DUE Coastcolour

Requirements Baseline

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The Coastcolour Team

BROCKMANN CONSULT

With

MUMM

GKSS FORSCHUNGSZENTRUM in der HELMHOLTZ GEMEINSCHAFT

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Revision History

Version	Date	Change	Author
1.0	28.04.2010	Initial version	Coastcolour Team
1.1 (internal to pro-ject)	31.05.2010	Overall correction from Zhongping Lee	Lee
		Chapter 4.4 Round Robin rewritten	Ruddick
1.2	30.08.2010	Update of chapters 3.3.2, 4.2, 4.3, 5.4.3, 5.4.4	Doerffer, Brockmann

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1   SCOPE OF THIS DOCUMENT

This document constitutes the requirements for the ESA DUE Coastcolour project. It is the reference, which specifies the requirements for the subsequent work.

The Requirements Baseline addresses, primarily, the product needs expressed by the Coastcolour Champion Users. It includes also requirements not directly formulated by users but added by ESA or identified by the Coastcolour team as necessary to create and deliver a meaningful set of products and an associated processing and dissemination system.

2   INTRODUCTION

The importance of the coastal zone for economic activities, and the anthropogenic stresses on the ecosystem, have been described and discussed widely throughout the past 20 years. Responding to this, ESA designed the MERIS instrument specifically to provide measurements most suitable for coastal zone management and research. In space for 8 years, MERIS has delivered a unique global dataset of coastal zones at 300m spatial resolution, which deserves dedicated processing with the most advanced algorithms, and provision of products targeted to specific user needs, properly documented and easily accessible.

The European Space Agency has launched the Coastcolour project to work towards these objectives by developing, demonstrating, validating and intercomparing different Case 2 algorithms over a global range of coastal water types, identifying best practices, and promoting discussion of the results in an open, public form. Coastcolour will fully exploit the potential of the MERIS instrument for remote sensing of coastal zone water. The product requirements have been derived from a user consultation process.

ESA organised the Coastcolour User Consultation in Cork, 19-20 March 2009. At this meeting general requirements were identified by the participants for the development and demonstration of the advanced use of MERIS for monitoring water constituents in Case 2 coastal waters. Following this workshop ESA issued a call for contribution to a representative group of members of the coastal ocean colour user community. These so-called "champion users" have been asked to:

- Provide a signed statement of their detailed user requirements (URD)
- Sign a letter of commitment to the project
- Advise ESA during the execution of the project, including attending a few of the progress meetings and workshops
- Evaluate the project outcomes at the mid-term and final project reviews.

32 users responded to this call in 2009, and during the initial month of Coastcolour another 8 users joined as champion users.

This first phase of the Coastcolour project aimed at a critical review of the project requirements, which are primarily (but not exclusively) the user requirements. The following chapters summarize the outcome of this phase and lay the foundation for the subsequent work programme.

Chapter 3 describes the sources for the requirements.

Chapter 4 is the main body of this document and details the requirements on products to be generated, algorithm requirements, i.e. scientific challenges to be addressed, technical product specification, software and delivery.

All User Requirement Document are annexed to this document.

3 REQUIREMENTS SOURCES

3.1 Overview

The primary source for drawing up the requirements baseline is the ESA Statement of Work itself, for the Coastcolour project. The Statement of Work has the overall goals of improving the MERIS products, especially in coastal waters, enhancing the product line, establishing uncertainties in the products, and linking to the user community. The Statement provides clear pathways for achieving these goals.

One of the requirements for the Coastcolour project is to establish appropriate links with international projects and organizations that are engaged in related work, to avoid duplication of efforts, to establish synergy and to inform the user community of the progress in Coastcolour.

Prior to the initiation of the project, ESA actively sought to engage the user community in the Coastcolour project, by soliciting statement of interest and user participation from diverse user communities. Interested users, labelled "Champion Users", were provided with a questionnaire designed to gauge their requirements and current activities, and their geographic areas of interest. The responses received have been organized according to geographic areas, leading to the identification of 12 sites where Coastcolour will focus its activities. These sites were reviewed during the Coastcolour kick-off meeting, and additional potential Champion Users were approached, to enhance geographic coverage and areas of particular interest. These include waters off Brazil, Thailand and India, African and Arctic coastal waters. Many of the Champion users have offered to provide in situ data for the project. The use of the data will vary according to agreement reached with the users, and would serve for (a) validation of products, (b) use in round-robin intercomparison of different algorithms, and (c) use in a web-GIS based open database. Since the initiation of the project, the Champion Users have been interviewed either by phone or in person by the Coastcolour team, with a view to clarifying their aspirations and expectations of Coastcolour, to ensure their engagement in the project right from the beginning, and to ensure that the project is oriented right at the outset to meet the user requirements to the extent possible.

3.2 International projects related to Coastal Ocean Colour

3.2.1 International Ocean-Colour Coordinating Group (IOCCG)

IOCCG is a committee with membership drawn from space agencies involved in ocean-colour missions and international scientific experts. The Secretariat is at the Bedford Institute of Oceanography, Canada. The committee produces a series of monographs on ocean-colour related topics, has an active capacity-building programme, actively coordinates ocean-colour related initiatives at the international level, and provides expert advice on ocean-colour as appropriate. Coastcolour members and Science Team are actively involved in IOCCG: Trevor Platt (Founding Chairman, and Chair of several IOCCG working groups); Shubha Sathyendranath, Mark Dowell, Prakash Chauhan and Roland Doerffer (Executive Committee members and chairs of working groups) and Stewart Bernard (Committee Member). Shubha Sathyendranath, Roland Doerffer, Trevor Platt, Zhongping Le, Mark Dowell and Stewart Bernard are also very active in organising and teaching in advanced training courses around the world for students from developing countries. Currently, Roland Doerffer is the Chair of the IOCCG working group devoted to establishing uncertainties in ocean-colour products, and Shubha Sathendranath is the Chair of the IOCCG working group on phytoplankton functional types. One of the important current activities of IOCCG is the Ocean Colour Radiometry Virtual Constellation (OCR-VC), which has the goal of coordinating various ocean-colour missions at the international level, to maximize its utilization.

3.2.2 Societal Applications in fisheries and Aquaculture using Remotely-sensed Imagery (SAFARI)

SAFARI is an international coordinating activity that brings together scientists interested in the use of remote sensing for applications in fisheries and aquaculture. Dr Platt is the founder and Director of the programme SAFARI, and has established its international Secretariat. Other Coastcolour

members active in SAFARI include Shubha Sathyendranath, Stewart Bernard, Mark Dowell and Steve Groom. The programme is very active: It has produced a monograph in the IOCCG series (published in 2009) and held an international symposium on remote sensing and fisheries in India in February 2010. Sathyendranath and Platt also organized an international training course on ocean-colour applications in connection with the SAFARI Symposium.

3.2.3   Chlorophyll Globally-Integrated Network (ChloroGIN)

It is a world network of regional networks for the observing chlorophyll concentration by remote sensing and in situ methods. Latin America, Africa, the Indian Ocean and the north Atlantic are the key regional foci at present. ChloroGIN was founded by Dr Platt, who remains its co-Chairman. The website for ChloroGIN was established and is maintained at PML (Steve Groom). Other proponents active in ChloroGIN include Mark Dowell, Stewart Bernard and Shubha Sathyndranath.

3.2.4   Inland and Near Coastal Remote Sensing Algorithm Working Group of GEO

Mark Dowell, Shubha Sathyendranath and Stewart Bernard are members of the Steering Committee that organised the workshop on Inland and Near Coastal Remote Sensing Algorithms, hosted by NASA in Washington DC, 19-21 May 2009. The workshop, organised as part of GEO task WA-08-01g, had for objectives the definition of current capabilities and limitations of complex inland and near-coastal-water algorithms; and development of an action plan to advance algorithm development and implementation to provide synoptic, management-relevant water- quality information for inland and coastal waters using global and/or regional algorithms. Carsten Brockmann was among the participants of the workshop. The meeting was well-attended, and the participants agreed on follow-up actions, including testing and value demonstration of simple products such as water clarity and eutrophication indices, potentially within a ChloroGIN-style network, as well as the longer-term development and value demonstration of more sophisticated, powerful, better-constrained products. The proponents of the Coastcolour project proposal will maintain an active dialogue with the GEO algorithm workshop activities, to mutual benefit. The Coastcolour project will benefit from this exchange, since the proponents of the project will be able to avoid duplication of efforts undertaken by the working group, and to take into account the recommendations of the working group.

3.2.5   The Partnership for Observation of the Global Oceans (POGO)

POGO is a consortium of major oceanographic laboratories around the world, with representation at the Director level. It is concerned with all aspects of ocean observations, remotely-sensed and in situ. It is an influential body that has championed, amongst other things, the SAFARI and ChloroGIN programmes, which are reviewed annually at the POGO meeting. POGO is allied strongly with GEO. Shubha Sathyendranath was the Executive Director of POGO for eight years, and now remains a member of the POGO Secretariat. Trevor Platt is the current Executive Director of POGO. The international Secretariat for POGO is at PML.

3.2.6   Intergovernmental Group on Earth Observations (GEO)

GEO is committed to implementation of a Global Earth observation System of Systems. It advances through execution of various tasks. The tasks are organized according to various societal benefit areas. The GEO tasks that are relevant for Coastcolour are SAFARI (GEO Task AG-06-02 relevant to fisheries benefit area) and ChloroGIN (GEO Task EC-09-01c relevant to societal benefit area Ecosystems) and the inland and near-coastal working group (GEO Task WA-080-1g related to societal benefit are Water). ChloroGIN is also one of the important capacity building activities of GEO and Shubha Sathyendranath is the point of contact for ChloroGIN at GEO. The GEO Coastal Community of Practice, which is evolving, may provide the link within GEO among the many coastal tasks within GEO. The Coastal Theme Report of IGOS (International Global Observation Strategy) is related to the Coastal Community of Practice of GEO and has now been subsumed by the latter. The OCR-VC, which is also a recognized activity of GEO, is the other initiative which has the potential to evolve into an overarching task that would link all ocean-colour related activities within GEO.

3.2.7 Global Ocean Observation System (GOOS)

GOOS is the marine component of GEOSS, and ChloroGIN is a recognized as a pilot project within GOOS.

3.2.8 Land Ocean Interaction in the Coastal Zone (LOICZ)

Another important research programme of high of high relevance for Coastcolour is LOICZ, the Land Ocean Interaction in the Coastal Zone, which is part of the International Geosphere Biosphere Programme (IGBP). LOICZ coordinates many coastal research programs worldwide, organizes workshops and trainings courses on coastal issues. Recently a working group on harmful algal blooms has been established, which is of importance for Coastcolour. LOICZ is also important for the outreach of Coastcolour, because it coordinates a research community, which is not so much directly involved in ocean colour research but in the utilisation of its results and products. Thus, for a wide dissemination of Coastcolour results and products, LOICZ will be an important channel. The international LOICZ office with its general secretary, Dr. Hartwig Kremer, is hosted by GKSS and Roland Doerffer acts as the liaison between LOICZ and Coastcolour.

3.2.9 The ESA Climate Change Initiative (CCI)

The ESA CCI has the ambitious long-term goal of optimizing the sustained delivery of climate-quality records of essential climate variables through optimal merging of multiple satellite data streams. Ocean colour is one of the essential climate variables identified by ESA, and in the initial phase of the CCI call, the ocean-colour work will focus on the open ocean (Case 1 waters), and will be mainly devoted to primary products from ocean-colour data, such as chlorophyll concentration and inherent optical properties. However, it is understood that in phase two of CCI, the ocean-colour CCI will be augmented with the inclusion of coastal waters, with the Coastcolour project providing the essential input to achieve this objective. It is therefore crucial that Coastcolour and the ocean-colour ECV proceed in close collaboration with each other. At the time of writing this report, the ocean-colour CCI team is not yet known. However, the Coastcolour project is committed to working closely with this team.

3.3 Champion User Characteristics

The information collected in the User Requirement Documents of the Champion Users constitutes the main source of requirements for the project. In the following paragraphs these champion users are briefly presented.

3.3.1 Overview

The objectives of this project are related to the needs of both the scientific community studying the bio- and geophysical processes in coastal waters, and the companies and government agencies specialised in providing water quality information services (for example to the aquaculture industry, local authority water quality managers, etc.).

The majority of the analysed[1] 36 globally distributed Champion Users are European Institutions, but users from North America (Canada, U.S.A and Puerto Rico), Africa (Morocco, Egypt and South Africa), Australia and Asia (Korea and Japan) are also represented (Figure 1a). More than half are government agencies, some are either Universities or research institutes belonging to Universities and just a few are private companies or Global projects (LOICZ). Three are joint collaborations of Government agencies with research institutions (Figure 1b).

[1] After completion of the analysis 4 users joined. They are listed below but included in the analysis presented in this chapter. They would not change the results significantly.

a)

b)

c)
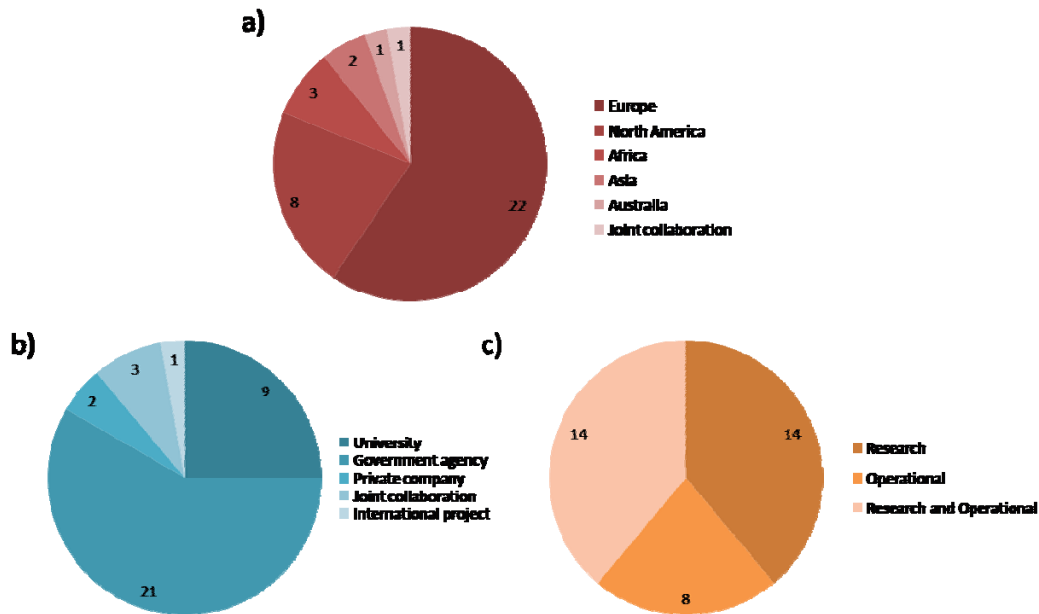
Considering the Users primary objectives, research is the main goal, but more than half have also operational purposes or just set operational tasks as a priority (Figure1c). Many of the research institutions have monitoring responsibilities and, conversely, some governmental agencies are research oriented.

