Enhancing Data Reliability in Nuclear Monitoring: The Characteristic Curve Method for Reducing Daily Variations

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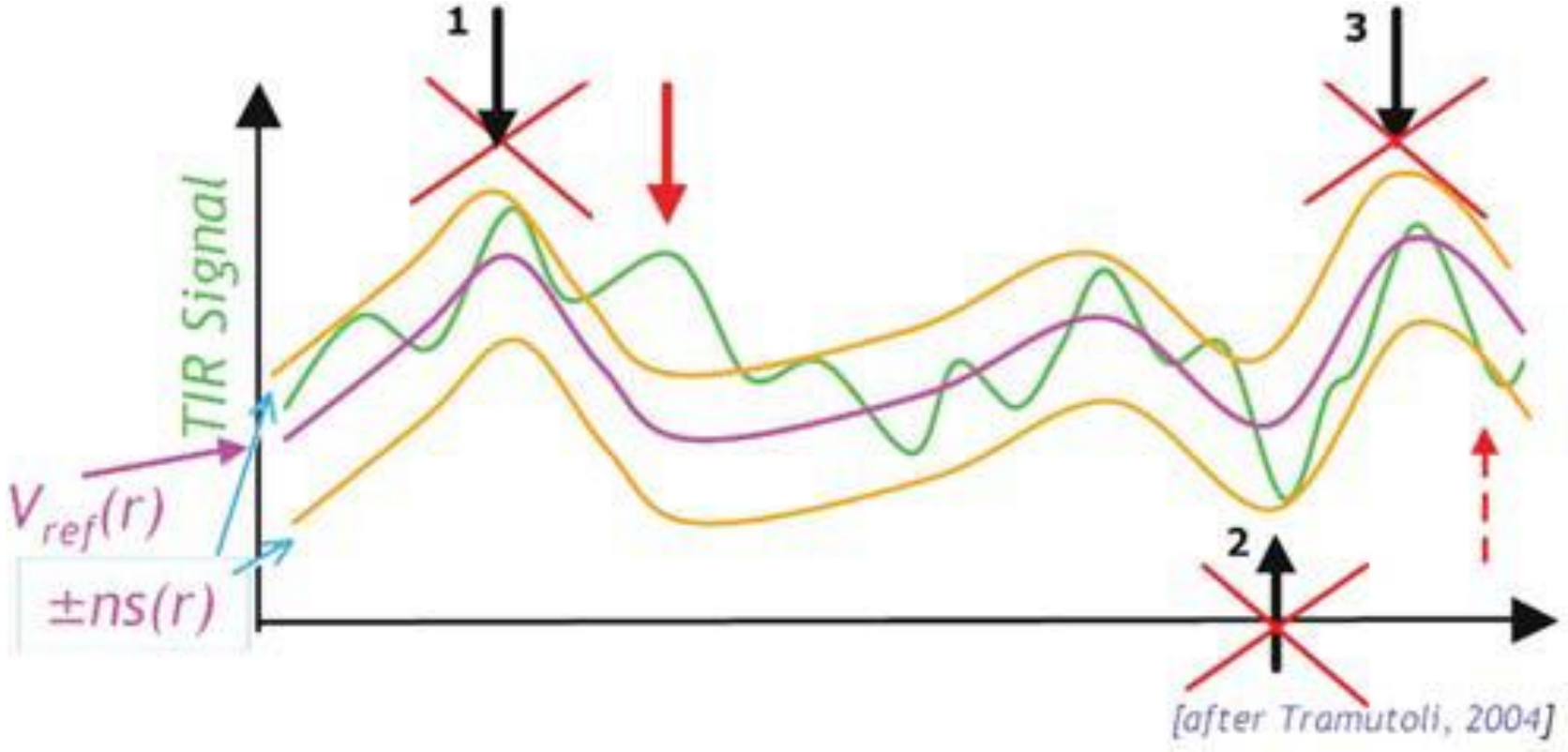
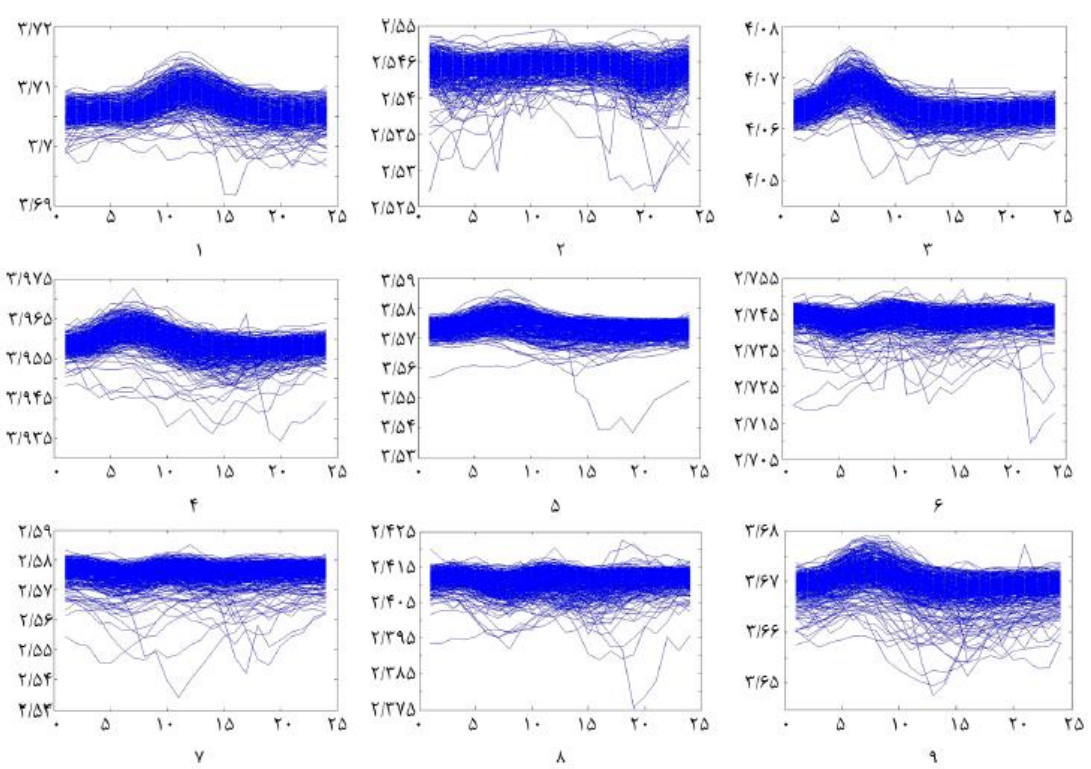
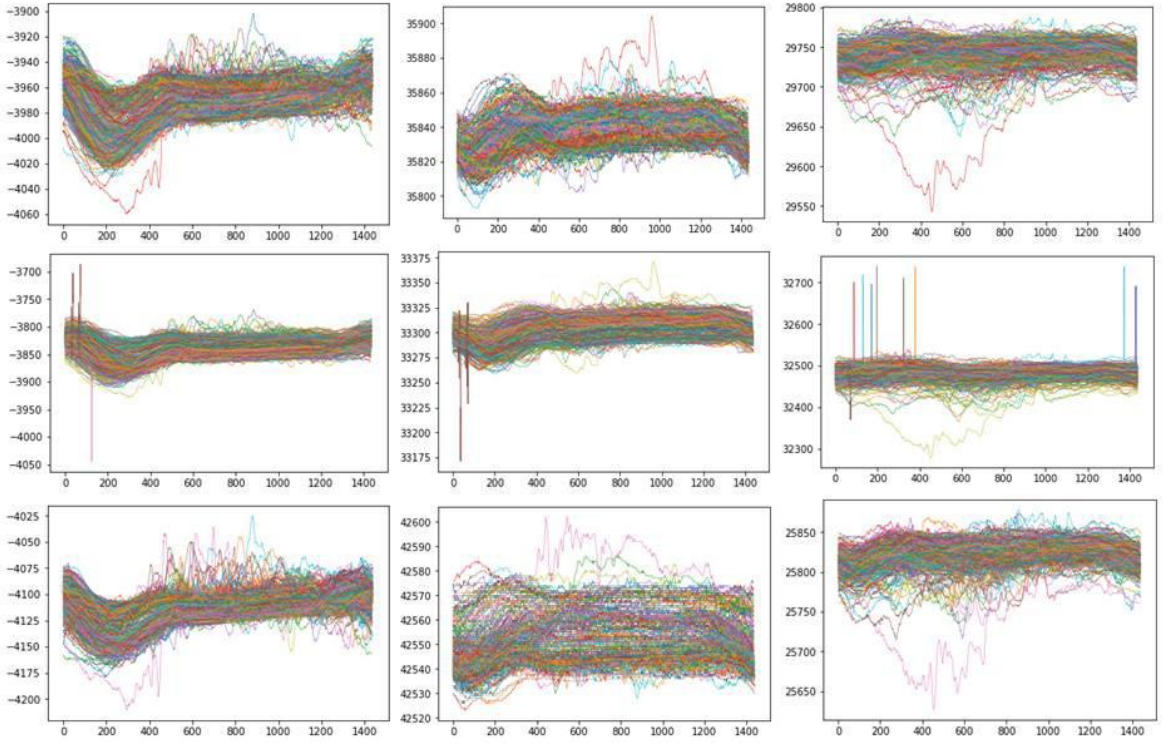
The concept of the anomaly detection from a time series of registered parameters



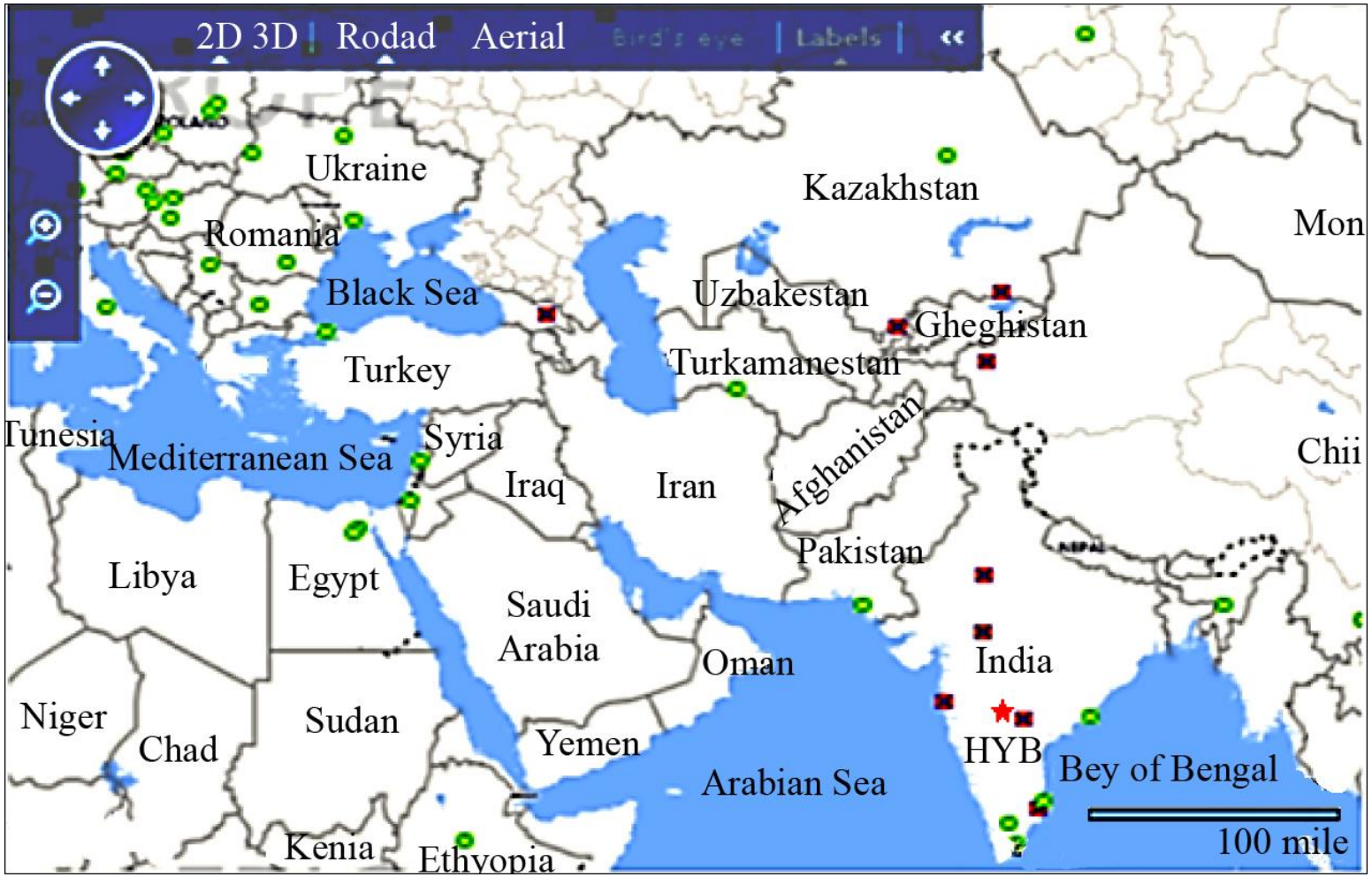
Characteristic curve method
previous studies (geomagnetic data from intermagnet)





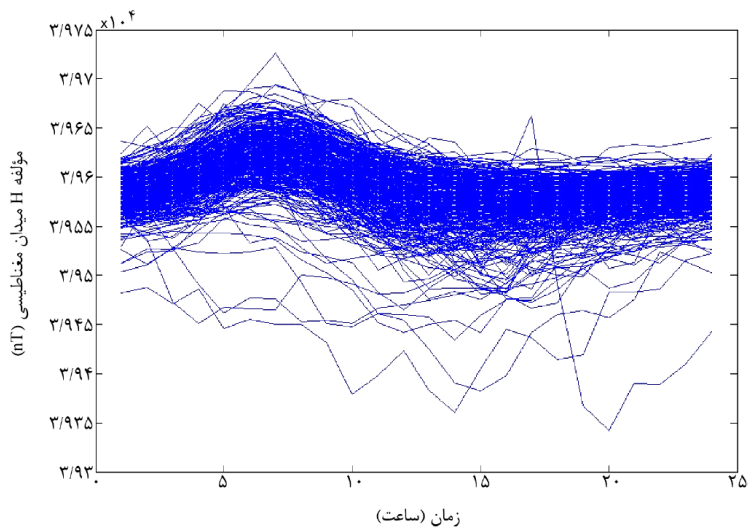
https://intermagnet.org/

Map of geomagnetic stations (green) and stations used in the analysis (red). The location of the September 29, 1993 Killari, India earthquake is marked with a star

