



## Midnight variations of Es-spread in the ionosphere before earthquakes

Elena V. Liperovskaya (1), Alexandra S. Silina (1), Victor A. Liperovsky (1), and Claudia-Veronika Meister (2)

(1) Institute of Physics of the Earth of the Russian Academy of Sciences, Bolshaya Gruzinskaya 10, 123995 Moscow, Russia,

(2) Institut für Kernphysik, Technische Universität Darmstadt, Schlossgartenstraße 9, 64289 - Darmstadt, Germany

(c.v.meister@skmail.ikp.physik.tu-darmstadt.de)

In the present work ionospheric effects before earthquakes with magnitudes  $M > 4.0$  are studied.  $E_s$ -spread data are analysed, which are observed every 15 minutes by the vertical ionospheric radar stations in Petropavlovsk-Kamchatsky and Middle Asia. Considered is the mean probability of  $E_s$ -spread observation at different  $f_oE_s$  frequencies. The  $E_s$ -spread dependence on the season and the year of the 11-years solar activity cycle are studied. Investigating the seismo-ionospheric effects, days with increased solar and geomagnetic disturbances are neglected.

The analysis shows that about 1-3 days before earthquakes with depths  $H < 80$  km appearing at midnight, the frequency of occurrence of  $E_s$ -spread increases, which indicates a strengthening of the E-layer turbulization.  $E_s$ -spread is most often observed when the distance  $R$  between epicenter and radar station is not larger than the sum of 150 km and dimension  $R_o$  of seismic earthquake preparation region described by the Dobrovolskyi formula,  $R_o = \exp(M)$  km,  $R \leq R_o + 150$  km. For earthquakes with epicentres at larger distances and seismic shocks with deeper epicentres no midnight effect is observed. The authors suggest that the  $E_s$ -spread may be caused in the sporadic layers by acoustic waves with periods between 20 s and 5 min, and maximum acoustic disturbances caused by phenomena at the earth's surface should occur at an almost vertical wave propagation. It is mentioned that the turbulization of the E- and F-layers before earthquakes do not occur at the same time.