GNSS and Space Weather Research

Bin Wang

China Satellite Navigation Project Center

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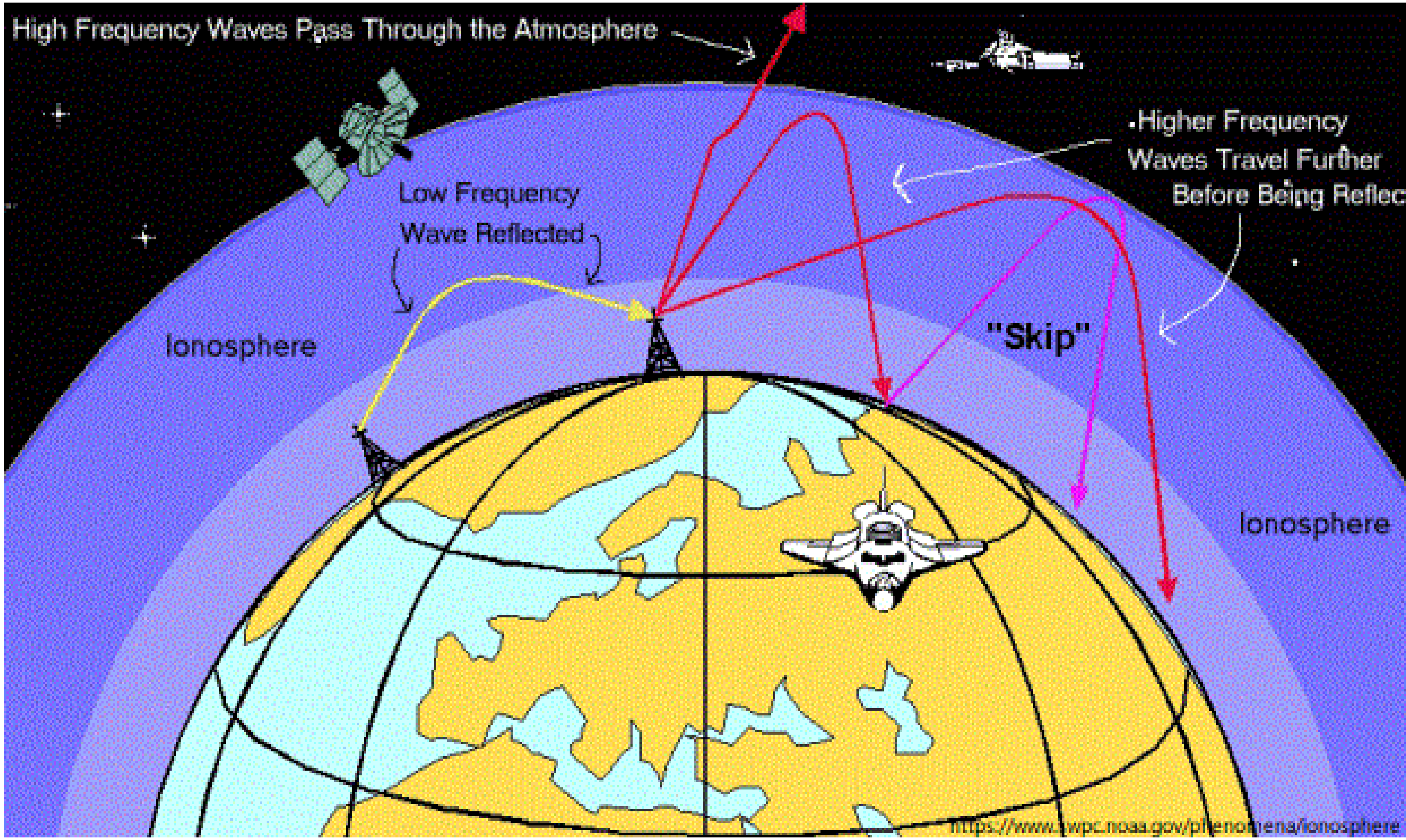
Ionosphere Impact

01 Ionosphere Impact

1. Essentials

The density of the ionosphere changes mainly according to the solar activity, it reflects and modifies radio waves used for communication and navigation.

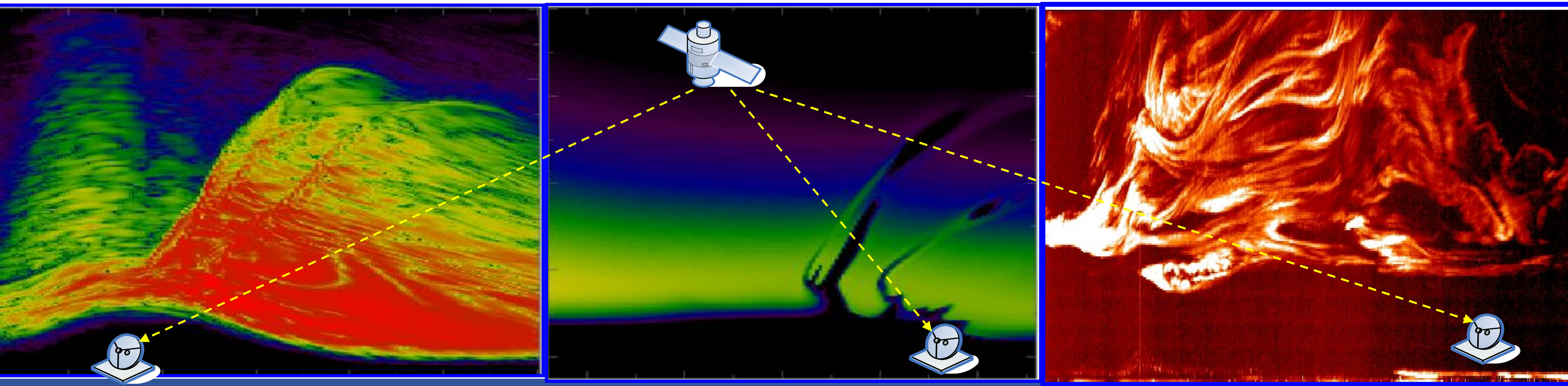
- **Ionospheric Storms**
- **Ionospheric Scintillation**
- **Ionospheric Disturbance**
- **……**



01 Ionosphere Impact

2. Ionospheric Scintillation

➢ Scintillation is caused by small-scale (tens of meters to tens of km) structure in the ionospheric electron density along the signal path, usually named as ionosphere irregularities.



