Acronim: **(EC GHHD), European Centre Geodynamical Hazards of High Dams**

ევროპის საბჭო
შეთანხმება დიდი კატასტროფების თაობაზე
ევროპული ცენტრი
მაღლივი კაშხალების გეოდინამიკური რისკი
საქართველო, თბილისი
0193 თბილისი, მ. ალექსიძის ქ. № 1

Logo:

COUNCIL OF EUROPE
EUR-OPA MAJOR HAZARD AGREEMENT
EUROPEAN CENTRE
GEODYNAMICAL HAZARDS OF HIGH DAMS
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Centre's seat: **M.Nodia Institute of Geophysics, Ministry of Education and Science of Georgia**

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The Chairman of the Scientific Council: Prof. M. Wieland (Switzerland)
Members of Scientific Council: Prof. B. Ducarme, Royal Observatory of Belgium,
Prof. J. Bonnin (France), Prof. V. Sgrigna (Italy), Prof. A. Savich (Russia),
Prof. T. Chelidze (Georgia), Dr. V. Abashidze (Georgia)

Centres' objectives**: The Centre is created for development of multinational, multidisciplinary approach to the problems of geodynamical hazards, generated by high dams, including:**

1. development and testing of modern methods of multidisciplinary monitoring of local and regional geodynamical processes in the proximity of large dams on the basis of Enguri Arc Dam International Test Area

2. mathematical modeling of geodynamical processes at large dams, prediction of impending geodynamical events (earthquakes, tectonic deformations, landslides) and prognosis of response of large dams to these impacts

3. monitoring of physical-chemical processes and associated variations in physical properties of foundation rocks

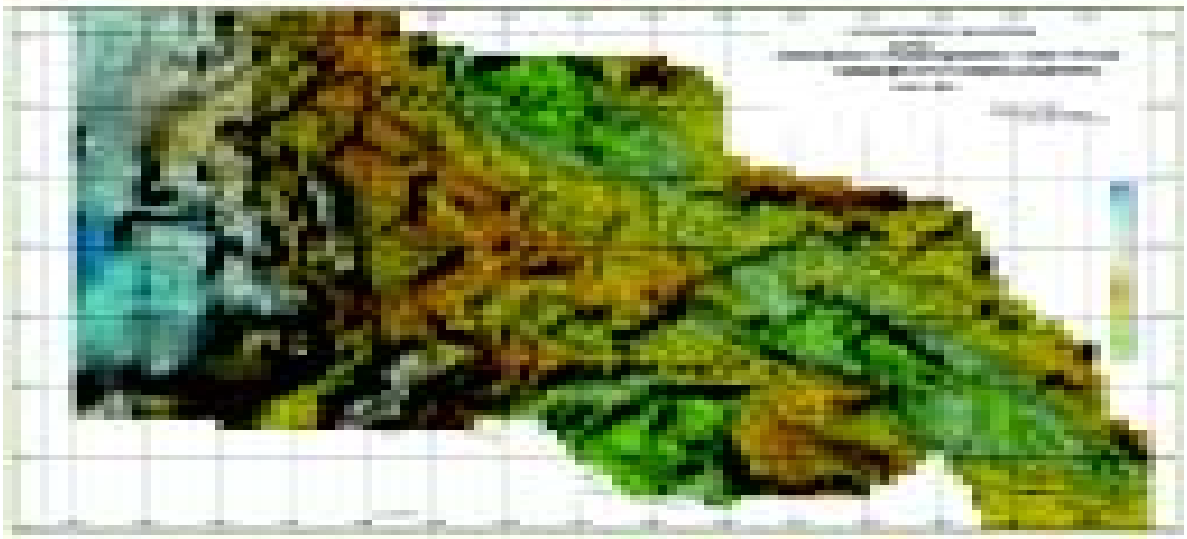
4. creation of databases of geodynamical observations on large dams

5. analysis and generalization (in collaboration with other european centres) of possible geodynamical hazards, creation of scenarios of possible damage and instructions for public education on what to do in case of alarm, during and after the disaster.

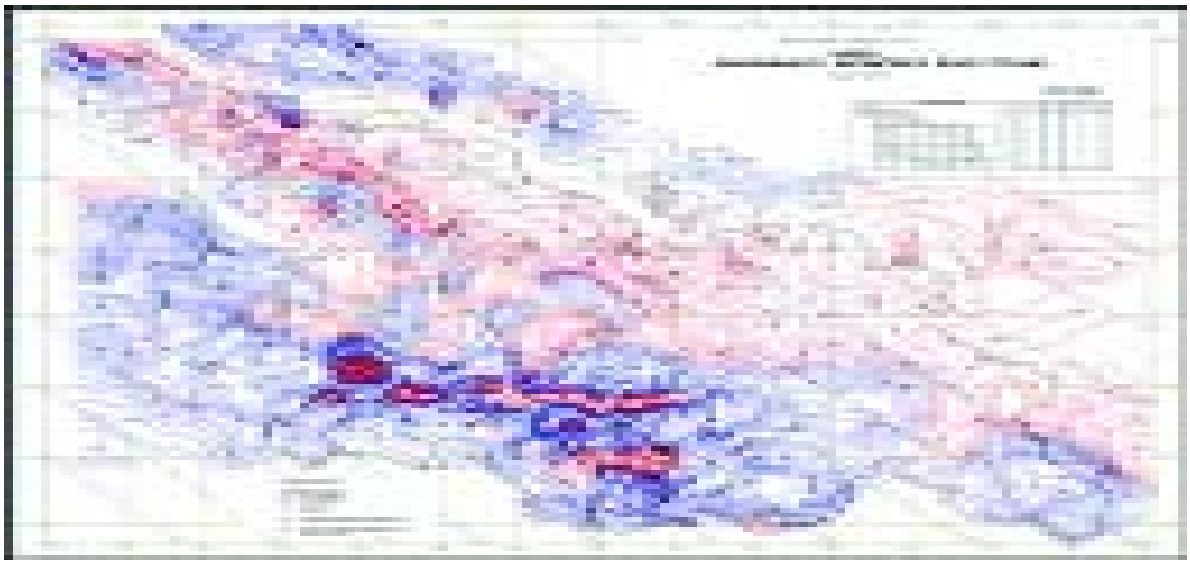
6. active participation in international, regional and national projects related to major disasters and environmental problems.

The general problems-Gallery

1. Mapping and monitoring of geophysical fields (gravity, seismic, electromagnetic, etc) on the territory of Georgia for revealing their spatial-temporal regularities



