

Recent Activities on Space Weather in China and Perspectives on International Collaboration

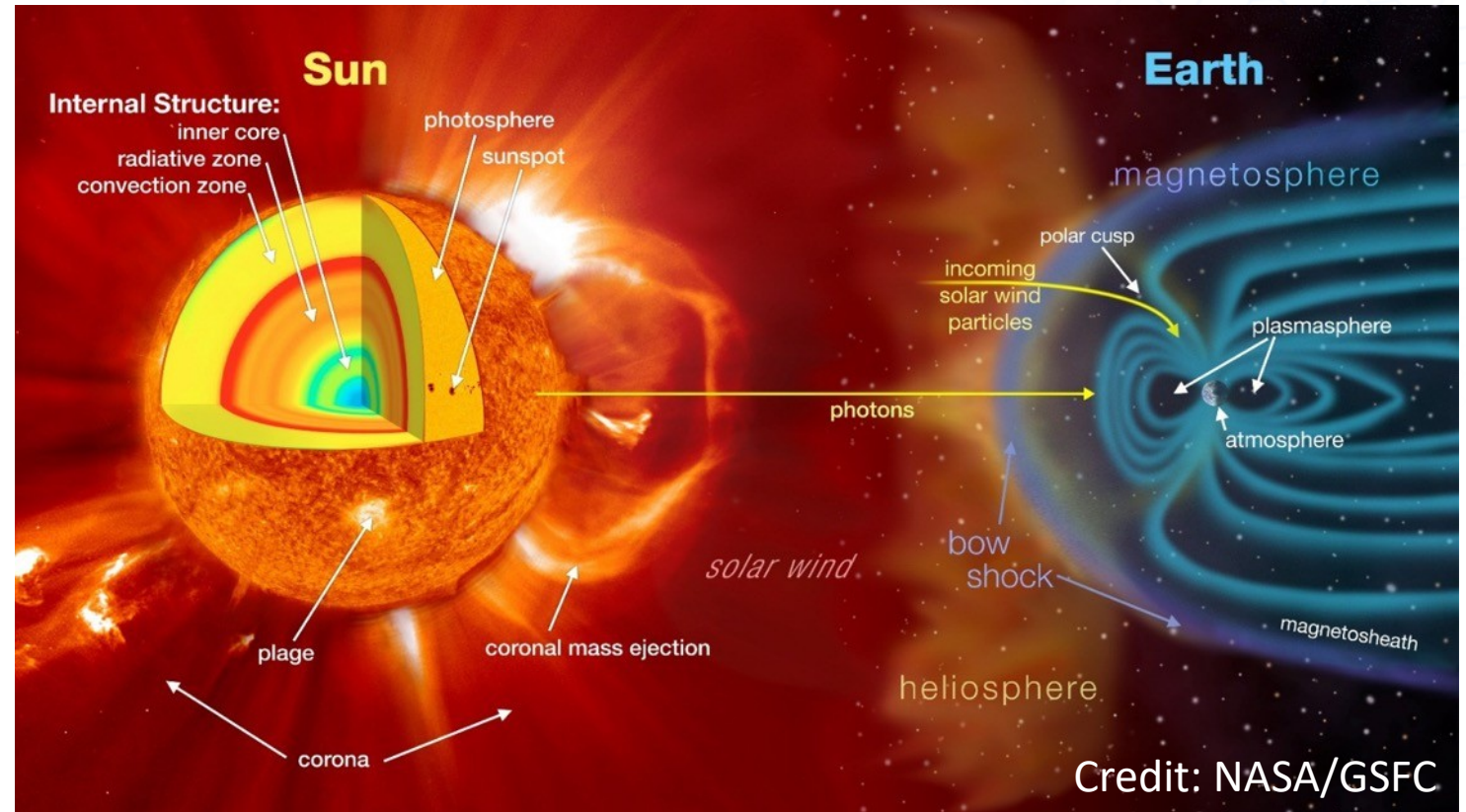
Bingxian Luo

National Space Science Center, Chinese Academy of Sciences

Feb 2024

Space Weather: Solar-Earth Connection

- Sun
- Solar Wind/Interplanetary
- Geospace Environment
 - Magnetosphere
 - Ionosphere
 - Thermosphere



OUTLINE

01. The ASO-S (Kuaifu) Mission

**02. International Meridian Circle
Program**

**03. Regional Warning Center-China in
ISES**

Advanced Space-borne Solar Observatory (ASO-S, Kuafu-1)

ASO-S, China's first comprehensive solar exploration satellite, was launched in October last year.

Payloads	Objective s
Full-disc vector Magnetograph (FMG)	Magnetic Field
Lyman-alpha Solar Telescope (LST)	CMEs
Hard X-ray Imager (HXI)	Solar Flares



Solar Physics (2023) 298:68
<https://doi.org/10.1007/s11207-023-02166-x>

RESEARCH



The Advanced Space-Based Solar Observatory (ASO-S)

Wei-qun Gan¹ · Cheng Zhu² · Yuan-yong Deng³ · Zhe Zhang¹ · Bo Chen⁴ · Yu Huang¹ · Lei Deng² · Haiyan Wu⁵ · Haiying Zhang⁶ · Hui Li¹ · Yang Su¹ · Jiangtao Su³ · Li Feng¹ · Jian Wu¹ · Jijun Cui⁵ · Chi Wang⁵ · Jin Chang¹ · Zengshan Yin² · Weiming Xiong⁵ · Bin Chen⁵ · Jianfeng Yang⁷ · Fu Li⁷ · Jiaben Lin³ · Junfeng Hou³ · Xianyong Bai³ · Dengyi Chen¹ · Yan Zhang¹ · Yiming Hu¹ · Yaming Liang⁵ · Jianping Wang² · Kefei Song⁴ · Quanfeng Guo⁴ · Lingling Zhang⁴ · Peng Wang⁴ · Haicao Bao² · Caixia Cao² · Yanping Chen² · Tao He² · Ye Zhang² · Xing Liao² · Hu Jiang² · Ying Li¹ · Jie Zhao¹ · Jingwei Li¹ · Yunyong Zou¹ · Haidong Ji⁸ · Mei Gu⁹ · Yonghuang Zhe¹

