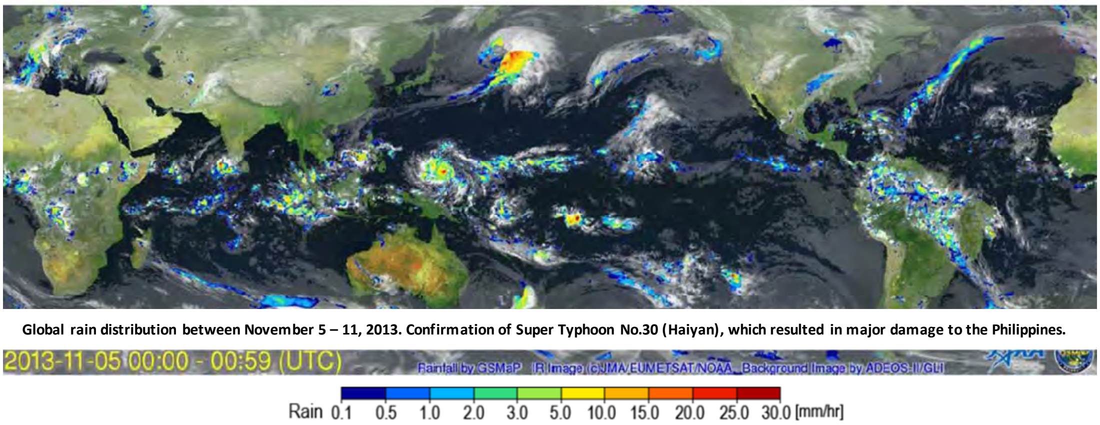
(3) Contribute to International Society

(a) Contribute to global hydrological information

Combining satellite data such as world rain distribution bulletins and images with geospatial information can contribute to timely flood warnings, drought monitoring and prediction, and glacier-induced flood forecasting in developing countries and other regions with scarce hydrological information.

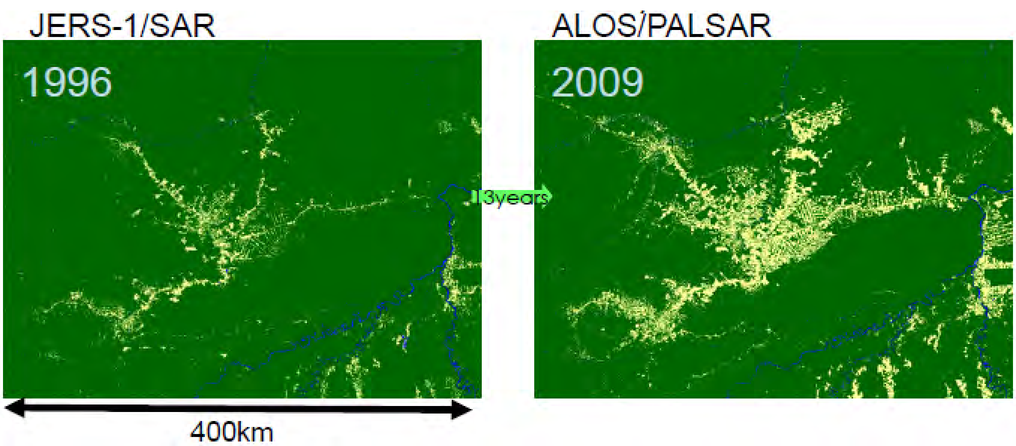
Made possible via stable acquisition of TRMM / PR late stage usage data



Global rain distribution bulletin via Global Satellite Mapping of Precipitation (GSMaP)

(b) Contribute to resolve global disasters and environmental issues

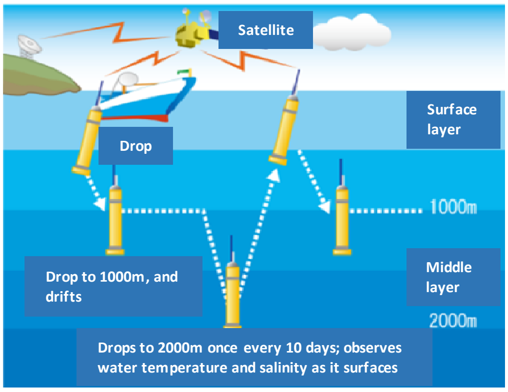
Using the International Charter Space and Major Disasters and the Sentinel Asia framework, we have provided satellite observational data for understanding the damage caused by natural disasters in Asia and around the world and for use in creating reconstruction plans. Additionally, our satellite data has contributed to reducing illegal logging in the forests of the Brazilian Amazon, to more efficient wetlands management, and to more effective World Heritage site management throughout the world.



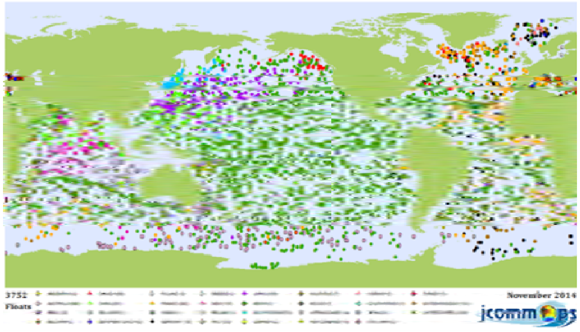
Monitoring illegal logging in Brazil via satellite

(c) Contribute to the Argo Scheme

Our nation has cooperated with international institutions and other organizations in nations around the world to maintain the observation network consisting of roughly 3600 Argo floats. We also manage Argo data from the Pacific Ocean, contributing to the international project for the real-time observation of the world's oceans.



