SEISMOTECTOGENESIS CONCEPT REALIZATION ON THE EXAMPLE OF THE TAIWAN SEISMIC FORECASTING AND MONITORING EXPERIMENT

L.N. Doda, Chief Specialist, Research Center for Earth Operative Monitoring, Moscow, Russia
127490, Moscow, Dekabristov st., b.51, h. 25, e-mail: ntsomz@ntsomz.ru
O.V. Martynov, Dr.Sc. (Tech), Full Professor, Tula State University, Tula, Russia
S.A. Shopin, Senior Staff Scientist, Tula State University, Tula, Russia
V.S. Bobrovskiy, Cand.Sc. (Tech), Chief Executive Officer, Distant School Cosmo-meteo-tectonics, Petropavlovsk-Kamchatsky, Russia
V.L. Natyaganov, Cand.Sc (Phys&Math), Associate Professor, Moscow State University, Moscow, Russia
I.V. Stepanov, Scientific Associate, Research Center for Earth Operative Monitoring, Moscow, Russia
I.V. Shugan, Dr.Sc. (Phys&Math), Chief of Laboratory, Prokhorov General Physics Institute of the Russian Academy of Sciences, Moscow State University, Moscow, Russia

Abstract

On the basis of the developed by authors seismotectogenesis concept reflecting the mechanism of earthquake preparation and start up it was formed earth-space system for earthquake precursors monitoring and determined predictive relations to estimate preparing earthquake parameters basing on its data. A number of successful seismic forecasting and monitoring experiments were performed. The results of the Taiwan experiment are presented. The conclusion about the possibility of performing similar experiments in any seismogenic region of the Earth was made.

1. Seismotectogenesis concept

Earthquake (EQ) prediction problem as the definite answer to the questions triad “when? where? and how powerful?” has not been solved by the present time. Therefore discovery of every regularity slightly disclosing the secret of the EQ preparation and start up must be welcomed by the geophysical community. Authors of the present work propose the collection of empirical generalizations underlying the regularities of the EQ preparation and start-up. Let’s list the mentioned regularities in a strictly hierarchical order briefly stating their physical essence.

1) Movement of the masses in the Earth body (Earth shells) associated with external cosmic and intraterrestrial causes reflected in the dynamics of the terrestrial gravitational field gradient and its informational components – definite frequency complexes (Martynov, 2008).

2) Proton tectogenesis based on the hydrogen migration in the geospheres and its interaction with the medium of the Earth (Larin, 1980, Kuznetsov, 1991); tectogenesis is regulated by the Earth rotation and revolution instabilities.

3) Global electro-rotational loop of protons and electrons migration providing conservation of their balance in the Earth shells according to the principle "so much has come – so much has gone" and mechanism of the preparation and start up of EQs.

4) Cause-effect relation between gravitational anomalies, Earth rotation and revolution instabilities, proton diffusion, electrotelluric field anomalies and seismotectonical processes. Location coincidence and concurrency of the mentioned anomalies may indicate approaching of the strong EQs with M6.0+.

5) Local manifestations of the global geophysical anomalies as seismotectonical responses in the Earth shells during preparation and start up of the EQ. Cloud seismotectonic indicators (also known as seismic clouds or linear cloud anomalies) being the one of such responses allows region localization of the potential EQ and estimation of the expected magnitude (Morozova, 2005; Doda, 2009)

6) Magnetic meridian directivity of seismotectonic process start up determined by the EQ chains along projections of the start up geomagnetic force tubes on the geoid.

7) Trigger mechanism of the EQ start up on the 14^{th} or 22^{nd} day after geoeffective solar events causing geomagnetic disturbances of the definite class (Doda, 2003). This allows EQ occurrence time forecast.

Above mentioned regularities are necessary (1–5) and often sufficient (7) conditions of EQ start up mechanism.

