THE INTERNATIONAL CONFERENCE ON THE 120TH ANNIVERSARY OF THE BULNAY EARTHQUAKE:
ADVANCES IN ASTRONOMY AND GEOPHYSICS

ANALYSIS OF IONOSPHERIC RESPONSES DURING THE STRONG GEOMAGNETIC STORM OF 2024

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Outline

- ✓ General overview
- ✓ Theory
- ✓ Database compilation
- ✓ Results and Analysis

General overview

In Mongolia, the Ulaanbaatar Geomagnetic Observatory has been operational since 1965, serving as a foundation for the long-term observation of the temporal variations in the Earth's magnetic field. Through these observations, researchers have continuously studied the values of the main geomagnetic field, its secular variation, and daily fluctuations. The publication of the first list of geomagnetic storms in 1978 marked the beginning of geomagnetic storm research in Mongolia (Chimeddorj, 1978). Since then, specific types of geomagnetic variations observed in the country have been studied in detail. Using data from ground-based geomagnetic stations, researchers have examined how solar wind parameters influence variations in the geomagnetic field (Sukhbaatar, 1983).

A research method used to analyze patterns and processes occurring in the magnetosphere involves constructing the current systems of geomagnetic storms using data from global geomagnetic observatories. This method is known as the TIM **Technica Inverse Magnetogram**. It was developed in the mid-1970s by the Russian scientist V.M. Mishin (Mishin, 1990), and has since been adopted and applied in our geomagnetic research (Amarjargal, U., 2015; Sukhbaatar, 2016).

Using this method, we processed geomagnetic storm data and developed a model that, for the first time in Mongolia, enabled high temporal resolution identification of the different phases of geomagnetic storms (Amarjargal, B., 2020).

Theory

The Earth exists under the influence of the solar wind, a continuous plasma flow emitted by the Sun (Parker, 1958). Based on the theoretical formulation of the magnetosphere by Chapman and Ferraro, the interplanetary shock waves compress the Earth's magnetosphere, after which the structural configuration of the magnetosphere is determined by the enhancement of the geomagnetic field. Near the Earth's surface, particularly around the equatorial region, the variation in the geomagnetic field can be expressed in terms of measurable changes as follows:

$$\Delta H = 26.1 \times 10^{4}\left(\sqrt{P_2} - \sqrt{P_1}\right)\gamma$$

P 1 — Solar wind pressure before the compression of the Earth's magnetosphere

P 2 — Solar wind pressure after the compression of the Earth's magnetosphere

ΔH — Variation in the horizontal component of the Earth's magnetic field

Dst — Disturbance Storm Time index, which quantifies geomagnetic activity

1 γ=10^{-5} Гс=10^{-9} Тесла= 1нТ

Database compilation

1. A geomagnetic storm database was compiled using data from ground-based magnetic observatories: ULN, MTT, GVA, HBD, including field measurements of variations in the geomagnetic field (1994–2024).
2. In addition, a satellite data archive was established from the ACE and WIND spacecraft missions (2024).
3. A GNSS-based dataset was also compiled from the IGS ULAB station (2024).
4. Furthermore, radar-based measurements were incorporated from the SuperDARN (Super Dual Auroral Radar Network) system (2024).

