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Poster 3

ATMOSPHERIC CORRECTION OVER TURBID WATER FOR GOCI-II: A PRELIMINARY STUDY

Atmospheric correction process plays an important role in ocean color remote sensing that estimates water reflectance at the surface from the top-of-atmosphere at satellite level by removing path reflectances mainly contributed from light scattered by the atmosphere. The atmospheric correction algorithm for the general ocean color sensors employs two near-infrared (NIR) bands to estimate aerosol radiances in visible wavelengths based on the black pixel assumption in NIR. However, the black pixel assumption is no more valid over turbid water due to a relatively strong backscattering of suspended particles in the water. Therefore, water reflectance models in NIR bands have generally been applied to iteratively separate aerosol radiances and water radiances in NIR. We describe this water reflectance model for the Second Geostationary Ocean Color Imager (GOCI-II) which will be following the GOCI mission. While the GOCI uses 660 nm band to estimate water reflectances at 745 and 865 nm, the GOCI-II can additionally use 620 and 709 nm band which makes it more advantageous for the estimationof NIR water reflectance. The reflectance model is preliminarily validated by simulation dataset generated by radiative transfer code.

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Poster 7

PREDICTION OF PHOTO-PROTECTIVE CAROTENOIDS AT GLOBAL SCALE

As phytoplankton cells are exposed to natural dynamic light fields, they develop various combined mechanisms in order to optimize their light harvesting and photosynthetic electron transport. Especially under high light conditions algal cells evolve various physiological protective mechanisms to dispose excess light energy to prevent damage of the photosynthetic apparatus. Among these mechanisms the so-called xanthophyll cycle (XC) is one of the most important one, which avoids overexcitation of the photosynthetic systems by thermal dissipation of the excess energy. In response to high light phytoplankton cells accumulate XC-pigments to avoid the photodamage, which would cause photoinhibition. The mechanistic model for photoinhibition proposed by (Marshall, Geider & Flynn 2000) predicts how changes in light, nutrients and temperature influence the parameters of the photosynthesis-irradiance relationship. The model does not parameterize a variable XC-pigments pool size, hence, it predicts the changes in light absorption parameters that would take place with a constant XC-pigments pool. We inserted this model in the global biogeochemical model REcoM2 to predict the photo-protective needs of phytoplankton in terms of the XC-pigments pool size. Two global scale databases of HPLC pigments showed how the predicted photoprotective response correlates with photo-protective carotenoids pool at global scale, with the advantage that the model prediction is separable per phytoplankton group. Our results show higher concentration of XC-pigments in lower latitudes being non-diatom phytoplankton the main contributor. XC-pigments pool size and its relation to photosynthetic pigments are relevant when describing the light harvesting by phytoplankton at the global scale.

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Poster 11

AN INVESTIGATION OF THE SUBSURFACE CHLOROPHYLL MAXIMUM DYNAMICS IN THE MEDITERRANEAN SEA FROM A BIOGEOCHEMICAL-ARGO FLOAT DATABASE

As commonly observed in oligotrophic stratified waters, a Subsurface (or Deep) Chlorophyll Maximum (SCM) frequently characterizes the vertical distribution of phytoplankton chlorophyll in the Mediterranean Sea. Occurring far from the surface layer "seen" by ocean color satellites, SCMs are difficult to observe with adequate spatio-temporal resolution and their biogeochemical impact remains unknown. BGC-Argo profiling floats represent appropriate tools for studying SCMs dynamics. Based on data collected from 36 BGC-Argo floats deployed in the Mediterranean Sea, our study aims to address two main questions: (1) Do SCMs result from a carbon biomass increase or from physiological acclimation? (2) Which environmental factors control their occurrence and dynamics? First, we analyzed the seasonal and regional variations of the chlorophyll concentration (Chla), particulate backscattering coefficient (bbp), a proxy of the Particulate Organic Carbon (POC), and environmental parameters (PAR and nitrates) within the SCM layer over the Mediterranean basin. The vertical profiles of Chla and bbp were then statistically classified, and the seasonal occurrence of each of the different types of SCMs quantified. Finally, a case study was performed on two contrasted regions and the environmental conditions at depth were further investigated to understand which parameter controls the SCMs. In the Eastern Basin, SCMs result, at a first order, from photoacclimation process. Conversely, SCMs in the Western Basin reflect a biomass increase at depth benefiting from both light and nitrates resources. Our results also suggest that a variety of intermediate types of SCMs are encountered between these two end-member situations.

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Poster 15

AUTOMATED PROCESSING AND UNCERTAINTY ESTIMATION FOR SEA LEVEL HYPERSPECTRAL RADIOMETRIC DATA FOR SATELLITE VALIDATION

A network (WATERHYPERNET) of automated hyperspectral radiometers is being set up to provide water reflectance measurements in the visible and near infrared bands for the purpose of satellite validation. The system consists of two TriOS RAMSES hyperspectral radiometers (one radiance and one irradiance) making measurements over a range of azimuth and zenith angles, using a sun-tracking instrument pointing package. Data will be transmitted to shore daily and processed and web-distributed automatically and in near-real time for integration in satellite mission validation analyses. This work will present an automated, end-to-end data processing methodology to provide hyperspectral radiometric data, including uncertainty estimates for every data value (wavelength), for the purpose of satellite validation.

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Poster 19

SPATIAL PATTERNS AND OPTICAL ANALYSIS OF WILDFIRE-DERIVED ASH IN THE SANTA BARBARA CHANNEL

In December 2017, the Thomas Fire became the largest wildfire in California history, burning nearly 300,000 acres of primarily forested land. The fire, coupled with unusually strong Santa Ana winds, produced a plume of smoke, ash, and soot that extended more than 1000 km offshore, inundating the Santa Barbara Channel (SBC) with ash for 6 weeks. Here we describe the distribution of Thomas Fire ash in the SBC using an optical approach. This work was made possible by adapting a previously planned cruise aboard R/V Sally Ride on December 15-22. We highlight image analyses from water samples acquired in the surface ocean and at the chlorophyll maximum 4 times daily using an Imaging FlowCytobot (IFCB) that imaged ash particles. We supplement these observations with depth profiles of inherent optical properties to determine the extent to which the dissolution of ash in seawater affects absorption and scattering. We then describe how our image analysis determined properties of ash across depth, space, and time. We use a semi-quantitative approach to link ash observations to biogeochemically and ecologically relevant covariates: euphotic depth (determined using a profiling radiometer), phytoplankton taxonomy (determined through image and pigment analysis), and phytoplankton physiology (chl/carbon as derived from inherent optical properties). We assess the spatiotemporal variability of these parameters. Finally, we compare our findings to a typical December month in the SBC using a twenty-year HPLC pigment and optics dataset, and we discuss the implications of predicted increases in forest fire on microbial life in the SBC.

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Poster 23

MULTI TEMPORAL ANALYSIS OF PARTICULATE AND DISSOLVED MATTER IN THE NORTH ADRIATIC SEA

The North Adriatic Sea (NAS) is a shallow and semi-enclosed regional sea in the Mediterranean Sea. Bio-optical properties of this optically complex basin are strongly influenced by river inputs and by meteo-marine conditions. In this work we study the dynamic of the particulate and the dissolved matter in the NAS, analysing two parameters retrieved from satellite data: the particulate backscattering coefficient (bbp) and the dissolved and particulate absorption (adg). We perform this analysis at different temporal scales, exploiting the different temporal resolution and spatial coverage of different satellite sensors. The CMEMS (Copernicus Marine Environment Marine Service) MULTI operational product, being retrieved from the merging of all available Ocean Color data streams, provides daily spatial coverage of the basin since 1997. We exploited the spatial coverage and the long time series of this product to analyse the properties of the entire basin, on a daily basis, during autumn/winter, in response to major floods and resuspension events. Due to its large swath, VIIRS SUOMI NPP orbits can overlap during the same day within 1 hour and 40 minutes. As recently suggested by Arnone et al. (2017), we then analysed the available overlapping orbits to describe short time scales variations in optical properties of the NAS related to sub-mesoscale processes of plume spreading within the basin.

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Poster 27

THE OCEAN COLOUR CCI IN-SITU DATA SET: VALIDATION OF OCEAN-COLOUR REMOTE SENSING PRODUCTS IN THE SENTINEL ERA

Chlorophyll concentration is the principal photosynthetic pigment in phytoplankton, and a key variable in the global carbon cycle, recognised as an Essential Climate Variable (ECV) by the Global Climate Observation System (GCOS). Ocean colour remote sensing enables regular global observations of chlorophyll-a but calculation of trends requires a long and consistent time-series derived from multiple missions. The Ocean Colour Climate Change Initiative (OC-CCI) project focuses on water-leaving radiance in the visible domain which is merged from ESA's Envisat MERIS, NASA's SeaWiFS and MODIS-Aqua and NOAA's Suomi VIIRS sensors, and then used to derive chlorophyll-a, inherent optical properties and diffuse attenuation coefficient. A major next step is to include data from the Sentinel-3 OLCI sensors. The need for high-quality in situ data to develop and validate ocean-colour satellite products is well acknowledged by the scientific community and space agencies. This work presents the latest developments in the OC-CCI in-situ database including validation and uncertainty characterization of the OC-CCI products. The database comprises in-situ measurements of remote-sensing reflectance, chlorophyll-a concentration, inherent optical properties, diffuse attenuation coefficient and total suspended matter, from 1997, at the global scale, gathered from several sources (see Valente et al, 2016, ESSD). Inclusion of in situ data requires conversion of "raw" data into a consistent format, quality control (including identification/removal of duplicates), reduction of data in time/space, metadata propagation and merging of all data into one unique table. The database was designed to be easily accessed and used by the OC community, and is available on https://doi.pangaea.de/10.1594/PANGAEA.854832.

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Poster 31

HYPERSPECTRAL POLARIMETRIC IMAGING OF THE OCEAN SURFACE

Hyperspectral imaging of the ocean is usually carried out by sensors on moving platforms, aircrafts or satellites, and is associated with scanning procedures for the acquisition of 3-D data cubes (along-track, cross-track and spectral). We present a state-of-the-art snapshot hyperspectral imager which simultaneously acquires spectra with 4nm spectral resolution in the wavelength range of 450-950nm with a 40 degrees field-of-view (FOV). The imager does not require any along track movement and allows for the continuous collection of data from stationary structures or slow moving platforms such as ships or helicopters. In addition, a computer controlled filter wheel installed in front of the imager allows for division-of-time Stokes vector image acquisition of the ocean surface. Results are presented from several sets of measurements from ocean platforms in the NYC area, Duck, NC and from shipborne observations along the Florida coast. Measurements made by the imager are compared with simulations using a vector radiative transfer (VRT) code showing good agreement. Analysis of pixel-to-pixel variability of the total above water radiance (Lt), sky radiance (Ls) and derived water-leaving radiance (Lw) for the viewing angles of 20-60 degrees in different wind conditions led to the estimation of possible errors in measurements of these radiances in un-polarized and polarized modes for the whole spectral range. The coefficient for skylight reflectance from the ocean surface is retrieved from these measurements; variation of the coefficient is assessed as a function of viewing angles and wavelength under various water and atmospheric conditions and compared with VRT simulated values.