A strict hierarchical ordering of regularities reflects the sequence and interaction of processes of EQ preparation and start up mechanism. Achievement by the parameters involved in the mentioned regularities of certain limiting, resonance or other critical values is the spatio-temporal area of EQ preparation process transition into start up and later in the EQ event itself. It's worth to note that after the occurrence of EQ, processes further evolve in the reverse sequence relative to the mentioned regularities chain. This fact was confirmed by the effects accompanying the nuclear explosions. Their response in the Earth shells occurs mirroring the sequence of EQ preparation indicators appearance. It confirms similarity of their start up mechanisms (Doda, 2009).

On the base of developed concept it has been solved the problem of middle-term EQ forecast with 2–3 weeks event forestalling (as the inverse problem of EQ preparation and start up) among the seismoinductive indicators in the Earth shells. Also it was formed combined earth-space monitoring system for acquisition of data containing EQ preparation indicators.

2. Monitoring system for earthquake preparation indicators

Despite the fact that by the present time it is known more than 200 precursors of EQs, determination of the time and magnitude of approaching EQ with acceptable accuracy still fails. Moreover classic precursors actually are not the precursors at all. From the our concept point of view they are local manifestations of the global geophysical anomalies (mentioned above regularity 5). But in this case on what foundations should monitoring systems be based and what are the

criteria for the selection of anomaly indicators? Authors and colleagues have managed to form such a system, which includes the following main structural elements:

1) Special gravity measurements stations of the “Forecast” Centre of Tula State University

2) Subterranean proton measurement stations of Distant School Cosmo-meteo-tectonics (Petropavlovsk-Kamchatsky, Russia)

3) Electrotelluric measurement stations Kakioka, Memambetsu, Kanoya (Kakioka Magnetic Observatory, Japan, http://www.kakioka-jma.go.jp) and Pyrgos, Chios and Athenes (Greece).

4) International Earth remote sensing systems including geostationary satellites METEOSAT, MTSAT, GOES and low-orbit satellites Terra, Aqua, Resurs-DK1 and etc. Remote sensing satellite data is thematically processed and organized in the updatable databases by the Research Center of Earth Operative Monitoring (RC EOM).

5) Database of International Earth Rotation and Reference Systems Service (Paris Observatory, Earth Rotation Center, http://hpiers.obspm.fr/eop-pc/).

6) Geophysical and solar parameters databases with open Internet access: NOAA / NWS Space Weather Prediction Center database (http://www.swpc.noaa.gov/), Solar Terrestrial Activity Report (http://www.solen.info/solar/index.html), ATC Technologies Solar & Astrophysics Laboratory database (http ://www.lmsal.com/solarsoft).

Special gravity measurements stations are multichannel wideband gradiometers (WBG) having special construction. WBGs are intended to register dynamical disturbances of terrestrial gravitational field gradient. Sensing elements of WBGs are asymmetrical torsion systems analogous to the Cavendish torsion balance containing hypersensitive weights-antennas having complex geometrical shape. Construction of the weights-antennas and their geometry produce the filter for the selective extraction of informational components (definite frequency complexes) in the dynamics of terrestrial gravitational field gradient (Martynov, 2008; Shopin, 2009). For reconstruction of anomaly disturbances sources parameters on the base of the performed measurements, it is used several similar torsion systems having different spatial orientation and suspension fiber lengths and, as a result, different natural frequencies. Torsion systems complex is placed above the horn-type hyperbolic antenna designed using special procedure. Antennas are oriented along the planet southern geomagnetic pole. Primary information about changes in the Earth inner core dynamics, processes on the core-mantle boundary is reflected in the field structures of the Earth shells especially at the boundaries of the tectonic plates. The image of such changes is recorded on the gravity stations in Tula through the process of polarization. Occurrence of certain typical anomalies in the WBG instrumentation system data is an indicator of approaching EQ or other natural disaster (Martynov, 2008).

Proton diffusion measurement instruments designed by D.A. Kuznetsov (Petropavlovsk-Kamchatsky) are based on the brilliant conjecture and model of V.I. Vernadsky about Earth gas breathing which main component is hydrogen.

