“Geomagnetic Variations and Space Weather Hazard Assessment in the Mongolian Region”

Munkhzul JARGALNEMEKH, Amarjargal BAT-ERDENE

Institute of Astronomy and Geophysics, MAS

munkhzul.j@iag.ac.mn

July 28, 2026

Outline

- ✓ Research Objectives
- ✓ Physical Background
- ✓ Data
- ✓ Results
- ✓ Conclusion

Research Objectives

- Develop a long-term geomagnetic storm catalog for Mongolia covering the period 1995-2026 and examine its relationship with solar activity (Sunspot Number, SSN).
- Investigate the physical mechanisms of the 5-6 December 2020 sudden-commencement (SSC) CME-driven geomagnetic storm through integrated analysis of satellite and ground-based observations.
- Examine magnetopause compression, magnetic reconnection, and the propagation delay of the solar wind disturbance to improve understanding of Sun Earth interactions and regional geomagnetic responses.

Significance

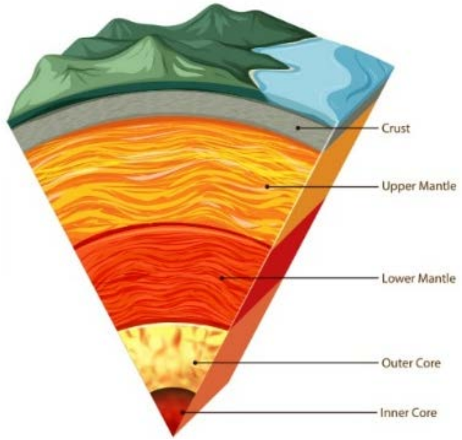
- Enhance the regional geomagnetic storm database for space weather research in Mongolia.
- Demonstrate the application of integrated satellite and ground-based observations for investigating geomagnetic storm processes.
- Contribute to regional space weather hazard assessment through improved understanding of geomagnetic storm dynamics.

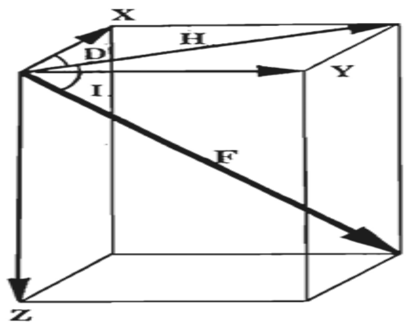
Solar Wind
↓
Magnetosphere
↓
Ground Observations

