The Sounding Instruments on Second Generation of Chinese Meteorological Satellite FY-3

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Overview of Report

- A Forward Look of the Weather Satellites
- Current Status of Chinese Weather Satellites

A Forward Look of the Weather Satellites

Leo_SAT

- FY-3A will be Launched in 2006(ex.)
- FY-3B will be launched in 2009(ex.)
- FY-3C/D/E/F will be improved based on FY-3A/B and then will be operational around 2010

Geo_SAT

- FY-2C Launch 2004
- FY-2D Launch 2006
- FY-2E Launch 2009

FY-3 series

The second generation of polar-orbiting meteorological satellites are developing

The Mission of FY-3 Series (1)

- Global sounding capability:

  To obtain three-dimensional thermal structure and water vapor distribution of the atmosphere, cloud and other parameters, to support NMC global NWP

The Mission of FY-3 Series (2)

- Global imaging capability:

  To monitor severe weather, hydrological and meteorological disasters and biosphere environment, provide information for climate observations

- Data collection and transmission capability

Main specifications of the FY-3 (1/2)

- Orbit altitude: 836 km
- Orbit: Sun-synchronous, inclination=98.728
- Eccentricity: better than 0.0034
- Descending Nodal time: 10:10 am (LST)
- Shift Nodal time maintained: 10 mins(2 years)
- Power: 1100 watts (orbital average, estimated)
- Weight: 2200 kg (estimated up to now)

Main specifications of the FY-3 (2/2)

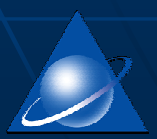
- Attitude control: Three axis stabilization
  - Pointing accuracy: better than 0.3 degree
  - Pointing stability: better than 0.004 deg/sec
  - Pointing knowledge requirement: better than 0.05 deg
- Solar panel: tracking to the sun

- The Imaging Mission:

VIRR	Visible and InfRared Radiometer
MERSI	Medium Resolution Spectral Imager
MWRI	Microwave Radiation Imager

- The Sounding Mission

IRAS	InfraRed Atmospheric Sounder
ASI	Atmospheric Sounding Interferometer
MWTS	MicroWave Temperature Sounder
MWHS	MicroWave Humidity Sounder



SBUV	Solar Backscatter Ultraviolet Sounder
TOU	Total Ozone Unit

- The Complementary Mission

SIM	Solar Irradiation Monitor
ERM	Earth Radiation Measurement
SEM	Space Environment Monitor

Basic Information for Each Instrument

Name of Instrument	Number of Channels	Field of Views /line	Spatial Resoluation at Sub point
VIRR	10	2048	1.1
IRAS	26	56	17
MWTS	4	15	50/75
MWHS	5	90	15
MERSI	20	2048/8192	1.1/250
SBUS	12	240	70/10
TOU	6	31	50
MWRI	6	240	15-70
ASI		TBD	

VIRR Channel Characteristics

Channel No.	Wavelength (μ m)	Dynamic range	Detecting Sensitivity
1	0.58~0.68	ρ: 0~90%	S/N≥3(ρ=0.5%)
2	0.84~0.89	ρ: 0~90%	S/N≥3(ρ=0.5%)
3	3.55~3.95	190~340K	NEΔT≤0.4K(300K)
4	10.3~11.3	190~330K	NEΔT≤0.22K(300K)
5	11.5~12.5	190~330K	NEΔT≤0.22K(300K)
6	1.58~1.64	ρ:0~80%	S/N≥3(ρ=0.5%)
7	0.43~0.48	ρ:0~50%	S/N≥3(ρ=0.5%)
8	0.48~0.53	ρ:0~50%	S/N≥3(ρ=0.5%)
9	0.53~0.58	ρ:0~50%	S/N≥3(ρ=0.5%)
10	0.900~0.965	ρ:0~90%	S/N≥3(ρ=0.5%)

IRAS Channel Characteristics (1/4)

