

Progress and Achievements of Fengyun Meteorological Satellite Program since 2022*

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Abstract Fengyun meteorological satellites have undergone a series of significant developments over the past 50 years. Two generations, four types, and 21 Fengyun satellites have been developed and launched, with 9 currently operational in orbit. The data obtained from Fengyun satellites is employed in a multitude of applications, including weather forecasting, meteorological disaster prevention and reduction, climate change, global environmental monitoring, and space weather. These data products and services are made available to the global community, resulting in tangible social and economic benefits. In 2023, two Fengyun meteorological satellites were successfully launched. This report presents an overview of the two recently launched Fengyun satellites and currently in orbit Fengyun satellites, including an evaluation of their remote sensing instruments since 2022. Additionally, it addresses the subject of Fengyun satellite data archiving, data services, application services, international cooperation, and supporting activities. Furthermore, the development prospects have been outlined.

Key words Fengyun meteorological satellites, Data services and application, International cooperation and support

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1 Introduction

In April 2023, China marked a notable milestone with the successful launch of its first precipitation measurement satellite, the Fengyun-3G (FY-3G) meteorological satellite. Four months later, Fengyun-3F (FY-3F), a new member of the “mid-morning orbit” satellite series, was successfully launched. These accomplishments have positioned China as the sole nation in the world to operate civil meteorological satellites in four near-earth orbits: early-morning, mid-morning, afternoon, and inclined.

Currently, 9 Fengyun satellites are operational in space. Of these, five are in polar orbit, while the remaining four are in geostationary orbit^[1,2]. Figure 1 illustrates the current Fengyun satellite that is operational in orbit. The FY-3G officially began operational services on 1 May 2024, while the FY-3F is anticipated to complete its commissioning by the end of June 2024, thereby enabling operation in July 2024.

This report presents an update on the status of current polar orbiting, or Low Earth Observation (LEO), and Geostationary (GEO) meteorological satellites in

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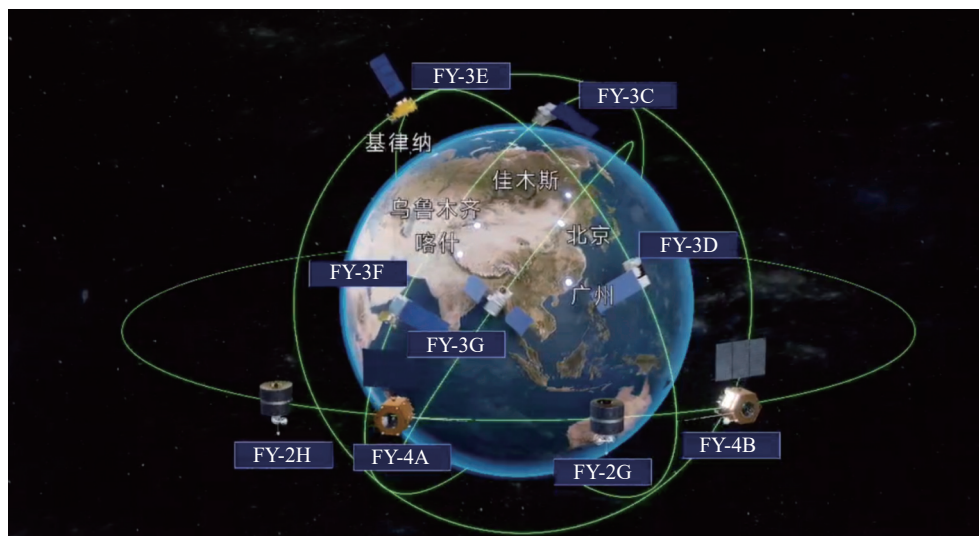


Fig. 1 Operational Fengyun satellites in space

Chapter 2 and Chapter 3. Chapter 4 introduces the data service, including the release of a user-friendly platform for FY satellite data utilization in 2023. As the Fengyun satellite system continues to evolve and develop, Chapter 5 discusses the growing international user community and highlights progress in international regional cooperation, with a particular focus on the Emergency Support Mechanism of Fengyun Satellite (FY_ESM) and its application in the Belt and Road countries. In Chapter 6, the future planning of the Fengyun satellites is presented.

