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Environmental data gaps in Black Sea catchment countries: INSPIRE and GEOSS State of Play

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ABSTRACT

This paper presents the results of a large analysis of environmental data gaps in countries of the Black Sea catchment performed in the context of the FP7 enviroGRIDS project in 2010. We also assessed the level of compatibility of the data to the European directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) and to the international standards of data interoperability as advocated by the Group on Earth Observations (GEO) and implemented in the Global Earth Observation System of Systems (GEOSS). Many environmental datasets were analyzed at different scales (national, regional, European, and global) and the analysis revealed gaps in spatial and temporal environmental data coverage and problem of data compatibility at different scales.

The analysis enabled the identification of areas where further efforts are needed to reinforce the existing observation systems in the region, such as monitoring systems to provide data on water quality in rivers, on the state of marine environments, or on pollution and nutrients loads from land based sources. A significant proportion of environmental datasets is not accessible or has limited access, so further efforts are needed to make them available to decision makers and scientists following the GEO data sharing principles. Compatibilities of many data sets and observation systems to international interoperability standards are low in this region, and we discuss what further efforts are needed to improve the situation and how this is relevant to environmental policies.

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1. Introduction

Some areas of the Black Sea catchment are regularly facing severe environmental, social and economic problems. In the last decades the region has undergone major socio-economic changes having significant environmental implications (Black Sea TDA, 2007). After the decline of environmental conditions in 1970–80s the encouraging signs of improvement have been registered in 1990s–2000s, with for example the significant decrease of nutrients loads to rivers (DRBM Plan, 2009), and the rise of zooplankton and small pelagic fish stocks in Black Sea (Black Sea TDA, 2007). Protection of environment and mitigation against environmental degradation and relevant social and economic problems are getting higher priorities in national and regional policies.

The International Commission for the Protection of the Danube River (ICPDR) and the Commission on the Protection of the Black Sea Against Pollution (short name: Black Sea Commission or BSC[1]) are the major international bodies dealing with protection of the environment in the Black Sea catchment area. These two Commissions regularly provide assessments of the state of environment in order to elaborate measures to be undertaken to achieve regional environmental objectives. However, these assessments are sometimes ongoing under limited, even missing, important data and information (DRBM Plan, 2009; Black Sea SAP, 2009; Diagnostic Report, 2010).

The EC FP7 enviroGRIDS project (Lehmann et al., 2015) aims at gathering, storing, distributing, analyzing, visualizing and disseminating crucial information on the environment of the Black Sea catchment. Its aim is to increase the capacity of decision-makers and other stakeholders to use it for development of most relevant management options targeting especially the needs of the BSC and ICPDR. The project provides direct scientific and technological support to the European directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (European Commission, 2007a) or European INSPIRE directive. EnviroGRIDS also contributes to building capacities of the Global Earth Observation System of Systems (GEOSS) implemented by the Group on Earth Observations (GEO) (Group of Earth Observations, 2005).

INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive does not require collecting new spatial data, but foresees that data should be collected only once and then stored and maintained at the most appropriate level and made available. Moreover, the infrastructure should further ensure the possibility of combining data from different sources in a consistent way and sharing them among users and applications. INSPIRE mainly addresses those policies and activities that may have direct or indirect impact on the environment, but there are also implications and overlaps with other activities, policies and initiatives with complementary objectives (Craglia, 2010).

The purpose of the GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system (GEO secretariat, 2008). GEOSS aims to provide data to decision-support tools for a wide variety of end users (GEO secretariat, 2011). This system of systems is proactively linking existing and planned observing systems around the world and supports the development of new systems where gaps currently exist. It promotes common technical standards so that data from thousands of different instruments can be combined into coherent data sets (GEO secretariat, 2009). Differently from INSPIRE, which is legally-binding and requires EU Members states to implement the Directive, GEOSS is a voluntary-based partnership involving any data providers globally.

To ensure the efficient and effective sharing of environmental data, data policies can be considered as key elements. These policies are often developed at either national or international levels whereas researches are often conducted at the local or regional/trans-boundary level within specific jurisdictions. Consequently data access principles adopted internationally by scientific communities must be supported by national policies and laws in which participating researchers are working. This necessity of coherence between data sharing principles adopted by large, international scientific collaborations and national policies/jurisdictions is a major concern for initiatives like GEOSS and Internet technologies have facilitated collaborations in scientific research from distributed locations and in a certain way have canceled physical boundaries between countries. However to ensure and facilitate access to and reuse of data, frameworks like GEOSS and INSPIRE should embed and ensure that national policies and laws support data sharing not only at the national but also at the regional and global levels (Fitzgerald et al., 2009).

As of 2010 when our gap analysis was performed, both GEOSS and INSPIRE were in developing phases. The purpose of our current analysis is therefore to identify the existing observation systems, networks, services, and datasets for the Black Sea region and to clarify if these meet the requirements of both initiatives. Another purpose is to identify gaps and areas where further efforts are needed to reinforce existing observation systems in this region. Finally, the question is addressed as to whether data sharing is sufficiently developed to serve the needs of environmental policies specific to the Black Sea, especially those targeted by the ICPDR and BSC.

