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Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model – An unified concept for earthquake precursors validation

S. Pulinets [a,b,*], D. Ouzounov [c,d]

[a] Institute of Applied Geophysics, Rostokinskaya str., 9, Moscow 129128, Russia
[b] Institute of Space Research, RAS, Profsoyuznaya Str. 84/32, 117997 Moscow, Russia
[c] Chapman University, One University Drive, Orange, CA 92866, USA
[d] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

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ABSTRACT

The paper presents a conception of complex multidisciplinary approach to the problem of clarification the nature of short-term earthquake precursors observed in atmosphere, atmospheric electricity and in ionosphere and magnetosphere. Our approach is based on the most fundamental principles of tectonics giving understanding that earthquake is an ultimate result of relative movement of tectonic plates and blocks of different sizes. Different kind of gases: methane, helium, hydrogen, and carbon dioxide leaking from the crust can serve as carrier gases for radon including underwater seismically active faults. Radon action on atmospheric gases is similar to the cosmic rays effects in upper layers of atmosphere: it is the air ionization and formation by ions the nucleus of water condensation. Condensation of water vapor is accompanied by the latent heat exhalation is the main cause for observing atmospheric thermal anomalies. Formation of large ion clusters changes the conductivity of boundary layer of atmosphere and parameters of the global electric circuit over the active tectonic faults. Variations of atmospheric electricity are the main source of ionospheric anomalies over seismically active areas. Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model can explain most of these events as a synergy between different ground surface, atmosphere and ionosphere processes and anomalous variations which are usually named as short-term earthquake precursors. A newly developed approach of Interdisciplinary Space–Terrestrial Framework (ISTF) can provide also a verification of these precursory processes in seismically active regions.

The main outcome of this paper is the unified concept for systematic validation of different types of earthquake precursors united by physical basis in one common theory.

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1. Introduction

The history of this model runs to more than 15 years. The first ideas appeared as early as in 1994 (Pulinets et al., 1994) where several elements such as natural radioactivity, aerosols, and atmospheric electricity were gathered in attempt to explain the seismo-ionospheric variations. First calculations, which could be considered as the first version of the model appeared in 1998 and 2000 (Pulinets et al., 1998, 2000). But later, from the one-directed problem of anomalous electric field penetration from the ground surface into ionosphere, the model has transformed into multi-task interdisciplinary subject, where air ionization by radon plays the key role in processes of energy transformation within the atmosphere.

Probably the more accurate determination would be not the model, but physical conception. Different models based on the same physical concept can differ in their accuracy depending on mathematical procedures and approaches used in the model but the same physical phenomena cannot be explained by different physical mechanisms, we have only one energy conservation law, and only one set of Newton laws. Here we propose the complex chain of the physical processes which reflect the physical nature of different geochemical, atmospheric, ionospheric and magnetospheric anomalous variations observed few days – 1 week before the strong seismic shock within the area named in the literature as earthquake preparation area (Dobrovolsky et al., 1979). Our approach to validation fulfilled on the basis of multi-parameter measurements data for several hundred strong earthquakes and model calculations lead to incontrovertible conclusion that the observed phenomena can be explained only if we use the physical conception presented in the paper. From this perspective we cannot agree with authors of (Liperovsky et al.,

* Corresponding author at: Institute of Applied Geophysics, Rostokinskaya str., 9, Moscow 129128, Russia. Tel.: +7 916 0305157.
E-mail address: pulse1549@gmail.com (S. Pulinets).

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2008) that different physical mechanisms can explain practically the same precursors.

Air ionization and the latent heat transformations are the fundamental factors of the energy balance of our atmosphere. Cosmic rays and solar radiation (Pudovkin and Raspopov, 1992; Svensmark and Friis-Christensen, 1997), natural ground radioactivity (Hoppel et al., 1986), thunderstorm discharges (Papadopoulos et al., 1993; Neubert et al., 2008), radioactive pollution (Boyarchuk et al., 1997) – all these processes contribute to the air ionization and consequent latent heat release due to water vapor condensation on new formed ions. Ions ability to be good centers of water vapor condensation has been proved recently in laboratory experiments (Svensmark et al., 2007).

Air ionization by increased radon release before earthquakes is only small part of the total ionization balance, and identification of the atmospheric processes initiated by earthquake preparation is the art of short-term earthquake prediction, and their explanation is the purpose of the present paper.

The Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model described in this paper provides both the understanding of the physical processes involved in generation of anomalous atmospheric and ionospheric phenomena before strong earthquakes, and main scaling factors, which can be derived from the measured anomalies registered within the earthquake preparation area from one to several days in advance before an impending earthquake.