Physical Background

Institute of Astronomy and Geophysics
Mongolian Academy of Sciences

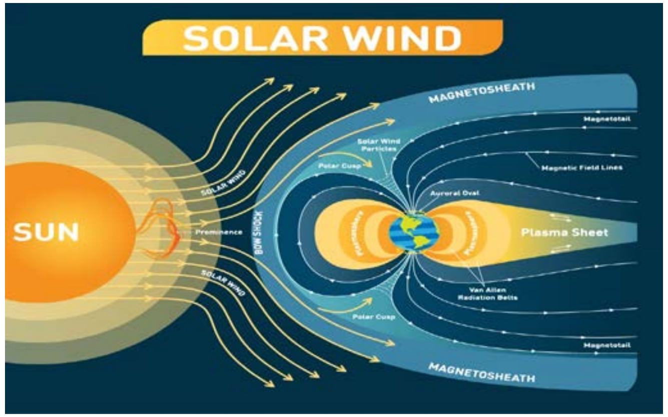
Internal Magnetic Field Sources

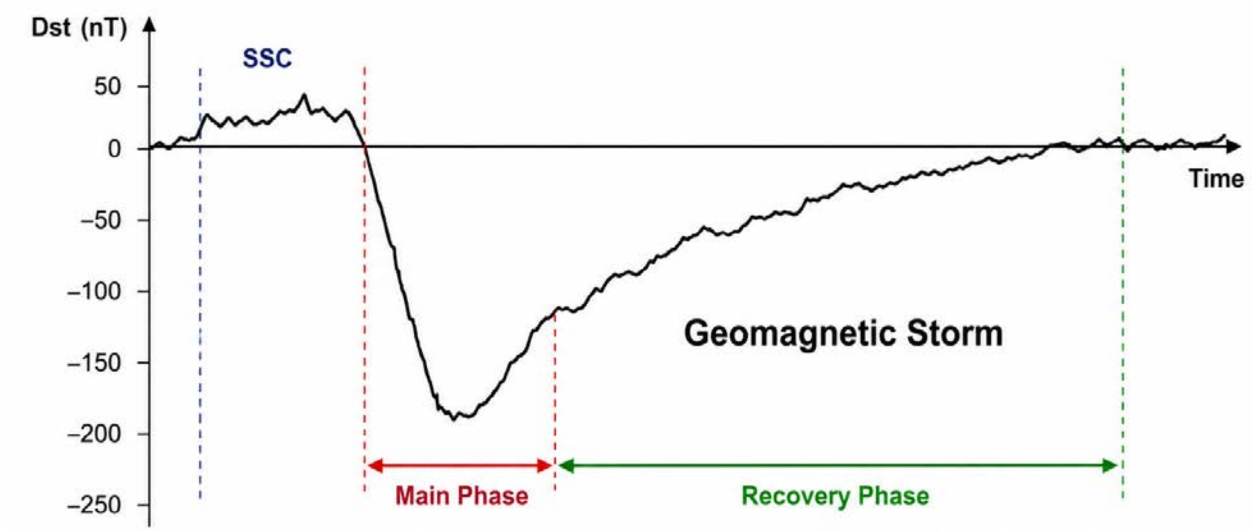




$$H = \sqrt{X^2 + Y^2}$$

External Magnetic Field sources



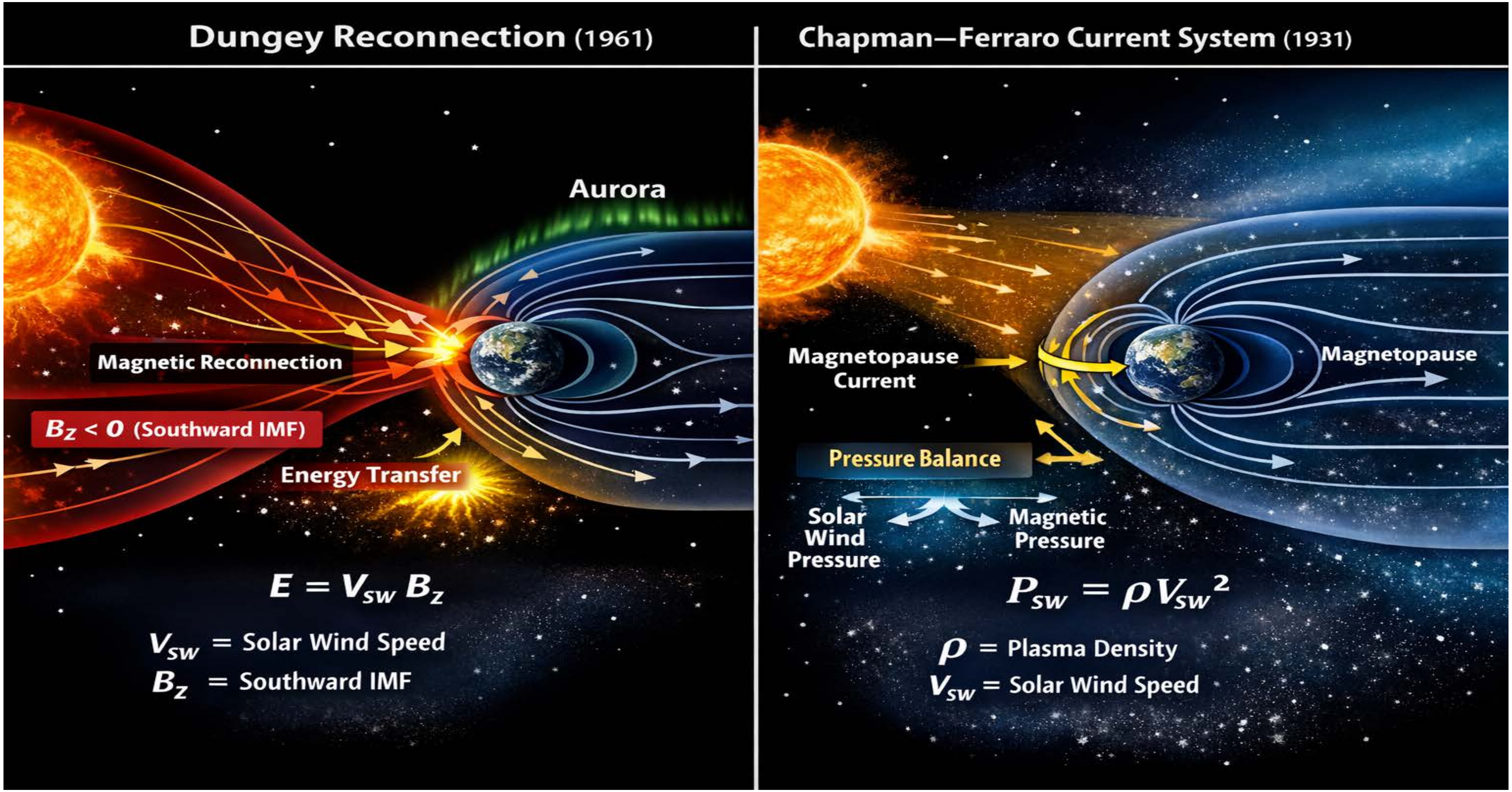


Dst index indicates the intensity of geomagnetic storms

Magnetospheric Current Systems

- Magnetopause current
- Ring current
- Magnetotail current
- Field-aligned currents

Physical Background



Magnetic reconnection and solar wind dynamic pressure are the primary physical drivers of geomagnetic storms.

Data Sources

OMNI Database
- *Solar wind speed (Vsw)*
- *Bz, IMF*
- *Dynamic pressure (Pdyn)*
- *SYM/H index*

Cluster Mission
- *IMF (Bx, By, Bz)*
- *Plasma velocity (Vx)*

Ground based magnetometer of Mongolia HVD-MAGDAS
- *(H, D, Z components)*

INTERMAGNET
- *Ground magnetic field*
- *H component*

10 Hz magnetic field data

↓

1-minute averaging

↓

Selection of 5 International Quiet Days (IQD)

