INTERUNIVERSITY UPPER ATMOSPHERE GLOBAL OBSERVATION NETWORK (IUGONET) META-DATABASE AND ANALYSIS SOFTWARE

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ABSTRACT

An overview of the Interuniversity Upper atmosphere Global Observation NETwork (IUGONET) project is presented. This Japanese program is building a meta-database for ground-based observations of the Earth's upper atmosphere, in which metadata connected with various atmospheric radars and photometers, including those located in both polar regions, are archived. By querying the metadata database, researchers are able to access data file/information held by data facilities. Moreover, by utilizing our analysis software, users can download, visualize, and analyze upper-atmospheric data archived in or linked with the system. As a future development, we are looking to make our database interoperable with others.

Keywords: Metadata database, Upper atmosphere, Ground-based observation, Earth and planetary sciences, Analysis software, Interdisciplinary study

1 INTRODUCTION

The term the "Earth's upper atmosphere" is applied to mean approximately the mesosphere, thermosphere, and ionosphere, situated at altitudes between 80 km and 1000 km. The atmospheric layer is difficult to observe at such altitudes compared with the "lower atmosphere" of (for example) the troposphere and stratosphere because *in situ* measurements of this layer are nontrivial. Hence, researchers have needed to develop ground-based observational instruments to measure parameters in the upper atmosphere such as atmospheric temperature, wind speeds, neutral/ionized gas densities, and chemical composition. After performing such observations, researchers working in assorted institutions archive the majority of the resulting data almost independently. In contrast, the driving energy of dynamic phenomena taking place in the upper atmosphere (or "geospace"), such as aurora, meteorological disturbances, and geomagnetic disturbances, primarily originates from solar radiation and solar winds. Thus, to understand the mechanisms behind these upper atmospheric phenomena and their long-term variations, a system is required that facilitates the querying, accessing, and analyzing of observational data that are typically seen by only a particular institute or research group.

1.1 IUGONET concept and realization

The Interuniversity Upper atmosphere Global Observation NETwork (IUGONET) project started in 2009 based on the needs of the aforementioned Solar–Terrestrial Physics (STP) research community as well as a new movement emanating from other fields to enhance interdisciplinary research in this field (Hayashi, Koyama, Hori, Tanaka, Abe, Shinbori, et al., 2013). IUGONET is a Japanese interuniversity program founded by the National Institute of Polar Research (NIPR), Tohoku University, Nagoya University, Kyoto University, and Kyushu University, with the aim of building a database for ground-based observations of the upper atmosphere. These "IUGONET institutions" archive data observed by radars, magnetometers, photometers, radio telescopes, helioscopes, and so on, at various altitudes from the Earth's surface to the Sun.

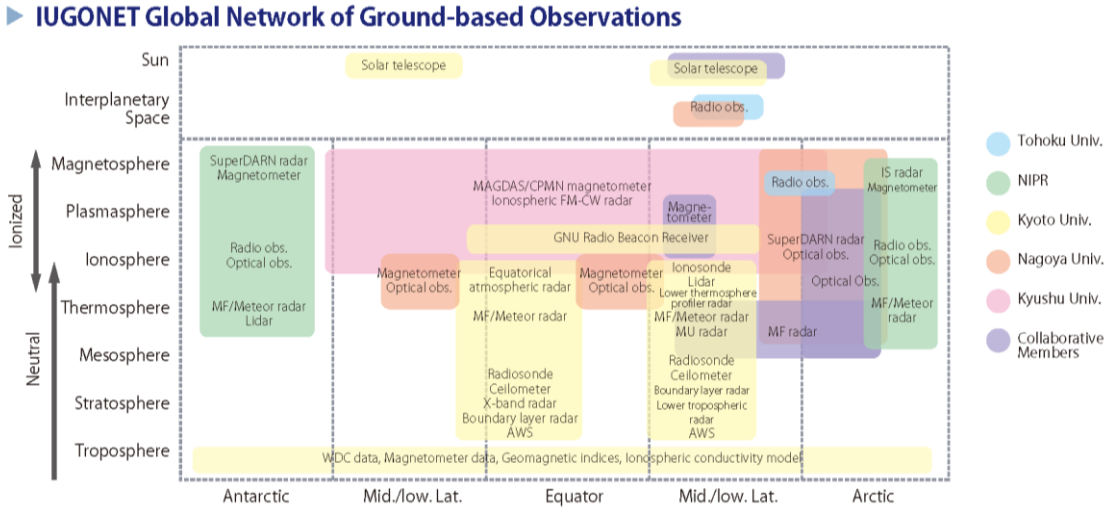


Figure 1. A conceptual cross-section showing principal ground-based observational data archived in the IUGONET metadata database. The horizontal axis denotes geographical areas from the Antarctic to Arctic whereas the vertical axis denotes altitude from the Earth's surface to the Sun. Colors demark those organizations holding the data

