EARTH OBSERVATION BLACK SEA AND DANUBE BASIN PRIORITIES

Constanta, Romania
28th-30th September, 2016

Table of Contents

Meeting abstracts

A link to all meeting abstracts can be found here:

http://www.eo4blacksea.info

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1. Introduction

This documents aims at collecting and elaborating on the major discussion points gathered during the ESA/ROSA/NIMRD scientific consultation meeting on Earth Observation (EO) and Black Sea and Danube Basin Priorities held on 28-30 September 2016 in Constanta, Romania.

The meeting, with a participation of approximately 70 experts, aimed at reviewing and discussing the existing scientific knowledge gaps and application priorities areas in the Black Sea and Danube Basin where EO may contribute for the next decade.

The outcome of the meeting and its conclusions will contribute to guide ESA's research, applications and data infrastructure investments for the time frame 2017-2021. In the short term, the meeting will support the definition of a number of preparatory activities to be started in 2017 in support of the Black Sea and Danube Basin EO research and applications community.

It is worth mentioning that the meeting did not cover all areas of research, science and applications relevant to the Black Sea and the Danube Basin, and that this document only provides a partial outlook, addressing some of the discussion points identified at the meeting.

2. General principles

- Remote sensing was widely recognised as an essential tool for the monitoring of the Black Sea and the Danube basin.

- For an accurate monitoring of the region, not only the sea basin should be investigated, but also the coastal and catchment areas. The collection and integration of these three components (sea basin, coastal areas and catchment areas) is essential. In this context, the Black Sea should be considered in the context of its catchments in an integrated-system approach.

- Remote sensing cannot be consider in isolation but there is an strong need for maintaining and reinforcing the in-situ data infrastructure. This is of critical importance both for calibration and validation activities. In this context, the above integrated approach shall be implemented exploiting the available in-situ and EO measurements in combination with suitable models (see also DANUBIUS-RI).

3. Scientific gaps

3.1. Gaps in observations

A number of important EO-based parameters/variables are not available (with a suitable quality) for the Black Sea. This includes:

- Salinity observations, which are not of enough quality (RFI, coastal contamination, low resolution), hence a dedicated approach for the black sea correcting for these effects and enhancing the resolution (e.g., downscaling) are required.

- Ocean colour data, specially chlorophyll, are not suitable for use in the special case of the Black sea waters. Dedicated activities aimed at developing and validating (including dedicated campaigns and lab analysis of IOP) dedicated products for the Black-see is needed.

- The exploitation of novel techniques for coastal altimetry that may reduce current differences between tide-gauges and traditional altimetry far from the coast is strongly needed.

- The morphology of the coast is also important. In this context, for what concerns the height of the waves, the Black Sea does not have a wave observation point. EO may support this aspects of physical oceanography with dedicated products.

- Missing information on aerosols. There is a need for fine scale data on the coastal area.

3.2. Climate data

- Absence of long-term strategy of monitoring and study of the Black Sea climate change as one of the key elements of environmental management. In this context, there is a lack of knowledge on key physical and biogeochemical processes controlling the Black Sea ecosystem state.

- EO may contribute to cover this knowledge gap. In this context, there is a need for dedicated long-term consistent EO-based dataset for the Black-sea region. In fact, some CCI products are not suitable for use at Black-sea regional level (e.g., ocean colour). In this context, the consistence of products is absolutely required in order to allow the study of cycles combining different variables.

- To promote an exchange of terrestrial, atmospheric and oceanographic climatic data sets among interested research teams and other institutions from different countries, the creation of a dedicated Baltic Exploitation Platform providing access to Black Sea

observations (EO and in-situ), tools, processing capacity and research results is recommended.

3.2 Physical oceanography

It is of critical importance to acquire a better understanding of the physical processes responsible for horizontal and vertical mixing and exchange between the shelf and the deep basin. This includes the deep water circulation, thermohaline structure, diapycnal temporal and spatial variability.

To achieve this, a better combination of EO data and modeling is needed including data assimilation experiments to provide better 3D reconstructions of the heat, salt and water balance (exchange through the straits, river runoff, ground water, precipitation and evaporation) in the Baltic sea.

