Chapter 10

Japanese Satellite Earth Observation: Status and Policy Issues

Teruyuki Nakajima

10.1 Introduction

The global Earth observation satellite system has continually progressed and evolved, with the development of international meteorological frameworks such as the World Weather Watch (WWW) and Global Atmospheric Research Programme (GARP) in the 1960s; with increased awareness of the global climate and environmental problems, thanks to NASA's Mission to Planet Earth, the European Space Agency's (ESA) ENVISAT, and JAXA's ADEOS/ADEOS-II satellite programs; the Global Climate Observing System (GCOS) in the 1990s; and the implementation of the UN Framework Convention on Climate Change (UNFCCC), the intergovernmental Group on Earth Observations (GEO), and others from the 2000s. This progress is linked to various policy mechanisms, both in terms of program development and the utility of remote sensing results and applications. This article discusses some important aspects of current issues related to Earth observation policies.

10.2 Development of National Satellite Earth Observation Programs

JAXA has operated 20 Earth observation satellites in total, four of which (GOSAT, GCOM-W, GPM, and ALOS-2) remain operational in 2016. After enactment of the Basic Plan on Space Policy, Japanese national space utilization planning has been governed by the Space Policy Committee (SPC) of the Cabinet Office. The SPC has

T. Nakajima (✉)

Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA),
2-1-1 Sengen, Tsukuba, Ibaraki 305-8505, Japan
e-mail: nakajima.teruyuki@jaxa.jp

Fig. 10.1 National Earth observation work plan

identified seven new governmental priorities: positioning, remote sensing, communication/broadcasting, space science, human space activity, space solar power, and space transportation. The SPC also determined the national Earth observation work plan (CAO 2016) shown in Fig. 10.1. Geostationary meteorological satellites (the Himawari series), greenhouse gas observation satellites (the GOSAT series), and advanced optical and SAR imaging satellites for Earth surface monitoring have been approved. There is, however, currently a serious gap in capability after 2022 for other remote sensing categories, though it should be noted that the SCP will begin investigating a plan for a GCOM-W follow-on mission from the 2016 fiscal year.

In contrast, other countries have been very active in planning new Earth observation missions. There are now more than 150 satellites planned to contribute to global climate change and environmental initiatives, such as the European Commission (EC) Copernicus program, the UN Global Framework for Climate Services (GFCS), and others.

In this situation, it is important to have a strategic vision and satellite build program for the 2020–2040 period. A new trend for this period will be a close collaboration between space agencies and weather/climate agencies, illustrated by the collaboration between ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in the Copernicus program, and the collaboration between NASA and the National Oceanic and Atmospheric Administration (NOAA) in the Joint Polar Satellite System (JPSS) program. China and Korea are also very actively planning capabilities for this period.

It is therefore a matter of urgency for Japan to reinforce its national Earth observation satellite planning to support the growing challenge of understanding and contributing to solutions for global climate change and other related environmental problems. There has been no high-level national platform in the Cabinet Office for professionals to discuss and manage such huge requirements and to chart the path for the development of capabilities. A subcommittee for Earth observation under the SPC should be established.

Another important activity for enhancing national Earth observation planning in Japan is to strengthen the bottom-up planning by academic organizations. From 2014, the Science Council of Japan (SCJ) established the Earth Observation Sub-Committee under the Earth and Planetary Science Committee. In 2013, the Remote Sensing Society of Japan started a Task Force Sub-Committee for discussion of future space development. The Task Force now comprises more than 20 societies/associations. The SCJ and Task Force discussions and commendations indicate that national Earth observation satellite missions have contributed to research and social services and that Japan should continue to develop various applications for cutting-edge science and service of society. It is important to also note the high citation index and H-index of scientific papers related to Earth observation satellites.

Figure 10.2 shows the ‘dream’ roadmap toward 2050 proposed by the SCJ (2014). It is significant to find that the research community identifies a need for Earth observations across all periods to inform scientific investigations and provide services for society, in areas such as cloud and climate systems, as well as disaster prevention, among others. Related issues for making observations useful are development of various systems to enable maximum use of observation data and models for climate projections, accurate forecasting of severe weather phenomena for disaster prevention, and other applications, as raised also by the International Council for Science (ICSU) Future Earth Initiative. One of the future directions is to build combined applications of Earth observation and Earth system modeling, including human dimensions and associated High Performance Computer Infrastructure (HPCI).

