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IONOSPHERIC CO-SEISMIC EFFECTS AFTER MW 5.9 EARTHQUAKE IN GREECE ON 29 MARCH 2024

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Abstract: **Analysis and study of the spatial and local co-seismic ionospheric response as a result of the earthquake in Greece on 29 March 2024 is the main idea of this investigation. For the purposes of the present study, three types of ionospheric data: a) from the vertical sounding of the ionosphere; b) data obtained through an empirical model for forecasting the critical frequencies for the territory of Bulgaria and c) Total Electron Content (TEC) data were used. The main results show the presence of a positive response of the ionosphere, which is most significant near the epicenter of the earthquake and decreases with distance from it. There is also a delay in the response of 12-14 hours and the delay increasing with displacement to the equator and low latitudes. The obtained partial spatial variabilities of the ionospheric response confirm these results.**

Data and methods: **The behavior of the solar and geomagnetic activity, represented by the Kp-index and F10.7 respectively, was analyzed (data are available at: https://omniweb.gsfc.nasa.gov). The regular ionospheric variabilities are removed by using relative deviation of foF2 and TEC. Three types of data for investigating the ionospheric co-seismic response to the described above earthquake on the territory of Greece are used. The first type of data for the F2-layer critical frequency (foF2) from the vertical sounding of the ionosphere was obtained from the database of GLOBAL IONOSPHERE RADIO OBSERVATORY (GIRO)-https://giro.uml.edu/didbase/scaled.php. The second type of data for the ionospheric parameter foF2 was calculated from an empirical model for forecasting the critical frequencies for the territory of Bulgaria. The third type of ionospheric TEC data analyzed here was downloaded from: https://www.izmiran.ru/ionosphere/weather/grif/Maps/TEC/.**

