Acta Astronautica 69 (2011) 18–23

Contents lists available at ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

Earthquakes forecasts following space- and ground-based monitoring

L.N. Doda [a], V.R. Dushin [b], V.L. Natyaganov [b], N.N. Smirnov [b,*], I.V. Stepanov [a]

[a] Scientific Center for Earth Monitoring, Moscow, Russia
[b] Faculty of Mechanics and Mathematics, Moscow M.V. Lomonosov State University, Moscow, Russia

A R T I C L E I N F O

Article history:
Received 26 February 2011
Accepted 28 February 2011

Keywords:
Space
Monitoring
Geomagnetic activities
Earthquakes
Gaseous eruptions
Solar activity
Clouds

A B S T R A C T

The latest results on short-term forecasts of earthquakes in different regions using space monitoring are presented based on a new concept of seismo-tecto-genesis. The model approaches to theoretical explanations are discussed. The main attention is paid to the results of joint Russian–Taiwanese seismic activity forecast experiment, which resulted in several forecasted earthquakes 2009–2010 in the predicted zone and of predicted magnitude.

1. Introduction

Despite the definite skepticism concerning short-term forecasts of earthquakes [1] answering the main questions: when, where and what will be the magnitude?—now it can be stated that definite positive steps have been taken. Empirical scheme for short-term forecast [2,3] developed in the Scientific Center for Earth monitoring based on statistical data analysis makes it possible to make forecasts of strong earthquakes with the magnitude $M>6.0$ highly reliable (more than 95%) with the accuracy of ± 2 days, $\pm 3^\circ$ longitude and ± 0.3 magnitude [4]. The method is confirmed and officially registered. Validation of the scheme was performed retrospectively using the available data as well as the forecasting of new events.

2. Basic features of short-term forecast

Empirical scheme for short-term forecast developed in the Scientific Center for Earth monitoring based on statistical data analysis and some theoretical background are present on the website http://www.ntsomz.ru and described in [4]. Major geophysical manifestations monitored to perform forecasts are the following:

(1) Switching on mechanism takes place after geoeffective manifestations on the Sun (eruptions) approximately on the 14th or 21st day. The following empirical formula was developed based on statistical data analysis to determine the daytime for earthquake:

$$d_* = d_s + [(14 \text{ or } 21) \pm 2] + 27n \tag{1}$$

where d_s is the day of Sun activity manifestation with the number of cycles $n=0$, 1 or 2.

(2) Seismic process initiated by geomagnetic disturbances has the orientation following magnetic meridian and could be triggered in the zone of intersection of that meridian with the network of lithosphere fractures, which accumulated sufficient elastic energy due to mechanical stresses.
To evaluate longitude λ_* for seismomagnetic meridian in the Mercator projection, the following algorithm was developed:

$$\begin{aligned} &\lambda = \pm\gamma\varphi + (\lambda_s - 45^\circ n_j) \\ &\quad n_j : k(i+1) - k(i) \geq 2 \\ &\quad i = 0 \div 8, \quad j = 1 \div 8 \end{aligned} \tag{2}$$

* Corresponding author. Tel.: +7 495 9391190; fax: +7 495 9394995.
E-mail addresses: ebifsun1@mech.math.msu.su, mech.math.msu@inbox.ru (N.N. Smirnov).

0094-5765/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.actaastro.2011.02.012

where λ and φ are the longitude and latitude in the Mercator projection, respectively, λ_s is the longitude of the Sun projection (determined from astronomical tables on the date d_s), n_j is the number of the 3-h time interval of the jth order, wherein the condition for earthquake triggering is satisfied (the difference of neighboring geomagnetic indexes k is not less than 2) and coefficient $\gamma = tg11^\circ \approx 0.19$ is positive under the condition $|\gamma\varphi| \geq \lambda_*$ and negative under the condition $|\gamma\varphi| < \lambda_*$, $\lambda_* = \lambda_s - 45^\circ n_j$.

