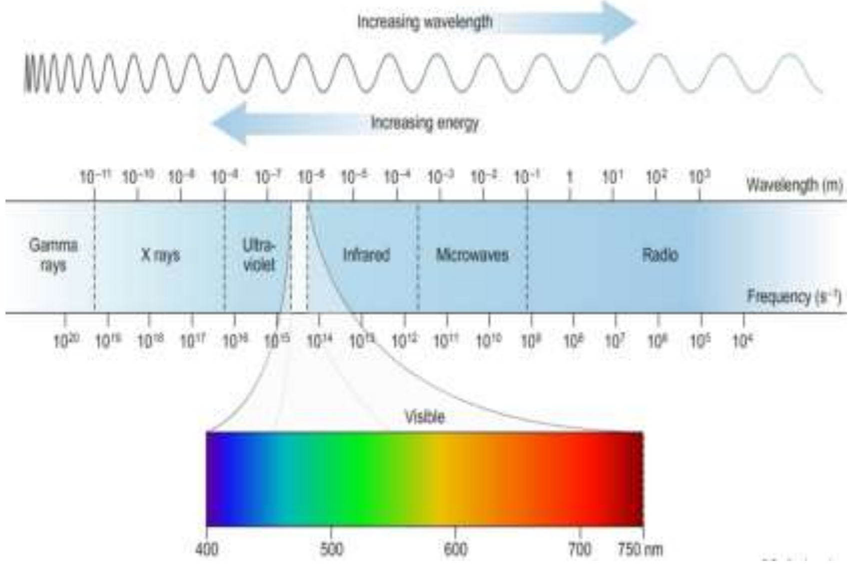
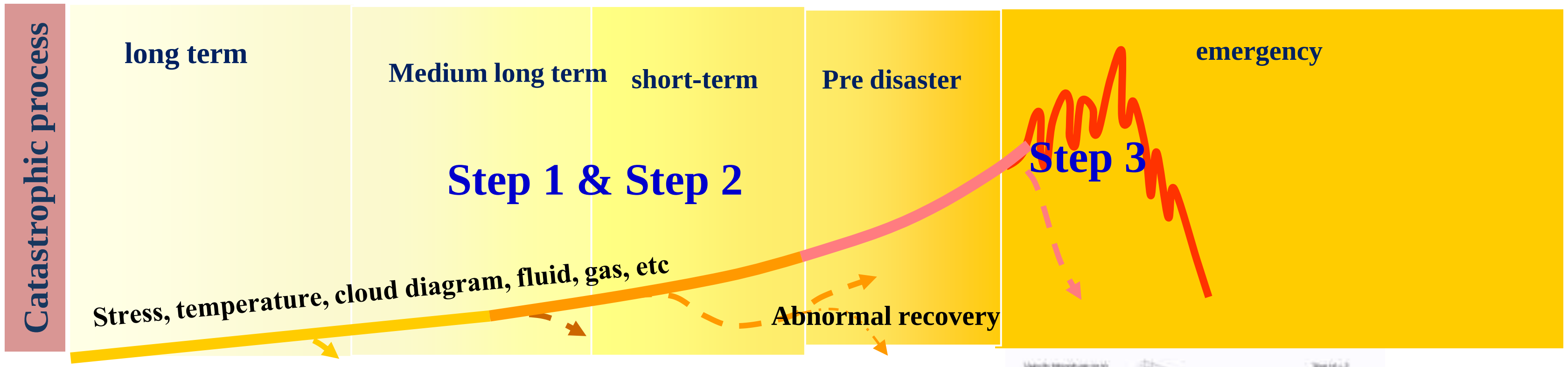
The current status of the CSES mission and the main scientific results

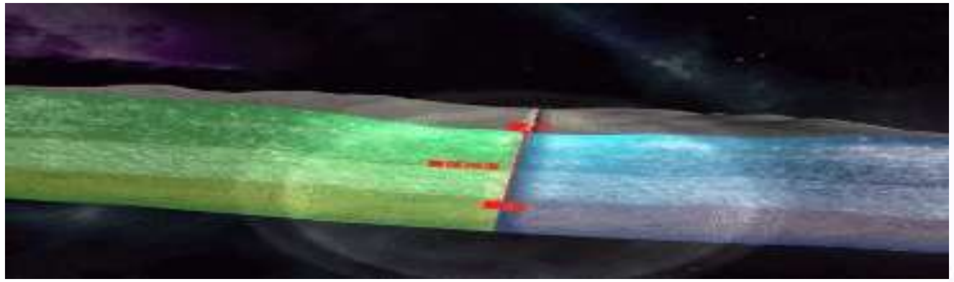
Zeren Zhima (Droma)
on behalf of the CSES team
National Institute of Natural Hazards, Ministry of Emergency Mangement (NINH), P.R.C

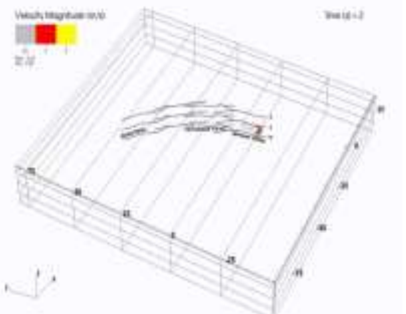
Space technology application in Natural Hazards prevention and reduction



Risk perception and troubleshooting | Monitoring, prediction | Emergency rescue







Disaster	R.S
Earthquake	Optical, IR/HP, SAR,EM
Landslide	Optical, SAR
Flood	Optical, SAR, IR/HP
Forest and grassland fire	Optical, IR/HP, EM
Urban disaster	Opticial, SAR, IR

GNSS: Global navigation satellite system
SAR: Synthetic Aperture Radar
IR: Infrared remote sensing
Hyperspectral: HP
EM: Electromagnetism remote sensing

Step 1: Precursor monitoring and early warning

IR, GNSS, EM, Hyperspectral

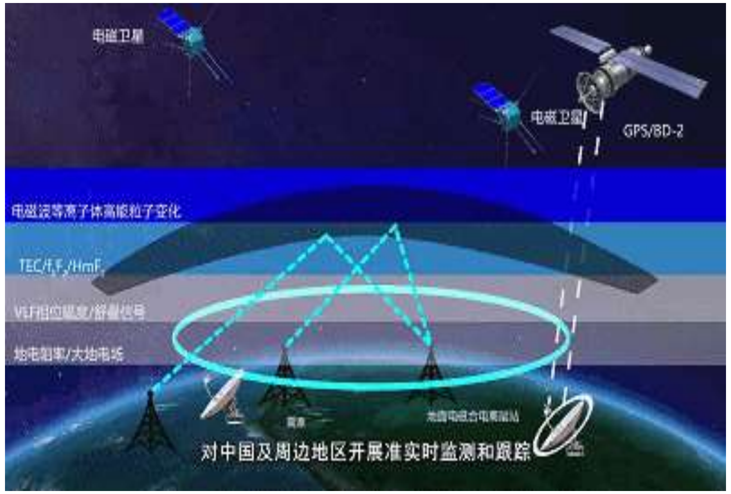
Step 2: Risk assessment

Optical, IR, GNSS, SAR

Step 3: Emergency response and disaster assessment

Optical, IR, SAR

China Seismo-Electromagnetic Satellite (CSES)



The CSES (China Seismo-Electromagnetic Satellite) mission, was launched into a sun-synchronous circular orbit on February 2, 2018, at an altitude of 507 km in the upper ionosphere.

Style of orbit	Sun synchronous orbit
Altitude (km)	507
Inclination (deg)	97.4º
Period (min)	94.6
Descending node	14:00pm
Revisiting period (day)	5

Key objectives of CSES mission

Observation objectives:

To detect the electromagnetic field and waves, plasma parameters and energetic particles in the ionosphere

To provide quasi-real time observations over China

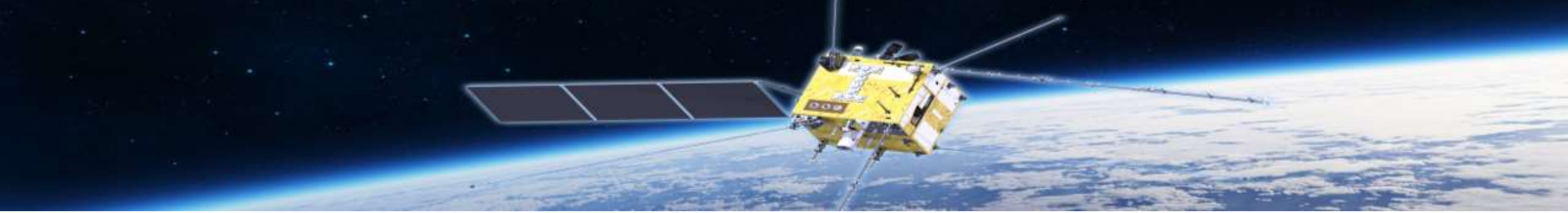
To monitor the space perturbations induced by major earthquakes.

Scientific objectives:

To study and extract the features of seismo-ionospheric perturbations, looking for the possibility of short-term earthquake forecasting;

To provide observational evidence for Lithosphere-Atmosphere-Ionosphere coupling theory interpretation;

To support Earth science study

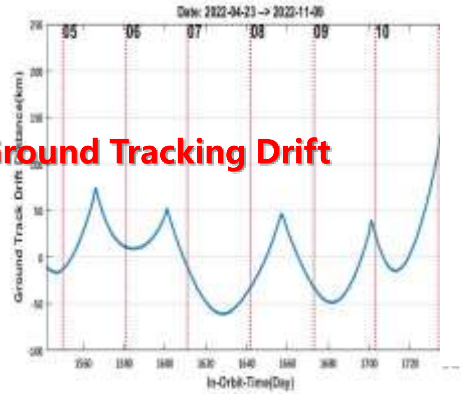


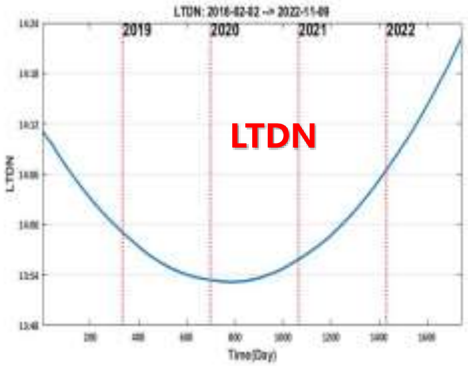
Main Content

1. The current status
2. Data outcomes
3. Scientific outcomes
4. Challenges & perspectives
5. Follow-up Plans
6. Swarm/CSES cooperation

The current status of the satellite platform

1)The sub-systems onboard platform are working stable and in good condition

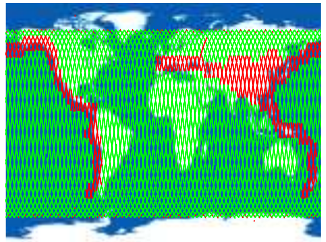


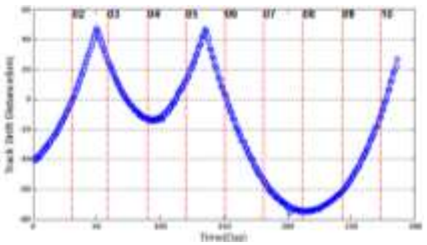


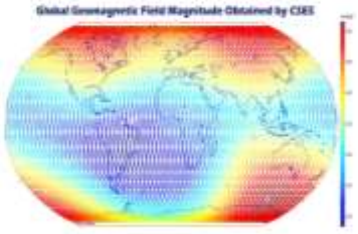
Index	Specifications	Requirements	In-orbit status	Conformance
1	LTDN	14:00±15min	14:22	Yes
2	Ground Tracking Drift	±60km	105km	Yes
3	Fuel Remaining	0-42kg	36.54kg	Yes

Evaluated on Dec. 2022:
Conclusion: The platform is stable

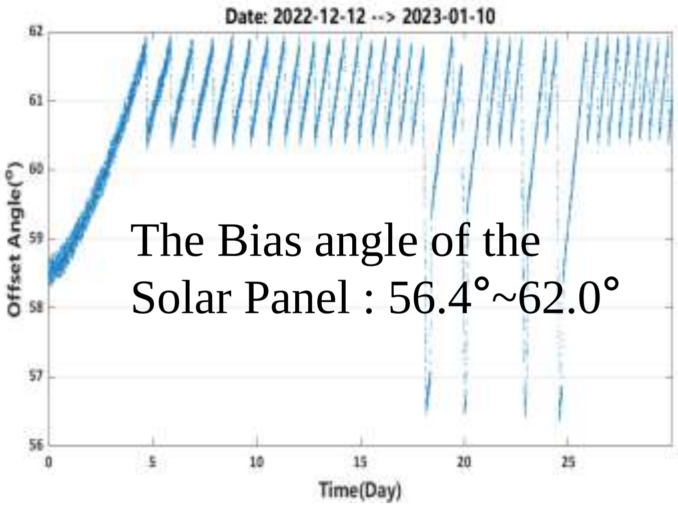
2)Working Modes still Operate perfectly

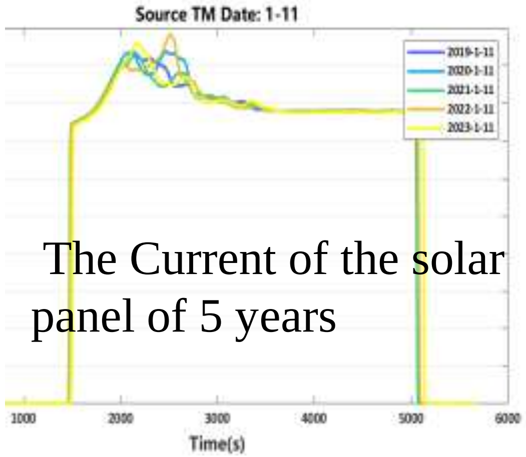




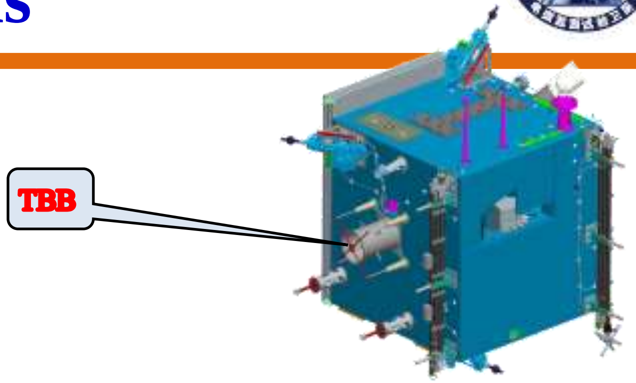


3) The satellite power supply working in good condition

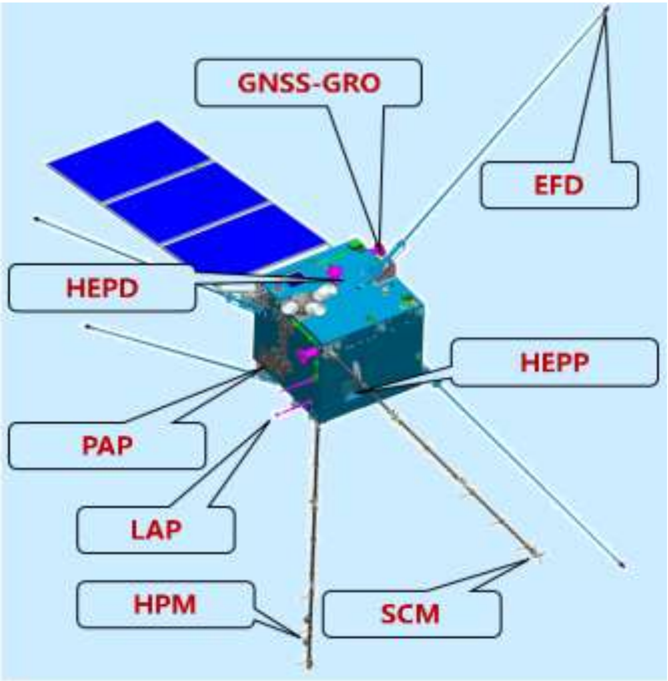




The current status of scientific payloads



Payloads	Detections	First-six months in-orbit test (2018.11)	Five -years in-orbit evaluation (2022.12)
High Precision Magnetometer (HPM)	The geomagnetic field	Good health condition	Stable and reliable
Search-Coil Magnetometer (SCM)	The variant magnetic field	Good health condition	Stable and reliable
Electric field detector (EFD)	The space electric field	Good /HF noise+	Stable and reliable
Plasma analyzer package（PAP）	The in-situ ions	Contaminated	Stable
Langmuir probe (LAP)	The in-situ electrons	Good health condition	Stable and reliable
GNSS Occultation Receiver (GOR)	TEC/Ne Profile Airrefraction/temperature/pressure Ionospheric scintillation index	Good health condition	Stable and reliable
Tri-Band Beacon (TBB) 50/400/1066MHz		400 MHz malfunction	Stable
Energetic particle detector (HEPP-H, L, X ray）	Proton flux：1.5MeV～200MeV Electron flux： ≥100keV	Good health condition	Good health condition
Italian Energetic particle detector (HEPD)	Proton flux: 30- 100 MeV Electron : 30 – 200 Mev	Good health condition	**Down time since 2022.7**



Conclusion:

The scientific payloads are stable, the data quality of the majority of payloads is reliable, and CSES 01 can operate stably for more years in future.

The status of the Scientific Application Center

NINH, MEM, P.R.C.