2. Background

The Black Sea catchment covers almost a third of Europe (Fig. 1). The largest river is the Danube (Table 1) flowing through 10 European countries. The Black Sea catchment with a total surface area of about 2,500,000 square kilometers comprises territories of 23 countries: namely Albania, Austria, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, The Czech Republic, Georgia, Germany, Hungary, Italy, FYR Macedonia, Moldova, Montenegro, Poland, Romania, The Russian Federation, Serbia, Slovakia, Slovenia, Switzerland, Turkey, and Ukraine. Of these

[1] Hereinafter the abbreviation BSC stands for the "Black Sea Commission" (to be distinguished from the same abbreviation often used in enviroGRIDS project documents to denote the "Black Sea catchment").

Fig. 1 – Black Sea catchment map.

countries seven have more than 90% of their surface within the catchment. The total population for the entire catchment calculated using the global dataset "Landscan" (Budhendra et al., 2002) for the year 2007 was approximately 183 million.

Due to large catchment area as compared to its own area, the Black Sea is extremely vulnerable to pressure from the land-based human activities and the health of its ecosystem is dependent on both the coastal and non-coastal countries of its river basin (Danube Watch, 2002). There is an evident link between the riverine nutrient loads, particularly from the Danube, and eutrophication in the Black Sea (Black Sea TDA, 2007). The reduction of nutrient loads to the Black Sea is a primary goal of the Danube River Basin Management (DRBM) Plan implemented by Danube countries and coordinated by the ICPDR (DRBM 2009). The same targets – reduction of nutrient and pollution loads to the sea from land-based sources – are set in the Black Sea Strategic Action Plan implemented in Black Sea countries under coordination of the BSC (Black Sea SAP, 2009).

Achieving the environmental sustainability and ensuring human well-being in the Black Sea catchment region strongly depends on sustainable water resources management. It requires elaboration of coherent cost effective measures in all Black Sea catchment countries. This should be based on comprehensive scientific analysis of past and present states of the environment and human development in the region, and on the ability to make adequate reliable prognosis for the future. The success of such analysis, prognosis and ultimately decision-making, in turn, is strongly dependent on the availability of respective environmental datasets, existence of observation systems able to further produce the required environmental data and ability of the informational infrastructure to deliver the data to end users through interoperability standards.

GEOSS is simultaneously addressing nine Societal Benefit Areas (SBA) of critical importance to people and society (GEO secretariat, 2011). It aims at empowering the international community to protect itself against natural and human-induced disasters, understand the environmental sources of health hazards, manage energy resources, respond to climate

Table 1 – Major Black Sea rivers and their catchment area, length and total runoff (Water Balance of the Black Sea, 1996; EEA Technical Report No 71, 2002).

Name	Catchment area (km^2)	Length (km)	Total runoff (km^3/year)
Danube	817,000	2860	208
Dnieper	505,810	2285	51.2
Don	425,600	1950	21.6
Kizilirmak	78,600	1151	5.02
Dniester	71,990	1328	10.2
Southern Bug	68,000	857	3.0
Kuban	58,700	870	12.8
Yesilirmak	36,100	416	4.93
Chorokhi	22,000	500	8.69
Rioni	13,300	228	12.8

change and its impacts, safeguard water resources, improve weather forecasts, manage ecosystems, promote sustainable agriculture and conserve biodiversity.

The GEOSS Data Sharing Principles are (Uhlir et al., 2009):

- The full and open exchange of data, metadata and products shared within GEOSS, recognizing relevant international instruments and national policies and legislation.
- All shared data, metadata and products will be made available with minimum time delay and at a minimum cost.
- All shared data, metadata and products being free of charge or no more than cost of reproduction will be encouraged for use in research and education.

The vision of GEOSS is to realize a future whereby decisions and subsequent actions for the benefit of humankind are based upon coordinated, comprehensive and sustained Earth observations and information.

The INSPIRE Directive is a major milestone for the use of Geospatial Information in Europe, and is a central contribution to environmental policy and sustainable development. The Directive is a legal agreement that encourages European countries to maintain up-to-date metadata on identified themes (Table 2). It promotes the interoperability of datasets and services, the facilitation of network access and the sharing of data (European Commission, 2010a). To ensure that the spatial data infrastructures of the Member States are compatible and usable within a community and transboundary context, the Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting) (European Commission, 2010b).

3. Methodology

The gap analysis was undertaken with contribution of all enviroGRIDS project partners (see Lehmann et al., 2015). The methodology included the following steps:

- Collection of information from the project partners with the help of an online Questionnaire.
- Formulating the requirements on the environmental data and observation systems in the Black Sea catchment.
- Extensive Internet search, including searching the GEOSS Portal (2010) for Black Sea catchment data and information.
- Analysis of the identified datasets and observation systems against the requirements.
- Assessment of their level of compatibility with the INSPIRE and GEO standards of interoperability.

The online Questionnaire (See Supplementary Material) was developed to acquire information from the project partners about available datasets and observation systems at different scales, from local and national to regional and global. The Questionnaire included several sections on: (1) observations performed within the partners' area of activity at organizational, national and regional levels; (2) available data within the partners' area of activity at organizational and country levels; (3) GEOSS/INSPIRE-compatible spatial data and information included or available for including into a Spatial Data Infrastructure (SDI); and (4) "wish list" of needed observations and data. The questionnaires were analyzed for identifying (a) user needs, (b) data and observation system availability, and (c) gaps in data and observation systems.

