Global Center for Asian and Regional Research
University of Shizuoka

NaDiR

Turning Ideas into Space Reality: The Journey from UNISEC-Global's MIC to PRELUDE

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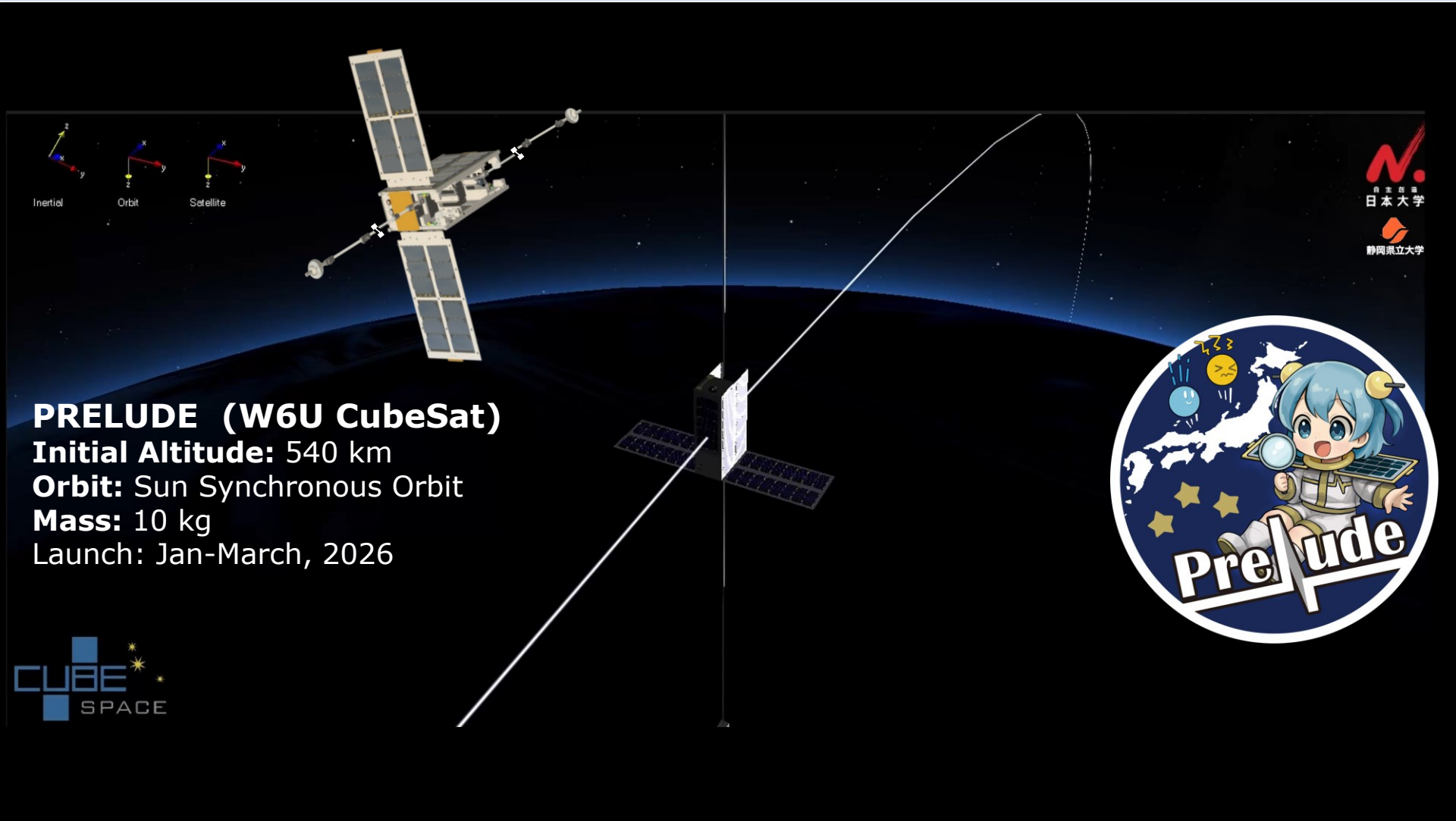


PRELUDE (W6U CubeSat)
Initial Altitude: 540 km
Orbit: Sun Synchronous Orbit
Mass: 10 kg
Launch: Jan-March, 2026

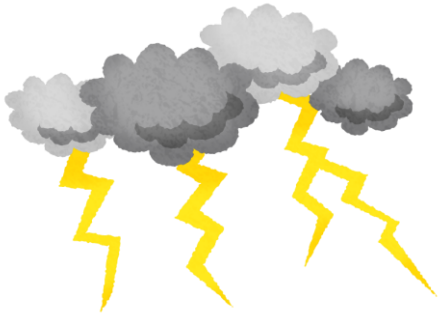
My research subjects

Prediction and forecast for various natural hazards using electromagnetic observation