Figure 1 is a conceptual diagram showing the research areas covered by IUGONET institutes. Observation sites are widely distributed from the North to the South Pole. Including NICT, we currently collaborate with three Japanese institutions outside of the IUGONET, the other two being the Solar Observatory/National Astronomical Observatory of Japan and the Kakioka Magnetic Observatory/Japan Meteorological Agency (JMA). In addition, Tohoku University hosts the Asia VLF (Very Low Frequency) Observation Network data of Chiba University. We also incorporate solar image data measured and meteorological data obtained at sites with upper atmospheric radars. Although we now live in the "satellite era", ground-based observations are fundamentally important because we are able to directly perform several long-term observations at the same facility.

The goals of IUGONET are summarized as follows.

- To provide a new research platform that enables the sharing of metadata associated with ground-based observations collected by IUGONET institutions since the International Geophysical Year 1957–1958.
- To develop analysis software to access and analyze data in an integrated manner.
- To facilitate both a better understanding of global upper atmospheric phenomena and interdisciplinary research.

The remainder of this paper describes (1) the functionality of IUGONET and (2) IUGONET developments since Hayashi et al. (2013) first reported on the project activities. Specifically, in Section 2, we give an overview of the characteristics of our metadata database (MDB) from a user perspective before listing recent updates to the MDB in Section 3. A brief explanation is then given in Section 4 of our analysis tool, iUgonet Data Analysis Software (UDAS). Finally, conclusions and future activities are outlined in Section 5.

2 IUGONET MDB

Our project website (http://www.iugonet.org/en/index.html) contains a range of information on the IUGONET and its related subjects, including the project purpose, our members, and presentation materials from scientific meetings as well as both the IUGONET MDB and the UDAS software. Figure 2 shows the MDB top page (http://search.iugonet.org/iugonet/), which contains four tabs to enter query keywords. Researchers in related research fields should find it straightforward to input keywords in this webpage and search for data covering a specific time interval of interest. The second and third tabs narrow queries to only near-Earth (geospace) and heliospheric (solar) data, respectively, and users can limit the search further to those data from observation sites within a chosen geographic region. The rightmost tab provides a simple entry point for beginners to search from, which uses a latitude–height cross section similar to that shown in Figure 1.

In addition to the "Spatial" tab, we have prepared several tools to assist novices and researchers from other research fields in using our system. They can first link to the "Registration List to IUGONET MDB" in the left column of the MDB top page (Figure 2), which lists data files and parameters registered within the MDB. Through this list, users can easily identify whether the concerned data are under preparation or have already been registered. Second, as will be shown in Section 2.2, we have prepared Keyhole Markup Language (KML) files such that we can display the location of IUGONET observatories and instruments via Google Earth. Before that, however, we show an example of using the MDB to discover auroral images.

