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Optimized setup and long-term validation of anomaly detection methods for earthquake-related ionospheric-TEC (Total Electron Content) parameter over Italy and Mediterranean area

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Near the end of the last century and the beginning of the new, different types of geophysical parameters (components of the electromagnetic field in several frequency bands, thermal anomalies, radon exhalation from the ground, ionospheric parameters and more) have been proposed as indicators of variability potentially related to the earthquakes occurrence. During the last decade, thanks to the availability of historical satellite observations which has begun to be significantly large and thanks to the exponential growth of artificial intelligence techniques, many advances have been made on the study of the seismic-related anomalies detection observed from space.

In this work, the variations in Total Electron Content (TEC) parameter are investigated as indicator of the ionospheric status potentially affected by earthquake related phenomena. In-depth and systematic analysis of multi-year historical data series plays a key role in distinguishing between anomalous TEC variations and TEC changes associated with normal ionospheric behavior or non-terrestrial forcing phenomena (mainly dominated by solar cycles and activity).

In order to detect the differences between the two types of variation, we performed an optimal setting of the methodological inputs for the detection of seismically related anomalies in ionospheric-TEC using machine learning techniques and validating the findings on multiple long-term historical series (mostly nearly 20-year). The setting was optimized using techniques capable of combining multi-year time series of TEC satellite data and multi-year time series of seismic catalogues, simulating their behaviors in tens of thousands of possible combinations and classifying them according to criteria established a priori. Input setup and validation were done by investigating possible links between TEC anomalies and earthquake occurring over Italy and Mediterranean area. We will show and comment the results of both, optimal input setting and statistical correlation analyses consequently performed, and we will discuss the potential impact of these on future developments in this field.

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