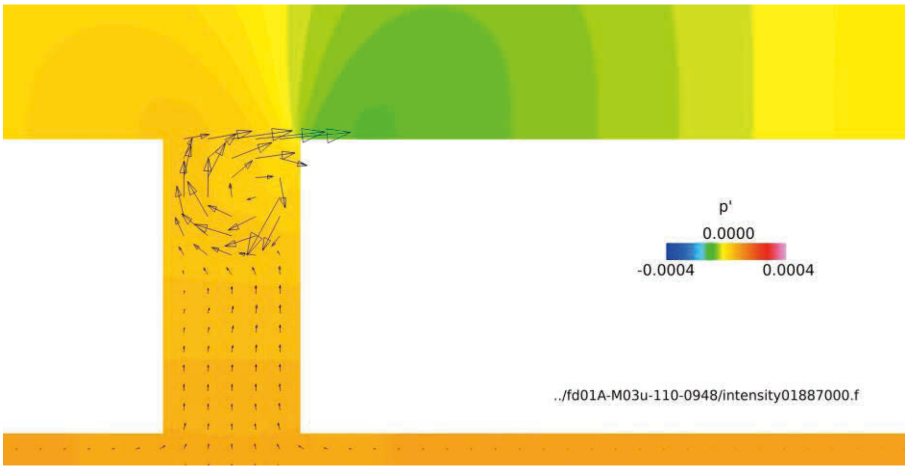

Fig. 1: The sound pressure and the velocity vector around the hole of the sound absorbing liner (Video. Video is available on the web.)

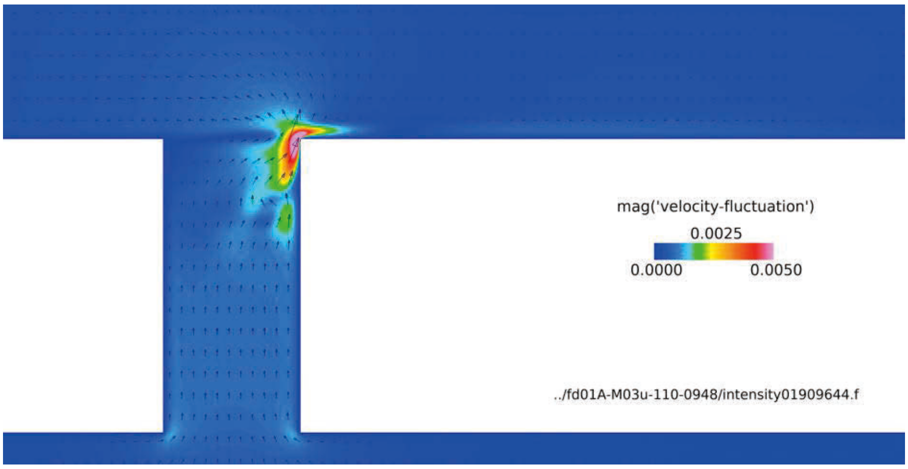

Fig. 2: The fluctuation component of the velocity due to the incident sound (Video. Video is available on the web.)

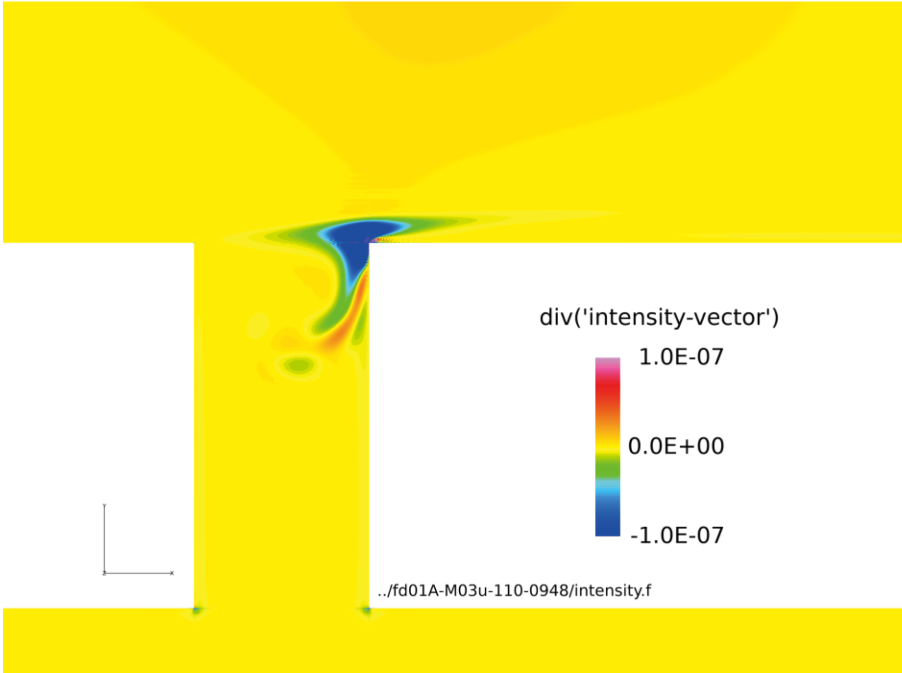

Fig. 3: Divergence of time-averaged sound intensity

Publications

- Non peer-reviewed papers

1) Shunji ENOMOTO, Tatsuya ISHII, Toshio NISHIZAWA, Hidemi TOH, Numerical Analysis of an Acoustic Liner Performance in Grazing Flow, 25th AIAA/CEAS Aeroacoustics Conference, AIAA-2019-2613

2) Shunji Enomoto, Tatsuya Ishii, Numerical Analysis of Multiple Hole Acoustic Liner Performance in Grazing Flow, JSASS-2019-2141-F+A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	12 - 96
Elapsed Time per Case	37 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.31

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	3,456.96	0.00
SORA-PP	118,145.36	0.77
SORA-LM	3.37	0.00
SORA-TPP	427,719.82	25.82

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	30.22	0.03
/data	2,172.36	0.04
/ltmp	4,512.13	0.38

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	12.23	0.31

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Nonlinear Aeroelastic Framework for Multi-fidelity Analysis

Report Number: R19EDA101S01
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11581/

Responsible Representative

Hitoshi Arizono, Aeronautical Technology Directorate, Structures and Advanced Composite Research Unit

Contact Information

Hitoshi Arizono(arizono.hitoshi@jaxa.jp)

Members

Hitoshi Arizono, Youichi Sano, Natsuki Tsushima

Abstract

Nonlinear Aeroelastic Framework for Multi-fidelity Analysis

Reasons and benefits of using JAXA Supercomputer System

Because high fidelity analysis is very expensive for simulation

Achievements of the Year

An unsteady vortex-lattice aerodynamic method and a fast unstructured CFD code are coupled with the structural model subject to the large deformations, providing different fidelity solutions.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 64
Elapsed Time per Case	2 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	12,095.78	0.00
SORA-PP	481.02	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	15.89	0.01
/data	158.95	0.00
/ltmp	3,255.21	0.28

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Analyses on Hypersonic Experimental Aircraft

Report Number: R19EA2121
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11525/

Responsible Representative

Hideyuki Taguchi, Research Plan Manager, Propulsion Technology Research Unit, Aeronautical Technology Directorate

Contact Information

Hideyuki Taguchi(taguchi.hideyuki@jaxa.jp)

Members

Motoyuki Hongoh, Masaharu Hiruma, Hideyuki Taguchi, Yuki Kayama, Hiroyuki Tanaka, Mizuki Fukazawa, Junichi Oki, Yutaka Ikeda, Manami Fujii

Abstract

This research aims at the demonstration of the thrust control method of a hypersonic pre-cooled turbojet engine using liquid hydrogen fuel and the aircraft / propulsion integrated control method. We acquire the control characteristics of the hypersonic integrated control experiment aircraft to establish the aircraft / propulsion integrated control method taking into account the mutual interference of hypersonic airframe and hypersonic engines. In addition to defining the required specifications of hypersonic aircraft, we present the design specifications of the hypersonic experimental aircraft for carrying out flight demonstration of hypersonic pre-cooled turbojet engine.

Ref. URL: http://www.aero.jaxa.jp/eng/research/frontier/hst/

Reasons and benefits of using JAXA Supercomputer System

We need a long calcularion time to obtaine the aerodynamic characteristics of the overall hypersonic experimental aircraft by CFD analyses.

Achievements of the Year

Aerodynamic performances of the High Mach Integrated Control Experimental Aircraft (HIMICO No.1) was evaluated by CFD analyses. (Fig.1, Fig.2, Fig.3)

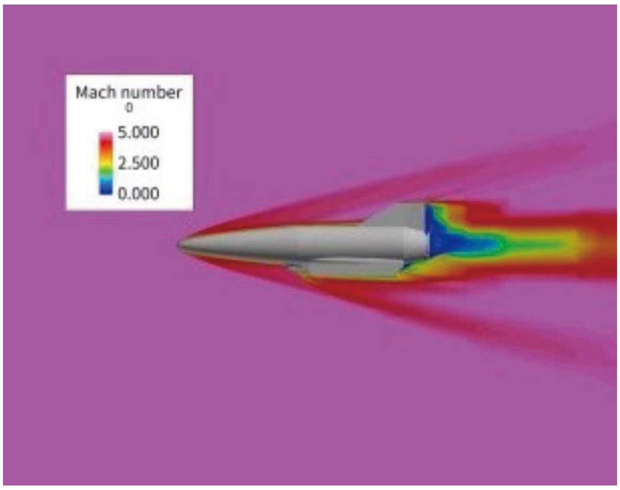

Fig. 1: HIMICO Unit1 Vehicle with Ojive shape (HIMICO Unit1 Mach Contour, Mach5, AoA = 0deg)

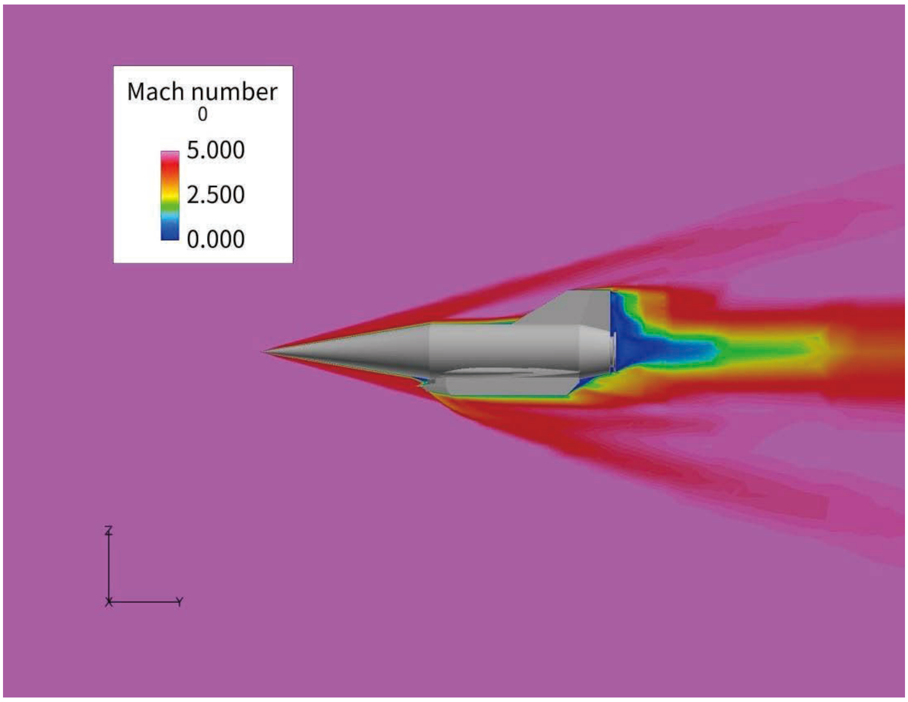

Fig. 2: HIMICO Unit Vehicle (HIMICO Unit1,M Mach Contour, Mach5, AoA = 0deg)

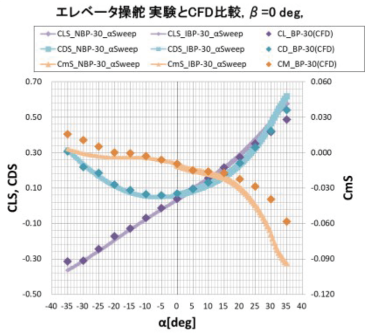

Fig. 3: HIMICO Unit1 Vehicle with -30deg of elevator angle(HIMICO 1, Mach Contour and Streamline, Vertical Three-Component Force Compared with Wind Tunnel Test, Mach5)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 2
Elapsed Time per Case	30 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 4.96

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	44,812,321.74	5.45
SORA-PP	12,343.40	0.08
SORA-LM	8,930.08	3.73
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	2,636.91	2.20
/data	78,220.40	1.34
/ltmp	13,671.88	1.16

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	2.04	0.05

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical analysis on atomization and spray combustion

Report Number: R19EA2150
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11526/

Responsible Representative

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Members

Kazuaki Matsuura, Naoki Nakamura, Mitsumasa Makida, Huilai Zhang, Jun Iino, Kinya Saito

Abstract

A numerical study is performed to clarify phenomena on atomization and spray combustion.

Reasons and benefits of using JAXA Supercomputer System

The atomization phenomenon requires a high calculation load, and the use of super computer is necessary.

Achievements of the Year

The numerical simulation of a planer prefilming air-blast atomaization was conducted. Due to the poor grid resolution, it was turned out that the breakup phenomenon of the ligaments to droplets could not be captured adequately. Based on these numerical simulation results, next numerical simulation will be conducted with finer grid size.

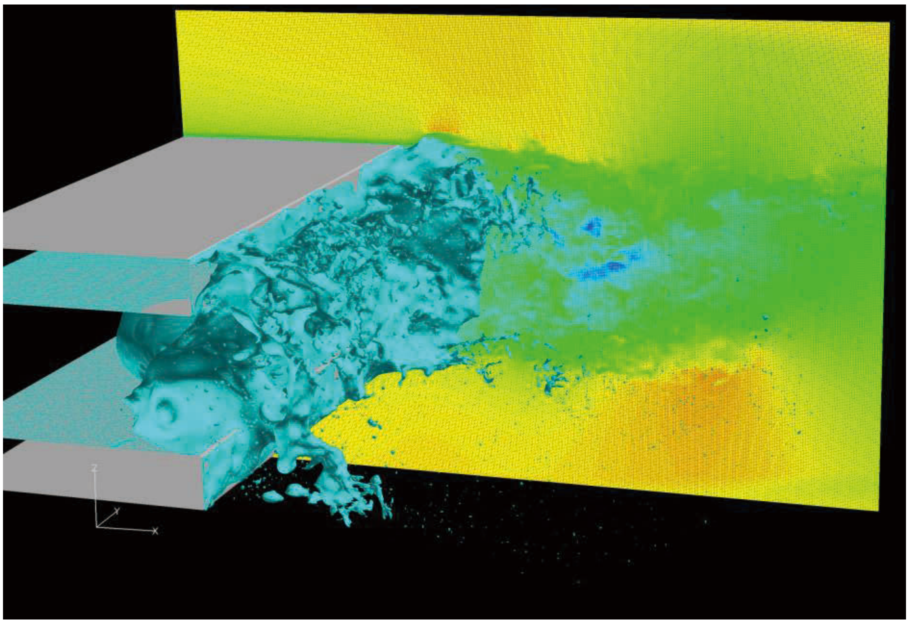

Fig. 1: Atomization of a planar liquid sheet with air flow.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	96 - 768
Elapsed Time per Case	1000 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 1.15

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	10,423,016.00	1.27
SORA-PP	2,046.18	0.01
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	325.29	0.27
/data	26,633.14	0.46
/ltmp	2,752.98	0.23

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.11	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research and development for system integration of silent supersonic airplane technologies

Report Number: R19EA3800
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11534/

Responsible Representative

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Members

Junichi Akatsuka, Naoko Tokugawa, Hiroaki Ishikawa, Yoshikazu Makino, Dongyoun Kwak, Keisuke Ohira, Atsushi Ueno, Satoshi Kondo, Tatsunori Yuhara, Ryo Shimada, Shinya Koganezawa

Abstract

It is important to acquire world-class high level technology in order to enhance the international competitiveness of Japan's aircraft manufacturing industry, especially for supersonic transport. In addition, the advantage is great, such as revitalizing economic activities from the business and tourism aspects by shortening the travel time of supersonic flight, and the health aspects of passengers such as suppression of economy class syndrome. Based on this, the purpose of this project is to acquire the key technologies required to realize a "quiet supersonic aircraft" and contribute to the development of the aircraft manufacturing industry and air transport in the future. In this project, R&D on sonic boom estimation, measurement and evaluation technologies will contribute to the formulation of international standards at ICAO required for over land supersonic flight. The integrated design technology that simultaneously satisfies both low boom, low drag, low noise and weight reduction are developed to present a concept of a supersonic transport that simultaneously satisfies these technical goals.

Ref. URL: http://www.aero.jaxa.jp/eng/research/frontier/sst/

Reasons and benefits of using JAXA Supercomputer System

To develop a future supersonic transport that satisfies the requirement of low sonic-boom and low aerodynamic drag, it is necessary to estimate aerodynamic properties and sonic-boom properties by accurate numerical simulation. JSS is used to estimate aerodynamic performances of various configurations with high accuracy and high efficiency for the designing of the low-boom supersonic transport.

Achievements of the Year

The aerodynamic assessment of the designed configuration was performed by applying the CFD analysis with RANS equation under the actual flight condition simulating the engine exhaust condition in order to design under the condition close to the actual supersonic transport. This analysis clarified the influence of jet exhaust to the low sonic boom performance and designed the configuration to reduce the influence. It has been found that the CFD analysis used in the low-boom design has sufficient performance through the 3rd AIAA Sonic Boom Prediction Workshop (SBPW3) comparing with the other participants. Figure 1 shows the pressure distribution obtained by CFD analysis of the earlier version of NASA X-59 that was the subject of SBPW3, and Fig. 2 depicts the near field pressure signature of the sonic boom away from the 3-body length. It can be seen that the near-field pressure signature of the JAXA own grid captures more clearly than the given grid (Required grid).

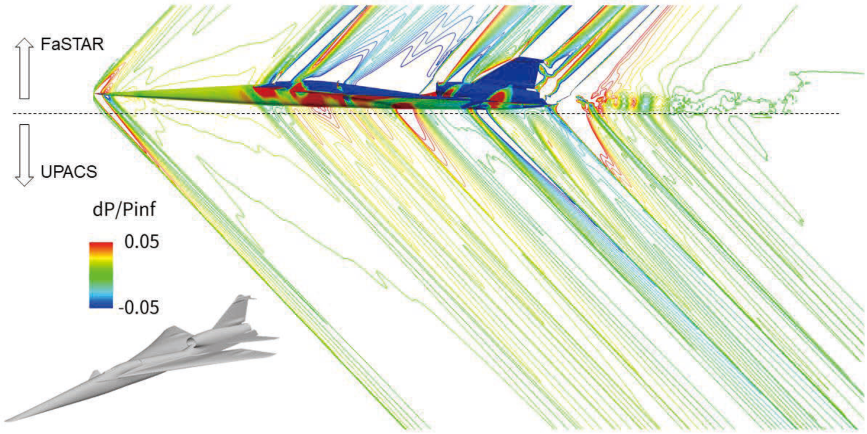

Fig. 1: Pressure distribution of the earlier version of NASA X-59

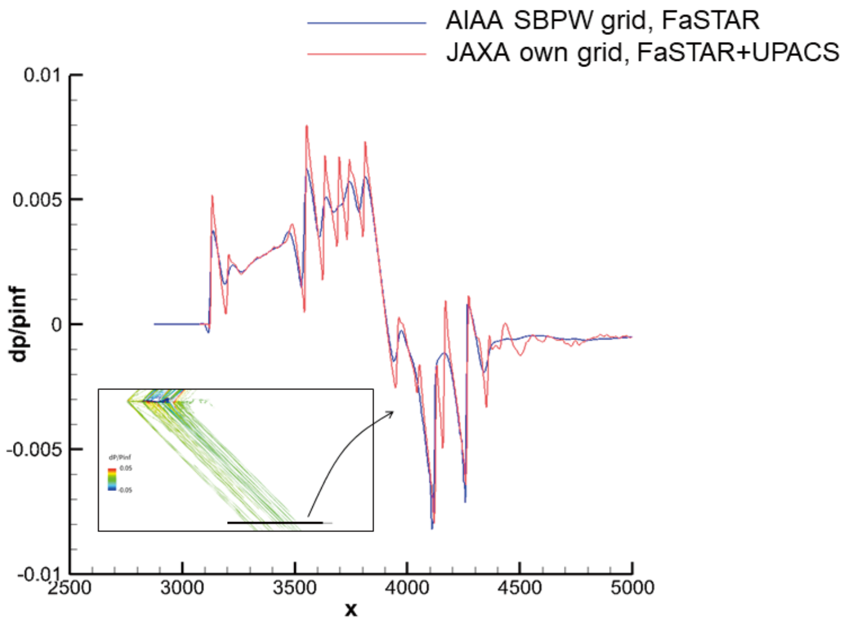

Fig. 2: Near-field pressure signatures

Publications

- Peer-reviewed papers

Akatsuka, T., "Comparison of Prediction Methods on Jet Noise Shielding and Reflection Effects," Aerospace

Technology Japan, Vol.17, No.6, pp.597-602, 2019

- Invited Presentations

Naka, Y., Kanamori, M., Ishikawa, H., and Makino, Y., "Evaluation of sonic booms measured in D-SEND#2 flight test," 178th Meeting of the Acoustical Society of America (ASA), 2019

- Oral Presentations

Suzuki, H., Ishikawa, H., and Ueno, A., "Optimal Trajectory of S4 for Reducing Sonic Boom Loudness," Asia Pacific International Symposium on Aerospace Technology (APISAT), 2019

Akatsuka, J., and Ishii, T., "System Noise Assessment of NASA Supersonic Technology Concept Aeroplane Using JAXA's Noise Prediction Tool," AIAA Science and Technology Forum and Exposition (AIAA SciTech 2020) , 2020

Ishikawa, H., Koganezawa, S., and Makino, Y., "Near-fileld pressure signature prediction by JAXA," 3rd AIAA Sonic Boom Prediction Workshop, 2020

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	128 - 512
Elapsed Time per Case	20000 Second(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.67

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	5,420,559.09	0.66
SORA-PP	140,687.99	0.91
SORA-LM	11,683.91	4.88
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	494.81	0.41
/data	15,139.93	0.26
/ltmp	9,082.04	0.77

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	13.83	0.35

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research of High-Speed Rotorcraft Technologies

Report Number: R19EA3304
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11533/

Responsible Representative

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Members

Yasutada Tanabe, Noboru Kobiki, Masahiko Sugiura, Hideaki Sugawara

Abstract

Aiming to achieve a flight speed as high as twice of the conventional helicopters, a new concept of compound helicopter is proposed. Key technologies such the system integration, remarkable reduction of the aerodynamic drag and optimized rotor design are investigated.

Ref. URL: http://www.aero.jaxa.jp/eng/research/frontier/rotary

Reasons and benefits of using JAXA Supercomputer System

The newly proposed compound helicopter utilizes 4 rotor/propellers. CFD analysis involving the whole aircraft requires large amount of memories and long-time computations. Super-computers such as the JSS2 is a must infrastructure for this kind of research.

Achievements of the Year

To obtain validation data for CFD analysis, a compound helicopter scaled-down model was tested in a wind-tunnel. A flap is added to the fixed-wing under the main rotor, the landing gear can be stored inside the fuselage during forward flight and a fairing is added to the main rotor hub to further reduce the drag of the aircraft. Also, to reduced the drag caused by the rotor/wing interaction, a new technology is propsed and it is confirmed through wind-tunnel testing and also CFD simulations. Samples of overlapped moving grids used by rFlow3D, a CFD code specificly developed for rotorcraft is shown in Fig. 1. A flowfield around a rotor and a fixed-wing is shown in Fig. 2. A sample of CFD analysis for a whole compound helicopter is shown in Fig. 3.

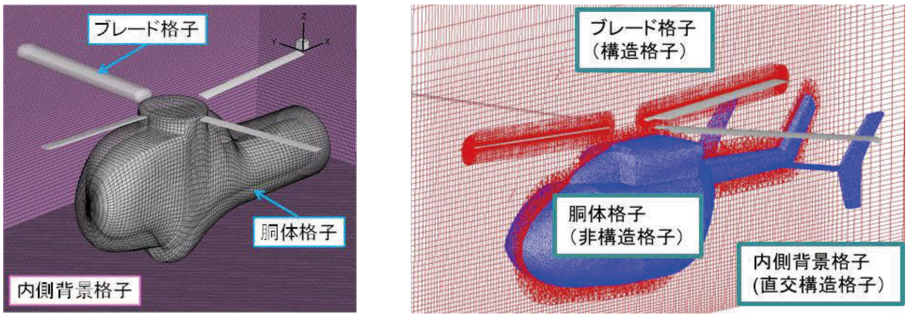

Fig. 1: Moving overlapped grids for rFlow3D

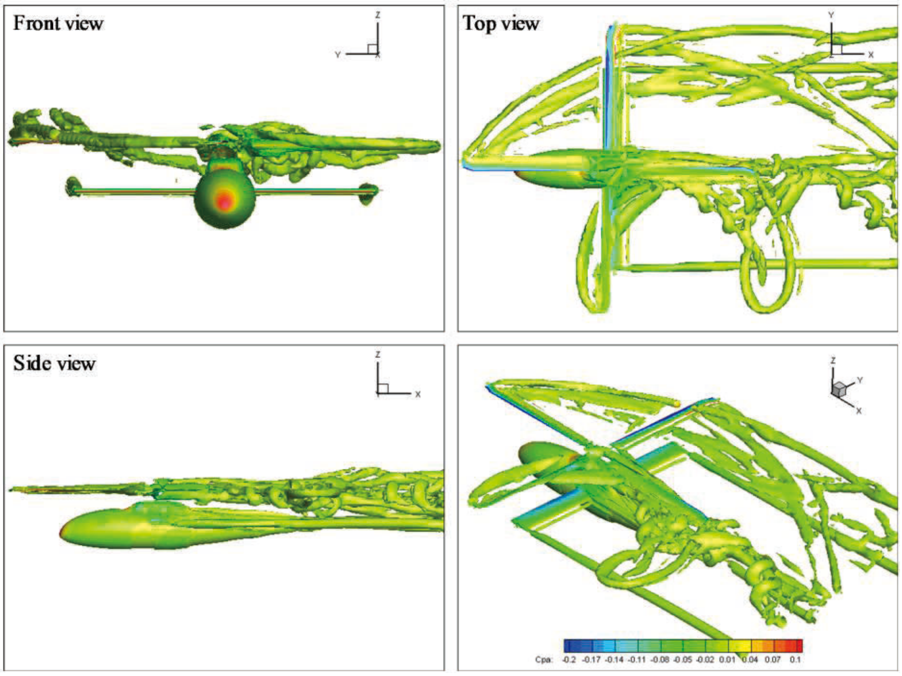

Fig. 2: Flowfield around a rotor with a fixed-wing

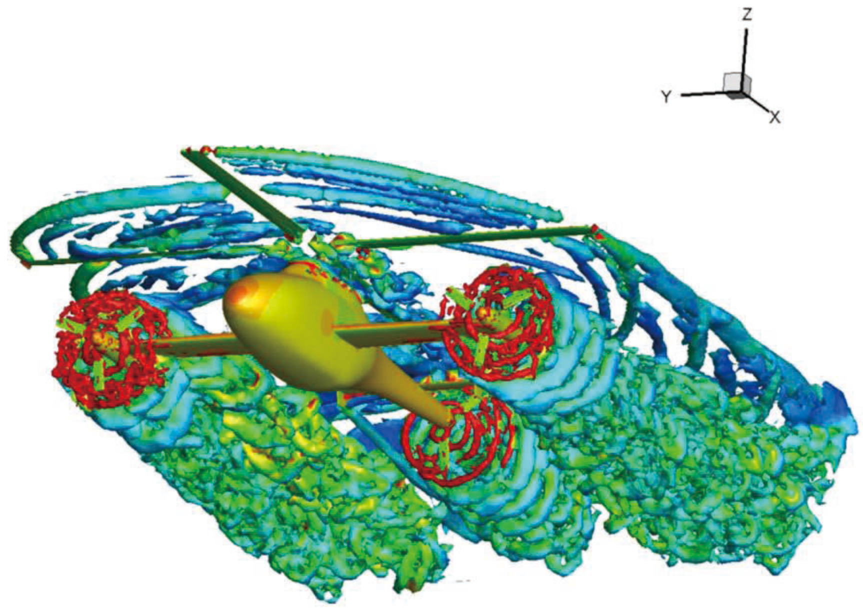

Fig. 3: A sample of CFD analysis for a full configurated compound helicopter

Publications

- Peer-reviewed papers

1) Hideki Sugawara, Yasutada Tanabe: Numerical Investigation of Rotor/Wing Aerodynamic Interactions at High Advance Ratios, Journal of Aircraft,Vol. 56, No. 6, pp.2285-2298, November-December 2019.

- Non peer-reviewed papers

1) Hideaki Sugawara, Yasutada Tanabe, Masaharu Kameda, Effect of Lift Share Ratio on the Aerodynamic Performance of a Winged Compound Helicopter, 8th Asian/Australian Rotorcraft Forum, Ankara, Turkey, Oct. 30 - Nov. 2, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	240 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.35

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	650,636.93	0.08
SORA-PP	281,727.54	1.82
SORA-LM	0.00	0.00
SORA-TPP	276,790.79	16.71

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	123.69	0.10
/data	5,918.56	0.10
/ltmp	680.63	0.06

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research of Multi-Physics Simulation Technology

Report Number: R19EDA201N03
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11586/

Responsible Representative

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Members

Kan Ohkubo, Yuya Ohmichi, Takashi Takahashi, Masashi Kanamori, Kento Yamada, Tomoaki Ikeda, Keita Nakamoto, Kenichi Kubota, Hiroki Tsujimura, Takaaki Miyajima, Yuya Kino

Abstract

The purpose of this research is to obtain the simulaiton technology to analyze phenomana relating with multi-physics such as acoustic fluid dynamics and multi-phase flows.

Reasons and benefits of using JAXA Supercomputer System

JSS2 was used to conduct the simulaiton of liquid with a particle method, which needs the resource of JSS2 to deal with tens of millions particles in a large computational domain.

Achievements of the Year

Water spray generated from a tire of an aircraft running on flooded runway was simulated using explicit MPS method. The results show that the accuracy of spray's angle can be improved by considering the deformation of the tire. The resources was also used to improve the aerodynamic force model acting on a droplet from air stream, and improvement of the accurary was confirmed through comparison with other simulation method such as VOF.

Publications

- Peer-reviewed papers

1) H. Tsujimura, K. Kubota, T. Sato: Development of Aerodynamic Force Model Based on Potential Flow for Liquid Droplets Analyzed by Particle Method, Transaction of JSASS, to be published.

2) IkedaTomoaki, Acoustic Propagation Prediction Using the Inhomogeneous Wave Equation on the Cartesian Grid, The 11th Asia-Pacific International Symposium on Aerospace Technology 2019.

3) Hirai Shiku, Fukushima Yuma, Ohbayashi Shigeru, Misaka Takashi,Daisuke Sasaki, Ohmichi Yuya, Kanamori Masashi,and Takahashi Takashi, Influence of Turbulence Statistics on Stochastic Jet-Noise Prediction with Synthetic Eddy Method, J. of Aircraft, Vol.56, No.6, 2019.

- Non peer-reviewed papers

1)K. Kubota, S. Koga, Y. Iijima, S. Koike, K. Nakakita: Research on Prediction Technology of Water Spray Generated from Aircraft Tire, JAXA Special Publication: Proceedings of the 51st Fluid Dynamics Conference / the 37th Aerospace Numerical Simulation Symposium, JAXA-SP-19-007, 2019.

- Oral Presentations

1) K. Kubota, H. Tsujimura, T. Sato: Particle Simulation of Water Spray Generated from Tire of Aircraft, Proceedings of the Conference on Computational Engineering and Science, Vol.24, 2019.

2) K. Kubota, S. Koga, Y. Iijima, S. Koike, K. Nakakita: Research on Prediction Technology of Water Spray Generated from Aircraft Tire, Proceedings of the 51st Fluid Dynamics Conference / the 37th Aerospace Numerical Simulation Symposium, 1A17, 2019.

3) H. Tsujimura, K. Kubota, T. Sato: Development of Aerodynamic Force Model Based on Potential Flow for Liquid Droplets Analyzed by Particle Method, 32nd International Symposium on Space Technology and Science, 2019-e-39, 2019.

4)Ikeda Tomoaki,For the Practical Computations of Acoustic Propagation Using the Inhomogeneous Wave Equation, 51st Fluid Dynamics Conference/37th Aerospace Numerical Simulation Symposium, 2019.

5)Takahashi Takashi,Ura Hiroki, Ikeda Tomoaki, Okubo Kan, and Tsuchiya Takao, Study on Numerical Analysis and Measurement Techniques of Aircraft Interior and Exterior Noise in ISSAC, 51st Fluid Dynamics Conference/37th Aerospace Numerical Simulation Symposium, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	80 - 200
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 1.09

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	7,187,182.41	0.87
SORA-PP	763,903.44	4.95
SORA-LM	1,833.71	0.77
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	593.07	0.49
/data	13,899.40	0.24
/ltmp	8,579.80	0.73

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.04	0.18

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research of unsteady flow simulation toward prediction of full flight envelope

Report Number: R19EDA201N01
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11584/

Responsible Representative

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Members

Takashi Ishida, Atsushi Hashimoto, Kenji Hayashi, Takashi Aoyama, Takahiro Yamamoto, Masashi Kanamori, Yuki Ide, Hideaki Aiso, Keita Nakamoto, Andrea Sansica, Tomoaki Matsuzaki, Paul Zehner, Hisato Takeda, Yoimi Kojima, Yuuki Asada, Kanako Yasue, Ryosuke Fuse, Kei Shimura, Ryohei Kirihara, Manabu Hishida

Abstract

The research related to unsteady flow simulation of the aircraft buffet phenomenon is conducted aimed for the prediction of full-flight envelope.

Ref. URL: http://www.aero.jaxa.jp/eng/research/basic/numerical/

Reasons and benefits of using JAXA Supercomputer System

A huge amount of computational resources is needed to simulate the aircraft buffet phenomenon which is high-Reynolds number and complex flow including flow separation.

Achievements of the Year

We have simulated low-speed and high-speed buffet toward CFD prediction of full flight envelope. We employed a lattice Boltzmann method(LBM) for the low-speed buffet. Combinig the LBM with a building cube method(BCM) enable large-scale computation. Figure 1 is a result of low-speed buffet simulation on NASA-CRM, where 400M cells are employed in the simulation. The small vortices at the separated shear layer are well resolved. Figure 2 is a result of gloabal stability analysis of high-speed buffet. The unstable modes related with the shock oscillation is obtained. The frequency of the unstable mode increases with the swept angle, which agrees with previous reports qualitatively.

Fig. 1: LBM analysis of low-speed buffet on NASA-CRM

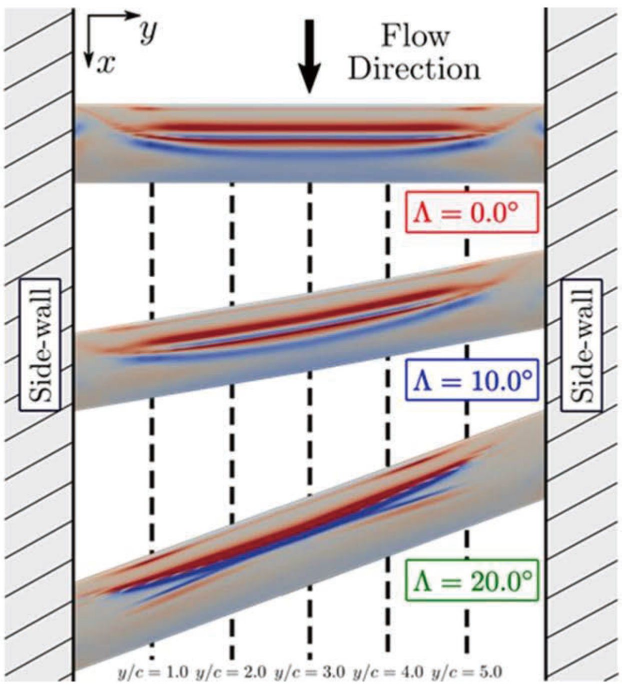

Fig. 2: Global stability analysis of high-speed buffet on swept wing

Publications

- Peer-reviewed papers

1) Andrea Sansica, Hashimoto Atsushi, Ohmichi Yuya, Global Stability Analysis of the JAXA H-ll Transfer Vehicle Re-Entry Capsule, IUTAM Transition 2019, submitted

- Non peer-reviewed papers

1) Andrea Sansica, Hashimoto Atsushi, Jean-Christophe Robinet, Supersonic Sphere Flow Unstable Bifurcations, 32nd International Symposium on Shock Waves

- Oral Presentations

1) Takashi Ishida, Daichi Asaoka, Masaharu Kameda, Unsteady flow simulation around an airfoil with low-speed and high angle-of-attack conditions by Lattice Boltzmann Method, 33th CFD Symposium

2) Takashi Ishida, Takahiro Yamamoto, Kenji Hayashi, Keita Nakamoto, Yuya Ohmichi, Masashi Kanamori, Takashi Aoyama, Introduction of JAXA's Research Activities on Elucidation and Prediction of Buffet Phenomena on Aircraft, The 51th Fluid Dynamics Conference/The 37th Aerospace Numerical Simulation

3) Andrea Sansica, Hashimoto Atsushi, Side-Wall Effects on the Global Stability of Swept and UnsweptWings at Buffet Conditions, The 51th Fluid Dynamics Conference/The 37th Aerospace Numerical Simulation Symposium

4) Ishida Takashi, Flow Simulation around 30P30N with BOXFUN Grid, APC-V

5) Hisato Takeda, Takahiro Yamamoto, Kenji Hayashi, Takashi Ishida, Ryotaro Sakai, Atsushi Hashimoto, Takashi Aoyama, Computation of 30P30N in Various Turbulence Models by FaSTAR Code, APC-V

- Poster Presentations

Takashi Ishida, Kazuyuki Nakakita, Masashi Kanamori, Yuya Ohmichi, Andrea Sancica, Kanako Yasue, Masataka Kohzai, Shunsuke Koike, Yosuke Sugioka, Research on prediction of buffet phenomena in ISSAC project, JAXA Aeronautical Symposium 2019

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	128 - 2048
Elapsed Time per Case	240 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 6.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	54,477,608.38	6.62
SORA-PP	218,092.71	1.41
SORA-LM	12,151.02	5.07
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	633.93	0.53
/data	63,941.54	1.09
/ltmp	13,710.69	1.16

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	102.86	2.59

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research on Airframe Noise Reduction Design (FQUROH+)

Report Number: R19EDA101R21
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11578/

Responsible Representative

Kazuomi Yamamoto, FQUROH+ Team, Aviation Systems Research Unit, Aeronautical Technology Directorate

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Abstract

This research is being carried out as part of the FQUROH (Flight Demonstration of Quiet Technology to Reduce Noise from High-Lift Configurations) project aimed at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear, which draws international attention to reduce noise in areas around airports, to a level applicable to future development of aircraft and related equipment. This contributes to reduction of aircraft noise in local communities around the airport and airline operating costs by reducing landing fee. One of the objectives of the FQUROH project is to verify the feasibility of practical noise reduction concepts and design methods based on advanced, large-scale computational simulations based on Large/Detached Eddy Simulations (LES/DES).

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

Reasons and benefits of using JAXA Supercomputer System

The JSS2 was used to understand detailed physics of noise generation, and to optimize noise reduction designs. The FQUROH project aims to accelerate technology maturity of airframe noise reduction methods using advanced large-scale, high-fidelity computational simulations on the JSS2's high performance computing platform and to demonstrate the high-fidelity design technologies through flight tests. Computational simulations using the JSS2 made it possible to design low-noise devices by understanding detailed physical phenomena, which was difficult to obtain only with wind tunnel tests.

Achievements of the Year

A reduced dissipation approach for improving the numerical resolution was used in aeroacoustic simulations for a slat, which is known as one of major airframe noise sources, in order to capture vortices around it relating to the noise generation and gain a further understanding of its noise generation mechanism (Fig. 1). Noise reduction concepts for the slat were proposed and evaluated based on the findings on aerodynamics and aeroacoustics obtained from benchmarking problems using a high-lift airfoil for slat noise simulations. These concepts were assessed and the noise reduction design for the actual aircraft was also investigated through aeroacoustic simulations around the representative part of the main wing with the deployed slat as well as the slat track rail.

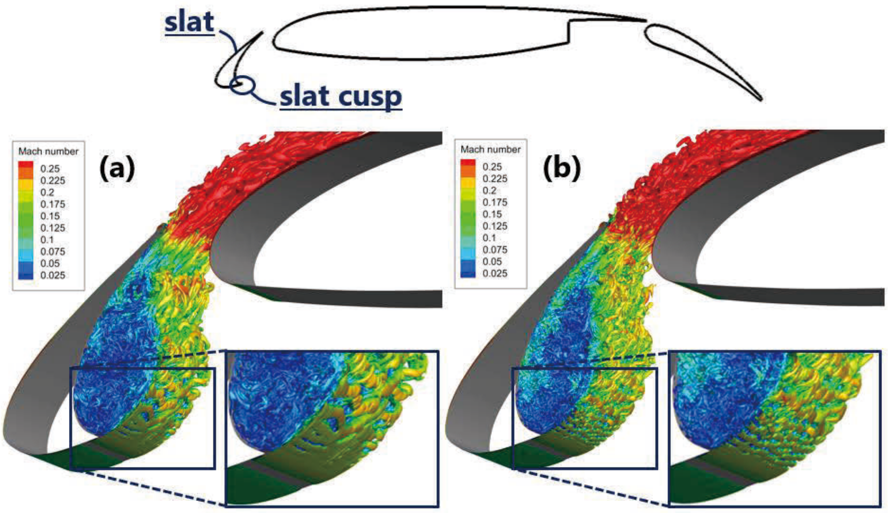

Fig. 1: Improvement of the numerical resolution of vortices in a shear layer, shed from a slat cusp: (a) without and (b) with the reduced dissipation approach.

Publications

- Non peer-reviewed papers

1) Sakai, R., Ishida, T., Murayama, M., Ito, Y., and Yamamoto, K., "Slat Noise Simulation on Unstructured Grid with Reduced Dissipation Approach," AIAA Paper 2019-2405, 25th AIAA/CEAS Aeroacoustics Conference, Delft, the Netherlands, May 2019, DOI: 10.2514/6.2019-2405.

2) Ueno, Y., Isotani, K., Hayama, K., Takaishi, T., Ito, Y., Yokokawa, Y., Murayama, M., and Yamamoto, K., "Validation of Noise Reduction Design for Landing Gear in the FQUROH Flight Demonstration Project," AIAA Paper 2019-2506, 25th AIAA/CEAS Aeroacoustics Conference, Delft, the Netherlands, May 2019, DOI: 10.2514/6.2019-2506.

3) Murayama, M., Yokokawa, Y., Ito, Y., Takaishi, T., Yamamoto, K., Sakai, R., Hirai, T., and Tanaka, K., "Computational Analysis of Noise Reduction Results for Flap Side-Edges in the FQUROH Flight Demonstration Project," AIAA Paper 2019-2577, 25th AIAA/CEAS Aeroacoustics Conference, Delft, the Netherlands, May 2019, DOI: 10.2514/6.2019-2577.

- Invited Presentations

1) Yamamoto, K., "A Flight Demonstration Project for Airframe Noise Reduction Technologies, FQUROH," Asia Pacific International Symposium on Aerospace Technology (APISAT) 2019, Gold Coast, Australia, December 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	3456
Elapsed Time per Case	297.6 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 2.59

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	22,822,086.70	2.77
SORA-PP	113,067.53	0.73
SORA-LM	4,432.49	1.85
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	66.10	0.06
/data	27,601.85	0.47
/ltmp	2,021.15	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	280.18	7.05

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research on Techniques of Sound Absorbing Liner Analysis

Report Number: R19EDA101P01
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11576/

Responsible Representative

Tatsuya Ishii, Aeronautical Technology Directorate, Propulsion Research Unit

Contact Information

Nobuhiko Yamasaki, Department of Aeronautics and Astronautics, Kyushu University(yamasaki@aero.kyushu-u.ac.jp)

Members

Soufiane Ramdani, Genki Omagari, Nobuhiko Yamasaki (Kyushu University), Kenichiro Nagai, Tatsuya Ishii

Abstract

The technique to analyze the sound absorbing lines with bias flows, the air flow through porous plate, is to be established and used for the clarification of the physics behind it.

Reasons and benefits of using JAXA Supercomputer System

The current LES calculation rerquires large computer resources, and in the present fundametal reseearch aiming at the eluciation of pyisical pheenomena, the largest merit is that the researcher can perform the cost-free calculation.

Achievements of the Year

In the study, the CAA using LES is applied to 2-D slit apertures.

Figure 1 shows the results of current CAA, theoretical results, and theoretical results. Models with straight and tapered aperture, and with/without bias flow are discussed. Straight aperture model without bias flow shows the narrow absorption frequency range, whereas the higher and wider absorption range is observed for tapered aperture model. The current CAA model is validated with experimental and theoretical results.

The study also discusses the flow field around the apertures and effect of flow structures around the apertures on the absorption performance of the resonators. Fig. 2 shows the flow field with and without bias flow excited by sound source of 100 and 115 dB. The results indicate that the presence of vortex shedding increases the absorption coefficient. Increases in the sound pressure level intensifies the vortex shedding, thereby leading to a better absorption performance than that for lower sound pressure levels. Additionally, the introduction of a bias flow (which is a method to facilitate the vortex shedding even for lower sound pressure levels) improves the absorption performance.

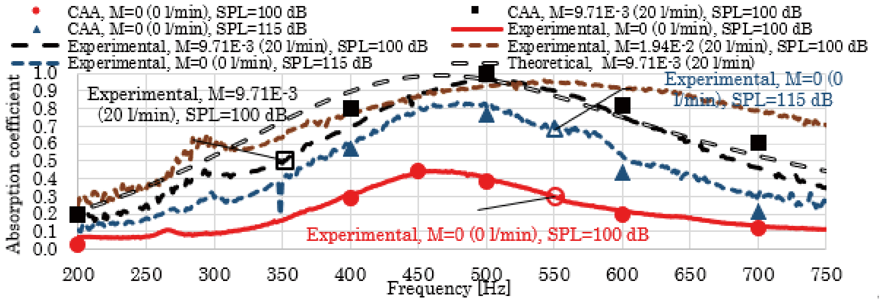

Fig. 1: Absorption coefficients for tapered slit aperture

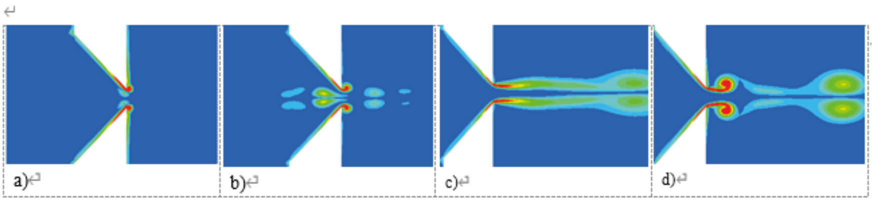

Fig. 2: Non-dimensional vorticity for tapered aperture: a) 500 Hz and 100 dB without bias flow, b) 500 Hz and 115 dB without bias flow, c) 500 Hz and 100 dB with bias flow M = 9.71x10(-3), d) 500 Hz and 115 dB with bias flow M = 9.71 x 10(-3)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	2 - 32
Elapsed Time per Case	24 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	35,289.89	0.23
SORA-LM	269.92	0.11
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	104.90	0.09
/data	286.10	0.00
/ltmp	3,906.25	0.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research on the performance improvement of practical aero-engine fuel injector

Report Number: R19EBA30200
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11563/

Responsible Representative

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Members

Kazuaki Matsuura, Mitsumasa Makida, Naoki Nakamura, Jun Iino, Huilai Zhang, Kinya Saito, Kunihiko Sakata, Asuka Akino, Toshio Matsuno, Harumi Toriyama

Abstract

Our study is focusing on the improvement of fuel injector performance. Numerical simulations on air-flow, atomization, fuel/air mixing, combustion, and thermal analysis on such injectors in realistic shapes are of our interest.

Reasons and benefits of using JAXA Supercomputer System

In order to analyze air-flow, atomization, fuel/air mixing, combustion, and thermal analysis of a realistic shape fuel nozzle precisely, we conduct the flamelet combustion analysis using large size of database, and the use of super computer is necessary.

Achievements of the Year

A numerical simulation on an aero-engine lean-staged fuel injector was performed for a conditon at which combustion oscillation was observed in our experiment. It was also observed in the CFD result as shown in the figures below.

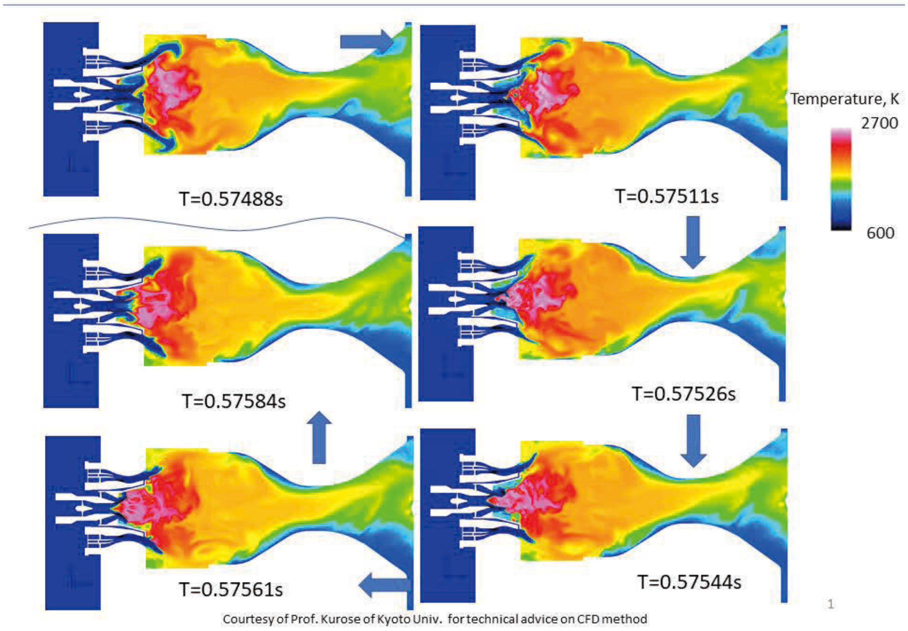

Fig. 1: Time evolution of temperature distribution during an oscillation cycle.

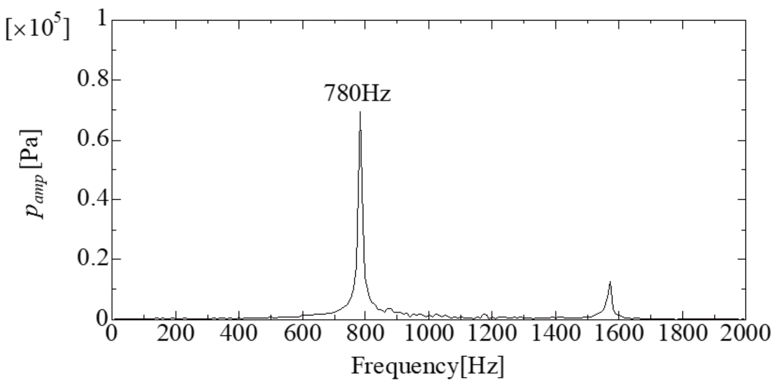

Fig. 2: Frequency spectrum of pressure in the combustion chamber.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512
Elapsed Time per Case	104 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.96

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	8,597,280.89	1.04
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	381.56	0.32
/data	44,675.39	0.76
/ltmp	13,495.17	1.15

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.11	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Simulation of impact damage in thin CFRP laminates

Report Number: R19EA1601
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11521/

Responsible Representative

Toshiya Nakamura, Director, Aeronautical Technology Directorate, Structures and Advanced Composite Research Unit

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Yuichiro Aoki(aoki.yuichiro@jaxa.jp)

Members

Yuichiro Aoki, Toshiyuki Kasahara

Abstract

Study on simulation method for progressive failure in composite materials

Reasons and benefits of using JAXA Supercomputer System

Parallel calculation of JAXA supercomputer system enables to reduce the total computation time because the progressive failure analysis of composite materials require a lot of iterative simulation.

Achievements of the Year

A progressive failure model that can simulate the impact damage failure for 8ply CFRP laminates is established (Fig. 1). Delamination initiation and growth in the laminates during impact are considered, and the following findings are obtained.

The damage propagation shows the different behavior at the impact energy level larger than 5.34J. With the 6.67J impact energy, damage continues to propagate even after unloading. The propagation rate increases in proportion to the energy.(Fig. 2)

Especially, it was found that the delamination propagates significantly between the layers immediately below the middle layer of the laminate. This is because the magnitude of stress near the middle layer is more prominent than others due to the combination of internal shear stress and in-plane tensile stress caused by bending deformation during impact.(Fig. 3)

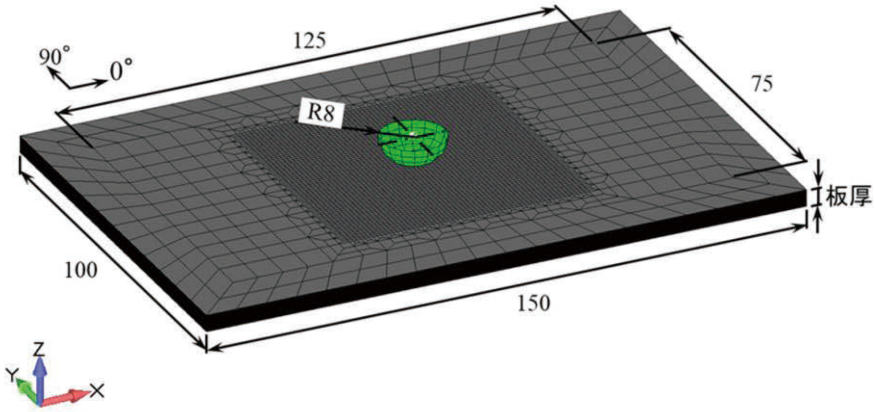

Fig. 1: Finite element model

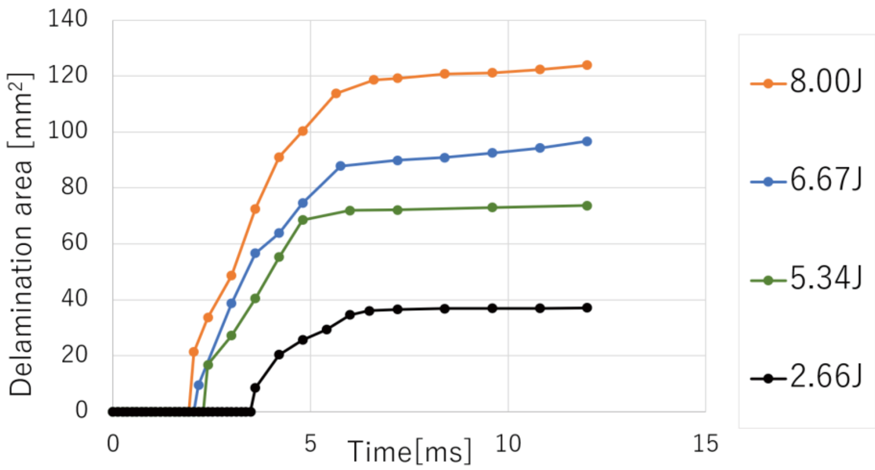

Fig. 2: Comparison of delamination propagtion history with different impact enegies

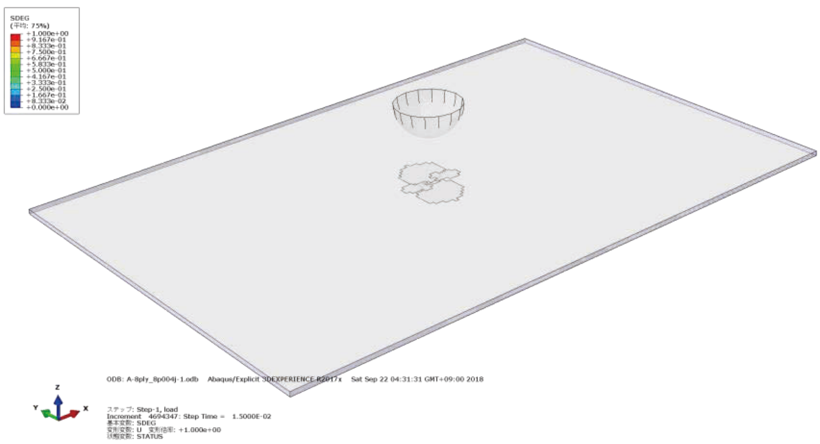

Fig. 3: Typical impact damage prediction result at 8.00J impact energy

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	2 - 228
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	76.53	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	36.56	0.03
/data	49,193.72	0.84
/ltmp	7,486.98	0.64

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study of the Effect of Boundary Layer Ingestion (BLI) on Aircraft Propulsion

Report Number: R19EDA201P73
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11595/

Responsible Representative

Keiichi OKAI, Assoiciate Senior Researcher, Aeronautical Technology Directorate, Aeroengine Technology Demonstration Section

Contact Information

Keiichi OKAI(okai.keiichi@jaxa.jp)

Members

Keiichi Okai, Shotaro Ogushi, Junichi Kazawa, Akiyoshi Masaki

Abstract

In this study, evaluation of unsteady aerodynamics in aircraft fan under strongly distorted inflow condition simulating airframe/engine integration configuration with Boundary Layer Ingestion (BLI) benefit suited for future electric aircraft. Under these BLI conditions, aircraft fan suffers almost all the flight path strongly distorted inflow conditions, the present study investigates the fan flows in detail through the numerical simulations.

Reasons and benefits of using JAXA Supercomputer System

The srudy deals with fan aerodynamic flows under inlet conditions of asymmetric distorsion inflow. For the purpose, high-resolution and full-annula duct flow analysis is necessary with the use of JSS2 supercomputer.

Achievements of the Year

Fan rotor unsteady aerodynamic flow analysis was conducted under the inflow distortion condition simulating airframe/engine integration configuration suited for future electric aircraft. By comparing non-distorted inflow condition case (left), Fig. 1 reveals the effect of distortion under BLI conditions (left in the figure) and performance data and flow characteristics (such as entropy shown in the figure) can be used for understanding the mechanisms of the fan aerodynamics under BLI configuration.

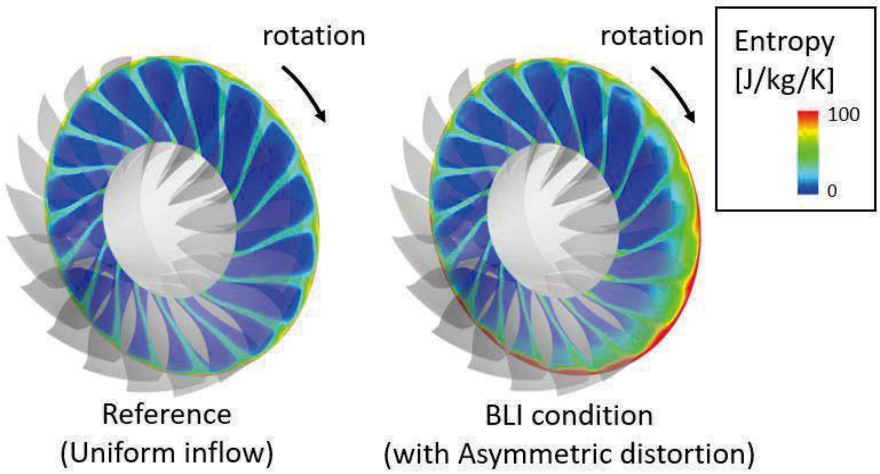

Fig. 1: Entropy distribution downstream of fan rotors

- **Publications**

N/A

- **Usage of JSS2**
- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	486
Elapsed Time per Case	80 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 2.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	17,822,100.28	2.17
SORA-PP	35,119.35	0.23
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	958.95	0.80
/data	19,583.96	0.34
/ltmp	4,985.61	0.42

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on multi-dimensional time series data analysis

Report Number: R19EDA201N04
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11587/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

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Members

Yuya Ohmichi, Keita Nakamoto, Mami Hayakawa, Kento Yamada

Abstract

Knowledge extraction techniques for large datasets are important because the computers and numerical simulation techniques have been highly developed and they produced huge datasets. In this study, we have been developing knowledge extraction tools which extract patterns from large data sets obtained by unsteady fluid simulations.

Reasons and benefits of using JAXA Supercomputer System

To perform feature extraction analysis utilizing the large scale memory of LM node, and massively parallel analysis using MA nodes.

Achievements of the Year

Using the developed knowledge extraction tool, we extracted several dominant structures existing in the compressible flow field around a sphere. In addition, instability phenomenon on the three-dimensional cavity tone phenomenon was clarified.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 512
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.24

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	2,119,501.16	0.26
SORA-PP	1,860.24	0.01
SORA-LM	1,456.44	0.61
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	465.48	0.39
/data	11,974.52	0.20
/ltmp	1,906.62	0.16

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.04	0.18

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

System Operation of the Digital/Analog-Hybrid Wind Tunnel (DAHWIN)

Report Number: R19EA2405
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11528/

Responsible Representative

Shigeru Hamamoto, Aeronautical Technology Directorate, Aerodynamics Research Unit

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Mami Hayakawa(hayakawa.mami@jaxa.jp)

Members

Hiroyuki Kato, Shigeru Kuchiishi, Makoto Ueno, Seigo Koga, Atsushi Hashimoto, Yuichi Matsuo, Kanako Yasue, Kohji Suzuki, Mami Hayakawa

Abstract

Through the operation of the JAXA Digital/Analog-Hybrid Wind Tunnel (DAHWIN), we aim to realize complementary use of Experimental Fluid Dynamics (EFD) and Computational Fluid Dynamics (CFD). Specifically, a series of DAHWIN functions (e.g. CFD before wind tunnel testing, test preparation using pre-CFD data, real time EFD/CFD data monitoring, and EFD/CFD data integration) are served to users.

Reasons and benefits of using JAXA Supercomputer System

DAHWIN requires a number of high-fidelity and large-scaled computations (3D RANS analysis) based on the JAXA 2m x 2m transonic wind tunnel testing, and needs to use the supercomputer.

Achievements of the Year

For the CFD analysis using DAHWIN, the system was applied to a total of 8 JAXA 2m x 2m transonic wind tunnel tests and functions including test preparation using pre-CFD data and real time EFD/CFD data monitoring were utilized.

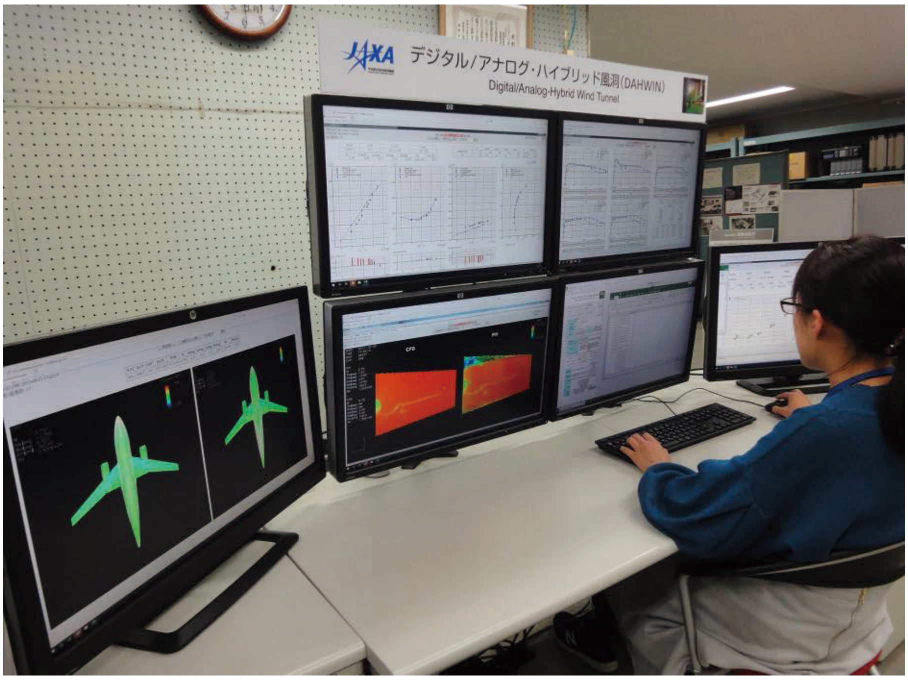

Fig. 1: EFD/CFD real time data monitoring using DAHWIN

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	512
Elapsed Time per Case	30 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	16.43	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	766.08	0.64
/data	23,897.37	0.41
/ltmp	7,475.89	0.64

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.50	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Systematic improvement of build and comparison of aerodynamic models of aircraft

Report Number: R19EDA201N05
Subject Category: Aeronautical Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11588/

Responsible Representative

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Members

Makoto Ueno, Hiroya Toriida, Yuko Ueno

Abstract

A research to realize efficient validation of numerical simulation using experimental data such as flight test and wind tunnel test data utilizing mathematical model.

Reasons and benefits of using JAXA Supercomputer System

It is necessary to perform CFD computation including flow around a whole aircraft because it requires highly parallelized computation. Additionally, the JSS2 was chosen because the FaSTAR CFD solver is optimized, as well.

Achievements of the Year

To compare flight test results with ground test, such as wind tunnel testing and computational fluid dynamics (CFD), CFD analysis was performed. It includes Reynolds number effect confirmation and stabilizer deflection angle effect estimation in comparison between wind tunnel testing and flight test.

(Figures are not presented because the results are not public at this moment.)

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	25
Elapsed Time per Case	12.5 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 1.43

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	12,790,706.82	1.55
SORA-PP	7,780.47	0.05
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	645.38	0.54
/data	73,106.68	1.25
/ltmp	4,689.42	0.40

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.25	0.03

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Common Business

Development and maintenance of S&MA platform "Quality Engineering Tool"

Report Number: R19EH2900
Subject Category: Common Business
URL: https://www.jss.jaxa.jp/en/ar/e2019/11613/

Responsible Representative

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Members

Yuji Kado, Hiroshi Yanaka, Takafumi Nakagawa

Abstract

Using the quality engineering tool developed by JAXA, we evaluate the suitability for nonlinear simulation. In this study, we use wallstat, a wooden building seismic simulator owned by Kyoto University, to calculate the valid range of parameters.

Reasons and benefits of using JAXA Supercomputer System

The purpose of using a supercomputer is to speed up computation.. The calculation of wallstat takes 40 minutes per case on a general PC. The quality engineering tool needs to perform 6000 calculations in one case study, which takes 160 days in total.

Achievements of the Year

N/A

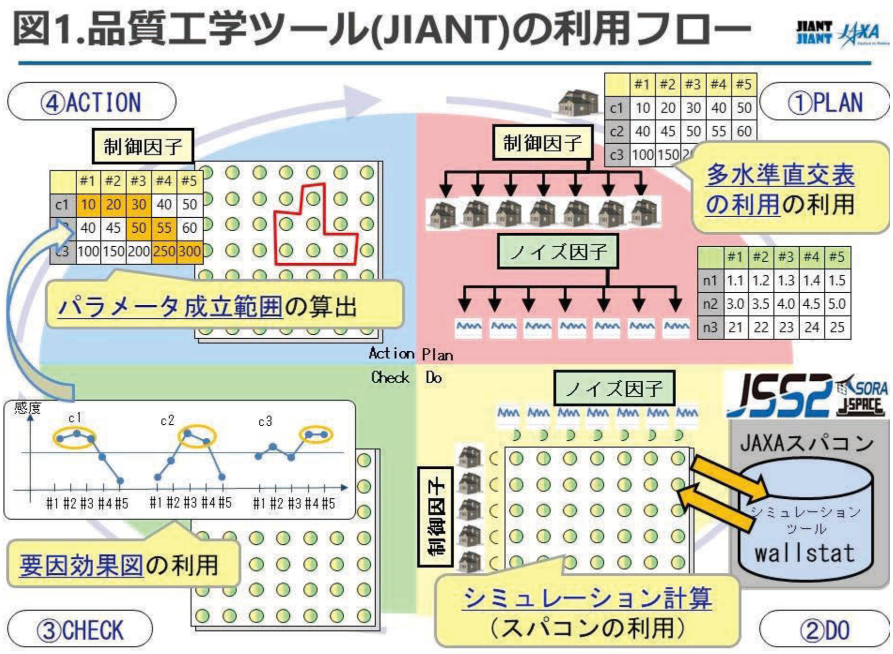

Fig. 1: N/A

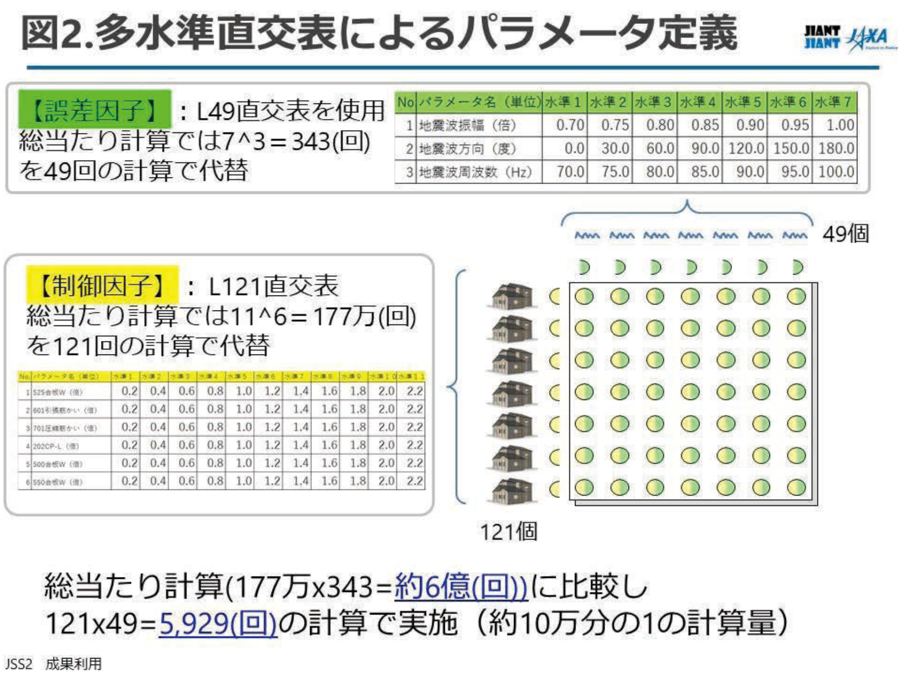

Fig. 2: N/A

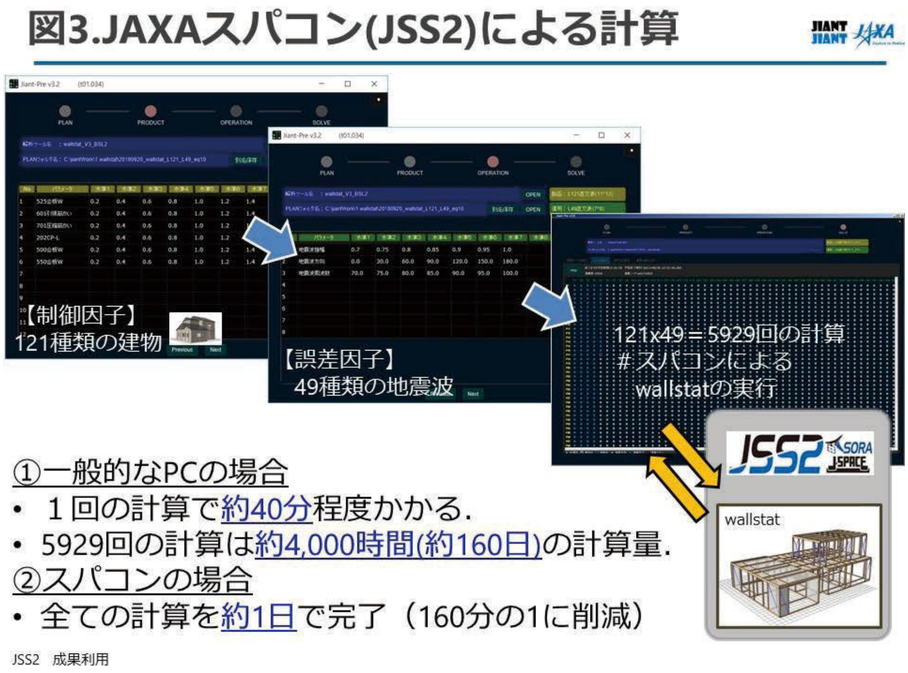

Fig. 3: N/A

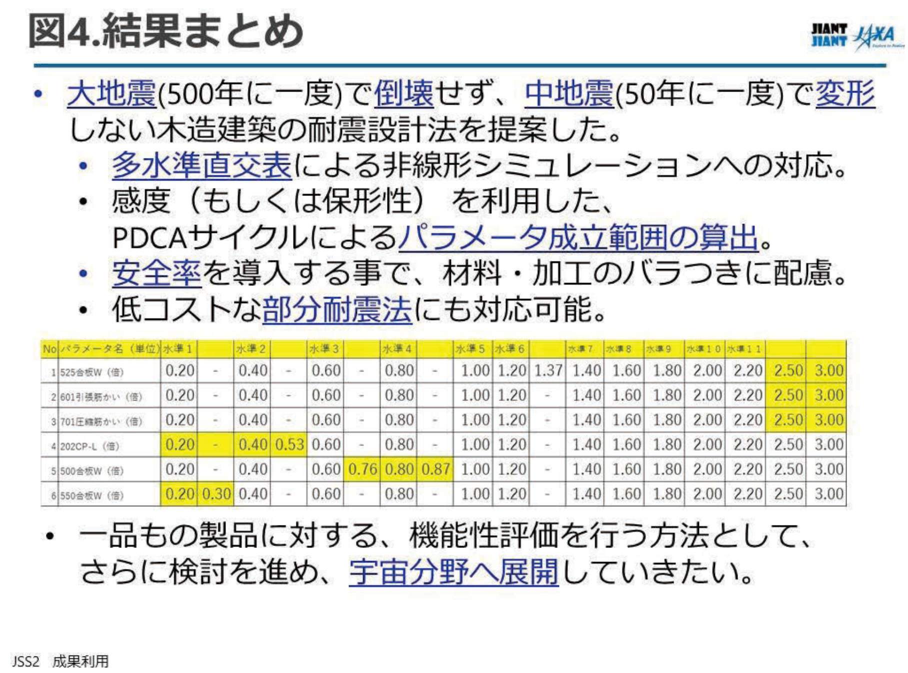

Fig. 4: N/A

Publications

- Non peer-reviewed papers

Yuji Kado, Development of quality engineering tool to support S&MA activities in JAXA, 32th ISTS, 2019

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	7200 Second(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.08

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	174,250.33	1.13
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	23.84	0.02
/data	49,066.57	0.84
/ltmp	4,882.81	0.41

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of fluid analysis system for turbomachinery using CFD software named UPACS

Report Number: R19EH6901
Subject Category: Common Business
URL: https://www.jss.jaxa.jp/en/ar/e2019/11614/

Responsible Representative

Hiroyuki Iwamoto, Business Development and Industrial Relations Department

Contact Information

Mitsumasa Makida, Aeronautical Technology Directorate, Propulsion Research Unit (makida.mitsumasa@jaxa.jp)

Members

Mitsumasa Makida, Shunji Enomoto, Ryoji Takaki, Junichi Kazawa, Kazuomi Yamamoto, Yosuke Matsumura, Yoshinobu Yamade, Hiroshi Koizumi, Masayuki Kakehi

Abstract

For turbo machines including centrifugal compressors,a software package will be developed to analyze flow phenomena in more detail by utilizing JAXA's fluid analysis technologies.

