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Application Of Fusion Techniques Between Radarsat And Landsat Images for Landuse Distribution At Cartagena (Colombia) Using Supervised Classification

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Use of satellite images has been of great help for studies of landuse distribution in different places at different conditions. Landsat images have been one of the best ones due to their great spectral resolution (Landsat TM-7 with 7 bands), but their limited spatial resolution of 30m has been of the biggest disadvantages for detailed landuse studies. In the other hand Radarsat images have one of the best spatial resolution (6 m) but poor spectral resolution (pancromatic mode). Besides their good spatial resolution Radar images have other advantages over other images like their capacity to operate under any climatic conditions and at any time (day or night). Radar images are able to get information even in cloudy conditions and this characteristic make them perfect for studies of coastal zones and specially on tropical areas, where most part of the year are covered by clouds. The study area in this case was located at a tropical area (09 ° 33'45" N and 75°23'45"W) so it was absolutely necessary to find a solution to perform the best detailed landuse distribution in order to actualize coastal zone management plans for the area.

Nowadays techniques have been able to overcome these disadvantages. Application of fusion techniques were able to solve these limitations, by the combination of the best characteristics of these two types of images. In this specific case the good multispectral resolution of Landsat images and the good spatial resolution of Radarsat images were combined in order to obtain a completely new image, but only with 20 m of spatial resolution since Radarsat resolution was decreased due to the exaggerated difference in spatial resolution between the two images (6m and 30m). This is very much recommended to decrease errors created during the pixel to pixel fusion. With this new image obtained a good and detailed landuse distribution was performed by the application of supervised classifications in the study area. The results obtained were of good percentage of reliability and then used for new coastal zone plans.

Laser remote sensing of coastal and terrestrial pollution by FLS-Lidar

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The FLS-series lidars were primarily developed for monitoring of marine environment. Further developments and field trials have shown that extending their application to diagnostics of chemicals on different types of underlying surfaces (water, soil, industrial sites, land and agricultural vegetation, etc.) is highly feasible. Natural aquatic and terrestrial targets containing organic pollution and vegetation have been studied in field experiments. The specificity of lidar applications in coastal shallow waters has been investigated with FLS-lidars operating at tuneable and fixed sensing wavelengths. Additional requirements on analytical lidar technologies have been determined due to specific measurement conditions: small depths of sensed water column; typically lower water transparency and higher amounts of suspended solids; effects of bottom and shore underlying surfaces on lidar echo signals. Modified FLS-A lidar has been used recently in airborne experiments aimed to monitor the land areas of oil transportation and storage. The library of LIF spectra of underlying surfaces have been compiled and systematized. The field tests have proved the ability of FLS-A lidar to distinguish the fluorescence of minor oil pollution on different spectral backgrounds usually recorded in airborne measurements. Techniques for real-time data acquisition, processing and analytical quantification are characterized.

Integrated Monitoring of Coastal Habitats using Airborne Remote Sensing

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The Environment Agency of England and Wales have been involved in a collaborative project with English Nature to provide remote sensing solutions to the problems associated with management and monitoring of coastal Special Areas of Conservation (SACs). This paper examines two areas of this project: increasing coastal habitat classification accuracy and detection of morphological change. Data were gathered using the ITRES Compact Airborne Spectrographic Imager (CASI) to provide multispectral data and the Optech Airborne Laser Terrain Mapper (ALTM) to provide digital surface models (DSMs).

Multispectral remote sensing has previously been used for mapping the extent of coastal vegetation classes. However, there are ecological bases for including additional data in classifications, particularly slope and in the case of intertidal vegetation, elevation. This study used data derived from the ALTM DSMs to provide additional data layers in classifications. Neural network classifiers were used to assess increases in saltmarsh and sand dune vegetation classification accuracy when ALTM data were used in addition to multispectral data. Results are presented that show an increase in discrimination between intertidal land cover types when ALTM data are used in conjunction with fine spatial resolution multispectral imagery.

ALTM data provides the opportunity for precise and accurate monitoring of changes in coastal morphology. However, the accuracy of such monitoring is limited by the interaction of the uncertainty of the system with the terrain morphology, particularly slope. A simple filtering system was devised that accounts for the impact of terrain on the overall uncertainty of change detection using ALTM surfaces. Results are presented that show the impact of the filtering system on ALTM change detection.

Drop of DOM/Raman ratio in water fluorescence lidar signal *versus* laser intensity

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Strong decreasing of dissolved organic matter to Raman band amplitude ratio in water versus intensity of laser pulse was observed. The second harmonic of Nd:YAG pulsed laser is used in fluorescence lidar as a pump. The pulse duration and repetition rate was 8 ns and 1 Hz, accordingly. The beam intensity on the water surface was not high and varied from 0.4 to 50 $MWcm^2$. The correction of estimation procedure of DOM concentration by Raman band intensity and its application in mapping of coastal water pollution is discussed.

New approaches to determination of temperature and salinity of seawater by laser Raman spectroscopy

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Temperature and salinity are characteristics of seawater widely used in oceanology. Their simultaneous remote determination is a topical problem, and the laser Raman spectroscopy method has a special position in the solution of this problem. In particular, this method provides determination of absolute thermodynamic temperature, different from passive methods implemented with radiometers. However, the results obtained with laser Raman method before had the precision of determination of the sought parameters (0.5°C and 0.5 ‰) that did not fully satisfy the requirements of oceanology.

Recently, new opportunities connected with development of principally new algorithmic approaches to the solution of inverse problems, have emerged. Revival in active development of determination methods for temperature (T) and salinity (S) is also due to the perception of the fact that *T* and *S* are the indicators of ecological state of water areas. Anomalies in *T* and *S*, caused by pollution ("thermal pollution"), by the formation of freshened lenses; possible role of salt in the change of fluorescent characteristics of some organic admixtures in water evidence this fact.

The paper reports successful application of artificial neural networks (ANN) for the solution of the described problem. Two approaches have been used: 1) direct solution of the inverse problem using experimental water Raman spectra to train the ANN; 2) creation of optimal analytical model for the dependence of the spectrum on temperature and salinity (using Group Method of Data Handling, GMDH) with successive training of ANN based on this model. The results, merits and shortcomings of the new approaches to the solution of the described inverse problem of Raman spectroscopy, are discussed.

The Role of Remote Sensing in Understanding of Coastal Processes in the Eastern part of the Gulf of Finland in the 20th Century

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Some results of the study of morphodynamical processes in the coastal zone in the eastern part of the Gulf of Finland in the Baltic Sea, based on the analysis of multi-temporal aerial images, are presented. Their relevance for coastal engineering is discussed.

First images of coastal zone in the River Neva Bay were taken from balloons in the early 1900s. The most intensive use of aerial images for monitoring the river coasts and the Bay was recorded in the 1920s - 1930s and, with new techniques, in the 1950s-1980s. VNIIKAM's database of aerial images for the eastern part of the Gulf of Finland contains images obtained in the 1950s-1990s. Satellite imagery complements aerial imagery since the 1970s. Database of satellite imagery includes high resolution data from film cameras and scanners onboard national satellites of "Kosmos", "Resurs-O" and "Resurs-F" series, and images from Landsat, SPOT and other satellites.

These remotely sensed images were analyzed together with historical maps using GIS technology. It is interesting to note that the plans of small roads and gardens around the famous palaces in the environs of St. Petersburg located on the coasts of the Gulf (Peterhof, Strelna, Dubki) rested without change from the beginning of the century. This fact was used for precise geolocation of images in the course of joint analysis of images and historical maps of the region.

Change detection of coastline based on the analysis of satellite and aerial images of last decade showed that the position of coastline in this region varied by 5 to 100 m. Maximal change was observed in the point Dubovskoi near Sestroretsk and in the coastal zone near the construction site of the Storm Surge Barrier. During the 20-th century the forest coverage in the coastal zone decreased and the urbanized area increased. Unfavorable trend in coastal ecosystem dynamics in the 20-th century was a result of industrial development, wars and changing of life style of population.

Polarizable Aviation LIDAR (PAL-1) As Means Of Fisheries-Biological and Oceanographic Airborne Research Carrying Out

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Recently appeared keen necessity of data truth and accuracy rise, which obtain in carrying out of closely sea surface layer air research, including during execution of air surveys tool-making, which carry out in the interests of fisheries oceanography. One of way it achievement is wide spread of air remote sensing active methods using, where certain role belong to LIDAR systems.

Using of LIDAR allow to carry out of water sounding through line between air and water, penetrating at the sea closely surface layer. Besides, if laser sounding impulse is linearly polarizable and has two receiving and recording channels, which are intended for recording of two echo-signal components with reciprocally orthogonal polarization has possibility to make identification of displayed object in echo-signal analyze.

Indicated task was realized for polarizable aviation LIDAR (PAL-1) with success and effectiveness. It was designed and manufactured by “MULTITEKH” company from S.- Petersburg. PAL-1 has not analogues at Russia in modern stage for carrying out of air research in the interests of fisheries oceanology. This LIDAR system is set and operate onboard of An-26 “Arktika” research aircraft by PINRO specialist during last two years.

During this time PAL-1 was highly successfully, reliably, effectively and qualitatively used in remote sensing detection of upper sea water layers vertical profiles and optical characteristics to depth of natural transparency for difference water area, detection of fish aggregations, and first mackerel, and also in chlorophyll fluorescence pigments recording from board of research aircraft.

Determination of oil pollutants concentrations in Caspian sea (mouth zone of river Volga) by shipboard laser spectrometer

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At present the great attention is devoted to investigation of Caspian sea region. Caspian sea is a unique, rich of mineral and biological resources, marine basin. This region has excellent perspectives to further intensive industrial development. One of the most important scientific problems is ecological monitoring of Caspian sea coastal zone and mouth zone of river Volga. In our laboratory in 1993 we elaborated laser spectral method, which provides direct (without preliminary sample preparation), absolute quantitative determination of petroleum hydrocarbons in sea water. We developed portable laser spectrometer to realize this method of water investigation. The spectrometer was used in expedition along river Volga and north part of Caspian sea coastal zone on ecological patrol ship "Russia", which belongs to VO "Zarybezhgeologia", in August - September 2002. Water analysis was carried out during ship motion in special quartz flowing cuvette under laser excitation at 266 nm (for diagnostics of DOM, oil pollutants, suspended organic matter) and 532 nm (for diagnostics of chlorophyll "a" and suspended organic matter) wavelengths. To detect spectra of radiation from flowing cuvette we used multichannel optical spectral analyzer, interfaced with Notebook. Real-time experimental results revealed possibility to determine concentrations of oil pollutants not only in sea, but also in rich of organic compounds river water during ship motion. Minimal possible to determine concentration of oil pollutants was 10 mkg/l in case of processing spectra by differential spectroscopy method. The concentration can be decreased in case of processing spectra by Artificial Neural Networks. These quantitative results were obtained by comparison of experimental samples with certified standard sample of oil products in water-soluble matrix (passport GSO 7117-94). We used obtained results to draw maps of oil pollutants distribution in work area.

Optical Remote Sensing in Support of Eutrophication Monitoring in the Southern North Sea

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Spring mean and maximum Chlorophyll-a concentration is a main factor to determine the eutrophication status of the Belgian Coastal Zone as agreed within OSPAR in 2002. Other important assessment parameters to measure the degree of nutrient enrichment - the amount of inorganic phosphate and nitrogen in winter – appeared to be above thresholds for most measurements performed in the period 1974-2002.

As the standard in situ monitoring programme does not give a clear picture of the temporal and spatial distribution of Chlorophyll-a, it is logical to complement these measurements with optical remote sensing. However chlorophyll concentrations derived from SeaWifs are unreliable in this region because of high yellow substance absorption. The possibilities of the new European ocean colour sensor Meris for chlorophyll-a detection are presented. Meris images were validated with in situ measurements of the Belgian Coastal Zone for the period 2002-2003. Based on this validation the accuracy of these products and their suitability for eutrophication monitoring are assessed.

An important limitation of Meris is the limited amount of useful images due to cloud cover. The combination of data from different ocean colour sensors and/or with in situ measurements to allow a better temporal coverage – especially for not missing phytoplankton blooms – is discussed.

The OSPAR common assessment criteria have been established recently and may need some refinement in the future. Perspectives for combining optical remote sensing with ecosystem modelling are discussed for this purpose.

The use of hyperspectral data in coastal zone vegetation monitoring

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The Dutch coastal dunes belong to the most extensive protected nature areas of The Netherlands. In order to maintain biodiversity and restore threatened flora and vegetation nature managers apply several management measures, with support of the government. Accurate monitoring systems are necessary to evaluate the effects of nature management and to investigate spatial changes in the vegetation. Therefore a classification method has been developed based on hyperspectral imagery in combination with an expert system. This method gives the opportunity for rapid classification with an overall accuracy of 60-70%.

Airborne hyperspectral data were acquired by the GER EPS-A scanner for the Amsterdam Water Supply Dunes, one of the most ecologically complex dune areas of The Netherlands. A supervised classification method has been used applying the Spectral Angle Mapper, in combination with an expert system. The Spectral Angle Mapper algorithm determines the similarity between two spectra (e.g. known vegetation type spectrum and image pixel spectrum) by calculating the angle between the two spectra. The spectra are treated here as vectors in n-dimensions, where n is the amount of bands measured in the spectra. The expert system adds extra information about environmental conditions such as lime content and ground water level to the classification in order to distinguish vegetation types, which are otherwise spectrally difficult to identify.