The end-users were identified as follows:

- International organizations dealing with environmental issues in the region (primarily BSC and ICPDR).
- National authorities.
- Local authorities.
- Scientists.

The needs for environmental data and observation systems were derived from the enviroGRIDS project objectives (Lehmann et al., 2015), particularly those linked to the hydrological modeling of the Black Sea catchment water resources using the Soil and Water Assessment Tool (SWAT) (Srinivasan et al., 1998, Gassman et al., 2007). The requirements for environmental data and observation systems were defined on the basis of end user needs, which were compiled into the list of data themes with desired spatial and temporal resolution.

An intensive Internet search was undertaken in order to determine the relevant environmental datasets at country,

Table 2 – Spatial data themes addressed by INSPIRE (European Commission, 2007b).

Annex I		Annex III
1 Coordinate reference systems	1 Statistical units	11 Area management/restriction/-regulation zones & reporting units
2 Geographical grid systems	2 Buildings	12 Natural risk zones
3 Geographical names	3 Soil	13 Atmospheric conditions
4 Administrative units	4 Land use	14 Meteorological geographical features
5 Addresses	5 Human health and safety	15 Oceanographic geographical features
6 Cadastral parcels	6 Utility and governmental services	16 Sea regions
7 Transport networks	7 Environmental monitoring Facilities	17 Bio-geographical regions
8 Hydrography	8 Production and industrial facilities	18 Habitats and biotopes
9 Protected sites	9 Agricultural and aquaculture facilities	19 Species distribution
Annex II	10 Population distribution and demography	20 Energy Resources
1 Elevation		21 Mineral Resources
2 Land cover		
3 Orthoimagery		
4 Geology		

European and global levels. This involved browsing through the web sites of institutions and portals of Ministries of Environment, Hydro-Meteorological offices and other state agencies in countries, European agencies (such as EEA, EuroStat, ESA), and agencies operating with data on a global scale: UNEP, WHO, FAO, NOAA, and NASA. An important part of the Internet search was dedicated to the GEOSS portal (http://www.geoportal.org), which provided a direct web interface to access the GEOSS and search for information, services and resources for each of the Societal Benefit Areas.

Analysis of the obtained information required organization and systematization in order to specify relevance of the identified datasets and observation systems to the end-user needs (i.e. the priority environmental problems to be tackled by the end users) and to GEO SBAs. Considering the multidisciplinary character of most environmental datasets, the same dataset could be related to several environmental problems/SBAs. The information was entered into special cross-tables (see Table 3, full table available in Myroshnychenko et al., 2011), after which the relevant datasets and observation systems were analyzed thoroughly against elaborated requirements.

Assessment of the level of compatibility with the requirements of INSPIRE was made only with respect to spatial data, metadata and information services in EC Member States of the Black Sea catchment on the basis of national reports on INSPIRE implementation and on the INSPIRE State of Play Reports 2010 (Vandenbroucke, 2010).

4. Results

4.1. *Acquired data*

The Questionnaire returned a list of more than 50 types of data needed by the project partners and end-users. Requirements to spatial and temporal resolution of each kind of data were also very diverse. Considering the practical impossibility of performing gap analysis against each variety of data, the most important data themes/categories (total 24) were identified and more generalized data requirements were formulated (see left columns of Table 4).

Complemented by the Internet search, a total of about 200 environmental datasets and 30 observation systems were collected from 15 project partners in eight Black Sea catchment countries and two international environmental agencies (BSC and ICPDR).

4.2. *Relevant datasets*

By constructing a cross-table (Table 4) between the datasets and their relevance to the project, end user needs and GEO SBAs, a short list was derived illustrating the representativeness of the datasets at different scales:

- On a global scale, a total of 30 datasets were selected, including Globcover and MODIS Land Cover (land cover); DSMW, HWSD and ERS/MetOp Soil Moisture (soil); GRDC (hydrology) and GPCP (meteorology); WorldClim (GIS layers) and Climate of the World (climate data); GRUMP and GPW (population); ESRI and VMAP (GIS).

Table 3 – Fragment of cross-table with examples of datasets (Legend: A – accessible; E – exists; U – useful; empty cell – not applicable).

Dataset name	Data theme/ Category	BSC priority transboundary problems					ICPDR end user needs	Project/ SWAT	GEOSS SBAs								Resolution	Web link
		Eutrophication	Chemical pollution	Changes in marine living resources	Biodiversity changes	Climate change			Disasters	Health	Energy	Climate	Water	Weather	Ecosystems	Agriculture	Biodiversity	
Globcover	Land cover	A	A		A	A		A	A	A		A	A		A	A	A	300 m	http://due.esrin.esa.int/globcover/
GRUMP	Population	A	U		U	U	A	A	A	A	A	A	A		A	A	U	30″	http://sedac.ciesin.columbia.edu/gpw/
Nature 2000	Protected areas			A	A	U			A	A		U	A		A	A	A		http://www.eea.europa.eu/data-and-maps/data/natura-2000
Black Sea TDA GIS	GIS	U	U	A	A	U			A	A		U	A		A		A	1:100,000, 1:200,000	mailto:secretariat@blacksea-commission.org
ICPDR TNMN database…	Water quality, hydrology…	E	E			U	A	E											www.icpdr.org/wq-db

Table 4 – Availability of data for enviroGRIDS project and end-users (Legend: A: Accessible; E: Exists, but access to data is restricted/limited; M: Missing).