Channel No.	(cm-1)	Central wavelength (μ m)	Half-power Band width(cm-1)	Main Absorber	Max. Scene Temperature (K)	NE △ N (mW/m2-sr-cm-1)
1	669	14.95	3	CO_2	280	4.00
2	680	14.71	10	CO_2	265	0.80
3	690	14.49	12	CO_2	250	0.60
4	703	14.22	16	CO_2	260	0.35
5	716	13.97	16	CO_2	275	0.32
6	733	13.84	16	CO_2/H_2O	290	0.36
7	749	13.35	16	CO_2/H_2O	300	0.30

IRAS Channel Characteristics (2/4)

Channel No.	(cm^{-1})	Central wavelength (μm)	Half-power Band width (cm^{-1})	Main Absorber	Max. Scene Temperature (K)	NE Δ N (mW/m^2-sr-cm^{-1})
8	802	12.47	30	window	330	0.20
9	900	11.11	35	window	330	0.15
10	1030	9.71	25	O_3	280	0.20
11	1345	7.43	50	H_2O	330	0.23
12	1365	7.33	40	H_2O	285	0.30
13	1533	6.52	55	H_2O	275	0.30
14	2188	4.57	23	N_2O	310	0.009

IRAS Channel Characteristics (3/4)

Channel No.	(cm^{-1})	Central wavelength (μ m)	Half-power Band width (cm^{-1})	Main Absorber	Max. Scene Temperature (K)	NE Δ N (mW/m^2-sr-cm^{-1})
15	2210	4.52	23	N_2O	290	0.004
16	2235	4.47	23	CO_2/N_2O	280	0.006
17	2245	4.45	23	CO_2/N_2O	266	0.006
18	2388	4.19	25	CO_2	320	0.003
19	2515	3.98	35	window	340	0.003
20	2660	3.76	100	window	340	0.002

IRAS Channel Characteristics (4/4)

Channel No.	(cm^{-1})	Central wavelength (μ m)	Half-power Band width(cm^{-1})	Main Absorber	Max. Scene Temperature (K)	NE Δ N (mW/m^2-sr-cm^{-1})
21	14500	0.69	1000	window	100%A	0.10%A
22	11299	0.885	385	window	100%A	0.10%A
23	10638	0.94	550	H_2O	100%A	0.10%A
24	10638	0.94	200	H_2O	100%A	0.10%A
25	8065	1.24	650	H_2O	100%A	0.10%A
26	6098	1.64	450	H_2O	100%A	0.10%A

MWTS Channel Characteristics

Channel No.	Central Frequency (GHz)	Main Absorber	Band Width (MHz)	NE Δ T (k)	Antenna Beam Efficiency (%)	Dynamic Range (K)
1	50.30	window	220	0.3	＞90	3-340
2	53.74	O_2	220	0.3	＞90	3-340
3	54.96	O_2	220	0.3	＞90	3-340
4	57.95	O_2	220	0.3	＞90	3-340

MWHS Channel Characteristics

Channel No.	Central Frequency (GHz)	Main Absorber	Band Width (MHz)	NE Δ T (k)	Antenna Beam Efficiency (%)	Dynamic Range (K)
1	150(V)	Window	1000	0.9	≥95%	3-340
2	150(H)	Window	1000	0.9	≥95%	3-340
3	183.31±1	H_2O	500	1.1	≥95%	3-340
4	183.31±3	H_2O	1000	0.9	≥95%	3-340
5	183.31±7	H_2O	2000	0.9	≥95%	3-340

MERSI Channel Characteristics (1/4)

Channel No.	Central wavelength (μm)	Band width (μm)	Sub-point resolution (m)	NEΔT ρ (%) K (300K)	Dynamic Range(ρ)、(K)
1	0.470	0.05	250	0.45	100%
2	0.550	0.05	250	0.4	100%
3	0.650	0.05	250	0.3	100%
4	0.865	0.05	250	0.3	100%
5	11.50	2.5+Δ	250	0.4 K	330k
6	0.412	0.02	1000	0.1	80%