2 Update on the Fengyun Satellite Program

2.1 FY-3G

FY-3G, the 6th flight of the FY-3 series, was launched on 16 April 2023. It is the third precipitation measurement satellite in the world, which is capable of proactive measurement. FY-3G is the first precipitation measurement satellite of Fengyun-3 batch 03, operating in an orbit inclined 50°. This marks the inaugural instance in China of a satellite-borne active-passive microwave joint measurement of a precipitation system, wherein the measurement of a three-dimensional structure is realized.

The FY-3G is equipped with four operational instruments, namely, a Ku/Ka-band dual-frequency Precipitation Measurement Radar (PMR), a Micro-Wave Radiation Imager for Rainfall Mission (MWRI-RM), a Medium-Resolution Spectral Imager for Rainfall Mis-

sion (MERSI-RM), as well as a GNSS radio Occultation Sounder (GNOS). Their name and status are shown in Table 1. The primary payload of the satellite, a precipitation measurement radar, represents a significant technological advancement, as it is the first of its kind independently developed in China^[3].

The primary objective of FY-3G is to detect precipitation in mid to low latitudes across the globe, while optimizing the detection capabilities of payloads. The products encompass four categories: cloud radiation, land and sea surface, atmospheric parameters, and space weather, with 24 main parameters covering precipitation/snowfall within the range of 50 degrees north and south latitude. These products meet the main needs of the World Meteorological Organization Integrated Global Observing System (WIGOS). In response to the incorporation of active radar detection capabilities in FY-3G, a novel category of remote sensing products has been devised, comprising three-dimensional raindrop spectral parameter profiles, three-dimensional phase states, and three-dimensional precipitation rate profiles. These are designed to detect the fine internal structure of precipitation.

Table 1 Instruments on FY-3G

No.	Instruments	Statuses
1	PMR	New
2	MWRI-RM	Improved
3	MERSI-RM	
4	GNOS-II	Inherited

2.2 FY-3F

FY-3F was launched on 3 August 2023. The FY-3F will replace the FY-3C, which has been in orbit for an extended period, and will continue to carry out optical and microwave imaging observations of the Earth's atmosphere system as well as vertical detection in the sun-synchronous morning orbit. On the basis of ensuring global meteorological imaging and atmospheric vertical detection services, it has strengthened the comprehensive observation capabilities of the Earth system, improved the detection capabilities of atmospheric components such as ozone and sulfur dioxide in the stratosphere and troposphere, as well as the energy balance of Earth radiation. FY-3F, along with FY-3D, FY-3E, and FY-3G in orbit, collectively constitute a low-orbit meteorological satellite observation network. It has further enhanced China's capabilities and levels in global numerical weather forecasting, global climate change response, ecological environment monitoring, and comprehensive disaster prevention and mitigation.

The designed operational lifespan of the FY-3F is 8 years. It is equipped with 10 remote sensing instruments, shown in Table 2, including MERSI (medium resolution spectral imager), HIRAS (hyper-spectral infrared atmospheric sounder), MWTS (Micro-Wave Temperature Sounder), MWHS (Micro-Wave Humidity Sounder), GNOS (GNSS Occultation Sounder), OMS-L (Ozone Monitoring Suite –Limb), OMS-N (Ozone Monitoring Suite –Nadir), ERM (Earth Radiation Measurement), and SIM (Solar Irradiance Monitor). FY-3F incorporates several new instruments, including the OMS-L and OMS-N. The MERSI, MWRI, and ERM have been improved, while the remaining 5 instruments are inherited.