Requirements to datasets			Availability for project and end user needs				
Data theme/category	Resolution		Scales				Consideration
	Spatial	Temporal	Global	European	Regional	National	
GIS satisfying project requirements and end-user needs (i.e. additionally containing detailed river network, environmental threats, protected areas, etc.)	At least 1:200,000	Most recent	M	M	E	E/M	The required GIS of regional scale exist in BSC and ICPDR, however they do not cover the whole Black Sea Catchment, and their usage is restricted. The national GISs should exist in the countries, however only one such GIS, with restricted access, was reported via Questionnaire. We assume that required GISs in other countries are either restricted or missing.
DEM (elevations)	30 m	Most recent	A	–	–	–	Global dataset meets the requirements.
Land cover/use	1 km	Since 1990	M	A/M	A/M	A/M	European datasets meet requirements but covers only EU countries. Global and European datasets are not compatible. National datasets from non EU countries were not reported.
Soil	1 km		A	A	–	–	Global and European datasets meet requirements. European dataset is derived from Soil Geographical Database of Eurasia available at scale 1:1,000,000. National datasets may have better resolution (two such datasets were reported), however the issue of their compatibility has to be studied.
Population	100 m	Since 1990	M	A/M	M	E	European datasets meet requirements but covers only EU countries.
Meteorology (in situ)	All existing stations in Black Sea catchment	Daily	E	E	E	E	Data on all scales exist but rather not accessible. The freely accessible global dataset contains very few data from the Black Sea Catchment.
Meteorology (remote sensing)	0.25°	Daily	A	–	–	–	Global dataset meets requirements.
Hydrology	All existing stations in Black Sea catchment	Daily	E	E	E	E	Data on all scales exist but rather not accessible. The freely accessible global dataset contains very few data from the Black Sea Catchment.
Oceanography (in situ)	Stations in coastal waters of Black Sea countries and in open sea	Quarterly	M	M	M	M/A	The frequency of observations at all scales does not meet requirements (except some countries, such as Romania)
Oceanography (remote sensing)	Whole Black Sea	Daily	A	–	A	–	Global and regional datasets meet requirements.
Pollutants discharges	All industrial and municipal sources in Black Sea catchment	Monthly	M	M	E	E	Data of regional scale (Danube) are available.
Pollutants emissions	Per enterprises or administrative units	Monthly	M	M	M	E	Spatial resolution of data on global, European and regional level is not sufficient. National data usually exists but not accessible.
Pollutants deposition from atmosphere	Coastal zone	Monthly	M	M	M	M	The network of stations measuring atmospheric deposition is rather sparse.

Pollutants in sea water, sediments and biota	Black Sea	According to monitoring program	M	M	E/M	E/M	Data exist with gaps, particularly with respect to pollutants in sediments and biota.
River water quality	All existing stations in Black Sea catchment	Monthly	M	E/M	E/M	E/M	Data not freely accessible. Data at some stations do not meet frequency requirements.
Sea water quality	Stations in coastal waters of Black Sea countries and open sea	Quarterly	M	M	M	M	The frequency of observations at all scales is inadequate (except some countries, such as Romania)
Climatic data (climatic stations)	All existing stations in Black Sea catchment	Daily	E	E	E	E	Data on all scales exist but rather not accessible. The freely accessible global dataset contains very few data from the Black Sea Catchment.
Climatic data (remote sensing)	Best available (1 km × 1 km)	Monthly, daily (depending on data)	A	–	A	–	Global and regional datasets meet requirements.
River biology	Best available	Quarterly	M	M	E	E/M	Data may not meet temporal requirements.
Marine biology	Best available	Quarterly	M	M	M	A/M	Data do not meet temporal requirements in most cases.
Biodiversity	Best available	Quarterly	M	M	E/M	E/M	Data do not meet temporal requirements in most cases.
Invasive species			M	E/M	M	E/M	The European network ERNAIS poorly covers Black Sea Catchment
Agriculture	Administrative units	Yearly	M	M	E	E	Data of required spatial resolution are not freely accessible.
Disasters	Best available	Permanent monitoring	E	E	E	E	Data exist but may not be accessible, particularly at country scale.

- At the European scale, 25 datasets were selected, including CORINE Land Cover; EuroDEM; ESBD (soil); EEA Waterbase; Airbase; Nature 2000; EuroGlobalMap.
- At the regional scale, 16 datasets were selected from regional environmental programs such as the Black Sea Information System, and the Danube Transnational Monitoring Network database.
- At a country and local level, more than 160 datasets were identified.

Table 4 shows the requirements to the data together with availability of that data at different scales and provides additional explanations. The full list of analyzed datasets and associated details (e.g., URLs) can be found in Myroshnychenko et al. (2011).

