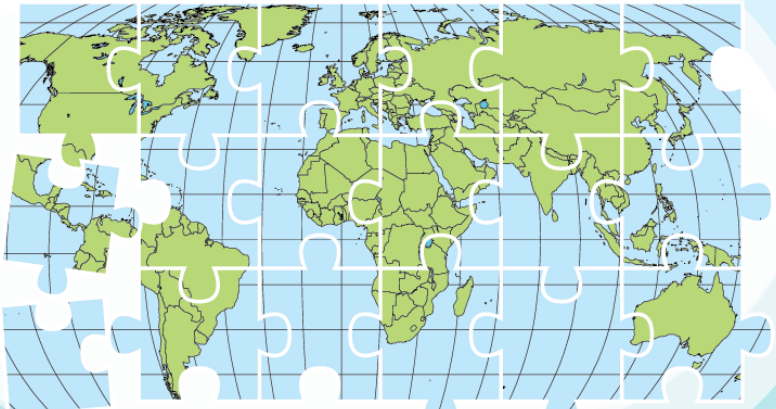
Measuring and Modeling of Multi-Scale Interactions
in the Marine Environment

IEEE/OES
Baltic Symposium 2014



May 26. – 29. 2014
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BOOK OF ABSTRACTS

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2014 – IEEE/OES Baltic International Symposium *„Measuring and Modeling of Multi-Scale Interactions in the Marine Environment.“* May 26 – 29, Tallinn, Estonia

2012 – IEEE/OES Baltic International Symposium *„Ocean: Past, Present and Future. Climate Change Research, Ocean Observation & Advanced Technologies for Regional Sustainability**.“*** May 8 – 11, Klaipeda, Lithuania.

2010 – IEEE/OES Baltic International Symposium *„Integrated Oceanographic Observation Systems And Data Bases For Climate Change Research.“* August 25 – 27, Riga, Latvia.

2008 – US/EU-Baltic International Symposium *„Ocean Observations, Ecosystem-Based Management and Forecasting.“* May 27 **–** 29, Tallinn, Estonia.

2006 – US/EU Baltic International Symposium *„Integrated Ocean Observation Systems for Managing Global & Regional Ecosystems Using Marine Research, Monitoring & Technologies.“* May 23 **–** 25, Klaipeda, Lithuania.

2004 – USA-Baltic International Symposium *„Advances In Marine Environmental Research, Monitoring And Technologies.“* June 15 **–** 17, Klaipeda, Lithuania.

FOREWORD

The 6th IEEE/OES Baltic International Symposium will be held in Tallinn, Estonia. In 2014 the Symposium celebrates its 10th anniversary - the first symposium in this continuous series was held in 2004 in Lithuania and now is returning for the second time to Tallinn. It is our great pleasure to welcome you back!

The current symposium theme "Measuring and modeling of multi-scale interactions in the marine environment" highlights research towards improved understanding of the marine environment as a system; in order to better anticipate the future state of the oceans we must understand the feedbacks and interactions on different scales. The symposium serves as a forum where scientists, engineers and policy makers can exchange knowledge and induce cooperation. We expect that this book of abstracts will be a useful guide through the symposium and afterwards as well.

We wish you a pleasant stay in Tallinn and fruitful scientific discussions!

/Organizing Committee/

ABSTRACTS

GLIDERS FOR STUDIES OF MULTI-SCALE VARIABILITY IN THE BALTIC SEA

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The Baltic Sea consists of several sub-basins with different physical characteristics and motion scales. The general circulation and meso-scale eddies are in continuous interaction. Usual monitoring with research ships gives a general picture of the conditions, but if no batfish is used, the picture has very little details. The use of gliders in ocean research and monitoring has increased greatly in the last decade. In Europe, a pan-European glider infrastructure is being planned in the EU-funded GROOM project. The Finnish Meteorological Institute and Plataforma Oceanica de Canarias organised a joint experiment on the Bothnian Sea and Archipelago Sea to study the use and potentials of gliders in these shallow, low-salinity conditions. The horizontal length scale of the glider observations in 100-m-deep waters is about 400 m. This is well below the internal Rossby-radius of deformation. Thus, gliders provide good possibilities to study multi-scale interactions and exchange processes between coastal and open-sea waters. We used the glider both in section mode in the open-sea area and as a virtual mooring in the semi-enclosed archipelago. Our experiments proved the usefulness of gliders in the Baltic Sea.

CHANGES IN BALTIC SEA SURFACE TEMPERATURE EXTREMES

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The probability of extreme sea surface temperatures (SST) occurring seems more apparent for the future in the Baltic Sea; therefore, prediction and inferences of such are essential. This study analysed the mean change of the SST in the Baltic Sea and calculated return periods using extreme value distributions of the 21st century. To illustrate the application of extreme value theory, annual SST maxima from the Baltic Sea regional climate model based on NEMO-LIM3 (Hordoir et al., 2013) were analysed. The changes were estimated from the control simulation of the 20th century (1971-2000) and were assessed for the following projected periods: 2011-2040, 2041-2070, and 2071-2099 forced by the IPCC SRES A2 emission scenario. Under that scenario, results indicate that the warm extremes (e.g. 30-year return values) will occur more frequently than those of the current condition and also show different spatial patterns. In addition, the strength of the spatial variability in the Baltic Sea will be reduced gradually towards the end of the 21st century.

CONTINUOUS ONLINE MONITORING OF THE SURFACE WATERS OF THE BALTIC SEA FROM A FERRY BETWEEN RIGA AND STOCKHOLM

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SOOGuard is a fully automatic, compact modular flow-through system primarily intended for surface water monitoring from ships, boats, or other moving platforms, also known as a ferrybox system. It was designed with integrated software and hardware capabilities, which make this system easily adjustable for particular needs. Simple and robust construction allows wide use of this system with low running costs, and also by non-specialists. In June 2013, one of these systems was installed on M/S ROMANTIKA (TALLINK), which makes daily crossings of the Baltic Sea between Riga and Stockholm. Parameters are measured at about a 5-m depth along the route at 1-min intervals and transferred immediately to the server on shore using cost-effective GSM/GPRS protocols, where they are displayed in real-time on an open-access webpage: http://on-line.msi.ttu.ee/lvferry2/. The set of parameters measured includes: Temperature, Salinity/Conductivity, Oxygen, Chl A, Turbidity, Phycocyanin, and pCO2. As the ship route covers different watermasses, from a river mouth to open sea and archipelago sea areas, this set of parameters allows us to study and monitor a wide range of processes, extending from coastal open sea exchange and riverine water distribution (ROFI) to thermohaline circulation and vertical water exchange processes in the open sea. The same data could serve operational oceanographic needs, providing validation and real-time assimilation into operational hydrodynamic models (HIROMB, NEMO, HBM, etc). The embedded webpage analysis tool enables an expert system allowing specialists to hindcast the state of a marine system in a straightforward manner, practically in real-time if each of the parameters is measured at sea. We will describe the system and its functionality, discuss the possibilities and challenges of operating the system, as well as interpretation of measured data. Data quality control will be discussed with a further focus on particular biogeochemical implications and emphasis on multiscale analysis of processes in the marine environment.