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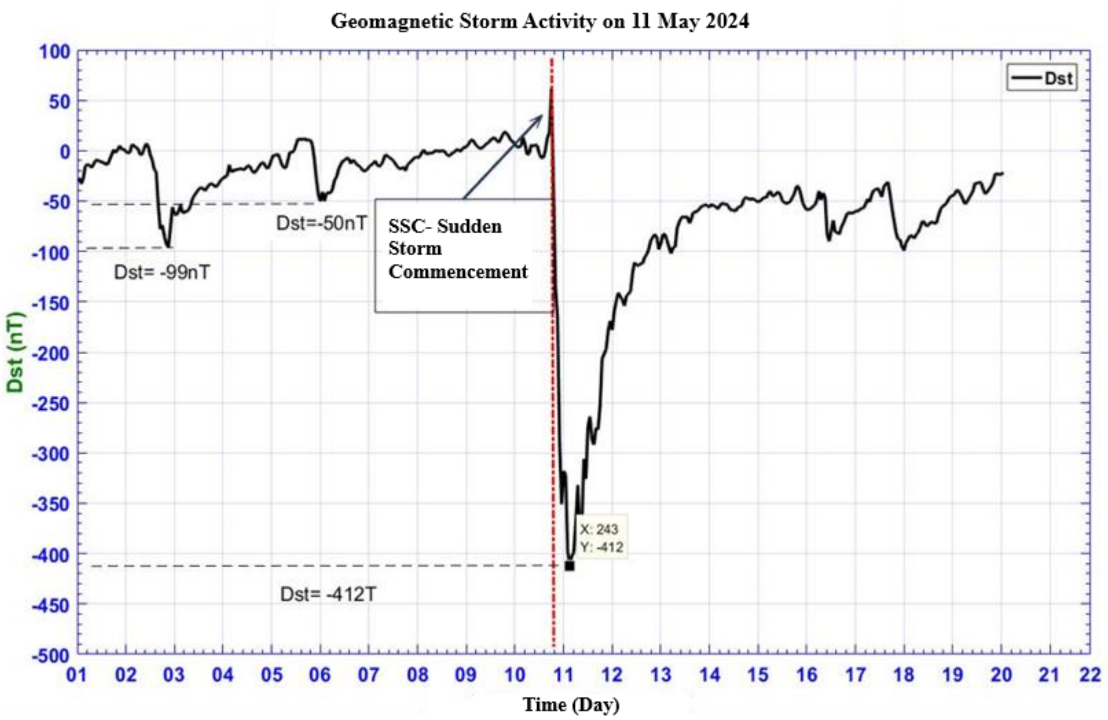
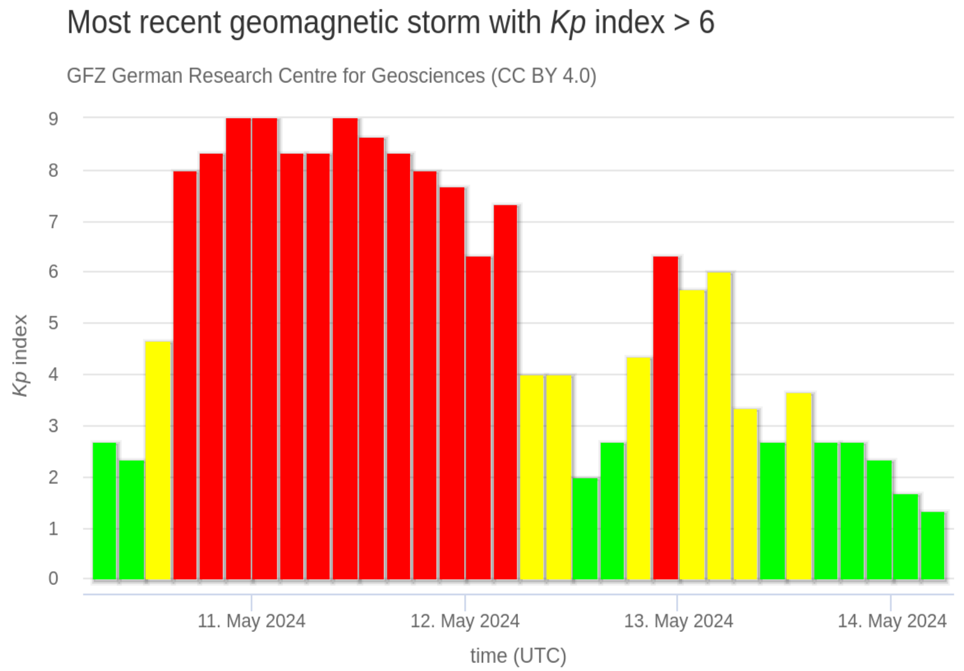
Result A dynamic study of the strong geomagnetic storm May 10, 2024.

