



**EARSeL Special Interest Group
Remote Sensing of the Coastal Zone**

**6th Workshop on
Remote Sensing of the Coastal Zone**

Matera, Italy, 5-7 June 2013

Abstract Book

Issue: 17 May 2013

Mapping aquatic vegetation through remote sensing data: a comparison of different Vegetation Indices performance

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Keywords: Aquatic vegetation, Vegetation Indices, Remote sensing, Separability, NDWVI, WAVI

Abstract:

Studying and mapping aquatic vegetation through remote sensing is a powerful and effective way to monitor vegetation status, growth and bio-physical parameters, because of the advantages synoptic view have on traditional in situ survey. In this field, Vegetation Indices (VIs) are one of the most used and useful tools. This work aims at running a brief comparison of different VIs in mapping aquatic vegetation over 3 distinct study areas and wetlands ecosystems in Italy, by employing multi-spectral and multi-sensor dataset ranging from aerial to satellite data, with varying spatial (1-30 m) and spectral resolution (0.01-0.15 μm), in order to evaluate the best performing ones. Along with well known indices such as NDVI, SAVI and EVI, two newly derived indices targeted particularly at monitoring aquatic vegetation features are tested: NDWVI and WAVI. From VIs results over the diverse, multitemporal and multisensor dataset, performances in terms of both aquatic vegetation mapping capabilities and vegetation features separability were assessed. Best performances were shown in most of the cases by the newly introduced indices (WAVI, in particular), thus demonstrating the usefulness of a specific index for mapping aquatic vegetation, and the integrated use of them with other VIs can be envisaged in order to effectively exploit and discover a wider range of aquatic vegetation features from multispectral remote sensing data.

Chlorophyll estimation in mangrove forest for potential use as an indicator of vegetation conditions

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Keywords: Mangrove, Chlorophyll, hyperspectral, radiative transfer model.

Abstract:

Chlorophyll (Chl) is a leaf biochemical element that on its own accord has been used in remote sensing as an indicator of plant primary productivity and a proxy of predicting biogeochemical processes in ecosystems (Baret et al., 2007; Haboudane et al., 2002). Plant Chl significantly vary when exposed to different natural and anthropogenic conditions, and for this reason a good parameter choice for ecosystem studies. Researchers have used various approaches to estimate Chl in the past, however, remote sensing images have become a lucrative option since they cater for issues of scale, costs, flexibility on method and most importantly Chl distribution dynamics in a canopy can be well observed in the visible domain of optical image reflectance (Curran et al., 2001). There are existing algorithms that can be used to link variations in spectral reflectance pattern displayed in an image to Chl in plants which either rely on establishing statistical linkage between spectral reflectance and vegetation attribute using regression equations or physical approach that adhere to laws of energy transfer within a medium. This study uses a physical model or radiative transfer model (RTM) referred to as the Soil Leaf Canopy Model (SLC) (Verhoef & Bach, 2003). SLC is composed of three sub models for Soil (4soil) for the leaves (Prospect) and for the canopy (4SAIL2) in addition to sun and sensor angles geometry. An outstanding advantage of the SLC as an RTM is that it incorporate structural and architectural designs in a vegetation canopy when simulating the reflectance e.g. clumping, leaf angle, brown materials, vertical distribution of green and brown leaves, hot spot and soil moisture that makes representation of canopy characteristics from image data to ground observation more realistic. The model was parameterized to suit mangrove canopy characteristics and sensitivity analysis was conducted to ensure that the model was responsive enough to slight variations in canopy variable, a desirable attribute for any modeling set up. The mangrove spectral reflectance was simulated using the SLC model followed by an inversion by use of Look up Table (LUT) applied to hyperspectral image and Chl distribution map was generated.

The Chl obtained from model inversion was compared to field measurements to assess the quality of the model derived Chl estimates. The objective of this work was to assess the feasibility of using remote sensing techniques as an alternative to ground survey methods to retrieve Chl for potential use as an indicator of mangrove vegetation and ecosystem conditions in areas speculated to suffer from negative environmental impact of human activities.

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SPATIAL PATTERN OF POSIDONIA OCEANICA MEADOW DETECTED BY DAEDALUS SENSOR IN THE AREA OF CIVITAVECCHIA (CENTRAL TYRRHENIAN SEA, ITALY)

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Keywords: Posidonia oceanica, satellite/airborne passive HR multispectral remote sensing, phenology, sea coastal ecosystems monitoring, water column optical parameters

Abstract:

Currently the Italian shallow coastal water habitats are poorly mapped, and for those maps that do exist, the spatial resolution is poor and the information is dated . The spatial distribution of benthic cover and seagrass in coastal waters is of key importance in managing and monitoring our shallow

water environments often subject to both increasing anthropogenic impacts and climate change effects. In this context we present an implemented methodology for effective monitoring and mapping of *Posidonia oceanica* (PO) meadows using satellite/airborne remote sensing techniques calibrated by means of sea truth measurements and laboratory genetics analyses. Preliminary results using Daedalus airborne sensor are presented referring to the *P. oceanica* meadows at Civitavecchia site (central Tyrrhenian sea). This coastal area, 100 km far from Rome (Italy), is characterized by current hydrodynamic strong variations and anthropogenic factors that affect the health of seagrass meadows with frequent turbidity and suspended sediments in the water column. During 2011-2012 years point measurements of several biophysical parameters (biomass, shoot density, phenology and genetic) related to PO phenology were acquired on various stations distributed along 20 Km of coast between the Civitavecchia and S. Marinella sites. The processed point samples measurements were then exploited for Daedalus sensor multispectral data calibration with the support of satellite (MERIS) derived water quality parameters to obtain an improved thematic map of the local PO distribution.

Classification and monitoring of salt marsh habitats with fully polarimetric airborne SAR remote sensing

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Keywords: SAR, polarimetry, salt marshes, vegetation habitats

Abstract:

Within the GMES programme there is much interest in the ability of remote sensing technology to deliver operational solutions to many areas of life including environmental management. Integrated Coastal Zone Management (ICZM) seeks to find a balance between human use and sustainable functioning of coastal zone ecosystems. Coupled with general interest in ecosystem services, this research explores methods for characterising coastal salt marsh zone habitats in terms of the environmental benefits and affordances they confer with the use of under-exploited Synthetic Aperture Radar (SAR) remote sensing techniques, thereby providing additional information in support of the management of coastal zones. The research consists of examining the use of full polarimetric airborne S- and X-Band for habitat mapping of salt marsh areas, following common habitat classification schemes as National Vegetation Classification (NVC) or Habitat Directive Annex 1. This will be done on the basis of a data set which is acquired over the Llanrhidian salt marsh in Wales in July 2010 with the Astrium Airborne Demonstrator, as a precursor test system to the upcoming NovaSAR-S mission. This SAR data set provides an excellent opportunity to research the potential of high resolution fully polarimetric SAR for classification of salt marsh habitats, by characterising botanical and structural composition of specific salt marsh vegetation zones. SAR-derived information, such as backscatter coefficient, band ratios and polarimetric decomposition parameters are extracted. These are used as data layers to perform object-based image analysis to identify the main vegetation habitats, as well as pixel-based analysis of structural information about vegetation cover and density. Classification results will be validated with newly acquired and existing ecological field data. This presentation will focus on classification results from the airborne SAR data set, the use of polarimetric information and the added value for vegetation mapping. Discussion: This research has shown that SAR data can be used to identify salt marsh habitats and to support ICZM. Ongoing research is improving the applicability of satellite and airborne SAR sensors to a range of coastal zone problems and is exploring how the combination of a multi-sensor and multi-temporal SAR approach gives more insights into long-term dynamics of intertidal land cover and ecosystem functions. These are particularly important in intertidal habitat areas and for the

ecosystem services they provide. Future research will examine: 1. Broad scale habitat classification with the use of multi-temporal, dual- and quad-polarimetric satellite ALOS PALSAR L-Band SAR data. 2. Correlation analysis between tidal heights (the research area is subject to an average tidal range of 8 metres) and SAR backscatter signatures, based on multi-temporal ALOS PALSAR data.

Biomass mapping of mangrove forest by object-oriented classification of high resolution satellite data

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Keywords: forest biomass, high resolution satellite data, mangrove forest, object-oriented approach

Abstract:

Mangrove forests in tropical and subtropical countries play important roles from the viewpoint of ecosystem services such as water quality maintenance, storm wave protection, fish habitat and ecotourism activities as well as carbon stocking. This study aims to map aboveground biomass using an object-oriented approach for high resolution satellite data. The study area is Pohnpei State, Micronesia, which is located in the Pacific Ocean. QuickBird panchromatic and multispectral data (0.7m and 2.8m of ground resolution, respectively) were used for this study. Forty-one sample plots with the size of 30m*30m or 20m*50m were established to estimate aboveground biomass. Segmentation using QuickBird panchromatic and multispectral data was conducted by software of object-oriented classification. Objects corresponding to mangrove forests were selected by the spectral characteristics and other information such as roads and elevation. Spatial statistics of each band in each object were calculated and the relationship between the statistics and forest biomass from the field survey was investigated. Biomass of each object was estimated from the derived relationship and mapped for the whole area of Pohnpei State, Micronesia.

Topographical monitoring of coastal areas with UAV imagery

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Keywords: UAV, DSM

Abstract:

Coastal areas are subject to significant topographic changes that need to be monitored. This is done by comparing detailed digital surface models (DSM) of different epochs. Appropriate DSMs can be produced by airborne laser scanning, in a fully automatic manner. Digital aerial photography, combined with very reliable image matching techniques now available, can also produce high resolution DSMs, in a nearly automatic manner. However, these two airborne techniques can only be justified in relatively large areas, and small frequency, in order to be affordable. Surveys of small areas, and with high time frequency, are more appropriate for alternative techniques, such as the unmanned aerial vehicles (UAV). Very light and easy to operate UAV systems are now available, as well as photogrammetry software packages, at affordable prices. This paper describes the use of a Sensefly Swinglet UAV in the generation of DSMs in beaches and dunes in a coastal region of Portugal. Images are acquired by a Canon Ixus 12 megapixel camera, with large overlaps, and a DSM is generated using AGISoft Photoscan software. Although an approach based only on positions acquired by the onboard GPS receiver is possible, it is not accurate enough for this study purpose. Ground control points need to be considered and surveyed using high accuracy differential, dual frequency GPS receivers. In some situations these points must be previously marked on the ground, but in the present case, much field work could be avoided by using common features found in aerial photos from previous works. DSMs and orthoimages with a resolution of 5 cm/pixel, and a vertical accuracy of 10 to 20 cm could be obtained. These allow for assessments of volumetric changes in sand, as well as ground cover, such as the sensible vegetation of the dunes. Comparisons are made with the similar work carried with conventional aerial photography. A synergistic monitoring program can be carried with less frequent conventional photography, and frequent UAV data acquisitions, few days after storm events. The UAV based survey will bring significant cost reductions, and more accuracy in the monitoring of these sensible areas.

ANALYSIS OF PERFORMANCES OF HYPERSPECTRAL LIDAR FOR WATER POLLUTION DIAGNOSTICS

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Keywords: remote sensing, hyperspectral, fluorescence, wavelet transform, feature extraction, classification

Abstract:

The paper is aimed at the analysis of the performances of hyperspectral lidar for detection and classification of organic compounds in water environment in comparison with laser fluorosensor operating with discrete detection channels. We demonstrate that hyperspectral laser induced fluorescence (HLIF) spectrum holds all relevant spectral information about the target object in contrast to the discrete detection channels sensors data. In order to extract the significant features from HLIF data the multiresolutional analysis namely discrete wavelet transform (DWT) is applied. The feature extraction is automated using the sparsity-norm optimization method. The resulting features have clear spectral representation and are used in automatic object classification. The classification results and selectivity are compared with the discrete detection channel sensors data on a number of oil pollutants. The experimental results demonstrate high value of classification accuracy and the ability to sub classify similar organic compounds from the single group of objects. The comparison with discrete channels sensors data shows the significant increase in overall performance of oil pollution detection and classification.

