6th Space Environment Symposium., at Kitakyushu, on Sept. 29-30, 2009

SUN

MAGDAS *(MAGnetic Data Acquisition System)* Project at SERC and It's Application for Space Weather

K. Yumoto, and MAGDAS Group
Space Environment Research Center, Kyushu Univ.

Content
1. IHY Program
2. MAGDAS Project at SERC
3. ISWI Program
4. SERC-JAXA Collaboration
5. Summary

Geospace

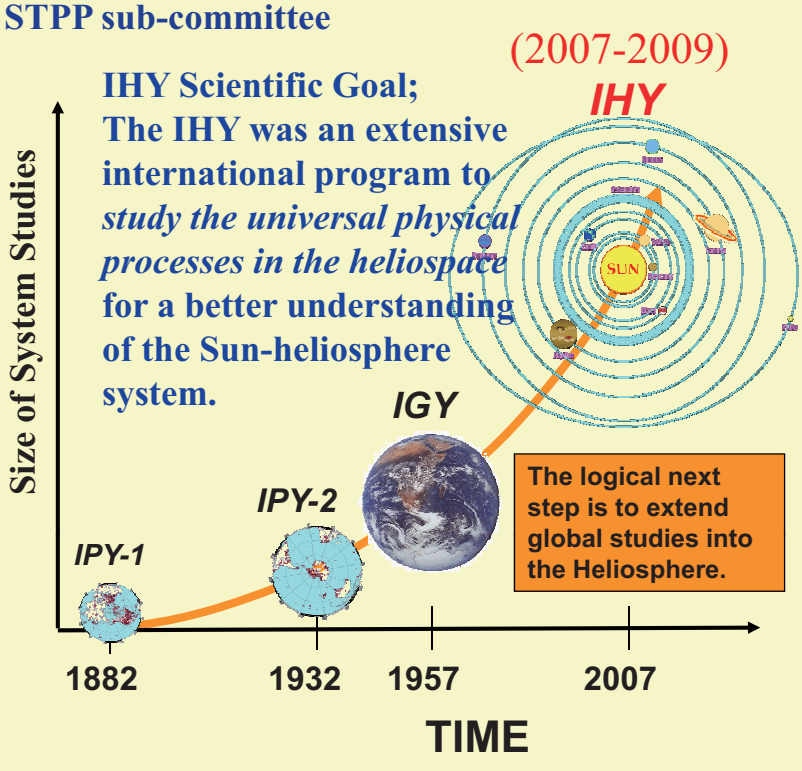
Figure courtesy of Space Physics and Aeronomy Section Slide Set, American Geophysical Union

1. International Heliophysical Year (IHY) Activities in Japan

by STPP sub-committee

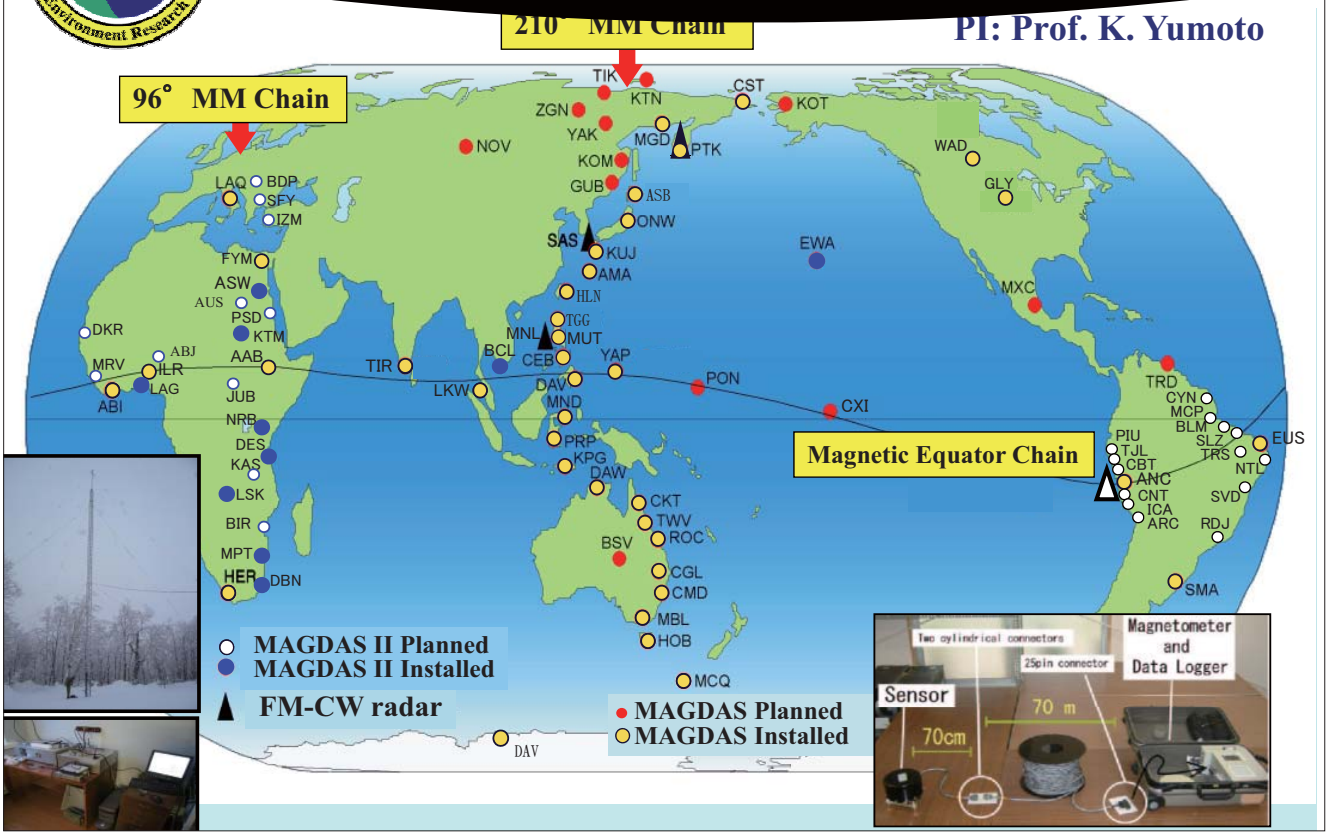
Program in Japan
1. Satellite Missions
   2.1 Hinode Project
   2.2 QSAT Project
2. Ground Network Projects
   2.1 CHAIN Network
   2.2 IPS Network
   2.3 Muon Detector Network
   2.4 MAGDAS Network
   2.5 OMTIs Network
3. Public Outreach
4. IGY Gold Club Program
5. Workshops & Meetings

IHY Scientific Goal;
The IHY was an extensive international program to *study the universal physical processes in the heliospace* for a better understanding of the Sun-heliosphere system.

