Application of the ionospheric parameters on the seismic research --Seismic-ionospheric effect detected from China Seismo-Electromagnetic Satellite

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The ionosphere is located at the altitude of 60 kilometers above the earth surface and the top of the ionosphere is about 500km. Figure 1 shows the basic structure of the ionosphere, where D, E and F layers are all clearly concluded. In addition, F layer can be divided into F1 and F2 layers. F1 layers and D region always disppear in nighttime. The seismic-ionospheric research began in 1960s, when American scientists studied the Alaska M8.5 earthquake in 1964, they first found that the disturbance of plasma density before this earthquake. Since then, many researchers engaged in this field. Based on the promising seismic-ionospheric research, China government launched the Seismo-electromagnetic satellite, CSES for short, on February, 2018 for both the earthquake observation and geophysical research. As the data is available now, in this research we adopt the observed data from CSES. The basic information of this satellite is listed in Table 1. There are four consecutive shallow focus earthquakes in a short period in Indonesia during July to Augst, 2018, where Table 2 shows the detailed information about these four earthquakes, and figure 2 shows the specific locations of four epicenters on the map. As for the data sources, there are mainly three kinds of data. The first kind is the Ionospheric Electron density (Ne for short) from CSES satellite. Figure 3 shows the launch and flight status of CSES satellite where a total of 8 payloads concluded, and we adopted the electron density from Langmuir Probe PayloadIn this research. The second kind of data is Ne corresponding with the observed data from International Reference Ionosphere model 2016 (IRI 2016). The third kind is the global ionosphere map from CODE whose time resolution is 1 hour, spatial resolution is 2.5deg*5deg. We adopt these data to evaluate the reliability of the CSES satellite data. First, we used the following formula to calculate the percent disturbance of electron density from CSES satellite. After calculation, we found that there are mainly four significant anomalies on July 27, 31, August 07, and 14 respectively, shown as figure 3. Compared with the earthquake time listed in table 2, these four disturbances just happened before the four earthquakes, which maybe the seismic-ionospheric effect. And the red star in these figures represent the epicenter. After checking different kinds of space weather index, we can exclude that the disturbance is caused by space weather. As for the IRI 2016 model can be seen as the background data without any seismic factors, so we adopt the corresponding Ne from IRI model to evaluate the reliability of CSES data. From figure 4, it is clear the abnormal orbits in figure 3 also show the similar disturbance. As the orbit revisiting period is 5 days, figure 5 shows the comparison between the revisiting orbits of CSES on July 31 and August 14, the other two orbits go through the same location 5 or 10 days before. From this figure, the electron density shows obvious swelling on the abnormal days while the electron temperature shows the opposite trend. Then we used the grid data from CODE to calculate the disturbance about VTEC. Figure 6 (a) shows the percent disturbance of VTEC on August 1, 2018, from 5:00UT the abnormal around the epicenter is gradually increased, till 15:00UT the abnormal area disappeared. It is worth noting that the anomaly did not change with time, which means it is not triggered by sun activity. The percent disturbance of VTEC on Aug. 14, 2018 also shows the similar results from figure 6 (b). In the following research, we counted all the earthquakes that occurred in Indonesia over a 10-year period during 2007-2017 between 106.45 E-126.45 E and 8.3 S-1.7 N from USGS to check the anomalies of

ionospheric vertical TEC from CODE. After selecting the earthquake accidents whose depth is less than 50km, and magnitude is greater than M5.8, there are a total of 35 earthquakes in the end, shown as figure 7. Figure 8 shows the statistical results of the count of TEC anomalies 15 days before and after these 35 earthquakes. It is obvious that 1-7 days before one earthquake in Indonesian region, the number of ionospheric parameter anomalies is more than other time.

Keywords: Seismic-ionospheric effect, Electron density, Total electron contents, CSES satellite