A remote sensing approach for connecting the historic 2011 Mississippi River flood to wetland sedimentation on the Delta

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Keywords: suspended matter, coastal flooding, coastal morphodynamics, Ocean Colour Remote Sensing for Coastal Waters

Abstract:

Wetlands in the Mississippi River deltaic plain are deteriorating in part because levees and control structures starve them of sediment. In Spring of 2011 a record breaking flood brought discharge on the lower Mississippi River to dangerous levels, forcing managers to divert additional water to the adjacent Atchafalaya River Basin. We quantify differences between the Mississippi and Atchafalaya River inundation and sediment-plume patterns using field-calibrated satellite data, and assess the impact these outflows had on wetland sedimentation. An ad hoc processing was developed to establish the relationship between field suspended sediment concentration (SSC) data and the corrected MODIS reflectance at 645 nm. We show that the focused, high-momentum jet from the leveed Mississippi delivered sediment far offshore. In contrast, the plume from the Atchafalaya was more diffuse; diverted water inundated a large area, and sediment was trapped within the coastal current. Maximum sedimentation (up to several centimeters) occurred in the Atchafalaya Basin despite the larger sediment load carried by the Mississippi. Little accumulation occurred along the shoreline between these river sources. The correspondence between zones of high shoreline deposition, and coastal SSC patterns indentified from satellite data, is strongly suggestive of plume-derived deposition on marshes. Our findings allow us to set an hydrodynamic theory that provides a mechanistic link between river-mouth dynamics and wetland sedimentation patterns, which is relevant for plans to restore deltaic wetlands.

Observation of the Douro estuary turbid plume using high-resolution MODIS ocean color images

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Keywords: Douro estuary; turbid plume; MODIS-Aqua; Ocean colour; nLw555;

Abstract:

Estuarine plumes are relevant to many aspects of the coastal environment, from shelf circulation to biogeochemical processes and sediment transport, which will in turn influence various socio-economic factors that may affect the entire population in the river's mouth area. The Douro River

is one of the longest rivers in the Iberian Peninsula with share length of about 930 km between Spain and Portugal. It drains into the Atlantic Ocean close to Oporto, the second largest Portuguese city. The river estuary is limited upstream by a dam which controls the freshwater inflow and stops the tidal wave propagation. Consequently, river inflow into the estuary is characterized by high short-term variability, ranging between 0 and more than $1000\text{m}^3\text{s}^{-1}$, in a temporal scale of hours. In the north-western Portuguese coast, the Douro river outflow represents the most important freshwater input into the Atlantic Ocean. This outflow is intensified by rainfall episodes which promote a significant supply of nutrients and suspended matter to the continental shelf through the river plume. The spatial characterization of Douro turbid plume, in shape and seasonal variability becomes a critical research issue. Because river plumes often present strong suspended sediment signals, the ocean color images - specially the green light wavebands in the visible region of the electromagnetic spectrum - have been frequently used in their detection. The purpose of this work is to highlight the observability of the Douro turbid plume in high resolution ocean color satellite imagery and also to analyze the spatial and temporal variability of the estuarine plume through those images. The ocean color product, that has been used to detect the reflectivity of the ocean, is the normalized water-leaving radiance at 555 nm (nLw_{555}) from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Aqua satellite. Available high-resolution L1A files from MODIS covering the Douro River region of influence were downloaded via FTP from the Ocean Color Website (<http://oceancolor.gsfc.nasa.gov>) and processed using the SeaDAS software (SeaWiFS Data Analysis System, version 6.4). A more suitable atmospheric correction for coastal turbid waters based on a NIR-SWIR (near-infrared, shortwave infrared) combined algorithm was applied to all daily images to improve L2 final product. To study the temporal variability of the Douro turbid plume, the swaths were interpolated into a regular lat-lon grid (spaced by $0.005^\circ \times 0.005^\circ$) and a time series of the plume area, within a box off the mouth of the estuary, was built. A pixel was considered turbid if the nLw_{555} exceeds a threshold of $1.3\text{ mWcm}^{-2}\mu\text{m}^{-1}\text{sr}^{-1}$. Only images with more than 75% cloud free pixels, in the box area, were considered. From the analysis of the atmospherically corrected MODIS-Aqua data obtained in the frame of this study was found strong seasonal variability in the area extension of the plume water, as well as in turbidity levels, which are significantly correlated with river discharge seasonality. Furthermore, the structure (coherence, direction and extension) of the plume in the coastal zone was found to be strongly influenced by weather patterns (wind speed and direction).

Impact of the Hydrological Events on the Danube Delta's Coastal Morphodynamics and Ecosystems

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Keywords: Danube Delta's coastal geomorphology, river mouths morphodynamics, coastal sedimentations processes, sediment management

Abstract:

Experimental researches, as well as multi and inter-disciplinary approaches, related to the deltaic coastal geomorphology, in that order, the shore response developments on short terms in the fronts of big river mouths, were become important in the last decades, in direct proportionality with socio-economical developments of deltas. The present work emphasize the results of the coastal morphodynamic processes study induced in front of Danube River Delta, mainly affecting the safe navigation, but also human activities, in connection with sediment unbalanced situations and sediment management at local and regional scale. The work is extended based on the analysis of last five years hydrographic and geomorphologic survey/field campaigns, included in the national geomorphologic monitoring, in parallel with the analysis of the shoreline variability based on historical maps/aerial photography/satellite images on the Danube Delta's branches areas. Thus it is described the evolutions of the main geomorphologic parameters in the adjacent areas of the Danube River mouths and its influence of the navigations accidents, and especially nearfuture developments in a transboundary area. The measured quantities and parameters, where studied on its seasonal/annual and multi-annual variability and as well for certain violent hydrological events in the Romanian coastal zone.

A SENSOR-NETWORK FOR MONITORING THE DYNAMICS OF SEDIMENT TRANSPORT

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Keywords: sensor network, pressure sensor, multispectral transmissometer, wave measurement, sediment transport

Abstract:

Changes in the sediment budget have a huge influence on morphology and light conditions of coastal waters and are determining the rate of macroalgae and phytoplankton growth. A better understanding of the scattering of suspended matter and sediment due to tides and waves is crucial to comprehend their impact on the marine ecosystem. Based on the results of hydrodynamical modeling it is assumed that waves have a higher impact on sediment stability than current. This hypothesis shall be verified with novel in situ sensors which make it possible to investigate the dynamics of currents, waves, sediment erosion and transport during extreme weather conditions when ship-based observations and remote sensing data are not available. The results shall lead to a better understanding of morphological changes in tidal areas which are present in satellite images following storm events. With this aim, a network has been developed consisting of a variable number of pressure sensors for measuring water level and surface waves, as well as multispectral transmissometers (MST) for monitoring the local amount and dynamic of sediment and suspended particulate matter (SPM) as a function of tides and waves. The individual sensors are deployed in a two dimensional grid just above the seabed to measure light transmission and pressure with high temporal and spatial resolution. Due to an encapsulation of the sensors including the optical transmissometer surfaces an efficient protection against biofouling has been achieved. Hence, the

instruments can be installed in the region of interest a long time before a storm event occurs. On demand a pyro-electrical actuator is activated and releases a spring that opens the sensor housings, making the network suitable for long-term surveys. Data transfer is realized via a CAN bus system, that is known to be very robust and flexible. Due to the modular electronic setup various interfaces can be integrated to incorporate additional kinds of sensors if needed.

Assessing turbidity and total suspended matter algorithms using field reflectance measurements in the Río de la Plata turbid estuary

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Keywords: Total suspended sediment, Ocean color, MODIS, SWIR, Río de la Plata

Abstract:

The Río de la Plata estuary is located in the eastern coast of southern South America at approximately 35 °S and is one of the largest estuarine systems of the world, which. The system carries a large amount of sediments and nutrients to the ocean, which in turn influence the biological productivity, sedimentological processes and underwater visibility. During two weeks (nine days) water

leaving reflectance, turbidity (T) and total suspended matter (TSM) concentration were measured at the Río de la Plata. The objective of the present study is to test the performance of existing one-band and band-ratio T and TSM ocean color remote sensing algorithms using field data collected during the field campaigns. Algorithms for retrieval of TSM were tested, including a band ratio of MODIS red (620-670) and near infrared (841-876) band, and a one-band algorithm for the MODIS 841-867 band. A similar one-band algorithm was used to estimate T. Variability of the water leaving reflectance in the short wave infrared (SWIR) region at 1020 and 1071 nm was analyzed and its relation to TSM and T was investigated. A significant correlation was found between estimated and measured TSM ($r \sim 0.8$). The one-band algorithm showed a systematic underestimation of -20% (mean relative error) and a relative uncertainty of 22% (mean absolute relative error), while the band-ratio showed a systematic overestimation of 20% and a relative uncertainty of 25%. Better results were found for the T algorithm; it showed a higher correlation ($r=0.87$) and lower mean relative and absolute differences (6% and 11%, respectively). Even though the water leaving reflectance in the SWIR was not negligible, there was no significant correlation between TSM and T and reflectance in the 1020 and 1071nm bands, probably due to the low sensitivity of the SWIR bands to the moderately turbid waters found in this study (30-160 mg l⁻¹). Limits of the optimal range for TSM retrieval in this spectral region are discussed. These results suggest the potential use for the Río de la Plata of existing algorithms that were calibrated using field data from other turbid regions of the world. The mapping of TSM and T using MODIS imagery then depends on a suitable atmospheric correction for these extremely turbid waters.

Operational modeling for rip currents prediction

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Keywords: Rip currents, operational modeling, data-assimilation, video imagery Argus

Abstract:

On many beaches all over the world, rip currents are known as a serious hazard to beach users. These seaward-directed currents typically pull swimmers offshore. Improving insight into the near shore hydrodynamics may provide useful information to assess where and when dangerous conditions could be expected. This paper will discuss the development and application of a real-time hydrodynamic model in combination with an advanced data-model integration method to derive the last, best-known near shore bathymetry. The operational model system includes coupled depth-averaged flow-wave models, nested to cover the entire North Sea with high resolution near the coast, and forced by wave conditions predicted by the global Wavewatch III model, astronomical tidal components, and wind and pressure fields. The reliability of the predicted hydrodynamics depends strongly on the imposed initial bathymetry. For that reason, the paper will especially focus on the provision of an up-to-date bathymetry by the so-called Beach Wizard tool (Van Dongeren et al., 2008). With this data-model assimilation method the near shore sub-tidal bathymetry can be accurately estimated based on video-derived observations of wave roller dissipation, and variation of the intertidal shoreline, and of wave celerity. The depth-related properties are derived from sea-surface information obtained using the Argus optical remote sensing technique developed for sampling the near shore environment (Holman and Stanley, 2007). The data-model assimilation method is currently used for the daily update of the near shore bathymetry at Egmond, The Netherlands, to be used by the operational model system in order to provide warnings to lifesavers and swimmers via a website.

COMBINING REMOTE SENSING AND BUOY MEASUREMENTS FOR MONITORING THE DYNAMICS OF DISSOLVED ORGANIC MATTER AND TURBIDITY IN OPTICALLY COMPLEX LAKE

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Keywords: remote sensing, turbid lakes

Abstract:

Dissolved organic matter (DOM) plays a significant role in the carbon and energy cycle of lakes and it can have a broad effect on the proportions of auto- and heterotrophic processes. Moreover, high concentrations of chromophoric dissolved organic matter (colored fraction of DOM) and also turbidity can strongly influence the underwater light field that in turn modifies the primary productivity.

