ROMANIAN ACADEMY

ROMANIAN NATIONAL COMMITTEE
OF GEODESY AND GEOPHYSICS

NATIONAL REPORT

ON GEODETIC AND GEOPHYSICAL ACTIVITIES IN ROMANIA

2015 – 2018

*(Draft)**

Prepared for the XXVIIth IUGG General Assembly
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FOREWORD

The National Report of the Romanian Committee of Geodesy and Geophysics (RNCGG) prepared for the XXVIIth 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 and international research projects, 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 2015-2019, since the last IUGG General Assembly held in Prague, Czech Republic.

The possibility of presenting a quite comprehensive volume is a consequence of the continuous improvements in the organizational policy of the RNCGG by appointing 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 an 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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IACS ACTIVITIES IN ROMANIA

2015 – 2018

NATIONAL REPORT ON CRYOSPHERIC SCIENCES

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FOREWORD

The present report describes the activities carried out in Romania in the Cryosphere Section of the National Romanian Committee of Geodesy and Geophysics. The main domains represented within the Cryosphere Section are: (1) Snow and Avalanches; (2) Continental Glaciers/ Permafrost and (3) Cryosphere, Atmosphere and Climate.

The *Snow and Avalanches* issues covered by Romanian scientists consist of:

- monitoring snow cover and assessing avalanche risk in Romania using in-situ measurements, satellite data and model results.

In the field of the *Continental Glaciers and Permafrost* the most significant results recently reported by Romanian researchers focus on:

- permafrost detection in the Southern Carpathians;
- studies of Scărișoara Ice Cave from the Western Mountains in Romania.

Recent results of Romanian scientist regarding the *Cryosphere, Atmosphere and Climate* cover the topics:

- updated analysis of observed snow cover variability and change for the Romanian territory;

future projections of snow depth over Romania under the RCP 4.5 and RCP 8.5 scenarios.

PART I: Snow and Avalanches

The monitoring of snow cover evolution in the mountain area of Romania contributes to the protection of lives, properties and infrastructure.

Avalanche risk has been identified in the Romanian mountains and risk assessment studies are continuously updated. The program of snow-related meteorology which started in the National Meteorological Administration in February 2004 (under the coordination of "Centre d'Etudes de la Neige", Grenoble) has been carried out to meet the demand for information related to snow cover avalanche conditions. The National Meteorological Administration (http://www.meteoromania.ro) through the Regional Forecasting Center in Sibiu, the Department of Geography of the West University of Timișoara and the Faculty of Geography from the University of Bucharest are the leading institutions in the avalanche monitoring and research.

Snow avalanches change landscapes and frequently disturb forest stands. Such disturbances in trees have been used to date past avalanches, study their extent and document their triggers by the dendrogeomorphological approach. The dendrogeomorphological approach combined with snow-related analysis using meteorological data have provided the tools to reconstruct past avalanche activity (Voiculescu et al., 2016; Pop et al., 2016; Pop et al., 2018, Mesesan et al., 2018).

Remote sensing data have been also used to detect and make an avalanche inventory for areas in the Southern Carpathian (e.g. Solberg et al., 2016; Török-Oance et al., 2016).

Past avalanches analysis provides the knowledge to document the hazard component of the avalanche risk. Studies regarding avalanche-related impact components and risk assessments have been also carried out (e.g. Voiculescu and Popescu, 2016).

PART II: Continental Glaciers and Permafrost

In the last years, several activities carried out by Romanian scientists focused on glacial/periglacial geomorphology and permafrost detection. The team of West University of Timisoara, Department of Geography, coordinated by Professor Petru Urdea has contributed to Data and Information Service for CliC (http://clic.npolar.no/).

Several studies used combined physical and geomorphological approach to detect and characterize the permafrost presence in the mountain areas in Romania.

An important research area refers to the Ice Cave Scărişoara located in the Western Carpathians (e.g. Perșoiu and Onac, 2019). The Carpathian Mountains across Slovakia and Romania are home of several ice caves located at elevations between 700 and 1200 m above sea level. The Scărișoara Ice Cave (Romania) which is located in the Apuseni Mountains at 1165 m above sea level hosts one of world's largest and oldest underground glacier.

PART III: Cryosphere, Atmosphere and Climate

Numerical experiments with regional climate models have been used to investigate in more detail the physical mechanisms involved in regional response to present and future global warming (Bojariu et al, 2015). The comparison of observed snow data and simulated ones for the historical period shows a reasonably well resembles between model results and measurements at the Romanian level (Figure 1).

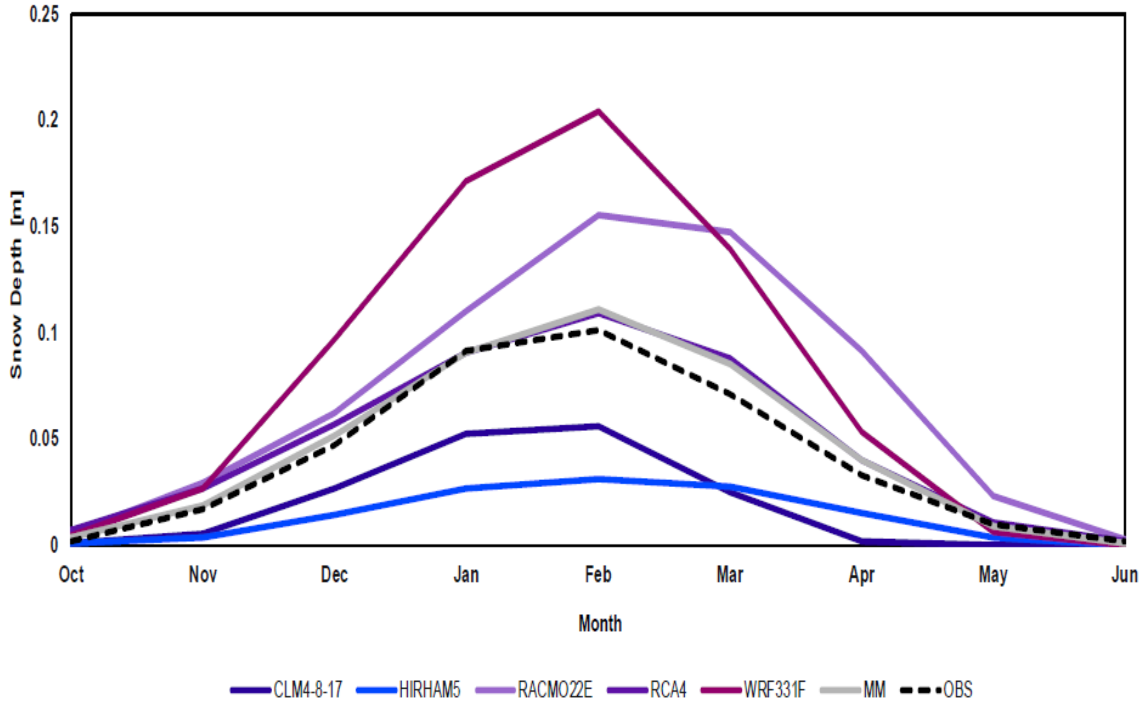

Figure 1: Observed (dotted line) and simulated monthly values of averaged snow depth (colored soild lines, in m) over Romania from 5 numerical experiments with 5 RCMs covering the interval 1972-2001. Ensemble mean of the RCM simulations is in grey (MM). Data are fromthe EURO-CORDEX initiative (after Bojariu et al. (2017)

The analysis of future projection in snow depths and amounts (Figure 2) draw the attention to possible climate-change related impacts on snow in several Romanian regions and hence to the climate-change influences on related socio-economic activities.

Seasonal snow amounts will strongly decline all over Romanian territory. The decrese in snow amount could be larger than 80% (compared with the reference period October-April 1971-2001) in areas from the Western, central and Southern Romania. In mountains, the reduction is slightly smaller ranging from 60% to 80% at the end of the 21st century, in the worst-case scenario. The reduction in snow amounts has impact on many socio-economic activities. For instance, the number of days with good ski conditions in a season is decreasing in the Carpathians under climate change (Figure 3) (Bojariu et al., 2017).

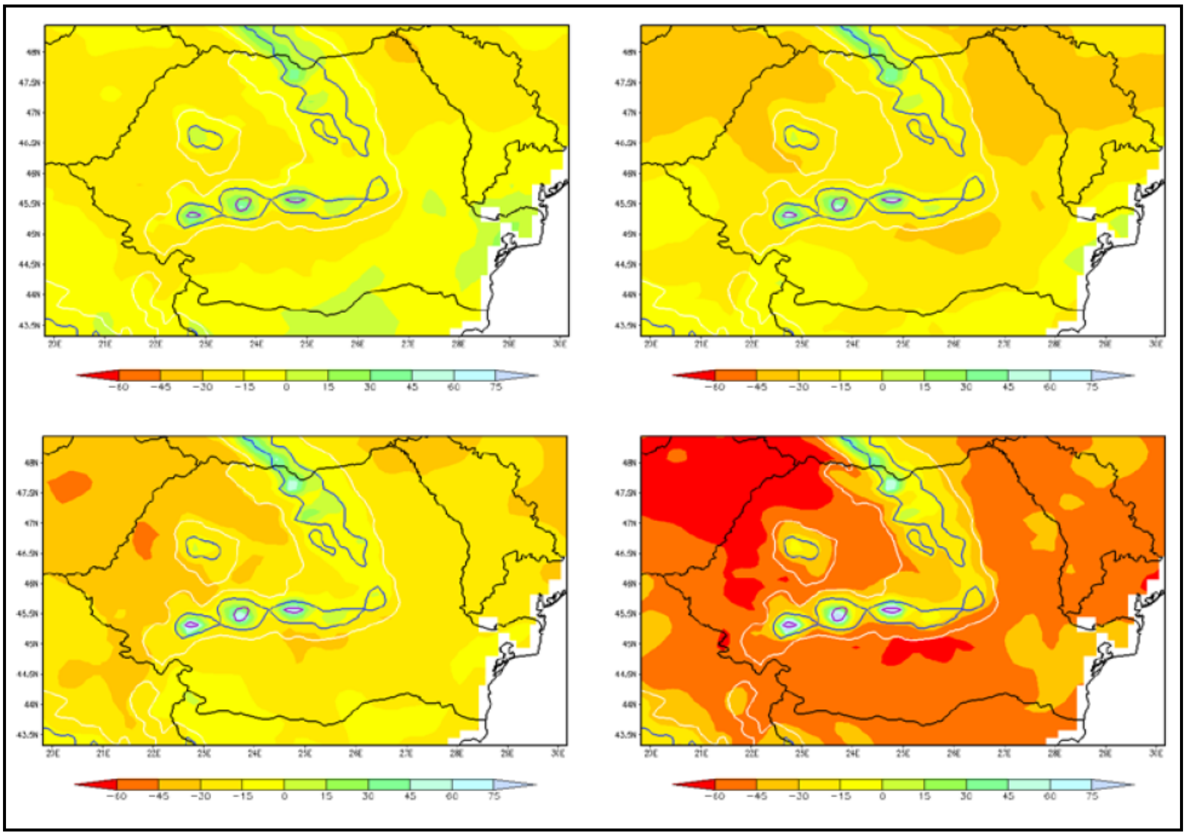

Figure 2: Changes in mean snow melt ampunt (in %) in Romania for the intervals 2021-2050 (upper panels) and 2070-2099 (bottom panels) under scenarios RCP 4.6 (left panels) and RCP 8.5 (right panels). The reference period of present climate is 1971-2000 (after Bojariu et al., 2017)

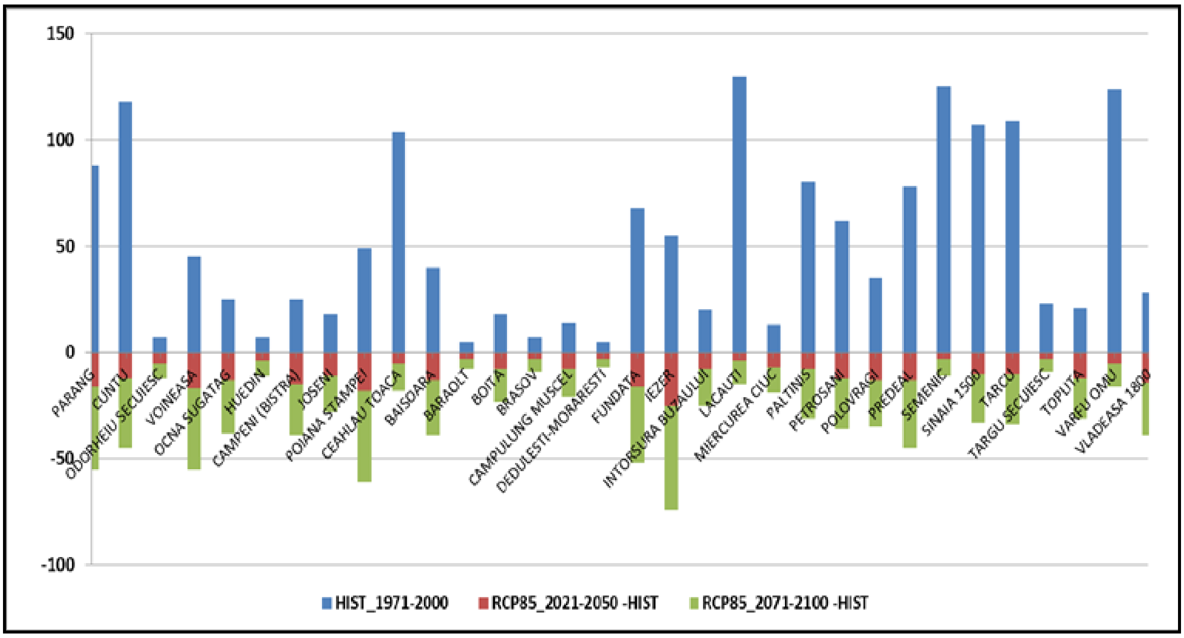

Figure 3: Mean number of days in a ski season with ski conditions (i.e. snow depth larger than 30 cm) at 32 Romanian mountain stations, in the interval 1971-2001 (blue) and changes under RCP 8.5 scenario for periods 2022-2050 (red) and 2072-2100 (green) based on bias-corrected outputs of 5 RCM models (after Bojariu et al., 2017)

Participation of Romanian specialists in national and international projects or programmes

International programs and projects

- **European FP7 CryoLand - GMES Service for snow and land and ice**

Period: 2011-2015
Project manager of the Romanian team in the project: Dr. A. Diamandi (National Meteorological Administration, Bucharest, Romania)
CryoLand is a project carried out within the 7th Framework of the European Commission aimed at developing downstream services for monitoring seasonal snow, glaciers and lake/river ice primarily based on satellite remote sensing. The services target private and public users from a wide variety of application areas, and aimed to develop sustainable services after the project is completed (Malnes et al, 2015).

- **EEA Grant Snowball - Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective**

Period: 2014-2017
Project manager: Dr. G. Stăncălie (National Meteorological Administration, Bucharest, Romania)
The Snowball project delivered a prototype snow monitoring system that combines daily satellite data from Sentinel-1 and Sentinel-3 with in-situ weather station observations and state-of-the-art snowpack and climate modelling. Three important applications of snow monitoring have been demonstrated: hydrological modelling, snow-melt induced flash flood warning and snow avalanche risks. The project also assessed the impact of snow under present and future climate conditions on: flash flood statistics due to snow melt contributions, and groundwater.

Papers in reviewed journals

2018

Pop, O. T., Munteanu, A., Meseşan, F., Gavrilă, I. G., Timofte, C., Holobâcă, I. H. 2018: Tree-ring-based reconstruction of high-magnitude snow avalanches in Piatra Craiului Mountains (Southern Carpathians, Romania), *Geografiska Annaler: Series A, Physical Geography*, 99-115, doi: 10.1080/04353676.2017.1405715;

Meseșan, F., Gavrilă, I.G., Pop, O.T., 2018: Calculating snow-avalanche return period from tree-ring data, *Nat Hazards,* **94 (3)**, 1081-1098, doi: 10.1007/s11069-018-3457-y.

2017

Bojariu, R., Corbus, C., Mic, R. P., Matreata, M., Craciunescu, V., Milan, N., Dumitrescu, A., Birsan, M. V., Dascalu, S.I., Gothard, M., Velea, L. Cica, R., Grecu, C. L., Pasol, A. A., 2017: Climate change impact on snow-related processes, in Stăncălie G. (Coordinator) *Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective*, 63-90, Bucureşti, Printech, 2017, ISBN 978-606-

23-0733-2;

Stăncălie, G., 2017: Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective, pp 163, Bucureşti, Printech, 2017, ISBN 978-606-23-0733-2

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Voiculescu, M., A Onaca, P. Chiroiu, 2016: Dendrogeomorphic reconstruction of past snow avalanche events in Bâlea glacial valley–Făgăraş massif (Southern Carpathians), Romanian Carpathians, *Quat. Int*, **415**, 286-302, doi:10.1016/j.quaint.2015.11.115

Voiculescu, M., Popescu, F., 2016: Management of Snow Avalanche Risk in the Ski Areas of the Southern Carpathians–Romanian Carpathians in Zhelezov G. (eds) *Sustainable Development in Mountain Regions,* Springer, Cham, doi:10.1007/978-3-319-20110-8_13, ISBN 978-3-319-20109-2, Online ISBN 978-3-319-20110-8;

Török-Oance, M., Ardelean, F., Voiculescu, M., Milian, N., 2016: First Snow Avalanche Inventory in the Romanian Carpathians Based on Very HighResolution Satellite Images, Conference proceedings: 36th Earsel Symposium Frontiers on Earth Observation, 44-45.

2015

Malnes, E., Buanes, A., Nagler, T., Bippus, G., Gustafsson, D., Schiller, C., Metsämäki, S., Pulliainen, J., Luojus, K., Larsen, H. E., Solberg, R., Diamandi, A., Wiesmann, A., 2015: User requirements for the snow and land ice services – CryoLand, *The Cryosphere Discuss.*, **9,** 791–816, doi:10.5194/tcd-9-791-2015.

IAG ACTIVITIES IN ROMANIA
2015-2018

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National Report on Geodetic and Geophysical Activities in Romania - ISBN -

Contributions in Geodesy

Section I: Positioning and Reference Frames

1. Background

For the time interval 2015-2018 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. At present the situation still remains the same even efforts to unlock were done especially by professional body – Romanian Geodesists Union (UGR).
The National Agency for Cadastre and Land Registration (NACLR) under Ministry of Regional Development and Administration is the state responsible institution for geodetic and mapping activities in Romania. From a budget financing public institution NACLR was transformed since 2014 in a self-financing institution. NACLR includes the national mapping activities and 42 Cadastre and Land Registration Offices. As research and production institution acts the National Centre for Cartography (former 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, but after September 2014, it comes back to previous financial form.

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 2007-2012. The new geodetic network it is built as an active continuously operating network. As technological equipments the GNSS (GPS/GLONASS) receivers are included into the network. Galileo GNSS technology started to be implemented and Beidou for few private networks.
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. 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). In 2012, the last 15 GNSS permanent stations were installed increasing the GNSS permanent network up to 74 stations.
Romania it is member of the EUPOS (European Position Determination System) organization contributing to the standards adopted by members from Central and East European countries and EUPOS infrastructure by realizing *ROMPOS (Romanian Position Determination System)* based on the 74 GPS and GNSS permanent stations (Figure 1a and b).

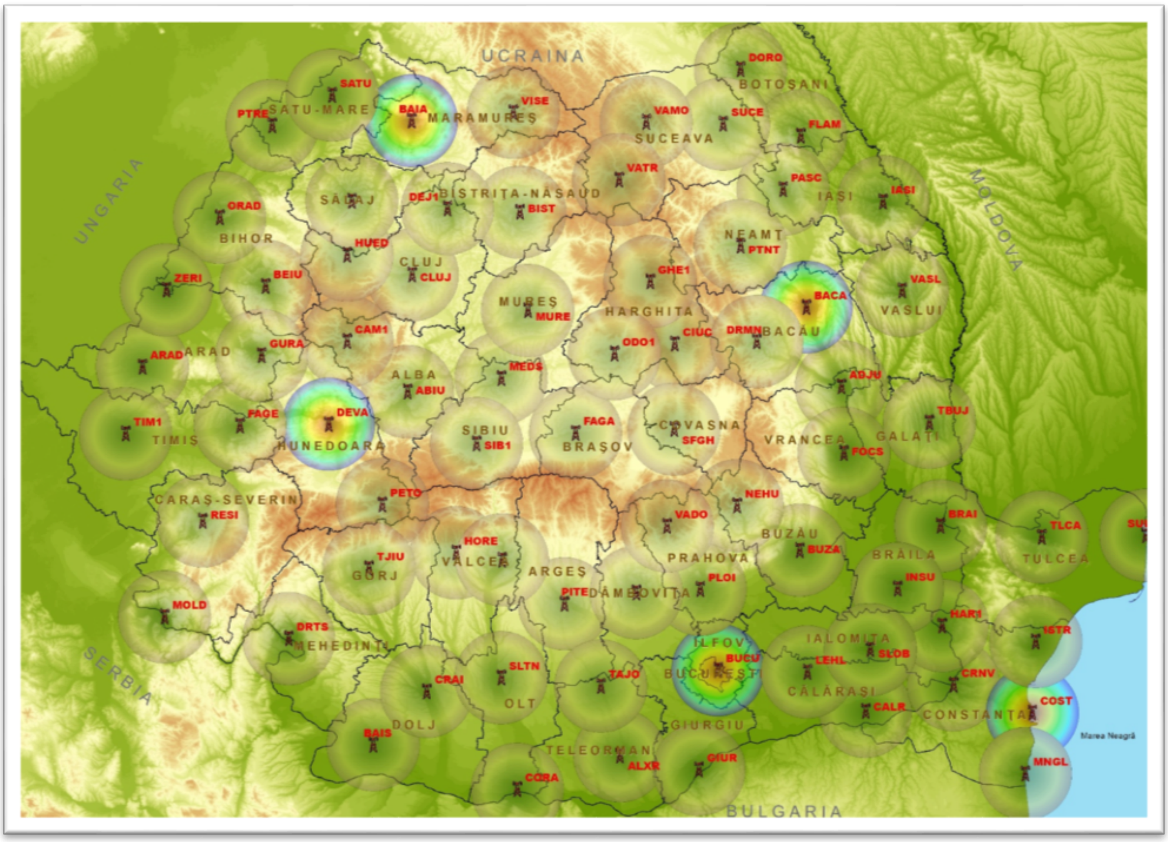

Figure 1a: Romanian National GNSS Permanent Network (ROMPOS)

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 (Figure 2). 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 stations coordinates is better than +/- 1cm.

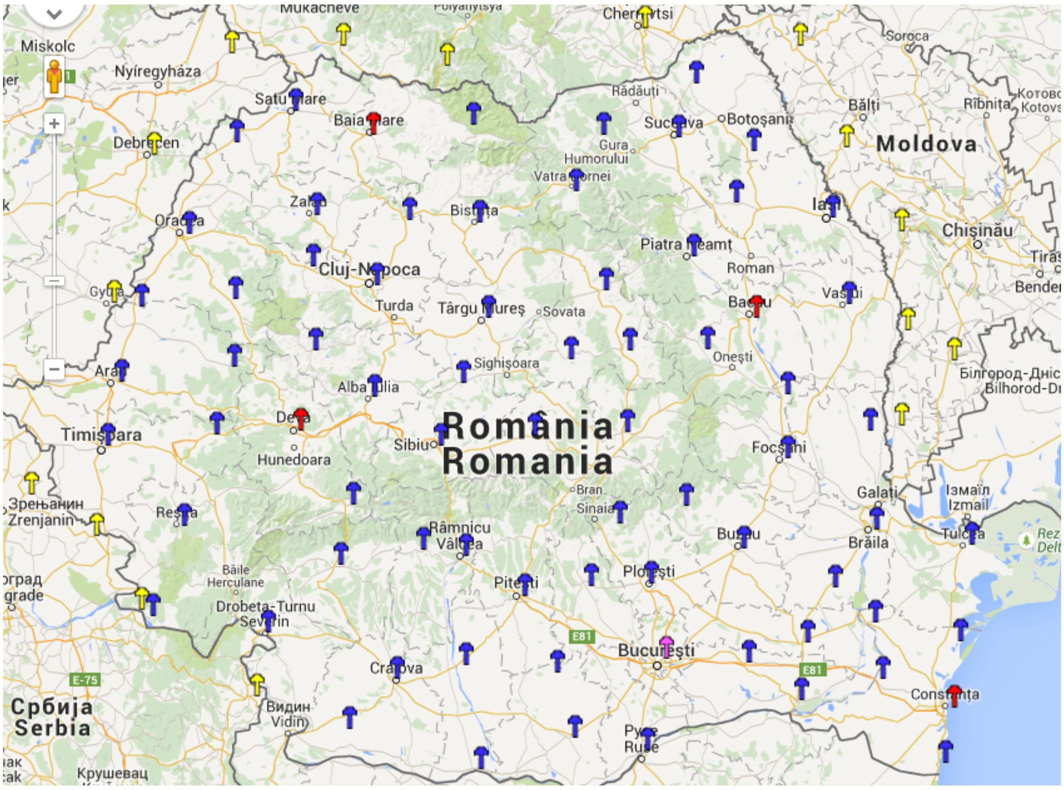

Figure 1b: ROMPOS – including neighbor countries stations
(red – IGS/EUREF/EUPOS sites; yellow included stations from HU, MD, SR and UA)

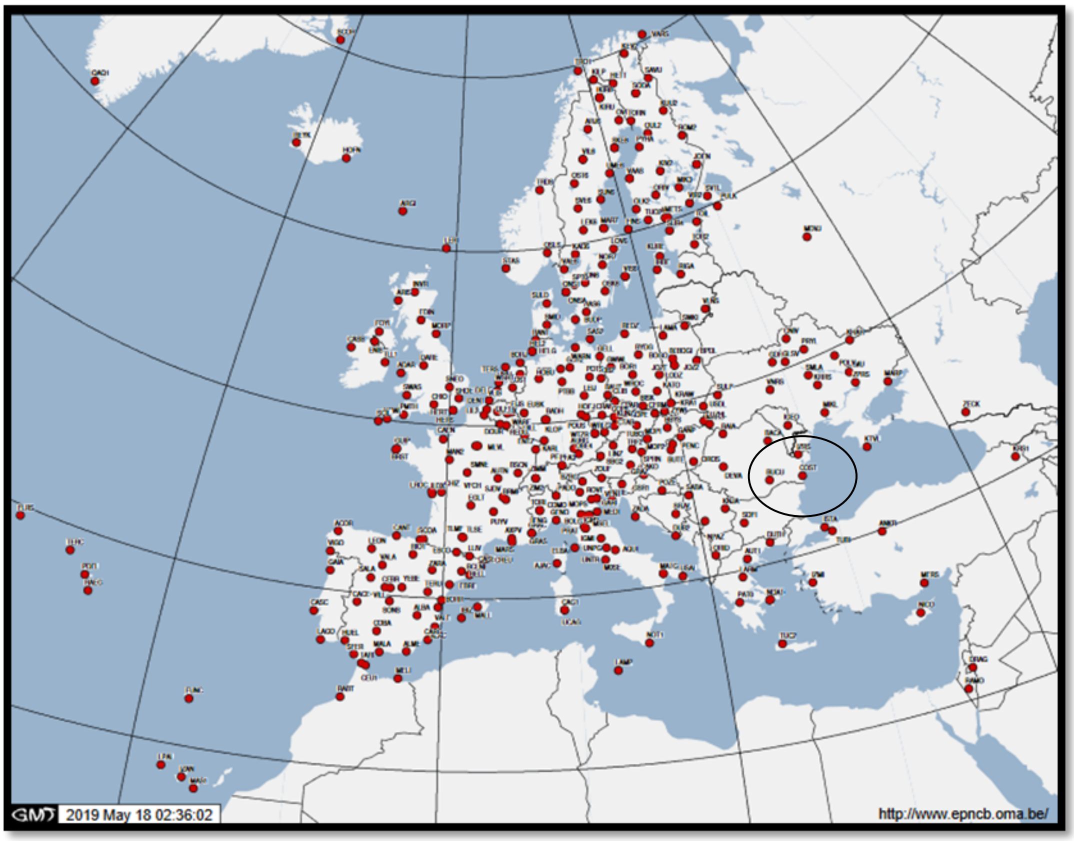

Figure 2: IGS and EUREF-EPN stations in Romania (Bucu, Baca, Baia, Cost, Deva)

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 European Vertical Reference System (EVRS).
National Spatial Geodetic Network is structured on classes, using the precision and density criteria, as in the Table 1.

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 km^2 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	74 GNSS permanent stations 1 point / 3250 km^2 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 ./700km^2 Uniform Distribution	- regional and local geodynamics measurements, high precision topographic determinations
National Spatial Geodetic Network Class C	C	3.0	About 4750 points 1point/50km^2 Uniform distribution	- high precision topographic measurements, cadastre; -partial realized
National Spatial Geodetic Network Class D	D	5.0	At least 1point/5km^2 even distribution	- topographic measurements, densification networks, G.I.S. - partial realized

MSE – Mean Square Error of the 3D position determination

Class B network was observed in 2003 and the results were included into national database in 2005 (Figure 3). From the total number of stations about one third has 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 it is realized in general for cadaster with no uniform distribution and the precision of these stations will be less than 5 cm. [http://gnss.rompos.ro]

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

3. Leveling Network - Romanian Contribution to EVRS Realization

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 neighbor 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.

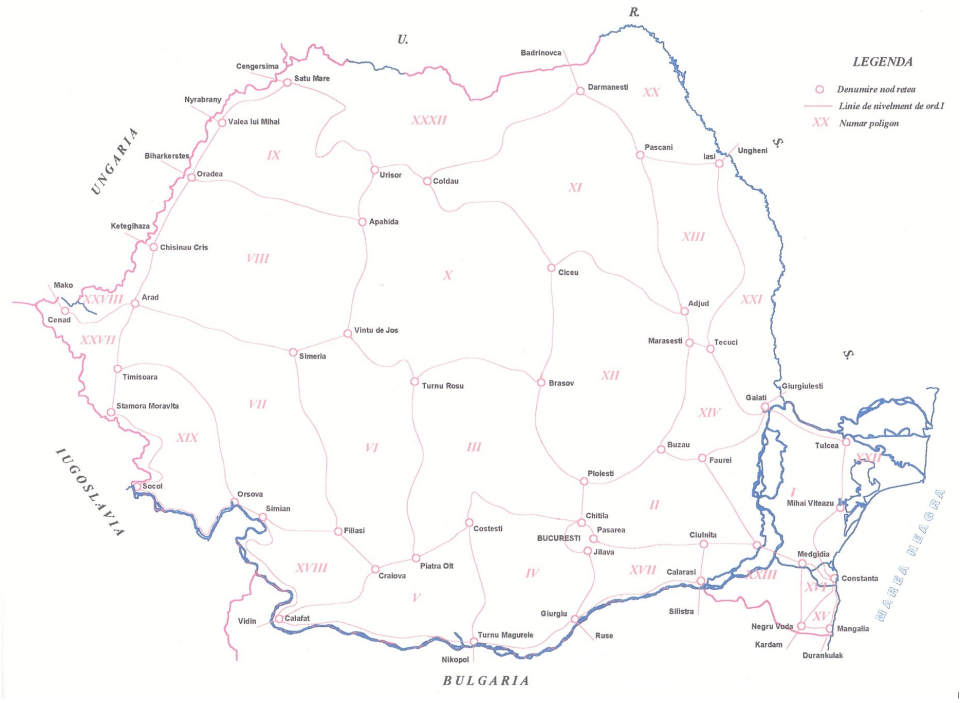

Figure 4: Romanian Leveling Network

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 and EVRF2007.

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 (Figure 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 Cadaster and Land Registration.

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 EVRF2000 and 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 figure 6.

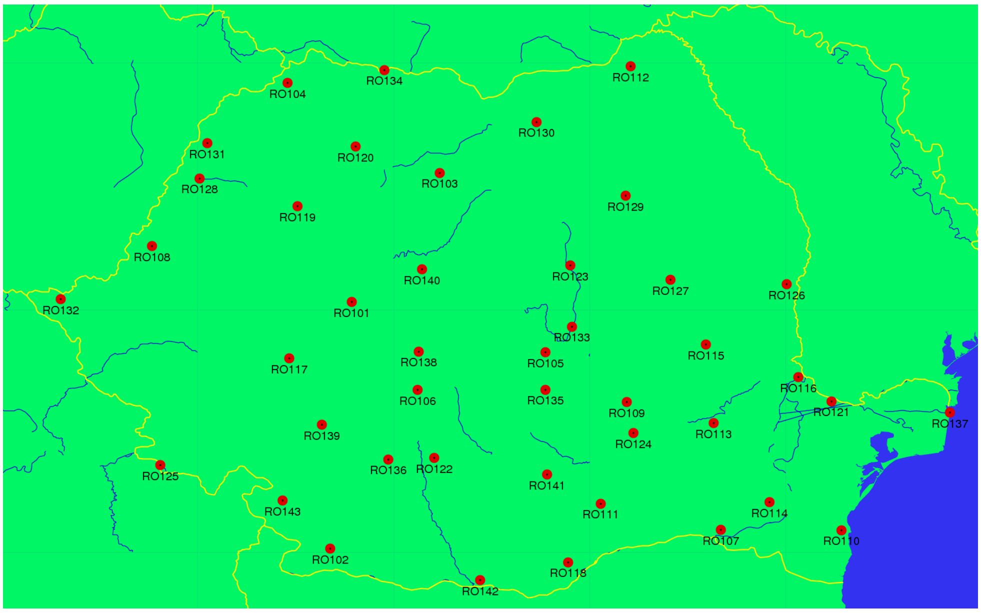

Figure 5: Romanian contribution to EUVN_DA project (2009)

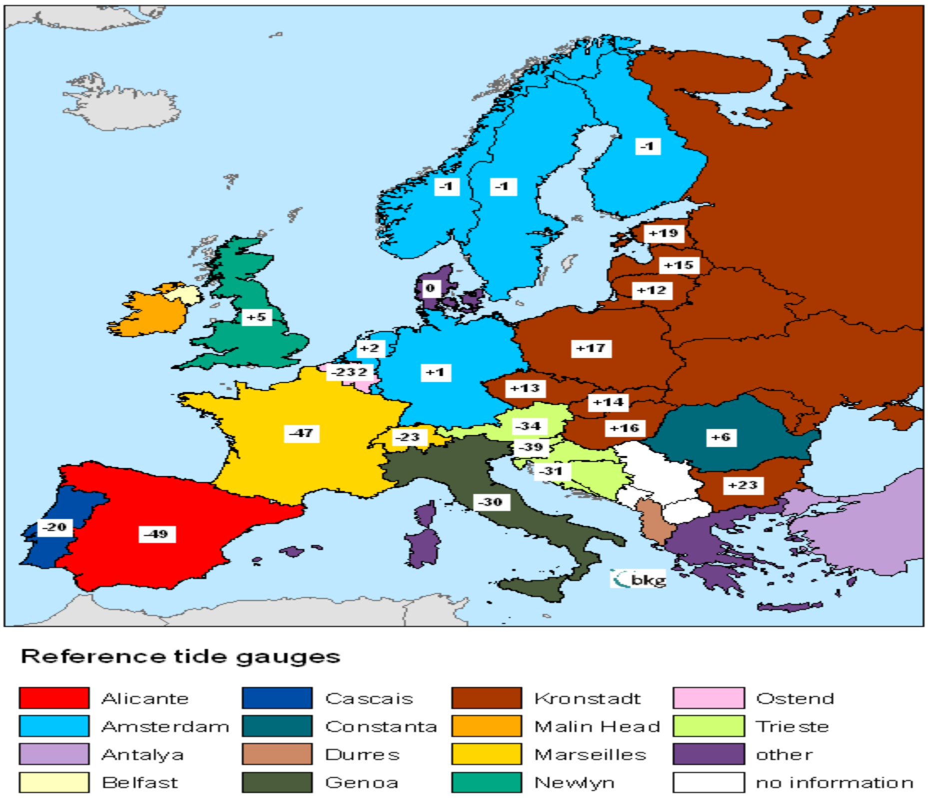

Figure 6: Mean differences between EVRF2007 and national height reference systems (+6 cm Romania)

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 included this option in the software package for coordinate transformation *TransDatRO* which is published on internet and was 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.

- 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 leveling campaign was started by NACLR in 2010 and was continued in 2011 and 2012 in the metropolitan area of Bucharest (Figure 7). The goal of the project was to establish and densify the national leveling datum for this area by precise (geometric) leveling. The project included gravity observations in this area in order to compute a local quasigeoid (+/- 5 cm rms).

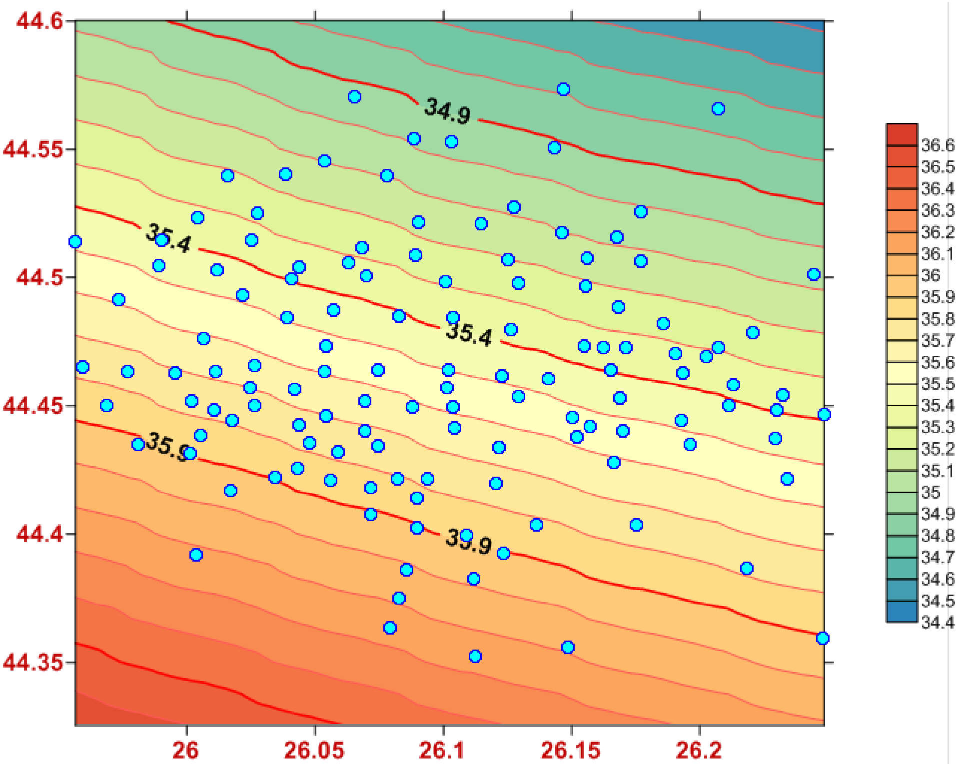

Figure 7: Local quasigeoid for Bucharest and Ilfov County (129 points observed)

In the last three years determination of the new gravimetric quasigeoid of Romania was started in parallel with continuation of GNSS/leveling observations in order to contribute to this project. In a number of three counties (from 42) the observations were done and the results (Figure 8) are included in the new version of *TransDatRo* software.

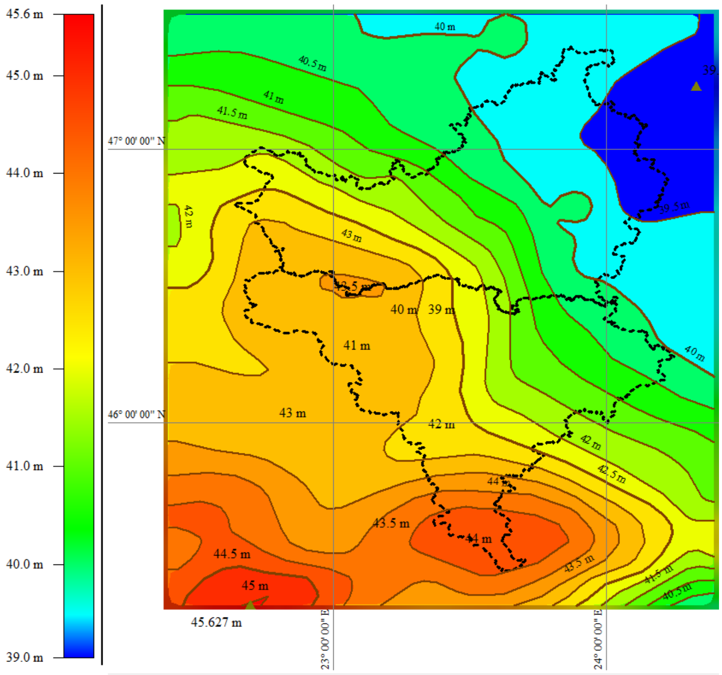

Figure 8: Local quasigeoid for Alba and Cluj Counties (preliminary results)

4. PROJECTS

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

- **European Position Determination System (EUPOS) – interregional cooperation**

The main objectives of the project are to strengthen the cooperation and cohesion between the participating countries and regions from Central and East Europe and to create awareness for the benefits of satellite-based applications. It can be reported that the goal will be 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. New standards for the EUPOS components were developed and implemented and a common data centre will be created. Cross border cooperation was improved and GNSS realtime data exchange extended step by step. Cooperation agreements were signed with relevant organizations in Europe (EUREF, EUMETNET).
Romania by NACLR participated at EUPOS conferences between 2014-2018.

- **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 August 2014 version 9.0 was released, and the limits were updated regularly.
- **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 5.1 of this product was released in 2014 and new updates are available.
- **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. Version 8.0 for Romania was provided in October 2014 and new updates are available.

- **Euro Digital Elevation Model (EDM)** - The main objective of the project is a digital representation of the ground surface topography of Europe, (not including 'first surface' elevations such as vegetation and man made structures). Geospatial elevation data is used by the scientific and resource management communities for applications relevant for environmental hydrologic cartography such as ortho-rectification of imagery, creation of relief maps, flight simulations, design of mobile telephone networks, geological structure studies. EuroDem data are essential for applications Fast Track Services, which are to be implemented within GMES (Global Monitoring for Environment and Security). The participants have also taken into consideration the financial aspects, aiming at creating a cheap product comparing with the prices of other products from the market. EuroDem is provided from the national data bases by the National Mapping and Cadastral Agencies. According to the Eurogeographics policy, the updating as well as the distribution of the product is regulated by agreements signed by all projects partners, including ANCPI.
- **Ortophoto products in Romania** – In the time interval 2014-2018, ortophoto products were realized as: large scale ortophoto for Bucharest (1: 500 scale) and at 1:1000 scale for other main cities in Romania ; Starting with 2010 year, Military Topographic Directorate provided ortophoto products for Ministry of Agriculture and other state institutions.
- **Cross border cooperation programmes** – FAIRWAY Danube project (2015-2020)

In order to improve navigation on the Lower Danube area, some European projects are underway. The focus of FAIRway Danube project (2015-2020) is to provide current and harmonized information about shallow sections, water levels and water level forecasts (Figure 9). Available depths will be used optimally by adapting the location of the waterway to the current riverbed conditions. In parallel, FAIRway Danube is aiming at preparing the harmonized rehabilitation of the Danube and its navigable tributaries. The bilateral conventions and agreements signed by Romania and Bulgaria, as well as between AFDJ Galati - Low Danube River Administration (Romania) and IAPPD Ruse - Executive Agency "Exploration and Maintenance of the Danube" (Bulgaria), establish the responsibilities for maintaining the appropriate airworthiness conditions from km 845 to km 375. The authorities of both states have agreed to significantly improve airworthiness in the Danube section, their intention being to minimize as much as possible periods of time when commercial navigation is not possible: both during the winter, when ice climbs occur, and in summer when the Danube level is very low. As a support of the FAIRway Danube project, geodetic activities in that area included in last years geodetic observations (GNSS, leveling, bathymetry, Lidar). Previous geodetic studies performed by TU of Civil Engineering Bucharest – Research Centre on Spatial Geodesy, Photogrammetry, Remote Sensing and GIS (GEOS) established connections between CRS (Coordinate Reference Systems). If 2D connections are more easily to be established, the height connection between the old and new CRS on the left and right bank of the Lower Danube are more difficult to be established. GEOS contributed to this project by realizing a local quasigeoid model on the project area with an accuracy of 3-5 cm (Figure 10). The model established the connection between the ellipsoidal heights (ETRS89) and EVRF07 normal heights with the possibility to transform to the Black Sea 1975 (RO) and Baltic Sea 1982 (BG) datums. A user friendly software (DARAT) was realized, too (Figure 11).

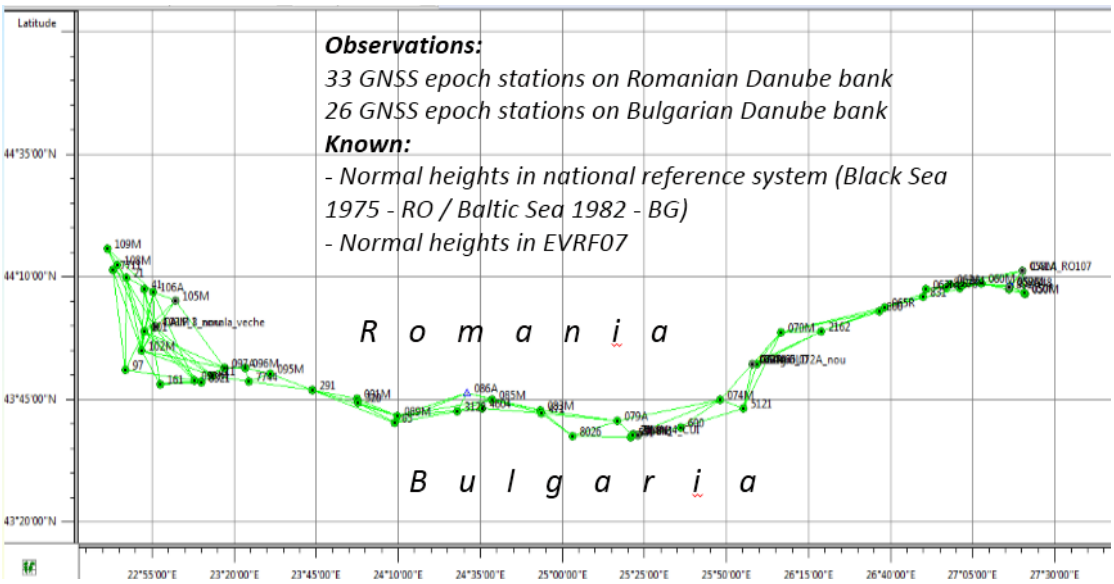

Figure 9: GNSS/Leveling network – FAIRWAY DANUBE PROJECT

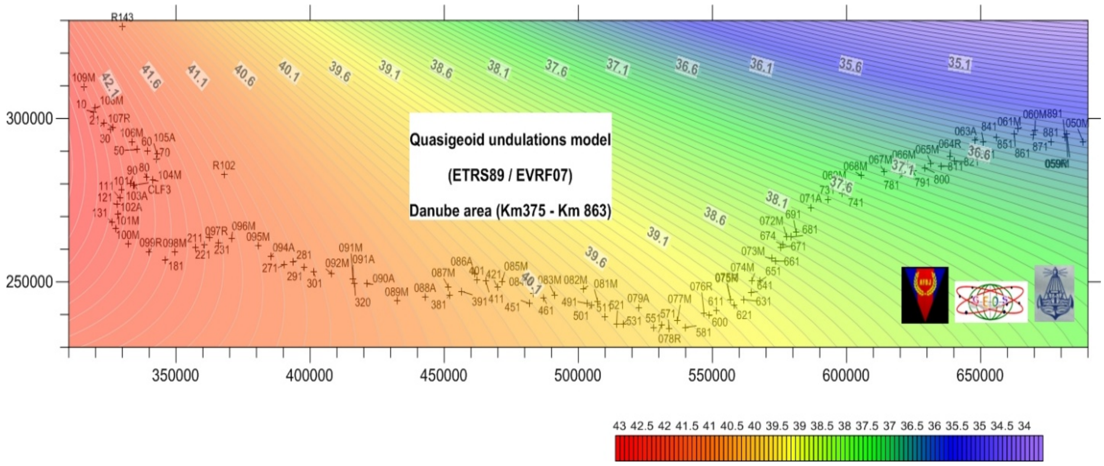

Figure 10: Map of quasigeoid – Danube area - crossborder Romania - Bulgaria

Figure 11. Danube River Altitude Transformation (DARAT) sofware

- **Realization of a support system for hydrographical works on the Danube to assure minimum navigation depths - BORD**

Overall Objective of the project is to improve the safety of navigation of the Danube, in compliance with the European Directives and the Danube Commission's recommendations, taking into account the anticipated increase of cargo and passenger traffic during the next 10-15 years.
The project was submitted by River Administration of the Lower Danube Galati for funding approval within the Operational Program "Transports" (POS-T) 2007-2013, Priority Axis 3, Key Area of Intervention 2- Improvement of Traffic Safety on all transport modes. The project was financed from EU-ERDF grants (85%).
Specific Objective: setting in place a network of geodetic landmarks in support of the topo-hydrographical works on the Danube, for the monitoring of the minimum navigation depths and the improvement of fairway maintenance activities (floating and costal signaling, topo-hydrographic surveys, dredging). *Aim of the project*: to create a network of geodesic landmarks along the Romanian Danube sector, the Danube-Black Sea Canal and Poarta Alba - Midia - Navodari Canal, network to be used for the river bed dynamics monitoring and meant to provide exact data for the realisation of accurate Electronic Navigation Charts. A total of 432 landmarks in 144 locations situated at about 10 km spacing between were installed in 2014. Coordinates were computed from GNSS and leveling observations in ETRS89 and EVRS reference systems. The network was connected with national geodetic network (GNSS and leveling) and can be used for horizontal or vertical positioning in the area of Danube (Figure 12).

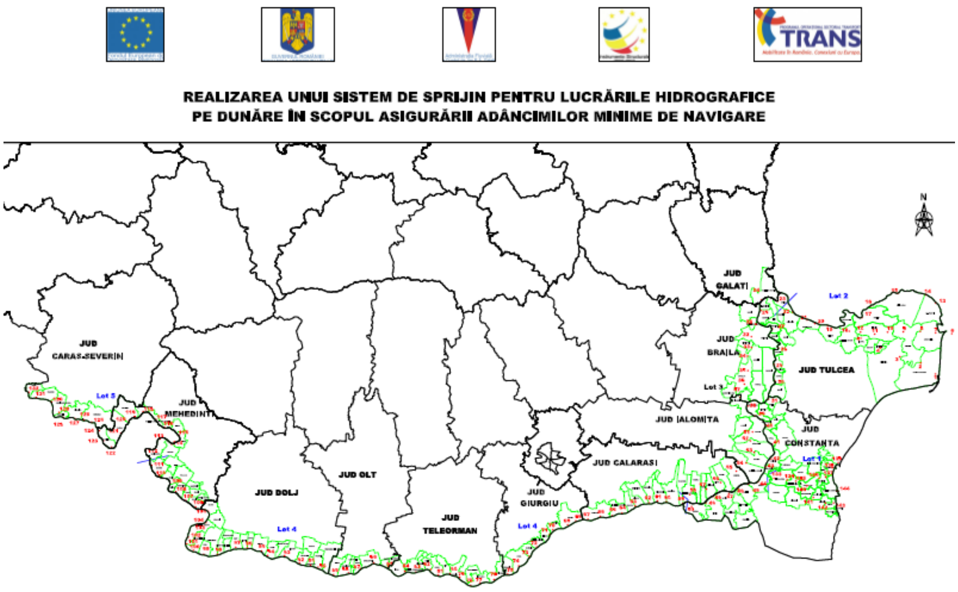

Figure 12: Sketch of the BORD geodetic network along the Romanian Danube sector

- **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/GNSS technology and other significant data sources. Romania participates 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*.

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 – present). CEGRN was continuously extended with new stations, especially permanent stations in the last decade. Romania sends at present continuously GNSS data from 7 permanent stations to CEGRN data center in Graz (Austria) excluding the five Romanian EPN stations. Totally, data from 12 permanent stations are available continuously (Figure 13).

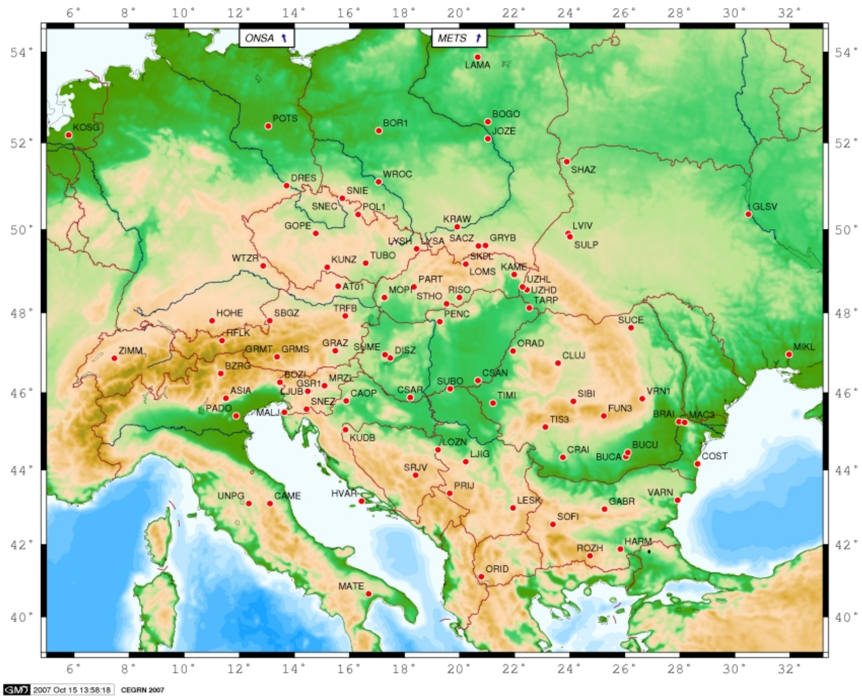

Figure 13: CEGRN network (http://cergop.oeaw.ac.at)

- **VRAGEO Project**

VRAGEO is a service proposed in response to Partnerships Program - Applied Research Projects - Competition 2013, Priority area 3- Environment, Research direction 3.4.6. Natural and technological hazards; researches on risk assessment and impact studies. The main objective of

VRAGEO is to enable free and open access to seismic hazard information in Romania due to Vrancea source in support of GMES (Global Monitoring of Environment and Security) through the development of an operational framework, a set of supporting tools and advanced geospatial surveillance methodologies of Vrancea tectonic active region. Project started in July 2014 and ended in Decembre 2016. For monitoring of the geophysical parameters having precursory character in Vrancea area, time-series geospatial data will be used in three distinct directions: 1) Pre-seismic crustal deformation with millimeters-centimeters precision order through GPS, radar satellite interferometry (TerraSARX, ALOS, future Sentinels); 2) Geomagnetic and ionospheric anomalies, short term or immediate seismic precursors over strong earthquakes areals expressed through Total Electron Content TEC provided by GPS permanent network stations or from real-time IPS - WDC for Solar-Terrestrial Science data (Figure 14); 3) Possible thermal surface anomalies inferred through surface latent heat flux (SLHF) and Land Surface Temperature (LST) changes from time-series satellite data in IR regions (NOAA-AVHRR, Terra/Aqua-MODIS, Landsat TM/ETM, ENVISAT, Sentinels).

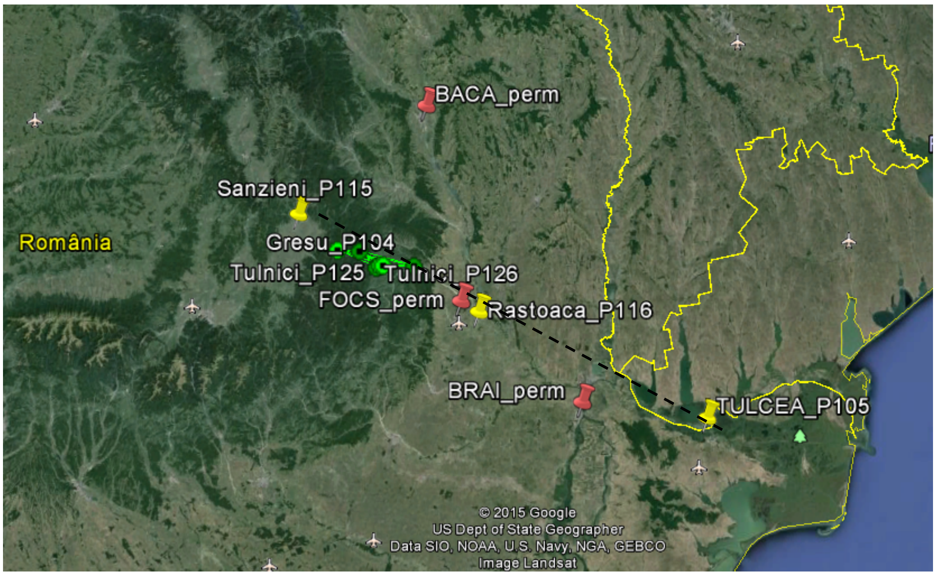

Figure 14: VRAGEO (geodynamic) network (red – perm. stations, yellow – epoch stations)

- **OTHER ACTUAL PROJECTS (NACLR)**

- Rehabilitation of the first-order precision leveling network by GPS, recognition and determination in the characteristic points compatible with the Class D geodetic network and the determination of a quasigeoid for the Danube Delta.
- Establishment of a gravimetric calibration polygon in the area of Sinaia, Prahova county.
- Calculation of the transformation grids and the development and modernization of the Romanian Positioning System (ROMPOS) - Integration of transformation grids into the TransDatRO application and updating of the application options (for counties executed in 2018 with gravimetric determinations).
- Establishment of the Class D National Geodetic Network in the area of the cities, in order to ensure the systematic cadastre introduction in the areas of interest.
- Determination of a gravimetric quasigeoid for the area of Romania.
- Geodetic and oceanographic measurements at sea gauges in the ports of Constanta, Mangalia and Sulina for the time tracking of the Black Sea level oscillations compared to 0, by linking to the leveling network and integrating the national geodetic networks into the EUREF and EUVN European reference systems;

- Manage, monitor, develop and ensure the operation of ROMPOS;
- Keeping up-to-date information on permanent GNSS stations in the EUREF and EUPOS databases and ensuring the exchange of GNSS data under national and international agreements and protocols.
- Participation in the activities of the VOLTA project (innoVation in geOspatial and 3D daTA);
- Realization of digital orthophotomaps for municipalities and towns.

Section II: Advanced Space Geodesy

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

Romania participates 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 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.

Members of the *EUPOS* cooperation (2011) 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 (Figure 15).

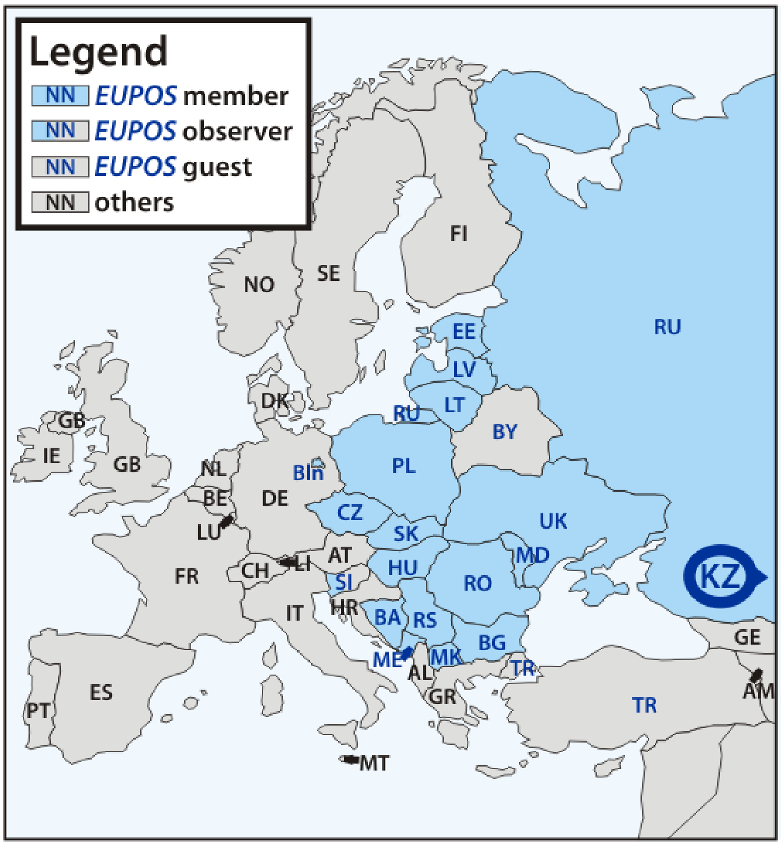

Figure 15: Distribution of EUPOS members (www.eupos.org)

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 16).

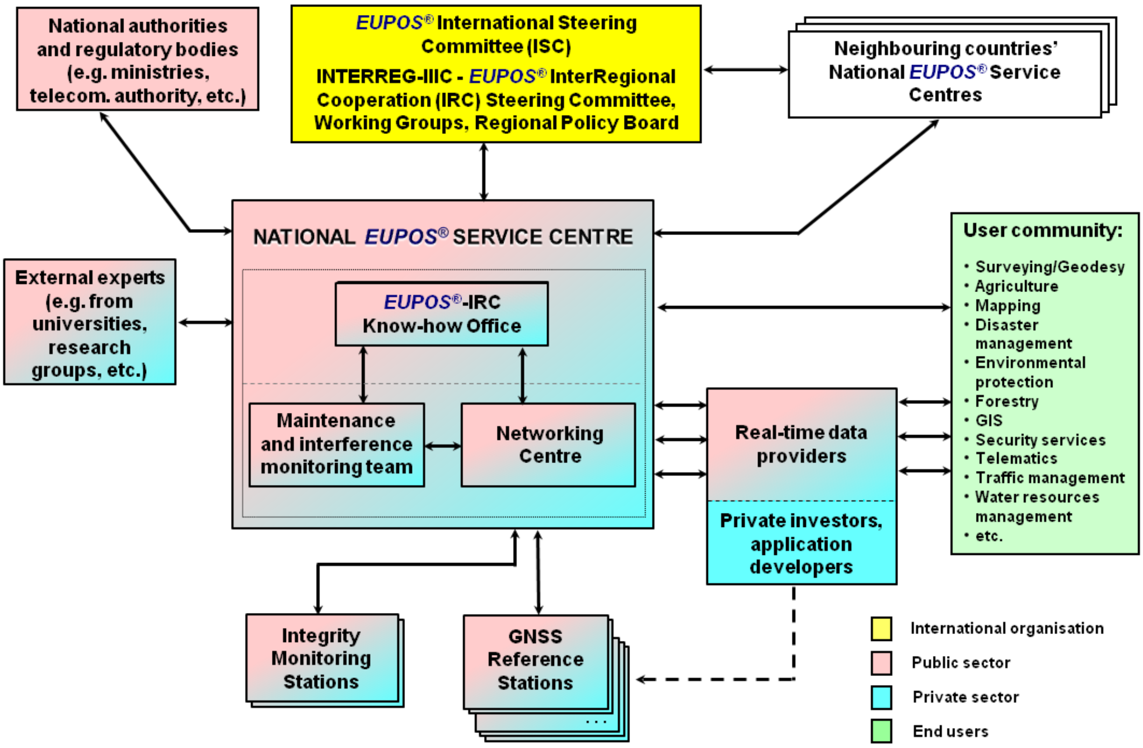

Figure 16. EUPOS National Service Centre structure

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). *EUPOS* provides DGNSS correction data referred to ETRS.

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 was finalized in 2012 at 74 stations (Figures 17 and 18) with station's spacing of about 70km.

