WHAT THE NATIONAL GEOINFORMATION CENTER IS GOING TO CHANGE?

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Abstract. The NATIONAL GEOINFORMATION CENTER (NGIC) is a newly established scientific infrastructure for integration of data, data products, and facilities from all Earth observation research institutions in Bulgaria. NGIC will bring together scientists, research infrastructures and ICT (Information & Communication Technology) experts, to develop new concepts and tools for accurate, durable, and sustainable products and services concerning geo-hazards and geo-resources which are relevant to the environment and human welfare. Our vision is that integration of the existing research infrastructures will increase access and use of the multidisciplinary data from the Earth monitoring networks and laboratory experiments.

NGIC mission is to build on new e-science opportunities to monitor and understand the dynamic and complex Earth System, to provide permanent access to geo information, to deliver reliable data and services and to support the effective prevention from natural and anthropogenic disasters and industrial accidents.

NGIC has federated organization model, which means that the sources of data are owned by their independent entities and there is no absolute authority that may imperatively force rules. The center has adopted conceptual model of system architecture that uses both service and microservice concepts and may be altered according to the specifics of the organization environment and development goals of particular information system. The sustainable result of the work of NGIC will be a solid basis for conducting research on Earth and the processes associated with it, as well as an indispensable tool for managing the risk of natural disasters and accidents

Key words: scientific infrastructure, geoinformation, Earth science, Earth observation, data products and services.

Introduction

The Earth Science community worldwide has already begun to reap the benefits of integrated accessible data. A very good example is the successful progress of the European Plate Observing System project (EPOS) which started its preparation phase in 2008 and recently obtained the legal status of European Research Infrastructure Consortium (ERIC). It is now accepted that the study of the Earth is necessarily multidisciplinary and requires the access to data and products generated by different communities with different data formats and processing procedures. The understanding of Earth dynamics and tectonic processes for example relies on the analysis of seismological data, ground deformations inferred from terrestrial and satellite observations, geological and petro-chemical studies and laboratory experiments to investigate the chemical and physical processes occurring at depth. In this framework, the next generation of researchers must be able to use multidisciplinary data and prepared to collaborate for cross-disciplinary investigations. This is one of the key challenges for future research in all disciplines. Effective prevention from natural and anthropogenic disasters and industrial accidents requires as well permanent access to reliable data and products acquired by different Earth observation systems. And those are only parts of the benefits from developing a complete, sustainable, multidisciplinary research platform to provide coordinated access to harmonized and quality controlled data from diverse Earth science disciplines, together with tools for their use in analysis and modelling.

NGIC consortium

The NATIONAL GEO-INFORMATION CENTER (NGIC) is a newly established distributed scientific infrastructure for cooperation and integration of human resources, products and data from monitoring networks and observatories and their integrated analysis. It is part of the National road map for scientific infrastructure (2017-2023), adopted by the Council of Ministers of Bulgaria. The partners joined in the research consortium are four institutes working in the field of Earth observation: the National Institute of Geophysics, Geodesy and Geography (NIGGG), the National Institute of Meteorology and Hydrology (NIMH), the Institute of Oceanology (IO), the Geological Institute (GI), and two institutes competent in ICT: the Institute of Mathematics and Informatics (IMI) and the Institute of Information and Communication Technologies (ICT).

Technical characteristics of the partners

NGIC is a distributed scientific infrastructure with national territorial coverage and integrates monitoring networks, observatories, observation stations, laboratories, computing centers and other specialized equipment of the participating partners. Existing technical resources include unique facilities, scientific equipment and computer networks, the most important of which are as follows (Miloshev et al., 2019):

National Institute of Geophysics, Geodesy and Geography - BAS
(www.niggg.bas.bg)

