Aerodynamic prediction of 30P30N airfoil using 2D BCM
（BCMを用いた30P30Nの2次元空力予測）

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Case

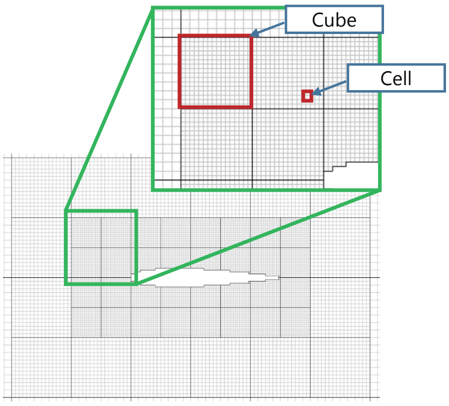
1. Aerodynamic prediction of 30P30N airfoil
   1-1 2D steady analysis

2. Flap separation prediction of 30P35N airfoil
   2-1 2D steady analysis

3. Noise prediction of 30P30N airfoil
   (near and far field)

Flow solver

- BCM (Building Cube Method)
  - Cartesian mesh based solver



BCM mesh around NACA0012 airfoil

- Merits
  - Easy parallel computation
  - Easy grid generation for complex shapes
  - Higher order spatial accuracy
- Demerits
  - Shape reproducibility
  - Difficulty in resolving the boundary layer

Computational method

	BCM-NS
Governing Eq.	Compressible NS Eq.
Discretization	Cell-centered finite volume
Inviscid Flux	SLAU 3rd-order MUSCL
Viscous Flux	2nd-order central difference
Time integration	LU-SGS
Turbulence model	SA-noft2-R

Wall boundary treatment
- Immersed boundary method (Ghost cell approach)
  Density & pressure → Zeroth-order interpolation
  Velocity → Linear interpolation

Grid

	Coarse	Medium	Fine (L1)	Extra Fine (L2)
Minimum grid size	9.54e-5	4.77e-5	2.38e-5	1.19e-5
Total cube number	8,259	15,645	15,645	15,645
Total cell number in Cube	16*16	16*16	32*32	64*64
Total cell number	2,114,304	4,005,120	16,020,480	64,081,920
5.5 deg	○	○	○	○
9.5 deg	-	-	○	○
14.0 deg	-	-	○	-
20.0 deg	-	-	○	-
24.0 deg	-	-	○	-

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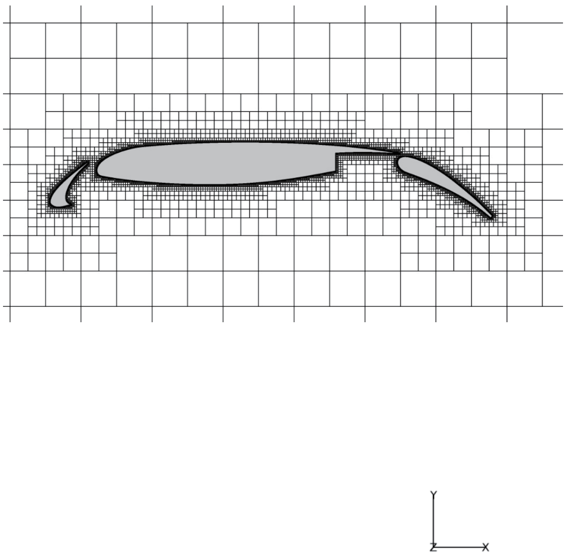
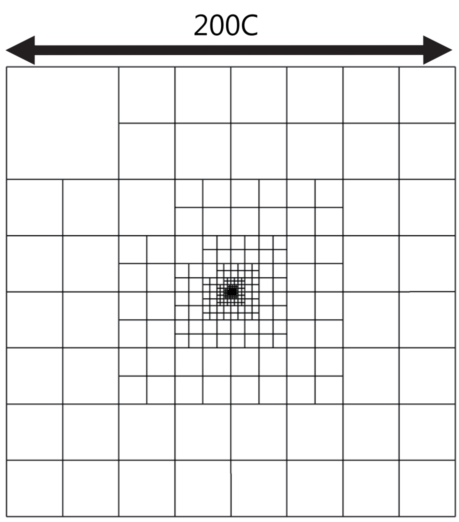
Cube allocation