CLOUD MASKING SCHEMES FOR SATELLITE OCEAN COLOR DATA IN THE BALTIC SEA AND APPLICATIONS TO CYANOBACTERIA BLOOM ANALYSIS

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One of the most important steps in utilizing ocean color remote sensing data is subtracting the contribution of the atmosphere from the signal at the satellite to obtain marine water leaving radiance. To be done accurately, this requires clear sky conditions, i.e. all clouds need to be excluded or masked from the data prior to atmospheric correction. The standard cloud mask used routinely in the processing of NASA's global ocean colour data is based on a simple threshold applied to the Rayleigh-corrected top-of-atmosphere radiance. The threshold is kept purposefully low to ensure high-quality processing on a global scale. As a consequence, the standard scheme can sometimes inadvertently mask extreme optical events, such as intense blue-green algal (cyanobacteria) blooms in the Baltic Sea. These blooms have important ecological and environmental impacts on the basin and require appropriate monitoring. Therefore, an assessment of 4 existing cloud masking schemes that could provide valuable alternatives for the Baltic Sea was carried out by systematically testing their application to time series of SeaWiFS and MODIS data. By applying them to a number of years of satellite data, temporal and spatial implications were analyzed and a new hybrid cloud mask was developed and similarly tested. For comparison, selected MERIS scenes were also examined using the ESA operational MERIS cloud mask. The results indicate that by replacing the standard cloud mask, an increase of up to 23% in ocean coverage over the course of a seasonal cycle in the Baltic Sea may be possible. Major occurrences of intense blooms can be recovered while at the same time not introducing any significant extra cloud into the processing. The full inclusion of the cyanobacteria blooms, even their most intense manifestations, into Baltic data series allows a more comprehensive analysis of their spectral characteristics, with powerful implications for their detection, monitoring, and inter-annual evolution.

TURBULENCE, NON-NEWTONIAN FLUIDS, AND A NOVEL PHASE TRANSITION

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We show that in Newtonian as well as non-Newtonian fluids turbulent and non-turbulent (slow) motion components coexist whereby only the turbulent component exhibits dissipative patches with their characteristic dense millwork structure, enabling fast mixing over scales from the energy-containing down to the micro or Kolmogorov scale. Under certain (shear-thickening) conditions in non-Newtonian fluids the turbulent range shrinks to zero and turbulent mixing breaks down. This phenomenon could be predicted by a novel theory and could also be observed in an industry laboratory. Similar behaviour is expected for the transition of suspended sediments to fluid mud and vice versa in tidal flows, e.g. in the Mekong delta, Vietnam, or in the outer Elbe estuary near Brunsbüttel, Germany.

DEVELOPING A SYSTEM FOR MAPPING SENSITIVE MARINE AREAS

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Natural values of marine ecosystems often overlap with human activities. In order to reduce or even eliminate conflicts arising a considerable amount of information is needed: identification of marine activities, their location and scale, as well as the environment's response to separate pressures or different sets of impacts. Furthermore, the value itself can be estimated differently, since valuation assessments range from the anthropocentric to biocentric point of view. In this study, the concept of a system for mapping the most sensitive marine areas in the Lithuanian marine area is introduced. It is based on biological valorization of marine benthos and the sensitivity assessment numerical scales of species and biotopes. Both are being integrated into the geospatial database. Integration of such information into a GIS-based multi-criteria evaluation system can generate sensitivity maps of benthic habitats. These maps can provide important information on the most threatened to anthropogenic pressures marine areas. The system could also serve as a tool for marine spatial planning and providing a good background for decision making, i.e. the placement of activities in the least sensitive areas.

MAKING HYDROLOGICAL MAPS OF THE GULF OF FINLAND USING REMOTE SENSING DATA

Belonenko, Elizaveta

The creation of a series of thematic maps of the Gulf of Finland is considered, based on MODIS Aqua and Landsat data and according to contact measurements of hydrological characteristics of the water surface.

For processing of images and creation of maps the following software is used: ERDAS IMAGINE, SeaDAS, MapInfo Professional, MicroStation.

The mapped phenomena are interpreted on the basis of subsatellite measurements of sea surface temperature, water turbidity, concentration of a chlorophyll-a, and other hydrological characteristics corresponding to the period of satellite supervision.

ADAPTIVE RESPONSE OF BIOTA TO THE TEMPORAL HYPOXIA IN THE NEVA ESTUARY (BALTIC SEA)

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High nutrient inputs to coastal areas of the Baltic Sea result in summer macroalgal blooms initiated by opportunistic filamentous algae. It is known that macroalgal respiration resulted in sediment anoxia and macroalgal detritus coupled with hypoxia/anoxia enhanced the production of hydrogen sulfide. The hypoxia is influenced strongly on bottom environments, facilitating decreasing abundance of benthic species. This paper studies dynamics of littoral trophic webs and adaptation of this biocenosis to low oxygen level induced by decaying macroalgae in the Neva estuary. The temporal hypoxia (5.4-24.5% or 0.6-2.8 mg/l) in the area near the bottom is usually recorded during 6-8 weeks of July-September, when great masses of drifting algae mats (phytomass of 315-445 g/m^2 at dry weight) are concentrated in coastal areas. The invertebrate community in the stressed habitats consists of eurybiotic taxa (chironomids, mollusks, and alien amphipods). Based on microscopic analysis of gut content and the Stable Isotope analysis (C, N) of tissues in dominating plant and animal taxa inhabiting the littoral zone, we demonstrated that alien amphipod and species are omnivorous possessing mixed feeding strategies and acting as grazers, collector-gatherers, and predators, and are the link between these types of communities. At the same time, they are able to tolerate the hypoxia caused by the algae decomposition over prolonged periods until they eventually migrate to areas with more favorable conditions. This behavioral adaptation can be considered as a mechanism facilitating the dominance of these taxa in the shallow coastal zone of the Baltic eutrophic areas. The role of such species in littoral food chains was assessed as important, and their impact on producer- and first-level consumers due to euryphages (varying percentage of plant and animal food in a diet) was variable, depending on types and oxygen conditions in habitats.

MODELLING WAVES WITH A HIGH-RESOLUTION WAVE MODEL IN THE COASTAL AREA OFF HELSINKI

Björkqvist, Jan-Victor; Tuomi, Laura; Pettersson, Heidi; Tikka, Kimmo; Fortelius, Carl; Kahma, Kimmo K.

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The coastal area off Helsinki in the Gulf of Finland has both a complex shoreline and bathymetry, which makes modelling the wave field especially challenging. As the shoals near the coast can potentially concentrate wave energy, the availability of a wave model that can accurately predict wave conditions is important to meet the needs of the heavy marine traffic and maritime spatial planning. The area outside Helsinki was modelled with the WAM third generation spectral wave model, using a high resolution 0.1 nmi grid. The modelled results were compared to measurements from six wave buoys during the period between August and November 2012. Wave buoy measurements are available from the open sea area in the central Gulf of Finland, from the outer edge of the archipelago and from four locations near the coastline inside the archipelago. The model predicted the wave field at the open sea with good accuracy. A comparison of the modelled wave field against the measurements available at the edge of the archipelago revealed a tendency of the wave model to overestimate the wave energy when waves were propagating from the south-west over an area of shallow depth. Studies with the coefficients used in depth-induced wave breaking and bottom friction source terms resulted in minor improvements in the accuracy of the modelled wave field. The possible deficiencies in the accuracy of the bathymetric data might be contributing to the overestimation of significant wave height. The results from the wave model were compared to those of a parametric wave-ray model to get a better understanding of the wave refraction in the area. The available altimeter data was also used to evaluate further the behaviour of the modelled wave field. Preliminary results showed that the wave model had a tendency to overestimate the wave energy at the locations of the wave buoys near the coastline.