Observation by Argo float



Floats active around the world (approx. 3,600 active as of January 2015). Japanese floats are mainly deployed in the Sea of Japan and central/western region of the North Pacific Ocean (in purple).

[Overall Review]

The past ten years have seen advancements in satellite and other observation systems, resulting in a steady flow and greater use of Earth observation data. By reflecting the policies of national and local governments and providing information to the public, observation systems have contributed to improved risk management, reducing natural and man-made risks, providing comprehensive observations/monitoring of the global environment, and mitigating damage caused by natural disasters.

Improved observational systems and the steady flow of data also contribute to expanded uses of observational data in weather forecasting, sea ice monitoring, agriculture, fisheries, and other fields. We have seen advances in operational usage for numerical weather forecasting, sea ice assessments, and ocean and fisheries information, as well as contributions to new fields such as trend analysis for grain supply and demand and continental shelf surveys. Observational systems truly contribute to socioeconomic development and improved quality of life.

Moreover, observations capitalizing on our nation's observational capabilities have exposed the degree of damage caused by natural disasters and illegal logging, contributing solutions to a variety of social issues in Asia-Pacific and around the globe. In particular, Japan contributes to international observation and data networks, including the worldwide ocean buoy network and the construction of GEOSS, which is an observation and information network system providing Earth observation and data analysis. In this way, Japan's Earth observations have helped our nation accomplish our role in international society through the advancement of international cooperation, contributing to building a sustainable society. These contributions have been recognized by the international community, encouraging greater advancements in Earth observations as a tool for science diplomacy.

3.2 Earth Observation Systems Integration

The *Earth Observation Promotion Strategy* describes the benefits of integration brought about through close coordination among relevant institutes and government ministries and sustained operations. The ideal form of this integrated Earth observation system includes important factors such as identifying needs and reflecting them in implementation policies, the cooperative use and joint management of facilities and equipment, the rational adoption of new observations, the utilization of the private sector, implementation policy transparency, publicizing results, stronger quality assessment and quality management, long-term continual observations, promotion of data sharing and data usage, and the training of the next generation of human resources.

We have conducted our review of the initiatives described below, keeping in mind the viewpoint mentioned above:

a) Establish Coordination Centers

Coordination Centers serve as a platform to collect information related to international observational needs and progress, as well as to create implementation plans. Coordination Centers promote cooperation between and among institutes and government ministries, providing a system to respond opportunistically to pressing issues. In so doing, these centers seek to promote more effective and efficient Earth observation activities. Influenced by the *Earth Observation Promotion Strategy*, the Japan Meteorological Agency within the Ministry of the Environment led a project in 2006 to establish a Coordination Center for global warming. This center embarked on efforts to strengthen institute coordination, to standardize/circulate observational data, and conduct other activities related to global warming. The center has helped advance coordination among related institutes with respect to natural disasters such as earthquakes, tsunamis, and volcanoes, based on existing frameworks.

Besides these coordination centers, institutes and government agencies are working on observational plan proposals and mutual data use in fields such as the terrestrial carbon cycle, the north polar region, and biodiversity. Here, these organizations are engaged in effective, efficient observations that incorporate the needs of the end users. Related institutes share existing facilities and observational equipment, making use of international cooperation and private sector activity to make possible the type of wide-area observations and observation categories not performed in the course of regular observations.

b) Encourage data sharing and utilization

Systematic collection of observation data, rational management, data integration, and information consolidation are crucial to the promotion of solutions-oriented Earth observation. The following initiatives have been introduced to encourage data sharing and integration, in addition to cooperative observations conducted among the institutes and government ministries mentioned above.

Earth observation data and metadata collected by Earth observation institutes, as well as data serving as the basis of geospatial and other information, represent the entryway for initiatives in database coordination and data/metadata integration to improve end user convenience, promoting cooperation across agricultural, health, hydrologic cycle, and ecosystem and other diverse fields. These initiatives include the Data Integration and Analysis System (DIAS, sponsored by MEXT), the Geographical Survey Institute’s Global Map project (sponsored by MLIT), and the GEO Grid of the National Institute of Advanced Industrial Science and Technology (sponsored by METI).

In particular, the results produced by DIAS since its inception in 2006 have facilitated the realization of platform for integrating observation data and forecast data. Archiving metadata from various data sources in a standardized format provides greater efficiency compared to widely distributed databases, providing access to necessary data in a convenient format. Moreover, DIAS is accomplishing a role in international contributions to Earth observation, connecting data centers in countries participating in GEOSS.