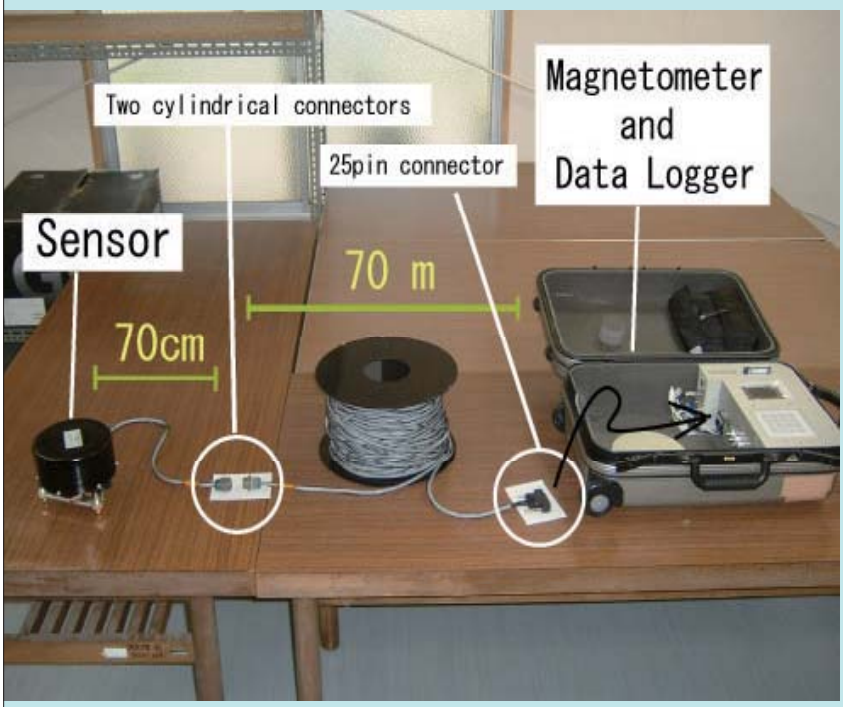


2. MAGDAS (MAGnetic Data Acquisition System) Network at SERC, Kyushu Univ.

PI: Prof. K. Yumoto



2-2. MAGDAS Magnetometer



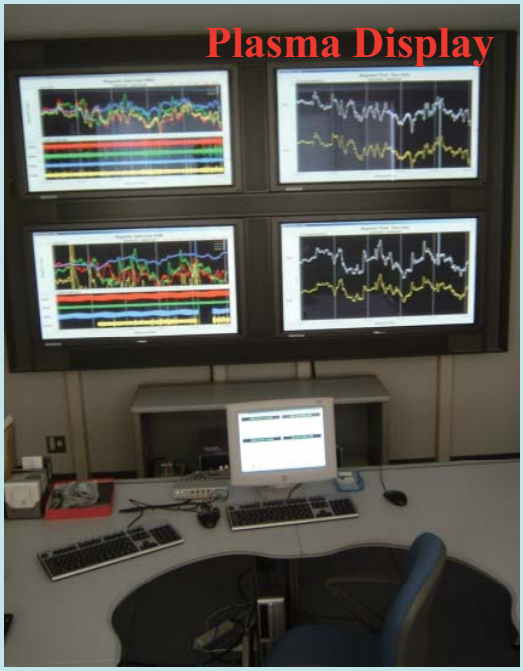
- **Tiltmeter of sensor**
  Range: ± 1°,
  Resolusion: 0.2 arc-sec
- **Thermometer of sensor**
  Range: ±60℃,
  Resolusion: 0.002℃
- **Observation ranges**
  ±1000nT, ±2000nT,
  (±65000nT)
- **16bit A/D converter**
  0.031nT/dig, 0.061nT/dig
- **Sampling rate**
  1-sec, 1-min
- **Estimated noise level**
  0.02nTp-p
- **Total weight**
  14.5 kg

MAGDAS-A: Fluxgate magnetometer system with data logging and transfer units.

2-3. MAGDAS Installation

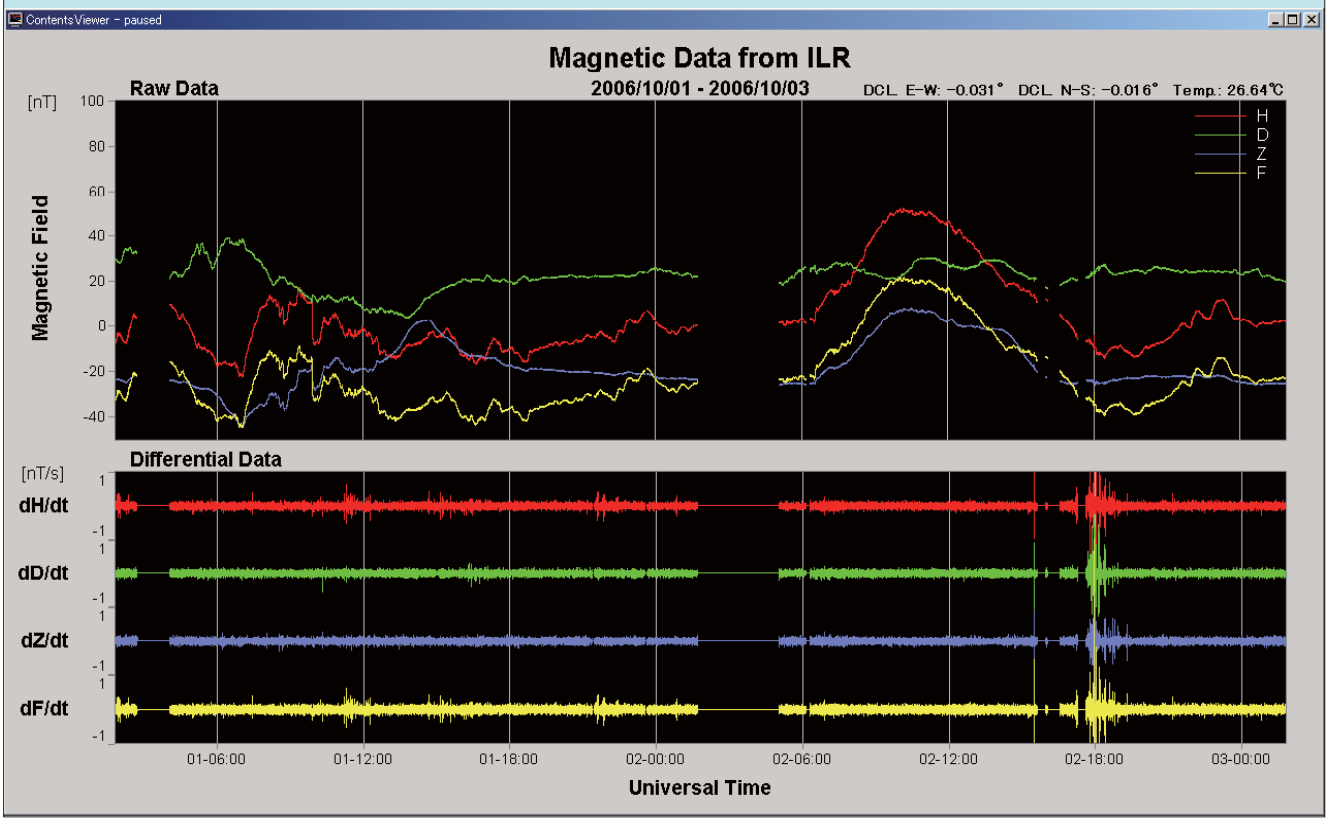
Redeemer's University in Lagos, Nigeria
Installed on 04 Sept. 2008

2-4. MAGDAS Data Acquisition & Monitoring System



MAGDAS-B: The data obtained at the overseas stations are transferred to the SERC, Japan, in real time by using three possible ways: Internet, Telephone line or Satellite phone line

2-5. MAGDAS Ordinary Data (1) and Differential Data (2) in Nigeria



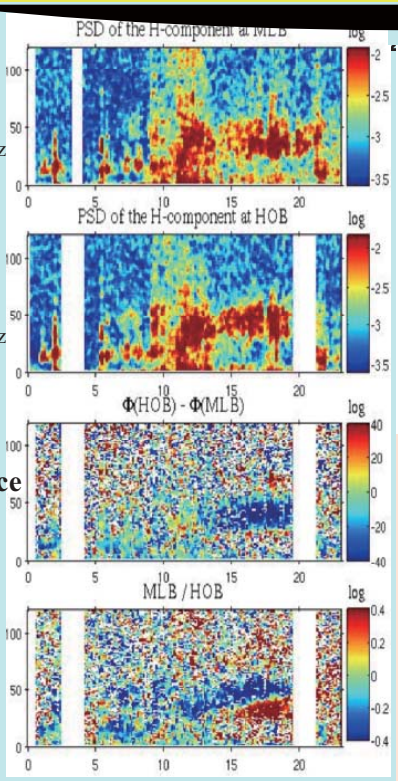
2-6.1) Estimation of Plasma Mass Density by MAGDAS ULF Pulsation Data (2)

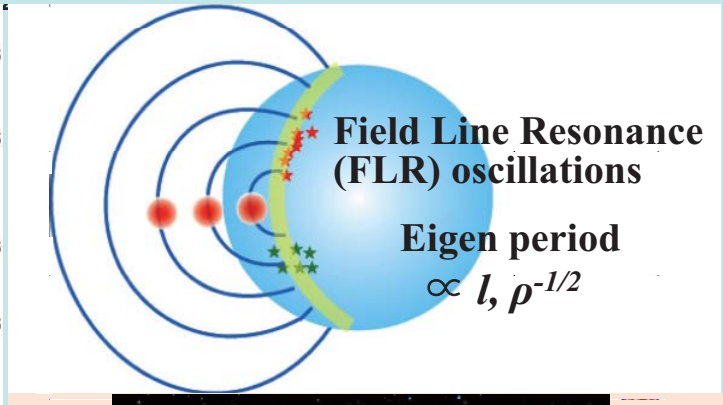
MLB
Power spectra
f mHz

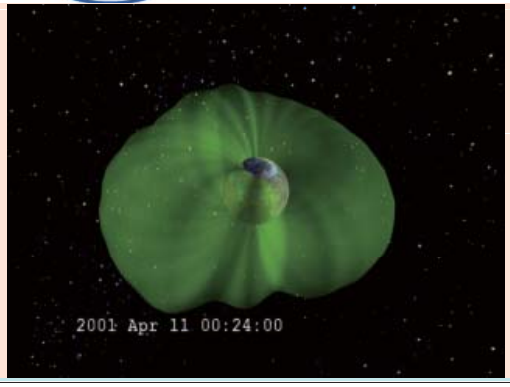
HOB
Power spectra
f mHz

Phase difference
(HOB)-(MLB)

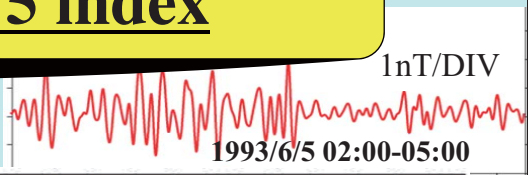
H-amplitude
Power ratio
(MLB)／(HOB)