Two new ultraviolet to visible hyper-spectral instruments, OMS-L and OMS-N, employ a combination of limb and nadir hyper-spectral detection to enhance the detection capabilities of atmospheric components, greenhouse gases, and aerosols. The performances of certain instruments have undergone a notable enhancement. The enhancement of the detection channels of MWRI and ERM, the improvement of the calibration device of MERSI, and the significant improvement of the signal-to-noise ratio have collectively led to an augmented detection capability for global atmospheric temperature,

Table 2 Instruments on FY-3F

No.	Instruments	Statuses
1	OMS-L	New
2	OMS-N	
3	MERSI-III	Improved
4	MWRI-II	
5	ERM-II	
6	HIRAS-II	Inherited
7	MWTS-III	
8	MWHS-II	
9	GNOS-II	
10	SIM-II	

atmosphere system radiation budget, and weak ocean signals in the reflection band.

The products of FY-3F include 6 categories and 48 types, including images, cloud radiation, land and sea surface, atmospheric parameters, atmospheric composition, and space weather. These products address the primary requirements of the WIGOS.

3 Status of Current Fengyun Satellites

3.1 Status of Current LEO

At present, the operational Fengyun LEO satellites in orbit include FY-3C, FY-3D, FY-3E, and FY-3G, which were operational on 1 May 2024. In addition, FY-3F is currently undergoing commissioning and is scheduled to commence operational service in July 2024. The status of them are shown in Table 3. FY-3 LEO meteorological satellites have successfully conducted observations in four distinct orbital regimes: early morning, morning, afternoon, and inclined orbits.

Information regarding the instruments carried on FY-3E/G/F is as follows^[4].

MERSI-LL, comprises a total of 7 channels, including 1 low-light channel and 6 thermal infrared channels. Two infrared split window channels (10.8 and 12.0 microns) have a spatial resolution of 250 m, while the remaining channels have a spatial resolution of 1000 m.

HIRAS-II, an infrared sounding instrument with a nadir spatial resolution of 16 km and a cross-track scanning model. It is primarily used for numerical weather prediction and atmospheric composition detection.

MWTS-III, the number of channels in the original 50–60 GHz frequency band has been increased from 13 to 17. The newly added channels include 23.8 GHz

Table 3 Current Fengyun LEO satellites (as of 1 June 2024)

Orbit type (Local time of descending node/ascending node)	Satellites currently in orbit	Equatorial crossing time (designed)	Equatorial crossing time (present)	Launch date	Status	Main instruments
Morning orbit (07:00 LT–12:00 LT)/ (19:00 LT–24:00 LT)	FY-3C	10:00 LT	07:39 LT	23 Sept. 2013	Partially operational	VIRR(O) MERSI(S) IRAS(S) MWRI(S) MWTS-II(S) MWHS-II(O) TOU(O) SIM(S) ERM(O) GNOS(O) SEM(S)
Afternoon orbit (12:00 LT–17:00 LT)/ (00:00 LT–05:00 LT)	FY-3D	14:00 LT	13:45 LT	15 Nov. 2017	Operational	MERSI-II(O) HIRAS(O) MWTS-II(O) MWHS-II(O) MWRI(O) GAS(T) GNOS(O) WAI(O) IPM(O) SEM(O)
Early-morning orbit	FY-3E	5:30 LT	5:30 LT	5 Jul. 2021	Operational	MERSI-LL(O) HIRAS-II(O) MWTS-III(O) MWHS-II(O) GNOS-II(O) WindRAD(O) SSIM(O) SIM-II(O) X-EUVI(O) Tri-IPM(O) SEM(O)
Drifting	FY-3G			16 Apr. 2023	Operational	See Table 1
Morning orbit	FY-3F	10:00 LT		3 Aug. 2023	Commissioning	See Table 2

Note (O) indicates that the instrument is in a state of operational readiness, whereas, (S) denotes that the instrument is currently in a state of shutdown.

channel for total water vapor column measurement, 31.4 GHz channel for window area, 53.246 ± 0.08 GHz and 53.948 ± 0.081 GHz channels for tropospheric temperature detection.

MWHS-II (Micro-Wave Humidity Sounder), flying on FY-3E/F, 4-frequency/15-channel MW radiometer for nearly-all-weather humidity sounding, with a special resolution of 15 km and swath of 2700 km.