Reasons and benefits of using JAXA Supercomputer System

To analyze the detailed flow field around turbo machnes, it is necessary to confirm the prediction accuracy of the analysis by DES. For this purpose, a large-scale analysis will be performed in various flow conditions, so it cannot be performed without JSS2.

Achievements of the Year

It was confirmed that the flow field around the centrifugal compressor could be analyzed by DES using UPACS. In addition, we analyzedthe flow field around the centrifugal compressor with up to 800 million grids and confirmed that there was no problem with parallelization performance of UPACS.

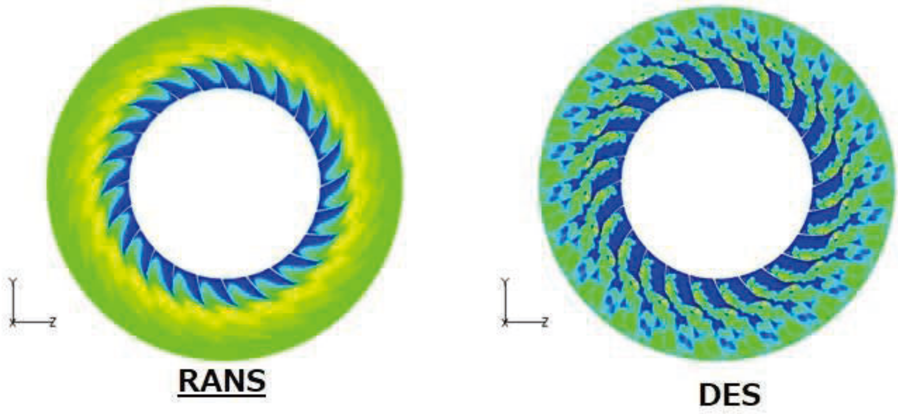

Fig. 1: Flow Fields around the centrifugal compressor (Entropy Distribution, left:RANS, right:DES)

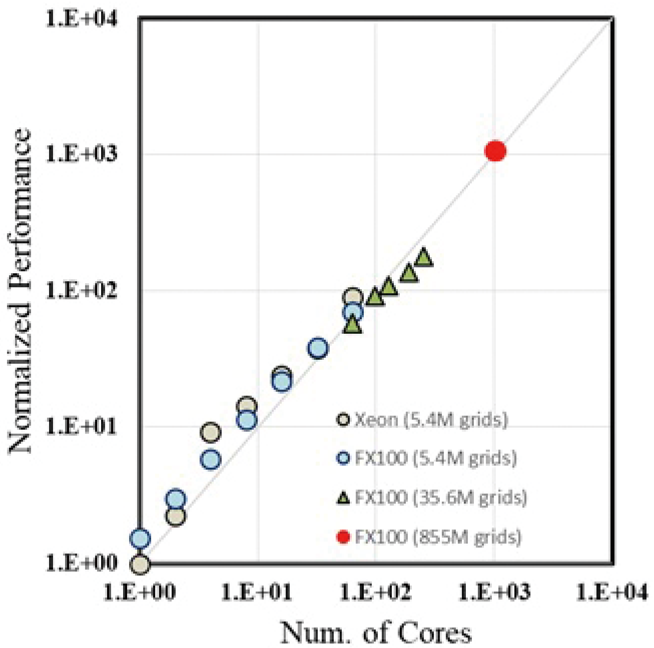

Fig. 2: parallelization performance of UPACS

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64 - 1024
Elapsed Time per Case	12 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	91,954.74	0.01
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	128.60	0.11
/data	14,937.85	0.26
/ltmp	3,110.91	0.26

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	119.34	3.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Competitive Funding

Aerodynamic Investigation of a Multiple-Rotor Drone in Ground Effect

Report Number: R19ECMP17
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11569/

Responsible Representative

Yoshikazu Makino, Unit Director, Aviation Systems Research Unit, Aeronautical Technology Directorate

Contact Information

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Members

Yasutada Tanabe, Hideaki Sugawara, Riku Tanaka, Kuniyuki Takekawa

Abstract

Larger and heavier drones are being developed along with new trials to built multiple-rotor type eVTOLs which can carry several people. However, the flowfields around multiple rotors where the neighboring rotors are rotating in different directions are very complex and not well understood. Espeicially when the multicopters are hovering near the ground, the so-called ground-effect is considered different with the conventional single rotor helicopters. In this study, utiliizng the Grants-in-Aid for Scientific Research (KAKENHI), the flowfields and the performance of a quad-rotor drone at different hovering height from the ground are investigated.

Reasons and benefits of using JAXA Supercomputer System

Very large number of computational grid is required to resolve the flow around multiple rotors and near the ground. Superior computational power of the super-computer is a necessary.

Achievements of the Year

Computational model based on a prototype variable-pitch controlled quad-rotor drone is created. Flowfields and the drone performance are investigated for the drone hovering at several different height from the ground. It is found that the flowfields for the quad-rotor drone are much complex compared to those of a single rotor. The computational model is shown in Fig. 1. The flowfields for different hovering heights are shown in Fig. 2. The downwash distributions on the central section of the drone are shown in Fig. 3.

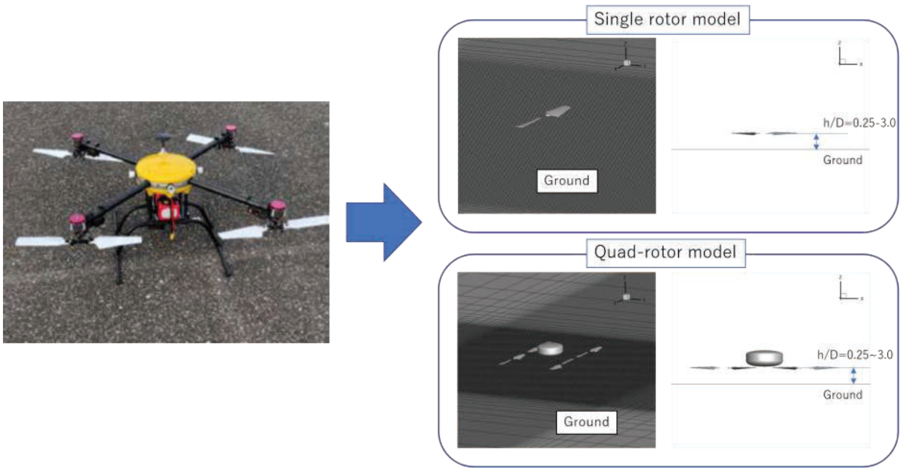

Fig. 1: Computational model of a quad-rotor drone

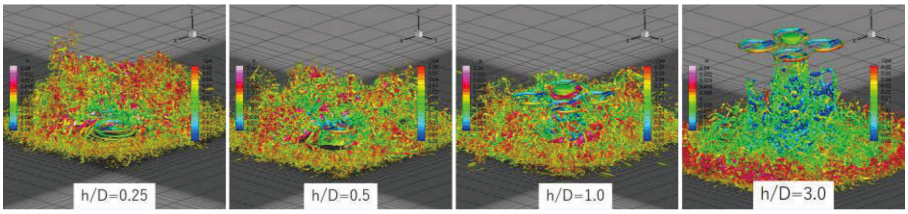

Fig. 2: Flowfields around quad-rotor drone for various hovering height from ground

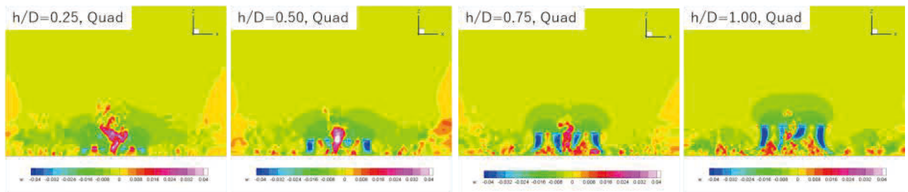

Fig. 3: Downwash distributions on the central section of the drone

Publications

- Peer-reviewed papers

1) Takuzumi NISHIO, Shigeru SUNADA, Kohei YAMAGUCHI, Yasutada TANABE, Koichi YONEZAWA, Hiroshi TOKUTAKE: Note on a Method for Simulating Rotor Motion when Accelerating During Descent, Transactions of JSASS, Vol. 17, No. 5, pp. 577-581, July 2019.

2) Takuzumi Nishio, Shigeru Sunada, Yasutada Tanabe, Koichi Yonezawa, Hiroshi Tokutake: Approximate Added Mass Method for a Rotary Wing, AIAA Journal, Vol. 57, No. 7, pp.3090-3093, July 2019.

- Non peer-reviewed papers

1) Yasutada Tanabe, Hideaki Sugawara, Koichi Yonezawa, Shigeru Sunada, Hiroshi Tokutake, Influence of Rotor Blade Twist on the Ducted Rotor Performance, 8th Asian/Australian Rotorcraft Forum, Ankara, Turkey, Oct. 30 - Nov. 2, 2019.

2) Koichi Yonezawa, Hironori Matsumoto, Kazuyasu Sugiyama, Yasutada Tanabe, Hiroshi Tokutake, Shigeru Sunada, Aerodynamic Characteristics of a Quad-Rotor-Drone with Ducted Rotors, 8th Asian/Australian Rotorcraft Forum, Ankara, Turkey, Oct. 30 - Nov. 2, 2019.

3) Kazuhiro Fukuda, Soshi Okada, Hiroshi Tokutake, Shigeru Sunada, Yasutada Tanabe, Koichi Yonezawa, External Environment Estimation of Drone for Wall Collision Avoidance, APISAT 2019, Surfers Paradise Marriott Resort, Gold Coast, Australia, 4-6 December 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	500 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.38

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	503,302.30	0.06
SORA-PP	546,064.19	3.54
SORA-LM	0.00	0.00
SORA-TPP	197,986.55	11.95

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	4,492.68	3.74
/data	13,316.77	0.23
/ltmp	2,485.80	0.21

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.94	0.20

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Fundamental Researches of Fluid and Combustion for the Hypersonic Flight

Report Number: R19ECMP18
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11570/

Responsible Representative

Kouichi Okita, Director, Research Unit IV, Research and Development Directorate

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Members

Masahiro Takahashi, Masatoshi Kodera, Toshihiko Munakata, Masaaki Fukui, Masaharu Takahashi, Susumu Hasegawa, Sadatake Tomioka, Shun Takahashi

Abstract

The wind tunnel tests by using sub-scaled models play important roles for the development of the air-breathing propulsion system for a hypersonic transporter. However, in some cases, the flow of the wind tunnel is "vitiated" due to the heating process and/or the complex flow-path of the facility. To rise the total temperature to produce the high Mach number flow, a combustion heating is usually applied, introducing the water vaper to the air stream. The complex flow-path of the facility would increase turbulence. Both the phenomena might affect the supersonic combustion process. To clarify the effects of the flow vitiation and ultimately, to establish the adjustment methodology that can deduce the data of real flight from the wind tunnel data, JAXA has initiated the 5-years study. The final goal is conducting the flight experiment to obtain the data on the supersonic combustion in an actual flight condition and verify the methodology.

Reasons and benefits of using JAXA Supercomputer System

Recently, hydrocarbon fuels become more promising fuels for a supersonic combustor than hydrogen because of those high thrust density. A gaseous ethylene is selected as the fuel for the present flight experiment. Ethylene is rather simple hydrocarbon, but much more chemical species contributes to the combustion process than hydrogen. In addition, the flow conditions in the supersonic combustor and those around the hypersonic flight test vehicle are quire severe. As a result, the CFD for the present design evaluation requires large computation time. Furthermore, many cases of the CFD must be executed for aerodynamic design of the flight test vehicle and the combustor model within the scheduled period. Therefore, the use of the JSS2 system is essential for the success of the present research program.

Achievements of the Year

(1) Flow-path design of a supersonic combustor for JAXA flight experiment

Flow-path design of a supersonic combustor for JAXA flight experiment was continued by using three-dimensional RANS simulation with a skeletal mechanism for ethylene-air combustion. Influence of the geometry of the flame-holding cavity and that of the fuel injection schemes on combustion were investigated numerically and some of the promising configurations have been selected. It is noted that, based on the CFD design study results, the combustor test models were manufactured and the combustion tests were conducted to fix the combustor configuration and fuel injection scheme. The whole combustor test model including an air capturing inlet was also manufactured and was tested in the Ramjet Engine Test Facility at JAXA Kakuda space center to confirm its operationality. Data accumulation for the CFD validation, including the measurements of the cross-sectional distribution of the combustion gas composition at the combustor exit, were also conducted, and the detailed CFD validation is undergoing.

(2) Development of a tool for predicting facility dependence on supersonic combustion

3D RANS simulation was continued to be carried out from last year to investigate the effect of water vapor in the air on scramjet combustion.

Various reduction mechanisms for ethylene / air combustion, which were generated from a detailed mechanism through the CHEMKIN-Pro / Reaction Workbench, were applied to 2D CFD for supersonic combustion flows, and the results were compared to the one with the detailed mechanism in order to verify the prediction ability.

(3) Evaluation of aerodynamic characteristics for JAXA flight experimental vehicle

Aerodynamic characteristics of JAXA flight experimental vehicle were predicted by using JAXA FaSTAR code for the flight Mach number range from 2 to 7 and the ranges of both the angle of attack and the yaw angle from 0 degree to 10 degree. Based on these aerodynamic characteristics data, the stability analysis and the trajectory calculation for the flight experimental vehicle were conducted. The inlet flow CFD was also conducted to obtain the flow condition at the combustor entrance, which is necessary for the combustor flow analysis.

(4) Development of a tool for predicting facility dependence on aerodynamic heating

A coupled analysis method of fluid dynamics and thermal heating is being developed to predict an effect of turbulence and combustion-heating of a test gas on the aerodynamic heating relating to duplication of flight condition in ground test facilities. The temperature distribution inside the object in a hypersonic non-equilibrium flow was investigated by the flow-thermal coupling analysis.

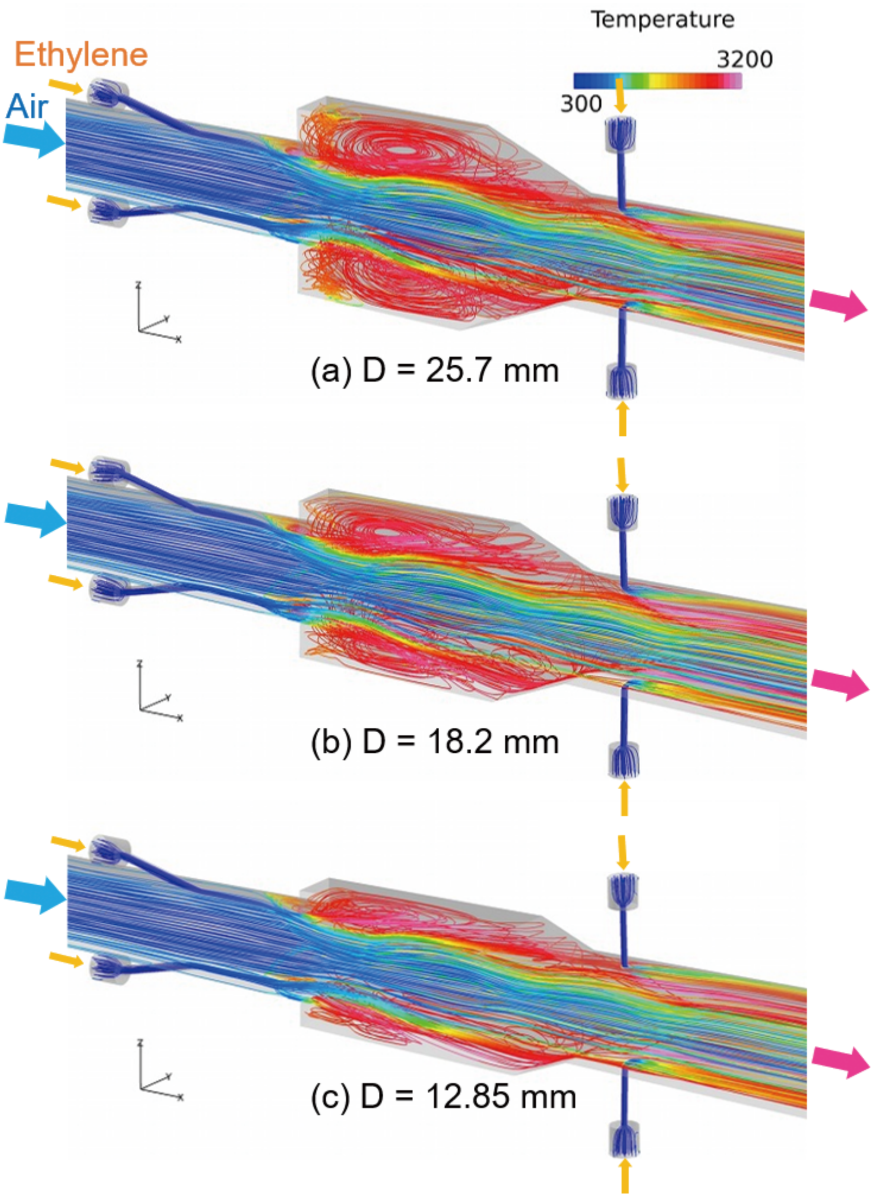

Fig. 1: Flow-path design study of supersonic combustor model for JAXA flight experiment (Influence of flame-holding cavity depth D on combustor flowfield, streamline with color presentation of local static temperature): (a) D = 25.7 mm, (b) D = 18.2 mm, (c) D = 12.85 mm.

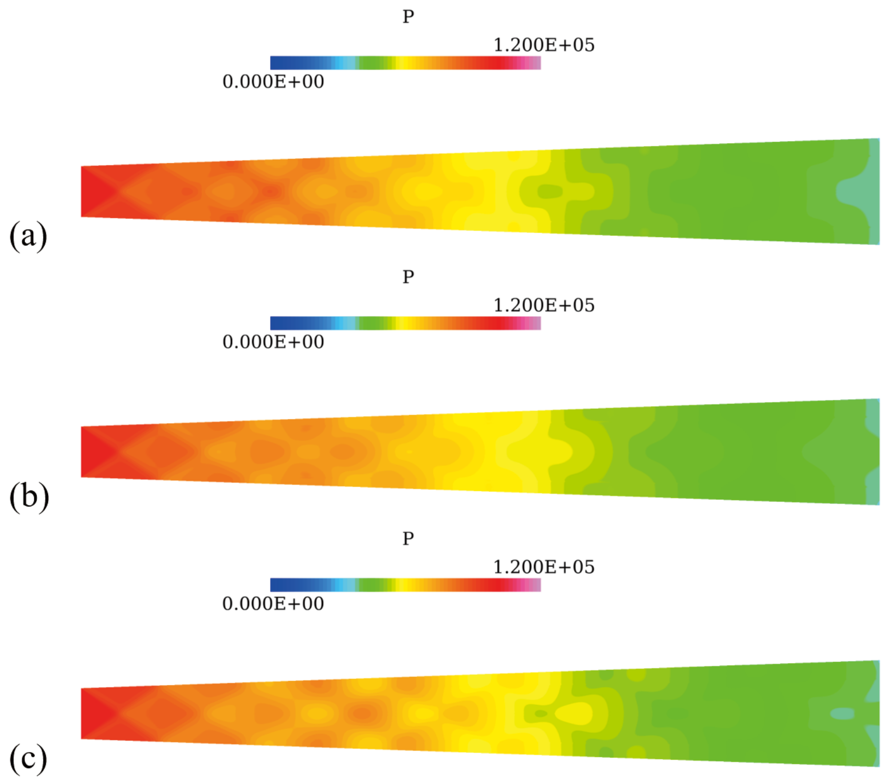

Fig. 2: Evaluation of prediction capability of reduced reaction mechanisms in application to two-dimensional supersonic combustion flow. Comparison of pressure distributions between reduced and detailed reaction mechanisms: (a) reduced mech. (23 species), (b) reduced mech. (34 species), (c) detailed mech. (111 species)

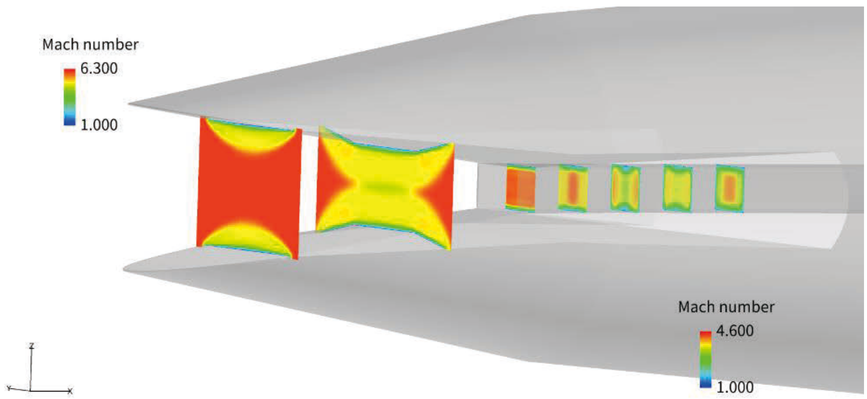

Fig. 3: Predicted Mach number distribution of inlet flow for flight test model: Flight Mach number is 6, both angle of attack and yaw angle are 0 degree.

Fig. 4: Temperature distributions obtained by non-equilibrium flow and thermal coupling analysis: (a) flowfield, (b) inside the object.

Publications

- Peer-reviewed papers

Takahashi, M., Tomioka, S., Kodera, M., Kobayashi, K., Hasegawa, S., Shimizu, T., Aono, J., Munakata, T., "Numerical Study on Combustor Flow-Path Design for a Scramjet Flight Experiment," Transactions of JSASS, Aerospace Technology Japan, 2020 (under peer-review).

- Non peer-reviewed papers

1) Takahashi, M., Tomioka, S., Kodera, M., Kobayashi, K., Hasegawa, S., Shimizu, T., Aono, J., Munakata, T., "Numerical Study on Combustor Flow-Path Design for a Scramjet Flight Experiment," Proceedings of 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019.

2) Takahashi, M., Tomioka, S., "Flow-path Design of a Combustor Model for a Supersonic-combustion Flight

Experiment," Proceedings of 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

3) Takahashi, M., Kobayashi, K., Tomioka, S., "Combustion Test Results of a Supersonic Combustor Model for a JAXA Flight Experiment," Proceedings of FYR1 Space Transportation Symposium, 2020 (to be published).

4) Kodera, M., and Tomioka, S., "Investigation of Air Vitiation Effects on Scramjet Engine Performance," Proceedings of 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019.

5) Kobayashi, K., Tomioka, S., Takahashi, M., and Kodera, M., "Reaction Mechanism Reduction for Ethylene-Fueled Supersonic Combustion CFD," Proceedings of 63rd Space Sciences and Technology Conference, 2019.

6) Hasegawa, S., Tani, K., Tomioka, S., "Numerical Simulation of the Flow inside the Inlet for the Hypersonic Flight, " Proceedings of 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

7) Mizuno, Y., Takahashi, S., Yamada, G., Yamashita, R., "Fluid-solid Thermal Coupling Simulation of Hypersonic Flow," Proceedings of 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

8) Mizuno, Y., Yamashita, R., Takahashi, S., Yamada, G., "Accurate Prediction of the Aerodynamic Heating using Hypersonic Flow and Thermal Transfer Coupled Simulation," Proceedings of 63rd Space Sciences and Technology Conference, 2019.

9) Mizuno, Y., Takahashi, S., Yamada, G., Yamashita, R., "Investigation of Aerodynamic Heating under Hypersonic Flow using Coupled Flow - Thermal Analysis," Proceedings of ASIA PACIFIC INTERNATIONAL SYMPOSIUM ON AEROSPACE TECHNOLOGY, 2019.

- Oral Presentations

1) Takahashi, M., Tomioka, S., Kodera, M., Kobayashi, K., Hasegawa, S., Shimizu, T., Aono, J., Munakata, T., "Numerical Study on Combustor Flow-Path Design for a Scramjet Flight Experiment," 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019.

2) Takahashi, M., Tomioka, S., "Flow-path Design of a Combustor Model for a Supersonic-combustion Flight Experiment," 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

3) Takahashi, M., Kobayashi, K., Tomioka, S., "Combustion Test Results of a Supersonic Combustor Model for a JAXA Flight Experiment," FYR1 Space Transportation Symposium, 2020.

4) Kodera, M., and Tomioka, S., "Investigation of Air Vitiation Effects on Scramjet Engine Performance," 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019.

5) Kobayashi, K., Tomioka, S., Takahashi, M., and Kodera, M., "Reaction Mechanism Reduction for Ethylene-Fueled Supersonic Combustion CFD," 63rd Space Sciences and Technology Conference, 2019.

6) Hasegawa, S., Tani, K., Tomioka, S., "Numerical Simulation of the Flow inside the Inlet for the Hypersonic Flight, " 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

7) Mizuno, Y., Takahashi, S., Yamada, G., Yamashita, R., '"Fluid-solid Thermal Coupling Simulation of Hypersonic Flow," 51st Fluid Dynamics Conference / 37th Aerospace Numerical Simulation Symposium, 2019.

8) Mizuno, Y., Yamashita, R., Takahashi, S., Yamada, G., "Accurate Prediction of the Aerodynamic Heating using Hypersonic Flow and Thermal Transfer Coupled Simulation," 63rd Space Sciences and Technology

Conference, 2019.

9) Mizuno, Y., Takahashi, S., Yamada, G., Yamashita, R., "Investigation of Aerodynamic Heating under Hypersonic Flow using Coupled Flow - Thermal Analysis," ASIA PACIFIC INTERNATIONAL SYMPOSIUM ON AEROSPACE TECHNOLOGY, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	32 - 1920
Elapsed Time per Case	400 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 1.89

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	17,100,809.54	2.08
SORA-PP	6,134.46	0.04
SORA-LM	11.77	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	201.86	0.17
/data	12,027.24	0.21
/ltmp	3,304.04	0.28

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.40	0.19

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Investigation on the structure of rotating detonation wave

Report Number: R19ECMP12
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11568/

Responsible Representative

Shingo Matsuyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Shingo Matsuyama(smatsu@chofu.jaxa.jp)

Members

Shingo Matsuyama

Abstract

In this study, combustion analysis by large eddy simulation (Large-Eddy Simulation, LES) was carried out in order to clarify propagation characteristics and detailed structure of rotating detonation wave. Two-dimensional and three-dimensional simulations were carried out for stable operating conditions in the combustion test of the rotating detonation combustor conducted at the Kakuda Space Center from the equivalence ratio of 0.6 to 1.6 to reproduce the rotating detonation wave propagating in the combustor.

This work was supported by Innovative Science and Technology Initiative for Security Grant Number JPJ004596, ATLA, Japan.

Reasons and benefits of using JAXA Supercomputer System

To perform a combustion LES considering more than 20 chemical species generated by the combustion of methane fuel is very expensive, so that it is impossible to carry out it on usual workstations. In addition, the use of a supercomputer is indispensable in order to execute a large number of parametric analyses for a plurality of injection conditions in a realistic computing time.

Achievements of the Year

LES of non-premixed rotating detonation of CH4 and O2 was carried out assuming an annular combustor with 101 mm diameter. It was shown that the propagation velocity of the rotating detonation wave obtained by two dimensional (Fig. 1) and three dimensional (Fig. 2) LES with the equivalence ratio of 0.6 to 1.6 was about 70% against the Chapman-Jouguet velocity. The propagation velocity obtained by the simulation was slightly higher than that obtained by the combustion test, but the approximate tendency was successfully reproduced.

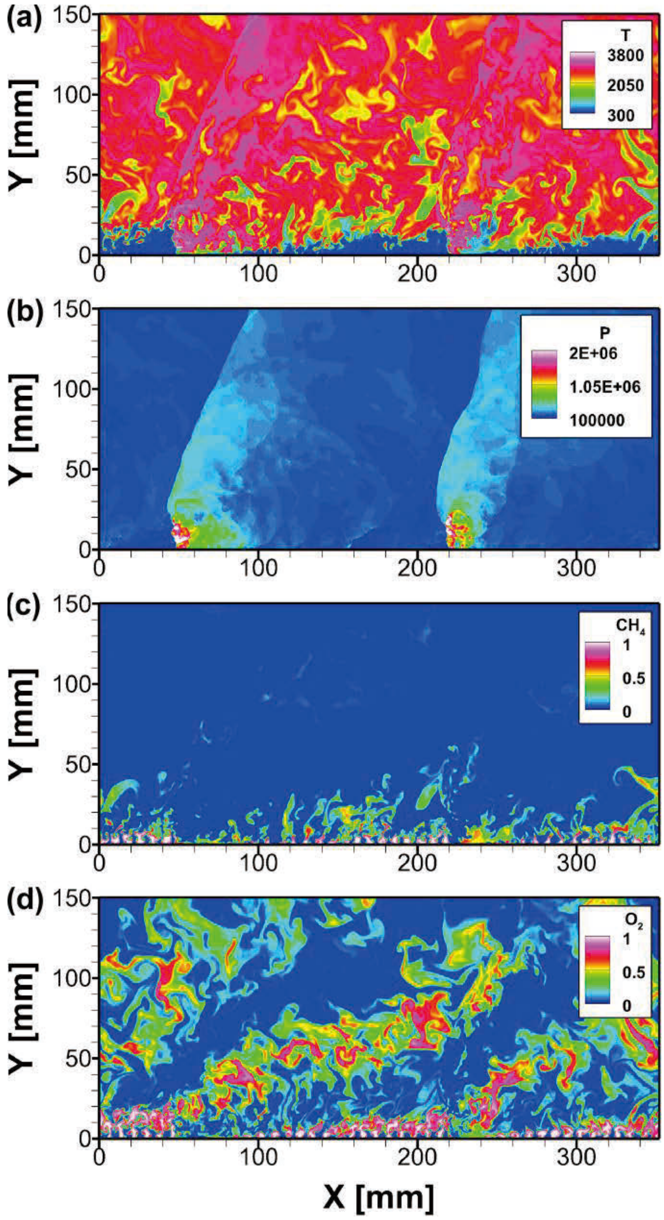

Fig. 1: Instantaneous contours of (a) temperature, (b) pressure, and mole fractions of (c) CH4 and (d) O2 by the two-dimensional LES at ER = 1.0.

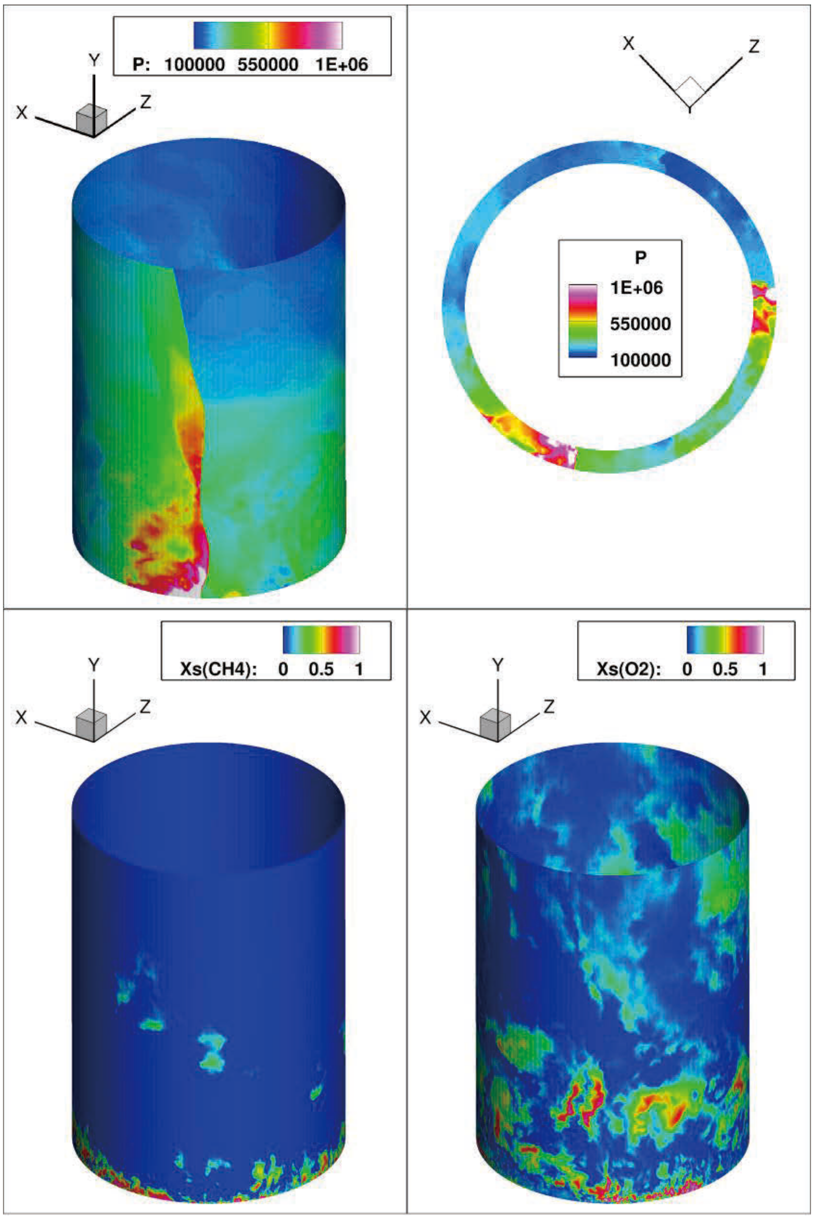

Fig. 2: Instantaneous contours of pressure (upper) and mole fractions of CH4 and O2 (lower) at t = 1.0 ms by the three-dimensional LES at ER = 1.0.

Publications

- Non peer-reviewed papers

1) Shingo Matsuyama, Kazuya Iwata, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "Combustion Simulation of Rotating Detonation with a Non-premixed CH4/O2 Injection", Proceedings of the 57th Symposium (Japanese) on Combustion, B215,.2019.

2) Shingo Matsuyama, Kazuya Iwata, Yoshio Nunome, Hideyuki Tanno, Toshiharu Mizukaki, Makoto Kojima, and Hideto Kawashima, "Large-Eddy Simulation of Rotating Detonation with a Non-premixed CH4/O2 Injection", AIAA Paper 2020-1174, 2020.

3) Shingo Matsuyama, Kazuya Iwata, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "LES of Rotating Detonation with a Non-premixed CH4/O2 Injection", Proceedings of the Symposium on Shock Waves in Japan, 1C1-2, 2020.

4) Kazuya Iwata, Shingo Matsuyama, Makoto Kojima, Yoshio Nunome, Hideto Kawashima, Hideyuki Tanno, and Toshiharu Mizukaki,"Research Progress at JAXA on Fundamental Understanding of Wave Dynamics and Performance Evaluation of Rotating Detonation Rocket Engine", Journal of the Combustion Society of Japan, Vol.62 Issue 200, 2020.

- Oral Presentations

1) Shingo Matsuyama, Kazuya Iwata, Makoto Kojima, Yoshio Nunome, Hideyuki Tanno, Hideto Kawashima, and Toshiharu Mizukaki, "Combustion Simulation of Rotating Detonation with a Non-premixed CH4/O2 Injection", the 57th Symposium (Japanese) on Combustion,.2019.

2) Shingo Matsuyama, Kazuya Iwata, Yoshio Nunome, Hideyuki Tanno, Toshiharu Mizukaki, Makoto Kojima, and Hideto Kawashima, "Large-Eddy Simulation of Rotating Detonation with a Non-premixed CH4/O2 Injection", AIAA Scitech 2020 Forum, 2020.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	220 - 1920
Elapsed Time per Case	360 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	2.49	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	342.25	0.29
/data	1,628.02	0.03
/ltmp	279.02	0.02

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

JAXA-SUBARU Cooperative Research

Report Number: R19ECMP10
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11566/

Responsible Representative

Yasutada Tanabe, Aeronautical Technology Directorate, Aviation Systems Research Unit

Contact Information

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Members

Yasutada Tanabe, Hideaki Sugawara, Kuniyuki Takekawa, Masafumi Sasaki

Abstract

Compound helicopter is one of the next-generation rotorcraft to achieve high-speed flight. However, the increased drag due to the aerodynamic interaction between the rotor and the fixed-wing is one of the technology issues for this type of rotorcraft. The purpose of JAXA-SUBARU cooperative research is to clarify the amount of the drag increase and understand the interactive mechanism through wind-tunnel test and numerical simulation.

Reasons and benefits of using JAXA Supercomputer System

There are many computational cases and the prior simulations for the wind-tunnel tests are required. To obtain simulation results efficiently, the supercomputer system is required.

Achievements of the Year

Wind-tunnel testing and numerical simulations are conducted for three different wings as shown in Fig.1. In the wind-tunnel tests, the rotor-test-stand affects the measurements of the aerodynamic forces significantly. The test data are corrected referring to the numerical simulation result where only simpler models are included. Figure 2 shows the comparison of the lift-to-drag ratio between the corrected test data and the simulation result. The summation of the isolated rotor and winged-body and the combined rotor/winged-body are compared in Fig. 2. There remains some discrepancies between the results of the tests and simulations, however, the reduction ratios of the lift-to-drag ratios are in good agreement between both results. The lift-to-drag ratio of the combined rotor/winged-body decreases by about 20% compared with the summation of isolated results. It is clarified that the aerodynamic drag increases significantly due to the aerodynamic interaction between the rotor and wing.

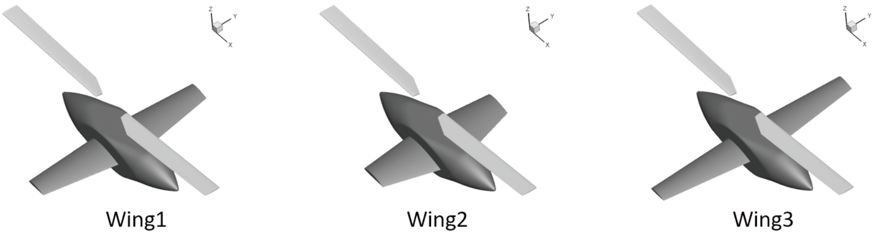

Fig. 1: Models of the combined rotor and winged-body

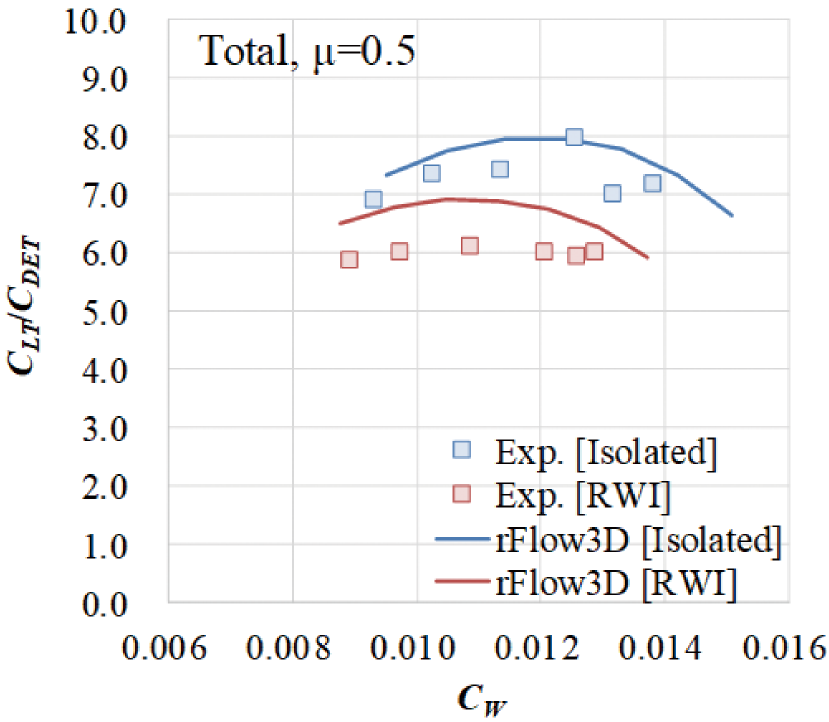

Fig. 2: Comparison of the results of the lift-to-drag ratio for the combined rotor/winged-body between the wind-tunnel test and the numerical simulation

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	336 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.24

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	49,563.41	0.01
SORA-PP	348,715.72	2.26
SORA-LM	3.84	0.00
SORA-TPP	162,833.95	9.83

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	5,048.99	4.20
/data	16,667.34	0.29
/ltmp	4,764.44	0.40

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.94	0.20

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Optimization of rotor blade

Report Number: R19ECMP11
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11567/

Responsible Representative

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Members

Yasutada Tanabe, Masahiko Sugiura, Hideaki Sugawara, Kuniyuki Takekawa

Abstract

Search the optimized rotor blade for high-speed rotorcraft.

Ref. URL: http://www.aero.jaxa.jp/eng/research/frontier/rotary/

Reasons and benefits of using JAXA Supercomputer System

High-fidelity CFD is utlilized to obtain the aerodynamic performances of the rotors in hovering and in high-speed flight for rotor blade optimization. A lot of design samples must be evaluated so that the JSS2 supercomputer is a must requirement.

Achievements of the Year

Optimization of a helicopter rotor blade are conducted regarding twist angle and chord length. As a result, an optimal blade shape shows approximately twice L/DE (Lift by Effective Drag) of the conventional blade shape (Baseline) at high-speed flight, while maintaining approximately the same figure of merit of the baseline during hovering flight (Fig. 1). CFD result examples are shown in Figs. 2 and 3.

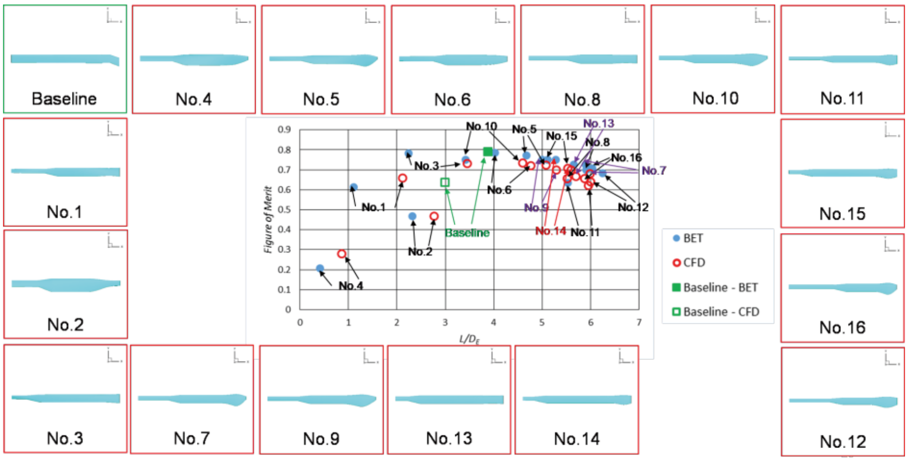

Fig. 1: Analyses based on simple Blade-Element-Theory and CFD for the evaluation of optimized rotors

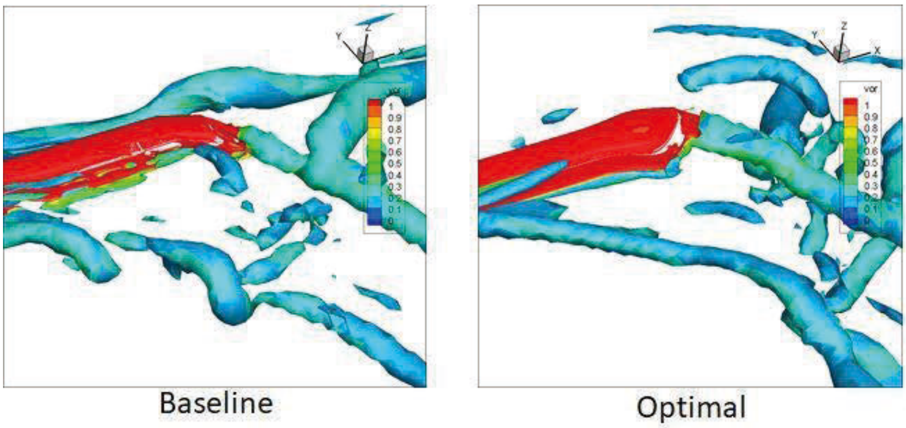

Fig. 2: Rotor wake in hovering flight

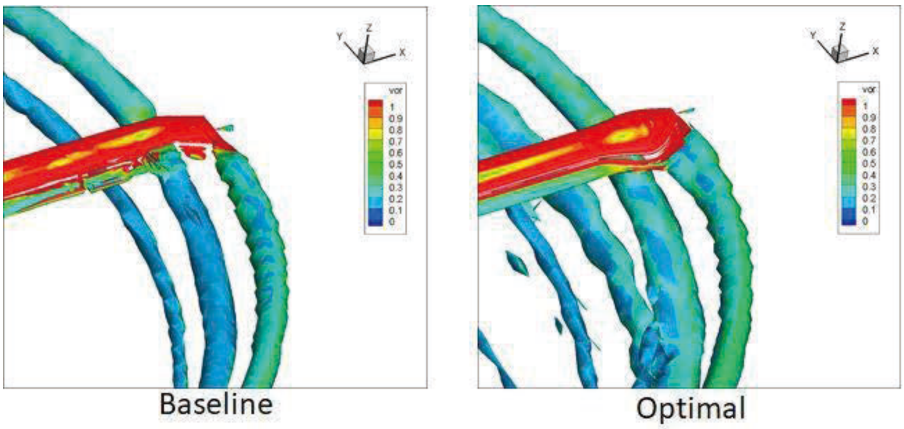

Fig. 3: Rotor wake in high advance ratio (0.7) forward flight

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	430 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.63

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	2,770,946.66	0.34
SORA-PP	689,724.48	4.47
SORA-LM	433.17	0.18
SORA-TPP	116,515.98	7.03

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	4,562.61	3.80
/data	6,806.35	0.12
/ltmp	858.19	0.07

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.94	0.20

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Post-K Priority Issue 8D: Research and development of core technology to innovate aircraft design and operation

Report Number: R19ECMP06
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11564/

Responsible Representative

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Abstract

We develop a high-speed/high-precision computational program using a quasi-first principle method, which can faithfully reproduce the actual flight environment to understand the true nature of fluid phenomena. Specifically, we develop a high-precision compressible flow solver with geometric wall models and LES (Large Eddy Simulation) wall models based on hierarchical, orthogonal and equally spaced structured grids.

Ref. URL: http://www.postk-pi8.iis.u-tokyo.ac.jp/sub_d.html

Reasons and benefits of using JAXA Supercomputer System

We need large computer like JSS2 because our calculations must be large scale computations. Moreover, JSS2 has a similar architecture to the our target computer FUGAKU.

Achievements of the Year

We proceeded with the development of a compressible fluid analysis program FFVHC - ACE using a hierarchical, orthogonal and equally spaced structured grid method.

In this fiscal year, larger scale analysis with approximately up to 4.5 billion grid points, was performed, in comparison with the trial calculation of the detailed geometry of the actual aircraft (JSM_CRM_LEG model) conducted last year,confirming that large-scale analysis was possible. Figure 1 shows the calculation results for a Mach number of 0.2, a Reynolds number of 10^6, and an angle of attack of 7 degrees. In this figure, the vortex around the JSM_CRM_LEG model is shown. Figure 2 compares the results of the last year's survey with about 800 million grid points and the results of this year's about 4.5 billion grid points. It can be seen that finer vortices are captured as the grid resolution increases.

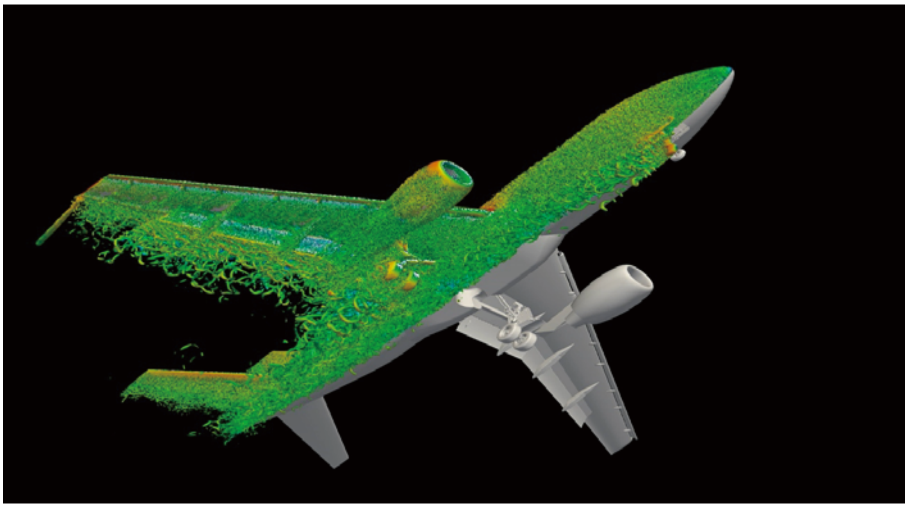

Fig. 1: Flow around detailed geometry model(JSM_CRM_LEG model) (Video. Video is available on the web.)

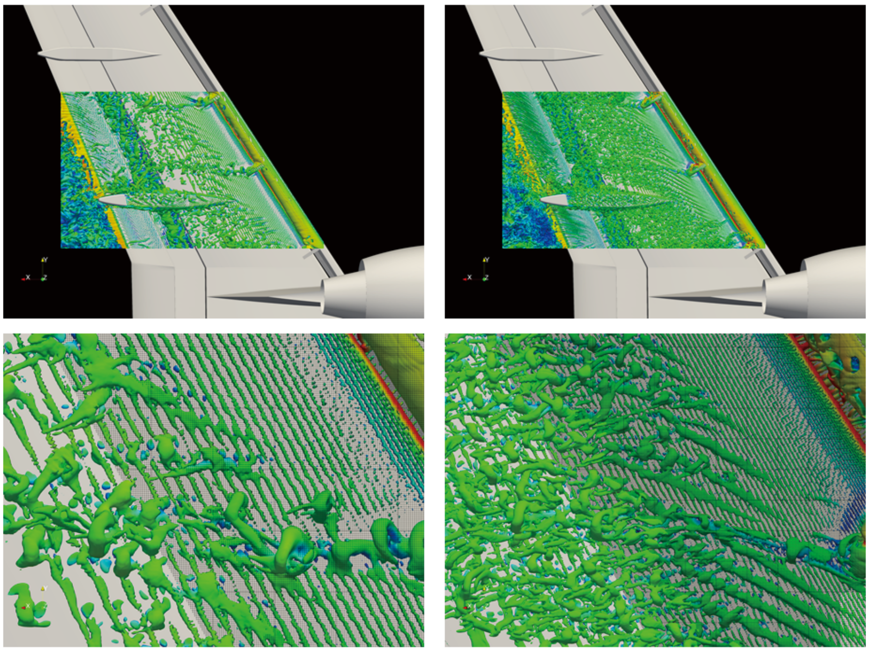

Fig. 2: Fine vortex reproducibility due to differences in grid resolution(800 million grid points and 4.5 billion grid points)

Publications

- Non peer-reviewed papers

R. Takaki, S. Kawai, Y. Fukushima, Y. Tamaki, S. Tsutsumi and H. Shibata, Development of a high-speed and high-precision turbulent flow solver using hierarchical cartesian grids, pp165-171, JAXA-SP-19-007

- Invited Presentations

High-speed tuning of fast flow analysis program - from FX100 to FUGAKU -, 132nd Computational science

colloquium

- Oral Presentations

1) R. Takaki, S. Kawai, Y. Fukushima, Y. Tamaki, S. Tsutsumi and H. Shibata, Development of a high-speed and high-precision turbulent flow solver
using hierarchical cartesian grids, 51st Fluid Dynamics Conference/37th Aerospace Numerical Simulation Symposium, 2A01

2) R.Takaki, High-speed and high-precision turbulent flow solver using hierarchical cartesian grid: FFVHC-ACE, 1st Application Collaboration Development Conference

3) R.Takaki, Performance evaluation and high-speed tuning of FFVHC-ACE, 2st Application Collaboration Development Conference

4) R. Takaki, High-speed tuning of FFVHC-ACE, 3rd Integrated Workshop for Manufacturing with HPC

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 2048
Elapsed Time per Case	300 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 4.52

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	40,982,603.08	4.98
SORA-PP	8,951.93	0.06
SORA-LM	450.53	0.19
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	2,649.31	2.21
/data	32,394.35	0.55
/ltmp	10,575.27	0.90

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	36.47	0.92

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

SGS Stress Transport Equation-based SGS Modeling for Comprehensive LES Model

Report Number: R19ECMP08
Subject Category: Competitive Funding
URL: https://www.jss.jaxa.jp/en/ar/e2019/11565/

Responsible Representative

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Members

Shingo Matsuyama

Abstract

In this study, we aim to realize a comprehensive LES that does not require any tuning for model parameters to the target flow field by solving the SGS stress transport equations. The SGS stress equations are derived exactly from the spatial filtering operation, but requires modeling for the unclosed terms contained in the equations. Therefore, in this study, the unclosed terms are modeled by a priori test using a DNS database of turbulent plane jet, and we try to establish a new LES model with SGS stress transport equations.

Ref. URL: https://kaken.nii.ac.jp/en/grant/KAKENHI-PROJECT-18K03963/

Reasons and benefits of using JAXA Supercomputer System

In order to model the unclosed terms in the SGS stress transport equations, a priori test using statistical data by DNS is required for high Reynolds number condition. For performing DNS under high Reynolds number condition of Re > 10000, a numerical mesh of the order of one billion points is required. Such large-scale simulation can be executed only on a supercomputer, and therefore, supercomputer system is indispensable for carrying out this research.

Achievements of the Year

LES analysis was carried out for a plane turbulent jet at Re = 10,000 by incorporating SGS stress transport equation modeled by a priori test using DNS database into LES framework. The obtained SGS stress distribution was similar to that of the priori test, although it was a preliminary result (Fig. 1).

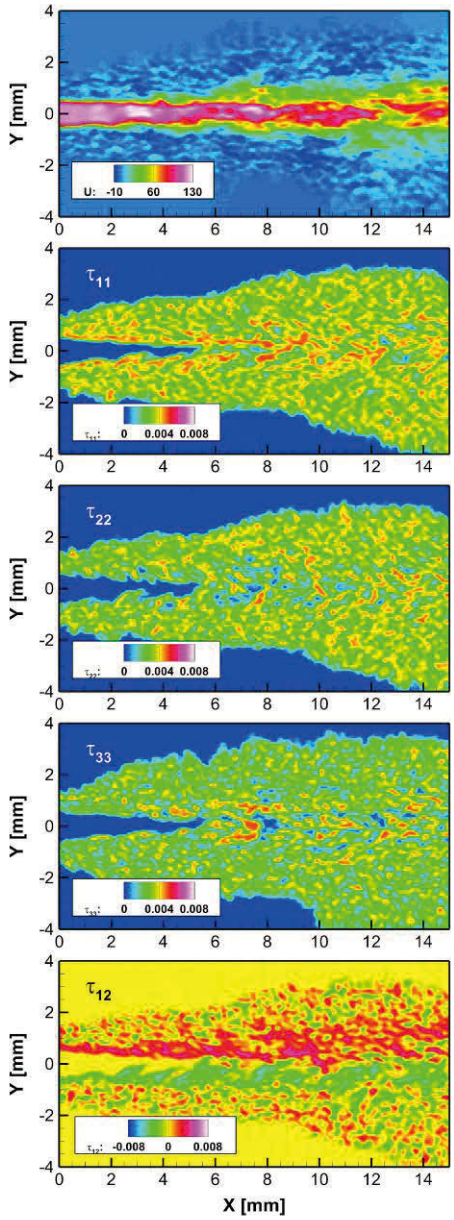

Fig. 1: Instantaneous contours of velocity u and SGS stresses (tau_{11}, tau_{22}, tau_{33}, and tau_{12}).

Publications

- Non peer-reviewed papers

1) Shingo Matsuyama, "A prioi test using DNS data of a turbulent plane jet for LES modeling with SGS stress transport equations", Proceedings of the JSFM Annual Meeting 2019, 2019.

2) Shingo Matsuyama, "LES of a Turbulent Plane Jet by an SGS Stress Transport Equation-based Model", Proceedings of the 33rd CFD Sympoium, A09-4, 2019.

3) Shingo Matsuyama, "LES of a Turbulent Plane Jet by an SGS Stress Transport Equation-based Model", Proceedings of the 35th TSFD Sympoium, 2019.

- Oral Presentations

1) Shingo Matsuyama, "A prioi test using DNS data of a turbulent plane jet for LES modeling with SGS stress

transport equations", the JSFM Annual Meeting 2019, 2019.
2) Shingo Matsuyama, "LES of a Turbulent Plane Jet by an SGS Stress Transport Equation-based Model", the 33rd CFD Sympoium, 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	750 - 1500
Elapsed Time per Case	660 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	303,526.40	0.04
SORA-PP	2.15	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	342.25	0.29
/data	1,628.02	0.03
/ltmp	279.02	0.02

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Cooperative Graduate School System

Fundamental Research on Noise Generation Mechanisms from Airframe

Report Number: R19ECWU02
Subject Category: Cooperative Graduate School System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11572/

Responsible Representative

Kazuomi Yamamoto, FQUROH+ Team, Aviation Systems Research Unit, Aeronautical Technology Directorate

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Members

Yutaku Yan, Kazuomi Yamamoto, Mitsuhiro Murayama, Yasushi Ito, Takehisa Takaishi, Ryotaro Sakai, Tohru Hirai, Kentaro Tanaka, Kazuhisa Amemiya, Gen Nakano

Abstract

The noise reduction technology for high-lift devices and landing gear draws international attention to reduce noise in areas around airports. FQUROH (Flight Demonstration of Quiet Technology to Reduce Noise from High-Lift Configurations) aims at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear to a level applicable to future development of aircraft and related equipment. In this business code, as the fundamental research on noise generation mechanisms from airframe, unsteady flow simulations for aeroacoustics evaluation were conducted to understand the basic physical phenomena of the noise caused by the interference between the main landing gear storage and the side brace flow from the main landing gear of the aircraft.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

Reasons and benefits of using JAXA Supercomputer System

Due to high computational cost of high-fidelity unsteady flow simulations on the grids with fine resolution for aeroacoustics evaluation, the use of JSS2 is required to obtain multiple cases of the simulation within a limited period.

Achievements of the Year

The purpose of this research is to understand fundamental physics of flow interaction around the side-brace and the gear bay which could be airframe noise sources from main landing gear in the low-frequency range. Two-dimensional unsteady flow CFD simulations were conducted for the simplified problem which consists of an open cavity and a cylinder. The simulations with several different relative positions of the cylinder to the cavity revealed change of fluctuation mode of cylinder wake and shear layer by the cylinder positions (Figs. 1 and 2).

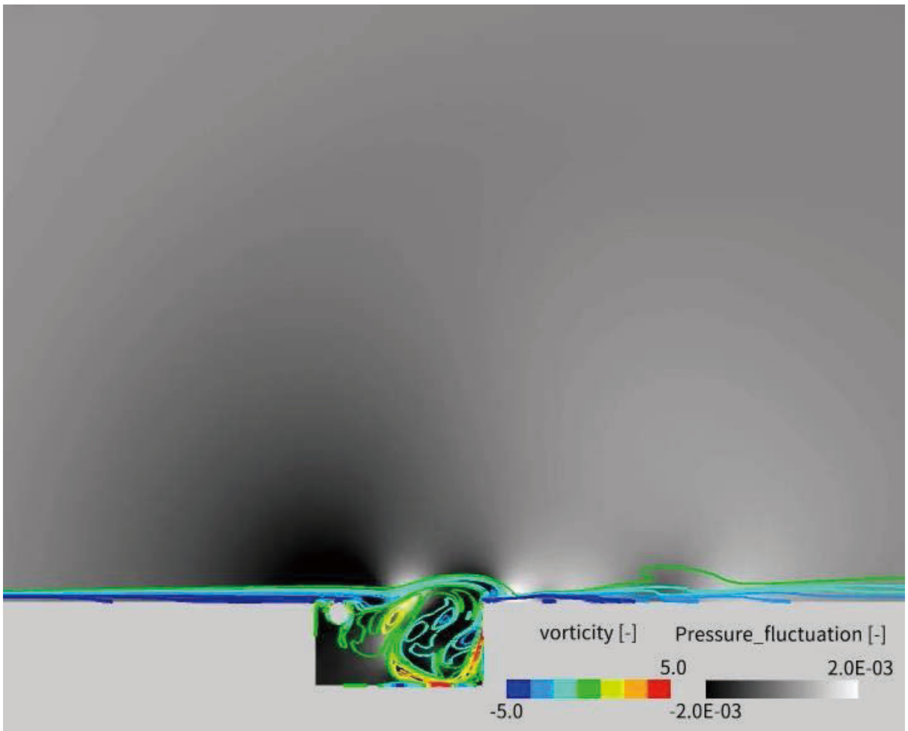

Fig. 1: Comparison of pressure fluctuations and vorticity contours with different relative positions of cylinder: (a) Cylinder inside cavity (Video. Video is available on the web.)

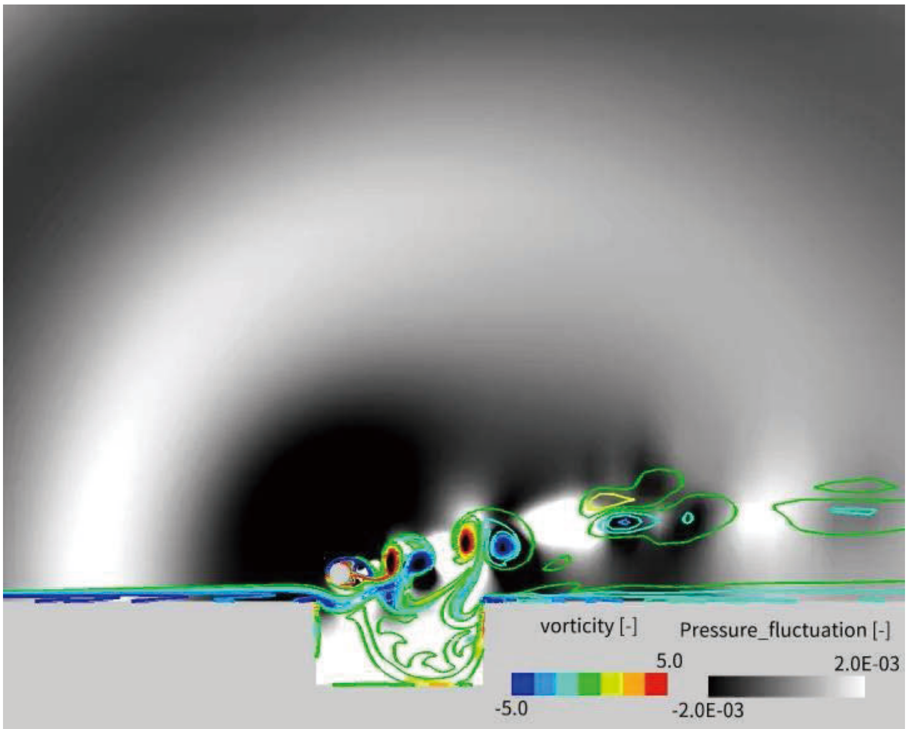

Fig. 2: Comparison of pressure fluctuations and vorticity contours with different relative positions of cylinder: (b) Cylinder outside cavity (Video. Video is available on the web.)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	80 - 120
Elapsed Time per Case	7200 Second(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.08

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	310,386.20	0.04
SORA-PP	16,327.98	0.11
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	303.96	0.25
/data	35,825.54	0.61
/ltmp	3,871.48	0.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	280.18	7.05

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Migration in gravitationally unstable protoplanetary discs

Report Number: R19ECWU00
Subject Category: Cooperative Graduate School System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11571/

Responsible Representative

Elizabeth Tasker, Associate Professor in the Division of Solar System Science at ISAS / JAXA.

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Members

Elizabeth Tasker, Ngan Kim Nguyen

Abstract

A long standing problem in planet formation theory is how the orbits of young planets change due to the drag of the gas still surrounding young stars. This project explores how gravitatonal structures (e.g. spiral arms) in the gas disc can affect this migration process. By modelling the motion of a planet in a gas disc around a star, we hope to demonstrate that the orbit of the planet depends on structures in the gas, thereby suggesting that different discs can result in different planet periods.

Reasons and benefits of using JAXA Supercomputer System

The tools needed for this project are three-dimensional hydrodynamical simulations, run on several hundred cores. This is beyond what is possible on a desktop computer. The code used (ChaNGa) is designed for supercomputer facilities parallised with MPI,. Many different simulations are needed to see how different disc structures (depending on factors such as cooling and mass) affect the migration of a planet.

Achievements of the Year

Established theoretical calculations of planet migration dictate the rate at which a low-mass planet will move through the planet-forming disc (protoplanetary disc). To prove that disc structure could affect the migration, we had to first prove that our planet moves as expected in a light disc without strong structurual features. Challenges included: (a) Choosing the right range of planet masses. The effect of the planet on the gas is smaller for a low-mass planet, making it difficult to correctly resolve the physics. However, a large planet would cause a gap to form in the gas and move to a different migration regime. (b) Adding the planet's mass to the disc had to be done gradually to prevent a sudden interaction. (c) Realistic cooling had to be included. The result for a 33 Earth mass planet is shown in Figures 1 and 2. The average torque (figure 2) on the planet shows that this has settled to a steady rate in good agreement with the theoretical prediction. The planet's orbit is slightly elliptiical (figure 1), but this is beng dampled by the gas. We then placed the planet in a heavier disc. The migration of the planet increased due to the strongly pull from the more massive disc and the rate began to vary due to the disc structure developing (figure 3).

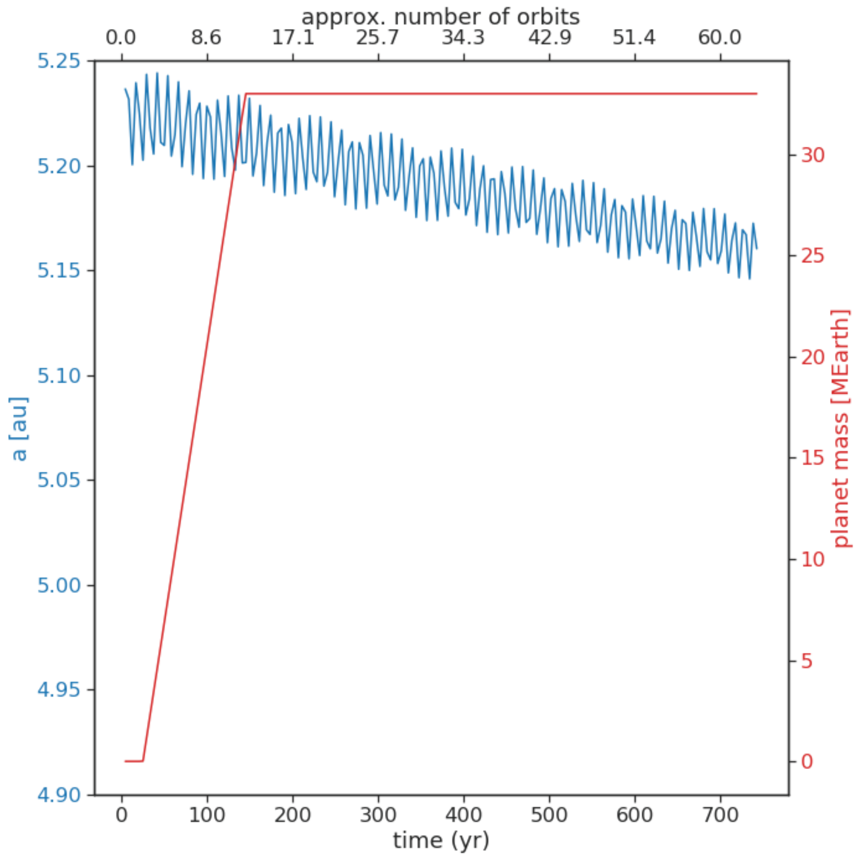

Fig. 1: The migration rate of a 33 Earth mass planet in the protoplanetary disc. Left side axis shows the planet's distance from the star. The planet's orbit is elliptiical, but becomes more circular due to damping from the gas.

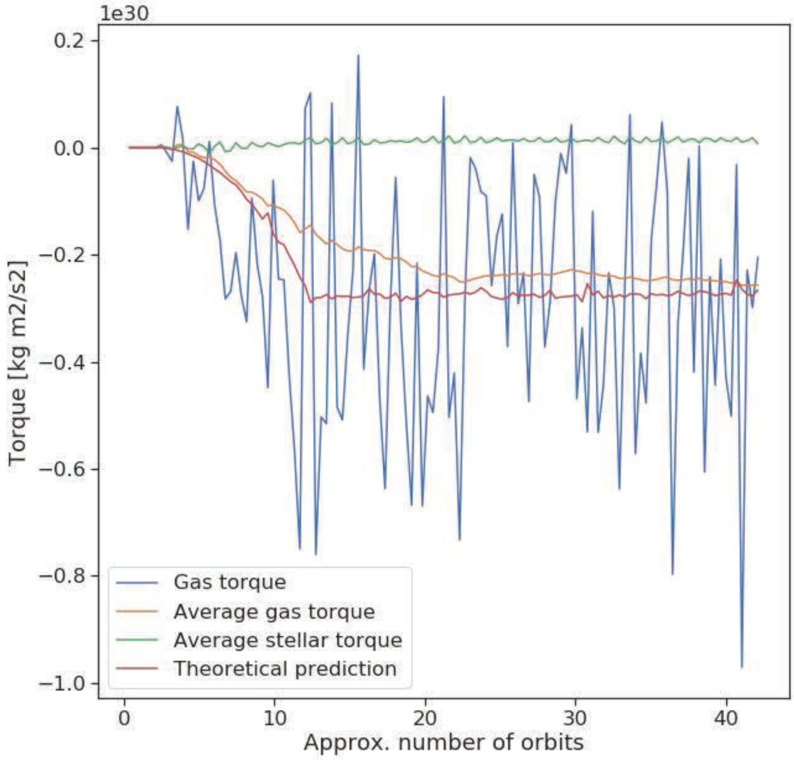

Fig. 2: The torque on the planet from the protoplanetary disc. The blue line shows the instantaneous torque on the planet at each output. The average torque is shown by the orange line. It rapidly settes to a value similar to the theoretical prediction (red line).