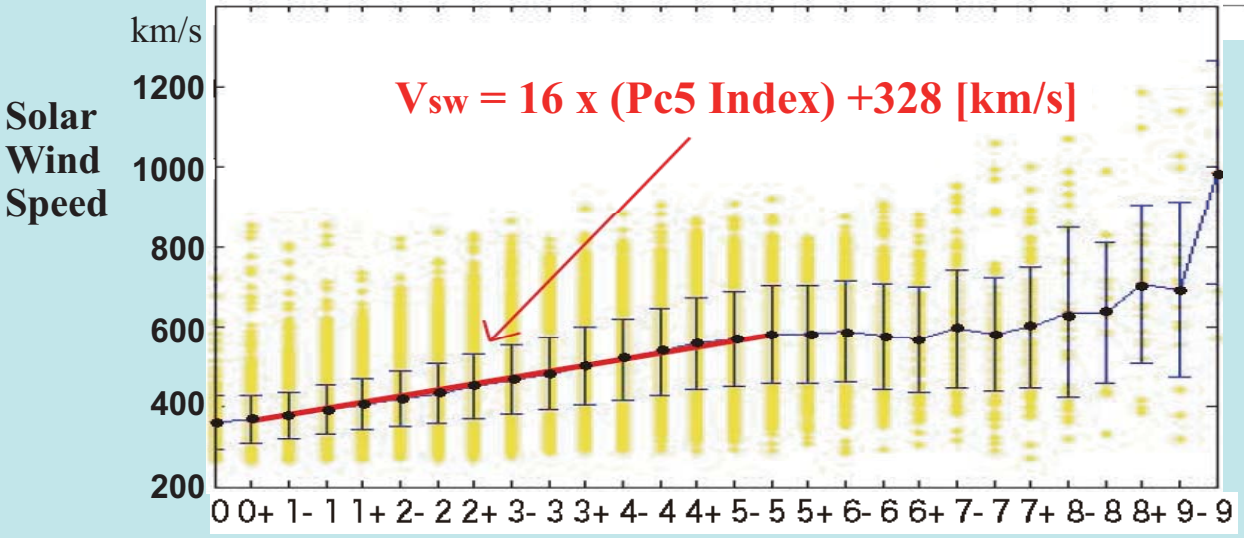




2-6.2) Estimation of Solar Wind Speed by Low-latitude Pc 5 index



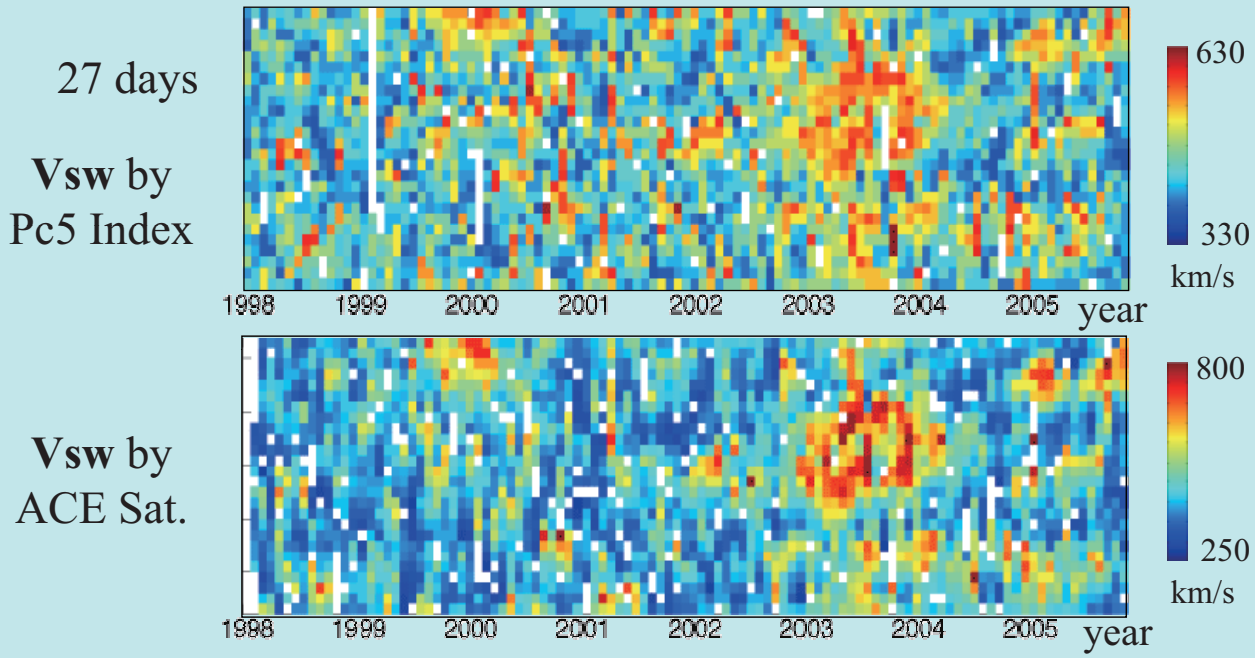
1998/8/1-2004/7/31



Pc5 Index at Low-latitude at MSR (G.M. Lat. = 37º)

http://www.serc.kyushu-u.ac.jp/pc5/index_e.html

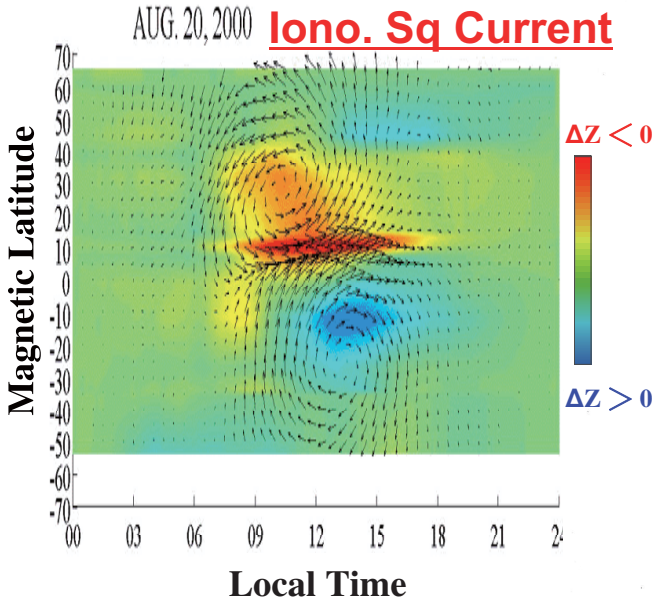
2-6.2) Comparison of Solar Wind Velocities Obtained by Pc 5 index and ACE Satellite during 1998-2005

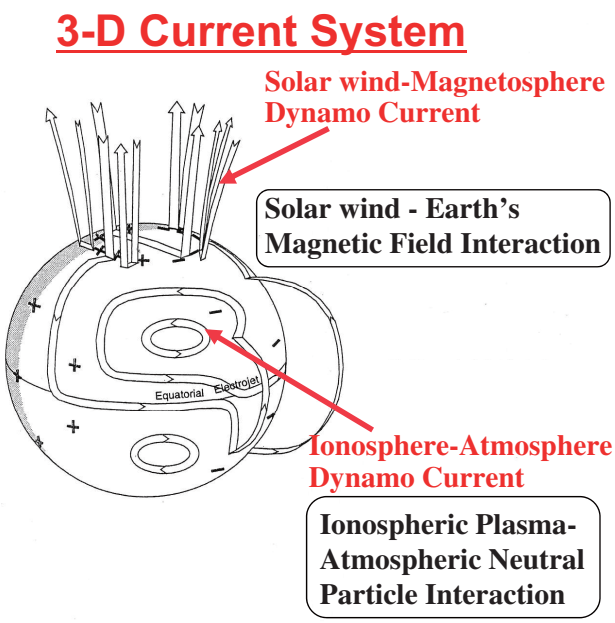


Good agreement of high velocity patterns

2-6.3) Imaging of MAGDAS Data (1)

for Understanding of Solar wind-Magnetosphere-Ionosphere-Atmosphere Coupling system and its environment change