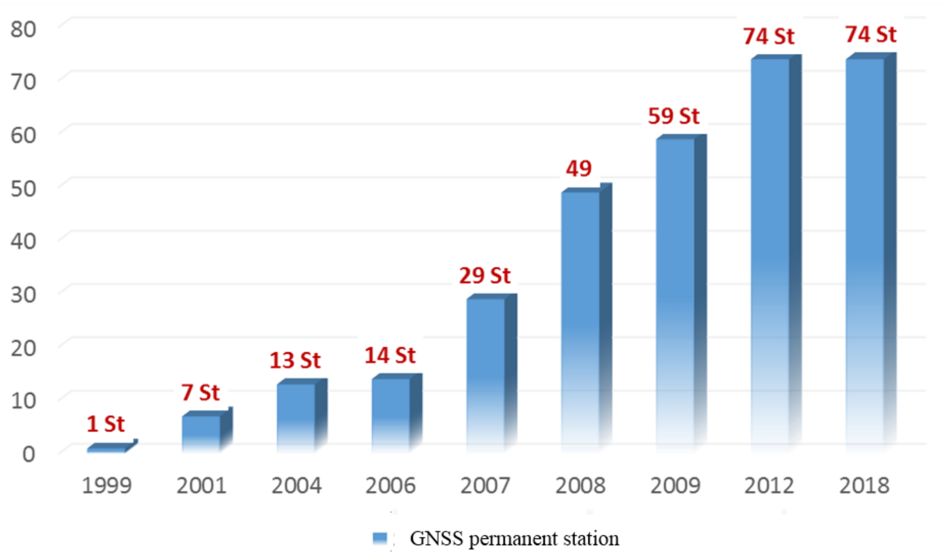

Figure 17: ROMPOS GNSS permanent stations evolution

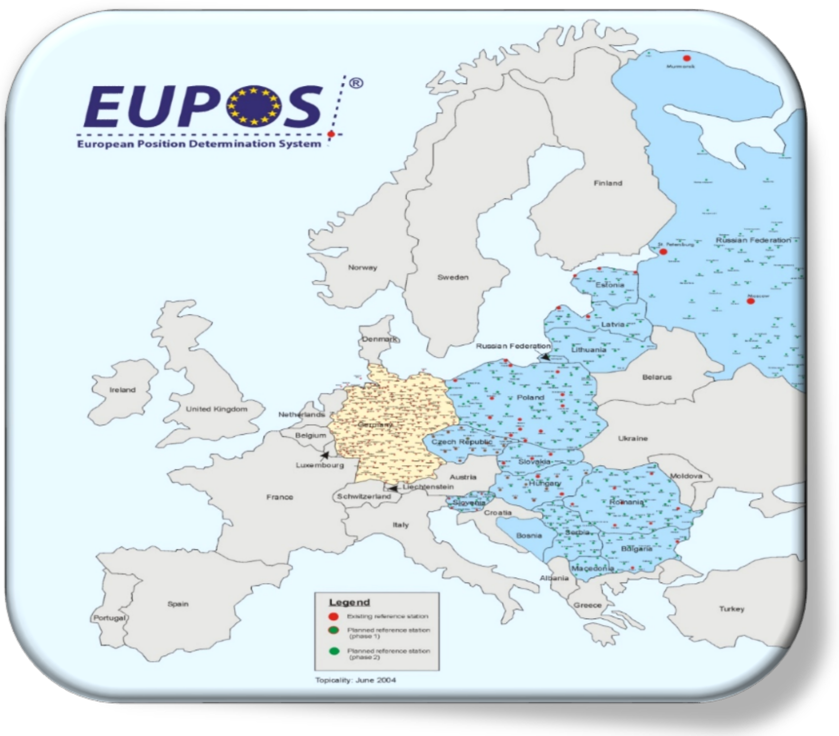

Figure 18: EUPOS countries and GNSS permanent stations

ROMPOS services includes three services (Figure 19):

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

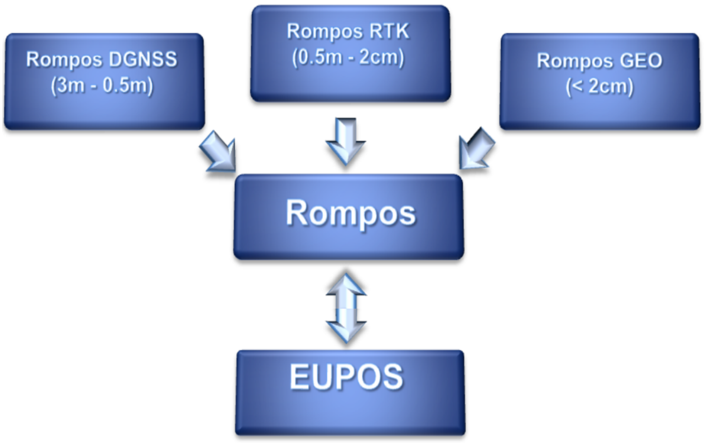

Figure 19: ROMPOS (Romanian Position Determination System) Services

- *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;
- *ROMPOS 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 (updated 2016), Moldova (2010), Ukraine (updated 2015), Bulgaria (2015) and Serbia (2015).
In addition to the standard quality check procedures provided by commercial GNSS permanent network software, a new procedure it is developed under EUPOS umbrella and ROMPOS stations are included in the pilot tests performed (Figure 20).

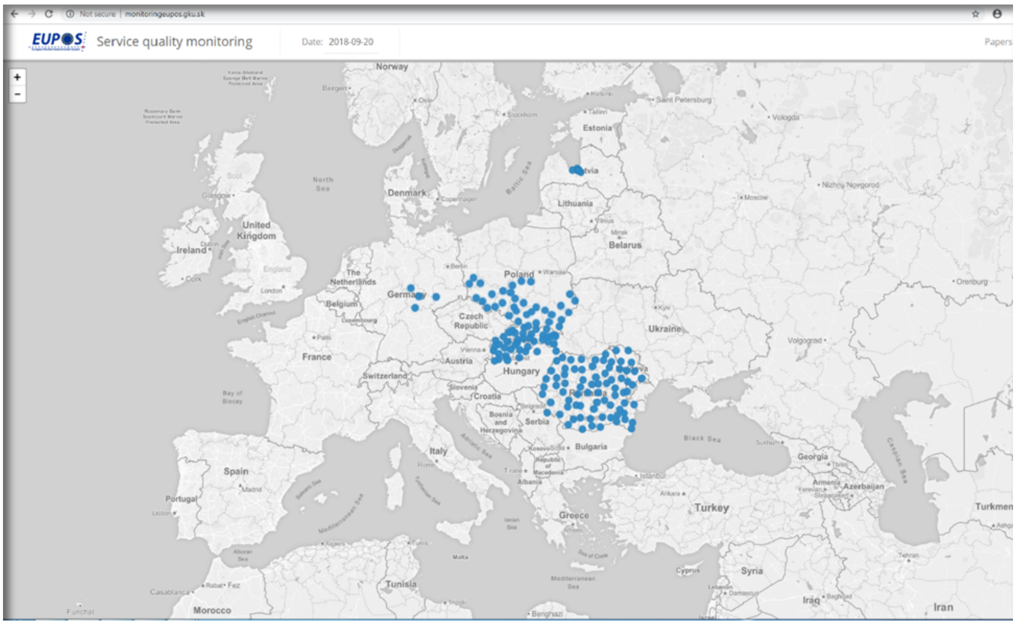

Figure 20: EUPOS Service quality monitoring including ROMPOS stations
[http://monitoringeupos.gku.sk/]

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 reference frame establishment (ITRF, ETRF) and cross-border studies, geodynamics, engineering surveying based on GNSS (large structures monitoring).

- **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 three 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 offers 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. The figures 21a, 21b and 21c presents the EGNOS signal acquisition at Faculty of Geodesy in Bucharest (GNSS permanent stations BUCU). The tracking data indicate that for this position the elevation angle it is less than 50 degrees for any of the EGNOS satellites (Table 2).
A number of about six ROMPOS GNSS permanent stations are capable to provide GALILEO signals in addition to GPS and GLONASS signals.

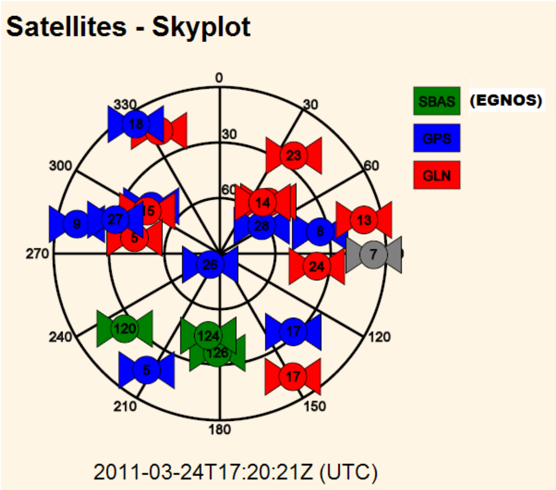

Table 2: ENGOS satellite information

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 21a: GPS, GLONASS and EGNOS tracking at GNSS/EGNOS permanent station in Bucharest

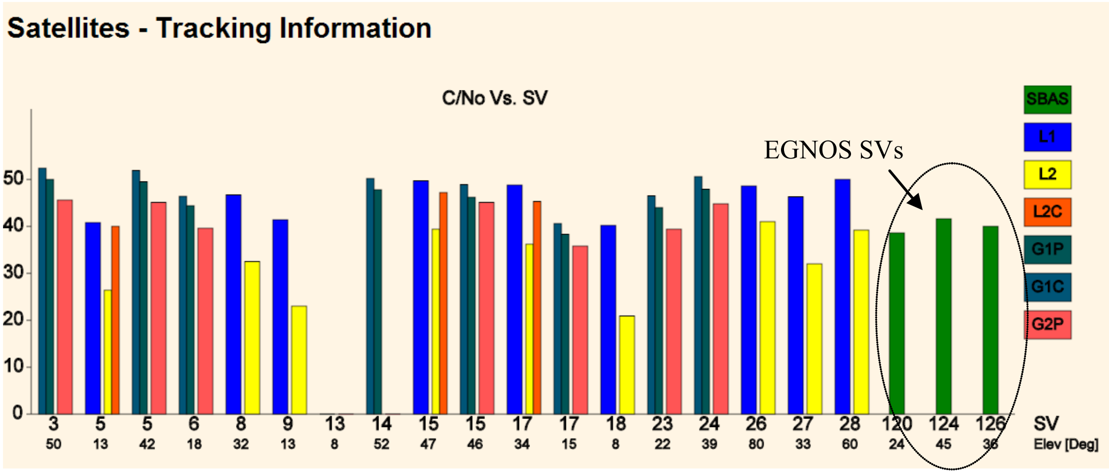

Figure 21b: GPS, GLONASS and EGNOS signal at GNSS/EGNOS permanent station in Bucharest

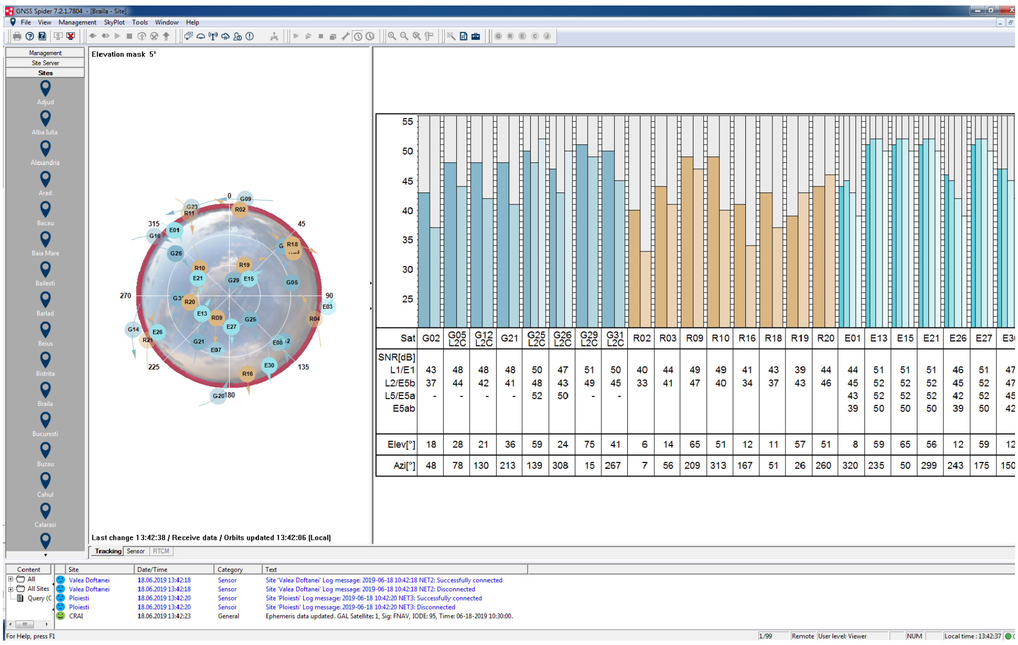

Figure 21c: GPS, GLONASS and GALILEO signal at ROMPOS stations

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 are going to be done for the modernization of the gravity network. Since 2004 there are no new absolute gravity determinations in Romania.
NACLR started a new project for quasigeoid determination in Romania, based on gravity, GNSS and leveling data. Gravity observations are performed with Scintrex (CG5) equipments (Figure 22).

Figure 22: Gravity observations with Scintrex Autograv CG5

- **AGEO Project -** Astro-geodetic platform for high accuracy geoid determination (acronym AGEO). Financed by Romanian Space Agency - Programme for Research-Development-Innovation for Space Technology and Advanced Research – STAR; Project reference: *Astro-geodetic platform for high accuracy geoid determination (acronym AGEO). This work was supported by a grant of the Romanian National Authority for Scientific Research, Program for research - Space Technology and Advanced Research – STAR, project number 216. Coordinating organization:* Technical University of Civil Engineering Bucharest, Faculty of Geodesy (TUCEB-FG); *Partners:* Astronomical Institute of the Romanian Academy (AIRA), Geogis Proiect s.r.l. *Start date of the project / End date of the project:* 29.11.2013 – 29.11.2015

Short description of the project: Geoid determination and/or validation by CCD astro-geodetic vertical deviations determinations; *Project goal*: Design, perform and test of a mobile platform for astro-geodetic measurement capable to provide real time vertical deviation at a satisfactory precision and low cost by astronomical and geodetic measurements (Figure 23).

Figure 23: Astro-geodetic observations for vertical deviation determination

Objectives:

a. Developing a rigorous mathematical algorithm for astro–geodetic determinations of vertical deviation;

b. Designing and testing a cheap, easy to use and a precise mobile observing platform for astro–geodetic determinations of vertical deviation;

c. Automation of vertical deviation determination by astro–geodetic measurements, the observing platform being able to provide real time vertical deviation at a satisfactory precision. This objective consists in implementing the mathematical algorithm into dedicated software for astronomical observations guidance, analyzing and controlling.

Estimated results: Efficiency, precision and accuracy increasing of the astro-geodetic determination at cm level or better accuracy for geoid determination (Figure 24).

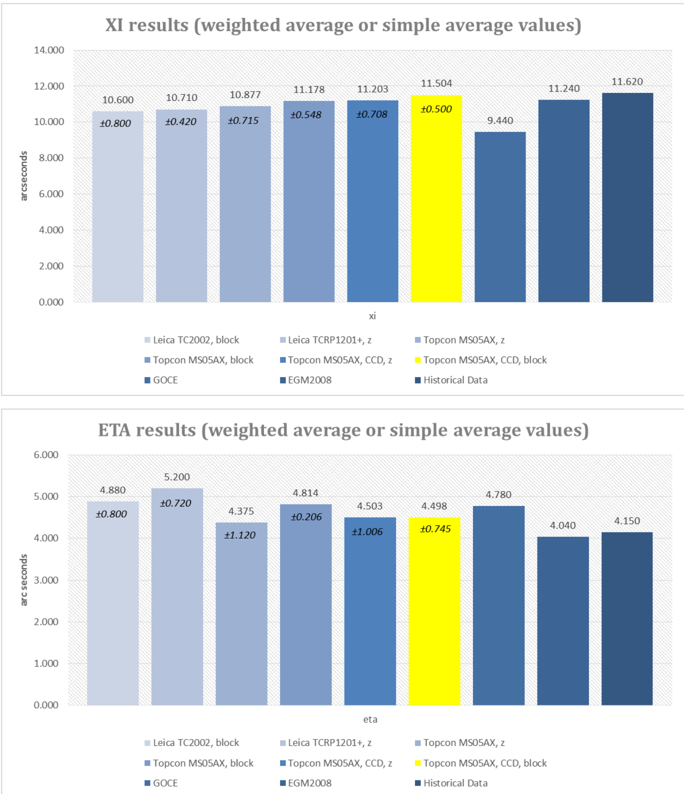

Figure 24: Results of experiments for vertical deviation components (xi, eta)

Section IV: General Theory and Methodology

The theoretical and practical aspects of the Geodesy as geoscience continued the evolution in 2011-2014 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;
    - 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 cadaster, 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 NMA (National Metrological Administration).

- 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 cadaster 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 Cadaster 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 and updated (TOPRO 5);
- Standards for scanning and georeferencing of old cadastral maps were adopted and updated;
- 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 and updated 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:*
    a. *Global datum transformation that is accomplished by a conformal transformation;*
    b. *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, Naţional 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).

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 figure 25 (distortions are presented as vectors).

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

The big distortions observed in figure 25 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.

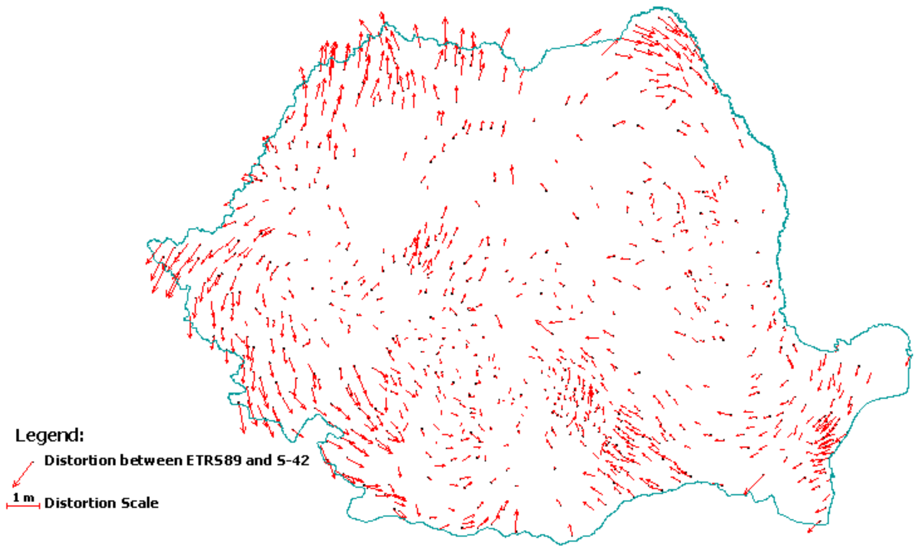

Figure 25: Distortions between ETRS89 and S-42

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 Table 4presents the statistic situation of coordinate differences on geodetic common points, available at the present moment, after distorsion modelling.

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.

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

PRIVATE GNSS PERMANENT NETWORKS

TRIMBLE VRS NOW Services

Trimble company realized in USA and Europe, GNSS services based on GNSS permanent station networks. Trimble services are known under the name „Trimble VRS Now" due to the VRS (Virtual Reference Station) concept implemented for the first time by this company. *Trimble VRS Now* includes real-time services DGNSS and RTK. Starting with 2012, *Trimble VRS Now* services are available in Romania. These services are provided in Romania based on a GNSS permanent network including 9 GNSS permanent stations installed in the area (Figure 26). There are a various number of GNSS receivers able to work with *Trimble VRS Now* services, able to process CMR and CMR+ data formats. Such equipments are provided mainly by *GISCAD SRL* company in Arad. Access to these services can be realized by *SYSCAD SRL* company in Bucharest. There are available few types of registration (monthly, yearly). There are *first private DGNSS/RTK services* provided in Romania by a private company *with full country coverage*.

Figure 26: Trimble VRS Now GNSS permanent stations in Romania

Leica TGREF Services

Leica Geosystems company realized in last few years DGNSS/RTK services based on GNSS permanent networks under the name of „Leica SmartNet" in Europe and other areas [http://www.smartnet-eu.com/]. In Romania, Leica Geosytems represented by TopGeocart SRL company established a GNSS permanent station network named *TGRef* including 8 stations and DGPS, RTK (single base) and postprocessing services (Figure 27). RTK service transmits corrections in Leica proprietary format.

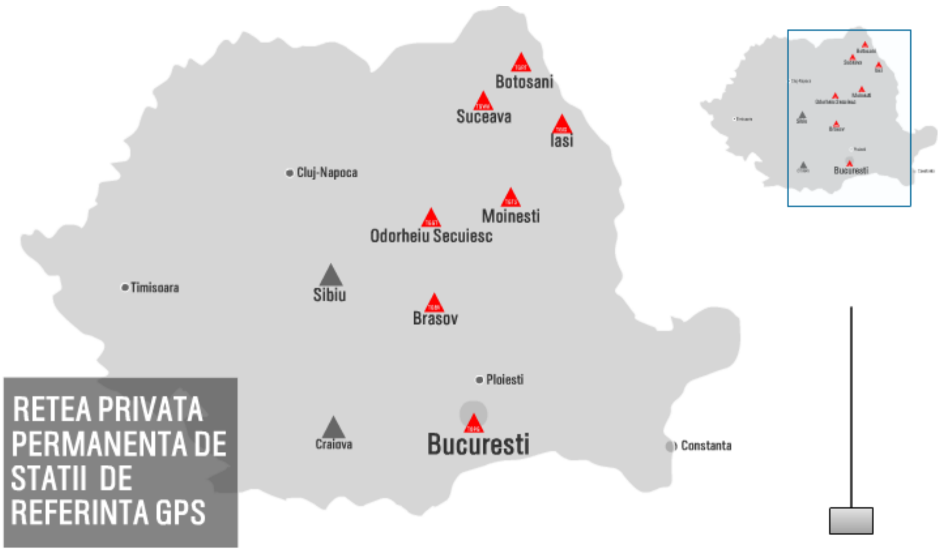

Figure 27. Leica TGRef permanent stations in Romania

Topo Service (GNSSPos) Services

Topo Service GNSS permanent network includes 44 stations situated in Romania (Figure 28), Bulgaria, Serbia, Macedonia and Moldova.

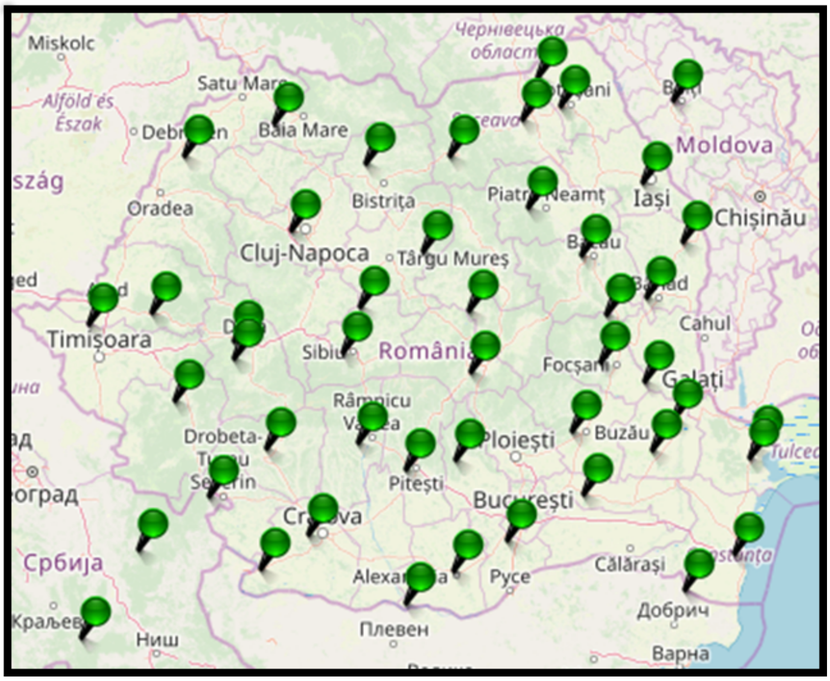

Figure 28: Topo Service GNSS permanent stations [https://pivot.gnsspos.ro/Map/SensorMap.aspx]

Topo Cad Vest Services

Topo Cad Vest is a private network of 19 permanent GNSS stations across Romania, and 4 additional stations located in Bulgaria near the Romanian border.
At present, it is intended to put into operation another 14 stations (blue ones in Figure 29).

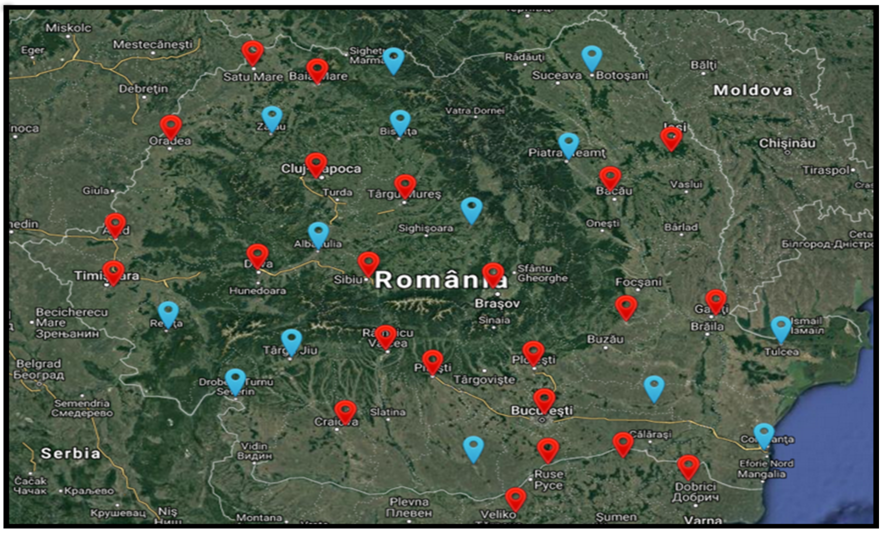

Figure 29: Topo Cad Vest permanent stations *[https://www.topocadvest.ro/]*

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2018

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- 18th SGEM GeoConference on Informatics, Geoinformatics and Remote Sensing, www.sgem.org, SGEM2018, 17-26 June 2018, Albena, Bulgaria.

2017

- 17th SGEM GeoConference on Informatics, Geoinformatics and Remote Sensing, www.sgem.org, SGEM2017, 25 June –5 July 2017, Albena, Bulgaria
- GeoPrevi 2017: Smart Solutions for a Secure and Valuable Property, 14-16 September 2017, Bucharest, Romania.

2016

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- Geomat 2016, 3-6 November 2016, Iasi, Romania;
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2015

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- GeoPrevi 2015, 8-9 May 2015, Bucharest, Romania.

IAGA ACTIVITIES IN ROMANIA
2015-2018

IAGA RELATED ACTIVITIES IN ROMANIA
2015-2018

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Division I: Internal Magnetic Fields

Working Group I.1 Theory of Planetary Magnetic Fields

Based on the newest global models and maps, a systematic analysis of the topographic and magnetic features over the largest craters on Earth, Mars and Moon has been carried out. Firstly, craters have been identified by their quasi-circular features from the most recent and detailed topographic maps and then, from available global magnetic maps. Then, we have used the intensity field to establish tendencies and patterns of the magnetic signatures. A large variety of magnetic signatures are encountered in the impact structures of the terrestrial bodies and here we document systematic trends in the amplitude and frequency of the magnetic patterns inside and outside of these structures.

The main magnetic characteristics of the chosen impact craters are presented by means of a QML (Qualitative Magnetic Label) parameter: the mean field strength (nT), within each ring and outside (at a distance of one radius) was considered to obtain this qualitative parameter. The values of QML are 1, 2 or 3, in ascending order, computed for each ring of the crater by normalizing the minimum and maximum values of anomalies. These qualitative levels allow us to associate labels, such as (1-2-2-3), as in the case of Isidis crater from Mars, presented here, which describes the magnetic behavior from inside to outside the craters rims. In this case, the crater has three rings, with the lowest magnetic value in the center, a medium one between the first and third ring and with the most intense one outside the crater, at 1-radius distance (Figure 1). The same approach was applied to Mars and Moon.

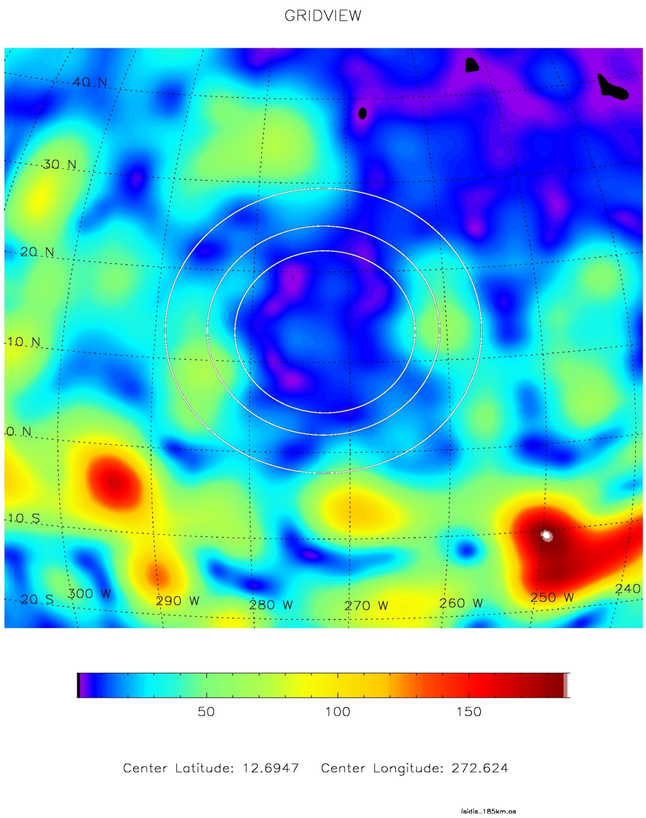

Figure 1: The crater three rings, with the lowest magnetic value in the center, a medium one between the first and third ring and with the most intense one outside the crater, at 1-radius distance

On Earth, the magnetic signature is visible only over a few and large craters (see the table below). It is important to note (see the QML values) the short-wavelength characteristics of strong crustal fields within the crater, compared with outside impact structure. The absence of this feature on smaller craters is possibly due to a more rapid decay of short-wavelength than long-wavelength magnetization above the craters at WDMAM compilation altitude (5 km).

Name	D_{max}(km)	#Rings	$\|\Delta T\|_{max}$ inside (nT)	Age (My)	QML (mag. char.)
Chicxulub	170	3	350	65	(3-3-2-1)
Manicouagan	103	3	0	214	(3-2-2-2)
Clearwater-W	50	3	500	290	(3-2-2-1)
Sudbury	260	4	2000	1850	(3-2-2-2-2)
Vredefort	293	4	300	2020	(3-2-2-2-2)

The strongest Mars magnetic anomalies are mainly located in the Noachian crust (around 4 Gy) of the southern hemisphere. The younger giant impact craters such Hellas (3.99 Gy), Argyre (4.04 Gy), Isidis (3.81 Gy) and the oldest in this group, Utopia (4.11 Gy) show an absence of central magnetic anomalies because the crust has presumably been demagnetized by these impacts after the cessation of the Martian dynamo, at about 4.15- 412 Gy.

Name	D_{max} (km)	# Rings	$\|B\|_{max}$ inside (nT)	Age (Gy)	QML (mag. char.)
Isidis	1878	3	12	3.81-No	(1-2-2-3)
Huygens	463	3	10	3.95-No	(1-1-1-1)
Hellas	3996	3	10	3.99-No	(1-2-2-3)
Ares	3360	3	40	4.16-No	(2-2-3-2)
Daedalia	2568	3	60	4.17-No	(2-2-2-1)

Generally, all Imbrian and late - Nectarian craters are completely demagnetized with no significant magnetic anomalies with QML type such Orientale. Some of the early-Nectarian impact craters are not so strongly demagnetized, with short scale anomalies inside inner rings. Few of them have a stronger magnetic signature than the background fields such as Moscoviense or Crisium. These craters might provide a timing cessation time-window of the lunar former dynamo.

Name	D_{max}(km)	#Rings	$\|B\|_{max}$ inside (nT)	Age-groups (Wilhelms, 1984)	QML (mag. char.)
Orientale	964	4	3	Imbrian (1)	(1-1-1-2-2)
Imbrium	1212	2	2	Imbrian (3)	(1-1-2)
Humorum	849	4	2	Nectarian (4)	(2-3-3-3)
Crisium	1069	5	6	Nectarian (4)	(3-3-2-2-2-2)
Serenitatis	677	2	2	Nectarian (4)	(3-2-2)
Moscovienese	630	3	2	Nectarian (6)	(3-2-2-2)
Apollo	511	2	5	pre-Nectarian (7)	(2-1-1)

A systematic analysis of the topographical and magnetic features over 98 largest impact craters on Earth, Mars and Moon was done using only global models and maps. The intensity field was used to establish tendencies and patterns of the magnetic signature of these impact craters from the three terrestrial bodies. On the Earth, the pattern of large impacts which alter the entire depth of crust is complex. This complexity, together with the existence of a core magnetic field component on the same scales as the long wavelength crustal field, makes the interpretation of the magnetic signature more difficult. Measurements of the magnetic field of Mars revealed significantly lower magnetic field intensities over the gigantic impact craters. As for Martian craters, some of the largest lunar craters exert magnetic field which appears lower than that of neighboring terrains, indicating that impacts alter the magnetic character of the rocks. Mars and Moon's global magnetic fields may have already been weak when meteorites struck to form large craters some 4 Gy ago. In their case, shock waves from the largest meteorite impacts could disrupt the field enough to demagnetize rocks in the crater.

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Working Group I.2 and I.3 Paleomagnetism, Rock- and Environmental Magnetism

Since 2011, the research activity in the Laboratory of Magnetism of Rocks and Sediments from the Geological Institute of Romania (G.I.R.) has focused on both Palaeomagnetism, and Rock- and Environmental Magnetism (according to the IAGA Working Groups I.3 and I.4, respectively).

The Laboratory of Petrophysics and Paleomagnetism performs determinations of the magnetic susceptibility of rocks and its anisotropy, as well as determinations of the density of rock and sediment collected from the field. Also, determinations are made of the time variation of the magnetic field vector. This is done by means of measurements of the residual component of the geomagnetic field carried out during thermal demagnetization with the progressive temperature variation, or by electromagnetic demagnetization with an alternative electric field demagnetizing device. These determinations can be used to establish the age of rocks or sediments when they are devoid of fossil content or when age determinations can not be made by radiometric methods for eruptive or metamorphic rocks. In the case of metamorphic rocks, only the dating of the last metamorphic process that affected the rock can be obtained.

For this purpose, the following devices are used:

- Demagnetizer in alternative current for demagnetizing rock samples in order to determine the remanent magnetic component;
- Thermal demagnetizers for demagnetisation of rock samples in order to determine the remanent magnetic component and the hysteresis curve;
- The JR4- spinner magnetometer is used to determine the value and direction of the remanent magnetic field of the rocks;
- KLY1 magnetic susceptibility bridge used to determine magnetic susceptibility and anisotropy for rock samples under laboratory conditions;
- KLY2 magnetic susceptibility bridge used to determine magnetic susceptibility and anisotropy for rock samples under laboratory conditions;
- BS2 Bartington Susceptibility Meter with Two Frequency Sensor MS2B used to determine magnetic susceptibility and its anisotropy for rock samples under laboratory and field conditions. Also, by comparing the susceptibility values obtained for the same sample with two frequencies, one can calculate a structural factor relative to the dimensions of the grains with magnetic properties of the rock;
- Kappametre KT5 to determine the magnetic susceptibility of rock, on the field.

Papers and abstracts published/presented at international/national meetings:

Published papers

Niculici E, (2017), Use of magnetic susceptibility data for the litologycal analysis and to establish the sedimentation rate in a hydrographical basin from the Sub-Carpathian area of Romania, 17th ternational Multidisciplinary Scientific GeoConference SGEM, **17**, 415-422, oi:10.5593/sgem2017H/33/S12.052;

Radan S.-C., Radan S., Catianis I.,Grosu D., Pojar I., Scrieciu A., (2016), An environmental magneto-lithogenetic study. I. Insights from surficial sediments, *Geo-Eco-Marina*, **22**, 51-74;

Radan S.-C., Radan S., Catianis I.,Grosu D., Pojar I., Scrieciu A., (2016), An environmental magneto-lithogenetic study. II. Insights from surficial sediments, *Geo-Eco-Marina*, **22**, 75-107;

Radan S.-C., Radan S., Catianis I., Scrieciu A., (2015), Relationship between the magnetic susceptibility and lithological composition in sediment cores from lakes of Matița-Merhei

Depression (Danube Delta, Romania): towards a proxy method of sedimentological and enviromental fingerprinting, *Geo-Eco-Marina*, **20**, 45-86;

Rădan, S., Panin, N., Rădan S.C. (2015a), SEQS 2013: Correlations of Quaternary fluvial, eolian, deltaic and marine sequences – Meeting and field trip in Romania, *Quaternary International*, **357**, 1-3;

Rădan, S., Panin, N., Catto, N.R., Rădan S.C. (Editors) (2015b), Correlations of Quaternary Fluvial, Eolian, Deltaic and Marine Sequences: SEQS 2013, *Quaternary International*, **357**, Elsevier, 344p;

Conferences

Rădan S.C., Rădan S.,Catianis I., Grosu D., Pojar I., Scrieciu A., (2018), An integrated enviromagnetic and lithogenetic study in the lakes of the southern Danube Delta wing. Evidences from surficial sediments and short cores, 16th Castle Meeting New Trends on Paleo, Rock and Environmental Magnetism, Chęciny, Poland, Published by the Institute of Geophysics, Polish Academy of Sciences–Geophysical Data Bases, Processing and Instrumentation, **423** (C-112), 121-122, doi:10.25171/InstGeoph_PAS_Publs-2018-062;

Within the frame of the Physics Faculty, paleomagnetic research has been developed in several directions, namely: *applications in studying geological processes*, *paleovariation of the geomagnetic field*, *rock magnetism and paleoclimate*.

Papers published/presented at international/national meetings:

Published papers

Moldovan O. T., Constantin S., Panaiotu C., Roban R. D., Frenzel P., Miko L., (2016), Fossil invertebrates records in cave sediments and paleoenvironmental assessments: a study of four cave sites from Romanian Carpathians, *Biogeosciences*, **13** ,483–487;

Panaiotu C.G., Dimofte D., Necula C., Dumitru A., Seghedi I., Popa R-G., (2016), Revised paleosecular variation from Quaternary lava flows from the East Carpathians, *Romanian Reports in Physics*, **68(1)**, 416–424;

Seghedi I., Popa R.-G., Panaiotu C.G., Szakács A., Pécskay Z., (2016), Short-lived eruptive episodes during the construction of a Na-alkalic basaltic field (Perşani Mountains, SE Transylvania, Romania), *Bull Volcanol*, **78**, 69;

Vișan M., Panaiotu C.G., Necula C., Dumitru A., (2016), Palaeomagnetism of the Upper Miocene- Lower Pliocene lavas from the East Carpathians: contribution to the paleosecular variation of geomagnetic field, *Scientific Reports*, **6**, 23411; doi: 10.1038/srep23411.

Constantin D., Camenit A., Panaiotu C., Necula C, Codrea V, Timar-Gabor A., (2015), Fine and coarse-quartz SAR-OSL dating of Last Glacial loess in Southern Romania, *Quaternary International*, **357**, 33–43;

Necula C., Dimofte D., Panaiotu C., (2015), Rock magnetism of a loess-paleosol sequence from the western Black Sea shore (Romania), *Geophysical Journal International*, **202**, 1733–1748;

Necula C., Panaiotu C., Schinteie G., Palade P., Kuncser V., (2015), Reconstruction of superparamagnetic particle grain size distribution from Romanian loess using frequency dependent magnetic susceptibility and temperature dependent Mössbauer spectroscopy, *Global and Planetary Change*, **131**, 89–103;

Division IV: Solar Wind and Interplanetary Field

In the last four years, the research direction, namely space climate/space weather, has been continued at the Institute of Geodynamics of the Romanian Academy, in close relation with the VarSITI program (Variability of the Sun and Its Terrestrial Impact) of SCOSTEP (2014-2018) and the BBC SWS Regional Network cooperation (Balkan, Black Sea and Caspian Sea Regional Network on Space Weather Studies)..

These studies have been focused on the following research lines:

- study of coronal mass ejections (CMEs) and of high speed streams in the solar wind (HSSs);
- analysis of the solar wind impact on geomagnetic activity;
- analysis of long-term (decadal, inter-decadal and centennial) solar and geomagnetic activities;
- solar/geomagnetic forcing on terrestrial climate.

1. Study of CMEs and HSSs

Coronal mass ejections (CMEs) are enormous eruptions of magnetized plasma expelled from the Sun which can create major disturbances in the interplanetary medium and trigger severe magnetic storms when they collide with the Earth's magnetosphere. It is important to know their real speed and propagation direction in order to accurately predict their arrival time at the Earth. The relationship between CMEs and flares has been intensely analysed and no definitive answer has been found. Case-by-case correlations have been studied by our group also. Examples are presented in Besliu-Ionescu et al. (2015) where the impact of the flare/CME event over the magnetosphere has studied and, in Besliu-Ionescu (2018).

The HSS catalogue has been published online at: http://www.geodin.ro/hss-sc23/ covering the entire period of the solar cycle 23. Another page: http://www.geodin.ro/varsiti/, presents a complex catalog of the HSSs produced by coronal holes and their effects in terrestrial magnetosphere as geomagnetic storms for solar cycle 24, work that was supported by a VARSITI grant (Maris Muntean et al., 2018). The catalogue is updated on a yearly basis.

Published papers

Maris Muntean, G., Besliu-Ionescu, D, Dobrica, V., (2018), Complex catalogue of high speed streams and geomagnetic storms during solar cycle 24 (2009 – 2016), *VarSITI Newsletters*, **17**, 4-6;

Besliu-Ionescu, D., (2018), The Journey of a CME in the heliosphere in June 2015, *VarSITI Newsletters*, **17**, 9-10.

Besliu-Ionescu, D., Mierla, M., Maris Muntean, G., (2015), Magnetic crochet associated to the seismically active flare of March 29 2014, *Romanian Geophysical Journal*, **58-59**, 04;

Conferences

Beșliu-Ionescu, D., Dobrica, V., Pomeran, M., Zanogeanu, A., (2018), On the detection of CMEs using PROBA3/ASPIICS, Solar System studies from the ground to in-situ observations, Proba-3 Science Working Team Meeting #7, Noordwijk, Olanda, 27-28 September;

Maris Muntean, G., Besliu-Ionescu, D., Dobrica, V., (2018), Investigating and cataloguing HSSs during SC24, The 10th Workshop "Solar influences on the magnetosphere, ionosphere and atmosphere", Primorsko, Bulgaria, 4-8 June;

Beşliu-Ionescu, D., Dobrica, V., (2018), CME association with flares: pro or con?, Outlook in Astronomy, Astrophysics, Space and Planetary Sciences, Cluj-Napoca, Romania, 17-19 May;

Beşliu-Ionescu, D., Nedelcu, D. A., (2018), Study of Orbital Decay during high solar activity Outlook in Astronomy, Astrophysics, Space and Planetary Sciences, Cluj-Napoca, Romania, 17-19 May;

Besliu-Ionescu, D., Talpeanu, D., Mierla, M., Maris Muntean, G., (2017), On Geoeffectiveness of CMEs During SC24, Second VarSITI (Variability of the Sun and Its Terrestrial Impacts) General Symposium, Irkutsk, Russia, 10 – 15 July;

Besliu-Ionescu, D., Mierla, M., Maris Muntean, G., (2017), Study of CME-ICME properties during geomagnetic storms of SC 24, Ninth Workshop "Solar Influences on the Magnetosphere, Ionosphere and Atmosphere", Sunny Beach, Bulgaria, 30 May - 3 June;

Maris Muntean, G., Besliu-Ionescu, D., Talpeanu, D., Lacatus, D., Paraschiv, A., (2016), High Speed Streams in the Solar Wind During the 24th Solar Cycle (2008 – 2015), First VarSITI (Variability of the Sun and Its Terrestrial Impacts) General Symposium, Albena, Bulgaria, 6 – 10 June;

Besliu-Ionescu, D., Mierla, M., Maris Muntean, G., (2015), The Influence of Apr 10, 2001 CME on the Magnetosphere, The Seventh Workshop "Solar influences on the magnetosphere, ionosphere and atmosphere", Sunny Beach, Bulgaria, 1-5 June.

2. Analysis of the solar wind impact on geomagnetic activity

An extensive study of the energy transfer from the solar wind into the magnetosphere has been performed by our team (e.g. Besliu-Ionescu et al., 2016). The energy transfer has been analysed using the Akasofu parameter (Akasofu, 1981) for the entire period of the solar cycle 23. Preliminary results show that the energy is being deposited with a different rate than the energy absorbed by the Earth's magnetosphere during geomagnetic storms.

Publications

Beşliu-Ionescu, D., Mierlă, M., Mariș Muntean, G., (2016), Analysis of the Energy Transferred from the Solar Wind into the Magnetosphere during the April 11, 2001 Geomagnetic Storm, *Sun and Geosphere*, **11 (2)**, 97-104.

Conferences

Besliu-Ionescu, D., Talpeanu, D., Maris Muntean, G., Mierla, M., (2016), Comparison Between negative Bz Duration and Geomagnetic Storm Main Phase Duration During Moderate Geomagnetic, First VarSITI (Variability of the Sun and Its Terrestrial Impacts) General Symposium, Albena, Bulgaria, 6 – 10 June;

Besliu-Ionescu, D., Mierla, M., (2015), Study of energy input into the magnetosphere during SC23 intense geomagnetic storms, 12th European Space Weather Week, Ostend, Belgium, 23-27 November;

Besliu-Ionescu, D., Mierla, M., Maris Muntean, G., (2015), Energy coupling functions between the solar wind and the Earth magnetosphere, Solar Variability and its Heliospheric Effects, Athens, Greece, 2-6 November;

Besliu-Ionescu, D., Mierla, M., Dobrica, V., Maris Muntean, G., (2015), Magnetospheric Energy Input during Intense Geomagnetic Storms in SC23, European Geosciences Union General Assembly, Vienna, Austria, 12 – 17 April.

3. Analysis of long-term solar and geomagnetic activity

The analysis of long-term solar and geomagnetic activity has been carried on within the frame of the Institute of Geodynamics of the Romanian Academy. The evolution of parameters describing the heliosphere-magnetosphere-ionosphere system has been investigated from the view point of medium- and long-term variabilities, retrieving information for the last century (12 solar cycles #13-24). By using the Hodrick-Prescott (HP) and Butterworth filtering the long-term variations, at inter-decadal (22 years) and sub-centennial (80-90 years) timescales, has been obtained and has been showed that the actual trend in space climate is given by the superposition of the inter-decadal and sub-centennial variations on the long-term inter-centennial trend.

Conferences

Dobrica V., Demetrescu, C., Stefan, C., (2017), Space climate in the heliosphere-magnetosphere environment. Consequences in solar cycle 24, Second VarSITI (Variability of the Sun and Its Terrestrial Impacts) General Symposium, Irkutsk, Russia, 10 – 15 July;

Dobrica, V., Demetrescu C., (2017), Assessing the present trend in the heliosphere-magnetosphere-ionosphere system, Ninth Workshop "Solar Influences on the Magnetosphere, Ionosphere and Atmosphere", Sunny Beach, Bulgaria, 30 May - 3 June;

Demetrescu, C., Dobrica V., (2016), Magnetic (~22 years) and Gleissberg (80-90 years) signals in the solar-terrestrial system, Asia Oceania Geosciences Society (AOGS) Assembly, Beijing, China, 31 July – 06 August;

Dobrica, V., Demetrescu, C., (2016), Solar cycle 24 trends in space weather, Asia Oceania Geosciences Society (AOGS) Assembly, Beijing, China, 31 July – 06 August;

Demetrescu, C., Dobrica, V., (2015), Long- and short-term responses of the heliosphere-magnetosphere environment to solar activity variations, Solar Variability and its Heliospheric Effects, Athens, Greece, 2-6 November;

Dobrica, V., Georgieva, K., Kirov, B., Demetrescu, C., (2015), Geomagnetic activity: long- and short-term variability, sources, Solar Variability and its Heliospheric Effects, Athens, Greece, 2-6 November;

Dobrica, V., Demetrescu, C., (2015), Long-term evolution of geomagnetic activity. An analysis of its solar and magnetospheric sources, International Union of Geodesy and Geophysics General Assembly, Prague, the Czech Republic, 22 June – 02 July;

Stefan, C., Dobrica, V., Demtrescu, C., (2015), Short-term variability of the magnetopause standoff distance, International Union of Geodesy and Geophysics General Assembly, Prague, the Czech Republic, 22 June – 02 July.

4. Solar/geomagnetic forcing on terrestrial climate

In the present report interval 2015-2018, the study of the influence of solar and geomagnetic activity on climate has continued by investigating long-term statistical correlations between stratospheric and tropospheric temperature, from reanalyzed data bases, and solar/geomagnetic indices. At solar cycle timescales, the geoeffective solar variability has been inferred by means of maps of correlation coefficient (significance 95%), between stratospheric and troposheric temperatures and solar/geomagnetic indices, showing well defined solar activity signal in temperature at local or regional scale rather than at the global one for troposheric levels, while in the stratosphere correlations of one sign characterize large areas.

Knowing that the possible changes in temperature and precipitation regime are expected to lead to changes in the water regime of rivers, the long-term evolution of Lower Danube discharge in connection to variations in the precipitation in the Upper-Middle and Lower Danube Basins, has been examined from the viewpoint of multi-decadal variability associated with Atlantic variability and with solar variability at decadal and multi-decadal timescales. It has been showed that at the decadal timescales the Lower Danube discharge variability might be directly driven by solar variability, while at multi-decadal timescales the solar variability affects firstly the Atlantic Multi-decadal Oscillation and then the hydroclimatic regime. Therefore, the climate variations, as shown in temperature, precipitation, and, at the end of the causal chain, in Danube river discharge, a result of direct action of large-scale circulation patterns, would ultimately be modulated by solar activity.

Published papers

Pirloaga, R., Dobrica, V., (2016), The north temperate climate on long-term timescales. Connection to solar variability, *Romanian Journal of Physics*, **61 (5-6)**, 1098-1107;

Dobrica, V., Pirloaga, R., Stefan, C., Demetrescu, C., (2017), Inferring geoeffective solar variability signature in stratospheric and tropospheric Northern Hemisphere temperatures, J. Atmos. Sol-Terr. Phy., 180, 137-147, doi: 10.1016/j.astp.2017.05.001;

Dobrica, V., Demetrescu, C., Mares, I., Mares, C., (2017), Long-term evolution of the Lower Danube discharge and corresponding climate variations: solar signature imprint, *Theor Appl Climatol,* **133**, 985-996. doi:10.1007/s00704-017-2234-2.

Conferences

Mares, I., Dobrica., V., Demetrescu, C., Mares, C., (2016), Hydrological response in the Danube lower basin to some internal and external forcing factors of the climate system, European Geosciences Union General Assembly, Vienna, Austria, 17 – 22;

Dobrica, V., Demetrescu, C., (2015), Solar Signals at Schwabe and Hale Timescales in Temperature and Precipitation as Integrated by River Discharge Data. Case Study – The Danube River Basin (Central and South-Eastern Europe), Asia Oceania Geosciences Society (AOGS) Assembly, Singapore, 02 – 07 August;

Dobrica, V., Pirloaga, R., Stefan, C., Demetrescu, C., (2015), On geoeffective solar variability signature in northern temperate climate zone at specific atmospheric levels, European Geosciences Union General Assembly, Vienna, Austria, 12 – 17 April;

Mares, I., Dobrica., V., Demetrescu, C., Mares, C., (2015), Influence of the atmospheric blocking on the hydrometeorological variables from the Danube basin and possible response to the solar/geomagnetic activity, European Geosciences Union General Assembly, Vienna, Austria, 12 – 17 April;

Dobrica V., Demetrescu, C., Stefan, C., Pirloaga, R., (2015), Decadal variability of NH temperatures and its connection with solar variability, Sun-Climate connections Conference, Kiel, Germany, 16-19 March.

Acknowledgements. This report was prepared by Dr. Venera Dobrica, Dr. Diana Besliu-Ionescu, Dr. Crisan Demetrescu, Georgeta Maris-Muntean..

Division V: Geomagnetic Observatories, Surveys and Analyses

Working Group V-OBS: Geomagnetic Observation

1. National Geomagnetic Observatory (SUA)

Geomagnetism has developed tremendously since the days of Gauss, Humboldt or others. Surlari (SUA) is the unique Romanian geomagnetic observatory and has been functional continuously for over 76 years. The Acad. Prof. Liviu Constantinescu, physicist, born on November 26, 1914 was one of the founders of the Romanian School of Geophysics and the scientific personality that marked the history of Surlari Observatory since its establishment - 1943. His presence as the head of the Surlari Observatory for 15 years (1943-1957) consolidated its prestige on national and international level. Now, as INTERMAGNET member, the very first goal is to promote modernization of observatory practice in order to achieve the present standards. The continuous recording main and back up equipments consist of two suspended FGE fluxgate variometers (DTU), two GSM90 Overhauser magnetometers (Gem Systems) and two improved MAGDALOG dataloggers developed at Niemegk observatory, Germany for observatory practice. For the absolute measurements a DI-Flux single axis magnetometer (Bartington) mounted on a Zeiss 010B theodolite and a G856 proton magnetometer (Geometrics) for scalar measurements are the magnetic reference instruments for variometers. GFZ from Helmholtz Center for German Research supports Surlari with further software upgrades and preparation of quasi and definitive data in order to improve data quality. In this way, a long-term geomagnetic observatory with real-time data on INTERMAGNET web site, and with the status of an IMO has been accomplished. Our future challenges are to keep constant the temperature of fluxgate sensors as well as their electronic parts in order to obtain the accurate baseline values of the variometers and to improve, together with Romanian ROMATSA experts, aeronautical and airport safety on Romanian territory.

A research team involved in running the Surlari Geomagnetic Observatory, doing geomagnetic measurements (Figure 2) in the national repeat stations network, and producing and analyzing global geomagnetic field models developed in 2018, in the frame of a National Program, a new standard procedure to characterize, in nearly real-time, the spatial distribution and the temporal evolution of the internal geomagnetic field on the national territory. The continuously updated isogonic charts, based on the accurate local magnetic measurements and geomagnetic global models represent the basis for forecast activities. The nearly real-time availability of geomagnetic declination information is crucial for the safety of the air navigation over the national territory (Figure 3). This activity represents an interesting application of geomagnetic data gathered by magnetic observatories, repeat stations and satellites.

As a member of ESA, Romania has been participating in the Space Situational Awareness Program since 2012. The research, monitoring and forecasting of the extra-atmospheric space is materialized in Surlari Observatory through specific services and products in the frame of the SAFESPACE - SWE Project and few National Projects, work in progress. In this way, are ensured, at national level, facilities and services essential to the safety and security of the economy and society.

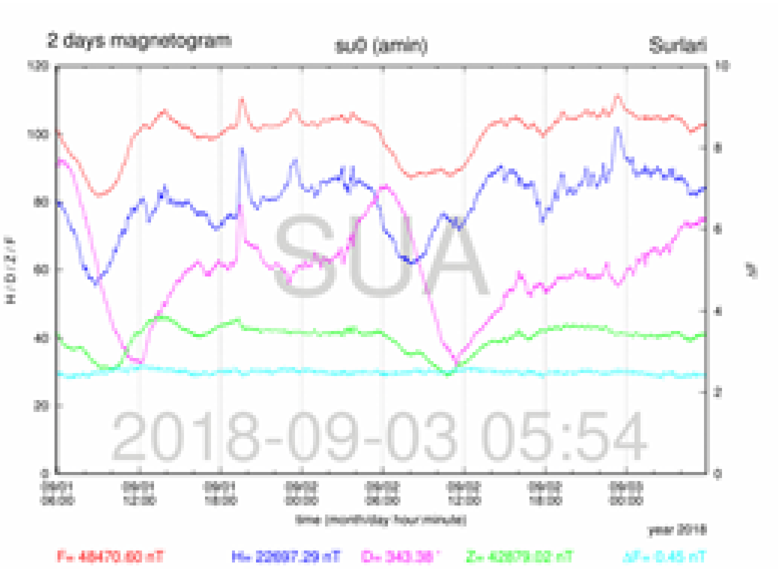

Figure 2: Exemple of magnetogram record from Surlari Observatory

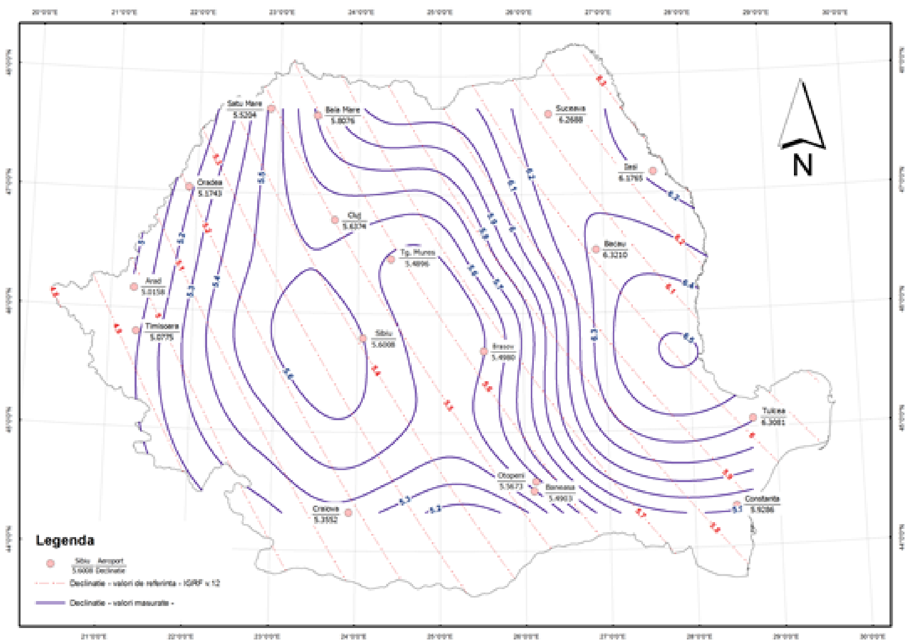

Figure 3: The geographical distribution of magnetic declination isogons for the epoch 2017.5 from the IGRF-12 model (red curves) and declination distribution - measured in the aeronautical variation network – purple isolines. The measured airports are marked with red dots.

Surlari Observatory celebrated 75 years of geomagnetic measurements in 16-19 October 2018. The main topics of the Round Table and Workshop were the practical and theoretical problems associated with observations of the natural geomagnetic field at geomagnetic observatories and their applications. Also, one day of DI measurements was set on the main pier of Absolute Measurement Lab in the observatory. The intent was to stimulate participant discussions in aim of the exchange of information and experience related to the methodology of such observations. The subjects of the presentations were: Magnetic Observatories: from compass to flux-gate epoch; From deep core to space: long term and short term variations of geomagnetic field; Magnetic Observatories and Satellites: a needed synergy to characterize

the geomagnetic field; Magnetism and our world: from current to future applications. The selected presentations at the meeting will be considered for publication in a 2020 special issue of the Romanian Geophysical Journal. The sessions were attended by approximately 60 participants coming manly from Romania and from four countries outside. Inspiring keynote addresses that shaped the conversation were given by Prof. Dr. HDR Mioara Mandea from Centre National d'Etudes Spatiales, France, Secretary General of IAGA, Christopher Turbitt and Simon Flower from British Geological Survey, UK, INTERMAGNET Operations Committee officers as well as Dr. Hans-Joachim Linthe, GeoForschungsZentrum, former head of Niemegk Observatory, Germany.
There were nearly 20 papers presented and the intent was to stimulate participant discussions in aim of the exchange of information and experience related to the methodology of geomagnetic observations.

Papers and abstracts published/presented at international/national meetings:

Published papers

Asimopolos L., Asimopolos N.-S., (2018), Considerations about infrastructure, devices and physical principles in geomagnetic field metrology, *Oltenia. Studii si comunicari. Stiintele Naturii*, **34 (1)** ISSN 1454-6914, 27-34;

Asimopolos N.-S., L. Asimopolos, (2018), Evaluation of electromagnetic field variations from monitored data in planetary observatories, *Oltenia. Studii si comunicari. Stiintele Naturii*, **34 (2)**, ISSN 1454-6914, 37-44;

Asimopolos L., Asimopolos N.-S., (2018), Methods of smoothing and filtering geological and geophysical data, Geology & Applied and Environmental Geophysics, SGEM, **18 (1.1)**, 237-244, ISBN 978-619-7408-35-5, doi: 10.5593/sgem2018/1.1;

Asimopolos L., Asimopolos N.-S., (2018), Determination of the associated pattern for geomagnetic perturbations, Geology & Applied and Environmental Geophysics, SGEM, **18 (1.1)**, 755-762, ISBN 978-619-7408-35-5, doi: 10.5593/sgem2018/1.1;

Asimopolos N.-S., L. Asimopolos, (2015), Study on the high-intensity geomagnetic storm from march 2015, based on terrestrial and satellite data, Micro and Nano Tehnologies & Space Tehnologies & Planetary Science, SGEM, **18 (6.1)**, 593-600, ISBN 978-619-7408-50-8, doi: 10.5593/sgem2018/6.1;

Conferences

Asimopolos L., Asimopolos N.-S., (2018), Trend evaluation of magnetic anomalies from Assarel copper mine, CBGA 2018- XXI International Congress of the CBGA, Geologica Balcanica, ISBN 978-954-90223-7-7, 256, Salzburg, Austria, September 10–13;

Asimopolos L., Asimopolos N.-S., (2018), Organizing and multi-criteria's analysis of database from Surlari Geomagnetic Observatory, CBGA 2018 - XXI International Congress of the CBGA, Geologica Balcanica, ISBN 978-954-90223-7-7, 257, Salzburg, Austria, September 10–13;

Asimopolos N.-S., L. Asimopolos, (2018), Comparative analyses of data recorded in different planetary geomagnetic observatory, CBGA 2018 - XXI International Congress of the CBGA, Geologica Balcanica, ISBN 978-954-90223-7-7, 261, Salzburg, Austria, September 10–13;

Besutiu, L., Zlagnean, L., Isac, A., Romanescu, R., (2018), On the volcanic hazard in Romania - geophysical insights into the Ciomadul volcano, Natural Hazards. Assessment and Mitigation, ELSEDIMA International Conference, Cluj-Napoca, Romania 17 – 19 May;

Niculici E., Iancu L., Farnoaga R., Sandulescu A., Isac A., (2018), Surlari Observatory, a revised standard procedure for navigational purposes as a response to societal needs, The fourth Anniversary, Round Table and Workshop, 75 years of geomagnetic measurements of the Romanian Centenary, Bucharest, Romania;

Isac, A., V. Dobrica, R. Greculeasa, L. Iancu, (2016), Geomagnetic measurements and maps for National Aeronautical Safety, GEOSCIENCE, Romanian Society of Applied Geophysics, Bucharest;

Isac A., Dobrică V., Mandea M., (2015), Geomagnetic field data for the Romanian National Aeronautical Information Service, The XXVI th General Assembly of the International Union of Geodesy and Geophysics, Prague, 22-29 June;

Isac A., (2015), Report on definitive data check, INTERMAGNET Meeting, Colloquium on Geomagnetism, German Research Centre for Geosciences GFZ, Potsdam, Germania, 16-22 June;

2. National Network of Repeat Stations

In the time interval 2015 – 2018, the national network of repeat stations consisting of 26 stations has been reoccupied as much as possible every year by a systematic survey of the geomagnetic field, supporting the international scientific community efforts in creating and maintaining a repeat station database to be used together with satellite and observatory data in complex geomagnetic field modelling at regional and global scale. Measurements have been done by means of a LEMI-204 DIFlux instrument, 2 Geometrics G-856 proton magnetometers, and 2 QHMs. The values obtained for the geomagnetic elements H, D, I, Z and F have been reduced to the middle of the year (geomagnetic epoch year.5) in which measurements were taken, by means of records provided by the Surlari geomagnetic observatory (IAGA code SUA) and maps with geographical distribution on the Romanian territory have been developed.

In cooperation with the Geological Institute of Romania (Surlari geomagnetic Observatory), the geomagnetism group from the Institute of Geodynamics of the Romanian Academy has been involved in providing declination maps over Romanian territory necessary to the Romanian Air Traffic Services Administration to compute periodically the magnetic headings used to fly from an airport to another and to deliver updated Romanian aeronautical maps in accordance with the European legislation regarding aeronautical safety requirements.

Published papers

Greculeasa, R., Dobrica, V., Isac, A., (2016), The evolution of the geomagnetic field on the Romanian territory. Measurements in the secular variation national network between 2010 and 2014, *Romanian Geophysical Journal*, **58-59**, 29-36, 2014-2015.

Isac, A., Dobrica, V., Greculeasa, R., Iancu, L., (2016), Geomagnetic measurements and maps for national aeronautical safety, *Romanian Geophysical Journal*, **60**, 21-33.

Conferences

Greculeasa, R., Dobrica, V., Demetrescu, C., (2018), Romanian secular variation network in the context of the 75 years of SUA geomagnetic observatory, 75 Years of Geomagnetic Measurements of the Romanian Centenary, Bucharest, Romania, 16-19 October;

Greculeasa., R., Dobrica, V., Demetrescu, C., (2015), Romanian secular variation network. Geomagnetic measurements 2013-2014, MagNetE Workshop, Budapest, Hungary, 16-18 September.

3. Marine Magnetic Researches

Since the resume in 2005 of the systematic geophysical and geo-ecological investigation of the Romanian offshore, over 13,400 km of gravity lines and over 48,000 km of magnetic lines have been acquired on the entire surface of the Romanian maritime space and over most of the Bulgarian one. Mainly during the last years, an increasing involvement of marine magnetometry in projects dedicated to the study of the submarine cultural heritage and to enhancement of maritime space safety is noticed.

The main tasks for which the marine gravity and magnetics had to involve have been: (a) - the systematic mapping of the Romanian offshore, (b) - the research and service contracts with offshore operators, (c) - the study of submarine cultural heritage and (d) - the maritime space security enhancement.

a. The geoscientists of GeoEcoMar were able to cover the entire maritime space of Romania and most of the Bulgarian one with a network of complex geophysical lines, 4 km apart one from the other (Figure 4 and 5).