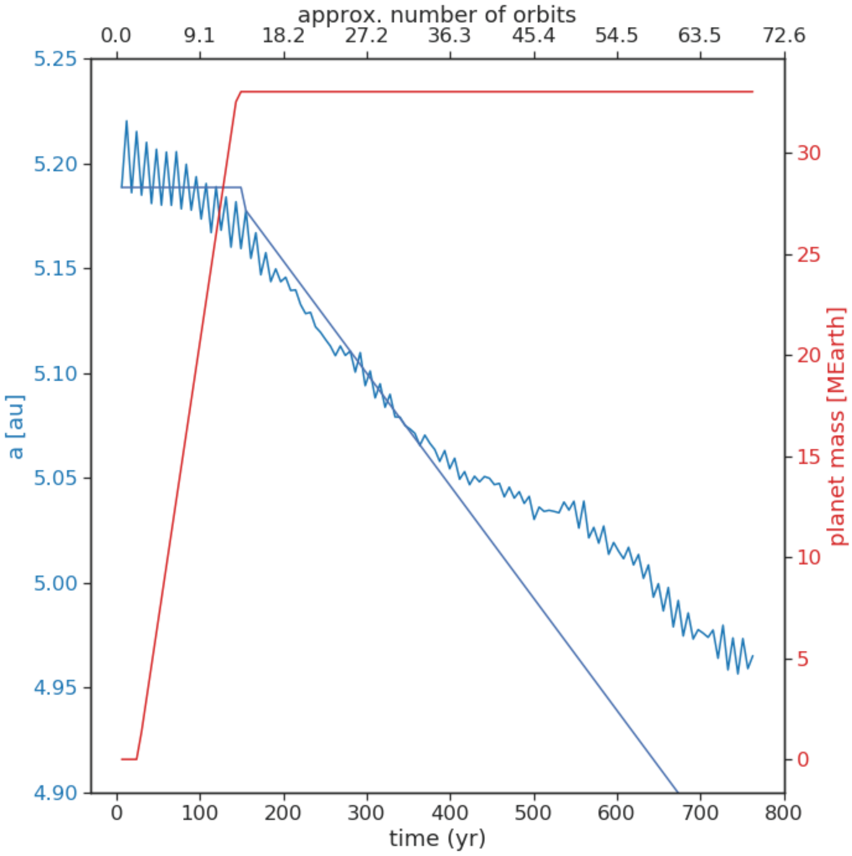

Fig. 3: The migration rate of a 33 Earth mass planet in a heavy protoplanetary disc (10 x mass as in Figure 1). The migration rate is more rapid due to the larger gas mass and less steady as the disc becomes assymmetric.

Publications

- Poster Presentations

"Planetary Atrmospheres and Habitability", 14 - 18 October, 2019, Okinawa. http://www.resceu.s.u-tokyo.ac.jp/symposium/resceu_sympo2019/

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	144 - 264
Elapsed Time per Case	50 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.25

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	683,254.12	4.43
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	7.95	0.01
/data	79.47	0.00
/ltmp	1,627.60	0.14

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on spacecraft dynamics

Report Number: R19ECWU24
Subject Category: Cooperative Graduate School System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11574/

Responsible Representative

Shujiro Sawai, Institute of Space and Astronautical Science, Department of Space Flight Systems

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Members

Haruaki Seta, Yusuke Maru

Abstract

design and evaluation of an intake for an ATR (Air-Turbo Rocket) engine for a reusable sounding rocket with an airbreathing propulsion system.

Reasons and benefits of using JAXA Supercomputer System

The use of JSS2 enables very high-speed analysis when evaluating the characteristics of the designed intake by CFD, so that performance evaluation under a variety of flight conditions can be performed.

Achievements of the Year

In order to combine the reusable sounding rocket with the airbreathing engine, it is necessary to install an air intake on the airframe. The purpose of the present study is to design the intake of the reusable sounding rocket with the Air-Turbo Rocket (ATR) engine and to evaluate the characteristics.

The characteristics of the designed intake shape were evaluated by CFD. From the inviscid analysis, it was confirmed that the flow field formed as designed (Fig.1). On the other hand, from the viscosity analysis, it was found that the influence of the boundary layer greatly affected the intake performance.(Fig.2) However, if the mainstream Reynolds number was tripled, the performance degradation due to the boundary layer was mitigated.(Fig.3)

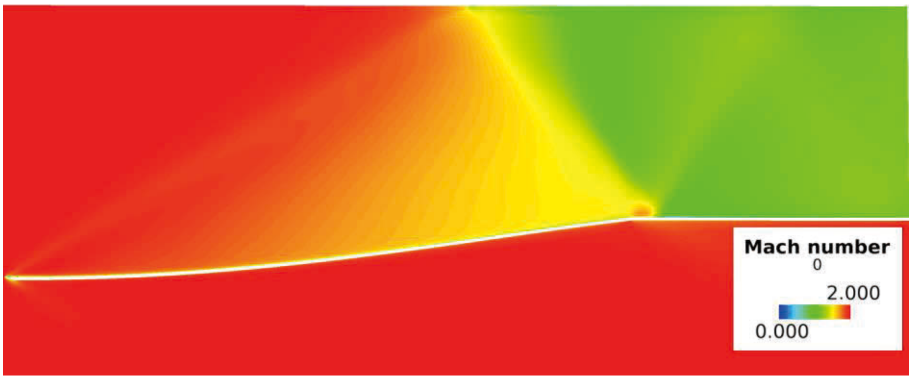

Fig. 1: Flow Mach number contours in the designed intake in inviscid flow.

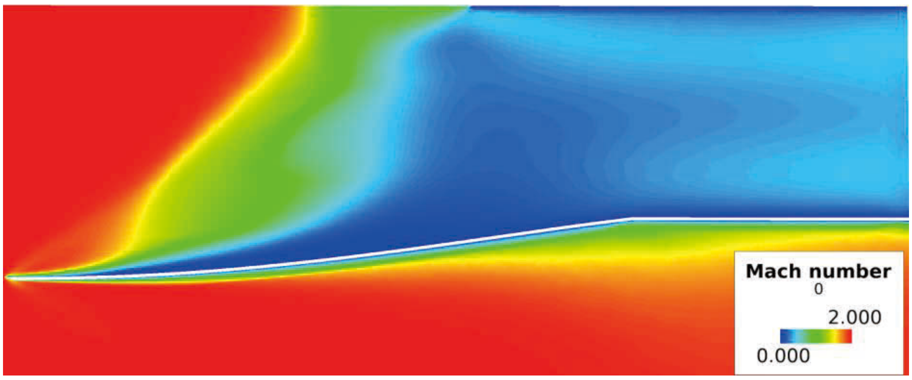

Fig. 2: Flow Mach number contours in the designed intake in viscous flow.

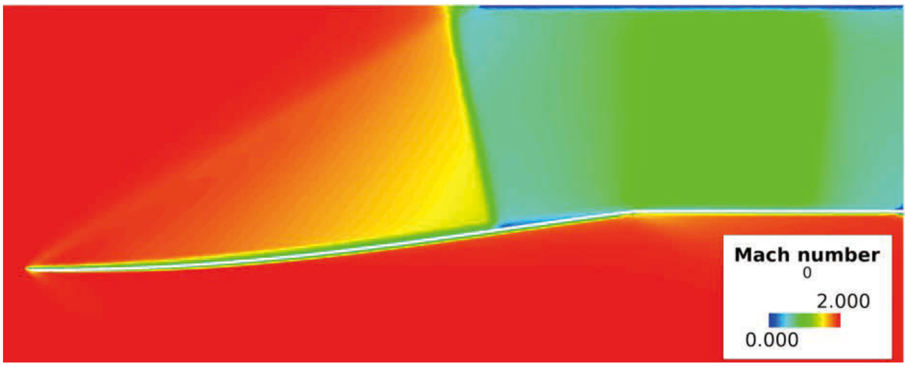

Fig. 3: Flow Mach number contours in the designed intake in viscous flow and triple Reynolds number.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	256
Elapsed Time per Case	8.3 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	321,558.47	0.04
SORA-PP	9,957.36	0.06
SORA-LM	276.23	0.12
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	484.78	0.40
/data	9,845.10	0.17
/ltmp	3,580.73	0.30

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

JSS2 Inter-University Research

Computational Study on Aerodynamic Characteristics of Slender Body Configurations

Report Number: R19EACA12
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11539/

Responsible Representative

Keiichi Kitamura, Associate Professor, Yokohama National University

Contact Information

Yuya Takagi(takagi-yuuya-ks@ynu.jp)

Members

Keiichi Kitamura, Yuya Takagi

Abstract

In this study, we conducted CFD on the aerodynamics of the RV-X with a double-cone nose. In particular, we forcused on the side-force characteristics at high-angles of attack, and we performed large-scale calculations. The side-force characteristics betweeen wind tunnel testing and CFD at 60° angle-of-attack were qualitatively matched, and the flow field by CFD was qualitatively consistent with the surface flow field visualized by an oil-flow technique. In addition, we succeeded in clarifing the side force mechanism at 60° angle-of-attack. In the future, we try to clarify the side force mechanism at 90° and 120° angle-of-attack.

Reasons and benefits of using JAXA Supercomputer System

Goal

We clarify the mechanism of the side-force generation on slender-body such as the reusable rockets at high angles of attack, and give insights on actual flight.

Nesessity

According to the previous studies, in order to resolve vortices generated around the body and fins, it is known that the unsteady calculation needs at least 30 million elements. However, in the side force analysis, 180 million elements are needed to resolve the vortices near the boundary layer. Therefore, we used JSS2 so as to reduce computational time.

Use

Since it was necessary to reduce the computational time for large-scale calculation, we used JSS2.

Achievements of the Year

We performed the calculations about the reusable rocket experimental vehicle RV-X, and we obtained the aerodynamic coefficients and flow fields. Especially, we focused on the mecanism of the side-force generations at high angles of attack. Fig. 1 shows the mesh configuration, we reproduced both the body part and the sting part in the experimental setup. Fig. 2 shows the validations about the pitching moment and the side-force characteristics, and the calculated and experimental results were qualitatively in good agreement. Particulary, we focused on the side-force generation mechanism at angle of attack 60°. We found that the side-force was gradually generated with the separated vortices at both first and second cones, and side-force increased toward the aft of the body (Fig. 3, Fig. 4).

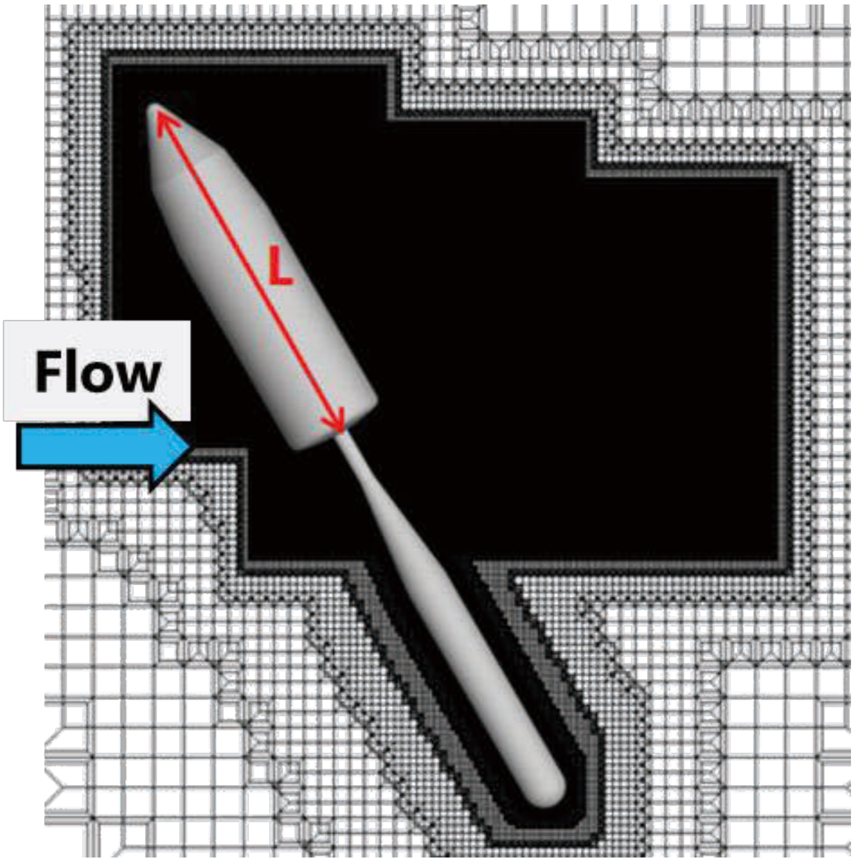

Fig. 1: Mesh Configuration.

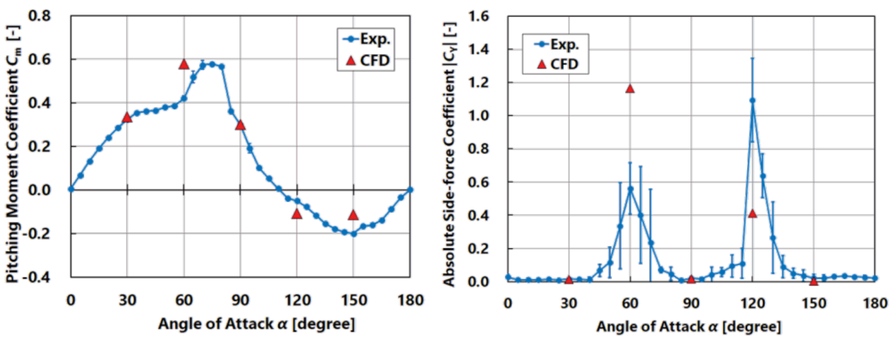

Fig. 2: Comparisons of Aerodynamic Coefficient between Calculated and Experimental results.

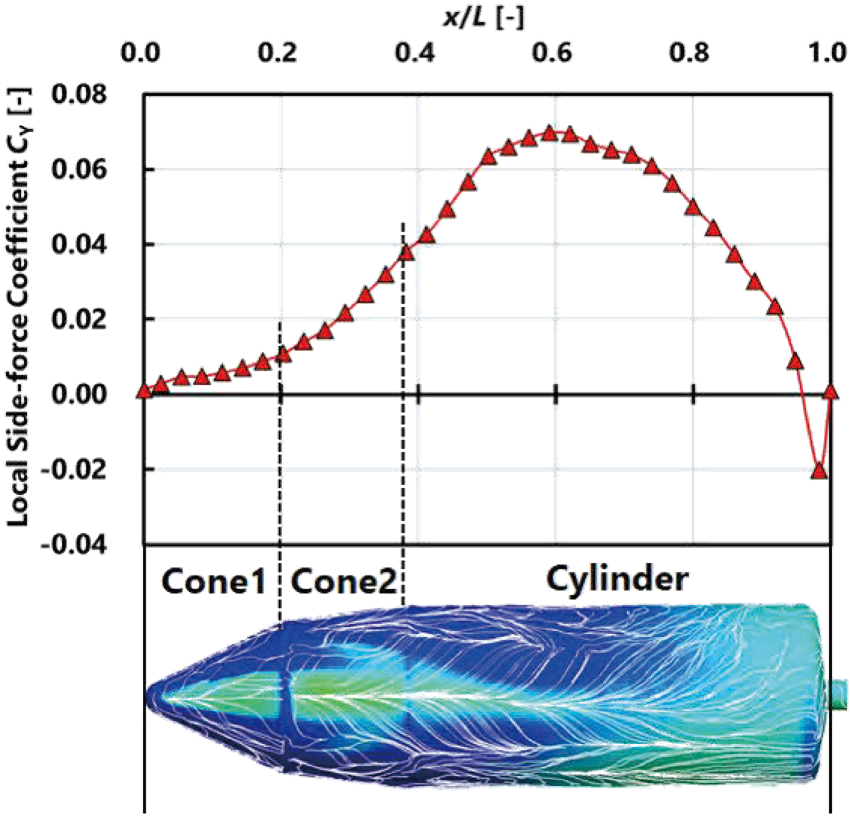

Fig. 3: Local Side-Force Coefficient and Pressure Distribution at AOA 60°

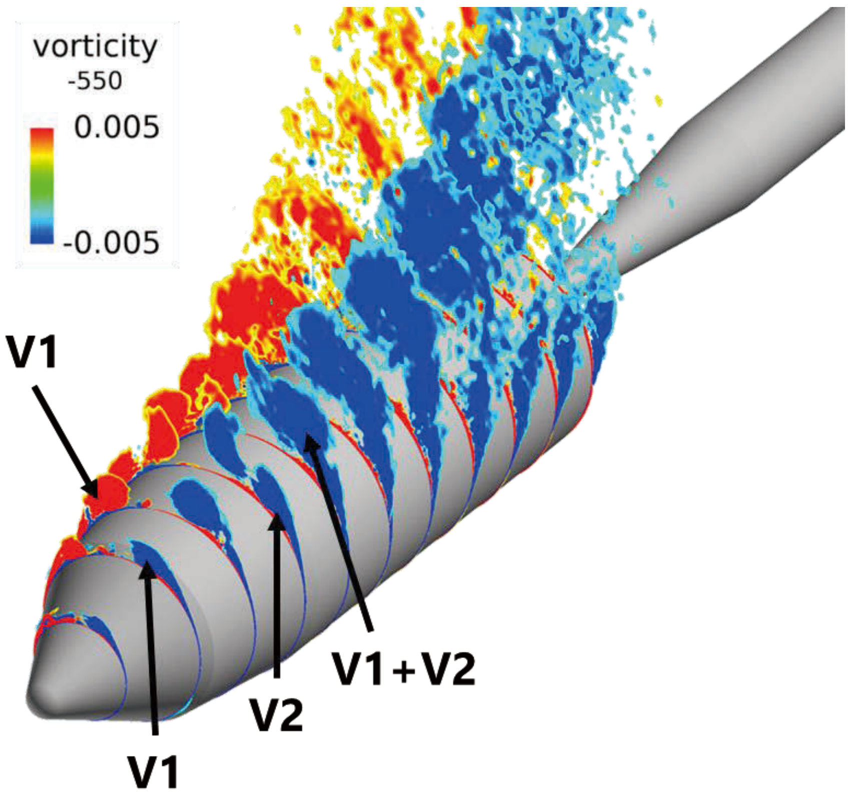

Fig. 4: Vorticity Magnitude at AOA 60°

Publications

- Oral Presentations

Yuya Takagi, Keiichi Kitamura, and Satoshi Nonaka: Delayed Detached-Eddy-Simulation on High Angle-of-Attack Aerodynamic Characteristics of Slender-Bodied Reusable Rocket with Fins and Vortex Flaps, 50th JSASS Annual Meeting, Meguro, 1C09, 2019 (in Japanese).

Yuya Takagi, Tomotaro Muto, Keiichi Kitamura, and Satoshi Nonaka: Wind Tunnel Testing and Numerical Analysis on High Angle-of-Attack Characteristics of Double-Cone Reusable Rocket, 63rd Space Sciences and Technology Conference, Tokushima, 1H-04, 2019 (in Japanese).

- Poster Presentations

Yuya Takagi, Keiichi Kitamura, and Satoshi Nonaka: Delayed Detached-Eddy-Simulations on High Angle-of-Attack Aerodynamic Characteristics of Slender-Bodied Reusable Rocket with Vortex Flaps at Different Deflection Angles, 63rd Space Sciences and Technology Conference, Tokushima, P71, 2019 (in Japanese).

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512 - 4096
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.30

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,883,212.00	0.23
SORA-PP	28,132.33	0.18
SORA-LM	29,529.45	12.33
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	240.33	0.20
/data	4,901.89	0.08
/ltmp	1,367.19	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Construction of LES model for high Mach number multiphase flow based on DNS analysis

Report Number: R19EACA11
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11538/

Responsible Representative

Kota Fukuda, Ascossiate Professor, Tokai University

Contact Information

Kota Fukuda, Ascossiate Professor, Tokai University(fukuda@tokai-u.jp)

Members

Kota Fukuda, Taku Nonomura

Abstract

In order to construct LES model for high Mach number multi-phase turbulent flow, direct numerical simulation (DNS) of high Mach number and low Reynolds number flow around a particle will be carried out and construction of its data base and examination of the flow phenomena will be conducted.

Reasons and benefits of using JAXA Supercomputer System

In this project, direct numerical simulation (DNS) of high Mach number and low Reynolds number flow around a particle and construction of the data base will be carried out using a boundary-fitted coordinate system. Large scale numerical simulation is essential to construct the data base.

Achievements of the Year

In this study, the transonic flow over an isolated sphere up to a Reynolds number of 1,000 was investigated by the direct numerical simulation (DNS) of the three-dimensional compressible Navire-Stokes equations. The Mach number effects on the types of flow patterns, the flow geometry, and the drag coefficient were investigated. As a result, we confirmed that (1) the wake is significantly stabilized at the transonic regime; (2) the increment of the drag coefficient in the continuum regime due to the Mach number effect can be characterized with regardless of the Reynolds number even though low-Reynolds number conditions, (3) and the increment of the pressure and viscous drag coefficients are predictable by Prandtl-Glauert transform and the movement of the position of the separation point, respectively, up to a Mach number of approximately 0.8.

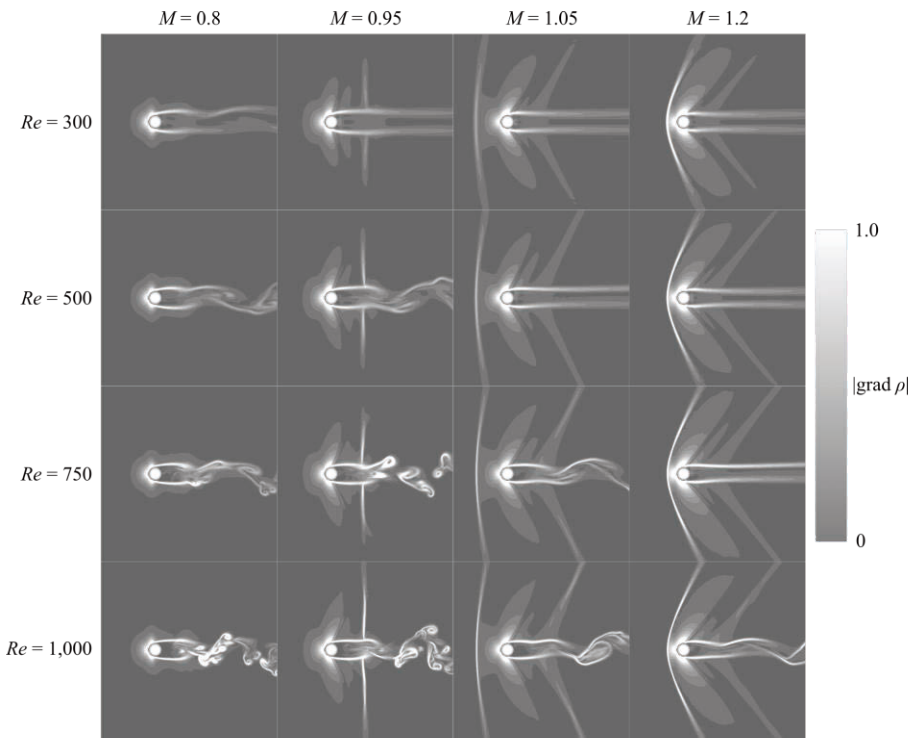

Fig. 1: Mach number and Reynolds number effects on the wake sructure of a stationaly isolated sphere (distribution of the absolute value of the density).

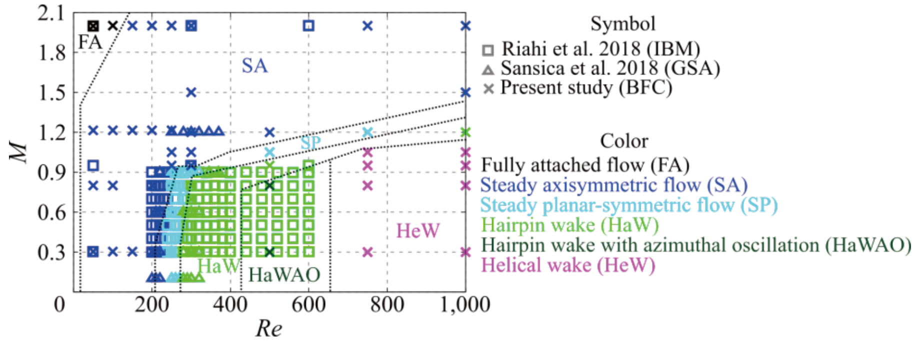

Fig. 2: Relationship between the separation point and the total drag coefficient

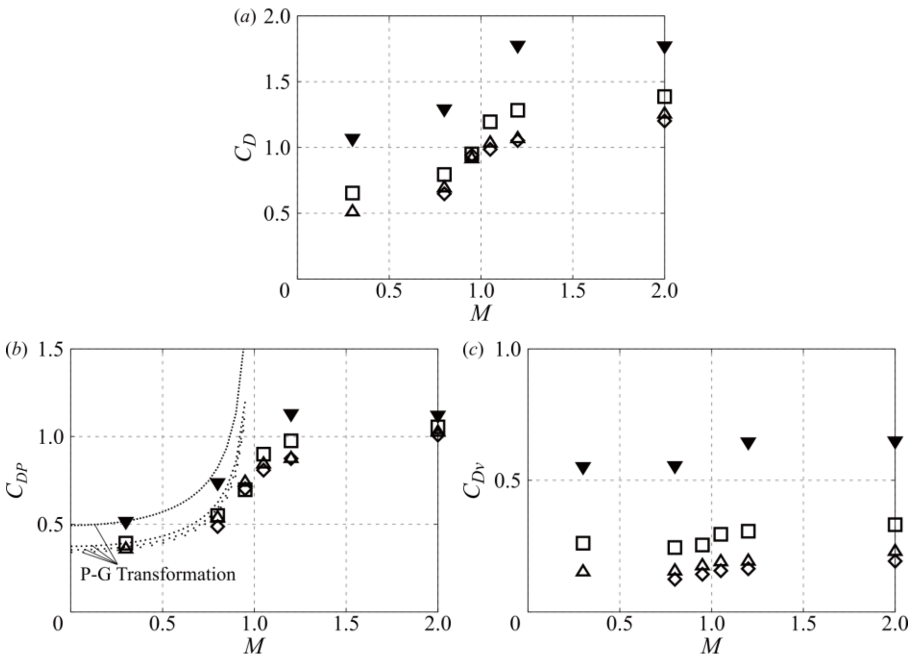

Fig. 3: The map of flow regime of stationaly sphere at the compressible low-Reynolds number flow.

Publications

- Oral Presentations

Nagata, T., Nonomura, T., Takahashi, S., and Fukuda, K., "onsideration of Mach and Reynolds numbers effect on flow field and drag coefficient of a particle in transonic flow at Reynolds number between 300 and 1000," Proceedings of the 51st Fluid Dynamics Conference / the 37th Aerospace Numerical Simulation Symposium, 1E08, Tokyo, July (2019)

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	16 - 289
Elapsed Time per Case	200 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.29

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	2,523,635.64	0.31
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	42.35	0.04
/data	24,530.76	0.42
/ltmp	3,044.58	0.26

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	18.89	0.48

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Data staging technique for improving post-processing performance in large-scale CFD analysis

Report Number: R19EACA42
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11556/

Responsible Representative

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Members

Keichi Takahashi

Abstract

Conventional post-processing of CFD simulations was achieved by saving the entire simulation output on a parallel file system and then processing the output. However, this approach is becoming increasingly challenging due to the limitations in storage size and IO bandwidth. Therefore, data staging, where the simulator transfers its output to a post-processing application during runtime, is attracting attention. In this research, we evaluate the feasibility of leveraging data staging technologies on HPC environments exemplified JSS2 and analyze the requirements for data staging middleware and HPC environment.

Reasons and benefits of using JAXA Supercomputer System

We used JSS2 because it comprises two subsystems, which are the main compute system (SORA-MA) and the pre/post-processing system (SORA-PP), and it allows communication between the two subsystems.

Achievements of the Year

In this fiscal year, we improved the practicality of staging between SORA-MA and SORA-PP. In the last fiscal year, we ported ADIOS2, which is a staging middleware developed at Oak Ridge National Laboratory, and successfully achieved staging communication between MA and PP. We ran ADIOS2's adios-reorganize utility on the IO nodes in MA to relay the communication between MA and PP.

However, the following two issues remain when applying staging to a large-scale CFD analysis spanning over thousands of processes: (1) low throughput: the achieved throughput is less than 10% of the bandwidth of the underlying interconnect on both subsystems. (2) large memory footprint of the communication bridge: the communication bridge consumes up to 2x - 3x of the data size. We tackled these two issues since they are critical obstacles when applying staging to large-scale CFD analysis.

Regarding issue (1), we believe that this is caused by the fact that ADIOS2's staging engine SST uses TCP/IP instead of RDMA. In fact, RDMA achieved much higher throughput than TCP/IP on the two systems (measured using network benchmarks). Regarding issue (2), we analyzed the memory allocations and deallocations in adios-reorganize using a heap profiler (Valgrind Massif). The profiling results revealed that the SST engine allocates multiple redundant buffers for communication. Furthermore, dynamically growing the buffers is causing reallocations and making the memory footprint even larger.

We believe that using SSC, which is a newly developed staging engine in ADIOS2, can solve these two issues. Since SSC's backend is MPI, RDMA is used instead of TCP/IP. Also, SSC maintains fewer buffers than SST. Based on these analysis and discussion, we ported the SSC engine to MA and PP and confirmed that functional tests are passing with SSC. In the next year, we conduct a detailed performance evaluation using the SSC engine and verify if issues (1) and (2) are successfully solved.

Publications

- Non peer-reviewed papers

Seiji Tsutsumi, Naoyuki Fujita, Hiroyuki Ito, Daichi Obinata, Keisuke Inoue, Yosuke Matsumura, Keichi Takahashi, Greg Eisenhauer, Norbert Podhorszki, Scott Klasky, "In Situ/In Transit Approaches for Post-Processing in Large-Scale Numerical Simulation", 33rd CFD Symposium.

- Oral Presentations

Seiji Tsutsumi, Naoyuki Fujita, Hiroyuki Ito, Daichi Obinata, Keisuke Inoue, Yosuke Matsumura, Keichi Takahashi, Greg Eisenhauer, Norbert Podhorszki, Scott Klasky, "In Situ and In Transit Visualization for Numerical Simulations in HPC", In Situ Infrastructures for Enabling Extreme-scale Analysis and Visualization (ISAV 2019).

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1 - 128
Elapsed Time per Case	5 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	11,189.95	0.00
SORA-PP	275.58	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	95.37	0.00
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development and application of multiphase flow solver for moving object using Cartesian grid

Report Number: R19EACA10
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11537/

Responsible Representative

Shun Takahashi, Tokai University

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Members

Shun Takahashi, Taku Nonomura

Abstract

The particulate flow is solved by the direct numerical simualtion using Euler-Euler approarch method. The objective is to investigate the interaction between the flow and particles and to develop the particulate model for the large scale compressible multiphase flow simulation.

Reasons and benefits of using JAXA Supercomputer System

The particulate flow becomes expensive in order to investigate the interaction between the flow and particles using Cartesian grid and the immersed boundary method. Also, the number of the time integrations becomes large due to obtain the equilibrium state of the particulate flow.

Achievements of the Year

The compressible flow analysis with high resolution was conducted by using the Cartesian grid method. Fig.1 shows flow distributions around two particles which the computational grid is set to be the particle diameter divided by 100. When the shock wave cross the particles, the influense of the distance between the particles is displayed in Fig. 2.

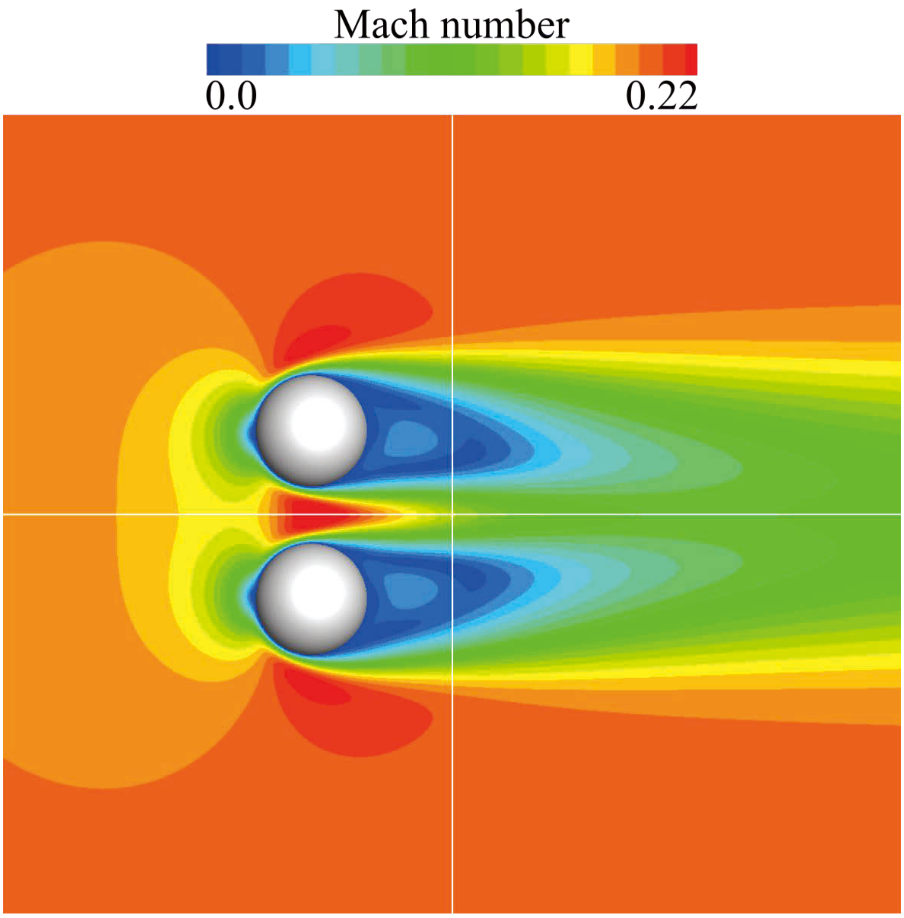

Fig. 1: Mach number distributions of flow cross two particles

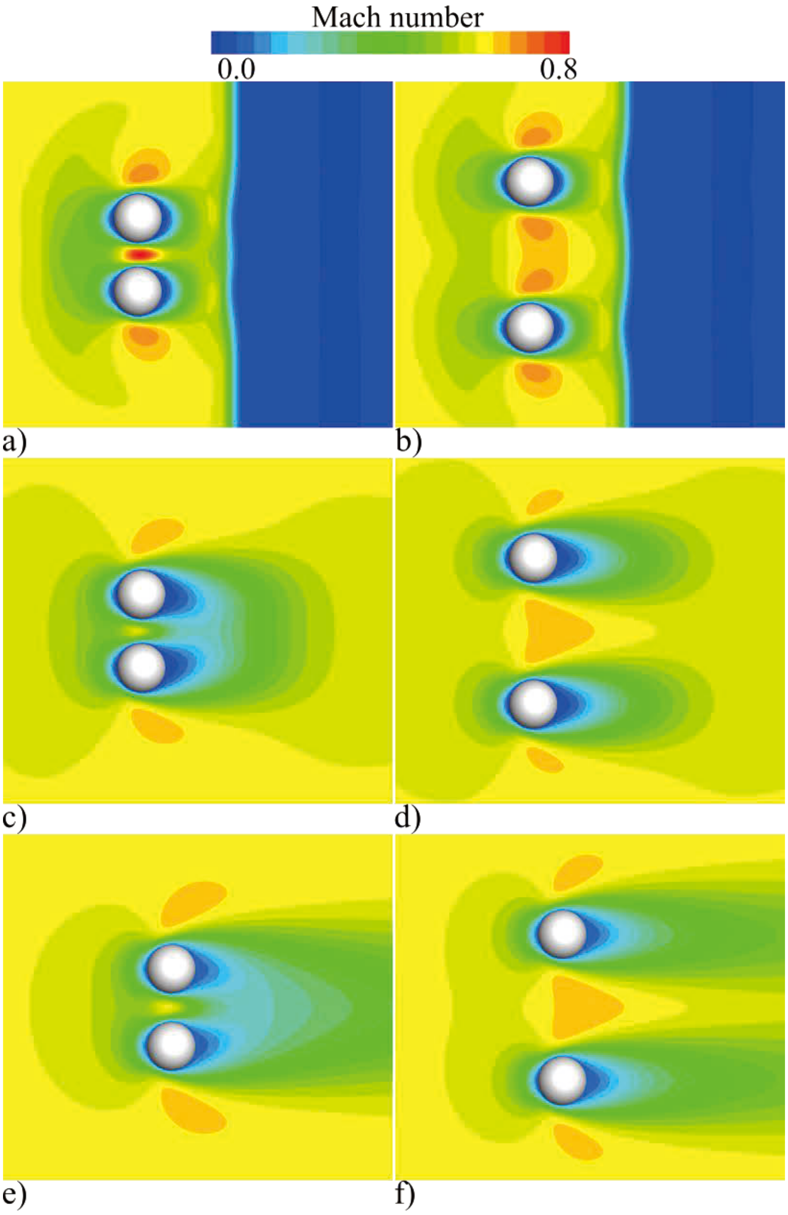

Fig. 2: Mach number distributions of shock wave cross two moving particles

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	16 - 128
Elapsed Time per Case	140 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.24

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	2,203,081.64	0.27
SORA-PP	2.20	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	32.82	0.03
/data	5,457.26	0.09
/ltmp	1,091.45	0.09

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	8.89	0.22

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Direct numerical simulation for understanding on flow over vortex generators

Report Number: R19EACA44
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11558/

Responsible Representative

Taku nonomura, Associate Professor, Tohoku University

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Taku Nonomura (Tohoku University)(nonomura@aero.mech.tohoku.ac.jp)

Members

Taku Nonomura, Takayuki Nagata

Abstract

In the present study, we investigated the fundamental characteristics of the supersonic vortex generator implemented on the slip wall by the direct numerical simulation of the Navier-Stokes equation. The characteristics of the flow over vortex generators at subsonic and transonic conditions have been investigated by numerous researchers. However, there are few studies at supersonic conditions, so that we investigated the flow characteristics in quite simplified conditions and proceed with the understanding of the flow physics.

Reasons and benefits of using JAXA Supercomputer System

In this project, direct numerical simulations of the three-dimensional compressible Navier-Stokes equation are conducted, so that large scale computational resources are required even though the low-Reynolds-number conditions. In addition, there are many parameters such as the freestream Mach number, the arrangement and the sphape of the vortex generator.

Achievements of the Year

In this study, flow over a pair of vane-type vortex generator is investigated by solving the Navier-Stokes equation. A pair of the vane-type vortex generator implemented on a slip wall in laminar flow is considered so that the problem setting could be simple. The Reynolds number based on freestream quantities and the height of the vanes is set to be 500. The effect of the arrangement and geometry of vanes on the circulation coefficients, induced flow velocities, and aerodynamic force coefficients of VGs are investigated. In addition, a new circulation coefficient, normalized by freestream velocity and the height of the vortex core was introduced and its effectiveness is examined. This new parameter, C_gamma, include the height of the vortex core, so that appears to be a better measure of VG effectiveness on momentum exchange in near wall region. From the computational results, the wider arrangement can introduce the effective vortices with small drag. Also, the longer vanes can introduce strong and effective vortices with smaller drag coefficient.

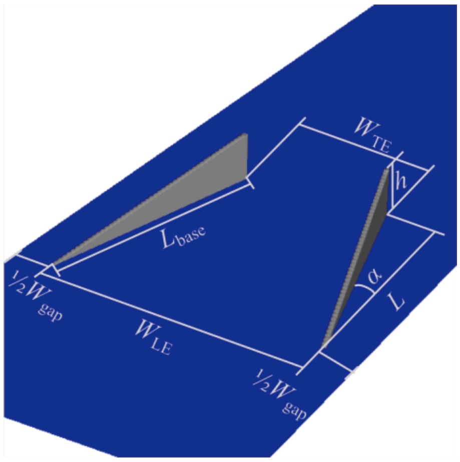

Fig. 1: Problem setting.

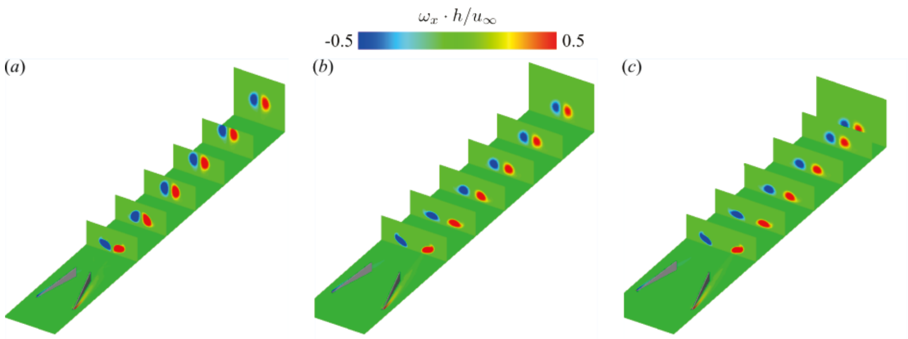

Fig. 2: Effect of L/h on distribution of streamwise vorticity: (a) WTE/h = 1.5; (b) WTE/h = 3.0 (baseline); (c) WTE/h = 3.5. Cross-sectional contours are drawn every 5.0h from trailing edge of VGs.

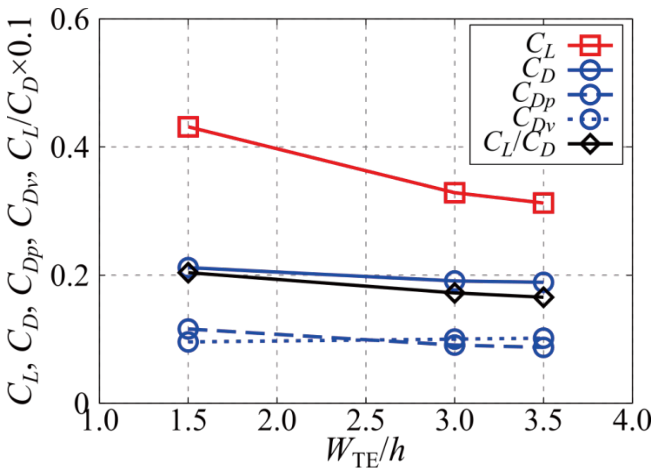

Fig. 3: Effect of WTE/h on aerodynamic force coefficients.

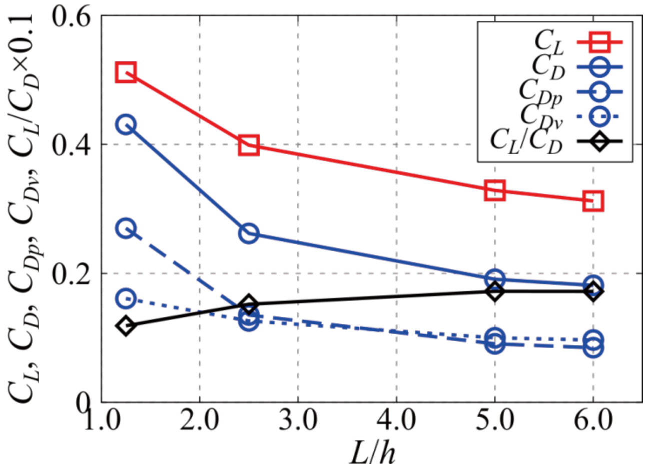

Fig. 4: Effect of L/h on aerodynamic force coefficients.

Publications

- Oral Presentations

Nagata, T., Daspit, J. T., Nonomura, T., and Loth, E., "Direct numerical simulation of supersonic flow over a counter-rotating vane-type vortex generator implemented on slip wall," ASME-JSME-KSME Joint Fluids Engineering Conference 2019, AJKFLUIDS2019-5312, California, USA, July, 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 289
Elapsed Time per Case	150 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.18

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,645,333.92	0.20
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	32.82	0.03
/data	5,457.26	0.09
/ltmp	1,091.45	0.09

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	6.27	0.16

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Discharge-flow coupling simulation of nanosecond-pulse-driven plasma actuator

Report Number: R19EACA16
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11542/

Responsible Representative

Naofumi Ohnishi, Professor, Tohoku University

Contact Information

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Members

Naofumi Ohnishi, Shintaro Sato

Abstract

Dielectric-barrier-discharge (DBD) plasma actuator is a promising device as an active flow control. The purpose of this project is to clarify mechanism of separation control around an airfoil by using nanosecond-pulsed-driven plasma actuator.

Ref. URL: http://www.rhd.mech.tohoku.ac.jp/

Reasons and benefits of using JAXA Supercomputer System

The use of the super computer is necessary to conduct simulation of flow field with the discharge simulation because the Poisson's equation for electric potential, which requires high computational cost, is solved every time step. The difference of the time scale between the discharge and flow also increases the computational cost.

Achievements of the Year

We conducted a discharge simulation of nanosecond-pulse-drive plasma actuator toward the low-voltage operation. Two types of applied voltage waveforms were applied to the plasma actuator in this study: positively-DC-biased negative pulse and negatively-DC-biased positive pulse. The discharge structure, charge profile of the dielectric surface and produced electrohydrodynamic force depends on the voltage waveform (Fig. 1). We will conduct a discharge-flow coupling simulation by using the database obtained from the discharge simulation to clarify the flow control mechanism of plasma actuators as future work.

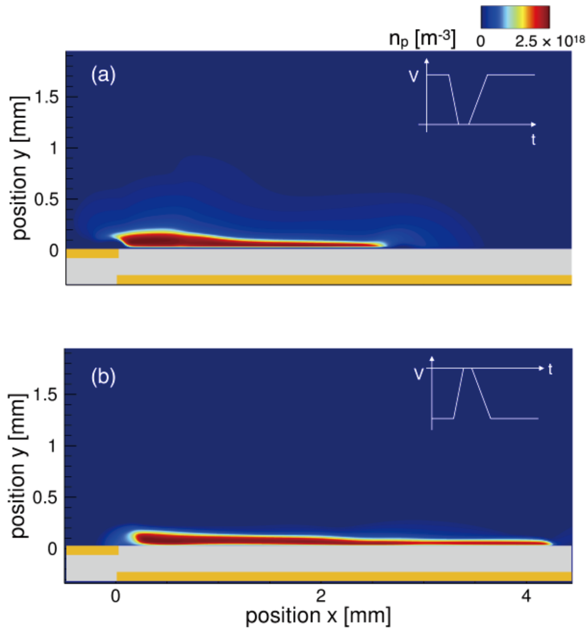

Fig. 1: Spatial distribution of number density of positive ion when (a) positively-DC-biased negative pulse and (b) negatively-DC-biased positive pulse are applied.

Publications

- Peer-reviewed papers

1. S. Sato, H. Furukawa, A. Komuro, M. Takahashi, and N. Ohnishi, "Successively accelerated ionic wind with integrated dielectric-barrier-discharge plasma actuator for low-voltage operation", Sicentific Reports 9, 5813 (2019).

2. S. Sato, H. Furukawa, M. Takahashi, and N. Ohnishi, "Computational study of discharge process in plasma actuator for enhanced electrohydrodynamic force generation toward low-voltage operation", Transactions of the Japan Society for Aeronautical and Space Sicences, Aerospace Technology Japan, accepted.

- Oral Presentations

1. S. Sato, H. Furukawa, M. Takahashi, and N. Ohnishi, "Proposal of a plasma actuator for enhanced electrohydrodynamic force generation toward low-voltage operation", 32nd International Symposium on Space Technology and Science & 9th Nano-Satellite Symposium, Fukui, June 15-21, 2019.

2. S. Sato, H. Furukawa, A. Komuro, M. Takahashi, and N. Ohnishi, "A study of integrated plasma actuator toward low-voltage operation", Akita, September 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	2 - 960
Elapsed Time per Case	72 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.07

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	572,105.65	0.07
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	195.50	0.16
/data	9,813.31	0.17
/ltmp	2,929.69	0.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	6.46	0.16

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Feedback Control of Flow Separation Using DBD Plasma Actuator

Report Number: R19EACA26
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11547/

Responsible Representative

Kengo Asada, Tokyo University of Science, Department of Information and Computer Technology, Postdoctoral Researcher

Contact Information

Kengo Asada(asada@rs.tus.ac.jp)

Members

Kengo Asada, Takuto Ogawa

Abstract

The project develops flow control technic by using dielectric barrier discharge (DBD) plasma actuator to establish high efficient and robust vehicle systems such as rockets, aircrafts, and motor vehicles. We propose and demonstrate feedback control methods to adapt unsteady flows over the vehicles through a series of high-fidelity unsteady simulations.

Reasons and benefits of using JAXA Supercomputer System

To perform large-scale three-dimensional unsteady flow simulations using the compressible fluid solver LANS3D, which has a wealth of computational achievements with a JAXA supercomputer system.

Achievements of the Year

High-fidelity large-eddy simulations of the flow (Re=63,000) controlled by a DBD plasma actuator (PA) over a NACA0015 airfoil were performed to verify the effectiveness of the feedback control model which we propose. The present feedback model (Fig. 1) drives PA located in the vicinity of the leading edge according to the passing of vortices above a pressure sensor on the upper side of the airfoil. The passing of vortices is detected by abrupt pressure decrease compared to a moving-averaged pressure value. In the present model, the time range of the moving average is varied according to FFT analysis.

By last year, we had verified the validity of the control model at the angle of attack after stall (over 12 degrees). Since the proposed control model is assumed to be used in a wider range of conditions, this year we examined whether the proposed control law is effective at angles of attack (4, 6, and 8 degrees) before the stall.

Figure 2 shows the lift-drag ratio (L / D) of each control method at each angle of attack. The proposed control model (feedback) gives a higher lift-drag ratio as compared to the non-control case (Baseline). It can be seen that a lift-drag ratio equal to or greater than that of the burst operation (ON / OFF switching periodically) is provided.

In burst drive, it is necessary to set control parameters such as drive frequency to appropriate values in advance, but the proposed control model automatically changes the ON / OFF of PA to improve the lift-drag ratio.

Figures 3 and 4 show the vortex structures by iso-surface of Q-criterion colored by freestream velocity in the feedback control case (Feedback) and non-control case (Baseline) at 6 degrees, respectively. In the Baseline case, the laminar separation occurs at the leading edge, followed by a turbulent transition. In the Feedback case, the spanwise vortex structures pass along the airfoil surface. The plasma actuator is driven once when the spanwise vortex structure is passing above the pressure sensor, and the additional vortex structures are generated by actuation. These processes orderly arrange the vortices and contribute to keeping the steady aerodynamic performance.

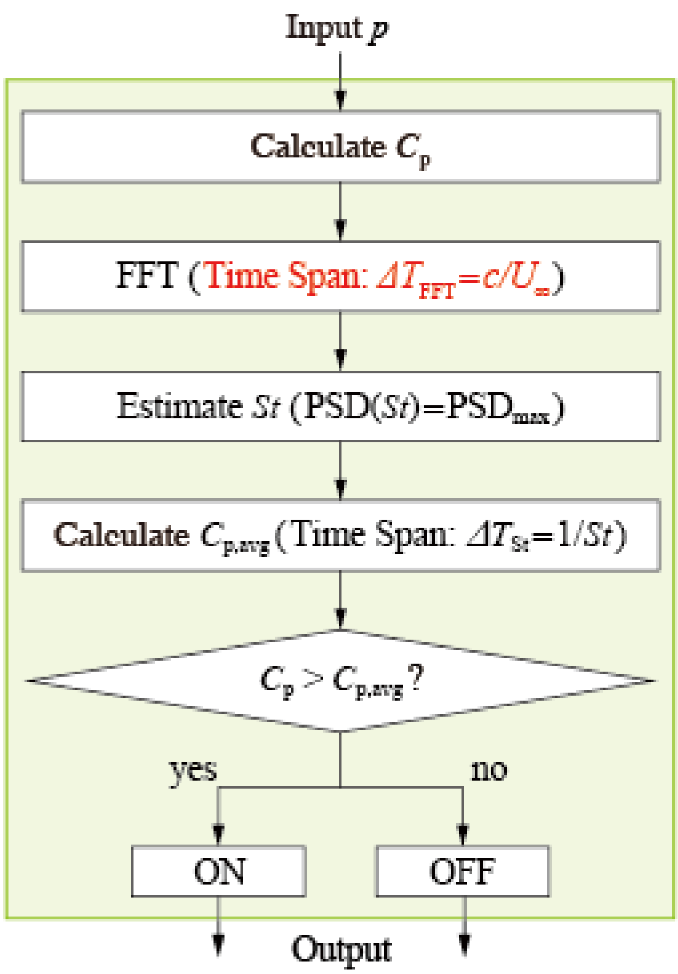

Fig. 1: Proposing feedback control model of separated flows.

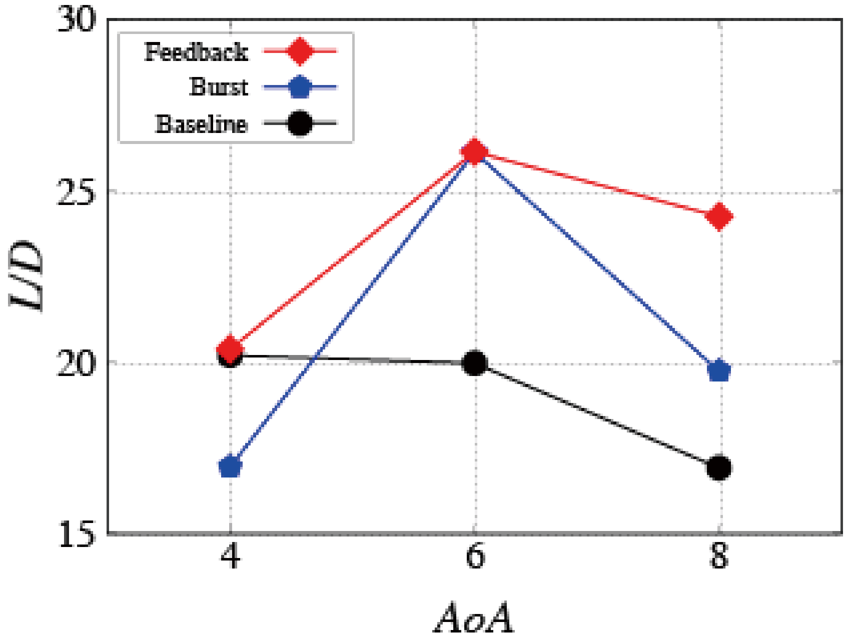

Fig. 2: Lift and drag ratios (L/D) when each control method is applied to the flow around the NACA0015 airfoil.

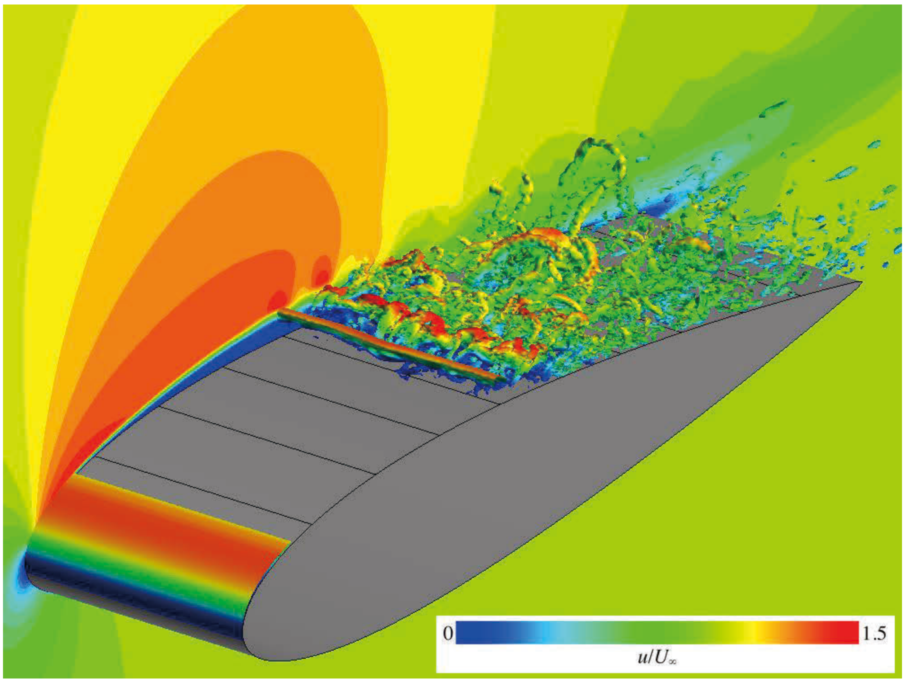

Fig. 3: Vortex structures by iso-surface of Q-criterion colored by freestream velocity under the uncontrol case (Baseline) at 6 degree.

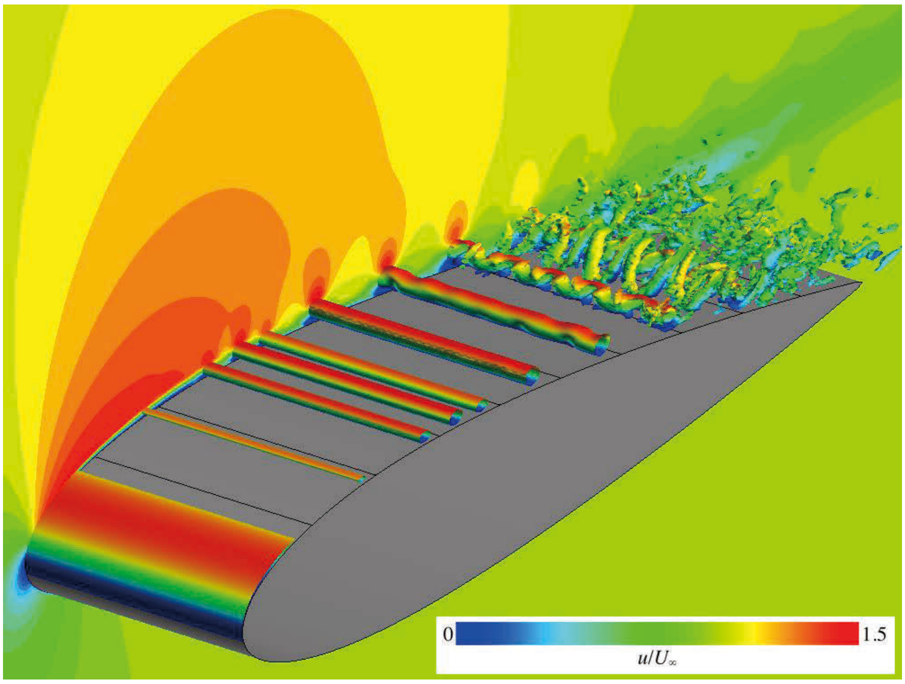

Fig. 4: Vortex structures by iso-surface of Q-criterion colored by freestream velocity under the feedback control (Feedback) at 6 degree.

Publications

- Non peer-reviewed papers

Ogawa, T., Asada, K., Tatsukawa, T., and Fujii, K., "Computational Analysis of the Control Authority of Plasma Actuators for Airfoil Flows at Low Angle of Attack", AIAA Scitech, Orland, Florida, USA, Jan. 2020.

Ogawa, T., Asada, K., Tatsukawa, T., and Fujii, K., "Large-eddy simulations of flows controlled by DBD plasma actuator for better wing performance at cruise conditions", JSME Conference 2019, Akita, Sep. 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	79 - 84
Elapsed Time per Case	30 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.29

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	2,576,897.21	0.31
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	52.45	0.04
/data	15,315.10	0.26
/ltmp	2,929.69	0.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Fundamental study of propagation of one-dementional detonation waves

Report Number: R19EACA45
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11559/

Responsible Representative

Toshiharu Mizukaki, Professor, Tokai University

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Toshiharu Mizukaki(mzkk@tsc.u-tokai.ac.jp)

Members

Toshiharu Mizukaki, Hatsuming Wang

Abstract

Detonation waves is a self-sustaining combustion wave. By using the detonation waves, a propulsion system which has a high-thermal efficiency and a thrust efficiency, compared with the ordinaly engines, would be made. The porpose of this research is to establish a process of numerical analysis on propagation of the detonation waves with CHARIOT, which was developed by JAXA.

Reasons and benefits of using JAXA Supercomputer System

A numerical simulation on propagation of detonation waves needs a simoultaious calcutation of cpmpressible fluids and reactive fluids. Forethemore, the compressible fluid analysis needs a three-dimensional analysis and the reactive fluids analysis contains more than a houndred reactive schemes. Therefore, a high-performance super computer such as JSS2 is needed to carry out our calculation. On the other hand, JSS2 has an ecelent enviloment, for numerical analysis, including mesh generators and visualization softwares. The enviloment helps us to carry out effective numerical analysis with large-scale calculation.

Achievements of the Year

With CHARIOT developed by JAXA, we carried out one-dimensional calculation on propagation of detonation waves to determine the dependency of the initial condition, pressure, temperature, and partical velocity, on pressure history at mesurement points as same as at experiments, Fig.1. Several initial conditions were examined. Results are shown bellow;

- Calculated peak overpressure and pressure decay fairly agreed well under the condition; the fuel, oxidizer, stoichiometric ratio, and the initial pressure were Etheren, Oxgen, 1.0, and both 100 kPa and 48 kPa, Fig.2.
- For the calculation, the initiation temperature, the initiation pressure, and the initial particle velocity are needed. The values of them affect caluculated pressure histories, Fig. 3.
- With decreasing of the initiation temperature, disagreement of the calculated pressure profile with physical

phenomena obviously appeared, Fig. 3a, b, and c.

- The calculation done under stoichiometric condition, result of pressure history was far away from real phenomena, Fig.3d.
- We will continue parametric servay to determine proper condition for this research.

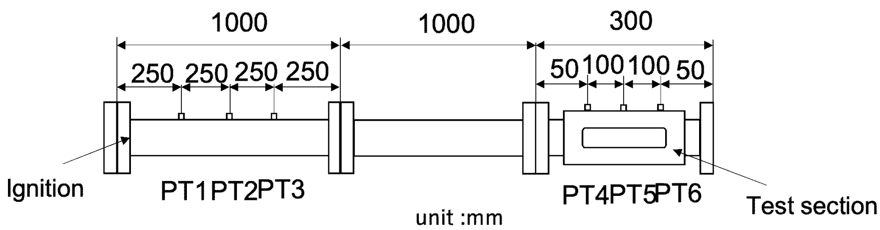

Fig. 1: Schematic diagram of the detonation tube and pressure measurement point.

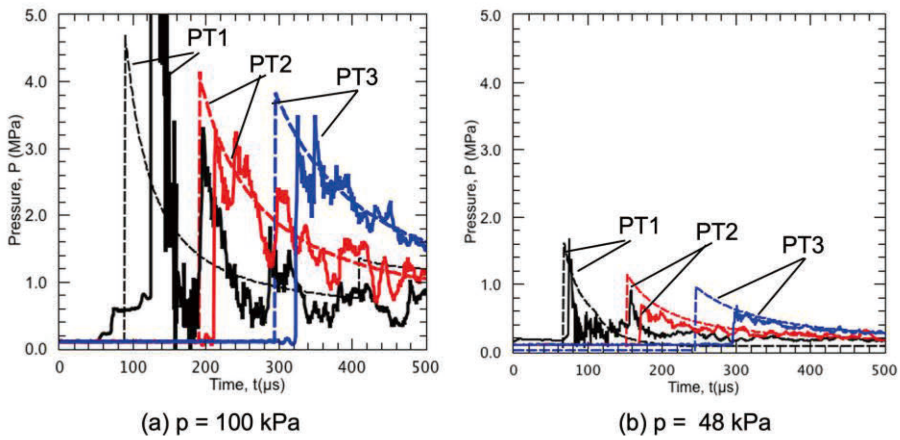

Fig. 2: Comparision between calculated and experimental pressure profiles; the initial pressure 100 kPa, and 48 kPa.

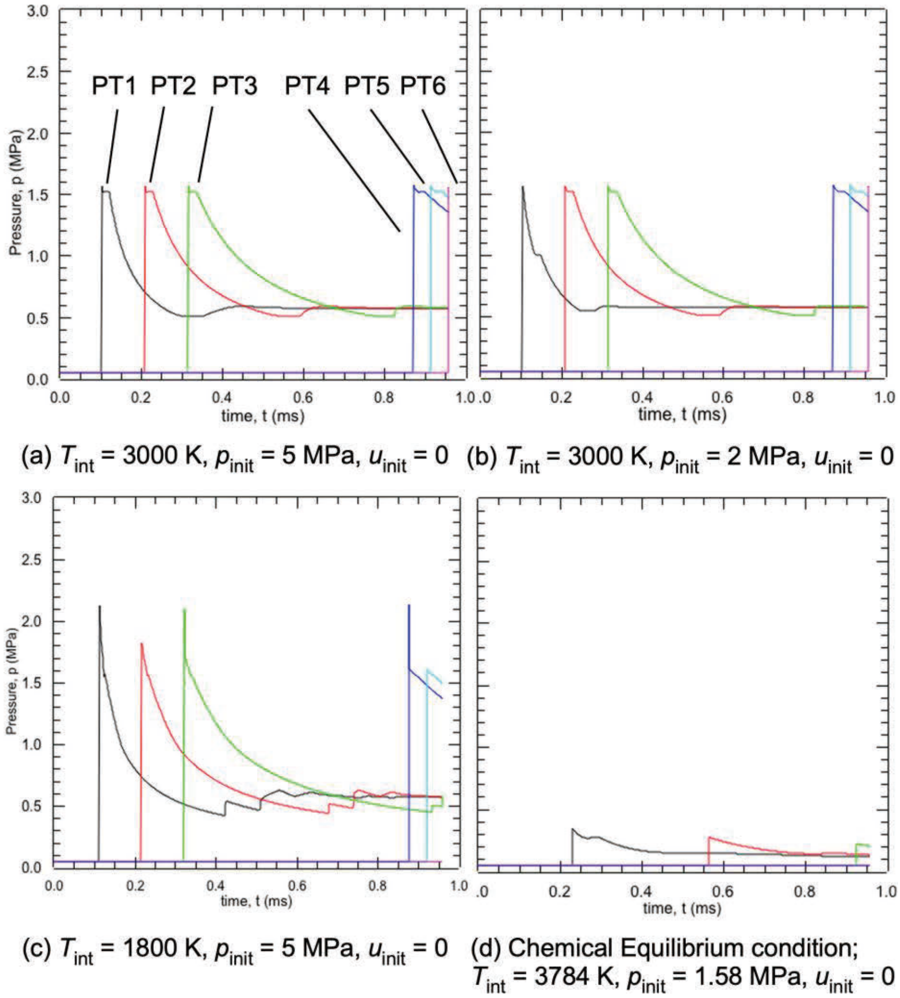

Fig. 3: Comparision of pressure history with the initiation condition.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	10 - 40
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	23,838.49	0.00
SORA-PP	1.83	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	247.96	0.21
/data	4,978.18	0.09
/ltmp	2,929.69	0.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

High-fidelity numerical simulation of compressible turbulent flows

Report Number: R19EACA37
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11552/

Responsible Representative

Soshi Kawai, Professor, Department of Aerospace Engineering, Tohoku University

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Members

Soshi Kawai, Sayako Ishitsuka, Ryo Kamogawa

Abstract

In this study, wall-resolved large-eddy simulation (WRLES) and wall-modeled LES (WMLES) were conducted to clarify the mechanisms of turbulence generation in WMLES, and also to investigate the predictability of WMLES of the separated flow. From the results, we found that the near-wall LES grid-scale turbulence structures behaves as the pseudo streak-like structures, which act as the streaks and lead to the turbulence generation. We also observed that the mean velocity and Reynolds shear stress obtained by the WMLES show a good agreement with the WRLES in the separated flow although the skin friction slightly deviates from the WRLES results.

Reasons and benefits of using JAXA Supercomputer System

In this study, high-fidelity WRLES was carried out as a reference database to evaluate and analyze the WMLES data. The WRLES requires high computational cost to resolve the small turbulent structures in the inner-layer. Therefore, massively parallel computations using supercomputer, such as the JSS2, are required.

Achievements of the Year

(a) In this study, we conducted WRLES and WMLES of the flat plate turbulent boundary layers and investigated the mechanisms of near-wall turbulence generation in WMLES. The mechanisms of turbulence generation in WMLES are investigated by comparing the turbulence statistics and the instantaneous velocity fluctuations obtained by the WMLES and WRLES database. In the WMLES, the near-wall turbulence structures show ejection and sweep events with the two-layer structures, structures very close to the wall and its above near outer-layer (figure 1). From figure 2, the turbulent structures near the outer layer is resolved by the LES grid, and is found that the length scale is almost matched to the length scale obtained by the WRLES. The other structures very near the wall has a non-physical spanwise length scale that depends on the grid scale (and not physics). The streamwise length scale of these non-physical structures is close to that of the WRLES. Thereby, the near-wall LES grid-scale structures behave as the pseudo streak-like structures, and lead to the generation of the Reynolds stress and accurate prediction of the outer layer turbulence statistics.

(b) WMLESs with equilibrium (EQBL) and non-equilibrium (NEQBL) wall models were conducted for the flat-plate turbulent boundary layers with large adverse and favorable pressure gradients, involving flow separation and reattachment. The predictability of the turbulence statistics obtained by the two types of the wall-models, EQBL and NEQBL models, is investigated by comparing with the turbulence statistics database obtained by WRLES. The Reynolds number based on momentum thickness and the Mach number is equal to 2000 and 0.2, respectively. Both the models with/without the equilibrium boundary layer assumptions show a good agreement with the WRLES results for the mean velocity and Reynolds shear stress (see figure 4) although the skin friction shows a discrepancy (see figure 5). This implies that WMLES can accurately predict the flowfield where the physics in the outer layer turbulence are important because the important physics in the outer layer are accurately resolved by the WMLES.