Dedicated EO products are need to better describe the coastal dynamical processes including wind-wave propagation and assimilation into suitable models to characterize the costal circulation, nutrient fluxes, sediment transportation and processes that may affect the shore-line displacement in intra-decadal time scales.

In this context, the development of long-term datasets of multidisciplinary measurements of currents, temperature, sea level anomalies, salinity, turbidity, chlorophyll "a", PAR, etc., based on satellite and autonomic mooring buoys technology is an important requirement.

It is important to stress the link between the physical oceanography and biochemical ecosystems. In this context, there is missing information regarding the interaction between the meso-scale processes and the biogeochemical dynamics (for example, the use of H_2S). Therefore, a suitable framework for performing an inter-comparison of the existing physical and biochemical ecosystem dynamic models and validate them on the base of in situ observations and EO datasets is needed. The Baltic Exploitation Platform may provide a suitable environment to achieve this goal.

3.3 Deoxygenation

One of the most urging scientific issue to be addressed in the Black Sea is the impressive deoxygenation trends observed on the last 60 years (Murray et al. 1989, Konovalov et al. 2001,2003,2006, Capet et al. 2016). Although related to eutrophication in the 80s, the Black Sea deoxygenation is now clearly fostered by global warming and is therefore not expected to slow down in the coming decades, with potential detrimental consequences on marine resources. For one, habitat compression (i.e. 44% of the oxygenated volume lost in the past 60 years) is expected to constitute an important pressure on marine populations (e.g. Stramma et al., 2012), increasing vulnerability to fishing pressure and requiring a vertical reorganisation of trophic levels.

The potential to issue managerial preventive policies (e.g. fisheries and discharge water) to minimize the societal impacts of this deoxygenation lies in our ability to predict how climate change will affect the different components of the deoxygenation process, namely the balance and distribution of organic matter respiration and physical ventilation processes.

This encompasses the quantification of primary production, dense water formation, and transport mechanisms for heat, oxygen, nutrient and organic matter on the horizontal (i.e. shelf/open sea) and on the vertical, or rather, along and across isopycnals. Of known relevance for the latter is the quantification and characterization of mesoscale (e.g. eddies, meanders, filaments) and sub-mesoscale (e.g. fronts, internal wave-shore interaction) processes.

Earth observation from space could form the basis for such quantifications: e.g.,

- Multi-sensor high resolution altimetry products, in particular in the coastal/shelf regions where mesoscale structure are known to concentrate (cf. kinetic activity belt between Rim current and shelf break) would provide a census and classification of mesoscale/submesoscale features (eddies, filaments, meanders, fronts).
- Regionally calibrated ocean colour products would provide a better estimation of primary production.
- Dense water formation rates might be assessed from the temporal variations of surface temperature and salinity.

Subsurface profilers (e.g. (BIO)-ARGO, gliders, Aqualog) can be used in synergy with remote sensing (composite analysis) to characterize synthetic vertical structures associated with the surface expression of mesoscale/submesoscale processes.

Estimations of resulting lateral and vertical fluxes can be derived directly and/or tuned with the help of process-oriented modeling.

The ARGO and Altimetry era extends now for more than 10 years in the past providing the range required to relate interannual variability with air temperature signal and thereby potential global warming consequences.

Deoxygenation is not specific to the Black Sea, but the co-occurrence of both seasonal hypoxia (eutrophication-controlled, north western shelf) and anoxic depth shoaling (climate-controlled, open sea) certainly makes it an emblematic basin for the study of deoxygenation. It therefore appears as essential that a Black Sea specific platform/infrastructure/network includes deoxygenation as major scientific priority.

Besides, as deoxygenation emerges as an urging global threat, the resulting knowledge/expertise could be exported in other regional or oceanic area via for instance the IOC-GO2NE network (http://on.unesco.org/2d1QhGw).

3.5 Danube basin science questions

The Danube is the European second longest river. Originating in the Black forest area of Germany, it flows through central Europe before emptying into the Black-se at the Danube delta in Romania. The drainage basin is the most international in the world as it touches 19 counties. Dedicated effort is needed to better understand and predict the different processes affecting this strategic system.

The river is a major transportation route especially because of the Europa-Kanal (completed 1992) which links it to the Rhine River, enabling transport from the Back Sea to the North Sea.

