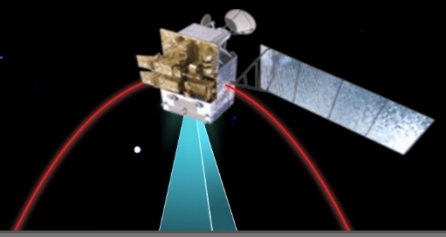
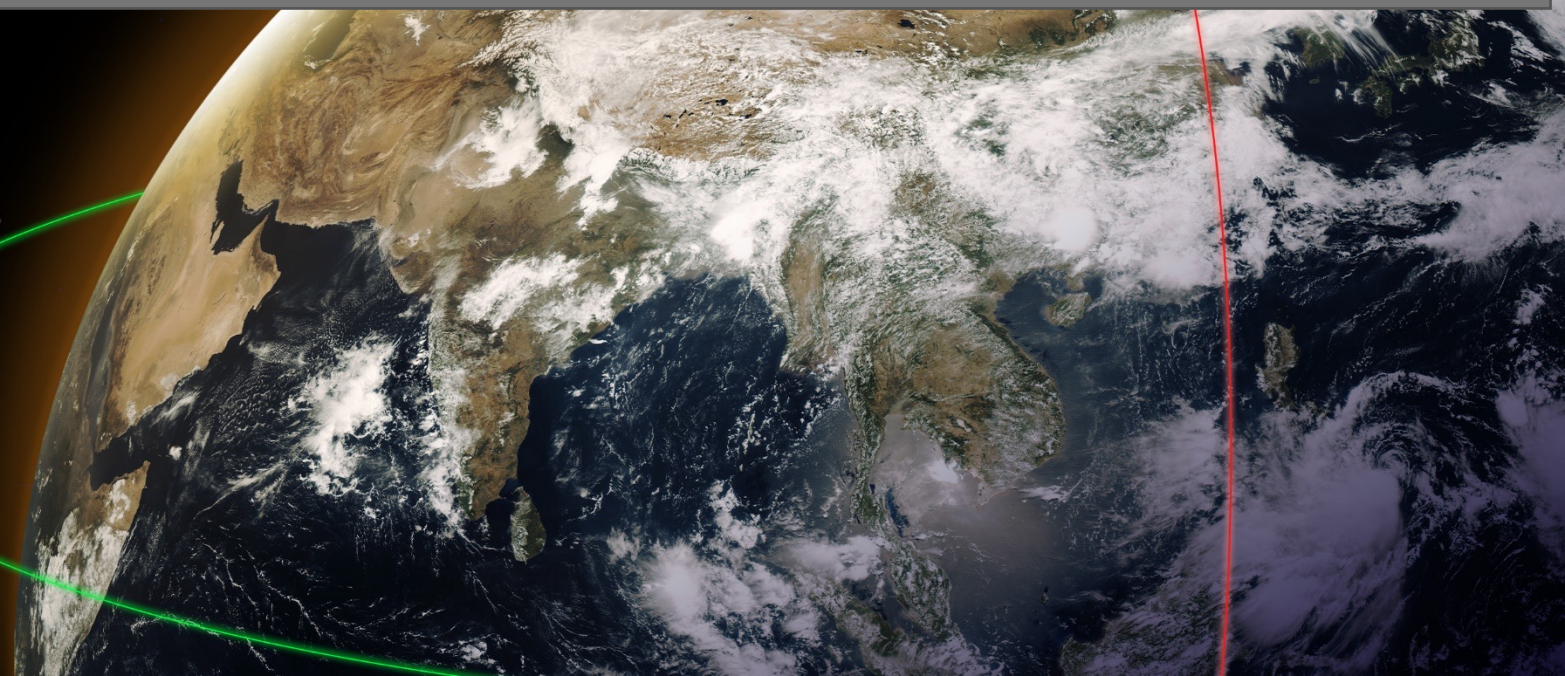


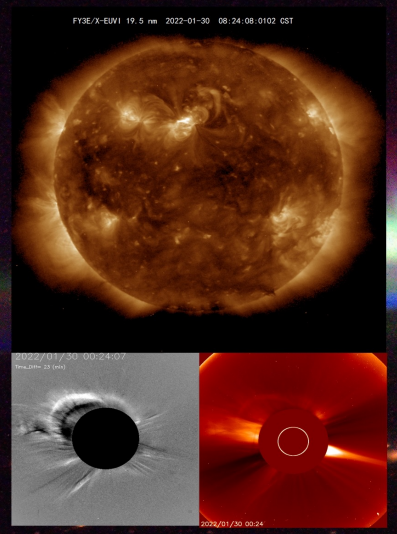
Progress of Space Weather Operations of China Meteorological Administration



China Meteorological Administration
February, 2023

The importance of space weather service

A geomagnetic storm doomed 38 SpaceX Starlink satellites



A M1.1 class flare was observed in the active region 12936 at 6:45 am on January 30. A CME was found to be associated with the flare.

A minor geomagnetic storm with kp=5 for 6 hours was observed at 14:00 on February 3.

At the same time as the aurora occurs, the magnetospheric plasma deposition and the lower atmosphere thermal expansion, increasing the atmospheric density in low Earth orbit and increasing the drag of satellite flight by about 50%

Another minor geomagnetic storm with kp=5 for 6 hours was observed at 23:00 on February 5

Space X launched its latest batch of 49 Starlink satellites at 2:13 on February 4.

The Starlink satellite entered safe mode at the orbit position of 210 km, and the solar panel was rotated 90 degrees urgently to reduce air resistance.

