SEVENTH FRAMEWORK PROGRAMME

FP7-SPACE-2010-1

SPA.2010.1.1-01

Stimulating the development of downstream GMES services

Coastal Biomass Observatory Services

Final report

Project acronym : **CoBiOS**

Project full title : **Coastal Biomass Observatory Services**

Grant agreement n°. : **263295**

Date of document : **06-05-2012**

Author : **S. Peters + CoBiOS team**

Deliverable characteristics

Lead beneficiary	VU-IVM
Contributors	Peters, S.W.M., Eleveld, M., van der Woerd, H.J. Lenhart, H., Körner, U., Große,F., Attila, J., Kaitala, S., Simis, S., Koponen, S., Anttila, S., Junttila, S., Alasalmi, S., Pyhalahti, T. Laanen, M.L., Hommersom, a., Poser, K., Marueda, A., de Reus, N., Kaas, H., Andersson, H., Erichsen, A.C., Closter, R.M. Stelzer, K., Lebreton, C., Lange, U., Desmit, X., Hayden, B., Vanhellemond, Q. Boye-Hansen, L., Blaas M., Gaytan, El Serafy, G.

Consortium

No	Name	Short name	Country
1	Vereniging voor christelijk hoger onderwijs wetenschappelijkonderzoek en patienenzorg	VU-IVM	The Netherlands
2	Universitaet Hamburg	UHAM	Germany
3	Suomen Ymparistokeskus	SYKE	Finland
4	Water Insight BV	WI	The Netherlands
5	DHI	DHI	Denmark
8	Brockmann Consult GMBH	BC	Germany
9	Institut Royal des Sciences Naturelles de Belgique	MUMM	Belgium
10	Geographic Resource Analyses & Science AS*Gras	GRAS	Denmark
11	Stichting Deltares	Deltares	The Netherlands

IPR

1: Introduction

1.1 Executive summary

The focus of the CoBiOS project was on the monitoring and prediction of eutrophication caused by nutrient pollution leading to high biomass algal blooms. High biomass algal bloom events occur each year in many places in the European waters, causing nuisance (smelly foam on beaches) and potentially dangerous situations when there are toxic species or when the biomass decays rapidly and sinks to the bottom to form pools of hypoxic matter. High biomass events often reach the public through newspapers and internet since they cause disruptions in the recreational use of beaches and coastal waters. This type of blooms influences the turn-over of fisheries and aqua-cultural operations in many ways, sometimes with large economic losses.

CoBiOS aimed to integrate satellite products and ecological models into a really operational and user-relevant information service on high biomass blooms in Europe's coastal waters. Remote sensing can offer high quality harmonized Chl-a and Kd products including error statistics that can be used for the monitoring of bloom events. However, the observations lack complete coverage due to cloud interference. They also lack predictive value. During high biomass bloom events in coastal waters, the shape and location of blooms changes completely during a period of 2-3 weeks. Since blooms are brought to life by periods of sunshine, these are often but not always periods in which there is rather good coverage of satellite images. Therefore it is important to combine remote sensing products with hydro-ecological models.

Through theoretical analysis, a good understanding was achieved of the main parameter expressing biomass (Chlorophyll-a) and the various means of monitoring and modelling this parameter. The project has gained a deep understanding in how the parameter "transparency" is calculated in non-optical way in various ecological models and how this links to the optical descriptions of this parameter. Methods were proposed and implemented to drive ecological models with satellite observed (gap-filled) daily maps of transparency or its proxy "total suspended matter". Using MERIS images, methods were designed to come to an ensemble mean Earth Observation product that significantly reduces uncertainty with respect to using a single map/method. Trials were successfully executed to test the existing and improved methods and models. In general providing TSM information to ecological models significantly improves the description of the underwater light climate and the predicted Chlorophyll-a. Modelled biomass development predictability was investigated under permutations of wind-fields, nutrients, model parameters, riverine inputs etc. Validation data was collected mainly from buoys and Ferrybox systems and used, together with consolidated validation methodologies, to validated improved outcomes of satellite products and ecological model outputs. After successful adaptation of all services to MODIS, four operational service lines were put into place. In each service line an Earth Observation service provides daily data to an ecological model service. Monitoring and modelling results are automatically placed on the CoBiOS webportal (http://cobios.waterinsight.nl) to give users an overview of past and current events and predictions of 3 days in the future. Based on the portal info, early warning bulletins can be generated together with time series plots and longer term animations. The system was successfully demonstrated to a number of users (from various stakeholder communities) who expressed the interest the use of the system after the lifetime of the project. CoBiOS partners participated and contributed to various coastal waters oriented European services discussions and contributed to a white paper expressing the need for a pan-European Coastal waters monitoring concept using satellite observations.

1.2 Summary project context and the main objectives

The focus of CoBiOS is on the monitoring and prediction of eutrophication caused by nutrient pollution leading to high biomass algal blooms. High biomass algal bloom events occur each year in many places in the European waters, causing nuisance (smelly foam on beaches) and potentially dangerous situations when there are toxic species or when the biomass decays rapidly and sinks to the bottom to form pools of hypoxic matter. High biomass events often reach the public through newspapers and internet since they cause disruptions in the recreational use of beaches and coastal waters. This type of blooms influences the turn-over of fisheries and aqua-cultural operations in many ways, sometimes with large economic losses. CoBiOS aims to integrate satellite products and ecological models into a really operational and user-relevant information service on high biomass blooms in Europe's coastal waters.

Remote sensing can offer high quality harmonized Chl-a and Kd products including error statistics that can be used for the monitoring of bloom events. However, the observations lack complete coverage due to cloud interference. They also lack predictive value. During high biomass bloom events in coastal waters, the shape and location of blooms changes completely during a period of 2-3 weeks. Since blooms are brought to life by periods of sunshine, these are often but not always periods in which there is rather good coverage of satellite images. Therefore it is important to combine remote sensing products with hydro-ecological models.

Main objectives:

1) To collect, review and consolidate existing knowledge and data related to optical measurements and modelling parameters of coastal waters biomass development.

2) To define and analyze methods to improve the underlying information production lines of CoBiOS. On the one hand we intend to improve the quality of Earth observation products by incorporating error statistics products and to expand the portfolio of EO-products with harmonized water transparency products which are suitable to drive ecological models. On the other hand we will expand the capability of ecological models with methods to predict relevant additional information such as: biomass transport vectors and growth/decay rates. We will study the best schematization to use EO-transparency data to force ecological models and we will study methods to compare model results in terms of Chl-a concentration with satellite observations of the same parameter.

3) To implement the improvements in models and EO-products and to test the enhanced output quality by running two series of hind cast trials: one with the original models and one with the improved models (forced by EO-transparency data).

4) To collect relevant in-situ validation data during the Near Real Time operational phase and to actively engage key-users of the CoBiOS services in the validation of the service performance and the quality of the EO-data products and model information products.

5) To demonstrate the novel CoBiOS information system by operationally running the models and EO products service chains during an extended Near Real Time demonstration phase.

6) To set-up and fill the CoBiOS web-portal with maps of high biomass algal bloom events.

7) To communicate the extent of the events by means of early warning bulletins to professional users.

The CoBiOS project is organized in the following Work Packages:

WP1: management

WP2: preparation and consolidation of data, protocols, validation formats etc.

WP3: theoretical development of EO-transparency products, model interfaces and assimilation methods

WP4: Implementation of tools and methods, testing and trial runs

WP5: Validation activities, including the collection of in-situ validation data during the demonstration trials

WP6: demonstration runs of the operational services

WP7: dissemination and service sustainability development

CoBiOS was set up to achieve the objectives in 36 months. An incremental and iterative approach was implemented to ensure that, at the end, CoBiOS results perfectly fulfil the initial objectives. To this aim the project is split into 6 phases as follows:

Phase 1: Preparation (3 months)

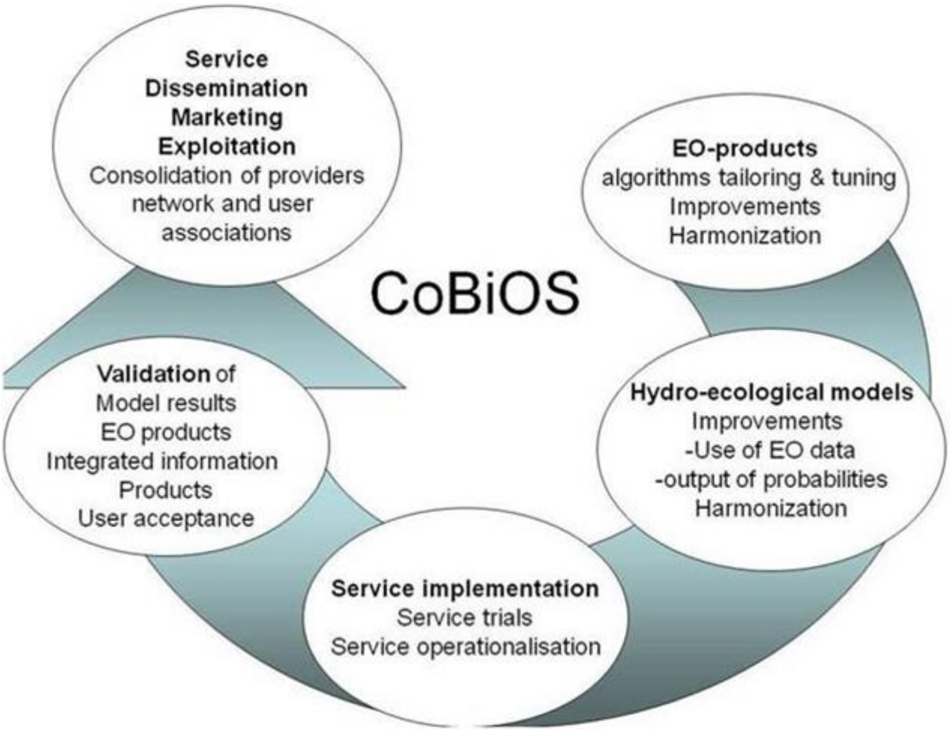
Phase 2: R&D support to CoBiOS Services development processes (12 months)

Phase 3: Implementation of tools and methods (6 months)

Phase 4: First and second end-to-end trial and validation of results (6 months)

Phase 5: Third, operational demonstration trial and validation (6 months)

Phase 6: Conclusion of earlier started dissemination and service sustainability activities



1.3 Summary of the main S&T results/foregrounds

During the first year of CoBiOS an inventory was made of available resources (satellite images, models, methods for Kd estimation from MERIS data, etc.). An overview was made of available satellite data (MERIS and MODIS in various levels of processing). At Brockmann Consult an ftp server and the MERCI system were opened for satellite data retrieval by project partners. Also at Brockmann Consult the CoastColour archive was opened for the provision of (full resolution) satellite data. An overview of relevant MyOcean data has been made and set of initial procedures to enable data exchange and file access from MyOcean to CoBiOS partners has been established. This allows each partner to prepare conversion tools. Together with the other CoBiOS partners, the formats and initial interfaces to the CoBiOS end user portal have been defined and a start was made with the architecture design of the CoBiOS portal. For the purpose of harmonization of data and to understand the differences between e.g. Chl-a derived from satellite observations and Chl-a measured in-situ, a large number of national and international measurement protocols was collected, evaluated and archived. Many sources of in-situ data have been inventoried, including National Monitoring Programs, Ferrybox, SmartBuoys, and Open Repositories. The Catalogue provides information about the available in situ-measured parameters, the locations and time spans of measurement; it includes an estimate of the number of measurements per year, and an estimate of the data quality and quality check procedure. The source and availability of the data is always indicated, with contact persons and acknowledgement indications. A Validation Board has been introduced and early users' recommendations have been taken into account. To provide user relevant services, CoBiOS has made an early start with the identification of user requirements. A major innovation in CoBiOS is to use EO products to introduce the vertical diffuse attenuation coefficient (Kd) into the ecosystem models. Therefore a study of current methods was conducted resulting in a report describing the theoretical best-practice to derive a Kd product directly from EO data, which may serve as a basis for further algorithm testing and development.

An important development during the second year of the project was the departure of MERIS. This meant that we had to change the focus to operational use of MODIS. First the experiments were completed studying the harmonisation of satellite products. For MERIS images we have decided to use a standard for radiometric correction and output file formats. The results of several algorithms were bundled into one file for a number of days and a number of regions to allow us to come to an uncertainty product. Some of the algorithms were re-parameterized to adapt to local conditions. Using a number of different approaches, we have developed several KDPAR products. For MODIS we did the same but the number of proprietary algorithms is less and the quality of the results is somewhat affected by noise. Fortunately we have been able to develop algorithms for MODIS that provide approximately the same accuracy for total suspended matter and chlorophyll in the North Sea. In the Baltic Sea artifacts show up where high sediment areas are falsely recognized as phytoplankton blooms. The ecological models were tested for their ability to provide probability numbers in cases where we permutated wind speed and direction, various amounts of run-off, various amounts of nutrients and some intrinsic model parameters. An index was developed to assess the effect of the permutations on the dynamics of phytoplankton development. We have come to realize that the parameter Kd has different meanings in models and from satellite observations. In ecological models Kd is calculated from the components carbon, mineral particles and salinity. In remote sensing terms Kd is defined by optical properties. We have been able to bring the knowledge of optical properties to the coefficients that determine the Kd in the ecological models. Based on an extensive survey we have defined a set of methods to evaluate the difference between model results without remote sensing, and models results where the model was driven by remote sensing input. Software was developed to integrate the new methods in the existing processing chains of the service providers. From initial model experiments it was concluded that a number of parameters determine the prediction of the onset and duration of phytoplankton blooms. For example long-term variation in the wind fields and the initial settings of internal model parameters have large effects on the predictions.

In the third year all the service lines were developed towards operational status. Because MERIS-Kd was no longer an option, some of the models were driven alternatively by daily TSM fields derived from MODIS. Gapfilling was performed using the DINEOF method and software, implemented to the systems of the various partners. Especially for winter months the surface visibility frequency is very low, so the DINEOF method needed some adjustment to produce reasonable results for those months. To present the results from EO and models in a sensible way to users various tools were developed:

1) Early warning bulletins, showing daily results together with 2 previous days and predictions for 3 consecutive days in the future. Users found the bulletins very useful, especially if they are annotated giving some expert judgment comments and interpretation guides.

2) The portal website was developed containing a side-by-side view of 2 user defined maps. The user can select Chlorophyll-a observations for one of the regions from one of the providers and/or model predictions for the region from one of the providers. The portal contains relevant background information and fact-sheets for all the services. A backbone system was set-up to receive and process the results from service providers.

3) Movies are being produced using an automatic movie generator tool to allow the visualization of processes during longer periods in the past.

4) Time series plots are generated and show to the user per OSPAR or HELCOM box.

After the production of systems and services, users were approached to test and use the systems for a certain period and provide feedback. To collect relevant feedback two questionnaires were developed (one of which on-line). In general the users appreciate the CoBiOS service, are interested in continuation after the project and some are interested to purchase services. From discussions with users from HELCOM and OSPAR it has become apparent that some of the CoBiOS products play a significant role in the monitoring and reporting of these gremia. Especially Chlorophyll-a as indicator for eutrophication - and transparency measurements - connect to ongoing monitoring and decision making. The products of the service lines were validated against e.g. available in-situ data using consolidated validation measures and methods. Cross validation between satellite Chl and model Chl was performed with variable results. The performance of the service lines and systems was also validated. In general delivery within the day was achieved, with sometimes short interruptions because of hardware maintenance or software updates. A non-service period of 14 days was caused by the shutdown of the US administration which caused unavailability of MODIS data. We think that it should be noted that, although not asked in the questionnaire, we have the impression that National users are tempted to wait to see what form of services MyOcean can offer in this respect, because these inherently will be free of charge. The consortium has been very careful not to express negative opinions about MyOcean products to the National users in our area, but our own analysis shows that our models in general do not benefit from MyOcean met-ocean products while our EO products are suitable for the Northern European waters where the MyOcean products are not. Extreme care has to be taken that the anticipation on MyOcean operational products is not going to disturb the market and the user base created by projects such as CoBiOS. Although the project started with an orientation on MERIS, the projectteam has successfully demonstrated that biomass development in coastal areas can be monitored and modelled using MODIS-AQUA data as well. This provides an extra perspective on long-term service continuity since also succeeding sensors such as VIIRS and Sentinel-3 will be able to provide relevant data using the CoBiOS methods.

1.4 Potential impact

High biomass algal bloom events occur each year in many places in the European waters, causing nuisance (smelly foam on beaches) and potentially dangerous situations when there are toxic species or when the biomass decays rapidly and sinks to the bottom to form pools of hypoxic matter. These pools can resurface and form dead zones where massive marine life mortality occurs. On the other hand, it may be profitable in the future to monitor high biomass blooms because they could be harvested as biofuel or as fertilizer (since the world stock of phosphates is decreasing rapidly). High biomass events often reach the public through newspapers and internet since they cause disruptions in the recreational use of beaches and coastal waters. This type of blooms influences the turn-over of fisheries and aqua-cultural operations in many ways, sometimes with large economic losses.

The CoBiOS project aims to integrate satellite products and ecological models into a really operational and user-relevant information service on high biomass blooms in Europe's coastal waters. The service aims to reduce economic losses by giving timely warnings for high algal biomass development and predictions on algal biomass movement and fate. CoBiOS will provide strategic information on which new biomass harvesting initiatives can be based.

The ecological state of surface water can be read from several simple measurements and indicators such as the concentration of Chlorophyll-a (Chl-a) as proxy for algal biomass and Secchi disk depth, suspended matter concentration or turbidity, all as measurement or proxy for water transparency. In-situ measurements are expensive, time consuming (and therefore unrepresentative for the natural variability in large coastal waters) and unsuitable to monitor changes in NRT to allow for timely warning for events of foam formation, oxygen depletion and dead zone formation.

Remote sensing can offer high quality harmonized Chl-a and Kd products including error statistics that can be used for the monitoring of bloom events. However, the observations lack complete coverage due to cloud interference. They also lack predictive value. Therefore it is important to combine remote sensing products with hydro-ecological models. Such an integration of information sources will provide novel and detailed information for many types of analyses and potential commercial spin-offs.

CoBiOS has established these information services which can be used to:

• Provide information on the state (EO) and evolution and fate (models) of near coastal high biomass blooms

• Evaluate and predict the probabilities of nuisance (foam, biofouling of off-shore installations and ships), harmfulness (red tide, fish kills etc), decayed biomass accumulation,

• Follow patterns of nutrients pollution (eutrophication)

• Predict (and ultimately prevent) potential hypoxia and anoxia events/locations that might lead to oceanic dead zones and massive fish kills.

• Predict when and where bloom harvesting would be economically feasible

• Indicate locations/periods where fishing would benefit from decreased transparency (resulting in netting invisibility)

• Indicate areas where blooms have lower than normal intensity due to pollution or variations in insolation due to climate change.

In a wider context, CoBiOS services will provide novel information to be used in the framework of EU directives, the most important of which is the Marine Strategy Directive – (EMS, 2008). The European Marine Strategy framework directive (EMS) aims to achieve good environmental status of the EU's marine waters by 2021 and to protect the resources upon which marine related economic and social activities depend. The Marine Strategy will constitute the environmental pillar of the future maritime policy from the European Commission, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment. The other important EU directive that has links with the CoBiOS service products is the EC Bathing waters directive (2006).

The directive has requirements relevant to monitoring of bacteria, assessment (water quality evaluation), cyanobacterial risks and monitoring of other parameters such as the proliferation of macro-algae and/or marine phytoplankton. Regional Seas conventions such as OSPAR and HELCOM also have links with the CoBiOS services because they are concerned (amongst others) with pollution of the marine environment with nutrients and the consequent eutrophication.

CoBiOS results are being disseminated through the project webportal (cobios.waterinsight.nl) and have been presented on a number of user relevant meetings, such as meetings of HELCOM, OSPAR and EUROGOOS.

The consortium has decided, supported by the interest of key users, to keep the portal (and the services) alive for one year after the project to make the change from MODIS to Sentinel-3 based services. Together with related FP7 projects a white paper was written (currently send to National Delegates) to propose an operational coastal waters monitoring service using Copernicus satellites, data and infrastructures.

1.5 List of deliverables (available at: http://cobios.waterinsight.nl)

This final report provides an overview of activities and results obtained during the CoBiOS project. It is intended as a catalogue for the elaborated results and descriptions published in the deliverables. The following deliverables can be found on the public website.