The main aim of the study is to integrate the DOM and turbidity data from monthly in situ measurements, high-frequency (measured every 10 to 15 minutes) buoy measurements and satellite data in order to monitor spatial and temporal variation of these parameters in optically complex lakes. The study is carried out in lake Võrtsjärv, Estonia, where an autonomous buoy was collecting high frequency data from mid-June to mid-September 2008 and 2009 and monthly in situ measurements of water properties are carried out continuously. The lake is also large enough (270 km²) for remote sensing studies with MERIS type sensors (spatial resolution 300 m).

Using of the high frequency buoy data enables to calibrate satellite products more accurately as it increases the probability of getting match-up data. Probability of getting match-up data with monthly measurements is relatively low in our latitudes due to high cloud cover. More accurately calibrated satellite products allow us to map spatial heterogeneity of the parameters in the whole Lake Võrtsjärv (and also neighboring lakes) extending the point sampling to the whole lake (and neighboring lakes). Those integrated measurements are providing detailed information about the carbon dynamics and turbidity in the ecosystems of optically complex water.

A satellite-based operational system for remote sensing of the Baltic ecosystem

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Keywords: Remote Sensing, Coastal Waters, Baltic

Abstract:

The SatBaltyk (2010–2014) project is aiming to prepare a technical infrastructure and set in motion operational procedures for the satellite monitoring of the Baltic ecosystem. The system will deliver on a routine basis the variety of structural and functional properties of this sea, based on data provided by relevant satellites and supported by hydro-biological models. Among them: the solar radiation influx to the sea's waters in various spectral intervals, energy balances of the short- and long-wave radiation at the Baltic Sea surface and in the upper layers of the atmosphere over the Baltic, sea surface temperature distribution, dynamic states of the water surface, concentrations of chlorophyll a and other phytoplankton pigments in the Baltic water, distributions of algal blooms, the occurrence of upwelling events, and the characteristics of primary organic matter production and photosynthetically released oxygen in the water and many others. It is also intended to develop and, where feasible, to implement satellite techniques for detecting slicks of petroleum derivatives and other compounds, evaluating the state of the sea's ice cover, and forecasting the hazards from current and future storms and providing evidence of their effects in the Baltic coastal zone. The structure of the system and preliminary results will be presented.

SOMBRERO a submersible spectrofluorometer with underwater optical wireless communication

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Keywords: light-induced fluorescence, underwater optical wireless communication, chlorophyll-a, Mediterranean Sea, Red Sea

Abstract:

In the framework of the Scientific, Industrial and Technological Cooperation between Italy and Israel, the Israeli Ministry of Science and Technology and the Italian Ministry of Foreign Affairs approved the project UNELAS – Underwater network of laser sensors for water monitoring. The partners are the Satellite and Wireless Communication Laboratory of the Ben Gurion University of the Negev (BGU), Israel (PI: Shlomi Arnon) and the Diagnostic and Metrology Laboratory (UTARPRAD-DIM) of the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Italy (PI: Luca Fiorani). Building on the complementary experiences on underwater optical wireless communication (Israel) and bio-optical characterization of natural waters by light-induced fluorescence (Italy), UNELAS aims to demonstrate the deployment of an underwater sensor network for coastal zones monitoring. The Israeli group is developing an underwater optical communication device, based on its wireless technology to transfer the information from the submersible sensor to the processing center above the sea surface. The Italian group is developing SOMBRERO, an underwater spectrofluorometer, based on its experience on CASPER, a patented instrument for the bio-optical characterization of natural waters by laser-induced fluorescence (LIF). The breakthrough of SOMBRERO is the use of new technologies to reduce size, weight and cost. The innovative technology of SOMBRERO could be used to develop a constellation of underwater sensors linked by optical communication, revolutionizing our way to monitor salty sea and ocean environment, as well as lakes and ponds of fresh water. In addition, the Italian group examined the possible study areas in coastal zones by ocean color satellite images and bibliographical research, in order to find gaps in the actual knowledge of their ecological status, having in mind that SOMBRERO data could be used to validate present satellite images and to develop new regional algorithms.

IMPROVEMENT OF COASTAL PRE-PROCESSING OF MERIS DATA FOR ENHANCED WATER QUALITY SERVICES

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Keywords: PRE-PROCESSING, PIXEL CLASSIFICATION, AMORGOS, VALIDATION, WFD

Abstract:

Coastal processing of satellite data consists of several pre-processing steps that range from classification of pixels, flagging, through geometric correction, atmospheric correction including an adjacency effect correction to in-water processing taking regional specific inherent optical properties into account. This paper describes a coastal pre-processing chain that we developed for MERIS and which is transferable to MODIS and future OLCI data, with instrument specific modifications. In coastal areas small islands and complex coastline geometry as well as often strong tidal currents cause a high spatial variability of the marine reflectance. Then, sub-pixel geolocation accuracy is necessary for obtaining good spatial and temporal composites, and it is a keystone when looking for matchups of in situ data for validation purposes. The geocorrection of MERIS full resolution data is carried out using AMORGOS. It was developed by ACRI-ST under ESA contract. It has been shown that the accuracy of the geolocation after AMORGOS is better than 100m. The coastal processing continues then with a pixel identification approach that aims to be sensor independent and adaptable to the future sensors, including Sentinel 2 and Sentinel 3 instruments. Changes and improvements are being done continuously in several matters concerning cloud screening, glint detection, snow and ice identification and land-water separation. Investigations were done mainly within the framework of the Aquamar and CoastColour projects. With a better definition of the land-water separation and with the identification of mixed pixels, performing of the adjacency effect correction improves as well. The adjacency correction in coastal areas is done by means of the Improved Contrast between Ocean and Land (ICOL) algorithm developed by R. Santer (20XX). Within Aquamar the adjacency effect correction is investigated concerning its impact, applicability and application to Water Framework Directive (WFD) and Marine Strategy FD products. As an example of the improvement achieved with this pre-processing upgrading, we show two application areas. The first one is a service conducted in cooperation with the EU FP7 projects Aquamar and Freshmon and contains the

delivery of user defined water quality products for the Swedish Coast (Aquamar) and Swedish Lakes (Freshmon). The products contain information about the water quality parameters chlorophyll concentration, total suspended matter concentration, yellow substance absorption and K_d_{490} . The pre-processing includes improved geocorrection, improved land-water masking, pixel identification & flagging, adjacency effect correction, atmospheric correction. The water retrieval is based on the FUB water processing (Freie Universität Berlin) which is available as BEAM processor. Summarising the results we can point out that the improvement of the products is clear. For instance, the adjacency effect is reduced and more accurate water leaving radiance is extracted, affecting the accuracy of the water products as well. The radiometric correction provided further improvements on the radiometric data; and the use of AMORGOS resulted in two additional improvements: the positional accuracy of the images increased and the user does not need to geo-reference the image manually anymore. The second application concerns a further aggregation and tailoring of the basic EO products and is developed closely together with National Authorities in Germany and Sweden within the GSE downstream service project MarCoast. These users are responsible for the monitoring activities in the German Bight (North Sea) Swedish Waters and the reporting in the context of the Water Framework Directive (WFD) about the quality status of the coastal water bodies for that area. Products delivered contain chlorophyll and total suspended matter concentration, which are aggregated and statistically analysed per WFD water body to extract information that meets monitoring requirements. One example is the calculation of a seasonal percentile 90 of chlorophyll concentration per water body which is a quality element for phytoplankton. To monitor seasonal variability and to evaluate the sampling plan for the monitoring, time series analysis and plots have been performed. The improved processing and further aggregation leads to more reliable and user friendly products so that the integration into operational monitoring programmes can be further supported.

East Atlantic pattern modulates phytoplanktonic biomass and primary production interannual variability in N-W Mediterranean.

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Keywords: CHLOROPHYLL-A, PRIMARY PRODUCTION, MEDITERRANEAN, EOF, TELE-CONNECTION

Abstract:

Remotely sensed Chlorophyll-a, PAR and SST were used to compute regional estimates of primary production (PP) integrated throughout the euphotic layer for NW Mediterranean by means of a modified version of the Vertically Generalized Production Model. The variability of the primary production and phytoplanktonic biomass (assumed the Chl-a concentration as best proxy) has been analysed over a decade. The variability of the data has been decomposed through EOF analysis. We found a minimum of the annual production in 2003, when a summer heatwave strongly increased the stratification of surface waters, limiting the injection of nutrients into the surface layers. Maxima are found in 1999 and 2005, due to two particularly intense spring-blooms exceeding (spatially) the usual MEDOC blooming area. Coastal areas, near western Corsican and Sardinia shorelines, were interested by such a phenomenon. These two maxima, clearly identified in space and time by EOF analysis, are related to strong mistral-wind interannual events occurring during 1999 and 2005 winters, preceding blooms by some few months. Interannual wind events are in turn related to peaks in the East Atlantic pattern, which is the second mode of low-frequency variability in North Atlantic (NAO being the first). Biomass and production maxima are associated to an easterly extension of the usual production area, as well as to an intensification of production in the usual area. Exceptional deep water formation events in 1999 and 2005, with easterly spots close to the primary production observed anomalies, support the idea that such eastern PP interannual maxima are actually due to exceptional local production more than to easterly advection of biomass.

Detecting dominant Phytoplankton Size Classes (micro-, nano- and pico-phytoplankton) from SeaWiFS data in the Mediterranean Sea

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Keywords: satellite, SeaWiFS, picoplankton, nanoplankton, microplankton

Abstract:

In the recent years several works at “global-scale” was carry out to identify the contribute of different Phytoplankton Size Classes (PSCs) and Phytoplankton Functional Types (PFTs) to the total phytoplankton chlorophyll-a biomass. In this context the determination of bio-optical algorithms that allow to get qualitative and quantitative information about PSCs and PFTs from satellite data can provides an important instrument for a synoptic observation of the Phytoplankton community structure and its spatial and temporal variability, in order to improve the knowledge about the ecological and biogeochemical dynamics connected with it. Different models have been proposed to identify several PSCs and PFTs from ocean color data based on physical (Kostadinov et al. 2009), biological and ecological approaches (e.g. Brewin et al. 2011, Hirata et al. 2011). In the present work we applied the three models mentioned above to study the spatial distribution and temporal variability of three dominant PSCs in the Mediterranean Sea during the SeaWiFS mission from 1998 to 2010. SeaWiFS data were obtained from the MyOcean Ocean Colour Thematic Assembling Centre. Brewin et al. (2011) and Hirata et al. (2011) models were tested using a Mediterranean subset of the NOMAD SeaBASS in-situ dataset (Werdell and Bailey , 2002; Werdell et al., 2003; Werdell and Bailey, 2005). Preliminary findings indicate that the first model tends to slightly to underestimate the concentration of nanoplakton chlorophyll and overestimate the concentration of picoplankton chlorophyll. In the second model the nano plankton underestimation is less evident as well as the picoplakton overestimation. The test of the Kostadinov et al. (2009) model for the Mediterranean Sea is still in progress. The analysis of the spatial and temporal distribution of the three PSC components indicated that Picoplankton dominates all around the year with a maximun during summer and minima in autumn and winter in open sea regions not affected by

intense spring blooms. Coastal and intense bloom regions, instead, show the dominance of nano and micro plankton.

Optical variability of the Baltic Sea coastal waters and it's impact on the remote sensing signal

Optical variability of the Baltic Sea coastal waters

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Keywords: Baltic Sea, optical variability, inherent and apparent optical properties

Abstract:

Standard remote sensing products tend to fail in the Baltic Sea conditions. There may be several reasons behind that but one of the main reasons is optical complexity of the waters. Therefore, we decided to study optical variability of the Baltic Sea waters in order to be able to improve remote sensing algorithms and methods. The measurements were carried out in Estonian and Swedish archipelago waters as well as in open parts of the Baltic Sea. Parameters measured include spectral absorption, attenuation, scattering, and backscattering coefficient, volume scattering function at three wavelengths and three angles and water reflectance above and below the water surface. Each measurement was accompanied by taking water samples for laboratory analysis of chlorophyll-a, CDOM, TSS, SPIM and SPOM.