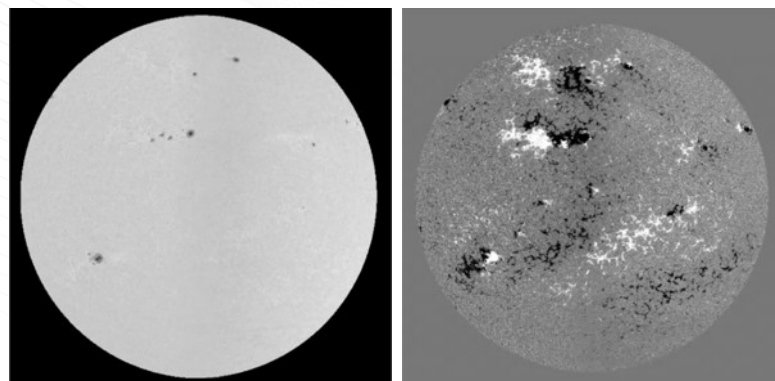
Received: 27 January 2023 / Accepted: 2023
© The Author(s), under exclusive license to Springer Nature B.V. 2023

Abstract

The Advanced Space-based Solar Observatory (ASO-S) was successfully launched at 23:43 UT on 8 October 2022. Here we describe the final technical status of the whole mission right before the launch, including the spacecraft platform and the three onboard payloads. The mission's science goals, organizations, preliminary performance in the commissioning phase, and the first-light results of the three payloads are briefly presented.

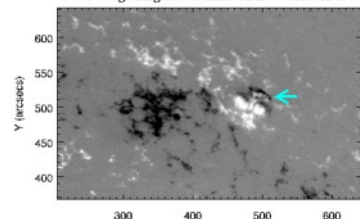
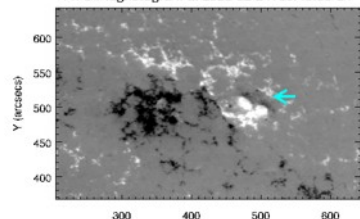
Observations of ASO-S (Kuaifu-1)

FMG Magnetogram

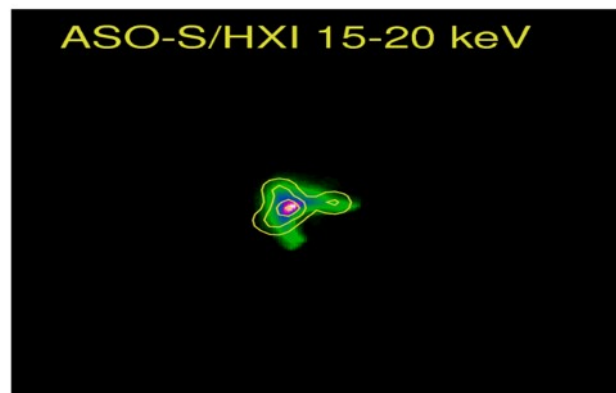
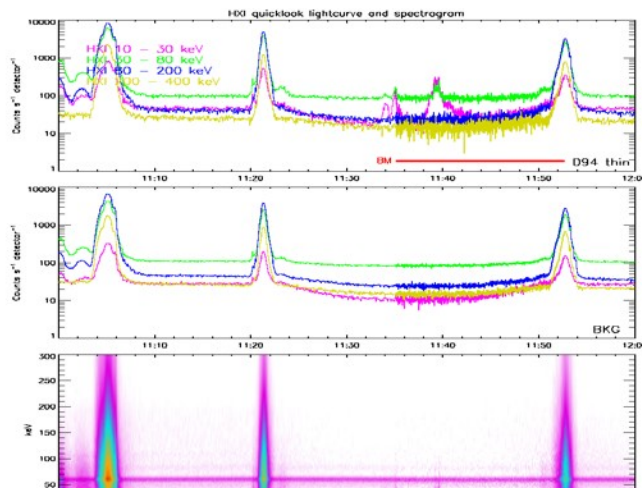


FMG magnetogram at 2023-02-24T06:45:36 UT

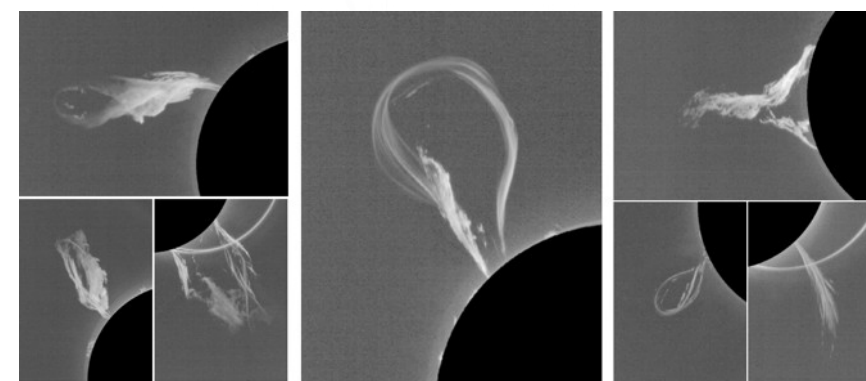
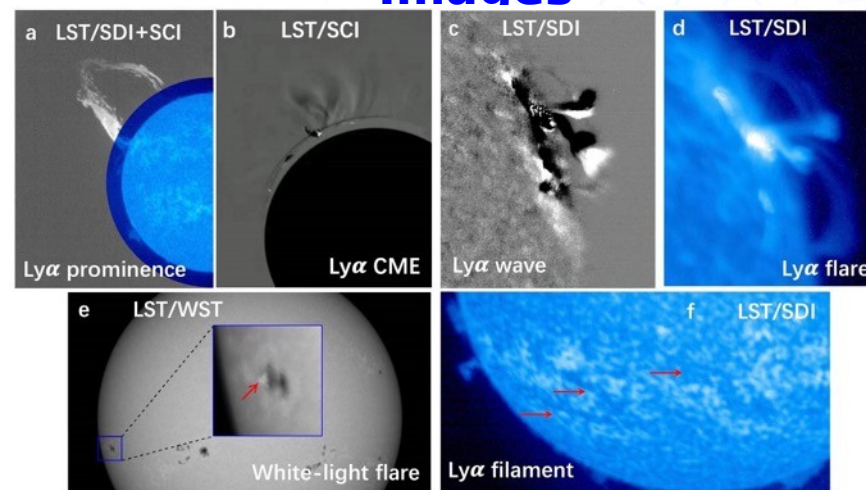
FMG magnetogram at 2023-02-24T19:00:32 UT



