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The current status of FY-3D

(Submitted by Xiang Fang, CMA)

Summary and Purpose of Document

This document introduce the current status of FY-3D, including payload information, main product, ground application system upgrades and data access methods.

ACTION PROPOSED

The second session is invited to:

(a) Take note of the current status of FY-3D;

(b) Provide comments for FY-3D data application.

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DISCUSSION

1. Introduction

FY-3D is the fourth satellite in China's second generation polar-orbiting meteorological satellite family. FY-3D will be put into operation as a principal satellite for low-orbit afternoon observation in China. It will be networked together with FY-3C, which was launched in September 2013, as part of a constellation of morning and afternoon observation by China's polar-orbiting meteorological satellites of a new generation.

FY-3D is a satellite with the largest number of spectral measurement channels (over 7000) in China, which will greatly enhance the capacity to detect the low-level atmospheric dynamic parameters, thermal parameters, GHGs and high-level atmospheric electric fields, magnetic fields and energetic particles of the earth, hence the capabilities and skills in such aspects as global NWP, global climate change response, ecological environment monitoring and space weather forecasting in China.

2. Main payloads

FY-3D is equipped with 10 advanced remote sensing instruments. Five of which are inherited instruments: microwave temperature sounder, the Microwave Temperature Sounder, the Microwave Humidity Sounder, the Microwave Radiation Imager, the space environment monitor suite and the GNSS Radio Occultation Sounder. Four instruments are newly developed: the Hyperspectral Infrared Atmospheric Sounder, the Greenhouse Gases Absorption Spectrometer, the Wide-angle Aurora Imager and the Ionospheric PhotoMeter. The Medium Resolution Spectral Imager has also been significantly upgraded and improved. (Payloads spectral parameters are listed in table 1.)

Table 1: Payloads parameters for FY-3D

Payload	**Number of channels (start-stop wavelength)**
the Medium Resolution Spectral Imager – Model II (MERSI-II)	25（0.413-12μm）
the Hyperspectral Infrared Atmospheric Sounder (HIRAS)	1370（3.92 -15.38μm）
the Microwave Radiation Imager (MWRI)	10（10.65-89 GHz）
the Microwave Temperature Sounder – Model II (MWTS-II)	13（50.3-57.29GHz）
the Microwave Humidity Sounder– Model II (MWHS-II)	15（89.0-183.31 GHz）
the GNSS Radio Occultation Sounder (GNOS)	29 (none)
the Greenhouse Gases Absorption Spectrometer (GAS)	5540（0.75-2.38μm）
the Wide-angle Aurora Imager (WAI)	1（140nm-180nm）
the Ionospheric PhotoMeter (IPM)	3（130-180 nm）
the space environment monitor (SEM)	25 (none)

1) The new instruments onboard FY-3D

The Hyperspectral Infrared Atmospheric Sounder (HIRAS), which uses the most advanced Fourier interference detection technology in the world, observes the systems of land and air in a hyperspectral resolution and in an infrared fashion, with the spectrum covering 1370 channels.

Compared with the existing FY-3 IR spectrometer, the number of spectral channels is increased by 70 times, with the spectral resolution being up to a wave number of 0.625 cm, which improves the accuracy of atmospheric temperature and humidity in profile inversion by more than one times as a much stronger support to long-term NWP.

The Greenhouse Gases Absorption Spectrometer (GAS) is the first remote sensing instrument carried onboard a FY satellite to watch global GHG concentrations. It captures the information on concentrations of major GHGs (carbon dioxide, methane and monoxide) in their global distribution over time to improve the quantitative estimation of surface GHG fluxes at regional scale, and the analysis and monitoring of global carbon sources and sinks as a robust body of data in support of GHG reduction set forth at the Paris Climate Conference.

The Wide-angle Aurora Imager (WAI) is the first remote sensing instrument in the world to acquire aurora images from a wide spatial range of fields. At high magnetic latitudes, it takes an aurora image of extreme ultraviolet band and of about 130° × 130° every two minutes at a spatial resolution of 10 km. It monitors the location of an aurora border, the ionospheric global imagey and the distribution of settling electrons to report the auroral intensity and range and the polar sediment particles before forecasting a potential magnetic storm, a potential magnetospheric substorm or the polar ionospheric weather pattern.

The Ionospheric PhotoMeter (IPM) retrieves nighttime electron concentrations and daytime oxygen-to-nitrogen ratio parameters by measuring the EUV band airglow radiation intensity of oxygen atoms and nitrogen molecules in order to monitor the changing ionospheric state. WAI and IPM contribute to the safety of China's space infrastructure that underpins the national strategy of being a power in aerospace.

2）The upgraded instrument onboard FY-3D

The Medium Resolution Spectral Imager – Model II (MERSI-II) is one of the core instruments in the FY-3 family. MERSI, which integrates the functions of two existing imaging instruments for FY-3, is the first imager in the world that obtains global infrared split-window data of a resolution of 250 m. It acquires global true color images of a 250 m resolution seamlessly every day to accurately and quantitatively retrieve such atmospheric, terrestrial and oceanic parameters as clouds, aerosols, water vapor, land surface features and ocean color as a scientific support to the global ecological well-being, disaster monitoring and climate assessment.

3) The inherited instruments onboard FY-3D

Building on the predecessor of FY-3C, the GNSS Radio Occultation Sounder (GNOS) features a bigger number of positioning and occultation channels for China's Beidou navigation satellites. It is the first detector in the world that receives signals from the two navigation satellite systems of GPS and Beidou at the same time with a total of 29 reception channels. It provides global atmospheric refractive indexes and atmospheric temperature, humidity and pressure profiles of high precision and high vertical resolution for NWP and climate monitoring as well as information on ionospheric electron density for space weather monitoring.

