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BROADBAND ULF PERTURBATIONS OF THE ELECTRIC FIELD IN COASTAL ZONE OF THE OKHOTSK SEA

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Abstract. In September 2017 SPbF IZMIRAN conducted an experiment on the study of ULF electromagnetic disturbances on the coast of the Sea of Okhotsk (Sakhalin Island). Data logging was performed by two geophysical stations GI-MTS-1 located on the coast near the water's edge and at a point remote at 160 m from the coast. It is found that the intensity of broadband (F = 0.001-0.1 Hz) ULF disturbances of the electric field in the coastal zone increases with increasing of the wind speed. This effect was reduced by 3-5 times at the remoted station. Above the Earth's surface, there is ~ 20% excess of positive charges over negative ones in aerosols since the Earth has a negative electrical charge. Probably, the observed ULF disturbances are caused by the displacement of the inhomogeneities of electric charges in aerosols above the electrodes of telluric lines. Concentration of the marine aerosol near the shoreline and, consequently, the concentration of positive charges increases with increasing wind speed and the intensity of ULF disturbances increase too. It was also detected an increasing in the intensity of broadband ULF perturbations of the electric field during tidal periods. The density of the marine aerosol appears to fall strongly when removed from the water's edge. During the seawater tide approaches to the telluric line electrodes installed on the shore and the density of aerosols and charges above the electrodes increases and broadband ULF disturbances are also amplified. At a station remote from the coast, the concentration of aerosols is small and the effect of the influence of the water tides is not observed. The correlation of variations with tides and wind speed is not recorded in a magnetic field at both stations probably due to the insufficient sensitivity of magnetic sensors.

Introduction

In September 2017 SPbF IZMIRAN conducted experiment on the coast of the Okhotsk sea (Sakhalin Island). Data logging was performed by two geophysical stations GI-MTS-1 located exactly on the coast and at a point remote at ~160 m from the coast. Each station consisted of three-component magnetic sensors (Bx, By, Bz) of the torsion type and two horizontal telluric lines with length of ~ 50 m (Ex, Ey). The Ex component was oriented orthogonally to the coast, Ey component - along the coast. The digital data were recorded on a flash card with 50 Hz sampling. The RMS sensitivity of the magnetic sensors was 2 pT at 1 Hz frequency, the sensitivity of the electrical sensors was 0.1 μV/m.

Various meteorological conditions were observed during the experiment. On September 18-19, the typhoon center passed over the location of the geophysical stations and the wind speed reached a hurricane force and exceeded 30 m/s. The storm at sea reached force of ~8. On the other days during the experiment, the wind did not exceed 5 m/s.

Results

Fig. 1 presents dynamic power spectra density of the horizontal components of the electric and magnetic field variations at the base point located 160 m from the coast for six days time interval in the frequency range F = 0.001 - 0.1 Hz. Dynamic power spectra of the electric components (Ex, Ey) are shown in the two upper panels. Magnetic components (H, D and Z) are presented at the three lower panels.

Diurnal power spectral density enhancements are clearly visible in the low-frequency part of the spectrum in both magnetic and electrical components. During the typhoon on September 18-19, there is an increase in the spectral power in the completely investigated frequency range. The same spectra for the maritime station located near the water edge are presented in Fig. 2.

Comparative analysis shows that broadband ULF perturbations associated with the sea tides are observed in the entire investigated frequency range in the horizontal components of the electric field only for the maritime station in contrast to the diurnal amplifications of the power spectral density. The maxima of these perturbations coincide with the maxima of the tides.

Fig. 3 shows the narrow spectral band at a frequency of 0.05 Hz that was allocated from the Figs. 1 and 2. The variation of H of the magnetic field component and the variation Ey of the electric field component at a point 160 m distant from the shore are shown on the two upper panels. The variation of the Ey component of the electric field at the maritime station located on the shore is presented in the lower panel. As can be seen from Fig. 3 during the typhoon the maximum value of the spectral power is observed in the electric field on September 18, 2017 both at the remote station and on the shore, and this maximum is an order of magnitude higher on the coast station. In a magnetic field, the increase in the intensity of the variations is much weaker.

