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A92 **Atmosphere, ionosphere, safety** / edited by O.P. Borchevkina,
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Proceedings of International Conference "Atmosphere, ionosphere, safety" (AIS-2023) include materials reports on: (1) — response analysis of the atmosphere — ionosphere to natural and manmade processes, various causes related geophysical phenomena and evaluate possible consequences of their effects on the human system and process; (2) — to study the possibility of monitoring and finding ways to reduce risk. Scientists from different countries and regions of Russia participated in the conference. Attention was given to questions interconnected with modern nanotechnology and environmental protection. Knowledge of the factors influencing the atmosphere and ionosphere can use them to monitor natural disasters and to establish the appropriate methods on this basis.

Content of the reports is of interest for research and students specializing in physics and chemistry of the atmosphere and ionosphere.

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The isotropy boundary (IB, dashed line) is shifted toward the equator as the magnetic field decreases (Figure 4). The isotropy boundary in different hemispheres differed by 5 degrees in the same UT and MLT sector.

This study shows the influence of the interhemispheric asymmetry of the Earth's magnetic field on the intensity of relativistic electron fluxes and, to a lesser extent, on energetic proton fluxes. The flux intensity increases with a decrease in the magnetic field at the orbit of the low-orbiting satellite. The lower the magnetic field, the longer the observation time of these fluxes. As the magnetic field decreases, the isotropy boundary is shifted toward the equator.

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SEARCH FOR THE EARTHQUAKE-RELATED IONOSPHERIC DISTURBANCES USING ROTI: A CASE STUDY

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Introduction. The ionosphere is the ionized region of the Earth's atmosphere that is located between ~60 and ~1000 km of altitude. It is largely impacted by solar events and geomagnetic activity, as well as by the changes in the neutral atmosphere, for example [1,2]. Since the establishment of the Mexican Space Weather Service (SCiESMEX, acronym in Spanish) that forms part of the National Space Weather Laboratory at the Institute of Geophysics, the systematic regional conditions monitoring allows us to perform the diagnostics and to study the behavior of the ionosphere over Mexico [3,4].

Several authors have addressed the ionospheric disturbances related to earthquakes that occurred in different regions [5-12]. The difficulty for these studies is that the ionospheric disturbances detected and associated with some earthquakes can be caused by other natural phenomena, as it is known that the ionosphere responds to changes in Space Weather conditions, explosions of different type, tropical cyclones, hurricanes, etc. Therefore, the key issue is to distinguish between the ionospheric disturbances triggered by earthquakes and by other events.

The disturbances registered after the impact of an earthquake are known as Co-seismic Ionospheric Disturbances (CID). In general, these are caused by the atmospheric waves generated by earthquakes. The triggering mechanism can include direct acoustic waves excited by vertical crustal movements or by the sea surface, Rayleigh surface waves and internal gravity waves. Once the atmospheric waves reach the heights of the F region of the ionosphere, they can produce irregularities in the electron concentration.

The ionospheric response characteristics and the mechanisms that produce disturbances can differ in each particular region. The response depends on the earthquake magnitude and the regional atmospheric and ionospheric conditions. According to the literature, the earthquakes of magnitude $M_w >$ 6 are likely to provoke the ionospheric response. The aim of this study was to verify the possibility of detection of the ionospheric response over Mexico using Rate of TEC index (ROTI). This is a case study.

Description of the considered event. The earthquake considered in this study occurred on September 22, 2022 in the Michoacán state at 07:16:09 UT (01:16:09 LT). Figure 1 shows the location of the epicenter whose geographic coordinates are as follows: Latitude 18.01°N, Longitude 103.18°W. The depth was 12 km. The earthquake was characterized by Mw=6.9 being one of the strongest recent earthquakes in Mexico. To identify the presence or absence of CIDs, the GNSS regional data was involved.

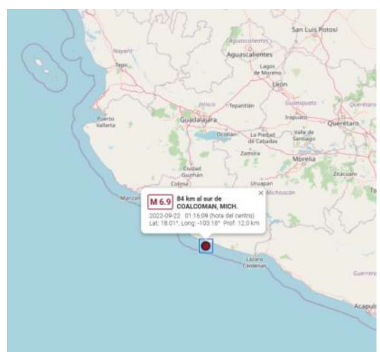

FIGURE 1. Michoacan earthquake location.

Data description. Regional GNSS data, provided by SSN, TLALOCNet and SSN-TLALOCNet networks, were involved in the analysis. Figure 2 illustrates the dual-frequency GNSS receiver station locations. First, slant Total Electron Content values were calculated. Then, the time series of ROTI [13] were obtained.

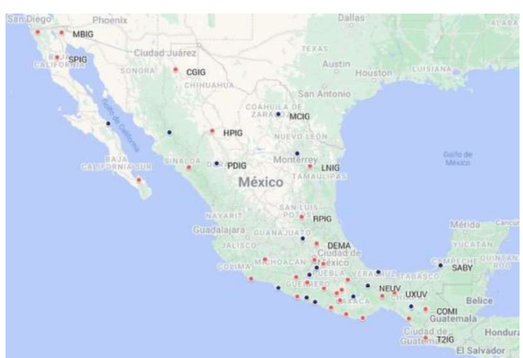

FIGURE 2. Map of GNSS receiver stations whose data were used for the study.

