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AND ITS APPLICATION PROSPECTS

by

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FY-2 GEOSTATIONARY METEOROLOGICAL SATELLITE SYSTEM AND ITS APPLICATION PROSPECTS

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Abstract

Abstract The text briefly introduces FY-2 geostationary meteorological satellite, the ground application system and the remote sensing products, and makes a preliminary analysis and prediction of the possible application prospects, of the remote products.

Subject Term Meteorological satellite, Geosynchronous satellite, Systems analysis, Application.

One of the main features of meteorological geostationary satellites is frequent monitoring of the dynamic variations of ground and atmospheric systems in observable regions, thus greatly enhancing the monitoring capability of catastrophic weather systems. The Fungyun-2 [FY-2] meteorological geostationary satellite has graphic and data broadcast functions so that local meteorological stations and applications departments can more conveniently obtain weather information and satellite remote sensing products. The FY-2 satellite also has the automatic data collection function. Together with a data collection platform (DCP), automatic collection and distribution of multiple environmental monitoring data on meteorology, oceans, hydrology, earthquakes, as well as agro-forestry can be realized. This will greatly enhance monitoring capability on the earth environment.

The FY-2 satellite system includes five components: satellite, carrier rocket, launch equipment, surveying and control stations, and application systems. The launch, carrier, and control utilize China's technical achievements in communications satellite. The article presents only briefly two parts: recent research and developments. In other words, this is the general situation with satellite application systems. In addition, a brief explanation and predictions are given on the applications prospects and satellite remote sensing products.

I. Satellite Functions

The FY-2 satellite is a geosynchronous meteorological satellite that will be positioned over the equator at 105E in a synchronous orbit at about 36,000km above earth. The satellite's exterior is a cylinder 2.1m in diameter and 1.6m in height. The launch mass is approximately 1300kg. The satellite attitude makes use of the spin-stabilized mode; the spin speed is (1000+/-1)rpm.

The satellite has the following fundamental functions:

1) By using a multichannel scanning radiometer, the satellite makes observations of the ground, and obtains digitized

and graphic data in the visible light, in infrared, and water vapor spectral regions.

2) By using the data collection system, the satellite automatically collects and transmits meteorological, oceanic, hydrological, and other environmental monitoring data from the data collection platform.

3) By using the cloud map broadcast system, the satellite transmits the original cloud maps, satellite remote sensing graphic products, and meteorological map facsimile information.

4) The satellite carries on board a space environment monitoring device for information about space environmental parameters.

There are dozens of systems in the fundamental satellite components: 1. multichannel scanning radiometer; 2. digitized transmission and cloud map broadcast transponders; 3. data collection system; 4. antenna system; 5. surveying and control system; 6. orbital and attitude control system; 7. power supply system; 8. thermal control system; 9. structural system; and 10. apogee engine.

One of the most important tasks of the FY-2 satellite is to make ground observations with a scanning radiometer, and to obtain remote sensing graphic data. The scanning radiometer has three wave segments of the detection channels; its operating mode follows the spin motion of 100rpm of the satellite. With each revolution, a scan is made of the earth from east to west. The observation range is within the angle $+/-10^{\circ}$, with its center at the point on the ground just beneath the satellite. One scan is 0.6s. After concluding each scan, the radiometer stepping mechanism moves approximately 140microradians from north to south. There is a total of 2500 steps in the north-to-south direction, thus yielding an earth circular disk-shaped picture with the line-of-sight angle being approximately 20^{0}x20^{0}. The time required is approximately 25min. After completing the observation of a picture, the stepping mechanism will return quickly to its beginning position in 2.5min. then after about 2.5min of stabilization time, the mechanism can start again, to scan with a new picture. Moreover, the radiometer can make scanning with a regional picture and a single-line scanner (repeated scanning of the stepping mechanism without proceeding by steps), as specifically required.

The main technical performance indicators of the satellite scanning radiometer are listed in Table 1.