In a general sense, users are looking for ways to develop or improve new algorithms for their study areas or want final validated products useful for their assessments and reports, for their clients, or for their own monitoring activities. Common to users with monitoring responsibilities is the will to adopt remote sensing techniques to better fulfil the objectives set by EU directives like the Water Framework Directive or the Marine Strategy Framework Directive. MERIS resolution and spectral bands characteristics are seen by the scientific community as suitable for high-quality products development with promising applications in the coastal zone. Near-real time access to data is a priority for the ones developing early warning systems (e.g. HABs) or responsible for operational application as directing research and fishing vessels. The importance of comparison of sensors data, methods and algorithms is highlighted by operational users with OC missions' calibration/validation responsibilities. Testing of the high spatial resolution data is a priority to provide proof-of-concept and ideas for design of future missions.

3.3.2   Users

A summary of each user will be presented hereafter. For further details please see attached Users Forms.

User 1 - Caribbean Coastal Ocean Observing System (CarICOOS), University of Puerto Rico

Type: University; Research and Operational

CarICOOS is one of eleven coastal observing systems and regional associations which along with federal agencies constitute the national coastal component of the US Integrated Ocean Observing System (IOOS). Researchers from the University of Puerto Rico, Mayagüez campus, are cooperating in the development and implementation of this monitoring system in the Caribbean and currently collaborating with NOAA CoastWatch (User 27) in the development of a suspended sediment product for the region using MODIS observations.

Coastcolour products will be used for the development of empirical relationships, which may yield estimates of dissolved and particulate organic matter, inorganic suspended material and photosynthetic pigments and improve observing needs on water quality data in the Caribbean region.

<u>Area of Interest</u>: Primarily shelf waters (<30m) surrounding the United States Virgin Islands and Puerto Rico.

User 2 - Centre for Environment, Fisheries and Aquaculture Science (CEFAS) – UK

Type: Government agency; Operational

CEFAS is an aquatic scientific research and consultancy centre that aims to be a source of high quality science used to conserve and enhance the aquatic environment, promote sustainable management of its natural resources, and protect the public from aquatic contaminants. CEFAS has been using remote sensing imagery for a wide range of applications, most frequently, for providing ecologists or fisheries biologists with information on environment conditions for sampling planning purposes. Remote sensing (plus in situ observations) allows cost-effective, synoptic view and monitoring of relevant parameters. Time series analysis of such parameters are also used to determine changes in 'water quality', useful for assessment and reporting on the state of the seas.

Coastcolour products will be combined with in situ data and model outputs to provide better assessments of water quality for UK seas. Primary use will be to satisfy observational needs for the Marine Strategy Directive, but equally important to drive their research into foodwebs, fisheries and ecosystem function. A fully validated satellite time series is considered to be extremely important to discern long term trends in ecosystem function related to climate change.

<u>Area of interest</u>: North Sea, English Channel, the Irish Sea and the Celtic Sea.

User 3 – Satellite Oceanography Group (GOS), Institute of Atmospheric Sciences and Climate (ISAC) of the Italian National Research Council (CNR) – Italy

Type: Government agency; Research and Operational

The ISAC is the institute of the CNR working in the research fields of: Meteorology and its applications; Climate variability, changes and forecast ability; Atmosphere structure and composition; earth observation. Within earth observation, the Satellite Oceanography Group (GOS) focuses on: operational oceanography, *in situ* (oceanographic surveys) data collection and analysis, satellite remote sensing algorithm development and generation of satellite value-added products for data assimilation into marine forecasting models, and for environmental monitoring of coastal water. Nationally, the group is responsible for the design and development of the Italian Coastal waters monitoring system, including oil spill detection and tracking.

GOS is already using MERIS data, having access to NRT FR L2 Mediterranean data, for monitoring purposes and for producing MERIS chlorophyll products in the framework of other projects (e.g. the MyOcean OC TAC).

Coastcolour will provide high quality remotely sensed OC data that will allow development of case2 water algorithm for the Mediterranean coastal waters, or to improve existing ones, and provide a complement data set obtained from other OC sensors. All of this will lead to better water quality products for monitoring the Italian coastal waters.

<u>Area of Interest</u>: Mediterranean Sea

User 4 - Council for Scientific and Industrial Research (CSIR) and Oceanography Department, University of Cape Town (UCT) – South Africa

Type: Governmental agency and University; Research and Operational

CSIR and UCT, in conjunction with the Department of Environmental Affairs and Tourism, operate the Marine Remote Sensing Unit (MRSU), mandated to undertake research and provide operational data in the marine earth observation field. The MRSU currently undertakes active research in ocean colour, SST, altimetry and synthetic aperture radar applications. It also processes and provides MODIS and MERIS data for sub-Saharan Africa, under the auspices of ChloroGIN and the FP7 DevCo-Cast and EAMNet projects. The MRSU co-ordinates taught and research based postgraduate modules

and degrees in marine Earth Observation (EO) at UCT, and runs/contributes to African EO training courses. The MRSU is based at UCT and the Centre for High Performance Computing in Cape Town.

The activities comprise: use of Coastcolour data for radiometric and geophysical validation of standard and experimental atmospheric and in water algorithms; development and application of regional analytical and empirical algorithms; assimilation of products into dispersion models for bloom transport forecasts; operational dissemination of standard and experimental products for HAB monitoring; engagement with end-users to refine products and ensure uptake.

Area of Interest: Southern Benguela

User 5 - Division of Land and Water, The Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Australia

Type: Semi-governmental; Research and Operational

CSIRO is Australia's national science agency covering 20 civilian areas of scientific and industrial research: within the Environmental Division, the Division of Land and Water and the Division of Marine and Atmospheric Research cover all aspects of Australian inland to estuarine to coastal to marine research – with strong links to international research. Within the Division of Land and Water, the Environmental Earth Observation Group is the largest Australian terrestrial and aquatic research group. Their activity focus on physics-based remote sensing inversion methods within data-assimilation approaches to environmental detection, monitoring, and hind, -now, and forecasting. They are also responsible for providing environmentally relevant data for end-users such as water quality managers and coral reef managers in the Great Barrier Reef World Heritage Area (GBR).

CSIRO intends to compare their methods against the best methods available internationally for complex coastal waters (and coral reefs) and explore MERIS resolution and spectral characteristics. Coastcolour matches the CIROS' requirements for the GBR water quality detection and monitoring.

Area of Interest: The Great Barrier Reef World Heritage Area and the Coral Sea.

User 6 - Bedford Institute of Oceanography, Fisheries and Oceans Canada and Dalhousie University – Canada

Type: Government Agency and University; Research and Operational

The Bedford Institute of Oceanography (BIO) is a government institute of the Canadian Department of Fisheries and Oceans (DFO). The institute deals with many aspects of management, and policy and decision making for fisheries, but also engages in research in all disciplines of oceanography (e.g. marine biology, chemistry and physical oceanography). The scope of ocean colour research at BIO includes in situ sampling, processing of satellite data (SeaWiFS, MODIS, and MERIS) and development of algorithms.

A recent agreement between the European Space Agency and the Canadian Space agency led to the distribution of MERIS full-resolution data over Canadian waters. It is now considered necessary to adapt the knowledge of the region to the specificities of the MERIS sensor. Emphasis on the monitoring of coastal ecosystems (i.e.: HABs, water quality in presence of aquaculture) requires new algorithms to interpret ocean colour data. Participation of the institute in the Coastcolour project will benefit the organisation by staying at the edge of the research in remote sensing of ocean colour in case 2 waters. Progress in the observation of coastal waters will also help BIO to fulfil its mandates as a service provider for users of the ocean (fisheries, aquaculture, and tourism).

Area of Interest: Bay of Fundy, Canada

User 7 - Maurice-Lamontagne Institute (MLI), Fisheries and Oceans Canada - Canada

Type: Government agency; Operational

The Department of Fisheries and Oceans (DFO) is the Canada's government agency responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters. Like User 6 (Bedford Institute of Oceanography), MLI is one of a dozen of institutes, which are spread along the Canadian coast and belong to DFO.

In general, DFO is responsible for the acquisition of *in situ* measurements that serves to monitor the oceanic environment and understand the mechanisms of marine ecosystems. It relies on a research workforce and operational capacity (ships, buoys, etc.), which allows access to the sea and to build datasets that are appropriate for the validation of ocean colour products.

Regarding satellite use, DFO operates three NOAA AVHRR receiving stations and feeds from existing ocean colour data streams (SeaWiFS, MODIS, MERIS). DFO uses ocean colour remote sensing to provide information on ecosystem dynamics and structure but this is mostly done as part of specific research projects. There is no national system to provide a suite of products for the coastal areas. Only regional production systems are available limiting the usefulness of the generated products for the Canadian collectivity. Coastcolour products will be a step forward for the implementation of such a monitoring system of Canadian coastal waters.

Area of Interest: Entire Canadian coastal and inland waters.

User 8 –Centre for Ocean and Ice (COI), Danish Meteorological Institute (DMI) - Denmark

Type: Government agency; Operational

DMI provides meteorological, oceanographic and related services for the community within the geographical area of the Kingdom of Denmark (Denmark, the Faroe Islands and Greenland), including surrounding waters and airspace. DMI's area of activity comprises forecasting and warning services as well as continuous monitoring of weather, sea state, climate, and related environmental planning (aviation, national defence, shipping, agriculture, sporting and recreational events, etc.). COI, therein, is responsible for providing information about the state of the sea at present, and for the near future, and for activities such as surge warnings, ice charting, waves, ocean currents, satellite surveillance, ocean climate and marine data.

DMI provides also environmental information (e.g. chlorophyll concentration, suspended matter concentration, light attenuation) for the national and international environmental monitoring companies and public users. The Institute has data access to ESAs rolling archive and is currently using a regional DMI processor for chlorophyll concentration and Case 2 regional processor for chlorophyll and suspended matter concentrations.

COI has a strong expertise in ecological modelling and intends to use the advantages of modelling-MERIS synthesis for the intercomparison between model results and MERIS data, for the improvement of ecosystem models and for the data assimilation.

Areas of Interest: North Sea and Baltic Sea; South-East Asia and Arctic region.

User 9 – European Environmental Agency (EEA) - EU

Type: Intergovernmental organisation (EU Agency); Operational

The European Environment Agency (EEA) is an agency of the European Union, whose task is to provide sound, independent information on the environment. EEA's mandate is to help the Community and member countries make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability; as well as to coordinate the European environment information and observation network (Eionet).

EEA produces state of the environment assessments for Europe and is currently developing an indicator of eutrophication based on ocean colour from SeaWiFS to be used in their assessments and also to be submitted to EU member states as a proposal of a way that ocean colour can be used in the context of implementing the Marine Strategy Framework Directive. The indicator analyses concentration and temporal trend of chlorophyll-a in the coastal zone of Europe, and EEA would like to investigate the feasibility of using MERIS data for the future extension of the time series. If a suc-

cessful methodology can be developed, MERIS data can potentially be used post SeaWiFS or even in time in the EEA as an indicator of chlorophyll-a,.

The EEA also has an ongoing activity to use the distribution of CASE I/CASE II waters from MERIS to describe the extent of coastal waters in Europe.

<u>Areas of Interest</u>: Pan-European with more emphasis on coastal zone

User 10 – Remote Sensing and Marine Optics Department -Estonian Marine Institute (EMI), University of Tartu - Estonia

Type: University; Research and Operational

EMI carries out basic and applied research in different fields of marine science from physics to fisheries, and teaches students at post-graduate level. Operationally, EMI is responsible for coastal water monitoring in the Estonian National Monitoring Programme, within which the Remote Sensing department (RSD) is responsible for the remote sensing sub-part, which is used for coastal monitoring. RSD is currently providing only qualitative information (relative bloom intensity maps, relative chlorophyll maps) to the programme as current standard products available fail in the Baltic Sea and especially in some areas of Estonian coastal waters. Intend to participate in the Coast Colour in order to develop reliable remote sensing algorithms and methods that will allow them to monitor water quality, more specifically, chlorophyll, CDOM and total suspended matter, and ice cover in those areas.

Quantitative monitoring of cyanobacterial blooms is also an issue. Mapping of the extent of cyanobacterial blooms is considered a straightforward task but estimating the biomass is still an unsolved problem. Their studies show that MERIS full resolution imagery should be the most appropriate type of data available for this task.

<u>Areas of interest</u>: Gulf of Finland and Baltic Proper, Lake Peipsi

User 11 – Institute for Coastal Research, GKSS Research Centre – Germany

Type: Government agency; Research (COSYNA project – North Sea)

The Institute for Coastal Research of GKSS is involved in developing monitoring techniques including measurements, data and information management and modelling. Another part of the institute is involved in climate studies of coastal zones.

A major program, funded by the Ministry of Research and Education, is COSYNA (Coastal Observation System for Northern and Arctic Seas). This will include the full chain from mainly automatic measurement systems including Ferryboxes, data processing, modelling, data assimilation, statistics and web based information services. Ocean colour shall play an important role in the observation system. By blending Coastcolour products specifically tuned for the North Sea, in situ data and model results, considerable better products are expected.

<u>Area of interest</u>: North Sea

User 12- Institute of Oceanography, Hellenic Centre for Marine Research (HCMR) - Greece

Type: Government agency; Research and Operational

The Hellenic Centre for Marine Research (HCMR) is a governmental research organization operating under the auspices of the General Secretariat of Research and Technology (Ministry of Development). It has the mandate to promote basic research in all fields of the aquatic environment and to deliver comprehensive scientific and technical support to the public. Their POSEIDON system provides operational information and forecasts for meteorological conditions, sea-state, currents, hydrological structure and water quality for the Eastern Mediterranean.

HCMR is concerned by the poor accuracy of ocean colour remote sensing products for case 2 waters in the coastal zone in comparison to in situ data. This is particularly the case for the Eastern Mediterranean and Black Sea coastal areas where 100% to 200% differences can be found, meaning that

ocean colour coastal products are too inaccurate to be of much use to the oceanography research and operational communities. An improvement in this is their biggest hope and requirement from the Coastcolour project.

Areas of Interest: All Eastern Mediterranean and Black Sea coastline. More specifically: the coastline of Crete; the NE Aegean where water flows in from the Turkish straits; Pagasitikos, Thermaikos, and Saronikos Gulfs.

User 13 – Institute for Computational Earth System Science (ICESS), University of California at Santa Barbara (UCSB) – USA

Type: University; Research

UCSB is one of the ten campuses of the University of California. UCSB offers a wide range of educational, academic and research activities. ICESS is an organized research unit, a department-level entity dedicated to supporting extramurally-funded research. Thirty independent research groups conduct and administer their research using the facilities and resources of ICESS. The research groups at ICESS cover a broad variety of topics in biogeochemistry and Earth science from atmosphere and clouds to biological and physical oceanography to remote sensing.