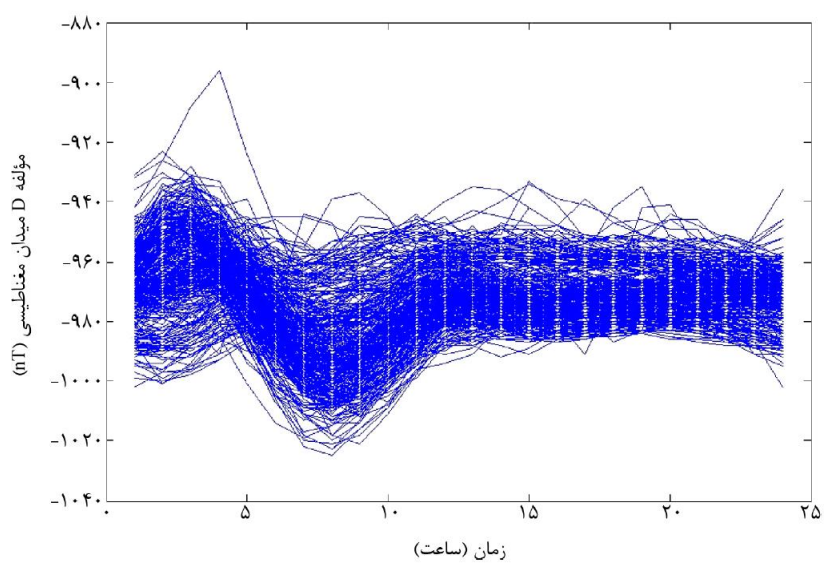


Various components of the magnetic field over 1 years, plotted together

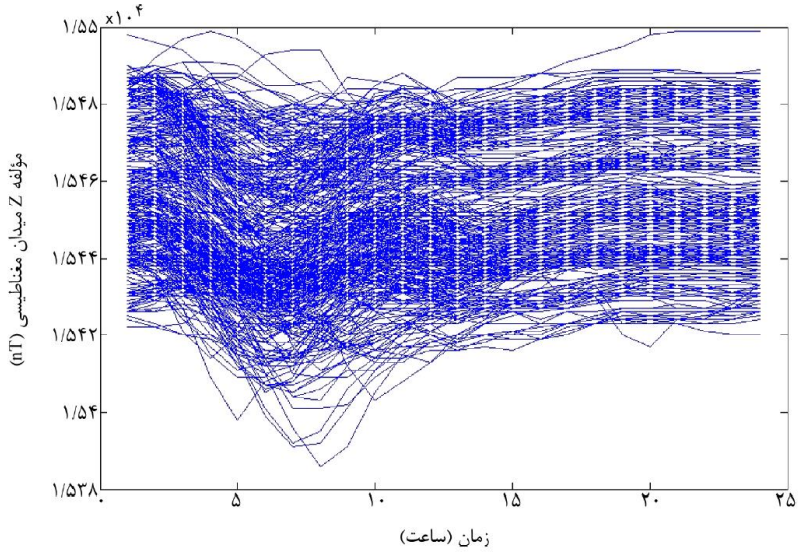
H



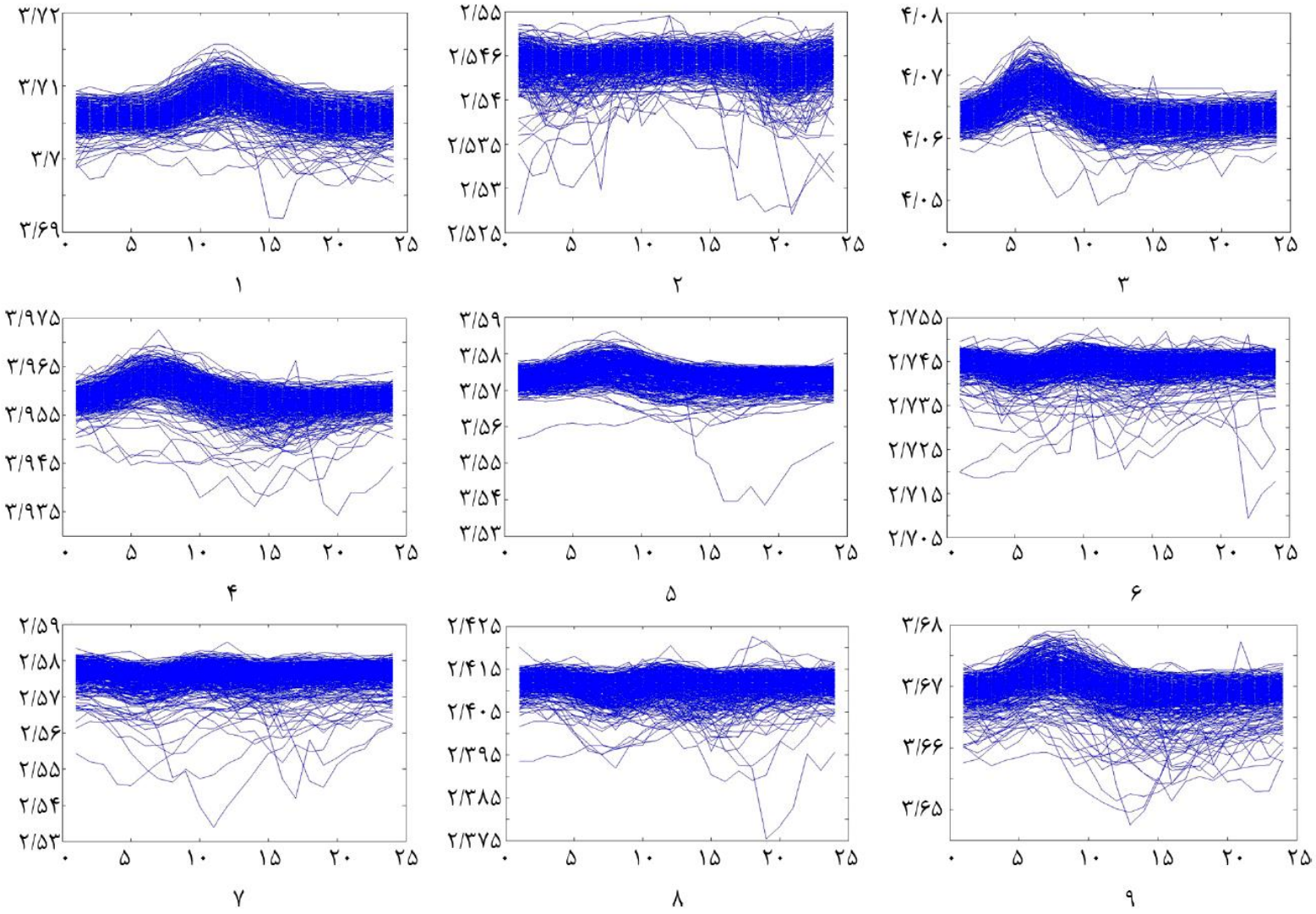
D



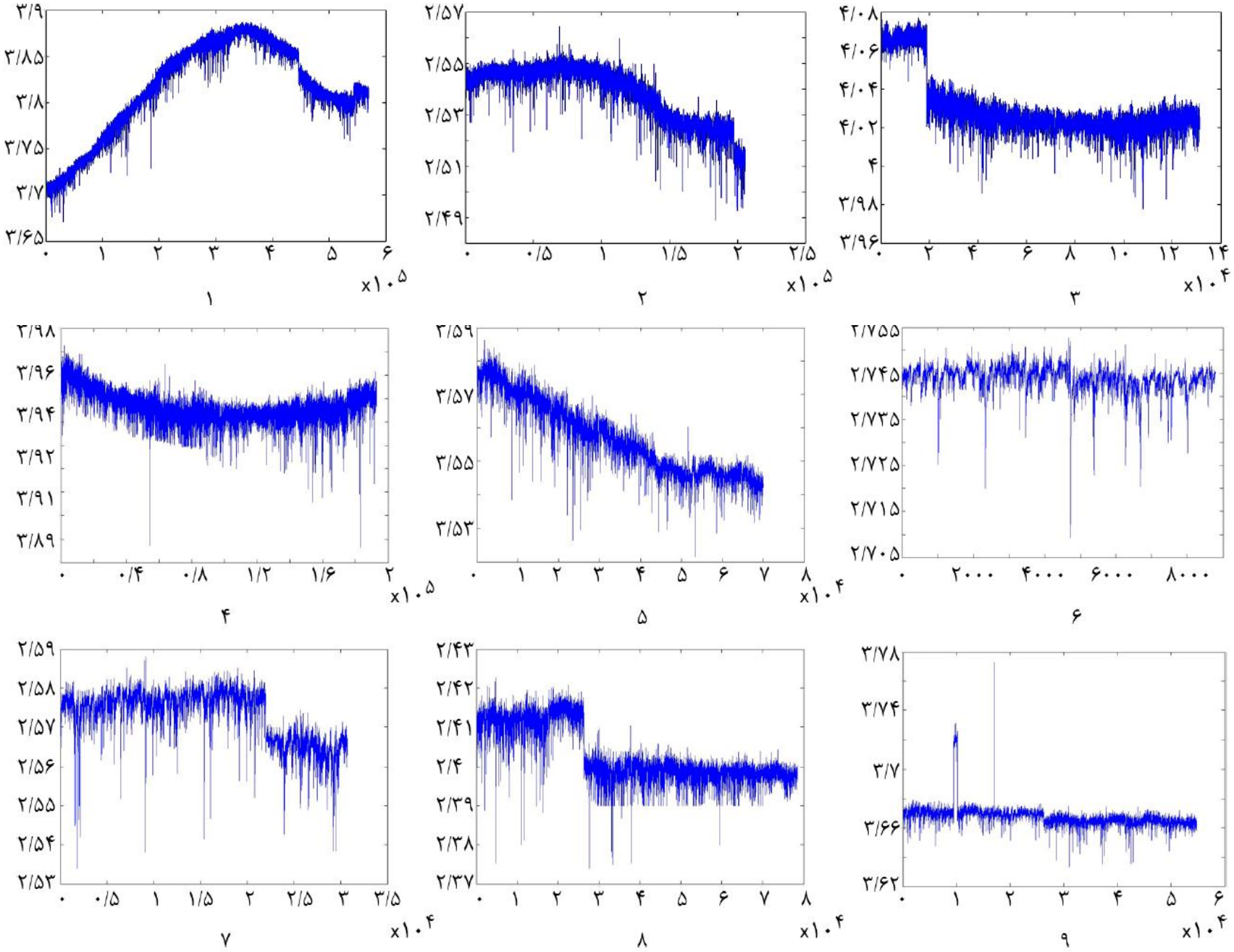
Z



H: Characteristic curve



H: All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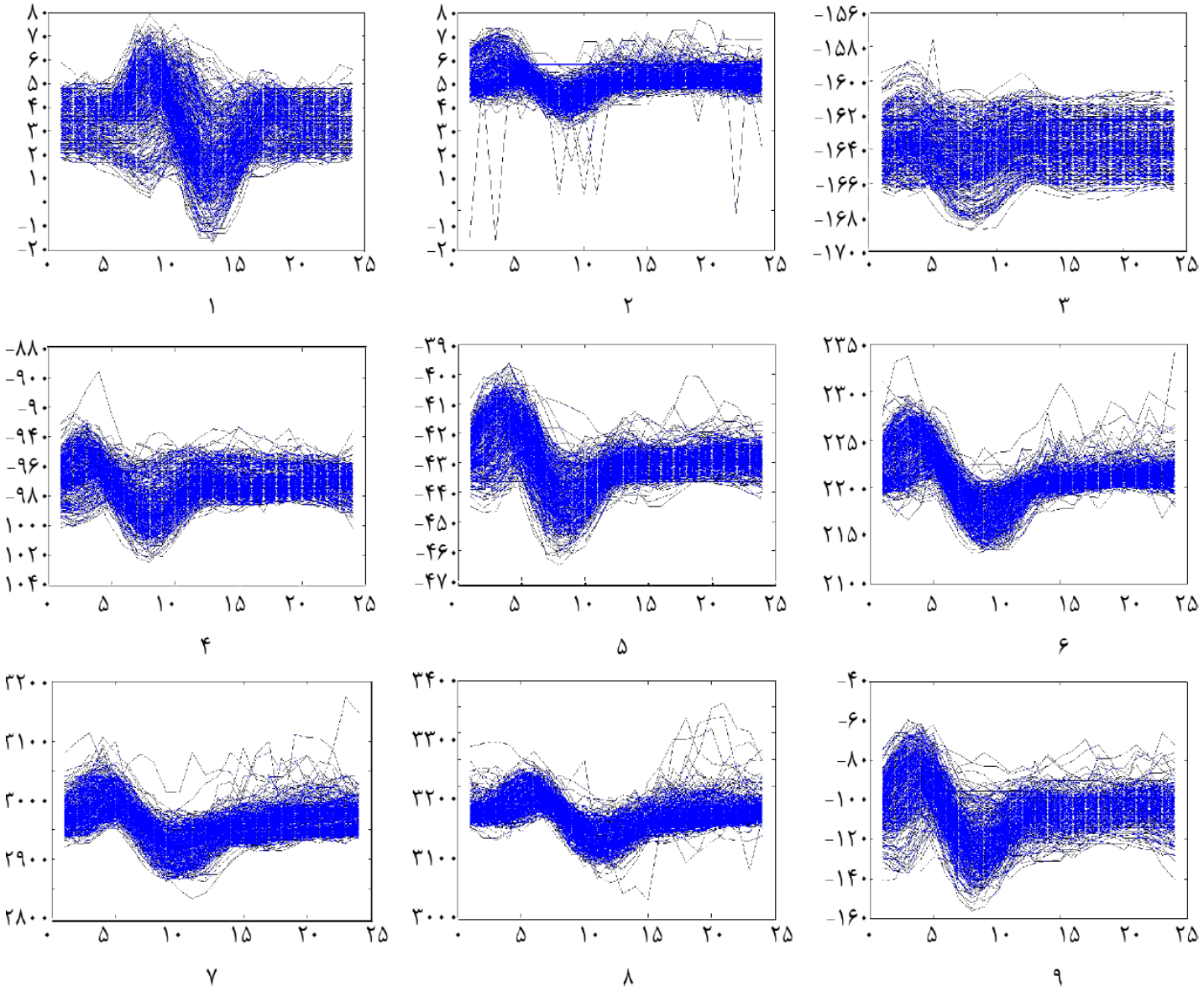
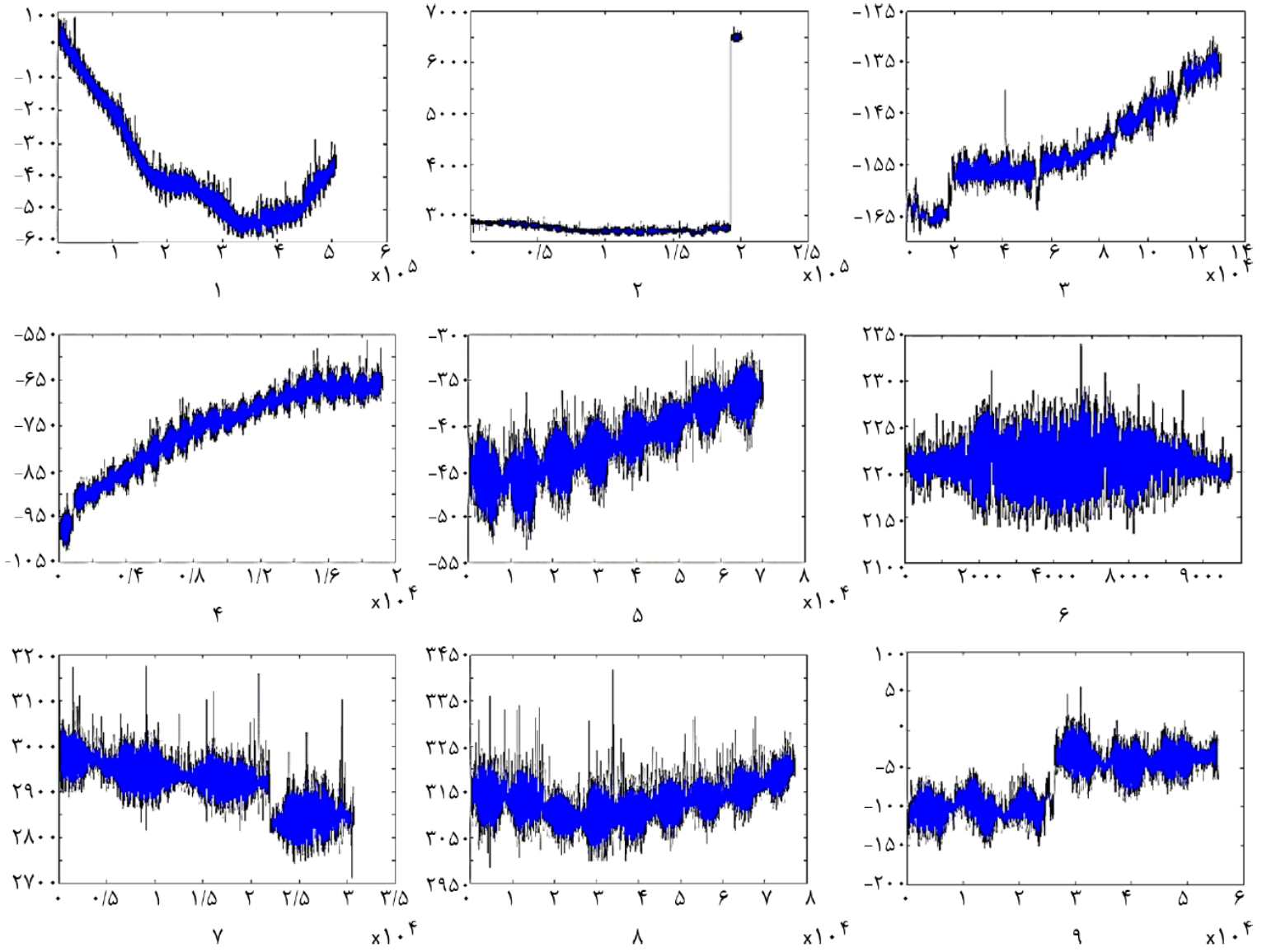
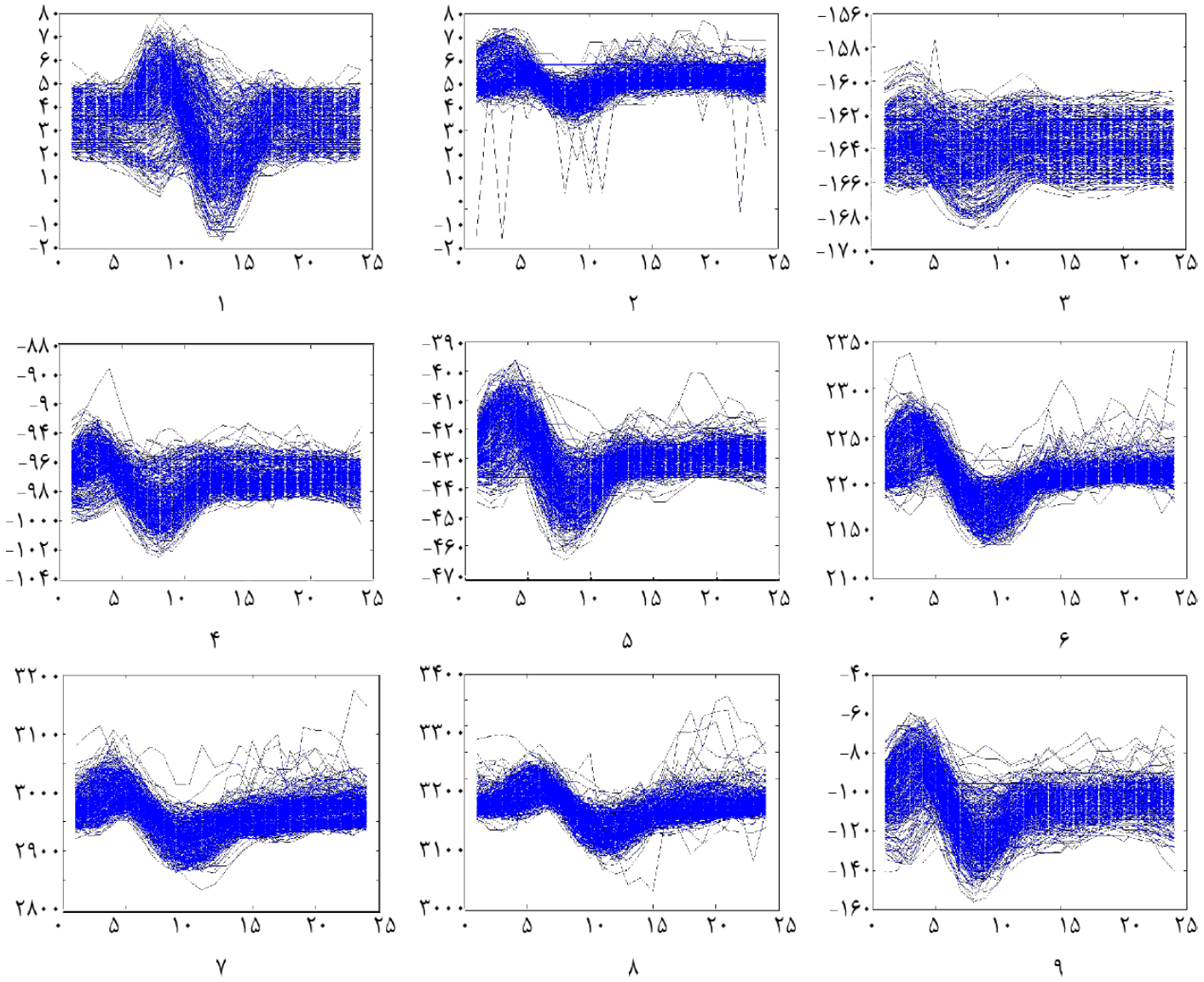
D: Characteristic curve



