ROMANIAN ACADEMY

ROMANIAN NATIONAL COMMITTEE
OF GEODESY AND GEOPHYSICS

NATIONAL REPORT*

ON GEODETIC AND GEOPHYSICAL ACTIVITIES IN ROMANIA

2007 – 2011

Prepared for the XXVIth IUGG General Assembly
Melbourne - AUSTRALIA
28 June -7 July 2011

Bucharest
2011

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FOREWORD

The National Report of the Romanian Committee of Geodesy and Geophysics (RNCGG) prepared for the XXVI-th General Assembly of IUGG aims at presenting the main directions and results of newly initiated and/or developed scientific researches of Romanian geoscientists, corresponding to the component associations, regarding the interdisciplinary study of the planet Earth.

In the framework of this volume, each section of the RNCGG has displayed, under the guidance of the national correspondents, the involvement of Romanian scientists and specialists in major national (especially in the frame of the National Programme of Research of Rsearch and Development - PNCDI) and international research projects (especially in the frame of the FP 6 and FP 7 Programme), the organization of significant conferences and symposia, as well as the main topics discussed by the Romanian participants.

A selective bibliography is presented as an important part of every contribution within the National Report, allowing to those interested to continuously follow the development of the research projects as well as the involved working groups, in view of establishing contacts that we hope will prove to be mutually profitable in the next future.

This report, conceived as an ensemble that allows the interested reader to get an accurate image upon the activity in geodesy and geophysics in Romania, includes the interval 2007-2011.

The possibility of presenting a quite comprehensive volume is a consequence of the continuous improvements in the organizational policy of the RNCGG, by appointing a new national correspondent (IACS) as well as new members and secretaries of the associations' committees. Significant efforts and dedicated work have been provided by Dr. Constantin Stefan Sava, RNCGG Secretary General and by all the associate editors. Their most important contribution is acknowledged and thanked.

The National Report represents also homage to our dear professors and former presidents of the Romanian National Committee of Geodesy and Geophysics, founders of the Romanian school of geophysics, Acad. Sabba S. Stefanescu and Acad. Liviu Constantinescu.

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INTERNATIONAL ASSOCIATION OF GEODESY

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Contributions in Geodesy

Section I: POSITIONING AND REFERENCE FRAMES

1. Background

For the time interval 2007-2010 geodetic activities in Romania were in progress according to the economy and social situation. Economical development in our country after integration into European Union concluded to some positive effects mainly for the time interval 2007-2009. The professional bodies reorganized and for geodetic activities the Geodesists Order was created by Law 17/2006 for organizing the geodesists profession according to the Law 7/1996 – Cadastre and Real Estate law. A drawback on this activity was done by suspending the Geodesists Order Law.

The National Agency for Cadastre and Land Registration (NACLR) under Ministry of Administration and Interior is the state responsible institution for geodetic and mapping activities in Romania. From a self financing public institution NACLR was transformed since 2009 in a state budget institution. NACLR includes the national mapping activities and 42 Cadastre and Land Registration Offices. As research and production institution acts the National Centre for Geodesy, Cartography, Photogrammetry and Remote Sensing. Due to the difficult economical situation, in 2009 and 2010, NACLR was reorganized by decreasing the employees number.

2. Global Navigation Satellite System (GNSS) Network

According to the global and European trends in the field of modern geodetic networks, Romania followed this trend by promotion and implementation of a new high accurate geodetic network in the time interval 2007-2010. The new geodetic network it is build as an active continuously operating network. As technological equipments the GNSS (GPS and GPS+GLONASS) receivers are included into the network.

Starting 1999, when it was installed the first GPS permanent station in Romania at the Faculty of Geodesy - Technical University of Civil Engineering Bucharest (BUCU) in cooperation with Federal Agency for Cartography and Geodesy Frankfurt a.M. (Germany), the new methods of global satellite positioning were introduced in Romania.

In 2001 the National Office for Cadastre, Geodesy and Cartography (reorganized in 2004 as National Agency for Cadastre and Land Registration) installed 5 GPS permanent stations in Braila, Suceava, Cluj, Sibiu, Timisoara (BRAI, SUCE, CLUJ, SIBI, TIMI) as a necessity for the precise geodetic measurements in the area. Romania as a CERGOP (Central European Regional Geodynamic Project) country member installed two GPS permanent stations in Craiova and Constanta in 2004 (CRAI, COST). In 2005 the continuously modernization of the National GNSS Permanent Network consisted in the installation of 5 new GPS permanent stations in Bacau, Deva, Baia Mare, Oradea and Sfântu Gheorghe (BACA, DEVA, BAIA, ORAD, SFGH). With their own funds or from PHARE and World Bank the GNSS network was continuously extended by the National Agency for Cadastre and Land Registration (NACLR) in 2007-2010. At the end of 2010 the Romanian GNSS permanent network included 60 GPS and GNSS permanent stations installed by NACLR and one GNSS permanent station installed at the Faculty of Geodesy, Technical University of Civil Engineering Bucharest Bucharest. The EUREF(EPN) station BUCU was introduced into the IGS network since 2005 and was modernized in 2008 with the help of the Federal Agency for Cartography and Geodesy Frankfurt a.M. (Germany). Other 6 stations were modernized in

2009 by replacing old equipments (Leica System 530) with new equipments (Leica 1200 GNSS+, AR25 antennas).

Romania it is member of the EUPOS (European Position Determination System) organization contributing to the standards adopted by members from 18 Central and East European countries and EUPOS infrastructure by realizing *ROMPOS (Romanian Position Determination System)* based on the 60 GPS and GNSS permanent stations.

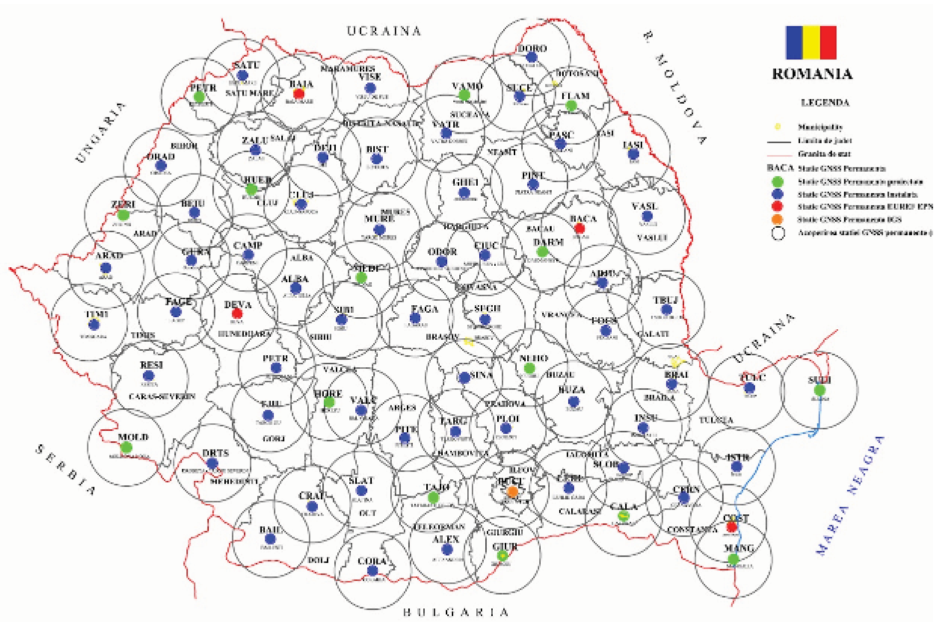


Figure 1a. Romanian National GNSS Permanent Network (ROMPOS) – 2010
(red – IGS/EUREF/EUPOS sites; blue – EUPOS sites; green – future sites)

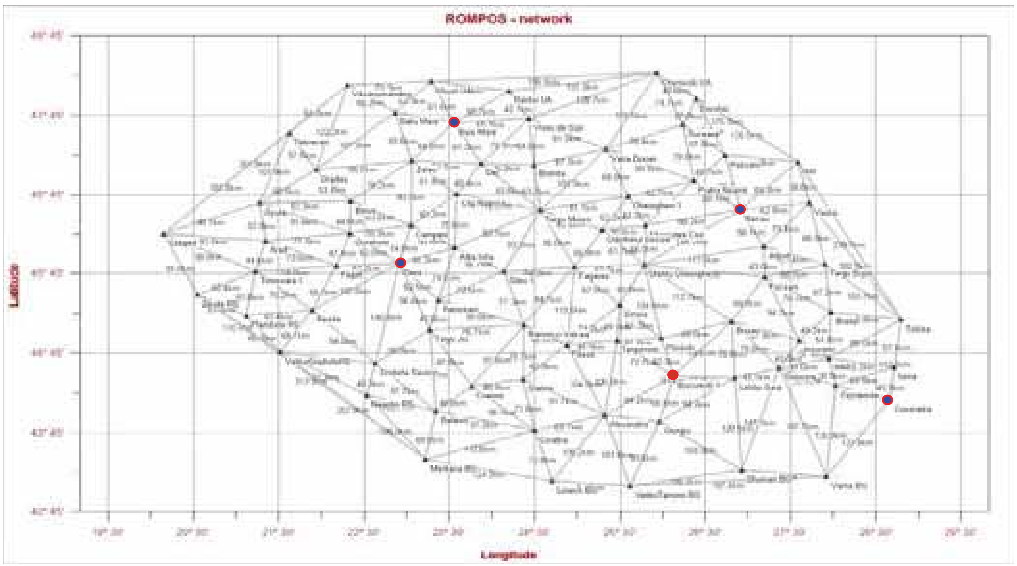


Figure 1b. ROMPOS – 2010 – distances between permanent stations
(red – IGS/EUREF/EUPOS sites; included stations from BG, SR, HU and UA))

In January 2006, the NACLR integrated in the EUREF-EPN (European Permanent Network) 4 new GPS permanent stations: BACA, BAIA, COST and DEVA as a contribution to the European reference frame maintenance and other special projects. The EUREF-EPN GPS station in Constanta (COST) it is located near to a tide gauge and it is connected with this by precise leveling. The accuracy for the coordinates of the stations are better than +/- 1cm. All stations are Class A according to EUREF-EPN standards.

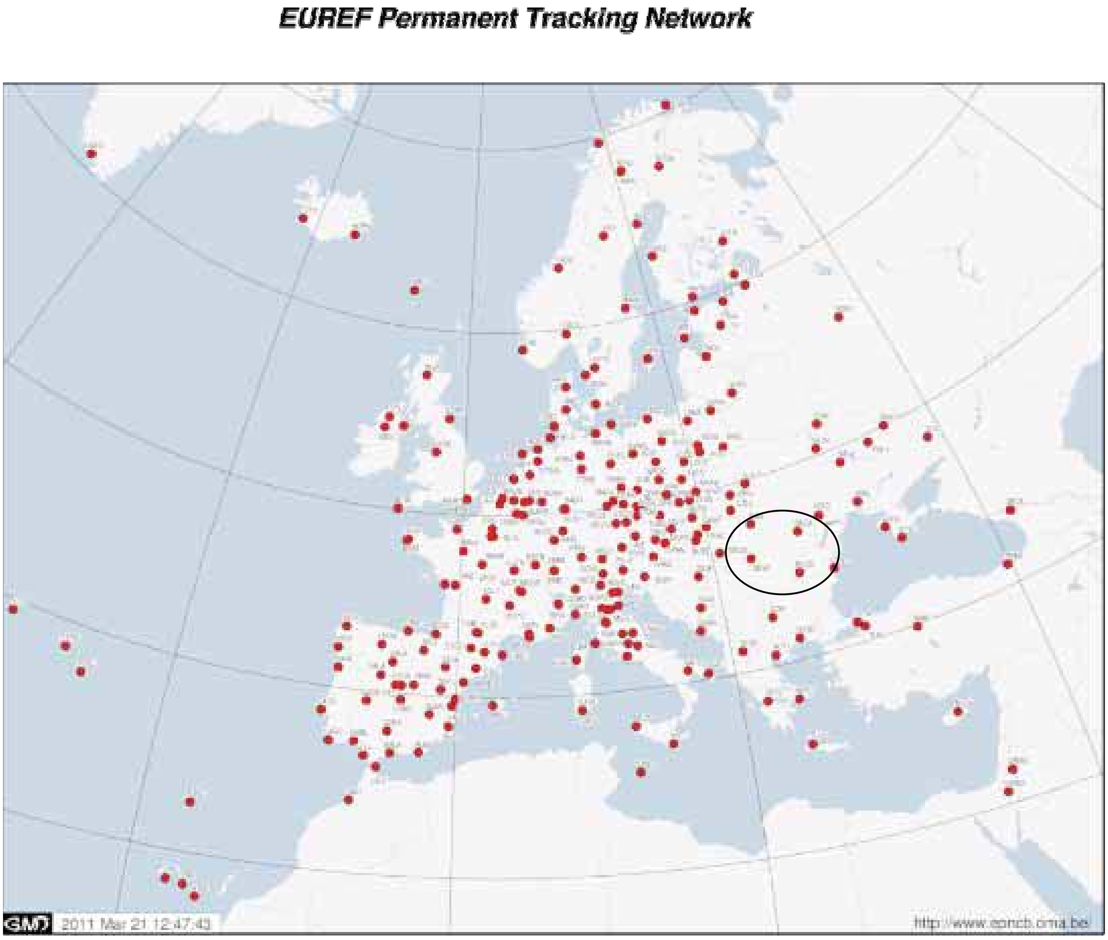


Figure 2. IGS and EUREF-EPN stations in Romania (Bucu, Baia, Baca, Cost, Deva)

The National Space Geodetic Network (GNSS) was proposed to be divided into "classes" to be separated from the old triangulation network divided in "orders". The proposed classes and present status are presented in the next table.

The National Spatial Geodetic Network (NSGN) is formed from the total ground points that have coordinates determined in the ETRS89 Coordinate Reference System and normal heights in Black Sea 1975 reference system, with the possibility to be transformed into the Vertical European System (EVRS).

National Spatial Geodetic Network is structured on classes, using the precision and density criteria, as in the following table.

Table 1. Classification of the NSGN components

Network class	ID	MSE (cm)	No. points/Density/ Distribution	Domain / Observations
National Spatial Geodetic Network Class A0	A0	1.0	*5 GNSS permanent stations (IGS and EUREF-EPN) 1 point / 50000 km²* *Uniform distribution*	- link to the global and European geodetic networks; - regional and local geodynamics measurements, deformation determination real time positioning services, meteorology
National Spatial Geodetic Network Class A	A	1.0	*73 GNSS permanent stations 1 point / 3250* km² *Uniform distribution*	- link to the class A0 network, - regional and local geodynamics measurements, deformation determination real time positioning services, meteorology
National Spatial Geodetic Network Class B	B	2.0	*330 points 1point ./700km²* *Uniform Distribution*	- regional and local geodynamics measurements, high precision topographic determinations
National Spatial Geodetic Network Class C	C	3.0	*About 4750 points 1point/50km²* *Uniform distribution*	- high precision topographic measurements, cadastre; -partial realized
National Spatial Geodetic Network Class D	D	5.0	*At least 1point/5km²* *even distribution*	- topographic measurements, densification networks, G.I.S. - partial realized

MSE – Mean Square Error of the 3D position determination

Figure 3. Class B - National Spatial Geodetic Network (NSGN)
(green – new monuments; blue – old monuments from triangulation network)

Class B network was observed in 2003 and the results were included into national database in 2005. From the total number of stations about one third have geometric leveling. A number of 86 stations are old triangulation markers observed by GPS with coordinates in national geodetic reference system Krasovski ellipsoid and Stereographic 1970 projection system). The Class B network was constrained on the Class A network. The precisions for the coordinates of these stations are less than 2cm. Class C network including more than 1000 stations was observed since 2005 till present and it is not yet complete. The precisions for the coordinates of these stations are less than 3cm. Class D network will be realized in general for cadastre with a no uniform distribution and the precision of these stations will be less than 5 cm. (http://gnss.rompos.ro)

3. Leveling Network - Romanian Contribution to EVRS Realization

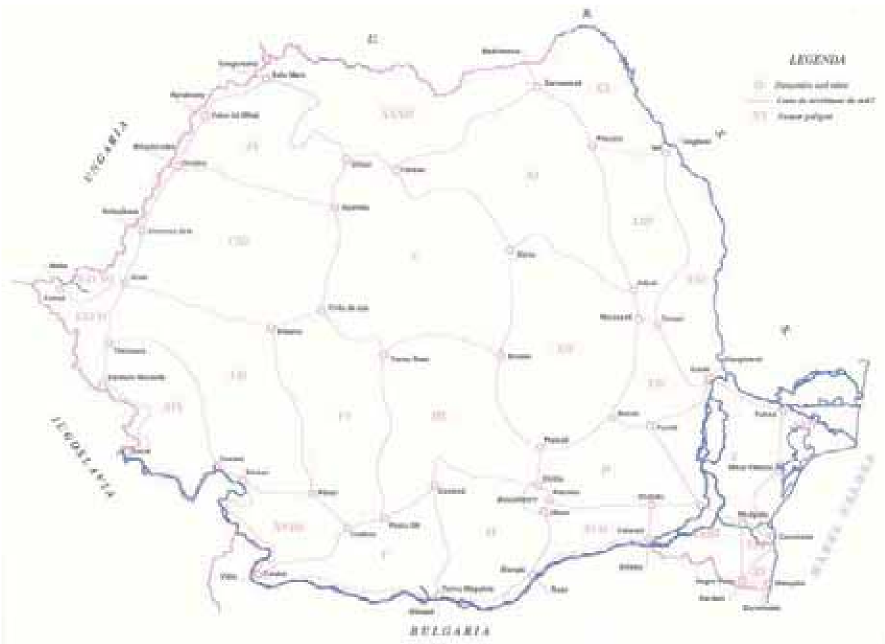


Figure 4. Romanian Leveling Network

The National Leveling Network it is divided in 5 orders (function of precision). The National Precise Leveling Network of Ist order consists in a number of 19 polygons with a length of 6600 km and includes 6400 points with a density of 1 point/km^2. 24 leveling lines establish the connections with neighbour countries: 2 with Ukraine, 1 with Republic of Moldova, 6 with Bulgaria, 10 with Serbia/Montenegro and 5 with Hungary.