Our results show that the all the measured parameters vary in a quite wide range. In the open parts of Baltic Sea absorption and backscattering coefficients varied respectively between 0.5 – 1.37 m⁻¹ and 0.005 – 0.2 m⁻¹. The values of absorption coefficients in Estonian and Swedish archipelago waters were up to 3 times and the values backscattering coefficients almost by order of magnitude higher than in open parts of Baltic Sea.

A Case II water model was parameterised in HydroLight 5.0 model to study the impact of different optically active components on the remote sensing signal. Preliminary results show that it may be quite difficult to estimate concentrations of optically active substances from remote sensing data if the formation of water reflectance is dominated by another substance. For example chlorophyll-a concentration may vary in a relatively wide range and still the variation may remain undetectable by remote sensing sensors if high quantity of CDOM determines the shape and value of water reflectance.

Developing phytoplankton spring bloom indicator in coastal WFD regions from MERIS data

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Keywords: Baltic Sea, phytoplankton, spring bloom

Abstract:

The spring is a period of extensive and rapid phytoplankton growth, during which the main part of the annual phytoplankton production occurs. Quantifying the bloom biomass is not easy using traditional methods, which do not react at a high spatial or temporal scale. In this study, the biomass is estimated through combining Earth observations (EO) and ship-of-opportunity (ferrybox) data, in order to obtain maximum spatial and temporal coverage. The principals of the applied method have been described in Fleming and Kaitala, (2006). While EO data can provide daily spatial and temporal coverage during non-cloudy periods, ferrybox operates frequently on its regular route.

The EO data for the spring bloom indicator development is MERIS (Medium resolution imaging spectrometer). The dataset that covers years 2006-2011 has been processed to chlorophyll a (chl-a) concentrations using FUB processor (Freie University of Berlin, Schroeder et al. 2007). This data will serve as basis for method development easily applicable to the forthcoming OLCI (Ocean and Land Colour Instrument) data after Sentinel 3A satellite launch.

The Alg@line ferrybox system collects water quality data with an automated equipment onboard eight merchant ships on the Baltic Sea. Salinity, temperature, turbidity, chl-a, and summerly cyanobacteria (phycocyanin fluorescence) are recorded with spatial resolution of 200 m. The water intake depth of the system is approx. 5 m. In addition, 24 water samples are taken on one transect. The study concentrates on indicators such as: initiation, amplitude, timing and duration of spring bloom. The spring bloom indicator is then further developed in order to produce an estimate of the total areal algal biomass. This information can be used to derive an estimate of the total primary production in spring bloom.

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The use of MERIS data for monitoring coastal WFD water bodies

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Keywords: MERIS, OLCI, chlorophyll-a, WFD classification, coastal water bodies

Abstract:

The reporting activities required by the EU water framework directive (WFD) and the marine strategy framework directive (MSFD) necessitate comprehensive collection of monitoring information from all water bodies of Finland and the adjacent open sea areas, including assessing of the status of these water bodies. These requirements cannot be fulfilled using traditional monitoring station measurements alone. The increased monitoring demand calls for the development and implementation of new monitoring methods and approaches. Currently available data consists of Earth observations (EO), ferrybox, traditional monitoring stations and mooring buoys. The inclusion of EO methods with other efficient techniques can assist in providing required monitoring actions, particularly in areas out of the reach of the traditional methods.

The coastal waters of the northern Baltic Sea are characterized by a fragmented coastline and a mosaic of islands, which set special requirements for monitoring. Among the satellite instruments available now and in the forthcoming years, MERIS (MEdium Resolution Imaging Spectrometer) and its follow-up instrument OLCI (Ocean Land Colour Instrument onboard Sentinel-3) can provide the best functionality for the estimation of parameters related to chlorophyll a (chl-a). The advantages of MERIS and OLCI concern both their spatial resolution of 300m and band combinations.

The Alg@line ferrybox system provides real-time information on the water quality with high-frequency automated sampling onboard eight merchant ships in the Baltic Sea. Alg@line devices measure salinity, chl-a, temperature, turbidity, and in summertime also cyanobacteria (phycocyanin fluorescence). The depth of the inlet is ca. 5 m below the surface with a spatial resolution of 200 m. The system includes a sequence water sampler storing 24 water samples along the route.

The data originating from five different types of monitoring methods are compared: EO, coastal monitoring stations, Alg@line, mooring buoys and a coastal field campaign with flow-through transect system on a moving boat. Comparison between EO and coastal monitoring station data is made using match-ups from years 2006 - 2011. For other comparisons, the period depends on the availability of the different data sources. The comparisons are carried out by showing time series and histograms calculated using the data produced by EO, Alg@line, mooring buoys and by traditional monitoring activities. Analysis on EO algorithm accuracy against five coastal field campaigns is shown. The campaign data consists of continuous transect measurements with ac-9 and water samples analyzed in laboratory. Our study area covers the Finnish coastal water area. The statistical analyses are made within water bodies included in the WFD ecological classification. Part of the validation is made using MERIS and MODIS (The Moderate Resolution Imaging Spectroradiometer) satellite instrument data.

Ground-level spectroscopy analyses and classification of coral reefs using a hyperspectral camera

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Keywords: coral reef, spectroscopy, classification, remote sensing, hyperspectral, glint, monitoring, survey

Abstract:

With the general aim of classification and mapping, remote sensing of coral reefs has traditionally been more difficult to implement in comparison to terrestrial equivalents. Images used for the marine environment suffer from environmental limitation (water absorption, scattering and glint); sensor related limitations (spectral and spatial resolution); and habitat limitation (substrate spectral similarity). Presented here is a novel approach for ground level surveying of a coral reef using a hyperspectral camera (400-1200 nm) that is able to address all of these limitations. Used from the surface, the image includes a white reference plate that offers a way for correcting the water column effect. The imaging system offers millimeter size pixels and 80 relevant bands, thus empirically bridging the gap between a spectroradiometer, hyperspectral remote sensing, and digital photography. Finally, the availability of pure pixel imagery improves significantly the potential for substrate recognition in comparison to traditionally used remote sensing mixed pixels. In this study, an image of a coral reef table in the gulf of Akaba, Red sea, is classified, demonstrating the benefits of this technology for the first time. Preprocessing included testing of two normalization approaches, three spectral resolutions, and two spectral ranges. Trained classification was done using Support Vector Machine that was manually trained and tested against a digital image that provided empirical verification. For the classification of 5 core classes the best results were achieved using a combination of 450-660nm spectral range, 5nm wide bands and employing red band normalization. Overall classification accuracy was improved from 86% for the original image to 99% for normalized image. Spectral resolution and spectral ranges seemed to have limited effect on classification accuracy. Imagery of this type can be successfully used for reef survey and monitoring using automatic classification procedures, making them an ideal tool for large scale survey.

An integrated approach of oil slick dispersion (a case study from offshore south Crete, Greece)

Oil slick dispersion

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Keywords: Man-made hazards, marine pollution, preparedness, civil protection

Abstract:

Technological disasters are commonly defined as emergencies characterized by a sudden threat to lives, property, public health, or the environment, arising from a failure of critical infrastructure

systems or the release, or potential release, of oil, radioactive materials, or hazardous chemicals into the air, land, or water. These emergencies may occur from transportation accidents, events at facilities that use or manufacture chemicals, or as a result of natural or man-made hazard events. Oil spills produced from explosions on the oil and gas production platforms (Piper Alpha, 1978; Montara, 2009 and the BP Deepwater Horizon spill, 2010) or sea accidents of tankers due to the heavy traffic of merchant vessels, comprise a major environmental and financial threat, mobilizing thousands of specially trained emergency response personnel and challenging the best-laid contingency plans. Although many spills are contained and cleaned up by the party responsible for the spill, some spills require assistance from local and state agencies. The Mediterranean Sea comprises an E-W trending ocean basin formed during the breakup of Pangea and subsequent convergence with North Africa. In such a setting, the island of Crete lies in the forearc region of the Hellenic subduction zone. Nowadays the Hellenic arc is associated with moderate arc-parallel extension and strong compression perpendicular or oblique to it. The Hellenic nappes are the dominant sequences within the upper structure of Crete. The main scope of the present study is to combine bathymetry, geomorphological - geological data and oceanographic information to investigate the impact of the sea bottom morphology in oil spill dispersion. Near-coast morphological and structure data will be combined with information concerning the direction and speed of wind and sea currents in order to define how an oil spill will develop and expand in time. GIS techniques, are used for mapping the various topographic, geological and oceanographic features of the study area. The above information can be primarily used by emergency managers and urban planners to establish preparedness plans and alert systems.

Socio-ecological Systems Variation and Environmental Change Impact on a Subarctic Coastal Zone on the Sea of Japan: Trends and Drivers

Socio-ecological Systems Variation and Environmental Change Impact in a Subarctic Coastal Zone

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Keywords: Coastal, anthropogenic, environmental change, management, water quality, fisheries

Abstract:

Coastal sea areas have been focal points of human settlement and marine resource use throughout history and have been most impacted by coupled human-environmental drivers of change. This study examines drivers and trends of change vis á vis natural and anthropogenic forcing over time in some coastal water quality parameters, living resources, ecosystem goods and services and management/cultural practices on Ishikawa coast, Japan. In this study, the Ishikawa coastal zone was partitioned into three coastal regions (Kanazawa area- KNA, Noto area- NTA and Nanao area- NNA) based on the highly diverse and contrasting coastal systems and the need to better elucidate on the trends and drivers of change. While analysis of some water quality variables suggests that human perturbation over the years may be more relative than environmental change impact, coastal living and non-living resources appears to have been grossly impacted by coupled human-environmental forcing as a result of changes over the years in demographic pattern, coastal management and cultural practices. Analysis revealed ~45% reduction in total fisheries management bodies between 1965 and 2000 with similar trend within the last decade, thus, the need to strike a balance in the current dominant bottom-up approaches with adequate top-down policy will be required for sustainable fisheries management. Also, observed spatial pattern indicates that coastal developments, rapid and serious erosion, storm surges, and perhaps physical processes such as water residence time and environmental change, are factors that play an important role in promoting change in Ishikawa coastal zone. An attempt, therefore, to maintain the socio-ecological coastal landscape through continuous monitoring of coastal developments and activities will be a more targeted and effective adaptation strategy.

Nutrient fluxes fueling primary production in Ishikari Bay, oligotrophic subarctic coastal environment of Japan.

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Keywords: Nutrients, coastal, primary production, Ishikari Bay

Abstract:

We compute a ratio of riverine nutrient flux (RNF) to bottom nutrient flux (BNF) to determine the relative influence of oceanic and riverine nutrient fluxes on primary production dynamics in Ishikari Bay, oligotrophic subarctic coastal water potentially limiting in DIN (dissolved inorganic nitrogen) nutrient. Across spring, summer and autumn seasons, RNF:BNF ratio was significantly greater than 1.0 especially in spring and autumn for DIN and Si(OH)₄ nutrients, suggesting that, for these nutrients, riverine nutrient significantly fueled primary production. Strong inverse relationship ($r = -0.927$) between Chl a and salinity in autumn, and a corresponding increase in the apparent utilization of DIN and primary production indicate that DIN from the Ishikari River fueled primary production maximum in autumn. However, PO₄ nutrient flux ratio was significantly less than 1.0, especially in summer (0.1) and autumn (0.3), suggesting a possible bottom nutrient upwelling source. In spring, when ratio was close to 1 (0.8), coupling between bottom (upwelling) and surface (river) PO₄ nutrient is hypothesized since PO₄ concentration of river end-member was lowest and suspended particulate matter (SPM) concentration highest across season. Although, riverine nutrient fluxes are a major source of DIN and Si(OH)₄ nutrient supply in Ishikari Bay oligotrophic system, oceanic nutrient contribution from bottom upwelling and horizontal advection are a major source of PO₄ nutrient. We conclude that while riverine nutrient fluxes may significantly fuel primary production in an oligotrophic system like Ishikari Bay, information on the importance of estuarine circulation in buffering the supply of PO₄, not adequate in riverine nutrient is a significant insight in our study.