During this century, it is expected a temperature increase, both annually and in every season, for the Danube River Basin. While there are considerable differences among regions, the main future trends suggest that the highest temperature increases will be in the south-east of the Danube River Basin; annual precipitation is expected to change in many countries, resulting in increased precipitation in the north and decreased in the south. Lower precipitation in summer and higher in winter is expected in most areas. More extreme events such as torrential precipitation and widespread droughts will probably be more common, the latter mainly in southern and eastern parts of the Danube River Basin. These expectations are based on an analysis of the latest projects and studies with statements regarding climate change scenarios or trends available.

Possible adaptation measures for water management include preparatory measures for adaptation such as improving forecasting warning systems, ecosystem-based measures such as the restoration of water-retention areas, managerial measures such as the promotion of water-saving behaviour, technological measures such as the development of more efficient irrigation systems in agriculture, and policy approaches such as supporting institutional frameworks to coordinate all of these activities.

With the climate change strategy for the Danube, countries now have a tool that enables them to decide on adaptation measures that will be part of the 2nd Danube River Basin Management Plan and the Flood risk Management Plan. In this context, real time flood forecasting system already exist consisting of hydrological and hydrodynamic components, and provides early warning and precipitation forecasts.

As a main scientific priority for the Danube basin it is was recommended to initiate activities aimed at exploring the potential of EO and suitable models to characterise a predict droughts in the Danube basin.

4. Priorities for Applications

4.1 Introduction

The Black Sea and Danube regions represent a complex, inter-connected system exposed to a range of pressures including climate change, economic heterogeneity, alterations in socio-political structures, over-exploitation of natural resources and exposure to a range of security concerns, from proximity to conflict to organized crime.

A number of regional initiatives, cooperation frameworks and strategies have been put in place or are in the process of being put in place that are designed to tackle or mitigate many of these underlying pressures. The main thrust of an activity intended to expand the use of EO derived information within a regional context must be within the framework of the existing and planned regional cooperation structures. In addition, many of the Danube and Black Sea states also have national action plans and investment strategies addressing priorities such as stimuli for economic growth (in particular infrastructure development), climate resilience and environmental security. However these are often put together as part of wider regional cooperation actions. It is helpful therefore to summarise the existing and planned regional level activities for the Danube and Black Sea domains.

4.2 Existing and Planned Regional Initiatives

There are three types of regional initiatives which operate slightly differently and within which the participating states are faced with different responsibilities. These are:

- European initiatives and strategies. These include the Black Sea Regional Strategy (a sea basin strategy), the Danube Regional Strategy and the Western Balkans Regional Strategy (both of which are macro-region strategies). These are set up in the context of EU membership and, while taking into account local concerns, priorities and unique situations, often contain European level priorities translated for the region in question (eg Blue Growth). These are complemented by the application of European level legislation and initiatives such as Water Framework Directive, Marine Strategy Framework Directive, Habitats Directive and the Maritime Spatial Planning Directive. These are also complemented by separate EU level investment strategies such as Structural Funds (eg Inter-reg) and EU regional development policies for non-member states bordering the EU (the European Neighbourhood Policy)
- International and Inter-Governmental initiatives, bodies and agreements – these may be regional agreements in the context of the UN (eg Black Sea Convention, Carpathian Convention, International Convention for Protection of the Danube River) or other frameworks (eg Black Sea Economic Commission) as well as extended activities in the region by other Inter-governmental entities (eg OSCE, International Counter-Proliferation Programme, etc)
- Bilateral or multi-lateral cross-border cooperation agreements – these are focussed on specific technical cooperation and exchange activities (eg the Black Sea Border

and Information Centre enabling exchange of coastal surveillance data among all Black Sea states, the South East Europe Prosecutors Advisory Group etc)

The first and second category of agreement/initiative are generally focussed on common development objectives or achieving goals of common interest. The cross-border agreements are more focussed on implementing solutions to identified problems, eg vessel traffic movements or tackling cross-border crime.

4.3 Priority Issues to be Addressed

The Black Sea and Danube areas are addressed separately although there are two issues dealt with at the end of this section where both sub-regions are impacted. The main issues highlighted for the Black Sea are elaborated below.