MULTI-CYCLE ENSEMBLE OCEAN FORECASTING

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Forecasting the ocean leads to rapid error growth in response to errors in the initial conditions and applied forcing. As the error growth rates or forecast period increase, a single deterministic forecast becomes unreliable and a statistical description of the forecast skills becomes essential. However, ensemble forecasting at present remains computationally prohibitive for operational ocean forecasting. Several low-cost ensemble methods have been used in NWP and seasonal forecasting, such as time-lagged ensembles, super-ensembles, and bred-vectors. Time-lagged ensembles are directly applicable to a single sequential operational forecast system; however, Brankovic et al., [1990] showed that systematic errors reduced the gain from ensemble averaging. A novel approach is the so-called multi-cycle (M-cycle) ensemble. An M-cycle forecast system uses M cycles (each cycle is the standard data assimilating initialised model forecast) with only one cycle performed per forecast. The cycles are performed sequentially and then repeated every M forecast cycles. The background field has a factor M longer period to grow model errors compared with a standard sequential system; however, the gain is improved independence of the forecast model errors between the cycles.

In this talk we describe the Bureau of Meteorology Ocean Model, Analysis, and Prediction System (OceanMAPS), which has been implemented as a 4-cycle time-lagged system. By applying a least squares analysis to minimise the squared difference of the ensemble weighted average from the observations we obtain the weights for each ensemble forecast hour. Statistical properties and skills of the resulting forecasts are described. These properties (e.g. the ensemble variance) can be used to provide guidance to applications on the regions of the ocean showing ensemble spread above threshold values and to guide decision making where the uncertainties of the forecasts are critical.

RESULTS OF SATELLITE MONITORING OF OIL POLLUTION IN THE SOUTH-EASTERN BALTIC IN 2006-2013

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According to HELCOM data, during the last decade shipping has steadily increased around the Baltic Sea. This leads to increased pollution and other pressures on the marine environment. The dramatic rise in oil transportation significantly raises the risk of a large oil spill in the Baltic marine area.

Satellite monitoring of the sea surface of the South-Eastern Baltic was initiated by LUKOIL-KMN, Ltd. with the beginning of oil extraction on the "Kravtsovskoe" (D-6) oil field in June 2004. For the purpose of monitoring, radar data from four satellites were used: Envisat (ESA), Radarsat-1 (CSA), Radarsat-2 (MDA), and Cosmo-SkyMed (ASI). The satellites are equipped with radar tools (Synthetic Aperture Radar, SAR) allowing detection of spatial variability of small-scale wind waves, which are always observed at the sea surface as the pattern of returned signal intensity distribution (SAR images). Films of different origin, such as oil pollution, algae blooms, or ice fields locally modify the roughness of the sea surface detected by radar.

There are 462 satellite scenes which were received and analysed, and 877 oil spills were detected, including 452 oil spills in the area of monitoring. Due to the shape of the oil spill, it may be concluded that the main polluters of the sea surface are vessels. And according to SeatrackWeb (stw-helcom.smhi.se), the oil pollution in the area of Port Baltiysk could be a reason for oil pollution of the Curonian Spit's beaches.

Work was partly fulfilled within the framework of NATO SfP 984359 "Development of solutions for effective oil spill management in the South-Eastern Baltic".

VARIATIONS OF SEA SURFACE TEMPERATURE AND ICE CONDITIONS IN THE SOUTH-EASTERN BALTIC OVER THE LAST DECADE

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Thermal regime and ice formation processes in the South-Eastern Baltic for the period of 2003-2013 were observed. The sea surface temperature increase (+0.7° C/decade, p-level 0.05) was more intensive then the increase of air temperature (+0.02° C/decade, p-level 0.05). On the one hand, this is caused by the maximum negative trend of average seasonal air temperature in winter (-0.19° C/year, p-level 0.05), and on the other hand, sea surface temperature is influenced not only by air but also by water exchange and circulation.

According to the character of ice formation processes, different types of winters were detected. There were three soft winters during the period studied: 2006-2007, 2007-2008, and 2008-2009. Mild winters were observed in 2005-2006, 2009-2010, 2011-2012, and 2012-2013. Only one winter, 2010-2011, fits the severe conditions. The degree of ice propagation and stability of the ice cover were estimated. Short periods with different tendencies in ice formation were revealed. Hydrometeorological conditions of ice formation in the South-Eastern Baltic were shown. The study was conducted using satellite radar imagery, visual observations with photography, synoptic maps, and satellite data of infrared sea surface temperature. The research was conducted within the framework of the NATO SfP 984359 project.

INVESTIGATING THE BOTTOM BOUNDARY LAYER USING A SUBMERSIBLE PARTICLE IMAGE VELOCIMETER

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The main focus of this research is to assess the conformity of measured bottom boundary layer velocity profiles to theoretical velocity distribution which in laminar flow should note a logarithmic behaviour. The second goal is to apply these profiles to near-bottom sediment transport evaluation. Due to bottom roughness sediment transport in coastal waters mostly occurs under turbulent flow. In places where the bottom is flat and consists of fine grained sand the flow can be viewed as almost laminar. In current work the measurement stations were chosen to be located in the coastal area of Tallinn (Estonia), to have flat bed and to comprise high-amplitude waves with known propagation direction, mostly induced by high-speed vessels. Particle image velocimetry (PIV) device which was built in Marine Systems Institute at Tallinn University of Technology, was used to capture sediment particles moving along water. The size of a measurement area (field of view) was 1 meter by 1 meter. Lasers with sheet forming optics were used to illuminate the particles. Using PIV software subsequent video frames were processed and two dimensional velocity maps were generated. Further work involved statistical analysis and interpretation of the data. During extreme events when ship wakes crossed the station, strong turbulences were detected. When flow exceeded the critical shear stress, sediment resuspension was induced. The results were good enough to evaluate the bottom boundary layer velocity distribution.

This study was supported by Estonian Science Foundation (grant 9052) and Estonian Environmental Investment Centre (KIK 609).

TRACER DISPERSION FROM THE SOURCE BELOW THE THERMOCLINE DURING AN UPWELLING EVENT

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In general, upwelling is the vertical motion of water masses caused by horizontal divergence in the surface layer of the ocean. The vorticity dynamics of the upwelling events in the SE Baltic Sea has been analysed by A. Lehmann (Gurova et al., 2012). It was shown that the vorticity dynamics is related to depth variations in the direction of the flow.

The aim of the study was to reveal the path of the tracer distribution from the point source located below the thermocline and to evaluate the time needed for any dissolved material from the source at the bottom of the sea to approach the coastal waters during the upwelling event in the southeastern part of the Baltic Sea on the Lithuanian coast. The numerical simulation was carried out using the BSHcmod 3D hydrodynamic model adopted for the Lithuanian marine waters.

The modelled tracer distribution from the sources to the north of Klaipėda Strait up to the altitude of Palanga town has been analysed. In most cases, during an upwelling event the tracer from these sources has moved to the south from the source and has reached the coast in the vicinity of the Klaipeda Strait. It has then been spread with the surface water along the coast of the Curonian Lagoon down to Pervalka village (to the approximate altitude of 55°30’). It was shown that the tracer distribution during an upwelling event is influenced by the depth variation due to the so-called Old Riverbed of the Nemunas River in the SE Baltic Sea. It is also important to note that the relatively large portion of the Lithuanian seashore is exposed the water from below the thermocline during an upwelling event.

Gurova E. Lehmann A. and Ivanov A., Upwelling dynamics in the Baltic Sea studied by a combined SAR/infrared satellite data and circulation model analysis. OCEANOLOGIA, 55(3), 2013, 687–707.

