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TEC ANOMALIES BEFORE THE GREAT SICHUAN EARTHQUAKE

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Abstract.

1 INTRODUCTION

Searches of the ionospheric seismo-precursors have been performed during last 2-3 decades basing on different ground-based and satellite observations, including special satellite missions of the natural hazards monitoring. Nowadays GNSS-based (Global Navigation Satellite Systems) techniques are widely used to investigate the ionosphere modifications and in particular the ionospheric effects associated with seismic events[1–3]. The dense network of GNSS and in particular GPS (Global Positioning System) receivers fulfills simultaneous coverage in global scale. GPS technique provides measurements of the group and phase delays of the signals L1=1575 MHz and L2=1228 MHz with the 30-sec interval. This ionospheric delay can be transformed into the electrons content along the signal path between the GPS satellite and receiver, and then recalculated into its vertical projection. The vertical total electron content (TEC) is very sensitive to changes of the maximal electron concentration (NmF2) in the F2 layer of the ionosphere. This work presents the case study of the strong anomalous TEC disturbances associated with the Great Sichuan Earthquake of May 12, 2008, M 7.9, D 19 km, (31.0N;103.4E) as seismo-precursors.

2 CASE STUDY OF THE GREAT SICHUAN EARTHQUAKE TEC SIGNATURES

2.1 Geomagnetic situation

The upper atmosphere is very sensitive to the influence of the solar activity and to the impact going from the space. Thus, changes of the geomagnetic activity can lead to the generation of different ionosphere disturbances that may mask pre-earthquake signatures manifestations triggered possibly by seismo-ionosphere coupling processes.

As one can see in Fig. 1 (top panel) the Kp index is mostly less than 3 reaching distinct maxima values less than 5 by magnitude during May 1-13 and does not exceed 2.5 from May 7, 2008 till the main shock event. The Ap index (Fig. 1, middle panel) is also less than 10 units during May 7-13, 2008 and in general less than 15 units from the 1^{st} of May till the earthquake moment. The Dst index variations (Fig. 1, bottom panel) do not also have any significant disturbances. All the mentioned above allow us to consider the geomagnetic situation as relatively quiet and to neglect its possible influence on the TEC anomalous deviations.

