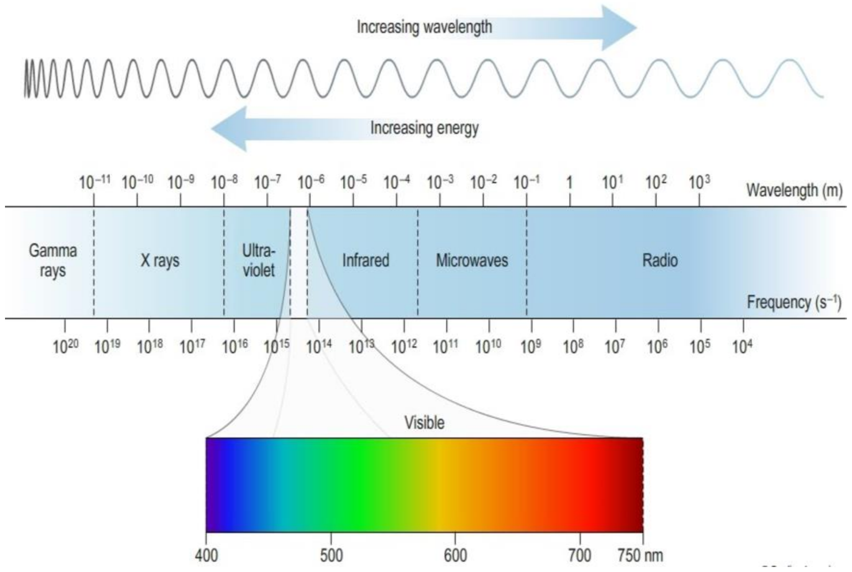
The CSES Mission Overview: status, outcomes, and follow-up plans

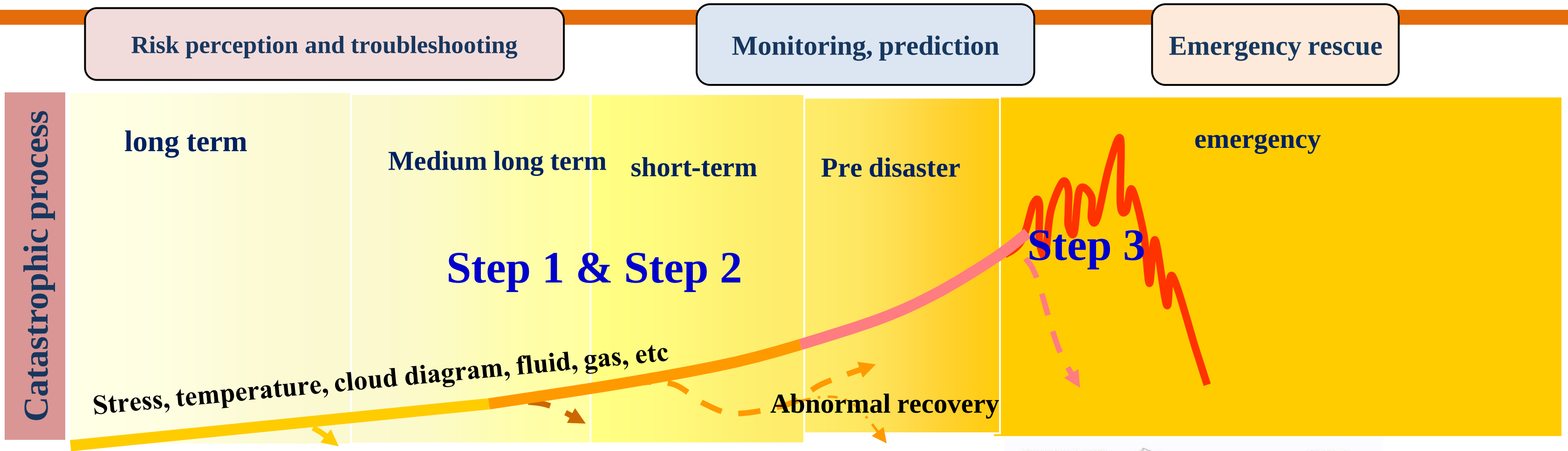
Zeren Zhima on behalf of the CSES team
China

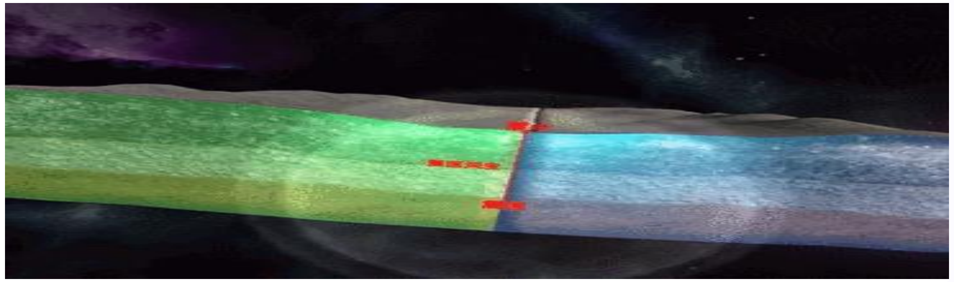
National Institute of Natural Hazards, Ministry of Emergency Management of P.R.C
(NINH, MEMC)

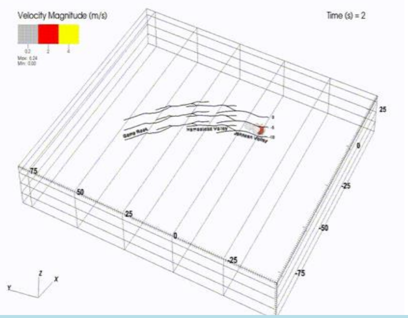
Space technology application in Natural Hazards prevention and reduction



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

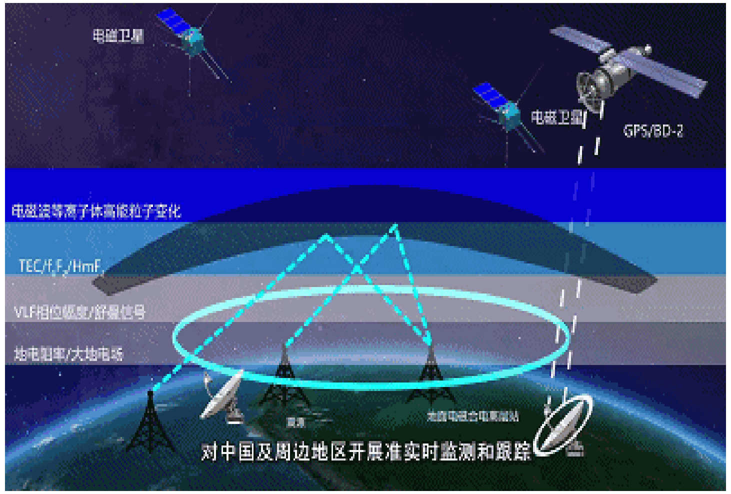
Step 2: Risk assessment

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

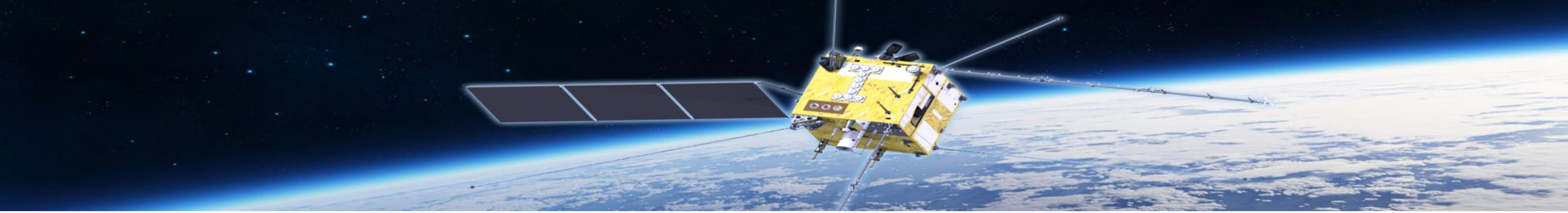
To monitor the space perturbations induced by major earthquakes.

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



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

I. The satellite platform

II. The scientific payloads

III. The Scientific Application Center

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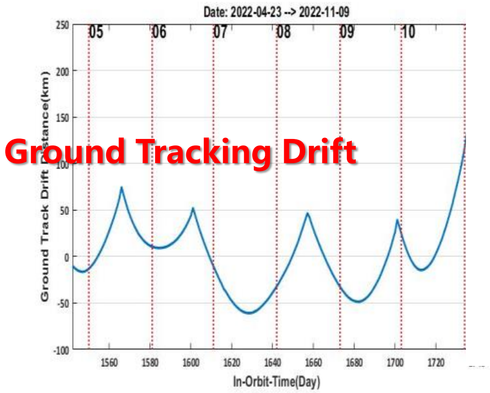
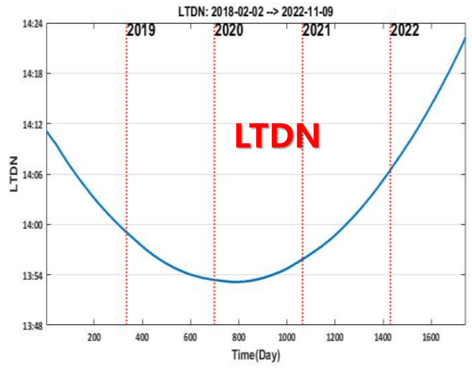
China Seismo-Electromagnetic Satellite Program

The current status of the satellite platform

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

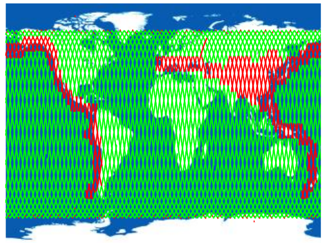


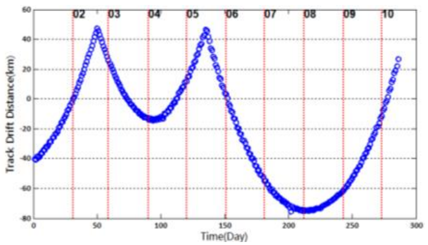


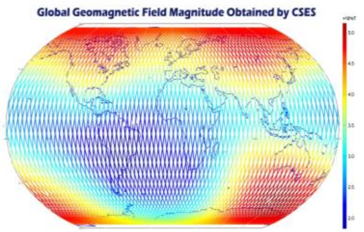
Index	Specifications	Requirements	In-orbit status	Conformance
1	LTDN	14:00±15min	14:22	Yes
2	Ground Tracking Drift	±60km	105km	Yes
3	Fuel Remaining	0-42kg	36.54kg	Yes

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

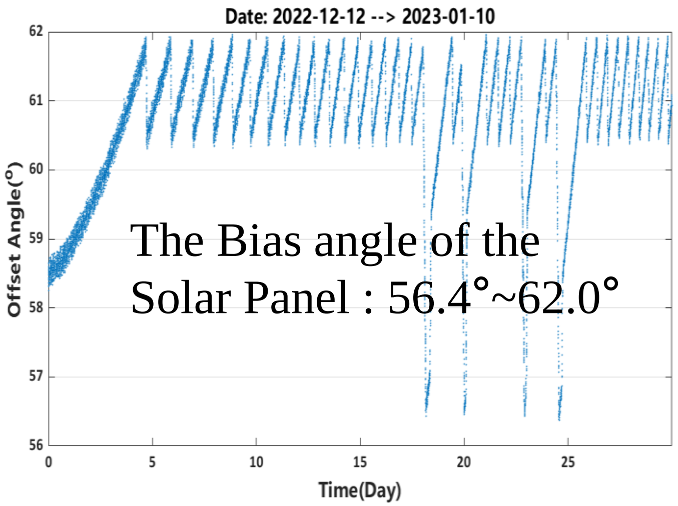
2)Working Modes still Operate perfectly

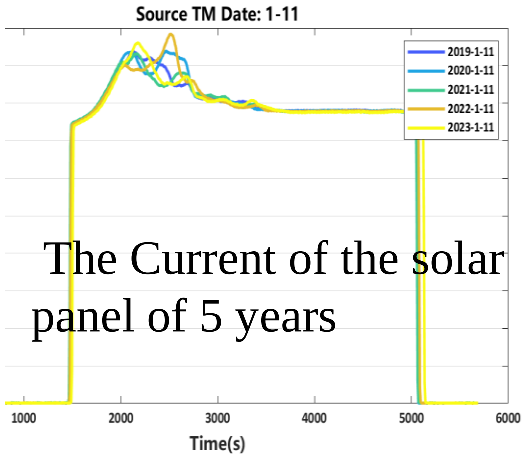






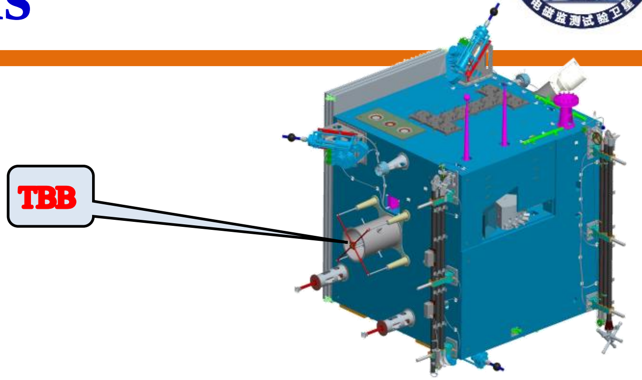
3) The satellite power supply working in good condition

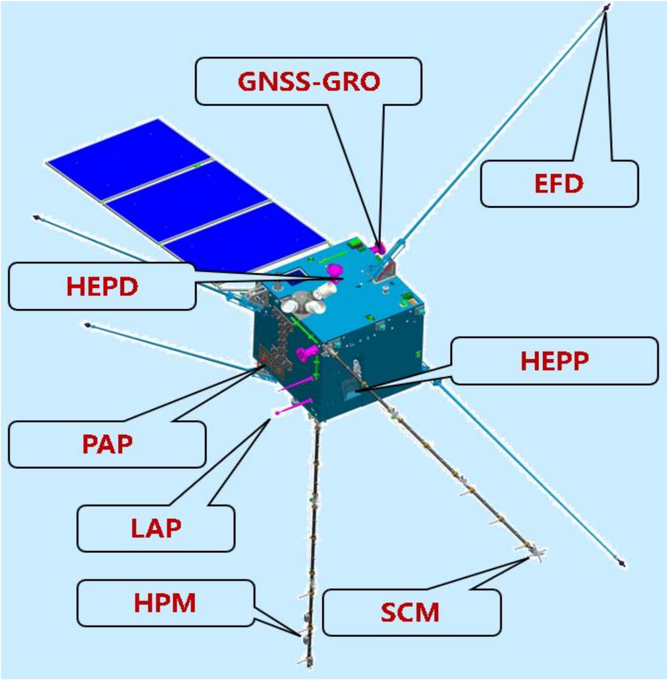




The current status of scientific payloads

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 at least two years.

The status of the Scientific Application Center

NINH, MEMC

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

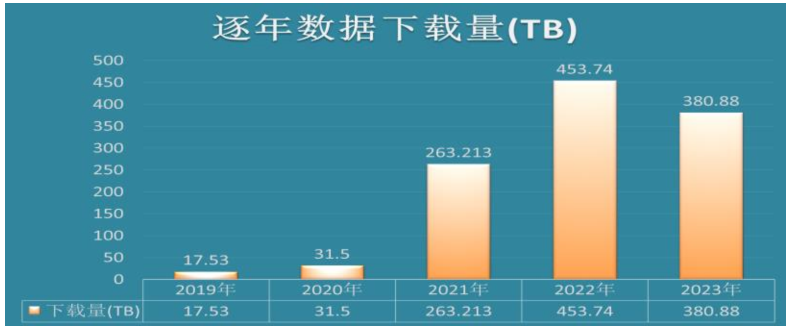
- ✓ Data products generation
- ✓ Data quality assessment
- ✓ Auxiliary data management
- ✓ Data products management

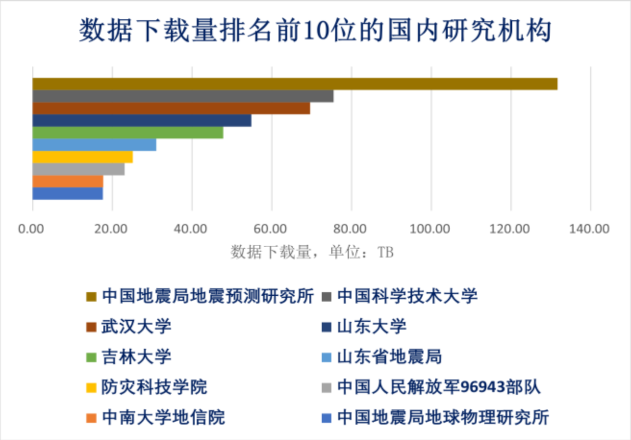
Data Sharing

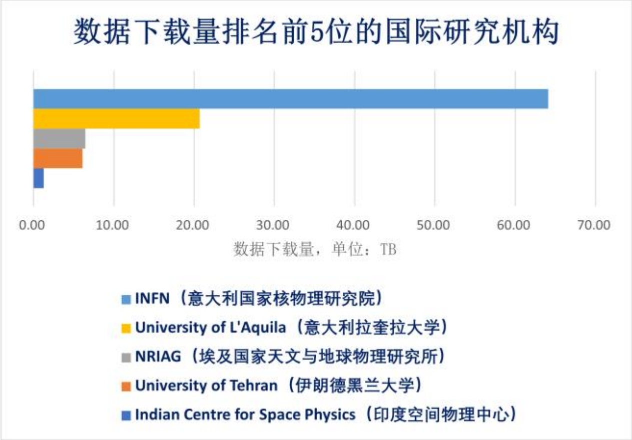
- Data pushing to CNEC, CEA
- Data pushing to ASI, Italy
- Data sharing website
- Data sharing to GEO, APSCO
- Data sharing to Individuals

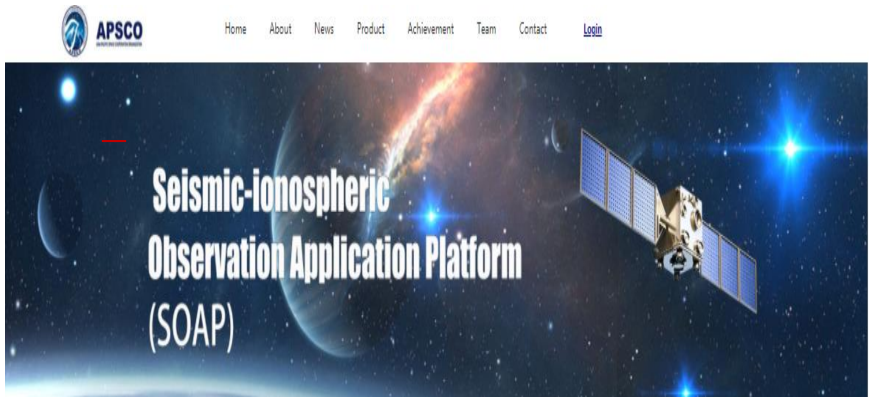
Data sharing service (https: //www.leos.ac.cn)

- Over 528 users registered, including 69 universities/institutions from 19 countries;
- Over 1,700 sharing services both domestically and internationally
- The shared data volume has reached over 1.14 PB.