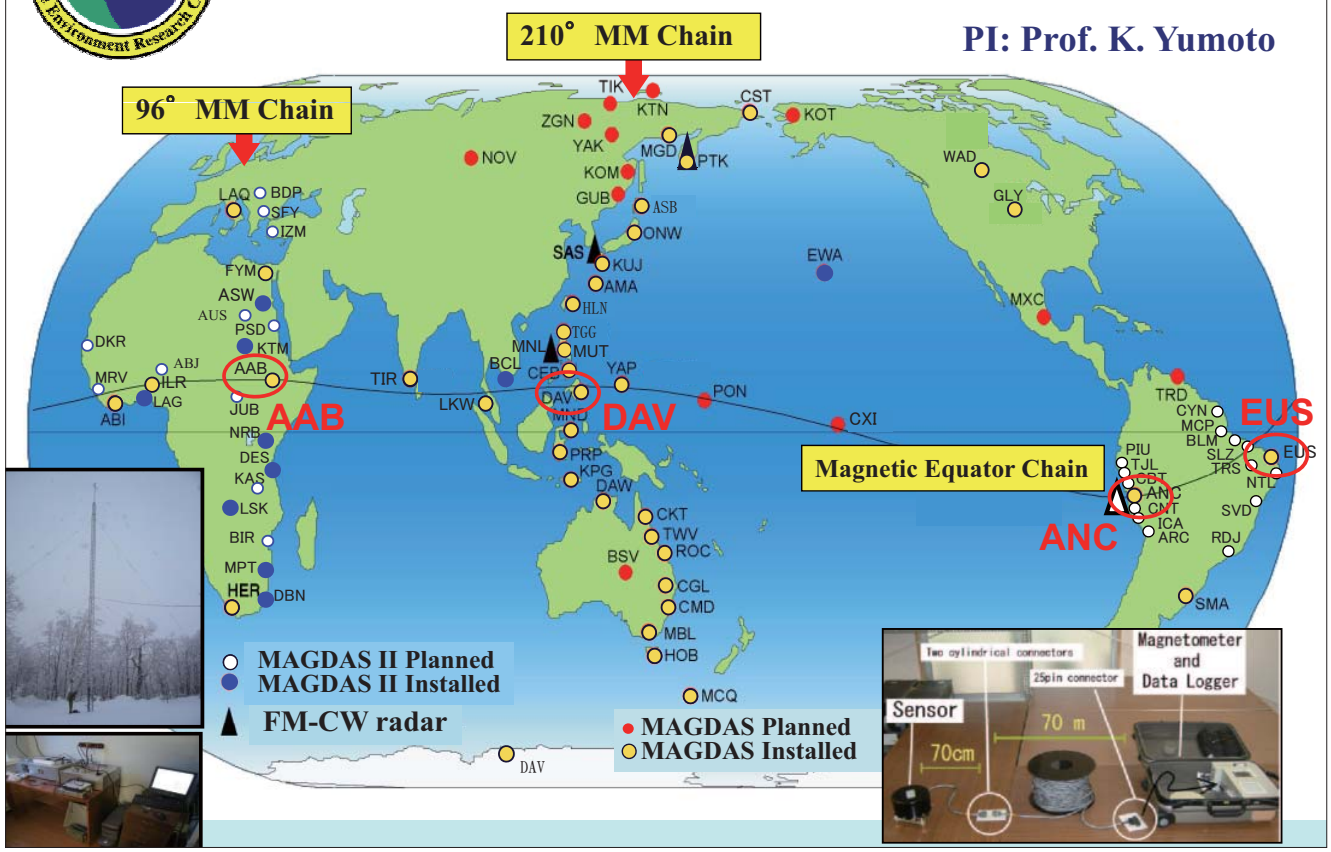


(left) Global equivalent ionospheric current pattern obtained from the ordinary MAGDAS/CPMN data.

(right) Three-dimensional current system in geospace.

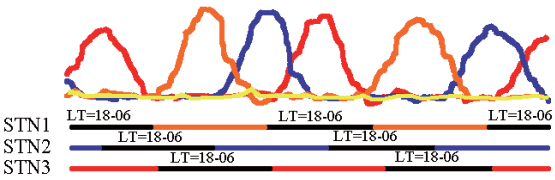
2-6.4) EE-index from MAGDAS for Understanding the Sun-Earth Coupling

PI: Prof. K. Yumoto



2-6.4) EE-Index (*EDst, EU, EL*)

Definition of *EDst*



$$EDst(m) = \sum_{S|_{LT=18\text{-}06}} ERs(m)|_{LT=18\text{-}06} \,/\, N(m)|_{LT=18\text{-}06}$$

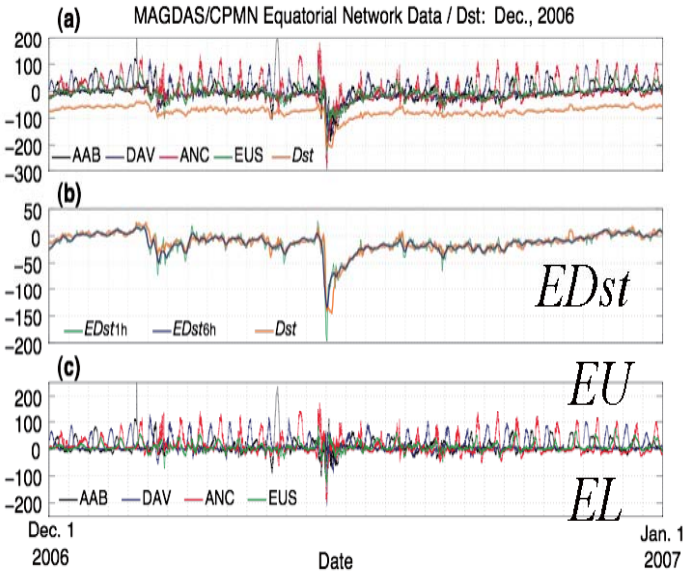
S: index of station

m: point of time in UT

EDst : the mean value of magnetic fields at the 4 stations during each local night time.

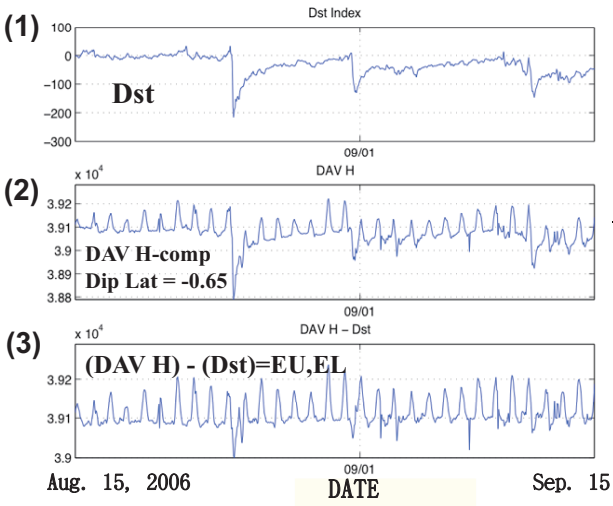
EU: Amplitude of EEJ

EL: Amplitude of CEJ



A new *EE*-index to monitor short- and long-term variations of the equatorial electrojet by adopting the MAGDAS/CPMN real-time data.

2-6.4) Understanding of Long-term Sun-Earth Coupling



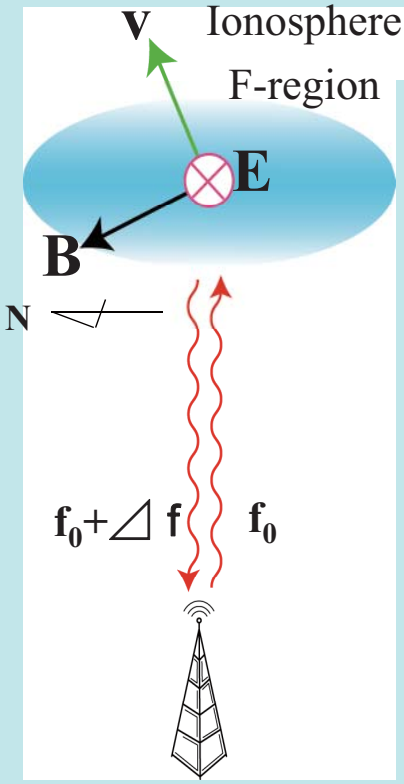
Long-term variations of (1) Dst, (2) H-comp. at DAV, and (3) by subtracting(1) from (2).

	Variable	Peak Period [Day]
A-I-M-sphere	(DAVH)-(Dst)	7.5, 14.5, 35.3
	DAVH	7.7, 9.2, 11.2,14.5,17.6, 22.5, 27.4
	Dst	7.7, 9.2, 11.2, 17.6, 22.5, 27.4
	Kp	9.2, 27.4
Solar Wind & Surface	IMF	9.2, 13.7 27.4
	Vsw	9.2, 13.0 27.4
	Tsw	9.2, 13.0 27.4
	Nsw	9.2, 11.2, 27.4, 35.3
	P_D	9.2, 11.2, 27.4, 35.3
	ε	9.2, 22.5
	F10.7	22.5 35.3

FFT analysis of parameters in geo-space, solar wind and solar surface region.

Study on long-term connections among solar surface, solar wind, and geo-space, by correlation analysis of parameters in these regions.