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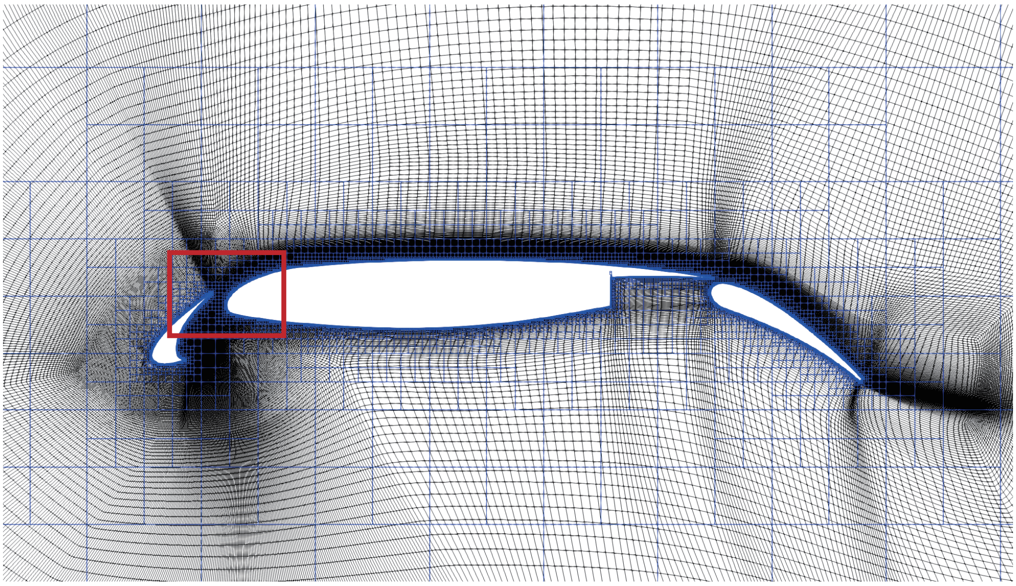
Grid (comparison L1 grid)



* Show cube boundaries

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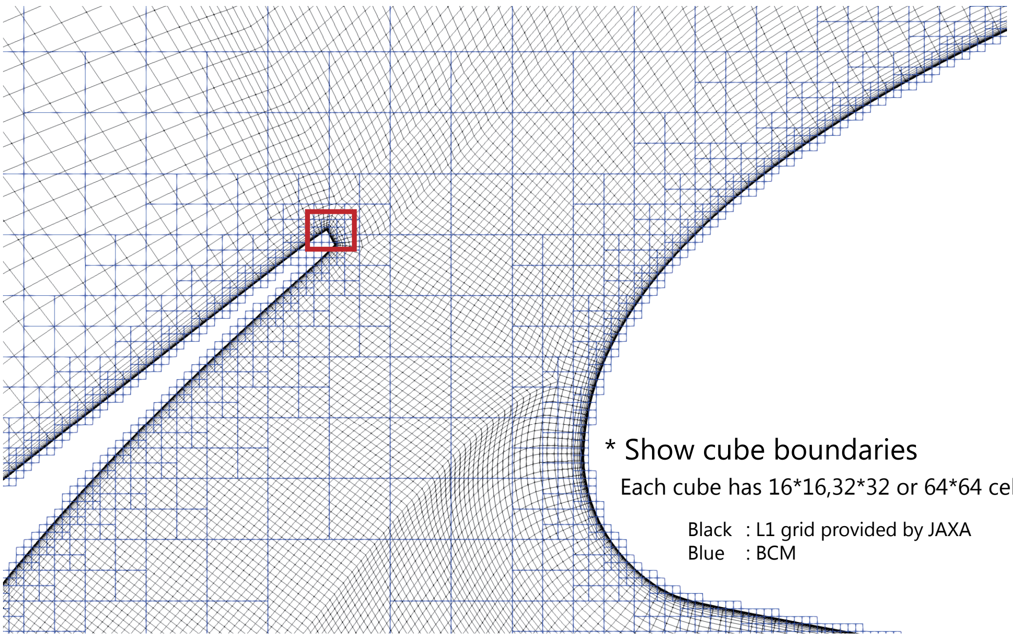
Grid (comparison L1 grid)



