

Master Plan of Large Research Projects 2017 and its Future

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Science Council of Japan (SCJ) called for proposal on Master Plan of Large Research Projects, *i.e.* Master Plan 2017. In this union session, each proposal will be evaluated by SCJ members and associate members and the result will be referred when Earth and Planetary Science Committee recommends candidates for "Selected Large Research Projects".

Keywords: Science Council of Japan, Masterplan 2017, Selected Research Project

Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts

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1. The Meteorological Society of Japan

The aim of this proposal is to promote climate and earth system research in the area of atmospheric science, oceanography including sea ice, glaciology, volcanology and ecology by a dedicated aircraft observation system.

In its annual guidelines in 2013, the Working Group for Earth Observation Promotion, Subdivision on Research Planning and Evaluation, Council for Science and Technology of MEXT summarized critical scientific issues for understanding of the global change. These include circulation and budget of the greenhouse gases, cloud and precipitation processes, changes in tropospheric species, climate change in polar regions, and changes in water circulation. The necessity of establishing well-organized aircraft observation system for conducting long-term research of the global change is also mentioned. In-situ measurements by state-of-the-art instruments on board aircraft provide accurate data for estimating key parameters with high temporal and spatial resolutions, which lead to improve our understanding of the critical processes.

The expected research area in which a breakthrough is achieved with aircrafts is the mechanism of the changes in climate and earth system. The climate change, especially the global warming, is caused by changes in the earth radiation balance due to greenhouse gases such as carbon dioxide. On the other hand, aerosols are known to work to suppress the global warming but remain the most uncertain factor on the radiation balance. Response of clouds is also known to be the most uncertain factor of the climate system to the global warming. Changes in heavy rainfalls and typhoons under the global warming are also urgent issues. Since Japan has been leading the world by the sophisticated numerical modeling and the satellite observations, synergetic use of the aircraft observations with them will lead great progress of research in this area. Furthermore, Asian region remains an observational gap of aircrafts though it is the "hotspot" of aerosols including PM2.5 and greenhouse gases and most frequently experiences strong tropical cyclones, so that Japan's contribution and leadership of the aircraft observation in this region is highly anticipated. Unfortunately, among the advanced countries in the world, Japan is the only country that does not have a research aircraft dedicated to the earth sciences, which is the motivation for making this proposal.

The aircraft which we think most suitable for our research is the Mitsubishi Regional Jet (MRJ) since it has enough space to simultaneously equip several observational instruments and it can be relatively easily refurbished for equipping the instruments by taking advantage of the domestic production. The cost of the aircraft will be about 6 billion yen and the operational/maintenance cost will be about 1.2 billion yen per year.

Having an aircraft for exclusive use for earth sciences has great advantages for both types of researches which requires long-term monitoring such as greenhouse gases and agile observations of hazardous events such as typhoons, heavy rainfalls and volcanic eruptions.

The Center for Orbital and Suborbital Observations, Institute of Space-Earth Environmental Research, Nagoya University will lead the program in the framework of the "Joint Usage/Research Center (JURC)". A JURC steering committee that consists of specialists of each research area from various organizations will be responsible for the research and operational plan.

A number of international organizations, organizations and universities of foreign countries sent us supporting letters expressing great expectation of our proposal such as Japan's leadership of the aircraft observation in Asian region and international cooperation in climate system studies and

typhoon observations over western Pacific. Moreover, high precision observations of greenhouse gases by aircraft are becoming increasingly important to realize the Paris Agreement of COP21.

Keywords: Climate, Earth system, Aircraft observations, Ecosystem, Oceans, Volcano

Earthquake and volcanic eruption prediction science through integrated onland, seafloor and ocean drilling observations

-Challenge of the spatio-temporal informatics in subduction zones-

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Japan, located in a tectonically active plate convergent zone in the world, is most vulnerable to natural hazards. Subduction of oceanic plates beneath Japan islands causes water and CO₂, which are essential energy sources and materials driving the earth and life systems, absorbed in the crust. It leads to a sudden loss of life and social infrastructures caused by natural disasters such as earthquakes, tsunamis, or volcanic eruptions. Since their recurrence interval is much longer than human life, their memories and lessons are difficult to inherit. What we the scientists can contribute is to record and describe the whole process as much as possible, to construct testable models as geological phenomena, and to challenge the assessment of the urgency of these natural hazards and their forecast.