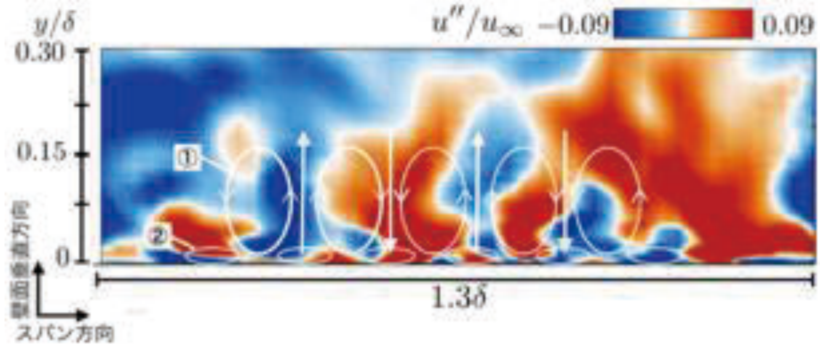

Fig. 1: Instantaneous streamwise velocity fluctuations in flat-plate turbulent boundary layer in spanwise/wall-normal plane obtained by WMLES at Re_(tau) =1400

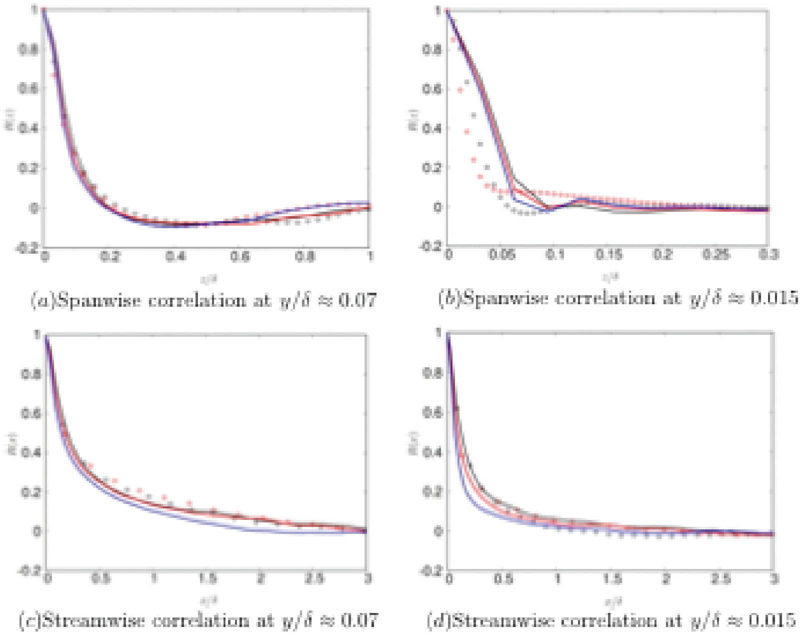

Fig. 2: Auto-correlation of instantaneous streamwise velocity fluctuations in flat-plate turbulent boundary layer at Re_(tau) = 1400

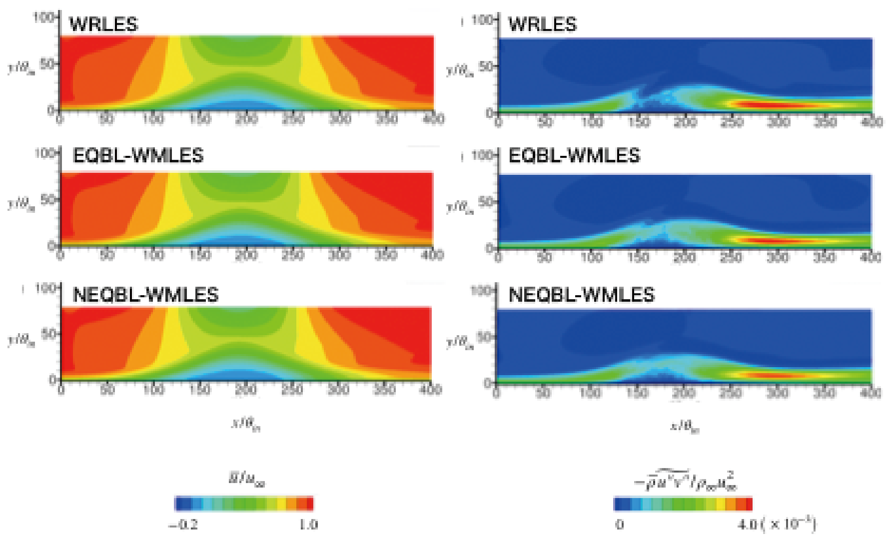

Fig. 3: Mean streamwise velocity distributions and Reynolds shear stress distributions in separated/reattached turbulent boundary layer in the x-y plane (a, WRLES; b, equilibrium wall-model; c, non- equilibrium wall-model).

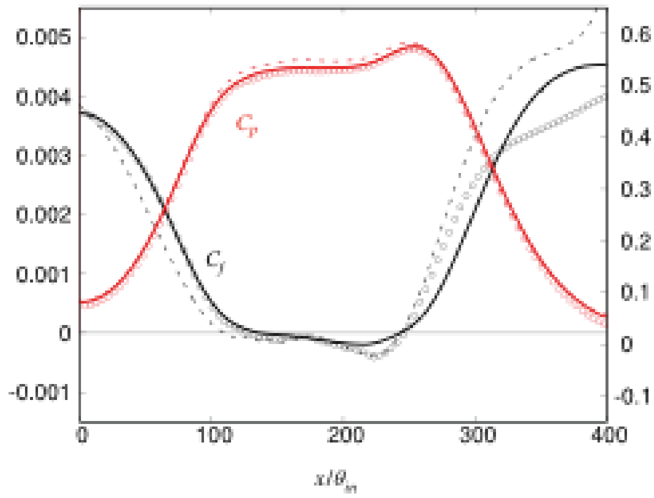

Fig. 4: Mean skin friction and wall pressure distributions in separated/reattached turbulent boundary layer (a, WRLES; b, equilibrium wall-model; c, non-equilibrium wall-model).

Publications

- Oral Presentations

S. Ishitsuka and S. Kawai, "Mechanisms of near-wall turbulence generation in wall-modeled large-eddy simulation," 33th CFD symposium, Sapporo, Japan 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	15 - 1930
Elapsed Time per Case	4000000000 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	152,565.24	0.02
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	13.67	0.01
/data	4,241.31	0.07
/ltmp	2,799.48	0.24

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Machine-learning based prediction of fluid dynamics

Report Number: R19EACA39
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11554/

Responsible Representative

Masanobu Inubushi, Assistant Professor, Graduate School of Engineering Science, Osaka University

Contact Information

Masanobu Inubushi(inubushi@me.es.osaka-u.ac.jp)

Members

Masanobu Inubushi, Susumu Goto, Keita Kohashi, Mikito Konishi, Daiki Watanabe

Abstract

Turbulence models play important roles in the aerospace science and technology, such as flows around aircrafts and of planetary atmospheres. Recently, they are developing rapidly empowered by machine learning methods (Duraisamy, Iaccarino, and Xiao, 2019), and will be a crucial building block of the aerospace science and technology in the near future. The present study is aiming for the integration of physics and data-driven methods for turbulence modeling.

Ref. URL: http://fm.me.es.osaka-u.ac.jp/inubushi/index-j.html

Reasons and benefits of using JAXA Supercomputer System

Machine-learning-based predictions and models of turbulence will be necessary for the future aerospace science and technology. The reason to use JSS2 is that we can develop these methods based on training data of turbulent flows with high-resolution, numerical calculations of which require a massively parallel supercomputer.

Achievements of the Year

In this year, we have developed a novel machine-learning (ML) method, which enables efficient predictions of chaotic dynamics with a surprisingly small amount of data. By conducting the direct numerical simulations of the Navier-Stokes equations, we have demonstrated that the energy dissipation rate of turbulence can be inferred by the proposed method, which utilizes the knowledge of turbulence from a small amount of training data. We expect that the proposed method provides a basis for the future ML-based turbulence modeling.

Publications

- Peer-reviewed papers

Masanobu Inubushi and Susumu Goto, Transferring Reservoir Computing: Formulation and Application to Fluid Physics, Lecture Notes in Computer Science 11731, 193, Springer (2019).

- Invited Presentations

(1) Keita Kohashi, Masanobu Inubushi, and Susumu Goto, Reservoir computing harnessing spatiotemporal nonlinear dynamics, Nonlinear Theory and Its Applications (NOLTA2020).

- Poster Presentations

(1) Masanobu Inubushi and Susumu Goto, Transferring Reservoir Computing: Formulation and Application to Fluid Physics, The 28th International Conference on Artificial Neural Networks.

(2) Masanobu Inubushi and Susumu Goto, Transferring reservoir computing: formulation and application to fluid physics, Deep Learning and Physics 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64
Elapsed Time per Case	24 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	7,954.70	0.00
SORA-PP	526.60	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	56.27	0.05
/data	5,168.92	0.09
/ltmp	6,835.94	0.58

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical investigation of combustible flows using the adaptive mesh refinement (AMR)

Report Number: R19EACA35
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11551/

Responsible Representative

Edyta Dzieminska, Sophia University

Contact Information

Tang Xinmeng, Sophia University(simondonxq@gmail.com)

Members

Edyta Dzieminska, Koichi Hayashi, Xinmeng Tang, Wataru Koido

Abstract

This research is to develop a 3D program with generalized coordinate system, that provides a flexible, efficient, accurate and have a compatible detailed chemical reaction system, for combustion and detonation issues. This program simulates combustion flows (especially combustion of hydroxygen mixture) numerically by AMR and we can understand further details of combustible features, flame propagation and DDT. As a result, a further fundamental structure of combustion flows would be revealed.

Reasons and benefits of using JAXA Supercomputer System

MPI and supercomputer are necessary for the numerical calculations of combustible flows in 2D and 3D physical models as it spends a lot of CPU cost. On one hand, the timestep is usually very small due to the high pressure and high pressure which results in a high local sonic speed. This timestep is usually of a range of 1 or 1/10 nanosecond. On the other hand, the requirement of high resolution results in a big grid quantity even with AMR. These make the simulation in 2D or 3D large-scale calculations. Therefore, the supercomputer would be necessary for use to perform such a research. Without it, we cannot get a valid CFD result.

Achievements of the Year

1. Numerical investigation of three wave speed relations as deflagration-to-detonation transition conditions that inherited to detonation waves (to be submitted)

2. Adaptive mesh refinement methodology is assembled onto General curvilinear system in order to do AMR simulation for complicated non-rectangular shapes and models.

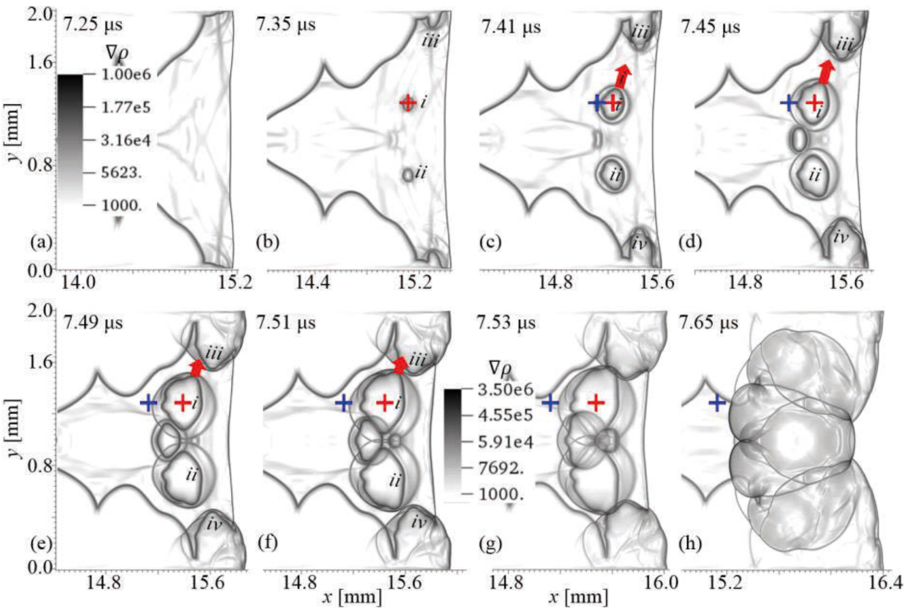

Fig. 1: Sequence of key events in a DDT process from conception of hot spot to triggering of detonation.

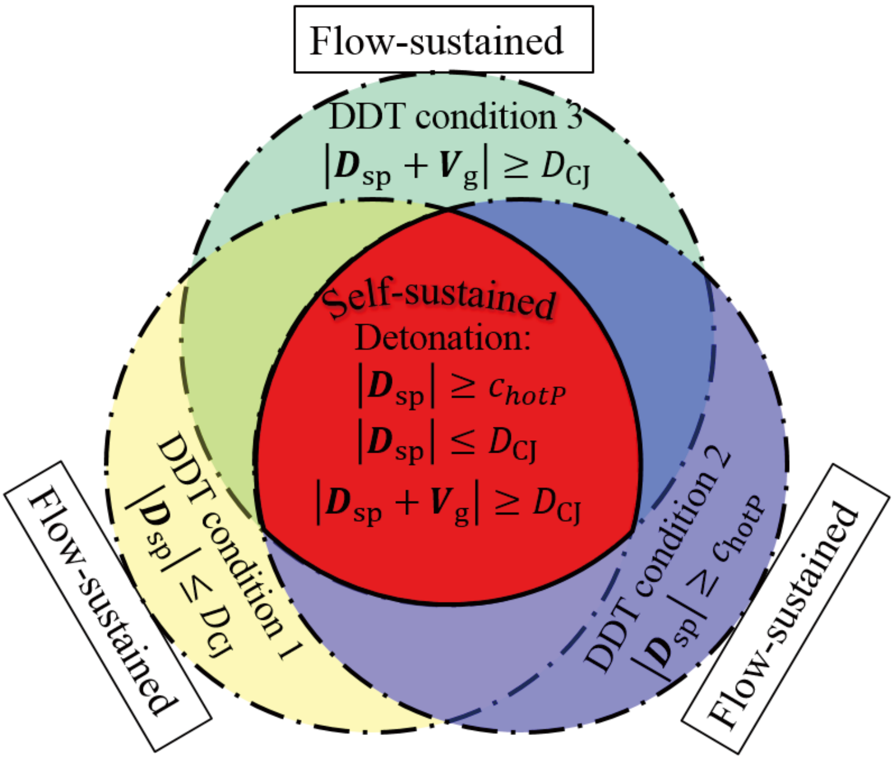

Fig. 2: Three flow-sustained relations of a spontaneous reaction wave which are essential conditions in a DDT process for onset of detonation. They are inherited to the detonation and become self-sustained.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	32 - 320
Elapsed Time per Case	500 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	167,787.60	0.02
SORA-PP	3,817.08	0.02
SORA-LM	5.58	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	19.07	0.02
/data	190.73	0.00
/ltmp	3,906.25	0.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical modeling of space plasma processes

Report Number: R19EACA28
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11548/

Responsible Representative

Seiji Zenitani, Project Associate Professor, Kobe University

Contact Information

Seiji Zenitani(zenitani@port.kobe-u.ac.jp)

Members

Seiji Zenitani, Iku Shinohara, Takahiro Miyoshi

Abstract

This project investigates basic processes in space plasmas, by using supercomputer simulations. In particular, we study "magnetic reconnection" in space, an abrupt change in magnetic topology. In order to support research activities by ourselves and by other groups, we develop massively-parallel simulation codes. They are publicly available on the Internet.

Ref. URL: http://th.nao.ac.jp/MEMBER/zenitani/openmhd-e.html

Reasons and benefits of using JAXA Supercomputer System

Space plasma processes are basically described by magnetohydrodynamics (MHD) equations, which are notoriously complex. Supercomputer simulation is necessary to predict the nonlinear evolution of the system.

Achievements of the Year

We have studied basic properties of plasmoid-dominated turbulent reconnection in solar coronal conditions. By carrying out a series of magnetohydrodynamic (MHD) simulations, we have found that the flux tranfer rate becomes faster than expected [4]. We have also developped a high-accuracy numerical scheme for particle-in-cell (PIC) simulations to study kinetic plasma phenomena [1].

Publications

- Peer-reviewed papers

[1] S. Zenitani & T. N. Kato, Multiple Boris integrators for particle-in-cell simulation, Comput. Phys. Commun., 247, 106954 (2020)

[2] W.-L. Teh & S. Zenitani, Thermodynamic Properties of Mirror Structures in the Magnetosheath: MMS Observations and Double-Polytropic MHD Simulations, Astrophys. J., 885, 22 (2019)

[3] W.-L. Teh & S. Zenitani, Thermodynamics of Dipolarization Fronts of Magnetic Reconnection in Anisotropic

Plasma: MMS Observations and Resistive Double-polytropic MHD Simulations, Astrophys. J., 890, 114 (2020)

- Other

[4] S. Zenitani & T. Miyoshi, Plasmoid-dominated turbulent reconnection in a low beta plasma, submitted to Astrophys. J. Letters

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	40 - 2000
Elapsed Time per Case	36 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	3,609.70	0.00
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	67.29	0.06
/data	1,228.12	0.02
/ltmp	3,146.70	0.27

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Simulations of Fully Developed Turbulence

Report Number: R19EACA05
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11536/

Responsible Representative

Susumu Goto, Professor, Osaka University

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Susumu Goto(goto@me.es.osaka-u.ac.jp)

Members

Susumu Goto, Yutaro Motoori, Ryo Araki, Tsukasa Shinohara, Sunao Oka, Atsushi Abe, Aoi Nishikawa, Yusuke Koide

Abstract

Since fully developed turbulence at high Reynolds numbers plays an important role in many systems of aerospace engineering, its prediction and control are important in various projects. We need to employ a turbulence model so that we can numerically simulate such extremely-high-Reynolds-number flows. Here, we note that such a model is on the basis of the universality of small-scale statistics of turbulence. The main purpose of the present study is to reveal the physical origin of this universality of turbulent flows. In particular, we aim at revealing details of the multi-scale motions (i.e. the hierarchy of coherent vortices and its sustaining mechanism) of different kinds of high-Reynolds-number turbulence under different boundary conditions by means of direct numerical simulations.

Reasons and benefits of using JAXA Supercomputer System

Turbulent flows are one of the most important research topics in the field of the aerospace engineering. The direct numerical simulations of fully developed turbulence require a massively parallel supercomputer with sufficient amount of memories and storages. These are the reasons why we use JSS2.

Achievements of the Year

This year, we focused on the analysis on a turbulent boundary layer at a sufficiently high Reynolds number and we have deepened the understanding of the sustaining mechanism of the turbulence. Fig. 1 shows an example of our numerical analysis. In this turbulence, there exists a hierarchy of coherent multi-scale vortices and low-speed streaks associated with those vortices. We visualize, in Fig. 1, the largest-scale coherent vortices (orange objects) and low-speed streaks (blue objects) identified in the velocity field coarse-grained with a Gaussian filter. We notice that these structures are similar to the well-known near-wall coherent structures in low-Reynolds-number turbulence. This implies that the sustaining mechanism of largest-scale vortices is common irrespective of the

Reynolds number.

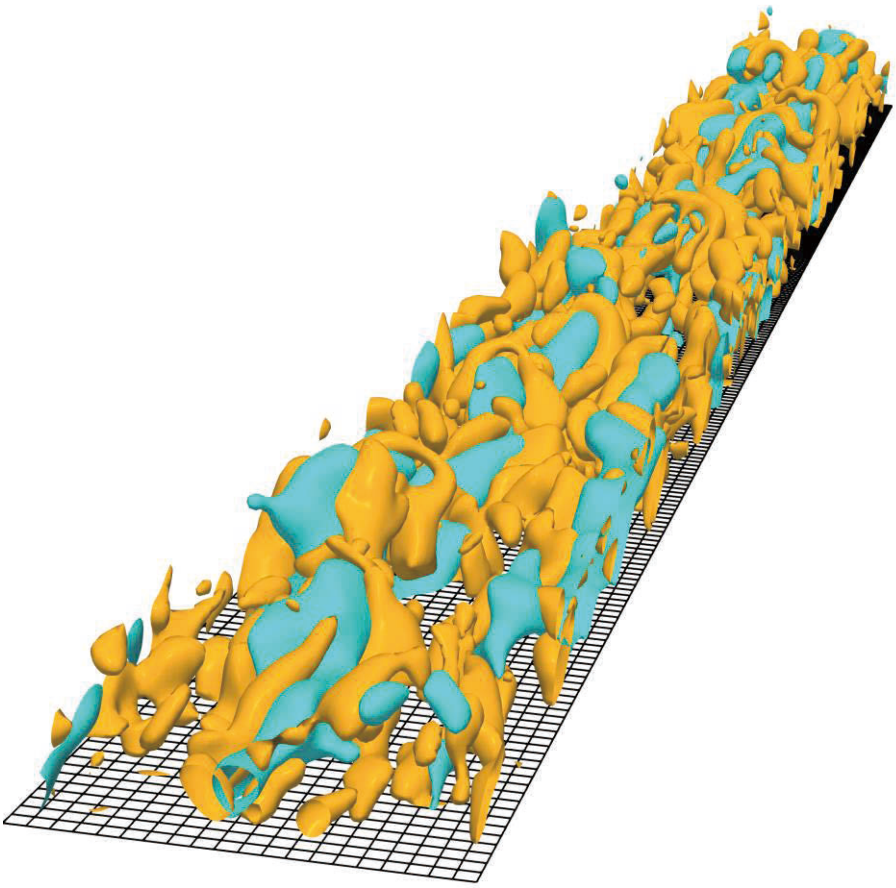

Fig. 1: Large-scale coherent vortices (orange objects) and low-speed streaks (blue objects) in a fully developed turbulent boundary layer. The Reynolds number defined by the momentum thickness is about 3000. These structures are identified for the coarse-grained velocity field obtained with a Gaussian filter.

Publications

- Peer-reviewed papers

1) Y. Motoori, S. Goto, Scale-dependent enstrophy production rates in a turbulent boundary layer, J. Fluid Sci. Tech. 14 (2019) JFST0016.

2) T. Yasuda, S. Goto, J. C. Vassilicos, Phys. Rev. Fluids 5 (2019) 014601.

- Oral Presentations

1) Y. Motoori, S. Goto, Energy cascade in turbulent channel flow, The 65th Workshop on "Investigation and Control of Transition to Turbulence"

2) S. Oka, S. Goto, Cluster of inertial particles and fluid acceleration in turbulence at high Reynolds numbers, Sixteenth International Conference on Flow Dynamics

3) R. Araki, S. Goto, Large spatial-temporal fluctuation and energy cascade dynamics in von Karman turbulence, Sixteenth International Conference on Flow Dynamics

4) S. Oka, S. Goto, Cluster of inertial particles and fluid acceleration in turbulence, 17th European Turbulence

Conference
5) S. Goto, Y. Motoori, Hierarchy of vortices in a developed turbulent boundary layer, 17th European Turbulence Conference,
6) Y. Motoori, S. Goto, Generation mechanism of the hierarchy of vortices in wall-bounded turbulence, Eleventh International Symposium on Turbulence and Shear Flow Phenomena
7) S. Goto, K. Komoda, J. Kanki, Turbulence in Precessing Containers, Eleventh International Symposium on Turbulence and Shear Flow Phenomena

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	64 - 96
Elapsed Time per Case	40 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.13

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	932,020.14	0.11
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,014.71	0.85
/data	97,751.66	1.67
/ltmp	11,718.76	1.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Study of Breakdown and Shock Wave Structures for Improvement of Flight Perofmrnace in a Beamed-energy Vehicle

Report Number: R19EACA17
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11543/

Responsible Representative

Masayuki Takahashi, Associate Professor, Tohoku University

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Members

Masayuki Takahashi

Abstract

The microwave-driven in-tube accelerator concept was proposed as a novel beamed-energy propulsion system, and breakdown and shock wave propagations are numerically reproduced to compare with conventional system.

Reasons and benefits of using JAXA Supercomputer System

It is necessary to use the JAXA supercomputer because multiscale physics, which has plasma transport, neutral gas compression and expansion, and electromagnetic wave proapgation, is simulated and a computational cost becomes high.

Achievements of the Year

Electromagnetic wave propagation, plasma drift-diffusion, and shock wave propagation were numerically reproduced in the microwave-driven in-tube accelerator, which indicated that the electromagnetic wave was focused at the rear of the vehicle and plasma was generated. A shock wave was induced because the plasma transported energy to neutral particles, and we can obtain thrust. The microwave-driven in-tube accelerator concept is a hopeful transporation system because its thrust performance is higher than concentional system.

Publications

- Peer-reviewed papers

Masayuki Takahashi and Naofumi Ohnishi, "Gas Propellant Dependency of Plasma Structure and Thrust Performance of Microwave Rocket," Journal of Applied Physics, Vol. 125, 163303 (2019).

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1 - 100
Elapsed Time per Case	50 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.11

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	961,450.13	0.12
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	476.84	0.40
/data	9,765.63	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical study of the convective structure in Venus atmosphere

Report Number: R19EACA14
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11541/

Responsible Representative

Ko-ichiro Sugiyama, Associate Professor, National Institute of Technology, Matsue College

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Members

Hiroki Ando, Koichiro Sugiyama

Abstract

Our purpose is to support the observation performed by AKATSUKI (Venus Climate Orbiter) by developing a numerical fluid dynamics model (cloud resolving model) and providing a lot of numerical simulation data. The motion of Venus' cloud-level convection, distribution of H2SO4 solution clouds and the propagation of gravity wave driven by convection obtained by our numerical simulation are very useful to analysis the cloud morphology at various altitudes and characteristics of gravity wave obtained by AKATSUKI. By comparing our numerical simulations data and the observation data of AKATSUKI, it is expected that atmospheric structure of Venus' cloud-level will be more clearly understood.

Reasons and benefits of using JAXA Supercomputer System

Supercomputer is used for developing and running our cloud resolving model. To reproduce the structure of convective motion and gravity wave propagation, it is necessary that the resolution of the model is set to be several tens to several hundred meters. To avoid the influence of the computational boundary and to compare with AKATSUKI's data, horizontal region of hundreds to thousands of kilometers is required. The numerical simulations with such high resolution and wide computational region can be performed using supercomputer only.

Achievements of the Year

Our purpose is to develop new Venus' cloud formation scheme and to perform numerical simulation using the scheme in order to investigate a possible structure of Venus' cloud-level convection and clouds distribution. Our cloud formation scheme is based on Imamura and Hashimoto (1998). The number densities of sulfuric acid (H2SO4) and water (H2O) in the gas and liquid phases are calculated. Formation, dissipation, and sedimentation of H2SO4-H2O solution droplets are considered in the scheme. Chemical reactions of sulfuric acid are also considered.

Fig.1 shows the results of our numerical simulation using similar settings of Imamura et al. (2014). The distribution of H2SO4 and H2O associated with convective motion are obtained successfully. H2SO4-H2O solution droplets are trapped in the convective layer (z = 49 - 56 km).

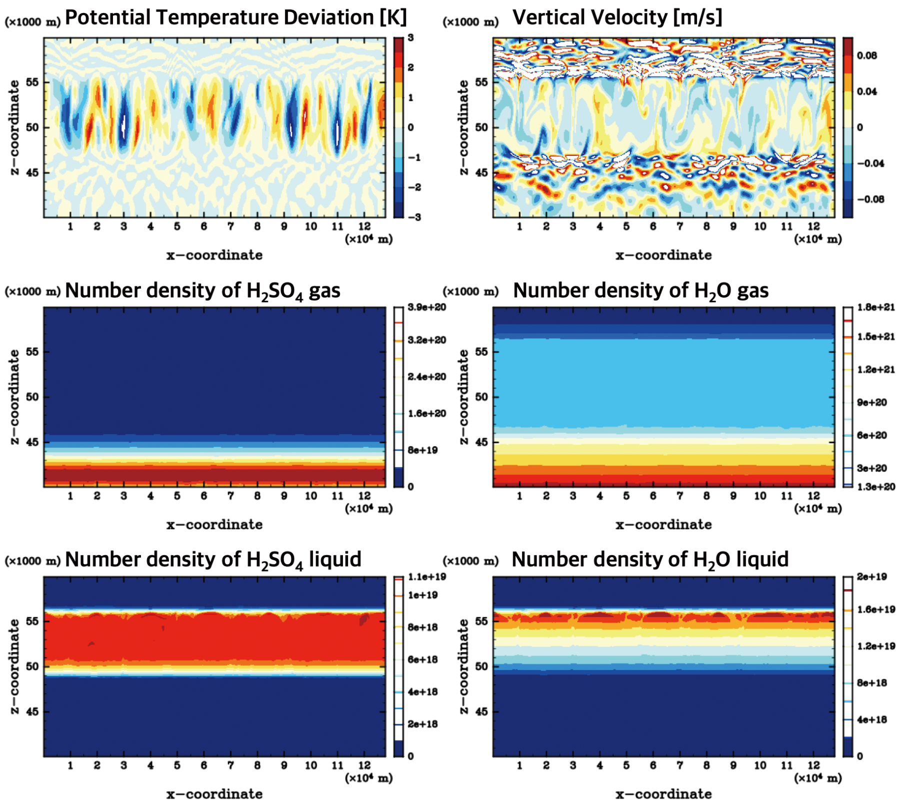

Fig. 1: X-Z cross section of vertical velocity, potential temperature deviation from horizontal mean, and number densities of H2SO4 and H2O for z = 40 km - 60 km

Publications

- Poster Presentations

1) Sugiyama, K., Fukuhara, N., Odaka, M., Nakajima, K., Ishiwarari, M., Imamura, T., Hayashi, Y.-Y., 2019: Development of Venus' cloud formation scheme for a convection resolving model, JPGU meeting 2019, 2019/05, PPS05-P08, Makuhari Messe (Japan).

2) Sugiyama, K., Fukuhara, N., Odaka, M., Nakajima, K., Ishiwarari, M., Imamura, T., Hayashi, Y.-Y., 2019: Development of Venus' cloud formation scheme for a convection resolving model, International Venus Conference, P19, 2019/05, Niseko (Japan).

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	16 - 128
Elapsed Time per Case	8 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	779.48	0.00
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	356.71	0.30
/data	3,287.00	0.06
/ltmp	1,302.08	0.11

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Study on Combustible Flow in Supersonic Flight Engines and Rocket Engines

Report Number: R19EACA01
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11535/

Responsible Representative

Nobuyuki Tsuboi, Professor, Department of Mechanical and Control Engineering, Kyushu Institute of Technology

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Members

Nobuyuki Tsuboi, Kouhei Ozawa, Takahide Araki, Toshihiro Iwasa, Nicolas H. Jourdaine, Shota Goto, Kodai Shimomura, Takuro Yoshino, Tomohiro Watanabe, Taishi Amano, Kanta Iwasaki, Nobuhiro Kurita, Naomi Takeshima, Darshan Manjunath

Abstract

Fundamental studies on nozzles and combustors for Japanese rocket engines and supersonic engines are performed by using numerical simulations.

Ref. URL: http://www.mech.kyutech.ac.jp/rfd/eng-theme.html

Reasons and benefits of using JAXA Supercomputer System

Academic and applicative researches on fluid dynamics and combustion mechanism, and development of effective numerical methods are carried out in order to develop Japanese rocket engines and supersonic engines.

Achievements of the Year

To validate the analysis code for the jet mixing in the supersonic crossflow, LES/RANS hybrid simulation on the round helium jet is performed. As a result, the shock waves and vortex structure near the jet exit are observed, as shown in Fig. 1. We confirmed that the analysis code can simulate the jet mixing in the time-averaged flow-field, as shown in Fig. 2.

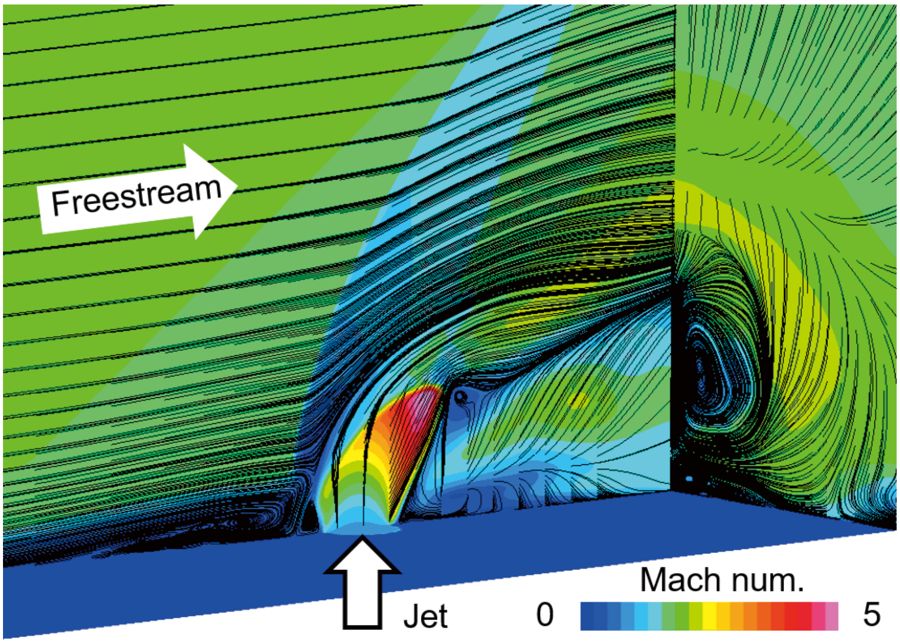

Fig. 1: Time-averaged Mach number distribution with streamline.

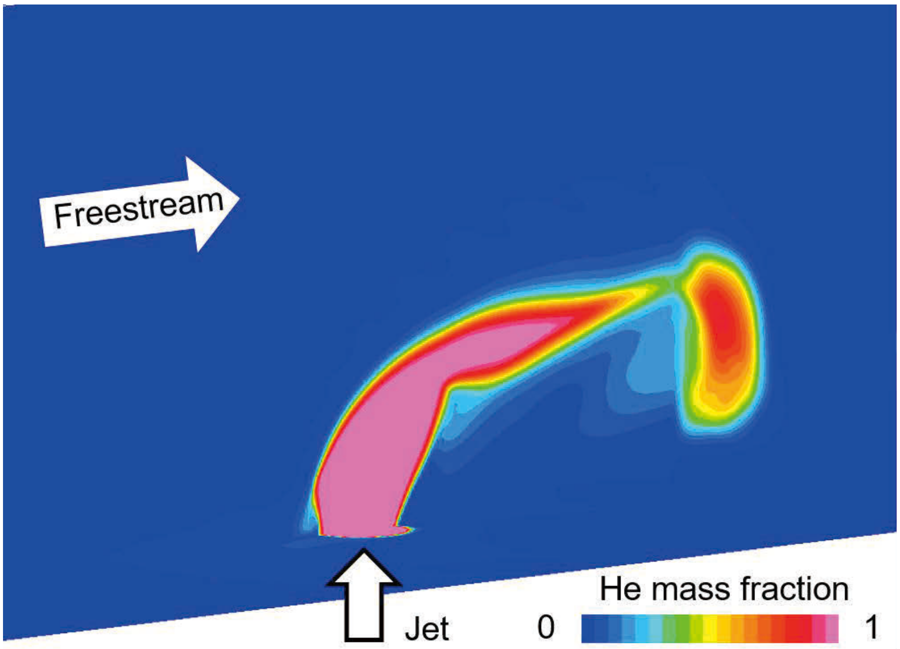

Fig. 2: Time-averaged Helium mass fraction distribution.

Publications

- Oral Presentations

[1]Toshihiro Iwasa, Nobuyuki Tsuboi, "Mixing characteristics of the slit-shaped hydrogen jet in supersonic crossflow", 32nd International Symposium on Shock Waves, OR-21-0357, Singapore, July, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	8 - 12
Elapsed Time per Case	360 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	366,280.03	0.04
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	104.90	0.09
/data	1,049.04	0.02
/ltmp	21,484.38	1.83

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Study on Rotor Performance of Mars Helicopter

Report Number: R19EACA41
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11555/

Responsible Representative

Makoto Sato, Associate Professor, Kogakuin University

Contact Information

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Members

Makoto Sato, Daichi Ogasawara

Abstract

Mars helicopter project is now going. Since the atomospheric density on Mars is about 1/100, the sound of speed is about 3/4 compared with those on Earth, we need to develop the high perfmance heli-rotar. In JAXA, the experimental measurements of the heli-rotar performance at low-Reynolds number condition have been conducted. In the present research, we conduct numerical simulations on the rotational flat-plate-airfoil flow in order to clarify the characteristics of the flow field.

Reasons and benefits of using JAXA Supercomputer System

We need to conduct the large-scale simulations on the rotational wing flow using "rFlow3D", which has been developed in JAXA.

Achievements of the Year

We have conducted the numerical simulation on the rotational flat-plate-airfoil flow. The computational object and conditions are decided based on the experiments at Tohoku University[1]. The computational parameters are the Reynolds number(7380-73800), pitch angle(0-30) and aspect ratio(2-4). Here, the results of AR=4 cases are shown. The flow solver is rFLow3D, which has been developed at JAXA.

Figure 1 shows Ct(thrust coefficient)-Cq(torque coefficient) curves. For the cases with low pitch angles, the trend of Ct-Cq curves is alomost the same.　On the other hand, For the cases with high pitch angles, Ct-Cq curve of Re=7380 shows different trend from other cases. Figure 2 shows vortex structures around flat-plate-airfoil for the case with Re=7380, 73800 and pitch angle 20 degrees.　The sequential sheddings of leading-edge vortices and their convections can be observed for the case of Re=73800.　On the other hand, the relatively large-scale separation vortex is shed from the leading-edge.　Figure 3 shows the vortex structures on the cross sections and Cp distributions.　From the comparison between the case of Re=7380 and Re=73800, it can be said that the region of the flat Cp becomes larger in Re=7380 than that in Re=73800. This is because the large-scale separation vortex from the leading-edge results in the large reverse flow region above the airfoil in Re=7380.

In addition to the rotational flat-plate-airfoil, now we are conducting the simulation on the "triangle-airfoil". Figure 4 shows the vortex structure around the rotational triangle-airfoil. The separation vortex is clearly different from that of the flat-plate-airfoil. The detailed analysis will be conducted soon.

[1] Okoucuhi, M. "Experimental research on aero-characteristics of rotar at low-Reynolds numer condition", Master Thesis of Tohoku University, (2013).

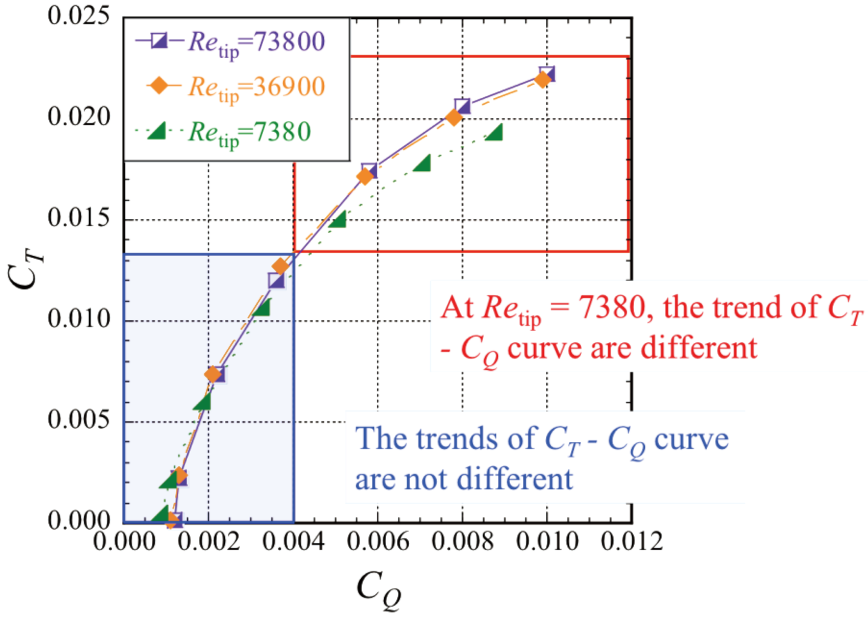

Fig. 1: Reynolds effect of Ct-Cq curve

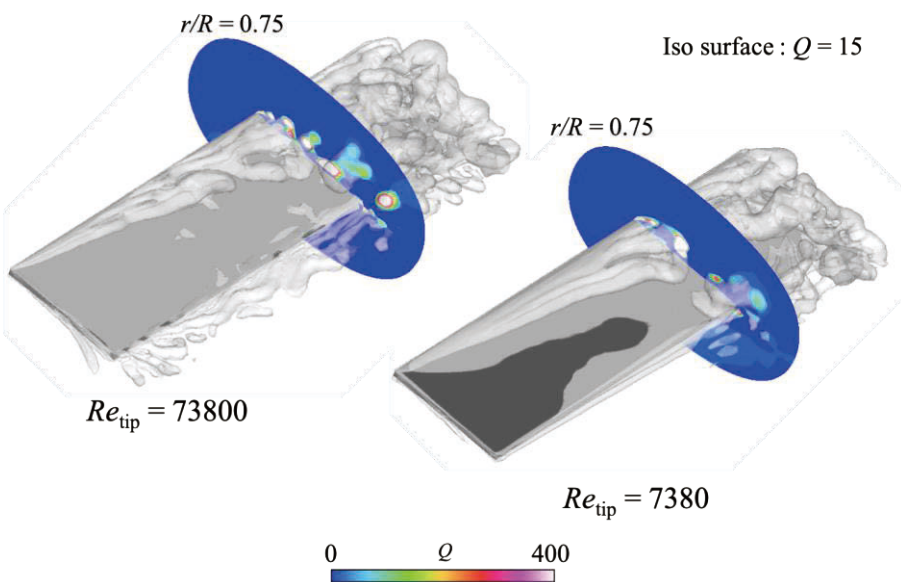

Fig. 2: Vortex structures around rotational flat-plate airfoil

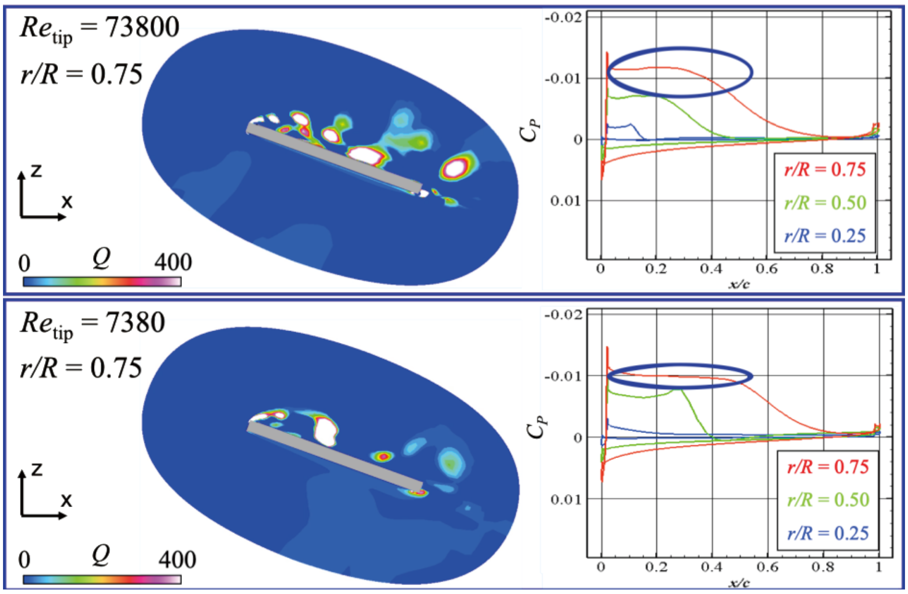

Fig. 3: Vortex structures and Cp distributions

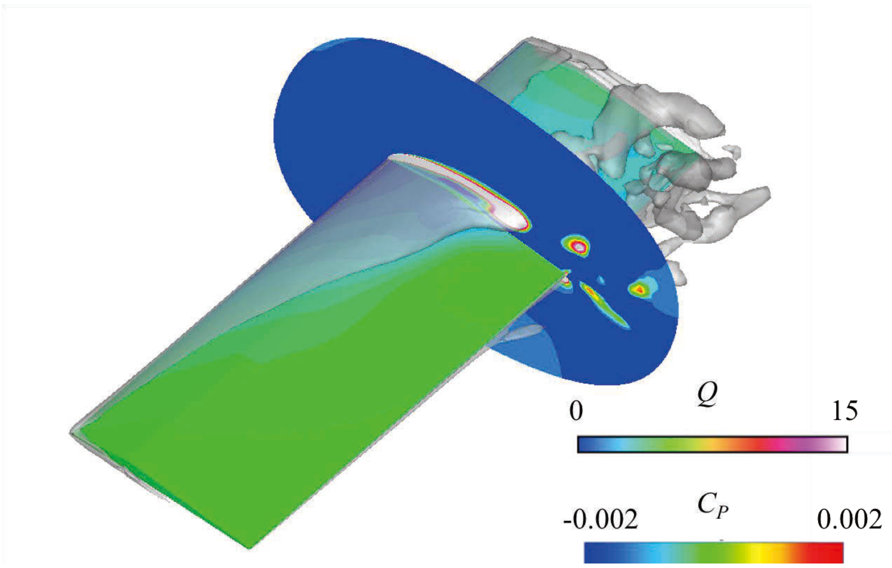

Fig. 4: Vortex structures around rotational triangle airfoil

Publications

- Oral Presentations

D. Ogasawara, M. Sato, H. Sugawara, Y. Tanabe, "Numerical simulation of a rotating blade using a flat-plate airfoil at low Reynolds numbers for Mars helicopter", 72nd Annual Meeting of the American Physical Society Division of Fluid Dynamics

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	400 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.18

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	469,490.28	3.04
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	19.07	0.02
/data	19,531.26	0.33
/ltmp	3,906.25	0.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Nunerical Study on Improvement of Airfoil Performance at Low Reynolds Number

Report Number: R19EACA43
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11557/

Responsible Representative

Keiichi Kitamura, Associate professor, Yokohama National University

Contact Information

Suguru Ogawa(ogawa-suguru-ps@ynu.jp)

Members

Keiichi Kitamura, Suguru Ogawa, Yoshikatsu Furusawa

Abstract

As a new form of vheicle of the Mars explolation, research and development of Mars airplanes are progressing mainly in JAXA in Japan. Since the Martian atmosphere has a low density and Mars airplanes fly in the low Reynolds number region, it is necessary to develop wings that exhibit high flight performance in this low Reynolds number region. In this study, the flow field structure around the wing in the low Reynolds number region is investigated in detail using numerical calculations. This report proposes a method to improve the wing performance and aims to clarify the mechanism.

Reasons and benefits of using JAXA Supercomputer System

In order to capture fine eddies near the boundary layer in laminar flow calculations, large-scale calculations with a grid exceeding 50 million cells are required, and JSS2 was used to greatly reduce the calculation time. In addition, JSS2 was used to perform a large-scale numerical calculation of the three-dimensional rotor using the flow analysis solver "rFlow3D" for the rotor developed by JAXA.

Achievements of the Year

A moving surface method was introduced as a method to suppress the laminar separation, and its effect was demonstrated with a three-dimensional wing (without considering the wingtip vortex). The moving surface method controls the flow near the surface by moving the wing surface in the direction along the flow. This flow is based on the Couette flow. This method is applied to a part near the wing surface to control the separation by supplying momentum enough to overcome the adverse pressure gradient (see Fig. 1). The calculation conditions are Re = 23000, Mach number 0.2, angles of attack 3, 6, 9 degrees. Here, the airfoil is Ishii wing and the chord length is 1m. The moving surface speed was set to half that of the uniform flow. From the calculation results, remarkable improvements of the lift-drag ratio were achieved at all angles of attack by applying the surface movement method (3 degree 13.7 -> 19.5, 6 degree 13.0 -> 27.6, 9 degree 6.75 -> 25.8). Figure 2 shows the visualization result of the isosurface of the Q value (Q = 0.5) colored by Cp at an angle of attack of 6 degree as a representative case. From Fig. 2 (a), it can be seen that the flow separated at the leading edge of the wing reattached near the middle of the wing and formed a complicated three-dimensional flow field. However, when the moving surface method was applied [Fig. 2 (b)], the leading edge separation was suppressed. It is considered that the negative pressure increased due to the attached flow at the leading edge of the wing, and as a result, the pressure drag was greatly reduced, which led to a significant improvement in the lift-drag ratio. In addition, it was clarified that the application of the moving surface method suppressed the leading edge separation, which otherwise had produced three-dimensionality, resulted in the approximately two-dimensional flow field. Since the surface movement method is less affected by the surrounding environment than other methods, a certain effect can be expected in the Martian environment.

Additionally, we conducted numerical simulations on the aerodynamic interaction between the propeller and the fixed wing in which the airplane with propeller propulsion flying at low Reynolds number cases. The Reynolds number based on the fixed wing chord is Re = 30000, the free stream velocity is 9 m/s, the advance ratio is J = 0.8, and the angles of attack are from -5 to 15 degrees with 5-degree intervals. The airfoil of the fixed wing is Ishii airfoil (the chord length is 50 mm, and the span length is 200 mm), and the propeller is APC Propellers 6x4E which was developed for a model propeller. The propeller is installed forward the leading edge or backward the trailing edge of the fixed wing of the center of the span length by the same distance as the chord length. As a result, in the case that the propeller is located in front of the propeller (Fr. Prop.), the lift coefficient increased linearly against the angle-of-attack (Fig. 3) because the propeller slipstream suppressed the growth of separation over the fixed wing. Thrust coefficient was about 15 - 35% larger than the case of the propeller only (Fig. 4). On the other hand, in the case that the propeller is located behind the propeller (Rr. Prop.), aerodynamic forces acting on the fixed wing were not much different from the case of the fixed wing only, and thrust coefficient was 55 - 220% larger than the case of the propeller only. However, the azimuthal fluctuation of thrust coefficient was very large because the slipstream of the fixed wing interfered with the propeller and therefore the advance ratio fluctuated locally. These results suggest that the design of an airplane flying at low Reynolds numbers must take into account the aerodynamic force fluctuations caused by the propeller/wing interaction.

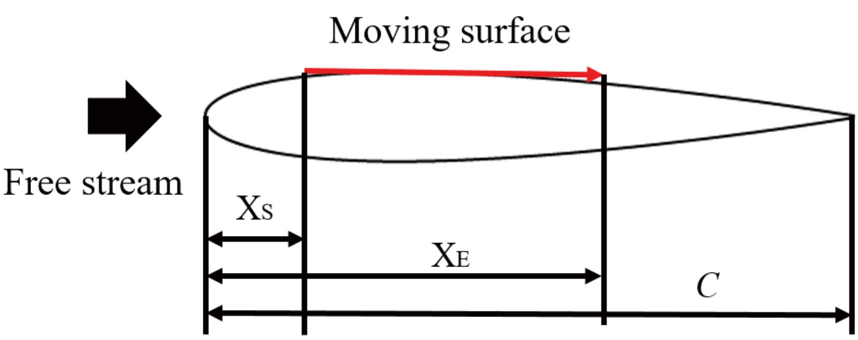

Fig. 1: Schematic diagram of moving surface method

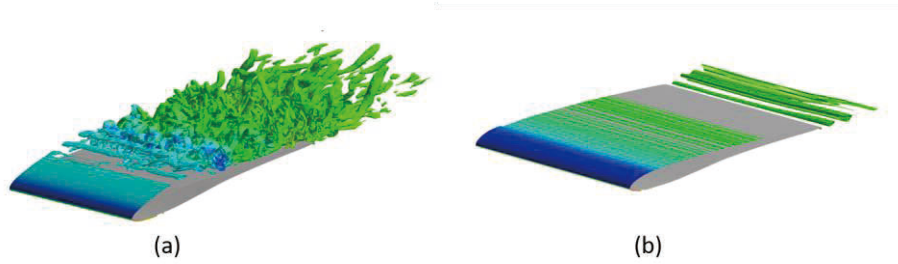

Fig. 2: Q iso-surface colored with Cp (-1.5 < Cp < 1.0) (momentary field) (a) without moving surface method (b) With moving surface method

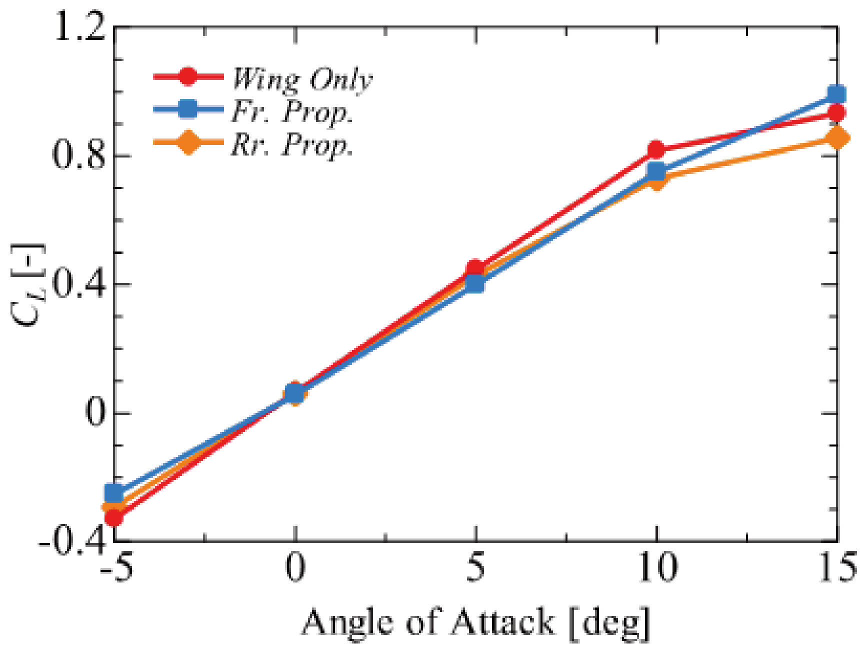

Fig. 3: Comparison of lift coefficients at each angle of attack

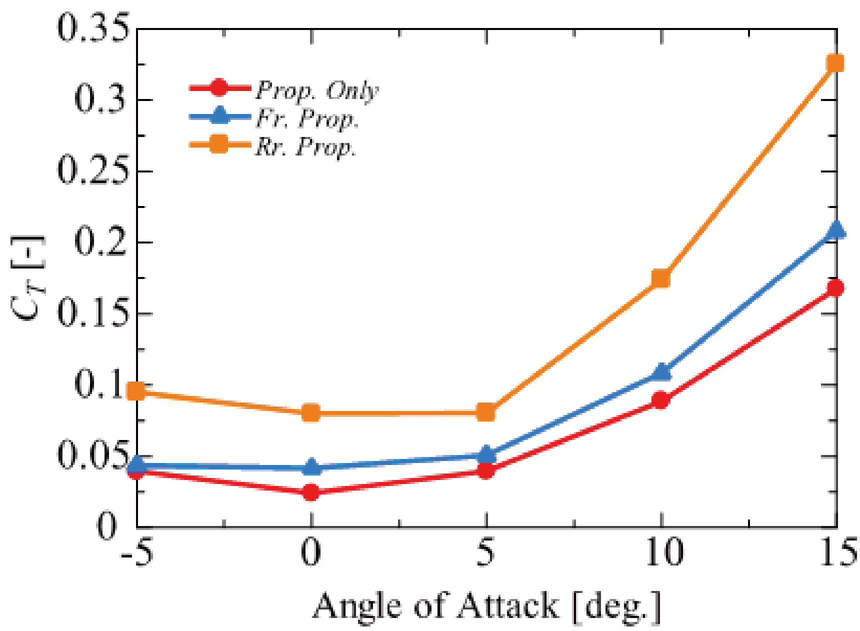

Fig. 4: Comparison of thrust coefficients at each angle of attack

Publications

- Oral Presentations

Suguru Ogawa, Keiichi Kitamura, "Improvement of Low Reynolds Number Aerodynamic Characteristics of Wing by Moving Surface Method," JSASS-2019-1036, 2019 (in Japanese)

Yoshikatsu Furusawa, Keiichi Kitamura, "Numerical Simulation on Wing/Propeller Interaction by Tractor Propeller," JSASS-2019-1027, 2019 (in Japanese)

Yoshikatsu Furusawa, Keiichi Kitamura, "Numerical Investigation on Unsteady Aerodynamic Characteristics of Propeller/Wing Interaction at Several Angles-of-Attack," JSASS-2019-4539, 2019 (in Japanese)

Suguru Ogawa, Keiichi Kitamura, "Improvement of the Aerodynamic Characteristics of Wing by Moving Surface Method at Low Reynolds Number", 32nd International Symposium on Space Technology and Science (ISTS), 2019

Yoshikatsu Furusawa, Keiichi Kitamura, "Unsteady Numerical Simulation on Angle-of-Attack Effects of Tractor-Propeller/Wing and Pusher-Propeller/Wing Interactions," AIAA Science and Technology Forum and Exposition 2020, 2020

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	512 - 2048
Elapsed Time per Case	140000 Second(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,496,626.64	0.18
SORA-PP	252,879.23	1.64
SORA-LM	1,855.79	0.77
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	6.68	0.01
/data	4,901.89	0.08
/ltmp	1,367.19	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	2.37	0.06

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Physics and modeling of compressible thermal turbulent boundary layers

Report Number: R19EACA31
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11549/

Responsible Representative

Soshi Kawai, Professor, Tohoku University

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Ryo Hirai(hirai@klab.mech.tohoku.ac.jp)

Members

Soshi Kawai, Ryo Hirai, Yuki Mori

Abstract

LES study of near-wall turbulent physics in heated/cooled-wall compressible turbulent boundary layers is conducted. The study reveals the relation between the mean-velocity profiles and turbulent structures in the conditions with wall heat flux. Also, Further, based on knowledge obtained in the LES study, improved LES wall-model is proposed for the thermal wall-bounded flows.

Ref. URL: http://www.klab.mech.tohoku.ac.jp/index.html

Reasons and benefits of using JAXA Supercomputer System

Especially in the cooled-wall conditions, the Reynolds number based on the wall friction velocity (i.e., inner-layer scaling) becomes high, and high-fidelity LES computations of compressible thermal turbulent boundary layers with cooled wall require significant computational costs. Therefore, a large-scale parallel computation using a supercomputer, such as JSS2, is mandatory.

Achievements of the Year

In this study, the LES analysis of heated/cooled-wall turbulent boundary layers is conducted to investigate the detailed turbulent physics in wall-bounded flows involving wall heat flux. Also, a wall-modeling in LES is improved based on the knowledge obtained by the LES analysis. In this year, the computations of the wall-resolved LES (WRLES) and wall-modeled LES (WMLES) were conducted under the following conditions. The Reynolds number and Mach number of incoming flows are set as Re=5,000 and M=2.28, respectively (the reference length of Re is the momentum thickness of the boundary layer). As the spatial discretization method, the sixth-order compact difference scheme is used. The time integration method is the third-order TVD Runge-Kutta method. In this study, we consider three different heated/cooled wall temperature conditions, Tw/Tr =0.5,1.0,2.0 (where Tr is the recovery temperature). The cooled-wall conditions are the cases of Tw/Tr < 1.0, the heated-wall conditions are the case of Tw/Tr > 1.0, and the quasi-adiabatic-wall condition is the case of Tw/Tr = 1.0.

Figure 1 shows the distributions of (a) transformed mean-velocity considering the density and dynamic viscosity variations [Trettel & Larsson (2015), Patel et al. (2015)] and (b) the viscous stress. Compared to the van Driest transformation usually used for compressible turbulent boundary layers, the velocity scaling law shown in Fig. 1 (a) agrees well among the cases. However, a slight off-set can be seen near the log-layer. In this research, it becomes clear that the off-set in the mean velocity profiles is induced by the viscous stress profiles shown in Fig. 1 (b).

Based on the total shear stress balance in equilibrium flows, the differences in the viscous stress in Fig. 1 also cause the differences in the Reynolds shear stress profiles. Also, the Reynolds shear stress closely relates to turbulent structures, therefore, the turbulent structures are considered to differ between the cases. Figure 2 shows instantaneous stream-wise velocity fluctuations in the inner-layer at y*=15 (y* is the semi-local length scale). Compared to the quasi-adiabatic case (Fig. 2 (a)), smaller structures in the heated case (Fig. 2 (b)), and larger structures in the cooled case (Fig. 2 (c)) are observed. These differences in the turbulent structures suggest the cause of the log-law offset as shown in Fig. 1 (a).

In this study, based on the analysis of the LES flowfields, the improvements of the LES wall-model are achieved by a modification of the length-scale in eddy viscosity approximation. Figure 3 shows the profiles of (a) van Driest transformed velocity and (b) temperature. Good agreements between the improved WMLES and the WRLES are seen in Fig. 3 (a,b). The results suggest that the proposed wall-model works well for flat-plate thermal turbulent boundary layers.

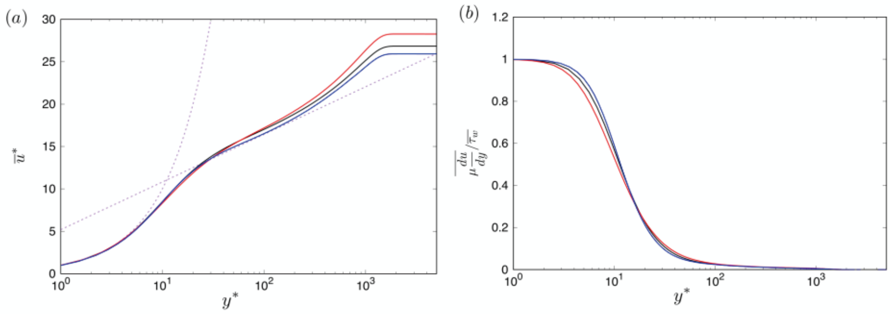

Fig. 1: Comparison of thermal turbulent boundary layers with adiabatic/heated/cooled walls. Distributions of (a) transformed mean-velocity considering the density and dynamic viscosity variations [Trettel & Larsson (2015), Patel et al. (2015)] and (b) the viscous stress. Black, quasi-adiabatic; red, heated; blue, cooled; dotted, wall-law.

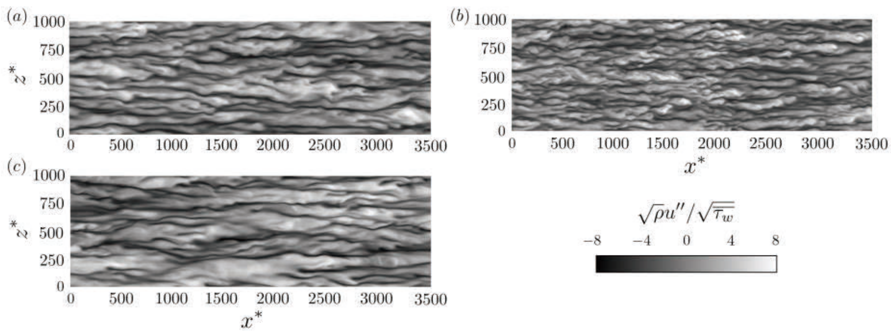

Fig. 2: Contours of instantaneous stream-wise velocity fluctuations at y*=15. (a) quasi-adiabatic, (b) heated, (c) cooled.

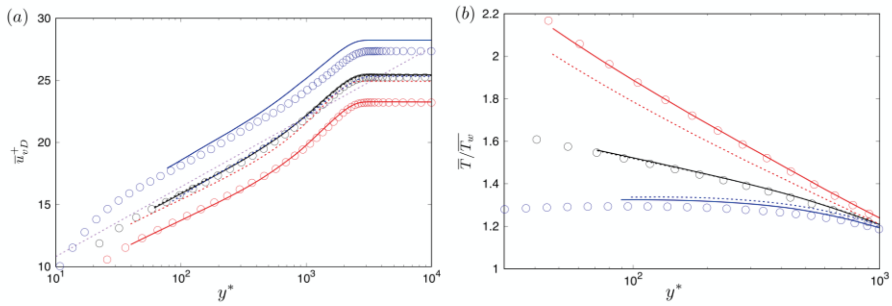

Fig. 3: Predicted turbulence statistics in the thermal turbulent boundary layers with adiabatic/heated/cooled walls obtained by the proposed wall model. Distributions of (a) van Driest transformed mean-velocity and (b) mean temperature. Symbol, reference (WRLES); solid, improved WMLES; dashed, conventional WMLES. Black, quasi-adiabatic; red, heated; blue, cooled; dotted, wall-law.

Publications

- Oral Presentations

(1) R. Hirai, S. Kawai, "LES analysis for wall modeling of thermal turbulent boundary layer with wall heat flux", 37th ANSS

(2) R. Hirai, S. Kawai, "Assessment of Wall-Modeled LES for Turbulent Boundary Layers with Heated/Cooled Wall", 72nd Annual Meeting of the APS Division of Fluid Dynamics

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	660 - 1020
Elapsed Time per Case	120 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.11

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	976,363.17	0.12
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	291.82	0.24
/data	14,657.98	0.25
/ltmp	3,125.00	0.27

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Requirement analysis for LiteBIRD's optical system

Report Number: R19EACA34
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11550/

Responsible Representative

Ryo Nagata, Researcher, High Energy Accelerator Research Organization (KEK)

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Members

Ryo Nagata

Abstract

Primordial gravitational wave background is generically predicted by cosmic inflation theories. Amplitude of the waves indicates energy scale of cosmic inflation. LiteBIRD, the 2nd ISAS strategic large mission, makes a full-sky map of the microwave background polarization to detect a signal of the gravitational waves. Since the signal of primordial gravitational wave origin (B-mode pol.) is expected to be much weaker than that of primordial density fluctuation origin which has been already observed, it is essentially important to identify and mitigate systematic errors.

In this year, we achieved performance verification of LiteBIRD's low frequency telescope (LFT) by simulations with real beam pattern given by measurement of a 1/4 scaled model of the telescope. To identify true optical characteristics at performance tests, we have to understand behavior of measurement errors. By performing full beam convolution simulations, we quantified how beam imperfection found in the measured beam pattern affects our science and learned how to improve the measurement system of the scaled model.

Ref. URL: http://litebird.jp/eng/

Reasons and benefits of using JAXA Supercomputer System

Since LiteBIRD will achieve scan observation for full sky polarization mapping, beam convolution is repeated at a frequency of about 20Hz (and for a period of one year). Beam functions, which are measured by use of the 1/4 scaled model, spread over an area of several thousand square degrees with arcminute resolution. For every sampling, integrands are evaluated on O(10^6) grid points. The integrations with incessant coordinate transformations require a high performance computing resource.

This inter-university research is powerfully promoting the LiteBIRD project which is the 2nd ISAS strategic large mission. The outcomes of this research are counted as bases of LiteBIRD's optics design.

Achievements of the Year

We investigated an impact of beam imperfection found in the measured beam pattern of the 1/4 scaled model by performing a simulation suite of LiteBIRD observation which consists of scan, beam convolution, and map making.

(Fig.1) shows the differential beam map of two detectors in the 45(=180/4)GHz band whose sensitivity directions are mutually orthogonal. (Top-left window in the figure 1) shows the measurement system for the scaled model. While the measured beam patterns are roughly consistent with designed beam pattern of the telescope, it contains irregular structure such as cross-polarization due to feed pattern imperfection, mismatch of beam centers, and widely spreading scan noise. (Fig.2) shows angular power spectra of false polarization leaked from temperature inhomogeneity of the microwave background. In the main beam area, we found false polarization due to 1% differential ellipticity originating from cross-polarization. In the area of very near sidelobes, the centers of the two beam pattern exhibited mismatch of 40arcsec, which made false polarization of the flat spectrum in the figure. Also, it was indicated that large angular correlation in the polarization map was contaminated by measurement errors in the far sidelobes including scan noise. Owing to these evaluations, we obtained a concrete principle for updating the measurement system based on quantitative requirements.

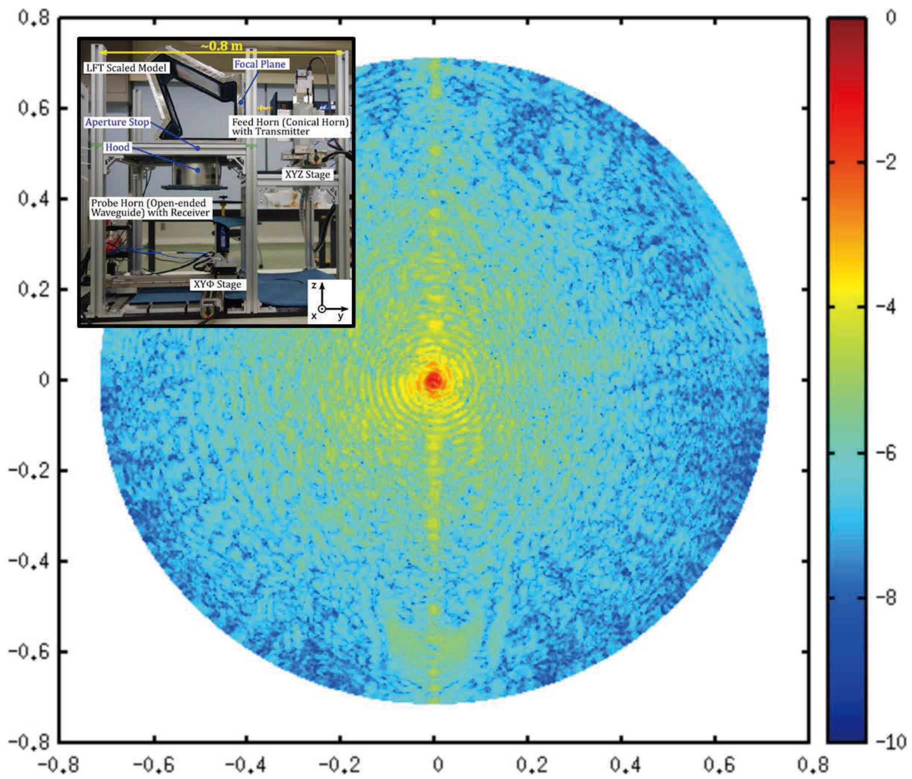

Fig. 1: Differential beam pattern of LiteBIRD LFT 1/4 scaled model (top-left window) at 45 (=180/4) GHz band : H.Takakura et al., IEEE TST vol. 9, issue 6 (2019)

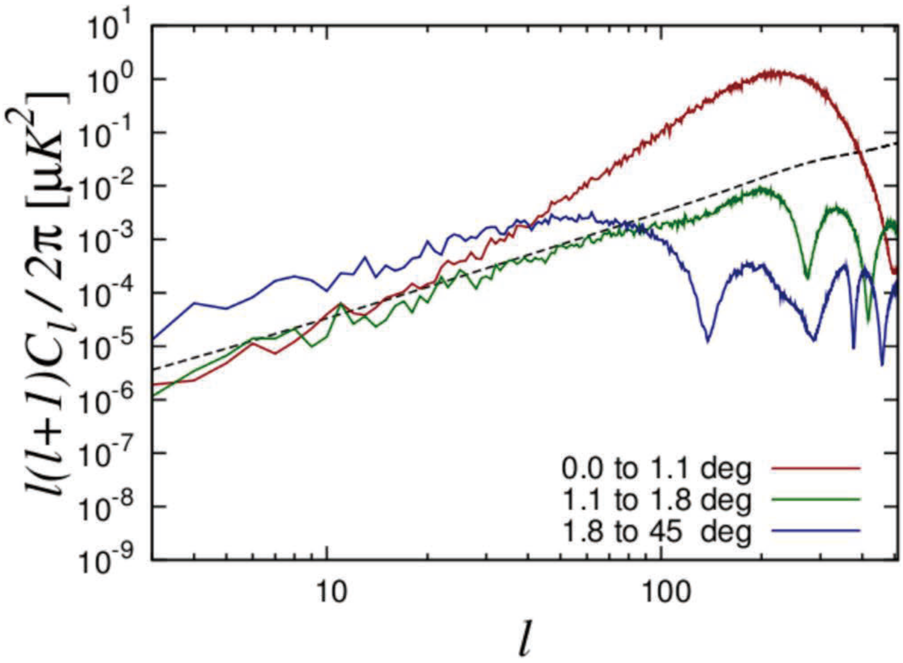

Fig. 2: Angular power spectra of false polarization due to beam mismatch

Publications

- Non peer-reviewed papers

LiteBIRD: an all-sky cosmic microwave background probe of inflation: Bulletin of the American Astronomical Society 51, 7, 286 (2019)

- Oral Presentations

Ryo Nagata, "On the systematic effects of LiteBIRD observation XIII", Astronomical Society of Japan 2019 autumn annual meeting

- Web

http://litebird.jp/eng/

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	32
Elapsed Time per Case	2.5 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.23

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	2,114,525.58	0.26
SORA-PP	22.21	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	1,907.35	0.03
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.25	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Reynolds Number Effect on Aerodynamic Characteristics of Slender Bodies

Report Number: R19EACA21
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11546/

Responsible Representative

Keiichi Kitamura, Associate Professor, Yokohama National University

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Members

Keiichi Kitamura, Hayato Kawashima

Abstract

In order to obtain the drag value of a slender body such as rockets from a wind tunnel test, the base pressure correction and cavity pressure correction are typically required to remove the effect of a sting. The drag greatly depends on the correction method, which requires a careful treatment. Based on this background, in this study, we made a detailed comparison between the wind test results and the numerical calculation results. As a result, it was found that the cavity pressure should be treated as much as the uniform flow static pressure even when strong shock waves occur around the body. It was also found that the base pressure measurement should be performed avoiding the most leeward position where a locally high-pressure occurs; by applying both the corrections, the error can be suppressed to within 1% at an angle of attack of 15 degrees.

Reasons and benefits of using JAXA Supercomputer System

In this research, there were many calculation cases because we handled various shapes and angles of attack, and the number of grid points was very large because we required high-resolution results. For this reason, we needed to use the supercomputer.