II. Ground application systems

The composition of the geostationary meteorological satellite application systems is shown as in the attached figure, including the following components:

Command and data acquisition (CDAS) and at the same time, the main ranging station (MRS), in addition to three subranging stations (TRS1 and TRS2), at Guangzhou, Urumqi, and in Australia; the system operational control center (SOCC); and the data

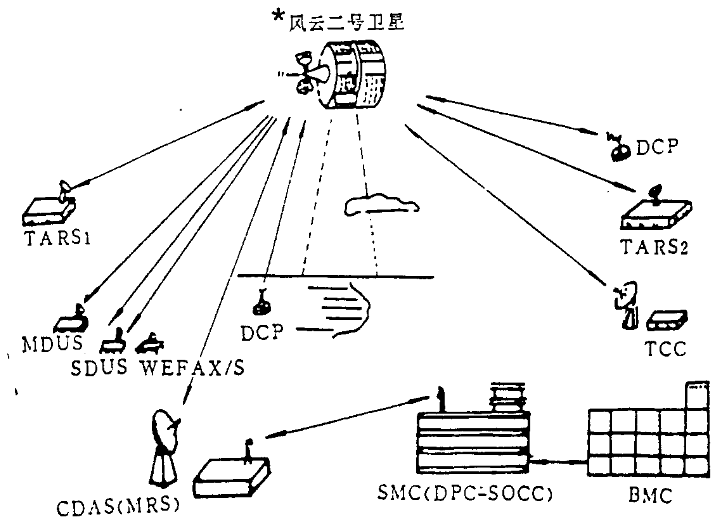
TABLE 1. Main Technical Performance Indicators of Scanning Radiometer on Board FY-2 Satellite

1 项目	2 可见光	3 红外	4 水汽
5 探测波段/μm	12 0.55～0.75 (第一颗星允许放宽至0.5～1.05)	10.5～12.5	6.3～7.6
6 星下点分辨率/km	1.25～1.44	5～5.67	5～5.67
7 信噪比 (均方根值)	S/N≥6.5 (反射率2.5%) 13 S/N≥43 (反射率95%) 13	—	—
8 噪声等效温差NEΔT/K	—	0.5 (300K)	≤1.0 (260K)
9 量化等级/bit	6	8	8
图像帧扫描线行数 10	10 000	2 500	2 500
11 观测方式	14 正常观测 20°×20°地球圆盘图 15 区域观测 15种区域可选 16 单线扫描 位置可任意确定		

KEY: 1 - item 2 - visible light 3 - infrared 4 - water vapor 5 - detection wave segment 6 - resolving power/km at point just beneath satellite 7 - signal-to-noise ratio (root-mean-square value) 8 - noise-equivalent temperature difference 9 - quantization level 10 - number of scan lines of a picture frame 11 - observation mode 12 - It is allowed to broaden to the range of 0.5 to 1.05 for the first satellite 13 - reflectivity 14 - normal observation: 20°x20 circular disk graphic on earth 15 - regional observation: selectable for 15 regions 16 - single line scan: position can be randomly determined.

processing system (DPC). These three above-mentioned components are the core.

Secondly, these are the medium-scale data utilization station (MDUS); the small-scale data utilization station (SDUS); the weather map acquisition station (WEFAX/S); and the data collection platform (DCP).



Attached diagram: Block diagram of application system for FY-2 geostationary meterological satellite

KEY: * - FY-2 satellite

In addition, in the figure there is a tracking and control center (TCC), which is the Xi'an Satellite Control Center, and its subordinating control stations. The main user of the satellite data is the Beijing Meteorology Center. These components will be briefly presented below.

2.1. Command and data acquisition station (CDAS)

The Command and data acquisition station is the key between the satellite and ground application systems.

