Space Weather Activities in China

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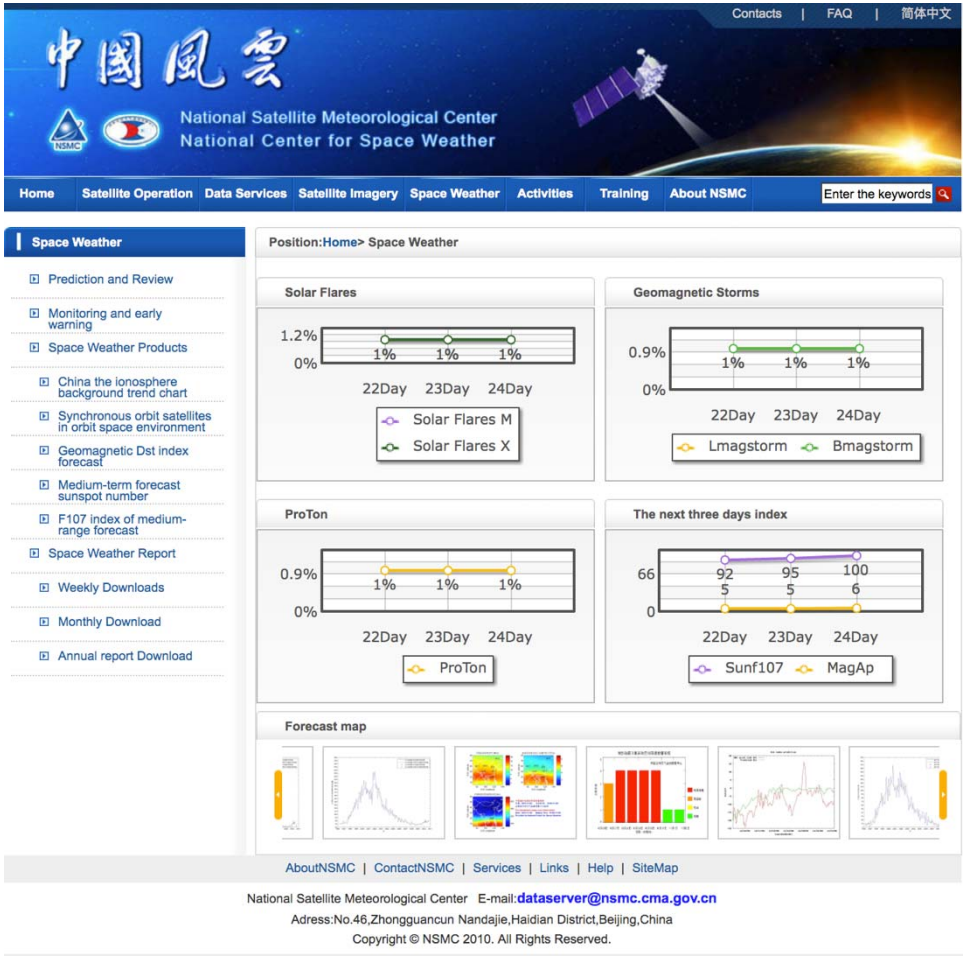
Outline

- Establishment of National Space Weather Forecast Station
- Space Weather Observations
  - CAS-ESA Joint Mission – SMILE
  - International Meridian Circle Project
  - Thermospheric Density Observation Satellite
  - SanYa Incoherent Scatter Radar (SYISR)
- Space Weather Services for space missions
  - China Manned Space Mission
    - Tiangong 2
  - Strategic Priority Program
    - DArk Matter Particle Explorer satellite (DAMPE)
    - QUantum Experiments at Space Scale (QUESS)

China Meteorological Administration
- National Space Weather Forecast Station



The National Space Weather Forecast Station of China Meteorological Administration (CMA) was established on November 27, 2015.

Space weather forecast is officially included in weather services in China.

