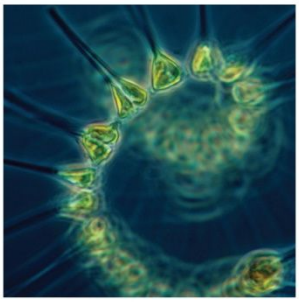
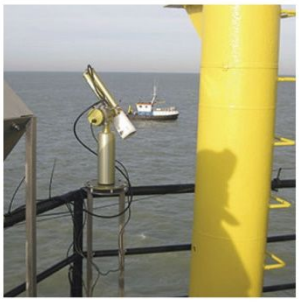
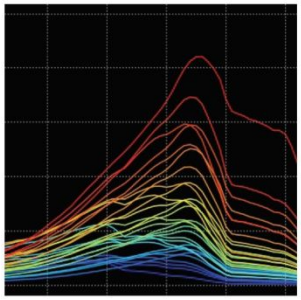
HIGHROC

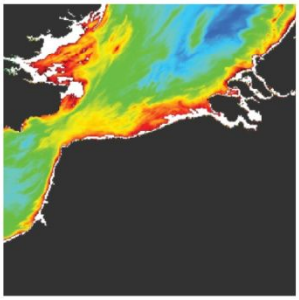
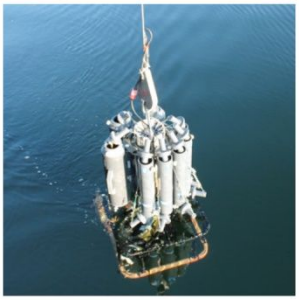
Science Conference

7-9 NOVEMBER 2017, BRUSSELS

How to exploit the large variety of ocean colour space borne data to provide a high spatio-temporal monitoring of coastal ocean?



highroc

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HIGH spatial and temporal Resolution Ocean Colour Remote Sensing (The HIGHROC Project)

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Rodney Forster, *University of Hull (UHULL)*
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And Eliza Capuzzo (CEFAS), Kate Collingworth (CEFAS), Sorin Constantin (was at LOV), Naomi Greenwood (CEFAS), Liesbeth De Keukelaere (VITO), Pierre Jaccard (NIVA), Héloise Lavigne (RBINS), Carole Lebreton (BC), Anna-Birgitta Ledang (NIVA), Sabine Marty (NIVA), Guillaume Morin (LOV), Bouchra Nechad (was at RBINS), Marit Norli (NIVA), Stefani Novoa (was at LOV), Anouck Ody (was at LOV), Tiago Silva (CEFAS), Kerstin Stelzer (BC), Dimitry Van der Zande (RBINS), Quinten Vanhellemont (RBINS).

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oral presentation

Session: introduction

The FP7/HIGHROC ("HIGH spatial and temporal Resolution Ocean Colour") Project has been developing the next generation of optical products for coastal water services. These products are based on both mainstream ocean colour sensors (Sentinel-3/OLCI, VIIRS) and other satellite missions such as the meteorological MSG/SEVIRI sensors and the land-oriented Landsat-8 (L8) and Sentinel-2 (S2) missions. SEVIRI gives data every 15 minutes from a geostationary orbit, offering much better temporal coverage in periods of scattered clouds and the possibility to follow diurnal and tidal processes in cloud-free periods, albeit at reduced spatial resolution. S2 and L8 offer much better spatial resolution, down to 10m (S2), allowing detection of many human impacts invisible at 300m resolution, albeit with lower frequency of acquisition. The HIGHROC project has carried out R&D activities to:

• develop algorithms for processing water colour data (atmospheric correction, suspended particulate matter and chlorophyll a estimation, euphotic depth, etc.)

• carry out in situ measurements, improve the methodologies for making such measurements and use these measurements for calibration and validation of algorithms and products

• develop image processing chains to mass process data from all the relevant missions

Services based on these new products have been supplied to end-users in User Service Trial regions to further refine the products with the objective of providing long-term sustainable services. This core user group covers a range of applications including: coastal water quality monitoring, e.g. the European Union Water Framework and Marine Strategy Framework Directives; Environmental Impact Assessment of activities and constructions at sea; sediment transport associated with offshore construction, sand extraction and dredging activities, etc. This presentation will show some of the highlights of the project, including results from S2, L8 and SEVIRI.

Increasing the satellite match-up numbers with autonomous bio-optical profilers

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oral presentation

Session: In situ measurements and validation

There is always deficit in match-up data for developing and validation of remote sensing algorithms. Sampling at sea and on lakes is time consuming and expensive and often it is not possible to organise the fieldwork exactly at the time of satellite overpass. Moreover, it is not always possible to organise the sampling during cloud free days in order to get match-ups. Autonomous systems is one of the possibilities to get match-up for every (at least partly) cloud free image. Estonian Marine Institute and the EPFL have installed two similar Thetis bio-optical profilers (SeaBird Scientific) in coastal waters of the Baltic Sea and Lake Greifensee in Switzerland. These systems measure remote sensing reflectance above and below the water surface and many bio-optical parameters (spectral absorption and attenuation coefficient; backscattering at several wavelengths; fluorescence of chlorophyll-a, CDOM and phycocyanin, temperature, salinity, oxygen, etc.) while profiling through the water column. The Thetis profiler is parked at the sea/lake bottom and is profiling through the water column at pre-defined times which can be synchronised with satellite overpasses. In the end of each profile the data is transferred to institutes server allowing near real time processing and storage. These two systems differ from other Thetis as they allow measuring reflectance above the water surface. In our presentation we will share first experiences in using such autonomous systems in European coastal and inland waters.

Variability of inherent optical properties of Norwegian waters with implications for satellite product validations.

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Sabine Marty, *NIVA*
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oral presentation

Session: In situ measurements and validation

With the Space Component of the Copernicus program including the dedicated Sentinels from the ESA's families, Earth Observation data is fed into a range of services for monitoring the marine environment. As part of the Copernicus program this also includes the Norwegian waters. Various algorithms are developed for case 1 and case 2 waters for the various satellites available. Due to differences in the inherent optical properties in Norwegian waters compared to other regions in Europe, but also large variability within Norwegian waters, these algorithms and the corresponding products are of variate quality for the Norwegian coastal regions. Using water sampling from Ferrybox systems from the the Ferrybox lines Color Fantasy (Oslo-Kiel) and MS Trollfjord (Bergen-Kirkenes) and monitoring water sample data from the coastal monitoring program ØKOKYST run by the Norwegian Environmental Agency, water sampling is performed up to twice a month for some regions along the Norwegian coast. These data are used for validations of the satellite products developed by the S2plus and S3plus chain in FP7-project HighRoc. Using data from specific regions, we show historical and recent results of the inherent optical properties and satellite products from of our regions emphasizing the need for updated algorithms for deriving satellite products of good quality.

Verification of MSI low radiance calibration over coastal waters, using AERONET-OC network

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oral presentation

Session: In situ measurements and validation

The ESA S2RadVal (Sentinel-2 Radiometric Validation) project aims at developing a method for validating the radiometry of Sentinel-2 Level-1c product in case of low radiance values. MSI acquisition over coastal waters constitutes a target of choice for this verification due to the presence of suspended particles that increase the magnitude of reflectance with respect to open ocean. Additionally, Aerosol type and amount largely contribute to the signal received by the sensor of the satellite. The AERONET-Ocean Color (OC) network can supply sea conditions and optical properties in several bands matching some of Sentinel-2/MSI ones. The proposed verification method consists thus in simulating Sentinel-2/MSI observations acquired over AERONET-OC stations comparing both simulations, made through 6SV radiative transfer model, and observations, accounting for their respective uncertainties. Sentinel-2/MSI observations acquired over AERONET-OC stations are extracted from the corresponding tiles in band 1 to 8, and if a concomitant AERONET-OC measure exists, the MSI observations are simulated with a modified version of 6SV, tailored to maximize the use of AERONET-OC data, in particular the water-leaving radiance and the spectral variations of the aerosol optical thickness. In this talk, we will present the method used to replaced the Case I computed reflectance emerging from the sea by the product derived from the AERONET-OC water-leaving radiance measured in situ -thus taking into account the presence of suspended matter other than the chlorophyll-a- and the contribution to the global uncertainty from various parameters, following the recommendations of the Guide to expression of Uncertainty Measurement. MSI data acquired since July 2015 have been processed so far. These first results will be presented and discussed.

