

国家空间天气监测预警中心
National Center for Space Weather



On the Operation of Space Weather in CMA

XiaoXin Zhang , Dan Du

**National Center for Space Weather
China Meteorological Administration**

Outline

- 1. About NCSW in China***
- 2. Space Weather Activities in CMA**
- 3. Related Activities in WMO**
- 4. Summary**

1. About NCSW in China

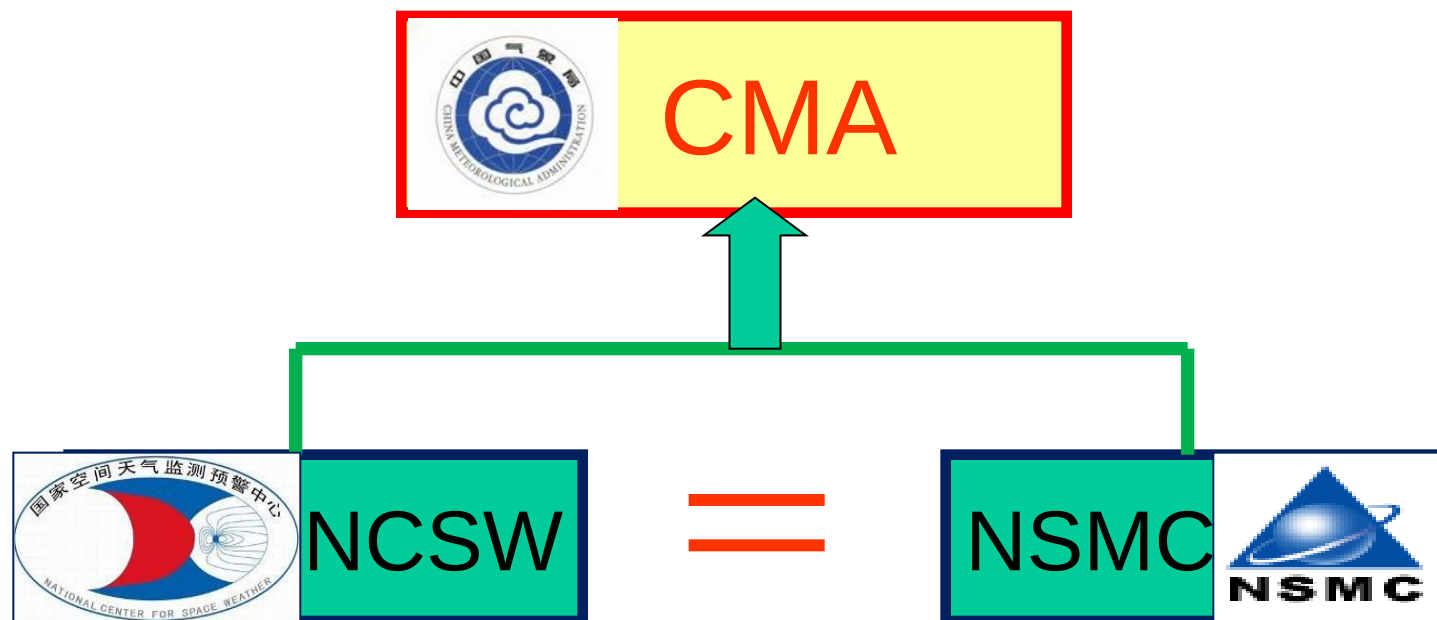
China has acknowledged that space weather, as well as the weather and climate, should be an integral part of important guarantee for the further harmonious development of society.

- ◆ **The National Center for Space Weather (NCSW) was established in 2002 and assigned to the National Satellite Meteorology Center of CMA;**
- ◆ **NCSW acts as the national center authorized by the National Council, to carry out the space weather operations;**
- ◆ **NCSW started to provide space weather products and services on July 1, 2004**



National Center for Space Weather (NCSW)

China Meteorological Administration



National Center for Space Weather

National Satellite Meteorological Center

***One institute,
two names***

- ◆ **NCSW space weather operation is an essential part of the China meteorology**

Missions of NCSW

- to meet the demands for space weather services in responding to space weather hazards for sustainable development of China, and to make national surveys and assessments on space weather hazards;
- to coordinate inter-departments strengths, to plan national space weather monitoring layout, and to optimize operational deployment of resources;
- to steer development of the space weather and relevant disciplines, and to promote advances of scientific & technological productivity;
- to increase international recognition of China's role in this field, and to make contribution to peaceful utilization of the space.



国家空间天气监测预警中心
National Center for Space Weather



Outlook of National Center for Space Weather



***Welcome to visit our Center
when you visit Beijing !***

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1. About NCSW in China
2. *Space Weather Activities in CMA*
3. Related Activities in WMO
4. Summary

2.1 Space-based Observations

□ The FY meteorological satellites have become the ideal platform for space weather observations and are critical for

- ◆ Developing, driving, and validating space weather models, Operations and Services.
- ◆ Understanding of the solar activities and Geospace environments.

I. LEO Satellites

- FY-1 (D)
- FY-3 (A)
- FY-3 (B)
- **FY-3 (C)**
- **FY-3 (D)**
- **FY-3 (E)**
- ...



II. GEO Satellites

- FY-2 (C)
- FY-2 (D)
- FY-2 (E)
- FY-2 (F)
- **FY-2 (G、H)**
- **FY-4 (A)**
- ...

Current SWx Sensors : FY-1/FY-3

●FY-1 (D) & FY-3 (A/B)

✓ *Energetic particle detectors*

✓ *SEM Units*

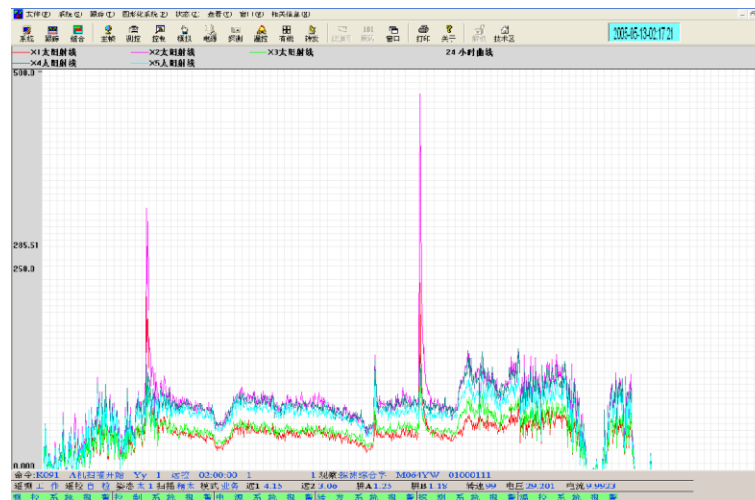
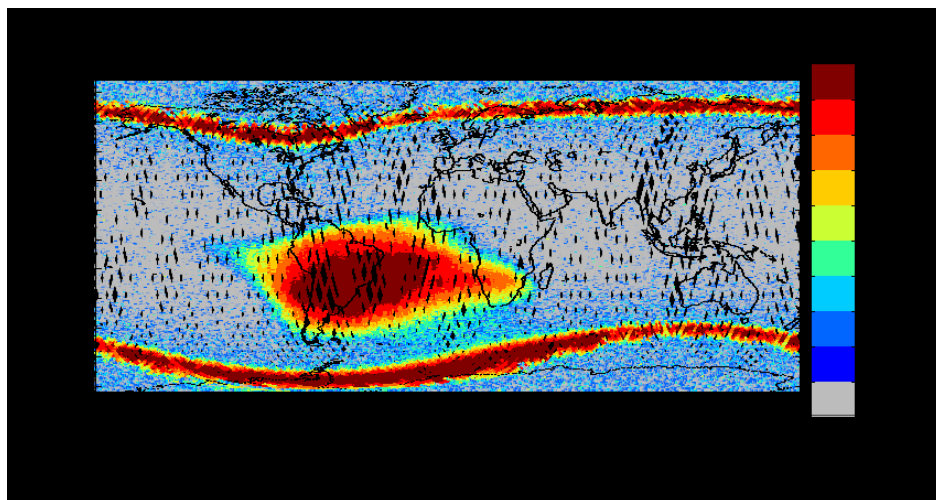
- ◆ High energy particle detector
- ◆ Single-events-upsets monitor
- ◆ Surface charging detector
- ◆ Radiation environment monitor

●FY-2 (D/E/F, C still there,)

