

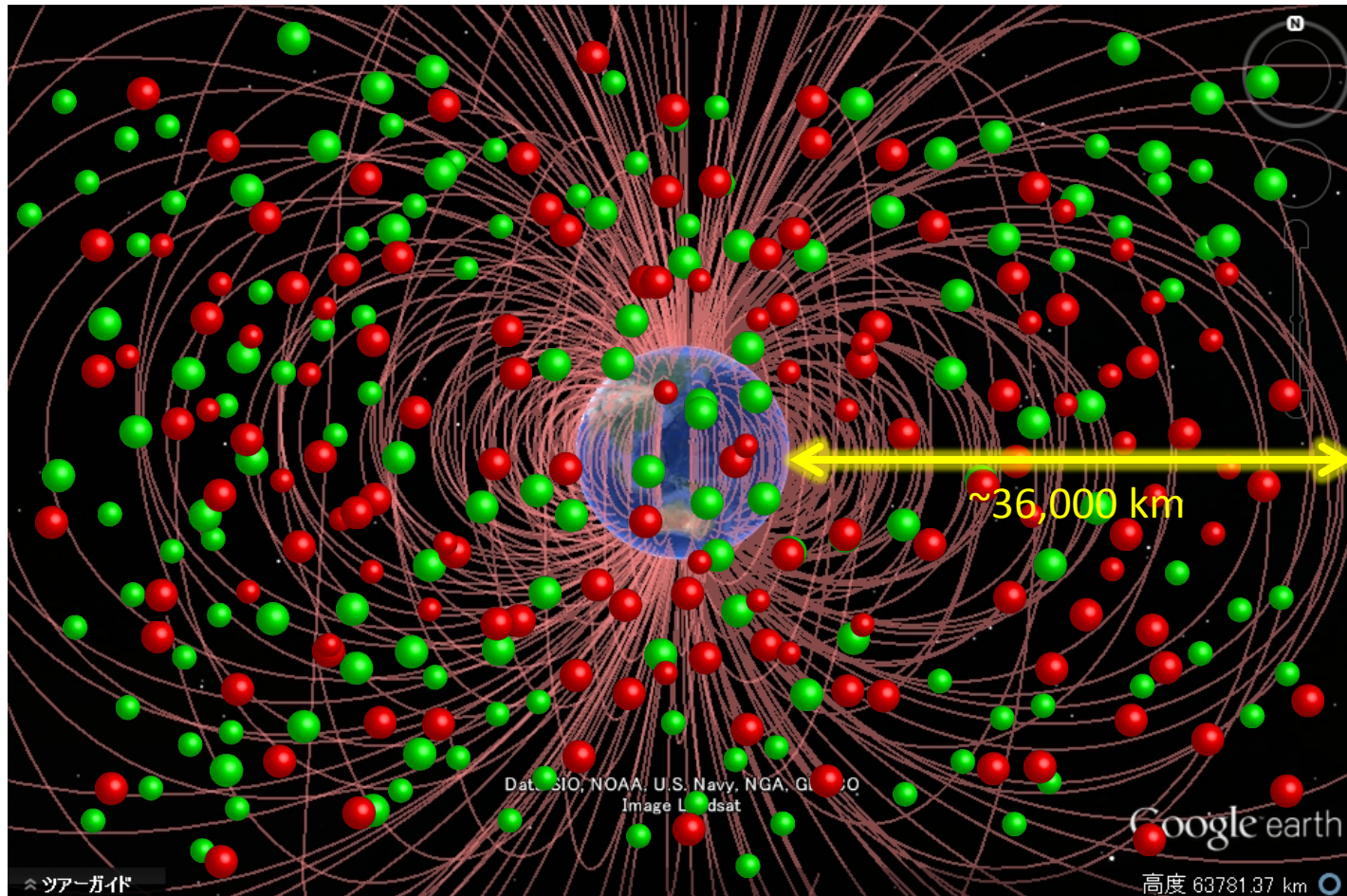
# Research data sharing in the field of solar-terrestrial physics

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World Data Center for Geomagnetism, Kyoto  
Graduate School of Science, Kyoto University

# Solar-terrestrial physics?

- Solar-terrestrial physics
  - is the study of various phenomena taking place in the area from approximately 50 km altitude to the Moon's orbit (~360,000 km altitude).