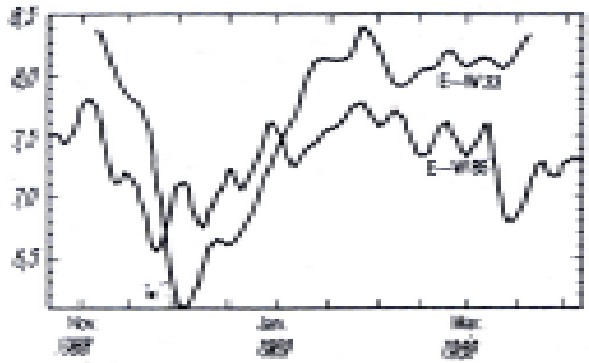
Gravity anomalies map of Georgia



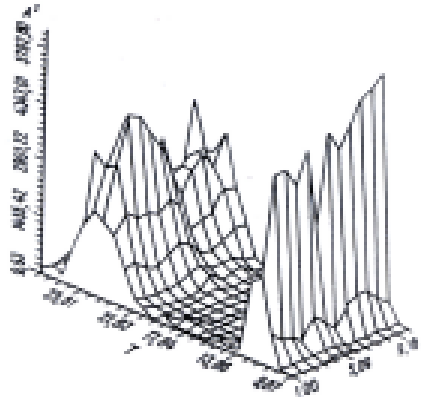
Magnetic anomalies map of Georgia

2. Earth's structure, dynamics and evolution models

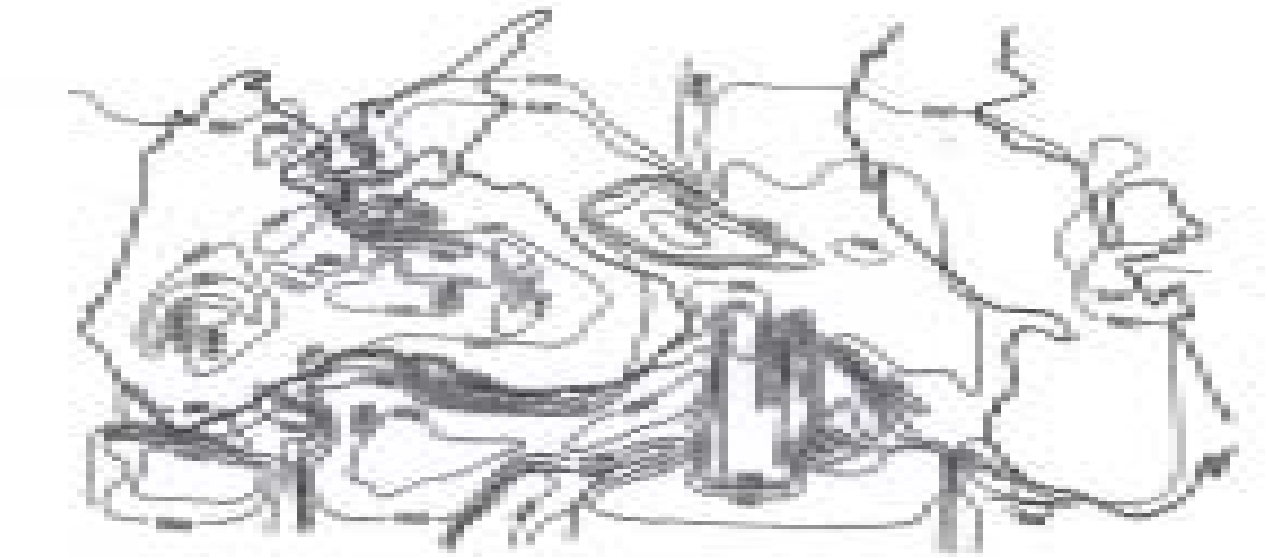
- Earth tides and Physics of the Earth's Interior
- Free oscillations of the Earth
- Variation in amplitude of tidal waves before earthquake
- Tidal triggering of earthquakes
- Geothermal and thermoelastic models of Caucasus



γ-factor variation of the M, wave for the period 21.10.1988 - 2.05.1989 from tiltmeter records at Spitak Earthquake (* – moment of earthquake)

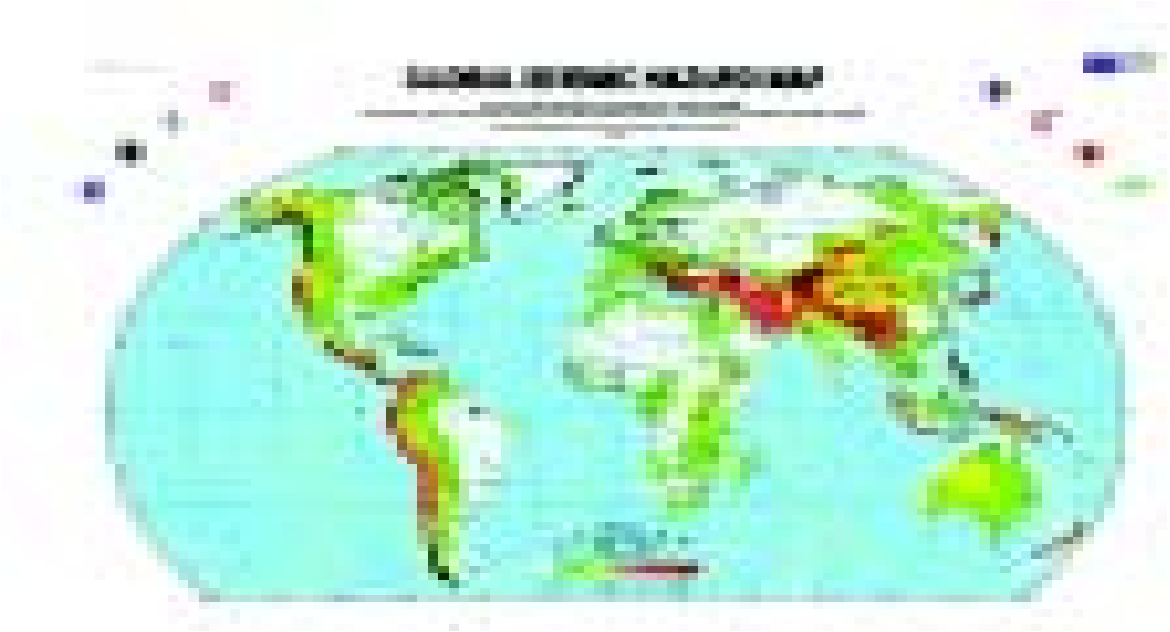


Spectral density variation in the E-W direction for the period 21.10.1988 - 2.05.1989 (465-hour step).

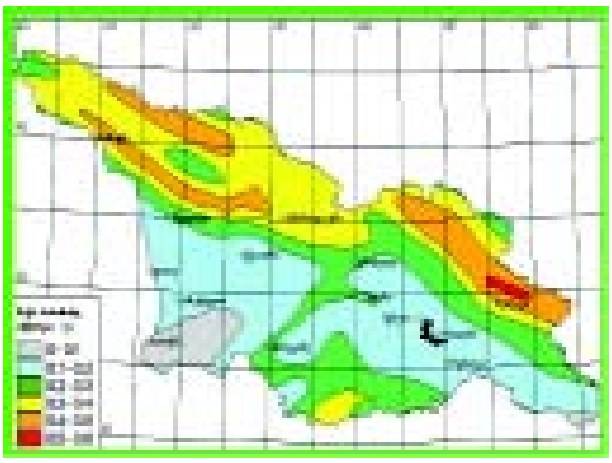


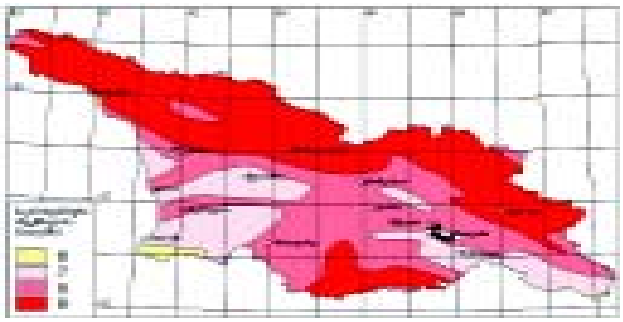
Vertical component of thermoelastic strain according to geothermal model of Caucasus and adjoining territories

3. Seismology, seismic hazard/risk assessment and earthquake prediction

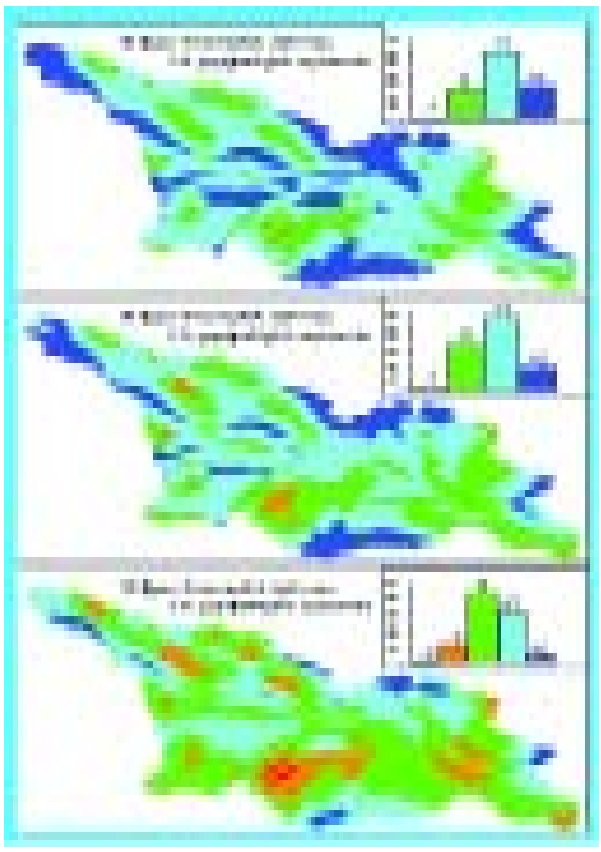


Institute of Geophysics (Georgia) takes part in compilation of map





Seismic hazard map of Georgia (MSK)



The difference (in MSK) between prognostic seismic hazard maps and observed macroseismic field (areas are blue of high seismic potential in future decades)

4. Dynamics of Atmosphere and Sea and Modeling of Ecological Systems

At the present time a creation of Monitoring/Forecasting System for the natural environment is very important that will enable to observe operatively current mode and future states of the Black Sea and atmosphere. The necessary stage for creation of such a prognostic system is development of mathematical models of dynamics and ecological systems for the sea and atmosphere. Nowadays a series of mathematical models are developed:

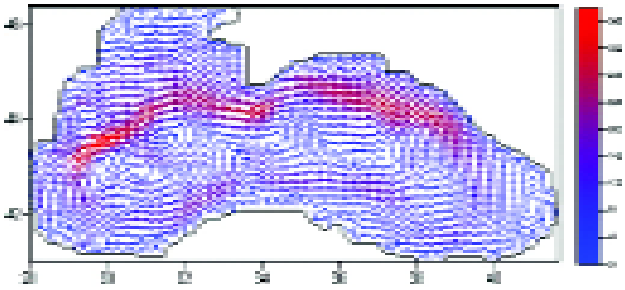
- Basin-scale baroclinic model of the Black Sea circulation with 5 km space resolution and nested-grid model of regional circulation in the Georgian coastal zone with 1km ace resolution;
- Non-stationary hydrodynamic models of large-scale, middle-scale and meso scale atmospheric processes;
- 2-D and 3-D mathematical models of dispersion of non-conservative polluting substances in the Black Sea;
- Mathematical method of detection of the source of contamination in the sea basin, *etc.*

For the purpose of illustration, calculated annual mean hydrophysical fields in the Black Sea obtained by the model of the Black Sea dynamics are presented. The nested-grid regional model was successfully tested for a part of the Georgian sector of the Black Sea within the framework of the **ARENA** International project.