Comparison between remote sensed data and in situ measurements in coastal waters: the Taranto Marine Sea case

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The objective of the activity described in this paper has been to evaluate the contribution of the remote sensing for a constant monitoring the areas of interest with a temporal frequency difficult to achieve with traditional techniques and the efficiency of an integrated approach on costal areas of small spatial extension as the ones of the Taranto seas (3 nearly closed basins with low spatial extension, approximately 55 km^2 totally, and small depth, 7 m., 10 m. and 20 m. average depth for the 3 basins). In order to achieve this goal a long time data series of in situ measurements has been compared with the values derived from two low spatial resolution, high temporal frequency (daily) satellite sensors. The ground measurements have been made regularly for a multi years period, on a network of 9 field stations. The in situ measurements of chlorophyll concentration has been compared with the corresponding values derived from the SeaWiFS sensor. For each image a preprocessing step, based on a clustering approach, has been used for a preliminary separation between “pure” sea pixel and “mixed” or cloud covered points. The estimated chlorophyll concentration for the “pure” sea pixels set has been computed both using standard operational procedures both semi-empirical image based approach for atmospheric correction. The Sea Surface Temperature values has been derived from AVHRR sensor using standard tools. Finally, in order to compare point based in situ measurements with remote sensed map, a bi-dimensional dynamic model of the two basins of the Taranto gulf, has been developed. This model describes water fluxes and chemical and biological components diffusion. Through this model, space and ground/sea data, at different spatial and temporal resolution and spacing, has been integrated. The comparison between in situ and RS data will be shown as well as the temporal and spatial dynamics of temperature and chlorophyll concentration.

Sand Characterisation along the Belgian Coast Based on Airborne Hyperspectral Images

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Airborne hyperspectral images were acquired at low tide over the Belgian coastline in order to distinguish between different sand types occurring along the beach. After radiometric, geometric and atmospheric correction, all images were 'normalized' to relate the reflected radiance from wet parts of the beach to the radiance from dry parts of the beach. The classification is then based on the small absorption and reflectance features presented in the signatures and not on the absolute reflectance level. The first derivative of the normalized images enables us to classify the sand into 7 different types by means of a spectral angle mapper algorithm. The seven types differ in mineralogical composition, grain size distribution, % of organic matter and % of carbonates content. The method used proved to be very efficient to detect the coarse-grained (sea)sands used for beach nourishments. High resolution elevation models, obtained through airborne laser scanning, are used to calculate quantitatively the erosion or sedimentation. The combination of the hyperspectral technique to trace the 'nourishment sands' and the erosion maps derived by laserscanning, results in a convenient and cost-effective method for monitoring beach nourishments and beach morphology.

Quantification of suspended sediments in estuarine waters from remotely sensed (SPOT, Landsat) data. A semi-empirical approach

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The study concerns the quantification of suspended sediments in highly turbid estuarine waters from high and mid spatial resolution remotely sensed data (SPOT-HRV, Landsat-ETM+, MERIS, MODIS). It is applied to the following areas: the Gironde and the Loire estuaries (France), where suspended sediment concentrations (SSC) in surface waters vary in the range (20 – 1000 $mg.l^{-1}$).

The methodology is essentially empirical. Based on in situ optical measurements, calibration relationships are established between the remote sensing reflectance (R_{rs}) signal and SSC. These relationships, obtained using reflectance ratios between near-infrared (NIR) and visible (VIS) wavebands, are few dependent on the sediment grain-size and mineralogy, and also few dependent on the illumination conditions (e.g. the cloud cover). Consequently, they can be applied to satellite images, even if no simultaneous in situ measurements were carried out at the moment of the satellite overpass. They allow an accurate estimation of concentrations, once satellite data are corrected from atmospheric effects. Resulting SSC maps are presented.

A bio-optical model is used to explain the obtained empirical results. It relates the inherent and apparent optical properties of the considered estuarine waters. Scattering by sediments is modelled using the Mie theory. Absorption by sediments is modelled according to the existing knowledge in the domain. The modelled optical properties are validated by comparison with in situ (AC9) measurements.

Finally, experiments are done in order to study the bi-directional aspects of reflectance for such turbid waters. Coincident in situ measurements of the R_{rs} signal, just above the water surface, and irradiance reflectance, just below the surface, are carried out. The obtained results are discussed, notably concerning the correction of surface effects (sun glint, sky glint) related to above water optical measurements.

Fluorescence characteristics of the surface water layer of Arctic Seas based on lidar and spectrophotometric methods.

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Shipboard fluorescence lidar spectra and ground truth data from a large number of stations combined with CTD measurements collected during two summer expeditions of r/v OCEANIA to Arctic Seas are analyzed to estimate chlorophyll and non-algae dissolved/suspended substances.

The Greenland and Norwegian Seas constitute a very important region which is the mixing area of salty and warm water of the Spitsbergen current with cool and fresh glacial water. Therefore the investigations of the DOM and phytoplankton biomass changes in the surface water layer, influenced by such factors as salinity and temperatures of water, allow to investigate the patchiness of fresh and ocean water inflow.

The light source of the FLS-12 lidar system is a dye-laser that allows choosing the most suitable wavelength to excite chlorophyll *a* as the marker of phytoplankton biomass. The Gaussian deconvolution of the lidar-induced return signal provides the signal integrals of the separate spectral bands of water Raman scattering and dissolved organic matter (DOM) and chlorophyll *a* fluorescence signals that are used to calculate the fluorescence factors of DOM and chlorophyll *a*. Simultaneously the water samples from the surface layer (0 – 1 m) were taken to carry out the comparative ground truth measurements allowing correlation of *in si*tu concentration of chlorophyll *a* obtained by spectrophotometric method with the fluorescence factors of chlorophyll *a*. The salinity, temperature and density profiles of water were made along the routine transects across the area characterized by surface currents and mixing water regions.

Dynamics and Morphodynamics in Sandy Coastal Environements: Application to the Aquitaine Coast

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The Aquitaine coast (France) is representative of sandy coastal environments with long linear beaches boarding a large continental shelf and interrupted by the Gironde estuary and the Arcachon inlet. It is a mixed-energy environment with meso-tidal and long swell influences. In order to monitor the hydro and morphodynamics of this environment, we are using several techniques including optical and radar remote sensing.

First of all we are using SPOT optical images to analyse rhythmic sub-tidal and inter-tidal bar morphology and dynamics. The method is based on semi-empirical inversion of shallow water reflectance in term of bathymetry. We will summarize the results obtained at medium scale based on a set of 16 images: the bar morphology, their time of response and preliminary analysis of physical forcing based on wave rider recording. Then , we will focus on new results at smaller scales of extreme events with a series of images obtained in hivernal conditions.

Second, Synthetic aperture radar are used for different dynamic aspects mainly for inlets. The PYLA 2001 campaign allowed deploy the polarimetric RAMSES radar in band P (with a wave length of about 1m), developed by l'ONERA. The oceanic part of this campaign aimed to both study the feasibility of capturing ocean surface salinity variability in the Gironde estuary and to obtain the surface currants in the Arcachon inlet. We will compare the results of two flights in April and May 2001 across the salinity gradients by a 3D hydrodynamic model. The experimental results will also be compared to the simulated variation the backscatter as a function of surface salinity. At last we will briefly present the ability of the radar images to retrieve surface currents in the Arcachon Inlet as compared to 2D hydrodynamic model forced by tidal effects.

Change in the spectral response of a mangrove forest before and after an hurricane event and a restoration effort.

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Mangroves are the dominant vegetation in more than 70% of tropical and subtropical coasts of the world. In Mexico the mangrove forests are decreasing at an alarmingly rate, it is estimated that in the last 30 years more than 60% of the basal coverage of this ecosystems have been lost. The geographical distribution of mangroves makes them vulnerable to the effect of hurricanes. The need to conservate this forests and restore the degraded is urgent.

The mangrove forest of Ventanilla, Sta. María Tonameca, Oaxaca is composed mainly of red mangrove (*Rhizophora mangle).* Before it was devastated by hurricane Paulina the 8th of october of 1997, the canopy was 30 meter high. The population of Ventanilla made a restoration effort, in a ecotourism development context. A nursery was constructed and the well developed plantules were planted the year after the hurricane.

The spectral response was obtained from 7 Landsat satellite images, 3 previous (1990, 1993 and 1997), 1 after the climatic event (1997), and 3 after the restoration effort (1999, 2001and 2002). The comparison of this images in the time series analysed permitted to estimate the change relationship of the spectral response between them, and the zones with more and less coverage.

A survey of total suspended matter in the southern North Sea based on the 2001 SeaWiFS data

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Total suspended matter (TSM) in the North Sea was studied with Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Level 1A Local Area Coverage (LAC) data. All SeaWiFS data covering the southern North Sea for 2001 were acquired and processed using the SeaWiFS Data Analysis System (SeaDAS 4.0) with MUMM's turbid water extended atmospheric correction algorithm. Subsequently, the POWERS TSM algorithm was used to derive TSM concentration (in mg l^{-1}) from SeaWiFS sub-surface irradiance reflectance in band 5. Seasonal variation in TSM concentration was extracted from composites, and statistics on TSM concentrations were produced for any location within the research area. Spatio-temporal distribution of TSM concentrations is important for, amongst others, the underwater light climate. For management of the North Sea, information on supply, transport and deposition of TSM is also required.

This paper shows that this information can all be derived from SeaWiFS data. Persistent high TSM concentrations were found near the Flemish Banks and the German Bight, and in the Greater Thames Estuary and East-Anglian Plume. Supply of TSM came from fluvial input, erosion of coastal areas and bottom sediments, and primary production. Combining TSM concentration with knowledge of the general circulation in the North Sea yielded information on surficial (net) TSM transport. On the other hand, currents and the position of fronts were also derived from patterns in TSM concentrations. Deposition of TSM occurred in places with low current velocity and little wave action. An example of settling after storm was also perceived.

The results show that SeaWiFS images are an excellent source for monitoring TSM content.

Matrix method of laser fluorimetry of complex organic compounds in water

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In the report the possibility of the complex organic matter in water laser fluorimetry inverse problem dimensionality increase is researched by means of synthesise of some spectroscopy methods and measuring of matrix elements. Elements of the matrix are intensity values (number of photons) of fluorescence with different arguments values.

Test of this idea was carried out for two-fluorophor system including intermolecular energy transfer between the different type fluorophors (donor and acceptor) and between one type fluorophors in exited state. The second type of transfer leads to singlet-singlet annihilation of excitations. The synthesis of two laser methods (kinetic and non-linear fluorometry) was examined. In this case elements of matrix are normalized intensities of fluorescence which were measured with different strobe delay time of the receiver t_{del} relatively of the laser pulse and photons density flow of exciting radiation F. t_{del} and F are arguments of kinetic curves and saturation curves accordingly. The numerical modelling showed that matrix elements depend on required photo-physical parameters of the system in different ways in particular on rate constants of energy transfer. This permits to determine these constants by the method of solution of the multi-parametric inverse problem using the matrix formalism. The sensitivity and errors of the parameters reduction were investigated with help of artificial neural network algorithms.

The matrix method was experimentally verified on binary solutions of organic pigments with different rate of intermolecular energy transfer. It was used for determine of photo-physical parameters of nature organic complexes and the aqueous humus substance in particular.

Integration of two Lidar Fluorosensor Payloads in Submarine ROV and Flying UAV Platforms

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Strategic lines of international organizations recently converge on the need to have a reliable, distributed and independent net, dedicated to the environmental monitoring. In this framework particular attention deserves the survey of marine ecosystems, which is a problem of primary importance in ecological control due to the high probability of accidental risks. Coastal waters must be considered a major target for this kind of surveillance, with accidental oil-tanker releases, possible unauthorized industrial wastes – including dangerous organic pollutants (PCB, dioxins, PAH) – and of anthropogenic discharges (DOM and detergents).

At the ENEA remote sensing laboratory the former development of ship-borne lidar fluorosensors, carried on in the frame of the Technological Sector of the Italian National Research Program for Antarctica (PNRA), led to the design of submarine and flying payloads.

A compact underwater apparatus was realized and already tested in the XVII Italian Antarctic Expedition (2001/02) on the coastal area of the Ross Sea near terra Nova Bay, where the instrument was used as a payload of a Remotely Operated Vehicle (ROV) both from a pack-located station and from a small boat. The technical layout and characteristics of the submarine lidar fluorosensor will be presented and discussed, together with preliminary results collected during immersions. In different marine contests this instrument can be dedicated to various underwater studies (oceanography, marine biology, glaciology, sedimentology) and to the identification of extraneous objects at the sea bottom (industrial wastes, archeological remains) or to the identification of oil spills releases and residuals.

A second instrument, currently under development, consists of a lightweight flying payload, to be installed on a unmanned aerial vehicle (UAV) for large sea surface and territory monitoring.

Monte Carlo analysis of underwater LIF measurements

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A new lidar fluorosensor apparatus, designed to remotely detect range resolved seawater and biological parameters, has been installed onboard of a submersible vehicle and tested in the frame of the XVII Italian Antarctic Campaign. Such system is capable to store the full echo time profile, from which depth profiles of concentrations and other quantities can be extracted. For the data analysis, the PREMAR code has been employed. This semi analytic Monte Carlo radiative transfer model includes the main optical interactions of relevance in the application of the laser induced fluorescence technique and allows a better understanding on the accuracy of lidar measurements.

Combination of Lidar, MODIS and SeaWiFS Sensors for Simultaneous Chlorophyll Monitoring

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Ocean colour satellites have changed our way to observe the Earth: planetary maps of the surface chlorophyll-a concentration, and hence of the phytoplankton primary productivity, can be retrieved in few days. Nevertheless, these results are the product of complex calculations: atmospheric corrections and bio-optical algorithms have to be applied on the raw water-leaving radiances measured by the spaceborne radiometers. For this reason, the remote sensed images have to be calibrated and validated by in situ instruments, usually operated from marine buoys, fixed stations and research vessels (RVs).