Improved pollution detection and monitoring for the Black Sea
This would be executed in cooperation with the Black Sea Commission. Requirements included the detection of pollution events both from vessels and shore based facilities, identification of the polluting entities and developing a robust statistical characterisation of trends in pollution for the Black Sea. EMSA already operate the CleanSeaNet service for the Western Black Sea which provides a basic vessel discharge detection and polluter identification capability for Romanian and Bulgarian waters. The development proposed here would complement the CleanSeaNet capability by detecting a wider range of discharges and being extended geographically to the entire Black Sea. In addition, this would be supported by dedicated capacity building in the region to develop local capabilities to extract pollution information from satellite data and to strengthen operational capabilities to understand and effectively use the satellite derived information.

Implementing Maritime Spatial Planning for Black Sea Coastal States
Requirements include both support to the baseline mapping and characterisation of activities taking place in the maritime space. These datasets are required as the basis for elaborating a planning tool for the Black Sea states as they put maritime spatial planning in place as required by EU directive. In addition as maritime spatial planning becomes fully operational, this will generate further requirements such as regular mapping of changes in maritime activities to ensure the spatial planning approaches are up to date. Information to be collected includes hydrographic data (eg bathymetry, coastline), environmental data (eg sediment concentration, currents, waves, benthic habitat distribution etc), infrastructure distribution/status (eg pipelines, cables, ports, discharge points, wind farms, aquaculture cages, etc) as well as patterns of activity (eg shipping, leisure activities, marine mammal movements etc). This is a high priority action given the timescale for when MSP has to be operational within EU Member States. A further consideration here is the EU Black Sea Strategy which has identified improved transport infrastructure and tourism as two sectors for expansion as part of the Blue Growth agenda. These will clearly have an impact on, and be constrained by, the Maritime Spatial Plans being established for the sea basin.

Optimized Data Collection, Exchange and Analysis for Black Sea Convention, MSP and MFSD

EU Coastal States are required to collect and analyze a range of diverse data to support regulations such as the Marine Strategy Framework Directive, the Water Framework Directive, the Maritime Spatial Planning Directive as well as requirements for ecosystem service based approaches for management of natural resources, habitats etc in the region. In addition, Black Sea states are required to collect and analyze a range of environmental parameters to characterize the state and evolution of Black Sea as part of their obligations under the Bucharest Convention.

At present EO derived information is not used extensively in support of any of these analysis and reporting obligations. At the same time, there are significant gaps in the data being collected and the analysis being performed, in particular with respect to emerging requirements such as ecosystem status characterization. There is significant potential benefit to be gained from an overall integrated approach to the combination of EO and conventional data for both archived historic data and new data to strengthen monitoring capabilities, extend analytic capabilities and support new developments such as regional and local modeling and the elaboration of more complex indicators to address emerging environmental and sustainable development concerns. This would combine state of the art EO based analytics with existing data collection and analysis linked to the Maritime Framework Strategy Directive, Maritime Spatial Planning and ecosystem based approaches for managing habitats and natural resources in the region.

Specific immediate impacts and benefits include the reuse of environmental data and analyses implemented for MFSD and WFD to support Maritime Spatial Planning and integrated Territorial Planning and Maritime Spatial Planning as well as implementing actions identified in the EU Black Sea Regional Strategy to support regional economic growth (eg developments in coastal tourism and maritime transport) as well as support to support environmental impact assessments. This would include characterization of coastal habitats and ecosystem status, collection of basic hydrographic information (eg coastal bathymetry, wave statistics, sediment and chlorophyll concentrations etc) as well as maritime traffic patterns, renewable and non-renewable energy related infrastructure developments etc. By using EO derived information to extend the coverage of the monitoring and analysis to include non-EU Member States in the sea basin, this could contribute significantly to improving the environmental status of the region and support sustainable economic growth in this EU Neighbourhood.