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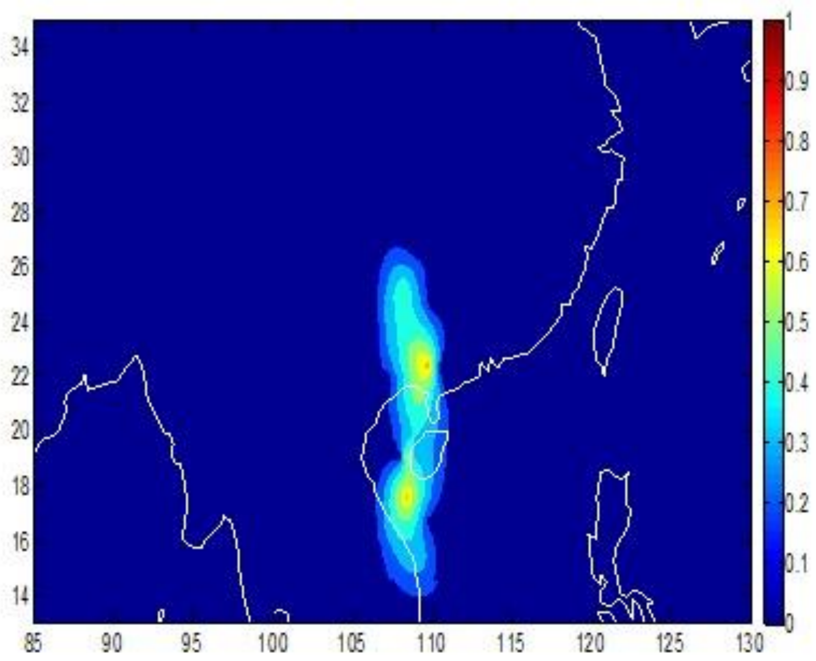
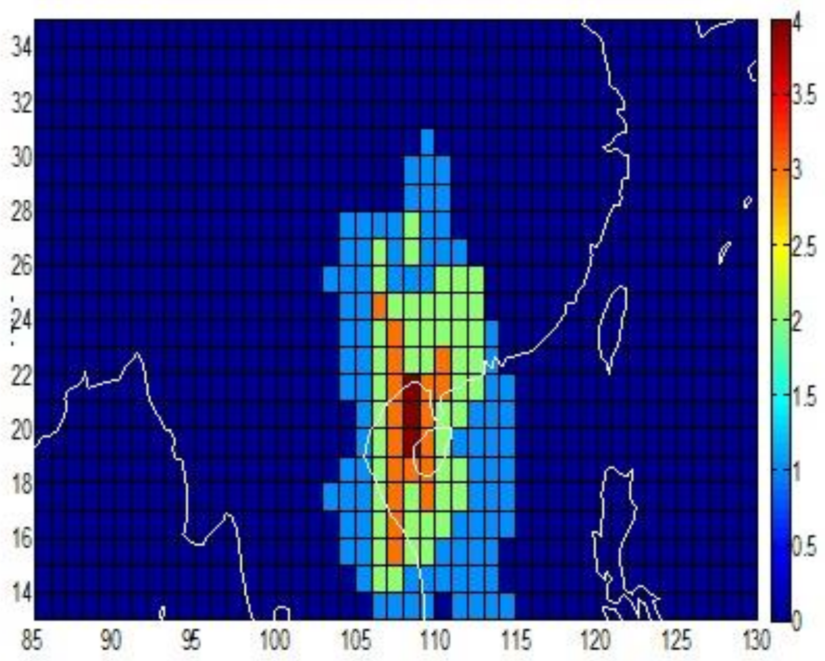
Ionosphere Impact

2. Ionospheric Scintillation

➢ The ionosphere scintillation can reduce the accuracy and the confidence of GNSS service, even cause lock-lose of the signal.

