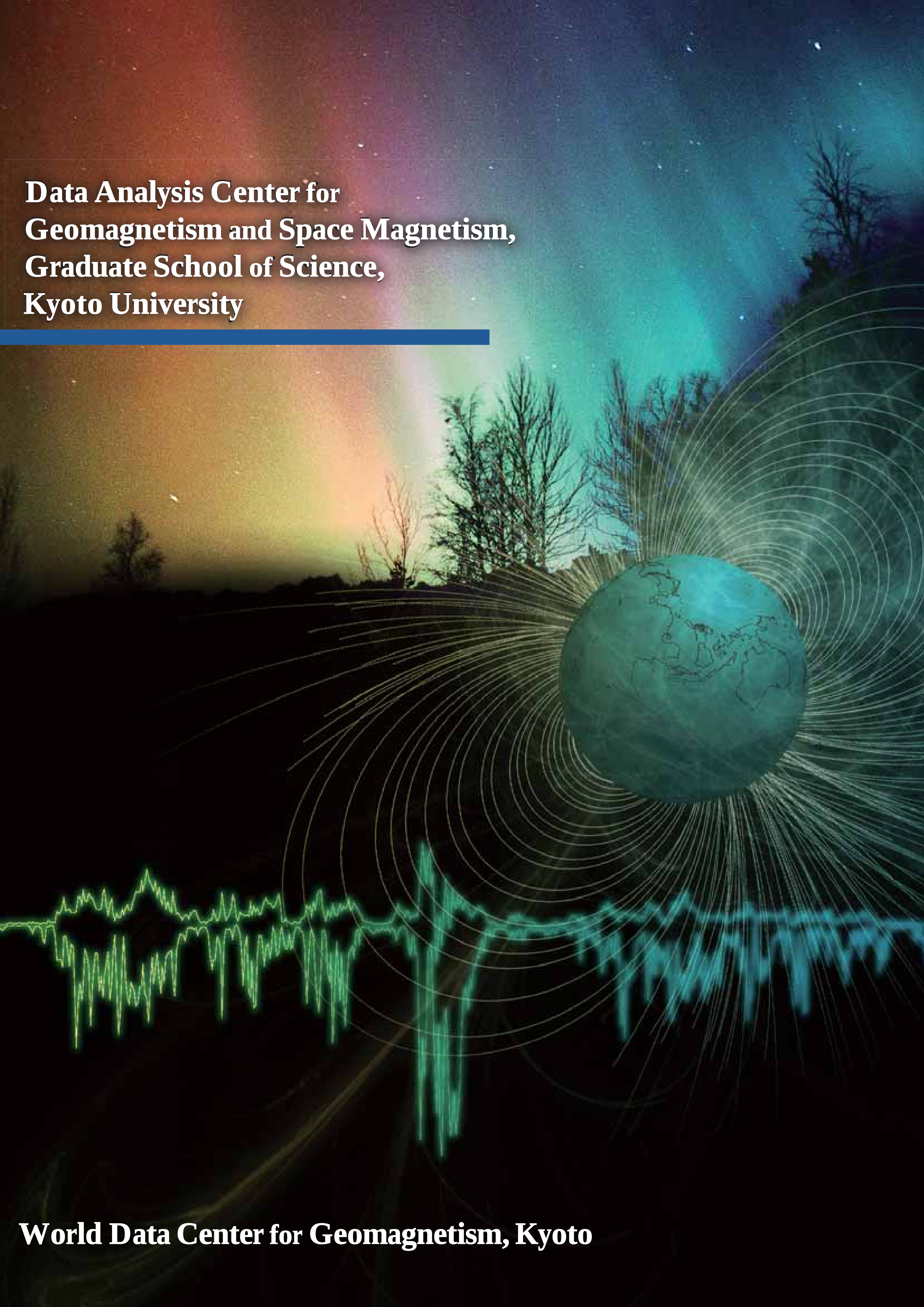
Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University

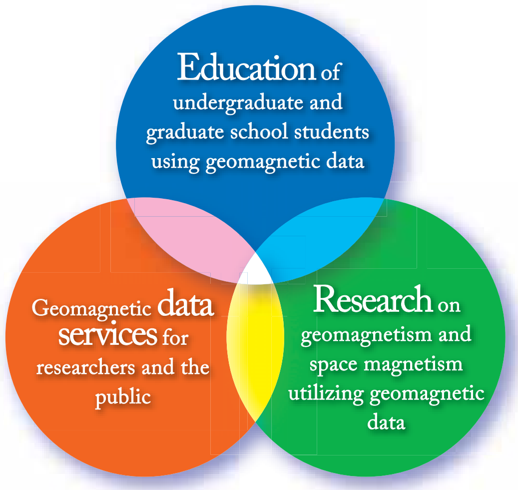


World Data Center for Geomagnetism, Kyoto

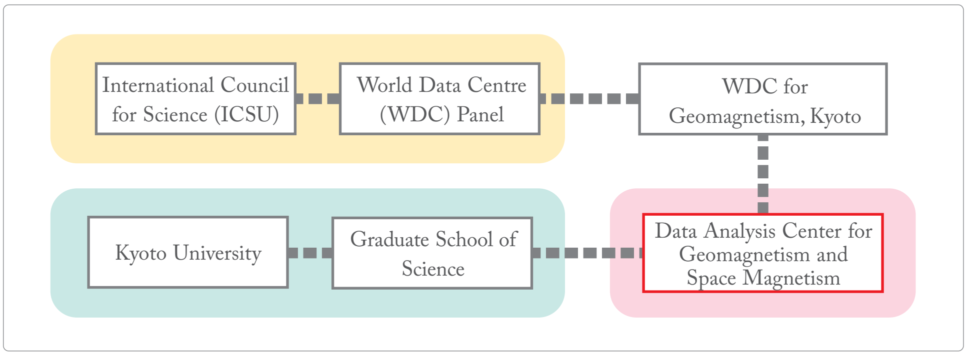
Outline of Data Analysis Center for Geomagnetism and Space Magnetism

The Data Analysis Center for Geomagnetism and Space Magnetism has dual aspects: it is a facility of the Graduate School of Science, Kyoto University and, at the same time, it is part of the international organization, World Data Centers. As a university institution, we are in charge of student education as well as scientific research on Geomagnetism and Space Magnetism. On the other hand, it is also our task to collect geomagnetic data from all over the globe and distribute those data to researchers and data users, as a World Data Center for Geomagnetism.

It is a unique feature of the Data Analysis Center for Geomagnetism and Space Magnetism that three elements; “education” , “research” and “data service” , are contained in one institution. This is the very reason why the advanced and cutting-edge research, education and data service are possible here in the Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University.



Synergy of the three elements above enables the advanced research, education and data services.



History

Forerunner: World Data Archive for Geomagnetism

In 1957, in order to put the International Geophysical Year (IGY) into effect, an IGY Special Committee of ICSU proposed to found several WDCs all over the world so as to promote exchange of data. The Faculty of Science, Kyoto University was assigned to establish WDC-C2 for Geomagnetism since it was well-known for its achievements in geomagnetic research. It led to the foundation of the World Data Archive for Geomagnetism in Kyoto University Library in December, 1957.

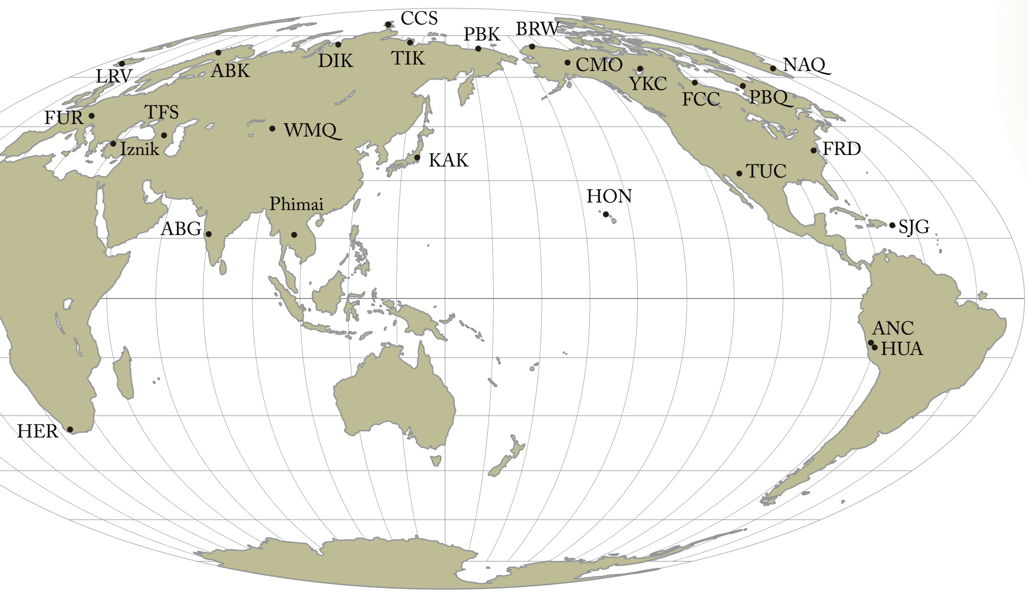
The archive serviced geomagnetic data for 19 years owing to voluntary work by faculty members of Science, Engineering and Liberal Arts in addition to the effort of a newly designated administrative staff, both of which were supported by provisional research budgets.

