National Report for

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

(IUGG)

Activity Reports on Geodesy and Geophysics in Japan for the Period from 2003 to 2006

JULY 2007

JAPANESE NATIONAL COMMITTEE FOR
THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

SCIENCE COUNCIL OF JAPAN

CONTENTS

Foreword

Masaru KONO

Chair, Japanese National Committee for the International Union of Geodesy and Geophysics

Although Japan is one of the nine countries which together formed the International Union of Geodesy and Geophysics (IUGG) when it was founded in 1919, it took a long time for us to be able to host the General Assembly of the IUGG in our country. In the mean time, the Scientific Assemblies of the Associations were occasionally held in Japan since such meetings were initiated in 1969. Starting with IAPSO Assembly of 1970 held in Tokyo, IAGA in 1973 (Kyoto), IAG in 1982 (Tokyo), IASPEI in 1985 (Tokyo), and IAMAS/IAHS jointly in 1993 (Yokohama) held the Scientific Assemblies in Japan. Finally, the 23rd General Assembly of the IUGG came to Japan and was held in Sapporo, in Hokkaido Island.

In organizing this General Assembly, the Local Organizing Committee (Seiya Uyeda, Chair; Kiyoshi Suyehiro, Secretary-General) devoted significant time and energy for making it a fruitful meeting. With the main theme of "State of the Planet: Frontiers and Challenges", the Assembly provided a forum to discuss various aspects of the Earth system, with emphasis on interdisciplinary research focused on global trends in environmental and global change. More than four thousand scientists attended the IUGG in Sapporo, helping make the first ever General Assembly held in Asia a great success. This year (2007), the General Assembly visits another founding member country of the IUGG: Italy at Perugia.

Since the IUGG Assembly in 2003, not only the National Committee, but also the geoscience community at large in Japan, experienced substantial changes in organization. Science Council of Japan (SCJ), which is the national adhering body to the IUGG and other ICSU-based Unions, completely reformulated itself at the start of its 20th term (October 2005—September 2008). The result is the discontinuation of the former structure with more than 180 disciplinary committees, among them the former National Committee for Geodesy and Geophysics acting for the IUGG. In their place, 30 disciplinary committees were newly created, each covering a field from the literary and social sciences, medicine and the biosciences, to the physical-chemical sciences and engineering. The Earth and Planetary Sciences (EPS) Committee is one of these 30 disciplinary committees, under which the present National Committee for the IUGG is created as a subcommittee.

The EPS Committee of the SCJ, unlike the old National Committee for Geodesy and Geophysics, covers all the fields related to the earth and planetary sciences, including geophysics, geology, geography, planetary sciences, and others. Consequently, under the EPS Committee, there are subcommittees acting as the National Committees for the IUGG, IUGS (International Union of Geological Sciences), INQUA (International Union of Quaternary Research), and IGU (International Geography Union). Moreover, because of the VERY international nature of the earth and planetary sciences, the EPS Committee has more than twenty other national committees for various international organizations and programs, such as SCOR (Scientific Committee of Oceanic Research), IYPE (International Year of the Planet Earth), and so on.

The reorganization of the SCJ not only altered the national committee structure but also now influences the scientific community in fundamental ways. The Japanese community for earth and planetary sciences were traditionally subdivided into medium to small sized academic societies, each covering narrow field. For example, there was not a single unified geophysics society, such as the AGU in the USA or EGU in Europe. Instead, there are societies more or less corresponding to the Associations in the IUGG (Geodetic Society for IAG, Seismological Society for IASPEI, etc.), and even to their subdisciplines (Snow and Ice Society). However, because of the reorganization of the SCJ and others, the need for unity across the breadth of the earth and planetary sciences became widely recognized. The result was the formation of the Japanese Geosciences Union (JPGU) in May 2005. The JPGU now

consists of 46 member societies covering geography, geology, geophysics and space and planetary sciences. The cumulative number of JPGU members is about 40,000, and its annual spring meeting held every year in May in Makuhari (east of Tokyo) offers more than 3,000 presentations and attracts over 4,000 participants.

The move to unification is, however, not just a recent phenomenon. As early as 1990, five geophysics societies (Geodesy, Geomagnetism and Aeronomy, Planetary Sciences, Seismology, and Volcanology) started the joint spring meeting. These meetings, hosted by voluntary groups at various universities, were coordinated by a standing committee headed by Yoshimori Honkura. The same five societies merged the two journals in 1997, *Journal of Geomagnetism and Geoelectricity* and *Journal of Physics of the Earth,* to form a more cross-disciplinary joint journal *Earth, Planets, and Space*. The founding editor of this journal was again Yoshimori Honkura. However, as the joint meeting grew in size every year, voluntary groups based in a university faced increased difficulty hosting and organizing it. In 2001, Yozo Hamano and others in University of Tokyo took the initiative in forming an organization with the aim of carrying out the joint meetings, which was the foundation for the JPGU formed in 2005. The SCJ is also encouraging this sort of joint efforts by multiple academic societies, so that they are not restricted to the field of earth and planetary sciences, but similar efforts to unite many small societies are on-going in other disciplines such as dentistry and chemistry.

How this move affects the activities of the earth and planetary science community in the long run is still unknown. But there is no turning back, and we hope that it fosters exciting progress in scientific research through more intensive communication among the different subfields. The global problems we face today, such as climate change or the mitigation of large scale natural hazards, require multidisciplinary approach in any case. The unification of earth and planetary science should provide more research opportunities to these complex and challenging problems.