* Show cube boundaries

Each cube has 16*16,32*32 or 64*64 cells

Black : L1 grid provided by JAXA
Blue : BCM

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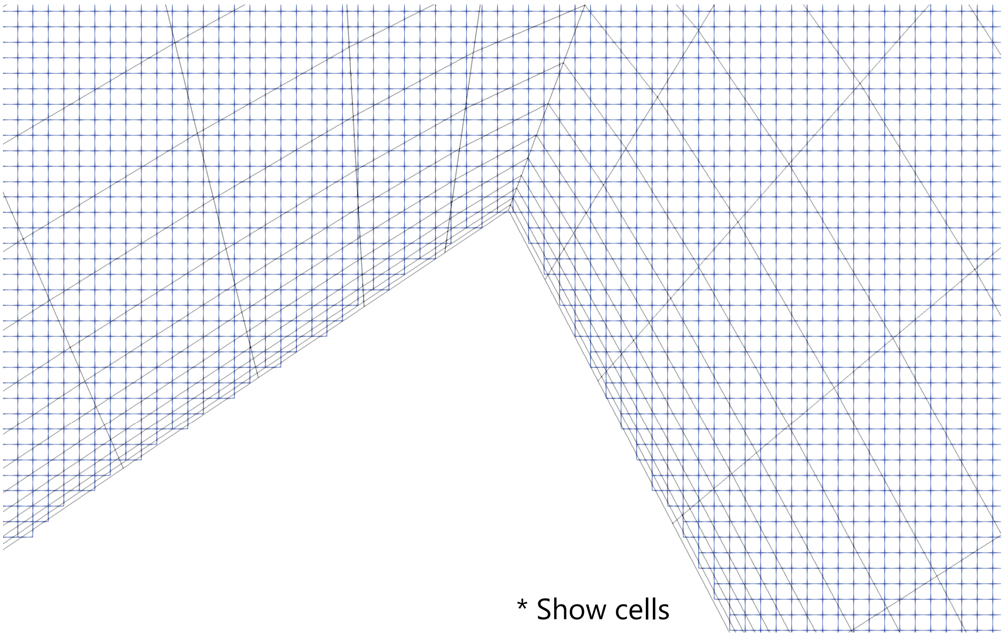
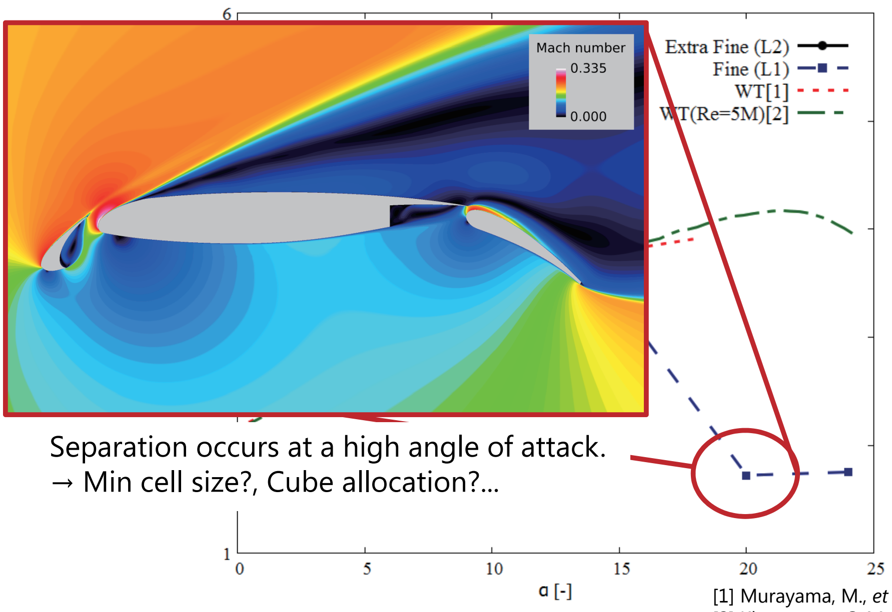
Grid (comparison L1 grid)



* Show cells

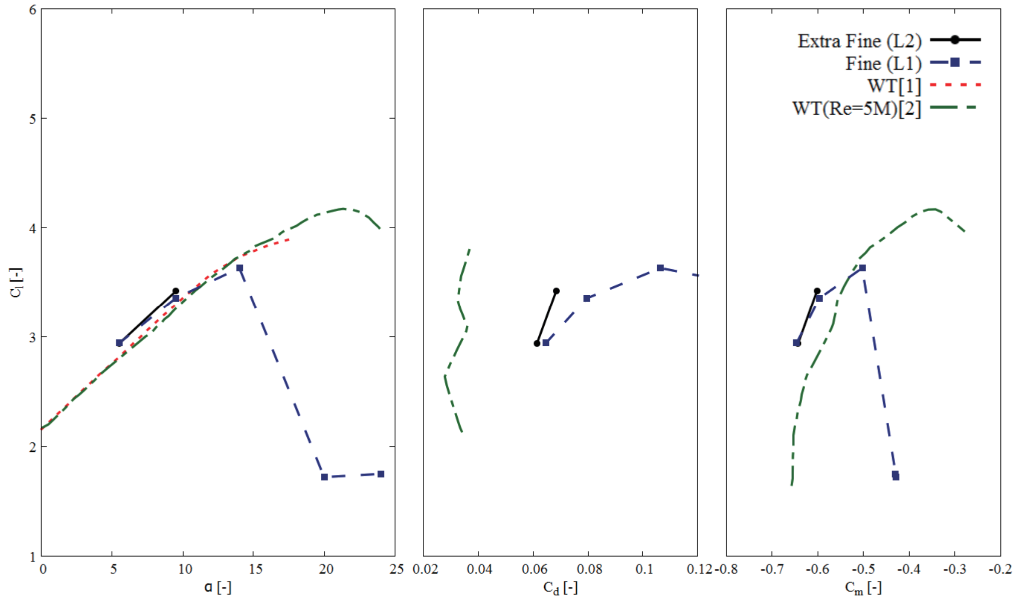
$C_l - \alpha$



Separation occurs at a high angle of attack.
→ Min cell size?, Cube allocation?...