Stelzer, K., Lebreton, C., (2012) Functional description of project Satellite data collection, archiving, and distribution system: CoBiOS Deliverable D2.1

Simis, S., Desmit, X., Eleveld, M., (2012) Validation data measurement protocols for CoBiOS: CoBiOS Deliverable D2.2

Desmit, X., Hayden, B., Simis, S., Lenhart, H., Blaas, M., Kaas, H., Lange, U. (2012) Catalogue of in situ data: CoBiOS Deliverable D2.3

Lebreton, C., Lange, U. (2012) Updated Service Validation Protocols: CoBiOS Deliverable D2.4

Kaas, H., Peters, S. (2012) CoBiOS Initial user requirement analysis: CoBiOS Deliverable D2.6

Simis, S., Desmit, X., Stelzer, K., Lebreton, C., Boye-Hansen, L., Peters, S., Eleveld, M., Lenhart, H., (2012) Algorithm comparison for the use of the downwelling attenuation coefficient (Kd) in ecosystem models: CoBiOS Deliverable D3.1

Eleveld, M., Lebreton, C., Stelzer, K., Attila, J., Simis, S., Boye-Hansen, L., Desmit, X., Vanhellemond, Q., Peters, S. (2013) Methods and protocols for satellite data harmonisation and error statistics: CoBiOS Deliverable D3.2

Lenhart, H., Körner, U., Große, F., Erichsen, A., Kaas, H., Desmit, X., Aguilar, S., El Serafy, G., (2013) Methods to derive probabilities from model results: CoBiOS Deliverable D3.3

Blaas M., H.J. van der Woerd, S.W.M. Peters, X. Desmit, H.J. Lenhart, C. Lebreton, H. Kaas, H. Andersson, A.C. Erichsen, R.M. Closter, G.Y. el Serafy (2013) Integration of Ocean-Colour Earth Observation Data & Biogeochemical Models: CoBiOS Deliverable D3.4

Attila, J., Kaitala, S., Simis, S., Koponen, S., Anttila, S., Junttila, S., Alasalmi, S., Desmit, X., Lennhart, H., Lange, U., Lebreton, C., Eleveld, M., Gaytan, S., Blaas, M. (2013) Methods for cross comparison of EO data and models: CoBiOS Deliverable D3.5

Lenhart, H., Koerner, U., Grosse, F., Desmit, X., El Serafy, G., Anderson, J., Erichsen, A. and Kaas, H. (2014) Report of results of service trial 2: CoBiOS Deliverable D4.5

Simis, S., Attila, J., Pyhalahti, T., Lange, U., Lebreton, C., Poser, K., Hansen, L., Desmit, X. and Ruddick, K. (2013) EO-products validation and outlook to future sensors: CoBiOS Deliverables D5.3&5.7

Lenhart, H., Koerner, U., Grosse, F., Desmit, X., El Serafy, G., Anderson, J., Erichsen, A. and Kaas, H. (2014) Model forecast quality assessment: CoBiOS Deliverable D5.4

Lange, U., Attila, J., Simis, S., Kaas, H., Hansen, L., Lebreton, C., Lenhart, H., Desmit, X., El Serafy, G., Hommersom, A. and Peters, S. (2013) Validation of service performance (5.5), Operational service validation (6.2) & MyOcean Assessment and Feedback (6.3): CoBiOS Deliverables D5.5 & D6.2 & D6.3

Marruedo, A., Peters, S. and Lenhart, H. (2014) Socio-economic impact assessment: CoBiOS Deliverable D5.6

El Serafy, G., Hansen, L. and Kaas, H. (2014) CoBiOS Portal as NRT-service: Products Description and User training Plan: CoBiOS Deliverables D6.1 & D7.2 & D7.6

WP2: Preparation of data and protocols and infrastructure

WP2.1 Acquisition, archiving and pre-processing of satellite input data

To assess the EO data requirements of the partners a questionnaire was drafted and sent to all partners. Furthermore an inventory was made of different satellite processing types and data providers. An FTP architecture was set up for EO data exchange and filled with images. Data were collected from various sources (ESA, CoastColour archives and NASA archives) based on SLA's with these projects/services. Agreements were made about the standard MERIS products that will be used within this project (also linking to the work in WP3.2), namely L1B 3rd reprocessing data, corrected for Radiometry and some other standard corrections. Depending on the area of interest further processing with either C2R or FUB is probably the best choice. In preparation of the harmonization analysis in WP3.2 a selection of good MERIS images at matchup locations/times were selected and made available to the team on the FTP site.

D2.1 describes the status of the remote sensing data available for the CoBiOS project. It presents a catalogue of the data available to the consortium, where they originate from, and the first implementation of a mass access and downloads system where the data can be retrieved. It also compiles which data are in the end required by the consortium. MyOcean and MarCoast2 signed SLAs with CoBiOS, in order to give access to some of the required data.

Data from MyOcean: Deltares on behalf of CoBiOS has signed an SLA with MyOcean in March 2011. The EO data made available cover the Atlantic North West Shelf (and European Ocean) and the Baltic Sea for ocean colour products such as Kd, reflectances, CHL, CDOM, Secchi depth, and Absorption coefficients. 1km and 2km resolutions are available depending on the products, and both archived and NRT data are accessible. Data are obtainable from MERIS and MODIS or a merging of MERIS, MODIS, and/or SeaWiFS. The SLA with MyOcean will also provide SST data from merged sensors.

Data from ESA: The standard ESA Products will provide the reference data of surface reflectances and water quality products. On 1st July, ESA opened the archive for third reprocessing data. Changes from second to third reprocessing are affecting both L1b as well as L2 products.

Data from NASA: The standard L2 MODIS Aqua products are freely available for all to use from the dedicated NASA website. These products will provide a different set of reference and comparison.

Data from the CoastColour project: Data from CoastColour comprises advanced TOA reflectances, water leaving reflectances and water parameters such as IOPs, CHL, and TSM concentrations, CDOM, Z90 or Kd.

BC on behalf of MarCoast-2 has signed an SLA with to make available the standard MarCoast-2 products for MERIS FR and RR. With the signature of the SLA, CoBiOS agrees to contribute to the MarCoast-2 validation process, which consists of the validation of the products themselves as well as the assessment of the service. The MarCoast-2 service provider compiles a validation report and a utility report has to be written by the CoBiOS consortium.

Access to the data for CoBiOS partners: Data access has been arranged through dedicated ftp servers at BC and through the MERCI system.

WP2.2 Review and update of validation data measurement protocols

A list of in situ measurements that are relevant to CoBiOS was based on the results from the WP2 questionnaire that was circulated among all project participants. Overviews were compiled of operational measurement protocols that are of relevance for in situ measurements used to generate or validate CoBiOS products, for the geographic areas that they respectively operate in. The in situ measurement protocols are divided into two categories. First, those that fall under national monitoring schemes and where standard (unchanging) protocols are in use, and for which quality assurance is not an issue, but where the ecosystem modelling community nevertheless needs to be informed of the methods in use. Second, those methods that are used only by experts in the field and from which validation data are generated more sporadically as they do not fall under national monitoring programmes. The latter are few, and described separately (Rrs, Kd, IOPs). Gaps were identified in the available information (taken as-is, as not all protocols are known to the users).

The description of the protocols was originally foreseen to cover many specialized laboratory methods as had been the case for other, previous, projects (MERIS LAKES, REVAMP, GlobColour etc.) but it turned out to be more beneficial to the CoBiOS project to focus exclusively on those parameters that serve to generate or validate CoBiOS products, and to provide an index of established methods used in the various monitoring programmes, which has proven difficult to come by or interpret (language issues), but could lead to a better understanding of the modelling researchers of the data they use to validate or generate ecosystem model results. The D2.2 documents measurement protocols for in situ validation parameters relevant to the CoBiOS project and is complementary to the catalogue of (historical) in situ data published as CoBiOS.

WP2.3 Historic validation datasets

A catalogue was set up that includes only metadata information for in situ data. The catalogue includes metadata information (NMP, FerryBoxes, SmartBuoys, ICES) for the North Sea and Baltic Sea, in the form of tables. The Catalogue (D2.3) is a very useful (also for externals) collection of the metadata information about initially-available in situ data (historical data). Many sources of data are inventoried, including National Monitoring Programs, Ferrybox, SmartBuoys, and Open Repositories. The Catalogue provides information about the available in situ-measured parameters, the locations and time spans of measurement; it includes an estimate of the number of measurements per year, and an estimate of the data quality and quality check procedure. The source and availability of the data is always indicated, with contact persons and acknowledgement indications. A map in the Introduction makes the synthesis of all available datasets in the North Sea and the Baltic Sea, and offers a useful helicopter view that may guide the user through the pages and tables of the Catalogue (Fig 2.3.1).

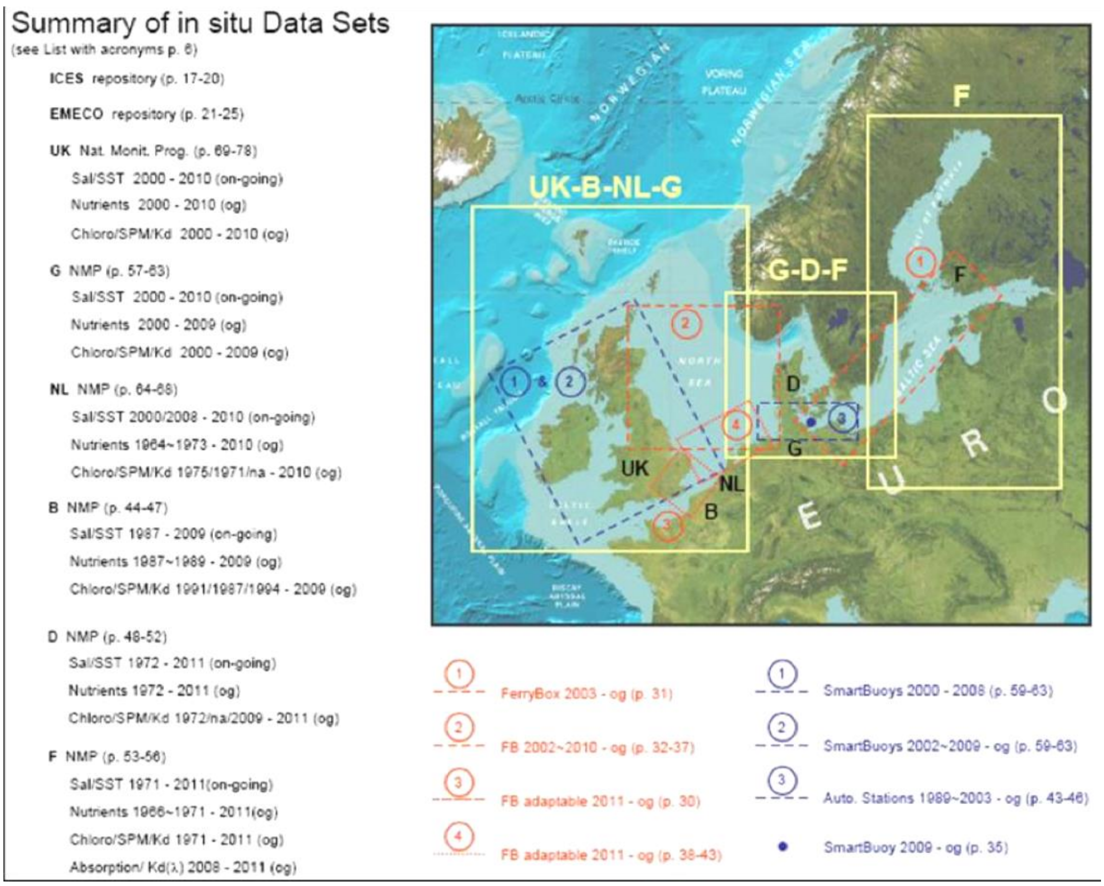


Fig. 2.3.1 Geographical locations, time periods, and page references of main in situ monitoring programs collected in the present report. Black: national monitoring programs (yellow frames on the map). Red: FerryBox. Blue: SmartBuoys and Automatic Stations.

WP2.4 Review of service validation protocols

A review of the MarCoast and Aquamar service validation protocols was performed. It is important to note that these protocols only deal with the validation of EO-data and services. Based on discussions and input from modelling partners the existing protocols were adapted to suit CoBiOS purposes, i.e. review of validation methods also for ecological models.

In general validation reports for services like the MarCoast and the CoBiOS services have the following general contents:

1. Service and Products
    - Parameters
    - Temporal and spatial resolution
    - Technological concept of the service
    - Main in- and output data for each processing step
    - Shortcomings and limitations
    - Management (Delivery, Backup systems for human resources and hardware, …)
    - Performance (Duration of delivery, availability, …)
2. User requirements
    - Parameter (in other words: Which answers should be given?)
    - Positional accuracy and precision
    - Temporal accuracy and precision
    - Thematic accuracy and precision
    - Service performance requirements
3. Validation
    - Validation strategy
    - Validation results
        - Service performance
        - Statistical validation
    - Validation assessment
4. Service assessment
    - User assessment
    - Service provider assessment
    - Potential improvements

The statistical validation of the products and the services is very important to install user confidence. A preliminary inventory showed that a suitable list of parameters and their priority would be:

Methods	Mandatory	Optional	Comments
1. Subjective assessment			
2. Visualization techniques			
2.1 Mapping	X		Quantitative data only
2.2 Frequency distribution	X		Quantitative data only
2.3 Contingency tables	X		Qualitative data only
2.4 Time series plots	X		Quantitative data only; if appropriate
2.5 Transect plots			Quantitative data only; ; if appropriate

Methods	Mandatory	Optional	Comments
2.6 Change detection			Spatial information only (point and polygon features)
3. Measures of deviation			Quantitative data only
3.1 Mean absolute error	X		
3.2 Root mean square error	X		
3.3 Ratio of standard deviations			
3.4 Percentage model bias	X		
3.5 Median error			If error skewness is substantial
3.6 Model efficiency			
3.7 Error distribution			
3.8 Skewness of error distribution	X		
3.9 Cost function (normalized bias)	X		
4. Statistical tests			Quantitative data only
4.1 Regression	X		
4.2 Taylor diagram		X	
4.3 Simplified Taylor diagram		X	
4.4 Target diagram	X		
5 Temporal and Spatial analysis			Quantitative data only
5.1 Start of season	X		If appropriate, i. e. within the focus of the model and user requirements
5.2 Duration of season	X		If appropriate
5.3 End of season	X		If appropriate
5.4 Spatial trajectory from start to end	X		If appropriate
6. Other statistical measures			
6.1 Receiver operator characteristic		X	
6.2 Multidimensional scaling (MDS)		X	
6.3 Sensitivity/Uncertainty analysis		X	

Table 2.4.1 Mandatory and optional validation methods to be used for validation of CoBiOS EO/model services.

The applicability of these statistical parameters and methods will largely depend on the availability of sufficient in-situ data of sufficient quality.

WP2.5 Interface with MyOcean

A Service Level Agreement (SLA) has been established between CoBiOS and the GMES Marine Core Service MyOcean. This specifies the MyOcean data that is made available to the CoBiOS partners and the conditions of use. (With the SLA there is also the possibility to channel feedback to the Marine Core Service MyOcean.)

- An overview of the MyOcean data has been made.
- An set of initial procedures to enable data exchange and file access from MyOcean to CoBiOS partners has been established. This allows each partner to prepare conversion tools, as necessary, for the Service Implementation and Trials (WP4) and the Validation of Services and Products (WP5).

Together with the other CoBiOS partners, the formats and initial interfaces to the end user portal (WP 6 and WP 7.2) have been defined

WP2.6 Inventory of user requirements

Initial user requirements were collected from discussions during the KO-meeting (M2) with the user board. Evidently it is important not only to look on the service provider side to assess the quality and the form of the information (early warning bulletins etc.) but also on the user side. What are the costs associated to false positives and false negatives? What are the time frames within which users can respond to a warning before they suffer damage? Which methods are available to the user for prevention and remediation and how expensive are these? It is clear that this type of information will be hard to get and falls rather without the scope of this project, but it will, in the long run determine the success of the services. During M2 it was decided to postpone the activity in WP2.6 until the end of the first year because some users are involved in multiple projects and because the project has little to show in the early stages. In the last quarter of the first year a questionnaire was designed. Selected users completed the questionnaire during interviews with service providers in the consortium. The results provide many insights into the formats, frequencies and type of information users are interested in.

The user requirements report (D2.6) describes the initial identification of the user requirements for the CoBiOS project. The purpose of the present initial user requirement analysis is not to give final answers but to make a survey of the important issues to be considered. The basis of the present initial requirement analysis is 1) a UCEB (User and Customer Executive Board) analysis of user requirement presented at the kick-off meeting in January 2011 and 2) interviews with key end users of the planned services. The interviews are conducted face-to-face based on a questionnaire prepared by the project. Furthermore, 3) a user meeting was held together with the ASIMUTH project.

The initial user requirements address the possible application of the planned services, the relevant parameter and products, confidence estimated, presentation of data, the optimal resolutions, frequency of publication, dissemination media, etc. Each service covers a region of the North and Baltic Sea and shall target the users in these regions (in local languages or English).

The major take home messages of the initial analysis are:

- Daily services is called for
- The primary media should be a website
- Forecast services predicting the conditions 3-7 days ahead should be a product
- Supportive parameters describing the state of the sea in general are required
- General as well as tailor-made special services are required
- Some (more) kind of confidence estimates are requested
- Confidence estimates should minimise false positive and false positive warnings of events
- Stability measures as recommended by ocean colour user should be considered
- Cost expenses should be considered
- Most of the governmental/federal end user did not requested training
- The services must be sustainable and reliable

WP3 EO Data harmonization and model improvements

WP3.1: Comparison of algorithms for Chl-a, Kd and CDOM

A questionnaire was circulated among the partners to gather background information / algorithm requirements. The D3.1 report provides an overview of existing validation efforts for a set of candidate algorithms for the CoBiOS ecosystem models. It should assist the EO algorithm developers, product suppliers, and ecosystem modellers in the CoBiOS project to decide what caveats or performance issues (including the lack of validation) still exist in their existing suite of products. In those cases where either current products do not perform well enough, or validation data are lacking, this document can be interpreted as support for the introduction of new algorithms into the ecosystem models. The CoBiOS preparatory questionnaire for WPs 2-3 highlighted the current use of algorithms for EO-data to resolve CDOM, Chl, Kd, and TSM, as well as tentative future use by some of the models (Table 3.1.1). At least two of the CoBiOS ecosystem models already build their K_d product from CDOM, Chla, and TSM information suggesting that improvements in K_d retrieval as well as the more specific water quality parameters from EO data will be reflected in improved model results. With few exceptions, the algorithms that are in current or planned use are described in peer-reviewed publications.

Model	K_d	CDOM	Chl	TSM
3D-MIRO&CO	MUMM-KparV2	(in K_d model)	(in K_d model)	MERIS/MODIS std
DELFT3D-GEM	Sallinity (CDOM proxy), TSM, POC, Chla. (empirical)	Hydropt	Hydropt	Hydropt
ECOHAM	TBD	C2R	C2R	C2R, TSM climatology (to be implemented)
MIKE 3D	C2R for DK	C2R for DK	C2R for DK	C2R for DK

Table 3.1.1. Algorithms used in CoBiOS ecosystem models: Use of EO-based algorithms to resolve CDOM, Chl, Kd, and TSM in the CoBiOS ecosystem models as currently used or planned for the near future. Legend – Yellow: algorithms described in literature but validation incomplete or uncertain for relevant region or parameter of interest. Green: algorithms and validation reports are provided (in this report or elsewhere) for the region and parameter of interest.

A major innovation in CoBiOS is to use EO products to introduce the vertical diffuse attenuation coefficient (Kd) into the ecosystem models. D3.1 therefore includes a description of the theoretical best-practise to derive a Kd product directly from EO data, which may serve as a basis for further algorithm testing and development. Validation efforts on existing Kd retrieval algorithms are reported. In many cases, the ecosystems currently rely on an empirical definition of Kd as a function of secondary optical parameters (chlorophyll-a, suspended matter load, and absorption by chromophoric dissolved organic matter).

WP3.2: Methods/protocols for harmonized satellite products including error statistics

A way to proceed to harmonization of satellite products would be to use an ensemble mean of results of suitable and validated algorithms. Since the physical background of some algorithms is slightly different and the parameterizations are often local, we feel that an ensemble of algorithms results is meaningful and, in the situation of threat detection, could lead to decreased uncertainty. The steps in the evaluation process were:

1) Collecting 3rd reprocessing RR L1 and L2 IPF scenes, as requested from partners (20 scenes) and set on ftp for partners to download (BC)
2) Processing with regional algorithms (VU-IVM, SYKE, WI, BC, GRAS) and comparison with (regional) in situ data. Because this test was done outside automated processing lines this was a considerable effort for most partners.
3) L3 binning, collocation and pixel extraction for defined coordinates of processed L2 products for each region (BC)
4) Presentation of the results including comparison to in-situ data

Due to the successful preparations we could make a good evaluation of an ensemble approach for deriving confidence products from layers of EO-results. We also could make a good evaluation of the performance of each algorithm as compared to the ensemble mean which, in our eyes, is more useful than trying to arrive at the best algorithm. Based on a preliminary comparison with in-situ Chl-a data it appeared that the ensemble mean for Chl-a is rather close to the observed values. Improvements for several algorithms were identified and for some algorithms we decided to leave them out of future ensembles.

E.g. Figure 3.2.1 shows Chlorophyll maps from all algorithms, as well as the mean CHL map in the centre for the test date 05.08.2006. CHL values for this date have been compared with in situ measurements obtained from LANU (Landesamt für Natur und Umwelt, Schleswig Holstein) (see Figure 3.2.2). Apart from a few points, the algorithms do not agree much with the in situ measurements, but they nearly all lie within the standard deviation of the mean CHL. One should also note that the BCFUB and BCQAA algorithms give the lowest values of all compared algorithms, as can also be seen in Figure 3.2.1.