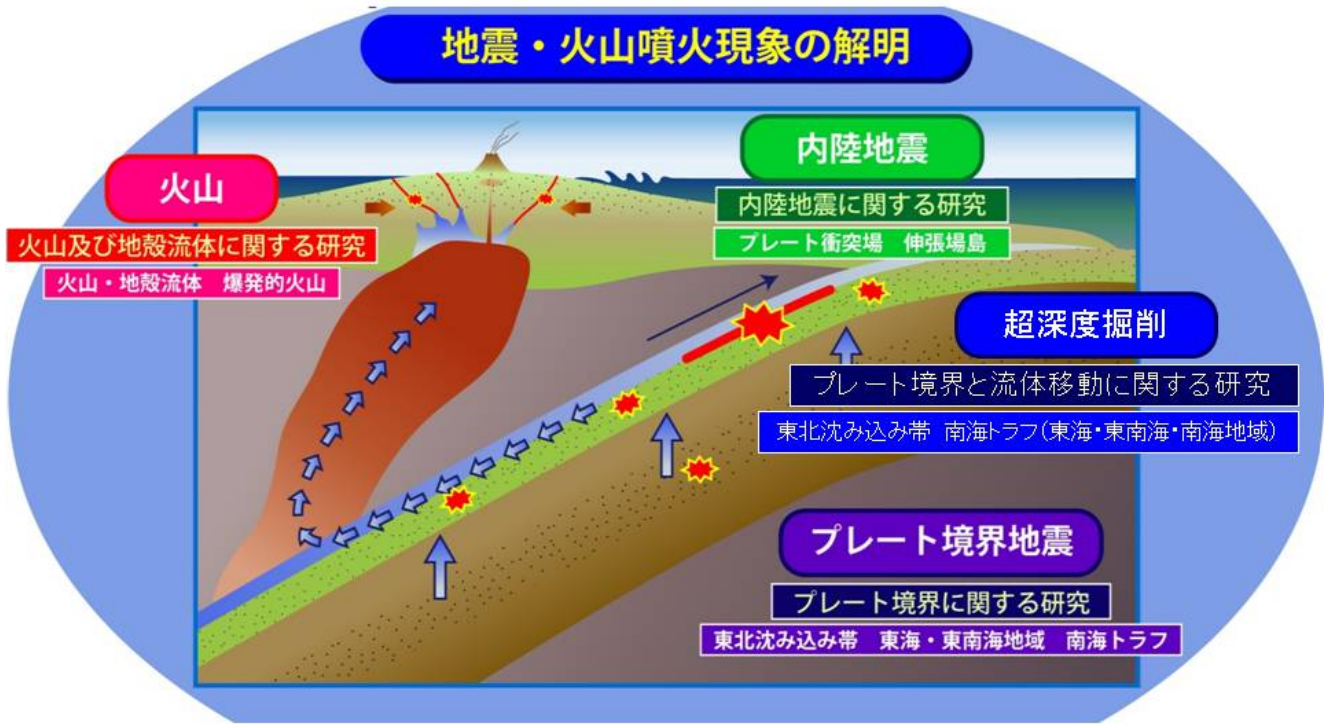
Through the installation and integration of seafloor/onland seismological and geodetic observatory network and ultradeep borehole observatories, this Master Plan attempts to understand the phenomena unique to subduction zones (e.g., formation and evolution of island arc, convergent plate interaction by means of plate motion and mantle rheology, magma formation and upwelling, earthquake cycle and fault zone coupling, physical and chemical processes related to the fluid-rock interaction and fluid migration, life, fluid and energy in deep earth, etc. These new findings are essential for uncover the secrets of earthquake and volcanic eruption, contributing to construct the physical model that serves to create a novel prediction science.

For the seafloor real-time cable network, we propose 1050 seafloor and 150 (shallow) borehole observatories connected with 21,000 km cables around Japan islands. They are installed as a complementary system with the existing networks. Onland, we propose to install ~10,000 observatories with the next-generation dense seismic and volcanic monitoring sensors. Within 5 years, we envision to have the ultradeep drilling into the Nankai seismogenic fault at 5 km below the seafloor off Kii Peninsula. We also plan to drill shallow (~1000m) boreholes in Nankai Trough off Muroto and off the Japan Trench.