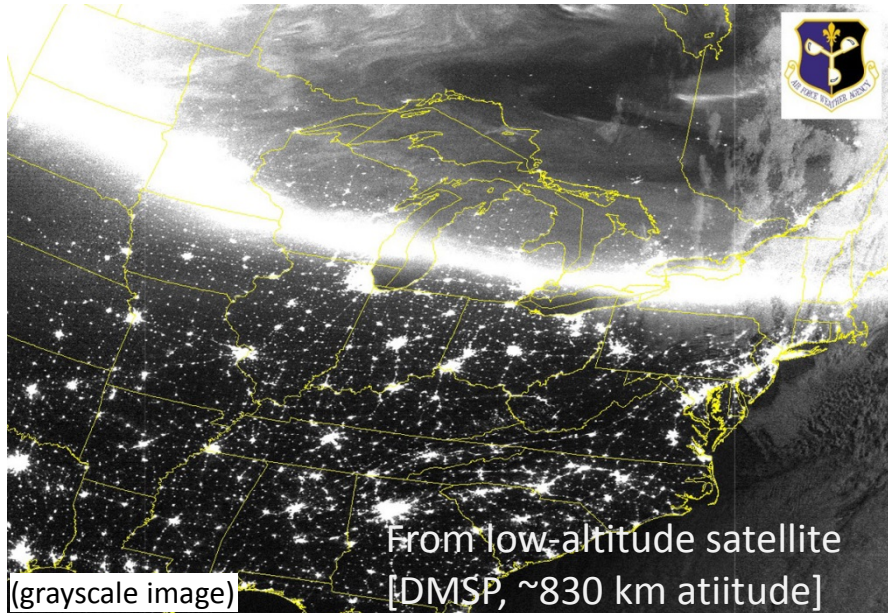


# Auroral optical images

From ground



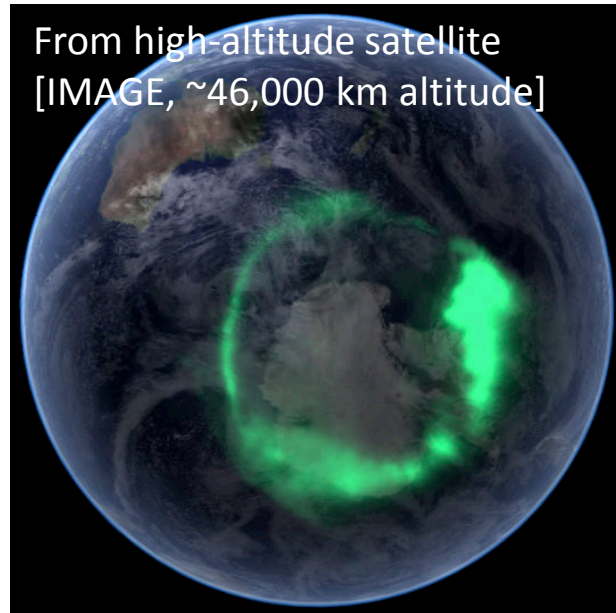
From Space Shuttle  
[~400 km altitude]



From low-altitude satellite  
[DMSP, ~830 km altitude]

(grayscale image)

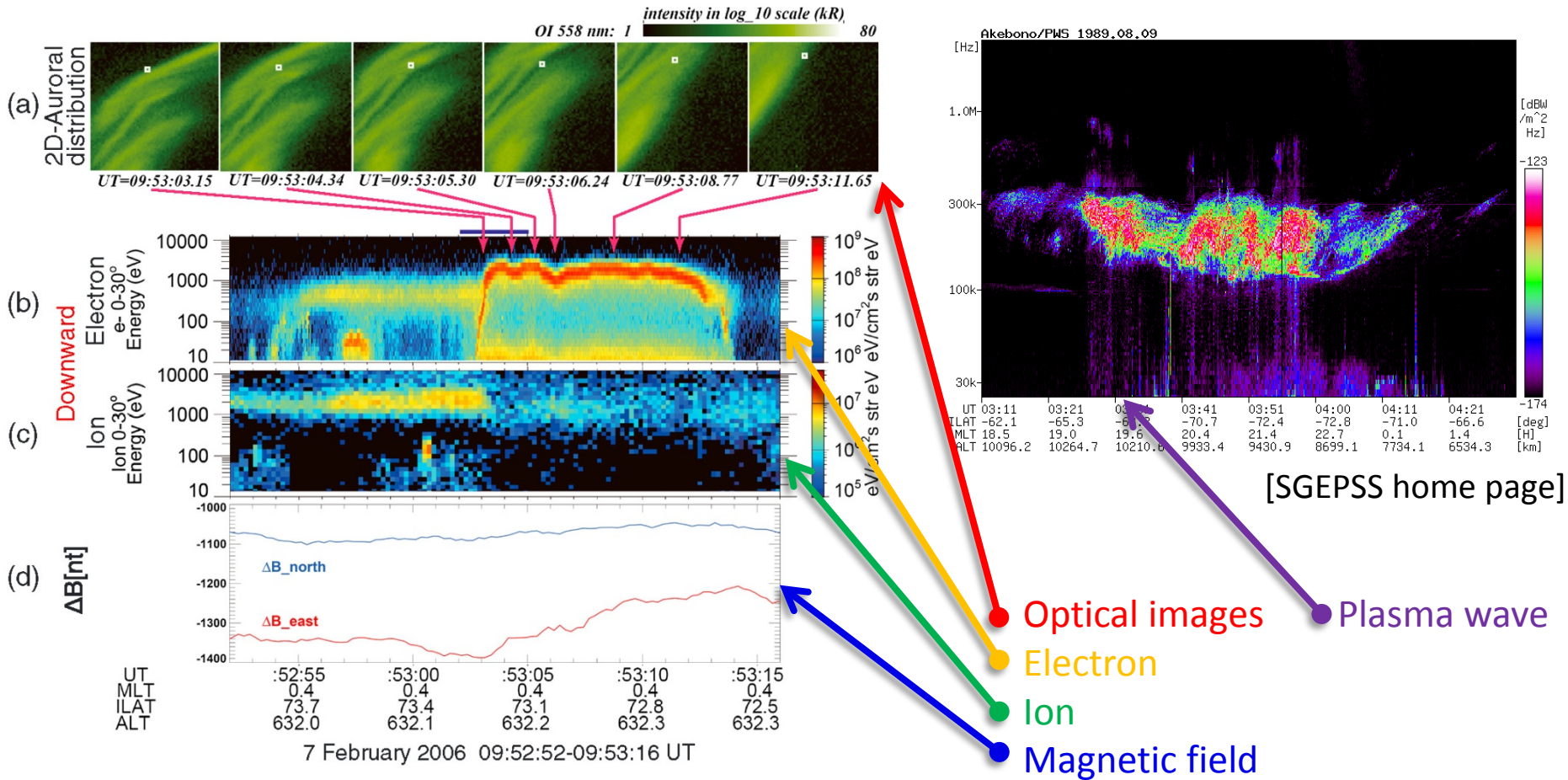
From high-altitude satellite  
[IMAGE, ~46,000 km altitude]



All images  
courtesy of  
NASA

# Aurora from different points of view

- It is important to observe aurora from different points of view.