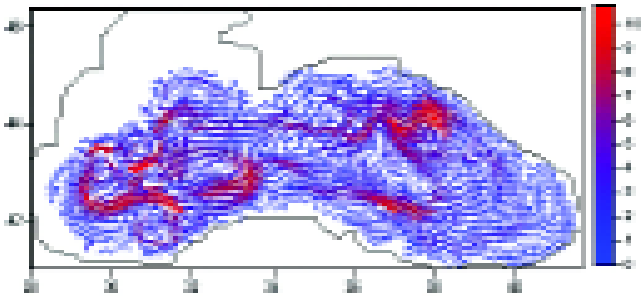
Under this project, a pilot experiment on operational functioning of the Black Sea Nowcasting/ Forecasting System was performed for the first time in July 2005.

At present our research interests are focused on a coupling of the Black Sea and atmosphere numerical models and development of prognostic coupled regional model of the system " the Black Sea-land-atmosphere".

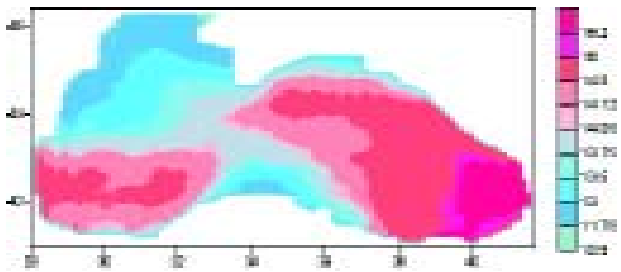
Currents z = 7 m



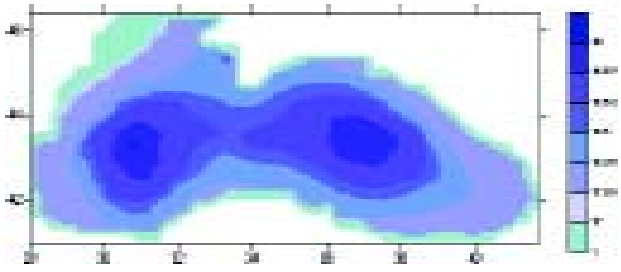
Currents z=305 m



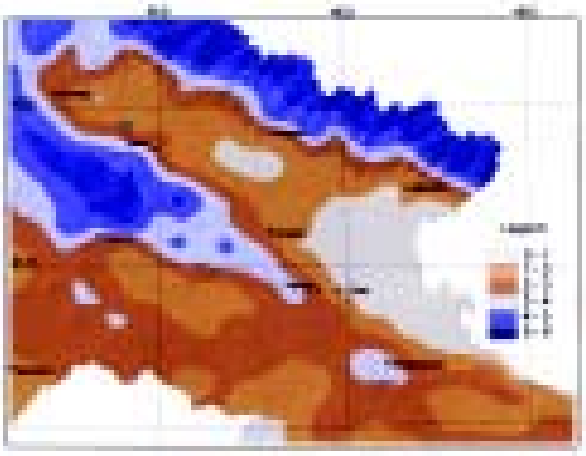
Temperature z=7 m



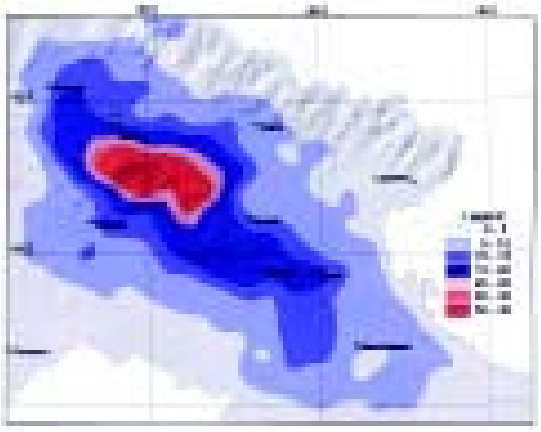
Salinity z=7 m



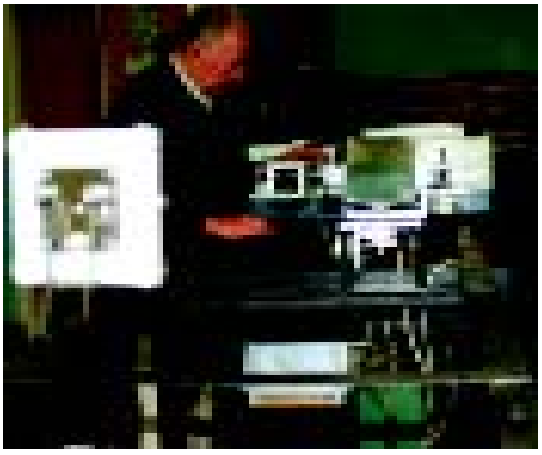
5. Physics of clouds, aerosols and weather modification



The mean annual distribution of convective clouds on the territory of Kakheti

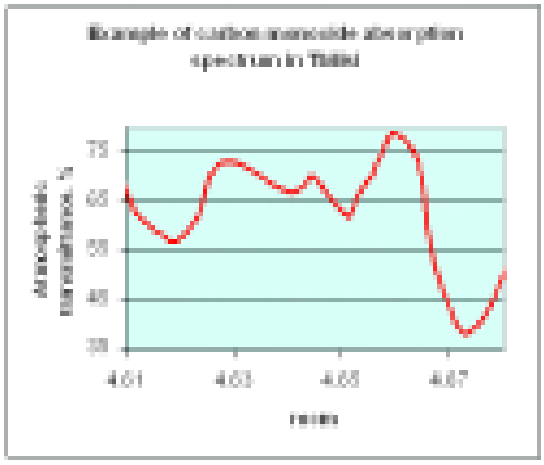


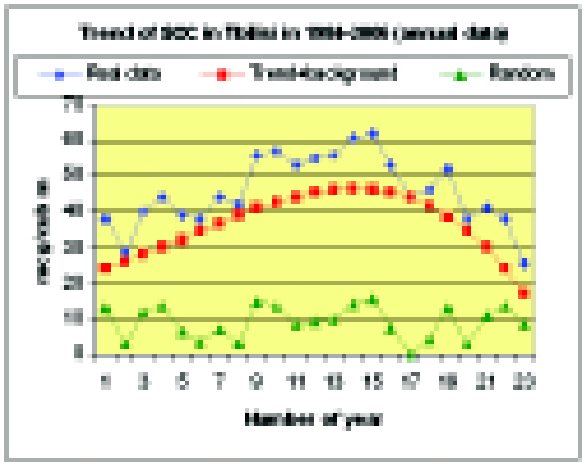
The distribution of the mean annual potential of expected hail cases in Kakheti