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Poster 35

USE OF CRAMER-RAO BOUNDS APPROACH TO PREDICT THE MINIMUM UNCERTAINTIES IN THE INVERSION OF OCEAN COLOR OPTICAL PROPERTIES

An analytical approach based on Cramer-Rao Bounds (CRBs) is proposed to investigate the uncertainties in ocean color optical properties. Based on given bio-optical and noise probabilistic models, CRBs can be computed efficiently for any set of ocean color parameters and any sensor configuration, directly providing the minimum estimation variance that can be possibly attained by any unbiased estimator of any targeted parameter. Here, CRBs are explicitly developed using (1) water reflectance models corresponding to deep and shallow waters, resp., and (2) probabilistic models describing the environmental noises observed within ocean color satellite sensors, namely Sentinel-2 MSI, HICO, Sentinel-3 OLCI and MODIS sensors. For both deep and shallow waters, CRBs are shown to be consistent with the experimental estimation variances obtained using published remote-sensing methods, while not requiring one to perform any inversion. CRBs are also used to investigate to what extent perfect a priori knowledge on one or several geophysical parameters can improve the estimation of remaining unknown parameters. It is shown that pre-existing knowledge of bathymetry (e.g., derived from LiDAR) within the inversion helps to greatly improve the retrieval of bottom cover for shallow waters. Finally, CRBs are shown to provide valuable information on the best estimation performances that may be achieved with the MSI, HICO, OLCI and MODIS configurations for a variety of oceanic, coastal and inland waters. CRBs are thus demonstrated to be an informative and efficient tool to characterize minimum uncertainties in inverted ocean color geophysical parameters.

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Poster 39

RELATION BETWEEN ORGANIC CARBON AND CHLOROPHYLL IN THE NORTHERN ADRIATIC

Dissolved organic carbon (DOC) as well as particulate organic carbon (POC) represent dynamic fractions in the global C cycle and are now recognised as important factors which trace global change. POC and DOC in coastal areas predominantly come from biological (mostly phytoplankton) production as well as from terrigenous input. Shallow basin of the northern Adriatic (NA) which is significantly influenced by freshwater (mainly Po River), as well as advection of oligotrophic waters from the central Adriatic, and variable and complex circulation controled by the Adriatic-Ionian Bimodal Oscillating System (BiOS), was selected as a site for monitoring relation between phytoplankton activities and organic matter production and distribution in the year period 2016-2017. Our study has shown that the NA is a highly dynamic system, and that distribution of DOC and POC is influenced by the freshwater input. The highest and most variable concentrations were observed at the westernmost stations SJ108 (up to 1.789 and 1.145 mg/L of DOC and POC respectively, March 2017) closest to the freshwater source in the surface layer, decreasing towards the eastern part of the basin. The lowest concentrations were measured in winter in the bottom layer of station SJ107 (0.928 and 0.044 mg/L of DOC and POC respectively). Strong correlation was found between DOC, POC and chlorofill a concentrations (R ranges from 0.50 and 0.92 depending on the season and station, $P<0.05$), which all are negatively correlated with salinity. The strongest correlation was always found for the westernmost stations SJ108 and SJ 101.

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Poster 43

DIURNAL VARIABILITY IN MARINE BIOGEOCHEMISTRY WITH THE GEOSTATIONARY OCEAN COLOR INSTRUMENT USING SEADAS/L2GEN

Short-term temporal variability in marine biogeochemistry at the surface is not well understood at a synoptic scale because current polar-orbiting Ocean Color sensors lack temporal resolution to adequately to resolve short-term variability (~hourly to multiple days). However, geostationary satellite sensors provide the capability to quantify these changes. The Geostationary Ocean Color Instrument (GOCI), launched in 2010 by the Republic of Korea, is a pioneer in the study of these marine processes since it is the only Ocean Color sensor to date able to capture multiple images of a single location per day. In this study, we analyzed the diurnal variability of the biogeochemistry in the coastal waters adjacent to the Republic of Korea using GOCI. GOCI data were processed to level 2 using the SeaDAS/l2gen package using an updated vicarious calibration. The ocean color products retrieved were chromophoric dissolved organic matter (CDOM) absorption at 412 nm, chlorophyll-a concentration, and particulate organic carbon (POC). The CDOM absorption retrieval developed by Mannino et al. (2014) for the northeast U.S. coast was evaluated, validated, and optimized for the region of study. An estimation of uncertainties in the remote sensing reflectances was included as well. In situ data from AERONET-OC were used for the validation of the atmospheric correction scheme, and ship-based observations from the KORUS-OC field campaign were used for the validation of the GOCI ocean color products.

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EVALUATION OF DERIVED TOTAL SUSPENDED MATTER PRODUCTS FROM OCEAN AND LAND COLOUR INSTRUMENT IMAGERY (OLCI) IN THE INNER AND MID-SHELF OF BUENOS AIRES PROVINCE (ARGENTINA)

The Ocean and Land Colour Instrument Imagery (OLCI) sensor provides moderate spatial and temporal resolution of marine data, becoming a promising tool for monitoring environmental changes in coastal waters. Therefore, it is fundamental to test and validate the resulting products from diverse algorithms to ensure the quality of the data. The complex waters of southern Buenos Aires Province inner and mid-shelf, characterized by the presence of estuaries and river inputs, are highly influenced by total suspended matter (TSM) variability. In this study, we evaluate the performance of four TSM products in different waters (estuarine, coastal and mid-shelf waters) with in situ data. Three products were obtained using neural networks (NN), i.e. OLCI L2 ESA standard product (TSM_NN), Case 2 Regional Coast Colour processing chain using a standard (C2RCC_STD) and a new NN (C2RCC_NEW); and one product using the combination of an alternative Baseline Residual Atmospheric Correction approach and the Nechad 2010 TSM algorithm (BLR_NCHD). In general, TSM match-up results indicate that the OLCI TSM_NN and CR2CC_STD products are acceptable (R^2 of 0.87, n=20, RMSE= 23-28 mg/L). Better correlation results were obtained for C2RRC_NEW (R^2= 0.9) although error is relatively higher (RMSE= 51 mg/L), tending to overestimate TSM in estuarine waters. The best results were obtained for BLR_NCHD product (r^2=0.89, RMSE=6.43 mg/L). Future efforts needed to improve TSM retrieval involves the evaluation of the conversion factor between backscattering to TSM for the NN approaches and the evaluation of the atmospheric correction using in situ water reflectance measurements.

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COASTAL AND INLAND WATER PIXELS EXTRACTION ALGORITHM (WIPE) FROM HIGH SPATIAL RESOLUTION OPTICAL SENSORS OLI/LANDSAT 8 AND MSI/SENTINEL-2

Identification of water pixels over natural water bodies is a prerequisite step prior to applying algorithms dedicated to estimation of bio-optical properties of surface waters from spatial remote sensing observations. This is particularly important for high spatial resolution observations such as those delivered by OLI on Landsat-8 or MSI on Sentinel-2. In the frame of this study, we developed a two-step algorithm (referred to as WiPE) dedicated to the extraction of water pixels for OLI and MSI. In contrast to other approaches based on the top of atmosphere (TOA) reflectance, this algorithm uses the Rayleigh corrected TOA reflectance, $\rho_{rc}(\lambda)$, as input parameter allowing the spectral signature of each object to be better characterized. The first step, based on the $\rho_{rc}(\lambda)$ spectral shape analysis of each object, allows water pixels to be discriminated from clouds, vegetation, barren land, and constructions. The second step, in which the $\rho_{rc}(\lambda)$ spectra are transferred into the Hue-Saturation-Value space, greatly improves the detection of cloud shadow over waters. This second step, based on the processing of the whole image, does not require any knowledge on the position and altitude of clouds. This algorithm has been successfully tested for OLI and MSI images collected over a broad range of aquatic environments. WiPE, specifically designed for the extraction of water pixels, generally shows better performance over turbid waters than the standard algorithm (Fmask).

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Poster 55

INTER-COMPARISON OF VECTOR RADIATIVE TRANSFER CODES FOR ROUGH OCEAN SURFACE

An increasing number of polarimetric sensors are emerging during recent years, vector radiative transfer code is crucial for the forward modeling, atmospheric correction, and bio-optical inversion algorithm development. Most open source vector radiative transfer codes are well validated for the atmosphere, however, ocean color remote sensing not only requires information about atmosphere, but also the interaction on and below the ocean surface, e.g., ocean color routine atmospheric correction algorithm relies on high accuracy vector radiative transfer code for either flat or rough ocean surface. In this study, we present intercomparison results of three open source vector radiative transfer codes (the SORD [Korkin, et al., 2017], SCIATRAN [Rozanov, et al., 2017; Rozanov, et al., 2014], and 6SV [Kotchenova, et al., 2008; Kotchenova and Vermote, 2007; Kotchenova, et al., 2006]). The relative differences between the three models and Natraj's tabulated values [Natraj, et al., 2009] are generally within 1% for pure Rayleigh cases. The results have shown a good agreement between SORD and SCIATRAN, while 6SV has a relatively larger discrepancy for rough ocean surface.

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TOWARDS FIDUCIAL REFERENCE MEASUREMENTS OF OCEAN COLOUR RADIOMETRY: ABOVE WATER RADIOMETRY FROM THE ATLANTIC MERIODIONAL TRANSECT AND VALIDATION OF SENTINEL-3 OLCI.

Fiducual reference measurements (FRM) represent the highest quality standard for data to be used in satellite validation activities. These measurements must meet several criteria including: SI traceability, instrument intercomparison, and full uncertainty characterisation. In situ radiometric validation data are scarce, and efforts have been made to develop underway systems to provide more data and greater global coverage. However, this data can be subject to a wide range of uncertainties and, to be of validation quality, should meet FRM standards. Presented here is a summary of the approach used to generate FRM quality measurements from the underway above water radiometer systems aboard the Atlantic Meridional Transect cruise 26. Two above water and one in-water radiometer were calibrated and intercompared during the cruise. An uncertainty budget was derived for the underway radiometry data, based on the Joint Committee for Guides in Metrology Guide to Uncertainty in Measurements (JCGM-GUM). The benefits of the uncertainty budget are two-fold. Firstly, thresholds can be implemented to select measurements with the lowest uncertainties for validation of satellite data. Secondly, the budget can be derived over time and the relative sources of uncertainty evaluated to direct further work. Summaries of uncertainty over the cruise track were calculated and key sources of uncertainty identified. Different thresholds were then used and matchups with OLCI data were extracted for validation.

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Poster 63

GLAZ: WHERE OCEAN COLOR MEETS ART

"Glaz" is a Breton word for the indeterminate shade between green and blue, the colour of the sea in Brittany. Glaz is also used to describe the colour of plants. Glaz is the title of both the 2017 exhibition at Frac Bretagne and one major artworks of Nicolas Floc'h: a green productive painting that produces the colour blue. The Pièce « Glaz » shows a photobioreactor where micro-algae are cultivated. For Glaz, it contains a phytoplankton, a cyanobacteria (Synechococcus). Blue pigment called phycocyanin is extracted from the algae and applied to the walls of the south gallery of the Frac Bretagne. For "Gulf Stream", neon tube drawing reproduces the twists and curves of the Gulf Stream. Starting on the lower left, the flow follows the contours of Florida, before crossing the Atlantic and working its way up towards the north on the right, where it meets Europe. The white neon (natural light tone) is positioned on top of the blue pigment of Glaz applied to the wall. A sound pièce, « The Colour of Water », Productive Sound Painting, introduce words by Hubert Loisel. Hubert is a specialist in the analysis of the colour of the ocean and is recorded talking about monochromy, surface, strata, light, and transparency. He also discusses the absorption of colour, pigments, shades, reflection of light, and production. This pictorial vocabulary is linked to the ocean, where the colours visible to the human eye or satellites convey information about primary production, that is to say the evolution of life in the ocean.