The safe mode brings the problem of insufficient power supply and the power of the electric propulsion engine is not enough to counteract the effects of decreasing orbital altitude and increasing air resistance.

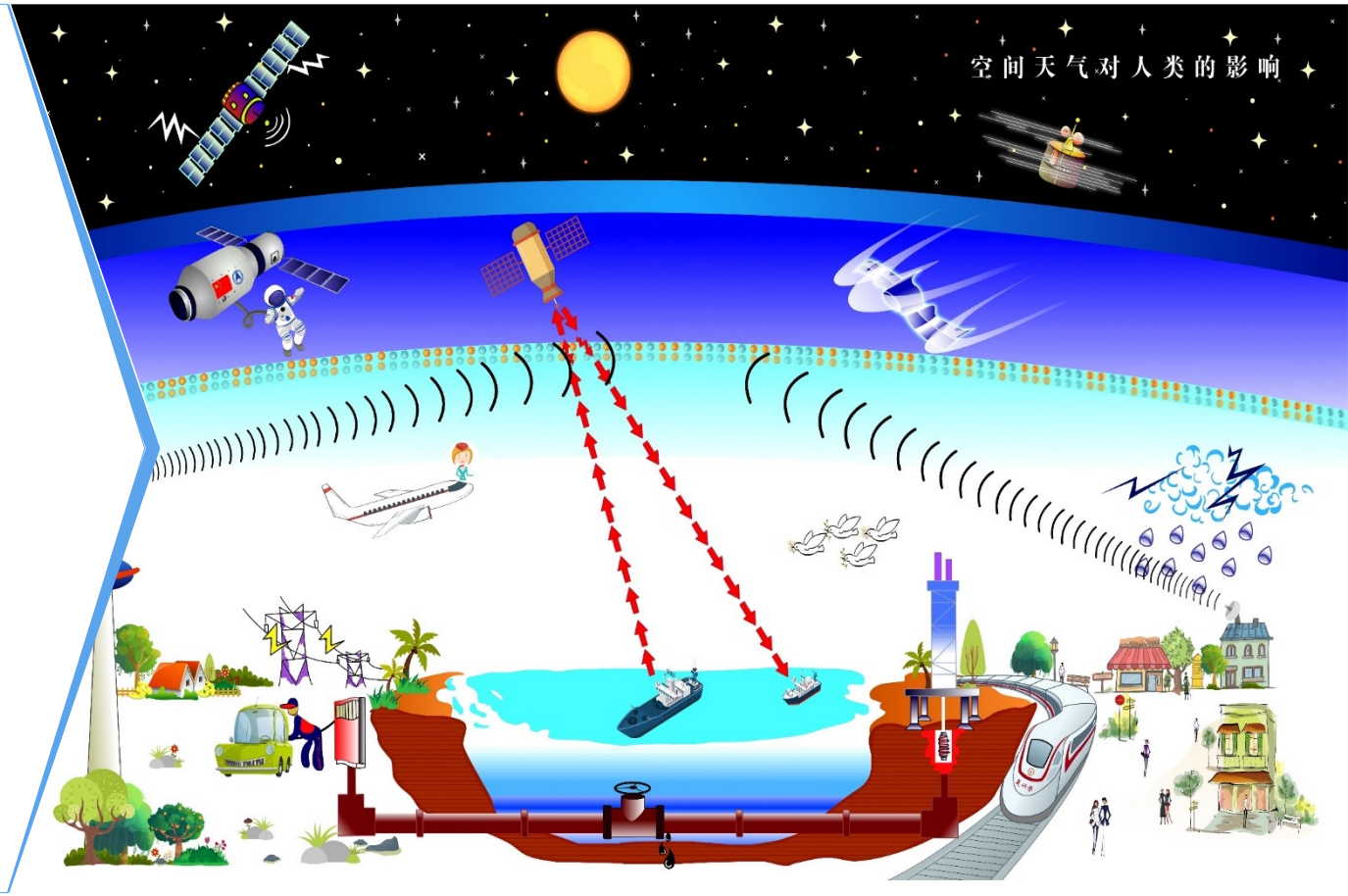
As of February 13, 6 satellite crashed confirmation, 32 satellite suspected has crashed, the remaining 11 satellites is still running.

NSMC NCSW

Space Weather Operation in CMA

Who Are We ?

- In 2002, CMA was authorized by the National Council to establish the National Center for Space Weather (NCSW), assigned to the National Satellite Meteorological Center(NSMC).
- NCSW began to provide space weather operational service on July 1, 2004.
- NCSW has preliminarily developed **a complete operational system** covering space weather monitoring, forecasting, and service.