Satellite and payloads

- Operation tasks plan (1/week)
- Platform status check (1/day)
- Payloads status check (1/day)
- Satellite ground comparative experiments

Ground systems

- Hardware/software running
- Data access tracking
- Data transmission checking
- Italian data transmission

Data procesing

- Data products generation
- Data quality assessment
- Auxiliary data management
- Data products management

Data Sharing

- Data pushing to CNEC, CEA
- Data pushing to ASI, Italy
- Data sharing website
- Data sharing to GEO, APSCO
- Data sharing to Individuals

Data outcomes #1: Standard Data Productions

The observations from CSES:

The geomagnetic field： FGM+CDSM

DC to 15 Hz: the vector and scalar values

The magnetic field/wave： SCM

ULF: ~ Hz - 200 Hz, sampling rate 1024 Hz

ELF: 200 Hz - 2200 Hz, sampling rate 10.24 kHz

VLF: 1.8 kHz- 20 kHz, sampling rate 50 kHz

The electric field/wave： EFD

ULF: DC – 16 Hz, sampling rate 128 Hz,

ELF: ~ Hz – 2.2 kHz, sampling rate 5 kHz

VLF: 1.8 kHz – 20 kHz, sampling rate 51.2 kHz

HF: 18 kHz – 3.5 MHz, sampling rate 10 MHz

The in-situ plasma: PAP+LAP

Ion/Electron density, temperature

Ion contents (H+, O+, He+)

Ion drift velocity (Vx, Vy, Vz)

Plasma/satellite floating potential

The ionospheric structure: GRO+TBB

TEC, relative TEC, HmF2, NmF2

Ne Profile, Profile of air temperature and pressure

Ionospheric scintillation index and tomography

The energetic particles: HEPP+HEPD

Energetic Electron:

0.1 - 3 MeV, 1.5 - 50 MeV， 30 - 200 MeV

Energetic Proton: 2 - 20 MeV， 30- 100 MeV

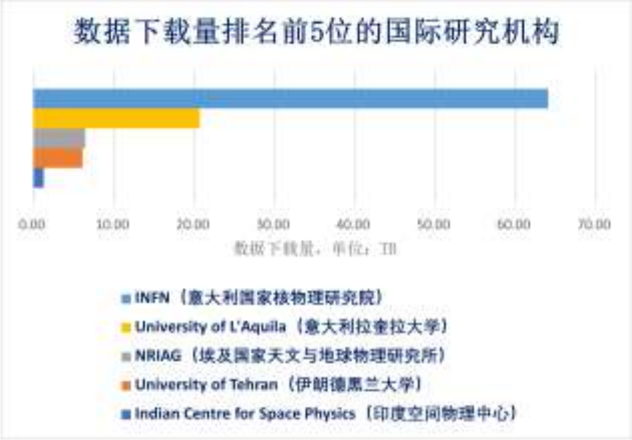
Solar X ray: 0.9 - 35 keV

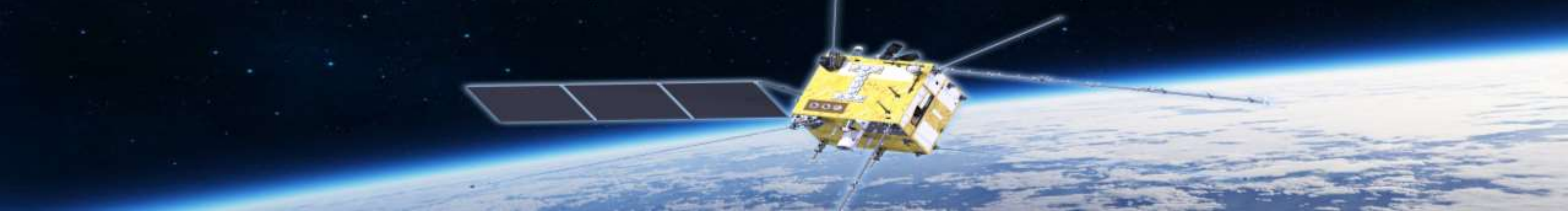
Standard data products from CSES:

- **Level 0:** Raw data
- **Level 1:** Preliminary physical quantity
- **Level 2/2A:**
  Calibrated data with satellite orbit information and coordination information;
- **Level 3**: Time sequential data after resampling
- **Level 4**: Global or regional interpolation map

Data sharing service (https: //www.leos.ac.cn)

- Over 600+ users registered, including 70+ universities/institutions from 19+countries;
- Over 2,000 sharing services both domestically and internationally
- The shared data volume has reached over 1.3 PB+.
- Or contact:zerenzhima@ninhm.ac.cn (when needed)





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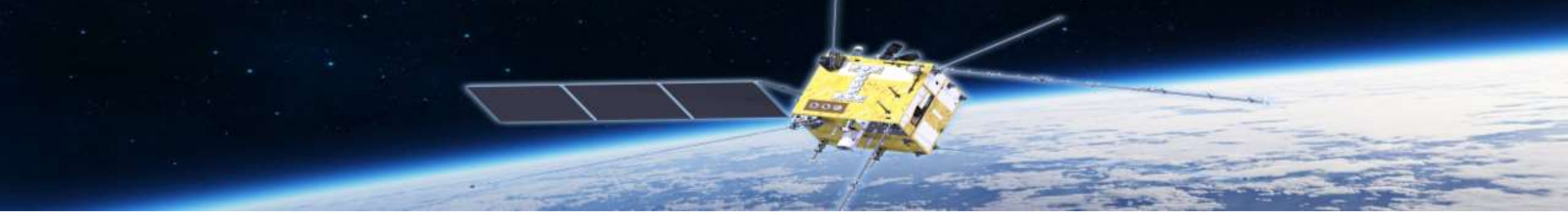

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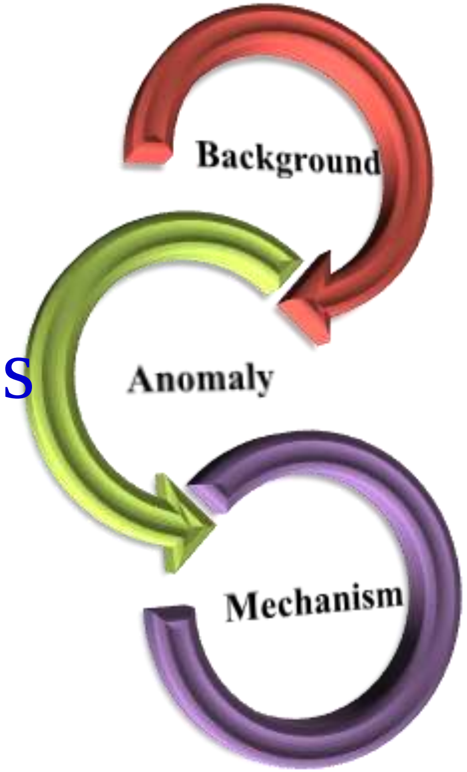


1) Space environment

2) Geophysical field models

3) Natural hazards disturbance
(e.g., earthquake, space weather, volcano… etc.)

4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Background #1: Space Environment (1)

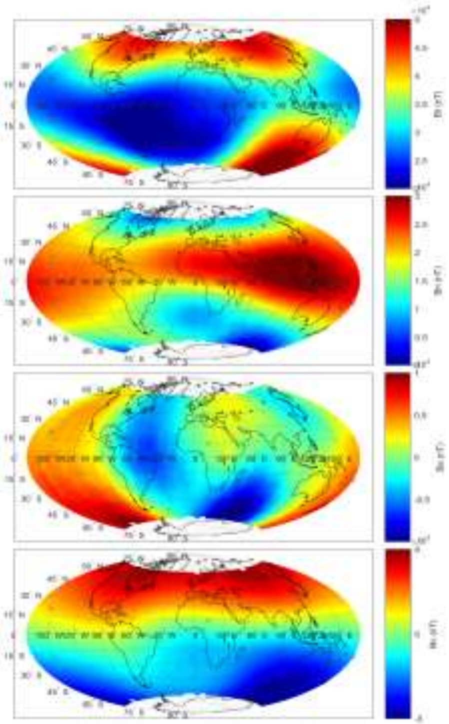
1) The geomagnetic field

F

B_N

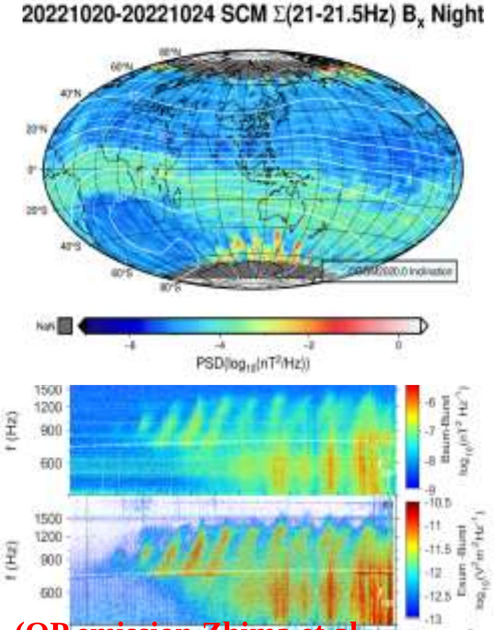
B_E

B_c

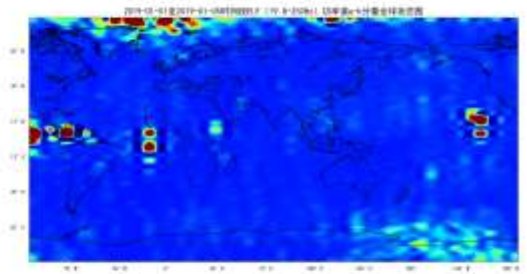


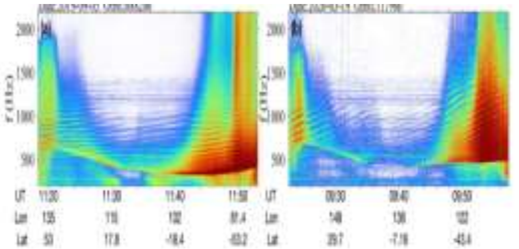
(Yang et al., 2021, JGR)

2) The EM field/waves in ULF/ELF/VLF/HF band

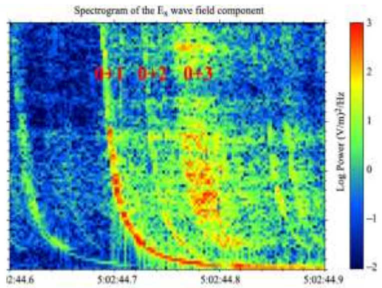


(QP emission Zhima et al., 2020, JGR,地球物理学报)

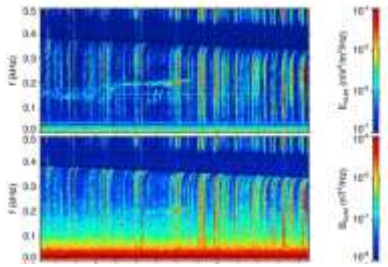




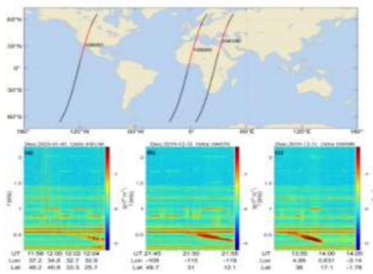
(MLR waves, Hu et al., 2022, JGR)



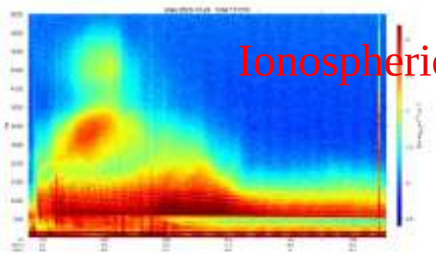
Lightning Whistler (袁静等， 2020a,b）



Ion cyclotron waves Hu et al., submission)

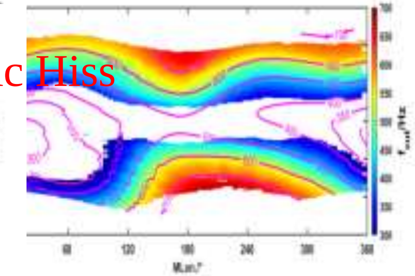


Zhao et al,, 2022, JGR)

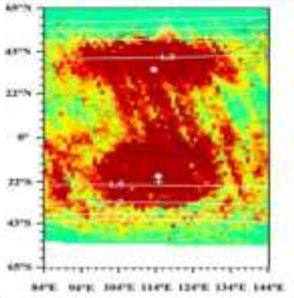


Ionospheric Hiss

,Lv et al,, 2023,Frontiers



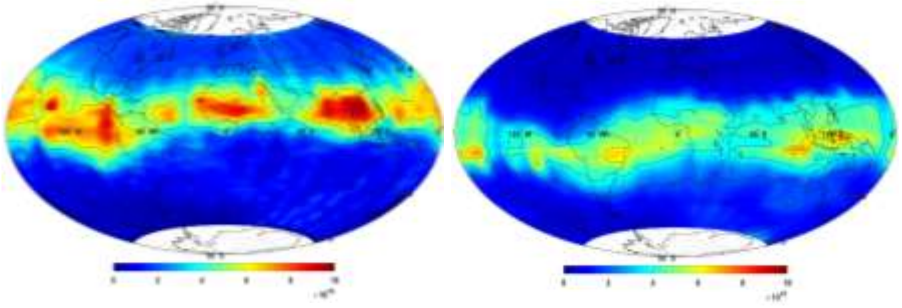
Wang et al,, 2023, JGR)



VLF transimitter Zhao et al., 2020, JGR

Background #1: Space Environment

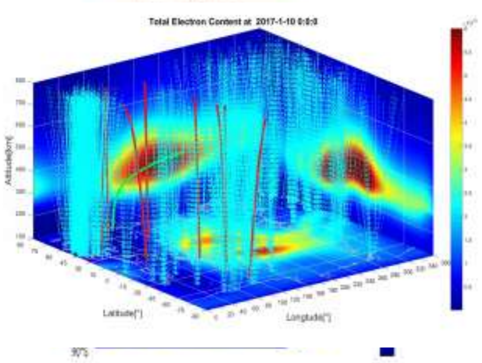
3) The ionosphere plasma environment



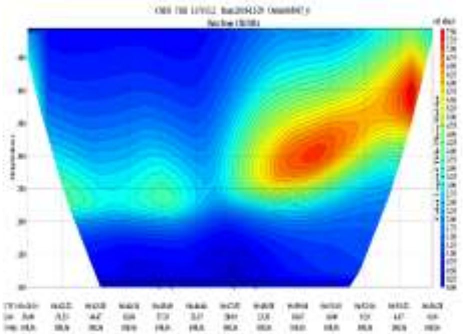
(a)July 12 - 19, 2018 (b)Nov. 18 -27, 2018

Yan et al. JGR， 2021

TEC



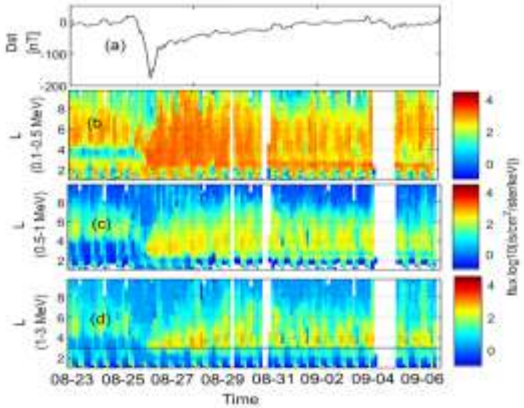
Ne-TBB



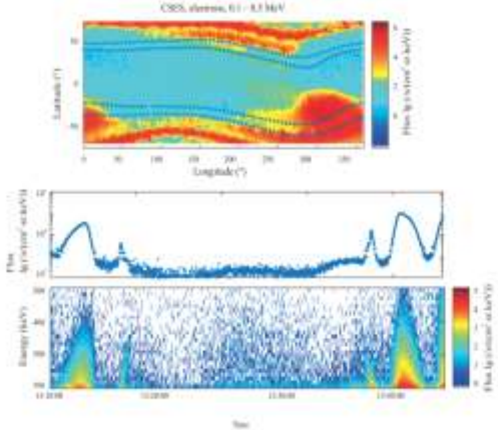
Xu et al. RS， 2023, submission

4)The energetic particle and wave-particle interaction

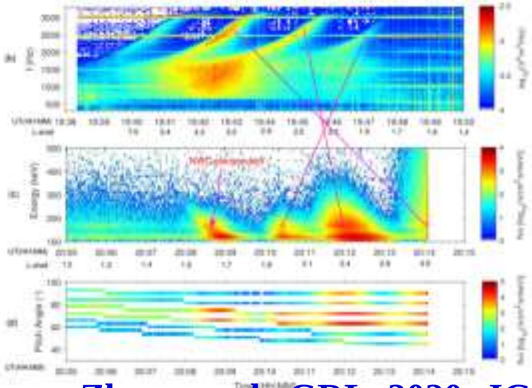
Whistler waves accelerate relativistic electrons



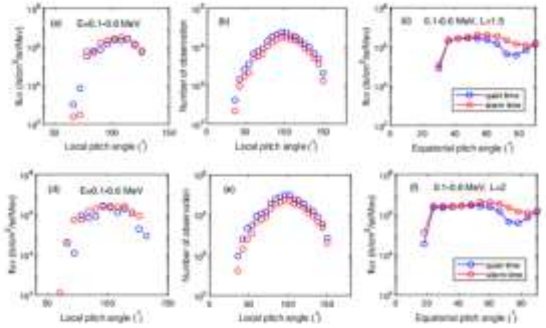
Ground-based man-made NWC electron precipitation belt



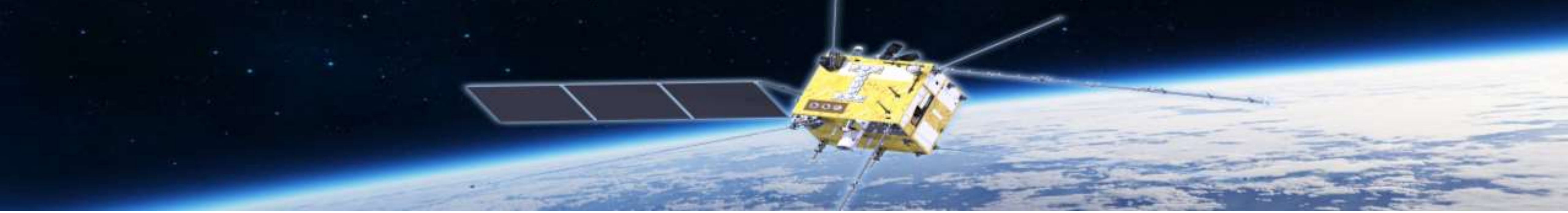
QP waves and induced electron precipitation



Magnetosonic wave accelerate electrons in inner belt

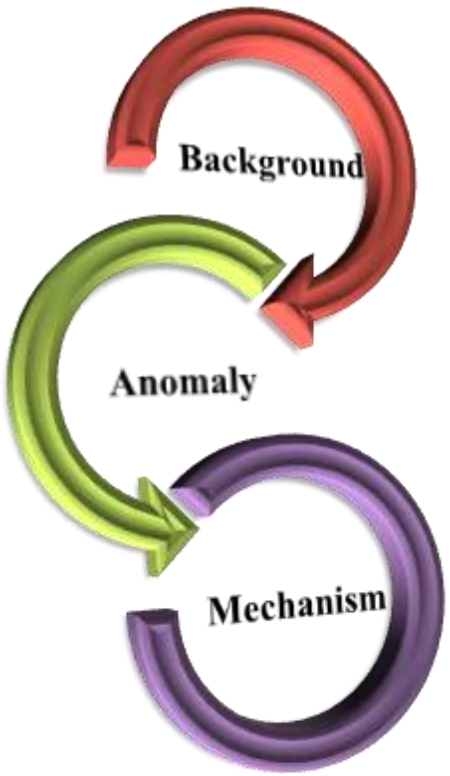


Zhang et al., GRL, 2020; JGR, 2021; Chu. et al., 2020; Zhao et al., JGR2019;



Main Content

Scientific outcomes



1) Space environment

2) Geophysical field models

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(e.g., earthquake, space weather, volcano… etc.)