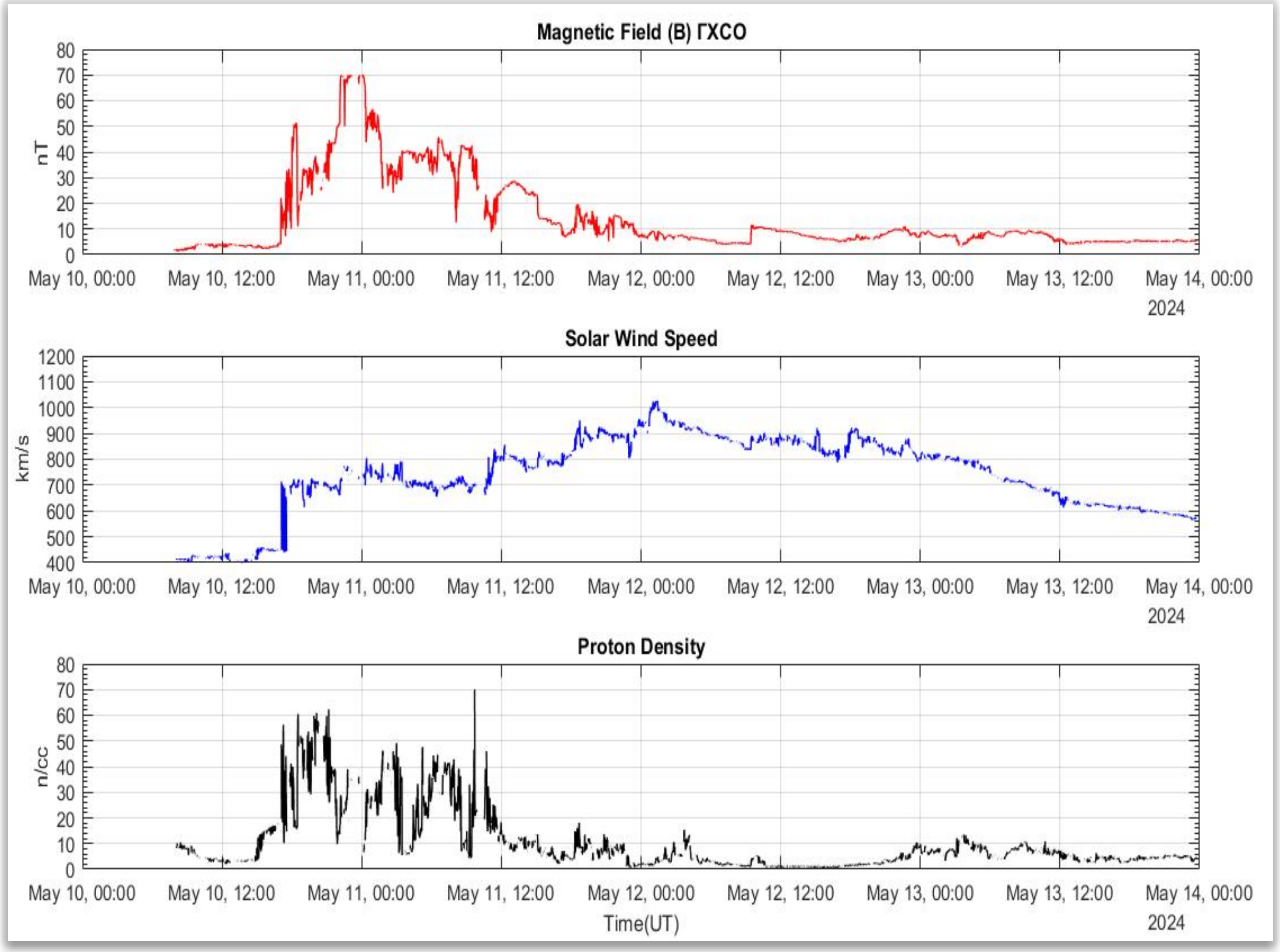
Parameter	Value
Geomagnetic storm level	G5 (extreme)
Dst-index	−412 nT
Kp -index	9 (maximum)
Duration of the storm	2024.05.10–2024.05.13





A dynamic study of the strong geomagnetic storm May 10, 2024. Mothers day storm

Satellite data. OMNI



B – IMF increased above 65 nT

The magnetic field at IMF showed a sharp increase around May 10, 12:00 UT, peaking near 70 nT, indicating the onset of a geomagnetic disturbance. Elevated levels persisted for over two days, associated with a coronal mass ejection (CME) or a high-speed solar wind stream.