According to this model deep hydrogen is stored in the Earth core in the form of hydride compounds (FeH_4 and etc) and hydrogen outflow to outer Earth shells is compensated by the space protons. Developing this idea, V.N. Larin formulated the hypothesis of primordial hydride core of the Earth still preserving its original composition (Larin, 1980). Outflow of hydrogen together with the fluids to the outer Earth shells is regulated and synchronized by the rotary regime of the planet. Saturation of geological material with hydrogen changes the physical characteristics of the latter. In particular, iron becomes "swelled and more fragile", other materials change their plasticity and conductivity. First of all, hydrogen is transported from the depths to the surface in the zones where a solid material structure is broken, i.e. through mantle channels, boundaries of the tectonic plates and crust fractures. Owing to the pervasive property of the hydrogen, on the crust lengthy sections in the result of hydrogenization of materials mechanical properties of the interacting plates and blocks are changed, stresses and deformations appear. Accumulation of the latter in the amount sufficient for the release of seismotectonic energy is the necessary condition for EQ start up. Their emergence in different geophysical fields is usually called precursors (or forerunners). Described above geophysical processes are the essence of the proposed by V.N. Larin phenomenon of proton tectogenesis (regularity 2) occurring due to the migration of hydrogen in the form of protons from the Earth core to the near space. Proton tectogenesis intensity depends on the intensity of migration of protons and deuterons through the Earth shells to the surface and next into space.

Recording of the proton flows is performed by the hollow iron sensors-rods having special filler compound inside. Buried in soil to the depth of 1.5–2.0 m garlands of sensors are connected by the system of iron electrodes with total quantity of 14 pcs placed on 3 levels with depths differences of 0.3–0.5 m. A pair of electrodes in bore pits and a certain amount of soil between them are underground electrical two-terminal networks. Their total quantity is 29. Subterranean DC (ε=) and AC (ε~) EMFs are measured by the M880 multimeter. Total quantity of the measured subterranean electrical parameters (ε= and ε~) is 58. Developed method of subterranean electrical measurements for registration of fine structure of proton migration through irregularities on the boundary of tectonosphere and atmosphere proved the existence of the global seismotectonical effect. These measurements allow to register abrupt changes of proton migration fine structure before the EQ. Proton tectogenesis has electrical nature and global type and can be described by the by means of the circuits theory (Bobrovskiy, 2010).

Proton subterranean electrical measurements confirmed the suitability of return from the electrotelluric field concept to the concept of earth currents flowing in the Earth interior electric circuits. Therefore it's not by chance that proposed earth-space monitoring system includes spatially distributed telluric measurement stations in Greece and Japan. Their buried orthogonal measurement lines with lengths between hundreds of meters and several kilometers with the lead electrodes on the ends allow to recognize the global component of the earth currents.

Described 3 groups of stations allow to register responses to the global geophysical anomalies forestalling strong EQ occurrence. Processed and analyzed by appropriate techniques measurement data allow to identify cause-effect relation between the processes according to the regularity 4. Concurrency of the anomalies in the registered processes indicate the approaching of the strong EQs. This fact was repeatedly confirmed by the recent catastrophic EQs analysis. Mentioned regularity was confirmed also during seismic forecasting and monitoring experiment conducted from October 2009 to May 2010 for Taiwan-Philippine region.

3. Taiwan experiment: outcome and results

Group of russian researchers, authors of this paper performed during 7 months the experiment on the Taiwan-Philippine seismogenic zone. Experiment objectives were:

1) Verification of the main regularities of the seismotectogenesis and EQ start up mechamisms concept

2) Working-off of the elements of the proposed EQ preparation indicators monitoring system and geophysical data collection system for spatially-distributed stations (Tula, Kamchantka, Japan, Greece, Moscow)

3) Identification of the strong EQ preparation indicators in the Taiwan-Philippine region and preparation of EQ forecasts on their basis.

4) Working-off of the cooperation with concerned organizations (Russian Expert Council for Earthquake Forecasting, Seismological Centre of the Taiwan Central Weather Bureau, Taiwan Central Marine Bureau and some Taiwan research centers) on the information exchange and seismic hazard notification.

Experiment results surprised even its participants. It was obtained 5 sequential successful forecasts of seismic events realizations with M6.0+ occurred in the expected area having 7^0 radius. Only one event occurred on the December 19, 2009 with magnitude M6.4 was missed.

