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Editorial

Editorial of Special Issue "Detecting Geospace Perturbations Caused by Earth"

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A systematic multiparametric and multiplatform approach to detect and study geospace perturbations attributed to preparation processes related to natural hazards is fundamental in order to obtain useful insights on a series of complex dynamic phenomena of the Earth system, namely, earthquakes, volcanic and Saharan dust events, as well as geomagnetic disturbances. In particular, integrated analysis and interpretation of data from ground-based and spaceborne observations of the lower and upper atmospheres are of paramount importance for understanding the associated physical processes. In this Special Issue, we include pertinent studies on this field of research, presenting recent results and highlighting future directions for advances in the topic.

Tramutoli et al. [1] investigated the impact of volcanic and Saharan dust events on the ionosphere, analyzing a number of independent observations. They utilized observations by the Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions (DEMETER) satellite, Global Positioning System total electron content (GPS TEC), National Oceanic and Atmospheric Administration (NOAA)-derived outgoing longwave Earth radiation (OLR) and atmospheric chemical potential (ACP) measurements, along with ground- and satellite-based medium infrared/thermal infrared (MIR/TIR) observations. Their study confirmed the perturbing effects of volcanic and dust events on tropospheric and ionospheric parameters. For instance, the Mt. Etna (Italy) volcanic activity of 2006 was probably responsible for the ionospheric perturbations revealed by DEMETER and by GPS TEC observations. Furthermore, the volcanic activity also affected the OLR and ACP analyses. Similarly, two massive Saharan dust episodes in 2008, detected by robust satellite techniques (RST) using Spinning Enhanced Visible and Infrared Imager (SEVIRI) optical data, probably caused the ionospheric anomalies recorded, based on DEMETER and GPS TEC observations, over the Mediterranean basin.

Ippolito et al. [2] applied a multiparametric approach using variations of sporadic E-layer parameters (the height and the transparency frequency) together with variations of the F2 layer critical frequency, foF2, at the Rome ionospheric observatory to study crustal earthquakes that occurred in 2016 next to the town of Amatrice, Italy, together with the previous events that took place from 1984 to 2009 in Central Italy. They managed to clarify the earlier obtained seismo-ionospheric empirical relationships linking the distance in space (km) and time (days) between the ionospheric anomaly and the impending earthquake with its magnitude.

Marchetti et al. [3] dealt with the pre-earthquake lithosphere–atmosphere–ionosphere coupling (LAIC) process. They presented an analysis of the ESA Swarm mission magnetic field data preceding the Mw = 7.1 California Ridgecrest earthquake that occurred on 6 July 2019. Their procedure investigated the track-by-track residual of the magnetic data acquired by the Swarm constellation from 1000 days before the event and inside Dobrovolsky's area. Through an automated analysis of the anomalous Swarm three-satellite tracks, it was possible to detect an increase in anomalies around 200 days before

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the mainshock. Such an increase in anomalies is considered as possibly related to the preparatory phase of the California Ridgecrest earthquake. The result was validated after comparison with two equivalent areas centered at the same geomagnetic latitude and with a longitude that corresponds to the US East Coast (82.5° W) and to Europe–Spain (3.3° W). The comparison is essential to exclude possible global perturbations of the geomagnetic field. The detected anticipation times are sufficiently compatible with those expected by the Rikitake empirical law.

Oikonomou et al. [4] aimed at simultaneously analyzing ionospheric (TEC retrieved from global navigation satellite system (GNSS) networks) and atmospheric (ACP extracted from an atmospheric model) abnormal variations prior to three large earthquakes in Mexico. They applied different methods (statistical and spectral analysis on TEC, global ionospheric maps (GIMs), ionospheric precursor mask (IPM) methodology, time series and regional maps of ACP) in order to provide additional evidence and gain new insights of the pre-earthquake physical mechanism that leads to earthquake precursory phenomena. They found that both large- and small-scale ionospheric anomalies occurring from a few hours to a few days prior to the seismic events may be linked to the forthcoming events, and most of them are nearly concurrent with atmospheric anomalies happening during the same day.

In the frame of complex systems, Zitis et al. [5] studied the time series of the Disturbance storm time (Dst) geomagnetic activity index in terms of the empirical financial analysis method known as technical analysis, focusing on the temporal evolution of geospace magnetic storms. Specifically, they employed the combination of three very popular tools of technical analysis, the simple moving average (SMA), Bollinger bands and the relative strength index (RSI). The goal of their exploratory study was to formulate an analysis approach of Dst time series during the evolution of magnetic storms in analogy to asset price time series analysis in high-volatility periods. This analysis approach was developed after the analysis of more than 20 storm events, revealing all the technical analysis features (appearing in financial time series during high-volatility periods) which, in specific temporal sequences of occurrence, appear to be associated with the onset, main development and recovery phase of a magnetic storm. They focused on the fact that the results of this study enhance the view that quantitative analysis methods may successfully be transferred between finance and geophysical systems. Their results show that Dst time series around the occurrence of magnetic storms can be successfully analyzed by the same empirical tools applied to financial time series for investment analysis.

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