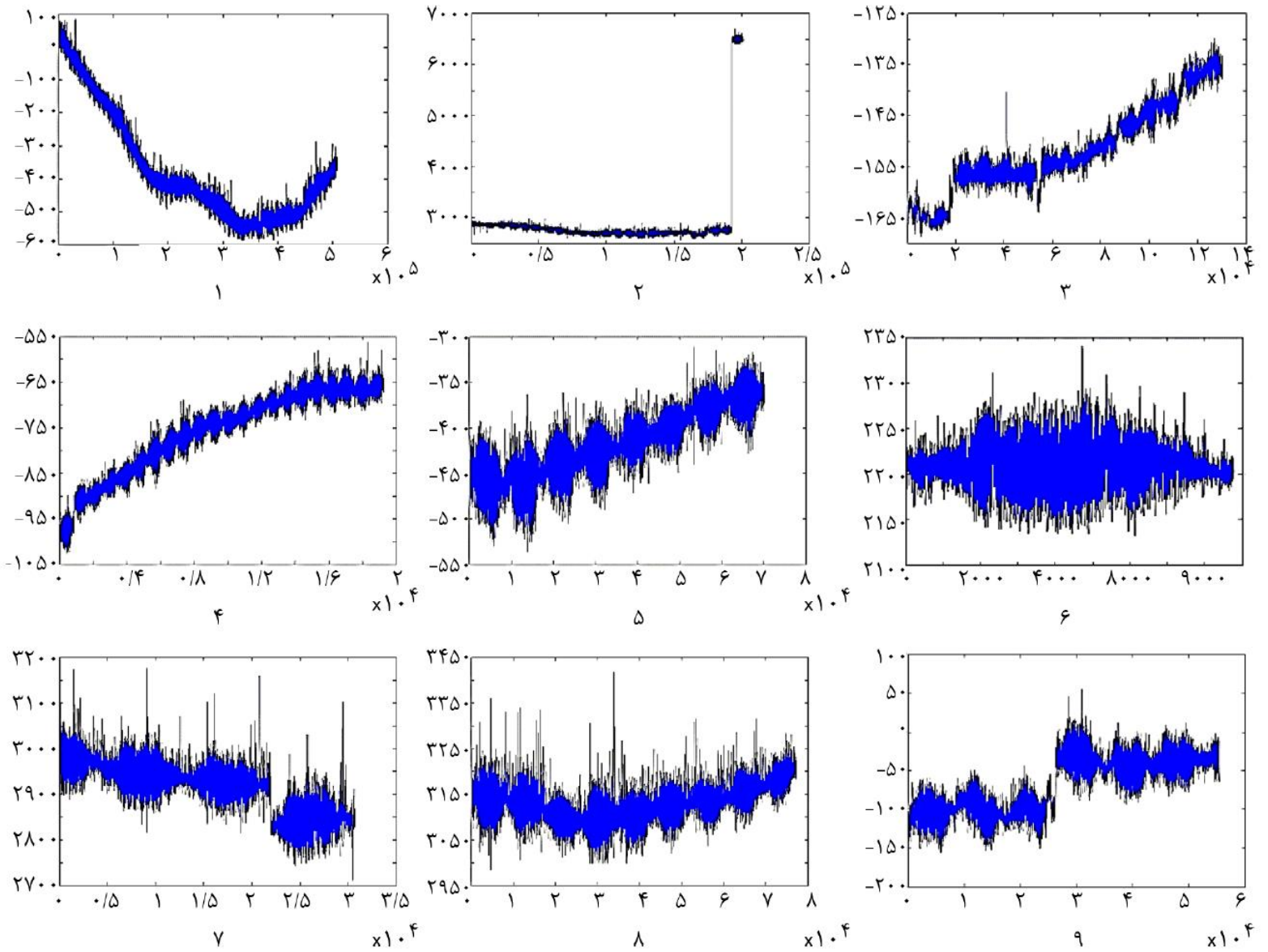
D: All



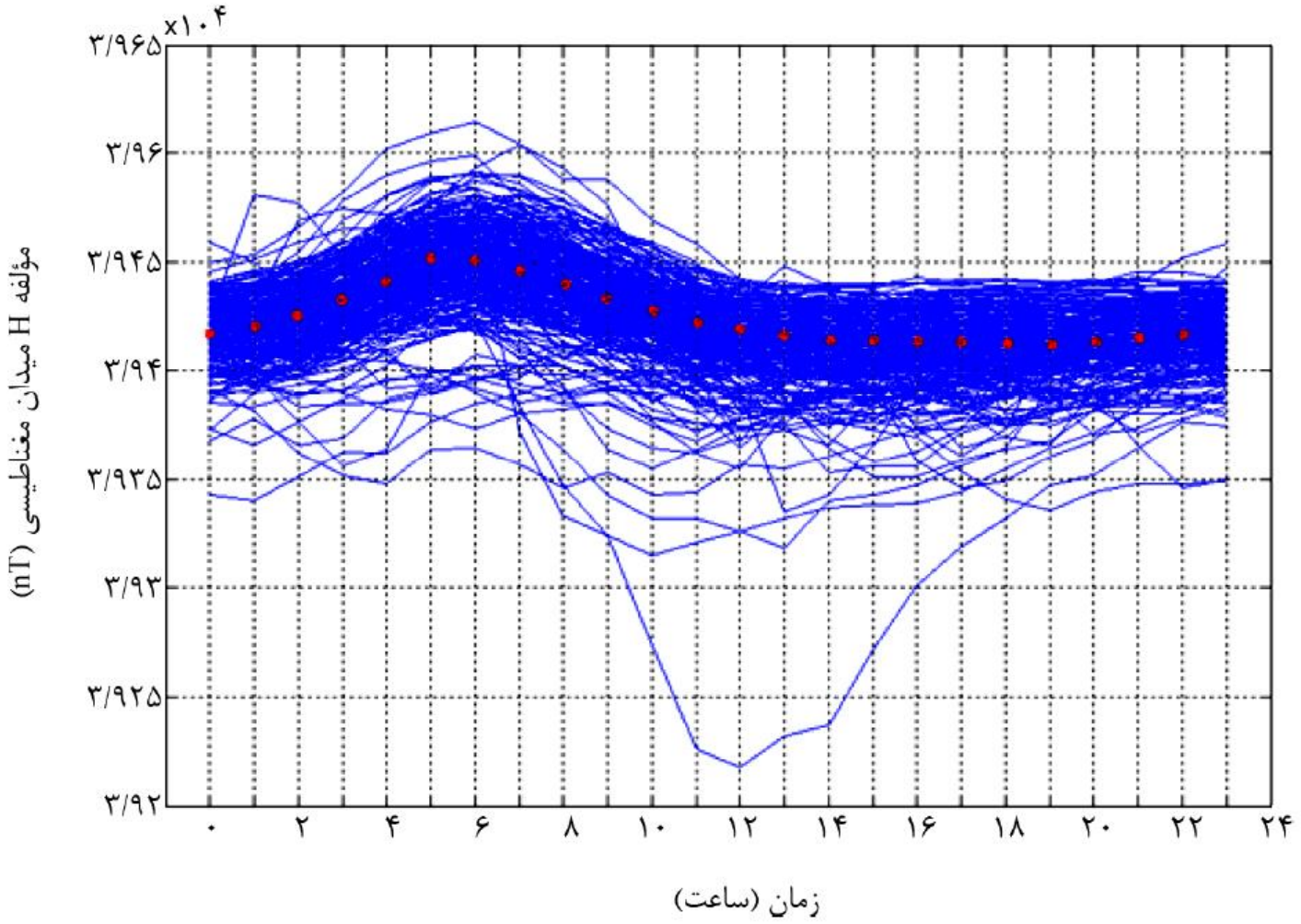
Z: Characteristic curve



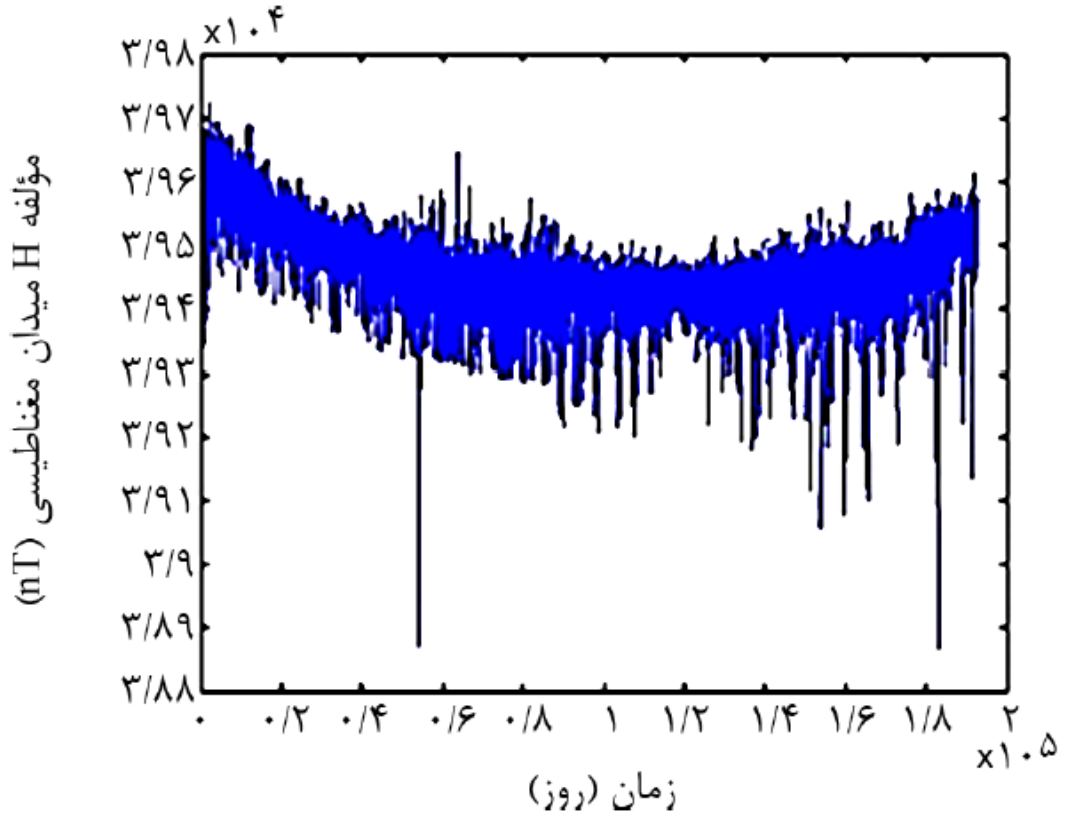
Z: All

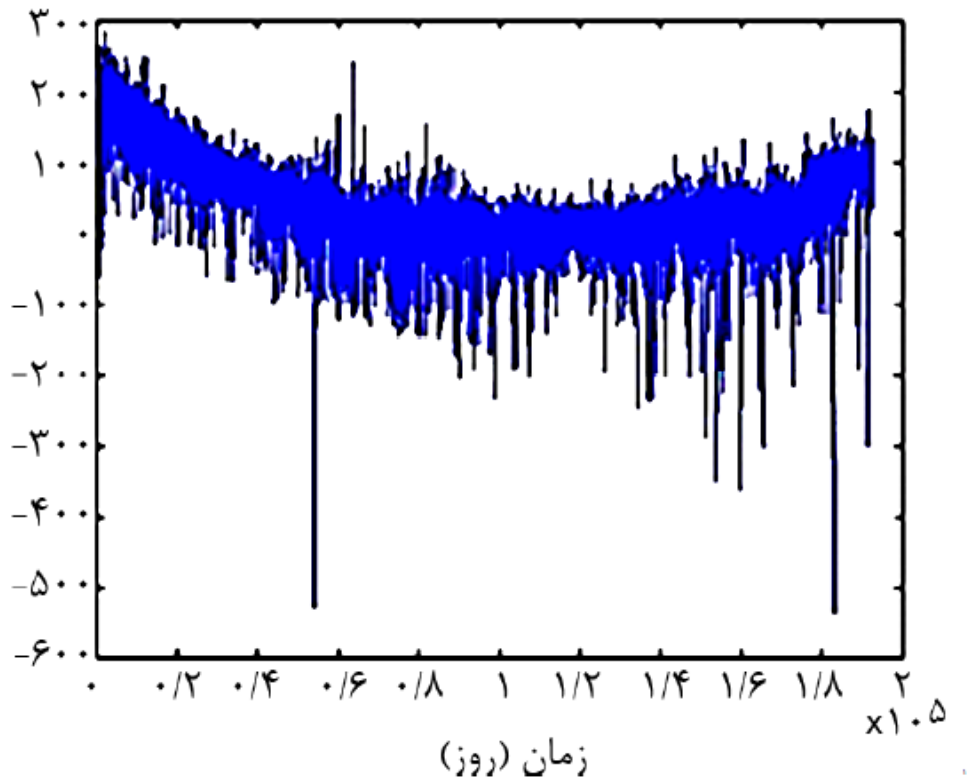


Method for determining the characteristic curve of the H components at a given station

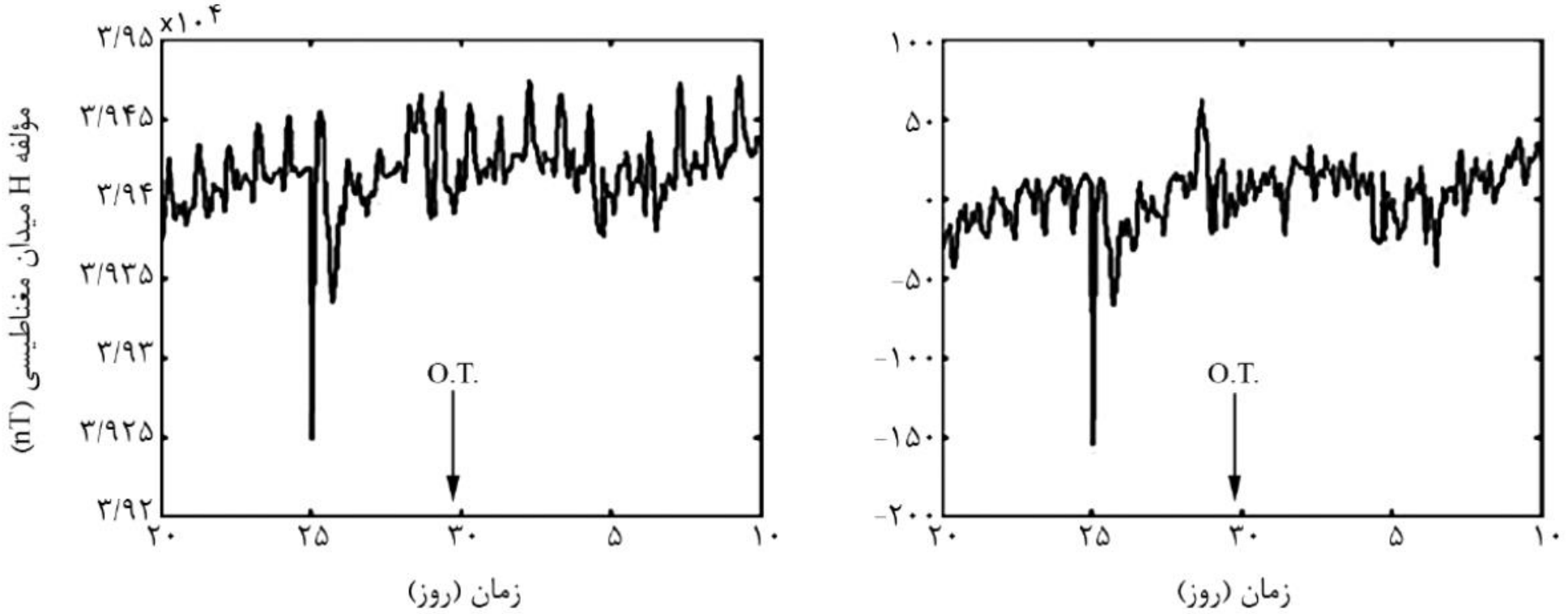


Raw magnetic records (left) and processed records (right) from the Hyderabad station



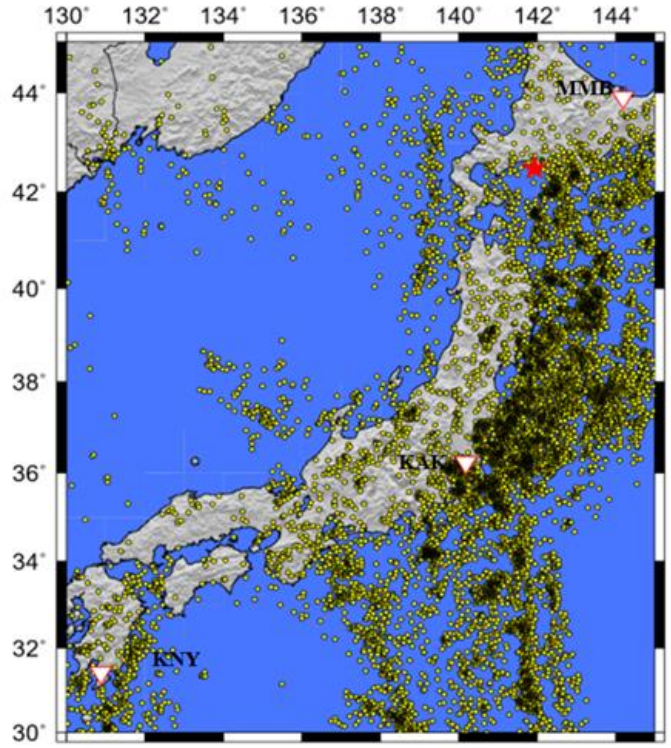


"Raw and processed magnetic records associated with the September 29, 1993 earthquake in India



Investigation of September 5th 2018 Japan (MW = 6.6) earthquake precursors using geomagnetic data in Japan

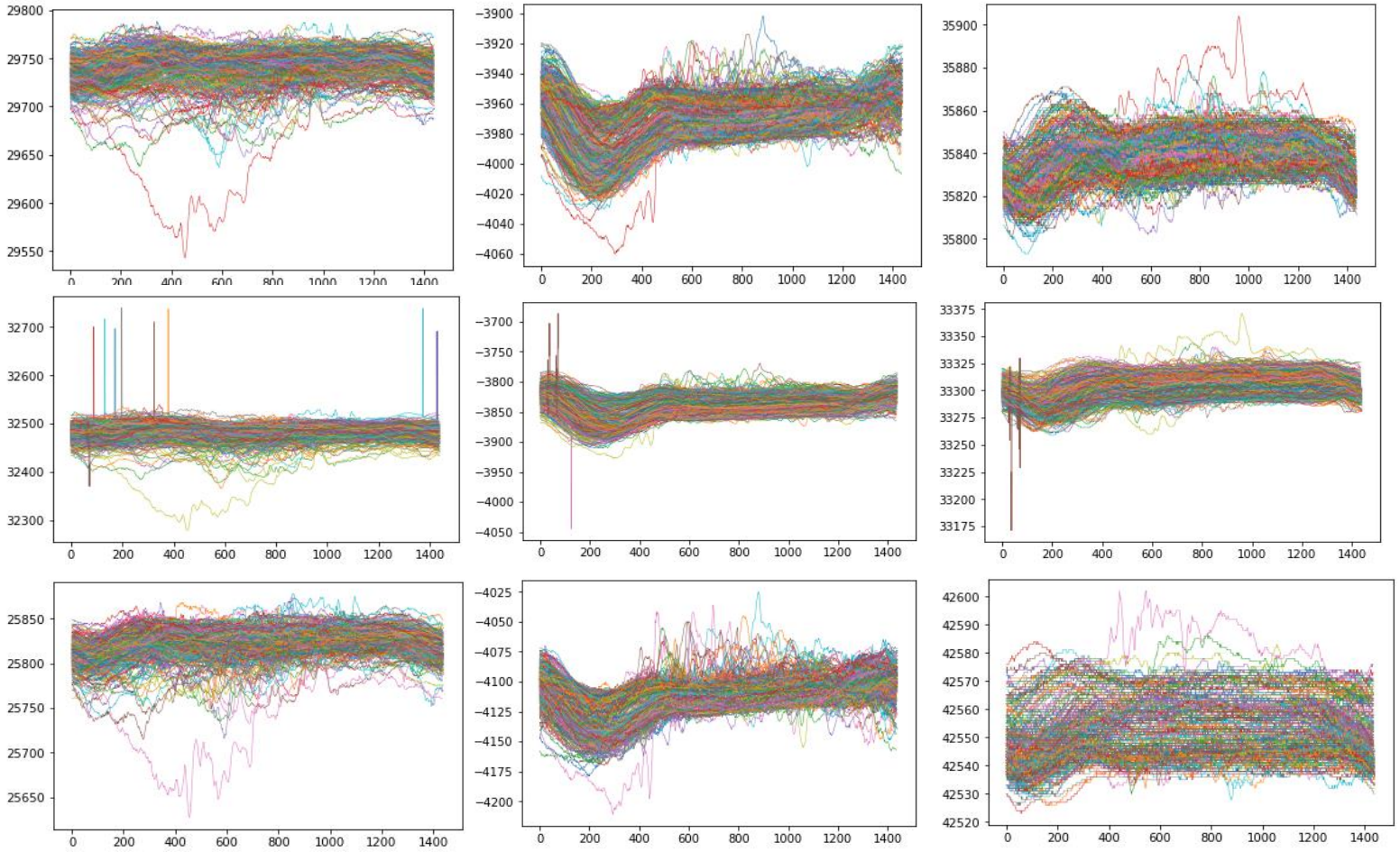
Hamideh Taherinia & Shahrokh Pourbeyranvand



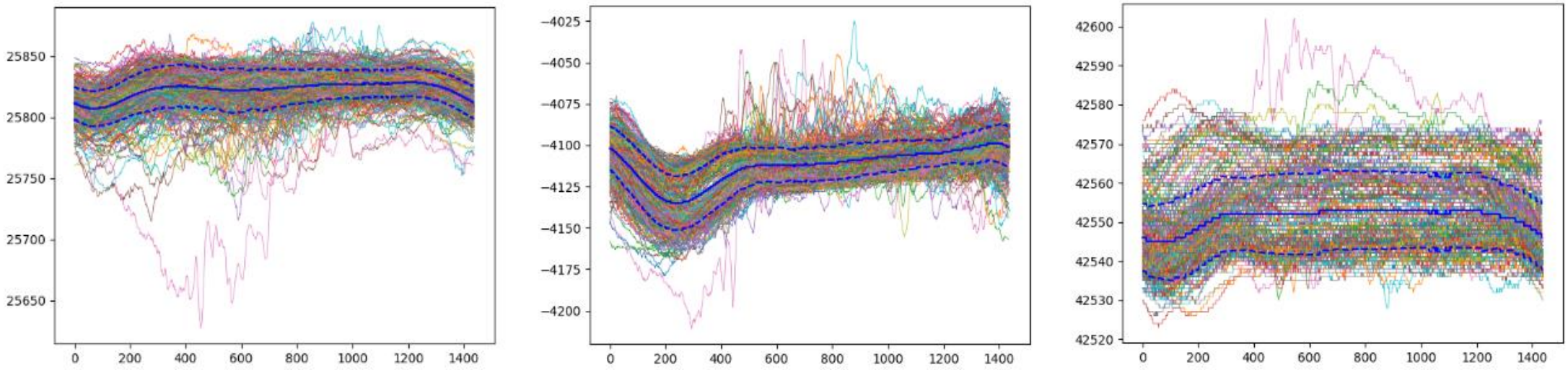