MERSI Channel Characteristics (2/4)

Channel No.	Central wavelength (μm)	Band width (μm)	Sub-point resolution (m)	NEΔT ρ (%) K (300K)	Dynamic Range(ρ)、(K)
7	0.443	0.02	1000	0.1	80%
8	0.490	0.02	1000	0.05	80%
9	0.520	0.02	1000	0.05	80%
10	0.565	0.02	1000	0.05	80%
11	0.650	0.02	1000	0.05	80%
12	0.685	0.02	1000	0.05	80%

MERSI Channel Characteristics (3/4)

Channel No.	Central wavelength (μm)	Band width (μm)	Sub-point resolution (m)	NEΔT ρ (%) K (300K)	Dynamic Range(ρ)、(K)
13	0.765	0.02	1000	0.05	80%
14	0.865	0.02	1000	0.05	80%
15	0.905	0.02	1000	0.10	90%
16	0.940	0.02	1000	0.10	90%

MERSI Channel Characteristics (4/4)

Channel No.	Central wavelength (μm)	Band width (μm)	Sub-point resolution (m)	NEΔT ρ (%) K (300K)	Dynamic Range(ρ)、(K)
17	0.980	0.02	1000	0.10	90%
18	1.030	0.02	1000	0.10	90%
19	1.640	0.05	1000	0.05	90%
20	2.130	0.05	1000	0.05	90%

SBUS Channel Characteristics (1/3)

Channel No.	Central Wavelength(nm)	Band Width(nm)
1	252.00±0.05	1+0.2，-0
2	273.62±0.05	1+0.2，-0
3	283.10±0.05	1+0.2，-0
4	287.70±0.05	1+0.2，-0
5	292.29±0.05	1+0.2，-0

SBUS Channel Characteristics (2/3)

Channel No.	Central Wavelength(nm)	Band Width(nm)
6	297.59±0.05	1+0.2，-0
7	301.97±0.05	1+0.2，-0
8	305.87±0.05	1+0.2，-0
9	312.57±0.05	1+0.2，-0

SBUS Channel Characteristics (3/3)

Channel No.	Central Wavelength(nm)	Band Width(nm)
10	317.56±0.05	1+0.2，-0
11	331.26±0.05	1+0.2，-0
12	339.89±0.05	1+0.2，-0
Cloud Cover Radiometer	379.00±1.00	3+0.3

TOU Channel Characteristics

Channel No.	Central Wavelength(nm)	Band width(nm)
1	308.68±0.15	1+0.3，-0
2	312.59±0.15	1+0.3，-0
3	317.61±0.15	1+0.3，-0
4	322.40±0.15	1+0.3，-0
5	331.31±0.15	1+0.3，-0
6	360.11±0.25	1+0.3，-0

MWRI Channel Characteristics

Channel No.	Central Frequency (GHz)	Polarization	Main Absorber	Band Width (MHz)	NE△T (K)	Antenna Beam Efficiency	Dynamic Range (K)
1	10.65	V.H	Window	180	0.5	≥90%	3-340
2	18.7	V.H	Window	200	0.5	≥90%	3-340
3	23.8	V.H	H2O	400	0.8	≥90%	3-340
4	36.5	V.H	Window	900	0.5	≥90%	3-340
5	89	V.H	Window	4600	1.0	≥90%	3-340
6	150	V.H	Window	3000	1.3	≥90%	3-340

FY-4 series

The second generation of The Geostationary meteorological satellites

- ✓ Three-Axis stabilization
- ✓ More powerful imager
- ✓ Sounding capability
- ✓ Lightning detection
- ✓ Data collection
- ✓ Powerful ground control capability
- ✓ Application and services system

FY-4 is expected to be launched beyond 2010.

SUMMARY

Meteorological satellite observations include rich information, which needs us to make great contribution to retrieve theory and algorithms.