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Poster 67

PHYTOPLANKTON DYNAMICS AND PARTICLE DISTRIBUTIONS IN A COASTAL NORWEGIAN BIOLOGICAL HOTSPOT

The size structure and the photophysiological status of a phytoplankton community has assumed to directly impact the size and the nature of a particle as well as the energy transfer to upper trophic levels. Yet, little is known regarding the relationship of phytoplankton size and particle size distributions in marine systems. Here, we present data from a novel combination of in-situ optical instruments, including: particle imaging (Silhouette Camera, SilCam), inherent optical properties (Laser In situ Scattering Transmissometry-100, LISST-100) and fluorescence-based photophysiology (Pulse Amplitude Modulation and Fast Repetition Rate Fluorometers) collected from several sites along the coast of Norway. Pigment chemotaxonomy (High Performance Liquid Chromatography, HPLC) was also investigated to give information about phytoplankton community structure and their light harvesting versus photoprotective properties. We hypothesized that sites with intense mixing resulted in a greater proportion of large phytoplankton, such as diatoms. Large proportion of diatoms resulted in the dominance of mesozooplankton taxa (copepods, including aggregates or fecal pellets) due to intense grazing compared to sites with less abundance of diatoms. The slopes of power-law fitted particle size distributions from distinct optical measurements (HPLC, SilCam and LISST) were used to understand the impact of phytoplankton size structure to the total particles in the water. Understanding the fate of phytoplankton on the nature, size and shape of particles in the water column will help to improve our knowledge of pelagic processes and carbon flux occurring in costal marine ecosystems.

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HYPERSPECTRAL AIRBORNE REMOTE SENSING OF MARINE LITTER IN THE GREAT PACIFIC GARBAGE PATCH

For more than 40 years marine litter (ML) has been monitored using net tows, occasionally coupled with numerical distribution models. Net tows provide a fundamental ML knowledge-base but have a limited spatiotemporal coverage, a single survey covering at most 0.002 km^2 of the total sea surface area. We present a proof-of-concept of a complementary monitoring approach, airborne remote sensing of ML in the Great Pacific Garbage Patch. Hyperspectral imagery was captured by a SASI-600 airborne spectrographic imager in the shortwave infrared (SWIR, 950-2450 nm) and true-color images from an Optech-CS-4800i RGB camera mounted on a C-130 Hercules aircraft. The RGB mosaics obtained were inspected for ML that was classified into container, net, float, rope and unknown/other. We then selected the top 30 largest items, > 0.1 m in length, within each ML category to investigate the matching SWIR information. The analyses revealed unique SWIR spectral features common to ML, making it possible to discriminate ML pixels from seawater pixels. Moderate to very strong similarities were determined by spectral angle mapping for each ML class. At-sensor radiances of submerged ML were lower in comparison to radiances of the floating portions. Absorption features at ~1215 and 1732 nm were evaluated for potential detection and quantification of ML from remote sensing through an intervening atmosphere. The appropriateness of common airborne SWIR imagers was explored in relation to monitoring spectral properties of ML. Study findings provide important information to those working towards developing effective remote sensing solutions to monitor ML from above-water platforms.

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SEASONAL AND LATITUDINAL VARIABILITY OF BIOGEOCHEMICAL PROPERTIES ALONG BRITISH COLUMBIA AND SOUTHEAST ALASKA USING SENTINEL-3 OLCI DATA

The coastal ocean of British Columbia (BC) and Southeast Alaska (SEA) is defined by complex topography at the interface of the north Pacific and the Pacific Temperate Coastal Rainforest. Massive freshwater discharge, with high terrestrial carbon loads, drive complex ecosystem dynamics, including the food web support for higher trophic levels such as forage fish and salmon. The objective was to investigate latitudinal patterns of remotely-sensed properties from BC to SEA. Chlorophyll-a (Chla), Total Suspended Matter (TSM), and absorption by Coloured Dissolved Organic Matter (aCDOM) were obtained from Sentinel-3 OLCI sensor from April 2016 to April 2018, through distinct algorithms (C2RCC and POLYMER), and latitudinal transects extracted. Values fell within expected ranges, supporting the suitability of the algorithms. TSM presented similar latitudinal variability during spring and summer, defining important regions: Fraser River plume (4-100mg/L), northern Vancouver Island (NVI; 0.5-10mg/L) and adjacent waters to Skeena and Nass rivers (2-7mg/L). In the fall, Discovery Passage also showed consistent high TSM (up to 100mg/L). Chla had similar variability as TSM during spring and fall (reaching 20mg.m^{-3} in spring), while the vicinity of Banks Island was important during summer. Consistent patterns were not detected in aCDOM, although peaks (up to 0.8m^{-1}) were detected at the Discovery Passage, NVI and adjacent to the Fraser, Skeena and Nass rivers, suggesting smaller scale processes, potentially related to rainfall-based discharges. In future, satellite and in situ oceanographic data will be coupled with hydrological dynamics of the watersheds to define the bio-optical and biogeochemical provinces along the salmon migration route.

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DEMONSTRATION OF AN ANALYTICAL MODEL FOR THE COMBINED DESCRIPTION OF CDOM ABSORPTION AND FLUORESCENCE SIGNATURES

Colored dissolved organic matter (CDOM) plays a fundamental role in aquatic environments and is monitored in the context of water quality assessment and studies on biogeochemical cycles. We recently developed a Gaussian light absorption and emission model (GLEAM) for an analytical description of both absorption and fluorescence signatures of CDOM in the UV and the visible wavelength range. Fluorescence is modelled as a function of excitation an emission wavelength and related to absorption signals. Here, we demonstrate the potential of this model for composition analysis of CDOM and remote sensing modelling. Application to a test data set of freshwater CDOM absorption and excitation-emission-measurements gives insight into the wavelength range which is affected most by fluorescence. Finally, we discuss the challenges of fluorescence measurements in absolute units and its need for radiative transfer modelling.

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Poster 83

DECADAL COMPARISONS OF PARTICULATE MATTER IN REPEAT TRANSECTS IN THE ATLANTIC, PACIFIC AND SOUTHERN INDIAN OCEANS

Basin-wide sections of beam cp (proxy for particulate matter concentration - PM) collected during numerous oceanographic programs over the last four decades (WOCE, SAVE, JGOFS, CLIVAR, GO-SHIP, etc.) record seasonally variable concentrations in euphotic surface waters, very low concentrations through most of the water column, and very low to very high concentrations near the seafloor. Sections re-sampled at decadal intervals show that sub-surface particle distributions are very similar over these time spans: areas of high eddy kinetic energy (EKE) are more likely to have high bottom PM concentrations, whereas areas of low EKE (most of the ocean) are very likely to have low PM concentrations. Quantifying the temporal and spatial distribution of particles in the ocean helps in identifying and understanding mechanisms affecting the sources and sinks of particles. We added O_2 contours to sections to track relationships between PM and oxygen concentration, which sometimes seem correlated and sometimes not. The general O_2 distribution in these sections is very similar, even though decades apart in time. Mapping the intensity of PM in benthic nepheloid layers aids in understanding deep ocean sediment dynamics, linkage with upper ocean dynamics, and in assessing the potential for scavenging of adsorption-prone elements near the deep ocean seafloor, as investigated in the GEOTRACES program. Temperature sections across the Antarctic Circumpolar current show evidence of large eddies that affect particle distribution in both surface and bottom 500 m of water.

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SYNCHRONICITY OF MICROBIAL COMMUNITIES IN THE NORTH PACIFIC SUBTROPICAL GYRE

Optical properties are excellent proxies for particle concentration, size, and primary production in the open ocean. We find that the dynamics of microbial growth and abundance in the North Pacific Subtropical Gyre (NPSG) is so intrinsically linked to the light cycle that their collective activity can be captured by bulk changes in optical properties. Here, we describe diel changes in particle concentration, size, production and diversity in the NPSG obtained from high-resolution underway flow-through observations of beam attenuation and particulate backscattering coefficients, particle size distributions (LISST), dissolved oxygen, and imaging flow cytometry data (IFCB). We observe striking coherence between particle concentration estimates (LISST and IFCB) and beam attenuation, oxygen, and particle backscattering. These optical proxies for particle concentration are minimal at dawn and maximal at dusk. This pattern is consistent with the idea that, as a whole, microbial communities double in size, divide, and increase in concentration (and hence carbon) during the day when light is available. Phytoplankton-specific IFCB data corroborate these bulk observations. We observe variation in the amplitude and baseline of diel cycles over time and space. Importantly, these features appear to be related to the seasonal variability and abundance of grazers and detritus. Optically-derived production estimates agree well with incubation-based productivity measurements. We find that medium-sized particles (~2-20 micrometers) control the distribution of bulk optical properties, and that mesoscale features such as eddies modulate community structure and production. These results may help better inform future models of the pathways and fates of carbon in the subtropical ocean.

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CONTRIBUTION OF LOCAL RADIATIVE FORCING ON ARCTIC SEASONAL SEA ICE MELT

A series of buoys have been deployed on Arctic seasonal sea ice of thickness 1.0 – 1.5 m to investigate the contribution of local radiative forcing to ice melt. WARM buoys that measure incident and transmitted light as well as temperature within the sea ice and upper water column were co-located with ice mass balance buoys that measure ice thickness, and temperature at high vertical resolution (10 cm) through the ice. At the cluster deployed in March of 2017 in the Canada Basin sea ice melt of approximately 4 cm per day was observed throughout June and July, linked with a rapid increase in cumulative energy absorption within and beneath the ice. Transmission of solar energy intensified at the beginning of June with radiative flux to the underside of the ice increasing from 5 to 25 W m^{-2} between June 5th and 21st. A total of 10 MJ m^{-2} was deposited during this period, a 47% increase in energy storage. Melt ponds were observed on the surface of the ice starting June 21st, 11 days after the initial increase in light transmission. Over the next 16 days the ice thickness reduced from 1.8 to 0.86 m with 31 MJ m^{-2} of energy deposited by July 7th, and a further 26 MJ m^{-2} by July 24th when the ice had largely melted. These data inform the partitioning of radiative heat input and basal ice melting rates.

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RADIATIVE TRANSFER SIMULATIONS BRING TO LIGHT SPECTRAL NICHES FOR CYANOBACTERIA

The radiation field incident on the water surface offers a continuum of colors that could be exploited by aquatic phototrophs. However, with increasing depth the incident radiation field weakens in an exponential fashion. The inherent optical properties of water and dissolved and particulate substances within the water column impose a wavelength depended attenuation. Based on HydroLight modelling we demonstrate that the molecular characteristics of pure water have a clear effect on the photosynthetic energy availability near the euphotic depth. The resonance structure of water molecules shows as enhanced areas of absorption in the visible part of the spectrum. These so called vibrational stretching modes of the water molecule are referred to as the 7th, 6th and 5th harmonics and can be identified at 449, 514 and 605 nm respectively. In addition, vibrational transitions modes can be discerned at 550 and 605nm which are known as the 5.1st and 6.1st subharmonics. The (sub)harmonics constrain the energy availability of phytoplankton growth and we argue that cyanobacteria that harbor phycobilin-pigments are optimally tuned to the prevailing light conditions. The absorption peaks of phycobilin-pigments bridge that gaps between the absorption peaks of chlorophyll-a and we show that they conveniently occupy the spectral niches that are demarcated by the (sub)harmonics of the water molecule.