Results

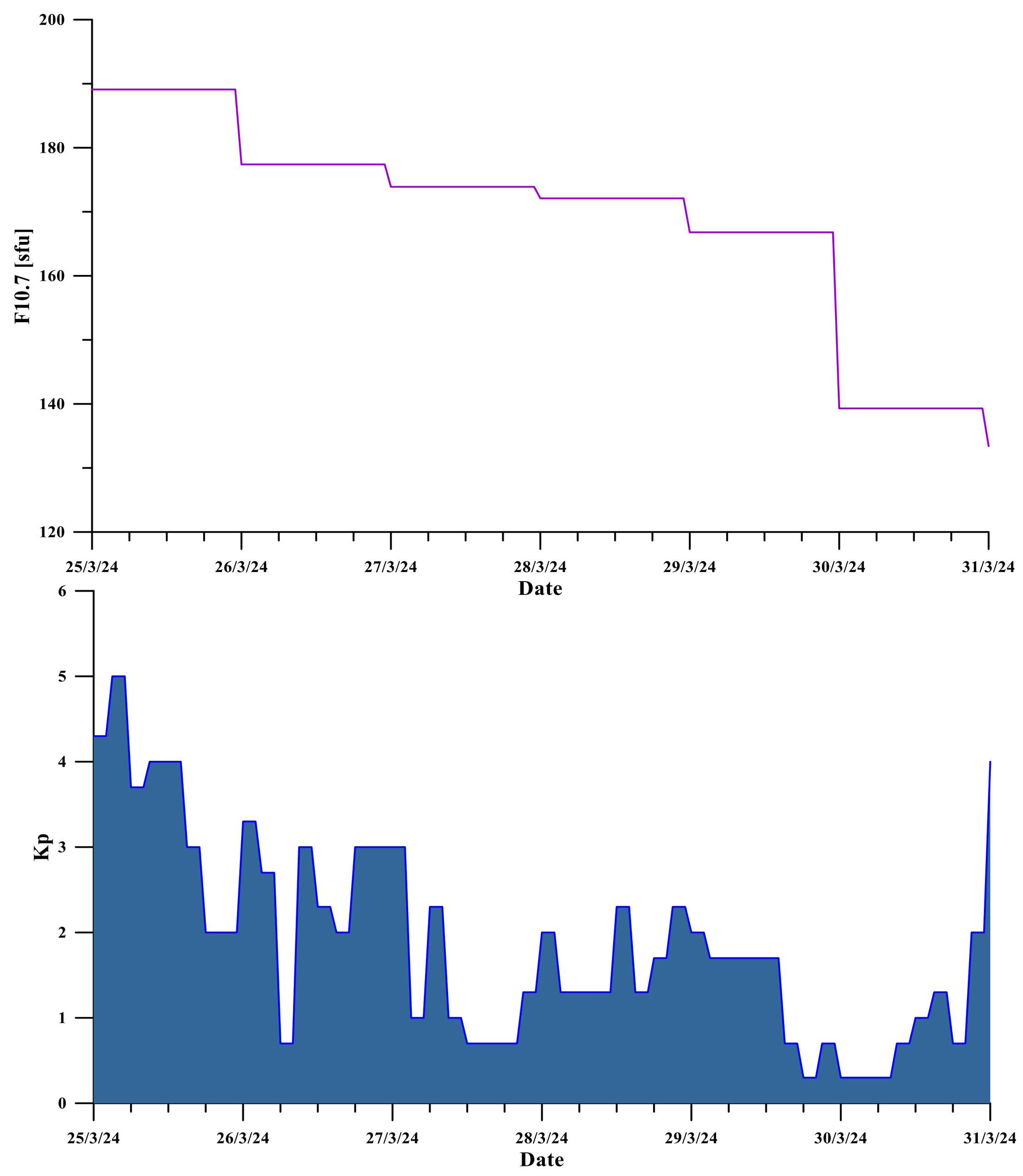

Figure 1 Behavior of solar activity (top panel) and geomagnetic activity (bottom panel).

Figure 1 shows the behavior of solar and geomagnetic activity, which illustrate quiet conditions according to the accepted classifications of parameters Kp and F10.7. This makes it possible to study the local and partial spatial variability of the ionosphere, presented in Figure 2 and Figure 3.

Figure 2 presents a comparison of the behavior of the ionosphere for selected points for the period 28-30 March 2024. The figure shows: a) relative deviation of TEC (bottom panel) - closer to the epicenter of the earthquake, b) relative foF2 from Athens ionospheric station (middle panel) - more distant point and c) model foF2 values from empirical model for Sofia (top panel) - at a great distance from the epicenter. The black line shows the moment of occurrence of the earthquake on 29 March2023 at 07:12:49 UTC. It can be seen from the figure that all ionospheric parameters demonstrate a positive response. The most significant reaction around 0.5 is observed at the point of closest distance (bottom panel), and the reaction decreases with distance from the epicenter. Another anomaly that the Figure 2 shows is the delay of the maximum response, which varies from about 8 hours (top panel) to 10 hours (bottom panel).

Figure 3 illustrates in more detail the distribution of the ionospheric response in a given interval of selected longitudes and latitudes. It can be seen from the figure that before the onset of the earthquake at 07UT the behavior of relative TEC around the coordinates of the epicenter is negative, while at 10UT after the earthquake the values are positive in a limited latitudinal range. During the following hours, the positive anomaly in the ionosphere gradually increases and covers a larger area, as the relative deviation of the TEC reaches its positive maximum of about 0.5 at the hours around 22UT. The most distinct positive reaction is in the hours between 19UT-22UT at low latitudes between 33°N-38°N. The obtained results in Figure 3 confirm the local analysis of the ionospheric variability proposed above, in which it is clearly seen that the co-seismic effect decreases with the distance from the epicenter, and that the delay of the maximum positive ionospheric response is about 13 hours.