Membership of Japanese National Committee for the International Union of Geodesy and Geophysics Science Council of Japan as on July 1, 2007 (the 20th Term: from October 2005 to September 2008)

Chair:	Prof. Masaru KONO	(Tokyo Institute of Technology)
Secretaries:	Prof. Shiro IMAWAKI	(Kyushu University)
	Prof. Shuhei OKUBO	(University of Tokyo)
Members:	Prof. Kimio HANAWA	(Tohoku University)
	Prof. Yohsuke KAMIDE	(Kyoto University)
	Prof. Mitsuhiro MATSU'URA	(University of Tokyo)
	Prof. Setsuya NAKADA	(University of Tokyo)
	Prof. Teruyuki NAKAJIMA	(University of Tokyo)
	Prof. Masayoshi NAKAWO	(Research Institute for Humanity and Nature)
	Prof. Kuniyoshi TAKEUCHI	(Yamanashi University)

Membership of Japan National Committee for Geodesy and Geophysics Science Council of Japan as on October 1, 2003 (the 19th Term: from October 2003 to September 2005)

Chair:	Emeritus Prof. Atsuhiro NISHIDA	(Institute of Space and Astronautical Science)
Secretaries:	Prof. Masaki KAWABE	(University of Tokyo)
	Prof. Mitsuhiro MATSU'URA	(University of Tokyo)
Members:	Dr. Mizuho ISHIDA	(National Research Institute for Earth Science and Disaster Prevention)
	Prof. Hideji KIDA	(Kyoto University)
	Prof. Setsuya NAKADA	(University of Tokyo)
	Prof. Shuhei OKUBO	(University of Tokyo)
	Prof. Yasuo SAKURA	(Chiba University)
	Prof. Hisashi UTADA	(University of Tokyo)
	Prof. Tetsuo YAMAMOTO	(Nagoya University)

I. *Activity Report of the National Committee for Geodesy*

Shuhei OKUBO
Chair of the National Committee for Geodesy

National Committee (NC) for Geodesy, Japan hosted the IUGG XXIII General Assembly at Sapporo in 2003 as a member of Science Council of Japan. More than 4100 researchers from 79 countries and regions attended the Assembly. In August, 2005, NC sent official delegates to a Joint Assembly of the IAG, IAPSO and IABO held in Cairns, Australia. Besides these General Assemblies, several international meetings related to geodesy were held in Japan, e.g. "International Workshop on GPS Meteorology - GPS Meteorology: Ground-Based and Space-Borne Applications" at Tsukuba in 2003 [1], and "The 3-rd International e-VLBI Workshop" at Chiba in 2004 [2].

In addition to international activities, the Geodetic Society of Japan (GSJ) holds general meetings twice a year. In 2004, GSJ celebrated her fiftieth anniversary. As part of the commemorative activities, GSJ published two books in Japanese: an introductory book on geodesy for the general public [3] and a CD-ROM textbook on geodesy for researchers and university students [4].

During the period 2003 to 2006 a variety of geodetic activities have been undertaken in Japan. We may name some major ones out of them. The Japanese continuous GPS observation network (GEONET: GPS Earth Observation Network System) has been reinforced qualitatively and quantitatively. The number of continuous sites has been increased to about 1200, and the acquired data are transferred on a real time basis. Analysis strategy has been updated to realize a better accuracy. GEONET, the world's largest regional GPS network, serves not only for geodesy but also for meteorology, seismology, volcanology and ionosphere sciences.

The first geodetic VLBI observation within the VERA (VLBI Exploration of Radio Astrometry) network was carried out in November 2004 by the National Astronomical Observatory of Japan. Regular observations scheduled three times per month started in December 2004. The VERA network, composed of 1020 km to 2270 km baselines, attains the observation precision of 2 mm in horizontal coordinates and 7-8 mm in vertical ones with one 24-hour observation in S/X bands.

Another new important geodetic facility is "Daichi", the Advanced Land Observing Satellite (ALOS), which was successfully launched in January 2006. Daichi, equipped with the L-band Synthetic Aperture Rader (SAR) sensor, can be used to monitor changes in the deformation of the surface regardless of vegetation.

Research and development studies of seafloor positioning using GPS/Acoustic techniques have been continued by two university groups (Nagoya University and Tohoku University) and by the Japan Coast Guard (JCG). The former succeeded in detecting horizontal seafloor crustal movement as large as 30 cm during the 2004 Off the Kii Peninsula earthquake [5,6] while the latter revealed an intraplate crustal movement of 7.3 cm/yr WNW relative to the stable part of Eurasian Continent at a seafloor reference station located landward of Japan Trench [7].

The development of the onboard instruments for the coming lunar exploration mission SELENE has already been finished and proto-flight tests are continued under various conditions. SELENE is expected to be launched in the summer of 2007.

International geodetic activities have also been made intensively. Continuous observations with five superconducting gravimeters have been maintained under the Global Geodynamics Project (GGP). The domestic GGP group succeeded in submicrogal coseismic gravity change with excellent agreement to

theoretical expectation [8]. An Absolute Gravity Standard Station Network in East and South-East Asia has been established as a part of the Asia-Pacific Space Geodynamics Project cooperation campaigns in the International Association of Geodesy (IAG) and the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). A joint team of Japanese and U.S. researchers began a four year project of integrated geodetic observation in 2005, called International Geodetic Project on South Eastern Alaska, for detecting the crustal deformation and studying the viscoelastic structure of the Earth in that area.

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II. *Activity Report of the National Committee for Geomagnetism and Aeronomy*

Yohsuke KAMIDE
Chair of the National Committee for Geomagnetism and Aeronomy

We report herewith on IAGA-related research activity in Japan over the period of 2004-2007 in terms of three areas: "Solar-Terrestrial Research," "Earth and Planetary Interior," and "Meetings, Reorganizations and Research Programs." The following is a summary of what has been accomplished over the last four years in each of these three areas:

1. Solar-Terrestrial Research

1.1. Sun and interplanetary space

The Japanese solar observation satellite "Hinode" was successfully launched in September 2006, and a new solar observation system, "SMART," was installed at the Hida Observatory. They are expected to be the new major data sources in the research of solar flares and coronal mass ejections.

Observations of the solar wind has continued using the interplanetary scintillation (IPS) technique, which is capable of observing the structure and dynamics of the solar wind in three dimensions (3D) with a relatively short time cadence. To make the solar wind observations with higher spatial and temporal resolution using the IPS tomographic method, construction of a large IPS antenna began in 2006. A test of solar wind predictions is being carried out under collaboration between CASS/UCSD and STEL. The 3D structure and propagation of coronal mass ejections (CMEs) have also been studied jointly by a cosmic ray group and a solar wind group.

Construction of a global network of muon detectors in four countries has been completed and high-quality observations of high-energy cosmic ray streaming, showing dramatic variations in response to every CME approaching Earth, has started. The network is able to sense cosmic ray precursors for the CME arrival at Earth. In collaboration with the Tibet air shower experiment, the sidereal anisotropy of the intensity of very high energy cosmic rays was examined, indicating that the observed anisotropy provides useful information on the local interstellar magnetic field surrounding the heliosphere.