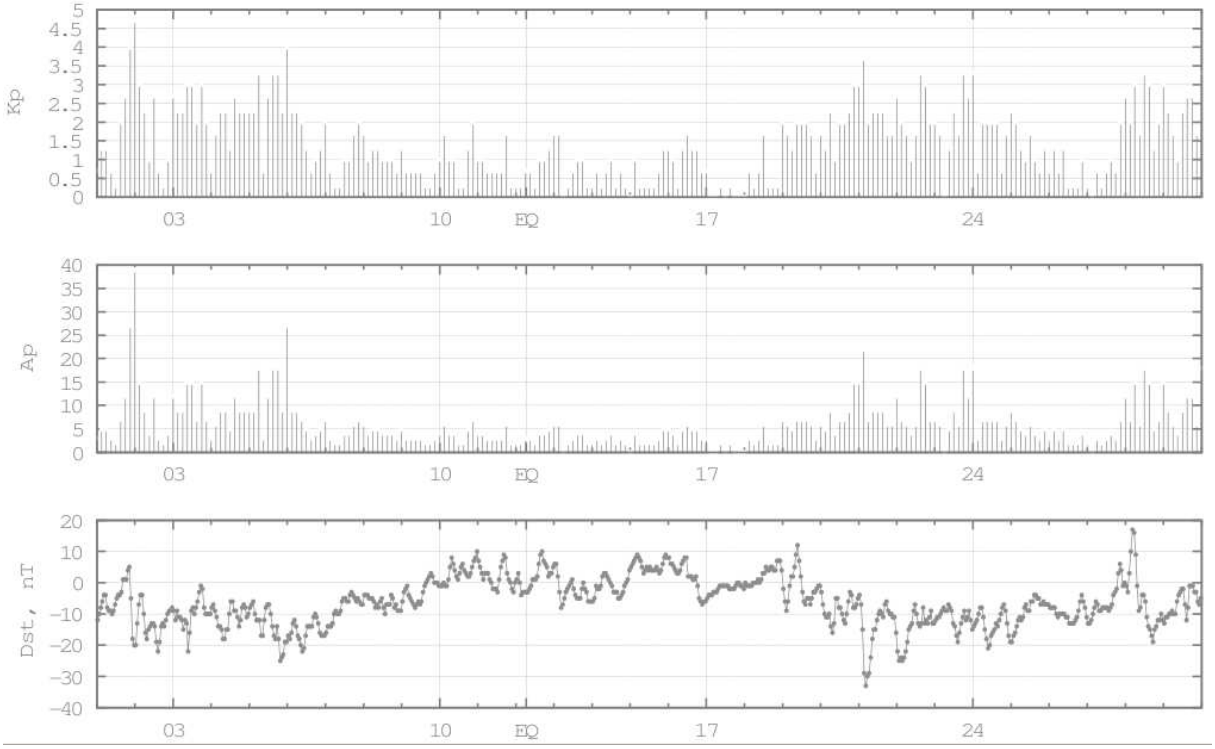

Figure 1: Kp (top panel), Ap (middle panel) and Dst (bottom panel) indexes for May 1-30, 2008. EQ the earthquake release time (May 12, 06:28UT).

2.2 Pre-earthquake TEC variations anomalies

We defined the TEC anomaly as strong local TEC deviations from the non-disturbed conditions linked to some geographical position near the vicinity of the forthcoming earthquake epicenter area and possibly with similar effects at the magnetically conjugated region. We calculated the quiet non-disturbed TEC level as running median for 3 days before and 7 days after the current calculation moment. We calculated and analyzed differential TEC (e.g. Fig. 2) maps for a few days before the Great Sichuan earthquake using provided by the NASA service Global Ionospheric TEC Maps in IONEX file format (ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/) as input for processing. As one

can see in Fig. 2 the observed anomalys area had linear dimensions of 10 deg. in latitude and 40 deg. in longitude. It took place as TEC increase relative to the non-disturbed level and existed from 06UT till 12UT May 9, 2008. Maximum of the deviations manifestation exceeded more than 60% in magnitude. Similar effects were also observed at the magnetically conjugated area. The situation was relatively quiet just before the moment of the earthquake (06:28UT) and no precursors were observed. We checked the question if the observed anomaly was due to the selected quiet conditions calculation method rather than due to physical processes manifestation. We recalculated differential TEC deviations maps using 7-days before to the calculation moment running average. The main TEC anomaly features remained unchanged that allowed us not to consider hem as the numerical noise or the calculation methods feature.

3 CONCLUSIONS

1. TEC variations anomalies were observed 2 days before the Great Sichuan Earthquake and looked like the strong TEC increase for more than 60magnitude. They occupied 10 deg. in latitude and 40 deg. in longitude at the near- epicenter region and existed from 06UT till 12UT May 9, 2008. Similar effects took place at the magnetically conjugated area too.

2. Those anomalies are not due to the solar or geomagnetic activity and can not be explained by digital noise or by calculation methods features.

3. Strong linkage of the anomalies to the near-epicenter area and its morphological features allow us to treat them as seismo-precursors.

4. Magnetic conjugation of the observed anomaly strongly evidences in favour of the hypothesis of the F2-region ionospheric plasma vertical drift under influence of the zonal electric field of seismic origin as the main cause of the phenomena[3].