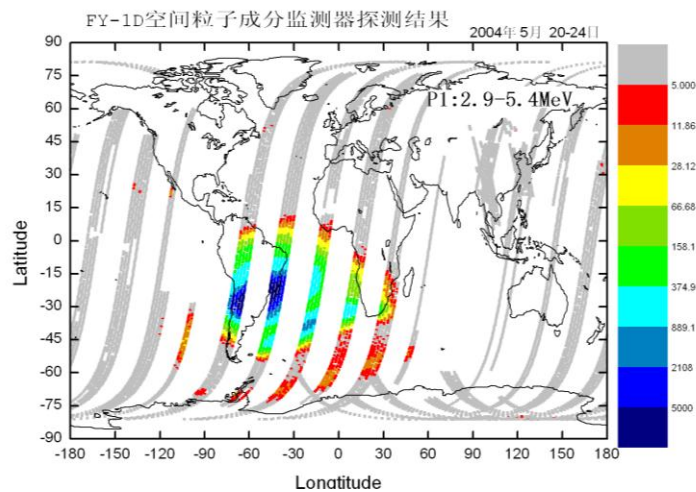
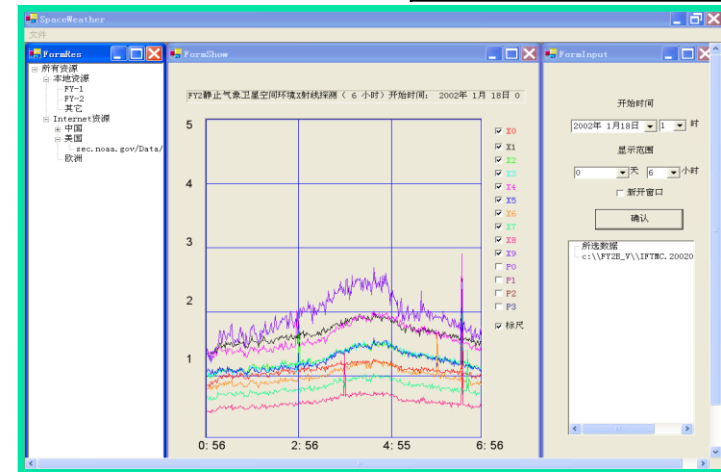
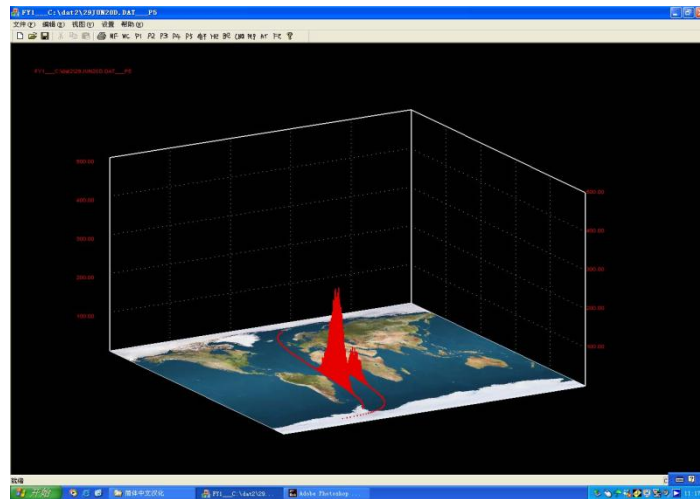
✓ *Space Environment Monitors*

- ◆ electrons
- ◆ protons
- ◆ heavy particles

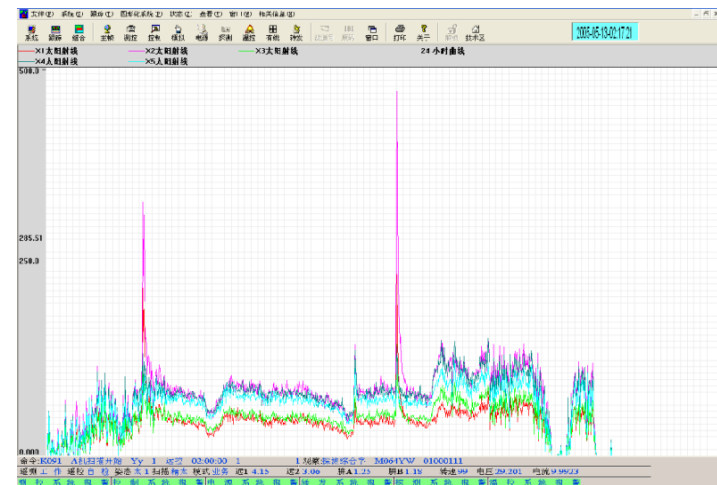
✓ *X-ray flux Monitor*



Spwx monitor and analytic system

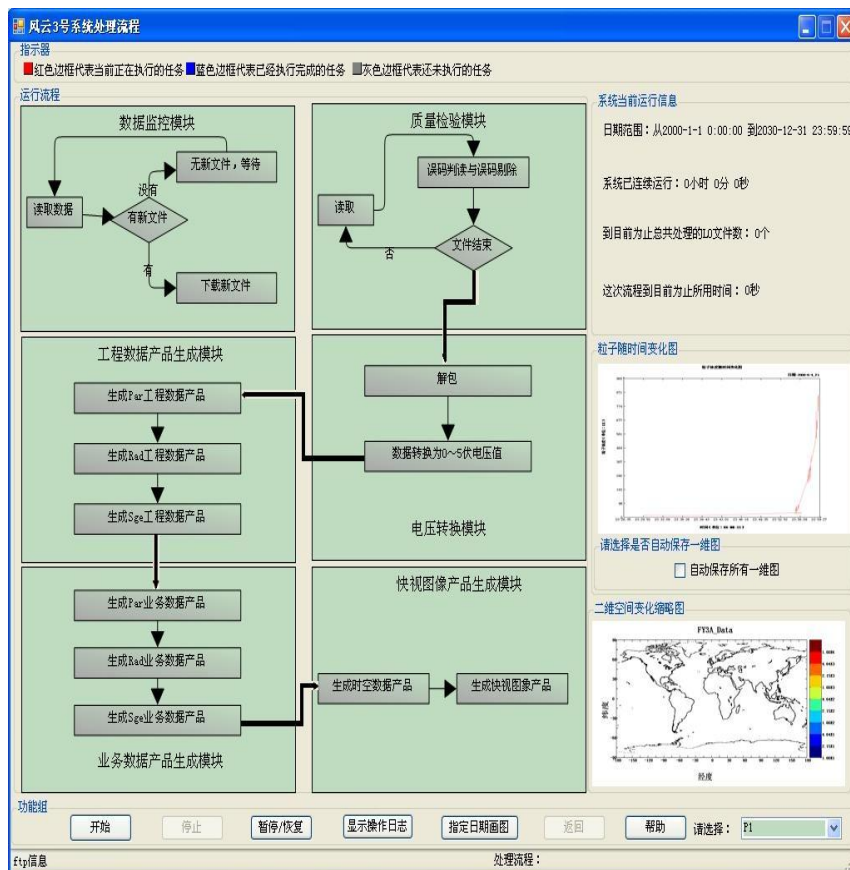


FY-1D High energy Particle Monitoring

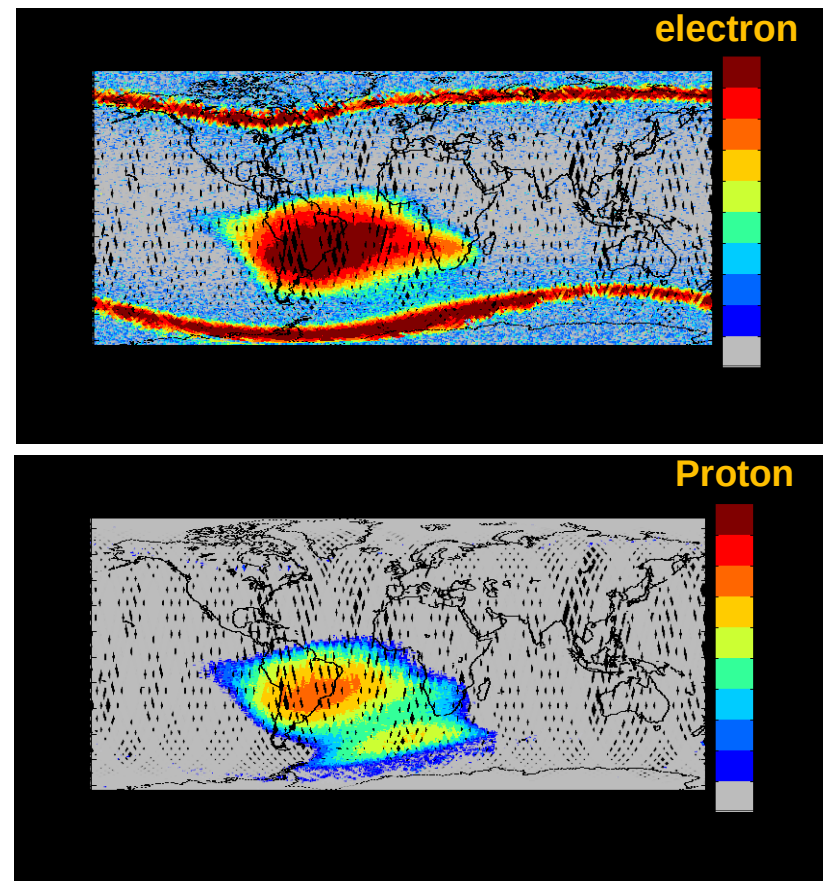


FY-2 High energy Particle Monitoring

FY-3A/B Satellites: Operation and products



Operation
System



Monitoring
Products

□ Ground-based Sensors

● Solar activities

- Solar optical telescope (2010)
- Solar radio telescope (2011)
- Solar magnetic field telescope (2012)



