Machine Learning for Detecting Time-Transient Phenomena in the Ionosphere and Correlation with Seismo-Induced Events

Megha Babu, Dr. Marco Cristoforetti, Prof. Roberto Iuppa

Fondazione Bruno Kessler, Trento, Italy.
University of Trento, Italy

PhD SST Space Science and Technology

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Introduction

The ionosphere's dynamic nature renders it susceptible to anomalies influenced by various terrestrial and extraterrestrial factors. Among these anomalies lie potential precursors to seismic events. Machine Learning, with its prowess in pattern recognition and anomaly detection, emerges as a potent tool in this endeavor.

Research Objectives

- Investigate the relationship between time-varying ionospheric data and seismic events.
- Develop a Machine learning model capable of capturing the temporal patterns and dynamics in the ionospheric data related to seismic events.

Data Collection

- **Ionospheric Data**
  - VLF Power spectra data of electric and magnetic fields from DEMETER with frequency resolution of 19.5 Hz and a time resolution of 2s.
- **Earthquake Data**
  - The earthquake data : USGS EQ Catalogue. (2005-2010)
  - Magnitude ≥ 5

The Grid-based Approach

Feature Extraction

1

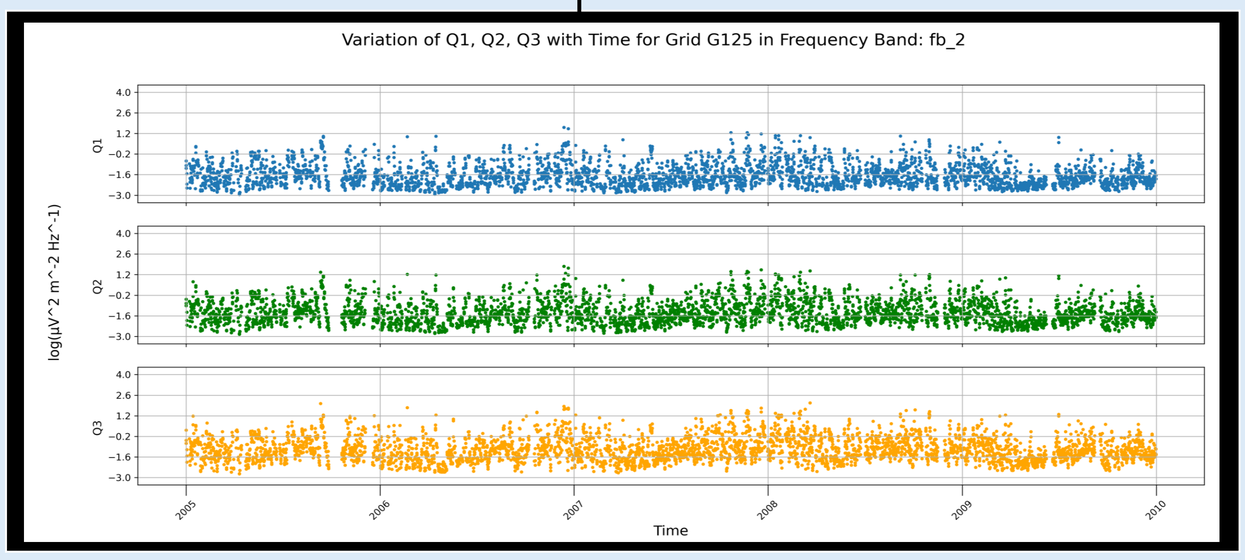
- Divide the earth into grids of $20^o \times 20^o$ dimension.
- Eleven low-frequency bands of spectra, ranging from 19.53 Hz to 153*19.53 Hz are selected for analysis.