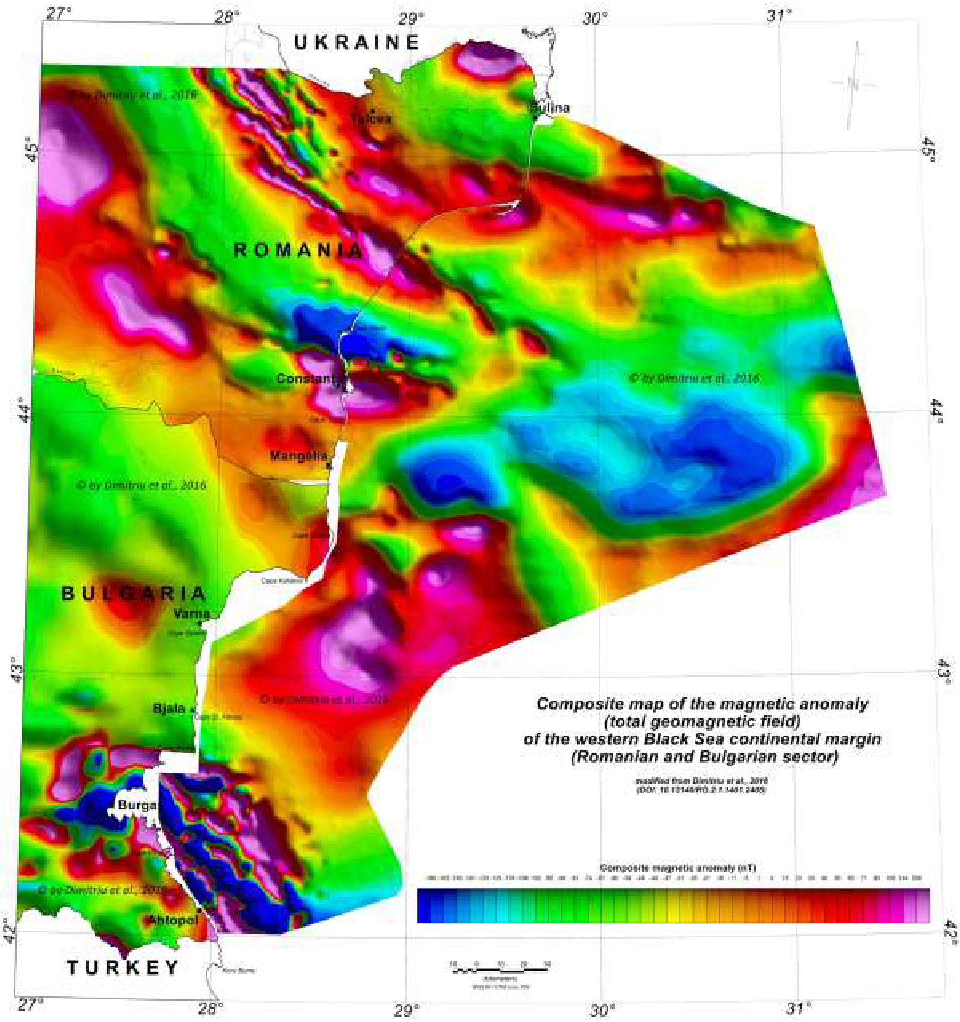

Figure 4: The magnetic anomaly (total geomagnetic field) of the western Black Sea continental margin (Romanian and Bulgarian sector)

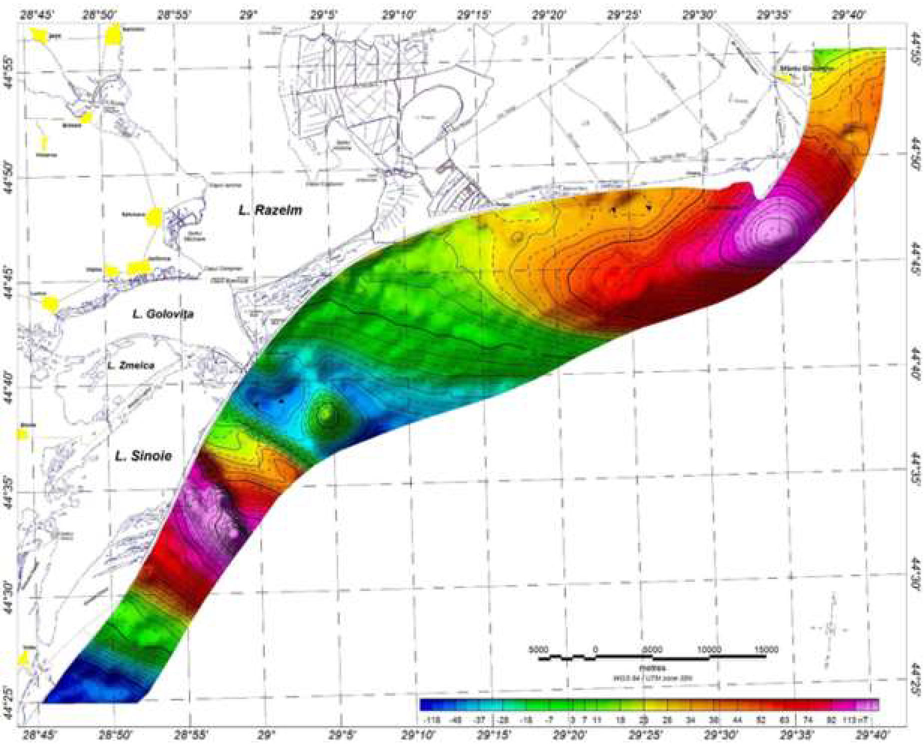

Figure 5: The map of the total magnetic field anomaly corresponding to that elongated littoral sector (Sf. Gheorghe – Vadu) totally lacked of geophysical information until that time

b. Marine magnetometry was also requested during the last 10-15 years by the most important companies that operate on the Romanian offshore for the accurate identification of pipelines paths, for finding lost objects and tools (anchors, chains, corers, penetrometers, etc.), for the complex site characterization of locations where drilling rigs, pipelines, oil terminals were to be deployed, etc. Magnetometry is in particular extremely effective in tracking the real route of submarine pipelines and cables, even when these are buried in sediments, which makes their detection by acoustic methods difficult or uncertain. In the figure 6 the real routes of the oil and gas pipelines pinpointed by magnetics may differ quite substantially from those depicted on the official navigation charts or on hydrocarbon exploitation maps.

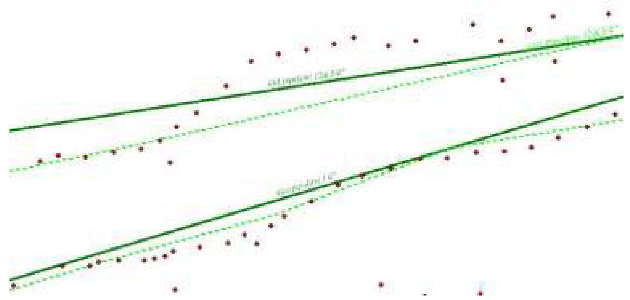

Figure 6: The real routes of the oil and gas pipelines pinpointed

c. Several scientific projects (MAR-S, HERAS) and research contracts namely dedicated to the study of submarine cultural heritage have been carried out in recent years, and marine magnetometry has been one of the main geophysical investigation methods involved. Thus, some of the main discoveries by the scientific team onboard R/V Mare Nigrum, during the first sea cruise organized within HERAS Project are exclusively due to magnetometry (Figure 7).

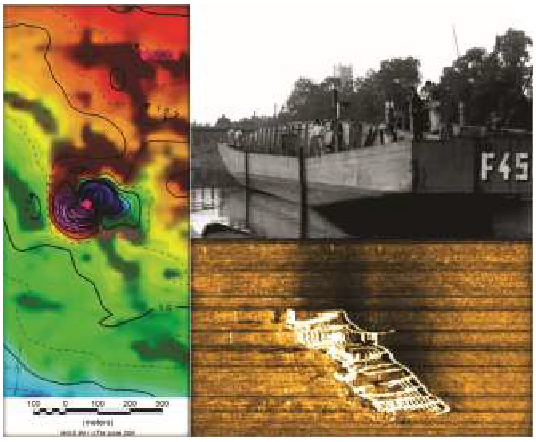

Figure 7: The map of the magnetic anomaly, the acoustic image and the picture of the shipwreck found on the seabed – possibly a German landing craft

d. An important contribution for the study and enhancement of maritime space security was brought by magnetometry within MAR-S project, implemented by GeoEcoMar during 2017-2018. The main tasks of the project were to experiment and prove the effectiveness of a set of geophysical methods (e.g. magnetometry, bathymetry, side-scan sonar and other) of investigation and monitoring of the maritime space, for the accurate location and identification of submerged objects and also to gather, structure and hierarchize all available and new acquired information in a dedicated GIS database.
Here is presented a composite map depicting the integrated interpretation of geophysical data, made for Midia offshore. The magnetic targets found are represented by red dots, the acoustic targets by small yellow dots and the snags by light-green dots. The position of previously known and assumed shipwrecks is presented in figure 8. Big, black circles are locations where shipwrecks were found on the seabed. Big, black crosses are locations where the existence of shipwrecks was infirmed. The white question mark indicates the location where the existence of an unknown, dismembered and covered by sediments shipwreck is supposed. The dark-green, dashed heavy lines represent alignments which could correspond to both known (central sector) and unknown former minefields (northern and eastern sectors). The black, dashed heavy line is the route of the pipeline that connect marine terminal with the onshore refinery (background of maps is the official navigation chart issued by the Romanian Hydrographic Directorate):

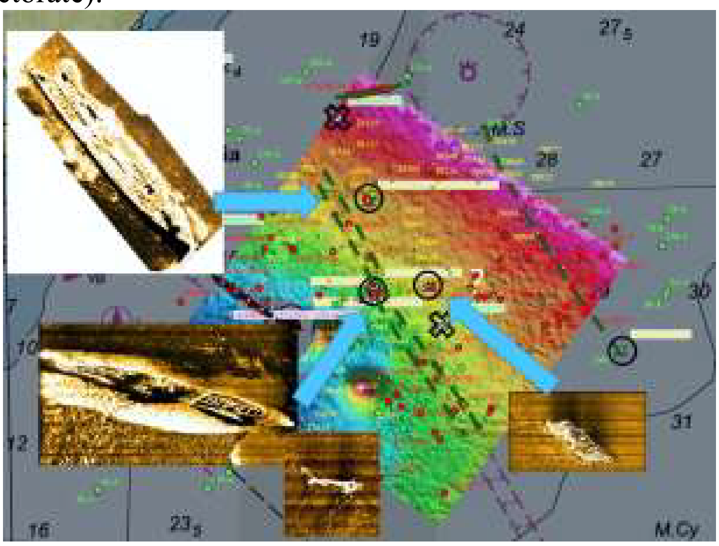

Figure 8: A composite map depicting the integrated interpretation of geophysical data, made for Midia offshore

Marine magnetometry demonstrates, in particular, a notable capability to integrate and prove its usefulness for the new domains of advanced offshore research: the identification and geo-ecological assess of dumping sites, the search, accurate location and recovery of various objects and tools (e.g. anchors, chains, corers, containers, boxes, barrels, pipelines, cables, etc.) lost or deployed on the seabed or covered by sediments, situation which dramatically diminish the efficiency of classic video and acoustic search methods. Besides its remarkable and unanimously recognized capability for discovery and accurate location of the ferrous wrecks, marine magnetometry proves also to be effective in the case of non-ferrous shipwrecks, but having onboard a cargo (e.g. amphoras, ceramics, weaponry, ammunition, etc.) or ballast with above average magnetic properties. Thus, marine magnetics continuously strengthens its widely accepted position as a main provider of extremely useful information for disclosing the submerse cultural heritage and also for enhancing the maritime space safety and security.

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Acknowledgements. This report was prepared by Dr. Anca Isac, Dr. Radu Dimitriu, Dr. Venera Dobrica, and Dr. Crisan Demetrescu.

Working Group V-MOD: Geomagnetic Field Modeling

1. Secular variation studies. New insights from long time series of observatory data and long-term main field models

The studies regarding long-term evolution of the main geomagnetic field have continued by approaching (1) the short-term constituents of the secular variation, at inter-decadal (20-30 years) and sub-centennial (60-90 years) time scales, present in observatory data and main field models and (2) the relation between length-of-day (LOD) fluctuations to geomagnetic field and flow oscillations in the fluid outer core.

The evolution of sub-centennial constituent of the radial field at core surface in the *gufm1* model has been investigated. By means of Time-Longitude (t-λ) and Time-Latitude (t-φ) plots a clear westward movement of the sub-centennial constituent field features, in the 20°N-20°S latitude band, with northward and southward components of the movement, has been identified and then by applying the Radon transform, the traveling speeds of the ~80-year variation at the core-mantle boundary level have been inferred. Consequently, the evolution of the radial field at core surface at sub-centennial time scale was characterized by two types of azimuthal flows, equatorial and high latitude ones, responsible for the observed westward drift of the surface field, and by meridional displacements of the core surface magnetic flux patches.

As regards the importance of eliminating, from observatory and main field model data, prior to any discussion on secular variation, of the signal related to external variations, our studies have continued by showing that not accounted for in modelling, the external contribution to observatory annual means maps into the main field Gauss coefficients, leaking as noise into the main field values given by models. We showed this external noise in long time-span geomagnetic models, such as gufm1 (1590-1990) and COV-OBS (1865-2010), by means of simple filtering procedure (Butterworth), for the European observatory locations.

The declination annual means time-series longer than a century provided by geomagnetic observatories, together with several historical declination series were analyzed in terms of frequency constituents of the secular variation at inter-decadal and sub-centennial time-scale, by using Hodrick-Prescott and Butterworth filtering. We suggested that the geomagnetic jerk concept should be considered as a more general notion, namely the evolution of the secular variation as a result of superposition of two (or more) constituents describing effects of processes in the Earth's core at two (or more) time-scales (sub-centennial, inter-decadal and 11-year).

The relationship between the evolution of the geomagnetic field and the Earth's rotation has been a new research direction recently developed. Generally, the Earth's rotation is governed by the conservation of the angular momentum of the Earth, with transfers between the solid part (inner core plus mantle) and fluid volumes in contact with (atmosphere and oceans, on one hand, and outer core, on the other). The Earth's rotation rate is expressed by the length of day (LOD). A rich scientific literature is linking LOD fluctuations to geomagnetic field and flow oscillations in the fluid outer core. In the same way as for the evolution of the geomagnetic field, by applying a Hodrick-Prescott filtering and then a Butterworth one, we have showed that while the sub-centennial oscillations of the geomagnetic field, produced by torsional oscillations in the core, could be linked to oscillations of LOD at a similar time scale, the oscillations at decadal and sub-decadal time scales, of external origin, could be found in LOD too.

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2. The geomagnetic disturbance field: induction and space weather studies

The external geomagnetic field arising from the magnetospheric and ionospheric current systems, developed at the interaction of solar wind and heliospheric magnetic field with the Earth's magnetic field, presents a high variability and might be used in providing information related to magnetic and electromagnetic induction, on one hand, and to magnetosphere and solar terrestrial processes, on the other hand. The last topic is known as space weather hazard and has been intensively studied by our group in the time interval 2015-2018, covered by this report, to correspond to international scientific efforts.

Information on the lateral variation of the electric properties of the crust and mantle, based on the disturbed geomagnetic field recorded during intense geomagnetic storms (Dst<-150 nT) in the solar cycle 23 (1997-2007) at European geomagnetic observatories and on the magnetic induction model, has been inferred and results have been reported at various conferences.

Large geomagnetic storms represent a significant space weather hazard through ground and near-Earth impacts. In this respect our group focused on both the study of the solar source – solar wind – geomagnetic storm chain and the surface electric field (E), the geophysical input in assessing ground space weather impact of geomagnetically induced currents (GICs) hazard, one of the better recognised examples of space weather. Based on the geomagnetic field recordings from European geomagnetic observatories, during intense geomagnetic storms from solar cycle 23 and 24 (2008-2018), and on information regarding the underground electric conductivity, the surface electric field over Europe produced by the variable magnetic field of geomagnetic storms has been determined. The geographical distribution of the maximum induced surface geoelectric field over Europe has been mapped showing that the maximum value, Emax, has not been reached at the same moment at all observatories and its orientation has been dependent on that moment of the storm development. These works showed that the geoelectric hazard (GICs) is significant above the 50ºN (S) geomagnetic latitude. Further work would include the determination of the actual GICs, which is an engineering problem and needs knowledge of the power grid.

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Division VI: Electromagnetic Induction in the Earth and Planetary Bodies And Inter-Associations (IAGA-IASPEI-IAVCEI) Working Group: Electromagnetic Studies of Earthquakes and Volcanoes (EMSEV)

In the interval 2015–2018 the electromagnetic researches involved in the frame of: (i) **IAGA DIVISION VI** (Electromagnetic Induction in the Earth and Planetary Bodies); (ii) **Inter-Associations (IAGA-IASPEI-IAVCEI) Working Group** on **"Electromagnetic Studies of Earthquakes and Volcanoes "(EMSEV)**, have included the following activities:

1. **Magnetotelluric studies for a better knowledge of the deep geoelectric structure on the Romanian territory.**

It is to mention that the Electromagnetic methods (EM) are the most sensitive for detecting partially interconnected, volumetrically minor yet tectonically important conducting phases such as partial melt, fluids and graphite. Therefore, they provide models on lithosphere/upper mantle conductivity, which are complementary to other geophysical data and aid at defining constraints to other geophysical and geological models, such as seismic tomography or reflection seismic models, temperatures or fraction of melt or volatiles. In the class of EM studies, the magnetotelluric sounding method (MTS) can provide information about the electrical properties of deep crust and upper mantle, by using sufficiently long data recordings of the Earth's electromagnetic components (Ex, Ey, Hx, Hy and Hz), in several sites, placed on profiles crossing the main geotectonic units from Romania, such as:

- resistivity model obtained by using 2-D forward modeling-finite element code, for to identify crustal geoelectrical structure (Figure 9): MTS51 – magnetoteluric sonding, TESZ – Trans European Suture Zone

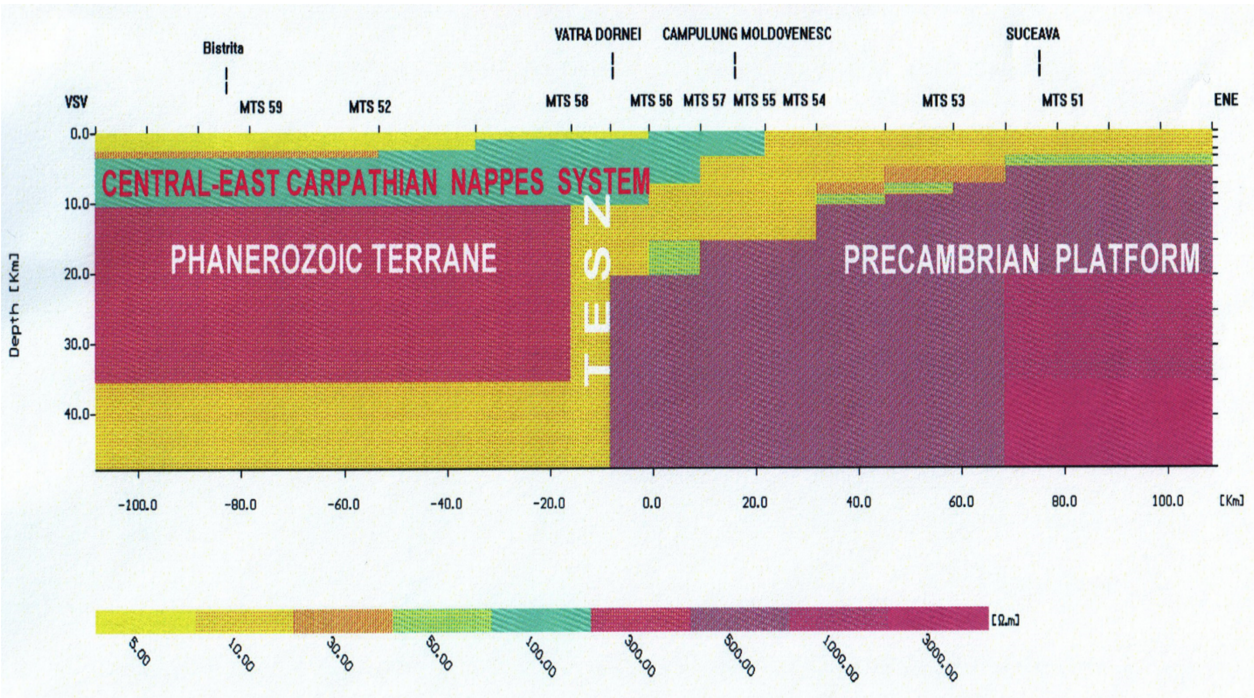

Figure 9: Magnetotelluric crustal resistivity model on the profile Bistrița - Vatra Dornei – Suceava

- lithospheric models for the East European Platform (EEP), Moesian Platform (MP) and Transylvanian Depression (TD) have been obtained by using 1-D resistivity inversion (see one example in Figure 10):

East European Platform

1-D resistivity model (ρ) in lithosphere

Layers	ρ[Ωm]	H [km]	Observations
1	10	10	Sedimentary cover of the platform
2	1000	35	Crystalline basement
3	10	10	Crust-upper mantle transition zone
4	500	120	Upper mantle
5	10		Asthenosphere

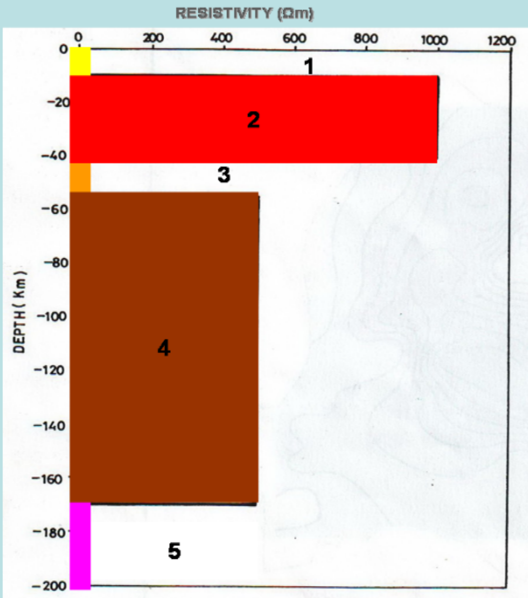

Figure 10: 1-D lithospheric resistivity model for the East European Platform

The 2D models and 2D and 3D tomographic images emphasizing the resistivity distribution at different depths, gave information regarding:

- the thickness of the East Carpathians flysch nappes systems and their over-thrust lineament with sedimentary cover of the EEP;
- the thicknesses of the volcano-sedimentary formations, platforms sedimentary cover and Carpathian Foredeep;
- the thicknesses of the crust and upper mantle for (EEP, MP, TD and Pannonian Depression);
- the major suture alignments (TESZ and Tethyan) and the crustal and lithospheric faults (Intra-Moesian, Trotuș and Peceneaga - Camena).

2. Pre-seismic geomagnetic signals related to Vrancea earthquakes

Department of Electromagnetism and Lithosphere Dynamics from Institute of Geodynamics of the Romanian Academy have realized electromagnetic researches in the frame of the Priority Program with the theme: "*The study of the natural variations of the electromagnetic field for a better knowledge of the terrestrial crustal structure and the establishment of the evolution of some parameters related causally to the strain release in the geodynamic active Vrancea zone*".

In compliance with the methodology elaborated, the following parameters have been used to emphasize geomagnetic pre-seismic signals related to Vrancea intermediate depth earthquakes:

- the normalized function Bzn which is time invariant in non-geodynamic conditions and it becomes unstable due to the geodynamic processes generated by the intermediate-depth seismicity, being associated with the resistivity changes along the high conductivity faults in the crust and upper mantle;

- the parameter Bzn* obtained by using a statistical analysis based on standardized random variable equation.

An example haw this methodology works is presented for the earthquake of Mw5.7 generated in 24 September 2016, in Vrancea zone, see Figure 11 (Stanica et al, 2018).

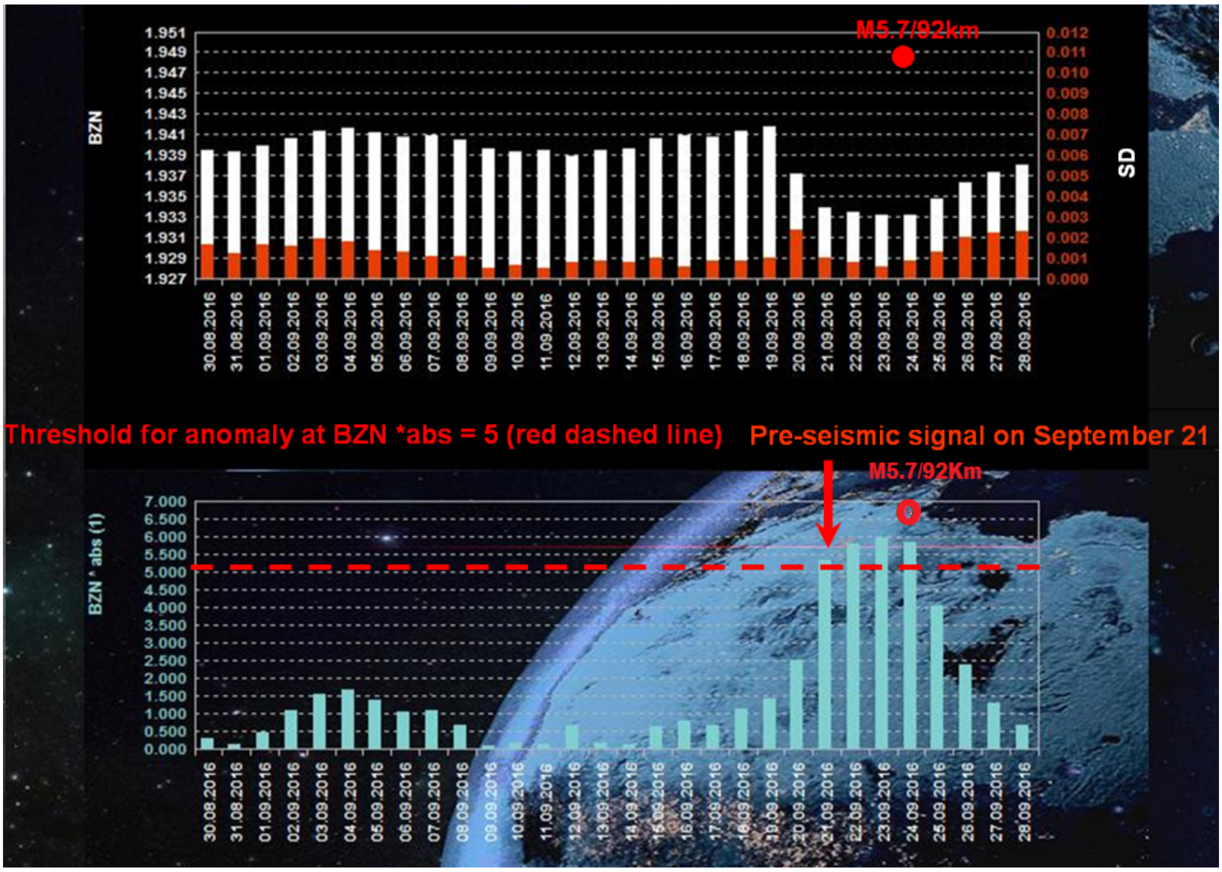

Figure 11: Real time, daily distribution of the geomagnetic parameters Bzn and Bzn* (photo image captured from the web site of the Institute of Geodynamics of the Romanian Academy, related to Mw5.7 earthquake, generated on September 28,2016), the ratio M5.7/92 is earthquake magnitude/ hypocenter depth

Papers and abstracts published/presented at international/national meetings:

Stănică D., Stănică, D. A., (2018), Pre-seismic geomagnetic signals related to the intermediate depth earthquakes generated in Vrancea zone on September 24 and December 28 2016, Scientific Conference, Academy of the Romanian Scientists, Book of abstracts, **1(1)**, 57;

Stănică D., Stănică, D. A., (2018), Geomagnetic precursor associated with Mw8.1 Chiapas-Mexico earthquake on September 8th 2017, Extended abstract at the Scientific Session Program, IGAR;

Stănică, D. A., Stănică D., (2018), Ground-based geomagnetic signature related to the Mw8.1 earthquake (Chiapas, Mexico), on September 8th 2017, Extended abstract, Abstracts Book, EMSEV Potenza meeting;

Stănică D., Stănică, D. A., (2018), Metode geoelectrice de investigație în România, in Istoria Geoștiințelor în România, Științele Geofizice, Editura Academia Romana, ISBN 978-973-27-2919-8, 36-40;

Stănică, D. A., Stănică D., (2017), Geomagnetic signal induced by the M5.7 earthquake occurred on September 24-th, 2016, in the seismic active Vrancea zone, Romania, EGU2017-6880, Geophysical Research Abstracts, **19**;

Stănică, D. A., Stănică D., (2017), Anomalous geomagnetic variations related to the Mw 8.1 Chiapas earthquake (Mexico), on September 8th 2017, GEOSCIENCE- SGAR;

Stănică, D. A., Stănică D., Blecki, J., Ernst, T., Jozwiak, W., Slominski, J., (2018), Pre-seismic geomagnetic and ionosfere signatures related to the Mw5.7 earthquake occurred in Vrancea zone on September 24 2016, *Acta Geophys*., **66**, 167-177, doi: 10.1007/s11600-018-0115-4;

Stănică, D. A., Stănică D., Vladimirescu N., (2016), ULF geomagnetic anomalous behavior related to M8.3 Coquimbo earthquake on September 16th 2015, Scientific Session Program, IGAR, April 6th;

Stănică D., Stănică, D. A., (2016), Real time electromagnetic monitoring system used for short-term earthquakes forecast related to the seismic-active Vrancea zone, EGU2016-2917 Geophysical Research Abstracts, **18**;

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Stănică, D. A., Stănică D., Vladimirescu N. (2015), Long-range anomalous electromagnetic effect related to M9 Great Tohoku earthquake, *Earth Sciences*, **4 (1)**, 31-38, doi: 10.11648/j.earth.20150401.13;

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Stănică D., Stănică, D. A., (2015), Electromagnetic imaging used to delineate the lithospheric geoelectrical structure and earthquake generation mechanism in Vrancea subduction zone, IUGG, Prague, Abstract volume;

Acknowledgements. This report was prepared by Dr. Dumitru Stănică and Dr. Dragoș Armand Stănică.

IAHS ACTIVITIES IN ROMANIA
2015 - 2018

Romanian IAHS Committee

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SUMMARY

Chapter 1. IAHS ROMANIA ORGANIZATION

The activities of IAHS organization in Romania took place under the supervision of the above-mentioned members of the Romanian IAHS committee.

Romanian IAHS activities implied not only different specialists and researcher in hydrology field, but also professional organizations or institutions, like:

Romanian Association of Hydrological Sciences
National Administration Romanian Waters
National Institute of Hydrology and Water Management
National Institute for Environment Protection Research and Development
National Institute of Research and Development - "Delta Dunarii"
National Institute of Marine Research and Development "Grigore Antipa"
Institute of Geography Bucharest
Geoecomar, Bucharest

One of the most important activities is education and efficiency increasing, which means the implication of some universities, like:

University of Bucharest – Faculties of Geography, Physics and Mathematics
Technical University of Civil Engineering Bucharest - Faculty of Hydrotechnical Structures
Politechnical University, Bucharest - Faculty of Hydropower
University Gheorghe Asachi, Iaşi
Ovidius University, Constanţa
University of Cluj
University of Agronomic Science and Veterinary Medicine, Bucharest- Faculty of Land Reclamation and Environment Engineering

Chapter 2. MAIN RESEARCH ORIENTATION IN THE FIELDS OF HYDROLOGICAL SCIENCES

During the last three years the Romanian hydrology achieved its activity through several exquisite research works covering practically all branches of hydrology.
The development of scientific hydrology in Romania had in view the basic needs of Romanian economy, the participation in the research of the present problems of hydrology as a whole, the harmonization of Romanian research activities with European research main direction, the elaboration of competitive methodologies and not in the last point, the adaptation of Eu Water Directive requirements to reality from Romania and the insurance of the adequate scientific frame in order to assure the implementation of WD.
The demands of the Water Framework Directive mainly extend the objectives of research in the following directions:

- To classify, identify and characterize the water bodies according to the unitary criteria at the level of the entire area of the European Community;
- To protect the inland surface waters, transboundary water courses, coastal waters and groundwater, the protection, maintenance and improvement of the state of the aquatic environment in the Community;
- To ensure the qualitative and quantitative monitoring of surface water and groundwater parameters, as well as the aquatic environment.

All these action directions pursue the preservation and improvement surface water quality, and especially groundwater for the supply of drinkable water for the population and leisure activities, as well as the restoration and protection of aquatic ecosystems affected by anthropogenic impact phenomena.
There are some major tendencies in the hydrological science in Romania now: -

- insurance of the quality during the research process: measured data quality insurance, models quality, new approaches in model validation, considering the uncertainty and uncertainty analysis
- using the new technology of Geographical Informational System GIS in hydrologie and water management
- space-time analysis based on new data sets, including new types of hydrological data (new types of measurement sensors, new approaches in data analysis)

Main research directions and results

The main themes addressed in Romania during 2015-2018 by the National Institute of Hydrology and Water Management (NIHWM), as well as by other institutions were:

- development of operational modeling platforms;
- modernization of the national hydrological system;
- hydrometric methodology;
- dynamic hydrology;
- the impact of climate change on water resources;

- hydromorphology;
- hydrological and hydraulic modeling;
- hydrological regionalization of the medium and extreme characteristics of the runoff;
- experimental hydrology (microscale studies and research);
- evaporation and evapotranspiration at ground, water and snow level;
- assessment of groundwater resources;
- mathematical modeling of surface and ground water resources;
- evaluation of hydrological parameters in natural regime and arranged regime;
- concepts and methodologies for planning in the field of water management (Hydrographic Basin Plans, Flood Risk Management Plans etc.);
- flood and drought risk management;
- ecohydrology;
- integrated concepts of water courses development and restoration that combine natural waterway mobility, and ecological dynamics, with the need to reduce the negative impacts of floods;
- the implementation of the European Directives;
- the development of the spatial database - GIS and the specific procedures in the field of hydrology;

A synthesis of these activities will be presented below:

The development of operational methodologies of elaborating forecasts and warnings for flash- floods (immediate hydrological hazardous phenomena)

For the implementation in the operative work of the operational framework methodology for the elaboration of forecasts and warnings for flash- floods, a number of activities were carried out, which focused mainly on the transposition in the GIS environment of the most important products and information generated by the regional and national systems (EFAS, SEEFFG), (ROFFG), numerical meteorological prognostic products for rainfall quantities, provided in real time by the National Meteorological Administration, as well as other products carried out within NIHWM, that can be used as support information in the decision-making process to develop warnings and forecasts devoted to these dangerous hydrological phenomena.

Elaboration and implementation of methodological instructions in the field of hydrometry

The analysis of the technical regulations, of the WMO guidelines and the standards in the field of hydrology and hydrometry, had as main purpose the updating and improvement of the methodological guidelines and instructions used for the hydrological activity and their updating, considering the numerous documents developed by the WMO in the field of hydrology and hydrometry, and the large amount of information that WMO guides, reports and manuals contain.

Annual summaries on the hydrological regime of the Danube and the Danube Delta based on data from hydrometric network and expeditionary measurements

Hydrological information and data accumulated during expeditionary hydrological measurements were centralized to a comparative analysis with measurements from previous years. These are inputs to analyze hydrological influence on the morphodynamics of the Danube riverbed, and the alluvia transit of the main arms of the Danube. Regarding the percentage distribution of liquid flow, the program of measurements carried out during the period 2014-2018, revealed a variation of the percentage distribution of the liquid flow on the main arms, depending on the hydrological regime.

Estimation of the impacts of climate change on the maximum flow regime and the determination of variation limits. Case study Crişul Repede and Crisul Negru

The study comprised several steps, as :

- Calibration of CONSUL hydrological model in the analyzed river basins;
- Establishing climate change scenarios;
- Preprocessing of meteorological input data at a spatio - temporal resolution, corresponding to the hydrological modeling requirements;
- Runoff simulation using the hydrological model (Figure 1);

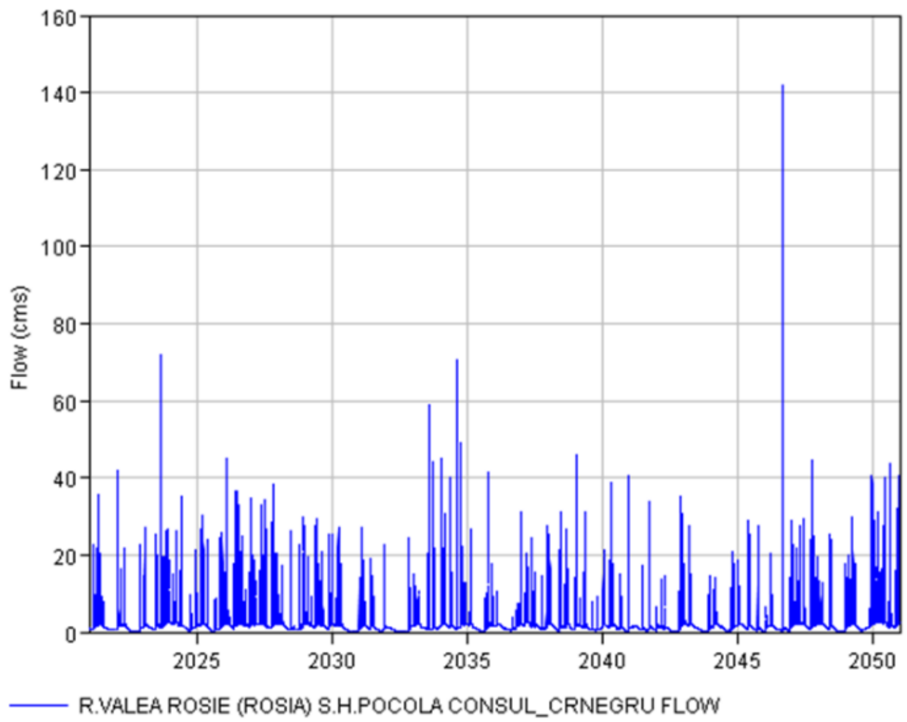

Figure 1: The hydrograph of the flows, simulated by the Consul hydrological model for 6 hours, during the period 2021-2050, at Pocola hydrometric station on Valea Rosie river, from the Crisul Negru basin, on the hypothesis of the climate change potential

- Analysis of the results of the impact study of the climatic changes and variables on the hydrological regime of the maximum flows (Figure 2).

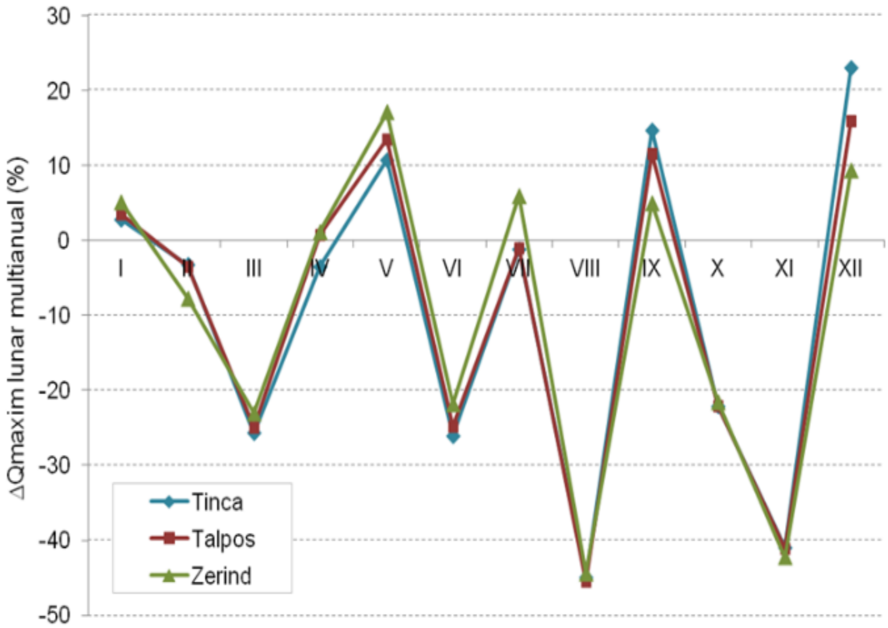

Figure 2: The variation of the relative deviation of maximum monthly instantaneous flows, multiannual averages, from the period 2021 to 2020 compared to the reference period1971 to 2000, in 3 sections of water flow simulation on the main course of the Crişul Negru river, resulting from the simulations performed with the CONSUL hydrological model

The estimation of the climate change impact on the maximum flow regime and the determination of some variation limits in the Someş and Crasna river basins

The main objective was to estimate the impact of climate change on the maximum flow regime of rivers in Romania, through hydrological simulation. There was used the CONSUL model, a deterministic mathematical model that allows runoff simulation in both small and large complex basins.

The results obtained in this paper are useful for the implementation of Directive 2007/60 / EC on flood risk assessment and management (preliminary flood risk assessment of Romanian territory), providing information on probable floods, information necessary to assess the potential negative consequences of future floods.

Evaluation of hydrologic drought events on rivers in Romania

The activities carried out within this research theme consisted of:

- The implementation of some methods used to assess the hydrological drought events in Romania
- The implementation of tests to detect the trend and change in the average flow time series.
- Standardized flow/runoff Index (SFRI) calculation.
- Calculation of minimum runoff indices (Figure 3).
- Estimation of water runoff deficit and identification of areas with varying degrees of severity of hydrological drought in Romania

- Flow series analysis based on trend detection tests and serial change (Figure 4).
- Analysis of drought periods identified based on the SFRI index.
- Analysis of minimum runoff indices.
- Identification of areas with different degrees of severity of hydrologic drought on rivers in Romania.

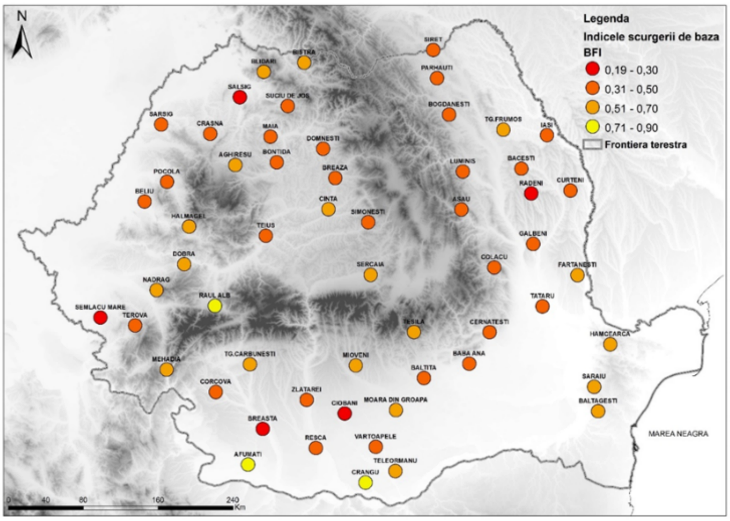

Figure 3: Basic runoff index (BRI) at the hydrometric stations in Romania

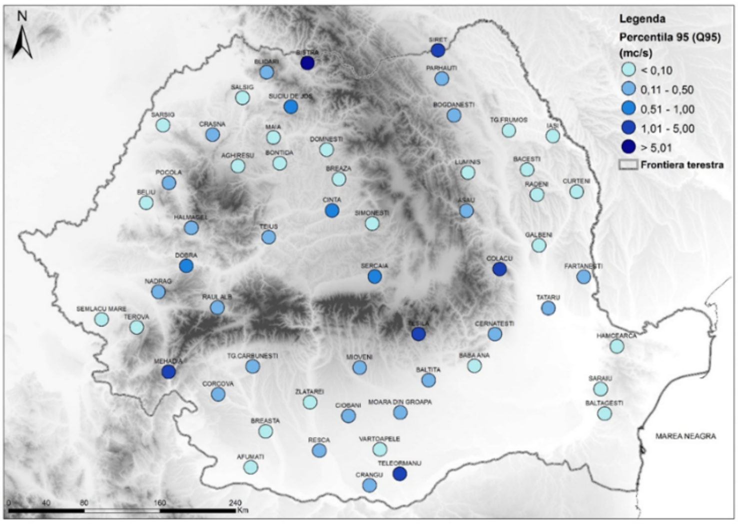

Figure 4: Multi-annual average flow (Q_{med}) at the hydrometric stations in Romania

The study was an overview of the assessment of the water drought in Romania from 1970 to 2015, based on statistical analysis of the calculation of minimum runoff indices, drought index and runoff indices for 132 hydrometric stations.

Upgrading the maximum runoff parameters set upstream of the reservoirs in Bistrița basin (ABA Siret)

The main purpose of the study was to calculate the maximum runoff parameters set upstream of the reservoirs in the Bistrița basin. The objectives proposed in the study were achieved by carrying out the following main activities:

- Updating the maximum runoff parameters in natural and arranged conditions, downstream the reservoirs selected as case studies from Bistrita basin.

- Determination of characteristic elements and synthetic components of flood waves on some sub-basins in Bistrita basin, in natural regime.
- Composition and propagation of synthetic of flood - waves using the hydrological model.
- Analysis of maximum flows, in flow-adjusted regime, with different probability of exceedance, calculated in the downstream sections of the analyzed reservoirs.

The main results of the study consist in the calculation of maximum flow rates with exceeding probabilities of 0.1%, 0.2%, 0.5%, 1%, 5% and 10% for the reservoirs in the Bistrita basin, at the downstream sections from the reservoirs.

Measures for restoring the connectivity of the water courses. Case Study.

The study aimed at proposing solutions for the restoration of the longitudinal connectivity in order to achieve the environmental objectives of the Water Framework Directive.
The study area was represented by the Bistrita water body - the Tănase confluence - Sieu confluence and the river sector related to Bistrita. The study presents four solutions of engineering design for the fish migration, for three thresholds considered significant hydromorphological pressures, that led to the designation of the analyzed water body as being heavily modified.
The design of the solutions has taken into account the local hydro-morphological characteristics as well as a series of recommendations of the specialized literature. Therefore, it is appreciated that the proposed solutions can be successfully implemented, presenting a high efficiency for the fish species intended to be moved upstream / downstream.

Identification of groundwater ecosystems directly dependent on groundwater bodies and further analysis of interdependence between groundwater bodies and associated surface systems (associated aquatic and terrestrial ecosystems), in accordance with the Water Framework Directive 2000/60 / EC and the 2006 Directive / 118 / EC. Case studies: ground water bodies belonging to ABA Argeş-Vedea

The objective of the study was to identify terrestrial ecosystems directly dependent on groundwater bodies, so that the information obtained to be used to updating the characterization of groundwater bodies in the next Management Plan of each Water Basin Administration for the period 2022-2027.

Development of conceptual and mathematical models of groundwater bodies to assess the effects of contaminated sites on them. Case studies: ROAG03 -Colentina, ROAG07 - Danube meadow (Giurgiu-Oltenita), ROAG10 - Danube meadow (Turnu Magurele-Zimnicea)

The main objective of the topic was the elaboration of the conceptual and mathematical models of the ground water bodies within the Argeş-Vedea Basin Administration: ROAG03 - Colentina, ROAG07 - Danube Meadow (Giurgiu-Olteniţa) and ROAG10 - Danube Meadow (Turnu Magurele-Zimnicea).

The three groundwater bodies were analyzed from three points of view: spatial, parametric and hydrodynamic. The geological and hydrogeological information collected from the observation drills at the National Hydrogeological Network (registered levels), river measurement campaigns, data taken from the hydrometric stations, were processed in the form of: isobate maps at the groundwater aquifer, 3D stratigraphic models, piezometric maps, hydrological parameters, numerical models of ground water bodies.

The continuation of identifying trends relevant to the concentrations of the main ground water body pollution indicators (for 40 bodies of ground water).

The main objective of this study was to continue the activity to identify the trends relevant for the concentrations of the main indicators of ground water body pollution by updating and completing the information for the period 2014-2017 for the elaboration of the Hydrografic Basins Management Plan (HBMP) 2022- 2027.
There were determined the trends and the trends reversals for 42 selected bodies, monitored by a total of 241 drillings, of which only 63 dills had a full range of recordings over a 10-year period, starting in 2007. The representativeness of monitoring points on the surface of ground water bodies is unsatisfactory in 38% of the analyzed situations (16 of the bodies are analyzed based on a single monitoring point). The analysis of identifying the increasing trends and reversing of the relevant trends in the concentrations of the pollution indicators, was done with the help of the GWStat software.

Evaluation of Romania's water surface resource

The main objective of the study is to assess the Romanian water surface resource, on the basis of a unitary methodology for estimating the water surface resource at the level of the main river basins afferent to the river basin administrations, for national reporting. The study was conducted in three stages:

- The establishing of working steps for estimating the water resource at the level of the main river basins and Water Basin Administrations for national reporting.
- Evaluation of the surface water resource at the level of the main river basins in Romania and the Water Basin Administrations for the year 2017.
- Processing of support data necessary for the analysis of water resource evolution - case study Siret river basin related to ABA SIRET.

The main results of the study consisted of:

- Specification of the calculation methodology of the water surface resource;
- Calculation of the water resource in the year 2017 for the main river basins in the country and for the Danube River and comparative analysis with the water resource from 2007 to 2016;
- Updating the 2017 database for hydrometrical stations in the Siret basin;
- Carrying out the map with specific average runoff isolates at Siret river basin

- Calculation of the water resource at hydrometric stations in Siret river basin and in significant confluence sections;
- Analysis of the spatio-temporal variability of the water resource from Siret river basin.

Updating maximum flows in natural regime, at the hydrometric stations within rates at ABA Siret

The main objectives of this study were:

- *Updating maximum values series,*
- *Calculation of maximum flows with different exceeding probabilities ,*
- *The probability calculations of flows corresponding to the defense altitudes.*

There was identified a number of 156 hydrometric stations that are currently in operation, of which 146 have been selected to have rows longer than 25 years that can be statistically processed. The results obtained from the statistical processing were zoned by synthesis relationships of the type q1% - f (F) or some variation graphs of type Q max 1% - f (F). The statistical processing was performed unitarily using the Weibull formula for the empirical probabilities attributed to all chronological flows series of maximum flows, and also the Pearson III distribution curve for the determination of the theoretical values, respectively the maximum flows with various probabilities.

Guidelines for making measurements and hydrological observations on the Danube

The aim of the study was to create the first version of the Guidelines for measuring hydrometric data for the Danube and the Danube Delta, in order to create a unified methodological framework for measuring hydrological parameters, specific to the hydrometric stations on the Danube and the Danube Delta.
The guideline for making hydrological measurements and observations on the Danube River supports the creation of a unitary framework for conducting hydrological measurements and observations at all hydrometric stations on the Danube River and the Danube Delta, thus, contributing to supporting and deepening the quantification of the characteristics and evolution of liquid and solid runoff of the river, in order to assess the hydrological regime, the dynamics and morphological changes of its bed, the estimation of the water resource and the assessment of the transport capacity of the alluvia on the Danube River.

Analysis of the potential impact of irrigation systems on water resources in terms of quantity as a result of the update of the Investment Strategy in the Irrigation Sector by evaluating the indicators related to the hydrological regime (according to the methodologies for establishing the hydromorphological indicators)

- Adaptation of the Methodology for the determination of hydromorphological indicators for Romanian water courses for the Danube River, and its application throughout the Romanian Danube sector;

- Calculation of the consumed average flow indicator and of the consumed maximum flow indicator.
- Calculation of the consumed average flow indicator and of the maximum captured flow indicator
- Calculation of the change in water level indicator in the reservoir and of the water volume variation indicator in the lake.

Preliminary hazard analysis at national level for flash - floods through simplified modeling

Hazard analysis for flash - floods in small river basins was configured within the ROFFG Operational System and detailed hazard analysis for flash - floods within small river basins was made by using a conceptual hydrological model with distributed parameters.

Hydrogeological studies support for the implementation in Romania of the groundwater provisions of the Water Framework Directive 2000/60 / EC and the Groundwater Directive 2006/118 / EC, in order to elaborate the Hydrographic Basins Management Plan 2022-2027

- Identification of the elements needed to determine the relationship between groundwater bodies, surface waters and associated ecosystems
- Identification of ground-based ecosystems directly dependent on the body of groundwater - Case studies: ABA Buzau-Ialomita groundwater bodies for which conceptual models were developed
- The relation of existing habitats in the area of sites of Community importance (SCI), according to the Natura 2000 classification, of the Buzau-Ialomita Basin Administration, with groundwater;
- Achieving the mathematical models of ground water bodies: ROIL07 (Figure 5); ROIL08; ROIL09; ROIL11 (Figure 6); ROIL14; ROIL17
- Assessment of the effects of contaminated sites on groundwater

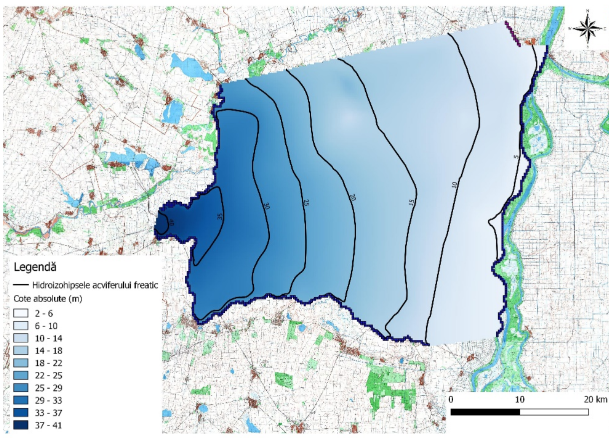

Figure 5: Numerical model of groundwater body ROIL07

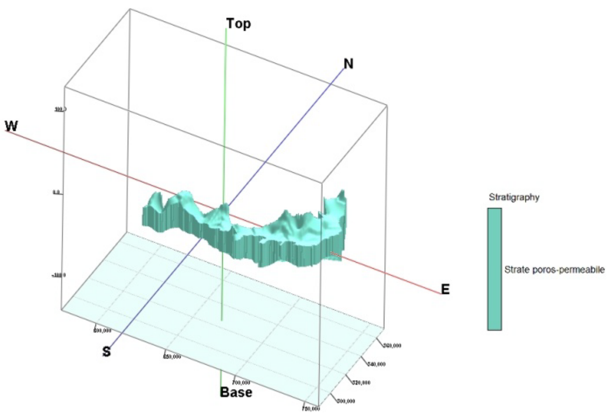

Figure 6: 3D stratigraphic model for the groundwater body ROIL11 - Danube meadow (Oltenița-Hârșova)

Coupled Land - Atmosphere Systems

The knowledge of water balance in a hydrographic river basin is the essential condition for an advisable exploitation of water reserves. The atmosphere detains a wide quantity of vapors which comes almost exclusively from the evaporation process at the surface of the planet. Evaporation is one of the most important elements in complete study of water balance as well as conceptual hydrological models, lately becoming a parameter of interest in climate change studies.

The knowledge of evaporation and evapotranspiration processes is essential for the analysis of climatic changes and hydrological budget. These processes vary regionally and seasonally so, for a good water management system, it's very important to have a thorough understanding of these processes.

In the last period (**2015-2018**) the most important studies consist in:

Spatial and temporal variability of evaporation in the Romanian Plain.

This study analyzes the spatial and temporal variability of evaporation, in order to highlight the regional characteristics and possible trends of this climatic parameter in Romanian Plain. It is based on processing series of climatic data from 14 evapometric stations in the study area. The results show that, in the lower parts of the plain (at less than 50 m in altitude), the annual evaporation exceeds 900 – 1000 mm per year, while at more than 200 m in altitude, its values are below 700 mm per year. Among climatic parameters controlling the evaporation, the most important are air temperature and wind velocity. Mann-Kendall test, applied on the series of annual and monthly values of evaporation, showed linear trends with spatial differences in trend slope (positive or negative) and signification degree.

Variability of evaporation and the impact on water resources of the Căldăruşani Lake (Romania).

Evaporation and evapotranspiration are major components of the water cycle and water balance. Studying them allows a better knowledge and understanding of the mechanisms and regularities that guides the natural water cycle and the associated processes. This study focuses on the Căldăruşani Lake and has as objective to analyse the temporal variation of the measured values of the evaporation and evapotranspiration and to estimate the volume of water lost by these processes in order to assess their impact on water resources of this lake. The results showed that, the annual evapotranspiration values are greater than 1800 mm, while the evaporation does not exceed 1100 mm. Open water evaporation and evapotranspiration play an important role in the analysis of lake's water budget, generating annual losses up to 40% of the water volume of the lake. The water lost by these processes is recovered in spring due to large amounts of rainfall and high rivers' flow supplying the lake during this season.

Implementation of some calculation methods of the evaporation in the catchments of Prut and Bârlad rivers.

Evaporation is a key element in achieving the water balance within a catchment, without which there is no possibility of making a judicious exploitation of water resources. It is important to be aware of this parameter, especially in dry periods and in those with intense vegetation, in order to estimate the necessary amount of water in atmospheric and soil drought.

For this reason, the catchments of Prut and Bârlad rivers were chosen, as they are located in an area vulnerable to drought and because it is essential to know the evaporation in such a region.

Obtaining the values of this parameter directly can be made in few places in the country; therefore, it is imperative to use indirect methods, too.

As a result, this study aimed at the estimation of the evaporation by using several calculation methods and its analysis in comparison with the values obtained directly. Methodologically speaking, this work is based on statistical analysis of the values of the actual evaporation and on the implementation of some calculation methods of the potential evaporation: Penman, Penman – Monteith, FAO, Thornthwaite, Priestley–Taylor.

The results of the study enable the usage of the direct data from the seven analyzed stations. They have immediate and practical application in providing evaporation data for the hydraulic and hydro-ameliorative works. For the analyzed catchments, the FAO method arises some deviations; consequently, its application is suggested to calculate the evaporation in this area.

Validation of the Cropwat Model at a Romanian experimental station and in other different climatic regions (Brazil, India and USA).

One of the most complex atmospheric processes, evapotranspiration, is an important parameter with several applications in climatology, hydrology, environmental studies and agriculture, being conditioned by different climatic conditions (air temperature, precipitations and relative humidity), relief, soil types and water resources (water availability for crop irrigation).

Taking into account that evapotranspiration measurements are difficult to carry out directly, because of the rarely available lysimeter installation, often found within experimental basins and stations, a number of applications have been developed (CERES, CRPSM, UCA, COMMOD, RIMMOD, ISOM), including the Cropwat Model. This model has already been validated in many countries, including Romania, by testing different crops (maize, peas, wheat and soybean) at the Căldăruşani experimental station (in SE Romania, Figure 7).

The study's aim is to estimate evapotranspiration by using the Cropwat Model (developed by FAO), for land plots covered with soybean crop, under different climatic regions: in the United State of America - Ohio State; Brazil - Rio Grande do Sul and Mato Grosso; Romania - South-East region and India - Madhya Pradesh. All five regions analyzed in this paper play an important role in the production of soybeans around the world, with the USA and Brazil ranking first and second among the world's biggest soybean producing countries and India occupying the fifth place. At the same time, Romania has become an ever more important producer over the years at a European level.

Figure 7: Evapotranspirometer on Caldarusani lake

The CropWat model estimates crop evapotranspiration by using a modified Penman-Monteith equation, where the input consists of climatology data: relative humidity, wind speed, sunshine duration, maximum and minimum air temperatures, precipitation, and also crop data: the standard crop coefficient, plant development stages, root depth, plant withering point, plant response capability, crop yields and plant height.

The study was performed by using data from both dry and humid years, provided by the National Institute of Hydrology and Water Management (Romania), the National Oceanic and Atmospheric Administration for India, the Midwestern Regional Climate Center for the USA and the National Institute of Meteorology of Brazil.

The results obtained in this study largely correspond to those presented in previous studies, carried out at experimental scale but also at a global scale, based on the satellite images. Thus, evapotranspiration in the case of soybeans crops exhibits higher values during dry years, characterized by lower rainfall values. In Brazil, soybean evapotranspiration reaches 650 mm/year, in Romania 550 mm/year, in India 600 mm/year and in the USA 500 mm/year. The highest daily values exceed 5 mm/day in all the study areas, during the period of maximum vegetation.

Knowledge of evapotranspiration is essential for managing periods of atmospheric and soil dryness, when the crops need irrigation of up to 300 mm/year. In conclusion, the Cropwat Model helped us to better know and understand the variability of soybean evapotranspiration for different climate regions and to identify the periods of the year when crops need irrigations, based on a few input data and on the experimental studies previously made.

The effect of evapotranspiration on the water reserve of Romanian lakes.

Over the last decades, hydrological research has been targeting the impact of evaporation on water reserves, present in lakes at specific moments of time. The results of these studies have shown that for reservoirs located in areas with a subtropical climate, the volume of water lost

through evaporation can exceed 250 million m^3/year – Algeria (Remini et al., 2009), reaching values as high as 400 million m^3/year – Morocco (Lahlou, 2000) and even 4,100 million m^3/year – Turkey (Gökbulak et al., 2006).
In Romania, there are very few studies following such an approach, thus underlining the importance of carrying out the present research. Having in mind the small number of evaporation-measuring rafts, available at national level, with only 14 such instruments currently existing, it is vital to determine evaporation for those lakes that are not being monitored, as well as the impact of this parameter on a lake's water reserves.
In this context, the goals of our study are: (i) to determine the average multiannual surface evaporation, for lakes that are not measured from an evapometric point of view, but present complex functions (supplying the population with water, generating electricity, mitigating floods) and (ii) to estimate the volume of water lost through this process for every lake included in the study. Evaporation was determined for a total of 20 lakes, by applying the modified Penman-Monteith method, using daily data on maximum and minimum air temperature, relative humidity, wind speed, duration of sunshine, which were extracted from the ROCADA database (Dumitrescu et al., 2015) for the 1961-2013 interval.
The validation of evaporation data, obtained through the modified Penman-Monteith method for the 20 analysed lakes, was carried out using maps of the annual distribution of evaporation in Romania, which were in turn created based on data gathered in the 1961-2013 interval from 54 evapometric stations.
Results indicate evaporation values of more than 700 mm/year for lakes situated at altitudes of less than 200 meters, values between 600 and 650 mm/year for lakes located in hilly or plateau areas and values of less than 450 mm/year for lakes found in depressions or in the mountains.
The estimation of the volume of water, lost through evaporation, was performed using the equation elaborated by Drobot and Şerban (1999) for the year 2013, which was chosen for two reasons: it was a normal year from a hydrological standpoint, compared to the 1961-2013 reference interval, and due to the availability of the hydro-morphometrically data for the lakes. The results show the volume of water, lost due to evaporation, ranges between 1.5 and 6 million m^3. This represents up to 15% of the total water volume of a lake, in the case of lakes located in lowlands, and reaches 1 million m^3, or about 2% of a lake's volume, in the case of water bodies found in depressions and in the mountains.

Evaporation and evapotranspiration in Romania.

Evaporation and evapotranspiration are two of the most important elements for achieving a comprehensive study of water balance components and of conceptual hydrological models, lately becoming parameters of great interest in research on climate change.
This study can be used for determining of evaporation and evapotranspiration rates at micro-scale using indirect methods. The importance of this study consists in identifying the regions exposed to significant water release in terms of water evaporation and evapotranspiration, in order to improve the practices and methods of water reserve management nationwide. In Romania, the spatial distribution of the analyzed variables is, for the most part, determined by the relief, which constitutes the main factor that dictates the particularities of both the local

and regional climate. Among the morphometric characteristics of the relief, altitude plays the most important role in the spatial conditioning of the analyzed parameters. The spatial distribution of evaporation and evapotranspiration, at annual, seasonal and monthly levels in Romania was made through the spatial interpolation method (Digital Terrain Model with a resolution of 30 m).

The results of the analysis revealed the following aspects: on a multi-year period, evaporation in Romania ranges from 300 mm - 800 mm / year, with the highest values recorded in the south east of the country and the Danube Floodplain (over 1,000 mm / year), western part (over 800 mm / year) and the lowest values registered in the mountain areas (less than 400 mm / year).

The values of evapotranspiration vary between 300 mm/year and 625 mm/year, with a maximum of over 650 mm / year in the plains and a minimum of less than 300 mm / year in the mountains (Figure 8).

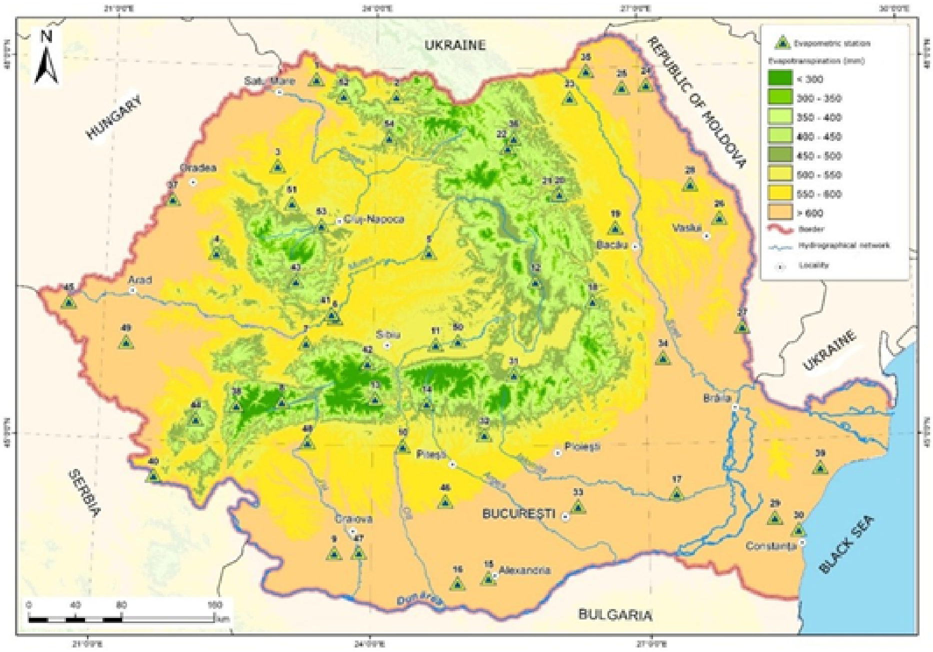

Figure 8: Spatial distribution of evapotranspiration in Romania, 1961 – 2013

Small scale research

In Romania, in order to know the characteristics on the runoff in the small river basins with an up to 150 Km^2, the research from 2015 to 2018 consist in:

The dominant runoff processes on grassland versus bare soil hillslopes in a temperate environment - An experimental study.

This study aimed to investigate the dominant runoff processes (DRP's) at plot-scale in the Curvature Subcarpathians under natural rainfall conditions characteristic for Romania's temperate environment. The study was based on 32 selected rainfall-runoff events produced during the interval

April – September (2014 – 2017). By comparing water balance on the analyzed Luvisol plots for two types of land use (grassland vs. bare soil), we showed that DRP's are mostly formed by Hortonian Overland Flow (HOF), 47% vs. 59% respectively. On grassland, HOF is followed by Deep Percolation (DP, 31%) and Fast Subsurface Flow (SSF, 22%), whereas, on bare soil, DP shows a higher percentage (38%) and SSF a lower one (3%), which suggests that the soil-root interface controls the runoff generation. Concerning the relationship between antecedent precipitation and runoff, the study indicated the nonlinearity of the two processes, more obvious on grassland and in drought conditions than on bare soil and in wet conditions (as demonstrated by the higher runoff coefficients). Moreover, the HOF appeared to respond differently to rainfall events on the two plots - slightly longer lag-time, lower discharge and lower volume on grassland - which suggests the hydrologic key role of vegetation in runoff generation processes.