The Nozomi spacecraft has proven to be of great use for heliospheric studies. For example, longitudinal variations of interplanetary neutral hydrogen Lyman alpha emission, as well as their relation to the solar photon flux, have been reported. The first attempt to monitor long-term variations in the solar wind mass flux at all heliographic latitudes has been made by combining IPS observations and the interplanetary Lyman alpha emission observations with the Nozomi spacecraft. It is now realized that the real heliospheric interaction is not simple and asymmetric, suggesting that further studies of the deflection in the global heliosphere structure are warranted.

1.2. Magnetosphere

The major driver of observational space physics over the last four years has been the data from Cluster-II, which the Japanese community has joined to use. With unprecedented multi-point measurements, the science community is setting up a scheme to separate spatial and temporal effects in the time series data obtained by each spacecraft. Together with the results from full particle simulations that have recently become available, the importance of multi-scale interactions as basic processes in plasmas in the solar-terrestrial system is increasingly recognized. The successful launch of THEMIS in February 2007 will allow the community to study data obtained simultaneously from more than 10 points in space.

Considerable advances in the studies of electron acceleration in the radiation belts during storms and substorms have been made by Japanese scientists through computer simulations of wave-particle

interaction, as well as through satellite data analysis. By using global MHD simulation codes for ionosphere-magnetosphere coupling processes, geomagnetic phenomena such as DP2, SC, and Pi2 pulsations have been studied, obtaining reasonable agreement with ground magnetic observations. Advances in the study of the upper atmosphere of non-magnetized planets and its escape have also been made through computer simulations.

1.3. Upper atmosphere

Equatorial Atmosphere Radar (EAR), all-sky airglow imagers, coherent radars, MF and meteor radars, the meridional ionosonde chain, Rayleigh and Sodium lidars, and TEC observations with GPS were deployed in Indonesia, Thailand, and near-by countries. Data from these observations were utilized for studies of the equatorial and low-latitude ionosphere. Advances in the studies of the equatorial Spread-F (ESF), in particular its time-spatial structures, have been made. Evidence was found for the existence of coupling between the ESF occurrence and variations in the lower atmosphere. Dynamical coupling of the ionosphere and the lower atmosphere was extensively studied on the basis of large disturbances of the ionosphere associated with the North Sumatra earthquake of December 24, 2004. In Japan, the detection of the propagation direction of HF and VHF radio signals from low latitudes or from the southern hemisphere was used to examine large-scale patterns and motions of the ESF. The airglow network in Japan revealed cases where the ESF extends to the latitudes of Japan.

For the mid-latitude ionosphere, an important finding was the hemispheric symmetry of the middle-scale traveling ionospheric disturbance (MS-TID), seen in airglow imagers at Sata, Japan and Darwin, Australia. Simultaneous experiment between the MU radar and a portable radar in Sakata showed clear evidence of electromagnetic coupling between F- and E-region ionospheric irregularities. GEONET, the network of over 1000 GPS receivers in Japan, provided a TEC database (GPS-TEC) useful for these studies. The development of the tomography from the GPS-TEC data has recently reached a level at which 3D spatial structures of the ionospheric plasma density over Japan can be discussed.

As for the polar region, the EISCAT Svalbard radar and the EISCAT UHF radar in Tromso were both used for the study of the ion drag force in the lower thermospheric wind. In August 2005, a small scientific satellite “REIMEI” was launched. The satellite captured 2D images of the aurora while observing precipitation of high-energy particles and the outflow of ions from the Earth. A Fabri-Perot Doppler imaging system, a riometer, and an all-sky camera have been deployed in Alaska and Canada by Japanese teams for the study of neutral winds and waves in the thermosphere.

By using a general circulation model of the atmosphere, simulation studies were conducted for tidal variations in the troposphere and thermosphere, as well as for the generation and propagation of large-scale traveling atmospheric disturbances. In addition, a real-time ionosphere/thermosphere model has been developed using real-time ionospheric parameters given by a global magnetospheric MHD model for space weather forecasts.

A unique instrument, ISUAL (Imager of Sprites and Upper Atmospheric Lightnings), was launched as a scientific payload of the FORMOSAT-2 satellite of Taiwan. The science team found a unexpected number of transient luminous events (TLEs), such as sprits and elves, over the whole globe, determining their physical parameters quantitatively.

2. Earth and Planetary Interior

2.1 Geomagnetism and Paleomagnetism

Rapid progress in research on the Earth and planetary dynamos has been made for the last four years. This is partly owing to the development of high-performance computer systems, in particular the supercomputers such as “Earth Simulator” and “TSUBAME.” Simulations of a quasi-Taylor state geomagnetic field were performed.

Paleomagnetic and rock-magnetic studies were carried out for rocks and sediments of different ages from various places. Among them, using marine sediment cores, studies of the relative paleointensity

for unveiling a possible relationship between geomagnetic field variations and Earth's orbital parameters were conducted. Studies of absolute paleointensity for volcanic rocks have also progressed: the average field intensity for the past ca. 5 Ma as well as intensity variations over transient periods, such as polarity transitions and geomagnetic excursions, were examined on the basis of a modified version of the Shaw method.

Oceanic and continental drillings have provided unique opportunities for obtaining materials for various types of paleomagnetic research. The Integrated Ocean Drilling Program (IODP) began in October 2003. A number of paleomagnetists have been involved in the expeditions. A riser-drilling vessel "Chikyu," constructed for IODP, will embark on scientific drillings in October 2007.

As for extraterrestrial magnetism, the lunar exploration mission SELENE is scheduled to be in orbit in the summer of 2007. The remnant of the magnetic field of the Moon will be measured, which will enable us to unveil its ancient (3 to 4 billion years ago) magnetic field.

2.2 Electromagnetic studies of the Earth's interior

The collection and distribution of geomagnetic and geoelectric data from the Ocean Hemisphere Project (OHP) resulted in three-dimensional electrical conductivity models of the mid-mantle in the Pacific and Europe. These are the first models comparable to the ones from seismic tomography, functioning as an indicator of the thermal condition in the mantle. The OHP was succeeded by a new multi-disciplinary, five-year project designed to reveal "a stagnant slab" in the mantle transition zone.

Efforts continued to promote major projects to identify basic electromagnetic properties on a regional scale. For example, the network MT project has further been carried out, compiling distributions of the electrical conductivity of the crust and upper mantle. An attempt to establish a regional geomagnetic reference field generated a few preliminary models for the region in and around Japan.