For most data themes/categories data exist at the required spatial and temporal resolutions for at least one of the scales. However, data on atmospheric pollutant deposition and data on sea water quality do not meet the requirements on temporal resolution at any scale. The other deficient data categories are oceanography (in situ), marine biology, and biodiversity. All these data categories are among the priority data needs of the Black Sea Commission.

The data available at the global scale meet the requirements of 37% of the categories. Four global datasets are satisfactory for all scales. The European datasets meet the requirements of 54% of the categories, while the regional datasets fulfill the requirements of 71% of the categories. The most detailed datasets, which comply with the requirements on both spatial and temporal resolution, exist at the national level for 92% of the categories.

The analysis confirmed that the accessibility of data is one of the main problems for environmental science and policy. The data at global and European scales are mostly accessible. However, when it comes to high-resolution data (actually those that meet the requirements), access to such data is rather restricted. Access to data at regional and national levels is usually limited or restricted. Moreover, a significant proportion of the datasets reported by the project partners are not available on the Internet. The proportion of data categories with limited or restricted access to data is around 45% of the total satisfying the requirements on both a global and European scale, while at the regional and national levels this rate reaches 65%. For example, for categories such as climatic, hydro-meteorological, agricultural, and pollutant discharges, the datasets of required spatial and temporal resolution do exist but are not accessible to most end users. This is considered as a significant gap, because such data are crucial for running and calibrating models used for the management of water resources.

4.3. *Observation systems and networks*

Analysis of identified environmental datasets in the Black Sea catchment shows that many of them are produced with the help of satellite-based platforms and instruments thus indicating that they are becoming a main tool for Earth observation. The prominent observation systems at global and European scale include numerous satellite platforms operated by space agencies of different countries, whose activities are coordinated by GEO, such as:

- Landsat, Terra, SPOT: assessment of land cover, vegetation.
- METOP: soil moisture.
- Aqua: sea color, chlorophyll, algal blooms.
- Terra, Aqua: disasters (flood, forest fire), etc.

Very important producers of environmental data on a global scale are the global networks of hydro-meteorological and hydrological stations. At the European scale, we identified the satellite platforms for Earth observations operated by the European Space Agency (ESA), European observation (partnership) networks such as the European Environment Information and Observation Network (EIONet) or Natura 2000 network, etc.

At the regional level there are regional monitoring networks organized by the respective international agencies such as the Transnational Monitoring Network (TNMN) of the ICPDR that helped obtaining data on the water quality of the Danube, the Black Sea Global Ocean Observing System (BS GOOS) under umbrella of the Intergovernmental Oceanographic Commission (IOC), which provides operational data on physical conditions, the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP) organized by the BSC to assess trends in states of the environment and to provide and support decision makers with environmental data.

The observation systems at higher scales/levels are based on observation systems at a national level implementing monitoring of the state of the atmosphere, land, waters, leaving resources, etc.

The significant numbers of datasets at all scales/levels are produced with the help of respective reporting systems assembling the data and information from different sources into thematic datasets. Examples are reporting systems of FAO (assembling information from countries on crops, soils, etc.), UNEP, Eurostat (populations, pollutants emissions, fresh water resources, etc.), and statistical agencies in countries.

We also analyzed observation systems and networks for their ability to satisfy end user requirements on data quantity and quality, and on spatial and temporal resolutions. The observations systems and networks analyzed in the region are able to produce all types of data and information required by end users, but some of them are outdated or have lost some of their capacity due to improper maintenance. This leads to gaps in the datasets produced by such observations systems. For example we identified gaps in availability of water quality and biodiversity data, which largely may result from underdevelopment of the respective monitoring systems, such as national monitoring systems involved in implementation of the BSIMAP (Diagnostic Report, 2010). Nevertheless, the analysis of the available datasets clearly indicated that in most cases the real problem is the limited or restricted access to data produced by observation systems, as well as weakness of data exchange mechanisms and services, rather than gaps in the observation systems themselves.

With respect to the most problematic data categories identified in the previous section, we conclude that they result from the gaps in observation systems. The capacity of monitoring networks/services does not correspond to end-user requirements for the following data types: pollutant deposition from the atmosphere, oceanography (in situ), sea water quality, and marine biology and biodiversity.

4.4. *INSPIRE implementation in Black Sea catchment*

The INSPIRE initiative functions at two levels. First, the INSPIRE Directive sets the objectives and asks Member States to pass their own national legislation establishing national SDIs (NSDI). Secondly, INSPIRE establishes an EU geoportal (http://inspire-geoportal.ec.europa.eu) operated by the European Commission to which the infrastructures of the Member States have to connect.

Within the enviroGRIDS project, the status of INSPIRE implementation as of 2010 was analyzed for EU Member States from the Black Sea catchments, namely Austria, Bulgaria, Czech Republic, Germany, Hungary, Romania, Slovakia, Slovenia, and Turkey as a candidate country. It is clear that some countries still have difficulties in detecting and/or actively involving the appropriate organizations, whether they are data custodians or not. This is especially true for organizations responsible for data sets from spatial data themes addressed by INSPIRE Annex III. But in general, at the local level contributors are still far from being integrated in the INSPIRE implementation. Table 5 shows total numbers of organizations that contribute to their national SDI according to INSIPRE State of Play Reports 2010 (Vandenbroucke, 2010).