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CAS-ESA Joint Scientific Space Mission
Solar wind Magnetosphere Ionosphere Link Explorer (*SMILE*)

Timeline and deadlines

9th ESA -China Space Science Bilateral Meeting Initiate the Joint Mission	May 2013
1st CAS-ESA Workshop (Chengdu)	February 2014
2nd CAS-ESA Workshop (Copenhagen)	23-24 September 2014
Joint call for missions → Short List	4th Quarter 2014
Selection of mission → 2 or 3 candidate missions	Late 2015
Study phase	2 years
Implementation phase	4 years
Launch	2021

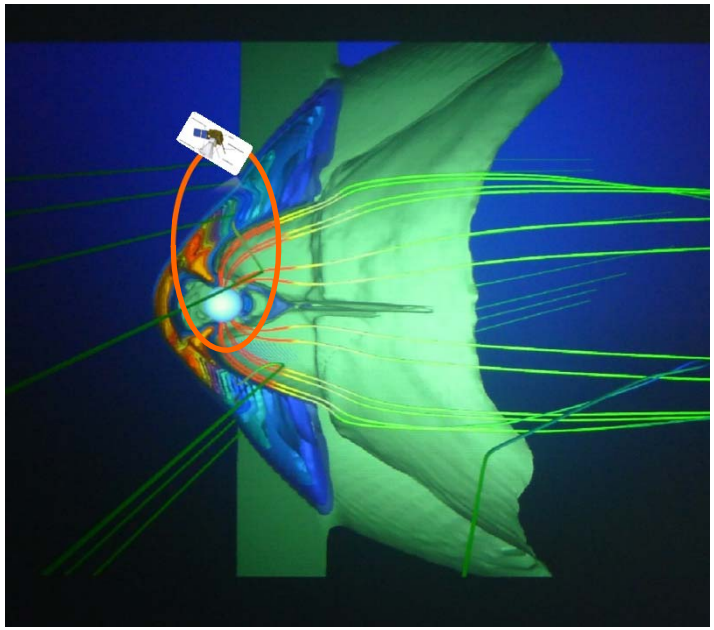
CAS-ESA Joint Scientific Space Mission
Solar wind Magnetosphere Ionosphere Link Explorer (*SMILE*)

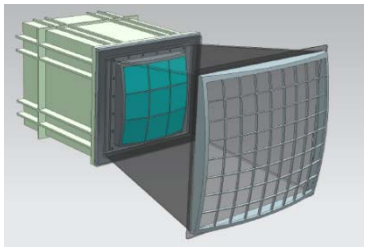
Scientific Objectives

- Investigate the dynamic response of the Earth's magnetosphere to the solar wind impact in a unique and global manner
- Combine X-ray imaging of the dayside magnetosheath and the cusps with simultaneous UV imaging of the northern aurora, while monitoring the solar wind conditions in situ
- Full chain of events that drive Sun-Earth relationships: dayside reconnection / magnetospheric substorm cycle / CME-driven storms

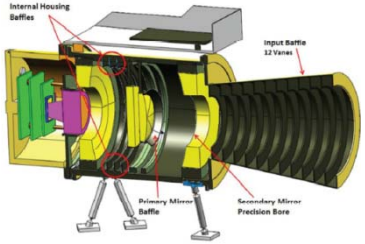
CAS-ESA Joint Scientific Space Mission
Solar wind Magnetosphere Ionosphere Link Explorer (*SMILE*)