MMB	KNY	KAK	Station (ID)
Memambetsu	Kanoya	Kakioka	Location
46.09°	58.58°	53.77°	Co-latitude
144.19°	130.88°	140.18°	Longitude
42 meters	107 meters	36 meters	Elevation
HDZF	HDZF	HDZF	Orientation
Fluxgate	magnetomenter theodolite	Fluxgate, Overhauser magnetometers	Instruments
Proton precession magnetometers	Proton precession magnetometers	Proton precession magnetometers	Absolute measurments
GMS	Internet	GMS	Communication

EGU General Assembly 2022

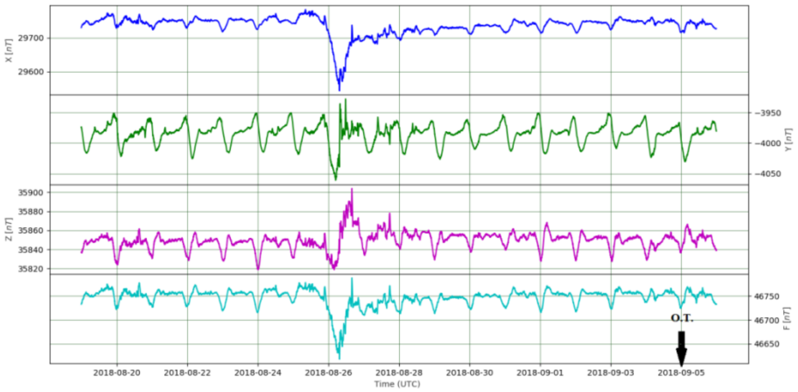
The characteristic curves related to the three stations (KAK, KNY, and MMB) over a one-year period represent the magnetic field components X, Y, and Z, from left to right , the horizontal axis represents time (minutes), and the vertical axis the magnetic field amplitude (Nanotsla)

