

Planning and management in the Baltic Sea region with land information from EO – BALANS

Olsson, B.

Swedish Space Corporation, Box 4207, S – 171 04 Solna, Sweden,
bol@ssc.se

Abstract

The Baltic Sea Region consists of a drainage basin shared by 14 different countries. There is a growing need for basic geographical data that is homogeneous and comparable across national boundaries to monitor the environment. The BALANS project is a co-operation between seven organisations in Sweden, Norway, Finland and Poland where both customers and Earth observation expert organisations are represented. The goal of the project is to produce and test the generation and use of land cover information from EO for the entire Baltic Sea Region, tailored to the needs of specific organisations. The project is divided into four phases. The first two phases concentrate on user requirements and the generation of a prototype database and user products. In the third phase the prototype products is tested with specific customers in demonstration case studies. This allows for iterative improvements to be made, and provides experience in integrating the products with other datasets and with the customers' day-to-day routines. The final phase provides a cost/benefit analysis and an assessment of the requirements and possibilities for a future operational situation.

I Objectives

I.1 Background

The Baltic Sea Region consists of a drainage basin shared by 14 different countries. Fundamental change occurring in some parts of the region

put the whole Baltic Sea environment at risk if economic growth is not combined with measures leading to sustainable development. The protection of the Baltic Sea environment is overseen by the Helsinki Commission (HELCOM), of which all countries in the region are members.

HELCOM is an executive organisation, and has a limited operational role. Most actions are carried out on its behalf by the member nations. Operational entities such as environmental protection agencies, national mapping agencies and meteorological offices are among those who carry out such actions. To support the regional approach, there is a growing need for basic geographical data that is homogeneous and comparable across national boundaries.

Using earth observation it can be possible to provide regular, homogeneous, regional land cover information. Such information is expensive to collect by traditional means, and existing information is difficult to integrate because of differences between national standards.

The BALANS project will address this need of information. The project is a co-operation between seven organisations in Sweden, Norway, Finland and Poland and is selected by the European Commission to receive funding for a period of 2½ years.

1.2 Project aims and measurable project objectives

The goal of the BALANS project is to produce and test the generation and use of land cover information from Earth Observation (EO) for the Baltic Sea Region, tailored to the needs of specific organisations. Such information must be readily updateable and include information on changes.

Customer-specific products are required that must have a relatively high spatial and thematic information content, while the approach adopted must make it technically and economically possible to establish a sustainable information service in the longer term that regularly provides such products for the whole region. These requirements suggest the creation of a Baltic Sea land information database, based upon medium-resolution EO data, from which a range of customer-adapted products can be generated.

The measurable objectives of the project are intended to form the basis for a possible future land monitoring system for the Baltic Sea Region:

- documentation of the detailed requirements of specific customer organisations for land information relevant to sustainable management initiatives in the region
- documentation of the state of the art in regional land cover mapping and monitoring from EO, including land cover nomenclature issues
- design and creation of a prototype land cover database and derived products
- validation of the database and products for specific test areas in the region
- execution of demonstration case studies in the region with specific customer organisations using tailored prototype products
- a cost-benefit analysis carried out in close co-operation with the customer organisations

2 Customer requirements

2.1 The customers' situation today

The BALANS project is targeting the land information needs of multiple users in the Baltic Sea Region (BSR). Thus, we first briefly describe some prominent characteristics and development features of the region, before turning to the major user categories and their current situation and future needs for land information.

2.1.1 Basic Baltic facts

The Baltic Sea Region covers an area of around 1.8 million km², of which one fifth is the surface of the Baltic Sea itself - the world's second largest brackish water body. Geopolitically, the region is highly diverse, with a mix of EU, EFTA, PHARE and TACIS countries. The Baltic Sea is surrounded by nine riparian states - Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden - and five peripheral states - Belarus, Ukraine, Slovakia, the Czech Republic and Norway. The total population is around 85 million. Since the 1970s the Baltic Sea Region has been looked upon as a model for regional environmental co-operation and pollution combating.