In situ data collection for validation of remote sensing products in the HIGHROC project

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L. Schulter, *DHI*
T. Hull, *Centre for Environment, Fisheries and Aquaculture Science (CEFAS)*
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oral presentation

Session: In situ measurements and validation

Remote sensing data has a wide-ranging variety of uses, from assessments of environmental status (as part of the EU Marine Strategy Framework Directive), to investigating the impacts of offshore activities, such as dredging. However, high quality in situ data are necessary to validate remote sensing products such that they can be used with confidence. Cefas has collected in situ data during the HIGHROC project from a variety of platforms. A suite of SmartBuoys measure turbidity, light attenuation coefficient Kd(PAR) and chlorophyll (from calibrated fluorescence), while the RV Cefas Endeavour is fitted with a Ferrybox system, measuring subsurface (4m) fluorescence and turbidity, continuously while the vessel is steaming. Additionally, during the HIGHROC project, estimates of Kd(PAR) have been calculated from light profiles collected during the International Bottom Trawl Survey in August in the North Sea. A database of 636 chlorophyll samples from HPLC has also been developed, primarily from surveys in summer in the North Sea and in autumn in the Celtic Sea (Peltic Surveys). The HPLC-derived chlorophyll-a was used to convert fluorescence from the vessel's Ferrybox fluorometer to chlorophyll-a concentration, on a per survey basis. This enabled the high-frequency fluorescence data to be used to provide chlorophyll-a estimates along the ship route at the subsurface. In situ data collected by Cefas has been used during the project to validate satellite products from Landsat8, Sentinel 2, Modis, VIIRS, and Sentinel 3.

Validation of ocean colour satellite products in European coastal waters as part of the EU-FP7 HIGHROC project

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Veronique Creach, *CEFAS*
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oral presentation

Session: In situ measurements and validation

Numerous high-quality match-ups between field measurements and satellite data are used to assess the uncertainties associated to satellite products developed in various European coastal waters as part of the HIGHROC project (www.highroc.eu). Satellite products include the spectral remote-sensing reflectance signal (Rrs, in sr-1), water turbidity (T, in FNU), vertical diffuse attenuation coefficient of Photosynthetically Available Radiation (KdPAR, in m-1), concentrations of suspended particulate matter (SPM, in g.m-3) and chlorophyll-a (Chla, in mg.m-3).High and medium spatial resolution satellite data respectively recorded by the L8-OLI and S2-MSI sensors ('S2plus' data) and by the MODIS, VIIRS and OLCI sensors ('S3plus' data) are processed using both general and regional algorithms developed in the project. Field measurements are recorded during oceanographic cruises, onboard instrumented ferries and by autonomous sensors on fixed platforms such as Aeronet-OC stations and SmartBuoys. At all sites satisfactory results are obtained for Rrs match-ups, especially in the green, red and near-infrared parts of the spectrum (NRMSE lower than 20%), with slightly higher differences in the blue part of the spectrum. This first step constitutes a validation of the atmospheric corrections. Positive results are obtained when comparing satellite-derived products (T, SPM, and KdPAR) to field data, with typical differences (NRMSE) lower than 20% despite the wide ranges covered by these parameters (e.g., SPM varying from 0,2 to 300 g.m-3). The remote sensing of Chla concentrations is less satisfactory (NRMSE of 30% and sometimes higher) in coastal waters dominated by non-algal particles where the use of the blue-to-green Rrs ratio reaches its limit.

Validation of various Sentinel-2 and Sentinel-3 products in optically complex coastal and lake water bodies

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Sampsa Koponen, *Finnish Environment Institute*
Kari Kallio, *Finnish Environment Institute*
Vesa Keto, *Finnish Environment Institute*
Hanna Alasalmi, *Finnish Environment Institute*
Antti Lindfors, *Luode Consulting Oy*
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oral presentation

Session: Coastal water applications

Coastal waters of the Northern Baltic Sea represent optically specific absorption- and pigment-scattering-dominated marine coastal area, the extreme among Case II waters, with especially high absorption of colored dissolved organic matter (aCDOM). Throughout coastal monitoring stations measurements show an average aCDOM(400) level of 3.2 m-1 but it can range between 11 – 28 m-1 on estuaries after heavy rains or melting period. For deriving water-quality information for a water body of this type the collection of in situ data to validate the performance of atmospheric correction algorithms as well as water quality products is important. A national project in Finland, VESISEN, is targeted to evaluate the usability of Sentinel-2, Sentinel-3 and Landsat8 instruments and the available algorithms (e.g. C2RCC, Polymer, OLCI L2 product) against various data sources. The in situ water quality dataset that covers the coastal waters and lakes is national monitoring station data gathered during 2015–2017. The other dataset consisted of coastal estuary field campaigns with an automated flow-through system installed on board vessels. The measurement system (Lindfors et al., 2005) includes an ac-9 attenuation and absorption meter (by WetLabs) for total absorption and attenuation coefficients at nine wavelengths between 412 and 715 nm. The water for flow-through measurements and for additional water samples was taken from a depth of 0.5 m. Radiance and irradiance measurements were made at stations during water sampling. In addition, chl-a data collected via Alg@line ship-of-opportunity (analysed water samples and flow-through fluorometer) was utilised for validation of the available chl-a algorithms in the open Baltic Sea. The first results suggest the use of Polymer (Steinmetz et al., 2011) for deriving atmospherically corrected reflectances over the coastal waters of Finland. C2RCC (Brockmann et al., 2016) processor can be used to derive coastal turbidity and aCDOM with sound accuracy using S2/MSI. The VESISEN project aims at implementing EO as one part of national coastal and lakes water quality monitoring program in Finland. For this purpose, automated methods for excluding areas contemned by land, canebrake or effects caused by the seabed have been developed using available high accuracy GIS data.

GOCI provides valuable information on brown algae blooms in East China Sea

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oral presentation

Session: Coastal water applications

Ocean color observations from a geostationary orbit have advantages over those from polar orbits in monitoring coastal water phenomena such as harmful algae blooms, floating algae blooms, transport of low saline water mass from rivers. In this study, we present successful monitoring of Sargassum horneri blooms in the East China Sea in 2015. S. horneri serves as important habitat for various marine life, including several species of commercially valuable fish. However, the brown algae that accumulate along the coast can cause problems. Semimonthly images of fractional area per pixel supported previous findings based on field surveys for years, but also indicated that the blooms may begin earlier as early as January and may spread much wider area in East China Sea than previously known. The 2015 bloom event in the ECS resulted in significant economic loss to local Porphyra and Saccharina aquaculture sites, abalone industry, and required significant efforts to clear out seaweed washed ashore. Near-realtime information based on daily GOCI observations was useful for local authorities to deal with this quasi-annual event of Sargassum blooms.

Using high resolution satellite turbidity and sea surface temperature imagery to describe river plume interactions in the Northern Adriatic Sea

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oral presentation

Session: Coastal water applications

Sea surface temperature (SST) and turbidity (T) derived from Landsat-8 (L8) imagery were used to characterize river plumes in the Northern Adriatic Sea (NAS). Sea surface salinity (SSS) from an operational coupled ocean-wave model supported the interpretation of the plumes interaction with the receiving waters and among them. In this study we first used L8 OLI and TIRS imagery of 19 November 2014 capturing a significant freshwater inflow into the NAS for mapping both T and SST at 30 meters resolution. Sharp fronts in T and SST delimited each single river plume. The isotherms and turbidity isolines coupling varied among the plumes due to differences in particle loads and surface temperatures in the discharged waters. Thirty-meters resolution turbidity maps derived from (L8) images were then used to investigate spatial and temporal variations of suspended matter patterns and distribution in the area of Po River prodelta (Italy) in the period from April 2013 to October 2015. The main focus of the work was the study of small and sub-mesoscale structures, linking them to the main forcings that control the fate of suspended sediments in the northern Adriatic Sea. The main focus of the work was the mesoscale delineation of the major river plumes and study of small and sub-mesoscale structures, linking them to the main forcings that control the fate of suspended sediments in the northern Adriatic Sea.

Innovative satellite-based information provision for assessment of environmental status

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Dave de Koning, *Deltares,*
Eva Stierman, *Deltares, Rijkswaterstaat, TU Delft*
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oral presentation

Session: Coastal water applications

MSFD-Eutro is an interactive web-mapping service that shows chlorophyll indicator maps based on growing-season statistics (mean, and max as P90). MSFD-Eutro aims to facilitate the use and appreciation of ocean colour data by policy advisors and policy makers for the European Marine Strategy Framework Directive (MSFD). It is based on phytoplankton being an omnipresent aquatic primary life form which colours the water, because these single-celled algae contain the chlorophyll pigment. The colour of the water can be measured by satellite sensors. Trend analysis of CHL helps to understand the response of the marine ecosystem to changing environmental conditions and direct human pressures such as eutrophication. The status of a particular marine area with respect to eutrophication is determined by winter nutrient concentrations, but also by multi-year mean and maximum (expressed as P90) chlorophyll-a concentrations evaluated against certain thresholds (assessment levels). The Copernicus Marine Environment Monitoring Service (CMEMS) contains proven quality CHL-products for the Atlantic and Channel coasts. Similarly, we have seen good quality CHL-products for the turbid North Sea coasts based on MERIS standard L2, and we are testing OLCI standard L2 CHL-products for the Dutch Coast (Stierman et al, this conference). We have been integrating these into one suitable ocean colour CHL product for the entire OSPAR region. Our dynamic web tool will show yearly and six-yearly composites (maps) made from the blended products. These composite maps can be zoomed and panned in space and scrolled in time. Moreover, the web tool will allow the user to retrieve statistics of growing season and aggregated time-series of the data over assessment areas. We would like to present the current state and content of our tool, and its potential for the discussion on international harmonisation of assessment levels and methods.