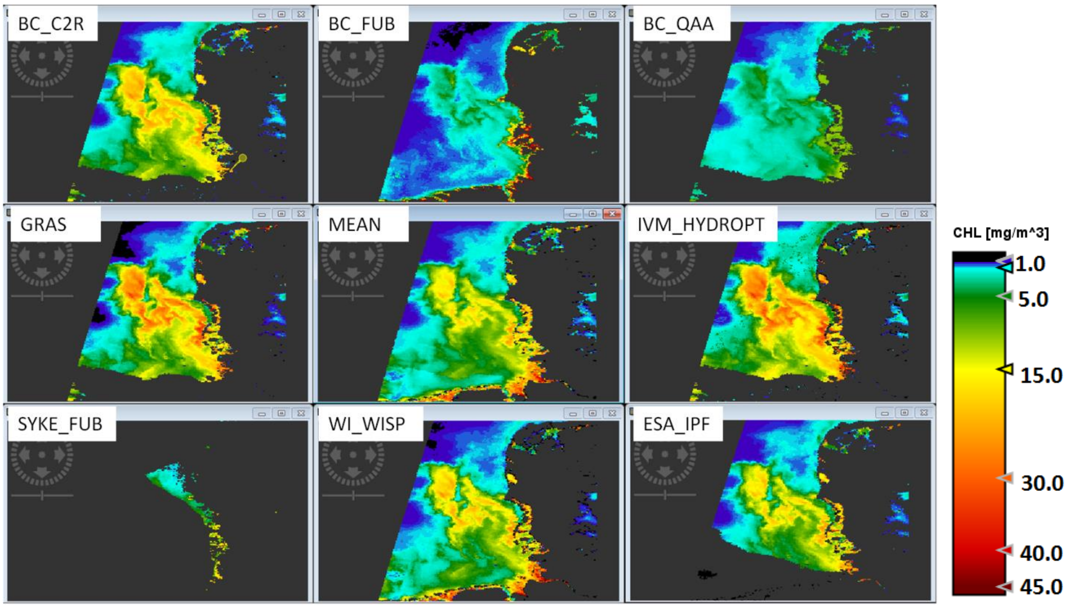


Figure 3.2.1 CHL maps from the different algorithms, with the mean map in the centre for the North Sea region on 08.05.2006

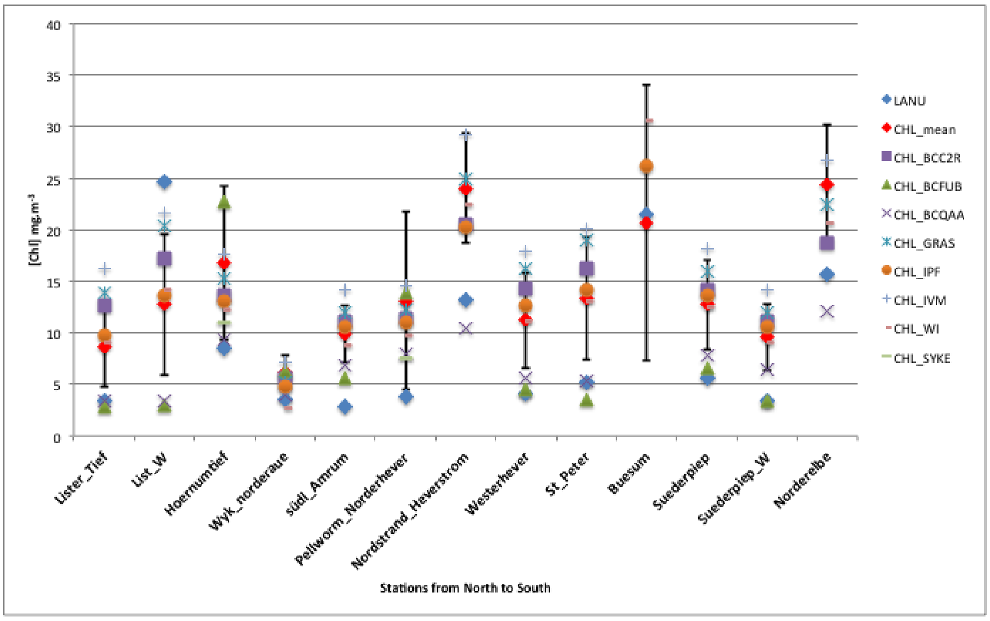


Figure 3.2.2 Algorithms comparison for Chlorophyll at the AlgFES stations on 08.05.2006

Wp3.3: Methods for probability extraction from model results

A Modelling workshop in September 2011 (M3) was prepared to address a common understanding between the CoBiOS partners how to proceed with the topic of probabilities for the model runs. In principle the process works as follows: First the biomass concentration is calculated in a hindcast model run up to the moment of the last available satellite image which is used for validation. The uncertainty in the following prediction (pink area) for the next days is highly dependent on the environmental conditions, more precisely on the representation of these conditions in the forcing data, as well as internal parameters within the biogeochemical model.

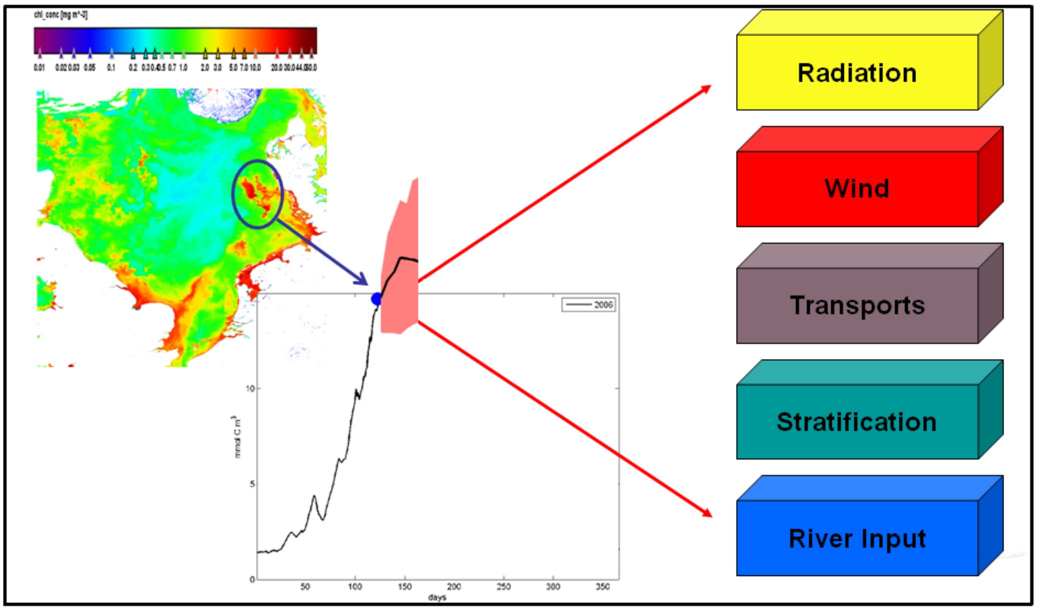


Figure 3.3.1: Practical illustration of predictability problems related to environmental forcing. The predicted biomass is highly dependent on the actual conditions of environmental parameters, as radiation, wind, stratification and river loads.

The aim of this deliverable D3.3 is to define a method that provides a measure for these uncertainties in the prediction. The discussion among the modellers showed clearly that the term “probability” in the context of CoBiOS is understood as a measure for the predictability for the future development of algae blooms. The key question is: “how good can a prediction be, given the uncertainty in the forcing and the internal dynamic of the ecosystem outlined by the biogeochemical model”. To answer this question a number of sensitivity experiments were designed and metrics for comparison and validation were determined.

Partner	Exercise	Model tool applied for study
Deltares	Test different forcings on Kd(original silt, EO-silt , EO-kd; with/without gapfillin)	GEM
UHAM	Test different scenarios on river loads	ECOHAM
MUMM	Test on windstress (advection, mixing), plus Channel Flux and River loads (thru discharge)	MIRO&CO-3D
DHI	Test on mixing 21coefficients (main drivers: wind stress, heat fluxes)	MIKE 3D FM
Deltares and DHI	Tests of phytoplankton model parameters	GEM and MIKE 3D FM

Table 3.3.1: Distribution of the sensitivity experiments among the participants.

Methods for the testing of the natural variability of e.g. the North Sea system to different conditions were prepared to come to sensitivity tests of the significant factors affecting model results at validation site. An aggregation of list of validation sites was made based on the response from the questionnaire as a common platform for the probability studies under WP3.3. Subsequently Model runs are carried out for validation and sensitivity studies at the validation sites. This includes the preparation of the aggregated in-situ measurements for model validation for the German part of the North Sea.

Wp3.4: Methods for use of EO-Kd in models

A first conclusion of this WP was that EO-Kd and model Kd have very different definitions and are calculated from different observations/parameters (Fig 3.4.1).

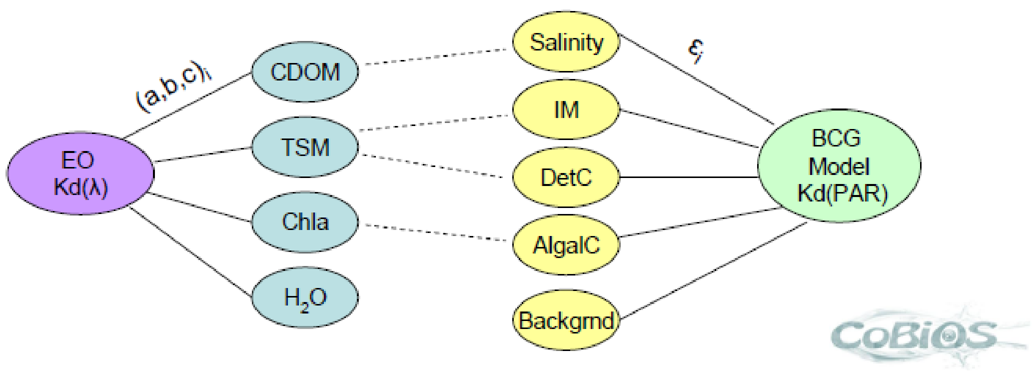


Figure 3.4.1 Scheme indicating the dependencies of underwater light attenuation (Kd) from the perspective of ocean colour earth observation (left) and a biogeochemical model (in this case the Delft3D Generic Ecological Model GEM (Blauw et al. 2009), right); (a,b,c) are the specific inherent optical properties relating the observed

constituents to the downward irradiance and its spectral attenuation Kd(λ); εi are the 'specific attenuation coefficients' relating the model constituent concentrations to the bulk extinction of the photosynthetically active radiation Kd(PAR).

Based on Literature review various Kd formulations were tested within the modelling frames of the partners and a first impression was obtained regarding the robustness of the models against changes in Kd forcings. EO-model exchange formats were investigated (to prepare EO data for the grid size of the model, nc format chosen) for first trials at comparison EO pictures and 2D model results. MUMM's model kPARv1, calculating the kd from EO-TSM, was implemented and used in the model MIRO&CO. MUMM's model kPARv2 has been developped meanwhile. Although all models use some formulation for Kd, the sub-models are different and even the parameter settings are different based on local observations. In Table 3.4.1 some varieties of the general expression (2.17) are compared. Many more variants can be found in literature but here the focus is on a few that apply an increasing number of constituents in the regression and those that are currently applied in CoBiOS. In this table the units are as follows: Kd & Kd_{BG} in m^{-1}, S in PSU, CDOC in gC/m^3, TSM in g/m^3, Chla in mg/m^3, POC in gC/m^3 , NAP in g/m^3, DET in gC/m^3, IM in g/m^3.

	K_{dBG}	S_{ref}	ε_S	ε_{CDOM}*	ε_{CDOC}*	ε_{TSM}	ε_{ALG}	ε_{POC}	ε_{NAP}	ε_{DET}	ε_{IM}
	m^{-1}	PSU	m^{-1}	-	m^2/g	m^2/g	m^2/mg	m^2/g	m^2/g	m^2/g	m^2/g
Devlin et al. (2008)	0.325					0.066					
Suijlen & Duin (2001)	0.04					0.055	0.021				
Tatman & Van Gils (2003)	0.067	34.92	1.57					0.3			0.036
Delft3D GEM "Flyand Version" (Tatman & Van Gils 2003)	0.08	34.97	0.97				0.009	0.1			0.012
Delft3D GEM CoBiOS version (Blauw et al. 2009)	0.08	34.97	0.97				0.009	0.1			0.025
MIRO&CO KparV2 (Nechad & Ruddick 2010)	0.04			a_y*		b_{bTSM}*	$0.739a_{Chl}$*		a_{NAP}*		
ECOHAM (Lorkowski et al 2012)	0.09					0.06	0.0126				
MIKE3FM &ECO Lab	0.1	-	-		0.1	-	0.0138			0.088	0.1
Lee et al. (2005) (linearized)	0.029*	*	*	1.19		0.056	0.029		*		

Table 3.4.1 Summary of Kd algorithms as discussed in D3.4. All expressions except KparV2 Nechad & Ruddick 2010) and Lee et al. (2005) are of the form of eq. (2.17): a linear combination of constituents contributing to total Kd, weighted by their 'specific extinction' ε. In equation (2.17), the units are as follows: Kd & KdBG in m-1, S in PSU (nondimensional), CDOC in gC/m3, TSM in g/m3, Chla in mg/m3, POC in gC/m3 , NAP in g/m3, DET in gC/m3, IM in g/m3, which sets the units of the specific extinction coefficients.

) DHI uses a conversion CDOM = <η>CDOC with <η>= 2.5:as for particulate organic material (see Appendix A). Lee et al. (2005) and. KparV2 relate CDOM effect directly to specific absorption of CDOM (yellow substance a_y).

The WP 3.4 also investigated how to fulfil the conditions that models need EO data without gaps. An existing method (DINEOF) was identified and implemented by the partners. Figure 3.4.2 below shows a scheme of the processing of the raw, gappy image series in to an interpolated of reconstructed data set.

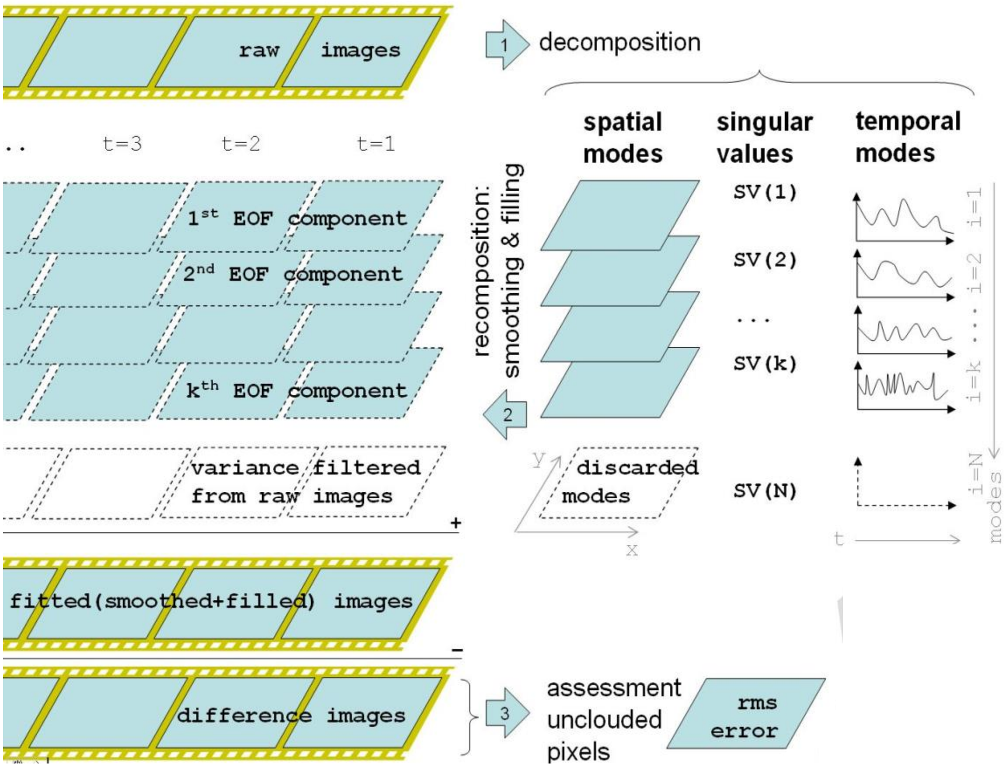


Figure 3.4.2 Illustration of the decomposition of a raw, gappy, time series of (x,y) (gridded) images into a set of spatial modes, temporal modes and corresponding singular values by means of Data Interpolating EOFs. (Adopted from De Boer et al. 2012)

For further details of application, the reader is referred to the various papers published by the GHER group (http://modb.oce.ulg.ac.be/mediawiki/index.php/Publications).

WP3.5: Methods for cross comparison EO data and models

The work on WP3.5 consisted on defining methods suitable for comparing model and EO results on North Sea and Baltic Sea. In addition to model and EO comparisons, the WP3.5 also made use of combining existing in situ data, such as ferrybox (Alg@line on the Baltic Sea) coastal and open sea monitoring station data as well as mooring buoys. The data collection has been done in other WP's (WP2.3 (historic data) and WP5.3 and WP5.4 (actual data)). In the deliverable report of WP3.5, parts of this available in situ data were used as demonstrative examples to be combined with the model and EO comparisons. For example, Baltic ferrybox data was used in comparisons of both model and EO results. The appropriate model parameters on the surface or at 5 m depth were compared against ferrybox derived chlorophyll-a distributions. The results were used in tuning of MIKE model parameters. The report also describes procedures to integrate the different data sources. During the WP3.5 work, a set of statistical measures were defined and agreed between the project partners:

"We suggest that the following methods are used as the minimum, wherever the appropriate data are available.

1. Statistics in Table 1 (below). These statistics should include least bias, RMSE, model efficiency, percentage model bias. Additional statistics are given in the D3.5.
2. Regression plots with correlation statistics (R, R^2, slope, intercept).
3. Target diagram
4. Time series comparison on a selected location, for example an *in situ* station.
5. Spatial and temporal comparisons that are feasible for each region. For all regions, a spatially aggregated time series comparison as demonstrated in D3.5. Whenever possible/feasible, the spatial and temporal comparisons between EO and model should be linked to available *in situ* data, i.e. transect or station data.
6. It is recommended to include visual comparison as well as statistical analyses as described in D3.5

WQ	In situ	r^2	RSD	Pbias (%)	ME	Skew	CF	N
Chl-a [µg/l]	Ferrybox		0.60	-10.58	-0.795	-1.48	0.89	19866
Chl-a [µg/l]	ST & AlgaWB		1.73	4.15	0.35	1.67	0.48	205
Chl-a [µg/l]	ST		1.42	-6.65	0.33	1.21	0.52	187
Turbidity [FNU]	ST	0.69	1.16	1.43	0.69	0.66	0.35	280
SST	ST	0.96	1.02	4.86	0.94	-0.29	0.20	403

Table 1.5.1. Recommended statistics to be used in validation, with example data (Alg@line ferrybox, monitoring station (ST) and EO data from the Northern Baltic region). RSD = ratio of standard deviations, Pbias (%) = percentage model bias, ME = model efficiency, Skew = Skewness, CF = cost function.

Temporal comparisons describe the differences and similarities between different types of data. Thus, time series on weekly or longer basis are important part of comparisons. A further suggestion is to use annual statistics in comparisons, such as annual mean, and coefficient of variation or standard deviation. In comparisons between EO and model, annual mean bias and RMSE are useful for demonstrating the differences between the two data sources." This set of criteria will be applied in the actual validation (WP5.3). The statistical measures were used to compare in situ and EO. Same statistics were also presented for in situ and model comparisons. In these statistics, both monitoring station and ferrybox data were applied. A traffic colour light system was defined and applied to describe the goodness of result statistics. In addition to the statistical measures, the deliverable report suggests and examines a set of spatial and temporal comparisons that are feasible for each region taking into account the available in situ. Time series using EO and in situ are presented for a selected location, for example on an in situ station or on a regional scale. A spatially aggregated time series comparison were demonstrated and suggested for use in final validation. The deliverable suggests that spatial and temporal comparisons between EO and model should be linked to available in situ data, i.e. transect or station data whenever possible. In validation activities, WP3.5 suggests to derive validation methods that are feasible and understandable on the end user level, i.e. can be linked to the on-going work and regions related with MSFD and WFD. For this reason, example results were calculated for HELCOM and OSPAR regions. EQR (ecological quality ratio) was used as an example of harmonized, end user oriented comparison on MSFD water bodies.