GNOS-II receives signals from GPS and China Beidou satellites, with the capacity to observe over 1000 occultation events per day.

WindRad is the first active microwave remote sensing instrument of the Fengyun series satellites. It is a dual-frequency, dual-polarization radar. It adopts a fan-

beam conical scanning system with an observation width of over 1200 km and a minimum detectable wind speed of 3 m s^{-1} . It adopts C and Ku dual bands, which are operated concurrently. Each band includes two polarization measurement methods, namely horizontal and vertical.

SSIM measures the solar spectral irradiance through the ultraviolet, visible and infrared channels. This allows us to obtain the solar spectral irradiance characteristics and capture the influence of solar activity on the spectral irradiance.

SIM-II is a high-precision absolute radiometer with an automated Sun-tracking function that has been independently developed by China. The spectral range is $0.2\text{--}20 \mu\text{m}$.

X-EUVI is the first solar X-ray-extreme ultraviolet dual-band imager in the world, and the first domestic space solar telescope. It has two bands: X-ray (0.6–8 nm) and EUV (19.5 nm).

Tri-IPM obtains UV spectrometry of the ionosphere performed under 3 different viewing angles.

SEM monitors high energy proton, high energy electron, medium energy proton, medium energy electron, heavy ions, and geomagnetic field.

PMR is a dual-frequency, single-polarization one-dimensional phased array radar. It provides a three-dimensional structure of precipitation. The information such as precipitation intensity and precipitation type will be retrieved.

MWRI-RM has 17 frequencies, 26 channels, in the range of 10.65 to 183 GHz. Conical: 53° zenith angle, Swath width 800 km.

MERSI-RM is an 8-channel VIS/IR radiometer, comprising 5 solar reflection band channels and 3 thermal infrared channels, all with a spatial resolution of 500 meters.

MERSI-III, flying on FY-3F, is a 25-channel radiometer (19 in VIS/NIR/SWIR + 6 TIR from 3.7–12.5 μm) designed for the measurement of ocean color and vegetation indices. The spatial resolution is 250 m for 4 VIS/NIR channels and 2 TIR channels, 1 km for other channels. The scan swath is 2800 km.

OMS-L is a new instrument used for detecting trace gases such as ozone on FY-3F, with a spectrum covering a continuous range of 290–500 nm and a total of 1000 channels.

OMS-N is a new instrument on the FY-3F that is capable of providing high spectral resolution of Earth's reflected radiation in the ultraviolet to visible wavelength range. The instrument spectrum covers three bands: 250–300 nm, 300–320 nm, and 310–497 nm, with a spectral resolution of 0.5–1 nm and a spatial resolution of 7 km $\times$ 7 km. It is capable of detecting the total amount of ozone, SO₂, NO₂, and vertical distribution information of ozone.

ERM-II is flying on FY-3F, comprises 3 broad-band channel radiometers for earth reflected solar flux and earth emitted thermal flux over total (0.2–100 μm), long (5.0–50 μm) waveband and short (0.2–5.0 μm) waveband.

3.2 Status of Current GEO

The operational Fengyun GEO satellites in orbit include FY-2G, FY-2H, FY-4A and FY-4B^[5]. FY-2F was decommissioned on 1 April 2022. The status of current Fengyun GEO satellites are shown in Table 4.

Information regarding the instruments on FY-2G/H is as follows.

VISSR (Visible and Infrared Spin Scan Radiometer): the improved version for FY-G/H, has five VIS/IR channels (0.55–0.75 μm , 3.5–4.0 μm , 6.3–7.6 μm , 10.3–11.3 μm , and 11.5–12.5 μm). The spatial resolution of VIS and IR channels is 1.25 km and 5.0 km, respectively. The image cycle is 30 min.

SEM (Space Environment Monitor): a space particle monitor and an X-ray monitor are mounted on FY-2 to detect the space environment in the proximity of the satellite, the solar activities, and relevant space phenomena. The SEM data is transmitted *via* telemetry to the ground system.