Remote sensing analysis of the Tiber River sediment plume (Tyrrhenian Sea): spectral signature of erratic vs. persistent events

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oral presentation

Session: Coastal water applications

Several coastal regions have been increasingly affected by intense, often catastrophic, flash floods that deliver significant amounts of sediment along shorelines. A crucial question regards the impact of these impulsive runoffs in terms of coastal sedimentation and sediment characteristics. Here we perform a satellite-based analysis that quantifies particle size distribution (PSD) of riverine suspended sediment, relating different discharge stages (i.e., erratic vs. persistent) to the grain-size distribution of the wash load. We estimate PSD through satellite retrieval of the particle backscattering coefficient spectrum. A monthly analysis of twelve-year datasets reveals that erratic stages are prone to deliver coarser sediment with respect to the persistent stages. This result agrees with previous studies related to suspended sediment rating curves and shows that coastal plumes generated by flashy events would give an effective contribution to coastal geomorphology by supplying the coarse material.

Processing large data sets for synergistic analysis of coastal processes – the SNAP batch processing capabilities

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oral presentation

Session: Satellite data processing

The investigation of coastal processes needs a large variety of data, of which Earth Observation data can be one. Sensors of different spatial, spectral and temporal resolutions are suitable for providing information about coastal waters water quality, and all need processing to produce a concise data set of water quality parameters. Once algorithms are developed, validated and applied to single products, the automated processing is the next step to produce the required data set for further analyses. Time series are one instance to compile the information in a common way. The ESA Sentinel Application Platform (SNAP) is a toolbox for analyzing and processing Earth Observation data. This platform was developed and customized for the Sentinel data and entails specific toolboxes for each (S1TBX, S2TBX, S3TBX), as well as for other sensors such as PROBA-V or SMOS, each also with their respective toolboxes. SNAP is well known for its Desktop Application and its ease of use in displaying Earth Observation data and analyzing possibilities with the several tools offered. One lesser known SNAP aspect is the capability to combine several of the processing tools together in a processing graph. These processing graphs can either be built directly from the Desktop Application and called from there, or on a script basis, which is then run from the command line. This presentation will show the utility of such an option and how it can easily be integrated within a working environment, e.g. incorporated in another programming language. A case study on how to generate time series from several sensors and plot them together will showcase this.

Use of DINEOF for ocean colour data applications

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oral presentation

Session: Satellite data processing

DINEOF (Data Interpolating Empirical Orthogonal Functions) is a technique to reconstruct missing data in geophysical datasets. It uses a truncated EOF decomposition to infer the missing data. The optimal number of EOFs to be used in the reconstruction is determined by cross-validation. As only the most important EOFs are retained, noise contained in the data is effectively removed as this noise is usually found in higher modes. The retained EOFs can be used to detect outliers in the dataset, and it is also possible to calculate an estimate of the reconstruction error. DINEOF has been applied to several ocean variables, including sea surface temperature, salinity and colour-related variables like total suspended matter, turbidity and chlorophyll-a concentration. Several examples will be shown using polar-orbiting and geostationary satellite data. The venue of very high spatial resolution satellite data for coastal applications opens new challenges for the application of DINEOF, as the short-lived nature of the small scale features being measured by these new satellites. Plans to adapt DINEOF to these new datasets and how to deal with the multiscale nature of the coastal ocean will be presented.

Atmospheric corrections of Sentinel-2 imagery over coastal and continental waters - through the Coastal-TEP

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Frank Fell, *Informus gmbh*
Hubert Loisel, *LOG*
Cedric Jamet, *LOG*
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oral presentation

Session: Satellite data processing

Making great benefit of Sentinel-2 imagery with its spectral capabilities and its short temporal revisit (now 5 days at middle latitudes with S2-a and S2-b) is of prime interest for coastal and inland waters applications. As for marine researches using spectral imagery from space sensing, one of the first challenge is to remove atmospheric contribution from the overall measurements to be able to interpret and invert water signal to retrieve water properties. ESA (through a SEOM funding) is supporting a project lead by ACRI, with contributions of skilled partners (Informus gmbh, LOG, CS) to develop a new type of atmospheric correction modules, that, once fully validated and qualified, will be put at the free disposal of all users through public platform (e.g. SNAP, C-TEP). We will present last results of today on efficient pre-classification of S2-imagery (affording cloud and cloud shadow flagging), glint and white caps corrections, topographic and adjacency effects consideration, and aerosols and gas corrections. The way to use it through the Costal TEP will be presented.

Data Cube Service for Copernicus (DCS4COP) - ease the integration, preparation and processing of various data sources for coastal downstream applications

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Gunnar Brandt, *Brockmann Consult GmbH*
Dimitri Van Der Zande, *RBINS*
Rodney Forster, *UHULL*
Kai Sorensen, *NIVA*
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oral presentation

Session: Satellite data processing

Copernicus has boosted the availability of Earth Observation data both in terms of quality as well as quantity. The handling of big data volumes, the integration of data streams from different sources, and the generation of high-quality information from the novel sensors of the Sentinels pose significant technical and scientific challenges to some Intermediate Business Users (IBUs, downstream service provider), in particular those entering newly the market. Lacking expert skills often hinder the user uptake of Copernicus products and services and eventually impede economic growth of the sector. The DataCube Service for Copernicus project (DCS4COP) addresses these obstacles by implementing the Copernicus Water DataCube Service (CoWaDaCS) - the first instance of a new service model, integrating Sentinel data, Copernicus Service data and user supplied data in a DataCube system. The CoWaDaCS can be implemented on virtually any of the emerging infrastructures, such as DIAS, national collaborative ground segments or ESA TEPs. The services offered by CoWaDaCS comprises Processing as a Service (PaaS), Software as a Service (SaaS), consultancy and training. Capitalising on the scientific achievements of the HIGHROC project and operated by experienced service providing institutions, CoWaDaCS will demonstrate the value of satellite Earth Observation data for the market segment of coastal and inland water services. The combination of access to high quality data, wide selection of thematic data layers, state-of-the-art tools and expert knowledge, and at the same time exploiting most recent IT solutions, will allow IBUs to concentrate on their value-adding downstream business.

Model selection algorithm for Chlorophyll-a content retrieval

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oral presentation

Session: New satellite sensors and algorithms

There are a number of algorithms for Chlorophyll-a (Chl-a) content retrieval from data acquired by optical imaging sensors. These algorithms may vary from sensor to sensor, depending on the spectral and spatial resolutions. State-of-art algorithms are often empirical polynomial regression models, trained by relating measured Chl-a content to Remote Sensing Reflectance (Rrs) through a so-called band ratio. These algorithms are usually trained on global datasets. Hence, the regression coefficients of these models need to be tuned, when the dataset is extended with regional or local match-up data. Also the choice of the spectral bands in the bands ratios may vary, depending on the dataset and sensor. Since these models are trained on global match-ups, they often result in erroneous Chl-a content estimates when they are applied to local waters. This is especially the case for optically challenging aquatic environments, such as coastal waters and inland lakes. Here, we present a model selection algorithm, which automatically choses the best Chl-a content retrieval model for any dataset. The proposed model first uses various feature ranking methods to assign relevance to features. These features can include spectral bands and/or other features, such as band ratios. Then the ranked features are used in several sophisticated regression models by sequentially feeding them into the models. At each step, regression performance measures are computed for every model candidate, as well as for the state-of-art models. The best alternative model(s) is compared to the state-of-art model(s) based on the computed regression performance measures, and the strongest model is chosen. This algorithm allows determining the most suitable Chl-a content retrieval model, with associated features, for any sensor and environment. This model selection algorithm can hence be used to choose the best model, both globally and locally.

Progress and Performance of the Multiwater Algorithm ONNS

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oral presentation

Session: New satellite sensors and algorithms

Recently the OLCI Neural Network Swarm (ONNS), an in-water processing scheme for the retrieval of ocean colour products from Sentinel-3/OLCI, has been introduced [Hieronymi et al., 2017]. ONNS consists of several blended neural networks that are specialized for 13 different optical water classes. These comprise clearest natural waters but also extreme absorbing or scattering waters. The algorithm determines different concentrations of water constituents, inherent and apparent optical properties, and a colour index. In addition, all products are delivered with an algorithm-inherent uncertainty estimate. Performance tests of the algorithm, based on simulated and in situ reflectances as well as atmospheric corrected OLCI satellite imagery, are critically assessed.