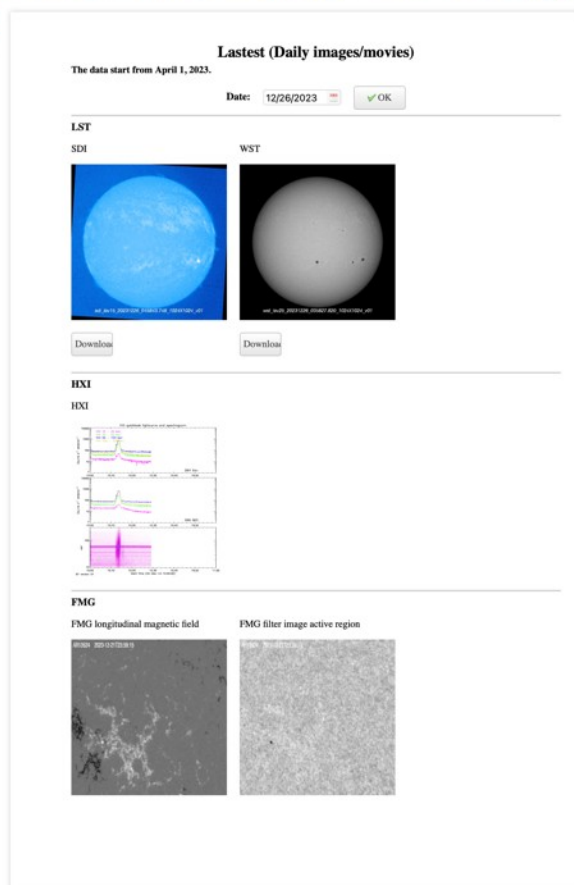
HXI Observations



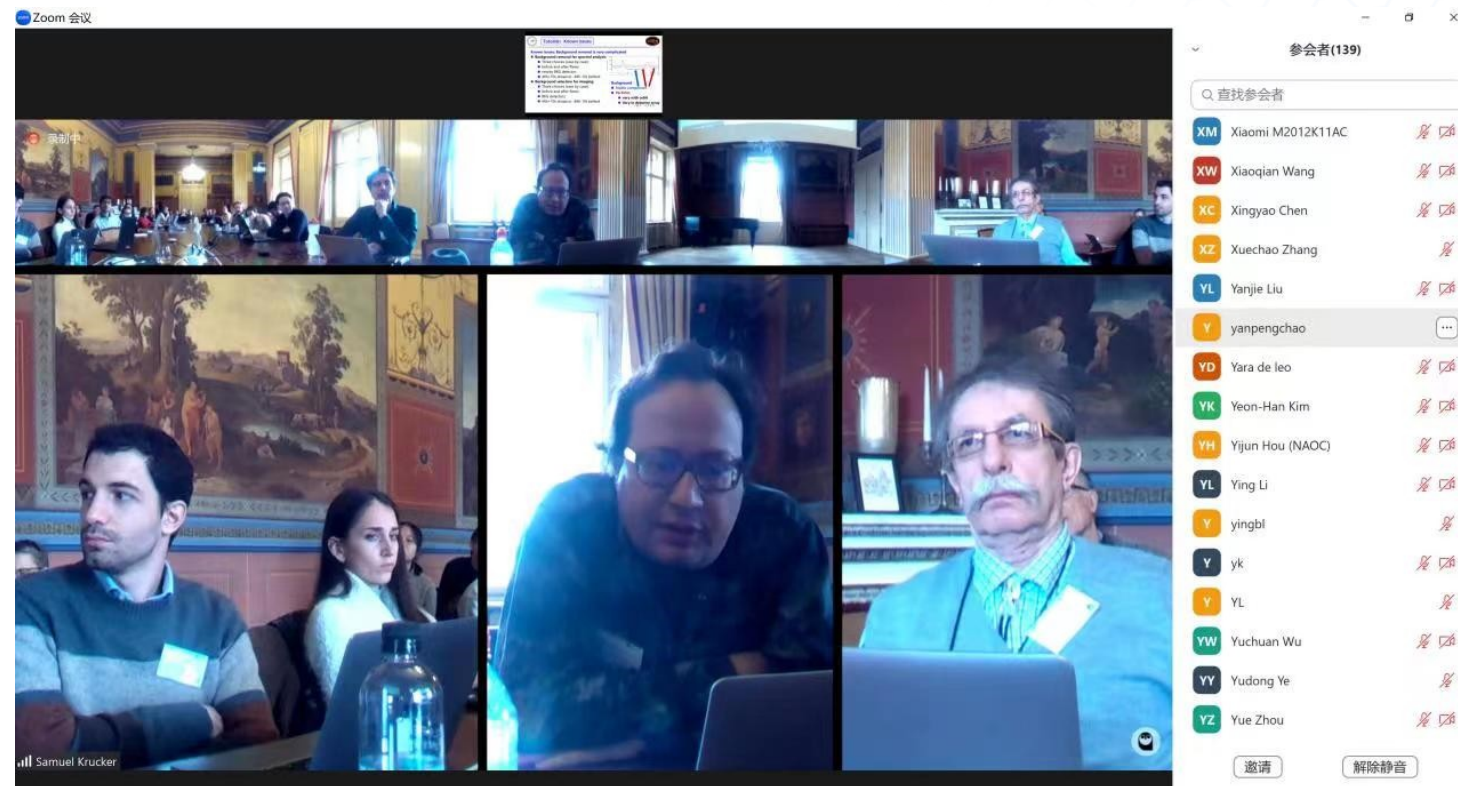
LST Images



Data Publication and International training conference



A data release and training conference on how to use the observation data was held online (April 11-12, 2023), which was attended by nearly 400 solar physics experts from 25 countries.