● Upper atmospheric and ionospheric phenomena

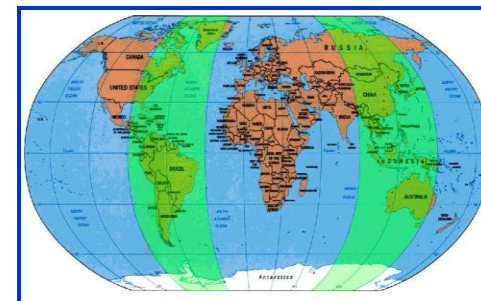
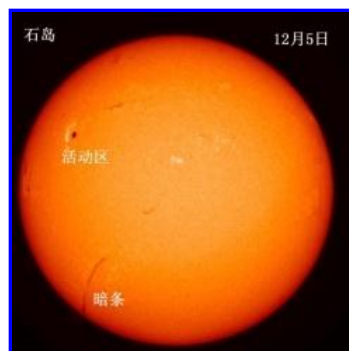
- 5 Ionosonde stations (2010)
- 4 Scintillation stations (2010)
- 4 Riometer stations (2010)
- 1 MF Radar (2012)
- 1 Optical FPI (2012)
- 1 Mobile Ionosonde (2012))



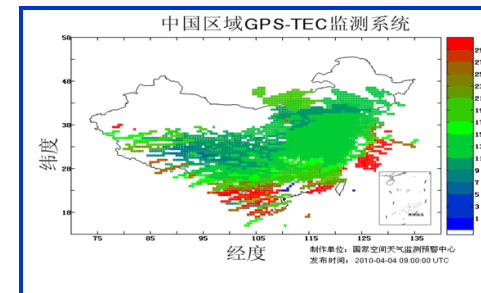
**Meteorological Monitoring and
disaster Forecasting Project**

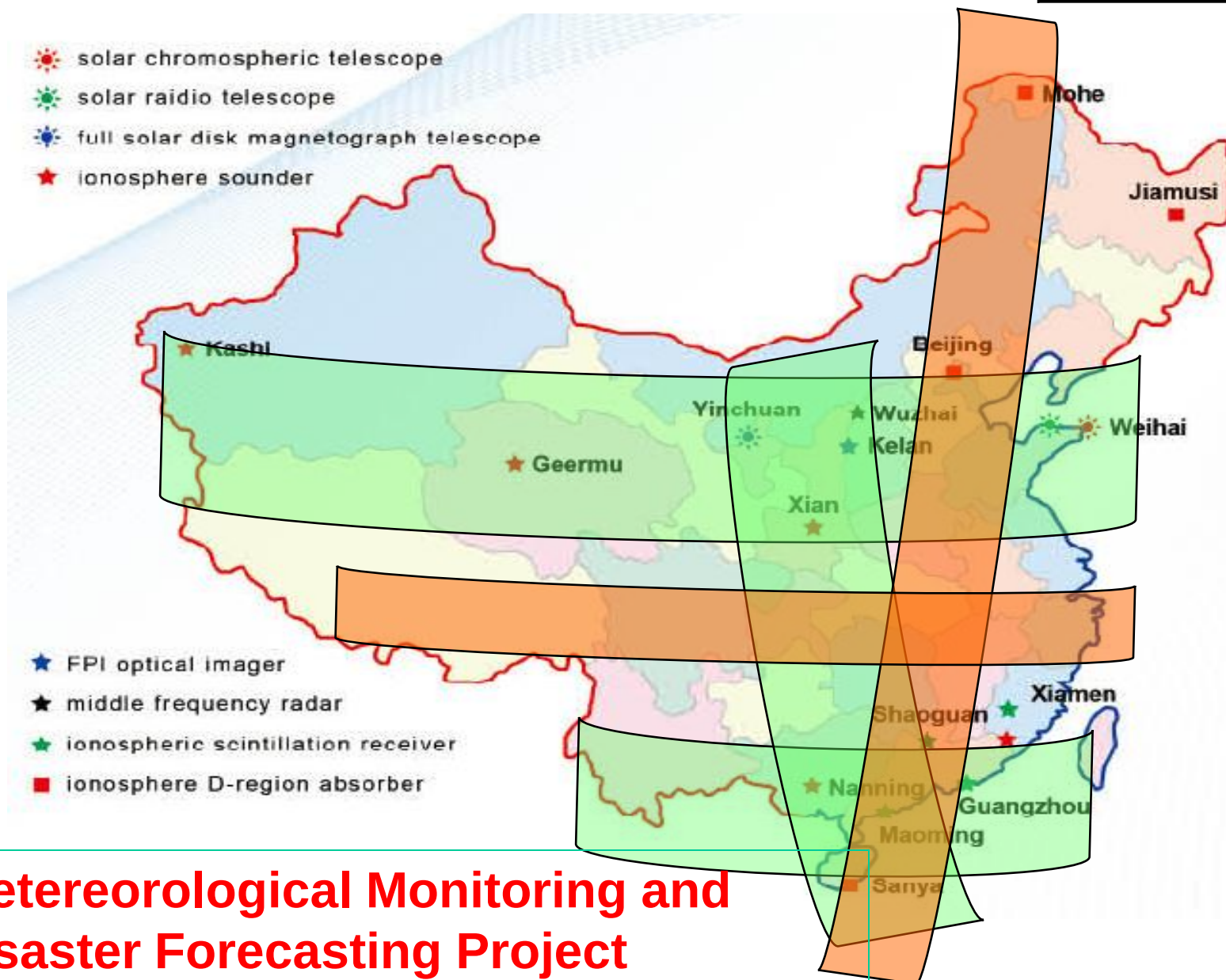
□ Based on the successful implementation of “Meridian Project” and “Meteorological Monitoring and Disaster Forecasting Project”, a ground-based space weather monitoring network has been set up.

- ◆ We continue to conduct a systematic investigation on the solar, upper atmospheric and ionospheric activities in CMA.



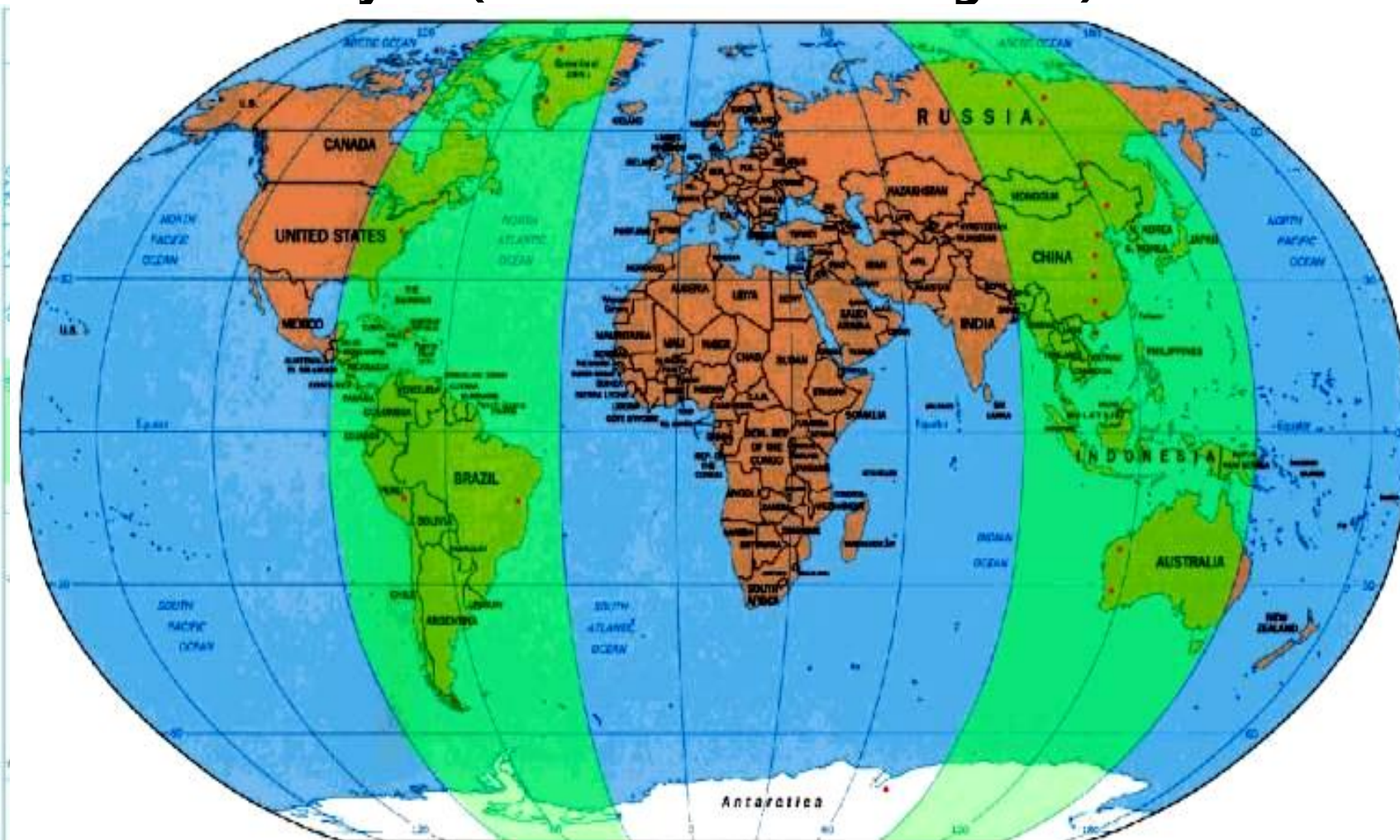
- ◆ More than 500 GPS/MET stations in CMA are available now for routine TEC map product.





