Earth Observations in China and the World: History and Development in 50 Years

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Abstract: Remote sensing, which came into being at the first International Symposium on Remote Sensing of Environment (ISRSE) 50 years ago, has enabled people to obtain objective and realistic spatial and temporal information through the application of Earth observation technologies and analyze and understand the macro-level changes of the Earth system from a spatial view. The technology of Earth observation from space has incomparable advantages in the study of the Earth. This article introduces the 50-year development of Earth observation in the world and the 30-year development of Earth observation in China and reflects on the building of China's Earth observation system.

Keywords: Earth observation from space; Earth observation system; 50^{th} anniversary of remote sensing

In 1962, the first International Symposium on Remote Sensing of Environment (ISRSE) was held in Ann Arbor, Michigan, United States, where the term "remote sensing" was officially used by the international scientific community for the first time, marking the birth of remote sensing and also ushering in an era of applying remote sensing technology to Earth observation from space.

Development of Earth observation from space

Since 1962, more than 320 Earth observation satellites have been launched worldwide, covering the atmosphere, oceans, land, and other Earth systems. From 1962 to 2012, the United States sent over 50 Earth observation satellites, the most in the world. In Europe, Russia, France, Italy, and Germany came out in front with 25 to 50 satellites each. China and India also took the lead, both having launched more than 25 Earth observation satellites. Canada, Brazil, and other countries sent 5 to 25 satellites each, followed by Argentina (SAC series), South Africa (SumbandilaSat), Nigeria (NigeriaSat series), and Australia (Fedsat), each owning several satellites.

According to statistics on international Earth observation satellites from 1962 to 2012, the total number of satellites launched in Europe reached 115. Among the 13 European countries with independently launched Earth observation satellites, Russia ranks first with 31 independently launched satellites. A total of 25 Earth observation satellites were launched by the European institutions composed of different European countries. During the 50 years, 111 Earth observation satellites were launched in the Americas, where the United States sent 94 satellites, accounting for 85% of the total. Asia and Oceania sent a total of 89 satellites, including 34 and 30 Earth observation satellites of India and China. Few countries in Africa had Earth observation satellites except South Africa and Nigeria, with two and three satellites, respectively.

By historical periods, from 1962 to 1980, a total of 14 Earth observation satellites were launched globally, when France, Italy, the European institutions, and the United States were the first countries to have Earth observation satellites. From 1981 to 1990, a total of 43 satellites were launched worldwide; in addition to the above-mentioned countries and institutions, China, Japan, Russia, and India also started their satellite missions. The 1990s saw a total of 89 Earth observation satellites launched, the first peak period for countries to send satellites. Eight additional countries, including Denmark, Germany, Canada, Brazil, and Argentina, joined the rank. In total, 174 Earth observation satellites were sent between 2001 and 2012, the most ever within a decade, and 26 countries had their own Earth observation satellites. In addition, different countries show distinctive characteristics in terms of the distribution of satellites. For example, the United States has the most satellites as always and the number is distributed relatively evenly in the three periods since 1981;

China, Italy, France, India, and European institutions have embraced the peak time in the most recent 10 years, especially China, which has nearly 80% of its total Earth observation satellites launched in the past decade.

After 50 years of development, human beings are able to use Earth observation technology to obtain a large amount of atmospheric, oceanic and terrestrial observational data with high precision and high spatial and temporal resolution. The development has featured the transformation of repeatable observation frequency from months to minutes, spatial resolution from kilometers to centimeters, electromagnetic spectra from visible light to microwave, observation modes from passive to active, observation perspectives from single to multiple, microwave remote sensing from unipolar to full-polarization, and antenna systems from real aperture to synthetic aperture, as well as the application of polarization technology. The advance of Earth observation technology enables mankind to obtain Earth data on a global scale. The abundant global data accumulated has laid a solid foundation for addressing issues related to resources, the environment, ecology, population, society, and economy.