This network was densified till 32 polygons with levelling networks of IInd -Vth order (see Figure 4). Normal heights are available for the National Leveling Network.

The Romanian contribution to UELN (2000) contains the nodal points of the polygons of first order (65 points) and 89 levelling observations.

In 2007 the National Agency for Cadaster and Land Registration introduced officially the results of a new adjustment of the leveling network performed by National Center for Geodesy, Cartography, Photogrammetry and Remote Sensing and Technical University of Civil Engineering Bucharest as “Black Sea 1975 datum (Edition 1990)”.

The EUVN97 (European Unified Vertical Network 1997) included 4 points from the Romanian Levelling Network: RO01 (Sirca-Iasi), RO02 (Constanta), RO03 (Timisoara) and RO04 (Tariverde – Height 0) points measured with GPS technology and absolute gravity. For these points the known ETRS89 coordinates and normal heights (precise levelling) in Black Sea 1975 datum were determined together with absolute gravity. For the ECGN project in September 2004, Austrian Federal Office of Metrology and Surveying (BEV– Bundesamt fuer Eich-und Vermessungswessen) in cooperation with Romanian National Agency for Cadastre and Land Registration (NACLR) and Military Topographic Directorate, performed an absolute gravity observation campaign in Romania. A number of 4 absolute gravity stations were observed by JILAg-6 absolute gravimeter. Romania participated with such information to the EVRS realization - EVRF2000.

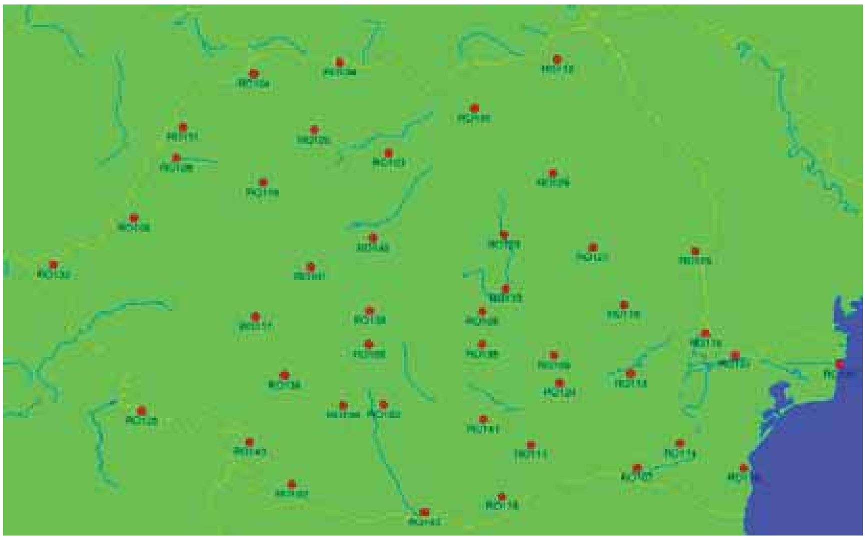


Figure 5. Romanian contribution to EUVN_DA project (2009)

After 2000 year Romania further contributed by providing new data including 43 stations with ETRS89 ellipsoidal heights and normal heights in national height reference system (Fig.5). This was the contribution to the EUVN_DA (Densification Action) project with final result the EVRF2007 realization. 25 European countries participated and submitted the data of more than 1500 high quality GPS/leveling benchmarks. The submitted data was validated and converted into uniform reference frames. The final report was discussed at Technical Working Group meeting and presented at the EUREF2009 symposium, held in Florence (Italy). The results were circulated to all contributing National Mapping Agencies including Romanian National Agency for Cadastre and Land Registration.

This action it is continued in Romania by NACLR. For each county it is planned to be realized a number of minimum 5 such stations. In 2010 there are fully covered a number of 10 counties (about 25% of total). New data will be provided periodically to the EUREF for inclusion in new EVRF realizations.

As a final EVRF2007 realization in Romania, a standard transformation parameters were computed by EVRF computing centre from Federal Agency for Cartography and Geodesy (BKG, Germany). These set of parameters realize the transformation of normal heights from Black Sea 1975 System to EVRF2007 (RO_CONST / NH to EVRF2007).

Transformation parameters were derived from 48 identical points (UELN nodal points) with a transformation RMS of 0.004 m, and residual deviation between -0.012 m and +0.013 m.

A general view of the EVRF2007 realization in comparison with national height reference systems can be seen on the next picture.

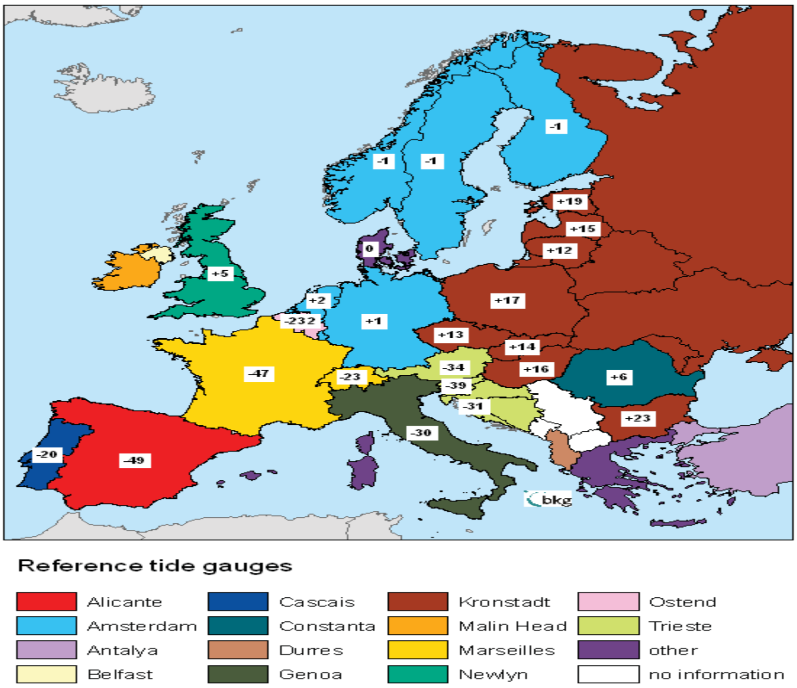


Figure 6. Mean differences between EVRF2007 and national height reference systems (+6cm Romania)

In 2009, NACLR finalized the coordinate transformation including a distorsion model from ETRS89 system to S42 (Krasovski ellipsoid) – Stereographic 1970 projection system and provided *TransDatRo* software and algorithm for the users.

Transformation of normal heights from Black Sea 1975 System to EVRF2007, finalized at the present moment, complete the most recent link between the national coordinate reference systems and pan-European systems. NACLR intends to include this option in the software package for coordinate transformation *TransDatRO* which is already published on internet and will be implemented on national geoportal for spatial data harmonization and interoperability. The transformation parameters were published on the on-line information system *(http://www.crs-geo.eu/),* which contains the descriptions of the different national Coordinate Reference Systems (CRS) for position in Europe as well as the transformation parameters from the national systems to the ETRS89 according to the ISO standard 19111 Geographic information - Spatial referencing by coordinates.

- About 60% of the GNSS permanent stations included in the national GNSS reference network, are connected by leveling with the national leveling network (precise leveling close to the building and than precise trigonometric leveling to the antenna).
- A new leveling campaign was started by NACLR in 2010 and will be continued in 2011 in the metropolitan area of Bucharest. The goal of the project it is to establish and densify the national leveling datum for this area by precise (geometric) leveling. The project will include gravity observations in this area in order to compute a local quasigeoid.

4. PROJECTS

Romania participate especially by National Agency for Cadastre and Land Registration to the international and national projects. The most important projects are mentioned below.

- **European Position Determination System (EUPOS) – interregional cooperation (IRC)** – 4E00261 (2006/2007)
  The main objectives of the project were to strengthen the cooperation and cohesion between the participating countries and regions and to create awareness for the benefits of satellite-based applications. It can be reported that the goal was achieved by the operation. The cooperation between the countries and regions was extended from only some higher level persons to the working level by the cooperation of the GNSS National Service Centres or Know-how offices, by the regional workshops and study visits.
  A new proposal of INTERREG IVC was launched in 2011 by representative institutions mainly from EUPOS countries.
- **Twinning project** RO 2006 / IB / OT – 01; PHARE 2006 / 018 - 147.02.01.03: (National Agency for Cadastre and Land Registration – NACLR – Romania / Cadastre, Land Registry and Mapping Agency - Kadaster – Olanda): *Geodetic Network Modernization and National Spatial Data Infrastructure,* was a project to support a good cooperation between similar (cadastre) agencies from EU and to transfer good practices from one institution to the other one. The project included more components, mainly geodesy and cartography including the new problems related with EU INSPIRE directive for national spatial data infrastructures.
- **EuroBoundaryMap (EBM) –** The objective of the project it is to realize a geospatial data set for Europe including the administrative limits of Romania, their codes and names for 1:100000 scale. In October 2008 version 3.0 was released, and in 2009 these limits were updated for the beginning of 2009 year.
- **EuroGlobalMap (EGM) –** The objective of the project it is to realize a uniform set of geospatial data at 1:1000000 scale for the entire Earth. Version 3.0 of this product was released in 2009 and the next update will be in 2011.
- **EuroRegionalMap (ERM) -** The objective of the project it is to realize a uniform set of geospatial data for Europe at 1:250000 scale structured in seven thematic layers: administrative boundaries, hydrographs, transport, localities, vegetation and soil, topographic names, and others (high power lines, tourist buildings, parks, national parks et al.). Update rate for this products it is one year.
- **Underpinning the European Spatial Data Infrastructure with a Best Practice Network (ESDIN) –** represents the european spatial data infrastructure realized based on the UE member states national spatial data infrastructures. ESDIN has as objective a better use of spatial data, reuse of digital data and realization of new products and services.
- **New ortophoto products in Romania –** In the time interval 2007-2011, new ortophoto products were realized as: large scale ortophoto for Bucharest (1: 500 scale) and at 1:1000 scale for other main cities in Romania (Ploiesti, Târgoviste, Constanta, Brăsov et al.); Starting with 2010 year, Military Topographic Directorate will provide ortophoto products for Ministry of Agriculture and other state institutions.

- **Cadastre and land registration** activities were continuously performed on private initiatives but also on state projects. Some projects were developed as the *CESAR ("Complementing EU Support for Agriculture Restructuring")*. Romania has received financing in the amount of EUR 47,700,000 equivalent from the World Bank toward the cost of the Complementing European Support for Agricultural Restructuring, and it intends to apply part of the proceeds toward payments under the contract for systematic registration of immovable properties. The National Agency for Cadastre and Land Registration (NACLR) invited eligible bidders for executing systematic registration of immovable properties in 19 administrative territorial units (UAT) within 13 counties.

  It is planned for CESAR project to support the *extension of national GNSS reference network with 15 new permanent stations* in order to finalize this network. For areas without or with bad GSM/GPRS coverage in Romania on the same project will be possible to achieve few mobile radio transmitters with a good coverage (30-50 Km radius) to be deployed in such areas to be able to broadcast RTK data (from ROMPOS system or locally generated corrections) for GNSS RTK users involved in projects as CESAR or other projects including RTK positioning.

- **GNSS technology for disaster management**

  In 2010 on the Danube and other rivers as Siret and Prut significant floods damaged the river surrounding areas in Romania. National Agency for Cadastre and Land Registration (NACLR) supported by GPS observations and leveling 3D positioning in the flooded area. Topographic and geodetic determination for flooded areas included mainly the accurate heights determination for the Siret and Danube level and surrounding areas. Rapid data transmission and data processing were necessary.

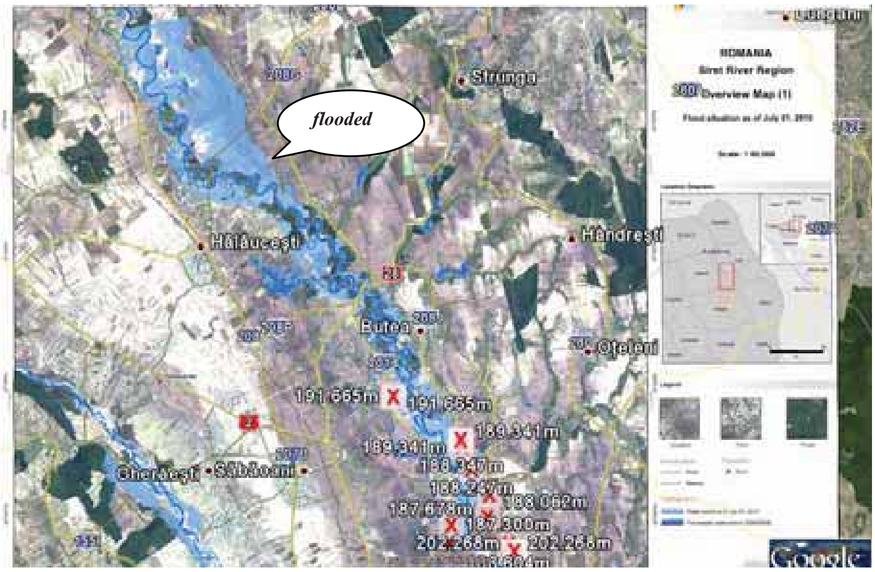


Figure 7. Flooded area on the Siret river - July, 2010 (red X – GNSS epoch stations)

Transformation from one reference system (ETRS89) to another (national reference system), plotting and interpretation together with other involved institutions and government bodies was necessary.

The main task of the geodetic services was the fast delivery of accurate and reliable results, especially heights. Special projects were performed along the Danube and

Siret river. GNSS technology provided a great support in disaster management and underlined the significant potential of this technology. Further improvement by use of DGPS/RTK capabilities provided by ROMPOS (EUPOS) services were proposed to be improved for a better response on emergency and disaster situations in cooperation with remote sensing registration provided by international and/or European agencies.

- **CERGOP (Central European Regional Geodynamic Project)**

The main objective of the project is to monitor the recent crust movements, detecting the borders of the tectonic plates and quantifying their three dimensional rates. The objective is achieved especially by the use of GPS technology and other significant data sources. Romania participate at this project since 1995 by Technical University of Civil Engineering and National Centre for Geodesy, Cartography, Photogrammetry and Remote Sensing Bucharest (former Institute for Cadaster, Geodesy, Photogrammetry and Cartography) to the Work Package 10. „Geodynamics of Central Europe“, WP.10.2. *Three Dimensional Plate Kinematics in Romania*.