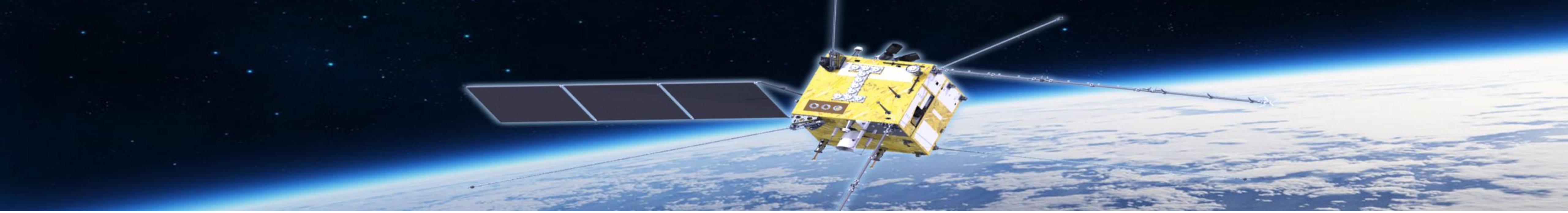








ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA
Technical University of Denmark DTU
agenzia spaziale italiana
cnes CENTRE NATIONAL D'ÉTUDES SPATIALES
INFN
GFZ Helmholtz Centre POTSDAM
EMSEV IUGG Inter Association
esa
IAA · INTERNATIONAL ACADEMY OF ASTRONAUTICS
cnes CENTRE NATIONAL D'ÉTUDES SPATIALES



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I. Standard data products

II. Themme datasets

III. Data processing,val/cal methods

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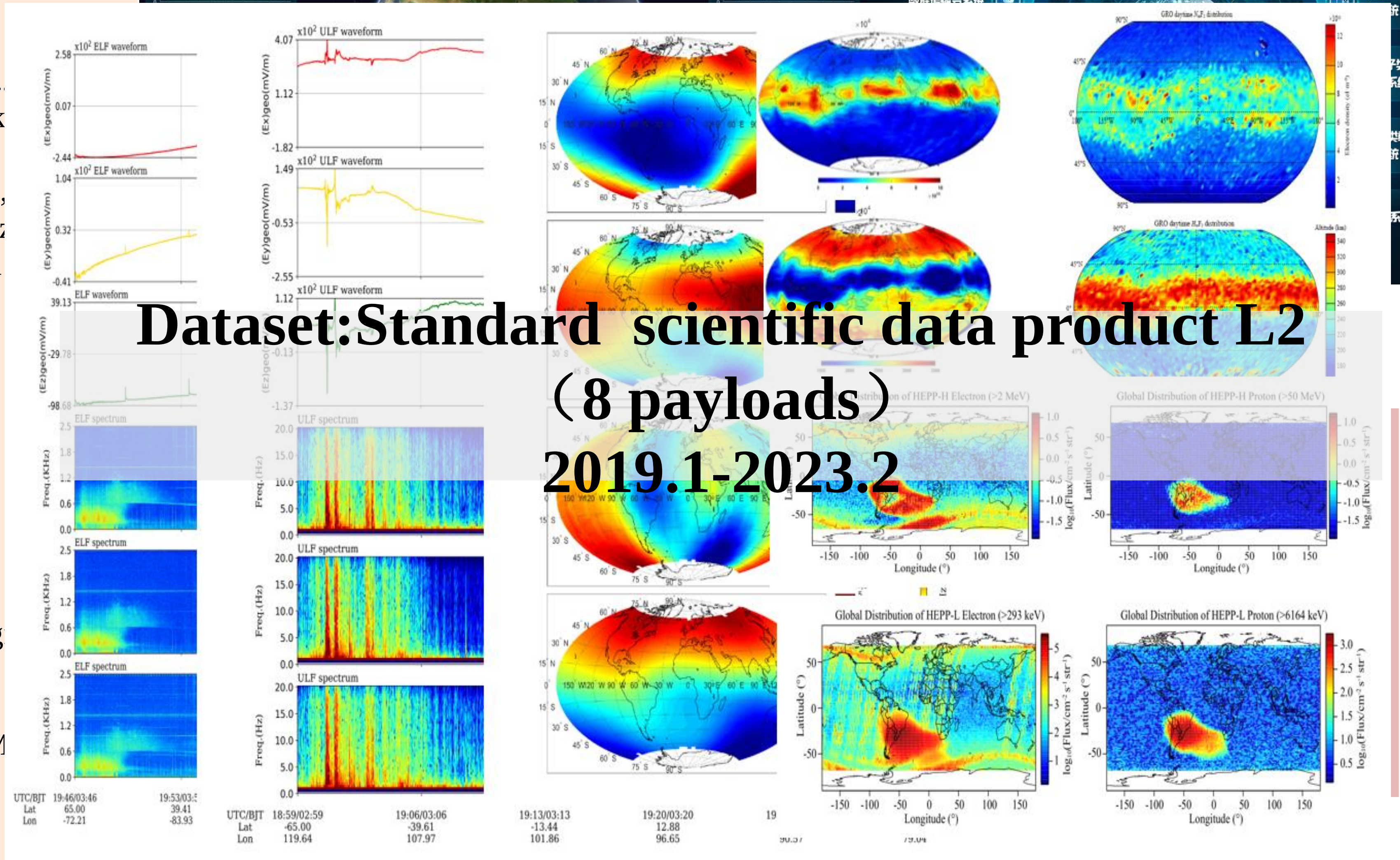
China Seismo-Electromagnetic
Satellite Program

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: 10 Hz - 200 Hz, sampling rate 1024
ELF: 200 Hz - 2200 Hz, sampling rate 10...
VLF: 1.8 kHz- 20 kHz, sampling rate 50 k
The electric field/wave: EFD
ULF: DC – 16 Hz, sampling rate 128 Hz,
ELF: 6 Hz – 2.2 kHz, sampling rate 5 kHz
VLF: 1.8 kHz – 20 kHz, sampling rate 51
HF: 18 kHz – 3.5 MHz, sampling rate 10
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
Ionospheric scintillation index and tomog
The energetic particles: HEPP+HEPD
Energetic Electron:
0.1 - 3 MeV, 1.5 - 50 MeV, 30 - 200 M
Energetic Proton: 2 - 20 MeV, 30- 100 MeV
Solar X ray: 0.9 - 35 keV

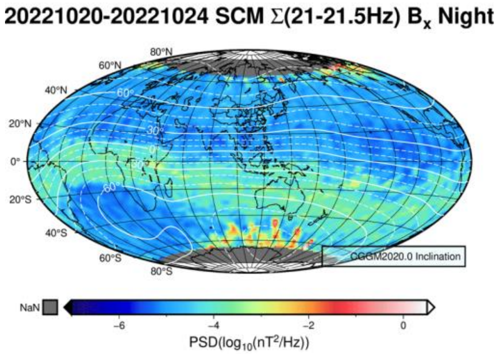


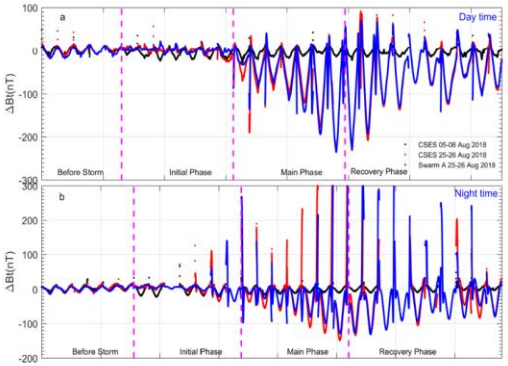
Dataset:Standard scientific data product L2
（8 payloads）
2019.1-2023.2

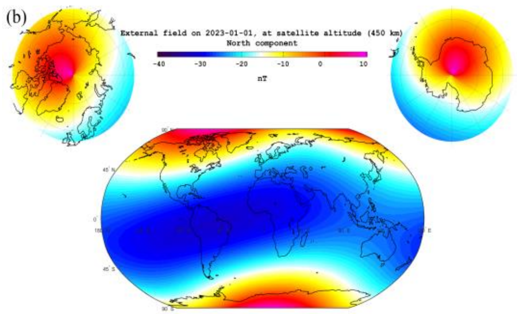
Data outcomes #2: Theme datasets

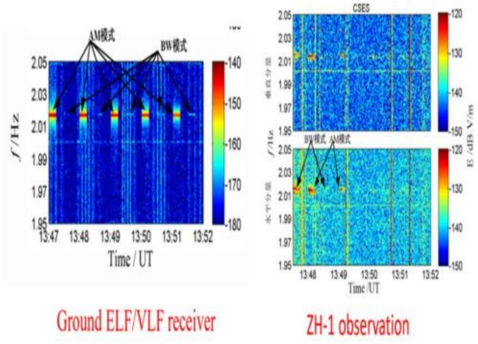
Theme dataset:

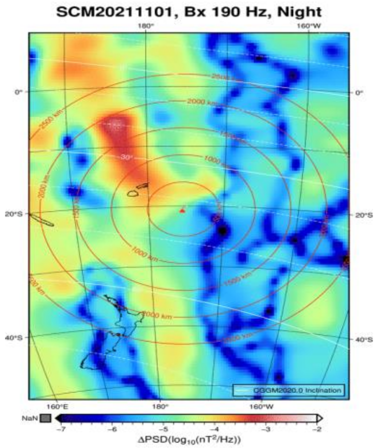
- ➢ Strong earthquake event dataset (56 events)
- ➢ Space weather event dataset (49 events)
- ➢ Volcano event dataset (1 event)
- ➢ Satellite-ground experiment dataset (3 Categories)
- ➢ Geophysical field model dataset (4 models)











Strong EQs dataset （56 events）

Space Weather dataset （49 events）

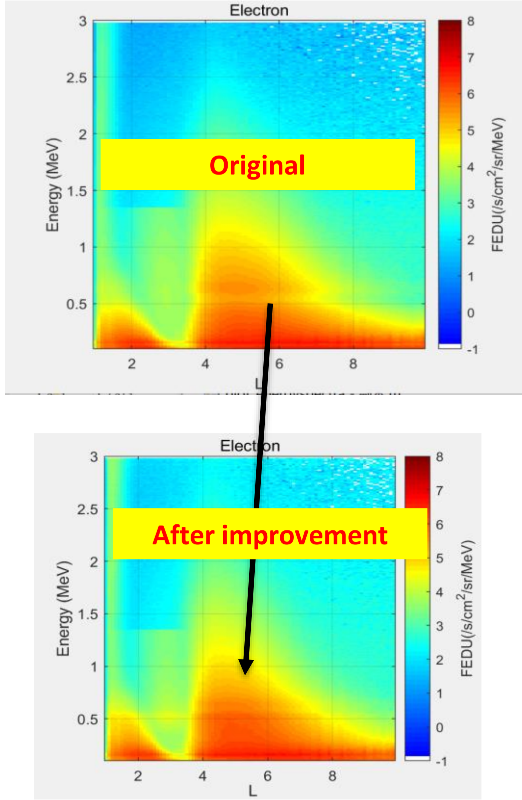
Geophysical field models （4 models）

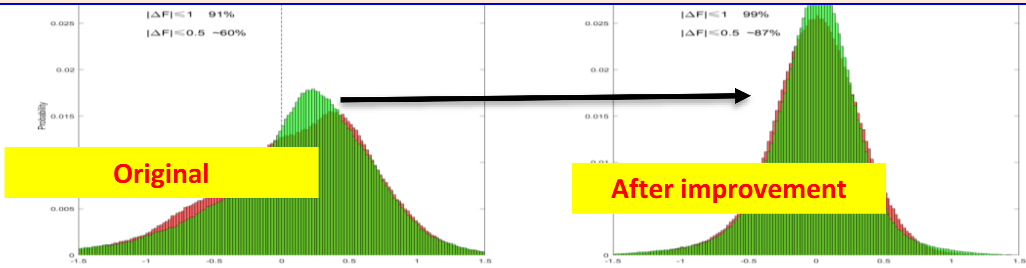
Satellite-ground experiments （3 categories）

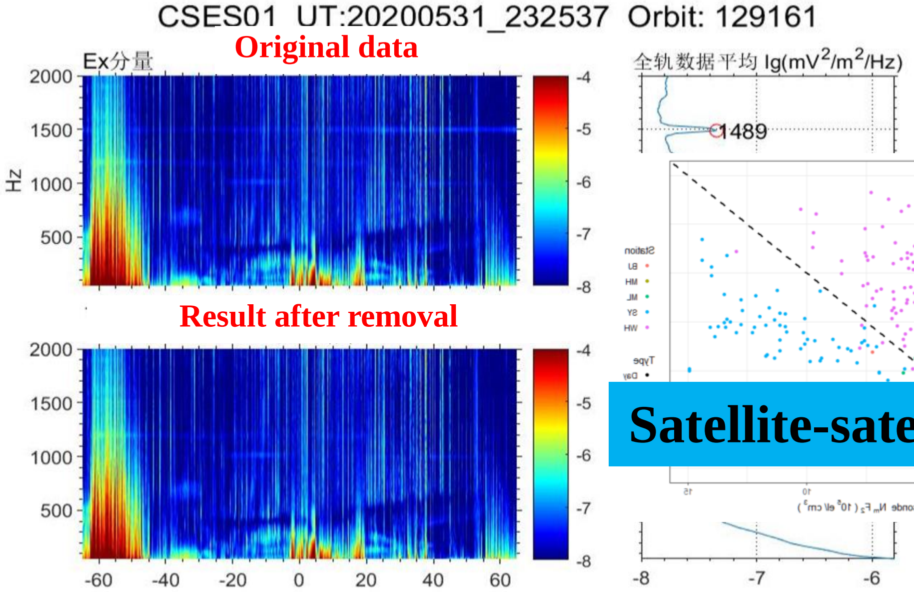
Volcano dataset (1 event)

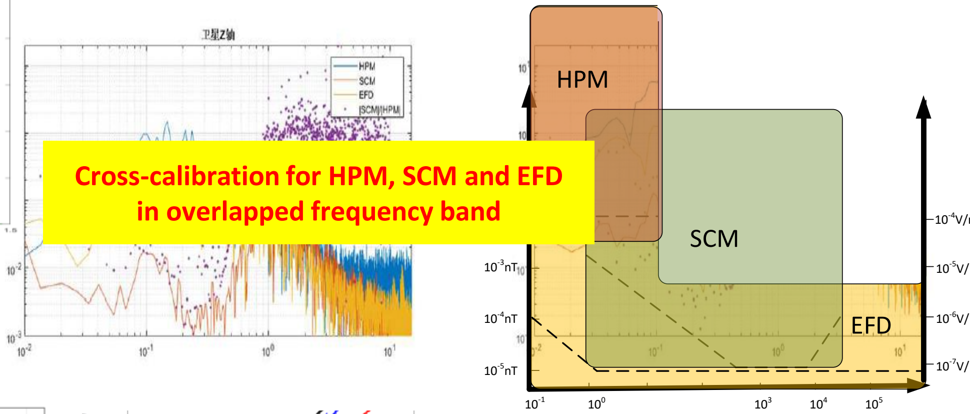
Data outcomes #3: Data processing,val/cal methods

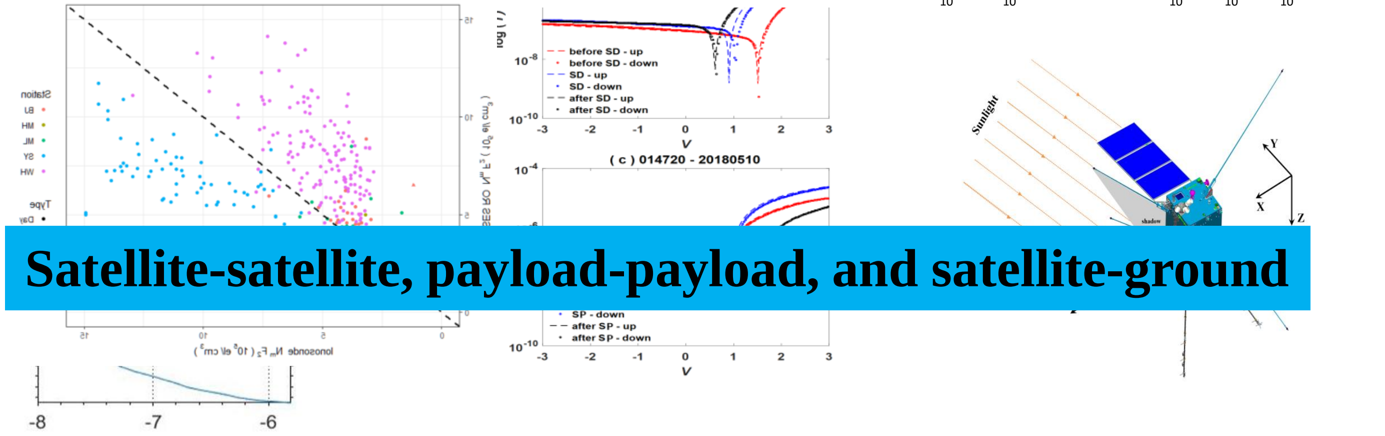
Oriented to the specific configuration of the CSES payloads, we broke through a series of key techniques in data processing, and data calibration/validation, some of the results are unique and exclusive to the world.