The CDAS is composed of the following subsystems:

antenna; power supply and thermal control subsystem; tracking and acquisition subsystem; launch subsystem; ranging subsystem; remote sensing subsystem; remote control subsystem; original cloud map demodulation and synchronized buffer subsystem; data collection platform, data receiving, and calibrated frequency subsystem; cloud map broadcast and graphic monitoring subsystem; systems analyzer subsystem; monitoring and control subsystem; frequency synthesizer and time unified service subsystem; and calibration subsystem.

In the orbital operation process of a FY-2 satellite, there are frequent information exchanges between the satellite and the CDAS.

There is the following information: uplink information from CDAS to satellite, uplink signals for broadening digitized cloud map from the main ranging station, the LR-FAX uplink signals, the S-FAX uplink signals, and the uplink signals of traffic remote control command from standard platforms.

There is downlink information from the satellite to the CDAS, including the downward signals of the original cloud map from the main ranging station, downward signals from subranging station No. 1, downward signals from subranging station No.2, downward signals from broadening digitized cloud map, LR-FAX downward signals, S-FAX downward signals, as well as remote sensing data and platform reporting data, among others.

Also presented are the various data exchanges between CDAS and SOCC, on the one hand, and DPC, on the other, including coding remote sensing, simulation remote sensing, three-point ranging data, remote control command, DCPR data, as well as information for cloud map data synchronizing, buffer system operation parameters, and system status.

2.2. System operation control center (SOCC)

The system operation control center is the traffic operations control core between the satellite and ground application systems. Through CDAS, the SOCC makes traffic controls on the FY-2 satellite, in addition to the command, dispatch, and management of traffic operations of the ground applications systems (including CDAS and DPC).

The fundamental components of SOCC are two sets of the HP9000/1240 central processor and the HP9000/400S graphics workstation, the SGI/310 graphics workstation, a communication network, a main control set, and other peripherals. The SOCC traffic and applications software includes execution software, public utility software, and applications software for accomplishing multiple operations. The principal application software includes a communication processing program, a real time processing program, a traffic control program, a display program, a monitoring program, as well as a graphic quality analysis program and other supplementary programs.

2.3. Data processing center (DPC)

The data processing center is a center for data processing, product reprocessing, data filing, and a distribution center for ground application systems.

The task undertaken by the DPC has the following features: large information quantity, high time effect of graphics processing, and complex operations. In addition to 24-h continuous system operation, it is required to have high reliability, so the entire DPC system adopts a three-level distributed-type computer system with the combination of concentration and dispersion, composed of a central processor, workstations, and networking microcomputers with division of labor according to missions, the entire DPC computer system can be classified into the following four subsystems:

(1) the front-end communication processor subsystem (including two SUN4/490 workstations and some communication controllers);

(2) central processor subsystem (including two M770/10 computers and multiple peripheral equipment, such as magnetic disks, and magnetic tapes);

(3) graphic workstation subsystem (including two SUN4/490 workstations and the attachment equipment); and

(4) local network product distribution subsystem (including local network equipment) and special distribution microcomputers.

The DPC software system includes computer system software and traffic application software. With the introduction of the system software in the computer system, these are simultaneously introduced together with the computer, as specified in the purchase contract. Some application software is designed and developed by the Satellite Meteorology Center. Since the DPC has very complex processing tasks, the software will amount to hundreds of thousands of lines. According to the function, the DPC software system is classified into ten software subsystems, as follows:

communication and local area network software, system operation management software, workstation system software, graphic and data preprocessing software, graphic products processing software, weather analysis products processing software, product processing software for digitized weather parametric products, processing software for weather products, digitized graphic database and filing software, and system test software.

III. Satellite Remote Sensing Products

Generated by the DPC system processing, the satellite remote sensing products can be divided into two categories: FY-2 satellite remote sensing graphics, and weather analysis graphics products, FY-2 satellite remote sensing digitized products, digitized remote sensing products, and GMS remote sensing digitized products. The main performance indicators of the various product types are listed in Tables 2 through 5.

Also, with regard to data collection platform information, DPC will be based on the type of platforms, the departments responsible for installing the platform, and the platform address code for compilation with classification in order to provide the users in appropriate modes.