Orbit and Payloads

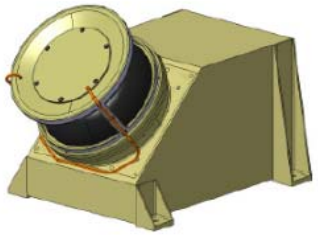




SXI



UVI



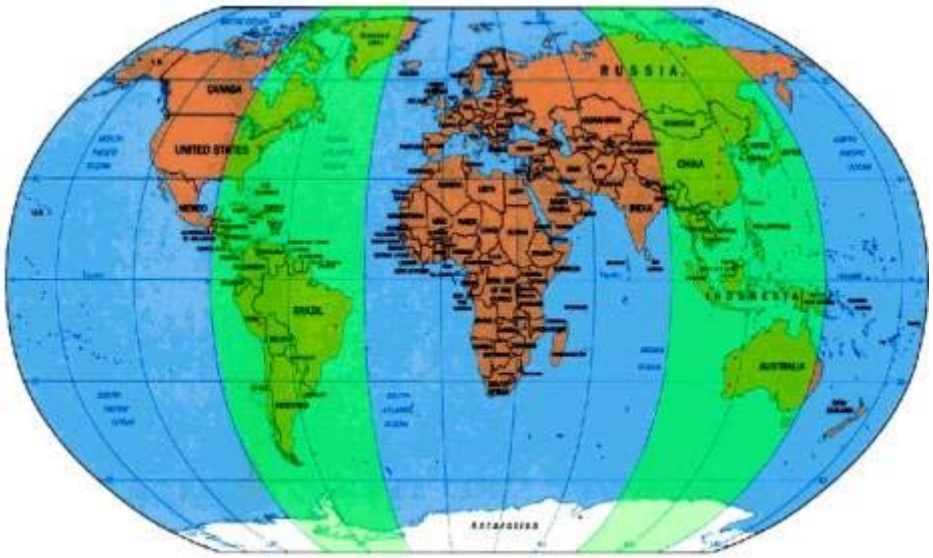
LIA

MAG

- Outside the magnetosphere
- Polar orbit, 20 Re apogee
- 3 years life time

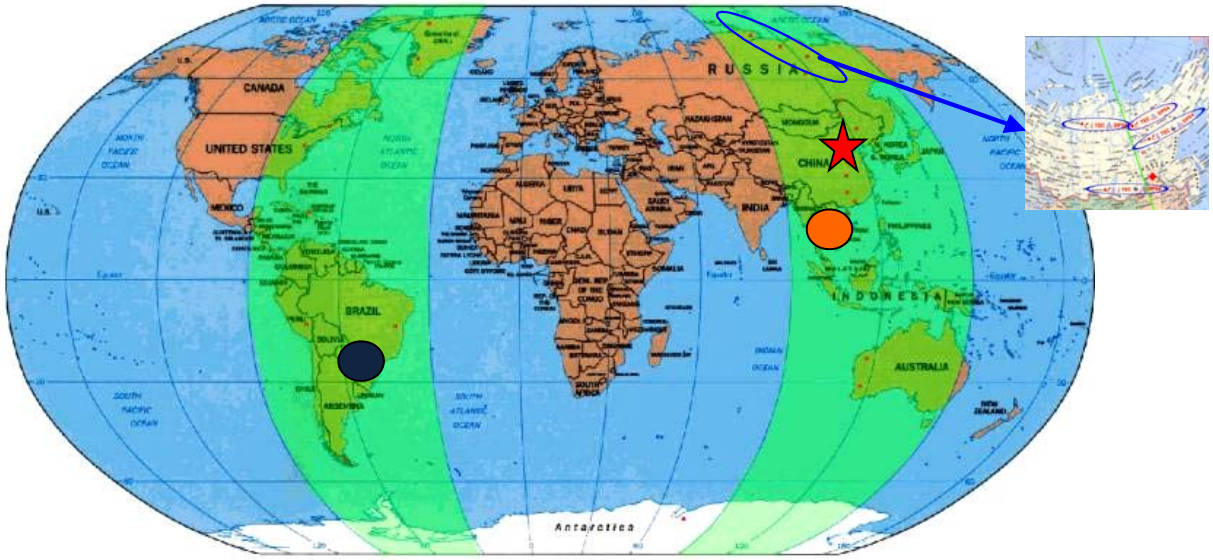
- SXI: X – ray Imaging of the magnetosphere
- UVI: UV imaging of the aurora
- LIA: Plasma measurement
- MAG: Magnetic field measurement

International Meridian Circle Project
China-Brazil joint laboratory on Space Weather



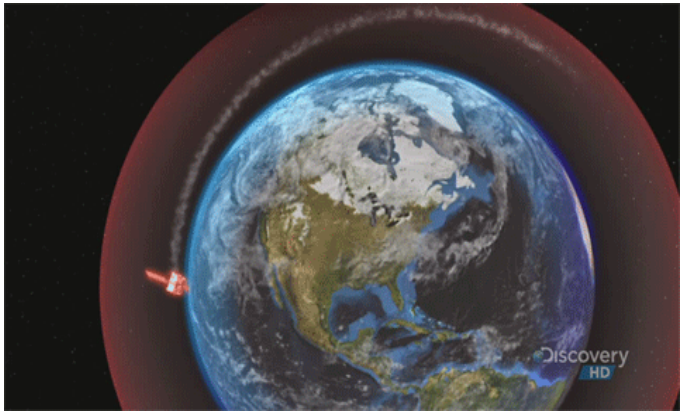
The International Space Weather Meridian Circle Project (IMCP), proposal to connect 120ºE and 60ºW meridian chains of ground based monitors and enhance the ability of monitoring space environment worldwide.