Earthquake

Tsunami

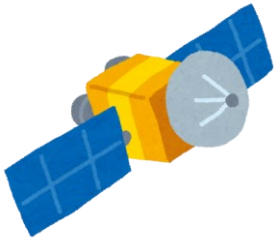
Lightning



Volcano eruption

Blizzard

Various instruments and places



Satellite

Balloon

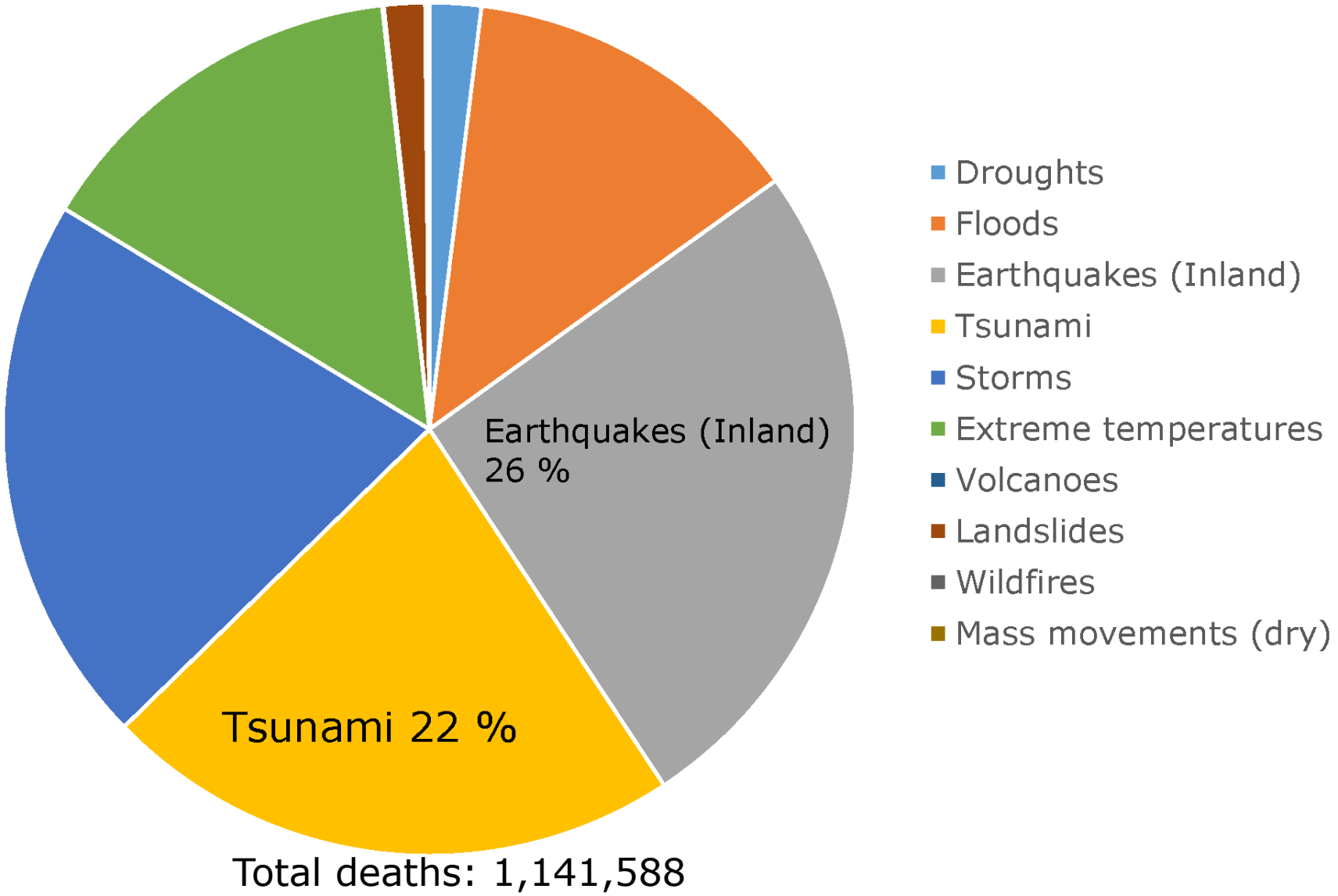
Drone

Mt. Fuji

Ogasawara Island

Syowa station, Antarctica

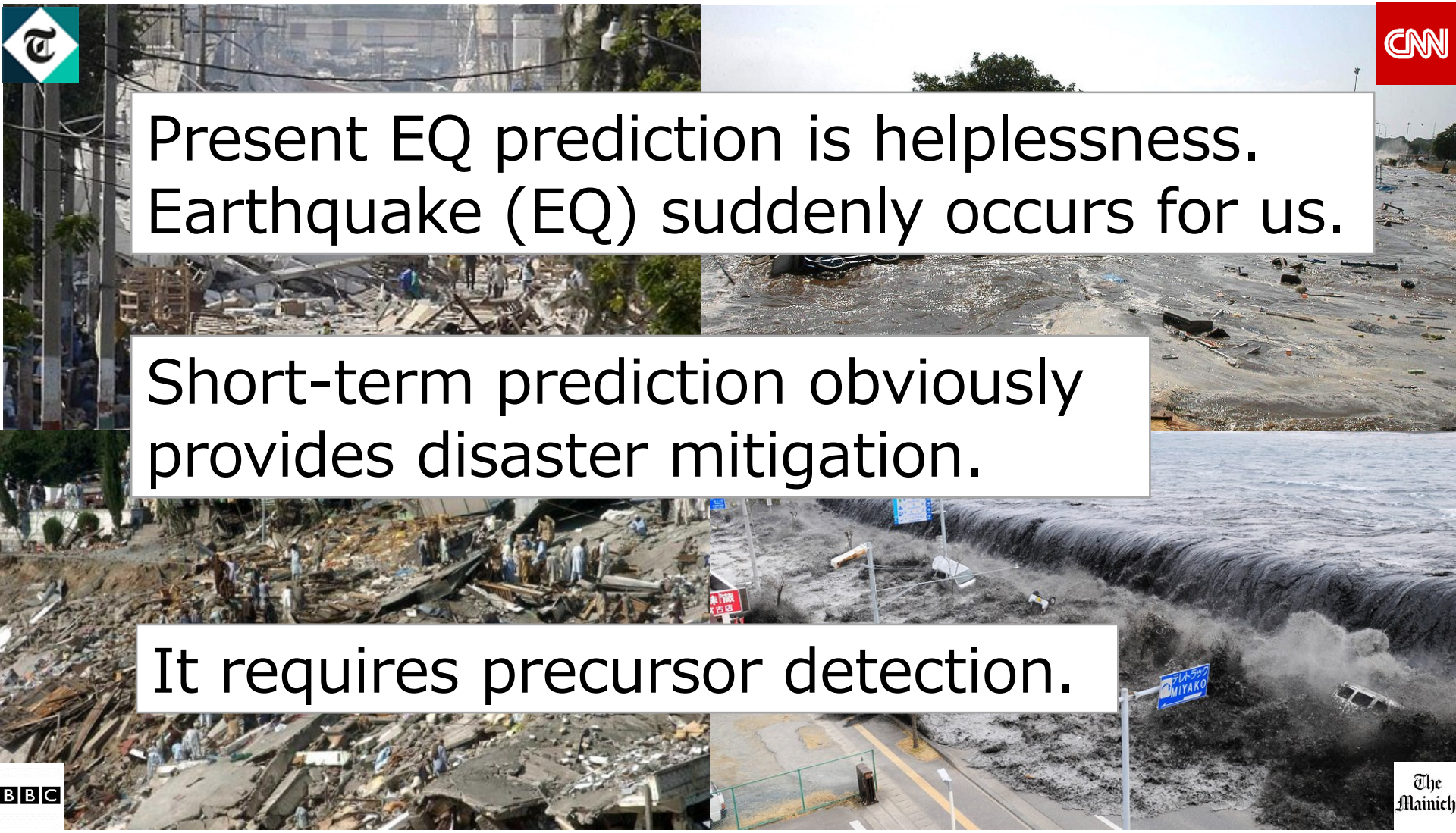
Natural Disaster 1996-2015



Total deaths: 1,141,588

2010 Mw7.0 Haiti Earthquake

2004 Mw9.3 Sumatra Earthquake



Present EQ prediction is helplessness.
Earthquake (EQ) suddenly occurs for us.

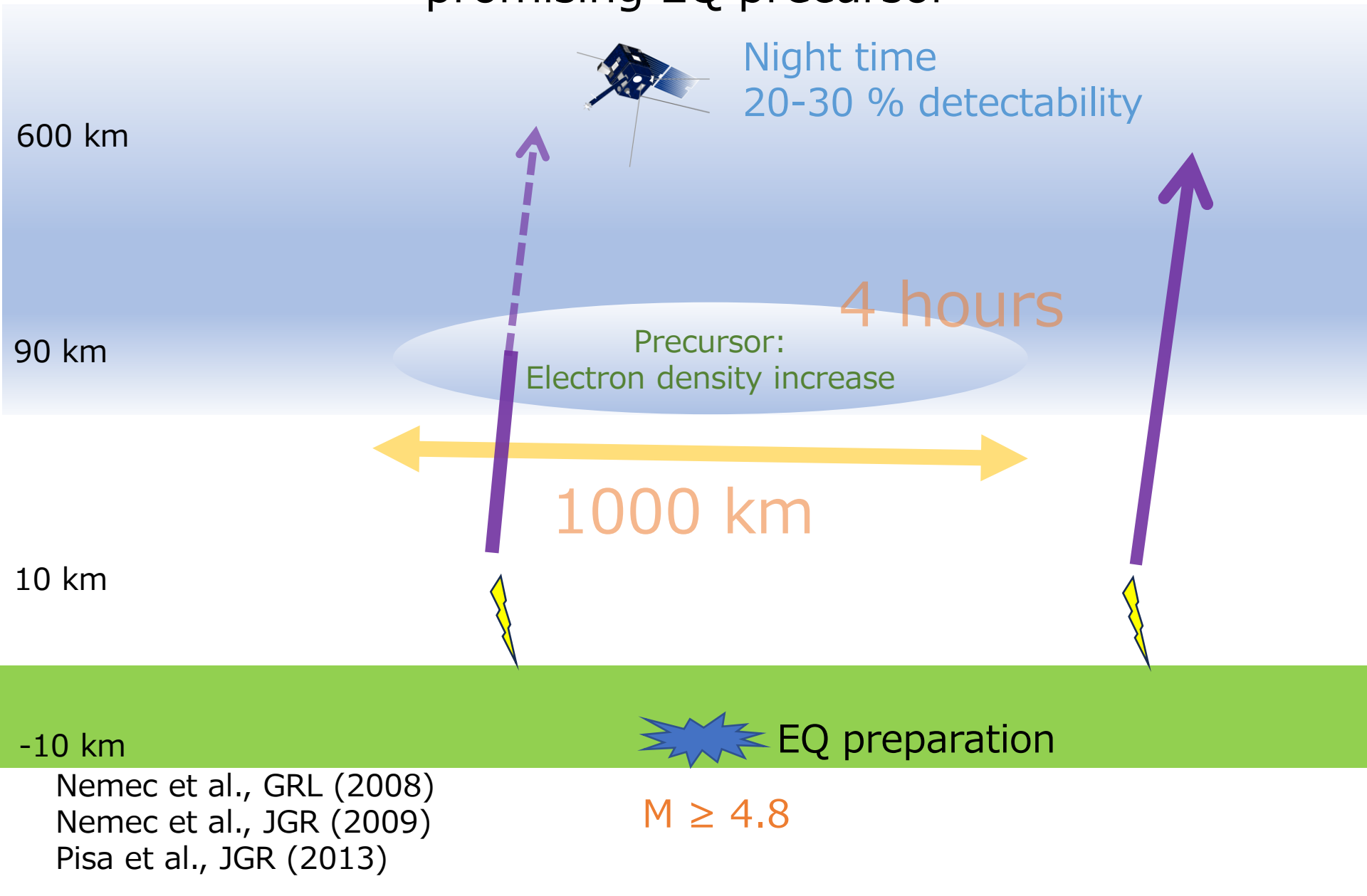
Short-term prediction obviously provides disaster mitigation.