↓

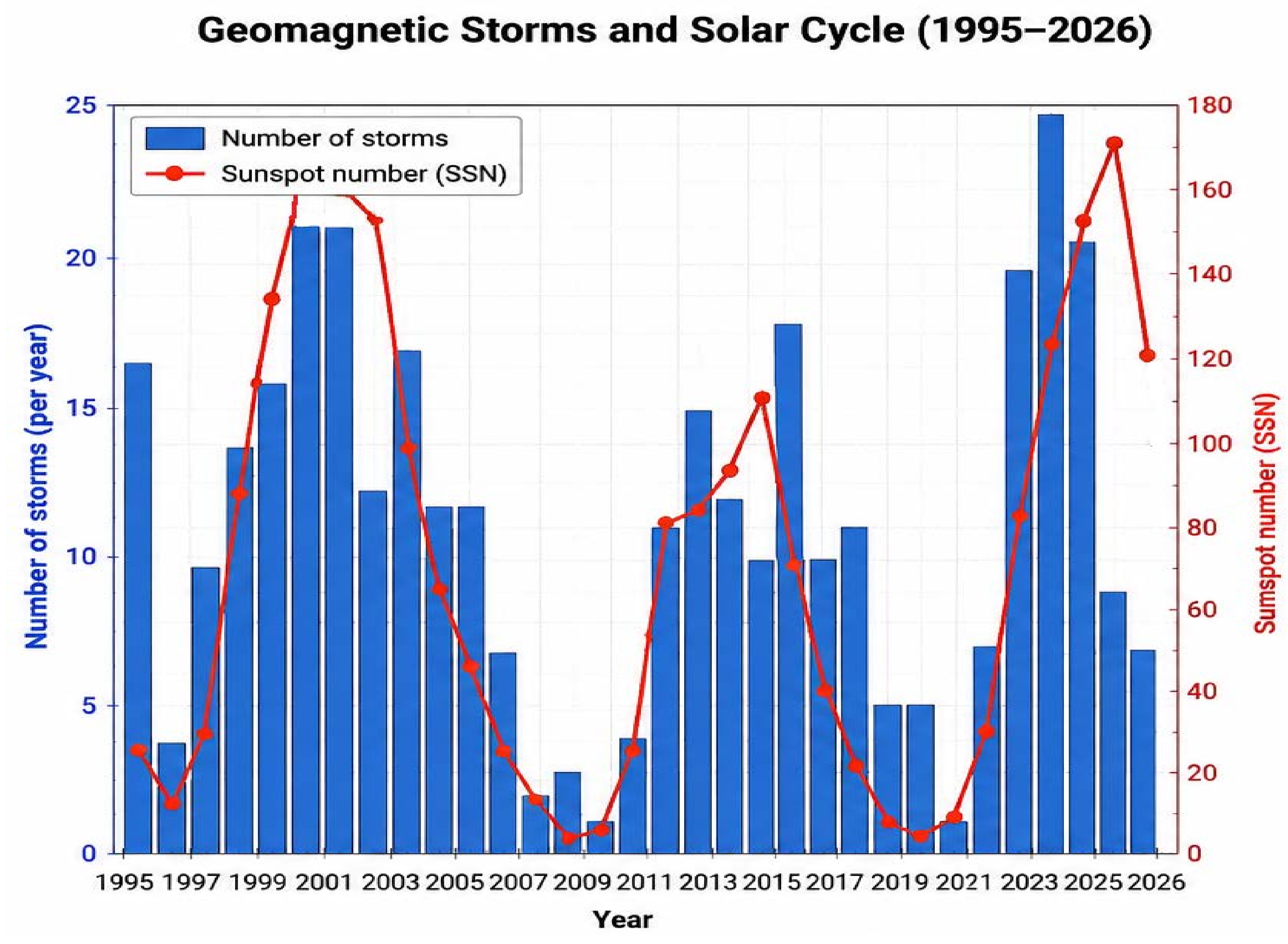
Baseline (Hq)

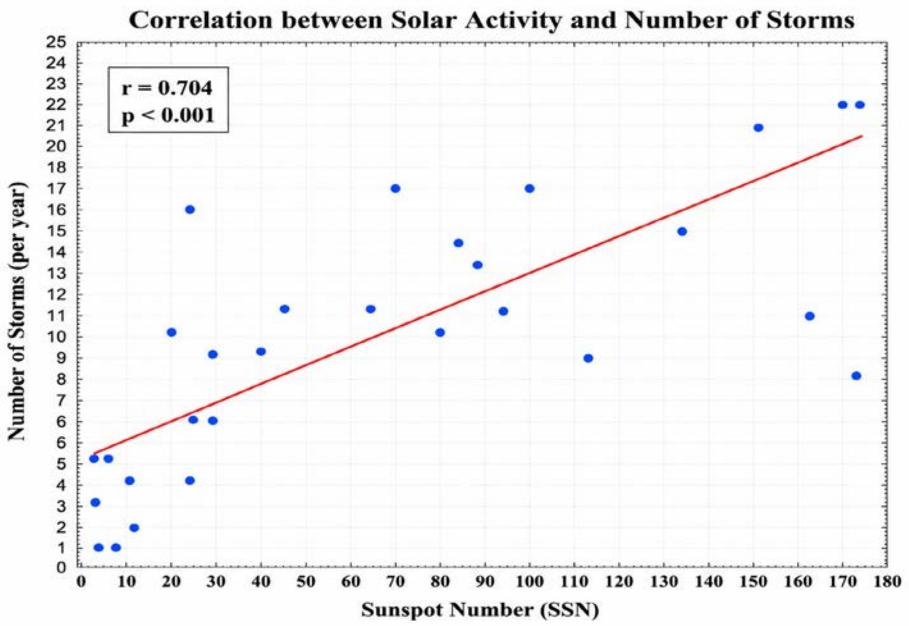
↓

$\Delta H = H - Hq$

Results: Long term Statistics of Geomagnetic Storms (1995-2026)