Scientific activity is centred on the biogeochemistry and bio-optical characterization of the Santa Barbara channel (SBC) waters with use of SST and ocean colour remote sensing to support this research. However, SeaWiFS and MODIS data over the SBC have issues with atmospheric correction and spatial resolution sometimes limits the usefulness of the data. As part of these sensors validation activities, they are interested in comparing their products with those of MERIS for the SBC coastal waters. Work will greatly benefit from the Coastcolour data as it is believed that the unique set of spectral bands available in MERIS and its high spatial resolution (FR) mode are well suited to study phytoplankton abundances and sediment plumes in the SBC from space, and even eventually useful for mapping out Kelp cover.

Areas of Interest: The Santa Barbara Channel area.

User 14 - Institut National de Recherche Halieutique (INRH) - Morocco

Type: Government Agency; Research

INRH is the Moroccan organization responsible for research and development activities in the field of Fisheries, Aquaculture and Water quality monitoring. Among other activities is responsible for fisheries stock assessment, ecological assessment of potential sites for aquacultures and continuous monitoring of the marine environment with respect to different biological and chemical pollution sources.

INHR has been using AVHRR, MODIS and MERIS data for several applications like the study of upwelling events, and spatial patterns analysis of intraseasonal and interannual variability of SST and Chlorophyll in the Moroccan Atlantic coast, however the products used so far are reduced resolution and not yet validated for the region. Expect Coastcolour to provide higher resolution data, properly validated for the region.

Area of Interest: Moroccan Atlantic and Mediterranean coasts

User 15 - Irish Environmental Protection Agency (EPA) - Ireland

Type: Government Agency; Operational

The EPA, together with the Marine Institute (User 16), is responsible for the protection of Ireland's environment through its monitoring, assessment, licensing and reporting roles.

Most of these requirements are fulfilled through routine in situ sampling, and therefore, monitoring more remote locations or large spatial areas is often expensive, difficult and in some cases impossible.

The use of remotely sensed chlorophyll data for the purposes of implementing the EU Water Framework Directive (WFD) has been assessed, but the main issues in relation to this is the validation of the data that is derived, the effectiveness to retrieve information from relatively small water bodies such as estuaries and coastal waters close to the coast, and the development of regional algorithms. Some progresses have been achieved (e.g. the OC5 algorithm – MarCoast project) but further development in this direction is welcomed.

High-resolution remotely sensed satellite data, properly validated for the region, would assist Ireland in meeting a number of existing and future legislative requirements and obligations under international conventions in an efficient, scale-appropriate and cost effective manner. These include: 1) the assessment of ecological status as required by the WFD; 2) the assessment of eutrophication status as required by the OSPAR Convention through the application of the Common Procedure; 3) the future screening of marine waters that is likely to be required in the future implementation of the EU Marine Strategy Framework Directive (MSFD); 4) and in the longer term providing inputs into models designed to assess the 'health' of marine ecosystems.

Areas of Interest: Irish Sea; continental shelf waters of Celtic Sea and Atlantic Ocean west of Ireland; coastal embayments such as Bantry Bay and Kenmare River Bay; and estuaries such as the Shannon and Slaney.

User 16 - Irish Marine Institute - Ireland

Type: Government agency; Research

The Marine Institute is the Irish national agency responsible for Marine Research, Technology Development and Innovation. It carries out most national monitoring activities related to phytoplankton composition, chlorophyll-a concentration and nutrients concentrations established to comply with the EU directives, in conjunction with other national bodies such as the EPA (User 15).

Coastal ecosystem research is carried out through the joint use of various in-situ datasets from dedicated oceanographic cruises and national surveys, and from permanent observation stations. International databases are also used for temperature (UK MetOffice), phytoplankton colour index and zooplankton taxonomic information (Continuous Plankton Recorder data, from SAHFOS). AVHRR (temperature), MODIS and SeaWiFS products (Chl-a), are also used for this purpose. The use of Coastcolour data could improve the confidence of their model of biomass estimates from qualitative index of phytoplankton colour, and provide information from semi-enclosed systems. This information will be used to complete the national monitoring plans for the assessment of the ecological status of the coastal marine environment, and support the preservation/achievement of the targets set by the international directives and conventions, such as Water Framework directive, Marine Strategy directive, OSPAR. It will also demonstrate that Ireland is in receipt of the advice of international conventions such as OSPAR and GCOS for the adoption of EO systems to improve monitoring capacity.

Areas of Interest: All shelf area around Ireland, including the remote banks in the Northeast Atlantic.

User 17 - TechWorks Marine Ltd – Ireland

Type: Private Company; Operational

TechWorks Marine provides clients with real time integrated water quality monitoring products and operational services. Work mostly with the aquaculture sector, providing real-time data on Chlorophyll, Turbidity, Dissolved Oxygen, Temperature and Salinity. This combination of data enables the monitoring of HAB events, their development and subsequent oxygen depletion. As part of a European project they have also been collecting data on CDOM in order to track jellyfish. TechWorks also provides integrated data acquisition platforms to a variety of clients including state agencies, engineering companies and academia.

In situ data collected could be used to validate Coastcolour products. The company would like to see a component of Coastcolour dealing specifically with aquaculture and in situ validation for value added product delivery to this industry.

Areas of Interest: Irish coastline, as close to shore as possible. Primarily the west coast of Ireland: Connemara, Mayo, Donegal, also West Cork, and Kerry.

User 18 - Department of Zoology, Ecology & Plant Science, University College Cork – Ireland

Type: University; Research

ZEPS teaches at all levels having at any given time as many as 24 research staff and 80 full-time postgraduate research students (at both Masters and PhD level).

Research strengths lie in the areas of marine, terrestrial and freshwater animal/plant ecology, among others, with emphasis placed on applied aspects of fisheries and aquaculture, including fish diseases, on genetic modification and food safety, and upon environmental quality, conservation and biodiversity.

In this case, the focus of research is on the surface distribution and abundance of jellyfish, as there is a concern that abundance is increasing globally as a result of climate change and degradation of marine ecosystems under the pressure of human activities. Worldwide, jellyfish blooms have already proved to have critical socio-economic impacts e.g. clogging fishing nets, causing mass mortalities of farmed salmon, blocking the cooling water intake of power stations, and causing the closure of beaches.

They are currently conducting regular ferry surveys across the Irish and Celtic seas for jellyfish data, Coastcolour could help with this research as it would allow correlating these data with as much environmental and biological data as possible in order to better understand the ecosystem role of jellyfish in coastal seas. MERIS FR-resolution would be suitable as sometimes jellyfish blooms occur at scales of <500m. The benefits of such information could provide early warning systems of jellyfish blooms.

Areas of Interest: Irish & Celtic Seas.

User 19 - Marin Ryan Institute for Marine Science - National University of Ireland, Galway, Ireland

Type: University; Research

The Martin Ryan Institute is the home of marine science research at NUI Galway. Through the basic and applied research programs, they promote the exploration and development of marine physical resources; increase understanding of aquatic biodiversity; analyzes effects of environmental change on aquatic ecosystems; and facilitate sustainable development of aquatic biological resources and aquaculture.

Current activities involve in situ sampling, coarse resolution imaging available on web, undergraduate and PhD projects, and public outreach.

Web-based imagery available for offshore activities does not meet the requirements for inshore work. As such, Coastcolour products will allow research on several subjects such as HAB monitoring, river plumes and sediment transport, study of large coastal lakes, coastal habitat mapping and eventually complement with SmartBay marine sensor technology in Galway Bay. Products will also be used in conjunction with in situ data for model calibration.

Areas of Interest: Initially on the west coast of Ireland but eventually the whole of Ireland.

User 20 - Joint collaboration between National University of Ireland Maynooth (NUIM) and Dublin City University (DCU) - Ireland

Type: University; Research

NUIM and DCU are universities with strong research orientation, research made through a several number of institutes. Of relevance to this project, National Centre for Geocomputation, Institute of Microelectronics and Wireless Systems, and Irish Climate Analysis & Research Unit in the NUIM side.

At the DCU the National Centre for Sensor Research and Clarity research centre should be mentioned.

NUIM & DCU are researching and developing a number of imaging technologies and Wireless Sensor Networks (WSNs) for various marine based application areas including environmental monitoring technologies and renewable energy. NUIM's imaging capabilities include lightweight spatial HD video systems that can be used on mobile platforms or configured as part of a wide area sensor network to monitor various coastal processes. At both NUIM and DCU, research into Autonomous WSNs is taking place. These include adaptive sensors, data fusion, self organization as well as OGC compliant Service Orientated Architecture (SOA) and Sensor Web Enablement (SWE). Bi-directional flow of coastal information via mobile devices (LBS) is also under investigation. DCU is designing and building a wide range of chemical, biological and physical sensors to sense and report on various in-situ parameters including temperature, salinity, pH as well as contaminants (biological and chemical).

Users want to investigate early warning and environment monitoring geospatial technology using flexible multispectral satellite sensors, mobile sensor platforms (airborne & water) and in-situ autonomous wireless sensor networks. Area of interest is the harsh, coastal-zone environment including bays and inlets. Coastcolour offers both synoptic coverage and spectral resolution to enable extended geographic reach and cross-validation of various sensing systems.

<u>Areas of Interest</u>: Galway Bay, West Coast of Ireland

User 21 - Department of Water Resources (WRS), International Institute for Geo-Information Science and Earth Observation (ITC) –The Netherlands

Type: Government Agency; Research

The International Institute for Geo-Information Science and Earth Observation (ITC) undertakes education, research and advisory services in earth observation and spatial information collection, analysis and management. ITC provides tools and methods for the exploitation and conservation of natural resources, particularly in developing countries. The Department of Water Resources (WRS) is a multidisciplinary scientific department specializing in scientific research and education in Earth Observation and Geo-information Sciences for the understanding, monitoring, predicting and sustainable use and management of water resources. Main research programs involve water scarcity, water usage, water quality, water and ecosystem interactions, and water and climate interactions.

For this project the area of interest is the Yangtze estuary in China. Sediment fluxes to the Yangtze estuary play an important role to the geomorphologic evolution of coastal environments (delta, mud flat and shorelines). These land base runoff flushed by the Yangtze River modulate the transportation of pollutants into the coastal waters and affect, therefore, the quality of the water and hence the living organisms. Understanding the bio geophysical, biogeochemical and ecological function of the Yangtze estuary in varying and changing climate is crucial to sustain this area and remote sensing offers the only realistic means of acquiring the required measurements to study this important and often inaccessible marine ecosystem.

Intend to develop a MERIS bio-optical model that characterizes the absorption and scattering coefficients of suspended sediment in the Yangtze estuary, with the purpose of contributing to the scientific, social and economic benefits of the Yangtze estuarine area.

<u>Areas of Interest</u>: The Yangtze estuary.

User 22 - Earth Observation Research Centre (EOC), Japan Aerospace Exploration Agency (JAXA) – Japan

Type: Government agency; Research and Operational

JAXA is the administrative institution resultant from the merge of the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory of Japan (NAL) and the National Space Development Agency of Japan (NASDA). It is now the government agency responsible for performing all the activities in the aerospace field from basic research and development to utilization. The EOC is one of its field centres and was opened for the establishment and development of satellite re-

mote-sensing technology to allow observation of the earth, and particularly, to study the environment and its effects globally. It receives data daily from several earth observation satellites, processing and providing it to data users and researchers both inside and outside of Japan.

Is currently developing GCOM-C/SGLI mission and one of the focus is the coastal algorithm development and applications including red-tide/HAB and water quality. As the launch of the sensor is planned in five years time, some of the pre-launch activities can profit from collaborative work with the Coastcolour project. MERIS FR data and new coastal advanced products will be useful to investigate coastal ocean-colour applications, like methodology demonstration of red-tide (HAB) monitoring and water quality in the coastal area, and of local optimization of the in-water optical models / inversion algorithms.

Areas of Interest: Around Japan, especially: 1) Seto-inland sea, 2) Tokyo Bay, 3) Kyusyu Ariake Bay, and 4) Off Tohoku.

User 23 – Korean Ocean Research and Development Institute (KORDI) -Korea

Type: Government agency; Research

KORDI's activities are undertaken in the various marine environment research fields as are Marine resources, Coastal & ocean engineering, Marine transportation & safety and Ocean observation techniques development.

KORDI has a database of optical measurements in the turbid & clear water (East Sea) and is interested in improving/developing algorithms, and performing calibration & validation activities for ocean colour sensors. Takes regular in-situ measurement validation for MERIS using optical in-situ data obtained in an observation tower but think the production of match-up data between in-situ & satellite measurement should be enhanced.

The need for regional optical properties information for suspended material is a major concern, and through Coastcolour, expects to improve coastal water resource management in their region.

Areas of Interest: Yellow Sea (coastal & central area); East China Sea; East Sea (Japan sea); and Bohai Sea.

User 24 - Land Ocean Interactions in the Coastal Zone (LOICZ)

Type: Global Project; Research

LOICZ is a globally active core project of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP). LOICZ aims to provide science that contributes towards understanding the Earth system in order to inform, educate and contribute to the sustainability of the world's coastal zone. Therefore LOICZ seeks to inform the scientific community, policymakers, managers and stakeholders on the relevance of global environmental change in the coastal zone.

LOICZ generates own scientific synthesis and assessment and works through an international portfolio of affiliated projects and capacity building activities. The coastal scale applied includes the water continuum from source to sea and combines natural and social science aspects.

Currently using images from NASA and ESA for ocean colour and terrestrial (land use and cover), with several validation activities being carried out in important coastal zones (Baltic, Mediterranean, and SW Europe).

Consider the coastal zones to have limited satellite imagery due to problems of scale and interpretation (bottom effect and land effect). Coastal zones are the major fabric of biogeochemical processes and thus more than other seas a reflection of human influences – however, a good long time observation is often lacking and so does the quantitative link to activities on land. The latter includes institutional dimensions and would benefit from improved coastal remote sensing information.

<u>Areas of Interest</u>: LOICZ is a global project paying special attention to: Coastal megacities (e.g. To-kyo, New York, etc.); Important estuaries and deltas (e.g. Ganges-Bramaputra, Amazon, Nile, etc.); The Arctic and Antarctic; Regional Seas under strong riverine influence; and Reference sites.

User 25 – Northern Gulf Institute (NGI), Mississippi State University (MSU) - USA

Type: University; Research

The Northern Gulf Institute (NGI), a National Oceanic & Atmospheric Administration (NOAA) Cooper-ative Institute, develops, operates, and maintains an increasingly integrated research and transition program focused on filling priority gaps and reducing limitations in current Northern Gulf of Mexico awareness, understanding and decision support. Research activities include monitoring coastal and inland water qualities, and their relationships with climate.

The group has access to standard MERIS products, through Cat-1 project with ESA, but would like to receive/have access to NRT FR MERIS Level 2/3 products, remote sensing reflectance in particular, to apply the processing algorithms they've developed to invert subsurface properties from such measurements. Believe that MERIS data resolution and spectral band characteristics will provide much more information for the coastal environments that they're interested.