It requires precursor detection.

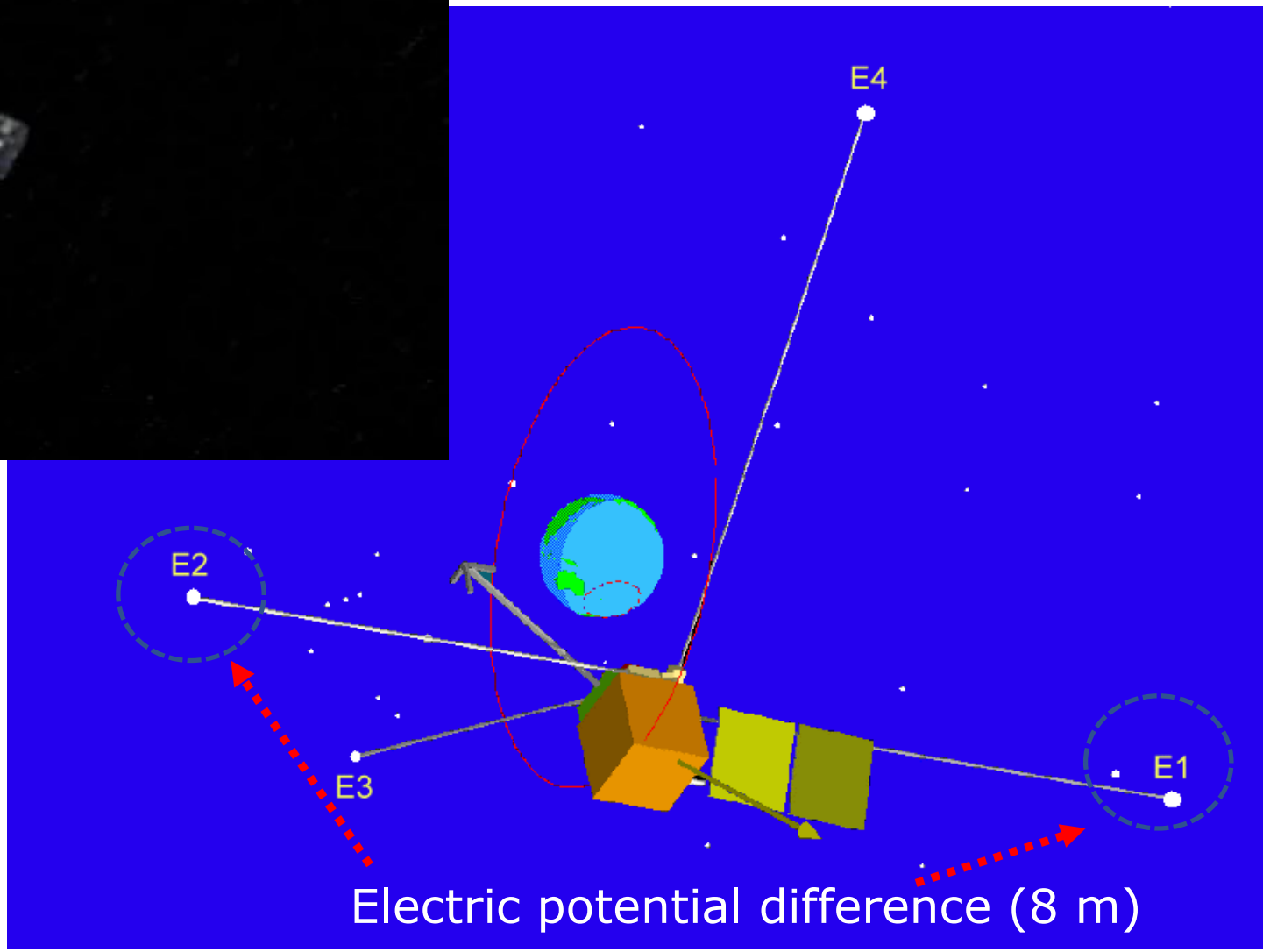
2005 Mw7.6 Kashmir Earthquake

2011 Mw9.0 Tohoku Earthquake

French DEMETER satellite (2004-2010) statistically found promising EQ precursor

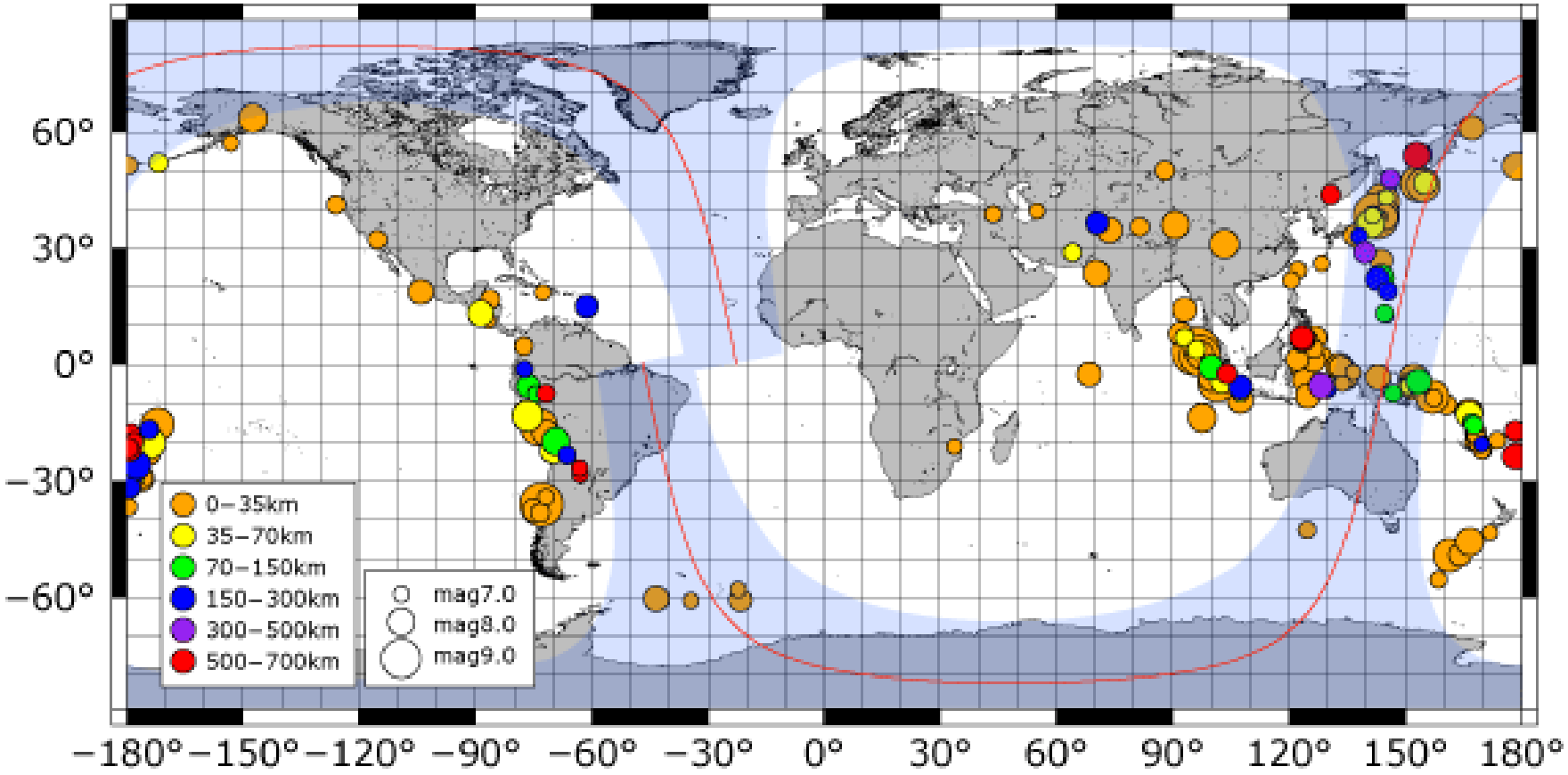


Nemec et al., GRL (2008)
Nemec et al., JGR (2009)
Pisa et al., JGR (2013)



Electric field measurement of DEMETER (2004-2010, CNES/France)

Ionospheric precursor detection



Rei Kawashima's triggering Collaboration with Masahiko Yamazaki

Prelude

Important key person: **Rei Kawashima** (Secretary-General of UNISEC-Global)

Feb. 2006: MK's presentation of ionospheric earthquake precursor at Space Writers Club
(I met RK for the first time.)

Mar. 2011: M9.0 Tohoku Earthquake during MIC1

Mar. 2012: RK interviewed the possibility of EQ prediction using small satellites to me.

May. 2012: RK proposed my MIC2 participation
with Prof. Kikuko Miyata (Meijo Univ.) and Prof. Kohei Tanaka (Keio Univ.)

Oct. 2012: Second prize at MIC2
"Project of Micro-Satellite Constellation for Earthquake Precursor Study"

Oct. 2016: Second prize at MIC4