[Overall Review]

To date, our nation has conducted regular observations handled by operational institutes and long-term observations based on large-scale projects. We have also seen some examples of cooperation for long-term observation in the shape of shared observation

facilities, personnel, and technologies at institutes, government ministries, research and development organizations, and universities.
Coordination centers established according to the *Earth Observation Promotion Strategy* are also designed to support efficient long-term observations through government ministry cooperation.

However, many Earth observation projects conducted by research institutions in particular struggle to continue over the long term, despite the important role of monitoring observation in understanding global climate change. This is due to the fact that these projects are funded by short-term, competitive funds. One reason for this situation is the lack of distinction between observation projects intended to achieve specific, short-term objectives and those designed to gather data over a longer period. Should this situation continue, it will become even more difficult to build upon prior research results, while the lack of young researchers has made it difficult to secure a sustained source of personnel. This could eventually lead to a decrease in observation activities and research, not to mention a decline in our nation's ability to develop observation technologies and equipment and an inevitable decline in observation quality.

Moreover, stable, long-term observations require defined needs-based observation categories, technological improvements for observation accuracy and other factors, maintenance for existing equipment, and replacement of obsolete equipment. Given these considerations, we must approach Earth observation from a medium- and long-term perspective.

We have embarked on initiatives to promote data sharing and integration, making steady progress in these efforts. However, our efforts have insufficient in providing a central source for information from disparate and multiple databases at institutions. We have also fallen short in efforts to improve convenience (e.g. collect user feedback) and promote two-way information flow. We must strengthen our encouragements for data usage, improving existing initiatives through better coordination. The goal of data integration and other efforts is to encourage the use of data. Accordingly, data must be provided via a system offering easy access and manipulation, ideally reflecting principles of data science.

3.3 International Earth Observation Framework

The framework document adopted at the Second Earth Observation Summit states that a comprehensively coordinated global Earth observation system would generate social benefits across a wide range of fields. Accordingly, it behooves regions, countries, and institutes around the world to work together in linking existing or new Earth observation systems to establish a comprehensive worldwide Earth observation system.

The following are some of the international efforts implemented over the last decade based on this viewpoint:

a) Global Earth Observation System of Systems (GEOSS)

GEOSS aims to promote the use of data through the establishment of a build data network. This initiative is working to solve social problems through observational data obtained in cooperation with international initiatives in Asia and Africa, including the Asia Water Cycle Initiative (AWCI) and the African Water Cycle Coordination Initiative (AfWCCI). GEOSS seeks to address issues such as biological diversity, forest carbon, water, and food security. The GEO Biodiversity Observation Network (GEO-BON) and Asia Pacific Biodiversity Observation Network are examples of regional networks formed as part of plans to integrate monitoring of ecosystems and biodiversity carried out in various locales. In addition, researchers at institutes in Japan and around the world have been cooperating in data quality assessment/ management and database construction. As of December 2014, 184 countries and agencies are participating in GEOSS.

b) Other Global Observation Systems

The Global Ocean Observing System (GOOS) is an international global observation program actively supported by Japan. GOOS is the product of an international effort to create a comprehensive, sustained ocean observation system to accurately observe greenhouse gases, the ozone layer, aerosols, acid rain, and other atmospheric constituents of global warming. Other global projects include the Global Atmospheric Watch program (GAW), which is an international observation scheme for providing scientific data, and the Global Terrestrial Observing System (GTOS), which is a project for collecting geographic data. These programs fall under the unified Global Climate Observing System (GCOS), supporting the United Nations Framework on Climate Change through the IPCC. Other projects include the flux observation network (FLUXNET), which observes heat, water, and carbon dioxide, and the International Long Term Ecological Research Network (ILTER), which is a large-scale ecological research project responsible for long-term surveys, observations, and public database construction.

c) **Global Environment Research**

There are a number of international research programs that use the results of global-level Earth observation (as in a) and b) above) to attempt to elucidate various phenomena in the global environment. These programs include the DIVERSITAS international joint research scheme for biodiversity science, the International Human Dimension Programme on Global Environmental Change (IHDP), the International Geosphere-Biosphere Programme (IGBP), and the World Climate Research Programme (WCRP). The Future Earth (FE) initiative is another program scheduled to begin during 2015 as a new international research framework to integrate, restructure, and strengthen the coordination among these various research programs. The purpose of the FE is to build a sustainable society by encouraging researchers and other stakeholders (government, industry, media, civil groups, etc.) to reach across the traditional borders of their respective fields and specialties to work together to resolve social issues.

d) Open Data Charter

In 2004, the Organization for Economic Cooperation and Development (OECD) held the Science and Technology Policy Committee Ministerial Meeting to address open access to scientific data. This meeting led to deeper international cooperation in developing guidelines to promote open access and greater use of publically funded research and development data. The G8 summit held in June 2013 addressed the open data principles described in the Open Data Charter, which the gathering agreed to and included in the summit communiqué.

In June 2014, the Japanese Cabinet approved the Declaration to be the World’s Most Advanced IT Nation, recognizing that public data is shared national property. This declaration indicates that the use of information resources is the key to economic growth, leading to solutions for a variety of issues. As such, the nation must quickly open data to the public and develop an environment allowing users to freely combined public data for use.