Fukuda et al. [2014]

# Observations in solar-terrestrial physics

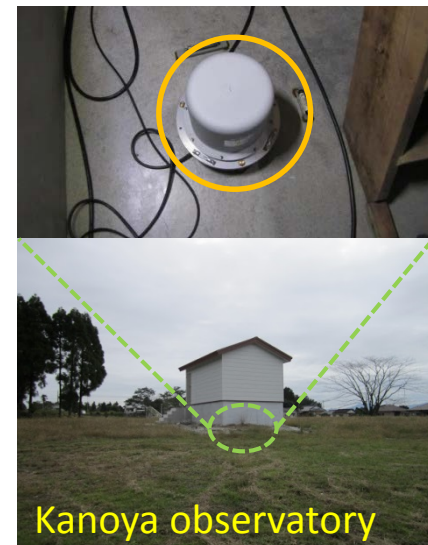
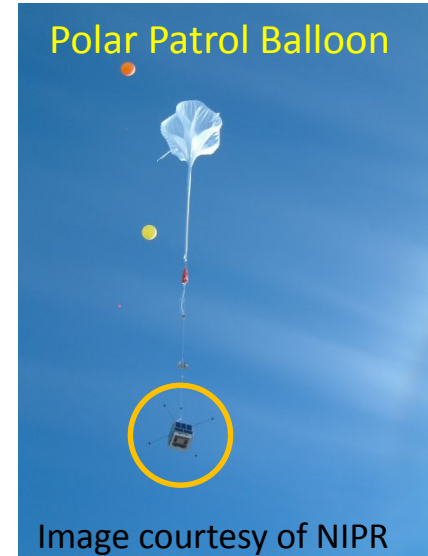
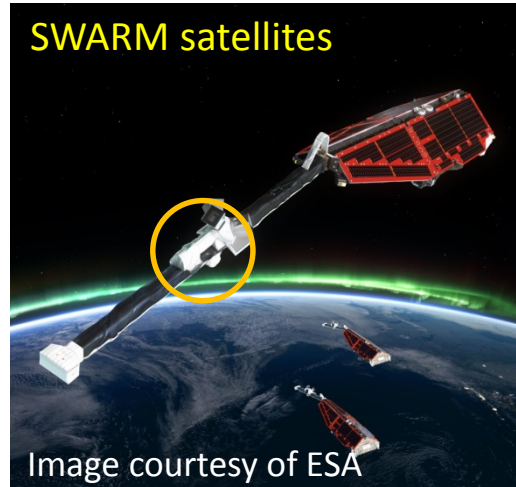
## Method of observations

- Optical image
  - wavelength (frequency)
- Plasma wave
  - wavelength (frequency)
- Particle
  - species ( $e^-$ ,  $p^+$ ,  $He^+$ ,  $He^{++}$ ,  $O^+$ , ...)
  - energy
- Field
  - magnetic field
  - electric field

## Carrier of instruments

- Space-borne
- Rocket-borne
- Balloon-borne
- Ground-based

## Magnetometers in different carriers



# Quiz

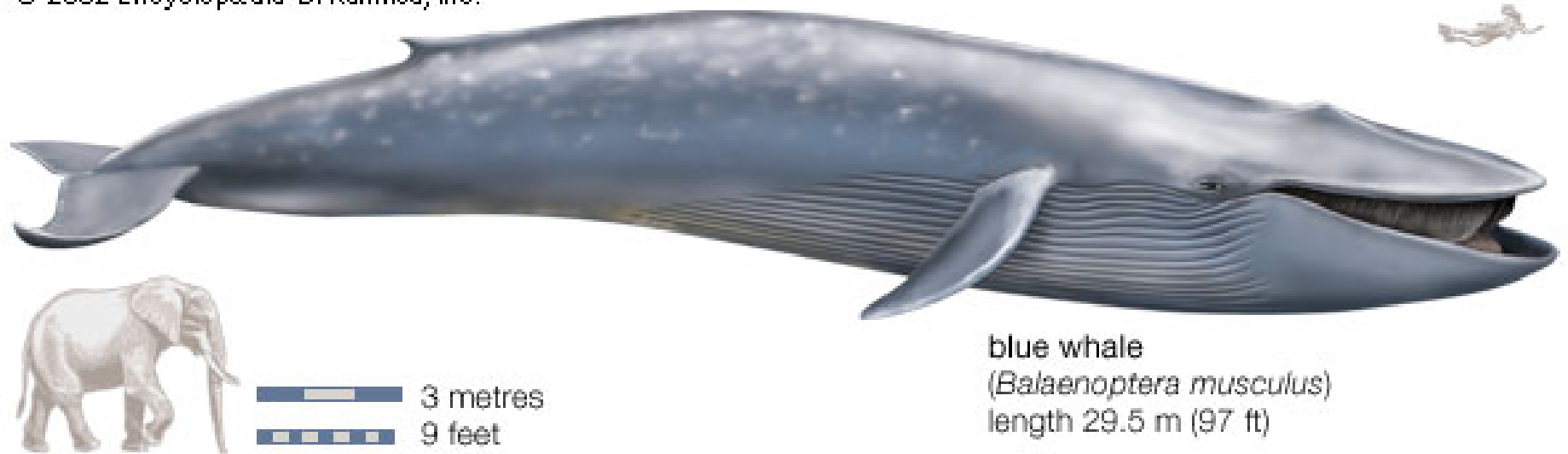
- Imagine that you are in the dark with your friends.
- Identify an animal in the dark with your flashlights and microphones.



# Quiz

- Imagine that you are in the dark with your friends.
- Identify an animal in the dark with your flashlights and microphones.

© 2002 Encyclopædia Britannica, Inc.



blue whale  
(*Balaenoptera musculus*)  
length 29.5 m (97 ft)