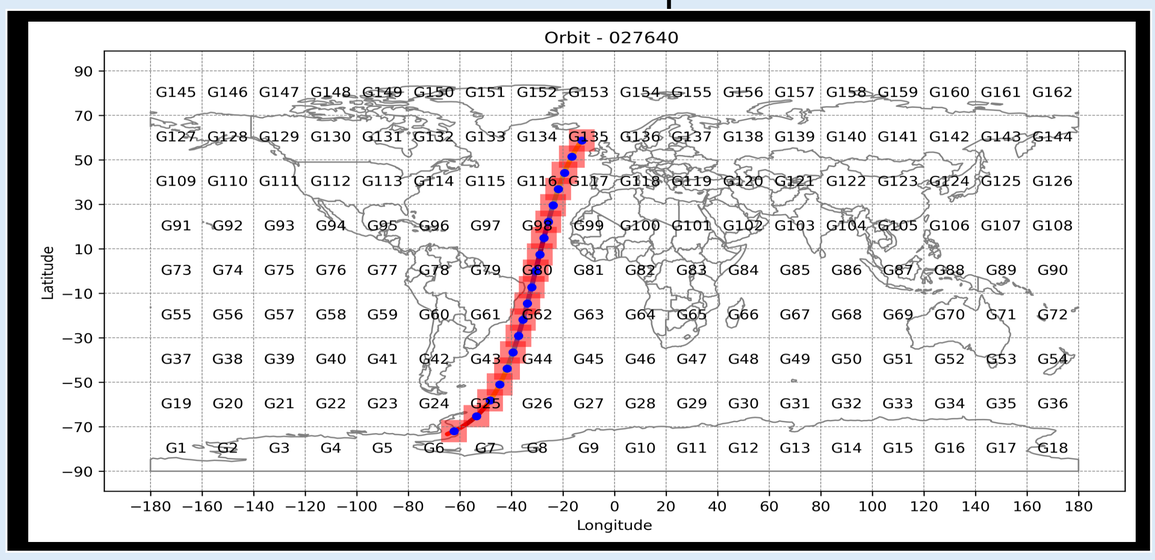
2

- At a time t_n of a half orbit with location (lat_n, $long_n$), a SQUARE AREA centered at given location with a width Δlat , $\Delta long$ ($10^o \times 10^o$) is considered.
- Quartile values Q1, Q2, and Q3 are calculated every 2' within the specified spatial and temporal parameters.

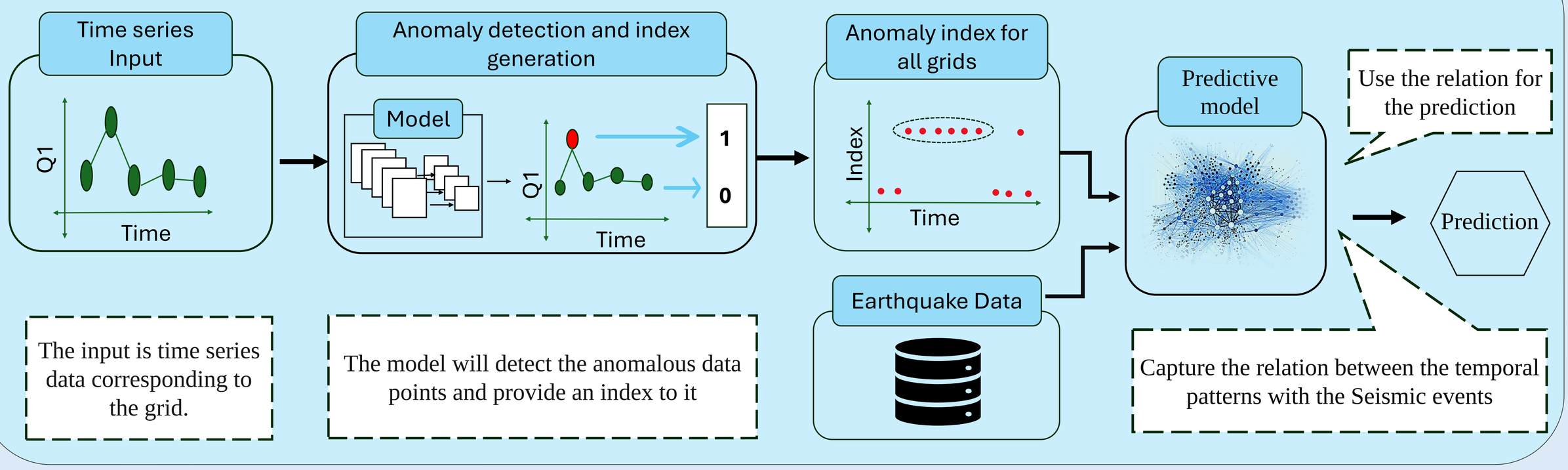
3

- The calculated values are assigned to the grid with the maximum intersection with the square area considered at a given time t_n.
- The final dataset contains time series data of 146 Grids.





Prototype



Relevance of Study

- Understanding the ionospheric response to earthquakes
- Developing accurate and reliable methods for predicting earthquakes can help to the development of early warning systems.
- Would enable better preparedness, mitigation, and response strategies, potentially saving lives and minimizing the economic and infrastructural losses associated with seismic events.

References

- Xiong, Pan, et al. "Identification of electromagnetic pre-earthquake perturbations from the DEMETER data by machine learning." Remote Sensing 12.21 (2020): 3643.
- Nassif, Ali Bou, et al. "Machine learning for anomaly detection: A systematic review." Ieee Access 9 (2021): 78658-78700.