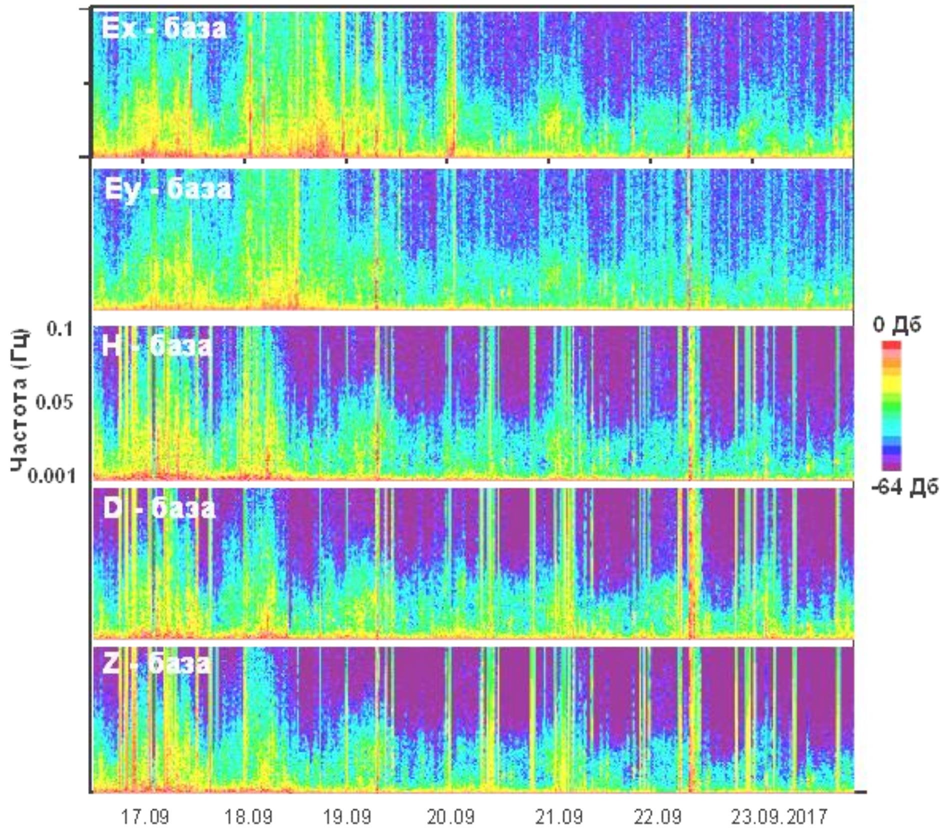

Figure 1. Dynamic spectra (F = 0.001 - 0.1 Hz) of the horizontal components of the electric field variations (Ex, Ey - *two upper panels*) and three orthogonal components of the magnetic field variations (H, D, Z - *three lower panels*) at base point located 160 m from the coast 17- 23.09.2017.

The likely cause of the observed coastal effects is the movement the inhomogeneities of the sea aerosol over the electrodes of telluric lines under the influence of the wind. The concentration of aerosol particles can reach 10^{11} particles per 1 m^3 with a strong storm, but usually 1 to 2 orders of magnitude less. The marine aerosol consists mainly of particles of NaCl (73%) and $MgCl_2$ (11%) [1,2].

Part of these particles acquire an electric charge under the influence of natural radioactivity, ultraviolet radiation of the sun, collisions, evaporation and other causes. The Earth's sphere is charged negatively ($\sim 7.4 \cdot 10^5$ Cl) and near the Earth's surface there is a downward electric field of ~ 130 V/m, so near the Earth's surface there is a ~ 20% excess of positively charged particles over negative ones.

The distribution of the aerosol density, as well as of the excess charges in it, is not uniform, especially on the shore where small-scale wind turbulence associated with the terrain is strong. Wind-induced heterogeneities of the positive charge above the telluric line electrode cause changes in the potential of the electric field recorded by the instrument. The density of the sea aerosol and the rate of transport of the charge inhomogeneities increase with increasing wind, so the intensification of the variations in the electric field in the coastal zone intensifies. The density of the marine aerosol drops strongly when moving away from the water's edge, therefore the density of aerosol charges above the electrode increases during tides and we observe the appearance of broadband ULF perturbations of the electric field. At a station remote from the coast, the concentration of aerosols is small and such a coastal effect is not visible. In the magnetic field, the coupling of variations with tides is not observed due to the insufficient sensitivity of magnetic sensors.

Conclusion

A new phenomenon is discovered - the generation of broadband ULF perturbations of the electric field in a narrow coastal zone of the sea. These perturbations are not associated with ionospheric sources and are probable caused by the displacement of the inhomogeneities of the electric charge under the action of the wind in the marine aerosol over the electrodes of telluric lines.