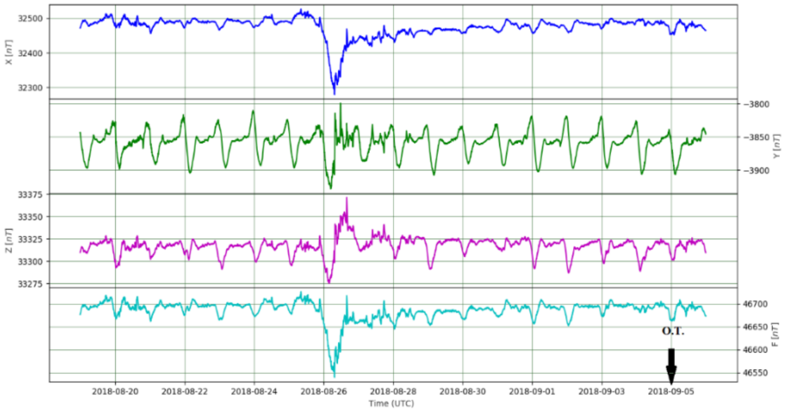


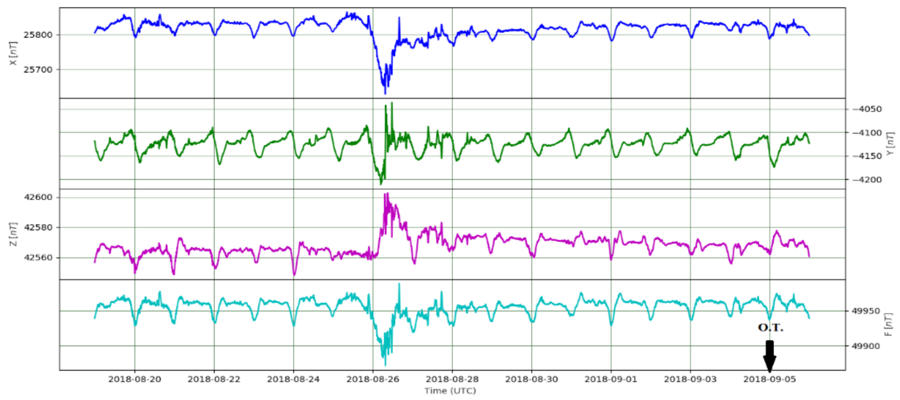
The mean curve (continuous line) at the MMB station for the X, Y, and Z components (left to right) of the magnetic field with a confidence interval are based on 1σ (dashed lines). The horizontal axis represents time (minutes) and the vertical axis represents the amplitude of the magnetic field (nanotsela)



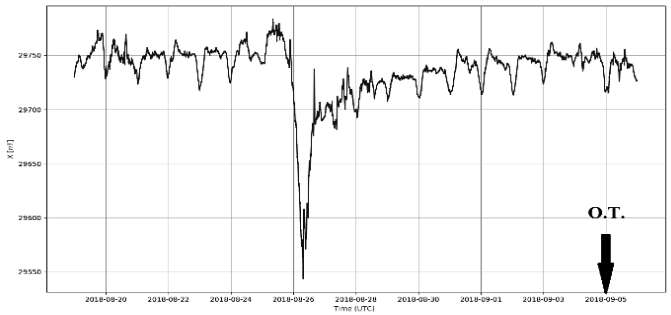
Pre-earthquake anomalies observed for all three components at the three KAK, KNY and MMB stations from (A, B and C, respectively)

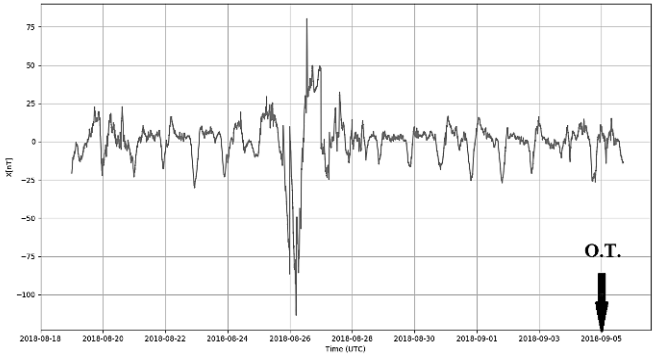


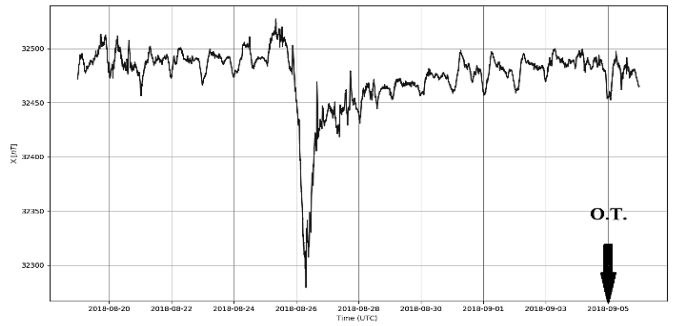


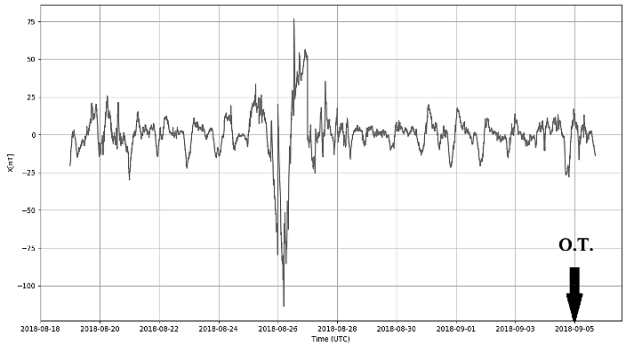


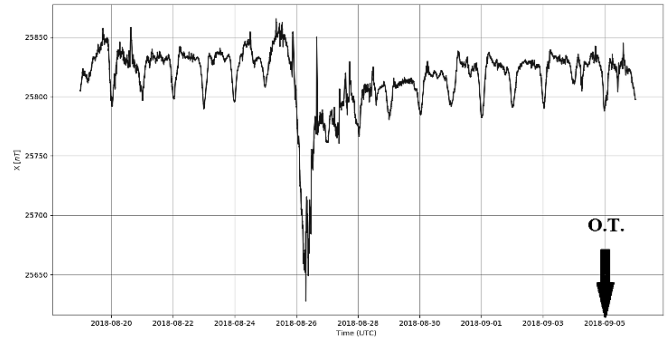
The raw (A) and processed data (B) at KAK station along with earthquake time for magnetic component (X, Y, Z)

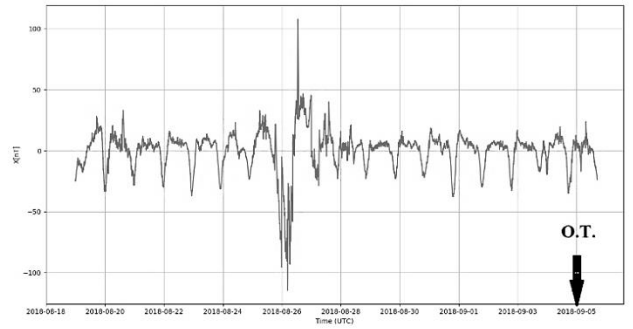




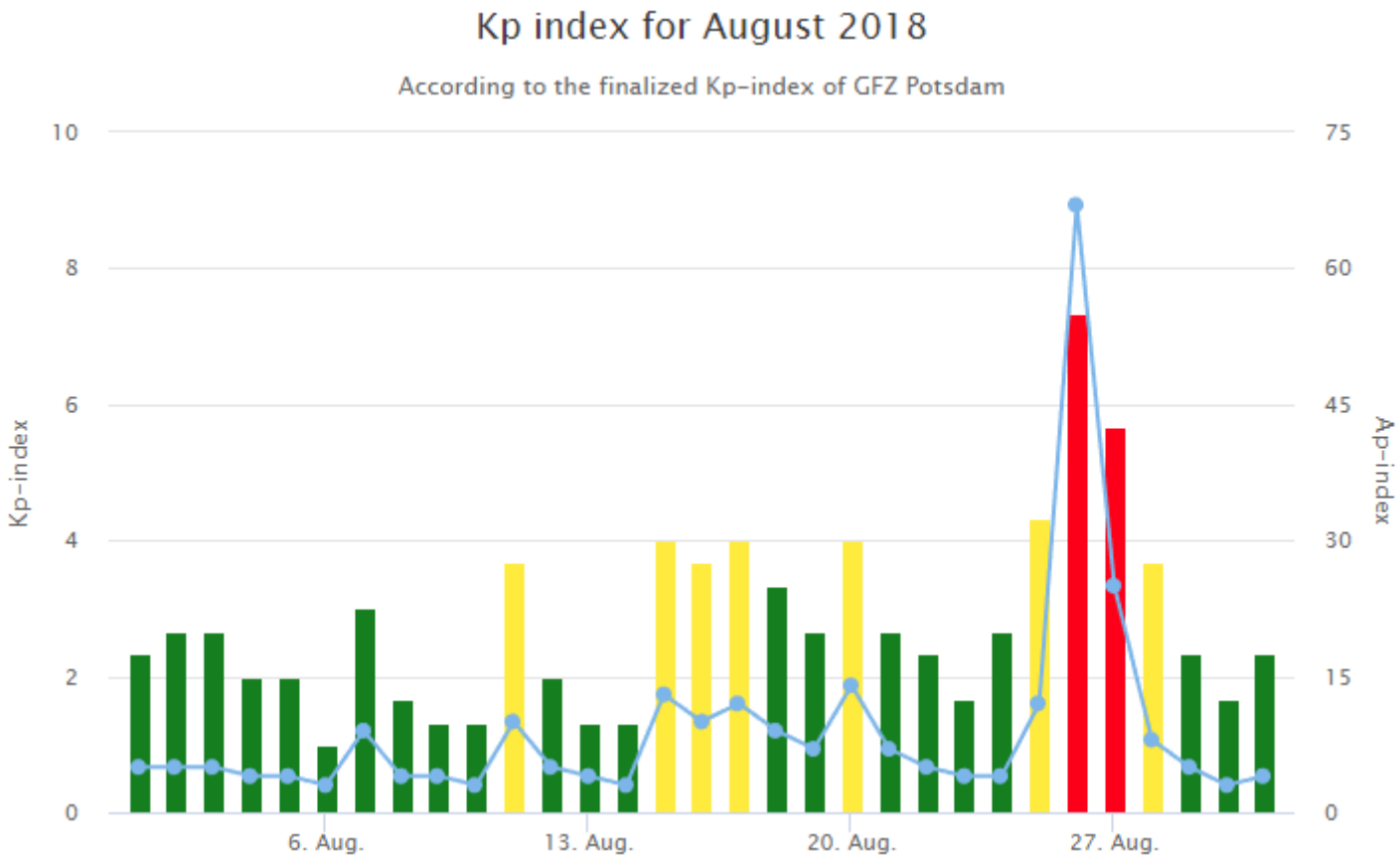




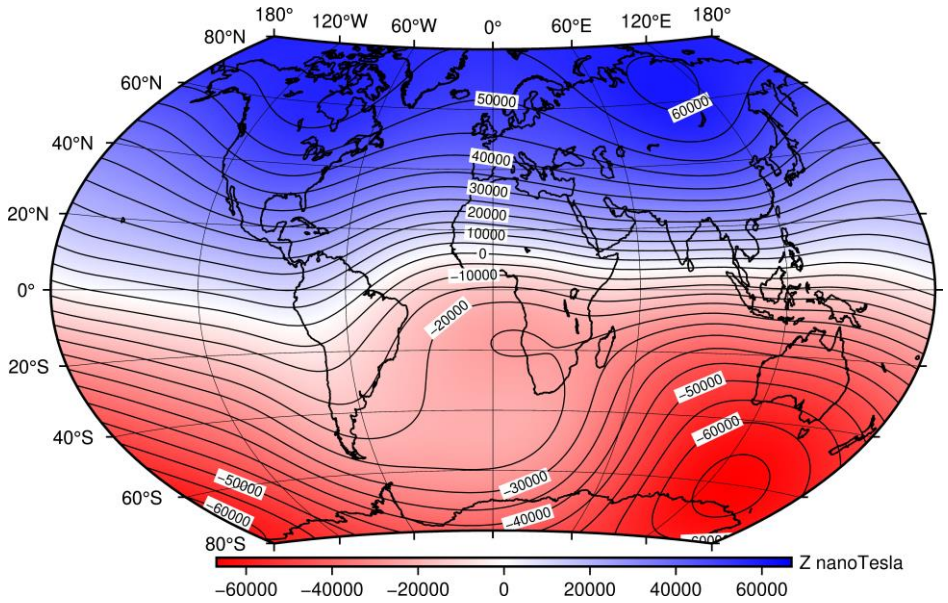


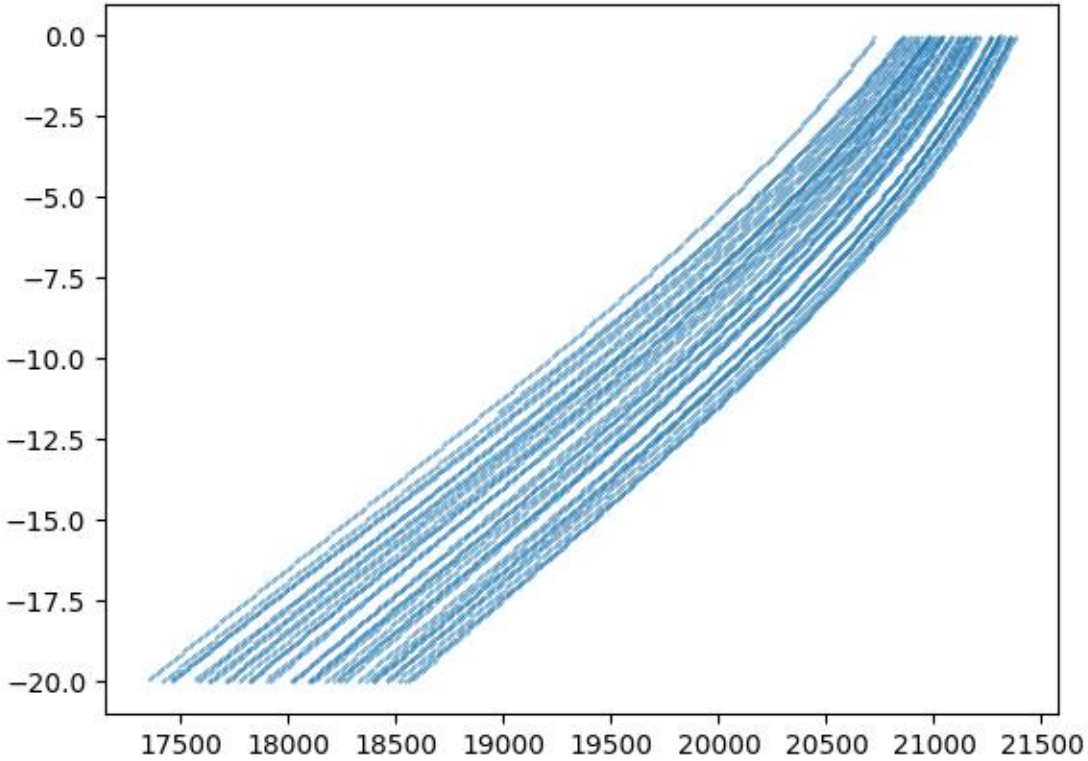


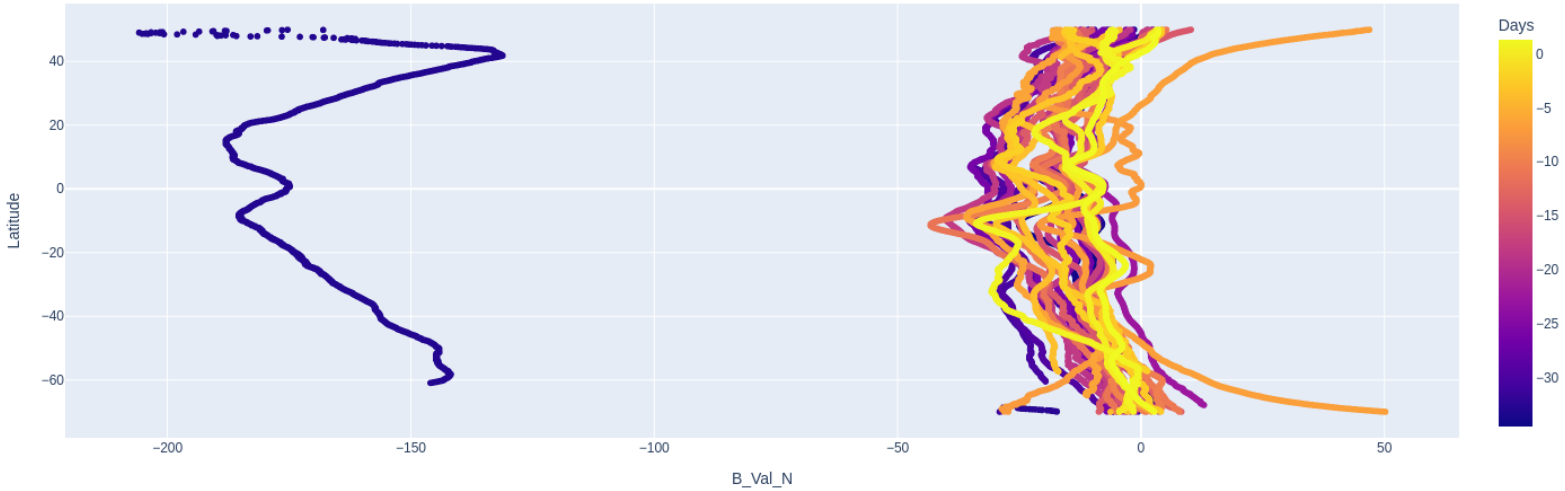
Magnetic Storm Reported (from spaceweatherlive.com)