[Overall Review]

Since the development of the GEOSS 10-year implementation plan at the Belgian Earth Observation Summit in February 2005, the intergovernmental Group on Earth Observations (GEO) has been holding ministerial meetings every three years to plan the structuring of GEOSS. Attendees discussed the importance of GEOSS at the G8 Hokkaido Toyako Summit of 2008 and the G8 L’Aquila Summit of 2009, with representatives declaring the need to strengthen observations, predictions, and data sharing within the GEOSS framework. Currently, the GEO debated the future of

GEOSS to receive approval for continued development activities and a new implementation plan as the program draws near the end of its original 10-year plan. These discussions addressed a number of different considerations, including stronger observation systems, observation data sharing, stronger coordination between users and policy decision makers, stronger coordination between the private sector and not-for-profit entities, coordination with developing nations (particularly capacity development). The *Earth Observation Promotion Strategy* itself was inspired by the GEO. Accordingly, it is incumbent on our nation to review the Earth observation implementation policies as part of the considerations of the next GEOSS 10-year implementation plan (responsible for the development of current activities) beginning in 2016.

We believe that promoting the wide availability and usage of public data will lead to the acquisition of new knowledge, the discovery of new industries, and better decision-making. As we considering the trends of data distribution in fields other than Earth observation at home and around the world, we must engage in strategies to accelerate the opening of data.

Rapid developments in Asia, Africa, Central and South America, lead experts to predict a significant increase in needs for Earth observation via satellite and other mechanisms. Japan must also consider how to engage complex issues such as science diplomacy and resource diplomacy.

3.4 Implementation Structure and Organization of Integrated Earth Observation Systems

In this section, we have conducted our review with an eye toward (1) functions required of an implementation structure and organization, and (2) the ideal implementation structure and organization.

[Review]

Under the implementation structure show in Figure 1, the *Earth Observation Promotion Strategy* has delivered a steady stream of results over the past 10 years. These results have included the promotion of Earth observation, the development of long-term observation systems through ministerial coordination, the promotion of multi-faceted Earth observation data usage through data integration, and the advancement of science diplomacy through stronger international coordination.

However, we face a number of important and pressing issues if we are to achieve advanced Earth observation for resolving issues, establish a clear roadmap and goals, build and promote a strategic Earth observation system via data sharing/integration, and build a platform for institutional cooperation and observation. These important issues include unifying Earth observation ventures underway in various fields, clarifying the organization responsible for headquarters functions in guiding the advancement toward solutions-based Earth observation systems, and structuring a system to deliver steady progress of Earth observation systems to resolve issues under the strong leadership of this organization.

Building a solutions-based Earth observation system requires the stable operations of Earth observation ventures that serve as foundational research and development. To accomplish this, we must secure the funds necessary for long-term observation and the maintenance a wide-area global observation network, ensure close coordination among institutes, and retain talented human resources. Given the serious budgetary constraints involved, institutes involved in observation ventures face a significant hurdle in overcoming these challenges. The related institutes and government ministries must come together to discuss what can be done in terms of cooperation in observation ventures and what form joint research projects should take.

4. Recent Developments Following the Adoption of the *Earth Observation Promotion Strategy*

Earth observation requires the clarification of needs demanding urgent action and efforts to respond adequately to those needs. While it is important to discover potential issues and respond efficiently and effectively to such issues as they manifest, it is also necessary to make strategic efforts based appropriately on changing conditions in society, science, and technology both in Japan and overseas.

Below, we summarize the various changing conditions that have occurred subsequent to the adoption of the *Earth Observation Promotion Strategy*.

4. 1. Changing Social Conditions

a) The progress of globalization, and the increasing occurrence of disasters and other events that threaten the sustainability and welfare of the human race

The large-scale floods in Thailand (2011) created a clear awareness in our nation of the enormous impact that natural disasters in other countries can have on our own economy when such disasters disrupt supply chains or cause other economic problems.

Over the past several years, we have seen major news accounts addressing the issue of transboundary pollution and its impact on our air and oceans. It is no longer sufficient to leave nations to monitor their own domestic situation; today we must engage in global monitoring to meet these challenges.

Amid the progress of globalization and the increasing interdependency of a global economy, disasters in other countries are no longer simply somebody else's problem. To ensure the public's ease of mind and security, develop economic society and improve quality of life, contribute to international society, and ensure the sustainability and welfare of the human race, we must build resilient societies without drawing distinctions between developing and advanced nations. As well, we must recommit to Earth observation as the foundation that will bring about this result.

The advancement of globalization means that we can no longer separate the deep interrelationships among ensuring the public's ease of mind and security, developing economic society and improving quality of life, and contributing to international society—three strategic priorities set forth in the *Earth Observation Promotion Strategy*.

b) Emergence and Impact of Climate Change

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report published between 2013 and 2014 states, "Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history….In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans…Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems." The Assessment Report also provides that, "Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks…Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself."