Intensive studies in tectonically active environments were also made especially by magnetotelluric and aeromagnetic survey to explore the distribution of fluids in the crust and their roles in the local/regional tectonic activities. In volcanic studies, a quantitative interpretation of self potential surveys on volcanoes became possible by elaborated laboratory experiments of the zeta potential.

3. Meetings, Reorganizations, and Research Programs

The XIth IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing was held at the Kakioka Magnetic Observatory and Tsukuba City on November 9-17, 2004. After four-years of extensive discussions, a report from this National Committee in the Science Council of Japan, entitled "Geomagnetism and Aeronomy in the 21st Century" was published in August 2004. It recommends several major research projects the Japanese science community should initiate. All national universities and some national institutions have been reorganized, making their management to be more independent from the government. The Japan Geoscience Union (JPGU) was established in May 2005 and our society, i.e., Society of Geomagnetism and Earth, Planetary and Space Sciences, became one of its members. The Japanese organization for IHY, recognized by the United Nations, was established in 2006, and four international projects, i.e., MAGDAS Project, Muon Detection Network, IPS Network, and Network of International Space Environment Service, have joined the IHY program. The Japanese eGY (electronic Geophysical Year) Committee was established in 2005 and the eGY Subcommittee in the Science Council of Japan was established in January 2007.

III. Activity Report of the National Committee for Hydrological Sciences

Masayoshi NAKAWO
Chair of the National Committee for Hydrological Sciences

The Japan National Committee for Hydrological Sciences, in the Science Council of Japan is one of seven national committees of the corresponding associations of the International Union of Geodesy and Geophysics. Its roles are to plan future hydrological research, to coordinate academic bodies related to Inland water and to act as the National Committee for IAHS.

The hydrological societies in Japan now consist of 15 independent societies: the Japanese Society of Limnology, the Japanese Association of Groundwater Hydrology, the Japanese Society of Snow and Ice, the Balneological Society of Japan, the Geochemical Society of Japan, the Japan Society of Civi1 Engineers, the Japanese Forestry Society, Japan Society of Hydrology and Water Resources, the Japanese Association of Hydrological Sciences, the Erosion Control Engineering Society of Japan, the Society of Agricultural Meteorology of Japan, the Japanese Society of Irrigation, Drainage, and Reclamation Engineering, the Geothermal Research Society of Japan, Japanese Geomorphological Union, and Japanese Society of Physical Hydrology. The current nine members of the National Committee are selected from the first nine societies. The chairman of the National Committee acts as the national representative for IAHS, and the members act as national correspondents of the international Commissions and Committees of IAHS.

Since there is no unified organization for hydrological sciences in Japan, the National Committee functions as the focus for collecting and distributing information concerning hydrological sciences.

A Symposium on the Present Status and the Future of the Water Circulation Studies with the Aid of Tracers was organized, by the National Committee, in September, 2005 at the Science Council of Japan.

As for the IAHS Project, Predictions in Ungauged Basins, a PUB special session was organized in the AOGS Annual Meeting at Singapore in September, 2006. In October, 2006, a PUB session was organized in the 3rd APHW meeting at Bangkok. A PUB Japan National Workshop was also organized in Mie Prefecture, Japan in November, 2006.

The National Committee for council members of IAHS recommended several candidates at the end of 2006 for IAHS council memberships well as for international Commissions and Committees of IAHS, to be elected at the IUGG General Assembly at Perugia in 2007. In addition, the National Committee recommended a candidate for the International Hydrology Prize.

IV. Activity Report of the National Committee for Meteorology and Atmospheric Sciences

Teruyuki NAKAJIMA
Chair of the National Committee for Meteorology and Atmospheric Sciences
Hisashi NAKAMURA
Secretary General of the National Committee for Meteorology and Atmospheric Sciences

The main organization for the Japanese research community in the fields of meteorology and atmospheric sciences is the Meteorological Society of Japan (MSJ) with the current membership of nearly 4100. Until the major reorganization of the Science Council of Japan (SCJ) in 2005, all the members of the National Committee for Meteorology and Atmospheric Sciences (the Committee, hereafter) had been appointed by the executive committee of MSJ for a term of three years. The current committee for the 20th term has been organized with members selected by a new selection rule set by SCJ under close communication with MSJ. The purpose of the committee is to review academic and research activity on meteorology and atmospheric sciences and to propose plans for activating and promoting future activity in the field. The committee also handles international affairs related to the International Association of Meteorology and Atmospheric Sciences (IAMAS).

1. General Research Activity

MSJ plays the central role in Japan in fostering meteorological research for its advance and opening up new research areas, cooperating with related academic societies and research organizations, both domestically and internationally. MSJ encourages communication among member scientists by sponsoring scientific workshops and symposia, including its semiannual general assemblies, by publishing its bulletin, international journals and research monographs, and by disseminating the latest scientific knowledge to the general public at an open symposium in every general assembly and at summer school every year. To meet the urgent need for the quick publication of important research outcomes, MSJ initiated a new online journal *SOLA* (Scientific Online Letters on the Atmosphere) in 2005. Founded in 1882, MSJ celebrates its 125th anniversary this year with the publication of a special issue of the Journal of the Meteorological Society of Japan.

A trend is a large increase in research collaborations with different academic disciplines, such as biology, that used to be far from meteorology. The particular trend has accelerated under the urgent and increasing demand for deeper understanding of the earth's environmental system as a whole and its predicted future. The development of “earth system modeling” under rapidly developing computer technology, as symbolized by the advent of the Earth Simulator (ES) in 2002, exemplifies this acceleration. Under such enhancing multidisciplinary collaborations, participation in annual assemblies of Japan Geoscience Union and general assemblies of IUGG, including its XXIII assembly held in 2003 at Sapporo, Japan, has increased.

2. Recent Research Highlights

Some of the novel outcomes from our research activity, including domestic and international projects related to World Climate Research Program (WCRP) and International Geosphere-Biosphere Program (IGBP) among others, are listed below:

- 20^{th}-century simulations and 21^{st}-century global warming projection experiments have been conducted on ES by using high-resolution state-of-the-art coupled general circulation models (CGCMs), including MIROC (by CCSR-NIES-FRCGC) and MRI-CGCM; these contributed to the 4^{th} assessment of the Intergovernmental Panel on Climate Change (IPCC).
- Non-hydrostatic cloud-resolving modeling has been advanced for regional domains and even for the global domain on ES. Ensemble forecast experiments have also been advanced, in part for contributions

to an international project (THORPEX) for skillful extended weather forecasting. The 4DVAR technique has been developed for a global CGCM on ES to produce global analysis data for 10 years.