- National Seismological Network (NOTSSI), consisting of 24 seismic stations (16 main and 8 grouped in two local networks), located on the territory of the whole country and a network of 17 stations located in northern Bulgaria. The network performs continuous monitoring of the seismic events in Bulgaria and the surrounding territories.
- National Accelerometric System (NAS) for registration, analysis and assessment of strong earth motions, consisting of 29 stations with national coverage. The network operates in a permanent registration mode for earth motions caused by seismic events.
- National Permanent GNSS Network, consisting of 21 stations located on the territory of the country. Data are collected, archived and processed in a specialized GNSS Processing Center at NIGGG equipped with modern computers and specialized software.
- National mareograph network for sea level monitoring consisting of 4 stations (Varna, Irakly, Burgas, Ahtopol).
- National Geomagnetic Observatory Panagyurishte, which performs continuous registration of the magnetic field on the territory of the country, as well as field measurements of the field elements. It has modern three-component vector variometers (FGE, DTU Space), two systems for absolute geomagnetic measurements (non-magnetic theodolite + magnetometer) and a field proton magnetometer GSM 19.
- National Geodetic Observatory Plana where a permanent GNSS station, a weather station and a telescope for astronomical observation are installed.
- Palaeomagnetic laboratory equipped with unique scientific equipment for measuring the magnetic properties of natural materials, including various types of magnetometers, kappa-meters, magnetizer and de-magnetization devices, laboratory sample heating furnace, electronic pH meter, centrifuge, separator etc.
- A system for chemical weather prediction working in continuous mode, using three internationally recognized models (CMAQ, MM5, SMOKE).
- Monitoring of Ozone/UV, based on one station for registration of UV radiation and a model for determining the total ozone content, working with satellite data.
- GIS center with computers and specialized software.
- "Ogosta" monitoring network for ecological monitoring of river, ground and soil waters, equipped with piezometers, telemetric apparatus for automatic monitoring of water level and physic-chemical indicators, portable equipment, etc.
- Experimental Laboratory of Karst, equipped with a professional multifunctional system for karst water analysis, microclimatic monitoring systems, speleo-radiological monitoring (radon detectors, CO2, gamma-radiation), dilatometer.

National Institute of Meteorology and Hydrology (www.meteo.bg)

- Ground-based stations: synoptic (37), climatological (77), precipitation (249), agro-meteorological (24), hydrological (170), hydrogeological (347), for precipitation acidity measuring (34|, for measuring the components of solar radiation (4), automatic meteorological and hydrological (over 150), experimental polygon for atmospheric boundary layer studies (1).
- Aerological measurements - Central Aerological Observatory Sofia. Daily measurements of vertical profiles of meteorological elements up to a height of 25 km by radiosondes.
- Satellite information
- Information from the meteorological satellites of EUMETSAT is received in "real time" mode, which is used in the operational short-range weather forecasts and in determining the state of the earth surface, for issuing warnings for dangerous meteorological phenomena, for detecting thermal anomalies, etc.
- NIMH maintains a complex information system for transferring, processing and archiving of data, disseminated by the Global Telecommunication System (GTS) and is part of the information flow of the World Weather Information Service of WMO,
- The Regional Telecommunication Center (RTC) in NIMH Sofia is one of the 15 GTS Regional Telecommunication Hubs (RTH) of the WMO. It provides information for the countries from Southeastern Europe and the Middle East. The Regional Telecommunication Center also offers real-time access to the national and international hydro-meteorological data and products. The center is responsible for the processing and selective exchange and dissemination of data: forecasts, aerological, radar, satellite and other information needed in the fields of meteorology, hydrology, agro-meteorology, oceanography and ecology.

Geological Institute – BAS (www.geology.bas.bg)

- National Monitoring Network for monitoring of dangerous geologic processes and phenomena, including monitoring of landslides and active faults on the territory of the country using 3D extensometers and 5 GNSS stations located along the Black Sea coast.
- Extensometric points are installed in a seismically active area of SW Bulgaria (Krupnik-Brezhani region and Kresna gorge) and in deep-seated landslides in the Eastern Rhodopes Mts.
- Modern systems for hydrogeological monitoring and analysis;
- Specialized Geotechnical Laboratory and field research equipment. related to the new BDS EN standards introduced;
- Geochemical equipment. Geolab laboratory for chemical and mineral composition research (ICP, LA-ICP, etc.), physical and mechanical properties of rocks, minerals and soils.
- Database for landslides, maps for geological structure of Bulgaria.

Institute of Oceanology – BAS (www.io-bas.bg)

- National monitoring network according to The Water Framework Directive and the Marine Strategy Framework Directive - 51 sampling stations in the coastal, shelf and open sea zones.
- Coastal observatories providing real time oceanographic and meteorological information and 3 laboratories
- A Research vessel 55.5 m long and a research submarine PC-8B, 6.5 m.

Institute of Mathematics and Informatics – BAS (www.math.bas.bg)

Department Software Engineering and Information Systems – performs scientific research in the fields of mathematical structures, modeling and mathematical informatics, leading to innovative applications in other sciences, in ICT, etc. IMI has premises and infrastructure that allow trainings and other educational initiatives.

Institute of Information and Communication Technologies (www.iict.bas.bg)

Department of Grid Technologies and Applications is in good relations with other leading institutions from Bulgaria and Europe, with interest in Grid, Cloud and HPC computing.