Improving maritime surveillance for fisheries control and law enforcement

Black Sea Coastal states such as Bulgaria and Romania have modern coastal radar and AIS surveillance providing effective control over vessel movements out to approximately 60 nautical miles from the coast line. However there are gaps in the surveillance coverage in other coastal areas and systematic airborne surveillance is quite limited. There is strong interest in combining satellite based vessel detection and tracking with coastal surveillance systems in particular for improved fisheries control, although such a surveillance capability could also effectively support other law enforcement needs such

as detecting trafficking activities, illicit discharges and protecting critical infrastructure. This could be based on Sentinel 1 data combined with satellite AIS for an initial period but also building on EMSA activity in the region. Progressively additional datasets could be integrated (eg Radarsat Constellation, optical satellites during summer etc). Near Real Time processing could be implemented at the Matera ground station (for which the coverage mask is almost the entire Black Sea) or else through EDRS downlinking to a local facility. A Near Real Time Exploitation Platform is planned by ESA so this could eventually be integrated into the operational chain.

In addition there is general interest in wider use of EO derived information for general characterization of the Black Sea, including eutrophication profiles and transport of nutrients, oxygen etc. To some extent basic data may be available from the Copernicus Marine Environment Service – however it is expected that these data will need to be integrated into customized local and regional models driven also by assimilation of additional data not provided by Copernicus.

Priority interests for the Danube Basin are elaborated below.

Drought characterization for the Danube Basin

Approximately every 10 years, significant drought conditions develop in the Danube Basin. In summer 2015, similarly to the summer of 2003, a large part of the basin was affected by a severe drought. Significant drought phenomena were experienced in Austria, Bosnia and Herzegovina, Croatia, the Czech Republic, Germany, Hungary, Moldova, Serbia, the Slovak Republic and Slovenia. Given the newly recurring character of droughts, efforts are being made by the ICPDR and its to devise strategies that aim to decrease the vulnerability of people in the basin facing such situations. At Danube basin wide level, it is foreseen that the issue of droughts and consequent impacts will play a significant role in the framework of the updated ICPDR Strategy on Adaptation to Climate Change planned for the year 2018 as well as the updated Danube River Basin Management Plan. Consistent basin wide information is required to support drought forecasting, detection of onset of drought and monitoring the status and quality of ground water over the hydrological network. Management planning also requires access to land cover information to characterize the impact on agriculture and other economic activities (in particular tourism), habitat and ecosystem status and navigation. In addition, planning mitigation measures such as artificial recharge of aquifers requires a detailed understanding of the hydraulics of the various aquifer systems.

Sediment Budget Estimation for the Danube

In the Danube Basin an increasing discrepancy between surplus and lack of sediment can be observed. This leads to an increase of flood risks and a reduction of navigation possibilities, hydropower production and biodiversity. Thus, sediment transport and sediment management are urgent issues, which can only be treated in a transnational basin wide approach. The lack of sediment management has been recognized by the ICPDR (International Commission for the Protection of the Danube River) in the Danube River Basin Management Plan in 2009 and 2015. Several initiatives to address aspects of sediment management in the river basin have recently started (eg the

DanubeSediment Inter-reg project led by Budapest University of Technology and Economics). However a comprehensive data collection and analysis capability has not yet been developed. Such an analysis could be implemented in cooperation with the ICPDR and cover the entire cycle of sediment movement, in particular:

- Sediment load within river and lakes and consequences from changes in flow regimes generated by riverbank developments (eg flood protection barriers)
- Sediment deposition on flood plains
- Sediment removal along river courses
- Monitoring of activities impacting sediment dynamics such as sand and gravel extraction
- Morphological change in the Danube delta linked to sediment deposition

Characterization of waste discharges into the Danube system

Urban waste discharges are reported at municipal level but systematic access to such datasets over the entire Danube network over extended time periods is difficult. At the same time, there is significant industrial activity within the drainage basin ranging from agricultural processing to sewage treatment, industrial manufacturing, chemical production, hydrocarbon refining and nuclear power generation. Systematic access to discharge information from all of these facilities over the entire basin in extremely difficult. As a result there is at present no systematic monitoring of the overall discharges or the impact such discharges make on the habitats or ecosystems in the region. Furthermore, it is not possible to analyse the impact that improved waste management regimes may have on these habitats or ecosystems. By putting in place a collaborative framework where such hetereogenous data could be systematically accessed and preserved and combined with EO based environmental monitoring, a holistic ecosystem based approach to the management of wastewater could be established.