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BEHIND THE MASKS OF COASTAL OCEAN COLOR

During standard processing of level 3 NASA Ocean Color data, suspect data is removed prior to spatial and temporal binning in order to provide high-quality composites. Default level 3 data masks may be triggered for example when satellite or sun remote sensing geometries are poor (i.e. high sunglint or high sensor view zenith angle), or when atmospheric correction errors are likely (i.e. derivation of negative water-leaving radiances). Besides accurately identifying when satellite data is likely to generate erroneous geophysical estimates, an ideal pixel mask should remove low-quality retrievals in a manner independent of the sought after underlying environmental conditions, so as to not impose selection bias on the distribution of the remaining data. For remote sensing of the coastal ocean, satisfying the latter criteria is challenging due to biological modification of remote sensing signals, such as the generation of non-zero NIR reflectances by dense algal concentrations (Siegel et al. 2000). Here we evaluate the phenology of default level 3 flags in coastal waters and find that climatological patterns in flag assignments track seasonal cycles in underlying phytoplankton biomass. Using normalized fluorescence line height as a biomass proxy in Monterey Bay, CA, we find that high biomass pixels are twice as likely to trigger default processing masks as low biomass pixels (60.6% of pixels above upper quartile, 30.8% of pixels below lower quartile). We investigate the propagation of masking effects to Level 3 products and ask: Does biology-dependent quality control alter our perspective of what is occurring in the coastal ocean?

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THE RECONSTRUCTION OF CHLOROPHYLL-A CONCENTRATION IN THE NORTHWEST PACIFIC CASE 2 WATER FROM MODIS DATA

In this study, remote sensing reflectance (Rrs) provided by MODIS-Aqua satellite data is used to classify satellite remote sensing data into different water types, and then establish the new algorithm of chlorophyll-a concentration. The results show that in case 2 water the correlation (R^2) between the new algorithm chlorophyll-a concentration (Chl-anew) and the in-situ data is 0.62 and RMSE = 1.63. Whether compared with the results (R^2 = 0.58, RMSE = 2.83) between the MODIS value (Chl-ars) and the in-situ value, or the ones (R^2 = 0.19, RMSE = 2.95) between the algorithm of Le et al.(2014) and the in-situ value, the optical property in case 2 water appears regional and the new algorithm in this study obviously would be more accurate. In this study, the chlorophyll-a concentration of the marginal sea of western North Pacific are less than those provided by MODIS, but in the open seas both values are corresponding. Actually the algorithm in this study can improve the overestimation of the original MODIS value.

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PHYSICAL SUBDUCTION AND SEQUESTRATION OF PARTICULATE ORGANIC CARBON IN THE NORTH ATLANTIC

The oceanic biological carbon pump encompasses a variety of mechanisms by which CO_2, fixed into organic form by phytoplankton, is transported from the sunlit surface layers to the interior ocean. Here, we investigate the physical arm of the biological pump; a process by which upper ocean density fronts within the eddy field generate submesoscale vertical velocities, injecting particulate organic carbon rich waters to depth. A suite of biogeochemical (BGC) Argo profiling floats, equipped to measure optical backscatter, are used to identify features of eddy driven subduction in the North Atlantic, a hot spot for carbon storage and biological activity. Once the characteristics of these water masses are identified, output from the Hybrid Coordinate Ocean Model (HYCOM) will be used to define trajectories over weeks to seasons. By combining observations and modeling, we will investigate how much of the subducted carbon may be sequestered on long timescales vs. the amount re-entrained into the deep mixed layer the following winter.

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ESTIMATING SIZE-FRACTIONATED CHLOROPHYLL WITH SATELLITE OCEAN COLOR IN THE CALIFORNIA CURRENT

Satellite-detected ocean reflectance contains information on optically active substances in the surface layer of which the concentration of chlorophyll-a (Chla) is usually dominant in typical oceanic environments. When the "mean" spectral remote sensing reflectance Rrs(λ) corresponding to the Chla level is removed, the remainder, i.e. the reflectance anomaly (RA), is expected to provide clues about secondary bio-optical properties such as the concentration of colored dissolved matter but also the differences in phytoplankton pigmentation and/or particle size-structure. We evaluate the potential of satellite-detected RA from MODIS-Aqua (2002-2017) and VIIRS (2012-2017) imagery in estimating in situ size-fractionated Chla in the California Current Ecosystem.

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Poster 119

TOWARDS THE USE OF A GLOBAL VEGETATION MISSION FOR COASTAL WATER QUALITY RETRIEVAL

We have investigated the potential of Proba-V imagery for deriving concentrations of Total Suspended Matter (TSM) and Turbidity (T) in near shore waters. The high revisit time, coastal coverage and the good image quality, provides opportunities to expand its current use from the typical land applications to coastal water applications. For this, a new atmospheric correction was developed for Proba-V which retrieves the water reflectances. In the atmospheric correction, aerosol information is derived from the SWIR band of PROBA-V following the SWIR black pixel assumption. Next, the turbidity is derived from the RED band of Proba-V. The Proba-V water refllectance was validated using Aeronet-OC stations, the Proba-V TSM/T products were validated with field data from the CEFAS smart buoys and with TSM and T matchups gathered in the Belgian coastal zone. A comparison with MODIS Turbidity products showed good agreement and the same seasonal T cycle. Finally, the Proba-V TSM products were used for the calibration and validation of a sediment transport model in the Belgian coastal zone.

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INCLUSION OF VARIABLES IN SEMI-ANALYTICAL MODEL TO RETRIEVE MARINE INHERENT OPTICAL PROPERTIES FROM DEEP WATERS

In optically deep waters, remote sensing reflectance (Rrs) is expressed as the ratio of the backscattering coefficient (bb) and the sum of absorption and backscattering coefficients (a+bb) with a multiplicative model parameter "g". Parameter "g" itself is expressed as function of g0, g1 and u (= bb/ (a+bb)). For oceanic case 1 waters and coastal waters, different constant values for g0 and g1 are proposed owing to varying scattering conditions and particle phase function. In this study, we used g0 and g1 as variables (instead of constants) in the semi-analytical model to retrieve marine Bulk Inherent Optical Properties (IOPs – a and bb) from Rrs. To assess the performance of proposed increase in variables, Rrs values at six SeaWiFS wavelengths 410, 440, 490, 510, 550 and 670 nm are taken from IOCCG Standard dataset (International Ocean Color Coordinating Group) are used as dataset, with Particle Swarm Optimization as the optimization technique for inversion of Rrs. Results show that the Multiplicative Bias values for Bulk IOPs (a – 0.79, bb – 1.37) obtained with model considering g0 and g1 as variables are better than the standard semi-analytical model (a – 0.77, bb – 1.41). We observed similar results using another statistic: Mean Absolute Error, for Individual IOPs and NASA bio-Optical Marine Algorithm Dataset. Hence, We propose to include g_0 and g_1 as variables for retrieval of IOPs from rrs using semi-analytical models.

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ABSORPTION BUDGET OF ATLANTIC AND POLAR WATERS IN FRAM STRAIT (ARCTIC OCEAN) IN LATE SUMMER.

Fram Strait is the main gateway for water masses exchange between North Atlantic and the Arctic Ocean. The West Spitsbergen Current transports warm and saline Atlantic Water (AW) northward, while Polar Water (PW) is carried southward by East Greenland Current. Here, we examine the absorption budget across optically contrasting surface waters in the Fram Strait. The contribution of main absorbing constituents: CDOM, phytoplankton pigments and detrital material, into a total non-water absorption, atot-w(l), was studied during two surveys in August/September 2014 and 2015. In AW CDOM absorption contributed to atot-w(l) from 77% at 350 nm to 53% at 412 nm. Contribution of CDOM decreased toward longer wavelengths being only 5% at 670 nm. Phytoplankton pigments absorption contributed from 43% at 443 nm to 64% at 670 nm to atot-w(l). The fraction of detrital absorption to atot-w(l) in AW varied from nearly 17% at 350 nm to 30% at 670 nm. In contrast, CDOM dominated the absorption budget in PW; its contribution to the atot-w(l) varied from ca. 95% at 350 nm to 77% at 433 nm, and was still significant (26%) at 670 m. The contribution of phytoplankton pigments to atot-w(l) was very low in PW except at 670 nm, where it reached 44%. The contribution of detrital absorption to atot-w(l) in PW was lower than in AW. Sea-ice melt water dilution did not change significantly the proportions between absorbing constituents compared to those observed in PW.

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MEASUREMENTS OF PARTICLE SIZE DISTRIBUTIONS IN NORWEGIAN COASTAL WATERS: A COMPARISON OF LISST-200X TO TRADITIONAL MICROSCOPY COUNTING WITH A NOVELTY

The particle size distribution (PSD) represents the relationship between the size of particles and their concentrations. Marine PSDs are relevant to a large number of varied fields, from biology and oceanography to climate studies and geology. The propagation of light in natural waters depends directly on the cross-sectional scattering area of the particles, and therefore the PSD provides important information about the optical properties of the oceans. The relevant size range for bio-optical studies is generally 0.01 micrometer to 1 mm, including virus, bacteria, sediments and phytoplankton [Jonasz and Fournier 2011]. The LISST-200X is a submersible laser-diffraction based particle size analyzer which is an improved version of the LISST-100X, able to make measurements at twice the depth, down to 600 meters. This makes the instrument especially suitable for measurements in the deep Norwegian fjords. The size range is 1-500 micrometer with 36 size classes. We have also taken water samples to filter and subsequently count and size particles the 'old fashioned' way using a microscope. However, since this is a very time-consuming and tedious method, we have developed a novel technique to ease this task: A software tool to measure length and width of particles from microscope images converts the non-spherical particles to 'equivalent' spheres [Grenfell and Warren 1999], which in turn are used to produce the PSD. Further we have compared the LISST-200X and the equivalent-spheres approach for several locations and depths from Norwegian coastal waters and fjords, to determine suitability and possible complementations for the two methods.

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OCEAN COLOUR FROM THE COPERNICUS SENTINEL-3 MISSION: PRODUCT STATUS AND ONGOING EVOLUTIONS

Copernicus Sentinel-3A OLCI has opened an era of European operational ocean colour observations and represents a significant achievement in the maturity, accessibility, continuity and routine utilization of ocean colour measurements. A consistent time series of OLCI-A products is now available, spanning over two years of operation. After the successful Sentinel-3B launch in April this year, OLCI-B is now also joining this record. The poster will describe the quality status of OLCI ocean colour products based on validations with in situ measurements and time series inter-comparisons with contemporaneous missions and climatologies. Guidance on the use of the products will be provided, including product limitations and the application of flags to mask cloudy or unreliable pixels. Sentinel-3 Validation Team, ocean colour sub-group (S3VT-OC), contributes important validation results and data for open ocean, coastal zones and inland waters. S3VT-OC validations will be summarized and OLCI capabilities further highlighted. Ocean colour product improvements and evolutions are a part of on-going OLCI activities, led by EUMETSAT and the S3 MPC ESA contract, to meet the mission requirements and the needs of data users. OLCI has an extended spectral and spatial resolution and precision compared to the past and contemporaneous missions. These capabilities are now being utilized to improve the processing and to address user needs with new products.

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PROCESSING OF CHRIS-PROBA HYPERSPECTRAL IMAGES TO RETRIEVE WATER QUALITY INFORMATION

The Compact High Resolution Imaging System (CHRIS) on the Project for On-Board Autonomy platform (PROBA-1) is an experimental hyperspectral satellite sensor which provides 13kmx13km images with 62 spectral bands from 415nm to 1050nm at a spatial resolution of 36m since 2001. To prepare the exploitation of hyperspectral data from future ocean colour remote sensing sensors and determine what extra information can be extracted, CHRIS images taken over different sites including inland waters, coastal waters and river months and plumes were processed to retrieve water reflectance and water constituents. CHRIS L1 data are affected by random noise but also by disturbance patterns characterized by a high degree of spatial and spectral coherence. The latter is inherent to the sensor itself and is partially reproduced from one image to another. As existing algorithms for CHRIS noise removal have focused mainly on vertical striping, we developed here a new algorithm which improves the quality of the reflectance spectra. An atmospheric correction algorithm originally developed for turbid coastal waters and high spatial resolution sensors was successfully adapted to CHRIS/PROBA data in order to retrieve hyperspectral water-leaving reflectance. Standard multispectral algorithms for chlorophyll-a and suspended particulate matter were applied to CHRIS data and compared with simultaneous images from multispectral sensors. The perspectives for retrieving new information about algae composition and suspended sediment characteristics (size/type) from the hyperspectral data are discussed.