DEPENDENCE OF THE NUMBER OF PRINCIPAL COMMERCIAL BALTIC SEA FISHES ON ABIOTIC FACTORS

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The aim is to search for possible statistical relationships between oscillations of the main commercial fish catches (cod, herring, sprat, flounder) and the variability of meteorological and geophysical processes

With this formulation of the problem, first of all, the following question should be answered: How much does the variability in catches reflect the dynamics of fish populations? It is clear that the catches are components not related to population dynamics and these include technical support fisheries, as well as the number of vessels in the fishery, quotas, and the number of storm days, etc. Yet, as shown by the results of the average value of catches, they are rather closely related to the overall population dynamics of field facilities.

Variability of catches, as well as population dynamics depends, including the variability of the set of natural factors, so to assess the relationship between these values is appropriate to use, including integral indices of atmospheric and oceanic circulation. The independent variables tested a set of 10 predictors for the period of 1982-2012.

Correlation and cross-correlation analysis was executed by the standard techniques used to obtain the regression dependence.

Steady regression dependencies with high coefficients of determination were obtained. A prognostic model of linear multiple regression catches depending on the variability of abiotic processes was built.

Statistical evaluation of the quality of regression models allows us to make conclusions about their adequacy.

OFFSHORE SPREADING OF BUOYANT BULGE FROM NUMERICAL SIMULATIONS AND LABORATORY EXPERIMENTS

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This study examines the ability of a three-dimensional hydrodynamic model, Regional Ocean Modeling System (ROMS), typically used for geophysical scale simulations to reproduce buoyant flow at laboratory scales of O[1 cm]. The laboratory experiments consist of a rotating circular basin filled with salty water into which fresh water is introduced perpendicular to a straight tank wall. The numerical domain is a rectangular basin with three open boundaries and a wall with a 5-cm-wide gap for the inflow channel. All together, 11 pairs of laboratory-numerical experiments and an additional 3 numerical experiments were conducted by varying rotation rate, ambient salinity, and inflow rate, including oscillatory inflow as a proxy for tides.

Development of a freshwater bulge and "downcoast" coastal current was observed in all experiments. Two phases of bulge spreading are identified. The initial rapid spreading phase lasts less than 0.3T and slow linear spreading lasts until the end of the simulation. During the first phase, a difference arises between numerical and laboratory setup. Bulge spreading agrees remarkably well with inflow Kelvin number around . When K>1/K<1, the model underestimates/overestimates the bulge offshore distance. Physical processes of discharged water have been affected in numerical simulations before the inflowing water enters the main basin. This does not have a notable effect on spreading during the second phase. During the second phase, bulge offshore distance grows linearly and irrespectively of the Kelvin number. Laboratory bulge spreading scales with internal radius during the first phase and with bulge Rossby radius during the second phase. Numerical bulge spreading scales best with inflow Rossby radius during both phases. This indicates difference in the way the model handles vertical mixing. Laboratory bulge offshore spreading during the second phase is proportional to geostrophic depth, while the numerical model scale with inflow depth.

VISUALLY OBSERVED WAVE CLIMATE IN THE GULF OF RIGA

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The Gulf of Riga is the third largest semi-sheltered gulf of the Baltic Sea. Its connections with the Baltic Proper and with the Moonsund (Väinameri) are narrow and shallow. As a consequence, wave fields in the Gulf of Riga are largely disconnected from the wave activity in the rest of the Baltic Sea and are governed by local winds. The basic properties of wave fields in this gulf are evaluated using recently digitized records of coastal visual wave observations at Ruhnu and Sõrve for 1954–2011. The observation site on the coast of Ruhnu Island (57°47' N, 23°15'32" E) is located close to the center of the gulf and evidently represents well the waves generated by winds from almost all directions. The other site (57°54'4" N, 22°03'28" E) near the tip of Sõrve Peninsula is almost completely sheltered from waves approaching from the predominant wind directions (southwest and north-northwest) and mostly represents waves excited by southern and eastern winds in the Gulf of Riga.The basic features of the wave climate in the Gulf of Riga are similar to those in other parts of the Baltic Sea. The average wave heights are relatively low, at about 0.5 m at Ruhnu and 0.35 m at Sõrve. Waves are shorter than in other parts of the Baltic Sea: The typical periods are 3–4 s at Ruhnu and below 3 s at Sõrve. The annual course of wave heights at Ruhnu is more pronounced than in the open parts of the Baltic Sea, but this course at Sõrve is relatively modest. The datasets reveal no distinct trend in the annual mean wave heights. While the Ruhnu dataset contains extensive interannual and decadal variations in the observed wave height, the observations from Sõrve show no substantial variations. The correlation between annual mean wave heights at these two sites and with data from the open Baltic Sea coast is modest. The results reflect the substantial anisotropy of the wave climate for the Gulf of Riga, which has relatively large wave intensity in its central and eastern regions.

STORMWATER IMPACT ON THE COASTAL AREA OF THE TALLINN BAY

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An unpleasant odour on the northern coast of Tallinn Bay has been a serious problem for several years. The waterfront area is becoming unattractive to tourists and holidaymakers, and the cause of this problem originates from the decaying green algae detached from its substrate.

The aim of this study is to clarify factors corresponding to the spread of algae in the investigated area and to offer solutions to the problem. For this reason, water samples from stormwater outlets, as well as from the coastal and open sea, were analysed against the nutrients – dissolved and total nitrogen and phosphorus. The current profile near the Pirita River estuary also was logged during summer and fall 2012. Analysis of water samples showed that in the summer nutrient concentrations in river and outlet water are two-three orders higher than in the open bay, and that the concentration of nutrients, especially of dissolved nitrogen, increases with rain intensity. This means that in rainy periods the nitrogen influx increases very rapidly due to both reasons – the greater amounts of outlet water and the higher nitrogen concentration in it at the same time. These data enabled estimation of nutrient daily influxes through the river estuary and distinctive outlets, and last at least using a model describing the distribution of nutrients over the coastal area.

It is shown that up to 95% of the load comes from the Pirita River and only 5% from the outlets, but despite this some greater outlets may play a role in algae blooms.

Modelling also showed that the impact of storm water outlets could be eliminated by pumping the storm water further (~1 km) into the open sea. As the environmental status of Tallinn Bay depends predominantly on the Pirita River influxes, this measure should be effective, cost effective, and harmless (to the bay) at the same time.

This study was funded by the Estonian Environmental Investment Centre (proj. 609).

PROFILES OF HG, CD, CU, PB AND ZN, PCDDS, PCDFS AND DL-PCBS IN THE BOTTOM BOUNDARY LAYER OF SOME NORTH ESTONIAN COASTAL AREAS

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A new patented device (US 8,511,184 B2, Aug. 20, 2013) for taking samples from the bottom boundary layer (BBL) was worked out at the Marine Systems Institute and constructed by Dimentio LLC. It was tested in Estonian coastal waters: Tallinn Bay, Kopli Bay, Muuga Bay, Ihasalu Bay, Kunda Bay, and Narva Bay. Compared to other sampling devices which have been used earlier, this new device enables simultaneous taking of undisturbed profiled samples from the bottom (soft) sediments, BBL, and water, i.e. to obtain samples with composition and stratification representing the actual condition at the site as truthfully as possible.