Achievements of the Year

Before investigating the Reynolds number effect of a slender body (Fig.1), first, we investigated the cause of the errors in the drag between the wind tunnel test result and the numerical calculation result in terms of cavity pressure correction and base pressure correction. As a result, in the wind tunnel test of the slender body at a uniform flow Mach number M = 1.3, by treating the cavity pressure as the same level as the uniform flow static pressure, the wind tunnel test results and the numerical calculation results agreed within 1% accuracy in the comparison of the forebody drag at attack angles of 0 to 15 degrees; for example, an error of 13% occurs when assuming vacuum, and 5% when assuming base pressure. In addition, as well as in the wind tunnel test, we tried to calculate the base pressure from the four measurement positions in the numerical calculation solution, and we investigated errors in the base pressure calculation caused by the differences of the measurement positions. As a result, in a wind tunnel test with a general base surface shape such as a circle or a square, by avoiding the location of the most leeward side where a local high pressure region occurs (Fig.2, Fig.3), the drag of the wind tunnel test results and that of the numerical calculation results can be nearly the same with only 1% difference (in the case of angle attacks of 15 degrees).

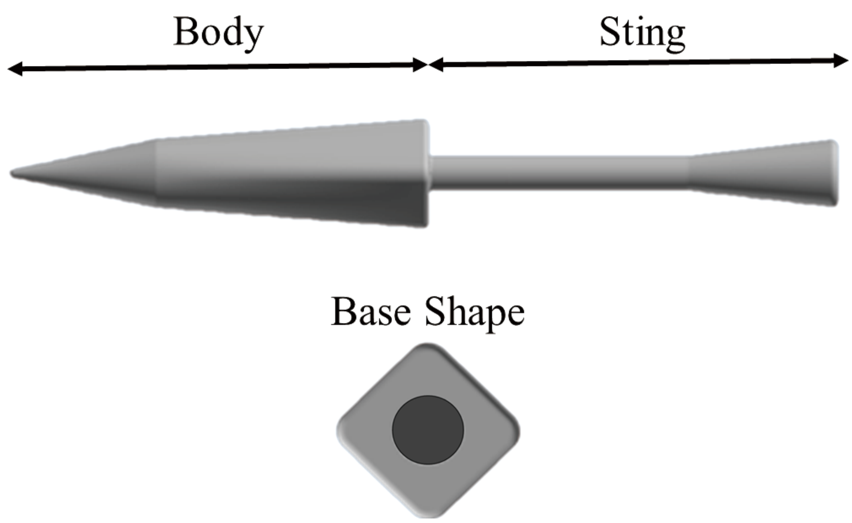

Fig. 1: Configuration (the case of square cross section)

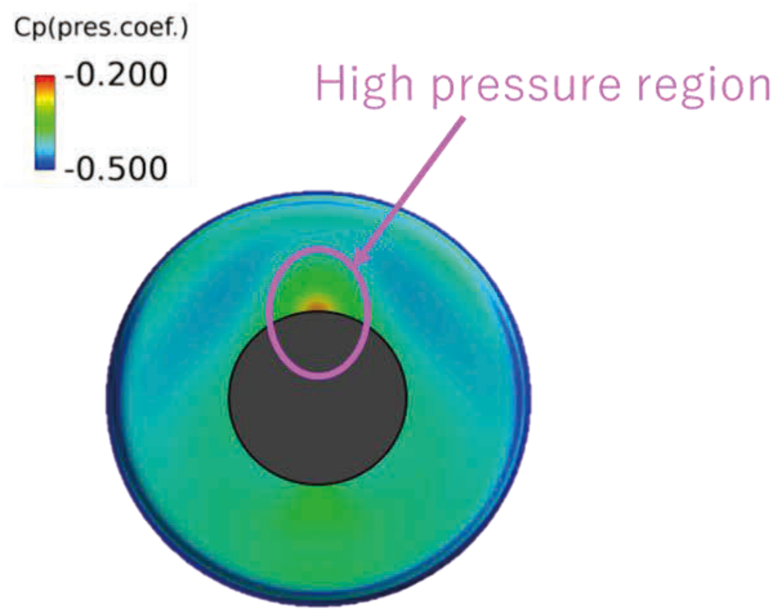

Fig. 2: Circle surface pressure distribution at angle of attacks of 15 degreees

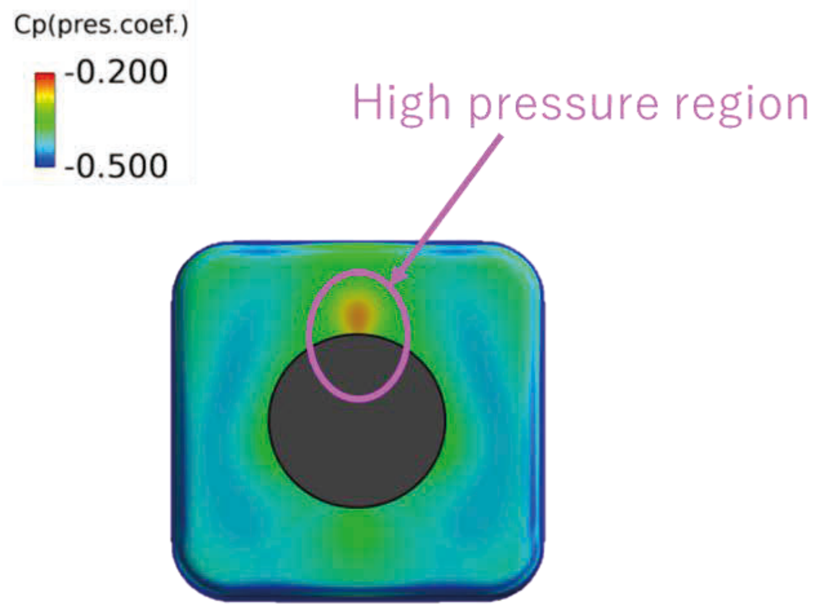

Fig. 3: Base surface pressure distribution at angle of attacks of 15 degreees

Publications

- Oral Presentations

1) Hayato Kawashima, Keiichi Kitamura, Satoshi Nonaka, "(1C02)Aerodynamics Analysis of Reusable Rocket in Transonic Flight", The 50th JSASS Annual Meeting,, Institute of Industrial Science, The University of Tokyo, Japan, April 18, 2019.

2) Hayato Kawashima, Keiichi Kitamura, Satoshi Nonaka, "Study on Correction Method of Base Drag in Transonic Wind Tunnel Test for Slender Body", Dynamics Symposium of Space Navigation, ISAS, JAXA, Japan, December 9, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	96 - 512
Elapsed Time per Case	8 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	81,633.87	0.01
SORA-PP	16,248.56	0.11
SORA-LM	215.72	0.09
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	6.68	0.01
/data	4,787.45	0.08
/ltmp	1,367.19	0.12

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Studies on nonlinear vortex dynamics in the later-stage of laminar-turbulent transition in compressible boundary layers

Report Number: R19EACA13
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11540/

Responsible Representative

Kazuo Matsuura, Associate Professor, Ehime University, Graduate School of Science and Engineering

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Kazuo Matsuura(matsuura.kazuo.mm@ehime-u.ac.jp)

Members

Kazuo Matsuura

Abstract

In hypersonic transitional flows, there are many complicated factors such as density fluctuation and temperature fluctuation due to the co-existence of the region slower than the speed of sound and the region faster than the speed of sound inside the boundary layer. Detailed investigations into the vortex dynamics occurring inside the boundary layers are expected. In this study, we aim to clarify the nonlinear vortex dynamics especially in the late-stage by conducting direct numerical simulations of laminar-turbulent transition in compressible boundary layers observed in hypersonic flows. Also, we develop a mathematical methodology to directly introduce vortices responsible for the late stage to the boundary layers, and its computational methods.

Reasons and benefits of using JAXA Supercomputer System

For the investigation of boundary layer transition of hypersonic flows, numerical simulation is a central tool because measurement is difficult due to the existence of acoustical disturbance in a wind tunnel. Because boundary layer transition is susceptible to disturbance, and in addition transition is hard to occur due to strong compressibility, powerful supercomputers that enable high-accuracy large-scale computation are necessary to get results in a short time period.

Achievements of the Year

A new method that evaluates dominant local dynamics by skeletonization, mathematical term decomposition and the re-combination of a reduced number of dominant terms around the skeleton points is proposed to clarify the dynamics of hairpin vortices generated during the boundary-layer transition under free-stream turbulence (Fig.1). The present method enables the automatic finding and categorization of the variations of the sets of dominant terms that govern local dynamics during the evolution of hairpin vortices.

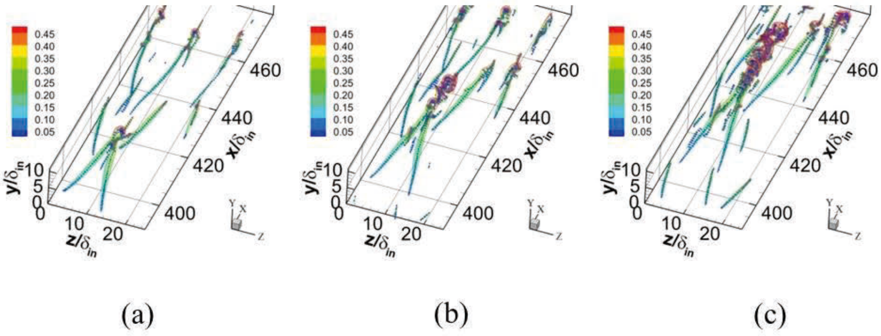

Fig. 1: Time evolution of hairpin and satellite vortices represented by the skelton points (blue points) and the transparent iso-surfaces (Free-Stream Turbulence Level=0.5%). The color on the iso-surfaces is Mach number. (a) t=258.0δin/u∞ (b) t=281.5δin/u∞ (c) t=305.0δin/u∞

Publications

- Peer-reviewed papers

Kazuo Matsuura, "Algorithmic Exploration of Dominant Terms Around Hairpin Vortices Generated During Boundary-Layer Transition Under Free-Stream Turbulence," Int. J. Environ. Impacts, Vol. 3, No. 1 (2020).

- Non peer-reviewed papers

Kazuo Matsuura, Yasuhide Fukumoto, A Study on Clustering of Hairpin Vortices in Transitional Boundary-Layer, 24th Japan Society of Fluid Mechanics, Chushikoku-Kyushu Branch, pp. 1-2 (2019).

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	16 - 64
Elapsed Time per Case	168 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	7,281.63	0.00
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	95.37	0.00
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study of high-fidelity simulations for compressible turbulent flows and aeroacoustics around complicated geometries

Report Number: R19EACA38
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11553/

Responsible Representative

Hiroyuki Asada, Department of Mechanical Engineering, Ritsumeikan University.

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Members

Hiroyuki Asada, Yoshifumi Ogami, Daisuke Nishida, Shinya Endo, Kazuki Miyata

Abstract

This study aims to develop a high-fidelity solver for aeroacoustics simulations. The solver is based on the high-order discontinuous Galerkin (DG) method which is one of the high-order unstructured mesh methods and the large eddy simulation giving highly accurate turbulent flow simulations.

Reasons and benefits of using JAXA Supercomputer System

The highly accurate simulations of turbulent flows and aeroacoustics require the high number of computational cells and high computational cost, and thus massive parallel computations using super-computer is mandatory to realize such simulations. Additionally, the high-order DG method is well suited to the massive parallel computations because high execution efficiency can be realized by this method.

Achievements of the Year

Effects of wall representation on numerical solutions for aeroacoustics are investigated. The wall represenation is deteriorated when coarse meshes are used to exploit the advantages of high-order DG methods. The deterioration is discussed in many works; however, detailed effects of this deterioration have not been examined particularly for aeroacoustics simulations. This study investigate these effects by comparing numerical results between the cases of curved mesh and linear mesh on a problem of acoustic propagation around a cylinder. The 4th-order DG method and explicit time integration scheme are employed for spatial and time discretizations, and sufficiently fine mesh giving grid convergence is used for the investigation. Figure 1 and 2 show the pressure distribution on the cylinder surface and enlarged view. In these figures, CX indicates that the cylinder is represented by X linear meshes. Although the global effects of the wall representation are small, the cases of C8 and C16 exhibit clear differences with other cases. The case of C16, i.e. the cylinder is represented by 16 linear meshes, occurs when the grid convergence is achieved with 16 meshes in the circumferential direction. For the high-order DG method, this situation occurs when the 8th-order scheme is employed (it is clarified in the grid convergence studies of this study). Therefore, we can say that the deterioration of wall representation has to be concerned when the 8th-order DG method is employed for aeroacoustics simulations. These results are obtained when the case of zero background flow, and it is possible that these effects of wall representation become prominent when the background is non-zero.

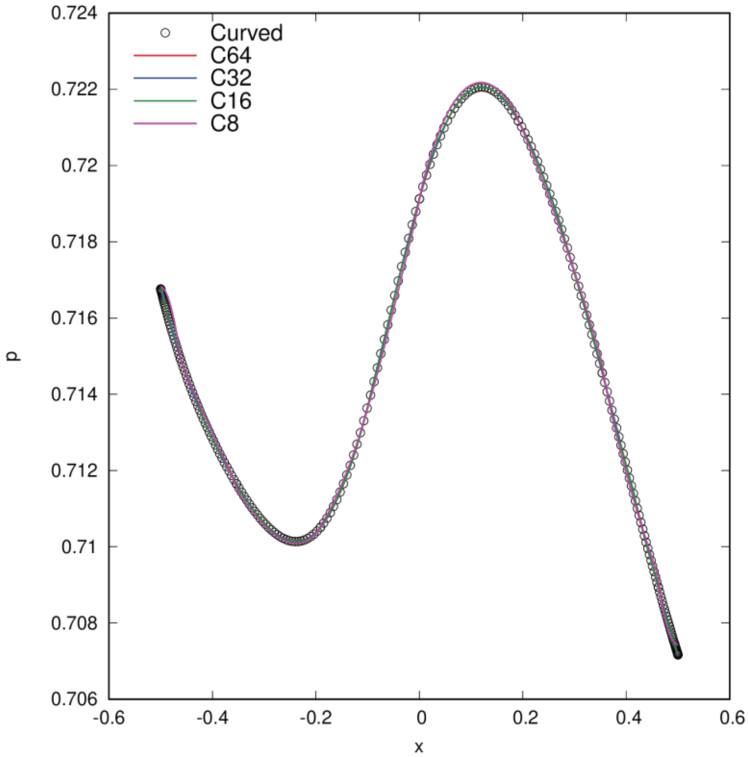

Fig. 1: Pressure distribution around a cylinder

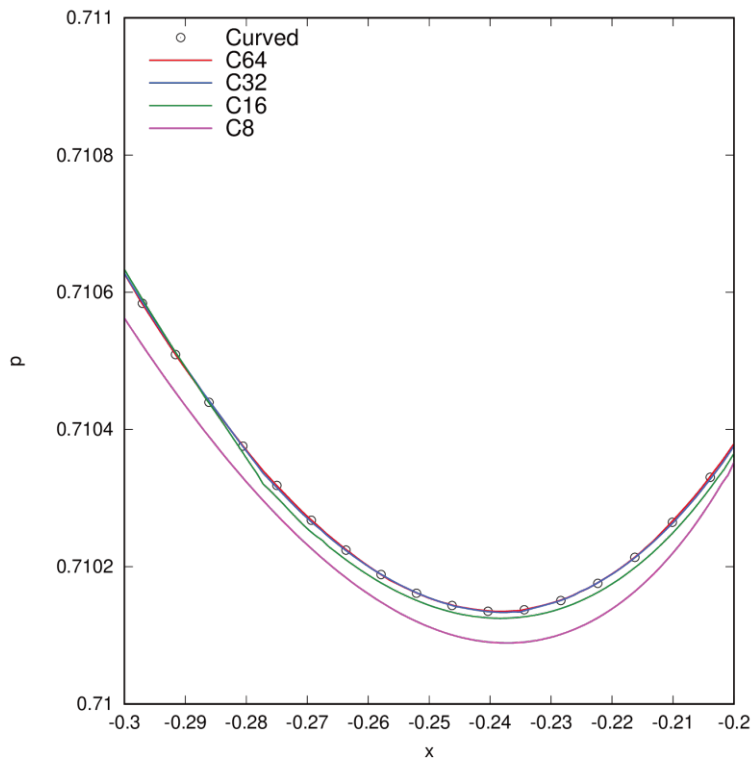

Fig. 2: Pressure distribution around a cylinder (enlarged view)

Publications

- Non peer-reviewed papers

1) H. Asada, "Dispersion and dissipation analysis for unphysical modes of high-order discontinuous Galerkin methods", AIAA paper, AIAA 2020-1317, 2020.

- Oral Presentations

1) H. Asada, "Dispersion and dissipation analysis for unphysical modes of high-order discontinuous Galerkin methods", Scitech 2020, Hyatt Regency Grand Cypress, Orland, Florida, January, 2020.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	32 - 1028
Elapsed Time per Case	30 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.23

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,998,807.64	0.24
SORA-PP	6,301.76	0.04
SORA-LM	4.30	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	3.18	0.00
/data	3,255.21	0.06
/ltmp	651.04	0.06

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on Aerodynamic Characteristics and Flow Fields for Mars Exploration Airplane

Report Number: R19EACA18
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11544/

Responsible Representative

Seiichiro Morizawa,　Lecturer, National Institute of Technology, Okinawa College

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Seiichiro Morizawa(morizawa@okinawa-ct.ac.jp)

Members

Seiichiro Morizawa

Abstract

The discussion on the aerodynamic characteristcs for a Mars exploration airplane was conducted. The atmospheric condition of Mars environment is quite different from that of Earth one. The flight condition of the airplane is low Reynolds number flow, and the aerodynamic data is insufficient for designing Mars airplan. So, study with CFD of fhe airplan was conducted for future Mars exploration. In this study, the effect of a clipped delta wing with and without dogtooth were investigated at a low Reynolds number flow (Re = 23,000).

Reasons and benefits of using JAXA Supercomputer System

In order to conduct three-dimensional CFD, a huge computatinal memories and costs are required. It is almost impossible to have a computation by the workstation at our laboratory. So it is nessesary to conduct our reseach with a super-computer.

Achievements of the Year

The lift-curve with dogtooth becomes slightly larger than that without dogtooth, but the maximum lift coefficient with dogtooth is small because the sudden drop in the lift-curve occurs at higher angle of attack and the stall of wing-tip is more pronounced. It is found that the leading-edge separations occurs in two positon, where are wing-root and dogtooth. However, it is difficult to discern them when the angle of attack is higher due to the acceleration of flow from dogtooth. By contrast, the drag-cure with dogtooth has almost the same as that without dogtooth, though there is a difference of the curve between these wings at higher angle of attack. The difference in magnitude relation of these wings is the oppised, and we have been currently analyzied the reason the difference.

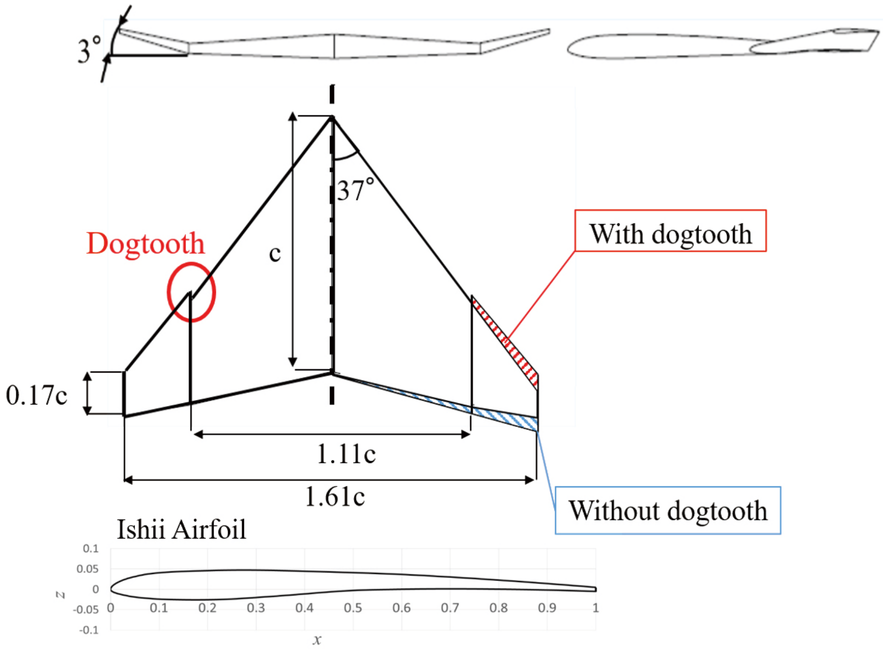

Fig. 1: Wing geometries of clipped delta wing with and without dogtooth

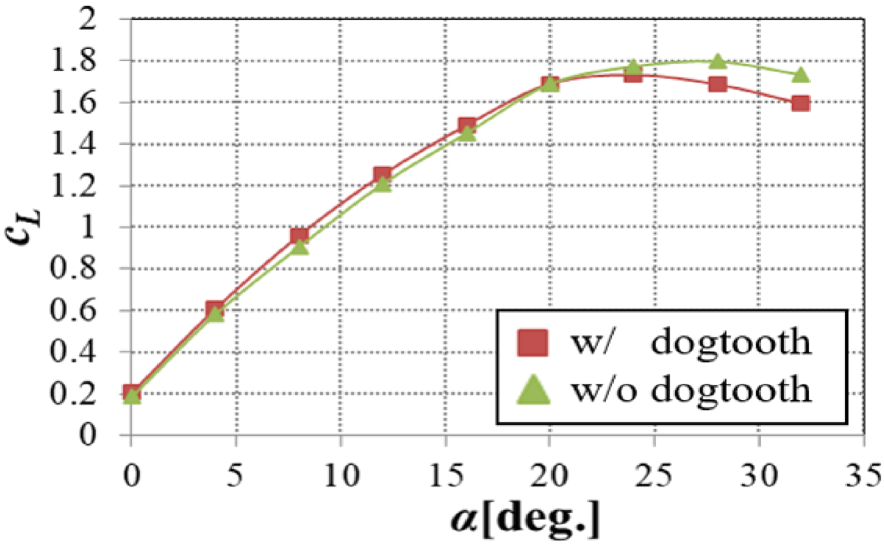

Fig. 2: Difference in lift coefficient with and without dogtooth of clipped delta wings

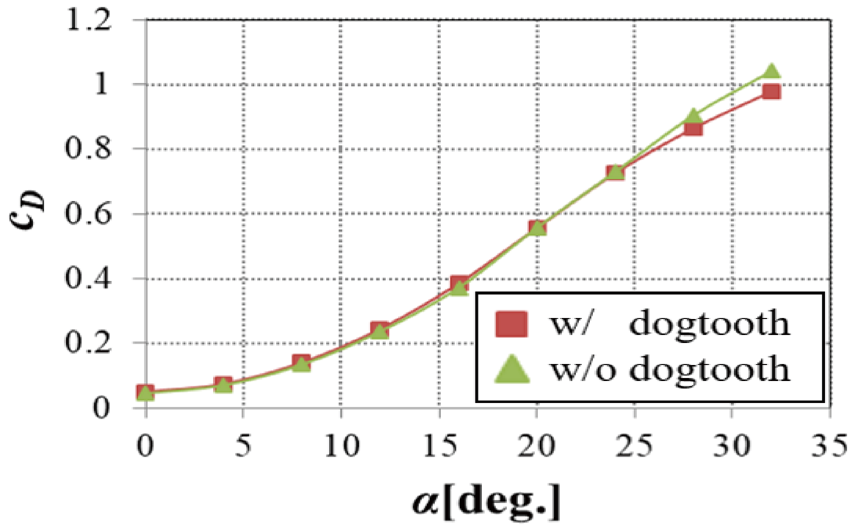

Fig. 3: Difference in drag coefficient with and without dogtooth of clipped delta wings

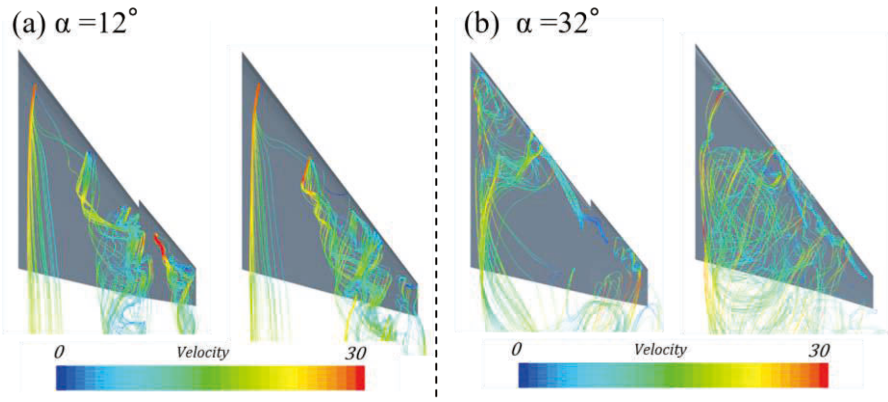

Fig. 4: Difference of flow field with and without dogtooth of clipped delta wings

Publications

- Oral Presentations

1) S. Morizawa, K. Tokura, and H. Kawazoe, "Aerodynamics Characteristics of Dogtooth on Clipped Delta Wing for Mars Airplane, " 32nd International Symposium on Space Technology and Science, e-47, Fukui, Japan, 2019.

2) N. Okamaoto, T. Unoguchi, H. Kawazoe, T. Matsuno, and S. Morizawa, "Aerodynamics Characteristics of a Mars Exploration Aircraft with the Delta Wing Deployed in Its flight, " 32nd International Symposium on Space Technology and Science, e-44, Fukui, Japan, 2019.

- Poster Presentations

1) N. Okamoto, M. Kosaka, T. Unoguchi, S. Morizawa, H. Kawazoe and S. Obayashi, "Numerical Estimation of the Flight Range of a Gliding Mars Exploration Aircraft Based on Experimental Results," Sixteenth International on Flow Dynamics, CRF-68, Sendai, Japan, November 6-8, 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1
Elapsed Time per Case	300 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	152,456.20	0.02
SORA-PP	146.52	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	243.19	0.20
/data	4,930.50	0.08
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Supersonic and hypersonic aerodynamic characteristics of a projectile with shock wave interference

Report Number: R19EACA20
Subject Category: JSS2 Inter-University Research
URL: https://www.jss.jaxa.jp/en/ar/e2019/11545/

Responsible Representative

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Members

Keiichi Kitamura, Hiroyuki Takimoto, Naoya Hase, Hiroto Yaginuma

Abstract

In the velocity region where shock waves are generated, there are various difficulties in numerical calculations, as well as many undiscovered flow physics. In this study, we performed various numerical calculations under supersonic conditions: high-speed buffet conditions for a wing with shock wave oscillation, supersonic flow conditions around rocket configurations including clustered cold plume jet interference, and a hypersonic flow around a blunt-body interacting with a side jet for its attitude control. Throughout these simulations, we pursued a new, shock-related, flow physics covering a wide range of velocity conditions.

Reasons and benefits of using JAXA Supercomputer System

Reproduction of shock wave oscillation by high-speed buffet, reproduction of cold plume jet interference in supersonic flow, and reproduction of aeroheating on blunt body by hypersonic flow / side-jet aerodynamic interaction are all tough calculations. Thus, they require high resolutions in space and time, and hence, the computation cost.

Achievements of the Year

1. Suppression of high-speed buffet by Vortex Generator

For a transonic two-dimensional airfoil NASA SC (2) - 0518 with a chord length c = 200 [mm], a Reynolds number Re = 5x10^6 with a uniform flow Mach number M = 0.7, we changed each parameter of Blade-type-VG (Figure 1 shows VG position Cv = 0.2 (= x / c), VG height Hv = 1.2 [mm], VG distance Dv = 40 Hv (= 48 [mm]), VG length Lv = 4 Hv (= 4.8 [mm]), with VG angle Av = 20 [degree]). As a result, compared with the base case where the normal shock wave and VG interfered, the lift was improved by arranging Cv more upstream, Hv lower, and Dv smaller. Lv and Av did not affect the flow field significantly.

2. Interaction of clustered cold plume jets ejected from rocket shape in supersonic flow

A supersonic jet was ejected from the nozzle of the three-dimensional projectile model in an environment with a uniform flow Mach number M = 1.5, and the interference between the jet and the uniform flow was observed. In this study, the number of nozzles was set to one or two. As a result, in the case where the distance between nozzles is the largest (the uniform flow interferes with the side surface of the nozzle: ref. Figure 2), the axial force does not increase and the propulsion performance is expected to improve.

3. Numerical Simulation on Hypersonic Heating associated with Jet Aerodynamic Interaction

Under the condition of uniform flow Mach number M = 8.1, supersonic air was injected from two nozzles (nozzle diameter Dj = 1.5 [mm]) installed behind a blunt body with length L = 120 [mm] and radius of curvature Rb = 20 [mm]. A set of numerical simulations were performed by changing the distance between the nozzles and their arrangement. As a result, when the nozzles were arranged in the direction of the freestream, the heat flux peak value became the maximum at the distance between the nozzles of 3.36 Dj (the smallest among the calculation cases), as shown in Fig. 3 for the heat flux contours and streamlines on the surface. It has also been clarified that the flow field upstream of the nozzle was not significantly affected by the arrangement of the nozzles.

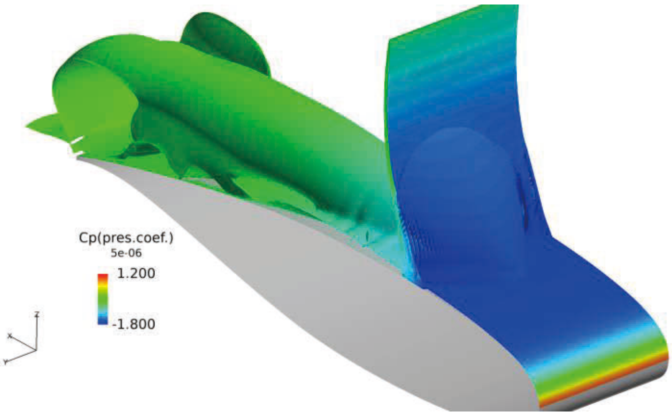

Fig. 1: Q iso surface colored with pressure coefficient Cp (suppression of high-speed buffet by Vortex Generator)

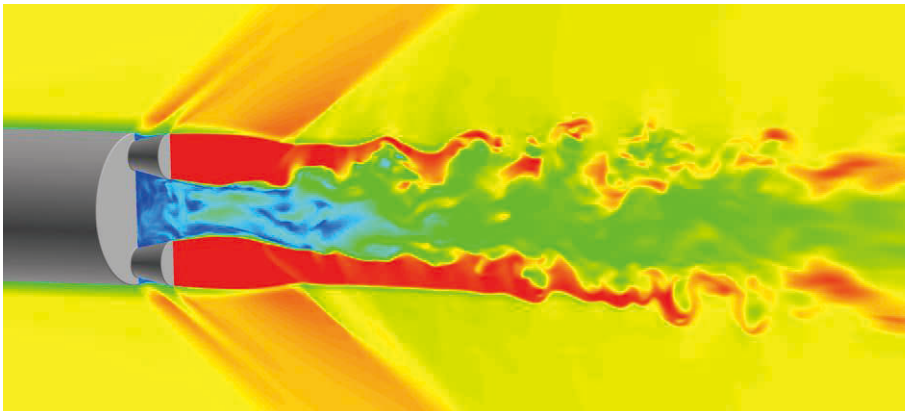

Fig. 2: Mach number for the case where the distance between nozzles is the largest

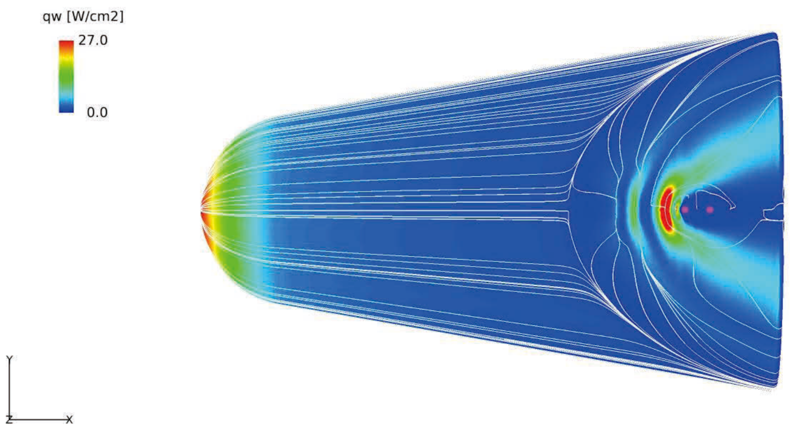

Fig. 3: Computed surface flow pattern and heat flux contours at distance between nozzles of 3.36Dj (Numerical Simulation on Hypersonic Heating associated with Jet Aerodynamic Interaction)

Publications

- Oral Presentations

Naoya HASE, Keiichi KITAMURA, "Hypersonic Aeroheating Computation on Side Jet Aerodynamic Interaction", The Japan Society of Fluid Mechanics Annual Meeting 2019

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	288 - 480
Elapsed Time per Case	30 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.33

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	2,498,744.81	0.30
SORA-PP	28,795.33	0.19
SORA-LM	12,351.37	5.16
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	288.01	0.24
/data	9,670.26	0.17
/ltmp	2,343.75	0.20

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	2.97	0.07

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research and Development

Aeroacoustic simulation of launch vehicle at lift-off

Report Number: R19EG3213
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11609/

Responsible Representative

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Abstract

It is required to predict and reduce the acoustic level of satellites caused by exhaust jet of rocket engines and transonic buffet. In this study, the lift-off acousitc analysis tool developed so far is coupled with the FEM tool to predict the acoustic level inside payload fairing, aiming to develop quiet launch vehicle.

Reasons and benefits of using JAXA Supercomputer System

It is necessary to carry out billions of LES analysis, and large computing resources are essential to achieve the target frequency resolution.

Achievements of the Year

Aero-vibro acoustic simulation for the prediction of harmful acoustic loading at lift-off of launch vehicle is developed. In this simulation technique, high-fidelity large-eddy simulation with computational aeroacoutics based on full-Euler equations is employed for computing jet aeroacoustics and their propagation to the outside of payload fairing. Acoustic field inside the payload fairing is computed by the coupled vibro-acoustic simulation based on finite element method.

A simplified fairing model is used for the validation of the present method. An impact hammer test is conducted for validating the structural model in FEM analysis. Then, accuracy of the coupling method is validated by using the acoustic vibration test result with a subscale rocket engine. According to the result obtined last year, the bolt model of FEM had large impact on the mode shape of the simplified fairing model and the internal acoustic level. Therefore, the parameters of the bolt model were identified by the Bayesian optimization for the experimental modal analysis results.(Fig.1) Then, the accuracy of predicting internal acoustic environement was examined.(Fig.2)

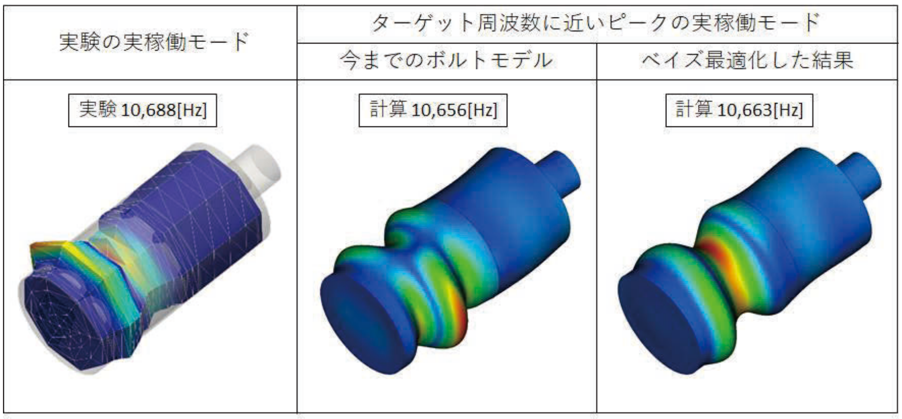

Fig. 1: Comparison of modal shape.

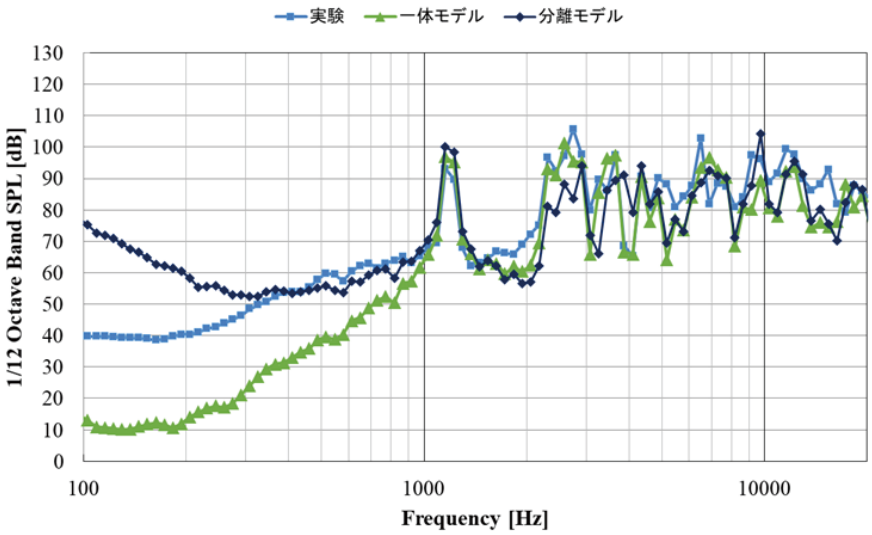

Fig. 2: Comparison of internal acoustic level.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	700 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.80

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	6,602,380.65	0.80
SORA-PP	112,991.44	0.73
SORA-LM	3,071.42	1.28
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	8,252.68	6.87
/data	39,807.28	0.68
/ltmp	5,776.75	0.49

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	125.96	3.17

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Combustion analysis technology

Report Number: R19EG3212
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11608/

Responsible Representative

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Abstract

To capture the unsteady phenomena in the liquid rocket engine, combustion large eddy simulations (LES) are carried out, and this evaluation tool is validated by comparing with a sub-scale test.

Ref. URL: http://www.kenkai.jaxa.jp/eng/research/software/software.html

Reasons and benefits of using JAXA Supercomputer System

Since the flow and combustion in rocket chambers are in a turbulent state and have nonstationary characteristics, LES analysis is essential. Even in this verification target, analysis calculation of about several million steps is required for grid of tens of millions of cells, so it is impossible to achieve the target without using supercomputer.

Achievements of the Year

1. Towards full-scale combustion chamber simulations, large eddy simulation (LES) of an oxygen/hydrogen subscale combustion chamber is performed. JAXA's in-house CFD solver LS-FLOW is used in the simulation. A new wall model for reacting flows is applied to characterize the near-wall flow, reducing about 1000 times of computational cost compared with the conventional wall resolved LES. For combustion modeling, the non-adiabatic flamelet progress variable approach is used. The number of grid point is approximately 83 million. Figure 1 shows the instantaneous temperature field. The present simulation captures the complex turbulent combustion field and flame/wall interaction structures.

2. In order to realize accurate and efficient combustion LES, we have developed a high-order unstructured grid

solver LS-FLOW-HO based on the flux reconstruction method. Localized Laplacian artificial diffusivity (LLAV) is introduced to stably capture the discontinuous interface of the multi-component, thermally perfect gas while maintaining the turbulence resolution. The Flamelet model, which can handle many chemical species efficiently, is adopted as the combustion model. Figure 2 shows the computational results of the methane / oxygen single injector combustor. The number of grid cells is 110,496, and the degrees of freedom are 2,983,392 (p2, third-order) and 7,071,744 (p3, fourth-order). Even with a coarse grid of about 3 cells in the shear layer, the development of turbulence has been captured with the fourth-order scheme. The parallelization method is MPI / OpenMP hybrid. It uses FX100's 2048 cores (144 processes times 8 threads) and the computation time is about 72 hours. In the future, tuning for further acceleration will be performed, and GPU will be supported by OpenACC.

Fig. 1: Instantaneous temperature field of Oxygen / hydrogen subscale combustion chamber.

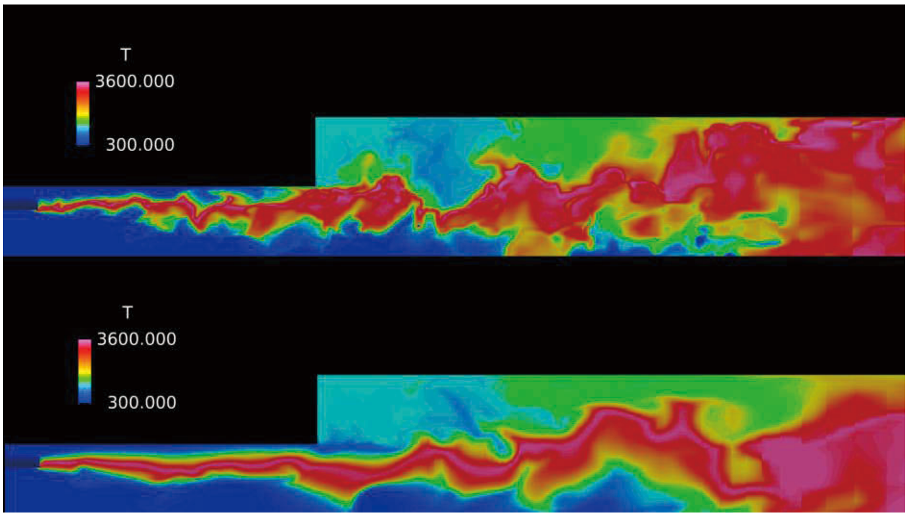

Fig. 2: Close up view of the temperature distribution near the injector (recess 12 mm). (Top: p3, fourth order, bottom: p2, third order)

Publications

- Peer-reviewed papers

Muto, D., Daimon, Y., Shimizu, T., Negishi, H., An equilibrium wall model for reacting turbulent flows with heat transfer, International Journal of Heat and Mass Transfer, 141, 2019, 1187-1195, 10.1016/j.ijheatmasstransfer.2019.05.101.

- Invited Presentations

Haga, T., Shimizu, T., Toward high-fidelity large-eddy simulation of liquid rocket combustors using flux-reconstruction method, Japan-Korea CFD workshop 2019.

- Oral Presentations

1) Haga, T., Muto, D., Daimon, Y., Negishi, H., Shimizu, T., Haidn, O., Combustion modeling study for GCH4/LOX and GCH4/GOX single element combustion chambers, Sonderforschungsbereich/Transregio 40 - Annual Report, 2019.

2) Muto, D., Daimon, Y., Shimizu, T., Negishi, H., Wall-modeled large eddy simulation for predicting wall heat flux in a rocket combustion chamber, 8th EUCASS, 2019, 10.13009/EUCASS2019-252.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	144 - 3840
Elapsed Time per Case	480 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 2.26

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	19,154,883.89	2.33
SORA-PP	193,720.34	1.25
SORA-LM	13,944.48	5.82
SORA-TPP	476.92	0.03

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	8,917.82	7.43
/data	116,157.45	1.99
/ltmp	19,652.93	1.67

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	129.86	3.27

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Development of High-fidelity Re-entry Safety Analysis Methods

Report Number: R19EG3216
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11612/

Responsible Representative

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Abstract

High-fidelity re-entry safety analysis code LS-DARC is under the development in JAXA in order to realize the accurate EC predictions and the design-for-demise for the rocket upper statges and space-crafts.6 Dof trajectory analysis, aerodynamics, heat flux, 3D thermal conductance can be considered by the coupling analysis code based on the reduced order models. Since models in LS-DARC is versatile and its turn-around time is very short, it has been applied wide range of aerospace engineering applications such as the research and development activities for HTV small re-entry capsule : HSRC and the fly-back re-usable rocket.

Reasons and benefits of using JAXA Supercomputer System

Probabilistic re-entry safety analysis based on the multi disciplinary coupling analysis with considering various uncertainty factors is essential. In addition consideration on the design parameter effect should also be considered. In addition, in-house computational environment is essential also for security reason. Consequently, JSS2 is essential.

Achievements of the Year

In this fiscal year, the re-entry safety analyses for the full configuration of the rocket upper stages and the rocket engine have been conducted for the LS-DARC development, which is the high-fidelity multi-desciplinary coupling analysis tool of JAXA.

As a result, the parameter sensitivity analysis on the expected casualty risk, the identification of the further improvement tasks especially on the heat flux and the aerodynamic characteristics models, tool improvements for the practical analysis on the complicated shapes and configurations have been carried out. Furthermore, the validation analyses for the analysis capability to handle separated multiple fragments have also been carried out. Schematic overview of models of LS-DARC and the example results of the surface heat flux is shown as Fig. 1.

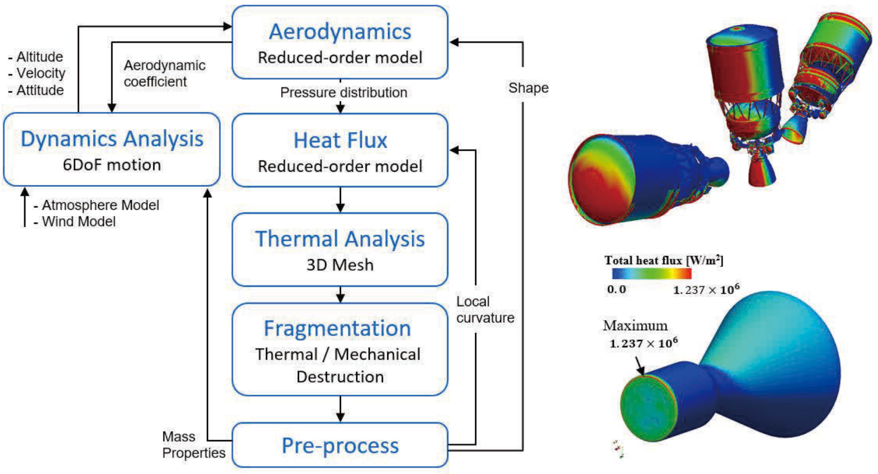

Fig. 1: Schematic overview of the multi-disciplinary high-fidelity re-entry analysis code LS-DARC, and surface heat flux distributions for HIIB upper stage and rocket engine.

Publications

- Non peer-reviewed papers

Fujimoto, K., Negishi, H., Daibo, T., Iizuka, N., Shimizu, R., and Okita, K., "High-fidelity Spacecraft-oriented Re-entry Safety Analysis Code of JAXA : LS-DARC," 10th IAASS, 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	MPI
Number of Processes	32 - 192
Elapsed Time per Case	168 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	105,968.96	0.01
SORA-PP	38.07	0.00
SORA-LM	0.00	0.00
SORA-TPP	3.15	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	406.85	0.34
/data	25,781.24	0.44
/ltmp	15,406.12	1.31

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.60	0.04

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Liquid-Propellant Propulsion System Simulation

Report Number: R19EG3215
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11611/

Responsible Representative

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Abstract

Next generation of space transport systems need not only to reduce costs with high perfoemance propulsion for a particular mission but also to meet requirements of various missions, for example moon lander, reusable upper stage rocket, Mars mission, and so on. Liquid-Propellant System Analysis has an important roll to develop the next generation space transport system. Utilizing 3D numerical simulation results of the liquid rocket compornents, componet models are developed for the system analysis. The system analysis will use for evaluation of the development and operation for liquid rocket or spacecraft.

Reasons and benefits of using JAXA Supercomputer System

Component models of liquid propulsion systems are conventionally very simple and sometimes not consistent with physics of fluid dynamis or structural behaivor of propulsion systems. However, because of the recent development of computer science, even computationally expensive models can be used for numerical analysis for designs. In addition, high-fidelity CFD clarified physical phenomena in the component, and it enhances to develop more accurate component models. Concequently, high-fidelity CFD analyses are essential to clarify the phenomena in the liquid propulsion system. JSS enables us to carry out trade-off studies with a wide range of parameter, which contribute to build new models and find out new insights of liquid propulsion systems.

Achievements of the Year

Pressure spikes, so-called water hummer, happen to liquid propulsion systems of spacecraft when thruster valves are closed in a very short time. The water hummber induces steady pressure oscillations in certain resonant frequencies, and such pressure oscillations are possibly enhanced if frequencies of thruster operations meet those of resonant frequencies of hydraulic systems. Introduce of buffer tanks which have larger volumes than feed pipes is one of the ways to supress the pressure resonance because the buffer tanks can damp the pressure oscillations. A drawback of the buffer tanks is the mass weight. So, the present study explored if any inner devices of the buffer tanks can enhance the damping effects of the pressure oscillations by running CFD simulations.

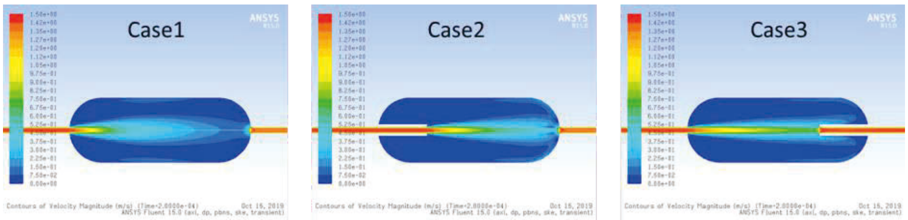

Fig. 1: Instantaneous profiles of the absolute velocity in buffer tanks

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1 - 16
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.59

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	212,429.01	0.03
SORA-PP	1,544,724.78	10.01
SORA-LM	15.46	0.01
SORA-TPP	564.83	0.03

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	558.68	0.47
/data	22,866.18	0.39
/ltmp	13,273.96	1.13

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.60	0.04

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Long-term orbital environment prediction by orbital debris evolutionary model

Report Number: R19EG3105
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11602/

Responsible Representative

Hiroyuki Sugita, Research and Development Directorate, Research Unit II

Contact Information

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Members

Satomi Kawamoto, Yasuhiro Kitagawa, Nobuaki Nagaoka

Abstract

Increase of space debris is a problem for reliability of future space activity. JAXA has researched space debris related technology for space debris mitigation and environmental remediation. The guidelines for countermeasures of space debris are researched based on the prediction of future orbital environment using the orbital debris evolutionary model (NEODEEM) jointly developed by JAXA and Kyushu University.

Ref. URL: http://www.kenkai.jaxa.jp/eng/research/debris/debris.html

Reasons and benefits of using JAXA Supercomputer System

NEODEEM predicts the situation of over 200 years orbital propagations of more than 20000 elements and orbital events by using Monte-Carlo method. Therefore, JSS2 is used to reduce run time and to process a large amount of data. Only SORA_PP is used for compatibility with PC version (WINDOWS).

Achievements of the Year

Study of some indices expected to be effective in reducing future orbit debris performed using NEODEEM, to evaluate the effects of various related parameters (e.g. dependency on the altitude of active debris removal (ADR) object (Figure 1) , ADR starting time (Figure 2), and dependency on disposal altitude and speed).

The impact on the orbital environment by mega-constellation system in which a huge number of satellites are placed in orbit is also evaluated.

These results are used as a basis for evaluating the effectiveness of countermeasures of debris mitigation and discussing international rules.

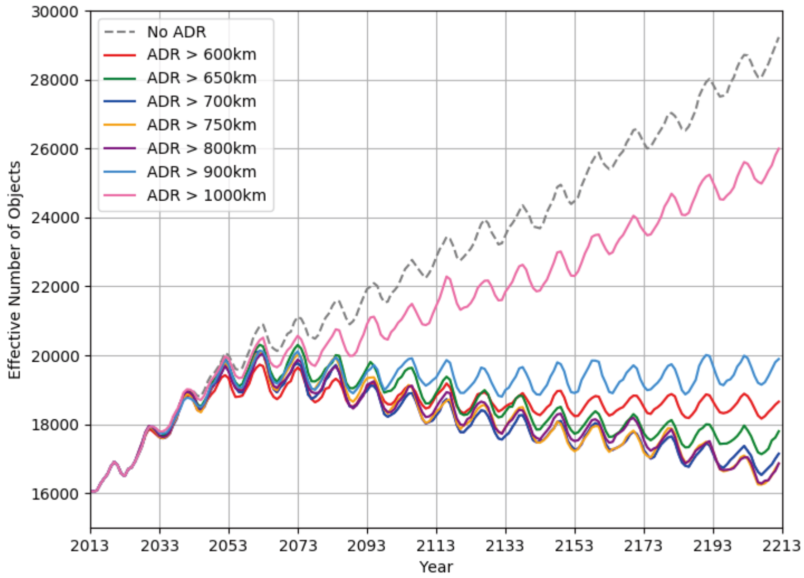

Fig. 1: Effect of ADR object altitude (five disposal objects per year)

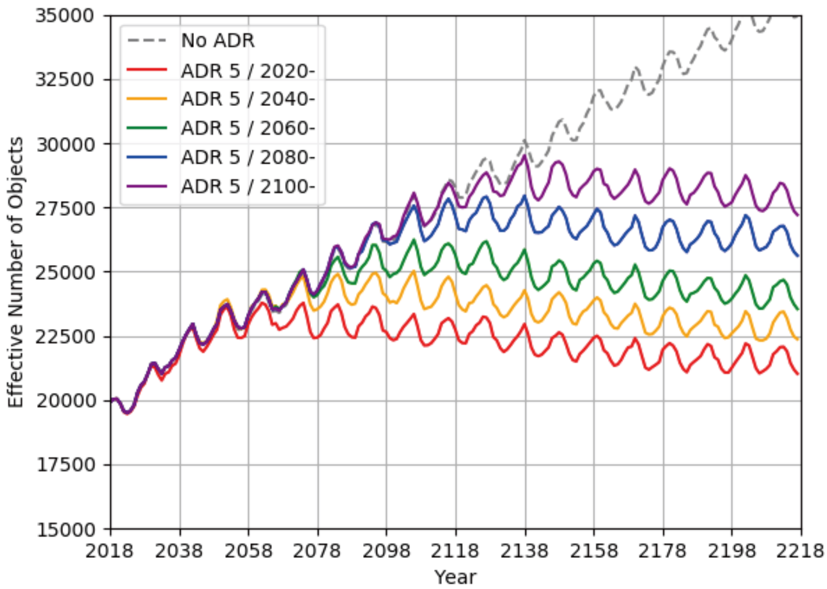

Fig. 2: Effect of ADR starting time

Publications

- Non peer-reviewed papers

1)Kawamoto, S., Nagaoka, N., Sato, T., and Hanada, T, "Impact on Collision Probability by Post Mission Disposal and Active Debris Removal", The First International Orbital Debris Conference (IOC) 2019.

2)Kawamoto, S., Nagaoka, N., Hanada, T., Abe, S. "Evaluation of Active Debris Removal Strategy Using a Debris Evolutionary Model", 70th International Astronautical Congress (IAC)　2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	Assigning Monte-Carlo runs with same initial conditions to multiple cores
Thread Parallelization Methods	N/A
Number of Processes	10
Elapsed Time per Case	60 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.25

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	691,812.13	4.48
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	19.07	0.02
/data	190.73	0.00
/ltmp	3,906.25	0.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.01	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Simulation of Rocket Turbopumps

Report Number: R19EG3214
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11610/

Responsible Representative

Eiji Shima, Research and Development Directorate, Research Unit III

Contact Information

Hideyo Negishi(negishi.hideyo@jaxa.jp)

Members

Hideyo Negishi, Shinji Ohno, Taro Fukuda、 Andrea Zambon, Ashvin Hosangadi

Abstract

Turbopumps are still one of key components in liquid rocket engine development in terms of cost, time, and risks. Furthermore, a turbopump itself is a complex system consisting of sub-components such as pump, turbine, bearing, balance piston, sealing and so on. From numerical simulation technology point of view, there is no technology able to evaluate performance of an entire turbopump system in the world. And also, accuracy and fidelity of numerical simulation technology for sub-components are still poor and cannot be used to reduce the number of experiments. Therefore, experiments are indispensable to evalute feasibility of considered design in engine development.

In this study, numerical simulation technology of an entire turbopump system able to be applicable in engine design phase has been developed enhancing accuracy and fedelity. We are aiming at reducing cost and time for future engine development by making full use of our numerical simulation to reduce the number of experiments. And also, innovative design methodology for higher performance rocket turbopumps has been investigated by using our numerical simulations.

Ref. URL: http://stage.tksc.jaxa.jp/jedi/simul/index.html

Reasons and benefits of using JAXA Supercomputer System

In this study, JSS2 has been used because of the following reasons:

(1) To make it possible to perform large-scale numerical simulations with high accuracy and fidelity

(2) To produce a lot of computed results on time within limited short period of time under JAXA's rocket development

(3) To ensure information security about rocket-related technical information in JAXA's network only

Achievements of the Year

In the fiscal year 2019, the three-dimensional compressible URANS simulation taking into account cryogenic physical properties based on NIST database was applied to liquid rocket hydrogen and oxygen pumps. The computed results showed that the computed pressures in the pumps agreed well with experimental results within 4% error. And also, a supersonic turbine simulation was carried out under the collaboration between DLR and JAXA. Based on the computed results, JAXA has proposed appropriate turbine geometries and measurement positions for a turbine rig test that will be conducted in FY2020.

The developed numerical simulation approach has been employed in the booster engine LE-9 development of H3 launch vehicle.

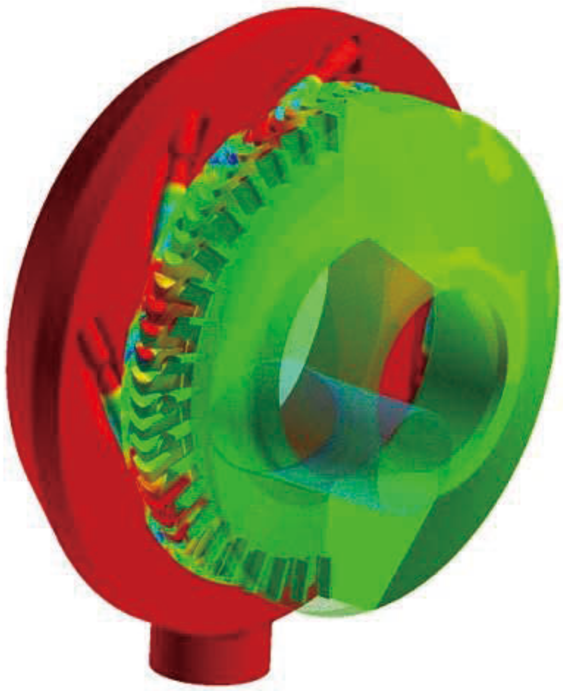

Fig. 1: Pressure distribution of the DLR supersonic turbine

Publications

- Non peer-reviewed papers

(1) Negishi, H., et al., "LUMEN Turbopump -Preliminary CFD Analysis of a Supersonic Turbine with Axisymmetric Nozzles," 32th International Symposium on Space Technology and Science, ISTS 2019-a-08, Fukui, Japan,June. 15-21, 2019.

(2) Negishi, H., et al., "Numerical Study of Tip Clearance Effects in a Centrifugal Pump with Unshrouded Impeller for Liquid Rocket Engines," AIAA Propulsion and Energy Forum, AIAA paper 2019-4433, Indianapolis, IN, August 19-22, 2019.

(3) Negishi, H., et al., "Numerical Study of Tip Clearance Effects in a Centrifugal Pump with Unshrouded Impeller for Liquid Rocket Engines," 81st Turbomachinery Society of Japan, Academic conference, Okayama, Japan, Sep. 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	FLAT
Number of Processes	128 - 16000
Elapsed Time per Case	300 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.51

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	4,396,117.93	0.53
SORA-PP	17,332.89	0.11
SORA-LM	1,069.75	0.45
SORA-TPP	847.35	0.05

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	482.46	0.40
/data	31,272.39	0.54
/ltmp	17,115.11	1.45

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	3.90	0.10

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Project support activity using numerical simulation

Report Number: R19EG3211
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11607/

Responsible Representative

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Members

Takayuki Ito, Ryoji Takaki, Seiji Tsutsumi, Hiroyuki Ito, Taro Shimizu, Junya Aono, Takanori Haga, Yuhi Morii, Masaharu Abe, Masayuki Kakehi, Mikiroh Motoe, Manabu Hishida, Hideyo Negishi, Yoichi Ohnishi, Miki Nishimoto, Yu Daimon, Ashvin Hosangadi, Takeru Fukuchi, Masaaki Ino, Osamu Fukasawa, Shinji Ohno, Andrea Zambon, Takenori Nakajima, Takashi Amemiya, Yutaka Umemura, Hironori Fujiwara, Hiroumi Tani, Keiichiro Fujimoto, Tetsufumi Ohmaru, Taroh Fukuda, Masashi Toyama, Kei Nishimura, Daiki Muto, Issei Masaie, Susumu Sato, Satoshi Ukai, Hidenao Takahashi, Kota Akai, Takahiro Shimizu, Rika Yamada, Kohki Tao

Abstract

Utilize the simulation technology of Reserch Unit III to deal with the technical problem solving in current JAXA project, and respond to the request for the project concerning issue. In addition, it realizes "added value (efficiency improvement, high reliability, cost / period reduction, ripple effect, etc.)" unique to numerical simulation technology.

Ref. URL: http://www.kenkai.jaxa.jp/eng/research/software/software.html

Reasons and benefits of using JAXA Supercomputer System

In order to respond timely to project requirements, it is necessary to simulate complex geometries of actual spacecraft and to analyze a large number of conditions in a short period.

Achievements of the Year

With regard to H3, SLIM, HTV-X projects, evaluation of design and risks as well as studies for improvement were carried out by making full use of the simulation technology of Reserch Unit III and JSS2.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	FLAT
Number of Processes	100 - 400
Elapsed Time per Case	100 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.53

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	3,474,184.09	0.42
SORA-PP	63,846.03	0.41
SORA-LM	2,219.54	0.93
SORA-TPP	80,091.41	4.83

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	10,060.64	8.38
/data	136,556.55	2.34
/ltmp	26,879.49	2.28

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	123.75	3.11

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research on Radiation Protection Technology

Report Number: R19EG3210
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11606/

Responsible Representative

Koji Yamanaka, Director, Research and Development Directorate, Research Unit I

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Kazunori Shimazaki, Research and Development Directorate, Research Unit I(shimazaki.kazunori@jaxa.jp)

Members

Aki Goto, Kazunori Shimazaki

Abstract

In order to realize future human space mission while ensuring astronauts safety, space-radiation protection technologies are required. Our goal is to establish the accurate estimation technology of space-radiation exposure doses and the method to optimize shielding designs for spacecrafts.

Reasons and benefits of using JAXA Supercomputer System

We use JSS2 for PHITS (Particle and Heavy Ion Transport code System) Monte Carlo simulations to estimate shielding effects of materials against space radiations. PHITS Monte Carlo simulations take a large amount of time when the computational system is large and complex, such as the system simulated manned-spaceship structure. Such simulations enable to be run at high speed with statistical accuracy by using JSS2.

Achievements of the Year

It is needed to establish exposure dose estimation technology based on numerical simulation using radiation transport code for radiation protection. We are addressing a dose prediction using a Monte Carlo code and verifying its validity by comparing with standard prediction tool historically used in the space development filed. PHITS (Particle and Heavy Ion Transport code System) Ver. 3.16[1-4] was used as the radiation transport Monte Carlo code and CREME96 [5] was used as a standard prediction tool in this study.

CREME96 can easily and quickly estimate the integral flux as a function of effective LET (Linear Energy Transfer) in a material placed behind Al-shielding against the galactic cosmic ray (GCR). The calculation can be, therefore, repeatedly performed in a short time while changing the shielding thickness. However, although this standard tool is very powerful and proven tools, it has some limitations. For example, it assumes a very simple flat plate structure. In addition, it cannot consider the influence of secondary particles (neutrons etc.) generated by nuclear reactions between Al-shieling and incident charged particles.

Then, the effective LET dependence of the integral flux in Si was calculated by CREME96 and PHITS when the

GCRs were the incident particle. For the GCR spectra, we used the GCR model (outside the Earth's magnetosphere at 1 AU) of the solar minimum (1977) provided by CREME96. The nuclides used were hydrogen (Z = 1) to nickel (Z = 28). Fig. 1 shows a part of the spectra used. In the calculation, a two-layer model of Al and Si was used. The Al shielding thickness was 100 mil and 3000 mil.

Figs. 2 and 3 show the calculation results. When the Al-shielding was thin (100 mil), the integral flux as a function of the effective LET showed good agreement between CREME96 and PHITS. When the Al-shielding was thick (3000 mil), a slight difference occurred at the low effective LET region and the region of 200 to 1000 MeV cm2 / g. These differences are probably due to differences in the used calculation code, nuclear cross section, etc. In particular, the influence of secondary particles cannot be considered in CREME96. Hence, the influence of secondary particles (in fact, particles generated by neutrons generated in Al) is shown by a blue dashed line in Figs. 2 and 3. As a result, in the case of Al-shielding 3000 mil, we can observe that the influence of particles generated by neutrons appears in the region of 200 to 1000 MeV cm2 / g. Therefore, PHITS will be able to estimate the radiation flux after shielding when the shielding is so thick that the influences of secondary particles cannot be ignored.

[1] T.Sato et al., J.Nucl.Sci.Technol.55, 684-690 (2018).
[2] A. Boudard et al., Phys. Rev C87, 014606 (2013).
[3] H. Hirayama et al., SLAC-R-730 (2005) and KEK Report 2005-8 (2005)
[4] K. Iida, A. Kohama, and K. Oyamatsu, J. Phys. Soc. Japan 76, 044201 (2007).
[5] https://creme.isde.vanderbilt.edu/

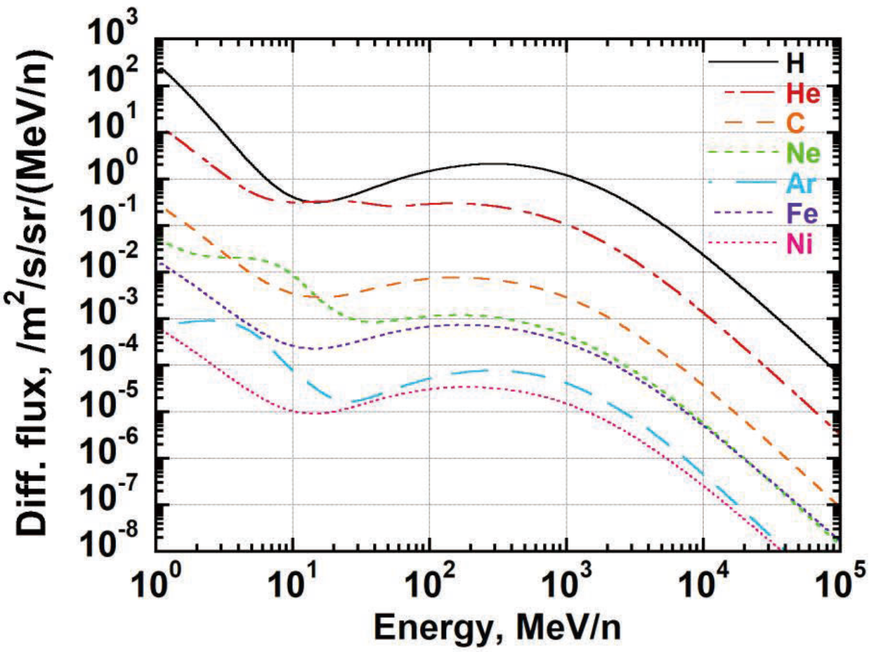

Fig. 1: Particle energy spectra obtained from CREME96 (1977 solar minimum).
Only H (proton), He, C, Ne, Ar, Fe, and Ni spectra are shown.

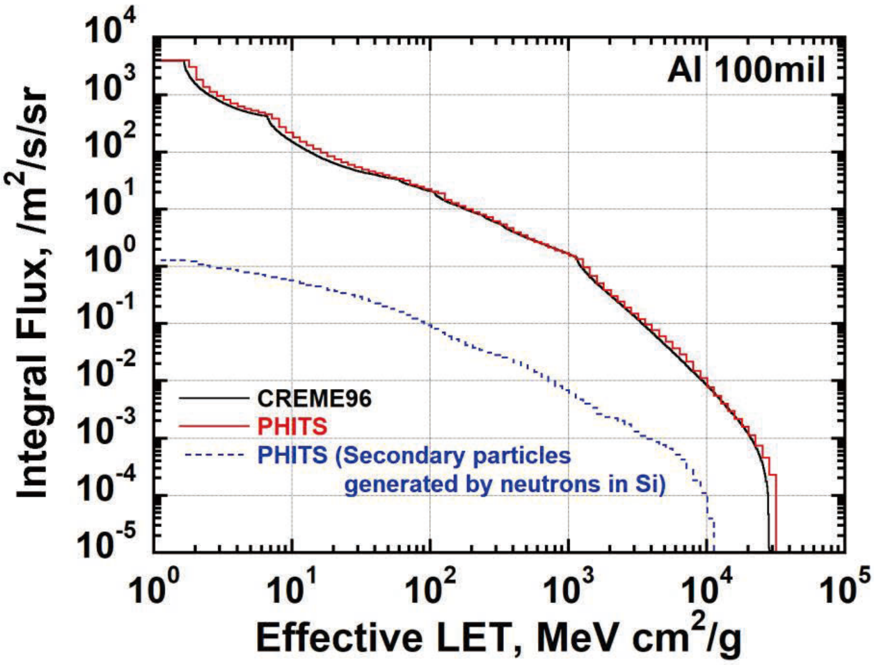

Fig. 2: Integral flux as a function of LET (Al shielding thickness is 100mil)

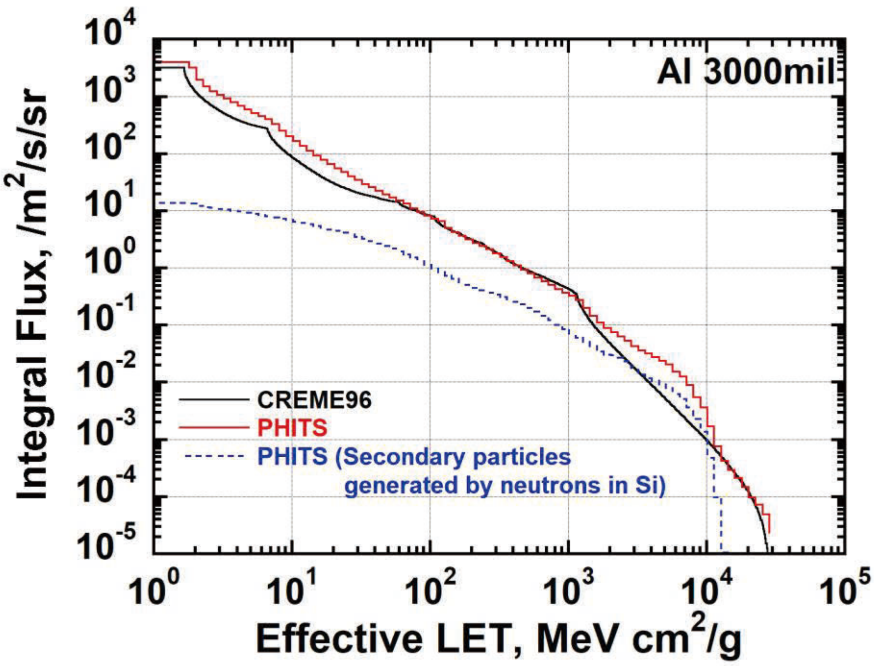

Fig. 3: Integral flux as a function of LET (Al shielding thickness is 3000mil)

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	48 - 300
Elapsed Time per Case	30000 Second(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.21

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	579,345.19	3.75
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	9,651.19	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Reserch of Vasitation Lidar data using HPC

Report Number: R19EDG20200
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11597/

Responsible Representative

Toshiyoshi Kimura, Director, Sensor System Research Group Research and Development Directorate

Contact Information

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Members

Rei Mitsuhashi, Yoshito Sawada

Abstract

To develop an analysis algorithm for vegetation lidar data, we calculate of vasitation lidar simulator and GPU computing using JSS2.

Reasons and benefits of using JAXA Supercomputer System

By calculation on multiple nodes equipped with sufficient memory, the time required for iteration of lidar data proccesing algorithm development is reduced. In addition, we want to comfirm result of distributed deep learning using big remote sensing data.

Achievements of the Year

In this fiscal year, the vegetation rider simulator developed by the Sensor Research Group was executed on JSS2, and more than 1 million cases of simulation could be executed in a short time. In addition, the simulation results were deep-learned using a GPU on the JSS, and a new data analysis algorithm was developed.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 4
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	62,703.96	0.41
SORA-LM	0.00	0.00
SORA-TPP	292.88	0.02

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	9.54	0.01
/data	9,813.31	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on Future Space Transportation System using Air-breathing Engines

Report Number: R19EG3205
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11605/

Responsible Representative

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Members

Masahiro Takahashi, Masatoshi Kodera, Masaaki Fukui, Toshihiko Munakata, Masaharu Takahashi, Sadatake Tomioka, Takuya Arakawa, Hironobu Nishiguchi, Ko Kurihara, Kazunari Hayashi, Hidemi Takahashi

Abstract

Reusable rockets have been being studied to reduce the cost of space transportation systems significantly in recent years. However, in order to extend the structural lifetime, it is necessary to operate them with relatively low engine power, leading to a decrease in launch capability. Therefore, air-breathing engines such as scramjets and rocket/scram combined cycle engines are promising to compensate the drawback. By using oxygen in the atmosphere as an oxidizer, it becomes highly efficient, and it can be expected to maintain and improve the launch capability even if it is reused. In this project, we will research and develop key technology for practical application of the engine.