Starting from FY-3, Chinese Meteorological satellites have sounding capability. FY series, with the combination of GEO/LEO satellites, will make contributions to the regional and global weather forecasting, Climate and environment monitoring.

Improvement for FY-2 C, D and E

- The number of spectral channels of Visible and Infrared Spin Scan Radiometer (VISSR) will be increased from 3 to 5
- To increase the temperature resolution of the infrared channels and the signal/noise ratio of the visible channels, and to support the application of the split window
- The data quantization level of the IR and WV channel will be increased from 256 to 1024

The spectral channels of VISSR

Channel	Wavelength (μ m)	
	FY-2 A,B	FY-2 C,D,E
VIS	0.50～1.05	0.50～0.75
IR1	10.5～12.5	10.3～11.3
IR2		11.5～12.5
IR3		3.5～4.0
WV	6.3～7.6	6.3～7.6

The characteristics of VIS channels of VISSR(1)

Item	Characteristics	
	FY-2 A,B	FY-2 C,D,E
Wavelength (μm)	0.50～1.05	0.50～0.75
FOV(μr)	40	35
Space resolution (km)	1.44	1.25
Dynamic range	0～95%	0～98%
S/N	6.5 (2.5%) 43 (95%)	1.5 (0.5%) 50 (95%)

The characteristics of VIS channels of VISSR(2)

Item	Characteristics	
	FY-2 A,B	FY-2 C,D,E
Number of detectors	4 (main) + 4 (alternate)	4 (main) + 4 (alternate)
Quantization level	64	64
Calibration	cool-space images and solar image to realize in-orbit calibration	same as FY-2 A,B

The characteristics of IR, WV channels of VISSR(1)

	FY-2 A,B	
	IR	WV
Wavelength(μ m)	10.5～12.5	6.3～7.6
FOV (μ r)	160	160
Space resolution(km)	5.76	5.76
Space resolution(km)	5.76	5.76
Dynamic range	180～330K	190～290K
Temperature resolution	0.6K	1.0K
Number of detectors	1(main)+1 (alternate)	1(main)+1 (alternate)
Quantization level	256	256
Calibration	On board blackbody calibration, once every 3 disks	

The characteristics of IR, WV channels of VISSR(2)

	FY-2 C,D,E			
	IR1	IR2	IR3	WV
Wavelength(μ m)	10.3～11.3	11.5～12.5	3.5～4.0	6.3～7.6
FOV (μ r)	140	140	140	140
Spatial resolution	5 km	5 km	5 km	5 km
Spatial resolution	5 km	5 km	5 km	5 km
Dynamic range	180～330K			180～280K
Temperature resolution	0.4～0.2K	0.4～0.2k	0.5～0.3 K	0.6～0.5 K
Number of detectors	1(main)+1 (alternate)	1(main)+1 (alternate)	1(main)+1 (alternate)	1(main)+1 (alternate)
Quantization level	1024	1024	1024	1024
Calibration	The ground calibration accuracy is 1K.Cool space and planet calibration is used for on-board calibration, once every 2 disks.			

Current Status of Chinese Weather Satellites

- FY-2 ： The Geostationary Meteorological Satellite
- FY-1 ： The Polar Orbiting Meteorological Satellite