Collected samples were analysed against Hg, Cd, Cu, Pb and Zn, 7 polychlorinated dibenzo-p-dioxins (PCDD), 10 polychlorinated dibenzofurans (PCDF), and 12 dioxin-like polychlorinated biphenyls (dl-PCBs). Chemical analyses showed that the content of the most toxic HELCOM metals Hg, Cd, and Pb was very low in most stations, but considerable amounts of Zn and Cu were found in the near bottom water layer (55 μg /L of Zn and 3 μg/L of Cu) as well as in soft sediments (50 mg/kg of Zn dry matter (d.m) and 20 mg/kg d.m.of Cu) at some stations. They exceeded the Estonian limit values for heavy metals in only a few cases. The highest concentrations of PCDD/Fs (WHO-TEQ 2005 value up to 6 ng/kg d.m.) and dl-PCBs were found in deeper areas of Tallinn Bay and Muuga Bay. Thus far Estonia has not introduced any quotas for dioxins and furans, but compared with the Norwegian classification the present results stood in the background value (< 10 ng/kg d.m.). Taking into account the maximum concentrations of all investigated metals and compounds that were found in the lower layers of sediments (6 – 15 cm), it can be considered that from the view of HELCOM metals, PCDDs, PCDFs, and dl-PCBs, the environmental status of BBL in investigated areas is very good.

The project was funded by the Estonian Environmental Investment Centre (proj. 657) and Estonian Science Foundation (grant 905).

ON THE POSSIBILITIES OF MONITORING ALGAE BLOOM WITH RADAR

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Intensive algae bloom is a serious threat to the ecology of inland waters and shelf areas. Optical satellite systems which are widely used to monitor algae bloom areas have strong limitations on their operation at night and/or during cloudy skies. A very effective all-weather and day-and-night instrument for algae bloom monitoring could be satellite microwave radars. Alpers et al. (2003) hypothesized this possibility, but there was no direct proof of the relation between radar backscattering and algae characteristics, and the very physical mechanisms of this relation were not well understood. This paper aims at better understanding these physical mechanisms, and also perspectives of quantitative characterization of algae bloom using radar.

The problem was studied in a field experiment on the Gorky Water Reservoir. Water samples with algae and surface biogenic films were collected simultaneously with radar measurements from a boat. Concentrations of main algae constituents and total algae concentration were measured. Laboratory studies of the damping of gravity-capillary waves on the water and film samples were performed, and the water viscosity and film elasticity were estimated as functions of algae concentration. Reduction of X-band radar backscattering with algae concentration was revealed, and the enhanced water viscosity and film elasticity were shown to be responsible for wave damping and for radar backscatter depression. Model calculations of radar backscatter were obtained to be in good agreement with the experiment. Nearly simultaneous and co-located boat and satellite TerraSAR-X observations have confirmed correlation between the areas of radar backscatter depression and enhanced algae concentration, even at moderate-to-strong winds, thus evidencing that radar can be used for monitoring of water biogenic pollutions.

This work was supported by RFBR (Projects 13-05-97058? 13-05-97043, 14-05-00876, 14-05-10075k,) and RAS (Program Radiophysics).

HOW TO DIFFERENTIATE BETWEEN COASTAL COOLING AND UPWELLING EVENTS IN SST IMAGES?

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We aim to find in MODIS (Aqua, Terra) SST pictures of the South-Eastern Baltic those characteristic features, which allow us to distinguish the differential coastal cooling from the coastal upwelling events, even though their manifestations look very similar. The basis is data from MODIS (Aqua, Terra) spectroradiometers for 2000-2013. We analyse horizontal SST profiles above coastal slopes under conditions of autumnal cooling and during well-known upwelling events. The SST profiles above slopes are formed as a result of joint contribution of heat exchange with the atmosphere and horizontal transport of heat from the sea. Satellite images of October-November, corresponding to the periods of well-pronounced decrease in air temperature (with time rate of change as large as 0.86-2.54 C/day) were analysed. The typical shape of the profiles, demonstrating the presence of differential coastal cooling over the distance of 10-20 km from the shore, allows for allocation of the region where thermocline meets the slope, and gives (for the given bathymetry) information on the current thickness of the upper mixed layer (UML). The shape of the SST profile is quite conservative, not sensitive to the steepness of the bottom slope, bathymetry peculiarities, and intensity of cooling and even wind conditions, indicating that sea-shelf heat exchange is in general close to the steady state. The SST drop from open to coastal area is about 2-3° C and does not depend on the thickness of the UML or the steepness of the slope. On the other hand, about 90 events of coastal upwelling in May-November 2000-2013 in the South-Eastern Baltic were selected and the features of the horizontal SST profiles above the same coastal slopes were analyzed. It appeared that the shape of the SST-profiles demonstrates the presence of upwelling quite definitely, which allows for effective differentiation from the coastal cooling effects.

These studies were supported by RFBR, grant number 13-05-01041a.

MODELING OF WIND WAVE-INDUCED SEDIMENT TRANSPORT IN THE COASTAL ZONE OF POLISH MARINE AREAS (SOUTHERN BALTIC)

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The specific question to answer in this research is how waves of certain characteristics affect the morphodynamics of the coastal zone. For this purpose, wind-wave fields were determined on the basis of a spectral model which takes into account the non-linear nature of fluctuation and also the processes of energy dissipation of the near shore zone.

In the whole Baltic Sea, the WAM model (WAMDI group, 1988, Komen et al., 1994) was used. In the coastal zone, we made use of the SWAN model.

As input data, we used a bathymetric map of the bottom and a homogeneous wind field (direction and speed value). Simulations were performed for 80 distinct wind cases. Subsequently, for each individual case the regional load of sediments was calculated using two different approaches to the modeling of transport. The former consists in determining transport directly from the wave parameters (significant wave height, peak period, propagation direction) with the use of the CERC formula. The latter method requires the designation of the wind wave-induced bottom orbital currents with a wave model, and then determination of the total sediment transport on the grid. Calculation of total load of fine sand is made by using the transport formula of Engelund-Hansen (1972). The result presents maps showing the orbital velocities, wave parameters, and sediment transport according to two methods used for main wind directions.

OBSERVATION OF HIGH-RESOLUTION WIND FIELDS AND OFFSHORE WIND TURBINE WAKES USING TERRASAR-X IMAGERY

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The space-borne synthetic aperture radar (SAR) is a unique sensor that provides two-dimensional information on the ocean surface. Due to their high resolution, daylight and weather independency, and global coverage, SARs are particularly suitable for many ocean and coastal applications. Numerous large-scale offshore wind farms have been built in European waters and play an important role in providing renewable energy; therefore, knowledge regarding the behavior of wakes induced by large wind turbines and their impact on wind power output is important. The spatial variation of the offshore wind turbine wake is very complex, depending on wind speed, wind direction, ambient atmospheric turbulence, and atmospheric stability. In this study, we present a case at the Alpha Ventus offshore wind farm to investigate turbine-induced wakes and the retrieved sea surface wind field. Using the wind streaks visible in the TerraSAR-X image and the shadow behind the offshore wind farm induced by turbine wake, the sea surface wind direction is derived and subsequently the sea surface wind speed is calculated using the latest generation of wind field algorithm XMOD2. The retrieved results are validated by comparing with QuikSCAT and LiDAR measurements, the results of the German Weather Service (DWD) atmospheric model, and in situ measurements of wind speed and wind direction.