<u>Areas of Interest</u>: Northern Gulf of Mexico; the Great Lakes; Caribbean; Great Barrier Reef; South and East China Sea.

User 26 - Ocean Biology Processing Group (OBPG), Goddard Space Flight Centre, NASA – USA

Type: Government agency; Operational

NASA's Ocean Biology Processing Group (OBPG) located at the Goddard Space Flight Centre is re-sponsible for: 1) the acquisition, processing, archival, distribution and the calibration and validation of ocean colour products from SeaWiFS and the ocean colour and sea surface temperature products from MODIS-Aqua, MODIS-Terra as well as maintaining and supporting the historic CZCS and OCTS data sets; 2) Evaluation, archival, and distribution of in situ measurements used in related calibra-tion, validation, and algorithm development activities (via SeaBASS/NOMAD); 3) Development and distribution of ocean colour data processing and analysis software (via SeaDAS).

Coastcolour, by providing retrospective and future FR MERIS data will facilitate long-term: 1) com-parison of radiometry and derived geophysical products from multiple space-borne sensors; and 2) regional water quality monitoring activities. The high spatial resolution (300-m) of MERIS will great-ly enhance existing water quality monitoring activities in Chesapeake Bay which is currently used to evaluate the water quality monitoring potential of ocean colour satellites in collaboration with oth-er USA institutions.

<u>Areas of Interest</u>: Chesapeake Bay and mid-Atlantic Bight.

User 27 - National Oceanic and Atmospheric Administration (NOAA); National Environmental Satellite Data and Information Service (NESDIS) and College of Oceanic and Atmospheric Scienc-es (COAS), Oregon State University (OSU) - USA

Type: Government Agency and University; Research and Operational

The NOAA CoastWatch mission is to provide and ensure timely access to near real-time satellite da-ta to protect, restore, and manage U.S. coastal ocean resources, and understand climate variability and change to further enhance society's quality of life. Primary users include Federal, State, and local marine scientists, researchers, coastal resource managers, and the general public. On the oth-er hand, the College of Oceanic and Atmospheric Sciences (COAS) at Oregon State University (OSU) conducts research and supports the development of new ocean colour sensors for the characteriza-tion of the coastal and open ocean. Their work includes collecting in situ optical, physical and bio-logical data, testing algorithms, working with engineers on instrument requirements and design, and the testing and validation of ocean products.

Currently COAS uses MODIS and SeaWiFS data along with extensive in situ sampling from ships, gliders and moorings and physical data and models for current and temperature fields. However, data used, from global algorithms for MODIS and SeaWiFS, fail frequently over the Columbia River Plume due to high suspended sediments and the coarse resolution of these sensors does not allow sampling close to the coast.

For the Chesapeake Bay, NOAA CoastWatch produces an operational *regional* MODIS chlorophyll-a product, amongst various other experimental products (e.g., Kd490, primary productivity for Chesapeake Bay).

Users intend to evaluate the Coastcolour products for their region, and proven products will be used routinely for HAB detection; Event Response; Sampling Site selection and for a range of studies of ecosystem dynamics on the Washington and Oregon Coasts as well as the U.S. East coast, Chesapeake Bay in particular to start (eventually to include other U.S. locations off the Gulf coast, in the Great Lakes, et al.)

NOAA CoastWatch hopes to continue its very successful partnership with ESA on MERIS data distribution and be able to distribute resulting Coastcolour data/products to as large of a user community as possible within the U.S.

Areas of Interest: The coastal waters off Oregon and Washington, USA and the estuaries and coastal waters of the Chesapeake Bay region off the East coast of the USA.

User 28 – Remote Sensing Group, Plymouth Marine Laboratory (PML) –UK

Type: Charitable Research Company; Research

PML's research programmes are focused on solving the complexities within marine ecosystems and developing relevant and integrated approaches for delivering a sustainable basis to marine ecosystem management and understanding the role of the oceans in the Earth System.

The Remote Sensing Group (RSG) comprises a multidisciplinary team of scientists with expertise in remote-sensing, physics, meteorology, engineering, computer vision and computer science, that undertake both research and operational data processing and validation of remotely-sensed data.

PML is involved in the ESA MarCoast project, and has tested their Case 2 algorithm applied to Aqua-MODIS data. This empirical algorithm may also be applicable to MERIS but will not satisfy the requirements for a complete range of properly validated ocean colour parameters in the coastal zone with appropriate spatial resolution including confidence estimates.

Another relevant project is the AlgaRisk pilot project for the UK Environment Agency that is developing capability to monitor and forecast nuisance and harmful algae blooms in the Western English Channel. However, this is currently limited by the accuracy and resolution of ocean colour products close to bathing waters and aquaculture industries which are the main areas of interest.

For algal bloom monitoring, Coastcolour products will significantly increase the capabilities for detecting blooms developing close to the coast, before they cause damage to the aquaculture and tourism industries. This project will also allow improvement of advanced algorithms for higher level satellite products such as Phytoplankton Functional Types, phytoplankton size class, particle size distribution, HAB species discrimination.

Area of Interest: Western English Channel where the sampling stations (called L4 and E1) are located, with optical data back to 2002.

User 29 - Roffer's Ocean Fishing Forecasting Service, Inc. (ROFFS™) – USA

Type: Private Company, Operational

ROFFS provide fishing forecasting analysis for commercial and recreational fisherman via satellite data by locating the more favourable conditions for fishing, and real time oceanographic analysis using satellite data to several organizations within the government and academic sectors for adaptive sampling decision making and general research cruise tracks as well as assisting oil companies in ship routing and rig monitoring. It is also funded by NASA in Dolphinfish, King Mackerel, and Blue-

fin Tuna research projects, studying these animals preferred ocean habitat to better regulate government stock assessment and monitoring off the East Coast of the United States and Gulf of Mexico.

Presently uses a combination of MODIS Ocean Colour/Chlorophyll products along with SST from NOAA AVHRR satellites, GOES, METOP-A, and MODIS along with buoy readings and Model data to analyze the real-time and historical (if needed) ocean conditions.

Coastcolour regionally tuned products and better resolution products will allow better monitoring of the ocean conditions and assist in tracking ocean features that are important to fish habitat, fish movement, spawning and fish well-being, and ultimately provide better information for the policy makers and regulation factors. Better resolution and data coverage will improve accuracy of real-time monitoring.

Area of Interest: East Coast of the United States, Gulf of Mexico, and the Bahamas. Also would be interested in the East Coast of Australia, Coast of Angola, and Coastal Trinidad.

User 30 – Marine Research Centre, Finnish Environment Institute (SYKE) - Finland

Type: Government agency; Research and Operational

SYKE is both a research institute, and a centre for environmental expertise. Research is focus on changes in the environment, and seeks ways to control these changes. SYKE's Marine Research Centre conducts wide-ranging research on the ecosystems, marine life and state of the open Baltic Sea and the coastal waters around Finland, also assessing the factors that shape the marine environment. One key focus area is measuring the loads of substances entering the Baltic Sea, and examining their impacts.

The current activities have extensively focused on detection of chlorophyll, algae blooms and in less extent to turbidity and total suspended solid material (TSM). Eutrophication is a major problem in the Baltic Sea, including for example floating cyanobacterial blooms.

SYKE is in the framework of MarCoast both producing and using ocean colour and sea surface temperature products for the Baltic Sea coast of Finland, but they severely lack coverage in the large archipelago areas and near coast due to land/rectification error masking processes form the results. Dedicated processing for these areas will yield additional useful data.

SYKE has a mandatory legal obligation to provide the administration several types of monitoring information and research concerning the marine environment (EU Marine Strategy and Water Framework Directive). The ecological and climate change research of SYKE will take full advantage of the Coastcolour information for completing these tasks.

Area of Interest: (Northern) Baltic Sea

User 31 - Department of Systems Ecology, Stockholm University - Sweden

Type: University; Research

The Department of Systems Ecology study both basic and applied ecological problems, with an emphasis on coastal and marine ecosystems and coupled social-ecological systems, and a long tradition of research on the Baltic Sea and its drainage basin.

Member of the MERIS validation team, with data submitted to the MERMAID database, is also responsible for validation activities of reflectance and aerosol optical properties over north-western Baltic Sea and lake Vänern; Aeronet-OC stations Pålgrunden (Vänern) and Gustaf Dalén (NW Baltic Sea).

Currently is receiving RR data on a regular basis, and FR data from Brockmann Consult only for targeted scenes.

Also is involved in a joint user regional project in order to provide end-users with water quality maps of good quality for the Great Lakes in Sweden (Vänern, Vättern and Mälaren), and currently being expanded to include Himmerfjärden. Project will use algorithms that have been tested and

developed (local algorithms for Secchi and Kd490) in their research on Baltic Sea data. Users are also informed on the best MERIS processors (IPF, C2R and FUB) for the area.

Intend to evaluate the effect of management tools on water quality in Himmerfjärden. The standard monitoring program has only limited coverage (in time and space); the improved resolution and reliable data at land-sea transitions provided by MERIS offer a good basis for enhanced investigation of Himmerfjärden and other coastal areas in the Baltic Sea.

Area of Interest: Aeronet-OC station Palgrunden (Vänern); Himmerfjärden stations.

User 32 - Environmental Hydraulics Institute, University of Cantabria – Spain

Type: University; Research and Operational

The Group of Oceanographic and Coastal Engineering (GIOC), it is one of the groups of research that forms a part of the Environmental Hydraulics Institute "IH Cantabria", mixed research institute between the University of Cantabria (UC) and the Foundation Institute of Environmental Hydraulics (FIHAC), situated in the Engineering School of Ways, Channels and Ports of the UC.

The areas of activity developed in the centre are focussed on teaching, research, development and technological transfer on the area of the transitional and coastal waters. Research fundamental lines include characterization and evaluation of coastal systems; Water quality in the coastal environment and areas of transition; in situ measurement techniques; Remote sensing of aquatic environments; and Coastal zone management among others.

Concerning EO, one of the main interests of the institute is the applicability of remote sensing techniques to the Water Framework Directive, in order to increase the monitoring of the water quality in time and space, otherwise impossible with the mere use of in situ field trips. Currently, using the data provided by GlobColour and SeaWIFS, however, the spatial resolution of both datasets constitutes an issue, mostly when dealing with coastal regions.

High-resolution data will permit the analysis of temporal series of parameters such as Chlorophyll concentration, sea surface temperature, Kd490, and water radiances that would constitute an important tool for the control of the water quality of the area under study, and the assessment of the impact associated to the presence of several submarine outfalls.

Coastcolour radiance and reflectance products will allow researchers to implement new algorithms (i.e. regional algorithms), and not just use of the water constituents estimated from the water signal.

Area of Interest: northern coast of Spain

User 33 – French Research Institute for Exploitation of the Sea (Ifremer) - France

Type: Government agency; Research and Operational

Through studies and expert assessments, Ifremer contributes to improve knowledge of the oceans and their resources. Ifremer has also a large monitoring activity for the surveillance of the marine and coastal zones and is responsible for managing the French ocean research fleet for the whole French scientific community.

Ifremer has a strong experience in validation of satellite products in coastal area based on their in situ network REPHY (*Le Réseau de Surveillance phytoplanctonique*). In order to evaluate the potential of the satellite technique to improve the monitoring required by the WFD performs daily comparisons of chlorophyll and turbidity in situ measurements with satellite data.

Would like to compare the 1.2km resolution MODIS and MERIS chlorophyll and mineral SPM maps obtained from their algorithm (which are also the products of the MyOcean OCTAC for the IBI-ROSS area) to MERIS FR processed by the Coastcolour consortium. This will allow evaluating the interest of the Full resolution for the surveillance of the area, and the relative quality of the products (chlorophyll and SPM) delivered after application of two different procedures (Ifremer and Coastcolour).

The end benefit would be a better monitoring of a coastal area particularly subject to eutrophication.

Coastcolour data could be integrated into a real time service to oyster farmers in Southern Brittany. This service will forecast and monitor eutrophication events (MyOcean and APOSTROPHE projects).

Area of Interest: Southern Brittany.

User 34 - National Institute of Oceanography & Fisheries - Egypt

Type: Government agency; Research

Institute main research areas include basic and applied marine research relevant to protection of marine and coastal environments, mapping and assessment of natural habitats and water quality parameters, preventing marine pollution, monitoring of algal blooms, fisheries management and development, and sustainable use of national and regional seas and aquatic areas.

Currently there is no regular sampling program for monitoring nutrient and sediments influx off the Nile delta and Egyptian Mediterranean coasts or for assessment of biological productivity and marine biogeochemistry. Data and in-situ measurements available on phytoplankton or chlorophyll concentrations and biological productivity in these coastal areas are very modest and scarce and therefore, there is a strong need for improving monitoring capabilities. Application and use of ocean-colour remote sensing data from current and higher resolution sensors would help in filling at least part of this lack of knowledge in this area and resolving many issues relevant to fisheries, coastal water quality, human health, etc.

Coastcolour products will allow: 1) assessment of marine productivity and variability of chlorophyll concentrations off the Egyptian Mediterranean coasts and SE Levantine basin; 2) assessment of impacts and extension of river plumes on quality and transparency of the coastal and offshore waters off the Nile delta and Alexandria city; 3) Monitoring existing anticlockwise gyres that develop in this region and assess its impacts on nutrient availability in the surface waters.

Area of interest: Nile delta shelf, Egyptian Mediterranean coasts, SE Levantine Basin, and Red Sea.

User 35 - Leibniz Institute for Baltic Sea Research - Germany

Type: Government Agency; Research and Operational

Leibniz institute performs interdisciplinary ecosystem research in the Baltic and other coastal regions such as Namibia, SE-Sumatra (Indonesia), Beibu Gulf (China/Vietnam), Cape Verde. Research includes phytoplankton development and harmful algae bloom, coastal discharge and exchange to the open Sea, upwelling and biological response. It is also the responsible for the German physical-biogeochemical monitoring of the Baltic Sea including harmful algae blooms.

For those purposes makes use of all available ocean colour sensors to get the best coverage of the study areas; of high resolution data of Landsat, SPOT, RapidEye; and selected channel, or colour information (RGB) and SST (NOAA).

Coastcolour products will support the monitoring of biological activity and bloom development; in particular of harmful algae blooms and their influence on coastal areas and better characterisation of transport processes in river discharge areas.

Area of Interest: Baltic Sea; SE Sumatra and other Indonesian waters; Beibu Bay west of Hainan Island (China/Vietnam); Upwelling areas off Namibia; Cape Verde.

User 36 – Institute for Coastal Research, GKSS Research Centre - Germany

Type: Government Agency; Research (COSYNA project – Arctic)

The Institute for Coastal Research of GKSS is involved in developing monitoring techniques including measurements, data and information management and modelling. Another part of the institute is involved in climate studies of coastal zones.

