Statistical Analysis of Electron Density Disturbances in the Ionosphere Caused by Earthquakes Using China Seismo-Electromagnetic Satellite

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China Seismo-Electromagnetic Satellite (CSES-1) is Chinese first satellite that is dedicated to monitoring ionospheric disturbance caused by earthquakes. It transits in a solar synchronous orbit with an altitude of 507 km and revisits the same place every 5 days. The payload of the satellite consists of eight kinds of scientific detection instruments.

Using the revisited orbit design of CSES-1, we analyzed the electron density (Ne) data of 10 orbits from 30 days before the earthquake to 15 days after the earthquake. Before analysis, we take the data that exceeds the mean value by 6 times, greater than and less than or equal to 0 as erroneous data, and replaced them with null values. After replaced the erroneous data, the average value of Ne of the 6 orbits before the earthquake is treated as the background field, which is quite consistent with the 27-day solar cycle. After the background field is obtained, this paper compares the Ne on the day of the earthquake and within 15 days after the earthquake with the background field to try to extract the disturbance signal in the ionosphere which may cause by the earthquake.

The above method was successfully applied to the Yangbi Ms6.4 earthquake in Yunnan on May 21, 2021 and the Qinghai Maduo Ms7.4 earthquake on May 22, 2021. The results show that, about 20 days before the earthquakes, the disturbance signal began to appear in the earthquake epicenter and around the seismogenic area. While the earthquakes approaches, the anomalies appear more and more frequently, and then disappear quickly after the earthquakes.

We apply this method to M ⩾ 6 earthquakes in the world and M ⩾ 5 earthquakes in the mainland of China and adjacent areas. The statistical results of these earthquakes show that:

1. The number of anomalies increases with the approach of earthquakes, both the global and Chinese regions. And the number of anomalies decreases rapidly after the earthquake.
2. The number of anomalies increased significantly from 10 days before the earthquake to 5 days after the earthquake.
3. With the increase of earthquake magnitude, the number of anomalies increased, and the appearing time of anomalies is also advanced, and the duration of the anomalies after the earthquake is also extension.