Meteorological Monitoring and disaster Forecasting Project

- Meridian Project (Meridian Circle Program)



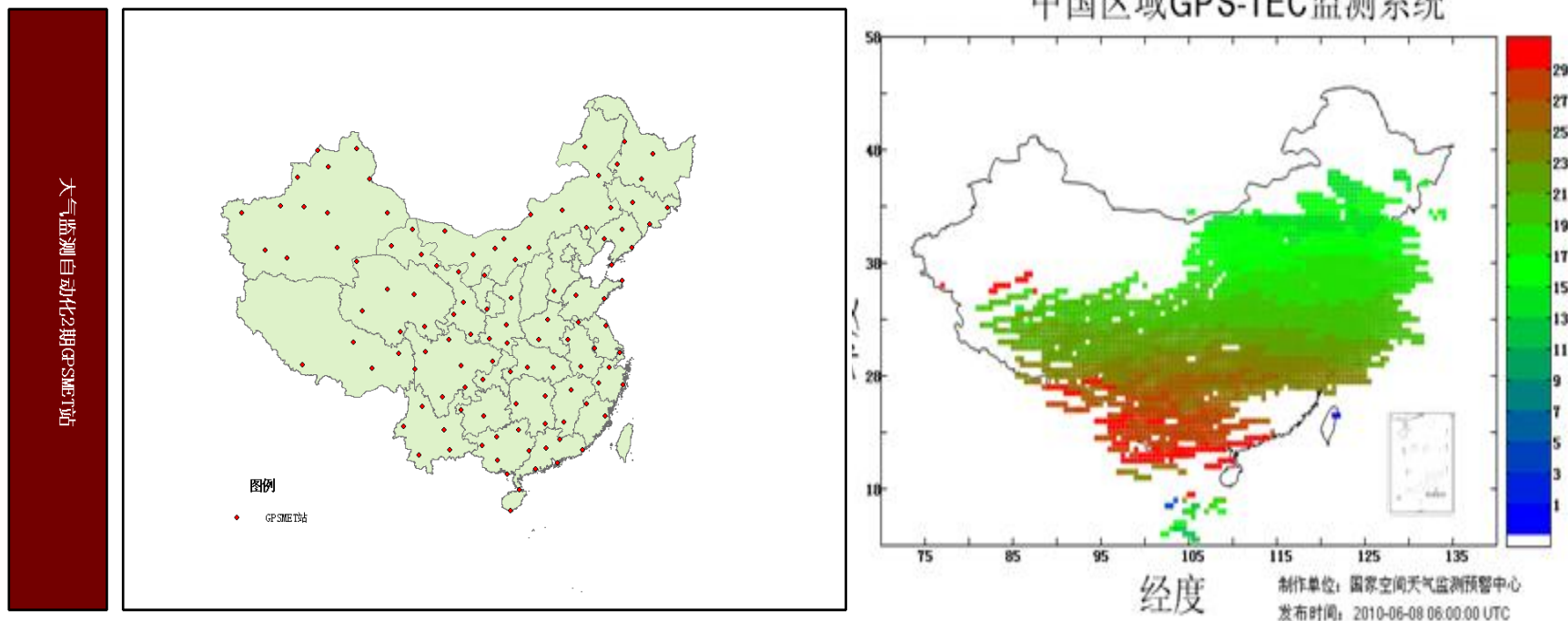
60° W

120° E

□ Ground-based Sensors (cont.)

● GPS/MET network

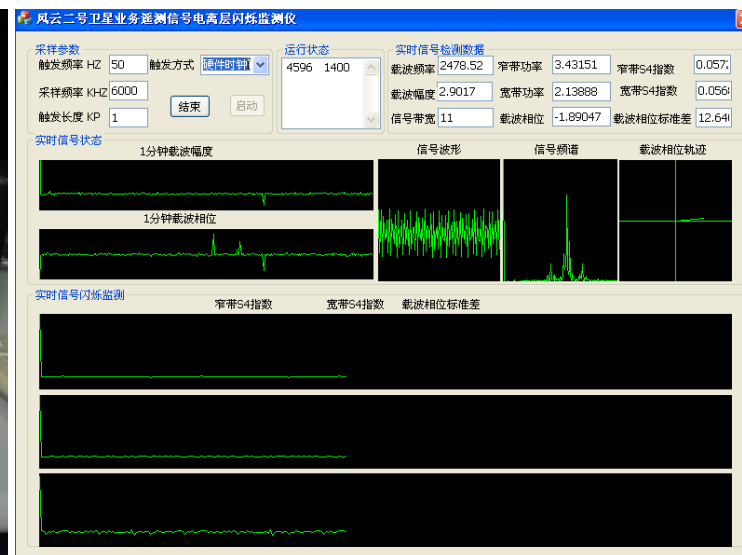
- TEC data (maps) over China from more than 500 GPS/MET stations are available now for routine operation in CMA. In near future (by 2015), the number of GPS stations will increase to about 2500 stations.

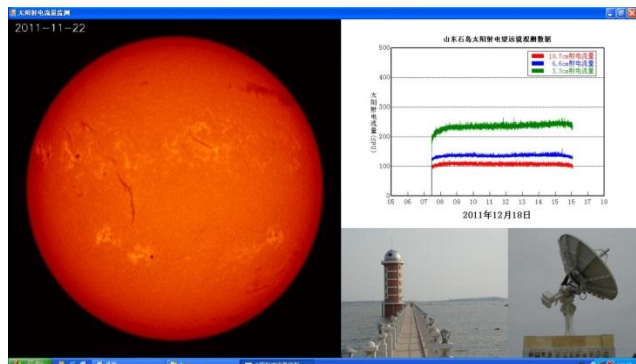


□ Ground-based Sensors (cont.)

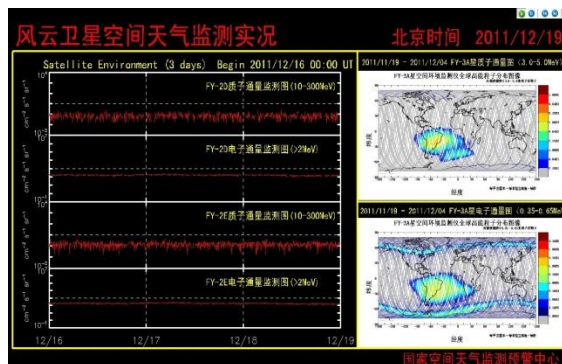
● FY-based Scintillation Receivers

- Scintillation Receivers, based on FY remote signal were developed for monitoring scintillation events along the communication link between satellite and ground station (operation in CMA).