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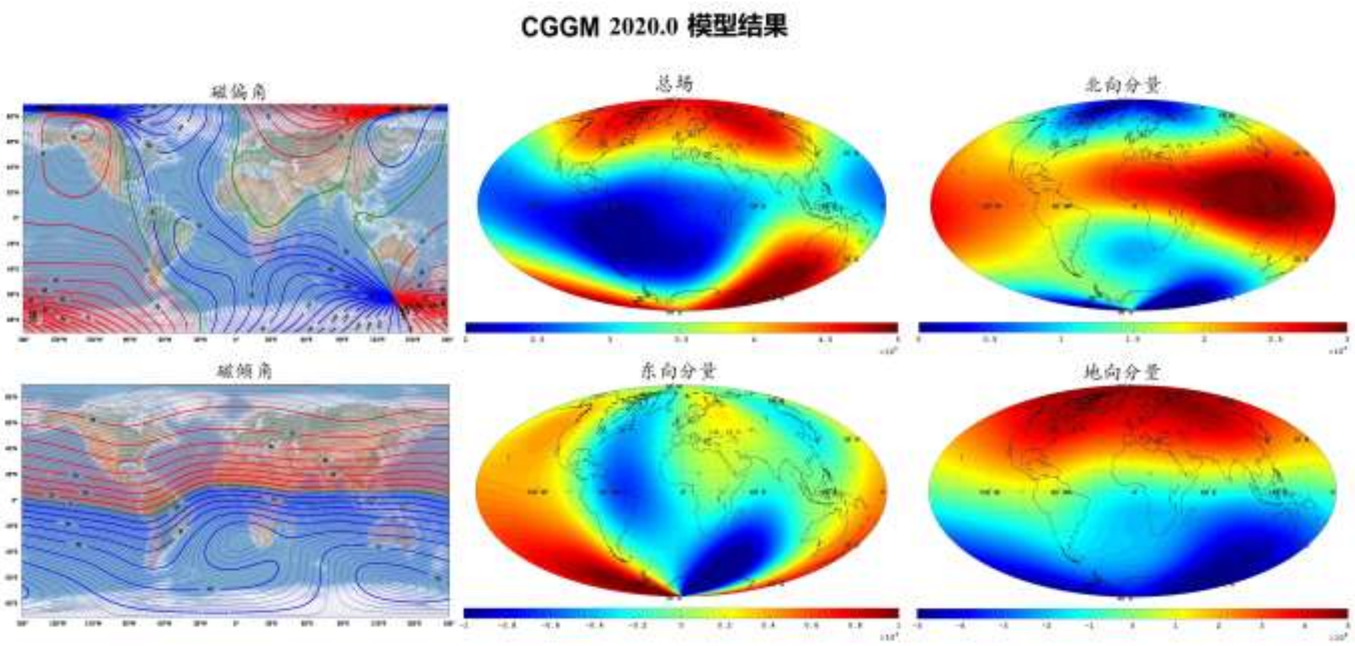
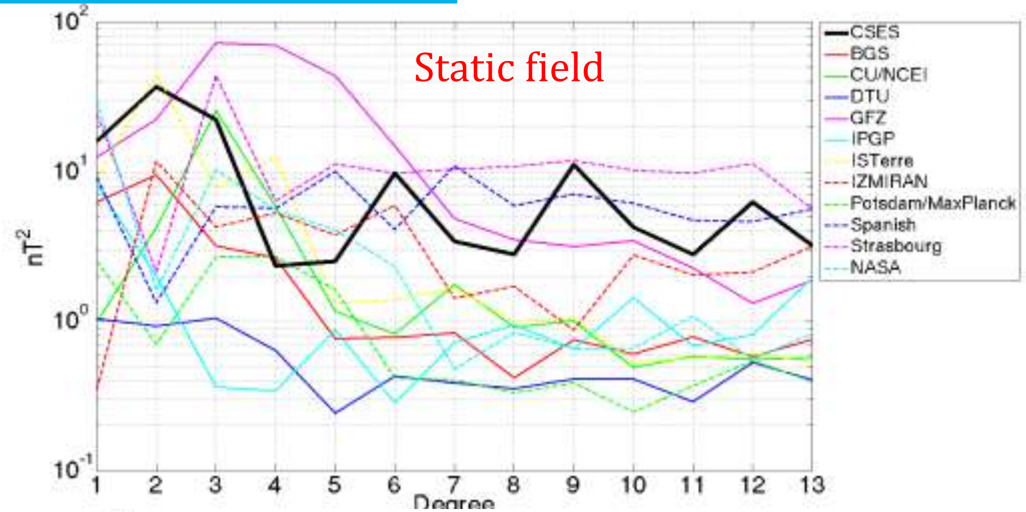
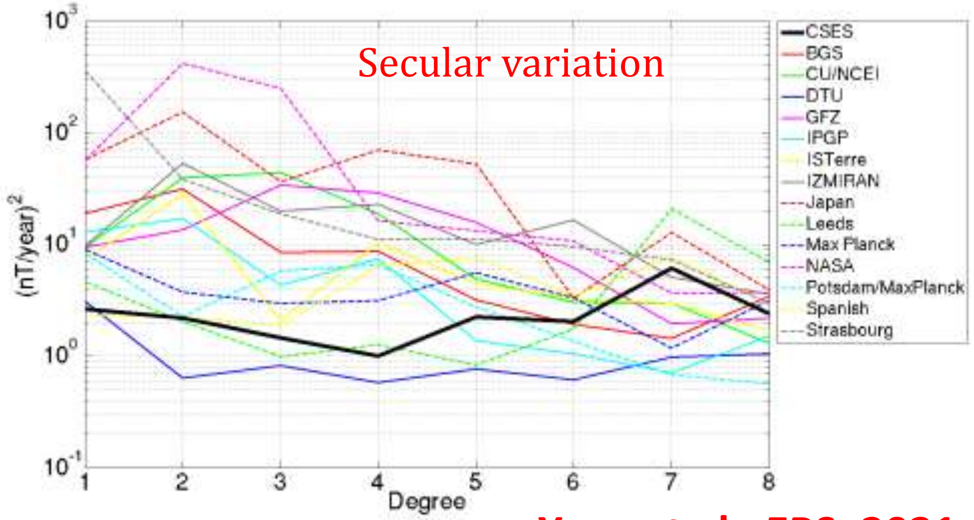
Background #2: geophysical field models-geomagnetic field

1) CSES Global Geomagnetic Field Model (CGGM)







- CGGM model is used to produce IGRF-13 products
- CGGM model is the first ever produced by a Chinese-led team
- CGGM model is the only model who didn’t use Swarm datasets

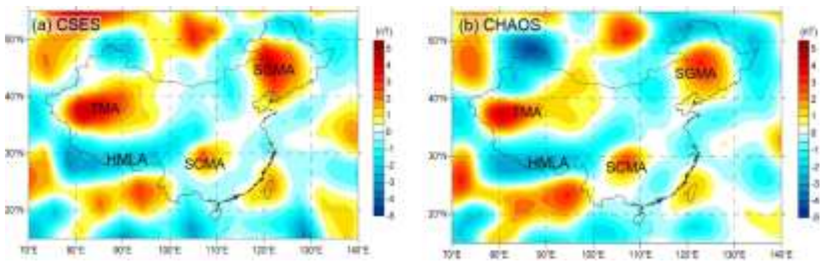
The comparisons of CGGM with the final IGRF-13 and other candidate models revealed a remarkable agreement

Yang et al., EPS, 2021

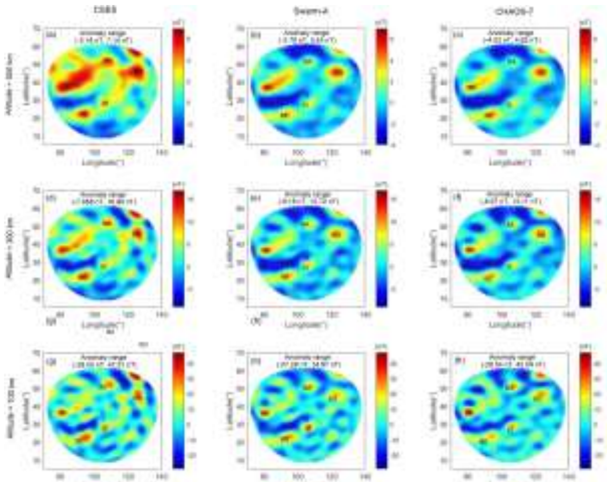
Background #2: geophysical field-lithospheric magnetic field

2) The lithospheric magnetic field models

a) Regional model -China

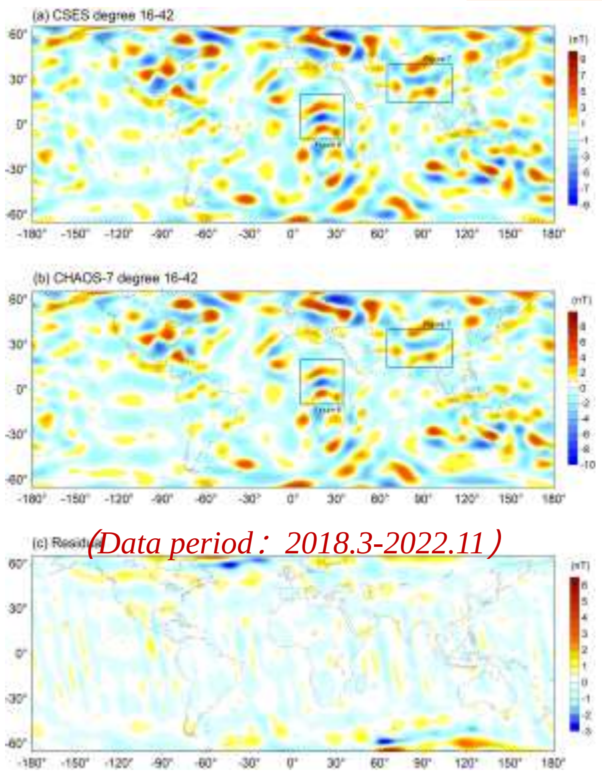


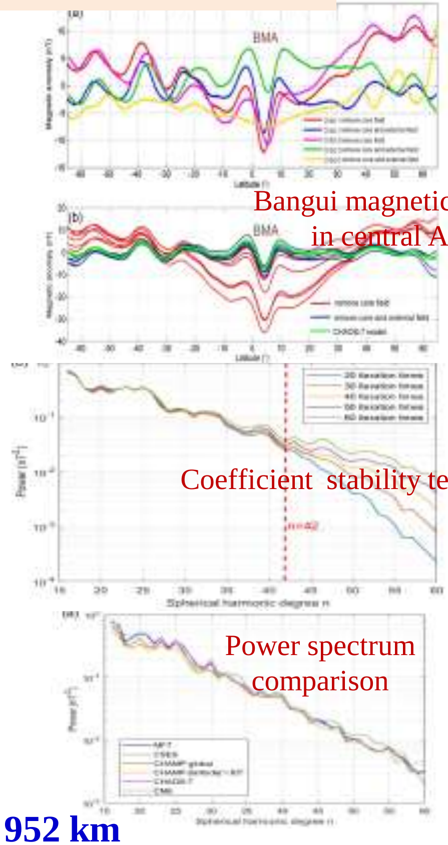
First CSES magnetic anomaly map in China (Wang et al., 2020)



Spherical cap harmonic model (Wang et al., 2023a)
maximum degree 53.17， wavelength 752 km

b） Global model



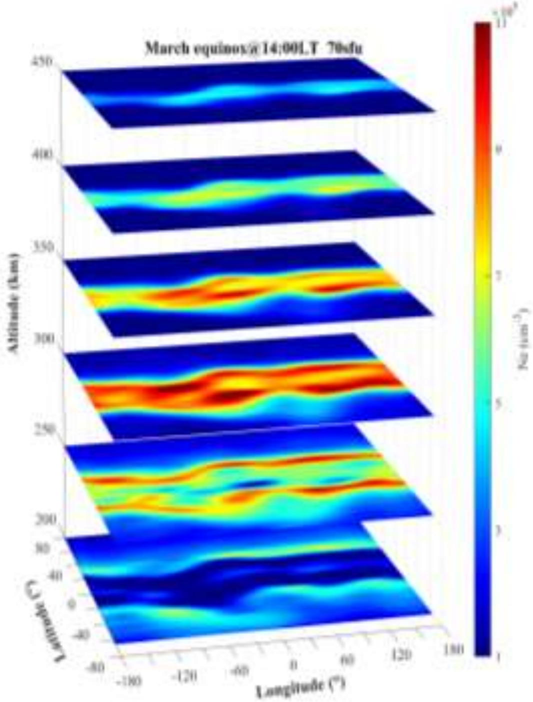


maximum degree 42, wavelength 952 km
Good agreement with other models up to degree 42 (Wang et al., 2023b)

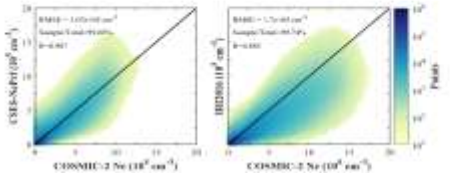
Background #2: geophysical field models-electron density

3) The electron density models

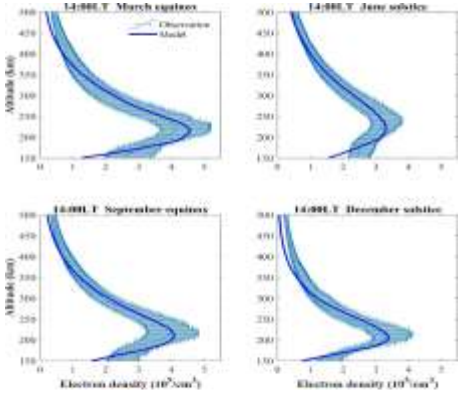
a) CSES data



3D electron density structure



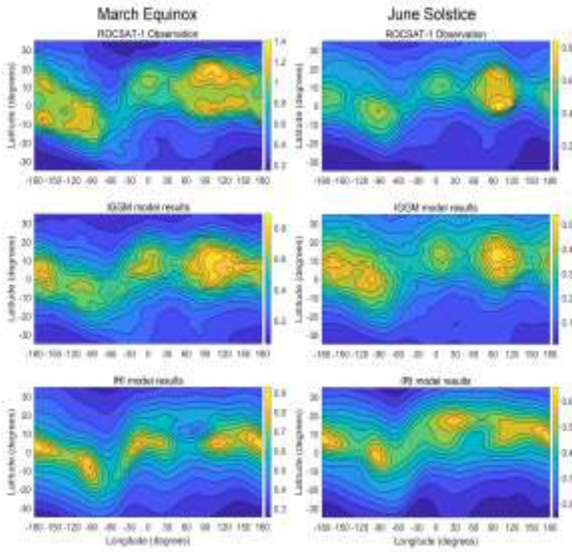
Better performance than IRI



The comparison between model reconstructed and observation of EDP around Beijing in four seasons

