DATA AND INFORMATION ACTIVITIES OF ICSWSE, KYUSHU UNIVERSITY, JAPAN

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ABSTRACT

In this paper, we introduce data and information activities of the International Center for Space Weather Science and Education (ICSWSE), Kyushu University, Japan. The principal data source is the MAGDAS (MAGnetic Data Acquisition System) project, which is a global network of geomagnetic observations operated by collaborations between ICSWSE and institutions in many countries. We operate 66 stations including more than 30 stations distributed along the 210^o magnetic meridian and more than 10 stations along the magnetic equator. We have established a semi-automatic data acquisition system via the Internet. Provisional data plots and geomagnetic indices derived from the project are available to the scientific community.

Keywords: Geomagnetism, Ground based observation, Magnetometer, Data citation, Metadata database, MAGDAS, ULTIMA, IUGONET, ICSWSE

1 INTRODUCTION

The International Center for Space Weather Science and Education (ICSWSE; formerly Space Environment Research Center, SERC, established in 2002), Kyushu University, was established in 2012 principally for the purpose of conducting research in space weather and related fields. A high priority is placed on collecting ground-based observational data. One of the major data collection efforts of ICSWSE came to be known as the "MAGDAS (MAGnetic Data Acquisition System)/CPMN (Circum-pan Pacific Magnetometer Network) Project", whose principal investigator is the director of ICSWSE (Prof. K. Yumoto).

The MAGDAS Project is a collaboration between ICSWSE and many host institutions in various countries. The observational instruments, such as magnetometers, are owned by and installed by ICSWSE. These are maintained by the host collaborative institutions. During installation, ICSWSE instructs collaborators how to operate and maintain the instruments. These instruments are locally maintained by host collaborators, and ICSWSE remotely monitors the instruments. MAGDAS data are collected by ICSWSE and distributed to researchers after required processing. Host institutions can use the non-processed data they maintain but cannot redistribute the data without asking ICSWSE. Non-processed data are not recommended for scientific usage (for more details, see Section 4). In addition, for capacity building of host institutions, ICSWSE organizes conferences for MAGDAS and related issues. See:

http://www.serc.kyushu-u.ac.jp/news/MAGSessRes2010/index.html,
http://www.serc.kyushu-u.ac.jp/news/MAGDASSchool2011/,
http://iswimagdas2012.dirgantara-lapan.or.id/

As of March 2012, 66 MAGDAS magnetometers have been installed all over the world. Each MAGDAS instrument sends observational data to ICSWSE in near real-time via the Internet. We use these data for space weather research and for other applications, for example, nowcasting and forecasting of solar-terrestrial events. Further information about the MAGDAS project is given in the next section.

It is important that any user can easily get detailed information related to MAGDAS. To meet the public demand we need to provide various MAGDAS information via our ICSWSE website. In addition, we plan to provide our MAGDAS information through the optimized metadata database system, IUGONET (Hayashi et al., 2012), with various software for data analysis developed in cooperation with other institutions (see Section 3).

However, to enable the MAGDAS Project to continue for many years, it is necessary to secure funding for the project. An important aspect of funding is in making sure that credit goes to data providers when their data are used in publications. Therefore, we have established "Data Citation Rules" to ensure that the credit goes to the appropriate data providers. This will help us to secure future funding to continue our observations. For long-term retention, preservation, and open access to scientific data, we need additional funds and human resources. This is a common problem for researchers wishing to ensure long-term preservation and provision of their data.

In this paper, we will introduce the following three topics: First, we describe the general concept of the MAGDAS project and its scientific applications. Second, we introduce the metadata database system and the analysis software for scientific usage of our data. Third, we mention the data usage rules and citation for long-term observation and collaboration.

2 MAGDAS/CPMN

MAGDAS/CPMN is a world-wide ground-based magnetometer network (Yumoto & the 210 MM Magnetic Observation Group, 1996; Yumoto & the CPMN Group, 2001; Yumoto & the MAGDAS Group, 2006; Yumoto & the MAGDAS Group, 2007). The Circum-pan Pacific Magnetometer Network (CPMN) has been conducted since 1996 by Prof. K. Yumoto, Kyushu University, as the principal investigator. The magnetometer system of each CPMN station is installed by a group of 3-axial (horizontal (H), declination (D), and vertical (Z) components, respectively) ring-core type fluxgate magnetometers, a data logging/transfer unit, and a power supply. The maximum sampling interval is 1 second. GPS signals are received to adjust the time-keeping system of the data logger/transfer unit. These data are logged into compact-flash memories (in some cases, magneto-optical disks or cassette tapes are used). Geomagnetic data are recorded as relative values. In 2005, the MAGDAS project was launched, and the CPMN was merged into MAGDAS. Since then, MAGDAS/CPMN is the generic name of our magnetometer networks. The MAGDAS magnetometer system is based on the CPMN magnetometer system (3-axial ring-core type fluxgate magnetometers, data logging/transfer units, and power supply units, GPS time adjustment systems, compact flashes for data storage), but there are some differences between the MAGDAS and CPMN systems. For example, geomagnetic data are recorded as absolute values in MAGDAS, in contrast to their recording as relative values in CPMN. Thus, we can estimate the total field strength from the three components of the MAGDAS magnetometers. In addition, for more accurate total field observations, we can connect an additional Overhauser magnetometer, one of the magnetometers used to measure the total magnetic field values, to the MAGDAS magnetometer logger by using the nuclear Overhauser effect (e.g., Anderson & Freeman, 1962). A MAGDAS magnetometer sensor has two tilt meters and one thermometer to monitor the environment of the sensor. The MAGDAS magnetometer system has a function that sends near real-time data to ICSWSE via the Internet. The instrument is entirely self-contained except for power and network connections. The MAGDAS-9 is a second generation magnetometer system for the MAGDAS project, and now we are replacing the first generation magnetometers (called MAGDAS-I) with MAGDAS-9 magnetometers. Figure 2 shows a MAGDAS-9 system and its specifications. MAGDAS-II mainly consists of the CPMN magnetometer system, but data transmission units are newly added for near real time geomagnetic monitoring.