Today, proposals for climate change mitigation and adaptation represent serious policy issues. The Central Environment Council Global Environment

Subcommittee convened in Japan in July 2013, where several expert committees were established, including the Expert Committee on Climate Change Impact Assessment. Deliberations were also introduced to discuss assessing the impact of climate change on Japan with an eye toward an overall government adaption plan (temporary name) in response to the impact of climate change. In March 2015, the Minister for the Environment solicited comments in response to "Report and Future Issues of Climate Change Impacts Assessment in Japan."

c) Earth Observation in Japan

Although China and India have launched their own satellites in recent years, data sharing among countries has only become more difficult. Developing nations that have enjoyed the support of Japan in the past are now launching satellites every bit the equal of our nation, making use of funding that appears to be easily available in abundance. At the same time, budget constraints make it more difficult to produce excellent research results at a time when sharing data obtained through the support of our nation has become so challenging.

d) Development and Review of Basic Plans Closely Related to Earth Observation

Since the adoption of the *Earth Observation Promotion Strategy*, Japan has created and revised government closely related to Earth observation of oceans, space, disaster prevention, and the environment, reflecting a widely building awareness of the importance and critical nature of Earth observation.

For example, the Basic Plan on Space Policy (January 2015) and the Basic Plan on Ocean Policy (April 2013) pointed to the importance of Earth observation in responding to global issues such as resources, energy, climate change, the environment, food, security, disaster prevention, and disaster countermeasures. The Basic Act on the Advancement of Utilizing Geospatial Information (March 2012), the Basic Disaster Management Plan (January 2014), and the Basic Plan for National Resilience (June 2014) all point to the importance of promoting research and observation for earthquakes, tsunamis, storm and flood damage, volcanic disasters, and snow damage. Further, the Basic Environment Plan (April 2012) addressed the importance of continuing to gather a wide range of information, as well as building an associated support foundation.

Japan's National Adaptation Plan (temporary name), which addresses the impact of climate change, and the Basic Plan on Water Cycle Policy are scheduled to be adopted during 2015. These policies are expected to make further contributions to

Earth observation for understanding the global environment and providing general management of the water cycle. Policy makers are currently deliberating the 5th Science and Technology Basic Plan looking ahead to 2016, while Earth observation as a contributor to solutions for social issues through science and technology innovation is rising in importance.

4.2 International Fields to Which Earth Observation Contributes

a) Global Integration and Data Sharing (Global Earth Observation System of Systems – GEOSS and Other Programs)

A number of different initiatives are under way to build comprehensively coordinated observation systems for effective and efficient global observation.
As noted in 3.3 Overall Review, deliberations are in progress at GEO regarding the future of GEOSS, which should receive approval for continuing development activities and a new implementation plan as the first GEOSS 10-year plan comes to a close.

Moving forward, there are numerous factors that will take on added importance, including improved Earth observation systems, the promotion of observation data sharing, better collaboration between users and government policy makers, better collaboration between the private and not-for-profit sectors, collaboration with developing countries, and particularly the strengthened capacity for development.

b) Stronger Coordination between Observation and Research (Future Earth, etc.)

We are witnessing the progress of initiatives designed to utilize scientific research through inter-disciplinary coordination for solving global-scale issues. Earth observation data serves as basic information for this research, requiring even greater levels of coordination between observation and research.

The Future Earth Initiative was announced at Rio +20. The International Council for Science (ICSU) is the main body guiding the progress of Future Earth. Inter-disciplinary coordination is one factor necessary to contribute to the construction of a sustainable global environment. At the same time, stakeholders from national and local governments, international organizations, development support institutes, and industry must be a part of this process, collaborating to create new knowledge. The pursuit of environmental preservation and sustainability locally and globally is one characteristic feature. Earth observation data will be extremely important as a source of basic data for building a sustainable global environment.

As with Future Earth and other global movements demanding solutions from science and research, we question the role and format of Earth observation. How should we accumulate, share, and use observation data? Will Earth observation evolve to influence the entire concept of observation itself? We must develop new ways of thinking not bound by conventional Earth observation strategies.

c) Responding to Global Issues (Sustainable Development Goals)

Policy makers are engaged in active debates over the reducing the risk of disasters, engaging in sustainable development, responding to climate change, and other similar international efforts aimed at solving the global-scale issues that we face today.

At the United Nations Conference on Sustainable Development (Rio + 20) held in Brazil in June 2012, delegates reached an agreement to begin development of Sustainable Development Goals (SDGs). SDGs are goals integrated into international development goals (post-2015 development agenda), taking over for Millennium Development Goals (MDGs) scheduled to be completed during 2015. SDGs meet the three pillars of sustainable development (economic, social, and environmental) and are scheduled to serve as universal goals for both advanced and developing nations.

Moving forward, policy makers believe that Earth observation in particular will play an important role in international strategies related to SDGs and environmental protection. SDGs are numerical targets, subject to ongoing monitoring, evaluation, and projections. As such, it is important to incorporate policies that ensure the achievement of SDGs.

The city of Sendai was host to the Third UN Conference on Disaster Risk Reduction in March 2015, where delegates adopted the Sendai Framework for Disaster Risk Reduction (post-HFA). This framework declared that access to early warnings and disaster risk information mitigates the scale of damages in the wake of a disaster. Delegates cited the importance of understanding disaster risks, facilitated through priority actions that include data collection, data analysis, data management, data utilization, and the use of geospatial information. France is scheduled to host the 21st Conference of Parties (COP21) to the United Nations Framework Convention on Climate Change at the end of 2015. There, delegates are expected to ratify a new international framework for measures against global climate change and global warming for 2020 and beyond.