The initiative for the seafloor onland observatories is taken at the Earthquake Research Institute, the University of Tokyo. The initiative for the ocean drilling project is taken at 7 leading universities and JAMSTEC, under the umbrella of J-DESC. We agreed that these two initiatives cooperate tightly through exchange of liaisons to each other.

Keywords: Prediction Research for earthquake and volcanic eruption, Earth science in subduction zones, Observatory network of earthquake and geodesy, IODP Ultra-deep drilling, YOTIKYO, J-DESC

沈み込み帯の科学：地震・火山現象の解明



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Global deployment of Deep Argo floats toward accurate prediction of future climate and ecosystem changes

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Long-term assessment and conservation of marine bio-resources are crucial in securing the global food supply. Given the present very rapid warming of global climate, however, marine environmental changes could be a very serious threat to humanity. Acidification of surface seawater and decrease of dissolved oxygen in subsurface layers have been detected recently; if these trends are significant, irreversible global/oceanic change on a longer time scale is a realistic possibility. Deep oceanic circulation plays a key role in marine environmental change. A recent numerical model suggests a global temperature change of more than 4°C and a decrease of marine biological production by 20% under conditions of weakened deep oceanic circulation. The actual features and mechanism of deep oceanic circulation are still largely unknown; comprehensive observation of the deep ocean is important in order to accurately assess the oceanic ecosystem.

The Oceanographic Society of Japan submitted a research proposal in association with 16 academic societies belonging to the Fisheries/Oceanography Research Liaison Council and the Paleontological Society of Japan. The proposal focuses on observation of turbulence in the deep sea with a turbulence sensor attached to a deep-sea Argo float (at a target depth of greater than 4000 meters) called "Deep NINJA." More than 10 floats of this type with conventional temperature and salinity sensors are currently in operation in the Southern Ocean. By deploying approximately 1000 floats, observation of temperature, salinity and turbulence will be conducted globally from the ocean surface to seafloor. The obtained data will be incorporated into a coupled atmosphere-ocean global climate model and simulation will be conducted using the leading Japanese supercomputer facility. Responses of the biological community to the reproduced paleo-environmental changes can be validated by paleontological data such as the microfossil record in sediment cores; such validation can be used to further refine the model. It is expected that far more accurate prediction of future climate, marine biological production and marine bio-resources can be achieved through the proposed research.

Keywords: Deep-sea Argo Float, Deep Ocean Mixing, Global Overturning Circulation, Climate Change Prediction, Paleo-environmental Change, Marine Bio-resources

Consortium for High-pressure Earth and Planetary Science

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We propose to create a platform for advancement of Earth and planetary sciences based on high-pressure technology combined with quantum-beam facilities, by forming a nation-wide consortium. The headquarters are to be located at the Premier Research Institute for Ultrahigh-pressure Sciences (PRIUS), run by Geodynamics Research Center of Ehime Univ., which has been functioning as the national joint research/collaboration center in high-pressure sciences since FY2013. The core institutional members of the consortium are Ehime Univ., Tohoku Univ., Univ. Tokyo, and Tokyo Inst. Tech., with some 25 major research groups in Japan. The consortium will play important roles in construction and up-grading of high-pressure beamlines at SPring-8, KEK, J-PARC, SAKULA etc., as well as in exchanges of human resources and experimental techniques among the constituting institutional members. The major scientific targets of the consortium are to understand the composition, dynamics, origin and evolution of the Earth and planetary bodies based on cutting edge technologies of high-pressure experiments, quantum-beam applications, and computational simulations. Developments of interdisciplinary sciences in Earth and planetary sciences, as well as in other research fields such as physics, chemistry, materials sciences, etc., are also important goals of the present consortium.

Keywords: high-pressure geoscience, quantum beam, consortium

Construction of a satellite Earth observation system

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Today the satellite observation systems are indispensably important for producing global and regional data sets that are used in scientific research and services of every life like weather forecasting. With increasing public concerns on the issues of climate change and environmental problems, a tight collaboration between space agencies and meteorological agencies have been promoted internationally. Each sectors of the world are making effort to establish geostationary and polar orbiter satellite systems to contribute to such coordination as in the plans by CEOS and WMO. Japanese contributions have been and are expected to be important in this international coordination, because of the advanced technologies producing unique and useful data sets from, for example, GOSAT, GCOM-W, GPM, ALOS-2, Himawari-8 and future GCOM-C, EarthCARE, GOSAT-2, and High resolution imagers. In this talk, we like to discuss the current issues of the earth observation and present ideas for future satellite system planning.