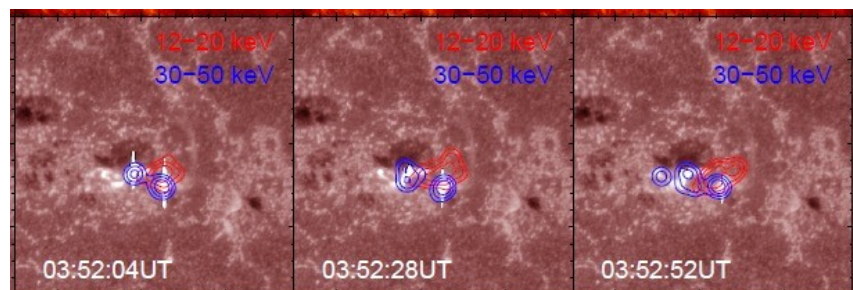
Data Website: <http://aso-s.pmo.ac.cn/sodc/imageBrowser.jsp>

International Collaborations

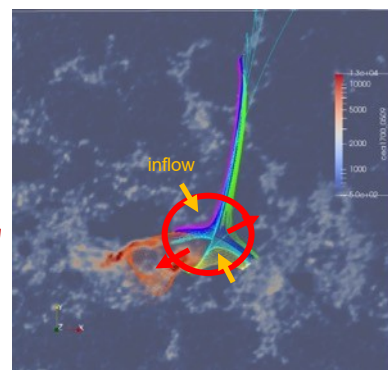
- ASO-S International Guest Research Program
- 3 ISSI or ISSI-Beijing International Research Team
- Collaborations Established with Solar Orbiter Payload teams
- China NSF: Key International Cooperation Projects
- Ministry of Science and Technology (MOST): High-end Foreign Experts Recruitment Plan
- Sino German Science Center Mobility Programme

Preliminary Scientific Results

(1) HXI Reveals the Detailed Motion of Hard X-ray Foot Points and the Mechanism of Flare QPP Production

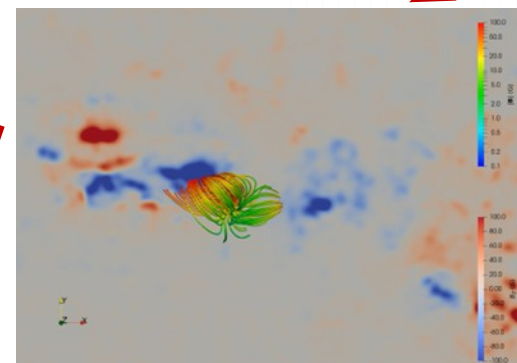


Multi band analysis of high temporal and spatial resolution HXI imaging



Magnetic field extrapolation and analysis

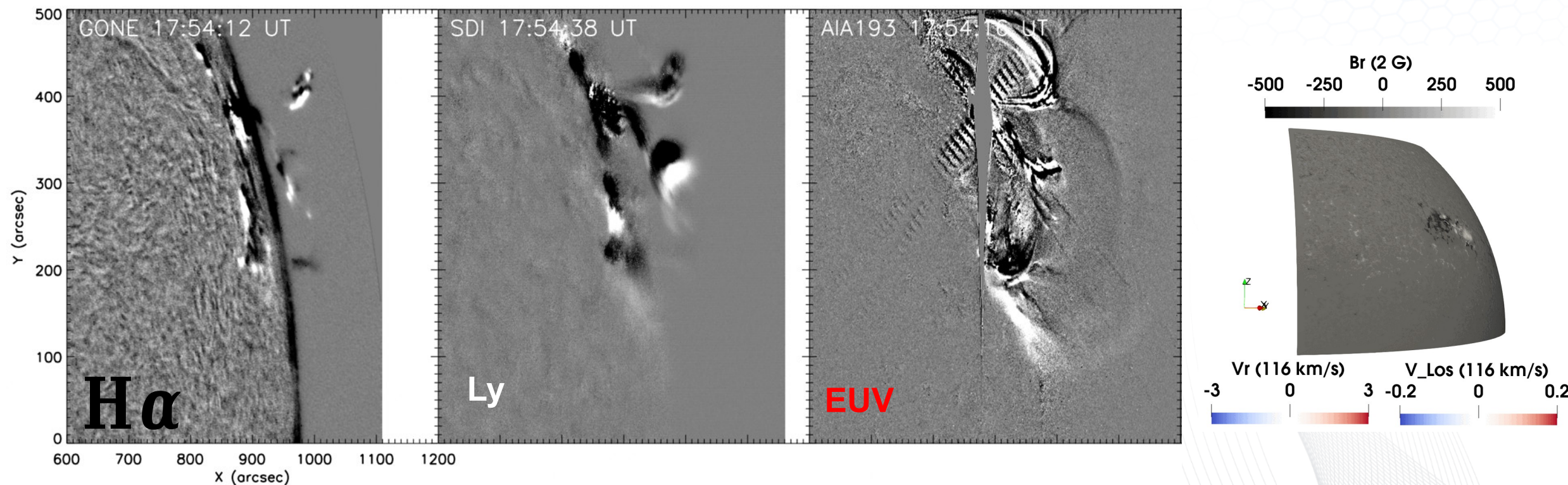
**QPP
Production**



Data driven MHD simulation

Preliminary Scientific Results

(2) SDI observed for the first time Wave (Source area: 20230303 X2.1 class flare)



OUTLINE

01. The ASO-S (Kuaifu) Mission

**02. International Meridian Circle
Program**

**03. Regional Warning Center-China in
ISES**

Chinese Meridian Project

1 Chain
From Sun to Earth

3 Networks
M, I, A

4 Focuses

High-latitude: Polar regions

Mid-latitude: North area of China

Low-latitude: South of China (Hainan)

High-land: Tibetan Plateau

- **295 instruments will be deployed at 31 stations across China and polar regions**
- **1.3 billion CNY (or \$200 M dollars)**
- **Completed and put into operation by the end of 2023**



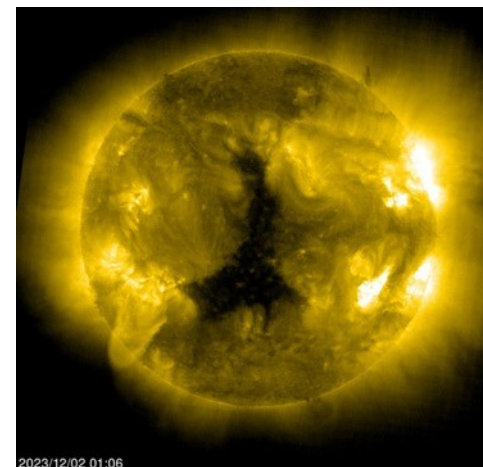
Data website: <https://data2.meridianproject.ac.cn/>