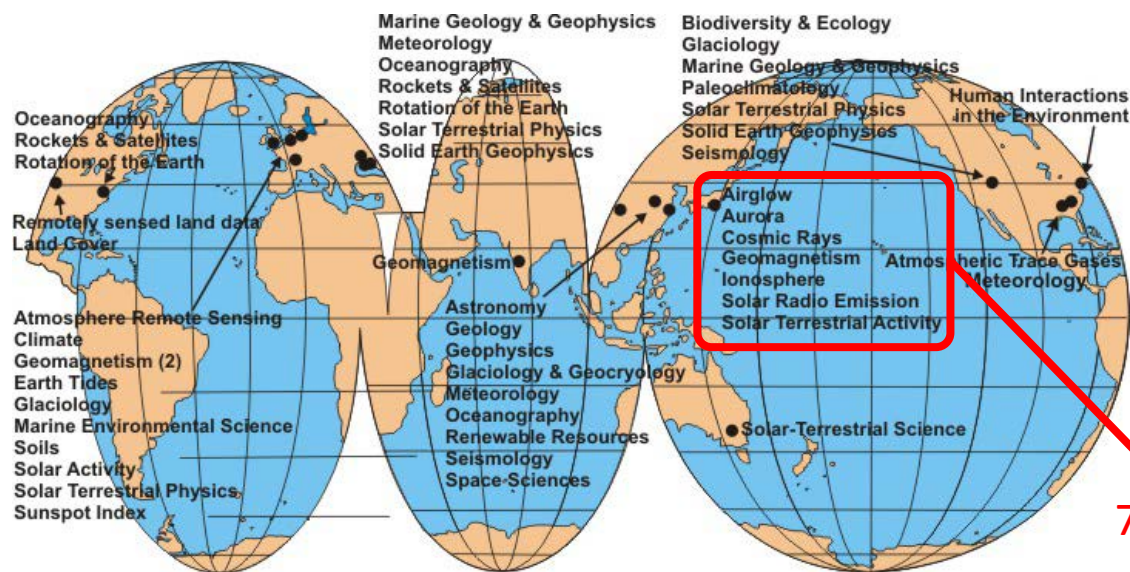
# Sharing observational results

	Quiz	Observational physics (Solar-Terr. Phys.)	Experimental physics
Target	Blue whale	Plasma phenomena in vast space	(Depend on research fields)
Size relative to observer	Huge	Huge	Small in most cases
Method of observation	Visual, auditory, tactile senses, ...	Optical image, wave, particle, field, ...	(Depend on research fields)
Attitude of observation	Passive	Passive	Active
Chance of observation	One-time-only	One-time-only	Multiple times
Strategy	Share observations	Share observations	Not share observations



# World Data Center (WDC) & World Data System (WDS)

- 1957-1958: International Geophysical Year (IGY)
  - 67 countries, ~4000 observational sites
  - **Earth sciences:** [Aurora](#), [airglow](#), [cosmic rays](#), [geomagnetism](#), [gravity](#), [glacier](#), [ionospheric physics](#), [longitude and latitude determinations](#), [meteorology](#), [oceanography](#), [seismology](#), and [solar activity](#)
- 1957-1958: The World Data Center (WDC) system was created.
  - to archive and distribute data collected from the IGY observational programs
- 2008: Reformed into the World Data System (WDS)
  - to promote **universal and equitable access to scientific data** covering a broad range of disciplines from the natural and social sciences, and humanities



7 WDCs in Japan

# WDC for Geomagnetism, Kyoto

- Geomagnetic field data (>150 observatories), geomagnetic indices, etc.

WDC for Geomagnetism, Kyoto

operated by  
Data Analysis Center for Geomagnetism and Space Magnetism  
Graduate School of Science, Kyoto University  
Kitashirakawa-Oiwake Cho, Sakyo-ku  
Kyoto 606-8502, JAPAN

TEL: +81-75-753-3929 (075-753-3929, inside Japan)  
FAX: +81-75-722-7884 (075-722-7884, inside Japan)

WDC for Geomag. KYOTO

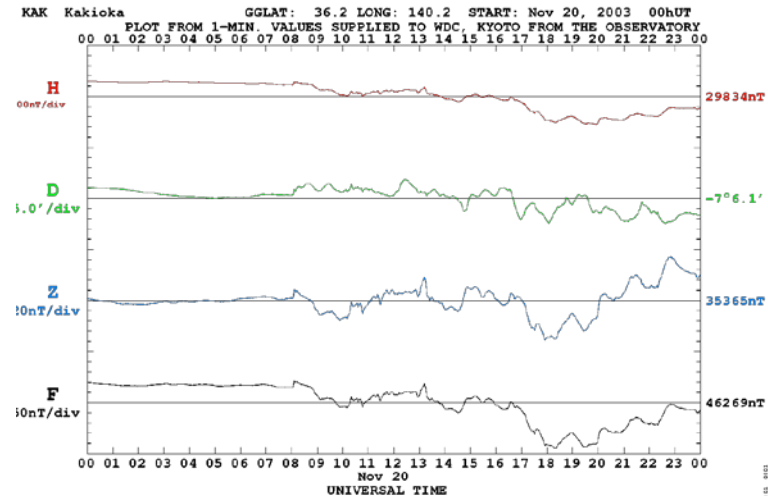
Home Page WDC for Geomag. Kyoto E's magnetic field? Data Service I-Magnet Link

1. [World Data Center for Geomagnetism, Kyoto](#)  
Data Analysis Center for Geomagnetism and Space Magnetism,  
Research, Publication list, Staff, Access Guide and Map, WDC system and others
2. [What is the Earth's magnetic field?](#)  
Magnetic north, geomagnetic and magnetic poles, Geomagnetic elements,  
Geomagnetic field observation and collection of the data (Geomagnetic observatories on the  
Google Earth),  
International Geomagnetic Reference Field and others
3. **[Geomagnetic Data Service](#)**  
Indices, Geomagnetic Field Data at the Observatories, Models, Data Catalogue and others
4. [INTERMAGNET Kyoto GIN Home Page](#)  
QL monitor of INTERMAGNET data, about INTERMAGNET and others
5. [Link to other sites](#)  
Kyoto University, ICSU/WDS's, Geomagnetic Observatories, Societies and others

Contact on this page: [ivemori@kugi.kyoto-u.ac.jp](mailto:ivemori@kugi.kyoto-u.ac.jp)

Logomark is designed by T. Hashimoto

Geomagnetic field variations at Kakioka, Japan  
[November 20, 2003]



# WDC for Ionosphere and Space Weather

- Ionospheric parameters (ionograms, 7 observatories)

WDC for Ionosphere and Space Weather

NICT archives and distributes ionospheric data and data related with space weather

Public Agency

Research Institute

WDC for Ionosphere and Space Weather

Educational Institution

General Public

ICSU World Data System and World Data Center for Ionosphere and Space Weather

The ICSU World Data System (WDS) was created through a decision of the General Assembly in 2008, restructuring the former ICSU World Data Centers (WDCs) established during the International Geophysics Year (IGY) of 1957-1958 and former Federation of Astronomical and Geophysical data-analysis Services (FAGS). WDS aims to ensure the long-term stewardship and provision of quality-assessed data and data services to the international science community in order to support the scientific research projects ICSU actively promotes.