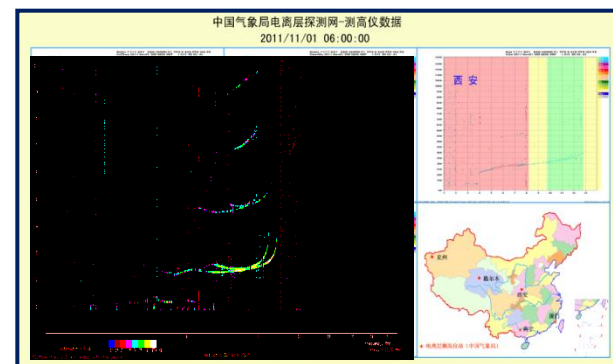




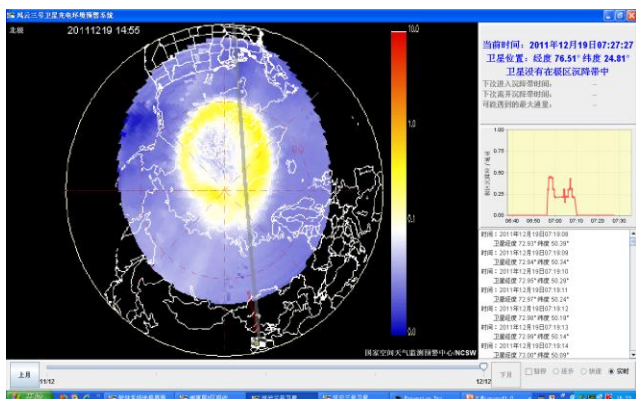
Solar activities



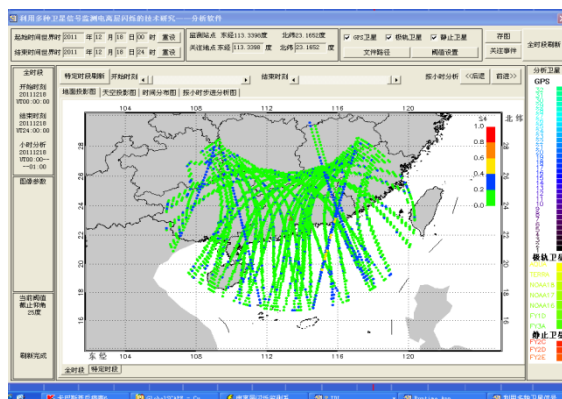
FY orbit Environments



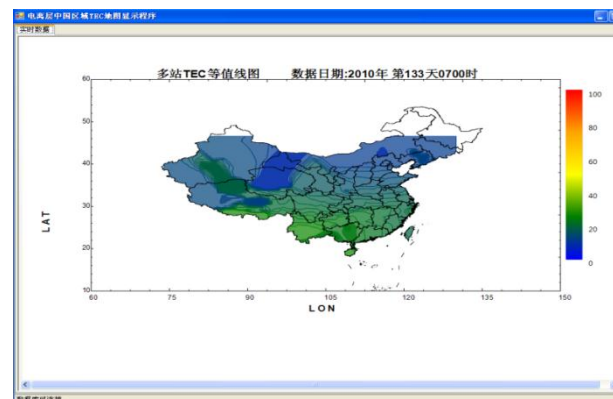
Ionosonders



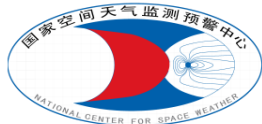
FY-3 Charging



Scintillation Receivers



GPS/MET TEC

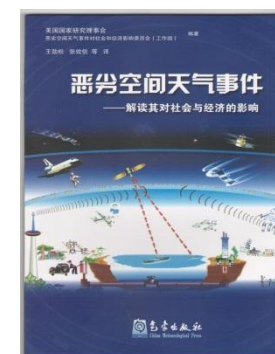
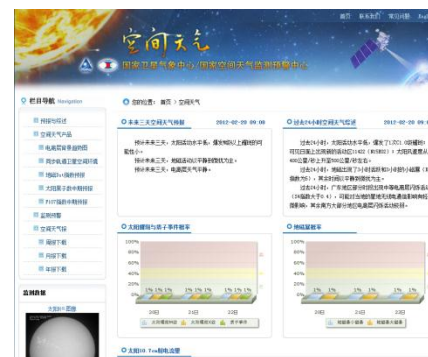


2.2 Operational Products and Services

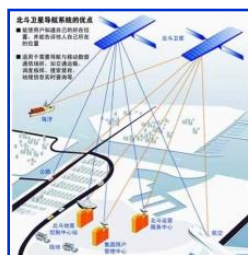
Forecast type	Forecast time	Operation products	
Long term	A year	Solar activity index	Yearly Solar Spot Number
			Solar F10.7cm flux
Mid-term	A month	Solar activity index	Monthly Solar Spot Number
			Solar F10.7cm flux
Short term	1-3 days	Solar activity indices	SSN、F10.7cm flux、flares、SPE、CME
		Geomagnetic activities	Storm、Ap index、Dst index
		Ionospheric weather	Ionospheric background, disturbances, storms、scintillations etc.
Warning	Several minutes to 3 days	Solar activities	Solar flares、SPE、CME
		Geomagnetic activity	Geomagnetic storms
		Ionospheric weather	Ionospheric storm、disturbances、Scintillations
Nowcast	Events	Solar activities	Solar flares、SPE、CME
		Geomagnetic activity	Geomagnetic storms
		Ionospheric weather	Ionospheric storm、disturbances、Scintillations

Products and Services in CMA

- NCSW currently delivers 3 categories of space weather monitoring, forecasting and services products to users through hard-copy bulletins, internet, cell phone, e-mail, special column of the China Meteorological Newspaper, and TV, etc.



- The space weather services are distributed widely to support the China's Shenzhou spaceship, and lunar exploration program, Beidou system, state grid, etc.



Space Weather forecast Symbols & Classification (V1.0)

空间天气预警符号

1. 太阳活动

共分为 4 个级别，具体级别及标志如下：



极低



低



中



高

Solar activity indicator

2. 地磁活动

共分为 4 个级别，具体级别及标志如下：



平静



小磁暴



大磁暴



特大磁暴

Geomagnetic activity Indicator

3. 地球同步卫星轨道辐射环境

共分为 4 个级别，具体级别及标志如下：



低



中



强



极强

GEO Orbit radiation Level

4. 电离层电波传播环境：

共分为 4 个级别，具体级别及标志如下：



好



一般



差

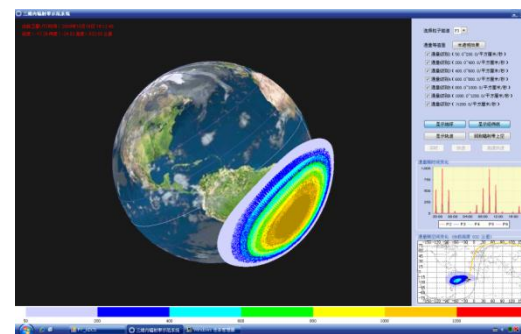
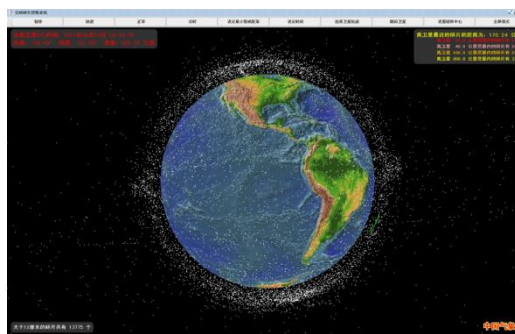
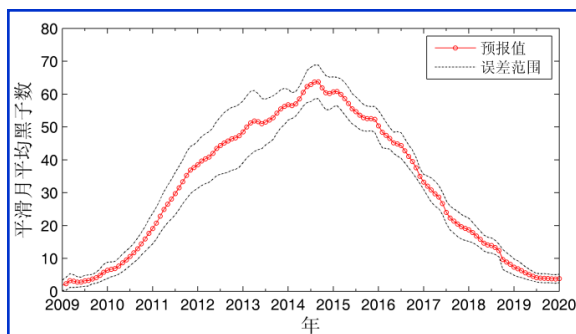


极差

Ionospheric communications Level

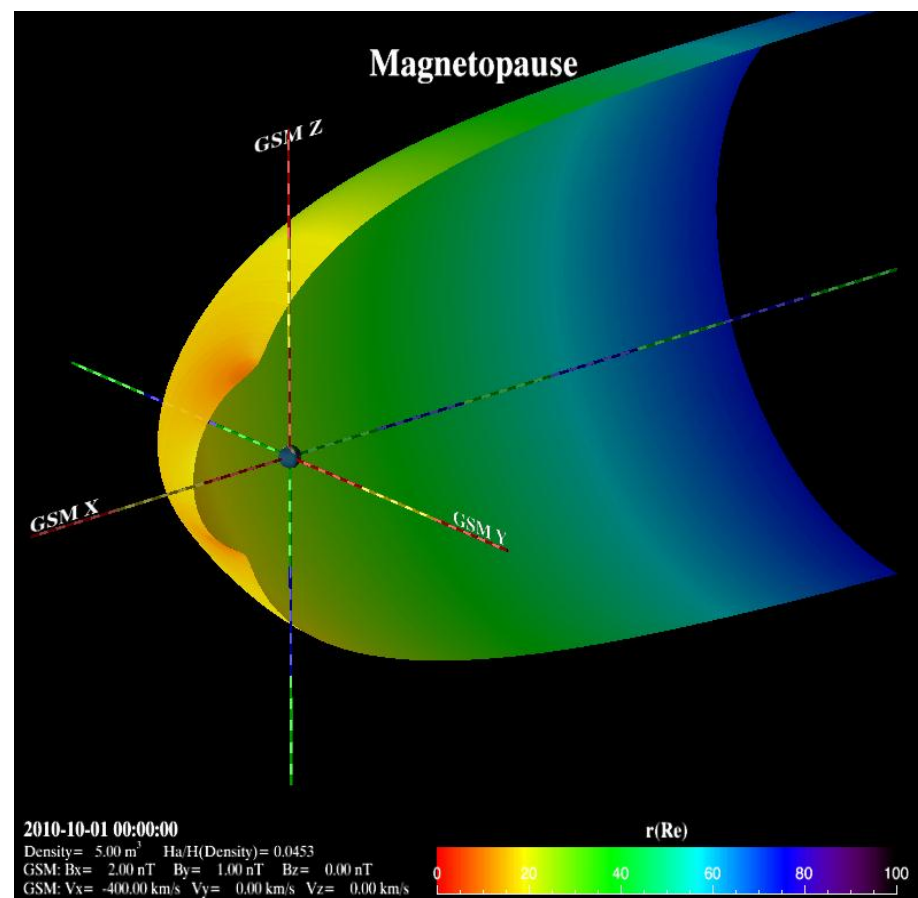
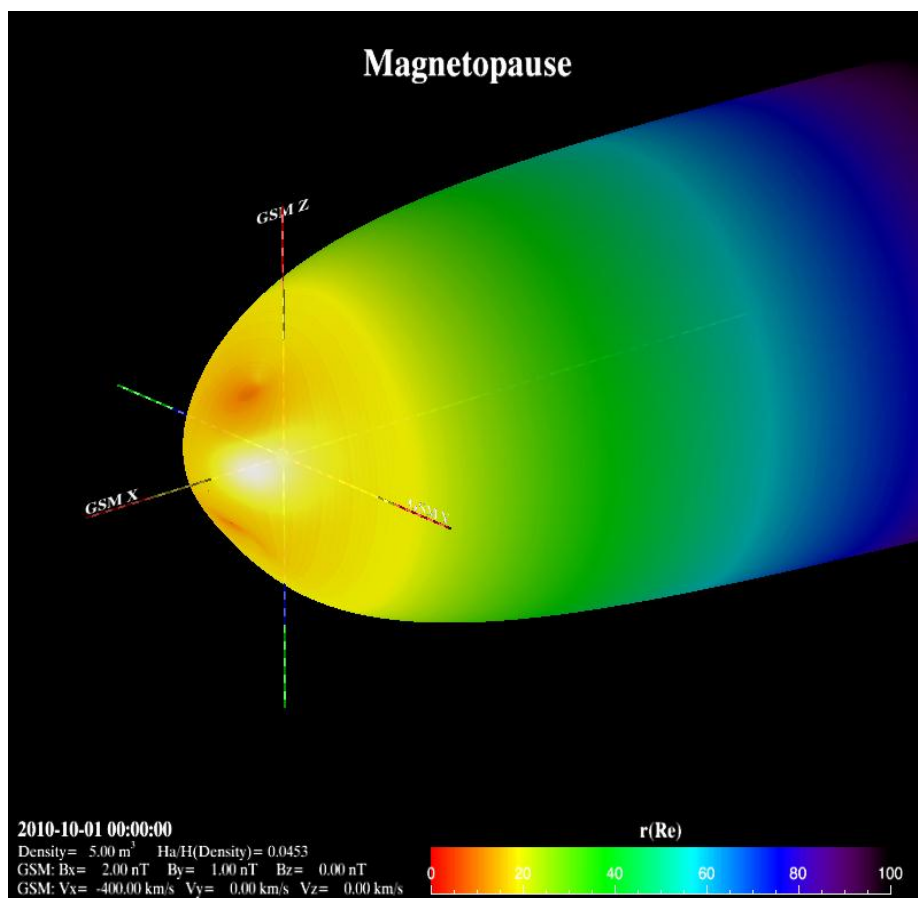
2.3 Application-oriented Research and Technology