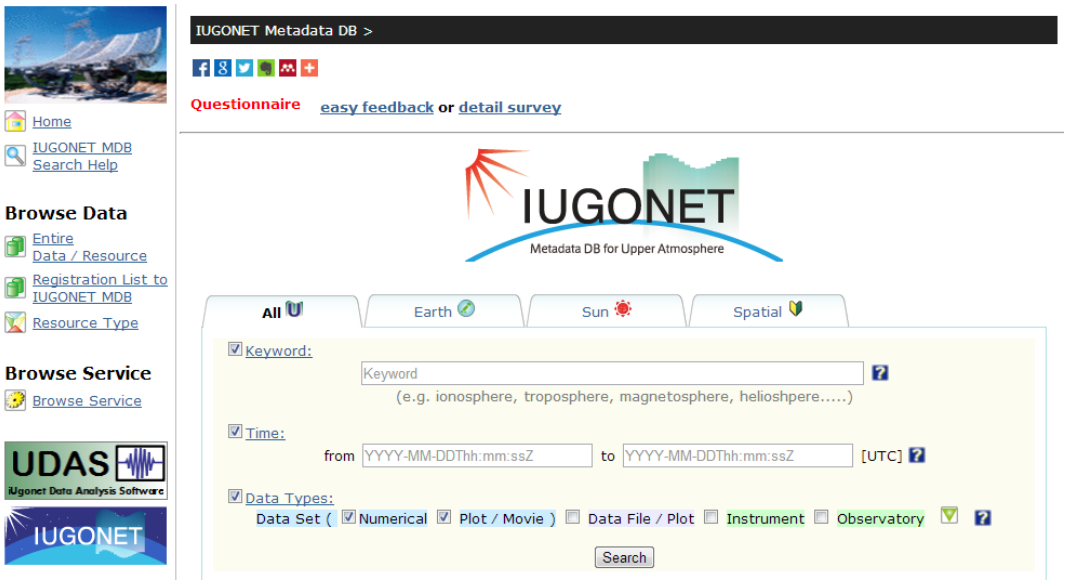


Figure 2. Top page of IUGONET MDB (http://search.iugonet.org/iugonet/)

2.1 An example of aurora image discovery

We begin by assuming the user already has sufficient expertize to know that "All Sky Camera" were appropriate keywords. Figures 3(a) and (b) then show the search results of a query using these keywords (although only two of the five returned results are shown in Figure 3(b)). Notice from Figures 2 and 3(a) that "Numerical" and "Plot/Movie" data types are both preselected by default because a user is considered to be predominantly interested in the datasets. Selecting the web address for the Tromso data (the red rectangle in Figure 3(b)), we access a webpage showing near-real time image files captured by the all-sky camera (Figure 3(c)).

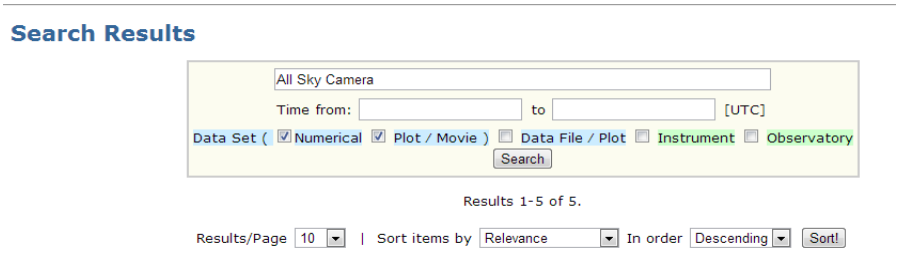
2.2 Browsing observatories and instruments via Google Earth

With many interdisciplinary research projects ongoing in both polar regions, researchers will be interested to know the types of data that can be accessed through the IUGONET system. Here we show an example of how to browse observatories and instruments with (meta)data in the MDB through the Google Earth interface.

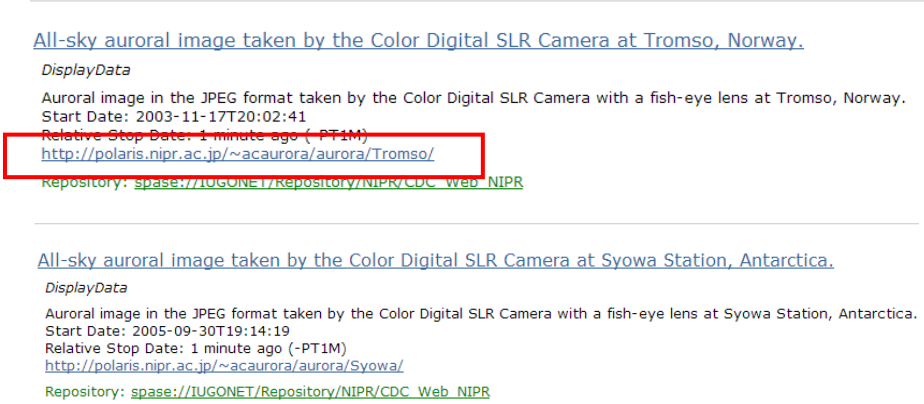
IUGONET adopted the Space Physics Archive Search and Extract metadata model (King, Thieman, & Roberts, 2010) to describe its upper atmospheric data (Hori, Kagitani, Tanaka, Hayashi, UeNo, Yoshida, et al., 2012).

According to that schema, metadata of an observatory, instrument, dataset, person, repository, or granule are registered as Extension Markup Language files. Converting those files to (zipped) KML files enables us to display the metadata on Google Earth by browsing the observation sites with a mouse (Figure 4). For instance, if the all-sky television camera at Showa Station (Antarctica) is chosen, the metadata of that instrument appears onscreen (Figure 4(b)). Clicking the associated web address takes the user to the description of the metadata (Figure 4(c)). By browsing registered metadata in this way, a user can thus determine keywords associated with the instrument, observe parameters, and so on and can enter these into the query screen outlined in the previous section and Figure 3. The KML files are presently beta-products and are available only on demand.