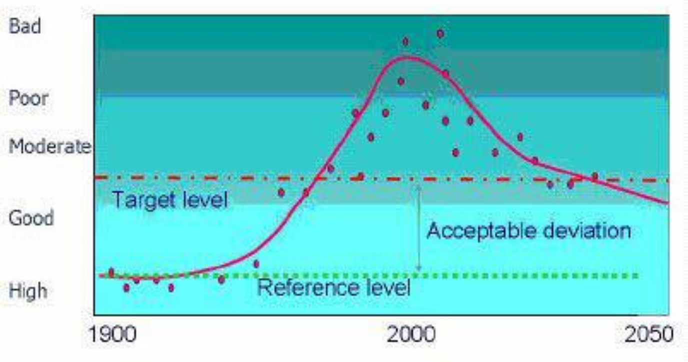


Fig 3.5.1: EQR defines the state of a region in relation to a target status representing a good ecological state

WP4

WP41: implementation of improved harmonized EO-products & connection to models

WP4.1 implements methods for providing harmonized products from the satellite processing chains and methods for generating standardized output from the satellite processing chains. The results are used in the ecological models and in the CoBiOS portal. At the start of the project MERIS was selected to produce the information needed for the services. The work package 4.1 supported the following activities:

1) To implement a meaningful and validated Kd_PAR product to drive the ecological models based on the recommendations from Deliverable 3.1.
2) To facilitate harmonization of algorithms and products. We started comparing the results of available (mostly proprietary) algorithms for Chl-a, TSM and CDOM (and later on also Kd_PAR) and noticed that the differences were mostly not too big and often quite explainable from knowledge of the algorithm structure and calibration (See Deliverable 3.2). Based on these positive results we decided to bundle products from all sensible algorithms to arrive at the accuracy index, which could e.g. be the standard deviation of the bundled product.
3) To implement a harmonized output format to enable the automation of the bundling procedure and to generate the statistics for the accuracy index. As a generic format the BEAM VISAT format was chosen and implemented for all individual processors.

Unfortunately, in the middle of this activity MERIS failed. This meant that all our processors had to be reconfigured to obtain, archive, pre-process and process MODIS AQUA images. Most of the partners have subsequently tested and adopted SeaDAS with various selections for atmospheric correction and adjusted the calibration and configuration of their algorithms to accommodate for the MODIS set of spectral bands. Partners compared MODIS and MERIS results to provide a quality statement about MODIS products to the modelling partners. As an example of the comparison of MODIS and MERIS we present figures 4.1.1a and 4.1.1b, where long-term annual mean observations of Chl-a and TSM in the Dutch coastal waters based on MERIS and on MODIS are compared.

In order to get a better understanding of the relationship of the adjusted MODIS algorithm results (WI: WIMON) with respect to the (VU: HYDROPT) MERIS results we made scatterplots of both datasets.

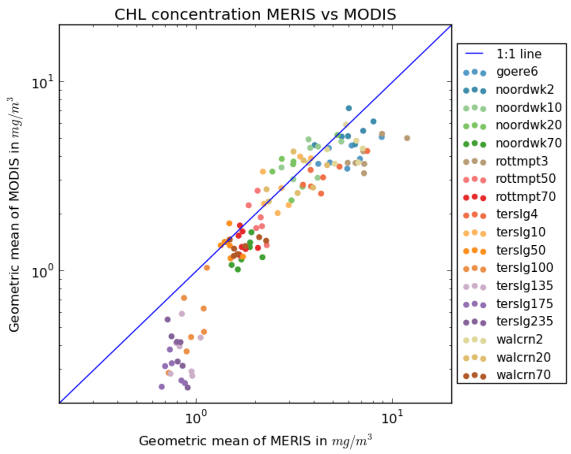


Fig 4.1.1a Comparison between mean annual MERIS and MODIS Chl-a results at mwtl stations

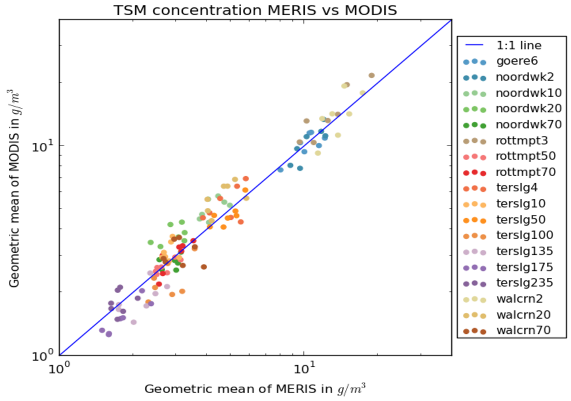


Fig 4.1.1b Comparison between mean annual MERIS and MODIS TSM results at mwtl stations

From Fig. 4.1.1a it is clear that MODIS and MERIS have approximately the same performance for Chl-a above a value of 1. Below 1, MODIS provides more realistic low values while MERIS values tend to remain constant around 0.8. Fig 4.1.1b shows that MODIS TSM is in very good agreement with MERIS TSM; the spread in MODIS TSM values is even lower than MERIS.

WP4.2 Software to implement model improvements:

The objective of WP4.2 is to implement the software required to take advantage of the developments made in WP3. This comprises software improving modelling by involving EO (and ferrybox) data, software for estimation of probability measures and software post-processing model results in order for the CoBiOS services to deliver products usable for the end users. These products comprise maps with area estimates, time series plots and probability estimates. A diagram showing the overall elements and flow of the CoBiOS service is shown in Figure 4.2.1. The black boxes indicate the subjects addressed by WP 4.2

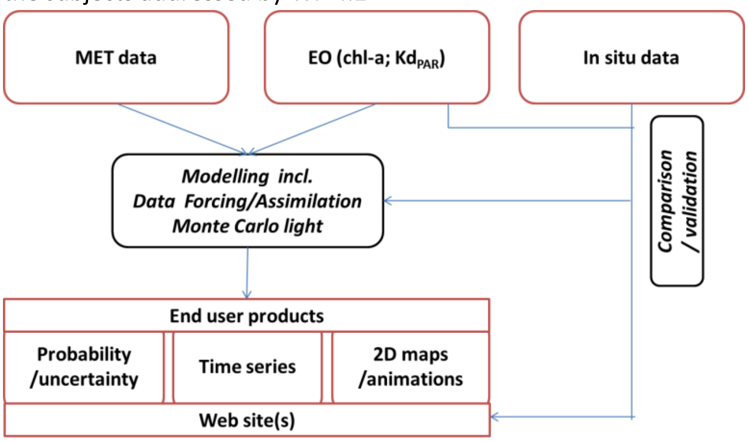


Figure 4.2.1. Diagram showing the elements and flow of the CoBiOS GMES service. The black boxes concern the model improvements develop in the CoBiOS project and implemented by the software described in the present document.

The CoBiOS service is divided into five service lines: 3 for the North Sea covering Belgium, Dutch and German marine waters, respectively, and 2 for the Baltic Sea covering the inner Danish marine waters and the whole Baltic Sea, respectively. For modelling of the three North Sea areas three different modelling tools are applied: 3D-MIRO&CO, ECOHAM, and Deltares GEM model. For the Danish/Baltic Sea services the MIKE by DHI tool is applied. With these tools physical-biogeochemical models for the focus areas have been established prior to the project (for the Danish waters/Baltic Sea one model supports both service lines) and the objective of the CoBiOS has been to improve these models by involving EO data on the environmental parameters chlorophyll-*a* (chl-a) and Kd_{PAR} in the modelling process and to add probability estimates to the product portfolio of the models/service lines.

In order to improve the models and thereby the CoBiOS GMES service, software has thus been developed to support:

- Exploration of the information provided by EO chl-a and Kd_{PAR} in the modelling.
- Estimation and extraction of probability measures

With regards to involvement of EO data software has been developed which allows for different exploration of the EO data. Three different strategies were addressed in the studies, requiring the following types of software:

- Software for using EO data as forcings to the models (studies with the Deltares GEM model)
- Software for data assimilation of EO data following the EnKF scheme (studied with the DHI MIKE model).
- Software providing statistical comparison schemes which allows for testing of the comparability of EO and model times series (studied with all models)

With regard to probability measures, it was decided that probabilities are calculated for each model from Monte Carlo ensembles runs. This required the following type of software:

- Software for execution of Monte Carlo runs
- Software for running sensitivity testing to determine the decisive forcing and model variables
- Software for extraction and presentation of probability measures

The sensitivity testing involved development of programs for extraction of key indicators describing the spring algal bloom.

WP4.3: Implementation Early warning bulletin texts & animations tools

For MERIS each service provider had established a quantitatively and qualitatively well-defined and validated chlorophyll product and a suspended matter product, while, within the context of this project new transparency products were developed. When starting to redevelop services using MODIS images, it was necessary to review and update our capabilities to produce chlorophyll maps and suspended matter maps of sufficient quality. It has taken the consortium until early 2013 to achieve this. Next to displaying map results in a portal, it has been deemed important to also actively communicate the extent of the events by means of early warning bulletins to professional users. Using preliminary results from WP4.4 and 4.5 methods were designed to generate early warning bulletins in NRT that contain sections with the latest satellite results and model predictions (expressed as probabilities) together with a section where a data provider can enter comments and interpretations. These bulletins form an important part of the information chain because here we can provide the synthesis of the information. As a starting point an existing bulletin tool was used that is currently used to provide bulletins to http://www.fytoplankton.nl and expand the tools using input from the user board of CoBiOS. A standardized tool was made to generate animations from the series of JPGs that are visible within the CoBiOS portal (CoBiOS.waterinsight.nl).

Early warning Bulletin

A concept of an early warning bulleting has been developed within the consortium. The design has been kept simple, displaying information on a single A4 sheet. From left to right it shows a series of maps ranging from D-3 to D+3 (with D as the current date, plus or minus whole days). D-3 to D-1 is comprised of observed EO data, while D+1 to D+2 is Model prediction output. Usually, the EO data of the current day is not available yet for distribution, but if this is improved, the data range would ideally be D-2 to D0 of course. The layout is kept uniform to the portal. The logos of the providers of the maps are displayed to show the origin of the data (large maps only, smaller maps are of the same providers). The last field is for expert comments. See below for the conceptual High Biomass Bulletin example that can be found on http://CoBiOS.waterinsight.nl :

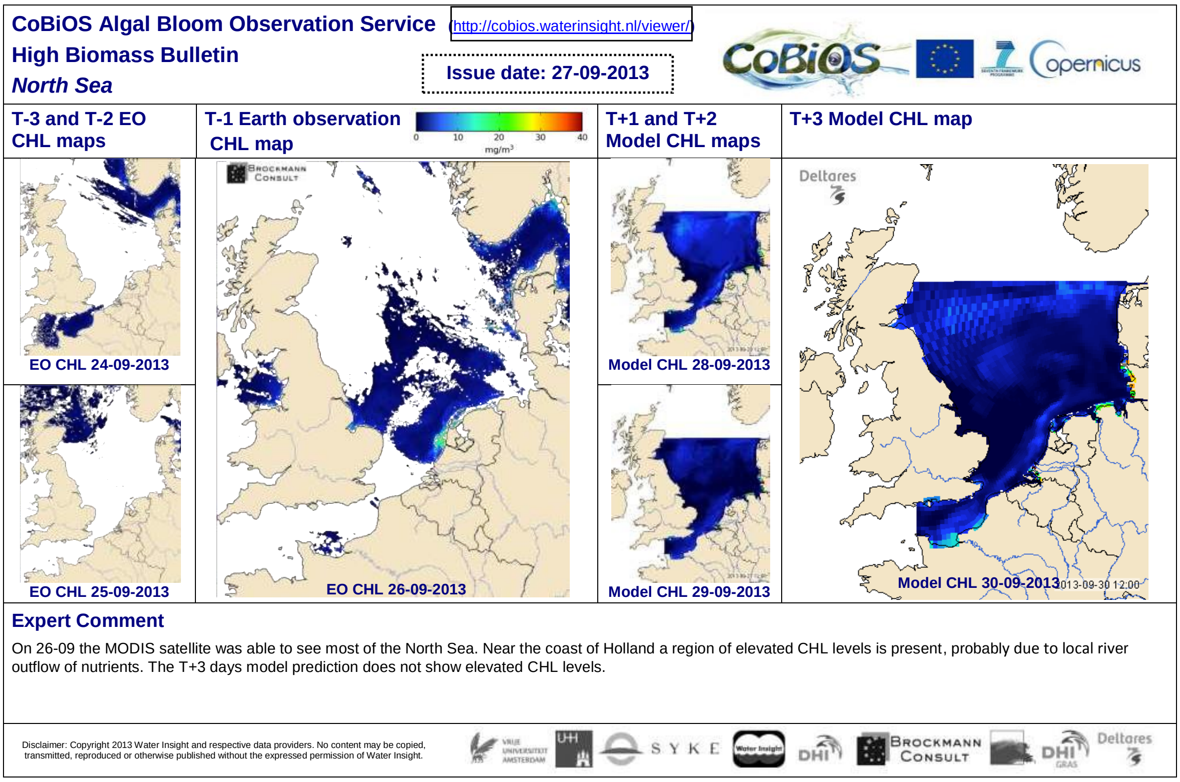


Figure 4.3.1: the example CoBiOS High Biomass Bulletin

For CoBiOS, it was agreed that the key feature of an early warning bulletin would be the expert comments (both explaining the remote sensing product and the model results), requiring at least one important human step in the otherwise completely automated generation.

Animated viewer of side-by-side 7 day maps (animation tool)

In the CoBiOS portal the main window shows a side-by-side view of 2 user-defined maps (http://CoBiOS.waterinsight.nl/viewer/ns). These are preconfigured to show, for the same area and dates, the chlorophyll maps from a model result provider on the left and the chlorophyll maps from a Remote Sensing provider on the right, while slowly scrolling through a 7-day cycle ending with the latest available day. In this way, most users can get the information they are interested in most without a single mouse-click.

Year-to-date parameter map movie tool

In the CoBiOS portal one of the tabs shows the year-to-date animation of daily maps per parameter (http://CoBiOS.waterinsight.nl/animation/, please allow for a substantial loading time). The purpose of the automated movie generator is to generate movies for different areas and partners. The movies are similar with respect to size, frame rate and layout. The automated movie generator takes images and converts them to a movie customs scripts and toolboxes. The images are provided by project partners through an ftp site. The images are then pre-processed to fit a frame template, to account for varying image and logo sizes.

WP4.4: Service trial 1: hindcast with original EO data and models

For the first trial the objectives are to run the models as they are, and to combine the model results with Earth observation products to arrive at a set of recommendations for the second trial and the operational phase. Especially

recommendations have to be provided for the improvement of Earth observation results. It is determined which probabilities and in which form can be derived from modelling experiments and runs.
For decades the marine ecological models have sustained progressive developments and been subjected to increasing complexity. They generate interest at the policy level because of their explanatory potential (budgets, fluxes, dynamics etc.) with regard to eutrophication and subsequent nuisances in coastal areas. More recently, attention has also been addressed to the model forecast capabilities, even if forecast capabilities in ecology remain to be improved. Especially, the scientific community and the decision makers are interested in knowing the uncertainty attached to a model prediction of e.g. chlorophyll *a*. Since ecological model responses to any perturbation are highly non-linear and may vary in wide ranges of possibilities, the model uncertainty may be estimated with a probabilistic approach. A probabilistic “perturbation-response” relationship may be established between the drivers (nutrient loads, wind, model parameters, etc.) and the chlorophyll *a* bloom. In parallel to these model developments, the validation techniques with observations have evolved from visual comparison to statistical comparisons. While models and validation techniques improved, the frequency of in situ sampling did not significantly increase. As a result, the complex ecological models are in need for new validation data. Though in situ observations remain absolutely essential, there is an increasing attention given to the remote sensing data, or Earth Observation (EO) data, as a complementary resource to in situ observations.

The Trial 1 is a large modelling exercise comprising three steps. Firstly, the prediction capabilities of four ecological models have been presented in hindcast to illustrate how they reproduce the dynamics of a chlorophyll *a* bloom. Secondly, the uncertainty attached to the model prediction of chlorophyll *a* has been estimated with an innovative probabilistic approach: the light-guided Monte-Carlo, that suits the high complexity of ecological models. The four modelling institutes have estimated the uncertainty in their model predictions of chlorophyll *a* with respect to the forcings and parameters considered most sensitive in their specific geographic domain. Thirdly, the modelled chlorophyll *a* has been compared to EO observations in order to scale the ecological model responses in time and space, and test its accuracy with regard to previously-studied parameters and forcings. The analysis on the parameters opens pathways for model improvements, and the analysis of the physical forcings illustrates how the model would respond under future changes in physical conditions, like e.g. pluviosity, wind, stratification, sediment transport etc. The failure of ENVISAT at some point to deliver MERIS data resulted in several adaptations in the different institutes, and more resources have been allocated to the estimate of model uncertainties than to the comparison with EO observations.

Model results illustrate the seasonal and short-time impacts of a forcing – or parameter – perturbation on the chlorophyll *a* dynamics. Regarding the Belgian model, 3D-MIRO&CO, it is concluded that an accumulation of small wind perturbations will largely affect chlorophyll *a* distribution at the spring bloom and thereafter, as the wind-driven advection of chlorophyll *a* and dissolved nutrients modifies the spatial distribution of the bloom. In contrast, any variation in the parameter cell lysis has a higher potential effect before and during the spring bloom. In order to improve 3D-MIRO&CO chlorophyll *a* predictions and achieve better spring biomass bloom intensities, it is concluded that one should first decrease the model parameter ‘phytoplankton cell lysis’ (mortality). Regarding the German model, ECOHAM, the perturbation of the riverine nutrient loads shows a larger impact at the coastal stations than at the offshore stations. This is probably a conclusion that remains valid in other eutrophied, shallow and river-enriched domains. The perturbations in river loads intensity tend to impact the duration of the chlorophyll *a* bloom more than its intensity. And a shift in the timing of the river loads will affect more the timing of the chlorophyll *a* bloom than its intensity. In essence, any perturbation of the riverine nutrient loads will first affect the timing and duration of the bloom before affecting the bloom intensity. Regarding the Dutch model, BLOOM, it is concluded that efforts should be spent on improving the modelled timing of the phytoplankton bloom through the use of the Kd and/or SPM EO data. This should improve the modelled daily to seasonal responses to light availability, and thus the timing of the bloom. Regarding the Danish model, MIKE3FM ECO Lab, it is concluded that wind is an important factor for the stratification of the Baltic Sea and the interconnecting seas, which then again is the most important external factor influencing the onset of the spring phytoplankton bloom. However, the year-to-year variability in the onset seems much larger than can be explained by minor correction to the wind fields. Hence, the long-term wind variations are more important than potential uncertainties. Internal parameters in the biogeochemical model have a significant impact on the onset and the abundance of the spring bloom, and further investigation is planned in Trial 2 to estimate the resulting uncertainty.

Probably EO Chl algorithms still need refinements, especially in turbid waters where the detection of chlorophyll *a* is more difficult. Yet, the available images already deliver a new information about the complexity of the chlorophyll *a* blooms, i.e. a high temporal variability during the spring bloom probably depicting rapid species successions, and a high degree of spatial patchiness. These features shown in EO data should be deeper studied and carefully validated as they result from processes still not understood. It is possible that the future phytoplankton models may benefit from these newly-observed features in some ways.

WP4.5: Service trial 2: hindcast with improved EO-data and models

It was decided by the consortium to switch to MODIS for the trial 2 but first we wanted to get confidence in our results. Especially the mapping of Chl-a in turbid waters with MODIS was rather uncharted territory for the partners. It did not make sense for the modelling partners to use MERIS results for trial 2. The need to switch to MODIS information as source for EO data forced the EO data provider of each service line to adopt new algorithms in order to provide high quality maps of TSM and Chl-a distributions. Based on this EO information the North Sea and the Baltic Sea service line used different approaches. The DHI modelling group made a number of independent simulations, which were then compared against Chl-a information both from SYKE and GRAS. All partners in the North Sea service line followed the approach to generate gap-filled Chl-a maps for direct delivery to the portal and daily gap-filled TSM distributions for further use within the ecosystem models. The later use of gap-filled TSM distributions put further demand on the TSM product, since the models require daily information starting with the first day of simulation. Therefore the TSM fields had to be gap-filled in space and time in order to serve as an adequate forcing for the ecosystem models.
Despite some time delay all model application in the North Sea service line followed the approach to implement gap-filled TSM maps for further use within the ecosystem models. First MUMM could benefit from the implementation of the TSM fields and conclude that the model is consistent and that any prediction three days ahead is obviously sufficiently constrained, even under changing hydrodynamical conditions. UHAM and Deltares models had to deal with differences in the models response between offshore and coastal regions.