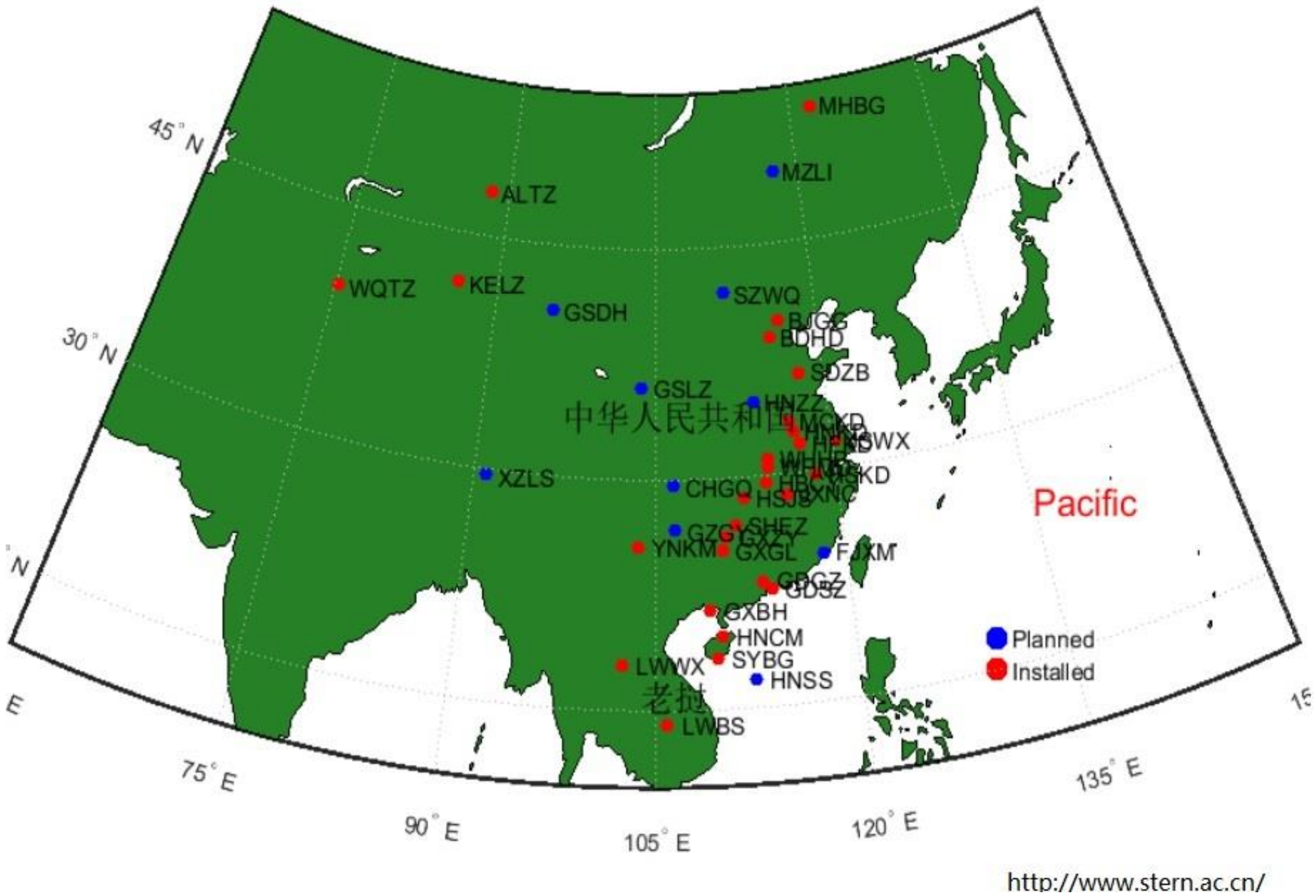




GNSS Applied In Ionosphere Research

02 GNSS Applied in Ionosphere Research

1.Ionosphere Monitoring Network



Ionosphere Monitoring Network established by CAS

GNSS TEC technique have been new Ionosphere monitor methods.

There have been many Ionosphere monitoring networks in the world.

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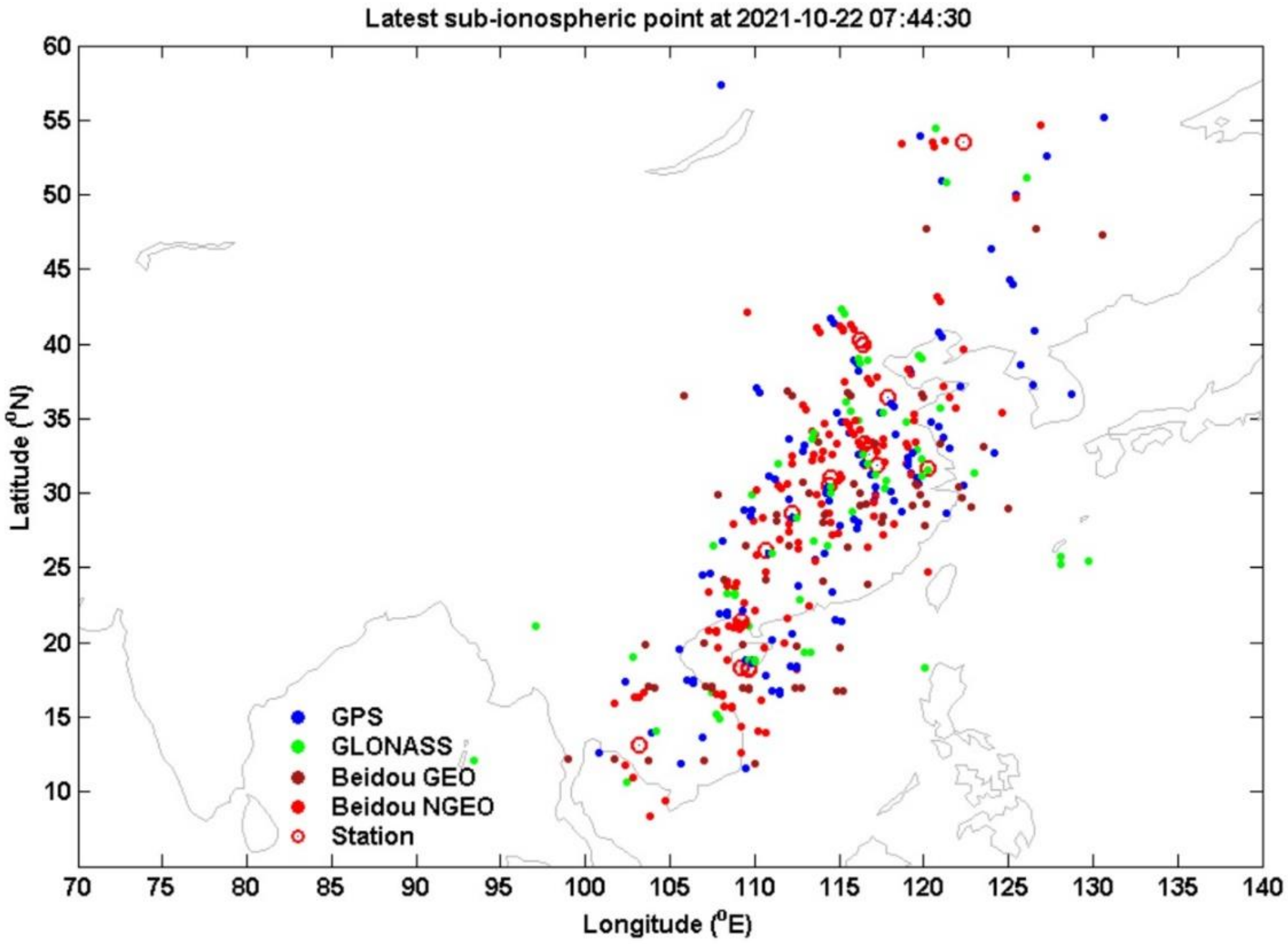
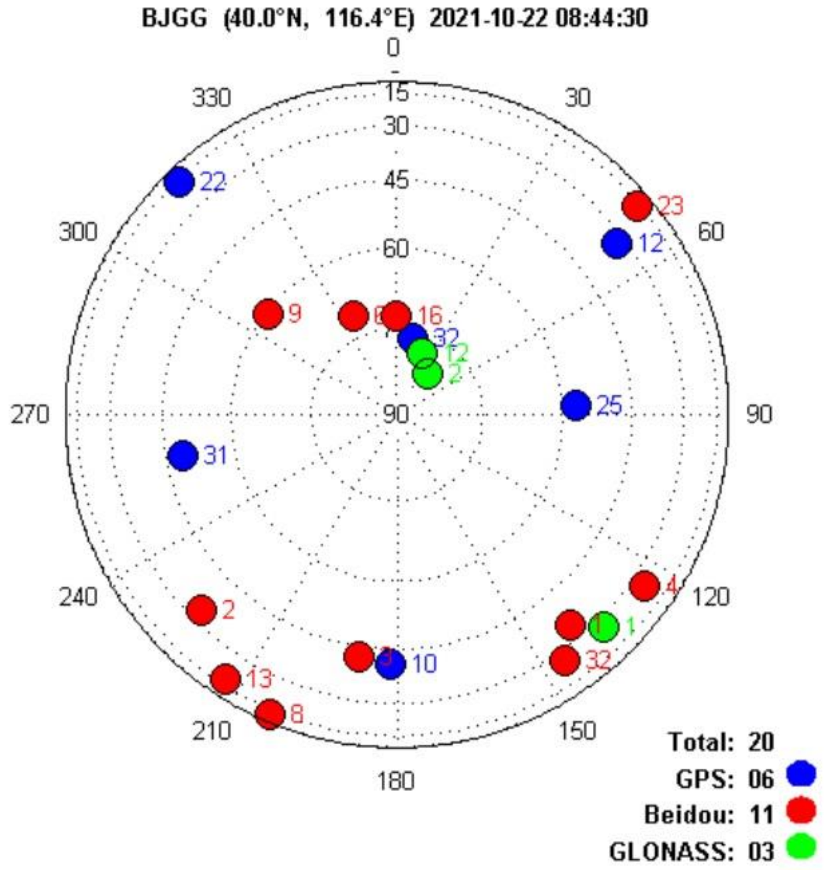
1.Ionosphere Monitoring Network