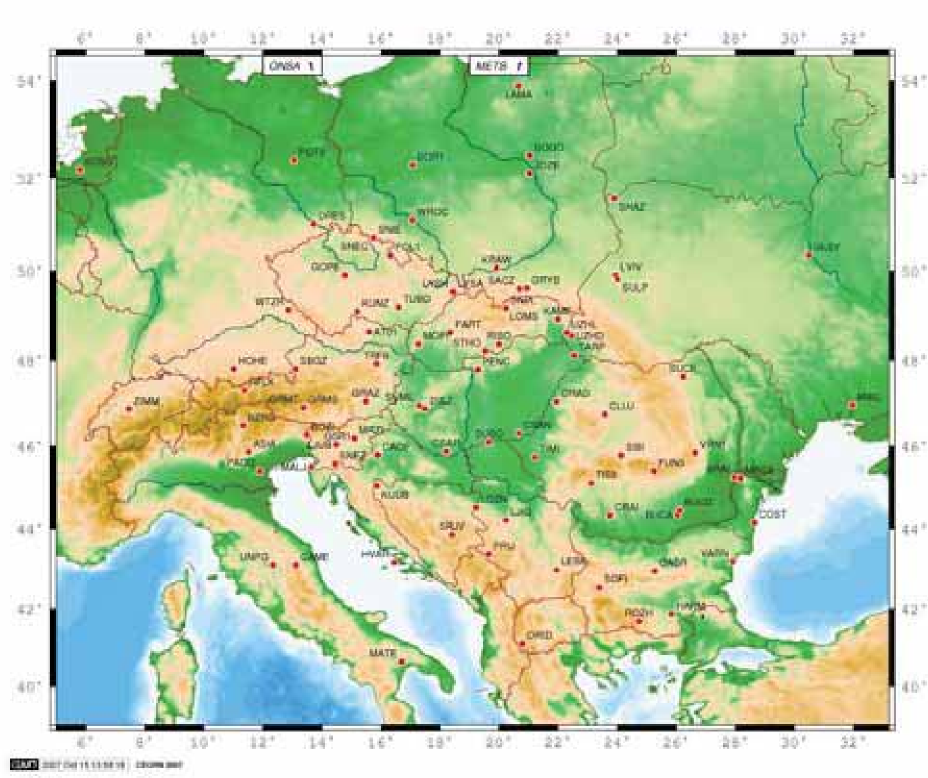


Figure 8. CEGRN network (http://cergop.oeaw.ac.at)

The main tasks of the project are:
- Romanian geodynamic research integration with Central European research;
- Establishment of reference geodetic network for geodynamic – CEGRN – Central European Geodynamic Regional Network, with less than 1cm accuracy;
- Tectonic plate velocity estimation on Romanian territory by geodetic methods (mainly GNSS);
- Realization of the monograph of Romanian geotectonic components;
- New technologies and methods for geodetic data processing;
- Close cooperation with similar institutions from participating countries;
- Dissemination of research results by different means (publications);

- New research projects proposals on geodynamic.

In the frame of the CERGOP a Central European Regional Geodynamic Network (CEGRN) was designed and realized including permanent and epoch stations observed by GPS technology. CEGRN was designed for geodynamic purposes (tectonic and geological position, markers, repeatability). The coverage includes the Central Europe (CEI countries) and was observed yearly (1994-1997) and every two years after (1999 – 2009). CEGRN was continuously extended with new stations, especially permanent stations in the last decade.

- **INDEGEN Project**

Based on the previous geological and geophysical information a special network for geodynamic monitoring of the Romanian territory has been designed and achieved. The network consists of three lines crossing the major lithosphere contacts: the Tornquist-Teisseyre Zone *(TTZ)* separating the East European Plate from the Intra-Alpine Microplate *(IaP)*, Peceneaga-Camena Fault, as the boundary between EEP and Moesian Microplate *(MoP),* and the Trans-Getica Fault *(TGF)* between MoP and IaP. The fourth line is crossing the Vrancea active geodynamic area located in the bending area of East Carpathians.

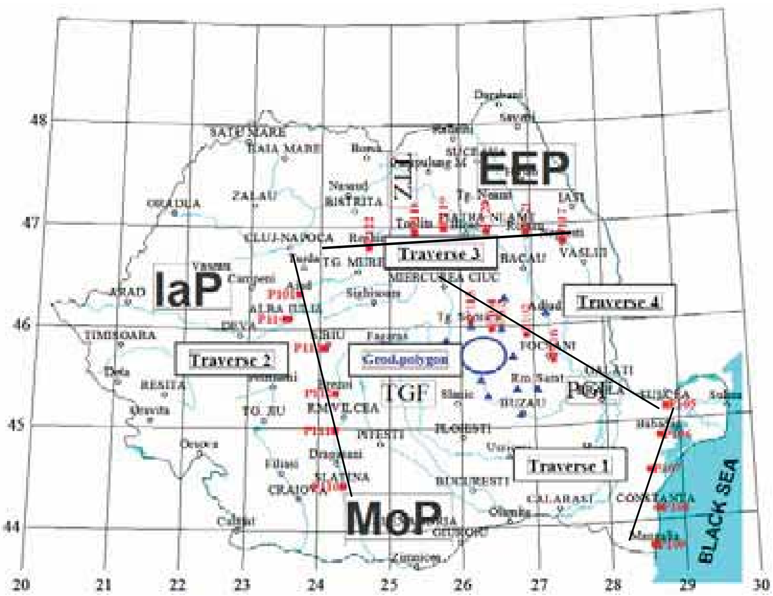


Figure 9. INDEGEN (geodynamic) network

The project INDEGEN (grant CEEX-2 MENER no. 732/2006-2008) started in 2006 with a duration of three years, managed by the Institute of Geodynamics of the Romanian Academy in co-operation with other scientific organizations: Technical University for Civil Engineering – Faculty of Geodesy, University of Bucharest, Geological Institute of Romania, and National Institute for Earth Physics. The main task of geodetic activities was to perform repeated GPS and leveling observations combined with other observation techniques as gravity. The geodetic network was observed in two campaigns from 2007 and 2008. Further investigation are necessary in order to calculate displacements and velocity vectors for that region.

Section II: ADVANCED SPACE GEODESY

- **EUPOS (European Position Determination System)**

Romania participate by National Agency for Cadaster and Land Registration at the EUPOS (European Position Determination System). The EUPOS initiative is an international expert group of public organizations coming from the field of geodesy, geodetic survey and satellite deployment. Partners from 18 CEE (Central and East European) countries have come together with the aim to establish in their countries compatible spatial reference infrastructures by using the Global Navigation Satellite Systems (GNSS) GPS, GLONASS and as soon as available GALILEO by building up Differential GNSS *EUPOS* reference station services. The *EUPOS* services *(RTK, DGNSS and Geodetic)* will allow a high accuracy and reliability for positioning and navigation and provide a wide range of geoinformation applications on this basis.

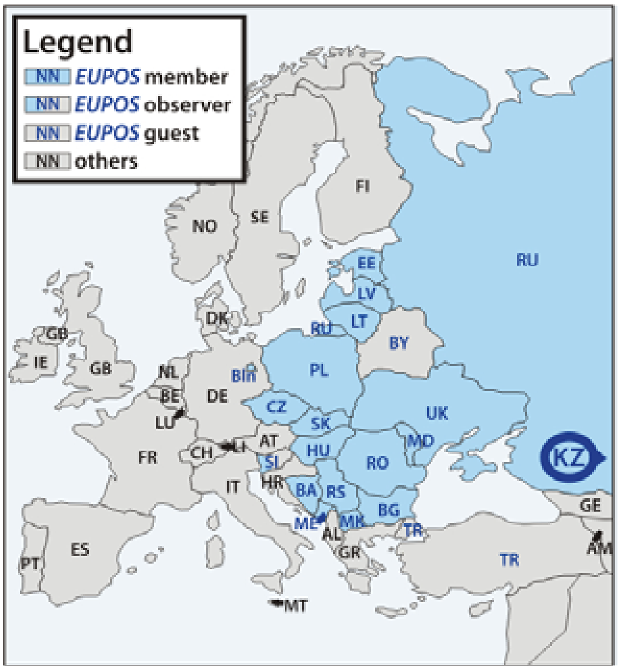


Figure 10. Distribution of EUPOS permanent stations (www.eupos.org)

Members of the *EUPOS* cooperation are topically Bosnia and Herzegovina, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Ukraine and the German State Berlin. Slovenia has an observer status.

This fundamental infrastructure is based technically on a network of DGNSS reference stations and adequate communication lines. The data products can be used in many different applications requiring accuracy better than 3 m up to the 1 cm level in real-time *(DGNSS and RTK services)* and sub-centimeter precision by post-processing *(Geodetic service)*. This “full scale accuracy” concept aiming all types of users from environmental protection, transport and public security, hydrography, maritime surveying, river and maritime traffic, fishing, machinery and vehicle control, to spatial data infrastructure developers and to geodesy. *EUPOS* is independent of private company solutions and uses only international and unlimited worldwide usable standards. In case international agreed standards do not exist, *EUPOS* is working on the standardization in the corresponding organizations like the Radio Commission on Maritime Services, Special Committee 104 (RTCM SC 104). *EUPOS* provides the GNSS observation data and real-time corrections for high precise positioning and navigation with guaranteed availability and quality.

The responsibility of developing and operating the *EUPOS* reference station network is distributed among participating organizations on national level, which give the characteristic flavor of the organization. The backbones of the developments are the International *EUPOS* Steering Committee (ISC) and the National Service Center (NSC) concept, that requires the establishment of a NSC in every participating country.

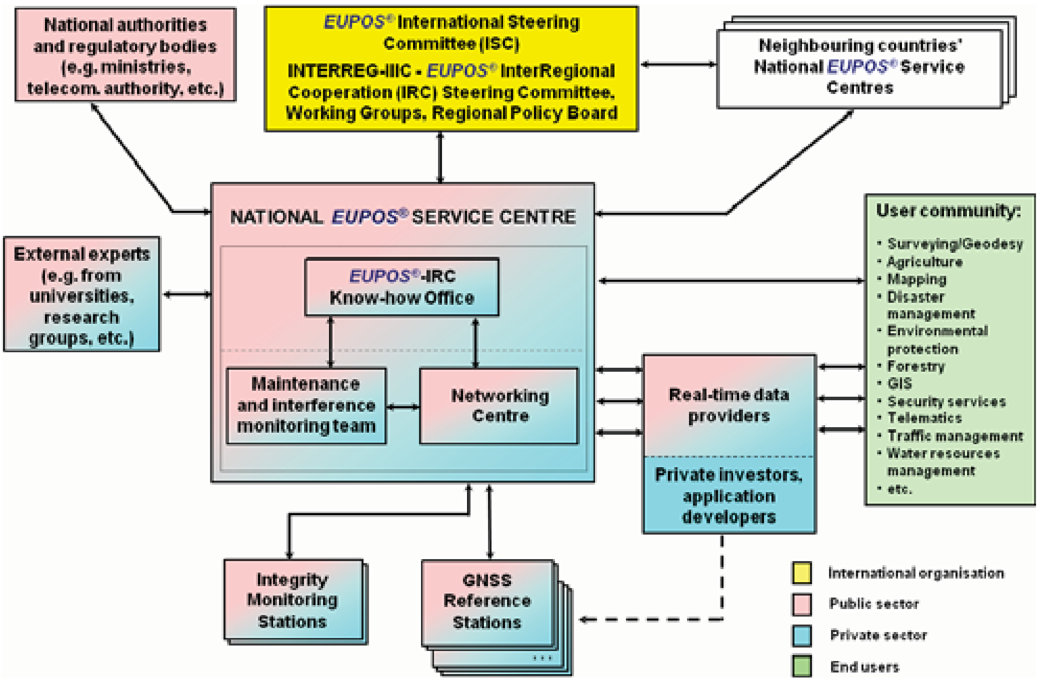


Figure 11. EUPOS National Service Centre structure

The NSCs are responsible not only for network developments and operation, but they are the focal points of user information, quality and integrity assurance and international relations with other *EUPOS* countries. The International *EUPOS* Steering Committee decides and agrees the organizational and technical framework of *EUPOS*. The ISC Office (ISCO) at the Senate Department for Urban Development in Berlin/Germany is the central point of contact for interests of international importance.

With the creation of the European Terrestrial Reference System (ETRS 89) in 1989, a three dimensional geodetic reference system became available for the whole Europe for the first time. Its spatial referencing connection is maintained up-to-date, notably through the EUREF Permanent Network (EPN), which contains the European stations of the International GPS Service (IGS). The ETRF base on the worldwide ITRF. *EUPOS* provides DGNSS correction data referred to ETRS.

Table 2. Number of the *EUPOS* reference stations

Country	Area [km^2]	Number of planned *EUPOS* reference stations	Number of realized *EUPOS* reference stations
Bosnia and Herzegovina	**51 000**	**26**	***(realization in 2009)***
Bulgaria	**110 950**	**23**	**12**
Czech Rep.	**78 870**	**27**	**27**
Berlin (Germany)	**891**	**4**	**4**
Estonia	**45 220**	**17**	**9**
Hungary	**93 030**	**36**	**35**
Kazakhstan	**2 724 900**	**500**	
Latvia	**64 600**	**19**	**19**
Latvia-Riga City	**307**	**5**	**5**
Lithuania	**65 300**	**25**	**25**
Macedonia (FYROM)	**25 434**	**14**	**14 (test network)**
Moldova	**33 700**	**15**	**2 in 2009**
Poland	**323 520**	**98**	**98**
Romania	***237 500***	***73***	***58***
Russian Federation	**17 075 400**	not defined currently	**31***
Serbia	**88 360**	**32**	**32**
Slovak Republic	**46 035**	**21**	**21**
Ukraine	**603 700**	**27** up to 2012 - only for *EUPOS* DGNSS and Geodetic	**9**
Slovenia **(Observer status)**	**20 270**	**15**	**15** *EUPOS* compatible

* Information not up-to-date

NACLR has implemented in September 2008 the EUPOS services by Romanian Position Determination System (ROMPOS) according to the EUPOS standards based on the GNSS network with 48 permanent stations. Since 2010 the station number increased to 58 and will be finalized at 73 stations with station's spacing of about 70km.

ROMPOS services includes three services:

- *ROMPOS-DGNSS*
- *ROMPOS-RTK*
- *ROMPOS-GEO*

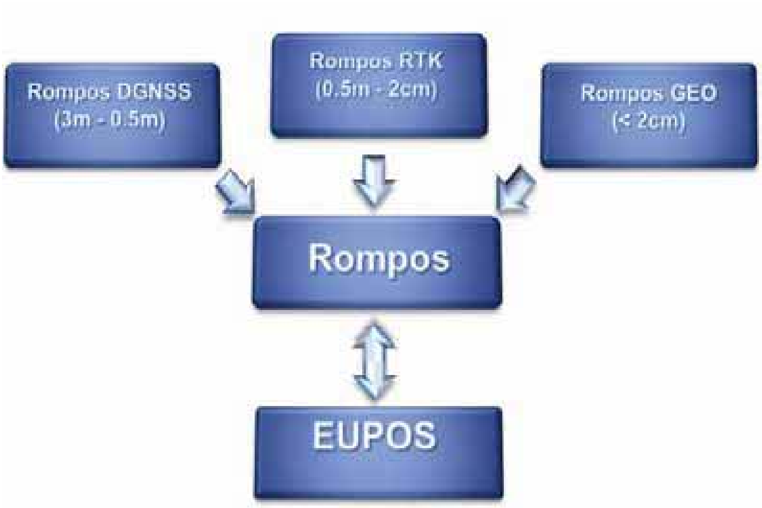


Figure 12. ROMPOS (Romanian Position Determination System) Services

- *ROMPOS DGNSS* for real-time DGNSS applications by code and code-phase measurements with metre up to sub-metre accuracy;
- *ROMPOS RTK* for real time DGNSS applications by carrier phase measurements with centimetre accuracy;
- *EUPOS Geodetic* for post processing applications by code and phase measurements in static or kinematic mode with decimetre up to sub-centimetre accuracy.

In the EUPOS frame, Romania established a very closed cooperation with specialists from EUPOS countries including all neighbour countries (Bulgaria, Serbia, Hungary, Ukraine and Republic of Moldova). GNSS cross-border data exchange was technically already realized between GNSS stations from Romania and agreements are signed with Hungary and Moldova.

New applications of the ROMPOS reference stations will be developed in the near future. Research activities are performed at Technical University of Civil Engineering Bucharest (Faculty of Geodesy) for GNSS meteorology and ionosphere/troposphere influences, reference frame establishment (ITRF, ETRF), geodynamics, engineering surveying based on GNSS (large structures monitoring) et al.

- **EGNOS**

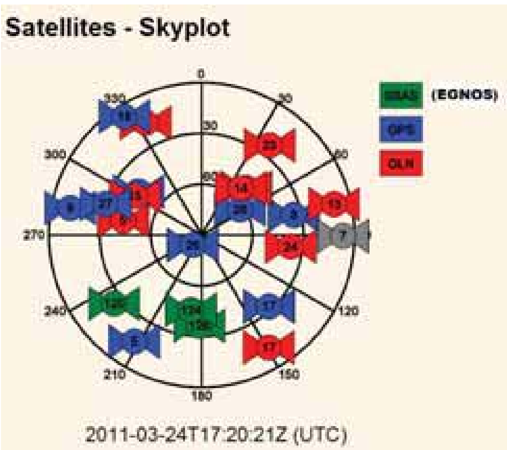
Known as a satellite-based augmentation system (SBAS), EGNOS provides both correction and integrity information about the GPS system, delivering opportunities for Europeans to use the more accurate positioning data for improving existing services or developing a wide range of new services. In the future EGNOS will be able to augment GALILEO in Europe.