Consideration by Science Council of Japan (SCJ)

In May, 1976, the STP Subcommittee of SCJ’s Special Committee on International Cooperation considered what WDCs in Japan ought to be. As a result, the committee adopted the resolution that the existing archive should be reformed to be a new research institution, since the role of the archive in promotion of research on Geomagnetism and Space Magnetism was predicted to become more and more important.

Establishment of Data Analysis Center for Geomagnetism and Space Magnetism and thereafter

April 18th, 1977	Data Analysis Center for Geomagnetism and Space Magnetism was established as a new institution in the Faculty of Science, Kyoto University. An associate professor was assigned.
1979	Moved to the 3rd floor of a new building (4th Bldg. of Faculty of Science)
1980	An assistant professor position was assigned.
1981	The 1st issue of the AE-indices Data Book was published and distributed.
1982	A technical staff position was newly assigned.
1983	A geomagnetic database “GEOMAG” was instigated within the Computing Center, Kyoto University
	Group Achievement Award was given by NASA for successful analysis of MAGSAT data
1985	Dst index was computed and has been distributed since October, 1985.
1988	A Solar-Terrestrial Physics database “STP” was constructed within the Computing Center, Kyoto University
1990	Geomagnetic observations were initiated at Shigaraki MU radar observatory.
	1st Bimonthly “WDC News” issued.
	Dst index with high temporal resolution (ASY/ASM indices) first computed.
1993	Quasi-realtime data acquisition initiated by Intermagnet Project.
	Geomagnetic observations at Mineyama DPRI Observatory in Tango Peninsula were initiated.
1995	Data transmission by way of Meteorological Satellite “Himawari” commenced from Tixie (TIK), Russia
	The official web page of this centre was opened.
1996	Quick Look of AE and Dst indices began.
	Quick Look geomagnetic data exhibited from web page.
	Realtime detection of Pi2 geomagnetic pulsations began.
1998	Reorganized as an institution of Graduate School of Science, Kyoto University.
1999	A full professorship was newly assigned.
2000	Analog data began to be made on-line.
	Geomagnetic observation started at Urumqi (WMQ) in China with one second time resolution.
2004	Geomagnetic observation started at Phimai in Thailand.
2005	Realtime data transfer commenced from Aso, Japan and Iznik, Turkey.
2007	Magnetometers were installed at Tbilisi (TFS), Georgia.
	Index for Pi2 geomagnetic pulsations began dissemination via the web.
2008	Magnetometers were installed at Alibag (ABG), India and realtime data transfer started.

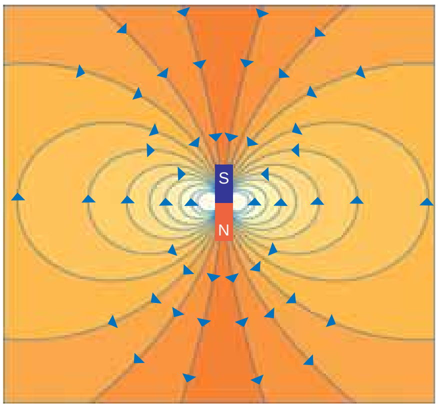


Importance of Research on Geomagnetism and Space Magnetism

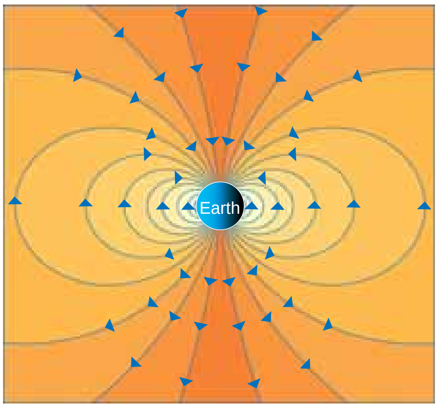
What's the geomagnetic field?

The Earth's core behaves like a very large magnet. The geomagnetic field associated with the core is like a magnet oriented South-North. Like poles of two magnets repel. Therefore a north seeking compass will direct itself toward the south oriented magnet inside the Earth. Hence the term North Pole to a person holding a compass. The geomagnetic field is directed into (out of) the Earth in the northern (southern) hemisphere in the vertical plane. At the equator there is no vertical part of the field. Only a horizontally directed field exists. Whilst at the poles only the vertical part exists. Everywhere else the field is made up of vertical and horizontal parts. (refer also to a column on P.8).

In the vicinity of Japan, the horizontal component of the geomagnetic field is as large as approximately 30,000 nT, while the strength of the vertical component is between 35,000 and 40,000 nT.



The magnetic field around a bar magnet.



The internal part of the geomagnetic field surrounding the Earth.

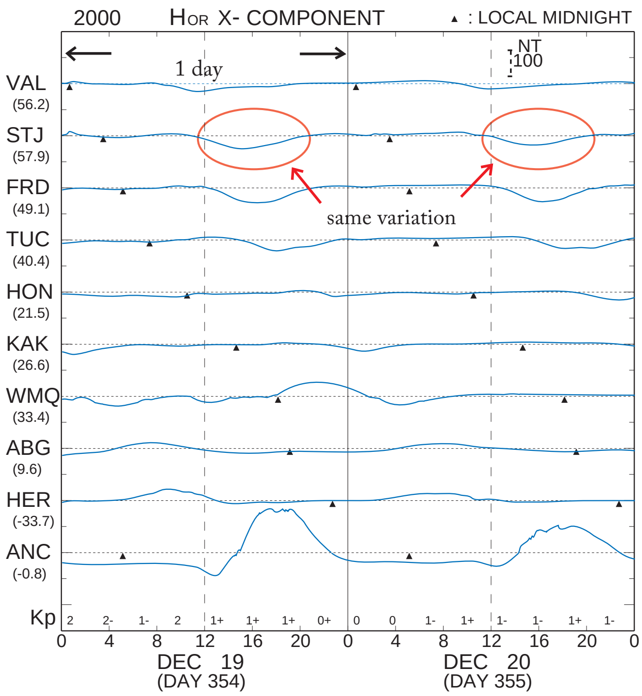
Magnetic Intensity of Celestial Bodies

Name	Magnetic Moment(Am^2)	Surface Intensity(nT)
Sun	(variable)	
Mercury	4.5×10^{19}	(very weak)
Venus	$< 5.0 \times 10^{19}$	(very weak)
Earth	7.9×10^{22}	~ 3×10^4 at the equator
Moon	$< 1.1 \times 10^{16}$	(very weak)
Mars	$< 2.0 \times 10^{19}$	(very weak)
Jupiter	1.6×10^{27}	~ 4×10^5 at the equator
Saturn	4.3×10^{25}	~ 2×10^4 at the equator
Uranus	3.9×10^{24}	~ 3×10^4 at the equator
Neptune	2.0×10^{24}	~ 2×10^4 at the equator
Neutron Star		~ 10^{16}
Magnetar		~ 10^{19}(?)

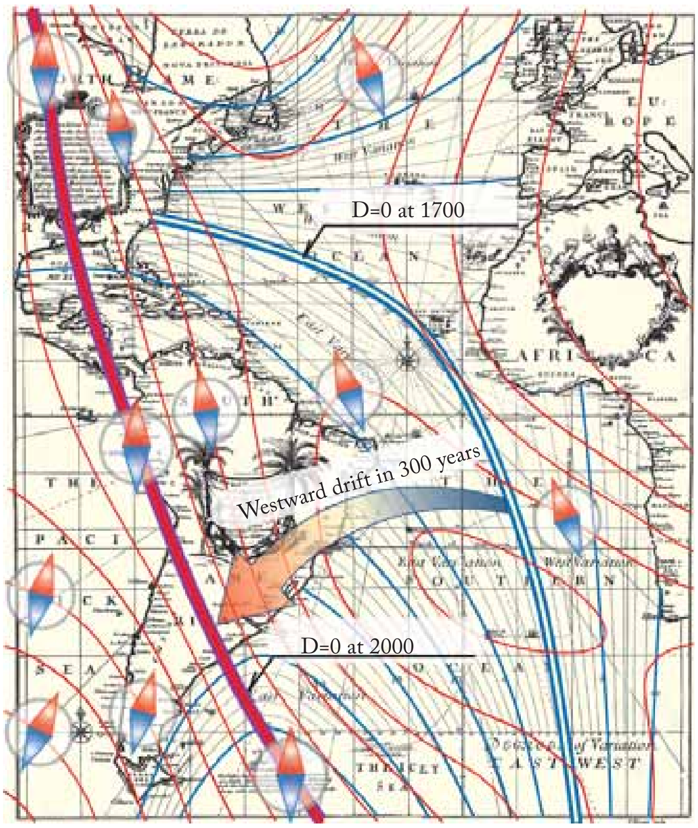
* nT, nanotesla, is a unit for strength of magnetic field (or magnetic induction). Medical magnets on the market are as strong as 10^8nT!