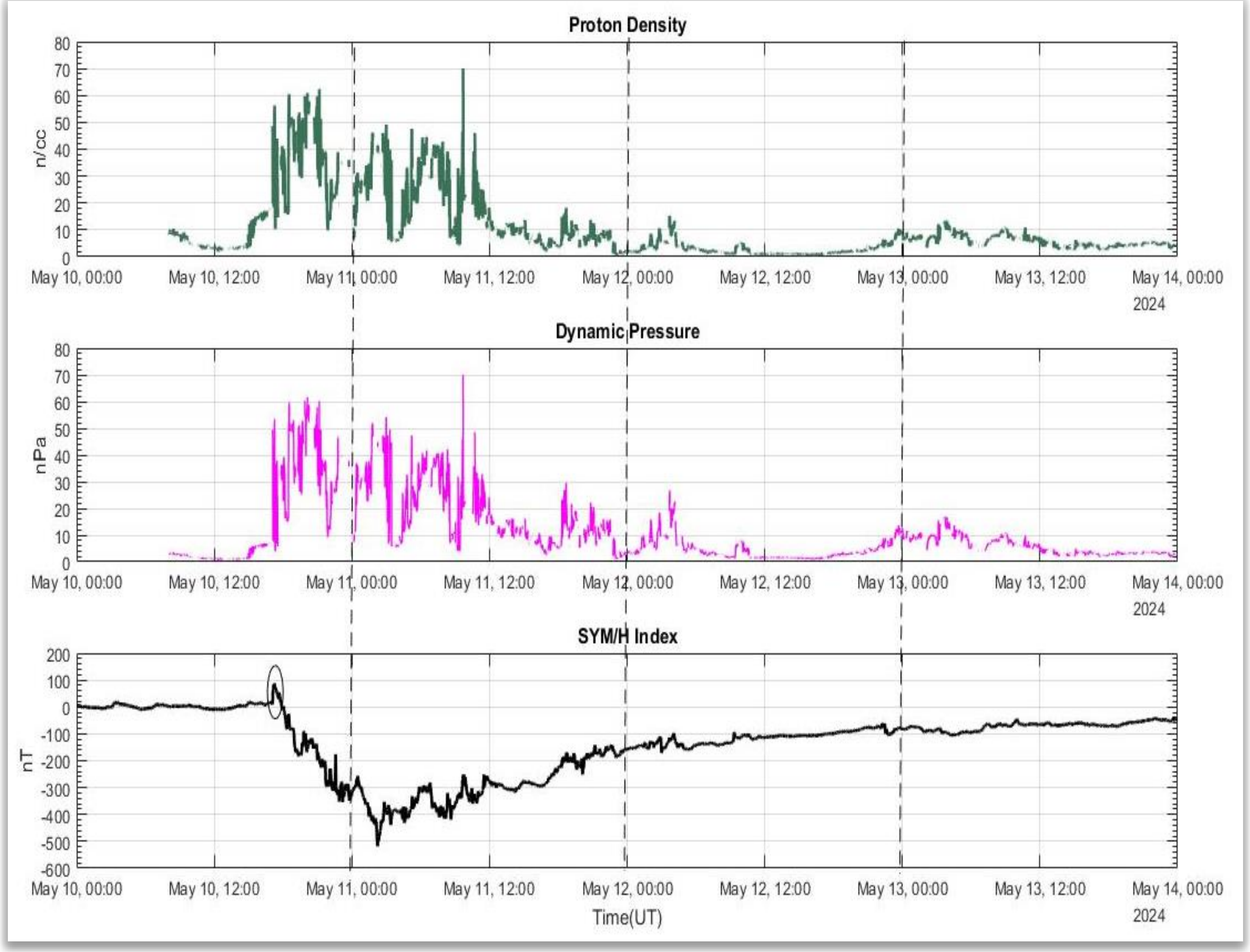
Vx > 1,000 km/s solar wind

The solar wind speed abruptly rose on May 10, reaching ~600 km/s, and peaked at around 1000 km/s on May 12. Such high-speed streams typically originate from coronal mass ejection CME on the Sun.

n/cc increased up to > 60 cm^{-3}

Proton density on May 10, reaching ~60–70 protons/cm^3, indicating an incoming shock, possibly from a CME. This increase compresses the Earth's magnetosphere, triggering geomagnetic storms.