Evaluation of GOCI atmospheric correction regarding the diurnal observation of ocean color variation

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oral presentation

Session: New satellite sensors and algorithms

The Geostationary Ocean Color Imager (GOCI) observes the Northeast Asia ocean environment and it can provide diurnal ocean color image from the geostationary orbit. The process of atmospheric correction for ocean color data acquired from satellite plays an important role in determining the quality of the derived ocean environmental products. For the diurnal observation, moreover, the stability of the atmospheric correction for various solar angles is additionally required. Small uncertainties of atmospheric parameters can significantly cause the diurnal instability of atmospheric correction performance. Various atmospheric radiances regarding directional effect is simulated by radiative transfer code to see the sensitivity. In the study, we first analyze that how the GOCI atmospheric correction is sensitive to the uncertainties along various solar angles through simulations. Then the uncertainty of remote-sensing reflectance (Rrs) resulted by the atmospheric correction is compared with the in situ diurnal variabilities of Rrs to what extent GOCI detect the diurnal changes in the marine environment.

The potential use of geostationary MTG/FCI to retrieve Chlorophyll-a concentration at high temporal resolution for the open oceans

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oral presentation

Session: New satellite sensors and algorithms

In a few years, the Flexible Combined Imager (FCI) on-board Meteosat Third Generation (MTG) will provide images of European Seas, the Atlantic Ocean and the Mediterranean Sea every 2.5 minutes (regions above 30°N) or 10 minutes (full disk). Although dedicated to meteorological applications, this sensor has blue, green and red spectral bands allowing to consider the adaptation of a band-ratio algorithm to retrieve chlorophyll-a concentration (Chl-a). However, the radiometric specification of the FCI sensor is far from the minimum requirement recommended for ocean colour sensors and the validity of FCI data for oceanic applications is not clear. We try to determine if, and under which conditions, Chl-a could be estimated from FCI data. From the NOMAD in situ dataset, a blue green band-ratio algorithm adapted to FCI spectral characteristics is proposed. Then, the impact of FCI radiometric noise on Chl-a estimations is investigated in detail. Results show that noise-induced Chl-a error increases with Chl-a and solar zenith angle. For a Chl-a estimation based on a unique pixel, this error ranges between 20% and 100% which prevents any direct utilisation and suggests that it is necessary to degrade the spatio-temporal resolution to obtain an acceptable noise-related uncertainty on Chl-a. With a spatial (9 pixels) and temporal (1 hour) averaging process, Chl-a can be estimated with a noise-induced error less than 10% for Chl-a up to 5 mg m-3 and solar zenith angle lower than 60°. Our analysis also showed that the noise-related error associated to the atmospheric correction process can be neglected compared to the radiometric noise of the visible bands themselves if it is assumed that aerosol type is uniform over large areas (9kmx9km boxes).

Suitability of Proba-V 100 m products for turbidity mapping in coastal areas

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oral presentation

Session: New satellite sensors and algorithms

Coastal areas are of high ecological and economic value, however they are subjected to intense human-induced environmental pressures. An effective monitoring system is therefore vital for the operational management and safeguarding of the coastal areas. Traditional in-situ sampling can be very labour-intersive and often doesn't cover the whole area at once. Satellite imagery can fill this gap. Typical ocean colour satellites have a spatial resolution of 250-300 m (e.g. MODIS 250 m channels, MERIS, Sentinel-3). Although ideal for a lot of applications, this can be insufficient for the monitoring of small scale features in near shore areas such as port or estuaries. The remote sensing community has already been looking to some extent into the usage of non-ocean-colour sensors to include these small features. Examples include Landsat, Sentinel-2, SEVIRI, Deimos and Formosat. This work shows the suitability of the Proba-V sensor (spatial resolution of 100 m) for the retrieval of water quality parameters. Proba-V was neither conceived as an ocean colour mission, but its specifications (spectral bands and signal-to noise ratio) allow to monitor the turbidity. Proba-V derived turbidty products, atmospherically corrected with an adapted version of iCOR (De Keukelaere et al. (Submitted)) and a modified version of Nechad et al. (2009), are compared with continuous buoy measurements (CEFAS Smartbuoys) and cross-validated with MODIS aqua products. References De Keukelaere, L., Steckx, S., Adriaensen, S., Knaeps, E., Reusen, I., Giardino, G., Brescani, M., Hunter, P., Van der Zande, D., Vaicute, D. iCOR Image Correction for Atmospheric Effects, Results for Landsat-8 OLI and Sentinel-2 MSI, European Journal of Remote Sensing (Submitted). Nechad, B., Ruddick, K. G., & Neukermans, G. (2009). Calibration and validation of a generic multisensor algorithm for mapping of turbidity in coastal waters. SPIE European International Symposium on Remote Sensing, Berlin

Atmospheric correction and aquatic applications of Landsat and Sentinel-2 satellite imagery

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oral presentation

Session: New satellite sensors and algorithms

We present a simple atmospheric correction method for aquatic applications of high resolution (10-60 m) satellite sensors, in particular the Landsat series (5, 7 and 8, launched in 1984, 1999 and 2013), and the Sentinel-2 series (A and B, launched in 2015 and 2017). The method assumes no water-leaving radiance in two shortwave infrared (SWIR) channels in the atmospheric windows around 1.6 and 2.2 micron, and that the observed signal in those channels can be fully attributed to the atmosphere. Top-of-atmosphere reflectances are derived from the images, either by using the coefficients provided by the space agencies (L8, S2A and S2B by default, and newer processing versions for L5 and L7) or by normalizing TOA radiances to the extraterrestrial irradiance (older processing versions of L5 and L7, optional for L8). A gas and Rayleigh correction is first performed, using a lookup table generated using 6SV. After Rayleigh correction, a non water masking is applied, using a 2.15% threshold on the 1.6 micron channel. The remaining signal in the 1.6 and 2.2 micron bands is used to estimate the multiple scattering aerosol reflectance, fitting a simple exponential model to the visible and near-infrared channels. Due to the low signal and low signal to noise ratio in the SWIR bands, a spatial smoothing is recommended before processing. By using SWIR bands for the atmospheric correction, the method is well-adapted for processing data over turbid and extremely turbid waters without imposing known water reflectance characteristics (i.e. particle type) during processing. Applications of high resolution imagery are also presented, including those related to human activities, such as the monitoring of the impacts of offshore construction and dredging and disposal activities. Potential for characterization of validation sites (e.g. AERONET-OC) and water quality monitoring in the first nautical mile (European Water Framework Directive) are explored. The potential for multi-mission time-series is illustrated. Validation results using the two Belgian AERONET-OC stations are presented.

The operational method of filling information gaps in satellite imagery using numerical models

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oral presentation

Session: New satellite sensors and algorithms

Monitoring of the marine environment, especially in coastal zone remains a challenging task due to dynamic changes and small to medium scales of the processes. Tracking global changes has been based on satellite remote sensing for years. However, it is often limited by the spatial and temporal resolution of the sensors, but also the presence of clouds that are opaque for most of the satellite imagery. Cloud cover restricts the number of available information and introduces analytical biases. A variety of advanced statistical methods have been developed in order to deal with that problem, but gap filling is still an issue to solve in the Earth Sciences. The multivariate approaches or spatio-temporal gaps distribution analyses apply mostly to areas or water basins large enough to capture regularities and surface patterns. Moreover, the Case-2-water type of the Baltic Sea impede the use of the common a priori assumptions or any global estimates. Last, but not least important is that they often result in severe decrease in spatial resolution. Here we propose to get advantage of eco-hydrodynamic models by complementing satellite information with modelled spatial data. A mosaic of consecutive satellite images is combined together with model using weights, which varies with distance from data gaps in the satellite images. This ensures smooth transition between the input maps and correction of single-pixel-contamination. Our method is efficient for the log-distributed values and produces Root Mean Square Errors (RMSE) lower than the input model or satellite datasets, which were checked against either individual in situ measurements or time series obtained from buoys. The optimal parameters were found for the Baltic Sea area and tested on the Sea Surface Temperature (SST) and chlorophyll a concentration. A particular attention was put on retaining the remotely sensed information to a high degree in order to preserve local mesoscale phenomena that are hard to capture through modeling. On the other hand, models have achieved enough advancement to become a reliable source of independent information and solve the problem of long-term information gaps without drastic decrease in spatial resolution.