Outline

01. CMA Space Weather Monitoring

02. CMA Space Weather Service

03. The plan for the future

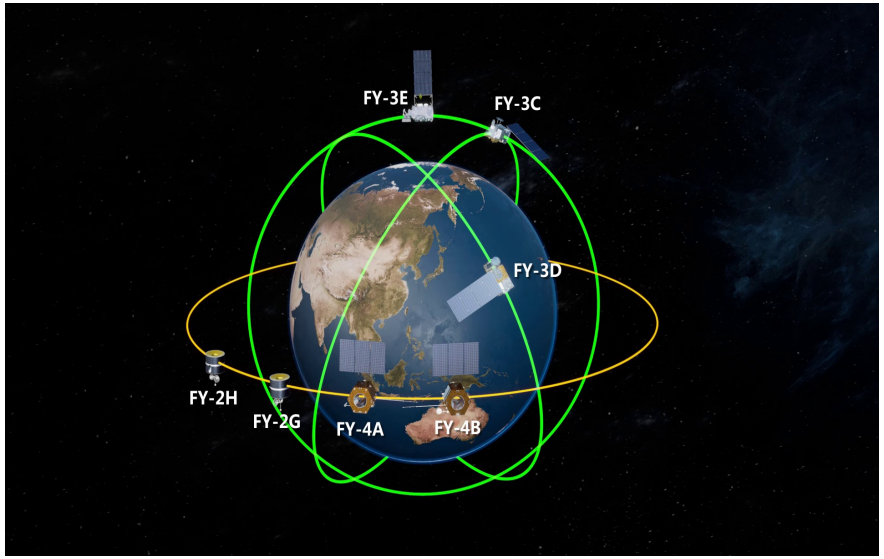
The space weather monitoring system based on the Fengyun series satellites and ground-based network has basically taken shape.

Space-based Observations

The FY satellites have become an ideal platform to monitor space weather.

The Polar satellites could monitor the impacts of energetic particles. The FY-3 can offer information of ionosphere and solar activities.

The Geo. satellites could measure solar X-ray and energetic particles. The FY-4 will provide the solar imaging, ionospheric image and geomagnetic field observations.



Fengyun Satellite Constellation

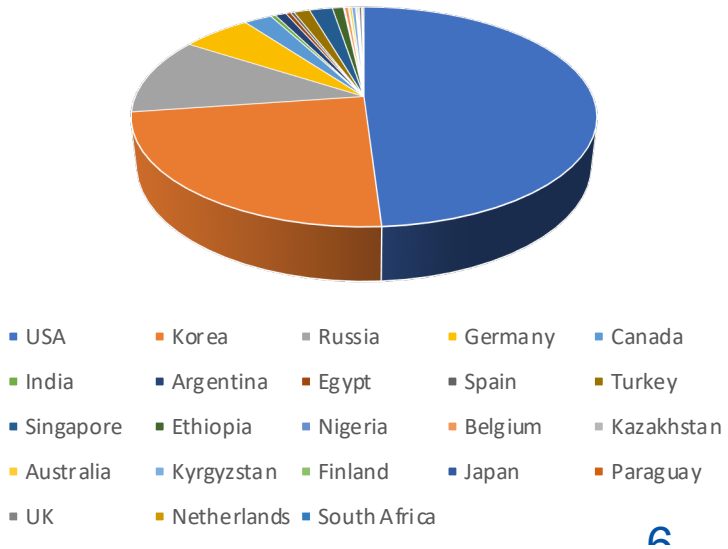
Space-based Observations

All seven FY satellites in orbits have carried space weather payloads

Satellite	Instrument
FY-2G/H	Solar X-ray flux Monitor 、High energy particle sensors
FY-3C	Global Navigation Occultation Sounder (GNOS)
FY-3D	High energy particle sensors 、Particle radiation dose detector、Satellite charging potential monitor 、Global Navigation Occultation Sounder (GNOS)、Wide-angle Aurora Imager (WAI) 、Ionospheric Photometer (IPM)
FY-3E	solar X-EUV imager、High and medium energy particle sensors 、Geomagnetic field monitor (FGM)、Particle radiation dose detector、Satellite charging potential detectors 、Global Navigation Occultation Sounder (GNOS) 、Tri-angle Ionospheric Photometer (TriIPM)
FY-4A	High and medium energy particle sensors 、Geomagnetic field monitor (FGM)、Particle radiation dose detector、Satellite charging potential monitor
FY-4B	High and medium energy particle sensors 、Geomagnetic field monitor (FGM)、Particle radiation dose detector、Satellite charging potential monitor

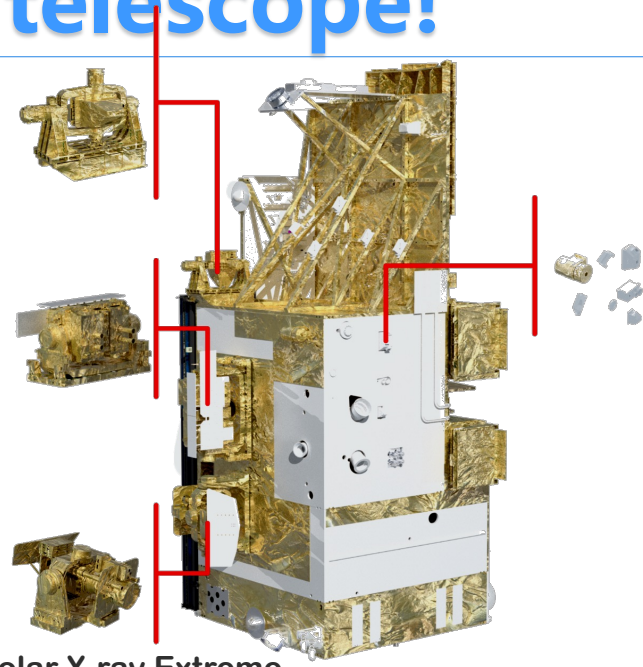
- 7 satellites currently on duty
- 26 sets of Instruments
- Monitoring solar、geomagnetic and Ionospheric activities.