2.1.2 Recent development trends

Starting with the disintegration of the Soviet Union and the unification of the two German states in the early 1990s, the BSR - its countries, ac-

tors and population - has and still is undergoing many rapid changes. As a result, there is increasing demand for transboundary land information. Some areas with particular relevance for the BALANS proposal are:

- Major changes in land use practices in several countries. Notable examples are the Estonian abandonment of agricultural land due to the removal of agricultural subsidies, changing agricultural practices in EU countries due to the Common Agricultural Policy, and clear-cutting forestry in Russian Karelia.
- The upsurge in new and expanded Baltic-wide activities and initiatives. These are characterised by increased possibilities for an integrated view of various economic and sectoral activities in the drainage basin, both as they concern joint environmental management activities and exchange of data and information.
- The clear trend in the BSR for increased recognition of the interconnectedness between economic development, land-use practices and environmental problems. This is influenced by increased international efforts to seek much broader solutions to environmental problems. The concept of sustainable development, as re-invented by the Brundtland Commission in 1987, has been crucial to this understanding, as demonstrated by VASAB 2010 (Visions and Strategies for the Baltic Sea Region 2010), and the Agenda 21 initiative for the region – Baltic 21.

- The greater accessibility of various application software has resulted in a strong increase in the capacity of most users to handle georeferenced data. Tools and data accessible via Internet have also contributed. BALLERINA - the environmental information gateway to the BSR on Internet - has paved the way for a more informed Baltic community by providing an internationally recognised focal point with links to all kinds of environmental and sustainable development information.

2.1.1 Customers and information needs

The customers for Baltic land information in the BALANS project can be divided into a small number of general categories that are also more generally applicable (Table 1). These groupings are useful since they help distinguish the different ranges of geographical coverage each customer type requires.

Table 1. Customer types in the BALANS project.

Customer type	Example type members	Needs for Land Information
Baltic-wide inter-governmental policy bodies/initiatives	HELCOM, VASAB 2010, Baltic 21, EEA	Policy support and monitoring of Baltic-wide environmental programmes and initiatives
Transboundary policy-related bodies and projects	Green Belt, Lake Peipsi and Lielupe Transborder projects, Oder Protection Commission, EU INTERREG 2C projects	To analyse ecosystems and landscapes in an environmental management and spatial planning context over larger sub-areas of BSR spanning international borders
Scientific bodies or projects with relevance to the Baltic	Baltic Basin Case Study, POPcycling, BALTEX, BASYS, Baltic HOME, Environmental Protection Agencies	Input to models and analyses for themes including energy and water balances, water pollution, meteorology, and persistent organic pollutant with coverage from national/sub-national areas to whole BSR
The general public	Environmentally concerned citizens, education, NGOs, mass media, politicians	Desire for environmental awareness - easy access to maps, statistics and other information on land cover and use in BSR for local areas to whole region

Specific customers and their responsibilities

Seven customers for Baltic Sea land cover information are involved in the BALANS project. They represent a broad sampling across the four customer types, different scales of interest – from national to the whole

BSR – and a selection of different geographical locations and situations around the BSR. These customers are the basis for the demonstration case studies later in the project. A description of these customers and their relevant responsibilities are presented in Table 2.

Table 2. BALANS customer descriptions and responsibilities.

No.	Customer description	Responsibility
1	Part of EPA responsible for scientific projects involving environmental impact and risk assessment <i>Finnish Environment Institute</i>	assessment, analysis and reporting on environmental risks associated with agriculture and forestry
2	Multi-nation transboundary river basin management project reporting to multi-nation <i>Daugava River Commission (establishment 1998)</i>	development of GIS-based Decision Support System for policy-making and monitoring
3	National organisation with responsibility for scientific projects/tasks including operational hydrological modelling at national and regional scales <i>Swedish Meteorological and Hydrological Institute</i>	assessment, analysis and reporting of water-borne nutrient loads for policy-making and follow-up activities at national and Baltic-wide levels
4	International project with specific responsibilities in an ecologically sensitive transboundary region <i>UNEP/GRID-Arendal</i>	providing information for preparation of protection plans and environmental policy in threatened areas
5	Organisation with national responsibility to contribute to scientific assessment of the state of the nation's environment <i>National Land Survey of Finland</i>	analysing and reporting on changes in patterns of land cover and land use at a national level every 3-5 years
6	Secretariat of multi-nation Baltic-wide spatial planning initiative <i>VASAB 2010</i>	to provide initiatives for the building up of a monitoring system for spatial development
7	Organisation with national and European-level responsibilities for providing the general public with access to environmental information <i>Environmental Satellite Data Centre</i>	repository and access point for various national and international environmental datasets

Customers' situation and needs

The types and general needs of the BALANS customers have already been described in the previous section. However, it is important to understand the specific activities that are linked to these responsibilities,

the current situation in terms of input land cover information, and the true requirements of the customers. Table 3 describes the needs of the specific customers involved in the BALANS project and demonstrates that the 250-metre resolution is appropriate.