Greenhouse gases (CH_4, N_2O, CO) study in Tbilisi

Surface ozone concentration (SOC) monitoring in Tbilisi





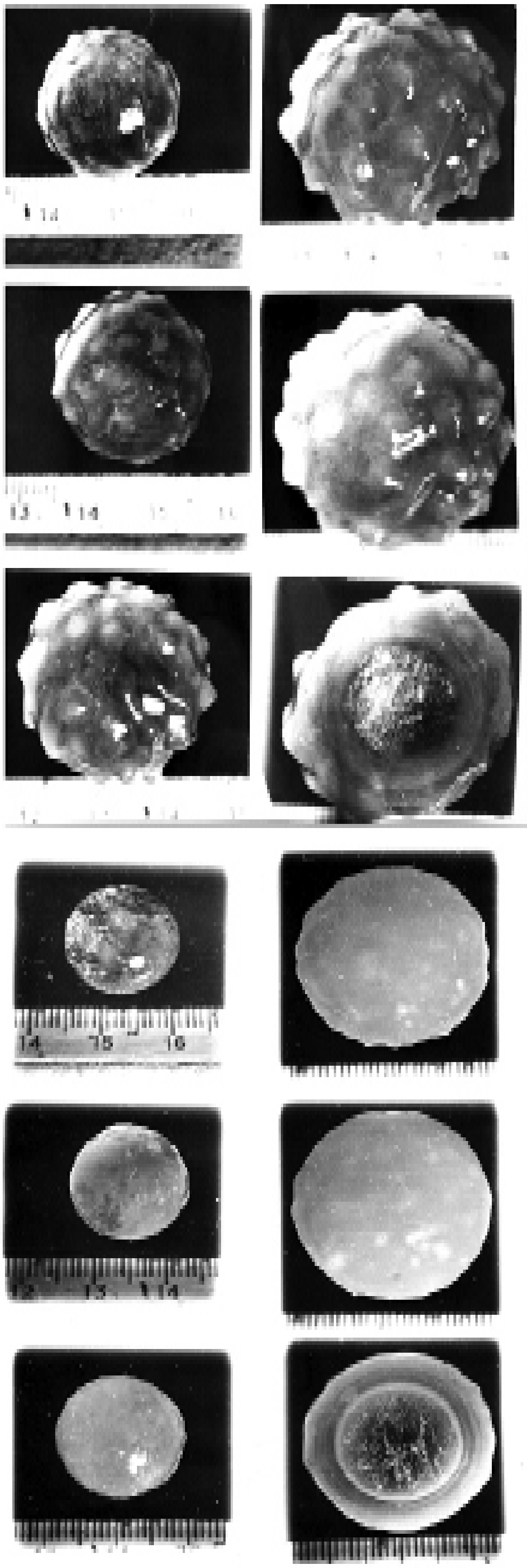
The Diploma of Discovery from Russian Academy of Natural Sciences (1999) for discovery of the new active substances for water crystallization in the atmosphere

ПОДТВЕРЖДАЕТ УСТАНОВЛЕНИЕ НАУЧНОГО ОТКРЫТИЯ

«СВОЙСТВО ОРГАНИЧЕСКИХ ВНУТРИКОМПЛЕКСНЫХ (ХЕЛАТНЫХ) СОЕДИНЕНИЙ ВЫЗЫВАТЬ АКТИВНУЮ КРИСТАЛЛИЗАЦИЮ ПЕРЕОХЛАЖДЕННЫХ ВОДНЫХ СИСТЕМ В АТМОСФЕРЕ»

Авторы открытия:

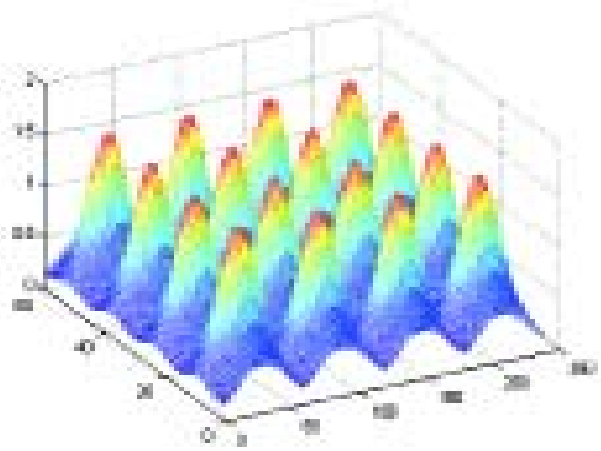
КАРЦИВАДЗЕ АМИРАН ИЛЬИЧ
ПАТРИКЕЕВ ВЕНИАМИН ВАСИЛЬЕВИЧ
МАЛКИНА АННА ДАВЫДОВНА



The evolution of hail particles in different environment

6. Solar-Terrestial Physics (cosmophysics, physics of magnetosphere and ionosphere)

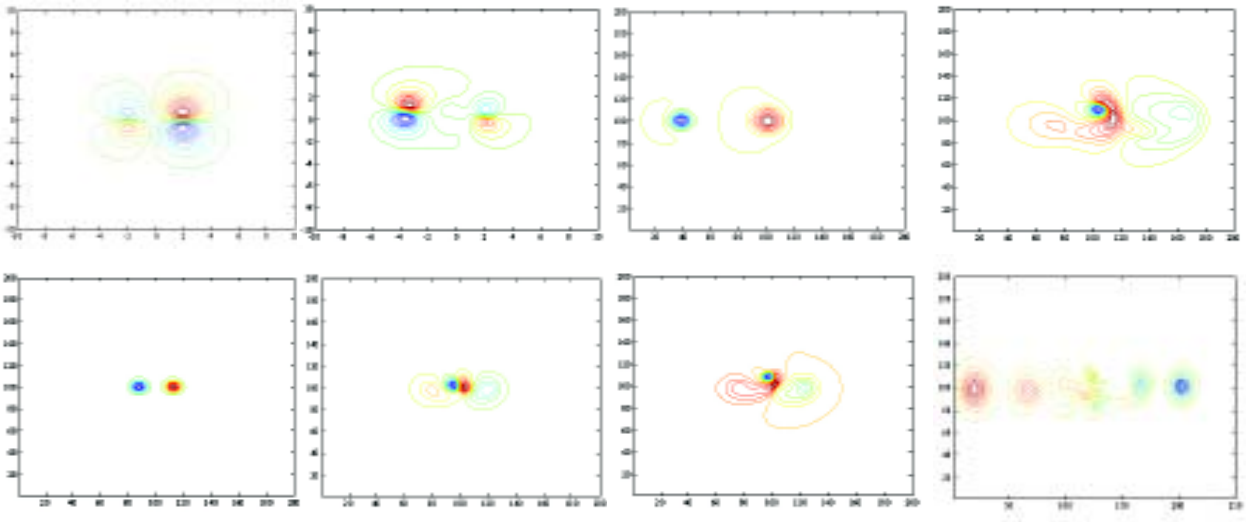
- On the basis of investigations (analytical, numerical) of linear and nonlinear stages of the dynamics of neutral and electromagnetic disturbances in the space environment (atmosphere, ionosphere, magnetosphere), it is revealed that in such perturbations self organize in the form of an ensemble of various stable enough nonlinear strongly localized solitary vortices.
- The macroscopic consequence the presence of the nonlinear solitary vortex structures in magnetized space environment is investigated. Strongly localized vortex structures contain the trapped particles and, kneading in the medium, excite sufficient density, electric and magnetic fields fluctuations and thus intensify the energy, heat ensemble of vortices. It is established, that interaction of structures with each other and medium particles causes anomalous diffusion in the medium. The effective coefficient of diffusion rootly depends on the stationary level of noise.



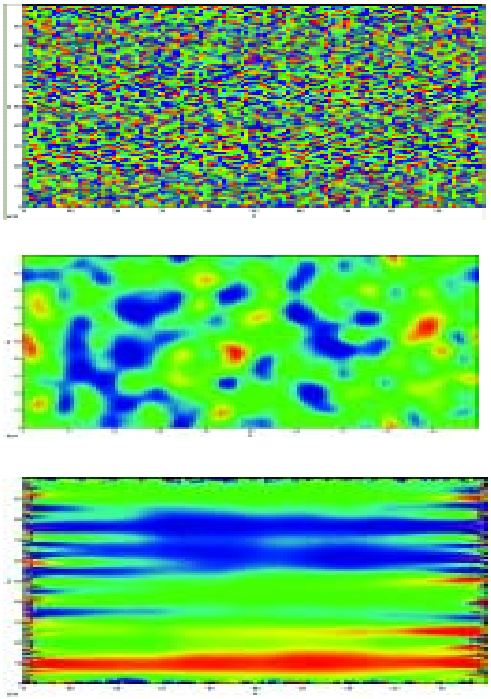
Vortex Ensemble as a Structural Element of the Strong Turbulence