EQ preparation indicators were regularly presented in advance of events on the sites of RC EOM (http://www.ntsomz.ru), "Forecast" Centre of Tula State University (http://www.nadisa.org) and on the joint Russian-Taiwan site (http://www.intaiwan.ru). Let's discuss in detail the set of indicators corresponding to the EQ realizations on the November 5, 2009 and April 26, 2010 with magnitudes 6.0 and 6.5 respectively.

First hit. Series of 4 strong typhoons in the September and October (Ketsana, Parma, Lupit, Mirinae) and EQ in the Ryukyu islands region on the October 30, 2009 with magnitude M6.8 indicated the tensity of geophysical situation on the Philippine plate. On October 27, 2009 Tula gravimetry station registered low frequency (LF) precursor correlated with anomalies of the Chandler trajectory of the Earth's pole, telluric (Pyrgos), atmospheric electricity (Kakioka) and proton measurements (Kamchatka). The set of mentioned above anomalies, coincided on October 27, 2009, detected on the basis of the earth-space monitoring system data, is presented on the Fig.1.

Cloud seismotectonic indicators (CSI) detected on MTSAT satellite photographs of October 31,2009 above the Philippine plate also indicated the preparation of the strong EQ (Fig.2).

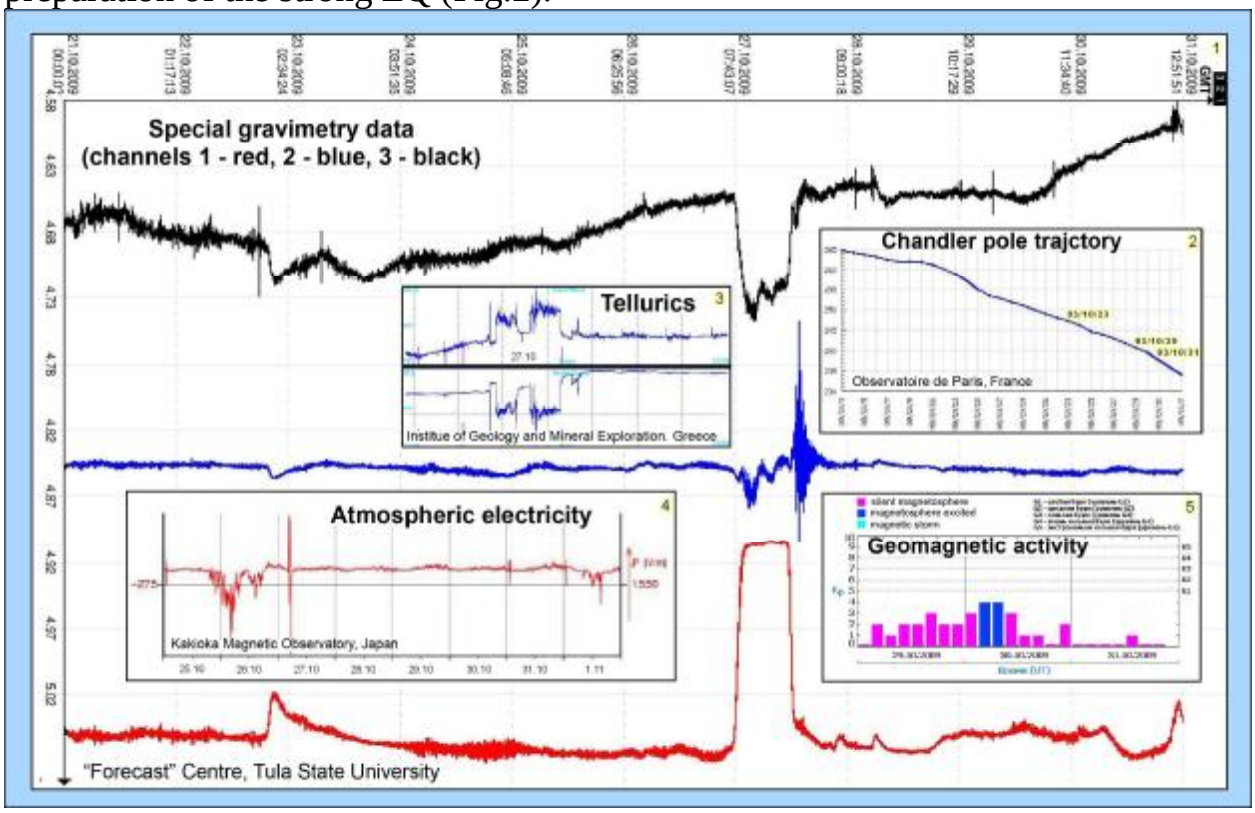

Fig. 1. *Global geophysical indicators of the strong EQ preparation as of October, 31st 2009*

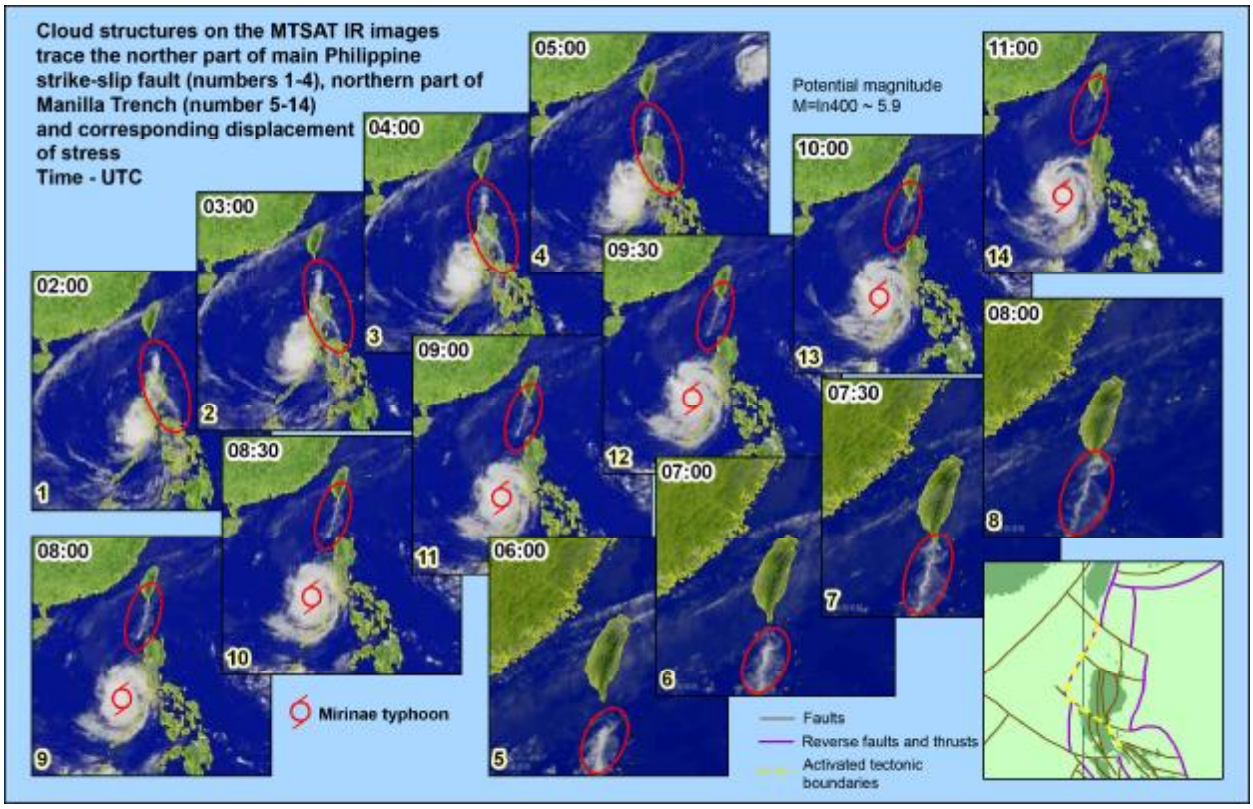

Fig. 2. *Cloud seismotectonic indicators in the Taiwan and Philippine regions as of October, 31st 2009*