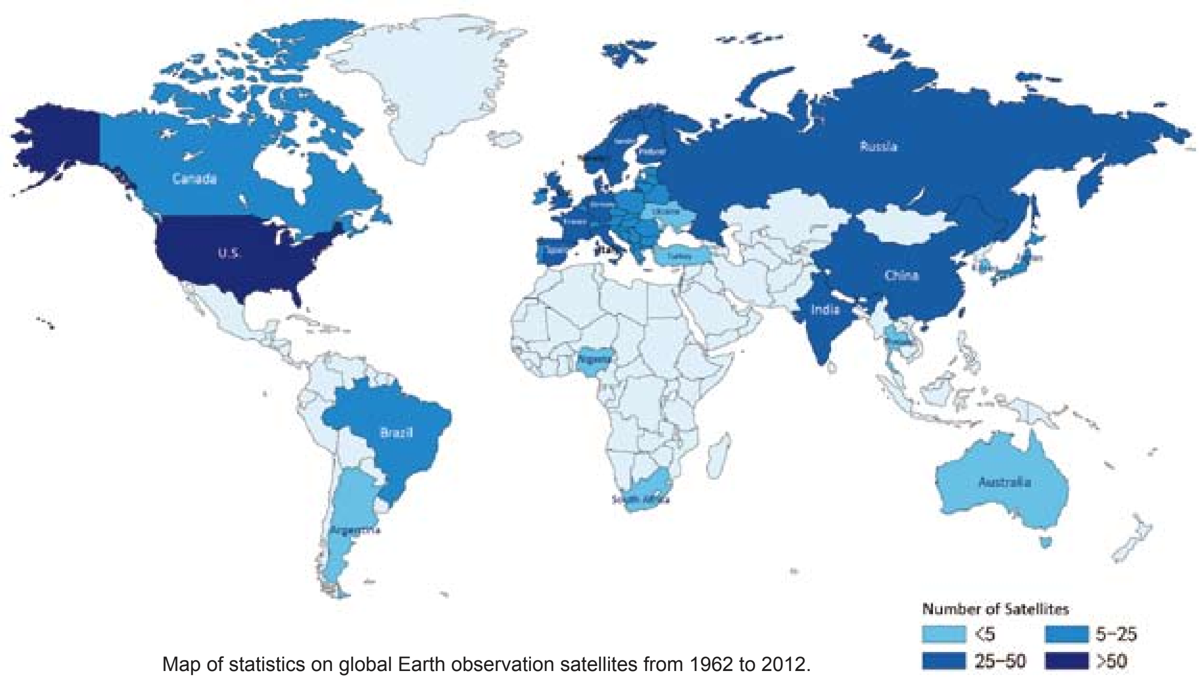
Global Earth Observation System of Systems

In 2005, an intergovernmental organization, the Group on Earth Observations (GEO), was set up in Brussels and the tasks and goals for the Global Earth Observation System of Systems (GEOSS) by 2015 were promulgated (GEO, n.d.; Battrick, 2005). Currently, GEO, which is composed of 88 countries, the European Union, and 67 international organizations, has been a powerful force and organizational system for Earth observation from space. The human being is entering a new era of systematic Earth observation.

To promote the construction of GEOSS, the first GEOSS 10-Year Implementation Plan (2005–2015) was officially initiated in 2005 under the impetus of GEO. GEOSS aims to establish a comprehensive, coordinated, sustainable global Earth observation system to gain a better understanding of Earth systems such as weather, climate, oceans, atmosphere, water, land, geodynamics, natural resources, ecosystems, and natural and human-caused disasters. GEOSS is also intended to provide decision makers with information services from initial observational data to professional application products. GEOSS plans to become an effective means to address global resource environment and sustainable development issues through the comprehensive utilization of Earth observation technologies while playing an important role in guiding GEO member countries to establish GEOSS at the national and regional levels. As the 10-year program will expire in two years, the future-oriented GEOSS development framework (2015–2025) will soon be available with year-long efforts of scientists from over 10 countries.

