Chapter 8

Chinese Earth Observation Program and Policy

Jinlong Fan

8.1 Development of the Chinese Earth Observation Program

With rapid economic development and global change, China is facing great challenges in managing natural resources, preserving the environment, and mitigating disaster risks. Chinese decision-makers have realized the important role that Earth observations have in effective and efficient management of Earth resources and reduction of disaster losses. In fact, Earth observation technologies have a special role in promoting sustainable economic and social development in all countries.

Before the year 2000, the major civil Earth observation satellite projects in China were limited to meteorological missions and the China–Brazil Earth Resources Satellite (CBERS). Investments were limited and developments were slow. In 2007, China (represented by 13 of its Ministries) released a 10-year plan for the China Integrated Earth Observation System at the Group on Earth Observations (GEO) Ministerial Summit in Cape Town, South Africa. The document outlined, for the first time, a prototype system of the Chinese Earth Observation Program. At almost the same time, the National Medium- and Long-term Plan for Science and Technology Development (2006–2020) proposed 11 key science and technology areas and 68 priority themes to be addressed in the next 15 years. Of these, 25 themes in eight key areas are directly related to Earth observations. In addition, the 11th National Five-Year Development Plan initiated 16 national key research projects, of which three are related to Earth observation science and technology. These developments highlight that Earth observation technologies are now recognized as major public goods that are urgently required in multiple areas.

J. Fan (✉)
National Satellite Meteorological Center, China Meteorological Administration,
Beijing, China
e-mail: fanjl@cma.gov.cn

A number of satellite series have been approved by the central government over the past 10 years. The Chinese Earth observation program uses a system-of-systems approach that incorporates meteorological, oceanic, and earth resources satellites, as well as private sector missions. The Integrated Chinese Earth Observations Program not only meets demands in China, but also makes contributions to the rest of the world. Chinese meteorological satellite data are distributed free of charge in line with international practice. International users may acquire data either through their own ground stations or the data portal operated by the National Satellite Meteorological Center (NSMC) of the China Meteorological Administration (CMA). At the 2007 GEO Ministerial Summit in Cape Town, South Africa, China also announced that CBERS satellite data were available free of charge. China has since built a CBERS ground station in South Africa (2008) and a HJ-1A ground station in Thailand (2011). China also promotes the use of high-resolution Chinese satellite data through the International Charter ‘Space and Major Disasters.’

8.2 Key Components of the Chinese Earth Observation Program

8.2.1 *Meteorological Satellites*

The Chinese meteorological satellite program, FengYun (FY), was initiated in the 1960s and is composed of both polar-orbiting (odd numbered) and geostationary (even numbered) satellites. Each satellite is assigned an incremental alphabetic suffix according to its launch sequence.

The NSMC operates both the polar-orbiting and geostationary components, but the development and implementation of the FY program—from satellite development, launcher design, and manufacture, to telemetry, control, and ground applications—is the result of joint efforts between many institutes in China. The FY program is designed to enhance China’s three-dimensional atmospheric sounding and global data acquisition capabilities, in an effort to collect more cloud and surface characteristics data from which meteorologists may infer atmospheric, land surface, and sea surface parameters that are global, all-weather, three-dimensional, quantitative, and multispectral.

FY-1 was China’s first generation of sun-synchronous orbiting meteorological satellites. FY-1A and FY-1B were experimental satellites, launched on July 9, 1988 and September 3, 1990, respectively. FY-1C and FY-1D (operational satellites) were subsequently launched on May 10, 1999 and May 15, 2002. To date, all FY-1 satellites have completed their missions. The FY-1 series carried the visible and Infrared radiometer (VIRR) and space environment monitor (SEM). VIRR provided Earth imaging capability with ten channels at 1.1 km nadir spatial resolution, while SEM observed energetic particles in solar winds.

China started to develop its geostationary meteorological satellites, named FY-2, in the 1980s. The first satellite, the experimental FY-2A, was launched on June 10, 1997 and positioned at 105°E above the equator. This was followed by another experimental satellite, FY-2B. The subsequent FY-2C, FY-2D, and FY-2E satellites had noticeably enhanced performance; for example, the onboard scanning radiometer had five channels rather than the three of its predecessors. The latest satellites in the series, FY-2F, FY-2G, and FY-2H, are designed to serve as a consistent and stable bridge to the second generation of Chinese geostationary meteorological satellites, as the first generation fleet approaches the end of its life in the 2015 timeframe.