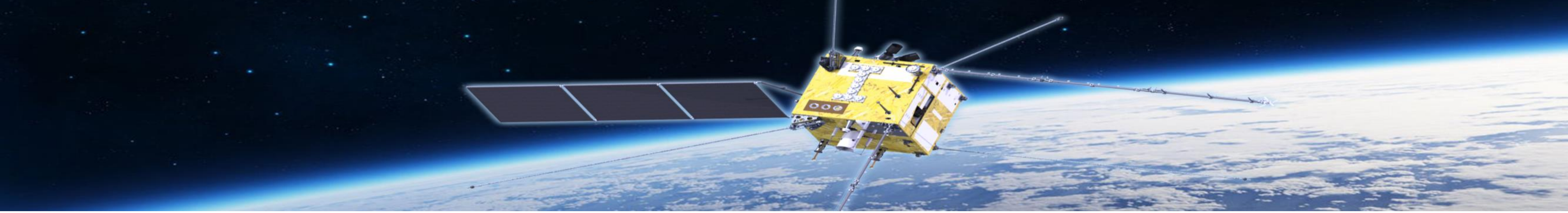












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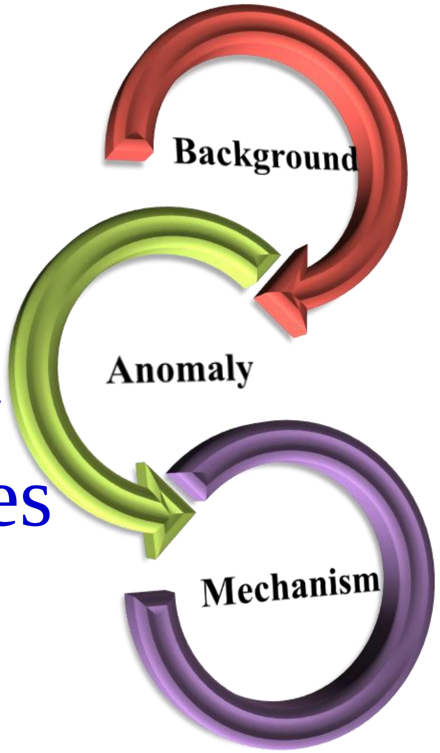


1) Space environment

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

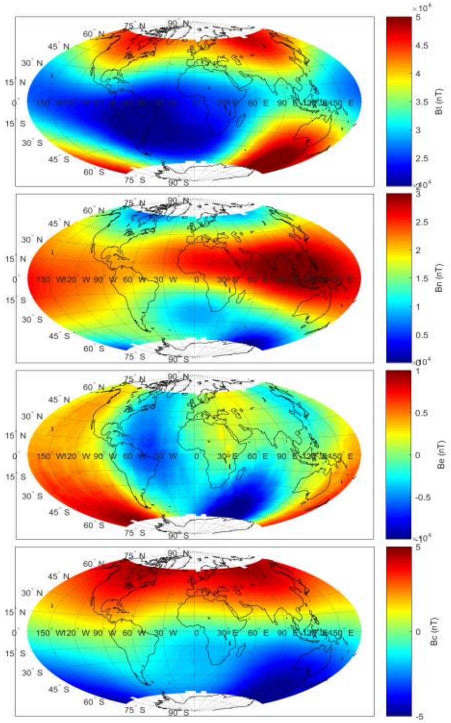
2) The EM field/waves in ULF/ELF/VLF/HF band

F

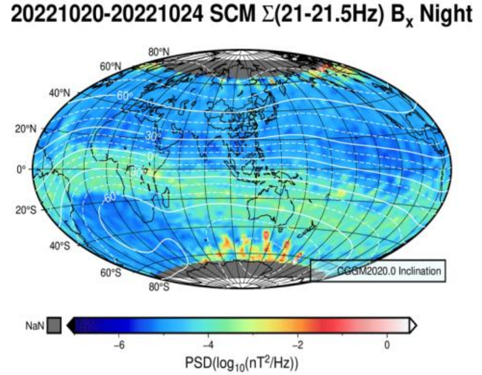
B_N

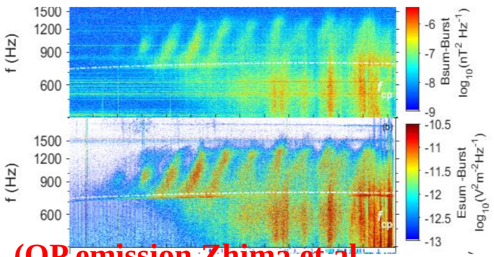
B_E

B_c

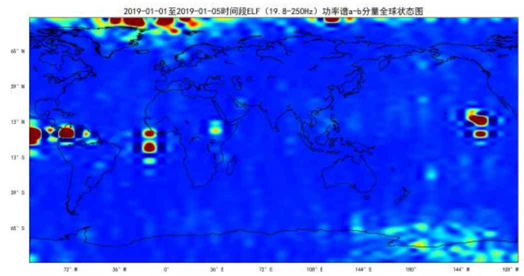


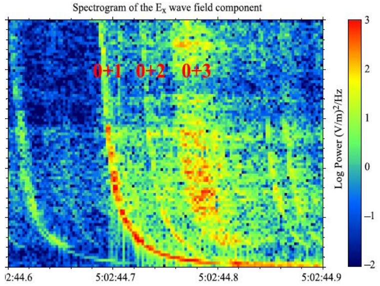
(Yang et al., 2021, JGR)



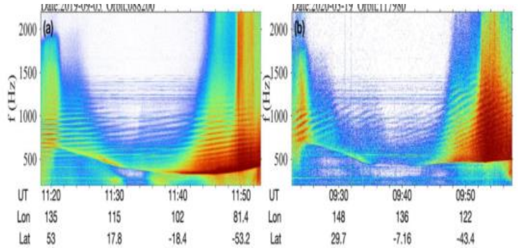


(QP emission Zhima et al., 2020, JGR,地球物理学报)

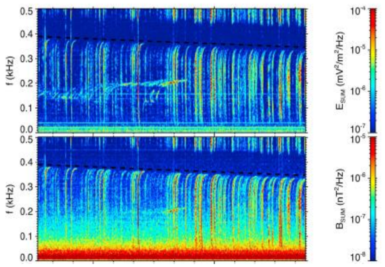




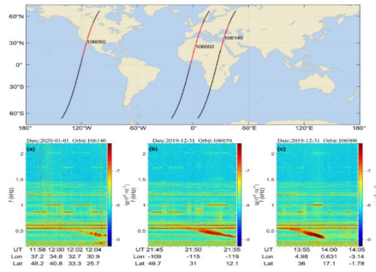
Lightning Whistler (袁静等， 2020a,b）



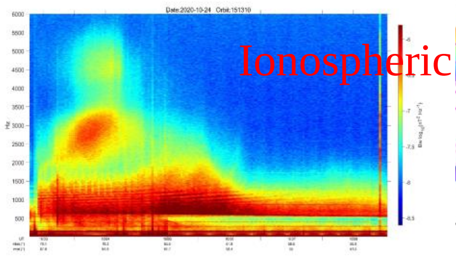
(MLR waves, Hu et al., 2022, JGR)



Ion cyclotron waves Hu et al., submission)

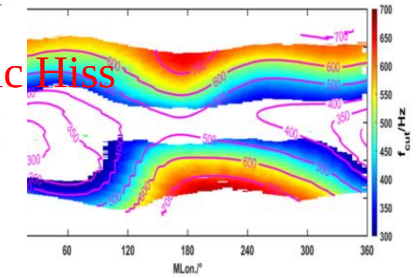


Zhao et al,, 2022, JGR)

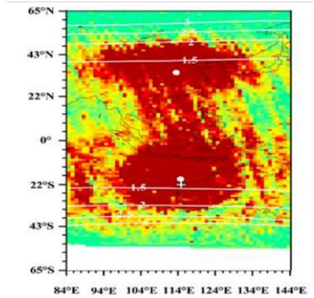


Ionospheric Hiss

,Lv et al,, 2023,Frontiers



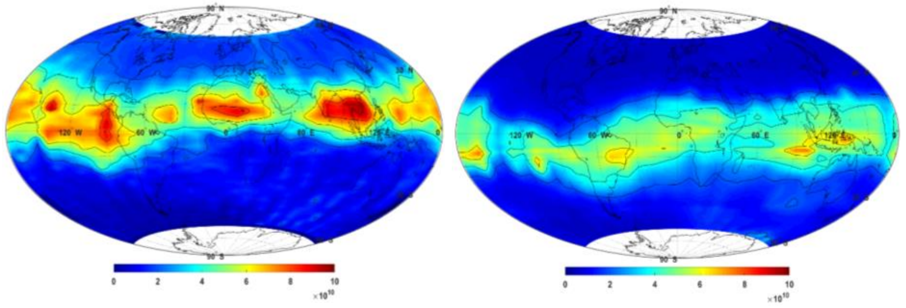
Wang et al,, 2023, JGR)



VLF transimitter Zhao et al., 2020, JGR

Background #1: Space Environment

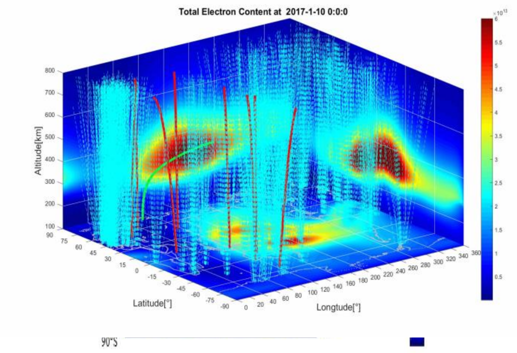
3) The ionosphere plasma environment

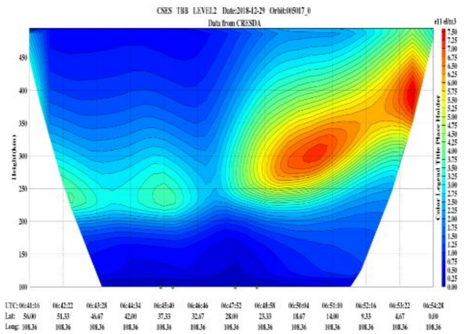


(a)July 12 - 19, 2018 (b)Nov. 18 -27, 2018

Yan et al. JGR，2021

TEC **Ne-TBB**

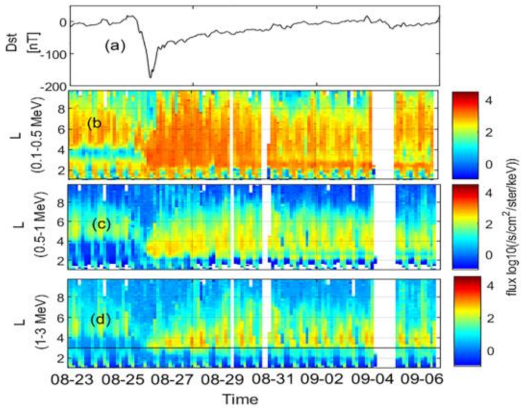




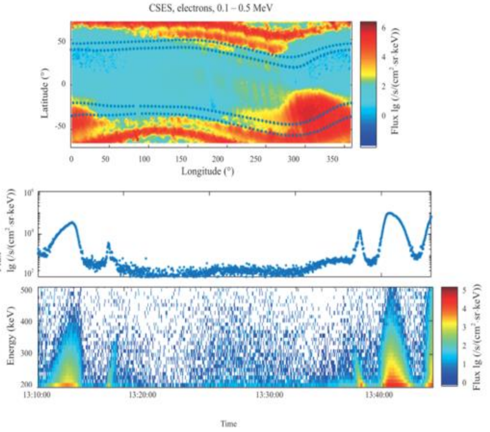
Xu et al. RS，2023, submission

4)The energetic particle and wave-particle interaction

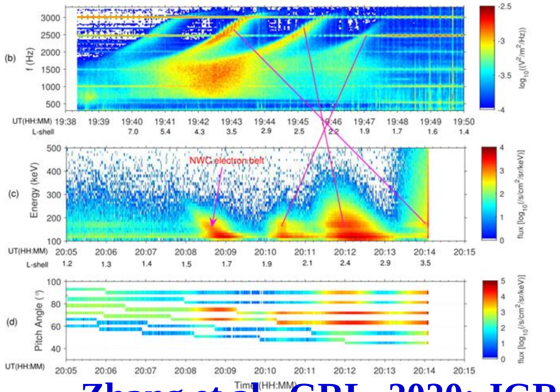
Whistler waves accelerate relativistic electrons



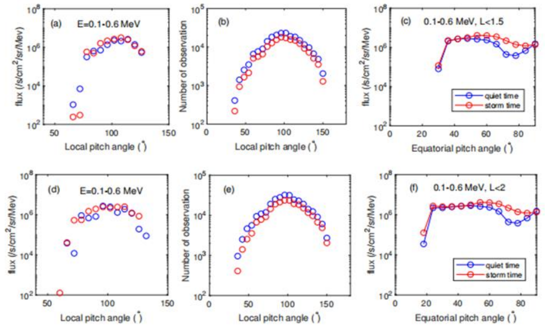
Ground-based man-made NWC electron precipitation belt



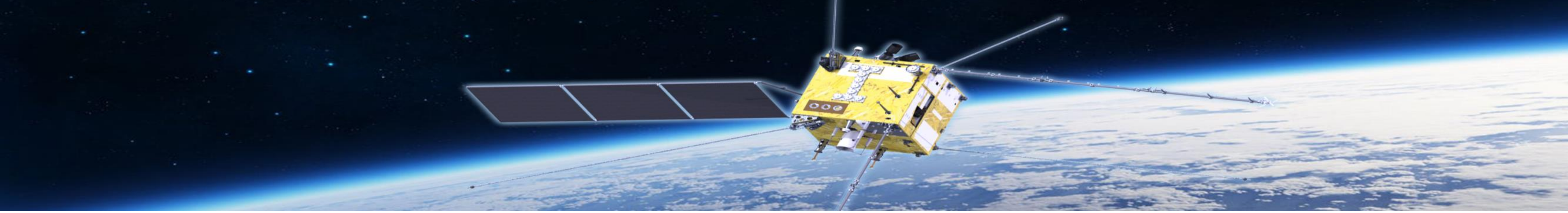
QP waves and induced electron precipitation



Magnetosonic wave accelerate electrons in inner belt



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



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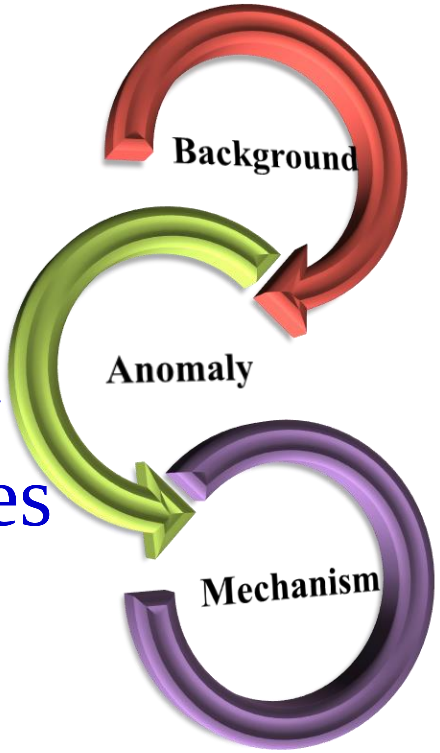


1) Space environment

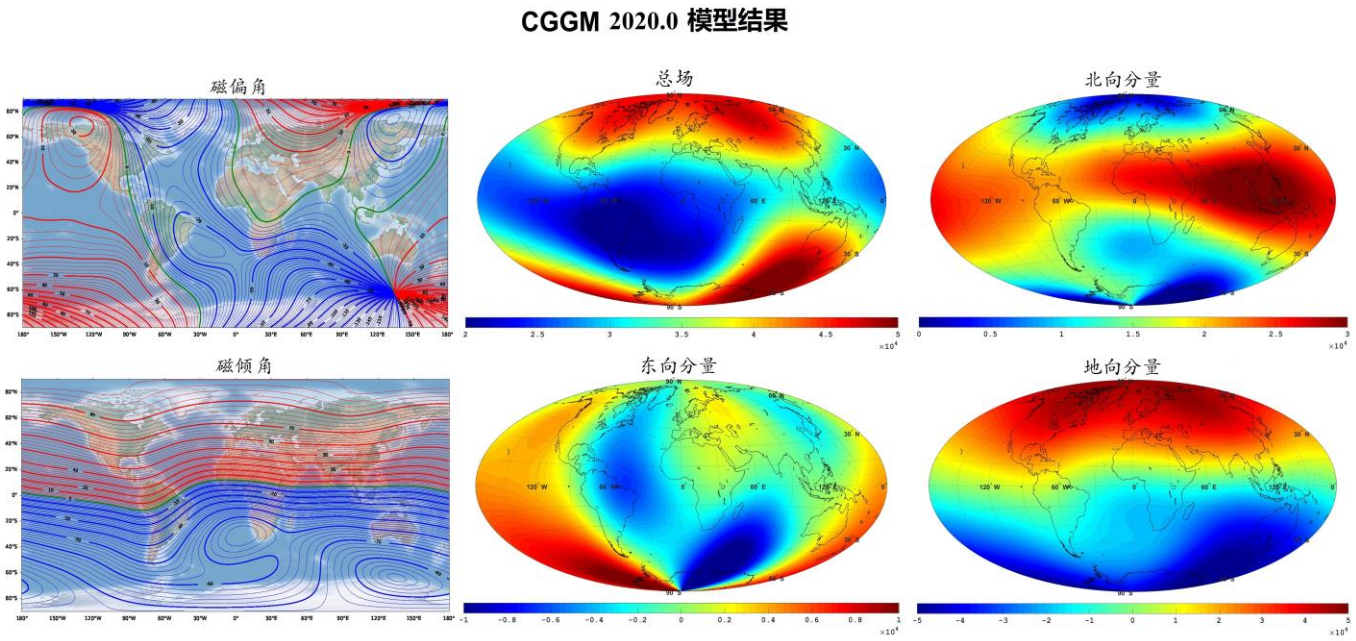
2) Geophysical field models

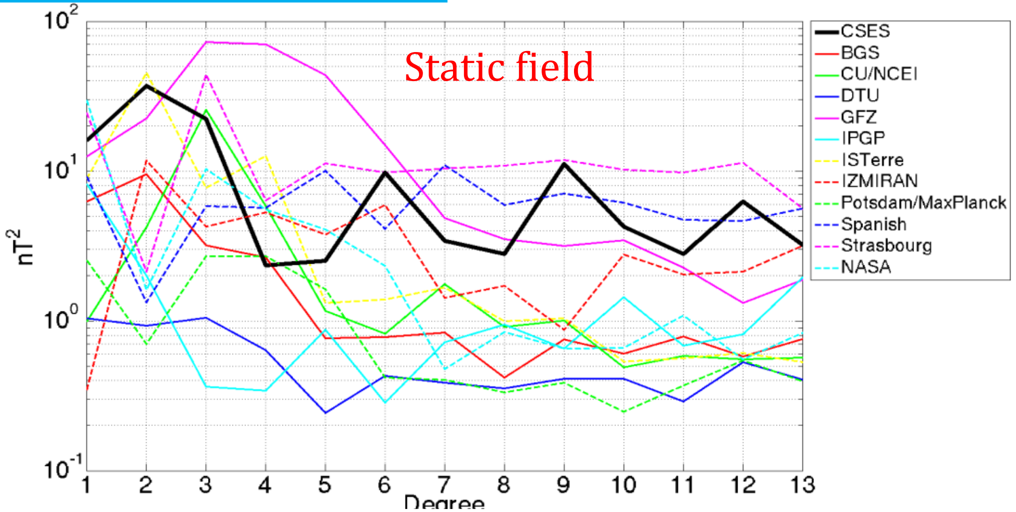
3) Natural hazards disturbance
(e.g., earthquake, space weather, volcano… etc.)