Distribution of foreign users (by download)

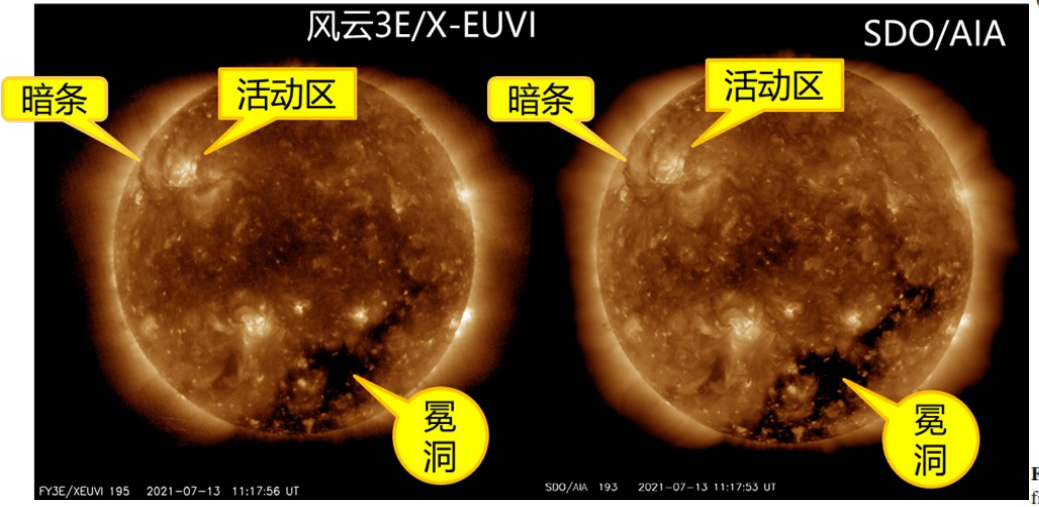


X-EUVI:China's first space-based solar telescope!

- **China's first space-based solar telescope!**
- **For the first time in the world, X-ray and extreme ultraviolet (EUV) imaging are integrated on the same instrument!**
- **Long-term, continuous, and high time resolution**
- 2 Bands：X射线（0.6-8nm）和极紫外（19.5nm）
- 8 channels： X1:0.6-8.0 nm； X2:0.6-6.0 nm；X3:0.6-5.0 nm；X4:0.6-2.0 nm；X5:0.6-1.6 nm；X6:0.6-1.2 nm；EUV1（19.5nm，thin）；EUV2（19.5nm，thick）



Solar X-ray Extreme Ultraviolet Imager



FY3E/XEUVI image compared with SDO/AIA image

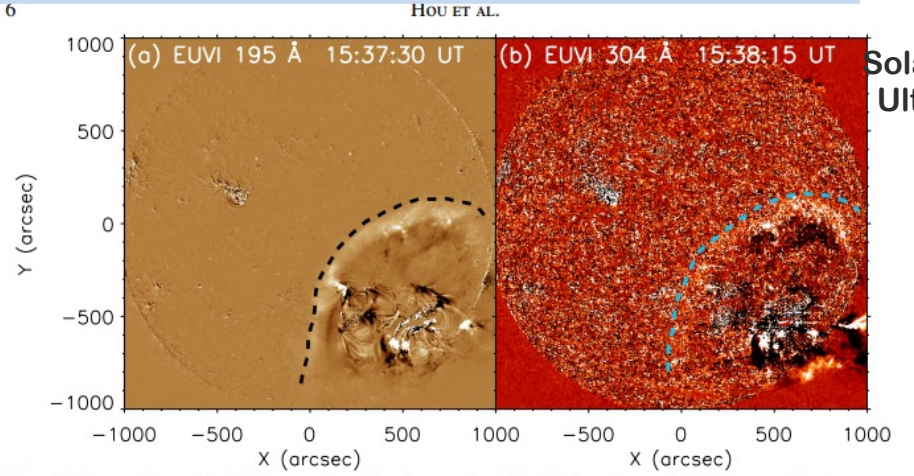
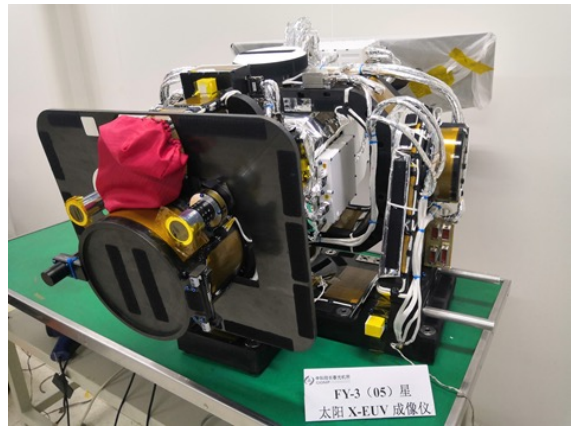


Figure 3. Propagation of the EUV wave from the edge-on view. The black and cyan dashed lines outline the wave-fronts obtained from the EUVI 195 Å (a) and 304 Å (b) running-difference images. An animation of this figure is



Chen, B., Ding, GX. & He, LP. **Solar X-ray and Extreme Ultraviolet Imager (X-EUVI) loaded onto China's Fengyun-3E Satellite.** Light Sci Appl 11, 29 (2022). https://doi.org/10.1038/s41377-022-00711-0

SEM-II: Breakthrough magnetic field vector detection without extension rod

- It is the first time to realize the magnetic field vector detection with six probes on the domestic LEO satellite!