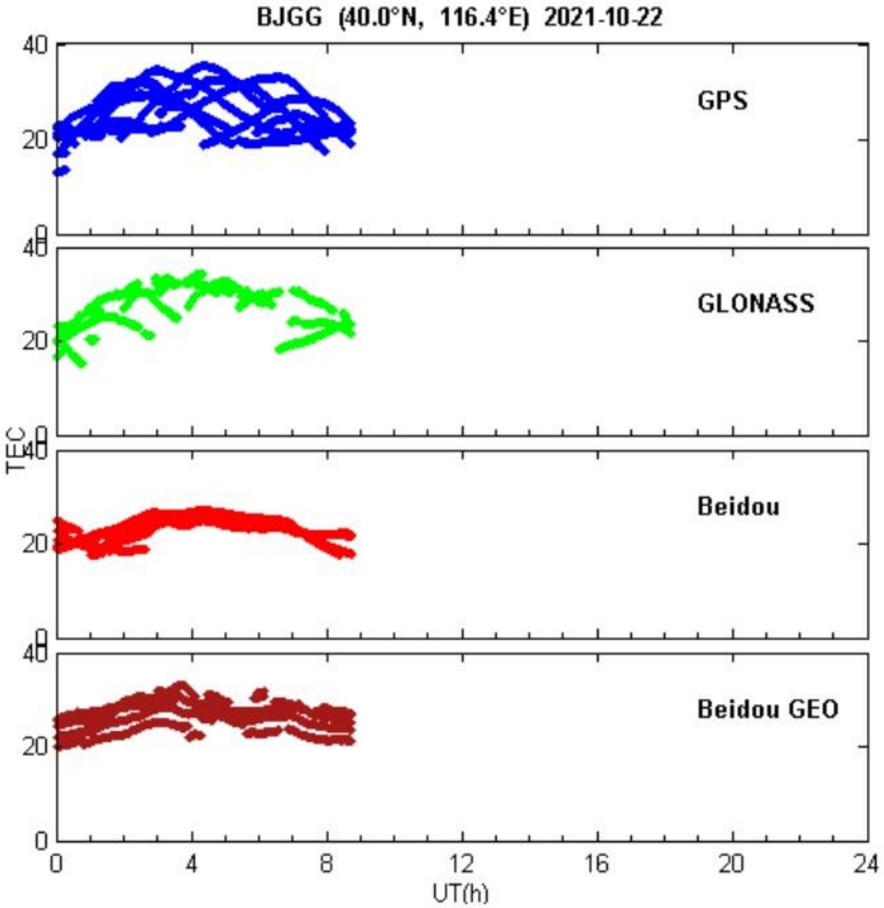


The sub-ionospheric point at about 400 km height can be derived in real time via calculating the GNSS satellites data.

