



## Response of the D-region ionosphere associated with large scale tropical Cyclones as observed from VLF radio signals

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It is now known that tropical cyclones can modify and modulate the ionosphere via a wide spectrum of upward propagating atmospheric waves originating in the troposphere from the strong convective cells of a cyclone. There are many reports of ionospheric disturbances due to cyclones using ionosonde or total electron content method. Few papers studied D-region disturbances due to cyclones based on Very Low Frequency (VLF) radio remote sensing method (Rozhnoi et al. 2014; Kumar et al. 2017; Nina et al. 2017). In this paper, we report D-region ionospheric disturbances corresponding to several large scale tropical Cyclones/Hurricanes in the North Atlantic zone by analyzing the amplitudes of VLF radio signals from transmitters like NML (25.2 kHz), NLK (24.8 kHz), NAA (24.0 kHz) received at several places in US and Europe. VLF data are taken from the Stanford University SUPERSID VLF network. Significant effects in the nighttime VLF signals and the modal amplitude minima around sunrise/sunset times of the receivers have been found for the radio propagation paths close to the cyclone tracks. FFT and wavelet analysis of the amplitude data confirm the presence of gravity waves and amplification of 2-5 days planetary waves during the cyclone period. We are also analyzing the cyclone effects on the mesospheric temperature over the radio paths/cyclone tracks.

A. Rozhnoi, M. Solovieva, B. Levin, M. Hayakawa, V. Fedun, “Meteorological effects in the lower ionosphere as based on VLF/LF signal observations”, *Nat. Hazards Earth Syst. Sci. Discuss.* 2, 2789–2812, 2014.

S. Kumar, S. N. Amor, O. Chanrion, and T. Neubert, “Perturbations to the Lower Ionosphere by Tropical Cyclone Evan in the South Pacific Region”, *J. Geophys. Res. Space Phys.* 122(8), 2017. <http://dx.doi.org/10.1002/2017JA024023>.

A. Nina, M. Radovanović, B. Milovanović, A. Kovačević, J. Bajčetić, and L. Č. Popović, “Low ionospheric reactions on tropical depressions prior hurricanes”, *Advances in Space Research*, 60, 8, 2017.