- International campaigns have been organized, including ADEC (Aeolian Dust Experiment on Climate impact) and ABC (UNEP/Atmospheric Brown Cloud) to measure and analyze Asian dusts and pollutants in order to reveal their chemical and physical characteristics.
- The National Institute of Polar Research (NIPR) has successfully recovered the deepest (3035m thick) ice core from the bottom of the Antarctic ice sheet. Its deepest part is estimated as ~720kyr old based on the oxygen isotope profile obtained.

3. Other Topics

After several years of a feasibility study for the Program of the Antarctic Syowa MST/IS radar (PANSY) under Resolution 8 adopted at the XXIII IUGG General Assembly, NIPR will introduce a small pilot radar system at the Syowa station in the International Polar Year 2007-8.

MAHASRI, a new continental-scale experiment under GEWEX (Global Energy and Water Cycle Experiment under WCRP), has been implemented in order to develop a hydro-meteorological prediction system for Asian monsoon variability. Its intensive observation periods are planned in 2008-9 for the International Monsoon Year and the Year of Tropical Convection.

CONTRAIL, a project for high frequency, wide-coverage measurements of CO_2 and other trace gases, has been started, using commercial aircrafts.

V. *Activity Report of the National Committee for the Physical Sciences of the Oceans*

Kimio HANAWA
Chair of the National Committee for the Physical Sciences of the Oceans

The former, 19th Term, National Committee for the Physical Sciences of the Oceans, Science Council of Japan ended in September 2005, and the present, 20th Term, committee began its activity in October 2006. The members of the National Committee for the Physical Sciences of the Oceans are listed at the end of this report. In this report, recent progress in physical and chemical oceanography in Japan is briefly reviewed for several research fields. Each member of the committee contributed in the preparation of this document.

1. Research on the Kuroshio

Since the Kuroshio plays an important role in global climate changes and has impacts on the local Japanese coastal areas, it is the major research target of numerous Japanese oceanographers. Fluctuations of the Kuroshio axis were detected with a spatial resolution of one third degrees of latitude and longitude, and a temporal resolution of 7 days, from late 1992 through 2006, using satellite altimeter data combined with surface drifting buoy data. An interesting result is the evolution of the stationary large meander of the Kuroshio south of Japan which occurred in 2004, suggesting that a small seamount located south of Kii-Peninsula may play an important role in the transition from the non-large meander path to large meander path; its importance has already been pointed out by a numerical experiment study. Interactions between the Kuroshio and mesoscale eddies have also been investigated by data analyses and numerical experiments; especially, small meanders of the Kuroshio southeast of Kyushu have attracted attention because they might be a trigger of the stationary large meander of the Kuroshio. The existence of the Ryukyu Current was suggested early 2000's; a considerable amount of water associated with the Current may be flowing east of the Ryukyu Islands to join the Kuroshio flowing out of the East China Sea through the Tokara Strait. Various oceanographic observations and numerical studies were carried out to reveal the Current. Also, oceanographic observations were carried out intensively east of Taiwan to better understand the flow field of the Kuroshio; they include observations using long-range ocean Radars as well as conductivity-temperature-depth recorders (CTD's), acoustic Doppler current profilers (ADCP's), etc.

2. Hydrographic Research on Three-dimensional Oceanic Structure and Circulation

Full-depth high-quality hydrographic observations were conducted as revisits of the WOCE (World Ocean Circulation Experiment) Hydrographic Programme (WHP) observations; other observations were conducted to clarify deep circulation. The former were carried out by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) with R/V *Mirai* for WHP P6, A10, and I3/I4 along the latitude circle at 20°S − 30°S during August 2003 − January 2004 and for WHP P10 along approximately 149°20′E in 2005 (URL: http://www.jamstec.go.jp/iorgc/ocorp/data/post-woce.html). The latter were conducted centrally by the Ocean Research Institute, The University of Tokyo with R/V *Hakuho Maru* in the Northwest, Central, and Northeast Pacific Basins (partly a revisit of WHP P15) in 2003, 2004, and 2005, including velocity measurements using lowered acoustic Doppler current profilers (LADCP) and moored current meters. Studies on deep circulation currents and long-term changes of deep water in the Pacific Ocean progressed by analyses of the hydrographic data obtained in this decade. These data were also used for study on surface and intermediate water masses such as the Subtropical Mode Water.

3. Japan Argo Project

The Japanese community participated in the International Argo project through the "Millennium Project" promoted by the Japanese government (2000-2004). Since 2005, JAMSTEC, Japan Meteorological Agency, and other agencies, including university groups, have continued to deploy Argo floats using independent research funds. In order to effectively manage the Japanese Argo project (Japan Argo), a new promotion committee was established in 2005 (URL: http://www.jamstec.go.jp/

J-ARGO/index_e.html). Until the present (April 2007), a total of about 400 Argo floats have been deployed in the Pacific, Indian and Southern Oceans.

4. Research on Tropical Pacific and Indian Ocean

FRCGC of JAMSTEC started experimental prediction of ENSO in the Pacific and IOD in the Indian Ocean (http://www.jamstec.go.jp/frsgc/research/d1/iod/). The 2006 IOD was correctly predicted well ahead in November, 2005 (http://www.jamstec.go.jp/jamstec-e/PR/0610/1016/index.html). More intensive real-time acquisition of subsurface ocean data will lead to better forecasting skill and thus greater contribution to the society. To achieve this, in close collaboration with NOAA and other agencies under the auspices of EOS/GEOSS, JAMSTEC has extended the TRITON surface buoy and ADCP mooring array from the western Pacific to the eastern Indian Ocean (http://www.jamstec.go.jp/iorgc/eng/list/p1c.html). Those activities will also contribute to better description and understanding of the oceanic and atmospheric processes involved in the air-sea interaction in the tropical climate system. We particularly note that the 2006 positive IOD event was captured for the first time by the in situ buoy array in the Indian Ocean.