Reasons and benefits of using JAXA Supercomputer System

The following points are raised as problems of engine design by ground experiments. 1) There are limits to reproducing various airflow conditions from takeoff to hypervelocity range. 2) Measured data is limited and complicated three-dimensional flow structure inside the engine can not be well identified. 3) Since the time and cost are limited, it is not easy to change the engine flow path configuration. Therefore, it is indispensable to utilize 3D CFD as a design tool, and a supercomputer is required for performing numerous CFD works efficiently.

Achievements of the Year

(1) 3D RANS CFD was conducted for a supersonic combustor with a cavity fueled by a methane/ethylene mixed fuel, and sensitivity analyses on boundary conditions and physical models were performed and the effect of the mixture ratio for the fuel was examined.

(2) In order to verify the prediction accuracy of a simple reaction mechanism for ethylene/air combustion, 2D CFD was performed for supersonic combustor flows and the results were compared with the ones using a detailed mechanism.

(3) Numerical analyses on non-reacting flows in a scramjet combustor were carried out using hybrid LES/RANS. It was observed that the fuel distribution changed unsteadily. In particular, the fluctuation was large near the cavity attached to the combustor, and periodic fluctuation was obseved. (Fig. 1)

(4) Thrust performance of airframe-integrated external nozzles of hypersonic aircraft under various environmental conditions in external flows and pressures was evaluated based on numerical simulation. The simulation tool was developed based on OpenFOAM. Results showed that the external-nozzle configuration with the boattail equiped upstream of the primary thruster and with the external nozzle designed by the method of characteristics had significant benefits in thrust performance under any conditions compared to that by the baseline (simple divergent nozzle) configuration. (Fig. 2)

(5) Since a total temperature loss may occur due to heat loss to water-cooled walls of a supersonic wind tunnel with vitiation air heater, which is used for direct-connect style combustion test of scramjet combustor models, 3D combustion CFD was applied to an internal flow of the facility to evaluate the total temperature loss. (Fig. 3)

(6) A ramjet mode flow field in a scramjet combustor with large scale separation was predicted with a RANS method. For finer prediction, modification of turbulent St number through the Scalar Fluctuation Model and/or the compressibility correction was applied. Prediction of a flow field through Pseudo-shock system for pressure recovery remained inadequate. (Fig. 4)

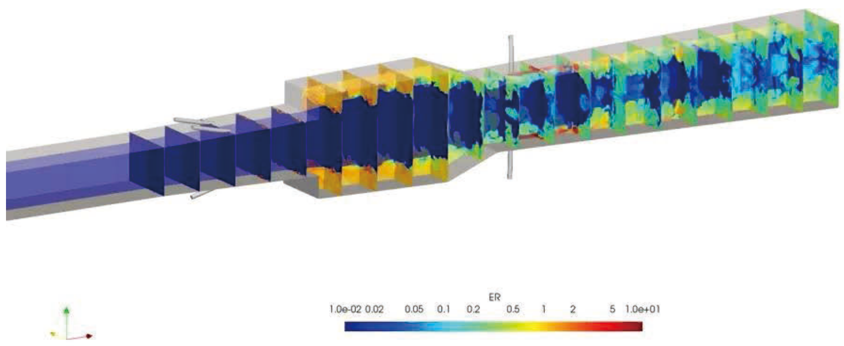

Fig. 1: Periodic fluctuation of equivalence raito distributions (Video. Video is available on the web.)

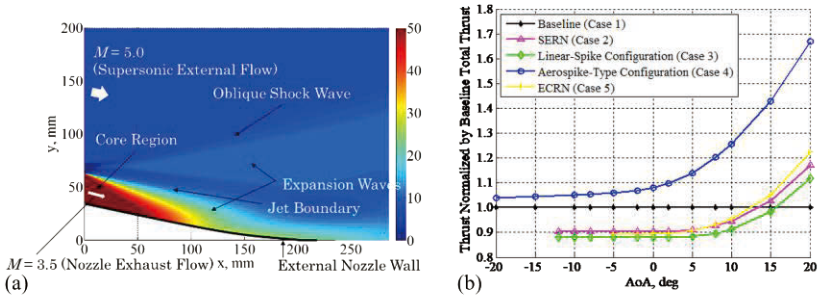

Fig. 2: (a) Pressure distribution around the airframe and nozzle under stable cruise condition at flight Mach number 5.0 for the configuration with the boattail, (b) Influence of the angle of attack on the thrust performance

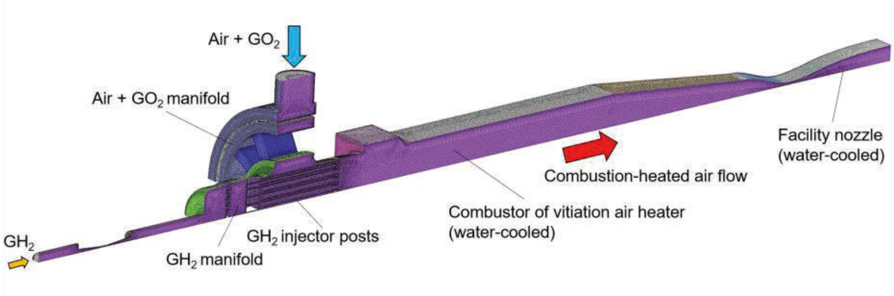

Fig. 3: Numerical grid for simulation to evaluate heat loss of test flow into water-cooled walls of supersonic wind tunnel with vitiation air heater: Unstructured grid, 1/4 space, about 16M elements

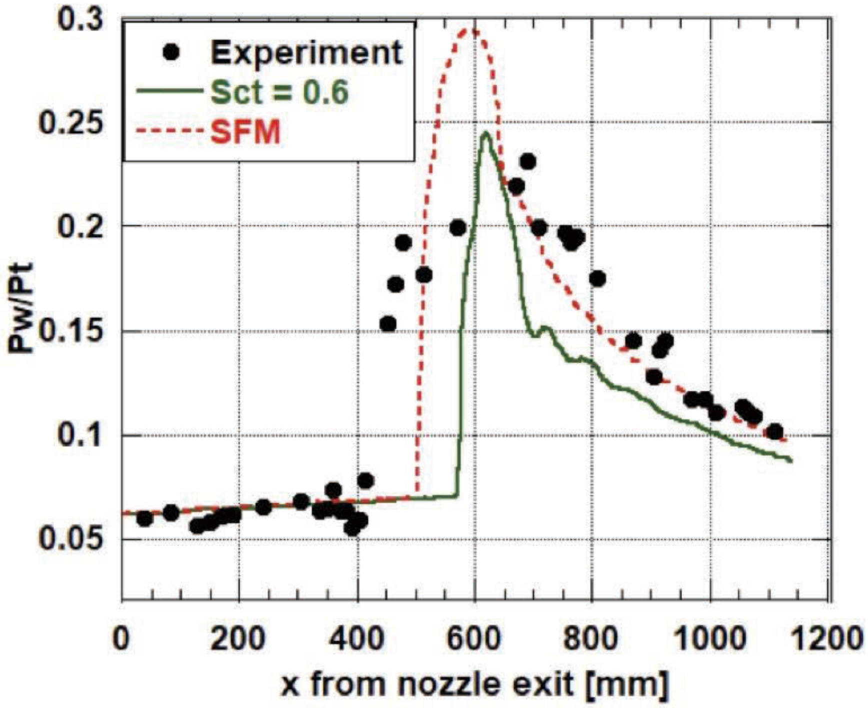

Fig. 4: Comparison of experimental and numerical pressure distributions under ramjet-mode operation with SFM application for RANS CFD

Publications

- Non peer-reviewed papers

[1] Hayashi, K., Matsuo, A., Kodera, M., Takahshi, M., and Tomioka, S., "Numerical Investigation of Turbulent Model on Shockwave/Boundary Layer Interaction,", Proceedings of Symposium on Shock Waves 2019 in Japan, 2020.

[2] Takahashi, H., Munakata, T., and Sato, S., "Effects of Flight Conditions and Attitudes on Thrust Performance of Hypersonic Aircraft Equipped with Airframe-Integrated Linear-Spike Nozzles," Proceedings of 51st Fluid Dynamics Conference and 37th Aerospace Numerical Simulation Technology Symposium 2019, JSASS-2019-2052-A, 2019.

[3] Nishiguchi, H., Kodera, M., and Tomioka, S., "Optimization of Mode Transition of a Dual-Mode Scramjet Combustor," Proceedings of 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019-a-36, 2019.

[4] Nishiguchi, H., "Study on the Improvement of Numerical Analysis Accuracy of a Dual-Mode Combustor Considering Two Combustion Modes," Master's thesis, 2020.

- Oral Presentations

[1] Takahashi, H., Munakata, T., and Sato, S., "Effects of Flight Conditions and Attitudes on Thrust Performance of Hypersonic Aircraft Equipped with Airframe-Integrated Linear-Spike Nozzles," 51st Fluid Dynamics Conference and 37th Aerospace Numerical Simulation Technology Symposium 2019, 2019.

[2] Nishiguchi, H., Kodera, M., and Tomioka, S., "Optimization of Mode Transition of a Dual-Mode Scramjet Combustor," 32nd International Symposium on Space Technology and Science and 9th Nano-Satellite Symposium, 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1000 - 2224
Elapsed Time per Case	144 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 2.21

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	17,282,337.40	2.10
SORA-PP	657,926.61	4.26
SORA-LM	935.58	0.39
SORA-TPP	394.86	0.02

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	139.88	0.12
/data	15,730.19	0.27
/ltmp	9,749.35	0.83

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.84	0.05

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Upper Weather Prediction

Report Number: R19EG3108
Subject Category: Research and Development
URL: https://www.jss.jaxa.jp/en/ar/e2019/11604/

Responsible Representative

Hideaki Hinagawa, Space Tracking and Communications Center, Flight Dynamics Team

Contact Information

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Members

Hiroshi Kato, Noriyuki Ohi, Yoshihiro Kasai, Daichi Obinata, Masaya Nakano, Yoshihide Sugimoto, Hideaki Hinagawa, Yuki Akiyama

Abstract

This study aims to develop the reanalysis system for upper atmospheric density to improve the satellite orbit prediction accuracy.

Reasons and benefits of using JAXA Supercomputer System

In order to realize atmospheric density reanalysis, it is required to perform atmospheric density model calculation with many calculation conditions simultaneously.

Achievements of the Year

The dveloped data assimilation system called SUBARU was established. SUBARU has three atmospheric density models, and we confirmed that SUBARU worked without problems in the case of one data assimilation parameter. Futhermore, we completed a system to compute orbital ephemeris generation using the density data provided from SUBARU. We are working on evaluation of the generated ephemeris.

Publications

- Oral Presentations

Hiroshi Kato, Hideaki Hinagawa, Kyohei Akiyama, Yuki Akiyama, Masaya Nakano, Daichi Obinata, and Shinichi Nakamura, " Development of Data Assimilation System for Atmospheric Density to Improve Satellite's Orbit Prediction Accuracy", JpGU 2019, May, 2019, Makuhari, Japan.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1
Elapsed Time per Case	20 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.09

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	56,117.64	0.01
SORA-PP	174,881.43	1.13
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	98.55	0.08
/data	82,106.31	1.41
/ltmp	9,309.90	0.79

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.85	0.20

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Skills Acquisition System

Basic research for system integration of silent supersonic airplane technologies

Report Number: R19ETET01
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11630/

Responsible Representative

Yoshikazu Makino, Aeronautical Technology Directorate, Aviation Systems Research Unit

Contact Information

Hiroaki Ishikawa(ishikawa.hiroaki2@jaxa.jp)

Members

Yoshikazu Makino, Hiroaki Ishikawa, Ryo Shimada, Masahiro Doi, Toshiya Yokoi, Shota Yamamoto

Abstract

The system integration design technologies for achieving low sonic-boom, low aerodynamic drag, low landing and take-off noise, and light weight simultaneously are the key technologies for future supersonic airplanes. JAXA is promoting the R&D for these technologies based on our experiences of demonstrating the advanced low-drag and low-boom design concepts.

Ref. URL: http://www.aero.jaxa.jp/eng/research/frontier/sst/

Reasons and benefits of using JAXA Supercomputer System

To achieve low sonic-boom, low aerodynamic drag, low landing and take-off noise, and light weight simultaneously, the multi-objective optimization tools are utilized in the design study. The super computer is necessary to obtain the multiple objective function efficiently with many numerical simulations.

Achievements of the Year

Buzz is self-excited oscillation phenomena of shock system, which appears at a supersonic diffuser of a supersonic inlet in subcritical operation. In order to suppress buzz, we proposed a new concept of supersonic inlet, which has a duct with constant cross-sectional area. Numerical analysis using the compressible fluid solver FaSTAR showed that flow field of the inlet based on proposed idea is more stable than traditional inlets.

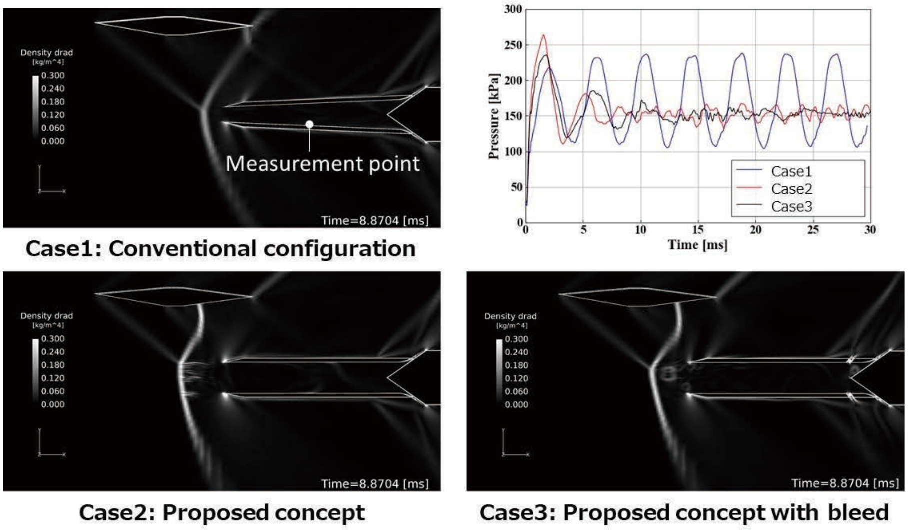

Fig. 1: Flow field and pressure time history

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	128
Elapsed Time per Case	5.3 Hour(s)

Resources Used

Fraction of Usage in Total Resources[*1](%): 0.53

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	4,149,941.89	0.50
SORA-PP	64,731.42	0.42
SORA-LM	884.46	0.37
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,472.18	1.23
/data	60,358.42	1.03
/ltmp	13,085.94	1.11

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.88	0.02

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

CFD analysis of wind turbine wake

Report Number: R19ETET09
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11635/

Responsible Representative

Yasutada Tanabe, Leader, High Speed Rotorcraft Research Section Aviation Systems Research Unit Aeronautical Technology Directorate

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The University of Tokyo, Keita Kimura(k.kimura@ilab.eco.rcast.u-tokyo.ac.jp)

Members

Keita Kimura, Yasutada Tanabe

Abstract

In a large wind farm (arrays of wind turbines), a wind turbine wake can cause power deficits of turbines stand in wake region. Because of that problem, Interests of recovery of wind speed in wind turbine wakes has emerged these days. In this study, several wake simulations were performed to obtain the characteristics of wind profiles in wind turbine wakes. We focused on scales and frequencies of wind fluctuations in wake regions in order to investigate the relations to recovery of wind speeds in wake regions.

Reasons and benefits of using JAXA Supercomputer System

In wind turbine wake simulations, comtutational domain should cover about 10 rotor diameters downwind because of its large impact range. On the other hand, to resolvethe fluctuations from rotational blades, grid scales need to be the order of chord length of blade tips. As a result, it is necessary to put large computational grid which has high grid resolution. Thanks to JSS2, such simulations of high computational cost can be performed.

Achievements of the Year

CFD simulations of a wind turbine were carried out by changing yaw angle periodically. Periodic changes of yaw angle can put wind fluctuations which scales are as large as the diameter of a turbine. All simulations are performed by using rFlow3D, which is designed for analysing rotational crafts. Fig.1 shows iso-surfaces of vorticity contours in a periodic yaw condition. Wake meandering caused by periodic change of yaw angle can be seen in this picture. Then, in order to focus on each scales and frequencies of wind fluctuations, dynamic mode decomposition (DMD) analysis is applied to the velocity fields and principal modes in velocity fields are captured. Fig.2 depicts a example of principal mode captured by DMD analysis. Periodic wind fluctuations based on diameter scale are confirmed in this figure. Finally, Fig.3 shows a power spertrum derived from DMD analysis. The frequency of the principal mode (a peak value) is around the frequency of changing yaw angles. According to the such kinds of analyses, it turned out that fluctuations based on wind turbine scales are greater effects on the recovery of wind speeds than tip vortex breakdowns.

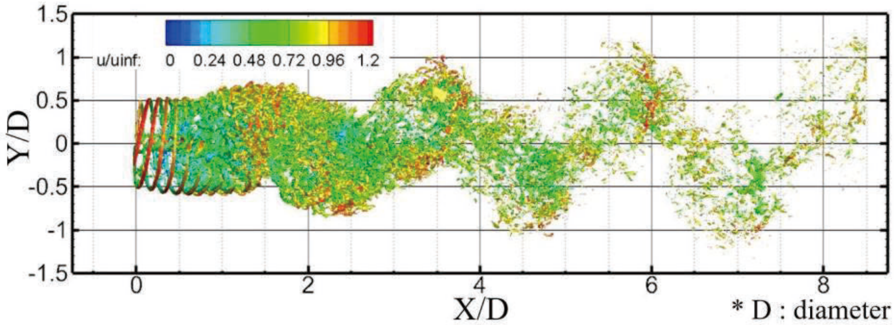

Fig. 1: iso-surfaces of vorticity in a case of periodic yawed condition

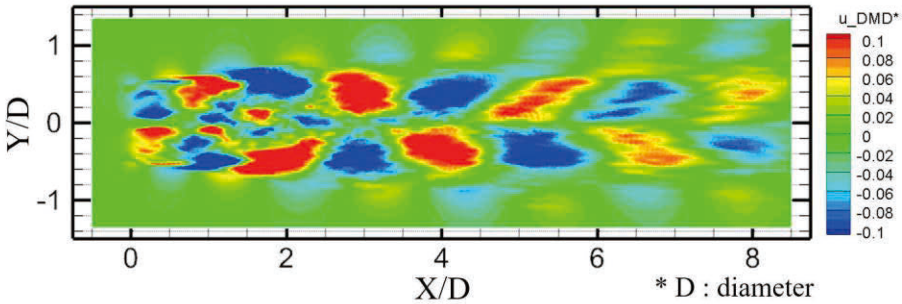

Fig. 2: contours of the principal mode of wind fluctuations derived from DMD analysis

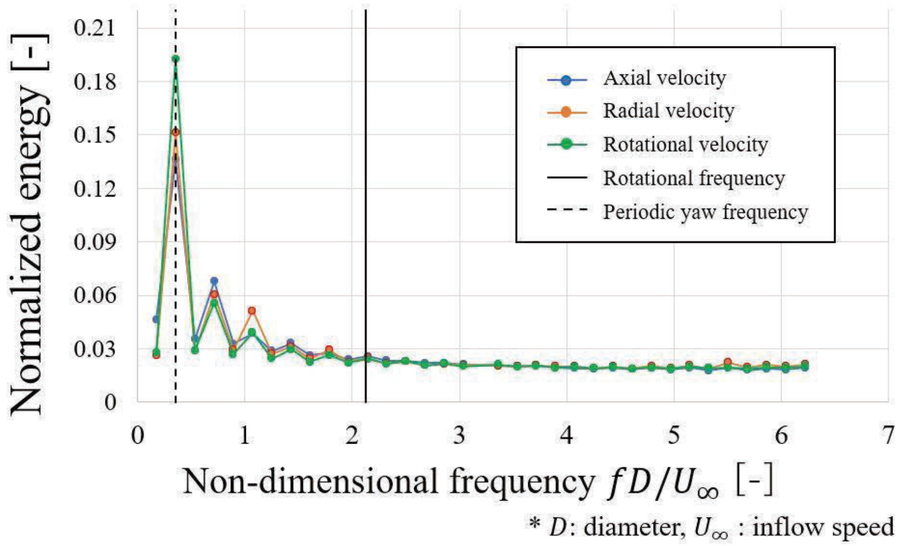

Fig. 3: Power spectrum of wind fluctuations derived from DMD analysis

Publications

- Peer-reviewed papers

1) Keita Kimura, Yasutada Tanabe, Yuichi Matsuo, and Makoto Iida. "Forced wake meandering for rapid

recovery of velocity deficits in a wind turbine wake", AIAA Scitech 2019 Forum, AIAA SciTech Forum, (AIAA 2019-2083)

2) Keita Kimura, Yasutada Tanabe, Makoto Iida "A numerical study of the wake interference and loss of energy for WPP", Journal of Wind Energy, JWEA, Vol.43 No.3(serial No.131), 2019.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 8
Elapsed Time per Case	400 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.49

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	292.36	0.00
SORA-PP	1,354,329.74	8.77
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	96.23	0.08
/data	10,653.41	0.18
/ltmp	2,130.68	0.18

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Computational analysis of compound helicopter

Report Number: R19ETET08
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11634/

Responsible Representative

Takeshi Akasaka, Associate Proffesor, Kanazawa Institute of Technology

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Members

Yasutada Tanabe, Yusuke Hamamoto, Hideaki Sugawara

Abstract

The purpose of this study is to investigate aerodynamic interaction between the rotor and the wing of a compound helicopter using CFD analysis.

Reasons and benefits of using JAXA Supercomputer System

The analysis of the aerodynamic interaction between the rotor and the wing using the helicopter aerodynamic analysis code rFlow3D is computationally intensive.

Achievements of the Year

The aerodynamic interaction between the rotor and the wing of a compound helicopter could be simulated in hover (Fig.1) . The aerodynamic interaction between the rotor and the wing of a compound helicopter could be simulated in high speed flight (Fig.2) . The aerodynamic interaction between the rotor and the wing of a compound tandem helicopter could be simulated in hover (Fig.3) .

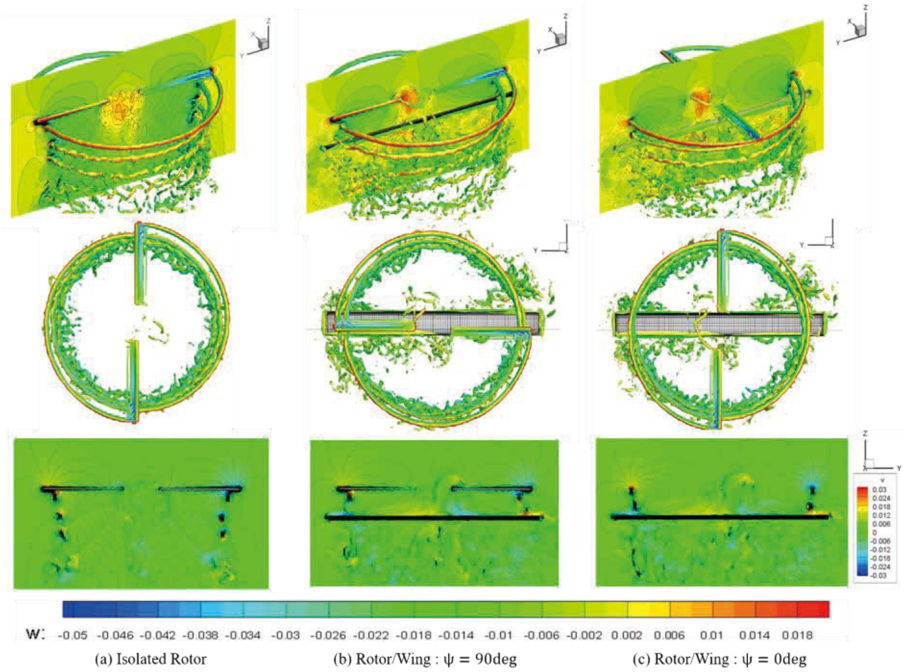


Fig. 1: Aerodynamic Interaction of compound helicopter between the rotor and the wing in Hover

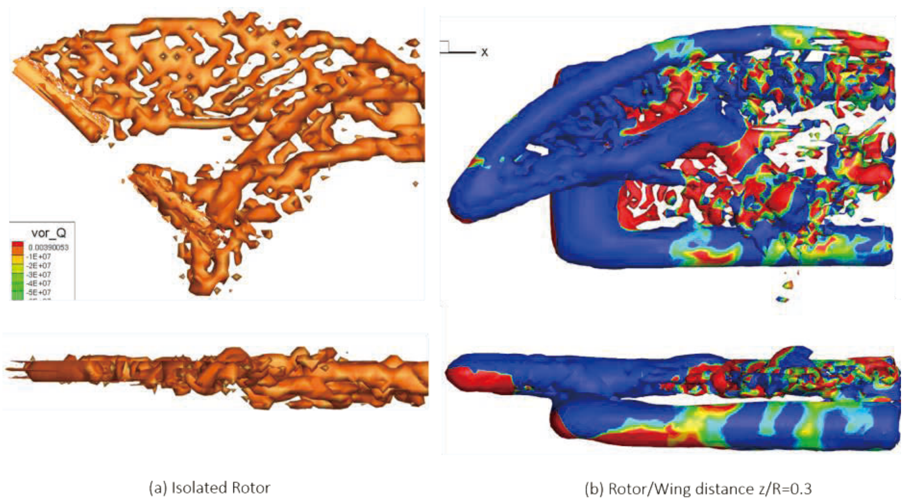
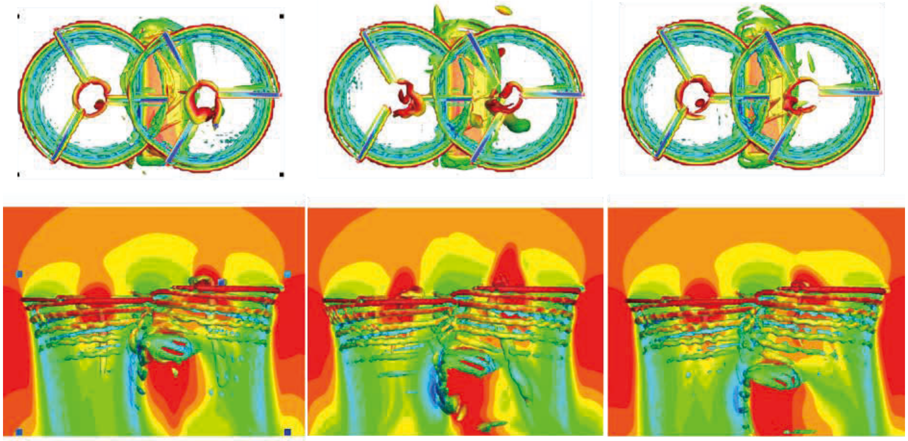


Fig. 2: Aerodynamic Interaction of compound tandem helicopter between the rotor and the wing in high speed flight



(a) Rotor/Wing distance z/R=0.3 (b) Rotor/Wing distance z/R=0.4 (c) Rotor/Wing distance z/R=0.5

Fig. 3: Aerodynamic Interaction of compound tandem helicopter between the rotor and the wing in hover : wing aspect ratio 3.75

Publications

- Non peer-reviewed papers

1) Hiroki Oshima, Takeshi Akasaka, Yusuke Hamamoto, Experimental Study of the Rotor-Wing Aerodynamic Interaction for Wing span in hover, 16th International Conference Fluid Dynamics, 2019.

2) Atsuya Harata, Rotor / Wing Aerodynamic Interference during High-speed Flight using CFD, Graduation thesis, Kanzawa Institue of Technology, 2020.

3) Kentaro Otani, Reduction of Aerodynamic Interaction for Compound Tandem Rotor in Hover, Graduation thesis, Kanzawa Institue of Technology, 2020.

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	864 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.07

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	174,551.77	1.13
SORA-LM	0.00	0.00
SORA-TPP	3,558.63	0.21

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	48.98	0.04
/data	7,546.17	0.13
/ltmp	1,331.68	0.11

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Environment Conscious Aircraft Systems Research in Eco-wing Technology:Aerodynamic System Design Technology

Report Number: R19ETET15
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11638/

Responsible Representative

Yoshikazu Makino, Aeronautical Technology Directorate, Aviation Systems Research Unit

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Members

Shoya Ogino, Shuhei Kondo, Masaru Hirata, Yuki Hasegawa, Mitsuhiro Murayama, Yasushi Ito, Ryotaro Sakai, Shinya Koganezawa, Dongyoun Kwak,

Abstract

Innovative drag reduction technologies are investigated to reduce the fuel consumption for a conventional aircraft configuration. Aircraft noise prediction technologies and the conceptual design technologies are also developed for future aircraft which achieve low noise and high efficiency.

Ref. URL: http://www.aero.jaxa.jp/eng/research/ecat/ecowing/

Reasons and benefits of using JAXA Supercomputer System

CFD analysis are used for the understanding of aerodynamic characteristics and evaluation of the performance in the aircraft design phase. Huge calculation resources and costs were required for the high fidelity and quick response CFD analysis for the optimum aerodynamic design process on complex aircraft geometry. JSS2 can achieve those requirements, the cost and time are drastically saved on the CFD analysis.

Achievements of the Year

The aerodynamic performance of an unconventional low-noise aircraft with engines mounted over the rear-fuselage was evaluated by CFD. Comparing with the initial geometry, modifications of the rear fuselage and nacelle geometries were improved aerodynamic performance. The aerodynamic sensitivities by the rear part geometries were obtained to reduce the interference between the airframe and propulsion systems. (Fig. 1).

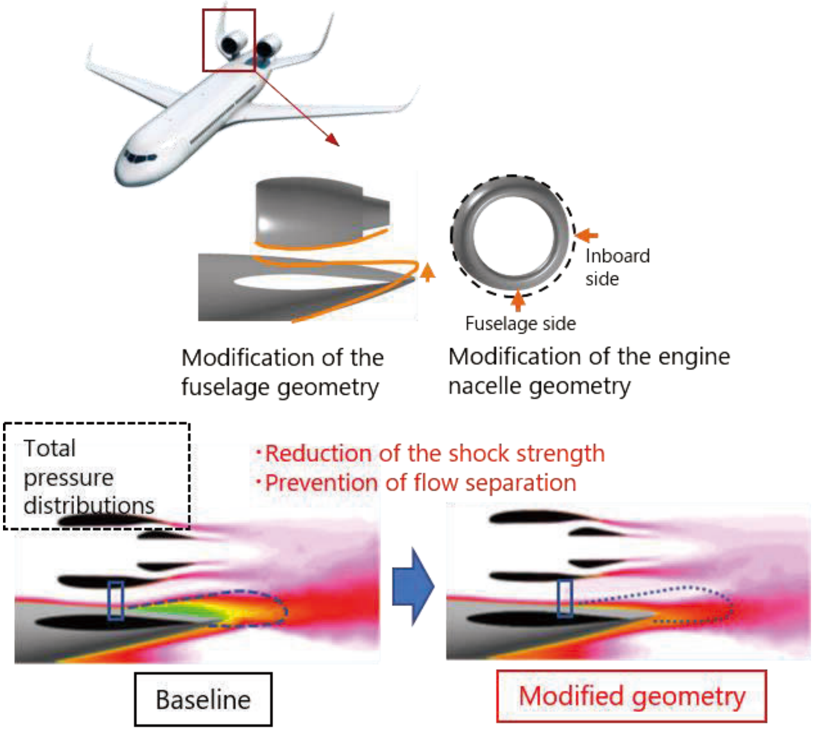

Fig. 1: Evaluation of aerodynamic performance by variations of the rear fuselage and nacelle geometries

- **Publications**

N/A

- **Usage of JSS2**
- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	128 - 256
Elapsed Time per Case	25 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.18

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,174,459.76	0.14
SORA-PP	62,144.96	0.40
SORA-LM	1,129.15	0.47
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,070.57	0.89
/data	51,641.92	0.88
/ltmp	9,097.57	0.77

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	71.57	1.80

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Forward flight performance of multirotor

Report Number: R19ETET07
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11633/

Responsible Representative

Yuto Sayama, Undergraduate student, Tokyo University of Agriculture and Techonology

Contact Information

Yuto Sayama(y-sayama@st.go.tuat.ac.jp)

Members

Yasutada Tanabe, Yuto Sayama, Kaito Hayami, Hideaki Sugawara

Abstract

Study of forward flight performance of multicopter

Reasons and benefits of using JAXA Supercomputer System

In order to perform a rotorcraft analysis tool.

Achievements of the Year

Numerical analyses are performed on a multicopter propeller using a rotorcraft CFD tool to investigate the effect of blade twist on forward flight performance. Results obtained by numerical analyses shows that the equivalent lift-to-drag ratio increases as a blade twist decreases at a high advancing ratio condition (Fig. 1)., As a result, it is suggested that the blade twist must be determined to balance a hovering performance with a forward flight performance.

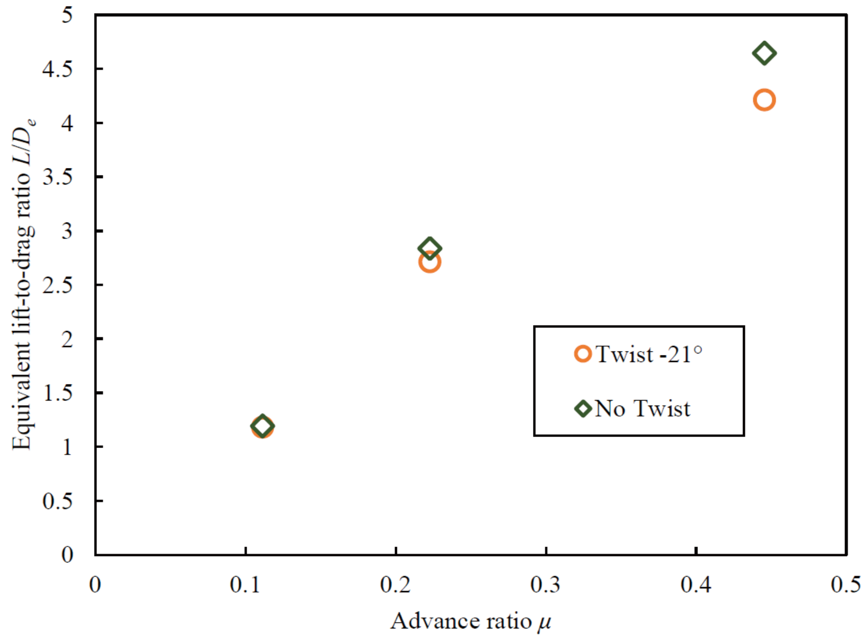

Fig. 1: The relation between the advance ratio and the equivalent lift-to-drag ratio. The untwisted blade get higher equivalent lift-to-drag ratio.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.06

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	78,729.71	0.51
SORA-LM	0.00	0.00
SORA-TPP	47,170.29	2.85

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	759.47	0.63
/data	17,311.80	0.30
/ltmp	3,284.80	0.28

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

High-spped rotorcrafts technology trainning

Report Number: R19ETET04
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11631/

Responsible Representative

Kaito Hayami, Graduate student, Tokyo University of Agriculture and Techonology

Contact Information

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Members

Yasutada Tanabe, Hideaki Sugawara, Kaito Hayami

Abstract

Study for the aerodynamic characteristics of coaxial rotors.

Reasons and benefits of using JAXA Supercomputer System

In order to perform a rotorcraft analysis tool.

Achievements of the Year

Numerical analyses are performed using a rotorcraft CFD tool to research a coaxial rotor which is a part of the next generation rotorcraft. The numerical results suggest two remarks.

[1]The applying of a transition model is valid for the rotorcraft CFD analysis. The improvement of numerical accuracy on the blade surface is attributed by the transition model (Fig. 1).

[2]Lift offset, which is a flight parameter of the coaxial rotor, can control the magnitude of vibratory thrust fluctuation generated on the rotor (Fig. 2). The adjustment of optimal lift offset in responce to flight condition realize the reduction of thrust fluctuation.

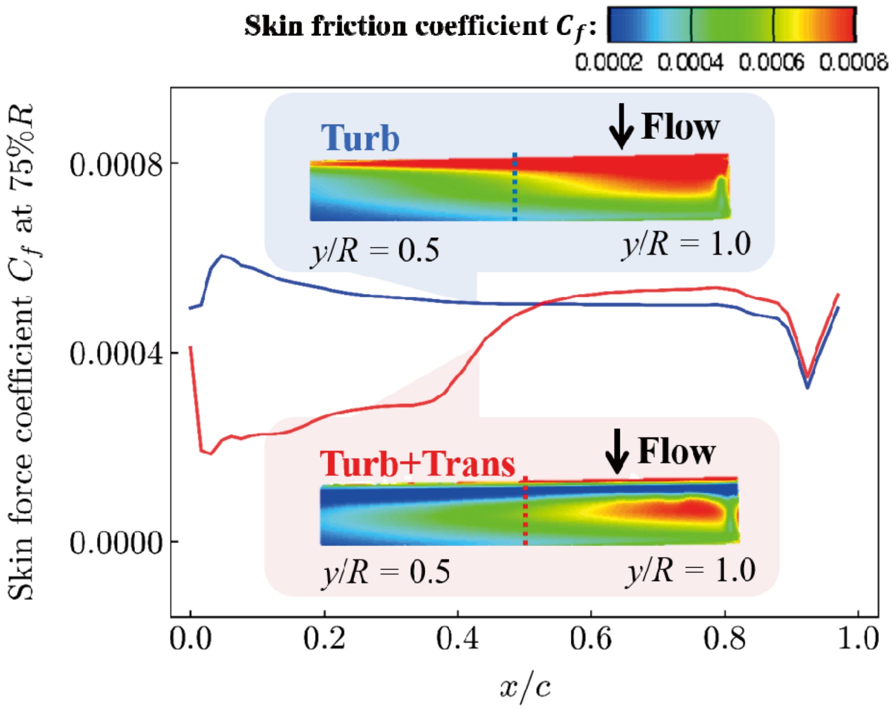

Fig. 1: The distribution of skin fricition on the blade upper surface at 75% radius chord-cross section. The blue line shows the results obtained by turbulence model (not considering transition), and the red line shows the results obtained by the turbulence+transition model. There is an obious difference between the two results, especially at 0-50% chord. The applying of transition model improves the numerical accuracy of skin friction.

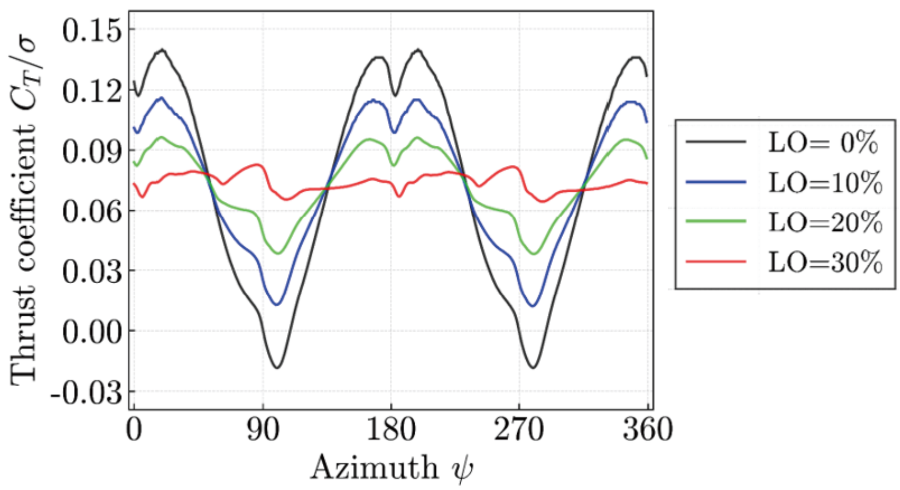

Fig. 2: The variation of thrust coefficient against the blade azimuth. Thrust fluctuates cyclically in response to the chages of blade azimuth. The fluctuation is also affected by lift offset (LO), and the amlitude of the flucutation is reduced.

Publications

- Oral Presentations

[1]Hayami, K., Sugawara, H., Tanabe, Y., and Kameda, M. , "Numerical Simulation of the Aerodynamic Characteristics of Coaxial Rotors", The Japan Society for Aeronautical and Space Sciences 50th annual meeting, (2019).

[2]Hayami, K., Sugawara, H., Tanabe, Y., and Kameda, M. "Investigation of Aerodynamic Interaction of a Lift Offset Coaxial Rotor by Numerical Simulation.", 8th Asian/Australian Rotorcraft Forum, (2019).

[3]Hayami, K., Sugawara, H., Tanabe, Y., and Kameda, M. "Numerical Investigation of Aerodynamic Interference on Coaxial Rotor", AIAA SciTech, (2020).

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.32

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	173,552.07	0.02
SORA-PP	562,500.28	3.64
SORA-LM	1.60	0.00
SORA-TPP	129,876.64	7.84

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	287.40	0.24
/data	12,428.98	0.21
/ltmp	2,308.24	0.20

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Simulation of the Ram Combustor

Report Number: R19ETET50
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11644/

Responsible Representative

AOYAMA Takashi, Director, Aeronautical Technology Directorate, Numerical Simulation Research Unit

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Members

Kazuya Uchiyama

Abstract

As the first stage of research and development aimed at realizing hypersonic aircrafts, High-Mach Integrated Control Experiment (HIMICO) is underway by JAXA and universities. The ramjet engine mounted on the experimental aircraft aims to start combustion by self-ignition of gaseous hydrogen fuel. However, self-ignition has not been successful in the combustion tests since 2017, and there are problems such as lack of experimental data and differences between flight conditions and experimental conditions due to the limitation of the number of experiments and the limitations of the combustion experimental facilities. Therefore, numerical analysis is performed to interpolate the experimental data and to grasp the combustion phenomena such as ignition and flame holding.

Reasons and benefits of using JAXA Supercomputer System

In LES considering detailed chemical reactions on a experimental scale with more than 10 million grid points, the computational cost is high. By using a JAXA supercomputer capable of parallel processing, analysis became possible within a realistic time.

Achievements of the Year

Focusing on the injector which injects gaseous hydrogen fuel into the combustor, the effect of differences in injector wall temperature on ignition was investigated. LES was performed for HIMICO ram combustor under three different boundary conditions of the injector wall temeprature: adiabatic wall and isothermal wall (300K, 500K). As a solver, we used a reactive flow solver developed by our laboratory based on JAXA's fast fluid analysis solver, FaSTAR, implementing species transport equations and Arrehenius equation. As a result, from the unsteady temperature distribution in the combustor, it was found that the lower the temperature of the injector outer wall was, the longer it took to ignite and that the ignition of the isothermal wall 300 K was delayed by 31% compared to the case of the adiabatic wall.

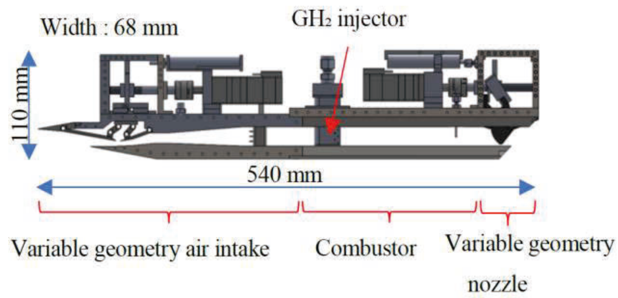

Fig. 1: Outline figure of ramjet engine for HIMICO

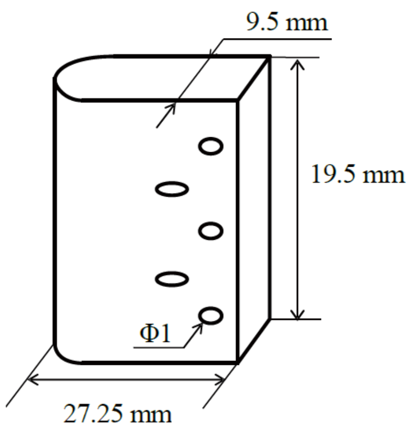

Fig. 2: Outline figure of injector

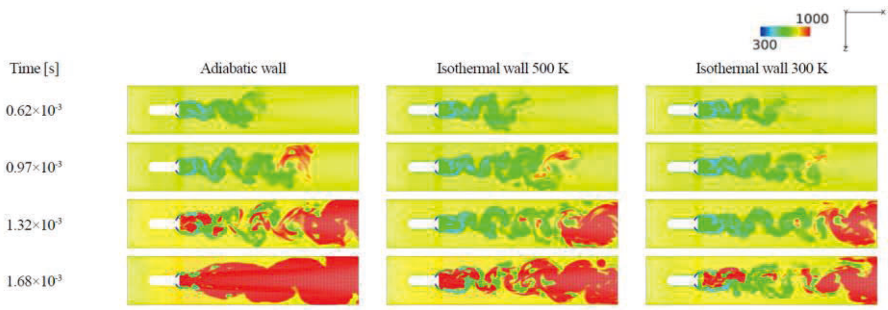

Fig. 3: Unsteady temperature distribution

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024
Elapsed Time per Case	100 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.07

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	473,185.17	0.06
SORA-PP	18,329.24	0.12
SORA-LM	79.92	0.03
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	238.42	0.20
/data	4,882.81	0.08
/ltmp	976.56	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Study of Supresonic Intake

Report Number: R19ETET10
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11636/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Waseda university, Department of Applied Mechanics, Masakazu Sano(hisi-g-hibiki@wasagi.waseda.jp)

Members

Masakazu Sano

Abstract

To discuss the flow inside of the intake and various phenomena, such as intake buzz, on the engine of High Mach Integrated Control Experiment, "HIMICO."

Reasons and benefits of using JAXA Supercomputer System

Complex flow inside of intake can be simulated by large capacity of computational resourece.

Achievements of the Year

Japan Aerospace Exploration Agency (JAXA) has been promoting High Mach Integrated Control Experiment, "HIMICO," as the first step for establishment of a Mach 5 class hypersonic aircraft. The purpose of HIMICO is to demonstrate the airframe/engine integrated control technology. Figure 1 is the enlarged view of engine for HIMICO. This intake has 3 ramps and air is compressed by oblique shock cauused by each intake. This intake also has a bleed slit between 2nd and 3rd ramps to bleed the boundary layer. The bleed air is emitted outside through two bleed holes opened on the both sides of the bleed plenum chamber. In this study, effects of sideslip on the intake for HIMICO is researched with CFD analysis. Fast Aerodynamic Routines, "FaSTAR"developed by JAXA is used as the calculation solver. Figure 2 is Mach number distribution of the entrance of intake. Figure 2 shows difference of flow between the right side and left side and is caused by pressure difference. There is a flow from the left side to the right side due to sideslip and this causes interference between the flow and the sidewall leading to the pressure difference. The left side is expansion side and the right side is compression side. This pressure difference also causes difference of amount of spillage from the bleed plenum chamber. In the expansion side, there is more spillage than the compression side and it covers the entrance of intake (Fig. 3.) This is an unstart condition. On the other hand, the center line of the intake shows start condition. This means there are two conditions at the same time in the intake, which is called "partial unstart condition." These CFD results are grately helpful to understand the phenomenon caused by sideslip.

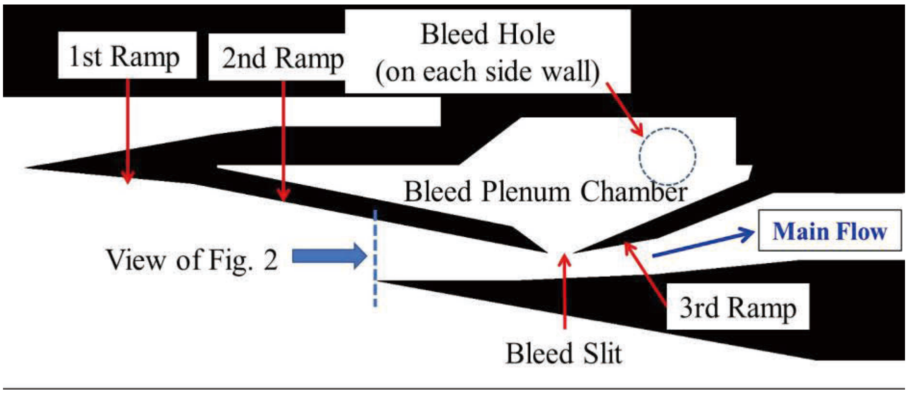

Fig. 1: Enlarged view of the intake

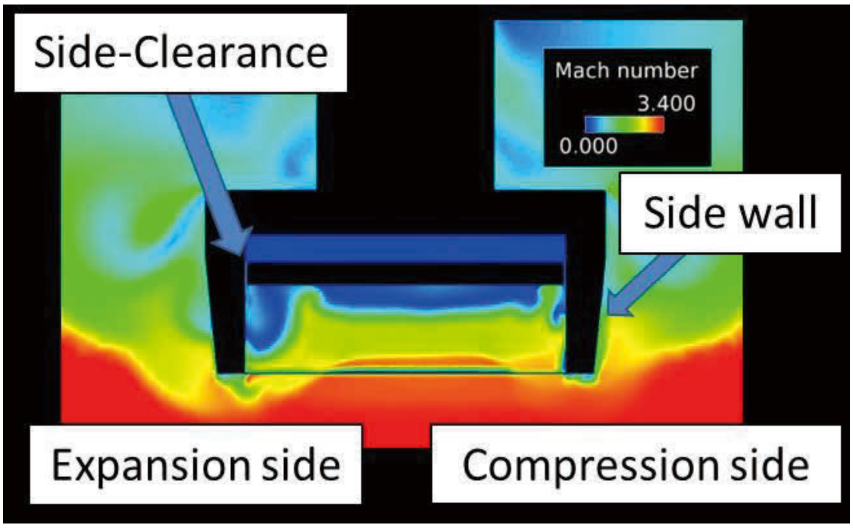

Fig. 2: Mach number distribution at the entrance of the intake

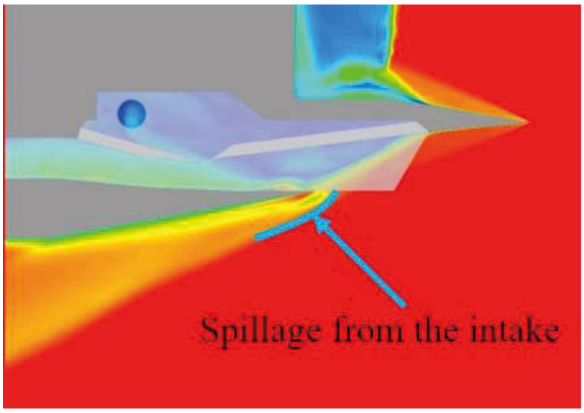

Fig. 3: Mach number distribution at the expansion side

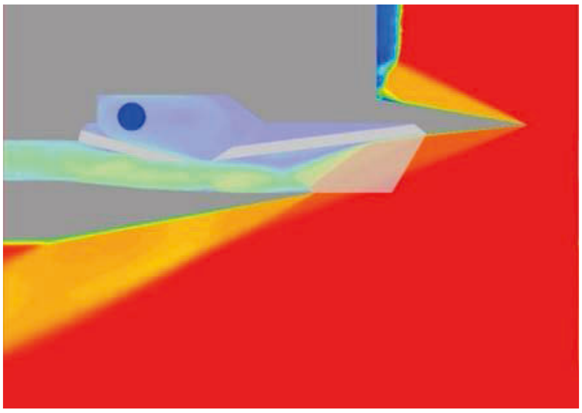

Fig. 4: Macu number distribution at the center line

Publications

- Peer-reviewed papers

1)Masakazu Sano, Toshiya Yokoi, Hidekazu Yoshida, Tetsuya Sato, Hideyuki Taguchi, "3-Dimensional Numerical Simulation of Hypersonic Intake for Pre-Cooled Turbo Jet Engine," Aerospace Technology Japan, 32nd ISTS papers

- Oral Presentations

1)Masakazu Sano, Toshiya Yokoi, Hidekazu Yoshida, Tetsuya Sato, Hideyuki Taguchi, "3-Dimensional Numerical Simulation of Hypersonic Intake for Pre-Cooled Turbo Jet Engine," 32nd ISTS

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	512 - 1024
Elapsed Time per Case	43200 Second(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.71

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	5,981,099.66	0.73
SORA-PP	27,357.80	0.18
SORA-LM	12,446.19	5.20
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	476.84	0.40
/data	9,765.63	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical study on low-speed buffet

Report Number: R19ETET26
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11642/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Masashi Kanamori(kanamori.masashi@jaxa.jp)

Members

Masashi Kanamori, Takahiro Yoshikawa

Abstract

Low-speed buffet is an aerodynamic vibration phenomenon that occurs during low-speed and high-angle-of-attack conditions. In order to safely fly an aircraft, it is important to analyze low-speed, high-angle-of-attack flows where low-speed buffet can occur. Therefore, in this project, CFD analysis is performed for around aircraft. As a method, DDES using RANS near the wall and LES in other areas is performed. In this DDES, we analyze RANS / LES switching closer to the wall. We aim to find analytical solutions that are closer to experimental values than conventional calculations.

Reasons and benefits of using JAXA Supercomputer System

It is absolutely necessary to prepare a computational grid with high-resolution near the separated zone in order to predict a low-speed buffet phenomenon accurately. The number of grid point is of the order of tens of millions, which is prohibitively large from a view point of a computation with a personal computer. The processing capability of JSS2 is therefore necessary for our research.

Achievements of the Year

In this our research, NASA-CRM was analyzed under two flow conditions. In the DDES analysis method, the switching position of RANS / LES is changed using the model parameter Cdes. Cdes = 0.65 is the default value. If it is larger than this, the RANS region expands, and if it is smaller, the RANS region narrows.

The first condition of the flow is an experiment performed with the European Transonis Windtunnel(Lutz et al., AIAA 10.2514/6.2015-1094, 2015), and the experimental values are compared. It can be seen that the cross-sectional pressure distribution at the blade root, which was difficult to reproduce by CFD analysis, approaches the experimental value when Cdes is reduced to about 0.1 (Fig. 1).

Next, it compares with the experiment performed in the low-speed wind tunnel of JAXA(Uchiyama et al., AIAA 10.2514/6.2019-2190, 2019). DDES analysis with Cdes of 0.1 gave better agreement on lift coefficients (Fig. 2).

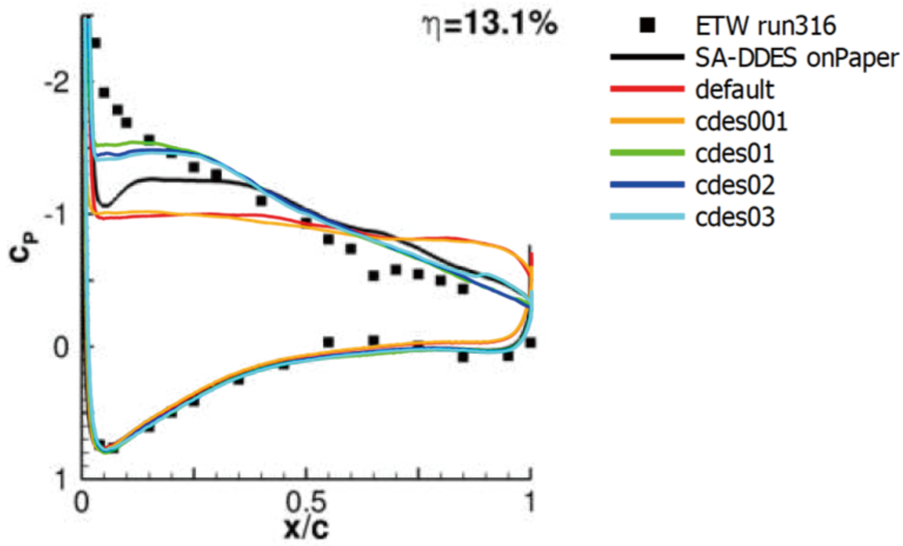

Fig. 1: pressure distribution in wing root section

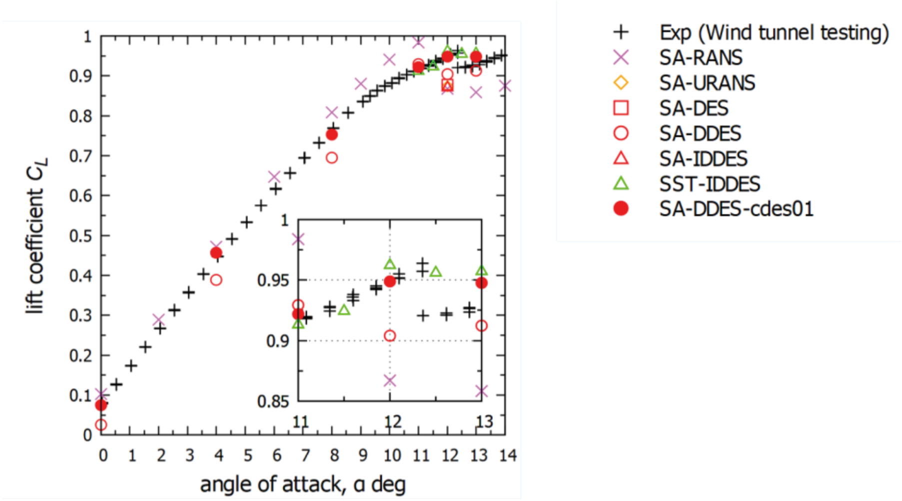

Fig. 2: variation of lift coeficient against angle of attack

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	480
Elapsed Time per Case	240 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.16

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	1,430,169.20	0.17
SORA-PP	1,858.61	0.01
SORA-LM	1,293.87	0.54
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	476.84	0.40
/data	9,765.63	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research of Lattice Boltzmann Method

Report Number: R19ETET17
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11639/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Takashi Ishida, Aeronautical Technology Directorate, Numerical Simulation Research Unit(ishida.takashi@jaxa.jp)

Members

Daichi Asaoka, Senju Fujii

Abstract

The research objective is to implement Cumulant LBM for collision operator and validate it in terms of the solution accuracy, stability, and cost for high-Reynolds number flow. In addition, the source code of implemented Cumulant LBM is tuned aimed for fast computation.

Reasons and benefits of using JAXA Supercomputer System

The computational cost of unsteady flow simulation by LBM is very high.

We use JSS2 to reduce the computational time by paralleization.

Achievements of the Year

Cumulant LBM was implemented to current our code and validated through the comparison with SRT and Cascaded LBM in terms of solution accuracy, stability, and cost. In addition, due to the code tuning by writting down matrix calclation and SIMD, multiple relaxation model such as Cascaded LBM and Cumulant LBM can compute at 1.7 times the cost of SRT model.

before

```
for (int n = 0; n < Q; ++n) {
   ftmp[I][n] = 0;
   for (int m = 0; m < Q; ++m) {
      ftmp[I][n] += rho[I] * (Minv[m][n] * (CM[m] * (1 - omg[m]) + CMeq[m] * omg[m]));
   }
}
```

after

```
T ftmp_[Q];
for (int n = 0; n < Q; ++n) {
   ftmp_[n] = 0;
}
for (int m = 0; m < Q; ++m) {
   for (int n = 0; n < Q; ++n) {
      ftmp_[n] += rho[I] * (Minv[m][n] * (CM[m] * (1 - omg[m]) + CMeq[m] * omg[m]));
   }
}
for (int n = 0; n < Q; ++n) {
   ftmp[I][n] = ftmp_[n];
}
```

Fig. 1: Example of SIMD for collision operator

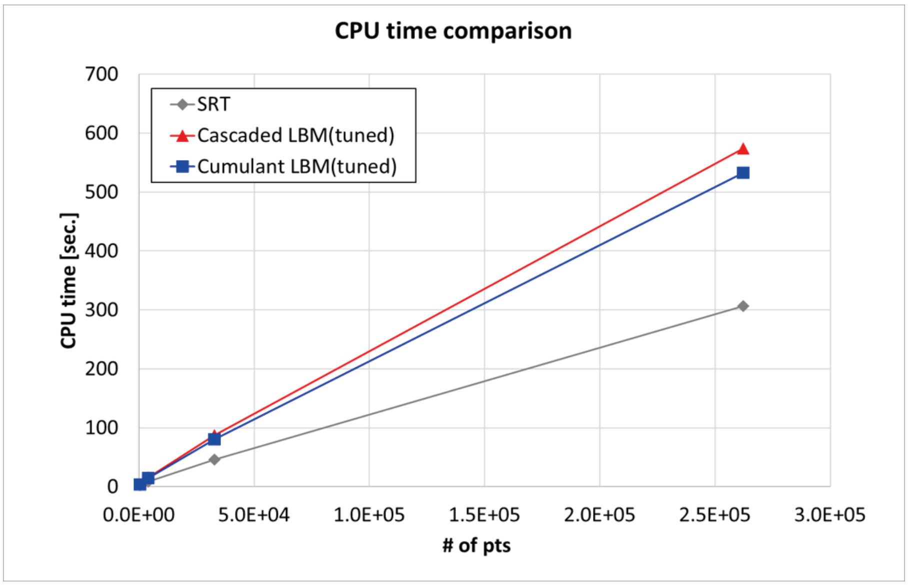

Fig. 2: Comparison of CPU time after code tuning

Publications

- Non peer-reviewed papers

1) Takashi Ishida, Daichi Asaoka, Masaharu Kameda, Unsteady flow simulation around an airfoil with low-speed and high angle-of-attack conditions by Lattice Boltzmann Method, 33th CFD Symposium

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	1000 Second(s)

Resources Used

Fraction of Usage in Total Resources[*1](%): 1.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	11,348,171.01	1.38
SORA-PP	15,318.40	0.10
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	495.91	0.41
/data	49,018.88	0.84
/ltmp	5,859.38	0.50

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research on combustor simulation

Report Number: R19ETET05
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11632/

Responsible Representative

AOYAMA Takashi, Director, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Himeko Yamamoto(himeko@toki.waseda.jp)

Members

Himeko Yamamoto

Abstract

For the development of a aircraft engine combustor with high environmental compatibility, we develop the combustion calculation methods that can reproduce the pressure propagation and chemical reaction with practical calculation cost. In addition, numerical simulations of the DLR scramjet test-engine combustor are conducted to evaluate these proposed methods.

Reasons and benefits of using JAXA Supercomputer System

It is necessary to use supercomputer to conduct development and verification of the combustion calculation methods.

Achievements of the Year

The laminar flamelet model, which is a tabulated chemistry method, is effective for reducing the inflexibility of numerical simulation of combustion. However, the recently proposed compressible flamelet model, which is applicable to compressible flow, has some problems of computational performance related to increased complication of the flamelet table and the pressure-calculation process. To address these problems of the conventional method (form0-lerp) of the compressible flamelet model which uses conventional formulation (form0) and flamelet table with linear interpolation (Lerp), we propose two formulations, namely form1 and form2. Form1 has the advantage of making the spatial gradient calculation of each chemical species mass fraction more efficient. Form2 has the advantage of eliminating the calculation procedure that depends on the number of chemical species. We also propose methods of utilizing artificial neural network (ANN) that produce synergistic effects with these formulations. In addition, to evaluate two particularly effective methods, form2-lerp and form2-ann, numerical simulations (Fig.2, Fig.3) based on the DLR scramjet test-engine combustor (Fig.1) are conducted.

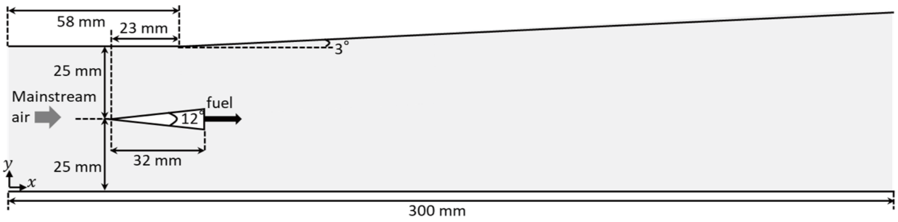

Fig. 1: DLR scramjet test-engine combustor

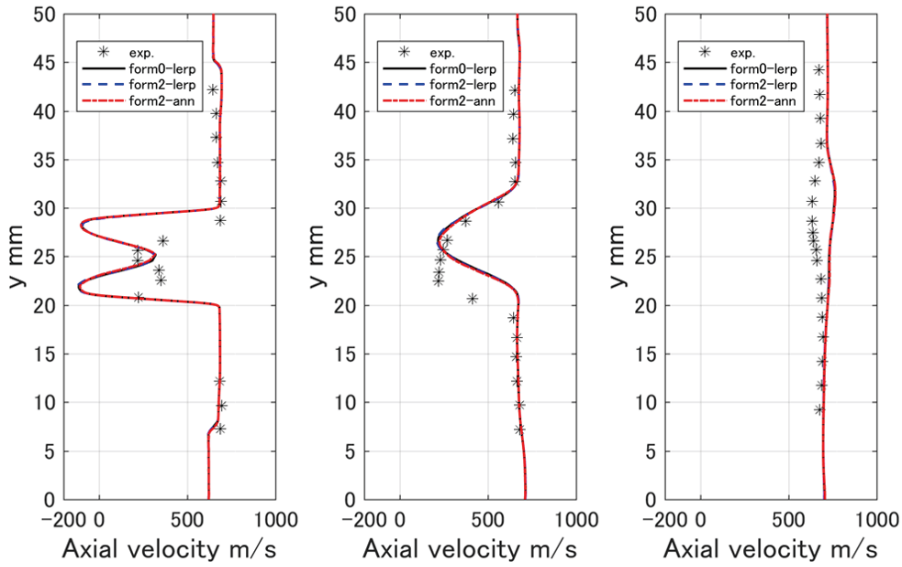

Fig. 2: Axial velocity distribution (experiment, form0-lerp, form2-lerp, form2-ann)

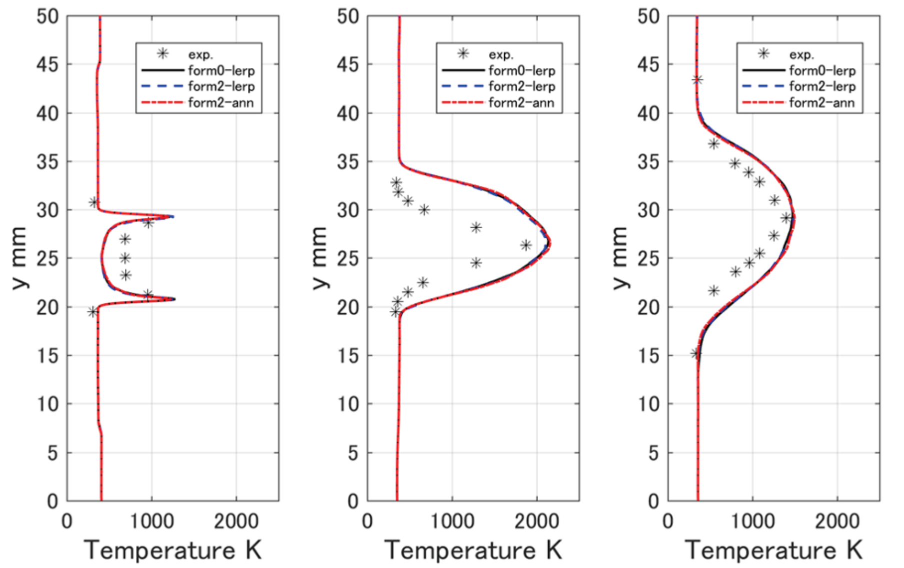

Fig. 3: Temperature distribution (experiment, form0-lerp, form2-lerp, form2-ann)

Publications

- Peer-reviewed papers

Himeko Yamamoto, Rui Toyonaga, Yusuke Komatsu, Koki Kabayama, Yasuhiro Mizobuchi, Tetsuya Sato, "Improved Methods of Laminar Flamelet Model for Compressible Flow", AIAA Journal, American Institute of Aeronautics and Astronautics (2020.3, accepted)

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	2 - 1024
Elapsed Time per Case	120 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.11

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	877,071.08	0.11
SORA-PP	7,887.09	0.05
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	476.84	0.40
/data	39,062.52	0.67
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.48	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study for Embedded Large Eddy Simulation

Report Number: R19ETET21
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11640/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Yoimi KOJIMA, Ph.D. Student, Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology(y-kojima@st.go.tuat.ac.jp)

Members

Yoimi Kojima

Abstract

We are developing new low-cost numerical simulation technology for aerodynamic problems, including transonic buffet and aeroacoustics. We aim to achieve high accurate simulation without expensive computational cost using Embedded-LES method. ELES allows us to execute embedded unsteady simulations that localize the high-numerical-cost region without suffering the accuracy of prediction.

Reasons and benefits of using JAXA Supercomputer System

The project needs vast computational resources so that we can validate the ELES method in turbulent flow conditions. Using the JAXA supercomputer system surely enhances our works by providing easy access to resources.

Achievements of the Year

In the past year, we have worked for developing the Embedded Large Eddy Simulation method so that we can get accurate results in numerical simulation of three-dimensional unsteady flow fields. Improvement of numerical schemes and its implementations for our code allowed us to use the ELES method for complex flow fields such as high-Reynolds number flow over a slat.

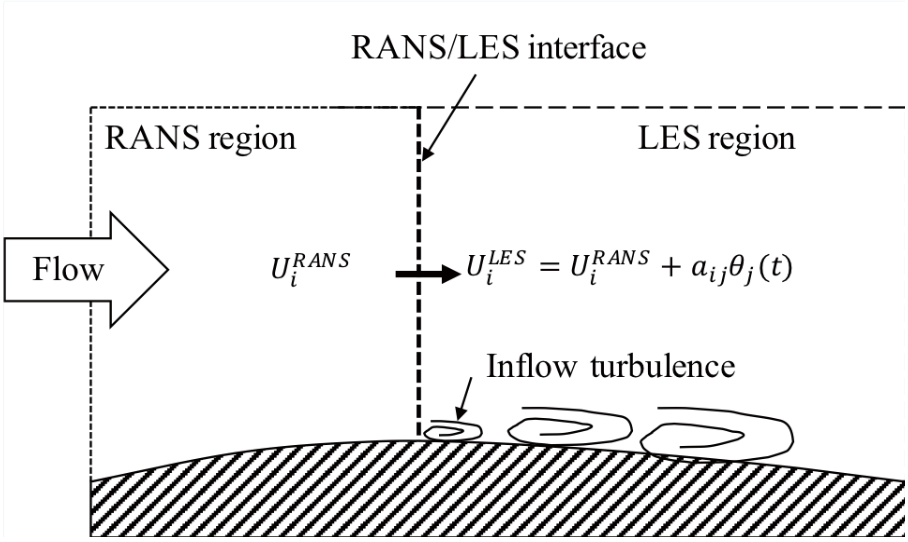

Fig. 1: Schematic of Embedded-LES method

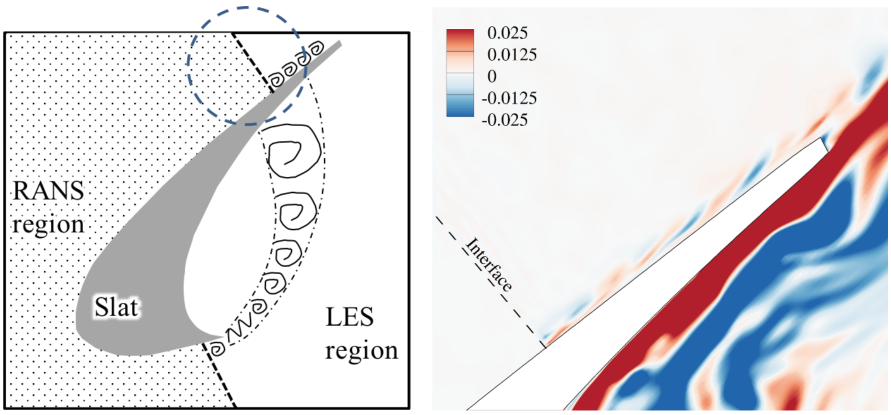

Fig. 2: Instantaneous span-wise velocity field around a RANS/LES interface in the slat flow case (around the trailing edge)

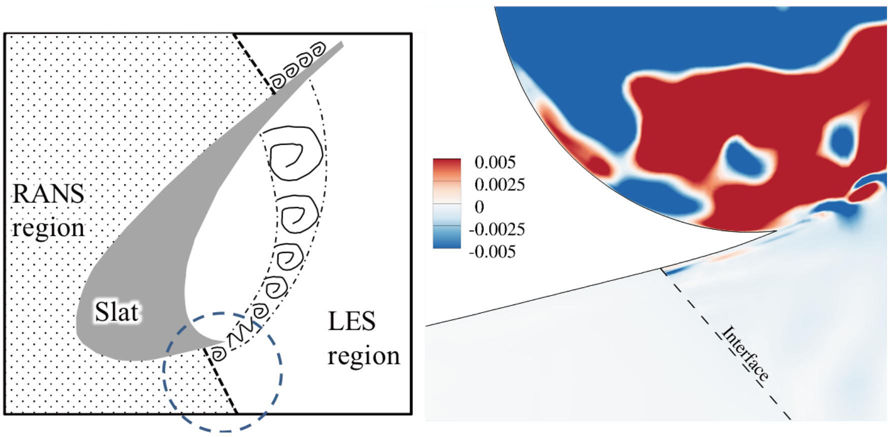

Fig. 3: Instantaneous span-wise velocity field around a RANS/LES interface in the slat flow case (around the cusp)

Publications

- Oral Presentations

Kojima, Y., Ishida, T., Hashimoto, A. & Aoyama, T., "Numerical Simulation of Unsteady Flow over a 30P30N Slat by Embedded-LES," AIAA Scitech 2020 Forum (2020) AIAA2020-2065.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024 - 1728
Elapsed Time per Case	300 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.11

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	675,465.42	0.08
SORA-PP	49,231.91	0.32
SORA-LM	61.91	0.03
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	47.68	0.04
/data	12,207.04	0.21
/ltmp	976.56	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	97.58	2.46

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on calculation method for chemical reactions in turbulent combustion

Report Number: R19ETET25
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11641/

Responsible Representative

AOYAMA Takashi, Director, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

KOMATSU Yusuke(ksw.koma2@asagi.waseda.jp)

Members

KOMATSU Yusuke

Abstract

Japan Aerospace Exploration Agency (JAXA) has been promoting research and development to establish hypersonic aircrafts which can cruise at Mach 5. High-Mach Integrated Control Experiment (HIMICO), which is a flight experiment under hypersonic conditions using the S-520 sounding rocket, has been planned in the first stage. Up to the present time, the supersonic wind tunnel tests and the combustion tests of the engine have been conducted. Then, it has been confirmed that the fuel self-ignites under certain experimental conditions in the combustion tests. However, the quantitative evaluation of the self-ignition condition and the data necessary for the performance evaluation of the engine are insufficient. Therefore, CFD analysis is used to interpolate the experimental data and to clarify the condition for self-ignition of the fuel.