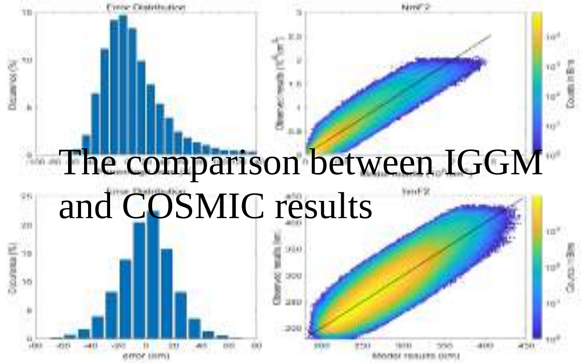
Huang et al., Space Weather, 2022

b) Multi-satellite data

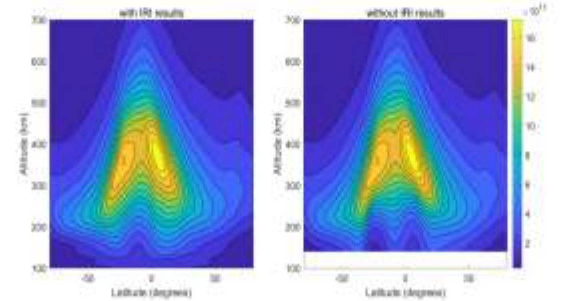


The comparison between IGGM (middle)/IRI (bottom) and ROCSAT-1 (top) observations

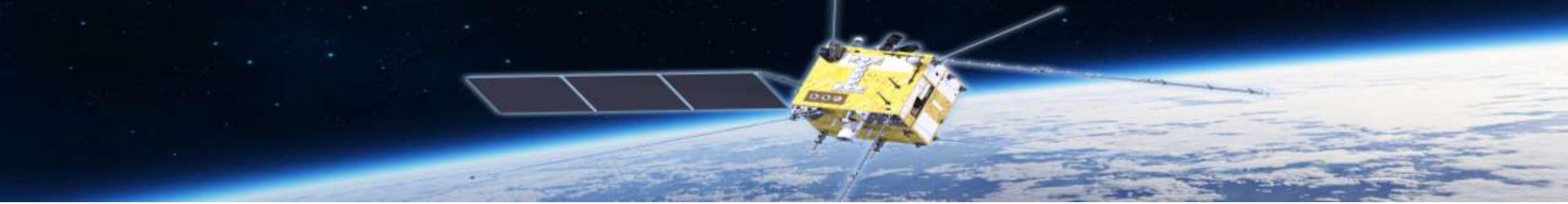
Results from IGGCAS



The comparison between IGGM and COSMIC results

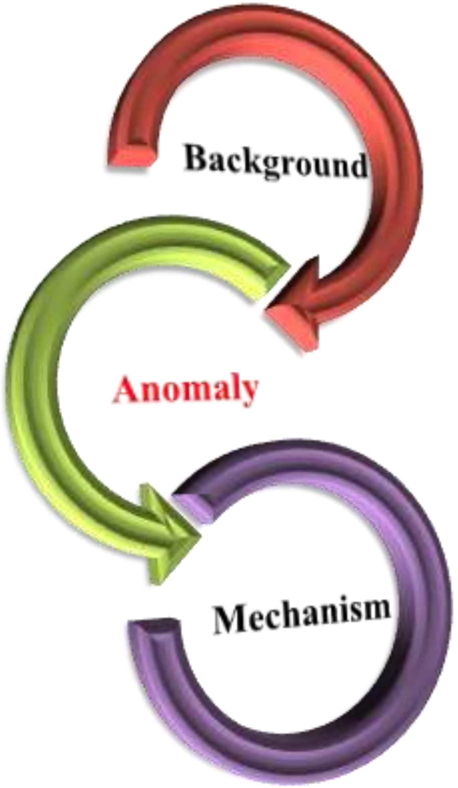


IGGM with IRI correction performs better than the one without IRI correction



Main Content

Scientific outcomes



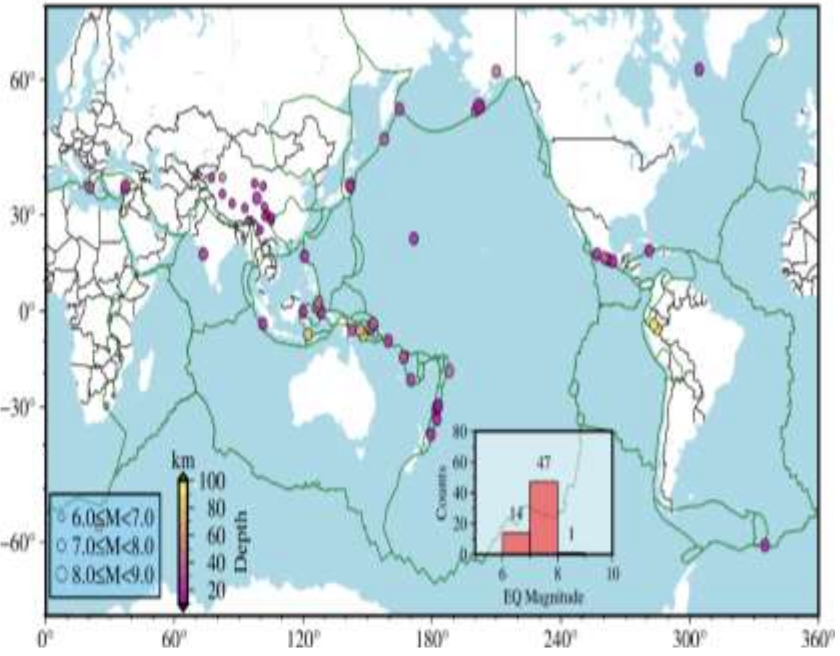
1) Space environment

2) Geophysical field models

3) Natural hazards disturbance
   a. Earthquake,
   b. Space weather
   c. Volcano… etc.

4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Anomaly #a: Earthquake-routine tracking monitoring



Febr. 2, 2018 to Freb. 2, 2023:

Global: 74 EQs (M 7+)

China: 16 EQs (M 6+)

Routine Processing:

Step 1: EQ influential area computation

Experimental equation of Dobrovolsky et. al, 1979

Step 2: Space weather condition check

Dst ≤ -30 nT or Kp ≥ 3

Step 3: Data cleaning

Health condition data of the platform and payloads

Step 4: Single-orbit analysis

Level 3 data : standard products from CSES scientific center

Step 5: Multi-orbits analysis

The sequence built by revisiting orbits

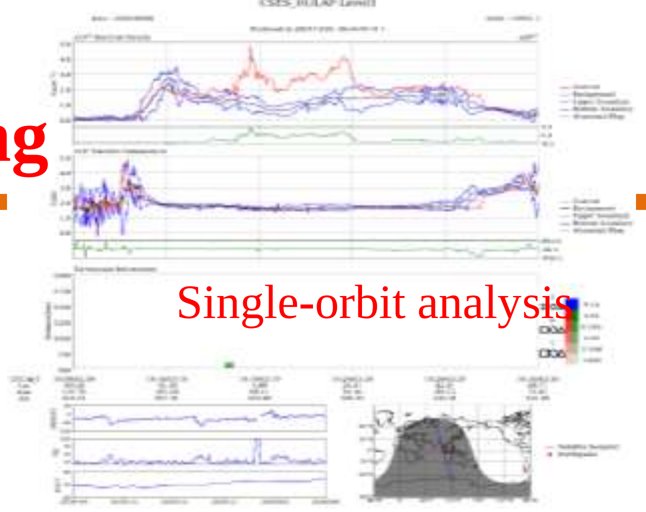
Step 6: Background map

Step 7: Multi-parameter comparisons

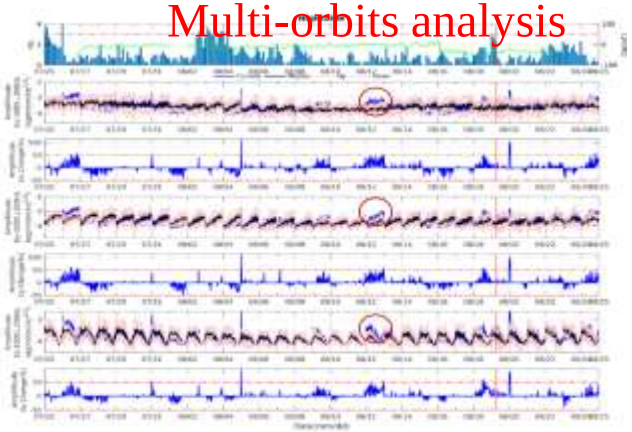
RS: Infrared/hyperspectral satellites

Ground: GNSS TEC, EM waves, electric field

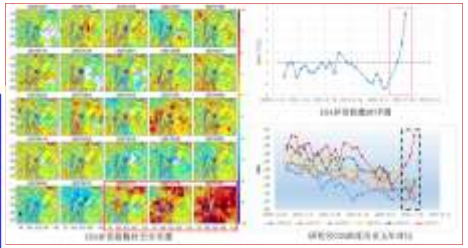
Single-orbit analysis



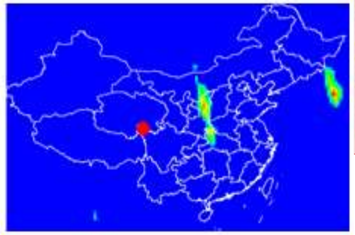
Multi-orbits analysis



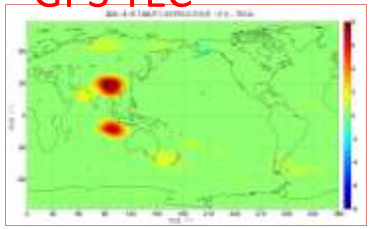
Hyperspectral



Infrared



GPS TEC

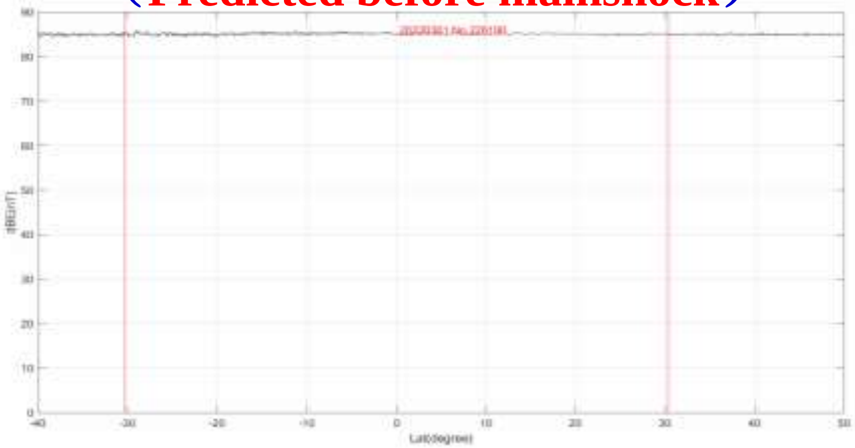


[Zhima et al., 2022]

Anomaly #a : Earthquake-case study examples

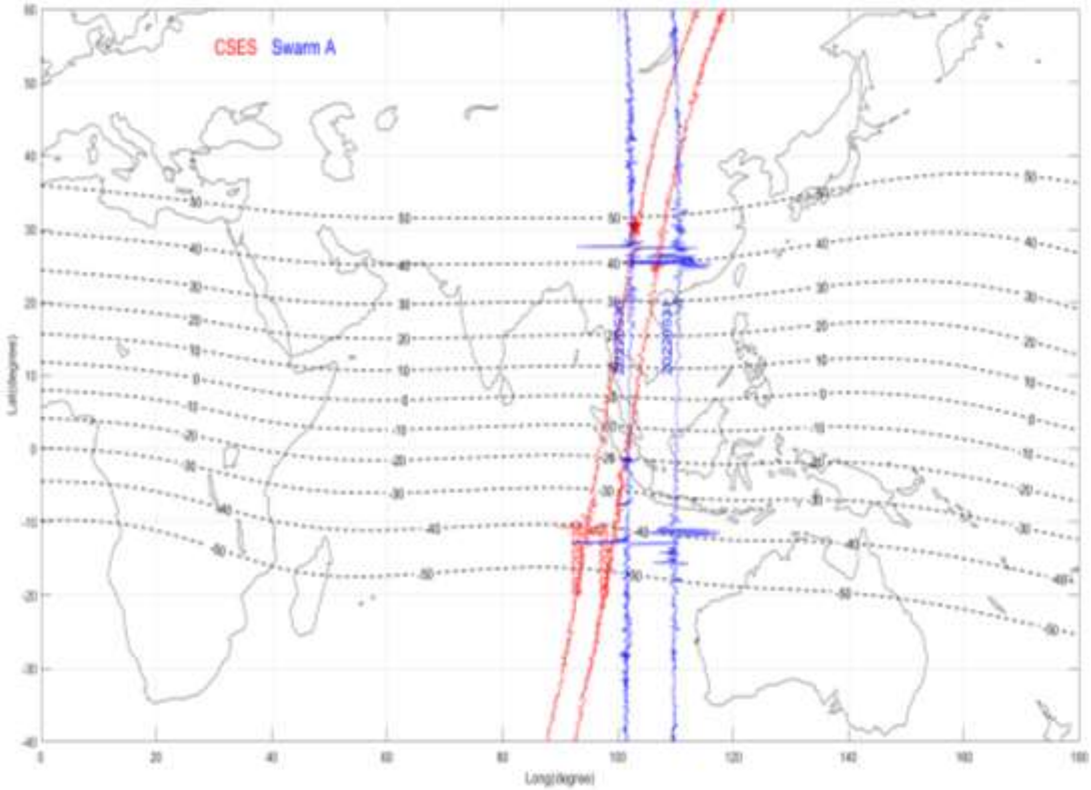
Ms 6.1 Lushan EQ on June 1, 2022 in China

（Predicted before mainshock）

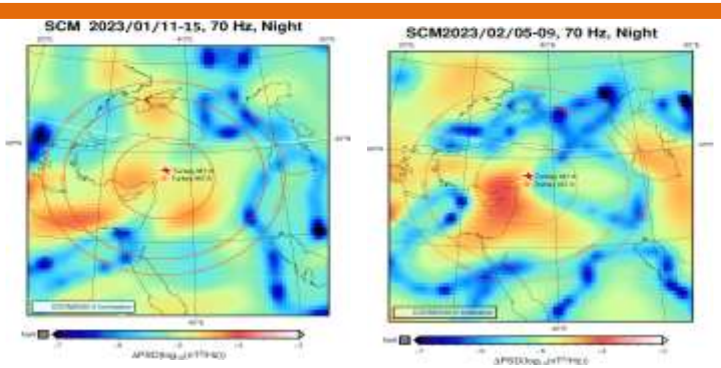


ULF pulsations two days before EQ [from Yanyan Yang]

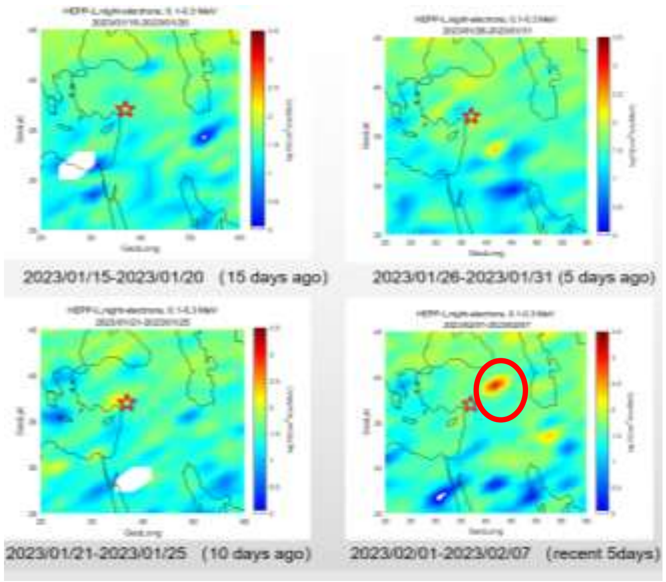
CSES and Swarm recorded the same signals on May 30, and 31, 2022



Anomaly #a : Earthquake-case study examples

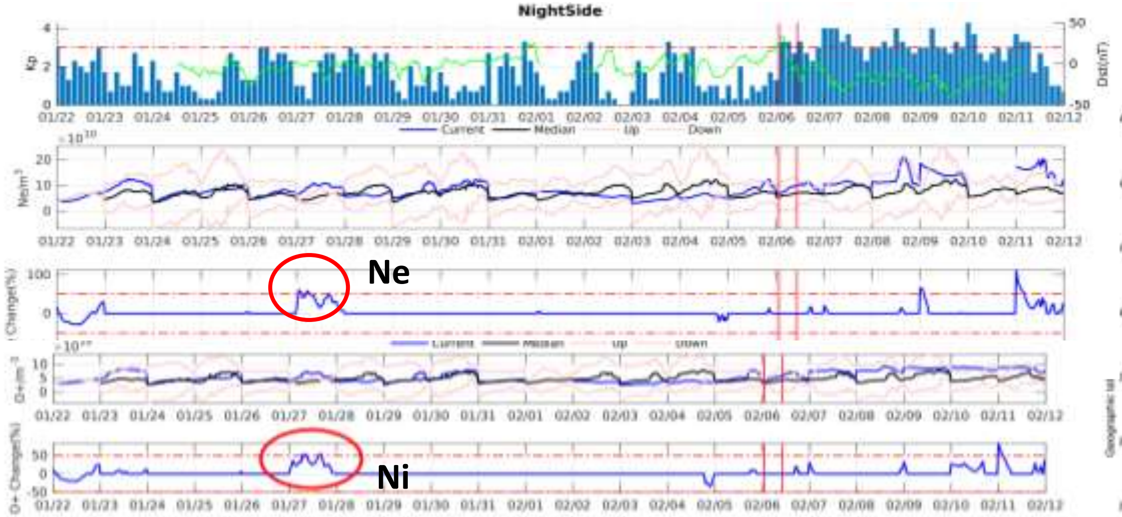


The magnetic field in ULF band 11 -15 days before EQ [from Qiao Wang]

