SEISMO-ELECTROMAGNETIC TEC DISTURBANCES OBSERVED BEFORE GREAT TOHOKU MARCH 11, 2011 AND TURKEY VAN OCTOBER 23, 2011 EARTHQUAKES

O.V. Zolotov¹, A.A. Namgaladze¹, B.E. Prokhorov²,³

¹ Physics Department, Murmansk State Technical University, 183010 Murmansk, Russia, e-mail: ZolotovO@gmail.com; ² Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany; ³ University Potsdam, Applied Mathematics, Interdisciplinary Center for Dynamics of Complex Systems, Germany

Abstract. GPS-observed ionosphere Total Electron Content (TEC) disturbances happened before M 9.0 Great Tohoku (Japan, Sendai) March 11, 2011 and M 7.1 Turkey Van October 23, 2011 earthquakes are described and discussed. Both cases revealed the TEC relative (%) deviations from quiet (undisturbed) background TEC variations that we interpret as possible seismo-ionosphere precursors to the earthquakes considered. The results obtained were compared to and revealed agreement with our previous TEC variations’ investigations for several other earthquakes.

Introduction

A series of our previous publications were devoted to the investigation of ionosphere TEC (Total Electron Content) variations before a few earthquakes including M 7.1 New Zealand Nov. 22, 2004, M 7.5 Peru Sep. 25, 2005, M 5.5 Kythera (Southern Greece) Jan. 8, 2006, and M 7.9 Wenchuan (China) May 12, 2008 earthquake [Namgaladze et al., 2008; Zolotov et al., 2011, 2012a, 2012b]. It was found that TEC disturbances (happened a few days before each one of these seismic events) revealed for each case are in general agreement with the main pre-earthquakes’ TEC variations’ features previously reported by many authors (see, e.g., [Pulinets and Boyarchuk, 2004] and references therein).

Haiti Jan. 12, 2010 earthquake was the first one for which we systematically checked not only stable repeatable day-to-day TEC disturbances at the given UT-moment, but also investigated time-evolution of the TEC disturbances during the whole 24 h, i.e. TEC disturbances behavior in dependence on local time, i.e. the sunset (and sunrise) terminator and subsolar-point positions. That allowed us to report new pre-earthquake TEC features [Zolotov et al., 2011, 2012a] related to solar illuminance and not presented in other authors’ publications: “ban-time” effect, i.e. (1) reduction of the relative (%) TEC deviations over background variation with sunrise terminator and subsolar point coming; (2) TEC disturbances renewal (often) after sunset terminator leaving. For the case of Haiti Jan. 12 earthquake we also proposed the physical mechanism of seismo-electromagnetic TEC disturbances generation (basing on the papers [Namgaladze et al., 2009a, 2009b]; see as well this issue [Namgaladze and Zolotov, 2012]).

This paper is aimed at 1) investigation of the TEC variations prior to the Great Tohoku (near the East Coast of Honshu), Japan, M 9.0, March 11, 2011 05:46 UT / 14:46 LT, (38.297°N, 142.372°E), D 30 km and Turkey Van, M 7.1, October 23, 2011 10:41 UT / 13:41 LT, (38.691°N, 43.497°E), D 16 km earthquakes; 2) intercomparison of the TEC features revealed with previously investigated cases of Haiti and other earthquakes.

To estimate pre-earthquake TEC variations we have built differential TEC maps relative to the quiet background (undisturbed) conditions. We used global ionospheric maps (GIM) of the TEC provided by the NASA in IONEX file format (ftp://cddis.gsfc.nasa.gov/pub/gps/products/ionex/) as the initial data for processing. The background TEC values (i.e. undisturbed conditions) were calculated as 7-days UT-grouped backward-running observations’ medians.

Main phenomenological features of the TEC disturbances before M 9.0 Great Tohoku March 11, 2011 earthquake

To reveal main features of the TEC relative disturbances before the M 9.0 Great Tohoku March 11 earthquake we analyzed the TEC relative disturbances (%) maps for March 08-11, 2011 (see Fig. 1). This event was complicated by two factors: 1) geomagnetic disturbances happened during considered time-
interval that generated TEC disturbances that are able to mask pre-EQs’ TEC manifestations. 2) A set of earthquakes (marked as small stars on Fig. 1) happened within the time interval and spatial area (centered relative to the M 9.0 EQ epicenter) of the size that is believed to be the typical for the pre-EQs’ TEC signatures.

As it follows from the Fig. 1, the most pronounced anomalies happened on March 8, 2011 during 04 UT - 20 UT in form of TEC increases. In spite of the “noise” in the TEC data due to the geomagnetic activity disturbances and other neighboring earthquakes’ impacts, the TEC anomalies kept the following features: 1) local long-living TEC increases near the earthquake near-epicenter and magnetically conjugated areas. These anomalies do not propagate along the meridians’ direction. The amplitude of plasma modification reaches the values of >40-60%. 2) The vertical projection of the epicenter position does not coincide with the maximum phenomenon’s manifestation location. The structure and spatial sizes of the disturbed areas are kept rather stable. 3) There are strong subsolar point and terminator-related effects.

![Figure 1. TEC relative deviations (%) from background undisturbed conditions for 02UT/11LT-24UT/09LT (from left to right) March 8-11 (from top to bottom), 2011. Big star denotes the earthquake epicenter position. Other stars – other earthquakes’ epicenters. Black curve – terminator. Orange circle – the subsolar point position. According to [Zototov et al., 2012b].](image)

**Main phenomenological features of the TEC disturbances before M 7.1 Turkey Van Oct. 23, 2011 EQ**

In case of Turkey Van M7.1 EQ geomagnetic activity in contrast to the previous EQ was rather quite, TEC enhancements (see [http://goo.gl/zRW9H](http://goo.gl/zRW9H)) of about ~40% by magnitude were observed during Oct. 20-23, 2011 both near the epicenter and magnetically conjugated areas and reached maximum on Oct. 21 (see Fig. 2). They existed from 14 UT to 20 UT and occupied ~10-15° × ~25-35° size areas. The terminator approaching triggered consequent anomaly reduction during 22-24 UT.
Discussion and Conclusions

Here we reported the TEC relative disturbances over quiet undisturbed variation that we treated as possible seismo-ionosphere precursors. In both cases major TEC features persisted: (1) local long-living TEC increases situated near the earthquake near-epicenter and magnetically conjugated areas. These anomalies do not propagate along the meridians’ direction. The amplitude of plasma modification reaches the values of >40%. (2) The vertical projection of the epicenter position does not coincide with the maximum phenomenon's manifestation location. The shapes and dimensions of the disturbed areas are kept rather stable. (3) There are effects related to the modification of the ionospheric F2-region equatorial anomaly. (4) There are strong subsolar point and terminator-related effects.

Revealed for both cases pre-EQ relative TEC disturbances fit the criteria often called as TEC precursors to earthquakes (see, e.g., [Pulinets and Boyarchuk, 2004] and many others). They also agree with “additional” pre-EQ TEC features (“ban-time”, terminator and subsolar point effects) firstly reported [Zolotov et al., 2011] for the case of Haiti Jan. 12, 2010 EQ and later checked on a wider set of EQs by Romanovskaya et al. [2012].

As for the physical mechanism of the observed pre-EQs’ TEC disturbances generation, this topic may be found in the papers of issue [Namgaladze and Zolotov, 2012; Karpov et al., 2012] devoted to this problem.

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References