International Meridian Circle Project
China-Brazil joint laboratory on Space Weather



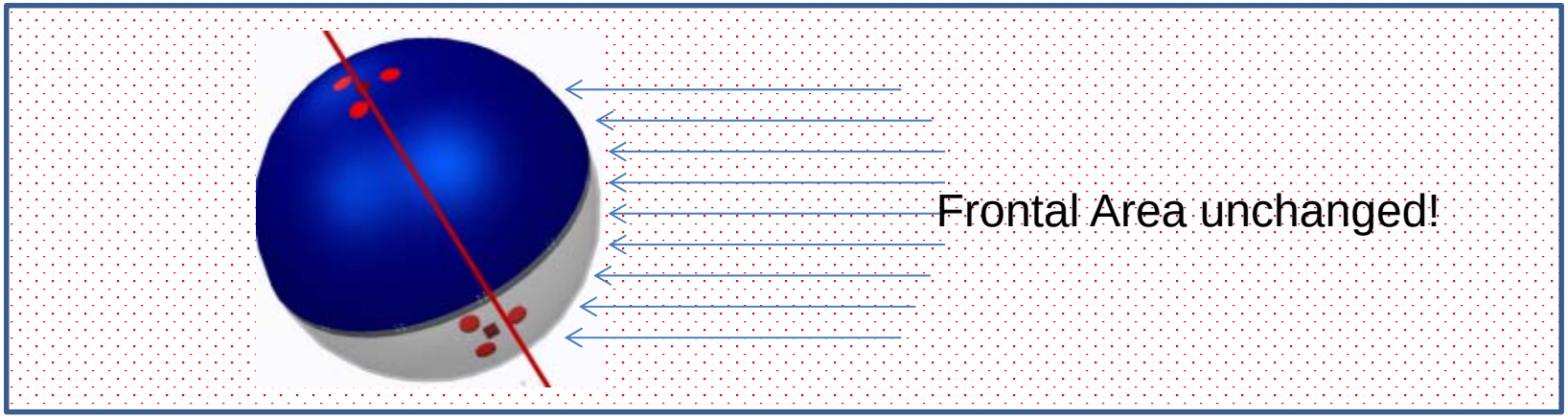
Thermospheric Density Observation Satellite - Derivation from Drag Measurement

- **Motivation:** Current thermospheric density models do not adequately account for dynamic changes in atmospheric drag for orbit predictions.
- **Needs:** Thermospheric data are needed for
  - Model calibration, first regionally then globally;
  - New model development with significant improvement.
- **Goal:** A small satellite:
  - High precision position measurement;
  - low-cost;
  - minimalist design.



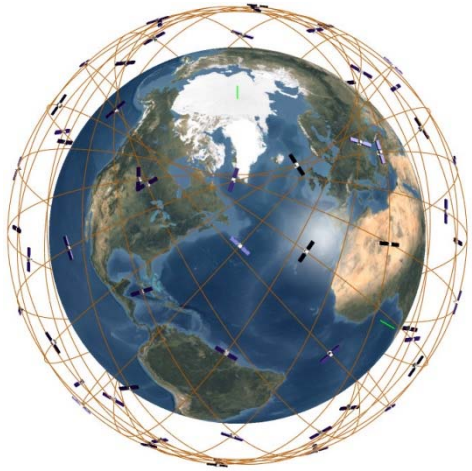
Thermospheric Density Observation Satellite - Derivation from Drag Measurement

- Mentality of designing:
  - To be launched together with a main satellite.
  - High precision position measurements: GNSS;
  - The frontal area *A* and the mass *m* of the satellite keep unchanged in orbit: A/m = constant;
  - Low-cost satellite with weak satellite attitude control.