Institute of Astronomy and Geophysics
Mongolian Academy of Sciences

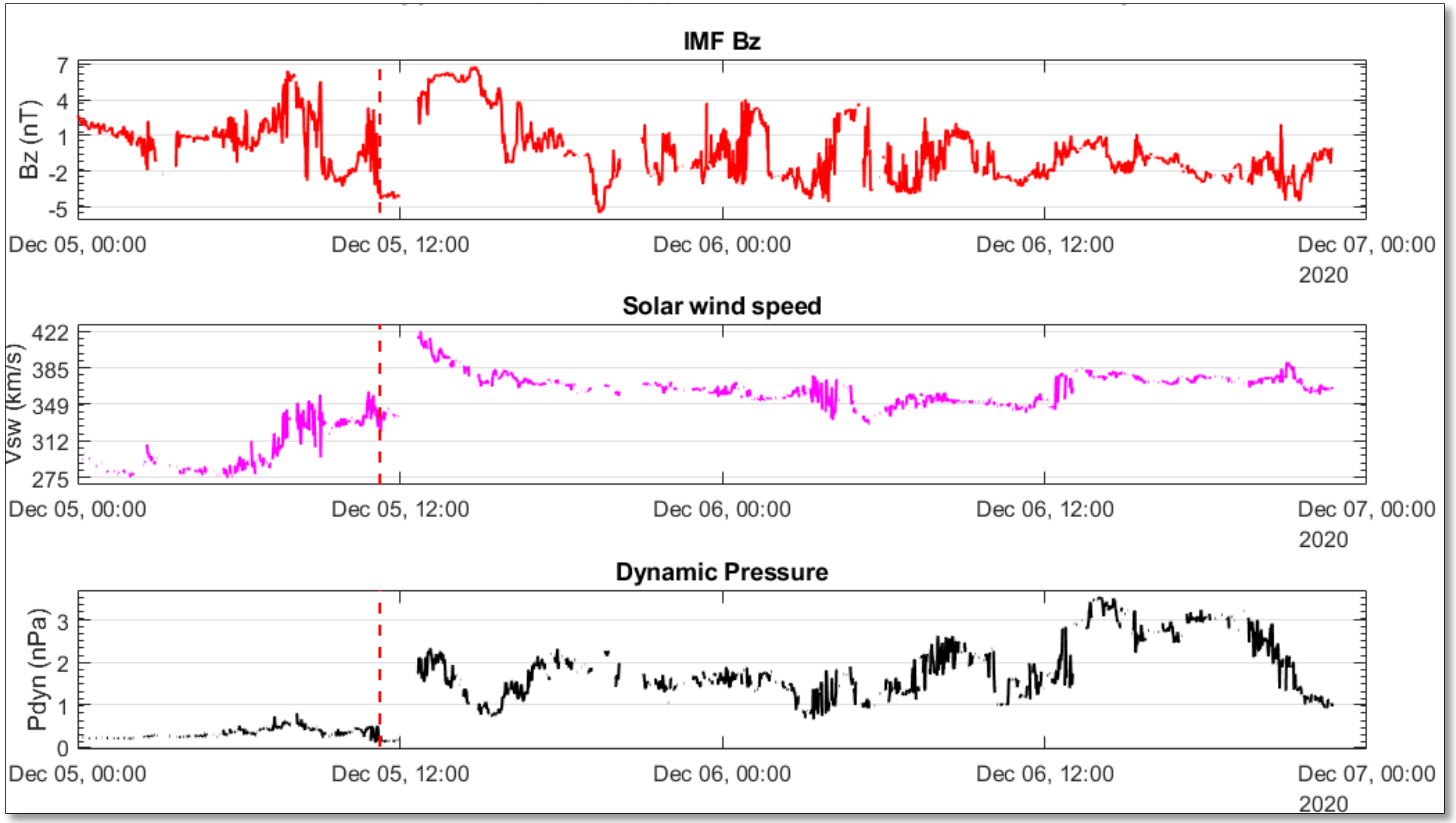




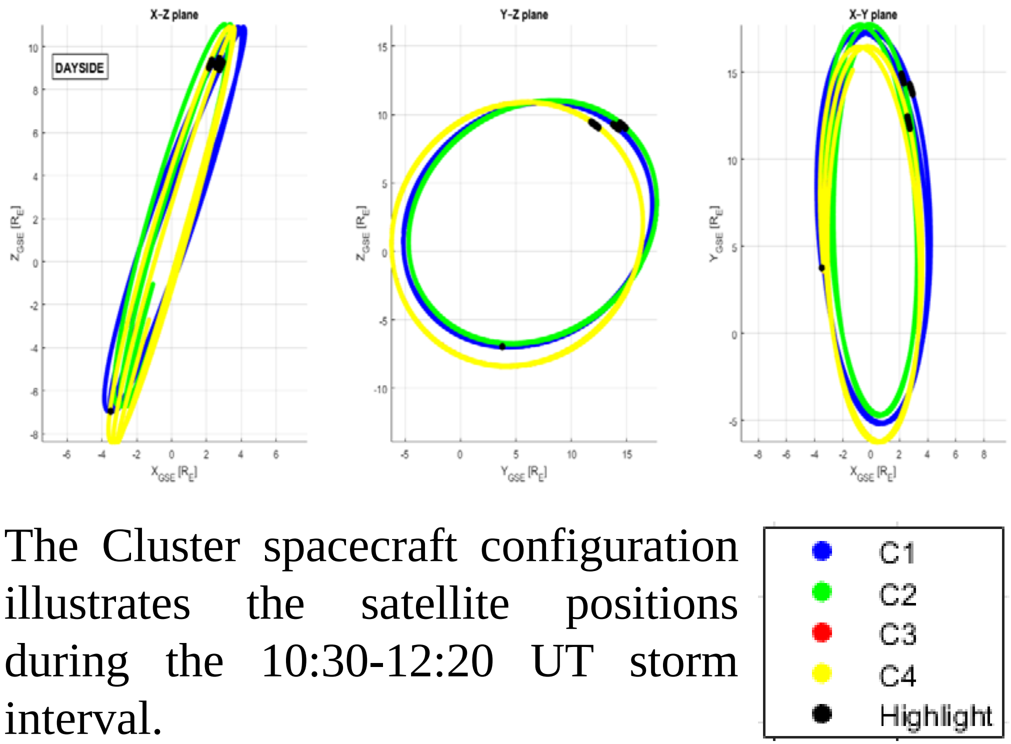
- ✔ 356 geomagnetic storms identified
- ✔ Strong positive correlation: $r = 0.704$
- ✔ Storm occurrence follows the solar cycle