AUTOMATED DETECTION OF CROSSING SEAS FROM SIMULATED WAVE SPECTRA

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The presence of crossing seas in the nearshore may lead to drastic amplification of local wave heights or to a substantial change in the orientation of the highest parts of the wave crest, owing to nonlinear interactions of waves in shallow water. The location and strength of the related effects can be roughly forecast based on the properties of crossing wave systems in the framework of the Kadomtsev-Petviashvili equation. We introduce an automated method for identification of crossing seas and singling out the properties of interacting wave systems from numerically simulated wave spectra in the Baltic Sea. The starting point forms two-dimensional wave energy spectra obtained within a multi-decadal (1957–1991) wave hindcast using the WAM model. Each spectrum spans 24 evenly spaced directions and 42 frequencies starting from 0.042 Hz (23.8 s) to about 1.067 Hz (0.94 s). The numerically replicated spectra usually contain a certain level of noise, which may lead to the detection of false maxima. As a result, more than 70% of raw spectra formally contain crossing sea states. Such noise is filtered out using a Gaussian-type convolution filter of the proper amplitude. We then test each sample of the resulting anti-aliased distribution with a pyramid-shaped stencil in order to find the spectral density, frequency and direction of all relative maxima. Once all of the maxima are found, their frequency and direction are then mapped back onto the initial unfiltered spectrum. Finally, the heights of the relevant, almost-unidirectional wave systems are evaluated. This procedure reduces the proportion of crossing spectra to the realistic level of about 20%.

ON THE POSSIBILITY OF SPONTANEOUS PATCH FORMATION IN THE GULF OF FINLAND

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Most environments on Earth, including seas and oceans, are spatially and temporally heterogeneous across a wide range of scales. Localised areas of increased concentration of any biogeochemical variables from ambient measures are often referred to as patches. An intrinsic mechanism of spontaneous patch-generation is a system of complicated three-dimensional motions in the water column affecting a two-dimensional field of items or substances that are concentrated at the sea surface. The surface fields may exhibit extensive contraction or expansion, depending on the sign of divergence of the surface velocity field. The most efficient generation of patches occurs when by semi-persistent localised convergence zones move along the water surface together with the surface current. Its impact can be characterised using the so-called finite-time compressibility of surface velocity fields. This measure systematically accounts for the correlation between an emerging patch, its Lagrangian transport, and relocation of the convergence field.

Velocity fields in the Gulf of Finland are analysed from the viewpoint of occurrence of relatively high levels (exceeding the clustering threshold) of finite-time compressibility, which correspond to the possibility of rapid spontaneous clustering of surface floats (e.g. plastic debris) or contaminants locked in the uppermost layer of the sea. Analysis of the duration of peaks of finite-time compressibility is performed using 3D velocity fields simulated for the period of 1987-1991 with the OAAS model (O. Andrejev and A. Sokolov) and with a spatial resolution of 1 nautical mile. We show that nine regions of the gulf display frequent values of finite-time compressibility above the clustering threshold. Six of these areas are located along the coast and roughly coincide with frequent downwelling areas, whereas three of these areas are located in the central area of the gulf.

INDICATOR METHOD FOR ESTIMATION OF THE HUMAN IMPACT ASSESSMENT FOR LOCAL COASTAL MUNICIPALITIES

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Use of the Human Impact Assessment (HIA) estimation method for local coastal municipalities allows evaluation of the natural-ecological state / environmental situation of a local coastal municipality, and provides an opportunity to show the hierarchy of municipalities and determining the HIA, vulnerability, and opportunity for its future development.

In the paper, the indicator method for estimation of HIA for coastal local municipalities and its main assumptions are formulated. Due to the analysis of HIA, the list of factors for estimation of the natural-ecological state / environmental situation of a coastal local municipality was obtained. For each selected factor, the method of indicator value calculation, as well as the calculation of the integrative indicator of the nature-ecological state for a coastal local municipality (or HIA for coastal local municipalities) as an average of indicators, is proposed. This integrative indicator which is calculated for each coastal local municipality of a region shows the state of the ecological situation in the area of a coastal local municipality.

Application of the method is considered for local coastal municipalities of Leningrad Oblast. Recommendations for reduction of human impact for local coastal municipalities are made based on the indicators and integrative indicator values.

ON THE DYNAMICS OF LAKE SHIRA

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Numerical modeling of currents in Lake Shira (Krasnoyarsk region, Russia) is implemented on the basis of POM. The wind of constant direction that increases during 12 h from 0 to 8 m/s, then remaining constant for 2 days and decreasing for 4 h to 0 m/s was set as the driving force. Analysis of sea surface elevation and current velocity distributions allows us to suggest that the dynamic of Lake Shira is mainly determined by the first mode of the Kelvin wave with a period of ~11 h spanning the whole lake. It is determined by the second mode with a period of 5-6 h to a lesser extent. Current velocity measurements with ADCP (RDI 600) mounted on the bottom confirmed the assumption about the significance of the first and second modes of the Kelvin wave in the dynamics of Lake Shira.

DOWNSCALING TO STUDY STRAITS, INLETS, AND TIDAL DYNAMICS: UNSTRUCTURED GRID MODEL SIMULATIONS IN THE NORTH AND BALTIC SEAS DURING A STORM SURGE EVENT

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One-way nesting, which is the most widely used downscaling approach in the coastal ocean, makes it impossible to account fully for the large-scale influence of coastal ocean processes; thus, the interaction between the coastal and open ocean is misrepresented. Unstructured grid models provide a seamless framework from the global to the coastal scale. The application of one such model (SELFE) to the coupled North Sea and Baltic Sea area is presented for a storm surge situation that occurred in December 2013. SELFE (A Semi-implicit Eulerian–Lagrangian Finite-Element model for cross-scale ocean circulation) is an open-source community-supported code based on unstructured triangular grids, and designed for the effective simulation of 3D baroclinic circulation. In our applications, far from the areas of major research interest, the model is forced by data originating from MyOcean operational products. The description of simulations is focused on the mesoscale and sub-mesoscale processes, which control the connection between very different oceanographic areas where there is a high demand for extremely fine resolution. Such areas include the straits connecting the Baltic and North Seas, the tidal inlets connecting the open ocean with the tidal basins, and the narrow topographic channels acting as propagators of exchange between coastal and open ocean.

PHYTOPLANKTON BLOOM PATTERNS FROM 14 YEARS OF AUTONOMOUS OPTICAL OBSERVATIONS IN THE BALTIC SEA

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The Baltic Sea exhibits two major annual phytoplankton bloom events during spring and summer, occasionally followed by winter bloom. Nutrient and light availability are driving forces behind the bloom succession. Temperature and variable mixing depth add to the variability in bloom duration and severity. The weather-driven phytoplankton bloom phenology has received little attention in literature, and tends to be disconnected from remote sensing studies of water quality, which are limited to cloud-free observations.

A dense network of autonomous sampling systems (ferryboxes) has been operational for more than two decades, offering high spatio-temporal coverage throughout the Baltic Sea. Here, we analyze a 14-year time series of phytoplankton pigment fluorescence from Algaline ships-of-opportunity. Nutrient information, modeled mixed-layer depth, and ice cover are used to explain high-level patterns found in bloom succession and magnitude.

Magnitude and timing of both spring and summer bloom were found to vary remarkably over the period studied. As expected, spring blooms are initiated by increasing irradiance (solar elevation and reducing ice cover) and the depletion of nutrients coincides with the peak of the spring bloom. In summer, deep mixing events appear to have triggered bloom development in several cases, suggesting nutrient renewal from deeper layers. Rare winter bloom events were found in periods of nutrient availability, suggesting that low-light tolerant species occasionally thrive under specific meteorological conditions.

Our results strongly support the assimilation of remote sensing and in situ observations with physical models. No individual source of information is sufficient to explain the complex bloom dynamics found in the Baltic Sea. Suggestions are presented (and open to discussion) on how data integration may take place at an operational level.