The Geostationary Meteorological Satellite

FY-2

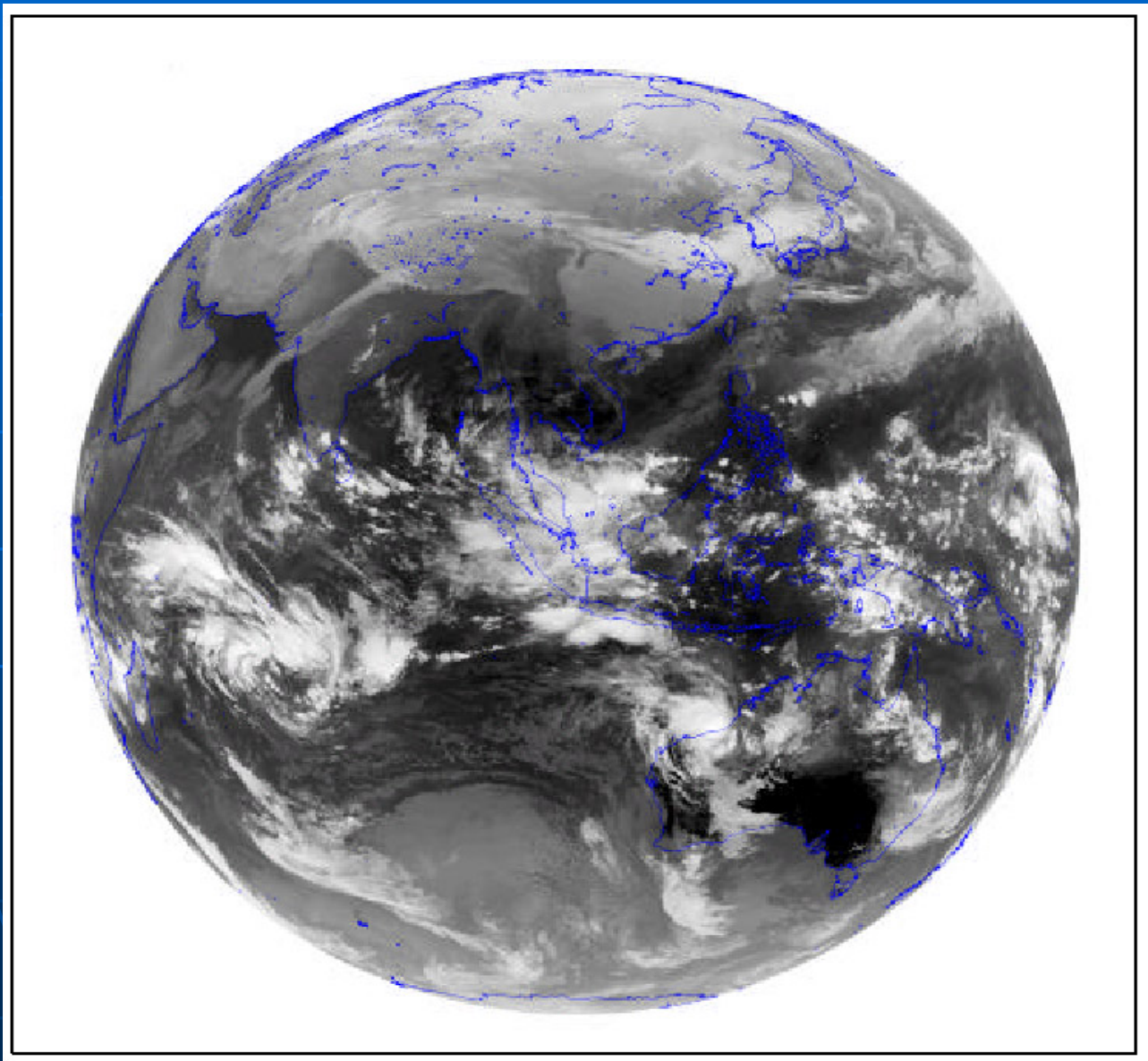
FY-2B

- It is at 105 oE.
- Except the eclipse period, It can operates 24 hours a day continuously at a low temperature status.
- The error rate of the satellite down-link is 10-4
- It transmits S-VISSR data every hour and is open to the international users.

FY-2B (cont.)