2. Radon contribution – fact or fiction?

Among the different short-term earthquake precursors radon is probably most controversial one and is a source for endless academic discussions. From one side we have profound and well documented studies showing clear connection of radon emanation with earthquake preparation process (Toutain and Baubron, 1998 and references therein), from other side we have the statistical tests demonstrating that radon cannot be used as earthquake precursor (Geller, 1997). Even well developed network of radon monitoring does not give the definite answer on the question of radon ability to be a reliable precursor (İnan et al., 2008). It seems that answer is in several issues unresolved or not taken into account up to date:

1. Different techniques and methodologies of radon monitoring. Some investigators measure radon in water, some in air in underground wells, some in open air, some in chambers (or tunnels) protected from the air turbulence. Different types of sensors are used (from simple α and γ counters up to sophisticated stations of radon monitoring). Some people make screening of the sensors limiting the energy range of registered particles, some take into account the radon progenies, some not. Such variety of different data types simply cannot be compared from the point of view of experimental physics.
2. The problem of radon transport in the Earth's mantle and crust is not established well. The mechanisms presented in various papers differ significantly. One authors claim that radon is carried by underground water due to its good solubility in water, other explain radon transport by including it in the bubbles of different types of gases released over active tectonic faults: hydrogen, helium, carbon dioxide, methane and others (Khilyuk et al., 2000).
3. The seismogenic radon sources are not established well also. It is obvious that results will be different if one will consider the Earth's crust as a main source, or the deep mantle source. There are some indicators (high $^3He/^4He$ ratio, CH_4 and CO_2 accompanying radon release) that radon before earthquake is transported from deeper layers (Heinicke et al., 1995; Schumacher and Abrams, 1996), and in these circumstances the arguments of poor radon content crust in the area is not valid.
4. Point measurements of radon. The gas migration along the tectonic faults is very dynamic, space and time variable. Having one or several static points of radon monitoring does not guarantee you to be able to register radon variation before earthquakes even in case of your points position are close to earthquake epicenter. And it means that all statistics based on one-point measurements is valid in the same extent as earthquake statistics for not complete catalogues in statistical seismology.

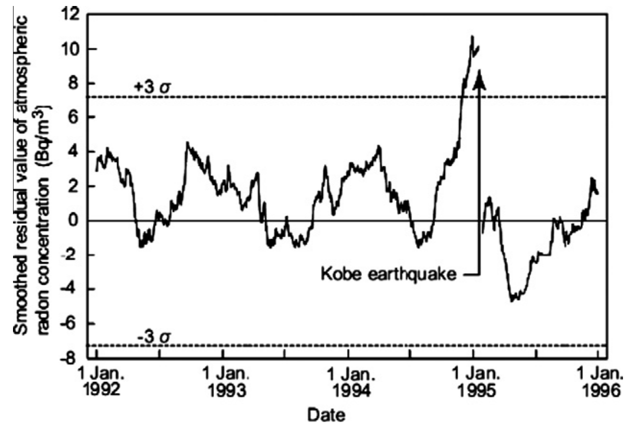

Fig. 1. Four years record of the radon variations measured in the vicinity of Kobe city at the altitude 5 m over the ground surface (from Omori et al. (2007)).

Nevertheless, the previous publications on correlation of radon with air conductivity, temperature and humidity (Garavaglia et al., 2000; Silva and Claro, 2005), radon and formation of anomalous clouds (Ondoh, 2004), radon and surface thermal anomalies (Pulinets et al., 2007a), radon and ionospheric parameters (Pulinets et al., 1997) attracted our attention to more comprehensive studies of radon interaction with boundary layer of atmosphere.

Finally the connection of radon variations with earthquake thermal anomalies was found what permits to avoid ambiguity of the single-point radon measurements and to use the satellite monitoring for mapping the radon activity within the earthquake preparation area (Pulinets, 2007). On this way we propose to use the thermal effects of air ionization produced by radon, and well established fact of overall radon release increase few days before earthquake. As an example of such increase we can propose the radon records before Kobe earthquake in 1995 (Omori et al., 2007), see Fig. 1.

3. Physical nature of thermal anomalies

Continuous monitoring of infrared emission (8–14 μ) at the top of atmosphere (10–12 km altitude) for all recent major earthquakes by remote sensing satellites (Ouzounov et al., 2006) permitted to establish their phenomenology. The anomalies start at the ground surface as linear structures of elevated temperature along different tectonic faults within the area of earthquake preparation. Detailed studies of surface thermal anomalies before Gujarat M7.9 earthquake on 26 of January 2001 (Genzano et al., 2007) demonstrated two main features: high temporal dynamics of thermal anomalies and their enormous spatial extension (see Fig. 2 of the cited paper). Another very important result is that the thermal anomaly appears not obligatory in the closest vicinity of the epicenter of anticipated earthquake. These features immediately give

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