The other study was **"How can the grasslands under rainfall events modify water balance in drought conditions"**. Taking into account the well-established influence of hillslopes grasslands on runoff processes, the purpose of this study was to investigate how grasslands can affect the water flow pathways on hillslopes, in drought conditions. This study was performed in experimental grassland at plot-scale (e.g., Festuca pratensis), in temperate humid continental climatic conditions of Curvature Subcarpathians, Romania. The rainfall, evapotranspiration, and soil moisture daily data, respectively 208 rainfall and 16 rainfall-runoff events data measured in grassland hills during the growing season (1 April up to 30 September 2015 and 2016) were used. Our results suggest that a runoff event response in extreme drought conditions occurs on grasslands only if precipitation exceeds the threshold of 31 mm Hortonian overland flow (HOF), while this threshold drops to 17 mm during moderate droughts and up to 8 mm for wet conditions. The rainfall events up to 16 mm proved to be insufficient to completely saturate the soil. Therefore, HOF has only a minor contribution in drought conditions, on grassland and light on bare soil. A complementary and negative effect of grasslands in drought conditions is the water resources suppressing on hillslopes.

Micro-scale hydrological field experiments in Romania. The paper (communication) presents an overview of hydrologic eld experiments at micro-scale in Romania. In order to experimentally investigate micro (plot)-scale hydrological impact of soil erosion, the National Institute of Hydrology and Water Management founded Voinesti Experimental Basin (VES) in 1964 and the Aldeni Experimental Basins (AEB) in 1984. AEB and VES are located in the Curvature Subcarpathians. Experimental plots are organized in a double systems and have an area of 80 m^2 (runoplots) at AEB and 300 m^2 (water balance plots) at VES (Figure 9). Land use of plot: rst plot "grassland" is covered with perennial grass (P1) and second plot (control) consists in "bare soil" (P2). Over the latter one, the soil is hoeing, which results in a greater development of inltration than in the rst plot. Experimental investigations at micro-scale are aimed towards determining the parameters of the water balance equation, during natural and articial rainfalls, researching of ows and soil erosion processes on experimental plots, extrapolating relations involving runo coe-cients from a small scale to medium scale. Nowadays, the latest evolutions in data acquisition and transmission equipment are represented by sensors (such as: sensors to determinate the soil moisture content). Exploitation and dissemination of hydrologic data is accomplished by research themes/projects, yearbooks of basic data and papers.

Figure 9: Experimental rainfall on runoff plots)

A hydrometric and hydrological approach test at microscale.

The objectives of this article were: to test the hydrometric accuracy of some water level variation measuring and recording devices using a metal measuring tank with weir, and to automatically determine runoff intensities and elements.

These field tests were performed in order to ensure high accuracy and low uncertainty of studies at hydrological micro-scale (plot scale). Hydrometric tests targeted two level measurement conditions: (i) rise and storage - without overflowing, volumetric measurement V= f (H); and (ii) rise and overflowing, weir measurement Q = f (H). Hydrometric accuracy was evaluated by comparing the measured and recorded level using three instruments with a tell-tale level. This field experiment was conducted in Voinești Experimental Basin, belonging to the National Institute of Hydrology and Water Management.

Levels series data were processed with the software application ParExp v1, in order to automatically convert them into discharges (Q). Hydrometric and hydrological test results highlighted certain aspects. The accuracy estimated for water fluctuation measurement and recording instruments in a weir water tank, for both level measurement conditions revealed accuracy errors (insufficient accuracy) when the runoff hydraulics was changed (storage Qacum ÷ overflowing Qdev). To remedy such instrumental deficiencies, a metrological control shall be performed under specific operational conditions (e.g., water tank) in order to meet increasing needs for high quality hydrological data (Figure 10).

The hydrological data processing using the ParExp v1 software application, at the junction of specific “rise and storage” and “rise and overflowing” flows indicated a temporal error (delay). The user may remedy this error by eliminating data from the Qacum-Qdev junction range until reaching the maximum/stabilized level. Finally, we estimate that through the improvement of some technical elements, hydrological data obtained at a micro-scale level can be used for hydrological models of calibration.

Figure 10: Aspects regarding field hydrometric tests

INHGA have also contribution to *Landslide Hydrology* research field development in 2017.

In the framework of **PSMLAND project** (http://www.geo-spatial.ro/psmland/), implemented in the ***Experimental Hydrology Department***, I.N.H.G.A., the hydro-meteorological conditions that triggered landslides in the Ialomita Subcarpathians, Romania, during the 2014 storm events, have been investigated with the aim to improve scientific understanding of the landslide initiation. The results obtained in the PSMLAND project have been published (Chitu et al., 2017) and will be briefly presented below.

Rainfall is recognized as triggering factor for landslides, but the complex interaction between land surface and atmosphere is often controlled by antecedent soil moisture conditions. Hydrological pre-conditions referring to soil moisture and groundwater level dynamic play a critical role in triggering slope failures and their estimation is required for understanding the role of rainfall in landslide initiation.

A detailed study of the numerous landslides that took place in the Ialomita Subcarpathians (Figure 11), Romania, during the 2014 storm events, was done by analyzing and quantifying the hydro-meteorological conditions and rainfall triggers. A high-quality data set regarding the spatial and temporal rainfall distribution, in situ and modelled soil moisture data, as well as discharge records are used for understanding the role of antecedent conditions in landslide occurrence. Precipitation and soil moisture measurements on soil profiles are used on local scale to gather information about soil saturation depending on rainfall characteristics, while adjusted radar precipitation estimates and discharge data were used for analysis of catchment's response to the main rainfall event that resulted to landslides.

Two different approaches were applied for identifying hydro-meteorological conditions responsible for landslide occurrence in 2014: *a local analysis* based on in situ soil moisture measurements and precipitation data that produced estimates regarding soil water saturation in relation with rainfall intensity in different soil types and *a regional analysis* based on rainfall-runoff modelling of the catchment's response to spatially distributed storm events for understanding spatial variation of soil moisture conditions and direct runoff.

The analysis of both local and regional hydro-meteorological conditions of the storm events of 2014 resulted in a better understanding of the relationship between precipitation, soil moisture conditions and landslides in the Ialomita Subcarpathians.

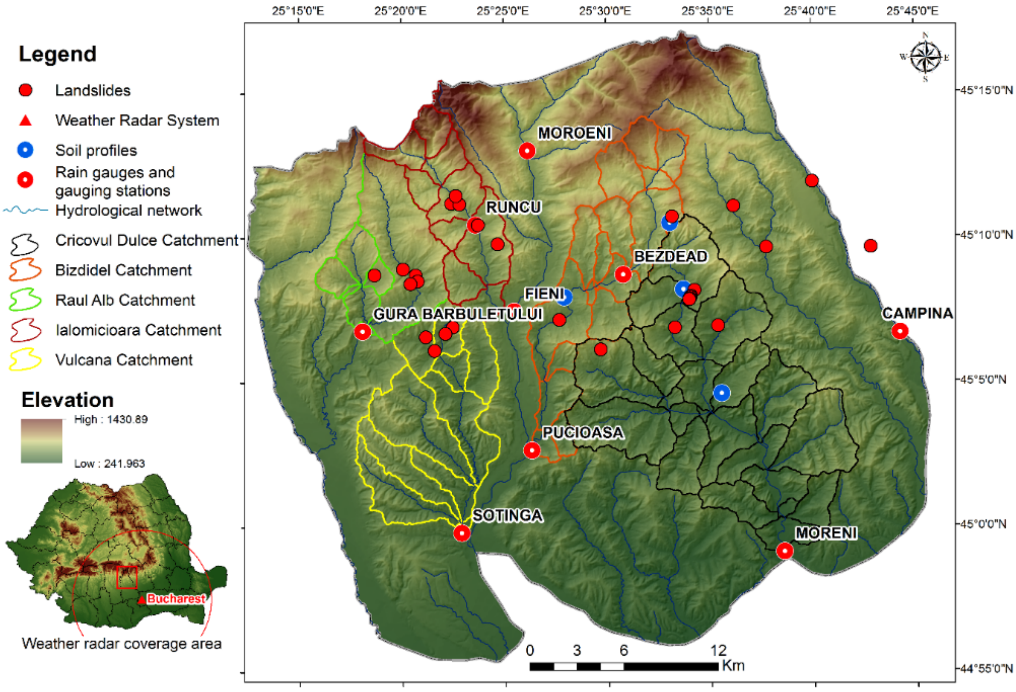

Figure 11: Location of Ialomita Subcarpathians (Source: Chitu et al, 2017)

The storm events of 2014 offered the opportunity to test the use of radar-based precipitation estimates for identifying the main spatial and temporal characteristics of the rainfalls that resulted in landslides in this specific area. From the regional precipitation analysis, it was observed that all three rainfall events analyzed had presented large heterogeneity at the catchment scale, however landslides were found to be concentrated in those catchment areas characterized by equally-high cumulative precipitation. The landslide occurrence in this specific area seems to be more related to low intensity - long duration rainfall than to high intensity - short duration rainfall, even if the time response of slopes to rainfall events was relatively short. The use of the radar-based precipitation estimates in this study proved to be a useful method for understanding the spatial distribution of landslides in relation to rainfall characteristics.

The local investigations of soil moisture conditions in relationship with rainfall characteristics reveal, otherwise than would have been expected, that the maximum degree of saturation on clay soil profiles does not temporally correspond with the landslide events. The low degree of saturation at the beginning of the rainy period - the time when the most important landslide event was produced, as well as the significant cumulative precipitation at the end of the rainy period which did not result in any more landslides lead us to consider that antecedent conditions were not critical for landslide occurrence in this specific area during the three storm events in 2014.

The regional investigations by means of the ModClark semi-distributed hydrological model, that integrates radar-based precipitation data, provided useful information about the spatial response of slopes to the main rainfall event occurred in 2014 (April 15-19). According to the environmental characteristics, different behaviors were identified. The high direct runoff values estimated in the subcatchments affected by landslides (the Cricovul Dulce and the Bizdidel catchments) explain the fast response of slopes to rainfall by slope undercutting - a

process which seems to be the driving force of these landslides. The significant soil infiltration that was expressed as precipitation loss in all subcatchments of the Raul Alb catchment sustains the hypothesis that the driving force in the case of the Gura Barbuletului landslide was an increase in pore water pressure due to a macropore flow along fault systems.
These results illustrate the regional pattern of the rainfall-triggered landslides in the Ialomita Subcarpathians. Future investigations will focus on applying the proposed approach on a higher number of rainfall-triggered landslide events, with the aim of statistically identifying rainfall-thresholds for landslide occurrence in this particular region of the Romanian Subcarpathians.

Chapter 3. PARTICIPATION OF ROMANIAN SPECIALISTS IN WORKING GROUPS INVOLVED WITHIN HYDROLOGY FIELD

The participation of Romanian specialists in national and international programs and projects is an objective necessity mostly motivated by the requirements of the economy to know the main hydrological and hydrogeological characteristics of water resources. That is why the projects and programs had aimed to establish the most efficient methods and models to determine the status of water resources under various circumstances.
The participation of Romanian specialists in international programs aimed at similar objectives – this time expanded at regional level, using at the same time the experience of specialists coming from different countries, involved in giving solutions to the scientific and technical problems raised by socio-economical requirements.

At **international level** we can mention participation of Romanian specialists in important international programs and workgroups current activities, like that mentioned bellow:

1. Participation within the activities of the Hydrological Workgroup "Regional Association VI – Europe" and WMO

- The18th Working Meeting of the Hydromorphology Experts Group, 07-08.09.2017, Austria, Vienna
- The 17th session of the Commission for Hydrology – World Meteorological Organization, 16-17.03.2017, Vienna, Austria
- Workshop SEE-MHEWS (OMM and USAID), 08-09.03.2017, Budapest, Hungary
- Workshopl SEE-MHEWS (OMM and USAID), 06-10.02.2017, Macedonia, Skopje
- The fifteenth session of the Commission for Hydrology – World Meteorological Organization – CHy15, 07 – 13.12.2016, Rome, Italy
- 3rd session of the Forum for Hydrology within the Hydrological Workgroup Regional Association VI – Europe, 20 – 23.09.2016, Bratislava, Slovak Republic
- Hydro DWG Workshop, 13-17.06.2016, Koblenz, Germany

2. **Participation within the activities of the International Hydrological Program (IHP- UNESCO)**, which is the most important international programs in water domain:

- Assurance of the secretariat activities for the International Hydrological Program (IHP- UNESCO) and the Central and Eastern European Network of Basin Organizations
- COP 21 Conference of the Parties to the United Nations Framework Convention on Climate Change, 30.11-11.12.2015, Paris, France
- Workshop „Flood Risk Management - Measures and Links to the Water Framework Directive", 11–12.11.2015, Zagreb, Croatia
- the 13rd International Conference for WFD implementation in Europe, organised by

European Group of Basin Organisations EUROPE – INBO 2015, 20 – 24.10.2015, Salonic, Greece

- Central and Eastern European Network of Basin Organizations Representatives Working Meeting and the Anniversary Symposium „State of the art measurements of-catchment-scale hydrological processes", 08 – 12.09.2015, Wageningen, Netherlands

3. Participations to the current activities of the European Committee:

- 33rd meeting of the Groundwater Working Group (WFD CIS WG GW), 17-18.10.2017, Nottingham, UK
- 24th meeting of the GW TG, 27-30.09.2017, Hof, Germany
- 23rd meeting of the GW TG, 03-06.05.2017, Samorin, Slovakia
- 32nd meeting of the Groundwater Working Group, 24-27.04.2017, Gozo, Malta
- 20th Meeting of the Working Group on Floods - WGF Workshop on pluvial flooding, 04 – 06.10.2016, Berlin, Germany
- The 19th Meeting of the Working Group on Floods - Review of the first Cycle of Implementation of the Floods Directive, 12 – 15.04.2016
- The 18th Meetings of the Working Group on Floods, 21 – 23.10.2015, Madrid, Spain
- The 29th Meeting of the Groundwater Workgroup, 04 – 07.10.2015, Luxembourg
- The Xth Annual meeting regarding European Flood Awareness System (EFAS), organised by Joint Research Centre, 27 – 30.04.2015, Brussels, Belgium
- The 17th Meetings of the Working Group on Floods, 09 – 11.03.2015, Brussels, Belgium

4. Participation at the current activities of the International Committee for the Protection of Danube River (ICPDR):

- ICPDR Workshop on the Relationship between Hydromorphological Alterations and Response of Biological Quality Elements in Rivers - How much water what do we need? Thresholds for reaching good ecological status - Example, 22-24.11.2017, Vienna, Austria
- Danube's Stakeholders Forum,11.2015, Budapest, Hungary
- the 15th Meeting of the Workgroup for Hydromorphology and the Workshop „Methodological Aspects of the Water Framework Directive (WFD) on Hydromorphology", 21-25.09.2015, Vienna, Austria
- Working meeting of the Groundwater Technical Group, 16 – 19.09.2015, Zagreb, Croatia

Chapter 4. **PARTICIPATION ON NATIONAL AND INTERNATIONAL SCIENTIFIC PROJECTS**

1. Participation in national projects (2015-2018)

- Flood hazards in Romania – identification of flood-prone areas in Romania at national and local scale **(VULMIN)** - PN-II-PT-PCCA-2011-3
- Pro-active operation of cascade reservoirs in extreme conditions (floods and droughts) using a Comprehensive Decision Support Systems (CDSS). Case study: Jijia catchment **(e-LAC)** - PN-II-PT-PCCA-2011-3
- Changes in climate extremes and associated impact in hydrological events in Romania **(CLIMHYDEX)** - PN II-ID-2011-2-0073
- Analysis of Precipitations and Soil Moisture Conditions Triggering Lanslide Occurrence in Subcarpathian Area between Prahova and Ialomita Valley **(PSMLAND)**- PN-II-RU-PD-2012-3-0624
- The Management of Local Aquifers for Thermal Storage as a Clean Technology for nearly Zero Energy Buildings **(MATES-nZEB)** - PN-II-PT-PCCA-2013-4
- Federation of Systems **(SCADA),** Collaborative Tool for Water Resource Management, Pilot Application on the Somes Basin - PN-II-PT-PCCA

2. Participation in international projects (2015-2018)

- Danube WATER integrated management **(Danube WATER)** - Romania-Bulgaria Cross-Border Cooperation Programme 2007-2013
- InfraStructure for the European Network (**IS-ENES2) -** UE's Seventh Framework Programme for Research (FP7)
- The prevention and protection against floods in the upper Siret and Prut River Basins, through the implementation of a modern monitoring system with automatic stations – **(EAST AVERT) -** Romania – Ukraine – Republic of Moldova Cross-Border Cooperation Programme 2007-2013
- Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective **(SNOWBALL)** – SEE 2009-2014.
- FREE and open source software tools for WATer resource management – **(FREEWAT)** - grant no. 642224 – HORIZON 2020/WATER 2014-2015/WATER-4a-2014.
- Managing crOp water Saving with Enterprise Services **(MOSES)** – grant no 642258 – HORIZON 2020/WATER 2014-2015.
- Gouvernance et gestion Integree des Ressources en Eau au Maroc **(GIRE)** - Programme Réussir le Statut Avancé RSA Projet de jumelage ENPI/2011/022-778
- Streghening cooperation between river basin management planning and flood risk prevention to enhance the stats of water of the Tisza River Basin (**JOINTISZA**) – Danube Transnational Programme
- Danube Sediment Management – restoration of the sediment balance in the Danube River (**DANUBESEDIMENT)** – Danube Transnational Programme

- Reducing the flood risk through floodplain restoration along the Danube River and tributaries **(Danube Floodplain**) - Danube Transnational Programme
- Danube River Basin Enhanced Flood Forecasting Cooperation **(DAREFFORT)** - Danube Transnational Programme

Chapter 5. PARTICIPATION ON NATIONAL AND INTERNATIONAL SCIENTIFIC CONFERENCES AND PUBLICATIONS

The scientific manifestations organized in Romania – conferences, sessions, symposia, “round tables” – have included in their programs from all the branches of hydrology the following topics:

- high or low runoff on rivers, including the Danube
- alluvial runoff
- snow-melting runoff
- the influence of atonal factors (afforested or carstic areas) on the surface runoff, evapotranspiration
- hydrology
- modern methods for obtaining the main parameters of water and solid runoff

At national scientific conferences, as well as international ones, most of the papers have been elaborated by the specialists from National Institute of Hydrology and Water Management, where is the strongest nucleus of hydrology specialists. In this context, numerous manifestations were organized, on national and international level, by this institute.
There are collectives including very good specialists at other institute with same profile, too: IREE, IRDDD, RIMR, Institute of Geography Bucharest and other Institutes of university education: TUCB (Faculty of Hydrotechnics), Polytechnic University Bucharest (Faculty of Hydraulics and Hydraulic Engineers), University of Bucharest (Faculty of Geography-Hydrology section, Faculty of Geology – Hydrogeology section) and many others institutes from the country. Some of these institutions also organized scientific national and international manifestations.

National conference and other manifestation

- INHGA Scientific Conference, 20-21.11.2018, Bucharest, Romania
- The annual Scientific Meeting "Geographical Sciences and Future of Earth", 18-19.11.2017, Bucharest, Romania
- INHGA Scientific Conference, 14-15.11.2017, Bucharest, Romania
- Workshop on ”Water Storage Estimation Using Advanced Satellite, Aerial and In-situ Observations”, 30.10.2017, Bucharest, Romania
- Scientific Conference „Grigore Cobălcescu, 28.10.2017, Iaşi, Romania
- INCD ECOIND – International Symposium “The environment and the industry”, - SIMI 28-29.09.2017, Bucharest, Romania
- Workshop final Project e-LAC, 28.09.2017, Iaşi, Romania
- Conference of the Association of Hydrogeologists in Romania: Certainties and uncertainties in the research and use of underground water resources, 15-17.09.2017, Iasi, Romania
- Workshop of Young Researcher, 9.12.2016, Bucharest, Romania

- Final workshop for the project: Platform for Geoinformation in Support of Disaster Management – GEODIM, 29.11.2016, Bucharest, Romania
- Conference "Re-shaping Territories, Environment and Societies: New Challenges for Geography", 18 – 19.11.2016, Bucharest, Romania
- Scientific Conference „Grigore Cobălcescu, 29.10.2016, Iaşi, Romania
- Workshop final Project CLIMHYDEX „Changes in climate extremes and associated impact in hydrological events in Romania", 28.10.2016, Bucharest, Romania
- Conference of Agriculture and Food engineering, the 20 – 22.10.2016, Iaşi, Romania
- Workshop Natural versus anthropogenic causes of climate variability and feedback from bio-geo-chemical processes –NatClimVar, 18 – 22.10.2016, Bucharest, Romania
- INHGA Scientific Conference, 11-12.10.2016, Bucharest, Romania
- Workshop Geoinformatics within SYNASC (SNOWBALL), 26-27.09.2016, Timişoara, Romania
- International Symposium Present Environment and Sustainable Development, XIth Edition, 3-5.06.2016, Iași, Romania
- GEODOCT - within the Doctoral School of Geology, 27.05.2016, Bucharest, Romania
- National Geomorphology Symposium, 19 - 22.05.2016, Piatra Neamț, Romania
- 3rd Conference Geography, Environment and GIS, 19 – 21.05.2016, Târgovişte, Romania
- The International Conference Air and Water – Components of the Environment, 8th Edition, 25 – 27.03.2016, Cluj – Napoca, Romania
- NIHWM National Scientific Conference "Panta Rhei – Everything Flows", 23.11.2015, Bucharest, Romania
- The 11th International fair ECOMEDIU, 15-16.10.2015, Arad, Romania
- Environment and climate in the context of rural development, 12-13.02.2015, Brașov, Romania;

International conference and other manifestation

- XXVII Conference of the Danubian countries on hydrological forecasting and hydrological based of water management, 26-28.09.2017, Golden Sands, Bulgaria
- 17th International Multidisciplinary Scientific Geoconference SGEM 2017, Science and Technologies in Geology, Exploration and Mining, 29.06 – 5.07.2017, Albena, Bulgaria
- Identifying challenges in Disaster Risk Reduction: Risk Data Hub for Disaster Risk Management, 28 – 29.06.2017, Varese, Italy
- European Geosciences Union General Assembly, 23 -27.04.2017, Vienna Austria
- GIS in the European Union, 10.11.2016, Bucharest, Romania
- International Conference 5th Particles in Europe, Sequoia Scientific, 3-5.10.2016, Budapest, Hungary
- Mid-Term Meeting, 28 – 29.09.2016, UNESCO, Paris, France
- MOSES Training Meeting, 28-29.09.2016, Cesena, Italy

- „Groundwater Thematic Workshop" within project „Establishment of a Peer Review Mechanism for the Improvement of the Water Framework Directive Implementation , 08 – 09.09.2016, Kalmar, Sweden
- The 33rd International Geographical Congress, 21 – 26.08.2016, Beijing, China
- XXIX Colloque de l'Association Internationale de Climatologie, 6-9.07.2016, Besançon, France
- 15th Plinius Conference on Mediterranean Risks, 9-11.06.2016, Giardini Naxos, Italy
- 2nd PannEx Workshop on the climate system of the Pannonian basin", 1-3.06.2016, Budapest, Hungary
- EXPOAPA, 16-18.05.2016, Bucuarest, Romania
- ESA Living Planet Symposium, 9-13.05.2016, Prague, Czech Republic
- European Geosciences Union General Assembly, 17–22.04.2016, Vienna, Austria
- 13th European Youth Parliament for Water, 13 – 19.03.2016, Burier, Switzerland
- Urban Hydrology Workshop within project "Curent trends and approaches in urban hydrogeology", 03 – 05.02.2016;
- International seminar JASPERS Networking Platform - „Climate Change Related Requirements for Major Projects in the 2014 – 2020 Programming Period", 28 – 30.09.2015, Brussels, Belgium
- 3rd Annual International Forum on Water, 12 – 14.07.2015, Athena, Greece
- International Multidisciplinary Scientific GeoConferences SGEM - Albena, Bulgaria, 17 – 22.06.2015
- The VII World Water Forum,13 – 19.04.2015, Gyeonggi, South Korea
- European Geosciences Union General Assembly, 13 – 18.04.2015, Vienna, Austria
- The IV Water Conference , 23-24.03.2015,Brussells, Belgium

Relevant Publication list:

2017

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IAMAS ACTIVITIES IN ROMANIA
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PART I: ORGANIZATION

Organization for Romania, a Section of the Romanian National International Union of Geodesy and Geophysics (IUGG) Committee, was constituted at the National Meteorological Administration (the former National Institute of Meteorology and Hydrology - Bucharest) in cooperation with the Faculty of Physics, Department of Atmosphere Physics of the University of Bucharest.

The National Meteorological Administration (NMA) represents the national service in the field of meteorology and the General Manager is the Permanent Representative of Romania with the World Meteorological Organization (WMO). The Scientific Manager is the co-president of IAMAS for Romania. The main activities developed within NMA are: basic operational activity (weather forecast, observation system, telecommunication, climatological database), research activity (numerical modeling, climate variability and climate change, physics of the atmosphere, air pollution, remote sensing and GIS, agrometeorology), education and training and international cooperation. At the Faculty of Physics, the Department of Atmosphere Physics, the students and the teachers work in the fields of Dynamic Meteorology, Physics of Climate, Thermodynamic and Radiation of the Atmosphere, Electricity of the Atmosphere and they collaborate with the researchers from NMA. Many research laboratories in the field of air and water pollution monitoring are present at the National Institute of Environment Research and Engineering (ICIM - Bucharest). Studies related to upper air are being performed especially at the Astronomical Institute (that IAMAS - Romania intends to attract within the association the next year) and ROMATSA. ROMATSA includes a National Center of Aeronautic Meteorology with 17 offices and airport meteorological stations, units corresponding to the OACI standards.

IAMAS has 10 commissions:

- International Commission on Atmospheric Chemistry and Global Pollution (ICACGP)
- International Commission on Atmospheric Electricity (ICAE);
- International Commission on Climate (ICCL);
- International Commission on Clouds and Precipitation (ICCP);
- International Commission on Dynamical Meteorology (ICDM);
- International Commission on the Middle Atmosphere (ICMA);
- International Ozone Commission (IOC);
- International Commission on Planetary Atmospheres and their Evolution (ICPAE);
- International Commission on Polar Meteorology (ICPM);
- International Radiation Commission (IRC).

The general objectives of IAMAS (to promote the study of the science of the atmosphere, to initiate, facilitate and coordinate international cooperation, to stimulate discussion, presentation and publication of scientific results, to promote education and public awareness) are also the objectives of the organization in Romania, although the activities related to these sections are different, some sections, such as: dynamic meteorology, climatology or air pollution enjoying more interest as against upper air or polar meteorology. In this view, we should mention the significant participation of the Romanian researchers in the international programs, especially the European ones, such as ALADIN, ETEX, and CLIVAR.

The Romanian Meteorological Society also supports the IAMAS activities for Romania.

Romanian IAMAS Activities:

- **Dynamic Meteorology**
- **Climate**
- **Atmospheric Physics**
- **Agrometeorology**
- **Remote sensing and GIS**
- **Nowcasting**

Professional Organizations:

- **Romanian Meteorological Society**

Institutions:

- **National Meteorological Administration (NMA)**
- **University of Bucharest: Faculty of Physics**
- **Romanian Civil Authority for Aeronautics (ROMATSA)**

National Conferences:

- **Annual Scientific Session of the National Meteorological Administration**
- **Annual Scientific Session of the Faculty of Physics, University of Bucharest**
- **Annual Conference of Physics**

Publications:

- **Romanian Journal of Meteorology**
- **Romanian Reports in Physics**
- **Romanian Journal of Physics**

PART II: PROFESSIONAL ACTIVITY

DYNAMIC METEOROLOGY

1. Research orientation

The research activity in meteorology developed the main activity domains: numerical atmospheric modeling and modeling of the pollutant transport, climatic modeling and studies (climate variability, climate change and climatic forecasting), studies on the physics of the atmosphere and of the ozone layer, studies based on satellite techniques, remote sensing and GIS, as well as studies of the climatic conditions impact on crops.
A new research direction is explored in NMA: regional climate prediction. This research aims to perform improved extended range predictions at regional at sub-regional scale over Romania on the range of monthly-seasonal prediction. A second objective is to produce high resolution climate scenarios for the next decades over Romania, based on available global scenarios from CMIP5 and recently CMIP6 data.
The results of the research activity were presented at internal and international scientific meetings and were published in specialized Romanian and international journals.

1.1. The COSMO numerical weather prediction model

The non-hydrostatic numerical weather prediction model COSMO (Consortium for Small-scale Modelling) is run operationally at the National Meteorological Administration since 2005. The current operational version of the model in NMA is 5.03. The COSMO model is integrated at two horizontal resolutions (7 km and 2.8 km respectively), four times a day, at 00, 06, 12 and 18 UTC.
The integration domains cover the entire Romanian territory with 201x177 grid points for COSMO-7km and 361x291 grid points for COSMO-2.8- km, as in the figure 1.

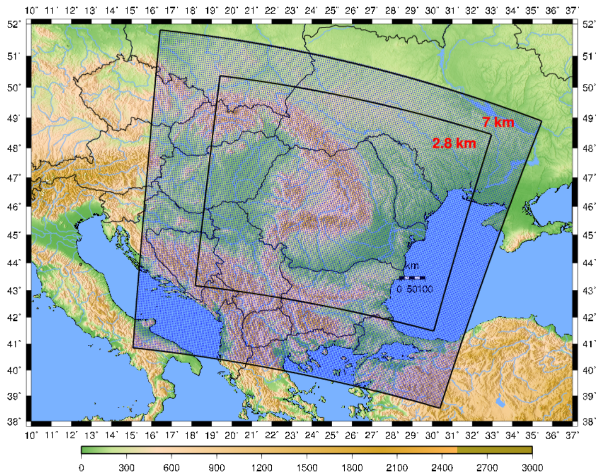

Figure 1: Operational integration domains for COSMO-7km and COSMO-2.8km

COSMO-7km is run with 40 vertical levels, using initial and lateral boundary conditions from the ICON (**Icosahedral Nonhydrostatic**) global model, supplied by DWD (Deutscher

Wetterdienst). The forecast period for the 7 km resolution of the model is 78 hours for the 00 UTC run, 90 hours for 12 UTC and 48 hours for the 06 and 18 UTC runs.

COSMO-2.8km is run with 50 vertical levels, using initial and lateral boundary conditions interpolated from the output of the COSMO-7km model. The forecast period for the 2.8 km resolution of the model is 30 hours for the 00 UTC and 12 UTC runs, and 18 hours for the 06 and 18 UTC runs.

Starting from 2009, the COSMO-7km model is run operationally using SYNOP data assimilation. For the 2.8 km resolution, SYNOP data assimilation began to be operational in 2013. Pre-operational activities are being conducted for data assimilation of TEMP and PILOT observations (for COSMO-7km and COSMO-2.8km) and radar observations (for COSMO-2.8km). Observation data from the bufr format (SYNOP and TEMP, PILOT) are processed in the netcdf format to be used during the data assimilation procedures, while radar information are available in grib1 format.

The data assimilation procedure uses a nudging scheme for SYNOP and TEMP, PILOT and latent heat nudging for the assimilation of radar data.

The output of the COSMO model at the 7 km and 2.8 km horizontal resolution is presented both in graphical form and as numerical results and is used by forecasters. Direct model output parameters include: air temperature, ground temperature and sea-level pressure, wind speed and direction and relative humidity, precipitation, streamlines and so on (Figure 2).

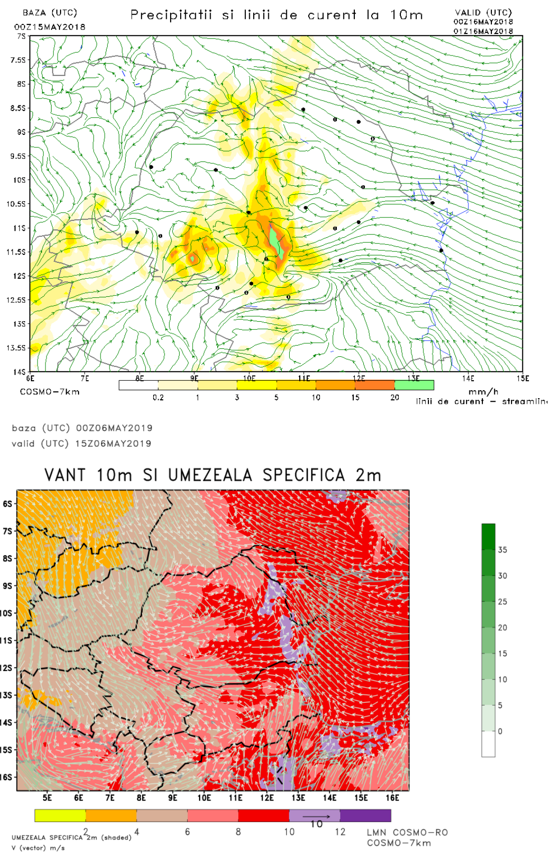

Figure 2: COSMO-7km numerical forecast: precipitation and 10 meter streamlines (top); 10 meter wind speed and wind direction and 2 meter specific humidity (bottom)

Post-processed parameters include fog stability index and snowdrift index (Figure 3).

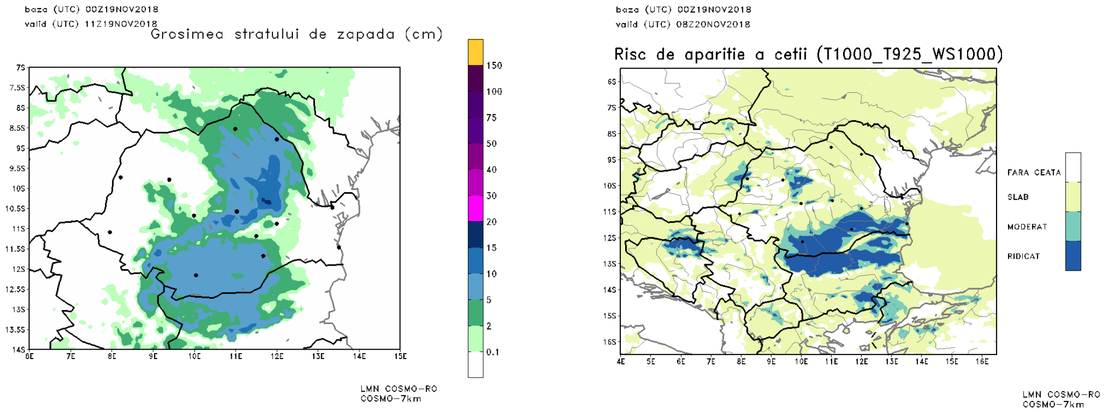

Figure 3: COSMO-7km numerical forecast: snow depth (left); fog stability index (right)

Starting with 2015, the **ICON** global model replaced the previous GME (Global Model) numerical weaher forecast model and is currently run by DWD at 13 km horizongtal resolution. Although ICON was initially developed as a global model, it is currently being adapted for limited area mode (ICON-LAM).

The ICON model has been implemented in NMA and is currently being tested for pre-operational use at two horizontal resolutions: 7 km and 2.8 km. The set-up of ICON-LAM for Romanian territory includes several configurations:

- ICON-LAM-7km: initial and LBC data from ICON global (same data used for operational COSMO-7km);
- ICON-LAM-2.8km: initial and LBC data from ICON global (same data used for operational COSMO-7km);
- ICON-LAM-2.8km: initial and LBC data from ICON-LAM-7km.

The output of the ICON-LAM model for Romanian territory at both resolutions is in netcdf format for model, pressure and height levels on a regular lat/lon grid (netcdf). Examples of forecast products from ICON-LAM-7km are presented in figure 4. For the 7 km resolution, output on native grid (grib2) is also produced, to be used as LBC for ICON-LAM-2.8km.

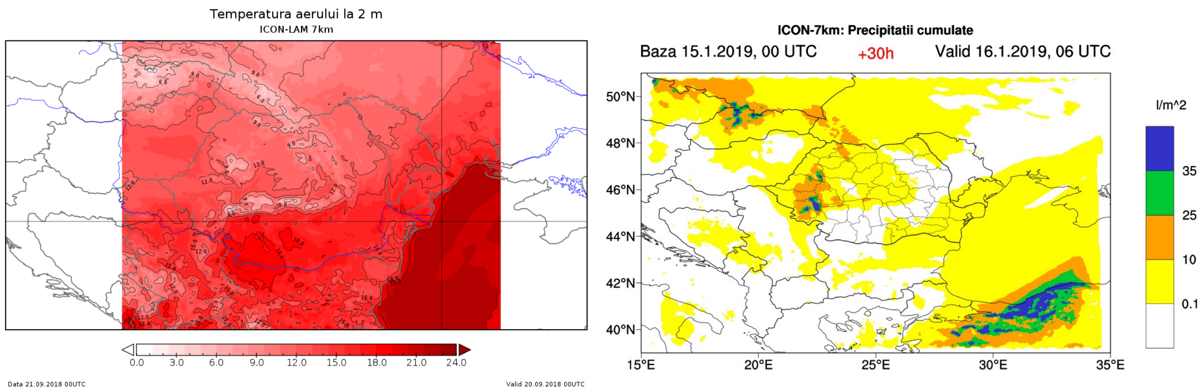

Figure 4: ICON-LAM-7km numerical forecast: air temperature (left); 24 hour cumulated precipitation (right).

1.2. The ALARO numerical weather prediction model

The current operational setup of the ALARO model (Figure 5), which has been operational since April 2016, has the following characteristics:

- ALARO-0 baseline cy40t1 version;
- semi-implicit semi-Lagrangian 2TL, Δt=240s;
- Δx=6.5 km, 240 x 240 points, 60 vertical levels, linear grid, Lambert projection;
- LBC from ARPEGE (3h frequency), DFI Initialization;
- 4 runs /day 00, 06, 12, 18 UTC - no DA;
- forecast range: 78/54/66/54 hours;

Specific improvements in physical parameterizations for ALARO-0 baseline consist in: dependency of critical relative humidity on the model resolution for Xu - Randall adjustment; microphysics (sedimentation of cloud water and ice); moist deep convection (modulation of the entrainment rate by the vertical integral of relative humidity, adaptive detrainment, mixed type of closure).

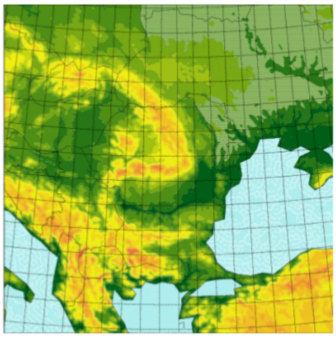

Figure 5: Integration domain and orography of the model: ALARO-Romania

The numerical products are visualized by using a graphical package developed within NMA and RC-LACE which is based on grib_api, perl and NCL-NCAR. The scheme of this package is presented in the figure 6.

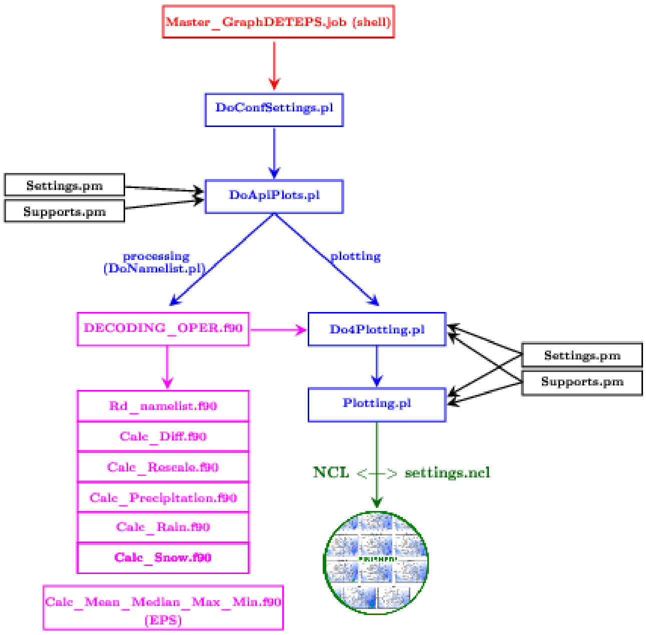

Figure 6: The graphical package scheme

Examples of the displayed meteorological parameters with the new developed graphical package are presented in figure 7.

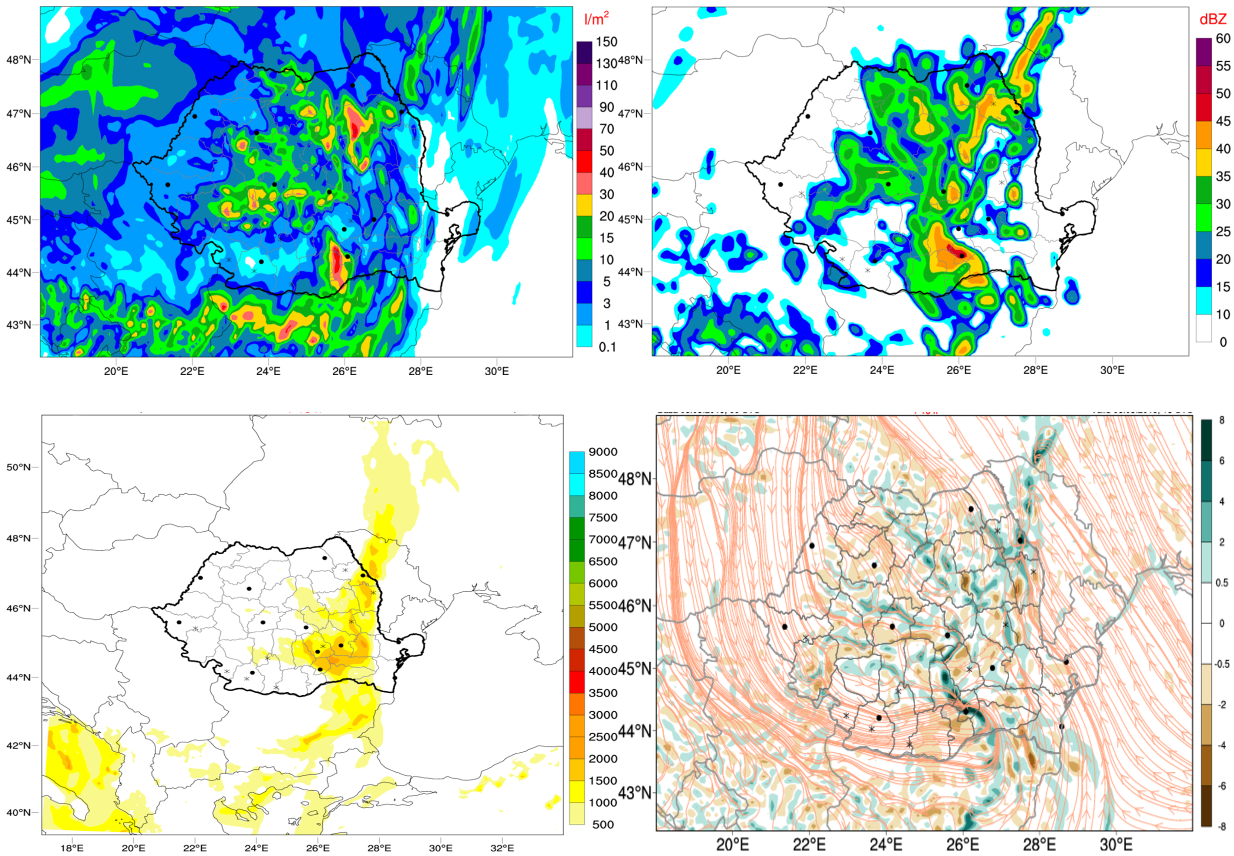

Figure 7: Examples of graphs: 12-hour cumulated precipitation (top, left), simulated radar reflectivity (top, right), CAPE (bottom, left) and MOCON plus streamlines (bottom, right).

The research-development activity unfolded by the group mainly took place within ALADIN and RC-LACE projects. The Romanian team contributed to:

- Several experiments carried out to analyze the impact of satellite data assimilation on the ALARO model precipitation forecast;
- Wind shear profile using SODAR data and ALARO model;
- Application of ENO technique to semi-Lagrangian interpolations;
- The trajectory search in the semi-Lagrangian advection scheme;
- Revision of the LAEF multiphysics scheme;
- Validation of the new ALARO-1 version;
- Development of a new graphical package.

1.3. Statistical adaptation and weather forecasts verification

1.3.1. Operational weather forecasts verification activities include procedures for ingestion and validation of diagnostic and forecast data using the VERA and VERCENTRE applications (12, 24, 48 and 72 hours forecast verification for the entire country and Bucharest, and for each Reginal Meteorological Centre, respectively). The two operational procedures used for objective verification of forecasts from meteorologists (at country level and regional) were initially developed in 2000. In order to reduce errors caused by the data ingestion/coding an automatic application was developed to process and transform the data in the format required by the verification procedures.

1.3.2. Operational verification of model forecasts is performed using the VERMOD application, with both daily and monthly scores computed for different anticipations.

1.3.3. New verification methods were introduced for operational activity:

- The SAL (Structure-Amplitude-Location) method for qualitative verification of precipitation forecasts is a relatively new verification method used for precipitation. This method provides valuable information on the quality of forecasts and consists of three distinct components that take into account the structure, amplitude and location of objects (areas with precipitation) in a domain of interest;
- The GRID-STAT and MODE (Method for Object-based Diagnostic Evaluation) methods were implemented using the Metv5.0 package developed by NCAR (National Center for Atmospheric Research);
- For GRID-STAT, observation data for 24 hour cumulated precipitation (0.01°x 0.01° resolution) from all available data on Romanian territory (synop and hydrological observations and radar data) were employed. The GRID-STAT method is a classical statistical verification for which both forecast and observation data are gridded. Compared to classical scores, Grid-Stat includes the (neighborhood) method that helps analyze forecast skill on selected thresholds, depending on the spatial scale. The Fraction skill score (FSS) score was represented as a quilt graphic (Figure 8);

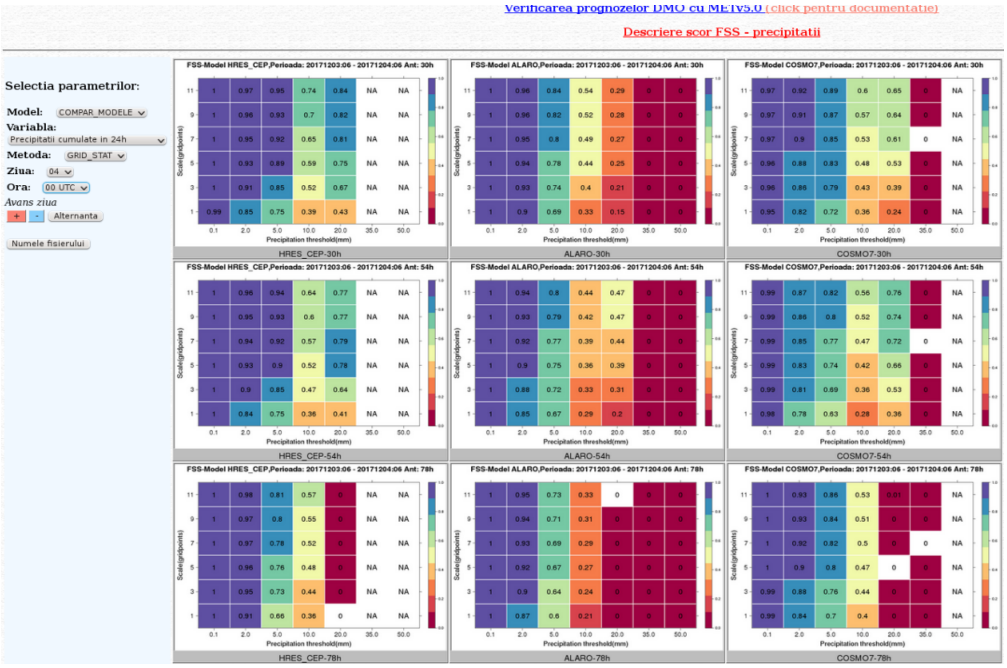

Figure 8: GRID_STAT: FSS for ECMWF, ALARO and COSMO precipitation forecasts, +24, +48 and +72 hours anticipation, for 4.12.2017.

- For the Method for Object-based Diagnostic Evaluation (MODE) the objects (precipitation areas) are defined using a convolution filter and thresholding (Figure 9). This method is used for the analysis of model forecasts for each threshold and each object (precipitation area).

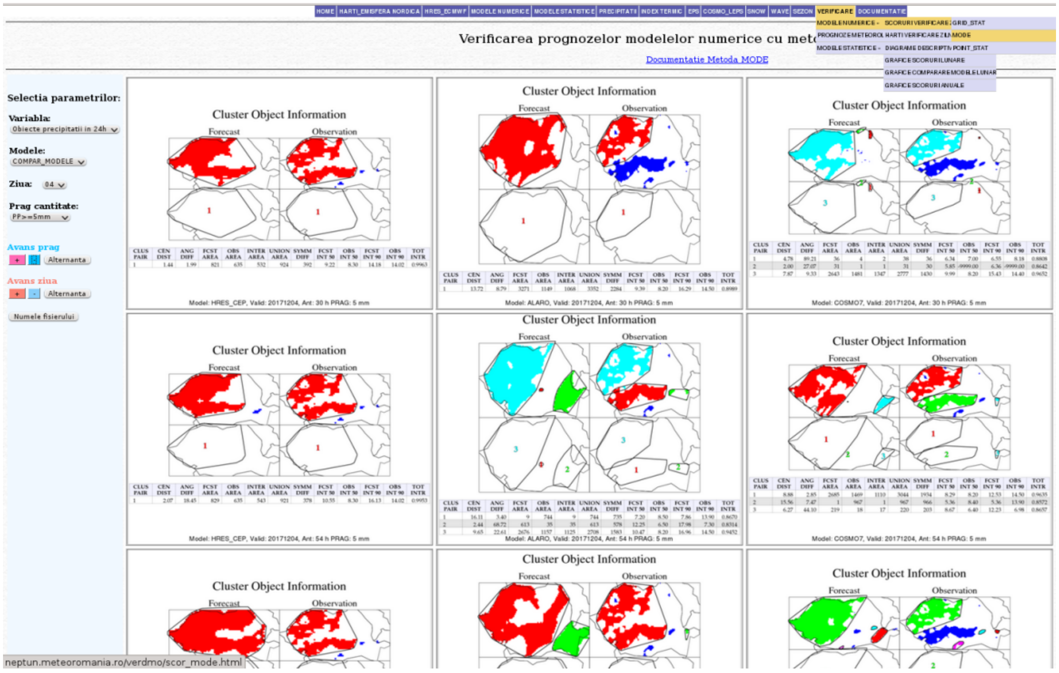

Figure 9: MODE applied for ECMWF, ALARO and COSMO forecasts for cumulated precipitation greater than 5mm, +24, +48 and +72 hours anticipation, for 4.12.2017

1.3.4. Operational statistical adaptation activities (MOS) include:

- MOS_ECMWF (2 times a day, for 00 and 12 UTC, with predictors generated from the ECMWF model);
- MOS_ARPEGE (4 times a day, for 00, 06, 12 and 18 UTC, with predictors generated from the ARPEGE global model);
- MOS_ALARO (2 times a day, for 00 and 12 UTC, with predictors generated from the ALARO limited area model);
- MOS_EPS_15 (is run on ecgate at ECMWF, 2 times a day, for 00 and 12 UTC, using a procedure developed in NMA);
- MOS_EPS_30 (is run on ecgate at ECMWF, 2 times a day, for 00 and 12 UTC, using a procedure developed in NMA).

1.3.5. Graphical representation of new products from the high resolution deterministic model HRES-ECMWF:

- precipitation type (starting from 2016), which is very useful in combination with the precipitation rate. This parameter is available twice a day at 00 UTC and 12 UTC.
- Dynamical tropopause (starting from 2018). This parameter is available twice a day at 00 UTC and 12 UTC.
- UV index (from Copernicus data, available from MARS).

The web viewing interface and products examples are shown below (Figures 10, 11 and 12).

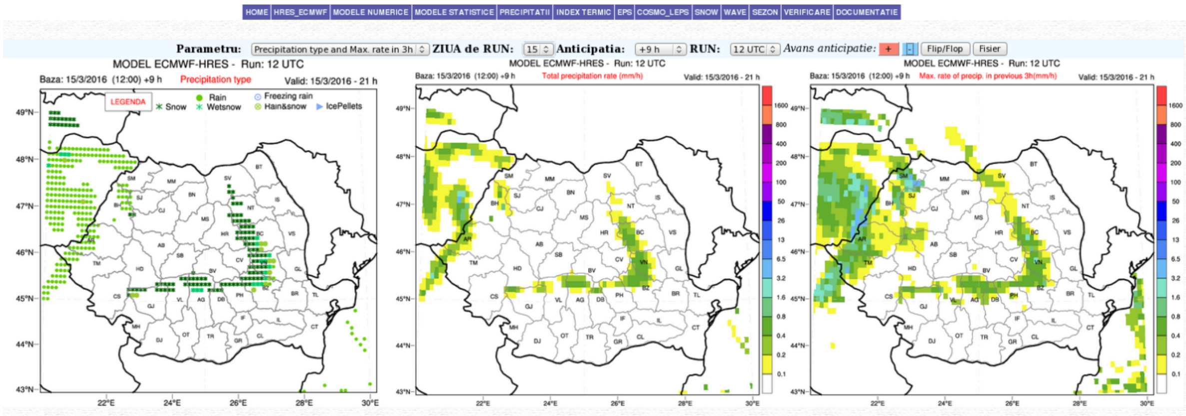

Figure 10: HRES-ECMWF graphical representation example: precipitation type (left), precipitation rate (middle) and maximum precipitation rate (right)

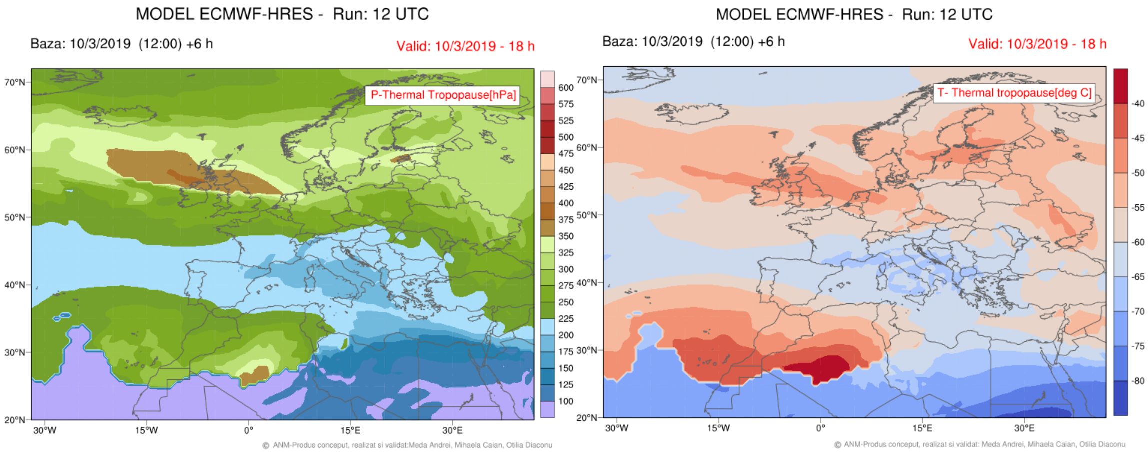

Figure 11: HRES_ECMWF graphical representation example: P-thermal tropopause (left) and T--thermal tropopause (right)

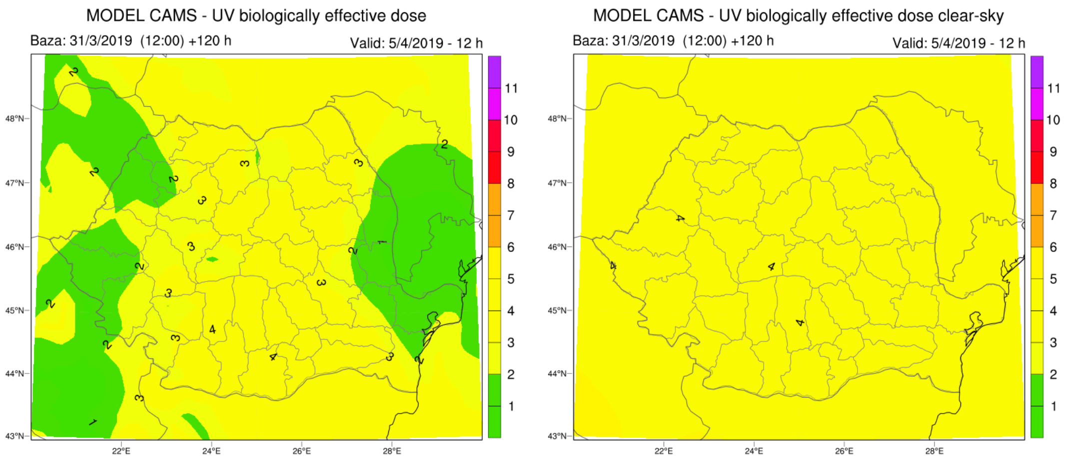

Figure 12: HRES_ECMWF graphical representation example: UV biologically effective dose (left) and UV biologically effective dose clear-sky (right)

1.4. Extended range prediction (month-season)

1.4.1. *Seasonal prediction: data processing, ensembles and statistical downscaling*

An operational platform of seasonal prediction products processed at NAM over Romania was implemented. Based on global multi-model predictions analysis (ECMWF, JMA, NCEP) we perform prediction of main dynamical (pressure, circulation), surface (temperature, precipitation) fields (Figure 13) with associated probabilities. The monthly forecast is updated weekly and the seasonal prediction is updated monthly. A validation of past re-forecasts from ECMWF center over last 40 years (1980-present) is ongoing with the aim to: i) use this information for calibrating the prediction ensemble over Romania and ii) to remove systematic model errors and perform statistical downscaling of these prediction to local scale, as required by users and impact assessment. The preliminary results carried out in 2019 for the ECMWF ensemble averages are presented Table 1 and Figure 14.

During the reported period, NAM has been involved in the H2020 MOSES project, where the ECMWF seasonal prediction have been statistically downscaled on high resolution scale (1kmx1km) over a pilot area in southeastern Romania for monthly mean of maximum (Tx) and minimum (Tn) temperature and precipitation (PP). The statistical model is based on CCA (canonical correlation analysis) and the results have been compared to those obtained direct from the ECMWF seasonal prediction and a bias correction method (Q-Q mapping) carried out by ARPA (Italy). The results show that the CCA method presents a higher skill comparing with the ECMWF system (Table 2 and Figure 15).

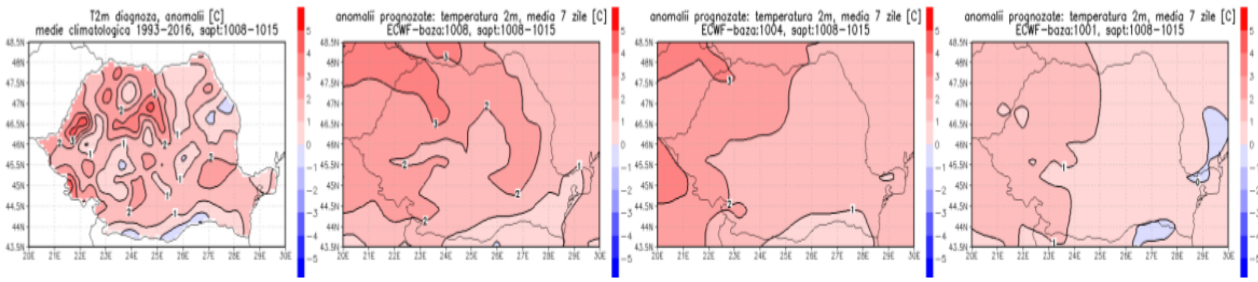

Figure 13: Predicted against Observed (first plot) weekly mean anomalies of the 2m temperature. Anomalies are relative to 1993-2016 climatology and predictions are shown for the first (of four) forecast week with anticipations of 9, 5, 1 days from right to left, from ECMWF ensemble forecast

Table 1: Performance of the ECMWF system (S5) in seasonal prediction of temperature over Romania (1981-2017) with 1-3 months ahead) and prediction started in March-May May. The performance is expressed by BIAS, RMSE (absolute/anomalies), temporal correlation between observed and predicted values and spatial correlation between long term monthly averages (observed and predicted)

Start month	**BIAS**			**RMSE**			**Temporal correlation**			**Spatial correlation**		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
March	-6.3	-6.3	-4.5	6.7/2.3	6.5/1.6	4.7/1.3	0.21	-0.05	0.28	0.76	0.87	0.88
April	-5.6	-4.3	-2.1	6.0/1.9	4.5/1.3	2.7/1.3	-0.21	0.33	0.40	0.88	0.88	0.90
May	-4.0	-2.0	1.0	4.3/1.3	2.6/1.3	1.9/1.3	0.22	0.40	0.49	0.87	0.90	0.90

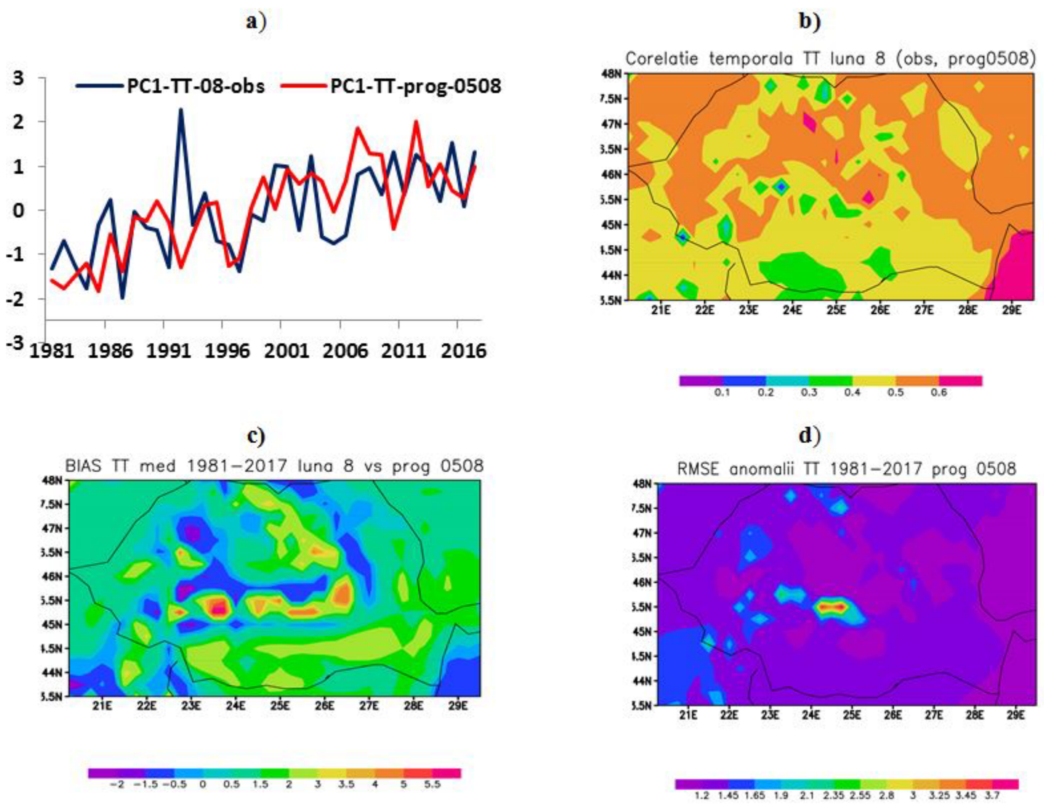

Figure 14: Performance of the ECMW system (1981-2017) in seasonal forecast of temperature in August over Romania (interpolated on 0.23x025 resolution) with prediction started in May: a) PC1-observed and predicted (temporal correlation of 0.52, fraction of the predicted anomalies with the same sign with observations: 0.71); b) spatial distribution of the temporal correlation between observed and predicted values, all significant 5% level; c) BIAS; d) RMSE of the anomalies

Table 2: Skill of the seasonal (JJA) prediction of three climate indices (Tx, Tn, PP) for the period 2011-2018, forecasted through the CCA-SDM developed by ANM using as predictors the ensemble average over 25 members of the ECMWF model as well as four individual members (M0, M10, M16, M23), Default Basic Module (DBM) represented by the ensemble forecast median (developed by ARPAE), and the new ECMWF system (ensemble mean over 25 members) for the Movila farm (grid-point 5670) and SCDA Braila farm (grid point 0316). The skill includes mean bias (BIAS), root mean square error (RMSE) and the frequency (%) of the anomaly sign correct forecast (ANS).