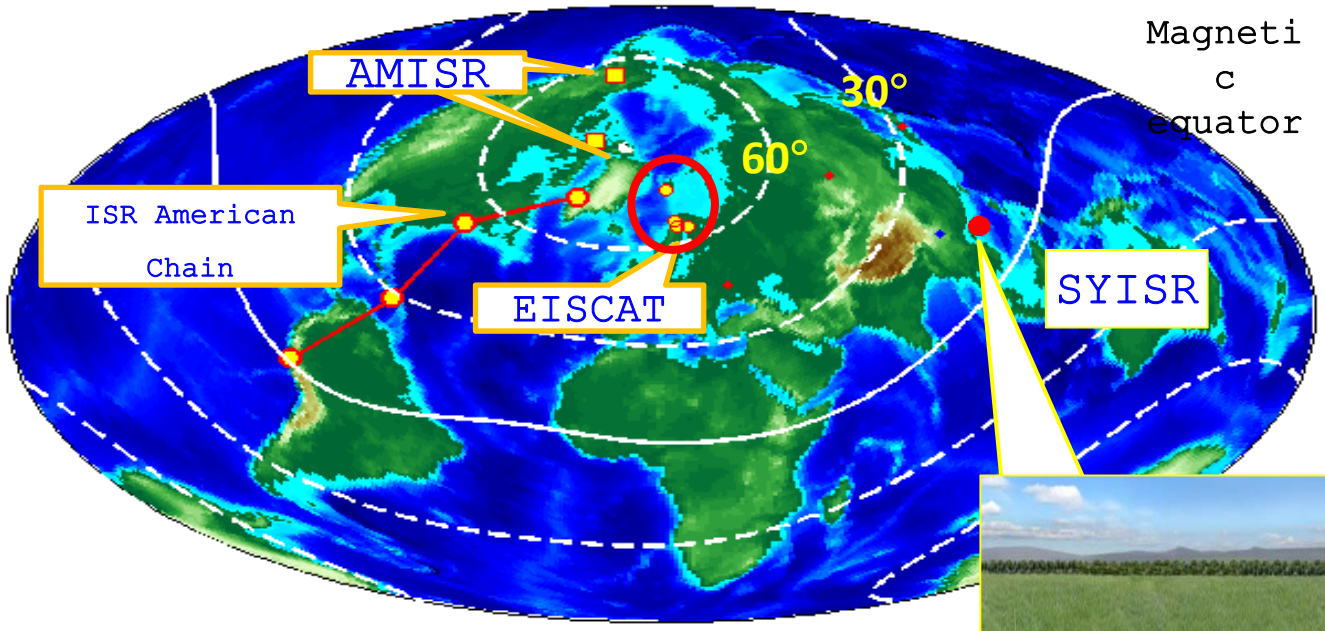


Thermospheric Density Observation Satellite - Derivation from Drag Measurement

- Progress:
  - Construction of the satellite completed in 2016;
  - Waiting for a launch opportunity at the earliest chance.
- Future plan:
  - A multi-satellite network for in-situ measurements is under conception research.
    - Different altitude
    - Different inclination
    - Different A/m ratio
    - Launch time optimized



SanYa Incoherent Scatter Radar (SYISR)



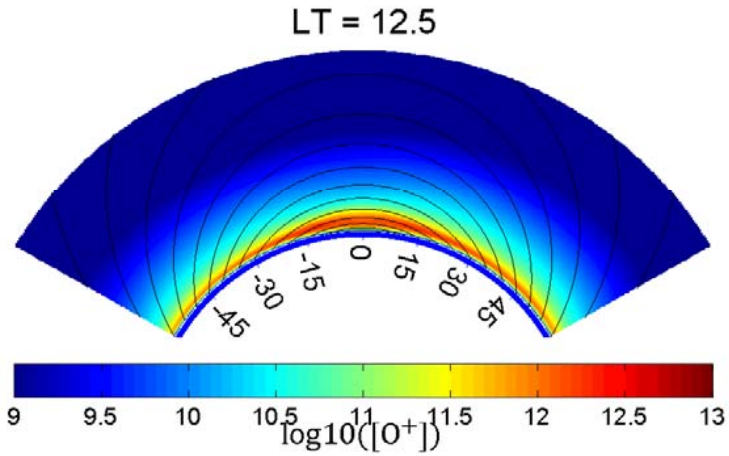
Technical Specifications

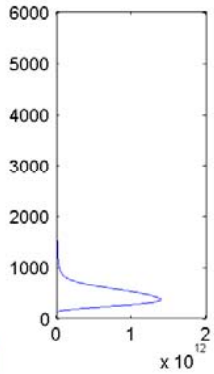
- TX Frequency: 440 MHz±10MHz
- Peak Power: 2MW;
- Max RF Duty: 10%