The EGNOS signal is broadcast by two Inmarsat-3 satellites – one positioned east of the Atlantic, and the other above Africa – and by ESA's Artemis satellite, which is also above Africa. These three satellites' orbits are in the equatorial plane, at three different longitudes, with each able to broadcast EGNOS services across Europe. Unlike GPS, EGNOS will offer integrity of signal, increased accuracy, coverage and a service level agreement (e.g. alert within specified time). This makes it suitable to provide a number of navigation services. For the most common applications, EGNOS gives a positioning accuracy of one to three metres, compared to the less accurate 10 to 15 m provided by GPS alone. The three services available are:

- Open Service
- Safety-of-Life Service
- EGNOS Data Access Server (EDAS)

The EGNOS *Open Service* has been available since *1 October 2009*. EGNOS positioning data are freely available in Europe through satellite signals to anyone equipped with an EGNOS-enabled GPS receiver. EGNOS Certification is now being managed by the European Commission, who have announced that since *1 March 2011,* EGNOS *Safety-of-Life* signal was formally declared available to aviation. For the first time, space-based navigation signals have become officially usable for the critical task of vertically guiding aircraft during landing approaches. EGNOS provides also a terrestrial commercial data service called the EGNOS Data Access Service (EDAS). EDAS is the single point of access for the data collected and generated by the EGNOS infrastructure. It supports the multimodal use of EGNOS (and later on Galileo) by disseminating EGNOS' services in real time. In order to understand the market's interest for EDAS data, a beta test was designed and works to allow industry, research institutes, and private and public organizations to free access to EDAS' data. This test provides information to the provider of the EDAS service about potential users and how they use the data.

In Romania EGNOS system it is at present less used and needs a better promotion in order to inform the potential beneficiaries of services. According to geographic position of Romania, at the eastern border of EGNOS services, a better coverage would be necessary in the future if uniform services should be provided for all EU countries. The figure below presents the EGNOS signal acquisition at Faculty of Geodesy in Bucharest (GNSS permanent stations BUCU).



Satellites - Tracking Information

SV	Type	Elev. [Deg]	Azim. [Deg]	L1-C/No [dBHz]	L2-C/No [dBHz]	L1	L2	IODE	URA [m]	Type
120	SBAS	24.41	231.78	38.1	-	C	-	75	N/A	-
124	SBAS	45.79	188.14	41.9	-	C	-	75	N/A	-
126	SBAS	36.35	181.51	40.8	-	C	-	118	N/A	-

Figure 13a. GPS, GLONASS and EGNOS tracking at GNSS/EGNOS permanent station in Bucharest

The tracking data indicate that for this position the elevation angle it is less than 50 degrees for any of the EGNOS satellites and this situation could generate problems in satelllite's tracking especially in urban canyons or small obstacles.

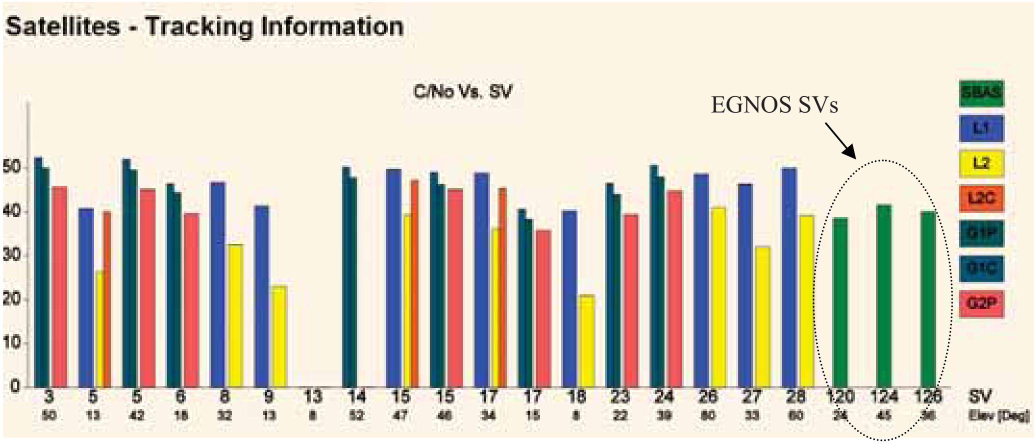


Figure 13b. GPS, GLONASS and EGNOS signal at GNSS/EGNOS permanent station in Bucharest

http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos
http://www.egnos-pro.esa.int/

Section III: DETERMINATION OF THE GRAVITY FIELD

The National Gravity Network of 1st and 2nd order (about 270 points) was observed by the Ministry of Defense – Topography and Cartography Directorate.

Gravity data at the present are not sufficient for the development of an geoid model with an accuracy of 10 cm or better. The EGG97 geoid model available from IAG was purchased by NACLR and tested in order to improve it locally by geometric method (local data and ellipsoidal heights from GPS). A new geometric quasigeoid solution was calculated in 2010 (TUCE Bucharest) based on EGG97 and about 600 ground markers with ETRS89 ellipsoidal heights and normal heights (Black Sea 1975 datum). Further efforts should be done for the modernization of the gravity network. Since 2004 there are no new absolute gravity determination in Romania.

This year (2011), Military Topographic Directorate intends start an important project with support from NIMA (USA) for gravimetric determinations in Romania. There are planned to be observed more than 17000 points in order to be able to generate a quasigeoid with an accuracy of better than 10cm.

Section V complements aspects of the gravity observations performed in Romania in the last time.

Section IV: GENERAL THEORY AND METHODOLOGY

The theoretical and practical aspects of the Geodesy as geoscience continued the evolution in 2007-2011 time interval. The uniform application of the new standards needed the elaboration of new methodologies for the success of the implementation. At the global level some standards organizations took the responsibility for the geosciences as **ISO**

(International Standards Organization). In Romania the counterpart of the ISO it is **ASRO** (Romanian Standardization Association).

The International GNSS Service (IGS), formerly the International GPS Service, is a voluntary federation of more than 200 worldwide agencies that pool resources and permanent GPS & GLONASS station data to generate precise GPS & GLONASS products. The IGS is committed to providing the highest quality data and products as the standard for Global Navigation Satellite Systems (GNSS) in support of Earth science research, multidisciplinary applications, and education. Currently the IGS includes two GNSS, GPS and the Russian GLONASS, and intends to incorporate future GNSS. You can think of the IGS as the highest-precision international civilian GPS community. The IGS global system of satellite tracking stations, Data Centers, and Analysis Centers puts high quality GPS data and data products on line in near real time to meet the objectives of a wide range of scientific and engineering applications and studies.

The IGS collects, archives, and distributes GPS observation data sets of sufficient accuracy to satisfy the objectives of a wide range of applications and experimentation. These data sets are used by the IGS to generate the data products mentioned above which are made available to interested users through the Internet. In particular, the accuracies of IGS products are sufficient for the improvement and extension of the International Terrestrial Reference Frame (ITRF), the monitoring of solid Earth deformations, the monitoring of Earth rotation and variations in the liquid Earth (sea level, ice-sheets, etc.), for scientific satellite orbit determinations, ionosphere monitoring, and recovery of precipitable water vapor measurements.

The primary mission of the International GPS Service, as stated in the organization's 2002-2007 Strategic Plan, “to provide the highest quality data and products as the standard for global navigation satellite systems (GNSS) in support of Earth science research, multidisciplinary applications, and education. These activities aim to advance scientific understanding of the Earth system components and their interactions, as well as to facilitate other applications benefiting society."

The IGS Terms of Reference (comparable to the by-laws of the organization) describes in broad terms the goals and organization of the IGS. To accomplish its mission, the IGS has a number of components: an international network of over 350 continuously operating dual-frequency GPS and GNSS stations, more than a dozen regional and operational data centers, three global data centers, seven analysis centers and a number of associate or regional analysis centers. The Central Bureau for the service is located at the Jet Propulsion Laboratory, which maintains the Central Bureau Information System (CBIS) and ensures access to IGS products and information. An international Governing Board oversees all aspects of the IGS.

The IGS is an approved service of the International Association of Geodesy since 1994 and is recognized as a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) since 1996.

Romania it is contributing to the IGS with postprocessing data from one GNSS permanent station *(BUCU*) and real time data (project *IGS-IP*).

EUREF *is the IAG Reference Frame Sub-Commission for Europe, integrated in the Sub-Commission 1.3, Regional Reference Frames, under Commission 1 – Reference Frames, following the implementation of the new IAG structure at the IUGG (International Union of Geodesy and Geophysics) General Assembly held in Sapporo, 2003.*

The Sub-Commission EUREF was founded in 1987 at the IUGG General Assembly held in Vancouver.

EUREF deals with the definition, realization and maintenance of the European Reference Frame - the geodetic infrastructure for multinational projects requiring precise geo-referencing (e.g. three-dimensional and time dependent positioning, geodynamics, precise navigation, geo-information) - in close cooperation with the IAG components (Services, Commissions, and Inter-commision projects) and EuroGeographics, the consortium of the National Mapping Agencies (NMA) in Europe. (www.euref-iag.net)

Romania it is contributing to EUREF/EVRF with GNSS permanent stations and epoch stations, leveling and gravity stations included as mentioned in *Section I*.

EuroGeographics as the central-hub for Europe's Geographic Information (GI) developments – a unique and diverse network working of all concerned with European GI; National Mapping and Cadastral Agencies (NMCAs), the European Commission and others. The websites contain information of national European Coordinate Reference Systems (CRS) and pan-European Coordinate Reference Systems for position and height. On the sites the following information can be found:

• Description of national Coordinate Reference Systems;

• Description of pan-European Coordinate Reference Systems (ETRS89 / EVRF2000);

• Description of Transformation parameters from national Coordinate Reference Systems to pan-European Coordinate Reference Systems including:

– qualitiy of transformation;
– verification data of transformation;
– possibility for online conversion and transformation of single points for test and verification purposes (position).

• The Joint **Research Centre of the European Commission** jointly organized with Eurogeographics and EUREF two Workshops (Spatial Reference Workshop 1999 and the Cartographic Project Workshop 2000 in Marne-la-Vallee). These Workshops laid the foundations for the definition of uniform European coordinate reference systems in position and height for the unique georeferencing of data. The Information System contains the description of national and pan-European Coordinate Reference Systems (CRS) for position and height orientates on the international standard 19111. It contains also the descriptions of transformations of national Coordinate Reference Systems of European countries to pan-European CRS. In the future a service module will be enabled for the transformation and conversion of coordinates for test purposes.

CRS-EU is a extension and advancement of the former existing and now in this system integrated information system about European Coordinate Reference Systems CRS (http://crs-geo.eu).

According to the international and European standards and recommendations, Romania has adopted or recommends the use of these standards. ***National Agency for Cadaster and Land Registration (NACLR)*** is the main civil public institution involved in the realization of standards and methodologies for cadastre, geodesy, cartography and land registration. NACLR implements the recommendations of the ISO, IGS, EUREF, Eurogeographics and EUPOS. Other Romanian institutions involved in the realization and implementation of geosciences standards are ASRO (Romanian Association for Standardization) and INM (National Institute of Metrology).

– One of the most important standard it is related to the Coordinate and Reference System to be used in Europe. Since 2008 in Romania was introduced ***ETRS89*** for GNSS applications and pan-European cartographic products. This reference system on present situation it is used in parallel with the national reference system S42 (Krasovsky ellipsoid) mainly due to the huge cadastre information who need a long time to be converted to the new reference system.

– The ***INSIPIRE Directive*** of the EU was transposed into national legislation in 2009 and National Spatial Information Infrastructure Committee was created by government decision (no.493/19 May 2010). The Committee it is coordinated by National Agency for Cadastre and Land Registration (NACLR) and includes representatives from all ministries;

– Standards adopted by EUPOS (European Position Determination System) were implemented in Romania for GNSS network (Class A);

– New standards for national reference topographic map at scale 1:5000 were released by NACLR in 2009;

– Standards for scanning and georeferencing of old cadastral maps were adopted;

– Technical standards for digital ortophoto realization at 1:5000 scale were realized based on the twinning project RO 2006/IB/OT–01, PHARE 2006 /018-147.02.01.03;

– New rules were realized and adopted (2010) by NACLR for authorization of private and state institutions or persons (from Romania or EU) to realize cadastre works in Romania.

– An important step in implementation of the ETRS89 in Romania was the realization of the ***direct and inverse coordinate transformation between ETRS89 CRS and S-42 CRS.*** *The strategy for coordinate transformation from European Coordinate Reference System (CRS) ETRS89 to national CRS S-42 (Krasovski 1940 – Stereographic 1970 Map Projection) it is based on a knowledge of the pattern of distortion data (due to large errors in the survey control network) and it consists of two main steps:*

1. Global datum transformation that is accomplished by a conformal transformation;

2. Interpolation of residual coordinate corrections from a grid of coordinate shifts.

The grid of coordinate shifts was generated using least squares prediction method for the distortion modelling between ETRS89 and S-42 which ensures a continuous transformation process that does not destroy spatial relationships established on the national local datum.

In order to provide the compatibility and precise georeferencing of spatial data into the ETRS89 (European Terrestrial Reference System 1989) for the pan-european products, according to the INSPIRE (Infrastructure for Spatial Information in the European Community) directive of the Europe Parliament from 14.03.2007, Național Agency for Cadastre and Land Registration (NACLR) provided an Order of the NACLR General Director for adoption of the ETRS89 Coordinate Reference System (CRS) in Romania. The implementation of the ETRS89 in Romania and the actual tendencies of the GNSS satellite technologies applications for the most of the geodetic works required the implementation of an standard algorithm for spatial data transformation from ETRS89 CRS to national CRS (Stereo 1970 projection) and opposite. This situation from Romania, similar with other European or World countries, requires serious problems for spatial data transformation from the old CRS to the new CRS (ETRS89), due to large distortions inside the triangulation networks as effect of the classical datum orientation of the S-42 CRS.

In order to underline the distortions between ETRS89 and S-42 CRS from Romania, there was used an conform orthogonal transformation (2D Helmert), based on a common set of coordintes from both systems. Table 3 presents the statistics of coordinate differences (distortions).

Table 3 – Statistics of coordinate differences for common geodetic points after Helmert 2D transformation (before distortions modeling)

Grid step = 15000 m
No of nodes = 2106

Statistic	East	North
Medium:	0.0000	-0.0000
Standard deviation	0.2648	0.3756
Max.:	0.8466	1.3288
Min.:	-0.8632	-1.1928
Total no. of common points	894	894
No. of points above +/-3*(Std.Dev.):	8	3
% points in +/-3*(Std. Dev.):	99.11	99.66

Statistics situation shows that standard deviation of coordinate differences it is about +/- 0.30 m. The value and the surface disposal can be seen in figure14 (distortions are presented as vectors).

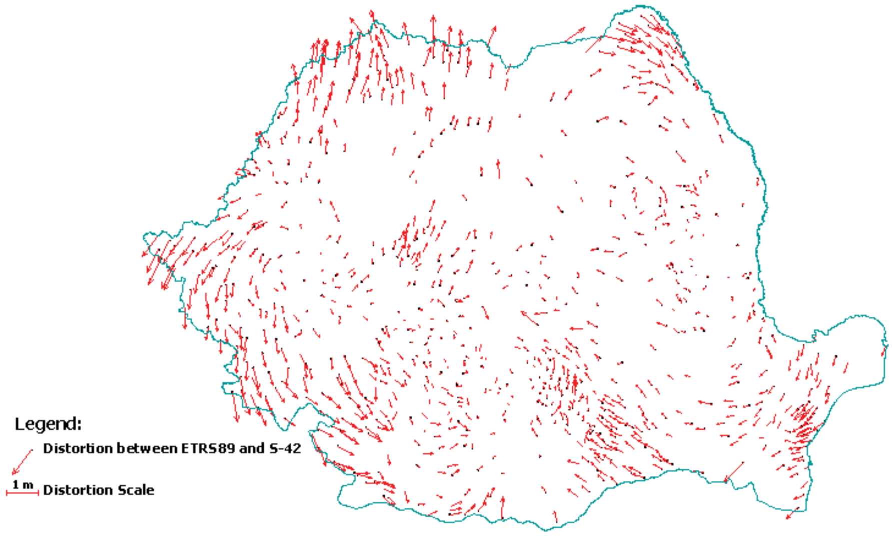


Figure 14. Distortion situation between ETRS89 and S-42

The big distortions observed in figure14 should be modelled by a proper technique according to the reality in order to provide a good transformation of spatial data from old datum to the new datum and oposite.

The transformation technique adopted it is similar to the techniques applied in other countries from Europe or abroad and this technique can be implemented also into the GNSS receivers for RTK applications and into the GIS databases for spatial data representation at big scales.

The existence of common points in a big number and well distributed positions on national surface it is a major requirement for the coordinate transformation from national CRS to the European CRS and oposite. Based on this set of data can be generated the distortion grids and can be predicted the distortions for any interest point in our country. NACLR included in his projects for this year the finalisation of the necessary common set of coordinates by GNSS observations done in triangulation points and of the transformation grid wich will be introduced into the GNSS receivers observing in Romania.

Based on other countries experience in transition from local datums to the new geocetric reference systems (ETRS89, WGS84), we can conclude that the transformation errors and transformation accuracies of points in Romania will be around ±10-15cm, sufficient for the mapping on big scales.

The following table presents the statistic situation of coordinate differences on geodetic common points, available at the present moment, after distorsion modelling.