FY-4B has shifted its position from 133°E to 105°E, assuming the role of the FY-4A in providing operational observation services since 5 March 2024. FY-4A has undergone a shift from 104.7°E to 86.5°E for degrading operation. There are 4 instruments on the FY-4B. The principal observation capabilities are similar to those of FY-4A, exhibiting notable enhancements in performance.

AGRI, in comparison with FY-4A, 1 new water vapor channel is added, 4 channel band settings are optimized, and the resolution of short wave and medium wave is improved to 2 km^[6]. Its details are shown in Table 5.

GIIRS, the spatial resolution of the infrared chan-

Table 4 Current Fengyun GEO satellites in orbit (as of 1 April 2024)

Satellites	Location	Launch date	Status	Instruments
FY-2G	99.5°E	31 Dec. 2014	Operational	VISSR
FY-2H	79°E	5 Jun. 2018	Operational	SEM
FY-4A	86.5°E	11 Dec. 2016	Degraded operational	AGRI GIIRS LMI SEP
FY-4B	105°E	3 Jun. 2021	Operational	AGRI GIIRS GHI SEP

nel has been enhanced from 16 km to 12 km. The resolution of the visible channel has been increased from 2 km to 1 km. See Table 6 for details.

GHI (Geostationary High-speed Imager), a recently deployed instrument on FY-4B, is the first long-line array in geosynchronous orbit with the capability of uninterrupted, one-minute imaging and observation in a

2000 km × 2000 km area with a resolution of 250 m. See Table 7 for detailed characteristics.

SEP is a suite that contains a Magnetometer for 3D magnetic field intensity, an Energetic Particle Detector detecting high-energy electron storms and proton events, and Space Weather Effect Detectors for the impact of space weather on spacecraft.

Table 5 Detailed characteristics of AGRI on FY-4B

	Central wavelength/ μm	Spectral interval/ μm	SNR or NE Δ T @ specified input	IFOV at s.s.p./ km
1	0.47	0.45–0.49	≥ 90 @ 100% albedo	1
2	0.65	0.55–0.75	≥ 150 @ 100% albedo	0.5
3	0.825	0.75–0.90	≥ 200 @ 100% albedo or ≥ 3 @ 1% albedo	1
4	1.378	1.371–1.386	≥ 120 @ 100% albedo or ≥ 2 @ 1% albedo	2
5	1.61	1.58–1.64	≥ 200 @ 100% albedo or ≥ 3 @ 1% albedo	2
6	2.25	2.10–2.35	≥ 200 @ 100% albedo or ≥ 2 @ 1% albedo	2
7	3.75 (high)	3.50–4.00	≤ 0.7 K @ 315 K	2
8	3.75 (low)	3.50–4.00	0.2 K @ 300 K or 2.0 K @ 240 K	4
9	6.25	5.80–6.70	0.2 K @ 300 K or 0.9 K @ 240 K	4
10	6.95	6.75–7.15	0.25 K @ 300 K or 0.9 K @ 240 K	4
11	7.92	7.24–7.60	0.25 K @ 300 K or 0.9 K @ 240 K	4
12	8.55	8.30–8.80	0.2 K @ 300 K or 0.4 K @ 240 K	4
13	10.80	10.30–11.30	0.2 K @ 300 K or 0.4 K @ 240 K	4
14	12.00	11.50–12.50	0.2 K @ 300 K or 0.4 K @ 240 K	4
15	13.30	13.00–13.60	0.5 K @ 300 K or 0.9 K @ 240 K	4

Table 6 Detailed characteristics of FY-4B GIIRS

Spectral range/ μm	Spectral range/ cm^{-1}	Spectral resolution/ cm^{-1}	NE Δ R or SNR
14.7–8.85	680–1130	0.625	$0.5 \text{ mW} \cdot \text{m}^{-2} \cdot \text{sr}^{-1} \cdot \text{cm}$
6.06–4.44	1650–2250	0.625	$0.1 \text{ mW} \cdot \text{m}^{-2} \cdot \text{sr}^{-1} \cdot \text{cm}$
0.55–0.90	N/A	N/A	200 @ 100% albedo