Spatio-temporal dynamics of the turbidity maximum in the Belgian –Dutch coastal zone

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Keywords: turbidity maximum, wind climate

Abstract:

The spatial extension of the turbidity maximum in the Belgian-Dutch coastal zone varies on different time-scales. The seasonality (with period of ~ 365 days) in the Aqua MODIS time-series of suspended particulate matter concentration is superimposed by SPM concentration variations acting on shorter time-scales (tidal-neap/spring and wind-induced variations). The variations due to meteorological forcing have a period between 3 and 5 days, and show that wind direction plays a significant role in the strength, position and extent of the turbidity maximum (as observed at sea surface). Over the last decades, trend analysis of wind directions shows an increase of southwesterly winds (Van den Eynde et al. 2011). The geographical extension of the turbidity maximum during the last decades was thus more often spreading towards the mouth of the Westerscheldt estuary as before. Houziaux et al. (2011) formulated similar remarks, based on a comparison of historical (100 year) and recent seabed samples. These authors have related the changes to mainly port and dredging works that have severely altered the fine-grained sediment dynamics; hence also the turbidity levels in the coastal zone. Our data suggest that the spatial extension of the turbidity maximum, and thus SPM concentration is further influenced by natural changes.

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Impervious surface areas classification from GeoEye-1 and WorldView-2 satellite imagery through OBIA approach in a coastal area of Almeria (Spain)

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Keywords: OBIA, SVM, impervious surface area, GeoEye-1, WorldView-2, feature set selection, Kappa test, accuracy assessment, sampling scheme

Abstract:

Impervious surface areas (ISA) coverage is a key indicator for estimation of ecosystem health, future water quality or the influence in the hydrology of a watershed. ISA could be also correlated with lower sediment discharge and local shoreline recession. In order to map impervious surfaces for a coastal area using very high resolution (VHR) imagery from GeoEye-1 and WorldView-2 satellites, an object-based image analysis (OBIA) approach has been performed. The non-parametric Support Vector Machine (SVM) classifier was applied to distinguish between two target classes: pervious and impervious. Moreover, different feature vectors were used to select the most appropriate set to achieve the highest accuracy as possible. Those feature sets combine i) basic information (spectral values of the red, green, blue, near-infrared, and panchromatic bands), ii) ratios between bands (red, green, and blue ratios, green/red ratio, and normalized difference indexes for red, green, and blue), and iii) texture information extracted through local variance computed at different window sizes (3x3, 5x5 and 7x7 pixels). The Kappa test was performed to check the statistically significant differences between all the feature sets for each satellite imagery and a separability matrix was constructed. Thus, the obtained accuracy results were compared in order to test which satellite imagery achieved the highest accuracy. Similarly, those results were compared with a similar experiment car-

ried out on archival aerial orthoimages which covered the same area. Statistically significant better accuracy results were provided by both satellite images if compared with archival aerial orthoimage when texture information was not included in the feature space, but lower differences were found between both VHR satellite imagery. However, no statistically relevant differences were observed between all data sources when texture information was added. Finally, the sampling method was tested. First, a pilot area was used to classify two different zones. Secondly, an ad hoc training was employed for each area and, finally, all the samples were tested to classify the entire area. Accuracy results proved that the distribution and number of samples were relevant for the final accuracy.

Oil pollution in the Gulf of Guinea studied with spaceborne SAR imagery

coastal zone oil pollution

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Keywords: Gulf of Guinea, oil spills, SAR images, oil pollution monitoring

Abstract:

The Gulf of Guinea lies in the north-easternmost part of the tropical Atlantic Ocean. It has some 45 billion barrels of proven petroleum/hydrocarbon reserves. Due to rapid growth of offshore exploration and offshore oil and gas production, the oil spills became frequently reported and documented in the coastal and open waters of the Gulf. Under frequent cloudy tropical weather conditions only radar remote sensing tools, such as synthetic aperture radars (SAR) are effective for oil spills detection. In this study for first time extent and statistics of oil spills using SAR images from the European Envisat satellite in the Gulf of Guinea are presented and discussed. To solve this task the European Space Agency archives have been screened and many Envisat SAR images showing dark patches on the sea surface found, after analysis most of them were attributed to oil spills. It is shown that the most part oil spills occurs and was detected in the exclusive economic zone and territorial waters of Nigeria (80%). Main source as expected is offshore oil production and transportation there. Illegal ship-made discharges have been also detected, but their total area (impact) and occurrence frequency are of less importance. The waters of Cameroon and Equatorial Guinea are the second most polluted area of region. Therefore, it is concluded that in this situation more attention has to be paid to protection of the marine environment of the Gulf of Guinea against oil pollution, as well as the routine oil spill monitoring of the Nigerian waters based on remote sensing must be established.

MAPPING THE POLAR CYANOBACTERIA COASTAL COMMUNITY THROUGH MULTI/HYPERSPECTRAL SATELLITE REMOTE SENSING

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Keywords: Passive Remote Sensing, Polar satellite platforms; Hyperspectral Remote Sensing; Hyperion; Cyanobacteria; Antarctic ecosystem monitoring; Pigment spectral responses.

Abstract:

Blue-green algae also known as Cyanobacteria is a phylum of bacteria that have existed for 3.5 billion years, and are the most important photosynthetic organisms on the planet for cycling carbon and nitrogen fixation. Cyanobacteria are important to be exploited for multi purposes: they are rich in chemical diversity and some strains can produce the free fatty acids, a precursor to liquid fuels. Although some cyanobacteria are micro-algal fuels that might be one of alternative of bio-energy products, other single cells or groups of cells are also notorious for causing nuisances such as dense and often toxic 'blooms' in lakes and seas. The extensive mapping and characterization of cyanobacteria of polar and alpine habitats are of particular interest because in general they represent here the predominant species contributing a major component of the ecosystem photosynthetic biomass. In addition the strong abiotic stresses in these harsh environments during past evolutionary ages have shaped their particular resilience capability with the production of specific coloured pigment and particular biochemical compounds potentially valuable for innovative biomedical applications and also for bio-energy products. In this context high spectral resolution imagery remotely sensed by polar satellite sensors and fluorescence data were tested for Antarctic cyanobacteria discrimination through spectral optical reflectance features of their specie-specific pigments in the framework of the Italian program for scientific research activities in Antarctica. Here we present an improved perspective that aims at the Antarctic ecosystem repetitive monitoring through integrated analyses

of whole ecosystem from space, by polar sensors, such as Hyperion, ALI and Landsat ETM+, having spectral/spatial resolution able to detect changes in cyanobacteria populations at spatio-temporal scales not anywhere available and suitable for their effective change assessment capabilities. Many work dealt with and algal blooms in sea or internal bodies waters which weakly affect the total reflectance signals, very few instead were focused on their detection over terrain where the noise signal arising from the substrate is very high, especially in polar areas characterized by visible high albedos from snow and ice covers and productive coastal shallow waters

The IOSMOS project: a multi-disciplinary approach for Ionian sea water quality monitoring

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Keywords: Ocean Color, Coastal Areas, Water Quality, Monitoring, Ionian sea

Abstract:

Estuaries and coastal zones are among the most productive ecosystems in the world, with both high ecological and economic values. They provide a wide range of economic benefits to many sectors, including fishing, industrial complexes and amenity services such as tourism and recreation. However, estuaries and coastal zones, being made up of a wide range of different habitats, are very dynamic and complex ecosystems. The growing level of anthropization, the irrational exploitation of resources and the climate changes are causing a strong modification of the coastal areas, representing a continuous threat to the biodiversity of these zones. This is why coastal water bodies are also of interest under the Water Framework Directive 2000/60/EC (WFD). The WFD establishes a framework for the protection of all surface waters (rivers, lakes, transitional and coastal) and groundwater at EU level and aims to achieve a good ecological status (or a good ecological potential for heavily modified water bodies) and a good chemical status by 2015. According to the WFD, the coastal water deterioration should be prevented and the aquatic ecosystem status protected and enhanced. Remote sensing data can give relevant information in this context, offering the capability to provide the spatial distribution of water constituents over large areas with high temporal rates and at relatively low costs. In particular, Ocean Color (OC) satellite sensors have already demonstrated to be useful in providing reliable information both on sea surface optical variables (e.g. upwelling normalized water-leaving radiances) and on bio-optical parameters such as chlorophyll-a (as a proxy of phytoplankton), suspended materials and dissolved organic matter. A study of these parameters and of their evolution in the space-time domain may furnish useful indications on the overall quality of the sea water for a specific area, offering, in addition the reference behaviors necessary for identifying significant changes (possibly induced by anthropogenic pressure) in the coastal environment. In this context, the main aim of IOSMOS (IONian Sea water quality MONitoring by Satellite data) - a Project for European Transnational Cooperation co-financed by the Operational Program ERDF Basilicata 2007-2013 - is the development of advanced and exportable satellite products for measuring the above mentioned coastal water parameters as well as for timely identifying short-medium term changes, potentially dangerous for the environment and/or human health. Original techniques, based on multi-temporal satellite data analyses, will be developed and validated in two testing areas (i.e. Basilicata, Italy and Crete island, Greece) on the base of airborne and in situ calibration campaigns. Their advantages, in terms of reliability, sensitivity and exportability, will be evaluated also by comparison with existing satellite products achievable by EOS-MODIS, NPP-VIIRS and SeaWiFS sensors. In this paper, first activities and preliminary results of IOSMOS project will be presented and discussed, starting from the preliminary long-term (up to 15 years) analyses of satellite records performed for the Ionian sea within the gulf of Taranto (Southern Italy) with particular attention to the area along Basilicata Region coasts.

On the potential of Robust Satellite Technique for coastal water quality monitoring

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Keywords: Ocean Color, Coastal Areas, Monitoring, Robust Satellite Techniques

Abstract:

The coastal marine environment is a complex and dynamic ecosystem, strongly subject to environmental degradation, because of both natural and anthropogenic causes. In the last years, several remote sensing-based approaches for coastal water monitoring and investigation have been proposed. In particular, several bio-optical parameters, differently related to the general sea water quality status, have been identified, by exploiting their specific spectral response in the visible and near-infrared (VNIR) region of the electromagnetic spectrum. Among them, key parameters are the Chlorophyll-a (Ch-a) concentration, as a proxy of phytoplankton, the dissolved organic material (Cromophoric Dissolved Organic Matter - CDOM) presence and some other parameters strictly related to water turbidity, such as Solid Suspended Matter (SSM). A few satellite packages have been used for these purposes, among them the Moderate-Resolution Imaging Spectroradiometer (MODIS), aboard Earth Observing System (EOS) Terra (since 2000) and Aqua (since 2002) satellites, is the one presently most suitable to follow the dynamics of the physical phenomena of interest because it guarantees the best trade-off among spectral, spatial and temporal resolutions. One of the main limit of MODIS-based Ocean Color algorithms is their low applicability in shallow waters (i.e. case 2 water), where the signal at the sensor can be significantly affected by bottom reflectance. To overcome this limits, in this work we implement the Robust Satellite Techniques (RST) approach on long-term historical series of MODIS data/products concerning sea water quality. RST is a general change detection methodology, based on the analysis of multiyear historical series of homogenous satellite data, which has been already applied for the detection and monitoring of different natural and environmental hazards, also in coastal areas. In particular, by means of

such a methodology, capable of deriving the historical behaviour (both in terms of expected values and normal variability) of each single pixel in the observed scene, the possibility to better identify and isolate signal contributions coming from bottom reflectance, is evaluated. This should allow us to a better characterization of the spectral response of the water column. In this work, a few parameters will be investigated by applying such an approach, also with the aim of assessing RST potential for the automatic detection of any water quality degradation sources (e.g. sea pollution).

