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Seismotectonics and ground–space monitoring of natural disasters precursors in the Earth

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ABSTRACT

Until recently, short-term prediction of earthquakes with answers to the main triad of questions (When? Where? What magnitude?) was considered to be an unsolvable problem. And if for the forecast of place and energy (or magnitude) a number of empirical regularities confirmed with theoretical models were set, but the principal possibility of short-term forecast of the time (a period from several days to months) of the beginning of earthquakes was denied by most professionals. To answer the first question of the main triad of forecast there were not reliable empirical regularities and model approaches. This was due to a flashing character in time and mosaic manifestation in the space of many types of earthquake precursors of different geophysical nature and ambiguity of their interpretations. However, the development of Internet technologies and means of ground and space monitoring of different environmental parameters have allowed in real-time to obtain, compare and analyze various anomalies in the Geosphere shells of the Earth: the magnetosphere, the ionosphere, atmosphere, lithosphere and deep layers of the Earth. This has led to a breakthrough in solving the main problems of Geophysics: short-term prediction of strong earthquakes.

1. Introduction

Space flight safety issues are closely related to ground based infrastructure safety. Natural disasters, earthquakes, etc. could cause irreversible damages to ground based infrastructure. Space observation monitoring along with other data analysis provides sufficient information for short-term forecasts of earthquakes. Moreover, for the practical implementation of short-term forecasts according to the scheme of the Scientific Center for Operative Monitoring of the Earth (SCOME) from the extensive knowledge, models and representations of the classical seismology only data about the location of the boundaries of lithospheric plates are important and needed.This is due to the fact that it is in the top gas shells of the planet where the most informative features of the preparation of strong earthquakes are well defined by means of space monitoring for anomalous disturbances of the natural environment. Such signs in the lower atmosphere are seism tectonic cloud indicators(STCI) and Outgoing Long wave Radiation (OLR), slightly above – ozone anomalies, and in the ionosphere – anomalies Total Electron Content (TEC).

2. Short-term earthquake prediction

According to the empirical scheme of Scientific Center of Operative Monitoring of the Earth (SCOME) of short-term forecast [1,2] earthquakes with a magnitude of $M \geq 6$ usually occur along the boundaries of lithospheric plates at the intersection with the zones of action of seism magnetic meridians (SMM). For the first time the algorithm of

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calculations of SMM for instrumental recorded geomagnetic disturbances from geoeffective phenomena on the Sun was described in details in [2], and in [1]there are the topological types of SMM and the data on forecasts by the SCOME scheme for more than thirty earthquakes for the period from January 2007 to January 2010 in various seismic regions of the world; in [2] the implementation details of the scheme SCOME seism prognostic experiment in Taiwan are described: 7 realizations of forecasts with $M6+$ for the period of 7 months.

The topological type of SMM with $\pm 3^{\circ}$ zones of their actions and earthquakes with $M \geq 4.5$ happened during the period of June 07–21, 2011 are presented in Fig. 1, which is one of the many examples of retrospective validation of main geophysical empirical regularities of forecast schemes [1,2]. In Fig. 1 potential forecast zones in areas where SMM intersect with the boundaries of lithospheric plates are shown with dashed circles, and their radii only visually increases from the equator to the poles due to distortions in the Mercator projection.

Let us notice that only two of four SMM in Fig. 1 occurred seism active for earthquakes $M6+$, in the zone of action of which there were three strong seism activities: along SMM-23/157 (blue“1”) in New Zealand, Papua New Guinea and Santa Cruz; along SMM 112/-68 (green“2”) in Peru, Chile (Antofagasta) and the Moluccan sea. All other earthquakes were with $M < 6$ and they are explained by the induced seismicity and aftershocks from the previous strong seism activities or earthquakes, when the SCOME scheme does not always work.

Until recently, most seismologists and geophysicists denied the possibility of short-term forecast of the time of seism activities, prepared in deep layers of the Earth. However, according to the SCOME scheme the most likely dates d_* of the possible sequences of earthquakes in zones SMM are determined by the formula

$$d_* = d_s + [(7 \vee 14 \vee 21) \pm 2] \quad (1)$$

where d_s is date of geoeffective events on the Sun such as flashes or coronal mass ejections, and the sign $\vee$ stands for logical operation “or”.