Earth observation from space in China

After over thirty years of development, China has become a giant in Earth observation from space. Its Earth observation system composed of resource satellites, environmental satellites, meteorological satellites, oceanic satellites, small satellites, and spacecraft has taken shape and the Beidou navigation satellite program has been formed, providing a wide range of services for the nation’s economy. CBERS-1,



Map of statistics on global Earth observation satellites from 1962 to 2012.

the first satellite developed jointly by China and Brazil, was launched in 1999, followed by CBERS-2, CBERS-2B, and ZY-3 satellites with optimized spatial resolution and imaging quality (Xu, 2012). In 2008, the HJ-1A satellite with a multispectral and visible light sensor and hyperspectral imager was successfully launched, and the subsequent "small satellite constellation for environment and disaster monitoring and forecasting" has disaster monitoring capabilities characteristic of medium resolution, wide coverage, and a high revisit rate (Fan, Wen & Chen, 2012). In terms of meteorology, China began to launch the Fengyun series of meteorological satellites in 1988 and has formed a geostationary and a polar-orbiting meteorological observation system (Yang, Zhang & Lu *et al*, 2012). In 2002, China launched its first oceanic satellite, HY-1A, carrying a 10-band ocean color scanner and a 4-band CCD imager. The subsequent HY-1B and HY-2 satellites had further improved performance in imaging breadth and revisiting cycle (Jiang, Lin & Liu *et al*, 2012; Jiang, 2001). With regard to miniature satellites, China successfully launched the SJ-5, Hangtian-Tsinghua-1, Naxing-1, and Beijing-1, which have improved and enriched China's satellite observation system. In 2010, China officially launched and implemented a high-resolution Earth observation program. The first satellite for the high-resolution system for Earth observation was sent successfully in April 2013 and has obtained satellite images with spatial resolution of 2 m, 8 m, and 16 m.

As to satellite data receiving, China's network of ground stations for remote sensing satellites, in operation since 1986, can receive data from over 10 satellites and has stored more than 3 million images of various satellite data. Its capacity to receive, process, and distribute satellite data is among the highest in the world, making it a valuable Earth observation database both domestically and internationally.

Reflections on the development of Earth observation from space

In view of the international development trends in Earth observation technology, China should first adapt its Earth observation to the country's strategic needs and the major requirements of the social, economic, and scientific development; determine the priority service areas of Earth observation from space; establish a multi-platform integral observation program; and highlight the observation system with emphasis placed on both large and small satellites. While constructing a framework for the national Earth observation system, China needs to analyze the existing Earth observing programs in the world and determine the Earth observation platform to be developed in line with the national strategic requirements. Meanwhile, in response to the demands of international Earth observing platforms and data, China can lay out its unique series of observing programs to bridge the global "data divide" in this regard.

The process of globalization will continue to accelerate and the environmental, resource, and other regional issues will gradually turn into global issues. Against this backdrop, China's Earth observation from space should pay attention to significant issues on the sustainable development of society and enhance the development of a science satellite program for global change with fast, repeated global data acquisition capabilities. Meanwhile, China should pay attention to the development of operational satellites to meet the country's strategic needs at a time of globalization, and enable China to better fulfill its international responsibility for addressing the sustainable human development crisis.

Conclusion

Earth observation technology can help people understand the Earth's physical, chemical, and biological systems in a more comprehensive way. By studying the evolutionary process of Earth observation technology and analyzing the capabilities of such technology, we can get a clearer picture of the scientific objectives and social application needs of Earth observation from space and enable Earth observation to serve society to the maximum extent. Grasping the development status and trends of Earth observation from space can help China build an effective and sustainable Earth observation mission and planning system suitable for coordination and cooperation, capable of systematic observation, and able to serve the country's significant political needs and sustainable socio-economic development in the context of globalization.

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