The principal components of the current MAGDAS/CPMN are three magnetometer chains: the 210 Magnetic Meridian (210MM) in the Asia region, the Magnetic Equator, and the 96MM (Africa region). In addition, we have the FM-CW (Frequency Modulated Continuous Wave) radar network to monitor global disturbances of electric and magnetic fields along the 210MM. Figure 1 shows the distribution of the MAGDAS/CPMN stations. Real time data transfer via the Internet is available. We have also had long-term ground magnetometer data since 1985. Real time data (e.g., data plots) are available via our portal website (http://www.serc.kyushu-u.ac.jp/data/).

We also provide some useful geomagnetic indices estimated from the MAGDAS/CPMN magnetometer data. The Pc 5 index shows a quantitatively-estimated level of Pc 5 pulsation activity at low latitudes. The reference paper for the Pc 5 index is now in preparation. We use hourly mean amplitudes of low-latitude Pc 5 observed at a MAGDAS/CPMN station to produce the hourly-mean local low-latitude Pc 5 index. According to a correlational analysis, we found a good correlation between estimated solar wind velocities from the Pc 5 index and in-situ data taken by the ACE satellite, which has been observing the solar wind velocity near the Earth since 1998 (Stone et al., 1998). This index enables us to obtain better understanding of the physical connection between Pc 5 pulsations and the temporal variations of the solar wind velocity. The estimated PC 5 index is available to scientists via the website (http://www.serc.kyushu-u.ac.jp/pc5/).

The EE-Index (generic name of three indices; *EDst*, *EU*, and *EL*), estimated from MAGDAS/CPMN real time data, has been proposed as being useful to monitor temporal variations of the equatorial electrojet in a long-term manner (Uozumi et al., 2008). The one-hour mean value of the horizontal components of geomagnetic variations observed at the nightside (between 18 and 06 in local times) MAGDAS/CPMN stations in the magnetic equatorial region are found to show temporal variations similar to those of the *Dst* index (http://wdc.kugi.kyoto-u.ac.jp/dstdir/index.html). We call the geomagnetic variations in the magnetic equatorial region the *EDst* index. We can use this index as a proxy for the *Dst* index for real-time and long-term geospace monitoring. By subtracting the *EDst* from the horizontal geomagnetic component measured at one of the equatorial stations, we can extract the equatorial electrojet and the counter electrojet components from the original geomagnetic observations at the observational point. We defined these values as the *EU* and the *EL* indices, respectively. Anyone can access these indices at the following URL: http://www.serc.kyushu-u.ac.jp/ee/.

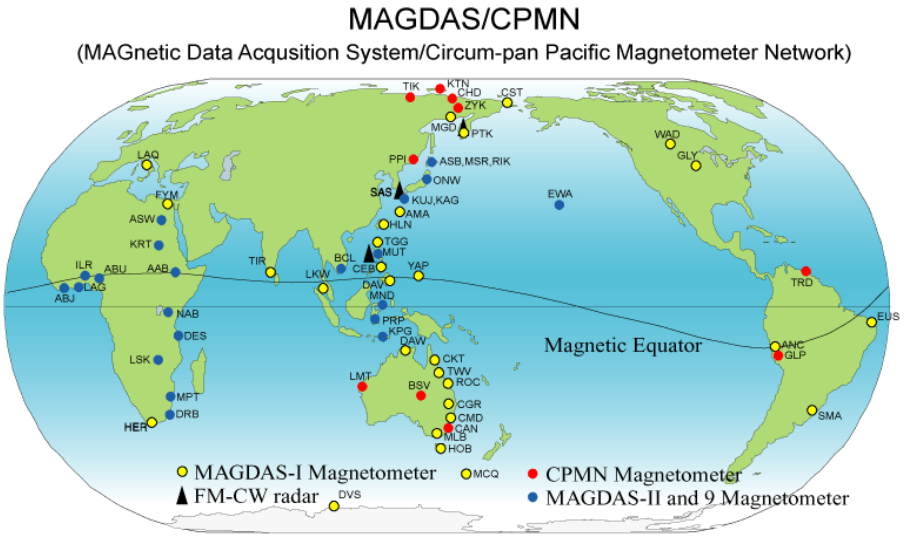

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Figure 1. Map of MAGDAS/CPMN activities. Black triangles denote FM-CW radar stations. Circles denote magnetometer stations. The color of each circle shows the current affiliation of the magnetometer (see text).