SanYa Incoherent Scatter Radar (SYISR)

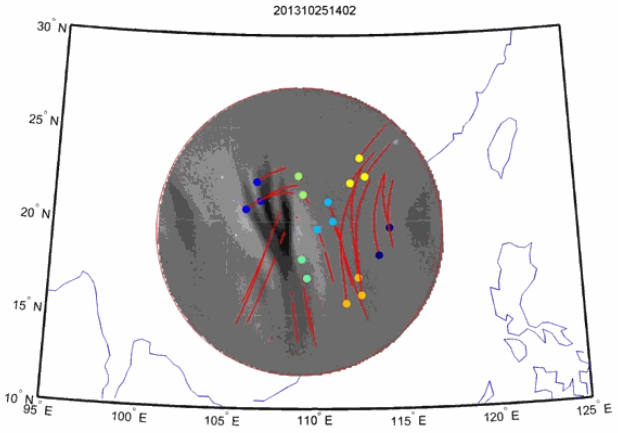
How Earth's atmosphere is coupled to space **is uniquely located** for studies at low latitude in the East-Asia

- Atmosphere-Ionosphere-Magnetosphere Coupling
- Plasma Bubbles & Ionospheric Scintillation
- Ionospheric Space Weather nowcasting and forecasting





Super magnetic storm



Bubble Evolution

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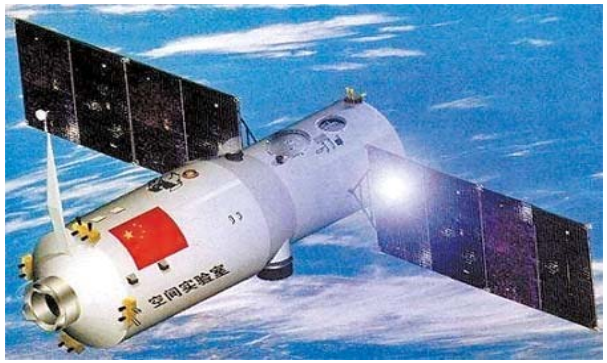
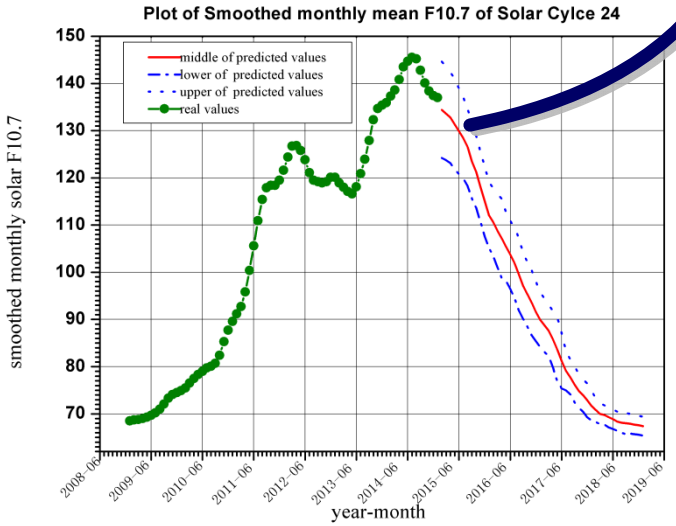
Space Weather Services for China's Manned Space Missions

- Monitored the space weather conditions 24 hours/day.
- Provided daily space weather forecasts 365 days/year.
- Provided space weather alerts timely.