There are many requirements for sustained Earth system observations from space, necessitating strong international coordination through groups such as the Committee on Earth Observation Satellites (CEOS), GEO, and the World Meteorological Organization (WMO). At the same time, space agencies must strive to reduce costs, extend mission lifetimes, and seek effective collaboration with the business sector. Such efforts can help humanity achieve affordability of sustained and critical observations of the Earth from space, for both research and societal applications.

Fig. 10.2 The ‘dream’ 2050 roadmap of the SCJ for atmosphere and hydrosphere sciences (SCJ 2014). *Coupled modeling includes problems related to mesoscale weather and cloud system resolution; aerosols, chemistry, turbulence/cumulus/gravity wave parameterizations; whole atmospheric modeling; ocean hierarchical structure modeling; and water cycle coupling. Observation and monitoring for this period includes Earth surface observation networks [weather stations, mesosphere-stratosphere-troposphere (MST) radar, marine radar, buoys]; aircraft and ship-based monitoring (including radioactive material); satellite-based measurements (of clouds, winds, temperature, water vapor, precipitation, greenhouse gases); long-term reanalysis of climate data; intensive regional observations (cloud radar, sondes, etc.); Asian biodiversity observations; Antarctic and Arctic ice core analysis, next-generation core technology; and measurements of solar conditions. **Human and Earth system modeling includes cloud system resolution/modeling; cloud microphysics, radiation, boundary layer turbulence processes, wave hierarchical structure, material transport and diffusion; ocean inter-process interaction; ecosystem–water cycle interaction; and information provision. Observation and monitoring required for this period includes multi-element and comprehensive observation networks (aircraft, radar, multi-function LIDAR, sondes, ground stations); adaptive observations (severe weather, transboundary pollution); global and coastal ocean observations (tsunami, radar profiling, buoys, environmental sample analysis); improvement of global low-Earth orbit/geostationary satellite observations (of clouds and aerosols, greenhouse gases, the water cycle, marine life, vegetation); global ice core sampling; middle atmosphere monitoring (of the ozone layer, noctilucent clouds); all water cycle processes; a geospace observation system; and a solar-terrestrial correlation measurement system. ***Human, Earth and solar-system modeling includes cloud and turbulence resolution/modeling and hydrology, marine flux, and solar activity process modeling. Observations required in this period include: those related to understanding geospace–atmosphere–human activity interactions; monitoring using networks of meteorological, hydrological, and ecological systems with adaptive pluralistic monitoring and operation; steady operation of satellite observations of the water cycle, climate change, and whole atmospheric layers; monitoring of abrupt and abnormal marine phenomena; comprehensive management of spatial and temporal variabilities of the marine ecosystem and resources; and Antarctic grid drilling and planetary ice sheet drilling.

10.3 Development of Earth Observation Products and Applications

Mitigation of and adaptation to the changing climate and environmental problems will continue to be a priority application of national Earth observation programs. The EC’s Copernicus program, which aims to secure operational Earth observation satellite data for climate and other services, is a good example. Another feature is the emergence of open and free Earth observation data policies that promote climate services and businesses for social applications.

Japanese efforts to actively use Earth observation data to address societal problems are not strong. In response, JAXA has enhanced the multi-satellite research activities of the Earth Observation Research Center (EORC) in important areas such as disaster prevention, ocean monitoring, water cycle/resource management, atmospheric monitoring, infrastructure monitoring, climate system/radiative process studies, ecosystems, agriculture, and public health (Fig. 10.3). Programs use data from the Advanced Himawari Imager (AHI) on board the world’s first third-generation geostationary satellite, Himawari-8, thanks to a collaboration with the Japan Meteorological Agency (JMA).