The geomagnetic field is perpetually varying. It even changes its polarity once in 10^5 - 10^6 years. There were many occasions in the past that the N-pole of a magnetic compass pointed toward not the north but the south. We call the temporal geomagnetic variation with a timescale of 10 - 1,000 years the as 'secular variation' in which strength as well as direction of the geomagnetic field vary. 'Geomagnetic storms' have a duration of several days, during which the geomagnetic field is severely disturbed from the normal. There is another phenomenon called a 'substorm', in which the geomagnetic field in the polar region is perturbed by strong electric currents flowing in the upper atmosphere with a timescale of tens of minutes. Bright auroras show intense variations at the time of substorms. These both occur because of unusual activity on the Sun.

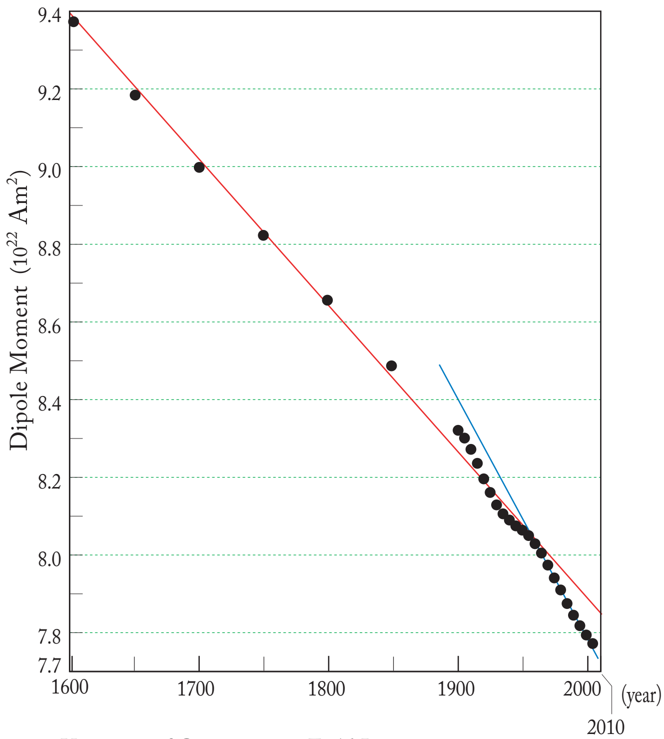
The geomagnetic field has also periodic variations at some specific periods of 27 days or 11 years. These periodic variations are considered due to respective periods of solar rotation or activities. In addition, the geomagnetic field shows daily variations because of the Earth' s (day/night) rotation.



A two-day plot of temporal geomagnetic variations.
All observatories show daytime variations.



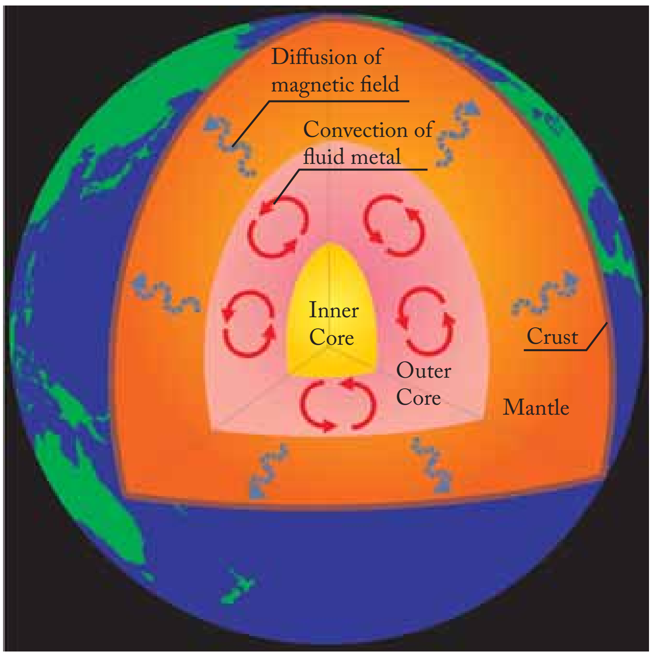
Secular variation of declination (angle between geographic and geomagnetic north)
Contours of declination in 2000 (red lines ▬) are superimposed on a map of declination published in 1702 by Sir Edmund Halley (blue lines ▬). It is evident from the figure that the line of null declination (a line along which magnetic compasses point toward the true north: the thick red line) has shifted toward the west as large as 70 degrees over 300 years.



Variation of Geomagnetic Field Intensity
The strength of the geomagnetic field has been decreasing for over several hundreds of years. If the decrease continues, we shall have no geomagnetic field within 1,000's of years. It, however, is very difficult to predict whether it is going to be true in the future, or the decrease is momentary.

How is the field generated ?

It is sure that the dynamo mechanism taking place in the Earth's outer core is playing an essential role in making the Earth a very large magnet, although the precise mechanism of the effect is still unknown. In order to do research on this subject, it is necessary to collect geomagnetic data of wider spatial coverage and longer time span. Because the dynamo theory is applicable to generation of magnetic fields on other celestial bodies such as planets and stars like the Sun, research on Geomagnetism is indispensable for studies of other astronomical bodies.



A schematic view of the geodynamo

Inner Core: The solid metal core of the Earth

Outer Core: The Earth's liquid core made of Fe, Ni etc.
Interaction between convective motions of liquid metal and the existing geomagnetic field generates new components of the geomagnetic field [the dynamo effect].

Mantle: A very thick (~2900km) layer of silicate rocks.
The geomagnetic field originated from the outer core diffuses and decays away all through the mantle, which is still observable at the surface.

Crust: A thin (at most several tens of kilometers) layer of crustal rocks, on which we reside.

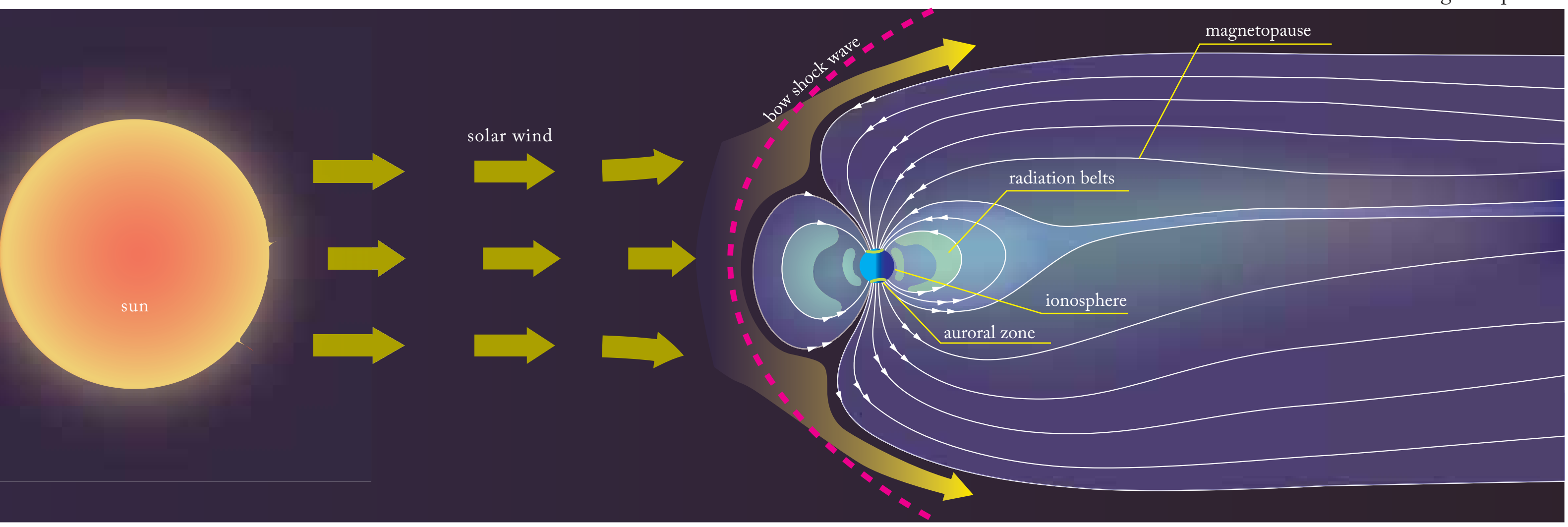
Geomagnetic field controlling the near-Earth plasma

The space higher than the atmosphere is not a vacuum but filled with charged particles (i.e., electrons and ions). Such medium consisting of charged particles is called "plasma" . The geomagnetic field controls the motion of plasma. For example, if you put a strong magnet close to a CRT display, you will see images on the display are distorted. This is because plasma beams which make images on the display are bent by the magnetic field of the magnet.