Table 4. Statistics of coordinate differences for common geodetic points after Helmert 2D transformation (after distortions modeling)

```
================================================
Grid step = 11000 m
No of nodes = 3816
------------------------------------------------
Statistic                       East       North
------------------------------------------------
Medium:                       0.0001   -0.0000
Standard deviation            0.0415    0.0456
Max.:                         0.1750    0.1644
Min.:                        -0.1729   -0.2022
Total no. Of common points       894       894
No. of points above +/-3*(Std.Dev.):15       18
% points in +/-3*(Std. Dev.):    98.32     97.99
------------------------------------------------
```

From this statistic situation analysis it can be deduced that the transformation algorithm adopted it is good and can provide precise and fiducial transformation results for all the users.

Meetings

- Romania it is a member of Eurogeographics organization and it is involved in their projects as *ESDIN, EBM, ERM* et al.. Romania by NACLR organized the ***8th EuroGeographics General Assembly in Sibiu, Romania from 5th - 8th October 2008***. More than 120 participants from 43 countries across Europe took part in that major event, having the opportunity to connect to the current requirements of modern societies with regard to the use of spatial information. The annual General Assembly focused on identifying the main priorities for the coming year and provided a mandate through a number of agreed actions. It was a real opportunity to bring together all EuroGeographics members for discussions, having the chance to vote on key issues such as association annual budget, membership subscriptions and the acceptance of new members. Last but not least existing relationship were strengthened and new ones were built.
- The ***2nd European Conference on Cadastre was held in Bucharest, Romania, 7-8 May 2010.*** The conference entitled "*The Cadastral surveyor – Paving the Way to the Future*" was organized by the European Council of European Geodetic Surveyors (CLGE) in cooperation with the Romanian Association of Private Surveyors, the Romanian Geodetic Union, and the Romanian Agency for Cadastre and Land Registration. The conference also included the launch of the adopted "*Code of Conduct of the European Surveyors*" that is an important and very useful document also in a global context as well as the adoption of the Bucharest Declaration stating some key principles of the role of the cadastral surveyors in serving society.

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Section V: GEODYNAMICS

STUDIES OF GEODYNAMICS

The Institute of Geodynamics runs a network of observatories of geodynamics, equipped with specific sensors. This report contains observations and research undertaken from 2007 to 2010 for the priority theme of the Romanian Academy "Complex geophysical research in geodynamical active areas with a special view to the Vrancea seismogenic area".

This time, we considered important to follow the pattern of atmospheric pressure variations on long-term crustal movements recorded at the level of underground geodynamic observatories, Crăciunești and Ursoiu, and the surface geodynamic observatory, Căldărușani.

The Institute concentrated its efforts on:

1. Continuous monitoring of local deformations by sensors placed at the level of underground geodynamic observatories (Ursoiu, Crăciunești) and of the surface observatory (Căldărușani)

2. Correlating the crustal deformations with two important geophysical parameters in order to:

   a) Understand the mechanism of response of the crust to the pressure and temperature variations
   b) Separate the crustal deformations caused by different causes (earth tides, loads due to rain, snow, etc.).

3. Observe the crustal deformation in the evolution of specific fingerprints of climatic and before major earthquakes.

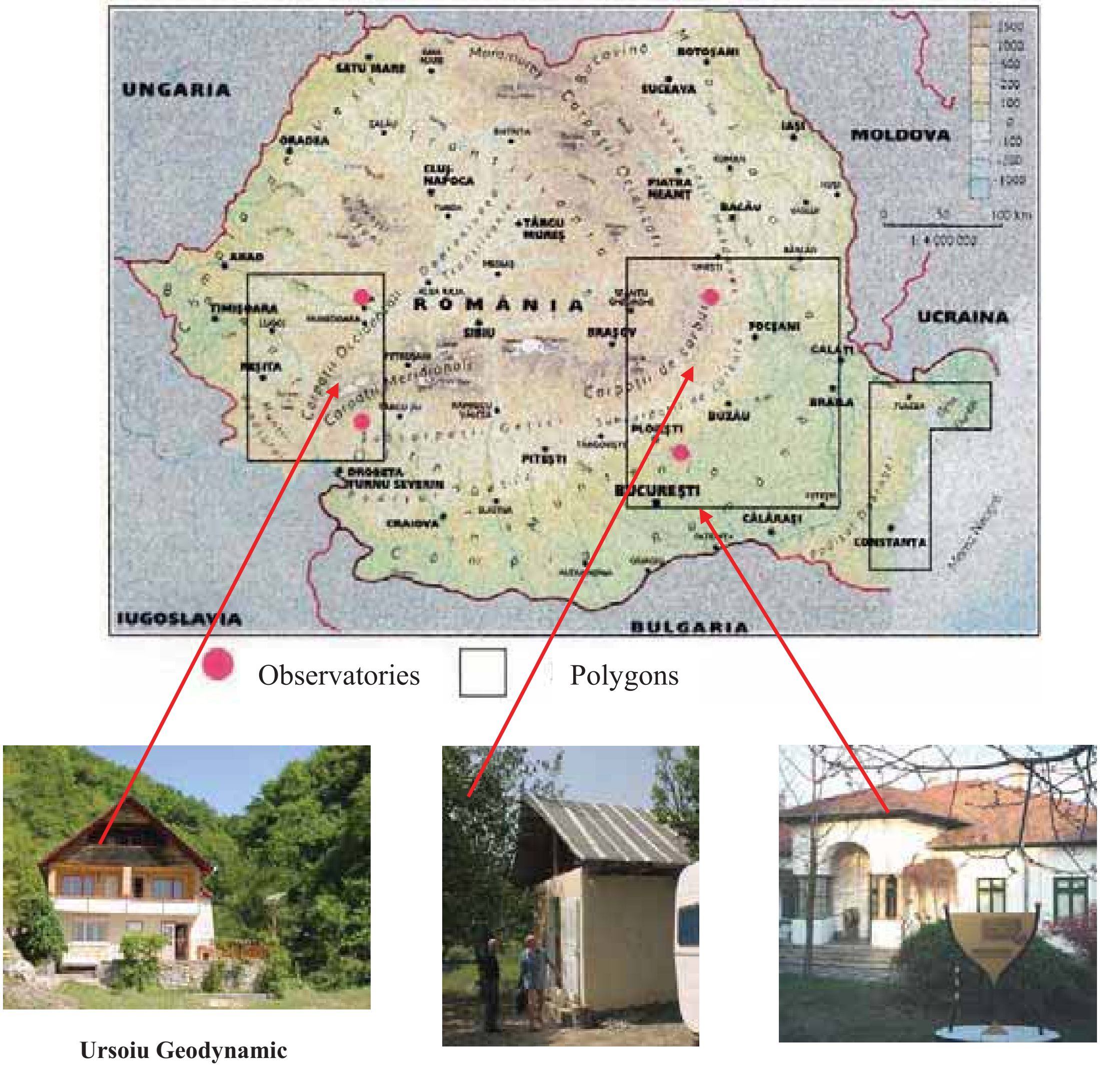
GEODYNAMIC OBSERVATORIES

We recall some important features of geodynamics observatories network coordinated by the Institute of Geodynamics of the Romanian Academy. It is composed of three polygons: Căldărușani-Tulnici geodynamic polygon, Crăciunești-Deva, Sarmizegetusa-Regia, Padeș-Gorj geodynamic polygon and Delta Dunării – Mangalia geodynamic polygons (Fig.1).

The Geodynamics Observatory Căldărușani is located in the Romanian Plain (26°16'12" longitude, 44°40'36 " latitude and altitude h = 75 m above), about 40 km N-NE of Bucharest, in a region associated with more active geodynamic stages, and an important fault (Intramoesic fault). The location of the observatory in this area allows the collection of useful information on the effects of the displacement of tectonic compartments, important information for understanding the mechanisms that lead to the accumulation of energy and the earthquakes triggering in the Vrancea region.

The Underground Geodynamic Observatory Ursoiu (22°53'51" longitude and 46°00'43 latitude) is situated at 470 m above sea level, in an old mine shaft, having between 600m and 800m from the entrance to the gallery, rooms with sealed doors to reduce drafts.

The Underground Geodynamic Observatory Crăciunești (22°52'28" longitude and 46°00'47 " latitude) is located in a disused mine shaft lies just north of Ursoiu observatory in similar geological conditions and altitude.



Ursoiu Geodynamic Underground Observatory

Tulnici Greodynamic Observatory

Caldarusani Geodynamic Observatory

Figure 1. Geodynamic Polygons and Observatories in Romania

The atmosphere is a complex interface between outer space and Earth's surface on the one hand, and an environment sensitive to its internal processing. From this perspective, atmospheric pressure and temperature are two important parameters whose variations can provide additional information related to the evolution of crustal deformation and, indirectly, subcrustal processes.

The air pressure changes reflected both the effect of temperature variations of the atmosphere, and the result of attraction of the Earth and its external bodies, mainly the moon and sun. In order to quantify these effects, we retained the variations of the atmospheric pressure, of the temperature and of the three directions of the crustal deformation: vertical, north-south and east-west.

We have used the north-south and east-west records from tiltmeters, vertical records from Askania gravimeters and the records from temperature and pressure sensors.

GEODYNAMIC SENSORS FOR CRUST DEFORMATION MEASUREMENTS

Analyzing the geodynamic phenomena by continuous recording of the crust deformations, indirect measurements were carried out, based on measurements of very small displacements of the sensitive elements from the system measurements. These displacements are measured by the help of displacement sensors which give a variable tension versus monitored displacement.

Water-tube tiltmeters (Figs.2 and 3) have a base of tens or hundreds of meters. For the complete recording of the variations in horizontal plane two clinometers are necessary, perpendicular on each other. Water-tube tiltmeters work in optimal conditions in a mining gallery where the temperature is constant. If the tiltmeters are situated in a location where the temperature has variations over 1^{o}C, the measurement of the temperatures of the two terminals and the application of a temperature correction is necessary. The latter can be theoretically calculated, but it must be verified experimentally, especially in the case of tiltmeters that do not have identical environmental conditions at the two terminals.

Figure 2. Water-tube tiltmeter (single terminal)

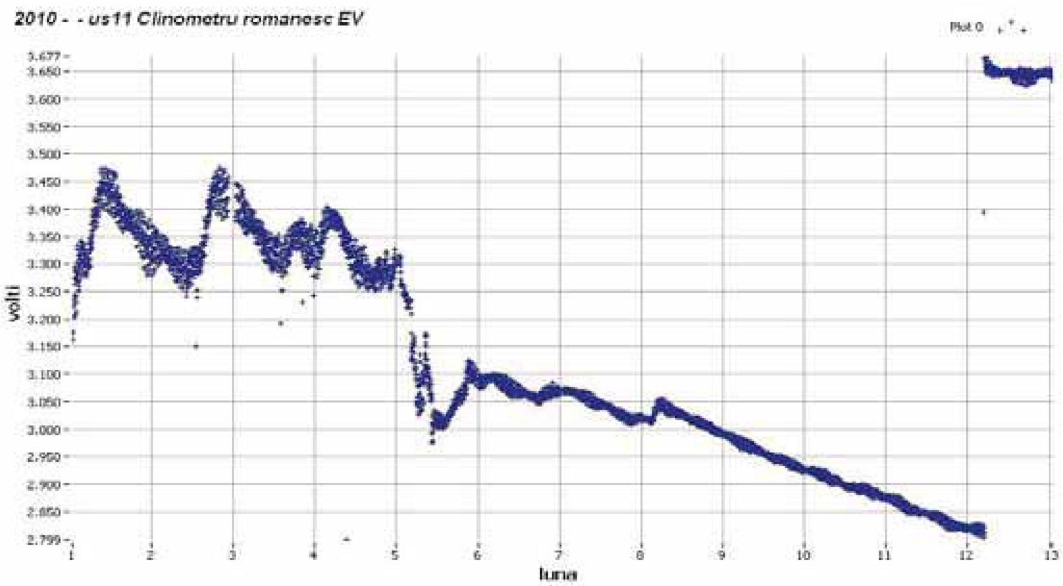


Figure 3. Tiltmeter primary recordings - 2010. URSOIU Geodynamical Underground Observatory

Tiltmeters with vertical pendulum (Fig.4) show the direction of G vector through a normal or inverse pendulum. The length of the pendulum represents the measurement base and is limited from design reasons at values of meters or tens of meters, fact that imposes a high sensitivity of the displacement sensors which are used. One pendulum can record the movement on two perpendicular directions in plane if it is equipped with displacement sensors.

Figure 4. Vertical pendulum

The recording gravimeters (Fig. 5) for observatory are ASKANIA GS11 type. This type of gravimeter was initially designated for the field measurements, using a direct reading, carried out by an operator. The instrument was modified and adapted for a continuous recording, replacing the system for reading with a displacement sensor of high sensitivity. In this way there are carried out continuous recordings of the variations of the intensity of G vector, with a higher sensitivity than the original device. The stability of the recordings was raised, as well, by assembling the instrument in fix location, continuous electric supply and by its maintenance in chambers with small variations of temperature. Gravimeters will be assembled on a concrete pile, very deeply embedded in terrain. The setting in perfect horizontal position has to be done periodically to eliminate the possible modifications of this position meantime, fact that have a sensitive influence over the recordings.

Figure 5. Askania gravimeter

The temperature of the chamber, in which gravimeter is set, must be rather constant for improving the thermostat functioning. This demand will be the best-achieved in underground observatories in which the variation of the temperature is maximum +/- 0.5^{0}C during one year.

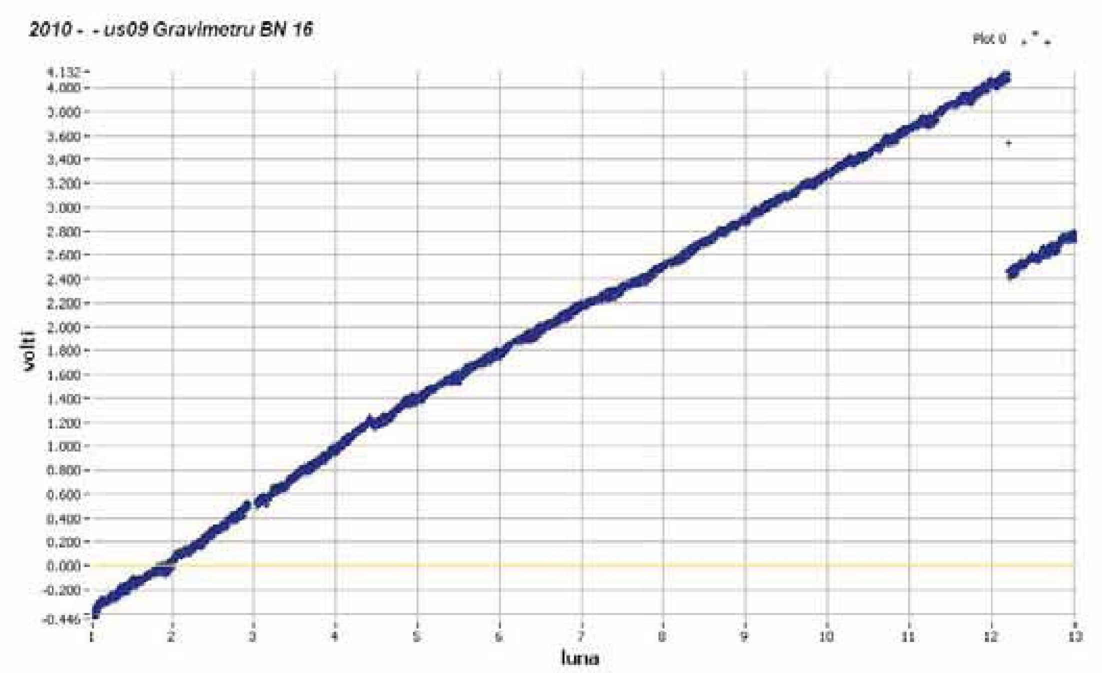


Figure 6. Gravimetric primary recordings - 2010. URSOIU Geodynamical Underground Observatory

At the other observatories the gravimeters are installed in special chambers, thermally insulated, situated in the underground, assuring a slow variation and small amplitude of temperature. In actual conditions the quasi-continuous recordings allow a good observation of the phenomenon of earth tides and allow noticing some anomalies, linked to the local conditions of surface or subsurface.

ACQUISITION SYSTEM

The electronic systems of acquisition of the data are different, from the professional ones of type National Instruments on 16 bites, with own software Lab View.