Results. First, ROTI series were analyzed at different Lines-of-Sites (LoSs) to GPS satellites during the time interval beginning from 30 minutes before the seismic event and four hours after it. In most cases, ROTI did not show significant peaks. Only small enhancements of the index were detected at the particular LoSs. Figure 3 illustrates the obtained variations; red vertical lines mark the beginning of small ROTI increases at each LoS. Furthermore, we constructed the sub-ionospheric points map that corresponded to the moments for each satellite-receiver pair (not shown for economy of space). It resulted that all the points were located northward from the Mexican territory. The distances from the epicenter and the time moments corresponding to each plotted point clearly indicated that ROTI showed weak disturbances. However, these were not related to the considered earthquake at the south of Mexico. Indeed, according to the literature some earthquakes do not generate large responses in the ionosphere, for example [14]. Probably, this was our case. It is also worth noting that some earthquakes can cause a rather weak response far from the epicenter (at a distance of ~500-800 km). For this study case, the detected ROTI peaks may not be clearly associated to the earthquake because of the geometry of LoSs at which these peaks were registered.

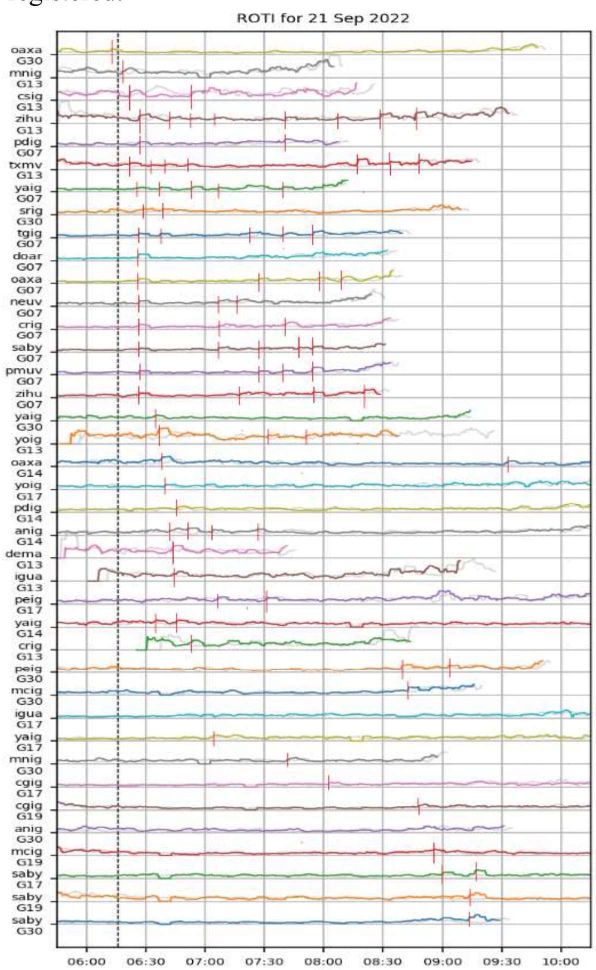

FIGURE 3. ROTI variations at LoSs between different receivers and GPS satellites on September 22, 2022. Dotted vertical line indicates the moment of the earthquake. The Y-axis unit is 0.3 TECU.

Conclusions. The preliminary analysis of the earthquake that occurred on September 22, 2022 in Mexico showed that no clear ionospheric response was detected with ROTI time series. It may be explained by the fact that ROTI is not the appropriate tool for the weak ionospheric disturbance detection in the region. The study of other ionospheric parameters is needed. Another possibility is that the GNSS data time resolution was low (1 sec). At the same time, it is possible that the ionospheric response was absent in this particular case.

Acknowledgments. *Angela Melgarejo-Morales expresses her gratitude to CONACyT in Mexico. This work is based on GPS data provided by TLALOCNet at Servicio de Geodesia Satelital [15] and the Servicio Sismológico Nacional [16], both at the Instituto de Geofísica, Universidad Nacional Autónoma de México (UNAM). ROTI values were obtained using the SIMuRG tool [17].*

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TEC ANALYSIS BASED ON WEEKLY REPORTS BY MEXICAN SPACE WEATHER SERVICE

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Introduction. The Mexican Space Weather Service (SCiESMEX, acronym in Spanish) realizes the continuous monitoring of regional Space Weather conditions. One of the parameters provided by the service is the weekly Space Weather report published at SCiESMEX official web page: www.sciesmex.unam.mx/blog/category/reporte-semanal-de-clima-espacial. Vertical Total Electron Content (TEC) is one of the parameters that is monitored. Hourly absolute TEC values and 27-day running median TEC values are reported every week. TEC values are calculated with data from GNSS receiver station UCOE located in the center of Mexico (Lat 19.8°N; Lon 101.68°W). Figure 1 shows its location.

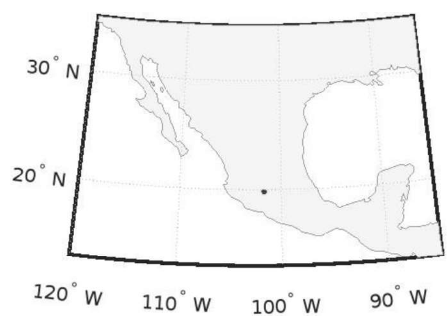

FIGURE 1. UCOE station location.

According to the previous studies, the short-term TEC enhancements are probable over the North American sector during geomagnetic storms [1,2]. The results of [2] were obtained with data limited to a time period ending in 2015. The aim of this work is to verify if the occurrence of the short-time TEC enhancements is still the feature of the ionosphere over Mexico. The weekly reports by SCiESMEX during the period between 2016 and 2022 were used to answer this question.

Results. For this study, we considered TEC to be increased/decreased when the positive/negative TEC deviation from its quiet median value exceeded 30%. The representative examples of TEC increases and decreases are shown in Figure 2 (left and right panels correspondingly). The statistical results are shown in Table 1. First, we revealed all the cases of TEC deviations being more than 30%. Further, these deviations were divided into those observed under disturbed and quiet geomagnetic