MACROALGAL BLOOMS AS A FACTOR OF POLLUTION IN THE EASTERN GULF OF FINLAND

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During the last decades the macroalgal blooms in most coastal areas of the eastern Gulf of Finland were recorded. In the middle of summer the biomass of macroalgae can reach high values. Detached decaying macroalgae accumulate on the shore and lead to secondary pollution of the coast. Elemental composition of two dominant species, Cladophora glomerata (L.) Kutz. and Ulva intestinalis L., was defined. On the basis of data on the biomass of macroalgae loading of carbon, phosphorus, nitrogen, sulfur and trace metals on coastal zone were assessed. Element content in algal biomass was different at different sampling sites. At sites where C. glomerata was predominant in the algal community, the loading of phosphorus, carbon, nitrogen and sulfur were 0.875±0.108, 160.7±2.5, 10.96±0.379 and 4.3±0.15 g per m2, respectively. At sites with U. intestinalis as the dominant species, the loading of phosphorus, carbon, nitrogen and sulfur were 0.443±0.05, 99.25±0.6, 2.9±0.2 and 3.6±0.3 g per m2, respectively. The content of trace metals in algal biomass varied in samples from different sites. The highest concentration of copper, lead and zinc were detected in algal tissues from Primorsk (northern shore) and were 15.5±2.23, 21.5±2.6 and 73.4±8.6 mg per kg DW. The highest concentrations of chromium and nickel were detected in algal tissues from the southern shore and reached 18.5±0.9 and 10.4±0.1 mg per kg DW.

Thus, the fast-growing macroalgae can be a source of additional loading of nutrients and trace metals in the coastal zone.

TOPOGRAPHIC PROPERTIES OF SEA ICE AND SURFACE ROUGHNES IN BOTH CRYOSAT-2 AND SAR SUB-FOOTPRINT SCALES

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The NASA IceBridge ATM Level-1B Elevation and Return Strength (ILATM1B) datasets from the 13.10.2013 ATM measurement flight of Operation IceBridge Mission Endurance (Weddell Sea/CryoSat-2) were used to study the topographic properties of sea ice and surface roughness in both Cryosat-2 and SAR sub-footprint scales.

The roughness of the sea-ice surface is also an important parameter for many other sea-ice research questions, such as modelling momentum and heat transfer between the pack ice and atmosphere and understanding the effect of sea-ice variations in a footprint scale of the satellite observations. For satellite altimeters, the sub-footprint sea-ice elevation variability has a direct effect on satellite freeboard measurements, since the method to retrieve sea-ice thickness is based on the travel times of several received echoes. For satellite SAR measurements, the magnitude of backscattering echoes also depends very strongly on the surface roughness of the sea ice.

Knowledge of the spatial variability or patchiness of sea-ice roughness is currently rather limited. Most of the earlier studies have been based on 1D laser altimetry measurements, either airborne or satellite. The majority of studies that use 2D laser altimetry data are, however, using 1D statistical methods for data analysis, and the focus is still on the elevations, not on the 3D structure of the ice surface. In this case study a new approach was used: The topographic properties of the sea ice surface were studied in sub-footprint scale by using terrain analysis techniques.

The presented study and preliminary results are one part of the ANTLOAD project 'To quantify Antarctic ice thickness by in situ observations, radar altimetry, and modeling, and use the results to assess the performance of ice-going ships'.

THE SPATIOTEMPORAL VARIATION OF AEROSOL IMPACTS ON CHLOROPHYLL CONCENTRATION IN THE SOUTH CHINA SEA

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The satellite-derived Orbview-2/SeaWiFS sea surface chlorophyll-a concentration (Chl-a) and Aqua/MODIS aerosol optical depth (AOD) data are used to investigate aerosol influence on the Chl-a in the South China Sea (SCS) in this study. By comparing the AOD retrievals with the in situ AERONET data around the SCS, a high correlation is found, and the correlation coefficient can even reach 0.9 on Dongsha Island, which is located in the northern SCS. In addition, the empirical orthogonal function (EOF) analysis of AOD in the SCS presents that the high AOD always happens around the offshore areas of China, Indo-China, Sumatra, and Borneo.

Through the EOF analysis, spring is the major season of occurring coarse aerosol particles (AOT_C). However, the amplitude of EOF variation is slightly constricted during the El Niño period, but the amplitude is enlarged during the La Niña epoch. The EOF analysis of fine aerosol particles (AOT_F) shows that the event may occur yearly or every six months, for the biomass burning is found in Indo-China during March and April, and so it is in Sumatra and Borneo from August to October. On the contrary, the EOF variance amplitude of AOT_F gets larger during El Niño, but during the La Niña period the amplitude is restricted. After the Chl-a data are analyzed through EOF, the result shows that the high value of Chl-a mainly appears in winter and it is found in some regions, including the northwestern offshore area of Luzon (the northern SCS), the Gulf of Thailand. The result also shows that the EOF amplitude of Chl-a is weakened both during the El Niño and La Niña periods. Compared with AOT_F, the AOT_C relates more highly and significantly with the Chl-a in the northern SCS.

Keywords: Remote sensing, Aerosol optical depth, Chlorophyll-a, South China Sea (SCS)

DUAL CO-POL SAR IMAGING OF OCEAN CURRENTS

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An approach recently suggested by Kudryavtsev et al. (2013) for analysis of co-polarized (VV and HH) SAR images is extensively employed to interpret imaging mechanisms of surface current features. Following this approach, co-pol SAR images are transformed into two other images: One whose intensity is dominated by polarized resonant scattering (PD), and the second whose intensity is dominated by non-polarized returns from breaking waves (NP). The PD image is related to short Bragg waves, which are fast-response waves, and this image carries information about wind field variability and surface slicks. The NP image is linked to «scalar» radar returns associated with breaking waves. Since wave breaks are sensitive to surface current, the NP image carries information about sub- and mesoscale ocean currents. While the NP image also strongly depends on wind speed, it reflects the combined impact of current and wind field features. Wind field variability can be effectively removed using the PD image. After wind removal, a new image clearly depicts surface current feautures.

A number of Fine Quad Pol Radarsat-2 SAR images acquired over the White Sea in July 2012 and supported by in situ ship measurements are presented and analyzed. These SAR images exhibit signatures of numerous upper ocean phenomena (internal waves, mesoscale current features, and temperature fronts), as well as near-surface wind field peculiarities. Distinctly different quantitative manifestations are derived in PD and NP images, being strongly dependent on radar-look-direction relative to the wind direction, wind speed, and scale of the ocean features. As revealed, the current features are well detected in NP images and almost invisible in PD images, suggesting that the modulation of wave breaking plays the dominant role in the formation of surface signatures, while the impact of Bragg waves' modulations is negligibly small.

The Radar Imaging Model is invoked to support the interpretation of these observations.

INVESTIGATIONS OF LAKE SHIRA WITH FIELD AND NUMERICAL STUDIES

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Our report focuses on field measurements in the lake during 2009-2013 and numerical modeling of flow structure.

The flow velocity, temperature and salinity distribution and fluctuations of the thermocline (density) were measured in summer.

Three-dimensional, primitive equation, numerical model GETM is applied to simulate hydrophysical processes in Lake Shira. The model is hydrostatic and Boussinesq.

An analysis of spatial and temporal variability of the major hydrophysical characteristics leads us to conclude that certain meteorological conditions may cause internal waves in this lake.