The ENEA lidar fluorosensor (ELF), aboard the RV *Italica*, measured continuously surface chlorophyll-a concentrations during the Italy – New Zealand and New Zealand – Italy transects (13 November – 18 December 2001, 28 February – 1 April 2002, respectively). This study is part of the MIPOT (Mediterranean Sea, Indian and Pacific Oceans Transect) oceanographic campaign and provided in situ data in marine zones among the less studied (Red Sea and Indian Ocean).

The ELF measurements were compared to the data collected by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the Moderate Resolution Imaging Spectroradiometer (MODIS). This study pointed out advantages, disadvantages and possible synergies of lidar fluorosensor and spaceborne radiometers. In particular, the SeaWiFS and MODIS bio-optical algorithms have been calibrated with the ELF measurements. The differences between the performances of the two spaceborne radiometers are also briefly discussed.

Use of ground level hyperspectral reflectance measurements for the synoptic mapping of estuarine intertidal sediments

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Monitoring and management of the coastal zone requires expert knowledge of a range of biological, physical and chemical parameters. The heterogeneous and dynamic nature of the coastal environment constrains the ability of traditional sample collection and analysis to accurately record changes in the ecosystem. Remote sensing methods have been proposed as an alternative method that will allow the capture of information at the relevant geospatial and temporal scales.

However, the costs of airborne remote sensing are presently high, and the introduction of remote sensing tools should first be preceded by an assessment of their ability to provide the relevant information that coastal zone managers require. This task is being done within the EU project Hierarchical Monitoring Methods (HIMOM), where many alternative approaches for recording ecosystem information from intertidal sediments are being designed by scientists and assessed by end-users. A low-cost alternative to aircraft and satellite remote sensing platforms is the use of handheld spectroradiometers and fluorimeters to measure surface optical characteristics. When used in combination with GPS, a mobile operator equipped with such instruments can rapidly and accurately record information over areas of 0.1<>5 km^2. The results of ground-level synoptic mapping will be compared with CASI imagery and aerial photography in terms of accuracy and cost. When tested over an annual cycle in the Westerschelde estuary, vegetation indices derived from ground-level reflectance spectra show a high degree of correlation with sediment surface chlorophyll concentration. Other indices are being developed to predict key sediment characteristics such as grain size and water content.

Coastline change analysis of the Meriç River by using multitemporal remotely sensed data

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One of the most important problems in management and monitoring of coastal areas is to define how the natural conditions have been in the past. Without giving a healthy answer to that question, it is not possible to define the sustainable development fully and precisely for the area in question. Satellite images help greatly in finding the answer to this question. Multitemporal satellite images are also used for monitoring of coastal areas and determination of coastline changes. Change detection is a technique which is used to determine the changes for a period of time.

In this study, coastline of the Meriç River and its basin area was selected as the study area. The research focuses on an area of approx.mately 1200 km^2 of western Turkey. The Meric river rises in the Rila Mountains (in Bulgaria) and flows into the Aegean in Turkey. The Meric river is the natural border between Greece and Turkey. Therefore, it's very important that detection of the coastline changing of the Meric river basin by using satellite data which is a reliable data resource. Changes in the areas, which have dynamic, structure such as study area has to be compared in the different time using different techniques. Data, which can be used for solving this kind of problem, is produced from satellite data.

In the study, Multitemporal Landsat-5 MSS image data were obtained for August 1988, 1991 and 1993. Geometric correction was carried out using 1:50 000 scaled topographic maps and nearest neighbour resampling algorithm, with root mean square (RMS) error of <0.5 pixels. Ratio and differencing images, on screen digitising, classification methods have been also used for analysing coastline change of the Meric river basin. Finally, the coastline changing of the Meric river was analysed according to the results obtained from different methods comparatively. At the end of the study, very essential differences were detected at the coastline of the Meric river over five years (1988-1993).

Study of spatial distribution of seawater diffuse attenuation coefficient K_d using airborne lidar remote sensing

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Remote sensing of some northern seas areas using Polarization Airborne Lidar PAL-1 have been carried out from board of AN-26 airborne-laboratory (AL) "Arctic". The small-size lidar PAL-1 has been created specially for AL "Arctic". It is the part of AL apparatus including, in particular, infrared radiometers, side-looking radar, TV and photographic cameras.

The source of the sounding light pulses of PAL-1 is YAG:Nd Q-switched laser with SHG. The wavelength of the sounding radiation is 532 nm, the laser-pulse energy is (30-100) mJ, the duration of laser pulses is 10 ns, the laser-pulse repetition rate is (5-40) Hz, the divergence of the sounding laser beam is ~0,15 degree. There are two identical receiving channels for co- and cross-polarized components of echo-signal reception. Telescopes of the receivers are 10 cm in diameter. Angular fields of view of telescopes are 2 degrees.

The diffuse attenuation coefficient K_d of near-surface seawater column is retrieved from the temporal waveform measurements of the total echo-signal power P(t). PAL-1 capability enables us to determine value $K_d \leq 0{,}25$ м$^{-1}$. The analysis of K_d determination errors is completed. The maps of K_d for the number of near-shore zones of Barents and Kara seas with used lidar data are plotted. These spatial distributions are characterized by strong variability, big size of K_d value changing range (0,04 – 0,25) м$^{-1}$ and presence of fronts. Coastal and dynamical processes have essential effect on K_d spatial distribution. This K_d distribution has its essential particularities as compared to seawater surface temperature distribution.

First results of the OROMA experiment in the Lister Tief of the German Bight in the North Sea

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The objective of the Operational Radar and Optical Mapping in monitoring hydrodynamic, morphodynamic and environmental parameters for coastal management (OROMA) project of the Fifth Framework Programme of the European Commission (EC) is to increase the effectiveness of monitoring technologies in coastal waters. Therefore, the research vessel *Ludwig Prandtl* of the GKSS research center was equipped with special sensors and instruments to measure the position of the ship, the water depth, the salinity, the water temperature, the current speed and direction, the modulation characteristics of short-wave energies, and relevant air-sea interaction parameters due to the presence of submarine sand waves. The field experiment of the OROMA project took place in the Lister Tief, a tidal inlet of the German Bight in the North Sea, from August 5 to 16, 2002. The sea bed morphology of the Lister Tief, consisting of a complex configuration of different bedforms, is four-dimensional in space and time. Normalized Radar Cross Section (NRCS) modulations of the GKSS shipbased X-band radar have been mapped in a sea area covered by sand waves during ebb and flood tidal current phases. The NRCS modulation data will be make available to the Bathymetry Assessment System (BAS), a new monitoring system for mapping water depths of shallow coastal waters based on radar measurements which was developed by the private company ARGOSS in The Netherlands.

Monitoring coastal marine thermal dynamics with AVHRR data in Golfo Dulce, Costa Rica

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The tropical ocean, labelled as “global heat engine”, plays a major role in global physical processes and affects global climate. Remotely sensed data from satellites provide a means of mapping and quantifying these dynamic oceanographic features. On the Land-Ocean interface, coastal marine thermal dynamics are especially important to coastal fisheries and marine habitats. The present study aims to analyze and map the spatio-temporal variability of coastal marine thermal processes, energy transfer processes and the interrelationship to El-Niño events. The study area is Golfo Dulce, a tropical gulf on Costa Rica’s southwestern Pacific coast. Golfo Dulce is characterized by its typical ‘Fjord-like’ morphology. The closeness of the gulf morphology accounts for the related deep anoxic conditions.

Annual AVHRR data from 1991-2001 and monthly data from 1998 have been processed for parameter extraction of sea surface temperature (SST). A non-linear algorithm has been used in this calculation, which has the advantage of removing some atmospheric distortion and correction for the satellite zenith angle. Other techniques have been applied for quality improvement, such as temporal data match and a cloud detection technique. Anomalous “hot pools” and “cold tongues” of sea surface temperature could be defined and detected in the gulf. Special attention has been paid to the comparison of monthly sea surface temperature, as observed by the satellite during 1998, with daily solar hours, rainfall and sea surface temperature during the El-Niño event in 1998.

The results of the non-linear calculation show that: the satellite zenith angle reduces SST by 0.21°C; date match affects SST by ± 0.2°C; and time match affects SST by ± 0.15°C. The research demonstrates that SST in the gulf is controlled by the factors of extra-terrestrial solar radiance, but is highly affected by climate change and horizontal heat flux. The SST is higher inside the gulf than outside. This is illustrated by a temperature gradient of 0.02 °C/km. Due to the coastal terrestrial impact, SST in the central part of the gulf is higher than in the shallow coastal waters. This is illustrated by a gradient of 0.25 °C/km. So-called “hot spots” and “cold tongues” have occurred with 3-4 year and 1-2 year cycles respectively. The energy transfer model shows that rainfall in the rainy season lowers SST by 3-5 °C, whereas El-Niño raises SST by 1-2 °C. It is shown that the El-Niño event directly affects sea surface temperature in the through horizontal heat flux rather than atmospheric climate change.

UNESCO Bilko project releases a new training module on Remote Sensing Applications to Fisheries Sciences

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This presentation reviews the UNESCO Bilko project that commenced in 1987 and continues today with the release of the eighth computer-based learning module. The primary aim of the project is to make remote sensing training materials accessible to those without specialist resources at their disposal and, to promote good teaching practice by tapping the diverse skills and expertise of an expert community. Considerable resources have been generated by the project including a DOS and Windows based image processing software package. Pedagogical materials include a wealth of short self-study lessons focused on a particular remote sensing technique, oceanographic phenomenon or sensor that students can work through in their own time. Collectively, the Bilko project provides a remarkably diverse but comprehensive resource for teaching coastal and marine remote sensing. Recently, the project has adopted a thematic framework in order to deliver more focused material and to keep pace with rapidly evolving remote sensing sensors, platforms and algorithms. The project currently serves some 1900 users located in over 70 countries and has supported several international workshops and training courses with both teaching materials and expertise. Several networks have been developed that are monitored by the Bilko steering committee including a network dedicated to Bilko lesson authors and a network for Bilko users. In December 2002 the Bilko project has released a new module on Remote Sensing Applications to Fisheries Sciences – From Science to Operation. This module offers state-of-the-art applications of the technology in seven lessons, accompanied by a review paper and selected reading materials from the PORSEC 2002 conference in Bali, Indonesia. All material is available from the Bilko project web site (http://www.bilko.org) or from the Bilko Project Office, ITC, Enschede, the Netherlands.

Support of Offshore Wind Parks with Synthetic Aperture Radar Wind Measurements

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In all European countries with shallow coastal waters and a strong mean wind speed offshore wind parks are planned and constructed. The fast development of wind energy production in Europe led to an installation of more than 18,000 MW by the end of 2001. Up to date offshore wind farms of about 100 MW have been installed. Several projects for offshore wind farms are being planed and have already been approved in the North and Baltic Sea. In total they will have an output of more than 5000 MW in the near future.

The construction and maintenance of offshore wind parks has to face the tough environmental conditions of the open sea, which results in extensive maintenance and expenses. Therefore reliable knowledge and forecast of the regional wind and the ocean wave fields is essential.

Space borne synthetic aperture radar (SAR) data, as acquired by the European satellites ERS and ENVISAT as well as the Canadian satellite RADARSAT, provide wind fields with a sub-kilometre resolution and a coverage of up to 500 km swath width. They are thus ideally suited to investigate the spatial fine structure of the wind- and wave fields, which is one of the major factors in the optimal siting of wind farms. Due to their high coverage and resolution SAR data can provide information on the impact of the single turbines on the wind field, e.g., especially the turbulence in the wakes generated by the turbines, as well as the effect of the entire wind park on the local climate due to the increase of turbulence in the marine boundary layer.

This study shows the potential of two dimensional high-resolution wind fields measured with space borne SAR to support the construction and operation of wind farms. The data can be used to minimize fatigue loading due to wind gusts as well as to provide short-term power forecasts in order to optimise the power output. Several examples of wind fields around the already existing offshore wind parks Utgrunden (South of Sweden) and Horns Rev (West of Denmark) and in the area of the sites under construction in the German Bight of the North Sea will be presented showing potential of SAR wind and wave measurements.

Potential of polarimetric SAR data in mapping first year sea ice pressure ridges.

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Pressure ridges are formed of piled ice blocks which size is function of the ice thickness at the time the ice sheet got deformed. On satellite SAR images these features are characterized as linear structures with a higher density of pixels brighter than the background. This is known to be due to the enhanced back scattering that occurs when an ice surface is almost normal to the SAR beam. Actually, the varying orientation of block faces increases the probability that a pixel be significantly brighter than the background. For smooth ice surfaces the back scattering is dominated by returns from those elements whose local incident angles lie closest to 0°. Our model addresses the ridge detection problem from its relation with the density of discreet elements contributing to the signal. Considering all possible orientations of an ice block, we compute the probability that the back scattering from an array of blocks identify a target as a ridge-pixel. This research work presents a set of simulations in which we test the configurations of a polarimetric system.

Chl-a and SST characteristics of the surface waters of the North Aegean Sea with special emphasis on the role of the discharge from the Dardanelles

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NOAA AVHRR SST data from 1995 – 1998 and SeaWiFS ocean colour data from 1998 – 2002 have been analysed in order to study surface water transport processes and surface water quality in terms of chl-a levels in the North Aegean Sea (NAS) with special emphasis on the discharge of water of Black Sea origin into the NAS via the strait of the Dardanelles. SST data and chl-a data strongly indicate that the discharge from the Dardanelles is often visible as a more or less well defined plume-like feature extending far into the NAS. Satellite data indicate that there is a seasonal variability of the initial transport pattern of the BSW in the NAS, often with transport to W/NW during Jan – May and during Nov – Dec and with transport often more to the W/SW during July – Oct. This late summer /autumn pattern is correlated with prevailing wind directions on Limnos island during this period. Basin scale chl-a data from 1998-2002 showed very clearly that the chl-a levels were significantly higher during the whole year in NAS approximately north of the island of Limnos. Chl-a data from two N-S transects off the mouth of the Dardanelles and from the western Sea of Marmara showed that there is a cyclic variation of the levels with minima occurring within the period from middle of June to early September. The temporal occurrence of the maxima was more difficult to distinguish but it seemed to be during early April to early May.