Reasons and benefits of using JAXA Supercomputer System

When numerical simulation including chemical reactions is performed on the actual combustor scale, the calculation cost becomes very large. Therefore, in order to perform numerical simulation within a reasonable time, we used JSS 2 which can parallelize.

Achievements of the Year

We developed a chemically reacting flow solver to elucidate the self-ignition phenomenon in the ram combustor for High-Mach Integrated Control Experiment and predict the self-ignition limit. Large-eddy simulations of the real scale combustor were performed using a detailed hydrogen-air reaction mechanism which consists of 9 species and 23 reactions. As a result, some of the mechanism of self-ignition, which had not been able to be clarified by test results, was clarified. For instance, self-ignition occurred in a lean, high-temperature region (Fig. 1), and the time to self-ignition had a strong correlation with the ignition delay time (Fig. 2). Although there is still a problem in predicting the self-ignition limit by numerical simulations, qualitative prediction is possible.

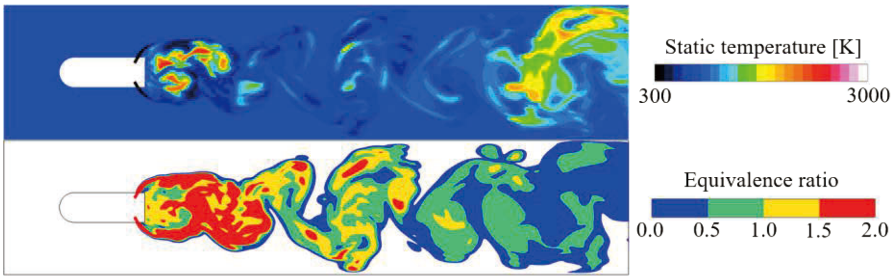

Fig. 1: Static temperature and equivalence ratio distribution

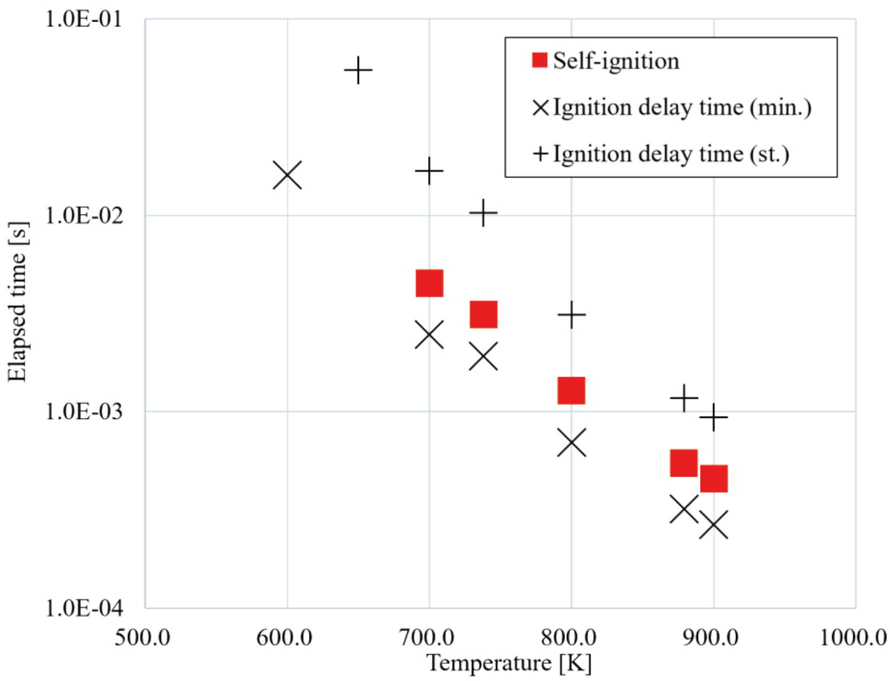

Fig. 2: Ignition delay time and time to self-ignition

Publications

- Oral Presentations

1) Komatsu, Y., Yamamoto, H., Sato, T., and Taguchi, H., Numerical Simulation of the Ram Combustor for High-Mach Integrated Control Experiment (HIMICO), 32nd International Symposium on Space Technology and Science, Fukui, Japan, 2019-a-33, Jun. 2019.

2) Komatsu, Y., Yamamoto, H., Sato, T., Mizobuchi, Y., Nambu, T. and Taguchi, H., Numerical Simulation of Self ignition in Ram Combustor for High Mach Integrated Control Experiment (HIMICO), 47th Annual Conference of GTSJ, C-20, Hakodate, Sep. 2019.

3) Komatsu, Y., Sato, T., Mizobuchi, Y., Nambu, T. and Taguchi, H., Numerical Simulation of Self-ignition with Detailed Chemical Kinetics in Ram Combustor for High Mach Integrated Control Experiment (HIMICO), Space Transportation Symposium FY2019, STCP-2019-021, Sagamihara, Jan. 2020.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1024
Elapsed Time per Case	180 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.66

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	5,869,603.13	0.71
SORA-PP	19,863.22	0.13
SORA-LM	206.23	0.09
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	476.84	0.40
/data	9,765.63	0.17
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on dynamic instability of a reentry capsule at transonic speed

Report Number: R19ETET12
Subject Category: Skills Acquisition System
URL: https://www.jss.jaxa.jp/en/ar/e2019/11637/

Responsible Representative

Takashi Aoyama, Aeronautical Technology Directorate, Numerical Simulation Research Unit

Contact Information

Aeronautical Technology Directorate, Numerical Simulation Research Unit(ohmichi.yuya@jaxa.jp)

Members

Masato Harafuji

Abstract

It is suggested that fluid phenomena of specific frequency may affect the dynamic instability of atmospheric entry capsules. In this study, numerical fluid calculation was carried out for the blunt body shape, and the wake structure was investigated using dynamic mode decomposition.

Reasons and benefits of using JAXA Supercomputer System

Large cost is required to simulate unsteady flow fields.

Achievements of the Year

Unsteady fluid simulation around a blunt body at subsonic speeds and pattern extraction by dynamic mode decomposition were carried out.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	128
Elapsed Time per Case	50 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.04

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	104,346.82	0.01
SORA-PP	24,899.36	0.16
SORA-LM	1,428.87	0.60
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	238.42	0.20
/data	42,480.49	0.73
/ltmp	976.56	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	17.33	0.44

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Space and Astronautical Science

NLFFF calculations of the solar coronal magnetic field based on Hinode observations

Report Number: R19EU0912
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2019/11647/

Responsible Representative

Yoshifumi Saito,, Institute of Space and Astronautical Science, Department of Solar System Sciences

Contact Information

Toshifumi Shimizu (shimizu.toshifumi@jaxa.jp)

Members

Yusuke Kawabata, Toshifumi Shimizu, Takahiro Hasegawa

Abstract

Our study focuses on understanding of the mechanism responsible for the occurrence of the solar flares. We derive 3D magnetic field structure in the corona by performing a 3D magnetohydrodynamics simulation using vector magnetic field maps acquired with the Hinode spacecraft. We investigate 3D magnetic field structure formed in the solar atmosphere responsible for the occurrence of solar flares.

Ref. URL: http://www.isas.jaxa.jp/home/solar/solarPlasma/whatsSolarPlasma.html

Reasons and benefits of using JAXA Supercomputer System

We perform 3D magnetohydrodynamics numerical simulations by using vector magnetic field data acquired with the Hinode spacecraft in order to derive 3D magnetic field structures in the solar corona. We need large computational resource in order to perform three-dimensional magnetohydrodynamics simulations.

Achievements of the Year

Nonlinear force-free field (NLFFF) modeling is a strong tool to derive the three-dimensional magnetic field in the solar corona, where the force-free approximation is valid. If we give the magnetic field map observed in the photosphere as a boundary condition, we can solve this nonlinear equation. However, Gary (2002) argued that the magnetic field at the photosphere does not satisfy the condition for the force-free. This year we attempted to obtain the chromospheric magnetic field (1000 km above the photosphere) with spectropolarimetric observations and compared it with the magnetic field dervied by the NLFFF modeling from the photsphere. We measured the shear signed angle (SSA) from the observed magnetic field and NLFFF. Our analysis shows that there is more twisted magnetic field in the chromosphere than photospheric magnetic field and the NLFFF estimated as shown in Figure 1.

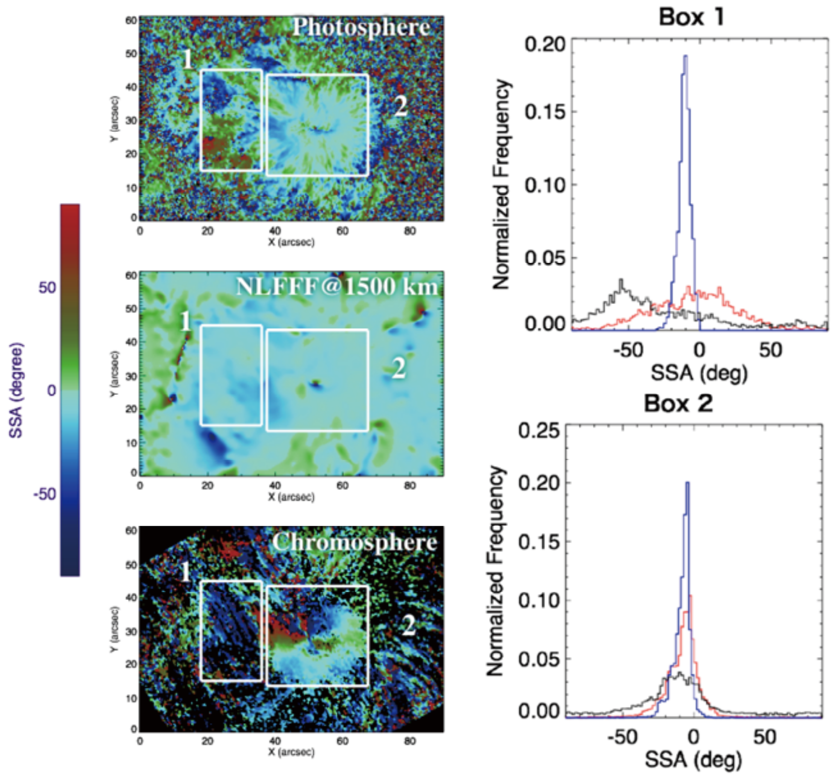

Fig. 1: Left panels: Top, middle, and bottom panels are he spatial distributions of shear signed angle (SSA) in the active region in the photosphere, NLFFF at 1500km height, and chromosphere, respectively. Right panels: The histogram of SSAs in the white rectangle of left panels. Black, red, and blue lines show the SSA in the photosphere, NLFFF at 1500km height, and chromosphere, respectively.

Publications

- Invited Presentations

Y. Kawabata, "Current status and future prospective of solar spectropolarimetry", JSPC symposium, Tokyo, February-2020

- Oral Presentations

Y. Kawabata, A. Asensio Ramos, S. Inoue, T. Shimizu, "Chromospheric magnetic field: A comparison of He I 10830 A observation with nonlinear force-free field extrapolation", Solar Polarization Workshop, Gottingen, August-2019

Y. Kawabata, A. Asensio Ramos, S. Inoue, T. Shimizu, " Three-dimensional magnetic field structure in active regions ~ Future prospective in EUVST era", ASJ meeting, Kumamoto, September-2019

- Poster Presentations

Y. Kawabata, A. Asensio Ramos, S. Inoue, T. Shimizu, "Chromospheric magnetic field: A comparison of He I 10830 A observation with nonlinear force-free field extrapolation", Hinode-13 Science Meeting, Tokyo, September-2019

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1 - 192
Elapsed Time per Case	20 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	5,750.94	0.35

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	25.61	0.02
/data	254.85	0.00
/ltmp	5,208.34	0.44

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Plasma Simulation on Advanced Space Propulsion Systems

Report Number: R19EU0904
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2019/11646/

Responsible Representative

Ikkoh Funaki, Associate Professor, ISAS

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Ikkoh Funaki(funaki.ikkoh@jaxa.jp)

Members

Shitan Tauchi, Ryota Hara

Abstract

Due to the limitation of the existing spacecraft technology level, it is very difficult to enable solar system explorations in a quick and cost-effective mannger. Objective of this study is to obtain a breakthrough spacecraft propulsion technology that enables solar system exploration of the next generations.

Reasons and benefits of using JAXA Supercomputer System

Design optimization of spacecraft propulsion requires a huge computer resource, hence supercomputer usage is very important.

Achievements of the Year

For a self-field magnetoplasmadynamic (MPD) thruster, the numerical simulation was conducted to verify and validate the experimental result. The numerical simulation was performed at a discharge current of 9 kA for a hydrogen propellant (0.4 g/s). As a result, the numerical result was in good agreement qualitatively with the experimental result as shown in Fig. 1. Although this numerical simulation code has not been validated yet, it can be improved by incorporating with adequate electrode model.

In addition, magnetohydrodynamic analysis was performed on the magneto plasma sail to investigate the influence of plasma injection conditions on thrust characteristics. This year, we dealt with the magneto plasma sail in the case of performing the plasma injection which combined the dynamic pressure and the static pressure. As a result of numerical analysis, it was confirmed that the pressure condition (ratio between dynamic pressure and static pressure) of the injection plasma affected the thrust characteristics of the magneto plasma sail, and the thrust gain peaked. From this result, it was found that there was an optimal condition for the pressure condition of the injection plasma.

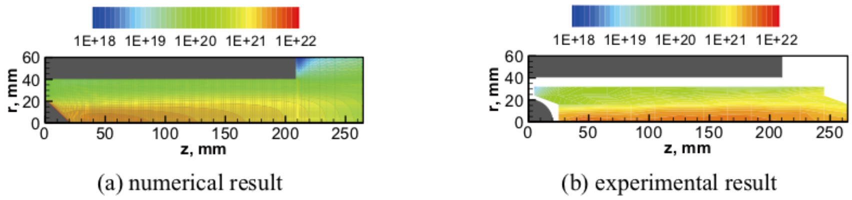

Fig. 1: Electron number density inside MPD Arcjet, m3. (H2, 0.4 g/s, 9 kA)

Publications

- Non peer-reviewed papers

Shitan Tauchi, Yuya Oshio, Akira Kawasaki, and Ikkoh Funaki, Characterization of a Quasi-Steady Self-Field MPD Thruster with Various Electrode Configurations, AIAA-2020-0191, AIAA SciTech Forum, Jan. 2020, Orlando.

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1
Elapsed Time per Case	10 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	172,259.24	0.02
SORA-PP	2,886.29	0.02
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	42.92	0.04
/data	429.15	0.01
/ltmp	8,789.07	0.75

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Plasma simulation for electric propulsion

Report Number: R19EDU10500
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2019/11599/

Responsible Representative

Kazutka Nishiyama, Associate professor

Contact Information

Yusuke Yamashita, Nishiyama laboratory(yamashita@ep.isas.jaxa.jp)

Members

Yusuke Yamashita, Kazutaka Nishiyama

Abstract

Plasma simulation for electric propulsion

Reasons and benefits of using JAXA Supercomputer System

It is available immediately after application

Achievements of the Year

Plasma numerical analysis and flow analysis of neutral particles in electric propulsion were performed. The number of parallel processing was performed by a method using MPI with 20 processes per node. This year, the main focus was on code tuning.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	20
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	13,688.82	0.00
SORA-PP	1,716.30	0.01
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	12.72	0.01
/data	127.16	0.00
/ltmp	2,604.17	0.22

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research and Development of Sample Return Capsule for future planetary exploration

Report Number: R19EU1600
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2019/11648/

Responsible Representative

Masaaki Mokuno (JAXA/ISAS Program Office)

Contact Information

Yamada kazuhiko(yamada.kazuhiko@jaxa.jp)

Members

Kazuki Nohara, Tomoya Kazama, Aoi Harashima

Abstract

Hayabusa is the first sample return mission to an asteroid in deep space and proved its significance worldwide. The sample return mission will become one of the important missions in future planetary exploration. A sample return capsule is indispensable technology to realize it. The objectives of this activity are to take over its heritage and to enhance its technology in order to realize the flexible and attractive future sample return mission.

Reasons and benefits of using JAXA Supercomputer System

Computational fluid dynamics related the sample return capsule was carried out using super computer. These results will be reflected in the design of future sample return capsules. It is generally difficult to reproduce the fluid dynamic condition in free flight of sample return capsule in ground tests. The numerical simulation is useful to understand the fluid dynamics phenomenon. However, the numerical simulation related to fluid dynamics requires the large computational resource. So, the super computer is indispensable. Its complex fluid dynamics around the sample return capsule can be understood, combining the results of both ground tests and numerical analyses using a super computer.

Achievements of the Year

In this year, we continued to compare the unsteady CFD using the computation grid created last year (Fig. 1) with the flow field visualization result by the PIV measurement method carried out in the low-speed wind tunnel test. The evaluated in the RMS fields (Fig. 2) about the flow velocity. Also, estimation of the wake flow region at the back of the capsule that affects the parachute attitude-behavior (Fig. 3) and comparison with the aerodynamic data obtained by the transonic wind tunnel test (Fig. 4). The evaluation of CFD analysis in the subsonic region was progressed. In the future, this numerical method will be utilized for the development of the aerodynamic database and prediction for the aerodynamic stability to future sample return capsule design.

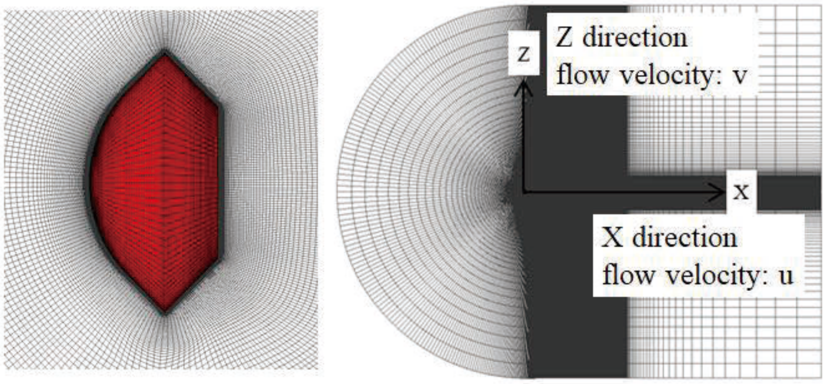

Fig. 1: Computational grid

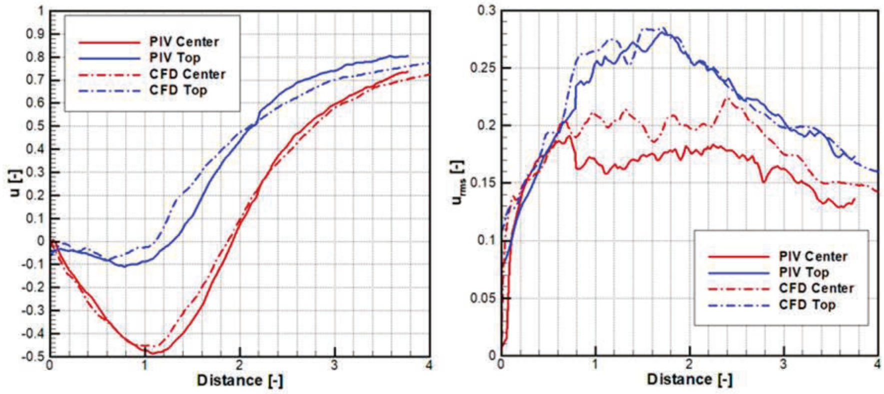

Fig. 2: Comparison with wind tunnel results and CFD analysis results about the distribution of u-velocity and u-RMS of streamwise velocity fluctuation in the wake flow along body axis.

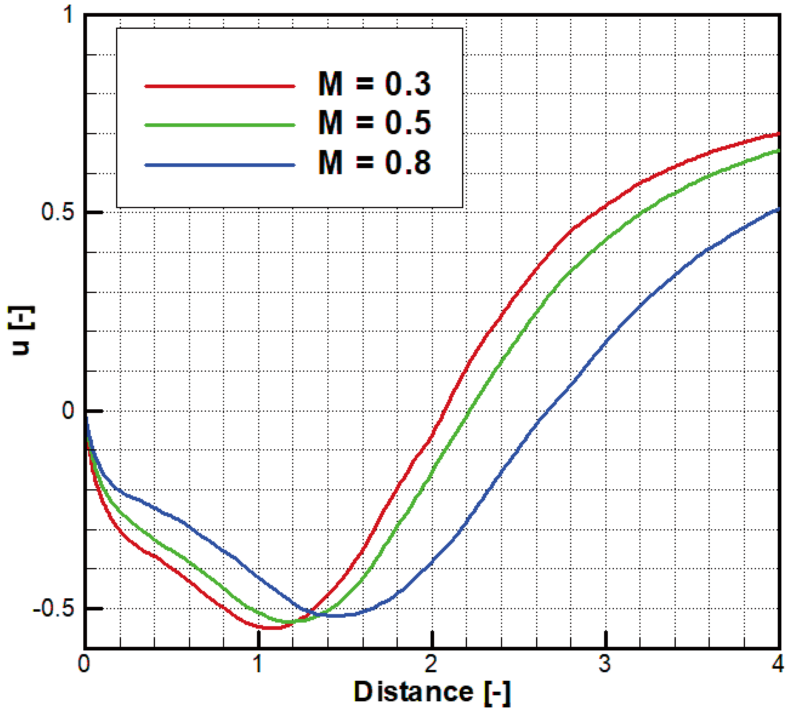

Fig. 3: Comparison of the u-velocity in the wake flow along body axis at Mach number=0.3, 0.5 0.8.

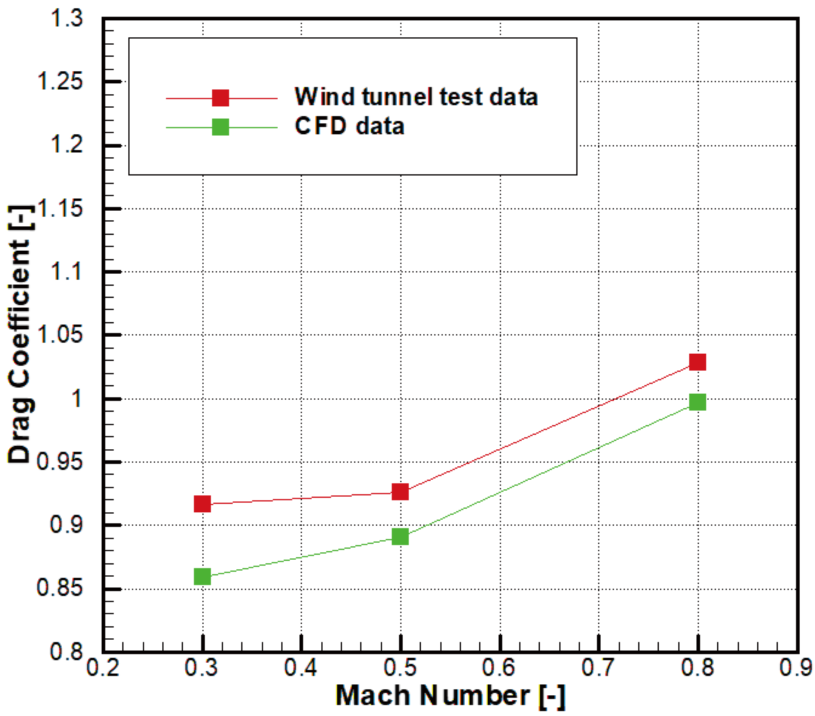

Fig. 4: Comparison with wind tunnel results and CFD analysis results about the drag coefficient.

Publications

- Oral Presentations

Kazuki Nohara, Kazuhiko Yamada, Nobuyoshi Fujimatsu, "A study on Hayabusa Type of Sample Return Capsle Downstream Flow Field",International Symposium on Space Technology and Science, Fukui, Japan, 2019e-53

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	128 - 256
Elapsed Time per Case	350 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	400,143.00	0.05
SORA-PP	27.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	17.48	0.01
/data	174.84	0.00
/ltmp	3,580.73	0.30

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	2.87	0.07

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study of high speed fluid

Report Number: R19EU0902
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2019/11645/

Responsible Representative

Akira Oyama, Associate Professor, Institute of Space and Astronautical Science, JAXA

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Members

Akira Oyama, Hiroaki Fukumoto, Shigetaka Kawai, Satoshi Sekimoto, Daiki Terakado, Yuta Ozawa, Satoshi Shimomura, Taku Nonomura, Shota Taniguchi, Takahiro Nakagami, Bimo Dwianto, Takuma Saito, Naruhiko Nimura, Yukito Tsunoda

Abstract

We conduct fundamental research on aerodynamics such as aerodynamic design of Mars aircrafts.

Reasons and benefits of using JAXA Supercomputer System

Large eddy simulation is required for accurate evaluation of aerodynamic characteristics of Mars airplane. Aerodynamic design of Mars airplane requires several hundred cases of CFD computation. Therefore, a supercomputer is necessary.

Achievements of the Year

Aerodynamics of Mars airplane has been studied in this fiscal year. In the high-altitude flight of Mars airplane planned in 2020 (MABE2), the flight can be high subsonic during its pull-up phase. Thus, we study Mach number effect in low Reynolds number condition using CFD (FIG.1). The results show that the lift coefficient increases and the pitching moment coefficient decreases during the pull-up phase. We also evaluate aerodynamic characteristics of the airfoil, which is obtained by an aerodynamic optimization using evolutionary algorithm and two-dimensional laminar flow simulation. Large eddy simulations of the flow around the optimized airfoil show the optimized airfoil has high lift-to-drag ratio at different angles of attack(FIG.2)(FIG.3). In addition, effects of vortex structures and laminar separation bubble on aerodynamic coefficients are revealed.

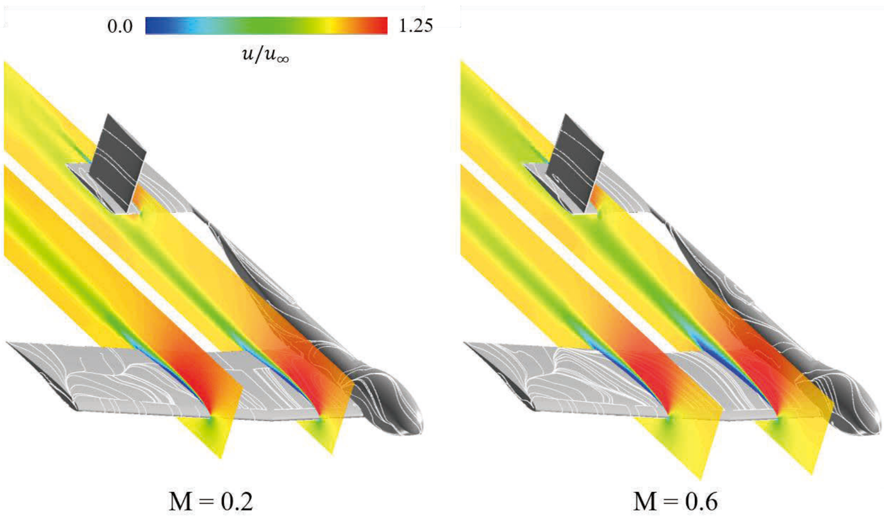

Fig. 1: Flowfield of a Mars airplane at angle of attack of 6 degrees.

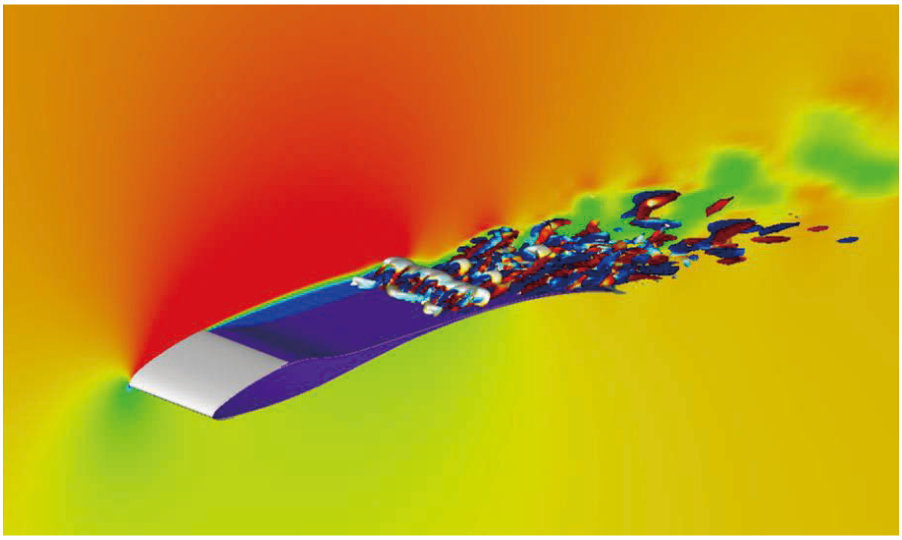

Fig. 2: Flow field around the optimized airfoil at 3 degrees of angle of attack

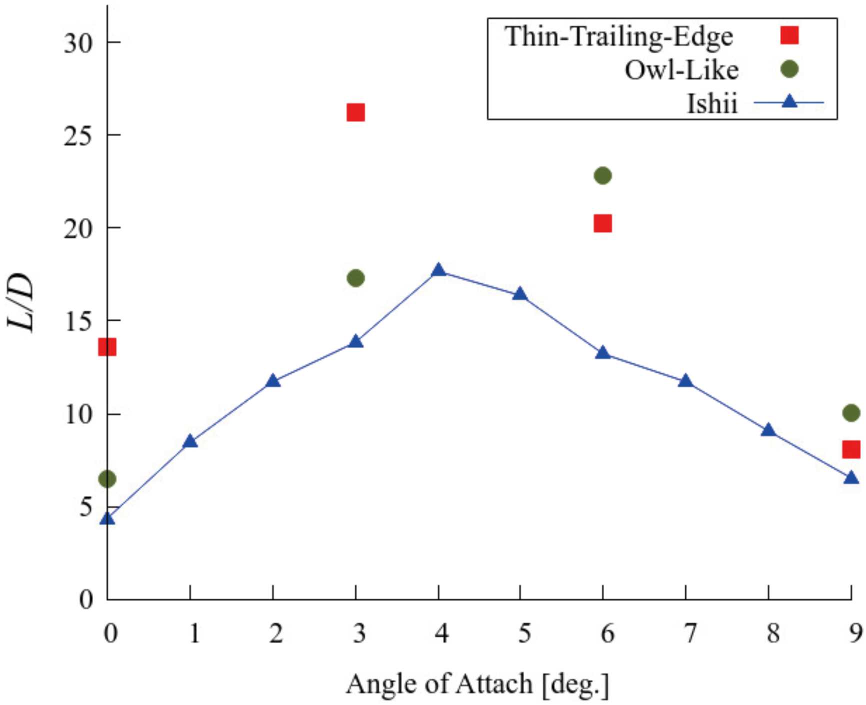

Fig. 3: Lift-to-drag ratio of the optimized airfoil

Publications

- Oral Presentations

Shota Taniguchi, Akira Oyama, Masato Okamoto, Masayuki Anyoji, Koji Fujita, and Hiroki Nagai, "Experimental and RANS analysis of full Mars airplane configurations," AIAA SCITECH FORUM 2020, Orlando, Florida, January 1-6, 2020.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	64 - 1536
Elapsed Time per Case	450 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.98

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	8,714,893.56	1.06
SORA-PP	989.87	0.01
SORA-LM	284.45	0.12
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	2,175.30	1.81
/data	56,400.28	0.97
/ltmp	17,796.76	1.51

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	12.19	0.31

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Space Exploration

Lunar landing site analyses

Report Number: R19EB0101
Subject Category: Space Exploration
URL: https://www.jss.jaxa.jp/en/ar/e2019/11562/

- **Responsible Representative**

Naoki Sato, JAXA Space Exploration Center Space Exploration System Technology Unit

- **Contact Information**

Takeshi Hoshino(hoshino.takeshi@jaxa.jp)

- **Members**

Takeshi Hoshino, Mitsuo Yamamoto, Hiroka Inoue, Hiroyuki Sato

- **Abstract**

Production of lunar polar mosaic for landing site studies.

- **Reasons and benefits of using JAXA Supercomputer System**

It has rich computing resources such as memory and processing units.

- **Achievements of the Year**

We created a multi-band mosaic of the lunar south-pole from Lunar Reconnaissance Orbiter Wide Angle Camera (WAC) data sets.

- **Publications**

- Oral Presentations

Sato,H. (2020) Polar WAC color mosaic and geology: Preliminary results, LROC-Diviner Science Team Meeting.

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	Manual Parallelization (submitted many independent sub-set jobs)
Number of Processes	1
Elapsed Time per Case	1 Hour(s)

Resources Used

Fraction of Usage in Total Resources[*1](%): 0.02

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	3,346.01	0.02
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	94.20	0.08
/data	53,363.91	0.91
/ltmp	6,123.74	0.52

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

System-level technical study for the future lunar polar exploration mission

Report Number: R19EEE20300
Subject Category: Space Exploration
URL: https://www.jss.jaxa.jp/en/ar/e2019/11600/

Responsible Representative
SATO, Naoki; JAXA Space Exploration Center Space Exploration System Technology Unit

Contact Information
HOSHINO, Takeshi(hoshino.takeshi@jaxa.jp)

Members
INOUE, Hiroka; HOSHINO, Takeshi; YAMAMOTO, Mitsuo

Abstract
Evaluation of optical navigation algorithms for the lander of future lunar polar mission

Ref. URL: http://www.exploration.jaxa.jp/e/index.html

Reasons and benefits of using JAXA Supercomputer System
It can be used by contructors and has rich computing resources

Achievements of the Year
The output cannot be made public

Publications
N/A

Usage of JSS2
- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	5 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	1,420.23	0.01
SORA-LM	3,669.32	1.53
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	93.91	0.08
/data	1,328.24	0.02
/ltmp	6,449.26	0.55

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Space Technology

Acceleration of aerosol product retrieval algorithm for Earth observation satellite using Artificial Intelligence (AI)

Report Number: R19EDR20100
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11598/

Responsible Representative

Makiko Hashimoto, Space Technology Directorate I, Earth observation research center

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Members

Makiko Hashimoto, Chong Shi, Kazuya Muranaga, Takashi Nagao

Abstract

With the advancement of satellite sensors, it is required to improve the accuracy of aerosol product estimation and estimate the multiple products simultaneously. Under such circumstances, the conventional LUT method and the method using direct radiative transfer require a huge amount of data and computation time, and it is impractical to extend the algorithm using those method. Therefore, we accelerate the algorithm by an Artificial Intelligence (AI) technique (here, a neural network technique). By using a supercomputer, it is possible to create a large amount of taining data in a short period of time to accelerate an algorithm (radiative transfer model) by using AI techniques. Applying the created general-purpose accelerated radiative transfer solver to GOSAT-2 / CAI-2, Himawari-8 / AHI, GOSAT / CAI, GCOM-C / SGLI, we aim to respond to the increase in data due to the higher resolution of atmospheric observation satellites and aim to provide near real-time data.

Reasons and benefits of using JAXA Supercomputer System

Importance of using JSS2: To educate radiative transfer model required for satellite analysis, it takes about 1.2 billion radiative transfer calculations to create training data. By using a large number of node (600 nodes, 32 cores/node) in JSS2 SORA-MA that we can use, the calculations that take 11 years by 1 node can be performed in about 10 days. In other words, the use of SORA-MA makes it possible to accelerate satellite data analysis. The accelerated radiative transfer model (called NN solver) educated using the calculated training data is applied to the CAI-2 Level 2 aerosol characteristic product derivation algorithm launched in 2018, and to the already launched Himawari and GCOM-C data. If necessary, the NN solver will be improved. As described above, it is necessary to create training data in a short time, and it is very important to use JSS2 SORA-MA.

Achievements of the Year

In this year, we improved the algorithm and the calculation time for deriving aerosol properties for the GOSAT-2/CAI-2 Level2. The acceleration has made it possible to analyze one day of observation data in one day.

-The JAXA supercomputer was used to create training data to accelerate the radiative transfer calculations used by the aerosol retrieval algorithm. The acceleration method is a neural network method (Takenaka +, 2019.NN + Active Learning). The number of training data is 1.2 billion (600 million in ocean case and 600 million in land case), and the time required for calculation is 9 days in ocean case and 7 days in land case. Compared to the original radiative transfer model, accuracy is less than 5.0E-4, calculation speed is reduced to ~ 0.45sec/time/wavelength (land) and ~ 1sec/time/wavelength (ocean) to 0.45E-6sec/time/wavelength (Fig. 1) (Takenaka, EORC).

- In addition to aerosol characteristics, we are developing an aerosol derivation algorithm that combines ocean properties such as chlorophyll, CDOM, and Sediment (SS).100 million training data for ocean case are calculated using JAXA supercomputer. Achieving a speed of more than 50,000 times with the AI-accelerated radiative transfer module(Fig. 2). Applying the algorithm for GOSAT-2/CAI-2, we derived the aerosol characteristics of the global ocean (Fig. 3) (Shi, EORC).

- Using the training data set calculated by JAXA supercomputer, we also have created this high-speed module for Himawari and GCOM-C (Takenaka, EORC) and applied it to data analysis of GCOM-C / SGLI for research (Sekiguchi, Tokyo University of Marine Science and Technology).

- As described above, as a result, we were able to create an AI-accelerated radiation transfer module and apply it to a satellite aerosol analysis algorithm.

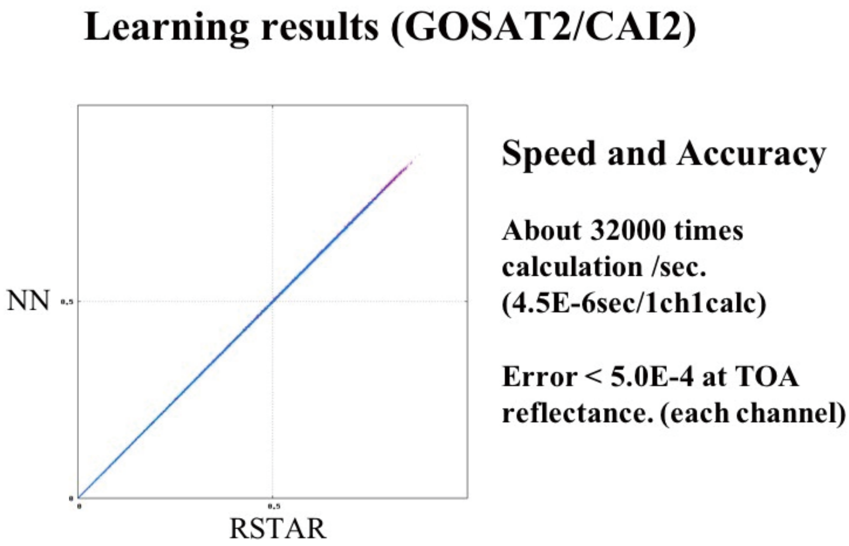

Fig. 1: Learning results for GOSAT-2/CAI-2. Speed and Accuracy. Comparison between the original radiative transfer model and the acceleratied modile (Neural Network solver). X-axis is original radiative transfer model, RSTAR, results, and Y-axis is the learning result.

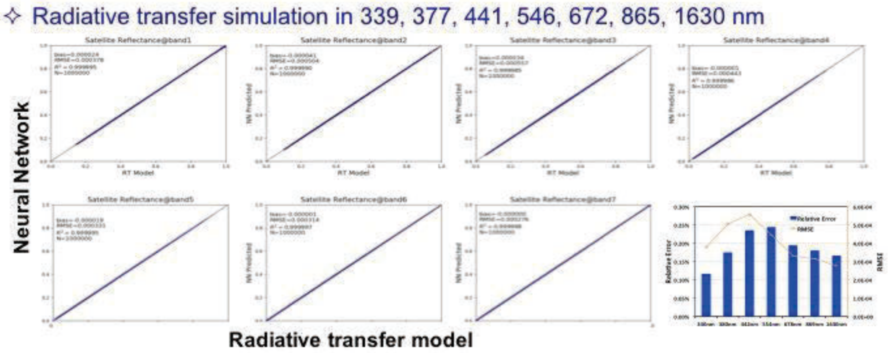

Fig. 2: Comparison between the original radiative transfer model and the accelerated modile including ocean properites. Based on the training data from the JSS2, an accelerated module (Neural Network solver) can be developed to replace the radiative transfer model during the satellite retrieval. X-axis is original radiative transfer model, RSTAR, results, and Y-axis is the learning result.

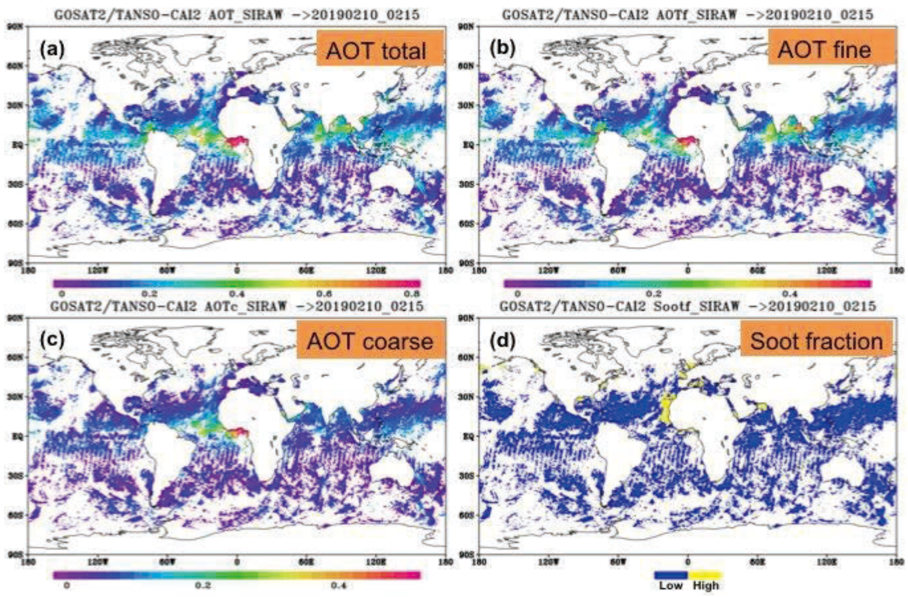

Fig. 3: Application of aerosol retrieval. Global aerosol distribution, total aerosol optical thickness (AOT), fine AOT, coarse AOT and soot volume fraction, by GOSAT2/TANSO-CAI-2 from February 10 to 15 in 2019.

Publications

- Peer-reviewed papers

1) Shi, C., M. Hashimoto and T. Nakajima, 2019: Remote sensing of aerosol properties from multi-wavelength and multi-pixel information over the ocean. Atmos. Chem. Phys., 19, 2416-2475.

2) Ma, R., H. Letu*, K. Yang, T. Wang, C. Shi, J. Xu, J. Shi, C. Shi, and L. Chen (2020), Estimation of Surface Shortwave Radiation from Himawari-8 Satellite Data Based on a Combination of Radiative Transfer and Deep Neural Network, IEEE transactions on geoscience and remote sensing, doi:10.1109/TGRS.2019.2963262.

3) Peng, Z., H. Letu*, T. Wang, C. Shi*, C. Zhao, G. Tana, N. Zhao, T. Dai, R. Tang, and H. Shang (2019), Estimation of shortwave solar radiation using the artificial neural network from Himawari-8 satellite imagery over

China, Journal of Quantitative Spectroscopy and Radiative Transfer, 106672.

- Oral Presentations

1) Shi C., Hashimoto M., Takenaka H., Nakajima T., Retrieval of Aerosol Optical Properties Using GOSAT/TANSO-CAI and GOSAT2/TANSO-CAI2, The 15th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-15), 3-5 June, 2019, Hokkaido, Japan.

2) Hashimoto M., Chong S., Yoshida M., Kikuchi M., M. Nagao T., and Nakajima T., Monitoring of Air Pollution from Space by GOSAT, GOSAT-2 and Himawari-8. LCLUC SARI 2019, 23 July, 2019, Johor Bahru, Malaysia.

- Poster Presentations

1) Shi C., Nakajima T., Hashimoto M., Takenaka H., Simultaneous retrieval of aerosol optical properties and ocean color based on the optimal estimation approach, European Geosciences Union, 7-12 April, 2019, Vienna, Austria.

2) Shi C., Nakajima T., Hashimoto M., Takenaka H., Remote sensing of aerosol optical properties and water-leaving radiance based on the optimal estimation approach, Japan Geoscience Union Meeting, 26-30 May, 2019, Chiba, Japan.

3) Hashimoto M., Takenaka H., Nakajima T. and Higurashi A., Aerosol retrieval and PM2.5 from space using GOSAT/TANSO-CAI, Japan Geoscience Union Meeting, 30 May, 2019, Chiba, Japan.

4) Hashimoto M., Takenaka H., Higurashi A. and Nakajima T., GOSAT-2/TANSO-CAI-2 and the aerosol product. IWGGMS, 4 June, 2019, Hokkaido, Japan.

5) Hashimoto M., Chong S., Takenaka H. and Nakajima T., Comparison of aerosol properties from GOSAT-2/TANSO-CAI-2 with ground-based observation and the error analysis using aerosol retrieval algorithm, JMA fall meeting 2019, 30 October, 2019, Fukuoka, Japan.

6) Hashimoto M., Takenaka H., Chong S. and Nakajima T., GOSAT-2/TANSO-CAI-2 Aerosol properties by Multiple wavelengths and pixels method, AGU Fall Meeting 2019, 9 December, 2019, San Francisco, USA.

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	A large amount of computation was performed using the number of available cores in MA
Number of Processes	1
Elapsed Time per Case	15 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 1.39

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	12,660,282.73	1.54
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	25.43	0.02
/data	10,274.26	0.18
/ltmp	5,208.34	0.44

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

ALOS / PALSAR data processing for the entire observation period

Report Number: R19ER0100
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11617/

Responsible Representative

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Members

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Abstract

Processing the synthetic aperture radar (PALSAR / PALSAR-2) data acquired by the terrestrial observation technology satellites "DAICHI" and "DAICHI-2" to generate user-friendly image products (Analysis Ready Data), Make an offer.

Ref. URL: https://global.jaxa.jp/projects/sat/alos/

Reasons and benefits of using JAXA Supercomputer System

JAXA is developing data disclosure to expand the use of earth observation satellite data.

As part of this, JAXA needs to process a large amount of data for the entire observation period of ALOS / PALSAR and ALOS-2 / PALSAR-2, and quickly release user-friendly image data.

To achieve this, JSS2 processing was optimal, so we used it.(Up to 350 parallel processing)

Achievements of the Year

In FY2019, we started processing all PALSAR data, and as of March 1, 2020, processed about 24% of the total(4,758,182 scenes). Development of the complete processing of PALSAR-2 data has been completed, and processing is scheduled to begin in FY2020. The provision of data from JSS2 to core users has also started for Tellus this fiscal year, and file transfer to NASA and Google Earth Engine is planned for the next fiscal year.

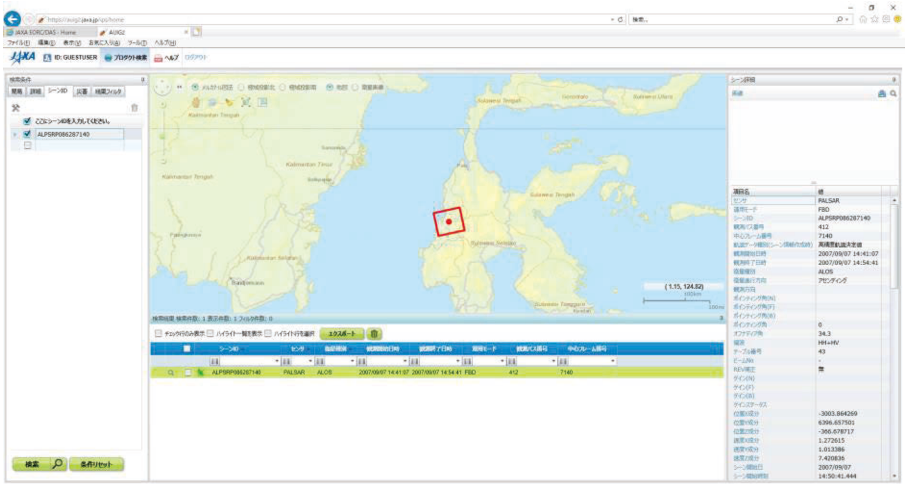

Fig. 1: Image of Indonesia (Celeves) observed by ALOS / PALSAR on September 7, 2007

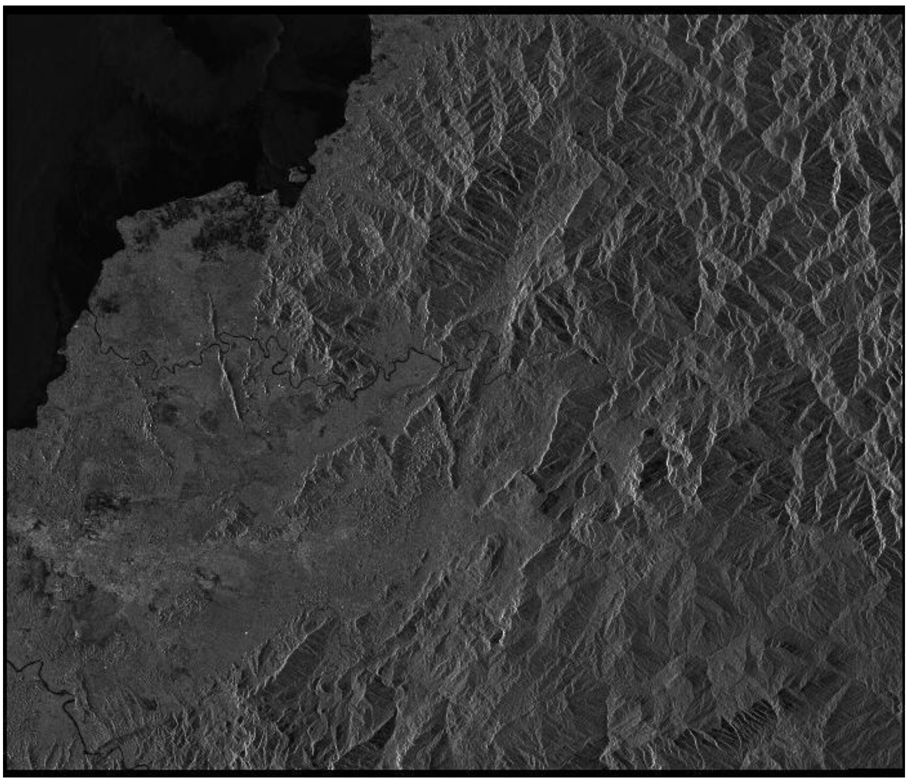

Fig. 2: Search screen in AUIG2

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	10 Minute(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.30

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	12.39	0.00
SORA-PP	645,824.71	4.18
SORA-LM	3.28	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	324.57	0.27
/data	101,954.19	1.75
/ltmp	42,545.59	3.61

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	221.03	5.56

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Atmospheric Environmental Monitoring Simulation

Report Number: R19ER2401

Subject Category: Space Technology

URL: https://www.jss.jaxa.jp/en/ar/e2019/11625/

Responsible Representative

Hiroshi Murakami, Reaserch area leader, JAXA Earth Observation Research Center

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Members

Daisuke Goto, Tie Dai, Yueming Cheng, Hiroshi Murakami

Abstract

This project is aimed at development of an integrated system of numerical modeling and satellite observation of air pollution for its reliable monitoring and prediction. Specially, an atmospheric air pollution transport model (NICAM-Chem) with a data assimilation technique using atmospheric aerosol products retrieved from GCOM-C/SGLI is developed as a prototype for the next generation forecast system in NIES, named VENUS. As a result, the system can reproduce much realistic air pollutions than ever before.

Ref. URL: https://www.eorc.jaxa.jp/en/research/topic/atmosphere/

Reasons and benefits of using JAXA Supercomputer System

In the project, we need to conduct numerical simulations and assimilations with higher spatial grid spacings over wide area for reliable monitoring and predictions of air pollutions over the region. This requires us to exploit high performance super computing resources of JAXA Supercomputer System 2 (JSS2) available at JAXA.

Achievements of the Year

We simulated aerosols in a global scale using an atmospheric air pollution model (NICAM-Chem). Especially, we focused on a remarkable dust transport from Saharan desert to East Asia including Japan on the end of March 2018. The horizontal resolution of NICAM-Chem is set at 56 km, which is the highest resolution among the assimilated simulations. The assimilation technique is a Localized Ensemble Kalman Transform Filter (LETKF) for aerosol simulation. Three numerical experiments were conducted as follows: (1) Without assimilation, (2) With assimilation with aerosol optical thickness (AOT) retrieved from GCOM-C/SGLI and (3) With assimilation with AOT from GCOM-C/SGLI and 3-dimensional aerosol extinction (Cext) retrieved from CALIPSO/CALIOP.

Figure 1 shows a horizontal distribution of both simulated and assimilated AOT on 23UST 27 March 2018 where a dust plume reaches Japan. Over the Saharan desert, the simulated AOT, i.e., non-assimilated AOT, tends to be overestimated compared to the assimilated AOT with only GCOM-C/SGLI, whereas the assimilated AOT with both GCOM-C/SGLI and CALIPSO/CALIOP are higher than the assimilated AOT with only GCOM-C/SGLI. It suggests that the AOT retrieved from GCOM-C/SGLI over the Saharan desert is underestimated compared to the real values. The AERONET measurement, which is independent from the assimilation in this study, were used in the validation. The comparison was conducted at Zanjan in Iran near the Saharan desert (Figure 2). The assimilated results provided higher correlation coefficient and lower room mean square error (RMSE), which shows the improvement of the model reproductivity, even though the limited numbers of the AERONET measurements. In the next fiscal year, we develop a data quality control and reproduce more realistic air pollutions captured by multiple measurements.

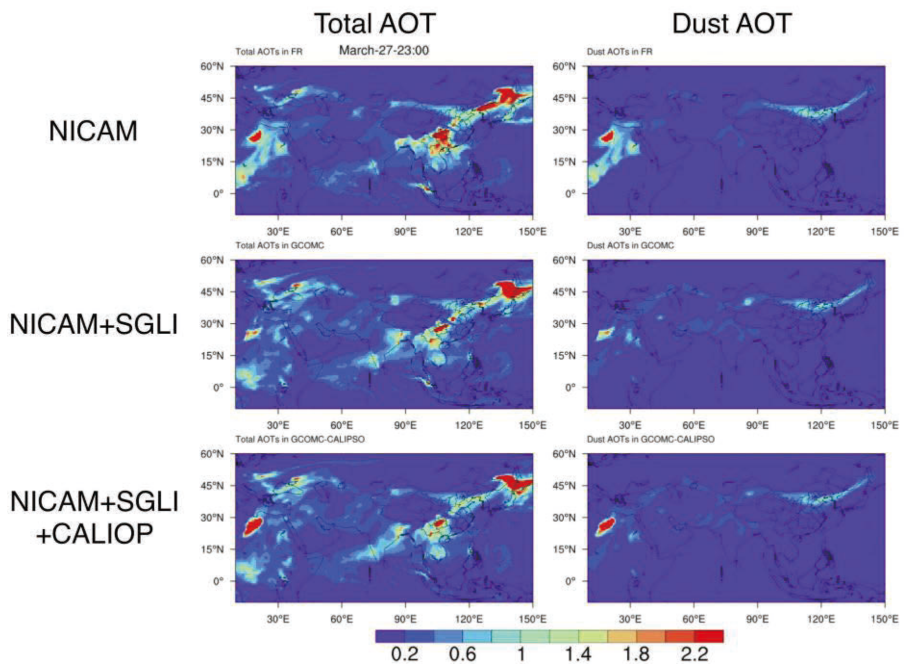

Fig. 1: A horizontal distribution of simulated and assimilated aerosol optical thickness (total AOT) and dust AOT. The results are three: NICAM-Chem without assimilation (upper panels), NICAM-Chem with assimilation using GCOM-C/SGLI (middle panels) and NICAM-Chem with assimilation using both GCOM-C/SGLI and CALIPSO/CALIOP (lower panels).

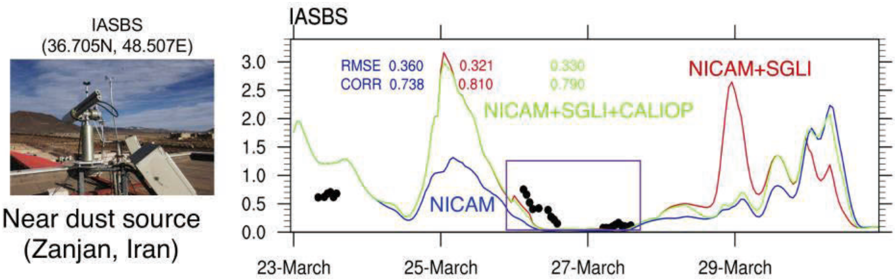

Fig. 2: Temporal variation of AOT at Zanjan, Iran in the end of March 2018. The black circle represents the AERONET measurement, the blue line represents NICAM-Chem without assimilation, the red line represents NICAM-Chem with assimilation using GCOM-C/SGLI and the green line represents NICAM-Chem with assimilation using both GCOM-C/SGLI and CALIPSO/CALIOP. The RMSE and correlation coefficient (CORR) are also shown in the right panel.

Publications

- Peer-reviewed papers

Cheng Y., Dai T., Goto D., Schutgens N.A.J., Shi G., Nakajima T. (2019) Investigating the assimilation of CALIPSO global aerosol vertical observations using Four-Dimensional Ensemble Kalman Filter. Atmospheric Chemistry and Physics, 19, 13445-13467, doi:10.5194/acp-19-13445-2019.

Dai T., Cheng Y., Goto D., Schutgens N.A.J., Kikuchi M., Yoshida M., Shi G., Nakajima T. (2019) Inverting the East Asian Dust Emission Fluxes Using the Ensemble Kalman Smoother and Himawari-8 AODs: A Case Study with WRF-Chem v3.5.1. Atmosphere, 10, 543, doi:10.3390/atmos10090543.

Goto D., Morino Y., Ohara T., Sekiyama T. T., Uchida J., Nakajima T. (2020) Application of linear minimum variance estimation to the multi-model ensemble of atmospheric radioactive Cs-137 with observations. Atmospheric Chemistry and Physics, 20, 3589-3607, doi:10.5194/acp-20-3589-2020.

- Oral Presentations

Goto D., Sugata S., Dai T., Cheng Y., Nakajima T. (2019) Application of a multi-model ensemble method for PM2.5 estimation, 16th Annual Meeting: Asia Oceania Geosciences Society (AOGS), Singapore, Singapore, August 2019

- Poster Presentations

Goto D., Morino, Y., Ohara, T., Sekiyama, T. T., Uchida, J., Nakajima, T., (2019) Development of multi-model ensemble method for radionuclides released from Fukushima nuclear accident, 2019 American Geophysical Union (AGU) Fall Meeting, San Francisco, USA, December 2019

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1 - 160
Elapsed Time per Case	20 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	1,167,068.41	0.14
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	1,648.27	1.37
/data	39,984.40	0.68
/ltmp	13,346.36	1.13

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Earth observation satellite data processing for GPM/DPR

Report Number: R19ER0200
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11618/

Responsible Representative

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Members

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Abstract

In recent years, worldwide interest has been increasing about the necessity of grasping the global environmental change. To deal with such problems, various approaches using observation technology from space have been carried out by satellites.

Global Precipitation Measurement (GPM) mission, as follow-on and expansion of Tropical Rainfall Measurement Mission (TRMM) satellite, is an international mission to achieve highly accurate and frequent global rainfall observation. it is carried with multiple satellite, GPM core satellite with Dual-frequency Precipitation Radar (DPR) jointly developed by JAXA and NICT, and with GPM Microwave Imager (GMI) developed by NASA, and another constellation satellites with Microwave Imager.

It also implements a system for estimating the global precipitation distribution based on the data acquired from GPM core satellite and another constellation satellites. It is named "GSMaP" (Global Satellite Mapping of Precipitation).

In addition, accumulation of long-term data is important to understand long-term climate change on a global scale. It is important to be able to use the data of the TRMM satellite operated from 1997 to 2015 as well as the data of the GPM satellite.

Ref. URL: http://global.jaxa.jp/projects/sat/gpm/

Reasons and benefits of using JAXA Supercomputer System

Processing of earth observation data includes "operational processing" performed routinely and "re-processing" performed once a year or so for several year data. The purpose of re-processing is to correspond with version-up of computing model and algorithm performed periodically. The amount of observation data grows year by year. Then, we need more and more time to complete reprocessing of all archived observation data. By using supercomputers, the calculation time is greatly shortened, and it is possible to provide products quickly to users.

In addition, the frequency of re-processing is about once every one to two years, so the necessary period of computer resource for re-processing is limited. If this computer resource is prepared on ourselves, it is inefficient in terms of the computer utilization. The use of JSS2 is advantageous in that it can relatively flexibly secure computer resources when we needed.

In this project, the total re-processing time is reduced by increasing the number of concurrently executing processes using MPI parallel processing called "workflow control".

Achievements of the Year

Using version 6 of the processing algorithm released in FY2018, the past GPM data was reprocessed from FY2018 to FY2019. The overview of GPM reprocessing is as follows. (The past TRMM data reprocessing was completed during FY2018.)

period of observation : 2014/3/8 - 2018/9/30
CPU usage time : Approx. 20,334.6 hours
Number of output files : 345,565 files
Total output file capacity : 149.0 TB

In addition, we plan to upgrade latent heat processing algorithm which are part of GPM processing and GSMaP processing algorithm in FY2020, we transferred input data for them to JSS2 in FY2019.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	10 - 12
Elapsed Time per Case	19.4 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	298.76	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	138.71	0.12
/data	139,195.64	2.38
/ltmp	20,526.42	1.74

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	23.54	0.59

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Greenhouse gases Observing SATellite (GOSAT) mission

Report Number: R19ER2100
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11623/

Responsible Representative

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Members

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Abstract

GOSAT continues its observations for 10-years beyond its 5-year mission, providing well-calibrated high spectral resolution data. The overall functions and performances are successful and no significant degradation of SNR and spectral resolution has been observed. Several anomalies were found onboard, but they have stabilized since. The Level 1 algorithms have been updated since launch in order to correct these anomalies.

Ref. URL: http://www.eorc.jaxa.jp/GOSAT/index.html

Reasons and benefits of using JAXA Supercomputer System

GOSAT mission utilizes JSS2 as one of the GOSAT Mission Operation System which processes the observation data of GOSAT. When processing algorithm is updated, JSS2 reprocesses all data observed in the past. When we calibrate products, JSS2 processes all data in the past.　Also, JSS2 is used as a remote storage of all data required for its reprocessing.

Achievements of the Year

(1)GOSAT TANSO-FTS Level-1 Reprocessing

We reprocessed 10 year TANSO-FTS data by utilizing JSS2 (30nodes) to correspond with next version-up (V220.220). It took only 22 days, and we could verify speed-up more than 30 times comparing to one 1.7-year by using the conventional GOSAT L1 processing computers.

(2)Calibration and validation of GOSAT TANSO-CAI data

On-orbit sensor sensitivity change is evaluated from TANSO-CAI observation data. We expect to determine the CAI Band 1 radiometric calibration factor (or formula) by calculation of radiative transfer model using in-situ and other satellite data. The CAI Band 1 has an important information of aerosol size distribution. Hence, Band 1 radiance is optimized to agree with calibrated radiances of Band 2 and Band 3. Calibration formula of Band 2 and Band 3 are obtained as three candidates. Thus, Band 1 calibration factor is determined by calculations in these three cases. Figure 1 shows a schematic flow of the CAI radiometric calibration method. Figure 2 shows the radiometric calibration factors.

Data period: June 2019 - February 2020 (every 4 months)

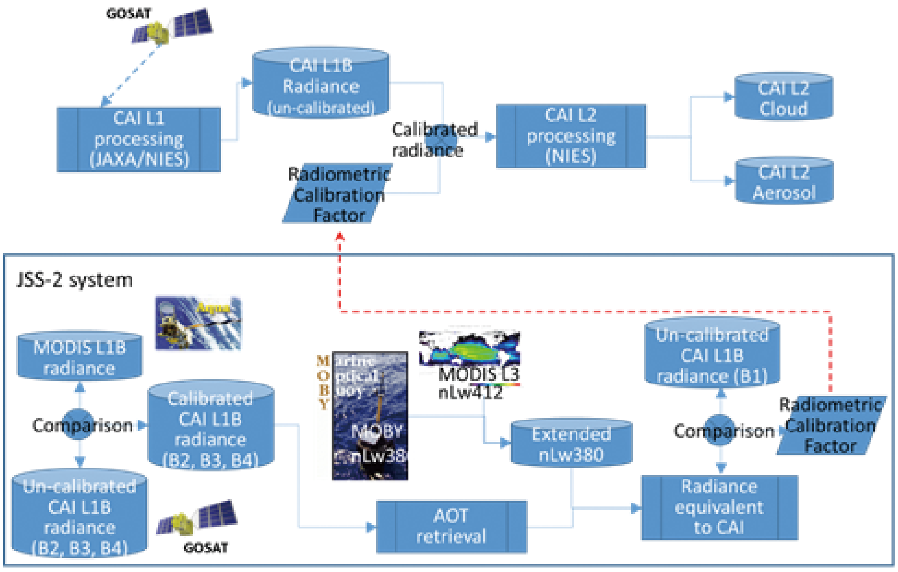

Fig. 1: GOSAT CAI processing flow (top) and radiometric calibration flow (bottom)

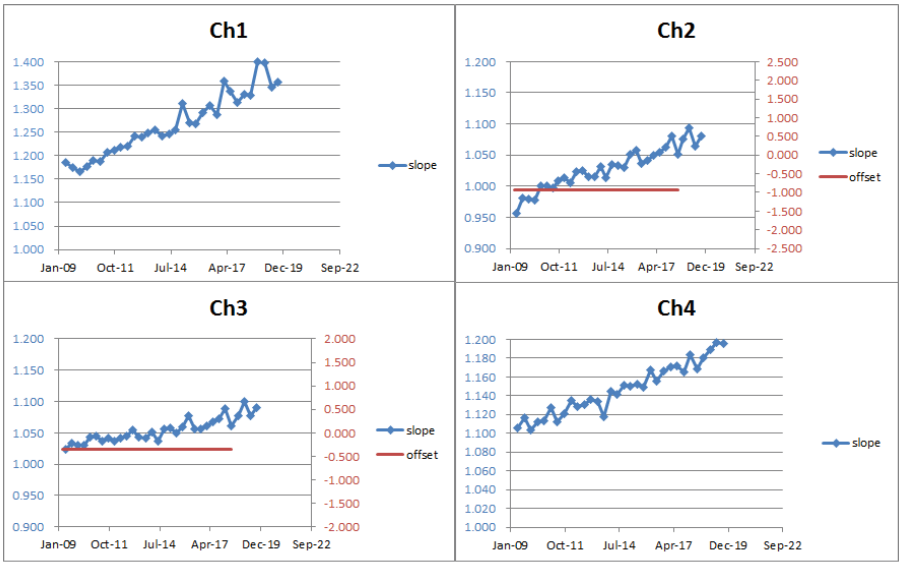

Fig. 2: CAI radiometric calibration factor by inter-satellite cross calibration method

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	30 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	183,656.84	1.19
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	210.66	0.18
/data	275,278.22	4.71
/ltmp	18,847.66	1.60

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	1.93	0.05

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Greenhouse gases Observing SATellite-2 (GOSAT-2) Project

Report Number: R19ER3500
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11627/

Responsible Representative

KUZE Akihiko, GOSAT-2 Project Team, Space Technology Directorate I

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Members

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Abstract

GOSAT-2 project retrieve and estimate the global concentration distribution of major greenhouse gases including the sources and natural absorbers with high level of accuracy to contribute to environmental administration as follows.

- Improved precision of climate change predictions
- Early detection of changes in the Earth system
- Better understanding of emission reduction level of the anthropogenic greenhouse gases and changing natural sink
- Contribution to air pollution monitoring policies

Also, GOSAT-2 project researches and develops new earth observation technologies required for future earth observing satellites.

Ref. URL: http://global.jaxa.jp/projects/sat/gosat2/

Reasons and benefits of using JAXA Supercomputer System

GOSAT-2 project utilizes JSS2 as one of the GOSAT-2 Mission Operation System which processes the observation data of GOSAT-2. When processing algorithm is updated, JSS2 reprocesses all data observed in the past. Also, JSS2 is used as a remote storage of all data required for its reprocessing.

As the reprocessing targets of GOSAT-2 products extends to all data observed in the past, more computer resources (core, memory, storage, etc.) are required than in the real-time processing.

It is necessary to use JSS2 to shorten the reprocessing time and to provide the reprocessing products to GOSAT-2 users in a more timely manner.

Achievements of the Year

We have been transmitting L0 data from the GOSAT-2 Mission Operation System to JSS2 in preparation for reprocessing of L1 products on JSS2 since observation by TANSO FTS-2 and TANSO-CAI-2 started.

In FY2019, we have updated the L1 processing algorithm for TANSO-FTS-2 and TANSO-CAI-2 three times and reprocessed the past observation data on JSS2 each time.

The version-up history of GOSAT-2 TANSO-FTS-2 1B product is shown below.

- Version 002.004 : Apr.2019 Preparation for initial calibration version (L+6M)
- Version 100.100 : Jul.2019 After initial calibration version (L+9M) (Release to general users)
- Version 101.101 : Apr.2019 Bug fix

The version-up history of GOSAT-2 TANSO-CAI-2 1A product is shown below.