Analysis of Chemical Contamination Risk for the Danube Basin

Historic presence of heavy metals and other contaminants in soils was one of the first issues identified by the European Environment Agency as many Central and Eastern European countries joined the European Union. In addition, extensive mineral extraction activities have resulted in a wide distribution of mine waste storage sites over a significant part of the Danube basin. On two separate occasions the retaining structures containing these toxic materials have failed (Kolontar,Hungary 2010 and Baia Mare Romania, 2003) resulting in significant discharges and environmental impacts. These elements represent a significant risk to the ecological status of the Danube basin and adjacent habitats and ecosystems but managing this risk requires the integration of a number of diverse elements including a range of monitoring, modeling and analysis activities. By integrating EO derived information with in-situ measurements, a more cost effective approach for monitoring of soil contamination and vegetation stress in contaminated areas, chemical contamination of river bed sediment and vegetation stress around mine waste storage sites can be put in place. State of the art modeling assimilating EO and in-situ data can support characterization of impacts while complementary EO techniques such as SAR Interferometry can monitor the stability of mine waste retaining structures on a regular basis.

There are a number of on-going project and frameworks that should be built on when implementing any action for the Danube basin. In addition to ICPDR, one of the main actors appears to the the Danubius network.

Priority interests covering both the Danube Basin and Black Sea coastal zone are elaborated below.

Implementing an Integrated Monitoring Approach for the WFD

Although the full scope of the WFD covers both inland water and coastal waters, in practice it is very difficult to connect the processes in the two regimes to provide an overall integrated approach. By using EO derived information over the entire basin and coastal region, consistent datasets can be generated that can then be related back to the data collected in support of both the separate inland and coastal areas by each member state. WFD required a baseline analysis in 2012 and another in 2018 as well as annual monitoring for each intervening year. It is proposed to conduct an improved analysis of the 2012 exercise to establish baseline conditions and then to provide customised support to the 2018 reference exercise. This would be structured as follows:

- monthly land cover/land use over the Danube drainage basin
- monthly statistics on surface water condition including chlorophyll concentration, transparency and sediment load
- monthly statistics on urban waste water discharges and precipitation
- monthly statistics on coastal water quality parameters (chlorophyll, transparency, sediment, algal bloom, frontal structures) as well as reference mapping of benthic habitats, coastline and bathymetry

This would be supported by customised analytic capabilities to characterise relationships between changes as well as assessing impact of specific policies and identifying emerging issues to be addressed

Developing customized climate resilience support information

The Black Sea and Eastern Danube Basin are already known to be highly sensitive to regional climate change pressures. Impacts include loss and degradation of water resources, land degradation and associated loss of ecosystem services as well as increased risk of geohazards such as flood and landslide. Due to the transnational but connected nature of climate change impacts, resilience planning in each country can be strengthened through access to a comprehensive regional monitoring and assessment capability building on and complementing data collection, exchange and analysis networks already put in place to support Danube/Black Sea environmental monitoring as well as national reporting requirements for EU directives.

Under this activity it is proposed to develop a combination of indicators to support resilience assessment and planning including:

- Regional level Essential Climate Variables variables – Priorities include river discharge, groundwater, albedo, land cover, above ground biomass, leaf area index fire disturbance, soil moisture, precipitation
- Regional level Biodiversity Variables – priorities include habitat structure, ecosystem extent/fragmentation, ecosystem status/composition, ecosystem disturbance

- Regional environmental parameters – in addition to data collected under WFD and other related monitoring requirements, there is interest to monitor surface water extent and status, sediment load, land surface motion as well as compiling statistics such as historic flood extent

Supporting a Comprehensive Monitoring Programme for the Danube Delta
The Danube Delta is a designated Wetlands site under the Ramsar Convention and an important economic and ecosystem resource for the region. However it is subject to a complex mix of pressures including climate change, pollution/contamination, illicit/illegal extraction of natural resources (timber, reeds, aggregates etc), unsanctioned construction, sedimentation, expanding levels of tourism and unmanaged irrigation. Sustainable management of the delta requires a combination of international, bilateral, national and regional government action. In order for such action to be consistent at each administrative level, it is essential that a common framework is easily accessible for monitoring and analysing the status as well as the various changes taking place in the delta.