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TRUE COLOUR OF 1,400 NEW ZEALAND LAKES: CLEAN, GREEN AND PRISTINE?

True colour is the colour of and object perceived by a human observer and can be derived using satellite-borne multispectral sensors. It does not suffer from the algorithmic difficulties hampering the retrieval of bio-geophysical variables in case 2 waters and therefore lends itself to the monitoring of inland waters across a range of optical water types. Our dataset of 44,947 observations of true colour in over 1,400 lakes in New Zealand was derived from Landsat 8 OLI. We found that 60% of lakes can be reliably categorised into blue, green and yellow colour bins. Thirty five percent of New Zealand's lakes are persistently yellow, indicating ubiquitous presence of optically active substances such as phytoplankton, suspended sediments or coloured dissolved organic matter. Blue water, indicating low levels of optically active substances, was found in 16% of lakes in our dataset and only 8% of lakes were predominantly green. About 40% of lakes show significant temporal variability in colour and flip between blue, green and yellow states. The time scales of transitions between colours vary between lakes and provide valuable insight into the mechanisms that drive lake ecology. For example, there are no blue or blue-green lakes in catchments where dairy pasture makes up more than 20% of land use. Due to the iconic status of lakes in New Zealand, water colour is regularly monitored by some regional authorities and remote sensing can help to manage these waterbodies more efficiently and provide ecological insights.

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ESTIMATION OF CHLOROPHYLL-A CONCENTRATIONS IN A HIGHLY TURBID PRODUCTIVE LAKE BY A CLASSIFICATION-BASED MODIS LAND-BAND ALGORITHM

Due to the saturation issues of the MODerate-resolution Imaging Spectrometer (MODIS) 1-km ocean bands, the 250 and 500 m resolution land bands are tended to be used in coastal and inland waters. However, these MODIS land bands can only provide limited wide spectral information. Thereore, it is a significant challenge to estimate chlorophyll-a in highly turbid productive waters. In this study, we present a classification-based chlorophyll-a estimation algorithm in a highly turbid productive lake, Taihu Lake in Eastern China. This algorithm uses four visible to near-infrared MODIS land bands. Firstly, Taihu Lake is classified into two classes by threshold segmentation of MODIS Rrs(555)/Rrs(645). The optical property of the first class (Class 1) is dominated by chlorophyll-a, while the second class (Class 2) is dominated by suspended particulate matter. Then, Rrs(859)/Rrs(645) was applied to estimate Chla in Class 1, and a newly-proposed Anti SPM Chlorophyll-a Index (ASCI) was used to estimate Chla in Class 2. Validation showed that the Average Unbiased Relative Error (AURE) of the derived Chla is 44.4%. The algorithm was further applied to estimate chlorophyll-a in Taihu Lake between 2000 and 2015, and the spatial and temporal patterns of the estimated chlorophyll-a agreed well with previous studies.

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IMPACT OF VISIBLE SOLAR RADIATION IN THE UPPER WATER COLUMN ESTIMATED FROM REMOTE SENSING ON TEMPERATURE AND MIXING IN UPPER OCEAN

The penetration of visible solar radiation in the upper ocean contributes to heating in the upper water column and this impact is modulated by constituents in water. Many models have been developed and used in dynamic ocean circulation models to include this factor. A recent study, however, found that the estimated transmission of visible solar radiation in the upper water column based on remotely-sensed chlorophyll concentration (Chl) has large uncertainties when compared with in situ measurements. It also found that the agreement in transmission is significantly better, especially for more turbid waters, when it was estimated centered on waters' inherent optical properties (IOPs). It is thus necessary to know to what extent such a transmission based on IOPs will affect upper layer heating and mixing when compared with traditional approaches based on Chl. We thus employed a 1-D ocean circulation model based on ROMS and compared the resulted temperature and mixing status to that obtained with the conventional Chl-based schemes. The results show that, although all used the same boundary conditions and ocean color information, these photosynthetically available radiation (PAR) vertical profiles resulted in different vertical temperature and upper water mixing, where the difference in temperature can be up to ~2°C while the mixed layer depth can be up to ~50 m. These results further advocate the application of IOPs products from satellite remote sensing to study the upper water dynamics and air-sea interactions in the global oceans.

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MAIN REASONS OF ERRORS IN SATELLITE DERIVED PRIMARY PRODUCTION MODELS: CASE STUDY OF THE WESTERN PART OF THE JAPAN/EAST SEA

Application of satellite derived models of primary production using ocean colour remote sensing data opens new possibilities of estimation of its time and spatial variability at different scales. However, it is always necessary to take into account that errors of model retrieval can affect wrong interpretation of this variability. In the study we analyzed errors of satellite derived primary production models and explain main reasons of its appearance for a case study of the western part of the Japan/East Sea (35-44°N, 130-137°E). As satellite derived primary production we used data of Vertical Generalized Production Model (VGPM) from Ocean Productivity database. Due to insufficient amount of in situ primary production data in the western part of the Japan/East Sea, satellite derived primary production was compared with modeled assessments, which were got using ship data of model input parameters (chlorophyll-a at different depths, assimilation number, euphotic depth etc). Applied analysis showed three reasons of errors of satellite derived primary production models: (1) accuracy of remote sensing chlorophyll-a, (2) oceanographic conditions - water stratification and (3) accuracy of assimilation number determination.

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CAPTURING COASTAL WATER CLARITY VARIABILITY WITH LANDSAT 8 AND CITIZEN SCIENCE

Coastal water clarity changes on varying temporal and spatial scales due to fluctuating weather and climate patterns and increasing human activity along coastlines. Systematic observations are required to assess how aquatic habitats will be impacted by dynamic coastal water clarity changes. This study combines Secchi disk depths (ZSD) collected by Massachusetts Water Resources Authority, Buzzards Bay Coalition, Provincetown Coastal Center for Studies, and the Narragansett Bay Commission citizen scientists with Landsat 8 (L8) derived ZSD to locally validate Lee et al. (2016) L8 ZSD algorithm for Boston Harbor (MA, US), Buzzards Bay (MA, US), Cape Cod Bay (MA, US), and Narragansett Bay (RI, US). From 2013-2016, 37 clear sky L8 images were selected and 13 of the 37 L8 images occurred on days when citizen scientists measured ZSD. The same day validation provided good agreement for Buzzards Bay (N = 25, RMSE = 1.03 m, R^2 = 0.65) and Cape Cod Bay (N = 15, RMSE = 0.94 m, R^2 = 0.71). Poor agreement was found for Boston Harbor (N = 45, RMSE = 1.38 m, R^2 = 0.01) and not enough same day matchups were found for Narragansett Bay. The good agreement for Boston Harbor and Cape Cod Bay allowed for the applicaiton of the ZSD algorithm to L8 images to create high spatial water clarity maps. The validation and creation of water clarity maps exhibits how citizen scientist and L8 measurements can be used in tandem to capture spatio-temporal changes in water clarity.

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THE COMPENSATION DEPTH IN THE OPEN OCEAN: A VIEW FROM THE WOCE HYDROGRAPHIC PROGRAM

The depth of the ocean's productive zone is unknown, except by mutual agreement. To address this unknown, I consider optical data from four, north-south, transects from the WOCE Hydrographic Program, two in the Atlantic (A15, A20), and two in the Pacific (P16, P19). The data were collected using a profiling package consisting of a MER2040 (including PAR), a beam transimissometer, and a fluorometer. An attached sampler and bucket sampling allowed two water samples to be collected with each cast. The overall distributions reflect the basin-scale oceanography. For example, in the Pacific, the deep chlorophyll maximum (DCM) (estimated from in vivo fluorescence) rises to shallower depths across the equator, and deepens in the north and south subtropical gyres. The base of the DCM ranges from 120-170 m. If it is assumed that the productive zone includes all autotrophic biomass (see Marra et al., 2014, Deep-Sea Research, 83:45-50), then the euphotic zone in these data extends much deeper than how it is usually specified, that is, the depth of 1% of surface PAR. The bottom of the deep chlorophyll maximum coincides with the depth of 1% of Ed(488).

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Wednesday, October 10
Poster Session 3
16:00–18:00

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UNDERWATER LIGHT AVAILABILITY ASSESSMENT IN THE VAIGAT-DISKO BAY, WEST GREENLAND: EFFECTS OF GLACIAL MELTWATER DISCHARGE

Global warming has led to increased supply of meltwater from glaciers to coastal systems such as fjords and coastal embayments along the coast of Greenland. Studies of the impact of increased glacial outflow on the underwater light field are however very limited. Arctic marine ecosystems are greatly impacted by the accelerated glacial melting. With an aim to understand the effects of meltwater runoff on the hydrography and bio-optical variability, profiles (CTD, ac-s, HyperPro II) were measured in the Vaigat and Disko Bay area located on the west coast of Greenland in summer 2017. The Vaigat-Disko Bay receives sediment rich glacial meltwater input from the Iluliissat Glacier. Declared as a UNESCO world heritage site, it is one of the fastest and most active glaciers in the world and annually calves about 10% of all Greenland calf ice. The Vaigat and Disko Bay were spatially sampled so as to provide high resolution mapping of the underwater light availability. Inherent optical properties (IOPs) and apparent optical properties (AOPs) were derived for the meltwater-influenced bay. From the acquired dataset a spatial assessment of underwater light availability is performed indicating areas of maximum light penetration and diminuation.

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DELAYED ISLAND EFFECTS CAN TRIGGER NITROGEN FIXER BLOOMS

The southwest tropical Pacific is characterized by low chlorophyll concentrations (typically below 0.1 mg m^{-3}) and depleted surface nutrients. In this mostly unproductive region, chlorophyll concentration however often increases in the vicinity of oceanic islands. These enrichments are caused by nutrient inputs by island-driven processes such as upwelling and mixing in lee eddies, island runoff, or iron enrichment from the island platform. This "island effect" is very common across the tropical Pacific, and is generally identified by inverse relationships between chlorophyll and distance to an island. Here we revisit the island effect using satellite chlorophyll, in situ observations collected during the 2015 OUTPACE campaign, and a simple model. We demonstrate that a second type of island effect exists, where the phytoplankton response is decoupled in time (several weeks) and space (hundreds of km) from the island-driven nutrient enrichment. This decoupling happens when nitrate is limiting, N:P ratios are low, and excess iron remains in the water masses after an initial bloom (the "classical" island effect). Slow-growing nitrogen fixers then start utilizing leftover iron and phosphate while water masses get advected away from the island. As a result, chlorophyll concentrations increase again and peak weeks later ("delayed" island effect). Such blooms can be very intense with chlorophyll concentrations over 10 times the average concentration in the region. This study suggests that the fertilizing effect of islands on phytoplankton and primary production may have been largely underestimated.

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REMOTE SENSING OF RIVERINE PARTICLES PROPERTIES IN THE GULF OF LYON, SOUTHERN FRANCE, USING COMPLEMENTARY IMAGES FROM SENTINEL 2 MSI AND SENTINEL 3 OLCI.