"Microsatellites observing atmospheric and space electricity for the science of serious natural disasters: Challenge to their mitigations"

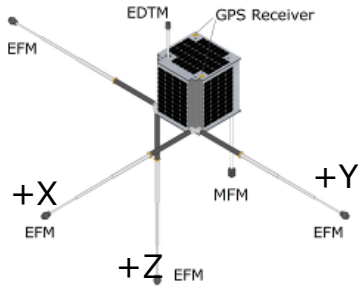
Mar. 2017: RK introduced Prof. **Masahiko Yamazaki** (Nihon University).
MY and MK decided the develop of EQ prediction satellite based on MIC2 and MIC4.
A development of PRELUDE (**Pre**cursory e**l**ectric field observation C**u**beSat **De**monstrator) started.

Feb. 2023: Additional Selection for the JAXA Innovative Satellite Technology Demonstration-4

Jan.-Mar. 2026 (expected): PRELUDE launched by Electron rocket (Rocket Lab)
2026-2027 (expected) PRELUDE operation

MIC2: Satellite design

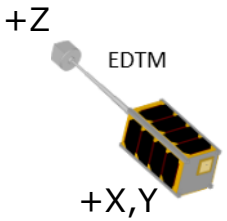
Main Satellite



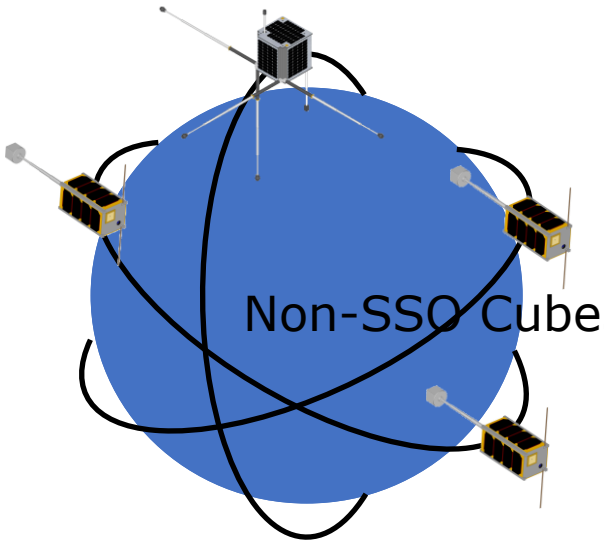
50 kg satellite to treat with a large amount of Mission Data on sun-synchronous orbit.

Sub Satellite

CubeSats on non-sun-synchronous orbit.



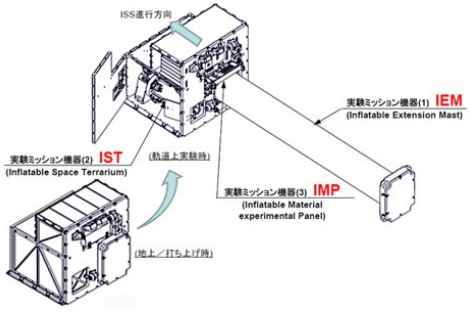
SSO Main Satellite (50 kg)



2-year lifetime

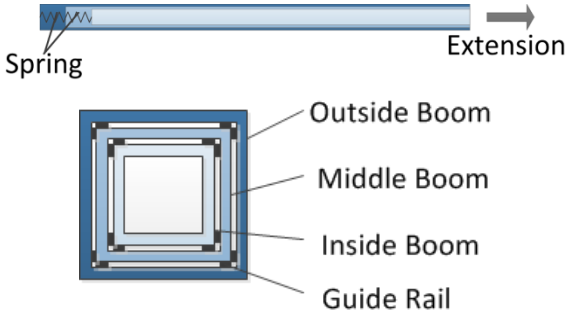
Inflatable Extension Mast (IEM)