The following figures (Fig. 4.5.1 and 4.5.2) represent the validation work by Deltares for 2 coastal station, the station Walcheren 2 km and the station Terschelling 4 km

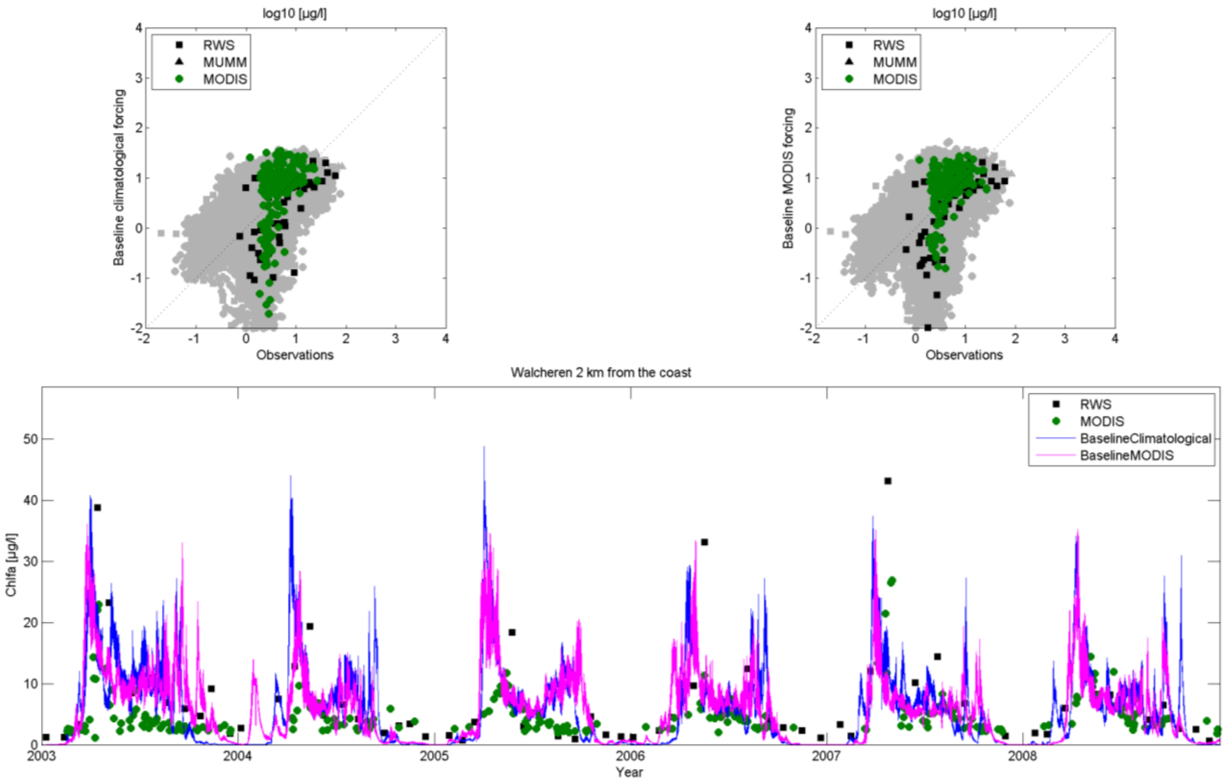


Figure 4.5.1: Chlorophyll-a values hindcasted at the stations Walcheren 2 km

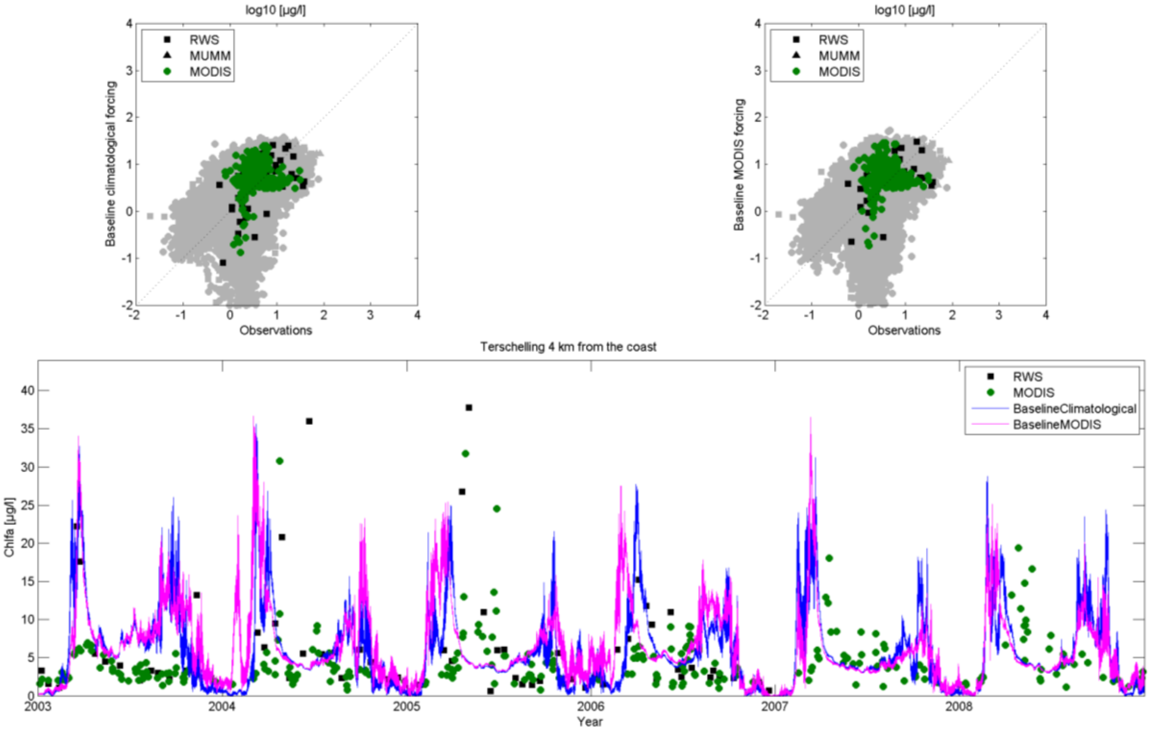


Figure 4.5.2: Chlorophyll-a values hindcasted at the station Terschelling 4.

It is clear from both figures that EO TSM driving forces, are having a positive effect on the start of the bloom and the maximum concentration of the bloom. From the figures it is also clear that the hind cast is not underestimating nor overestimating the concentration compared to the in-situ (ground truth) measurements except at low concentration noisy results is observed from the model results, smoothing of the EO-TSM is thus suggested by taking less modes in the DINOEF gap-filling procedure.

After model calibration, the model output has been plotted against all in-situ in comparison to the scatter plot for the year 2007 as first validation on the performance of the calibrated model compared with the model driven by EO TSM

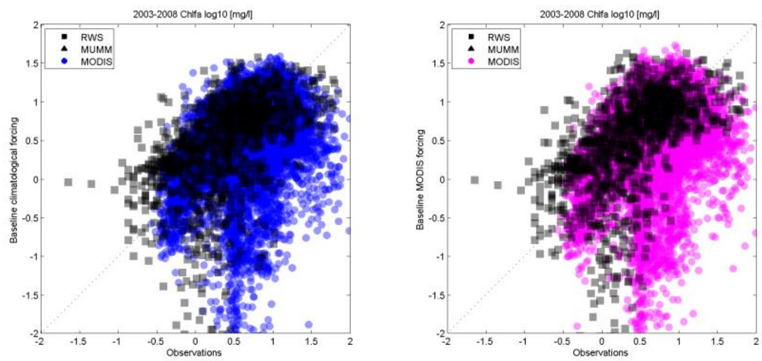


Figure 4.5.3: Scatter plot of Chla model against different types of observations. Left column shows the model results due to climatological TSM climatology, while the right column is the model results due to EO TSM driving forces. The in-situ chla observations are given in black and those of MODIS are given magenta (right) and blue(left).

From the figure 4.5.3, it is clear that the model performance has been improved mainly at high concentrations in comparison to the in situ measurements (black dots). It also indicates that the model underestimates the concentration at low concentrations.

The DHI modeling group used a different approach for the Baltic by the application of a number of independent ensemble simulation, which were than compared against Chl-a information both from SYKE and GRAS. The ensemble member with closest match to the remote sensed EO data is selected as the most reliable simulation of the status of the sea. Additional sensitivity test have also identified a number of internal model parameter determinant for the model output which supports reliable forecast.

Fig. 4.5.4 represents the work by DHI for the validation exercise for a measuring site within the Danish Baltic Sea Water. In this figure it can be seen that the model is in fact adjusted away from the in-situ data during the spring bloom.

The lack of an apparent improvement in the DHI model fit when EO data is taken into account is rather surprising, one could argue that if the model had a very good starting point, it would be difficult to improve the fit, but this is clearly not the case here. In order for the model to be improved by taking EO data into account it is obvious that EO data, when available, must have a higher accuracy than the model, otherwise it would not be worthwhile taking them into account. Thus an explanation for the lack of improvement is simply that EO data is not more accurate than the model.

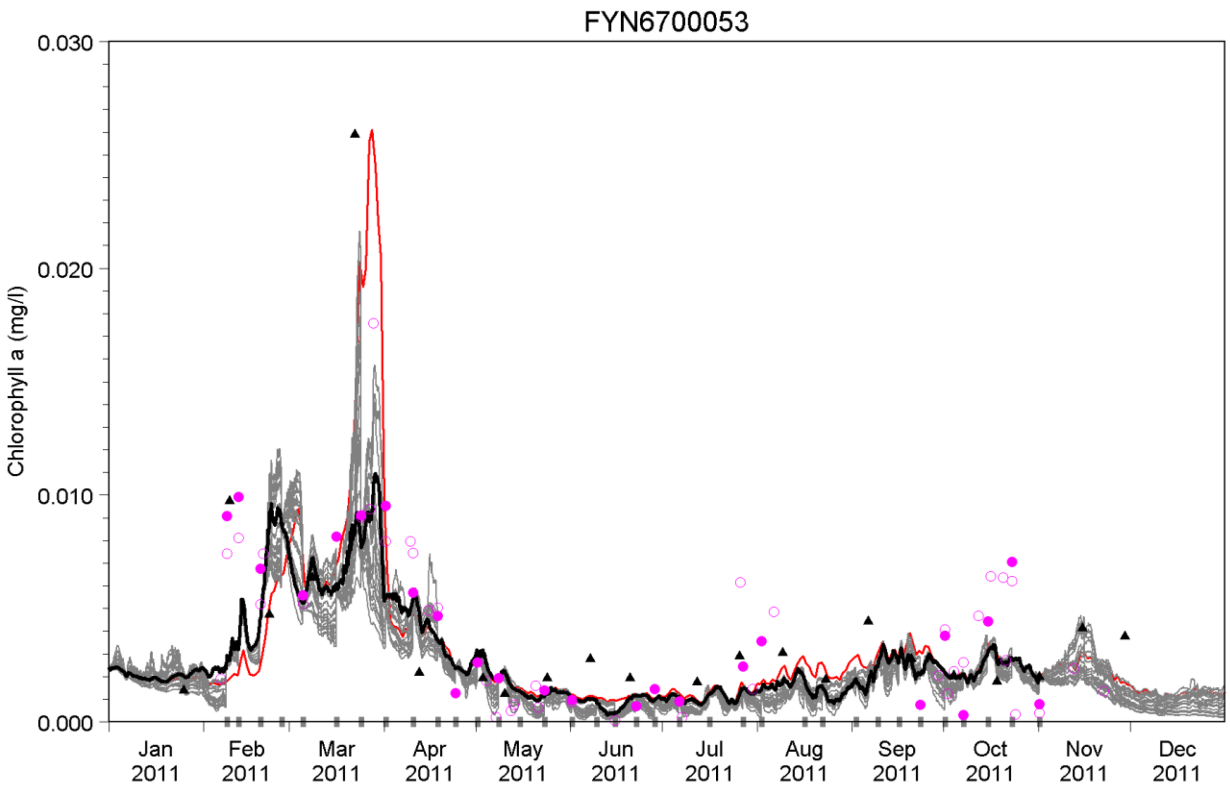


Figure 4.5.4: Time series at station FYN6700053 located in the Great Belt of the Baltic Sea, showing the DHI CoBiOS "baseline model" (red line) and the "filtered ensemble model" (applying EO-CHL data, black line). The grey lines show the individual ensemble members. In-situ measurements are shown as black triangles. EO data are shown as circles.

In essence model and the EO chlorophyll *a* product bring complementary information but do not always compare well. The comparison between model and EO derived chl-a requires the same level of spatial or temporal aggregation. This underlines the necessity of more data sources involving both model and EO data, e.g. like Ferrybox data supplementing traditional ship-bourne monitoring.

WP5: Validation of products and services

WP5.1: Implementation validation board + protocols

The validation of the service trials shall (1) consolidate the validation protocol, (2) prepare and test the routine validation activities performed during continuous operation of the service and (3) establish basic quality figures of the services. A spin-off of this activity is to better familiarize the user with the service by closely involve him in the validation activities. Finally this WP shall also prepare the future evolution of the service.

In the D5.1 the validation protocol has been consolidated. Especially the statistical methods, which have been described and proposed for the oncoming validations, were applied and assessed in practice. Outcomes of these assessments have been documented in deliverable 3.5 “Document describing methods for cross comparison o EO-data models”. This feedback as well as feedback from modellers will be included in the validation protocol.

The product validation of the four service lines has been defined. Methods to be applied in the validation comprise the following subjective and objective methods and plots:

Statistical measures

- Geometric mean, no log-transform, remove outliers
- Model Efficiency, Percentage Model Bias
- Pattern Statistics (R, σ*, RMSD’)

Statistical plots

- Illustration of the results in map plots
- Histograms or five number summaries presenting outliers
- XY scatter plots (R, R2, slope, intercept)
- Time series: Simple time series plots shall be supplemented by either cumulative plots or by bars with error bars representing monthly mean +- standard deviation
- Target diagram (RMSD’, B*, RMSD*) in situ points/validation sits

A central point of discussion was the spatial and temporal resolution to be used for the validation. Model results will provide 3 days prognoses for OSPAR and HELCOM areas. The validation will be based on time series for these areas. As a method for outlier detection, the inter-quartile range will be considered. Values will be considered as outliers, if they are n * IQRs above the third quartile or n * IQR below the 3rd quartile, where IQR (Inter-quartile range) = third quartile – first quartile. The value for n should be greater than 1.5, but the final value still has to be defined. Outliers shall be illustrated in scatter plots. Histograms or five number summaries are needed in addition (Min, P25, P50, P75, Max). Since calculations shall be performed on a linear scale, the usage of the geometric mean shall compensate the fact, that the values are not normally distributed. The geometric mean thus is used as a measure for the mean of the logarithmic values.

WP5.2: yearly update user requirements & SLAs

The objectives of this task are to regularly update the user views on CoBiOS services and products. During the transition time between MERIS and MODIS it was inconvenient for the users to be kept informed about discontinuities and possible devaluation of our services, before we had formed our own opinion about that. As a result, at the CoBiOS meeting at 2 September 2013 it was decided to not ask the users to sign the SLA for the short remainder of the project, but instead ask them if they are interesting in continuation of the CoBiOS service after the end of the project, and if they would be willing to pay for such a service. This was expected to lead to better results for the project and a good starting point for the commercial service. The template SLA version 1.0 as has been created in WP5.2 will serve as starting point for the SLAs for the commercial operational service. A user questionnaire has been set up, asking the

Users their opinions on all aspects of the CoBiOS service. At the final meeting a thorough evaluation with the users was carried out.

Summarizing the results of the user requirements, it can be concluded that the users appreciated the CoBiOS service as is. Most users were interested in continuation of the service after the end of the project (in the questionnaire, 7 answered to be interested, 0 answered to be not interested) and some of them indicate to be also interested in a commercial service (4 answered to be interested in a commercial service, 1 answered not to).

The inclusion of other parameters such as the sea surface temperature was already listed in the initial user requirements, but as this was out of the scope of the project and there was no extra time due to the loss on Envisat, such extra products have not been included in the portal. However, from the evaluation it becomes clear again that users are interested in a tailor-made portal with other parameters such as temperature, salinity and Secchi depth. Also tailor-made tools like automatic zooming to the region of interest are interesting for the users.

From the final meeting with the user the point was taken that the way forward is to aim at parameters that are valuable as indicators for processes such as eutrophication for e.g. HELCOM and OSAPAR. Also, it is requested to allow users to include the data in assessments or reporting. In that case documentation on how the data is obtained is required. Based on these results, it was decided to keep to CoBiOS portal one year longer (after the closure of the project) up and running, to allow improvements and tailor-made services to be set up for commercial services.

WP5.3 & 5.7 Validation of EO products & Outlook to future sensors

The validation results of Chl-a, turbidity/TSM and K_d(PAR)_products collected during the project were collected in the D5.3 & 5.7 document, providing an overview of the performance that may be expected in the EO product provision in each service line. Validation efforts covered both MODIS and MERIS instruments using several years of *in situ* validation data. The validation for each parameter and instrument was performed whenever relevant reference data was available for each region. The validation data are presented with consistent statistical measures, regression plots, boxplot and frequency histograms. Time series for monitoring station locations and spatially aggregated comparisons against ferrybox transect data are also presented because such trends are of particular interest in the detection of phytoplankton blooms. In addition, a limited number of products were compared between MERIS, MODIS and the more recent VIIRS instrument.

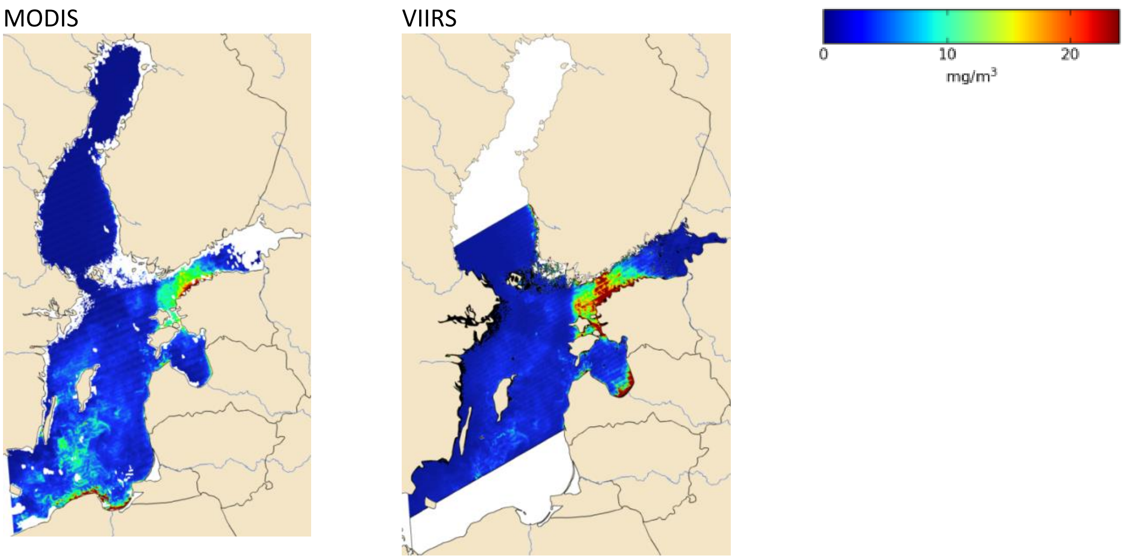


Figure 5.3.1 Comparison of MODIS and VIIRS derived Chl-a products on 7 July 2013.

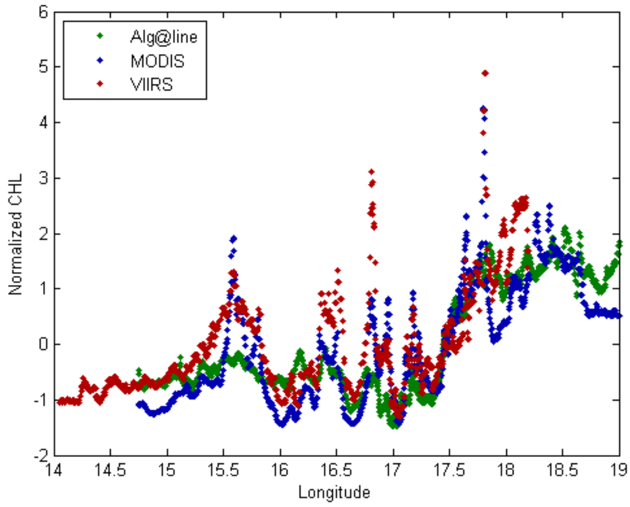


Figure 5.3.2 MODIS, VIIRS and Alg@line results along the MS Finnmaid transect on 7 July 2013. The comparison is presented as normalized Chl-a for the southern part of Baltic sea .

A complete overview of relevant polar orbiting (such as MERIS, MODIS and their follow-ons) and geostationary sensors based on the WMO OSCAR database1 was provided in the deliverable report. The work resulted in a ranking of current and future sensors for ocean colour applications. Considerations for this ranking were (1) the spectral capabilities of EO missions, (2) the bandwidth of each channel in the visible and near-infrared (narrow bands are more suitable), and (3) additional functionality or performance offered, such as polarisation, multi-angle viewing, and the radiometric resolution. The spatial resolution was not taken into account in this cross-cutting analysis.

Rank	Description	Sensors	CoBiOS perspective
1	High performance, open/coastal waters	SGLI, MODIS, (GLI)	Narrow bandwidth, accurate atmospheric correction for aerosol and semi-transparent clouds support coastal water applications. A 709-nm channel is lacking.
2	Good performance in open and coastal waters	OLCI, (MERIS)	A 709-nm channel and high radiometric accuracy support higher accuracy in coastal water applications.
3	Good performance in open waters	COCTS, OCS, OCM-3 OES, MERSI-1, MERSI-2, VIIRS, (CZCS, OSMI, SeaWiFS, OCM-1, OCM-2, OCTS,MOS)	Bright targets (high concentrations of suspended sediments, surfacing or high biomass phytoplankton bloom) can be detected but not adequately quantified.
4	Useful performance in open waters	3MI, APS-NG (Trasser, POLDER)	Polarisation and bidirectional reflectance measurements with very low ground resolution (4 km or more); these resolutions could be compared with data available from geostationary orbit (e.g. SEVIRI)

Table 5.3.1. Ranking of suitability of ocean colour satellite sensors by WMO OSCAR system with comments on CoBiOS perspective. Past sensors in parentheses.