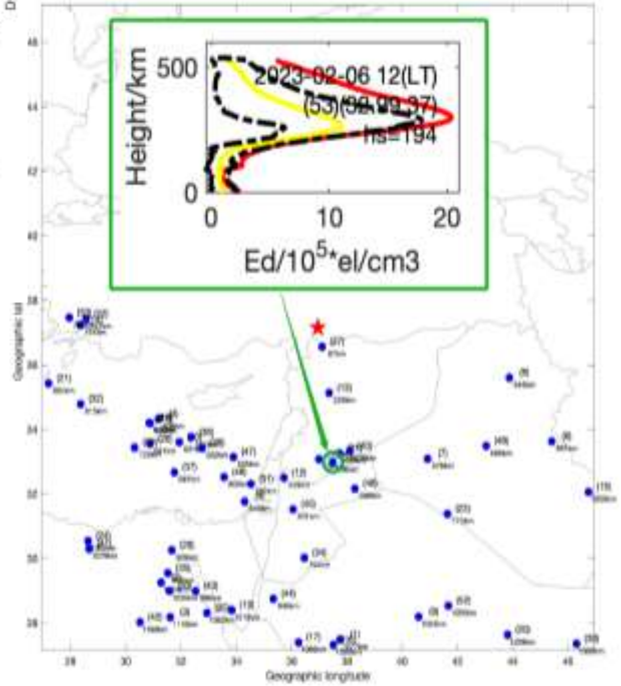


The particle flux enhancement 1 to 5 days before EQ [from Zhenxia Zhang]

Ms 7.6 Turkey-Syria two earthquakes on Febr. 6, 2023
（extracted after shock）



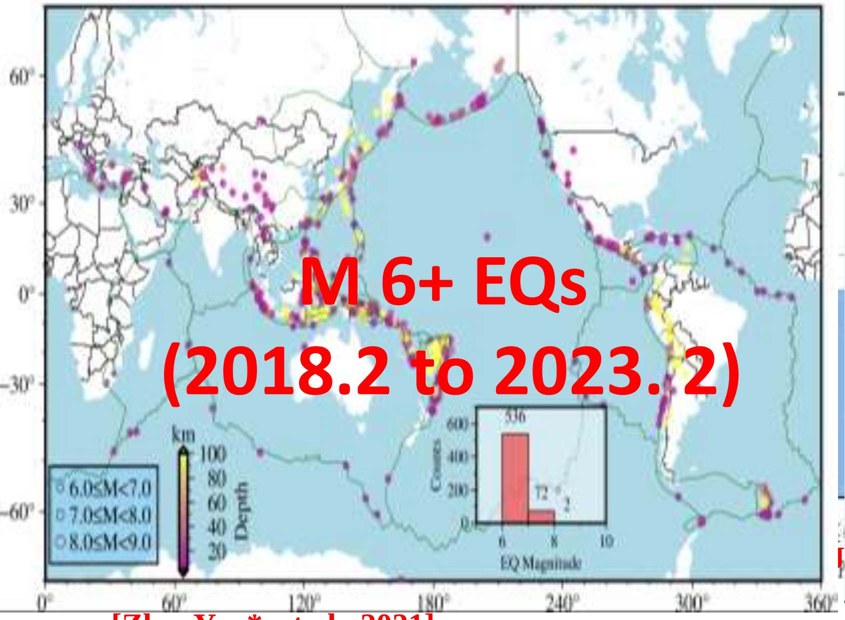
Electron/Ion density anomaly 11 days before EQ [from Rui Yan]



The anomaly of electron profile on the shock day [from Song Xu]

Anomaly #a: Earthquake-statistical analysis after EQs

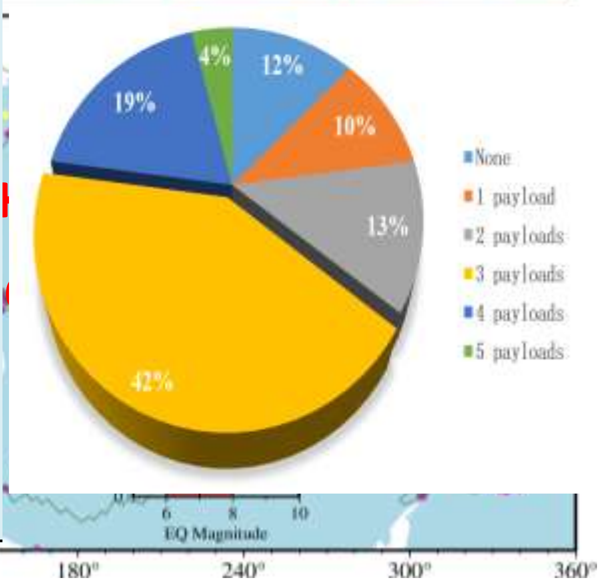
1) Plasma Parameters



[Zhu, Yan*, et al., 2021]

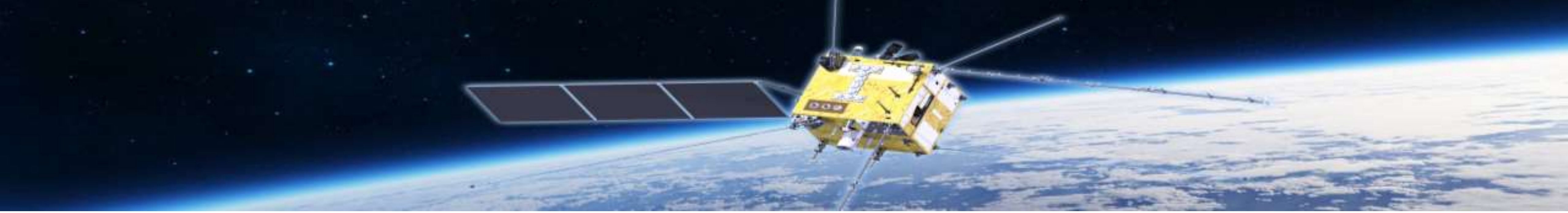
2) The multi-physical values

Payload	EQ (M>7 &depth <100km)		
	EQs (N)	Anomalies (N)	Anomalies (%)
SCM	42	30	71%
EFD	32	23	72%
HPM	47	5	11%
PAP	38	9	24%
LAP	38	28	73%
GOR	32	15	47%
HEPP	38	21	55%



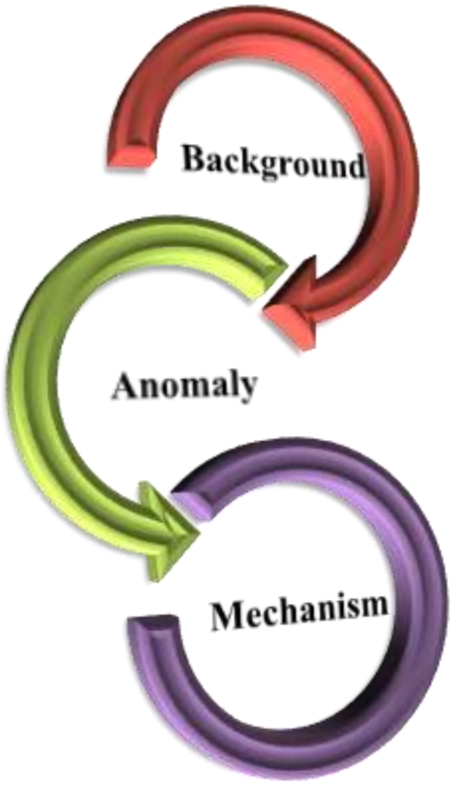
1. Anomaly mainly occurs 1-7 days and 13-15 days before EQs.
2. The detection rate depends on magnitude and focal depth.

1. The detection rates of LAP, EFD, and SCM are over 70%
2. ~60% of EQs can be recorded by 3 or 4 payloads simultaneously
3. Anomalies preferably occur on the mainshock day, 1-2 weeks before mainshock days



Main Content

Scientific outcomes



1) Space environment

2) Geophysical field models

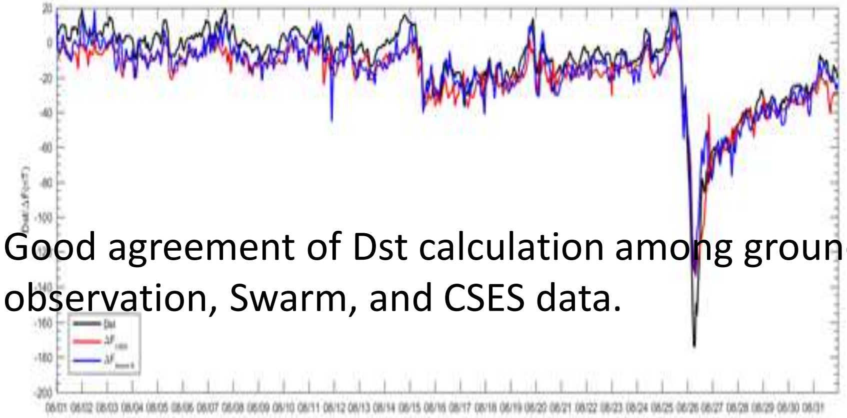
3) Natural hazards disturbance

   a. Earthquake,
   b. Space weather
   c. Volcano… etc.

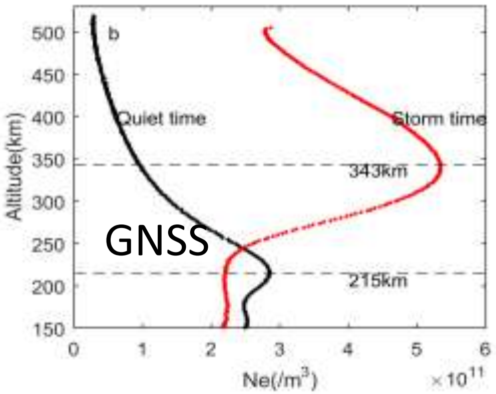
4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

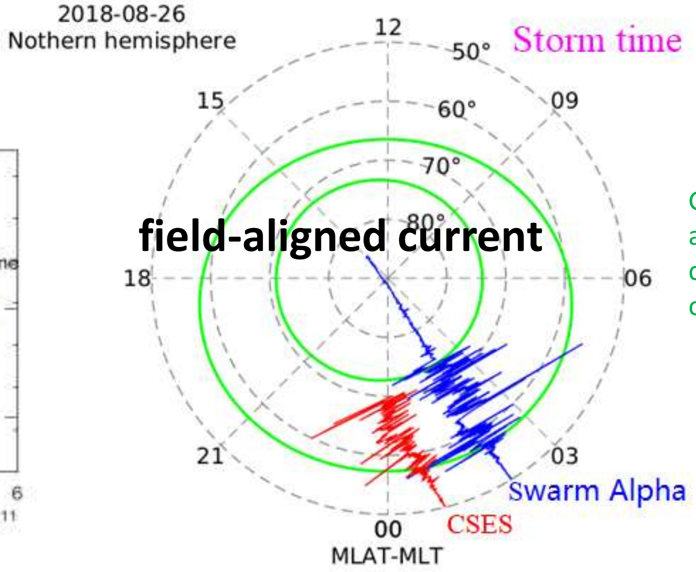
Anomaly #b: Space weather disturbances (1)

Well response to space weather event

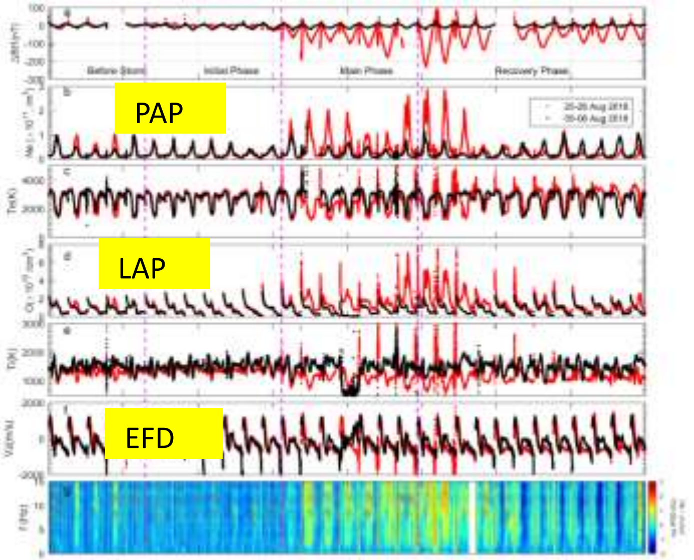


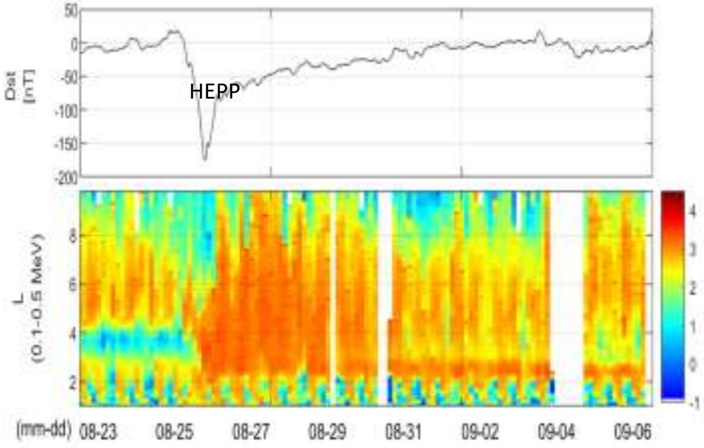
Good agreement of Dst calculation among ground observation, Swarm, and CSES data.

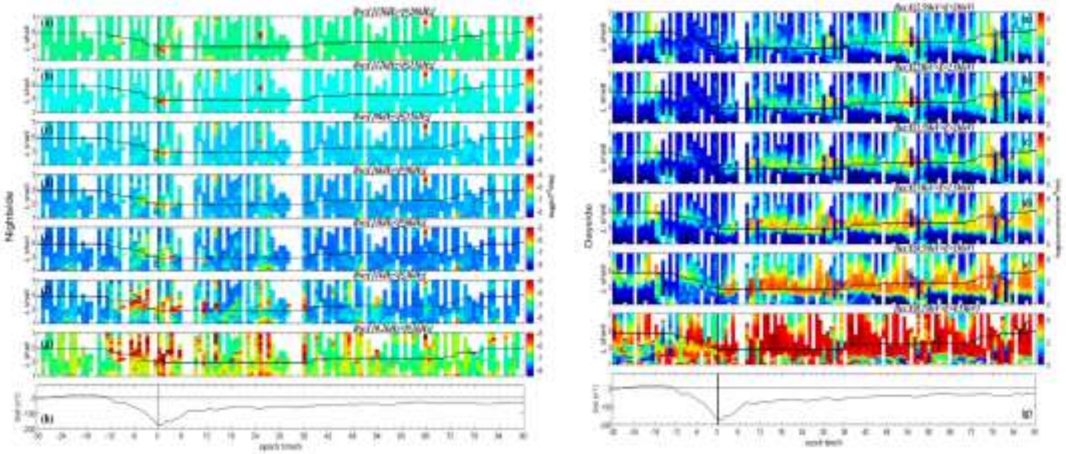




Green： The equatorial and polar boundaries calculated by the field-oriented current model





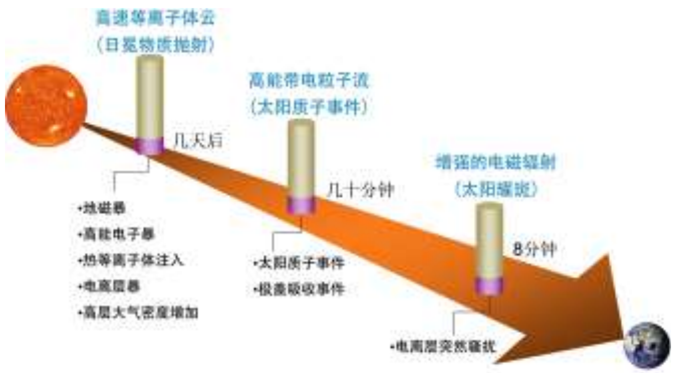


Yang et al.， Space Weather, 2020

Zhima et al.， 2021

Anomaly #b: Space weather disturbances (2)

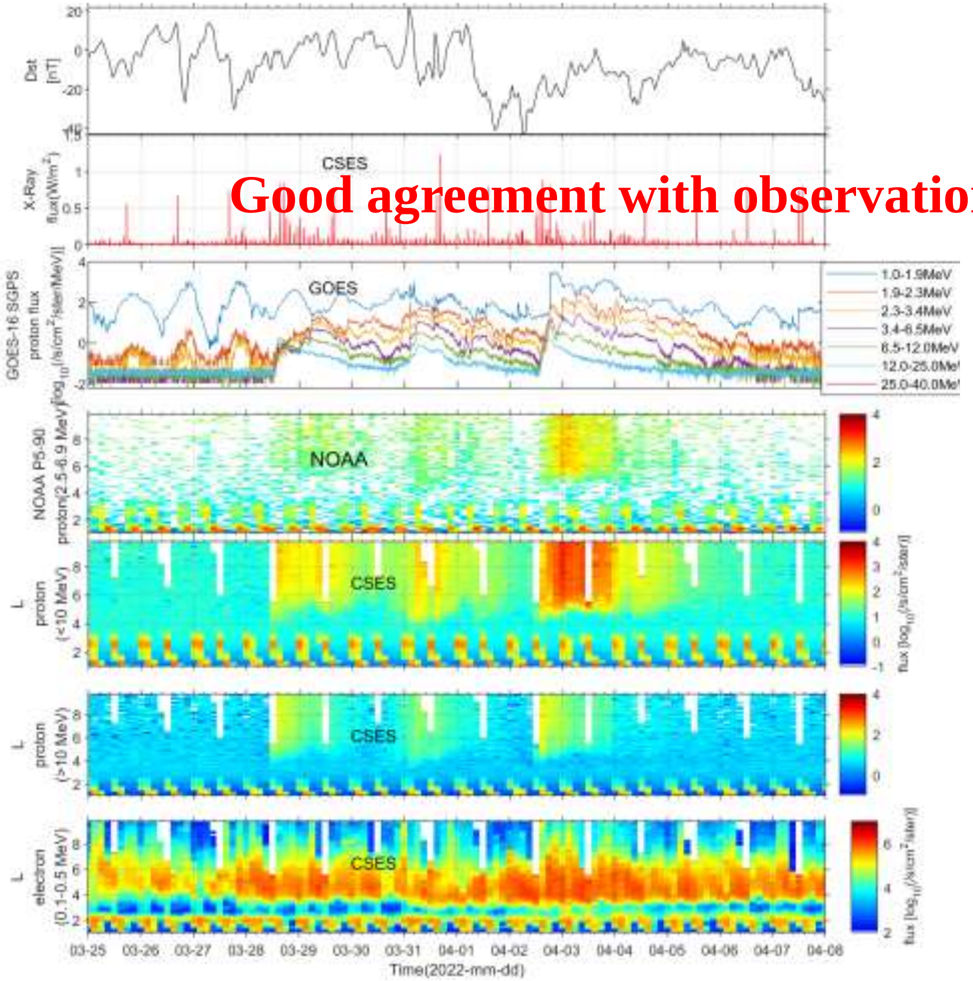
Rapid response to solar flare X-ray, solar proton event, and gamma-ray burst