Results: 5-6 December 2020, Geomagnetic Storm

Magnetosphere



Cluster Spacecraft Positions



The Cluster spacecraft configuration illustrates the satellite positions during the 10:30-12:20 UT storm interval.

Case rationale

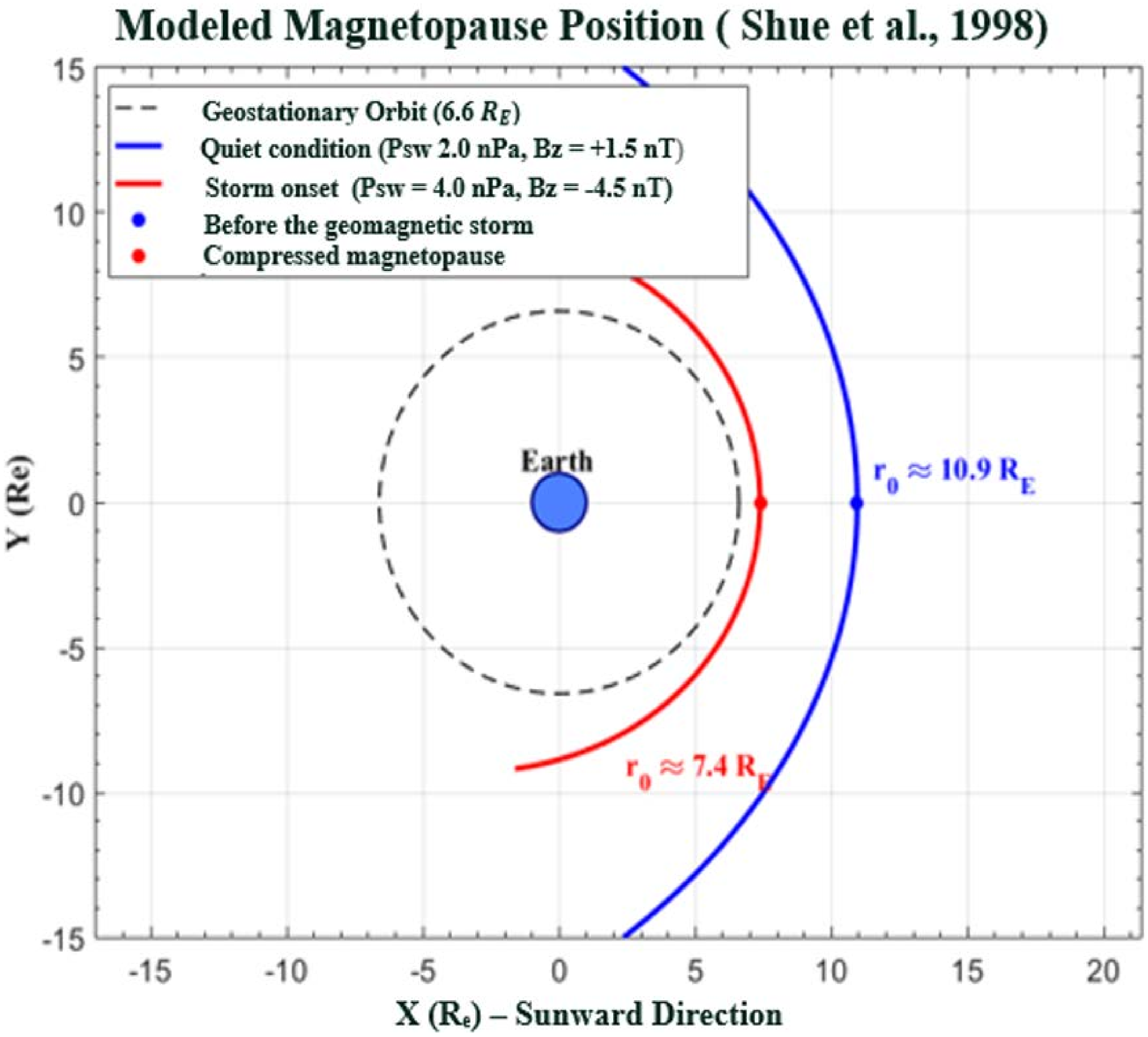
- *Rare storm during low solar activity (Solar Cycle 24-25 transition).*
- *Clear regional response (Dst < -40 nT).*
- *Multi-source observations (Cluster+ground).*

The OMNI observations show a southward turning of the IMF Bz, accompanied by increases in solar wind speed and dynamic pressure during the storm interval.