"Solar wind" , the supersonic plasma flow from the Sun toward the Earth, is deviated around the Earth without penetrating directly to the atmosphere, because the geomagnetic field around the Earth prevents the solar wind to do so. This causes a formation of "magnetosphere" where no solar wind plasma directly enters. At polar region you can see aurora when substorm occurs; this is because variations of the geomagnetic field affect motion of plasma particles around the Earth and cause precipitation of particles into the ionosphere.

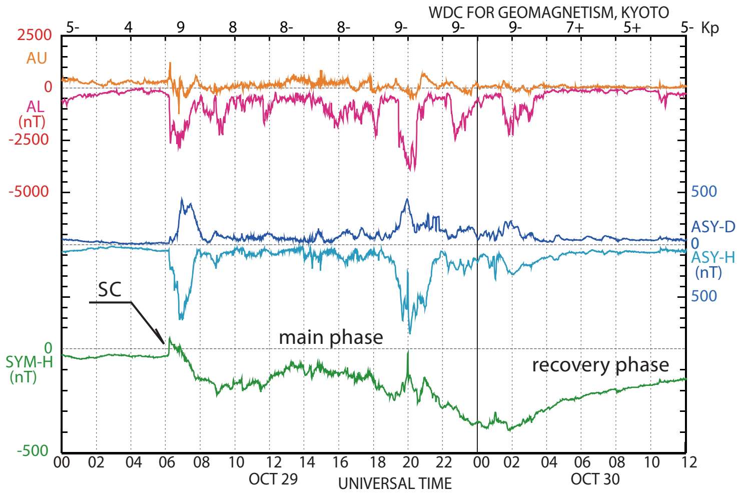
As stated above, the geomagnetic field is fundamental and indispensable parameter to study phenomena occurring in the near-Earth space. In the research field of "space physics" , a number of researchers are utilizing the geomagnetic field data.

Solar wind and magnetosphere



Typical appearance of curtain-type aurora

Aurora in the picture looks like forming a stripe. This appearance is caused by electrons which are precipitation into the atmosphere along the geomagnetic field lines. If you see aurora from its underneath, rules of perspective will make you find that the aurora seems to radiate from the center, changing its color from red to green. Such aurora is called "corona-type aurora" . (photo taken by Dr. Masatoshi Yamauchi at Kiruna, Sweden)

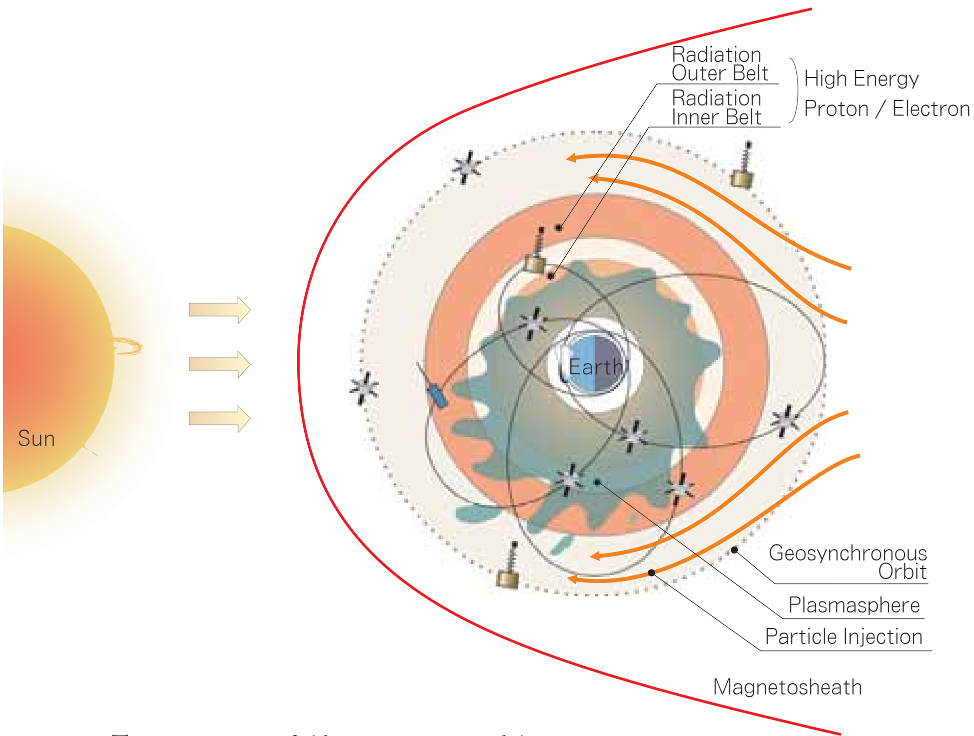


AE and ASY/SYM indices during geomagnetic storms, which have been derived by the World Data Center for geomagnetism, Kyoto for more than 30 years.

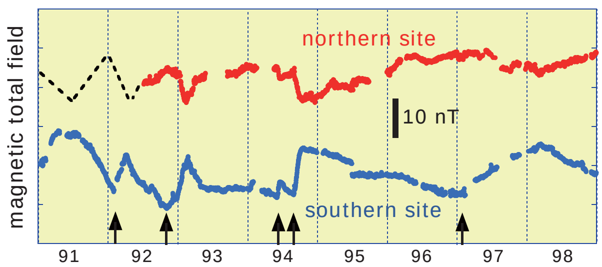
The ASY/SYM indices indicate that the geomagnetic storm started from around 06 UT (universal time) on October 29, 2003, which was preceded by a sudden increase of the geomagnetic field magnitude (SC). In the polar region a strong substorm was initiated and the AE (AL) index showed a variation larger than 2500 nT (upper panel). In mid- and low-latitudes, the SYM index indicates that the magnetic storm was very intense (lower panel). During magnetic storms, the radiation belt (the Van Allen belt) consisting of high-energy particles is developed.

Significance of geomagnetic field research for society

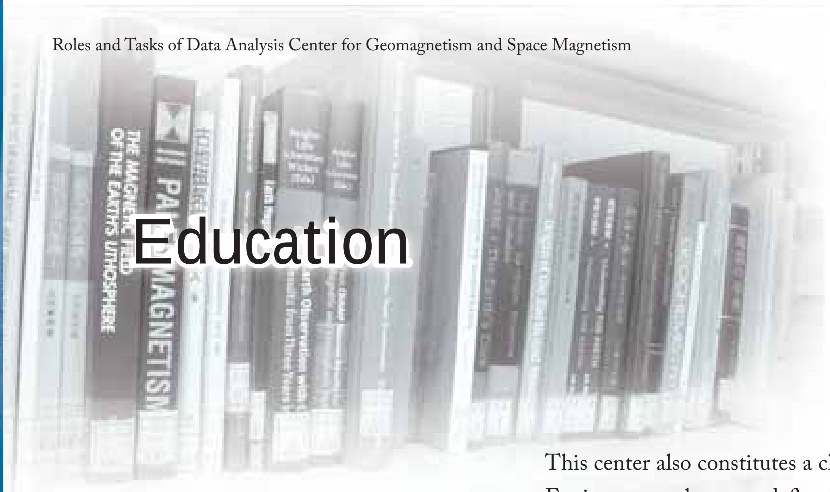
The geomagnetic field strongly impacts society. During magnetic storms which can be identified by large decrease of the geomagnetic field strength in low latitudes, the radiation belt is developed, causing frequent malfunction of man-made satellites. When the polar geomagnetic field is disturbed strongly; that is, when substorms take place, an electric current is induced over oil pipe lines and high-voltage power lines, and then it happens that such infrastructure is damaged severely. In order to predict such phenomena, research related to “space weather forecast” is in progress in Japan, U.S., and other countries. Geomagnetic field research is an important factor in daily lives.