Solar Radio Telescope

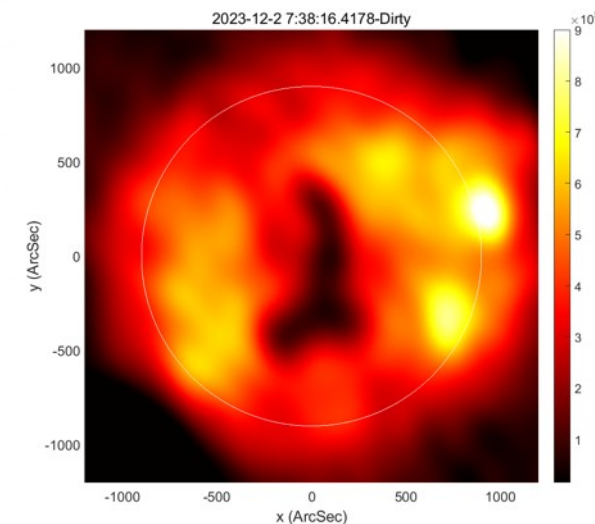


- Frequency : 150MHz - 450MHz
- No. of antenna : 313
- Array Diameter: 1000m

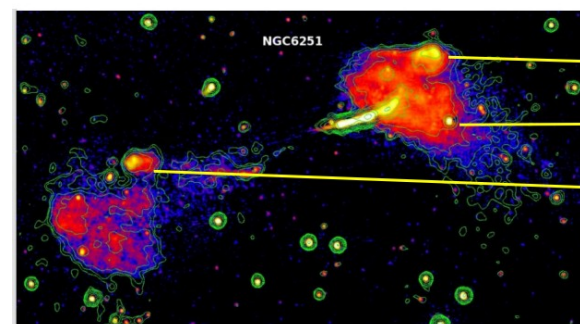
SOHO EUV-eit284 Image



DSRT Solar-Image

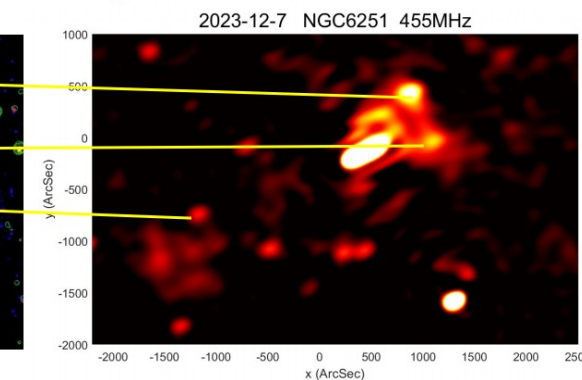


LOFAR Image

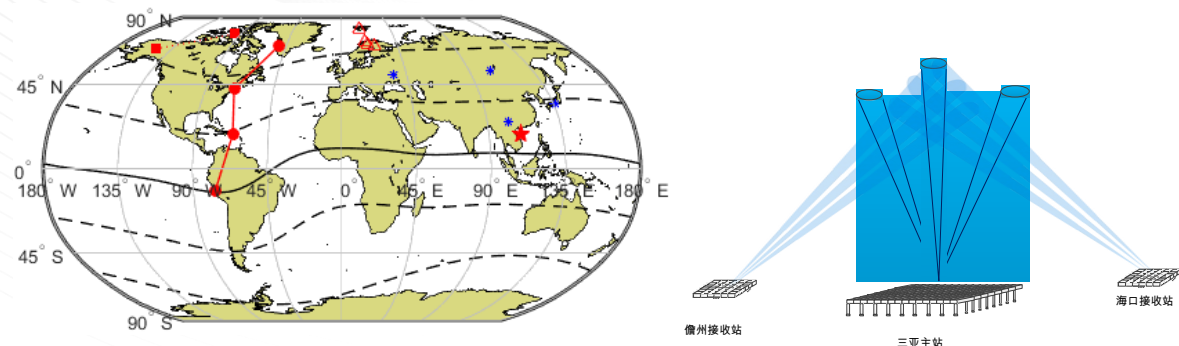


(Cantwell, T. M., et al., MNRAS, 2020)