Remote diagnostics of coastal zone / deep basin exchange from full spectra of normalized water-leaving radiance

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Coastal zone/deep basin exchange is being studied from the remotely sensed ocean colour data using a normalized water-leaving radiance L_{WN} at a fixed wavelength λ or a computed quantity like chlorophyll involving L_{WN} at several λ. Meanwhile the spectral range of modern colour scanners (SeaWiFS, MODIS etc.) is broad enough for obtaining both quantitative and qualitative indications of exchange processes due to varying contributions from CDOM, suspended matter, and other admixtures. To take advantage of this circumstance, the common visualization techniques was combined with a new approach based on clusterization of full L_{WN} spectra and obtaining the spectral-cluster images by mapping the cluster centroids as a multidimensional integral feature of oceanological conditions. The full spectrum approach (FSA) was applied to the SeaWiFS imagery of the Black and Baltic Seas showing evolution of mesoscale filaments, vortex dipoles, and local upwellings. These studies reveal new opportunities in diagnostics of the dynamics events, relevant to exchange processes, and led to the following tentative conclusions. 1. Mesoscale structures exhibit very orderly patterns of distributions of spectral clusters, the patterns being closely coupled with probable sources of CDOM or suspended particles and horizontal velocity field. 2. Cluster centroids are much more specific to local oceanological conditions as compared with L_{WN} at individual wavelengths; such specificity helps to distinguish inhomogeneities of similar strength and sign but of different origin. 3. The estimates of dimensions and shape of mesoscale structures, obtainable from the L_{WN} distributions, can depend on the wavelength choice while the FSA eliminates this problem. 4. The FSA is applicable to any point spectrum and fits well into the prospects of better spectral resolution of future ocean colour scanners and of wider use of hyperspectral observations.

Geochemical processes in coastal landscapes due to the Caspian sea-level fluctuations

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The Caspian Sea level fluctuations essentially determine a state of the coastal zone environment. Along accumulative shores the sea transgression gives rise to geomorphological, lythological, soil, biotic, as well as geochemical changes in the coastal landscapes. This is caused by formation and movement landwards of the bar-lagoon system, with a corresponding rise of the groundwater table, and also simultaneous vigorous development of vegetation in newly-formed hydromorphic and semi-hydromorphic areas. On the contrary, the sea regression leads mainly to the passive drowning of the shore zone and relatively poor changes in the coastal environment.

Geochemical conditions of the coastal landscapes highly depend upon the sea-level fluctuations. Regressive stages associate with a weak variability of geochemical environment in beach soils and sediments. They are characterized mainly by alkaline oxic conditions, and salinization as a leading geochemical process. Geochemical diversity of the coastal zone during transgressive stages is much higher. Conditions vary from neutral to highly-alkaline, and from oxic to highly unoxic (sulfide). Newly-formed processes are presented by sulfidization, gleyzation, ferrugination, organic matter accumulation, and salinization. They cause a formation of various contrast geochemical barriers in soils and sediments with a consequent re-distribution of chemical elements. Accumulation of heavy metals (HM) at geochemical barriers is quite distinct especially due to prevailing low background of HM levels in coastal soils and sediments.

Basic physical mechanisms of sand suspending in the nearshore zone under irregular waves

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The processes, which control the temporal variability of the suspended sand concentration near the bottom, have been examined by using field data concerning suspended sand concentration and fluid velocities. Optical and electromagnetic sensors with a high frequency response had carried out the measurements.

The lee vortex ejection is the basic mechanism of sand suspending for low energetic conditions, as they are existent in nearshore zone with slightly shoaling waves and rippled bed. The field measurements showed that suspension events coincide well with groups of high waves. The suspension events occurred twice per period and coincided with the times of the flow reversals.

With increasing wave shoaling and near-bottom velocity, the 2D bottom ripples transform into 3D ripples. In this case, the suspension events are formed at the measurement point only at the moment when the wave crest is passing and coincides with the flow reversals during a passing of backside of the waves.

The mechanism of the vortex ejection due to the shear instability of the bottom boundary layer is the most probable reason for sand suspension from the bottom in area which are located seaward of the wave breaking point. In those areas the waves are greatly deformed and the bottom is nearly flat.

The most intensive suspension events are created by the largest turbulent vortexes. The presented examples for different recording runs demonstrate, that at the moments of the most intensive suspension events the turbulent velocity in some times exceed its r.m.s. value. This conclusion is in qualitative agreement with the turbulence data under breaking waves.

From the physical point of view, the most effective way to understand the sand suspending process and to predict the suspension sand concentration fluctuation is the determination of relationships between concentration and macro turbulence parameters as well as between the macroturbulent parameters and the dissipation of wave energy by breaking. To obtain such relations, the investigation of the spatial - temporal variability of macro turbulence and sand suspension under breaking irregular waves is necessary.

Variability of sea ice cover in the Caspian and Aral Seas from satellite microwave data

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Stable ice cover forms every year in the Caspian and Aral seas and stays for several months, affecting navigation conditions and economic activity in the coastal areas and on the shelf. Ice extent varies significantly from year to year in response to changes in hydrometeorological conditions over the region and its variations may serve as an early indicator of the large-scale climate change.

Study of ice cover in these seas was done using two types of data. The first one is information from the Topex-Poseidon satellite, operating since 1992. This platform has two nadir-looking instruments – a dual-frequency radar altimeter and a passive microwave radiometer. The combination of data from these instruments provide information to estimate ice concentration, roughness and height of snow cover on ice. Other source of information is passive microwave data from the SMMR instrument onboard the satellite NIMBUS-7 (since 1979) and the SSMI instrument on board the DMSP series (since 1987), providing data on ice extent.

Analysis of time series of ice extent and types shows pronounced regional, seasonal and interannual variability. Variations of ice extent for last ten years show a warming signal: ratio of presence of ice cover in Topex-Poseidon observations in both Caspian and Aral seas decreased more than two times. In the Caspian sea such dramatic reduction of ice extent affects breeding habits and living conditions of the Caspian seal - the only mammal in this sea.

High Resolution Maps of Suspended Particulate Matter Concentration in the German Bight

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Monitoring and modeling of suspended particulate matter (SPM) is an important task especially in coastal environments. SPM concentration is one of the major parameters that regulates the penetration of light into the ocean and hence the primary production.

In this presentation a model for retrieving SPM concentration from satellite borne SPOT imagery will be introduced. Therefore, the synergy of satellite borne modular optical scanner (MOS) data and SPOT imagery were used. In a first step the SPM concentrations were retrieved from the rather coarsely gridded MOS data using the existing algorithms. The resulting MOS derived SPM concentrations were used to tune a model for retrieving SPOT SPM concentrations. Due to there very high resolution SPOT data are ideally suited to measure SPM concentrations in coastal areas like the Wadden Sea in the German Bight of the North Sea. Utilizing SPOT data the SPM concentrations were retrieved up into the small water inlets of the Wadden Sea. In the inlets concentrations between 6 and 40 mg/l were measured. These measurements are compared to several collected in situ measurements and explained by the local current and sea state situation.

Habitat for fisheries evaluation

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Habitat evaluation of high commercial value species is a major challenge. Food and shelter are two of the most determinant elements associated with spiny lobster *Panulirus argus* presence at Ascensión Bay, Sian'Kaan biosphere reserve, Mexico. To incorporate feeding grounds and shelter into lobster fishery evaluation, calibration of a Landsat ETM+ image and field data were used to develop a submerged bottom types map from the Bay. Fishermen distribute artificial shelters in lobster fields (irregular polygons mapped with a GPS device) facilitating to obtain a database with catches during lobster season. Using geostatistic techniques, density and distribution of lobsters in the bay were estimated. Spatial arrangement of the natural-artificial habitat explains in terms of annual catches 2000-2001 the productivity of lobster fields.

Along-track Interferometry (ATI) Observations of Currents and Fronts in the Tay Estuary

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Regions of intensified horizontal gradients (fronts) are common in the estuarine environment. Such fronts arise at interfaces between water bodies of differing salinity. Tidal intrusion fronts are a particular type of estuarine convergent front which form when the dense intruding sea water, confined laterally by the sides of the estuary, plunges beneath the ambient estuarine water to form a characteristic V-shaped plunge line. The study of such features is of interest because the overall effects on the pollution, sediment and water exchange processes are not yet well known on an estuary-wide scale.

In situ measurements of such features are severely hampered by the rapidly changing flow and suspended sediment. Remote sensing techniques therefore offer valuable information for the modelling of such features. Optical and thermal infra-red data, integrated with boat-based measurements and hydrodynamic modelling, have provided useful information about the convergent fronts in the Tay Estuary. However, these techniques still require repeated visits in order to estimate the velocity structure associated with these features.

The novel technique of along-track interferometry (ATI) using synthetic-aperture radar (SAR) offers information on the instantaneous surface velocities. Such observations were collected as part of the BNSC's SAR and Hyperspectral Campaign (SHAC) in June 2000. The interpretation of such data requires an understanding of the imaging theory for ATI. Here we discuss the extraction of information on the surface currents from this data-set. The results show detailed structure of the surface flow which may be compared with the understanding of the current flows obtained previous IR and optical data and from hydrodynamic modelling. The implications for the validation of 3D estuarine hydrodynamic models and for future studies of estuarine processes are discussed.

Experimental evidence of possibility of using the method of non-linear fluorimetry for diagnostics of phytoplankton state

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Earlier [1], the possibility of determination of the photophysical parameters of phytoplankton by method of non-linear fluorimetry has been demonstrated. It was suggested that non-linear fluorimetry could be used for diagnostics of the state of phytoplankton.

In this paper, practical realisation of method of non-linear fluorimetry is conducted. It was found that the method of non-linear fluorimetry allows to determine the parameter $A=\sigma\tau 2\gamma n_0$, where σ is the excitation cross-section of chlorophyll-a molecules (it takes into account both direct absorption of exciting radiation by these molecules and energy transfer on them from accessory pigments molecules); τ is the effective excited state lifetime of chlorophyll-a molecules taking into account all processes of deactivation of excitation except singlet-singlet annihilation); γn_0 is the maximal rate of the singlet-singlet annihilation (γ is the rate constant of singlet-singlet annihilation, n0 is the local concentration of chlorophyll-a molecules).

The values of the parameter A were determined for different functional states of monoculture of diatomic alga Thallassiosira Weisflogii: - in the state with open reaction centres (after dark adaptation), - in the state with closed reaction centres (after addition of herbicide DCMU), - under illumination by continuous white light of high intensity (comparable with the intensity of sunlight). It was shown that the functional status of alga essentially influences the value of the parameter A, thus making it possible to use the parameter A for diagnostics of phytoplankton state.

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Influence of a dam on a scours of river's bedforms at the estuary

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In the course of last 10 year we established that a regular separation of cylindrical eddies with the horizontal axis formed near the bottom of the decelerating flow along the flow direction is a most intensive mechanism of the bottom scour. As the intensity of the scour is proportional to the longitudinal velocity gradient the strongest scour is caused by an effect of the stationary waves (waves with immobile crests, which phase velocity is equal to the flow one with the opposite sign) which increase a local flow velocity gradient. They exist on a flow with $\mathrm{Fr} = \mathrm{u}/\sqrt{\mathrm{gh}} < 1$ (*u*- is a flow velocity, *g*- the gravitational acceleration, *h* – a flow depth) if a flow velocity is changing in the flow direction and *u* > 23.1cm/c. From a trough to a crest of a wave the flow velocity decelerates and a longitudinal gradient may be very high. To take into account of this mechanism of the bottom scour after the dam construction it is necessary to investigate the changing of a water level and a velocity field inside the reservoir.

The aim of this study is a laboratory investigation of wave phenomena on the water surface, the velocity field and the bottom scour in a reservoir after a dam construction.

Our investigation allows establishing the waves with the immovable crests were observed. From a trough to crest of this wave where the flow velocity is decreases we observed formation and separation of cylindrical eddies with horizontal transverse axes. They capture the bottom grains and strongly scour the bed. It is found that a period of an eddy separation and distance between neighbouring eddies can be defined based on the expressions which we have found earlier for the stationary flows. The last allows making close forecast of bedformes in the river at the estuary after construction the dam.

Exploitation of MERIS Data: Conception of products and services for coastal applications

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The scope of our study is the exploitation of hyperspectral sensors potential as MeRIS to provide repetitive information on natural resources in coastal zones. This information is hardly required for a more effective monitoring and management of such sensitive and dynamic areas. Our user-oriented approach should provide valid and systematic information on seashore to complete in situ measurements. Then new applications are developed and demonstrated via a multiscale, multidisciplinary approach of the coastal environment. This approach takes advantage of the temporal, spatial and spectral resolution of MERIS sensor. Moreover, Hyperion data are now available and airborne spectrographic data (CASI) have been acquired over our pilot sites. A special emphasis will be put on advanced data processing methods such as fusion of MERIS and TM to provide a product with the best resolution and repetitivity of the two sensors.