The geomagnetic field is important to delineate structure in the Earth and detect its changes. Since volcanic eruptions and earthquakes change the Earth’ s structure, the geomagnetic field also fluctuates accordingly. Attempts are being made to forecast the eruptions and earthquakes using the geomagnetic field.



Magnetic changes associated with the volcanic activity of Nakadake, Aso Volcano. Correlated magnetic total field changes are observed at north and south of the active crater. The inversed polarity suggests an equivalent magnetic dipole beneath the crater. Arrows indicate the periods of elevated volcanic activity, corresponding to the periods of minimum magnetization of rocks due to heat accumulation. Courtesy of Dr. Takeshi Hashimoto.



Education

Education at Graduate School

This center also constitutes a chair of Physics and Informatics of Natural Electromagnetic Environment that was defined as one of cooperative divisions to the Graduate School of Science, Kyoto University. Through this division, this center contributes to graduate education and supervises master's and doctoral research of many graduate school students.

Subjects in the master course

Solar-Planetary Electromagnetism I, II

Physical processes of the ionosphere and the magnetosphere as well as technical knowledge which is necessary in the course of study on electromagnetism in the Earth are lectured in this subject by teaching staff of this center and Solar-Planetary Electromagnetism Laboratory.

Seminar on Solar-Planetary Electromagnetism II, III

Using English textbooks on Solar-Terrestrial Physics, reading circles are formed by students in the master course, while the teaching staffs serve as tutors.

Subjects in the doctor course

Seminar on Solar-Planetary Electromagnetism II, III

Doctoral students are supervised individually or by small groups according to each research theme, and guided to complete their doctoral theses through appropriate suggestions and/or discussion.

Faculty Education

Faculty members of this center are in charge of the following subjects, in addition to supervision of several undergraduates undertaking compulsory research programs for graduation.

Subjects for undergraduates

Electromagnetism and Ionized Gas Dynamics

The elementary theory of magneto-hydrodynamics and plasma physics is lectured in this subject. The contents of the subject will be necessary when you begin to learn solar-terrestrial physics and geomagnetism.

Geomagnetism

Various disciplines of electromagnetism in the Earth are introduced by lecturing how to measure/analyze the geomagnetic field, theory of geodynamo, paleomagnetism, and electromagnetic monitoring of crustal movements. The basic theory of those disciplines is also given for further studying.

Exercise assignments of Earth and planetary sciences

Specific data processing and simulation using computers are assigned, in addition to practical exercises of geophysical field works, for profound understanding of what was lectured in "Geomagnetism" and "Electromagnetism and Ionized Gas Dynamics".

Research assignments of Earth and planetary sciences
T1. Earth and planetary plasma
T2. Earth and planetary electromagnetic fields

Based on the acquired knowledge through lectures of "Geomagnetism" and "Electromagnetism and Ionized Gas Dynamics", specific research assignments are given to each undergraduate in either T1 or T2 of his/her choice. Both T1 and T2 aim at learning how to carry out each research assignment by accumulating a research experience at a real spot under supervision of teaching staffs of this center.

(As for details, you should refer to "Guidebook for Educational Affairs" issued by Graduate School of Science or "Subject Handbook" by Faculty of Science.)

As an educational institution

Geomagnetic data and computer facilities indispensable to conduct research and exercise are provided by this center for undergraduates and graduate school students. As many as ten students visit this center daily.

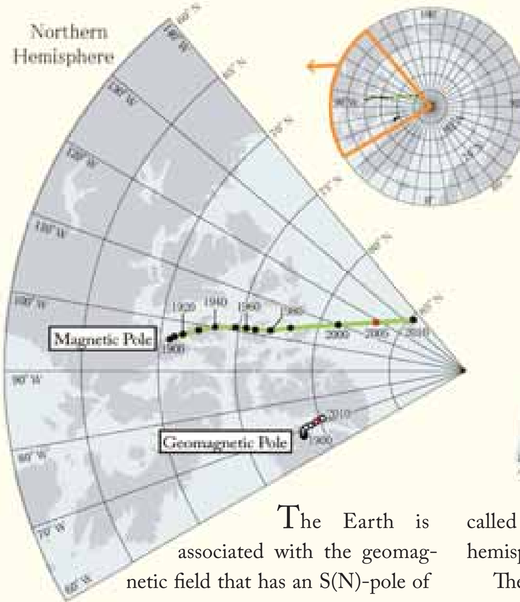
Number of degrees awarded at this center

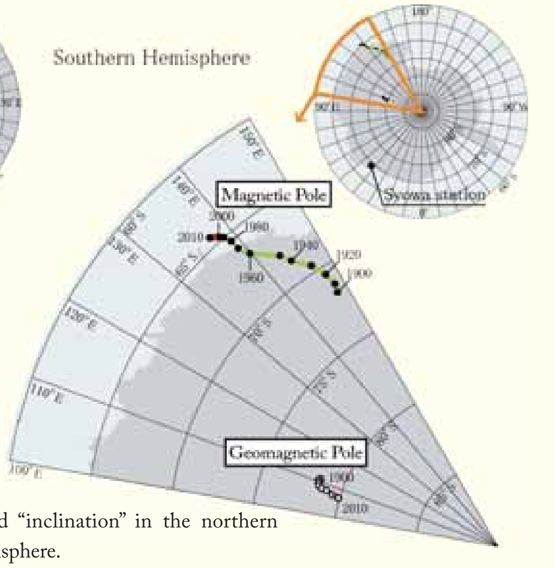
Since foundation of this center, 19 doctoral degrees and 44 master's degrees have been awarded under supervision of the teaching staffs at this center. These alumni/alumnae are now playing active roles in each field making use of the acquired technical knowledge.

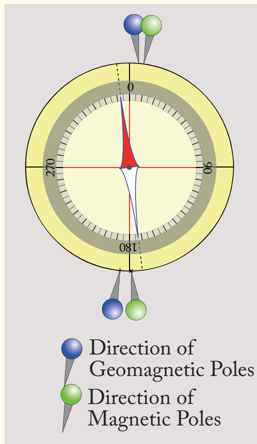
Outreach activities

We also devote ourselves to illustrate latest scientific results and technical knowledge in plain terms to the public. We have made the following feedback to community so far:

- Commentaries of "WDC News"
- Glossaries on this center's web pages
- Open campus
- Seminars for high school students
- Supply knowledge and materials to educators of geography
- Participation in the editorial board of "Chronological Scientific Tables" of Japan
- Participation in a special exhibition at the Kyoto University Museum (2008) etc.







The Earth is associated with the geomagnetic field that has an S(N)-pole of a magnet near the North(South) Pole. A magnetic compass, therefore, approximately points toward the north. However, the pointing direction is slightly different from the true north by an angle called "declination". Also, two pairs of poles can be defined for the geomagnetic field: the geomagnetic poles and the magnetic poles. The magnetic north corresponds to neither pole, since the geomagnetic field actually has a more complicated shape than a magnetic field generated by a bar magnet (See below). Moreover, a magnetic needle suspended at a center of balance does not keep horizontal. As a rule, the N-pole dips downward by an angle called "inclination" in the northern hemisphere.

The "geomagnetic poles" are the intersections of the Earth's surface and the axis of a bar magnet hypothetically placed at the center the Earth by which we approximate the geomagnetic field. There is such a pole in each hemisphere, and the poles are called as "the geomagnetic north pole" and "the geomagnetic south pole", respectively. On the other hand, "magnetic poles" are the points at which magnetic needles become vertical. There also are "the magnetic north pole" and "the magnetic south pole". The geomagnetic or magnetic south(north) poles correspond to the N(S)-pole of a magnet. By the two sets of diagrams in the left, we show predicted locations of the geomagnetic and magnetic poles by "International Geomagnetic Reference Field" (IGRF-10) from 1900 through 2010. These poles are drifting according to slow and smooth change in the geomagnetic field called "the geomagnetic secular variation".

In the rightmost diagram, we show the predicted declination at Kyoto in 2005 by IGRF-10 in addition to the predicted directions towards the geomagnetic and magnetic north poles. The reason why we have now westward declination in Japan is probably due to the presence of a strong positive geomagnetic anomaly around Lake Baikal in Siberia. The N-poles of magnetic needles tend to be attracted to the anomaly to show westward declinations around Japan.

Services

Operation of World Data Center for Geomagnetism, Kyoto

The worldwide Earth observation system was prepared as one of the International Geophysical Year projects in 1957. World Data Centers (WDCs) were established as well in order to collect/distribute various data not to mentioning the geomagnetic data acquired by the newly prepared system. WDCs are now being operated by research institutions (centers) in Japan, US, Russia, Europe, China and so on.

In Japan, Data Analysis Center for Geomagnetism and Space Magnetism, a research institution of Graduate School of Science, Kyoto University is in charge of operating the World Data Center for Geomagnetism, Kyoto.