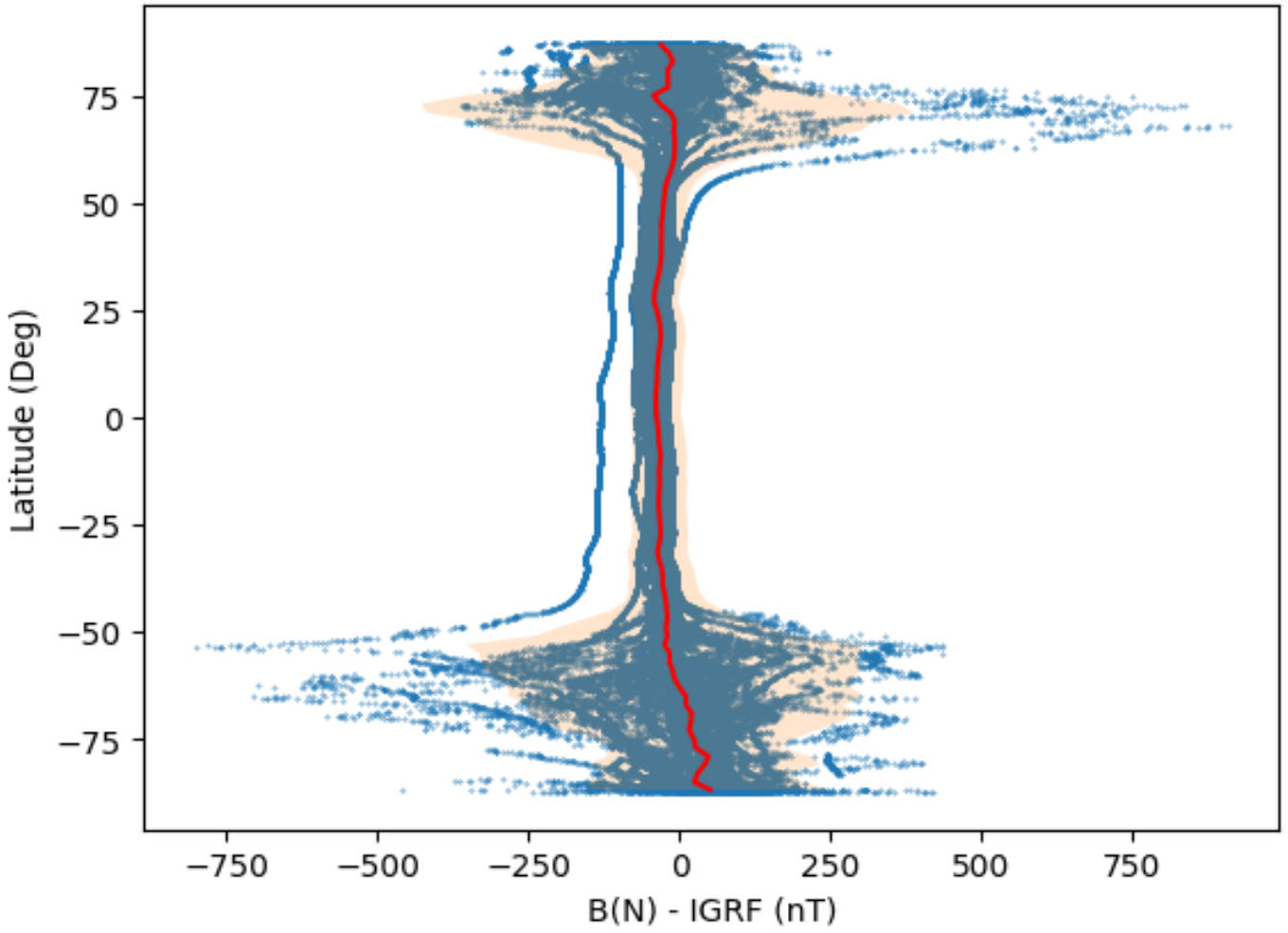
SWARM satellite data-IGRF



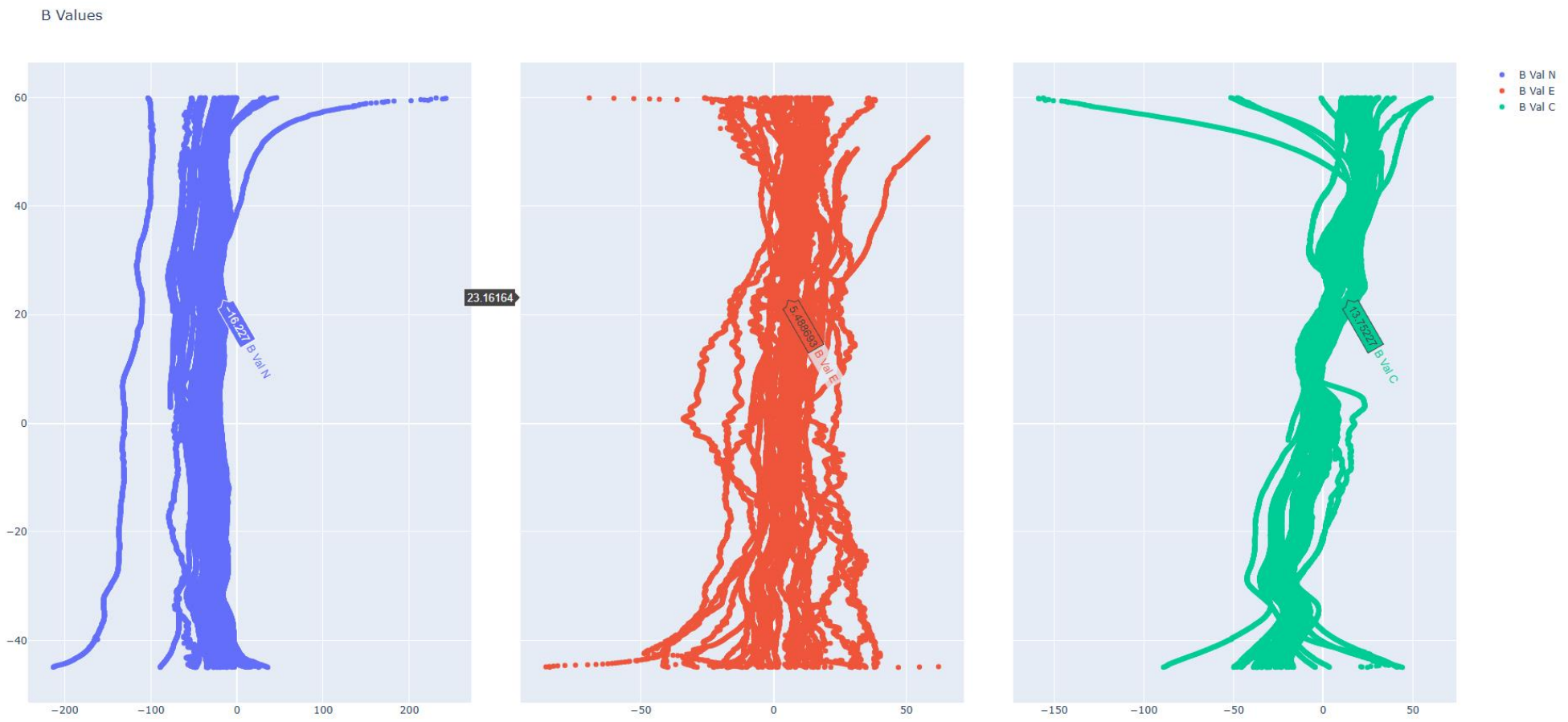




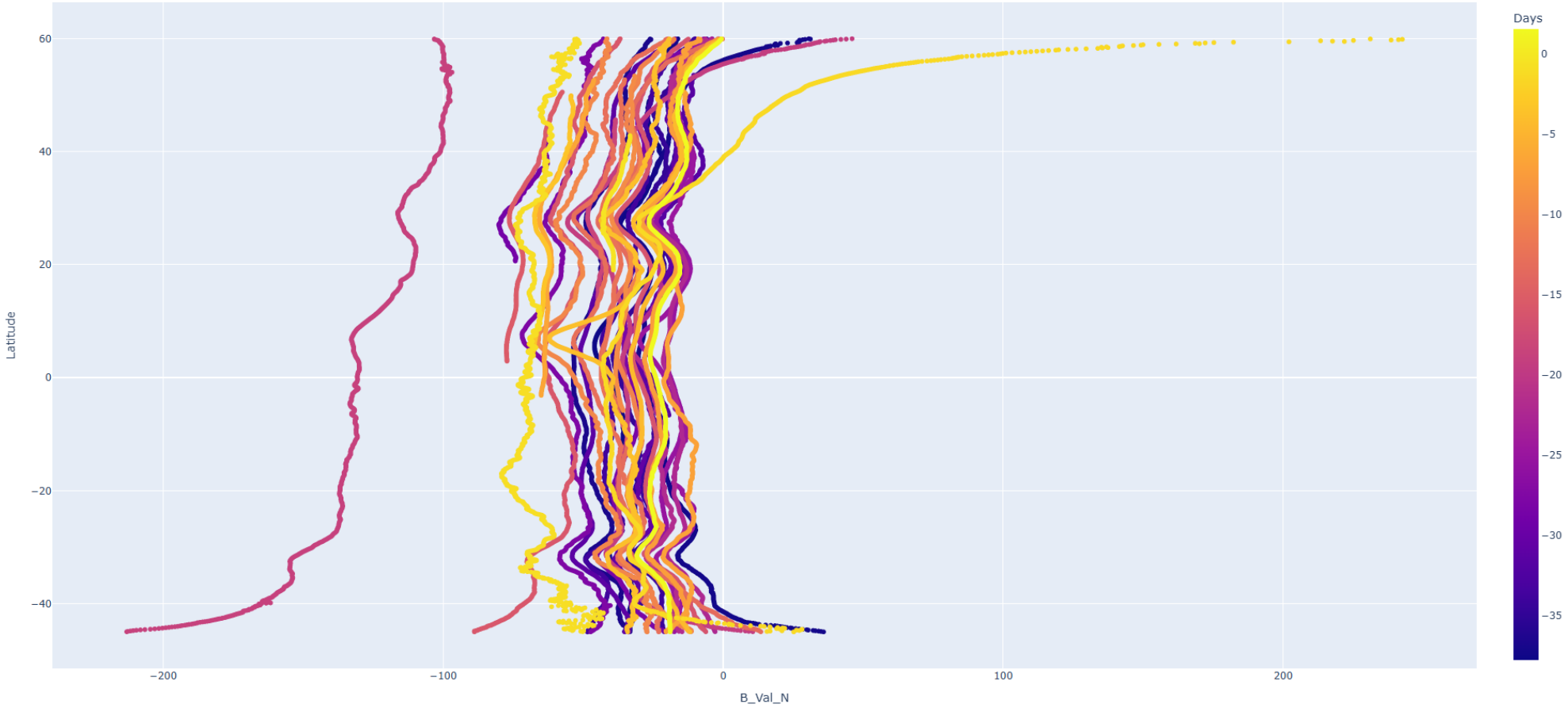
Latitudinal variation of geomagnetic field residuals from satellite observations, highlighting stable mid-latitude conditions versus noisy high and low latitudes influenced by auroral and equatorial currents.



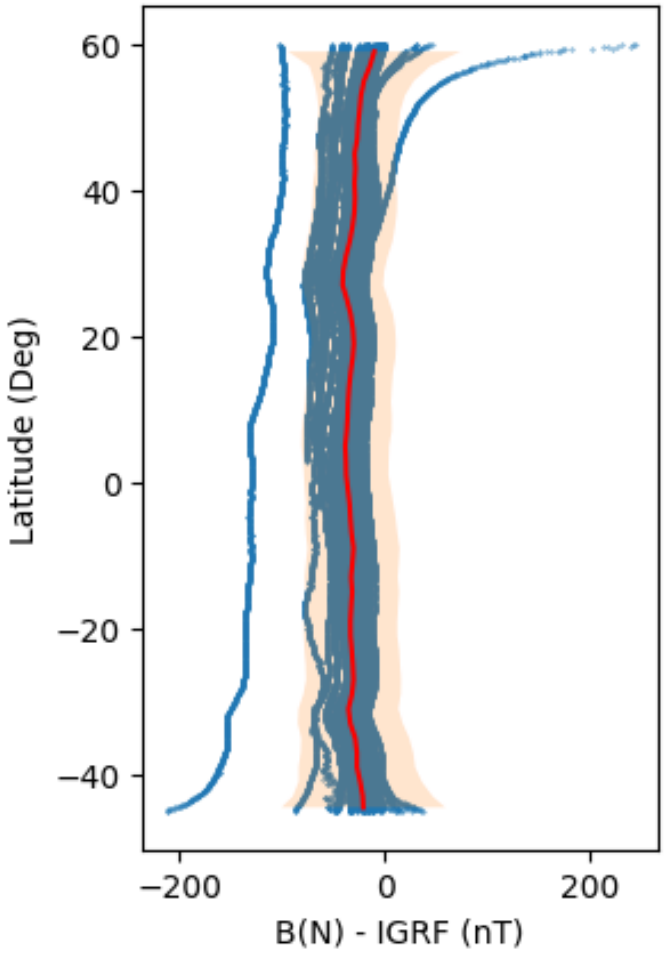
SWARM satellite data N, E and C components