A major program, funded by the Ministry of Research and Education, is COSYNA (Coastal Observation System for Northern and Arctic Seas). This will include the full chain from mainly automatic measurement systems including Ferryboxes, data processing, modelling, data assimilation, statistics and web based information services. Ocean colour shall play an important role in the observation system. The project is carried out by Alfred-Wegener Institute for Polar and Marine Research (AWI), GKSS Institute for Coastal Research, the Nansen Centre in St. Petersburg, the Permafrost Institute in Yakutsk and further Russian Partners

For the Arctic, intend to use MERIS data to observe and quantify the input of suspended matter and carbon from the eroding permafrost coast and the Lena River into the coastal waters of the Laptev Sea. A further site of investigation is the Kara Sea with its estuaries of Ob and Yenesei which will be covered by the Nansen Centre in St. Petersburg within the framework of a cooperation program.

There are only a very few stations where measurements of the coastal water is performed around the Arctic. Along the Siberian Coast the input of carbon from the Lena Delta is assumed to be very high. Satellite data are required to get more data and to improve the models of carbon and sediment transfer from the eroding permafrost soil, which is assumed to increase due to global warming.

Area of Interest: Lena delta and New Siberian Islands; Kara Sea with deltas of Ob and Yenesei

It is a goal of the project to broaden this user community and welcome additional users, worth mentioning that contacts have already been established with potential African and South American users.

User 37 – Indian National Centre for Ocean Information Services (INCOIS) - India

Type: Government Agency

The mission of INCOIS is to provide ocean information and advisory services to the society, industry, government and scientific community through sustained ocean observations and constant improvements through systematic and focused research.

Area of Interest: National Indian Waters

User 38 – EOMAP GmbH & Co KG - Germany

Type: Private Company

EOMAP GmbH & Co.KG is an independent SME located in Oberpfaffenhofen, near Munich, Germany. EOMAP creates solutions to produce standardized map products from earth observation data. Sophisticated map products based on multi- to hyperspectral remote sensing data, as well as classification software solutions, comprise EOMAP's core business. EOMAP's solutions rely on standardized physical models and work independently of scale, sensor type, and geographic location. The company offers customized, large-area mapping based on satellite and airborne imagery for a manifold of applications with a focus on aquatic remote sensing. EOMAP's services can be applied in environmental monitoring and spatial explorations, in particular for coastal zones, inland waters, wetlands, and other areas where high-precision mapping is required.

Area of Interest: Any worldwide – EOMAP would like to test the algorithms for multiple areas where high-value validation data are available to satellite records.

User 39 – Pabellon IAFE-Ciudad Universitaria - Argentinia

Type: Governmental Research Institute

There exist several groups within the Institute which perform both observational and basic research on topics related to astronomy and physics, like solar physics, astrophysical plasmas, relativistic quantum theories and gravitation, and quantitative remote sensing, amongst others. Apart from basic research, the Institute has also been involved in the training and education of MSc and PhD students within the Physics and Biology undergraduate and postgraduate courses at the University of Buenos Aires (Argentina). It has also been actively involved in the scientific divulgation, comprising dissertations and organization of workshops and courses.

<u>Area of Interest</u>: La Plata river estuary

User 40 – Instituto Nacional de Pesquisas Espaciais - Brasil

Type: Government Research Institute

INPE's missionis to foster science and technology in earth and space context and to be able to offer products and regular services in benefit of the country. INPE aims to become a National and international reference in both space and earth environment fostering knowledge and attending and anticipating demands on Brazilian society life quality progress.

<u>Area of Interest</u>: French Guyana & Amazon Delta, Antares-Ubatuba region

4   REQUIREMENTS

4.1   Regional Coverage

The 36 users have requested products from more than 40 individual areas of interest. These have been combined into 19 sites. These are shown in - below.

Table 1: List of CoastColour sites and connected with the sites. The coordinates of the polygons for each site can be provided on request as shape files, klm files or text files.

Site	Location	User
1	Northern West Shelf	(u2) CEFAS; (u8) DMI; (u9) EEA, (u11) GKSS; (u15) EPA; (u16) IMI; (u17) TechWorks; (u18) UCC; (u19) MRI; (u20) NUIM_DCU; (u24) LIOCZ, (u28) PML; (u32) UniCan; (u33) Ifremer, (u38) EOMAP
2	Baltic Sea	(u8) DMI; (u9) EEA, (u10) EMI; (u24) LOICZ, (u30) SYKE; (u31) SU; (u35) IOW, (u38) EOMAP
3	Mediterranean and Black Sea	(u3) CNR; (u9) EEA, (u12) HCMR, (u24) LOICZ
4	Morocco	(u14) INRH, (u24) LOICZ
5	Acadia	(u6) DU-BID; (u7) DFO, (u24) LOICZ, (u29) ROFFS
6	Chesapeake Bay	(u24) LOICZ, (u26) NASA_OBPG; (u27) NOAA_COAS, (u29) ROFFS
7	Oregon and Washington	(u24) LOICZ, (u27) NOAA_COAS
8	Plumes and Blooms	(u13) ICESS_UCSB, (u24) LOICZ
9	Puerto Rico	(u1) CarICOOS; (u24) LOICZ, (u25) MSU, (u29) ROFFS
10	Benguela	(u4) CSIR, (u24) LOICZ
11	China, Korea, Japan	(u8) DMI, (u21) ITC; (u22) JAXA; (u23) KORDI; (u24) LOICZ, (u25) MSU; (u35) IOW
12	Great Barrier Reef	(u5) CSIRO; (u24) LOICZ, (u25) MSU, (u29) ROFFS, (u38) EOMAP
13	Red Sea	(u24) LOICZ, (u34) NIOF

14	Indonesian Waters	(u8) DMI, (u24) LOICZ, (u35) IOW
15	Beibu Bay	(u8) DMI, (u24) LOICZ, (u35) IOW
16	Namibian Waters	(u24) LOICZ, (u35) IOW
17	Cape Verde	(u9) EEA, (u14) INRH, (u24) LOICZ, (u35) IOW
18	Lena Delta and New Siberian Islands	(u8) DMI, (u24) LOICZ, (u36) GKSS-ARCTIC
19	Kara Sea	(u8) DMI, (u24) LOICZ, (u36) GKSS-ARCTIC
20	Central California	(u13) ICESS, (u24) LOICZ
21	French Guyana and Amazon Delta	(u24) LOICZ, (u40) INPE
22	South India	(u24) LOICZ, (u37) INCOIS
23	Antares – Ubatuba	(u24) LOICZ, (u40) INPE
24	Lake Erie and Lake St. Clair	(u24) LOICZ, (u25) MSU, (u27) NOAA
25	Tasmania	(u5) CSIRO, (u24) LOICZ
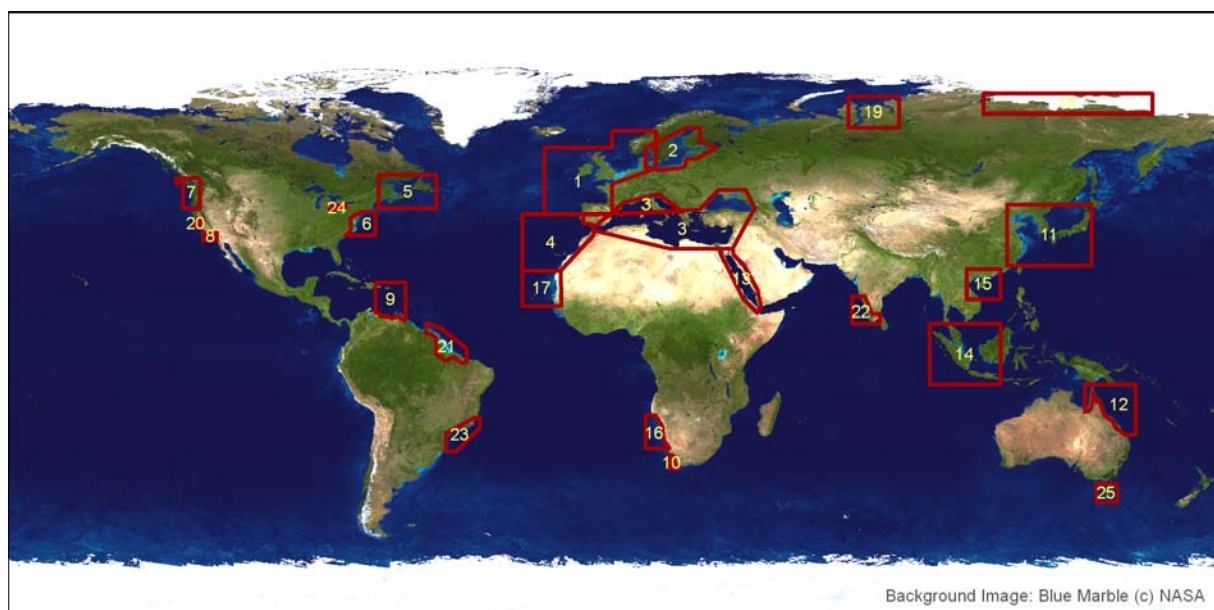
Figure 1: Map showing the location and extend of the test sites.

4.2 Product Requirements

4.2.1 Required Products

The following list is the synthesis of products requested by the users and grouped into standard products which will be generated for each site with well known algorithms, with a second group of experimental products which will be generated only for specific sites and where the algorithms are known but not yet well established, and other products which are unlikely to be produced in Coastcolour (actually only one product is left over on this list after conduction of the user inter-views)

Table 2: Consolidated list of products

1	Standard Products	
1.1	Level 1P	
1.1.1	TOA radiances / TOA reflectances (L1P)	These products include speckle destriping, smile correction, adjacency correction (tbd) and precise geolocation.
1.1.2	Pixel classification flags	Cloud, land, water, snow/ice, mixed land-water, partially cloudy, bottom reflection risk, out-of-scope spectrum, taxonomic types of blooms (cyanobacteria, red tides)
1.2	Level 2 radiometric products	
1.2.1	Bi-directional Water leaving radiance reflectance, RLw (Remote sensing reflectances)	
1.2.3	Fully normalized water leaving radiance reflectance, RLnw	
1.3	IOP	
1.3.1	total absorption coefficient (a_tot) at MERIS band 2, 443 nm	These coefficients can also be provided for all MERIS bands 1-7,8. The values are then derived from the bio-optical model, which has been used for the algorithm. Alternatively the IOP spectra of the model with its uncertainties can be provided, which then can be used to compute the IOPs at the other spectral bands.
1.3.2	total scattering coefficient (b_tot) at MERIS band 2, 443 nm	
1.3.3	phytoplankton pigment absorption coefficient (a_pig) at MERIs band 2, 443 nm	
1.3.4	Gelbstoff/CDOM absorption coefficient (a_gelb) at MERIS band 2, 443 nm	
1.3.5	Absorption coefficent of bleached organic particulate matter (a_poc) at MERIs band 2	
1.4	AOPs	
1.4.1	Downwelling irradiance attenuation coefficient kd for MERIS bands 1-7,9	
1.4.2	Maximal signal depth z90max (depth from which 90% of the reflected light comes from)	
1.4.3	Estimate of Secchi Disc depth from kd values	
1.4.4	Fluorescence Line height	calculated with standard procedure
1.5	Concentrations	
	Chlorophyll-a	All of these concentrations are derived from the IOPs. The conversion factors or equations will be documented and can be changed by the user, so that he can apply his own conversions in BEAM using the math expression tool
	Total suspended matter dry weight (TSM)	
	CDOM	
1.6	Uncertainties	
1.6.1	Per product uncertainty / error estimate	For all products an out of scope flag and index will be provided as well as an estimate of uncertainty
2	Experimental Products	
2.1.1	Turbidity in Formazine units	Requested by (u8) DMI

			→ shall be generated for sites (1) North Sea et al (2) Baltic Sea (11) China, Korea, Japan (14) Indonesian Waters (15) Beibu Bay (18) Lena Delta and New Siberian Islands (19) Kara Sea
2.1.2	1% depth of PAR		Requested by (u5) CSIRO → shall be generated for sites (12) Great Barrier Reef (25) Tasmania
2.1.3	Primary Productivity or Potential Primary Productivity		requires the knowledge of PI parameters, PPP is without nutrient limitations; requested by (u2) CEFAS, (u5) CSIRO, (u7) DFO, (u14) INRH, (u16) IMI, (u23) KORDI, (u28) PML, (u30) SYKE → shall be generated for sites (1) North Sea et al (2) Baltic Sea (4) Morocco (5) Acadia (11) China, Korea, Japan (12) Great Barrier Reef (17) Cape Verde (25) Tasmania
2.1.4	Phytoplankton Biomass estimates in gC m-3 or gC m-2 units		Requested by (u10) EMI, (u14) INRH, (u30) SYKE → shall be generated for sites (2) Baltic Sea (4) Morocco (17) Cape Verde
2.1.5	Concentrations of some taxonomic of unctional groups such as coccolithophorides, Cyanobacteria etc		if abundant in dominating concentrations; requested by (u7) DFO, (u8) DMI, (u23) KORDI, (u27) NOAA, (u35) IOW → shall be generated for all site because LOICZ would like to get it. Without LOICZ this parameter is asked to be generated for (1) North Sea et al (2) Baltic Sea (5) Acadia (6) Chesapeake Bay (7) Oregon and Washington (11) China, Korea, Japan (14) Indonesian Waters (15) Beibu Bay (16) Namibian Waters (17) Cape Verde (18) Lena Delta and New Siberian Islands (19) Kara Sea (24) Lake Erie & Lake St. Clair
2.1.6	Effective Fluorescence		Derived from difference of water leaving radiance reflectance between direct output of neural network and difference between top of atmosphere reflectance (RLtoa) and path radiance reflectance (RLpath).

			Requested by (u5) CSIRO, (u7) DFO
3	**Other**		
3.1.1	phytoplankton functional types		After discussion with the user this has been changed to taxonomic types of bloom events (cyanobacteria, red tides) and is cover by product 1.1.2 (requested by (u2) CEFAS
3.1.2	particle size distribution		Not possible Requested by (u6) BIO-DFO, (u28) PML

4.2.2 Algorithm, uncertainties and accuracy requirements

Table 4 provides a synthesis of the algorithm requirements as derived from the URDs and the subsequent interviews with the users. The list of planned products fulfils the requirements of nearly all users.

Problems occur in shallow water, where bottom reflection contributes to RLw.

Phytoplankton functional types requirements have been relaxed, now taxonomic types of bloom events (cyanobacteria, red tides) are requested, which is covered by the proposed Coastcolour product suite.

Only a few users can provide full data sets for setting up regional bio-optical models, but ranges and RLw measurements can be provided to constrain data for training NN, also factors for converting IOPs into concentrations are partly available.

Surprisingly only few users requested product uncertainties, and no user has put requirements on product accuracy. The latter is probably due to the fact that most users are expert ocean colour scientists and know that today no standard product is giving satisfactory results at all in the coastal zone. An accuracy requirement of 5% for the water leaving reflectance in the blue part of the spectrum is the typical value to be achieved, however, todays standard algorithms are far away from this goal. Some user express their expectation that Coastcolour products should be significantly better than the current standard products, in order to be able to perform good science and to support operational monitoring.

