Atmosphere-Ionosphere Coupling: The role of boundary layer in generation of ionospheric precursors of earthquakes

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ABSTRACT

The physical mechanism proposed for the local time dependence of the ionospheric precursors of earthquakes connected with the different mixing height of the boundary layer of atmosphere during night-time and day-time. Night-time temperature inversion keeps trapped the radon and ion clusters within the thin layer less than 100 m depth near the ground surface, what permits accumulate large amount of radon and cluster ions and generate the large negative spatial charge at the top of the layer. This will increase the value of atmospheric electric field from 100 V/m up to near 1 kV/m or more. According the existing models this field can create the positive anomaly within the ionosphere. The experimental results ща GPS TEC monitoring demonstrate the night-time positive anomalies limited by solar terminator. This result permits to combine two mechanisms of seismo-ionospheric coupling: electric field penetration into ionosphere during night-time and modulation of ionosphere potential through lower atmosphere electric conductivity changes in day-time conditions.

Key words: Boundary layer, Local time dependence, Ionospheric precursor, LAIC

Planetary boundary layer (PBL) or atmospheric boundary layer according to determination of [2] is: “the lowest 1-2 km of the atmosphere, the region most directly influenced by the exchange of momentum, heat, and water vapor at the earth’s surface”. If to look at its structure (at least at quiet fair weather conditions) we can observe the very different shape and behavior of the PBL in local time (Figure 1): the very narrow (100-300 m) layer during night, and sharply expanded during sunrise daytime layer reaching the altitude near 2 km. The upper boundary of PBL is monitored by lidars [1] and with the help of radon as a tracer [5]. During night-time (Figure 2, right panel) radon is pinned to the ground, especially by night temperature inversion conditions, while during daytime it is spread over the whole boundary layer up to 2 km altitude. According to model the maximum of radon concentration is reached just before the sunrise. Having in mind the presence of the natural electric field and different mobilities of the positive and negative ions we can expect the electric charges separation and generation of the space charges over the great area of earthquake preparation zone (for M7 the radius of this zone is 1000 km). Theoretical estimations show [4] that in conditions of low turbulence the negative space charge can form

over the area of increased ionization in presence of aerosols. Concentration of large negative ions N_2 essentially exceeds concentration of large positive ions N_1 as well as concentration of the light ions n_1 and n_2 in the electrode layer. It necessary to mark that in relation of light ion's concentration starting from altitude 0.5 m the concentration of negative light ions n_2 also exceeds the concentration of positive light ions n_1. The calculations also show that the value of electric field starting from 0.5 m height exceeds the value of the natural electric field equal to 100 V/m.

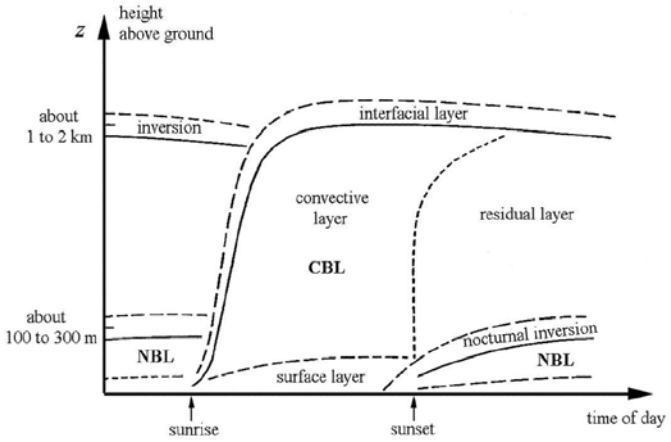

Figure 1. PBL development in the local time

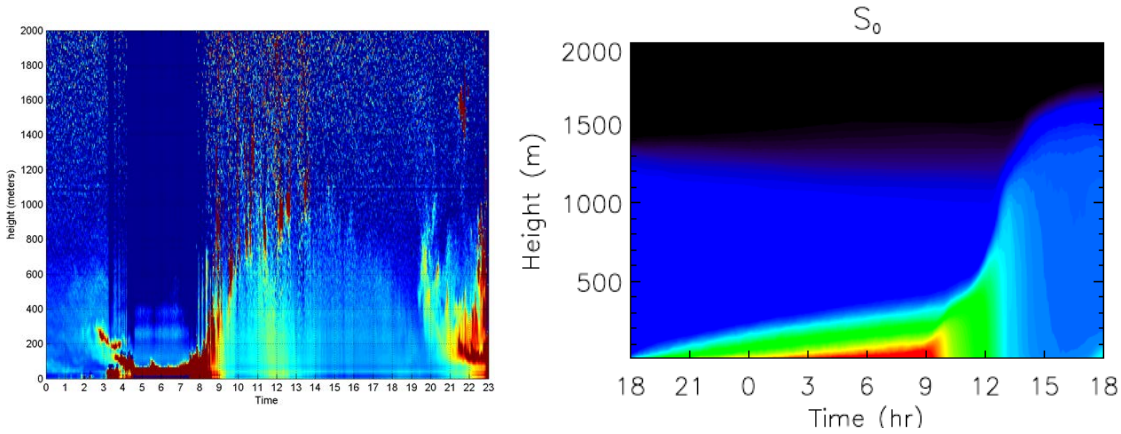

Figure 2. Left panel – distribution of aerosols (dark color) in PBL during one day; right panel – night-time increase of radon concentration due to temperature inversion