From the experience of different stakeholders and countries it is deemed to be very important that countries and individual technological stakeholders become active members of standardization organizations such as the Open Geospatial Consortium (OGC), the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). Also there is an overall need to work on capacity building, to create better awareness, and to train more experts to support the often complex tasks of INSPIRE and NSDI implementation. Many countries are lacking a good strategic document and implementation plan. Lack of sustainable funding seems to be an additional important issue.

Development of metadata must be further improved since it is critical for the whole infrastructure (Woldai, 2002; Nogueras-Iso et al., 2005; Yalcin, 2011). Especially the description of web services is still in its initial stage and deserves particular attention (Florczyk et al., 2012). There are increasingly more web services available within the individual countries, or even at a sub-national level. However, it is not so clear how these perform and whether they comply with interoperability standards. Over the last few years, as confirmed by reports of individual countries, many efforts have been made on the harmonization and interoperability of spatial data. Many countries are focusing on the development

Table 5 – SDIs in Black Sea catchment countries.

Country	SDI contributors
Austria	3
Bulgaria	8
Czech Republic	7
Germany	6
Hungary	4
Romania	1
Slovakia	5
Slovenia	3
Turkey	6

Table 6 – Available resources for Black Sea catchment in GEOSS in 2010.

Country	Systems and services										Capacity building	Showcase of datasets		International initiatives
	Early warning	Monitoring services	Analysing services	Mapping services	Assessment services	Alert systems	Geospatial web services	Data processing	Data provision	Total		Layers	Maps	
Austria	7	62	23	40	22	15	68	8	196	367	9	12	2	17
Belarus	7	61	23	39	21	14	63	8	197	363	9	12	1	18
Bosnia and Herzegovina	7	58	23	38	21	14	63	8	195	360	9	12	1	17
Bulgaria	7	59	23	39	21	14	62	8	193	358	9	12	1	17
Croatia	7	58	23	38	21	14	63	8	195	360	9	12	1	17
Czech Republic	7	62	23	40	22	15	68	8	196	367	9	12	2	17
Georgia	7	59	23	38	20	14	62	8	193	358	8	12	1	18
Germany	7	62	23	40	22	15	71	8	196	370	9	12	2	17
Hungary	7	58	23	38	21	14	63	8	195	360	9	12	1	17
Moldova	7	58	23	38	21	14	62	8	194	358	9	12	0	17
Montenegro	5	38	23	36	13	13	55	8	172	307	8	12	0	18
Romania	7	58	23	38	21	14	62	8	194	358	9	12	0	17
Russian F ederation	7	67	24	42	22	15	76	9	217	399	10	13	5	18
Serbia	5	38	23	36	13	13	55	8	172	307	8	12	0	18
Slovakia	7	59	23	39	21	14	63	8	195	359	9	12	0	17
Slovenia	7	58	23	38	21	14	63	8	195	360	9	12	1	17
Switzerland	5	40	23	36	13	13	55	8	173	310	8	12	1	18
Turkey	8	61	25	41	21	14	61	8	193	364	10	13	1	20
Ukraine	7	61	23	39	21	14	63	8	198	364	9	12	1	18
Europe	8	66	25	43	22	15	75	8	203	390	10	13	4	20
Global	10	77	29	50	23	18	95	10	248	466	12	23	14	20

Table 7 – GEOSS resources originating from the Black Sea catchment countries.

Country	Austria	Germany	Romania	Russian Federation	Switzerland	Ukraine
GEOSS resources	3	18	1	3	1	3

of national geoportals that aim to act as gateways to relevant geospatial data and information (Tang and Selwood, 2005). Geoportals are a key element of any SDI facilitating the discovery and access to organized collection of resources (e.g. data, services, tools, documents) allowing any data provider to share dedicated content on the Internet (Maguire and Longley, 2005).

4.5. *GEOSS information availability*

The availability of GEOSS resources (i.e., systems, datasets, and information services) for the Black Sea catchment countries as of 2010 is presented in Table 6. It is very similar for all countries, because most of the GEOSS resources are either at global scale (as follows from the name of the system), such as ASTER GDEM and ESRI GEO Portal, or the resources are delivered by the EU providers assuring complete coverage of territory of Europe, such as Corine Land Cover, CleanSeaNet, and AirBase.

Albania, Italy, Macedonia, and Poland are not included in Table 6 due to their relatively very small share in Black Sea catchment (estimated to less than 1%). The availability of resources for the Black Sea catchment with respect to the GEO SBAs appears to be rather good but the amount of information services and data resources originating from the Black Sea catchment countries (Table 7) remains small.

The lack of regional and local resources hampers the introduction of appropriate tools and instruments to support decision-making processes in GEO SBAs at an adequate scale. The enviroGRIDS project has aimed at reducing this misbalance between global and regional data in the Black Sea catchment. A search in the GEOSS geoportal using the ''Black Sea'' as a keyword is returning more than 550 registered resources (as of 2013) of which 27 services were established in framework of the enviroGRIDS project giving access to approximately 300 environmental data sets whereas only a few were available at the beginning of the project (2009).

5. Discussion

5.1. *On data gaps*

On the basis of environmental datasets we found that the level of availability of data from all categories is inversely proportional to the scale at which this data can be used. At the global scale, we were unable to find data that met the requirements in the 15 categories, whilst at country scale such data were missing only in two categories. On the other hand, the level of data accessibility decreases with scale.