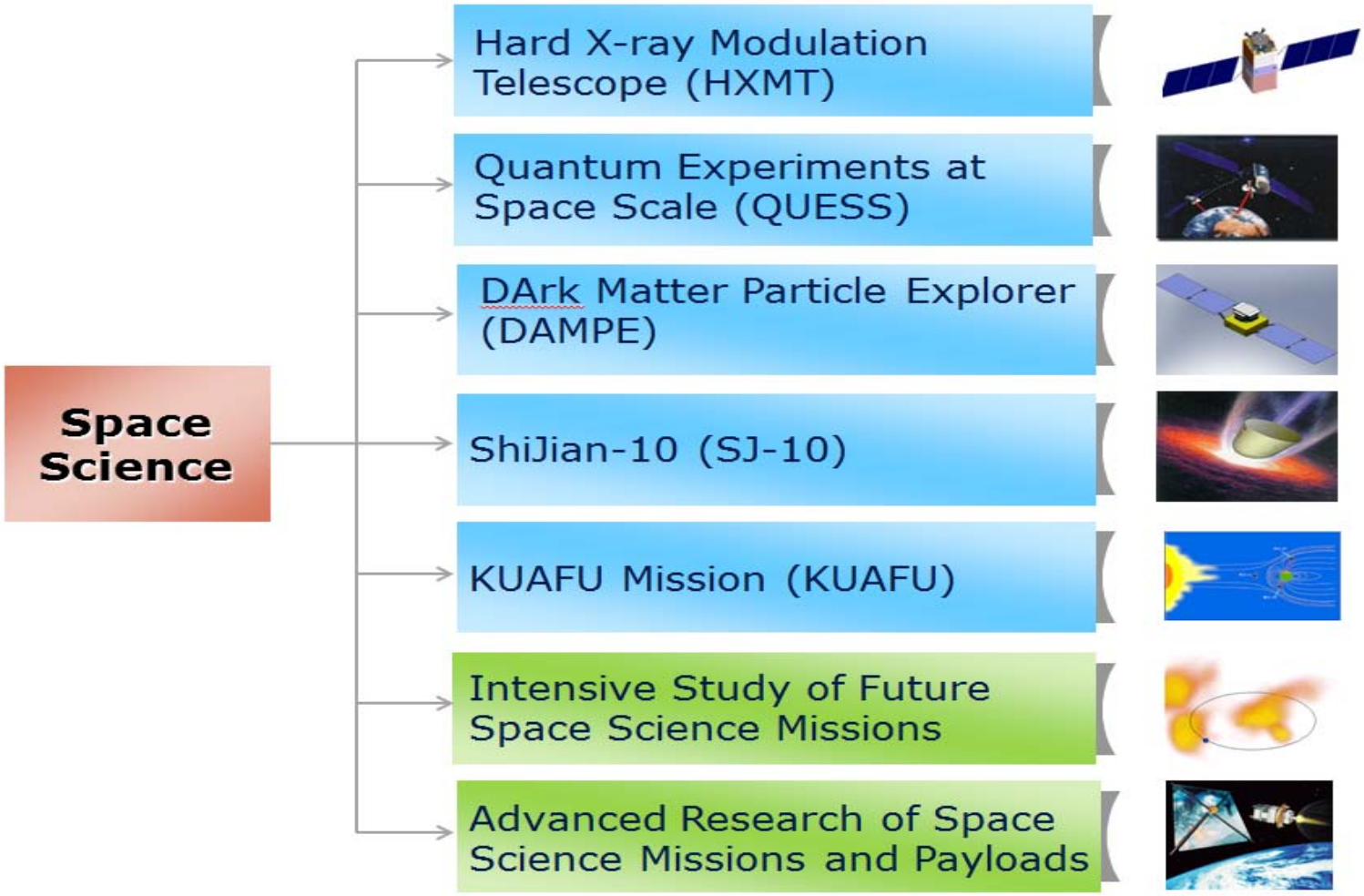


Tiangong-2



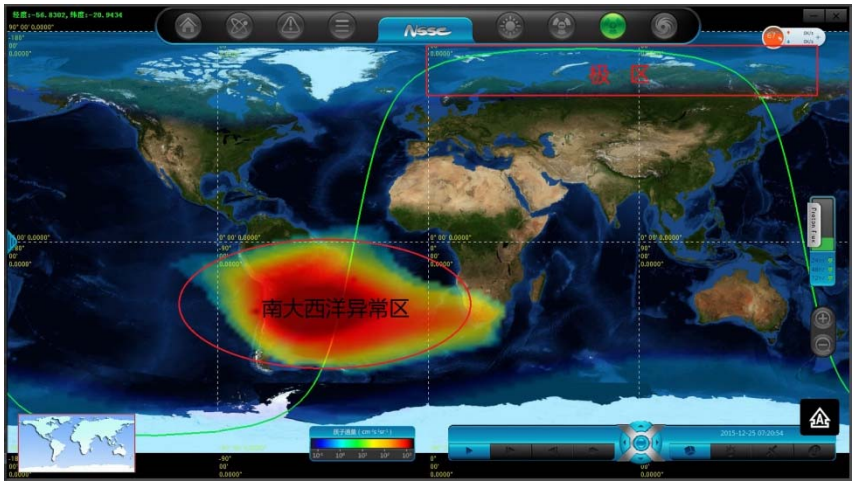
- Long-term forecasts of sunspot, F10.7 index , Ap index, ionospheric parameters and effect analysis for Tiangong-2.
- Verified the F10.7 and Ap index mid-term forecasts to assist orbit determination for Tiangong-2.
- Made sunspot, F10.7 and Ap index long-term forecasts of solar cycle 24-26 (from 2016 to 2040) for China space station.

Space Weather Services for Strategic Priority Program - Missions Included



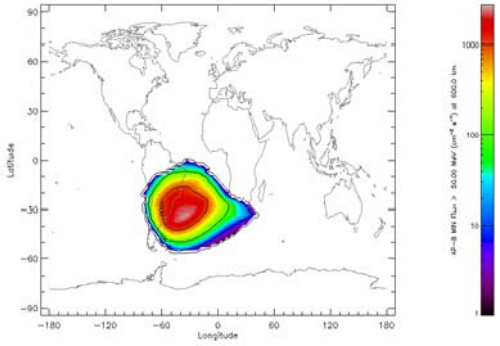
Space Weather Services for Strategic Priority Program - DArk Matter Particle Explorer satellite (DAMPE)

- Analyze the space radiation conditions on the orbit and their effects on the satellite.
- Provide time periods and energy spectrum flux when the satellite crosses the SAA.