- Dedicated one HP ProLiant SL390s G7 4U server with 8 NVIDIA Tesla M2090 GPU cards (total 4096 GPU cores and 4 TB of disk space for testing of services Big Data analysis
- Dedicated 4 servers from the Avitohol system, for the purposes of NGIC (HP Cluster SL250S GEN8, each with 2 Intel Xeon E2650v2 processor and 2 Intel Xeon Phi 7120P coprocessors)

Conceptual model of the NGIC system architecture

For the development of the basic system architecture model for NGIC more than 10 national and 5 international sources of Earth observation data and services have been studied (Branzov et al., 2019). The first significant observation is that most of national centers, governed by state organization (state agency, company, research institute) has vertical governance structure. Usually their operations are closely connected with everyday life (such as prognosis, warnings, etc.). The research activities support the main activities. The rest of the national centers are focused to establish a common infrastructure for research and development – federated structures with management team and researchers from the universities and research centers (personally, or institutionally). Further, basically all international centers have federated organization structure.

Analysis of enterprise system architecture models reveals that all of studied geoinformation centers implement service oriented architecture. Some of the centers in their implementation documentation explicitly state as principle usage of distributed services.

Five of centers either use microservice concepts in their architecture or plan their implementation (with at least one (EPOS) – with clear implementation plan).

Based on the findings of the analysis a basic conceptual model of architecture is proposed that uses both service and microservice concepts and may be altered according to the specifics of the organization environment and development goals of the NGIC information system (IS) (Branzov et al., 2019b). The purpose of the model is to be useful in the planning or optimization phases of NGIC information systems (IS) design cycle.

The conceptual model consists of three layers (Figure 1). It is based on the architectural concept for a service, defined as a system component (service provider) that acts to achieve desired end results under a request by another component (service consumer) (He, 2003) and microservice as independent, single purposed and loosely coupled component that supports interoperability through message-based communication (Nadareishvili et al., 2016).

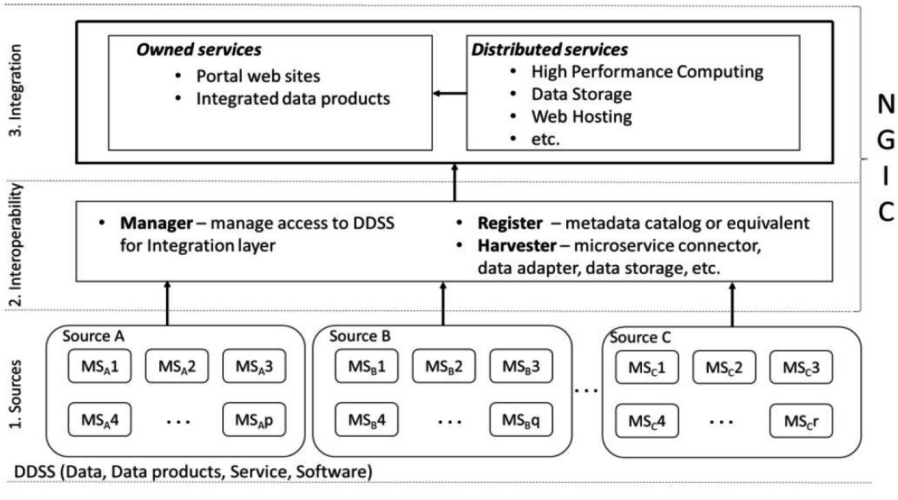

Fig. 1. Conceptual service-microservice model of NGIC (Branzov et al., 2019b).

"*Sources*" layer contains the providers of Data, Data products, Services and Software (DDSS) that are used by the system to produce advanced integrated products. Providers are presented as sources – collections of microservices. Microservice concept by definition is designed with purpose for providing maximum agility to development of the system, so, its usage provides optimal environment for scaling the systems in the scenarios as – expansion through adding new DDSS by existing source, expansion through adding a new source, shrinking through excluding either DDSS or entire source.

The components in "*Interoperability*" and "*Integration*" layers may use either monolithic service or microservice concept. Since they are centrally managed it is possible and convenient to implement the service management framework of choice.

"*Interoperability*" layer includes components that are mentioned in three abstract categories: "Manager", which regulate the access to the DDSS in "*Sources*"

layer; "Register", which provide automation of discovery and selection of DDSS; and "Harvester", which includes advanced automated subsystems for data collection from the sources (like data harvesters, data adapters, storages for data buffering, etc.). From these categories only "Manager" is mandatory, but practically in all contemporary geoinformation centered which are reviewed, the two others also exist.

"*Integration*" layer produces integrated data products (IDP). This is the layer where the value of the GIC is created and delivered. The service architecture is built around two columns – owned services, which provide the access to the IDP. The IDP itself are prepared by owned and distributed services, assured by the ICT support providers or providers that are not partners in NGIC.

Although one of the major characteristic of the "Sources is that they are always passive (i.e. they are designed only to response to requests), the layered nature of the model along with complete authority of NGIC over "*Interoperability*" and "*Integration*" layers allow implementation of virtually all other major patterns in manufacturing process of value-added products.