Skill	DBM			ECMWF			CCA-M10			CCA-M23			CCA-M0			CCA-M16			CCA-ens. average		
	Tx	Tn	PP	Tx	Tn	PP	Tx	Tn	PP	Tx	Tn	PP	Tx	Tn	PP	Tx	Tn	PP	Tx	Tn	PP
Movila																					
BIAS	-0.9	-0.5	10.0	-1.0	0.0	48.0	-0.3	-0.1	-7.0	-0.8	-0.1	34.0	-0.1	0.0	-5.0	-0.5	0.0	8.0	-0.3	0.0	9.0
RMSE	1.1	0.6	53.0	1.0	1.0	96.0	0.9	0.8	45.0	1.2	0.6	50.0	0.8	0.5	43.0	1.1	0.6	39.0	0.9	0.5	55.0
ANS	50.0	50.0	13.0	50.0	88.0	25.0	100.0	100.0	38.0	88.0	88.0	50.0	100.0	100.0	25.0	100.0	100.0	38.0	100.0	100.0	63.0
SCDA- Braila																					
BIAS	-0.9	-0.4	-7.0	-1.0	0.0	32.0	-0.5	-0.1	-19.0	-0.9	-0.1	26.0	-0.3	0.1	-18.0	-0.6	0.0	-5.0	-0.4	0.1	-4.0
RMSE	1.2	0.7	50.0	1.0	1.0	92.0	0.9	0.9	50.0	1.3	0.9	39.0	0.8	0.7	48.0	1.2	0.7	35.0	0.9	0.7	54.0
ANS	50.0	88.0	63.0	50.0	88.0	38.0	100.0	88.0	75.0	88.0	75.0	63.0	100.0	88.0	63.0	100.0	88.0	63.0	100.0	88.0	50.0

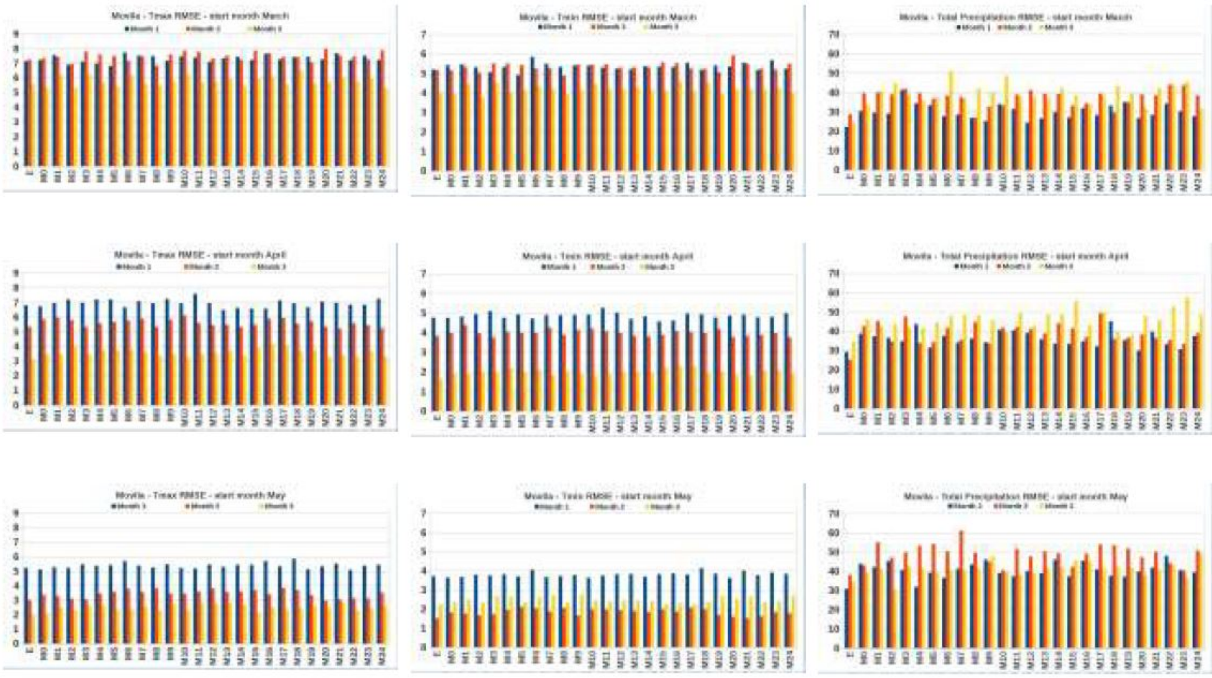

Figure 15: Score (represented by RMSE) of the ECMWF seasonal forecast (System 5) for each of the 25 members over a pilot area in SE Romania (spatial average), in prediction of monthly Tmax (left column), Tmin (middle column) and Precip (last column) for AMJ started in March (top row), MJJ started in April (middle row, and JJA started in May (bottom row), with various time ahead (1-3 months)(1981-2016).

1.4.2. *Extended predictions: downscaling at high-resolution*

The global predictions are dynamically downscaled (in a similar way as done in NWP prediction by Cosmo and Aladin models) in order to obtain fine-scale predictions. For this we implemented a prediction coupled-chain: RegCM regional climate model / ECMWF global model. Seasonal predictions are performed each month and validated against observations in order to assess the added value from increased resolution. Research activity related to this downscaling concerns: i) model optimization for high resolutions; ii) insertion of local data in the initial conditions, iii) identification and representation of main sources of regional extended prediction in the model; iv) ensemble prediction system. Model optimization was acquired through implementing a genetic algorithm (evolutionary type sub-class) that allowed identifying, from a multiple degree of freedom linked to various physical parameterizations, the configuration that minimized the biases at monthly time-scale. Research assessing added value from prediction' initialization and from inclusion of regional sources of predictability already indicate strong impact of high-resolution anomaly information from the sst over the North-Atlantic, Mediterranean and Black Sea, as well as from surface (land-cover, soil moisture, snow cover). Further research on these, focuses on: remote link with larger-scale modes of variability that control the regional slow-variability, such as stratosphere, oceans, sea-ice. The aim is to identify and derive regional indexes, as predictive support in addition to the dynamical downscaling.

1.4.3. *Research on regional climate*

♦ ***Extreme climate***

We perform case-study analysis in order to understand mechanisms of regional and sub-regional extremes, natural variability and their future change under a forced climate over our region. The main focus was on extreme flooding events: sensitivity monthly experiments shown added value from increased resolution (3km), non-hydrostatic effects and optimal numerical set-up (e.g. humidity advection) in the prediction of the timing, location and intensity of precipitating event and mechanism leading to extreme floods (Figure 16). Another focus was on predicting conditions for extreme late-spring events occurrence: pre-conditioning indexes were identified through model sensitivity simulations and validated for such extremes over last 30 years.

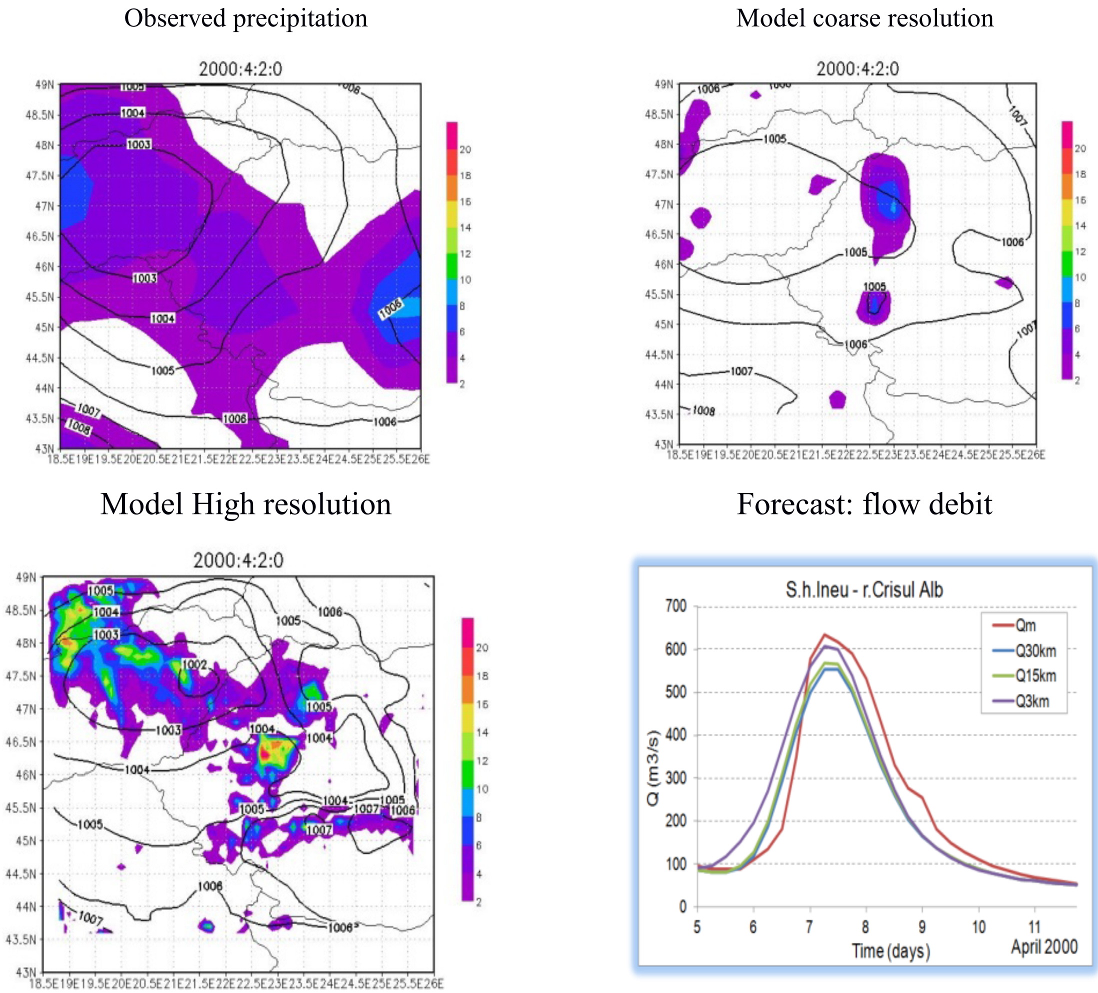

Figure 16: Prediction for an extreme flooding event: precipitation (observed and predicted at 30 and at 3 km resolution, from left to right); 4-th panel (right): resulting flow debit prediction versus observed at hydrometric station Ineu on the Crisul-Alb river computed with a hydrological model CONSUL based on predictions by three regional climate model RegCMv4.5 simulations at resolutions of: 30, 15 and 3 km for the 1-12 April 2000 extreme flooding event.

♦ ***User-support applications***

We compute regional and sub-regional derived measures from extended monthly-season predictions to support the prediction and delivery of climate warnings in departments for: agro-meteorology, hydrology, climatology. Examples are the prediction of drought SPEI-index 6 months in advance (Figure 17), number of hot-days over next 3 months, prediction of hydrological-budget warning index (based on precipitation and soil water content), late-spring frost index. Recent research is directed towards land-slide conditioning predictive indexes.

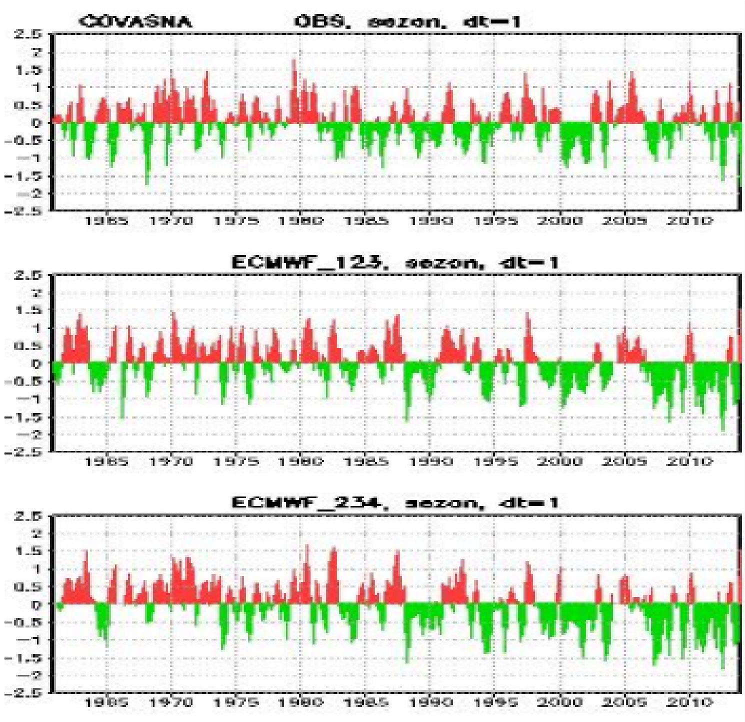

Figure 17: Forecasted SPEI index (middle and bottom panels), against observed SPEI index (top, ERAInterim); forecast is based on ECMWF ensemble prediction model; index is downscaled over Eastern Romania, with leading time of 1-3 (middle) and 2-4 (bottom) months. Negative/positive values of the index are for drought/wet classes.

1.4.4. *Regional climate scenarios: GHG and land-use anthropic forcing*

A new applied research for Romania is ongoing: downscaling at very high resolution (5km) of the actual and the future climate scenarios. Such data-basis will bring:

i) an actual climatological data-basis of meteorological fields over Romania that are not available from measurements (observations have a coarser resolution) or not measurable directly (runoff, deep-soil parameters, canopy layer, boundary layer, cloudiness/radiation, wind). This data-basis could be further exploited, after validation, for many climatological studies;

ii) climate change information on sub-regional scale, such as extremes (intensity, frequency, persistence), useful for societal planning;

iii) support mitigation and adaptation measures through performing user-defined sensitivity experiments of regional climate response to anthropic changes e.g. land-use, target warming-thresholds scenarios (Figure 18 illustrates estimated warmest temperature change at 5km resolution under a new land-cover, provided by VOLANTE project).

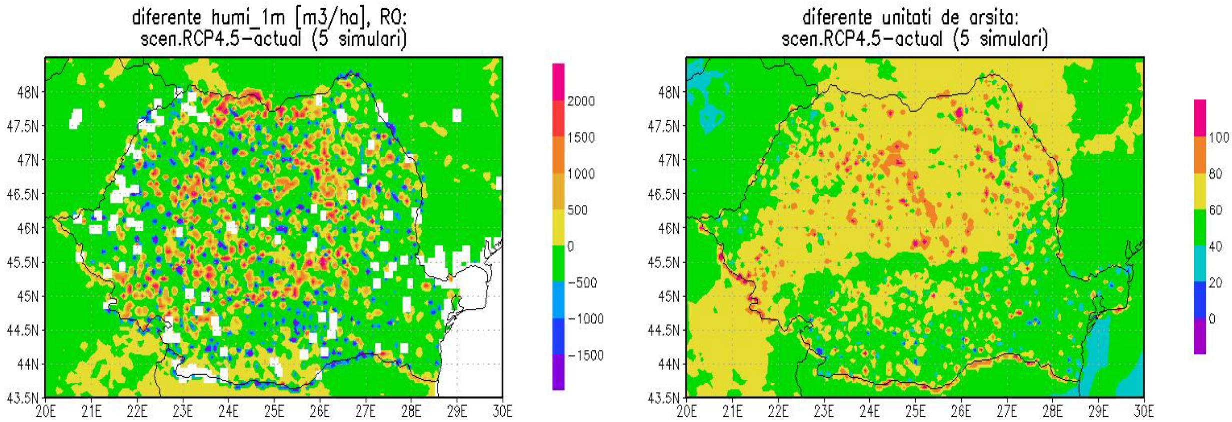

Figure 18: Estimated change in parameters soil water budget (left) and scorching-heat (number of days with daily maxima of 2m temperature higher than 30C): differences between scenario (RCP4.5 + VOLANTE land-use change) and the actual climate during extreme warmest summers, from an ensemble of 4 members of dynamical downscaling scenarios at 5 km resolution.

2. Participation of the Romanian specialists in international projects or programs

- The international ALADIN project (Aire Limitée Adaptation dynamique Développement InterNational; http://www.cnrm.meteo.fr/aladin/);
- The international RC-LACE project (Regional Cooperation for Limited Area modelling in Central Europe; http://www.rclace.eu/);
- COSMO Priority Projects:
  - SPRT: Support Activities, 2012 – present;
  - C2I: COSMO transition to ICON-LAM, 2018 - 2022;
  - CARMA: Common Area with Rfdbk/MEC Application, 2018 – 2020;
  - CDIC: Comparison of the dynamical cores of ICON and COSMO, 2015 – 2018;
- ECMWF special project: Testbed for the Evaluation of COSMO Model Versions, 2018 – 2020;
- CAMARO-D Danube - Cooperating towards Advanced MAnagement ROutines for land use impacts on the water regime in the Danube river basin (Interreg Danube Transnational Programme), 2017-2019;
- SAMIRA - SAtellite based Monitoring Initiative for Regional Air quality(ESA), 2016-2019;
- IRIDA - Innovative Remote And Ground Sensors, Data and Tools Into a Decision Support System For Agriculture water Management (ERA-NET Cofund Water Works 2014), 2016-2019;
- ECMWF special project COSMO NWP Meteorological Test Suite, 2016 – 2018;
- PRIMAVERA - PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment (Horizon 2020), 2015-2020;
- MOSES - Managing crOp water Saving with Enterprise Services (Horizon 2020), 2015-2018.

3. Organization of national and international scientific conferences

- **Joint LACE Data Assimilation Working Days and ALADIN Data Assimilation basic kit Working Days, Bucharest, Romania, 19-21.09.2018;**
- Statistical cumulus dynamics workshop, Bucharest, Romania, 15.06.2015.

4. Participation of the Romanian specialists in the international symposiums and conferences

Annual EWGLAM / SRNWP Meetings (2015, 2016, 2017, 2018);
Annual ALADIN Workshops and HIRLAM All Staff Meeting (2015, 2016, 2017, 2018);
C2I Workshop 2018, Langen, Germany, 15 – 19.10.2018;
Data Assimilation Working Days, Bucharest, Romania, 19-21.09.2018;
The 20th COSMO General Meeting, Sankt Petersburg, Russia, 3 – 7.09.2018;
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology, Budapest, hungary, 3–7.09.2018;
The 12th ELSEDIMA International Conference - Environmental Legislation, Safety Engineering and Disaster Management, Cluj-Napoca, Romania; 17 – 19.05.2018;
4th ICON Training Course of DWD and KIT, Langen, Germany, 16 – 19.04.2018;
COSMO / CLM / ART Training Course, Langen, Germany, 12 – 16.03.2018;
ICCARUS 2018, Offenbach, Germany, 26 – 28.02.2018;
Data Assimilation Working Days, Ljubljana, Slovenia, 18 – 20.09.2017;
The 19th COSMO General Meeting, Jerulasem, Israel, 10 – 14.09.2017;
COSMO / CLM / ART Training Course, Langen, Germany, 2 – 5.04.2017;
South-East European Multi-hazard Early Warning Advisory System (SEE-MHEWS-A), Budapest, Hungary, 8 – 9.03.2017;
COSMO / CLM / ICON / ART User Seminar, Offenbach, Germany, 6 – 8.03.2017;
3rd ICON Training Course of DWD and KIT, Langen, Germany, 28.02 – 3.03.2017;
Introduction to ECMWF Computing Facilities, Services and the Meteorological Archival and Retrieval System (MARS), Reading, UK, 20 – 24.02.2017;
ALARO-1 Working Days, Brussels, Belgium, 12 – 14.09.2016;
The 18th COSMO General Meeting, Offenbach, Germany, 5 – 9.09.2016;
POMPA Basic training on Implementing COSMO Model on GPU Processors, Zurich, Swizerland, 3 – 8.07.2016;
Technical Advisory Committee Representatives (TAC) Subgroup On Verification Measures 2016, Reading, UK, 31.05 – 1.06.2016;
COSMO / CLM / ART User Seminar, Offenbach, Germany, 7 – 11.03.2016;
Technical Advisory Committee Representatives (TAC) Subgroup On Verification Measures 2016, Reading, UK, 2 – 3.03.2016;
COSMO / CLM / ART Training Course 2016, Langen, Germany, 15 – 23.02.2016;
2nd ICON Training Course of DWD and KIT, Langen, Germany, 12 – 15.10.2015;
Data Assimilation Working Days, Bratislava, Slovakia, 30.09 – 02.10.2015;
The 17th COSMO General Meeting, Wrocław, Poland, 7 – 10.09.2015;
European Geosciences Union General Assembly, Vienna, Austria, 12 – 17.04.2015;

Consultancy Meeting on Data Integration for the Improvement of Radiological Consequences Assesments Capabilities, 7 – 9.04.2015;

COSMO / CLM / ART Training Course 2015, Langen, Germany, 23 – 31.03.2015;

COSMO / CLM / ART User Seminar, Offenbach, Germany, 2 – 6.03.2015.

5. Publications

5.1. Peer-reviewed ISI publications

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Caian, M., Koenigk, T., Doscher, R., Devasthale, A., 2017: An interannual link between Arctic sea-ice cover and the North Atlantic Oscillation, *Clim. Dyn.*, **50 (1-2)**, 423-441, doi: 10.1007/s00382-017-3618-9;

Iriza, A., Dumitrache, R.C., Stefan, S., 2017: Numerical modelling of the Bucharest urban heat island with the WRF-Urban system. Romanian Journal of Physics, *Rom. J. Phys.*, **62 (7-8)**, 810;

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5.2. Other journals articles and Proceedings papers

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Montani, A., Iriza-Burca, A., Dumitrache, R. C., Gofa, F. (contributors), 2015: Numerical Weather Prediction Meteorological Test Suite: COSMO 5.1 vs. 5.0, COSMO-Model Report, June;

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CLIMATE

1. Research orientation

Research in the field of climatology integrates climate monitoring and the use of in-situ observations, satellite products, reanalysis data and the results of regional climate models, in order to develop useful applications in various socio-economic fields, in the form of climatic products and services, adapted to user demands. The results of the research are turned into good account both in the form of publications and contributions in dedicated scientific events and through specific products (e.g., new sets of climatic indicators with an increased spatial and temporal resolution, under the conditions of present climate and in projections for future, covering areas of interest to the beneficiaries – river basins, Black Sea basin, agricultural areas; diagnostic and forecast climatic assessments at different time scales starting from the annual one to decade and century intervals, climate hazard risk maps).

2. Participation of the Romanian specialists in national and international projects/ programs

- **Changes in climate extremes and associated impact in hydrological events in Romania (CLIMHYDEX) –** funded by the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFSCDI)

The research activities have been carried out within four main issues summarized as following:

- ***Mechanisms controlling the variability of climatic extremes in Romania.***

o Analysis of a wide range of indices (21) describing the climate extremes (temperature and precipitation extremes in terms of duration and intensity, thermal stress indices, drought indices, frequency of rain showers, high temporal resolution rainfall intensity-novel index) through a comprehensive approach using advanced and complex statistical techniques with respect to their linear trend and shifts in the mean as well as identification of physical mechanisms controlling their variability using the CCA (canonical correlation analysis) method applied to combination of various large-scale predictors (novel approach;

o Relationship between precipitation extremes in Romania and air temperature; verification the validity of the Clausius-Clapeyron (CC) (Figure 19).

- ***Mechanisms generating short duration heavy rainfall using radar information*** to investigate the dynamic and thermodynamic, both synoptic and mesoscale, configurations associated with severe weather in eastern Romania.

- ***Development of statistical downscaling models.*** For seasonal climate extreme indices at station scale over Romania based on the CCA method; on high spatial (1km x 1km) and temporal (daily) resolution over two hydrological basins using a conditional stochastic model and artificial neural network (ANN).

- ***Climate change scenarios at various spatial and temporal scales*** have been carried using the statistical downscaling models applied to various GCMs (ENSEMBLES and CMIP5) and compared with some RCMs; a complex validation of some RCMs (EUROCORDEX) with respect to some extreme indices has been carried out.

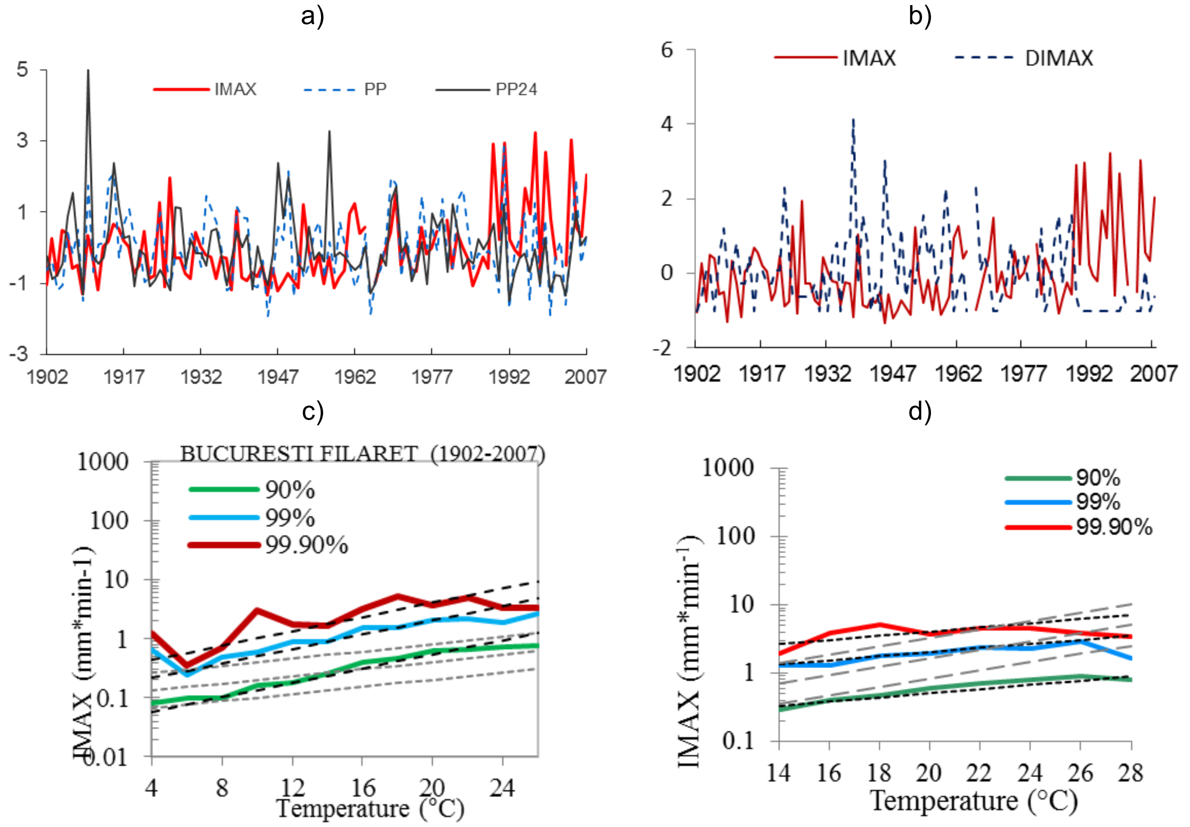

Figure 19. **a)** Comparison between standardized extreme rainfall intensity (IMAX), extreme daily intensity (PP24) and total precipitation amount (PP) at Bucuresti-Filaret station; **b)** Comparison between standardized extreme rainfall intensity (IMAX) and corresponding duration DIMAX at Bucuresti-Filaret station**; c)** and **d)** Scaling of observed extreme rainfall intensity (IMAX) with temperature for Bucuresti-Filaret station. Shown are different percentiles (90^{th} to 99.9^{th}) of IMAX distribution for each temperature bin. Exponential relation given by a 7% increase per degree and 14% per degree are rendered through the grey and black dotted lines, respectively. Note the logarithmic y-axis, due to which these exponential relations appear as straight lines. Adapted after *Busuioc et al. (2017).*

- **Evaluation of the adaptive genetic potential of the main coniferous species for a sustainable forest management in the context of climate change (GENCLIM)** – funded by UEFISCDI

The project focused on the assessment of the adaptive genetic potential of the Norway spruce, European Silver fir and Scots pine, the most economically and ecologically important coniferous species in Romania, in the context of climate change (genetica.icas.ro). Proper choices of the species but especially of the provenances / genotypes with high plasticity are among the most strategic measures to be taken. The transfer of the forest reproductive material adapted to environmental changes or the "assisted migration" is considered a measure that could facilitate adaptation of forest species, therefore increase the forest productivity.

- **Development of a standardized verification mechanism and QMS for the Moldova SHS (State Hydrometeorological Service)** – financed by the World Bank (2018-2019)

The project objectives falling under the National Meteorological Administration (NMA) remit as sub-consultant to JBA are:

- ***To support development of a SHS product verification mechanism***: Enhance the technical verification approach; develop systematic and consolidated product verification mechanism and user manuals.

- ***To support development of a SHS quality management system (QMS)***: perform gap analysis and develop procedures; staff training and coaching; revised documented quality procedures and Quality Manual.
- ***To provide expert coaching for additional service delivery improvement processes***: support user satisfaction surveys; support service delivery capacity.
- ***To support improved use and management of the weather radar of Chisinau International Airport***: elaboration and documentation of standard operating procedures on effective operation and exploitation of the radar; on-site training of SHS forecasters for optimal utilization of radar products; elaboration and documentation of a methodology for estimating the cost of delivering radar products; integration of the SHS radar data / products into the common radar system of the Romanian National Meteorological Administration.

♦ **HORESEC (Holistics of the impact of renewable energy sources on the environment and the climate) –** financed by UEFISCDI

The **HORESEC** project supports intelligent specialization in the energy field through a holistic analysis of renewable energy sources impact on climate change and on each other, fulfilling the objectives of sustainable development as well as advanced and progressive knowledge. Accelerate integration of RES set a new world record regarding grid's capacity to absorb intermittent energy, which is specific to renewable energy production, was driven by a fast reduction of related technologies expenses.

Increased share of RES in energy production greatly complicates the operation of current systems requiring new long-term storage solutions, developed in the HORESEC project. It will be carried out on a pilot plant test solutions for dynamic adaptation of the system to increase RES share in the energy production, including long-term storage solutions.

NMA is tasked to realize the high-resolution maps of wind speed and number of sunshine hours over Romania, and to assess the seasonal and annual variability and trends of the aforementioned meteorological variables.

♦ **Re-evaluation on genetic-ecological bases of the regions of provenance of forest tree species in the context of climate change** – financed by UEFISCDI within the "Nucleu" Programme

The project aims to update the mapping of the regions (and sub-regions) of provenance for the forest species over the Romanian territory, based on the present climate.

3. Participation of Romanian scientists at international symposia, courses and conferences

EMS Annual Meeting: European Conference for Applied Meteorology and Climatology, Budapest, Hungary, 3 – 7.09.2018;

European Geosciences Union General Assembly, Vienna, Austria, 8 – 13.04.2018;

European Conference for Applied Meteorology and Climatology, Dublin, Ireland, 4 – 8.09.2017;

European Geosciences Union General Assembly, Vienna, Austria, 23 – 28.04.2017;

4th UERRA General Assembly. ECMWF, Reading, UK, 21 – 23.11.2016;

GeoMLA 2016 – Geostatistics and Machine Learning: Applications in Climate and Environmental Science, Belgrade, Serbia, 23 – 24.06.2016;

2nd PANNEX workshop on the climate system of the Pannonian Basin, Budapest, Hungary, 1 – 2.06.2016;

European Geosciences Union General Assembly, Vienna, Austria, 17 – 22.04.2016;

3rd UERRA General Assembly. Toulouse, France, 1 – 3.02.2016;

IPCC Workshop on Regional Climate Projections and their Use in Impacts and Risk Analysis Studies, São José dos Campos, Brazil, 15 – 18.09.2015;

15th EMS Annual Meeting & 12th European Conference on Applications of Meteorology (ECAM), Sofia, Bulgaria, 07 – 11.09.2015;

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4.1. Peer-reviewed ISI publications

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Al-Khalidi, J., Dima, M., Vaideanu, P., Stefan, S., 2017: North Atlantic and Indian Ocean links withIraq Climate, *Atmosphere*, **8 (12)**, 235, doi: 10.3390/atmos. 8120235;

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4.2. Other journals articles and Proceedings papers

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4.3. Books and book chapters

4.3.1. Books

Birsan, M.V., 2018: *Basics of rainfall-runoff modelling* (Introducere în modelarea hidrologică), Ars Docendi, Bucharest, 66 p, ISBN: 978-973-558-999-8 (in Romanian);

Birsan, M.V., 2017: *Natural streamflow variability in Romania* (Variabilitatea regimului natural al scurgerii râurilor din România), Ars Docendi, Bucharest, 100 p, ISBN: 978-973-558-988-2 (in Romanian);

Bojariu, R., Birsan, M.V., Cică, R., Velea, L., Burcea, S., Dumitrescu, A., Dascălu, S.I., Gothard, M., Dobrinescu, A., Cărbunaru, F., Marin, L., 2015: *Climatic changes – from physical basis to risk and adaptation* (Schimbările climatice – de la bazele fizice la riscuri și adaptare), Printech, Bucharest, 200 p., ISBN: 978-606-23-0363-1 (in Romanian);

4.3.2. Book chapters

Bojariu, R., Dascălu, S.I., Gothard, M., Dumitrescu, A., Cică, R., Burcea, S., Velea, L., Bîrsan M.V., Craciunescu, V., Irimescu, A., Matreata, M., Chendeş, V., Boincean, B., Cazac, V., Potopová, V., Nita, I.A., 2018: *Variability and Change in Water Cycle at the Catchment Level*, in TV Hromadka II & P Rao (Eds): **Engineering and Mathematical Topics in Rainfall**, InTech, 115-129, ISBN: 978-953-51-5562-1, doi: 10.5772/intechopen.74047.

ATMOSPHERIC PHYSICS

1. Research orientation

In the last years our activity were focused on three main fields:

1.1. Solar radiation – activities and scientific preoccupations

In the 2015-2018 period, the radiometric network within the National Meteorological Administration has known an important development through the addition of more than 30 new locations in which the global solar radiation is measured. They are homogeneously distributed over the whole territory of the country and at the same time they cover various levels of altitude so that the radiometric network is now being able to describe in a more precise manner the state of the solar radiation at a given time.

Given the increased number of the solar radiation measuring sites and implicitly the increased amount of data that has been recorded, a special attention has been given to the quality control of the data. Over the course of the four aforementioned years, there were been done systematical verifications of the measured values whom results were converged in annual reports. Of the problems that were found, to be mentioned were a few shading issues that were observed at some of the high altitude sites in the morning or evening hours.

The research activity consisted of a number of studies. In of one of them, it was questioned the solar energetic potential of two groups of stations from distinct levels of altitude, namely over 1000m and under 100m. The idea came from the knowledge that on short periods of time, let's say several consecutive clear sky days, the solar radiation that is measured at a high altitude location cannot be but higher than the one that is registered at lower altitudes. That, of course, being considered for identical atmospheric conditions. In the same environment, the outcome was known, but of interest was to know what happens on longer period of times, in the context of unspecific weather conditions. For that, a statistic has been done for the months May, June, July and August of the years 2016, 2017 and 2018 using the mean monthly solar radiation. The four-month period was chosen in order to limit the variation of the solar radiation that is determined by the difference of latitude, which is less significant in the summer days. The results had shown that, on average, the solar radiation for the low altitude locations was with 5% higher than the higher altitude locations. The explanation was that the advantage in terms of solar energy potential that came with a higher altitude was negated in that case by an increased nebulosity.

In another study, the years 2016 and 2017 were compared by the means of cumulative clarity indexes. The clarity index represents the ratio between the ground, measured solar radiation and the extraterrestrial one. If it's used in the cumulative form, it can give a rough description of the weather during certain periods of time. Two of the sites for which the cumulative solar indexes were calculated were Târgu Logreşti, which is localized in the Getic Plateau, and Țebea in the Western Romanian Carpathians, both at altitudes close to 300 m. The results are presented in figure 20.

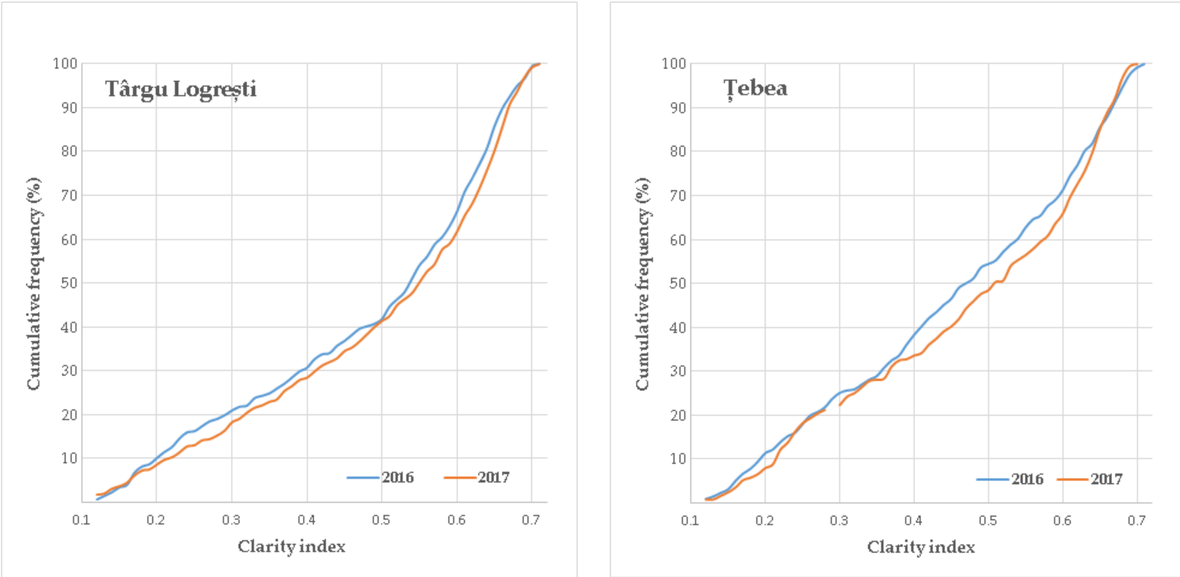


Figure 20: The cumulative frequency of the clarity index, calculated for the Târgu Logrești and Țebea stations for the years 2016 and 2017.

In both cases, the curves corresponding to the year 2017 are placed below those of the year 2016, with the difference that the Târgu Logrești station shows an increased level of similarity between the two years. The 0-0.3 range of the clarity index corresponds to the cloudiest of the days, the 0.3-0.6 interval, to days with moderate nebulosity and lastly, clarity indexes higher than 0.6 correspond to days with a clear or almost clear sky. Given those facts, we can conclude that the year 2016 is the one with an increased nebulosity. Also, notice how the curve representing the year 2017 approaches that of the year 2016 in the final 0.6-0.7 segment of the clarity index. The increasing slope of the 2017 year in the final part can be interpreted through an increasingly higher number of clear sky days compared to the previous year. Another aspect to be remarked is the gap between the two years that appears in the 0.4-0.6 interval of the clarity index for the Țebea station. That can be explained through a higher number of days with moderate nebulosity for the year 2016 when compared to the other year.

1.2. Boundary Layer - Mixing Height

Surface-based thermal inversions are of interest in air pollution meterology because the vertical movements of the cold air near the ground is blocked by the layer of warmer air of above, preventing thus the vertical dispersion of air pollutants emitted from ground sources.

In order to improve the determination of the mixing height of the planetary boundary layer the vertical profiles of temperature and potential temperature obtained from radiosoundings at the aerological station Afumati were analysed. To this end, the radiosoundings at 0 UTC and 12 UTC of the period 2016-2018 revealing surface-based temperature inversions were determined. For each such inversion, the strength, the depth of the inversion, and the vertical gradient of potential temperature of the inversion layer were calculated.

It was concluded that the majority of surface-based thermal inversions occured at 0 UTC. Hereafter, the surface-based thermal inversions determined in the radiosoundings at 0 UTC Afumati will be referred as thermal inversions. For the analysed period, most of the thermal inversions occured during the summer, and least during winter. The months containing the highest number of thermal inversions were: July and August in 2016, July in 2017, and July and September in 2018. The months containing the lowest number of thermal inversions were: October in 2016, November in 2017, and February in 2018. The maximum value of the strength of the thermal inversions was 15.1ºC in 2016 (in January), 14.1ºC in 2017 (in January), and 11.5ºC in 2018 (in December). The maximum value of the monthly mean of the strength of the thermal inversions was always attained in January during 2016-2018, and it has decreased from year to year (7.7ºC in 2016, 6.6ºC in 2017, 6.2ºC in 2018). The thermal inversions of strength between 6 ºC and 10 ºC occur during winter (especially in December and January) and autumn; however, in 2016 they also occured in April (Figure 21).

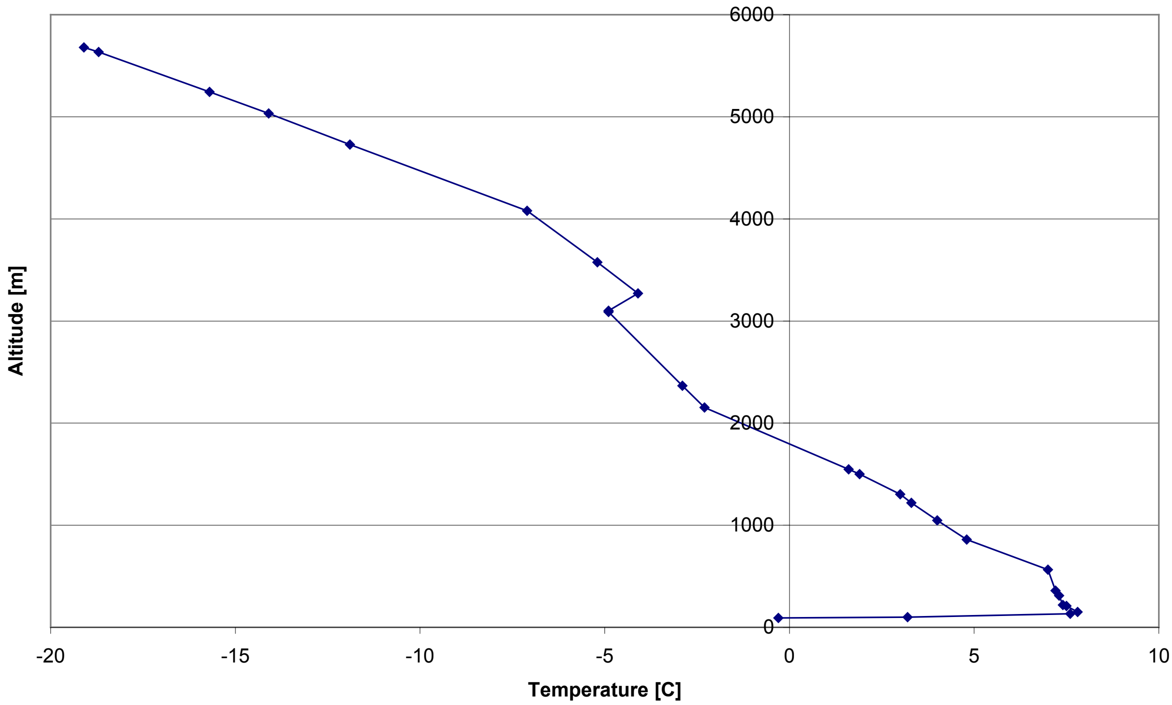


Figure 21: Example of thermal inversion whose vertical gradients of temperature and potential temperature are greater than 0.1 K/m (2 February 2016, 0 UTC Afumaţi)

1.3. Total Ozone

The main activities in the ozone field consist in monitoring of the ozone layer. Long-term monitoring is carried out in Bucharest since January 1980 and is performed with Dobson spectrometer No. 121.

♦ **The research activities** focus on the following topics:

- Ozone climatology related with meteorological condition on locale scale;
- Total ozone data analyzed with respect to changes in atmospheric circulation and natural variability;
- Annual and seasonal stratospheric temperature trends and tropopause height variations;
- Statistical analysis (trends) on local and regional scale;
- Besides the specialized studies, it has also to be mentioned: various articles for

general public aimed at correct explanation of the ozone depletion, mass-media information concerning the ozone layer, courses for students from the meteorological and environmental training system referring to the atmospheric ozone and its depletion.

- **Interaction with other programs and activities**

The Bucharest station is part of GAW (Global Atmospheric Watch) Ozone Network as "associated station".

2. Participation of the Romanian specialists in national and international projects/ programs

Romania is a permanent participant in the **WMO/GAW-GO3OS** and European Union Programs concerning the monitoring of the ozone layer.

3. Participation to national and international scientific symposia:

- International Day for the Preservation of the Ozone Layer; (every year, in mid-September);
- Annual Scientific Session of National Meteorological Administration;
- International Session of Dobson spectrophotometers Intercomparison.

4. Publications:

4.1. Peer-reviewed ISI publications

Manolache, G., Stefan, S., Iorga, G., 2018: Aerosol direct radiative forcing Relationships between PM_{10} seasonal variability in Bucharest area, Romania, *Rom. J. Phys*., **64**, 808;

Voinea, S., Manolache, G., Iorga, G., Stefan, S., 2018: Relationship between PM_{10} mass concentration aerosol optical parameters over Magurele Romania, *Rom. Rep. Phys.,* **70 (4)**, 705;

Stefan, S., Barbu, N., 2018: Study of the radar-derived parameters in hail-producing storms and estimation of hail occurrence in Romania using logistic regression approach, *Meteorol. Appl.*, doi: 10.1002/met.1726;

Toanca, F., Stefan, S., Labzovskii, L., Belegante, L., Andrei, S., Nicolae, D., 2017: Study of fog events using remote sensing data, *Rom. Re. Phys.*, **69**, 703;

Vasilescu, J., Marmureanu, L., Nemuc, A., Nicolae, D., Talianu, C., 2017: Seasonal variation of the aerosol chemical composition in a Romanian peri-urban area, *Environ. Eng. Manag. J.*, **16 (11)**, 2491-2496;

Grigoras, G., Stefan, S., Rada, C., Grigoras, C., 2016: Assessing of surface-ozone concentration in Bucharest, Romania, using OML and satellite data, *Atmos. Pollut. Res.,* **7 (4)**, 567-576, doi: 10.1016/j.apr.2016.02.001;

Manolache, G., Voinea, S., Skliros, D., Stefan, S., 2016: Comparative study of urban and rural atmospheric aerosols in and near Bucharest, Romania, *Environ. Eng. Manag. J.*, **16 (10)**, 2381-2389;

Marmureanu, L., Vasilescu, J., Nemuc, A., Nicolae, D., Belegante, L., 2016: Aerosol characterization based on chemical composition and optical properties *Rom. J. Phys.,* **61 (9-10)**, 1635-1650;

Bostan, D.C., Manea, E.F., Stefan, S., 2015: Total and partial cloudiness distribution in eastern Romania, *Rom. Rep. Phys.*, **67 (3)**, 1117–1127;
Iorga, G., Balaceanu (Raicu), C., Stefan, S., 2015: Annual air pollution level of major primary pollutants in Greater Area of Bucharest, *Atmos. Pollut. Res.*, **6 (5)**, 824-834.

4.2. Other journals articles and Proceedings papers

Buzdugan, L., Urlea, D., Bugeac, P., Stefan, S., 2018: Remote sensing of low visibility over Otopeni airport, *The 28th International Laser Radar Conference*, **176**, 11001, doi: 10.1051/epjconf/201817611001;
Urlea, D., Boscornea, A., Vâjâiac, S.N., Toanca, F., Barbu, N.,Stefan, S., Bunescu, I., 2018: Studies of Saharan dust intrusions over Bucharest using ceilometer's measurements and satellite data, *The 28th International Laser Radar Conference,* **176**, 11004, doi: 10.1051/epjconf/201817611004;
Nemuc, A., Binietoglou, I., Andrei, S., Dandocsi, A., Stefanie, H., 2016: Multiyear Aerosol Study Based on Lidar&Sunphotometer Measurements in Romania, *The 27th International Laser Data Conference (ILRC 27*), **119**, 24001, doi: 10.1051/epjconf/201611924001;
Stefan, S., Vajaiac, S.N., Boscornea, A., 2016: Microphysical Properties of Warm Clouds During The Aircraft Take-Off and Landing Over Bucharest, Romania, *The 27th International Laser Data Conference (ILRC 27)*, **119**, 16006, doi: 10.1051/epjconf/201611916006;
Stefanie, H., Marmureanu, L., Dandocsi, A., Stefan, S., 2015: Aerosol properties over Romania as seen by sunphotometer during 2014, *SGEM*, **4**, 835-842, doi: 10.5593/SGEM2015/B41/S19.108.

AGRO-METEOROLOGICAL

1. Research orientation

The main purpose of Agromonitoring Network is continuous surveillance of the agrometeorological phenomena (thermal, hydric and mechanic stress/risk) in order to identify in real time the most vulnerable areas and the dissemination of information towards the users aiming at making the right decision to prevent and mitigate the effects upon the crop efficiency.

Romanian agro-meteorological observations network is formed from 66 weather stations integrating a special program of agrometeorological measurements – soil moisture and phenological data (winter wheat, maize, sunflower, rape, fruit trees and vineyards.

The agro-meteorological stations are considered representative for the entire agricultural land of the country, those information received from all stations was used to map the spatial distribution of precipitation and to delineate the regions affected by different drought and heat wave intensities.

Soil water balance is directly affected by the crop water requirement through evapotranspiration, which is dependent mainly on temperature and stage of vegetation. Crop water requirements depend on local weather conditions, soil and plants' characteristics and plant stage of growth. Agricultural or pedological drought occurs when root-zone soil moisture is insufficient to sustain crops between rainfall events.

NMA Agrometeorology Laboratory developed specialized products, such as:

- ♦ **Base Products:**
    - Weekly agrometeorological prognosis / diagnosis, monthly and seasonal
    - Specialized agrometeorological studies
- ♦ **Specialized products (e.g., maps, graphs etc.):**

- *Parameters and maps of thermal vulnerability* and risks at national level, regional / local (temperature, cold/frost units, intensity and duration of the scorching heat, etc.)

- *Indicators of water stress at national, regional and local level* (precipitation, ETP, relative air humidity, rainfall, etc.)

- *Aridity indices* (standardized at the level of the entire agro network);

- *Agrometeorological forecast and diagnosis* (updated daily) includes specific information (air temperature, precipitation, ETP, soil moisture, crop water requirement) useful for assessing the occurrence of drought.

- *Soil moisture maps*, weekly agrometeorological information and seasonal forecasts which are updated daily according to the operational activity are made available to the public on the ***NMA website*** (***www.meteoromania.ro***) and on the new mobile application ***INOVAGRIA)***.

During 2015, the NMA upgraded the Agrometeorology department infrastructure with new specialized devices and new software integrated into a new ***AGROMETEO Data Platform*** which is a web application based on a module dedicated to agrometeorological responsables from each Regional Meteorological Centre (are users of regional type), figures 22-24.

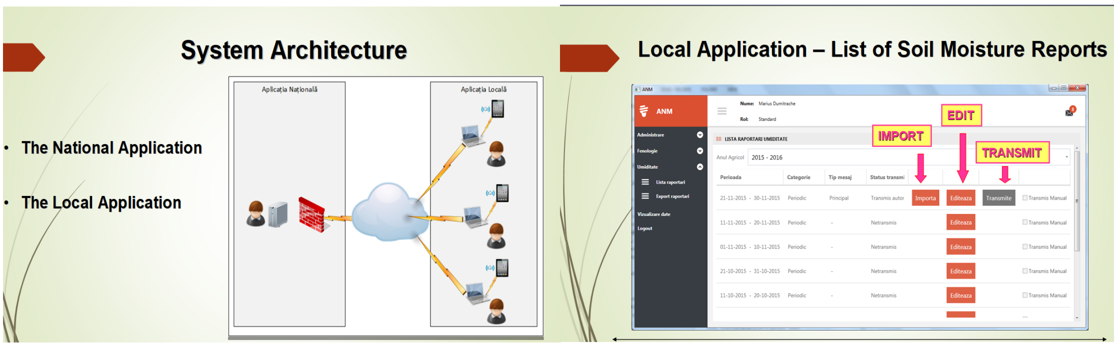


Figure 22: System architecture of the ***AGROMETEO Data Platform***

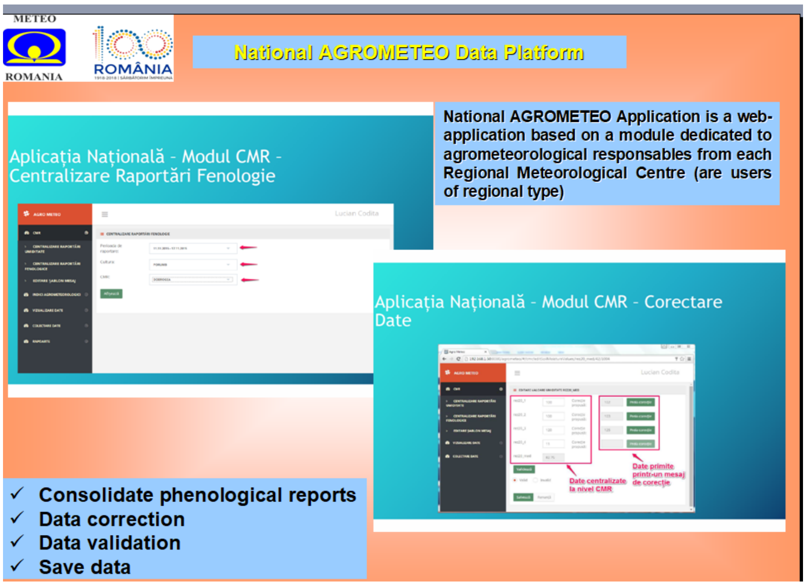
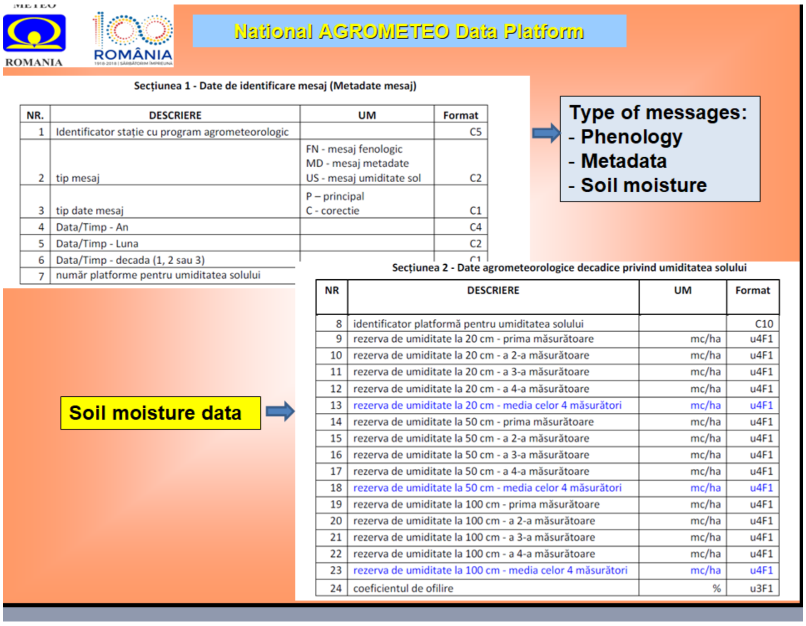


Figure 23: ***AGROMETEO Data Platform*** National Interface



Secțiunea 1 - Date de identificare mesaj (Metadate mesaj)

NR.	DESCRIERE	UM	Format
1	Identificator stație cu program agrometeorologic		C5
2	tip mesaj	FN - mesaj fenologic MD - mesaj metadate US - mesaj umiditate sol	C2
3	tip date mesaj	P – principal C - corectie	C1
4	Data/Timp - An		C4
5	Data/Timp - Luna		C2
6	Data/Timp - decada (1, 2 sau 3)		C1
7	număr platforme pentru umiditatea solului		

Secțiunea 2 - Date agrometeorologice decadice privind umiditatea solului

NR	DESCRIERE	UM	Format
8	identificator platformă pentru umiditatea solului		C10
9	rezerva de umiditate la 20 cm - prima măsurătoare	mc/ha	u4F1
10	rezerva de umiditate la 20 cm - a 2-a măsurătoare	mc/ha	u4F1
11	rezerva de umiditate la 20 cm - a 3-a măsurătoare	mc/ha	u4F1
12	rezerva de umiditate la 20 cm - a 4-a măsurătoare	mc/ha	u4F1
13	rezerva de umiditate la 20 cm - media celor 4 măsurători	mc/ha	u4F1
14	rezerva de umiditate la 50 cm - prima măsurătoare	mc/ha	u4F1
15	rezerva de umiditate la 50 cm - a 2-a măsurătoare	mc/ha	u4F1
16	rezerva de umiditate la 50 cm - a 3-a măsurătoare	mc/ha	u4F1
17	rezerva de umiditate la 50 cm - a 4-a măsurătoare	mc/ha	u4F1
18	rezerva de umiditate la 50 cm - media celor 4 măsurători	mc/ha	u4F1
19	rezerva de umiditate la 100 cm - prima măsurătoare	mc/ha	u4F1
20	rezerva de umiditate la 100 cm - a 2-a măsurătoare	mc/ha	u4F1
21	rezerva de umiditate la 100 cm - a 3-a măsurătoare	mc/ha	u4F1
22	rezerva de umiditate la 100 cm - a 4-a măsurătoare	mc/ha	u4F1
23	rezerva de umiditate la 100 cm - media celor 4 măsurători	mc/ha	u4F1
24	coeficientul de ofilire	%	u3F1

Figure 24: ***AGROMETEO Data Platform*** indicators

The agrometeorological data monitored by ***AGROMETEO Data Platform*** represent specialized information coming from the network's weather stations with agrometeorological programme, representative for areas of agricultural interest in Romania.

Main beneficiaries of agrometeorology informations are: Ministry of Environment, Water and Forests, Ministry of Agriculture and Rural Development, farmers, Agricultural Associations, public media, etc.
Between 12-14 April 2016, NMA hosted in Romania at Bucharest, The *Joint Commision of Climatology & Commision of AgroMeteorology meeting on Capacity Development* under World Meterological Organization.

2. Participation of the Romanian specialists in national and international projects/ programs

2.1. International collaboration

- **EEA Grants Project: Green Path to Sustainable Development**, 2014-2017

RO 07 Program – Adapting to Climatic Change 2009-2014
Partner countries: Norway (The Norwegian Association of Local and Regional Authorities – KS) and Romania (National Administration of Meteorology, Sibiu City Hall, Brasov City Hall, Tg. Mures City Hall and "Lucian Blaga" University of Sibiu).
https://caleaverde.ro/?lang=en

- **IRIDA Project: Innovative methods based on data and satellite techniques used to implement a decision support system on the management of water resources in agriculture,** 2016-2019

WaterWorks2014 Programme
Partner countries: Spain, Italy, Norway and Romania
http://irida.grupoinnovati.com/

- **CAMARO-D project: Cooperating towards Advanced Management Routines for land use impacts on the water regime in the Danube River Basin,** 2017-2019

Partner countries: Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovenia, Serbia.
http://www.interreg-danube.eu/approved-projects/camaro-d

- **DRIDANUBE Project: Drought Risk in the Danube Region (Danube Drought Risk),** 2017-2019

Programme: *Danube Transnational Programme* (DTP)
Piority Area 2: PA2. Environment and culture responsible Danube region
Partner countries: Slovenia, Austria, Czech Republic, Slovakia, Hungary, Romania, Croatia, Serbia, Montenegro, Bosnia and Herzegovina
http://www.interreg-danube.eu/approved-projects/dridanube

2.2. National Projects between 2015-2018

- **ADER 12.3.1 Project: The portal for soil information `in mirror` to that achieved by Joint Research Centre in Europe,** 2015-2018;
- **RO-RISK Project**: **National Risk Assessment Consultancy and expertise for drought risk assessment (meteorological and hydrological) at national level for the implementation of the project "National disaster risk assessment"**, 2015-2016.

3. Organization of national and international conferences

- ♦ DriDanube Project: National Training, Bucharest, Romania, 27.11.2018;
- ♦ Camaro-D Project: Cluster and pilot specific training-session for Stakeholders, Covasna, Romania, 7 – 8.11.2018;
- ♦ DriDanube and Camaro-D Projects: 4th Meeting, Bucharest, Romania, 10 – 12.10.2018;
- ♦ Camaro-D Project: The interdependencies between the management practices of the Natura 2000 sites and the water management practices in the Black River basin (Dialogue with interested stakeholders), Sfântu Gheorghe, Romania, 12.12.2017;
- ♦ Camaro-D Project: National Workshop, Covasna, Romania, 08.06.2017;
- ♦ DriDanube Project: DriDanube National Briefing Seminar, Bucharest, Romania, 29.05.2017;
- ♦ Green Path towards Sustainable Development Project: Workshop II, Sibiu, 6 – 8.05.2015.

4. Participation of Romanian scientists at international symposia, courses and conferences

Annual National Scientific Conference, Bucharest, Romania, 14 – 16.11.2018;
Camaro-D Project: Transnational meeting, Zagreb, Croatia, 16-18.10.2018;
1st International Congress on Agricultural Structures and Irrigation, Antalya, Turkey, 26 – 28.09.2018;
Camaro-D Project Meeting, Ljubljana, Slovenia, 14.06.2018;
Camaro-D and Proline-CE conference, Ljubljana, Slovenia, 12 – 13.06.2018;
International Conference „Agriculture for Life, Life for Agriculture", Bucharest, Romania, 7 – 9.06.2018;
13th International Symposium Present Environment & Sustainable Development, Iasi, Romania, 1 – 3.06.2018;
International Symposium: Precision Agriculture and Future Technologies, Current Work Needs and for Changing and Adapting the Professional Profile of the Modern Farmer, Braila, Romania, 20.04.2018;
European Geosciences Union, Vienna, Austria, 8 – 13.04.2018;
Irida Project: 3rd Meeting, Catania, Italy, 8 – 9.03.2018;
Camaro-D Project: 3rd Meeting, Prague, Czech Republic, 28.02 – 1.03.2018;
DiDanube Project: 3rd Meeting, Belgrade, Serbia, 28.02 – 2.03.2018;
Annual National Scientific Conference, Bucharest, Romania, 9 – 10.11.2017;
Dri-Danube project meeting, Brno-Královo Pole, Czech Republic, 4 – 6.10.2017;
Camaro-D Project: First thematic pilot cluster meeting, Belgrade, Sebia, 13 – 15.09.2017;
Training course on the use of satellite products for drought monitoring and agricultural meteorology applications, Budapest, Hungary, 24 – 28.04.2017;
Camaro-D Project: Kick-off, Budapest, Hungary, 22 – 23.03.2017;
DriDanube Project: Kick-off, Ljubljana, Slovenia, 15 – 16.03.2017;
Annual National Scientific Conference, Bucharest, Romania, 1 – 2.11.2016;

Annual National Scientific Conference, Bucharest, Romania, 19 – 20.11.2015;
International Conference „Agriculture for Life, Life for Agriculture”, Bucharest, Romania, 4 – 6.06.2015.

5. Publications:

5.1. Peer-reviewed ISI publications

Gagiu, V., Mateescu, E., Armeanu, I., Dobre, A.A., Smeu, I., Cucu, M.E., Oprea, O.A., Iorga, E., Belc, N., 2018: Post-harvest contamination with mycotoxins in the context of the geographic and agroclimatic conditions in Romania, *Toxins*, **10,** 533, doi: 10.3390/toxins10120533;

Gagiu, V., Mateescu, E., Smeu, I., Dobre, A.A., Cucu, M.E., Oprea, O., Iorga, E., Belc, N., 2017: A survey of the cereal contamination with deoxynivalenol in Romania, for 2011-2013 period, *Roma. Biotech. Lett.*, **22 (1)**, 12240-12249;

Mitrică, B., Mateescu, E., Dragotă C.S., Grigorescu, I., Dumitraşcu, M., Popovici, E.A., 2015: Climate change impacts on agricultural crops in the Timis Plain, Romania, *Rom. Agric. Res.*, 32, 93-101, ISSN 1222-4227.

5.2. Other journals articles and Proceedings papers

Oprea, O.A., Mateescu, E., Barbu, A., Tudor, R., 2018: Extreme dry years in the 21st century at the level of agricultural areas of Muntenia, Romania, *Proceedings of Agriculture for Life, Life for Agriculture*, **1 (1)**, 101-109, doi: 10.2478/alife-2018-0015;

Oprea, O.A., Mateescu, E., 2017: Thermal and water risk agro-meteorological parameters and their impact on winter wheat crops (*Triticum aestivum L.*) in Muntenia Region, *Agronomy*, **LX**, 512-519, ISSN: 2285-5785;

Gagiu, V., Doja, L., Mateescu, E., Smeu, I., Cucu, M.E., Dobre, A.A., Oprea, O., Iorga, E., Belc, N., 2016: Contamination with deoxynivalenol in the milling-bakery industry under the influence of climatic conditions from Romania, *J. Hygienic Engineering and Design*, **16**, 38-44;

Chitu, E., Giosanu, D., Mateescu, E., 2015: The variability of Seasonal and Annual Extreme Temperature Trends of the Latest Three Decades in Romania, *Agric. Agric. Sci. Procedia*, **6**, 429-437, doi: 10.1016/j.aaspro.2015.08.113;

Trif, A., Oprea, A.O., 2015: The impact of climate change on winter wheat crops and corn from Oltenia, between 2001-2014, compared with the reference period of 1981-2010, *Agric. Agric. Sci. Procedia*, **6**, 525-532, doi: 10.1016/j.aaspro.2015.08.079.

5.3. Books and book chapters

5.3.1. Book chapters

Sandu, I., Mateescu, E., 2016: *Anthropic climate change and climatic scenarios* (Schimbări climatice antropice şi scenarii climatice), in Balteanu, D., Dumitrascu, M., Geacu, S., Mitrica, B., Sima, M. (Coords.): **Nature and Society**, Romanian Academy, 593-596, ISBN 978-973-27-2695-2 in Romanian;

Sandu, I., Mateescu, E., Sirbu, C., Stancalie, G., 2016: *The impact of extreme meteorological phenomena on the environment, in the context of climate change* (Impactul fenomenelor meteorologice extreme asupra mediului, în contextul schimbărilor climatice), in Hera, C. (Ed.): **Global climate change. Care for natural resources**, Romanian Academy, 27-48, ISBN: 978-973-27-2526-9 in Romanian.

REMOTE SENSING AND GIS

1. Research orientation

The operative and research activities carried out within the Remote Sensing and Geographic Information Systems Laboratory (RSGIS) and the Satellite Meteorology Laboratory (SML) and are briefly presented herein. Research was carried out in various tasks and projects, involving, for instance, spatial data infrastructures for meteorological applications, monitoring of extreme hydro-meteorological events (drought, heat waves, cold waves, floods, wild fires etc.), assessment of moisture products derived from satellite data, or operational service aimed at supplying quantitative measurements of the vegetation cover and snow cover.

Since 2011, NMA represents Romania at European Commission in the **Copernicus User Forum Committee**. In the framework of the Copernicus Programs, Romania is engaged in the development of all the Copernicus core services, which are also supported by research and development projects financed by the National Programs, in cooperation with the Romanian Space Agency and other research institutes. NMA plays an important role to deliver information which corresponds to user needs within the "Copernicus service component".

INSPIRE directive triggers the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from local level to global level, in an interoperable way and for a variety of uses (Figure 25).