Due to the transboundary character of water resources management the data from countries should be available to decision makers both at regional and European levels. However, the international data exchange is unsatisfactory within the Black Sea catchment, which includes both EU and non-EU countries. This is especially the case among the Black Sea coastal states, where access to national and local environmental datasets in many cases is restricted, which decreases effectiveness of efforts on understanding environmental trends and elaboration of measures on mitigating threats to environment. The most significant gaps in environmental data availability were identified for large areas of the Black Sea catchment within Russia, Georgia and Turkey. Unlike the Danube countries, these gaps cannot be covered from datasets available at these scales, because the global datasets do not meet the requirements, while the European datasets do not extend to those areas. The solution for this problem could be the reinforced involvement in international data exchange of the national agencies responsible for observations in those countries.

The satellite based platforms and instruments are important for Earth observation. The success of remote sensing is predetermined by operability, uniqueness of obtained information, possibility to perform measurements over large territories at once, possibility to obtain information on remote areas, and relatively low cost of remote sensing observations in comparison with other methods. These factors are especially important for oceanic and sea observations that experience a lack of research resources over very large areas.

However, due to limitations of remote sensing methods the applicability of satellite-based Earth observation data (EOD) is mainly related to the Earth's surface and atmospheric processes. For example, EOD is not able to measure concentration of pollutants in rivers and sea waters, identify changes in biodiversity or obtain exact values of crop yields. On the other hand, for the examples listed above, EOD can help to trace propagation of pollution in the sea, assess potential changes in biodiversity due to land cover change and provide estimate of annual yield on the basis of land cover and rainfall data. Thus, the maximum benefit can be achieved when resources of the Earth observation systems from space are combined with the resources of traditional observation systems, networks and services.

The datasets, produced with the help of Earth observations operated by ESA, provide data coverage in most cases limited to the territory of the EU, while the Black Sea catchment extends significantly to the territories of non-EU countries. Due to the problem of data compatibility between the global and European datasets, the application of high-resolution qualitative ESA EOD data for the whole Black Sea catchment is limited; therefore end users and scientists may have to use global datasets of reduced quality. The problem of incompatibility of data exists at all scales, and increasing the level of compatibility with GEO and INSPIRE standards may greatly help to resolve this problem.

5.2. *On implementation status*

The compliance of the analyzed datasets with GEO interoperability standards at the global, European and regional scales is quite satisfactory. This follows from the fact that many datasets are already registered in the GEOSS portal. However, the national and regional datasets compliance with INSPIRE

and GEO interoperability standards is low particularly taking into account that most national datasets are not accessible through the Internet and also do not have the relevant metadata available.

The adequate water resources management and decision making in the Black Sea catchment area requires combining data from the different scales, which is directly linked to the issue of correspondence of datasets and observation systems to INSPIRE and GEO interoperability standards.

5.3. *On data availability/gaps for needs of Intergovernmental Commissions*

The ICPDR works to ensure the sustainable and equitable use of watershed freshwater resources in the Danube River Basin. The work of the ICPDR is based on the Danube River Protection Convention, the major legal instrument for cooperation and transboundary water management in the Danube River Basin. In 2000, the ICPDR was also nominated as the platform for the implementation of the transboundary aspects of the EU Water Framework Directive (WFD) (European Commission, 2000). Since its establishment in 1998, the ICPDR has effectively promoted policy agreements and the setting of joint priorities and strategies for improving the state of the Danube and its tributaries. This includes improving the tools used to manage environmental issues in the Danube basin, such as:

- the Accident Emergency Warning System (http://www.icpdr.org/main/activities-projects/aews-accident-emergency-warning-system),
- the Trans-National Monitoring Network for water quality (http://www.icpdr.org/main/activities-projects/tnmn-transnational-monitoring-network),
- the information system for the Danube (Danubis), and
- DanubeGIS (http://www.danubegis.org).

The mission of the BSC is the implementation of the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention[2], 1992), its Protocols and Strategic Action Plan (SAP) for the rehabilitation and protection of the Black Sea, updated in 2009. The activities of the BSC are addressed to the following major transboundary problems:

- Eutrophication/nutrient enrichment.
- Chemical pollution, including oil.
- Changes in marine living resources, overfishing.
- Biodiversity changes/habitats loss, including alien species introduction.
- Climate change.

The primary geographical scope of the Bucharest Convention is the Black Sea. In addition, the SAP covers pollution sources from coastal areas and stipulates Black Sea coastal states to endeavor effort to implement relevant provisions of the SAP at the Black Sea basin (catchment) level. The new Protocol on the Protection of the Marine Environment of the Black Sea from Land-Based Sources and Activities (Black Sea Commission, 2009), pending entry into force, also applies to pollution emissions originating from land-based point and diffuse sources, which reach the marine environment through rivers or other watercourses; input of polluting substances transported through the atmosphere; and other activities that may directly or indirectly affect the marine environment or coastal areas. Considering the above, the whole Black Sea catchment is an area of interest for the BSC with respect to the implementation of its mission.