True colour analysis of natural waters by ocean colour- and HR-sensors

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oral presentation

Session: New satellite sensors and algorithms

Stimulated by the European Citclops project, that aimed to develop new tools to involve citizens in the monitoring of natural waters, colour was identified as a simple property that can be measured via an App in smartphones (www.eyeonwater.org) or low-cost instruments. Because ocean colour satellite instruments provide superior coverage of natural waters, a simple algorithm to retrieve the same colour parameter from MERIS was developed and shown to be compatible with in-situ measurements. In a recent paper we demonstrated that colour, expressed mainly by the hue angle (α), can be derived accurate and consistently from SeaWiFS, MODIS, MERIS and OLCI data. The algorithm consists of a weighted linear sum of the remote sensing reflectance in all visual bands plus a correction term for the specific band-setting of each instrument. Hue-angle calculations is even possible for a range of High-resolution instruments, like Landsat-8 and MSR on Sentinel-2. The algorithm is now available for multiple instruments in the Optical Toolbox in the Sentinel Application Platform (SNAP).

Application of Polymer atmospheric correction to Sentinel-2 data

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oral presentation

Session: New satellite sensors and algorithms

The Polymer algorithm is a generic atmospheric correction method for ocean colour. Its principle based on the simultaneous use of all available spectral bands makes it very robust to the perturbations from the aerosols, the sun glint and the adjacency effect. Initially developed for the open ocean, it has been extended to process case 2 waters, with the inherent advantage of not requiring negligible water reflectance in near infrared bands. It is freely available and and can be applied to multiple sensors including Sentinel-2/MSI. The sun glint is a critical aspect of the Sentinel-2 water observations: since the revisit of both S2A and S2B is done in the same viewing conditions, many areas are continuously affected by sun glint over a season, leading to long periods of no coverage if the sun glint is not recovered. The results of Sentinel-2 MSI processed with Polymer will be presented, including validation results using AERONET-OC measurements.

Atmospheric correction and turbidity analyses with C2RCC for Sentinel-2 and Landsat-8 in rivers and coastal areas

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oral presentation

Session: New satellite sensors and algorithms

Optically complex waters are characterised by an uncorrelated mixture of optically active water constituents such as chlorophyll-a (proxy for phytoplankton), total suspended matter and yellow substance. Retrieval of concentrations of these constituents requires inversion of the water leaving reflectance spectrum, measured at top of atmosphere by ocean colour satellites. The Case 2 Regional CoastColour (C2RCC) processor was originally developed by Doerffer and Schiller and uses a large database of radiative transfer simulations inverted by neural networks as basic technology. Meanwhile major improvements were introduced, such as a 5-component bio-optical model and a coastal aerosol model. The concentration ranges have been enlarged and recent knowledge about backscatter and absorption gained from measurements in River Elbe were included. The training of Neural Networks – the core of the C2RCC algorithm – is meanwhile available for all recent and current ocean colour sensors as well as Sentinel 2 and Landsat 8. The C2RCC processor is available through ESA's Sentinel open source toolbox SNAP and is also used in the Sentinel 3 OLCI ground segment processor of ESA for the generation of the Case 2 water products, as well as in the processor for the upcoming MERIS 4th reprocessing. This presentation will focus on the usage of Sentinel-2 and Landsat-8 for rivers, lakes and coastal waters. Applications and validation results will be shown for highly turbid and scattering waters, but also over high absorbing waters which is still a challenging subject for many atmospheric correction algorithms.

New scientific and technological advances (measurement in situ and validation) with the Argos system in relation to new generation satellites

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poster presentation ***(poster #1)***

Session: In situ measurements and validation

HIGHROC Science Conference 7 to 9 November 2017 in Brussels for the color of ocean science :In situ measurements and validation Technological advances in satellite observation,stand-alone sea measurements and scientific computation,combined with the development of complex mathematical models and assimilation techniques,gave rise to this new component some fifteen years ago Of space oceanography. The physical and biogeochemical state of the ocean can now be reproduced, analyzed and predicted operationally anywhere on the globe and at any depth: for example,the speed and direction of ocean currents, temperature and salinity,height Concentration,thickness and drift of ice,color of water,chlorophyll concentration and nutrients. Operational oceanography in its modern form is based on the assimilation in three-dimensional models of observations measured at sea and measured by satellite, to propose a coherent representation in space and time of variables describing the physical and biogeochemical ocean. Together with these three factors, we must add the scientific maturity of data processing,modeling and assimilation techniques within the research community and the very structuring initiatives taken at the organizational level to explain the speed of development Of operational oceanography. The two most notable innovations of this decade are probably real time and data assimilation.These teams have succeeded in shortening and making reliable all the information processing times to be able to describe in real time the state of the ocean, and thus bring this digitalocean closer to the reality ofeveryday life. In Conclusion, we (AIPEA and AIPIA) believe that, in order to evolve Argo from its network,it is necessary to answer, and to broaden new scientific questions,and its field of application.We propose extending its capacity to the greatest depths,adding biogeochemical sensors, increasing its coverage of polar areas and marginal seas, sophisticating the ship,and its personnel who carry the Argo floats despite the fact that,We are aware that the use of Argo measurements in conjunction with altimetry satellites (Jason) has also led to remarkable advances in the representation of the necessary ocean,ocean forecasting and seasonal prediction. cordially Lebeau PEMHA THINA: Founding President AIPEA and AIPIA with the joint Spatial observation /Oceanography team Contact:6,Rue Ambroise Croizat 93200 Saint Denis (France) Phone:+33950859060 or+33614056769

Water quality from OLCI for Dutch coastal waters

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poster presentation ***(poster #2)***

Session: In situ measurements and validation

The Netherlands Directorate-General for Public Works and Water Management, Rijkswaterstaat, has been monitoring water quality of the Dutch North Sea for the last 35 years. A research vessel takes off to sample parameters such as chlorophyll (CHL) and total suspended matter (TSM) at fixed locations along transects perpendicular to the coast. Nowadays, the Copernicus programme allows open access to Sentinel satellite data, providing information on air and water quality. It is expected that products from Sentinel-3A's Ocean Land Colour Instrument (OLCI) can greatly improve the geographical and temporal coverage of water quality parameters. A study was initiated to validate water quality parameters CHL and TSM from OLCI observations. To verify the context of the OLCI products the following variables were evaluated too: the aerosol optical thickness (T865) used in the atmospheric correction, which is important for deriving the water-leaving reflectance (Oaxx_reflectance), and the Oaxx_reflectance itself, which is used to derive CHL and TSM. Rijkswaterstaat has been collecting water quality in-situ measurements for comparison with OLCI observations focussing on the months May until November of 2017. Meanwhile, OLCI's CHL and TSM have been compared with MERIS climatologies too. OLCI Oaxx_reflectance and T865 were compared with observations from AERONET-OC stations Thornton and Zeebrugge. The spatial distribution of T865 was evaluated by comparing OLCI with MODIS T865 observations. OLCI CHL from the OC4Me algorithm showed an underestimation compared to MERIS CHL climatologies. CHL values from the Neural Network were similar to MERIS algal-2 observations. OLCI TSM showed an underestimation compared to in-situ measurements and MERIS TSM. An underestimation of (scattering) TSM would imply an underestimation of Oaxx_reflectance, but showed an overestimation in the blue and green band compared Thornton AERONET-OC observations. OLCI's red and NIR Oaxx_reflectance correlated well with the AERONET-OC measurements. The OLCI T865 was overestimated compared to AERONET-OC measurements. These preliminary results imply that further research into radiative transfer models, lookup tables, vicarious calibrations and Neural Networks is needed to understand how CHL and TSM are influenced. This fundamental understanding is of interest for users and parties providing products and services for marine applications like the Copernicus Marine Environment Monitoring Service.

Evaluation of atmospheric correction algorithms in the extreme absorbing waters of the Laptev Sea

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poster presentation ***(poster #3)***

Session: In situ measurements and validation

Atmospheric correction (AC) in extreme absorbing waters is challenging. The signal coming out of the water is very low when the concentration of colored dissolved organic matter (CDOM) is high, particularly in the short visible wavelengths. Here, we assess the performance of AC algorithms to estimate chlorophyll-a concentration (CHL) and CDOM absorption at 443 nm (aCDOM443) in the optically-complex waters of the Laptev Sea. The performance of C2RCC, C2X, Polymer, and a modified version of the Polymer algorithm for Arctic waters are evaluated. The algorithms were applied to daily MERIS L1b data and the retrievals were validated against in situ measurements of CHL and aCDOM443 from field campaigns conducted in August/September of 2010 and 2011. Preliminary results of the inter-comparison and evaluation against in situ measurements are presented.

Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC)

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poster presentation ***(poster #4)***

Session: In situ measurements and validation

Fiducial Reference Measurements (FRM) are a suite of independent, fully characterized, and traceable ground measurements that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO). These FRM provide the maximum return on investment for a satellite mission by delivering, to users, the required confidence in data products in the form of independent validation results and satellite measurement uncertainty estimation over the entire end-to-end duration of a satellite mission. The FRM4SOC project, with funding from ESA, has been structured to provide support for evaluating and improving the state of the art in ocean colour validation through a series of laboratory and field inter-comparisons. The project makes a fundamental contribution to the European system for monitoring the Earth (Copernicus) through its core role of working to ensure that ground-based measurements of ocean colour parameters are traceable to SI standards. This is in support of ensuring high quality and accurate Copernicus satellite mission data, in particular Sentinel-2 MSI and Sentinel-3 OLCI ocean colour products. The FRM4SOC project also contributes directly to the work of ESA and EUMETSAT to ensure that these instruments are validated in orbit. For ocean colour measurements, whether they are made by satellite or in situ ocean colour radiometers, traceability to SI is achieved through an unbroken series of calibrations back to the primary standard for optical radiation: the NPL cryogenic radiometer.

Development of a standalone solar tracking hyperspectral sensor platform

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poster presentation ***(poster #5)***

Session: In situ measurements and validation

WATERHYPERNET – A network of hyperspectral radiometers for multi-satellite water reflectance validation

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poster presentation ***(poster #6)***

Session: In situ measurements and validation

Satellite agencies in Europe and the United States now guarantee a continuous flow of long-term data for ocean colour radiometry and chlorophyll a from the operational Sentinel-3 and VIIRS missions. In addition to these dedicated ocean colour missions, there is a fast-growing interest in exploiting higher spatial or higher temporal resolution data for coastal and inland waters from many other satellite missions, designed originally for terrestrial or meteorological applications. The exploitation of data from all such missions requires highly accurate atmospheric correction and validation of the resulting water reflectances.The experience from MERIS and MODIS has established that radiometric validation of ocean colour missions is best performed by autonomous ground-based instruments on fixed platforms, functioning continuously according to a standardised protocol and with harmonised calibration and data processing and public distribution of data. The AERONET-OC network [Zibordi et al, 2009] has clearly demonstrated this concept by providing a large number of high quality matchups in diverse water types for validation of all ocean colour missions. However, the AERONET-OC network is based on a multispectral instrument and cannot validate all spectral bands on all optical remote sensors. A new network is therefore being developed following closely the AERONET-OC federation concept but using the TRIOS/RAMSES hyperspectral radiometer. The instrument system consists of one radiance and one irradiance sensor on a pointing robot, controlled by a microprocessor and supplemented with GPS, inclinometer and video camera data feeds [Vansteenwegen et al – poster]. The measurement protocol is based on [Mobley, 1999], but includes additional scenarios for different viewing zenith and azimuth configurations. The systems will be deployed initially in Belgian coastal and inland waters, then at HYPERMAQ project partner sites in Argentina, China and France before full international expansion. The network will provide water reflectance data for the validation of all visible and near infrared bands of all optical missions, including Sentinel-3AB, Sentinel-2AB, PROBA-V, MODIS-AQUA/TERRA, VIIRS, Landsat-8, Pléiades, CHRIS-PROBA, MSG-SEVIRI … ENMAP, PACE, MTG and any future optical missions including nanosatellites.

Estimation of Phytoplankton variability in the Mediterranean Sea using the Diagnostic Pigment Analysis and satellite observations

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poster presentation ***(poster #7)***

Session: Coastal water applications

This study revolves around the estimation of phytoplankton size classes (PSC) and functional types (PFT) in the oligotrophic waters of the Mediterranean Sea using satellite data and in situ measurements. The preparatory phase is based on compiling phytoplankton HPLC pigment data collocalised with Globcolour Chlorophyll-a concentration (Chl-a) and remote sensing reflectance (Rrs) data, along with Sea surface temperature measurements (SST) from AVHRR. 8 HPLC pigments were chosen following the Diagnostic Pigment Analysis concept, where a specific diagnostic pigment (DP) is used to indicate the presence of a certain PFT/PSC through a DP/ΣDPs ratio. Meanwhile, Rrs at 4 wavelengths were associated to the in situ data, in order to reveal their link with the DPs, initially admitting that the Rrs signal contains the information emitted from the surface waters where the DP contribution is also taken into account. Moreover, the SST data was added as a hydro-physical parameter, characterized by a defined annual cycle, smoothening the relationship between the in-situ and remote sensing data. The link between these several components was made through Kohonen self-organizing maps (SOM), which is a type of artificial neural network that is trained using unsupervised learning. While these SOM classify the input data based on the Euclidean distance, the database was segregated into situations represented by each neuron of the SOM. Afterwards, decoding images of DPs was possible by associating remote sensing data to the DPs of the closest situation within the SOM. The latter exhibited dissimilar performance depending on the type of DP estimated; The R2 ranged between 0.65 and 0.3 with an average RMSE of 0.016 mg.m-3. But despite the difference in the performance, each DP revealed coherent patterns and the distribution of PSCs was then estimated. The Mediterranean Sea showed a distinguishable variability of the Micro-phytoplankton (Micro 20-200µm), Nano-phytoplankton (Nano 2-20µm) and Pico-phytoplankton (Pico 0.2-2µm); the Nano dominated in the Winter-Spring months, more abundant in the western basin, while the Pico dominated in the Summer-Autumn months. The Micro was recurrent on the coast and near hydrodynamic zones, such as the Gulf of Lyon and Rhodes Gyre, due to sufficient nutrient input.

Detection of floating aquatic plants using high spatial resolution imagery in the Río de la Plata estuary

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poster presentation ***(poster #8)***

Session: Coastal water applications

At the beginning of 2016 a huge amount of aquatic plants invaded the highly turbid waters of Rio de la Plata (Argentina) causing significant disruption of human activities via clogging drinking water intakes in the estuary, blocking ports and marinas and introducing dangerous animals from faraway wetlands into the city. Even though drifting aquatic plant detachments drift downstream the Paraná river every year in small amounts, large temporary invasions have been observed every 10 years. The large temporary invasion of aquatic plants that took place from January to April 2016 has been caused by the heavy rains, driven by a strong El Niño, that increased river levels in the La Plata basin. The event has been detected using different mid to high resolution remote systems. In this work we show the capability of high-resolution multi-spectral imagery like Sentinel-2, Landsat-8, and MODIS-250m, for mapping and quantifying the large aquatic hyacinth invasion in the RdP that started in January 2016. Both the large amount of particles as well as the increasing spatial resolution poses challenges for its correct detection. An index that uses bands in the red (to take into account chlorophyll-a absorption), the near-infrared, and short-wave infrared bands is proposed and validated using field measurements.

Correspondence between in-situ derived water reflectances from Río de la Plata and Kubelka-Munk model in the RED/NIR/SWIR range

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poster presentation ***(poster #9)***

Session: New satellite sensors and algorithms

In previous studies, such as in Shen et al. 2010, water reflectance is modelled as a function of IOPs via the Kubelka-Munk approximation of the Equation of Radiative Transfer. In this work, a total of 133 reflectance measurements (103 ASD, 30 RAMSES/Trios) in turbid waters of Río de la Plata were fitted via a simulated annealing optimization algorithm to a Kubelka-Munk theoretical expression of reflectance, in the spectral range 600-1000 nm, in which only the presence of non-algal particles (and water molecules) was considered. Two distinct RMSEs were used as cost functions in the simulated annealing optimization procedure: one calculated in hyperspectral mode, in the range 600-1000 nm (with the exception of the spectral range centered at the chlorophyll peak absorption at 670 nm) to check the global goodness of the model, and one computing difference between in situ and modelled "baseline residuals", defined as the reflectance peak after baseline subtraction of three consecutive triplets of the S3/OLCI bands centered at 620-709-779-865-1016 nm. This last cost function was evaluated to understand if these three "baseline-residuals" are potentially suitable and provide enough information to retrieve (highly scattering) water reflectances in the aforementioned OLCI bands without the need of prior atmospheric signal removal, via the Kubelka-Munk reflectance model.