For example, even patterns like "observer" and "publisher-subscriber" that require active side that rises events could be implemented in the top two layer – one approach is to implement a service that regularly pulls DDSS from "*Sources*" and builds repository that is under authority of NGIC; on the next step that service (or another) may push events on a bus or inform observers that are either services of NGIC or some outside consumers.

Data, data products and services of NGIC

Web site (Figure 2) of the National Geoinformation center (www.ngic.bg) has three main features which are going to be operational: 1)"**Risk**" section with information about Earthquakes, Air pollution, UV radiation, Magnetic storms, Coastal threats, Landslides and rock falls, etc.; 2)"**Thematic**" section which will cover all scientific topics of the partners and 3) "Data portal" where the Earth observation data will be organized.

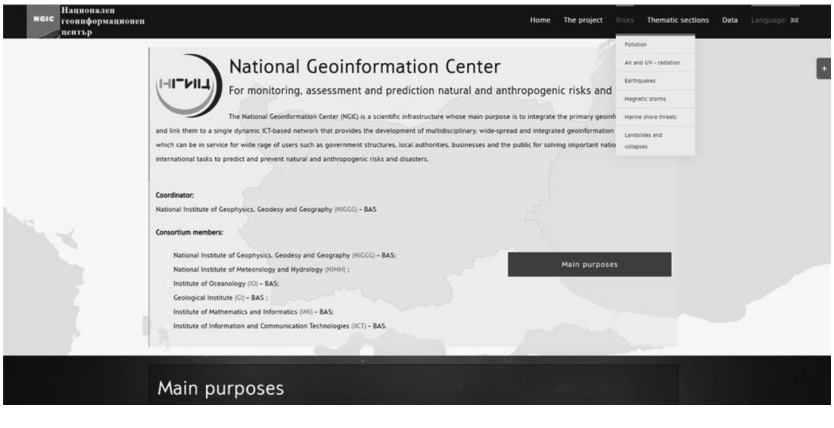

Fig. 2. Features of the National Geoinformation center web page (www.ngic.bg).

Conclusions

Considerable advances in information technology now make an integrated approach possible, easing access to the deluge of data and products available across Earth science and related fields. Accessible datasets will bring novel cross-fertilization of ideas and leads to innovative research that is the key to future success.

From a scientific research perspective, NGIC will provide open access to geophysical, geological and other Earth observational data, while promoting cross disciplinary approaches to Earth science studies. It includes new ways to access data, quality assured metadata and development of new data products and services.

Society needs resources to support home life, industry and business and it needs security in the face of natural hazards. Successful societies depend on the science base to assess the genesis, extent and conservation of natural resources, in order to exploit them and discover new sources without detriment to our environment.

Earth science data can contribute to more effective decision-making in multiple ways. Information can be used to identify emerging problems, trends and changes and monitor ongoing situations. NGIC services will help governmental institutions to make well-informed decisions based on accurate scientific data. Similarly, problems can be anticipated based on forecasts and analysis of future trends.

The overall effect that will be achieved by the establishment of the National Geo-Information Center (NGIC) will be to secure the science effort to understand the Earth system and to increase the quality of life reducing the human and material losses from natural disasters and industrial accidents.

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Какво ще промени създаването на Национален геоинформационен център?

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Резюме: Националният Геоинформационен Център (НГИЦ) е новосъздадена научна инфраструктура за интегриране на данни, услуги и технически капацитет на всички изследователски институти за наблюдение на Земята в България. НГИЦ ще обедини учени, научноизследователски инфраструктури и ИКТ (информационни и комуникационни технологии) експерти, за да разработят нови концепции и инструменти за точни, трайни и устойчиви продукти и услуги, свързани с природните опасности и георесурсите, които са от значение за околната среда и благосъстоянието на хората. Нашата визия е, че интегрирането на съществуващите изследователски инфраструктури ще увеличи достъпа и използването на мултидисциплинарни данни, получавани от мрежите за наблюдение на Земята и лабораторните експерименти.

Мисията на НГИЦ е да създаде нови възможности за наблюдение и изучаване на динамичната и сложна Земна система, за осигуряване на постоянен достъп до гео информация, за предоставяне на надеждни данни и услуги, и за подпомагане на ефективната превенция от природни и антропогенни бедствия и промишлени аварии.

НГИЦ има федерален модел на организация, което означава, че източниците на данни са собственост на институциите, които ги добиват и не се предвижда императивно прилагане на правила в това отношение. Центърът е приел концептуален модел на системна архитектура, която е съобразена със съвременните тенденции в системните архитектури, вкл. в областта на геоинформационните центрове и може да бъде използвана за развитие на НГИЦ.

Дългосрочният резултат от работата на НГИЦ ще бъде солидна база за провеждане на научни изследвания на Земята и процесите, свързани с нея, както и незаменимо средство за управление на риска от природни бедствия и аварии.