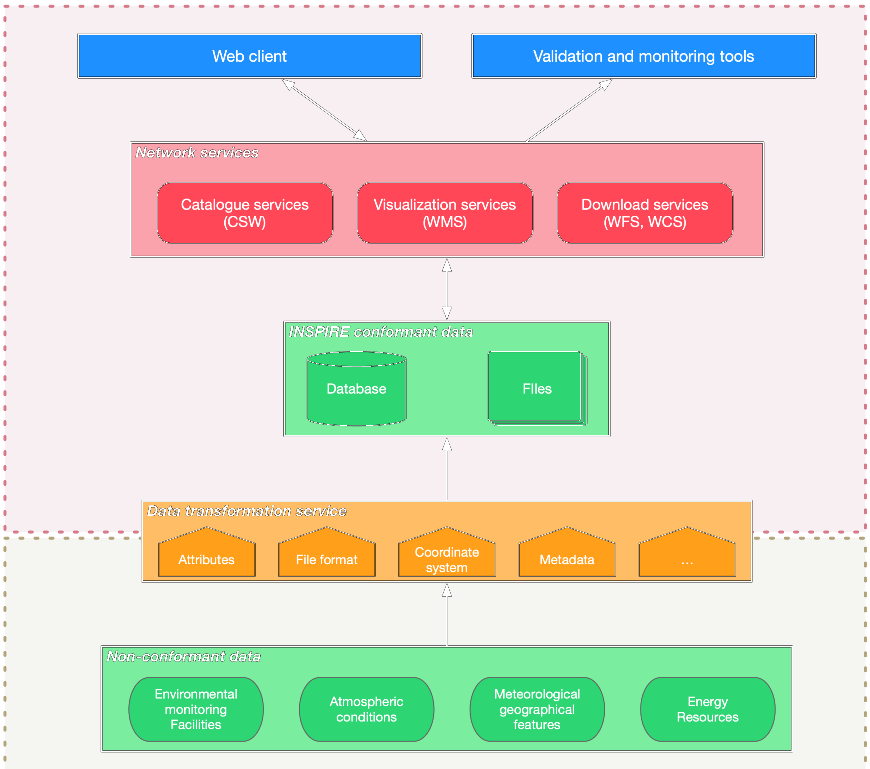


Figure 25: Generic Architecture of Spatial Data Infrastructure Romania

According to the INSPIRE Directive (2007/2/EC), NMA designed and implemented the following network services:

- ♦ Discovery services making it possible to search for meteorological spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata;
- ♦ View services making it possible, as a minimum, to display, navigate, zoom in/out, pan, or overlay viewable spatial data sets and to display legend information and any relevant content of metadata;
- ♦ Download services enabling copies of meteorological spatial data sets, or parts of such sets, to be downloaded and, where practicable, directly accessed;
- ♦ Transformation services enabling spatial data sets to be transformed with a view to achieve interoperability;

2. Participation of the Romanian specialists in national and international projects/ programs

2.1. International projects:

♦ The **SAMIRA Project** (SAtellite based Monitoring Initiative for Regional Air quality), 2016-2019, is an ESA funded project. The overall goal is to improve regional and local air quality monitoring through synergetic use of data from present and upcoming satellites, traditionally used in situ air quality monitoring networks and output from chemical transport models (Figure 26). Through collaborative efforts in four countries (Poland, Romania, The Czech Republic, and Norway) with different, but pressing air quality problems, SAMIRA aims to support the selected institutions and associated users in their national monitoring obligations as well as to generate novel research in this area.

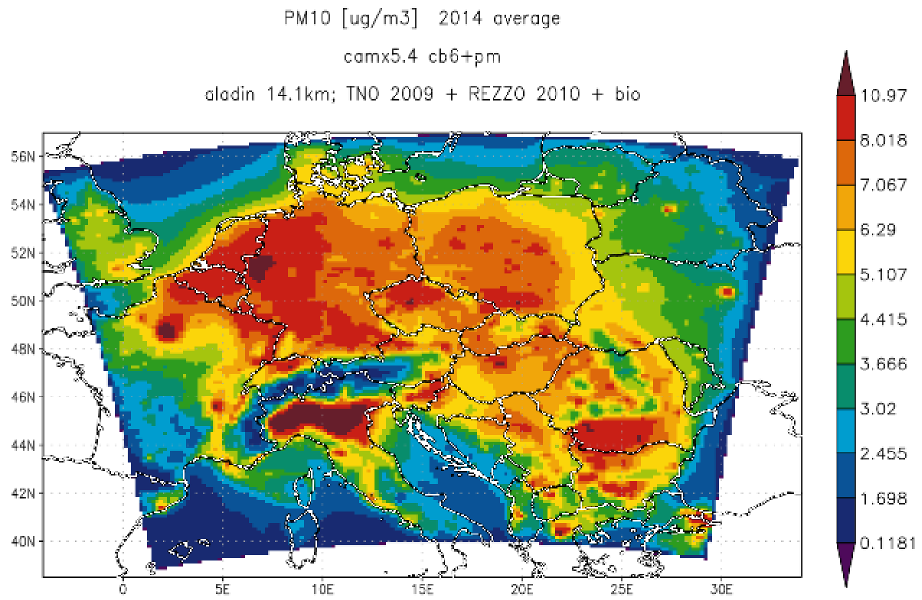


Figure 26: Output of CAMx chemical transport model for the European domain (spatial resolution 14.1 km). Source: CHMI.

♦ NMA contributed to the ERA Learn 2020 project **IMDROFLOOD** (Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators), between 2016-2018. To achieve one of the main goals of the project that consists in making accessible information about drought and floods at the catchment level to the larger public, a structured website (called IMDROFLOOD geoportal) was created (Figure 27). The geoportal has a user-friendly interface for on demand data access, removing usability barriers that could prevent or delay the optimal use of the data. Additionally, the geoportal follows the principles of open, modular and scalable technologies. This facilitates the development of a stable and flexible product by allowing a stepwise approach during the implementation of the geoportal. The prototype of the geoportal was built using exclusively open source solutions.

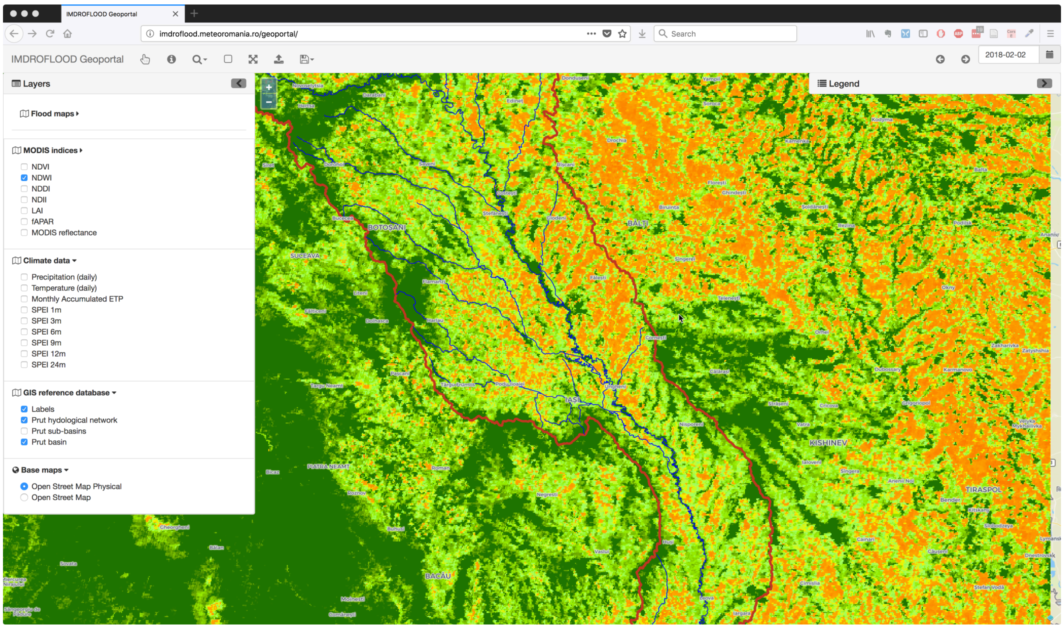


Figure 27: IMDROFLOOD geoportal interface

♦ From June 2014, the NMA coordinated the **SnowBall Project**, financed by the European Economic Area, Research within the Priority Sectors. The main objective of the SnowBall Project was to explore and develop methodology supporting the vision of developing a future service providing national authorities with hind-cast and real-time snow information retrieved from earth observation data.

A multi-sensor/multi-temporal algorithm was developed for estimating the snow humidity (MWS), through a combined use of optical and radar satellite data. MWS algorithm allows the estimation of the humidity degree of the snow layer (Figure 28). The map of the snow humidity is a novel product, at a 1-km spatial resolution, with a national coverage, which includes four thematic classes, based on the standard international classes (dry snow, humid snow, wet snow and very wet snow). The map yielded from satellite radar data (Sentinel-1) and optical data (Sentinel-3).

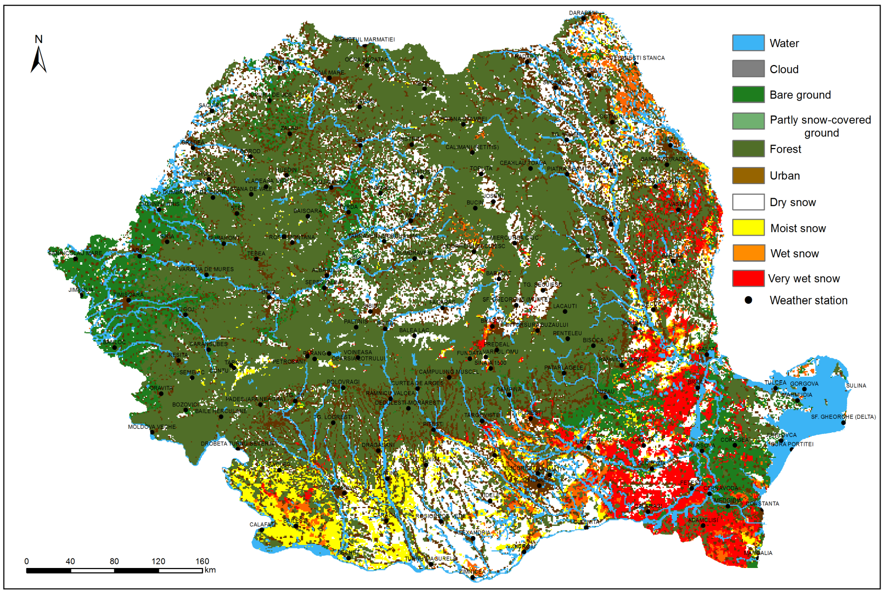
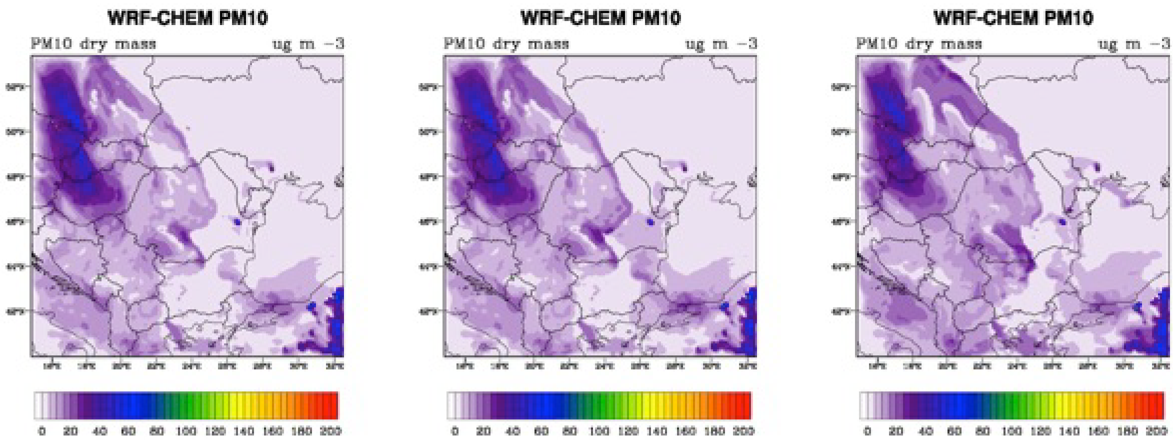


Figure 28: MWS product derived from Sentinel-1 and Sentinel-3 data on 4th of February 2017

♦ The **SiAiR Project** (Satellite & in-situ Information for Advanced Air Quality Forecast Services – SiAiR) was an ESA funded project lead by NMA and having as partners ZAMG (Austria) and SYSTEMA GmbH (Austria). The goal of the project was to define the assimilation of observations (satellite products and ground measurements) into the numerical modelling of the Romanian National Meteorological Administration for air quality purposes while assessing the impact of data assimilation on the PM10 forecasts performances. A comprehensive modelling system was developed in the frame of this project. The Air-Quality modelling activities in Romania, at NMA have been extended with PM10 measurements from ground stations and with satellite based PM10 estimates provided by the MODIS instrument (Figure 29).



(a) (b) (c)

Figure 29: Example of WRF-CHEM numerical forecasts – hourly PM10 concentration – WRF-CHEM integration from 25 June 2013 00UTC + 15h anticipation: (a) WRF-CHEM without assimilation; (b) WRF-CHEM with ground measurements assimilation; (c) WRF-CHEM with satellite and ground measurements assimilation.

♦ The **LIFE Project: CleanWater** had start in October 2010 and it is co-financed by the European Community Commission, General Direction for Environment, in the framework of LIFE + Program for Environmental Demonstrative Projects. The main objective of the project is to contribute to the development of a modern Romanian water management system by elaboration of a completely integrated system as basis for the Bârlad River Basin District Management Plan according to EU legislation (especially Water Framework Directive) and by gaining the knowledge and experience to be used later in management of other river basins of Romania (Figure 30).

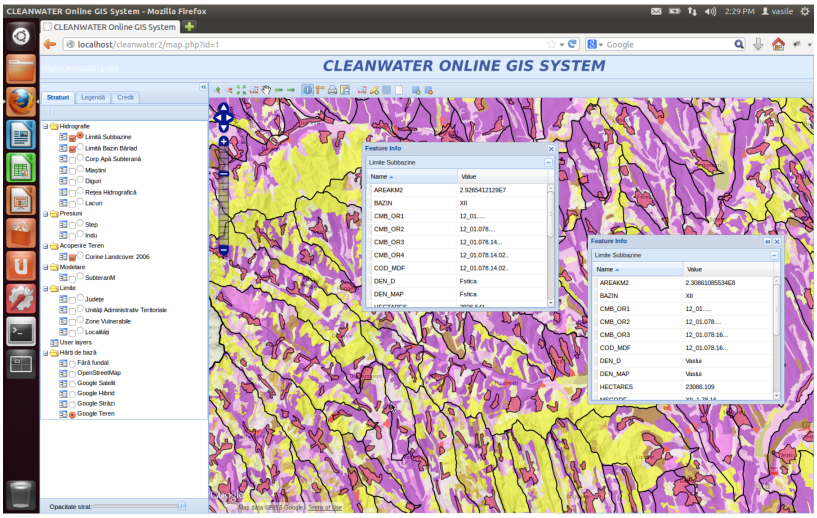


Figure 30: The CLEANWATER on-line GIS system

2.2. National projects:

♦ The **ASSIMO Project** (Assessment of Satellite Derived Soil Moisture Products over Romania) overall goal was to pave the way for the utilisation of satellite derived soil moisture products in Romania, by creating the framework for the validation and evaluation of actual & future satellite microwave soil moisture derived products, demonstrating its value, and by developing the necessary expertise for successfully tackling implementations in the relevant Societal Benefit Areas (as they were defined in GEOSS). An in-situ soil moisture network was implemented (RSMN – Romanian Soil Moisture Network) for the calibration/validation of the SMOS, SMAP and ASCAT soil moisture products. RSMN became a member of ISMN (International Soil Moisture Network). Methodologies for mapping satellite soil moisture products over Romania were developed and the accuracy of the satellite soil moisture products was assessed against RSMN observations.

♦ The **Ader 12.1.1. Project** (Agricultural information system and its compatibility with the general cadastre S.I.A) aim was to design and implement the architecture of the information system for agriculture (Figure 31).

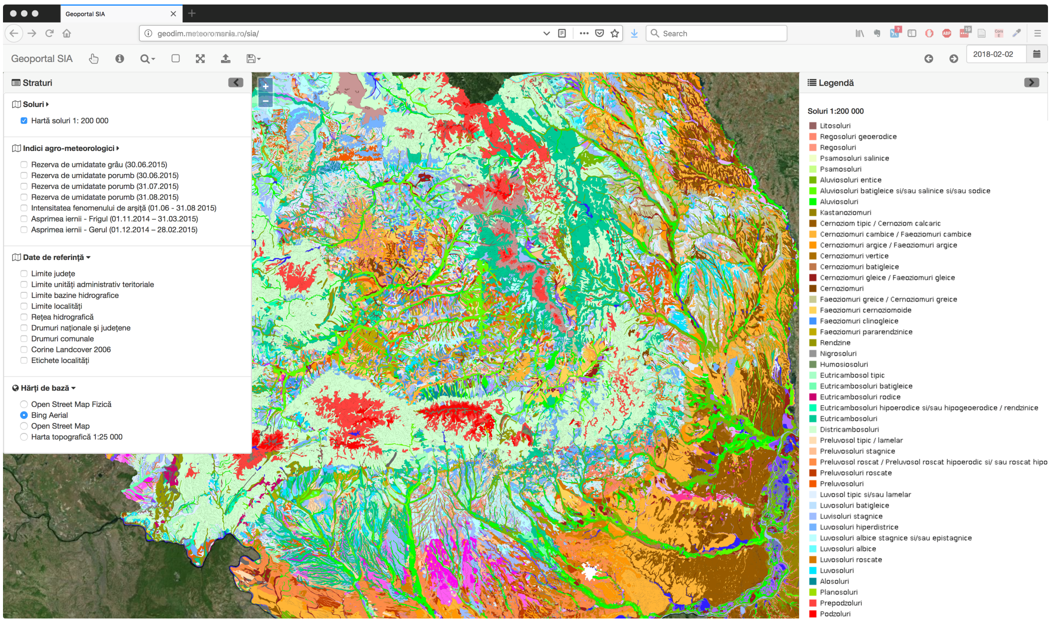


Figure 31: The Ader information system

♦ The **Medgame Project** (Serious Games based Virtual Centre for education and training in natural hazards emergency situations) overall goal was to develop an application that aims to imform and train population to cope with floods. Learning is done by simulating the action of a natural disaster (in this case, the flood scenario) on a small city.

♦ The **GEODIM Project** (Platform for GeoInformation in Support of Disaster Management) overall goal was to develop a downstream emergency response service for contributing to current disaster and risk management approach based on Earth observation data (Figure 32).

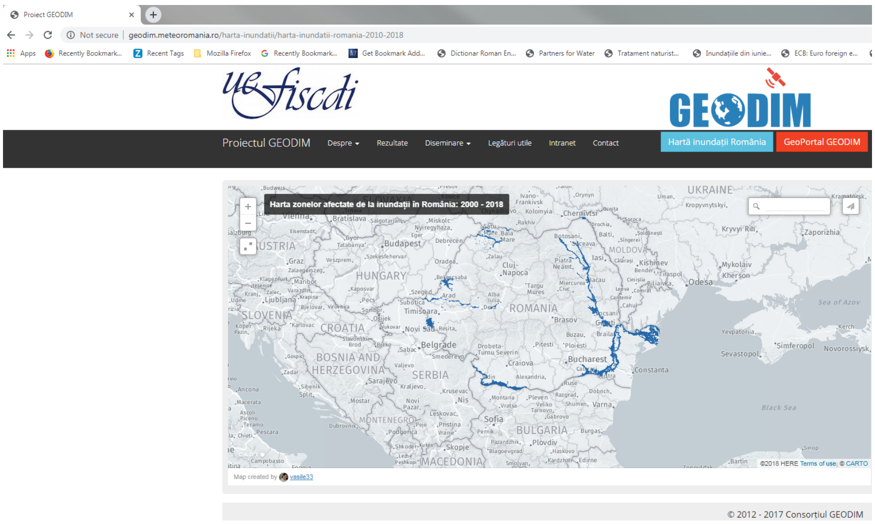


Figure 32: The GEODIM geoportal

3. Organization of national and international conferences

♦ Training course for implementation of a spatial data structure compliant with INSPIRE Directive requirements, within National Meteorological Administration, Bucharest, Romania, 14 – 20.12.2017;

- SNOWBALL Project: Final Meeting, Bucharest, 27.04.2017;
- Workshop on Water Storage Estimation Using Advanced Satellite, Aerial and In-situ Observations, Bucharest, 30.10.2017;
- GEODIM Project: Final Workshop, Bucharest, 29.11.2016.

4. Participation of Romanian scientists at international symposia, courses and conferences

International Conference: An inventory towards a new National Park, Bucharest, Romania, 10 – 11.12.2018;

Open Source Solutions Workshop, Timisoara, Romania, 23 – 24.11.2018;

ADAGUC Workshop, Utrecht, Netherlands, 21 – 23.11.2018.

Annual National Scientific Conference, Bucharest, Romania, 14 – 16.11.2018;

Workshop: Towards a better harmonization of snow observations, modelling and data assimilation in Europe, Budapest, Hungary, 30 – 31.10.2018;

Open Source Solutions Workshop, Bucharest, Romania, 12 – 13.10.2018;

EUMETSAT Meteorological Satellite Conference, Tallinn, Estonia, 17 – 21.09.2018

20th International Symposium on symbolic and numeric algorithms for Scientific Computing, Timisoara, Romania, 20 – 23.09.2018;

Montane and alpine grasslands under climate change – Ways in a sustainable future, Garmisch-Partenkirchen, Germany, 3 – 7.09.2018;

International Conference: Life for Agriculture, Agriculture for Life, Bucharest, Romania, 7 – 9.06.2018;

International Summer School on Applications with the Newest Multi-spectral Environmental Satellites, Bracciano, Italy, 10 – 20.06.2018;

Open Source Solutions Workshop, Cluj-Napoca, Romania, 20 – 21.04.2018;

Project manager training, International Charter „Space and Major Disaster", Darmstadt, Germany, 16 – 17.04.2018;

Annual National Scientific Conference, Bucharest, Romania, 9 – 10.11.2017;

Today's EU Space Programmes: Applications and Synergies with a view on Eastern Europe, Bucharest, Romania, 26 – 27.10.2017;

EUMETSAT Meteorological Satellite Conference, Rome, Italy, 02 – 06.10.2017;

Autumn School: Use of Satellite Information in Nowcasting, Thessaloniki, Greece, 11 – 15.09.2017;

International Symposium: Polar Ice, Polar Climate, Polar Change: Remote sensing advances in understanding the cryosphere, Boulder, Colorado (USA), 14 – 19.08.2017;

8th EARSeL Workshop on land Ice and Snow, Bern, Switzerland, 7 – 9.02.2017;

Open Source Solutions Workshop, Timisoara, Romania, 18 – 19.11.2016;

Annual National Scientific Conference, Bucharest, Romania, 1 – 2.11.2016;

International Symposium on Geographic Information Systems: Vulnerability and Risk Assessment Using GIS, Cluj-Napoca, Romania, 28 – 29.10.2016;

3rd European Conference on Flood Risk Management: Innovation, Implementation, Integration, Lyon, France, 17 – 21.10.2016;

The future of Copernicus: Extension and Expansion, Bucharest, Romania, 5 – 6.10.2016;

18th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing, Timisoara, Romania, 24 – 27.09.2016;

EUMETSAT Meteorological Satellite Conference, Darmstadt, Germany, 26 – 30.09.2016;

International Conference: Free and Open Source Software for Geospatial (FOSS4G), Bonn, Germany, 24 – 26.08.2016;

73rd Annual Eastern Snow Conference (ESC), Columbus, Ohio (USA), 14 – 16.06.2016;

International Conference: Agriculture for Life, Life for Agriculture, Bucharest, Romania, 9 – 11.06.2016;

Workshop on communication and publicity, Sibiu, Romania, 25 – 26.05.2016;

ESA Living Planet Symposium, Prague, Czech Republic, 9 – 13.05.2016;

Open Source Solutions Workshop, Cluj-Napoca, Romania, 15 – 16.04.2016;

International Conference: Air and Water Components of the environment, Cluj-Napoca, Romania, 20 – 22.03.2016;

EEA Conference: Achievements and future steps, Bucharest, Romania, 10.12.2015;

Annual National Scientific Conference, Bucharest, Romania, 19 – 20.11.2015;

International GIS Symposium, Iasi, Romania, 2 – 4.10.2015;

Copernicus - big data benefiting environment and society, Bucharest, Romania, 1 – 2.10.2015

EUMETSAT Meteorological Satellite Conference, Toulouse, France, 21 – 25.09.2015;

6th ESA Advanced Training Course on Land Remote Sensing, University of Agronomic Science and Veterinary Medicine Bucharest, Bucharest, Romania, 14 – 18.09.2015;

International Conference: Free and Open Source Software for Geospatial (FOSS4G) - Europe, Como, Italy, 14 – 18.07.2015;

26th General Assembly of the International Union of Geodesy and Geophysics - IUGG 2015, Prague, Czech Republic, 22.06 – 2.07.2015;

ADAGUC Workshop (Atmospheric data access for the geospatial user community), De Bilt, the Netherlands, 17 – 19.06.2015;

35th Earsel Symposium – European Remote Sensing: Progress, challenges and opportunities, Stockholm, Sweden, 15 – 19.06.2015;

ESA ATMOS Conference, Crete, 8 – 12.06.2015;

Romanian Space “Week”, Bucharest, Romania, 27 – 29.05.2015;

2nd SMOS Science Conference, Villafranca, Spain, 25 – 29.05.2015;

International Conference: Air and Water Components of the environment, Cluj-Napoca, Romania, 20 – 23.03.2015;

International Conference on Remote Sensing and Geoinformation of Environment - RSCy2015, Paphos, Cyprus, 16 – 19.03.2015;

Copernicus User Forum on Emergency, Brussels, Belgium, 22.01.2015.

5. Publications:

5.1. Peer-reviewed ISI publications

Crăciunescu, V., Stăncălie, G., Irimescu, A., Catană, S., Mihăilescu, D., Nerţan, A., Morcov, G., Constantinescu, S., 2016: MODIS-based multi-parametric platform for mapping of flood affected areas. Case study: 2006 Danube extreme flood in Romania, *J. Hydrol. Hydromech.*, **64 (4)**, 329–336, doi:10.1515/johh-2016-0040;

Manakos, I., Tomaszewska, M., Gkinis, I., Brovkina, O., Filchev, L., Genc, L., Gitas, I.Z., Halabuk, A., Inalpulat, M., Irimescu, A., Jelev, G., Karantzalos, K., Katagis, T., Kupkova, L., Lavreniuk, M., Mesaroš, M., Mihailescu, D., Nita, M., Rusnak, T., Stych, P., Zemek, F., Albrechtova, J., Campbell, P.K., 2018: Intercomparison of Global and Continental Land Cover Products in South Central and Eastern European Region, *Remote Sens*., **10 (12)**, 1967, doi: 10.3390/rs10121967;

Mihai, L., Stancalie, A., Sporea, A., Sporea, D., Nertan, A., Mihailescu, D., 2016: Drought Vegetation Monitoring using in situ and satellite data, in the Caracal Plain of Romania, *Rom. Rep. Phys.*, **68 (2)**, 799–812;

Solberg, R., Salberg, A.-B., Due Trier, Ø., Rudjord, Ø., Stancalie, G., Diamandi, A., Irimescu, A., Craciunescu, V., 2017: Remote Sensing of snow wetness in Romania by Sentinel-1 and Terra MODIS data, *Rom. J. Phys*., **62 (9-10)**, 821;

Stăncălie, G., Crăciunescu, V., Irimescu, A., Dana Negula, I., Nedelcu, I., Serban, F., Teleaga, D., Toma, S.A., Faur, D., Datcu, M., Virsta, A., 2016: Development of a downstream emergency response service for disaster hazard management based on Earth Observational data, *AgroLife Scientific J.*, **5 (1)**, 199-208, ISSN: 2285-5718.

5.2. Other journals articles and Proceedings papers

Andra-Topârceanu, A., Mafteiu, M., Verga, M., Andra-Topârceanu, M., Bugiu, S., Mihăilescu, D., 2015: Multidisciplinary analysis of the Balteni landslides (Romania), *J. of Geomorphology*, **17**, 69-80, ISSN: 1453-5068;

Angearu, C., Irimescu, A., Mihailescu, D., Vîrsta, A., 2018: Evaluation of drought and fires in the Dobrogea Region, using MODIS satellite data, *Proceedings of Agriculture for Life, Life for Agriculture*, **1 (1)**, 336-345, doi: 10.2478/alife-2018-0050;

Bordun, C., Nertan, A.T., Cimpeanu, S.M., 2018: Evaluation of Vegetation Fraction Cover in agricultural areas affected by prolonged drought in the South Region of Romania, *Proceedings of Agriculture for Life, Life for Agriculture*, **1 (1)**, 346-351, doi: 10.2478/alife-2018-0051;

Oprea. R., Cuculici, R., Nedelea, A., Ene, M., Mihăilescu, D., 2016: The land use in the Dobrogea Plateau and relationship with ecological groups of soils, *16th International Multidisciplinary Scientific GeoConference SGEM Conference Proceedings*, **5 (3)**, 661-668, ISBN 978-619-7105-67-4/ ISSN 1314-2704;

Poenaru, V., Badea, A., Cîmpeanu, S.M., Irimescu, A., 2015: Multi-temporal multi-spectral and radar remote sensing for agricultural monitoring in the Braila Plain, *Agric. Agric. Sci. Procedia*, **6**, 506-516, doi:10.1016/j.aaspro.2015.08.134;

Săndulache, C., Irimescu, A., Săndulache, I., 2015: Snowstorm – a climate risk phenomenon in Parâng Mountains, *Annals of Geography*, **LIV**, 37-52, ISSN: 1013-4115 (ISSN online: 2247-238X);

Săndulache, C., Săndulache, I., Grecu, F., Dobre, R., Irimescu, A., 2015: Geomorphological processes within the alpine level of Parang Mountains, *J. of Geomorphology*, **17**, 29-44, ISSN: 1453-5068;

Săndulache, I., Grecu, F., Săndulache, C., Irimescu, A., 2017: Cerna River Terraces between Baile Herculane and Orsova, *Analele Univ. Bucureşti (Geografie)*, **LVI**, 17-39, ISSN: 1013-4115 (ISSN online: 2247-238X);

Solberg, R., Rudjord, O., Salberg, A-B., Trier, O., Stăncălie, G., Diamandi, A., Irimescu, A., 2016: Single and multi-sensor snow wetness mapping by Sentinel-1 and MODIS data, *73rd Eastern Snow Conference Proceedings*, 110-118;

Stăncălie, G., Crăciunescu, V., Irimescu, A., 2015: Contribution of satellite data to the development of a downstream emergency response service for flood and related risk in Romania, *35th Earsel Symposium – European Remote Sensing: Progress, challenges and opportunities*, 301-306;

Stăncălie, G., Crăciunescu, V., Irimescu, A., 2016: Development of a downstream emergency response service for flood and related risks in Romania based on satellite data, *3rd European Conference on Flood Risk Management: Innovation, Implementation, Integration*, **7**, doi:10.1051/e3sconf/20160717007.

5.3. Books and book chapters

5.3.1. Books

Stăncălie, G. (Coord.), 2017: *Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective*, Printech, 163 p, ISBN: 978-606-23-0733-2.

Dima, V., Georgescu, F., Irimescu, A., Mihăilescu D., 2016: *Heat waves in Romania* (Valuri de căldură în România), Printech, 89 p, ISBN: 978-606-23-0666-3, in Romanian;

Georgescu, F., Roceanu, I., Stăncălie, G., Mălureanu, A., Radu, C., Beligan, D., Anton, M., Bărbieru, D., Munteanu, G., Dima, V., Irimescu, A., Cîrnu, C. E., Popescu, D., Stamescu, A., 2016: *Education and training of the population in natural disasters through Serious Games* (Educarea şi instruirea populaţiei în situaţii de dezastre natural prin intermediul Serious Games), Printech, 117 p, ISBN: 978-606-23-0665-6, in Romanian;

Georgescu, F., Dima, V., Irimescu, A., Stăncălie, G., Roceanu, I., Beligan, D., 2015: *Floods-risk phenomena. Population preventive education through educational games* (Inundațiile-fenomene de risc. Instruirea preventivă a populației prin jocuri educative), 96 p, Printech, ISBN: 978-606-23-0490-4, in Romanian;

5.3.2. Books chapters

Toulios, L., Romaguera, M., Stancalie, G., Spiliotopoulos, M., Struzik, P., Calleja, E., Tarquis, A., Kepinska-Kasprzak, M., Papadavid, G., 2016: *How can remote sensing data be integrated into water footprint (WF) and virtual water trade (VWT) assessment. An overview of the key input variables for WF of crops*, in Toulios, L., Struzik, P. (Eds.): **How the study of the water footprint of agricultural crops can benefit from the use of satellite remotely sensed data**, COST Action ES1106 EURO-AGRIWAT: Assessment of EUROpean AGRIculture WATer use and trade under climate change, 9-38, ISBN: 978-80-85754-38-4;

Stancalie, G., Nertan, A., Struzik, P., Toulios, L., Spiliotopoulos, M., Tarquis, A., Kepinska-Kasprzak, M., Calleja, E., Nunes, J.R., 2016: *Assessment of the most appropriate set of vegetation indices and biophysical variables in the context of a cost effective solution to monitor water stress, using satellite data*, in Toulios, L., Struzik, P. (Eds.): **How the study of the water footprint of agricultural crops can benefit from the use of satellite**

remotely sensed data, COST Action ES1106 EURO-AGRIWAT: Assessment of EUROpean AGRIculture WATer use and trade under climate change, 39-78, ISBN: 978-80-85754-38-4;

Struzik, P., Kepinska-Kasprzak, M., Spiliotopoulos, M., Toulios, L., Stancalie, G., Nertan, A., Papadavid, G., Nunes, J.R., 2016: *Assessment of required spatial, spectral and temporal resolution of satellite data for the analysis of water footprint relation to existing ground observation*, in Toulios, L., Struzik, P. (Eds.): **How the study of the water footprint of agricultural crops can benefit from the use of satellite remotely sensed data**, COST Action ES1106 EURO-AGRIWAT: Assessment of EUROpean AGRIculture WATer use and trade under climate change, 79-137, ISBN: 978-80-85754-38-4;

Toulios, L., Struzik, P., Stancalie, G., 2016: *Operational satellite remote sensing services for the detection of water resources and crop conditions monitoring*, in Toulios, L., Struzik, P. (Eds.): **How the study of the water footprint of agricultural crops can benefit from the use of satellite remotely sensed data**, COST Action ES1106 EURO-AGRIWAT: Assessment of EUROpean AGRIculture WATer use and trade under climate change, 138-144, ISBN: 978-80-85754-38-4.

VERY SHORT RANGE FORECASTING (NOWCASTING)

1. Research orientation

The main very short-range forecasting research activity is performed at the Romanian National Meteorological Administration within the Laboratory of Radar Network Coordination, Satellite and Nowcasting.

1.1. Forecasting and monitoring severe convective storms

The activity of Laboratory of Radar Network Coordination, Satellite and Nowcasting, which is the main laboratory for nowcasting techniques, also includes operational activities. However, the nowcasting forecasts are realized at the National Centre for Weather Forecasting. Besides the operational branch, research activities are performed in order to study the severe weather events associated with deep convection, thus to add improvements to the operational nowcasting activity. The main dataset used for severe weather research is composed of data provided by the national weather radar netwotk. Based on that, and corroborating with additional data, a special attention is paid to the study of convective systems that can produce severe phenomena.

1.2. Analysis of radar data for the assessment of severe hailstorms and hail risk

The assessment of spatial distribution of severe hailstorms and the risk associated with those has been performed on a regional scale. The studies used hail damage reports and radar-derived products (e.g. HKE) to assess the detection of hail and, particularly, the relation between hailfalls and the surface damage. Furthermore, the studies aimed at finding the usefulness of radar-derived products in updating the hail climatology of Romania, and at identifying the regions exposed to hail risk.

The research included, for instance, one study regarding the relationship between single polarization radar-derived parameters and the identification of severe hailstorms and surface damage, for a region in southern Romania (Figure 34). This was made using the reports from a number of 52 severe weather events that occurred in southern Romania. The main conclusions of the study were that: the radar-derived parameters can be used to identify the areas prone to severe hail, and that information is particularly valuable for the regions were ground measurements of hail are not performed and/or available; the time integration and spatial distribution of the radar-derived parameters offer extremely valuable information on the detection, swath, intensity and longevity of the hailstorms.

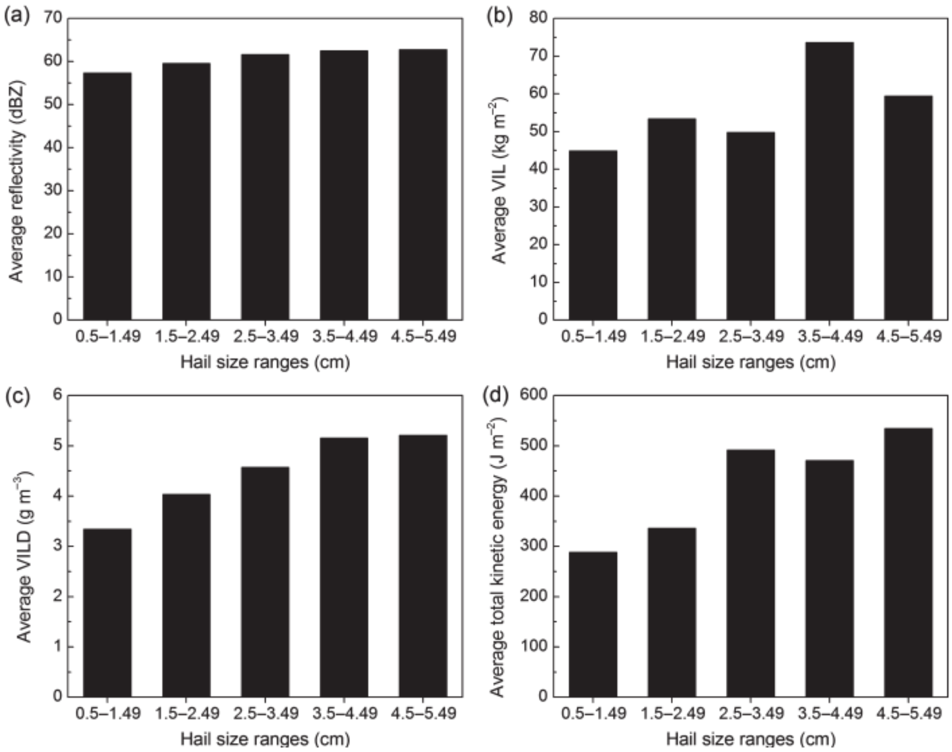


Figure 34: The hail size reported at ground versus the average composite reflectivity (CR) (a), average vertically integrated liquid (VIL) (b), average vertically integrated liquid density (VILD) (c) and average radar-derived total hail kinetic energy (HKE) flux (d), for May 2013, in the coverage area of Bucharest radar.

1.3. Thermodynamic synoptic and mesoscale configurations associated with heavy rainfall

Research studies on heavy rainfall events, for Romania, have been performed. One study was aimed at investigating the dynamic and thermodynamic, both synoptic and mesoscale, configurations associated with severe weather in eastern Romania. The synoptic features analysis was performed on reanalysis data, employing the empirical orthogonal functions (EOF), in order to cluster the severe weather events into classes. Therefore, applying the EOF analysis on the geopotential field at European scale, three eigenvectors that describe up to 73% of the data. Further, these vectors were projected on a number of 62 days with severe weather recorded in eastern Romania, between 1980 and 2009, resulting in eight classes of synoptic configurations. These classes were divided into several groups according to certain average thermodynamic characteristics (Figures 35 and 36).

An important finding is that by projecting the three eigenvectors, in positive and negative forms, on the numerical weather prediction models outputs, one can observe the most likely dynamic behavior to expect in a synoptic time interval. If a tendency stands out, then one can go to smaller time scale (i.e. 6h) to check if a certain archive case for the respective class has similar dynamics. Also, although the analysis and results characterize eastern Romania, the approach used within this study is general and can be performed on any region, using different synoptic domains and spatio-temporal resolutions.

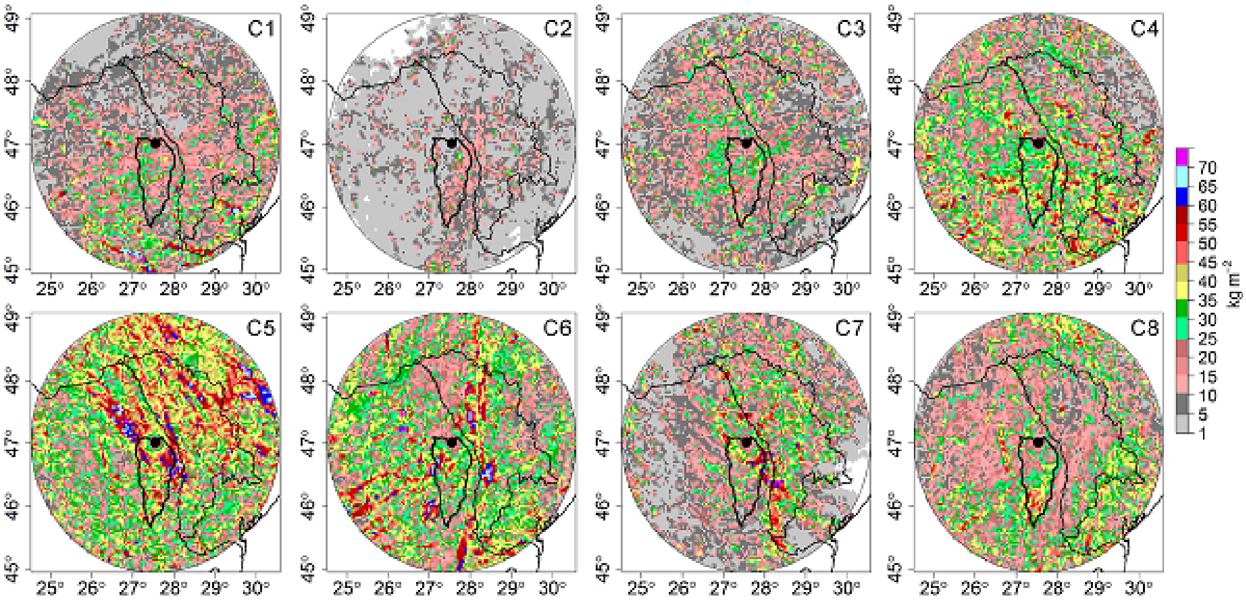


Figure 35: Spatial distribution of maximum VIL values (kg m^{-2}) for each of the eight classes.

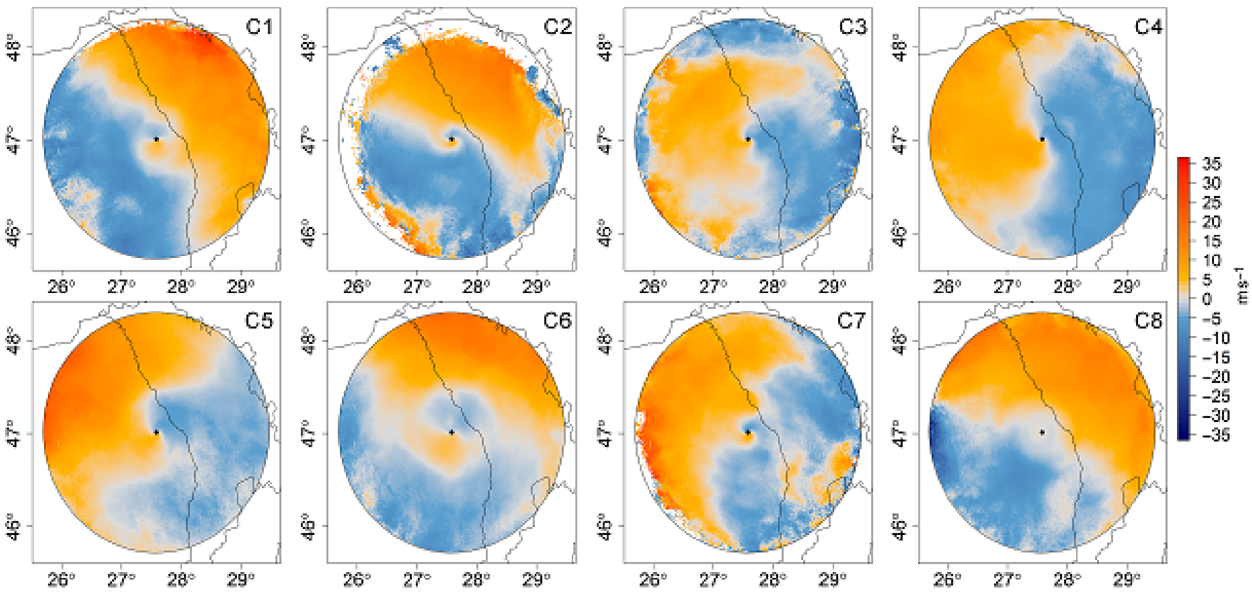


Figure 36: Spatial distribution of mean Doppler radial velocity (m s^{-1}) for each class at 3.4° elevation. Range ring around the radar has 150km radii, implying measurements from 0.6 km at radar location up to 10 km at the margin of the coverage area.

2. Participation of the Romanian specialists in national and international projects/ programs

2.1. International collaboration

♦ **IMDROFLOOD: Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators**, ERA-NET Cofund WaterWorks 2014, 2014-2017 http://imdroflood.meteoromania.ro/

3. Participation of Romanian scientists at international symposia, courses and conferences

European Geosciences Union General Assembly, Vienna, Austria, 17 – 22.04.2016;

16th EMS Annual Meeting & 11th European Conference on Applied Climatology, Trieste, Italy, 12 – 16.09.2016;

International Conference: Environment at a CrossrOards: SMART approaches for a sustainable future, Bucharest, Romania, 12 – 15.11.2015;

15th EMS Annual Meeting & 12th European Conference on Applications of Meteorology, Sofia, Bulgaria, 07 – 11.09.2015;

European Geosciences Union General Assembly, Vienna, Austria, 12 – 17.04.2015.

4. Publications:

5.1. Peer-reviewed ISI publications

Chitu, Z., Bogaard, T., Busuioc, A., Burcea, S., Sandric, I., Adler, M.J., 2017: Identifying hydrological pre-conditions rainfall triggers of slope failures at catchment scale for 2014 storm events in the Ialomita Subcarpathians, Romania, *Landslides*, **14 (1)**, 419–434, doi: 10.1007/s10346-016-0740-4;

Cărbunaru, D., Burcea, S., 2016: Thermodynamic configurations associated with heavy rainfall in Eastern Romania, *Int. J. Climatol.* **36**, 2238-2253, doi: 10.1002/joc.4491;

Cică, R., Burcea, S., Bojariu, R., 2015: Assessment of severe hailstorms and hail risk using weather radar data, *Meteorol. Appl.*, **22 (4)**, 746–753, doi: 10.1002/met.1512;

Burcea, S., Cică, R., Bojariu, R., 2016: Hail climatology and trends in Romania: 1961–2014, *Mon. Wea. Rev.*, **144 (11)**, 4289–4299, doi: 10.1175/MWR-D-16-0126.1.

IUGG

IASPEI

International Association of Seismology and Physics of the Earth's Interior

IASPEI ACTIVITIES IN ROMANIA

2015-2018

NATIONAL REPORT IN SEISMOLOGY AND PHYSICS OF THE EARTH'S INTERIOR

IASPEI ACTIVITIES IN ROMANIA 2015-2018

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FOREWORD

The present report describes the activities carried out in Romania, under the supervision of the "Seismology and Physics of the Earth's" section of the National Romanian Committee of Geodesy and Geophysics, organized in four main domains: Seismology, Structure of the Lithosphere, Engineering Seismology and Heat Flow Studies.

Romania is characterized by moderate-to-high seismic activity, experiencing 3-4 destroying earthquakes per century, located at the Carpathian Arc Bend, in the Vrancea region, in a particularly confined focal volume at intermediate depths. The strong earthquakes generated here are significantly affecting extended areas in Europe. From time to time, earthquakes in the 5-6 magnitude range are generated in the crustal domain, as well, mostly in the regions of contact between platform and orogen zones.

Since Seismology is a data-driven science, special efforts were made in the last decade to develop and improve the data management, including acquisition, processing and rapid exchange of seismic information. The National Institute for Earth Physics is operating now a network of 152 seismic stations connected in real time to the National Data Centre in Bucharest. Part of the stations belongs to GEOFON network (one station), VEBSN network (6 stations) and AFTAC (one array) and is continuously exchanging data with other seismological centres. This network is designed first to monitor natural and induced seismicity, and to rapid disseminate high-level information in case of large earthquakes. At the same time, a strong motion network of 46 high quality digital accelerometers is operating in Romania.

In the field of **Seismological Research and Seismic Monitoring**, important achievements were obtained during 2015-2018 period in the following domains:

- historical seismology and macroseismology;
- monitoring of natural and induced seismicity and early warning;
- seismic source physics;
- wave propagation;
- seismotectonics;
- geohazards;
- earthquake forecasting.

In the field of **Lithosphere Structure** the most significant results are referring to the deep structure of the lithosphere, determined from seismic data correlated with the available geological, geophysical and geodetic data.

In the field of **Engineering seismology** significant efforts were made to predict the peak values and spectral characteristics of the strong motion in large urban areas, like Bucharest. At the same time, important efforts were made to determine the site effects and microzonation maps for most of the cities from Romania.

In the frame of **Heat Flow Studies**, the geothermal structure and evolution of the lithosphere in various tectonic units, as well as problems of borehole climatology, such as inversion of borehole temperature data and air-soil heat transfer, were tackled.

Dr. Mircea RADULIAN

PART I: MONITORING OF NATURAL AND INDUCED SEISMICITY

The National Institute for Earth Physics (NIEP) operates a real-time seismic network designed to monitor the seismic activity on the Romanian territory, dominated by the Vrancea intermediate-depth (60-200 km) earthquakes.
The reduction of earthquakes impact on society is conditioned by the existence of a large number of high-quality observational data. The development in the last few years of the seismic network and of an advanced acquisition system are essential factors to achieve this goal.
Starting with 2002 the modernization of Romanian seismic network was based on the installation of new seismic stations acquired in real time. This network consists of digital seismic stations equipped with acceleration sensors (EpiSensor) and velocity sensors (broadband – STS2, CMG3ESP, KS2000, CMG40-T or short period – MP, SH-1, S13, Mark Product, etc).
The real-time digital seismic network consists of 152 seismic stations with three components and 2 arrays: BURAR with 12 elements and PLOR with 7 elements. All data recorded by this network are transmitted in real time at NIEP for automatic data processing, analysis and dissemination. The seismic stations locations and equipment characteristics for the real-time Romanian Seismic Network are shown in Table 1.

Table 1: Real-time stations existing in Romania

Station	LAT	LON	ALT	Station Name	Digitizer Type
ARR	45.3657	24.6332	924	Vidraru	Q330 Digitizer
BZS	45.6188	21.6401	260	Buzias	Q330 Digitizer
CJR	46.7133	23.5981	750	Cluj	Q330 Digitizer
GHRR	46.0605	27.408	209	Gohor	Q330 Digitizer
ISR	45.1187	26.5432	791	Istrita	Q330 Digitizer
CFR	45.178	28.1362	57	Carcaliu	Q330 Digitizer
AMRR	44.6102	27.3351	86	Amara	Q330 Digitizer
BISRR	45.5481	26.7099	866	Bisoca	Basalt Digitizer
BMR	47.6728	23.4969	227	Baia Mare	Q330 Digitizer
BUR01	47.6148	25.2168	1150.6	Bucovina Array	AIM24S Digitizer + Q330 Digitizer
BUR05	47.6326	25.2176	1184.8	Bucovina Array	AIM24S Digitizer + Q330 Digitizer
BUR32	47.633	25.1805	1397	Bucovina Array	Q330 Digitizer
CVD1	44.3207	28.0624	50	Cernavoda_1	Q330 Digitizer
DEV	45.887	22.898	249	Deva	Q330 Digitizer
ICOR	44.1168	27.8009	121	Ion Corvin	Q330 Digitizer
KIS	46.9975	28.8175	255	Chisinau	Q330 Digitizer
LEOM	46.4733	28.2467	54	Leova	K2 Digitizer
MDVR	44.7815	21.7128	720	Moldovita	Q330 Digitizer
MFTR	44.1779	28.4224	980	Murfatlar	Q330 Digitizer
OZUR	46.0956	25.7862	676	Ozunca	Q330 Digitizer
PLOR1	45.852	26.6466	706	Plostina Array	Q330 Digitizer
PLOR2	45.8502	26.6437	701	Plostina Array	Q330 Digitizer
PLOR3	45.854	26.6455	722	Plostina Array	Q330 Digitizer
PLOR5	45.8455	26.6635	650	Plostina Array	Q330 Digitizer

PLOR6	45.842	26.6416	720	Plostina Array	Q330 Digitizer
PLOR7	45.8603	26.6405	831	Plostina Array	Q330 Digitizer
PURM	46.5293	29.8723	40	Purcari	Q330 Digitizer
SCHL	45.5007	27.8302	520	Schela	Q330 Digitizer
SIRR	46.2653	21.663	544	Siria	Q330 Digitizer
SORM	48.135	28.3513	640	Sorm	Q330 Digitizer
TLBR	44.5445	28.0467	115	Topalu	Q330 Digitizer
VOIR	45.4371	25.0495	966	Voina	Q330 Digitizer
ADJ	46.0952	27.182	100	Adjud	K2 Digitizer
ASE	44.4445	26.0904	850	ASE-Bucuresti	K2 Digitizer
BAC	46.5669	26.9124	169	Bacau	K2 Digitizer
BBER	44.3085	26.1899	112	Berceni	K2 Digitizer
BDTR	44.4142	26.0224	67	Bucuresti Gradinita Dr. Taberei	K2 Digitizer
BFER	44.4049	26.0771	86	Ferentari	K2 Digitizer
BISC	44.4328	26.2135	125	Bucuresti Catelu	K2 Digitizer
BPLR	44.43	26.05	132	Politehnica Bucuresti	K2 Digitizer
BPO	44.4483	26.1378	143	ISU-Bucuresti Pompieri	K2 Digitizer
BTMR	44.437	26.1067	142	Geotec	K2 Digitizer
BUZR	45.1503	26.8099	141	Buzau	K2 Digitizer
BVCR	44.4301	26.1017	109	Bucuresti-Curtea Veche	K2 Digitizer
BVES	44.3862	26.1069	114	Bucuresti Gradinita Veseliei	K2 Digitizer
CLIR	44.3784	25.9414	84	Clinceni	K2 Digitizer
CLISU	44.1901	27.3557	590	ISU Calarasi	Basalt Digitizer
CNCR	44.4439	26.2619	105	Cernica	K2 Digitizer
COR	44.4656	26.0315	127	Giulesti	K2 Digitizer
CTISU	44.184	28.6491	740	ISU Constanta	Basalt Digitizer
CVDP	44.3421	28.033	62	Cernavoda Primarie	K2 Digitizer
DJISU	44.2971	23.8363	160	ISU Dolj	Basalt Digitizer
DTIR	44.4527	26.0717	84	Niculaie Titulescu	K2 Digitizer
FOC	45.7032	27.1906	86	Focsani	K2 Digitizer
GRISU	43.8898	25.9518	660	ISU Giurgiu	Basalt Digitizer
GSMB	44.4813	26.0273	89	Bucuresti-Gradinita	K2 Digitizer
INMR	44.5118	26.0773	104	INMH Bucuresti	K2 Digitizer
MHISU	44.6227	22.6535	102	ISU Mehedinti	Basalt Digitizer
OTISU	44.4278	24.3755	210	ISU Olt	Basalt Digitizer
PPC	44.9314	26.0201	154	Ploiesti-Protectia Civila	K2 Digitizer
PRAR	47.3616	26.2276	451	Petru Rares	Q330 Digitizer
SGEB	44.3812	26.1369	80	Bucuresti-Scoala	K2 Digitizer
TRISU	43.9719	25.3296	870	ISU Teleorman	Basalt Digitizer
BAIL	44.0201	23.345	100	Bailesti	Basalt Digitizer
BANR	45.3828	21.137	159	Banloc	Q330 Digitizer

COPA	44.1343	25.2172	114	Copaceanca	Basalt Digitizer
DRGR	46.7917	22.7111	923	Valea Draganului	Q330 Digitizer
EFOR	44.075	28.6323	103	Eforie	Basalt Digitizer
HERR	44.881	22.416	246	Herculane	Q330 Digitizer
HUMR	44.5281	24.9804	247	Humele	Q330 Digitizer
IAS	47.1931	27.553	195	Iasi	Q330 Digitizer
LEHL	44.4739	26.8194	900	Lehliu	Basalt Digitizer
MANR	43.8168	28.5876	72	Mangalia	Basalt Digitizer
NEHR	45.4272	26.2952	584	Nehoiu	Basalt Digitizer
PETR	45.723	27.2311	85	Petresti	K2 Digitizer
PUNG	44.2782	22.9325	131	Punghina	Basalt Digitizer
RASA	44.2144	27.1493	500	Rasa	Basalt Digitizer
SRE	44.6609	23.2038	386	Strehaia	Basalt Digitizer
SULR	44.6777	26.2526	129	Surlari	Q330 Digitizer
VASR	46.6415	27.7911	275	Vaslui	Basalt Digitizer
VLAD	43.9986	24.4038	138	Vladila	Basalt Digitizer
BURAR/BUR31	47.644	25.2002	1216.9	Bucovina Array	AIM24S Digitizer
TLCR	45.1861	28.8151	74	Tulcea	Q330 Digitizer
BAPR	44.4059	26.119	103	Bucurest - Parcul Copiilor	K2 Digitizer
BIR	46.2334	27.6436	168	Birlad	Q330 Digitizer
BSTR	44.4458	26.0984	125	Bucuresti-COS	K2 Digitizer
BUC	44.4107	26.0938	95	Bucuresti Cutitul de Argint	Makalu Digitizer
BUC1	44.3479	26.0281	120	Bucuresti Magurele	K2 Digitizer
CEI	47.6933	22.4619	169	Carei	Q330 Digitizer
CRAR	44.325	23.7999	125	Craiova	Q330 Digitizer
CVDA	44.3336	28.0374	43	Cernavoda	Q330 Digitizer
GISR	45.4411	28.0541	67	Galati ISU	K2 Digitizer
GIUM	45.485	28.2081	102	Giurgiulesti	K2 Digitizer
INCR	44.441	26.1611	145	Bucuresti Incerc	Q330 Digitizer
JOSR	46.7059	25.5154	749	Joseni	Q330 Digitizer
MDB	46.1497	24.3765	423	Medias	K2 Digitizer
PLAR	44.9142	26.0274	212	Ploiesti Astra	Q330 Digitizer
RMGR	44.6627	22.6922	119	Halanga	Q330 Digitizer
RMVG	45.0363	24.2848	264	Ramnicu Valcea	K2 Digitizer
TNR	45.652	24.273	519	Turnu Rosu	Q330 Digitizer
TSCT	44.1608	28.6572	70	Contanta - Port	Q330 Digitizer
TSMN	43.8011	28.595	70	Mangalia - Port Far Verde	Q330 Digitizer
TSSL	45.1621	29.7269	68	Sulina	Q330 Digitizer
TUDR	45.5939	27.6687	33	Tudor Vladimirescu	Q330 Digitizer
BIZ	46.9387	26.1029	549	Bicaz	Q330 Digitizer
TPGR	44.8565	28.4196	449	Topolog	Q330 Digitizer
ODBI	45.7633	27.0558	226	Odobesti	Q330 Digitizer

ZIMR	43.6572	25.3652	88	Zimnicea	Q330 Digitizer
GIRR	46.9551	26.5009	334	Girov	Q330 Digitizer
GRER	45.3801	26.9747	287	Greabanu	Q330 Digitizer
HARR	44.6893	27.9303	123	Harsova	Q330 Digitizer
JURR	44.7661	28.8769	37	Jurilovca	Makalu Digitizer
MTUR	45.2349	25.0739	1083	Matau	Q330 Digitizer
PGOR	44.9199	26.9768	102	Pogoanele	Q330 Digitizer
PRAR	47.3616	26.2276	451	Petru Rares	Q330 Digitizer
SECR	45.0355	26.0677	420	Seciu	K2 Digitizer
SGRR	44.2228	25.9743	115	Singureni	Makalu Digitizer
SIBR	45.8099	24.1757	463	Sibiu	Makalu Digitizer
STFAR	44.8629	24.9609	495	Stefanesti	Q330 Digitizer
TIM	45.7365	21.2211	134	Timisoara	K2 Digitizer
VARL	45.8996	27.8487	123	Varlezi	K2 Digitizer
ARCR	47.0855	24.3537	356	Arcalia - Bistrita Nasaud	Q330 Digitizer
DOPR	45.9675	25.3886	544	Dopca	Q330 Digitizer
GZR	45.3933	22.7767	850	Gura Zlata	Q330 Digitizer
LOT	45.446	23.7698	1361	Lotru	Q330 Digitizer
MILM	46.9186	28.8127	640	Milesti	Q330 Digitizer
MLR	45.4909	25.945	1392	Muntele Rosu - Romania	Q330 Digitizer
PLOR/PLOR4	45.8512	26.6498	680	Plostina Array	Q330 Digitizer
TESR	46.5118	26.6489	375	Tescani	Q330 Digitizer
TIRR	44.4581	28.4128	77	Targusor	PS6-24 Digitizer
VOIR	45.4371	25.0495	966	Voina	Q330 Digitizer
VRI	45.8657	26.7277	475	Vrancioaia	Q330 Digitizer
BUR02	47.6187	25.2209	1142.9	Bucovina Array	AIM24S Digitizer
BUR03	47.6085	25.2179	1205.3	Bucovina Array	AIM24S Digitizer
BUR04	47.6182	25.2122	1162.4	Bucovina Array	AIM24S Digitizer
BUR06	47.6169	25.2444	1213.1	Bucovina Array	AIM24S Digitizer
BUR07	47.6427	25.2324	1230.8	Bucovina Array	AIM24S Digitizer
BUR08	47.6441	25.2003	1215.4	Bucovina Array	AIM24S Digitizer
BUR09	47.6164	25.1901	1256.9	Bucovina Array	AIM24S Digitizer
IPH2	45.8502	26.6437	701	Infrasound Plostina	Q330 Digitizer
IPH3	45.854	26.6455	722	Infrasound Plostina	Q330 Digitizer
IPH4	45.8512	26.6498	672	Infrasound Plostina	Q330 Digitizer
IPH5	45.8455	26.6635	650	Infrasound Plostina	Q330 Digitizer
IPH6	45.842	26.6416	720	Infrasound Plostina	Q330 Digitizer
IPH7	45.8603	26.6405	831	Infrasound Plostina	Q330 Digitizer

The remote seismological stations have three-component seismometers for weak motions and three-component accelerometers for strong motion. In cooperation with the Institute of Geophysics and Seismology Kishinev, Republic of Moldova, we installed five seismic stations in Republic of Moldova at Leova (LEOM), Giurgiulesti (GIUM), Milestii Mici (MILM), Kishinev (KIS) and Soroca (SORM). All the data from the seismic from the seismic stations installed on the Republic of Moldova territory are received in real time at NIEP Data

Centre using seedlink connection.

The primary goal of the real-time seismic network is to provide earthquakes parameters from more broadband stations with high dynamic range in order to compute more rapidly and with better accuracy the location and magnitude of the earthquakes. Seedlink and Antelope™ program packages are used for real-time (RT) acquisition and data exchange (Popa et al., 2015).

The real-time digital seismic network developed by NIEP is represented in Figure 1. Near-future strategy includes installing additional broad band stations in the central and western part of Romania and other 40 strong motion stations in Bucharest city.

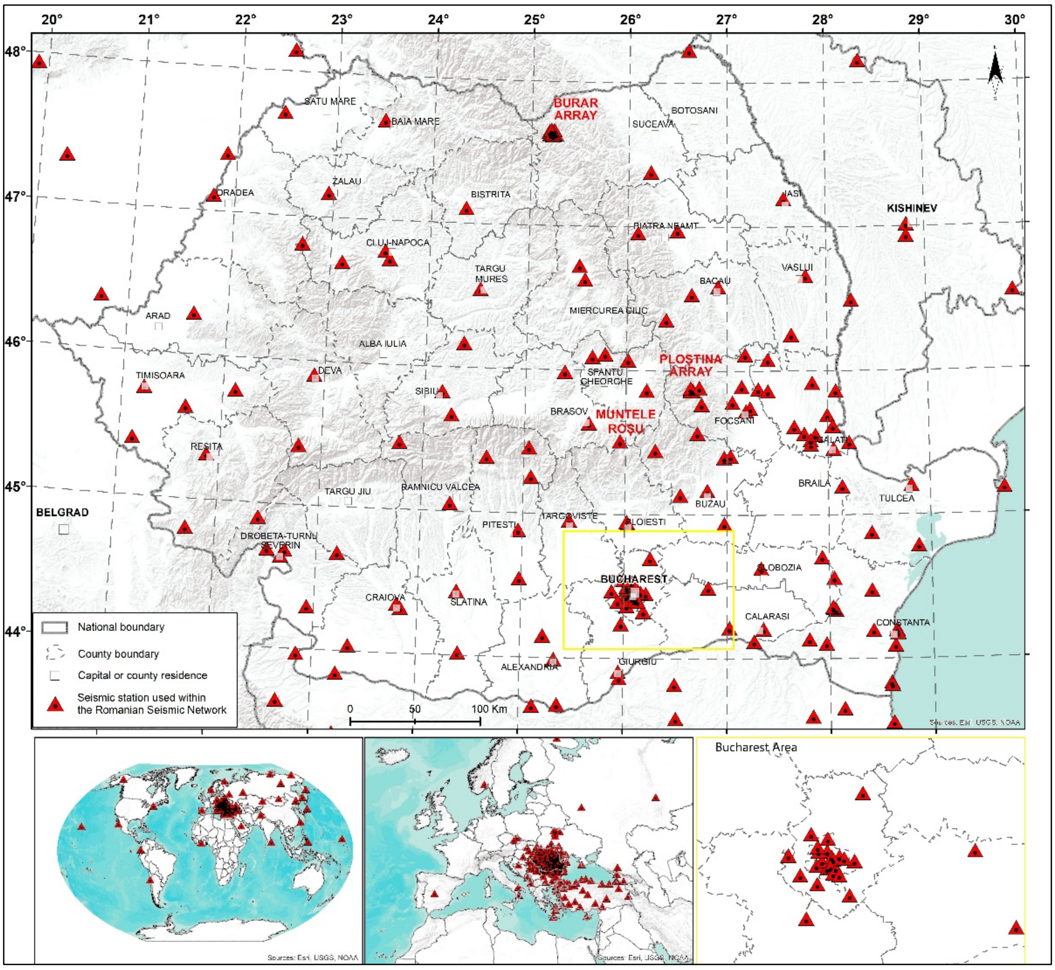

Figure 1: Real Time Seismic Network of Romania

A completely automated seismological system Antelope (developed by BRTT) (Figure 2) runs at the Data Center in Magurele. The Antelope™ data acquisition and processing software run on two workstations for real-time and post processing. The Antelope real-time system provides automatic event detection, arrival picking, event location and magnitude calculation. It provides graphical display and automatic location within near real-time after a local, regional or teleseismic event occurred (Neagoe et al., 2016).