Correction of remotely acquired benthic hyperspectral imagery for alterations produced by the atmosphere and water column

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Features on the sea bed can be mapped from airborne hyperspectral imagery provided that their effects on the measured reflectance spectrum can rendered independent of those produced by the atmosphere and water column. The linear effect of atmospheric light attenuation can be inverted in order to obtain the reflectance of the seabed at sea level. The non-linear effect of water column light attenuation can then be inverted to obtain the absolute reflectance of the seabed. Light attenuation by the atmosphere and water column can be determined by simultaneously measuring the radiance of coloured spectral reference sheets attached, respectively, to the beach and the seabed. Bathymetry can be determined by measuring the relative reflectance of standard features on the seabed (e.g., target sheets or sand patches) in green and red light spectral bands. Sun glint can be determined by measuring the relative reflectance of the sea surface in visible and near infrared spectral bands. Here, I describe how to perform these manipulations in order to obtain a full inversion of hyperspectral imagery and thus map features on the seabed.

Towards the Development of Specific Bio-optical Algorithms for the Estuary and Gulf of St Lawrence (Eastern Canada)

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The St. Lawrence ecosystem is a large, complex and mainly coastal environment with high variability in primary productivity and related physical factors. These physical variables include currents, vertical stratification and light penetration, as a function of freshwater runoff, winds, tides and bathymetry. The Estuary and Gulf of St. Lawrence may be bio-optically divided into sub-regions that have now been classified as Case 1 and/or Case 2 waters. The difficulties encountered in the development of algorithms for Case 2 waters, which are primarily encountered in coastal areas, are well known. In addition to the contribution of phytoplankton (using pigment absorption as a proxy), the effects of CDOM and particulate matter (both organic and inorganic) may be significant co-determinants of the optical signature. The size and complexity of the ecosystem requires the application of large-scale synoptic methods, specifically, access to ocean colour data derived from satellite-based sensors. In this context, the quantification of coloured dissolved organic matter (CDOM) becomes an essential element to characterize these coastal waters. Thus, fluorescence properties of CDOM were measured at different excitation and emission wavelengths from several stations, covering both Case 2 and Case 1 waters. We determined the spatial and temporal variability of the mixing processes of freshwater run-off and marine waters from the fluorescing components of CDOM. For example, the results showed that the Magdalen Shallows, usually geographically considered as a “Gulf-region”, should be optically classified as Case 2 waters throughout the year because CDOM in this region is strongly influenced by freshwater run-off. The general approach in the five-year ground-truthing programme has been to build a spatio-temporal data bank for the development of bio-optical algorithms for estimating primary production. The results of these studies will be extrapolated into a more general regional programme for coastal zone monitoring in Atlantic Canada.

Indicators of a Aerial Survey Analysis on the Portuguese Northwest Coast

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The Portuguese northwest coast has been changing. The sea action regime is the most energetic and dynamic force acting in this area and, is therefore, its main modeller agent. This coastal zone, in general, has significant coastal erosion problems, which are clearly visible in some areas. These problems are due to both natural causes and anthropic reasons. The coastal morphodynamics is changing, over small timescales (days, weeks) to several hundred years.

The main objective of this work, in the stretch Maceda – Furadouro, near Oporto, based on Aerial Survey Analysis and GIS tools and techniques, is to locally typify, classify and physically analyse the evolution of the coastal dynamic, in a medium and long term, as well as the hydromorphologies and hydroforms due to the wave action.

With this work, it's expected to improve the identification and typification of hydromorphologic patterns of breaking waves, sea bottom, and relation with local wave and tide regime, as well as, to improve the identification of coastal morphology patterns related with wave direction, sea bottom forms, wave highs and periods and beach profile.

Historical Change (1985-2001) of the Mangrove Coverage in the Southern Coast of México (Oaxaca)

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One of the most important components in the tropical coastal lagoons are the mangroves; they are littoral vegetable formations that realize functions of great importance such as the protection of the coastal zone against erosion caused by surge and wind, moderation of damages or effects by tropical storms and cyclones, furthermore they are a refuge for diverse wildlife. In recent years in the state of Oaxaca, southern México, the impact of anthropogenic activities on the coastal zone has increased considerably, frequently accompanied with the use of natural resources and sometimes with their overexploitation. The need of space for new human establishments has caused a change in the land use, where an important component like the mangroves has been replaced with housing complexes or agricultural fields. Due to lack of qualitative and quantitative information of the loss of mangroves in this region, was performed a coverage change pattern analysis with aerial photography of 1985, 1995, and 1999, and a SPOT image of 2001. After the aerial photography and the SPOT scene were georeferenced, we realized a visual interpretation of the coverage patterns for each year to estimate the trend of mangrove loss. it was found that the most important cause for disappearance of mangroves is due to uncontrolled population growing, which promote a change in the land use.

Primary productivity monitored with combined local and remote techniques in coastal and ice edge areas of Antarctic Ross Sea

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Photosynthesis in aquatic systems is considered to be responsible for more than 40% of the global carbon fixation on an annual basis, by converting light radiation into organic compounds. At present, considerable uncertainties still exist in the understanding of the processes that control artificial and natural CO_2 uptake.

The key question concerning the Southern Ocean is whether it is able, like the North Atlantic Ocean, to take up atmospheric carbon dioxide. This ocean, in fact, like all high latitude areas, is potentially strong in sequestering CO_2 from the atmosphere, but unfortunately data near Antarctica are still scanty, especially in winter when the weather conditions are particularly severe.

In the frame of the XVI Italian Antarctic expedition, the Lidar fluorosensor continuous data, satellite SeaWiFS frames and partial pressure of carbon dioxide values in surface water (pCO_2), were jointly analysed as collected along the cruise during the late Austral summer 2000/01. The survey and the thematic maps elaborated revealed the presence of high productivity areas in polynya regions and close to the ice edges. The lidar and the radiance data, reported here, are consistent with the results of previous campaigns conducted in the same investigated area, thus extending our database in primary productivity of the Antarctic sector under investigation. The relationship between pCO_2 and chlorophyll-a concentration are discussed in terms of biologically driven phenomena responsible for the pCO_2 undersaturation with respect to the atmospheric value during the Austral summer.

Comparison of time series of RS data and long term monitoring data: application and results for the Dutch and Belgian coastal zone

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Remotely sensed maps of water quality parameters can provide valuable information in addition to traditional monitoring systems. Especially the high spatial resolution of today's RS instruments is superior to the limited number of sampling stations used for in-situ measurement networks. In periods with optimal weather conditions daily coverage is possible, allowing the study of medium-term ecosystem changes such as algal blooms and the impact of storm events.

To be useful for the long-term monitoring, however, RS data must be comparable with the databases of (non-optically measured) water quality parameters that have been collected for many decades. But, validation with direct comparisons of RS data with in-situ measurements is difficult, because the chances of an occurrence of a 'match-up' between an in-situ sampling and a satellite overpass with cloud free conditions are very low. This paper will demonstrate statistical methods to compare RS data and in-situ measurements based on a three-year database of SeaWiFS maps of total suspended matter and Dutch monitoring data.

Fluorescence of dissolved organic matter in seawater at low temperatures

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Measuring the chromophoric fraction of dissolved organic matter (CDOM) in natural waters using its fluorescence signal is extremely useful in a variety of marine and freshwater applications. Gelbstoff fluorescence intensity can be used as a measure of CDOM content with good accuracy in remote sensing with LIDARs, if the effect of fluorescence quenching by temperature is taken into consideration. Water temperature is also one of the environmental factors controlling the process of CDOM formation and degradation. The changes in CDOM optical properties due to alteration of its composition at low temperatures under controlled conditions of ice cover developing, as well as temperature dependence of CDOM fluorescence efficiency were studied in the work. Emission and excitation fluorescence spectra were measured using a Perkin Elmer LS50 luminescence spectrometer, absorption spectra were detected by a Perkin Elmer Lambda18 spectrophotometer.

Formation and degradation of CDOM in seawater enriched with marine plankton cultures was observed during ARCTECLAB experiment in Hamburg in 2001. Fluorescence spectra with excitation at 230, 270, 308 and 355 nm and absorption spectra were measured for the filtered samples of seawater under ice, brine from the ice and melted ice in laboratory at fixed room temperature. The optical properties of the samples were compared with parameters of ice growing (ice thickness, ice and seawater temperature, changes in brine and seawater salinity), as well as with chemical and biological parameters of underlying seawater. Typically, CDOM fluorescence of brine samples is higher than that for seawater, and fluorescence of melted ice is almost negligible. Gelbstoff fluorescence (λ_{max}=400…420 nm) was rapidly rising for brine samples, but only slightly increasing for water samples within two-week period of ice cover growing. We observed changes in intensities for tryptophan-like (λ_{max}=345 nm) and tyrosine–like (λ_{max}=295 nm) fluorescence bands excited at 230 nm. Fluorescence intensities for both emission bands are higher for brine samples compared to seawater, and smaller for melted ice samples. Their behaviour with time ratio differs for water, brine and ice.

The effect of water temperature on fluorescence spectra of CDOM was studied in the laboratory at various temperatures from 6 to 60^{o}C. It was found that in all samples the fluorescence intensity is decreasing with rising temperature; this temperature effect is reversible. For gelbstoff fluorescence the temperature coefficient of fluorescence for all excitation wavelengths was equal to (0.5 $\pm$ 0.1)% per ^{o}C. No changes in the fluorescence band-shape were observed due to temperature. Fluorescence band-shape and fluorescence intensity of CDOM keep also constant after the samples were first frozen then melted and their temperature adjusted to the initial temperature. The study of the temperature effect on CDOM fluorescence is important for further calibration of LIDAR data measured in regions with horizontal temperature gradients, and for correction of in-situ measured CDOM fluorescence depth profiles.

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New ultra-violet lidar intended for determination of oil pollution and concentration of organic matter, chlorophyll, suspended matter in sea

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Pulse ultra-violet lidar (UVL) created for determination of concentration of dissolved organic matter, chlorophyll of phytoplankton and suspended matter in natural waters described. Technique of processing of fluorescent signals and experimental data received in the two marine expeditions of R/V “Academic Ioffe” 2002, across Atlantic ocean from p. Kaliningrad (Russia) to p. Ushuaia (Argentina) are shown.

The problem of the increasing pollution of natural waters by petroleum products demands creation of methods for the express control of concentrations of pollutants in water areas.

With the help of bulky ultra-violet lidar the measurements in the transatlantic trip of R/V "Vytyaz" in 1991 and in the voyage around of Europe of R/V "Academic Kurchatov" in 1994 were conducted [Pelevin V. N., Abramov O. I., Karlsen G. G., 1995]. In 2000 we decided to create a light and portable lidar, comfortable for application from small vessels. Besides the technique of processing of fluorescent signals was essentially advanced.

The receiving system of UVL gets three reference signals: energy of a laser impulse, UV signal, diffusely reflected from water, and signal of the Raman effect of water. Such design allows to proceed measurements as in very pure waters, as in polluted or very productive areas of seaport or upwelling.

The experimental data received on the way from Baltic sea to Falkland current in South Atlantic are described. The level of fluorescence of dissolved organic matter, chlorophyll and the signal formed by suspended matter in coastal zones of north European Seas were approximately 100 times bigger than in open ocean areas.

10-Fold Increasing of Backscattering Lidar Signal Caused by Oil Film on Water Surface

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Water in coastal zone is certainly the most important object for pollution monitoring and has been well investigated in the past by sampling and remote sensing technique as lidar. The lidar technique meets the requirement to improve the reliability of measurement of some parameters, for instance, oil film detection and its thickness estimation. Actually the last accident with oil tankership in coastal zone in Atlantic Ocean near Spain shows that the fast mapping and monitoring of oil spot could be help to solve many problems more effective.

In this paper we present an experimental data about 10-fold enhancement of backscatter signal from oil film on water surface in comparison with clean water surface, which was observed for the first time. The experiment was carried out using backscattering lidar based on the micro-Joule diode pulse laser. This lidar irradiated a water surface with extremely low (10^{-6} $Wcm^{-2}nm^{-1}$) mean power density, which is less or comparable with solar background. This advantage allows to study the laser beam propagation and reflection from oil-water interface without disturbing the medium. It was suggested that we have detected a large size clusters induced by oil film. Early, Y.Shen experimentally observed the ice-like structure on liquid water surface, which was induced by film of monolayer of long chain organics molecules. The influence of similar structural transition in water covered by oil film on increasing of the backscattering signal is discussed. The description of compact lidar with some Watts of power consumption and total mass around 1 kg is presented. Its application for monitoring of coastal zone from a super-light air-platform without operator in autonomic mode is discussed.

Y.R.Shen, Appl. Phys. B68, 295 (1999).

Surveying coastal zone topography with airborne remote sensing: Elements of strategy

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This paper addresses the need for coastal topography as expressed by users concerned with benthic habitats mapping. Beside substratum type, species distribution is mostly dependant on terrain hypsometric level, slope and exposure. These parameters are bound to be used together in probabilistic distribution models or more simply merged with imagery in 3D display to enhance interpretation. As underwater mapping techniques are somewhat a different range of tools, this investigation is limited to supratidal zones. Accuracies required here being on the order of 30-40 cm, two remote sensing techniques are examined and their conditions of applicability assessed.

Lidar surveys provide such an accuracy in all instances, whatever substratum and vegetal cover types as well as slope values currently encountered in tidal zones.

Photogrammetric techniques are investigated in relation with Lidar. They are shown to achieve the required accuracy provided two conditions are met: a) the availability of sufficient high quality ground control points, b) the textural quality of the ground observed. Tidal sedimentary areas clearly lack both these assets, making accuracy dramatically deteriorate. In mixed zones of hard and soft substrata, a strategy has to be implemented whereby methods are adapted locally to the specific needs of benthos and biodiversity mapping, keeping in mind constraints and costs incurred. The requirements in terms of horizontal resolution are also discussed.

Examples of the benefits of combining relief and planimetric data are given.