2-7. FM-CW Radar Doppler Observation



- Ionospheric electric field (***E***)
- Vertical drift velocity (***V***) of ionized layer
- Ambient magnetic field (***B0***) at the station

$$E = -V \times B_0$$

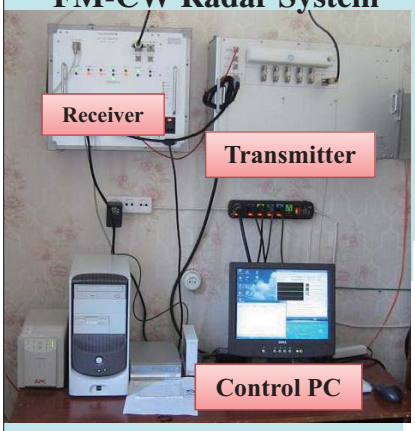
We can estimate ***V*** from Doppler shift (Δf) of the transmitting frequency (f_0). The relational is

$$V = -(c\,\Delta f) / 2f_0$$

- Transmitting Frequency : 8.0MHz (day) , 2.5MHz (night)
- Time resolution : 3 or 10 sec.
- Data accuracy of the vertical drift speed 1.46 m/s (8.0MHz), 4.67m/s(2.5MHz)

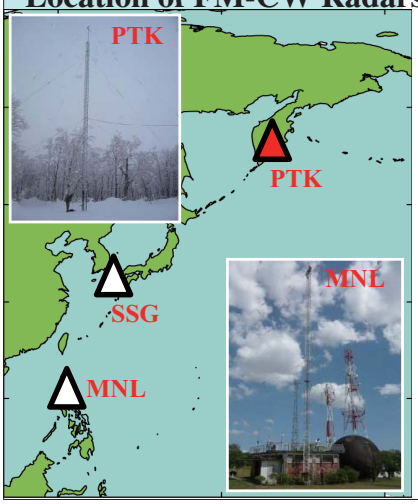
15

FM-CW Radar System

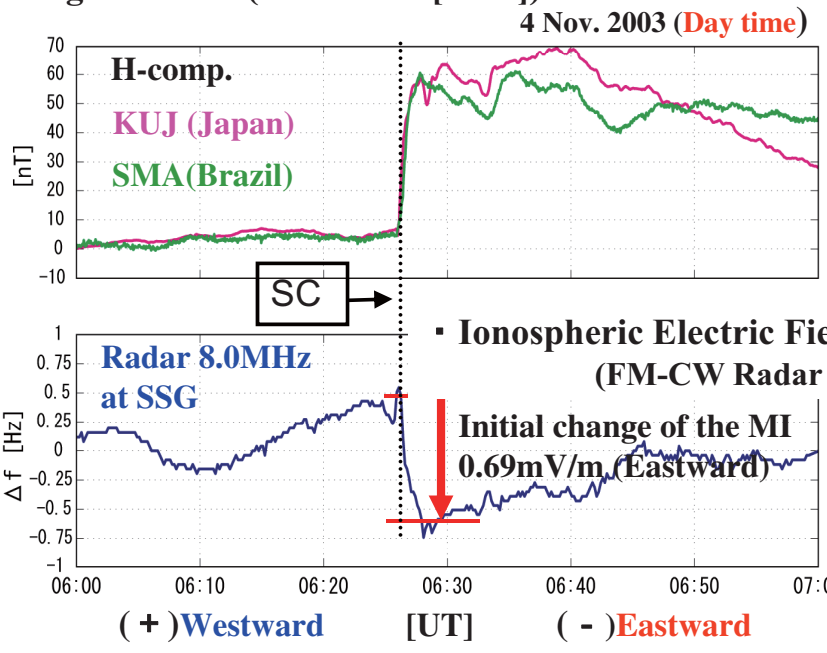


2-7.2) FM-CW Radar Observation for Monitoring of Ionospheric Disturbance

Location of FM-CW Radars



- Magnetic field (MAGDAS [1sec.])



- Ionospheric Electric Field (FM-CW Radar [3s

3-1. Draft provisional agenda of the UN Scientific and Technical Subcommittee at its forty-seventh session, in 2010

Feb.18, 2009

The following agenda items have been agreed by the Working Group:

Regular Items

1) General exchange of views and introduction of reports submitted on national activities
2) United Nations Programme on Space Applications
3) Implementation of the recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)
4) Matters relating to remote sensing of the Earth by satellite, including applications for developing countries and monitoring of the Earth's environment
5) Space debris
6) Space-system-based disaster management support
7) Recent developments in global navigation satellite systems

Items to be considered under work plans:

8) Use of nuclear power sources in outer space
9) Near-Earth objects
10) International Space Weather Initiative (ISWI)
2010 Consider reports on regional and international plans; Encourage continued operation of existing instrument arrays and encourage new instrument deployments;
2011 Consider reports on regional and international plans; Identify gaps and synergies in ongoing activities; Encourage continued operation of existing instrument arrays and encourage new instrument deployments;
2012 Finalize a report on regional and international plans; Encourage continued operation of existing instrument array, and encourage new instrument deployments.

3-2. Objectives of International Space Weather Initiative (ISWI); 2010-2012

Develop the scientific insight necessary to understand the science, and to forecast near-Earth space weather

- **Instrumentation and data analysis**
  - **Expand and continue deployment of new and existing instrument arrays**
  - **Expand data analysis effort for instrument arrays and existing data bases**
- **Coordinate data products to provide input for physical modeling (Joint with other more extensive modeling efforts)**
  - **Input instrument array data into physical models of heliospheric processes**
- **Coordinate data products to allow predictive relationships to be developed (Joint with Space Weather prediction organizations)**
  - **Develop data products to allow predictive relationships that enable the forecasting of Space Weather to be established**

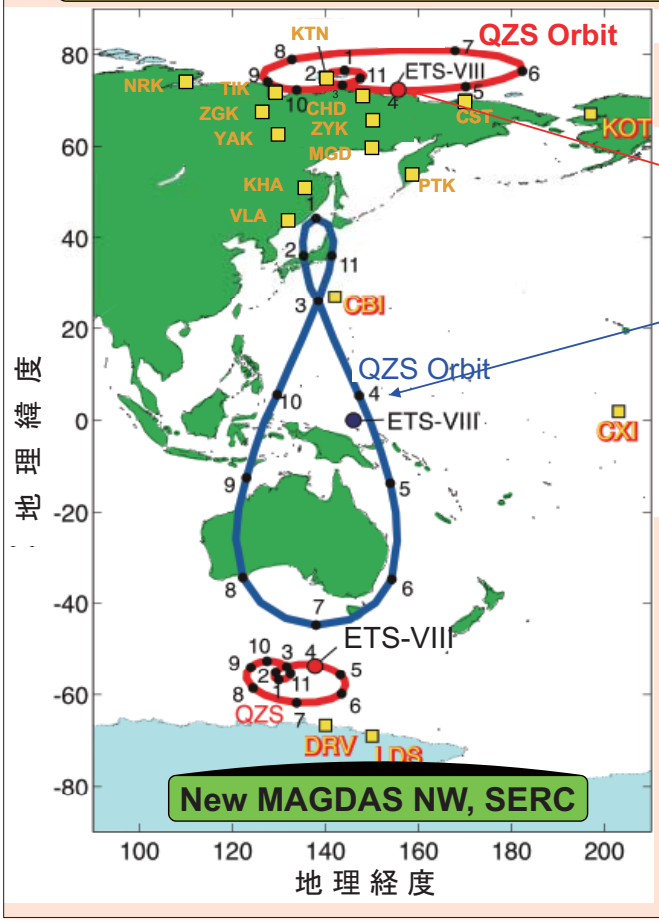
Education

- **University and Graduate Schools**
  - **Encourage and support space science courses and curricula in Universities that provide instrument support**
- **Public Outreach**
  - **Develop public outreach materials unique to the ISWI, and coordinate the distribution**

3-3. International Space Weather Initiative (ISWI); 2010-2012

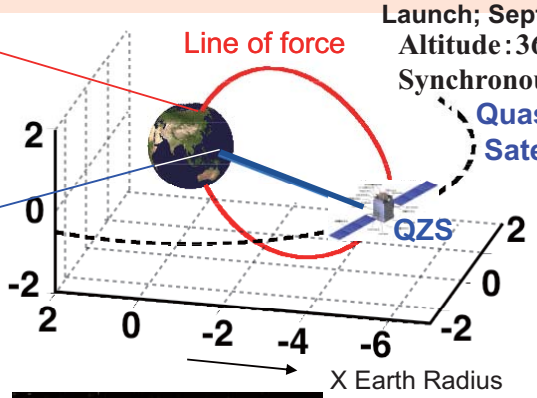
- The lead scientist or principle investigator funded by his/her country provides instrumentation (or fabrication plans) and data distribution
- The host country provides the workforce, facilities, and operational support typically at a local university.
- Host scientists become part of science team
- All data and data analysis activity is shared
- All scientists participate in publications and scientific meetings where possible

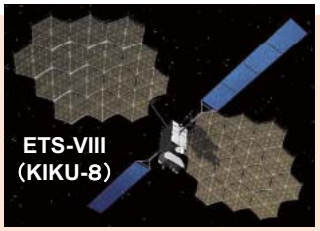
4-1. Coordinated Ground-Satellite Observation

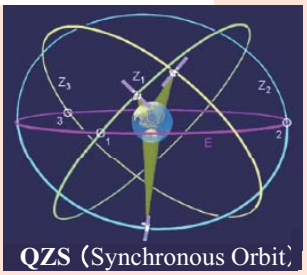


JAXA Satellites for Space Environment Measurement

Launch; Sept., 2010
Altitude：36000km
Synchronous Orbit
Quasi-Zenith Satellite







4-2. Scientific Objects of CG-S Obs.