- Being an important component of the space weather operations, the application-oriented research and relevant technology development have shown distinctive operational features.



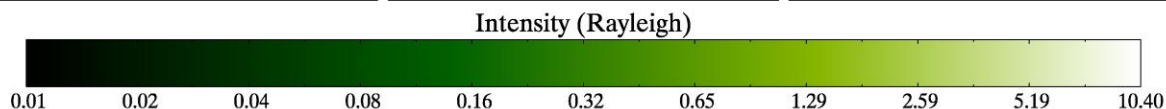
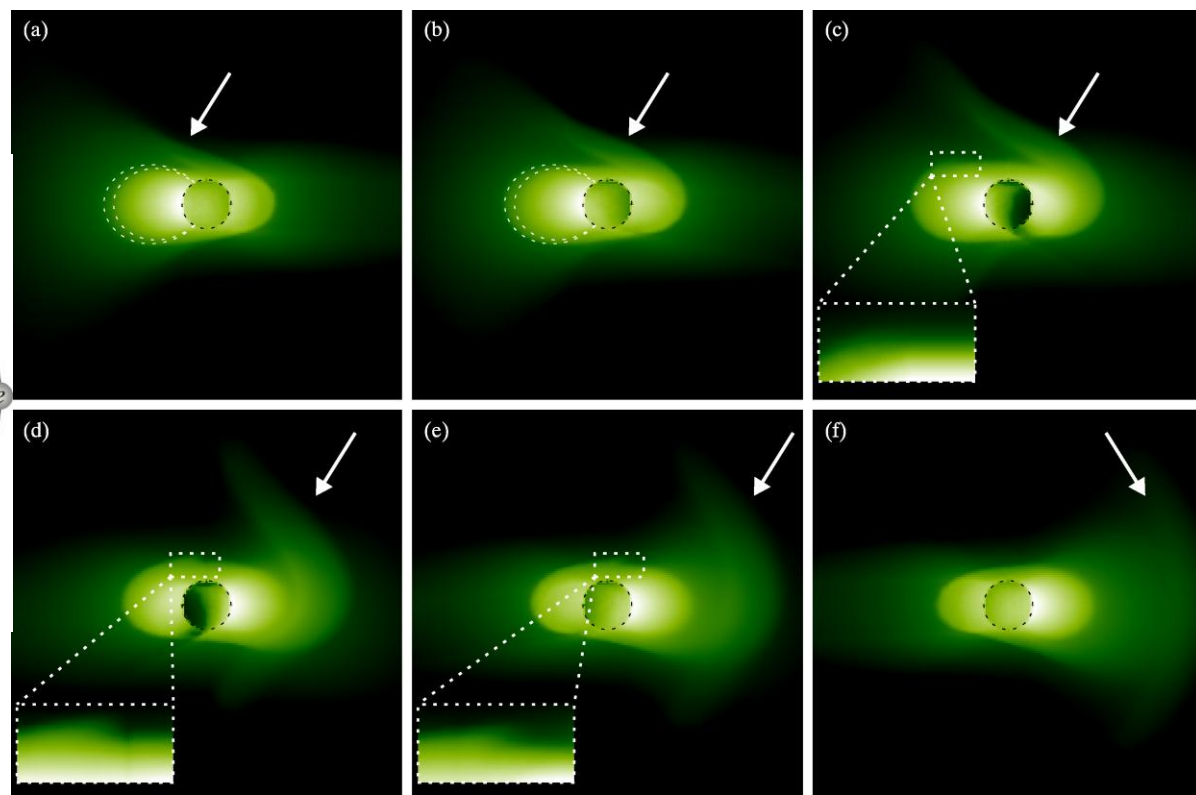
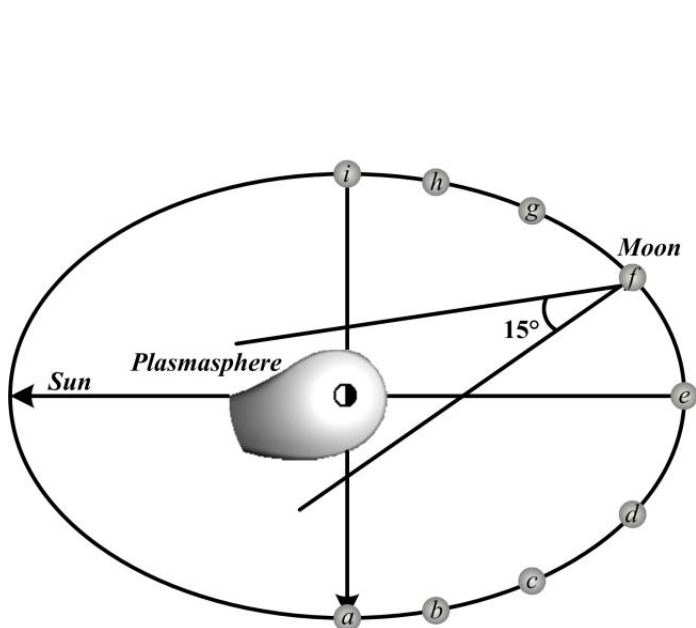
24th Solar Cycle Prediction Space debris Alerting System SAA warning System

2.3 Research and modeling (a) A new 3-D asymmetric magnetopause model



Lin, R. L., X. X. Zhang, S. Q. Liu, et.al., J. Geophys. Res., 115, A04207, 2010

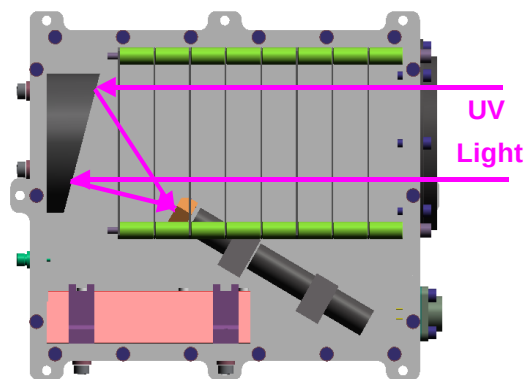
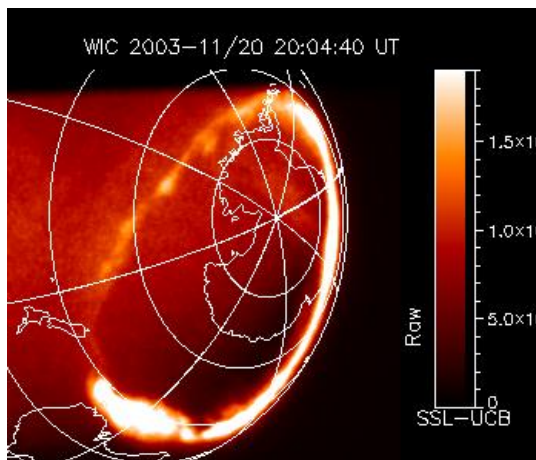
2.3 Research and modeling (b) Moon-based plasmasphere image simulation