Monopole and dipole wortex interaction in space plasma

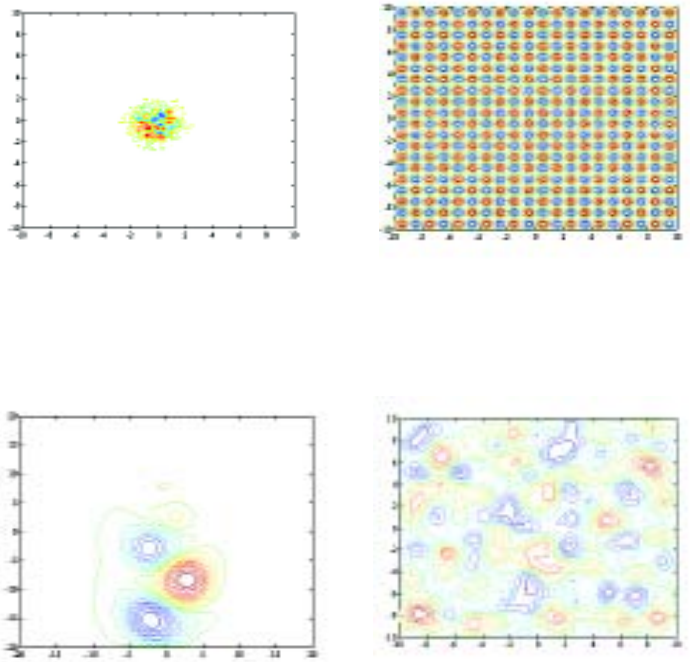
Monopole wortexes collision in atmosphere

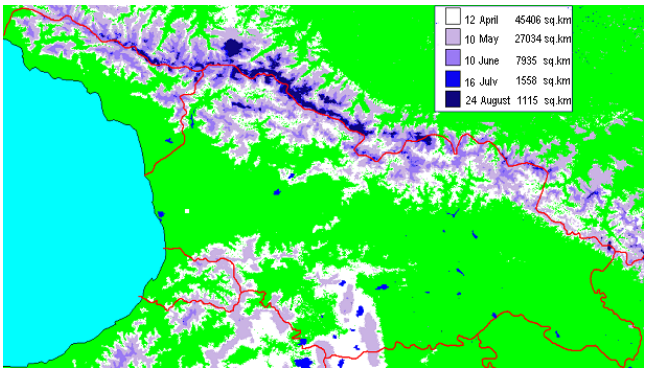


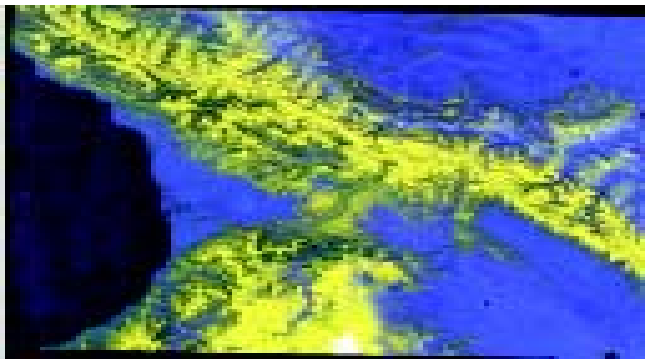
Random distribution and structure formation in space plasma



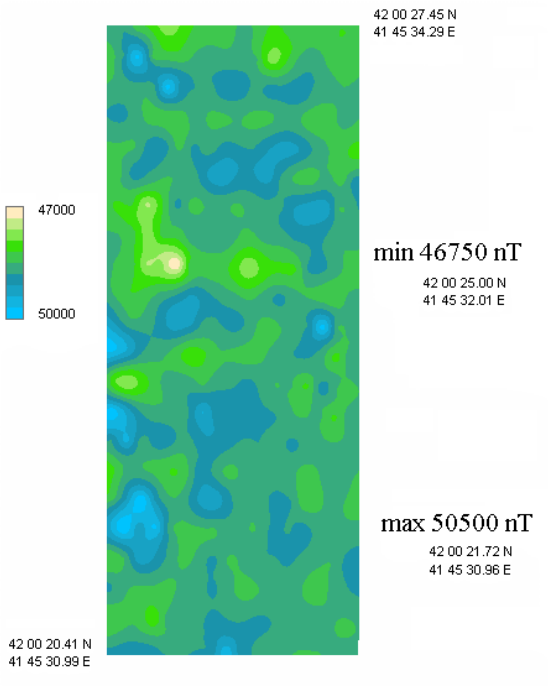
Structure formation in regular and chaotic flows







Ureki ,,Imedis qalaqi" anomaly of geomagnetic field



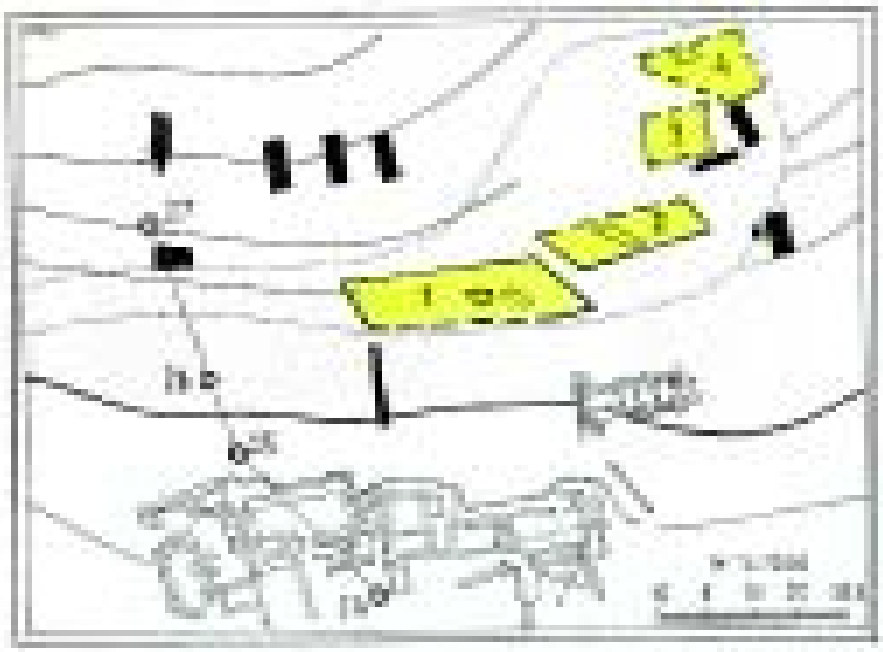
Solar-Terrestrial Connections Sector
Main results:

1. On the basis of the classic Kolmogorv's school theory of turbulence and results of other investigators achievements it is suggested generalized classic semi-empirical theory of turbulent neutral atmosphere and plasma medium. It is introduced four universal numbers of Reynolds, Richardson, Prandtl, and Pekle equal a unit

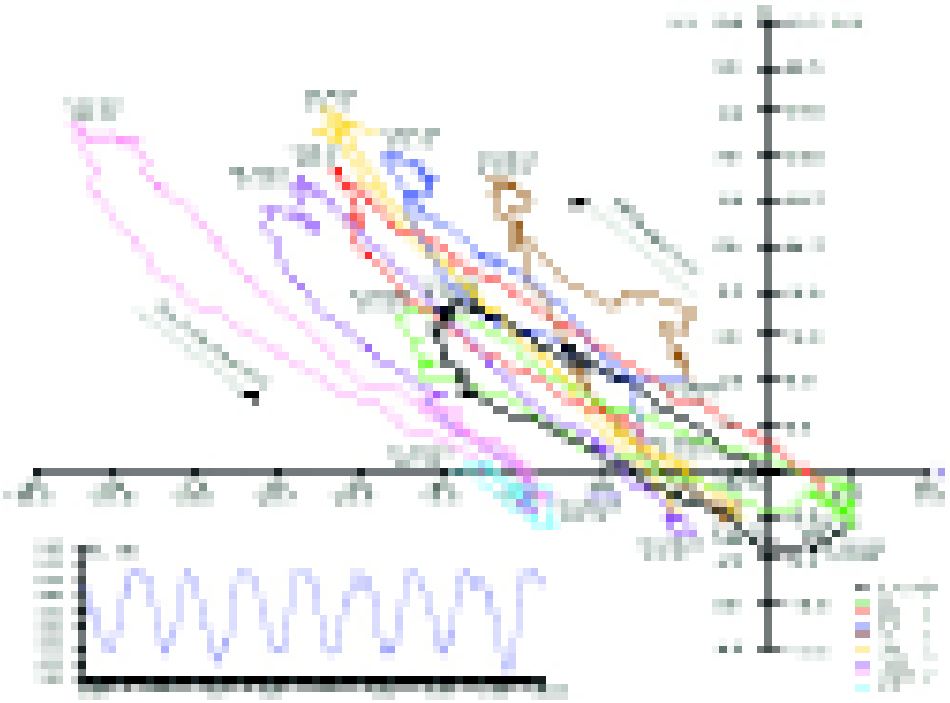
$(\mathrm{Re}_t = 1, \mathrm{Pr}_t = 1, Ri_c = 1, Pe_t = 1)$.