5. Data Assimilation Studies

Following the development of the earth-observing systems and high-speed computers, ocean data assimilation studies in Japan have markedly progressed, in both research and operational modes, during the last decade. Research activities have primarily been conducted in association with the Japan GODAE (Global Ocean Data Assimilation Experiment) consortium. Thanks to the great efforts of members, a variety of oceanographic products (e.g., sea surface and sub-surface temperature and salinity, ocean current, sea surface height and sea ice distributions), mainly in the western North Pacific Ocean and the Sea of Japan, are now distributed operationally on web site and by radio facsimile. These products are also available on the NEAR-GOOS Regional Real Time Data Base (http://goos.kishou.go.jp). Another remarkable achievement in terms of data assimilation studies is the construction of a leading-edge 4-dimensional variational coupled ocean-atmosphere data assimilation system. This system demonstrates a one-year-lead prediction capability of El Niño events and has the advantage of providing greater information content and forecast potential than do models or data alone. The reanalysis dataset is now accessible (http://www.jamstec.go.jp/frcgc /k7-dbase2/). Major groups within Japan GODAE are now in proceeding not only with ocean prediction and reanalysis but also with OSE/OSSE conducted by the international GODAE.

6. Ecosystem Modeling Studies

The Kuroshio area is major spawning area for pelagic fish, and Northern Pacific is well known as a productive area for these fish. Ecosystem modeling, coupled with physical modeling, has been conducted by Japanese Fisheries Agency and the PICES MODEL Task Team (http://www.pices.int/members/task_teams /MODEL.aspx) since 2000. Numerical models appropriate to the marginal seas, such as the Japan Sea, have also developed to reconstruct findings derived from observations, helping to clarify the underlying mechanisms. This has also included ecosystem model. A part of ecosystem modeling in the Sea of Okhotsk is supported by the Research Institute for Humanity and Nature (RIHN) (http://www. chikyu.ac.jp/AMORE/en/index-enf.htm).

7. Activity of Marine Biogeochemical Studies

As a new international project of marine chemistry, GEOTRACES (an international study of the marine biogeochemical cycles of trace elements and their isotopes) was set up in 2004; a Japanese marine geochemistry group has taken part in its establishment and advancement since 2003. GEOTRACES SSC and its Science Plan (published in September 2006) have been approved by SCOR. The project has three phases: (1) the preparation phase (planning, preparation and distribution of standards, inter-calibration, etc.), (2) the main phase (series of 12-15 sections to cover all major ocean basins, using compatible sampling and measurement protocols), and (3) the parallel and follow-up process studies phase. Several of the preceding cruises were conducted in the Pacific Ocean between 2003 and 2005 using R/V Hakuho Maru (JAMSTEC). (http://www.geotraces.org/)

SOLAS-Japan National committee was reorganized and approved as an IGBP subcommittee under the international committee of the Science Council of Japan in 2006. Since 2003, we have been holding the national symposia and the committee meetings annually.

Our research proposal, entitled “Linkages in Biogeochemical Cycles Between Surface Ocean and Lower Atmosphere” (W-PASS: Western Pacific Air-Sea interaction Study) to the Grant-in-Aid for Scientific Research in Priority Areas, was funded by MEXT and started in July 2006 as a 5-year project with over 70 members. The goal of the W-PASS is to achieve quantitative understanding of the key biogeochemical interactions and feedbacks between the ocean and atmosphere. Several cruises are planned with international collaboration; these include related core projects under IGBP and SCOR. SOLAS-Japan has also supported sending several young Japanese scientists to the SOLAS international summer schools held in France every two years. (http://solas.jp/)

8. Cooperative Studies with Asian Countries

The JSPS (Japan Society for Promoting Sciences) Multilateral Core University Program, ‘Coastal Marine Science (CMS)’ succeeding “Coastal Oceanography”, started its second phase in 2006 and will continue until 2010. The participating countries for this project are Japan, Indonesia, Malaysia, Thailand, Philippines, and Vietnam. This program consists of four core projects. Under this program, many symposia and workshops have been held, and cooperative studies have been promoted and enhanced.

Committee members at the 19th Term and 20th Term of Science Council of Japan

I. Membership of the 19th Term (from October 2003 to September 2005) as on 1 October 2003

Chair:	Prof. Masaki Kawabe (University of Tokyo)
Secretary:	Prof. Yutaka Michida (University of Tokyo)
Members:	Prof. Toshiyuki Awaji (Kyoto University)
	Prof. Toshitaka Gamo (University of Tokyo)
	Prof. Toshiyuki Hibiya (University of Tokyo)
	Prof. Shiro Imawaki (Kyushu University)
	Prof. Toshio Suga (Tohoku University)
	Dr. Kensuke Takeuchi (Japan Marine Science and Technology Center)

II. Membership of the 20th Term (from October 2006 to September 2008) as on 1 July 2007

Chair:	Prof. Kimio Hanawa (Tohoku University)
Secretary:	Prof. Yutaka Michida (University of Tokyo)
Members:	Prof. Toshiyuki Awaji (Kyoto University)
	Prof. Toshitaka Gamo (University of Tokyo)
	Prof. Shiro Imawaki (Kyushu University)
	Prof. Masaki Kawabe (University of Tokyo)
	Prof. Michio J. Kishi (Hokkaido University)
	Prof. Mitsuo Uematsu (University of Tokyo)
	Prof. Masaaki Wakatsuchi (Hokkaido University)
	Prof. Toshio Yamagata (University of Tokyo)

VI. *Activity Report of the National Committee for Seismology and Physics of the Earth's Interior*

Mitsuhiro MATSU'URA
Chair of the National Committee for Seismology and Physics of the Earth's Interior

In the last four years (2003-2007) there have been major organizational changes and significant progress in seismology and physics of the Earth's interior in Japan.

Changes in Organization

The 18th term (2000-2003) of the Committee for Seismology and Physics of the Earth's Interior, Science Council of Japan, expired in September 2003. The 19th term of the Committee started in October 2003, and Mitsuhiro Matsu'ura (Professor, University of Tokyo) was elected as the Chair. The 19th term of the Committee terminated in September 2005 with the sweeping reform of the Science Council of Japan. Under the new Science Council of Japan, the National Committee for Geodesy and Geophysics (the National Committee for IUGG) and the IUGG-related subcommittees, including the National Committee for Seismology and Physics of the Earth's Interior (the National Committee for IASPEI), were established in 2006; Mitsuhiro Matsu'ura was elected as the Chair of the National Committee for IASPEI. In 2006 the Seismological Society of Japan (SSJ) also established the IASPEI Subcommittee to support the activity of the National Committee for IASPEI. In 2005, on the other hand, the Japan Geoscience Union (JGSU) was established to unify almost all Earth science-related societies in Japan. The Seismological Society of Japan joined in JGSU as a member society.