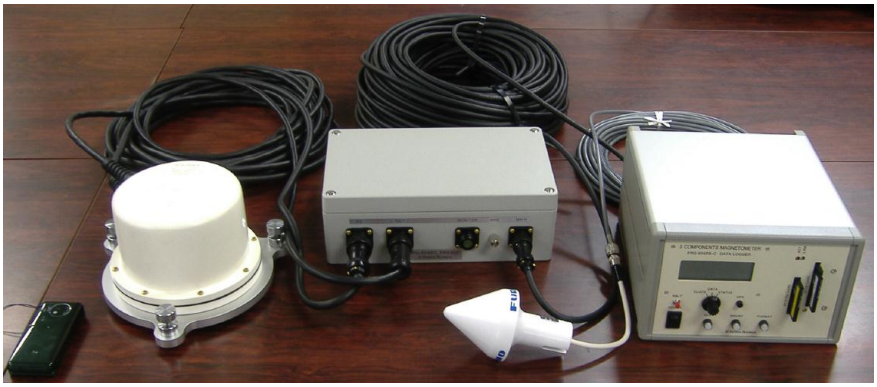

Figure 2. Current MAGDAS magnetometer system, called MAGDAS-9. This system consists of a data logging/transfer unit (right), a GPS antenna, a magnetometer main unit, a magnetic sensor, and a cellphone for reference (left), respectively. Total weight of items shown in this figure is 15.5kg. The type of geomagnetic sensor is that of a 3-axial components ring-core fluxgate. It has a ±70,000nT/32bits dynamic range and a 0.01nT resolution. For more details, see our website, http://www.serc.kyushu-u.ac.jp/magdas/MAGDAS_Project.htm.

3 METADATA DATABASE AND ANALYSIS SOFTWARE

The ICSWSE is a member of the IUGONET (Inter-university Upper atmosphere Global Observation NETwork, http://www.iugonet.org/en/). The IUGONET is a research project operated by five Japanese universities and

institutions (National Institute of Polar Research, Tohoku University, Nagoya University, Kyoto University, and ICSWSE) to build a metadata database and analysis software for ground-based observations of the upper atmosphere. Users can search for MAGDAS information via the IUGONET metadata database system. In addition, users can analyze MAGDAS data via the IUGONET data analysis software (note: online data access is restricted now. See below.). These tools allow researchers to use our database and data more easily.

The IUGONET metadata database (Koyama et al., 2012) has several fundamental functions of registering, retrieving, providing, and harvesting the IUGONET common metadata format (Hori et al., 2012). We provide the IUGONET metadata database with MAGDAS Data File/Instrument/Observatory/Data Set/Person/Repository metadata, which is written in the IUGONET common metadata format.

The IUGONET Data Analysis Software (UDAS) is a plug-in software which is based on the Themis Data Analysis Software suite (http://themis.ssl.berkeley.edu/software.shtml). Details are given by Tanaka et al. (2012). The UDAS has a function to erase the differences between actual data formats. We provide some procedures for reading our MAGDAS storage data format to UDAS. Thus, UDAS are in place to allow users to download and view MAGDAS data online.

4 DATA USAGE AND CITATION RULES OF ICSWSE

To protect our rights and those of researchers who provide data to ICSWSE, we regulate data usage by implementing various levels of restrictions depending on the type of user. Details of our regulations are shown in our Web pages (http://www.serc.kyushu-u.ac.jp/data/index.php). Our data usage rules are based upon the data citation rules employed by ULTIMA (Ultra Large Terrestrial International Magnetic Array, (http://www.serc.kyushu-u.ac.jp/ultima/ultima.html).

5 CONCLUDING REMARKS

The goal of MAGDAS is to become the most comprehensive ground-based monitoring system of the Earth's magnetic field. This ground-based network establishes a mutually complementary relationship with space-based observations. MAGDAS played a significant part in the IHY (International Heliophysical Year) that was held in 2007-2008 and in the ISWI (International Space Weather Initiative) that was held in 2010-2012.

Since MAGDAS is a research project conducted by scientists, we introduced restrictions in various levels for data usage to assure the priority of those who are managing day to day observations under the project. This is necessary to assure long-term operation of the project because we are completely dependent on competitive financial resources. Although we wish to open our data for general use in the future, we need additional funds and human resources, both of which are difficult to obtain for a small research group. Since such a situation is common among scientists who are producing data through their own research activities, we propose that the World Data System (WDS) includes “research data” as important data resources to be preserved and opened in the scope of WDS.

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