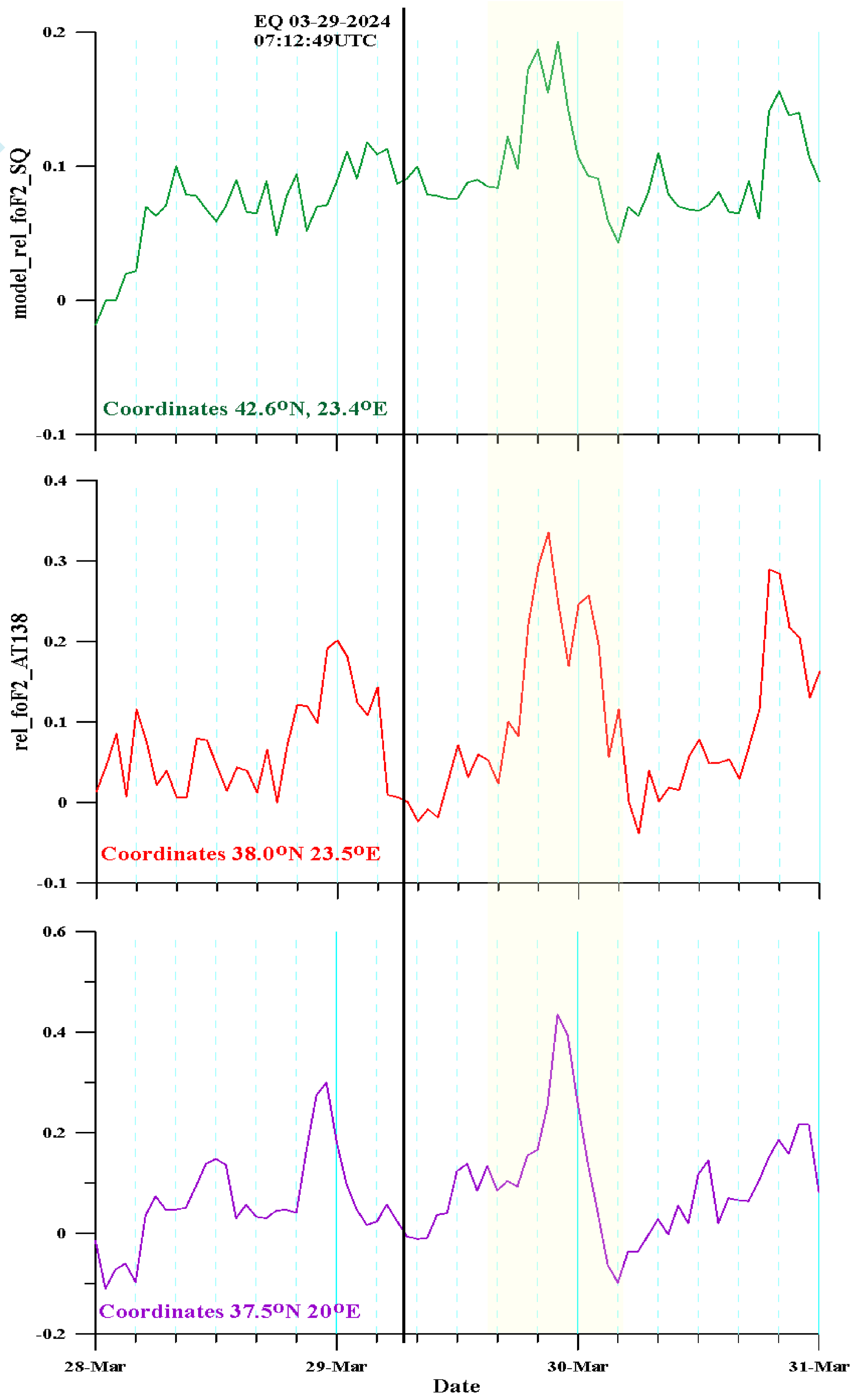

Figure 2 Variability of the ionosphere for selected points.