2. The turbulent area is considered as an ensemble of usual buoyancy waves and magnetic ones, characterized by seven parameters of turbulence.
3. Obtained expressions for spectral functions allow us to tell about capture the inertial intervals of the kinetic energy, pressure, and temperature fluctuated fields by the usual and magnetic buoyancy subranges partly or completely (on the base of observations in the mesosphere and low thermosphere).
4. Theoretical values of indicies' of the power spectra of the hierarchy mesoscale vortexes in the inertial subrange are: – 3, – 17/6, – 8/3, – 5/2, – 7/3, – 13/6, – 2, – 11/6, – 5/3; the indices' numerical values of the power spectra of the hierarchy of viscous subrange vortexes are: – 5/3, – 7/3, – 3, – 11/3, – 13/3, – 5, – 17/3, – 19/3, – 7.
5 Ratio of the spectral functions (ζ) of micro- scale to large-scale turbulent vortexes for inertial intervals of fluctuating kinetic energy, pressure and temperature fields gives a "square law" of the wave number exponent change as a result of action of only magnetic or jointly with usual Archimedes buoyancy, respectively: $\zeta_K \sim k^{-1/6}, \zeta_P \sim k^{-1/3}, \zeta_T \sim k^{-2/3}$ and $\zeta_{*K} \sim k^{-1/2}, \zeta_{*P} \sim k^{-1}, \zeta_{*T} \sim k^{-2}$
6. It is suggested a method of classification of mesoscale turbulent vortexes hierarchy in neutral and electroconductive environment having irregularities of various scales – from thousand km to some cm.
7. Considered mesoscale turbulent vortexes hierarchy in three intervals of kinetic energy, pressure and temperature fluctuating fields are in a good agreement with the experimental results obtained for ocean, upper stratosphere, mesosphere, lower thermosphere, E- and F -layers of the ionosphere, the magnetosheath, and numerical experiments modelling the process of the turbulent vortex structure evolution.
8. It has been indicated anomalous solar-diurnal variations of the neutron and hard cosmic ray components during crossing of the neutral IMF sector boundaries by the Earth and their effective role for stimulating large destructive earthquakes with a magnitude of $M \geq 6$. The 11-year period in the cyclicity of the occurrence probability of the above earthquakes has been revealed.
9. It is suggested the original method of investigation of the solar-diurnal variation both by means of sinchronous, precision measurements data of the neutron supermonitor and irregular magnetic field observations carrying out by our Cosmophysical and Magnetometrical Observatories.

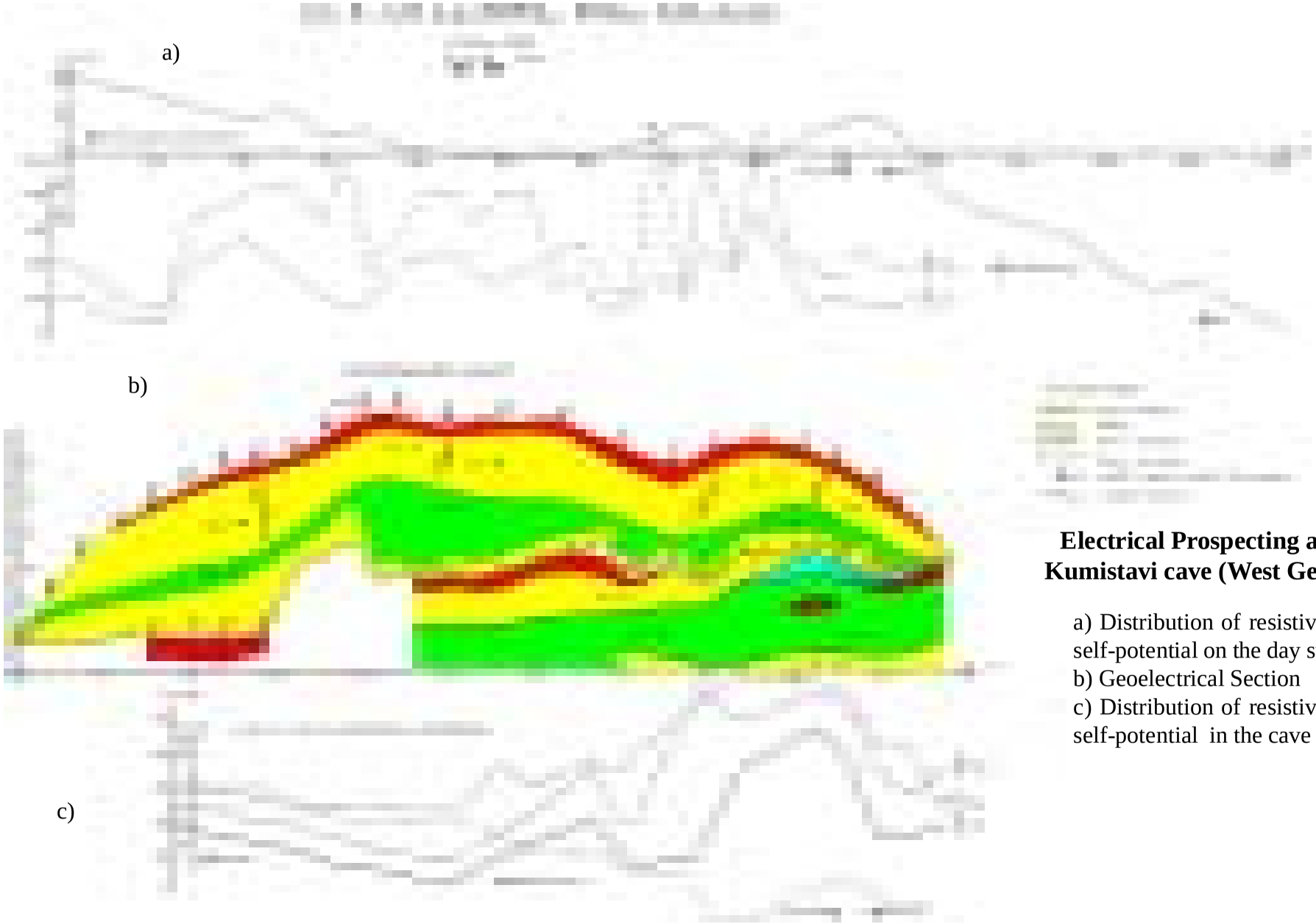
7. Engineering, prospecting and environmental geophysics, geohazards and associated risks, archaeogeophysics, hydrogeophysics, monitoring of stability of large engineering constructions



ARCHAEOGEOPHYSICS-ARMAZISTSIKHE 1,2,3,4,- areas promising for archaeological monuments, discovered by geophysical methods; quadrangles inside – productive trenches. Note very high percent of success. Black quadrangles – void trenches, dug out without involving geophysics.



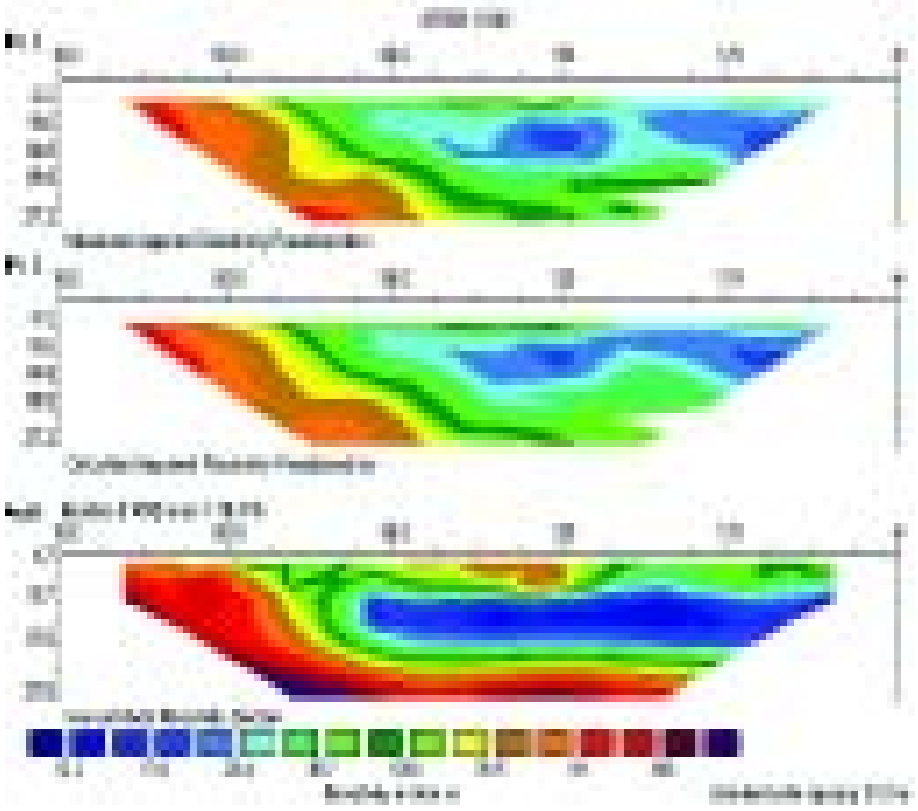
Tiltmeter records in the body of Inguri dam – Inguri dam International Test Area