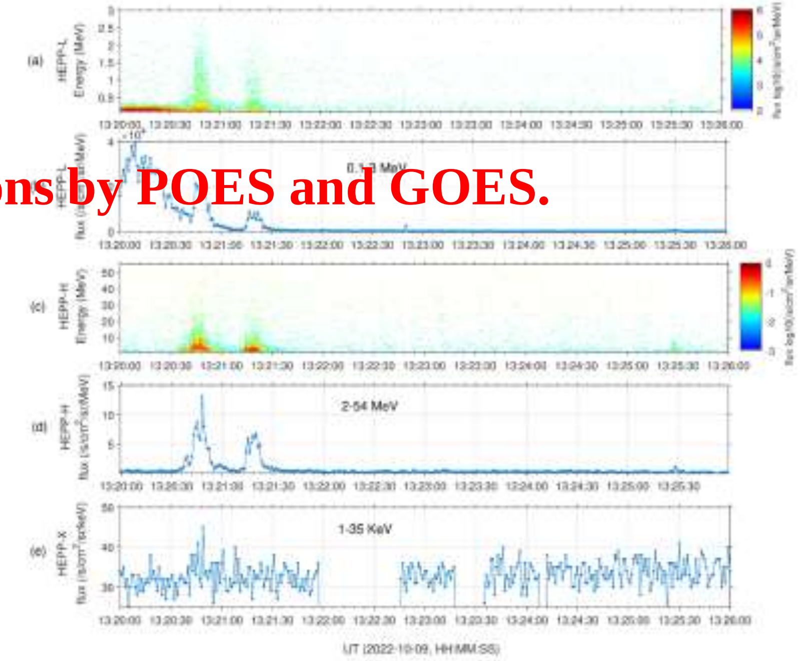
Based on CSES, Solar flare X-ray, solar proton event, geomagnetic storm and electron injection took place successively.

Zhang et al., 2021, JGR;

Wang L. et al., 2021;

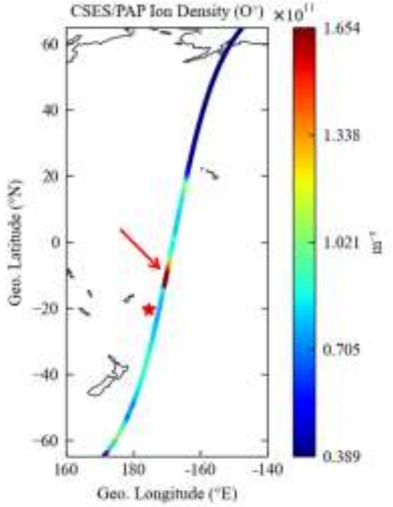


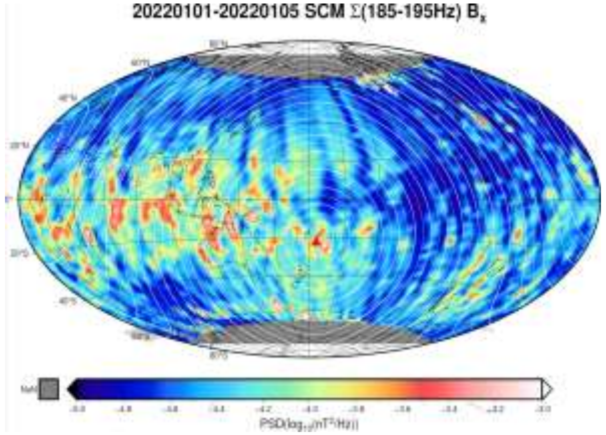
Good agreement with observations by POES and GOES.



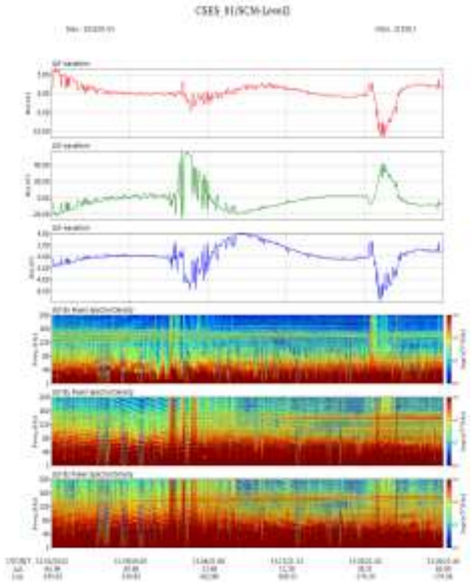
Response to the brightest gamma-ray burst by HEPP-L, H, X

Anomaly #c: Volcano, Solar ellipse, thunderstorm, artificial waves…

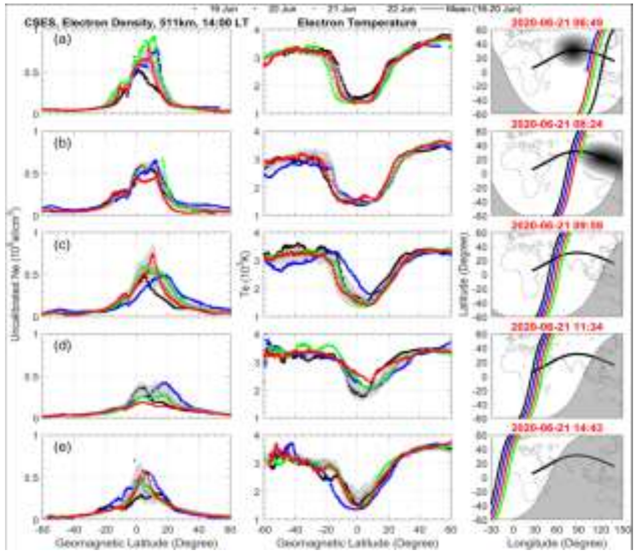




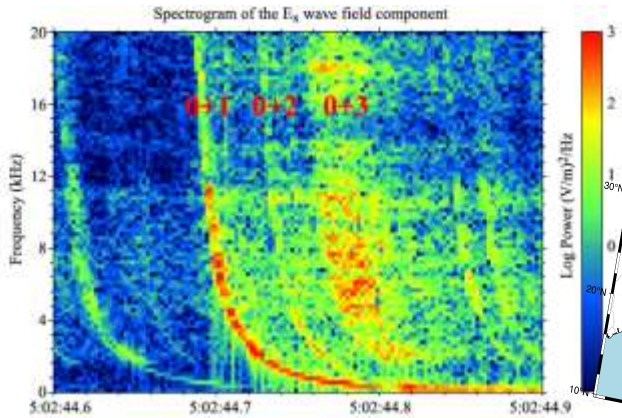
Before Tonga volcano eruption

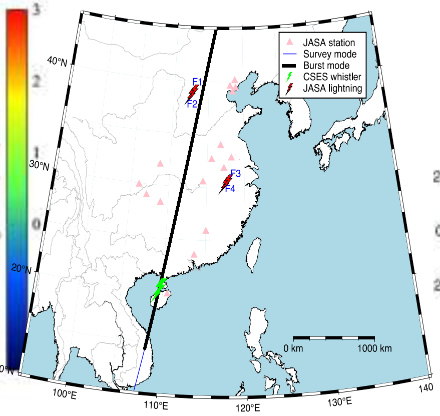


After Tonga volcano eruption

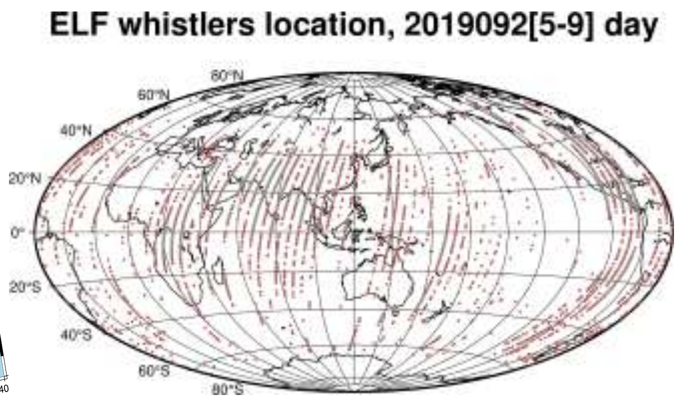


Solar Ellipse
Lei et al., 2020, JGR

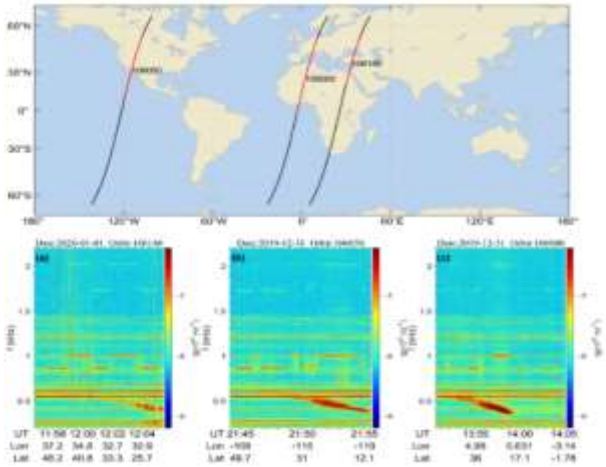




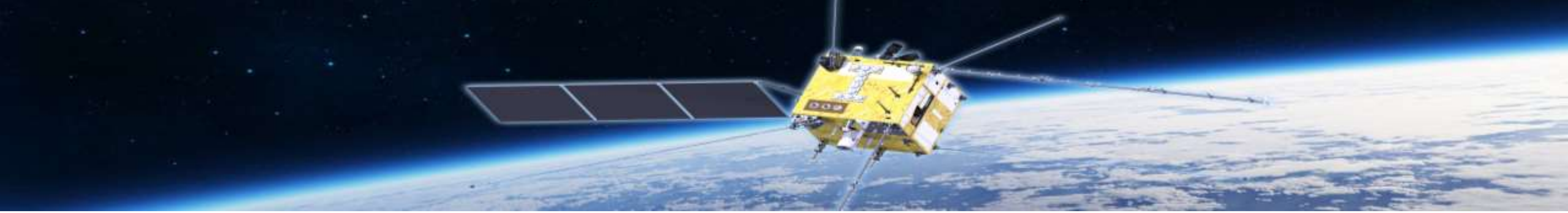
Lightning events
Yuan+Zhima etal., 2021



Wang Qiao etal., 2021

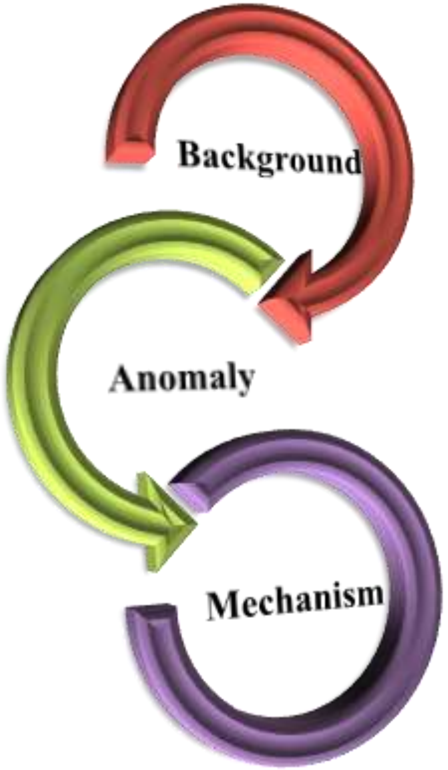


Electric power system
Zhao et al., 2022 JGR



Main Content

Scientific outcomes



1) Space environment

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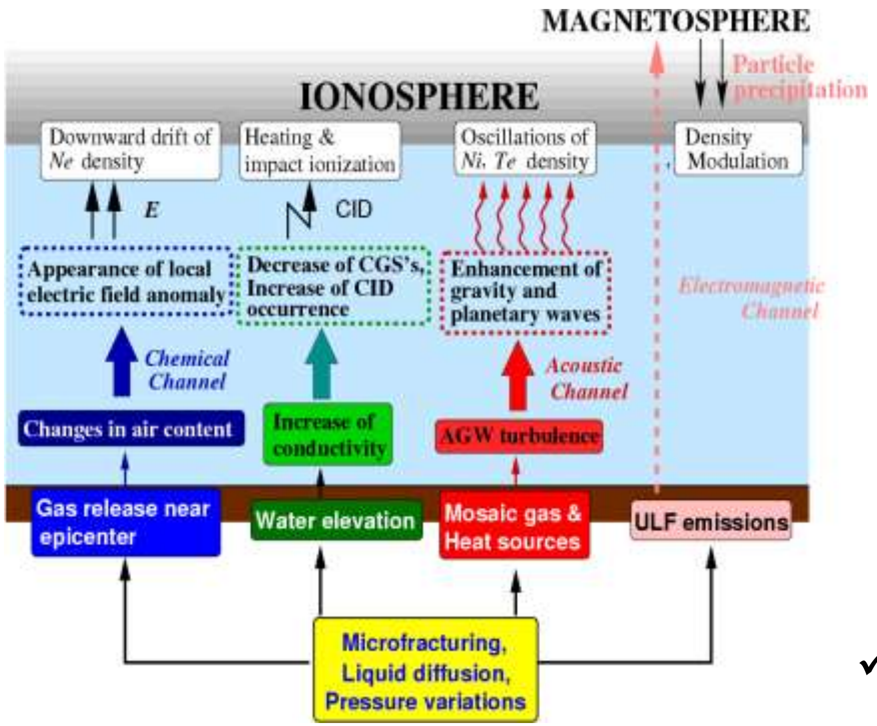
- **a. Earthquake,**
- **b. Space weather**
- **c. Volcano… etc.**

4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Lithosphere-Atmosphere-Ionosphere Coupling mechanism



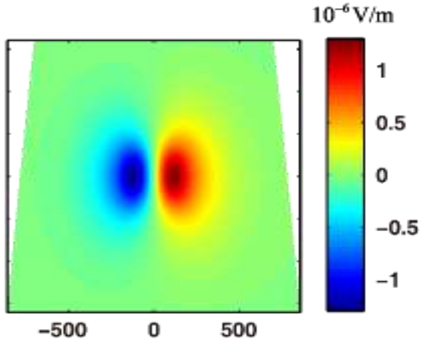
Hayakawa et al., 2004

✓ Electric field mechanism

Vertical electric field emerging from the seismogenic zone

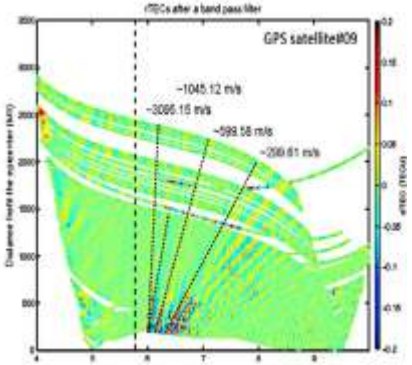
- Lithosphere:100-1000 V/m
- Ionosphere:10 mV/m

(no direct observational evidence found)



✓Acoustic gravity wave mechanism

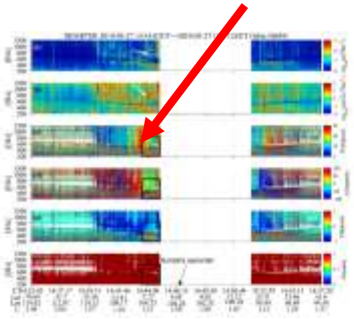
observational evidence : GNSS TEC etc



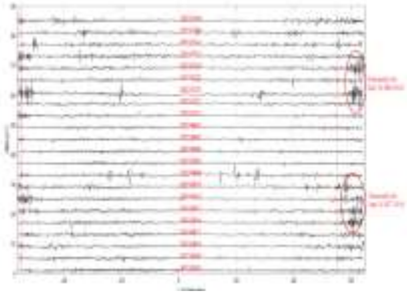
✓Electromagnetic wave mechanism (Pre-earthquake)