There is clearly considerable scope for an integrated approach fusing local, regional and national data collection and monitoring systems with large area EO based analysis both for current change and status characterisation and also for an improved understanding of the historical changes that have occurred over the last 20 years. A dedicated development linking customised EO information extraction with databases of in-situ data and appropriate analysis tools could rapidly ensure a comprehensive monitoring capability is put in place. This would include detection of relatively slow time changes (eg sediment build up, trends in soil moisture variation) as well as land conversion and land cover change, urban expansion etc and also rapid changes associated with illicit resource extraction or illicit construction.

In-situ data
A more general concern was raised with respect to the collection of in-situ data for the Black Sea region. Existing efforts result in extremely heterogenous space/time sampling of different parameters making both routine monitoring and validation of satellite derived information extremely difficult. A strong recommendation was given on the importance of supporting well structured collection and management of in-situ data over the entire sea basin.

4.4 Next Steps

A Dedicated Regional Initiative for the Black Sea and Danube Region is planned. This will include development activities as follows:

- Ensuring access to all required EO data for the region as well as availability of appropriate algorithms customized to take local conditions into account
- Putting in place access to scalable cloud based high performance computing resources to support both EO based analytics involving very large EO data as well as fusion of EO and non-EO data to support the generation of customised analysis and indicator information products

- The development and demonstration of customised applications of EO derived information to address the priority interests in the region (as elaborated in the previous section)

At this point, there are a significant number of possible application development activities that could be executed. It is planned to enter into extended discussions with national delegations in both ESA Member States (Romania, Hungary, Czech Republic, Slovenia, Austria) as well as PECS countries (Bulgaria, Slovakia) to determine the priority interests of each country. In addition, follow-up discussions are planned with key stakeholders including the Black Sea Commission and the International Convention for the Protection of the Danube River as well as the Carpathian Convention, UNEP and other international entities active in the region.

The Black Sea Commission is very active and should be involved through its advisory groups. ESA should take the lead of the advisory groups and set up annual meetings. Another idea is that ESA sets up a group of interested members (an EO steering group/committee), not necessarily using the members of the Black Sea Commission's advisory groups. There are biannual Black Sea events that might include EO as well (either merged in the same event as a special session or a side event). The "forum" plays also a very important role, but it shouldn't be organised annually.

Based on timing of priorities for complementary developments, the planned availability of the required data access and processing infrastructure and the planned utilisation of the EO developments, specifications for a restricted set of application developments as a dedicated tender in Q4 2017. This tender will be open only to ESA Member States which have contributed to the fifth slice of the EO Envelope Programme (so-called EOEP5). However it is planned to structure discussions with New Member States and PECS countries to determine how national level capabilities funded under separate schemes could be integrated. In addition, ESA Member States participating in EOEP5 can submit proposals for innovative national and regional applications and services under a Permanently Open Call for Proposals.

An action plan shall be elaborated to address the allocation of identified priority developments over the following lines:

- EOEP5 Black Sea/Danube Regional Initiative
- EOEP5 Permanently Open Call for Proposals
- NMS Incentive Scheme and PECS Calls for Proposals

This is intended to ensure that all national priorities for expanded use of EO in the region are effectively addressed.

5. Data Infrastructures

This section summarizes discussions and conclusions related to the underlying data access, storage, management, processing and analysis infrastructures.

A sophisticated WebGIS based interface to a range of Danube environmental datasets exist. A similar WebGIS capability has also been developed by TerraSigna as a respository from a range of Black Sea parameters (eg SST, Chlorophyll concentration etc). Such systems provide a viewing and basic manipulation tool for datasets already generated. However web based processing on demand for extracting new information from EO data does not appear to be widely available.

All Danube and Black Sea states have their own high performance computing based facilities. However the capability to access these processing resources externally (ie PaaS) is not clearly evident. Commercial capabilities such as Google Earth Engine and Amazon are easily accessible within the Danube and Black Sea Member States. Capacity to access such resources in other Black Sea countries was not clearly elaborated.

National Collaborative Ground Segment infrastructure is not operational in the majority of the Danube and Black Sea states. Several in-situ data archives are distributed around the region, mainly for environmental monitoring or Earth science. Some entities have compiled limited EO data archives (eg TerraSigna in Romania) but these are not comprehensive and access conditions for other stakeholders are not clear.