Keywords: Earth Observation, Satellite

New frontier of Earth, Space and Life Sciences pioneered by the developments of Science-oriented mass spectrometer

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So far, various mass spectrometers, which can determine elemental abundance, isotopic composition and molecular weight of macromolecules have greatly contributed to understanding of the Earth, Space and Life sciences. Above all, high-precision isotopic measurements of natural samples using sensitive mass spectrometers provide us an important clue to decipher the origin and evolution of the Earth and Planetary system. On the other hand, it is well known that many unknown/unresolved scientific issues are still remained because of technical restrictions of "general-purpose" commercially-available mass spectrometers. Therefore, "science-oriented" development of mass spectrometer has been highly desired.

Here, Osaka University, Geochemical Society Japan, and Mass Spectrometry Society of Japan collectively propose the ideas of an innovative development of mass spectrometers that are specialized for the "Scientific issues", in order to pioneer a new horizon of the Earth and Planetary Science (e.g. deciphering of the pre-solar history, Galactic chemical evolution, on-site real-time geochemistry, big-data geochemistry, and so on).

Future Earth - Towards Global Sustainability

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Future Earth is an international program towards global sustainable society through the integrated global change research and transdisciplinary studies with many social stakeholders. particularly, we emphasize the importance of international collaboration in Asia, where global environmental issues are so serious under the rapid economic growth and development in this region. High potential of natural disaster risks of this region also needs to be seriously considered which frequently cause environmental issues more seriously.

Keywords: global environmental issues, sustainability, Asia, interdisciplinary and transdisciplinary studies

Applying flying boat for promoting Geosciences

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We would like to propose applying flying boat for promoting Japanese Geoscience.

Keywords: flying boat, Large-scale Research Projects: Master Plan 2017

Study of Coupling Processes in the Solar-Terrestrial System

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We propose a project to study coupling processes in the solar-terrestrial system, focusing on the solar energy inputs into Earth's environment, and the response of the magnetosphere, ionosphere and atmosphere to these inputs. The solar energy can mainly be divided into two categories, the solar radiation, and the solar wind. The former, maximizes at the equator, generating various disturbances over a wide height range, while the electro-magnetic energy associated with the solar wind converges into the polar region. We propose to establish a large atmospheric radar with active phased array antenna, called the Equatorial Middle and Upper atmosphere (EMU) radar, in west Sumatra, under international collaboration with the Indonesian research institute. We will also participate in the construction of the EISCAT_3D radar in northern Scandinavia. In addition, we will develop a global observation network of radio and optical remote-sensing equipment from the equator to polar regions.

Keywords: Solar-Terrestrial coupling process, Equatorial MU Radar , EISCAT-3D Radar, global observation network

Integrated research of volcano dynamics with an ultra-low noise large muon detector array

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The mechanism of transport and eruption of magma from volcanoes is not well known. For example, linear, sheet-like bodies of magma which are intruded deep underground eventually transform into cylindrical shapes as they approach to near the surface. The magma may emerge as either explosive or effusive eruptions. Our detailed understanding about these phenomena would help us to better predict the eruption sequence of volcanoes, however the information that conventional geophysical surveys, such as seismic tomography or geodetic measurements, can provide is limited. Therefore, we need a more direct diagnosis method to explore the internal structure of a volcano. A new imaging technique called "muography" utilizes muons, elementary particles originated from cosmic rays, and has the capability to highly resolve the internal density profile of a gigantic object. For example, bubbly magma indicating magma convection was successfully imaged in the 2008 Satusuma-iwojima volcano observation campaign. In 2013, magma ascents and descents were successfully captured during an eruption of the same volcano. However, conventional muography provides only a 2-dimensional projection of the volcano and the time resolution is limited to 3 days. This present proposal envisages the idea of producing ultra-high-spatio-temporal resolution 3-dimensional images of a volcano by arraying an ultra-low-noise-high-positional-resolution muographic observation systems. By establishing these advanced muography technologies, advances in the imaging of underground structures, planetary geological explorations, and non-invasive inspections of historical heritages are expected. Also, we anticipate benefits to the social safety and security when these advanced muographic technologies are applied to industrial plants, such as nuclear reactors, blast and electric furnaces, and civil engineering structures.