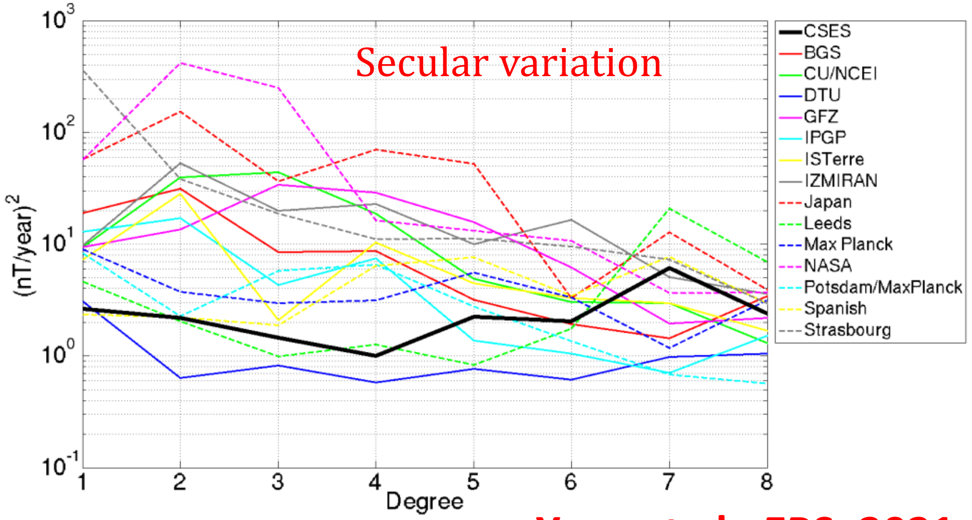
4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Background #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

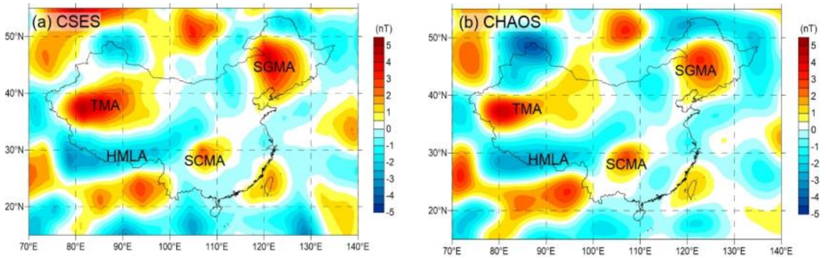
The comparisons of CGGM with the final IGRF-13 and other candidate models revealed a remarkable agreement

Yang et al., EPS, 2021

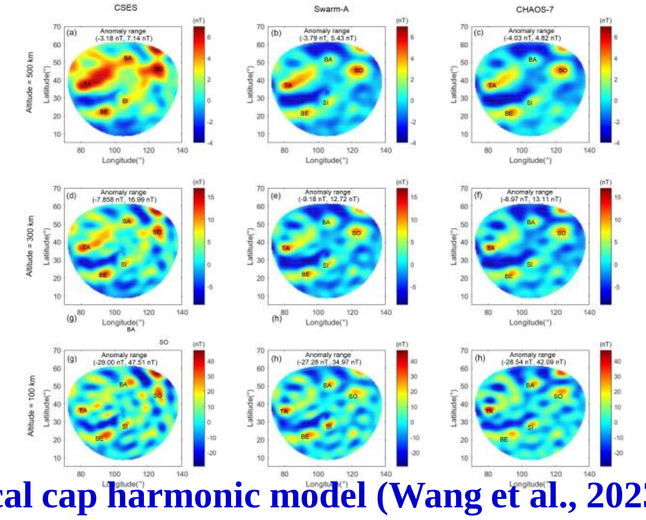
Background #2: geophysical field-lithospheric magnetic field

2) The lithospheric magnetic field models

a) Regional model -China

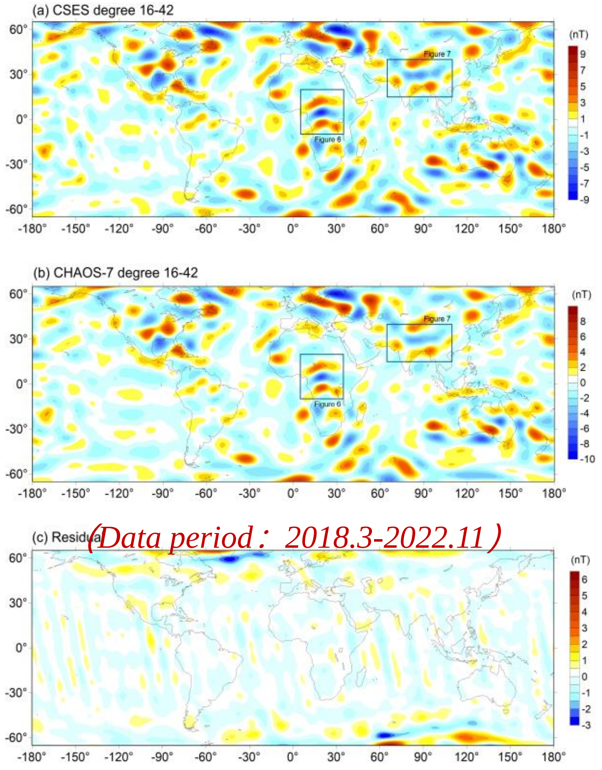


First CSES magnetic anomaly map in China (Wang et al., 2020)

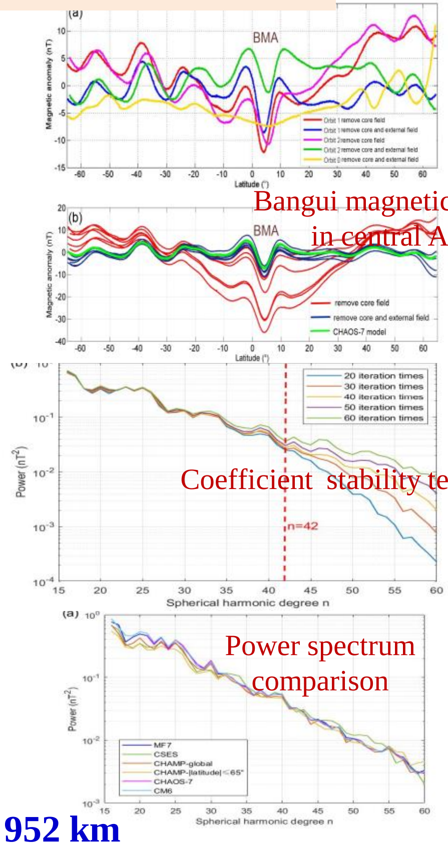


Spherical cap harmonic model (Wang et al., 2023a)
maximum degree 53.17， wavelength 752 km

b） Global model



（Data period： 2018.3-2022.11）



Bangui magnetic anomaly in central Africa

Coefficient stability test

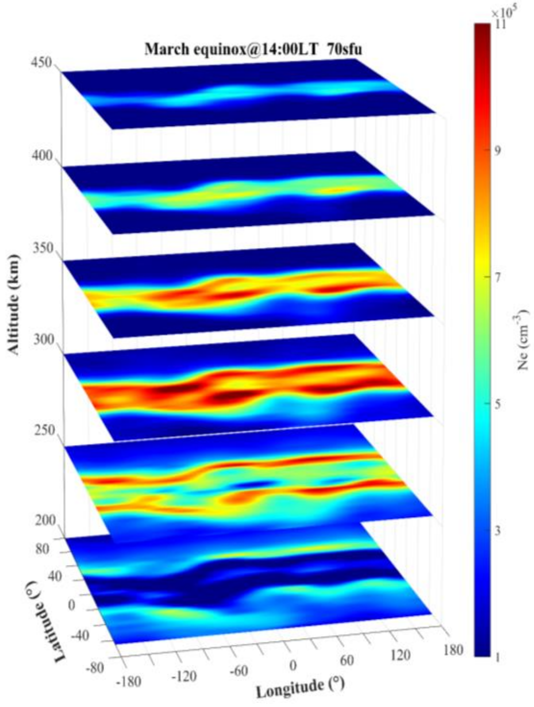
Power spectrum comparison

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

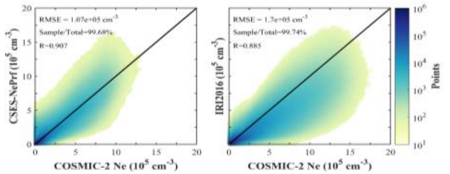
Background #2: geophysical field models-electron density

3) The electron density models

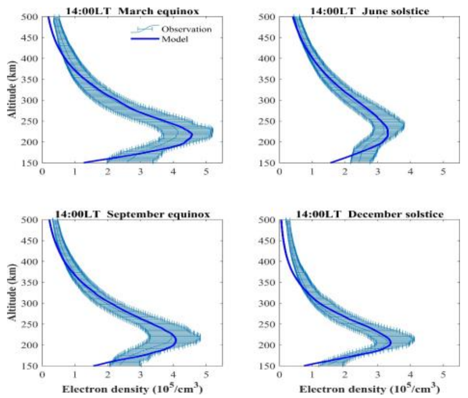
a） CSES data



3D electron density structure



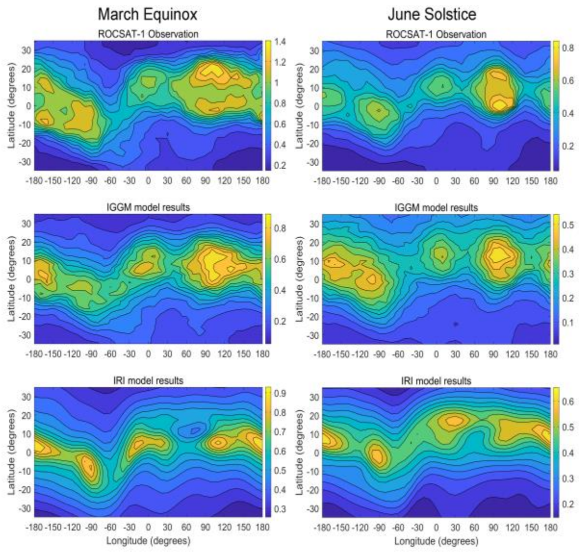
Better performance than IRI



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

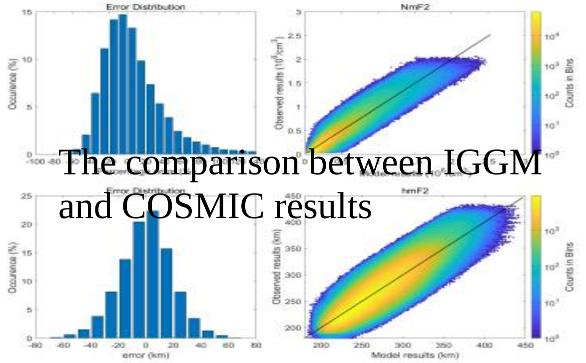
Huang et al., Space Weather, 2022

b） Multi-satellite data

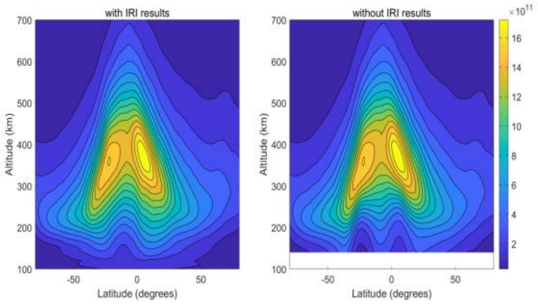


The comparison between IGGM (middle)/IRI (bottom) and ROCSAT-1 (top) observations

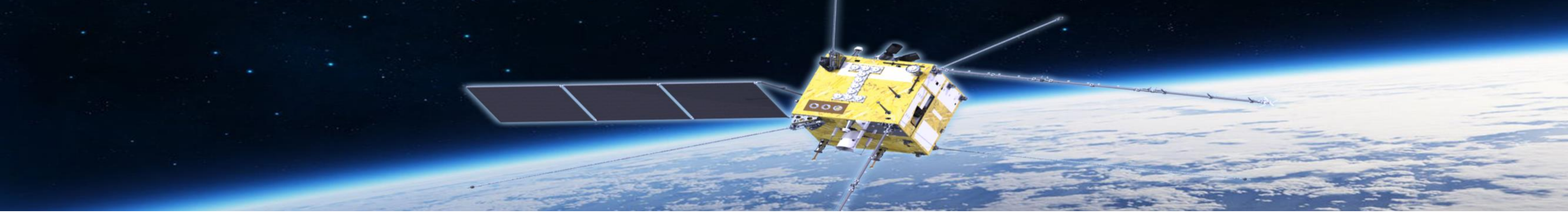
Results from IGGCAS



The comparison between IGGM and COSMIC results



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



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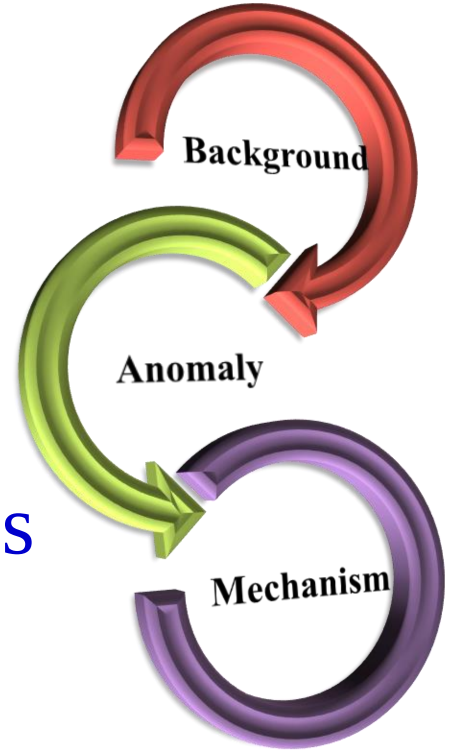


1) Space environment

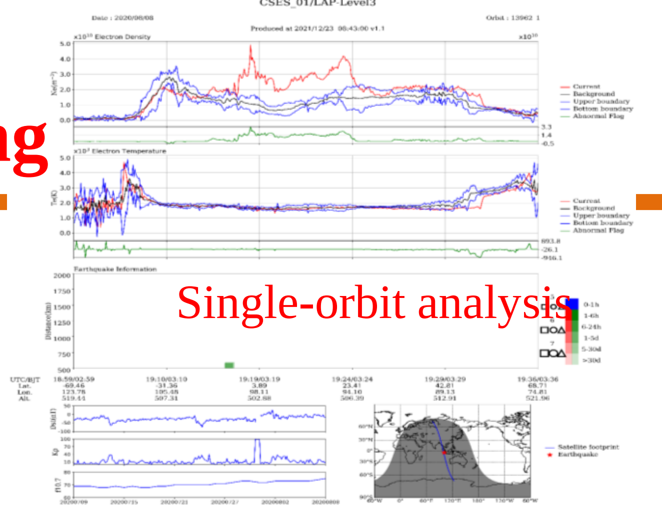
2) Geophysical field models

3) Natural hazards disturbance

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

4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Anomaly #a: Earthquake-routine tracking monitoring



Single-orbit analysis

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

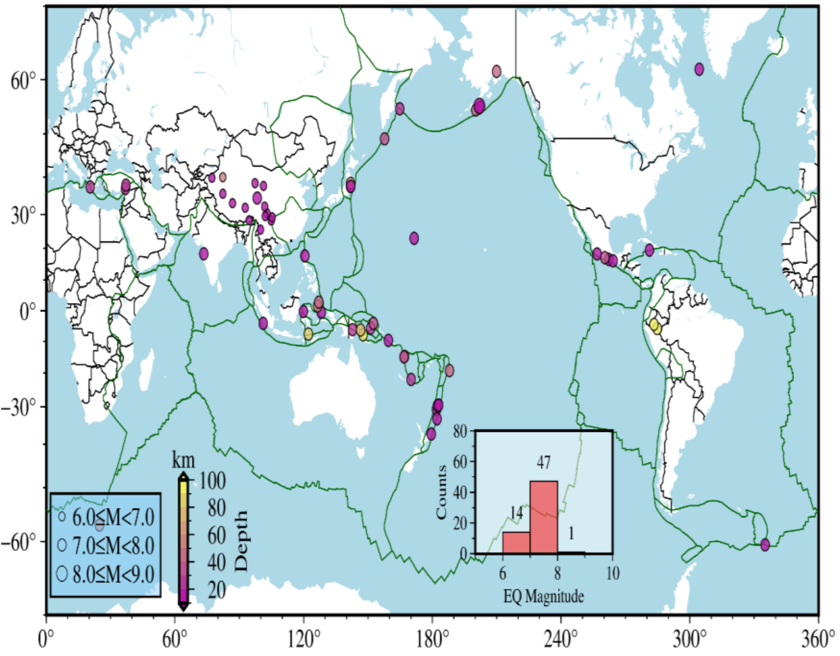
The sequence built by revisiting orbits

Step 6: Background map

Step 7: Multi-parameter comparisons

RS: Infrared/hyperspectral satellites

Ground: GNSS TEC, EM waves, electric field

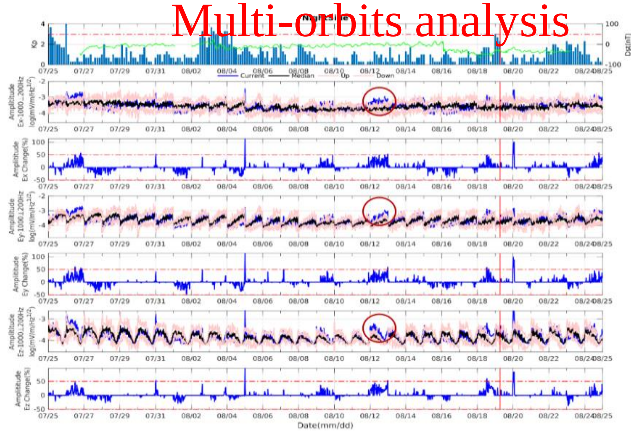


Febr. 2, 2018 to Freb. 2, 2023:

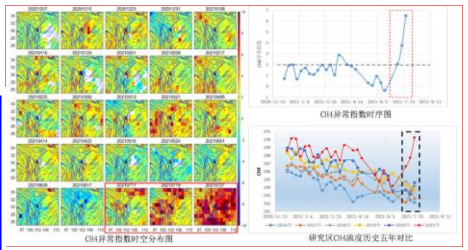
Global: 74 EQs (M 7+)

China: 16 EQs (M 6+)

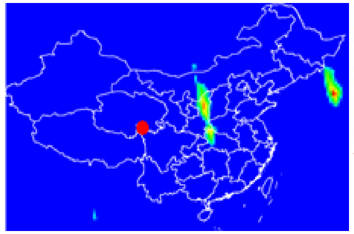
Multi-orbits analysis



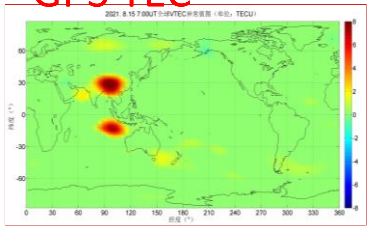
Hyperspectral



Infrared



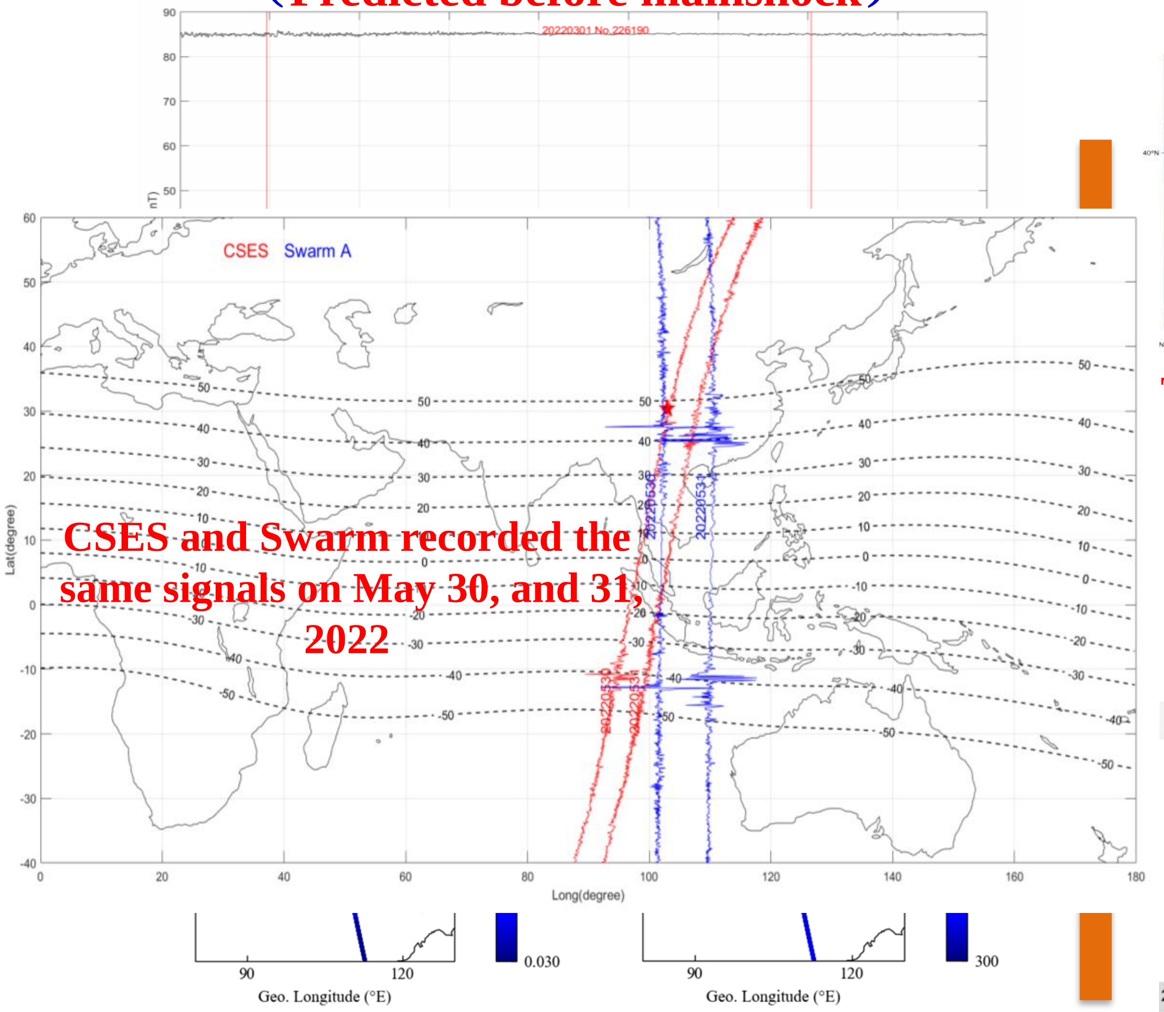
GPS TEC



[Zhima et al., 2022]