The specification of accuracy goals for products such as IOPs or concentrations is impossible for optically complex waters. The error/uncertainty/accuracy of the retrieval of one parameter depends on the level of concentration of the other parameters, as well as the error of those. This has been discussed by Doerffer recently on the ESA Living Planet Symposium.

In conclusion the users require a comparison of the CoastColour products with current standard ocean colour products, as well as with in-situ measurements. Their expectation will be met if the comparison shows a significant improvement in agreement.

A special algorithm for kelp detection is requested which is currently not available but possible using the 709 nm band of MERIS (as for the Maximum Chlorophyll Index, MCI).

4.2.3 Spatial resolution and temporal frequency Requirements

Almost all users point out the importance of the 300m spatial resolution of MERIS for coastal applications. One reason is the high spatial heterogeneity of coastal waters, but also explicitly mentioned is the need to get data very close to the coast in order to gather information required for Water Framework Directive reporting (CEFAS, IFREMER, EPA, UCC, SYKE), or to serve operational customers such as fish farms and mussel farms (Ifremer, KORDI, JAXA). The Water Framework Directive covers the coastal water up to 1nm off the baseline (SYKE translates this into 2km off the coast), and the US user ROFFS specified special interest in the first 5km off the coast. Several users discuss consistently that neither the products from SeaWiFS and MODIS, not the currently operational available MERIS products fulfil this requirement.

The users are less keen in specifying temporal frequency requirements. Probably due to the fact that most users are expert Marine Earth Observation scientists, the expectations are rather low, if mentioned at all (1 product per week, or even less frequent). However, for time series analysis (requested for example by EPA and EEA) it is important to avoid large gaps, and for applications which are not within the first few kilometres the high spatial resolution is less important. Hence it should be considered to introduce RR products where large gaps exist in the FR data. Only when these gaps are due to technical issues and not cloud coverage the RR data can mitigate the problem. Using the requirements for time series analysis as baseline it should be envisaged to avoid data gaps larger than 1 month.

Merging FR and RR requires a careful screening of the RR products for sub-pixel errors. Users point out that a careful screening is of very high importance (CEFAS, CSIRO), and this applies even more to RR than FR data.

4.2.4   Product delivery requirements (NRT, access and format)

Most users require CoastColour products for development or refinement of their own algorithms. This includes both scientific institute as well as operational users. For such purpose archived data are sufficient, and the users point out that it is more important to have as many archived data available as possible, i.e. they request data from before 2005.

However, some users develop services for operational monitoring, fisheries and fish farms and mussel farms. Such services require Near Real Time data access. In addition, all users from operational services require NRT data. In total 23 of the 40 users request NRT data access. This requirement is not always explicitly mentioned by the user but can be deduced from its application. The expectation for a NRT service varies between 1 day after acquisition down to as fast as possible / 1 hour.

No 4 users specify their need for data access. Two mention distribution via DDS (CSRI, South Africa, EMI Estonia where DDS is available through Tartu Observatory), for one it is assumed that an interest exists due to its link with the telecommunication section of the University (NUIM, Ireland). Only CSIR identifies access to data through DDS as of critical importance due to the poor internet quality in Africa.

Many users are systematically using SeaWiFS and MODIS data, which they download via http or ftp from a NASA server. DMI explicitly states that they want "online access", and for most other users it can be assumed that they expect the same online access as they are known from the US data.

Table 3: NRT requirements per user

User		NRT	Comment
1	CariCOOS	-	
2	CEFAS	-	
3	CNR	yes	
4	CSIR	yes	
5	CSIRO	-	
6	BIO-DFO	yes	
7	DFO QUEBEC	yes	
8	DMI	yes	
9	EEA	-	
10	EMI	yes	
11	GKSS	yes	
12	HCMR	-	
13	ICESS UCSB	yes	1 day is sufficient
14	INRH	yes	
15	EPA	-	

16	Marine Institute	yes	HAB warning system
17	Techworks	yes	
18	UCC	-	In the long term NRT might be required
19	NUI/MRI	-	
20	NUIM /DCU	yes	
21	ITC	-	
22	Jaxa	yes	HAB service
23	Kordi	yes	HAB and Jelly Fish service
24	LOICZ	-	
25	MSU	yes	
26	NASA OBPG	yes	
27	NOAA	yes	
28	PML	yes	
29	ROFFS	yes	"the faster the better"
30	SYKE	yes	
31	SU	-	
32	UNICAN	-	
33	Ifremer	yes	Real time service to oyster farmers
34	NIOF	-	
35	IOW	yes	
36	GKSS-Arktic	-	
37	INCOIS		
38	Eomap	yes	
39	IAFE		
40	INPE		

Table 4: Algorithm requirements

User	data for algo adaptation	Atmospheric corrrection	Basic IOPs,Chl., TSM, CDOM	Light field kd, z90, 1%par	PP parameters	Blooms /PFT	Others
Caricoos	TSM conversion	wants T865 data for own AC	yes	PAR 1% depth		phycoerythrin	bottom reflec-tion correction need
CEFAS	Primary produc-tion parameters will be available in 1 year time.		TSM, chl. total water column, sur-face multiplied with depth / upper mixed layer (tbc)	required for PP	Smyth semi-analytical model, testing the JRC primary produc-tion model of Mark Dowell, own model for PP	phytoplankton taxonomic if abundant, dia-toms, picos, coc-colithophores 3 useful groups	
CNR_Italy		all data incl. TOA, and BOA, AOT	yes all	Kd 490 MERIS bands 1-7 and 9)			want to devel-op hydrocar-bon algorithms
CSIR_South_africa		L1 data for own AC	all MEGS L2 data				only standard (MEGS) L1 and L2 archive + NRT
CSIRO	variability in IOPs and TSM concentration in GBR is 6 fold. this extreme var-iability will be handled by con-		CDOM important for freshwater plumes, uncertain-ties are key issue for all concentra-tions	bottom reflection a problem GBR		Trichodesmium outbreaks, Cyano-bacteria, Co-colithophores and Diatoms	need separation between TSM and NAP (non algal particles), Reef mask bot-tom reflection is available

User	data for algo adaptation	Atmospheric corrrection	Basic IOPs,Chl., TSM, CDOM	Light field kd, z90, 1%par	PP parameters	Blooms /PFT	Others
	version factors and algorithms is a concern for AD and TS, CDOM threshold for freshwater, Chl-a other pigments (HPLC), CDOM, AOPs and IOPs. spectra variability data						
DMI			TSM, Chl	z90 for data assimilation		HAB or exceptional blooms, locations, areas sufficient	NRT interest
EMI	AC-S, BB3, VSF3, CDOM, phycocyanin and Chl fluorometers	RLw	all data				all data from list, interest in sea ice
GKSS	AC-S, BB6, PSICAM etc.	RLw	All dta	Z90	PI parameters		all data from list, also for arctic region

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User	data for algo adaptation	Atmospheric corrrection	Basic IOPs,Chl., TSM, CDOM	Light field kd, z90, 1%par	PP parameters	Blooms /PFT	Others
HCMR_Greece			all			Pigments other than Chl. no longer required	error level of less that 10% when compared with in situ data.
UCSB	has spectral kd	importance of AC in turbid water	IOPs of all components				kelp detection using 709 band, may require special AC
INRH			chl.		yes		
IRISH_EPA			chl.				Chl maps to derive seasonal growth rates
IRISH_MI			Chl., TSM	Kd490 or KdPAR			
UniCork			Chl. (only FR)				
ITC		TOA and BOA, own AC	IOPs				will develop own algos
MSU		RLw	IOPs for comparison, has own algos	1%par			bottom reflection, water depth
NASA		TOA and BOA data					comparison with own AC

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User	data for algo adaptation	Atmospheric corrrection	Basic IOPs,Chl., TSM, CDOM	Light field kd, z90, 1%par	PP parameters	Blooms /PFT	Others
							and water algos
PML_UK			Chla, apig, atot, at all MERIS bands, back-scattering, SPM		PP		
ROFFS			main interest in Chlorophyll a				important NRT
SYKE	min, max, median of concentrations, monthly yearly		turbidity, Chl.	spectral kd, Secchi disk depth		phycocyanin, species composition, areas of floating alga	areas where bottom is witin 1% depth, mask with risk of land provided (small islands)
UniStockholm		water leaving reflectances	concentrations				ICOL seems to be very important
UNICAN		(L1 no longer important), RLw, nRLw	Chlorophyll SPM, CDOM,a_tot, b_tot, a_pig, a_gelb, a_poc	kd490, 1%PAR			salinity

User	data for algo adaptation	Atmospheric corrrection	Basic IOPs,Chl., TSM, CDOM	Light field kd, z90, 1%par	PP parameters	Blooms /PFT	Others
Ifremer			Chl., TSM, MEGS L2 products				NRT important
NIOF			chl, TSM			blooms in Nile delta	

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4.3 Scientific Requirements

In order to fulfil the product requirements of the users, algorithms have to be put in place to generate such data products. The requirement to have regionally optimised and adapted products induces additional challenges. The following chapters summarize the requirements to generate the products and challenges to be addressed. Details can be found in the Technical Specification Document.

4.3.1   Atmospheric correction

The correction of the influence of the atmosphere (shortly *atmospheric correction, AC*) is the most critical step in ocean colour remote sensing of case 2 coastal waters. All other steps in generating products depend on the success of the AC, with a few exceptions such as the MCI and the TOA FLH algorithms. Thus, it is also necessary to identify cases on pixel by pixel basis when the AC fails.

In the case of high concentrations of humic matter in the water (gelbstoff) the reflection of the water body can become extremely small so that algorithms fail, which are based on an extrapolation of the path radiance from the red and near infrared bands to the blue-green spectral range. They produce incorrect water leaving reflectance spectra, partly with negative reflectances in the first 1-3 bands. In clear water cases the reflectance in the red bands are very low and unreliable and cause a problem when submitted to the water neural network algorithm. To avoid these problem an atmospheric correction procedure is necessaryy, which reconstructs the water leaving radiance reflectance from TOA reflectance e.g. by using an artificial neural network. Furthermore it must be able to correct also sun glint contaminated pixels. Finally the adjacency effect has to be corrected, which is caused by the reflection of land surfaces or other bright targets in the vicinity of the area under observation.

Since aerosol optical properties can be different in the Coastcolour regions it will be necessary to compile adapted data sets for each region.

4.3.2   Water Algorithm

Coastal waters can be quite different with respect to the large variety of water constituents including various suspended solids, organic matter compounds, phytoplankton communities and floating material. Furthermore these constituents have varying optical properties and their vertical distribution can be different. In shallow waters also the bottom may contribute to the reflectance. All these properties have to be considered in regionally adapted bio-optical models. The variability has to be quantified for the determination of uncertainties. The algorithms to determine the requested variables have to be defined on the basis of the bio-optical model and the variability. The scope of the algorithm has to be defined and a procedure has to be developed to detect conditions which are out of scope.

Finally the algorithm must be able to determine the expected uncertainties.

4.3.2.1. Inherent Optical Properties

The inherent optical properties are the basic products which are computed from the water leaving reflectance. The total absorption and total scattering coefficients are the most stable products. These have to be split into the different components such as a_pig, or a_tsm according to the regional bio-optical model. For this purpose the regional bio-optical component models are necessary.

4.3.2.2. Apparent Optical Properties

The apparent optical properties (AOP) have to be derived from the IOP outputs, they comprise kd, the spectral attenuation coefficient of the downwelling irradiance from which the signal depth

(z90), the attenuation depth, the depth of the euphotic zone (z_eu) and the Secchi disc depth can be computed.

4.3.2.3. Fluorescence Retrieval/ Maximum Chlorophyll Index (MCI)

The solar stimulated fluorescence of phytoplankton chlorophyll and extremely high concentrations of chlorophyll can be derived without atmospheric correction. These algorithms are required for extreme cases and can be applied also to floating cyanobacteria and exceptional plankton blooms. Since they use spectral bands in the red to NIR range they can also be applied to shallow water, where the penetration depth is limited by pure water absorption.

4.3.2.4. Phytoplankton Products

4.3.2.4.1 Chlorophyll concentration

The chlorophyll concentration is the core biological variable, which is required by nearly all users. Since the absorption spectra are variable and depend on species compositon, bio-optical measurements are necessary to adapt the algorithm to local or seasonal conditions. The conversion parameters IOP-> concentration requires to be empirically determined from samples. They will be taken from the local user in the case that these parameters can be provided or from standard values, which are taken from measurements of the coastcolour team and / or literature.

4.3.2.4.2 Phytoplankton biomass

The biomass has to be defined by the user. It can be the dry or wet weight or, preferably, the carbon content. The conversion factors have to be delivered by the user of the site. If not available, published conversion factors will be used, which either convert a_pig or the chlorophyll concentration into biomass.

4.3.2.4.3 Phytoplankton types

Red tides

Phytoplankton types can only be determined if they have a characteristic absorption spectra, such as Red Tide forming species, cyanobacteria, phaeocystis and coccolithophorides. Other groups such as diatoms and dinoflagellates have a similar absorption spectrum so that they can hardly be distinguished from each other. However, in some optically complex coastal waters the separation of different species from other substances might be difficult or even impossible.

4.3.2.5. Primary Production

Primary production is the most complex product required by some users. It cannot be determined from ocean colour data directly, because it requires a model and some additional information including the PI parameters, which desribe the relationship between light and production per unit of chlorophyll. These data have to be provided by the users. Alternative standard values will be used, which then would produce a kind of potential primary production.

4.3.3 Validation Requirements

The control of the data products and the generation of uncertainty maps is a key issue for the acceptance of RS products for any scientific and operational application. Due to the complexity of coastal waters with respect to water constituents and optical components involved this requirement is a high challenge and we are in some cases at the limit what presently can be done. There are three areas how the quality of the data can be assessed, monitored and documented for the user.

1. The products have to be associated with respective algorithms for recognizing input spectra which are out of scope of that algorithm, and the uncertainty has to be determined for each of the

product. These associated quality algorithms will then provide this information in the form of flags and/or quantify the degree as numbers.

2. The products can be verified without any in situ data by tests regarding the noise level, artefacts such as striping or camera boundaries. One important issue is the quality of the atmospheric correction, i.e. the separation of the water leaving radiance reflectance from the TOA reflectance. This can be tested by analyzing the water leaving radiance reflectance and the path radiance reflectance along transects with cross strong gradients such as present in river plumes, blooms of coccolithophorids.

3. The data products have to be compared with in situ observations, which require accurate field measurements, the quality of which has also to be assessed and documented.

In order to assess the quality of the in situ data it is required that the data provider delivers all the information concerning radiometric data, instrument calibration history and maintenance, data processing, meteorological conditions and deployment strategy. Considering biogeochemical data, the complete knowledge of utilized protocols is essential; i.e., filtration process (type of filter, volume, vacuum pressure, filter washing), conservation of samples (liquid nitrogen, freezing temperature, time span between sampling and analysis). Specifically for higher level and experimentation products validation, a complete array of information is needed, namely: the equipment (i.e., methods and protocols used for phytoplankton biomass, pigments concentration, particle size distribution, and primary production).

