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Editorial: Near-earth electromagnetic environment and natural hazards disturbances: Volume II

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Editorial on the Research Topic
Near-earth electromagnetic environment and natural hazards disturbances: Volume II

Throughout history, human communities have faced consistent threats from natural hazards like earthquakes, volcanic eruptions, and tsunamis. Scientists strive to understand the process behind hazard formation and to accurately predict their occurrences. Since the 1980s, advanced space technology has allowed satellites to capture abnormal electromagnetic (EM) emissions, plasma density irregularities, and energetic particle precipitations near seismic fault zones, volcanic belts, and tsunami-prone coasts. Extensive efforts have been dedicated to rock-rupture processing experiments and ground-space comparative studies. EM precursors have shown promising potential for short-term earthquake prediction. In 2004, France launched the DEMETER satellite, operational until 2010, followed by China's China Seismo-Electromagnetic Satellite (CSES) in February 2018, focusing on earthquake monitoring from space.

This Research Topic serves two main purposes. Firstly, it validates and calibrates data from ground-based instruments and satellite platforms to explore the EM environment of near-Earth space, including the EM field, plasma parameters, energetic particle flux, and distributions. Secondly, it emphasizes cross-disciplinary studies of natural hazard monitoring, including earthquakes, volcanoes, tsunamis, and hurricanes/typhoons. By combining modelling and observation, the goal is to develop innovative methodologies for studying natural hazards and the interconnected mechanisms of the Lithosphere-Atmosphere-Ionosphere system. This Research Topic represents the second volume of the Research Topic.

This second volume includes four contributions which will be excellent references to future works on the Research Topic.

Zhang et al. statistically analyzed the electric perturbations in the Extremely Low Frequency (ELF) based on observation data from CSES before earthquakes (Ms $\geq$ 6.0) from 2019 to 2021, aimed to explore the relationship between shallow earthquakes and pre-earthquake ionospheric frequency electric field perturbations. Power spectrum ELF data of the ionospheric electric field were processed using the C-value method. A stable background field observation model was constructed using CSES data collected within a range of 15° above the epicentre, specifically from 75 to 45 days before the earthquake. The amplitude of the spatial electric field disturbance relative to the background field over the epicentre was extracted. Statistical analysis reveals that anomalies first appear 15–19 days and 10–14 days before the earthquake. These anomalies become more prominent 4 days before the earthquake and on the day of the earthquake. Stronger effects are observed for Ms > 7.0 earthquakes compared to those with lower magnitude, and marine earthquakes exhibit more pronounced anomalies than land earthquakes.

Recchiuti et al. conducted a study on the detection of EM anomalies over seismic regions during two strong earthquakes with a magnitude greater than 5. The authors proposed a novel technique for evaluating the EM background in the ionosphere above seismic regions. The background estimation was performed through a multiscale statistical analysis using electric and magnetic field datasets collected by CSES from 2019 to 2021. The analysis resulted in a map representing the average relative energy within a 6° x 6° latitude-longitude cell centred at the earthquake epicentre. Only EM signals that exhibited statistically significant deviations from the background were considered events suitable for further investigation. The authors applied this method to two strong seismic events: the 7.2 MW earthquake in Haiti on 14 August 2021, and the 6.0 MW earthquake in Crete on 27 September 2021. In the case of the Haitian earthquake, a distinctive signal with a characteristic frequency of 250 Hz emerged from the background. However, in the latter case, concurrent intense geomagnetic activity prevented the identification of any discernible signal separate from the background.

Zhu K. et al. conducted a study focusing on the analysis of the annual and semi-annual variations of electron density (Ne) variations in the topside ionosphere using data from CSES. The findings revealed a distinct pattern of Ne behaviour during the daytime, characterized by an amplification-linear-saturation pattern with a positive relationship to the solar activity index P10.7. Conversely, during nighttime, Ne generally exhibited a linear relationship. The annual variations of Ne displayed a longitude-averaged pattern, observed at most magnetic latitudes, with peaks occurring around the June solstices in the northern hemisphere and the December solstice in the southern hemisphere (except for nighttime in the northern hemisphere). In contrast, the semi-annual variation dominated at the magnetic equator and low magnetic latitudes, with two maxima during the equinoxes. The transition of the Ne dominant period occurred from the semi-annual variation in equatorial and low magnetic latitude regions to the annual variation in the middle magnetic latitude region, corroborating previous studies and providing additional insights into ionospheric characteristics at satellite altitude, particularly during nighttime.

Zhu F. et al. assessed and analyzed the global ionosphere maps (GIM) over China based on CMONOC GNSS data. GIM total electron content (TEC) data have been widely used for studying seismic ionospheric disturbance characteristics. However, limitations in spatial coverage of ground-based GNSS receivers often require interpolation or extrapolation techniques to obtain GIM TEC results in many regions, affecting their actual accuracy. The authors established a high-precision regional ionospheric map (RIM) model over China using CMONOC GNSS data. Their statistical analysis of China revealed that the average root mean square of the IGS GIM was less than 2 TECu (TEC units). A comparison between the TEC values calculated by the GIM and the RIM showed similar results. The difference between the two models was generally less than 2 TECu across most of China, except for certain low-latitude areas. Additionally, the correlation between the GIM and RIM was stronger during the daytime compared to nighttime, and it remained unaffected by space EM disturbances.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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