TABLE 2. Principal Performance Indicators of Satellite Graphics and Weather Analysis Products

1 产品名称	2 覆盖区域	次数/日 3	分辨率 4	输出方式 5
6 全圆盘图 (可见光、红外、水汽)	以105E,0N为中心的地球圆盘 9	8	可见光5km 红外、水汽 13 10km	14硬拷贝 15联机调用
7 分区图 (可见光、红外、水汽)	5个分区（圆盘图4个象限 10 和中国覆盖分区）	8	10km	14硬拷贝 15联机调用 LR-FAX
8 临时观测云图 (可见光、红外、水汽)	11 机动选择 (有15种区域)	12不定时	5km	15联机调用
兰勃托投影图 (可见光、红外、水汽) 16	以105E,30N为中心的中国覆盖地区 21	可见光10 红外、水汽 22 24	10km	23视频录相、24联机调用 LR-FAX
麦卡托投影海区图 (可见光、红外、水汽) 17	105E～150E 0～45N	可见光10 红外、水汽 22 24	10km	23视频录相 24联机调用 S-FAX
麦卡托投影图 (红外) 18	45N～45S 45E～165E	4	10km	24联机调用 S-FAX
云分析图 19	以105E, 30N为中心的中国覆盖地区 21	4	10km	24联机调用 S-FAX
降水指数图 20	以105E, 30N为中心的中国覆盖地区 21	4	10km	24联机调用 S-FAX

[KEY given on next page]

KEY: 1 - name of products   2 - coverage   3 - number of times per day   4 - resolving power   5 - output mode   6 - whole circular disk diagram (visible light, infrared and water vapor)
7 - regional maps (visible light, infrared and water vapor)
8 - temporary observation cloud maps (visible light, infrared and water vapor)   9 - circular disk on earth with center at 105E and 0N   10 - five subregions (four quadrants of a circular disk circle, and regional coverage of China)   11 - mobile selection (among 15 regions)   12 - not definite time   13 - 5km for visible light, and 10km for infrared and water vapor   14 - hard copy   15 - on-line output   16 - Lambert's projection (visible light, infrared, and water vapor)   17 - Mercator's projected oceanic diagram (visible light, infrared, and water)
18 - Mercator's projection (infrared)   19 - cloud analysis maps
20 - precipitation indicator maps   21 - coverage in China with center at 105E and 30N   22 - 10 for visible light and 24 for infrared and water vapor   23 - photograph at video frequency
24 - on-line output

IV. Application Prospects of Satellite Remote Sensing Data

The most unique features of a geostationary meteorological satellite are the frequent observations of the regions under observation, especially beneficial to the buildup and development of intensive convective catastrophic weather systems with short monitoring lifetimes. For example, meteorologists in China utilized data from the Japanese GMS satellite to monitor typhoons and other weather processes, with outstanding results. Cloud maps generated with geostationary meteorological satellites have become an indispensable data for weather analysis and forecasting.

The launching of the FY-2 geostationary meteorological satellite provides abundant data from satellite remote sensing, thus significantly upgrading the data acquired from the GMS satellite alone. First, the FY-2 satellite will be stationed

TABLE 3. Main Performance Indicators of Numerical Products from FY-2 Satellite

产品名称 1	覆盖区域 2	次数/日3	分辨率4	5输出方式
云风矢量 6	50N～50S 55E～155E	4	200km	12GTS电码 S-FAX 13联机调用
7 海面温度	50N～50S 55E～155E	2	50km	12GTS电码 S-FAX 13联机调用
对流层上层水汽含量 8	50N～50S 55E～155E	2	50km	13联机调用
9 云参数	50N～50S 55E～155E	8	50km	13联机调用
射出长波辐射 10	50N～50S 55E～155E	8	50km	S-FAX 13联机调用
11日照	50N～50S 55E～155E	1	50km	13联机调用