Acquisition and preservation of data

As one of the WDCs, this center is now collecting/preserving data from world's geomagnetic observatories as many as approximately 400. The geomagnetic data are transferred by postal mail, via geostationary satellites, or over the Internet. Main preserved data are as follows:

Period of Data Collection		1848 - Present (Primarily 1957 and after)
Media : Number of Volumes		Microfilm : ~9300, Microfiche : ~10000, Magnetic Tape : ~1000, Data book : ~3400, Geomagnetic Chart : ~80, Disk : ~10TB
Data distribution	Geomagnetic Field Data (About 400 Geomagnetic Observatories)	Digital data : 1sec. values, 10sec. values, 1min. values, 2.5min. values, 1hour values Analogue data : Normalrun magnetograms, Rapidrun magnetograms Magnetic Index : AE, Dst, K•Kp•Kn•Ks•Km, Ap•aa, ASY•SYM indices Geomagnetic Chart : Contour Chart
	Magneto telluric Data	1hour values, normalrun tellurigrams, rapidrun tellurigrams
	Satellite Magnetic Field Data	IMP, MAGSAT, DE-1, DE-2, GOES, ETS-VI, Oersted, others
	Miscellaneous Data	Solar, Interplanetary, Magnetosphere, Ionospheric Data

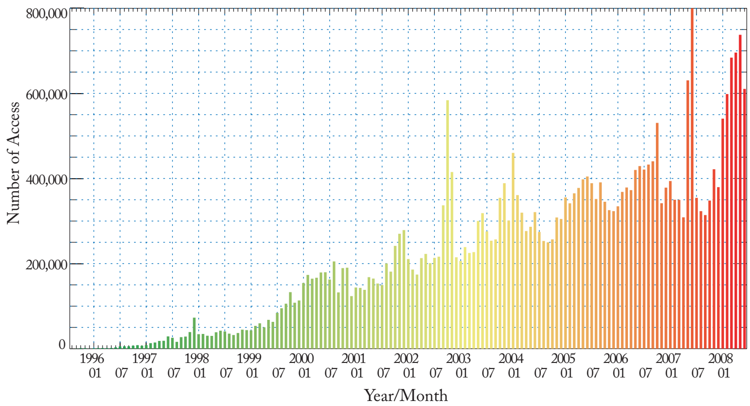
Data books and CD-ROMs issued by World Data Center for Geomagnetism, Kyoto.

Data distribution

Collected/preserved geomagnetic data are distributed to world's data users for free whenever requested. Data delivery on magnetic media is declining. Instead, digital data transfer directly over the Internet is rising.

A number of access is incoming to our center everyday from all over the world via World Wide Web and anonymous ftp. As of December, 2007, we have about 400,000 hits per month on our web page.

Change in the number of access to World Data Center for Geomagnetism, Kyoto.



Home page of this center
[http://wdc.kugi.kyoto-u.ac.jp/]

Display of real-time observation data


Mineyama observatory

Derivation and provision of geomagnetic index

The geomagnetic indices represent the degree of geomagnetic disturbance and are very important for research in geomagnetism and space physics. In this center we calculate three kinds of the geomagnetic indices, the AE indices, the Dst index, and the ASY/SYM indices; and provide them free to the global scientific community. (These three indices express geomagnetic disturbances at different latitudes. The AE indices are for disturbances in the auroral latitude, while the Dst and ASY/SYM indicies are for the mid- and low-latitudes. The Dst or the SYM index is a proxy for longitudinally symmetric disturbances, but the ASY index represents longitudinal asymmetry of geomagnetic disturbances.) We have been continually deriving and providing these geomagnetic indices since 1981.

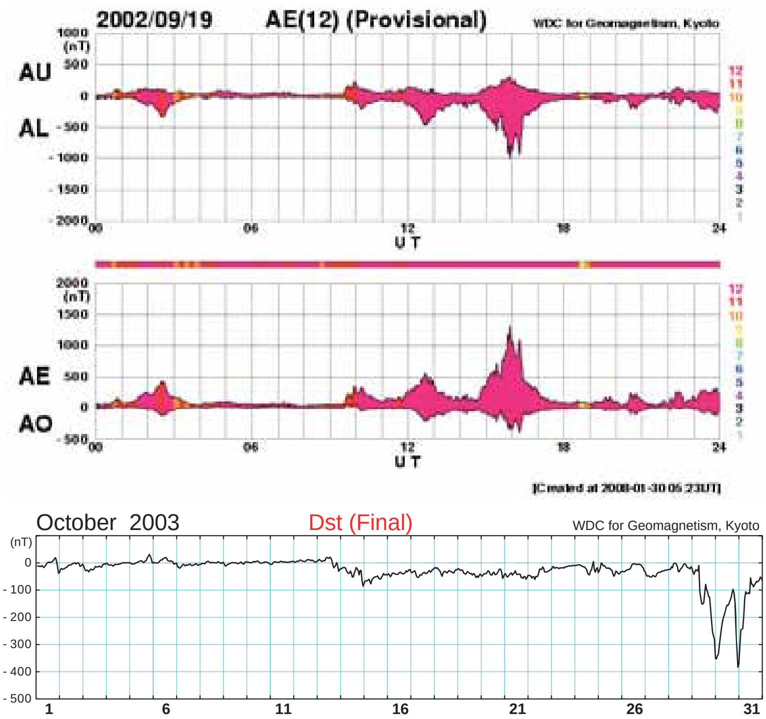
Considering this activity of this center, International Association of Geomagnetism and Aeronomy (IAGA) and Science Committee On Solar-Terrestrial Physics (SCOSTEP) adopted a resolution stating appreciation for World Data Center for Geomagnetism, Kyoto seven times.

We have started to calculate the geomagnetic indices in real-time, because geomagnetic field data can be collected through the network and the space weather prediction is now in progress. The real-time geomagnetic indices are provided from our home page.

Geomagnetic field observation

We make observations of the geomagnetic field at Mineyama, Kyoto and Shigaraki, Shiga. The obtained data are processed in real-time and transferred to this center. The real-time data from Mineyama and Shigaraki can be browsed from our home page or at LCD displays in this center.

We also installed magnetometers in Russia and collect the real-time geomagnetic field data by geosynchronous satellite communication or Internet. Since the Russian data are needed in calculation of the AE indices, the scientific community hopes continuation and success of this project. More recently, the joint observation projects are proceeding with China, Turkey, Thailand, Georgia, Peru, and other countries.



Geomagnetic indices available from the home page
(Upper panel: AE indices, lower panel: Dst index)

Research

Research on electric currents generated by the ionospheric dynamo

Cutting-edge results of this research topic are being given by making use of computer simulation and data from satellite/radar observation. These results can be regarded as successors of many years of research efforts on generation of ionospheric electric currents having been conducted in Department of Geophysics. We have succeeded in confirming the presence of field-aligned currents between the north and south hemispheres. The currents originating from the center of Sq-current vortices have been theoretically predicted to exist but actually discovered by precise analysis of satellite geomagnetic data conducted at this center.

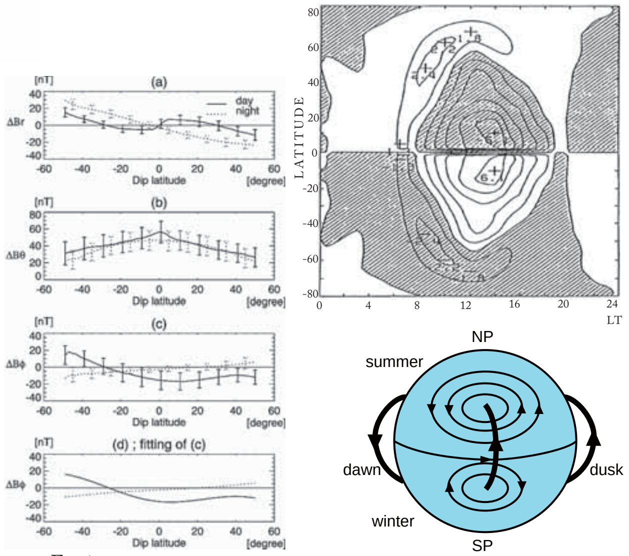


Fig.1

Fig.1 The field-aligned currents between the north and south Sq-vortices. The presence of the currents was first confirmed by the Oersted magnetic satellite data. The equatorial EW magnetic component shows negative values on the dayside (the lowermost diagram on the left). Upper right: The simulated field-aligned currents on the upper surface of the ionosphere (the hatched regions indicate incoming currents). Lower right: A schematic figure based on the simulation results. The magnetic field variations seen in the left diagrams can be explained by the electric current system depicted in this figure.