[1] http://www.wmo-sat.info/oscar

As expected, ENVISAT MERIS was found to be the most suitable instrument for the varied spectrum of coastal waters in CoBiOS. The capacity of satellite observations matching the quality of MERIS is limited until Sentinel-3 OLCI instrument becomes available. In all cases, the quality of the sensor must be matched with a suitable algorithm to interpret the radiance data in terms of the products delivered to the CoBiOS ecosystem models. In the more turbid range of waters, sensors with reduced spectral bands or band resolution can outperform the 'MERIS' type sensors.

At present, the CoBiOS service lines provide the ecosystem models with Chl-a products derived from MODIS, optimized for each service area. From the more limited waveband characteristics of MODIS compared to MERIS it should be expected that separating Chl-a presents more difficulties than with the extended functionality of MERIS. Indeed, depending on the area of study, the low concentration range can be affected by considerable scatter when comparing *in situ* against EO results. The upcoming OLCI sensor will allow the use of algorithms for Chl-a similar to MERIS but with higher radiometric resolution which may provide particularly useful in clear and dark waters (e.g. the Baltic Sea). Before OLCI operations start and if MODIS delivery should falter, the immediate fall-back option scenario includes the use of VIIRS.

In CoBiOS, the North Sea models rely heavily on a characterization of TSM as the primary influence on the underwater light climate. In the Baltic Sea, the light climate is strongly determined by dissolved matter whereas the particle population is dominated by phytoplankton, particularly in the seasons prone to exhibit blooms, except in shallow areas (including the Danish waters) and near rivers. The demonstrated products for TSM or Turbidity showed good or at least adequate performance for their roles in CoBiOS using both MERIS and MODIS sensors. We may therefore conclude that future sensors adhering to a minimum specification of MODIS will support the service. Radiometric accuracy is not a limiting factor for OLCI. Therefore, TSM observations will remain available in the foreseeable future. The nominal noise characteristics of VIIRS are not the most suitable for ocean colour observations, but an adequate TSM observations can likely be obtained.

Producing spectral K_d or K_d(PAR) from EO sources is in theory less challenging than deriving any of the traditional optical products (Chl-a, CDOM, and TSM). The difference lies mainly in the fact that K_d is a function of the bulk absorption and (back)scattering properties, thus needing no interpretation of the contribution of individual water constituents to the remotely sensed reflectance. We may expect that differences in the quality of retrieved K_d from different sensors will be smaller than those for individual water constituents, provided that a retrieval algorithm for the inherent optical properties can be adequately formulated.

In summary of these considerations, it seems likely that MODIS, VIIRS and/or OLCI will be the main sources of earth observation data for COBIOS-style services over the next five years.

WP5.4: Validation of model results and probabilities

The CoBiOS forecast system was designed to generate Chl-a forecast for the spring bloom in 2013. But because of the need to switch to MODIS information as source for EO data new algorithms had to be adopted in order to provide maps of TSM and Chl-a distributions. Despite some time delay all model application in the North Sea service line followed the approach to implement gap-filled TSM maps for further use within the ecosystem models.

MUMM could benefit from the implementation of the TSM fields and conclude that the model is consistent and that any prediction three days ahead is obviously sufficiently constrained, even under changing hydrodynamical conditions.

In Fig. 5.4.1. MUMM presents a spatial comparison between model and EO chl-a for the North Sea.

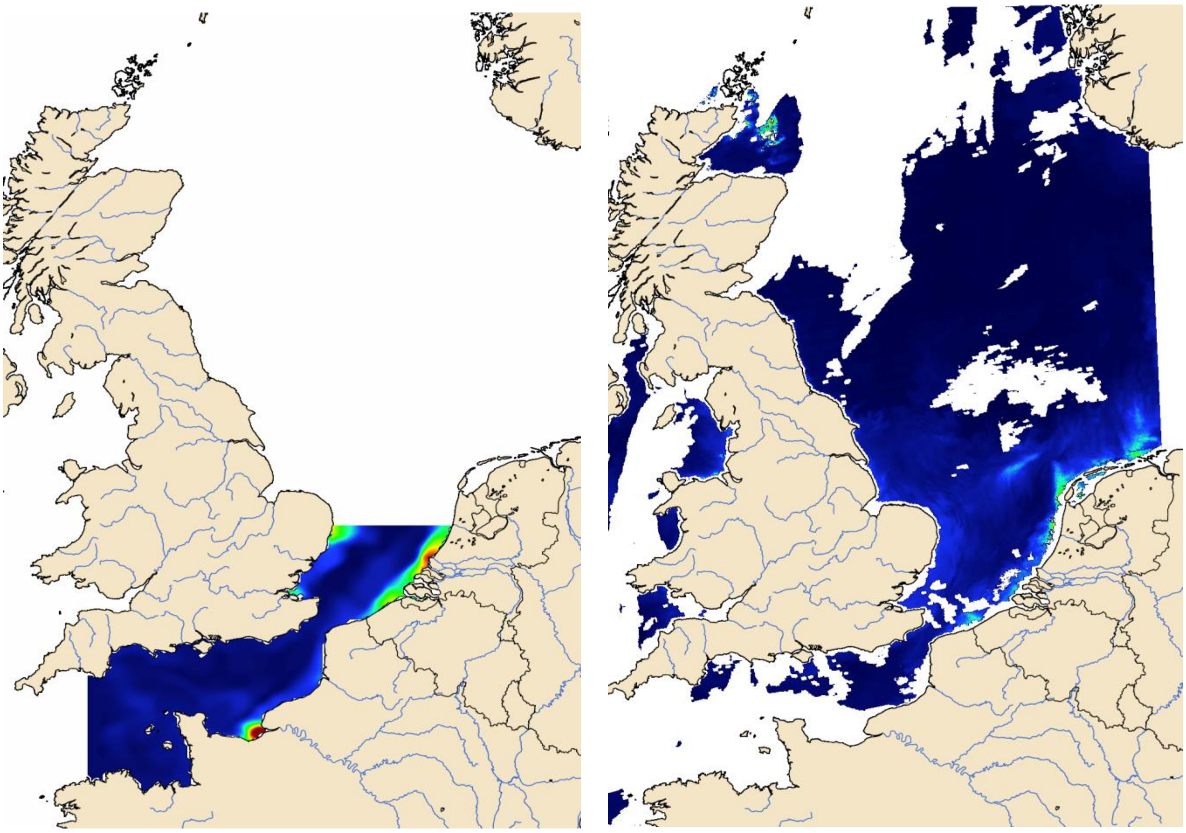


Figure 5.4.1: MO CHL (left) and EO CHL (right) maps on the 26th of August 2013 in the North Sea.

The comparison of CHL maps illustrates one of the major differences between EO and MO products, i.e. the spatial homogeneity of model results versus the spatial heterogeneity of EO products. In model results, the CHL follows a gradient between the river mouths, which are sources of nutrients, and the offshore. In EO products, the CHL exhibits a succession of patches in the coastal zone towards the offshore (see the detail of patches along the NL coast). The question arises whether these patches result from hydrodynamical or biological processes. In any case, the differences between MO and EO CHL brings complementary information. It also implies that any accurate comparison between MO and EO CHL will remain difficult in essence, and spatial or temporal aggregation may be required.

In addition, a comparison is presented in 2013 between MO and EO CHL time series in the Belgian OSPAR boxes, including their respective spatial variability in the boxes (Fig. 5.4.2). The median signals of MO and EO CHL are quite comparable in both Belgian OSPAR boxes, BC1 (coastal) and BO1 (offshore). The timing of the spring biomass bloom is quite well reproduced by the model even though the intensity of the modelled spring bloom is not as high as the one observed by remote sensing. The quality of the nowcast model prediction is quite remarkable when considering the fact that most forcings to the ecological model were taken from climatological time series. Essentially, only the hydrodynamics (resulting from wind, SST, pressure etc.) is based on 2013 forcings. This supports the idea that hydrodynamics plays a major role in controlling phytoplankton production in the English Channel and the Southern Bight of the North Sea. That information is encouraging for the development of operational forecasting systems of phytoplankton blooms.

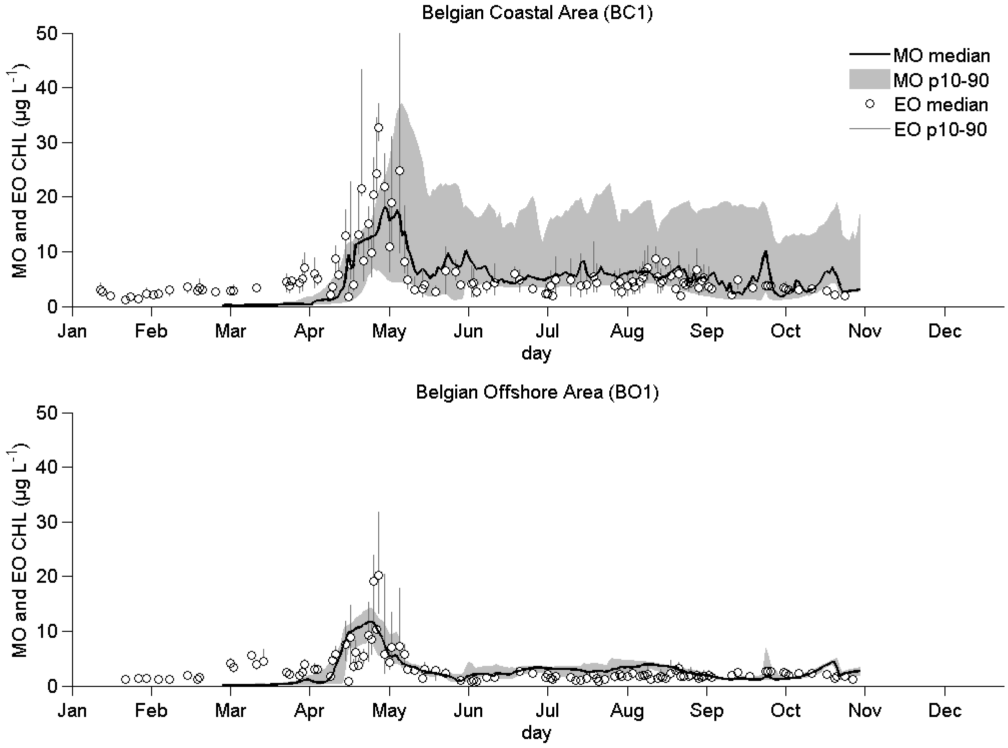


Figure 5.4.2: MO CHL and EO CHL time series in the year 2013 aggregated into OSPAR boxes BC1 (coastal) and BO1 (offshore). The median and the p10-p90 respectively illustrate the central tendency and the spatial variability in the OSPAR boxes.

The DHI modelling group used a different approach for the Baltic by the application of a number of independent ensemble simulation, which were than compared against Chl-a information both from SYKE and GRAS. The ensemble member with closest match to the remote sensed EO data is selected as the most reliable simulation of the status of the sea. Additional sensitivity test have also identified a number of internal model parameter determinant for the model output which supports reliable forecast.

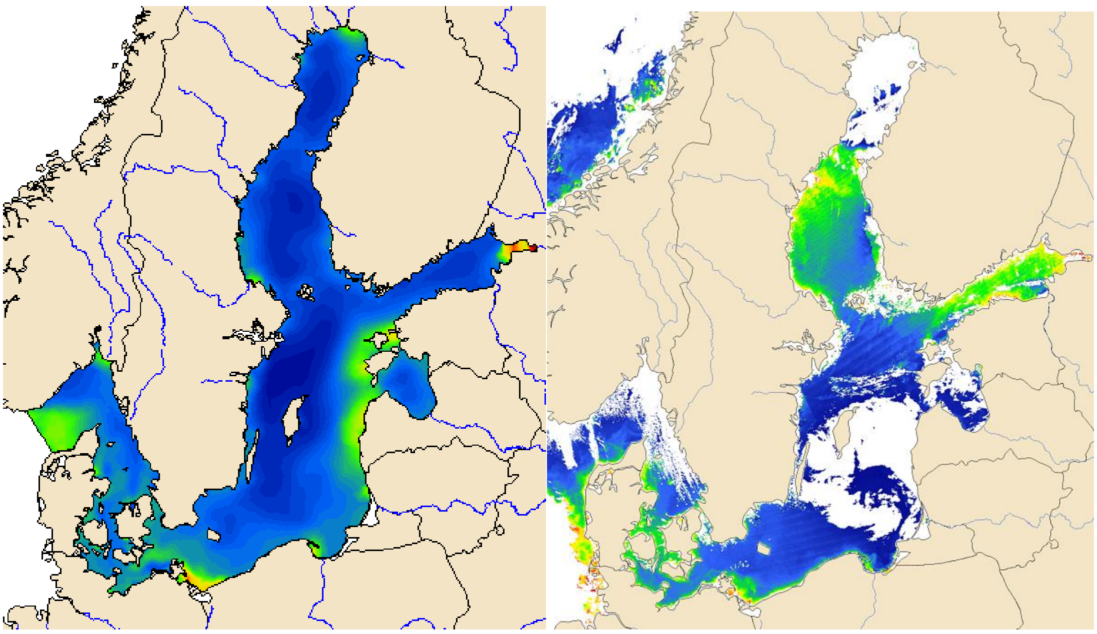


Figure 5.4.3: MO CHL (left) and EO CHL (right) maps on the 3rd of October 2013 in the Baltic Sea. Blue colours identify areas with 0-3 ug chl-a/l and the green areas with 3-6 ug chl-a/l.

Figure 5.4.3 gives a comparison of model and EO derived chlorophyll based on data from 3rd October 2013 for the Baltic Sea. This spatial comparison between model and EO revealed several interesting features. Both model and EO had elevated levels of chlorophyll in some coastal areas, especially near river mouths with high nutrient input, as well as lower levels in the central Baltic Sea. It was also apparent that the EO showed more small-scale features, such as fronts. The model was less patchy and exhibited a more gradual change in chlorophyll levels from coast to off-shore. In conclusion the two products shows the same overall patterns but with difference in the details.

DHI has implemented a Monte Carlo Ensemble where a number of ensemble members (20) are run simultaneously giving the basis for estimates of nowcast (T, becoming hindcast) and 3 days forecasts (T3+).

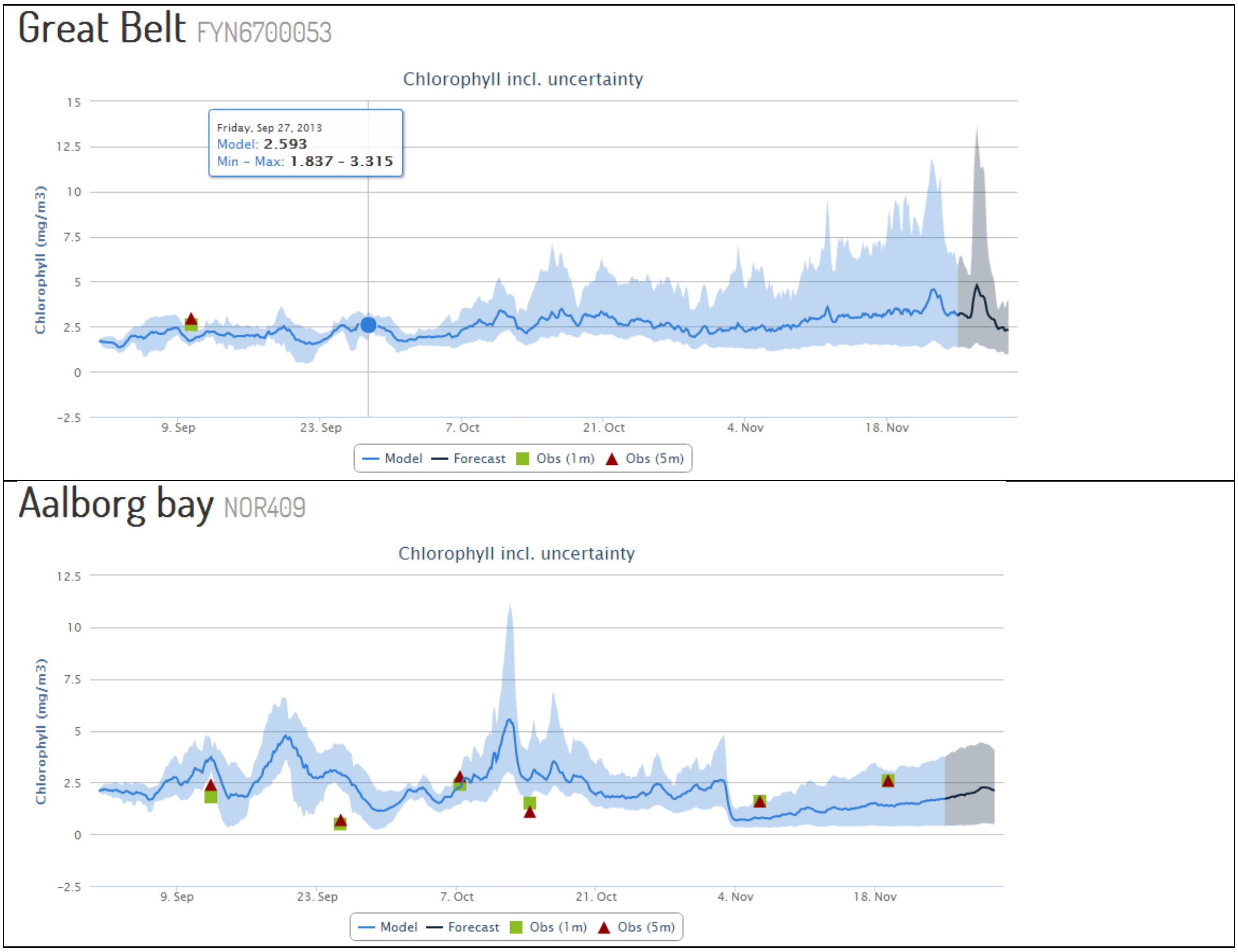


Figure 5.4.4. :Example of the ensemble forecast. (Top figure) is forecast results from Great Belt, and (bottom figure) is forecast results from Kattegat. Light blue shaded area indicates the probability of the single forecast and the dots (green and brown) indicates observations from the national monitoring program. Ensemble modelling is included in the dedicated Baltic Sea web service (www.baltic.waterforecast.com)

Figure 5.4.4 indicates that within a short timeframe such as the T+3days forecast periods, small changes in the physical forcings do not result in large changes in the model results. A changed wind field may displace the timing by some days but only after being forced over several weeks.

In essence for WP5.4 the model and the EO chlorophyll *a* product bring complementary information but do not always compare well. The comparison between model and EO derived chl-a requires the same level of spatial or temporal aggregation. This underlines the necessity of more data sources involving both model and EO data, e.g. like Ferrybox data supplementing traditional ship-bourne monitoring.

WP5.5 Validation of service performance

As part of the comprehensive validation activities performed within the CoBiOS project, the overall performance of the delivered service(s) had to be evaluated and assessed. This action completes the general validation process which mainly comprises four steps:

- Earth observation data validation (work performed within WP 5.3 and described in detail in deliverable 5.3)
- Model validation (work performed within WP 4.5 and described in detail in deliverable 4.5)
- Product validation (work performed within WP 5.4 and described in detail in deliverable 5.4)
- Service performance validation (work performed within WP 5.5 and WP6.2 and described in detail in deliverables 5.5 / 6.2 + 6.3)

The service providers with support of the users have performed the service validation activities; the users were involved in the validation steps, which included a comparison with in-situ data. Service performance in the context of the tasks of WP 5.5/6.2 is defined as the reliability of the service delivery of CoBiOS partners to the CoBiOS portal. The overall performance has to fulfil certain user requirements and thus significantly determines the user acceptance. It is defined by several characteristics, e. g. availability and timeliness of the service and depends on a variety of factors such as availability of input data, technical concept and the implemented processing chain. Each service provider specified the respective characteristics of his service line and the risks that may occur and finally the users were interviewed in order to receive their feedback to the services and validation results. The service performance has been collected from all service lines and an overall assessment has been performed. The results and the assessment of the operational service via the portal are described in detail in deliverable D55/6.2+6.3 which compiles results of all 4 service lines performance assessment (WP5.5), the operational performance assessment (portal delivery and service to users, WP6.2), users feedback on each service line and in general on the CoBiOS service, as well as an assessment on the MyOcean products used during the CoBiOS project (D6.3).

Service performance in terms of completeness of products as well as time, frequency and reliability of product delivery and service availability has been assessed for each service line during service trial 2 and the operational phase of the CoBiOS portal. The periods of product delivery for each service line are listed in 5.5.1. The frequency of successful product delivery has been evaluated on the web server as illustrated in Fig. 5.5.1. Generally, a daily frequency has been achieved. As depicted in the time series plot, four significant gaps ranging between 7 and 14 days occurred. At the beginning of August, a change in hardware (firewall) resulted in a download problem lasting approximately 7 days (BC). For the SYKE service, during August, a gap in delivery occurred due to updating the Chl-a algorithm and the atmospheric correction procedure.

In October the shutdown of the US administration resulted in a 14 days lasting breakdown of MODIS data provision. This gap has not been filled by all service providers afterwards, as the portal does not present products which are more than 3 days old.