Product name	payload	Operation/test	requirement	spatial resolution	Design error	Evaluation error
Magnetic field	SEM-II	Operation	-65000nt~65000nt	100 km	3%	1%

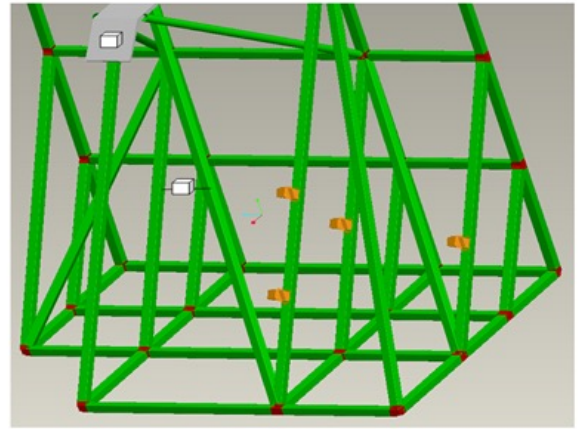


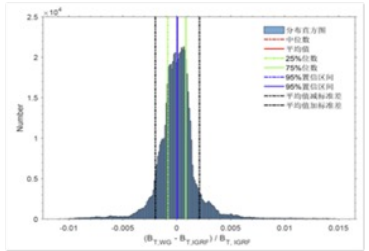
Figure 1 . Schematic diagram of the installation positions of six magnetic sensors on the truss at the top of the satellite, where four yellow hexahedrons are reluctance sensor monomers and two white cube squares are flux-gate magnetometers.

The percentage difference between the magnetic field data and the model (Average value、25%、75%、Standard deviation)

	Bx(%)				By(%)			
MAG1	-0.09	-0.42	0.31	0.66	-0.005	-0.40	0.39	0.60
MAG2	-0.03	-0.35	0.30	0.64	-0.02	-0.38	0.39	0.64
	Bz(%)				Bt(%)			
MAG1	0.14	-0.38	0.52	0.98	-0.02	-0.56	0.35	0.65
MAG2	0.12	-0.37	0.49	0.93	0.01	-0.49	0.34	0.66

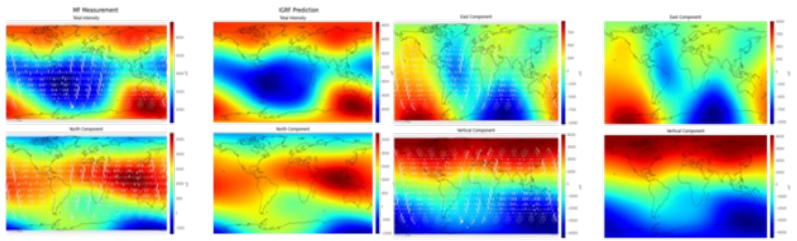
	Bx			By		
WG1	-0.03%	-0.32%	0.24%	-0.002%	-0.28%	0.29%
WG2	-0.03%	-0.35%	0.32%	-0.003%	-0.35%	0.37%
WG3	-0.07%	-0.40%	0.26%	-0.05%	-0.35%	0.29%
WG4	-0.07%	-0.38%	0.24%	-0.05%	-0.35%	0.25%
	Bz			Bt		
WG1	0.008%	-0.14%	0.15%	0.003%	-0.08%	0.08%
WG2	0.006%	-0.15%	0.17%	0.01%	-0.09%	0.09%
WG3	0.03%	-0.13%	0.20%	0.002%	-0.10%	0.10%
WG4	0.05%	-0.10%	0.23%	-0.0008%	-0.10%	0.10%

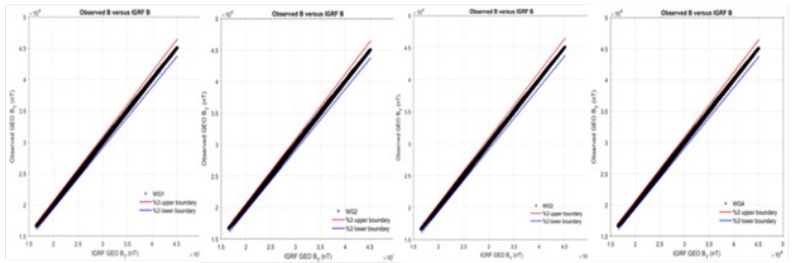
The magnetic field data of track 111 differs from the model by percentage (median、25%、75%、digit)



Histogram of the relative difference between the WG1 magnetic field intensity and the model

The consistency with IGRF is good



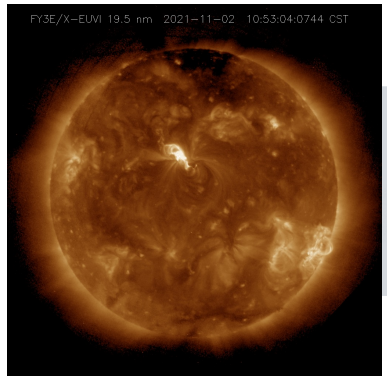


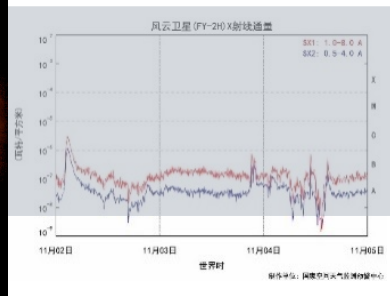
Six-point detection without extension rods:

- Two flux gate detectors and four giant magneto-resistance (GMR) detector are placed on the top truss in a gradient position.
- **The giant magneto-resistance (GMR) detector** Ferro-nickel alloy magnetic film resistive changes over magnetic field to measure the characteristics of magnetic field.