02 GNSS Applied in Ionosphere Research

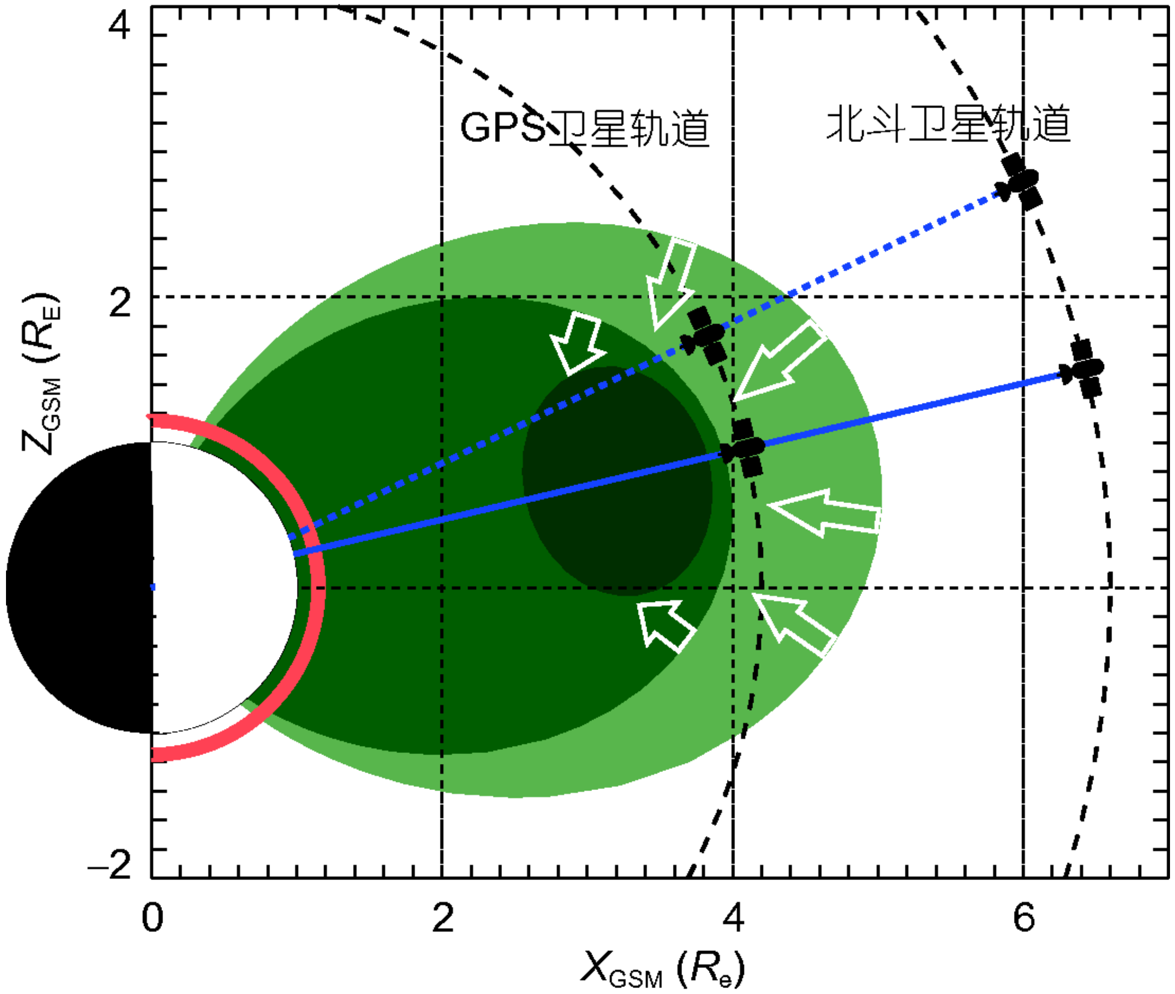
1.Ionosphere Monitoring Network





02 GNSS Applied in Ionosphere Research

2. Geomagnetic Storm Observation



The geomagnetic storm is a major disturbance of near Earth space environment, which can be reflected from TEC signals of GPS and BeiDou.

The white arrows indicate the motion of the plasma when the geo-magnetosphere was compressed by the interplanetary shock.

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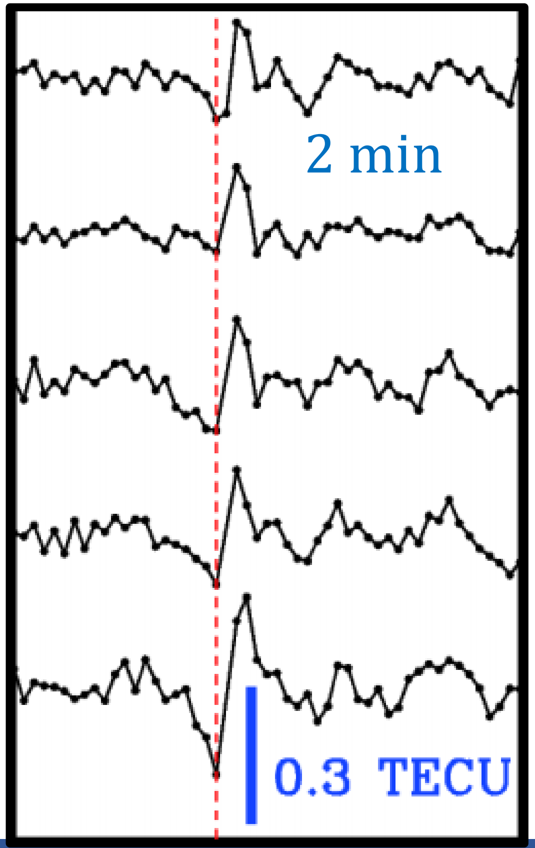
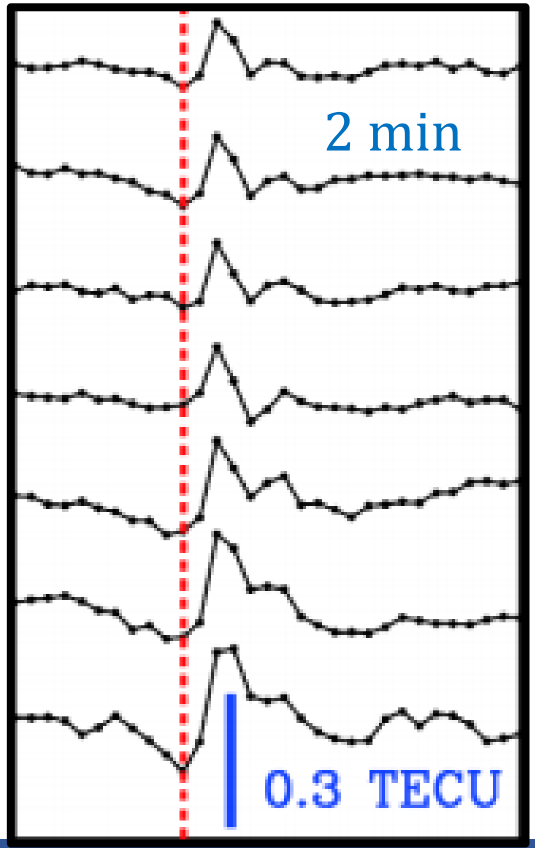
2. Geomagnetic Storm Observation

BeiDou



GPS



The geomagnetic storm is a major disturbance of near Earth space environment.

Intense geomagnetic storms usually start with a sudden commencement.

Total electron content (TEC) derived from navigation data can reveal features of storm sudden commencement.