Since 2015-2016, high-resolution-MSI (~10m) on Sentinel 2a&b, and moderate-resolution-OLCI (300m) on Sentinel 3a&b provide optical data suitable to monitor riverine particles dynamics and coastal processes.Particles fluxes in the Gulf of Lyon (France) are dominated by the Rhône river plume and secondly by smaller rivers. The aim is to test and adapt generic algorithms (Nechad_SPM, Han_SAA, Lee_QAA, Lee_Zsd) to retrieve particles concentration from S2 and S3 data from small to wide river plumes. A special attention is paid to evaluate their potentials to derive the mineralogical properties of interest. Several atmospheric and sunglint correction schemes are tested. Results highlight capabilities of Sentinel 2-MSI to monitor sub-kilometric coastal sediment dynamics, and complemented by Sentinel 3-OLCI that provides instantaneous images of larger plumes (e.g. Rhône flood). Benefits of simultaneous use of S2 and S3 data are analyzed. Main results can be summarized: 1 - MSI data compare well with in situ Rrs after applying atmospheric and sunglint corrections, which still need to be improved for OLCI sensors even though results obtained from band-ratio based algorithms provide satisfying results. 2 – Turbidity/SPM mapping from satellite Rrs depend on the algorithm used and vary by one order of magnitude. On a second order, particles composition (e.g. PIC) seems to have a higher effect on Rrs Spectra than PSD. 3 – In the perspective of coupling SWOT (altimetry) with optical satellite data to assess sediment fluxes, discrepancies between in situ and algorithms data in turbid waters emphasize the importance of further studies on river sediment.

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TOWARDS IMPROVED SATELLITE ALGORITHM VALIDATION TOOLS: A REVISED PIGMENT-BASED APPROACH FOR DISCRIMINATING PHYTOPLANKTON TYPES

Phytoplankton traits, such as morphology, nutrient acquisition, and life cycle strategies, influence a phytoplankton group's role within an ecosystem. These traits are used to categorize phytoplankton groups according to their biogeochemical function, namely phytoplankton functional types (PFTs). Defining PFTs requires knowledge of how these traits influence oceanic biogeochemical cycles, the food web and the biological carbon pump. PFT algorithms use Rrs-derived products, such as phytoplankton absorption, to model PFT community composition in the ocean. Coincident in situ observations of phytoplankton taxonomy with satellite-based observations are vital for ground-truthing the products of these algorithms. The CHEMTAX method is widely used to differentiate PFTs with in situ pigment data and provides both relative and absolute abundance of taxonomic groups.Limitations exist with this approach:it relies on accurate diagnostic pigment-to-Chlaratios for a region of interest, and Chlais sensitive to light regime and nutrient availability, reducing the accuracy of this method. Phytoplankton carbon (Cphyto) remains a better measure of biomass because it is not as sensitive to these environmental pressures. Through a series of controlled experiments conducted at the National Center for Marine Algae and Microbiota, we aimed to develop a set of refined pigment-to-Chlaand pigment-to-Cphyto ratios specific to phytoplankton species and physiological state. During this study we quantified changes in pigment content, pigment-to-Chlaratios and pigment-to-Cphyto ratios of 41 phytoplankton species. From this study, we will present preliminary results comparing the implementation of CHEMTAX using pigment-to-Cphyto ratios and revised pigment-to-Chla ratios to model phytoplankton community composition in the ocean.

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TOWARDS A LONG-TERM DATA SET ON LIGHT AVAILABILITY AND TOTAL CHLOROPHYLL-A DERIVED FROM SPECTRAL SIGNATURES OF VIBRATIONAL RAMAN SCATTERING IN HYPERSPECTRAL SATELLITE OBSERVATIONS

Vibrational Raman scattering (VRS) in the water is an inelastic scattering process that causes a spectral redistribution of the radiation in the ocean. It needs to be taken into account accurately to determine the underwater light field and to exploit this information in oceanic remote sensing applications. The VRS signal in hyperspectral satellite radiances has been investigated in the UV and used as a proxy for the effective in-water light path and for total chlorophyll-a estimations. For determining the light availability directly in the visible range and retrieving a spectrally derived PAR (photosynthetically available radiation) product, the VRS signature in the visible channel from hyperspectral radiances measured by the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) has been exploited. Since SCIAMACHY stopped measuring in 2012, newer hyperspectral sensors such as the recently launched TROPOspheric Monitoring Instrument (TROPOMI) on the Sentinel-5-precurser satellite could be used for light availability investigations from 2012 onwards. Here, we are presenting the VRS retrieval on top of atmosphere radiances measured by the Ozone Monitoring Instrument (OMI) that bridges the time period between 2012 and 2018 and has the same sensor design as TROPOMI. From the OMI VRS signal we derive the light availability, the diffuse attenuation coefficient (Kd490), in an approach similar to that used for SCIAMACHY observations, and additionally total chlorophyll-a. These products are then compared to SCIAMACHY results as well as total chlorophyll-a and Kd490 from MODIS-Aqua.

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UNCERTAINTIES IN ATMOSPHERIC PARAMETERS FOR DIURNAL REMOTE SENSING OF COASTAL OCEANS

The coastal oceans, bays, and estuaries are highly dynamic systems in nature with myriads of physical/biological processes occurring at short-time scales, i.e., hourly. Daily satellite ocean color observations, therefore, do not provide adequate observations over such dynamic systems. Diurnal ocean color observations from geo-stationary orbits or constellations of ocean color imagers in Low Earth Orbits can provide unprecedented information about the temporal variability of near-surface bio-geochemical properties and physiological responses of marine plants to various short-term physical forcings. High-quality hourly ocean color products at land-water interfaces, however, are subject to robust characterizations of ambient atmospheric conditions. In this study, we analyze how uncertainties in ancillary data (e.g., column trace gases) utilized in the atmospheric correction impact down-stream products. We will further examine sensitivity of these products to varying aerosol height distribution. These scenarios are tested using both observations made by the Korean Geostationary Ocean Color Imager (GOCI) and simulated datasets. We anticipate that the analyses help determine measurement requirements for diurnal atmospheric parameters, including trace gases, aerosols, and ancillary data, to achieve high-quality ocean color products.

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EARLY RESULTS FROM AUTONOMOUS OBSERVATIONS DURING EXPORTS 2018

The goal of the NASA EXPORTS project (Export Processes in the Ocean from RemoTe Sensing) is to develop a predictive understanding of the export and fate of carbon fixed in the euphotic zone, linking satellite remote sensing of the ocean surface to carbon production and cycling. In late summer 2018 a multi-platform field campaign is to be initiated at the Canadian Weather Station PAPA, with two ships for a month-long cruise and four autonomous vehicles (AUVs) including a glider, Lagrangian float, and two BioArgo floats providing persistence beyond the cruises. All AUVs are instrumented with T, S, O_2, chlorophyll fluorescence, and optical backscattering; additionally, each has unique sensors including an ADCP for zooplankton, transmissometer operating as a sediment trap, radiometers, pH, CDOM, and nitrate. The Lagrangian float will drift below the base of the euphotic zone, acting as a target for studies to be carried out by the Process Studies ship. The glider profiles to 1000 m, following the float and providing a larger spatial context for the float. Together they will qualitatively identify export pathways and quantitatively assess export fluxes. The BioArgo floats will quantify seasonal cycles and annual export of biogenic carbon pools over multiple years. Early results are presented here.

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SEABASS TIMESERIES VALIDATION TOOL

A new web-based Timeseries Validation Tool was designed for the SeaWiFS Bio-optical Archive and Storage System (SeaBASS) to provide comparisons over time between in situ measurements and satellite-borne ocean color instrument observations. Suitable timeseries sites were identified based on regions where multi-year records of in situ measurements related to one or more ocean color validation products could be obtained. These data included a combination of SeaBASS data submissions and external data sources (such as AERONET-OC). For each site, a polygon-shaped sampling-area was defined to capture nominally-homogenous waters. Within each site's boundaries, satellite measurements were averaged, and all available SeaBASS in situ data that had been previously prepared for validation were included. Users are presented with a number of configuration choices, including the option to evaluate weekly-, monthly-, or seasonally-averaged data. A list of standard ocean color satellite products is available, including remote sensing reflectance, chlorophyll a concentration, and GIOP products. This tool complements the existing SeaBASS Level-2 ocean color satellite Validation Search by allowing the evaluation of temporal trends of data streams (i.e., in situ, plus one or more satellite sensors), differing from the existing Validation Search which focuses on narrowly defined coincident measurements.

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OPTICAL CHARACTERIZATION OF MARINE PHYTOPLANKTON ASSEMBLAGES WITHIN THE WESTERN ARCTIC OCEAN

We utilize an extensive dataset of measurements within the Chukchi and Beaufort Seas to characterize the inherent and apparent optical properties of seawater associated with different phytoplankton assemblages. Hierarchical cluster analysis of pigment concentrations were used to partition surface phytoplankton assemblages into distinct communities of varying taxonomic composition and average cell size. Concurrent optical measurements of hyperspectral constituent absorption coefficients (phytoplankton, non-algal particles NAP, and colored dissolved organic materials CDOM), multispectral backscattering coefficients, and remote-sensing reflectance were then used to characterize the optical properties associated with each pigment-based phytoplankton assemblage. The results indicate measurable differences among classes in the average spectral shapes of phytoplankton absorption. However, similar or sometimes greater differences are also observed in the spectral shapes of non-phytoplankton absorption (NAP and CDOM) and the backscattering coefficient. Our analysis demonstrates that the interplay between the relative magnitudes and proportions of all optically significant constituents (including water) generally dampen the influence of varying phytoplankton absorption spectral shapes on remote-sensing reflectance, yet surprisingly there is still a marked discrimination of the spectral shapes of reflectance among the phytoplankton assemblages. This result supports a potential for the development of relatively simple ways to discriminate phytoplankton communities directly from ocean reflectance in western Arctic waters, but the approach is dependent on environmental covariations of optical effects associated with both phytoplankton and non-phytoplankton constituents. We discuss the accuracy and robustness of this method in comparison with more mechanistic approaches based on constituent IOPs for assessing phytoplankton community composition.

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WATERHYPERNET - A NETWORK OF HYPERSPECTRAL MULTI-LOOK RADIOMETERS FOR MULTI-SATELLITE WATER REFLECTANCE VALIDATION

A network of hyperspectral radiometers is being developed for radiometric validation of satellite missions. This network follows closely the AERONET-OC federation concept [Zibordi et al, 2009] but uses the TRIOS/RAMSES hyperspectral radiometer and a more extensive multi-look pointing scenario. The instrument system consists of one radiance and one irradiance sensor on a pointing robot, controlled by a small embedded computer board and supplemented with GPS, inclinometer and video camera data feeds. The measurement protocol is based on the abovewater method of [Mobley, 1999 and 2015], but includes additional scenarios for different viewing zenith and azimuth configurations. The system is being deployed initially in Belgian coastal and inland waters, then at sites in Argentina and France before full international expansion. The network will provide water reflectance data for the radiometric validation of all visible and near infrared bands of all optical missions, including Sentinel-2A&B, Sentinel-3A&B, PROBA-V, MODIS-AQUA&TERRA, VIIRS, Landsat-8, Pléiades, CHRIS-PROBA, MSG-SEVIRI, PlanetDove … ENMAP, PACE, MTG and ... any future optical missions, including nanosatellites. This presentation will provide the first results on system prototype testing and the results of numerical simulations demonstrating the advantages of hyperspectral and multi-look radiometry.