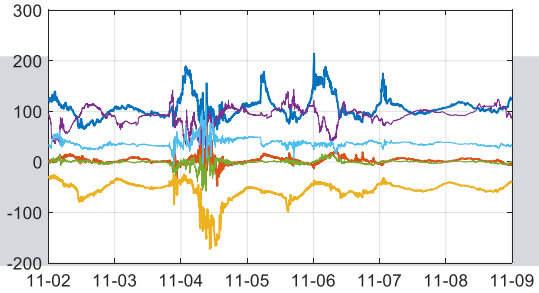
YU Xiangqian,LI Jiawei,XIAO Chijie, HUANG Cong,et.al, **Vector Magnetometer for Space Applications Based on a Low-Resource Magnetoresistance**. Acta Scientiarum Naturalium Universitatis Pekinensis, 2022-11-25.DOI:10.13209/j.0479-8023.2022.111

The “whole process” from sun to earth observed by Fengyun Satellite.

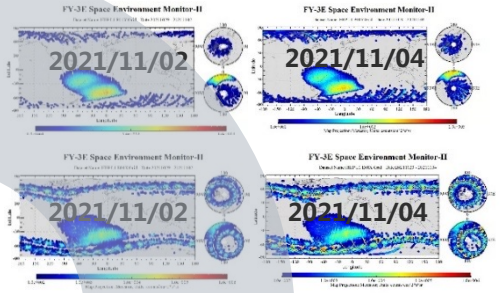




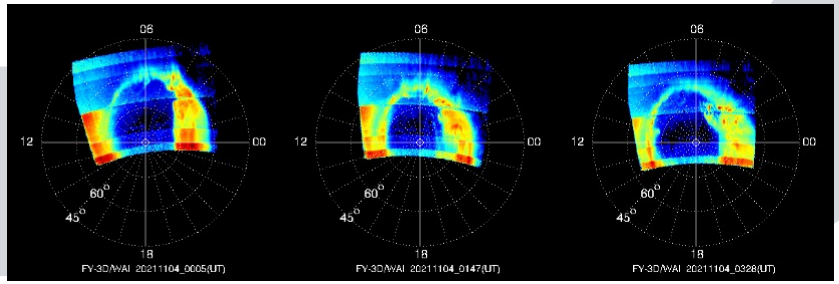
2021/11/02，A long-duration M1.7 solar flare was observed by FY-3E and FY-2H



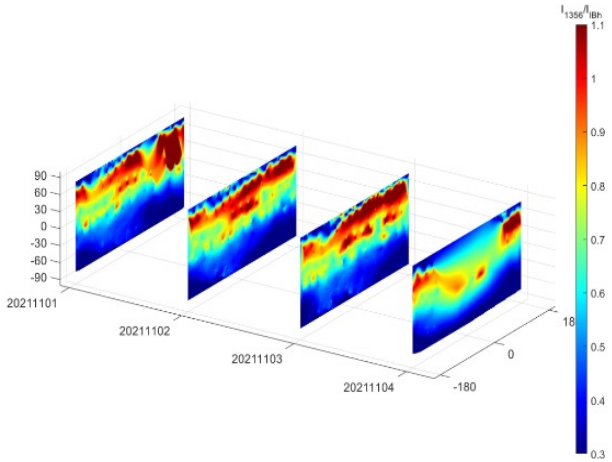
2021/11/04 FY-4B FGM



FY-3E SEM



2021/11/04,FY-3D WAI



2021/11/01-04 FY-3E IPM

Ground-based Observations

Observation stations of the sun, ionosphere and upper atmosphere

- More than 15 provinces (districts, cities),
- 84 sets of professional equipment,
- and nearly 1000 GPS stations

Outline

01. CMA Space Weather Monitoring

02. CMA Space Weather service

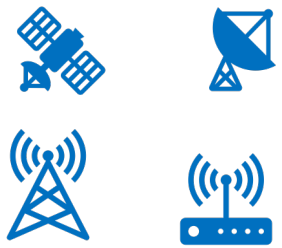
03. The plan for the future

The accuracy of space weather forecasting is comparable to the international level.

CMA Space Weather Forecast

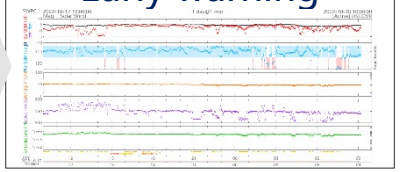
Near-time forecast 0-2h → Short-time forecast 6-12h → Short-term forecast 0.5-3d → medium and long term forecast 4-30d → Climate forecast 1m-11Y