The fields of science and technology are expected to contribute to the advancement of these measures, and Japan’s international Earth observation strategy will also play an important role.

4.3 Scientific Development and Technological Innovation

Dramatic advancements in information technology have led to the widespread use of information systems in corporate activities and private consumer settings. The pace of informatization in society is progressing more rapidly each day. More recently, Big Data (massive amounts of diverse data from across numerous sectors) has gained attention for its potential to uncover new knowledge and insights that may potentially lead to scientific discoveries and solutions to social and economic challenges.

Earth observation and global environmental research are producing ever-increasing amounts of data leading to improvements in observations and spatial and temporal models. Creating new knowledge through combinations of socioeconomic data, as well as other diverse data and information will contribute not only to social innovation, but also to foundations support judgments in the decision-making process. We would be wise to consider the ideal role of Big Data in *Earth Observation Promotion Strategy* policies.

DIAS is a program advanced by MEXT as a foundation for integrating global environment information. This program stores massive amounts of observation data (atmospheric, geographic, oceanic, anthropogenic, etc.) and data used to model climate change forecasts, combining, integrating, and analyzing this data to uncover and propose solutions to user needs. MEXT believes the DIAS program will serve as an effective means for building mechanisms to use Big Data obtained from global observations effectively for practical social benefits. In pursuing this program, Japan must consider how to construct an efficient and effective national system, bearing in mind the opportunities to link together and use varied foundational data sources, including the World Data System housed in the international program office of the National Institute of Information and Communications Technology (NICT).

4.4 Advancements in Observation Technologies

The world has seen increases in satellites and observation targets, as well as technological advancements in time and space resolution that have spurred gains in sensor resolving power for satellites and other equipment. Compared to the past, we now have access to information on the micro scale. These advancements have changed the scope of data collection and usage. Locations that could only be observed on site in the past can now be observed by satellites, generating valuable and useful data.

Both observational data and numerical models are important to the process of elucidating phenomena targeted by Earth observation. However, advancements in data assimilation technologies have resulted in improvements in the accuracy of simulation models based on observational data. Conversely, the use of simulation models can compensate for insufficiencies in observational data (geographically limited, fluctuations in observational intervals) to facilitate the design of effective observational networks. To ensure that the progress of these technologies satisfy social needs and lead to practical solutions, we must look at the traditional combinations of observation technologies with a fresh, discerning eye.

5. Conclusions

5.1. Accomplishments Over the Past 10 Years

To date, our long-term implementation of Earth observation efforts has led to numerous successes to (1) ensure the public's ease of mind and security; (2) develop economic society and improve quality of life; and (3) contribute to international society, as discussed in Section 3 above.

In more specific terms of ensuring the public's peace of mind (1), Earth observation technologies have been systematized to provide data to the Cabinet Office and other Japanese and foreign disaster prevention and preparedness organizations. This data includes disaster event and recovery status information for major natural disasters such as the Great East Japan Earthquake. Steady streams of satellite observational data are now used to understand conditions on the ground during disasters, as well as allow for continual observation of sea ice, sea surface temperatures, water vapor, precipitation, and soil moisture. Advancements in the Earthquake Early Warning System and observation network for torrential rains has made it possible for us to observe natural disasters. These advancements have led to significant developments in our comprehensive understanding of water cycle change, climate change, and natural disasters, while providing greater weather forecast and flood prediction accuracy. The combination of observational data for air, land, and ocean (including local observation via satellite observation and aircraft) has made it possible for us to collect quantitative measurements of absorption and dispersion of CO_2 on a global scale.

In terms of developing economic society and improving quality of life (2), we have seen continued and more sophisticated operational usage of satellite observational data, leading to advances across a wide variety of fields, including numerical weather prediction, typhoon analysis, sea ice monitoring, northern sea route numerical forecasts, and other meteorological, climate forecasting, and ocean monitoring services. At the same time, ocean surface temperature and other ocean data are used regularly to produce fisheries information that contributes to more efficient fishing vessel operations.

In terms of contributing to international society (3), we see that our nation's Earth observations have contributed to reducing illegal logging in the Brazilian Amazon, to improving World Heritage Site management around the world, and to better wetlands management. Further, we have leveraged the frameworks of the International Disaster Charter and Sentinel Asia to provide satellite observational data useful in understanding repercussions of natural disasters in Asia and other regions, cooperating with the society of nations as our data is used in proposing recovery plans and other projects.

We are engaged in efforts to utilize the data obtained for data and metadata integration to improve efficiency for data end users, as well as to coordinate government and institutional databases such as DIAS (METI), the Global Mapping Project (MLIT/GSI), and the GEO Grid (METI/AIST).

As a gateway to advance coordination among agriculture, health, water cycle, ecosystems, and other fields that use these databases, we have made progress in collecting metadata for Earth observation data acquired by Earth observation institutes, as well as in developing data that serves as the basis for geospatial information.

The preceding are what we believe to be the major achievements over the past 10 years since the adoption of the *Earth Observation Promotion Strategy*.