REMOCEAN system: a tool for the high resolution sea state monitoring of the coastal areas via X-band wave radar

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Abstract:

The monitoring of the sea state, surface currents and bathymetry of the seabed in coastal zones is a topic of significant and relevant interest for the knowledge and characterization of the morphodynamic processes. This challenge becomes even more difficult in the coastal areas affected by frequent storm surges, strong surface currents and changing bathymetry and where the continuous in-situ instrumentation and monitoring is impossible due to these dominant conditions.

For this reason the use of wave radar have an important role in this filed. In fact their utilization is continuously increasing thanks to the improved operative flexibility of the X-band radar system, due to their flexibility, durability, easy and continuous operation independently from external conditions and relatively low cost. It is possible to install them even on a movable platform and from there to scan the sea surface with high temporal an spatial resolutions.[1-3]

There are several published methods for the determination of the bathymetry from image sequences and all the method are based on the same basic principle, the geo-location of the wave crests. The wavelength in the intermediate water depth depends on the local depth and current field.

Therefore, by measuring the properties of the wave field (wave period and wavelength) and inverting them locally by assuming the validity of a known wave theory, the determination of the local depth and current vector is possible.

Here, we present the use of REMOCEAN system[4] for the sea state parameters estimation and the reconstruction of maps of the surface current and bathymetry in coastal zones, which exploits an innovative technique for a more accurate estimation of the surface current as well as of the bathymetry.

This technique determines the sea surface current and bathymetry as the quantity that globally maximizes the normalized scalar product (NSP) of the amplitude of the filtered image spectrum and a characteristic function accounting for the support of the relation dispersion.[5-7]

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Satellite remote sensing applied to off-shore wind energy

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Keywords: Satellite remote sensing, Off-shore wind farm, SAR wind speed

Abstract:

Wind as an energy resource has been increasingly in focus over the past decades, starting with the global oil crisis in the 1970s. The possibility of expanding wind power production to off-shore locations is attractive, especially in sites where wind levels tend to be higher and more constant. Off-shore high-potential sites for wind energy plants are currently being looked up by means of wind atlases, which are essentially based on NWP (Numerical Weather Prediction) archive data and that supply information with low spatial resolution and very low accuracy. Moreover, real-time monitoring of active off-shore wind plants is being carried out using in-situ installed anemometers, that are not very reliable (especially on long time periods) and that should be periodically substituted when malfunctions or damages occur. These activities could be greatly supported exploiting archived and near real-time satellite imagery, that could provide accurate, global coverage and high spatial resolution information about both averaged and near real-time off-shore windiness. In this work we present new methodologies aimed to support both planning and near-real-time monitoring of off-shore wind energy plants using satellite SAR (Synthetic Aperture Radar) imagery. Such methodologies are currently being developed in the scope of SATENERG, a research project funded by ASI (Italian Space Agency). SAR wind data are retrieved from measured radar backscatter using empirical geophysical model functions, achieving greater accuracy and greater resolution with respect to other wind measurement methods. In detail, we can estimate wind speed from X-band and C-band satellite SAR data, such as Cosmo-SkyMed (XMOD2) and ERS and ENVISAT (CMOD4) respectively. Then, using also detailed models of each part of the wind plants, we are able to calculate the AC power yield expected behaviour, which can be used to support either the design of potential plants (using historical series of satellite images) or the monitoring and performance analysis of active plants (using near-real-time satellite imagery). These methods have applied in several test cases, where we obtained successful results in comparison with standard methodologies.

Quantifying soil erosion on watershed for the coastal management. The case study of the Réunion Island.

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Keywords: Erosion, Universal Soil Loss Equation (USLE), Coastal Managment, Geographical Information System, Martinique, La Réunion

Abstract:

Soil erosion is a serious problem in high tropical islands. This tends to increase under the combined effect of an increase in major weather events (hurricanes and tropical storms) and changes in land use due to human activities (urban sprawl and increased agricultural areas). These rapid changes have a significant impact on the coastal environment in particular on coral reef ecosystems.

In Reunion, located in the Indian Ocean, the dynamics of land use are particularly important because of the growing population on a limited territory.

This study aims i) to present the methods for studying changes in land cover using satellite imagery SPOT5 (method based on the object), ii) evaluate the process of land erosion modeling using [Loss universal Equation-quantitative approach] and relevant markers [vegetation qualitative approach] iii) provide guidelines for the monitoring of tropical watersheds.

The first results show changes in land use of agricultural land to artificial spaces and loss of forest cover between 2002 and 2012. Both trends lead to increased sensitivity to soil erosion. On the basis of this results, this paper concludes with the proposal of indicators to better reflect these phenomena in coastal management.

Comparison between laser-induced fluorescence and satellite radiometry in the St. Lawrence Estuary

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Keywords: satellite radiometer, laser-induced fluorescence, chlorophyll-a, Atlantic Ocean

Abstract:

Climate state variables in the St. Lawrence Estuary (SLE) were very unusual during winter 2010. Indeed, satellite imagery and circulation models revealed that most of the SLE waters were ice-free during March 2011, an unprecedented finding since 1950. These climate modifications are expected to affect the lower and upper trophic levels of the SLE. Thus, synoptic monitoring of chlorophyll a concentration (chl) and chromophoric dissolved organic matter (CDOM), bio-geochemical variables related to primary production and functioning of food-webs, is essential to follow up ecosystem changes in the SLE due to climate variability. The reported research was mainly intended to use complementary active and passive optical sensing for developing accurate satellite-based biogeo-optical relationships in optically complex waters of the SLE, and with the final goal of mapping long-term ecosystem changes due to regional climate perturbations. The concurrent use of satellites and ship-based laser-induced fluorescence measurements represents a perfect balance between the greater spatial coverage of spaceborne radiometers and the minor atmospheric correction, the greater sampling frequency, and the more selective detection of chl and CDOM by laser-based systems. A preliminary campaign was carried out in September 2011 in the SLE near Rimouski (Québec), Canada, using a portable laser spectrofluorometer (CASPER, Compact and Advanced laser SPECTrometer for RIADE) developed by the Diagnostics and Metrology Laboratory (UTAPRAD-DIM) of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in the framework of the CLIMAT (Complimentary use of Lidar for IMproving sATEllite-derived bio-optical models in the St. Lawrence system) project in collaboration with the Institut des Sciences de la Mer de Rimouski (ISMER) de l'Université du Québec à Rimouski (UQAR). CASPER is a laser spectrofluorometer based on double filtration and double excitation and has been applied to detect both dissolved and particulate components of natural waters coming from aquifers, rivers, lakes and seas. It has been patented and has been awarded the "Research and Innovation Prize 2005" by Business Innovation Center Latium. The information gathered by CASPER has been compared with the imagery collected by ocean color satellite radiometers in the SLE.

Spectral analysis for assessing photosynthetic pigments and phytoplankton composition by shipboard compact and advanced laser spectrometer in Asinara Gulf (Sardinia).

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Keywords: casper, fluorescence, chlorophyll, deconvolution analysis, satellite remote sensing

Abstract:

Phytoplankton is an important biotic component and sensitive bio-indicator of general ecologic status of water bodies. Quantification of photosynthetic pigments is a necessary first step in determining the contribution of individual taxonomic groups. In vivo fluorescence of chlorophyll a (Chl a) and accessory phycobiliprotein (PBP) pigments is broadly used as an index of Chl a concentration and phytoplankton biomass. In recent years, the laser induced fluorescence (LIF) technique has been widely applied for water quality assessment in marine and freshwater environment. LIF technique allows no-time consuming, non-invasive and non-destructive sampling and without sample pre-treatment. The shipboard Compact and Advanced laser SPECTrometer (CASPER) is a fluorescence spectral system to detect and assess water fluorescence compounds. The prototype CASPER is based on double filtration and double excitation in order to detect both dissolved and particulate components of waters coming from aquifers, rivers lakes and sea. In this work the performance of CASPER for improving measurements of pigment concentration, including Chl-a and PBP pigments, providing detection and basic characterization of phytoplankton groups in the Asinara Gulf was examined. Furthermore to assess and characterize marker pigments in situ and in vivo the spectral deconvolution analysis has been performed on CASPER LIF spectra. A code written in R software environment has been used to process fluorescence signals recorded by CASPER and carry out the automatic spectral deconvolution procedure through a series steps. In situ measurements obtained by CASPER have also been used to test the potential of satellite remote sensing as a tool for near real-time monitoring of Chl a distribution in the study area. At the moment it is testing the performance of algorithms based on blue-green ratio and on reflectance in the red and near-infrared (NIR) spectral regions. Field studies confirmed CASPER system capability to effectively discriminate characteristic spectra of fluorescent water constituents, contributing to decrease the

time-consuming manual analysis of the water samples in the laboratory.

A Doppler lidar for remote sensing of wind fields in offshore wind farms

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Keywords: wind lidar, Doppler effect, wind turbines, offshore wind farms

Abstract:

For future multi-megawatt wind energy converters (WEC) in large-scale offshore wind farms new and advanced control strategies are required. Dynamic wind loads have to be reduced efficiently and with minimal controller operation, in order to deliver electricity to the grid in an optimized way.

Up to now the implementation of these visions suffers from fundamental obstacles, despite the progress in many fields of wind energy technology. Large uncertainties due to the complex inflow within the rotor area influence the control and operation of wind energy converters. This problem becomes even more serious with growing rotor diameters beyond 120 m. Current control concepts can only react to wind field fluctuations which have already caused changes in rotational speed or loads. When evaluating the averaged or instantaneous power production, it is unclear from which exact wind conditions they have been obtained. Thus, a precise performance analysis is impossible. These limitations can be overcome with Whirlwind 1, a new lidar instrument developed at the the ForWind Centre for Wind Energy Research, University of Oldenburg. Integrated into the spinner of a wind turbine the lidar allows to measure the incoming wind field remotely over distances of 500 m, typically. The data can be used to identify already small deviations from normal operation and to adapted control strategies for wind energy converter operation. The design and operational characteristics of the instrument is presented, and results of first test measurements are reported.

A systematic sampling design for water quality monitoring using integrated in-situ and remote sensing data

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Keywords: water quality, Chl-a, remote sensing, autonomous vehicle, in-situ, fusion, sampling strategy

Abstract:

Water quality monitoring is an important component of water management activities. Integrating data from both in-situ and remote sensing can help to overcome the limitations of each data set. The first step in the monitoring is data collection, which demands an optimal sampling design to ensure quality of the end results. This becomes even more important when data sets originating from two different sources have to be integrated. The spatial and temporal resolution of remote sensing and in-situ data vary, with respect to each other, and this has to be taken into account. Modern methods of in-situ data collection such as via autonomous vehicles equipped with sensors (e.g. Aqua

Drone[®]) allow spatial and temporal flexibility for designing a sampling strategy in synchronization with the remote sensing data. In this research, we propose a sampling strategy to acquire in-situ and remote sensing data, for integration, to estimate chlorophyll-a (chl-a) for monitoring algae blooms in drinking water reservoirs. The water components are heterogeneously distributed and exhibit spatial autocorrelation. The methodology involves variogram analysis of Airborne Prism Experiment(APEX) imaging spectroscopy data for prior estimation of the chl-a distribution on the surface water and design of an in-situ spatial sampling strategy using geostatistical techniques. The grid for in-situ estimation is so defined as to minimize estimation errors and uncertainty, and the samples are well distributed to have a spatial match-up between the pixels of remote sensing images. Also, as water is a highly dynamic system, time delay in acquiring in-situ samples within the same study area causes variation in the data set, contributing to errors and uncertainty. The temporal dynamics are taken into account while designing the spatial sampling grid size and number of grid samples. In addition, a window frame is defined using statistical criteria to achieve temporal match-up between in-situ and remote sensing data. Further, in-situ optical data has been used for calibration of data and validation of results. A 500m x 500m drinking reservoir near Antwerp (Belgium) was selected as study area because of its hydrodynamic simplicity and availability of a suitable data set. The future aim is to extend this study towards more complex water bodies such as rivers and coastal waters which are both hydrodynamically complex and compositionally dominated by optically varying water constituents.