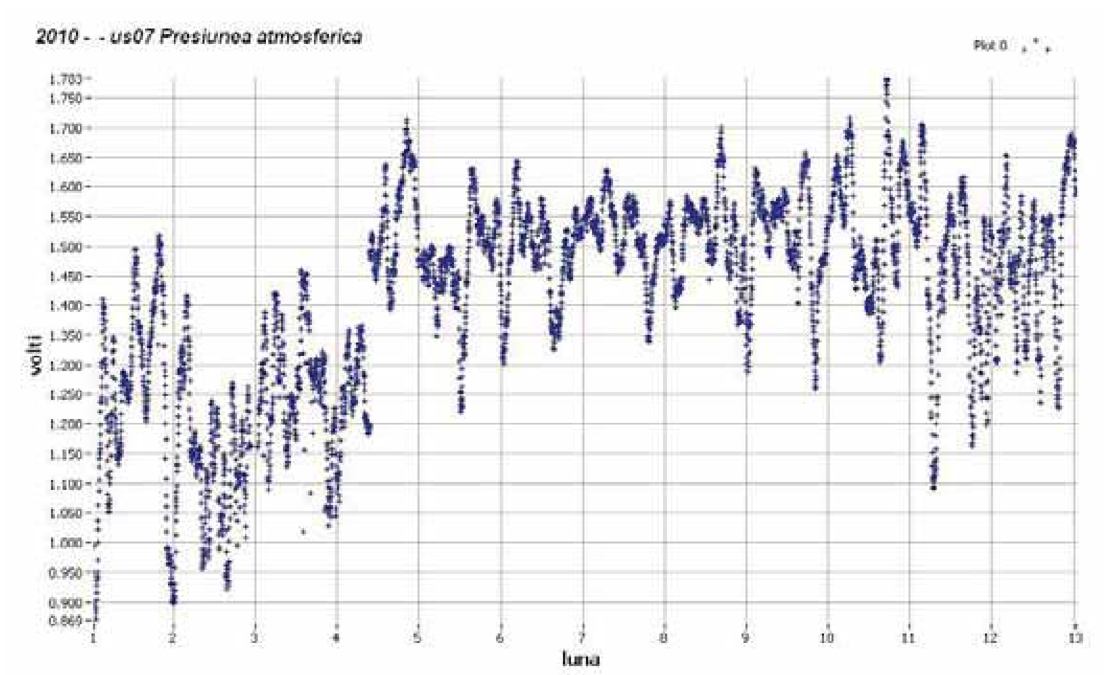


Figure 7. Pressure variations from Ursoiu - 2010.

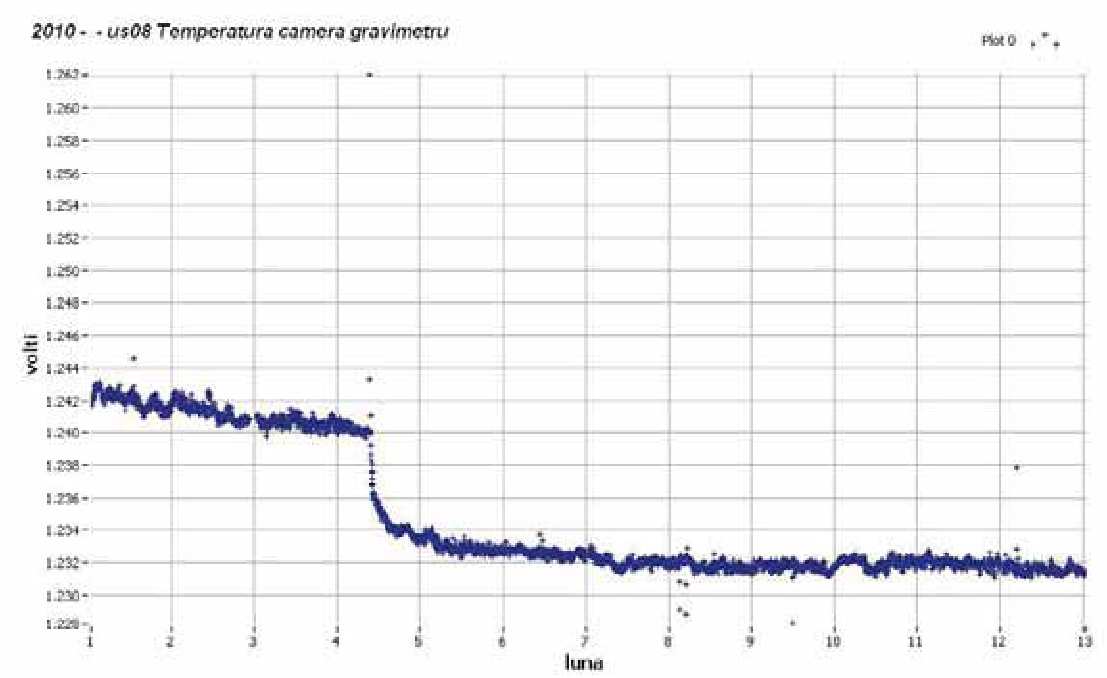


Figure 8. Temperature variations - 2010

We mention that the existence of a laboratory for calibration and ageing of the geodynamic equipment (LERAG) was necessary in the framework of the activity of research for realizing performing sensors for geodynamics.

NEW METHOD OF ANALYSIS OF THE DATA

A. Description of the HiCum stacking method of signal analysis, worked out in cooperation with the Royal Astronomical Observatory, Belgium

The analysis of any data bank representing a series of events fixed by time may prove the results to be random, non-random or a mixture of both. If the data is completely random no patterns will be found, but if any part of the data is non-random, then patterns can be detected either as a Gaussian distribution or, according to Fourier analysis, in a series of fundamental and harmonics of cosine waves. A common method of detecting these waves is to use Spectrum Analysis, which will detect the frequency and strength of all waves present, but it can be difficult to implement. However, in the situation where the detection of the presence or absence of a particular frequency is the primary objective, HiCum is a powerful tool.

HiCum is dependant on a large amount of data available and on the frequency of the wave to be detected. As each earth-tide component can be defined with a very high degree of accuracy, HiCum is a useful tool for determining whether earth-tides are influencing any of the parameters recorded in a series of timed events. ROMPLUS provides us a long series of timed events and is therefore suitable for analysis using HiCum. Using this method we are able to compare, for selected earth-tides component, the influence they may have on various parameters. In our case the parameters under consideration were occurrence, latitude, longitude, depth and magnitude.

The inspiration for HiCum came from the field of meteorology where stacking was first used in the late 19^{th} century by Darwin. In general terms a signal has its time base divided into a series of selected constant length time periods *T*. For the detection of earth-tides signals this time period would be the time period of the earth-tide in question e.g. the Solar time clock, S1, or the lunar time clock, M1. This time period is then represented by 360°. The time base for each of these periods is then normalized as shown in Fig. 9. The occurrence of an event, E_i, at time t_i can then be represented by the phase α_i, which is the difference between the event E_i time and the time of the original event in the series, t_0, modulo T (except an integer number of periods T).

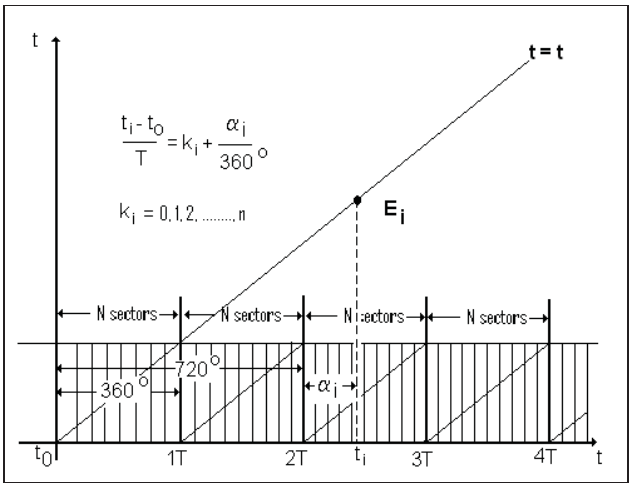


Figure 9. The time series partition into selected time period T. An event E_i occurring at time t_i will be α_i out of phase of the original event, t_0.

Each of these time periods are further divided into N sectors each of length 360°/N. The selection of an optimal number of sectors is done to find enough precision in phase and a significant number of events in each sector (even for small N).

For a parameter recorded at regular intervals, the data for each sector N (for example, in our case, the latitude, the longitude, the depth or the magnitude) is averaged and synchronized. These averages are then stacked producing a histogram bar representing the activity for this sector. This process is carried out for each sector until a complete histogram is produced for the time period under consideration (Fig.10). The histogram is then fitted, by nonlinear least square method, with the cosine function for that time period. The parameters of amplitude and phase are calculated. A graph can then be produced showing the link, in terms of phase and modulation, between the parameter under consideration and the chosen time period.

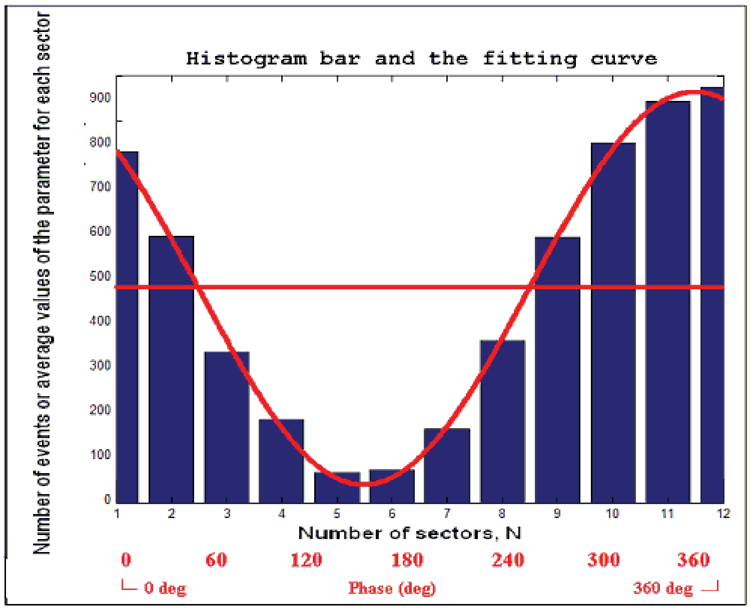


Figure 10. A histogram bar model, representing the distribution of the seismic activity or the average values of the parameter for each sector and a typical HiCum curve. The bars represent the results of the stacking of data, sector by sector (in this case N = 12 sectors). The cosine signal represents the phase of the detected signal in relation to the earth-tides under analysis and the amplitude of the modulation of the detected signal

In the case of data recordings of discrete events, such earthquakes, the total number of all events recorded in each sector N is the value of the histogram bar for that sector. The remainder of the computation is then carried out in exactly the same fashion as for continuous recordings.

HiCum is embedded in a computer program which can take the data from ASCII files and display simultaneously the parameters of the above trigonometric function in a series of graphs. Thus the tendencies for various parameters can be expressed in terms of period, phase, amplitude and amplitude modulation. The input format for the HiCum software is based on the Doodson argument [Melchior, 1978]. Figure 10 shows the characteristic features of a typical HiCum graph. The HiCum curve is a combination of the total output signal and the modulation of that signal by the selected earth-tides component, as detected by HiCum.

Using this method we are able to compare, for selected periodicities, influences on various parameters, in our case the parameters under consideration were occurrence, latitude, longitude, depth and magnitude. The selected time period will be that which is suspected to have an influence on the parameters in question e.g. the solar time clock S1. A time period is equivalent to an interval of width 360°. It is also necessary to select the optimal number of sectors for the HiCum computation.

B. HiCum Applied to the geodynamical data

We present a graphical example (Figs. 11a,b,c and 12a,b,c) of HiCum analysis for the three components of the theoretical earth tide data 2010 at the level of the Caldarusani and Ursoiu Geodynamical Observatories.

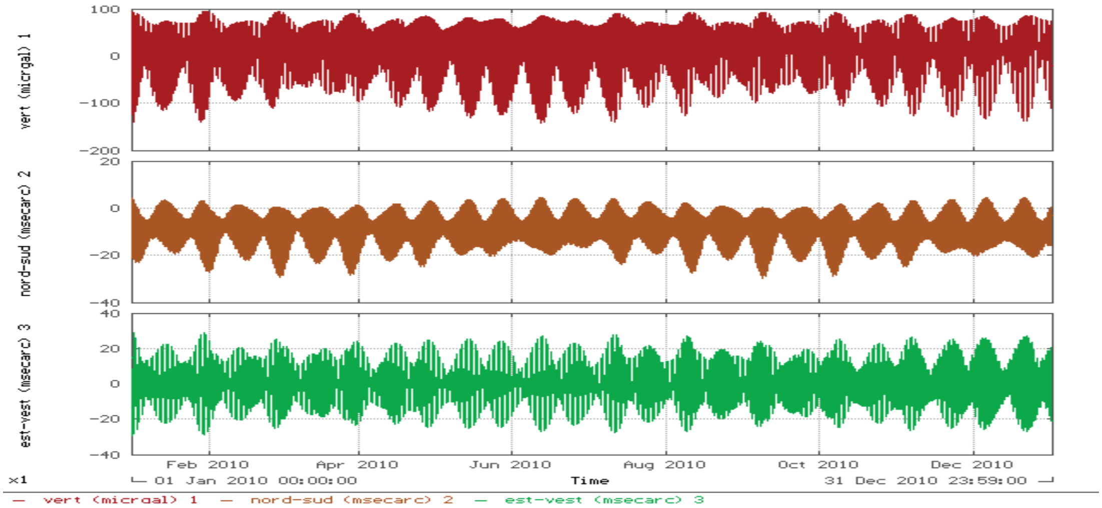


Figure 11a. Căldăruşani Geodynamical Observatory-2010. Theoretical variation of the earth tide components

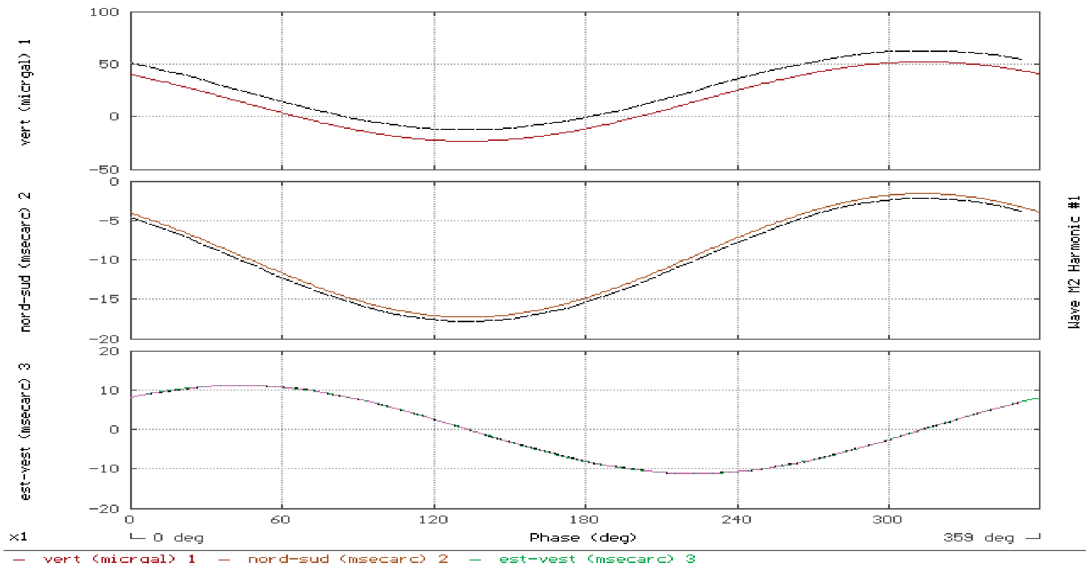


Figure 11b. Căldăruşani Geodynamical Observatory – 2010. The semidiurnal component of the three directions of the theoretical earth tides obtained by means of the HiCum method

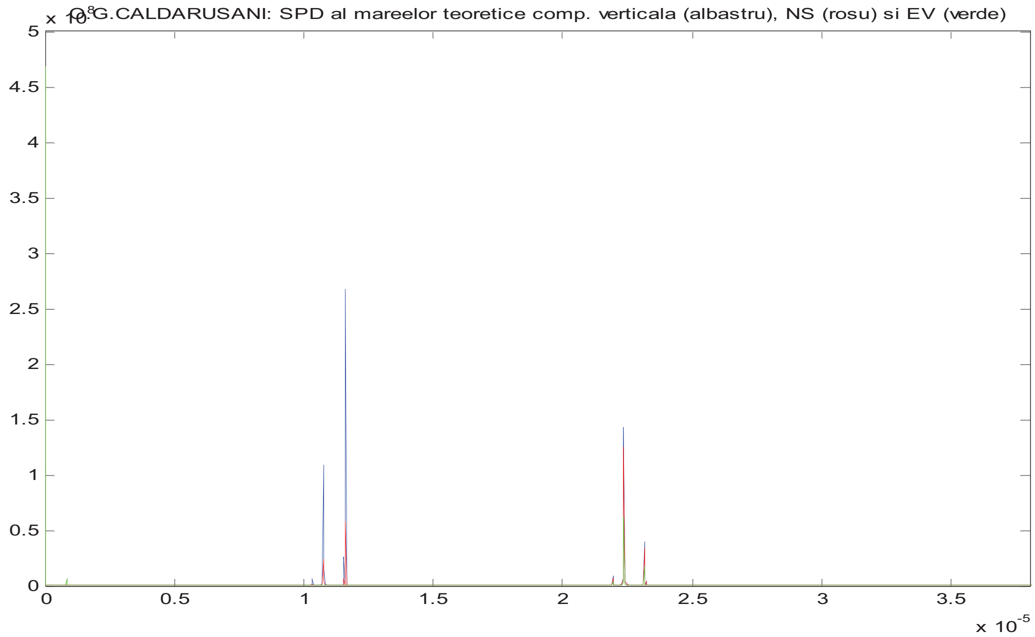


Figure 11c. Căldăruşani Geodynamical Observatory – 2010.
The power spectral density of the three components of the theoretical earth tides