IMF Bz ≈ -4 nT
Vsw ≈ 422 km/s
Pdyn ≈ 2-4 nPa

Magnetopause Compression During the Geomagnetic Storm

Institute of Astronomy and Geophysics
Mongolian Academy of Sciences

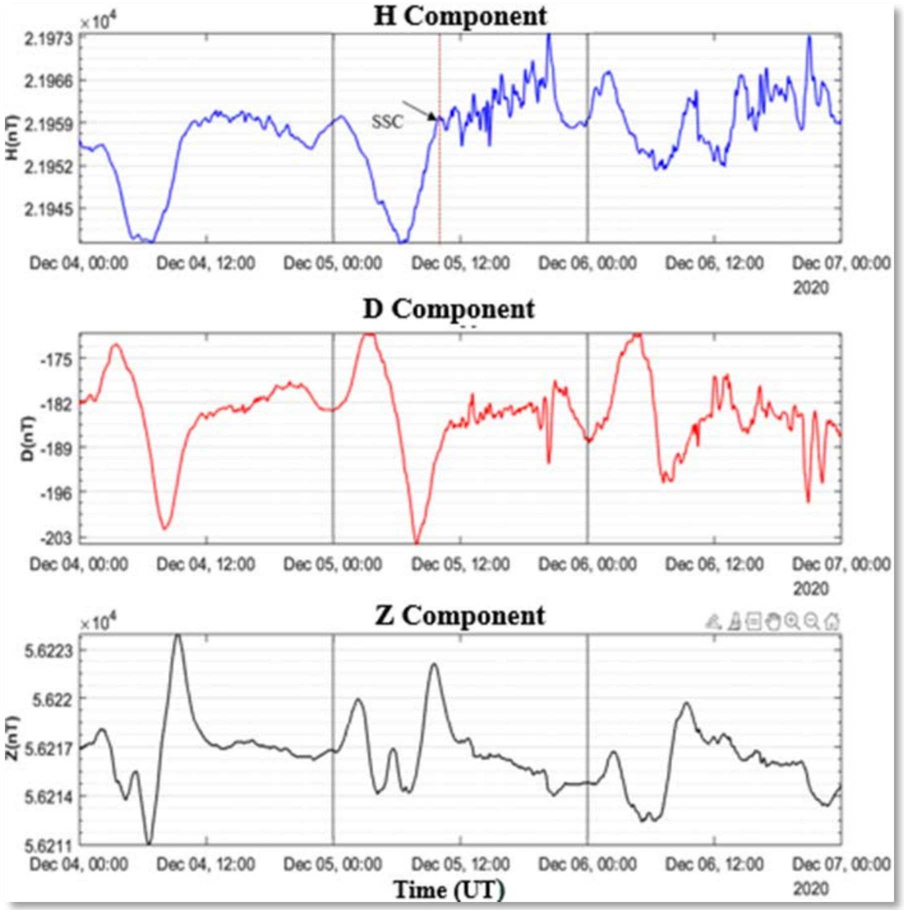


- Enhanced solar wind dynamic pressure compressed the dayside magnetopause.
- The subsolar stand-off distance decreased from ~10.9 R_E to ~7.4 R_E (R_E =6370 km)
- The modeled magnetopause compression is consistent with the observed geomagnetic sudden impulse (SI).

Results: Ground Magnetic Response (5 December 2020)

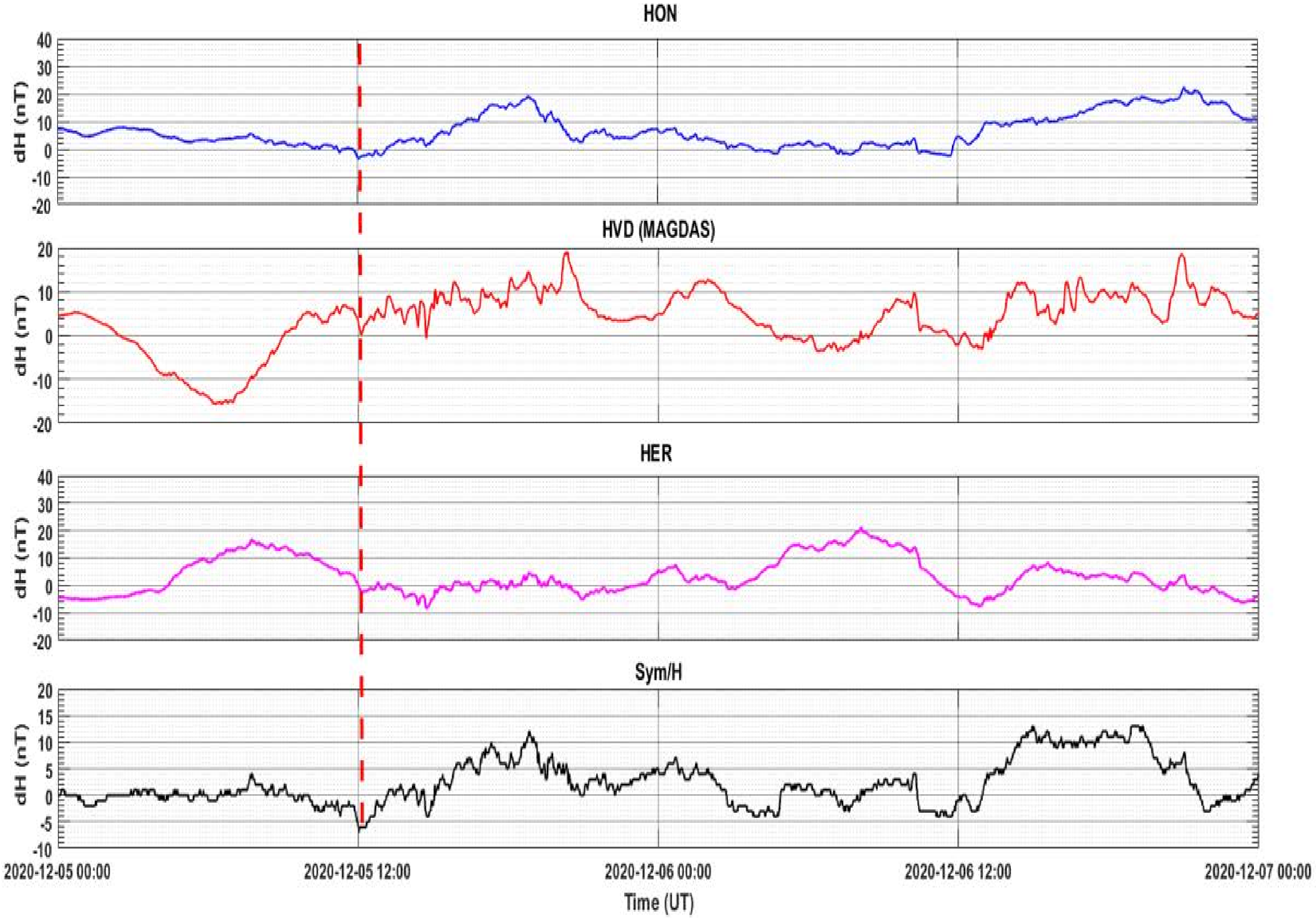
Institute of Astronomy and Geophysics
Mongolian Academy of Sciences