image

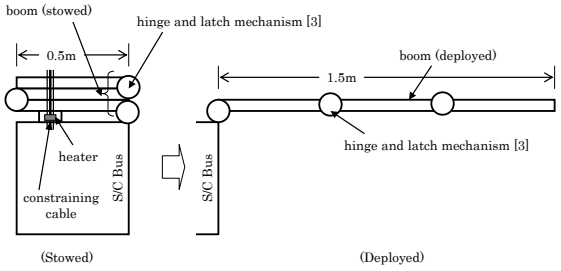


http://iss.jaxa.jp/kiboexp/news/120821_simple.html

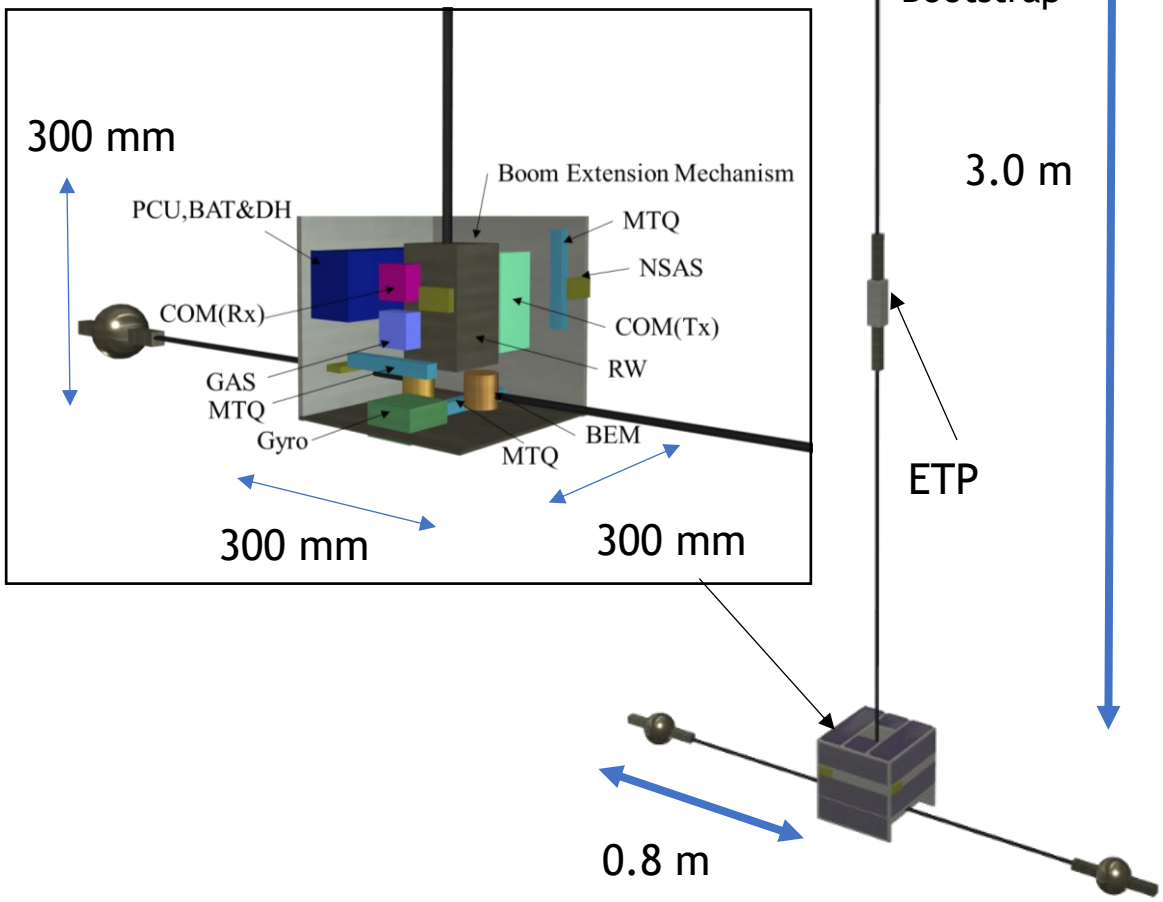
Telescopic Extension Mast (TEM)



Deployment Boom (DB)

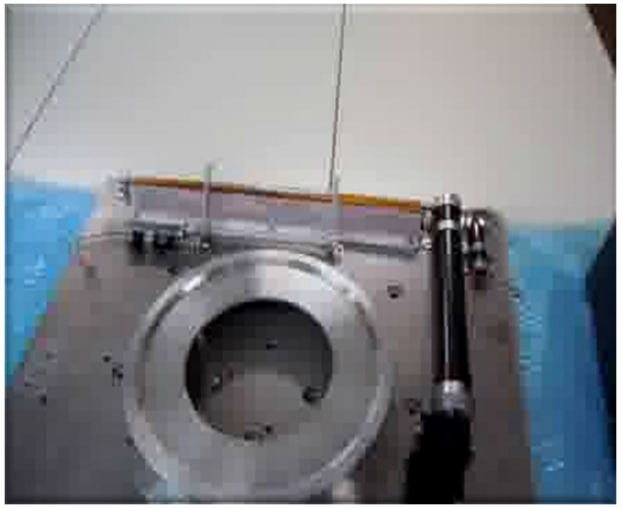


MIC4: Satellite design



Boom

[1]



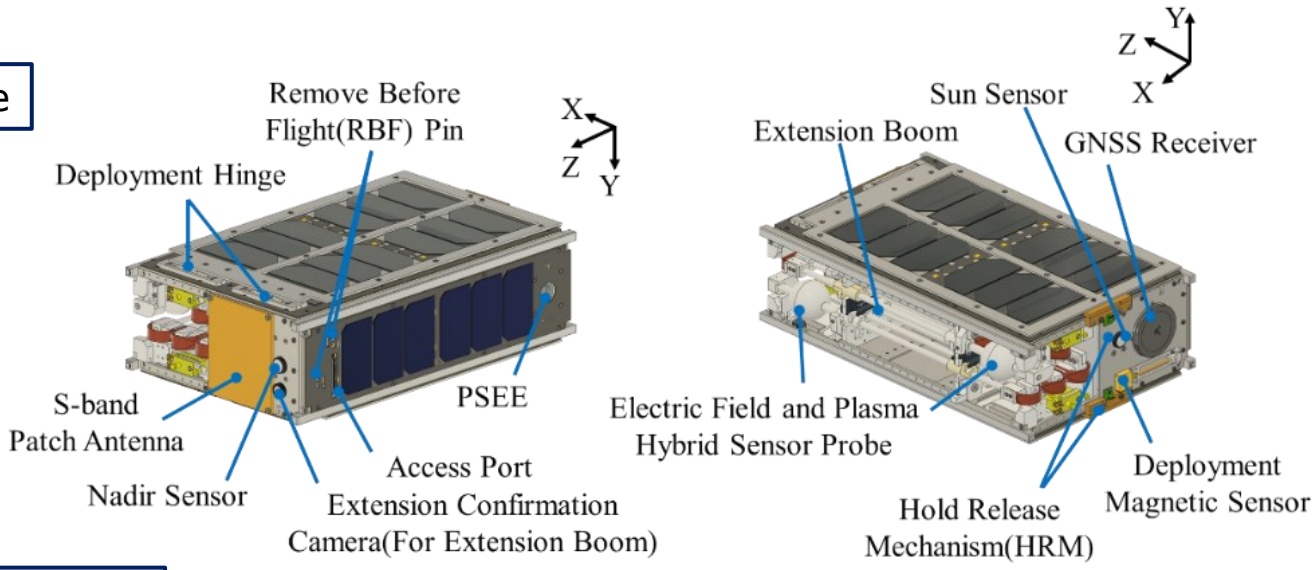
First natural frequency of longer boom is estimated to be around 3 Hz.

[1] http://www.i-qps.net/i-qps/service.html

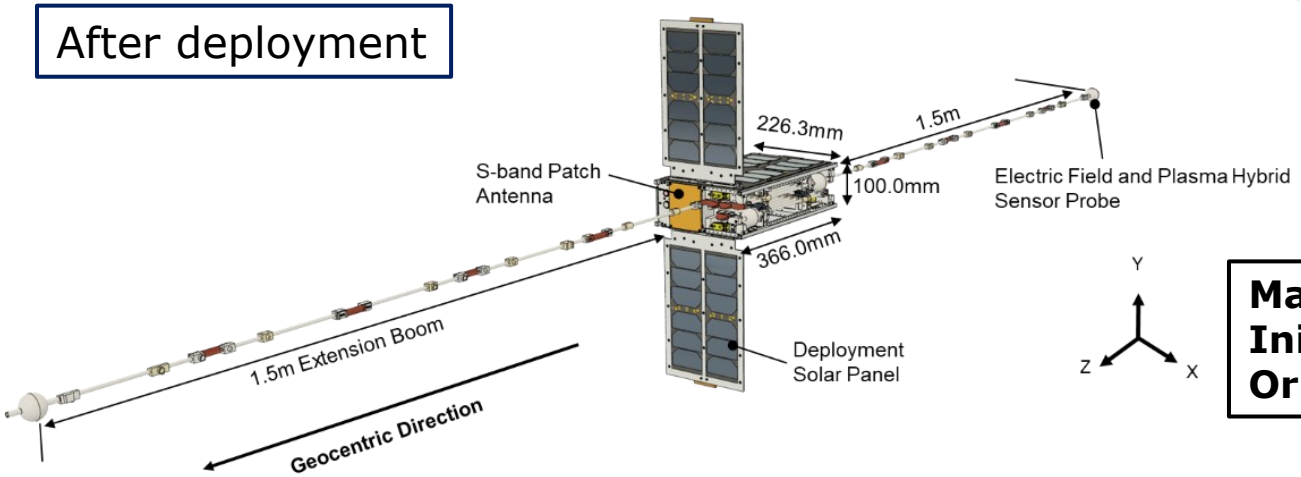
W6U CubeSat PRELUDE: Ambitious design!!