National Institute of Information and Communications Technology (NICT) has been operating a Regional Warning Center (RWC) of the International Space Environment Service (ISES). We also hosted and operated the WDC for Ionosphere under the auspices of ICSU WDC. Recognized for these contributions to international data-sharing efforts, the WDC for Ionosphere and Space Weather operated by NICT has been officially accepted as a Regular Member of ICSU WDS. Our organization collects and archives data and information on ionosphere and space weather, and makes them available to the public. Published data are used by a wide range of users including public organizations, research institutions, and universities.

Latest Archives

August 2015

[Vol.67 No.6 Ionospheric Data in Japan for June 2015 \(PDF\)](#)

July 2015

[Vol.67 No.5 Ionospheric Data in Japan for May 2015 \(PDF\)](#)

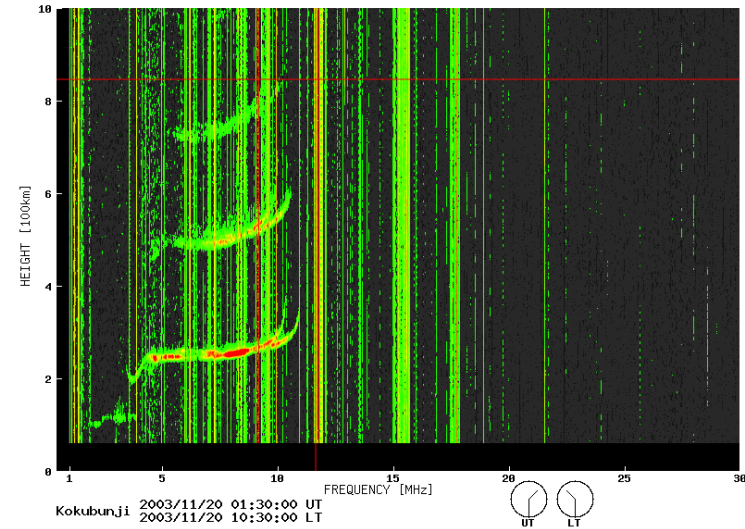
June 2015

[Vol.67 No.4 Ionospheric Data in Japan for April 2015 \(PDF\)](#)

NICT Space Weather and Environment Informatics Laboratory

Data Download

Ionogram at Kokubunji, Japan  
[November 20, 2003]

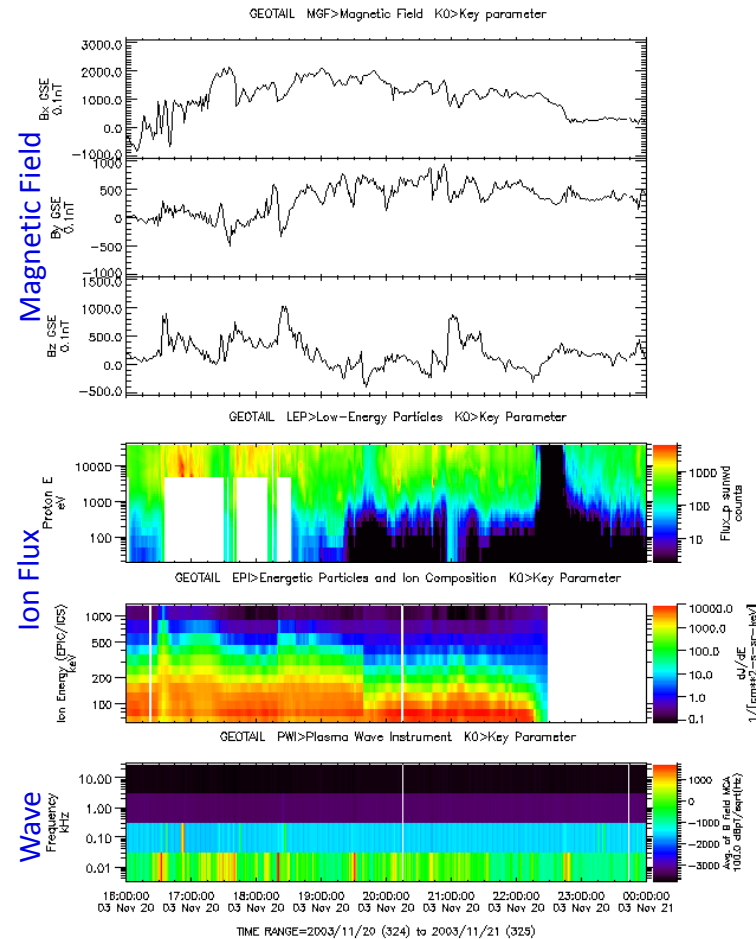


# NASA, Coordinated Data Analysis Web

- Public data from current space physics missions (>35 satellites)

The screenshot shows the CDAWeb website interface. At the top, there is a search bar and navigation icons. Below that, the NASA logo and 'GODDARD SPACE FLIGHT CENTER Space Physics Data Facility' are displayed. A navigation menu includes links for '+ SPDF HOME', '+ DATA & ORBITS', '+ MODELS at CCMC', '+ SCIENCE ENABLED', and '+ AND MORE'. The main content area features a 'Coordinated Data Analysis Web' banner with several data visualization thumbnails. On the left, there are sections for 'CDAWeb Mirror Site', 'Guides and Tutorials', 'Additional Services', and 'Additional Resources'. A red box highlights the text 'Public data from current space physics missions' in the 'Additional Services' section. Below this, there are two news items: one about ACE SWICS 2.0 data and another about Sunspot Number Index values. At the bottom, there are search filters for 'Sources' and 'Instrument Types'.

