Research data sharing in the field of solar-terrestrial physics

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

From low-altitude satellite
[DMSP, ~830 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
Quiz

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

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# Sharing observational results

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

Geomagnetic field variations at Kakioka, Japan [November 20, 2003]
WDC for Ionosphere and Space Weather

- Ionospheric parameters (ionograms, 7 observatories)

Ionogram at Kokubunji, Japan [November 20, 2003]
NASA, Coordinated Data Analysis Web

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

[Image of the Coordinated Data Analysis Web (CDAWeb) interface]

- GEOTAIL satellite data [November 20, 2003]

[Graphs and charts showing magnetic field, ion flux, and wave data]
European Space Agency (ESA), Cluster Science Archive

- Data archive for CLUSTER and DOUBLE STAR satellite missions

CLUSTER 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

Keika et al. [2009], 14 co-authors
Substorm expansion triggered by a sudden impulse front propagating from the dayside magnetopause
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.
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”.

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