In the methodology of short-term SCOME forecast seism tectonic cloud indicators (STCI) play an important role. It is new and the most informative type of earthquake precursors which are usually clearly visible in pictures from satellites in the visible or infrared ranges even in thick clouds. STCI do not only provide additional localization of places of possible earthquakes in zones of intersection of SMM with the boundaries of lithospheric plates, but also they allow to estimate the potential value of magnitude M with accuracy of ± 0.2 of future earthquakes with simple formula [1,2]

$$L/L_0 = \exp M \Leftrightarrow M = \ln L/L_0, \; L_0 = 1 \text{ km} \quad (2)$$

where L is the maximum linear size of STCI.

In formula (1) compared to [1,2] weak dependence from Carrington number of turns of the Sun in 27 days is omitted, but here are added: the possibility to get earthquakes in 1 week, and not only after 2 or 3 weeks. Seism efficiency of geomagnetic perturbations for seven days in deep layers of the Earth after recent (1–2 years) strong

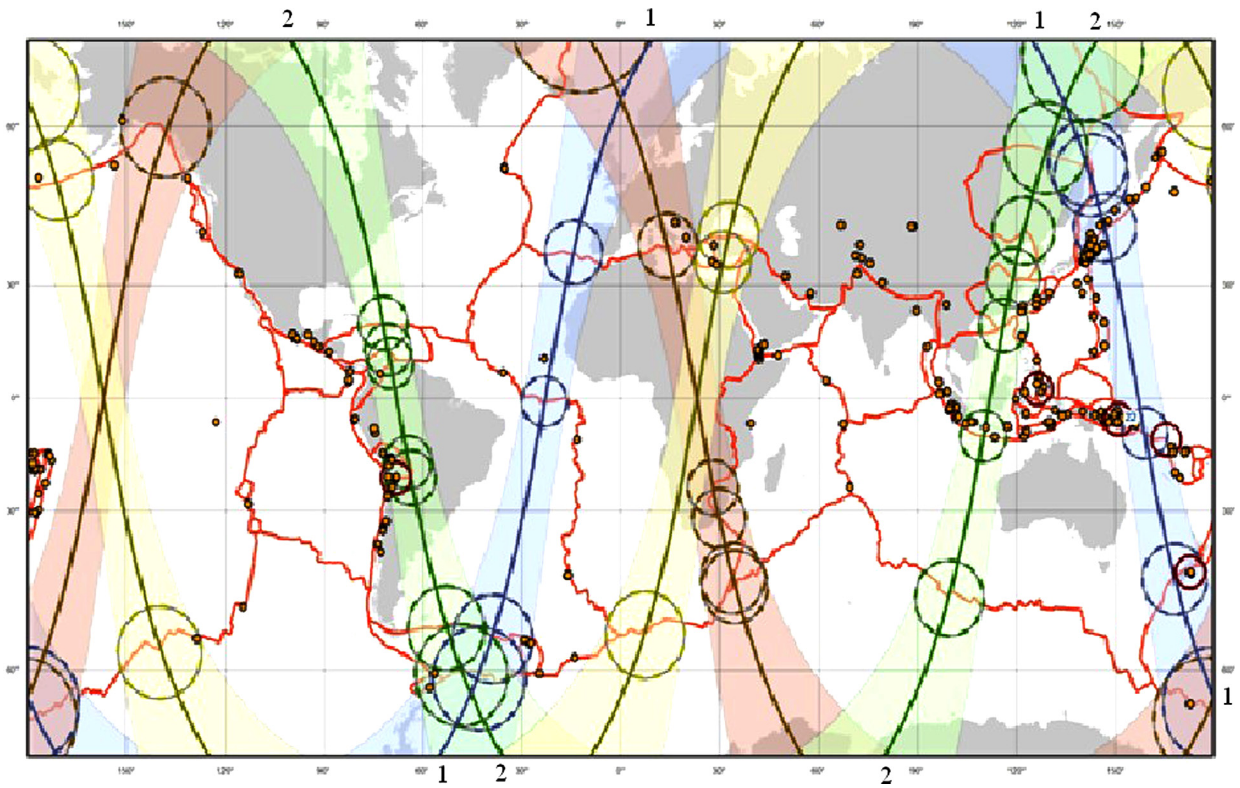

Fig. 1. Seismomagnetic meridians and chains of earthquakes in June 2011. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)