To observe the ionospheric electromagnetic phenomena, we are developing the PRELUDE satellite.

Launch state

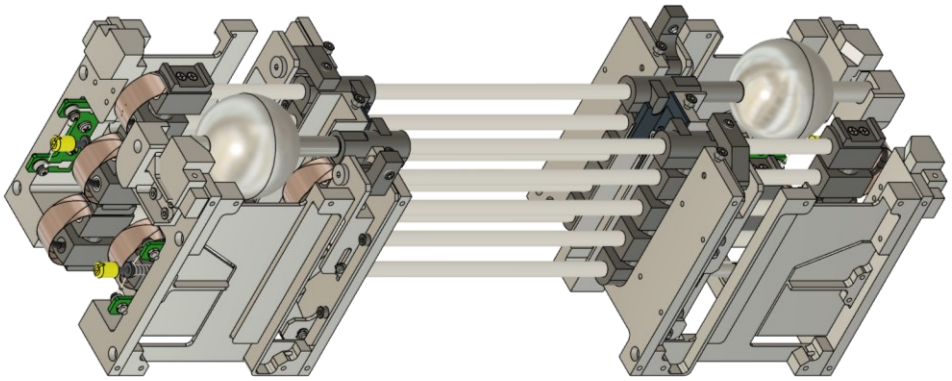


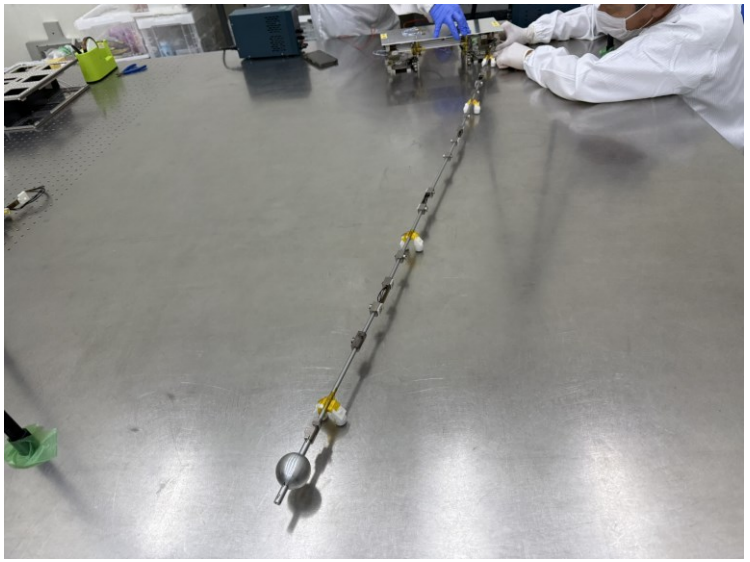
After deployment

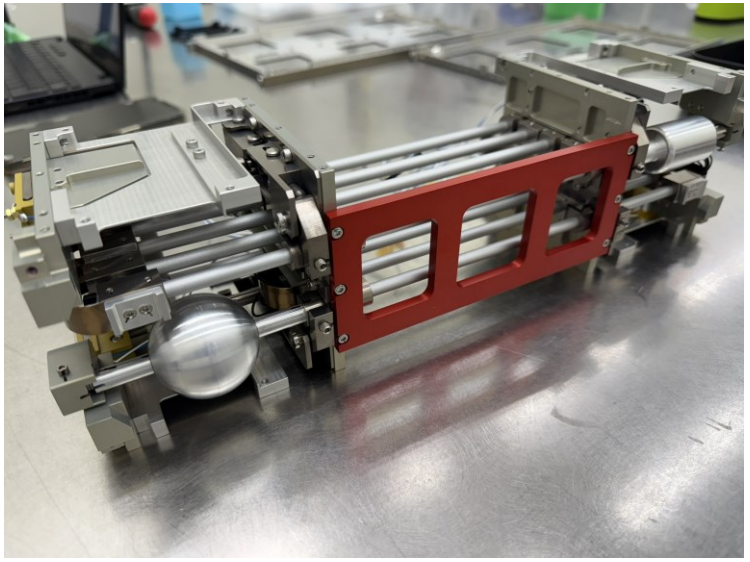


Mass: 8 kg
Initial Altitude: 540 km
Orbit: Sun Synchronous Orbit

Boom extension

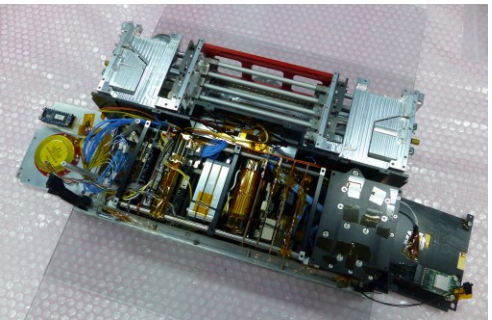
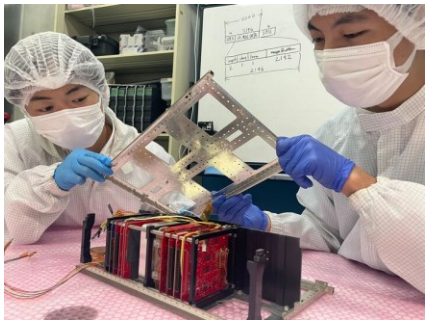
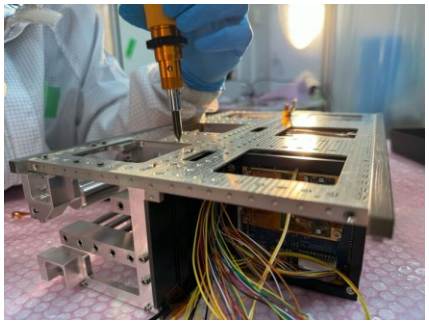






Conclusion

- MIC sowed the seeds for our real satellite, PRELUDE.
- UNISEC-Global is a treasure box that connects talented people from all over the world.
- Winning twice in MIC made it much easier to raise funds for the actual satellite development.
- Finally, PRELUDE is scheduled to be launched in early 2026.
- PRELUDE observes Earth's electromagnetic environment and contributes to space weather and various natural disaster studies.
- Now, Fundraising has begun for PRELUDE-2 and PRELUDE-3, aiming to build a constellation.

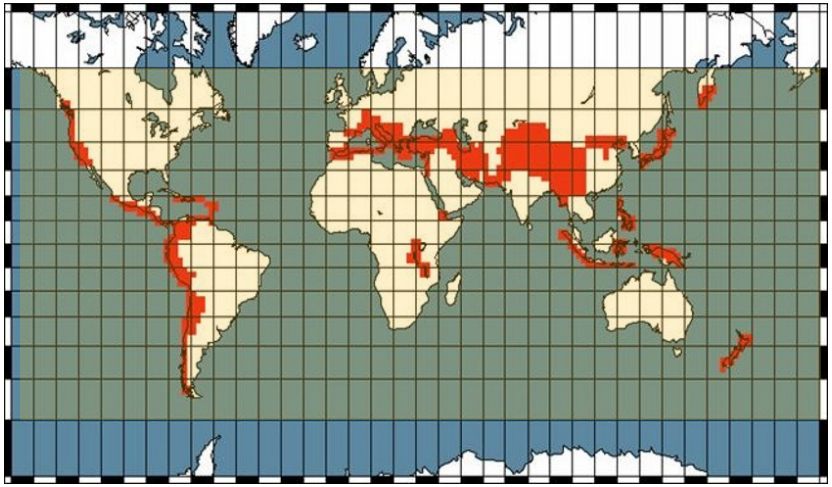




Wishing your MIC-born satellites will become real soon.