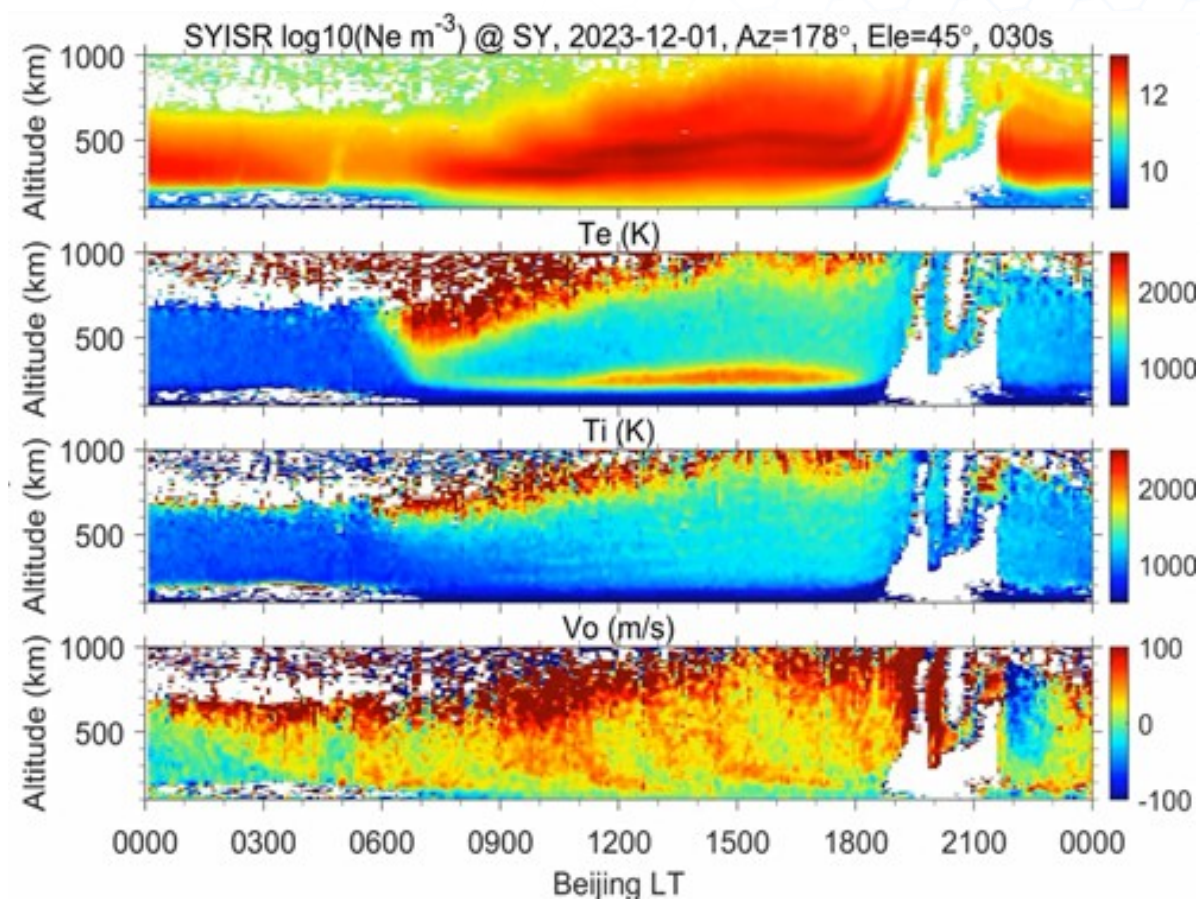
DSRT Image



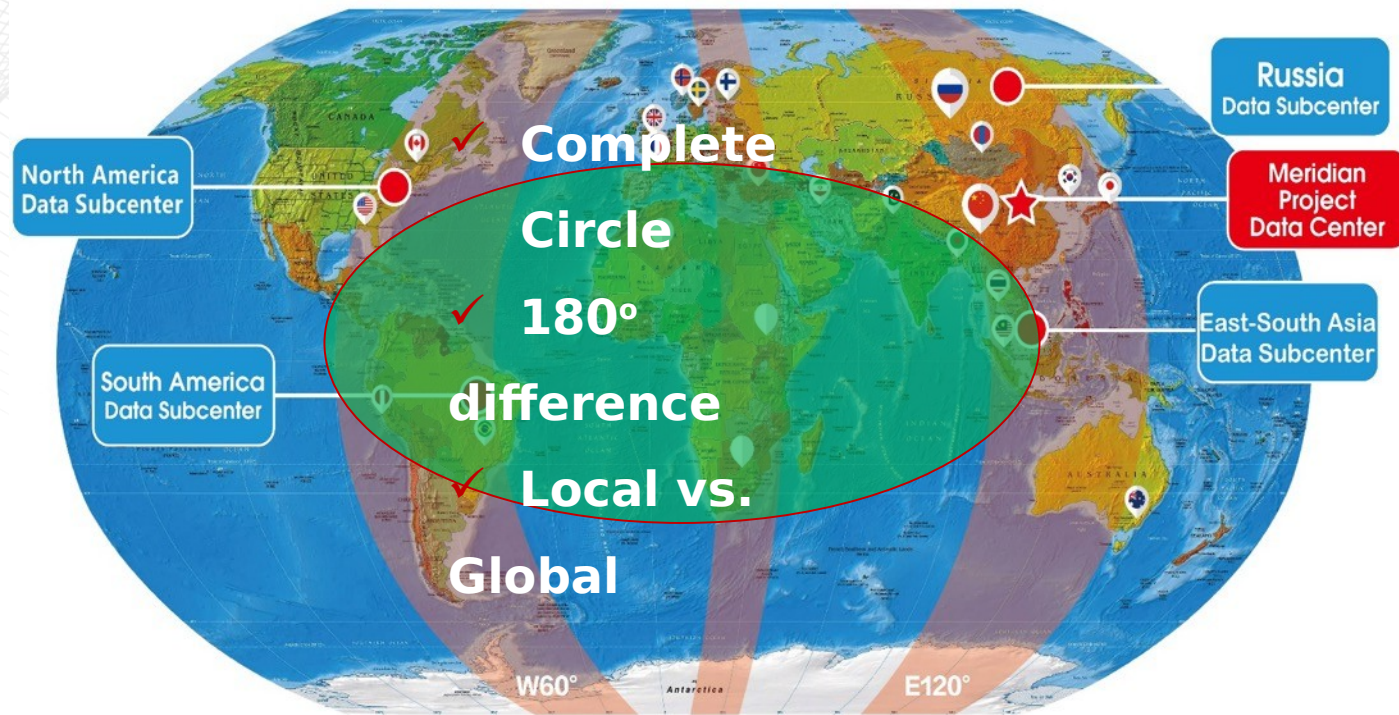
Sanya ISR



Observations During the Dec 1, 2023 Storm



International Meridian Circle Program (IMCP)



IMCP Headquarters Building



- IMCP is an outgrowth of the **Chinese Meridian Project**
- Integrate ground-based observatories along the 120° E and 60° W Great Meridian Circle