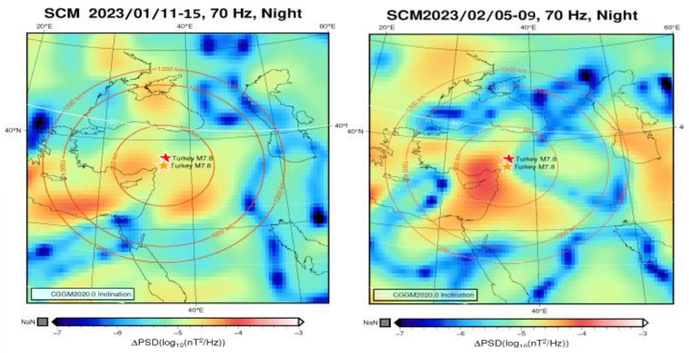
Anomaly #a : Earthquake-case study examples

Ms 6.1 Lushan EQ on June 1, 2022 in China
（Predicted before mainshock）

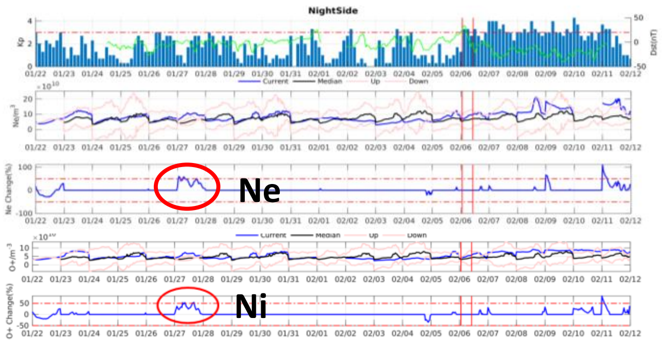


NO+/Ti enhancement 2 days before EQ [from Dapeng Liu]

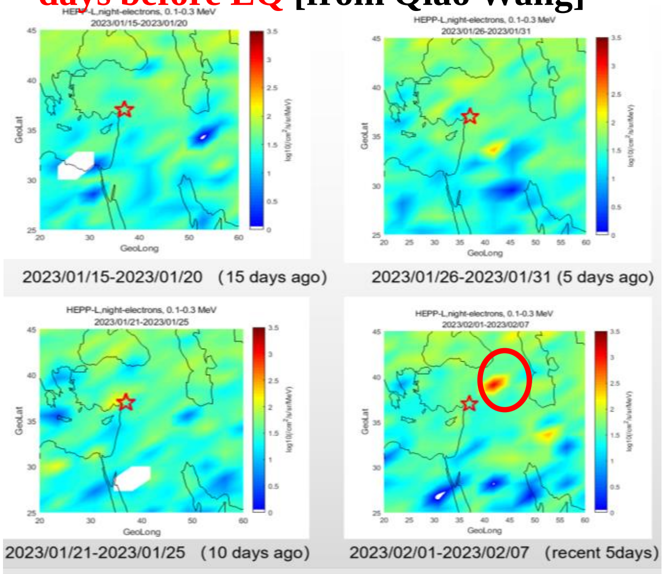
Ms 7.6 Turkey-Syria two earthquakes on Febr. 6, 2023
（extracted after shock）



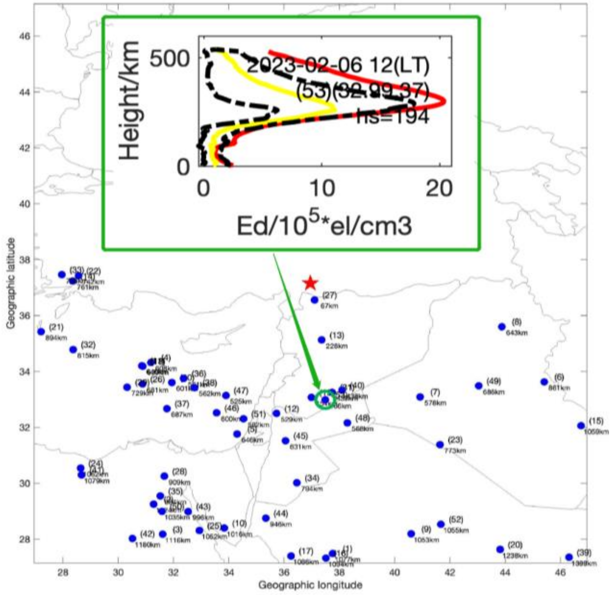
The magnetic field in ULF band 11 -15 days before EQ [from Qiao Wang]



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



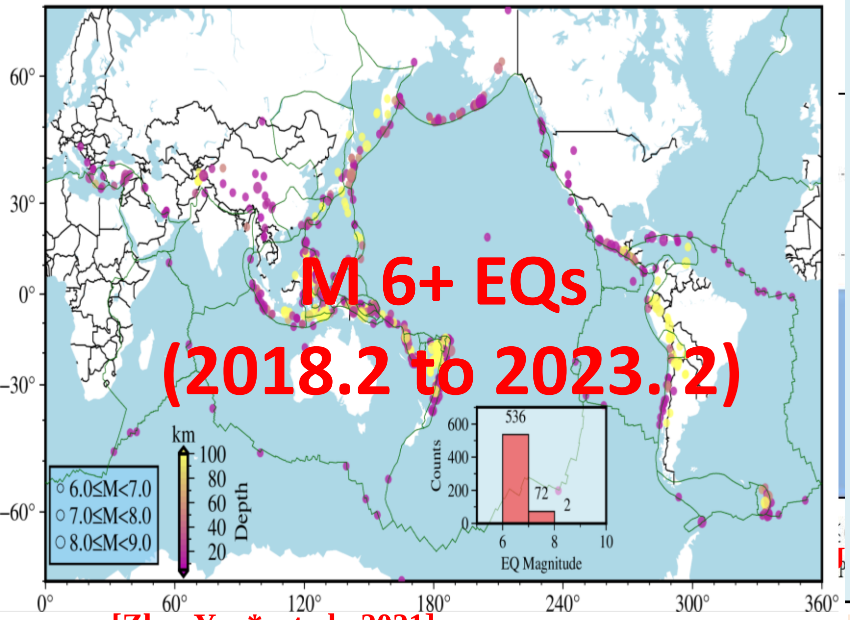
The particle flux enhancement 1 to 5 days before EQ [from Zhenxia Zhang]



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

Anomaly #a: Earthquake-statistical analysis after EQs

1) Plasma Parameters

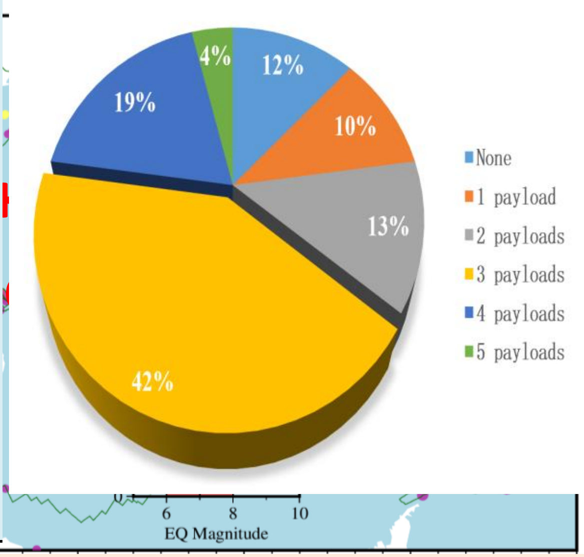


[Zhu, Yan*, et al., 2021]

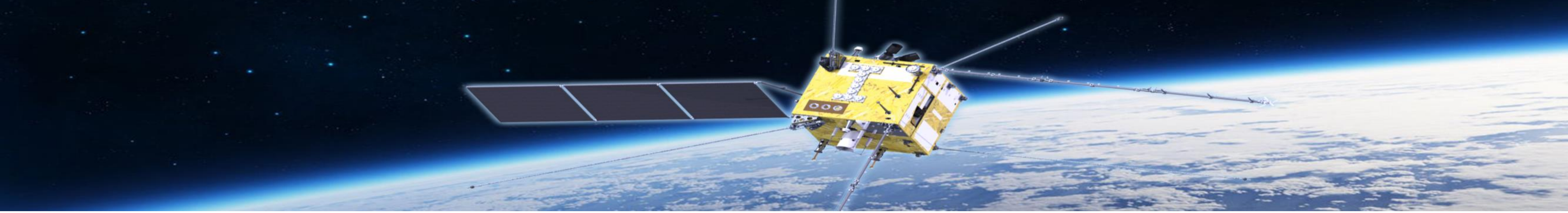
1. Anomaly mainly occurs 1-7 days and 13-15 days before EQs.
2. The detection rate depends on magnitude and focal depth.

2) The multi-physical values

EQ (M>7 &depth <100km)			
Payload	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. The detection rates of LAP, EFD, and SCM are over 70%
2. 88% of EQs can be recorded at least by one payload
3. 60% of EQs can be recorded by 3 or 4 payloads simultaneously
4. Anomalies preferably occur on the mainshock day,,7, 11-15, 20-25 days or before mainshock days
5. Anomaly predominately appear on the east and south sides of the epicenter



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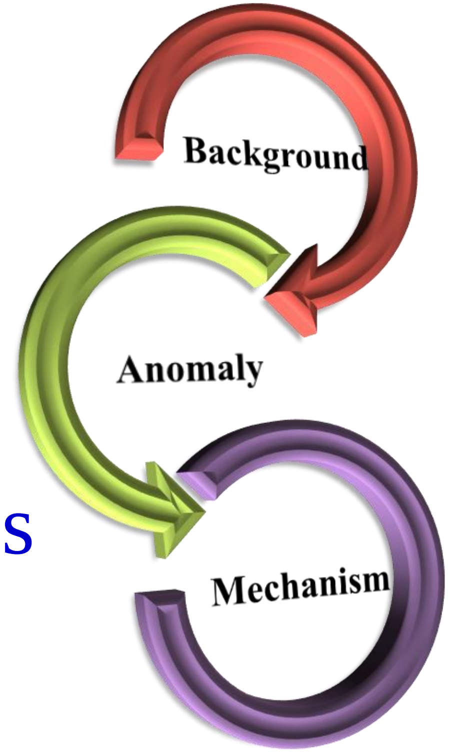


1) Space environment

2) Geophysical field models

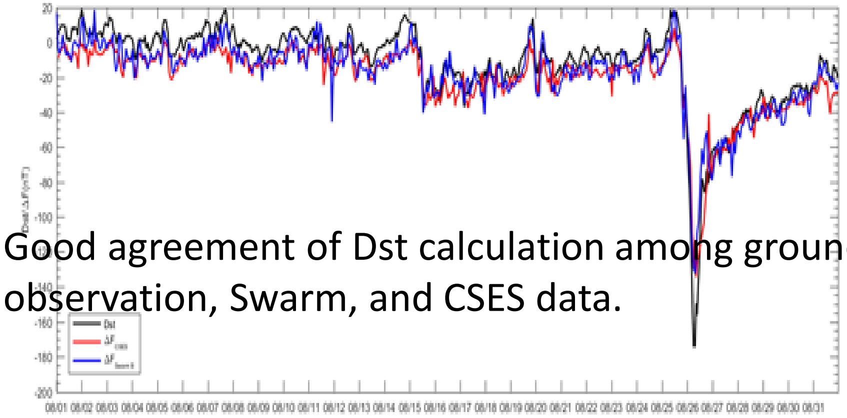
3) Natural hazards disturbance

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

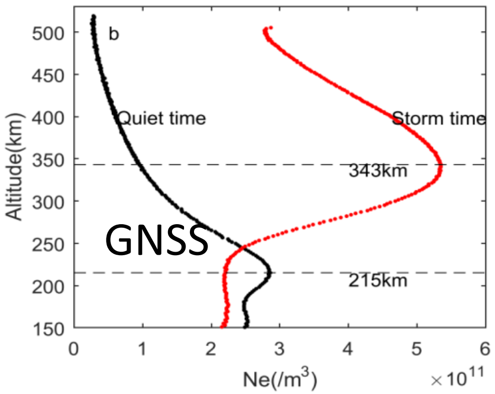
4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

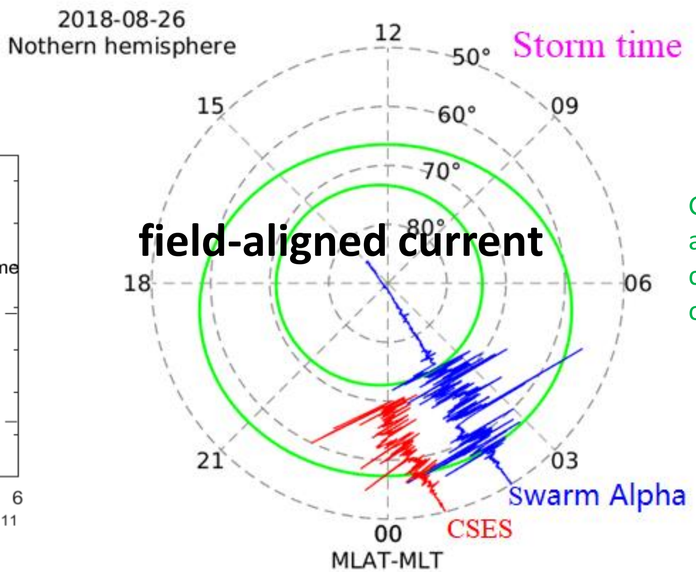
Anomaly #b: Space weather disturbances (1)

Well response to space weather event

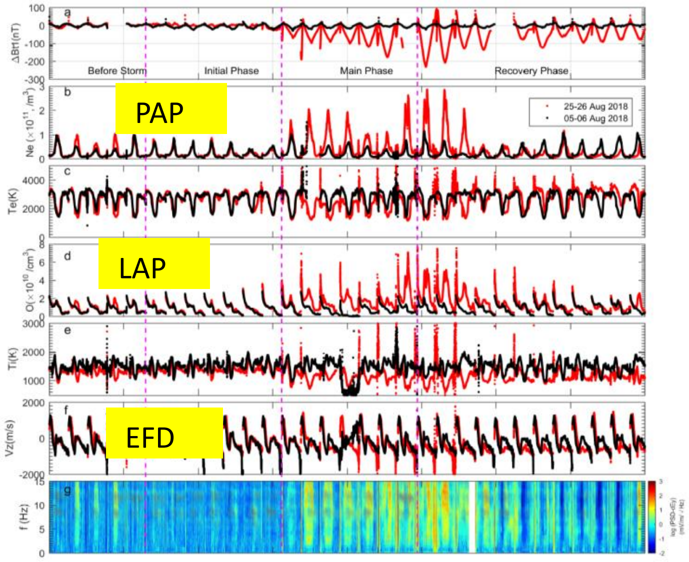


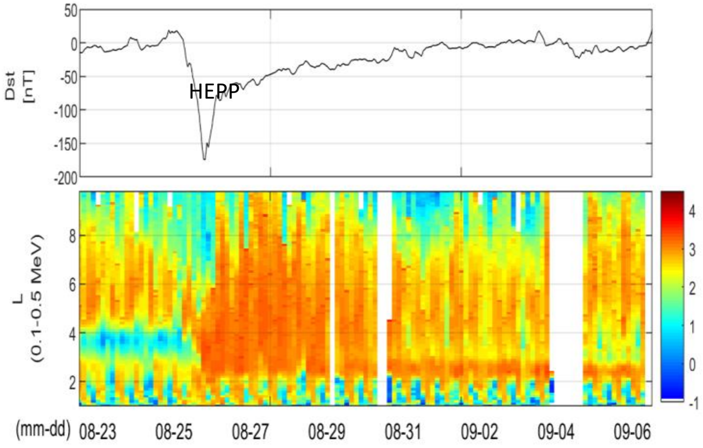
Good agreement of Dst calculation among ground observation, Swarm, and CSES data.