Table 3. Customer activities, current situation and true requirements.

Cust. No.	Activities	Current situation	Requirement
1	modelling of drainage basins, sub-drainage basins and NUTS areas using input data including land cover, soil type and DTM	land cover information generalised to 200 m, only available within national boundaries, previous versions not comparable	land cover data, approx. 200 m resolution, regularly updated and comparable in time, complete for all drainage basins flowing through country
2	assembly and integration of Daugava river basin datasets, including watersheds, pollution sources and levels and land cover	no consistent, comparable land cover data available for the region; includes four different countries	consistent, seamless land cover information for the river drainage basin at scale of up to 1:500,000
3	operational modelling of water and nutrient transport using meteorological, physiography (i.e. land cover) & emissions data	local and national-scale modelling; specific Baltic-wide modelling project, lacks appropriately detailed physiography data	up-to-date Baltic-wide physiography data at approximately 200 m resolution
4	detection, monitoring and mapping of ongoing forest changes associated with commercial forestry activities	sporadic coverage only of changes from field visits and some EO data	systematic & economic method to monitor forest changes over large area (100 x 1000 km), up to annually
5	comparison and analysis of land cover/use data at national scale to detect and assess changes	land cover/use available ('87-88 @ 25 m) and ('92-93 @ 25 ha), scales and nomenclatures incompatible	land cover/use product, 200 m resolution, comparable in time, updated at least every 3 years
6	development of system and/or services for national and regional planners providing relevant up-to-date spatial planning data, including land cover information	system/services under definition; need for Baltic-wide land cover information. BSR vector data (e.g. national boundaries, watersheds) separate development	regularly updated (every 5 to 10 years), homogeneous land cover information for the Baltic Sea region at scale of at least 1:1 million
7	provision of data access through Internet-based catalogue and browse services	no current Baltic-wide dataset on WWW, or with any interaction or extraction capabilities	up-to-date, widely applicable Baltic-wide environmental information

3 Work content

3.1 Project approach

Although available for some time, the potential of medium-resolution satellite data to provide useful information has yet to be fully exploited. The concept of a database of infor-

mation from such imagery from which products are subsequently derived is a major innovation in this project.

3.1.1 Study logic

Fig. 1 shows how different tasks integrate to complete the project. Four phases define the project:

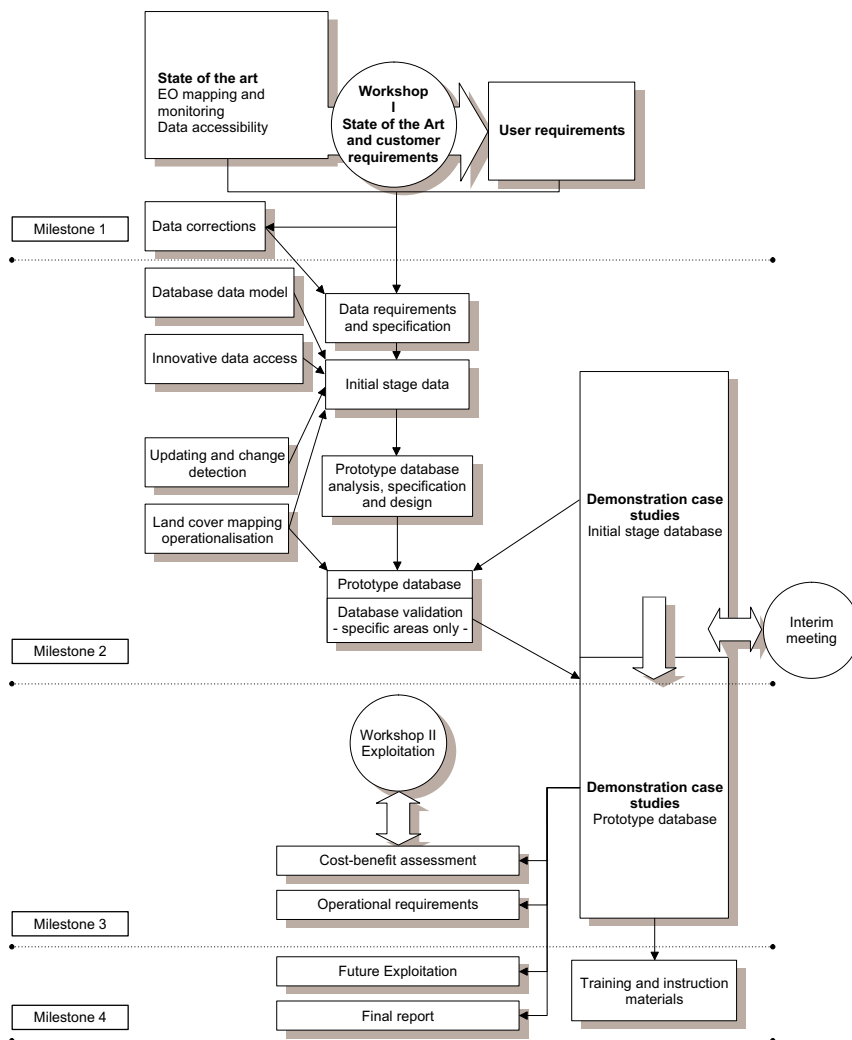


Figure 1. The study logic for the BALANS project.

1. *Customer Requirements and State of the Art.* The detailed analysis of the Customer Requirements is carried out in co-operation with the organisations involved in the demonstration case studies later in the project. These customers and other invited organisations contribute to this process through discussions and enlargements at a workshop. The various themes in State of the Art provide essential background information on technical feasibility and related issues.
2. *Initial specification, design and development and initial run of case studies.* Knowledge of the requirements and technical possibilities are used to create an initial database and derived products covering only part of the Baltic Sea region, which are then tested in the demonstration case studies (Fig. 2). Methodological development activities addressing the data model, data access, updating and change detection and automation contribute to this development.
3. *Demonstration case studies and Prototype database.* The initial products are tested by the customers and improvements implemented to create a Prototype database and derived products. Demonstration case studies are run again for the customers to test the products using more complete coverage of all areas, up to and including the whole drainage basin where appropriate. This leads to a critical review and final test conclusions.

Cost-benefit, future exploitation and operational requirements
 A cost-benefit analysis is carried out in close co-operation with the customers (Nordic KVANTIF 1987), the exploitation plans are drawn up in detail and the consequent operational requirements are determined.

3.1.2 Project innovations and methods

Sustainability

It is of key importance that the BALANS project is not an end in itself, but the beginning of a sustainable activity. This alone is a major innovation in the world of land cover information, where one-off projects are the norm. The long-term development of a healthy and growing customer base is a clear priority for all of the project partners. Establishing strong relationships with key organisations in the BSR is of paramount importance. In many cases, initial contacts have already been made during the proposal preparation.

Updates and change information

Land cover and usage are dynamic phenomena, so any land information dataset has a very limited period of actuality. Lack of an updating strategy is one of the greatest weaknesses of most land cover/use products, and a major area of concern for many BSR customers (Langaas, 1997). As an important part of achieving sustainability, the BALANS project will develop methods and strategies for regular updates. Such activities make possible the generation of

change information products of relevance to a number of customers.

Data acquisition

The BALANS project will principally use medium-resolution optical satellite data. High-resolution imagery will be used in specific areas, mainly as a validation source. Six of the seven test cases concern specific areas within the BSR. For the initial phase of the database medium resolution data will be acquired for these areas only. High-resolution data, or reference land cover products derived from such data, is already available over these areas. Mosaicked JERS-1 SAR data from the GBFM project will also be available.

An hypothesis in BALANS is that the classification of optical imagery is best carried out using Summer "peak green" imagery. Some forest classes and discrimination of agricultural land may be improved if seasonal data is used. However, the seasonal approach is less robust in that it requires several cloud-free passes over the same area during a year. It also implies a more expensive method.

A complete coverage of the Baltic Sea Region is planned for the later, prototype database stage in the project. If possible, the data for this coverage will be compiled from data acquired during a single year. The history of each pixel in the database

will be recorded so that the source of a specific pixel in the database can be traced.