Electromagnetic wave emerging from the seismogenic zone

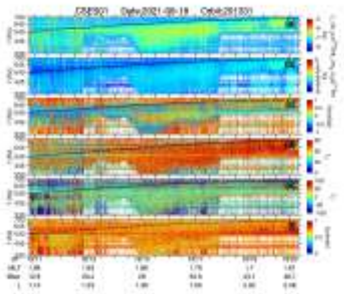
DEMETER



CSES



CSES

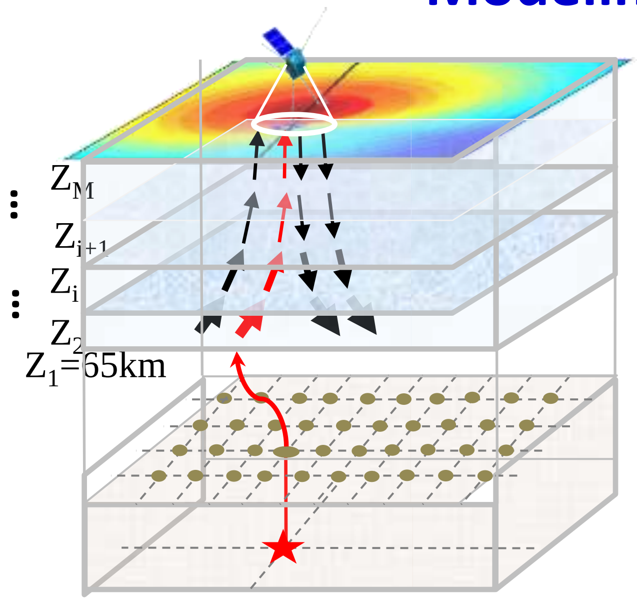


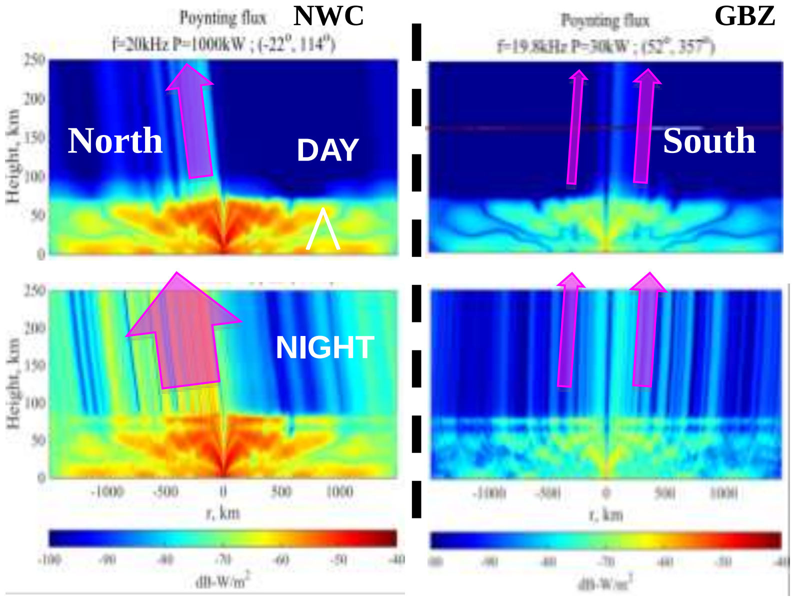
Three Channels：

- Chemical channel
- Acoustic channel
- Electromagnetic channel

Scientific outcomes #4: LAIC
1) VLF radio waves propagation model

Modeling results





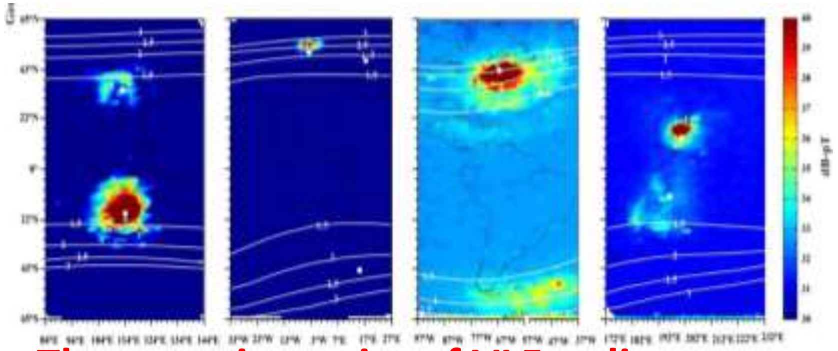
❖Propagation along the magnetic field line towards the top ionosphere

❖The stronger the radiation power and frequency, the stronger the energy that penetrates into the ionosphere

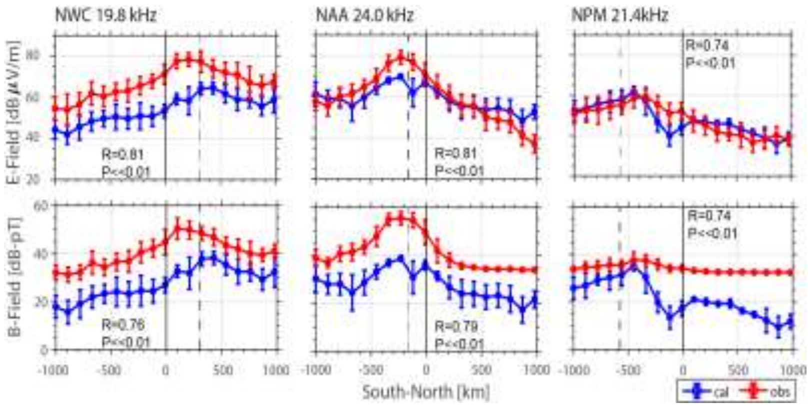
❖At night side the penetrating energy is stronger than that at dayside.

Zhao et al., 2020 a,b, Result in Phys.

Observational Evidence of CSES



The wave intensity of VLF radio over of ground transmitter



CSES (red) Vs model result（blue）

Zhao et al., 2019, JGR

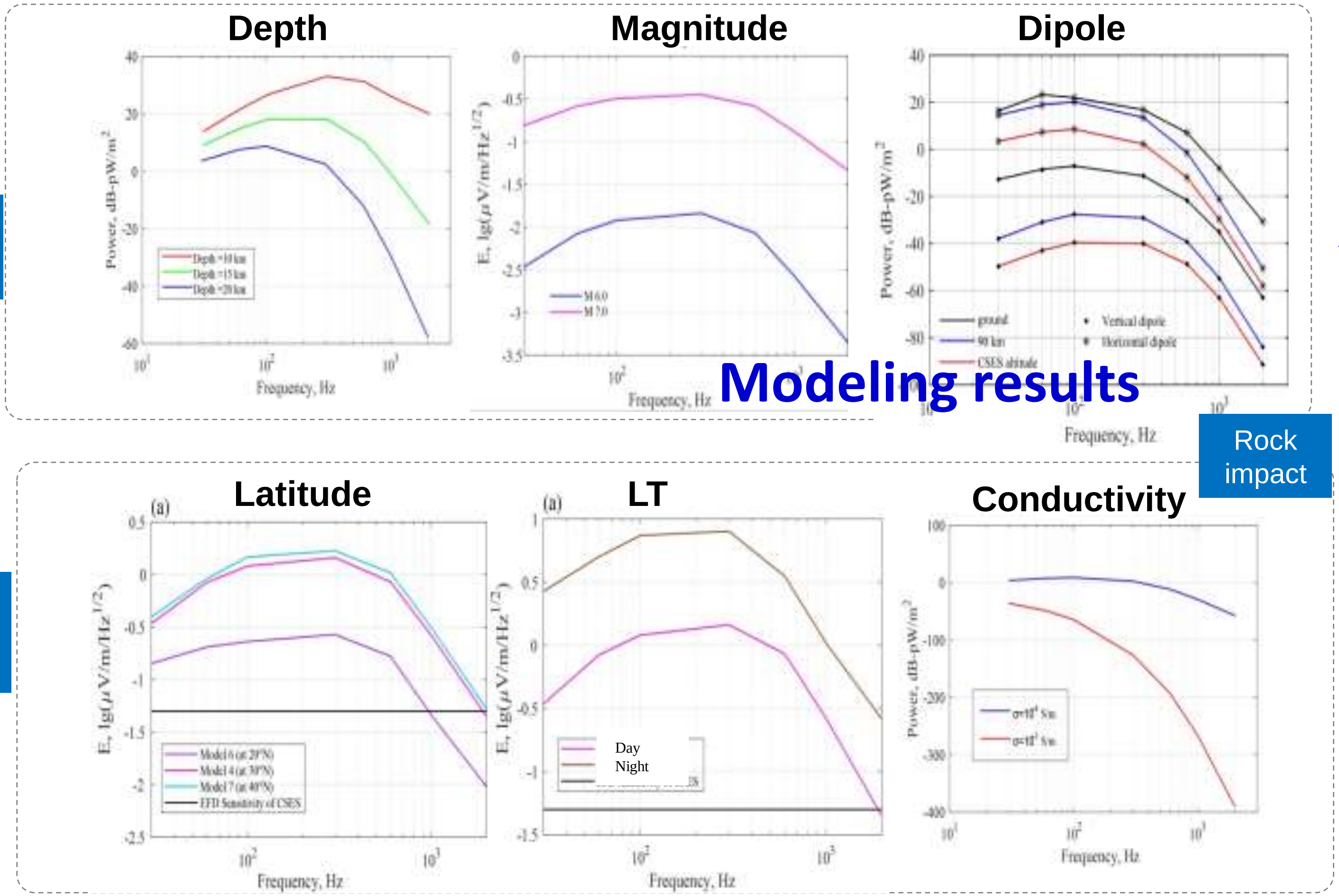
Scientific outcomes #4: LAIC

2) ELF wave propagation #conti#

Radiation source

Ionosphere impact

Rock impact



Modeling results：

a) EQs with M 6+ can be detected by the CSES.

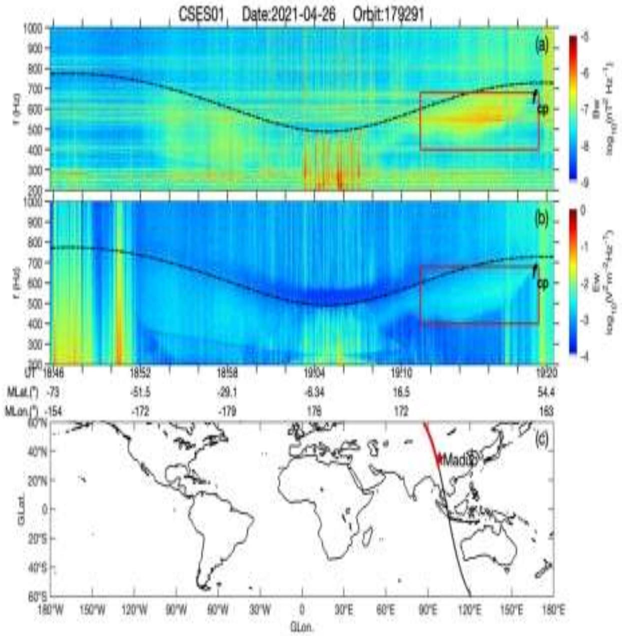
b) The power radiated from the dipole in the isotropic conductive medium decreases as the frequency increases because of the skin effect.

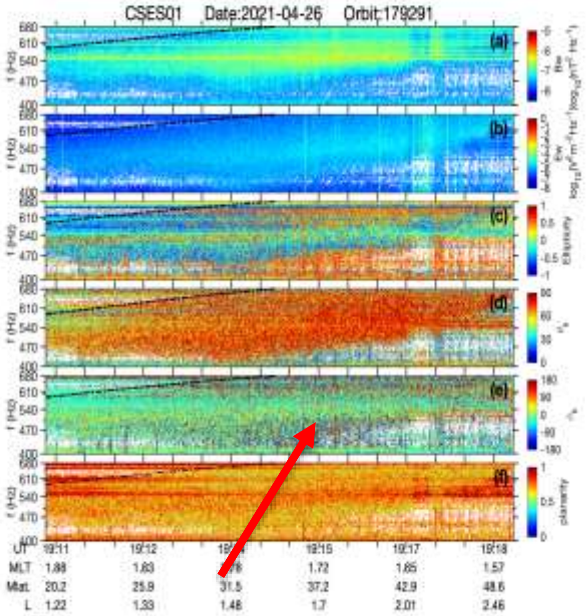
c) There is a dominant frequency range : < ~ 1000 Hz

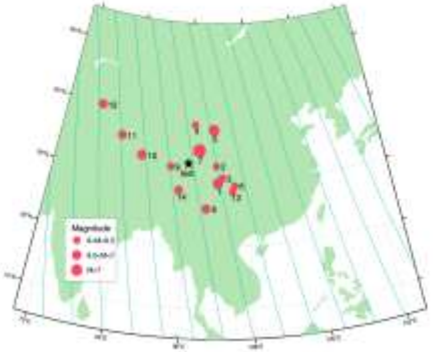
Zhao et al., 2021, Sci. Chi.Tec.Sci.

Scientific outcomes #4: LAIC
2) ELF wave propagation-observational evidence

The upward propagating EM waves over the epicenter







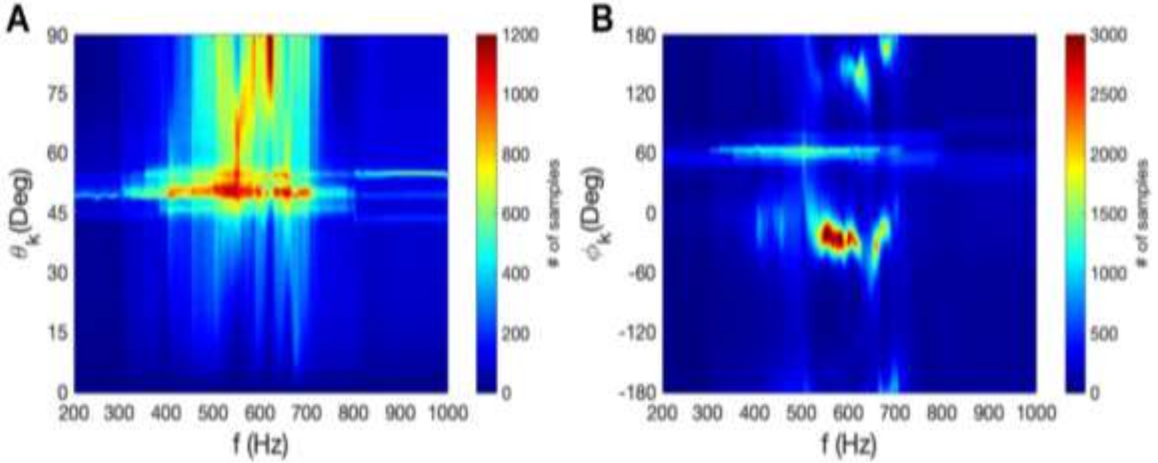
Strong shallow earthquakes

Depth: ≤ 30 km

Magnitude: ≥ 6

Area: mainland China

Time-Window: 2019 to 2022



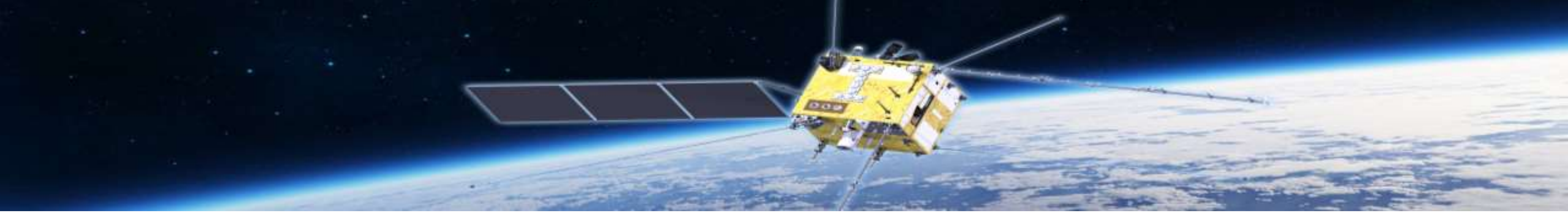
Case: Maduo (QH) Ms 7.4 EQ on May 22,2022

Observational Evidence:

The upward propagating EM waves mainly appear in the frequency band 300 to 800 Hz.

Zhima et al., 2020

Lv+Zhima* et al., 2023



Main Content

电磁监测卫星计划
China Seismo-Electromagnetic
Satellite Program

1. The current status
2. Data outcomes
3. Scientific outcomes
4. Challenges & perspectives
5. Follow-up Plans
6. Swarm/CSES cooperation

Challenges & Solutions # 1: High-quality data products

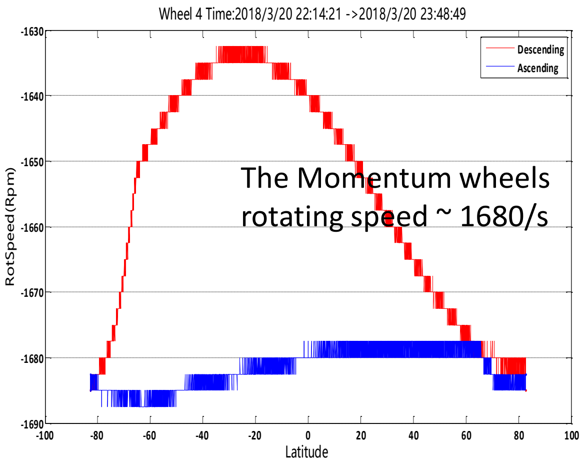
Challenge 1: Understanding about "our colleagues" in space.

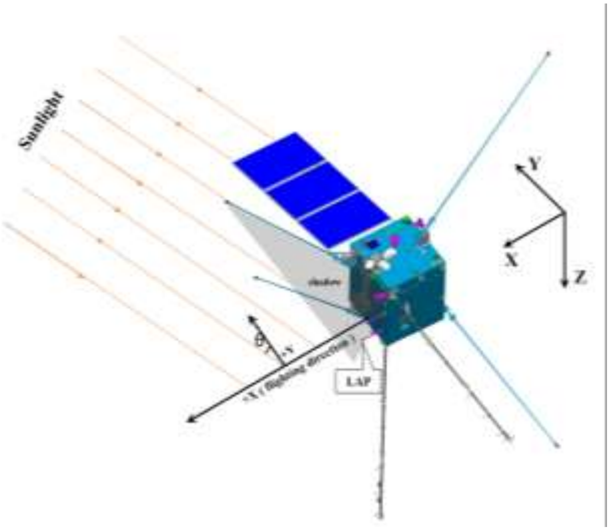
Are they in a good "mood", are they "healthy"?

