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# Editorial: Atmospheric disturbances: responses to phenomena from lithosphere to outer space

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Editorial on the Research Topic
Atmospheric disturbances: responses to phenomena from lithosphere to outer space

A large number of processes and phenomena that occur both in the Earth's layers (Veronis et al., 1999; Beletsky et al., 2003; Bochev and Dimitrova, 2003; Balan et al., 2008; Utada et al., 2011; Simões et al., 2012; Nina et al., 2020b) and in outer space (Inan et al., 2007; Srećković et al., 2017; Nina et al., 2018; Nina et al., 2021; Kolarski et al., 2022) constantly affect the terrestrial atmosphere. Although the effects that phenomena created in different areas produce in atmospheric layers depend on their characteristics and the observed geographical location, changes can very often be detected in large areas that include several atmospheric layers. Also, there are numerous influences on one atmospheric area (Nina et al., 2017; Silber and Price, 2017). In addition, changes in the atmosphere as a medium, in which other processes take place, have an impact on various processes and technologies in modern life (Jakowski et al., 2005; Stankov et al., 2009; Su et al., 2019; Nina et al., 2020a; Hunting et al., 2021). Therefore, the monitoring and understanding of spatio-temporal atmospheric changes are important for research in a number of scientific disciplines as well as for geoinformation technologies. Here, first of all, the importance of research into atmospheric changes related to natural disasters should be emphasized (Molchanov et al., 2004; Price et al., 2007; Maurya et al., 2016; Kumar et al., 2017; Vyklyuk et al., 2017, 2019; Manta et al., 2020; Malinović-Milićević et al., 2023). For example, the Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model based on the effects of ionisation provided by radon released from active tectonic faults before earthquakes is created in Pulinets et al. (2022).

In this Research Topic, studies of solar flare and seismic processes (possible) influences on the atmosphere are presented. Here, we briefly review and summarize these articles.

Barta et al. analysed the ionosphere during influences of solar flares that occurred on 5 and 6 December 2006. This study is based on data obtained in ground-based (by ionosonde and very low frequency (VLF) radio signals) and satellite (by GNSS and DEMETER satellites) observations. The obtained results show 1) an increase in VTEC (2%–5%)

during a stronger flare and the absence of its change in the case of a weaker flare, 2) a latitude dependent enhancement of fmin (first echo trace observed on ionograms) during both observed events in relation for quiet periods. In addition, a change in absorption of VLF signal from ground transmitters detected in low Earth orbit, and electron density profile versus ionospheric D-region altitude are presented.

Liu et al. proposed a way to explore the seismic activity of submarine faults. The study analyses disturbances in the atmosphere in the days leading up to, during, and after the Ms 6.2 Zhangbei earthquake that occurred on 10 January 1998, 150 km northwest of Beijing, using observations from satellites, reanalysis data, and satellite infrared cloud images. A positive thermal infrared (TIR) anomaly was detected in the area between the sea surface and the atmosphere above the Bohai Sea 2–3 days prior to the earthquake. The TIR strip was caused by clouds of low level arising from the release of gas from the Tancheng-Lujiang fault, which has a higher temperature than land surface gas, but not from the Zhangbei-Bohai fault that was previously considered. It was concluded that strip-shaped clouds that are the consequence of seismic activity and underwater release of gas were forced by a certain wind field and lowering boundary layer of the atmosphere.

Nina et al. extend research of VLF signal noise amplitude reductions before an earthquake to their studying during intense seismic activity. They analysed a time period from 25 October to 3 November 2016 when 981 earthquakes with magnitudes between 2 and 6.5 occurred in Central Italy. VLF observations confirm the noise amplitude reduction before individual not weak earthquakes that do not follow earthquakes after which the analyzed change is already present. In addition, this study point out the beginning of noise amplitude changes 2 weeks before the considered seismically active period.

Chakraborty et al. studied the altitude ($h$) profile of mid-latitude D-region response time delay ($\Delta t$) during solar flares of different classes. By solving "electron continuity equation" they estimated the variation of solar irradiation onto the ionosphere and investigated latitudinal variation (over both Northern and Southern hemispheres within the latitude range from $30^o$ to $60^o$) and seasonal variation (throughout the year) of $\Delta t - h$ profiles of each of these solar flares separately. They found h dependency of $\Delta t$ for all of the flares and their significant latitudinal variation. The methodology shown in the paper is not limited to the $\Delta t - h$ profiles just for the classes of solar flares in case, but is applicable to the entire range of available solar flares.

## Author contributions

AN, BM, SM-M, and SP all made substantial contributions to the conception and design of the work and to drafting and revising it for important intellectual content. All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication. All authors contributed to the article and approved the submitted version.

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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.

## Publisher's note



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