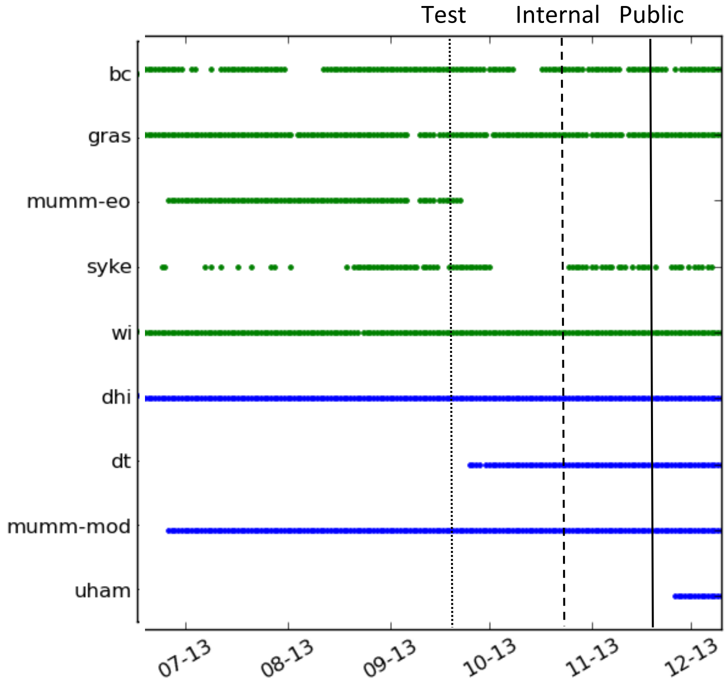


Figure 5.5.1: CoBiOS services: Frequency of product delivery for all earth observation service providers (green) and ecological modelling groups (blue). Each image is marked as a single dot. Vertical lines indicate the start of the upload test phase in September (dotted line), the internal usage of the portal in October (dashed line) and the start of the public CoBiOS portal in November (solid line).

As a matter of fact, the plot is a bit misleading as it does not differentiate between products, which have been provided in NRT and those which were uploaded with a significant delay and thus did not show up in the portal at all.

Service line	Chl EO products	Kd_{par} EO products	Chl Model products	Kd_{par} model products
Service line 1 (Gras-SYKE / DHI)	Since Jun 2013	Since Jun 2013	Since Jan 2013	Since Jan 2013
Service line 2 (BC / UHAM)	Since Jan 2013	-	Since Jul 2013	-
Service line 3 (RBINS)	July – Sep 2013	-	Since Jul 2013	-
Service line 4 (WI / Deltares)	Since Jan 2013	-	Since Oct 2013	-

Table 5.5.1: Period of service delivery for all products provided via the CoBiOS portal.

Step	Gras / DHI	SYKE / DHI	BC / UHAM	RBINS	WI/Deltares
Download time since availability	< 15 min	< 12 h (i. e. image from 12:00 h is downloaded at midnight)	After 48 h	6:00 h every day	< 15 min
Download	10 min	10 min		Few minutes	2 min
Processing for EO products	15		2 h	1 hour	5 min
Composite creation	15 min (at 21:00 h)			none	n. a.
Processing for modelling			10 h	Few minutes	3 h
Modelling	6 h		4 h (starting at 8:00 h)	6 to 12 hours	
Upload and online presentation	5 – 10 min	Until 12:00 h of the following working day	5 – 10 min	5 – 10 min	5 – 10 min
Total time EO	6 to 8 h	< 24 h (i. e. an images from 6:00 h will become available next day at 12:00 h)	48 h + 2 h 10 min (48 + 10 h for modelling)	1 hour	32 min
Time of EO product delivery	After 21:00 h	12:00 h next day	12:00 h (2nd or 3rd day)	12:00 h next day	As soon as product is available
Total time Model	6.5 to 8.5 h	< 24 h	4 h 10 min (+ 10 h EO)	6 to 12 hours	3 h
Time of model product delivery	Approx. 21:00 h	12:00 h next day	12:00 h next day	18:00 h same day	Latest 18:30 h same day

Table 5.5.2: CoBiOS service lines: Duration of the total processing chain for input of EO data to the ecological model.

Table 5.5.3 summarizes the main service performance characteristics of the service lines as presented in chapter 3. Summarizing, the duration of the processing is mainly determined by the following constraints:

1. A higher completeness can be achieved by downloading MODIS data for a certain day with a delay of 48 hours.
2. Certain steps, e.g. a final check of the products, require manual work and thus depend on regular working hours.
3. The availability of meteorological forecast data limits the forecast period of the models.

Conclusively, the duration of the processing does not depend on technological limitations of the processing chains or services, but on quality constraints (bullet 1 and 2) and external factors (see bullet 3).

Characteristic	EO service	Model service
Duration of processing	0.5 - 50 h after satellite overpass (Ferrybox data are available after 24 h)	3 – 8.5 h (14 h including EO processing)
Time of product provision	Shortly after 21:00 h same day to 12:00 h next day	Shortly after 18:00 h same day to 12:00 h next day
Frequency of service delivery	Daily	Daily to twice daily
Reliability	Mainly depending on external factors, such as availability of input data.	
Completeness of the products	Completeness of EO data depends on external factors, such as cloud coverage.	Model forecast depends on availability of daily weather data and forecasts
Availability of user support	5 days per week during working hours; 7 days including evenings for dedicated service provider web services	
Alert systems in case of failures	Automatic e-mail notification about failures. In case of download failure downloads have to be made manually.	Automatic e-mail notification about failures. If EO data are not available, Deltares uses an SPM climatology can be used as fallback option.

Table 5.5.3: CoBiOS service lines: Summary of the main performance characteristics.

WP5.6: Socio-economic impact assessment

Since the WP5.6 could only be executed at the point in the project where tangible results could be shared with users, the methodology that we used had to differ to some extent from the proposed GEOBENE methodology. Based on existing GEOBENE publications and questionnaires, we decided to make an inventory of:
-Who are the stakeholders
-What the historic occurrence is of harmful algae bloom events in our area and worldwide

-Some figures of costs damages of Harmful algae bloom events
-Possible management strategies / mitigation options
-Monitoring and forecasting strategies
Based on these insights an (on-line) questionnaire was formulated and sent to a selection of key users. The replies were collected, analysed and discussed with the users and the project team during the final meeting of the project.

The CoBiOS project has produced an information service (CoBiOS.waterinsight.nl) that shows the measured (by satellite) and predicted (by modelling) concentration of **Chlorophyll-a**. This pigment is a direct proxy for the amount of algal biomass and the degree of eutrophication. The information is of relevance to many users at different levels.

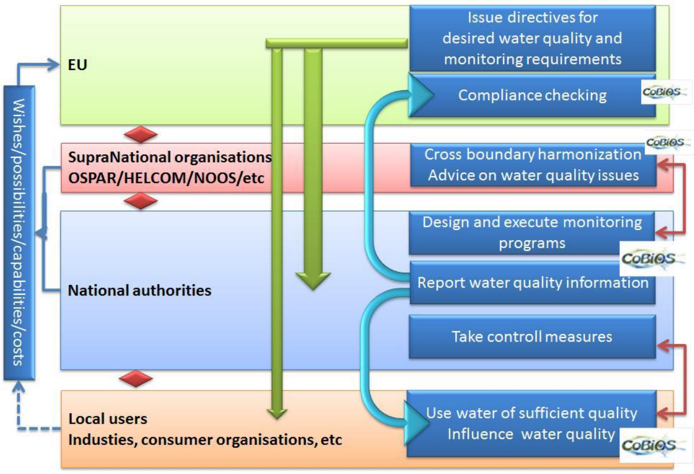


Fig. 5.6.1: Stakeholder overview

The figure above shows a simplified model of user levels and main tasks/activities related to water quality and interactions. By means of the CoBiOS logo it is indicated where we perceive a potential contribution of the CoBiOS information system to the activities of users. In our simplified model we assume that national authorities have the main task in collecting water quality information and disseminating this information to the EU (for compliance checking with EU-directives) and to local water users.

Stakeholder analysis:

EU directives: Marine Strategy Framework Directive (MSFD) and Water Framework Directive (WFD).

Marine Strategy Framework Directive

The MSFD aims to reach Good Environmental Status of the EU's marine waters by 2020 and to protect the main resources that are responsible of the marine related economic and social activities (European Comission, 2012). The MSFD also defines the list of characteristics of the monitoring programmes and programmes of measures for the member states (annex V and VI respectively) as well as the qualitative descriptors for determining good environmental status (annex I) (EC, 2008).

Water Framework Directive

The WFD is closely related to the MSFD. It sets the objective of reaching Good Status for all EU ground and surface waters, including coastal waters, by 2015, complementing the objective of reaching Good Environmental Status under the Marine Directive. Under article 2 of the WFD the areas covered by this directive are defined: surface, waters, ground waters, lakes, rivers, transitional water, inland water and coastal waters. Coastal waters since are closely related to marine waters, are defined as: ¨means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters¨ (EC, 2000).

Supranational level: HELCOM, OSPAR, EEA and NOOS.

Within the CoBiOS project, HELCOM and OSPAR conventions are defined as supranational users of the service offered, as well as the Environmental European Agency (EEA) and NOOS (North West European Self Operational Oceanographic System).

A good example of how CoBiOS relates to these organisations and Directives is by e.g. looking at the HELCOM system of ecological objectives:

Vision	*¨A healthy Baltic Sea environment, with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable human economic and social activities¨*		
Goals	*Baltic Sea unaffected by eutrophication*	*Baltic Sea life undisturbed by hazardous substances*	*Favorable status of Baltic Sea biodiversity*
Objectives	*Concentrations of nutrients closet o natural levels* *Clear water* *Natural level of algal blooms* *Natural distribution and occurrence of plants and animals* *Natural oxygen levels*	*Concentrations of hazardous substances close to natural levels* *All fish to eat* *Healthy wildlife* *Radioactivity at pre-Chernobyl levels*	*Natural landscapes and seascapes* *Thriving and balanced communities of plants and animals* *Viable populations of species*

Table 5.6.1: General outline of HELCOM system of ecological objectives. For each objective, a number of indicators with target levels must be agreed upon (Leppa & Backer, 2008).

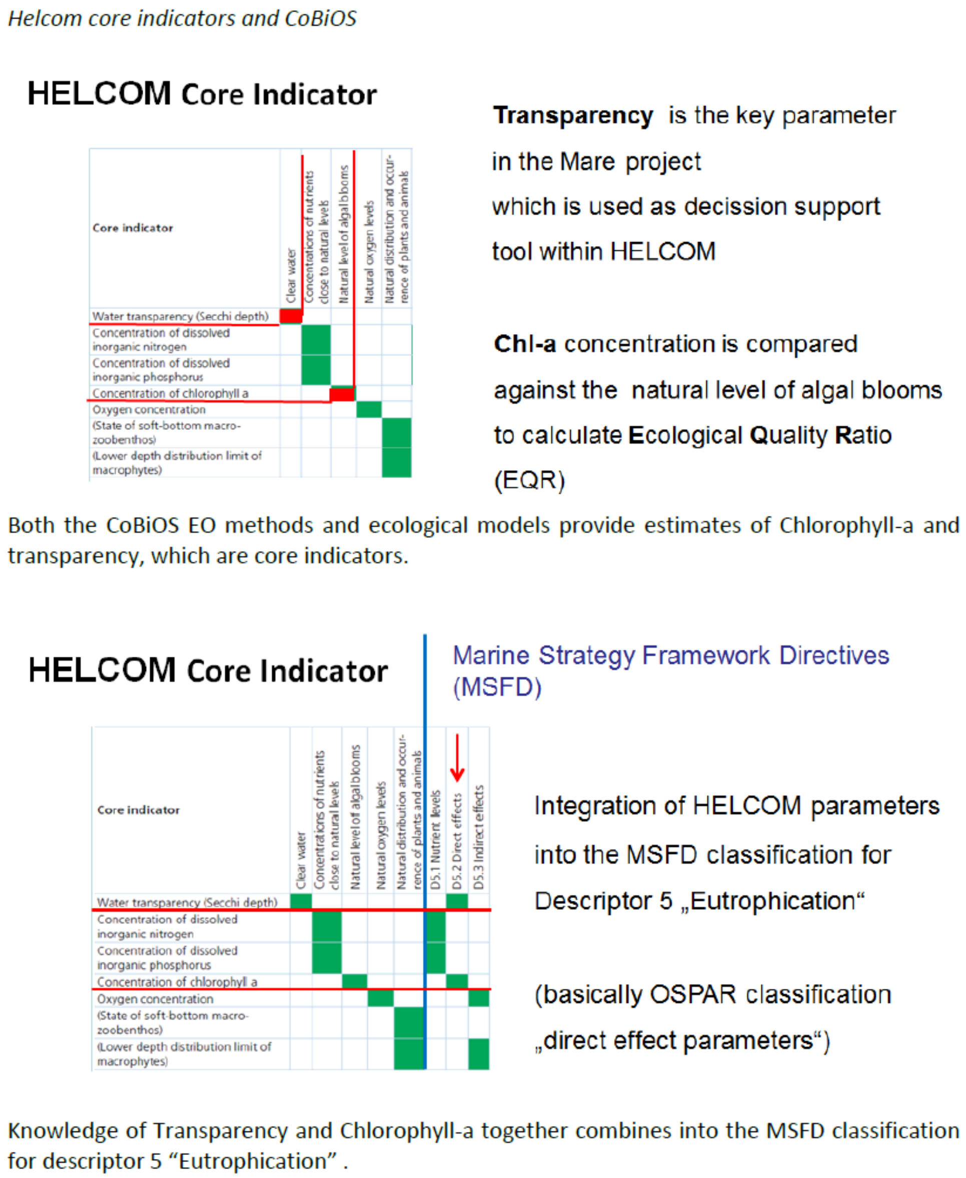


Fig 5.6.2: HELCOM core indicators and connection to CoBiOS products

The OSPAR conceptual approach towards Eutrophication assessment is based on a number of substances, processes and factors that lead to 3 different categories of effects. The CoBiOS provided information on phytoplankton by proxy Chlorophyll-a and transparency play an important role in the assessment of Cat. II: direct effects.

The results of the Socio-economic questionnaire can be summarized as follows: All interviewed users like CoBiOS. However, their willingness to pay ranges between 0-100%. Users that work for National Government are not willing to pay. User from Technological Institutions showed not very high willingness to pay, 26-50%. The users related with private company and related with national government but also with regional organizations, are willing to pay for the service offered in CoBiOS portal.

The perception of the user after being provided with information about HAB cost damages and assimilated models, only have changed for User 2 who works for a Big Technological Institute. After receiving more information about the economical influences of HAB events on different sectors of the society and new approaches developed for water quality monitoring that involve EO and EM, User 2 perceived more added values of the CoBiOS portal service for his/her organization.

It should be mentioned that User 2 has only knowledge on EO while the rest of the users have experience in both information types, EO and EM. It could be that the lack of experience in the field of modelling might have influenced

the user´s perception in a higher level comparing the other users, when for instance providing him/her information about modelling. Therefore, the type of background of the user could be an important factor when evaluating how users perceive the services offered and on which factor their perception about the service might depend.
The other users related to national governments, regional organizations and private company increased their confidence in CoBiOS portal after having read the information about assimilated models. However, they didn´t perceive more added values of the service provided by CoBiOS portal for their organization after the questionnaire.
It seems to be that when the users are better informed about the real potential of the service showed, their confidence in the service increases, and in few cases influences in the perception of the user on the whole product (e.g User 2). However, this fact didn´t lead to a change in their willingness to pay.
Apparently, users belonging to National Government are the less convinced about the several added values that this service might offer as well as the cost-efficiency of the service in terms of data reliability. It seems to be that the users belonging to National authorities' don´t see many reasons to pay for this service. In order to foster the interest of National authorities on this service information on the offered service´s added values should be provided. For instance, by providing examples or show cases of successful use of the CoBiOS portal by other users that in this case showed their interest on the services as well as willingness to pay, such as private companies. In this manner, if the private companies are using it and the performance of the service is successful it could be a demonstration for the national authorities that the system is worth it to pay. The perception of the user on the product would change as well as the value given to EO information systems. Or in other words, it could be suggested to use other users´ positive attitude towards the CoBiOS portal service to persuade other users that are not convinced about the service offered by successful show cases with cost effective results obtained with users with high willingness to pay for the service.

We think that it should be noted that, although not asked in the questionnaire, we have the impression that National users are tempted to wait to see what form of services MyOcean can offer in this respect, because these inherently will be free of charge. The consortium has been very careful not to express negative opinions about MyOcean products to the National users in our area, but our own analysis shows that our models in general do not benefit from MyOcean met-ocean products while our EO products are suitable for the Northern European waters where the MyOcean products are not. Extreme care has to be taken that the anticipation on MyOcean operational products is not going to disturb the market and the user base created by projects such as CoBiOS.

WP6: Demonstration of operational services

The overall objective of WP 6 is to demonstrate and validate the operational performance of CoBiOS Near Real Time (NRT) services. Demonstration of the service and feedback from users is crucial in order to ensure the future sustainability of the service.

WP6.1: End-to-end operational NRT service demonstration

The activities under WP 6.1 have the overall goal to demonstrate the services to interested stakeholders. During 2013 significant effort was made by all project partners to make each individual service chain truly operational. The EO service providers all faced the issues of having to change from ENVISAT MERIS to MODIS AQUA and the model service providers were all faced with complex data infrastructure setups where a number of external ancillary data sets needed inclusion with their in-house routines in a NRT manner; so all participants had significant new developments to implement before being truly operational. Since each model service provider is also dependent on input from an associated EO service provider links between the EO and model providers needed setting up also.

In the first half on 2013 this infrastructure between both Model <>EO service provider and between each partner and the portal was established. In early spring (March) the first CoBiOS derived data started flowing between DHI and GRAS for the locally adapted service covering Danish waters and the Baltic (see http://baltic.waterforecast.com) making both model and EO results available to the public.

In the following months the infrastructure for the official CoBiOS portal was maturing with partners stating upload to the central storage in June/July and and truly operational service in near real-time initiated in August. The NRT products consists of both modelled results (Kd and Chl-a), EO results (Kd and Chl-a) and Insitu data in the form of FerryBox data (Baltic only). The results are uploaded both in graphical format (PNG for online viewing) and as txt format (for time series visualisation of area statistics of OSPAR and HELCOM areas). Based on the project partners' experience in general and user feedback specifically the products developed and matured over this time to be of a uniform state (same appearance, coverace, overlays etc.).

The CoBiOS portal was kept password protected Until end November/early December to only allow access to people with understanding of the project status and acceptance to the fact that modifications were being made regularly (additional information becoming available such as animations, background information etc. and various plots being updated such as inclusion of uncertainty information of model results on the time series plots, increasing length of time series etc.). The password protection was removed after this period to give full and open access to the public.

A significant result under this work package is that all project partners managed to deliver the envisaged products in an operational manner. Despite the ENVISAT loss:

- The EO partners all succeeded during 2013 in getting a MODIS based product of sufficient quality ready allowing the modelling partners could include the information in their model environment and the products to be shown on the portal.
- The model partners managed during 2013 to setup the needed links with the EO partners and integrate the EO products into their model environment and make the output available in an operational manner.
- Ferrybox in-situ data was added to the time series plots for the HELCOM areas.
- The portal was populated with the data in NRT and made available to the public during the end of 2013 allowing the users to evaluate the service.
- The portal is today fully functional and still in operation.

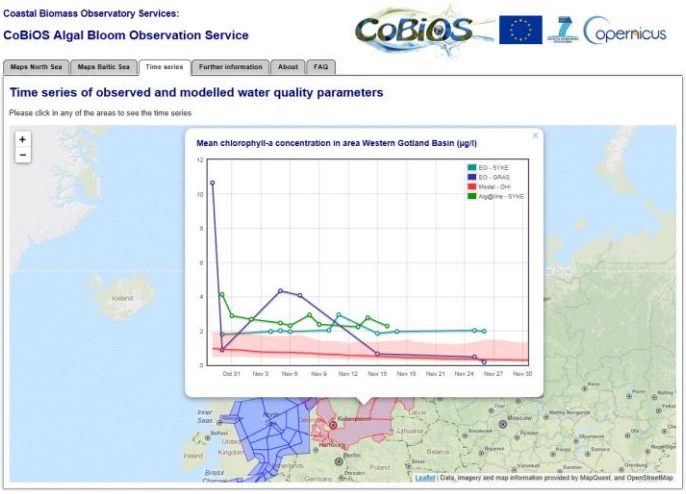


Figure 6.1.1. Example from the Portal of the time series plot of areal statistics based on each service providers uploaded information.

WP6.2: Operational service validation

The validation of the performance of the operational services is built on the experience gathered during the validation of the service trials (D4.4 and D4.5) as well as during the initial operational phase, which started in August. The content of the portal was publically made available in Nov. 2013. The service lines were set up and in the operational services, each service line provided images and statistics to the portal. The following figure shows the service lines that are providing data to the portal.