- An automatic image navigation system for FY-2B geostationary meteorological satellites have been developed in NSMC
- The system is based on a PC workstation running windows 2000.
- The orbital parameters, attitude parameters, misalignment parameters and beta angle parameters are turned out automatically and routinely without any manual operation.
- In the normal condition, user can receive the accurately navigated FY-2B satellite images

Automatic Navigation Result of FY-2B



FY-2B IR Channel Animation

01(UTC) May 31, 2002~ 01(UTC) June 1, 2002

The Polar Orbiting Meteorological Satellite

FY-1

The main functions of the FY-1

- To acquire global surface and cloud images day and night, and to measure surface and cloud top temperatures
- To measure composition of the space particle near the satellite orbit and to provide space environmental parameters
- To disseminate the observed data such as CHRPT, CDPT

FY-1C/D

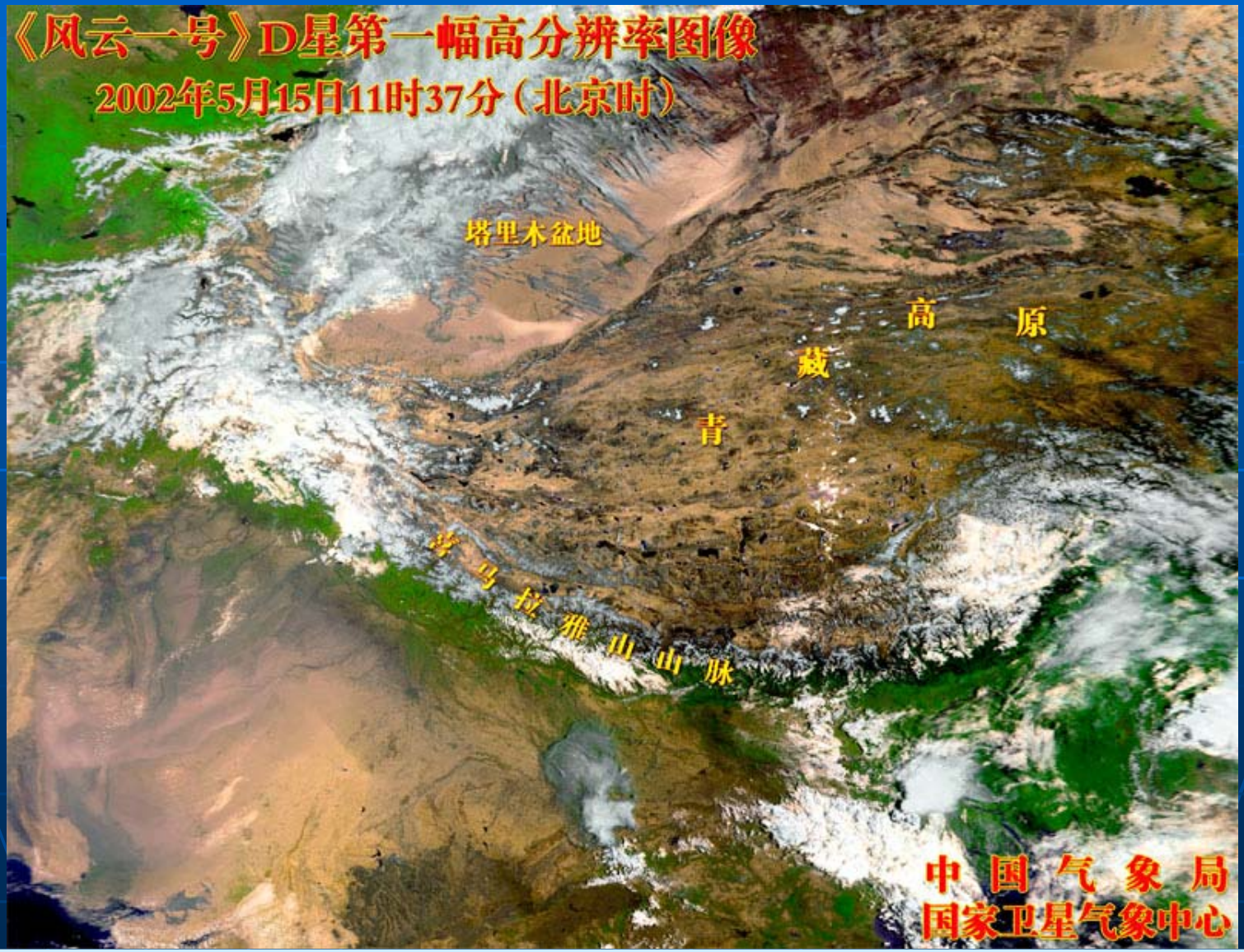
- The FY-1C/D are developed on the basis of the previous experimental meteorological satellites FY-1A/B
- The FY-1C satellite was launched on May 10, 1999
- FY-1C has exceeded the designed life time by one year now. It is still on a good working condition
- The FY-1D was launched on May 15, 2002
- Now FY-1D is in the period of orbiting test and the orbit parameters of the satellite are distributed to the users through Web site
- After the orbiting test, the satellite changes into operational mode ,the orbit parameters will be sent through GTS

