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Perturbation of the atmosphere – ionosphere electric current and the formation of accompanying earthquake precursors

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Numerous phenomena related to earthquakes and volcano activities can be registered by modern geophysical instruments in the Earth's atmosphere and ionosphere. Many of these phenomena are observed during the earthquake preparation period - weeks, days and hours before the seismic event. These phenomena can be caused by the growth of seismic related DC electric field in the ionosphere. Analysis of the observational data shows following characteristics of such fields:

- Enhancement of seismic activity and typhoons produces DC electric field disturbances in the ionosphere with magnitudes up to 10 mV/m.
- These disturbances occupy an area of the order of several hundred km in diameter above the earthquake region
- DC electric field enhancements arise in the ionosphere up to 10 days before earthquakes.
- Quasi-stationary electric field on the Earth surface in the earthquake epicenter area does not exceed the background value.
- Seismic related TEC disturbances are generated by the enhancement of DC electric field in the ionosphere up to 10 mV/m.
- Seismic related DC electric fields can reach the breakdown value and stimulate the electric discharges at tropospheric heights.
- Our critical analysis of the published models in which there are made attempts to explain above mentioned characteristics of DC electric field shows that one speculation can be only the base of the model.

The following data were taken into account in the formulation of the model. Concentration of charged soil aerosols in the atmosphere in seismic region increases by one to two orders of magnitude days to weeks before earthquakes. Similar effect was observed in the intense radon and other radioactive

substances outbursts on the eve of large earthquakes. The key role in seismo-ionospheric coupling belongs to the electromotive force (EMF) which is included in the global atmosphere – ionosphere closed electric circuit. The EMF is located in the lower atmosphere including the surface of lithosphere. The external EMF is excited in a process of vertical atmospheric convection and gravitational sedimentation of charged aerosols and radioactive elements in the near – ground level of the atmosphere. Aerosols are injected into the atmosphere due to intensified soil gas elevation in the lithosphere during the enhancement of seismic activity.

In the frame of the model we performed the theoretical investigations. Equilibrium values of ion number densities are determined by the atmosphere ionization, the recombination process and the adhesion to aerosols in the atmosphere. The source of ionization is gamma radiation and alpha particles of nuclear decay. The light single-charged ions and the heavy ions are produced as a result of light ions adhesion to aerosols in the atmosphere near the Earth's surface. The spatial distribution of EMF external current, atmospheric conductivity, number density of aerosols and DC electric field in the convective atmosphere is described by the self-consistent set of nonlinear equations. The feedback between EMF and generated electric field had been determined. The cause of this phenomena is the potential barrier to charged particles when its traverse Earth`s surface. As a result the value of EMF external current is defined on the vertical component of electric field on the surface. A mechanism of feedback leads to the limitation of electric field on the Earth`s surface. The calculation method for spatial distribution of DC electric field associated with electric current disturbances in the atmosphere – ionosphere circuit has been developed. Input parameters of model are the atmosphere turbulence and convection, atmosphere radioactivity and aerosols density near the ground.

Calculation results are as follows. Disturbance of the electric current flowing in the circuit leads to the DC electric field growth in the ionosphere up to 10 mV/m. Under particular conditions the seismic related DC electric field can reach the breakdown value in part of the lower atmosphere. The amplitude of DC electric field on the surface does not exceed a limit value of about 100 V/m by the feedback mechanism. Theoretical results are confirmed by observational data of seismic related DC electric field.

The application of above mentioned theory to interpret pre-seismic phenomena leads to following results. The formation of large enough DC electric field in the ionosphere exceeding a definite threshold value leads to an instability of acoustic-gravity waves and generation of periodic or localized ionospheric structures in a form of solitary dipole vortices or vortex chains and associated plasma density and electric conductivity disturbances in the ionosphere. The excitation of horizontal spatial structure of conductivity in the lower ionosphere results in the formation of magnetic field- aligned currents and plasma layers stretched along the geomagnetic field. Excitation of horizontal small-scale irregularities of electric

conductivity in the lower ionosphere is a key factor for the generation mechanism of ULF magnetic field oscillations, electron number density fluctuations and ELF electromagnetic emissions observed on satellites and Schumann-resonance-like anomalous line emissions observed on the Earth surface before earthquakes. Small-scale (4-10 km) irregularities of plasma density with relative amplitudes of up to 10 - 30 % and correlated electromagnetic ELF emissions with amplitudes 3-10 pT at frequencies ~450 and ~140 Hz respectively are excited within geomagnetic field tubes (3-4 deg. in latitudes) connected to the epicenter region several days prior to an earthquake. The magnitude of ULF geomagnetic field oscillations detected in the seismically disturbed ionosphere prior to earthquakes lie in a range from 0.2 to 3 nT. Seismic related disturbances of the lower ionosphere produce an anomalous effect in Schumann resonance phenomena including unusual enhancement of the fourth harmonic and shift in frequency ~ 1Hz from conventional value at this harmonic.

The electric current flowing into the ionosphere from the atmosphere results in electron number density distribution in the F, E layer of ionosphere including the anomalous sporadic E layers. Electric current in the D layer of the ionosphere leads to formation of the electron density disturbances by changing the charge carrier from electrons to negative ions and by the electrons heating.

Existence of seismic related electrical discharges has been confirmed by over the horizon observation of VHF electromagnetic signals. Pre-earthquake VHF electromagnetic radiations are generated in the atmosphere at altitudes 1 to 10 km over the quake zone. Seismic related disturbances in the troposphere create the conditions for over-horizon propagation of signals from ground-based VHF transmitters on the routes passing through the earthquake area. Pre-earthquake DC electric field reaching the breakdown level initiates the following phenomena in the lower atmosphere:

- Chaotic electric discharges.
- Heating of the atmosphere in the discharge region and the generation of outgoing radiation.
- Broadband electromagnetic VHF emission.
- Airglow in visible range of wavelengths.

Refraction and scattering of VHF radio waves in the troposphere providing the over the horizon reception of ground-based VHF transmitter signal