Keywords: muon, muography, magma, volcano, imaging

Frontier of Polar Science - Study on Global Environmental Change through Development of the Antarctic and Arctic Observations -

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This plan proposes installation of a platform in the polar region in order to contribute to the understanding the global environmental change by providing invaluable information from the Antarctic and the Arctic region. Recently the global environmental change is of great interest for the governments and general public, as well as scientists on the earth and planets. The Arctic and the Antarctic regions significantly affect global environment and also provide invaluable information on its variation. In the Arctic region, for example, temperature increase due to the global warming is the largest on the globe. The climate change is most significantly emerging which causes change of ecology, human economic activity and life. On the other hand, very little is known on the response of the huge Antarctic ice sheet to the global warming, and hence a possible change in Antarctica on a global scale and its prediction are of greatest interest. Variations in the polar regions are not independent but connected through ocean and atmosphere circulations, and therefore it is necessary to consider them to be one unified system. Moreover, the Arctic and Antarctic regions are the best observation and/or investigation field for space/planetary sciences, atmospheric/hydrospheric sciences, and solid earth sciences, indicating that the polar regions are important windows for earth and planetary sciences.

Keywords: Polar Science, Antarctic , Arctic

An integrated research program elucidating the solar system environment leading the emergence of life

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By constructing the "planetary science research consortium" which integrates multiple academic sites to cooperate with ISAS and drives complementary programs on instrumental developments, human resource cultivations, and so on, multilateral researches coupled with planetary exploration missions are conducted to reveal the solar system environment leading the emergence of life. The consortium enables us to plan strategic designs of exploration missions, to realize missions and to maximize scientific returns from the missions. Accordingly, the features and their evolution scenarios of the solar system environment for the emergence of life will be revealed from various directions with factual evidences.

Promotion of direct explorations into deep space will stimulate younger generation by providing ambitious hopes and also will unveil new aspects of intellectual properties shared by all human beings. Moreover, their promotions by academic-industrial cooperation will contribute to enhance industrial innovations.

Keywords: space exploration, planetary science

Ecosystem disturbances and regime shifts due to extreme rainfall events

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Stability and predictability of ecosystems are essential for the security and sustainability of our life. In recent years, many freshwater ecosystems experienced abrupt disturbances due to extreme climate events, and some of them are yet to recover. Climate warming increases and intensifies such extreme events along with a long-lasting unidirectional forcing to ecosystems. While societal demands are increasing, there is a need for practical guidelines to assess potential damages and resilience of ecosystems in response to extreme climate events, our current understanding is limited due to a lack of observations and theories. This project, led by the Japanese Society of Limnology under the collaborations with other societies such as Japan Society of Civil Engineers and so on, aims to evaluate the impacts of extreme climate events and the unidirectional long-term climate change on freshwater ecosystems through intensive monitoring aided by social networking services. In particular, it focuses on the impact of extreme rainfall events on an array of systems with different residence times that are expected to receive different degrees of disturbance (devastating - small). The project also aims to detect qualitative changes and regime shifts in the systems associated with the unidirectional climate change through long-term monitoring. The project center is located at the University of Shiga Prefecture where observational data are sent on a real-time basis. Monitoring sites are placed on selected rivers, lakes, and marshes in all prefectures, including Lake Biwa, Oze Marshland, Otakigawa drainage system, and Monobe River, where potential regime shifts and abrupt changes are observed by society members and other local people. The increase in extreme rainfall events is a global environmental issue, and qualitative and quantitative ecosystem changes are disastrous to people all over the world. For example, floods transport local species to another area and destroy local vegetation and landscape, resulting in degradation of ecosystem services provided by *in situ* food web including microorganism, insects, and fish. If we do not have reliable data, governments cannot restore their original ecosystems after the abrupt change caused by floods. We are primarily concerned about keeping the systematic description on our environments before and after extreme events. Due to the scale and urgency, the problem should be tackled by the Japanese Society of Limnology as a responsible organization. Through this five-year project, the society organizes a collaborative network of researchers and residents, and aims to develop a system in order to release up-to-date information on the ecosystems that receive devastating disturbances.

<http://www.jslim.jp/>

Keywords: lakes, rivers, marsh, forests, resilience

Concluding remarks of the session

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A brief summary of the session and an effort and support system made for large-scale research plans in the Earth and Planetary Sciences to be adopted as the highest priority SCJ Master Plan projects will be given.

Keywords: Earth and Planetary Sciences, Highest priority large-scale research project, Science Council of Japan