COMPARATIVE ANALYSIS OF IONOSPHERIC VARIATIONS BEFORE STRONG EARTHQUAKES

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Abstract. At two ionospheric stations Petropavlovsk and Magadan the series of deviations of critical frequencies foF2 from their moving average values are considered before strong earthquakes. The irregular variations at both stations are compared to exclude the identical changes connected with geomagnetic disturbances and to reveal seismo-ionospheric effects. It has been found that positive deviations are predominated in the time of preparation of strong earthquakes. They become more intense with increase of magnitude of earthquakes.

Introduction

Anomalies of electronic concentration of the ionosphere at middle latitudes, which are connected with seismic activity, are usually less than ionospheric disturbances observed during global geomagnetic storms, therefore the seismic effects are quite often difficult to identify. The earthquakes occur both in geomagnetic quiet and disturbed periods. It is a note in this connection that geomagnetic storms are global phenomena, whereas premonitory ionospheric effects of earthquakes are essentially local.

In general, characteristics of F2-layer are qualitatively identical at stations if they are located from each other on distances no more than 500-700 km. However at such distances one of the stations can be in a zone of seismic activity, and another - outside of it, so that seismo-ionospheric disturbances should be marked at the first station and to be absent or be less intense at other. In order to reveal seismo-ionospheric disturbances, the comparative analysis of data at two stations of radiosounding Petropavlovsk and Magadan has been made.

Earlier, data at two stations are compared with each other, and daily correlation coefficients of ionospheric parameters are calculated. It is received that before strong earthquakes the correlations are quite often broken (Gaivoronskaya et al., 2002; Gaivoronskaya, 2005). Now hourly variations of critical frequencies foF2 are examined in more detail.

Methods

There have been considered ten strong earthquakes in 1992-1994 with magnitudes from M=5.4 up to M=7.5 at seismic region - Kamchatka. Zone of active preparation of earthquakes usually covers the area in radius of 200-300 km (Bowman et al., 1998; Dobrovolsky et al., 1979), thus the earthquakes with epicenter on distances not farther than 250 km from Petropavlovsk-na-Kamchatke have been chosen.

The ionospheric F2-layer is the most variable of regular layers, and its critical frequency foF2 is one of the most accurately measured parameters of ionosphere, therefore that frequency has been taken for analysis of data series obtained at stations located near earthquake areas. We have examined the series of ΔfoF2 deviations of critical frequencies of F2-layer from their moving average values at two ionospheric stations Petropavlovsk and Magadan. Usually the average values are calculated for a month, they are derived from the data for the previous and following 15 days. In case of forecasting of seismic events it is necessary to calculate average values only for previous period of 15 days when results of radiosounding are known. The hourly irregular variations received at two stations Petropavlovsk and Magadan are compared with each other:
\[ \Delta f_{\text{o}}F_2 (P-M) = \Delta f_{\text{o}}F_2 (P) - \Delta f_{\text{o}}F_2 (M) = [f_{\text{o}}F_2 (P) - f_{\text{o}}F_2 (M)] - [C (P) - C (M)], \]

C is the moving average value of frequencies on previous 15 days. Thus it is possible to exclude the significant ionospheric variations connected with geomagnetic storms, and also some distinctions between average values \( f_{\text{o}}F_2 \) at two stations.

Fig. 1 illustrates results of calculations of variations \( \Delta f_{\text{o}}F_2 \) (P) at station Petropavlovsk (above) and relative variations \( \Delta f_{\text{o}}F_2 \) (P-M) by comparison of data of stations Petropavlovsk and Magadan (below). On horizontal axis the hours of local time of Petropavlovsk are marked. Irregular variations are calculated within 12 days, from 23 February till 5 March 1992, when there are a series of earthquakes, the greatest of which with magnitude \( M = 6.8 \) was registered on 2 March 1992. A few days before the geomagnetic storm take place. In the top figure the significant negative irregular variations connected with geomagnetic storm are visible, while at the bottom figure the negative disturbance practically is absent. However at bottom figure the positive disturbance 7 day prior to the main seismic shock is noticed.

Fig. 2 shows another example of relative variations \( \Delta f_{\text{o}}F_2 \) (P-M) before an earthquake on 8 June 1993. In that case there is a catastrophic earthquake with magnitude \( M=7.5 \) and a series of aftershocks. Considerable positive deviations are observed before the main shock and one of the aftershocks.
Results

So only a small part of energy of earthquakes penetrates into ionospheric altitudes, the disturbances of critical frequencies foF2 caused by seismic activity are difficult to reveal on the background of daily irregular variations, particularly on the background of ionospheric storms. Comparative analysis of data of radiosounding at two stations Petropavlovsk and Magadan allows us to exclude the disturbances connected with geomagnetic storms and to select seismo-ionospheric effects.

It is received that 10-12 days before strong earthquakes in 1992-1994 the irregular positive variations are predominated at station Petropavlovsk as compared with station Magadan. Calculations show that positive deviations become visible in the period preceding strong earthquakes with magnitude M=5.8 and more. Positive variations are more expressed with larger magnitude of earthquake. It confirms that the effect is just connected with seismic activity.

References

Gaivoronskaya, T.V. (2005), Ionospheric variations in seismically active regions, Izvestia, Physics of the Solid Earth, 41, N3, 56-60.