Hovd Observatory (HVD-MAGDAS) Magnetic Field Components (H, D, Z)



H
↓
ΔH

ΔH- Variations of Geomagnetic field

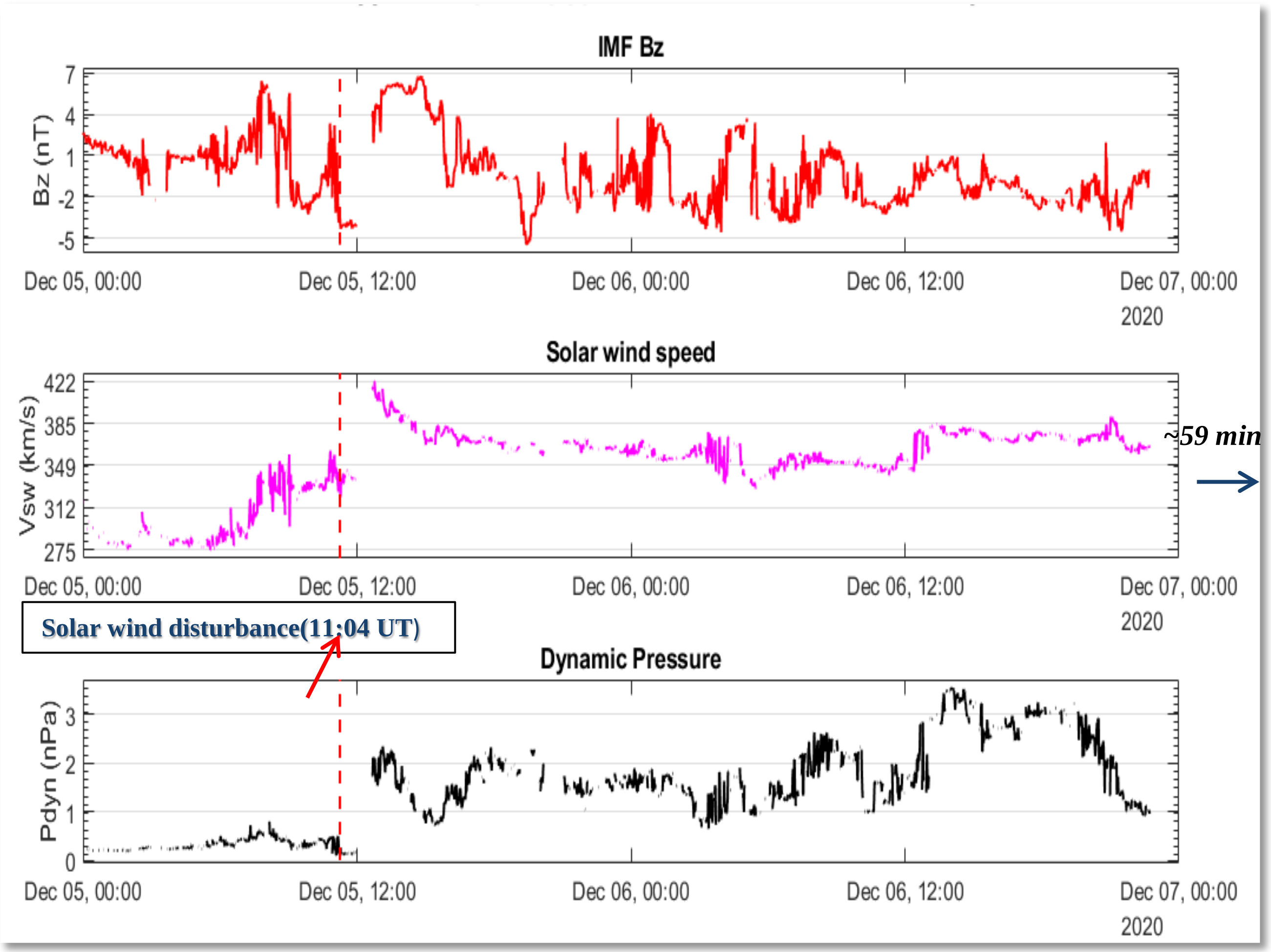


- SSC was identified in the H component at HVD in Mongolia
- Consistent ΔH responses were observed at HON, HVD, and HER.