Plan for Mission Realization : Observation Area

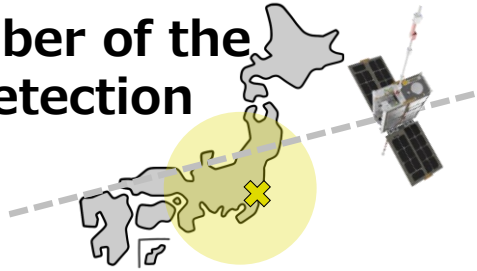
■ Observation Area

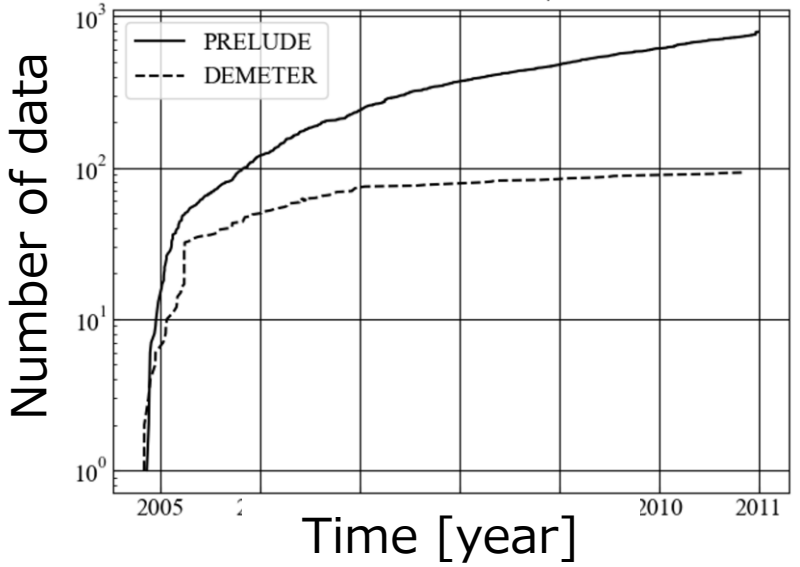
DEMETER : collected data only in a specific area.
PRELUDE : Expands observation area to collect more data.



Red: DEMETER observation area
Yellow: PRELUDE observation area

■ Count the Number of the Earthquakes Detection



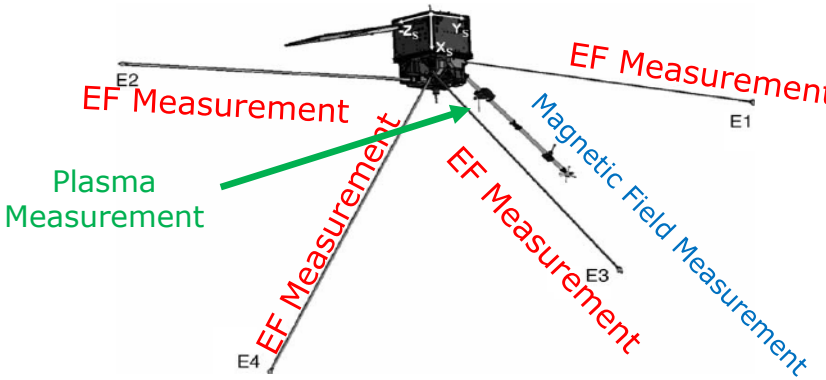


PRELUDE :132 detected / 1year
DEMETER: 15.5 detected / 1year

PRELUDE improves both the quality and quantity of data compared to DEMETER. The small size also allows for future constellations.

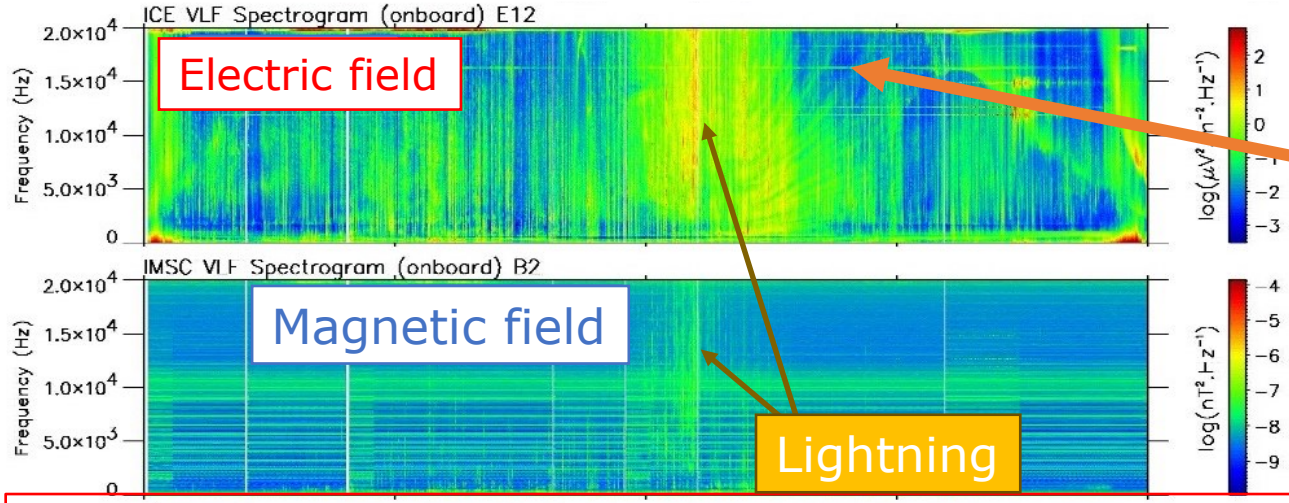
Advantages of Electric Field (EF) Measurement at Satellite Altitude

- At satellite altitudes, when comparing magnetic field and electric field measurements, both require sensor boom deployment, but electric field measurement offers higher sensitivity and is technically simpler.
- For example, focusing on Whistler (electromagnetic waves in plasma originating from lightning discharges), the signal should be detected synchronously in both electric and magnetic fields, but magnetic field measurements are found to be low in sensitivity.