[1] Murayama, M., *et al.* , AIAA 2014-2080
[2] Klausmeyer, S, M., *et al.* , NASA-TM-112858

C_l, C_d, C_m



[1] Murayama, M., *et al.* , AIAA 2014-2080
[2] Klausmeyer, S, M., *et al.* , NASA-TM-112858

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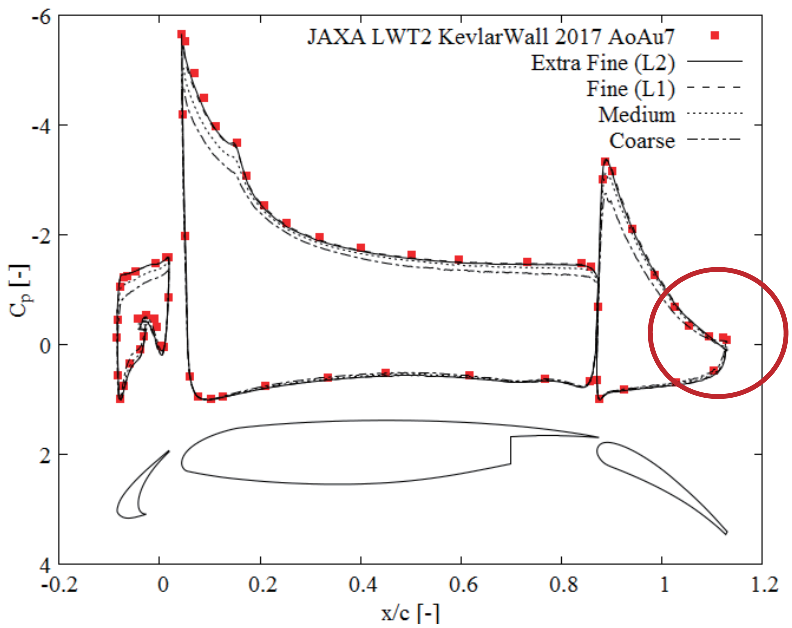
Cp (AoA 5.5deg)



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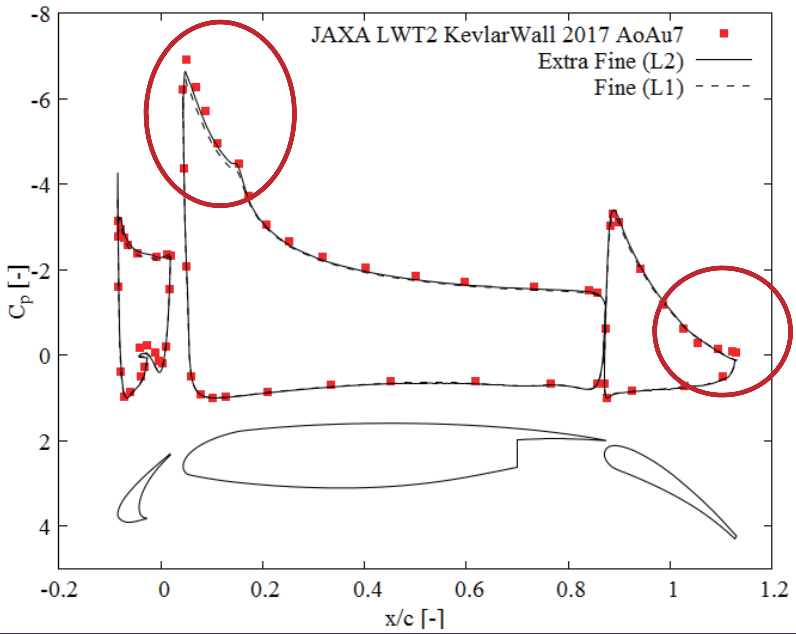
Cp (AoA 9.5deg)



Conclusion

We analyzed 30P30N airfoil by BCM

・The Fine(L1) grid and Extra Fine(L2) grid analysis result shows the same tendency as the experiment at the low angle of attack.

・These fine grids simulations could not predict precisely at the high angle of attack. (Separation occurs in the simulations)

→ Revise Cube allocation and Analysis conditions.

・The aerodynamic coefficient is estimated to be large.

・The trend of the pressure coefficient distribution differs at the trailing edge of the flap in experiment and simualtion.

→ Due to two dimensional analysis?