He, F., X. X. Zhang, B. Chen, et al., J. Geophys. Res., 116, A11203, 2011

2.4 further projects

- ❑ ***FY-3 02 (C/D/E/F): New Payloads (2012-2018)***
 - Ionospheric Photometer (IPM)
 - Wide-angle Aurora Imager (WAI)
 - GNSS Occultation Sounder (GNOS)



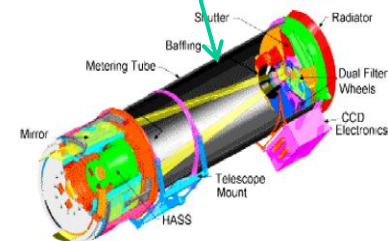
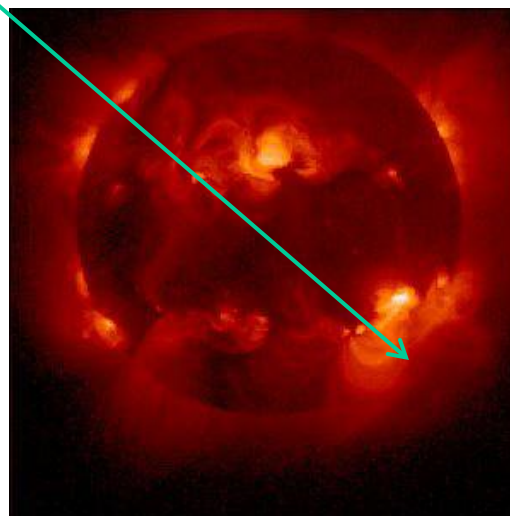
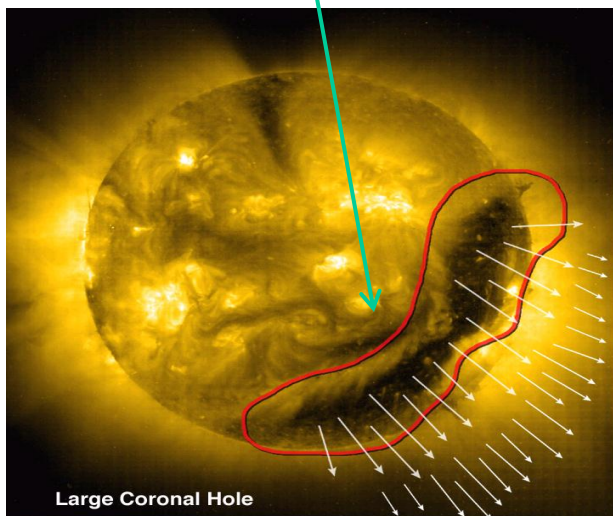
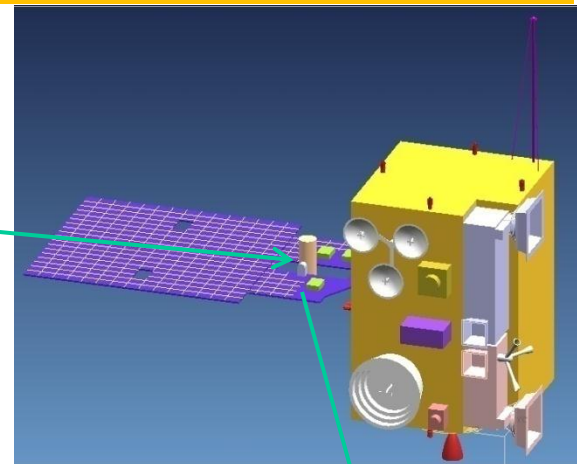
□ ***FY-4 : New Payloads (2014-2015)***

- Geomagnetic field detector: FGM
- Solar X-ray & EUV Imager (SXEI)

□ ***Solar Flare***

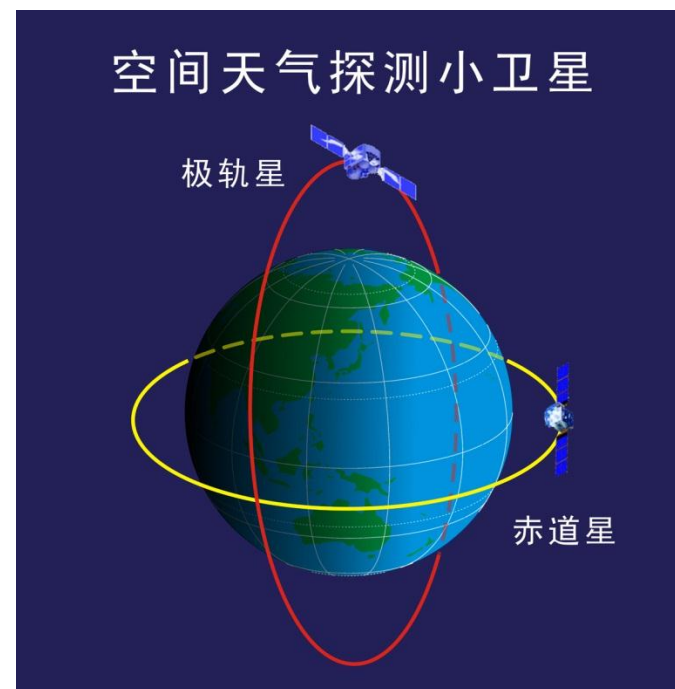
□ ***CME***

□ ***Coronal Hole***

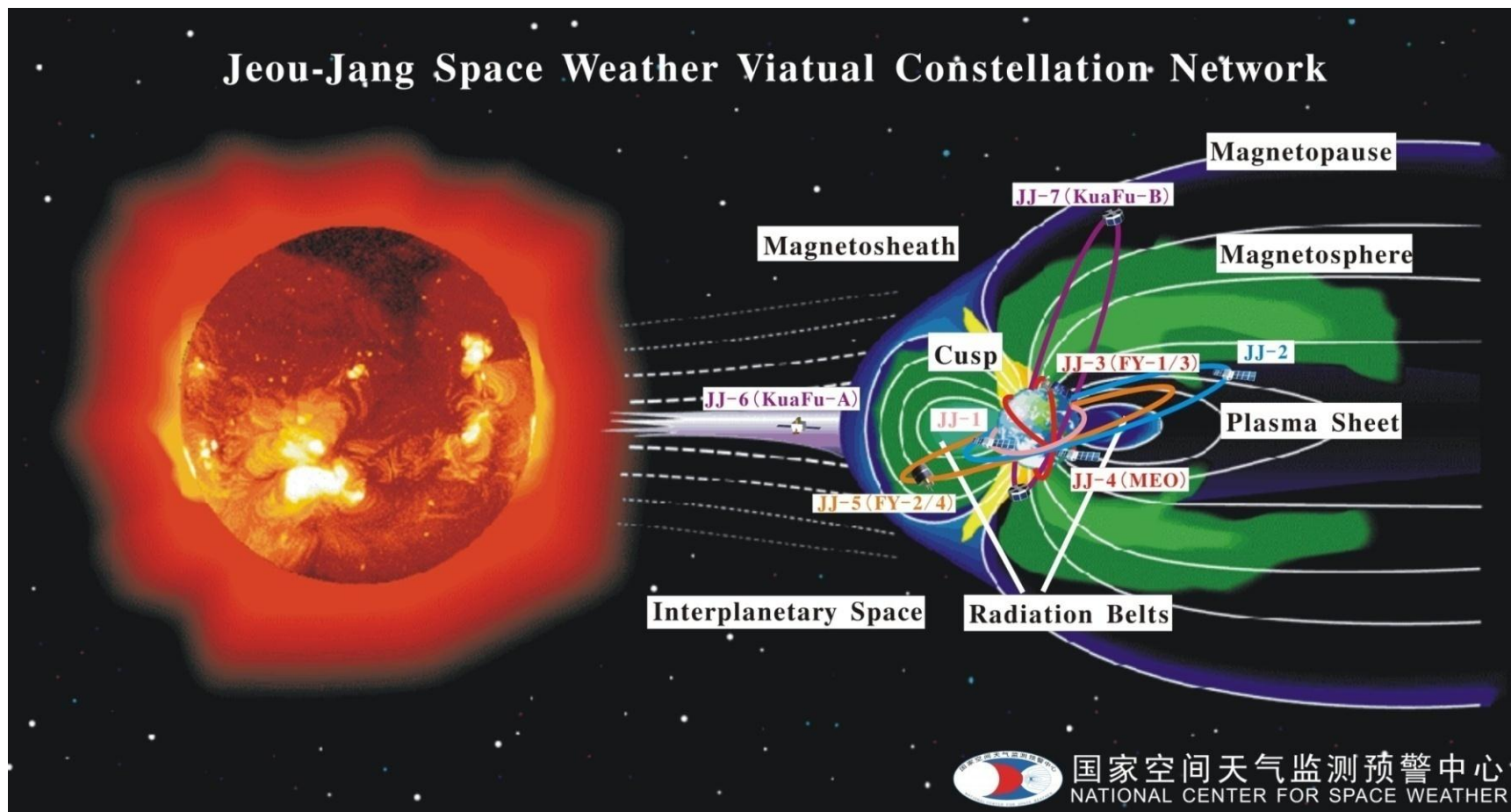


❑ Special operational satellites for ionospheric weather

- With the dawn-dusk polar orbit of 800-1500 km, the satellite could get the ionospheric images and solar activities (Sun-synchronous orbit -> FY-3)
- The equator satellite is in low Earth orbit 300-800 km and could in-situ monitor the small scale structure of ionosphere.