First group of CSI appeared above the northern end of the main Philippine strike-slip fault on 02:00–05:00 UTC (images 1–4). After Mirinae typhoon passed away CSI continued to appear above the Philippines from November 2, 22:30 till November 3, 02:00. Length of the CSI located along the northern part of the Manilla Trench was 400 km which corresponds to the potential magnitude of M=ln400~5.9. The actual EQ magnitude according to different sources (U.S. Geological Survey, European-Mediterranean Seismological Centre, Central Weather Bureau of Taiwan) was 5.8–6.0 which was within the accuracy of magnitude estimation method of ± 0.2.

Seismomagnetic meridians (geomagentic force tubes projections at the start of geomagnetic disturbance) corresponding to geomagnetic disturbances of October 23, 2009 (equatorial longitudes 120^0/-60^0) and of October 30, 2009 (equatorial longitudes 127^0/-53^0) allowed to estimate possible time interval of the EQ as "before the November 13". Most probable dates according to the regularity 7 were November 6, 13 and 20 ±2 days. Actual EQ occurred on November 5 coinciding with the expected date within the mentioned accuracy. So the forecast came true in sense of the location, date and magnitude of EQ.

This forecast was published on the RC EOM website (http://www.ntsomz.ru) on November 3, 2009 and also it was presented by the Dr.Sc. I. Shugan at the meeting in Tainan University on Novermber 4, 2009. Realized on the following day forecast aroused shock and amazement ("it is impossible, but may be...") among those who attended the presentation. Later it was developed 4 successful forecasts of the following events: February 07, 2010 M6.3; February 26, 2010 M7.0 (Ryukyu islands, Okinawa); March 4, 2010 M6.4; April 26, 2010 M6.5. All mentioned events occurred in the predicted areas having 7^0 radius on the 14th or 22nd day ±2 days after geomagnetic disturbances. Actual magnitudes of events match the predicted estimates.

Last realization of forecast submitted to the Russian Expert Council for Earthquake Forecasting on the March 19 occurred on April 26 in Taiwan off-shore area with magnitude M6.5. Expected magnitude was M6.4±0.2. EQ occurred in the 7^0 area and coincided with expected date. It should be noted that in the forecast it was also marked out 1°×1° subzone on the Taiwan island itself. In the mentioned subzone 5 EQs with magnitudes of Ms 5.1–5.5 have occured (with background magnitude M4.3). After the April 9, expiration date of the initial forecast, it was twice prolonged for 14 days and realized on the 17th day (methodologically admissible time constraint is 28 days).

As before, forecast was developed with the use of gravity, proton and electrotelluric measurements and CSIs. Mentioned data is presented on the Fig.3 and Fig.4. Geophysical data analysis revealed synchronous anomalies in all classes of indicators on April 24. CSI were regularly appeared above the Taiwan-Philippine plate.

One of the CSI examples is presented on the thematically processed satellite images on Fig.3. Three CSIs (A, B, C) are shown on the map. Using the CSI C having length of about 660km the expected magnitude of M6.4 was estimated. Seismomagnetic start up meridian of the April 5 storm corresponded to the

following potential dates: April 19 and April 26 ±2 days. Actual EQ has occured on April 26 with magnitude of 6.5 which well conforms with expected magnitude estimate.

Forecasts and experiment materials were presented on April 9, 2010 by the Dr.Sc. I. Shugan on the meeting in Taiwan Central Marine Bureau (Kaoshiung). The presentation aroused great interest of audience and many question.