Concentration, transport, fluxes and dynamics of suspended sediments along a continuum from rivers to river plumes using high spatial resolution ocean color satellite data

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poster presentation ***(poster #10)***

Session: Coastal water applications

Quality of coastal waters is directly affected by terrestrial substances transported by rivers. It is thus of primer importance to (i) better understand the transport of particles from rivers to coastal waters, (ii) better quantify the fluxes and mass of sediments that reach the coastal zone and (iii) better understand the river plume area and dynamics through different forcings. Here, we first show that the new capabilities of recent ocean color satellite sensors represent an efficient way to assess these questions. Then, we present a study of the Rhône River sediment transport based on OLI (Landsat-8) and MODIS (Aqua and Terra) data. The high resolution of OLI allows estimating sediment concentration inside the river. OLI transect from inside the river to the offshore part of the plume shows that sediment concentration drastically decreases when particles reach the ocean, illustrating dilution, flocculation and sedimentation processes. The distance from the mouth of this drastic decrease seems increasing with river freshwater discharge. The MODIS temporal resolution and coverage allow providing robust relationships between river freshwater discharge and river mouth sediment concentration as well as plume sediment mass and area. Comparison between solid discharge that reaches the river mouth and mass of the surface river plume suggests that only ~10% of the sediment mass stay within surface waters while ~90 % settle. Suspended sediment concentration as well as relationships with river discharge are in good agreement with in situ data confirming the potential of satellite data for sediment transport understanding and monitoring of solid fluxes at river mouths.

Dynamics of Suspended Particulate Matter in a Macro-Tidal River Plume (the Gironde) as observed by Ocean Color Satellite Data

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poster presentation ***(poster #11)***

Session: Coastal water applications

The Gironde river plume area is unique in terms of Suspended Particulate Matter (SPM) dynamics. Multiple factors contribute to the variations of SPM at multiple time scales, from river outputs to wind stress, currents and tidal cycles. The formation and evolution of the Maximum Turbidity Zone (MTZ) inside the estuary also plays a significant role. Thus, detailed analyses and monitoring of the region is important for better understanding the mechanisms governing the turbid plume dynamics, for proper future management and monitoring of SPM export from the estuary to the coastal ocean. In this study we use two types of satellite information in order to achieve this goal: data collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) sensors. The combined information allows accounting for multiple time scales, i.e. from seasonal to diurnal cycles. We show and parametrize the overall effects of river discharge rates over the plume extension; for the first time we clearly observe and explain the diurnal cycle of SPM dynamics in the river plume. Despite the limited capabilities of the SEVIRI sensor, geostationary data was successfully used to derive such information and results similar to in-situ datasets were obtained.

Estimation of the lakes optical water types from satellites images

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poster presentation ***(poster #12)***

Session: Coastal water applications

Remote sensing is a powerful tool for regular monitoring of lakes and coastal zone. Under programme Copernicus European Space Agency have been launched new satellite sensors, which provides us spectral, spatial and temporal resolution to monitor optically complex waters. However the variation of lakes water colour is large and standard products often fail. Classification of optical water types helps to clarify relationships between different properties inside a certain class and quantify variation between the classes. Optical water types were statistically identified from in situ measurements. Classification shows, that different optical water type have different remote sensing reflectance spectra and each water type is associated with a specific bio-optical condition. In this study, we also investigate how well it is possible to define different optical water types form the in situ measured reflectance spectra, from satellites images and from images with different atmosphere corrections.

JMP-EUNOSAT: towards joint monitoring and assessment of eutrophication in the North Sea using satellite products

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poster presentation ***(poster #13)***

Session: Coastal water applications

Based on the initial MSFD assessment by all member states in 2012, the European Commission highlighted "the need for greater coherence with related EU legislation (WFD and Habitats and Birds Directive) and for more coherent and coordinated approaches within and between marine regions and sub-regions". While preparing for the second cycle of MSFD assessment, various OSPAR groups (Intersessional Correspondence Group on Eutrophication (ICG-EUT) and the Hazardous Substances and Eutrophication Committee (HASEC)) have identified incomparability of monitoring methods for chlorophyll as a main issue hampering a coherent assessment of the common indicator chlorophyll a in the greater North Sea. This results in different GES determinations across national borders that cannot be explained by differences in water quality. Satellite data from ocean colour sensors (i.e. SeaWifs, MODIS, MERIS, VIIRS, Sentinel-3) can provide spatially coherent data on chlorophyll concentrations using various type of algorithms (e.g. blue/green-ratios, neural networks, red-edge ratio). Still, to this point it is not officially used as a tool for MSFD eutrophication monitoring in the North Sea by the member states. To enable a coherent assessment of chlorophyll between all OSPAR member states bordering the North Sea it is necessary to develop a well validated coherent satellite-based chlorophyll product for the MSFD monitoring. To accomplish this we evaluated publicly accessible satellite-based chlorophyll products provided by different services (i.e. HIGHROC, CMEMS, ODESA) and determined the validity of these products for different water types (e.g. turbid, clear or absorbing waters) so that the choice of satellite product is determined by environmental conditions per (cross-border) assessment area, rather than national preferences of member states. In this work we will present the results of a validation exercise of the most important North Sea satellite-based chlorophyll products using the Coast Colour Round Robin data set.

Suspended particles characteristics in Pärnu Bay, Baltic Sea

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poster presentation ***(poster #14)***

Session: Coastal water applications

Pärnu River, the largest river in Estonia, flows into the Pärnu Bay in the Baltic Sea. River inputs induce a sediment plume visible from satellite data. In this area, the coast of Estonia is shallow. Thus optical properties of coastal waters are influenced by particles coming from the river and from resuspension by storms. The anthropic influence caused by ships and dredging may also influence coastal water properties. The sediment outflow may have an important impact on the ecosystem and for the management of the bay. The nature and characteristics of the suspended particles in Pärnu Bay are highly variable and few studies were conducted in this area. The goal of this study is to validate Sentinel-2 and Sentinel-3 satellite products and develop algorithms for complex coastal areas. These questions are included in a PhD project submitted in spring 2017 to University of Tartu. In collaboration with CEFREM laboratory (Centre de Formation et de Recherche sur les Environnements Méditerranéens), a joint unit of CNRS and University of Perpignan in Southern-France, field campaigns will be organized during different seasons to study variability of suspended particles characteristics in the Pärnu bay under various river outflow conditions and study the contribution of storms. We will use an innovative approach, using a set of instruments containing in-situ laser and holographic granulometry (LISST-100X, LISST-HOLO), a CTD, optical sensors. On the poster we show the background of this study using satellite and historic data, of plume's actual size, turbidity range and nature of particles.

Monitoring of Norwegian waters using FerryBox and satellite: the Glomfjord case study

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poster presentation ***(poster #15)***

Session: Coastal water applications

Remote sensing of ocean color provides crucial insight on the dynamics of environmental conditions along the Norwegian coast. Use of satellites and instrumented ferries greatly increases our capacityto obtain these data at high spatial and temporal resolutions. The proper validation of these measures is critical, especially at high latitudes where remote sensing is challenging. The Glomfjord is on the Norwegian coast (67°N), just north of the Kvilvik fjord. During the summer, phytoplankton blooms can be observed along the entire coast of Norway. Glomfjord has an important input of fresh water during summer due to meltwater from surrounding glaciers. This influx of freshwater likely transports particles enclosed in the ice and from terrestrial sources into coastal waters. Other inputs of freshwater and particles could come from a hydroelectric power plant located at the head of fjord, which releases water from mountain lakes into the inner fjord, and a fertilizer factory that outflows effluent and nutrients into the system. The objectives of the study is to identify differences in ocean color along the Norwegian coast and assess use of ferrybox data to validate satellite data.

Clear view on a turbid estuary: An operational service for innovative/integrated management of coastal/marine resources

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poster presentation ***(poster #16)***

Session: Satellite data processing

We present a feasibility study for setting up an operational service for water quality monitoring in the Eems-Dollard estuary based on Earth Observation. Estuarine waters of this area are turbid and highly dynamic in time and space, for which point-based monitoring overlooks the fine spatio-temporal scales of water quality variables. Data from earth observing satellites are capable of capturing the spatio-temporal variability required for an integrated monitoring system. The proposed service employs EO data at three spatial resolutions (low from Sentinel 3-OLCI and GHRSST; medium from Sentinel 2-MSI and Landsat 8-OLI; and high from RapidEye) to operationally derive water quality variables relevant for the estimation of water primary production. Three atmospheric correction methods were evaluated and inter-compared. Validation in-situ radiometric measurements showed that C2X yielded better results, in terms of water leaving reflectance, than Acolite and C2RCC for Sentinel 2. Derived concentrations of sea surface temperature, suspended particulate matters (SPM) and chlorophyll-a (Chl-a) agreed with in-situ measured values and the historically-known ranges. The results of this feasibility study revealed that EO-based products of water quality variables probably have sufficient accuracy and is of primary importance for the operationalization of monitoring services.