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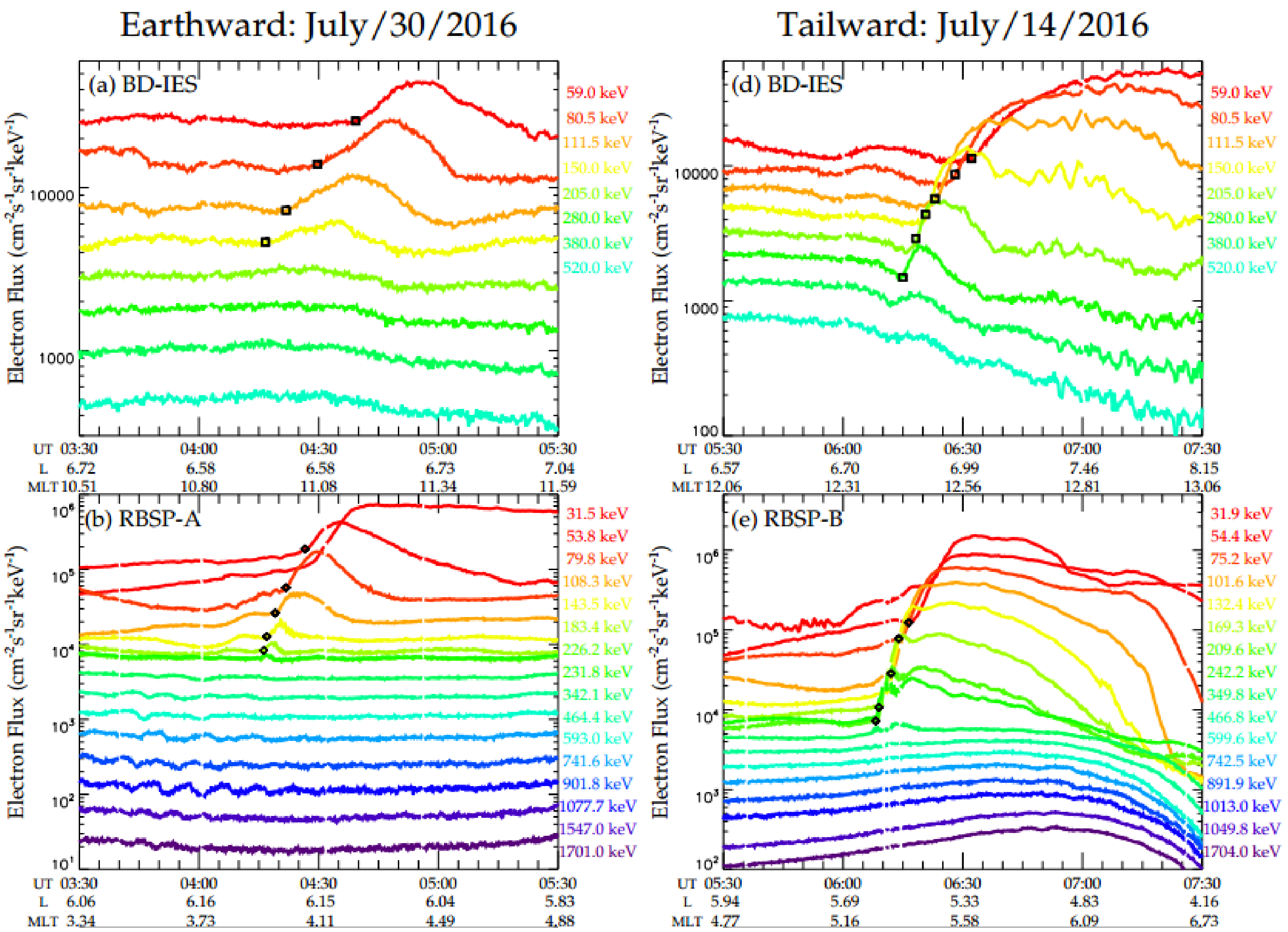
3. GNSS as Platforms for Scientific Instruments



Joint Observations of Substorm

Substorm, another major geomagnetic activity, observed by instruments onboard RBSP and BeiDou satellites.

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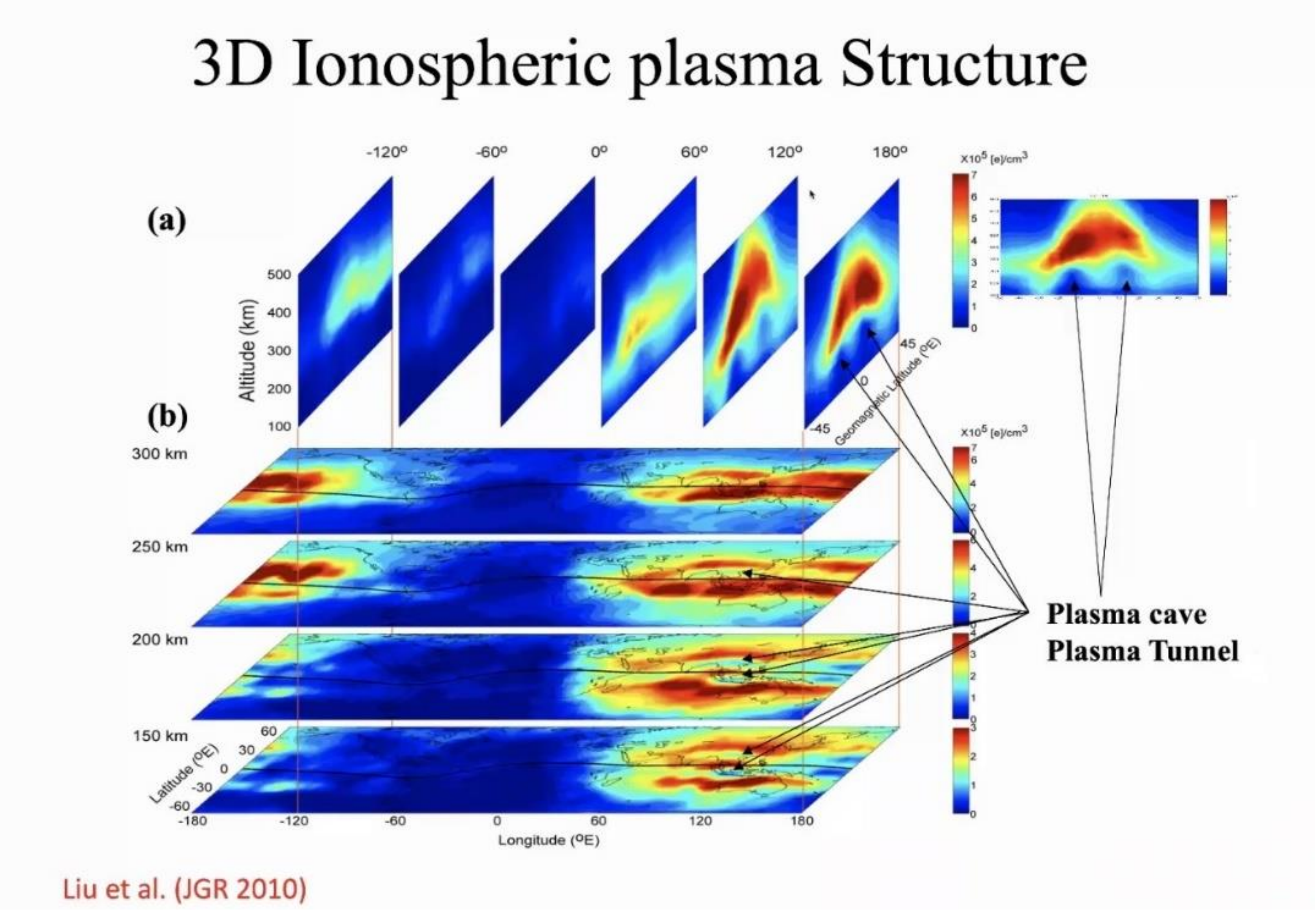
4. Three Dimension Ionospheric Plasma Structure



Real-time monitoring of the ionosphere will contribute to the modeling work, which is necessary for the nowcast and forecast of the ionosphere.