(3) Magnitude M for the expected earthquake can be determined by

$$\frac{L}{L_0} = \exp M \Leftrightarrow M = \ln\frac{L}{L_0} \tag{3}$$

where L is the maximal length of the linear cloud structure induced by seismic activity and tracking the lithosphere fractures in the zone of seismomagnetic meridian. These structures could be observed by Earth observation satellites.

The above mentioned group of phenomena is a new type for earthquake precursors [5], which make it possible to determine potential magnitude and geographical localization [3,4].

Formula (3) is a generalization of a known Dobrovolski formula [6], if L is replaced for R—radius of the zone of precursors in the Earth crust. The last could be hardly detected technically, while stagnant cloud structures staying in the zone for many hours insensitive to wind

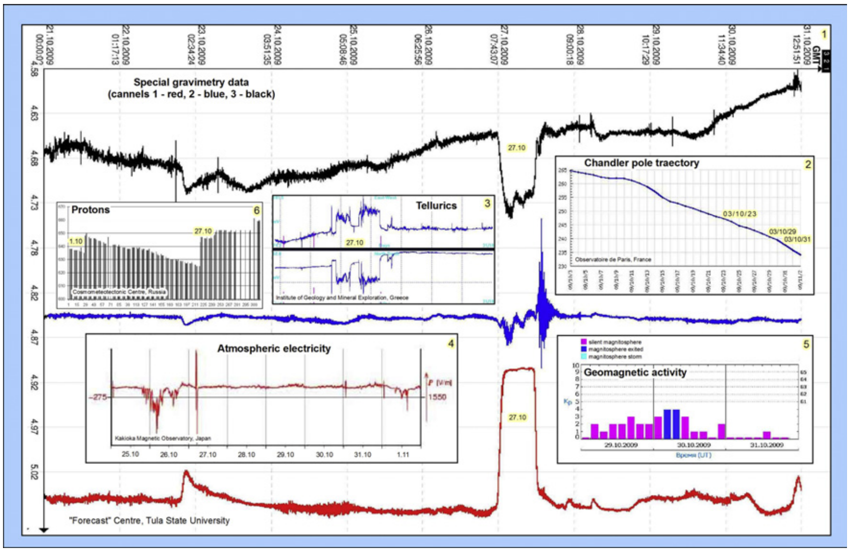

Fig. 1. Global geophysical indicators of the strong EQ preparation as of October 31st, 2009.

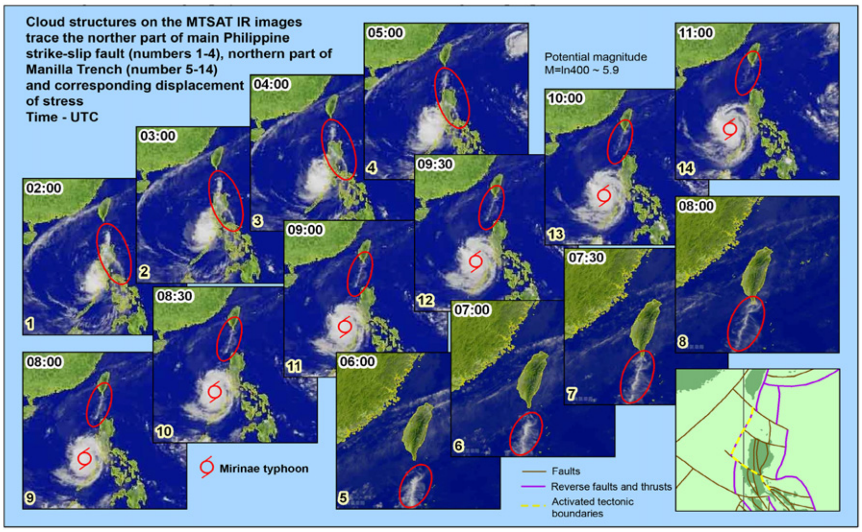

Fig. 2. Cloud seismotectonic indicators in the Taiwan and Philippine regions as of October 31st, 2009.