- Help to determine control strategy when the satellite crosses the SAA.

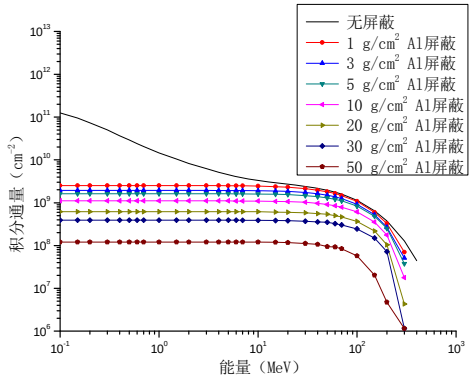


Space Weather Services for Strategic Priority Program - QUantum Experiments at Space Scale (QUESS)

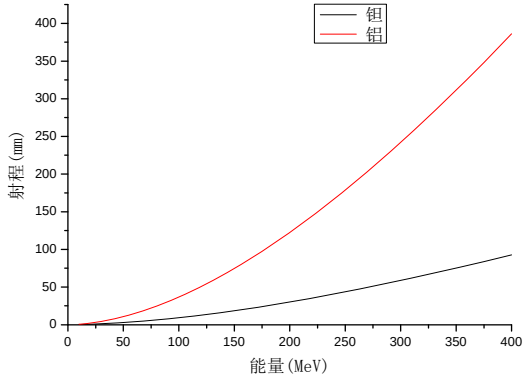
- The key payload of QUESS, Single Photon Avalanche Diode, is sensitive to proton irradiation.
- We carried out analysis of high-energy proton environment for different altitudes of satellite orbit and evaluated the cumulative proton fluence during the mission life.
- We evaluated the shielding abilities under different thicknesses, and calculated the transmitting proton spectrum as well as the proton-induced displacement damage effect for different shielding materials.



Proton distribution at 600km of altitude



Shielded flux for radiation belt protons



The range of protons in Aluminum and in Tantalum

Thanks for your attentions!