5.2 Challenges to Overcome in the Next 10 Years

Earth observations are observations related to physical, chemical, and biological properties, as well as the functions of our atmosphere, oceans, geography, and the interior of the earth. These observations serve as fundamental data for gaining a comprehensive understanding of the current condition of the earth and for future forecasts.

To date, Japan's continued long-term Earth observation efforts have produced numerous beneficial results. The *Earth Observation Promotion Strategy* was first established with the understanding that "massive natural disasters have occurred with alarming frequency, threatening people's ways of life. The results of wide-ranging and large-scale human activities are beginning to be witnessed across the globe in the form of transboundary dispersal of pollutants, climate change, the extinction of species, exhaustion of resources, and other phenomena." Since then, however, the advancement of globalization and heightened mutual economic interdependence has made foundational global observations all the more important for the ease of mind and security of our citizens, for social economic growth, and for the sustainability and welfare of humankind.

The following outlines the challenges that we must overcome over the next decade to ensure the ease of mind and security of our citizens, social economic growth, and the sustainability and welfare of humankind.

a) Formulate responses to pressing social needs

Since the Great East Japan Earthquake, the citizens of Japan have shown a greater concern with the risks of earthquakes, tsunamis, and other disasters. Besides earthquakes and tsunamis, citizens need information related to localized torrential downpours and resulting floods, landslides, volcanic eruptions, and other disasters. To date, Japan has attempted to leverage leading-edge technologies to create observation networks for capturing data at the earliest stages to provide warnings. While these efforts are intended to maintain our economy and contribute to the public's ease of mind and security, recent increases in extreme weather events across the globe have given rise to fears of what could happen when we are unable to forecast such disasters. Global warming has become yet another such risk attracting a great deal of concern. Climate change and other long-term environmental shifts can lead to abnormal weather, extreme weather-related disasters, and the loss of biodiversity. Once these shifts have occurred, there is no path to recovery. We must exercise consistent and sustained monitoring of medium- and long-term shifts and the impact of these shifts, quickly detecting signs, forecasting changes, and taking action for the future.

b) Contribute Earth observation data to resolve policy issues

As we engage in measures to fight climate change, protect biodiversity, and implement global policies that address both of these issues, we see the important role of Earth observation in providing scientific knowledge to serve as the basis for legal frameworks and initiative discussions. For example, Reducing Emissions from Deforestation and Forest Degradation (REDD+) requires basic forest data in order to manage and preserve forests, as well as to validate the effectiveness of REDD+ efforts. In another example related to biodiversity, the evaluation of the progress of the Aichi Biodiversity Targets as agreed in the 10^{th} Convention on Biological Diversity and assessment of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) require baseline data related to the deterioration, preservation, and recovery of biodiversity and ecosystem services.

In recent years, the phrase "ecosystems services" has come into use, meaning the benefits that humankind receives from the existence of ecosystems. These services include, for example, the availability of food and water, services that regulate stable climate conditions, cultural services, and more. Some are attempting to measure ecosystems services in terms of systems that provide a quantitative value to the public. In the future, we expect to see this valuation play a role in decision making for development and preservation. In assessing the value of these ecosystem services, long-term sustained observational data will be used to define and measure categories and indicators.

c) Promote data utilization and develop capable human resources

Over the past several years, regular consumers have had access to various process-level data via mobile devices. The advancement of new technological innovations across a wide range of fields has expanded the use cases of Earth observation data to a degree not considered when first drafting the *Earth Observation Promotion Strategy*. Furthermore, we must consider how to provide Earth observation and other data to those individuals who have challenges in using information and communications technologies.

To centralize observational data and related output models for public and private use, we must discuss and decide how to archive this data, how to create value through data integration, and how to promote the usage of data in sectors not presently availing themselves of it. These discussions must include considerations of sharing research outcomes, open science trends, the promotion of mutually beneficial data usage, and the public use of DIAS and other basic data.

We must also promote greater coordination of observation and research being conducted at various institutions. This coordination will require human resources capable of serving as mediators between research and society.

d) Implement long-term, continual Earth observation

The long-term, continual Earth observations to date have led to positive results in our abilities to ensure the public’s ease of mind and security, to develop economic society and improve quality of life, and to contribute to international society (as discussed in Section 3). Long-term, continual satellite, ocean, and geographical observations are also vital to overcoming the issues described in a) through c) above.

As society and our environment change, we must consider policies as part of government and institutional operational monitoring pointing to important observational categories that ensure long-term, continual Earth observations. In particular, we must provide answers to pressing social needs while accumulating data. We must promote strategic initiatives that tie this data to more meaningful results. To accomplish this, we will implement measures to assess the necessity of existing observation categories and the level of contribution to issue resolution. We will also work to uncover new observation categories. Once our nation has identified the observation categories that we should track long-term, we then need to secure the appropriate observational structures and systems.

e) Increase collaboration between disciplines, furthering the engagement of a diversity of stakeholders, and develop human resources capable of facilitating these relationships

In using observational data for the benefit of society, we see many applications in forecasts and real-world social fixes via models that use Earth observation data in particular. Secondary research outcomes to date include determining the correlation between human activity and Earth observational data, as well as analyzing/forecasting socioeconomic impact of humankind based on Earth observational data. These outcomes are useful for research and development/international contribution related to urban development and environmental preservation. However, we must also develop human resources capable of advancing technological development that connects Earth observational data with our society if we are to see practical contributions to strategic business planning, consumer products, and technological development plans.