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Poster 206

IMPROVEMENTS OF THE BRIGHT PIXEL CORRECTION FOR OLCI AND THE SENTINELS 3: STATE OF THE ART AND OPPORTUNITIES

Our recent research activities in the fields of the BPC[1] for OLCI[2], performed in the scope of the S3 MPC[3], showed that starting from the existing Level 2 processor, we could reduce the spatial noise by 15% (at 400nm) to 50% (at 900 nm), for very clear waters, and by 5 to 40% for coastal waters while keeping in the same time statistically equivalent validation performance when comparing with in-situ data. The first part of our presentation aims at showing the improvements of the corrected version of the OLCI Level 2 processor. Beyond this, we investigate in the second part possible ways to further improve the level 2 processor. We particularly focus on the introduction of the spatial information knowledge in the inversion, typically the spatial continuity of the aerosol properties. The basic assumption in the atmospheric correction is the ability to separate the spectral signatures of the atmospheric and the water contributions to the signal. Nevertheless, this assumption often fails, even if considering the 1.02 µm band for OLCI. In such case, the introduction of a priori onto the spatial covariance of the aerosol is particularly relevant and helps to unmix the two contributions. We show different strategies, from the literature, and quantify the results for OLCI in terms of: water reflectance estimation improvements; gains in spatial coverage; reduction of the estimated uncertainties; cost in terms of computation. [1] BPC: Bright Pixel Correction [2] Ocean Land Colour Instrument [3] MPC : Mission Performance Center setup by ESA & EUMETSAT

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Poster 210

DEVELOPING A COMMUNITY OF PRACTICE FOR APPLIED USES OF FUTURE PACE DATA TO ADDRESS FOOD SECURITY CHALLENGES

Over the past 20 years, continuous ocean color satellite measurements have transformed our understanding of processes that support life in the ocean and improved our ability to monitor critical ecosystems. Historical ocean color satellite measurements yielded valuable biological information such as the concentration of chlorophyll. The Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission is building advanced instruments to optimize ecosystem monitoring. Combining higher spectral resolution data from PACE with information from other satellites, in situ measurements and models, will enable identification and tracking of marine biological indicators and their response to multiple stressors to guide sustainable management and conservation efforts. We describe early efforts to engage a community of practice around food security to increase satellite data product use in support of resource management, business decisions, and policy analysis. Understanding and considering the needs of applied researchers as well as non-traditional users of satellite data early in the PACE mission-design process will ultimately broaden the base of informed users to improve planning and preparation and mitigate food insecurity.

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Poster 214

A SIMPLE FORMULA FOR EMPIRICAL OCEAN COLOR ALGORITHMS FOR ABSORPTION COEFFICIENT OR CHLOROPHYLL CONCENTRATION APPLICABLE FROM CLEAR TO TURBID WATERS

In the past decades for quick and easy production of chlorophyll concentration (Chl) from remote sensing reflectance spectrum (Rrs), a wide range of empirical algorithms have been developed, where separate algorithms were proposed for "clear" and "turbid" waters. Thus, if there are both clear and turbid waters in an ocean color image, an empirical switch scheme has to be designed in order to obtain a continuous image product, which usually results in jump or discontinuity of the product value at the clear-turbid boundary. To avoid this arbitrary switch and to obtain robust estimation of absorption coefficient or Chl from ocean color, we propose a simple formula (termed as OCmax2) for the empirical retrieval of Chl or absorption coefficient from Rrs. It is found that, compared to the widely used OC4-type algorithm, OCmax2 can improve the coefficient of determination (R^2) from ~0.88 to 0.99 for a(440) (the total absorption coefficient at 440 nm) in a range of ~0.01 – 20.0 m^{-1} (equivalent Chl is roughly ~0.01 > 500 mg/m^3). Especially, the sensitivity of OCmax2 to the change of a(440) is more than tripled compared to OC4 type of algorithm for a(440) > 0.3 m^{-1} (Chl roughly > 5 mg/m^3). These results indicate its robustness and seamless applicability from clear to highly turbid coastal areas that cover nearly all natural waters. Applications of OCmax2 to both in situ data and satellite images in coastal areas are further demonstrated, and advantages and limitations of OCmax2 are also presented.

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Poster 218

A NEW ALGORITHM FOR DERIVING VIIRS INHERENT OPTICAL PROPERTY PRODUCTS IN GLOBAL HIGHLY TURBID COASTAL AND INLAND WATERS

In coastal and inland waters, the normalized water-leaving radiance spectra are determined by water inherent optical properties (IOPs). The complex feature of the water IOPs makes it challenging for accurately retrieval of IOPs from satellite measurements. This presentation shows that remote-sensing reflectance model in the turbid waters can be significantly simplified at the near-infrared (NIR) wavelengths, thus particle backscattering coefficient (bbp(λ)), phytoplankton absorption coefficient (aph(λ)), and dissolved and detrital absorption coefficient (adg(λ)) can be derived from normalized water-leaving radiance spectra nLw(λ) at the NIR wavelengths. Using the HYDROLIGHT simulated water-leaving radiance spectra and in-situ measurements in Lake Taihu, we show that the bbp(λ), aph(λ), and adg(λ) values derived using the NIR IOP algorithm generally match well with true values in turbid coastal and inland waters. bbp(λ), aph(λ) and adg(λ) products derived using the NIR IOP approach are also compared with those from other IOP algorithms such as the quasi-analytical algorithm (QAA). Based on evaluation results, an IOP algorithm combining the NIR-based IOP algorithm for coastal/inland turbid waters and the QAA IOP algorithm for open oceans is proposed. Specifically, using China's east coastal region as an example, nLw(λ) spectra at the NIR bands are derived using the NIR and SWIR combined atmospheric correction algorithm from measurements of the Visible Infrared Imaging Radiometer Suite (VIIRS), and VIIRS-derived nLw(λ) spectra are used as inputs for retrievals of IOPs. We demonstrate that the combined IOP algorithm can produce high-quality bbp(λ), aph(λ), and adg(λ) data for both the turbid coastal/inland waters and the open ocean.

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MARITIME AEROSOL NETWORK AS A COMPONENT OF AERONET –CURRENT STATUS AND FUTURE CHALLENGES

Maritime Aerosol Network (MAN) as a component of Aerosol Robotic Network (AERONET) started collecting data on aerosol optical properties over World Ocean in October of 2006. Over the years more than 500 cruises were completed and data archive consists of over 6000 days of measurements. MAN deploys handheld sunphotometers and utilizes the calibration procedure and data processing traceable to AERONET. A public domain web-based data archive dedicated to MAN activity can be found at https://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html. Within MAN framework data acquisition was extended to the areas that previously had very little or no coverage at all and thus provided an important reference point in aerosol optical studies. MAN represents an important strategic sampling initiative and data acquisition from ships of opportunity complements island-based AERONET measurements. The ship-borne aerosol optical depth (AOD) data offer an excellent opportunity for comparison with global aerosol transport models, satellite retrievals and provide useful information on aerosol distribution over the oceans. Data archive can help understanding discrepancies between measurements and/or simulations for particular areas of the World Ocean. The program exemplifies mutually beneficial international, multi-agency effort in atmospheric aerosol optical studies.

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Poster 226

ASSESSING THE INFLUENCE OF OPTICALLY ACTIVE CONSTITUENTS ON THE RADIATIVE HEATING OF LAPTEV SEA SURFACE WATERS

Studies have shown that the high concentration of colored dissolved organic matter (CDOM) in Arctic waters increase the energy absorbed in the mixed layer and potentially contributes to sea ice melt. Here, we investigate the effect of changes in the water optically active constituents on the heat budget of the Laptev Sea surface waters. This region is heavily influenced by the Lena river; the second largest river discharge into the Arctic Ocean, carrying high loads of CDOM and suspended matter. We simulate the radiative heating by using coupled atmosphere-ocean radiative transfer modelling and in situ measurements of CDOM absorption (aCDOM(443)), total suspended matter (TSM) and chlorophyll concentration (Chla) from the TRANSDRIFT XVII expedition during August-September of 2010. Results showed that at the highest CDOM station (aCDOM(443) = 1.77 m^{-1}) 5% more energy was absorbed in the surface layer (upper 5 m) compared to the lowest CDOM station (0.2 m^{-1}), which translates to an increased heating rate of about 0.24°C/h. In contrast, the highest TSM (TSM = 7.2 g/l) led to an increase of 2.1% in the absorbed energy and 0.1°C/h in the heating rate compared to the lowesr TSM station (0.04 g/l). We further investigate the implications of the optical contribution of CDOM and TSM on surface heating and ice melt. In addition, using satellite remote sensing data of aCDOM(443), TSM, Chla and sea surface temperature as input to RTM, we present the spatial distribution of radiative heating of Laptev Sea surface waters for a typical summer day.

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Poster 230

FAST MONTE-CARLO RADIATIVE TRANSFER IN THE ATMOSPHERE AND OCEAN USING SMART-G

Monte-Carlo radiative transfer solvers are a powerful tool by their flexibility and ability to take into account virtually any physical process, but their applicability is generally limited by their demands in terms of processing power. The SMART-G (Speed-Up Monte-Carlo Advanced Radiative Transfer code with GPU) uses GPGPU (General-purpose processing on graphics processing units) technology through the CUDA framework to implement a fast code that simulates the propagation of light in the atmosphere, through the wavy sea-surface and in the ocean. This code accounts for polarization and works in either plane-parallel or spherical shell geometry. For typical simulations, an acceleration factor of several hundreds is obtained compared with CPU calculation. Advanced variance reduction techniques have been implemented. We present this code, its domain of application, cross-comparison with other reference radiative transfer simulations and two examples of fast sensitivity studies: one on the effect of the atmosphere sphericity on the Rayleigh polarized reflectances and one on the influence on nearby land on the observed ocean reflectances at the TOA, the so-called "adjacency effects". We describe also the way SMART-G handles spectral computations (band models, k-distribution or high spectral resolution absorption) including inelastic scattering and fluorescence and the way we produce also Jacobians of outgoing radiation versus oceanic, atmospheric and surface parameters.

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Poster 234

ASSESSING THE UNCERTAINTIES IN IOP RETRIEVAL AND IN-SITU VALIDATION FOR A COASTAL ENVIRONMENT.

Approaches have been developed to allow the retrieval of water Inherent Optical Properties (IOP) from above-water reflectance. The performance of these models is consistently improving, however their sensitivity to uncertainties in measurements is yet to be fully explored. We quantified the impacts of uncertainties associated to input data for different IOP retrieval models and how their outputs perform compared to uncertainties of in-situ IOP measurements. All samples and radiometric measurements were carried out in the Damariscotta river estuary (Maine, USA) at 5 stations in 2 consecutive days, as part of the 2017 Ocean Optics Class (NASA/University of Maine). In each station we obtained vertical profiles of temperature, salinity, chlorophyll fluorescence, light absorption, beam attenuation and backscattering and collected discrete water samples for particle light absorption and chlorophyll-a concentration. Finally, above and in-water radiometric measurements were conducted using the HyperSAS and HyperPRO profiler, respectively. All IOP retrieval models showed less variability in the output data when using Rrs from HyperPRO in buoy mode. IOPs obtained from the filter pad technique have proven to be highly variable, while the best validation of retrieved IOPs is achieved when using AC-S data. The better performance of in-situ measurements (HyperPRO and AC-S) versus above water (HyperSAS) and discrete samples is likely due to the reduced effect of surface waves in the light field and sample handling, respectively. We plan to run forward simulations with Hydrolight and compare both retrieved and measured IOPs and Rrs.