Electrical Prospecting at the Kumistavi cave (West Georgia)

a) Distribution of resistivity and self-potential on the day surface
b) Geoelectrical Section
c) Distribution of resistivity and self-potential in the cave

HYDROGEOPHYSICS – MARNEULI REGION



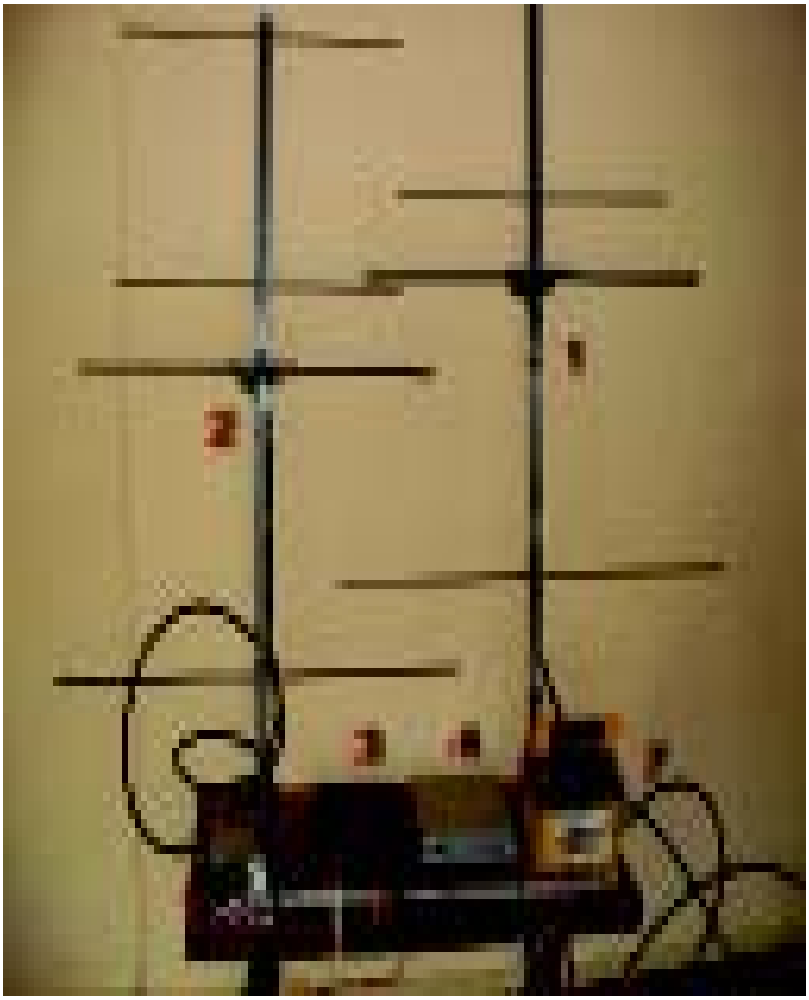
Electrical resistivity section (Poladaury valley). From top to bottom: measured AR, calculated AR and the result of inversion

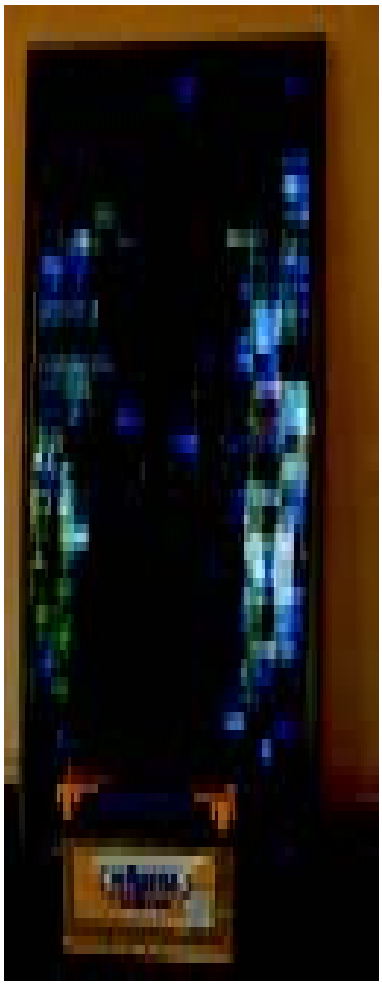
Geomophological hazards and geophysics

The representatives of EUR-OPA Major Disaster Agreement at the Council of Europe (experts Mr. Massue, Dr. Maquaire) on mission at the Douroudji debris flow area

EUR-OPA Major Disaster Agreement of Council of Europe, European Centre "Geodynamical Hazards of High Dams", Tbilisi, Georgia
M. Nodia Institute of Geophysics, Tbilisi, Georgia

Acoustic Early Warning Telemetric System of Debris flow/Mass-movement





1 - receiving aerial
2 - transmitting aerial
3 - transmitting block
4 - receiving block
5 - power supply of receiving block
6 - acoustic sensor
7 - reserve battery of receiving block
8 – solar battery for the transmitting block
9 – reserve battery of transmitter

Power Requirements for:
Transmitting - Solar panels (10.5-27 V) +battery (10.5- 14 V); Consumed power 3.5-4 W; Emitted power - 0.8 W; Environment: T from-10^{0}C to 50^{0}C; Humidity: 5%-95% Receiving - Battery 10.5-14 V; Consumed power – 4-5 W.

Operating Frequency **172.725 MHz**
Operating Distance **12-15 km**

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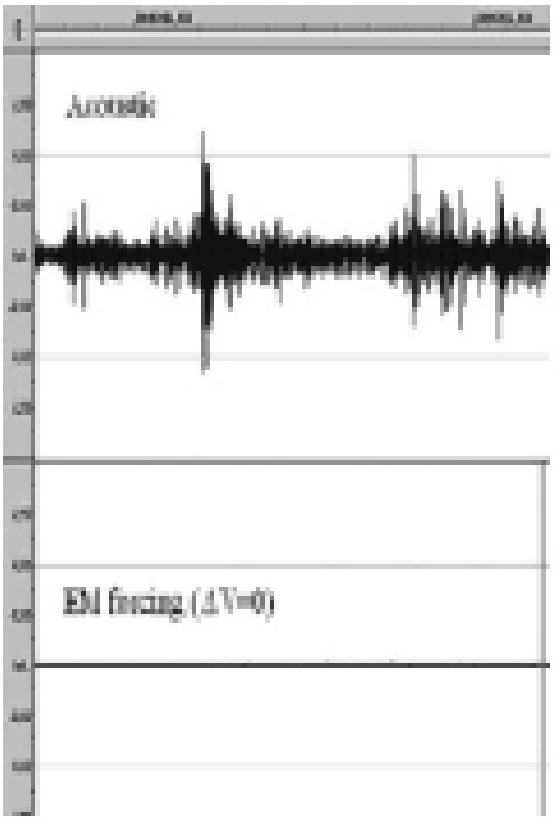
8. Fractals and Nonlinear Dynamics in Geophysics

• Recent methods of analysis of so-called disordered systems show that many objects and processes that earlier were considered as completely random reveal clear evidence of having some ordered structure in both time and space. These new methods (fractals, percolation, nonlinear dynamics and complexity theories) allow visualization and quantitative assessment of the level of complexity (orderliness) of these structures, using both theoretical models and experimental data.

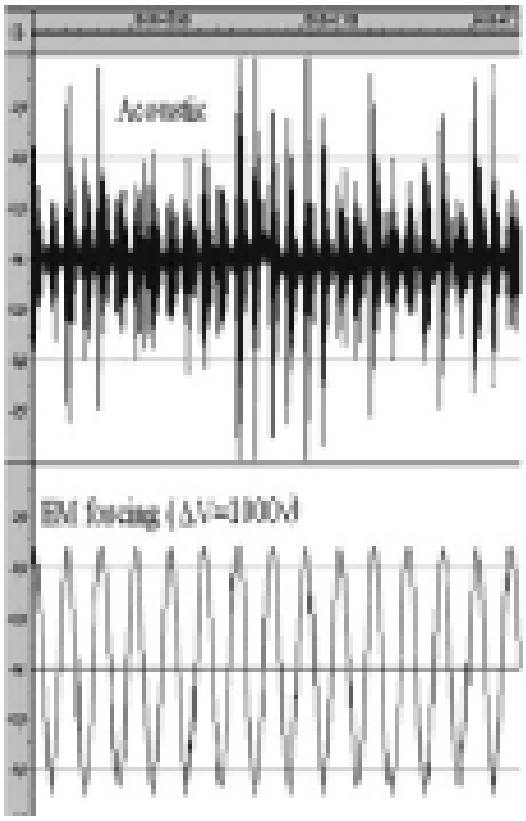
• The physical properties of geophysical medium are not always self-consistent and manifest fractal behavior on selected spatial and temporal scales. Mechanical percolation theory (suggested in 70-ies by T.Chelidze) can be used for modeling geometry of fracture process. Namely, we consider fractal and connectivity aspects of delayed failure, including energy emission during fracturing. Special attention is paid to relating the intensity of geophysical anomalies to the strain in the framework of the pressure-induced anomalous strain-sensitivity (percolation) model, which explains naturally the observed heterogeneity of response of a geophysical media to the strain variation.