Building on its predecessor, the Microwave Humidity Sounder – Model II (MWHS-II) features an improvement in the accuracy in calibrating instrument radiation, the sensitivity in detection and the life for service. Using the five atmospheric humidity detection channels near the water vapor absorption line of 183.31GHz and the eight atmospheric temperature detection channels near the oxygen absorption line of 118.75GHz in combination with the detection results from the two window channels of 89GHz and 166GHz, MWHS-II acquires global profiles of vertical distribution of atmospheric humidity and temperature and products like rainfall verification, path ice water thickness and precipitation intensity as the information on the initial atmospheric humidity field for NWP.

Building on its predecessor, the Microwave Temperature Sounder - Model II (MWTS-II) features an increase in the number of channels near the oxygen absorption band of 50-60GHz from 4 to 15 by subdivision to improve the capability and performance of the microwave thermometer. It observes the atmospheric vertical temperature distribution around the clock and in all weather conditions to

produce a better initial field for NWP models and a higher accuracy in weather forecasting.

The Microwave Radiation Imager (MWRI) is one of the important imaging instruments for FY-3. The observation of the Earth's surface 10.65-89GHz dual-polarized passive microwave radiation energy derives the information on wind field, land surface and sea surface precipitation, precipitable water, cloud water, thickness of liquid on the atmospheric path, thickness of ice water on the path, height and thickness of the melting layer, soil moisture, sea ice, sea surface temperature and snow cover. It maintains the features designed for the first three satellites as well as a stable continuous observation, hence well placed for climate observation and research.

The Space Environment Monitor (SEM) mainly detects the particle radiation on the orbit of a satellite, the in-situ changing magnetic field vector, the accumulated instrument radiation and the changing satellite surface potential, the data from which are used to support space activities, satellite design, space research and space weather warning and forecasting.

3. FY-3D Main products

There are 80 products generated from 10 payloads of FY-3D. Among which, 52.8% are inherited products, 16.8% are new products, 30.3% are updated product. (See table 2.)

Table 2. FY-3C/D products comparison with FY-3A/B

No.	Product type	FY-3A/B Products	FY-3C/D Products
1	Atmosphere Products	Cloud, fog, cloud abundance, cloud type, cloud phase, cloud-top temperature and height, cloud optical thickness, outgoing longwave radiation, atmospheric precipitable water, dust monitoring, cloud motion vector in polar regions, aerosol on ocean surface, aerosol on land surface, precipitation monitoring, ice water thickness, atmospheric temperature and humidity profile, cloud water content, land surface precipitation, total ozone, ozone profile	Ultraviolet aerosol index, GNOS atmosphere density profile, GNOS atmosphere profile, GNOS atmosphere reflectivity profile, GNOS low-level humidity profile, Atmosphere condition product FY3D adds CO2, CO, CH4, O2, etc. atmosphere compositon products.
2	Land Products	Global fire points, land surface reflectivity, land surface temperature, vegetation index, snow identification, leaf surface index, effective radiation for photosynthesis index, net primary productivity, land surface bi-directional albedo/reflectivity, land cover product, snow depth / snow water content, land surface humidity/ drought index / flood index	
3	Ocean Products	Sea surface temperature, sea ice monitoring, Ocean color	Sea surface wind speed
4	Space weather products	High-energy particle, surface potential, radiation dose	GNOS electron density profile, aurora image projection product, The oxygen nitrogen airglow products

4. Global networking and coverage by stations receiving FY-3 polar-orbiting meteorological satellites

FY-3D ground application system is much more advanced than the previous ones.

It is the first time that the domestic remote sensing satellite data are received and transmitted by the North and South Poles stations plus four domestic ground stations to the data processing centers in a real-time manner, with two stations (installed in Antarctica and Kashgar) added to the current system.

The global data reception has grown in capacity by increasing the number of antennas from seven 12 m ones to fifteen12 m ones plus three 7.3 m ones.

The satellite-earth data transmission rate has increased from 360Mbps to 480Mbps, indicating a faster communication and a larger capacity.

The network has transformed in capacity from the traditional three-tier architecture to a SDN one to provide a flat network access and an automatically adapted network support to an access device. With the pooling of resources, it is more automatic, more rapid and more reliable.

The computing capacity has increased from 40TFlop to 700TFlop by a factor of nearly 20.

The online data storage capacity has increased from 0.9PB to 9PB while the near-line one from 10PB to 80PB by a factor of nearly 10.

These improved capabilities will ensure that FY-3D ground application system captures and processes global data and distributes them to global users.

5. FY-3D satellite data service

FY-3D data is distributed by three ways:

FY-D satellite data direct receiving system: CMA has constructed 27 provincial level FY-3D direct receiving stations, and provided FY-3D data pre-processing software package.

Satellite data broadcasting: International users are able to access FY-3D satellite data via global data transfer protocol, such as CMACast, GTS and DBNet.

Website: users are able to search and download FY-3D quasi-real-time and historical data via FY satellite service website (http://www.nsmc.org.cn).

6. In-orbit test and following plans

FY-3D satellite has begun its in-orbit test on Dec 11, 2017, the test plan is as follows:

2017.12.11 – 2018.01.31 : Satellite platform testing

2018.02.01 – 2018.03.31 : Satellite remote sensing instrument testing

2018.04.01 – 2018.05.31 : Satellite product testing and experimental application

FY-3D is planned to be operational in June, 2018. By then, FY-3D data will be distributed for global users.

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