GEOTAIL satellite data [November 20, 2003]



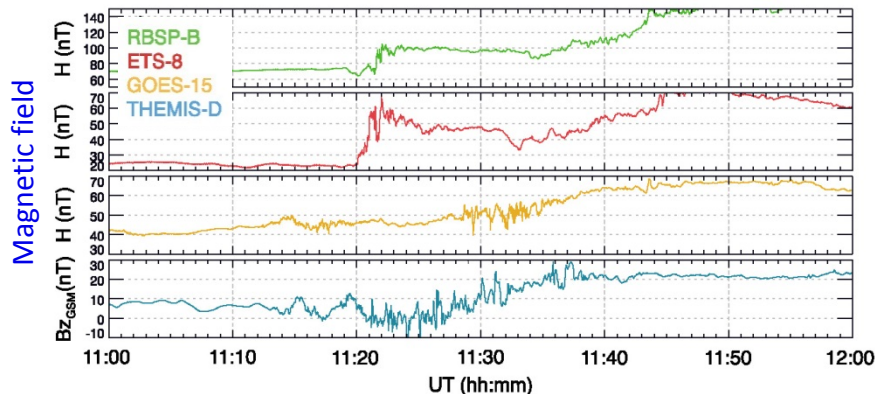
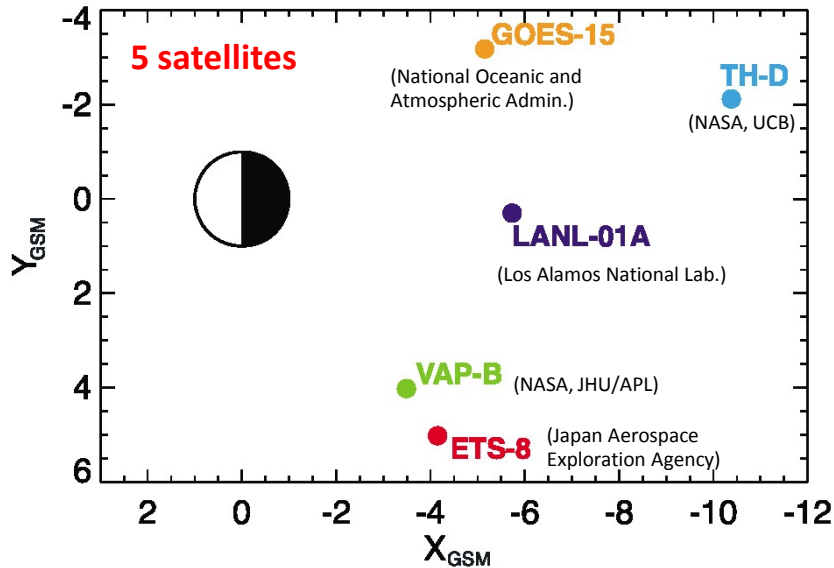


# Examples of papers employing multi-satellites

Gkioulidou et al. [2015], 10 co-authors

Spatial structure and temporal evolution of energetic particle injections in the inner magnetosphere during the 14 July 2013 substorm event

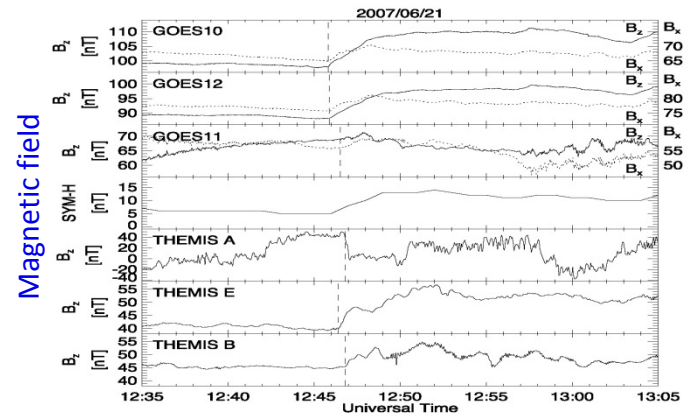
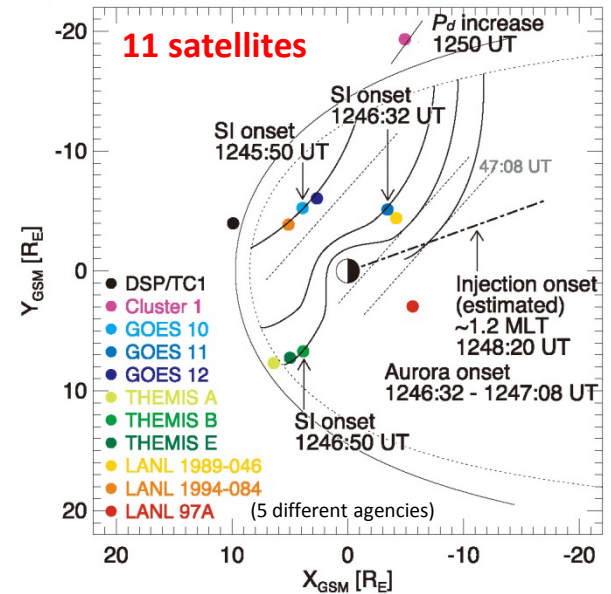
Matina Gkioulidou<sup>1</sup>, S. Ohtani<sup>1</sup>, D. G. Mitchell<sup>1</sup>, A. Y. Ukhorskiy<sup>1</sup>, G. D. Reeves<sup>2</sup>, D. L. Turner<sup>3</sup>, J. W. Gjerloev<sup>1</sup>, M. Nosé<sup>4</sup>, K. Koga<sup>5</sup>, J. V. Rodriguez<sup>6,7</sup>, and L. J. Lanzerotti<sup>8</sup>