KEY: 1 - name of products 2 - coverage 3 - times per day 4 - resolving power 5 - output mode 6 - cloud and wind vectors 7 - temperature at ocean surface 8 - water vapor content in upper troposphere 9 - cloud parameters 10 - emitted long-wave radiation 11 - insolation 12 - GTS code 13 - on-line output

over the equator at 105E. This is a relatively ideal position from which to observe mainland China, as well as its adjacent seas and surrounding areas, capable of monitoring all regions of China, including the Qinghai-Tibet Plateau and Northwest China. In addition, weather systems from the Arabian Sea and the Bay of Bengal can be observed. The enhancement from monitoring the upstream region of China's weather will greatly upgrade the capabilities of weather analysis and forecasting in China.

Secondly, the observation times of the FY-2 satellite will be

TABLE 4. Main Performance Indicators of Graphic Products from GMS Satellite

1 产品名称	2 覆盖区域	次数/日 3	分辨率 4	输出方式 5
6 全圆盘图 (可见光、红外)	以140E, 0N为中心的地球圆盘 10	8	10km	13 硬拷贝 14 联机调用
7 兰勃托投影图 (可见光、红外)	以105E, 30N为中心的中国覆盖地区 11	12 可见光10 红外24	10km	15 视频录相 14 联机调用
8 麦卡托投影海区图 (可见光、红外)	105E～150E 0N～45N	12 可见光10 红外24	10km	15 视频录相 14 联机调用
麦卡托投影图 9 (红外)	45N～45S 80E～160W	4	10km	联机调用 14

KEY: 1 - name of products 2 - coverage 3 - number of times per day 4 - resolving power 5 - output mode 6 - whole circular disk map (visible light and infrared) 7 - Lambert's projection (visible light and infrared) 8 - Mercator's projected ocean region (visible light and infrared) 9 - Mercator's projection (infrared) 10 - circular disk on earth with center at 104E and 0N 11 - coverage in China with center at 105E and 30N 12 - 10 for visible light and 24 for infrared 13 - hard copy 14 - on-line output 15 - photography of video frequency

TABLE 5. Principal Performance Indicators of Numerical Products from GMS Satellite

1 产品名称	2 覆盖区域	3 次数/日	4 分辨率	5 输出方式
6 云参数	50N～50S 90E～170W	8	50km	联机调用 9
海面温度 7	50N～50S 90E～170W	2	50km	联机调用 9
射出长波辐射 8	50N～50S 90E～170W	8	50km	联机调用 9

KEY: 1 - name of products 2 - coverage 3 - number of times per day 4 - resolving power 5 - output mode 6 - cloud parameters 7 - temperature at ocean surface 8 - emitted long-wave radiation 9 - on-line output mutually compensating with the Japanese GMS satellite. The combination of data from the two satellites will provide satellite data once every half hour, thus being very beneficial to the dynamic monitoring of weather system evolution. In addition, the radiometer on the FY-2 satellite carries the visible-light and infrared channels, in addition to the water-vapor channel that the present GMS channel (GMS-4) does not carry. Thus remote sensing information will be increased, being helpful to upgrading the applications in weather and other fields.

Besides the various graphic products, with the secondary processing from the DPC, the quantitative digitized products with a certain accuracy can be obtained. Other than the important application values in weather, meteorology, and digitized forecasting, as well as other areas in meteorology, these quantitative products have extensive application potentials in oceanic, hydrological, agro-forestry, and other environmental monitoring.

Brief descriptions are given in the following passages on the application prospects of remote sensing data and products from the FY-2 satellite.