(a)



(b)



(c)

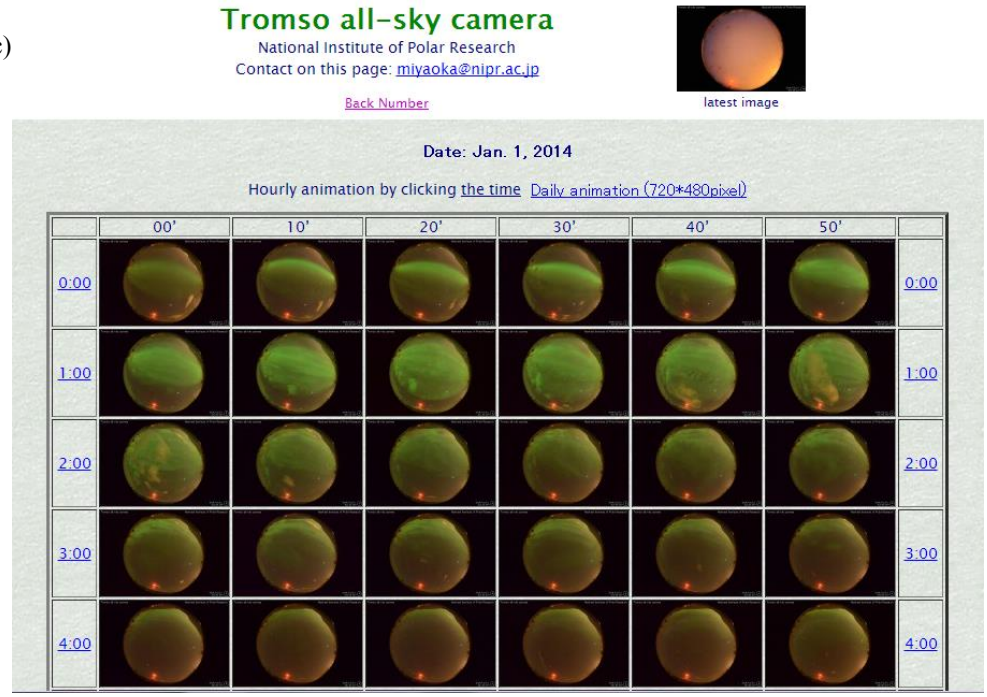
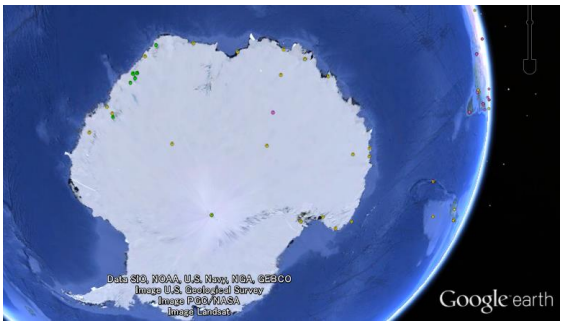


Figure 3. A search example using the keywords "all sky camera". (a) Initial search screen; (b) Search results (only two of the five datasets are shown); (c) The web address of the first result accesses all-sky camera images captured at 10-min intervals in Tromso, Norway (1 January, 2014), the red dot is a light near the observatory.

3 UPDATES TO IUGONET MDB

Recent developments to the MDB include continual updating of the IUGONET system and adding of new metadata. At the end of November 2013, the number of registered metadata had reached over 9.9 million, comprising 9,940,404 "Granule" metadata that can refer to each data file, 1,015 "Dataset" metadata, 811 "Observatory" metadata, 910 "Instrument" metadata, 208 "Person" metadata, and 20 "Repository" metadata. Of particular importance was our completion of registering the "Observatory" and "Instrument" metadata. The completion of such basic information has facilitated the viewing of entries in the MDB, as shown in Figure 4 and in certain tables on the IUGONET website (http://www.iugonet.org/en/mdblist.html).

(a)



(b)

©2013 Google Earth

(c)

All-sky TV camera (ATV) at Syowa Station, Antarctica.