International Collaboration

12 Agreements/MoU , **3** Letter of support

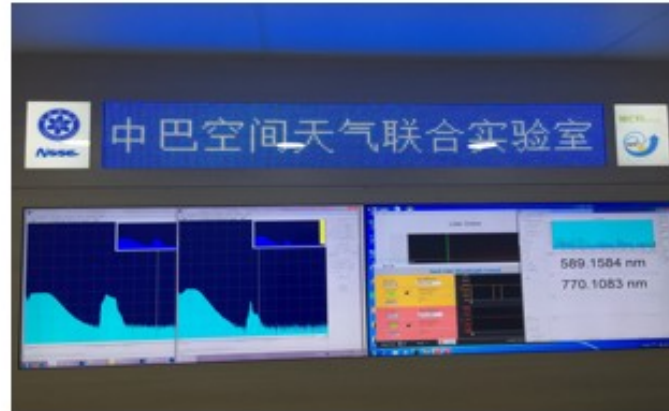


国际组织 International Organization



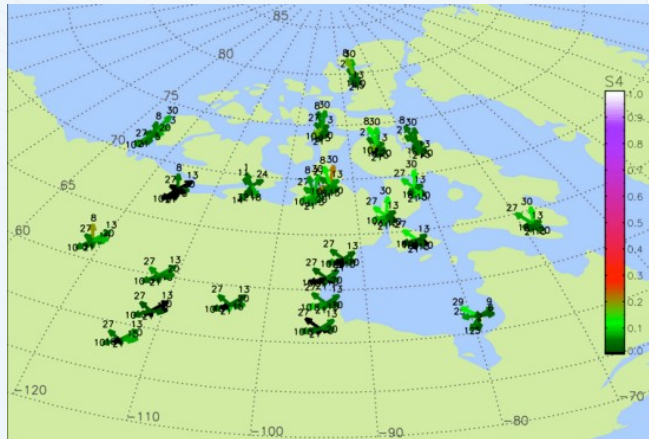
Facilities under joint construction

2017, China-Brazil Joint Laboratory for Space Weather



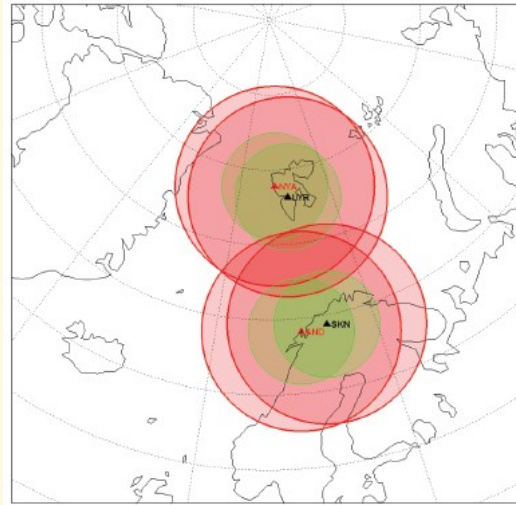
North Polar Region (Canada, Europe, Chinese Polar Stations)

Canada High Arctic Ionosphere Network (CHAIN)

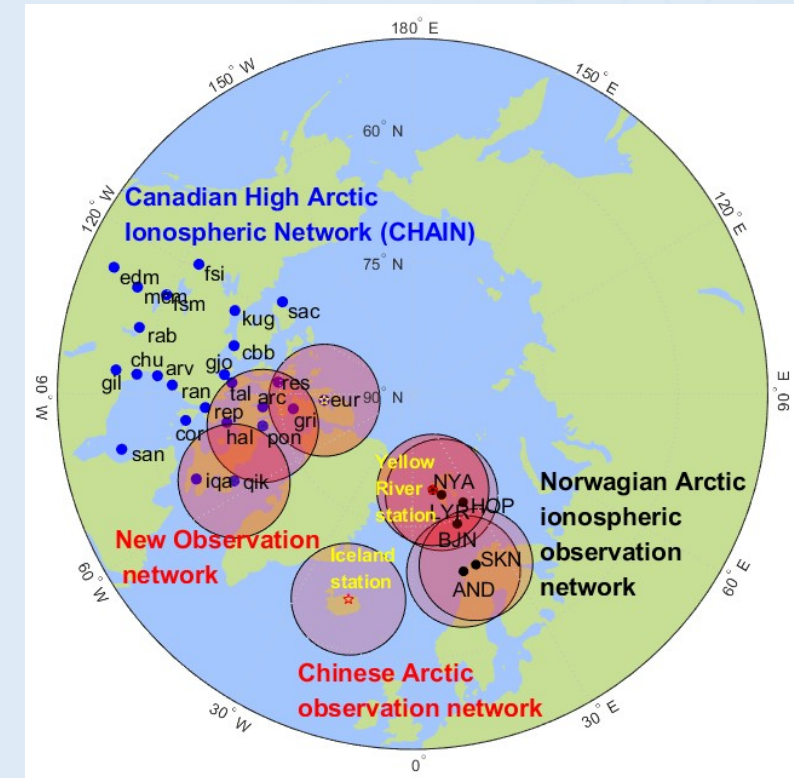


- 25 GNSS receivers
- 6 Digisondes
- ...

University of Oslo Network



- 4 GNSS receiver
- 4 All sky imagers
- ...

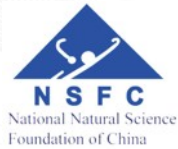
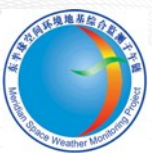