All data has to be characterized with metadata, such as date, time, geographical location, and ancillary data (sea surface temperature, water depth).

Based on this information it shall be assessed if the data can be used directly for validation or if any conversions or adaptations have to be applied due to e.g. different protocols.

One major issue for the comparison with in situ data is the high degree of patchiness and dynamics of many coastal waters. Even in the case of a perfect measurement of a sample, the relationship with the product of a certain pixel remains uncertain due to the extremely different volumes as well as the synchronicity of the two types of samples.

Validation of the products with in situ data will be performed using statistical analysis such as correlations and frequency distributions, furthermore transect analysis by comparison with ship transect data and comparison with data of other satellite instruments.

The software shall support the validation as much as possible the process to run algorithm changes on a set of match-up products and perform standardised tests.

4.3.4   In-situ data requirements

In situ data are necessary not only for the validation of algorithms and products but also for the construction of bio-optical models as the basis of the algorithms for each of the test sites or water class.

The following in situ data are necessary to construct a bio-optical model: number of optical components, which determine the reflectance spectra, their inherent optical properties (absorption and scattering coefficients), the relationship between IOPs and concentrations and the variability / uncertainties for all parameters.

For the full radiative transfer models, which are used to simulate the calibration/training data sets, also the scattering functions, $b(\theta)$, or phase functions of particles (hydrosols, aerosols) are needed.

In the case of aerosols they will be computed using a Mie Code with the particle size distributions as well as the refractive indices as inputs. These properties will be partly derived from AERONET data base or from standard aerosol optical models. In the case of hydrosols, data of users (when available), own measurements of the team and literature values will be utilized. It is expected that for most areas phase function measurements will not be available. In these cases existing phase functions will be adapted to achieve measured bb/b ratios, which are available from measurements of band bb.

When special products are required, such as primary production, further parameters (e.g. PI parameters) have to be provided. In all cases, where no site or water class specific bio-optical data are available, data from literature or the generic data set will be used. However, the quality of the data for constructing the bio-optical model, determines to a large extend the quality of the algorithms and data products. Thus, the simulated reflectance spectra or the kd values will be compared with data for validation to check whether the bio-optical model comprises the cases observed for validation. Also the validation of the algorithm will proof the quality of the bio-optical model and its underlying data.

4.3.5   Documentation Requirements

4.3.5.1. Algorithm Theoretical Baseline Documents

Up to date ATBDs are required for all retrieval algorithms used. All ATBDs of all methods used shall be publicly available via the Coastcolour web portal

4.3.5.2. Consensus Case2 Regional Protocols

Users are increasingly interested in developing and/or utilising existing ocean-colour algorithms and data products tailored for their specific AOI. A series of synthesized protocols is required that documents agreed approaches for defining regional empirical and semi-analytical algorithms, including data requirements, available tools such as the BEAM, regional reflectance model module, etc. The protocols should address the following specific topics:

(a) An overview of the individual steps required to defining a regional ocean colour algorithm and documenting existing software and tools that can be used to undertake such a task.

(b) Specific documents going in more depth on the following:

- Minimum requirements for in-situ data for defining a regional algorithm

- Methods for the definition and parameterisation of a reflectance model (forward model) for a specific regional of interest, including techniques for atmospheric correction and modelling marine optics.

- Approaches to solving the inverse problem, including a comparison of different methods.

4.4   Round Robin Requirements

4.4.1   Introduction

Contacts with the Champion Users since the kick-off of the CoastColour project provide the following clarification of the User Requirements for the Round Robin exercise.

Firstly it was clarified at the kick-off meeting (3.2.2010) that the most important objective of the Round Robin activity within CoastColour is "to help users find the best algorithm/product for their region". This follows closely from the project objective given in the Statement of Work (SOW) "to develop, validate and demonstrate best-practice regional optimisations of MERIS Case 2 algorithms". The SOW gives the Round Robin task as to "organise open regional algorithm Round Robin comparing results of regional algorithms for MERIS and other ocean colour sensors" and notes the importance of encouraging external participants.

There is a long-term scientific interest in comparing ocean colour algorithm performance in order to understand how performance differences can be related to algorithm design. Progress in science made during CoastColour may also contribute to improved convergence or consensus within the ocean colour community regarding design of algorithms for Case 2 waters. However, within the lifetime of the project the main objective of the Round Robin exercise remains to help users find the best product/algorithm for their region. It is noted that the purpose of the Round Robin is not to choose the best processor for use within CoastColour. For reasons of timing this choice needs to be

made before the Round Robin activity is completed. However, at the end of the Round Robin activity the users should have a better idea of the best processor/algorithm for their region, whether this is the CoastColour algorithm, the standard (MEGS) MERIS algorithm or an alternative local or global algorithm.

4.4.2 Feedback from users

At the time of writing updated feedback was available from 25 out of the 32 champion users. Of these 13-16 expressed an interest to participate in the Round Robin exercise. Some of these users could contribute in situ data (marine reflectance, inherent optical properties and/or chlorophyll a measurements). Most of them have a local algorithm for chlorophyll a retrieval. A few have an algorithm for Inherent Optical Property retrieval. Potentially up to 7 have the capability to perform atmospheric correction at least for their local site, however it was not clear whether this capability is specific to MERIS or applicable to individual spectra as opposed to full images.

There was a general confusion over the scope of the Round Robin exercise with a tendency to confuse this activity with more general site-specific validation and product intercomparison activities. For example one user pointed out that their method for evaluating algorithms/products is to compare histograms for chlorophyll a over a few, large spatial subsets of their region of interest. This is clearly not a method that can be applied to all CoastColour test sites, since its relevance is quite specific to the interests of a single user.

There were also many questions about in situ data policy with different levels of accessibility being required for the in situ data of users. Some questions were received about whether algorithms would be run centrally or locally, and whether comparison data would be central or distributed.

However, the general impression was of considerable enthusiasm to be involved in the project via the Round Robin exercise.

4.4.3 Implications for the implementation of the Round Robin exercise

In view of the widely differing user impressions of what the Round Robin exercise will consist of in terms of input data (top-of-atmosphere or atmospherically-corrected? In situ, satellite or simulated?) and output data (marine reflectance and/or chlorophyll a and/or inherent optical properties?), it is clearly necessary to provide clarification of both the high level organisation of this exercise (definition of input/output parameters) as well as the details of how this will be achieved (responsabilities, formats, visualisation and analysis methods, etc.). This will be achieved by the Round Robin Protocol.

It should be clarified that participation in the Round Robin is not the only interaction that users may have with the CoastColour project. While the Round Robin exercise provides a uniformised framework for intercomparison of algorithms, including user-proposed algorithms, across all regions, the users can also collaborate by providing their own evaluation of the full CoastColour dataset for their region according to their individual site-specific criteria and methodology.

4.5 Product Specification Requirements

4.5.1 Input data requirements

The Statement of Work specifies the following input data:

- MERIS FR FRS data from 2005 to 2010 shall be processed

- where not sufficient FR data are available, use RR in addition.

The URDs and also the interviews did not provide a specification of "sufficient FR data available". All users were interested in Level 2 product and little requirements on Level 3 data (which would be easier to conclude on "sufficient"). An exception is EEA who is interested in indicators, highly integrated in space and time.

For the Round Robin exercise simulated TOA and water leaving reflectances have to be produced. They shall cover representative conditions for the test sites selected for the round robin.

For the algorithm intercomparison SeaWiFS, MODIS, and - if available – OCM and GOCI data shall be extracted over the sites and for selected time periods. Preference shall be given to such sites and time where appropriate in-situ data for validation are available.

4.5.2 Product Data Flow overview

Figure 2 gives an overview of the products that are generated, together with the timing.

The main processing line is in the centre of the figure. It starts with the L1b FRS, which are delivered by ESA. This dataset includes all MERIS FRS products acquired by ESA. These data need to be quality controlled, and the products over the sites covering the areas of interest of the champion users need to be extracted.

Due to timing of the project the L1P processing shall be performed in two chunks. The first set is a smaller set (< 10.000 products), to be ready early in the project and to be used for development and testing of the L2 prototype processors, but also for the Multi-sensor Round Robin exercise. The second, larger set comprises all remaining products.

In parallel with the L1P and prototype L2 processing, the FRS products of the AOIs shall be processed with the public MEGS (ODESA) to standard L2 products and will be reformatted into the Coastcolour format and grid. In a multi-sensor intercomparison the subset processed with the L2 prototypes will be compared with the MEGS processed products, corresponding products of MODIS, SeaWiFS, GOCI and OCM (if available) and in-situ data. If available, results from the Round Robin participants will be included in the intercomparison.

The result of this product intercomparison shall lead to the final design and implementation of the L2 processor. The right branch of the figure shows the MERIS RR data stream. According to user needs on data requirements, the FRS dataset shall be completed with RR data. This requires identification of required data and extraction of these from the global RR data archive. The L1b RR data have to be processed with a similar processing chain than the L1P processing. Geocorrection with AMORGOS is not necessary due to the larger pixel size, which is far above the geometric accuracy, and it would not be possible technically. A radiometric recalibration is not necessary because the RR data will be at third reprocessing level at that time. The L1P RR products will be merged into the dataflow of FRS data during L2 processing, and the final Coastcolour L2 dataset shall be processed.

4.5.3 Format requirements

The CoastColour users are all familiar with ocean colour products; all use the US SeaWiFS and MODIS data in the OBPG HDF-4 format and all use MERIS RR and (partly) FR data in the ENVISAT N1 format. Although not systematically asked for, some user identify that they use BEAM to access the MERIS and SeaDAS for the OBPG data.

Only few users include format in their requirements. They are more worried by parameters to be generated and algorithm to be used, and data availability. However, one user (ROFFS) finds a formulation that can be considered as consensus: "the data shall be easy to use". This can be best achieved by using one of the currently most widely used file types for scientific data, namely NetCDF and HDF, and by implementing a format that is as close as possible to that of one of current/future ocean colour sensors. Being an ESA mission, MERIS and OLCI should have preference when possible.

Although not many statements have been made by users concerning a specific format, 3 users request support of the files by BEAM, i.e. they would like to use the BEAM API in order to easily implement reading (writing?) routines in their software (NUIM/DCU, Ireland; NOAA, USA; NIOF, Egypt).

Implementing support for the CoastColour products in BEAM has further the advantage that the BEAM PCONVERT tool will be available to read CoastColour products and export them in a large number of raster image formats as well as important scientific data formats.

Two users (LOICZ, SYKE) request output of CoastColour products in a GIS compatible format, so that they can be imported into GIS systems. A quasi standard would be the ESRI shape file format, but also GeoTIFF is supported by GIS systems. With BEAM it is possible to export any opened product in GeoTIFF, and PCONVERT can be used in batch-mode for an operational processing.

Coming back to the file format, it should be taken into account that the file format for the input L1P and the output L2 products shall ideally be the same in order to reduce specification redundancies and ease data access and software development. Most importantly, the file format shall be

1. self-describing and self-contained,

2. supported by a number of imaging applications and software libraries,

3. well-known and accepted within the EO user community.

Both, the HDF and NetCDF data formats meet these requirements; in fact they have been developed to support scientists, researchers and engineers and are in use in a number of ESA projects such as GlobCover (HDF), GlobColour, Medspiration, GlobAerosol, Globvapour and the Sentinel 3 L1/L2 Product Definition and Proto studies (all NetCDF).

The growing number of ESA projects utilizing the NetCDF format is actually reason enough to go for it. Another major impact is described in the following. Applications reading and writing HDF- and NetCDF-formatted files typically use a dedicated library to do that. HDF and NetCDF libraries are available for a number of programming environments and languages, e.g. C, Java, IDL and MATLAB. In contrast to HDF, a pure Java implementation of the NetCDF 3 and 4 formats is available (which even can read HDF 4 and 5). The HDF Java library actually is a wrapper of the HDF C library and as such uses a shared library binding, which makes it highly dependent on specific hardware architecture (32/64 bit). A pure Java implementation of the file-formatting library is highly desirable as all the processing chains developed in this project will be implemented in Java and compiled against the BEAM Java APIs. Platform and architecture independence is an important issue since it shall be easy to deploy the processing code on different computers in order to parallelize the data processing and address the NRT requirements in this project.

A common product format is currently under development for all ESA Glob* projects as part of the Globtoolbox project. It shall be investigated if this format is also applicable to the Coastcolour products. Alternatively, as part of the public MEGS development currently ongoing (ODESA) a flexible netCDF based format has been developed. Also this is a candidate product format that shall be considered.

4.5.4   Common Grid

CoastColour users are mainly remote sensing experts; they require easy access to MERIS FR data and products of best possible quality. They will integrate these data into their further processing chains, use them for validation or algorithm development. For all these use cases Level 2 type of data are required, i.e. data in satellite coordinates, but no higher temporal or spatial integration level (i.e. no Level 3 or higher data).

This implies that Coastcolour products shall remain in the original satellite coordinates. The grid of the MERIS FRS product shall not be changed. In fact, it would become impossible to use the data for validation, intercomparison with other satellites and algorithm development if the products would be projected, or spatially / temporally integrated.

User require the data in highest spatial resolution, i.e. 300m. this implies that a merged FR / RR product, the RR data shall be resampled to a corresponding FR grid.

4.5.5   Meta Data

The Coastcolour products shall contain meta data to describe its content. The meta data shall include at least

- Processing software version

- Processing auxiliary data version

- Processing centre and date

- Location on earth (lat, lon)

- bathymetry

- sun and viewing geometry

- ECMWF data (copy from MERIS FRS)

Wherever possible the meta data shall be compliant with the CF Conventions.

4.5.1   Level 1P Product

The Level 1P product shall contain TOA radiances in 15 MERIS bands, the detector index, and the geolocation information at pixel grid resolution. The product shall further contain a copy of the MERIS L1b data as well as L1P flags (pixel classification, spectrum classification).

4.5.2   Level 2 Product(s)

The Level 2 products shall include water leaving radiance reflectances (directional and normalised) and associated errors at pixel level. It shall further include aerosol optical depth and the Angstrom exponents at 865nm. The product shall include algorithm specific flags.

Further, the product shall include inherent and apparent optical properties as defined in the algorithm section of this document. All variables shall be accompanied by per-pixel error estimates, where algorithmically possible.

4.5.1   Product design and sizes

There are no explicit requirements on the product size. However, at Level 2 large number of bio-geophysical variables can be generated, and not all variables will be available for all sites. It should be considered to distribute the Level 2 variables into several Level 2 products; those containing variables common to all sites (surface reflectances, IOPs, ...) and those containing site specific products.

