

Statistical analyses of z test, and ROC curve on anomalies of the ionospheric TEC associated with earthquakes in China during 1998-2015

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In this study, we examine 62 M6.0 earthquakes reported by China Earthquake Networks Center http://www.csndmc.ac.cn/newweb/catalog_direct_link.htm and the ionospheric total electron content (TEC) of the global ionosphere map (GIM) at a fixed location (32.5°N, 95°E, the location center of those earthquakes) retrieved from CODE (Center for Orbit Determination in Europe, CODE, <ftp://ftp.unibe.ch/aiub/CODE/>) in China during 1998-2015. The statistical significances of the pre-earthquake ionospheric anomalies (PEIAs) of the GIM TEC associated with the earthquakes are further investigated by z test and ROC curve. Here, we subdivide the earthquakes into three groups, 37 6.0 M<6.5, 18 6.5M<6.9, and 7 M7.0, to avoid a possible confounded effect and find the associated characteristic of the observed PEIA of each group. Meanwhile, we randomize the observed anomalous days to verify the significance of the PEIAs. Statistical results show that the anomaly characteristic of the polarity, appearance local time, duration, lead day, etc. before the earthquakes is essential to detect PEIAs. Three negative anomaly zones (i.e. one for each earthquake group) with significant z test: Zone A (1800-2200 UT (00:20-04:20 LT, post midnight to pre-dawn) 4-5 days before 37 6.0M6.0<6.5 earthquakes), Zone B (0100-0400 UT (07:20-11:20 LT, morning) 3-6 days before 18 6.5M6.5<7.0 earthquakes), and Zone C (0400-1000 UT (10:20-16:20 LT, pre-noon to afternoon) 3-5 days before M7.0 earthquakes). It is found that 59.5% (22 out of 37) of 6.0M6.0<6.5, 72.2% (13 out of 18) of 6.5M6.0<7.0, and 85.7% (6 out of 7) of M7.0 earthquakes are preceded by the PEIA of negative TEC anomalies. This depicts that the greater earthquake have a better chance to be leaded by the PEIAs. ROC curve further confirms that the PEIA is a reliable earthquake precursor. Finally, a logistic regression is applied to find the relationship between earthquake parameters and PEIA strength.

Keywords: z test, ROC curve, logistic regression