A new time-series station for continuous measurements in the Wadden Sea (southern North Sea)

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In the tidal inlet of Spiekeroog island, southern North Sea, a time-series station was set up in summer 2002 as part of the research programme ”BioGeoChemistry of tidal flats” run by the University of Oldenburg. The purpose of the station is to provide continuous data on physical, biological and chemical parameters. This allows to quantify the water and material flux between the backbarrier tidal flat and the open sea, and to characterise the material transformation in the tidal flat area by biogeochemical processes during high tide. Due to its novel design, operation of the station will also be possible during winter and under extreme weather conditions (storms, spring tides, sea ice …) when data sampling with conventional platforms such as ship, buoys or smaller poles could previously not be performed.

In addition to instruments recording physical and chemical parameters, the time-series station is equipped with optical sensors for the measurement of data that are specific for dissolved and particulate matter in the water column. This covers instruments for hyperspectral seawater transmissometry and daylight reflectance, and fluorescence of gelbstoff and phytoplankton pigments. Due to this instrumentation, the station is suitable for determining ground truth data of ocean colour images in North Sea coastal waters where the interpretation of ocean colour data is particularly difficult due to extreme loads of suspended mineral particles and yellow substances.

Determination of Class Mixing Value for Extracting Waterline Using Neural Network in Korean Tidal Flat

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There are several ways to extract the waterline from remotely sensed images. These include digitizing through visual investigation, applying density slicing method or an edge detection method to a single band, and classification using multiple bands. As a result of an analysis of the characteristics of tidal flats and spectral reflectance associated with waterline we found that a single band cannot accommodate the complicated tidal flat environments. This arises from the fact that the nature of waterline is transitional in very shallow water. A neural network algorithm was applied to a total set of 29 satellite data including 25 Landsat TM, 3 ETM and one EOS-Terra ASTER image for extracting waterline in the Gomso and Saemangum tidal flat, Korea. A series of field surveys have been carried out to obtain grain size, moisture contents, field spectrometer measurement, and waterline tracking using DGPS simultaneously with satellite observation. The neural network not only distinguishes between tidal flats and seawater, but it also provides continuous outputs that represent mixed portions of both features i.e. the portion of the pixel covered by water. We compared the class mixing values from neural network with the density slicing results of each band. The neural network output provided the closest to the ground truth and that of the ETM TIR band. Consequently, we determined a different class mixing value according to tidal condition because of the variation of surface and interstitial water content. This result can be used for high-resolution satellite data such as IKONOS and KOMPSAT II that don't carry a thermal sensor.

Safer navigation in coastal areas with the aid of radar-measured surface currents

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High-frequency (HF) radars are able to map surface currents off shore by means of land-based stations. The Doppler shift of the backscattered signal is used for measuring the radial current speed relative to the radar site. Guided propagation along the conductive sea surface (ground wave) allows measurements beyond the horizon. HF radars provide surface currents in real time on a regular grid. Recently, the University of Hamburg developed a new HF radar called WERA (Wellen Radar) which allows to simultaneously measure currents and waves (Gurgel et al., 1999).

EuroROSE experiments: In 2000, coastal currents off the Atlantic coasts of Norway and Spain have been measured and modelled during two experiments of the European Radar Ocean Sensing (EuroROSE) project (funded by EU). The objective of EuroROSE is to develop a radar based ocean monitoring system in support of safe navigation in port approach areas and otherwise densely operated sea areas. Radar measured data have been assimilated into a fine gridded numerical model with the aim of predicting, for a few hours, currents and waves.

The 27-MHz WERA provides surface current velocities on a grid with 1 km resolution and an extent of about 40 x 40 km. Two WERAs were deployed in order to measure the two-dimensional velocity vector with a sampling rate of 20 min. HF-measured surface currents represent a vertical average of velocity. The WERA used senses currents to a depth of about 1 m. Coastal currents are computed by a suite of nested ocean models. The Princeton Ocean Model (POM) is used, as implemented and modified by The Norwegian Meteorological Institute (DNMI), cf. Breivik and Saetra (2001). The inner model has a spatial resolution of 1 km and 17 density levels. In the area covered by WERA, the height of the uppermost model layer is about 0.6 m. Optimal interpolation (01) is applied for assimilating the current velocities measured by WERA.

This paper presents fields and time series of current velocity as measured by WERA and compares them with model results. The comparison of predicted and measured current velocities reveals a decrease of the correlation coefficient from higher than 0.9 (nowcast) to about 0.7 (6 h prediction).

Conclusions: The EuroROSE project aimed to develop a tool to be used by Vessel Traffic Service operators, harbour and coastal managers, to monitor and predict the significant met-ocean conditions with high time/spatial resolution in limited areas surrounding locations of dense operations. This paper demonstrates the importance of radar-measured current fields which describe the nowcast and are needed as initial values for the forecast of numerical models. The main objective of the WINGS-FOR-SHIPS project (funded by

EU) is to improve the decision making process of ship masters on board of high speed crafts related to environmental information. As part of this project, two WERAs will be deployed on Corsica in fall 2003.

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Applying of airborne imagery and GIS technology for detection, classification and mapping of industrially important water vegetation

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A consumption of seafood, including algae, increases with each years all over the world. The examples of commercial application of algae in medicine, perfumery and other branches are also well-known. The brown algae (fucus, laminaria) are more important. The quantity of publications devoted to estimation of algae biomass and their industrial production increases.

For investigation the seas and coastal zones the complex of the aircraft equipment «ARCTICA» has been designed. The complex «ARCTICA» includes IR-radiometer, radiometer AIR-2, IR-scanner «MALAKHIT», digital camera Nikon D1X, camera RA-39, camera TK-10/18, polarimetric lidar PAL-1, radars with the synthesized aperture (SAR) RSA-4, RSA-23, VHF-radiometer «FISH», video complex «Panasonic», navigation equipment and meteorological complex.

In the summer 2002 in the southern part of the White Sea had been conducted aircraft observations using digital camera Nikon D1X. The aim of this study was: detection of fucus distribution, discrimination of the fucus from others algae species and soil substrate, assessment of areas occupied by fucus and densities of vegetation.

As a results of the Nikon D1X images unsupervised and supervised classification the following classes were determined: dense covering (of laminaria and fucus) and stones; rarefaction covering (fucus), stones and sand; dense covering (fucus), gravel and sand; sandy tidal flats with spots of fucus; sandy substrate.

Airborne Hyperspectral Potential for Coastal Biogeochemistry of the Scheldt Estuary and Plume

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Estuaries are obligate pathways for the transfer of dissolved and particulate material from the continent to the marine system. The Scheldt basin covers one of the most populated and industrialised areas of Europe and its tributaries drain an area of about 21,860 km^2. The amounts of nutrients discharged by the Scheldt increased considerably during the past 20 years. Due to the dilution and metabolic processes of the downstream river flow in the estuary, an important variability of several parameters can be observed amongst which phytoplankton species and concentration, particulate organic matter, colour dissolved organic matter and suspended matter. The goal of this research is to explore the potential of CASI-SWIR airborne hyperspectroscopy in retrieving some of the biogeochemical parameters of interest in the Schedlt estuary and plume (Belgium-Netherlands coastal zone). A 13 sampling stations field survey was realised in order to cover as quickly as possible the wide range of water quality encountered from the mouth of the estuary to the outer limit of the plume. Correlation was searched between classical ground truth measurements and the rich information provided by numerous CASI-SWIR spectral bands carefully chosen. These relations were used to derive synoptic view of the spatial distribution of phytoplankton pigments and species concentration, particulate organic matter, coloured dissolved organic matter and mineral suspended matter in the Scheldt estuary and plume. Synthesis of these hyperspectral-mapping products with other complementary satellite maps and ground data set will allow ocean scientists to derive substantial information about ecosystem processes in the Scheldt estuary and adjacent coast.

Blue fluorescence of NADPH as an indicator of marine primary production

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The determination of biomass and primary production of photosynthetically active phytoplankton in the ocean is of great interest in ocean remote sensing. Absorption and fluorescence of chlorophyll *a* are commonly used for measurements of these parameters. Ocean colour data make it difficult to quantify photosynthetically active phytoplankton. The application of lasers makes it possible to derive such data with higher accuracy, but necessitates the use of complex methods such as pump-and-probe fluorescence spectroscopy for determining the physiological state of photosystems in phytoplankton.

A more direct method is the measurement of Nicotinamide-adeninedinucleotid-phosphat (NADPH) which is the direct metabolic product of photosynthesis. At the end of the light-driven electron transport chain electrons from water oxidation are transferred to NADP, leading to its reduced form NADPH. Its absorption maxima are at 260 and 340 nm, it emits fluorescence in a broad band centred at 340 nm.

We report on investigations of the absorption and fluorescence properties of NADPH in free form, and bound to marine phytoplankton cells. In addition to these parameters, fluorescence decay time characteristics are analysed for its potential to distinguish NADPH from other substances which might absorb light and emit fluorescence at the same wavelengths.

Aim of these studies is to examine the fluorescence of seawater samples *in situ* and with lidar remote sensing, as an appropriate indicator of biomass and photosynthetic activity.

Peculiarities of Coastal Waters Dynamics in Shallow Areas of the Barents and the White Seas Revealed from Different Kind of Remotely Sensed Data

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The results of thematic interpretation and analysis of satellite images data set of the Barents Sea and of the White Sea obtained in different ranges of electromagnetic specter will be discussed. For this study have been used a following sources of passive and active remotely sensed data: LANDSAT/MSS, RESURS-F/KATE200, ADEOS/AVNIR, RESURS01-N4/MSU-S, SeaStar/SeaWiFS, ERS/SAR, JERS-1/SAR, RADARSAT/SAR, OKEAN-7/SLR.

Processing of remotely sensed data set for a chosen sub-areas of coastal zones of the northern seas has been made using modern software, including GIS technologies. Thematic interpretation of satellite images have been made with support of regionally oriented knowledge - data on subject collected mainly from literature (meteo- hydrological regime data, reference books, articles, reports, historic data and others), available cartographic materials, including existing bottom topography maps, and concomitant characteristics of hydrological/meteorological conditions.

In a preferable weather conditions on the satellite images (both in visual and in radar ranges) can be detected a features of bottom topography and a patterns of sea surface dynamics caused by wind/waves, currents and processes of ice melting.

For different sub-areas of the Barents Sea and the White Seas the following aspects will be illustrated and discussed in detail: peculiarities of coastal waters dynamics and sediment transport, dispersion of fresh rivers water into sea, bottom topography features reflected in visual and radar images, sea surface waters dynamics during tidal events, variability in suspended sediments concentration.

The results obtained prove the effectiveness of using remote sensing technology for monitoring and investigation of the northern seas water environment. The new knowledge obtained can be used for hydrodynamics modeling, for water resources management and environment protection, for planning the oil and gas drilling operations, for ensuring measures of sustainable development of the northern seas areas.

Spectral Characterization of the Coastal Zone: Comparison between Water-leaving Radiance and Photosynthetic Carotinoids

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Total chlorophyll concentrations are related to water-leaving radiance, and it was demonstrated that hyper-spectral data with a spectral width FWHM of about 10 nm provide information on plankton blooming at two selected wavelengths. In addition, spectroscopic investigations on the presence of photosynthetic carotenoids and their relation to water-leaving radiance were carried out in a eutrophicated coastal environment. The salinity gradient surveyed was from 0 to 29 with nutrient supply through a waste water treatment facility (WWTF). Aside from chlorophylls, the major photosynthetic carotenoids were analyzed by HPLC and statistically evaluated against spectra simultaneously measured as water-leaving radiance. Regressions were established between water-leaving radiance and concentrations of 19'-hexanoyloxyfucoxanthin, 19'-Butanolyoxyfucoxanthin, fucoxanthin, peridinin, prasinoxanthin and a-carotene.

In field tests, spectral reflectance measurements were carried out using a spectro-radiometer (GER 1500) covering the UV, visible and near infrared. This spectrometer has a full width half maximum (FWHM) of 3 nm and covers the spectral range from 350 nm to 1050 nm. The results are presented as percent of the incident solar irradiance which can be given as Rrs(0+, l) = Lu(0+,l)/ Ed(0+,l), where Lu(0+,l) is the upwelling water-leaving radiance and Ed(0+,l), the incident downwelling irradiance.

Regression analysis identified the specific wavelengths in which major absorption and reflectance can be attributed to the presence of the photosynthetically active carotenoids.

Characterisation of the tidal flat water column with optical measurements

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The East Frisian tidal flats are continuously influenced by open marine (from the North Sea) and on-shore processes. During ship cruises near the island of Spiekeroog (Germany), we investigated the input/output of dissolved and particulate matter between the tidal flats and the North Sea. We studied the tidal dynamics by optical measurements (e.g. fluorescence, attenuation and reflectance of the water column), supplemented by biogeochemical, salinity and temperature (CTD) measurements.

First results on the optical characterization and quantification of the dissolved and particulate load between the backbarrier tidal flats and the open North Sea (e.g. total suspended matter, yellow substance, DOC) will be presented. A look on the dissolved and particulate input from small coastal tributaries into the backbarrier tidal flat system and the transport to the North Sea will be taken. All optical data will be discussed in comparison to the biogeochemical and CTD data.

Seasonal variability in spectral reflectance of coastal dune vegetation

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The coastal dunes belong to the most important ecosystems in the Netherlands, and form an extended area of joined nature reserves along the Dutch coast over a length of more than 100 kilometres. They have suffered from prolonged desiccation, changes in land use, diminished coastal dynamics and acidification. In the Amsterdam Water Supply Dunes, nature management is applied to counteract the deterioration of threatened dune vegetation and to maintain biodiversity. An efficient and reliable monitoring system is necessary to investigate autonomous vegetation development and to evaluate the effect of nature management.