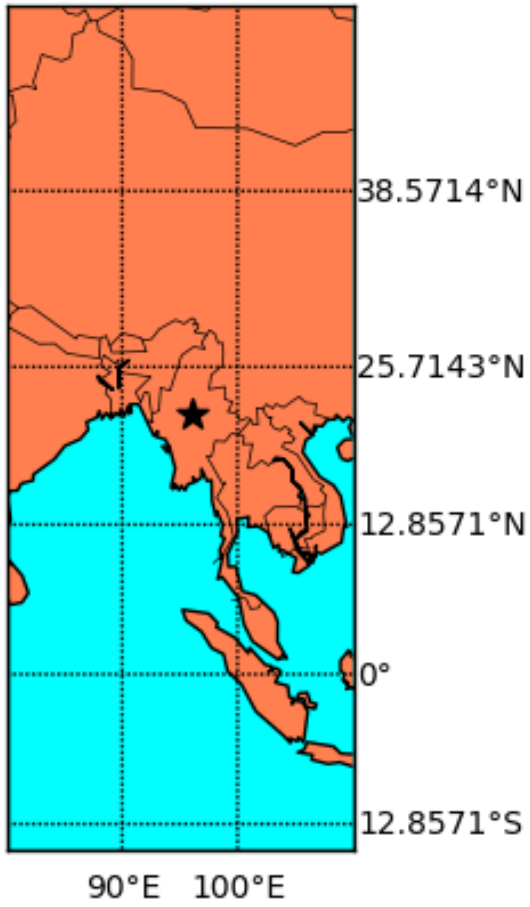


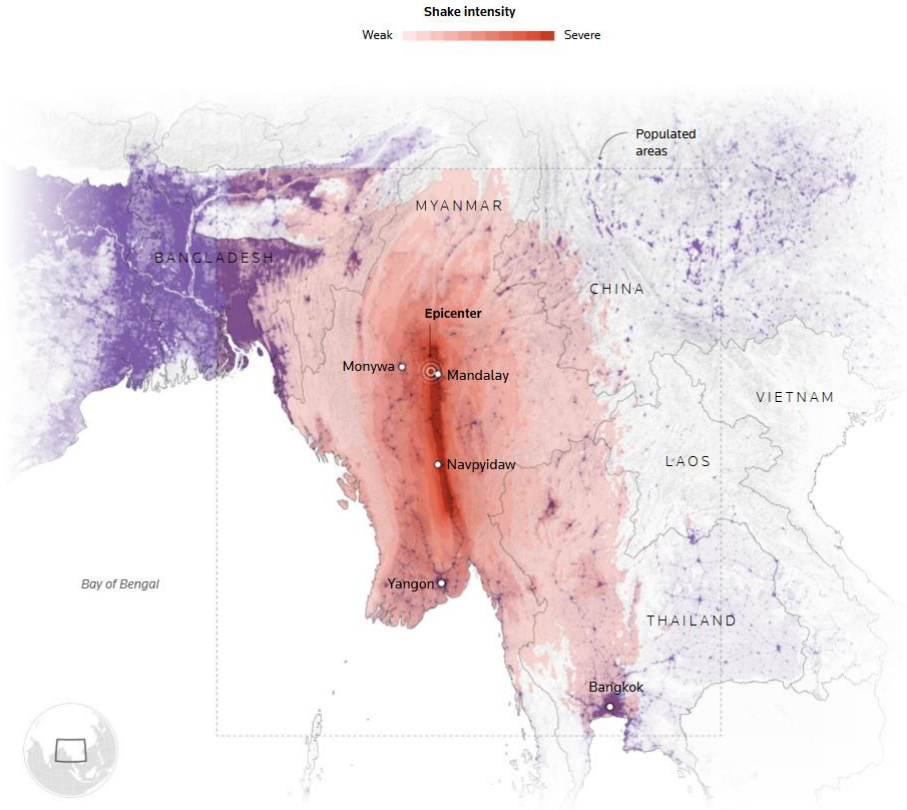
Application of the characteristic curve method



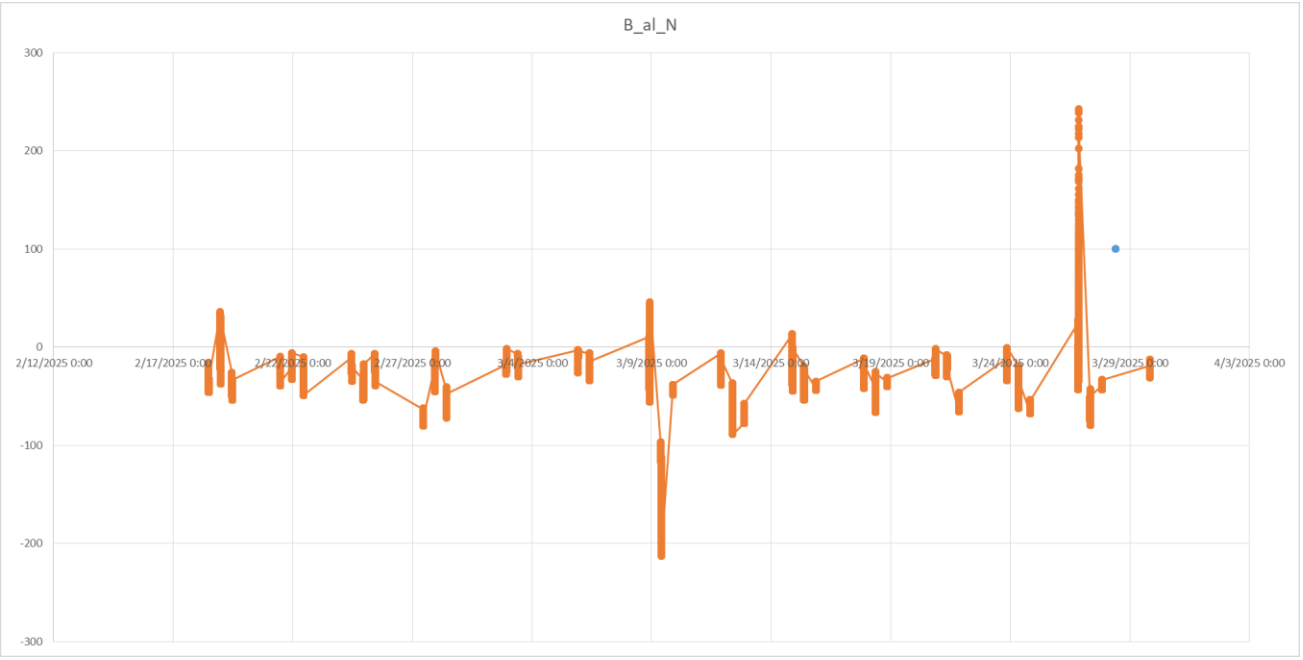
March 28, 2025 Myanmar 7.7 magnitude earthquake

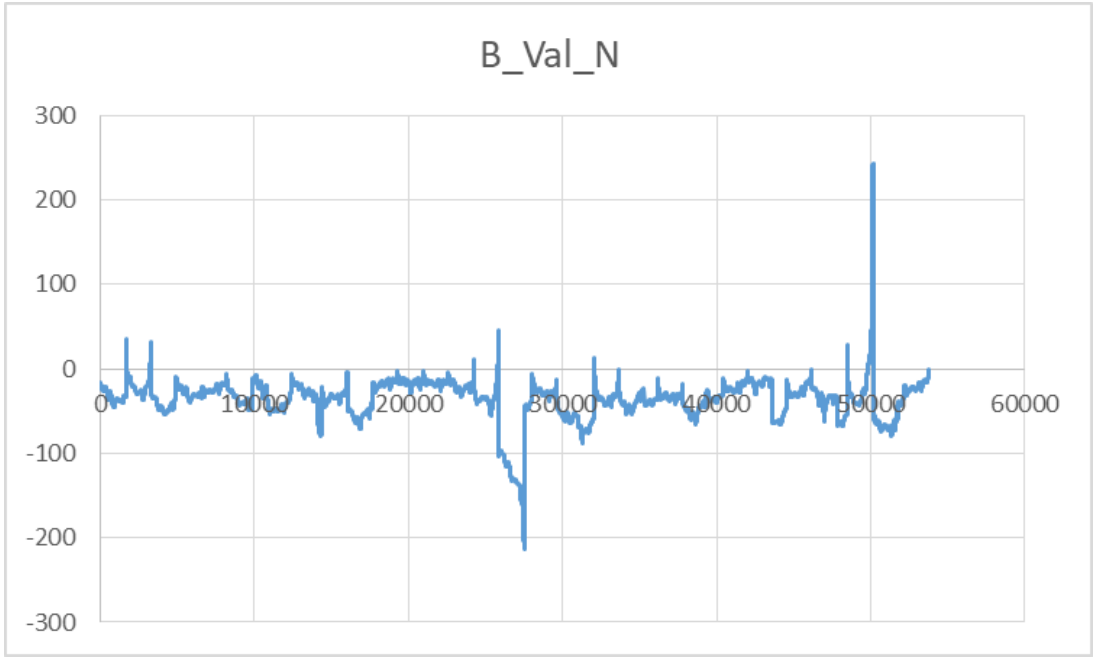




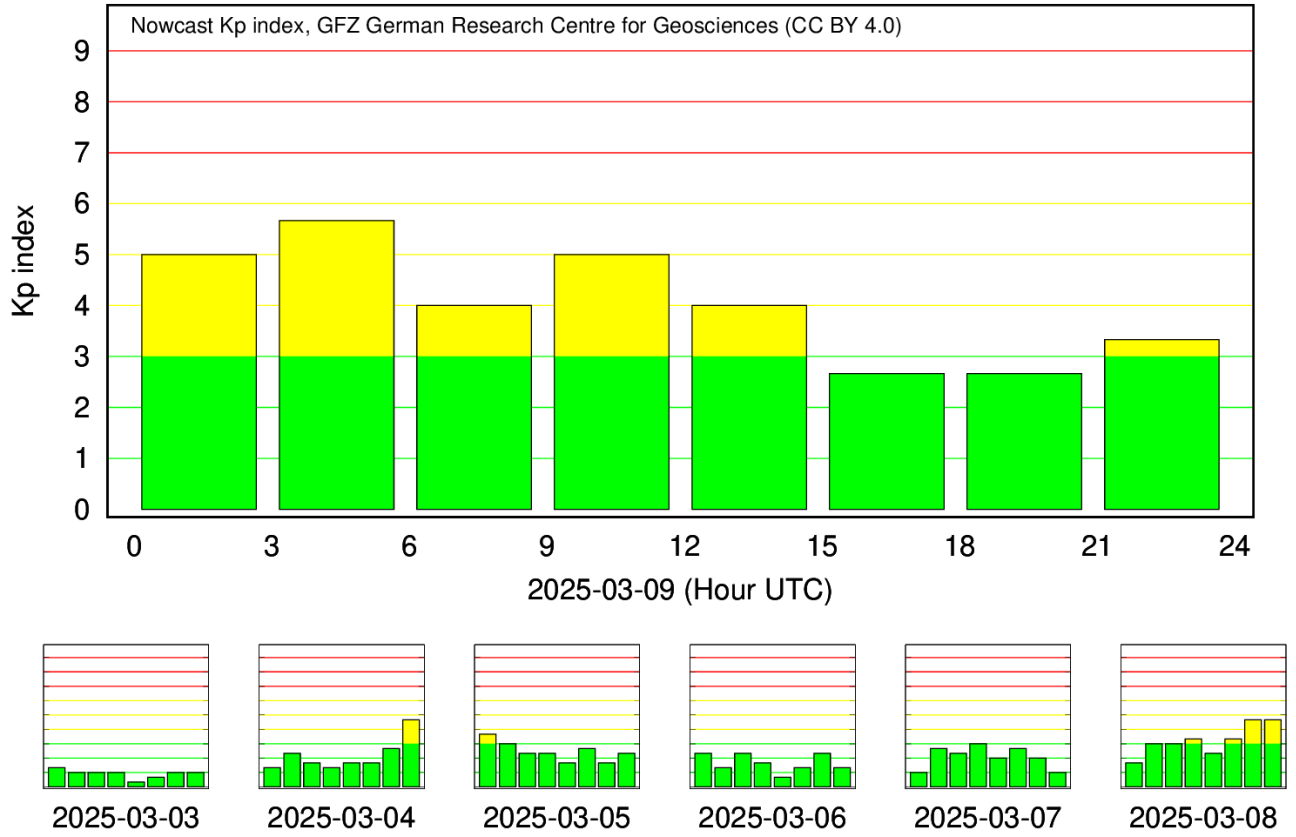


Anomaly in the data: Precursor?