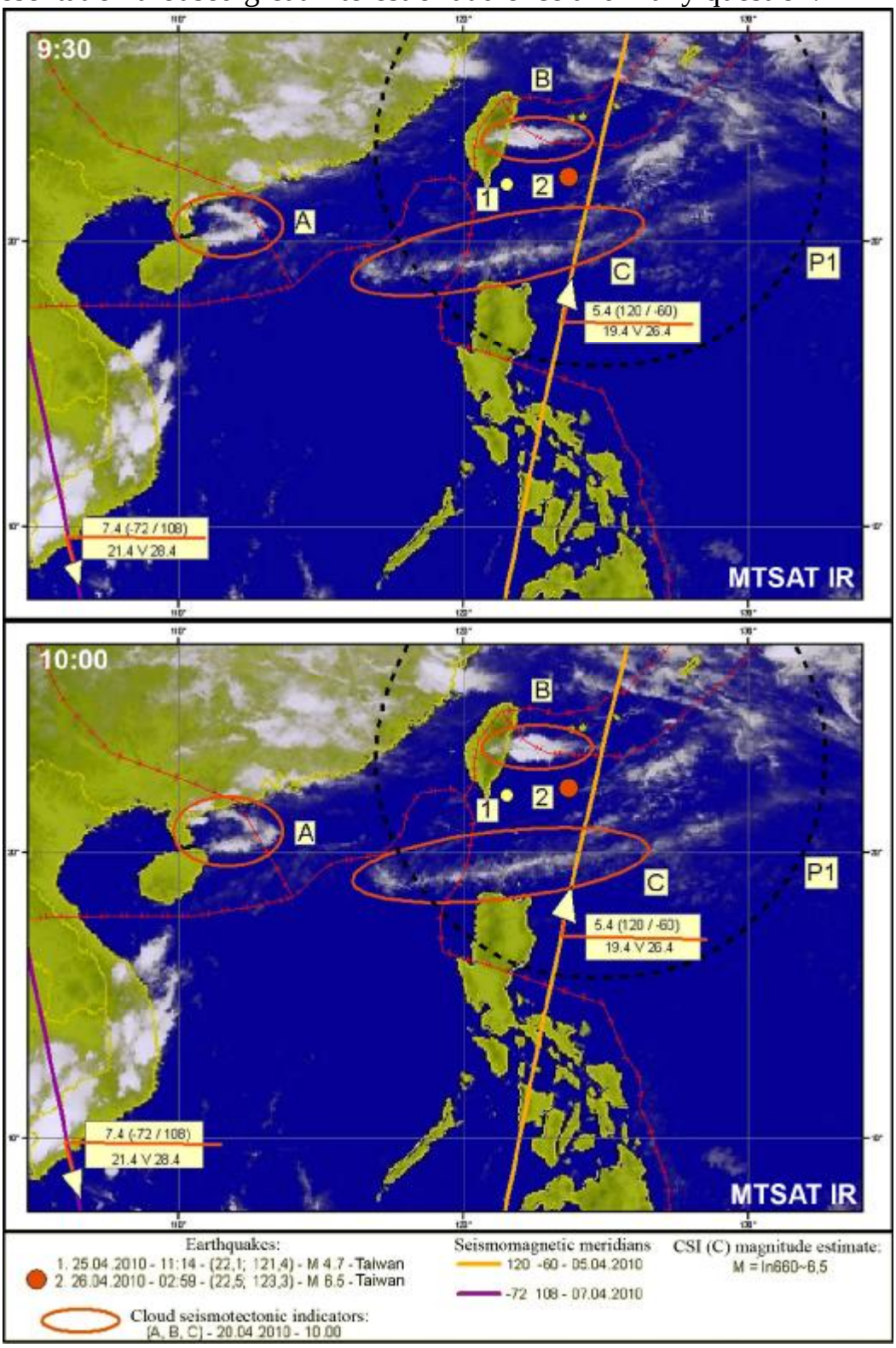

Fig. 3. *Cloud seismotectonic indicators in the Taiwan and Philippine regions as of April, 20th 2010*