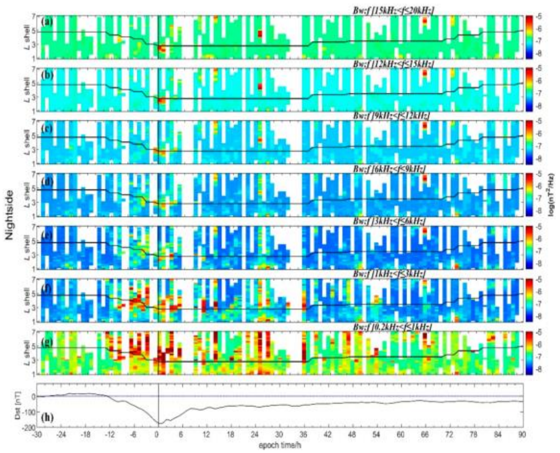


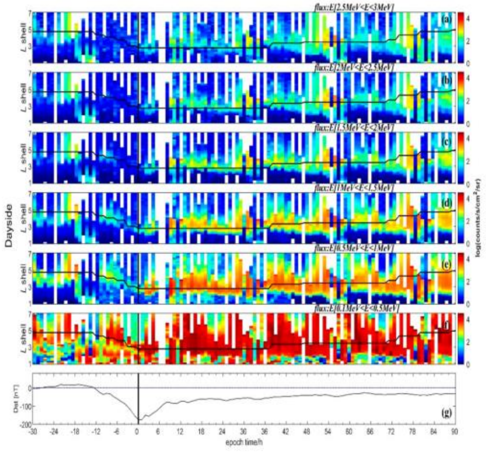


Green： The equatorial and polar boundaries calculated by the field-oriented current model







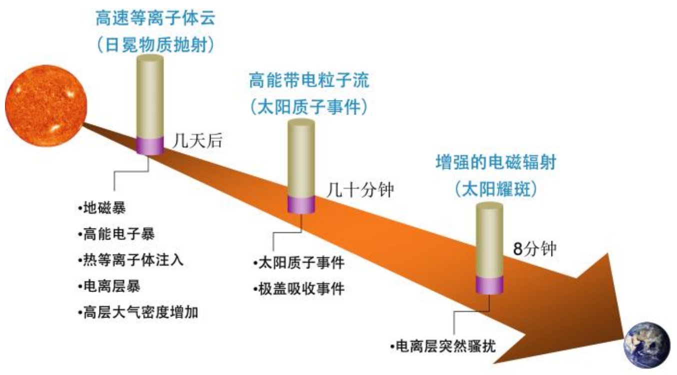


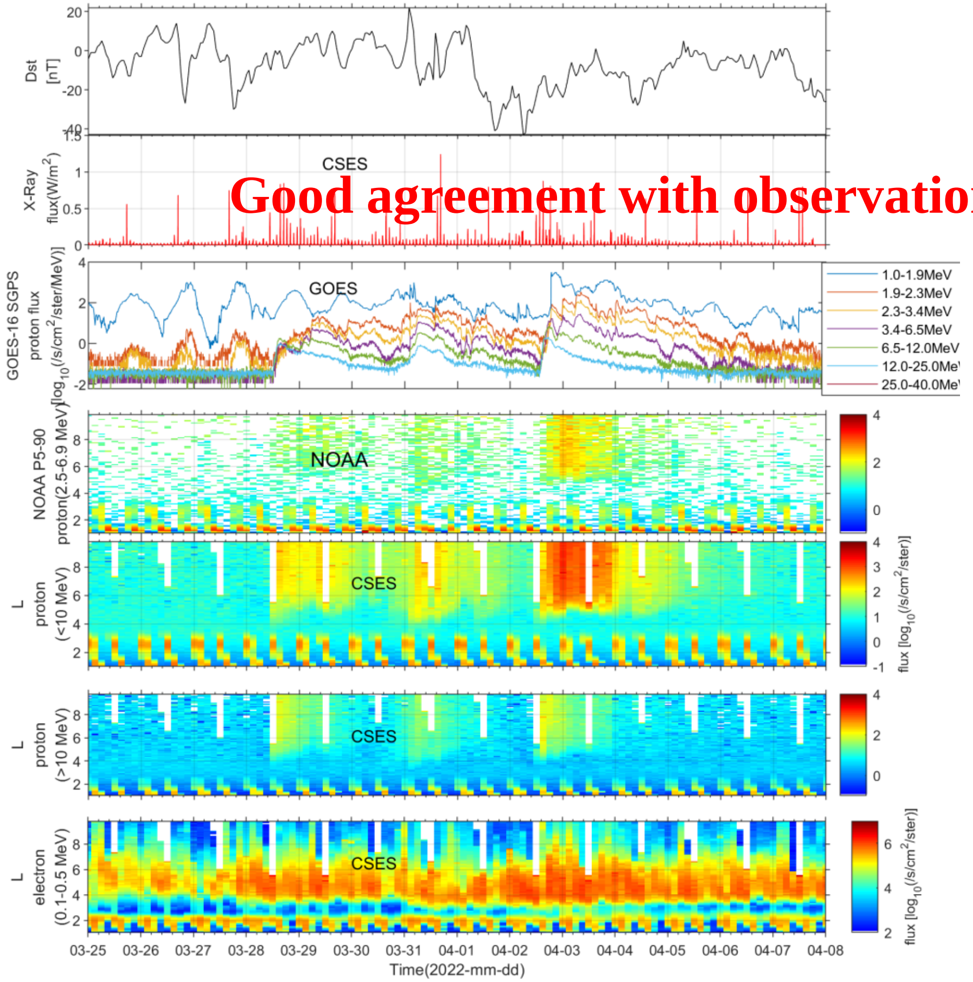
Yang et al., Space Weather, 2020

Zhima et al., 2021

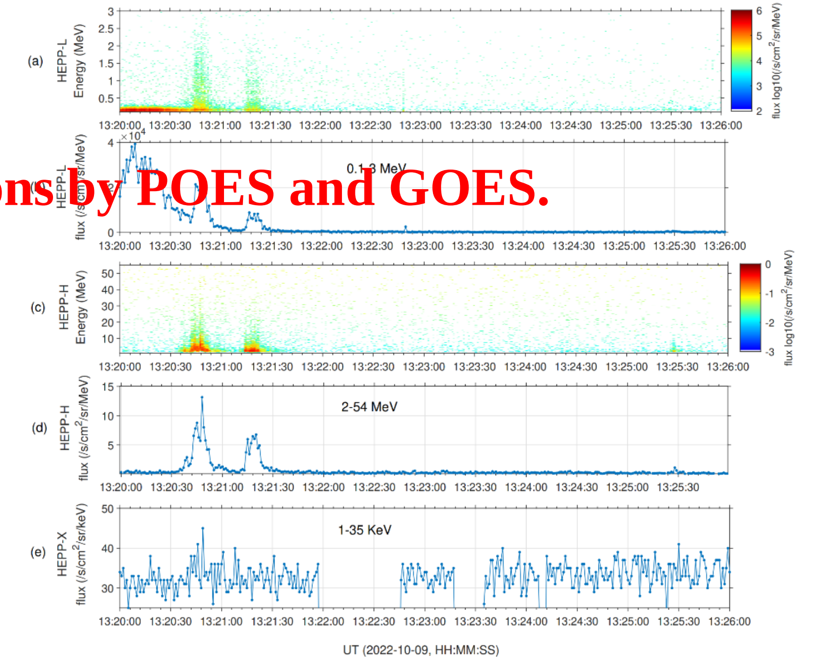
Anomaly #b: Space weather disturbances (2)

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





Good agreement with observations by POES and GOES.



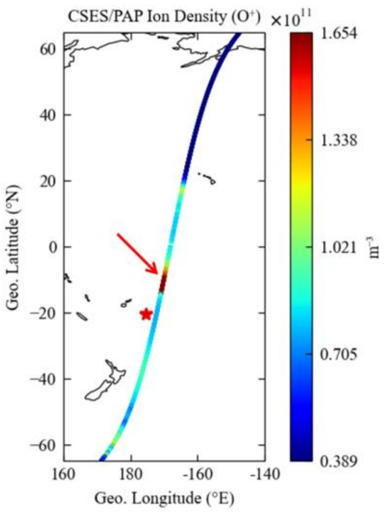
Based on CSES, Solar flare X-ray, solar proton event, geomagnetic storm and electron injection took place successively.

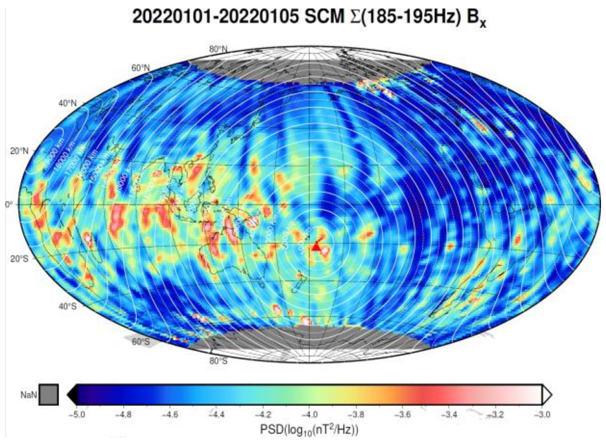
Zhang et al., 2021, JGR;

Wang L. et al., 2021;

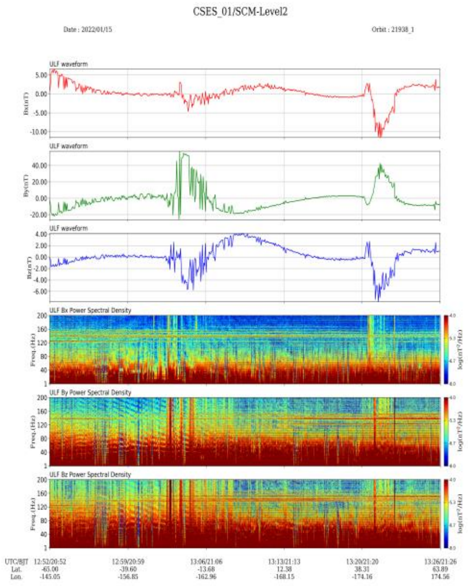
Response to the brightest gamma-ray burst by HEPP-L, H, X

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

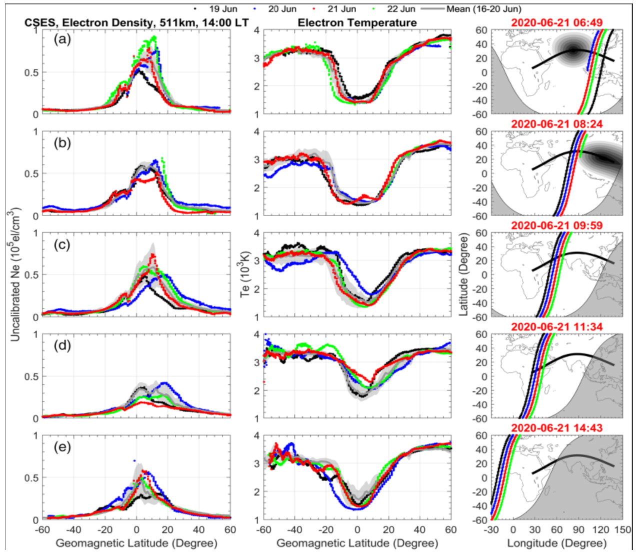




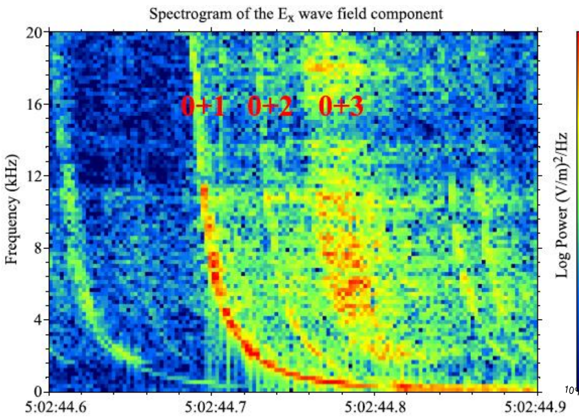
Before Tonga volcano eruption

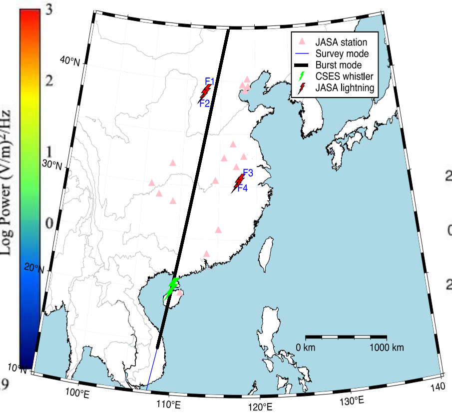


After Tonga volcano eruption

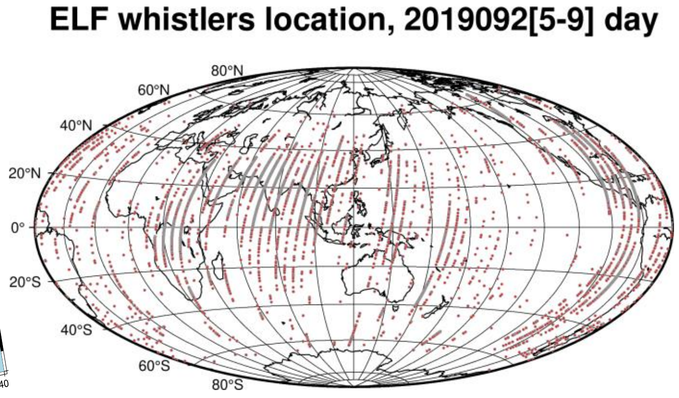


Solar Ellipse
Lei et al., 2020, JGR

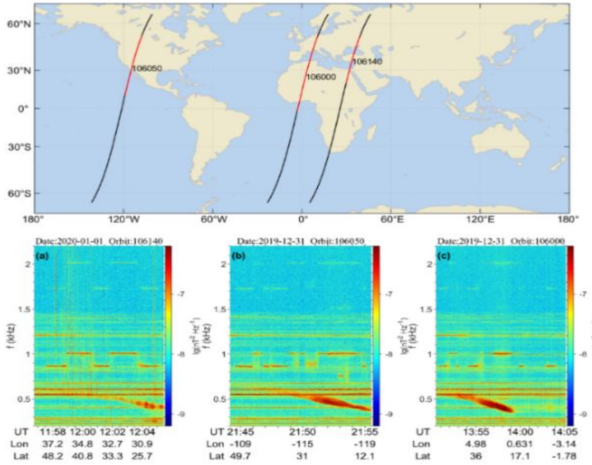




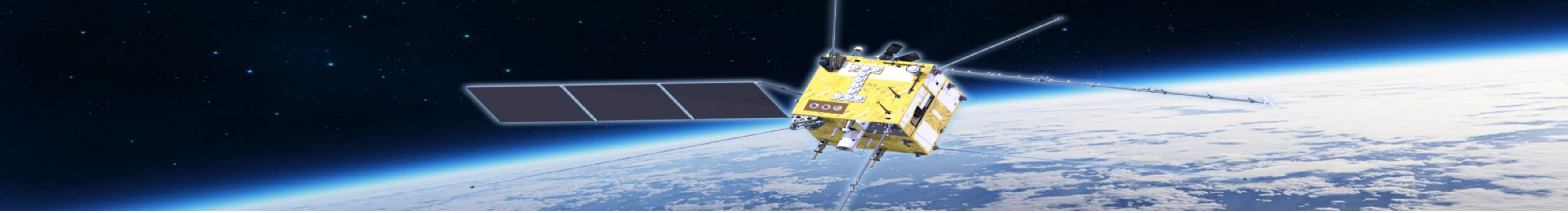
Lightning events
Yuan+Zhima etal., 2021



Wang Qiao etal., 2021



Electric power system
Zhao et al., 2022 JGR



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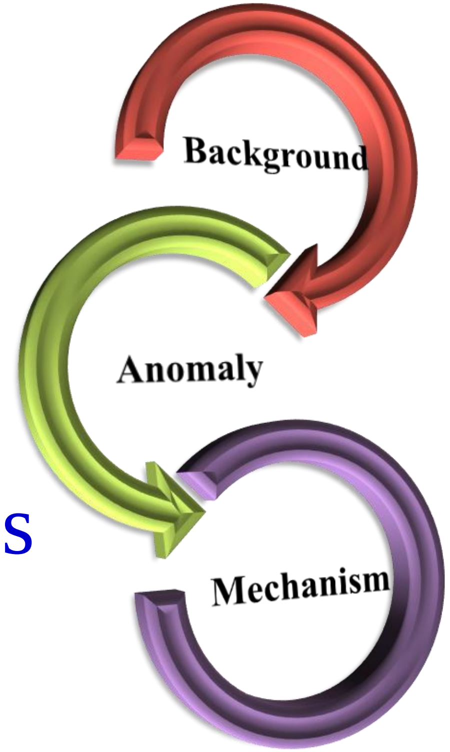

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a. Earthquake,
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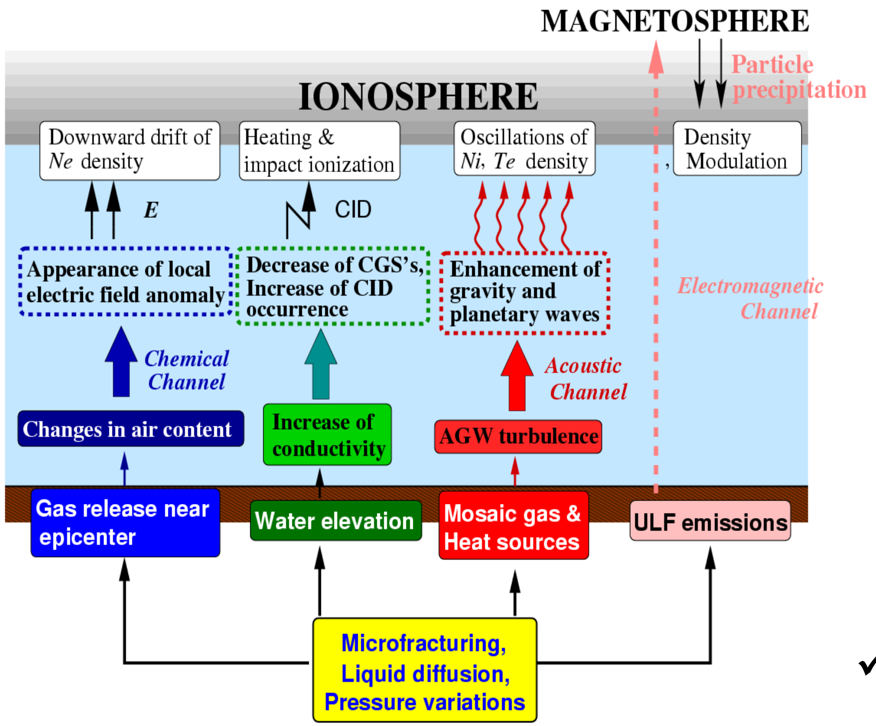
c. Volcano… etc.