Research on short-period variations of geomagnetic field

Using both the geomagnetic field data in high time-resolution and the solar wind/magnetospheric data obtained by satellites, we have been studying various types of geomagnetic pulsations and sudden commencement (SC) of geomagnetic field increase which is generated by compression of the magnetosphere due to shock waves in the solar wind. These phenomena can be understood by applying the magneto-hydrodynamic equations. We also identify Pi2 pulsations in an automated way from the real-time geomagnetic field measurements at 6 stations which are separated in longitudinal direction. Results of detection of Pi2 pulsations are displayed at the home page in almost real-time and this project contributes to the space weather prediction.

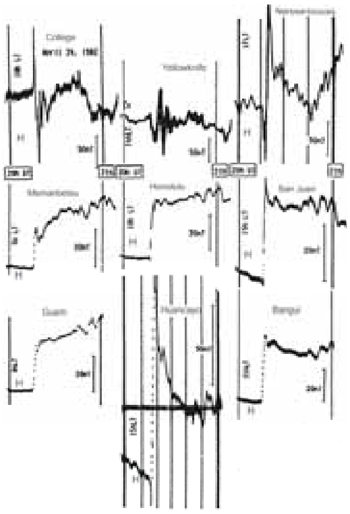


Fig.2

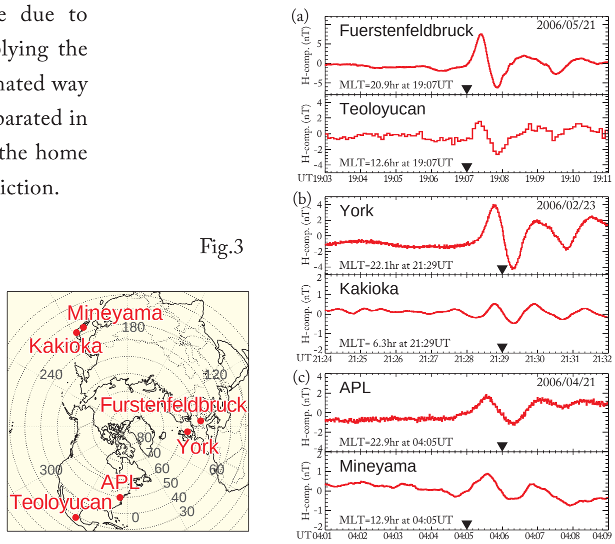


Fig.3

Fig.2 Global variations of the geomagnetic field at SC

Fig.3 Real-time detection of Pi2 pulsations

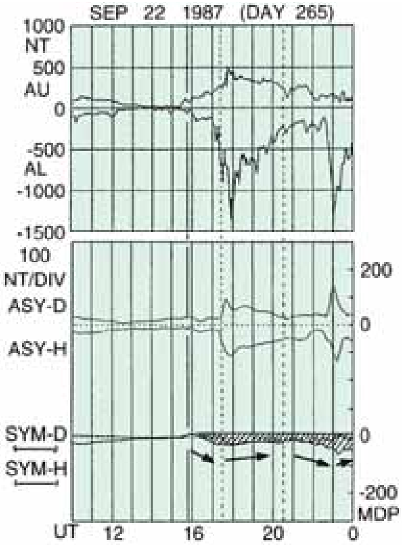


Fig.4

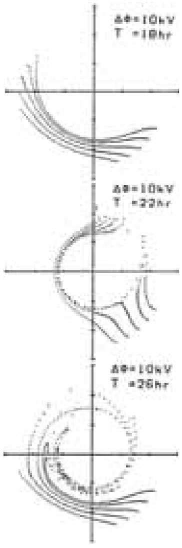


Fig.5

Research on magnetic storms and substorms

We are the first in the world to simulate the electric current system during geomagnetic storms by tracing charged particles in a realistic geomagnetic field model. This study intended to not only understand mechanisms of geomagnetic storms/substorms but also predict them in a quantitative manner. We also achieved a number of success by analysis of the geomagnetic indices.

Fig.4 Relation between geomagnetic storms and substorms, which was revealed from analysis of the geomagnetic indices AE, ASY and SYM.

Fig.5 Result of tracing of charged particles during a magnetic storm

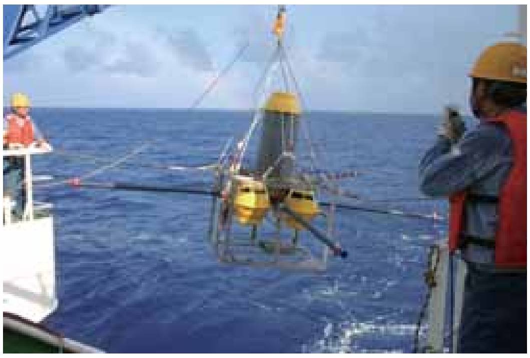


Photo.1

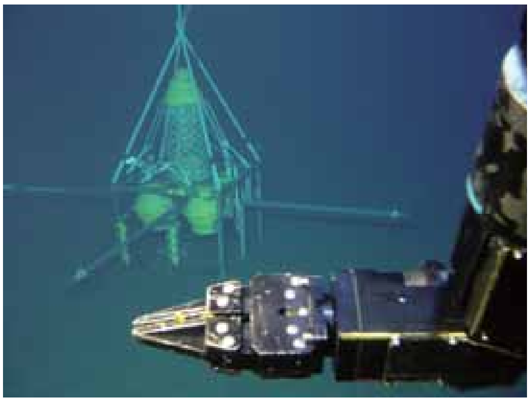


Photo.2

Electromagnetic research in the Earth and at the seafloor

Geomagnetic data is very important as one of the observational means to delineate the structure and dynamics in the Earth. We are not only collecting/providing data but also making use of the collected data in order to reveal the Earth's deep electrical conductivity structure that contributes to investigate the geodynamo process. Furthermore, development of electromagnetic instruments and data analysis are being made in conjunction with a long-term electromagnetic observation project at the seafloor. The long-term geomagnetic data observed at the seafloor deeper than 5,000m were open to the public through the WDC for Geomagnetism, Kyoto for the first time in the world, which is considered to be one of the most fruitful results of the long-term observation project.

Photo.1 The newly developed "SeaFloor ElectroMagnetic Station (SFEMS)" just before launch from a research vessel. The station is equipped with an Overhauser-type absolute scalar magnetometer and a fluxgate-type vector magnetometer and capable of unmanned continuous operation for years at the seafloor.

Photo.2 Pin-point installation of SFEMS to the desired position at the seafloor by a submersible. Successive long-term observation is made possible by replacement of SFEMSs. The metal arm in front is the submersible' s manipulator (by courtesy of ROV "Kaiko7000II", JAMSTEC).

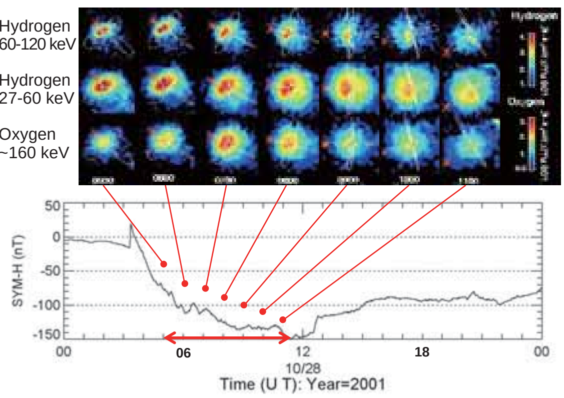


Fig.6

Research on structure and dynamics of magnetosphere

We are participating to the satellite project and contribute to data analysis, collection of magnetic field and particle data, and creation of database. We discovered a current system which has been unknown, and found an observational evidence of existence of a current system which was predicted by previous researchers. Moreover, analyzing high-energy particle data, we also discovered a relation which is contradictory to the common sense between the geomagnetic field variations and ring current particles.

Fig.6 Temporal variations of energetic neutral atoms which were created from ring current particles (upper panel) and temporal variations of the SYM-H index which is calculated by averaging the geomagnetic field variations (lower panel).

Research on methods of data acquisition/services

We take part in realtime geomagnetic data acquisition over the globe which is indispensable for the sake of space weather forecast. We also in charge of studying data transmission methods using the Internet, wireless transfer and communication satellites' relay function. It was not until these methods were put into practical use that quasi-realtime service of geomagnetic indices was actually enabled.

Recently, we also concentrate on installation of magnetometers overseas and data acquisition by those instruments. We are converting microfilms to digital image files and puts them online, since those microfilms contain a large volume of old geomagnetic data.

Photo.3

Photo.4

Photo.3 Realtime data transmission by a combination of a commercial communication satellite and the Internet (Atmospheric Science Observatory at Phimai, Thailand).