- Version 000.001 : Apr.2019 Preparation for initial calibration version (L+6M)
- Version 100.100 : Jul.2019 After initial calibration version (L+9M) (Release to general users)
- Version 101.101 : Apr.2019 Bug fix

The FTS-2 L1B and CAI-2 L1B product has been available to general users from "GOSAT-2 Product Archive" (https://prdct.gosat-2.nies.go.jp/en/index.html) since July 2019.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	5 Minute(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	14,958.23	0.10
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	148.93	0.12
/data	129,931.83	2.22
/ltmp	30,501.32	2.59

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical analysis for turbo pumps

Report Number: R19EK2305
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11616/

Responsible Representative

Masashi Okada, Project manager, H3 Project Team

Contact Information

Satoshi Ukai(ukai.satoshi@jaxa.jp)

Members

Hideyo Negishi, Satoshi Ukai, Mizuho Aotsuka

Abstract

Design evaluation using numerical simulation is carried out for technical issues of the LE-9 engine turbo pump.

Reasons and benefits of using JAXA Supercomputer System

In order to carry out large-scale numerical analysis of multiple cases in a short period of time.

Achievements of the Year

The analysis of forced resonance of turbine rotors has been carried out, and the results have been reflected to LE-9 turbo pump design.

Publications

- Non peer-reviewed papers

Azuma et al, "The Development Status of LE-9 Engine Turbopump for H3 Launch Vehicle", AIAA Propulsion and Energy Forum, Indianapolis, AIAA Paper 2019-4439, August, 19-22, 2019

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	XPFortran
Thread Parallelization Methods	OpenMP
Number of Processes	20 - 960
Elapsed Time per Case	500 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 2.91

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	26,411,763.52	3.21
SORA-PP	8,077.66	0.05
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	3,680.62	3.07
/data	16,850.50	0.29
/ltmp	2,393.54	0.20

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.26	0.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Numerical Simulations for H3 Rocket Development

Report Number: R19EK2302
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11615/

Responsible Representative

Masashi Okada, Space Technology Directorate I, H3 Project Team

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Members

Kuniyuki Takekawa, Seiji Tsutsumi, Masashi Kanamori, Masaaki Ino, Hironori Fujiwara, Masaharu Abe, Hiroyuki Ito, Shinji Ohno, Takenori Nakajima, Hideyo Negishi, Yu Daimon, Takanori Haga, Taro Shimizu, Junya Aono, Tetsufumi Ohmaru, Taroh Fukuda, Masashi Toyama, Osamu Fukasawa, Kohki Tao

Abstract

Please refer to the following URL: http://global.jaxa.jp/projects/rockets/h3/

Reasons and benefits of using JAXA Supercomputer System

Risk management is the key to make a success of a large-scale development project like H3 rocket. This is because its development schedule and cost could be significantly influenced by the face of imminent risks when new technologies are under system-level verification and validation. In order to complete the project under defined period and cost, a variety of efforts are essential for planning and process of technology development itself in terms of efficiency and certainty. In that context, numerical simulation technologies and JSS2 have been playing one of major roles to make the H3 project success.

Achievements of the Year

With regard to the booster engine, 'LE-9', under detailed design phase, evaluation of design and risks as well as studies for improvement were carried out by making full use of JSS2. In FY2019, numerical simulations of the combustion chamber and turbopump design were performed to improve their designs and contributed to the LE-9 engine development.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	FLAT
Number of Processes	128 - 16000
Elapsed Time per Case	300 Hour(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 13.81

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	125,280,237.90	15.23
SORA-PP	15,096.88	0.10
SORA-LM	8,765.75	3.66
SORA-TPP	2.17	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	10,919.58	9.09
/data	91,673.05	1.57
/ltmp	4,300.14	0.37

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	123.94	3.12

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Precise Orbit Determination by using MADOCA on JSS2

Report Number: R19ER0800
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11620/

Responsible Representative

Koichi Inoue, Space Technology Directorate I, Satellite Navigation Unit

Contact Information

Hiroshi Takiguchi(takiguchi.hiroshi@jaxa.jp)

Members

Hiroshi Takiguchi, Sho Miyoshi

Abstract

Satellite Navigation Unit has been generating the precise orbit and clock products of GNSS satellites by using MADOCA (Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis), and been distributing to user via network routinely. On the JSS2, we aim to realize fast computation for the long-term data analysis and simulation.

Ref. URL: https://ssl.tksc.jaxa.jp/madoca/public/public_index_en.html

Reasons and benefits of using JAXA Supercomputer System

To improve the MADOCA products accuracy, we need to do long-term data analysis. By using JSS2, we have been expecting the reduction of the data analysis time.

Achievements of the Year

SNU has been generating and providing the precise orbit and clock products of GNSS satellites by using MADOCA on the general-purpose PC routinely.

In this fiscal year, we carried out the following tests related to the improvement of routine precise orbit determination (POD);

1) Generation of the Ultra-Rapid product every single hour.

In routine operation, we generate the Ultra-Rapid product every 6 hours due to the ability of a general-purpose PC, but we confirmed that we could generate it every single hour by using JSS2.

2) Routine real-time POD.

We adjusted the real-time data communication environment between JSS2 and our general-purpose PC, and tried real-time POD. We confirmed that real-time POD was possible without any problem.

3) Identification of malfunction of real-time POD.

We performed the re-analysis and identified the malfunction of real-time POD. We confirmed that by using JSS2 enabled high-speed calculations and reduced time.

4) Validation of the GNSS system combination on simultaneous real-time POD.

In routine operation, we carry out simultaneous real-time POD with the combination of GPS, GLONASS, and QZSS system due to the ability of a general-purpose PC. We confirmed that even if Galileo was added to this combination, it could be done without any problem.

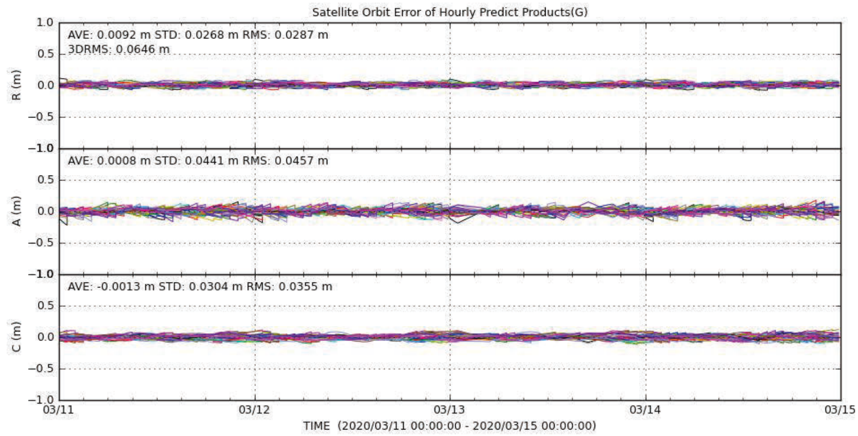

Fig. 1: The evaluation results of the predicted part in the Ultra-Rapid products which generaed every single hour with reference to the IGS Rapid products. From the top, Radial, Along and Cross components.

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	30 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.05

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	23.01	0.00
SORA-LM	0.00	0.00
SORA-TPP	71,634.01	4.32

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	100.14	0.08
/data	2,584.46	0.04
/ltmp	1,953.13	0.17

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research for data assimilation of satellite global rainfall map

Report Number: R19ER0201
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11619/

Responsible Representative

Riko Oki, Deputy Director, Space technology Directorate I, Earth Observation Research Center

Contact Information

Space technology Directorate I, Earth Observation Research Center, Takuji Kubota(kubota.takuji@jaxa.jp)

Members

Koji Terasaki, Shunji Kotsuki, Kaya Kanemaru, Kenta Kurosawa, Ying-Wen Chen, James Taylor

Abstract

This study explores an effective use of satellite data including GSMaP and GPM/DPR through an advanced ensemble data assimilation method for improving numerical weather prediction (NWP) and pioneering a new precipitation product based on an NWP model and satellite observations, named as NICAM-LETKF JAXA Research Analysis (NEXRA).

Ref. URL: https://www.eorc.jaxa.jp/theme/NEXRA/index_e.htm

Reasons and benefits of using JAXA Supercomputer System

In this study, the JSS2 is used for the NICAM-LETKF experiments to assimilate satellite observations and to conduct NWP model forecasts. The JSS2 is a necessary infrastructure for our study to conduct massive computations for the ensemble-based data assimilation and ensemble atmospheric simulations.

Achievements of the Year

(1) GPM / DPR direct assimilation experiment

In this fiscal year, model parameters related to the terminal velocity of snow were optimized by assimilating GPM / DPR observations. The temperature and water vapor fields from the lower to middle troposphere were improved by modifying the terminal velocity parameter of snow (Fig. 1). However, in the upper troposphere, the temperature field was degraded. Generally, a constant value is used for this parameter everywhere. However, data assimilation allows estimating different values for each altitude, and this may mitigate the degradation in temperature. In the next fiscal year, we plan to continue the research on parameter estimation for cloud microphysics schemes using GPM/DPR observations.

(2) NICAM-LETKF hydrological assimilation system

Continuing with RA8, NICAM-LETKF was used to develop a coupled data assimilation system for land-based observation data. In addition to atmospheric observation data assimilated by NICAM-LETKF, as the first step of assimilation of hydrological observation data, we performed a data assimilation experiment using soil water content provided by global land reanalysis GLDAS. All coupled data assimilation experiments showed good results with reduced errors in soil moisture for GLDAS compared to the control experiments. In the coupled data assimilation experiments, partially strongly-coupled data assimilation, which updates the atmospheric model variables by assimilating soil moisture observations but does not update the land surface model variables by assimilating atmospheric observations, provided the best result. The results suggest that the estimation of atmospheric states by assimilation of soil moisture observation be effective.

(3) Improvement of model radiation bias by model parameter estimation

A method for model parameter estimation was investigated. In climate predictions, it is important to maintain the radiation balance of the Earth system properly, and tuning of model parameters is required to reduce the radiation bias of the model. In the default model settings, cloud cover was an issue, and cloud reflections caused excessive upward shortwave radiation at the top of the atmosphere. The parameters of the large-scale condensation scheme were estimated using the cloud amount observed by the Advanced Microwave Scanning Radiometer 2 (AMSR2) onboard the GCOM-W (Global Change Observation Mission-Water) satellite. As a result, we obtained results that improved cloud cover and drastically reduced the radiation bias of the model.

(4) Development of NICAM-LETKF=GSMaP_RNC Seamless Forecasting System

The world's first global precipitation seamless forecast system was developed by combining precipitation forecasts from NICAM-LETKF and GSMaP_RNC. The prediction of precipitation is obtained as a locally-optimized weighted average of the forecasts from both NICAM-LETKF and GSMaP_RNC. The experiment was conducted with the training period for 1 year from September 2014 for finding the optimal weights at each location, and the verification period as the subsequent year. GSMaP_RNC outperformed NICAM in the forecast accuracy up to 7 hours ahead but reversed after that. The result that the prediction became more accurate at all forecast lead times by merging both.

(5) Accounting for the horizontal observation error correlation in data assimilation

In this fiscal year, we conducted data assimilation experiments to explore methods accounting for the horizontal observation error correlation of the Advanced Microwave Sounding Unit-A (AMSU-A) which has the most significant impact in the NICAM-LETKF numerical weather prediction. The horizontal observation error correlation of AMSU-A was estimated using the method proposed by Desroziers et al. (2005). By explicitly considering observation error correlations in data assimilation, geopotential fields in the lower troposphere tended to degrade. However, the accuracy of the analyses for temperature, zonal wind, and humidity improved by up to about 5% (Fig. 2). In addition, the accuracy of forecast was improved.

(6) Improving the base assimilation system of NEXRA

The performance of a new NICAM-LETKF system which is planned to be the base model of the next generation of NEXRA has been tested on JSS2. The new NICAM-LETKF system newly assimilates the microwave radiance observed by the Advanced Technology Microwave Sounder (ATMS) and the humidity profiles observed by

Microwave Humidity Sounder (MHS) in addition to PREPBUFR, AMSU-A and GSMaP_NRT. Results show that the atmospheric field obtained from the new NICAM-LETKF system shows a good agreement with reanalysis data JRA55 (Fig. 3).

(7) The development of high resolution of NEXRA

In this fiscal year, a new forecast system with 14-km resolution in horizontal is developed. The 14-km resolution in horizontal is also called as cloud system resolving resolution, which is able to resolve the life cycles of cloud systems. The initial data for this new forecast system are linearly interpolated from 112 km analysis data obtained from the current NICAM-LETKF system. Meanwhile, the large condensation scheme used in 112 km NEXRA is replaced to the cloud microphysics scheme (NSW6). We conducted a forecast experiment for the typhoon KROSA which hit Hiroshima prefecture of Japan in August 2019 by using this new forecast system. Results show that the forecasted typhoon path of KROSA has good agreements with observations (Fig.4). At the time before KROSA hit the Hiroshima prefecture, the structure of the large eye of the typhoon KROSA is also well captured in this high-resolution experiment.

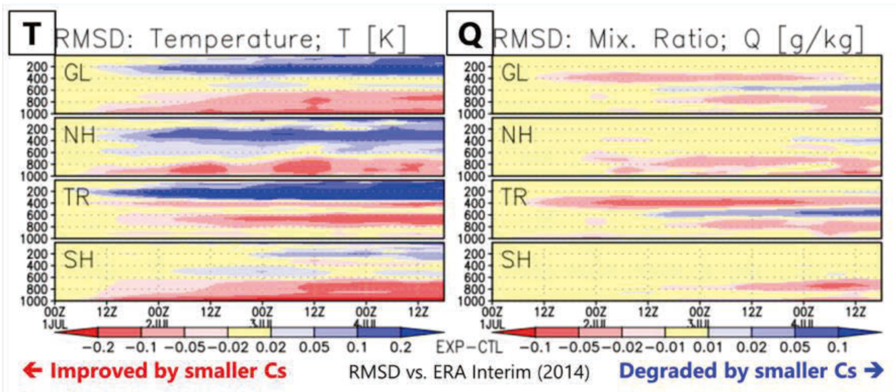

Fig. 1: Time-series of change in root mean square error against ERA-interim of (left) temperature (K) and (right) specific humidity (g/kg) by modifying terminal velocity of snow. Negative value indicates improvement. Four panels show the global (GL), Northern hemisphere (NH), Tropics (TR), and Southern hemisphere (SH), respectively.

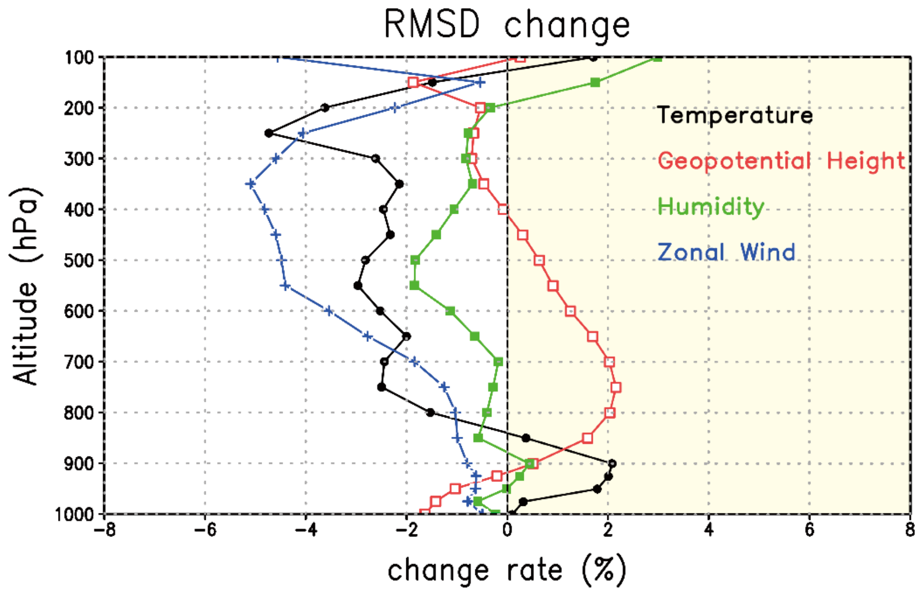

Fig. 2: Difference in analysis root mean square error with and without accounting for horizontal observation error correlation. The colored solid lines indicate (black) temperature, (red) geopotential height, (green) specific humidity, and (blue) zonal wind, respectively.

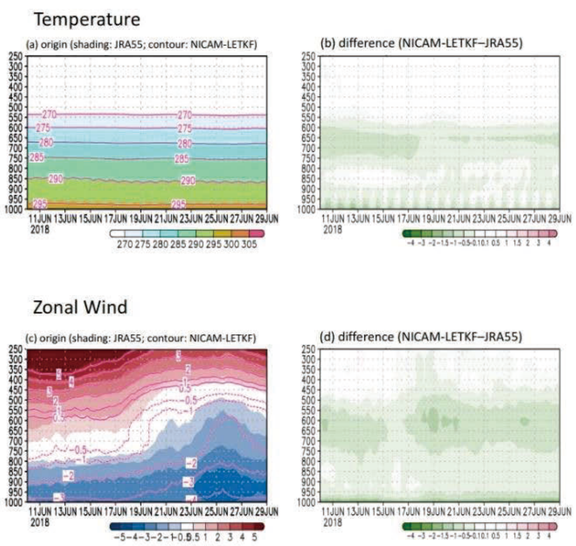

Fig. 3: Time-height sections for the temperature (the upper panel, unit K) and zonal wind (the lower panel, unit m/sec) fields. (a) shows the comparison between the temperature obtained from new-NICAM-LETKF (contours) and JRA55 (shadings) and (b) shows the difference. (c) shows the comparison between the zonal wind obtained from new-NICAM-LETKF (contours) and JRA55 (shadings) and (d) shows the difference. The unit of the vertical axis is hPa and the duration is from 00Z10JUN2018 to 18Z29JUN2018 (UTC).

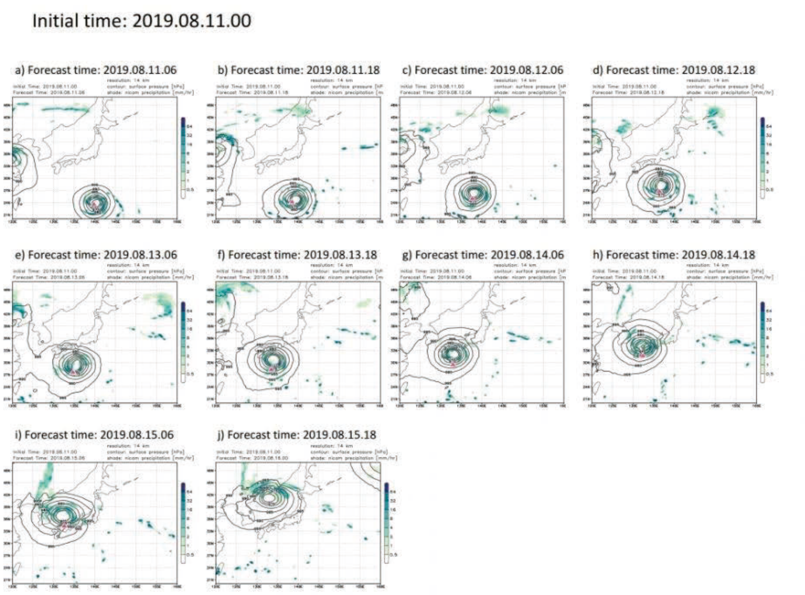

Fig. 4: The 12 hourly snap shots for the 14-km NEXRA forecast experiment for typhoon KROSA (2019) with the initial time at 00Z11AUG2019 (UTC). Contours and shadings denote the sea level pressure (unit: hPa) and hourly precipitation (mm/hr), respectively. The pink triangle in each snap shot shows the observed typhoon center.

Publications

- Peer-reviewed papers

1. Kotsuki, S., K. Kurosawa, S. Otsuka, K. Terasaki, and T. Miyoshi, 2019: Global Precipitation Forecasts by Merging Extrapolation-Based Nowcast and Numerical Weather Prediction with Locally Optimized Weights. Wea. Forecasting, 34, 701-714. https://doi.org/10.1175/WAF-D-18-0164.1
2. Kotsuki S., Kurosawa K., and Miyoshi T. (2019): On the Properties of Ensemble Forecast Sensitivity to Observations. Quarterly Journal of the Royal Meteorological Society, 145, 1897-1914. https://doi.org/10.1002/qj.3534
3. Kotsuki, S., Sato, Y., & Miyoshi, T. (2020). Data assimilation for climate research: Model parameter estimation of large‐scale condensation scheme. Journal of Geophysical Research: Atmospheres, 125, e2019JD031304. https://doi.org/10.1029/2019JD031304

- Invited Presentations

1. 2019/5/29 Kotsuki S., Sato Y., Terasaki K., Yashiro H., Tomita H., Satoh M. and Miyoshi T.: Model Parameter Estimation with Data Assimilation using NICAM-LETKF. JpGU Meeting 2019.
2. 2019/6/4 Takemasa Miyoshi, Big data assimilation: A new science for weather prediction and beyond, 14TH INTERNATIONAL EnKF WORKSHOP IN VOSS, PARK HOTEL VOSSEVANGEN, VOSS, NORWAY
3. 2019/6/13 Takemasa Miyoshi, Big Data Assimilation: A New Science for Weather Prediction and Beyond,

Seminar, DWD, Frankfurt, Germany

4. 2019/6/17 Takemasa Miyoshi, Big Data Assimilation: A New Science for Weather Prediction and Beyond, Seminar, LMU, Munich, Germany

5. 2019/7/10 Takemasa Miyoshi, HPC challenges in numerical climate simulation and weather prediction, INTERNATIONAL HPC SUMMER SCHOOL 2019, R-CCS, Kobe, Japan

6. 2019/7/17 Takemasa Miyoshi, Advancing data assimilation as a science hub: from weather forecasting and beyond, ICIAM2019, University of Valencia, Valencia, Spain

7. 2019/9/26 Takemasa Miyoshi, Invited talk, 6th CREST Big Data Application Camp for Researchers, Shonan Village Center, Kanagawa, Japan

8. 2019/11/12 Takemasa Miyoshi, Big Data Assimilation: 30-second-update Weather Forecasting and Perspectives toward DA-AI Integration, Big Data, Data Assimilation and Uncertainty Quantification, Institut Henri Poincare, Paris, France

9. 2019/11/27 Takemasa Miyoshi, Big Data Assimilation:A New Science for Weather Prediction and Beyond, seminar, ACADEMIA SINICA, Taipei, Taiwan

10. 2019/11/28 Takemasa Miyoshi, Big Data Assimilation:A New Science for Weather Prediction and Beyond, seminar, National Taiwan University, Taipei, Taiwan

11. 2019/11/29 Takemasa Miyoshi, Big Data Assimilation:A New Science for Weather Prediction and Beyond, seminar, National Central University, Taoyuan City, Taiwan

12. 2019/12/5 Otsuka, S. and T. Miyoshi: Overview of the rapid-update weather forecasting with the phased-array weather radar, 2019 6th KNU CARE Workshop on Phase array radar and Nowcasting, Daegu, Korea

- Oral Presentations

1. 2019/4/8 Takemasa Miyoshi, Shigenori Otsuka, Takumi Honda, Guo-Yuan Lien, Yasumitsu Maejima, Yoshito Yoshizaki, Hiromu Seko, Hirofumi Tomita, Shinsuke Satoh, Tomoo Ushio, Tatiana V. Martsinkevich, Balazs Gerofi, and Yutaka Ishikawa, Big Data Assimilation: Past 5 Years and Perspectives for the Future, EGU2019, Austria Center Vienna (ACV), Vienna, Austria

2. 2019/4/9 Takemasa Miyoshi, Shunji Kotsuki, Koji Terasaki, Kenta Kurosawa, Shigenori Otsuka, Kaya Kanemaru, Hisashi Yashiro, Masaki Satoh, Hirofumi Tomita, Kozo Okamoto, and Eugenia Kalnay, Enhancing Data Assimilation of GPM Observations: Past 6 Years and Future Plans, EGU2019, Austria Center Vienna (ACV), Vienna, Austria

3. 2019/4/14 Takemasa Miyoshi, Big Data Assimilation: A New Science for Weather Prediction and Beyond, Japan-Israel meeting, Collabo Shiga 21, Otsu, Japan

4. 2019/5/30 Kotsuki S., Terasaki K., and Miyoshi T.: Ensemble-Based Data Assimilation of GPM/DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM. JpGU Meeting 2019, Chiba, Japan

5. 2019/7/30 Takemasa Miyoshi, Big Data Assimilation: Past 5 Years and Perspectives for the Future, AOGS, Suntec Singapore Convention & Exhibition Centre, Singapore

6. 2019/8/2 Takemasa Miyoshi, Enhancing Data Assimilation of GPM Observations: Past 6 Years and Future Plans, AOGS, Suntec Singapore Convention & Exhibition Centre, Singapore

7. 2019/8/26 Takemasa Miyoshi, Big Data Assimilation: A New Science for Weather Prediction and Beyond, Seminar, CIMA, Buenos Aires, Argentina

8. 2019/9/17 Takemasa Miyoshi, Shigenori Otsuka, Takumi Honda, Guo-Yuan Lien, Yasumitsu Maejima, Marimo Ohhigashi, Yoshito Yoshizaki, Hiromu Seko, Hirofumi Tomita, Shinsuke Satoh, Tomoo Ushio, Balazs Gerofi, Yutaka shikawa, Naonori Ueda, Kana Koike, Yasuhiko Nakada: Big Data Assimilation: Past 6 Years and Future Plans, 39th International Conference on Radar Meteorology, Nara Kasugano International Forum IRAKA, Nara, Japan

9. 2020/1/13 Takemasa Miyoshi, Big Data Assimilation: Real-Time Workflow for 30-Second-Update Forecasting and Perspectives Toward DA-AI Integration, AMS 100th Annual Meeting, Boston Convention and Exhibition Center, Boston, USA

10. 2020/1/24 Takemasa Miyoshi, Enhancing Precipitation Prediction Algorithm by Data Assimilation of GPM Observations, The Joint PI Meeting of JAXA Earth Obervation Missions FY2019, TKP Shinbashi Conference Cetre, Tokyo, Japan

11. 2020/2/10 Koji Terasaki and Takemasa Miyoshi, Accounting for the horizontal observation error correlation of satellite radiances in data assimilation, Brest, France

12. 2020/2/17 Takemasa Miyoshi, "Big Data Assimilation in Weather Prediction: From K to Fugaku", The 2nd R-CCS International Symposium, Nichii Gakkan Kobe Port Island Center, Kobe, Japan

- Poster Presentations

1. 2019/8/21 Ying-Wen Chen, Kaya Kanemaru, Masaki Satoh, Koji Terasaki, Shunji Kotsuki, Takemasa Miyoshi, and Takuji Kubota: The resent progress of NICAM-LETKF forecast system, The 2019 University Allied Workshop on Climate and Extreme Weather, Chiba, Japan

2.2019/9/16 Kotsuki S., Kurosawa K., Kanemaru K., Terasaki K. and Miyoshi T.: A New Evaluation Method for Cloud Microphysics Schemes Using GPM Dual-frequency Precipitation Radar. 39th International Conference on Radar Meteorology, Nara, Japan

3.2020/2/3 Kotsuki S., Terasaki K., Satoh M. and Miyoshi T.: Ensemble-Based Data Assimilation of GPM/DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM. 4th workshop on assimilating satellite cloud and precipitation observations for NWP, Reading, UK

4.2020/2/17 Koji Terasaki and Takemasa Miyoshi, Towards big data assimilation in Fugaku by accounting for the horizontal observation error correlation of satellite observations, R-CCS international symposium, Kobe, Japan

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	5 - 400
Elapsed Time per Case	12 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 4.32

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	37,398,934.21	4.55
SORA-PP	8.87	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	2,412.80	2.01
/data	767,040.60	13.13
/ltmp	15,625.01	1.33

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	40.25	1.01

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Research of Precipitation Measuring Mission

Report Number: R19ER1400
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11621/

Responsible Representative

Riko Oki, Earth Observation Research Center

Contact Information

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Members

Tomohiko Higashiuwatoko, Takeshi Masaki,Munehisa K. Yamamoto, Takuji Kubota, Tomoko Tashima, Moeka Yamaji

Abstract

Calculation of the global rainfall map derived from Tropical Rainfall Measuring Mission (TRMM) during a period from 2000 to 2014 using the GSMaP algorithm (V07).

Checks of consistency between the TRMM Precipitation Radar (PR) algorithm (V8) and the GPM/DPR algorithm (V06) with long-term observation data.

Ref. URL: https://www.eorc.jaxa.jp/TRMM/index_e.htm

Reasons and benefits of using JAXA Supercomputer System

The JSS2 is necessary for calculation of the long-term data which consists of multiple satellites and sensors for the precipitation measurement with earlier computational times for algorithm evaluations, improvements, and long-term production. Because of the complexity of the processing algorithms, strict business progress management, emergency response, detailed user response by the operation side, etc. are required. When we do not use the JSS2, it can be said that reprocessing in a short period cannot be achieved.

Achievements of the Year

GSMaP validation test was performed to evaluate the algorithm for the GSMaP major versionup scheduled in 2020. A series of GSMaP modules such as forward calculation, retrieval, and gridding part are executed for a total of eight months data, and the difference and validity of the estimated rainfall before and after the replacement of the database and algorithm for orographic/nonorographic rainfall classification scheme.

In some tests, significant overestimation was observed under orographic rainfall detection area or in some areas (Fig. 1) due to insufficient DB samples for GPM/DPR, and due to the value of hail density which is largely depended on the estimated precipitation. After the replacement of DB for TRMM/PR and dynamic value of hail density based on freezing precipitation depth, the rain estimation is improved (Fig. 2).

In JSS2, processing time was shortened by executing parallel processing, which led to acceleration of the development cycle.

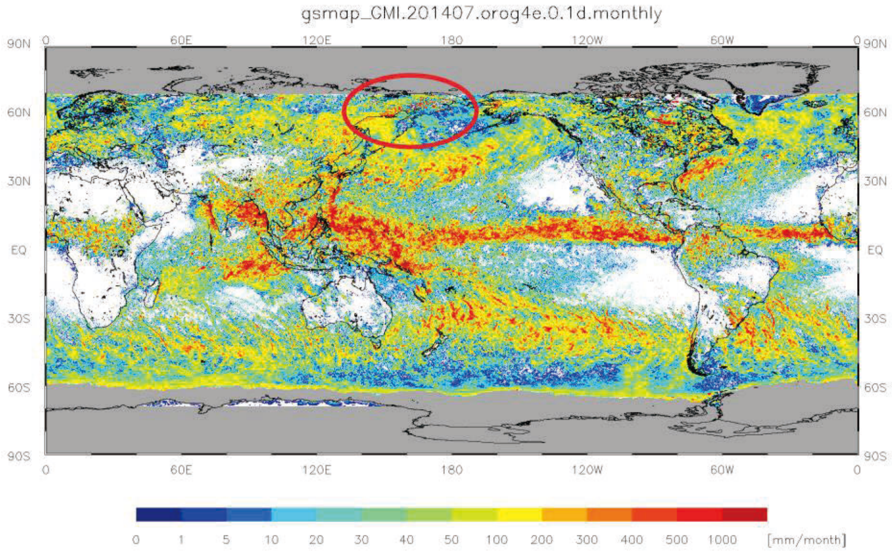

Fig. 1: Monthly mean rainfall in July 2014. Database for orographic/nonorographic rainfall classificat ion sheme is 5 years of GPM/DPR data. Precipitation in Chukchi region in Russia (red circle) and some areas of the middle- and high-latitudes is significantly overestimated.

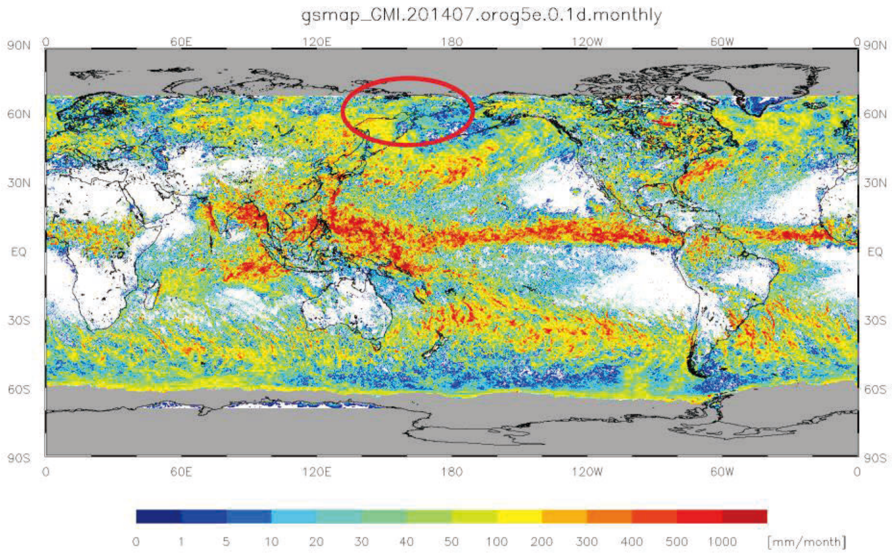

Fig. 2: The same as Caption 1 but for database for orographic/nonorographic rainfall classification sheme is 11 years of TRMM/PR data.

Publications

- Peer-reviewed papers

1. M. Yamaji, H. G. Takahashi, T. Kubota, R. Oki, A. Hamada, and Y. N. Takayabu, 2020: 4-year Climatology of Global Drop Size Distribution and its Seasonal Variability Observed by Spaceborne Dual-frequency Precipitation Radar, JMSJ, in revision.
2. Y. You, N.-Y. Wang, T. Kubota, K. Aonashi, S. Shige, K. Kachi, C. Kummerow, D. Randel, R. Ferraro, S. Braun, Y. Takayabu, Comparison of TRMM Microwave Imager Rainfall Datasets from NASA and JAXA, JHM, in press.
3. T. Kubota, K. Aonashi, T. Ushio, S. Shige, Y. N. Takayabu, M. Kachi, Y. Arai, T. Tashima, T. Masaki, N. Kawamoto, T. Mega, M. K. Yamamoto, A. Hamada, M. Yamaji, G. Liu and R. Oki, 2020: Global Satellite Mapping of Precipitation (GSMaP) products in the GPM era, Satellite precipitation measurement, Springer, in press.
4. T. Mega, T. Ushio, T. Matsuda, T. Kubota, M. Kachi and R. Oki, 2019: Gauge-Adjusted Global Satellite Mapping of Precipitation, IEEE Trans. Geosci. Remote Sens, vol. 57, no. 4, pp. 1928-1935, doi: 10.1109/TGRS.2018.2870199.

- Non peer-reviewed papers

1. Kuleshov, Y., Kubota, T., Tashima,T., Xie, P., Kurino, T., Hechler, P., Alexander, L.V., 2020: WMO Space-based Weather and Climate Extremes Monitoring Demonstration Project for East Asia and Western Pacific, WMO Bulletin, in press.
2. Yuriy Kuleshov, Lynette Bettio, Takuji Kubota, Tomoko Tashima, Pingping Xie, Toshiyuki Kurino, Peer Hechler, 2020: Drought monitoring in Australia: utilizing products from the WMO Space-based Weather and Climate Extremes Monitoring Demonstration Project, WMO Statement on theState of the Global Climate in 2019, in press.
3. T. Kubota, 2020: GSMaP: Monitoring Rainfall from Space to Protect Communities, Scientia, https://doi.org/10.33548/SCIENTIA392
4. Y. Kuleshov, K. Inape, A. B. Watkins, A. Bear-Crozier, Z.-W. Chua, P. Xie, T. Kubota, T. Tashima, R. Stefanski, T. Kurino, 2019. Climate Risk and Early Warning Systems (CREWS) for Papua New Guinea. IntechOpen, DOI: 10.5772/intechopen.85962.
5. Y. Kuleshov, T. Kurino, T. Kubota, T. Tashima, P. Xie, 2019. WMO Space-based Weather and Climate Extremes Monitoring Demonstration Project (SEMDP): First outcomes of regional cooperation on drought and heavy precipitation monitoring for Australia and South-East Asia. IntechOpen, DOI: 10.5772/intechopen.85824

- Oral Presentations

1. Yamaji, M. R. Oki, T. Kubota, T. Tashima, Y. Kaneko, K. Yamamoto, T. Iguchi, N. Takahashi, and Y. N. Takayabu. 2019: Recent results of the Global Precipitation Measurement (GPM) mission in Japan. EGU2019-3903, EGU General Assembly 2019, April 2019, Vienna, Austria.
2. Yamaji, M. et al. 2019: JAXA Earth Observation Program and Data Product. CGMS-47 Working Group II session, agenda item 9, May 2019, Sochi, Russia.
3. T. Kubota et al., Precipitation Extremes Monitoring Using Global Satellite Mapping of Precipitation (GSMaP) product, JpGU Meeting 2019, May 2019, Makuhari-Messe, Chiba.
4. Tashima, T., T. Kubota, and R. Oki. 2019: Precipitation Extremes Monitoring Using GSMaP Products. 32nd ISTS symposium, June 2019, Fukui, Japan.

5. Yamaji, M. and T, Kubota. 2019: Impact Study on the Accuracy of Global Satellite Mapping of Precipitation (GSMaP) Caused by Future Small Precipitation Radar Constellation. 32nd ISTS symposium, June 2019, Fukui, Japan.
6. M. Yamaji, T. Kubota, and R. Oki. 2019: OBSERVING SYSTEM SIMULATION EXPERIMENT ON THE ACCURACY OF GLOBAL SATELLITE MAPPING OF PRECIPITATION (GSMAP) BY FUTURE SMALL PRECIPITATION RADAR CONSTELLATION. WE2.R2.4, IGARSS 2019, July 2019, Yokohama, Japan.
7. T. Tashima, T. Kubota, and R. Oki. 2019: Precipitation Extremes Monitoring Using Global Satellite Mapping of Precipitation (GSMaP) Products. IGARSS 2019, July 2019, Yokohama, Japan.
8. T. Kubota et al. Recent Status of the Global Precipitation Measurement (GPM) Mission in Japan, AOGS 2019@Singapore on Aug. 2019
9. Kubota, T., 2019JAXA GSMaP & Applications Status, NASA PMM Science Team Meeting 2019, Indianapolis, U.S.
10. Yamaji, M. et al. 2019: Application of Global Satellite Mapping of Precipitation (GSMaP) in Asia-Pacific region. APRSAF Space Application Working Group, Nov 2019, Nagoya, Japan.

- Poster Presentations
1. Yamaji, M. et al. 2019: JAXA Earth Observation Program and Data Product. CGMS-47 Working Group II session, agenda item 9, May 2019, Sochi, Russia.
2. Yamaji, M., H. G. Takahashi, T. Kubota, R. Oki, A. Hamada, and Y. N. Takayabu. 2019: Gloal Drop Size Distribution observed by GPM/DPR. Poster1-01, 39th International Conference on Radar Meteorology, Sep. 2019, Nara, Japan.
3. Yamaji, M., H. G. Takahashi, T. Kubota, R. Oki, A. Hamada, and Y. N. Takayabu. 2019: Global Drop Size Distribution in Liquid Phase and its Seasonal Variability Observed by GPM/DPR. #217, NASA PMM Science Team Meeting 2019, Indianapolis, U.S.

- Web

JAXA Global Rainfall watch

https://sharaku.eorc.jaxa.jp/GSMaP/index.htm

EORC TRMM

https://www.eorc.jaxa.jp/TRMM/index_e.htm

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	24 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	0.00	0.00
SORA-PP	21,193.57	0.14
SORA-LM	43.20	0.02
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	60.40	0.05
/data	71,147.32	1.22
/ltmp	10,904.95	0.93

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	23.54	0.59

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Retrieval of greenhouse gas concentrations from GOSAT-2 observations

Report Number: R19ER3501
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11628/

Responsible Representative

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Contact Information

Nobuhiro Kikuchi (Earth Observation Research Center)(kikuchi.nobuhiro@jaxa.jp)

Members

Kenji Kowata, Takehito Yoshida, Fumie Kataoka, Makiko Hashimoto, Shin Ishida, Tomoo Yamasaki, Hideyuki Noguchi, Nobuhiro Kikuchi

Abstract

Atmospheric concentrations of carbon dioxide, methane and carbon monoxide are retrieved from hyper sectral data measured by The Greenhouse Gasea Observing Sattelite 2 (GOSAT-2). Develement, validation and imprivement of the retrieva algorithm are also carried out.

Reasons and benefits of using JAXA Supercomputer System

The JAXA supercomputer system is used to retrieved greenhouse gas concentrations from measurement data of the GOSAT-2 satellite. About 100 hours of CPU time is needed to process 1day mesurement data. It takes about 1 hour to process 1 day measurement data, using 10 nodes of the PrePost system computers with 12 cores.

Achievements of the Year

GOSAT-2 was launched in October 2018, and the measurement spectral data (Level 1 data) have been released since August 2019. We are developing the JAXA/EORC research algorithm (Level 2 algorithm) which derives from the Level 1 data the atmospheric concentrations of carbon dioxide, methane and carbon monoxide. GOSAT-2 has an advantage that it has spectral windows in both shortwave infrared (SWIR) to measure the solar-reflected spectra and the thermal infrared (TIR) to measure the thermal emission spectra from the atmosphere. The goal of our level 2 algorithm is to retrieve vertical profiles of carbon dioxide and methane concentrations in the troposphere with up tp 2 layers by using the SWIR and TIR measurements in combination, and thereby to improve the accuracy of the estimates of greenhouse gas emission. In this year, we retrieved column averaged concentrations of carbon dioxide, methane and carbon monoxide from the SWIR. Figure 1 shows the monthly mean of the column averaged concentrations of carbon dioxide in September 2019. Similarly, Figure 2 and 3 show the monthly mean of methane and carbon monoxide concentrations, respectively. Our next plan is to include TIR measurements in our level 2 algorithm to derive vertical profiles of carbon dioxide and methane.

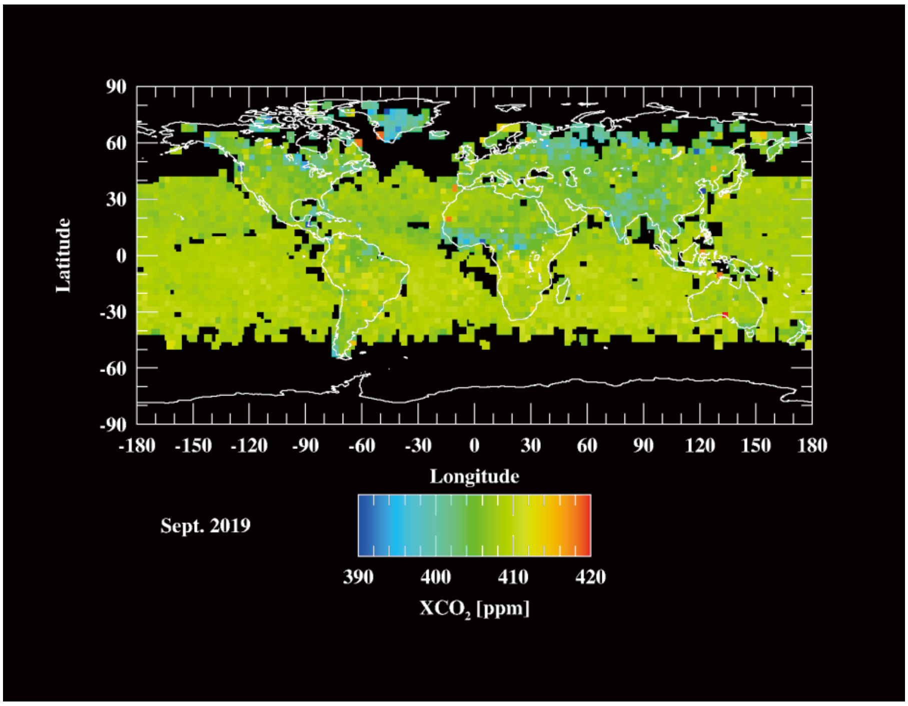

Fig. 1: Monthly mean of the column averaged concentrations of carbon dioxide in September 2019 derived from the Level 1 data of GOSAT-2.

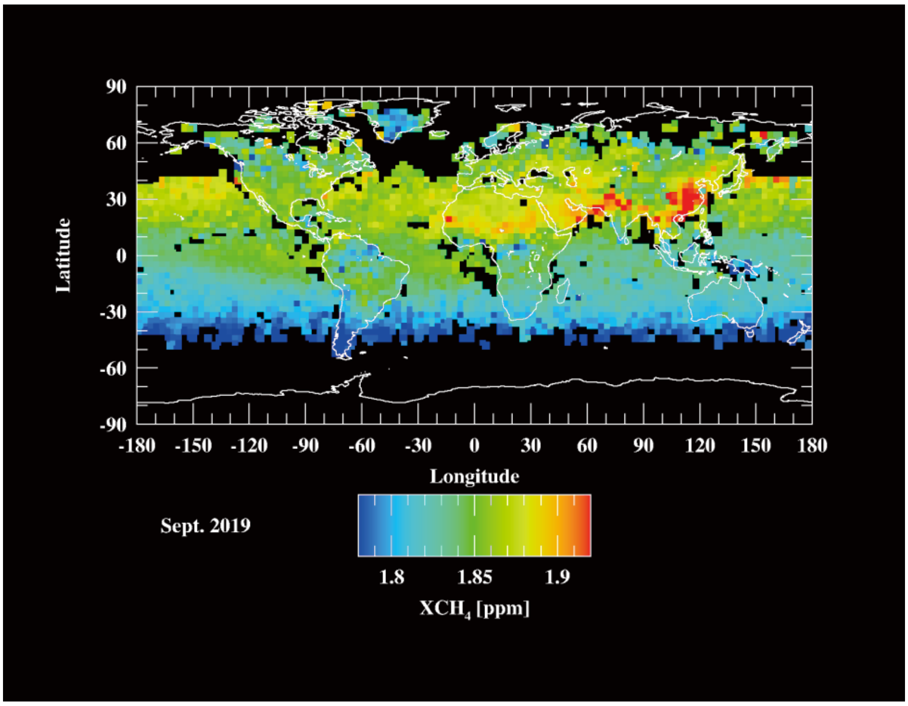

Fig. 2: Similar to Figure 1, but for methane.

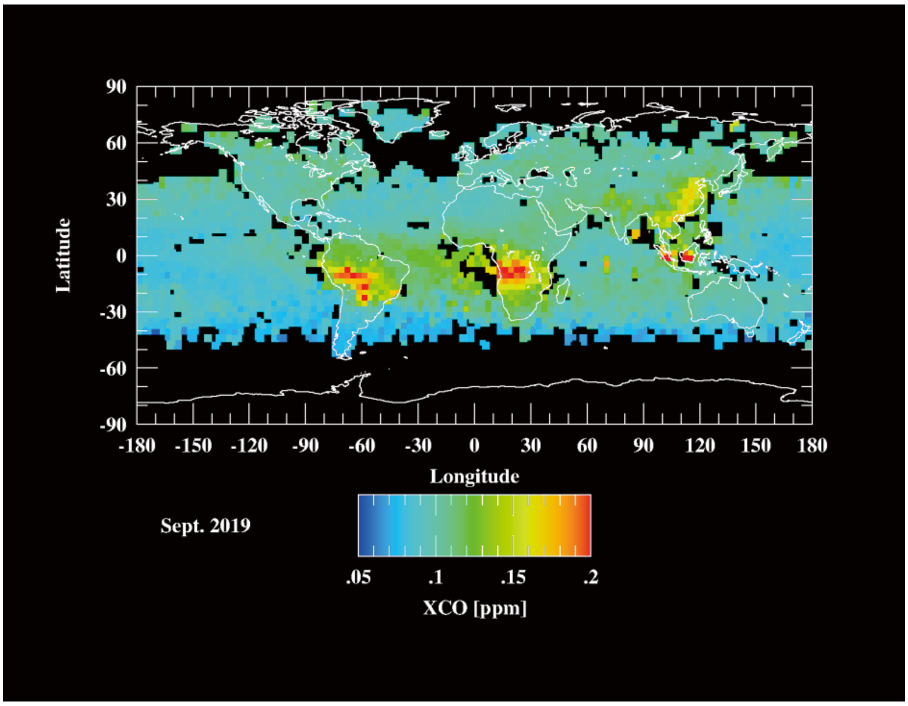

Fig. 3: Similar to Figure 1, but for carbon monoxide.

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	10 Hour(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.13

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	307,881.14	1.99
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	35.29	0.03
/data	49,533.87	0.85
/ltmp	7,226.57	0.61

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Study on development of satellite-based ocean data assimilation system

Report Number: R19ER2402
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11626/

Responsible Representative

Riko Oki, Deputy Director, Earth Observation Research Center, Space Technology Directrate I

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Members

Misako Kachi, Tsutomu Hihara, Hidenori Aiki, Shun Ohishi

Abstract

To enable satellite information ore familiar and easy to utilize, we develop "ocean forecast" without missing area by using the ocean model and data assimilation system with the highest spatial resolution (about 3km) in Japan to utilize satellite-based ocean, snow and ice products produced by JAXA at the maximum. At the same time, we promote studies on climate variations, with a focus on polar region, to improve accuracy of prediction of global warming and evaluation of its impacts.

Ref. URL: https://www.eorc.jaxa.jp/en/earth_observation_priority_research/ocean/

Reasons and benefits of using JAXA Supercomputer System

The data assimilation system and model cannot execute in Linux computers generally used at EORC, since the regional ocean models are high spatial resolution (~ 1-3km), satellite data is assimilated to the system daily, and forecast three-dimensional ocean physical parameters about 10-80 days in future. Therefore, we need super computer to do this study.

Achievements of the Year

We established new nearshore systems with a horizontal resolution of 1/100 degree around the Chao Phraya and Mekong River to use of high-resolution GCOM-C/SGLI sea surface temperature. Also, we improved the existed western Pacific and southeast Asian coastal systems as bellows: to output each terms in the heat and salinity budget equations including the analysis increments, to implement Adaptive Observation Error Inflation (AOEI) and Relaxation-To-Prior Perturbation/Spread (RTPP/S) for computational stability, to modify setting of vertical layers for improvement of a mixed layer, and to investigate the impacts from additive inflation for prevention of shrink of ensemble spread leading to filter divergence.

We have integrated the one-way nest high-resolution data assimilation systems including western Pacific, southeast Asia coastal, the Chao Phraya and Mekong nearshore systems with a horizontal resolution of 1/12 degree, 1/36 degree, 1/100 degree, respectively. The nearshore systems demonstrated the data assimilation impacts of satellite sea surface temperatures and salinity. The new systems also showed substantial improvements in low sea surface temperature biases caused by high sensitivity to atmospheric forcing and unrealistic fields at each ensemble member. We also confirmed that additive inflation improves the shrink of ensemble spread leading to filter divergence.

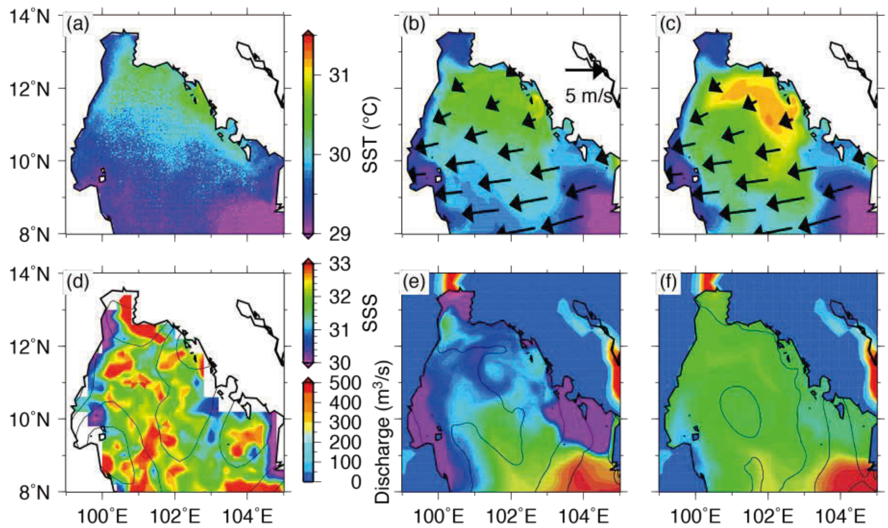

Fig. 1: Monthly-mean fields of the Chao Phraya River nearshore system in December 2015. Upper figures show sea surface temperature (color) and wind (vectors), and lower figures show sea surface salinity and river discharge (color on the ocean and land area, respectively) and sea surface height (contour). Left, middle, and right figures indicate satellite observations, simulation with data assimilation, and that without data assimilation, respectively.

Publications

- Invited Presentations

Ohishi, Shun, Tsutomu Hihara, Hidenori Aiki, Joji Ishizaka, Yasumasa Miyazawa, and Misako Kachi, 'An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS', JpGU Meeting 2019, Chiba, May 2019

- Oral Presentations

Ohishi, Shun, Tsutomu Hihara, Hidenori Aiki, Joji Ishizaka, Yasumasa Miyazawa, and Misako Kachi, 'An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS', GODAE Ocean View Symposium 2019-Ocean Predict '19, Halifax, May 2019

- Poster Presentations

Ohishi, Shun, Tsutomu Hihara, Hidenori Aiki, Joji Ishizaka, Yasumasa Miyazawa, and Misako Kachi, 'An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS', The

Joint PI Meeting of JAXA Earth Observation Missions FY2019, Tokyo, Jan. 2020

Ohishi, Shun, Tsutomu Hihara, Hidenori Aiki, Joji Ishizaka, Yasumasa Miyazawa, and Misako Kachi, 'An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS', Ocean Sciences Meeting 2020, San Diego, Feb. 2020

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	20 - 40
Elapsed Time per Case	4 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources*1(%): 0.94

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	8,350,452.52	1.01
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	42.92	0.04
/data	83,866.16	1.44
/ltmp	8,789.07	0.75

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Utilization of JSS2 for AMSR-E higher level data processing

Report Number: R19ER1501
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11622/

Responsible Representative

Takeshi Hirabayashi,　Derector of The Satellite Applications and Operation Center

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Abstract

AMSR-E*1, AMSR2*2 estimates various geophysical parameters by measuring radio waves in the weak microwave band radiated from the Earth's surface and the atmosphere with multiple frequencies and multiple polarizations.

Geophysical parameters include water vapor, cloud liquid water, precipitation, sea surface temperature, sea surface wind speed, sea ice concentration, snow water equivalent, and soil moisture.

The long-term geophysical record will play an important role in climate change monitoring and will provide valuable information for understanding the Earth's climate system, including water and energy circulation.

We will reprocess and provide AMSR-E high level product and AMSR2 high level product with the same algorithm (including improved algorithms), and provide a long-term data set useful for users.

*1 : Advanced Microwave Scanning Radiometer for EOS equipped in Earth Observation Satellite 'Aqua'

*2 : The Advanced Microwave Scanning Radiometer 2 equipped in Global Change Observation Mission - Water "SHIZUKU" (GCOM-W)

Reasons and benefits of using JAXA Supercomputer System

By using JSS2 with a large scalability processing environment and executing processing of enormous scenes in parallel, it becomes possible to provide products to users more quickly.

Achievements of the Year

Reprocessing for correction was carried out because there was an error in the version notation for some of the products generated by reprocessing last year (FY 2018).

Publications

N/A

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	3 Second(s)

Resources Used

Fraction of Usage in Total Resources[*1](%): 0.04

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	4,628.36	0.03
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	133.06	0.11
/data	109,277.78	1.87
/ltmp	14,718.20	1.25

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	7.96	0.20

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Utilization of JSS2 for GCOM-C satellite control and mission operations

Report Number: R19EAR20500
Subject Category: Space Technology
URL: https://www.jss.jaxa.jp/en/ar/e2019/11561/

Responsible Representative

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Members

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Abstract

GCOM-C*(SHIKISAI) was launched on Dec 23rd, 2017. It is conducting long-term and continuous global observation and data collection to understand the mechanism of changing radiation budget and carbon cycle needed to project future temperature rise accurately.

When upgrading the algorithm version, it is necessary to re-process by going back to the past data. Since it requires a very large-scale re-processing capability, a re-processing test for portability to JSS2 will be conducted.

*)GCOM-C : Global change Observation Mission-Climate

Reasons and benefits of using JAXA Supercomputer System

By using JSS2 with a large scalability processing environment and executing processing of enormous scenes in parallel, it becomes possible to provide products to users more quickly.

Achievements of the Year

We tested whether reprocessing of GCOM-C could be ported to JSS2. Most of the processing was confirmed to be portable without any problems. Problems remain in some processes, and testing is ongoing. (As of March 4)

Publications

N/A

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	16 Minute(s)

- **Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.14

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	0.00	0.00
SORA-PP	257,337.48	1.67
SORA-LM	3.35	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	248.75	0.21
/data	197,951.09	3.39
/ltmp	27,018.24	2.30

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

Overview of JSS2 Usage

Usage summary of JSS2 in FY2019

SORA-MA system, which is the main computing resource of JSS2, is the target of the following analysis.

Resource allocation

Five usage classifications shown in Table 1 are set, and even if JSS2 is very crowded, use is guaranteed up to the allocation rate set for each usage classification.

When JSS2 is vacant, crowded classifications could use resources exceeding the allocation limt, and efforts are made to make effective use of resources.

The allocation results in Fig. 1 show the result of the overall control by the job scheduler. Specified Project Use have been growing its portion year by year since the production of JSS2.

Table 1: Usage classification and allocation

Usage classification	Basic resource allocation
Specified Project Use	=< 50%
General Use	-
Small Scale Use	=< 10%
JSS2 Inter-University Research	=< 5%
JAXA Facility Utilization	=< 10%

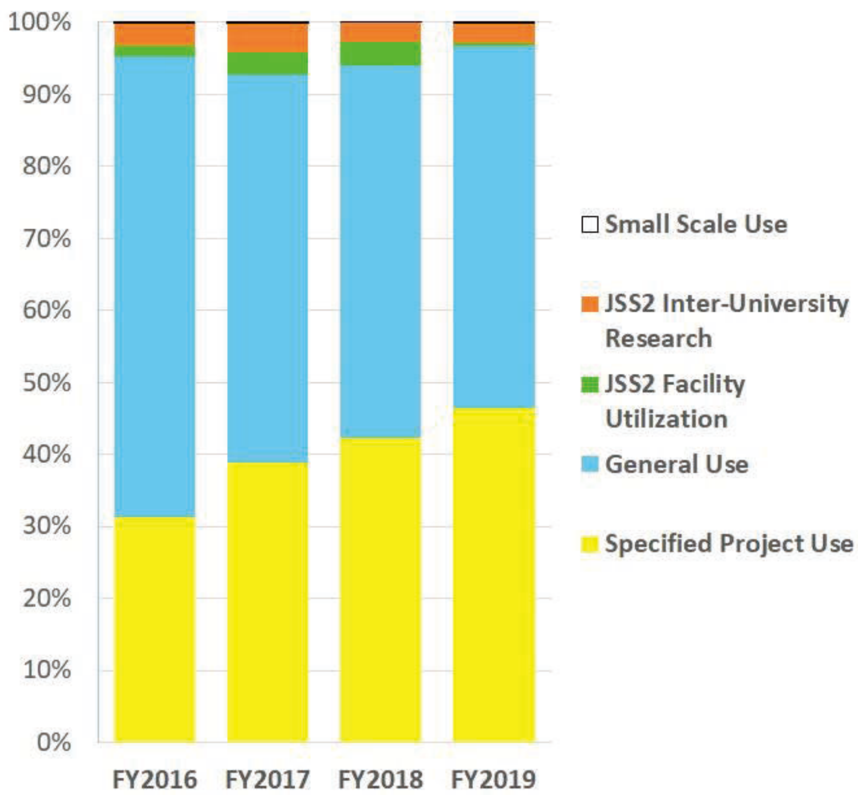

Fig.1: Trend of Usage classification and allocation (FY2016-2019)

Usage result of specified projects

In FY2019, new projects were selected in light of the new business plan. They are:

- Aeronautical Science and Technology
- Space Transportation System
- Expansion of Satellite-related Processing
- Satellite Remote Sensing

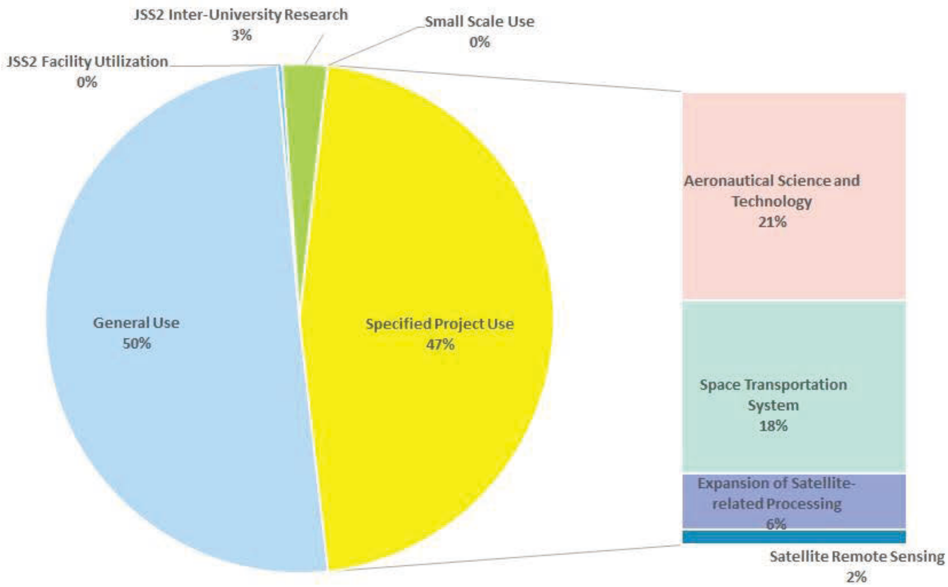

Fig.2: Usage of Specified projects (FY2019)

Usage result by field

Top application of Aeronautical Technology is 50%, while Space Transportation and Competitive Funding/Contract Research follow as the second and third positions. Contributions to extrnal include Contract Research, Student Training and JSS2 Inter-University Research.

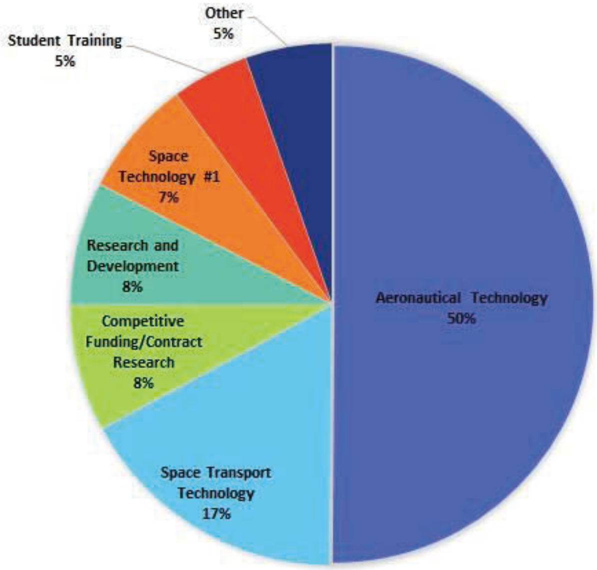

Fig.3: Usage result by field

SORA-MA Operating status

The occupancy rate had steadily increased from FY2016 to FY2018. In FY2019, it was as high as FY2018, although it dropped in March 2020 due to the file system failure.

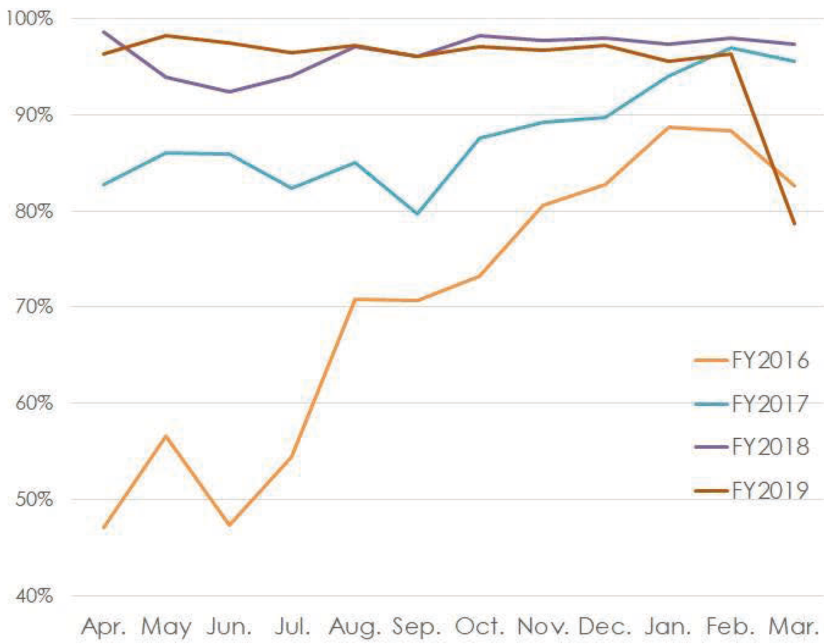

Fig.4: Trend of the occupancy rate (FY2016-2019)

Job trend analysis

The following is the analysis of the maximum number of parallel processes by each business/study theme on SORA-MA system, and their total core time consumed in the year.

Table 2 shows the distributions of the total core time which are categorized by 5 with the maximum number of processes of the themes. Compared with FY2018, it is observed that the jobs are shifting to bigger number of parallel processes.

Table2: Max. Number of Processes by themes and total core time

Max. Number of Processes by themes	Distribution of Total Core Time	
	FY2018	FY2019
10,000 -	4%	18%
1,000 - 9,999	54%	64%
100 - 999	32%	15%
10 - 99	8%	2%
1 - 9	2%	0%

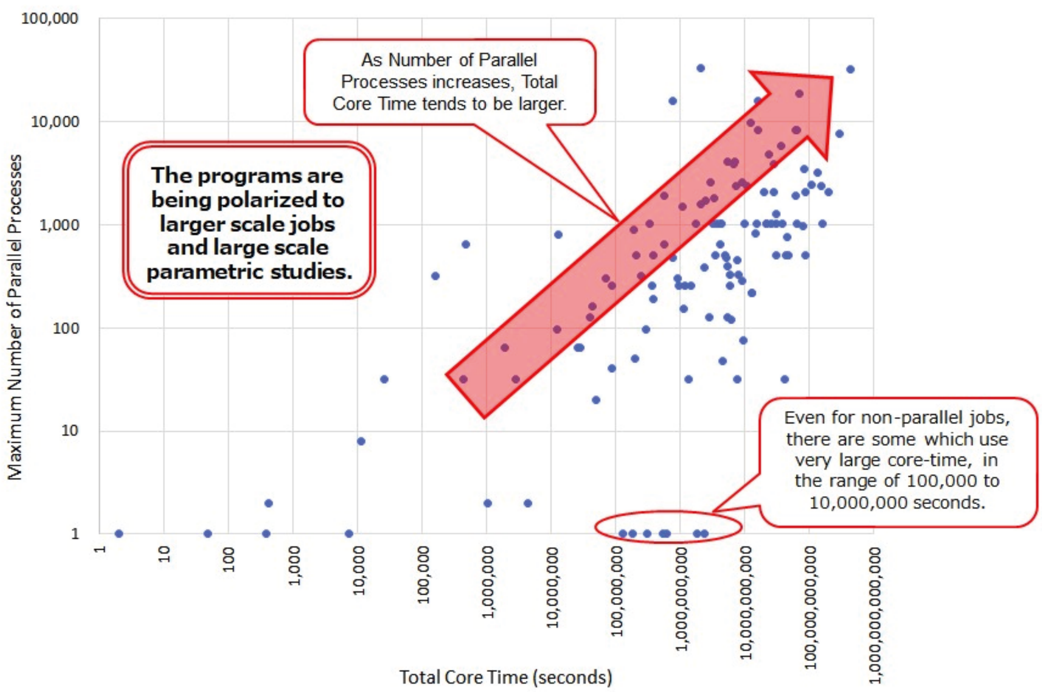

Fig.5: Correlation between number of parallel processes and core time

Attachment 1: JSS2 system configuration and specifications

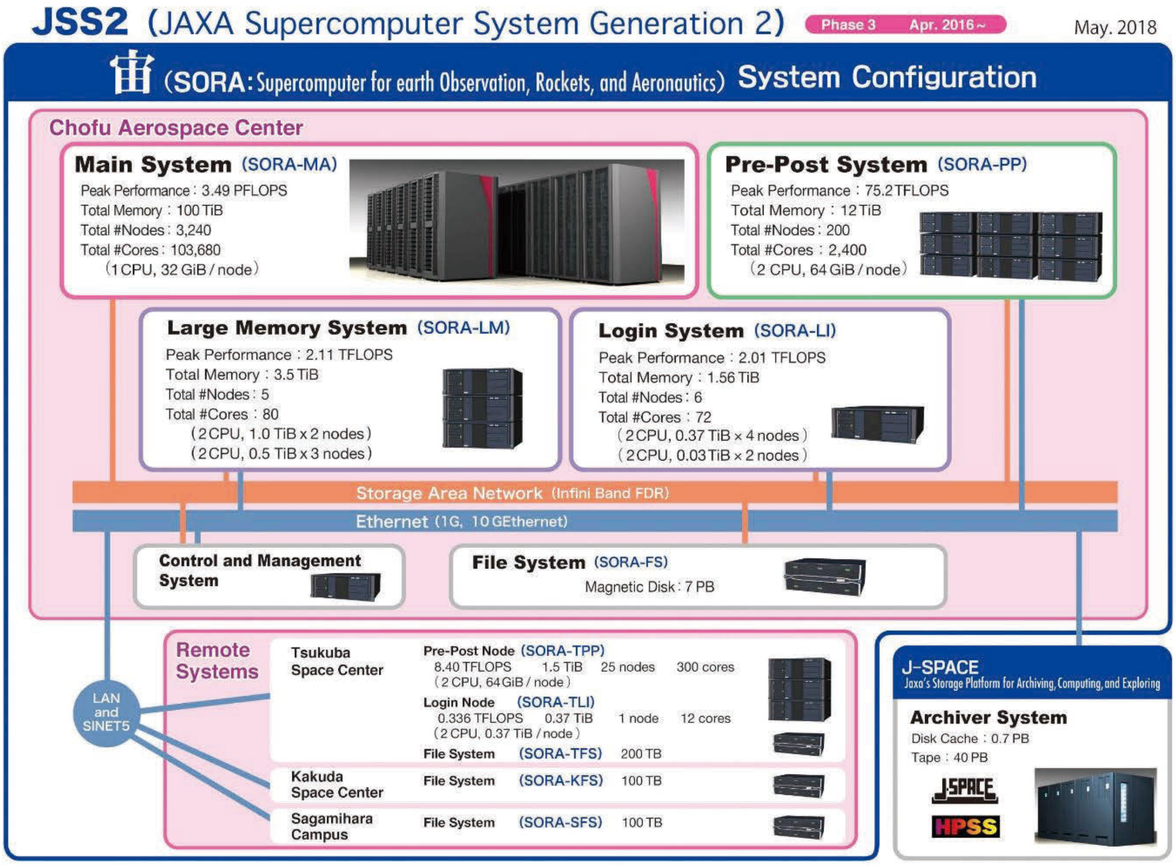

Fig.6: JSS2 system configuration

Table 3: Major Specifications

System name	Main System (SORA-MA)	Pre-Post System (SORA-PP)	Large Memory System (SORA-LM)	Tsukuba Pre-Post System (SORA-TPP)
Model name	Fujitsu FX100	Fujitsu RX350 S8	Fujitsu RX350 S8	Fujitsu RX350 S8
Total #nodes	3,240	200	5	25
Theoretical peak performance	3.49PFLOPS	75.2TFLOPS	2.11TFLOPS	8.40TFLOPS
#cores/CPU	32	6	8	6
#CPUs/node	1	2	2	2
Memory size/node	32GB	64GB	1024/512GB	64GB

Attachment 2: Usage Fee list

Table 4: Usage Fee list of JAXA Facility Utilization (Japanese)

2019 年度 JAXA スーパーコンピュータシステム利用料金（供用システム: MA, PP, LM）

項 目		料 金
直接経費	基本利用料	27,884 円／月 （27,864 円分の CPU 利用料と 100GB までの共有ファイル利用料(20 円)）
	ノード利用料	MA システム単価 0.00968 円／（ノード・秒） PP システム単価 0.01195 円／（ノード・秒） LM システム単価 0.02580 円／（ノード・秒）
	共有ファイル利用料	基本利用料以上の共有ファイルを利用する場合 100GB～の単価 0.20480 円／（GB・月） （JAXA が認めた容量に限る）
	アーカイバ部利用料 （オプション）	0.08485 円／（GB・月）
一般管理費		直接経費の 9.1%
消費税		別途，精算時に法定消費税額を加算する

（注）算定基準は，設備等使用料算定要領(産学官連携部長通達第 16-7 号）第 3 条第 2 項による。

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