□ Space weather Virtual Constellation

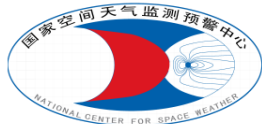


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□ ***Space Weather activities in WMO***

- Executive Council endorsed principle of WMO activities in support of Space weather
- In May 2010, the Inter-programme Coordination team on Space Weather (ICTSW) was established, with focus on:
 - Harmonizing observations
 - Exchange of data and products through the WMO Information System
 - Definition of products, warning procedures
 - Linkage between research and operational communities
- Cooperation with ICAO, IMO, ITU, ISES, OOSA/COPUOS etc.



Inter-Programme Coordination Team for Space Weather (last update 25 July 2012)

- Australia – Phil Wilkinson
- Belgium – Ronald Van der Linden
- Brazil – Clezio Marcos De Nardin
- Canada – Larisa Trichtchenko
- China (Co-chair) – Xiaoxin Zhang
- Colombia – Jaime Villalobos Velasco
- Ethiopia – Yitaktu Tesfatsion
- Finland – Kirsti Kauristie
- France – Nicole Vilmer
- Germany – Norbert Jakowski
 - European Commission - Joint Research Centre – Elisabeth Krausmann
 - European Space Agency – Alain Hilgers
 - International Civil Aviation Organization – R. Romero
 - International Space Environment Service – David Boteler
 - International Telecommunication Union – Sergio Buonomo
 - UN Office of Outer Space Affairs – Hans Haubold
 - WMO – Jerome Lafeuille
- Japan – Ken Murata
- Pakistan – Muhammad Ayaz Amin
- South Africa – Lee-Anne McKinnel
- South Korea
- Switzerland – Werner Schmutz
- Russian Federation – Vyacheslav Burov
- United Kingdom – David Jackson
- United States (Co-chair) – Terry Onsager,
Jim Head, Joe Davila, Kelly Hand

□ Variables measured in space weather Area

- Ionospheric Total Electron Content (TEC), foEs, foF2, h'F, hmF2, Ionospheric plasma velocity, Ionospheric Radio Absorption, Ionospheric Scintillation (S4 and Sigma Phi), Spread F (h'P);
- Proton flux density energy spectrum, Heavy ion flux density energy and mass spectrum, Cosmic ray neutron flux density, Electron flux density energy spectrum, Vector magnetic field;
- Interplanetary magnetic field, Solar wind density, Solar wind temperature, Solar wind velocity;
- Solar X-ray flux, Solar EUV flux, Solar X-ray image, Solar EUV image, Heliospheric image, Solar Call-K image, Solar H-alpha image, Solar magnetic field, Solar radio emission, Solar white light image, Wide-angle solar corona image.

All requirements in Space Weather



1	Variable	Layer	Goal	Breakthrough	Threshold	IK Goal	IK Breakthrough	IK Threshold
2	Cosmic ray neutron flux density	Surf-Earth	5 (%)	10 (%)	25 (%)	1000 km	2000 km	5000 km
3	Electron flux density energy spectrum	Geo	5%	10%	25%	45 degrees	90 degrees	180 degrees
4	Electron flux density energy spectrum	Leo	5%	10%	25%	45 degrees	90 degrees	180 degrees
5	Electron flux density energy spectrum	Neo	5%	10%	25%	45 degrees	90 degrees	180 degrees
6	Electron flux density energy spectrum	L1	5%	10%	25%	degrees	degrees	degrees
7	foEs	Icnos	0.05 MHz	0.1 MHz	0.2 MHz	100 km	200 km	500 km
8	foF2	Icnos	0.05 MHz	0.1 MHz	0.2 MHz	100 km	200 km	500 km
9	h'F	Icnos	1 km	5 km	10 km	100 km	200 km	500 km
10	Heavy ion flux density energy and mass spectrum	Geo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
11	Heavy ion flux density energy and mass spectrum	Leo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
12	Heavy ion flux density energy and mass spectrum	Neo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
13	Heavy ion flux density energy and mass spectrum	Helio	0.05	0.1	0.25	360 degrees	360 degrees	360 degrees
14	Heliospheric image	Helio	0.05	0.1	0.1	1 arcsec	1 arcsec	5 arcsec
15	hmF2	Icnos	1 km	5 km	10 km	100 km	200 km	500 km
16	Interplanetary magnetic field	L1	0.05	0.1	1 (nT)	N/A	N/A	N/A
17	Ionospheric plasma velocity	Icnos	50 km. s ⁻¹	100 km. s ⁻¹	200 km. s ⁻¹	10 km	50 km	300 km
18	Ionospheric Radio Absorption	Icnos	0.1 dB	0.5 dB	1 dB	100 km	200 km	500 km
19	Ionospheric Scintillation (S4 and Sigma Phi)	Icnos	0.10%	1%	10%	50 km	100 km	200 km
20	Ionospheric Total Electron Content (TEC)	Icnos	0.1 TECU	0.5 TECU	2 TECU	100 km	200 km	500 km
21	Proton flux density energy spectrum	Geo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
22	Proton flux density energy spectrum	Leo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
23	Proton flux density energy spectrum	Neo	0.05	0.1	0.25	45 degrees	90 degrees	180 degrees
24	Proton flux density energy spectrum	Helio	0.05	0.1	0.25	360 degrees	360 degrees	360 degrees
25	Solar CaII-K image	Sun	1%	1%	10%	1 arcsec	1 arcsec	5 arcsec
26	Solar EUV flux	ID	5%	5%	20%	N/A	N/A	N/A
27	Solar EUV image	Sun	1%	1%	10%	1 arcsec	1 arcsec	5 arcsec
28	Solar K-alpha image	Sun	1%	1%	10%	1 arcsec	1 arcsec	5 arcsec
29	Solar magnetic field	Sun	1%	1%	5%	1 arcsec	1 arcsec	5 arcsec
30	Solar radio emission	ID	5%	5%	20%	N/A	N/A	N/A
31	Solar white light image	Sun	1%	1%	10%	1 arcsec	1 arcsec	5 arcsec
32	Solar wind density	L1	5%	10%	20%	N/A	N/A	N/A
33	Solar wind temperature	L1	5%	5%	20%	N/A	N/A	N/A
34	Solar wind velocity	L1	5%	5%	20%	N/A	N/A	N/A
35	Solar X-ray flux	ID	0.05	0.05	0.2	N/A	N/A	N/A
36	Solar X-ray image	Sun	1%	1%	10%	1 arcsec	1 arcsec	5 arcsec
37	Spread F (h'P)	Icnos	1 km	5 km	50 km	10 km	200 km	500 km
38	Vector magnetic field	Surf-Earth	0.1 (nT)	0.3 (nT)	1 (nT)	100 km	200 km	500 km
39	Vector magnetic field	Geo	0.1 (nT)	0.3 (nT)	1 (nT)	28420 km	68000 km	264200 km
40	Vector magnetic field	Leo	0.1 (nT)	0.3 (nT)	1 (nT)	1 km	10 km	100 km
41	Wide-angle solar corona image	Helio	1%	1%	25%	1 arcsec	1 arcsec	5 arcsec

Space Weather Product Portal



World Meteorological Organization

Working together in weather, climate and water

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ISES

IPS (Australia)



Canada Space Weather



ESA (Europe)



Institute of Applied Geophysics (Russia)



DLR (Germany)



Radio Research Agency (R. Korea)



CMA (China)



INPE (Brazil)



FMI (Finland)



NICT (Japan)



Solar Influences Data Analysis Center,
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* Coordination with ICAO: Review*

Concept of Operations (ConOps) for International Space Weather Information in Support of Aviation

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* Observing Gap Analysis: Review

□ CMA-NOAA

- The Joint Working Group meeting (JWG-17) between the CMA and NOAA.
- Focusing on: Data exchange and Instrument calibration in space weather activities



□ Cooperation on Space Weather in CMA

□ Domestic

The “Special Fund for Meteorological Research in the Public Interest” led by CMA has become the most stable financial support for space weather operations.

□ International

NCSW get actively involved in the activities of the International Space Environment Services (ISES), the Inter-programme Coordination Team for Space Weather (ICTSW), etc.

NCSW is devoted to seek more collaborative opportunities on space weather data exchange, products and services, and quality assessments between CMA and other space agencies, such as, NOAA and CSA.



Australian Government
IPS Radio and Space Services

Outline

1. About NCSW in China
2. Space Weather Activities in CMA
3. Related Activities in WMO
4. Summary

4. Summary

- ❑ China has acknowledged that space weather, as the natural extension of meteorology, should be an integral component of “weather” ;
- ❑ NCSW continue to develop the space weather observing facilities to monitor and forecast for space weather hazards;
- ❑ Space weather activities span national boundaries, and need the effective international cooperation and also need endorsing WMO participation.



国家空间天气监测预警中心
National Center for Space Weather



Thanks!

