Geophysical Research Abstracts
Vol. 16, EGU2014-5588, 2014
EGU General Assembly 2014

Dynamics of the charged and neutral components of the upper atmosphere during earthquake preparation

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Electric fields with the intensity of several mV/m and typical horizontal scale of several hundreds of kilometers have been reported after from the measurements by Intercosmos-Bulgaria-1300 and DEMETER satellites over seismic active regions. Formation of seismogenic electric fields is often explained by the external electric current flowing between the ionosphere and earthquake epicenter. It is generated as a result of air ionization and convectional transport and gravitational sedimentation of the charged aerosols over tectonic faults. Charge separation occurs in consequence of that light positive charged aerosols move upwards while heavy negative charged aerosols move downward. Our recent numerical calculations using the Upper Atmosphere Model (UAM) showed that electric current with the density of about 10^{-8} A/m^2 acting over the area of 200 by 4000 km is required to produce such electric field at the ionosphere height, which generate typical pre-earthquake total electron content (TEC) disturbances through the vertical plasma transport by electromagnetic $[\boldsymbol{E} \times \boldsymbol{B}]$ drift. In the present study we investigated temporal variations of the three-dimensional structure of the upper atmosphere under the action of the seismogenic electric fields using the UAM. The external electric current was used as a model input in the UAM electric potential equation, which was coupled with the continuity, momentum and heat balance equations for the charged and neutral components. Simulation results showed complicated structure of the electron density in the form of the plasma bubbles. The external electric current also produced weak disturbances of the neutral temperature, density as well as wind velocity as a result of the neutral and charged particles collisions. The calculated neutral gas disturbances propagated poleward and upward from the epicenter with the speed of 300-500 m/s, i.e. weak internal gravity waves (IGW) were generated. Similar but weaker effects were obtained in the magnetically conjugated point. By comparing calculation results with those obtained using NRLMSISE-00 empirical model of the neutral atmosphere, we conclude that the action of generated IGWs on the TEC variations is insignificant in comparison with the direct action of seismogenic electric field via electromagnetic plasma drift.