Contribution to Activities of ASC

The National Committee for IASPEI and the Seismological Society of Japan first delegated Kazuro Hirahara (Professor, Nagoya University) as a national representative to the 5th General Assembly of Asian Seismological Commission (ASC) held on October 18-21, 2004 in Yerevan, Armenia,. The President of ASC nominated Kazuro Hirahara as a Bureau member of ASC. At the 6th General Assembly of ASC held on November 7-10, 2006, in Bangkok, Thailand, Japan was nominated as the host country for the 8th General Assembly of ASC to be held in 2008. In January 2007 the National Committee for IASPEI and the Seismological Society of Japan formed the Local Organizing Committee for the 8th General Assembly of ASC in Japan.

National Earthquake Prediction Research Project

The first phase (1999-2003) of the national project for earthquake prediction research finished in March 2004 with great progress in basic understanding for the physical process and tectonic environment of earthquake generation. The second phase (2004-2008) of the earthquake prediction research project started in April 2004. The main subjects in the second phase are the observational study for better understanding of the crustal activities associated with the entire process of earthquake generation cycles and the development of a predictive simulation system for earthquake generation. In the last four years the concept of strength asperity as a unit of earthquake rupture has been established. A prototype of the predictive simulation system for earthquake generation cycles at plate interfaces in and around Japan has been developed.

Seismic Activity in and around Japan

In the period of 2003-2006, seven large earthquakes occurred in and around Japan. On September 26, 2003 a M8.0 earthquake (the 2003 Tokachi-oki earthquake) occurred in Hokkaido (the northern part of Japan). On September 7, 2004 a M7.4 earthquake (the 2004 off Kii Peninsula earthquake) occurred in the Tonankai region (the southwestern part of Japan). On October 23, 2004 a M6.8 inland earthquake (the 2004 Niigata-ken Chuetsu earthquake) occurred in the Chubu region (the central part of Japan). On March 20, 2005 a M7.0 intraplate earthquake (the 2005 west off Fukuoka-ken earthquake) occurred in Kyushu (the western part of Japan). On August 16 a M7.2 earthquake (the 2005 off Miyagi-ken

earthquake) occurred in the Tohoku region (the northeastern part of Japan). On November 5, 2005 a M7.1 normal-faulting earthquake (the 2005 off Sanriku earthquake) occurred in the Pacific plate. On November 15, 2006 a M7.9 earthquake (the 2006 eastern Kuril Islands earthquake) occurred in the eastern part of Kuril Islands. All of these earthquakes were observed through the nation-wide dense seismic and geodetic observation networks and were analyzed in detail by Japanese seismologists.

The Passing of Leading Seismologists

During the last four years many leading scientists in seismology and physics of the Earth's interior passed away: Toshi Asada (Emeritus Professor, University of Tokyo) on January 10, 2003; Masayuki Kikuchi (Professor, University of Tokyo) on October 18, 2003; Shigeji Suyehiro (Former Director General of Japan Meteorological Agency) on December 8, 2003; Hitoshi Takeuchi (Emeritus Professor, University of Tokyo) on April 20, 2004; Ryosuke Sato (Emeritus Professor, University of Tokyo) on May 12, 2004; Tokuji Utsu (Emeritus Professor, University of Tokyo) on August 18, 2004; Tsuneji Rikitake (Emeritus Professor, University of Tokyo) on August 22, 2004; Keiiti Aki (Science Director Emeritus of Southern California Earthquake Center, University of Southern California) on May 17, 2005. The passing of these leading scientists may suggest the end of the glorious days of classical seismology.

VII. *Activity Report of the National Committee for Volcanology and Chemistry of the Earth's Interior*

Setsuya NAKADA
Chair of the National Committee for Volcanology and Chemistry of the Earth's Interior
Eisuke FUJITA
Secretary General of the National Committee for Volcanology and Chemistry of the Earth's Interior

There has been significant volcanic activity and progress in volcanology in the last four years (2003-2006).

1. Eruptive events

The volcanic activity from 2003 to 2006 was more stable than that from 1999 to 2002, when there were major eruptions at Usu and Miyakejima. Small volcanic eruptions occurred at Tokachidake, Meakandake, Asama, Miyakejima, Sakurajima, Satsuma-Iwojima, Fukutoku-Okanoba, and Suwanosejima.

At Asama volcano, small eruptions occurred from February to April 2003 for the first time since 1990. The most active period started on September 1, 2004, when four middle-scale eruptions occurred by November. Associated with these eruptions, volcanic bombs struck the flank of the volcano, and ash-falls were observed as far as 200km from Asama. A seismic swarm was also recorded and a lava pond was observed at the bottom of the summit crater. This was the most activity since 1983.

Sakurajima had some explosions from 2003 to 2005 within the summit crater, and a small eruption occurred outside the summit crater on June 4, 2006, the first since 1949.

High levels of volcanic activity without explosive eruption were observed at several volcanoes. Volcanic gas was still being emitted from Miyakejima, even though the activity was decreasing. Seismic activity and abnormal phreatic activities were episodically observed at Aso.

2. Volcanological Studies

There was specific progress in geophysics, geochemistry, and geology and much new knowledge and many new techniques were acquired, helping clarify the characteristics of Japanese volcanoes. Integrated observations contributed to improving comprehensive models for volcanic processes.

Dense broadband seismic observation and ground deformation observation revealed magma migration before and during observation. At Asama, this kind of observation also led to an interpretation that magma intrusion occurred shortly before the eruption. Specific long-period earthquakes, indicating the interaction between magma and hydrothermal system, ceased before the eruption. The analyses of explosion earthquakes suggested models of magma's expansion just prior to the explosion, magma's vesiculation due to pressure-release, and successive magma ascents. Absolute and relative gravitational observation revealed the location of the magma head. SAR analysis was able to estimate the lava effusion quantity and the variation of lava cake depth at the summit of Asama. Low electric resistivity areas correspond to the intruded magma, which is inferred from geodetic surveys. A semi-real-time thermal observation system using satellite data detected an abnormal increase of temperature preceding the eruption.