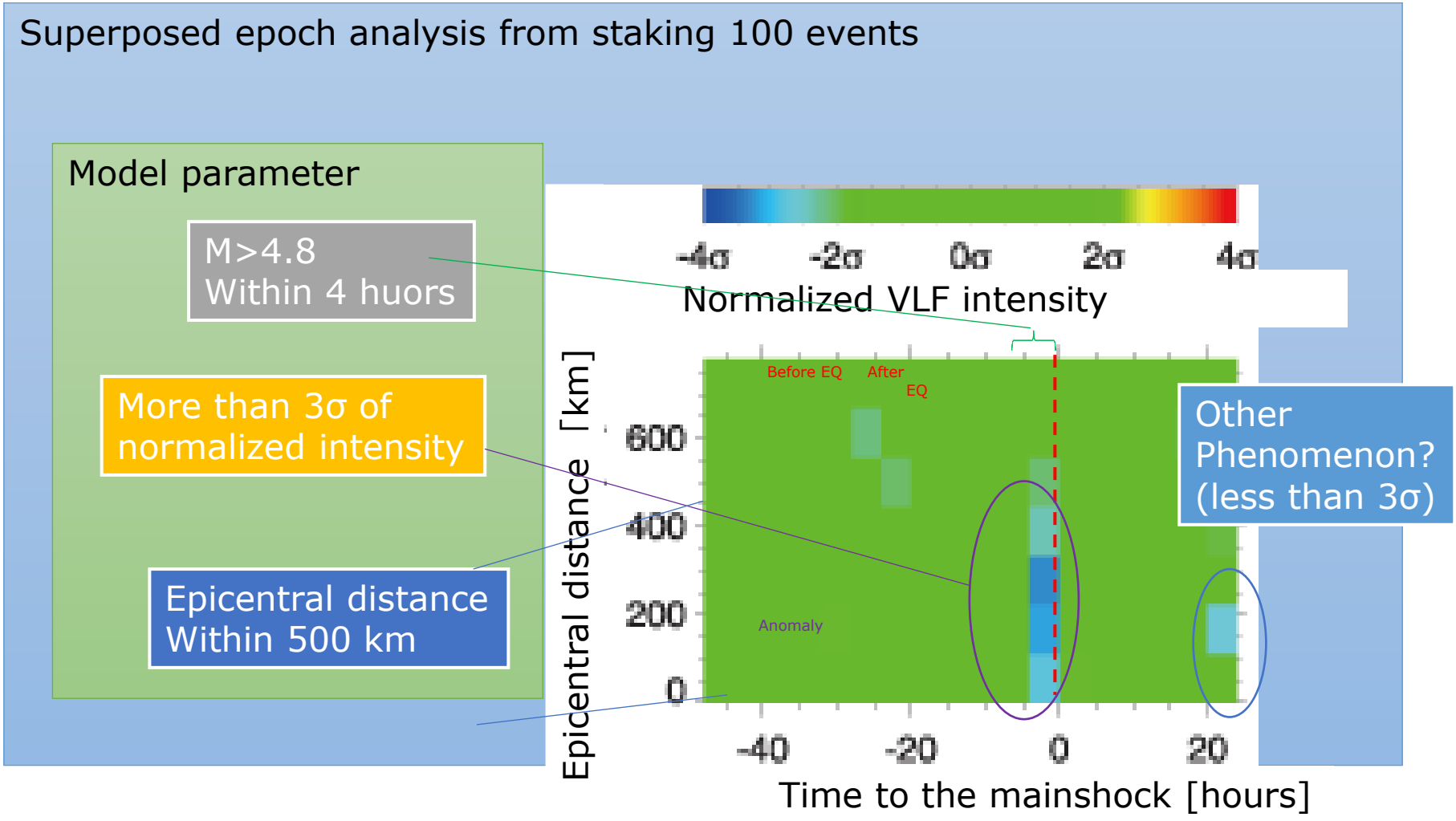


DEMETER Observation Sensors

DEMETER Nighttime 1-Orbit Time-Series Spectrum Data



In radio wave observations, including background noise, electric field measurements exhibit higher sensitivity than magnetic field measurements.

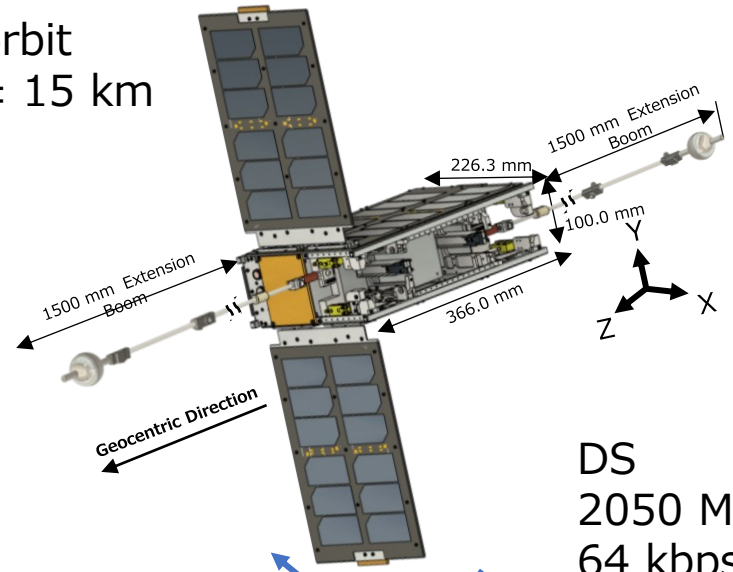


Statistical study of pre-seismic VLF intensity decrease

(=Background VLF intensity) [Nemec et al., GRL, 2008]

Cloud ground station

Sun synchronous orbit
Altitude: 540 km ± 15 km
Local time: 15:30
Inclination: 97.5



Present PRELUDE employs S-band communication.
If needed, S-band can be replaced by X-band.

DS
2050 MHz
64 kbps
QPSK

US
2285 MHz
256k~2Mbps
BPSK

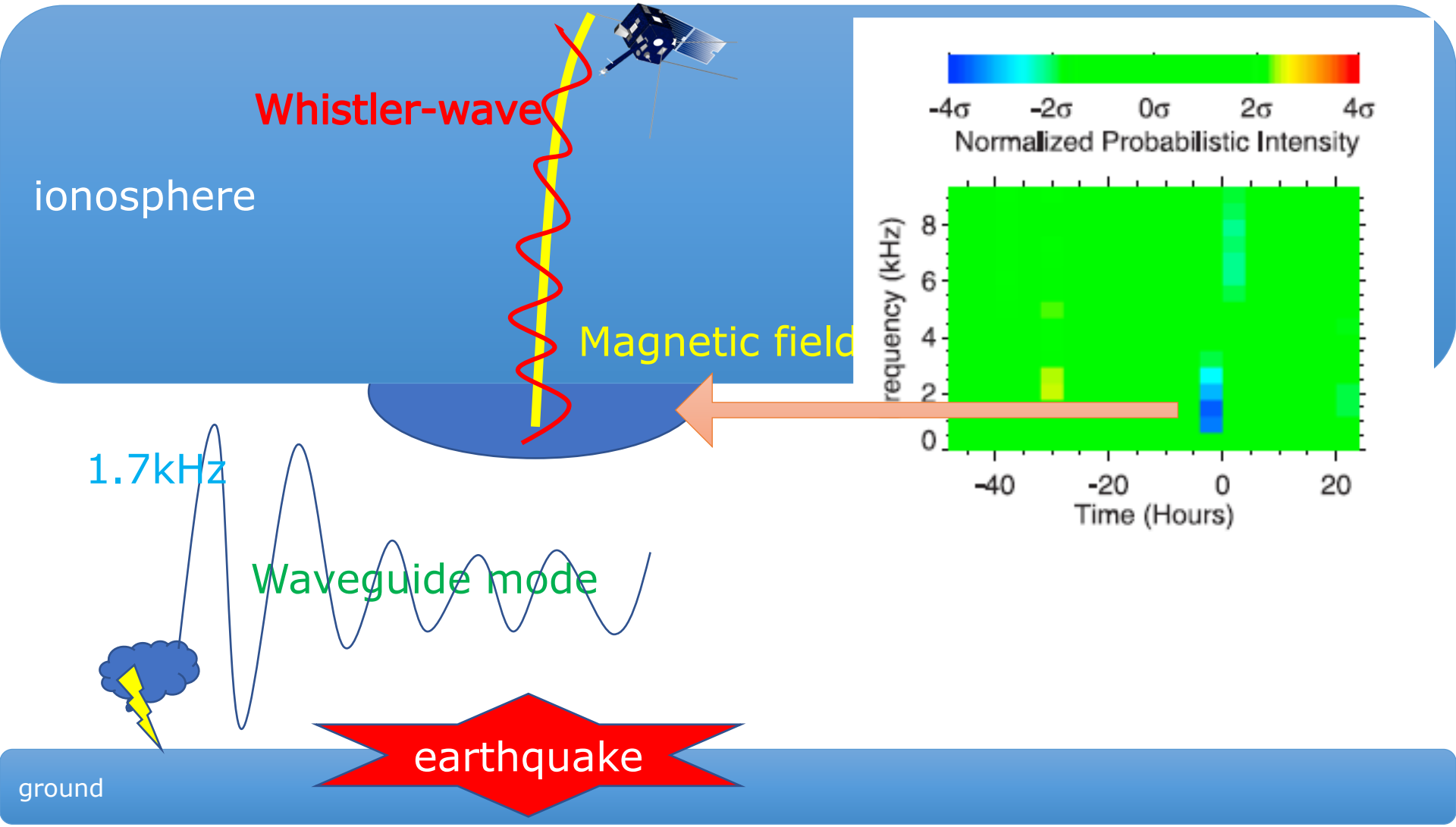
Remote control

GS operator

StellarStation

KHI (Gifu)

BAKU(Azerbaijan)


Whistler-wave
ionosphere
Magnetic field
-4σ
-2σ
0σ
2σ
4σ
Normalized Probabilistic Intensity
Frequency (kHz)
8
6
4
2
0
-40
-20
0
20
Time (Hours)
1.7kHz
Waveguide mode
earthquake
ground