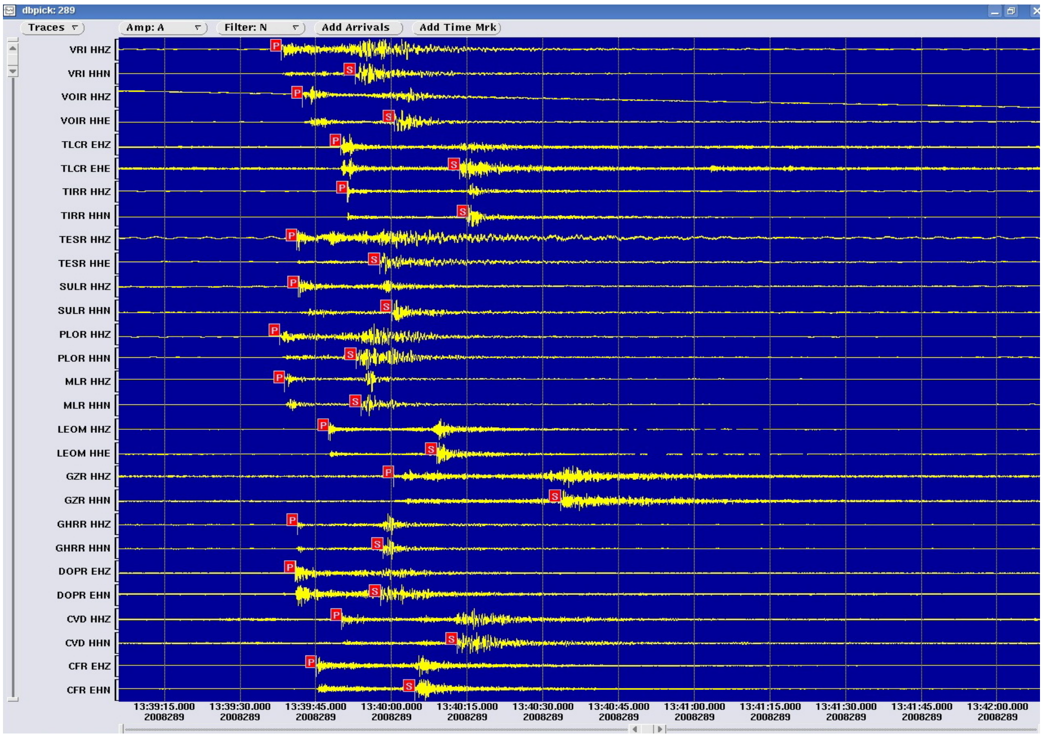

Figure 2: Example of manual data processing with Antelope software

SeisComP 3, another automated system, has been running at NIEP since 2014 providing the following features: data acquisition, data quality control, real-time data exchange, network status monitoring, real-time data processing, issuing event alerts, waveform archiving, waveform data distribution, automatic event detection and location, easy access to relevant information about stations, waveform and recent earthquakes (Figures 3 and 4).

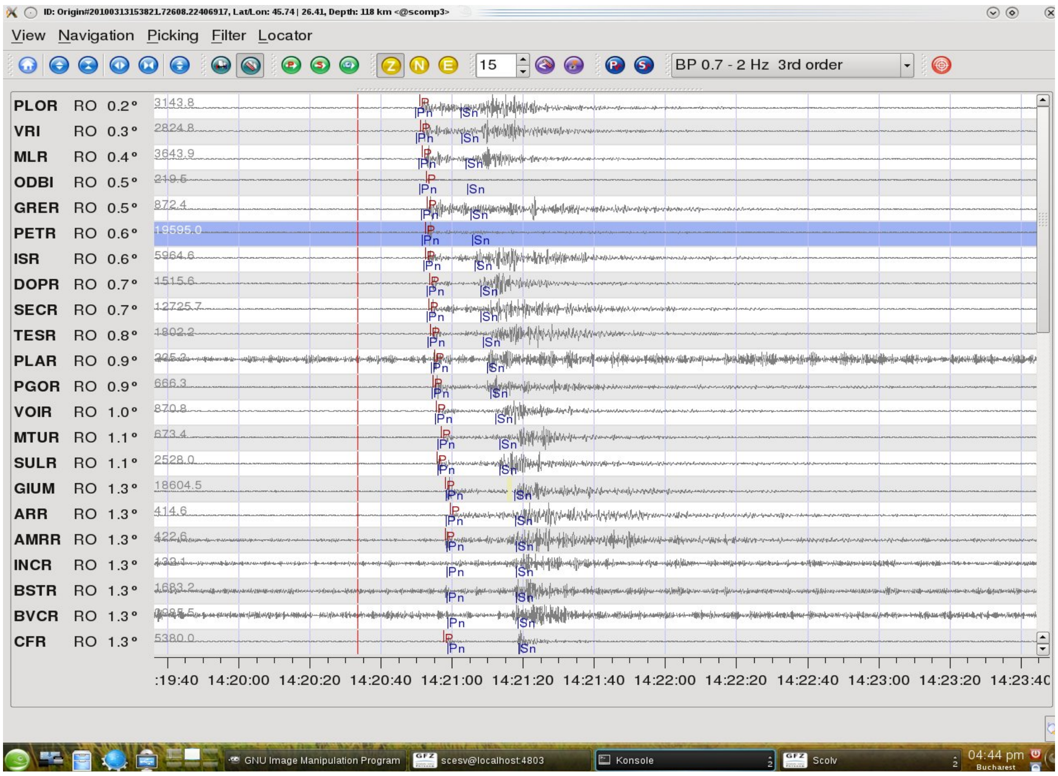

Figure 3: Automatic detection using SeiscomP 3 Software

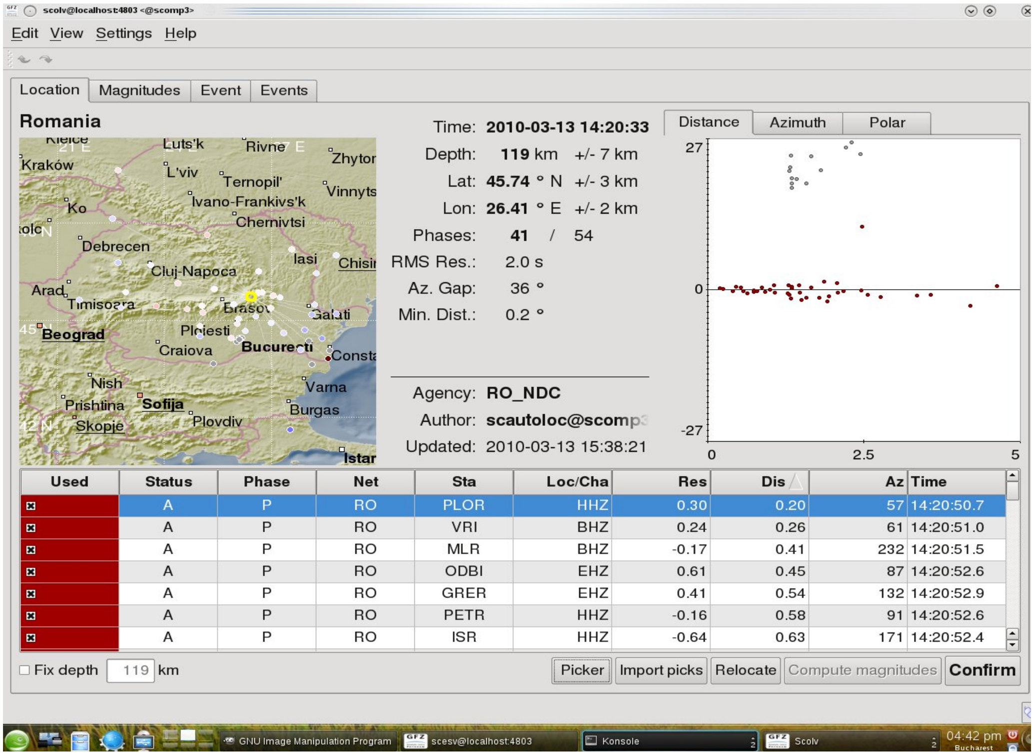

Figure 4: Seismic data processing using SeiscomP 3 Software

The Romanian Seismic Network exchanges data with international organizations like ORFEUS and IRIS and with data centers from other European countries via Internet. The provided data consist in near real-time waveform data from 6 broadband stations: Iasi (IAS), Dragan (DRGR), Craiova (CRAR), Bucharest (BUC1), Vrincioaia (VRI), Muntele Rosu (MLR) and Bucovina (BURAR) array (Figure 5).

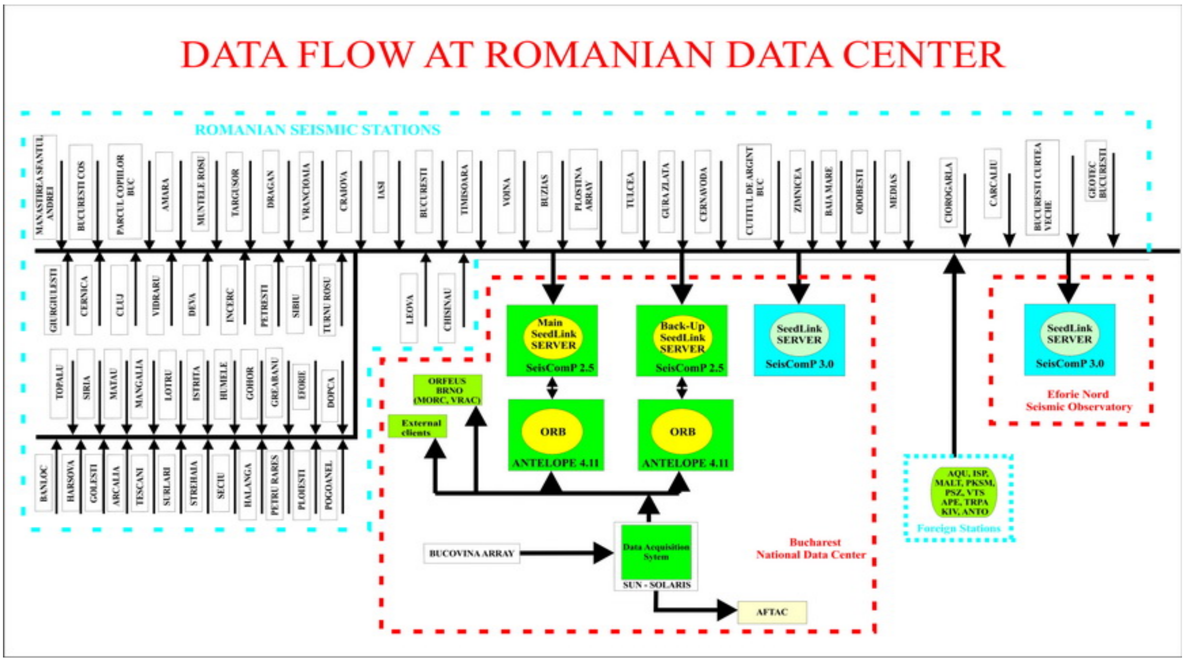

Figure 5: Data Flow at Romania Data Center

For automated data acquisition from seismic stations at NDC two servers are used, one main server which use Antelope 5.7 software and the second one with Seiscomp 3 program,

considered as back-up. For data acquisition at seismic stations we use for 34 stations Antelope 8.0.2 program who runs on a pc light called Marmot and for other 118 stations a seedlink server is used from the SeisComP 3 package. For data acquisition from the seismic stations we use seedlink protocol from Seiscomp 3 package with chain pluggin or orb pluggin.
Both systems produced information about local and global parameters of earthquakes. In addition, Antelope is used for manual processing (association events, magnitude computation, database, sending seismic bulletins, calculation of PGA and PGV, etc.), generating ShakeMap products and interacts with international data centers.
In order to make all this information easily available across the Web and to establish a more modular and flexible development environment, the National Data Center has developed tools to enable centralizing of seismological data from software such Antelope. Because Antelope is using a dedicated database system (Datascope, a database system based on text files) we moved the data to a more general-purpose database, Mysql, which acts like a hub between different acquisition systems used in the data center. Mysql database also provides better connectivity at no expense in security (Figure 6).

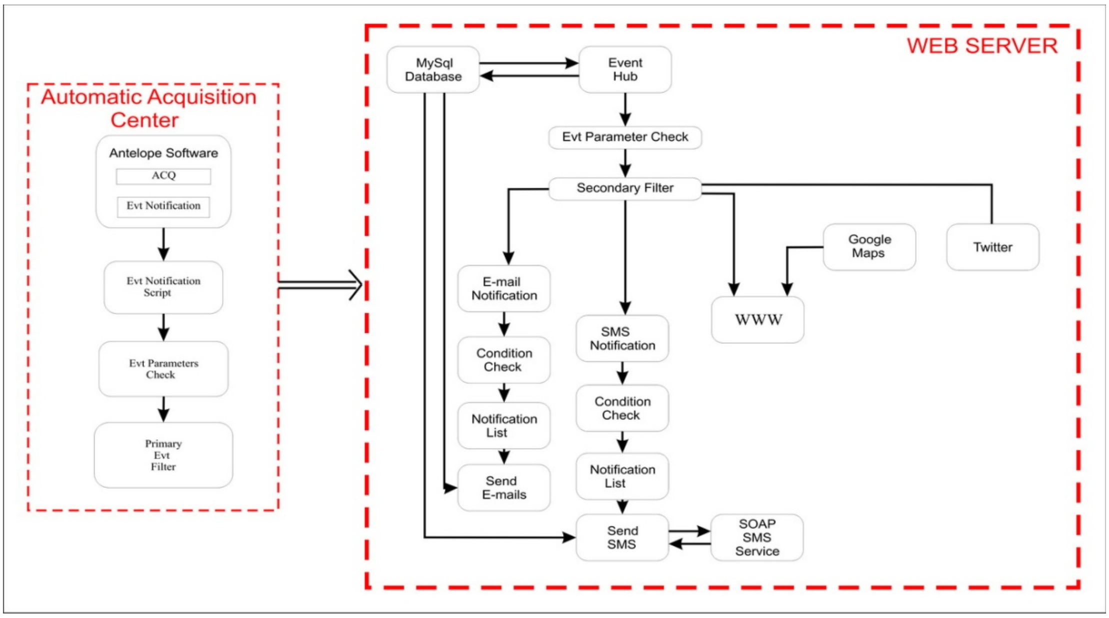

Figure 6: Web Server Configuration

Mirroring certain data to MySQL also allows the National Data Center to easily share information to the public via the new application which is being developed and also mix in data collected from the public (e.g. information about the damage observed after an earthquake which internally is being used to produce macroseismic intensity indices which are then stored in the database and also made available via the web application). For internal usage, there is also a web application which uses data stored in the database and displays earthquake information like location, magnitude and depth in semi-real-time.
Another usage of the data collected is to create and maintain contact lists to which the data center sends notifications (SMS and emails) based on the earthquake parameters.
Lately, improvements have been made to get rapid evaluation of the source parameters (location, moment tensor) by implementing optimized applications (Craiu et al., 2015; 2016 a, b; 2017 a, b; Ionescu et al., 2016; Lizurek et al., 2017; Neagoe et al., 2017; Tataru et al., 2017). At present an Early Warning System is operational for earthquakes located in Romania (Marmureanu et al., 2015a, b; Behr et al., 2016; Clinton et al., 2016). Investigations were made to characterize seismic station sites on the basis of geology inestigation and ambient noise analysis (Grecu et al., 2016; 2018; Constantinescu et al., 2017).

Impetuous development of the seismic network let to a significant improvement of the monitoring (Ardeleanu and Neagoe, 2016 a, b) and decrease of the magnitude threshold for detecting seismic events. This is why, the weight of artificial events has tremendously increased in the Romanian routine catalogue (Romplus). Consequently, several discrimination techniques have been proposed to filter the catalog (Stancu et al., 2015; 2016; Borleanu et al., 2016; Ghica et al., 2016; Dinescu et al., 2018).
NIEP has more than 25 years of experience in global seismological monitoring in support of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). It is participating to the international verification activities with the seismic station Muntele Rosu, which was included in the auxiliary seismic network of the International Monitoring System, and with the operation of the Romania's National Data Centre (NDC). In order to ensure Romania's technical contribution to CTBT at the operational standards required by the Treaty, since 1999 an important upgrade has been under development both at the seismic station Muntele Roşu and at the NDC, involving both technical cooperation with the Government of Japan and technical assistance from the CTBT Organization. Hence, in the fall of 2001 a new seismic monitoring system was installed and is now fully operational, by recording continuous earth motion data at Muntele Rosu site and transmitting these data in real-time to the facilities in Bucharest, in the framework of the Japan International Cooperation Agency project „Technical Cooperation for Seismic Monitoring System in Romania".

Plostina seismo-acoustic array is located in the central part of Romania, in Vrancea region, (Figure 7). The array deployment started in 2007, when four seismic elements (PLOR1, PLOR2, PLOR3 and PLOR4) were installed. In 2009, two more seismic sites (PLOR 5 and PLOR6) were added, and the infrasound array deployment was initiated, by placing of three infrasonic instruments (IPH4, IPH5 and IPH6), collocated with the corresponding seismic locations. In 2010, another seismo-acoustic element (PLOR 7 and IPH7) was added and during 2012, sites 2 and 3 where equipped with infrasound sensors. Plostina seismo-acoustic array is currently distributed over an area of 3.5 km^2.

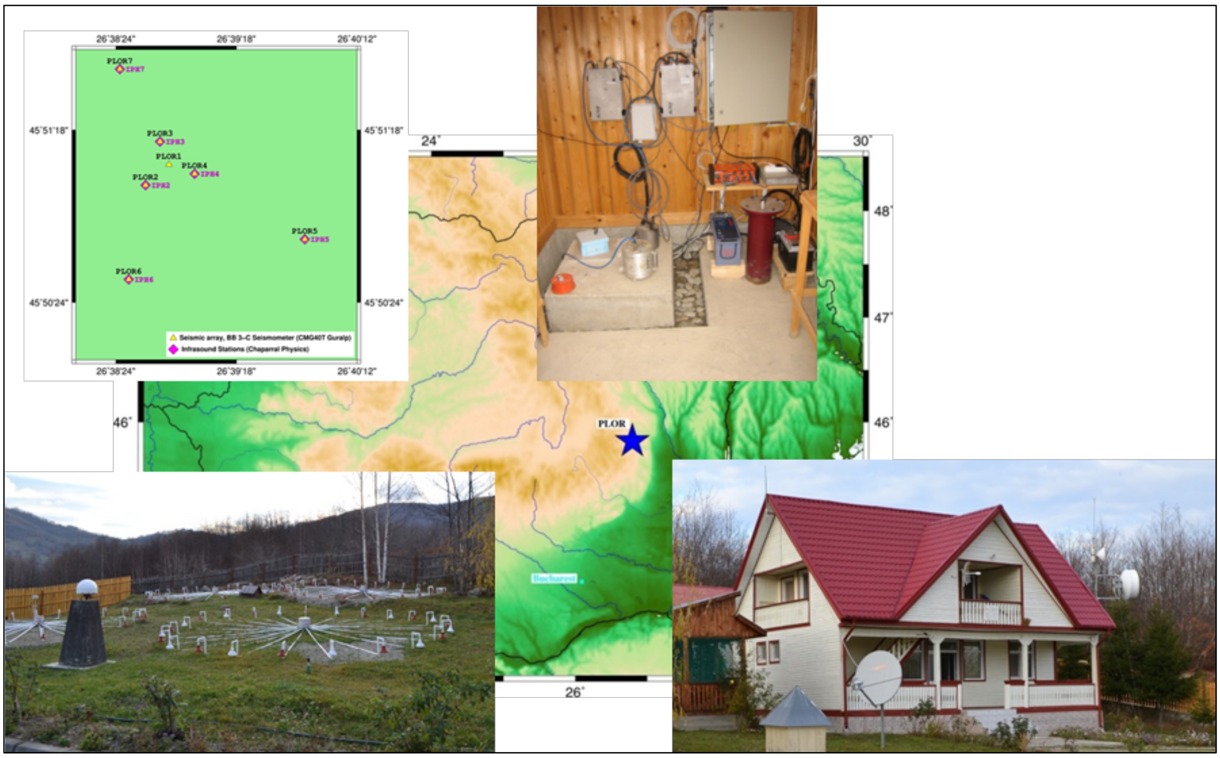

Figure 7: Plostina Observatory and elements of integrated system operating in the area (PLOR* - seismic array, IPH* - infrasonic array)

Presently, at Plostina, NIEP operates an integrated system (Figure 8) which includes advanced technologies such as: seismic and infrasound arrays, strong motion sensors, magnetic field and electric field monitoring, soil temperature measuring, and a weather station. The main applications of this system are:

- monitoring of the local microseismic activity
- acoustic measurement (infrasound monitoring of explosions, mine and quarry blasts, volcanic eruptions, earthquakes, aircraft etc.) (Stancu et al., 2015a, b)
- observation of the magnetic field variation in correlation with solar activity
- observation of the variation of radioactive alpha gases concentration
- observation of the variation of telluric currents.

Since July, 2002, a new seismic monitoring system, **Bucovina Seismic Array (BURAR)**, has been established in the Northern part of the country (Figure 7), in a joint effort of the Air Force Technical Applications Center (AFTAC), USA and NIEP. Data recorded by BURAR array are continuously transmitted in real time to the National Data Center of USA in Florida and to NDC, in Magurele. BURAR seismic array consists of 10 seismic stations located in boreholes and distributed over an area of 5 km^2. Nine stations are equipped with short-period vertical sensors (GS-21) and one station is equipped with broad-band three-component sensor (KS 54000).

In 2008 five new elements equipped with 3-C broadband sensors were installed aiming to obtain the most convenient array combination of 3-C elements for the recording and identification of the secondary seismic phases, to optimize the array response, achieving a superior sensitivity and resolution of BURAR in S-type seismic signals identification.

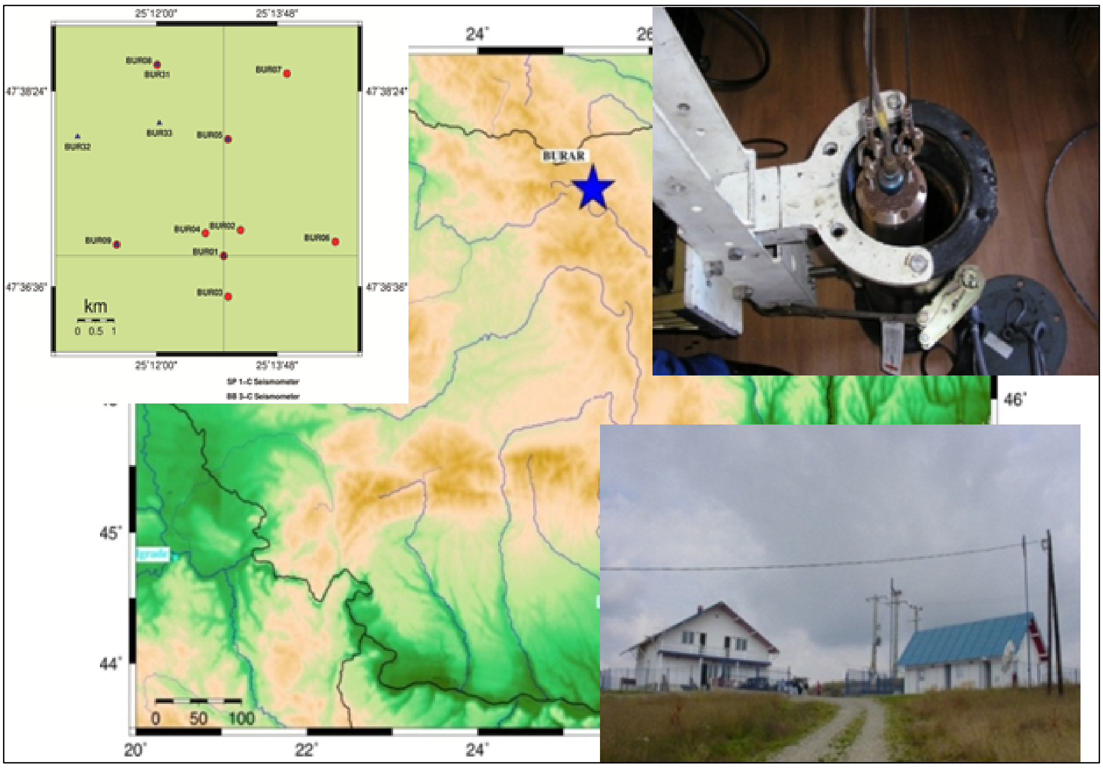

Figure 8: Bucovina Observatory (BURAR) and array elements distribution

The NIEP GPS Permanent Network

The development of the Romanian GNSS/GPS (Global Navigation Satellite System/Global Positioning System) network started in 2001 when the first permanent station was installed at

Lăcăuţi. Since then, the network has grown to 22 active stations and is still expanding (Figure 9). The main purpose is to monitor the seismically induced movement, to determine the surface velocity in the studied regions and to correlate the surface kinematics with land processes (Muntean et al., 2017; Nastase et al., 2017; Zoran et al., 2017). GPS observed surface motion, combined with other independent geophysical investigations can support understanding and modeling of the ongoing processes in the study areas. The global nature of GPS makes possible to determine and monitor surface's vertical and horizontal components of displacements with high accuracy, which is needed for these studies. Repeated measurements over a long time span make the technique suitable for detecting the surface movements. The 20-Hz-sampling displacements for earthquakes that may occur in the Vrancea area represent important recordings for investigating coseismic contributions at frequencies higher than 1Hz.

Figure 9: GPS network settlements

The network was established as a result of an international research project based on a strategic partnership between: the National Institute for Earth Physics (NIEP), the Faculty of Geology and Geophysics – University of Bucharest (FGG), Delft University of Technology, the University of Utrecht and the Netherlands Research Center for Integrated Solid Earth Sciences (ISES) and, more recently, with TopGeocart company.
The stations have mixed equipment, a vast majority of it being produced by Leica Company: GRX1200GGPro and the GRX1200 + GNSS receivers type and antenna models LEIAT504, LEIAT504GG, LEIAR10 and LEIAX1202GG. We also operate 3 stations with Septentrio equipment. During the 2014, we used our newest Leica GR10 receiver in order to put in real-time our oldest station LACP. In the meantime, replacements of the old CRS 1000 and SR530 receivers took place. Attached below (Figure 10) one can see details about the equipment used, the locations, settlement and other pieces of information. Moreover, NIEP is equipped with Leica GRX 1230 and SR530 campaign receivers.

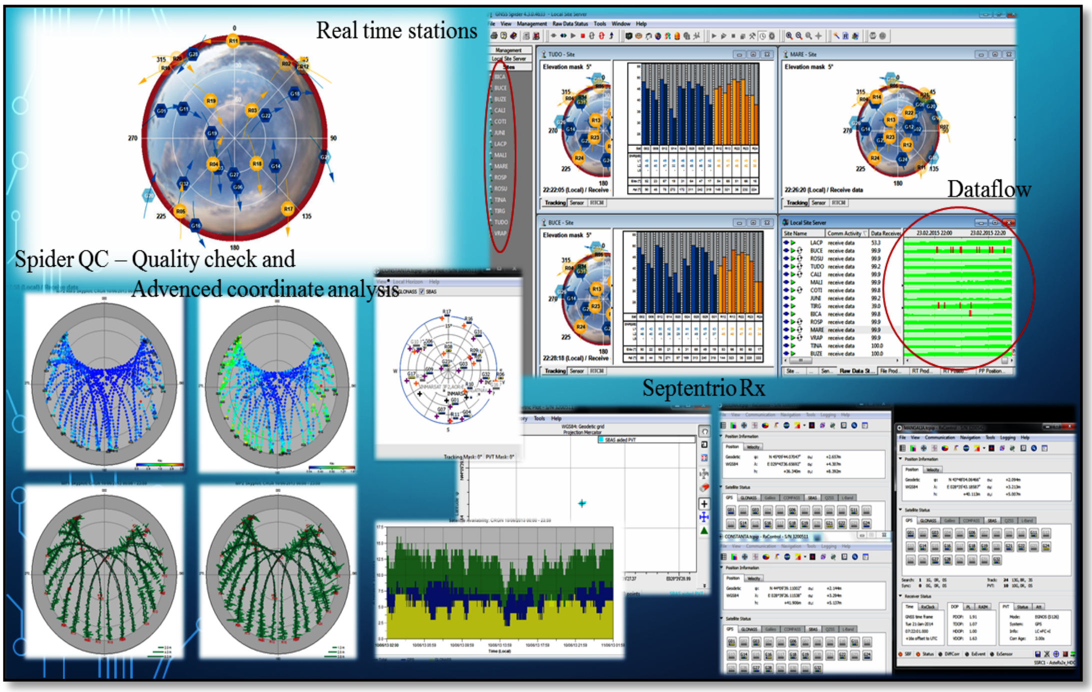

Figure 10: Software applications

Data acquisition is achieved in real time, in RAW DATA format and RINEX format, using Leica GNSS Spider and Septentrio Rx software. Furthermore, 8 of the network's stations simultaneously record Ring Buffer data on receiver's internal memory at a rate of 20 Hz. (0.05s).
Regarding post-processing, an agreement has been reached between NIEP and Jet Propulsion Laboratory ("JPL"), the latter is an operating division of the California Institute of Technology, regarding the following software license: GIPSY OASIS NPO – GPS Inferred Positioning System Orbit Analysis and Simulation Software. This license is available and will be used by the National Seismic Network Laboratory, with the purpose of monitoring crustal deformations by using GNSS data on Romanian territory. This is the basic software used to achieve data availability for the entire working period (Figure 5), time series and displacement vectors. More recently, LGO software (Leica Geo Office), GLab (developed by ESA-European Space Agency) and RTKLIB (Open Source Package) have been used for complementary purposes.

Among the most significant achievements in the past years we mention:

- A fully automated and networked system dedicated to digital acquisition and real-time processing of seismological data, as well as to rapid exchange of earthquake information has been implemented. At present, NIEP participates with 6 BB stations to the Virtual European Broadband Network and is ready to significantly increase its contribution to the objectives of the research infrastructures integrating activity, one of the main domains of the Structuring the European Research Area.
- The Romanian Earthquake catalogue (ROMPLUS) comprises updated, complete, user-friendly and rapidly accessible earthquake information. The catalog refers to earthquakes occurred in Romania and at the neighbour boundaries since 984 up to present, including information related to locations and other source parameters, as well as links to waveforms of strong earthquakes. Seismicity analysis is continuously performed implying updating of the earthquake catalogue, spatial-temporal-magnitude patterns in different seismic regions of Romania, earthquake sequences. Interpretation and reconsidering of historical data constitute an important issue for the seismic hazard investigation.
- Field investigations of microearthquakes and earthquake sequences;
- Research on natural and induced seismicity.

Future Developments of the Romanian Monitoring Network

The Romanian Seismic Network will be enlarged by the installation of new stations that will provide seismic data in real-time to the data center. The upgraded network will provide new data for site effects studies and microzonation purposes and will be used for developing and evaluations of the Shakemaps for all country and in the Bucharest area.
For future development, amongst others, the data center plans to compare the locations provided by Antelope 5.7 and Seiscomp3 using the same velocity global model.

Acknowledgements. *This report has been prepared by Dr. Alexandru Marmureanu, Eduard Nastase, Dr. Dragos Toma Danila, Dr. Mihaela Popa and Dr. Daniela Ghica*

PART II: SEISMOLOGY

The National Institute for Earth Physics (NIEP, http://www.infp.ro) is the leading institution for seismology in Romania, responsible for the earthquake monitoring of the territory and basic and applied researches in seismology. It was established in 1977 as an organization for research and development in Earth sciences. Now it is coordinated by the Romanian Ministry for Education and Scientific Research, being mainly financed by contracts from public sources. It has a wide background in earth sciences research, with focus on seismic source and seismotectonics, hazard assessment and earthquake forecasting.
The seismological research in Romania during 2015-2018 time interval has been focused on seven main directions:

1) **historical seismology and macroseismology**
2) **seismic source physics**
3) **wave propagation**
4) **seismotectonics**
5) **hazard assessment**
6) **earthquake forecasting**

Since Romania is an earthquake prone area, it is of crucial importance to obtain quantitative information needed for seismic risk mitigation and related public policies and seismic safety measures. The most damaging earthquakes in Romania concentrate in Vrancea region, located at the sharp bend of the Eastern Carpathians chain, in a well-confined focal volume at intermediate depths (60 to 200 km). The extremely peculiar seismotectonics and geodynamic processes in this area focused the attention of numerous seismologists. At the same time, taking into consideration the dramatic social and economical implications of the Vrancea earthquakes, major efforts have been made to seismic hazard assessment and seismic microzonation of the large urban areas affected by these earthquakes, and first of all of Bucharest, for long-term protection against earthquakes.

Historical seismology and macroseismology

Contemporary seismology must respond to necessity for security of modern and critical infrastructures (N.P.P., dams etc.). To come to this goal extensive research on historical earthquakes and their physical characteristics is of primary importance. Recently, significant steps forward have been achieved within the historical seismology field by collecting large amount of historical records for the earthquakes in Romania. The main attention was focused on the strongest earthquakes which control the maximum observed intensities and therefore largely determine the seismic hazard level and implicitly the anti-seismic design and strategy. Special attention was paid to those earthquakes which are important in defining specific seismogenic areas, but for which we have poor information.
New records were found in some archives which have not been investigated until now. Some of the discovered information indicated the occurrence of seismic events unknown so far. All the historical information has been evaluated and re-evaluated (Constantin et al., 2011; Rogozea et al., 2013, 2014). Different magnitude and depth estimations were calibrated against observation data. These results were obtained in the framework of the project "Fundamental Research of Historical Seismology and Paleoseismology needed for the assessment of long-term seismicity and seismic hazard" (2007-2016 National Strategic Plan for Research, Development and Innovation II) with the participation of two partners (ICM and GIR). Through this research we have succeeded the achievement of a database as complete as possible with the purpose of a more real seismic hazard assessment, which may lead to a significant reducing of the seismic risk.

In order to set the basis of some rigorous standards and norms of anti-seismic design, capable of assuring maximum security to buildings, in accordance with the idea of promoting and developing a national system, compatible with the European standardizing systems, a few large research activities were developed during 2015 – 2018 especially for re-evaluating and harmonizing of the macroseismic maps of the significant earthquakes occurred in Romania, both in the crust (Oros and Diaconescu, 2015; Oros et al., 2017), and at intermediate depth (Marmureanu et al., 2017; 2018; Rogozea et al., 2016a, b; 2017).

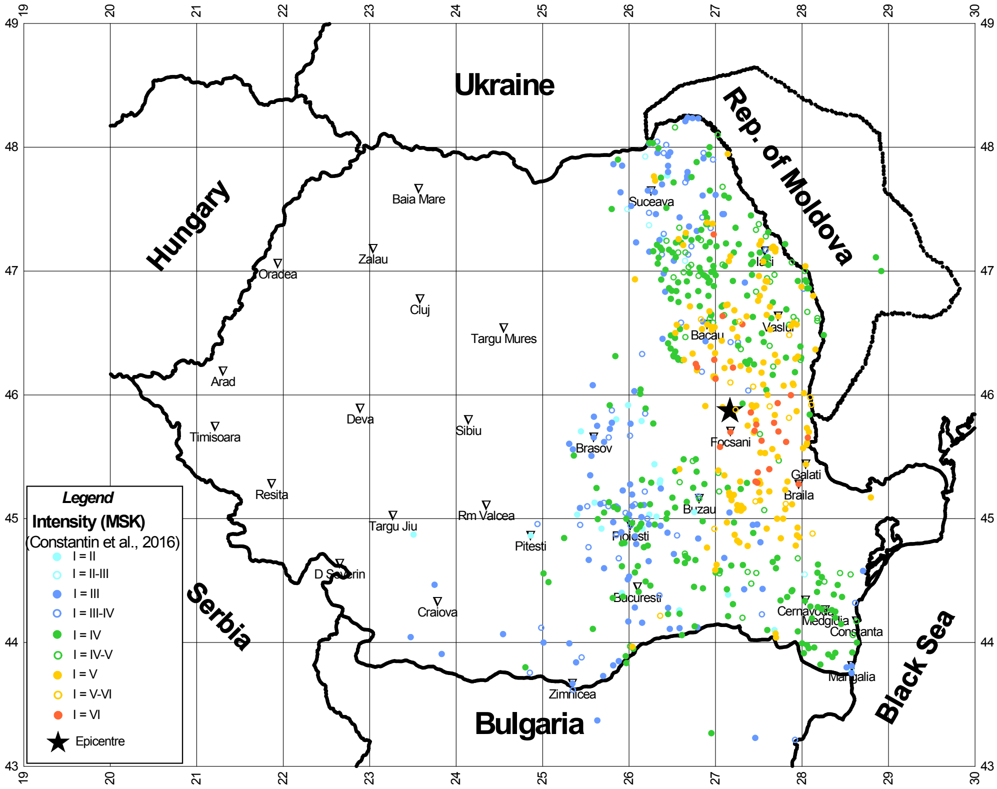

Figure 1: Intensity map of the November 22, 2014 Vrancea crustal earthquake (after Constantin et al., 2016)

Taking this into consideration, we have obtained important results, in the field of macroseismology, in the framework of the project "Seismic macrozoning of the territory of Romania, based on revalued macroseismic intensities corroborated with complex geological and geophysical data" (2007-2016 National Strategic Plan for Research, Development and Innovation II) with the participation of two partners (GIR and UB-FGG). As concerns this type of information, macroseismic investigations have been carried out in order to define macroseismic field of the recent crustal and subcrustal earthquakes occurred in Romania (Constantin and Pantea, 2013). This activity is continuous through evaluation of macroseismic effects of recent earthquakes using both type of collected data: online and classical macroseismic questionnaires (Constantin et al., 2016a, b, 2018; Moldovan et al., 2018a, b) (see Figure 1). We note in this regard the new perspective open by integrative work carried out on the basis of the results obtained within successive Central European Initiative projects coordinated by NIEP in cooperation with Dipartimento di Matematica e Geoscienze – University of Trieste, the Abdus Salam International Centre for Theoretical Physics of Trieste, International Institute of Earthquake Prediction Theory and Mathematical Geophysics of Moscow, and institutes in the border countries (Bulgaria, Hungary, Republic of Moldova, Serbia, Ukraine) (see Kronrod et al., 2013) and within the large European project "Seismic Hazard Harmonization in Europe" (SHARE, www.share-eu.org).[1]

[1] *Constantin A. P., Partheniu R., Moldovan I. A. (2016a) Macroseismic intensity distribution of some recent*

Seismic source physics

Modelling the earthquake source is one of the main tasks with the long-term goal to construct a quantitative physical model for the entire earthquake process, including tectonic stress accumulation, nucleation of rupture, and the dynamics of the rupture propagation and cessation. Integration of the multiple aspects of the earthquake phenomena, from the small scale (dynamic rupture) to large-scale (plate boundary tectonics) processes is becoming of increasing interest for many researchers.

The increase of the seismic network of the NIEP after 2015 in number and quality of instruments, the integration in the European virtual network have contributed to a better covering of the Romania territory and provided higher-quality database for seismic source studies. Besides the Vrancea intermediate-depth focus, where the most damaging earthquakes of Romania are generated, systematic investigations have been carried out in other seismogenic zones on the territory. A special focus has been drawn to cross-border integration data in the framework of a few European projects (SHARE project no. 226967; DACEA project no. 2 (1I) – mis etc code 636; ESNET project - mis etc code 641, SERA project).

Waveform inversion for small to large earthquakes have been applied using local and teleseismic recordings in order to retrieve source parameters and focal mechanism (Ardeleanu, 2018). The recent advance in both observations and computer simulations has strongly increased our performance in constraining the source parameters over a broad magnitude range. Instrumental recordings from historical events have been digitized and corrected to be used in re-assessing the source parameters of historical significant earthquakes (Paulescu et al., 2016). This kind of recovery of information from the past can be crucial for seismic hazard evaluation and seismic cycle analysis.

Another approach to understand the way the seismic cycle in the Vrancea region evolves has been the stress transfer modelling. Apparently, the major Vrancea earthquakes are generated alternatively in two separated segments on depth and this behaviour would be in favour of a stress coupling among these segments. Stress transfer plays a major role also in generating aftershock sequences.

A few studies dealt with the source properties for the earthquake sequences recorded recently in Romania (Placinta et al., 2016; Popescu et al., 2017). Empirical Green's functions were used to constrain source parameters (Poiata and Myiake, 2017; Popescu et al., 2017; Radulian et al., 2017).

Seismic source scaling properties, seismicity clustering and geometrical alignments have been investigated in correlation with the tectonics, geodynamics and other geophysical properties (Popescu et al., 2016a b; Rogozea et al., 2016). Possible coupling between the Vrancea subcrustal seismic activity and shallow seismicity in the overlying crust has been explored in a few studies. A lot of discussion has been addressed to issues related to the geotectonical models in order to explain the particular seismic activity at the South-Eastern Carpathians arc

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Romanian earthquakes, Romanian Journal of Physics, Vol. 61, No 5-6, 1120-1132.

Constantin A. P., Moldovan I. A., Craiu A., Radulian M., Ionescu C. (2016b) Macroseismic intensity investigation of the November 2014, M=5.7, Vrancea (Romania) crustal earthquake, Annals of Geophysics, 59, 5, S0542; doi:10.4401/ag-6998.

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Moldovan I.A, Manea L., Constantin A.P., Grecu B., Toma Danila D. (2018) Rapid seismic intensity assessment in Romania using internet macroseismology, Proc. of 18th International Multidisciplinary Scientific Geoconference, SGEM 2018, pg 931-938, Ed. STEF92 Technology Ltd., ISBN 978-619-7408-35-5, ISSN 1314-2704, DOI: 10.5593/sgem2018/1.1.

bend: oceanic slab detachment, continental delamination, deep instable gravitational root, etc., and their consequences on crustal movements, orogen features, magmatism, subsidence, heat flow and gravity.
The catalog of the fault plane solutions has been updated and several investigations have been performed in oder to constrain the stress field charactersitics in connection with the seismogenic areas (Bala et al., 2017; 2018; Craiu et al., 2015; 2017; Neagoe et al., 2017; Oros et al., 2017; Popa et al., 2018; Popescu et al., 2018; Radulian et al., 2018; 2019).
As concerns the seismicity in the crust, many investigations have been carried out in order to define potentially active faults and their geometric and dynamic parameters (Bala and Raileanu, 2015; Bala et al., 2015). These parameters constitute basic input data for seismic hazard evaluation. Numerical techniques have been proposed to simulate earthquake process in the Vrancea seismic source and to generate synthetic earthquake catalogues.
Studies dedicated to particular cases of seismic activity, such as the seismic swarm close to Galati city recorded in 2013 (Craiu et al., 2015; 2017; Ioane et al., 2015; Nastase et al., 2016; Popa et al., 2016; Tataru et al., 2016; Gheorghe et al., 2018) or the largest shallow event instrumentally recorded in the outer Carpathians in 2014, close to Marasesti city (Craiu et al., 2015; Ghita et al., 2017).
One of the main targets of the NIEP is to model the influence of the seismic source on seismic hazard distribution and to simulate the strong ground motion characteristics in dense-populated areas of Romania, and first of all in Bucharest. The relative deconvolution methods, like spectral ratios or empirical Green's function deconvolution were applied to retrieve the source parameters. Implications of the source directivity and focal depth effects upon the strong ground motion distribution have been analyzed as well (Pavel et al., 2015; Vacareanu et al., 2015).

Wave propagation

The seismic wave propagation is the main factor which controls the shape and amplitude of the ground motion as recorded at the Earth's surface. Modelling the propagation of seismic waves through complex three-dimensional structures is one of the most difficult challenges in seismology.
The lateral inhomogeneities in the lithosphere and the local geology beneath the site are critical in shaping the ground motion distribution and subsequently in mapping the seismic hazard.
The analysis of travel times for different body wave phases provides the basic information related to the seismic wave path trajectory and velocity of propagation from the earthquake focus to the observation point. Relative techniques are applied as well, using double-differences and waveform cross-correlation for large sets of earthquake recorded data. S to P converted waves, as recorded by the Romanian seismic network, were investigated to determine the crustal thickness in the SE Carpathians arc bend area.
Seismic tomography using local body wave travel times was carried out to determine three-dimensional velocity structure beneath Romania territory. Of special interest was the tomography imaging for of the Vrancea subducting zone and its neighbourhood. P- and S-wave tomography illuminates a well-defined high-velocity body dipping almost vertically, where intermediate-depth earthquakes are generated. However, the extension of investigation to the west and north shows possible deep lithospheric roots in the South-Eastern Carpathians back-arc region as well. They were tentatively put into correspondence with magmatic activities which are still active there.
The seismic wave attenuation has been investigated using modal summation technique to model the complete synthetic waveforms. This technique has been developed within the

Department for Earth Sciences of Trieste for one-dimensional and two-dimensional structural models (Ardeleanu et al., 2017; 2018). The spectral-ratio method has been applied as well to determine lateral variations in seismic wave attenuation. Scattering and absorption properties of the seismic waves coming from the Vrancea subcrustal source are investigated using coda waves (Borleanu et al., 2017).

The data recorded during long-range seismic experiments in Romania along different refraction profiles or by other temporary networks provide important additional information on specific wave propagation. They were designed mostly to investigate the Vrancea region but extended also recently to the west, in the Carpatho-Pannonian region (South Carpathian Project, in cooperation with the University of Leeds).

The receiver functions technique is a tool frequently used to determine the crust and upper mantle structure at regional and global scale. P- and S-wave receiver functions are computed at the broadband stations of the Romania network to estimate vertical structure in the crust and upper mantle.

Anisotropy properties in the seismic wave propagation provides important new information and constraints in the seismotectonic modeling of the Vrancea region (subduction, flow pattern in the upper mantle, slab delamination etc.). Shear-wave splitting is a powerful diagnostic of anisotropy that has been used to detect mantle fabric and flow beneath Vrancea seismic region. This kind of investigation is fundamental for understanding thermal structure in the upper mantle, slab dehydration, melt generation and transport, and slab dynamics. Both SKS and SKKS broadband teleseismic shear waves were analyzed in order to investigate mantle and crust anisotropy properties over country territory (Petrescu et al., 2017). Shear wave splitting let to delay times up to 2 s and is highly variable with a marked change of the fast direction from perpendicular to the Carpathians Arc in the foredeep region to a parallel direction in the Vrancea epicentral area. It was assumed that the anisotropy is caused by specific flows induced by the particular geometry of the lithosphere body descending in the upper mantle.

Another approach to investigate the crustal seismic-velocity structure that has been applied in the last years is the use of surface wave dispersion and the ambient-noise cross-correlation. For pairs of stations the Green's function is computed by cross-correlating long and multiple time series currently recorded by the seismic network. The method takes advantage of avoiding the often highly nonuniform and sporadic distribution of earthquakes and of the increased density of stations after the recent seismic network improving.

Seismotectonics

Several new models of the seismotectonics in the Vrancea seismic region were proposed in the last years. Other studies were focused on the correlation between seismotectonics, earthquake focal mechanism, structure of the deep crust in the seismic active zones of the Carpathians foredeep, Dobrudja and Southern part of the Transylvanian depression. Efforts were made to relate crustal seismicity patterns to active faults morphology following the procedure proposed in SHARE project (Bala et al., 2015; Diaconescu et al., 2016).

Focal mechanism solutions were analysed in order to determine the stress field and to correlate with the seismicity.

Implications of paleomagnetic research on seismotectonics in the Carpathians region were studied.

Main research directions:

1. Lithosphere structure at regional and local scale;

Structure of the lithosphere in Romania; Moho depth in Romania (Zaharia et al., 2017; Bala et al., 2018);

New models at the geologic and tectonic scale.

2. Dynamics of the lithosphere by complex interpretation of the actual movements of the crust; physical properties of the rocks.

3. Studies of the crustal seismicity, seismotectonic models associated and assessment of the dynamic properties of the crust (Diaconescu et al., 2017).

Crustal seismicity (Tataru et al., 2015; Diaconescu et al., 2016a; Zaharia et al., 2016);

Seismotectonic models (Diaconescu et al., 2016b, Oros et al., 2018a, b);

Assessment of the dynamic properties of the crust in Romania (Bala et al., 2016a, b; 2017a, b, c);

Improvement of seismic hazard assessment;

Reduction of seismic risk

In the last years several studies about the natural hazard at a local scale were performed.

4. Microzonation studies (local seismic hazard) of densely populated areas

Site effects analyses;

Advanced methodologies in processing of seismic refraction data;

Share wave seismic velocity determination in Bucharest (Manea et al., 2017)

Local seismic hazard with special view to the Bucharest area.

Subjects as dynamics of the lithosphere are also followed and study of the movements of the crust using GPS and satellite methods.

Hazard assessment

1. Seismic hazard

The seismic hazard assessment is a crucial step towards mitigation of urban earthquake risk and improvement of disaster prevention management. A permanent threat for urban areas on the Romanian territory and extended areas in Europe comes from Vrancea intermediate depths destructive earthquakes. Bucharest is among the megacities mostly affected by those large earthquakes. Extensive studies concentrate on the characterisation of the macroseismic field of Romanian earthquakes, such as Vrancea intermediate-depth events and also crustal earthquakes, from Romania. The earthquakes from Romania and adjacent areas are documented for a millennium (since 984 a.c.) and represent very peculiar characteristics. The seismic hazard was evaluated using probabilistic and deterministic approaches for all seismogenic sources from Romania.

To apply the probabilistic approach, attenuation laws corresponding to Vrancea earthquakes were empirically determined in terms of macroseismic intensity and peak ground acceleration and a maximum magnitude value was prescribed. The seismic hazard assessment in dense-populated geographical regions and subsequently the design of the strategic objectives (dams, nuclear power plants, etc.) are based on the knowledge of the seismicity parameters of the seismogenic sources which can generate ground motion amplitudes above the minimum level considered risky at the specific site and the way the seismic waves propagate between the focus and the site. Extremely vulnerable objectives, like large cities, hydroenergetic dams (Marmureanu et al., 2017b; Moldovan et al., 2017c, d) or nuclear power plants, are present all around Romania, and not only in the Vrancea intermediate earthquakes action zone (Marmureanu et al., 2017a). The best example is the western part of Romania that is not affected by Vrancea intermediate-depth earthquakes and where the crustal seismicity is high. In this part of the country are cities like Timisoara, Arad and Oradea and the "Portile de fier I and II" hydroenergetic dams.

The complete set of information required for a probabilistic assessment of the seismic hazard in Romania relative to the crustal and intermediate-depth sources (Marmureanu et al., 2016; Moldovan et al., 2016; 2017; Oros et al., 2017; Pavel et al., 2016; (Toma-Danila et al., 2017b) have been obtained: (1) geometrical definition of all seismic sources affecting Romania - Figure 2, (2) estimation of the maximum possible magnitude, (3) estimation of the frequency magnitude relationship, (4) estimation of the attenuation law and, finally, (5) computing PSH with the algorithm of McGuire – Figures 3 and 4.

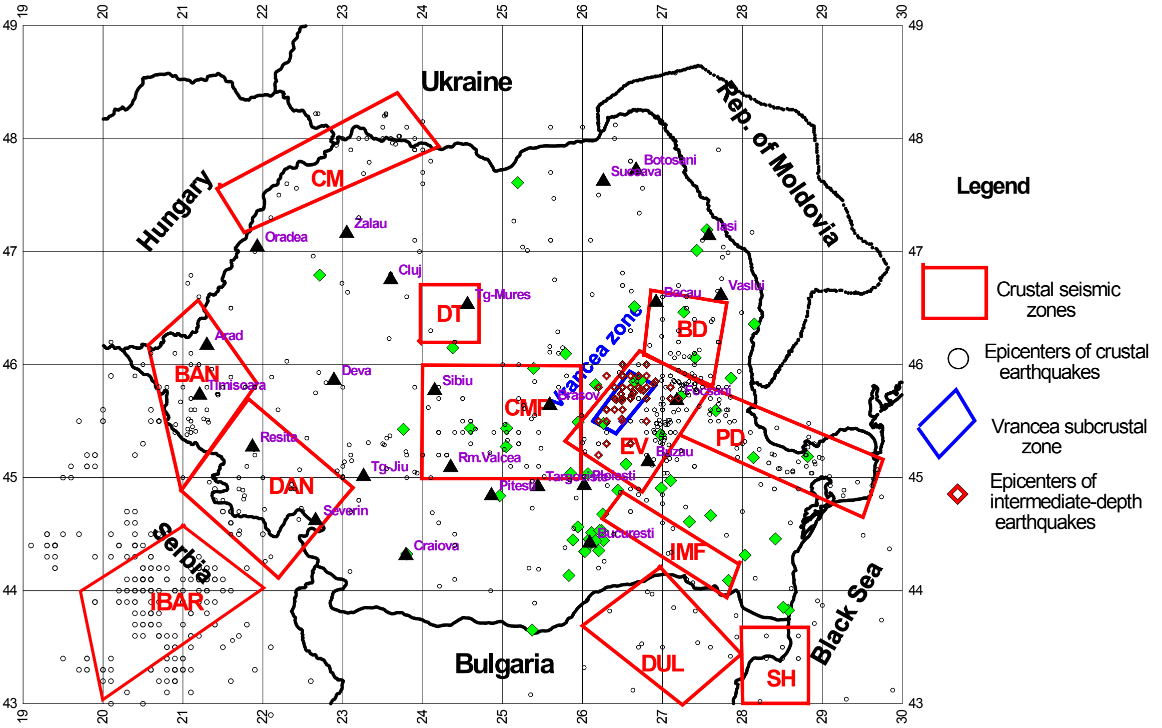

Figure 2: Seismic crustal and intermediate active zones in Romania and adjacent areas and their characteristics

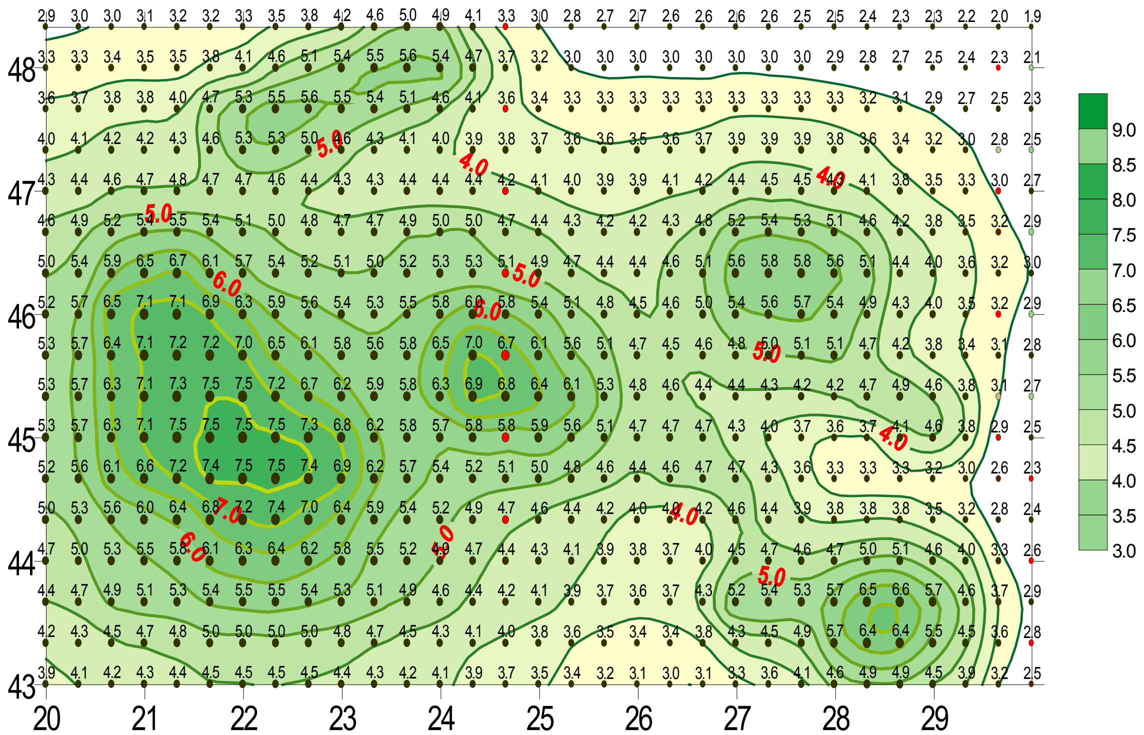

Figure 3: Hazard map for Romanian crustal sources and return periods of 100 years (after Moldovan et al, 2008)

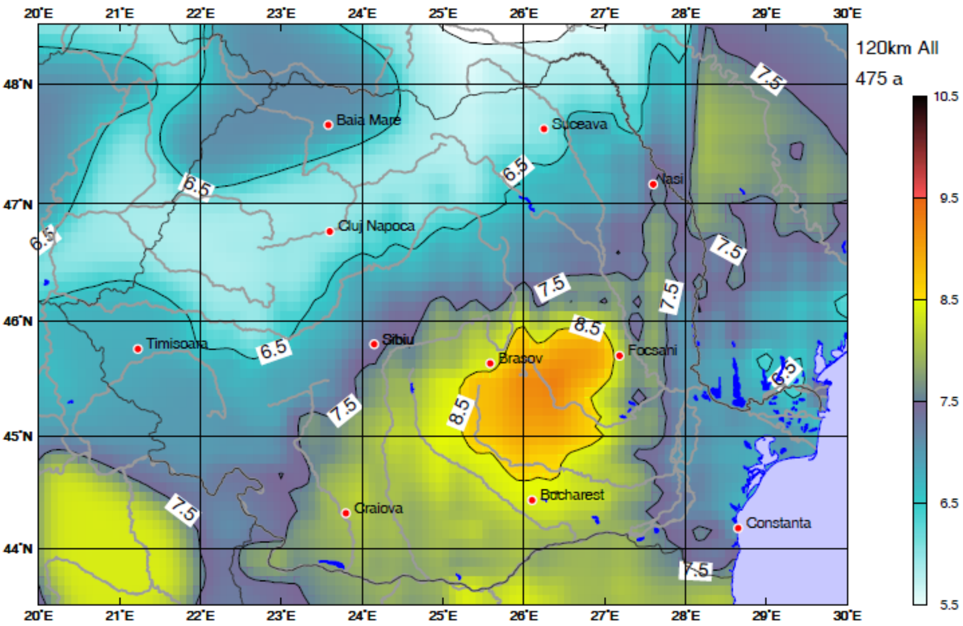

Figure 4: Seismic hazard from all source zones for a recurrence period of 475 years; colours represent intensities in MSK (after Ardeleanu et al, 2005)

Recent advances in computer technology make possible the use of the deterministic numerical synthesis of ground motion for seismic hazard calculations. The deterministic approach is completely different and complementary to the probabilistic approach. It addresses some issues largely overlooked in the probabilistic approach: (a) the effect of crustal properties on attenuation are not neglected; (b) the ground motion parameters are derived from synthetic time histories and not from overly simplified attenuation "functions"; (c) the resulting maps are in terms of design parameters directly, and do not require the adaptation of probabilistic maps to design ground motions; (d) such maps address the issue of the deterministic definition of ground motion in a way which permits the generalization to locations in which there is little seismic history.

2. *Other geohazards*

Besides earthquakes, other geohazards or geological hazards are events caused by geological features and processes that present severe threats to humans, property and the natural and built environment (landslides, volcanoes, avalanches, and tsunamis are typical examples of such events). A permanent target of NIEP is to characterize geohazards and their impact in Romania and neighboring countries and to develop efficient alert systems (Toader et al., 2015; Muntean et al., 2016; Nastase et al., 2016).
Recently, NIEP is participating within the FP7 project "Assessment, STrategy And Risk Reduction for Tsunamis in Europe - ASTARTE" (FP7 ENV.2013.6.4-3, Grant agreement no: 603839) and to the JRC program Global Tsunami Informal Monitoring Service (GTIMS). A few related results on tsunami monitoring and modelling scenarios for the Black Sea have been obtained (Partheniu et al., 2015; Constantin et al., 2017).

Earthquake forecasting

The failure in predicting the strong earthquakes of Northridge, California (1994), Kobe, Japan (1995) and Sahalin (1995) drew attention on the serious limitations of the standard earthquake prediction methods and at the same time provoked seismologists to look for new approaches of this extremely complex problem.

Vrancea seismogenic zone is a conspicuous active area in terms of its extraordinary seismotectonic features, outstanding persistent and highly recurrent seismicity displaying a remarkable regularity in occurrence of large events and manifestation of a plethora of geophysical precursors and severe socio-economic impact with a huge felt area.

Extensive analyses in order to detect premonitory changes in seismicity patterns as possible precursors of the Vrancea strong shocks were performed for past and future earthquakes. Analysis and discussions of a variety of precursory seismicity patterns belonging to all temporal developmental stages of the preparatory geophysical process leading to the major Vrancea earthquake of August 30, 1986 were performed and documented, clearly proving that the earthquake would not has been unexpected.

Different algorithms, like CN and the geostatistical method were applied to predict the strong Vrancea earthquakes. The CN algorithm has been initially created for the retrospective analysis of the seismicity patterns which precede the strong earthquakes within California-Nevada regions. The algorithm has been modified so that it can be applied, without any parameters adjustment, for all the seismic regions in the world. The method consists in analysis of a set of precursory phenomena reflected in the temporal evolution of the seismicity recorded in the earthquake catalogue. Although it was firstly conceived for crustal events, the CN algorithm can be also applied for prognosis of the intermediate earthquakes. The results are different depending on the seismic region which is under study. Thus, in case of Vrancea and Sicily regions where the paleosubduction is one of the possible interpretations, the results are positive (in case of Vrancea the strong earthquakes from 1977, 1986 and 1990 have been predicted), while for intermediate earthquakes within the regions where the subduction is still active, the algorithm can not be applied.

It has been recently experimented the electromagnetic and infrasonic methods to predict Vrancea intermediate-depth earthquakes and look for seismo-electromagnetic and infrasonic precursors. NIEP operates a real-time geomagnetic, electric, electromagnetic VLF/LF and infrasonic network (named The Romanian Electromagnetic Field and Infrasound Monitoring Network - MEMFIS) consisting of 6 stations, 4 of them centered in the Vrancea seismic zone and 2 of them outside the seismogenic zone (Figure 5).

The geophysical data (geomagnetic, electric and infrasonic data) are transmitted in an ASCII format, from the stations to the data center, using the TCP/IP protocol. The time resolution is given by the chosen sampling rate, and the accuracy is of +/- 1μs; the measurement resolution is of 24 bits. The data transfer rate is minimum 0.5 Mbits/s. The Romanian data center collects geomagnetic data from all stations of the real-time INTERMAGNET network.

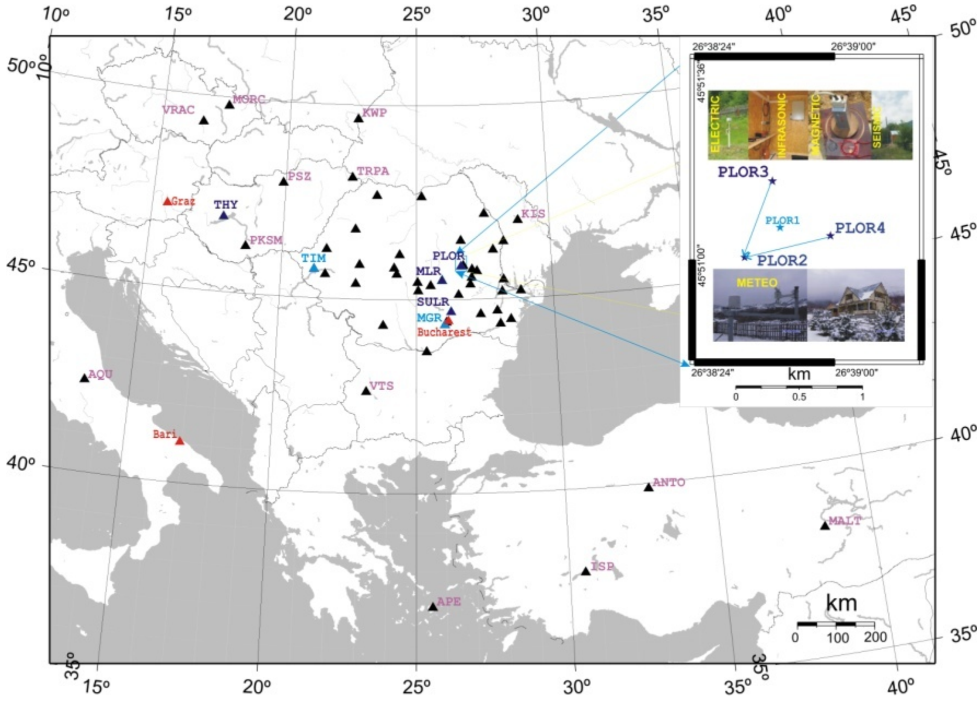

Figure 5: The Romanian seismic (black triangles) and geophysical network (blue and light blue triangles). On the figure are also marked the seismic stations that assures the real time seismic international data exchange and the THY Intermagnet station. In the upper right corner is presented the new Plostina geophysical network comprising seismic, magnetic, electric and infrasonic sensors

The Romanian Electromagnetic Field and Infrasound Monitoring Network (Table 1: http://www.infp.ro/cercetare/laboratoare/studii-magnetotelurice-si-bioseismice) is equipped with 4 triaxial fluxgate magnetometers (Bartington – Figure 6), with seismic sensors in each monitoring site, with 3 infrasound stations – MBAZEL2007 (Figure 6) and 1 Chaparral Infrasound sensor (Figure 7), 1 electrometer measuring the vertical atmospheric electric field - Boltek EFM100 (Figure 6) and one meteorological station –La Crosse WS-3600 (Figure 8).