4) Lithosphere-Atmosphere-Ionosphere coupling mechanism

Lithosphere-Atmosphere-Ionosphere Coupling mechanism



Hayakawa et al., 2004

Three Channels：

Chemical channel

Acoustic channel

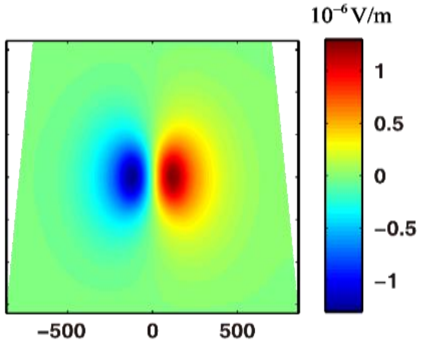
Electromagnetic channel

✓ Electric field mechanism

Vertical electric field emerging from the seismogenic zone

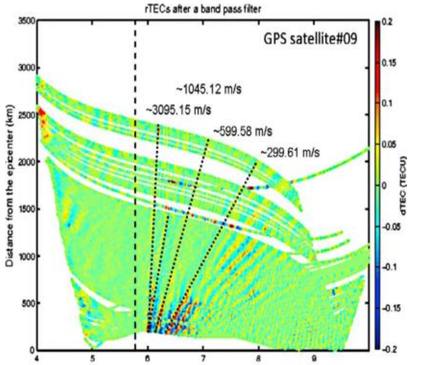
- Lithosphere:100-1000 V/m
- Ionosphere:10 mV/m

(no direct observational evidence found)



✓Acoustic gravity wave mechanism

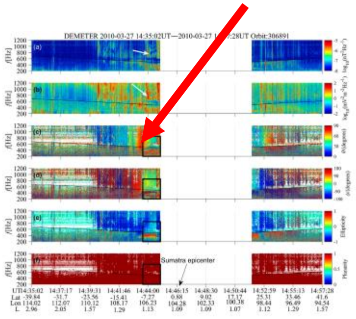
observational evidence : GNSS TEC etc



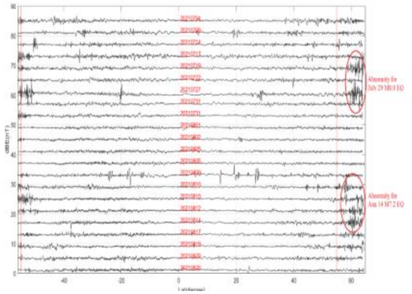
✓Electromagnetic wave mechanism (Pre-earthquake)

Electromagnetic wave emerging from the seismogenic zone

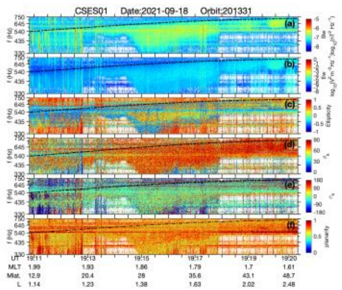
DEMETER



CSES

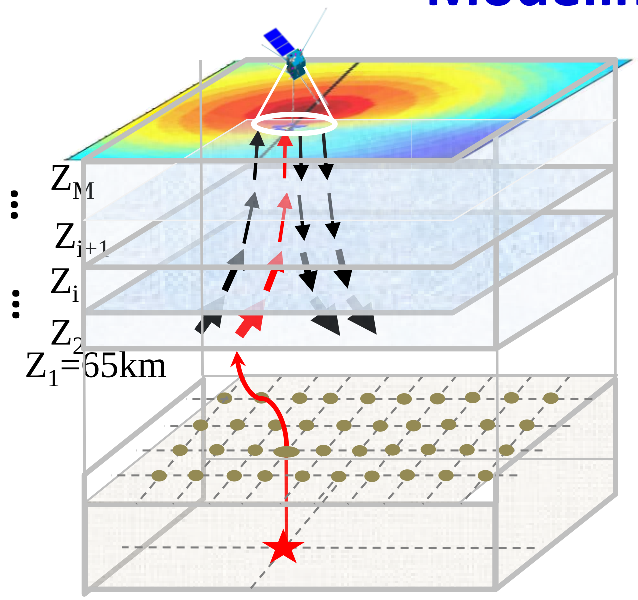


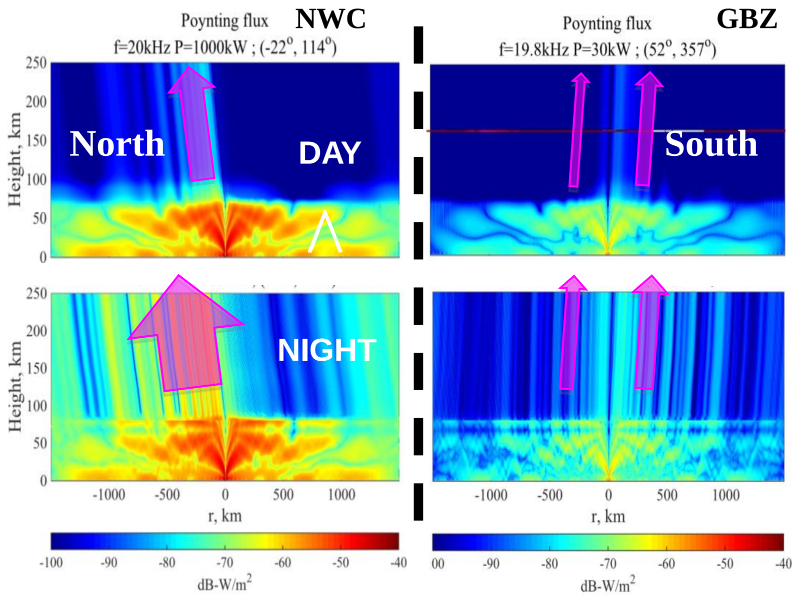
CSES



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

Modeling results





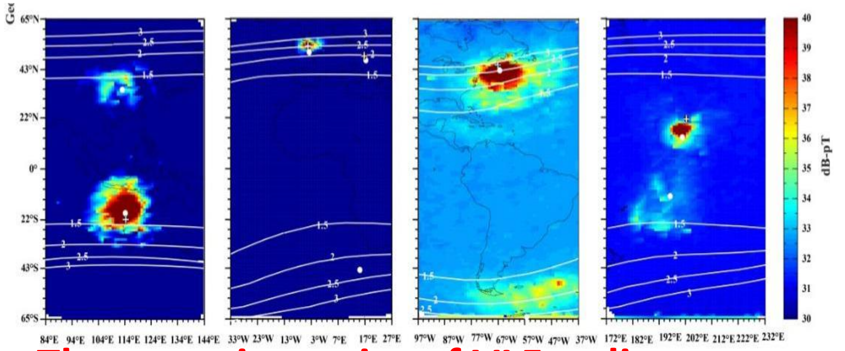
❖Propagation along the magnetic field line towards the top ionosphere

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

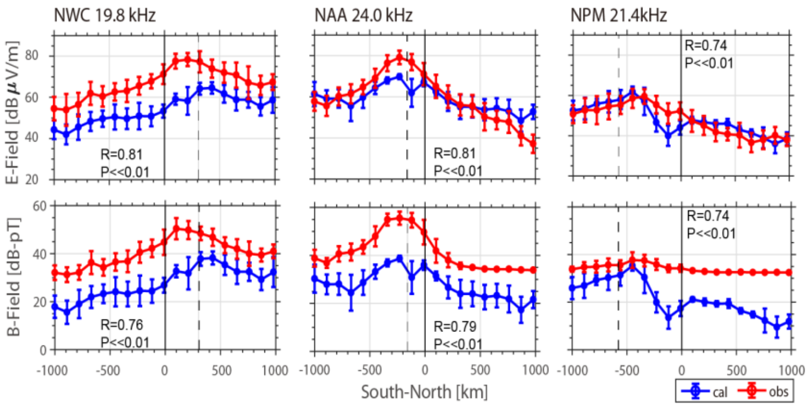
❖At night side the penetrating energy is stronger than that at dayside.

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

Observational Evidence of CSES



The wave intensity of VLF radio over of ground transmitter



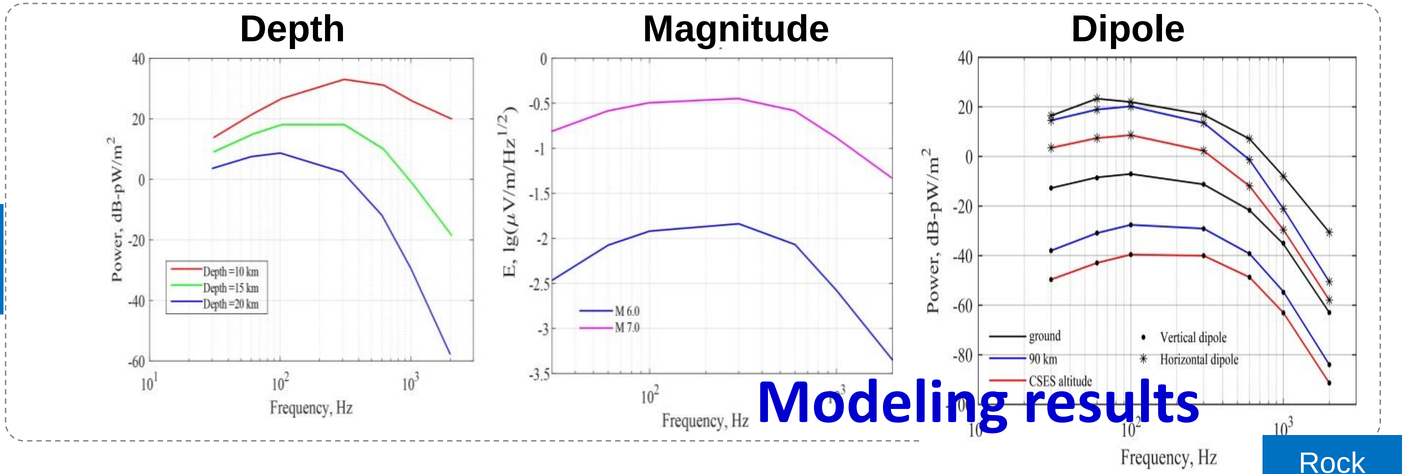
CSES (red) Vs model result（blue）

Zhao et al., 2019, JGR

Scientific outcomes #4: LAIC

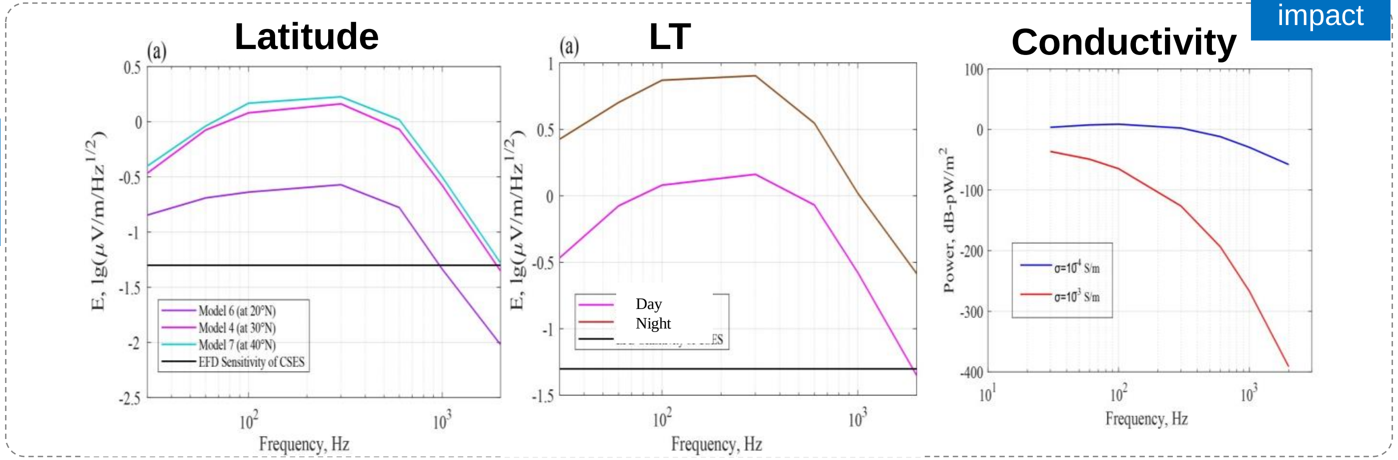
2) ELF wave propagation #conti#

Radiation source



Rock impact

Ionosphere impact



Modeling results：

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

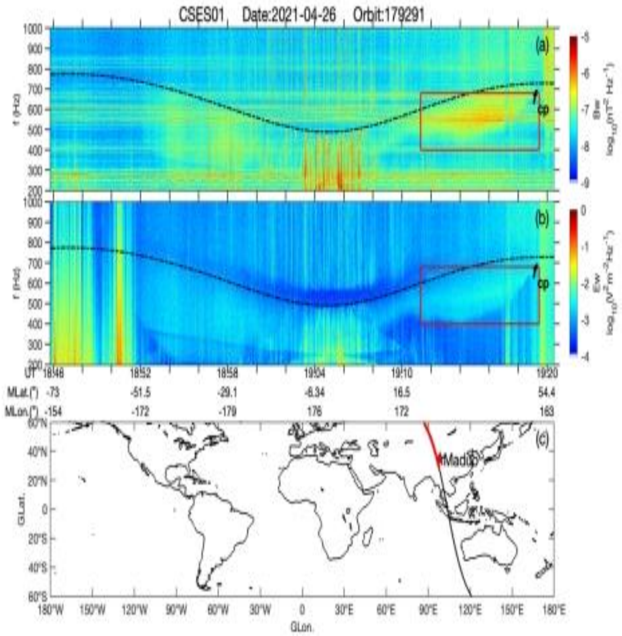
b) The power radiated from the dipole in the isotropic conductive medium decreases as the frequency increases because of the skin effect.

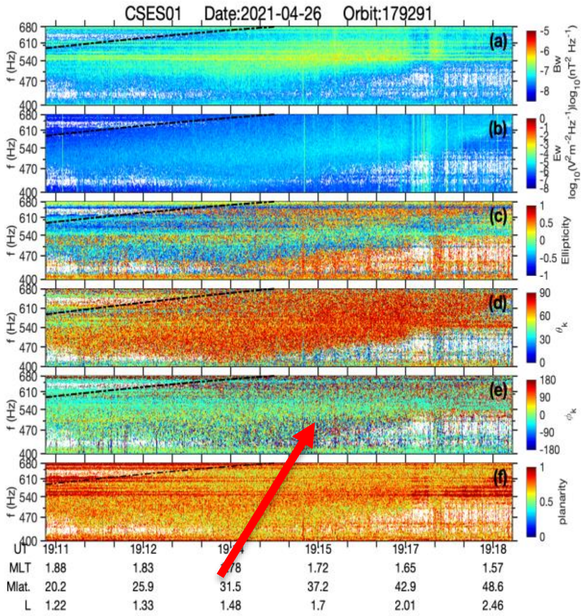
c) There is a dominant frequency range : ＜ ~ 1000 Hz

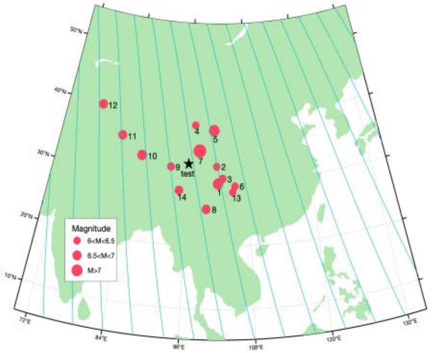
Zhao et al., 2021, Sci. Chi.Tec.Sci.

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

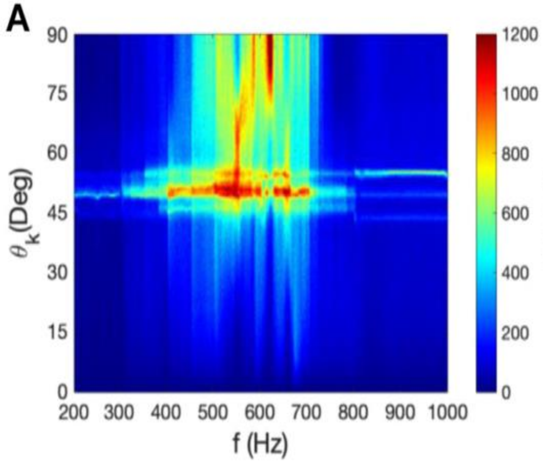
The upward propagating EM waves over the epicenter

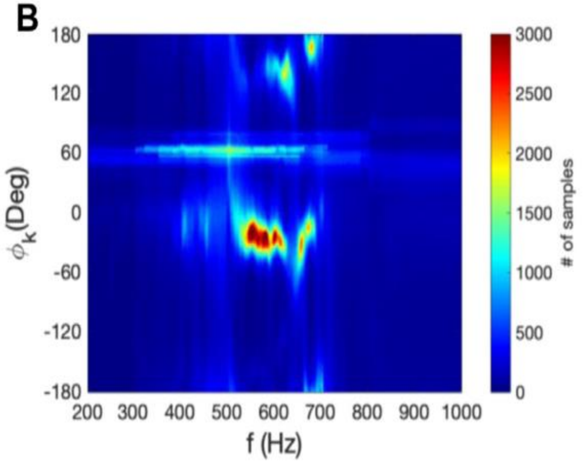






Strong shallow earthquakes
Depth: ≤ 30 km
Magnitude: ≥ 6
Area: mainland China
Time-Window: 2019 to 2022



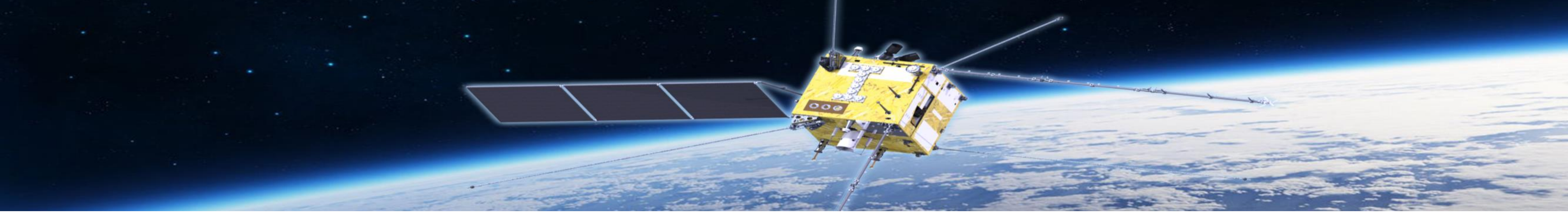


Case: Maduo (QH) Ms 7.4 EQ on May 22,2022

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



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5. Challenges & perspectives
6. Follow-up Plans

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

International cooperation on CSES mission

- **Sino-Russian cooperation (2003-)**

  Project: 2 project (government)+2 NSFC

- **Sino- French cooperation (2003-)**

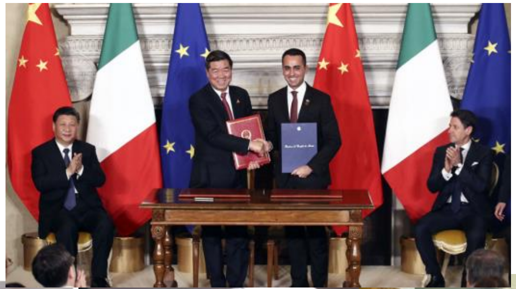
  DEMETER Scientific Center

  Project: 1 project (government）

- **Sino- Italian cooperation (2005-)**

  CSES -01: HEPD 01

  CSES- 02: HEPD 02、EFD 02 （INFN/INAF）



- **CNSA-ESA cooperation (2017-)**

  Swarm/CSES val/cal team, leading by ESA

  The highlight of 2020-2023 Swarm’s annual meeting

  Dragon-5 project

- **APSCO (Asia-Pacific Space Cooperation Organization(2014-)**

  Project: APSCO earthquake research project II

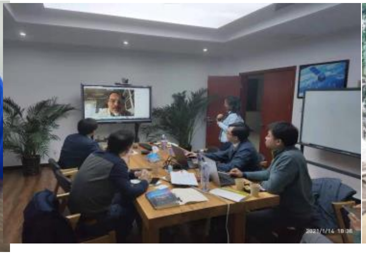
  SOAP: Stereoscopic Seismic-ionospheric Observation Application Platform

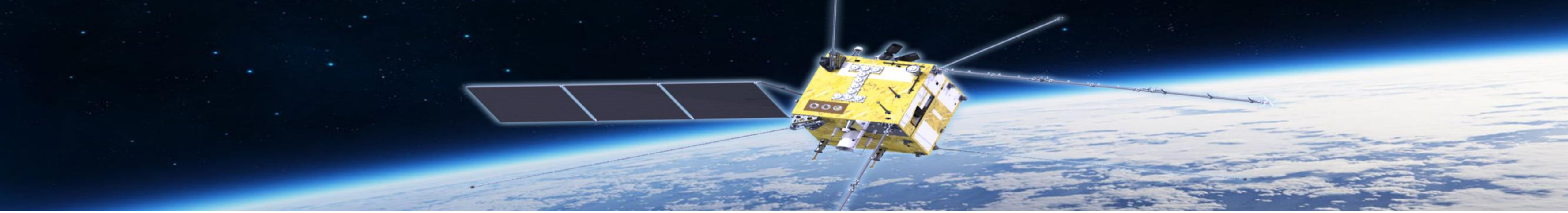
- **Others: America, Japan….**

Acknowledgment to other international teams or individuals not listed here !