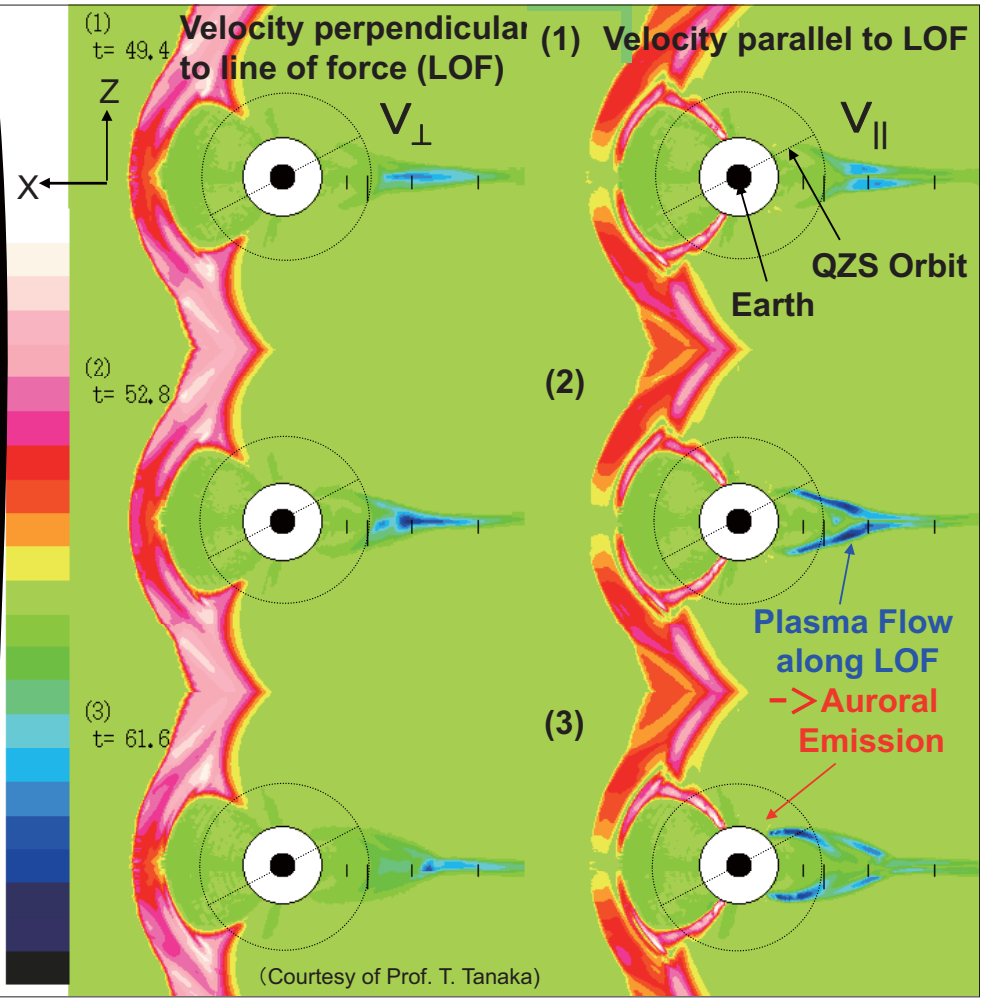
1) To clarify whole picture of storms by new MAGDAS.

2) Space environm. measurements by JAXA satellites.

3) Integrated study of electromagnetic, energetic particle and atmospheric changes during storms.

4) Establishment of a space weather technology.

・MHD simulation of plasma velocity during auroral substorms by T. Tanaka.



MAGDAS Project at SERC and It's Applications during IHY/ISWI (2007-2012)

http://www.serc.kyushu-u.ac.jp/

5. Summary

(1) MAGDAS and FM-CW radar along 210°MM, 96 °MM, and Magnetic Equator are very useful to study global natures of EEJ, Sq, pulsations, etc. for space weather and it's applications.

(2) SERC and JAXA will conduct *C*oordinated *G*round-*S*atellite *O*bservations during the ISWI (2010-2012).

Thank you for your attention !

2.3 What is Unique about ISWI?

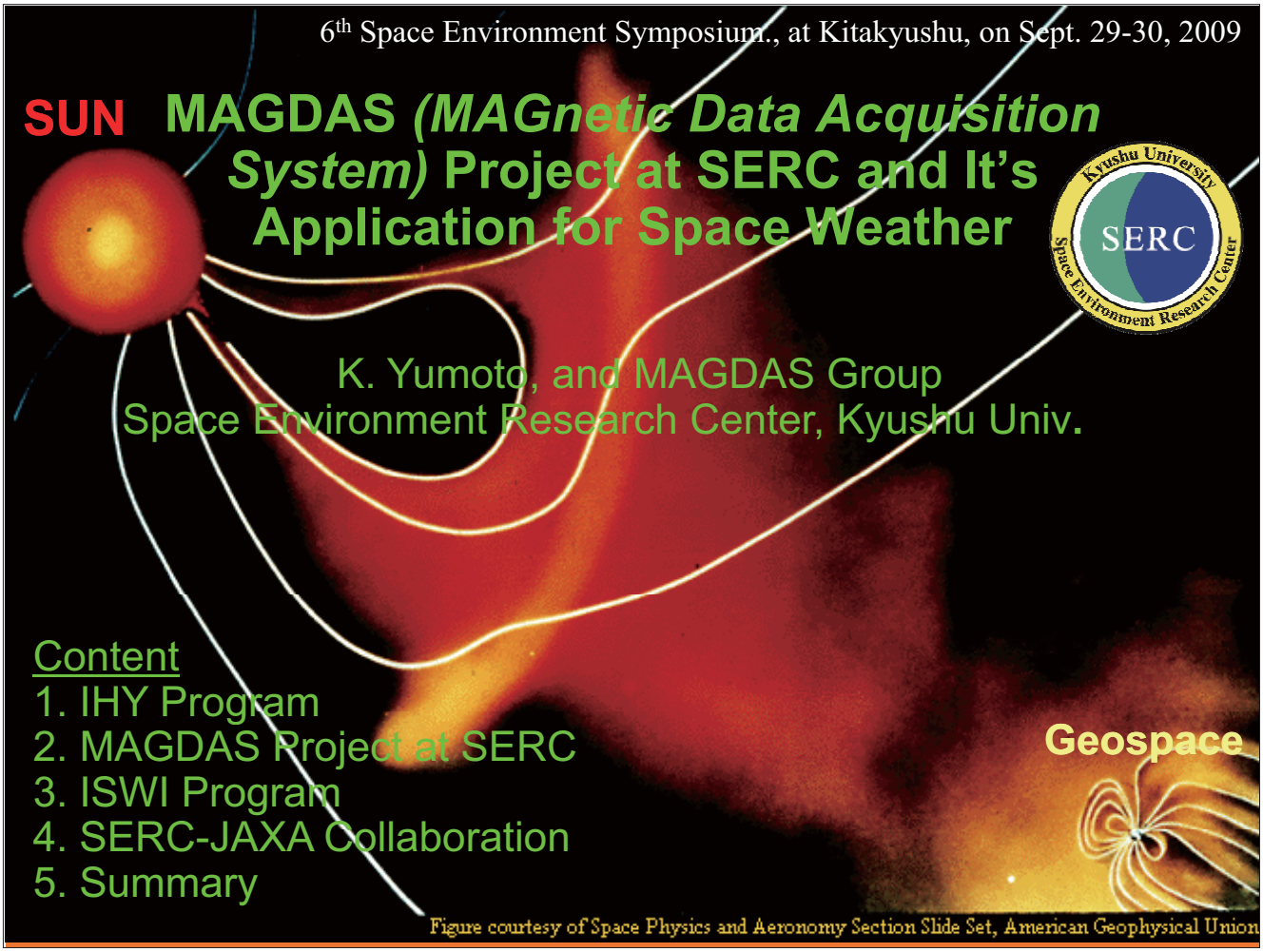
- **UN Endorsement**
  - Opens new opportunities for collaboration in countries with little/no Space Physics by involving governments and Universities or National Labs
  - Encourages governmental response
  - Allows broad dissemination of information in 6 languages to 192 countries of the UN
- **State Department Involvement**
  - Helps with import/export and technology issues
  - Help with Visas, security, logistics, etc.