Keika et al. [2009], 14 co-authors

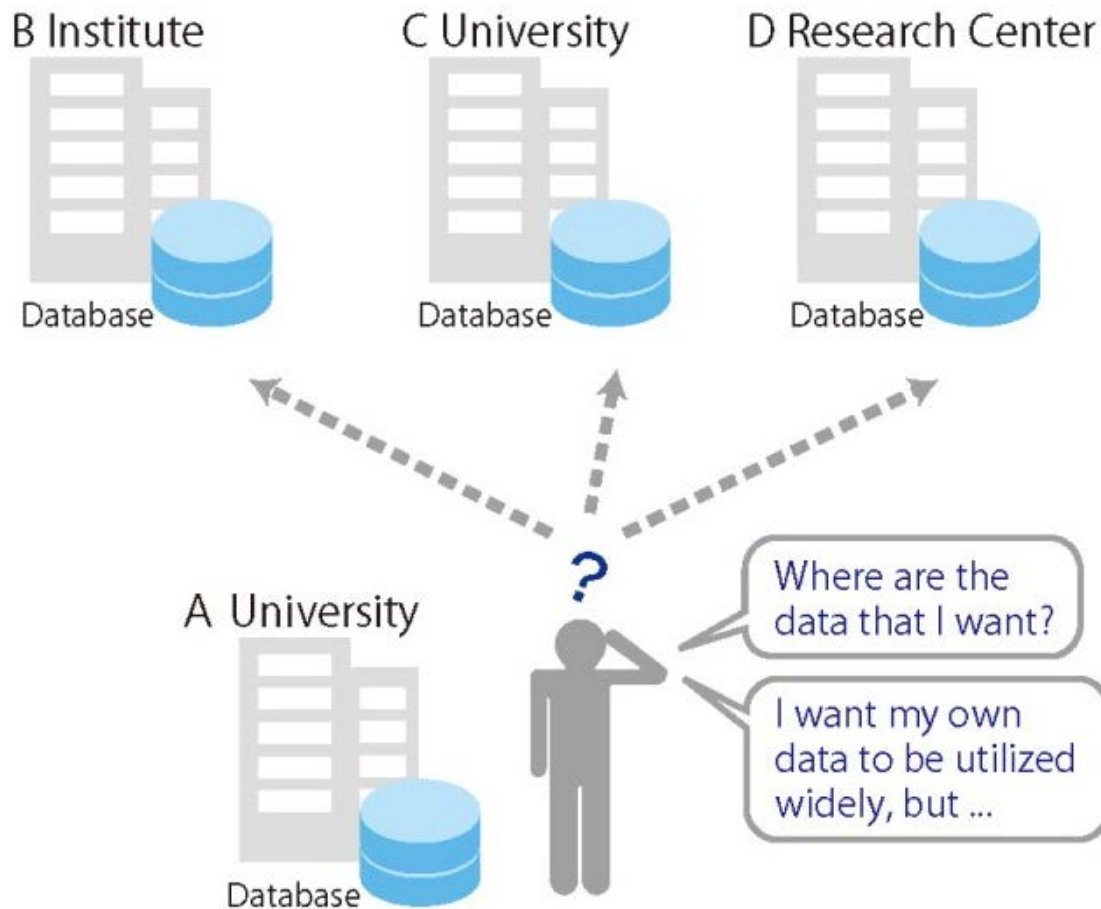
Substorm expansion triggered by a sudden impulse front propagating from the dayside magnetopause

K. Keika,<sup>1</sup> R. Nakamura,<sup>1</sup> W. Baumjohann,<sup>1</sup> V. Angelopoulos,<sup>2</sup> P. J. Chi,<sup>2</sup> K. H. Glassmeier,<sup>3,4</sup> M. Fillingim,<sup>5</sup> W. Magnes,<sup>1</sup> H. U. Auster,<sup>3</sup> K. H. Fornacon,<sup>3</sup> G. D. Reeves,<sup>6</sup> K. Yumoto,<sup>7</sup> E. A. Lucek,<sup>8</sup> C. M. Carr,<sup>8</sup> and I. Dandouras<sup>9</sup>



# Difficulty in finding database

- Data are open and ready to be shared, but it sometimes happens that users cannot discover the open database.
- This problem can be solved by creation and search of metadata database.



# IUGONET (Inter-university Upper atmosphere Global Observation NETwork)

- Metadata database for upper atmospheric physics
- Users are able to search the metadata DB via any web browsers.

**IUGONET Metadata DB (iugonet1@stel) >**

**IUGONET**  
Metadata DB for Upper Atmosphere

**Browse Data**

- Entire Data / Resource
- Registration List to IUGONET MDB
- Resource Type

**Browse Service**

- Browse Service

**UDAS**  
Iugonet Data Analysis Software

**Keyword:**  
Keyword (e.g. magnetometer, SMART, radio wave, imaging riometer....)

**Time:**  
from [YYYY-MM-DDThh:mm:ssZ] to [YYYY-MM-DDThh:mm:ssZ] [UTC]

**Data Types:**  
Data Set (  Numerical  Plot / Movie  Data File / Plot  Instrument  Observatory )

**Search**

Copyright © 2009-2012 IUGONET - Feedback  
Customized by IUGONET.  
Powered by DSpace Software.