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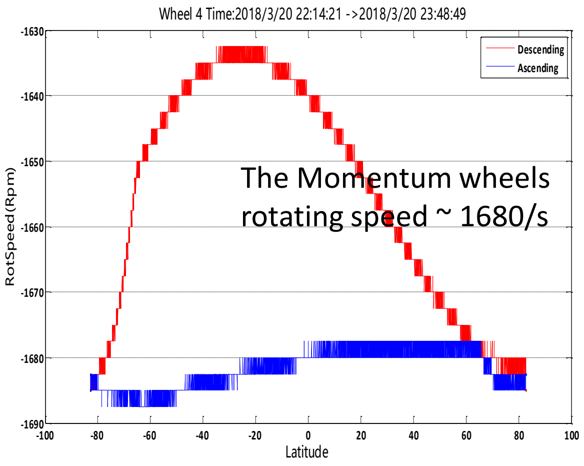
Challenges & Solutions # 1: High-quality data products

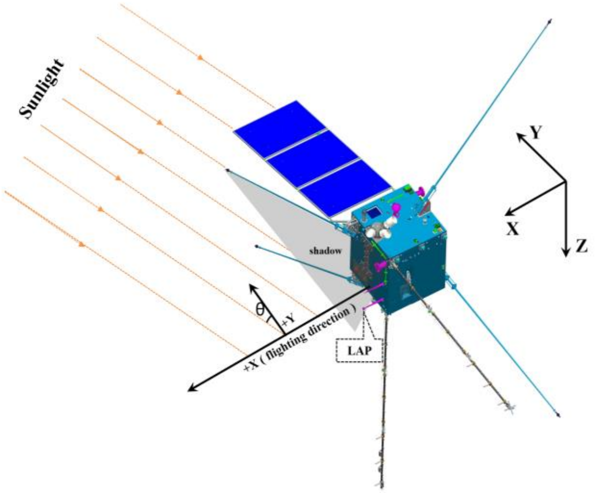
Challenge 1:

How To fully understand the behavior and performance of all the payloads in orbit?

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;
3. Need funding and working mechanism to organize scientists and engineers, operator sides involved



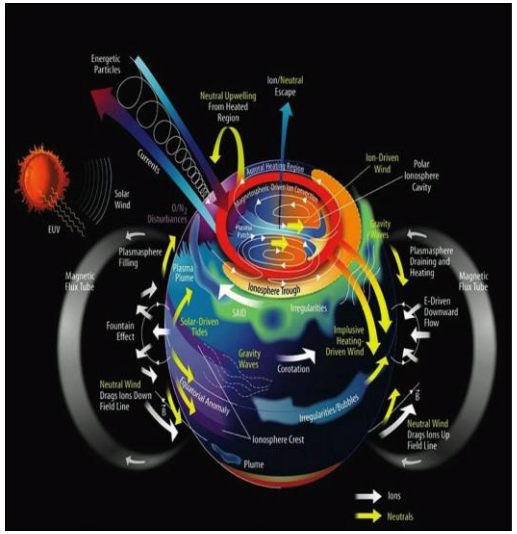


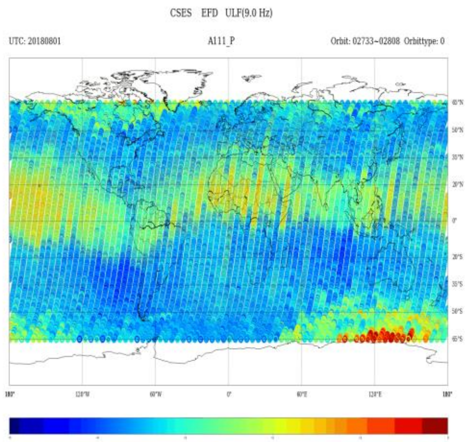
Challenges & Solutions # 2: background knowledge

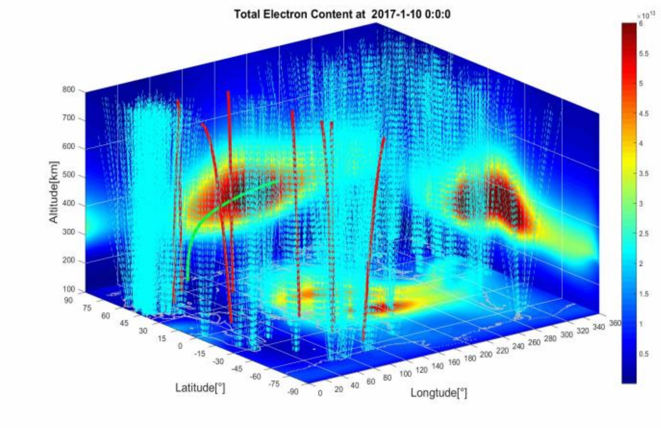
Challenge 2: How To fully understand the space environment?

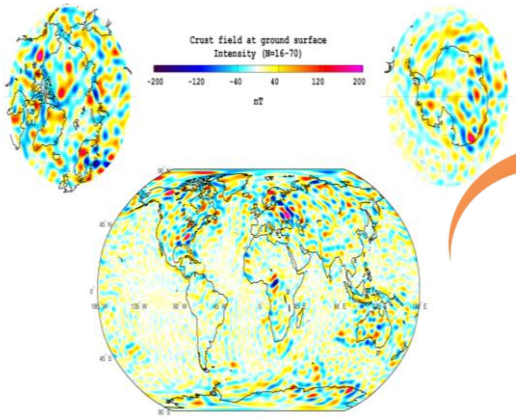
Solutions:

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

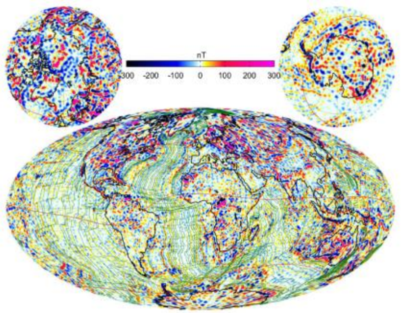








Model from a single probe



Model from constellation

Challenges & Solutions # 3: earthquake monitoring

Challenge 3: How to accurately identify the real precursors before earthquake

1. **Multi parameters comprehensive analysis and weekly discussion （NINH ）**

Experimental area: South-west China

Time-Window： Aug., 2021~Dec.,2022

Parameters： CSES+ Infrared/hyperspectral + Ground-based GNSS/ EM

EQ： M ≥6.0

Results: The successful prediction rate: 33%

Vs.

2. Single parameter automatic prediction experiment （IEF）

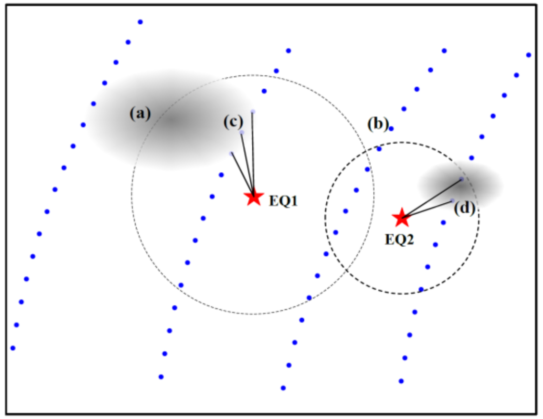
Experimental area: South-west China

Time-Window： Apr., 2021~Dec.,2021

Parameter： electron density

EQ: M ≥5.0

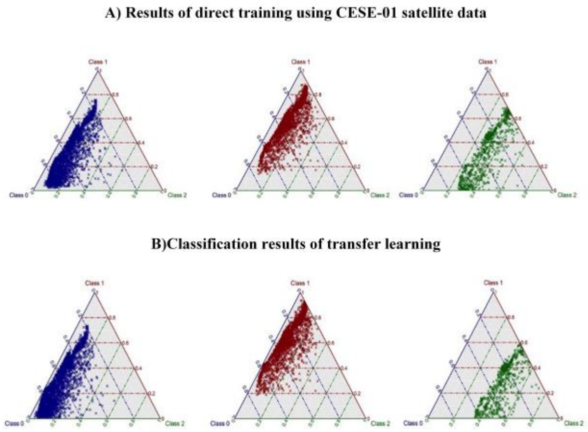
Results： The successful prediction rate: 10%



Limitations of single probe

Solutions:

1. Fully take advantage of existing satellite and ground platforms to build a virtual constellation
2. Application of AI technology to handle massive data



Big data intelligent identification application
Xiong et al., 2022, 2023

Challenges & Solutions # 4: LAIC

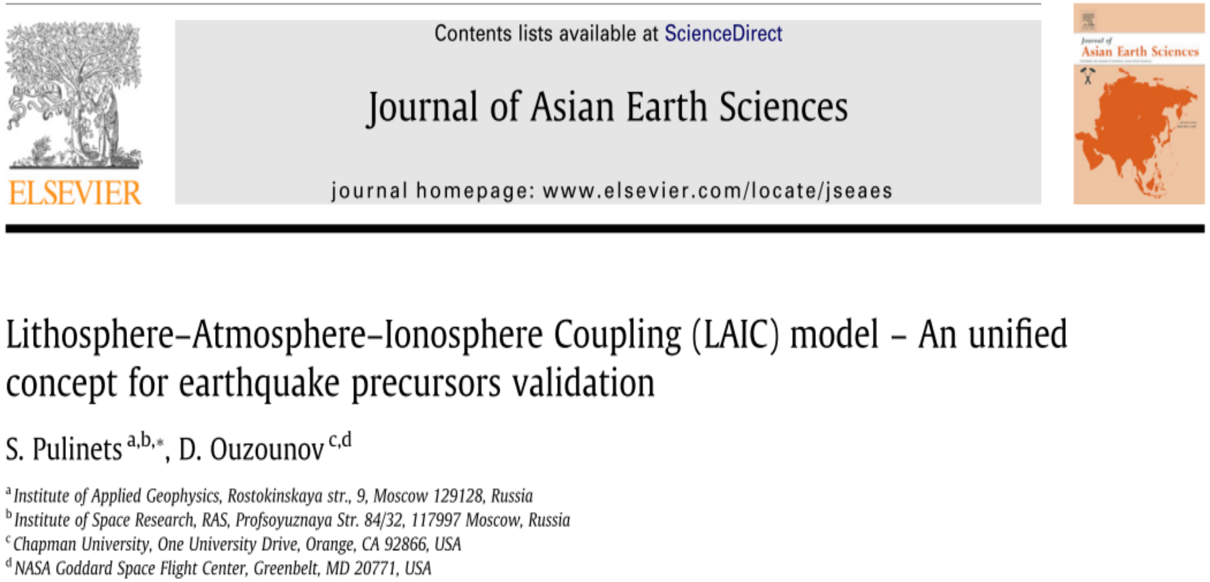
Challenge 4: how to uncover the mystery/puzzle of seismo-ionospheric disturbances

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) ***Stereoscopic Observations:***
   Multi-altitude/Multi-level/Multi-parameters
2) ***LAIC theory breakthrough:***



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Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model – An unified concept for earthquake precursors validation

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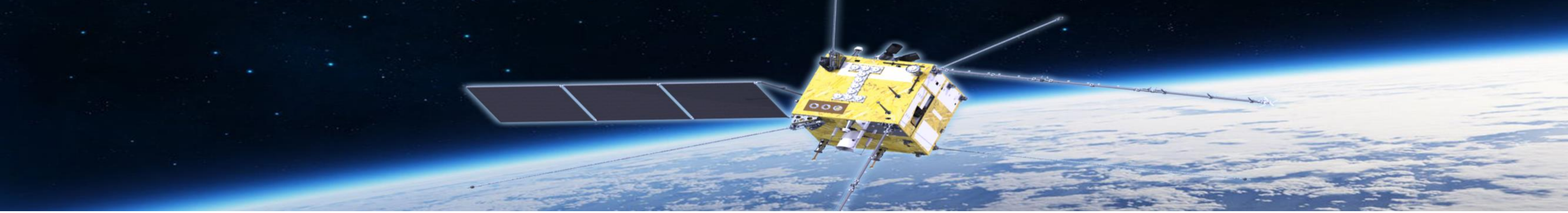
[c] Chapman University, One University Drive, Orange, CA 92866, USA
[d] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA



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Zhangheng mission (张衡计划）

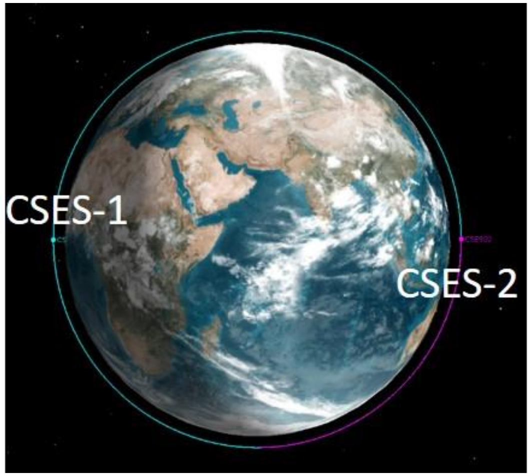
- The ZhangHeng mission, named after the ancient scientist Zhangheng who invented the world's first seismoscope.
- It is aimed to detect the **geo-physical fields of near earth space;**
- It is planed to launch a series of probes in recent decades.

Zhangheng-01: Electromagnetic satellites

CSES -01: Launched Feb. 2, 2018

CSES-02: Upcoming in 2024

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



Zhangheng-02: Gravity satellite (suspended)

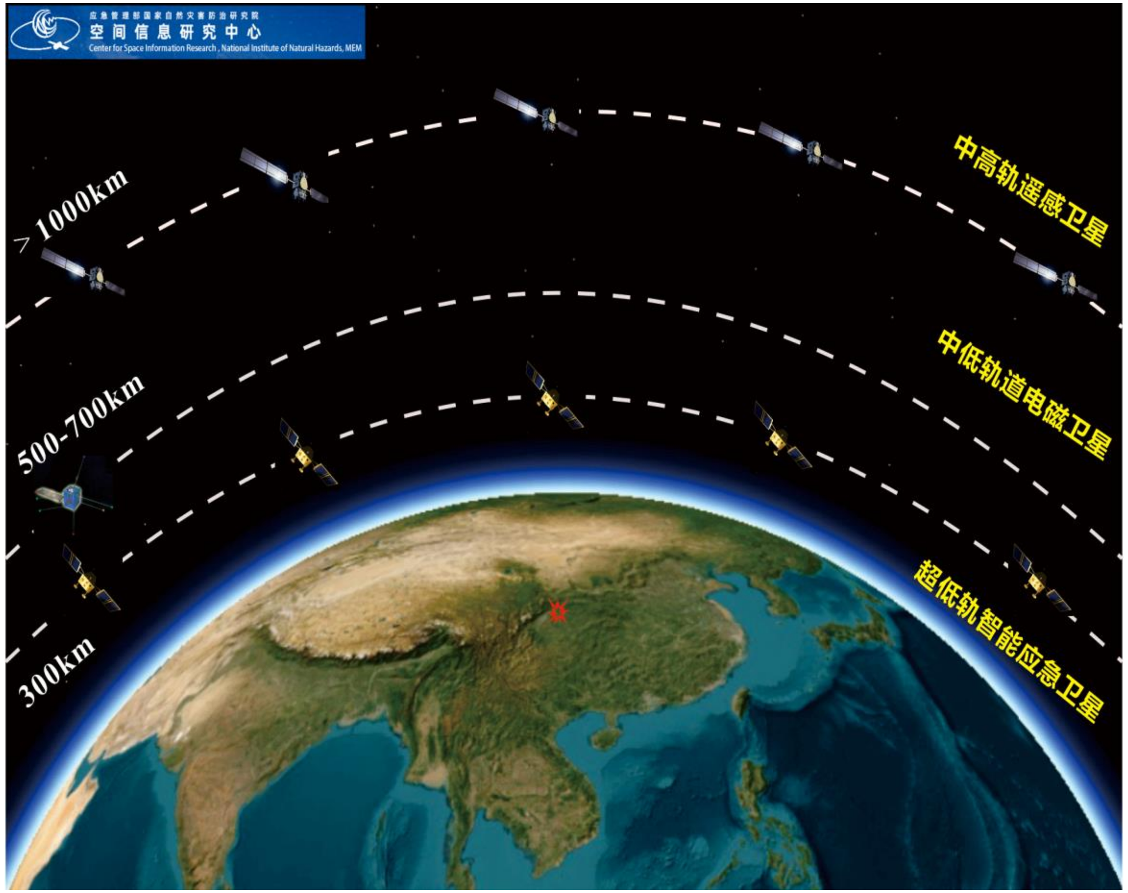
CSES 03 constellation（ in scientific demonstration discussion）

EM probes in (Low orbit 400 -800 km)

4 probes with a similar configuration as CSES 01/02

Integrated RS Intelligent Emergency constellations (200 - 400 km) –A new project

Integrated RS techniques (Optical, Infrared, Microwave, Electromagnetism) to serve for the advanced perception of natural disaster risks and rapid and intelligent emergency response capabilities



Near real-time monitor the Earth at different altitudes

Brief Summary

- The successful operation of satellite and ground systems
- The valuable datasets of long-term observation in near-Earth space
- A series of scientific applications progress achieved:

  #1 Serval unique and exclusive methods for data processing and data cal/val;

  #2 The knowledge about space environment with long-term observations

  #3 A set of geophysical field models built, providing references for science

  #4 The features of seismo-ionospheric disturbances and other natural event disturbances

  #5 The LAIC modeling was developed and observational evidence are accumulating

  Promoted International cooperation and exchange

Acknowledgments (No particular order)

Government departments 部门机构

国家发改委
国家财政部
国家航天局
应急管理部
Italian Space Agency
中国地震局
中国科学院
中国航天科技集团公司
国家自然科学基金委员会

Mission project team 工程队伍

国家国防科技工业局重大专项工程中心
中国航天科技集团公司五院总体部
航天东方红卫星有限公司
北京航空航天大学
INFN, Italy
INAF, Italy
Trento Univerity, Italy
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中国资源卫星应用中心
中国科学院空天信息创新研究院
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中国科学院国家空间科学中心
IWF, Austrian Academy of Sciences
中国科学院高能物理研究所
中国电子科技集团公司第22研究所
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IWF, Austrian Academy of Sciences
International Space Science Institute
Space Research of the Austrian Academy of Sciences
German Research Centre for Geosciences
Technical University of Denmark
Moscow University, Russia
Chapman University, America

Thank You For Your Attention!

*The selected main scientific results of the CSES mission will be introduced by **Dr. Yan Rui, Yanyan Yang, Zhenxia Zhang, and Jianping, Huang**.*

Please tune-in!

Welcome discussions on :

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