FY-1C/D (cont.)

- Two 10-channel VIS/IR scanning radiometers (MVISR) working in a mutual back up mode, they can be switched according to the tele-command
- A cosmic component monitor which transmits space environmental monitoring data to the ground through the telemetry system
- A two-frequency transmitter used to detect satellite motion orbit and to be used as the telemetry transmitter

THE FIRST IMAGE OF FY-1D

MAY 15, 2002 3:37(UTC)



FY-1C/D Specifications

Altitude	**Three-axis stabilized**
Orbit	**Sun-syn**
Orbit Altitude	**870 km**
Orbital Period	**102.3 min**
Inclination	**98.80°**
Eccentricity	**≤0.005**
Descending mode	**8:35 ~ 9:00 (LST)**

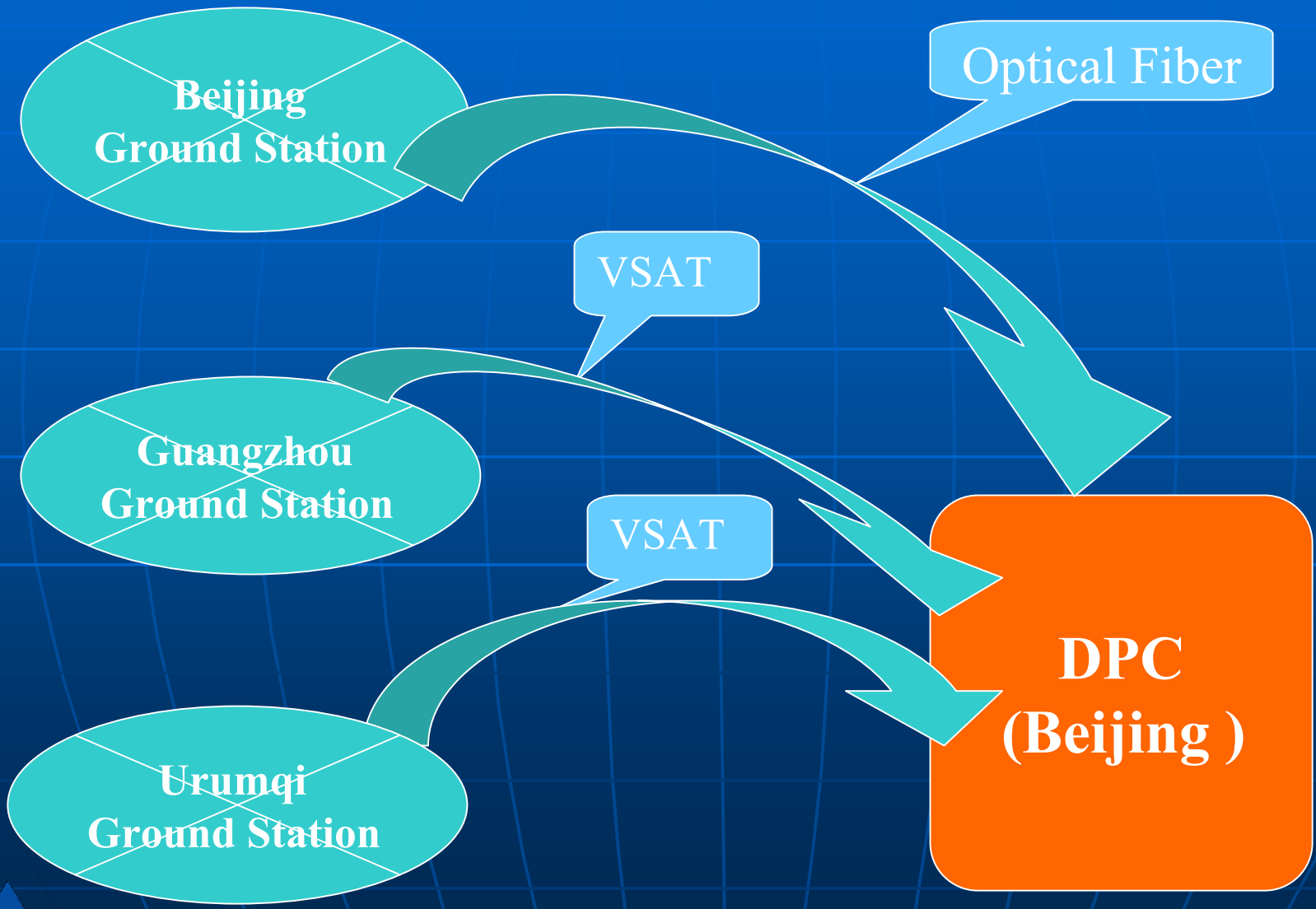
The Characteristics of MVISR

Rotate rate:	**360RPM**
Channels:	**10**
Sub-point resolution:	**1.1km**
VIS detector:	**Si**
IR detector:	**HgCdTe**
Data quantization:	**10bit**
Calibration accuracy:	**VIR-near-IR 5 - 10%** **ρ IR ± 1K(300K)**

Characteristics of MVISR

Channel	Wavelength(μm)	detecting sensitivity	Primary use
1	0.58-0.68	S/N≥3(ρ =0.5%)	Channel 1-6 Close to current NOAA/AVHRR3
2	0.84-0.89	S/N≥3(ρ =0.5%)	
3	3.55-3.95	NE Δ T≤0.4K(300K)	
4	10.3-11.3	NE Δ T≤0.22K(300K)	