Author of [6] put on the same picture the ionospheric anomalies (differential GIM maps) before Van M7.1 earthquake in Turkey on 23 October 2011 and position of terminator from 16 till 24 October 2011 (Figure 3, left panel). The down and dusk terminator's positions are shown by black lines. One can clearly see that all positive deviations close to epicenter and conjugated point are observed outside the daytime, and terminator – is distinct border of precursor activity. Right panel of Figure 3 presents the deviation of GPS TEC for GPS receiver within the earthquake preparation zone named precursors mask [3]. Both figures show the formation of positive anomaly in TEC during night-time. The blue spot in right panel after the end of positive anomaly shows sharp increase of air conductivity during sunrise and drop of ionospheric potential reflected as negative ionospheric anomaly.

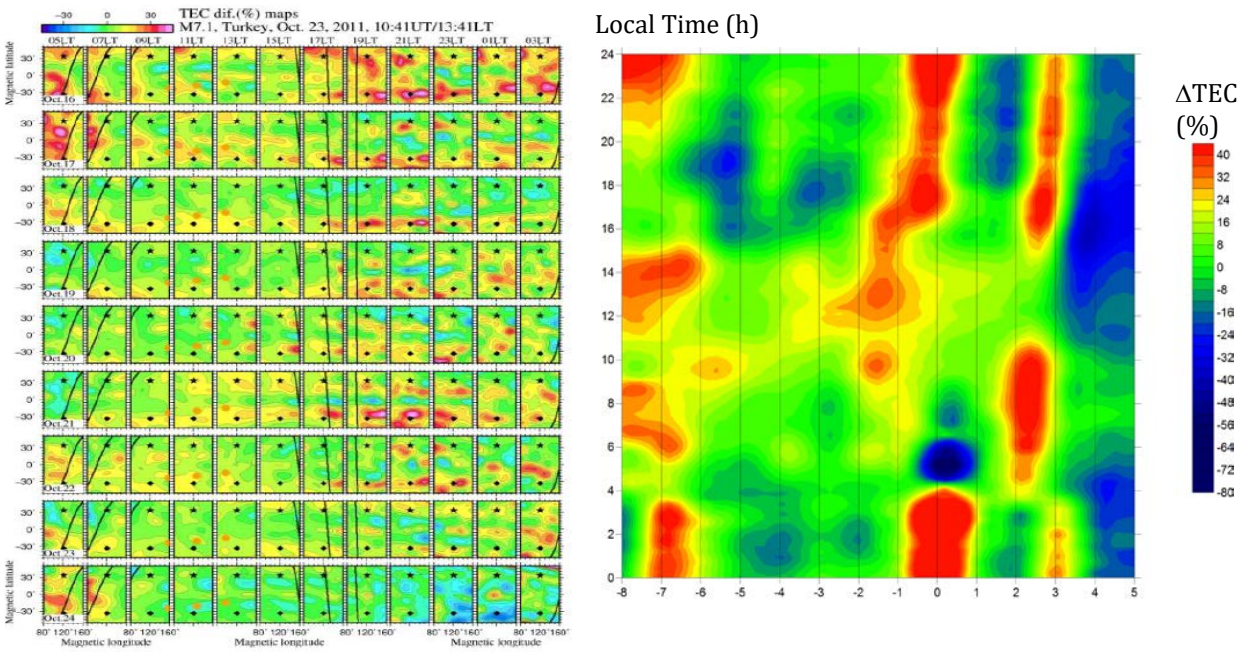

Figure 3**.** Left panel – differential TEC maps, black line – solar terminator position; right panel ΔTEC (color) in coordinates: days in relation of earthquake day – X axis, local time – Y axis

References:

[1] Eresmaa N., Härkönen J., Joffre S.M., Schultz D.M., Karppinen A., Kukkonen J. (2012) A Three-Step Method for Estimating the Mixing Height Using Ceilometer Data from the Helsinki Testbed. Journal of Applied Meteorology and Climatology. 51: 2172-2187.

[2] Kaimal J.C., Finnigan J.J. (1994) Atmospheric boundary layer flows: Their structure and measurement. Oxford University Press, New York, NY.

[3] Pulinets S.A., Ouzounov D.P., Davidenko D.V. (2014) Is Earthquake Forecasting Possible?! Integral Technologies of Multiparameter Monitoring of Geoeffective Phenomena in the Framework of the Complex Model of the Earth's Lithosphere–Atmosphere–Ionosphere Coupling, Moscow: Trovant, 144 p. (in Russian).

[4] Redin A., Kupovykh G., Kudrinskaya T., Boldyreff A. (2014) Surface Layer Electrodynamic Structure under Severe Aerosol Pollution. XV International Conference on Atmospheric Electricity, 15-20 June 2014, Norman, Oklahoma, U.S.A. P-07-11. 6 p.

[5] Vinuesa J.-F., Basu S., Galmarini S. (2007) The diurnal evolution of ^{222}Rn and its progeny in the atmospheric boundary layer during the Wangara experiment. Atmos. Chem. Phys., 7: 5003–5019.

[6] Zolotov O.V. (2015) Earthquake effects in variations of Total Electron Content, PhD Thesis, Sankt-Petersburg, 2015, 115 p.

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