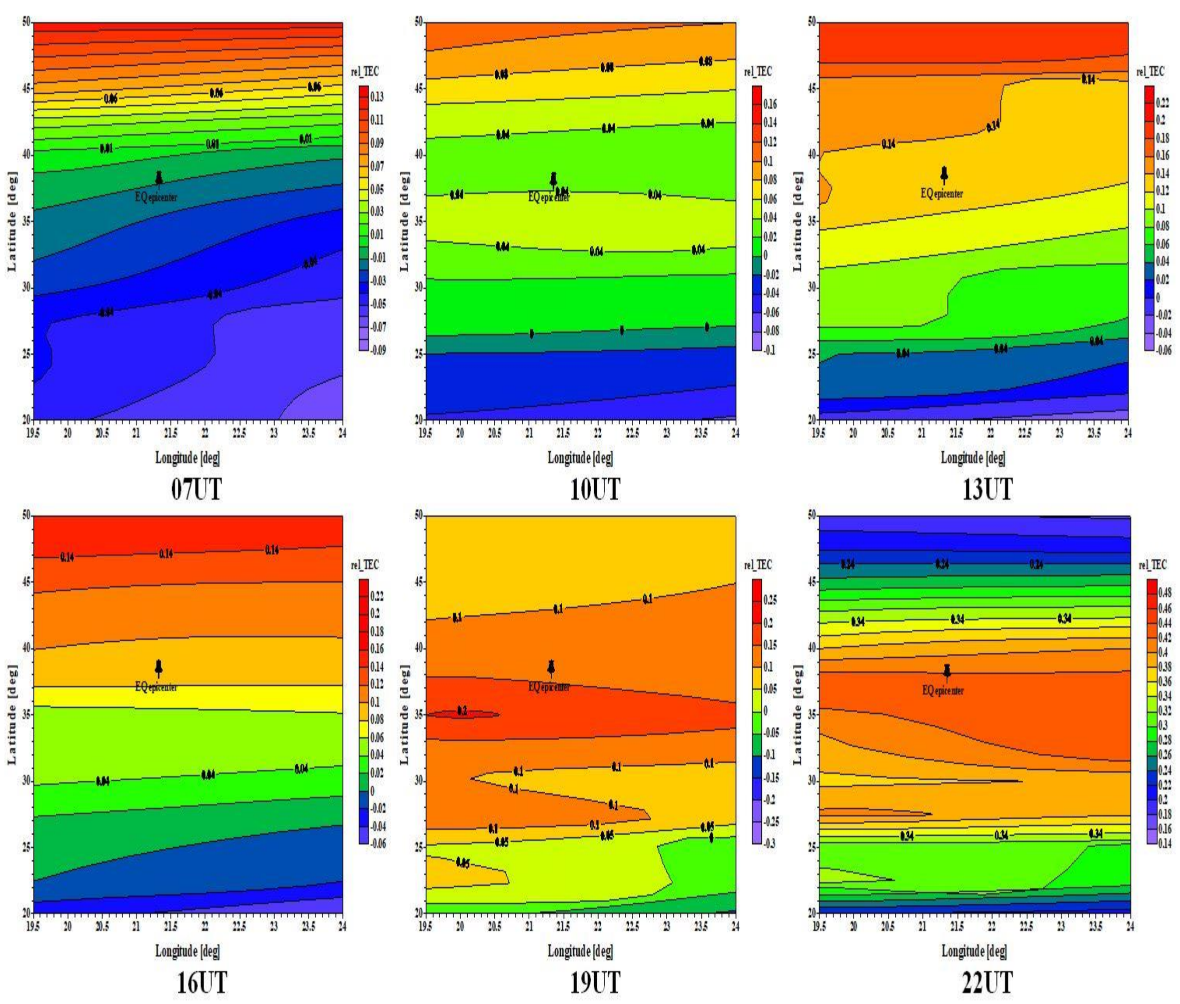

Figure 3 Partial spatial distribution of the TEC response for selected moments.

Conclusions: **The results found in the present study refer to the ionospheric anomalies that are most likely associated with the co-seismic effect resulting from the earthquake in Greece on 29 March 2024. Ionospheric parameters foF2 (measurements and model) and TEC data were used. The results of all types of ionospheric data found in the present study show a positive anomaly that occurred with a delay of about 12-14 hours after the earthquake. According to the results, the most significant positive ionospheric response (about 0.5) is observed at the closest point to the epicenter, and the response decreases with distance from the epicenter. The obtained partial spatial variabilities of the ionospheric response confirm these results. The knowledge regarding to the possible sources of the variability of ionosphere is very important for high frequency radio wave propagation and satellite navigation.**

Acknowledgement:

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