Table 7 Detailed characteristics of FY-4B GHI

Central wavelength/ μm	Spectral interval/ μm	SNR or NE Δ T @ specified input	IFOV at s.s.p./ km
0.675	0.45–0.9	> 300 @ 100% albedo	0.25
0.470	0.445–0.495	> 300 @ 100% albedo	0.5
0.545	0.52–0.57	> 300 @ 100% albedo	0.5
0.645	0.62–0.67	> 300 @ 100% albedo	0.5
1.378	1.371–1.386	> 300 @ 100% albedo	0.5
1.61	1.58–1.64	> 300 @ 100% albedo	0.5
11.4	10.3–12.5	0.2 K @ 300 K	2.0

4 Data Service and Application

4.1 Data Archiving

National Satellite Meteorological Center (NSMC) Data Center enriches meteorological satellite data in various ways. As of June 2024, the amount of satellite data archived has reached nearly 44 PB, covering 55 satellites in 12 series both domestically and internationally, with over 1500 types of data products. The evolution of satellite data archiving from 1988 to 2024 is shown in Figure 2.

4.2 Data Service

NSMC Data Center has built an integrated meteorological satellite data service system that integrates space and terrestrial realms through the adoption of a unified design, progressive development, and batch expansion philosophy for multiple batches of Fengyun meteorological satellite programs. Services have been developed to provide space-based data through satellite direct receiving stations and China Meteorological Administration's data broadcast system (CMACast). Through ground network data services such as the World Meteorological Organization Information System, Fengyun Satellite Data Service Network, and satellite data resource pool, access, exchange, management, and service of domestic and international satellite data have been achieved. The complete Fengyun meteorological satellite dataset, both real-time and historical data, will be accessible on the NSMC satellite data service website in English (<http://data.nsmc.org.cn>).

By the end of May 2024, the NSMC satellite data service website had registered in excess of 164000 users. The volume of data downloaded by users of Fengyun satellite data users has increased rapidly year on year, with a total cumulative service data of 39 PB since 2005, of which more than 13 PB was served in 2023 alone. In addition, NSMC actively explores the application of new technologies, including research on artificial intelligence applications and the construction of a rapid service system for hot events.

4.3 Fengyun Earth

In 2022, a lightweight design and real-time satellite application service platform, designated "Fengyun Earth", was developed to enhance the pivotal role of Fengyun meteorological satellites in core meteorological operations and promote the integration of satellite data across national, provincial, municipal, and county-level platforms^[7].

To meet the needs of forecasters, the Fengyun Earth utilizes big data, cloud computing, and artificial intelligence in order to efficiently manage a vast array of heterogeneous data sources and perform online real-time computations, providing users with a range of visualized remote sensing application products *via* a B/S architecture, including satellite cloud images, elements and events, severe weather, climate analysis, and model validation. The Fengyun Earth encompasses distinct 30 types with a total of 204 products under 5 categories, enabling rapid production of high-integrity, time-sensitive integrated products. The platform is based on a cloud-