Assuming a typical raster size of 4000 x 6000 pixels (corresponding to 1.200km x 1.800km) or 2.4e7 pixels, one single variable stored in a scaled 4 byte integer band makes up 91MByte. A spectral variable of 10 bands (e.g. surface reflectance) makes 910MByte plus another 91MByte for the associated uncertainty, i.e. 1 GByte. This should be considered as a reasonable size for a single product file. The next set of variables, e.g. IOPs and AOPs would also easily make up a product file of 1 GB depending on number of associated uncertainty products.
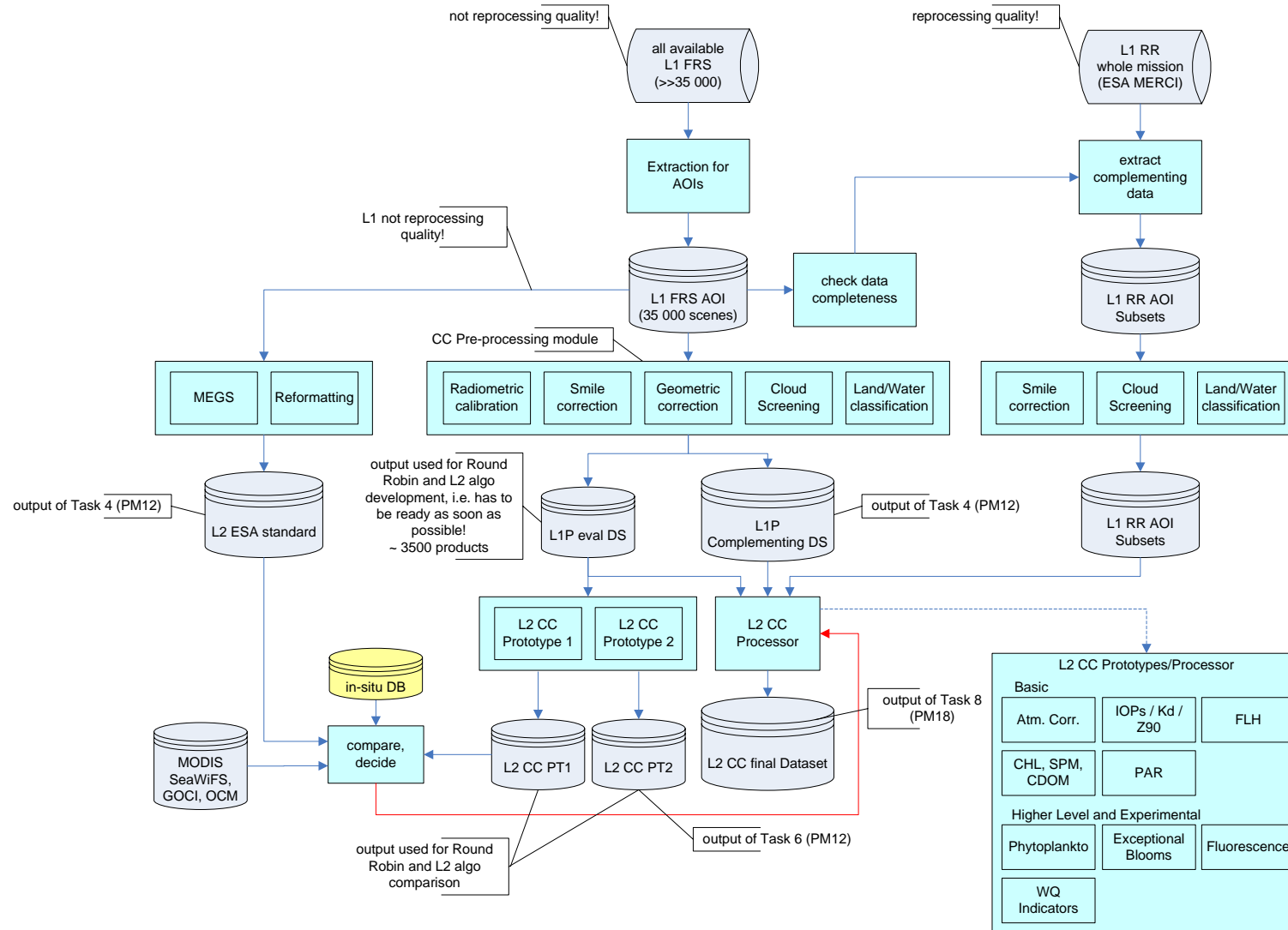
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Figure 2: Data flow and Products

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4.6 Processing Requirements

4.6.1 Processing times

The overall project schedule defines the processing time requirements:

The first set of products to be delivered in September 2010 is the Round Robin Data Package. This consists of Level 1P data as well as surface reflectances. The subset of products is estimated as ~ 10 000 products. The processing requires all Level 1P algorithms ready and validated, as well as the atmospheric correction implemented and tested. According to schedule the Level 1 software will be ready in May, and the atmospheric correction in June 2010. The processing of the Round Robin Dataset should hence be completed within two months. The production requirement should then be ~150 products per day. This includes parallelisation of processing.

The production of the remaining Level 1P data comprises another 25 000 products until December 2010 or in 3-4 months. This translates into a production requirement of 230 products per day.

The Level 2 processing starts in March 2011 and has to be completed in June 2011, i.e. within 3 months. This requires production of 388 products per day.

4.6.2 Near Real time processing

The Coastcolour processing chain that is used to generate the final (historical) products shall run for 6 months to generate near real time products. Input to this system shall be MERIS FR(S) products which are available in real time at the time of the demonstration service.

One user requested NRT data which shall be available within 1 hour after overpass of the satellite.

4.7 Software Requirements

4.7.1 Processing System

The mass production of higher level Earth Observation products can be split into two distinct elements:

1) The scientific processors. Each scientific processor is a piece of software that takes one or more input data, runs a specific scientific algorithm on these products (e.g. an atmospheric correction) and generates one or more output products. The challenge here is primarily the appropriateness of the scientific algorithm and its correct and effective implementation.

2) The processing system. This connects all scientific processors that are required to generate the finally resulting products, and takes care of running this chain of processors on all input data. It is a data management system (DMS) and a processing management system (PMS).

These two elements should be decoupled for maximum reuse. The processors should be configurable via external configuration information (typically stored in config files), invoked with a processing request (that specifies input and output data for a specific processing job) and should ideally provide status information during execution. The processors should terminate with a report on the completed job. The processing system should support these interfaces: it should maintain a configuration control database for the processors, prepare the processing requests, monitor the processing and register the result of the completed processing in product and processing meta data. It should finally take care of providing input data and submitting the output data to the next processing job.

In summary, the interface between scientific processors and processing system are

- Processor configuration
- Processing request
- Processing monitoring
- Input/output data management

If this is provided, the actual implementation language of a processor does not impact the processing system.

4.7.2 Scientific Processors

The scientific processors shall be available as public domain software. One user requested explicitly BEAM processors. The software shall be accompanied with proper documentation, i.e. software user manual, product user manual, algorithm theoretical basis document and validation report.

4.7.3 In-situ database

The in-situ data used for the project shall be stored in a database. This database has the primary objective to provide structured and well document access to the in-situ data, to be used for algorithm calibration and product validation. The secondary objective of the database is to make those in-situ data available publicly where the data originator has agreed. This requires technically a software in place which provides the required organised storage of the data along with associated meta data, and with the capability to be connected with a Webportal (see below). The software has to provide access control and different user profile, in order to grant user specific access rights to the data.

It is further required to define a Coastcolour Data Policy, which needs to be agreed with ESA and all in-situ data providers.

The Webportal (see below) shall include a functionality; it is required for extracting time series of the ocean-colour products over a given geographical location, and select the corresponding in-situ data from the in-situ database in order to generate statistics of match-ups with in-situ data held by Coastcolour.

4.7.4 Web Portal

The Coastcolour web portal shall be the host for the Coastcolour project. The portal shall provide information about the available regional Case 2 algorithms and data products, as well as an information resource facilitating the implementation of new regional algorithms. It shall further serve as a collaboration platform for the Coastcolour team. As such it is a typical Web 2.0 application requiring modern, rich featured portal server to be effectively realised.

The portal shall include the following elements:

The Coastcolour web portal will be a distributed system. It includes (basically):

- Central management (entry page, link to distributed facilities)
- Static content (project information, reference documentation, planning of the project, announcements for user workshops, Round Robin protocol, …)
- Internal Wiki
- Access to earth observation data
- Access to in-situ data
- Processing and analysis functions

4.7.4.1. Geographical database

The Web Portal shall include an interactive geographical database with the following functionalities:

- Information on the optical properties of different regional water types.
- A geographically mapped bibliography of regional algorithms including differentiation of optical water types through class-based approaches, so that the novice to the field can evaluate whether regional algorithms exist for their region or for a similar optical water type, and their performance in relation to standard global products.
- A facility shall be provided for registered users to update the bibliography.
- Information on the existing regional and class-based ocean-colour algorithms.

- Thematic products showing the optical classification of different waters (both traditional, Case 1/Case 2, and statistical classification products (e.g., novelty detection, fuzzy logic).
- Available cal/val information, and a bibliography of cal/val studies.
- Guides on how to access satellite data provided by the space agencies, and information on re-processing activities.
- Description and links to all sources of in-situ data.

4.7.4.2. FTP access

FTP access to all Coastcolour ocean-colour products over the Coastcolour AOIs (including TOA radiances, normalised water leaving radiances, ocean-colour products, ancillary data and error statistics). This section shall include all prototype and final Coastcolour products, as well as any relevant products contributed by the Coastcolour User Group.

A facility is required for extracting time series of the ocean-colour products over a given geographical location, as well as statistics of match-ups with in-situ data held by Coastcolour. Other information made available through ftp shall include

- ATBDs and all public project documentation. Links to best practice protocols for defining regional algorithms for a specific area.
- Links to related activities, and a page announcing future meetings.
- A password protected section containing project internal documentation, such as all draft document deliverables, RIDs, meeting minutes, actions database, monthly reports, project management plan, etc.

4.7.4.3. Additional requirements for the portal

The following requirements have been extracted from the ESA statement of work on the Webportal:

- Access to all data products hosted on the web portal shall require the user to enter their email address, which shall then be added to the Coastcolour mailing list.
- Access to the project internal section and the facility to update the bibliography shall require registration.
- The geographic database shall adopt a standards compliant map server (or equivalent) based architecture.
- The web portal shall be kept permanently online for at least the duration of the project. It is expected that members of the Science Team shall ensure maintenance of the web portal following the end of the contract.
- All data and information accessible via the portal shall by default be provided publicly and without restriction.
- All sources of data and information products shall be fully acknowledged.

5 ACRONYMS AND ABBREVIATIONS

AATSR	Advance Along Track Scanning Radiometer
AC	Atmospheric Correction
AMORGOS	Accurate MERIS ortho-rectified geolocation operational software
ANN	Artificial neural network
AOI	Area of interest
AOP	Apparent optical properties
API	Application Programming Interface
ATBD	Algorithm theoretical basis document
BC	Brockmann Consult
BEAM	Basic Envisat AATSR and MERIS toolbox
BOA	Bottom of Atmosphere
BRF	Bidirectional Reflectance Factor
CC	CostColour
CDOM	Coloured dissolved organic matter
CEOS	Committee on Earth Observation Satellites
Chl	Chlorophyll
ChloroGIN	Chlorophyll Global Integrated Network
CO	Centre of Oceanography of the University Lisbon
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CZCS	Coastal Zone Colour Scanner
DDS	ESA's satellite data distribution system
DEL	Delivery
DJF	Design justification file
DPM	Detailed Processing Model
DPQR	Demonstration products and qualification report
DQWG	Data quality working group
DUE	Data User Element of the ESA Earth Observation Envelope Programme
ECSS	European Co-operation for Space Standardisation
EE	Earth Explorer (Mission)
ENVISAT	Environmental Satellite (http://envisat.esa.int)
EO	Earth observation
EOLI	ESA Earth Observation Link
ERS	European Remote Sensing satellite
ESA	European Space Agency
ESRIN	European Space Research Institute (http://www.esa.it/export/esaCP/index.html)
FFH	Flora Fauna Habitat Directive
FR	Full resolution (300m resolution MERIS products)
FRS	Full resolution full swath
FTP	File transfer protocol
FLH	Fluorescence Line Height
fwNN	forward artificial neural network
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GIOP	Generic IOP algorithm
GMES	Global Monitoring for Environment and Security
GOCI	Geostationary Ocean Color Imager

HAB	Harmful Algal Bloom
ICOL	Improve Contrast between Ocean and Land
IDE	Integrated development environment
IGBP	Geosphere Biosphere Program
INPE	National Institute for Space Research
IOCCG	International Ocean Colour Coordinating Group
IOP	Inherent optical properties
IPF	Instrument Processing Facility
ITT	Invitation to tender
IVM	Institute of Environmental Studies
JAI	Java advanced imaging
JIIO	Java image input/output
JRC	Joint Research Centre
Kd(490)	Diffuse absorption coefficient at 490 nm
KO	Project kick-off
KORDI	Korea Ocean Satellite Center
L1, L2	Level 1, Level 2
L1P	A pre-processed version of the standard Level-1 data products.
L2R	Advanced atmospherically corrected L1P data
LISE	University of the Littoral Opal Coast
LOICZ	Land Ocean Interaction in the Coastal Zone
LTO	Linear tape open
LUT	Look Up Table
MEGS	MERIS Ground Segment Data Processing Prototype
MERCI	MERIS Catalogue and Inventory
MERIS	Medium Resolution Imaging Spectrometer (ESA instrument)
MODIS	Moderate Resolution Imaging Spectrometer (NASA instrument)
MUMM	Management Unit of the North Sea Mathematical Models
NASA	National Aeronautics and Space Administration
NIR	Near InfraRed
NRT	Near-real time
OCM	Ocean Colour Monitor
OLCI	Ocean and Land Colour Instrument
OSSD	Open Source Software Development
PAR	Photosynthetically active radiation
PM	Progress meeting
PML	Plymouth Marine Laboratory
POGO	Partnership for Observation of the Global Oceans
PUG	Product User Guide
Q4	4th quarter of the year (October-December)
QA4EO	Quality Assurance Framework for Earth Observation data
QAA	quasi-analytical algorithm
RB	Requirements baseline
RD	Reference document
REVAMP	Regional Validation of MERIS chlorophyll Product
RID	Review item discrepancy
RH	relative humidity
ROI IOCCG	Regional bio-Optical algorithms Initiative
RLw	water leaving radiance reflectances
RR	Reduced resolution (1km resolution MERIS products)

RRob	Round Robin
SAFARI	Societal Applications in fisheries and Aquaculture using Remotely-sensed Imagery
SAG	Science advisory group
SDD	Secchi disk depth
SeaWiFS	Sea-viewing Wide Field-of-view Sensor (GeoEye/NASA instrument)
SoW	Statement of work
SPH	Specific Product Header
SPM	Suspended particulate material
SUM	System User Manual
SW	Software
TOA	Top of atmosphere
TOSA	top of standard atmosphere
TS	Technical specification
TSM	Total suspended matter
UCM	User consultation meeting
UML	Universal modelling language
VISAT	Visualisation and analysis tool
WFD	Water Framework Directive
WP	Work package
WPD	Work package description
XP	Extreme programming

6   Annex: User Requirement Documents