A dynamic study of the strong geomagnetic storm that occurred on May 10, 2024



Ncc >60 см$^{-3}$

Around 12:00 UT on May 10, the proton density sharply increased to ~60 n/cc, indicating the arrival of a CME-driven shock. The elevated density persisted until May 11, marking a compressed magnetospheric environment.

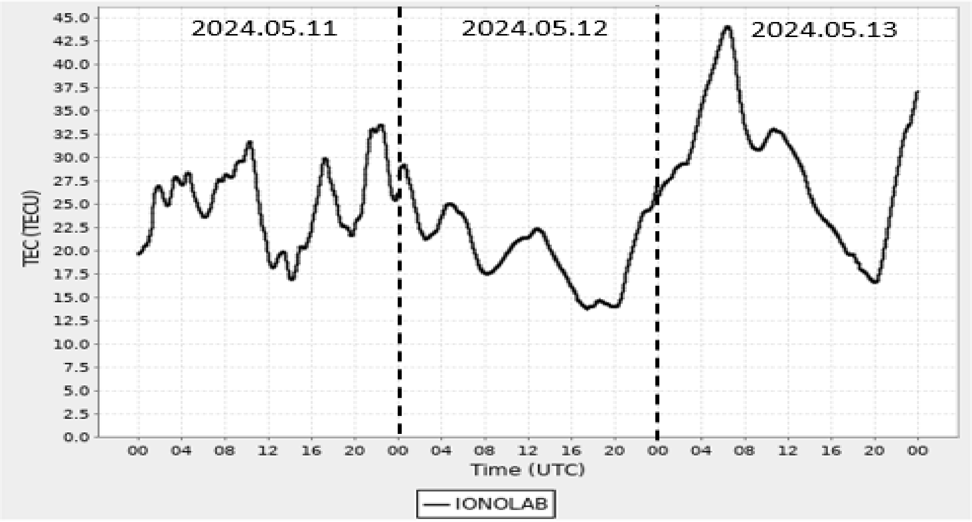
Pd – 60 nPa

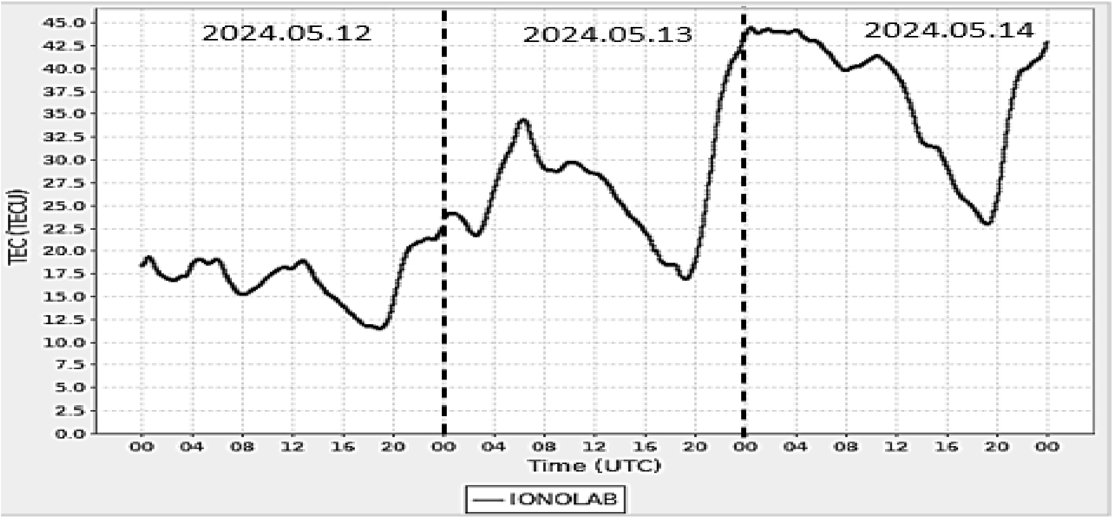
Dynamic pressure peaked between 60–70 nPa on the afternoon of May 10-11, leading to significant compression of the magnetosphere. This likely caused a geomagnetic sudden impulse (SI) and enhanced ring current injection.