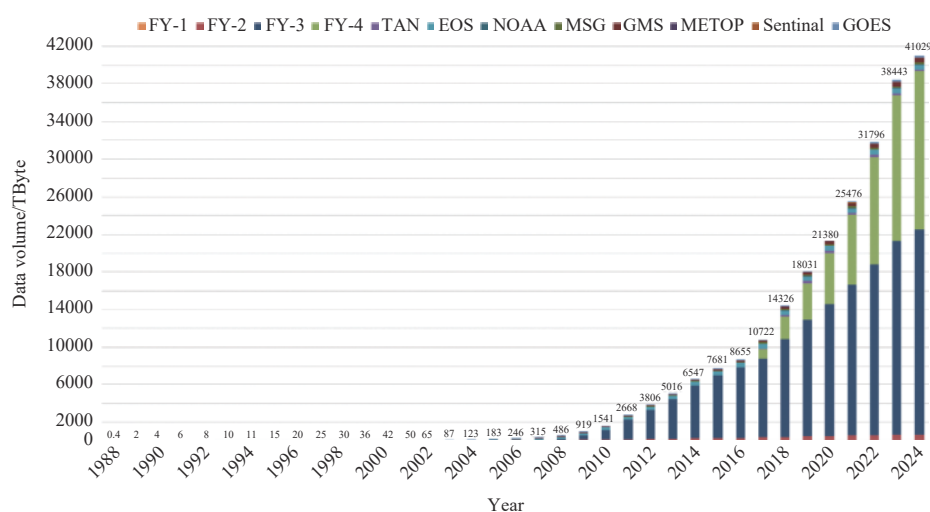


Fig. 2 Cumulative annual archive data volume in NSMC

edge lightweight service model and is capable of supporting simultaneous access by tens of thousands of users. Furthermore, it is able to deliver satellite products directly to forecasters' desktops. The application of AI to product algorithms (*e.g.*, satellite precipitation estimation, and convection initiation) results in enhanced quantification of products. It employs integrated intelligent observation and control technology, coupled with real-time scheduling and micro-services, to rapidly process and distribute multi-scale Fengyun satellite meteorological products. The times for accessing cloud image services are controlled within minutes. Furthermore, the integrated application of multi-source satellite inversion parameters enables detailed three-dimensional monitoring of critical weather systems.

Fengyun Earth was pilot-tested in May 2022, with the nationwide launch occurring in June of the same year. Fengyun Earth has provided a range of tiered services to professionals, industry users, and the general public, supporting a number of significant events, including the Universiade and Asian Games, critical weather processes like Typhoon Doksuri, and rural revitalization initiatives. To date, the platform has received in excess of three billion hits.

In order to provide support to international users engaged in satellite remote sensing applications and to enhance their capabilities, NSMC developed an international version of Fengyun Earth. This version enables the timely acquisition of meteorological satellite and numerical forecast data, the rapid production of quantified products and the provision of international services. It employs advanced AI technologies for the automated analysis, mining, and modeling of massive meteorological satellite data, enabling the intelligent identification of severe weather and extreme climate events, thereby enhancing user convenience and practicality. It offers five categories of quantified, multi-scale products including cloud images, elements, disaster events, climate, and model validation. These products are tailored to different business scenarios and customized to focus on specific meteorological elements, observational areas, and time frames for international users. The international version of Fengyun Earth was officially launched on 13 November 2023. As of the end of May 2024, it had been accessed by 47 countries with a total of 22000 visits.

5 International Cooperation and Supporting

5.1 International Services

Fengyun meteorological satellites play a crucial role in the World Meteorological Organization's Space Programme. NSMC maintains close cooperation with WMO, CGMS, CEOS, GEO, APSCO, and other international organizations, as well as satellite operators such as EUMETSAT and NOAA, on matters pertaining to instrument development, remote sensing applications, data exchange, and applications. Furthermore, it plays an active role in international governance, providing support for the United Nations Sustainable Development Goals and the UN Early Warnings for All Initiative. It continues to facilitate bilateral cooperation, with CMA and EUMETSAT renewing their cooperation agreement on the application, exchange, and distribution of meteorological satellite data in 2024, to promote data sharing, ground segment operations, and remote sensing application services.

Till 2023, 34 countries registered with the FY_ESM. In that year, Fengyun satellite responded to 31 international emergency service requests, including 23 that were initiated under the CHARTER mechanism and 8 that were initiated through the FY_ESM. It provided global meteorological disaster emergency services to countries in Asia, Africa, South America, and Oceania for disasters such as earthquakes, tropical cyclones, floods, fires, and maritime search and rescue operations.

The integrated global data-sharing system of Fengyun satellites is being continuously improved. The Fengyun satellite data is disseminated internationally *via* a multitude of channels, including direct reception stations, CMACast, dedicated lines, the Fengyun Data Sharing Network, public clouds, FTP, and human services. As of June 2024, the data service website covers 132 countries and regions, including 96 along the "Belt and Road" Initiative, and the data services have increased by about 210 TB since 2018.