Space-based and ground-based data

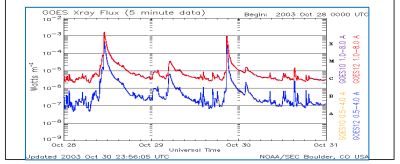


Database

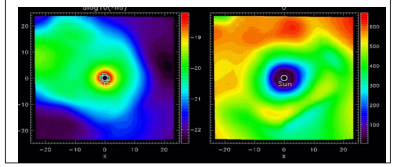
Early warning



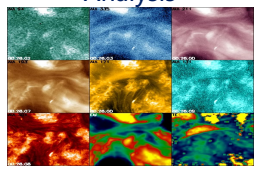
Statistical forecast

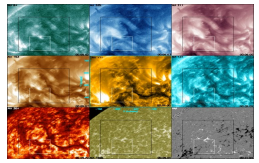


Numerical prediction



Comprehensive Analysis





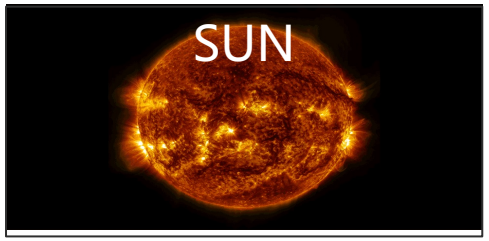
Pilot platform

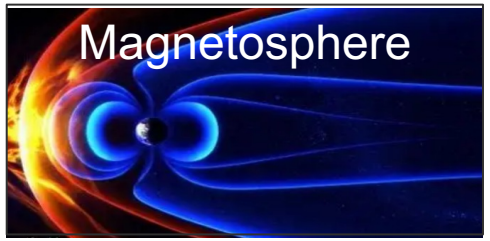
AI platform

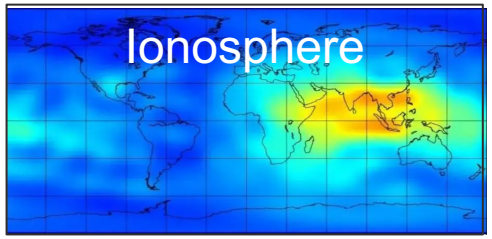
Reality check

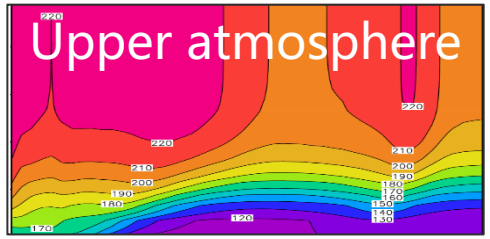
Physical process feedback

Model data support



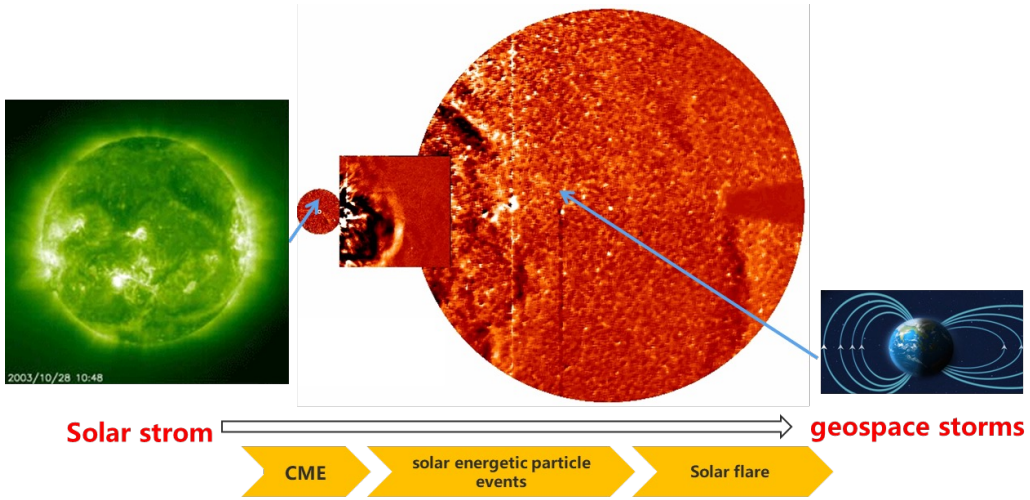


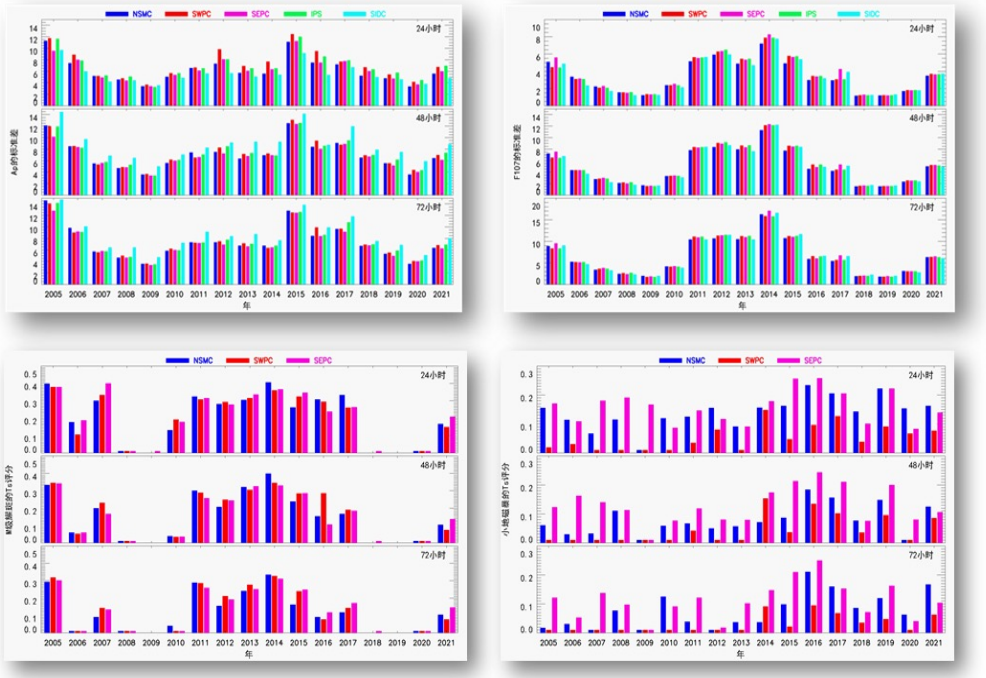




CMA Space Weather Forecast

Operational products





Reality check

- **Regions:**

Solar, Interplanetary, Magnetosphere, Ionosphere.