Monitoring of the vegetation is executed by the classification of large-scale remote sensing images. As the spectral characteristics of vegetation change during the growing season, the discrimination between vegetation types may vary too. Therefore the spectral reflectance of several dune grassland types has been studied in order to determine an appropriate period for collecting hyperspectral imagery. A GER field spectrometer was used to collect reflectance data in different periods from May to July 2001. The data were transformed into the wavelength bands of a hyperspectral GER EPS-A scanner, which was used to make a hyperspectral image of the Amsterdam Water Supply Dunes. The reflectance data were analysed using a Mann Whitney U-test and a multivariate CANOCO Redundancy Analysis. The results illustrate that the spectral characteristics of dry dune vegetation do change during the growing season. It is concluded that the best discrimination is achieved by the end of May and that a field spectrometer can help to determine a convenient period for hyperspectral imagery.

Metrology issues arising in shallow angle wave profiling LIDAR

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Sea surface profiling LIDAR operating from the shore or from a ship can be an important instrument for many areas of sea wave research. Unlike airborne LIDAR these systems operate from modest elevations, yet should be capable of scanning over ranges of up to 1000m, which in turn gives rise to very shallow angles of measurement. A characteristic of this scanning geometry is that the location of samples returned are non-uniformly distributed in space.

This class of LIDAR is being developed to enable a technique called *Deterministic Sea Wave Prediction.* This is a technology where ship motion is predicted up to 30 seconds in advance by building local sea wave models based on the measured profiles of swell systems advancing toward the ship's location. The dependence of typical DSWP models on traditional discrete spectral techniques introduces the requirement to re-map sets of N non-uniform sea profile data onto uniformly sampled equivalents. The high computational cost of the general change of basis is involved in this process and its detrimental effects upon prediction time motivated an examination of approximation methods. A metric Γ is discussed which measures the degree of departure form uniformity in terms of the Primary Band Limitation property which is associated with a generalisation of Nyquist's theorem.

The LIDAR system is also capable of remote sensing of wave profiles in the coastal zone. Again, given the shallow angle of measurement from a shore based station the issue of non-uniform sampling is also relevent and is discussed, together with other related metrology issues.

Segmented Interpolation Along the Coastline for AVHRR NOAA Images

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This paper presents an innovative interpolation method of remote sensed data, based on an appropriate check of the pixels that need interpolation and of the data points used for interpolation. The aim of the method is to project remote sensed data on a Mercator grid (Datum WGS84) to obtain a highly defined raster image especially along the coastline, where the sensor footprint includes simultaneously a portion of sea and a portion of land.

This interpolation method is mainly based on checking the points acquired by satellite sensor before computing interpolation. This check is based on a criterion of suitability for interpolation depending upon satellite points and regular Mercator grid pixels. For this purpose we defined some fixed geographical area formats for Mercator images which were accurately segmented into “land-pixels” and “sea-pixels”. This result was possible by developing a sub-pixel precise data navigation method for AVHRR NOAA remote sensed data which uses automatic geographical correction. Moreover, considering the dimensions and the shape of AVHRR NOAA sensor lobe, for each satellite point the closeness to the coast is taken into account in order to identify “mixed points”.

Considering land-sea classification, closeness to coast of satellite points and land-sea classification of Mercator raster image pixels, suitable points for interpolation are selected while unsuitable points are calculated again using close suitable points. The results show a remarkable enhancement in image definition along the coastline.

A numerical comparison, based on “in situ” sea measurements along the coastline, between SST (*Sea Surface Temperature*) images obtained from AVHRR NOAA data using segmented and ordinary interpolation, is also presented.

Estimating Water Clarity Parameters from NOAA-AVHRR images in a turbid estuary: Izmir Bay, Aegean Sea

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Remote sensing of ocean color is based on the measurement of water-leaving radiance in visible part of the electromagnetic spectrum. The total signal detected by the satellite sensor is corrected for the atmospheric noise. Then the optical water quality parameters in the surface layers of the ocean can be derived by using empirical algorithms. The algorithms in use generally fail in coastal waters, which are optically complex due to the presence of high amounts of total suspended matter. There are efforts on the development of new algorithms and new sensors to infer concentrations of phytoplankton pigments in coastal waters.

Eutrophication due to the supply of organic matter is one of the most important environmental problems of Izmir Bay. Monitoring the levels of chlorophyll - as an indicator for eutrophication – through remote sensing has substantial benefits for the management of eutrophication.

In this study, The Advanced Very High Resolution Radiometer (AVHRR) satellite imagery was evaluated as a potential data source for monitoring the water clarity conditions in Izmir Bay. The dataset covers in situ measurements carried out in the Bay for the period of 1996-1998 and corresponding AVHRR (NOAA-14) images. Although it does not have the sensitivity in the red and near-infrared to examine open ocean waters (case-1 waters), its sensitivity is suitable to examine the patterns in water clarity at turbid estuaries (case-2 waters) (Stumpf, 1987, 1992, Stumpf & Frayer 1997, Stumpf & Pennock 1989, 1991, Stumpf & Tyler, 1988, Tyler & Stumpf, 1989, Stumpf et al, 1999, Woodruff et al., 1999). Stumpf's (1992) algorithm is used to remove atmospheric effects from the images and retrieve the water leaving reflectances.

A performance analysis of the classification and manual digitising methods for the detection of coastline by using satellite image data

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The potential of remote sensing is very high for the monitoring of the Earth and the detection of its environmental changes. Therefore, remotely sensed images have been used in many fields as a reliable and valuable source of land-cover data for monitoring land-cover and land-cover changes at regional and global scale. Satellite images are also used for visual interpretation of coastal areas and determination of coastline.

This paper focuses on the expected performance of classification and manual digitising methods for obtaining coastline by using three available satellite data (Landsat TM (1992), Spot XS (1993) and Landsat-TM (1992) and Spot P (1993) merged image). For this purpose, Kucuk Cekmece Lake which is one of the most important water basin area around Istanbul, Turkey, was selected as the study area. Principal components analysis (PCA) for Landsat TM and Spot XS data, intensity-hue-saturation (IHS) transformation for Landsat-TM and Spot P registrated images and classification process was performed for digital image analysis.

In order to obtain the coastline of the lake, two different methods were applied to the satellite images. As first method, the coastline of the lake was obtained by manual digitising way on computer by using Landsat TM, Spot XS and Landsat-TM and Spot P merged image. As second method, all these data were classified separately by using ISODATA technique method of unsupervised classification and the vector data of the coastline of the lake was obtained after the raster-vector conversion process.

Finally, the coastline of the Kucuk Cekmece Lake was analysed and interpreted according to the results obtained by these two different methods comparatively and separately.

Coral reef habitat mapping in the Red Sea (Hurghada, Egypt) based on remote sensing

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Due to the attenuation effect of water, the intensity of light in water decreases exponentially with increasing depth. As a consequence, the spectral radiance recorded by a sensor is dependent both on the reflectance of the substrata and on depth. Also, with increasing depth, the separability of the spectra of different habitats declines which may lead to confusion during classification. Water column correction techniques are applied in order to restore the original reflectance.

After water column correction, the actual classification is made. Ideally for coral reefs, this is a combination of a geomorphological and an ecological classification. The geomorphological classification is based on visual interpretation of the satellite image, as pattern and context are very important decision elements, and on a bathymetric map made of the study area. The ecological classification uses the different multispectral bands of the images to distinguish several habitats. Only a coarse or medium level classification can be made using satellite imagery. Therefore no more than five classes are distinguished: coral reef, sand, algae, seagrass and deep water. Field data is used to define the different training sets

After the classification, contextual editing is applied to deal with possible misclassifications. During this post-classification step the context of the geomorphological map is used to ameliorate the ecological classification. Both mapping results are then combined in a hierarchical classification. This classification scheme makes it possible to integrate different sensors with different resolutions. When more detailed information becomes available, this can be incorporated in the existing scheme.

An accuracy test is worked out to facilitate the assessment of liability of the resulting habitat map.

The MERIS Chlorophyll maps of the North Sea: REVAMP first results

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REVAMP aims at supporting the monitoring of the eutrophication state of the North Sea by measuring and validating a key bio-geo-physical parameter (Chlorophyll or CHL concentration) using MERIS observations. Because of regional variations in North Sea water composition, REVAMP will develop and validate analytical regional algorithms for CHL maps. The end product will be a North Sea atlas for the period spring 2002 to spring 2003, containing CHL maps, accuracy products and Added Value Products (e.g. monthly mean values).

In this presentation the first results will be presented for the Dutch continental shelf. Much attention will be given to the interpretation of the MERIS coastal products, including technical aspects like accuracy, atmospheric correction, validation and coverage. The implications of regional explicit algorithms will be highlighted. Finally we will compare this information with the requirements made by coastal managers.

Integrated multi-Environmental Satellite remote sensing for North Sea and Baltic Sea coastal water monitoring

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Coastal waters, with their shallows, often high suspended sediment matter and DOC (Dissolved Organic Carbon), present particular problems for spaceborne remote environmental monitoring. Linked with the OROMA (Operational Radar and Optical Mapping in monitoring hydrodynamic, morphodynamic and environmental parameters for coastal management) project, optical remote sensing data from a range of environmental sensors (NOAA AVHRR, SeaStar SeaWiFS, EOS MODIS and ENVISAT MERIS) were investigated with the aim of providing near-real-time coastal zone and Case 2 water products.

Particular areas of interest were linked to data over four OROMA field and airborne test sites: Gulf of Gdansk, Lister Tief, Wadden Zee and Western Schelt. These sites have common problems associated with the wind and tidal current erosion/deposition of navigation channels and discharge outlets. The key requirement here is the provision of reliable low cost monitoring of these morphodynamic coastal areas.

While other researchers within the OROMA project undertake SAR and ground based radar bed-form mapping, optical remote sensing aimed to identify active coastal processes via the character and extent of suspended sediment.

The key problems in the extraction of accurate space borne remote coastal zone products are twofold; the limited spectral resolution of individual sensors, and unmixing the spectral contribution of TSM (Total Suspended Matter), DOC, Chl-a and salinity. Additional problems are associated with shallow water, sub-pixel and adjacent pixel land reflectance.

From an optical perspective, two areas were examined associated with OROMA near-real-time monitoring. Firstly, multi-satellite data fusion was investigated to optimise both cloud-free viewing opportunities and cross-sensor atmospheric correction inputs. Here, for example, SeaWiFS and MODIS atmospheric products were used to supplement GSFC climat data inputs into the twice-daily NOAA AVHRR product. Linked with the application of same-day multi-sensor data acquisition, the range of available near mid-day passes were utilised to extend the scope of winter (poor illumination) monitoring. Secondly, shallow water, mixed pixel and adjacency corrections were applied to remote sensing data associated with the test sites to improve on the satellite monitoring of two key water parameters, SPM and Chlor-a. It is here that the improved spectral and spatial resolution associated with MERIS and airborne data will be used to provide a model for local adjustments in the other environmental sensors algorithms.

New Ports in the Eastern part of the Gulf of Finland and Some Problems of Integrated Coastal Zone Management

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During the last decade Russia has been constructing new harbors in the eastern part of the Gulf of Finland: Ust-Luga, Vysotsk, Batareinaja, Primorsk and reconstructing St. Petersburg harbor and Vyborg harbor. Concerned with the impact of human activities in this region on the marine and coastal environments the City Administration and other regional authorities require new data sources for better understanding and control of such processes as coastal erosion, coastal water pollution, loss of natural habitat etc., and new tools for better management of coastal zone. Many important parameters that characterize the state and the change of the marine and coastal environments in the eastern part of the Gulf of Finland could be observed and mapped using remote sensing techniques and GIS technology in a more efficient way.

Application of remote sensing for Integrated Management of Coastal zone in the region could include the following items: (a) Oceanographic investigations, (b) Surge and flood forecasting, (c) Oil spill detection (including operational monitoring and predicting of oil spill extent and drift, and strategic support for oil spill emergency response decisions and actions), (d) Navigation routing and relevant activities, (e) Operational control of shipping (including detection of illegal dumping of oil sludge and garbage), (f) Monitoring of water quality, (g) Mapping of shallow water bathymetry and bottom substrate classification, (h) Accurate mapping of shoreline and its change.

An outline of the regional decision-support system incorporating the excising databases and monitoring facilities, and advanced remote sensing segment within GIS structure, is presented. Following the concept of “Baltic Europe” the idea of a relevant international system covering the entire Baltic Sea is put forward and discussed. An emphasis is put on the problems of operational monitoring of harbors, coastal zone and traffic lanes based on remote sensing techniques. The lessons of tanker “Prestige” are briefly discussed and taken into consideration.

Satellite radar remote sensing of intertidal flats for mapping, monitoring and prediction of benthic macrofauna

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Tidal flats have particular significance for ecosystems of estuaries. They accommodate a large proportion of benthic fauna. Our research in the Westerschelde has shown that the occurrence of benthic macrofauna can be predicted using a number of environmental variables, including sediment characteristics. Remote sensing can provide information on these variables.

Radar satellite remote sensing has great potential for monitoring intertidal areas, as images from clouded areas can be used. Numerous studies, especially in the field of agriculture, have demonstrated the dependence of radar backscatter on surface roughness and the dielectric properties of the surface, and, hence, moisture content, sediment grain-size distribution and salinity. However, to date, the use of radar for habitat mapping of intertidal flats has received very little attention, despite its potential.

In this research, the spatio-temporal distribution of sediment characteristics and surface roughness of tidal flats in the Westerschelde are assessed using Envisat ASAR imagery. A framework for the interpretation of the imagery is developed using additional information from side-scan sonar, as well as multispectral (Landsat) and hyperspectral (EPS-A/CASI) remote sensing, and extensive ground truthing. In addition, results from previous field campaigns are related to matching archived ERS-1/2 SAR imagery.

The resulting sediment maps are coupled to an extensive macrobenthos data set using canonical correlation and geostatistics. This allows predictive models for the distribution of benthic macrofauna on tidal flats to be developed.