Add > 3 All sky imagers, >3 photometers

Partially filling the coverage gap, but not enough

Ionospheric observational network in East/Southeast Asia

International cooperation



Pakistan



Thailand



Laos

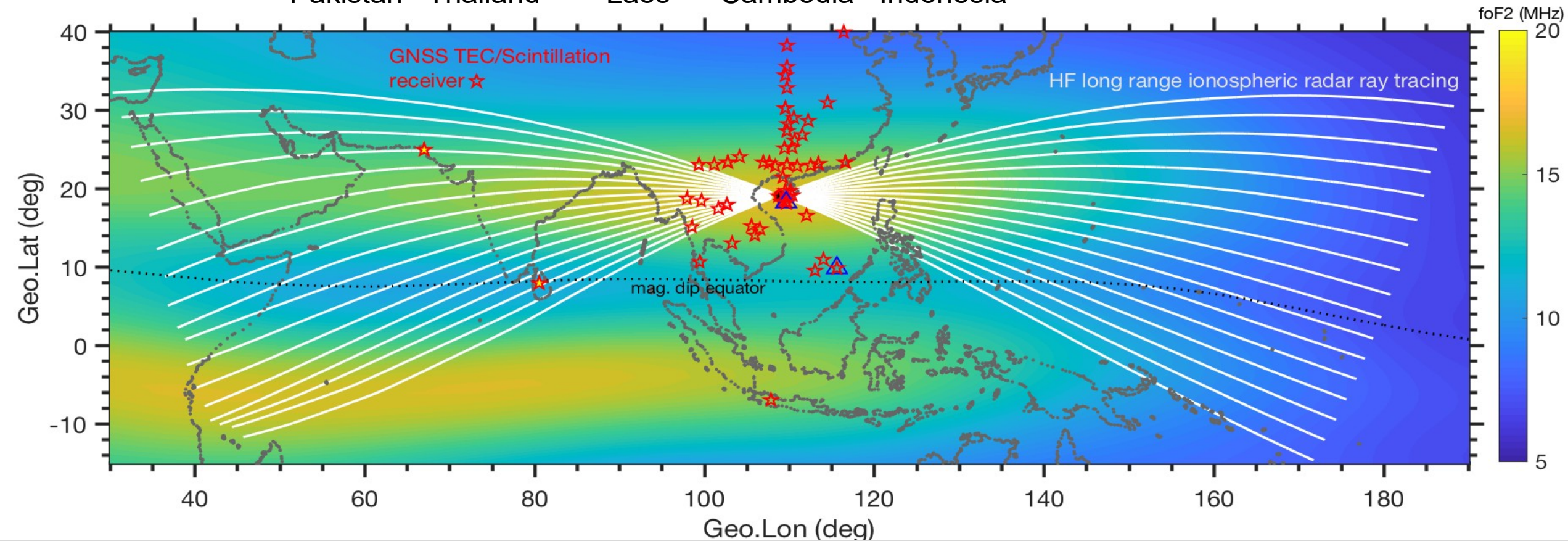


Cambodia



Indonesia

- GNSS TEC/scintillation receivers
- Ionosondes
- HF and VHF radars
- Airglow Imagers



Observing background ionosphere and plasma bubbles over a wide longitude from Indian ocean to west Pacific

IMCP 2023 → 2024



IMCP 2024 , August 6



Brazil



OUTLINE

01. The ASO-S (Kuaifu) Mission

**02. International Meridian Circle
Program**

**03. Regional Warning Center-China in
ISES**

Regional Warning Center – China in ISES



- **Establishment:** In 1992, RWC-China was established and joined in the ISES. The Space Environment Prediction Center (SEPC) in National Space Science Center (NSSC, CAS) was one of the subcenters in RWC-China. Another center is Solar Activity Prediction Center (SAPC) in National Astronomical Observatories (NAOC, CAS) .



Regional Warning Center – China in ISES



In 2023, SAPC moved to NSSC from NAOC, and merged with SEPC. According to the consortium of ISES, NSSC becomes the RWC-China.



Products and Services



General Public : forecasts, models

Contents : space weather parameters (SSN, F10.7, Ap, Dst, Kp, AE, GEO >2MeV Electron Flux)
space weather events (Solar Flare 、 SPE 、 Geomagnetic Storm 、 Relativistic Electron Flux Enhancement)

Issue : Website, Text message, email, App, Wechat, Weibo



Specific Users : Manned Space Mission, Lunar Exploration, Strategic Priority Program on Space Science


...

Contents : according to user needs,
space environment specification,
space environment effect evaluation...

Issue : according to user needs (fax, email, document)



Share Forecasts with ISES Members

**ISES**
International Space Environment Service


ISESMembersSpace Weather NowSpace Weather EffectsInfoDiscussions

Discussions >Latest ForecastsSpace Weather DiscussionsEnlil Discussions

Latest Forecasts[Print This Page](#)

AustraliaBelgiumBrazilCanadaChinaRepublic of KoreaJapanSouth AfricaUKUSA

RWC Locations



©ISES Regional Warning Centers
If you want to post your forecasting services on this portal, contact [Webmaster](#).

SEPC (China)


SPACE ENVIRONMENT FORECASTDate:2023 / 12 / 26

TUE , Dec 26 , 2023	WED , Dec 27 , 2023	THU , Dec 28 , 2023

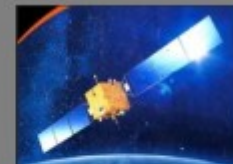
The Legend
 Quiet Orange Alert Relativistic Electron Enhancement Geomagnetic Storm
 Yellow Alert Red Alert Solar Proton Event Solar X-ray Flare

F10.7 Index			Ap Index		
The 10.7-cm solar radio flux forecast for the next 24/48/72 hours.			Geomagnetic Ap index forecast for the next 24/48/72 hours.		
24HR	48HR	72HR	24HR	48HR	72HR
165	165	160	6	8	10

Solar X-ray Flare				Geomagnetic Storm			
Probabilities for M and X class solar flares for the next 24/48/72 hours.				Probabilities for minor and major disturbances in Geomagnetic field for the next 24/48/72 hours.			
CLASS	24HR	48HR	72HR	CLASS	24HR	48HR	72HR


2023/12/202023/12/212023/12/222023/12/232023/12/242023/12/252023/12/26

Space Weather Services for China Space Missions



● 1999

● 2001

● 2002

● 2003

● 2005

● 2007

● 2008

● 2010

- Nov.20 神舟一号
- Jan.10 神舟二号
- Mar.25 神舟三号
- Oct.15 神舟五号
- Oct.12 神舟六号
- Oct.24 嫦娥一号
- Sep.25 神舟七号
- Dec.30 神舟四号
- 第一艘载人飞船
- 多人多天
- 第一颗绕月卫星
- 首次出舱

● 2016

● 2013

● 2012

● 2011



Sep.15 天宫二号
Sep.17 神舟十一号

- Dec.2 嫦娥三号
- Jun.11 神舟十号
- 首次落月探测
- 对接、授课

- Jun.16 神舟九号
- 人工对接试验

- Sep.29 天宫一号
- Nov.1 神舟八号



● 2017

● 2018

● 2020

● 2021

● 2022-2023



- Apr.20 天舟一号
- 第一艘货运飞船

- Dec.8 嫦娥四号
- 月球表面软着陆



- Jul.23 天问一号
- 首次火星探测



- NoV.24 嫦娥五号
- 月面采样返回任务



- Apr.29 "天宫" 天和核心舱



- Space Station

Summary

- Space weather monitoring, forecasting, and services has made significant development in China.
- We welcome usage of China mission data for space weather study.
- We welcome collaborations and contributions in the International Meridian Circle Program (IMCP).
- We will contribute to global space weather collaborations through space- or ground-based missions, and continue to exchange data and forecast in ISES and other international organizations.