Prototype Database

Land cover data is applicable in a range of contexts. These differ in the combinations of spatial and temporal resolution, and sophistication of classification scheme required. One customer might require the whole Baltic Sea drainage basin at 5 km resolution (i.e. a generalised product), while another might require a resolution of 250 m. For long-term exploitation of the results of the BALANS project a relatively large number of customers need to be attracted. They are likely to have a wide range of requirements. In order to meet such requirements an approach will be demonstrated in which prototype customer-specified products are derived from the database. Techniques such as generalisation will be used to facilitate the range of different products, analogous to approaches developed for CORINE Land Cover in Sweden and Finland (Paulsson 1994, Jaakola 1997).

To be able to support the production of a range of products from a common database, data needs to be stored at various intermediate stages. A complete BSR radiance or reflectance maps will be built up by compositing satellite images. To fa-

Complementary data in the BALANS project will include a combination of:

National land cover/use datasets
Topographic maps
Forest inventory data

CORINE Land Cover products
Regionalisation and stratification data
Datasets from customer projects

cilitate this, there must be full knowledge of each pixel. To this end, an innovative approach is planned where metadata is stored for each pixel so they can be traced to their original source image.

The core elements of the pixel tracing functionality can be prototyped and tested for a modest effort using an object-oriented technology such as Java. This is planned within the BALANS project. In the post-project exploitation phase, a true object-oriented database management system will be required, representing a significant development

step that is required before BALANS results can be brought to the marketplace.

Demonstrations

The Demonstration Case Studies in the BALANS-project are designed to test the generation of customer-specified products from the source database and the use of the customer-specific products in the day-to-day activities of the target customer.

A total of seven demonstration case studies will be carried out with seven different customers. An initial

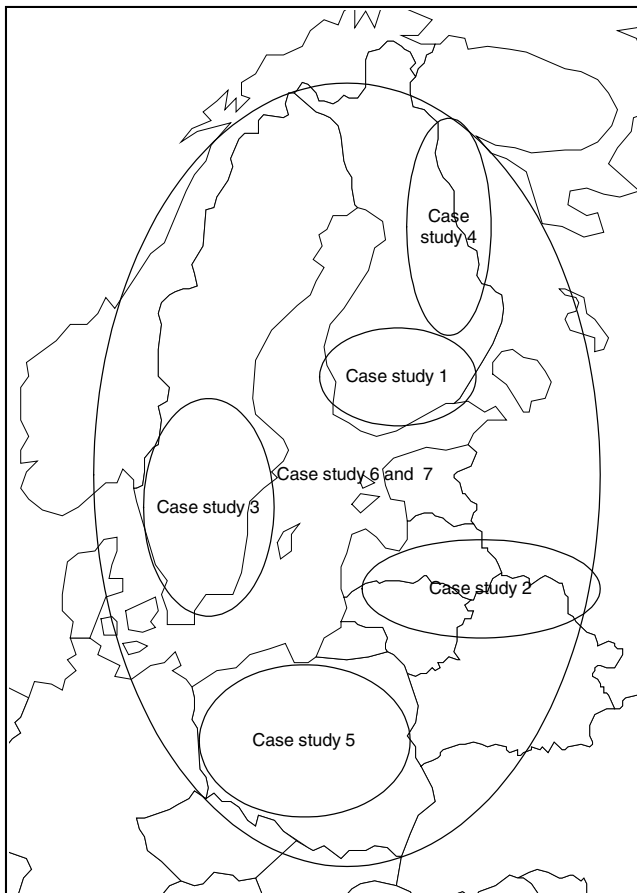


Figure 2. Demonstration case study locations.

run of the case studies will only involve five of these. A later run, where a prototype database of the whole BSR is available, will involve all seven. The locations and geographical extent of the case studies is indicated in Fig. 2.

- Environmental Satellite Data Centre (MDC), Sweden
- National Land Survey of Finland (NLSF), Finland
- Swedish Meteorological and Hydrological Institute (SMHI), Sweden
- UNEP/GRID-Warsaw (GRID-W), Poland.

3.2 Work schedule

The planned work schedule for the BALANS project is shown in Fig. 3.

4 Project structure

4.1 Project team

The BALANS project team consists of the following seven partners, of which three are Earth observation expert organisations and four are customer organisations.

- Swedish Space Corporation, (SSC), Sweden. (project coordinator)
- Finnish Environment Institute (FEI), Finland
- GRID-Arendal (GRID-A), Norway

4.2 Advisory group

An Advisory group will be linked to the project, for advising on general recommendations for the rational and sound realisation of the BALANS project.