5	11.5-12.5	NE Δ T≤0.22K(300K)	
6	1.58-1.64	S/N≥3(ρ =0.5%)	
7	0.43-0.48	S/N≥3(ρ =0.5%)	Ocean color
8	0.48-0.53	S/N≥3(ρ =0.5%)	Ocean color
9	0.53-0.58	S/N≥3(ρ =0.5%)	Ocean color
10	0.90-0.965	S/N≥3(ρ =0.5%)	Water vapor

FY-1 Data Flow Schematic diagram



Data Transmission of FY-1 C/D

- CHRPT: Similar to the current HRPT/NOAA, with doubled transmission rate
- GDPT: Global Delayed Picture Transmission, with reduced resolution of 4 km and global coverage for 4 selected channels
- LDPT: Local Delayed Picture Transmission for 20 min orbit time with 10 channels high resolution observations for any places over the world
- CHRPT for all users in the world

The transmission characteristics of CHRPT

- **The transmission frequency of CHRPT: 1700.5 MHz**
- **The transmission frequency of CDPT: 1708.5 MHz**
- **EIRP: 39.4dbm**
- **Polarization: right hand circular**
- **Modulation: PCM-PSK**
- **Modulation index: 67.5° ±7.5°**
- **Bit rate: 1.3308 Mbps**

The parameters of CHRPT

Number of words of frame	22180
Number of channels	10,2048 words/channel
Rate of frame	6 frames/second
Number of bits of words	10 bits/word
Rate of bit	1.3308 Mbps
Bit format:	split phase

The End