Since its designation as a Global Space Weather Center of the International Civil Aviation Organization (ICAO) in 2021, the NSMC has established a full-process operational specification for ICAO space weather services and a robust application platform for ICAO

space weather services. Additionally, it has conducted seven 14-day, 24-hour rotations^[8].

The International Fengyun Meteorological Satellite Users Conference was successfully held in Xiamen, Fujian Province, on 13–14 November, 2023. Participants from the WMO, the Food and Agriculture Organization, and more than 30 countries, including China, Yemen, Jordan, Thailand, Indonesia, the Maldives, and Tanzania, discussed the applications of Fengyun meteorological satellites in meteorological disaster mitigation and early warning. The conference comprised a training session, two roundtable meetings, and three sub-meetings, and four international service items were announced.

In 2023, a survey was conducted among 44 countries to ascertain the requirements and usage of Fengyun satellites. The survey was conducted both on-site and online, and the results indicated an overall international user satisfaction rate of 80%.

5.2 Belt and Road Services

Fengyun satellites provide services to global users, with a particular focus on those along the “Belt and Road”. The map below shows the global distribution of Fengyun users.

CMA has implemented a series of action plans with the objective of enhancing the capability of countries along the “Belt and Road” to receive data from Fengyun meteorological satellites.

The construction or upgrading of Direct Broadcasting systems (DB), CMACast, cloud services, and other similar initiatives enables countries in the region to receive real-time Fengyun satellite data. By 2024, over 30 countries in the “Belt and Road” region have established a variety of satellite data receiving systems, including 15 CMACast stations, 8 FY-2 stations, 2 FY-3 stations, and 2 FY-4 stations. Furthermore, over 30 countries have also downloaded Fengyun data via the NSMC’s FTP server. Additionally, the FY-3 preprocessing software package has been made available for free download and installation in 30 countries.

Moreover, user capabilities in “Belt and Road” countries have been enhanced through new tools developed by the NSMC. Three application tools are provided to assist users in processing Fengyun satellite data. The international version of Fengyun Earth is designed to provide core meteorological services, integrating

multi-source satellite data to offer timely, intelligent, detailed, and customizable remote sensing services. The Satellite Weather Application Platform 2.0 (SWAP 2.0) is tailored for weather analysis and forecasting, utilizing GEO Fengyun satellites. It is available in both web-based and standalone versions, displaying full-disk and regional images from FY-2H, FY-4A, and FY-4B, with support for multiple languages. The Satellite Monitoring and Remote Sensing Toolkit (SMART 2.0) harnesses data from FY-3, GAOFEN, NOAA, and other medium- and high-resolution Earth observation satellites. It focuses on monitoring environmental and biological changes across land surfaces, oceans, water bodies, and ice surfaces.

Additionally, ongoing endeavours are being made to facilitate scientific exchanges and enhance user training among “Belt and Road” countries. Initiatives include the organization of international users’ conferences, the delivery of training courses, and the facilitation of scientific exchanges. At the 2023 International Fengyun Meteorological Satellite Users Conference, technical training sessions were conducted on the application of Fengyun satellite data.

6 Future Plan

In the future, Fengyun-3H and Fengyun-3 fourth batch of satellites in LEO orbit, along with Fengyun-4C and Fengyun-4 third batch of satellites in GEO orbit, will be launched. The operational status of the second-generation Fengyun meteorological satellites will be maintained, with the objective of ensuring continuous and stable in-orbit operation of the Fengyun satellites. The third-generation Fengyun meteorological satellites, including the Fengyun-5 series and Fengyun-6, have also been planned and are currently undergoing requirement demonstrations^[9].

7 Summary

From 2022 to 2024, two Fengyun satellites were launched: FY-3G and FY-3F. Currently, 9 Fengyun satellites are in orbit. Fengyun LEO satellites have achieved network observation in four orbits, while Fengyun GEO satellites have formed an operational pattern of “net-

work observation and in-orbit backup”, providing data and product services to the world. They have been incorporated into the WMO global operational meteorological satellite sequence, becoming a pivotal force in the global Earth observation network. Their deployment has led to significant economic, social, and international benefits.

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