

Investigation of seismo-ionospheric earthquakes precursors in Total Electron Content disturbances before 2005-2007 strong seismic events

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Numerous ground-based and satellite measurements have shown the ionospheric E- and F-layer density increasing or decreasing over epicenters before seismic events [1-6].

We consider that the most probable physical mechanism of such anomalies formation is the vertical electromagnetic $\mathbf{E} \times \mathbf{B}$ plasma drift induced by a seismic electric field. This hypothesis was proposed in [7]. But there are alternative hypotheses of other physical mechanisms; their descriptions are given in [8-10].

We investigate seismo-ionospheric precursors of earthquakes in Total Electron Content (TEC) of the ionosphere using regular Global Positioning System observations [11]. TEC deviations (per cents) from the corresponding “background” conditions were calculated for each two-hour interval of years 2005-2007. There is no consensus of opinion which TEC distributions can be used as background values. Some investigations were carried out using empirically calculated background values [12]. Some authors investigated absolute TEC values and not TEC deviations [13]. 15-days medians were used in [14]. We apply moving 7-days average TEC distribution as background values for the investigated LT interval.

From the U.S. Geological Survey list we have selected seismic events of years 2005-2007 that are of $M \geq 6$ by magnitude and of $D \leq 80$ by depth. Earthquakes at subauroral and high geomagnetic latitudes were rejected. For the selected events global and regional relative TEC disturbances maps (per cents) were plotted considering eight days before each event for possible seismo-ionospheric precursors. The example of TEC disturbances map is shown in Fig.1 for 1-4 days before Indonesia, July 05, 2005, M6.7 seismic event.

According to the hypothesis on electromagnetic mechanism of the pre-earthquakes TEC anomalies formation, TEC disturbance was accepted as a precursor when it was observed near the epicenter and/or magnetically conjugated point and lasted for six hours at the least. Fig.1 demonstrates positive TEC disturbance observed one day before the event and identified as ionospheric precursor.

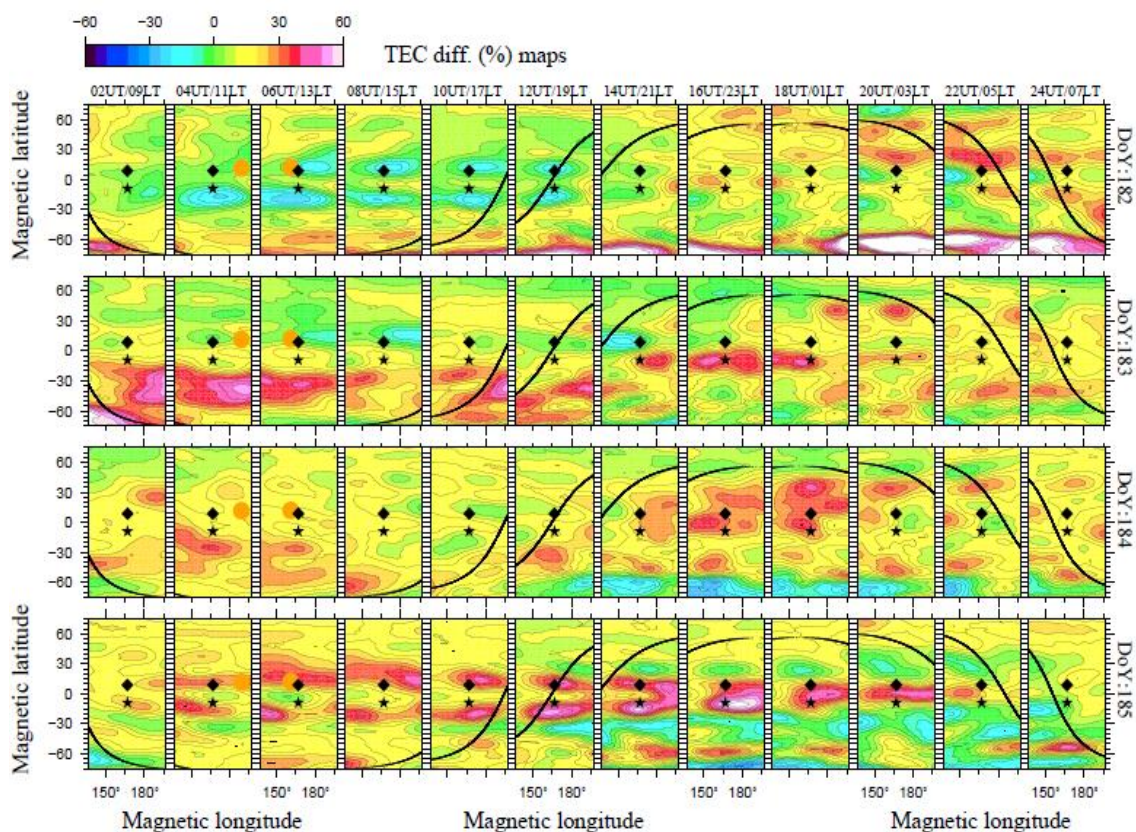


Fig. 1: TEC relative deviations (%) from the background variations 4-1 days (from top to bottom) before Indonesia, Jul. 05, 2005, M6.7 earthquake. Co-ordinates are magnetic latitude and magnetic longitude.

Star – the EQ epicenter position. Diamond – the magnetically conjugated point. Orange circle – the subsolar point. Black curve – terminator line. LT labels (above the panels) correspond to the EQ epicenter's position.

We have analyzed 91 events (29 for year 2005, 21 for year 2006 and 41 for year 2007) and found out that before 44 earthquakes the TEC anomalous variations were observed both near the epicenter and magnetically conjugated point. 29 revealed precursors showed positive effects in TEC, only 7 – negative effects. 8 maps with precursors demonstrated both negative and positive TEC disturbances near the epicenter and in the magnetically conjugated point. 20 events have precursors which last during day-time hours. For the most part of earthquakes the TEC precursors are revealed 1-4 days before events. The precursors of seismic events with the epicenter at middle and low latitudes are observed as disturbed TEC areas near the epicenter and magnetically conjugated point. The precursors of events with the epicenter at the equatorial zone (from -10° to $+10^\circ$ in geomagnetic latitude) can appear as only one disturbed area above the geomagnetic equator that can be explained by the equatorial ionosphere features.

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