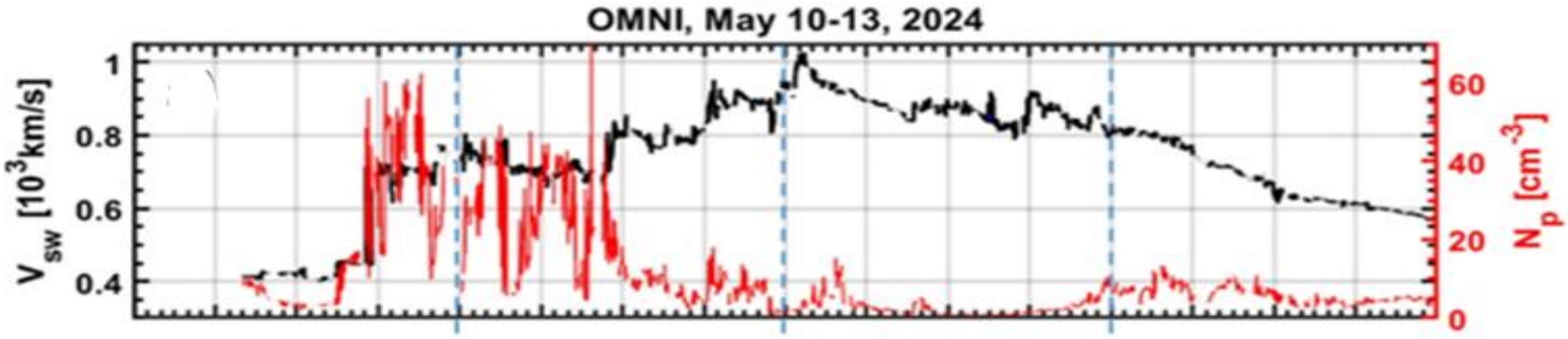
SYM/H= -512 nT

Magnetic activity

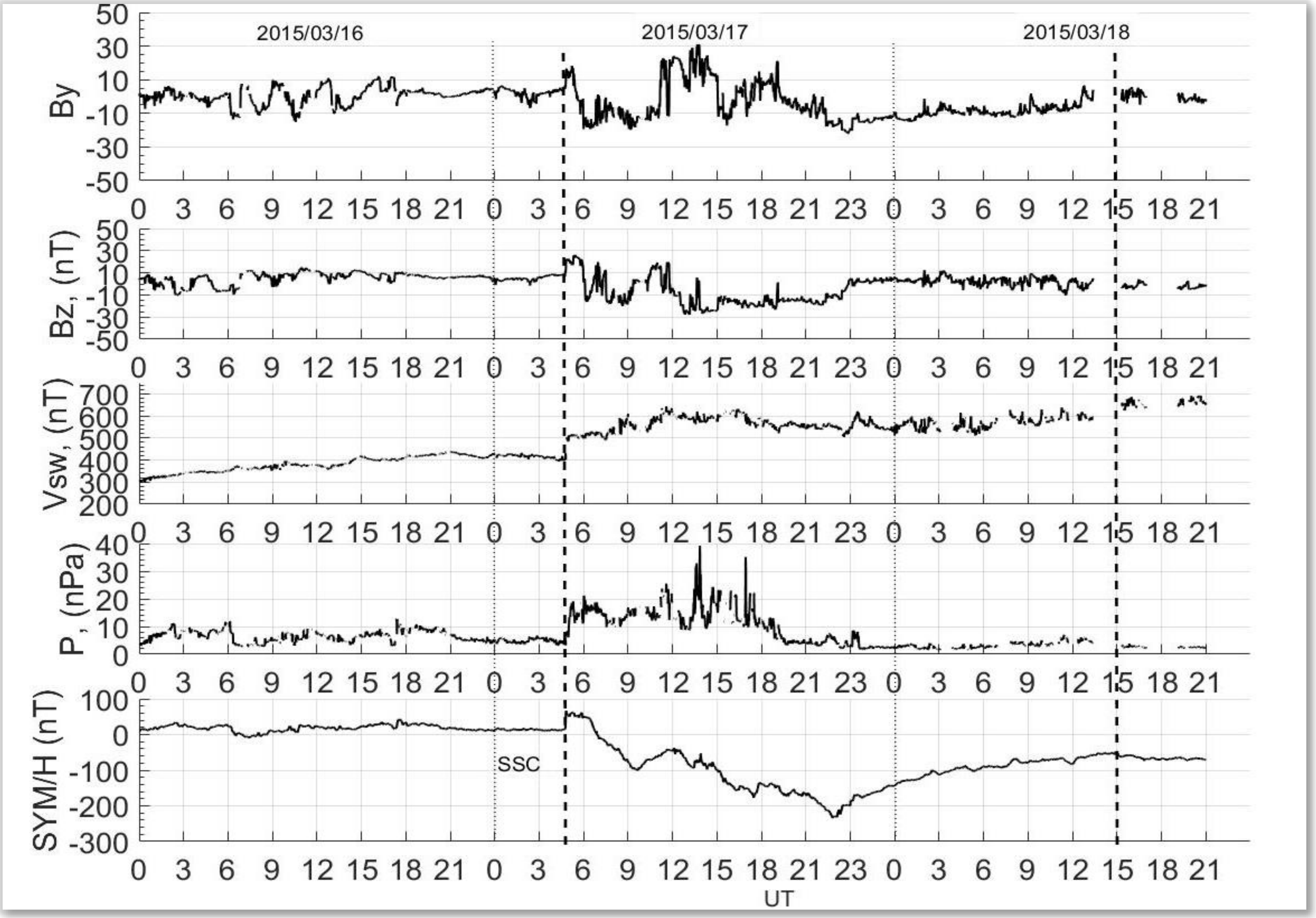
A dynamic study of the strong geomagnetic storm that occurred on May 10, 2024