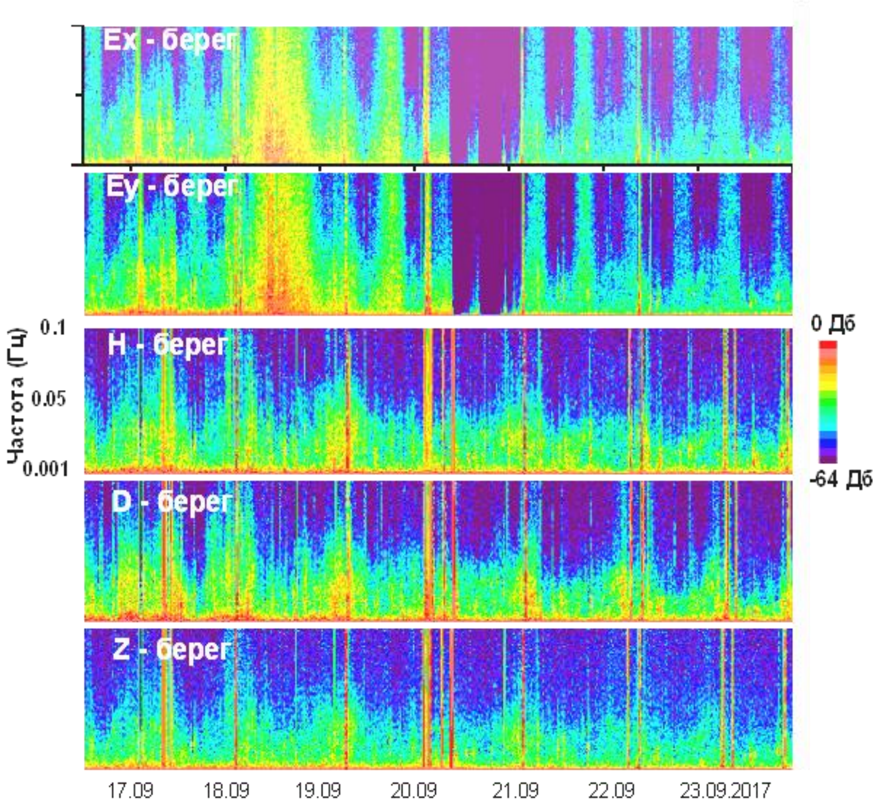

Figure 2. Dynamic spectra (F = 0.001 - 0.1 Hz) of the horizontal components of the variations of the electric field (Ex, Ey - *two upper panels*) and three orthogonal components of the variations of the magnetic field (H, D, Z - *three lower panels*) at the marine station point located on the shore 17 - 23.09.2017.

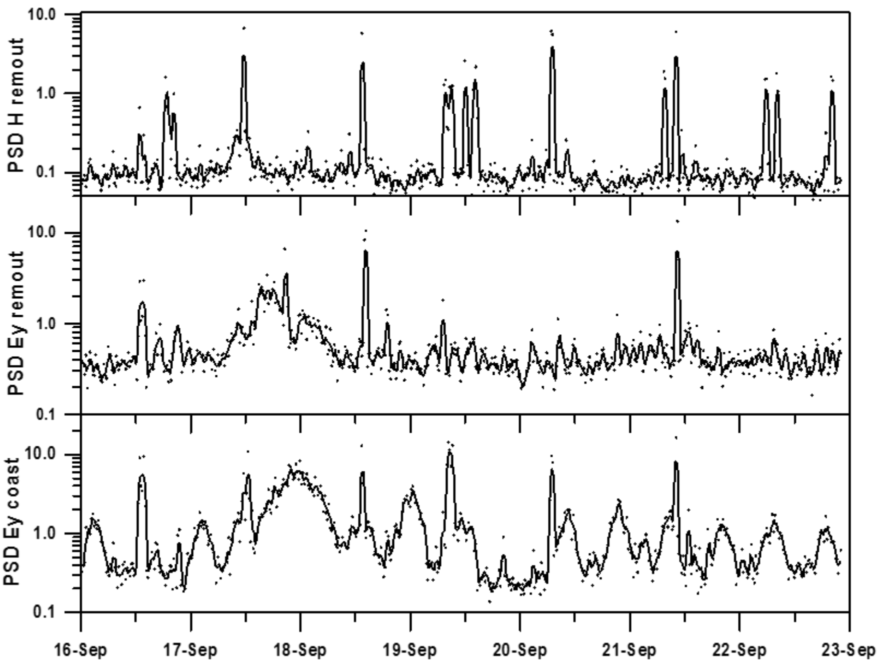

Figure 3. Spectral power density of variations of the electric field at a frequency of 0.02 Hz. *The upper panel* are the variations H of the magnetic field component, *the middle panel* are the variations Ey of the electric field component at a point 160 m distant from the shore, *the lower panel* are the variations Ey of the electric field component at the marine station point located on the shore.

References

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