Contributing to issue resolution, in particular, requires the participation of not only researchers, but also of a wide range of stakeholders representing government, industry, and private citizens. These are the conduits through which we share the knowledge of science to society. We must develop human resources capable of performing Earth observation—individuals who focus on contributing to social growth, who embrace a transdisciplinary viewpoint, and who build mechanisms that lead to the benefit of society. At the same time, these individuals need to be able to facilitate the profitable use of these mechanisms by a wide variety of end users.

f) Develop Earth observation that contributes to science diplomacy and international cooperation

When considering Japan’s future and our future generations, we understand the importance of demonstrating international leadership by contributing our nation’s resources to Earth observation and data utilization/research. We also understand the importance of advancing strategic initiatives in order to be recognized as a trustworthy partner by the other nations of the world. Given this understanding, we realize that, while our *Earth Observation Promotion Strategy* is currently specialized in Asia and Oceania, we must reconsider this strategy in light of global affairs. We should include contributing to Africa and South and Central America, expanding our sphere of influence and assisting in solving regional problems through Earth observations. We must also develop human resources capable of making these contributions.

Since adopting the *Earth Observation Promotion Strategy*, we have seen a dramatic increase in Asian nations funding their own Earth observation seeking to improve their national observation capabilities. While our policy in the past has largely consisted of providing support, it is time for us to revisit our policies of cooperation with other nations, given this improvement in their observational capabilities.

g) Drive science and technological innovation through Earth observation

Promoting international cooperation in Earth observation is important in terms of both science diplomacy and science and technology innovation. International cooperation is a gateway to observational data and research outcomes not obtainable through our nation's individual efforts. At the same time, international cooperation makes possible those structures that allow for long-term observation.

We also believe that promoting Earth observation research ahead of the rest of the world will lead to a sustainable society and a stronger contribution to our nation's industrial competitiveness. Accordingly, we must make steady progress in environmental technology innovations based on Earth observations and related data reflecting the integration of advanced Earth observation geostationary satellites, Earth observation data produced by supercomputers, and simulation technologies.

Furthermore, we understand that promoting science and technology innovation requires the integrated utilization of data that has been gathered for a variety of purposes. Examples of such integration include linking data gathered from Earth observation satellites, communications satellites, and geodesic satellites.

5.3 Future implementation policies and implementation structures for Earth observation

This review has provided a summary of progress based on the *Earth Observation Promotion Strategy*. We have prepared this review to contribute to considerations of implementation policies for our nation, reflecting the new 10-year implementation plan for GEOSS beginning in the year 2016. At the same time, we have also endeavored to reflect the content of the 5th Science and Technology Basic Plan and other policies.

Future Earth observation implementation policies and implementation structures must include functions as detailed below, if Earth observation is to contribute to the proper development of science and society. These functions must reflect the importance and characteristic features of Earth observation, the current state of our nation's Earth observation, the ideal future direction of Earth observation, and international trends related to Earth observation.

A. **[The role of the Earth Observation Promotion Committee]**

The Earth Observation Promotion Committee is organized under the MEXT Council for Science and Technology, as provided in the *Earth Observation Promotion Strategy*. This committee serves as a comprehensive promotion organization for creating annual policies with respect to Earth observation promotion, Earth observation systems, and international contributions. It works in close cooperation and coordination with related institutions and government ministries. Ten years have passed since the adoption of the *Earth Observation Promotion Strategy*, and the contributions of Earth observation to solutions for social problems is more important than ever. The task of the Earth Observation Promotion Committee is to take a big picture view of the path from observation to solutions, strengthening its functions and acting in a flexible manner.

The Earth Observation Promotion Committee is responsible for correctly understanding the seven Challenges to Overcome in the Next 10 Years (see Section 5.2), producing Earth Observation Implementation Policies for Japan covering the next decade. We regard this as a replacement of the implementation policies set forth under the original *Earth Observation Promotion Strategy*. The Earth Observation Implementation Policies for Japan should reflect new trends in Earth observation in Japan and around the world, as well as changes in the social condition, proposing initiatives to pursue over the medium and long term. Accordingly, we have revisited the current policy of annual across-the-board strategy revisions. Instead, the Earth Observation Promotion Committee will take the lead in revising policies on a three- to five-year basis, having ascertained the timing of new trends and developments related to Earth observation.

Meanwhile, the annual implementation plan provided under the *Earth Observation Promotion Strategy* will be addressed annually in accordance with the Earth Observation Implementation Policies mentioned above.

B. **[The role of the CSTI]**

The CSTI receives reports from the Council for Science and Technology (Earth Observation Promotion Committee) as needed to understand implementation policies and the progress of ventures based on these policies. The CSTI also receives reports from relevant institutions and government ministries to perform a comprehensive assessment and to follow up on the operational status of Earth observations.