A dynamic study of the intense geomagnetic storm on March 17, 2015, known as the "St. Patrick's Day Storm.

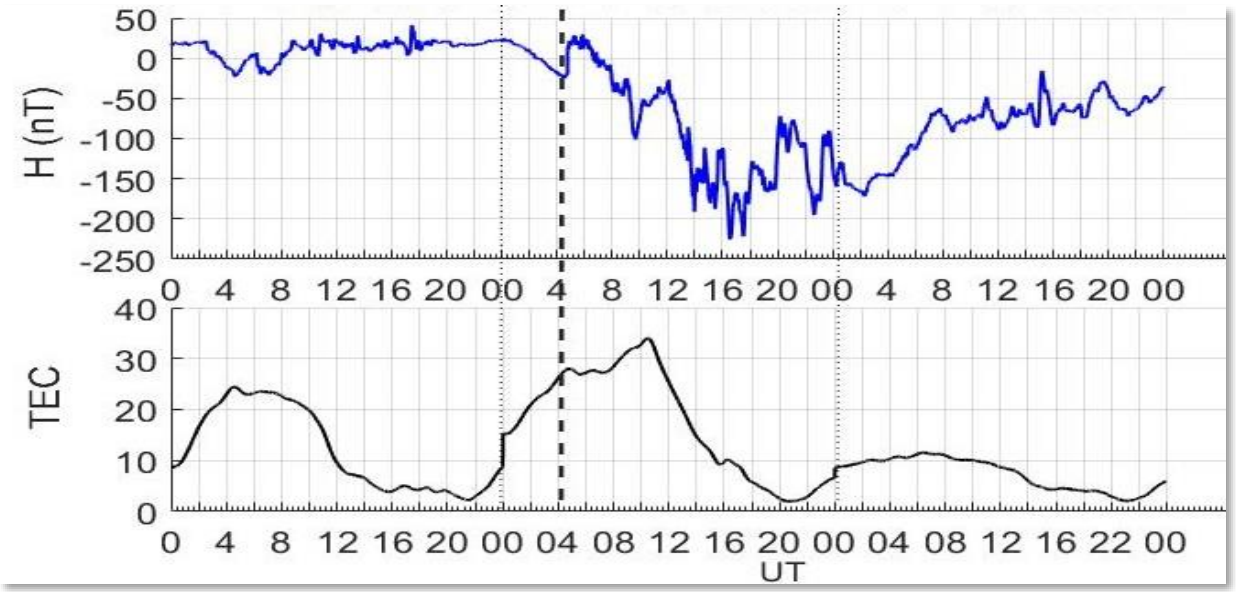


Magnetic field components:
By=15 nT
Bz=30 nT

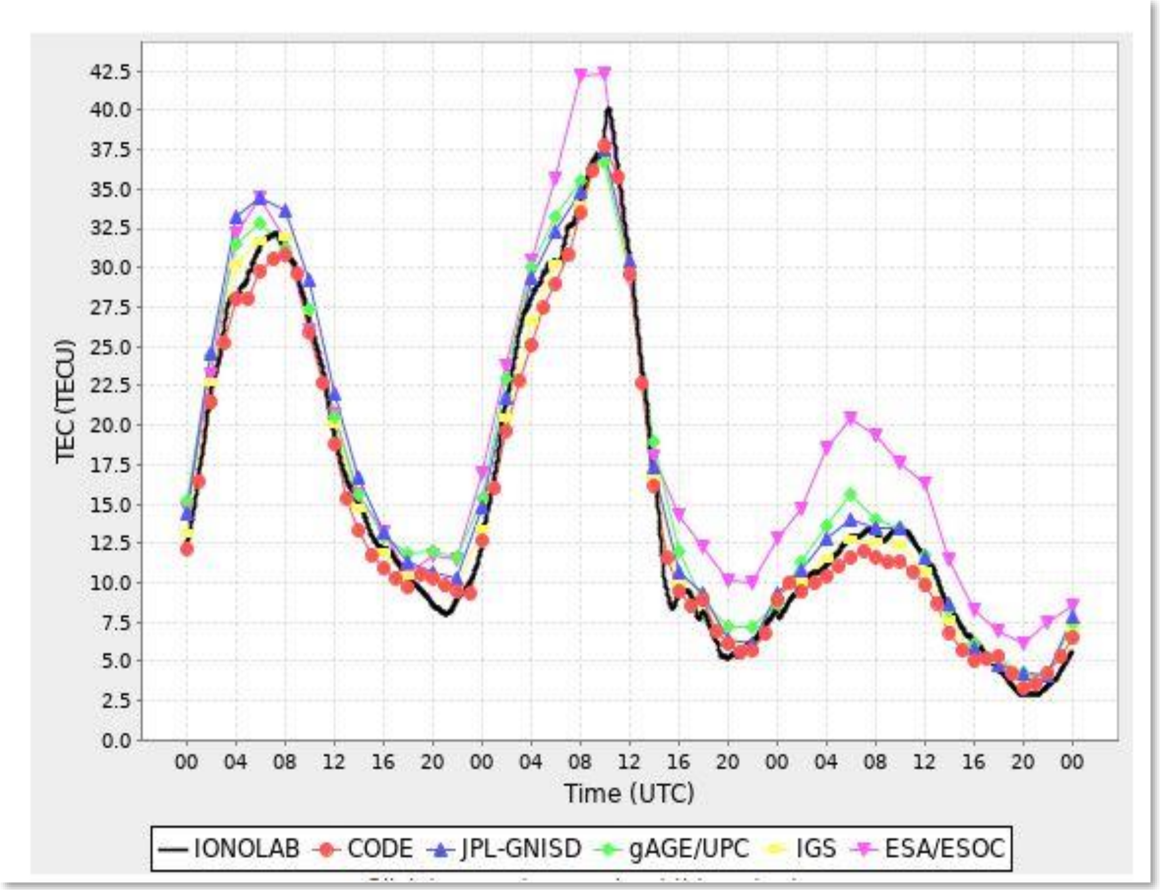
Solar wind parameters:
Velocity Vsw=400−500 km/s
Psw=8−30 nPa

Geomagnetic activity index:
SYM/H = -234 nT

Dynamic Analysis of the Strong Geomagnetic Storm on March 17, 2015 (St. Patrick's Day Storm)



H(nT)- variations in the magnetic field
TEC –Total Electron Content (ULAB)



Amarjargal, B. (2020). *Study of a strong geomagnetic storm*. Geophysics and Astronomy, (7), 75–79.

This figure illustrates how a significant decrease in the geomagnetic H component, due to a geomagnetic storm, A market increase in TEC was observed on March 16-17, with peak values reaching approximately 35-40 TECU march 17, reflecting enhanced ionospheric ionization, from March 18 onward, the TEC gradually decreased and showed a tendency to stabilize.

"Observation of Aurora"

https://upload.wikimedia.org/wikipedia/commons/6/64/Solar_Storm_of_May_10%2C_2024_over_Viola%2C_Arkansas.jpg