2.4.1 Current US Instruments (Feb 2009)

ID	INSTRUMENT	Lead Scientist	Country	Objective
1	Scientillation Network Decision Aid (SCINDA)	K. Groves (Hanscom AFRL)	USA	Study equatorial ionospheric disturbances to aid in the specification and prediction of communications degradation due to ionospheric scintillation in the earth's equatorial region
2	Coherent Ionospheric Doppler Radar (CIDR)	T. Garner (U Tex)	USA	To tomographically reconstruct the ionosphere and to provide input to Data Assimilation models
3	Atmospheric Weather Education System for Observation and Modeling of Effects (AWESOME) and SID (Sudden Ionospheric Disturbance Monitor)	U. Inan and D. Scherrer (Stanford)	USA	Lightning, sprites, Elves, relation to terrestrial Gamma Ray flashes , whistler induced electron precipitation, conjugate studies,
4	Remote Equatorial Nighttime Observatory for Ionospheric Regions (RENOIR)	J. Makela (U Illinois)	USA	Study the equatorial/low-latitude ionosphere/thermosphere system, its response to storms, and the irregularities that can be present on a daily basis.
5	African GPS Receivers for Equatorial Electrodynamics Studies (AGREES)	M. Moldwin and E. Yizengaw (UCLA)	USA	Understand unique structures in equatorial ionosphere, low/mid latitude plasma production, effect of ionospheric and plasmaspheric irregularities on communications
6	African Meridian B-field Education and Research (AMBER)	M. Moldwin and E. Yizengaw (UCLA)	USA	Understand low latitude electrodynamics, ULF pulsations, effect of Pc5 ULF on MeV electron population in inner radiation belts

2.4.2 Current Non-US Instruments (Apr. 2009)

ID	INSTRUMENT	Lead Scientist	Country	Objective
7	Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO)	A. Benz and C. Monstein (ETH-Zentrum)	Switz	Study the magnetic activity of a wide range of astrophysical objects with emphasis on the Sun and cool stars
8	South Atlantic Very Low frequency Network (SAVNET)	J.-P. Raulin (U Presbiteriana)	Brazil	Study of the SAMA region at low ionospheric altitudes and its structure and dynamics during geomagnetic perturbations
9	Magnetic Data Acquisition System (MAGDAS)	K. Yumoto (Kyushu U)	Japan	Study of dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electro-magnetic response of iono-magnetosphere to various solar wind changes, and the penetration and propagation mechanisms of DP2-ULF range disturbances
10	African Dual Frequency GPS Network	C. Amory-Mazaudier (CETP/CNRS)	France	To increase the number of real-time dual-frequency GPS stations worldwide for the study of ionospheric variability, response of the ionospheric total electron content (TEC) during geomagnetic storms over the African sector.
11	Space Environment Viewing and Analysis Network (SEVAN)	A. Chillingarian (Aragats)	Armenia	To improve short and long-term forecasts of dangerous consequences of space storms
12	Global Muon Detector Network (GMDN)	K. Munakata (Shinsu U)	Japan	To identify the precursory decrease of cosmic ray intensity that takes place more than one day prior to the Earth-arrival of shock driven by an interplanetary coronal mass ejection
13	Continuous H-alpha Imaging Network (CHAIN)	K. Shibata, S. Ueno (Kyoto U)	Japan	Solar activity, flares, filaments, filament eruptions
14	Optical Mesosphere Thermosphere Imager (OMTIs)	K. Shiokawa (Nagoya U)	Japan	Dynamics of the upper atmosphere through nocturnal airglow emmissions



0-1. Activities at SERC

1) MAGDAS Project for Space Weather Research and Application

2) Integrated Simulation of Solar-Terrestrial System

3) QSAT Project for Understanding Spacecraft Charge Built-up and Discharge

4) Administration of ULTIMA Consortium
(Ultra Large Terrestrial International Magnetic Array)

5) Local Education, Global Outreach, & Data Service
Everyday space weather now casting, global Outreach, & data service

0-2. Facilities of SERC


SERC
Main Building


MAGDAS Test Station
Sasaguri, Japan

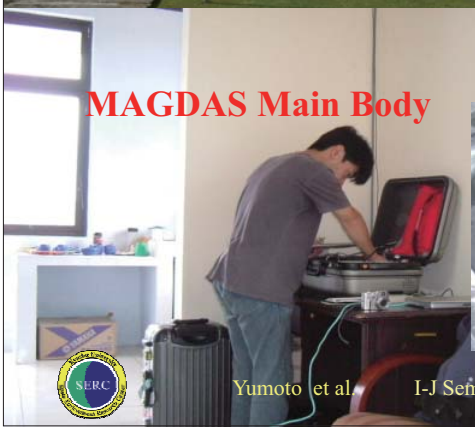

Kuju Observatory
Oita, Japan


FM-CW Radar
Kamchatka, Russia

2.1.2) MAGDAS Installation

2005/07/24

Parepare (Indonesia) MLAT = -14.0˚



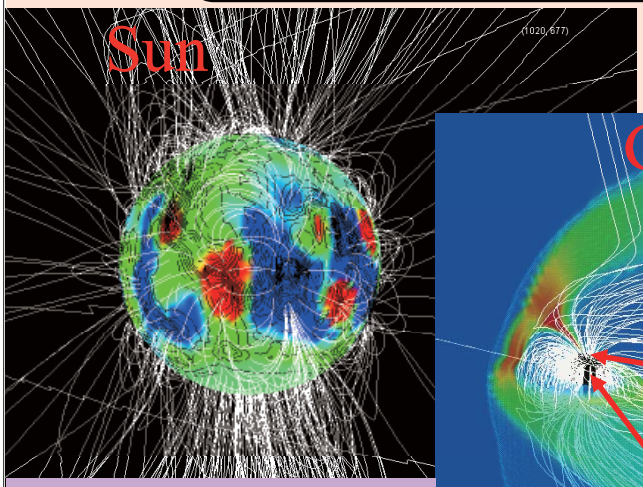
1-3. MAGDAS Installation

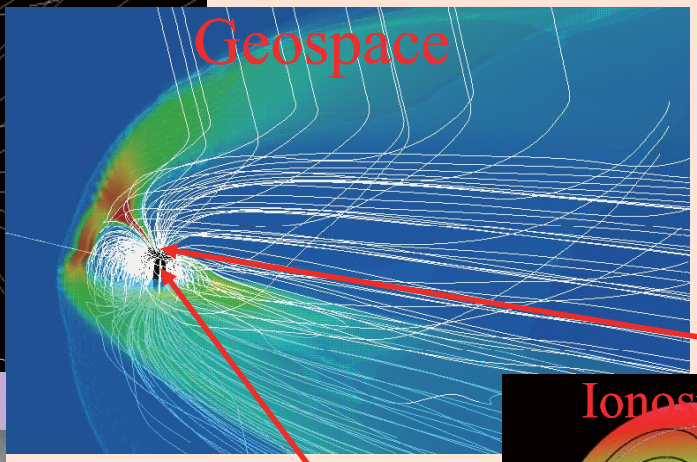
06/04/14 **Macquarie Island** MLAT = -64.5˚

Student and Staff at SERC, Kyushu Univ. set MAGDAS magnetometer in cooperation with staffs of Oversea Research Institute.

2-1. Integrated Simulation of Solar-Terrestrial System

Research and Development of Space Environment Simulator





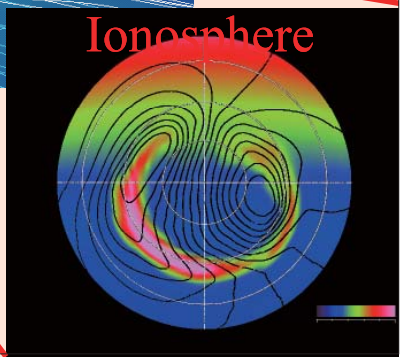
JST・CREST Program
Kyusyu Univ.
NiCT
Meteor. College

Parallel Computer

NiCT Cooperation

Finite Volume TVD Scheme・Parallel Computation・Visualizationi

NEC SX-8R （48CPU）
1CPU当たり 32GFLOPS（ギガフロップス）
TOTAL 1．5TFLOPS（テラフロップス）
地球シミュレーターの20分の1程度



3-1. QSAT Project

(1) Understand spacecraft's charge buildup and discharging.
(2) Education and research opportunities for students in an activity combining space sciences and satellite engineering.

Concept of Magnetometer

(1) Science Purpose;

Observation of the magnetic field disturbances caused by field-aligned currents (FACs) in the polar and equatorial region

(2) Units;

- a fluxgate sensor(90Lx50Wx50H,400g)
- electronics and data processor (240Lx150Wx95H,200g)
- 1.5m boom for the sensor

(3)Power consumption ;

1W

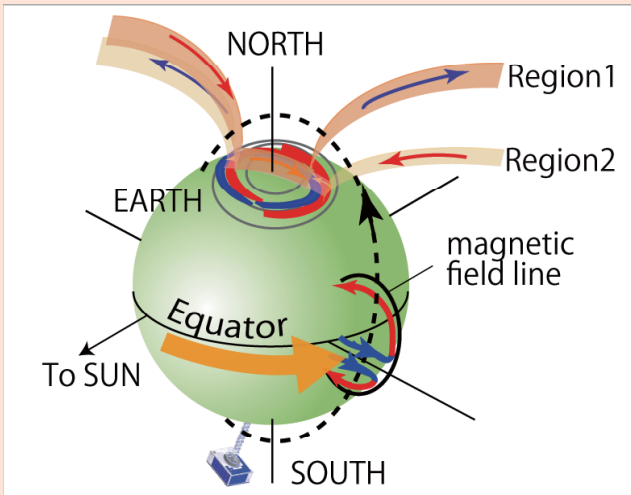


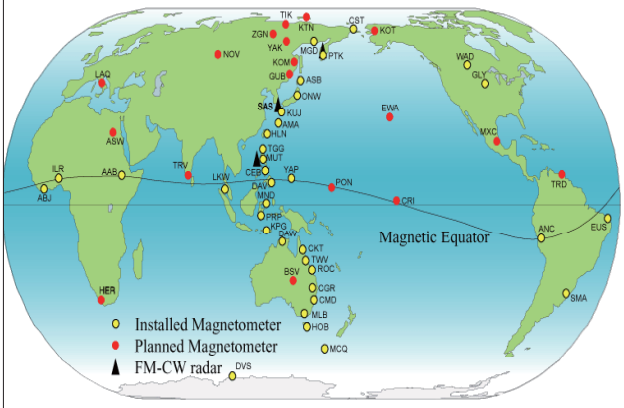
Illustration of the Field-Aligned Currents(FACs)