Table 1: The geophysical observatories
from the Romanian Electromagnetic Field and Infrasound Monitoring network

Observatory Code	Equipment	Latitude	Longitude	Altitude (m)
MLR	Seismic/magnetic	45.49N	25.95E	1360
SURL (SRL)	Seismic/magnetic	44.68N	26.25E	97
PLOR2	Seismic/magnetic +/-100uT /infras+/-50PA	45.8502N	26.6438E	694
PLOR3	Seismic/magnetic +/-100uT /infras+/-50PA	45.8539N	26.6455E	708
PLOR4	Seismic/vertical electric +/-20kV/m Boltek/infras MBAZEL2007+/-50PA / infras Chaparal/meteo	45.8512N	26.6499E	656
AZEL	VLF-LF/ meteo/ infras +/-50PA	44.3548N	26.0282E	76
Dobrudja Observatory	VLF-LF/meteo/vertical elctric Boltek	44.0750N	26.6325E	23

The monitoring sites are located in Vrancea seismic zone (Figure 5) and one of them is located near Bucharest, outside the epicentral area. The geophysical database consists in more than 10 years of geomagnetic recordings at Muntele Rosu Observatory and in one year of multiple geophysical recordings (magnetic, electric and infrasonic) at Plostina Observatory - PLO2, PLO3 and PLO4.

Figure 6: An outer image of PLO3 site and some of the equipments that are involved.in the monitoring process: Data Acquisition System, Microbarometer MBAZEL2007, Triaxial Fluxgate Magnetometer MAG-03MS. The Electric Field Monitor EFM-100 is installed at PLO4, in the vicinity of the Weather Station WS-3600.

Figure 7: The Chaparal infrasound sensor located at Plostina main building (PLO4)

Figure 8: A part of the meteorological station installed at PLO4

Starting with March 2009 the **Romanian Electromagnetic Field and Infrasound Monitoring Network** was enhanced with VLF and LF antennas (Figure 9) and one Elettronika receiver (offered by Prof. P.F. Biagi- Department of Physics, University of Bari - http://beta.fisica.uniba.it/infrep/GroupsEU/ROM/Research.aspx) and is operating in the Dobruja Observatory (Table 1). The amplitude and phase data are collected with a 60 s sampling interval.

Figure 9: Magnetic VLF and LF antennas installed on the roof of the Dobrudja Observatory

During the geophysical monitoring of Vrancea area there have been noticed a number of anomalies that have been identified to be in correspondence with local tectonic, atmospheric and space global phenomena (Dolea et al., 2015). Some possible anomalous animal behaviour prior to the Vrancea strong earthquakes was investigated as well (Constantin et al., 2017; 2018).

The results of several projects have been integrated into a precursor factor monitoring network with results that can be applied in the field of climate change effects. The multidisciplinary monitoring stations of INFP record the changes of geophysical, geochemical and geo-hydrological parameters as an effect of tectonic stress (Toader et al., 2016). The main purpose is to identify seismic precursor specific to tectonic fault zones. The result is the growth of the seismic alert service through: perfecting risk evaluation, seismic forecast, informing the decision factors regarding the impact minimization of natural disasters and the education of the population. Only a multidisciplinary activity can estimate a seismic event. The network monitors a large number of geophysical elements and geochemical parameters (geomagnetic, electric, electromagnetic - ULF, VLF and LF -, infrasonic and acoustic, borehole temperature, air ionization, gas concentration – CO_2/CO, radon, telluric currents) in correlation with tectonic, atmospheric, ionospheric or solar fields (Moldovan et. al 2015; Apostol et al., 2016; Toader et al., 2017; Zoran et al., 2017; 2018) to highlight the correlation of their variation with different natural and artificial, local and global phenomena (e.g. magnetic storms caused by solar activity or anomalies related to tectonic activity) (Maggipinto et al., 2015; Nastase et al., 2016; Oikonomou et al., 2017). Table 2 presents the structure of stations and the equipment. Each monitoring location is on a fault with a known geological structure (Figure 10). An example of a monitoring station is in figure 11.

Table 2: Structure of stations and the equipment

Station	Location	Sensors
BISR	Bisoca	Seismic velocity-acceleration, acoustic, radio ULF, inclinometer, radon, air temperature, pressure and humidity, CO_2/CO
LOPR	Lopatari	Acoustic, inclinometer, radon, air temperature, pressure and humidity
NEHR	Nehoiu	Seismic velocity-acceleration, acoustic, ionization, meteorological station, inclinometer, radon, air temperature, pressure and humidity, CO_2
MLR	Muntele Rosu	Seismic velocity-acceleration, acoustic, inclinometer, radon, air temperature, pressure and humidity, magnetic field, X, Y, Z
COVR	Covasna	Seismic velocity-acceleration, radio ULF
PLOR4	Plostina	Seismic velocity-acceleration, acoustic, infrasound, meteorological station, ionization, telluric field, air electrostatic field, inclinometer, air - ground – borehole temperature, radon, CO_2/CO
PLOR7	Plostina	Seismic velocity-acceleration, radio ULF, video camera for clouds, radiometer for solar direct and reflected monitoring (long and short waves)
VRI	Vrancioaia	Seismic velocity-acceleration, air - ground acoustic, radio ULF, infrasound, ionization, telluric field, solar radiation (pyranometer), ground temperature, meteorological station, air electrostatic field, scalar magnetic field, video for clouds, radon, air temperature, air pressure and humidity, CO_2/CO
ODBI	Odobesti	Seismic velocity-acceleration, acoustic, radio, telluric field, borehole temperature, meteorological station, radon, air temperature, pressure and humidity
PANC	Panciu	Seismic velocity-acceleration, radio ULF

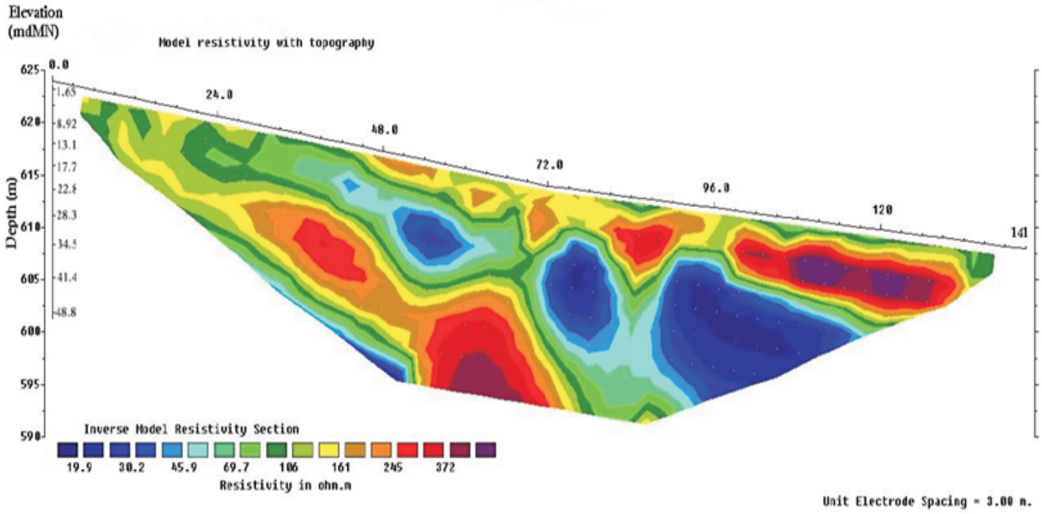

Figure 10: Electrical tomography, Plostina site PLOR4

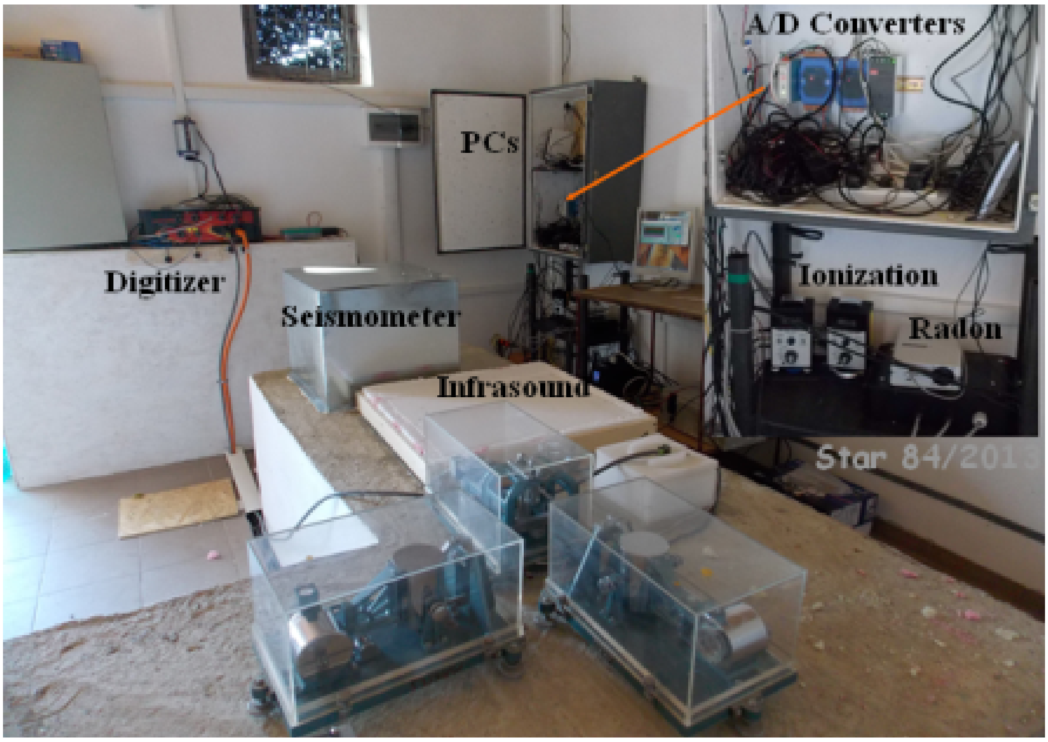

Figure 11: VRI monitoring station

The multidisciplinary network offers:

- On-line information from ground multidisciplinary monitoring stations installed inside and outside seismogenic zones, equipped with: seismic, geomagnetic – telluric and vertical electric field, acoustic (high frequency and infrasound), radio ULF/VLF/LF;
- Off-line information on Radon, meteorological, air ionization, CO_2, vertical temperature profile of a borehole, radiometer for solar radiation direct and reflected, clouds monitoring with video camera, lighting detection and animal anomaly behavior from online reports from the country;
- Own designed software for data acquisition, visualization and analysis;
- Possibility to extend the multidisciplinary monitoring stations with more improved and new sensors types (like borehole temperature, radon, $CO + CO_2$).
- Experience in earthquakes forecast based on precursors factors;

- Experience in providing seismic information to other organizations (e.g. EPOS – ORFEUS), experience that can be used in the project for geophysical data sharing among partners.
- Long term experience in interaction with authorities, intervention and decision factors.

The procedures are based on methods for assessing the time-dependent seismic hazard (Figure 12) and are complemented by seismic data analysis. The cumulative energy method is used, the bits of the Gutenberg Richter law, the tectonic stress, the breaking area and the correlation with the seismic breaks.

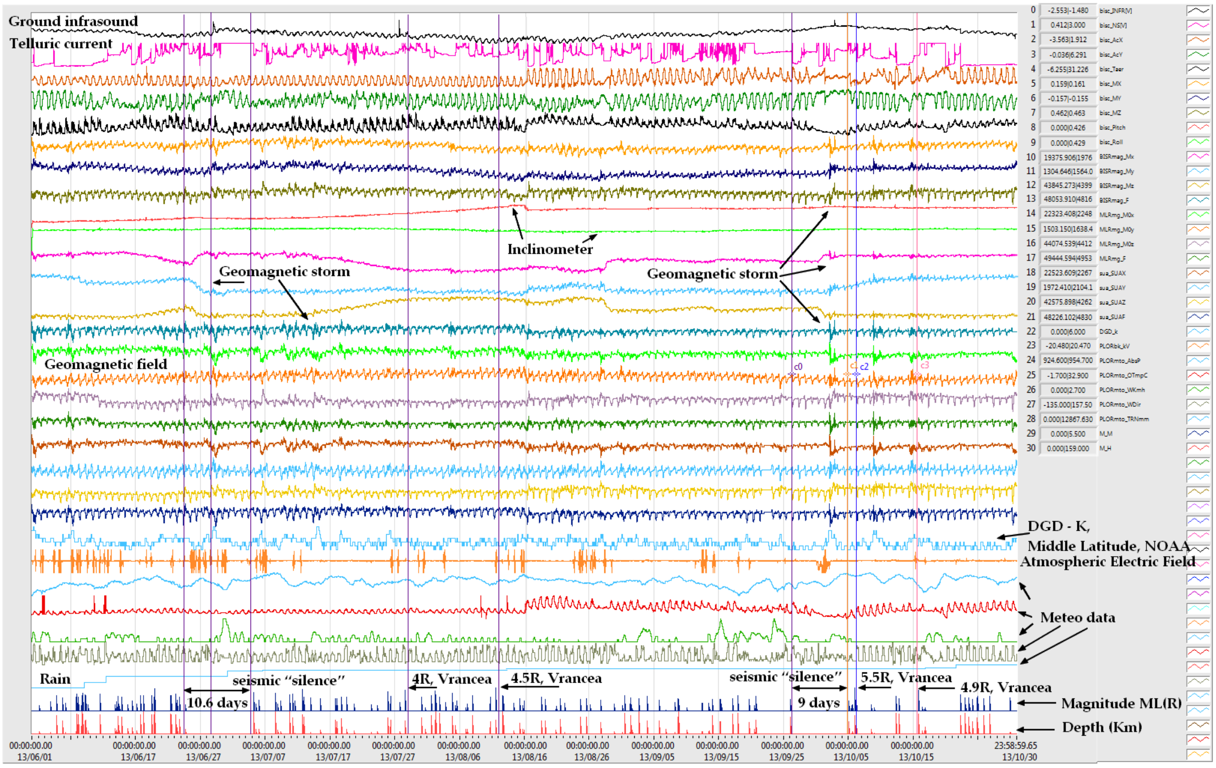

Figure 12: Analysis software for seismotectonic precursor phenomena

Acknowledgements. *This report has been prepared by Dr. Mircea Radulian, Dr. Iren-Adelina Moldovan, Dr. Angela Constantin, Dr. Victorin Toader, Dr. Andrei Bala*

PART III: ENGINEERING SEISMOLOGY

The evaluation and mitigation of the seismic risk is one of the permanent and urgent problems facing the Romanian society, equally implying work of seismologists, geologists and engineers. Significant efforts were made to predict the peak values and spectral characteristics of the strong motion in large urban areas, like Bucharest. At the same time, important efforts were made to determine the site effects and microzonation maps for the same city (Bala et al., 2015; Balan and Apostol, 2017; Grecu et al., 2016; 2018; Manea et al., 2015; 2016; Cioflan et al., 2018).
Every damaging earthquake demonstrates the importance of the local site effects and their worsening of the damage and economic losses. Another open problem is the correct definition of the local site effect and the possibility to control it to a certain degree. The experience gained of some recent earthquakes (Kobe, Loma Prieta, Mexico, etc.) shows the importance of quantifying the physical parameters of the local site and other local conditions which can affect the severity of ground shaking that a site may experience and the potential for locally induced effects, such as landslides, liquefaction, floods, fires, etc.
A number of studies have significantly contributed to the establishing of the response spectra to be used in connection with the large intermediate-depth earthquakes generated by the Vrancea region of Romania and the existing European Building Code Eurocode 8 was critically reviewed and improvements were suggested to orient it to the Carpatho-Balkan region.
The modal summation method and finite differences technique were applied to calculate the expected ground motion in Bucharest due to large intermediate-depth Vrancea earthquakes. The results outlined that the presence of alluvial sediments and the possible variation of the event scenario require the use of all three components of motion for a reliable determination of the seismic input.
Study of dynamic parameters of soils by using resonant columns and geophysical methods, realistic modelling of seismic input taking into account source, wave path propagation and local site effects have been permanent tasks for Romanian seismologists and important outcomes for seismological engineers. Laboratory analyses were made also to determine the attenuation effects for surface layers and its dependence on the strain level induced by large earthquakes (Balan et al. 2017b).
The role of the non-linear effects in the local site response has been the subject of several studies outlining their important contribution to the strong motion in Bucharest area (Marmureanu et al., 2015a, b; Balan et al., 2016; 2017a; Bratosin et al., 2017). This will be a challenge for seismological research in the next years.

Engineering Seismology

Two main (interrelated) topics were dealt within this frame:
- characterization of ground motion severity at a definite location;
- summarizing the outcome of analysis of accelerographic records obtaned during recent strong Vrancea earthquakes.

The concern for the characterization of ground motion severity was due to the direct experience of the destructive earthquake of 1977.03.04. The survey of earthquake effects, combined with the data provided by the strong motion record of Bucharest – INCERC, raised the need to consider intensity not only globally, but also as related to various spectral bands. A system of intensity quantification based on accelerographic data was developed and applied to the analysis of numerous ground motion records. An application forwarded to the NATO Office, Brussels, was accepted and NATO provided the Collaborative Linkage Grant No.

981619 for the Project *QUANTIFICATION OF EARTHQUAKE ACTION ON STRUCTURES*. The cooperative activities in this framework, in which researchers from Bucharest, Moscow and Chişinău were involved, lasted from 2005 to 2008. They included meetings in Bucharest, Chişinău and Moscow and led to the drafting of some joint papers. Finally, the NATO Office agreed to provide support for the publication of a volume with the same title. The main participants in these activities were the authors of this volume. Several publications on this subject were drafted and some of them were presented at the European Conferences on Earthquake Engineering of 2016 and 2018 and at the World Conference on Earthquake Engineering of 2018.

The activities devoted to summarizing the outcome of analysis of accelerographic records obtaned during recent strong Vrancea earthquakes relied on the infomation provided by the numerous valuable strong motion records obtained during the strong Vrancea earthquakes of 1977.03.04, 1986.08.30, 1990.05.30 and 1990.05.31.

The most relevant findings related to the features of the radiation pattern put to evidence are:

- the variability of directivity from one event to the other;
- in some cases, the variability of directivity, for a same event, from one spectral band to the other.

The features of the radiation pattern were evaluated also in relation to the variability of the spectral contents of ground motion, put to evidence by the ensemble of response spectra presented. As a most striking example, the results obtained show that, for a large area, the longer period ordinates of response spectra were unexpectedly low in case of the event of 1990.05.30. They also show that the source mechanism was of a nature that led to diferent directivities of radiation for different spectral bands. The challenge for a joint study of source mechanisms and of response spectra becomes obvious.

The most relevant findings related to the spectral contents made obvious by instrumental data and response spectra are related to the cases of stability and of variability respectively, of spectral contents of ground motion. The importance of the existence at relatively small depth of an interface characterized by a strong contrast of *S* wave propagation velocity for the adjacent layers, in order to provide a strong and stable influence of local conditions upon the ground motion characteristics must be emphasized again. Otherwise, the need to examine the characteristics of deep geological profiles is necessary.

The importance of these aspects for the predictability of ground motion features and for microzonation studies is obvious.

Earthquake Engineering

The main directions of work in this field were:

- studies on non-linear behaviour of soils and site response
- studies on the seismic vulnerability of structures;
- modernization of design codes;
- studies on base isolation;

Studies on non-linear behaviour of soils and site response were presented in conferences and research projects were completed.

The vulnerability studies were carried out essentially in analytical terms. Two main subjects were dealt with:

- Analysis of evolutionary vulnerability, mainly as a consequence of the cumulative effects of successive earthquakes;
- Vulnerability and risk analysis of multi-location systems, like lifelines, railway networks etc.

The studies on modernization of codes were intended mainly to adapt the codes for practice to the outcome of more consistent techniques of control of structural safety.
The studies on base isolation were oriented towards the analysis of specific criteria under the seismic conditions of Romania. The studies on earthquake protection principles were devoted mainly to a critical analysis of the specific obstacles to the control and mitigation of seismic risk to structures (Apostol et al., 2017a, b).
A very important progress in the domain of changing theoretical and practical knowledge in the domain of engineering seismology was done in the framework of international project Black Sea Earthquake Safety Net(work) – ESNET (2012-2014) where participated specialists from 4 countries along the Black Sea coast, Republic of Moldavia (Institute of Geology and Seismology, Academy of Sciences), Romania (National Institute of Research Development for Earth Physics), Bulgaria (National Institute of Geophysics, Geodesy and Geography) and Turkey(International Blue Crescent Relief and Development Foundation, KOERI - Kandilli Observatory and Earthquake Research Institute National Earthquake Observation Centre). Subjects from engineering seismology were discussed during the project meetings and presented in a book written during the project.

In order to take advantage of the Romanian Seismic Network that comprise nowadays of more than 140 seismic stations in real-time, since 2006 NIEP implemented the ShakeMap software (developed by USGS) that enables the automatic generation of maps and data for instrumental intensity, PGA, SA or PGV (Toma-Danila et al., 2017). These outputs are highly important for authorities and the large public immediately after an earthquake, since they provides geographically hints regarding the possible distribution of effects and areas that have to be investigated. Currently the 3.5 version of ShakeMap is in use. For the Vrancea Area a special ground motion prediction equation (GMPE), developed by Sokolov et al[2], was implemented. The overall computation time is under 8 minutes for an event, for an area between 20°E - 29°E longitude and 43.5°N - 48°N latitude.
The Near-real time system for estimating the seismic damage in Romania, implemented by NIEP in 2011 and currently at version 3 (from 2017), is capable of estimating seismic damage through a PAGER-like module, based on instrumental intensity values, population distribution and coefficients derived from intensity-casualty historical data, at national level, and also through a SELENA module, based on acceleration values, vulnerability curves for 39 representative building typologies in Romania, the Improved-Displacement Coefficient Method and casualty rates and 2011 national census data for residential buildings and residents, at city/commune level (and more detailed for Bucharest). Due to the characteristics of the intermediate-depth Vrancea earthquakes, each of these systems and modules is customized in order to better reflect local specificity (Toma-Danila et al., 2015 a, b). Risk evaluation has been extended to transportation networks in Romania (Toma-Danila et al., 2016) and in Bucharest city (Toma-Danila et al., 2016; Toma-Danila, 2018; Toma-Danila et al., 2018).

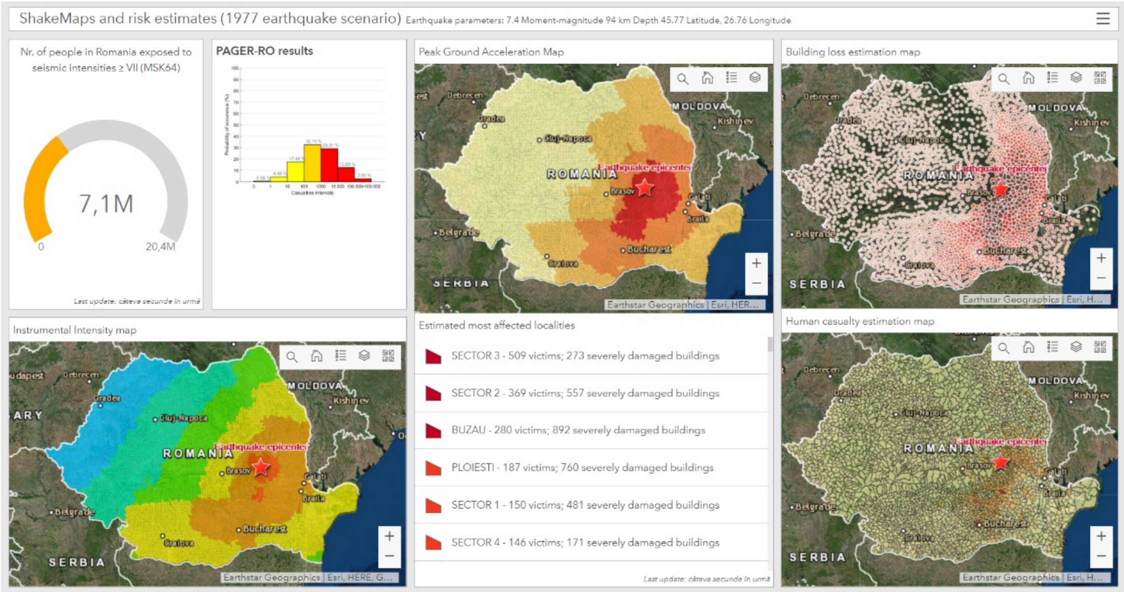

Figure 1: SeisDaRo3 dashboard for an earthquake scenario similar to the 4 March 1977 Vrancea earthquake, revealing the main outputs of this system

Currently, this system uses for building loss estimation the analytical methods (as the Improved-Displacement Capacity Method - I-DCM) implemented within the open-source software SELENA (SEismic Loss EstimatioN using a logic tree Approach), together with HAZUS methods for estimating the human casualties. The building stock is defined through 48 different capacity and fragility curves, depending on construction material, height and age. As hazard data, PGA and SA values obtained through the ShakeMap System and based on real recordings and attenuation relations are used. The area currently analyzed by the system consists of 19 Romanian Counties, capital Bucharest and 9 regions in northern Bulgaria; resolution of the data is at administrative unit (commune or city) level.

This system enabled also the analysis of Bucharest, one of the most vulnerable capitals in Europe due to earthquakes, to an even higher resolution extent, based on new census data (Armaş et al., 2015; 2016). The recently published results (Toma-Danila et al., 2015; Cioflan et al., 2016; Toma-Danila et al., 2018) highlight the need of greater impact mitigation actions, since many casualties are expected to occur during a future major Vrancea earthquake.

The important issue of seismic risk mitigation benefitted in the last time of the satellite observations that have begun to be widely used at local or regional scales (Balan et al., 2015; 2016; Gheorghe et al., 2018).

In the last years, a particular emphasis has been put on development of outreach and educational activities. For this purpose, an educational network has been developed in Romanian schools to monitor earthquakes and train scholars how to understand and interpret seismograms and earthquake phenomenon (Tataru et al., 2015; 2016 a, b; 2017a; Zaharia et al., 2016). At the same time, a mobile earthquake exhibition was created to be used for geophysical education and raising awareness (Tataru et al., 2015; Toma-Danila and Tataru, 2015; Tataru et al., 2016c; 2017b).

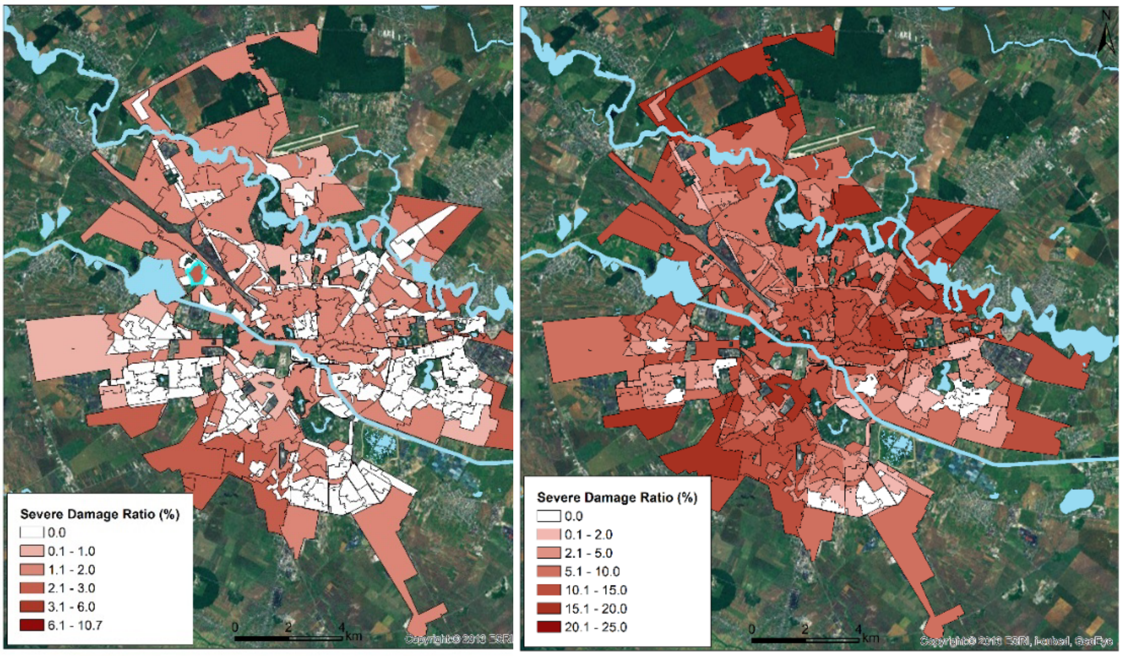

Figure 2: Percentage of severely damaged buildings in Bucharest, at neighborhood scale, for the 4 March 1977 scenario and maximum possible earthquake in the Vrancea Source[3].

Acknowledgements. *This report has been prepared by Prof. Dr. Horea Sandi, Dr. Stefan Balan, Dr. Carmen Cioflan and PhD. Dragos Toma-Danila.*

[3] Toma-Danila D., Armas I. (2017) Insights into the possible seismic damage of residential buildings in Bucharest, Romania, at neighborhood resolution. Bulletin of Earthquake Engineering, 15(3):1161-1184

PARTICIPATION OF THE ROMANIAN SPECIALISTS IN INTERNATIONAL AND NATIONAL PROJECTS OR PROGRAMMES

In the past four years the Romanian seismology has been actively contributing to:

(1) *World-wide interdisciplinary international research programs*

- Romania's technical participation in support of the Comprehensive Nuclear-Test-Ban Treaty (CTBT)

The National Institute for Earth Physics hosts the Romania's National Data Centre (NDC), with operates the seismic station Cheia-Muntele Rosu (MLR) for its uninterrupted participation to the global monitoring network of the verification system, and co-operates with national and international organizations for upgrading and maintaining. NDC receives and analyzed the data coming from MLR station and from the International Monitoring System, as well the products of the International Data Centre (IDC) from Vienna, Austria.

- European Plate Observing System (EPOS-IP), ESFRI Program, H2020, 2015-2019, INGV Rome, http://www.epos-eu.org/
- Earthquake global monitoring for tsunami generation, for earthquakes with magnitude M ≥ 7 (GTIMS-1), JRC, ISPRA Italy, 2013 – 2015
- Global Tsunami Informal Monitoring Service (GTIMS-2), JRC, ISPRA Italy, 2015 – 2017
- Atmospheric dynamics Research Infrastructure in Europe, H2020, 2015 - 2018
- Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe (SERA), 2016 – 2020, www.sera-eu.org
- All Risk Integrated System TOwards Trans-boundary hoListic Early-warning (ARISTOTLE), 2015 – 2020, http://pilot.aristotle.ingv.it
- Assessment, STrategy And Risk Reduction for Tsunamis in Europe (ASTARTE), FP7, 2013-2016, http://astarte-ro.infp.ro/

(2) *Bilateral cooperation*

- **The bilateral project on "Seismic microzoning of Bucharest"** with the University of Trieste (Italy) has the goal to estimate the ground motion parameters due to waves coming from complex seismic sources and propagating in highly realistic structural models to mitigate the seismic risk in Bucharest metropolitan area.

During several stays as visiting scientists at ICTP and DES - University of Trieste, a group of researchers from NIEP worked within different NATO and EC projects focused on Vrancea earthquakes and their implications to the seismic hazard using the deterministic method developed at DES – Trieste. Complex research on microzonation, seismic source and earthquake prediction (CN method) was carried out on this occasion.

- **The enhancement of the station Bucovina (BURAR) for signal detection and seismic phase identification at regional and teleseismic monitoring, AFTAC**

A bilateral cooperation between the National Institute for Earth Physics (NIEP) and the Air Force Technical Applications Center (AFTAC) of the United States of America started in 1999 aiming at installing and operating a seismic array in the northern part of Romania (Bucovina array). The array consists of 9 short-period stations and 1 broadband station and started to be fully operational in July 2002. Another bilateral cooperation (NIEP and the

Geoforschungszentrum Potsdam - GFZ) has been active since 1999 for the operation of the broad-band station Cheia - Muntele Rosu (belonging to the GEOPHON network). An important upgrade of the Cheia – Muntele Rosu station, as well as of the National Data Centre in Bucharest has been done since 1999, involving both technical cooperation with the Government of Japan and technical assistance from the CTBT Organization. Hence, in the fall of 2001 a new seismic monitoring system was installed and is now fully operational, by recording continuous earth motion data at Muntele Rosu site and transmitting these data in real-time to the facilities in Bucharest, in the framework of the Japan International Cooperation Agency project „Technical Cooperation for Seismic Monitoring System in Romania". Also, during 2001-2002, the CTBT Organization has supported the site preparation works at the seismic station Muntele Roşu and supplied equipment for establishing reliable data communications links between the seismic station, the NDC and the International Data Centre from Vienna.

- **Research and development studies of seismic sources for regional and local data (FA7022-11-C-0015),** 2011-2018 - AFTAC
- **Operations and Maintenance Support for the Romanian Seismic Array,** 2011-2018 - AFTAC
- **Bilateral cooperation Romania - Cyprus, Investigation of earthquakes signatures on the ionosphere over Europe,** INES, 2014-2015

(3) National programs and projects for research and developement:

NUCLEU Program

- Complex research on the seismic risk evaluation and reduction on the Romanian Teritorry (CERRS), 2009 - 2015
- Advanced multidisciplinary research to monitor and model the seismic phenomenon and reduce its effects (CREATOR), 2016 – 2017
- Advanced research on the monitoring and modeling of the seismic phenomenon and the reduction of seismic risk (CIRRUS), 2018

National Program for Research Development and Innovation PN II

- Harmonization of Seismological and Seismic Engineering aproaches: Conting the seismicity of Romania for an adequate implementation of the seismic activity in the European Code EN 1998 - 1 used for the seismic projection of buildings (BIGSEES), 2012-2015
- Bridging the gap between seismology and earthquake engineering. From the seismicity of Romania towards refined implementation of seismic action of European Norm EN 1998-1 in earthquake resistant design of buildings, 2012-2015
- Real-time earthquake alarm system for Romania (ResyR), 2012 – 2015
- Dams safety during large destructive earthquakes: evaluation, improvement, monitoring, warning and emergency action plans (DARING), 2014 – 2017
- Mobile Earthquake Exposition Expozitie (MOBEE), 2014-2017
- Seismic hazard based integrated seismic hazard monitoring of the Vrancea area through advanced geospatial and in situ methodologies (VRAGEO), 2014 – 2017
- Advanced research on seismic noise in Romania, 2015 – 2017

- The 3D distribution of the propagation velocities of the elastic waves from the upper lithosphere of the Transylvanian and Pannonic Basin depression in Romania (TRAPWA), 2014 – 2017
- Real-time real-time earthquake alarm system for Romania, 2013 – 2016
- Disaster risk assessment at national level (RO-RISK), SIPOCA, 2016

National Program UEFISCDI

- European Plate Observing System Europene EPOS-RO
- Strategies and instruments for the seismic risk reduction (REAKT-RO)
- Educational Seismic Network in Romania (ROEDUSEIS), 2012 – 2015
- Investigation of the ionosphere to identify seismic signatures over Europe, 2014 – 2015

National Program STAR

- Multidisciplanary complex system for monitoring clouds, aerosols and solar radiation in corelation with Vrancea seismic activity, AeroSolSys, 2013-2016
- Geospatial integrated techniques for seismic forecasting in Vrancea area (VRAFORECAST), 2014 - 2017
- Extensive use of experience in Space and Security activities, 2017 – 2020
- Complex multidisciplinary monitoring system of clouds, aerosols and solar radiation in correlation with Vrancea seismic activity (AeroSolSys), 2013 – 2016
- Romanian Cluster for Earth Observation, STAR, 2017 – 2019
- Extensive use of space and security experience (VESS), 2018 – 2020
- Stand-alone earthquake alert receiver able to generate „on-site” notifications, 2017 – 2020
- Institutional capacities and services for research, monitoring and forecasting of risks in extra-atmospheric space, 2017 – 2020

PARTICIPATION OF THE ROMANIAN SPECIALISTS IN THE NATIONAL AND INTERNATIONAL SYMPOSIUMS AND CONFERENCES

Many of the results obtained by the Romanian seismologists in the past four years have been presented at a series of national and international meetings as follows:

2018

- AGU Fall Meeting, 10 – 14 December 2018, Washington D. C.
- 6th Smart Cities Conference, 6 – 7 December 2018, Bucharest
- GEOSCIENCE 2018, 16 November 2018, Bucharest
- C65 International Conference ”Tradition and Innovation - 65 Years of Constructions in Transilvania”, 15 – 17 November 2018, Cluj-Napoca
- Infrasound Technology Workshop 2018, 5 – 9 November 2018, Vienna
- 75 Years of Geomagnetic Measurements of the Romanian Centenary Round Table and Workshop, 16 – 19 October 2018, Bucharest and Surlari Observatory
- EMSEV 2018 International Workshop, 17 – 21 September 2018, Potenza, Italy
- The 19th General Assembly of WEGENER on Earth deformation & the study of earthquake using geodesy and geodynamics, 10 – 13 September 2018, Grenoble, Franta
- 4th World Multidisciplinary Earth Science Symposium (WMESS), 3 – 7 September 2018, Prague
- 36th General Assembly of the European Seismological Commission, 2 – 7 September 2018, Valletta - Malta
- 17th International Balkan Workshop on Applied Physics (IBWAP), 10 – 13 July 2018, Constanta
- 8th International Multidisciplinary Scientific GeoConference, SGEM, 30 June – 9 July 2018, Albena
- Annual Scientific Communication of the Faculty of Physics, University Bucharest, 21 – 22 June 2017
- 16th European Conference on Earthquake Engineering, 18 – 21 June 2018, Thessaloniki
- 12th International Conference on Environmental Legislation, Safety Engineering and Disaster Management - ELSEDIMA, 17 – 19 May 2018, Cluj-Napoca
- The 19th Joint Geomorphological Meeting and 34th Romanian National Symposium on Geomorphology, 16 -20 May 2018, Buzau, Romania
- ARISE2 Final Workshop, 13 – 18 May 2018, Hamburg, Germania
- 3rd SCIENTIX Conference, 4 – 6 May 2018, Brussels, Belgium
- EGU, 9 -13 April 2018, Vienna
- African Regional Infrasound Workshop and Integrated Training for NDCs, 12 – 16 February 2018, Tunis, Tunisia
- Workshop on Coupling Earthquakes and Tsunamis, 30 January – 2 February 2018, Bayrischzell, Germany

2017

- Fall Meeting, AGU, New Orleans, LA, 11-15 December 2017
- Technical Workshop on Internet Macroseismology, 14 – 15 November 2017, Ljubljana, Slovenia
- Symposium of the Doctoral School of Geology GEODOCT 2017, Bucharest
- PROMARE - International symposium protection of the Black Sea ecosystem and sustainable management of maritime activities

- GEOSCIENCE 2017
- 1st Euro_Mediterranean Conference for Environmental Integration (EMCEI), Sousse, Tunisia, 2017
- World Multidisciplinary Earth Sciences Symposium, 11 – 15 septembrie 2017, Prague, Czech Republic
- PSHA Workshop, 5 – 7 September 2017, Lenzburg, Switzerland
- Joint Scientific Assembly of International Association of Geodesy (IAG) and International Association of Seismology and Physics of the Earth's Interior (IASPEI), 30 July – 4 August 2017, Kobe, Japan
- 16th International Balkan Workshop on Applied Physics (IBWAP), 11 – 14 July 2015, Constanta
- 17th International Multidisciplinary Scientific GeoConference SGEM 2017, 29 June - 5 July 2017, Albena
- 6th National Conference on Earthquake Engineering and 2nd National Conference on Earthquake Engineering and Seismology, 14 – 17 June 2017, UTCB, Bucharest
- 4-th Annual International Conference on Earth and Environmental Sciences, 5-8 June 2017, Athens
- Annual Scientific Communication of the Faculty of Physics, University Bucharest, June 2017
- European Association of Geoscientists & Engineers (EAGE), WS05 – Linking Active and Passive Seismics, 11 June 2017, Paris
- EGU, 23 -28 April – 2 May 2017, Vienna
- British Seismology Meeting, 5-7 April 2017, UK
- Session of Communications of Romanian Academy, 4 March 2017, Bucharest

2016

- American Geophysical Union Fall Meeting, 12 – 16 December 2016, San Francisco
- Scientific Communication Session GEO, 25 November 2016, Bucharest
- Romanian Academy, 23 November 2016
- 9th Annual International Conference of Education, Research and Innovation ICERI, 14 – 16 November 2016, Sevilia, Spania
- Risk Reduction for Resilient Cities Conference – RRRC, 3-4 November 2016, Bucharest
- International Day for Disaster Reduction, 12 October 2016, Romanian Academy
- 18th General Assembly of WEGENER Conference, 12 - 15 September 2016, Ponta Delgada, Azores, Portugal
- ESC 35th Gen. Assembly, 4 -11 September 2016, Trieste, Italia
- "Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate", Summer School 29 – 31 August 2016, Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences Telegrafenberg
- GI-FORUM Conference, 5 – 8 July 2016, Salzburg (Austria)
- 14th International Balkan Workshop on Applied Physics, 2 – 4 July 2016, Constanţa
- Annual Scientific Communication of the Faculty of Physics, University Bucharest
- International Conference on Urban Risks ICUR2016, 30 June – 2 July 2016, Lisbon, Portugal
- 16th International Multidisciplinary Scientific GeoConference SGEM, 28 June – 7 July 2016, Albena, Bulgaria

- The 8th International Symposium on Geography, Ladscapes: perception, knowledge, awareness and action, 24 – 26 June 2016, Bucharest
- 11th International Conference on „Environmental Legislation, Safety Engineering and Disaster Management" ELSEDIMA, 26 – 28 May 2016, Cluj –Napoca
- The 14th International Conference of the Geological Society of Greece, 25 – 27 May 2015, Thessaloniki
- Symposium of Doctoral School of Geology – GEODOCT, May 2016
- Antelope Users Group (AUG), May 2016, Rome
- EGU, 27 April – 2 May 2016, Vienna

2015

- Scientific Communication Session GEO 2015, 20-21 November 2015, Bucharest
- 8th Annual International Conference of Education, Research and Innovation (ICERI), 16 – 18 November 2015, Sevilla, Spania
- ECOSMART International Conference – Environment at a CrossrOards: SMART approaches for a sustainable future, 12-15 November 2015, Bucharest
- National Symposium 75 years from November 10th 1940 Vrancea Earthquake, November 10, 2015, Bucharest
- Infrasound Technology Workshop 12-15 October 2015, Vienna, Austria
- 8th congress of the Balkan Geophysical Society, BGS, 4 - 8 October 2015, Chania, Greece
- 15th International Balkan Workshop on Applied Physics (IBWAP), 2 – 5 July 2015, Constanta
- The 26th General Assembly of the International Union of Geodesy and Geophysics - IUGG, 22 June – 2 July 2015, Prague, Czech Republic
- Comprehensive-Nuclear-Test-Ban Treaty: Science and Technology, 22-26 June 2015, Vienna, Austria
- Annual scientific session of the Faculty of Physics, 19 June 2015, Bucharest - Magurele
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- "Floods, State, Dams and Dykes in Modern Times: Ecological and Socio-economic Transformations of the Rural World" International Symposium, 18-20 June 2015, Bucharest
- Symposium of the Doctoral School of Geology GEODOCT 2015, 29 May 2015, Bucharest
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IUGG

IAVCEI

International Association of Volcanology and Chemistry of the Earth's Interior

IAVCEI ACTIVITIES IN ROMANIA
2015-2018

International Association of Volcanology and Chemistry of the Earth's Interior

IAVCEI ACTIVITIES IN ROMANIA 2015 - 2018

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- Sapientia University, Faculty of Natural Science and Arts, Dept. of Environmental Sciences, Cluj-Napoca
- Alexandru Ioan Cuza University, Faculty of Geography and Geology, Iaşi
- Technical University of Cluj-Napoca, North University Centre of Baia Mare

Scientific symposia:

- National Symposium of Geophysics

Publications:

- Revue Roumaine de Géologie
- Revue Roumaine de Géophysique
- Studia Universitatis Babeş-Bolyai, Cluj-Napoca
- Analele Universităţii „Al. I. Cuza” Iaşi, Geologie
- Romanian Journal of Petrology
- Romanian Journal of Mineral Deposits
- Romanian Journal of Geophysics

PART I: INTRODUCTION AND ORGANIZATION

by Alexandru Szakács

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During the inter-IUGG General Assembly time period 2015-2019, the small and ever decreasing volcanological community in Romania continued to cope with serious problems related to the economic and social transition of the country in the post-communist era. Romania Joined the European Union at January 1st, 2007, a new status which was hoped to significantly improve the availability of both National and EU funds for scientific research, volcanology included. Those hopes have not been fulfilled, at least in the domain of IAVCEI-interest research. Both financial shortage and institutional problems strongly influenced IAVCEI-related activities in this period. Moreover, most of the active IAVCEI-member volcanologists went to official retirement during this period and a new generation of Romanian volcanologists, able to take over and continue volcanological research is hardly seen at this time, except for just a very few persons. The strong research nucleus active in these fields within the Geological Institute of Romania in the 90's dispersed early in the 2000's and remained so, and no other significant group aggregated later elsewhere excepting the Institute of Geodynamics of the Romanian Academy, where a small group led by two formally retired but informally active persons still exists.

In the same time, some research effort in volcanology shifted towards Universities, such as Babeş-Bolyai University and Sapientia University in Cluj-Napoca and North University Centre of the Technical University of Cluj-Napoca in Baia Mare. The "Alexandru Ioan Cuza" University in Iaşi is specialized in geochemistry, especially related to CEI topics. However, only few researchers are actively involved in volcanological investigation at each university center, mostly on individual basis, more ore less isolated from each other. They benefit from poor or no institutional support doing so. At this time there is no any strong and internationally recognized research group specialized in IAVCEI topics in Romania. Most of the scientific results reported here were obtained through unsupported and uncoordinated individual efforts of a few enthusiastic researchers.

At present small groups of researchers covering IAVCEI-interest topics are active in 1) the Institute of Geodynamics, Bucharest (volcanology in geodynamic context), the Babeș-Bolyai University, Cluj-Napoca (post-volcanic phenomenology) and 3) the A.I. Cuza University in Iași (geochemistry).

The trend of declining Romanian IAVCEI membership signaled in our previous reports, continued during the time period considered here. Currently only 4 Romanian researchers are IAVCEI members with their membership fees paid. Low wages (under US$ 7500/year in general), retirement and job instability precluded effectiveness of new membership recruitment, while a number of former IAVCEI members gave up their membership for similar reasons. The Romanian IAVCEI membership – a former "success story" (see Romanian IUGG Report, 1999) - continued shrinking, and this trend could not be reversed so far.

In such circumstances, the Romanian National IAVCEI Section considers further membership recruitment as one of its major current tasks. Membership "erosion" from the Group is caused by objective and subjective factors, such as inability to pay the annual membership fee because financial shortage, frustration related to unrealistic expectations upon subscription, poor fit of changing professional duties and interests with IAVCEI activities and research topics, job instability, etc. Despite of such "erosion", a few scientists with constant interest and dedication in IAVCEI-related science, still form - grouped in three research centers - the small stable and active core of the Romanian National IAVCEI Section. They are active in research and publication and are willing to take part in IAVCEI-organized activities and events.

Despite the difficulties, scientific progress in IAVCEI-related research domains has been attempted to be kept at a steady-state pace. Individual efforts have also been made to maintain and develop connection of researchers with the international community by publication, organization and attendance of scientific events (conferences and workshops), as well as participations in international cooperation and correlation projects.

Members of the Romanian National IAVCEI Section Committee have tried to actively interact with IAVCEI officials and leaders of IAVCEI Commissions (especially Commission on Volcano Geology) by electronic correspondence and personal contacts during international meetings whenever attendance was possible.

Research centers in Romania where IAVCEI-related topics are being investigated

Active research in IAVCEI-related scientific domains, such as paleovolcanology, petrology of volcanic rocks, igneous rocks-related mineralogy, granite studies, metamorphic petrology, geochemistry, ore geology in volcanic areas and geophysics of volcanic areas, is conducted mostly by individuals and small groups of professionals at a number of institutions in Romania, from which the IAVCEI membership is recruited:

- Institute of Geodynamics „Sabba S. Ştefănescu", Romanian Academy, Bucharest;
- The Geological Institute of Romania (Department of Mineralogy and Petrology; Department of Geophysics);
- „Babeş-Bolyai" University, Cluj-Napoca (Department of Mineralogy);
- Technical University of Cluj-Napoca, North University Centre of Baia Mare (Department of Mineral Resources, Materials and Environmental Engineering);
- University of Bucharest (Department of Mineralogy and Petrology, Department of Geophysics);
- „Alexandru Ioan Cuza" University (Department of Geology), Iaşi;

Membership: as listed at 01 February 2018 in the IAVCEI membership Directory

Marinel Kovacs	**Technical University of Cluj-Napoca, North University Centre of Baia Mare**
Viorel Mirea	**Institute of Geodynamics „Sabba S. Ştefănescu", Romanian Academy Bucharest**
Ioan Seghedi	**Institute of Geodynamics „Sabba S. Ştefănescu", Romanian Academy Bucharest**
Alexandru Szakács	**National Correspondent**
	Institute of Geodynamics „Sabba S. Ştefănescu"
	Romanian Academy, Bucharest

PROFESSIONAL EVENTS

Scientific events organized in Romania including IAVCEI-interest topics

- 4th International Volcano Geology Workshop, supported and sponsored by IAVCEI and IAVCEI Commission on Volcano geology „Challenges of mapping in poorly-exposed volcanic areas", organized in Eastern Transylvania, Romania, October 8-14, 2017 by the Institute of Geodynamics, Romanian Academy (Ioan Seghedi, Alexandru Szakács, Viorel Mirea, Madalina Visan)
- The INTAV international field Conference on Tephrochronology, Moeciul de sus, Romania, 24 Iunie-1 Iulie 2018, Ioan Seghedi and Alexandru Szakacs as co-organizers.

International scientific events with Romanian involvement in their organization

- XXIth Congress of the Carpathian-Balkan Geological Association, Salzburg, Austria, September 10 - 13, 2018. Session GT4: Magmatism in the Alpine-Carpathian-Balkan realm; Convenors: M. Kohut, A. Dobrescu, I. Seghedi, D. Prelević, K. Šarić, V. Cvetković, K. Németh & R. Lukács & F. Finger

Romanian participation to IAVCEI events and to events including IAVCEI-interest topics

- **The IUGG 26th General Assembly (Prague, June 22-July 2, 2015)** has been attended by a number of Romanian researchers with oral and poster contributions, some of them with IAVCEI-related topics:
  - Alexandru Szakács who presented an oral contribution in the IAVCEI Volcano Geology session and workshop, entitled "**Integrating the volcanic facies concept with the lithostratigraphic approach to mapping ancient volcanic areas. Examples from the East Carpathians, Romania",** authors Alexandru Szakács and Ioan Seghedi;
  - Marinel Kovacs who presented an oral contribution in the IAVCEI Volcaniclastic Sediments: Modern Applications for Marine and Earth Sciences session entitled **"Volcaniclastic sedimentation- witness of the interaction between volcanism and sedimentation in the Oas-Gutâi Neogene volcanic area (Eastern Carpathians, Romania)" ,** authors, Kovacs, M, Fülöp A, Pécskay Z, and a poster contribution in the IAVCEI Water and Magma session entitled **" Non-explosive and explosive magma-water interaction in the volcanic evolution of Oas-Gutai Mountains (Eastern Carpathians), Romania"** authors, Kovacs, M, Fülöp A.

- **The EGU (European Geosciences Union) General Assembly (Vienna, April 17-22, 2016)** has been attended by Ioan Seghedi who presented a poster entitled **"The Pliocene-Quaternary South Harghita (Romania) volcanic chain-ending segment - a review"**, authors Ioan Seghedi, Alexandru Szakács;

- **The "6th International Maar Conference" organized by the IAVCEI's Commission of Monogenetic Volcanism on July 29 – August 9, 2016 in Changchun, China**, was attended by Ioan Seghedi and Alexandru Szakacs with the oral contribution in Session 1 entitled **"Maar structures in Persani volcanic field, SE Transylvania, Romania – a revised volcanological study"**

- The 35th International Geological Congress, August 27 – September 4, 2016 organized in Cape Town, was attended by Marian Munteanu who presented two poster contributions with the titles "**Chemical variability of ore minerals in several epithermal deposits from the Gold Quadrilateral, Apuseni Mountains, Romania**" and „**Platinum group elements in south Longzhou Mountains, Sichuan, SW China**".
- The IAVCEI General Assembly in Portland, Oregon (USA) (14-18 August 2017) has been attended by Marinel Kovacs who presented an oral contribution entitled **" P-T evolution of the Miocene magmatic system from Gutâi Volcanic Zone (Eastern Carpathians, Romania)",** authors Kovacs, M, Fülöp A, Seghedi I, Pécskay Z, Yamamoto M, Jurje M. Other contributions:
  - Molnár K., Harangi S., Lukács R., Dunkl I., Schmitt A.K., Molnár M., NovothnyÁ, Kiss B, Seghedi I., 2017. **A detailed eruption chronology of the Ciomadul lava dome field (East Carpathians, Romania) based on (U-Th)/He zircon dating.**, submission 1031
  - Harangi S, Lukács R., Kiss B., Schmitt A.K., Bachmann O., Mészáros K., Seghedi I., Hauzenberger C., Mason P.R.D.. 2017. **Petrologic constraints for a warm magma storage prior to the latest eruption of the Ciomadul volcano, eastern-central Europe**, submission 992
- The 22th General Meeting of the International Mineralogical Association, 13-17 August, 2018, Melbourne, Australia, was attended by Alexandru Szakács who presented an oral conribution entitled **„World-class mineral/rock type localities and mineralogical museums in Romania as potential cultural heritage sites"**, authors, Alexandru Szakács, Ágnes Gál, Corina Ionescu"
- IAVCEI – 7th International Maar Conference, Olot, Spain, 2018, Abstract volume: **"Cyclic variation in intensity of explosivity during a maar-diatreme eruption on an ocean island volcano: implications for dynamic hazard models"** Bob Tarff, Simon Day, Hilary Downes and Ioan Seghedi, 188-189
- The INTAV international field Conference on Tephrochronology, Moeciul de sus, Romania, 24 Iunie-1 Iulie 2018, Ioan Seghedi and Alexandru Szakacs as organizers. Contributionbs:
  - Seghedi I., Szakács A., Pécskay Z. **Geological and volcanological outline of the Carpathian-Pannonian Region with emphasis on Romanian territory;**
  - Harangi S., Molnár K., Kiss B., Lukács R., Dunkl I., Schmitt A.K., Seghedi I., Novothny A., Molnár M., Oross R., Ntaflos T., Mason P.R.D. **Eruption ages and geochemical fingerprints of the distal tephras from the Late Pleistocene Ciomadul volcano, East Carpathians**

- Contributions to the EGU2018, Vienna meeting:
  - Szemerédi M., Varga A.,Tatu M., Seghedi I., Dunkl I., Pál-Molnár E., Lukács R. **Permian volcanism vs. Alpine nappe stacking: petrographic and geochemical observations for regional correlation of the Permian felsic volcanic rocks, Tisza Mega-unit (Hungary and Romania)**
  - Szakács A., Szűcs E., Gál Á., Wesztergom V. **TOPO TRANSYLVANIA within TOPO EUROPE: Introduction to an unfolding project**

- The sessions covering IAVCEI-topics at the XXIst Congress of the Carpatho-Balkan

Geological Association (CBGA) in Salzburg, Austria (23-26 September, 2018) have been attended by a number of Romanian researchers with oral and poster contributions, 4 of them with IAVCEI-related topics:

- Ioan Seghedi: **"Volcanology, petrology and geodynamic aspects of the Miocene magmatism in the Apuseni Mountains – a review"**
- Ioan Seghedi, Alexandru Szakács, Zoltan Pécskay, Viorel Mirea, Peter Luffi: **„ Debris avalanche deposits of the Calimani-Gurghiu-Harghita volcanic range (Eastern Transylvania, Romania)"**
- Marinel Kovacs, Alexandrina Fülöp, Zoltan Pécskay: **„Uncommon, composite volcanic structures in the Gutâi Volcanic Zone (Eastern Carpathians, Romania). Implications for the petrogenetic model"**
- Anca Dobrescu: **„Adakitic-like granitoids at west Getic basement of the South Carpathians - petrogenesis and thermotectonic events evidenced by zircon geochemistry"**
- Marian Munteanu, M.-E. Cioacă, G. Costin, A. Iorga-Pavel: **„Investigation of the platinum group elements contents in some mafic and ultramafic rocks from the Romanian Carpathians"**
- M. Szemerédi, R. Lukács, A. Varga, I. Seghedi, M. Tatu, I. Dunkl, E. Pál-Molnár, Sz. Harangi. **„Permian volcanism in the Tisza Mega-unit: new petrographic, geochemical and geochronological results from Hungary and Romania"**

PART II: PROGRESS REPORT OF SCIENTIFIC RESEARCH IN RELEVANT IAVCEI-INTEREST DOMAINS IN ROMANIA

Romanian researchers, whether IAVCEI members or not, achieved some significant progress of knowledge in a number of research domains which are within the area of IAVCEI interests. The following part of this report consists of a list of papers and abstracts published in the time interval 2015-2019, with Romanian contributors as authors and co-authors, from which a general picture of the main results obtained may emerge.

Books and fieldtrip guides

Seghedi I., Szakács A., Mirea V., Visan M., Luffi P. (2017), 4th International Volcano Geology Workshop, Transylvania, Romania 8-14 October 2018. Challenges of mapping in poorly-exposed volcanic areas. Field Guide and Abstracts 90 pp. Geological Institute of Romania. ISSN 2248-2563

Papers and abstracts

2018

Cazacu, B.C., Buzgar, N., Iancu, O.G. (2018), Geochemical and spatial distribution of heavy metals in forest soils adjacent to the Tinovul Mare Poiana Stampei peat bog, *Revista de Chimie*, **69 (2)**, 434-438;

Adumitroaei, M.V., Iancu, G.O., Rățoi, B.G., Doru, C.S., Sandu, C.M. (2018), Spatial distribution and geochemistry of major and trace elements from Mohoș peatland, Harghita mountains, Romania, *Holocene*, **28 (12)**, 1936-1947, doi: 10.1177/0959683618798174

Dobrescu A. (2018), Adakitic-like granitoids at west Getic basement of the South Carpathians-petrogenesis and thermotectonic events evidenced by zircon geochemistry. XXI International Congress of the Carpathian Balkan Geological Association, Abstracts, *Geologica Balcanica*, 131;

Kovacs, M, Fülöp, A., Pécskay Z. (2018), Uncommon, composite volcanic structures in the Gutâi Volcanic Zone (Eastern Carpathians, Romania). Implications for the petrogenetic model. XXI International Congress of the Carpathian Balkan Geological Association, Abstracts, *Geologica Balcanica*, 122;

Molnár, K., Harangi, S., Lukács, R., Dunkl, I., Schmitt, A.K., Kiss, B., Garamhegyi, T., Seghedi, I., (2018), The onset of the volcanism in the Ciomadul Volcanic Dome Complex (Eastern Carpathians): eruption chronology and magma type variation, *Journal of Volcanology and Geothermal Research*, **354**, 39–56;

Munteanu, M., Cioacă, M.-E, Costin, G., Iorga-Pavel, A. (2018), Investigation of the platinum group elements contents in some mafic and ultramafic rocks from the Romanian Carpathians. XXI International Congress of the Carpathian Balkan Geological Association, Abstracts, *Geologica Balcanica*, 308;

Serban M Sarbu, S.M., Aerts, J.W., Flot, J.F., Van Spanning, RJM, Baciu, C., Ionescu, A., Kis, B.M., Incze, R., Sikó-Barabási, S., Para, Z., Hegyeli, B., Atudorei, N.V., Barr, C., Nealson, K., Forray, F., Lascu, C., Fleming, E.J., Bitter, W., Popa, R., (2018), Sulfur Cave (Romania), an extreme environment with microbial mats in a CO_2-H_2S/O_2gas chemocline dominated by mycobacteria, *Journal of Speleology*, **47**, 2;

Seghedi I. (2018), Volcanology, petrology and geodynamic aspects of the Miocene magmatism in the Apuseni Mountains – a review. XXI International Congress of the Carpathian Balkan Geological Association, Abstracts, *Geologica Balcanica*, 119;

Seghedi, I., Szakács A, Pécskay Z, Mirea V, Luffi P. (2018), Debris avalanche deposits of the Calimani-Gurghiu-Harghita volcanic range (Eastern Transylvania, Romania). XXI International Congress of the Carpathian Balkan Geological Association, Abstracts, *Geologica Balcanica*, 142;

Szakács A., Pécskay Z., Gál Á. (2018), Patterns and trends of time–space evolution of Neogene volcanism in the Carpathian–Pannonian region: a review. *Acta Geodaetica et Geophysica.* **53 (3)**, 347–367, doi.org/10.1007/s40328-018-0230-3;

2017

Apopei, A.I., Damian, G., Buzgar, N., Buzatu, A., Andráš, P., Milovska, S. (2017), The determination of the Sb/As content in natural tetrahedrite-tennantite and bournonite-seligmannite solid solution series by means of Raman spectrometry, *Mineralogical Magazine*, **81 (6)**, 1439-1456, doi: 10.1180/minmag.2017.081.008;

Buzatu, A., Damian, G., Buzgar, N., Andráš, P., Apopei, A.I., Maftei, A.E., Milovská, S. (2017), Structural key features of bismuth and Sb-As sulfosalts from hydrothermal deposits—micro-Raman spectrometry, *Vibrational Spectroscopy*, **89**, 49-56, doi: 10.1016/j.vibspec.2017.01.002;

Gallhofer, D., von Quadt A., Schmid S. M., Guillong M., Irena Peytcheva I., Seghedi I., (2017), Magmatic and tectonic history of Jurassic ophiolites and associated granitoids from the South Apuseni Mountains (Romania), *Swiss Journal of Geosciences,* **110**, 699-719;

Kis B.M. (2017), Dissolved gases in mineral waters at the contact zone between the East Carpathians and Treansylvanian Basin (in Hungarian), *Acta Scientiarum Transylvanica*, Cluj-Napoca, 25/3;

Kis, B.M., Ionescu, A., Cardellini, C., Harangi, Sz., Baciu, C., Caracausi, A., Viveiros, F. (2017), Quantification of carbon dioxide emission of Ciomadul, the youngest volcano of the Carpathian-Pannonian Region (Eastern-Central Europe, Romania), *Journal of Volcanology and Geothermal Research*, **341**, 119-130;

Ionescu, A., Burrato, P., Baciu, C., Etiope, G., Kis, B.M. (2017), Inventory of onshore hydrocarbon seeps in Romania (HYSED-RO database), *Geosciences*

Ionescu, A., Baciu, C., Kis, B.M., Sauer, E.P. (2017), Evaluation of dissolved light hydrocarbons in different geological settings in Romania, *Chemical Geology*, **469**, 230-245;

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Túri, M., Palcsu L., Papp L., Horváth A., Futó I., Molnár M., Rinyu L., Janovics R., Braun Kovacs, M, Seghedi I, Yamamoto M, Fülöp A, Pécskay Z, Jurje M. (2017), Miocene volcanism from the Oaş-Gutâi Volcanic Zone (Eastern Carpathians, Romania) – link to the geodynamic processes of Transcarpathian Basin, *Lithos*., **294-295**, 304-318;

Kovacs, M, Fülöp A, Seghedi I, Pécskay Z, Yamamoto M, Jurje M. (2017), P-T evolution of the Miocene magmatic system from Gutâi Volcanic Zone (Eastern Carpathians, Romania); IAVCEI 2017 Scientific Assembly, Electronical Abstracts, p.546, Portland, SUA

Munteanu, M., Wilson, A.H., Costin, G., Yao, Y., Lum, J.E., Jiang, S.Y., Jourdan, F., Chunnett, G., Cioacă, M.E., (2017), The mafic-ultramafic dykes in the Yanbian Terrane (Sichuan Province, SW China): Record of magma differentiation and emplacement in the Emeishan Large Igneous Province, *Journal of Petrology*, **58**, 513-538;

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Apopei, A.I., Damian, G., Buzgar, N., Buzatu, A. (2016), Mineralogy and geochemistry of Pb-Sb/As-sulfosalts from Coranda-Hondol ore deposit (Romania) - Conditions of telluride deposition, *Ore Geology Reviews*, **72**, 857-873, doi: 10.1016/j.oregeorev.2015.09.014;

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Fedele, L., Seghedi, I., Chung, S-L., Laiena, F., Lin, Te-H., Morra, V., Lustrino, M., (2016), Post-collisional magmatism in the Late Miocene Rodna-Bârgău district (East Carpathians, Romania): geochemical constraints and petrogenetic models, *Lithos*., **266–267**, 367–382;

Seghedi, I., Popa, R-G., Panaiotu, C.G., Szakács ,A., Pécskay, Z. (2016), Short-lived eruptive episodes during the constructionof a Na-alkalic basaltic field (Perşani Mountains, SE Transylvania, Romania), *Bulletin of Volcanology*, **78**, 69, doi:10.1007/s00445-016-1063-y

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Túri, M., Palcsu L., Papp L., Horváth A., Futó I., Molnár M., Rinyu L., Janovics R., Braun M., Hubay K., Kis, B.M., Koltay G. (2016), Isotope characteristics if the water and sediment in volcanic lake Saint Ana, East-Carpathians, Romania, *Carpathian Journal of Earth and Environmental Sciences*, **11 (2)**, 475-484;

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