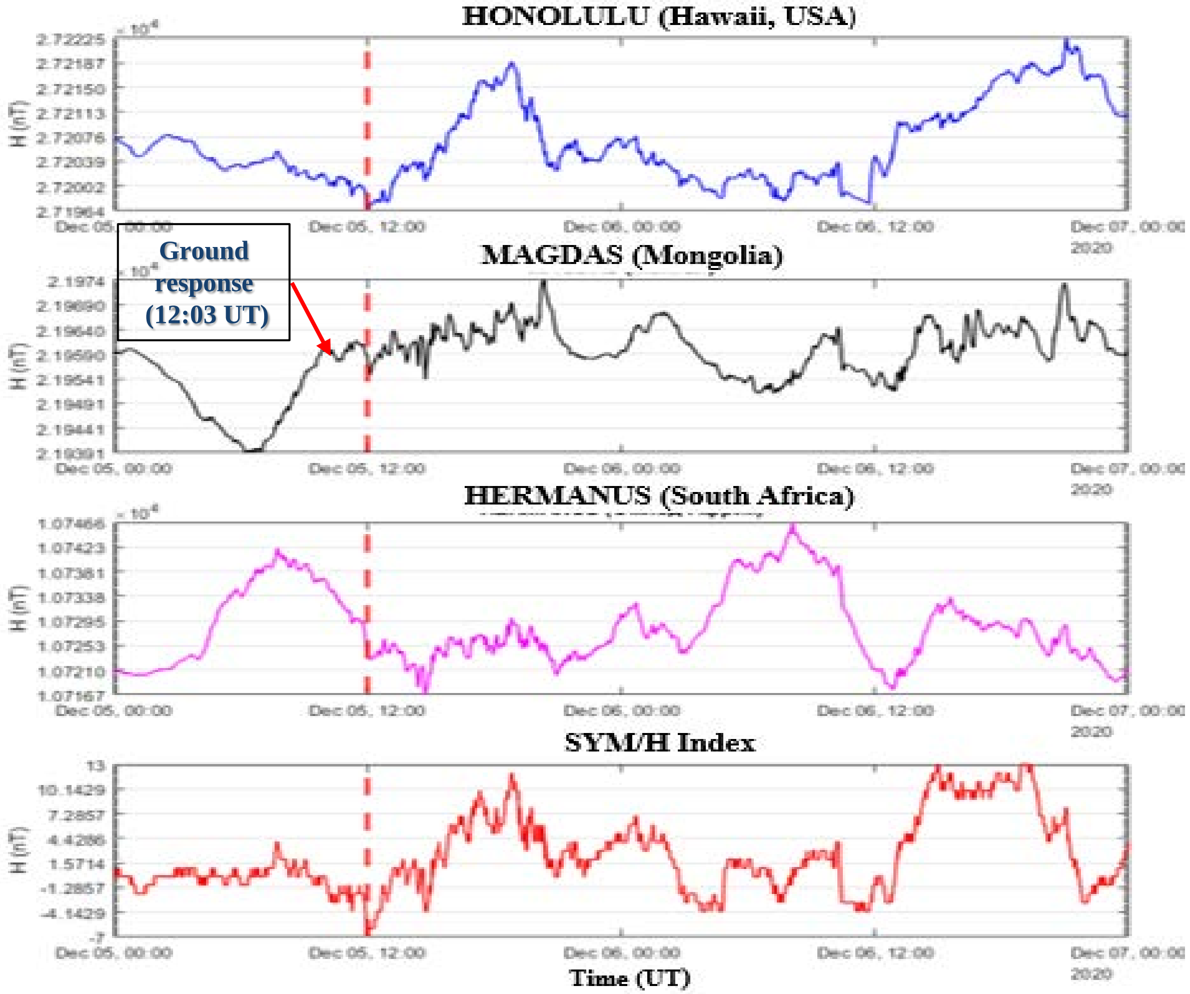
Results: From Satellite Detection to Ground Magnetic Response

Institute of Astronomy and Geophysics
Mongolian Academy of Sciences

Observations of Satellite (OMNI)



Observation of ground based Magnetometer



The solar wind disturbance detected at 11:04 UT was followed by a ground magnetic response at 12:03 UT (~59 min later), with the SYM-H index confirming the associated global geomagnetic disturbance.

Conclusion

In this study, geomagnetic variations and geomagnetic storms observed in Mongolia during the period 1995-2026 were investigated using geomagnetic data from the Ulaanbaatar Observatory. Based on these observations and solar wind data, the physical conditions responsible for space weather hazards, the response of the Earth's magnetic field, and the potential for early warning were examined.

- The southward component of the interplanetary magnetic field ($Bz < 0$), together with sudden increases in solar wind dynamic pressure (Psw) and solar wind velocity (Vsw), are the primary physical drivers of geomagnetic storms. These variations produce significant disturbances in the Earth's geomagnetic field and play a key role in the development of hazardous space weather conditions.

- The response of the Earth's geomagnetic field to changes in the solar wind parameters was found to occur with an average time delay of 49–59 minutes. This time lag indicates that geomagnetic storms can be forecast approximately 50 minutes in advance using real-time solar wind observations.

- The findings of this study provide a scientific basis for the development of space weather early warning systems aimed at protecting critical infrastructure, including satellites, electric power transmission networks, communication systems, and navigation services.

The results therefore have significant scientific and practical value for space weather monitoring and hazard mitigation.This study demonstrates that satellite and ground-based observations provide a consistent framework for investigating geomagnetic storm processes and assessing regional space weather hazards.

Thank you for your attention