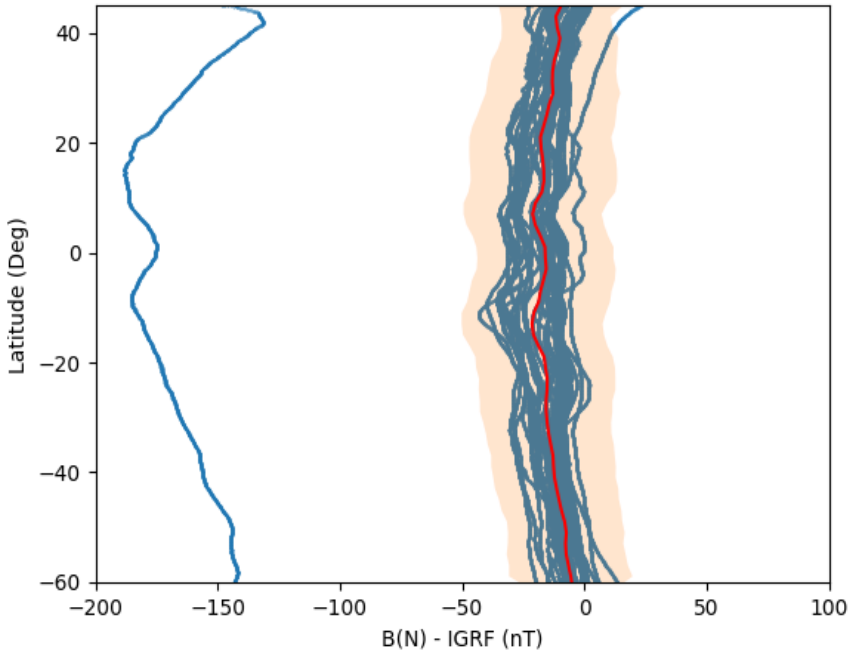


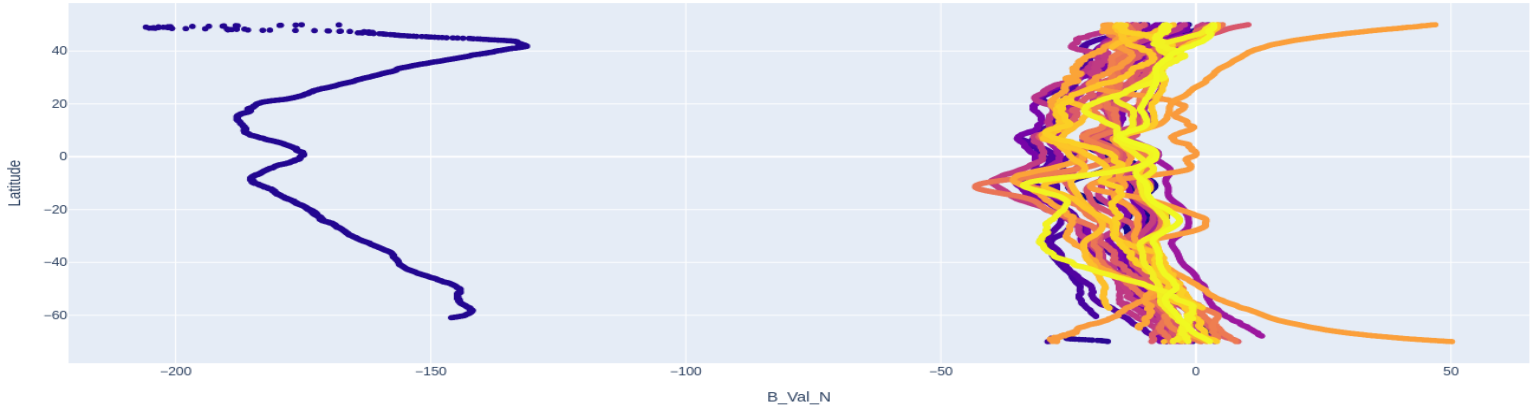


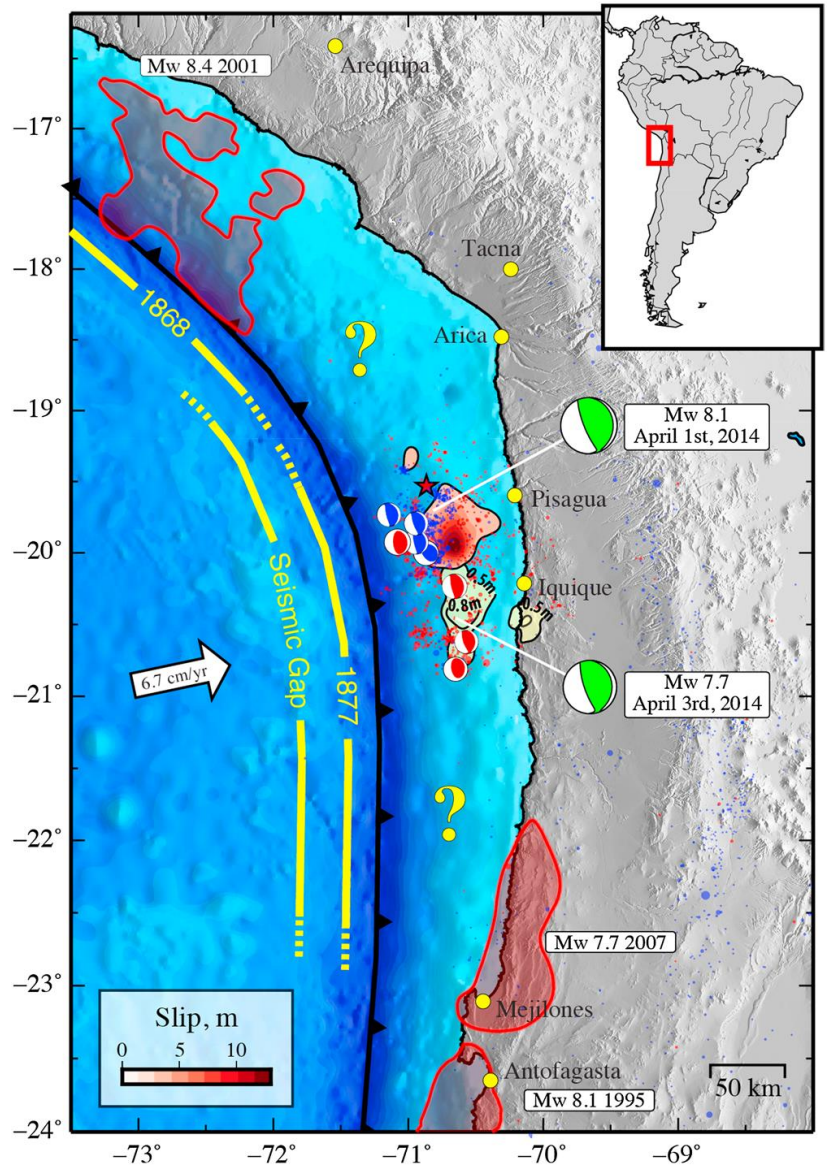
Magnetic storms



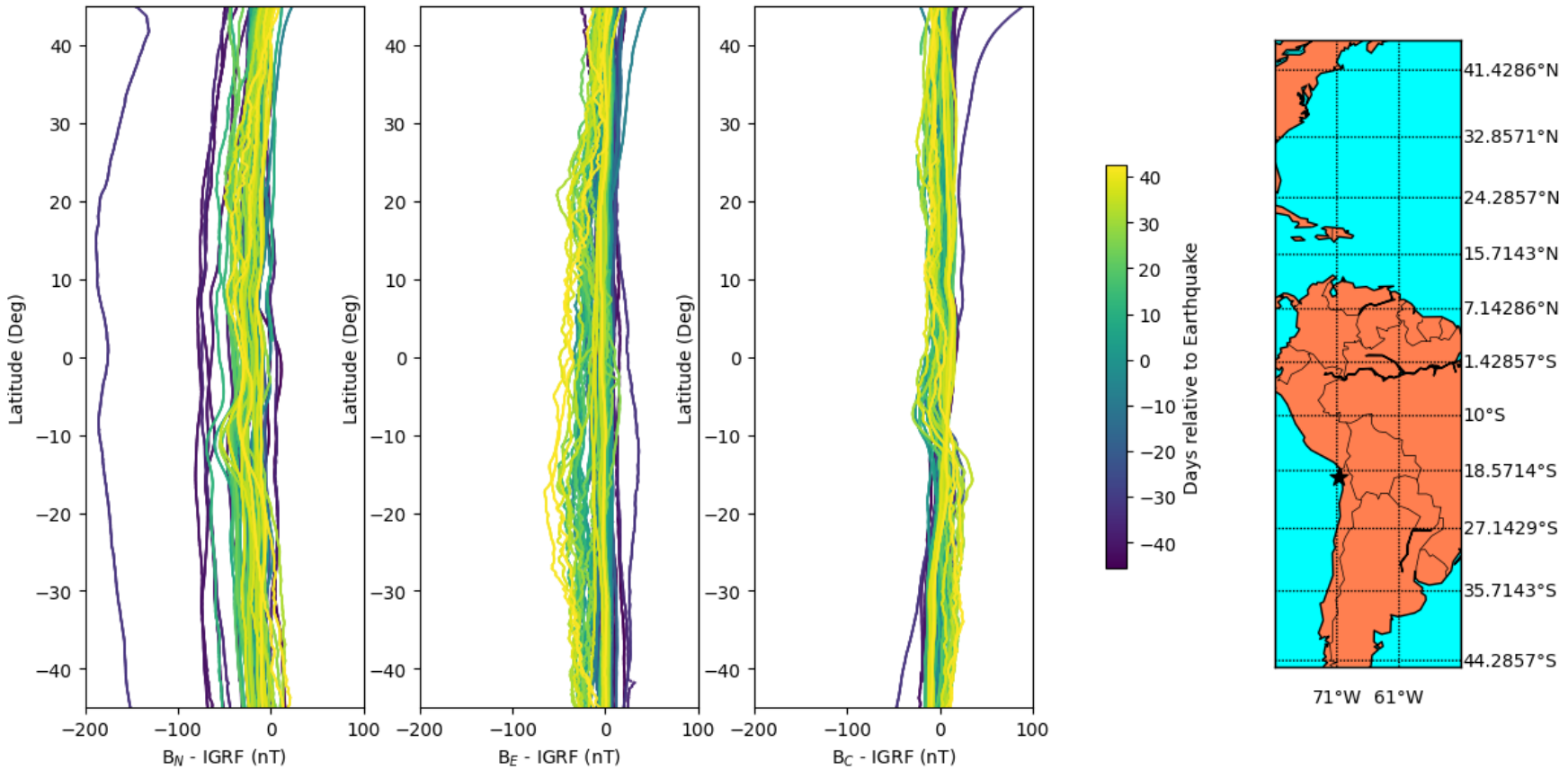
1 October 2014 Chile 8.2 Earthquake



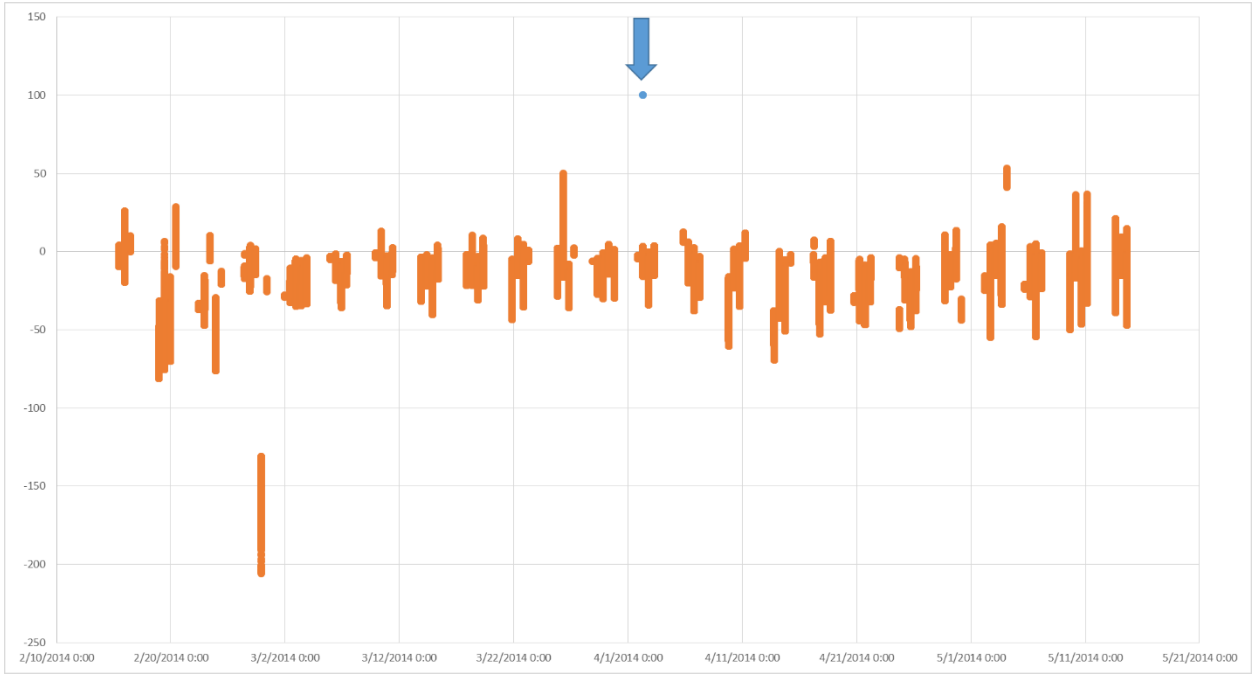




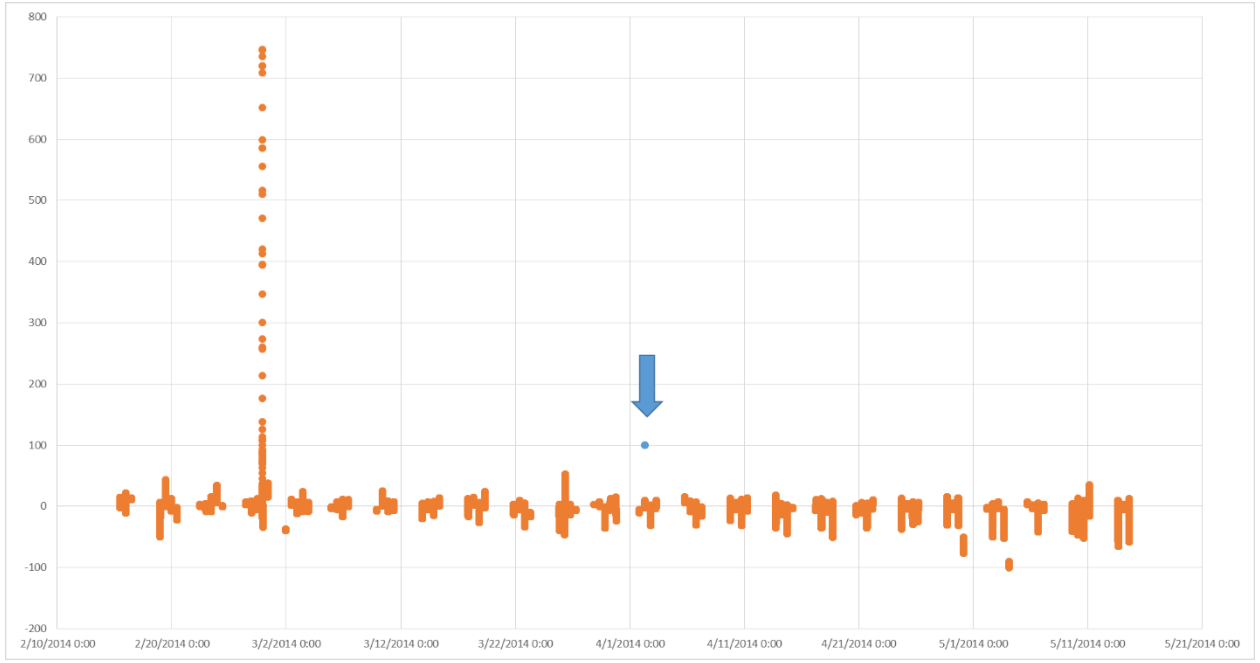
Characteristic curve analysis of Swarm satellite magnetic field data for earthquake precursor detection. Line plots show deviations from IGRF for BN, BE, and BC components versus latitude, with color-coded curves representing ±40 days around the earthquake. Shaded regions indicate ±2σ uncertainty bounds.



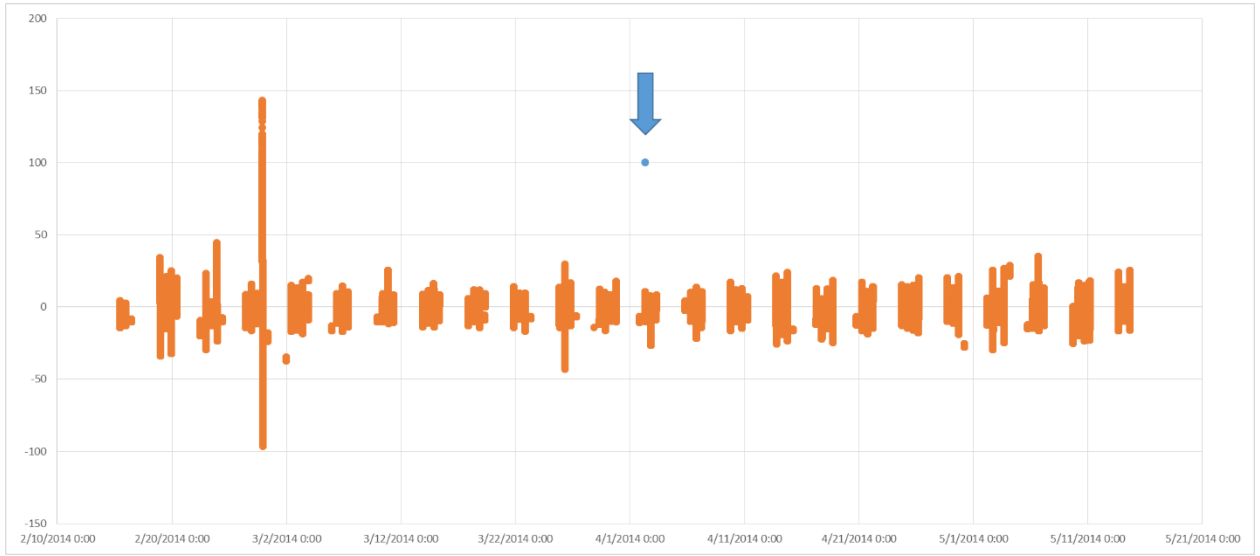
B_Val_N: Northward component



B_Val_E, Eastward component



B_Val_C, Vertical component



All figures show a clear anomaly 33 before April 1, 2014, Chile earthquake date

Conclusion

- The figures show a clear anomaly 33 before April 1, 2014, Chile earthquake date

- *De Santis et al. (2019)* detected a magnetic anomaly 27 days before this event
- The anomaly they reported is in the Y component
- It falls within the ±2σ range when re-evaluated using our method

- Our results reveal a statistically significant magnetic anomaly in the BN component 33 days before the event, exceeding the ±2σ uncertainty bounds. This anomaly was not mirrored in the BE or BC components, suggesting directional specificity and reinforcing the hypothesis of a localized lithospheric–ionospheric coupling mechanism.

Thank you!