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Investigation of nonlinear interaction in extremely low frequency /very low frequency radio signals in the course of the two mid latitude earthquakes

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This paper investigates the ionospheric turbulences generated in the Extremely Low Frequency (ELF)/Very Low Frequency (VLF) signals by wavelet bispectrum analysis and statistical methods. As in the turbulence the manifestation of nonlinearities and coherent structure indicates the frequencies coupling and phase coupling. Ionospheric plasma is very unstable and it can be easily disturbed. Development of turbulence in the ionospheric plasma is generated when instability is reached at the nonlinear stage. If turbulence is developed in geomagnetic quiet conditions then there is a high probability that the perturbations are produced by some aspects having their source at the epicenter of the earthquakes[1]. In this work we are analysing the ELF/VLF signals registered by the DEMETER over seismic region when geomagnetic condition are very quiet (Kp<3) and thus diagnosing the disturbed ionospheric plasma response which may be derived by the earth surface. Studies show that, these disturbances are generated by growth of Atmospheric Gravity Waves (AGWs) amplitude [2, 3, 4, 5] during the earthquake preparation stage. This instability is transformed by the electric field and form horizontal irregularities [6] which affect the VLF electromagnetic waves. These commence in the area of the epicenter and then developed ionospheric plasma turbulence [7].

Hence turbulence in the ionosphere studies before two earthquakes with magnitude M6-M8.2 that occurred during 2007 and 2009 in North- East of the map at mid latitude. The data retrieved from the satellite DEMETER, with full registration of the waveform of the electric field fluctuations in the ELF/VLF ranges. The observations were taken 11 days before the shock, under quite geomagnetic condition where K_p index≤ 3. These observations were calculated when DEMETER was lying in the radius of the earthquake preparation zone, which is calculated by the means of the Dobrovolsky formula: $R = 10^{0.43M}$[8]in which R denotes the radius of the earthquake preparation area in km and M is the earthquake magnitude on the Richter scale.

The wavelet bispectral analysis of the Instrument Champ Electrique (ICE) obtained signals of ELF frequency range shows nonlinear effects in this frequency range in the ionosphere 1 to 10 days before each earthquake. Small-scale plasma density irregularities during the ELF turbulence in the ionosphere over the seismic zone were diagnosed. ELF turbulence effects are causing the characteristics property change of the VLF transmitter signals propagated during these perturbations and then recorded onboard a satellite. The main effect consists in observable spectral broadening of VLF signals. Night time plasma bubbles within the affected region might be used as source of ELF turbulence for earthquake prediction.

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