Significant data collection, access, analysis and visualization limitations were reported for datasets collected under the Black Sea Convention. The development of a Black Sea node for the Copernicus Marine Environment Service in Bulgaria improves the situation with respect to EO derived information and regional ocean forecasting (current, etc) but gaps remain. In particular, connecting conventional Black Sea environmental datasets to other datasets, in particular EO derived information, territorial data, hydrographic data, economic data and maritime surveillance data, remains difficult due to gaps, lack of interoperability, lack of appropriate access and support capabilities (eg discovery). These issues constrain EO exploitation in two ways:

- Effective validation of the EO derived information is constrained due to the complexity of accessing the relevant in-situ data or the lack of in-situ data
- Generating more complex indicators (eg ecosystem status, natural capital assessment) is hindered by the lack of access to long term consistent data from the different required sources

To date, outside of Austria and Romania, there is limited awareness of developments such as the ESA Thematic Exploitation Platforms and the use of other capabilities such as IPT Poland also appears to be extremely limited. This result in most analysis being conducted on stand alone processors using data downloaded from the different providers, software installed on the user's machine and very limited collaboration functionality.

Data Visualization is based mainly on web-GIS and other similar approaches.

The Black Sea Commission confirmed strong interest in having access to infrastructure that could support improved data access and analysis. The analysis priorities are summarised in section 4 of this report.

In summary, the main issues to be addressed are as follows:

- Ensuring access to all countries in the region to the appropriate EO data (mainly Sentinel but also Landsat and commercial datasets). IPT Poland could support this requirement but is not currently configured to provide SAR data access and does not provide access to Eumetsat data. None of the non-EU members in the region are members of Eumetsat so data access conditions need to be clarified.
- For some applications (eg maritime surveillance) near real time access to satellite data is required. There is no suitable ground station in the Black Sea area although the Black Sea is within the coverage mask of the Matera Ground Station. Given the limited volume of maritime surveillance in the region and the availability of basic maritime surveillance services from EMSA, it is difficult to justify a dedicated new ground station in the region. However other developments could support an expanded maritime surveillance capability in the region, for example a NRT Exploitation Platform development executed by ESA.
- Ensure similar access to the various in-situ data archives distributed over the region as well as datasets held in international facilities such as UN GRID and the EEA Topic Centres
- Develop functionality to access the high performance processing resources in the region for the type of applications identified in the previous sections of this report
- Ensure availability in a suitable format of all necessary support tools (eg atmospheric correction etc) where necessary, appropriately customised for the region
- Develop appropriate analytic support capabilities, in particular in support of the more complex analyses to be executed in the region
- Investigate innovative visualization approaches linked to the priority applications identified in the previous section. This may be linked to the information being generated or other activities such as the visualization of query results.

6. Other recommendations

- The connection between the science community and the policy makers should be improved. In this context, research results should be presented to the decision makers. The results should reflect solutions to important problems specific to the Black Sea. Moreover, clear and unambiguous results may be generated by simple and easy to use tools, having in mind that the decision makers should not perform any data processing.

- The issue of standardisation is of critical importance in view of sharing data and results: there is a need to identify what to keep from the EU practices and what is different in the case of the Black Sea.

- The Black Sea Commission's (The Commission on the Protection of the Black Sea against Pollution) website (http://www.blacksea-commission.org/) may be a good place for sharing the results of the studies related to the Black Sea.

- Similarly, the International Commission for the Protection of the Danube River (ICPDR) , may represent the main hub or channel to share results of the Danube related projects.

- The need to communicate and exchange ideas is very high. The "Black Sea from Space" Workshop was a very good opportunity to meet the new-comers and discover new studies and results. It is recommended to repeat this exercise regularly.

- The problem of funding should also be addressed. Usually, within the EU calls, the Black Sea is considered together with the Mediterranean Sea, thus receiving less attention. Taking into account its uniqueness the Black Sea deserves a separate place, therefore dedicated calls.

- Furthermore, space is not distinctly addressed within the EU calls, forcing the participants to include space among different topics. As a recommendation, EU calls should pay more attention to the space domain and include it as a distinctive topic in the future programmes or at least to treat EO as a key technology, when addressing issues dealing with the Black-sea and Danube basin regions.