Monitoring subsidence of coastal lowland areas by satellite radar interferometry

The FP7 SubCoast project

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Keywords: Subsidence, PSInSAR, Monitoring

Abstract:

Coastal lowland areas may be affected by various geohazards; one of them is the subsidence that, when combined with sea level rise and extreme weather events, aggravates flood risk, deteriorating the flood defence and increasing the exposure, with a potential large range of social, economic and environmental impacts. Climate change can further amplify this problem in the next few decades. The shallow subsurface in lowland areas frequently contains compressible soils which are vulnerable to subsidence. Furthermore, these deposits have a substantial spatial variability due to sedimentation and erosion processes, introducing a spatial component in the vulnerability to subsidence. In addition to natural processes of ripening, compaction and peat oxidation, human factors also influence the terrain level: the extraction of natural resources like groundwater, salt, oil or gas in deeper layers (ranging from tens of metres up to thousands of metres) may cause subsidence at the surface. Space-based techniques can be today used for monitoring this phenomenon, in addition to traditional geodetic methods; in particular PSI (Persistent Scatterer Interferometry) data from radar satellite sensors can provide detailed information to assess with high precision the terrain motion for long periods and at different scales of investigation: local, regional, national. Within the EU FP7 framework, the SubCoast project aims to provide data on changes in land elevation for coastal lowland areas combining the information coming from PSI processing with other kind of data, providing services for stakeholders dealing with issues pertaining to hazard management, monitoring and policy development (e.g. water boards, infrastructure departments of ministries, provinces, regions and municipalities throughout European coastal regions, as well as authorities at European scale such as the European Environment Agency). Four pilot studies have been devised to develop the SubCoast service. These pilots include the Rhine Meuse Delta in the Netherlands, the Southern part of the coast of Emilia-Romagna region in Italy, and a part of the Baltic area that was subdivided into 3 countries: Denmark, Poland and Lithuania. The fourth pilot is comprised of a parallel 'European integration' of services.

Archaeological Sites in the Wadden Sea.

What can be seen on SAR Imagery?

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Keywords: TerraSAR-X, RADARSAT 2, archaeology, tidal flats, Wadden Sea

Abstract:

Four years ago, we described structures on TerraSAR-X (TSX) images of the German Wadden Sea that could be interpreted as manifestations of residuals of field systems from the 14th and 17th century. The significant structural elements of those landmarks are thin lines, mostly less than one meter in width, but with lengths of up to more than 100 m. Now we found those landmarks also on RADARSAT 2 (RS2) SAR images with a geometric resolution slightly coarser than that of TSX. Until now, the interpretation of those structures is knowledge-based. But there are also similar structures on several TSX and RS2 SAR images that are not anthropogenic and that make any automated identification a difficult task. Therefore, two different aspects will be discussed, in order to find strategies for an improved image analysis: On the one hand, it is necessary to understand which composition of structural elements determines an anthropogenic origin. On the other hand, their (intrinsic) characteristics, which affect the radar backscattering, should be identified. Combining our results gained from the analyses of the SAR images of two different sensors (RS2 Ultrafine resolution and TSX High Resolution Spotlight) now allows a closer look at the radar backscatter from those historical objects. In addition, the results are of great interest to local agencies, because some of the structure-forming elements can also be found in the vast lands of the remaining tidal flats in the World Heritage area of the German Wadden Sea. These natural forms have mostly fuzzy borders or complex and elusive outlines. The sharply contrasted and well traceable boundaries of the landforms in those archaeological sites allow to find a link between the radar signals and ground (soil) properties.

SAR images and AIS data in tasks of offshore oil spills detection associated with tank washing and illegal discharges oil spill monitoring in inland seas

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Keywords: Black Sea, large oil spills, tank washing, satellite monitoring, SAR images, AIS

Abstract:

During routine satellite monitoring of the eastern part of the Black Sea in 2011-2012 the unprecedented large (up to hundreds km²) oil slicks having a ship origin have been detected on synthetic aperture radar (SAR) images acquired by the Envisat, Radarsat-1 and Radarsat-2 satellites. These slicks had complicated, mostly linear form, and were found in the Russian sector of the sea or at its borders with the Ukrainian and Turkish sectors in summer period. Using data of the automated ship identification system (AIS) the successful attempts to identify the vessels involved in oil pollution have been made. On the basis of the complex analysis of SAR images together with AIS data, it is shown that the vessels responsible for these oil spills and their captains not always operated in the legal frameworks. The most possible source of these large spills is the tank washing in the open sea after transportation of vegetable oils, other liquid chemical substances and even oil products as well as discharges of engine room/bilge waters. Moreover tank washing, as a routine operation in the Black Sea, are frequently produced neglecting the requirements of the International Convention for the prevention of pollution from ships (MARPOL), and out of an operative range of national coastal AIS. This paper for the first time presents the results of monitoring that show that the central part of the Black Sea is chosen for tank washing operations as well as for illegal dumping of oily products. A legality of producing of these spills in the Black Sea in the frameworks of the MARPOL is also discussed. These and other similar events registered during the monitoring require attention of the international environmental and nature protection organizations. Summary maps of large oil spills detected in the Eastern Black Sea in 2011 and 2012 are presented and discussed. They allowed outlining the marine region, where tank washing and illegal dumping occur most frequently.

ENVISAT RADAR ALTIMETRY as a tool FOR COASTAL AND INLAND WATERS: the use of a microwave tomographic approach to achieve information about location and geometry of NON-WATER TARGETS

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Abstract:

Satellite altimetry systems use a nadir-looking radar to sense the water surface, in order to estimate water heights. Non-water targets (e.g. land, ships) are normally considered as contaminants of the pure radar signal reflected by the water surface.

Despite the native low resolution of conventional altimetry platforms, there's still the possibility to extract information about eventual land or artificial scatterers inside the antenna footprint, giving the opportunity to better understand how to detect, characterize and eventually remove the associated electromagnetic artefacts. In this paper, we use a tomographic technique to retrieve useful information about the location and geometry of these particular targets.

In this work, we will show results from a case-study based on the Costa Concordia cruise ship, which smashed its hull against the coast of Giglio Island, a tiny piece of land in the Tuscan Archipelago of the Northwestern Mediterranean. The ship is a strong artificial reflector located off-nadir with respect to the closest Envisat track (orbit 274) to the island. A signature in the Envisat waveforms due to the presence of the Concordia ship is revealed by a change-detection analysis applied to the images achieved by tomographic approach for different passes of the Envisat altimeter before and after the accident. The geometric characteristics of the ship and of the apparent electromagnetic target achieved by the approach are compatible with the Concordia ship in its final position.

Therefore, the tomographic technique is therefore a promising tool to make a mapping of targets in coastal and inland waters and to enhance the possibilities to mitigate such effects when dealing with water height measurements in the presence of such targets.

Towards an Improved Classification System of Intertidal Flat Surfaces Based on Satellite Optical and Radar Data

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Keywords: multi-sensor SAR intertidal flats sediment classification

Abstract:

High-resolution multispectral remote sensing data from satellite-borne optical sensors such as Landsat TM, ASTER, HyMAP or SPOT are already being used for the classification of sediments, macrophytes, and mussels on exposed intertidal flats in the German Wadden Sea. Since the use of those sensors in northern latitudes is strongly limited by clouds and haze, we suggest to include Synthetic Aperture Radar (SAR) data, thus allowing for an observation of intertidal flats that is independent of cloud coverage and daytime. Optical and SAR data from five test areas on the German North Sea coast are used to demonstrate the added value of our approach. The test regions represent areas of typical sediment distribution on intertidal flats, but also include vegetated areas and mussel and oyster beds. During summer season, some areas are covered by sea grass and green algae. Thus, a simple classification method that assumes bare sediments cannot be applied in those areas.

We demonstrate that SAR data have great potential to improve an existing monitoring system for intertidal flats and to complement the classification of sediments, macrophytes, and mussels in the German Wadden Sea. A total of more than 150 multi-satellite SAR data acquired at different radar bands (L, C, and X band, from ALOS PALSAR, from ERS SAR, Radarsat-2 and ENVISAT ASAR, and from TerraSAR-X, respectively) were used to analyse their potential for crude sediment classification on dry-fallen intertidal flats and for detecting benthic fauna such as blue mussel or oyster beds. We show that both multi-satellite and multi-temporal analyses provide valuable input for the routine monitoring of exposed intertidal flats on the German North Sea Coast.

Origin and Fate of Tyrrhenian surface waters in the Gulf of Naples

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Keywords: HF radar data, surface circulation, water exchange processes

Abstract:

The study of surface dynamics of coastal areas using land-based remote sensing systems permit to identify the circulation structures and transport processes resulting from the interaction of multiple co-occurring factors. The work here presented focuses on the Gulf of Naples (GoN), a marginal basin of the Southern Tyrrhenian Sea (Western Mediterranean Sea), which represents a critical coastal basin due both to its unique hydrographic and oceanographic features and to its socio-economic characteristics. The circulation of the GoN is driven both by local factors as the bottom topography and the wind stress, and by remote forcings as the complex large-scale circulation of the Southern Tyrrhenian Sea. In this work we investigated the surface circulation patterns within the GoN by means of high spatial and temporal resolution surface current data provided by a HF coastal radar system operating in the GoN since 2004. In particular the role of the local and remote dynamic factors in determining the fate of the surface waters in the GoN was evaluated. The computation

of the net fluxes time evolution in the interior of the GoN allowed us to reconstruct the inshore-offshore surface water exchange. The circulation patterns identified by means of HF radar data were also compared with high resolution satellite images, lidar data taken from the R/V *Urania* and 3D hydrodynamic model results. The presented integrated approach provides new outcomes to assess the surface water renewal and the prevailing exchange mechanisms between the GoN and the Southern Tyrrhenian Sea.

TS-X FOR NEAR REAL TIME MARITIME SECURITY AND SAFETY

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Keywords: TerraSAR, Offshore Windfarm, Maritime Safety

Abstract:

In this paper, we demonstrate the application of high resolution TerraSAR-X (TS-X) data for coastal applications in respect to maritime safety and security. New radar products of high resolution coastal wind field, sea state, underwater topography and ship traffic are derived and its use in near real time is demonstrated. Main applications are offshore wind farming, ship routing and monitoring, oil spill detection and improvement of high resolution weather prediction. Satellite products are delivered to coastal users in NRT, i.e. in less than 15 minutes as email attachments. The retrieved sea surface wind field is used in support of offshore wind farming. Case studies over Alpha Ventus, the first offshore wind farm in Germany, are presented to investigate spatial variations of turbulence wakes generated by offshore wind turbines under different wind conditions. Detailed comparisons of the retrieved TS-X wind field with in situ measurements at the FiNO1 research platform and results of the model are shown as well. Further we present an algorithm (XWAVE) to derive significant wave height (from TerraSAR-X data without the need of a priori information. The algorithm is based on spectral analyses of TS-X data, using a geophysical model function. The coefficients are fitted to collocated in-situ buoy measurements using the least squares method. Wind speed information provided by the XMOD algorithm is additionally combined in the algorithm. TS-X data are especially suitable for the study of sea state variability in coastal areas due to their high resolution. Coastal wave fields have been derived from TS-X data and verified with numerical wave model results and with in-situ buoy measurements over the area of the North Sea.