Applicability test on a previously proposed approach for phytoplankton group identification

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poster presentation ***(poster #17)***

Session: New satellite sensors and algorithms

A database of Rrs(λ) spectra, C2X database, based on five phytoplankton groups was built using HydroLight simulations for various water optical conditions. In our last report, we have proposed an approach to identify phytoplankton groups, using remote sensing reflectance spectra only, by spectrally comparing an input test spectra with Rrs(λ) spectra in the C2X database (Xi et al. 2017, submitted; details of the C2X data in Martin et al. 2017). The performance of the approach was tested using another simulated Rrs(λ) dataset with 128 spectra of phytoplankton algae from six taxonomic groups arranged into five spectral groups. For 120 water optical conditions, the identification was found high at most occasions except for waters with a low phytoplankton contribution and for waters dominated by NAP. Though the proposed approach was based on simulated datasets, its applicability in natural waters was also preliminarily tested by using in situ Rrs(λ) spectra from Lake Taihu, China. Cyanobacteria were successfully identified as a dominating group in waters with high chlorophyll concentration in Lake Taihu. To furthermore test whether the approach is applicable in various natural waters, we have collected a large set of in situ data from waters with different optical types, including coastal waters such as the German Bight and British coastal waters, and inland waters such as Elbe River and several lakes in Germany. Both in situ Rrs(λ) and absorption spectra are used to identify the dominating phytoplankton group in these waters. In situ Rrs(λ) spectra are taken as input of the proposed identification approach, while in situ absorption measurements are spectrally compared with the absorption spectra of various phytoplankton species from 128 cultures to determine the phytoplankton groups that they belong to. Identification results from both approaches are compared, and the identification performance of the Rrs-based approach can therefore be evaluated for natural water applications.

Optical remote sensing for bathymetry and seabed mapping in the coast of Ireland (BaSMaI)

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poster presentation ***(poster #18)***

Session: New satellite sensors and algorithms

The coastal shallow water zone can be a challenging and costly environment in which to acquire bathymetry and other oceanographic data using traditional survey methods. Navigation hazards and water column properties make some of these areas unfeasible to survey using ships or LiDAR. Thus, much of the coastal shallow water zone worldwide, and in particular within the Irish coastline, remains unmapped. The aims of BaSMaI are to allow reliable derivation of coastal bathymetry, water column and seafloor properties using a combination of multispectral data (Sentinel-2), hyperspectral data (UAV) and in situ data. The methodology will utilize a set of case studies, in a variety of coastal environments, to implement robust and novel research in Ireland in the fields of satellite image processing using empirical and physical modelling. Satellite bathymetry and coastal mapping products, and more importantly their repeatability over time, can offer practical solutions for a more effective management and sustainability of coastal environments and services.

Model selection algorithm for Chlorophyll-a content retrieval

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poster presentation ***(poster #19)***

Session: New satellite sensors and algorithms

There are a number of algorithms for Chlorophyll-a (Chl-a) content retrieval from data acquired by optical imaging sensors. These algorithms may vary from sensor to sensor, depending on the spectral and spatial resolutions. State-of-art algorithms are often empirical polynomial regression models, trained by relating measured Chl-a content to Remote Sensing Reflectance (Rrs) through a so-called band ratio. These algorithms are usually trained on global datasets. Hence, the regression coefficients of these models need to be tuned, when the dataset is extended with regional or local match-up data. Also the choice of the spectral bands in the bands ratios may vary, depending on the dataset and sensor. Since these models are trained on global match-ups, they often result in erroneous Chl-a content estimates when they are applied to local waters. This is especially the case for optically challenging aquatic environments, such as coastal waters and inland lakes. Here, we present a model selection algorithm, which automatically choses the best Chl-a content retrieval model for any dataset. The proposed model first uses various feature ranking methods to assign relevance to features. These features can include spectral bands and/or other features, such as band ratios. Then the ranked features are used in several sophisticated regression models by sequentially feeding them into the models. At each step, regression performance measures are computed for every model candidate, as well as for the state-of-art models. The best alternative model(s) is compared to the state-of-art model(s) based on the computed regression performance measures, and the strongest model is chosen. This algorithm allows determining the most suitable Chl-a content retrieval model, with associated features, for any sensor and environment. This model selection algorithm can hence be used to choose the best model, both globally and locally.

A near-shore phytoplankton bloom in Belgian waters observed from space

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poster presentation ***(poster #20)***

Session: Coastal water applications

With the launch of the first Sentinel-2 (S2) satellite on June 23, 2015, the capabilities of space-borne remote sensing of coastal and inland water quality improved considerably. A single S2 satellite has a revisit time of 10 days globally, but can observe the Belgian coast twice in every 10 day period. A second S2 unit will be launched in 2017, which will double this revisit frequency. The main imager on board of S2, the MultiSpectral Imager (MSI), has a spatial resolution of 10-60 m and is hence able to resolve small features in surface turbidity of aquatic ecosystems. Moreover, thanks to the inclusion of a spectral band at the red spectral edge, the chlorophyll a absorption in the red can be quantified. In the past year, the mapping of chlorophyll a concentration at 20 m spatial resolution with S2 imagery has been demonstrated by various teams. Here we present the discovery of a near-shore phytoplankton bloom that occurred early May 2016 in the very near-shore part of the Belgian coastal zone, in front of the port of Oostende. These images reveal a bloom with an extreme concentration of chlorophyll a. This kind of bloom would be very difficult to detect with ship-borne measurements, due to the bloom location and extent, and the shallow depth of the water. Traditional ocean colour satellites lack the required spatial resolution to resolve these near-shore events . With a five or ten day revisit time, and these novel chlorophyll and suspended sediment mapping capabilities, the S2 mission will contribute significantly to the understanding of near-shore phytoplankton dynamics and sediment transport not only in Belgian waters, but also globally. S2 derived data will be of significant importance for the near-shore monitoring required by the European Water Framework Directive.

Atmospheric correction for coastal and inland water application of very high resolution satellite imagery

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poster presentation ***(poster #21)***

Session: New satellite sensors and algorithms

Coastal and inland waters can be characterized by very dynamic variability on short temporal and spatial scales. Very high spatial resolution satellite imagery (<10 m) can provide new insights into sediment transport processes in and around ports and offshore constructions. Furthermore it can be used to provide remotely sensed observations for specific case studies in small or narrow water bodies, to assess sub-pixel scale effects in medium resolution imagery and to characterize fixed validation sites for traditional ocean colour sensors. There are generally no standard atmospherically corrected products over water for the very high resolution sensors and using existing approaches poor results may be obtained for water applications. In this poster a generic algorithm for the atmospheric correction of very high resolution optical satellite imagery is presented. The algorithm takes advantage of multiple dark targets in the scene, which are spatially resolved, and switches to the best bands and targets for the determination of the aerosol signal. The algorithm is applied to imagery from the Pléiades constellation for inland and coastal sites, and is validated with AERONET and AERONET-OC data. Pléiades is a series of two identical, pointable satellites with four broad spectral bands (blue, green, red, and NIR) and a panchromatic channel respectively at 2.8 and 0.7 m spatial resolution. A practical application of monitoring dredging activities and small scale sediment transport around the port of Zeebrugge is demonstrated. The impact of the monitoring station on which the AERONET-OC instrument is mounted is assessed, both in terms of the optical signal of the structure and its shadow, and the structure's impact on the local spatial variability.

Studies on Intelligent Underwater Image Processing for classification of different Species in Active Zones

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poster presentation ***(poster #22)***

Session: Satellite data processing

Studies on marine ecosystems are critically and highly important for analysing the health of coastal environments since we have vast marine natural resources. Large global changes and climate change in particular, have significant impact on the environment and will cause crucial impact on humanity in future. These studies on underwater ecosystems highlight the deterioration of marine environment and to mitigate the deterioration of marine environment require a truly interdisciplinary approach that complement and supplement each other. Overfishing is a critical issue. Over 70% of the world's fish species have been exploited or depleted (FAO). Overfishing makes the ocean ecosystems more vulnerable to other disturbances and that cause billions of fish and other species to die each year. Unsustainable fishing is the largest threat to ocean life, habitat and food security of over a billion persons. Fifteen out of seventeen of the world's largest fisheries are heavily exploited that predicts a bleak future for the whole world. If people get accurate information on quality fish and its availability, it will be easy to safeguard and protect the ocean as an inexhaustible supply of food. Underwater image processing for detecting, recognising and classification of different fish species based on shape, size, colour, texture etc in active zones will help to discover ecological phenomena promoting commercial and environmental applications. At the same time it will be useful in highly cost effective underwater imaging research/development and also for further scientific studies. This project proposes classification of different fish species and communities present in active zones using ontology based underwater image processing. Image based classification provides higher quality results. Ontology based hybrid techniques with suitable image processing algorithms and recording data are on the move. Initially the aim is to classify fish species based on its shape only. Then classification based on other features like colour, size, texture,cotour etc will be taken in to account so as to get larger data base and high accuracy. The current experimental results of dealing freely swimming and live fish in natural environment, shows very good success out-performing the existing and previous approaches.