Photo.4 All World Data Center meeting (May, 2007)
We actively participate in various international conferences in order to discuss cooperation between data centers, promotion of data exchange using cutting-edge technologies and construction of databases.

Research on electromagnetic disturbance of the Earth's surface origin

Majority of the upper atmospheric phenomena such as auroras, geomagnetic storms and pulsations are regarded of solar or solar-wind origin. It, however, turns out that there exist geomagnetic pulsations excited by earthquakes, volcanic eruptions and typhoons. Microbarometric variations are also observed at this center in addition to electromagnetic fields, because those variations can be related to very low frequency sound waves that interact with the upper atmosphere.

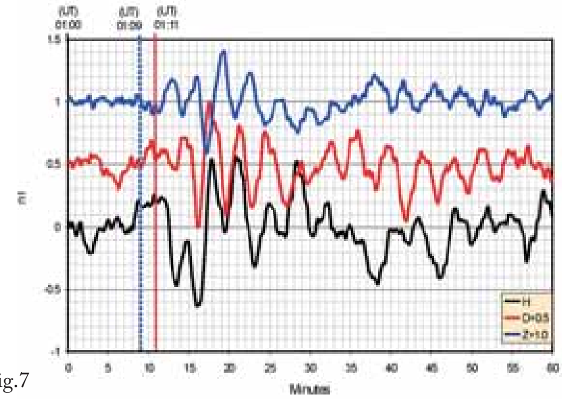


Fig.7

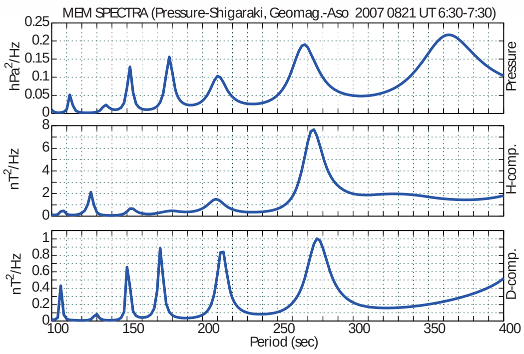


Fig.8

Fig.7 Anomalous geomagnetic pulsations discovered at the time of the great earthquake off the Sumatra Island in 2004. The pulsations were observed at Phimai Observatory, Thailand.

Fig.8 Common spectral peaks of microbarometric and geomagnetic oscillations. The pressure and geomagnetic data were observed at Shigaraki and Aso, respectively.

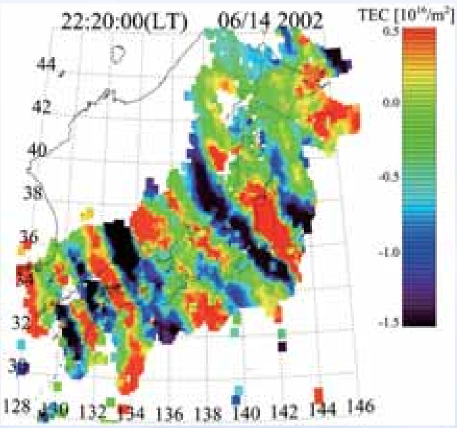
Research on the geomagnetic secular variation

We try to detect the geomagnetic secular variation with timescales of 100 – 1000 years from samples taken at archeological remains. Those timescales are considered important for revealing the geodynamo effect that is generating the geomagnetic field in the outer core of the Earth.

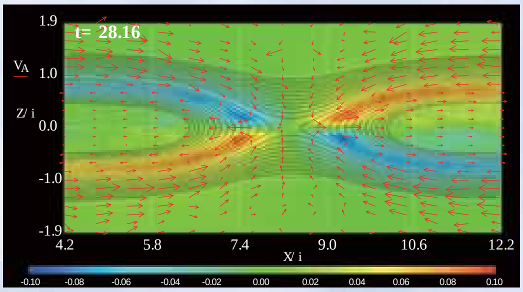
Photo.5

Photo.5 Measurements of remnant magnetization at an ancient remain of a fireplace (a roof tile kiln in the mid-7th century).

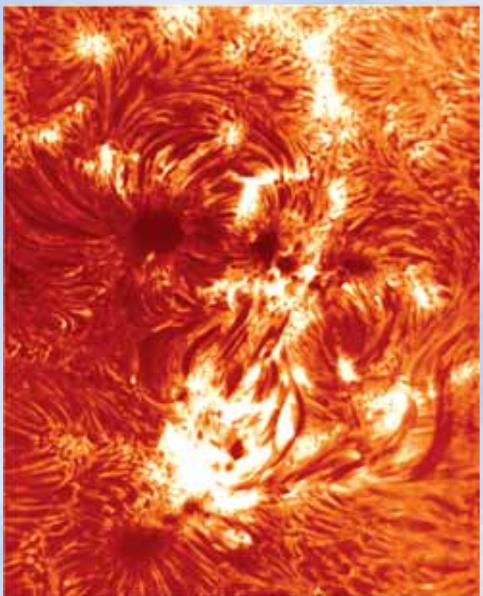
Eruption at the active crater of the Aso Volcano (by courtesy of Aso Volcanological Laboratory).



[http://stegps.kugi.kyoto-u.ac.jp/]
(By courtesy of Solar-Planetary Electromagnetism Laboratory.)



Computer simulation of magnetic reconnection (by courtesy of Solar-Planetary Electromagnetism Laboratory)



Active regions of the Sun (by courtesy of Hida Observatory).

Studies related to Graduate School of Science, Kyoto University

Magnetic fields play fundamental roles everywhere in nature from the microscopic world to the universe. Even in Graduate School of Science alone, to which this center belongs, various natural magnetic fields are being explored. Since studies on Geomagnetism and Space Magnetism share the basic principles with the following disciplines, synergistic collaboration is possible by mutually exchanging useful knowledge and information.

Research on geomagnetic changes associated with volcanic activity

People at Institute of Geothermal Sciences are trying to delineate the relationship between volcanic eruptions and the associated geomagnetic changes.

Research on the atmosphere of the thermosphere and the ionosphere

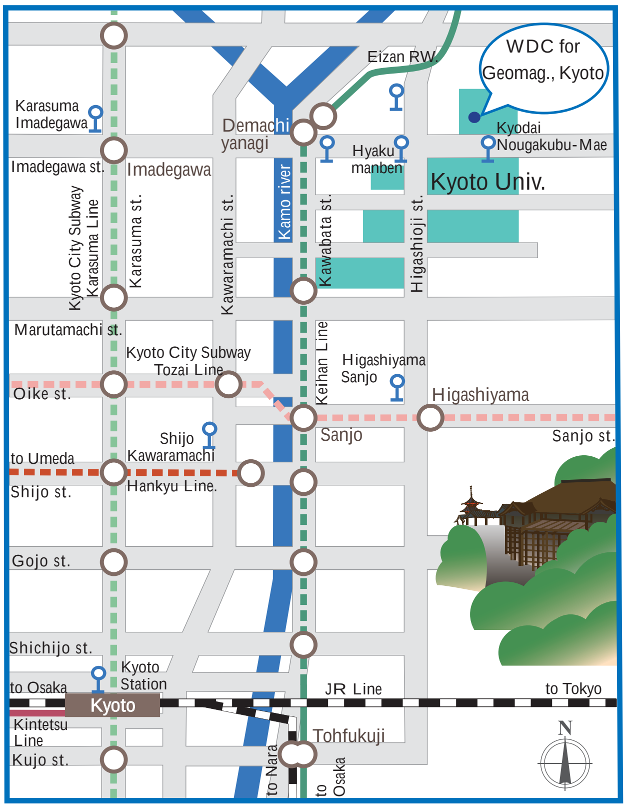
Telecommunication and precise positioning are affected by various perturbation caused by energy input from the magnetosphere to the atmosphere of the thermosphere and the ionosphere. At the Solar-Planetary Electromagnetism Laboratory in Department of Geophysics, mechanisms for generation and propagation of atmospheric and plasmatic perturbations in the thermosphere and ionosphere are investigated using radio waves from GPS satellites and optical observations.

Research on plasma in magnetospheres of the Earth and other planets

In the Solar-Planetary Electromagnetism Laboratory, research on characteristics of plasmas in magnetospheres of the Earth and planets, and structures of magnetic fields as well as their dynamics is conducted by computer simulations in addition to data analyses of satellite and ground observations.

Research on phenomena on the Sun's surface

It is well-known that the magnetic field plays the essential role in plasma phenomena on the Sun such as flares. Kwasan and Hida Observatories of Graduate School of Science are not only carrying out precise observation of the Sun's surface but also conducting theoretical studies by numerical simulations .



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