Solutions:

1. Keep going through data val/cal or quality control in the whole lifetime of the mission ;

2. Continue to develop advanced data processing algorithms;



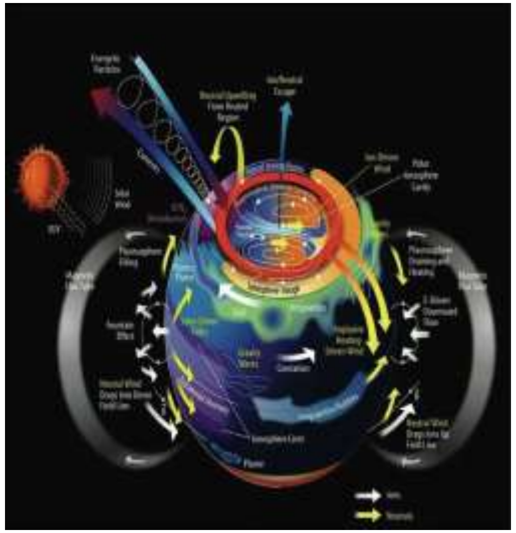


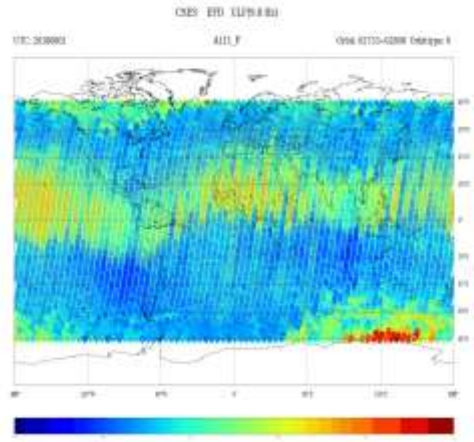
Challenges & Solutions # 2: background knowledge

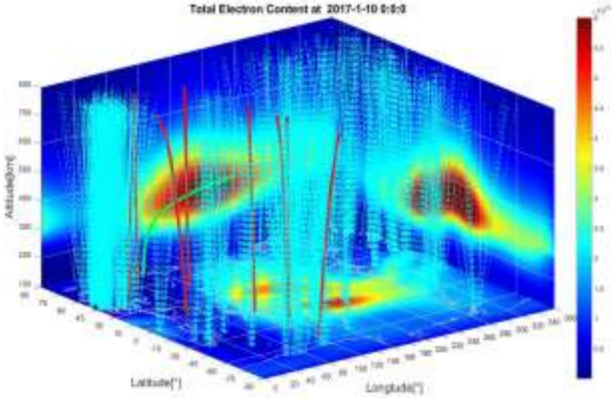
Challenge 2: The well knowledge about the space environment

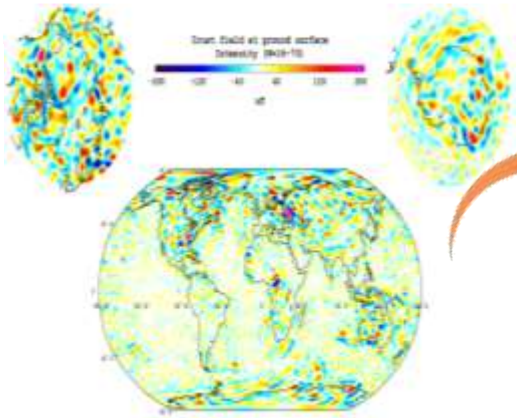
Solutions:

1. To build background maps for multi parameters based on long-term observations and AI technology ;
2. To build models of geomagnetic field or ionosphere (3D, 4D)
3. To obtain accurate statistical knowledge on the regular patterns

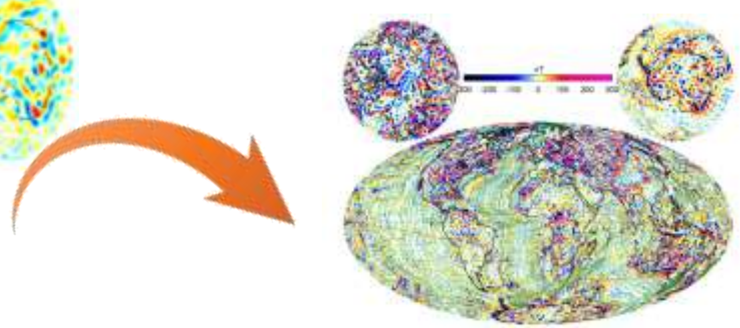








Model from a single probe



Model from constellation

Challenges & Solutions # 4: LAIC

Challenge 3:

How to accurately identify the real precursors before earthquake

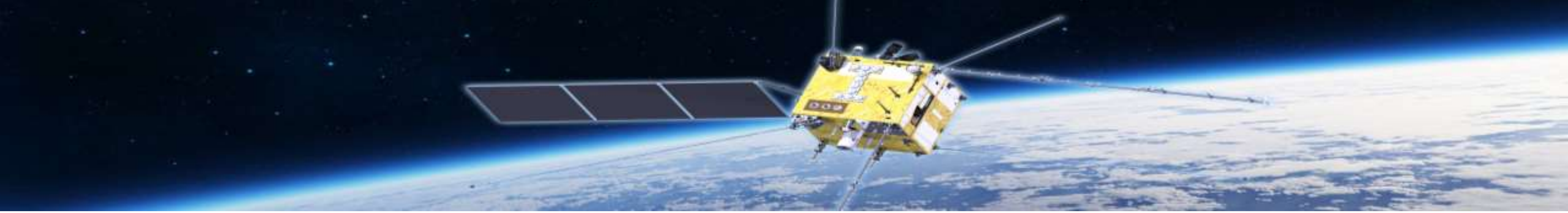
How to uncover the puzzle of seismo-ionospheric coupling mechanism

The LAIC mechanism still lacks reliable experimental evidence with direct and simultaneous observations at different layers or altitudes.

It involves geophysical, chemical, and even biological knowledge to interpret coupling mechanisms.

Solutions:

1. Take full advantage of existing satellite and ground stations to build a virtual space-groud platform
2. Application of AI technology to handle massive data



Main Content

1. The current status
2. Data outcomes
3. Scientific outcomes
4. Challenges & perspectives
5. Follow-up Plans
6. Swarm/CSES cooperation

Zhangheng mission (张衡计划）

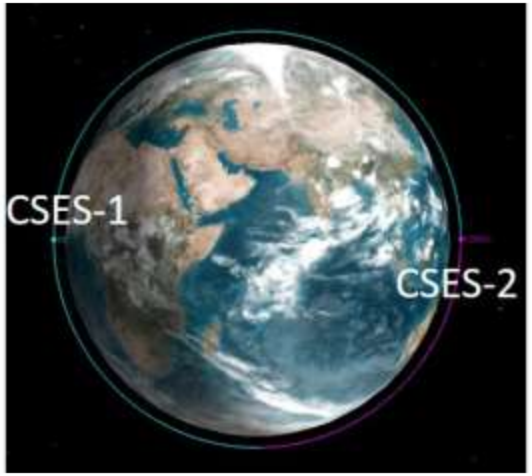
- The ZhangHeng mission, named after the ancient scientist Zhangheng who invented the world's first seismoscope.
- It is aimed to detect the g**eo-physical fields of near earth space;**
- It is planed to launch a series of probes in recent decades.

Zhangheng-01: Electromagnetic satellites

CSES -01: Launched Feb. 2, 2018

CSES-02: Upcoming in December 12th, 2024

CSES-03: scientific demonstration analysis: Aug. 17, 2023



Next generation mission charged by NINH, MEM, P.R.C.

1. The CSES-03 (Low orbit 400 -800 km)

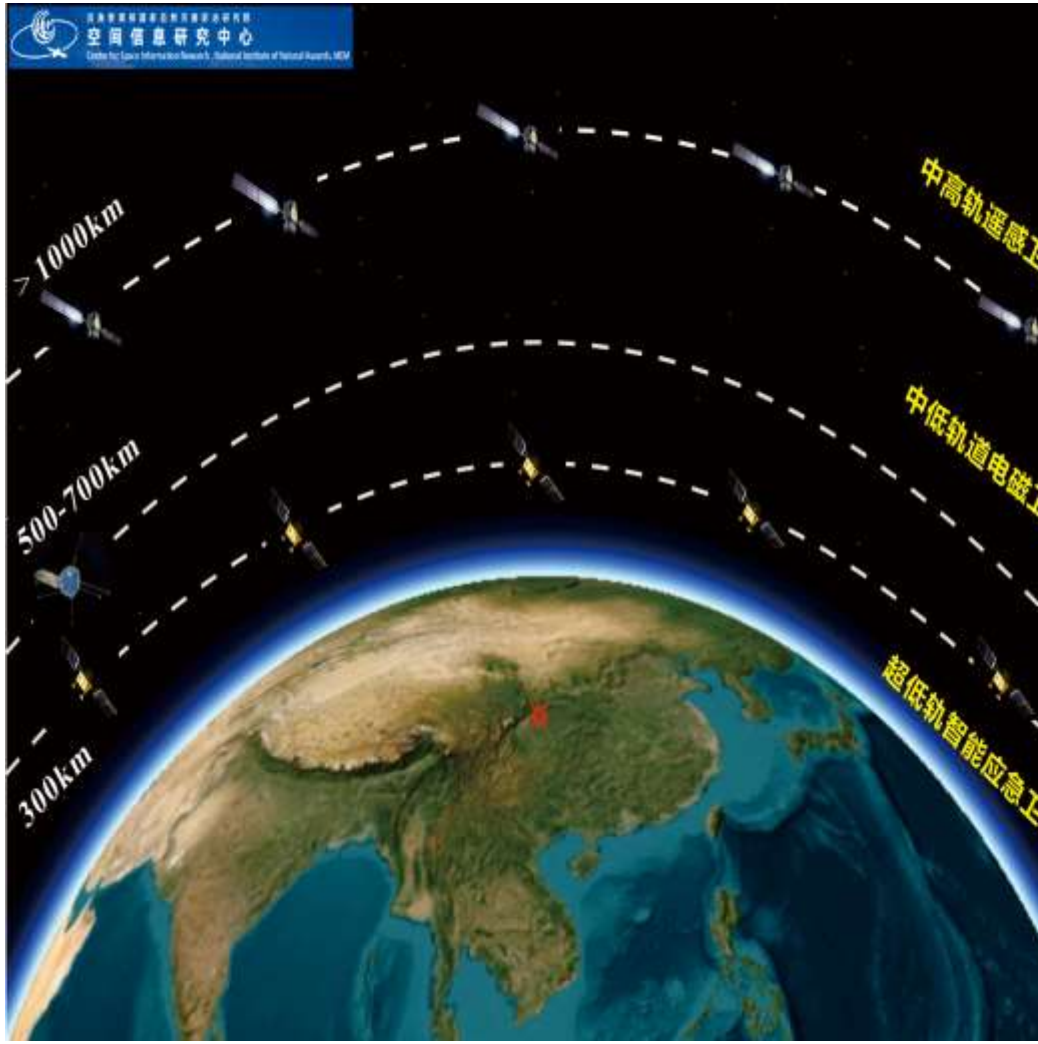
At least 3 EM probes with in next 10 years after CSES 02;

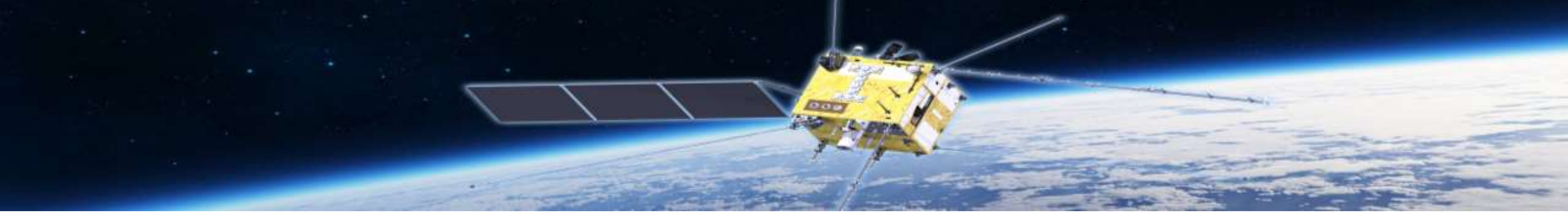
2.Integrated Remote Sensing Intelligent Emergency constellation (Ultra-low orbit 200 - 300 km) –A new mission

200-300 probes in total, 9 test probes in 2024 -2025

Integrated RS techniques : Optical, Infrared, Microwave, BD GNSS, Electromagnetical payloads

Objective: To serve for the early perception of natural disaster risks and rapid and intelligent emergency response capabilities





Main Content

电磁监测卫星计划
China Seismo-Electromagnetic Satellite Program

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Swarm/CSES cooperation: The past

1) Apr. 24-25, 2019 : the 2nd CNSA-ESA Earth Observation Workgroup Meeting

Gravity Subgroup (WG5) & Electromagnetism (WG2)

The Swarm/CSES cal/val expert team

3) CSES 4th workshop October, Changsha, 2019

Session on Geomagnetic field model

2) Swarm 9th workshop, September, Prague, 2019

Session on Swarm-CSES Synergy

The 10th-13th Swarm data quality workshop is hybrid meeting during the COVID-19 pandemic

Swarm/CSES cooperation: The past

4) Oct. 21 to 25, ISSI-BJ （The International Space Science Institute in Beijing) :

The electromagnetic data validation and scientific application research based on CSES satellite

6) CNSA-ESA video meeting on space cooperation held on June. 2020

7) Dragon Cooperation project

5) **ESA EO visiting ICD in Jan.15, 2020**

(Josef Aschbacher, Karl Bergquist et al.)

The cooperation between CSES and Swarm team has been continuously selected as highlights

Highlights since last DQW

esa

- We are here!
- Completed the Level-1b mission wide reprocessing
- Started development of fast data ("NRT") parallel chain
- Executed the counterrotating phase with variable Swarm-A and Swarm-C separation (ongoing)
- Science workshop on Magnetosphere-Ionosphere-lower Atmosphere Interactions – way forward
- Ground segment migration from physical platform to cloud based virtual environment
- Continued close collaboration with CSES with improved data exchange and scientific publications

Highlights since last DQW

esa

- Got the Swarm mission extension through 2025 recommended
- Completed the mission wide reprocessing and TTO of new baseline
- Completed the counterrotating phase with variable Swarm-A and Swarm-C separation - unique datasets with opportunities for new science
- Continued close collaboration with CSES with improved data exchange and scientific publications - new dataset released.
- Started orbit raise campaign of Swarm-A and Swarm-C (…and Swarm-B) to get all three spacecrafts through solar cycle 25 – first part completed
- Started planning for new science opportunities with Swarm in the 2023 - 2025 timeframe
- Participated actively at the Living Planet Symposium (LPS) with several Swarm related sessions
- Released several new datasets
- Swarm mission central in ESA internal cross directorate WG on Heliophysics
- Increased our presence on Twitter (@esa_swarm)

Highlights since last DQW

esa

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Swarm Family and Friends

esa

Swarm-E/CASSIOPE e-POP

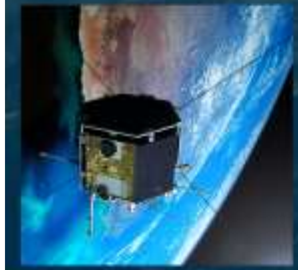
Although the routine Swarm-E operation has come to an end, e-POP is still going strong. Phase F activities and new opportunities

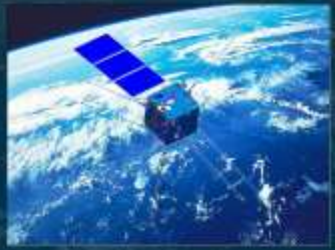
CSES

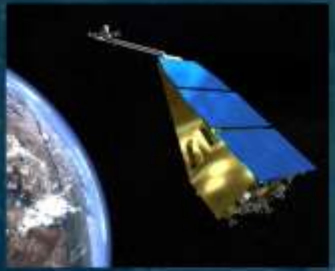
CSES data made available in "Swarm-like" data format to encourage joint analysis of Swarm and CSES magnetic data

MSS-1: First Macau Science Satellite

Launched on 21 May 2023
Ongoing commissioning of satellite
Strongly encourage close collaboration on data format and data sharing to the community







THE EUROPEAN SPACE AGENCY

Cited from slides of Swarm Mission Manager: Anja Stromme

Swarm/CSES cooperation: The future

1. **To jointly carry on the electromagnetic field, plasma data validation among Swarm,CSES and MSS.**
2. **To jointly utilize the data to achieve high-level scientific outcomes**

   e.g., ionospheric environment, the geomagnetic field modeling, the Lithosphere-Atmosphere-Ionosphere coupling mechanism and modeling

3. **To jointly explore the advance natural hazards prevention techniques**

   e.g., earthquakes, volcano, geo-magnetic storms, thunderstorm, severe weather etc.

4. **To establish a stable long-term cooperation mechanism on geophysical-field satellites**

   CSES welcome Swarm team's earlier participation on CSES 03 mission

Big Congrats to the huge success of Swarm mission!

Thank Swarm's support to CSES!

Welcome discussions on :

Data processing, dataval/cal methods, scientific application, CSES 03 mission, etc

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