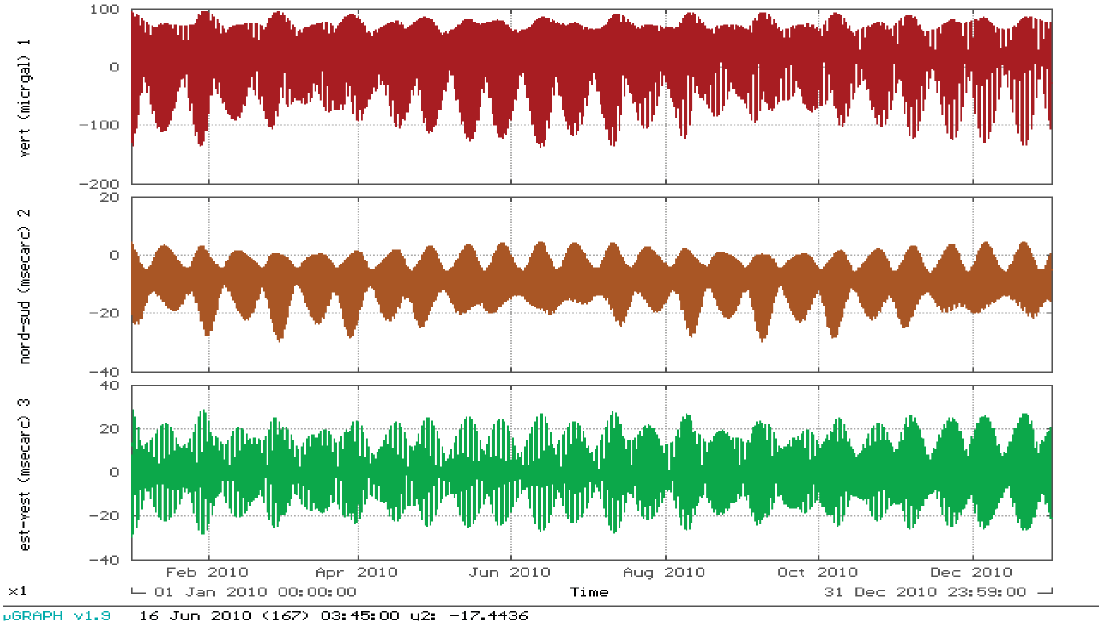


Figure 12a. Ursoiu Underground Observatory-2010.
Theoretical variation of the earth tide components

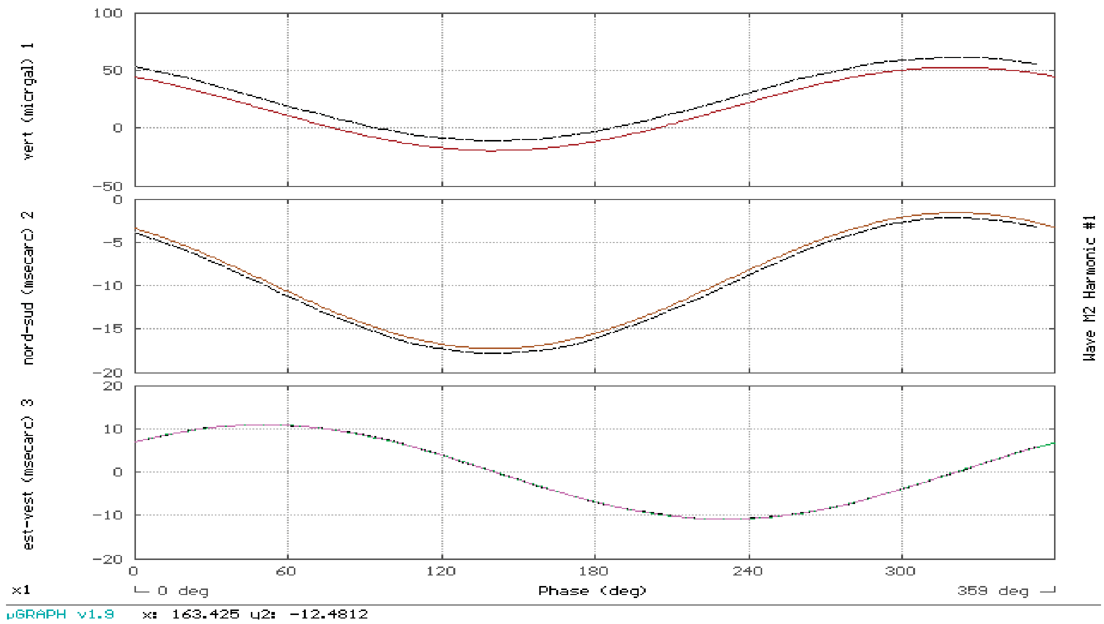


Figure 12b. Ursoiu Underground Observatory- The semidiurnal component of the three directions of the theoretical earth tides obtained by means of the HiCum method

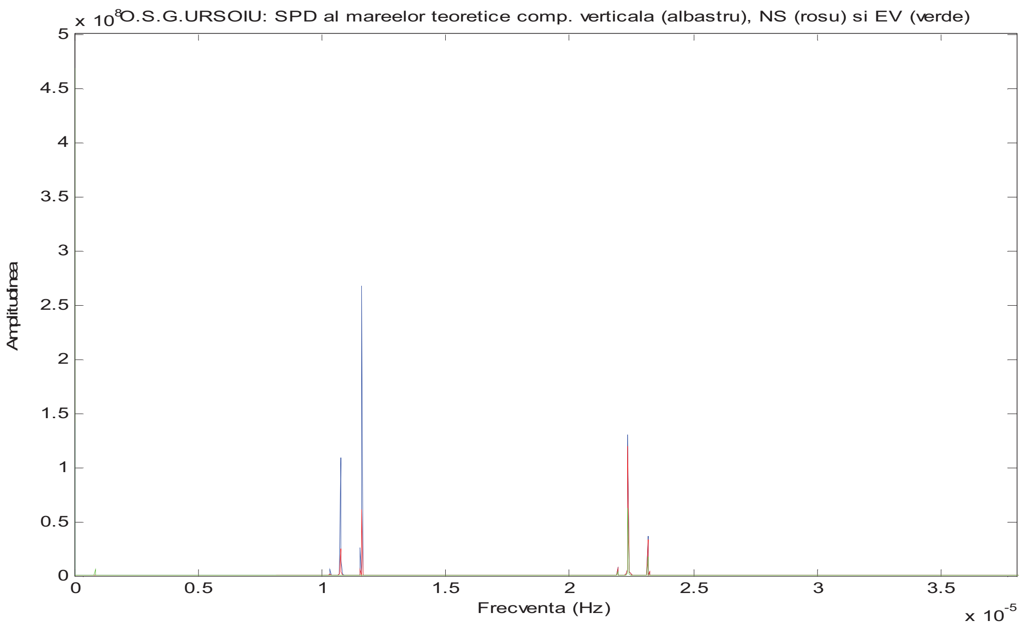


Figure 12c. Ursoiu Underground Observatory .The power spectral density of the three components of the theoretical earth tides

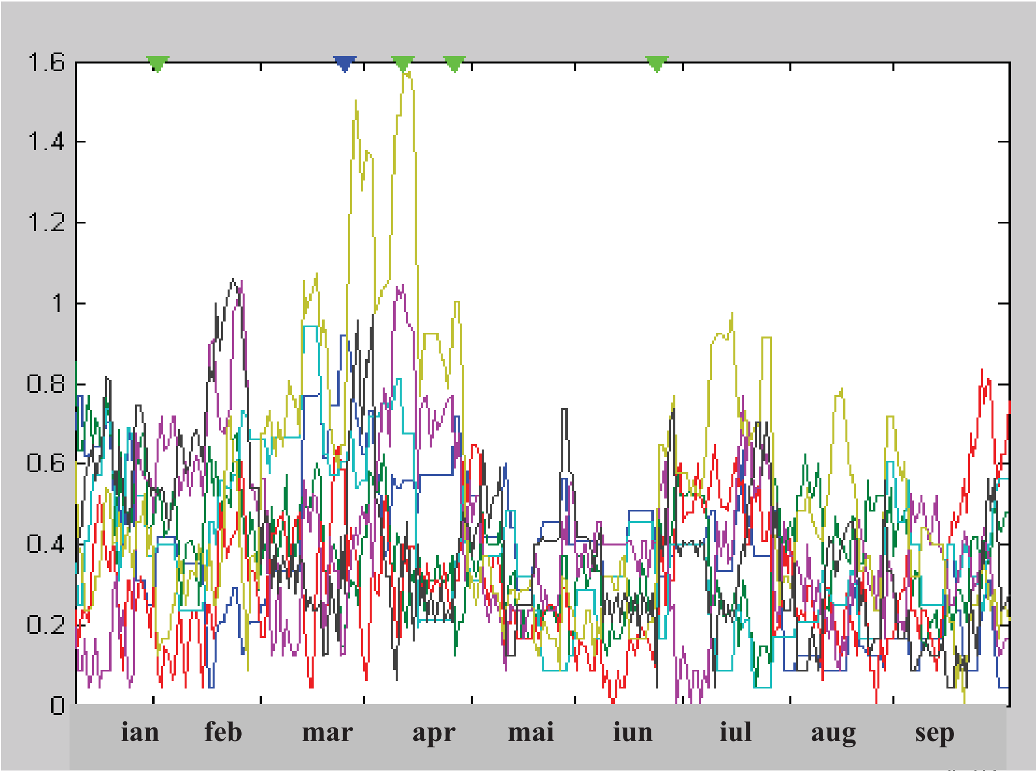


Figure 13. The amplitude variation of the sinusoidal curve obtained by interpolation HiCum method for seismic activity Vrancea area (January-October 2009), for seven different periods, using mobile windows of 33 day shifted by one day

▽- romanian earthquakes with magnitude **4.5** ≤ ***Mw*** < **5.0**

- romanian earthquakes with magnitude ***Mw*** ≥ **5.0**

Values of the amplitude of the sinusoidal curve obtained by interpolation HiCum method for seismic activity:

T= 1 h

T = 8h

T = 12h

T = 24h

T = 7d

T = 13.66 d (Mf period)

T = 29 d (sinodical moon period)

THE PRESENCE OF THE PRESSURE VARIATIONS IN THE RECORDS

The study of the of the atmospheric pressure influences on the crustal deformation is not simple. The Earth's atmosphere, defined by highly fluctuating parameters, can be measured and survey only by advanced techniques and a dense network of observation stations. An example is the weather getting harder to do in terms of sudden changes, in terms of the variations of the coefficients of the nonlinear equations in the currently used algorithms.

Variations of different amplitudes and frequencies of some important geophysical parameter can be found in the geodynamical records (Ex: component daytime or semidiurnal). These parameters are: daily temperature variations associated with the corresponding atmospheric pressure variations, earth tides and anthropogenic activity.

We have analyzed by means of the FFT and HICUM methods, the common periods of the atmospheric pressure variations and crust deformation variations recorded by sensors mentioned in Chapter geodynamic observatories.

Processing of the data was done with the MICROGRAPH program and own programs written in MATLAB environment.

We found:

– A band of low frequency corresponding to the relatively random variation of the temperature and to the seasonal periods related to the movement of Earth's revolution around the sun and the rotation axis inclination to the ecliptic;

– A band of frequencies corresponding to diurnal solar attraction of the Moon on air masses and frequencies "daily" due to the Earth's rotation axis;

– A band of frequencies corresponding to the semidiurnal moon-sun attraction.

DISSEMINATION OF RESULTS

The researchers of the "Sabba S. Stefanescu" Institute of Geodynamics of the Romanian Academy were present with a lot of scientific communications to prestigious national and international symposium, conferences and workshops. Their scientific activity is also reflected in many papers published in appreciated scientific revues.

International cooperation

In the report interval, several important international cooperation programs of the Institute of Geodynamics have continued, such as:

Virtual International Laboratory of Geodynamics (2001-to present) - "Sabba S. Stefanescu" Institute of Geodynamics of the Romanian Academy in cooperation with the United Institute of Earth Physics "O. Yu. Schmidt" of the Russian Academy of Sciences

CIPACT 930173-ERB-351 PL 926540 Contract, Co-operation Program between the Royal Observatory of Belgium and the Institute of Geodynamics of the Romanian Academy - studies of the influences induced by earth tides on the geophysical data.

and others have been established:

Unesco Chair in Geodynamics (2004-to present) - Agreement between the United National Educational, Scientific and Cultural Organization and "Sabba S. Stefanescu" Institute of Geodynamics of the Romanian Academy (Romania)

Extreme Events, Causes and Consequences (**E2C2)** Project (2005 – 2008) E2-C2 is a Specific Targeted Research Project (STREP) within a Pathfinder Initiative aimed at Tackling

Complexity in Science and initiated by the New and Emerging Science and Technology (NEST) Program of the European Commission, as part of its Sixth Framework Program (FP-6). E2-C2 is coordinated by Michael Ghil (ENS), with Pascal Yiou (LSCE) as Associate Coordinator.

Research stages (2007-2008) at the Royal Observatory of Belgium in the frame program of a Phd on the theme "Studies of the gravimetrical influences induced bz earth tides on the intermediate Vrancea seismic activity".

THE UNESCO CHAIR IN GEODYNAMICS - ROMANIA

In the year 2005, within the Institute of Geodynamics "Sabba S. Stefanescu" was established **The UNESCO Chair in Geodynamics**, dedicated to the training of geoscientists in the field of Complexity science (non-linear approach, computational modeling, chaos theory, catastrophe theory, fractal geometry, etc.) and also to the coordination of inter- and trans- disciplinary research in the project: **The Earth – A Living Complex Planet**.

Context

To analyze and characterize **Complexity** is a challenge posed to the human mind which must structure *a new ontological framework*, a *new set of concepts*, a new *methodology* and an *adequate experimental technique* that would all be qualitatively different from those used today. This framework, labeled as the Science of Complexity [1], has been defined through the integration of last years results concerning the non-linear approach of phenomena in nature, results obtained by a series of new disciplines such as *Synergetic*, *Chaos Theory*, *The Catastrophes Theory* etc. Additionally, the appearance and progress in new related fields like *Fractals*, the *Theory of Bifurcations*, as well as the *Cellular Automatons Theory* and *Neural Computers* generated many novel and convenient mathematical models for describing the surrounding reality. Therefore, the **Science of Complexity** can be considered a collection of models and theories capable of allowing the understanding of local-global, part-whole type of relationships in a sufficiently general way so it can be applied to the study of all that is living, starting with genes, organisms and ecosystems and going as far as the study of transitions from atoms to materials and products, from computers to local networks and Internet, from citizen to group and society.

The Science of Complexity can be viewed as an integrating science, capable of ensuring an inter and trans-disciplinary approach [2], to generate connections between different areas of knowledge, to create bridges between specialists in different research areas, from different schools and from different cultures, bringing them together in interdisciplinary teams targeting strategically important topics, such as those demanded by ensuring a sustainable development.

The Science of Complexity is considered today the central pillar with which one can restructure information in a new and coherent paradigm that is comprehensible to all social levels, thus also having a catalytic role by accelerating the flow of information and knowledge to society. Furthermore, it generates the primary activities imposed by the joint Man-Environment evolution, a fact that traditionally has not been generally known or 'advertised' to the public at large since Evolution had been usually linked only with ecosystems and biological species, or – as a special case of the latter – to the appearance and gradual enrichment of the human intelligence along the ages. Nevertheless, one of the key contributions of the Science of Complexity towards a new paradigm is highlighting this entwined two-fold interdependent concept of Man-Environment evolution that is both reflected and provided by a constantly more complex and far-reaching design, control and utilization of products and systems, themselves with a previously unseen level of complexity.

From this perspective, the sociological, economical or engineering studies/ sciences must be reconfigured and integrated in a larger and broader subject (meta-science) that transcends, yet combines them interdisciplinary in order to create this new framework in which each part would also depend on and be supported by elements from the other ones.

In a first stage, the generation and application into practice of the previously mentioned phenomenon has already been started as an increasing number of researchers more and more frequently refer to such novel meta-domains, e.g. *bioeconomy, biogeophyisics, geobiophyisics, astrobiophyisics* as well as *bioelectronics, microelectromechanics* and *jurisdynamics*. It should be clear that, once such a meta-science has been generated, disciplines like economics and sociology will no longer be studied separately or independently, but interdependently and always within the context of their interactive co-evolution with **the Planet Earth System**.