The FY-2 series is equipped with a stretched visible and infrared spin scan radiometer (S-VISSR) that scans the full Earth disk every 30 min at a spatial resolution of around 5.0 km (IR) and 1.25 km (VIS). The satellites are also equipped with SEMs to monitor the space environment where the satellites operate.

China's second-generation polar-orbiting meteorological satellite series, FY-3, began with the launch of the experimental FY-3A and FY-3B satellites on May 27, 2008 and November 5, 2010, respectively. The operational FY-3C satellite, with 11 instruments and enhanced remote sensing capabilities, was launched on September 23, 2013. The FY-3 program has a life expectancy of 15 years.

FY-4 is China's second-generation geostationary meteorological satellite series. These new generation satellites are designed with enhanced imagery scanning capabilities, desirable for monitoring small- and medium-scale weather systems. FY-4 satellites are also equipped with vertical atmospheric sounding and microwave detection capabilities to address 3D remote sensing at high altitudes. They are also able to make solar observations of extreme ultraviolet and X-ray emissions, in a bid to enhance China's space weather watch and warning capability. FY-4 satellites will come in two varieties, carrying either optical or microwave instruments. An optical satellite will carry a ten-channel 2D scanning imager, an interferometric vertical detector, a lightning imager, CCD camera, and an Earth radiation budget instrument. The satellites will produce full-disk earth images every 15 min.

8.2.2 Oceanic Satellites

The Chinese oceanic satellite program, HaiYang (HY), has been designed to detect ocean color and to support ocean bio-resource utilization, ocean pollutant monitoring and prevention, offshore resource exploration, and marine science. Eight oceanic satellites will be launched before 2020, including four ocean color satellites, two dynamic ocean environment satellites, and two ocean radar satellites.

HY-1 series satellites carry an ocean color scanner and coastal zone imager to measure global ocean color, temperature, and coastal zone dynamic change. HY-1A was an experimental mission launched on May 15, 2002 and equipped with a ten-channel ocean color scanner (3-day revisit frequency, 1.1 km nadir spatial

resolution) and a four-band CCD (7-day revisit frequency, 250 m nadir spatial resolution). The follow-up satellite, HY-1B, was launched on April 11, 2007.

HY-2 series satellites measure marine environment dynamics and are used for all-weather assessments of offshore and global sea surface wind fields, sea surface height, significant wave heights, and sea surface temperature. Remote sensing payloads include a microwave scatterometer, radar altimeter, scanning microwave radiometer, and calibration microwave radiometer. The first HY-2A satellite was launched on August 16, 2011.

HY-3 will be an ocean radar satellite series used to detect ocean waves, ocean ice, and oil leaks, among other features.

8.2.3 Earth Resources Satellites

CBERS, also known as ZiYuan-1 (ZY-1), is a joint program between China and Brazil that was initiated in the 1980s. The CBERS program was designed to meet the needs of both countries and to allow them to enter the emerging market of satellite imagery. Despite an initial commitment to just two satellites, a series of missions have now been jointly built by China and Brazil. Following CBERS-1 and -2, both governments decided to expand the cooperation to include CBERS-2B, -3 and -4.

ZY-1-02C was the third satellite in the CBERS-2 series, but it was developed exclusively as a Chinese project with no Brazilian participation. It was the first high-resolution Chinese imaging mission. ZY-1-02C launched on December 22, 2011. CBERS-3 was launched on December 9, 2013 but unfortunately failed to reach its orbit. CBERS-4 was successfully launched on December 7, 2014. It will be followed by further joint China–Brazil missions.