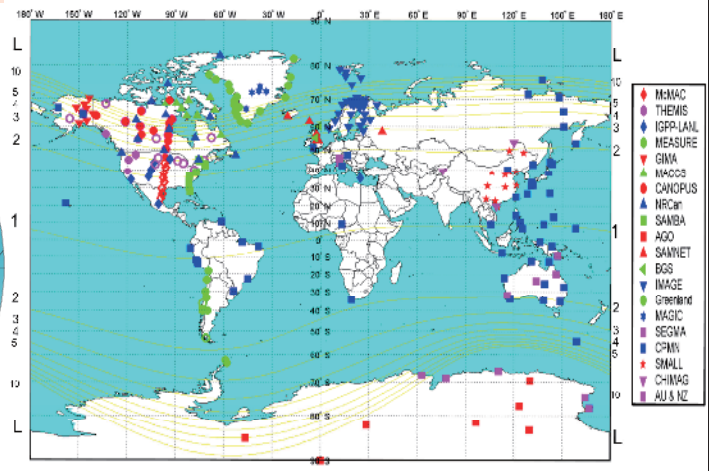
4-1. ULTIMA Consortium
(Ultra Large Terrestrial International Magnetic Array)

ULTIMA is an international consortium that aims at promoting collaborative research on the magnetosphere, ionosphere, and upper atmosphere through the use of ground-based magnetic field observatories.

MAGDAS/CPMN

(MAGnetic Data Acqusition System/Circum-pan Pacific Magnetometer Network)



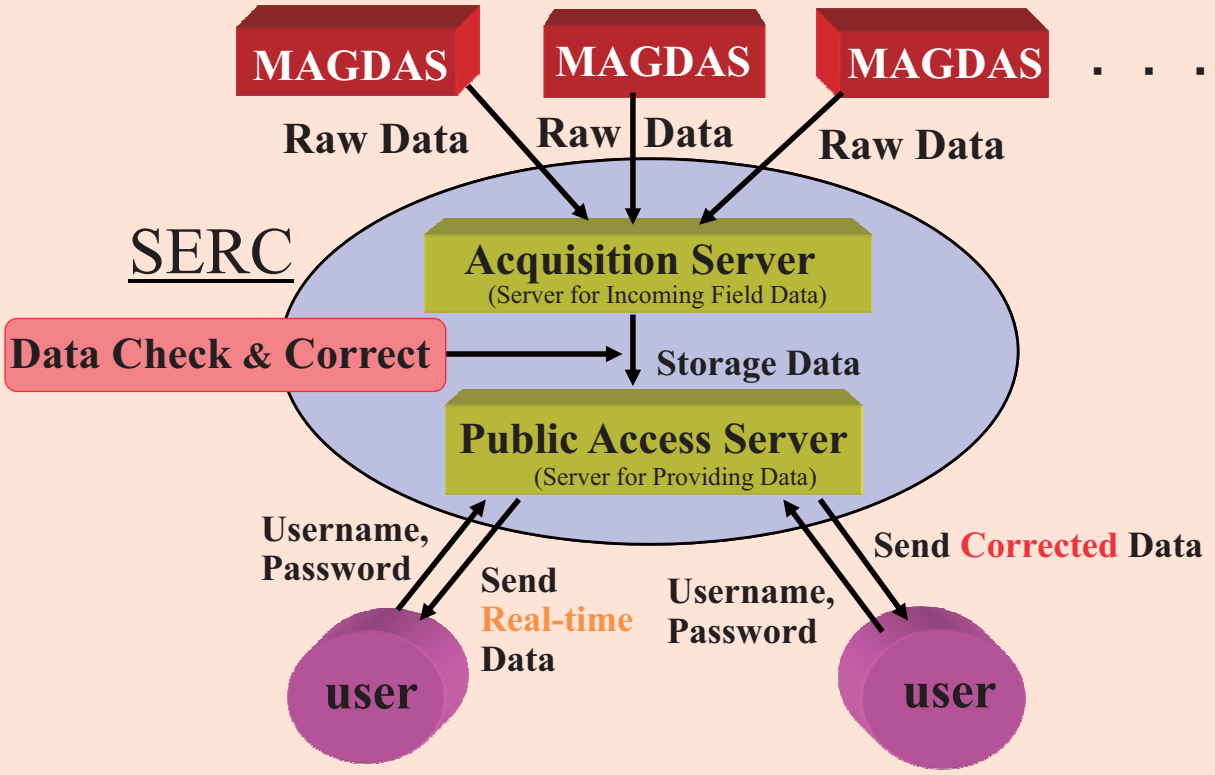


http://www.serc.kyushu-u.ac.jp/ultima/ultima.html

5-1. Local Education and Global Outreach

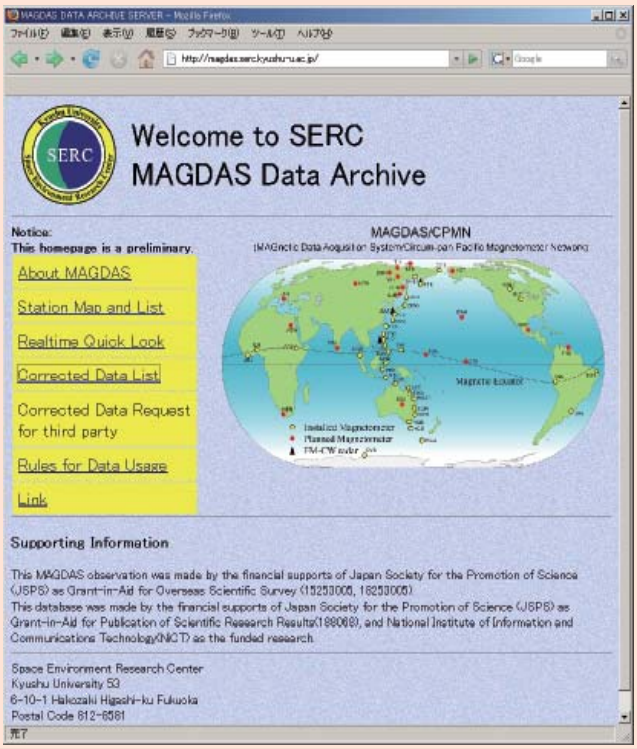
Every day space weather “now casting” to train and educate KU students for space weather forecasters in the future, and to globally disseminate space weather information from SERC as a service to the scientific community and the general public.

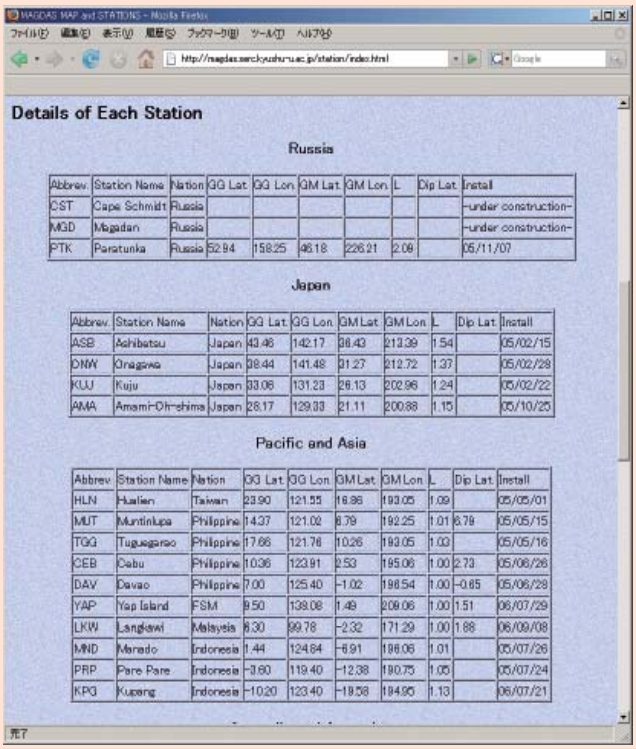
5-2. Schematic Diagram of MAGDAS Database Service



5-3. MAGDAS Database Service through SERC Home Page

http://magdas.serc.kyushu-u.ac.jp





Space Weather Activities at SERC

http://www.serc.kyushu-u.ac.jp/

6. Summary

(1) SERC promotes MAGDAS, QSAT projects, and ULTIMA consortium during IHY period.
(2) SERC conducts space weather analysis for local education and global outreach.
(3) SERC offers to scientific community the MAGDAS database, Pc 5- and EE-index.