At Izu-Oshima, the seismicity in the summit caldera synchronizes with both expansion and contraction of the whole island area, and the expansion rate correlates with the subsurface CO_2 content. A long-term electric survey at Izu-Oshima volcano clarified the detailed three-dimensional resistivity structure.

The tomographic inversion of Fuji, using both artificial and natural earthquake data, suggests the existence of a super-critical water region at around a 10 to 15km depth and magmatic fluid at deeper than 20km.

A precise chemical evolution model of magma including timings of magma mixing and eruption was proposed for the Usu volcano. The temporal change of volatile components in the shallow rhyolite reservoir of Satsuma-Iwojima was interpreted as being linked to the process of depressurization in the magma reservoir, degassing due to convection in conduit, and the supply of volatile components from basaltic magma in the deeper part.

Eruptive history analyses were carried out for many volcanoes to make plans for long-term prediction of volcanic eruptions. For Fuji, there was an active period that formed a volcanic edifice "Sen Komitake" with basaltic ejecta, preceding the well-known Shin-Fuji, Ko-Fuji and Komitake active periods. In addition, the details of flank eruptions in the last 10,000 years, especially eras of flank eruptions in the last 2,000 years, became clear. The diversity of magma of Fuji volcano results from mixing between the differentiated magma in the shallow reservoir and magma being episodically supplied from a deep (10 to 20km) reservoir, the location of which was inferred from seismic tomography. The Unzen volcano activity that started about 0.5 million years ago was classified into three periods with distinct characteristics.

SO_2 gas emission at Miyakejima volcano was observed by satellite and airborne multi-spectral scanners (MSSs), both of which provided data coincident with those of COSPEC. The airborne MSS also employed a technique to reduce the eruptive column effect. In-SAR analyses using the data acquired by the new satellite DAICHI (ALOS) have detected overall ground deformation of many active volcanoes.

A new emission quantity observing instrument, Differential Optical Absorption Spectroscopy (DOAS), was developed. This is one-third to one-fifth the weight and size of COSPEC instruments. The development of the sensor for the chemical components of volcanic smokes enabled observation near the gas-emitting field. A system for visualizing the SO_2 distribution in an eruptive column revealed the detailed temporal variation.

3. National Project for Predicting Volcanic Eruptions

The seventh 5-year plan of the national project was proposed by the Council for Science and Technology in 2003 after reviewing the achievements of the project since 1974. The proposed plan consists of three parts: (1) Enhancement of volcano monitoring and observational research, (2) Promotion of basic research for more accurate predictions of volcanic eruptions, and (3) Improvement of the scheme for predicting volcanic eruptions.

Based on this project, universities conducted comprehensive joint volcano observations at Kusatsu-Shirane, Ontake, Asama and Usu and dense seismic-array observations at Fuji, Kuchinoerabu and Asama. Detailed structures in terms of seismic wave velocity were developed at Hokkaido-Komagatake, Fuji, Kuchinoerabu and Asama volcanoes using active seismic sources. Analyzed results suggested a high-velocity region upheaval beneath the volcanic centers. At Iwate volcano, analysis using receiver functions of far-field seismic data suggested a low S-wave velocity zone at about 30km depth. Analysis of later seismic phases in Unzen volcano seismic data revealed the magma plumbing system with magma pockets.

The temporal movement of the activity source toward the western region in Iwate volcano was detected by analyzing data of seismicity and ground deformation. A model of the magma system was inferred to consist of an intruded dyke and hydrothermal system. A magma system was indicated by seismic and geodetic data analyses at Miyakejima volcano.

University researchers conducted a challenging project incorporating observation, field and laboratory experiments, and modeling, entitled "Dynamics of Volcanic Explosion," based on a

Grant-in-Aid of MEXT (2003-2007). This project focused on elemental processes and source mechanisms of volcanic explosion, including the effects of multi-phase flow and fragmentation. This project also developed an observational robot vehicle named "MOVE."

The Japan Meteorological Agency (JMA) started to assemble monitoring data in collaboration with universities and institutions, marking significant progress in monitoring ability.

4. International Activities

Universities conducted observation research on volcanoes in Indonesia, the Aleutian Islands, Taiwan, and other areas, collaborating with foreign universities and national organizations through various agreements.

The Unzen Scientific Drilling Project (International Continental Scientific Drilling Program, ICDP) penetrated the conduit of the last eruption and collected conduit samples. These samples disclosed a conduit zone consisting of a dyke complex and revealed that the gas exclusion from magma began earlier (or deeper) than did the crystallization in the conduit. It was concluded that a slow magma ascent was essential for the effusive mode of eruption at Unzen.

Volcanological research in the ocean areas advanced under the Integrated Ocean Drilling Program (IODP) that started in 2003. For example, a large-scale young lava flow exhibiting off-ridge volcanism was found on the sea floor in the southern region of the East Pacific Rise by a scientific vessel and submersible. A model in which the distribution of volcanoes in NE Japan originated from the finger-like distribution of hot mantle within the mantle wedge was proposed.

The National Research Institute for Earth Science and Disaster Prevention (NIED) conducted research on Iwojima Caldera with USGS and research on "Development of Hazard Mitigation Methods for Volcanic Lava Flow" based on the Japan-Italy agreement with INGV. The Geological Survey of Japan (AIST) collaborates with the Geological Survey of Austria in aeromagnetic and gravitational surveys to reveal the shallow subsurface structure at Italian volcanoes. GSJ also collaborates with INGV and Italian universities to model gas emitting processes based on the observation of the volcanic eruption plume and further collaborates with the Indonesian Directorate of Volcanology and Geological Hazard Mitigation (DVGHM) to study caldera-forming eruptions in Indonesia.

As quick responses to foreign volcanic eruption, for the 2003 Anatahan volcano eruption in the Northern Marianas, universities conducted collaborative research with USGS and the Emergency Management Office (EMO) in Saipan.

Universities, NIED, and JMA conducted a group-training course held under the auspices of the Japan International Cooperation Agency (JICA). NIED dispatched a specialist to Ecuador to advance volcanic observation techniques. JMA collaborated with the Philippine Institute of Volcanology and Seismology.

The Tokyo Volcanic Ash Advisory Center (VAAC), JMA, reported volcanic ash information in the area from Kamchatka to the Philippines and contributed to safe flights of aircraft.