## List of Data Registered in the IUGONET Metadata DB As of March 2014

As of March 2014

- Tohoku University**
  - Onagawa Geomagnetic Data (Search Coil)
  - Iitate HF-Band Jupiter-Sun Wide-Band Radio Data
  - Iitate UHF-Band Jupiter Narrow-Band Radio Data
  - Iitate VHF-Band Solar Radio Spectral Data
  - Zao HF-Band Jupiter Narrow-Band Radio Data
  - Zao HF-Band Jupiter Wide-Band Radio Data
  - Athabasca LF-Band Standard Radio Wave Phase-Amplitude Variation Data
  - Ny-Alesund LF-Band Standard Radio Wave Phase-Amplitude Variation Data
  - Alaska Geomagnetic Data (Search Coil)
  - Alaska Aurora Imaging Data
  - Asia VLF Observation Network (AVON)
- National Institute of Polar Research**
  - Syowa Station:
    - Auroral Observation
    - Geomagnetic Observation
    - Upper Atmosphere Physics Monitoring Observation
    - Imaging Riometer
    - 1-100Hz ULF/ELF Electromagnetic Wave Observation
    - Fabry-Perot Imager
    - SuperDARN HF-Radar
    - MF Radar
    - Sodium Lidar
    - Unmanned Magnetometer Network Observation around Syowa Station
    - Upper Atmosphere Physics Observation at Zhongshan Station
    - All-Sky Imager at South Pole Station
    - Conjugate Observation at Iceland
    - EISCAT Radar
    - NIPR/Norway Svalbard Meteor Radar (NSMR)
    - NIPR/Norway Tromsø Meteor Radar (NTMR)
    - Auroral and Airglow Observation (Svalbard, Tromsø)
- Kyoto University; Data Analysis Center for Geomagnetism and Space Magnetism**
  - Geomagnetic Indices (Final)
  - Geomagnetic Indices (Provisional)
  - Geomagnetic Indices (Quick Look)
  - Geomagnetic Field Digital Data (WDC Final)
  - Geomagnetic Field Digital (WDC Prompt)
  - Geomagnetic Field Analog Data
  - Geomagnetic Field Digital Data (Original Observations by WDC for Geomag., Kyoto)
  - Statoscope Data (Original Observations by WDC for Geomag., Kyoto)
  - Geomagnetic Field Model (IGRF)
  - Ionospheric Conductivity Model
  - Catalogue for Archived Geomagnetic Field Data
- Kyoto University; Research Institute for Sustainable Humanosphere**
  - Shigaraki MU Observatory:
    - MU Radar (Troposphere and Stratosphere)
    - MU Radar (Mesosphere)
    - MU Radar (Ionosphere)
    - MU Radar (Special Obs.: Meteor/RASS/FAI)
  - Radioisonde
    - Boundary Layer Radar
    - L-Band Lower Troposphere Radar
    - Wind Profiler Radar (LQ-7)
  - Ionosonde
    - Meteor Radar
    - Lower Thermosphere Profiler Radar
    - Lidar
    - Ceiliometer
    - AWS
    - All Sky Camera
  - Equatorial Atmosphere Observatory:
    - EAR (Troposphere and Stratosphere)
    - EAR (FAI)
    - Boundary Layer Radar
    - Kotobang Meteor Radar
    - X-band Weather Radar
    - Ceiliometer
    - Radioisonde
    - AWS
    - All Sky Camera
  - Others:
    - MF Radar (Pontianak, Pameungpeuk)
    - Serpong Boundary Layer Radar
    - Meteor Radar (Serpong, Blak)
    - Dawin Radioisonde (Campaign Observation)
    - GNU Radio Beacon Receiver (GBRR)
    - GPS
    - Wind Profiler Radar (LQ7) (Blak, Manado, Pontianak)
    - Automatic Weather Station (AWS) (Blak, Manado, Pontianak)
    - Radioisonde (Bandung, Pontianak, Serpong, Uji)
- Kyoto University; Kwasan and Hida Observatories**
  - Flare Monitoring Telescope (FMT):
    - FMT Full-Disk Solar Images
    - FMT Event List
    - FMT Event Movies
  - Solar Magnetic Activity Research Telescope (SMART):
    - SMART H  $\alpha$  Full-Disk Solar Images
    - SMART H  $\alpha$  Partial Solar Images
    - SMART Event Catalogue
    - SMART Event Movies
    - SMART Solar Photospheric Magnetograms
  - Domeless Solar Telescope (DST):
    - DST H  $\alpha$  Partial Solar Images
    - DST Spectrograph Quick-look Solar Images
    - DST Spectrograph Data
  - Ca II K Full-disk Hellograms
- Nagoya University**
  - Atmosphere:
    - Campaign Observation of NOx and Ozone Mixing Ratio
    - Aerosol Observation
    - Atmospheric Molecule Observation by Infrared Spectrometer in Japan
    - Atmospheric Molecule Observation by Millimeter Wave Spectrometry at Japan and South America
    - Ionosphere and Magnetosphere:
      - 210 Magnetic Meridian (210MM) Magnetometer Chain
    - STEL Magnetometer
    - Optical Mesosphere Thermosphere Imager (OMTI)
    - Ionospheric Scintillation at Indonesia and Norway
    - VHF Radar at Indonesia
    - VLF/ELF Measurement in Japan and Canada
    - EISCAT Radar
    - MF/Meteor Radars at Norway
    - Optical Observations at Norway
    - SuperDARN Hokkaido HF Radar
    - Heliosphere:
      - Multi-Directional Cosmic-Ray Muon Telescope
      - Interplanetary Scintillation
- Kyushu University**
  - Ground Geomagnetic Observation Data
  - FM-CW Radar Observation Data
  - Geomagnetic Pc5 Index Data
  - Geomagnetic EE Index Data
  - Geomagnetic F12 Index Data
  - Sq Equivalent Current Pattern Model from MAGDAS/CPMN Observation
- Collaborative Members**
  - Solar Observatory, National Astronomical Observatory of Japan
  - White-Light/H-Alpha Full Disk Image (He-1 10830, Si-I 10827, Fe-I 15648)
  - Full Disk Stokes Map
  - National Institute of Information and Communications Technology
  - Aurora Web Camera (Alaska)
  - MF Radar (Alaska/Wakkanai/Yamagawa)
  - 1.3GHz Wind Profiler Radar (LQ4)
  - Kakioka Magnetic Observatory, Japan Meteorological Agency
  - Geomagnetic Field Data (1-hour/1-min/1-sec, Kakioka/Memambetsu/Kanoya/Chichijima)
  - Geomagnetic Field Data (0.1-sec, Kakioka/Memambetsu/Kanoya)
  - Geoelectric Field Data (1-hour/1-min/1-sec, 0.1-sec, Kakioka/Memambetsu/Kanoya)
  - Atmospheric Electric Field Data (1-hour/1-min, Kakioka/Memambetsu)

As of March 2014



# Summary

- Solar-terrestrial physics is a study of plasma phenomena in near-Earth space.
- The plasma phenomena
  - are naturally excited and cannot be controlled by observers, who can only make passive observations.
  - are transient and the same event does not occur.
  - have so large spatial scale that it is difficult for observers to cover completely.
- This makes researchers in solar-terrestrial physics share observational data.
- World Data Centers are established in 1957-1958 to archive and distribute data collected during IGY.
- Data from satellite missions and ground observation projects are usually open to public.
- Data sharing is an accepted culture in solar-terrestrial physics.
- Metadata database provides potential users with an opportunity to discover data that are already available but are not noticed by them. → IUGONET
- Solar-terrestrial physics is a good showcase for data scientist/informatics scientists to evaluate future possibility of “open science data” or “open research data”.