(1) Applications of graphics and weather analysis products

The graphic products are the meteorological cloud maps, which are still the most important forms of satellite remote sensing data applied in weather analysis and forecasts. In a cloud map, the cloud clusters and cloud systems are the direct reactions of dynamic and thermodynamic processes in the atmosphere, as well as the interactive process between the atmosphere and its underlying surface. By carefully analyzing cloud map features, we can expose the occurrence and development of multiple-scale weather processes in the atmosphere. For example, we can monitor and analyze the equatorial convergence belt, high-altitude troughs, cold eddies, tropical windstorms, and other tropical weather systems. In monitoring and forecasting rainstorms, the process by which rainstorm cloud clusters occur can be monitored by direct view through interactions of planetary-scale systems, weather-scale systems, and rainstorm cloud clusters, with the analysis of planetary cloud maps. In analyzing medium-scale, intensive convective weather systems, cloud maps can also provide direct-view information on squall lines, gust peaks, and thunderstorms, among other weather systems. Generally, with the unique features, motions, and variation trends of cloud types of cloud clusters and systems in cloud maps, and with cloud parameters (cloud-top temperature and cloud-top height, among others) with certain accuracy can be used to provide information about multiple weather processes. This provides forecast services in weather analysis. To better exploit the function of satellite cloud maps in weather forecasting, especially in supporting the forecast services of the stations at the fundamental level, the FY-2 satellite application system data processing center can provide users with cloud type classifications of cloud maps and cloud systems on the basis of fundamental graphics products of the FY-2 satellite by utilizing the satellite remote sensing information of cloud maps with the necessary conventional observation of weather data for exploiting the experience of differentiating cloud maps gathered by meteorologists, with the combination of computer automatic differentiation and man-machine interface for developing the cloud analysis maps and precipitation indicator maps for weather analysis. It is estimated that such products will be welcomed by weather forecasting personnel in better exploiting the functions of satellite remote sensing data in weather analysis and forecasting.

(2) Applications of remote sensing data products of the FY-2 satellites

With secondary processing of remote sensing graphic data from the FY-2 satellite, multiple digitized products (see section III) can be obtained. These numerical products will have more extensive areas of applications.

By using assimilation processing in conventional weather data, cloud wind vectors and sea surface temperature data can be considered as the initial field of the numerical forecasting mode. In the vast ocean, especially due to rare conventional observation data, satellite data will have important functions. The cloud parameters, sea surface temperatures, emitted long-wave radiation, insolation, and other numerical products are important to the regional and global monitoring of environment and weather.

Other than the meteorological applications, the sea surface temperature data have important applications in fishing ground forecasting of oceanic fisheries, analysis of oceanic current, interaction between the ocean and the atmosphere, and maritime navigation, among other fields.

The emitted long-wave radiation data directly indicates the interaction among the cloud cover in the atmosphere, rainfall, convective intensity, latent heat of condensation, atmospheric vertical circulation, and interaction between ocean and atmosphere. These data are also the source of information for ground coverage status and insolation in bright sunlight. Therefore, in recent years the emitted long-wave radiation is widely emphasized in weather analysis, interaction between the ocean and the atmosphere, ocean environmental research, as well as analysis and forecasting of long-term variations of weather and environment.

(3) Applications of remote sensing products of water-vapor channel

The remote sensing data of the water-vapor channel from the FY-2 satellite can be used to provide numerical products of water vapor contents in the upper troposphere for providing water-vapor graphics. Since the wave segment of the water-vapor channel of the scanning radiometer on board the FY-2 satellite is between 6.3 and 7.6micrometers, and there is only one water-vapor channel, the geographic distribution features of total water-vapor content in the atmosphere can only be obtained.

By applying the water vapor content data and water vapor graphics, it is possible to distinguish the existence of cirrus, to improve the altitude orientation accuracy of the cloud and wind vectors, as well as to calculate the water vapor and wind. With analysis of the boundary features and shape patterns of water vapor clusters, we can monitor the weather systems of atmospheric ascending motion, higher-altitude troughs, downward surges, cyclones, air torrents, subtropical high pressure, and equatorial convergence belt, and other weather systems. Therefore the water-vapor graphics are also important data in weather analysis. By combining with the visible-light, and the infrared channel cloud maps, this will further upgrade the application level of satellite remote sensing data in weather analysis and forecasting.

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