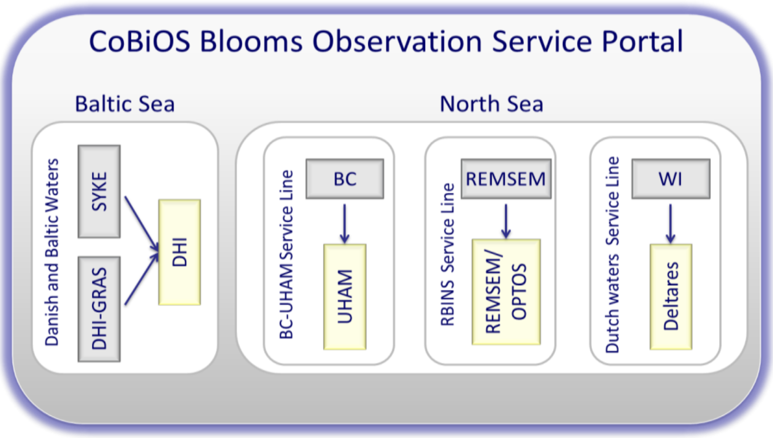


Figure 6.2.1: Illustrative overview of the four CoBiOS service lines. For details about the respective processing chains see D5.5/6.2.

The provision of data consists of two actions: the upload to the WI server (1) and the upload to the web server (2).

(1) The individual service providers are delivering both, images of their respective service area and statistic for predefined regions, to the portal. The images are provided as png files with all relevant meta information in the file name (area, service provider, data type, parameter, date). Optionally, also a description of the situation shown in an image file can be supplied as a text file adhering to the same file naming convention. The statistics are provided as comma separated text files, also containing all relevant meta information in the file name. These files are uploaded to an ftp server located at Water Insight and processed at WI to be shown on the CoBiOS portal (see below).

(2) Once, the images and statistics files have been uploaded to Water Insight's ftp server, they are further processed and pushed to the web server for display on the portal. The ftp server is checked automatically every 5 minutes for new files.

During the operational phase of the CoBiOS portal, there has been no downtime of the server.

The following table (Table 6.2.1) shows the failure that might occur, the probability and the dedicated risks. Failures are of such kind that either the satellite data are not available or the processing fails (modelling or satellite data). A general risk that occurs when working with EO data is the cloud coverage, which is not a technical problem.

	Failure						Risk					
No	Category				Failure description [2]) & Reason [3])	Probability [%] or low, moderate, high [4])	Risk category(ies)				Risk description [5])	Consequence low, moderate or high [6])
	External factors	Processing	Model run	Output & delivery			Completeness	Accuracy	Reliability	Availability & Delivery		
1	x				Satellite, sensor, ground segment or download failure (NASA).	Low-moderate	x	(x)		x	Critical as no data would be available. Due to temporal gaps important events will be missed.	Moderate -high
2	x				Cloud cover or sun glint may prevent acquisition of data	Moderate	x	x	x	x	Due to spatial gaps important events may be missed.	Moderate
3	x				No meteorological forecast available	Low	x			x	Model will not be updated with latest information.	Low-moderate
4	x	x			Change of input products (MODIS formatting, calibration)	Low to moderate			x		The system needs to be adjusted to new input data and therefore delay in processing and delivery; late or no awareness of important events.	Moderate
5		x			Software or hardware failure in EO processing chain (e. g. L1 to L3 processing)	Low	x			x	Service breakdown. Due to temporal gaps important events will be missed. Backup systems are in place to allow quick normalisation of situation).	Low
6		x	x		Upload failure from EO to model service provider	Low				x	EO or EM products will still be delivered with a delay as soon as the download will be possible again. Usually, internet failures are short (max a few minutes), sometimes they last longer (few hours) and only very occasionally a failure lasts more than 24h.	low
7			x		Software or hardware failure – Model	Low	x			x	Ditto	Low
8				x	Upload failure (FTP server)	Low				x	Due to temporal gaps important events will be missed.	low
9				x	Web server failure	Low	x			x	Ditto	Low

[2]) Failure mode of concern.
[3]) Reason for occurrence of failure mode.
[4]) Assumed probability of the failure mode to occur (semi) quantitatively.
[5]) Potential consequence of the failure mode i.e. how it may affect the service' ability to meet user requirements and expected quality criteria.
[6]) Consequence of the failure mode (semi-) quantitatively.

	Failure						Risk					
No	Category				Failure description [2]) & Reason [3])	Probability [%] or low, moderate, high [4])	Risk category(ies)				Risk description [5])	Consequence low, moderate or high [6])
	External factors	Processing	Model run	Output & delivery			Completeness	Accuracy	Reliability	Availability & Delivery		
10	x				Any other severe failure (e. g. electricity breakdown, fire, ...)	Low				x	This problem might remain short- or mid-term.	Moderate - high

Table 6.2.1: Overview about failures and their risk related to input data service processing and delivery.

WP7: Dissemination, Market analysis, market strategy and exploitation

To set-up and fill the CoBiOS web-portal with maps of algal bloom events and related information products. To communicate by means of early warning bulletins to professional users and to demonstrate the evolution of blooms using animations of model sequences. To issue CoBiOS facts (via a WIKI website), newsletters and brochures to inform a broad spectrum of potential users of the CoBiOS services. By means of marketing analysis, licensing schemes, business and exploitation plans to provide a sustainable commercial continuation of the CoBiOS service portfolio beyond the lifetime of the project. CoBiOS will engage in user training to ensure maximum compatibility of the CoBiOS information products with the day-to-day practice and systems of the users.

WP7.1: Communication & Promotion

In the first year all the dissemination materials were prepared. A logo was made, a project website was constructed (www.cobios.eu) which has now been integrated with the CoBiOS portal: (http://waterinsight.cobios.nl). The website contains information about the project and all publicly available deliverables. Also a flyer and policy brief were made and templates for presentations, posters etc. The CoBiOS team visited and presented at a number of relevant conferences and workshops.

WP7.2: CoBiOS Portal

The CoBiOS web portal was discussed on several consecutive meetings. On the one hand partners were cautious to create a new web portal on top of existing portals managed by Marcoast and Aquamar. On the other hand there was discussion about the uniqueness of client – service provider and how such relationships can be established / maintained using a general webportal. Basically the portal architecture allows the partners to exchange data in agreed formats and protocols. To help the discussion, it was decided to first build a small prototytpe to get a clear picture of the possibilities and intricacies of building the backbone within the scope and limitations of the project. Next the design of the web-portal was finalized, and the system was implemented. Gradually it was filled with the operational products from the service lines. As background information for the users, factsheets were written per service line. After a brief testing period, the portal was opened for users.

The CoBiOS Portal contains ecological information on the development of phytoplankton (algae and cyanobacteria) blooms in coastal seas that is collected from all partners and presented on the portal. EO data is processed to Chlorophyll-a maps and provided by BC, RBINS-Nature (formerly MUMM) , WI, GRAS & SYKE. Model data and forecasts are provided by Deltares, RBINS-Nature, UHAM & DHI. The partners worked together to produce combined forecasting information.
Each Service line is formed by at least two partners. This combination of EO and forecasting systems is based on national and/or regional considerations. Those service lines are described in fact sheets.
Presently, 3 days forecast of Chlorophyll-a maps are shown on the portal together with a time series for regions defined by e.g. OSPAR and HELCOM boxes for every service line. The statistics shown identify the variability expected in the forecast for each region. In the North Sea, the service lines RBINS-Nature, the BC-UHAM service line, and the Dutch waters WI-Deltares service lines while in the Baltic Sea, the Danish Waters and Baltic Sea Services are operational. Factsheets with further details on each service line are also given.

The products shown on the portal demonstrate the developed end-to-end service lines among the various partners combining Earth Observation data (EO) with Model Results (MO) and the integrated CoBiOS data dissemination approach (the portal). The portal enables users to evaluate the usefulness of the services and data products, advice on potential improvements and advice on how to maximize the general usefulness of

CoBiOS. The CoBiOS Portal, the various CoBiOS products on the portal are displayed grouped by geographic coverage (North Sea and Baltic Sea) and information type (2D-maps or time series of area statistics). The information is provided in near-real-time (NRT) with the most recent observations and modelled forecast available also (current day +/- 4 days). The area statistics are based on the official OSPAR and HELCOM areas and the calculated area means are displayed for the most recent 30 day period. Examples of near real-time data made available through the CoBiOS portal are:

- 2D maps covering the North Sea based on EO and MO
- Time series of area statistics: OSPAR areas of the North Sea on EO and MO.
- 2D maps covering the Baltic Sea
- Time series of area statistics: HELCOM areas of the Baltic Sea based on EO, MO and Ferrybox data.

WP7.3: Business models, IP, licencing & organization

Based on D7.3 in the version of the end of the 2nd year, discussions were held between partners in order to decide how the CoBiOS services would run after the project's end. Progress of the business model was discussed during dedicated Teleconferences, as well as during other more general telephone calls and meetings. Since it has been proven during the validation period that the MODIS products could be trusted and useable, 4 individual service lines were developed, in order to cater to users' needs on a national basis. There is a service line for each country represented within the CoBiOS consortium, which delivers daily products and statistics to the CoBiOS portal (see Fig 7.3.1). During the 3rd year it was also assessed with user interviews, how good and reliable the CoBiOS services were found, and whether a continuation of the CoBiOS services would be welcome and in which sense. It was also assessed which other projects could benefit or compete with the services proposed by the CoBiOS consortium.

As it is now, the CoBiOS business model describes the 4 national services lines that have been created, and which all delivered individually to the CoBiOS portal until the project's end. Each partner agreed to deliver (at least) Chl maps to portal (either from remote sensing or from ecosystem model), as well as statistics (e.g. mean or median) for pre-defined regions in the North Sea (from OSPAR) and Baltic Sea (from HELCOM). Attention has been made to deliver harmonised products, and deliver common products as statistics (mean/ median, standard deviation, percentile 10 and 90) for pre-defined OSPAR and HELCOM boxes in the North Sea and Baltic Sea, respectively. Fig. 7.3.1 shows the general data flow within the service lines.

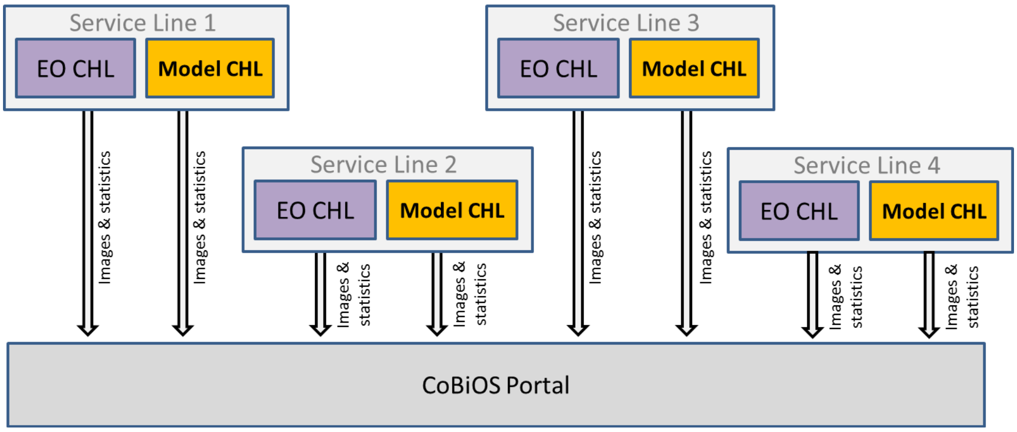


Figure 7.3.1 Input to the portal from the individual service lines with harmonized products (images and statistics).

It was decided that the CoBiOS services would continue for one year after the end of the project. The costs of generating and delivering the products to the portal, as well as maintaining the portal would be the responsibility of each partner. The CoBiOS consortium association is a representative of each CoBiOS partner agreeing to continue services in 2014. Each partner agreed to sign a Memorandum of Understanding, in which they agreed on the level on how they will continue the service, with limitations when applicable. The final considerations about the CoBiOS business model were laid down in Deliverable 7.4. As a late addition, it should be mentioned that CoBiOS partners contributed to the “coastal waters services white paper”, where operational continuation of CoBiOS services were proposed under the umbrella of DG-Enterprise and co-existing with a MyOcean follow-up.

WP7.4: Market analysis, marketing strategy & Data policy

The market analysis and marketing strategy were discussed with the consortium and the user board during the first annual meeting. In principle it was foreseen that, based on the portfolio of products to be developed in the CoBiOS project, services would be set up for an expanding community of users. Unfortunately after the first year the satellite ENVISAT ceased to send data to the Earth. This also meant that the development of services was temporarily set back and a new starting point had to be made for using MODIS images. This also had as consequence that a period of low communication with the users of the project had to be put into place to give the service providers the opportunity to rebuild their services around the MODIS products. It also meant that the content of the services was changed, especially with respect to the number of proprietary products to be delivered by service providers. For MERIS each service provider had established a quantitatively and qualitatively well-defined and validated chlorophyll product and a suspended matter product, while, within the context of this project new transparency products were developed. When starting to redevelop services using MODIS images, it was necessary to review and update our capabilities to produce chlorophyll maps and suspended matter maps of sufficient quality. It has taken the consortium until early 2013 to achieve this. Meanwhile the contacts with the potential users were kept on a very low level. Still the marketing strategy was discussed during the second annual meeting which took place in February 2013 in Hamburg. In the third year the market analysis document was completed with a stakeholder analysis, an analysis of current water quality services products/service portfolios and a simple cost-benefit (SWOT) analysis. During the final meeting market perspectives were discussed with the extensive group of end-users and recommendations were collected and integrated into the Deliverable 7.5 document.

Based on the previous chapters it is possible to perform a SWOT analysis. SWOT stands for strengths, weaknesses, opportunities, and threats where strengths and weaknesses are internal factors and opportunities and threats are external factors.

Strengths

- The combination of EO and Model based information in a truly operational manner at Northern European level is unique. The CoBiOS project thereby fills a gap in the currently offered suite of products/service by competing projects/services.
- The CoBiOS products and the portal have been developed and chosen in close cooperation with associated end users. This ensures a need and interest for the offered products.
- The data and knowledge infrastructure within the project is well defined and developed.
- The internet based service is fully functional and offers a number of tools that allows analyses to be performed through the webpage. It is possible for end users to tailor-make their products and areas of interest following request through individual CoBiOS partners. The potential competitors do not offer the same degree of flexibility and user-friendly services for the coastal areas.
- The system and products are well defined and described. A thorough documentation has been prepared for the system and the available products. The documentation is available to the end users through the CoBiOS web page.
- The commercial potential has been a central part of the project from the beginning. The CoBiOS project is therefore well prepared for the commercialisation.
- Through the CoBiOS project a strong network of people working with the aquatic environment is accessible.
- The dissemination and use activities have spread the knowledge about CoBiOS to the relevant institutions/persons. The coming year will further increase this knowledge so CoBiOS will be well known among potential end users.
- There is overlap in the service providers geographical coverage which ensure potential backup provision of information should a partner stop delivering information to the portal.

Weaknesses

- The system currently relies on MODIS AQUA for the EO based water quality information. Although significant improvements have been made on the retrieval accuracy during the project the outputs are of lesser accuracy compared to the previous MERIS information and the future OLCI information. This 'quality gap' may introduce uncertainty by the potential end users for the service usability.
- Future pricing of the CoBiOS products is unclear. In order to get a detailed image of the market conditions more precise pricing policies are needed.
- The service providers in CoBiOS are in addition to being partners in the project also competitors within their field. This introduces risks of conflicts due to the overlapping market areas (both geographically and thematically).

Opportunities

- There is an interest for the products. The end user feedback shows there is a demand for the services offered by CoBiOS and that a 'willingness to pay' exists from a number of the major potential customers.
- The market for the services offered by CoBiOS is currently not match by other service providers/projects in a truly operational way. Large projects like e.g. MyOcean are no table to offer information about the coastal zone in a sufficient spatial resolution and of the needed quality.
- This market gap opens up for potential further available funding for service improvements and operation of the services through e.g. Horizon2020 initiatives or by an integration of the service into the Copernicus downstream service portfolio
- The internet based structure with no necessary software needed to extract basis information ensures a large number of potential end users since the informations are readily available.

Threats

- Several research projects are engaged in similar activities as CoBiOS. Their current commercial potential is uncertain but pressure from these is foreseen.
- Strong partnerships like e.g. MyOcean/ECOMF are likely to target the coastal area as an area for expansion in the future. It is unknown if this is a realistic threat or merely speculation.
- National institutions e.g. meteorological institutions and oceanography centres have a well-established data and knowledge infrastructure and generally participate in competing activities already (MyOcean for instance). Given their access to national funding as well as their potentially political favourable situation (they are well represented in various decision making fora) may give them an advantage compared to SMEs and commercial companies trying to operate in the same market.
- Users may not be willing to allocate their increasingly tight budget for 'novel' information.

WP7.5: Training of users

In order to support the use of the products on the CoBiOS portal, it is important for the users to have access to descriptions of the products presented on the portal, both with regard to content, data processing and validation. The objective of the WP7.5 activities to be reported in D7.6 has been to describe the plan for the user training and to present the material supporting the training. The work package involved three activities:

- User training planning
- Investigation of the users position on user training
- Preparation of training material

For the user training it was planned to conduct training for each service line individually, i.e. for Belgian users, Dutch user, German user, Danish user, Finnish user respectively. At introductory training sessions the Portal was presented, involving hand on exercises on the web as well as presentation of a pptx describing the North Sea and Baltic Sea services, respectively.

Through a questionnaire the user's attitude towards on the site training was investigated. In general the users found that on the site training was not necessary providing that the Portal does include documents explaining each product, the background of the products (EO procedures, modelling procedure, etc., how they are generated and how they are calibrated/validated.

The second User Questionnaire (D5.2, Appendix 2, the first user questionnaire was D2.6 Initial User Requirements) comprised 4 questions relevant to the training component (part B). The purpose with the questions was to explore the user's perception of the CoBiOS Portal and which type of training the users prefer. The four questions were:

1. How do you rate the appearance of the CoBiOS portal?
2. How easy do you find it is to understand the design of the Portal and access the information and data that you have interest in?
3. Do you find it necessary to receive training as introduction to the content and the applicability of the content of the Portal?
4. How would you prefer to be introduced to the Portal?

In all 10 users answered the questionnaire: 6 from Finland, 1 from Denmark, 1 from Belgium, 1 from The Netherlands and 1 from Germany. All users are academics involved in national monitoring and status assessment (WFD, MSFD, national information networks). Most users are employed by national governmental agencies; one is employed at an independent non-for-profit research organization supporting the governmental agencies.

In summary, the users found that the CoBiOS Portal has a good appearance. One user found that the website looked unfinished giving the rating 'not so good' but expecting that this will change when the website is fully developed. The design is appreciated and rated as easy-very easy to understand. Only one user out of 10 found it 'not so easy' to comprehend. The same user did obviously also find it difficult to the find the information of particular interest. In general, the users did however rate it as easy-very easy to access the information of interest.

With regard to training the most users found that it is not necessary to receive introductory training in order to use the Portal and explore the content. One of the two users requesting training expressed that it was due to the present status of the website and that the expectation is that inclusion of short explanatories would cancel this need. Request for short explanatories is consistent with all users – one user does also ask for a downloadable manual.

Based on the questionnaires is concluded that the CoBiOS Portal is intuitive and thus easy to work with and find relevant information. It was nevertheless a key requirement that the Portal in its final version does include more short explanatories guiding the user to understand what they see and thereby better understand the possible application of the products provided by website. In the following chapter the explanatories produced by the project has been compiled. These are included in the final Portal. Furthermore based on recommendation from users 'mouse over' explanation should be introduced in the final version to further improve the understanding of the products.

During the final meeting of CoBiOS these impressions were again confirmed by the users in the audience

WP7.6: Coordination with ongoing and future EC funded projects

Just before the Kick-off meeting a joint meeting was organized between Asimuth and CoBiOS partners with guests also from outside the projects to make an inventory of the state of the art of Algae Early Warning systems in Europe. The results of this meeting were published in a report which can be found on the CoBiOS website.

At the end of the joint CoBiOS-Asimuth workshop a short group discussion was held after all the presentations. One of the main themes was that of information dissemination, and how best to 'reach' and communicate with the users of the information services. There was wide consensus that the scientific and research community is capable of producing a wide range of information on (harmful) algal blooms that can be of relevance to the user community. During the workshop, several examples of interactive web-portals were shown, in which the user can, for example, zoom into an area of interest, select relevant parameters, look at maps, data points (time series or transects) of forecasted or historical information. However, in practice, many current users seem to want only a simple message (per email or sms) if there is a problem expected in their area of interest. Identifying the specific and tailored information that different users want and providing this to them in an automated way will be a challenge to all the algae warning service providers.

A second topic discussed briefly was that of sustainability of services after the EU funding as finished. It is clear that a sustainable service also needs a sustainable source of income. This may be government and/or users. The user community is primarily the aquaculture industry, and water managers, and to some extent the tourism and recreation sector. All participants recognized this future challenge.

Finally, it was recognized that the two EU projects, ASIMUTH and COBIOS, have quite a bit in common and could both benefit from interaction over the coming years, perhaps with joint workshops or other means of exchanging information. The project leaders have agreed to stay in contact and see how this can best be arranged.

During the 3rd year of CoBiOS the white paper on Coastal Water Quality services was written together with the representatives of the above mentioned projects and submitted to REA for distribution to the National Delegates.