4.3 BALANS Network

Additional to this, there will also be a network of national contact points for the BALANS project, the BALANS Network. This network will be spread over the countries within the region, both members and non-members of the European community, which not already are covered by partners of the project or by

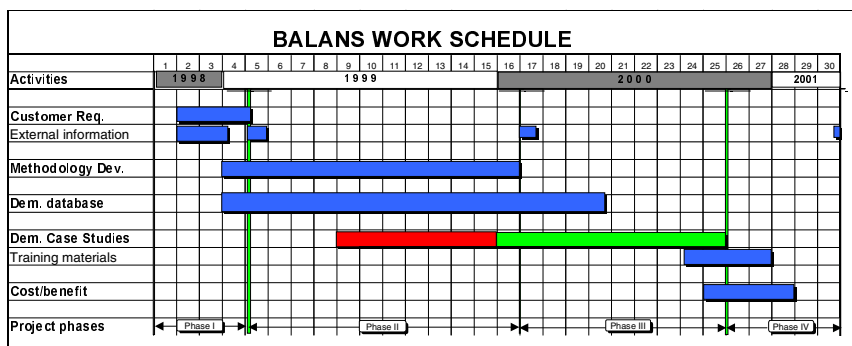


Figure 3. Demonstration case study locations.

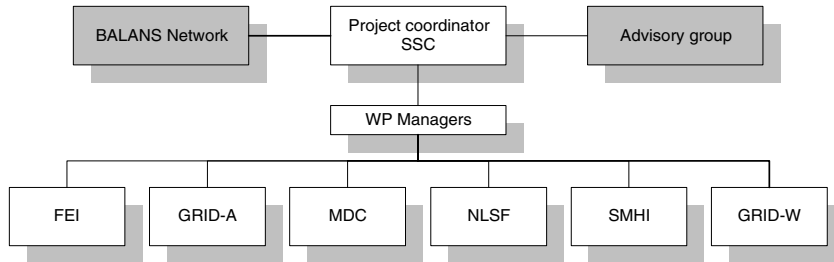


Figure 4. Structure of the BALANS project.

the Advisory group. The network will act as contact points and will have the role of receiving and passing information on to their own national networks. The members of the network will be invited to workshops and other meetings of relevance. The work on user requirements will especially benefit of this network, taking their specific needs and requirements in consideration. Fig. 4 shows how the project team, advisory group and BALANS Network are linked.

References

- Jaakkola, O. 1997. Multi-scale land cover data bases by automatic generalisation. In: ICC 1997, Stockholm (in print).
- Langaas, S. 1997. Transboundary European GIS Databases: A review of Baltic Sea Region Experiences. In: Burrough, P. & Masser, I. (eds.). European Geographic Information Structures. Taylor and Francis, Basingstoke (forthcoming).
- Nordic KVANTIF. 1987. Community benefit of digital spatial – digital map databases, economics and user experiences in North America.

- Project report 1–3. VIAK, Arendal, Norway. 124 p.
- Paulsson, B. 1994. A Computerized Generalization Approach for Land Cover Maps. XFF640 Swedish Space Corporation.

Acronyms and abbreviations

BALANS	Planning and Management in the Baltic sea Region
BALLERINA	Baltic Sea Region On-line Environment Information Resources for Internet Access
BALTEX	Baltic Sea Experiment
Baltic 21	The Agenda 21 for the Baltic Sea Region
BASYS	Baltic Sea System Studies
BGIS	The Basic Geographic Information of the Baltic Drainage Basin
BSR	Baltic Sea Region
CORINE	Co-ordination of Information on the Environment
EEA	European Environment Agency
EFTA	The European Free Trade Association
EPA	Environmental Protection Agency
EU	European Union

FEI	Finnish Environment Institute	NLSF	National land Survey of Finland
GBFM	Global Boreal Forest Monitoring	SMHI	Swedish Meteorological and Hydrological Institute
GRID-A	Grid-Arendal	SSC	Swedish Space Corporation
GRID-W	Grid-Warsaw		
HELCOM	Helsinki Commission	VASAB 2010	Vision and Strategies for the Baltic Sea Region 2010
MDC	Environmental Satellite Data Centre		
NGO	Non-governmental organization		