Development of a 3D-particle image velocimetry system (PIV) for coastal and river monitoring

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Due to flow, motion of the sea and tides, a heavy load in rivers and near the shore causes an important stress for bed pitching, coastal protection and other constructions. The cost of maintenance, amounting to several million EURO a year, could be reduced by using mathematical models in order to optimise such buildings. Stationary monitoring of currents and loads with a high spatial and temporal resolution is a key to achieve the necessary data to provide a sufficient quality of these models.

In the introduced project a laser measuring system to measure the flow velocity for three dimensions is developed and will be tested in turbulent waters. The principle of system is based on particle image velocimetry (PIV) and will deliver 3D-current vectors with a high resolution in time and space to be used for validation and calibration of numeric model for constructions in rivers. The system is constructed to be operated for a one year period being resistant to critical loads generated by flow, wave propagation and tides.

In the follow up of this project, the sediment flow near the shore and in estuaries can be envisaged as well as turbulence monitoring in dynamic mixing processes of brackish water or at the sea surface. These further important fields of use for the developed equipment should be complemented by high performance and efficient numeric 3-dimensional modelling and fluorescence detection for biological applications.

Barents Sea Airborne Research on the Basis of Ecosystem Principles

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Many years PINRO carries out research of the Barents Sea with using of technical means and methods, which are based on application aircraft - air research. During this time is traveled way from making of simple visual observations to carrying out research on base of modern technical means, and also up-to-date technology of getting, processing, analyze, interpretation and presentation data on base of GIS application.

At present air research at the Barents Sea have complex disposition, i.e. carries out simultaneous data getting about conditions on sea surface and distribution of marine biological objects with using of remote sensing technical means, which work in the optic, infrared and very high frequency electromagnetic wavelengths range. All airborne research carry out onboard of specially equipped aircraft-laboratory An-26 “Arctica”. On base of indicated principle realization get many oceanological and biological parameters along aircraft-laboratory flight route and some swath in the direct closely of it’s in near real time. After analyze and interpretation these parameters calculates and determines of it’s spatial distribution structure on base of ArcView 3.1 using.

Joint system analyze of all above indicated data, allowing estimate in complex correlation oceanological environment - biological object, beginning from simple microorganism, finishing marine mammals and fish, provides realization of ecosystem approach, that gives opportunity to look on such research of other, new position.

Elastic and Raman lidar sounding of coastal waters: theory, computer simulation, inversion possibilities

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Lidar sounding is a remote sensing method, which is capable of fast, accurate and inexpensive 3-D characterization of wide areas of ocean that is badly needed for ecological monitoring. The lack of reliable retrieval techniques is the main obstacle preventing lidar sounding from giving optical parameters of seawaters.

An analytical theory of the polarized elastic and Raman lidar returns from stratified seawater with multiple scattering will be presented and the analysis of the information content of the lidar signals will be performed at this base.

The software providing real-time simulation of the airborne ocean lidar performance, which estimates the lidar return signal and its components due to the atmosphere, atmosphere-ocean interface, seawater, and bottom in various regions of the world's oceans with specific water stratification, in daylight and at night and under different weather conditions, will be demonstrated. The successful comparison of this lidar return simulations with experimental data obtained during HyCODE 2001 test will be demonstrated.

This software was used as a tool to develop and verify various retrieval techniques including the coupling of the multi-spectral elastic and non-elastic lidar returns. The set of new techniques to retrieve the absorption and scattering depth profiles in coastal water from inversion of elastic lidar return, polarized signal, Raman lidar return will be compared and analyzed. The lidar detecting and mapping of the algal blooms in coastal waters will be discussed.

New fast code for radiative transfer with polarization in the system atmosphere-ocean: application to the satellite remote sensing

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A new fast code to simulate radiative transfer with polarization in visible and IR for the atmosphere – ocean system, which computes all 16 elements of the 4x4 Green's Matrix and provides Stokes parameters of multiple-scattered radiation at any point of a system. The atmosphere and ocean are considered as stratified media, the layers being realistically modeled by introducing parameters of molecular and aerosol/hydrosol scattering and absorption from developed data banks.

Our newly developed techniques, including the multi-component method and new theory of polarized light propagation, provide extremely timesaving and accurate computations. The wind-ruffled ocean surface is included as a pseudo-layer.

Evaluating this, we performed detailed comparison with results of Masuda's code and Monte Carlo computation (G.Kattawar, H. Tynes), which showed the excellent agreement. With this fast computer code, highly accurate data were obtained in a fraction of the time required by other methods. In addition, the code does not require the use of powerful computers; it can be run, quickly, on an ordinary personal computer. These features make this code to be a very practical Simulator for development and validation of various retrieval techniques for satellite remote sensing with use of POLDER like instruments. The examples of simulation of POLDER data and retrieval technique validation are presented.

Integration of remote sensing with geographic information systems (GIS) for an assessment of water quality variables in Finland

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Geographic Information Systems (GIS) have developed from the need to combine spatial attribute information about land surface (or the Earth surface) with its cartographic representation in order to perform spatial analysis. Remote sensing and image analysis techniques provide access to spatial information on different scales. New detectors and new imaging technologies are increasing the capability of remote sensing to acquire digital spatial information at very fine resolutions, in the order of a few meters from satellite platforms and a few tens of centimeters from airborne platforms. The integration of such capable data acquisition with analysis techniques is becoming increasingly important for the assessment of water quality variables.

This study will focus on monitoring of water quality variables, change detection of water quality variables and output of water quality maps. The paper shows that data from different sources can be integrated in order to assess water quality variables in the Gulf of Finland. A case study employing optical data (e.g., Landsat TM, AVHRR, MODIS and MERIS) and microwave data (e.g., ERS-2 SAR) is carried out to monitor water quality in the study area. The obtained results indicate that the integration of multi-temporal remote sensing data with GIS has a great potential for the operational assessment of water quality variables through the applied methodology.

Remote sensing in the marine boundary layer over coastal areas

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The contribution of aerosol particles to moisture and energy exchange processes at the sea surface, to the global salt flux, their role in cloud droplet formation processes and their influence both upon the maritime atmospheric radiation balance and propagation at visible and infra-red wavelengths or visibility assessment are of increasing concern. Visibility decreases due to a reduction of the contrast ratio by scattered light. This has a significant influence on both the performance of electro-optical systems and our experience in everyday life. A thorough understanding of such phenomena is essential to an accurate assessment of many processes important for the development of coupled ocean-atmosphere global circulation models, including the pollution problem. Due to its light attenuation and scattering properties, aerosols are important factors in satellite investigations of the ocean surface.

The wind dependence of the aerosol type which is predominant in the marine boundary layer is especially clear in coastal areas where wind direction and duration play the decisive role on the type of particles which can be found in the marine boundary layer. The aerosol concentrations and size distribution at the sea surface allow for the determination of the aerosol component of extinction and optical thickness in the atmosphere. Knowledge of these parameters and combining them with variations of wind speed and direction as well as other hydrometeorological factors allows for corrections to be made in the model of radiation transmission in the real atmosphere.

Remote Sensing of the Neva Bight

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The recently completed HYMNE project (Hydrographic Monitoring of the Neva Bight) was designed specifically to provide the scientific basis for an operational hydrographical monitoring system as a management tool for preserving the ecological and economic resources of the hydrosphere within the metropolitan region of St Petersburg and the neighboring parts of the Baltic Sea. It was an INCO/Copernicus project involving scientists from Germany, UK, Finland and Russia. The main component of the system will incorporate ground-based radar data on a high resolution grid, and the main thrust of the HYMNE project was to develop and test such a system. In addition, sea truth and satellite measurements were undertaken, as well as an in-depth study of the environmental impact of the River discharge into the Eastern Gulf of Finland/Neva Bight region. Of particular interest was the effect of the newly constructed flood protection barrier on the circulation and mixing of the river and gulf waters.

Ground based X-band radar was used to detect hydrodynamic parameters, such as the surface current during the ice free season, and ice floe mobility during winter conditions.

The radar was mounted on the shore close to the barrier opening for the shipway. It could be shown that the sea surface current can be calculated from the radar signal Doppler shift detected at two positions. For this, the frequency shift acquired from each individual position must be corrected for the effects due to the local wind and wave impact. The radial components from two stations were composed to obtain a map of sea surface current vectors. To observe the ice floe mobility, time series of the radar images were Fourier decomposed. Arial structures due to stationary ice fields were recognised to induce a signal with zero frequency. Signals with non zero frequencies were detected over moving ice fields. It could be shown that the number of floes and their speed correlates with the detected frequency.

In addition to the ground based radar measurements, both SAR and optical satellite data were analysed. The period of research coincided with the end of the lifetime of ERS2, and so only a limited number of SAR scenes were available, none during the fieldwork campaigns. The 35-day repeat was too long to obtain any useful information on water and ice-floe movements, but did provide periodic overviews of the general situation. Little previous work has been done using SAR in shallow, polluted, turbid river basins where it is difficult

to separate the scattered signal from ice from that from water, but some algorithms were developed which would, in principle, allow information about the ice-type, pollutant concentration and liquid water equivalent to be determined if sufficient temperature and salinity in-situ data were available.

Optical data from SeaWiFS, from the NASA data archive, and AVHRR, provided by the German Federal Maritime and Hydrographic Agency, were analysed, for the period May 1998 to September 2000. About 20 cloud-free SeaWiFS and 121 AVHRR images were available for this period. The turbidity pattern derived from SeaWiFS could be related to the typical algal distribution in the Gulf of Finland and to the suspended sediment pattern in the Neva Bight. Some phenomena from single days were observed, particularly those associated with the water passing through the barrier, and the distribution of chlorophyll in the Eastern end of the Gulf. However, due to the limited number of images, it was not possible to provide a statement concerning a regular pattern of the river currents., Seasonal sea surface temperature patterns were also studied by calculating mean and standard deviations in ten different areas and related to available *in situ* data. Statistically significant relationships between the water masses at the barrier and the surrounding waters were derived. Detailed results will be presented.

The OROMA Project

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Preliminary results will be presented for the OROMA project (Operational Radar and Optical Mapping in monitoring hydrodynamic, morphodynamic and environmental parameters for coastal management). The project aims to conduct experimental monitoring to increase the effectiveness of such technologies in coastal regions to meet with end-user requirements. Data from mobile ground/ship radar systems, SAR and optical satellite data and ground truth data will be integrated and inverse modelling will be used to assess the coastal status. Thematic maps will be produced, and near-real-time presentation of monitoring parameters mapped into a geo-coded grid to be distributed via electronic networks for quick access by managers.

Four test sites are being studied. Extensive ship and ground-based radar measurements are being conducted in the Lister Tief (Germany) to map the normalised radar cross-section (nrcs). From these maps, the actual bathymetry at the sandy sea floor will be derived by inverse modelling. During the three years of the project, repeated mapping of the nrcs will produce a time series of bathymetric maps which will help to estimate the eroding forces. This work will be supplemented by SAR from ERS and ENVISAT, and airborne optical measurements from VIFIS. The problem being studied is the transport of sand around the north of the island of Sylt. The inverse modelling technique is being developed to produce the bathymetry from data acquired by airborne and satellite radars. One challenge of the project is to transfer this technique to maps acquired under the special condition of low grazing angles used in ground-based systems. Optical remote sensing and in situ measurements in the Western Schelt and Wadden Zee in the Netherlands are intended to monitor the health of the deep water shipping V lanes. Particularly significant here is the monitoring of suspended sediment, Chlor-a and pollution hazards with ongoing channel and port developments. These techniques are also being used in the southern Baltic to study the erosion and deposition of sediment along the coast at Gdansk, and the erosion of the Hel peninsular .For the Gulf of Gdansk test site, interest is specifically targeted on the operational monitoring of the changing nature of the Vistula outlet, here changing depositional patterns when linked to winter ice produce unpredictable river backup flooding. Airborne optical data, and MERIS, Sea WiFS and A VHRR satellite data are all being used with the aim of meeting end-user requirements for the thematic mapping of suspended sediment and algae. Particular problems to be examined here include modelling the impact of non-water pixels and shallow water as well as uncertainties in current Case 2 water atmospheric .correction.

Black Sea Environmental Changes Detection by Satellite Remote Sensing Data

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The coastal and shelf zones of the Black Sea are a mosaic of complex, interacting ecosystems with immense economic significance, rich natural resources and ecological communities, and concentrated human activities. They contain biologically productive, diverse ecosystems that provide a vital habitat for many commercial and endangered species being of global interest on several levels. The environmental crisis and subsequent dramatic changes in the Black Sea's ecosystem and resources are a direct effect of both natural and anthropogenic causes: an enormous increase in the nutrient and pollutant load from three major rivers, the Danube, Dniestr, and Dniepr; from industrial and municipal wastewater pollution sources along the coast; and from dumping on the open sea.

An important aspect of Black Sea coastal zone management is a comprehensive knowledge of the physical and biogeochemical processes and the availability of relevant, up-to-date, and reliable information on the environmental state in the near-shore area. Such information is related to geomorphologic processes, coastal erosion, sedimentation transport, mapping of macrophyte fields and derived estimation primary production, and assessment of the water-column quality (concentration of sediment, chlorophyll, terrigenous substances).

Environmetal impact assessment and detection of spatio-temporal changes is very important for protection, conservation and restoration.

A multitemporal data set consisting of LANDSAT TM and SAR ERS-1 images for Romanian North-Western part of Black Sea coastal zone was used for comparing and mapping landcover change via change detection.

The main aim of this paper is to conduct a comprehensive analysis based on existing historical and more recent data to establish the link between phytoplankton bloom development and related harmful phenomena in the North-Western part of Black Sea and changes in the Danube watershed.