Mission:

Structuring a **Science of the Entire Earth** by integrating the expertise of the geosciences in an inter- and trans-disciplinary vision, able to allow the understanding of the co-evolution of processes that assure the Earth's geostasis.

Goals:

Consequently, in this new context one may expect increased interest and more intense studies in the following possible directions:

(1) Stimulating knowledge transfer between different fields and encouraging pluri- and inter-disciplinary approaches;

(2) Evaluating the capability of present day's methodologies of efficiently understanding theoretically and experimentally the transition from part to the whole, from complicated to complex;

(3) Discovering or/and inventing new experimental concepts, models, theories, methods and techniques of monitoring and evaluating hierarchical dissipative systems that evolve far from thermo-dynamical equilibrium;

(4) Developing researches and studies dedicated to conceptualizing and understanding co-evolutionary processes that assure planet Earth's geostasis, applicable in the design of durable development policies, social-economic development and the continuous training process of human resources.

(5) Developing and successfully using an educational infrastructure that can ensure the transfer and filtration of information and specific knowledge and know-how.

The main target is to educate the new generation and re-educate the current one by shifting from the current Newtonian paradigm to one related to nonlinearity and complexity. This should result in a better understanding of current phenomena, increased capacity and willingness to assimilate new knowledge and adopt an exploratory frame of mind in order to further generate new knowledge. Therefore, a long-term consequence of such a new educational infrastructure should be the creation and propagation through society of a life-long learning attitude, based on a formal 'standard' education but also including an informal one and a non-formal one as well, while at the same encompassing both localized and delocalized aspects (e.g. e-learning).

Partners:

The Romanian Academy of Scientist
The Academy of Technical Sciences, Romania
The Academy of Agricultural Sciences, Romania
The Polytechnic University of Bucharest, Faculty of Applied Sciences
The Polytechnic University of Bucharest, Faculty of Electronics and Telecommunications
The Polytechnic University of Bucharest, Faculty of Computer Science
The University of Bucharest, Faculty of Physics, Magurele
The International Institute of Biodynamic, Romania, UNESCO Institute

Activities:

1. Research projects, completed in bachelor, master and/or doctoral degree thesis
   - 1.1 Modeling of structuring by fragmentation processes, consequences in geodynamics
   - 1.2 Modeling the geodynamic active area: Vrancea zone by using cellular automata technique.
   - 1.2 Fractal Antennas: concept, applications, implications for bio-geophysical measurements
   - 1.3 Chaotic resonance, consequences in adapting measurement equipment and experimental protocols to the requirements imposed by a non-linear approach
   - 1.4 Synchronizing chaotic oscillators, experiments on Chua oscillators
   - 1.5 Wigner-Ville and Wavelet techniques; applications in processing of seismic records

Studies and researches

1. Geobiodynamics and Roegen[1] Type Economy [1] [2]

The evolution of economic phenomenon in today's exponential globalization and development of goods is defined as a "turbulent" evolution, in which predictability is continuously reduced and the influence of social or bio-geophysical phenomenon becomes important. Economic stability is becoming more and more dependent on the labor market mutations (information society, knowledge economy) and on global climatic changes.

The exponential growth of good production in the context of scarce global and unevenly distributed resources generates both social and economic problems. Solving these problems requires studies at the Geo – Bio – Socio – Economic interface.

In our studies we explore the vision of Nicolae Georgescu Roegen, who contributed significantly to **bioeconomics** and the ecological economics. The basic problem in this first

[1] "Nicholas Georgescu-Roegen, born Nicolae Georgescu (Romania, Constanta, Romania, 4 February 1906; Nashville, Tennessee, 30 October 1994) was a Romanian mathematician, statistician and economist, best known for his 1971 magnum opus [2], which situated the view that the second law of thermodynamics, i.e., that usable "free energy" tends to disperse or become lost in the form of "bound energy", governs economic processes. His book is considered a founding book in the field of thermoeconomics." Roegen introduced into economics the concept of entropy from thermo-dynamics and did foundational work which later developed into evolutionary economics. Also his work contributed significantly to bioeconomics and to ecological economics" - WIKIPEDIA

[2] The paper "Geobiodynamics and Roegen Type Economy", C. Udriste, M. Ferrara, D. Zugravescu, F. Munteanu received the 2010 Romanian Academy Award

approach was to find a model in which the entropy is related to the economical phenomena [3]. For this purpose a formal correspondence between economic processes and thermodynamic laws was identified, with heuristic implications for characterizing the dynamics and evolution of economical systems. Based on this formalism, the study of the problem of an economical equilibrium in the case of aggregating together initially stable and independent economical subsystems in a final functional entity was initiated, e.g. the set up of the European Community's economy.

Similarly, we intend to extend the physics' black hole concept in order to apply it in economy as well. The published results [4,5] represent a preliminary step in defining the bio-economic process and generating a model able to capture on one side, the coupling between geo-physical and clime processes, and on the other side, social and economic processes.

2. The study of time evolution of the mechanical oscillation measured the crust – atmosphere interface in an urban area

By using continuous monitoring systems specific to the experimental Geodynamics, the studies tries to discriminate between the anthropic and natural component, to characterize the "noise" that define the "normal" fluctuation of the mechanical oscillations (micro-seismicity). Some major objectives:

- identification of a pattern of the anthropic activity in a metropolis, the stability over time and,
- identification of some deviations from the specific pattern and the correlation with some socio-politic processes that generate the urban social dynamics.

The experiment fits in a broader theme that aims to study, from a non-linear perspective, the coupling between the processes and phenomena that assure the stability of an ecological system, to define specific parameters capable to characterize objectively the property called: life quality, to offer a conceptual and methodological basis for understanding and monitoring energy-material and informational evolution that assure the geostasis at the scale of the whole Earth.

For the experiment we use two different classes of sensors:

- a seismic accelerometer mounted on a special pillar inside the Laboratory for the Calibration and Verification of Geo-dynamic Devices (LERAG) of the Institute of Geodynamics (IG-SSS-AR) and
- a high-sensitivity hydrophone placed in a borehole executed near the same building, in the courtyard of the Institute (see picture 4-6)

Acquisition, signal processing and storage is done using an acquisition board (National Instruments type). Monitoring is done in an urban area, crowded, with intense human activities. The location of the sensors is in the pictures below.

Figure 1. The position of IG-SSS-AR on the Bucharest map.

Figure 2. General map of IG-SSS-AR

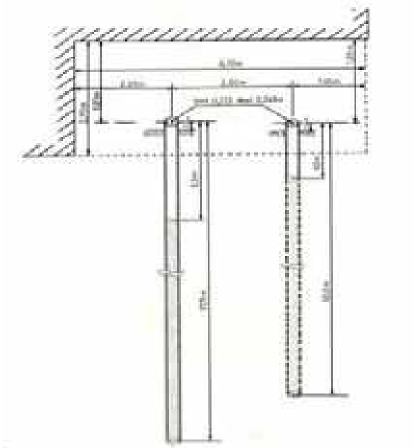


Figure 3. The boreholes(vertical section)

Figure 4. LERAG map (measure points)

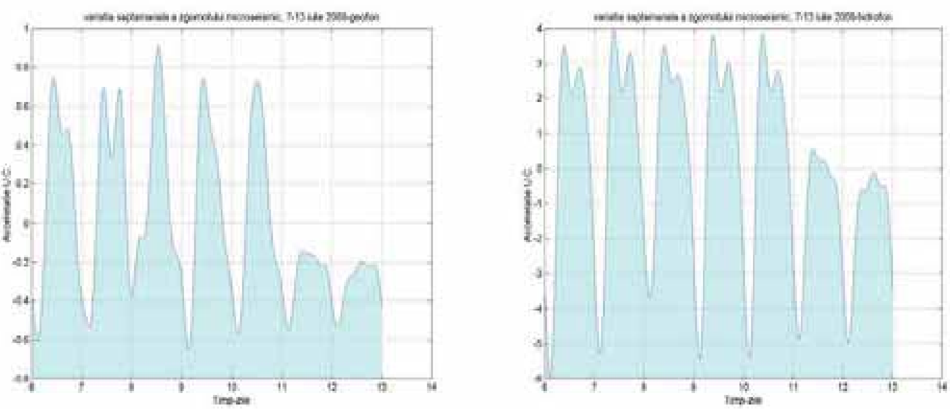


Figure 5. The weekly variation of the mechanical energy oscillations;
7 to 13 July 2008, geophone (left), hydrophone (right)

In Figure 5 is represented the variation of the average energy signals delivered by the geophone, respectively hydrophone, in the 0.1-250Hz band. We can see a daily pattern, more stable in the case of the hydrophone and significantly lower on Saturdays and Sundays. Continuous monitoring of these oscillations has revealed significant variations during legal holidays (picture 6 - Easter), but also on certain days of the week. The significance of these variations can be correlated with spontaneous (self-organized) or organized social processes. Application of nonlinear analysis methods of the acquired data and monitoring meteorological and socio-economic parameters allow the use of advanced processing techniques like data mining, thus contributing to a better understanding of the evolution of social community (self-organization / organization phenomenon) and of interaction between living and non-living systems inside an ecosystem with intense anthropic activity.

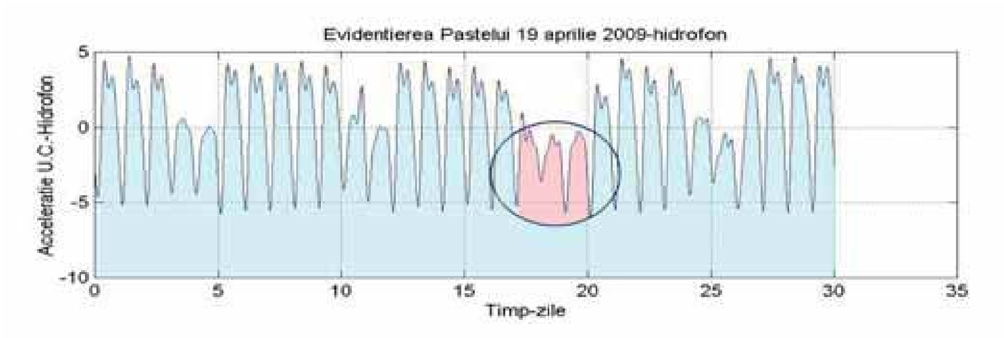


Figure 6. The variation of the mechanical energy oscillations during April 2009 (Easter holiday)

3. The design of an Artificial intelligence-based system for improved seismic risk assessment in VRANCEA zone

The accurate **evaluation of the seismic risk** of a certain geographical region is a major objective in modern geophysical research. Many studies were made to understand better the cumulative processes of stress build-up in seismic regions, as such processes are implicitly responsible for the ultimate triggering of earthquakes. Recently, such studies have had a new impetus due to the application of a very new set of theories and models that are all known as the 'Science of Complexity'. After Mandelbrot's introduction of the fractal geometry and the subsequent appearance and affirmation of the Chaos Theory and the Catastrophes Theory, seismic events have been reinterpreted as typical examples of manifestations for the dynamics of nonlinear systems. Self-organization has quickly become the most important and often used concept in modeling earthquakes [6,7]. Other studies, made using large databases that included any seismic events of magnitudes larger than 2 on the Richter scale, highlighted variations between intervals with acceptable or high predictability of the seismic events, and those in which such events seemed to have occurred randomly. This observation led to the conclusion that the degree of predictability itself for seismic events is a variable that changes in time. From this point of view, the earthquake was re-interpreted as an expression of the **geocomplexity**, and this new point of view reoriented the research in this area towards understanding complex phenomena. Specifically, this marked the beginning of a new stage in geosciences in general, and in seismologic research in particular, especially regarding the practical application of the main concepts, models, theories and methods provided by the new paradigm of Complexity.

In this research program, one assimilates a seismically active region with a **nonlinear complex and hierarchically structured system**, then the following features can be deduced or assumed as characterizing this system:

a) Each seismic event modifies irreversibly the system's structure, and for this reason a new re-assessment of the situation and re-adaptation of the analytical model has to be carried out permanently;

b) Each seismic event discharges a specific amount of energy (recorded in earthquakes as the magnitude, e.g. on the Richter scale), and this energetic variation modifies the internal state of the system and provides totally new and different initial conditions for the newly started phase of charging. The immediate result of such a behavior is a much reduced predictability, yet not impossible;

c) The energy discharged by each seismic event that 'resets' the local system is radiated/transferred to neighboring systems of equal or inferior hierarchical position. For this reason the accurate understanding of the evolution in time of a seismic region cannot be carried out without an initial thorough and multidimensional monitoring (at the same or from a higher hierarchical level) using a network of various types of sensors;

d) When the system is in the critical state preceding the seismic discharge, the triggering factors can alternate or combine with inhibiting ones, resulting in a reduced classic predictability of the seismic event. At the same time, this also highlights two necessary purposes (or requirements) for which a sensor network intended to monitor a seismically active region must be designed and set up: - capable to evaluate objectively when the monitored system (i.e. the seismic region) evolves in a critical state, and -closely monitor the low intensity processes that are resonant with the epicenter, and that could thus bring valuable information about how the triggering signal appears;

e) The monitored seismic region is just another element of a larger and also hierarchically organized system (Gaia) [8], being coupled and interdependent on the interaction with other similar systems in this super-system. This means that other important data can be obtained by monitoring the energy exchange, and other types of exchanges, between adjacent and subordinated systems, both living or not;

f) The changes in the structure of the system will always take place as a function of the variations in the fluxes of energy, information and matter. As such, these changes will obey universally valid laws (pattern, alometric constants) which can also be used in our analytical model that controls the system in order to characterize in real-time the evolution and behavior of the observed region.

The theoretical approach that is used for the scientific design of the **Artificial intelligence-based system** suppose to combine all the above listed principles and methods derived from the Science of Complexity. A preliminary critical review of the results obtained using classical, i.e. analytical, tools will be initially carried out in order to ensure the best results in the application of the cellular automata for the desired purpose. The other essential component of the system is the software for analysis, control and decision, and that will be obtained by the direct application of discrete modeling based on the concepts and laws of the Deterministic Chaos Theory. The set of simulation models thus obtained will be interlinked in an interactive assembly called **multimodel**[3]**.** Once both the hardware and the software are

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[3] A great deal of speciality terms have been used extensively in this project proposal. For the reader's convenience, we detail below their meaning for an easier understanding of this document.

1. **Evolution** - the trajectory followed by the system in an abstract mathematical space that is equivalent to the reality and describes it from a different point of view (e.g. topologically). Examples of such abstract spaces are the phase space (which can be used to describe the state of the system), and the morphological diagrams on a catastrophe surface.

realized and integrated together, the operation of the resulting hardware-software assembly will be tested by observing its detailed behavior when subjected to various stimuli. This testing will be practically implemented by subjecting the cellular automata-multimodel assembly to various experiments and/or by running numerous Monte-Carlo simulations. The obtained results will set up **a database** that will be interactively used to **train a neural network**. The ultimate aim is to make the neural network capable to discern the specific patterns associated to each model within the multimodel, and to permanently assess the similarity between the picked-up signals (originated from a battery of various sensors *a priori* installed in the seismically active region to be observed) and these characteristic patterns. We should highlight that this is one of the **key points of the originality** of this proposed project: by *integrating together cellular automata, a multimodel, a neural network and a data acquisition & processing block*, an entirely novel type of system is obtained, namely an **intelligent and self-adaptive, i.e. self-learning, monitoring system** capable to dynamically evaluate the on-ground situation in real-time. **To our knowledge, no such system is existent in Romania or in the entire Eastern and Southern Europe.** The system will be used to monitor a part of the Vrancea county, a very well-known seismically active region, where were located the epicentrum of most of Romania's high-magnitude earthquakes.

Recent studies have shown that a system with artificial intelligence that itself behaves chaotically will, under the influence of a specific flux of data/stimuli, synchronize itself with the monitored Reality. Therefore, it can be stated that the intelligent monitoring system proposed to be built and used in our project will asymptotically converge towards 'self-identification' with the monitored reality itself. It can be concluded that the project will bring an essential contribution to the understanding of the synchronization of chaotic systems and the application of such a phenomenon in an intelligent monitoring system intended to observe a part of the Vrancea county.

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2.Multimodel – An assembly of models (dynamic systems) and computational simulations employing cellular automata (intelligent agents) capable to discriminate/classify the data flux (streaming) provided by the sensors from the monitored reality.

3.Informational filter– An assembly of methods for the multiscalar evaluation of a data flux (streaming) provided either by sensors directly from the monitored reality, or from the multimodel's database.

4.Inteligent (active) monitoring - Self-adaptive system (neural network) that processes the acquired sensor data and which ultimately provides information about the monitored system by extracting and processing the relevant data in accordance to the utilized multimodel.

5.Heuristics - System of logic procedures and methodical rules for theoretical (re)search activities.

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