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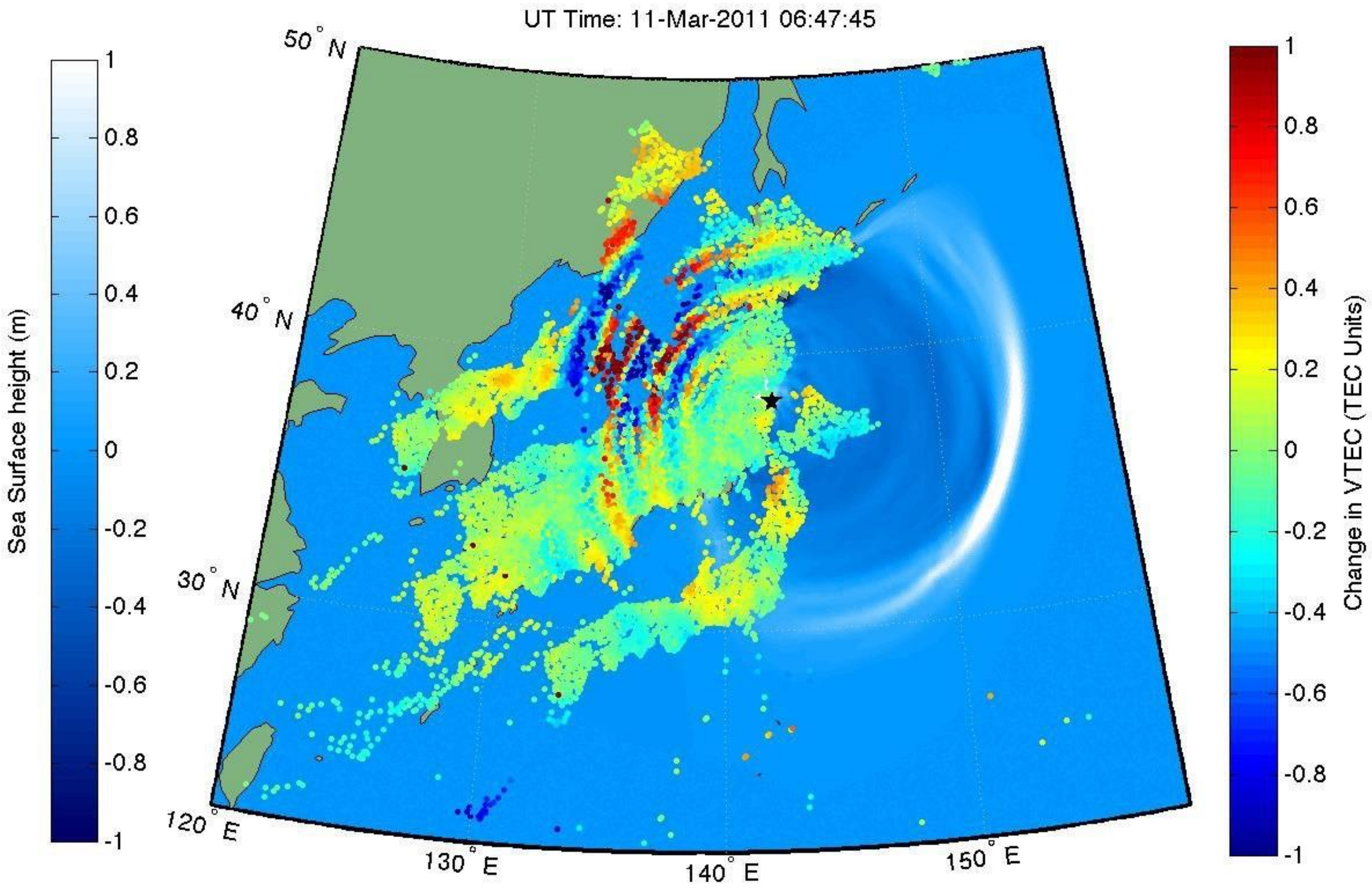
5. Earthquake and Tsunami Warning



https://www.jpl.nasa.gov/images/nasa-sees-tohoku-oki-earthquake-and-tsunami-in-earths-upper-atmosphere

Ionosphere monitoring can be used as warning signal in earthquake and tsunami events.

02 GNSS Applied in Ionosphere Research

- Space weather (ionosphere) events can affect the performance of GNSS service.

- GNSS can supply more monitoring ways for space weather (ionosphere) research and be carrying platform for space weather payloads.