- **Timelines:**

Long- Mid- and Short-terms, warning and nowcast.

- **Products:**

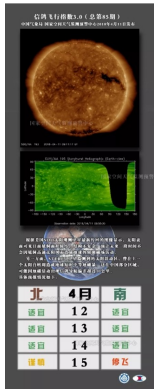
Daily, monthly, annual and user-tailored monitoring and forecasting products.

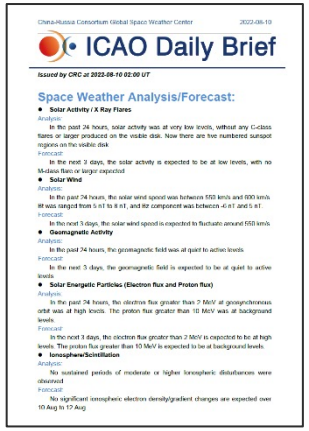
- **Accuracy:**

Comparable to the international level.

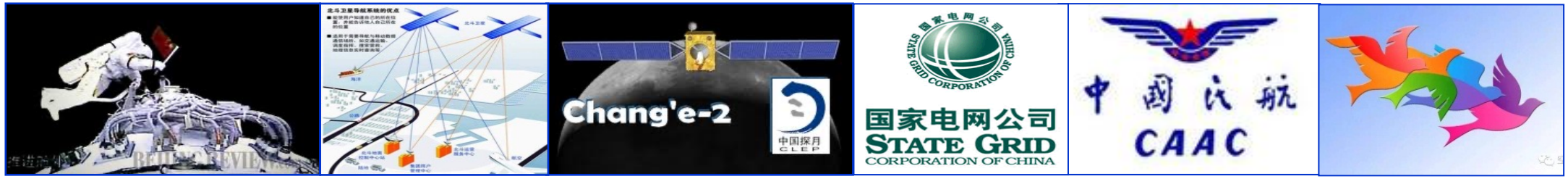
Public Awareness and Applications service

- ✓ CMA routinely delivers daily, monthly, and annual monitoring and forecasting products and services to users through hard-copy bulletins, internet, phone, SMS, e-mail, public media, Wechat，APP etc.





- ✓ CMA also provides special services for customers.

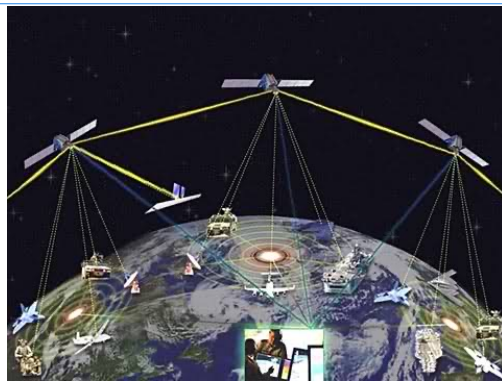


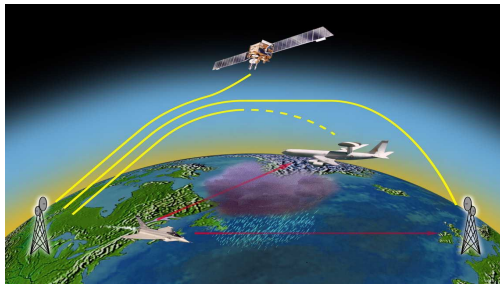
Outline

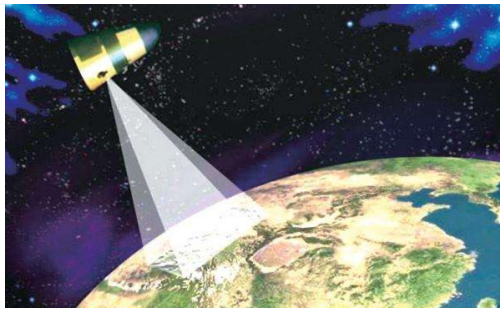
NSMC NCSW

The plan for the future

1. continuously build the space weather observation network
2. improve our ability of early warning of space weather disasters
3. establish cross-industry standards and norms of space weather risk defense;
4. strengthen opening-up and cooperation, promote information sharing

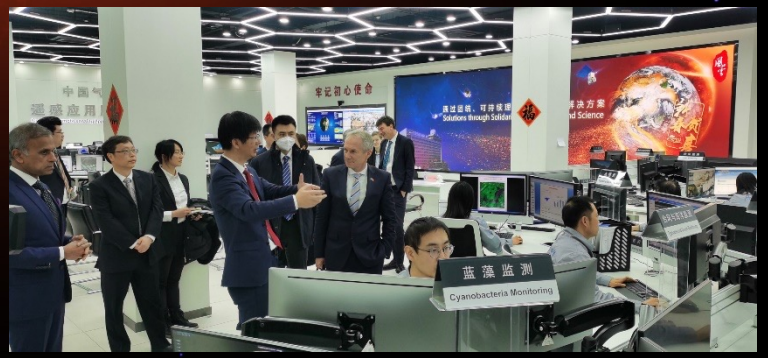






NSMC NCSW

Solutions through Solidarity, Sustainability and Science



China Meteorological Administration (CMA) has welcomed Mr. Csaba Kőrösi, President of the Seventy-seventh session of General Assembly of the United Nations on Feb 3 , 2023.

Email:maotian@cma.cn