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Poster 238

QUANTIFYING DISSOLVED ORGANIC CARBON EXCHANGES ACROSS WETLAND-ESTUARINE INTERFACES USING HIGH RESOLUTION SATELLITE IMAGERY

Quantifying carbon fluxes and exchanges across wetland-estuarine interfaces is critical for assessing the role of tidal wetland ecosystems in estuarine and coastal water quality, biogeochemistry, and ecology. The Operational Land Imager (OLI) onboard Landsat 8 provides a promising tool for monitoring dissolved organic carbon (DOC) dynamics in nearshore aquatic environments because of its high spatial resolution of 30 m and the inclusion of a blue band centered at 443 nm. Its applications, however, to retrievals of biogeochemical exchanges across tidal wetland-estuarine interfaces are limited by its coarse revisit period (every 16 days) relative to the strong (sub-diurnal) variability of water properties in tidally influenced systems. In this study, we developed a Landsat-8/OLI based DOC algorithm by correlating multiple Landsat-8 Rrs bands to field measurements of DOC in the estuarine waters adjacent to the Blackwater National Wildlife Refuge marshes in the Chesapeake Bay. Despite its ecological importance, since 1938, Blackwater's 29,000-acre preserve has lost approximately 5,000 acres of marshland. Algorithm evaluation using satellite data across different seasons over multiple years resulted in relative errors of less than 20%. Implementation of the algorithm demonstrates the potential of using Landsat-8/OLI to assess seasonal variability in wetland-estuarine DOC exchanges and capture the spatial extent of marsh influence on estuarine water quality. Results from the high spatial resolution satellite remote sensing observations were integrated with numerical simulations from an advanced coupled hydrodynamic-photochemical-biogeochemical estuarine model to quantify land-ocean carbon exchanges across spatial and temporal scales.

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HUE COLOR ANALYSIS OF INLAND AND COASTAL WATERS WITH HIGH SPATIAL-RESOLUTION SENSORS

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 and 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 accurately 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 are even possible for a range of High-resolution instruments, like OLI on Landsat-8 and MSI on Sentinel-2. In this presentation we will focus on the accuracy of the proposed algorithms and dependency of the hue angle on the spectral response curves. The new product will be demonstrated for a number of Sentinel-2 and Landsat-8 images of complex inland waters.

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Poster 246

GLOBAL DOC STOCK AND TEMPORAL VARIABILITY IN COASTAL WATERS (MERIS 2002-2012)

Diverse algorithms have been recently proposed to assess dissolved organic carbon (DOC) concentration in coastal waters from the optical properties of the colored dissolved organic matter (CDOM, absorption coefficient and spectral slope) with the aim of mapping DOC using the information provided by ocean color radiometry. While numerous CDOM and DOC inversion algorithms have been proposed for regional applications, recent developments have illustrated the possible assessment of DOC (CDOM) over large spatial scales. The performance of the "generalized" formulations currently documented for estimating CDOM and DOC has been evaluated on the basis of a large in situ data set covering very contrasted coastal waters. The DOC maps generated for the MERIS archive have been then used to estimate the coastal waters DOC stock at global scale, characterize its distribution taking into account the nature of the coastal environment (large rivers influence, coastal systems influenced by mangroves, tidal marshes, seagrass meadows…) and assess the DOC temporal variability over the MERIS time period at different time scales (sub-annual, annual, inter-annual). The observed spatio-temporal patterns are finally discussed considering the environmental factors driving DOC dynamics.

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HYPERSPECTRAL LIGHT AVAILABILITY ACROSS AND ALONG THE PACIFIC OCEAN – FROM CHILE TO NEW ZEALAND AND UP TO ALASKA

The characterization of the underwater light field by in-situ observations is essential to develop and improve ocean color remote sensing algorithms as well as realistic aquatic light model parameterizations. In-situ measurements from profiling systems are commonly utilized, however only a few datasets exist covering the Pacific Ocean, especially the southern Pacific and its gyre system. Here, surface waters are known to be the most oligotrophic and optically clearest in the global ocean. The underwater light field was observed on three cruises with R/V Sonne (2015 – 2017) by using a hyperspectral free-falling optical profiler covering the visible spectrum. We sampled waters from Antofagasta (Chile) to Wellington (New Zealand) as well as waters around New Zealand down to 55° South and up to Dutch Harbour, Alaska (USA). The data along the meridional and zonal transects across the Pacific Ocean cover different water masses with a broad range of influencing parameters: from ultra-clear waters with deep chlorophyll maxima at 200 m depth, to temperate as well as cold near-shore and coastal waters with low light penetration depths and deep chlorophyll maxima around 30 m. Furthermore, the underwater light field from 2016 and 2017 will be combined with above water hyperspectral remote sensing reflectance measurements from an underway installation onboard the vessel.

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Poster 254

DATAPRESENCE: A VISION FOR THE FUTURE OF DATA AT SEA

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New technologies developed for research vessels to enable virtual participation, situational awareness and adaptive sampling at sea; the ability to integrate data from a broad suite of ocean and meteorological sensors and facilitate quality real-time data collection and data visualization to inform the science mission, enable shore side participation, and encourage education and community outreach. The design of the next generation Regional Class Research Vessel (RCRV) for the U.S. academic research fleet includes advanced datapresence systems and capabilities. We envision these capabilities as a tool to facilitate research at sea while providing an interdisciplinary approach to ocean science research, one that enhances observational, experimental, and analytical capabilities. This presentation will introduce our vision of datapresence to the community with an emphasis on the optics components of the system including proposed underway sensors, preliminary methods developed for QA and QC of data, and tools for data visualization as demonstrated by data from research cruises utilizing our datapresence prototype.

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A PRACTICAL METHOD FOR ESTIMATING THE LIGHT BACKSCATTERING COEFFICIENT FROM THE REMOTE-SENSING REFLECTANCE IN THE CONDITIONS OF THE BALTIC SEA AND EXAMPLES OF ITS POSSIBLE APPLICATION

Based on empirical data collected in the region of southern and central Baltic Sea a simple and practical method for estimating the light backscattering coefficient in the surface layer of seawater from the remote-sensing reflectance spectra has been developed. This method relies on the following two observations: 1) the existence of a relatively strong statistical correlation between the two mentioned optical quantities in the range or red light wavelengths (e.g. at 620 or 650 nm), and 2) the fact that in the conditions of the Baltic Sea the spectral shape of the light backscattering coefficient of suspended particles varies only to a small extent and can be approximated by an averaged shape. In the case of backscattering coefficient of seawater, whose measured values changed in the examined waters by more than one order of magnitude, the accuracy of its estimation by means of the proposed simple method can be characterized by a standard error factor of 1.28 or less (which corresponds to the relative error of estimation ranging from -22% to +28%). In addition, examples of the possible application are provided. The developed method can be used as one of the stages of simple algorithms for estimating the spectra of light absorption coefficient in seawater, without a need for any additional a priori assumptions regarding the spectral shape of absorption by dissolved and suspended seawater constituents.

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A GLOBAL ALGORITHM FOR THE RETRIEVAL OF SEA SURFACE TEMPERATURE FROM LANDSAT 8 TIRS IMAGE

Because of the high spatial resolution (30 m) and free access, Landsat 8 data have great potentials in illustrating coastal eddy, thermal plume contamination and water quality at fine scales. As such, there have been algorithms developed for the retrieval of sea surface temperature (SST) from Landsat 8 TIRS data. Such algorithms, due to its site-specific nature and narrow temperature range occurred at algorithm development, however, have limited applicability to other regions of the globe. This study attempts to establish a Landsat SST algorithm that is applicable to wider range of environments. Specifically, after compiling 670 in-situ Landsat-8 matchup data with SST ranging 0°~35°, 335 data points were employed to develop a relationship between Landsat channels 10/11 data and measured SST. For the other 335 points it is found that the retrieved SST from Landsat-8 agree with measured SST excellently, where the coefficient of determination (R^2) is 0.98 and the root mean square error (RMSE) is 1.1. In comparison, the RMSE between MODIS and measured SST is 1.46 although the R^2 value is also 0.98. These results highlight the global applicability of Landsat-8 data and algorithm for a fine-scale SST product, although further refinement in the future is envisioned.

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PRIMARY PRODUCTION IN THE ARCTIC WATERS

The plankton algal primary production in the world ocean was a subject of interest since more than 50 years. Knowledge of the phenomenon is crucial for understanding of marine ecosystems functioning and explaining changes of ocean productivity, i.e. the availability of marine plankton, which is the base of the trophic pyramid and the beginning of the food web necessary for the growing of organisms from higher level and fish important from economic point of view. The ^{14}C technique involves addition of $^{14}CO_2$ in to the water sample, where during photosynthesis the algae incorporate the tracer into organic matter. If the total content of CO_2 in the experimental water is known, and if the known amount of $^{14}CO_2$ is added, the rate of primary production can be calculated. The frequency of pelagic primary production measurements are relatively low because of methodology (usually one incubation per day in midday) and high costs both vessel as well as buying ability of isotope ^{14}C and its price. Despite this the in situ measurement of primary productions in different region were conducted and collected by research time from Marine Optics Department of Institute of Oceanology of Polish Academy of Sciences (IO PAS) since 1993. The largest number of measurements was made in the Baltic Sea region, a few in situ expositions were conducted in the Arctic, 1997, 2002 and 2003. Results of those experiments will be presented at the poster.

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REMOTE SENSING OF ORGANIC CONTENT IN SUSPENDED PARTICLES

The suite of water quality products based on remote sensing has been limited largely to those associated with water turbidity and chlorophyll concentration. We are expanding the suite of options in this study. Here, we inverted VIIRS satellite reflectance data in the Chesapeake Bay using the Quasi-Analytical Algorithm and the Generalized Stacked-Constraints Model, and obtained particulate absorption and backscattering coefficients. These data were matched up with field-measured particulate organic carbon (POC) and suspended particulate matter (SPM) obtained through the Chesapeake Bay Program. We show that the particulate absorption to backscattering ratio is correlated with the POC to SPM ratio, with the degree of correlation varying with location. Specifically, the lower bay has the highest correlation and the upper bay has the lowest correlation. Although it remains to be assessed whether such a correlation holds in other regions, our results shed light on obtaining organic content information from remote sensing, which can be a new water quality product independent from turbidity and chlorophyll.

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USING WORLDVIEW IMAGERY TO STUDY CHLOROPHYLL-A CONCENTRATION IN SOUTH NATION RIVER, EASTERN ONTARIO, CANADA

There are numerous stresses degrading surface water quality, categorized generally as natural processes and anthropogenic influences. Rivers are easily prone to water quality degradation due to being abused for the disposal of wastewater. Rivers' water quality has a substantial role in the ecological and human health, and economic development. Therefore, it has become an essential task worldwide to prevent and control the declining water quality in rivers. Eutrophication is a serious pollution problem. Chlorophyll-a (chla), a photosynthetic pigment available in all kinds of phytoplankton, can be addressed to determine the eutrophication status. Reliable information on chla concentration at a sufficient spatial and temporal scale should be collected to address the highly heterogeneous nature of water quality in rivers and implement protective techniques to improve water quality conditions. Traditional laboratory approaches can be logistically intractable if the end point of interest is dense spatio-temporal datasets. The use of satellite remote sensing can reduce some of these logistical constraints, while at the same time provide chla characterization with high spatial resolution and frequent temporal coverage. In this study, an ordinary least square (OLS) linear regression model is used to estimate the concentration of chla (avg: 8.4 mg m^{-3}) in South Nation River from the WorldView band ratio of RedEdge to Blue ($R^2 = 0.58$). The best band combination was selected based on the highest absolute value of calculated Pearson correlation coefficient. The spatial variations of chla on a selected date in fall 2015 is also calculated using the derived OLS regression model.

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