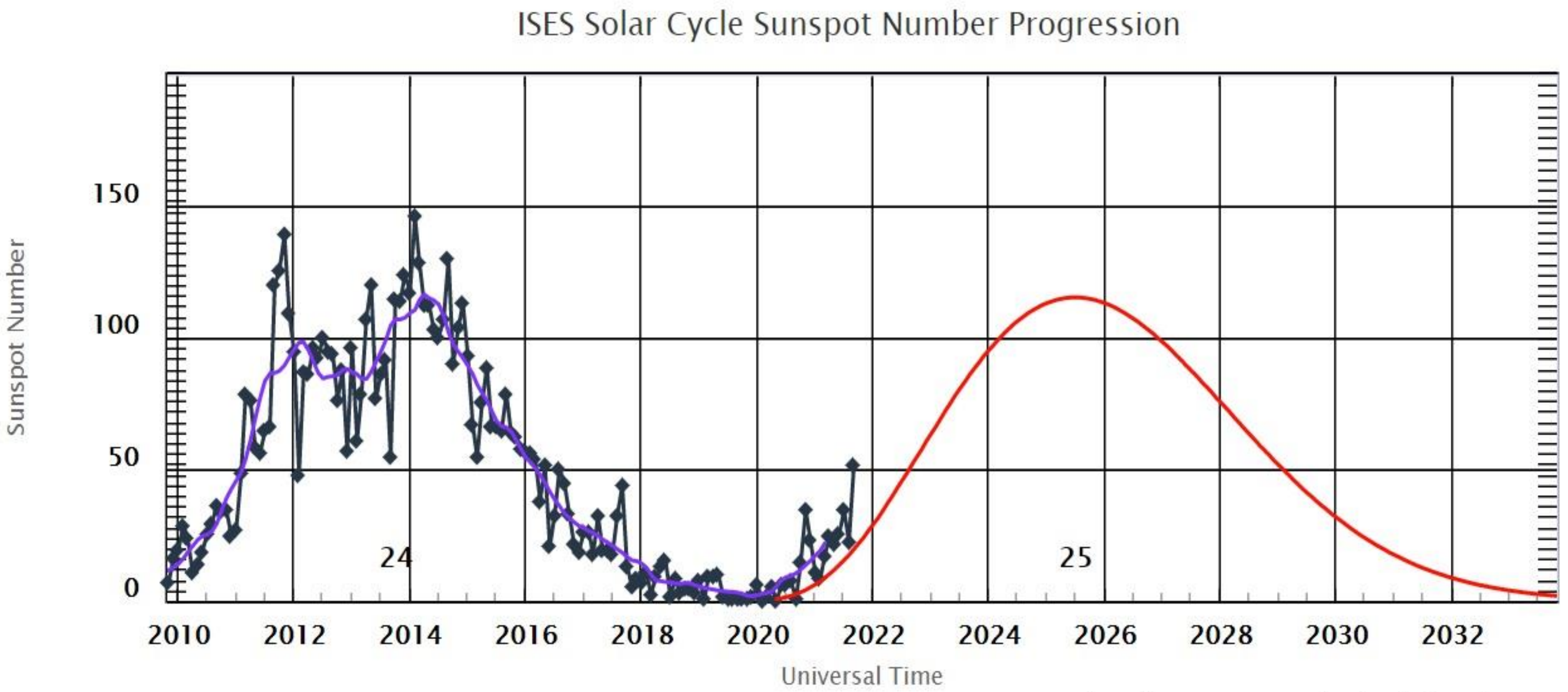
- With the help of GNSS, better space weather models can be built, and such models will be useful in many fields.

Space Weather threaten to GNSS

03

Space Weather threaten to GNSS System

The Challenge and Opptunity



https://www.swpc.noaa.gov/products/solar-cycle-progression

03 Space Weather threaten to GNSS System

The Challenge and Opptunity

- The upcoming of the 25th solar cycle certainly is challenge and test for the GNSS. The stability of GNSS service will be verified in severe space weather events.

- Severe space weather events is also opptunity for the developing of the space weather model. Many space physicists are waiting for the upcoming of the 25th solar cycle.

Space Weather payloads onboard BDS

03 Data of Space Weather

1. Data released in ICG-14

关于发布北斗导航卫星空间环境载荷数据的公告

来源：北斗网　发布时间：2019-12-09

为促进北斗系统搭载的空间环境载荷相关合作与交流，现将批准的北斗导航卫星空间环境载荷数据予以发布（内容附后），供研究交流。

文件中所有参数由载荷制造方提供，参数的具体定义、描述和文件格式说明可参考数据说明文档。首批载荷数据为“成像电子谱仪”观测数据，观测数据为卫星轨道50至600千电子伏的电子通量。后续北斗卫星搭载的一系列载荷将持续开展空间环境探测试验，并适时发布数据。

特此公告。

http://www.beidou.gov.cn/yw/gfgg/201912/t20191209_19614.html?from=timeline

中国卫星导航系统管理办公室

二〇一九年十二月九日

附件：

1、“成像电子谱仪”数据说明文档

2、“成像电子谱仪”数据说明文档（英文版）

3、北斗导航卫星空间环境载荷数据文件

500 MB data file

2015.10-2018.12

Image Electron Spectrometer (IES)

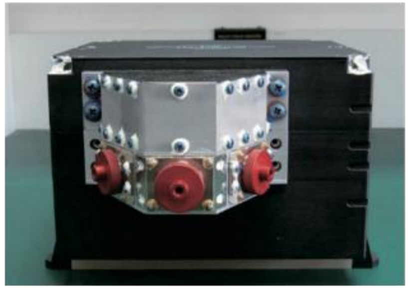


Table 1 Characteristic parameters of BD-IES sensor head

Parameters:		Energy range (50-600 keV)
Electron channel:	E1	50-68
	E2	68-93
	E3	93-130
	E4	130-170
	E5	170-240
	E6	240-320
	E7	320-440
	E8	440-600
Field-of-view		$\pm15° \times 180°$
Angular coverage (range/intervals)		180°/9
Geometric factor ($cm^2 \cdot sr$)		$\sim 2.0 \times 10^{-3}$ *(for each direction)

*the geometric factor is the average value of nine directions.

02 Payloads Packages on BDS

1. Space Plasma and Satellite Surface Charging Monitor

Payload	Characteristic Parameter	Function
Low Energy Electron/Ion Spectrometer	Energy: 0.1~15 keV FOV: 2π Resolution: ＜15%±2%	Detect parameters of in-situ electrons and ions, such as energy, flux, density and velocity.
Magnetometer	Range: -65000 nT ~ +65000 nT Noise: 10 nT	Measure the environmental magnetic field around the satellites.
Radiation dosimeter	Radiation dosage：0～10^7rad	Measure total radiation dose to evaluate the lifetime of satellite.
Surface potential detector	Surface potential：0.1 ～10 kV	Monitor the satellite’s surface potential.

02 Payloads Packages on BDS

2. Energetic Electron Detection Packages

Payload	Characteristic Parameter	Function
Medium-energy Electron Spectrometer (MES)	Energy: 50~600keV FOV: 30°×180° Geometric factor: < ~2.0×10^{-3}	Measure the energy spectra and flux changes of medium electrons in the outer radiation belt.
High-energy Electron Detector (HED)	Energy: 0.5~3.0MeV FOV: 30° cone-angle Geometric factor: < ~1.0×10^{-2}	Measure the energy spectra and flux changes of high electrons in the outer radiation belt.
Deep Dielectric Charging Monitor (DDCM)	Charging Voltage: -2.5 kV to 0 V Charging Current: 0.01-50 pA	Measure the deep dielectric charging current and voltage.

Thank you

http://en.beidou.gov.cn