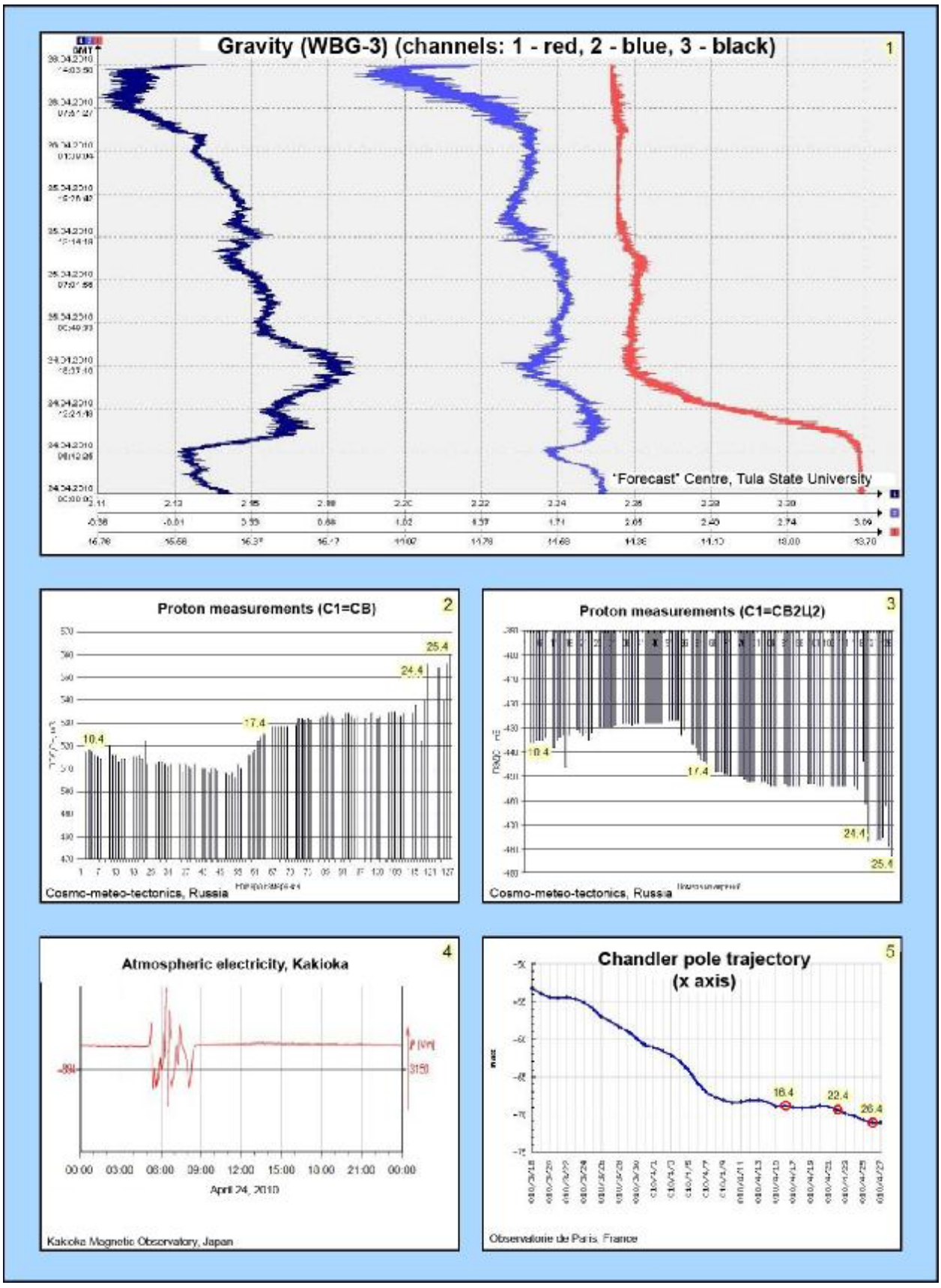

Fig. 4. *Global geophysical indicators of the strong EQ preparation as of April, 26th 2009*

Conclusions

All specified experiment objectives have been reached. Obtained results – successful forecasts for 5 of the total 6 occurred strong seismic events – confirm the high realizability of forecasts developed on the proposed seismotectogenesis concept basis. Similar experiments can be performed in any seismically unsafe region with the positive results. But still it has not been resolved the problem of the constructive cooperation with concerned organizations on the operational expertise of forecasts and decision-making at the level of state institutions. This problem must be discussed and solved at the international level within the bounds of the international cooperation and financing.

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