Instrument

The all-sky television camera (ATV) is a panchromatic high-sensitivity camera recording all-sky auroral images at 30 frames/sec. Until JARE39 (the 39th Japanese Antarctic Research Expedition), a silicon intensifier target (SIT) tube had been used as a light-receiving el ement. During JARE40, the light-receiving element was changed to a night viewer (Hamamatsu C3100R) and an analog CCD camera, a nd the installation location was moved from a roof to an optical dark room. The light receiving section consists of a fish eye lens (Fish eye-Nikkor 8mm, F2.8), the night viewer, a relay lens, and the CCD analog camera (Tokyo Electronics CS8300 or Hamamatsu C3077-7 0). CCD images are recorded at a video rate of 30 frames/sec using S-VHS (until JARE45) or a HDD/DVD recorder (after JARE46).
Type: Imager
Investigation Name: Auroral Observation at Syowa Station
Observatory: spase://IUGONET/Observatory/NIPR/misc/SYO

Figure 4. Antarctica-based observatories and instruments registered in the IUGONET MDB as viewed through Google Earth. (a) Observatories in Antarctica; (b) Selection of all-sky camera instrument metadata at Showa Station; (c) Metadata description of all-sky camera

3.1 Digitalization of analog data

Following Hayashi et al. (2013), for the past year-and-a-half (2012–2013), we have been registering moderately old data, digitizing information recorded on rolls of paper and magnetic tapes. For example, Kwasan and Hida Observatories at Kyoto University are registering Ca II K full-disk solar images recorded on with photographic plates for the period 1926 to 1969, after digitizing the analog data and applying corrections and calibrations. Furthermore, Kakioka Magnetic Observatory/Japan Meteorological Agency and Kyoto University are generating 1-min digital data files of geomagnetic field intensities in which digitized data of magnetograms from 1955–1975. The Solar–Terrestrial Environment Laboratory at Nagoya University has finally been digitalizing analog Very Low Frequency receiver data stored on magnetic tapes in Kagoshima, Japan.

3.2 Automatic updates

A number of websites linked to the IUGONET MDB are automatically updated every day. In such cases, users can access the most current observation data through the MDB. We also have established schemes to generate and to register updated "Granule" metadata. Data for which such automatic updating occurs include the Equatorial Atmospheric Radar data and Medium Frequency/Meteor Radar data over Indonesia, which are produced by a research project of Kyoto University, and Low Frequency Radio Transmitter Observation data from Tohoku University.

4 ANALYSIS SOFTWARE

IUGONET does not regulate the data format employed by its institutes. Instead, we have developed the UDAS software, in collaboration with the Exploration of Energization and Radiation in Geospace Science Center (Miyoshi, Ono, Takashima, Asamura, Hirahara, Kasaba, et al., 2012), to handle various types of formatted data using the same platform (Tanaka, Shinbori, Hori, Koyama, Abe, Umemura, et al., 2013). UDAS is a plug-in software for the THEMIS Data Analysis Software Suite (TDAS; Angelopoulos, 2008), which is written in Interactive Data Language (IDL) and is available online (http://www.iugonet.org/en/software.html). UDAS/TDAS/IDL enables us to download, plot, and analyze observed data registered in IUGONET database relatively easily by utilizing the 25 load procedures we have thus far released (http://www.iugonet.org/en/software/loadprocedures.html). "Granule" metadata are also used to access the observational data through UDAS.

5 CONCLUSION AND REMARKS

The IUGONET project is building a meta-database for ground-based observations of the Earth's upper atmosphere, in which metadata are connected with various atmospheric radars and photometers. By querying the metadata database, researchers are able to access data file/information held by data facilities, and by utilizing our analysis software, users can download, visualize, and analyze upper-atmospheric data archived in or linked with the system.

As a future development, we are looking to make our database interoperable with others as well as to manage the ever-expanding metadata holdings of IUGONET. We are currently in the preparatory stages of developing an associative search (Koyama, Abe, Yagi, Umemura, Hori, Shinbori, et al., in press). Another important consideration is increasing the interoperability and/or metadata exchange with databases built by other groups. With the Near Earth Space Data Infrastructure for E-science (ESPAS) project having a similar objective to IUGONET, we have thus signed a mutual Memorandum of Understanding to establish a formal collaborative framework, including a study of an ontological approach. Furthermore, we are incorporating observational data from satellites and the International Space Station into our structure for making/linking metadata databases. We hope to contribute toward enhancement of scientific research activities in the fields of STP, climate, and geophysical environment by developing effective data systems. We welcome all offers of cooperation in this endeavor, metadata inputs, feedback, and especially interconnection with other databases.

6 ACKNOWLEDGEMENTS

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