Ship traffic has been monitored and compared to AIS data. The performance to detect small boats is tested in campaigns with the Federal Police .

Routine oil spill cases have been monitored over North Sea Platforms and shipping lanes.

In order to enhance the repetition frequency of available satellite data and thus achieve more than daily coverage further data from Cosmo-Skymed and Radarsat are being used. Results from Campaigns over the German Bight and the Baltic together with users from national authorities are shown.

Studies are performed in the framework of the national project DeMarine and the ESA and EU projects MARISS and DOLPHIN.

Developing Integrated Remote Sensing and GIS Procedures for Oil Spill Monitoring At Libyan Coastal Zone

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Abstract:

Remote sensing (RS) and geographic information system (GIS) can contribute significantly to the correct interpretation of the slick signatures visible on satellite images. Initially, GIS has proven to be an excellent management tool for resource assessment, oil spill response and planning, and damage assessment. The approach to the problem of oil spill mapping includes integration of the geographical, remote sensing, oil and gas production/infrastructure data and slick signatures, detected by satellite images, in GIS. Compiled from data from several sources including nautical maps, geodatabases, ground truth and remote sensing data, GIS allows the retrieval of key information, such as predicting oil spill locations, revealing offshore/onshore sources, and estimating the intensity of oil pollution. Remote sensing and GIS technologies can improve the identification and classification of oil spills, leading to construction of the final product, an oil spill distribution map. This approach has been applied to oil spill mapping in libyan coast. We conclude that the combination of GIS and remote sensing RS technologies provides an ideal solution for understanding the spatial/temporal distribution of oil spills in the marine environment and is considered as the core of the oil spill monitoring system.

Remote sensing applications in direct receiving Spot 5 conditions for cross-border amazonian coastal monitoring and natural resources assessments :

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Keywords: Crossborder French Guiana Brazil territories - Guyamapa initiative - indicators of coastal and oceanic environment status and short term evolutions - cooperation - SEAS Guyane direct receiving facility

Abstract:

The Guyamapa Project is a broad collaborative initiative based on the mutualization of remote sensing solutions dedicated to environmental monitoring and natural resources assessments in the French / Brazilian crossborder Territory. Funded by the "Amazonie" Operational European Program in French Guiana, with CNES, IRD and INPE co-funding, it associates scientists and public services in charge of environmental monitoring on both sides of the French Guiana / Amapa State. It aims at creating conditions for common crossborder actions subsidizing public policy makers with objective reproducible and verifiable informations extracted from spaceborn data sets and ground collections. Guyamapa contemplates 7 synchronuous operations : (1) Spot 5 data set ortho-rectification and classification, indicator implementation; (2) Forests, soils and water status indicators; (3) Agriculture and forest degradation indicators; (4) Coastal natural processes and resources dynamics indicators; (5) Malaria transmission risks indicators, (6) Common trans-national Landcover taxonomy, (7) Geospatial data base and webservices. For each operation, Guyamapa is built on French/Brazilian teams working on common objectives, with common methods, pursuing the elaboration and difusion of common indicators inside the crossborder territory. Started in january 2012, the project already offers important results in terms of : original data acquisition and SVM classification methods, construction of common methods for the construction of common indicators informing on the state of the crossborder environment and its dynamics, definition

of transverse landcover taxonomies for monitoring from space. The Coastal Group has identified crossborder phenomenons, processes and dynamics of prior interest, through the elaboration of 5 coastal indicators: (a) characterization of mudflats maturity and consistancy dynamics along the coast; (b) coastline evolution trends in the last 3 decades; (c) coastal landscape evolution and landcover changes; (d) biomass indicators and small fisheries predation on resource; (e) practices, representations and conflict surges in small fishing activities in crossborder territory. In association with CLS (Collecte Localisation Service) 4 oceanic indicators informing on marine environments between Para State (Brasil) and Georgetown (Guyana) will be produced: (a) superficial water colour, suspended and dissolved matter; (b) superficial water temperature; (c) superficial currents; (d) waterlevel. These last indicators will be recomputed with new and improved algorithms for the 2002-2012 period, except water level for the 1992-2012 period. Guyamapa is and will provide substancial information to environmental managers and stakeholders, in the specific context of the cross border territorial dynamics where access is very difficult and predation on natural resources desordonated. The methods based in large part on satellite image acquisition and processing by the SEAS Guyane direct Spot 5 receiving facility in Caiena will, together with the specific webser-vices developped by the project, ensure reproductibility of the approches and a first common frame dedicated to cooperation and collaborative actions in favor of the Amazonian environment of this region.

ALOS AVNIR-2 and PRISM Images for the damage detection of the Coral reef, Spermonde Archipelago, Indonesia

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Keywords: Coral reef, image fusion, percent cover, destructive fishing

Abstract:

Coral reefs are important because of their high biodiversity and their key role in the tropical marine biosphere. Furthermore, coral reefs are very valuable as a socioeconomic resource as they make important contributions to the gross domestic product of many countries. Despite these natural and socio-economic advantages, many factors are threatening coral reefs. ALOS AVNIR-2 and PRISM image of 2007, 2008 and image of 2010 were used to examine changes in coral reef, around Barrang Lompo small island, Spermonde archipelago, Indonesia. Prior to coral reef bottom-type classification, The image fusion technique were done to combine relevant information for two images into single image to produce the high spatial resolution, from 10 m² become 2,5 m². Subsequently, a multi-component change detection procedure was applied to these indices to define changes. Percent cover of life coral divided into four class, they are < 24,9%, 25-49,9%, 50-74,9% and more than 75%. Preliminary results showed significant changes during the period 2007–2010 as well as changes in percent cover of coral reef. On the other hand, they are threatened by human impacts such as destructive fishing.

DETECTING LONG TIME CHANGES IN BENTHIC MACROALGAL COVER USING LANDSAT IMAGE ARCHIVE

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Keywords: remote sensing, benthic habitats, Landsat

Abstract:

Changes in the extent and species composition of shallow water benthic algal cover are indicators of ecological state of coastal waters. Usually there is very little known about the spatial distribution of benthic habitats over large coastal zones as the in situ sampling with underwater video, diving or grab samples is very time consuming and expensive. Moreover, there are rarely long time series available about the extent and type of benthic habitats that would allow to study trends taking place in the coastal environments.

Landsat series satellites have operated for 40 years and the archive is now freely available for research. Sensitivity of the Landsat sensors is too low for water quality applications. However, it has been demonstrated that Landsat series satellites can be used in the case of such relatively bright aquatic environments like coral reefs. Our aim was to test can the Landsat sensor be used for mapping shallow water benthic algal cover and changes in it in such optically complex environment like coastal waters of the Baltic Sea. Our preliminary results show that the Landsat imagery can be used for mapping of the extent of benthic algal cover and interannual changes in it. Getting more detailed information (e.g. shifts in species composition) is probably not possible due to low sensitivity of the instrument, just three spectral bands penetrating the water column, optical complexity of the water column and spatial resolution of the sensor (30 m) that is high compared the heterogeneity of benthic algal cover in Estonian coastal waters. Nevertheless, the information about long time changes in benthic cover is a very valuable information for coastal studies.

OBSERVATION OF SAN ROSSORE REGIONAL PARK COSTAL AREA WITH DAEDALUS MULTISPECTRAL SCANNER AND HYPERION HYPERSPECTRAL SENSOR

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Keywords: Hyperspectral sensors, multispectral scanners, coastal zone monitoring, calibration and validation activities

Abstract:

In the framework of the TELAER Announcement of Opportunity for the multispectral scanner Daedalus, a remote sensing campaign has been performed in the Migliarino, San Rossore, Massaciucoli Regional Park on August the 10th, 2012. The park is located along the seaside near Pisa city and its central part lies between the Serchio and Arno rivers. The site has been designed by our Institute as the main test site for remote sensing campaigns. The site is devoted to calibrate and validate the data acquired by aerospace hyperspectral sensors and to test in field instrumenta-

tion. During the campaign, a set of four flights over San Rossore has been performed by TELAER STA using the multispectral scanner Daedalus on board of an AP68TP-600 Viator airplane. Simultaneously an acquisition set has been performed by the hyperspectral sensor Hyperion and the multispectral camera ALI mounted on Earth Orbiter – 1 satellite, as well as in field measurements for providing atmosphere characterization. Data collected by all these sensors, operating in the visible and infrared spectral ranges, have been processed to characterize the coastal area and the land coverage, and to assess some biogeochemical parameters for environmental studies. Attention has been paid to correct the atmospheric effects on the acquired images, to obtain spectral reflectance maps of the observed surfaces from at-sensor radiance images. The outcomes of the processing of images gathered during this remote sensing campaign will be presented and discussed.

Estimation of optically active constituents in the Scheldt estuary, a wavelet approach

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Keywords: wavelet, estuary, water quality, hyperspectral

Abstract:

We present a wavelet based approach to quantify optically active constituents in the Scheldt estuary from simulated Airborne Prism EXperiment (APEX) high spectral resolution data. Continuous wavelet analysis is used to detect features at various wavelengths and frequency scales. These wavelets provide a potential solution for improved feature detection from high spectral resolution data, like APEX. Fine wavelet scales extract narrow, high frequency spectral features, which are often noise. These scales are often related to high frequency noise. Coarser wavelet scales extract broad, low frequency spectral features. The simulations are based on the Hydrolight radiative transfer code. Water leaving reflectance is simulated using different combinations of Chlorophyll-a (Chl-a), Total Suspended Matter (TSM) and Colored Dissolved Organic Matter (CDOM) concentrations and inherent optical properties (IOPs) measured at the Scheldt estuary. Different types of noise are introduced in this dataset. For instance, atmospheric noise is introduced by upscaling the water leaving reflectance with Modtran to at-sensor-radiance and applying an atmospheric correction with wrong estimates of the atmospheric parameters (e.g. the Aerosol Optical thickness). The wavelet analysis enabled us to reduce the influence of errors in the prediction of the optically active constituent of interest.

Mapping reefs in Puerto Morelos, Mexico, using IKONOS

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Keywords: Coral Reef, Mapping, Benthic Habitats, Classification, Ikonos.

Abstract:

In this study we assess the capacity of IKONOS data for discriminating the diverse coral-reef habitats at the Puerto Morelos Reef National Park in Yucatan Peninsula (Mexico) and for providing baseline maps for future monitoring of the changes and evolution of the reef system. An IKONOS image was used in combination with checkpoint ground sampling and classified using a supervised maximum likelihood classifier (in ENVI 4.5). We show that it is possible to map the reef with acceptable accuracy for the lagoon where the main habitat types, including vegetation, corals, and bare substrate are discriminated. But, in areas close to the shore and in the front-reef zone there were significant misclassifications as well as a failure to delineate spatial structures evident on the ground and in aerial imagery. These difficulties and failures occurred either in the areas deeper than 5-8 m where depth limits light transmission (particularly in the red channel), or when the spectral response of habitats were too close to be discriminated. This highlights the need to combine these data with other methods, such as acoustic mapping, in order to provide more accurate representations of the benthic habitats of entire reef systems. Indeed, benthic terrain models derived on the same area

from acoustic data (Kongsberg EA 400) show the structures that were not discriminated on the IKONOS image.