• Modern linear and nonlinear tools of time series analysis allow revealing ordered patterns in these complicated recorded geophysical sequences. Extent of complexity of these time series can range from close to determinism or low dimensional chaos to high dimensional (measurable) nonlinear dynamical structure. Application of new universal tools reveals such details in experimental time series, which were beyond the reach of classic data analysis methods and helps to understand and predict geophysical phenomena on different scales.

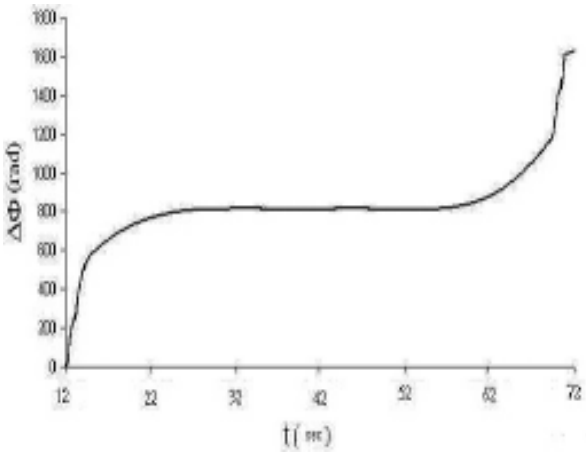
Stick-slip under external forcing as a model of seismic process' triggering/synchronization



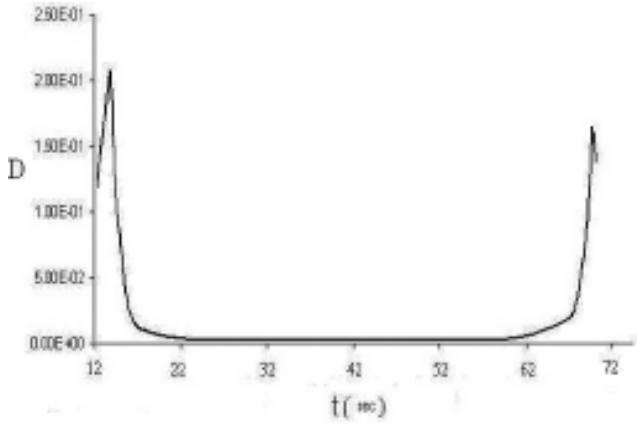
Acoustic emission (AE) during stick-slip without forcing



Acoustic emission during stick-slip with electromagnetic (EM) forcing

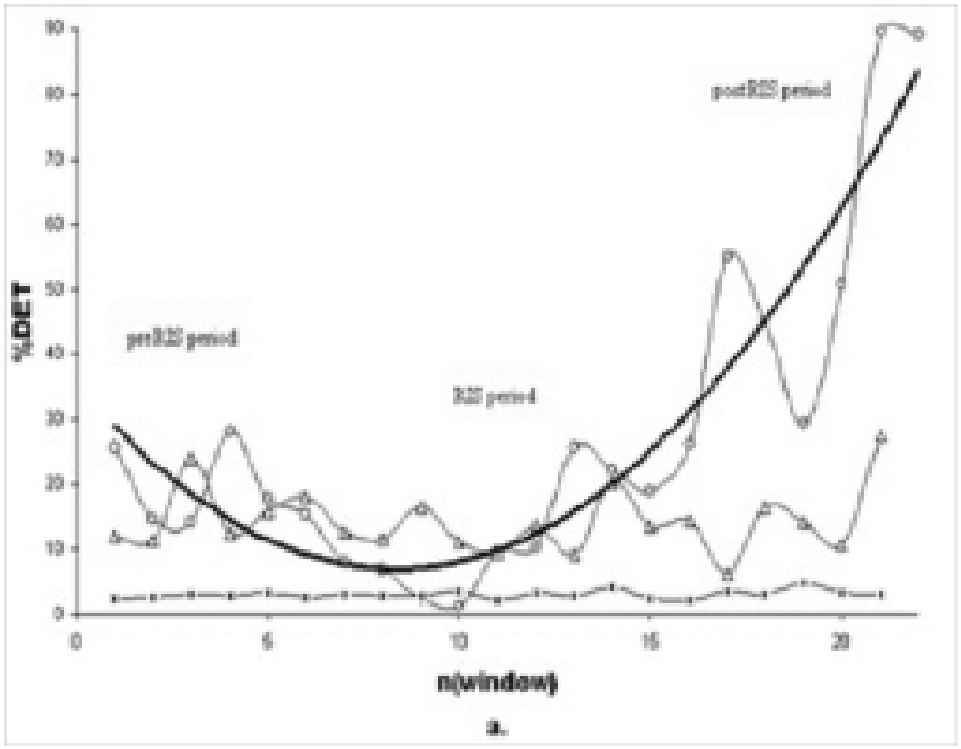


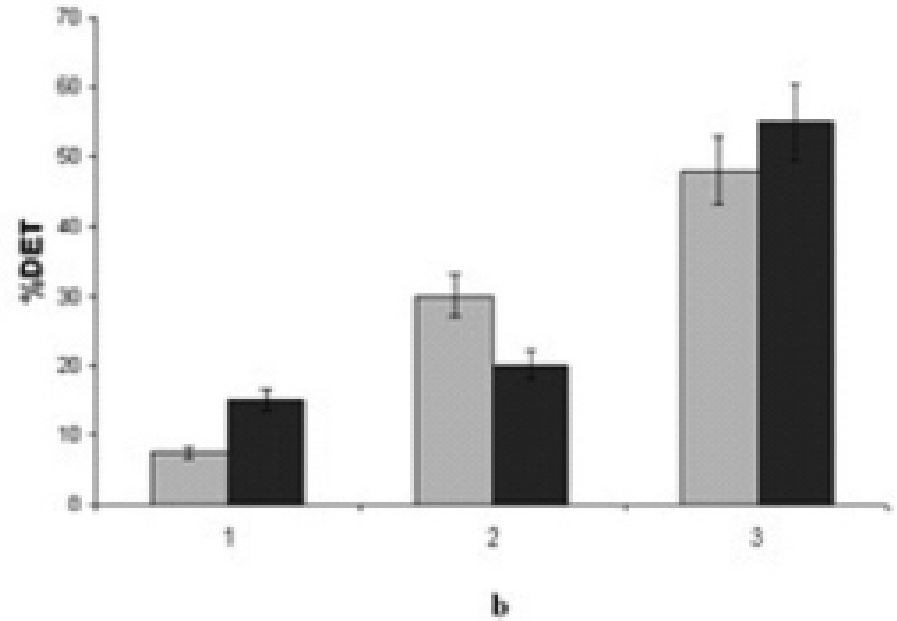
Phase difference between AE and EM forcing applied in the time interval 22-62 sec.



Phase difference coefficient D. EM forcing was applied in the interval 22-62 sec.

Increase of order in seismic processes around large reservoir induced by water level periodic variation, Nonlinear Dynamics, 399-407, 51, 3, 2008





a) RQA % DET of daily number of earthquakes calculated for consecutive non-overlapping one year sliding windows (circles). Averaged results of RQA % DET for 20 shuffled (asterisks) and phase randomized (triangles) surrogates of daily number of earthquakes in consecutive one year sliding windows; b) RQA % DET of magnitude (black columns) and waiting time (grey columns) sequences: (1) Before dam construction, (2) during first fillings and (3) during periodic regime of filling and mscharge.

Modern equipment for geophysical and ecological investigations

Electrical prospecting system SARIS

Water laboratory DREL/2800-spectrometer
Radon measurements system -SISIE
Tree sets of online Grounwater Monitoring system Type “Flash-com” (water level, temperature and conductivity)
Microscope Konuspix Digital, web Camera&PC.
Portable field thermo-conductivity meter (model WTW 197i) Software for numerical modelling of underground water systemd FEFLOW
Electrical prospecting system SARIS
Proton magnitometer (observatory)
Fluxgate magnetometer ((observatory)

Proton magnitometer

Fluxgate magnetometer