Fig. 10.3 The crosscutting research fields of JAXA’s EORC

Monitoring sea surface temperature (SST) and sea ice coverage using AMSR-2 (GCOM-W imaging radiometer) is useful for weather forecasting and climate projections. The Global Satellite Mapping of Precipitation (GSMaP) initiative produces a high-precision, high-resolution global precipitation map using data from multiple satellites, including microwave imagers and the core radar instrument of the Global Precipitation Measurement (GPM) mission. Satellite monitoring systems have proven especially useful during serious natural disasters, such as the flooding of the Kinu river, increased volcanic activity in the Hakone mountains, and the Kumamoto earthquake. As a result, Japanese society is increasingly interested in satellite monitoring. It is important to recognize that improved communication and data dissemination networks have amplified this interest.

Long-term time series of emissions of various short-lived atmospheric components can be obtained by integrating atmospheric chemistry transport models with such space technologies as Ozone Monitoring Instruments (OMI), Microwave Limb Sounders (MLS), Tropospheric Emission Spectrometers (TES), and Measurements of Pollution In The Troposphere (MOPITT) (Miyazaki et al. 2015). Column loadings of Long-Lived Greenhouse Gases (LLGHGs) have also been observed by GOSAT and OCO-2. This has increased our ability to accurately monitor global LLGHG emissions from human activities and to take collective action for their reduction through UNFCCC mechanisms such as Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) for carbon monitoring and attribution. A recent study (Turner et al. 2015), for example, showed that the U.S. Environmental Protection Agency (EPA) inventory of methane was underestimated in the North American continent. Shortening the cycle of data assimilation and inversion will change the strategy for controlling the enforcement of LLGHG emissions and air pollutants subject to control by the UNFCCC and the Climate and Clean Air Coalition (CCAC). Such accelerated construction of the emission inventory can yield new strategies for building co-benefits for climate and public health by combining monitoring data and atmospheric chemistry modeling.

Observations using the L-band SAR instruments PALSAR and PALSAR-2 have enabled JAXA to undertake accurate global-scale forest monitoring. One example, 1200 km² of observations over Brazil from 2009 and 2014 (by ALOS and ALOS-2, respectively) revealed a total deforestation area of 25 km² for the region of interest. ALOS-2 has also observed the crustal movement of the Hakone area caused by volcanic activity and landslides from the earthquakes in Nepal and Kumamoto. Data have been provided to local governments and authorities (in support of disaster response actions) through national channels and the International Charter on Space and Major Disasters.

Recent progress in SAR technology has even made it possible to monitor subsidence of reclaimed land. Time series interferometry quantitatively visualizes deformation that reveals subsidence area over monitored structures. The results

show good agreement between interferometry and ground measurement data within 11.5 mm root mean square error. Such a capability can lead to new infrastructure management and city planning services. This feature is especially important for Japan, as authorities work to investigate and replace old infrastructure developed in the high growth period of the 1960s and 1970s.

10.4 Conclusions

There is a global trend of expanding Earth observation satellite program planning for the 2020–2040 period, but Japanese plans for this period are not well established. The space work plan in the category of other remote sensing is not yet determined beyond 2022 as shown in Fig. 10.1. This category includes important satellites from which useful data are obtained for cloud microphysics, Earth radiation budget, vertical stratification of atmospheric constituents, and others to improve Earth system and environmental models. It is therefore necessary to enhance Japan's national Earth observation program planning process to prepare and contribute to solutions for changing global climate and environmental problems. At the same time, Japan should further connect satellite Earth observation with advanced modeling and societal services in order to attain maximum use of Earth observation systems. Through this connection, comprehensive satellite data analyses will become more feasible and useful, not only for short-term weather forecasting and long-term global warming projection, but also for medium-term forecasting such as for seasonal weather change and agriculture.

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Author Biography

Teruyuki Nakajima has greatly contributed to studies of the earth radiation budget, climate impacts of clouds and aerosols, and air pollution, including from the Fukushima Nuclear Power Station accident, by building observation systems and models for atmospheric constituents. He has served and promoted Earth science as the secretary general of the International Association of Meteorology and Atmospheric Sciences (IAMAS) and has held positions as a member of the Science Council of Japan, president of the Atmospheric and Hydrospheric Sciences Section of the Japan Geoscience Union, and a member/officer of the World Climate Research Programme (WCRP)/Joint Science Committee. He also contributed to the Intergovernmental Panel on Climate Change (IPCC) assessments of global warming as a lead author for the Third and Fifth IPCC Assessment Reports.

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