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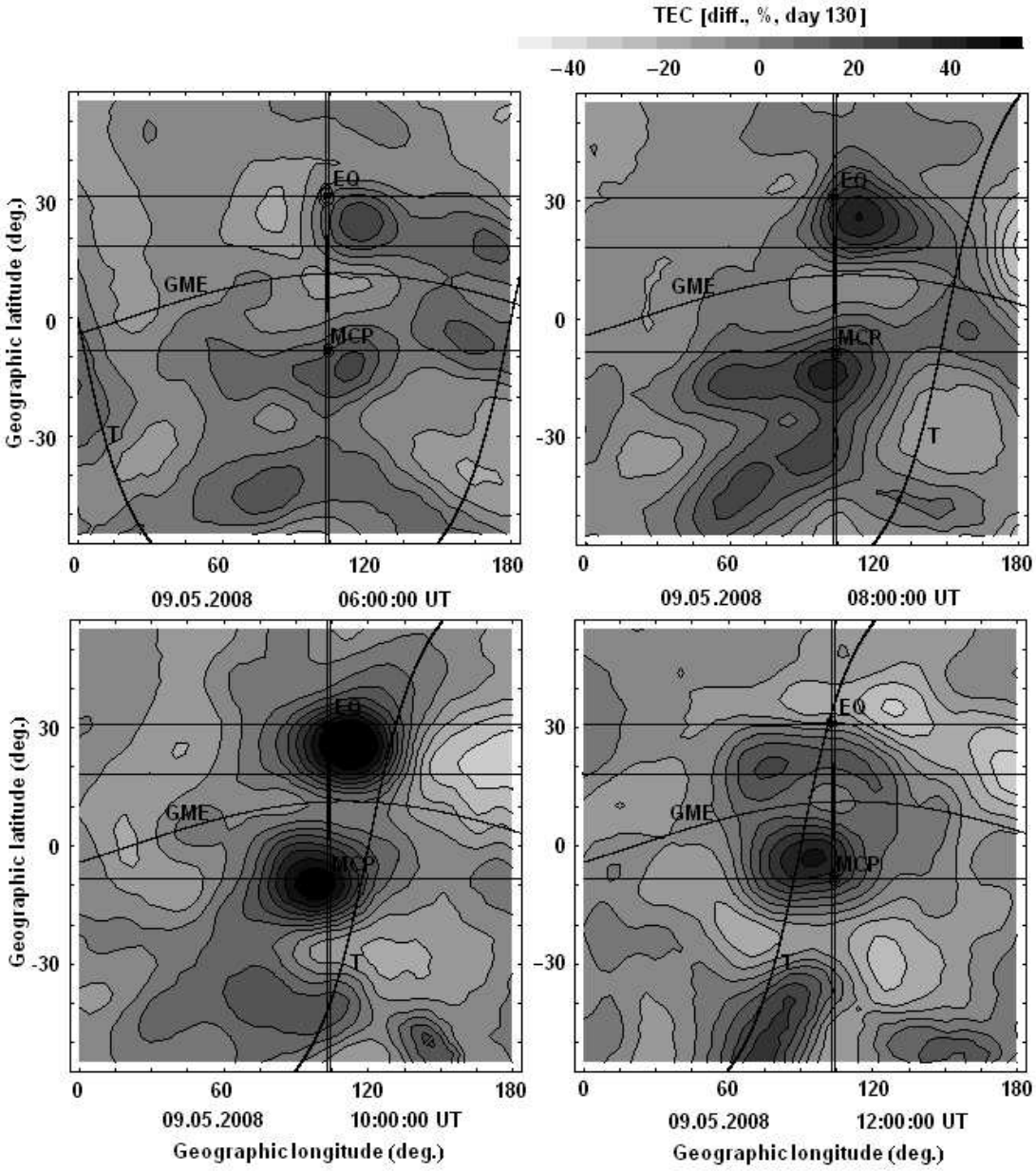

Figure 2: Maps of the TEC deviation from quiet background values for May 9, 2008, 06UT (top left), 08UT (top right), 10UT (bottom left) and 12UT (bottom right). EQ - the earthquake epicenter; MCP the magnetically conjugated point; GME geomagnetic equator; T terminator line.

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