Both Commissions are organizing monitoring of the respective water bodies and ensure regular data flow into their information systems – the Danubis for ICPDR and BSIS for BSC. They established the Danube-Black Sea Joint Technical Working Group to co-ordinate works aiming to reduce nutrient inputs into the Black Sea from the Danube. The activities of the Working Group include the exchange of information on pollution loads.

Our gap analysis found that with respect to end user needs of ICPDR, most required data are available at regional (Danube) or European scales, but there are some gaps in availability of data on pollutant deposition from the atmosphere. The situation on data availability for end user needs of the BSC is however less satisfactory:

- There are significant gaps in the availability of marine environmental data from the water column, sediments and biota, which, considering the limitations of EOS, gives evidence of gaps in corresponding observation/monitoring systems.
- There are gaps in data on pollution loads to the Black Sea from land based sources, including rivers.
- An observation system to monitor pollutants deposition from the atmosphere is missing.

The gaps in environmental data and information put decision makers in a position where decisions are made under, sometimes, great deals of uncertainty, which increases the risk of taking non-optimal decisions leading consequently to non-effective usage of resources. The growing potential of GEOSS and implementation of INSPIRE will provide further support for decision making in the two regional Commissions. Of particular interest here are also the contributions of the enviroGRIDS project in terms of availability of a high-resolution hydrological model for the Black Sea catchment (Bacu et al., 2013), sets of scenarios of future changes (Mancosu et al., 2015), and the availability of the dedicated geospatial portal for the Black Sea catchment (see http://portal.envirogrids.net) (Gorgan et al., 2013).

The availability of the Black Sea catchment hydrological model will indeed provide possibilities for proper assessment of the water resources, as well as nutrients and pollution loads to the Black Sea from rivers, which will help covering gaps in data availability (Cau et al., 2013). Bringing the results of SWAT and other informational resources through SDI into GEOSS and INSPIRE will assist decision making and provide useful geographical and environmental information to the public authorities and citizens (Giuliani and Gorgan, 2013). However, it is crucial that this be a two-way process, so that data and information collected through ICPDR and BSC are made available widely through GEOSS and INSPIRE in order to support decision makers beyond both Commissions' scientific circles of influence.

[2] The parties to Bucharest Convention are Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine.

6. Conclusions

The performed analysis of environmental data gaps in the Black Sea catchment was based on information, provided by project partners and an intensive Internet search. It cannot be considered as exhaustive, particularly with respect to national data. Nevertheless, the analysis was sufficient to present the overall situation with respect to availability of environmental data and highlight the main gaps and problems.

The large amount of datasets relevant to the project and end-users data needs have been identified at different scales from national to regional, European and global. The analysis revealed gaps in spatial and temporal environmental data coverage, as well as the problems of data compatibility at different scales and problem of data accessibility.

We found that access to data is limited or restricted in many cases, particularly at a national level, so the data accessibility appears to be the main problem preventing the effective usage of data. Even access to the project partners' data in many cases is either limited or restricted. To prevent this obstacle throughout the project a data policy was elaborated that envisaged different types of data access licenses and encouraged free data access and exchange for non-commercial purposes. The data access policy was developed and approved by all project partners, most of them being data-holders committed to share their data for the project under this data policy, further encouraging other stakeholders to do the same. However, we realized that an accepted data policy that is non-binding officially (as was the case in enviroGRIDS) is often not enough to completely unlock access to data in some institutions.

Our gap analysis allowed identifying areas where further efforts are needed to reinforce the existing observation systems in this region. These are observation/monitoring systems to provide data that satisfy our initial requirements, which are mainly:

- data on marine environment (water column, sediments and biota); pollution from land based sources, including rivers, for the needs of BSC;
- data on pollutant deposition from atmosphere for the needs of ICPDR and BSC;
- data on pollution discharges into rivers and river water quality, hydrological and climate data, particularly in non-EU countries for needs of modeling the Black Sea watershed with the help of such tools as SWAT.

A significant amount of identified datasets are either not accessible or have limited access, so further efforts are needed to make them available to decision makers and scientists following the GEO data sharing principles. Further efforts are also needed to resolve the problems of data compatibility. Combining data from different sources and geographical scales to support the decision-making processes is directly linked to the issue of correspondence of datasets and observation systems to INSPIRE and GEO interoperability standards and much effort is still needed in many Black Sea catchment countries (Charvat et al., 2013).

An effective way to continue this effort is through capacity building (Giuliani et al., 2013). Initiated in enviroGRIDS, a series of courses were developed targeting both high-level decision makers capable of changing national data policies and technicians able to set up new local SDI needed to register existing data and metadata flows into GEOSS and INSPIRE. This series of workshops entitled ''Bringing GEOSS services into practice'' (Giuliani et al., 2014) have already been attended by more than 350 participants around the Black Sea and in other localities in Europe and Africa. We are continuing that effort through the improvement of the workshops and their delivery to other stakeholders in the Black Sea regions. Our hope is that that gaps identified in this study can be filled quickly through a common effort lead by key institutions such as ICPDR and BSC. In this respect it is worth reiterating that ICPDR and BSC should consider applying for institutional membership in GEO, as it will extend possibilities for data exchange and for filling gaps in environmental data. A better informed, and therefore better managed Black Sea catchment is at stake.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2014.04.001.

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