8.2.4 China High-Resolution Earth Observation System

The China High-resolution Earth Observation System (CHEOS), also known as GaoFen (GF), is one of 16 tasks that are listed in the National Medium- and Long-term Plan for Science and Technology Development (2006–2020). The program was proposed in 2006 and approved and initiated in 2010. CHEOS is a series of small satellites for high-resolution land observation being developed between 2010 and 2020. The entire GF series of satellites will be in orbit by 2020, mostly sun synchronous around 10:30 or 06:00 except for GF-4, which will be placed into geostationary orbit. The design lifetimes are 5 years for GF-1/2 and 8 years for GF-3/4/5. China plans to launch six GF satellites between 2013 and 2016. The main goal of the GF series is to provide near-real-time observations for disaster prevention and relief, climate change monitoring, geographical mapping, environment and resource surveying, and precision agriculture.

8.2.5 Environmental Protection and Disaster Monitoring Constellation

The Environmental Protection and Disaster Monitoring Constellation mini-satellite constellation, also known as HuanJing-1 (HJ-1), is a national program to construct a network of Earth observation satellites. The overall objective is to establish an operational Earth-observing system for disaster monitoring and mitigation using remote sensing technology in order to improve the efficiency of disaster mitigation and relief.

The HJ-1 constellation is comprised of three mini-satellites, referred to as the '2 + 1 constellation'. HJ-1A and HJ-1B were launched together on September 6, 2008. HJ-1A was equipped with two optical wide view CCD cameras (WVC) and one hyperspectral imager (HSI). Both WVCs take images with four bands at 30 m spatial resolution with a swath width of 700 km. HSI measures 110–128 bands at 100 m spatial resolution with a swath of 50 km. Likewise, HJ-1B was equipped with two optical WVCs as well as one infrared multispectral scanner (IRMSS). HJ-1C was launched on November 19, 2012, equipped with an S-band synthetic aperture radar (SAR) payload.

8.2.6 The Private Sector

Twenty-First Century Aerospace Technology is a private company that has received scientific funding support primarily from the Ministry of Science and Technology of China. The company operates Beijing-1 and Beijing-2, a constellation of three small Disaster Monitoring Constellation (DMC) satellites. Beijing-1 was equipped with a 4-m panchromatic camera and a 32-m multispectral camera with a swath of 600 km. The camera, developed by Surrey Satellite Technology Ltd. (SSTL, UK), had a design lifetime of 5 years. Beijing-1 was launched on October 27, 2005. This was followed up with the launch of three Beijing-2 DMC satellites on July 11, 2015, each carrying a 1-m panchromatic camera and a 4-m multispectral camera.

The Jilin-1 series is privately owned and operated by Chang Guang Satellite Technology Co., Ltd. The series includes one optical satellite, two video satellites, and one experimental satellite. The first satellite in the series, Jilin-1A, was launched in October 2015. By 2030, it will be joined by a further 137 satellites, forming a large constellation. Jilin-1A is capable of 0.72-m panchromatic/2.88-m multispectral imaging as well as 1.12-m spatial resolution video capture.

Beijing-1/2 and Jilin-1 are market-oriented satellite programs that aim to promote the commercial service of remote sensing technology in China.

Author Biography

Jinlong Fan is a research scientist with the National Satellite Meteorological Center of the China Meteorological Administration (NSMC-CMA). He is involved in the Earth observation program of China and has contributed to the processing of global medium-resolution satellite data and its application in the fields of disaster reduction, agriculture, and the environment. He served as a seconded expert at the Group on Earth Observations (GEO) Secretariat in Geneva from 2008 to 2011 and promoted the creation of the GEO Global Agricultural Monitoring (GEOGLAM) initiative. Recently, he has been involved in numerous international activities, including serving as a Chinese partner principal investigator (PI) for the Stimulating Innovation for Global Monitoring of Agriculture (SIGMA) project, which is funded through the European Commission's FP-7 Program; a Chinese PI for the 3rd and 4th Dragon Program, a cooperation between the European Space Agency (ESA) and the Ministry of Science and Technology (MOST) of China; a member of the Committee on Earth Observation Satellites (CEOS)/Coordination Group for Meteorological Satellites (CGMS) Working Group on Climate; and a member of the expert panel on the Asia-Pacific drought mechanism, initiated by the UN Economic and Social Commission for Asia and the Pacific (ESCAP).

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.