COMBINING AIRBORNE AND TERRESTRIAL LASER SCANNING TO MONITOR COASTAL PROCESSES

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Laser scanning is a remote sensing technology using laser pulses for acquiring high-resolution and high-accuracy spatial data about the 3D surface of the object measured. This study explores the potential of the terrestrial laser scanner (TLS) mounted on a tripod to quantify relatively short-term and spatially inhomogeneous changes to the subaerial beach, and to characterise the intensity of coastal processes. The joint effect of different physical processes (wave loads, wind impact) on beach evolution is studied using two beach segments of the Tallinn Bay area as an example. The extent and distribution of erosion and accumulation spots near the 'Russalka' monument and in a certain location of Pirita Beach are analysed by means of creating and comparing two Digital Terrain Models (DTM) of these areas from scanning point clouds obtained in different seasons. The study reveals not only corresponding volume changes along shorelines but also several features of redistribution of sand in the study areas. The results are verified against similar measurements made using an airborne laser scanner. As expected, after elimination of systematic errors, the ALS/TLS combination yields sub-decimetre accuracy for height determination on those beaches. Based on these worked-out examples, we also discuss the benefits and shortcomings of combining the two laser scanning methods for monitoring coastal processes, issues related to methodology for such field measurements, the process of eliminating possible systematic errors, final data processing, methods of analysis and interpretation of the results, and the accuracy of the results.

EXPLORING SEA SURFACE HEIGHTS BY USING AIRBORNE LASER SCANNING

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Globally, sea surface heights (SSH) are determined using satellite altimetry (SA). However, the achieved SA data resolution is relatively low; moreover, near coastal areas or in enclosed water bodies the SA data have poor accuracy. In order to monitor SSH regionally airborne laser scanning (ALS) can be used. ALS is a remote sensing technology for acquiring high-resolution and high-accuracy spatial data about the 3D surface of measured object. A Light Detection and Ranging (LiDAR) device mounted on an aircraft emits laser pulses and registers the reflections from a land or water surface, resulting in a point cloud.

A case study was carried out on the southern shores of the Gulf of Finland, the Baltic Sea. Several intersecting ALS profiles flown at different altitudes were used. In order to validate the accuracy of resulting SSH, cross-validation between intersecting ALS profiles and comparisons with the regional geoid model, in conjunction with tide gauge readings, were used. Additionally, attempts were made to identify the usability of data acquired from different elevations and at different scan angles, and also an optimal width of the nadir-corridor containing good quality ALS data.

MODELLING PRIMARY PRODUCTION BASED ON SATELLITE DATA IN DIFFERENT TYPES OF LAKES

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The productivity of lakes has a marked importance in the estimation of their ecological state and for predicting their development in the future. Data on seasonal and spatial variations of primary production is needed to estimate the ecological state of lakes. In situ approaches are not suited to reliable measurement of primary production on a large scale. Combining model simulations with remote sensing may provide a desirable solution. We used a semi-empirical model that estimates primary production as a function of photosynthetically absorbed radiation and quantum yield of carbon fixation. The necessary input parameters of the model can also be obtained from satellites, facilitating a totally new perspective for primary production studies of lakes. The input parameters needed for the model are: concentration of chlorophyll a, downwelling irradiance, and the diffuse attenuation coefficient. The objective of this study is to evaluate and validate how well a lake primary production model using satellite products as input data performs in different types of lakes. In this study, the productivity was modelled for large oligotrophic and eutrophic lakes in Switzerland and Estonia. The model simulation results obtained with the satellite data as an input were validated against real in situ data. Based on the result, we can study temporal and spatial changes in the ecological state of lakes.

WIND WAVE DIRECTION IMPACT ON THE LONGSHORE SEDIMENT TRANSPORT RATE, SE BALTIC SEA COAST

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The Lithuanian coast of the southeastern part of the Baltic Sea represents a generic type of more or less straight, high-energy (in Baltic Sea conditions), actively developing coasts that contain a relatively large amount of finer, mobile sediments, are open to predominating wind directions, and are exposed to wave activity for a wide range of wave approach directions. The combination of the angular distribution of winds and the geometry of the coast are such that the wave-induced longshore sediment transport is, on average, to the north over the entire Curonian Spit and the mainland coast of Lithuania. Analysis of the field data performed by the Žilinskas from 1976-2007 revealed that the length of accumulative sections has been considerably reduced. Accordingly, the length of the gradually eroding sectors has increased at the end of the 20th century. In this study, potential variations were analysed in the longshore sediment transport rate due to changes in the wind wave directions.

Sediment transport rate is estimated by the energy flux model, also known as the Coastal Engineering Research Centre (CERC) model. The study area covers the entire coast of Lithuania. The entire coast was divided into 90 grids, approximately 1-km-long beach sectors, at the 3 m depth isobaths. Wave directions are calculated every 10 degrees.

Most intensive longshore sediment transport from south to north was induced by waves from the south. When changing wave approach direction to the SW, the longshore sediment transport rate becomes smaller. Waves from the WSW induce longshore sediment transport from the opposite direction, from north to south. Westerly waves already induce maximum sediment transport to the south. It should be noted that wave direction shifting further to the north induces sediment transport to the north again.

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IMPERMANENT WAVE CLIMATE REGIME IMPACT ON SHORELINE CHANGES ON THE SE BALTIC SEA COAST

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Short-term seashore position variation under an impermanent wave climate on the Lithuanian coast was studied. The Lithuanian coast (90,6 km) of the southeastern part of the Baltic Sea represents a generic type of more or less straight, actively developing coasts that contain a relatively large amount of finer, mobile sediments that are open to predominating wind directions and are exposed to wave activity for a wide range of wave approach directions.

In this study, the assesment of long- and short-term coastal changes was performed using cartographic maps from 1947–2010. Twenty locations of the shoreline from different years were derived from collected historical topographic maps and orthorectified aerial photos using ArcGis 9.3 software. In order to determine the pattern of shift, the relative distance to the historical shorelines was measured along 179 transects. Wind wave data (wave height, direction, and period) was based on the meteorological data from Klaipeda hydrometereological station from 1961–2010.

According to shoreline changes, the Lithuanian coast was divided into three groups: accumulative, erosive, and quasi-stable. Quasi-stable shoreline sectors in the short term (3–5 year period) may have accumulation and erosion features.

Analysis of the wave data showed that during the last fifty years there were no considerable changes in wave intensinty (yearly mean wave height varied from 0,6 to 1 m), while substantial changes in wave approach direction (from W–NW to SW and back) have occurred.

Short-term shoreline movement depends on the predominant wave direction. During calm wave conditions even an insignificant change in predominant wave direction could cause noticeable shore retreatment or accretion. At the same time, accumulative or errosive shoreline sectors (in the long-term perspective) are not influenced by the intermittent wave climate.

This study was partially supported by “Lithuanian Maritime Sectors’ Technologies and Environmental Research Development" (VP1-3.1-ŠMM-08-K-01-019).

ADVANCES IN COASTAL WETLAND REMOTE SENSING

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To plan for wetland protection and sensible coastal development, scientists and managers need to monitor the changes in coastal wetlands as the sea level continues to rise and the coastal population keeps expanding. Advances in remote sensor design and data analysis techniques are providing significant improvements for mapping natural and man-induced changes in coastal wetlands. New techniques include fusion of multi-sensor, multi-resolution, multi-temporal images; object-based and knowledge-based classification algorithms; wetland biomass/health mapping with lidar, radar, and imagery; high-resolution satellites; hyperspectral sensors; and wetland monitoring using drones. Results of case studies show that analysis of the new satellite and aircraft data combined with some on-the-ground observations enables researchers to effectively determine long-term trends and short-term changes of wetland vegetation and hydrology. The objective of this paper is to review recent developments in wetland remote sensing and to evaluate the practicality and cost of the new techniques.

ADVANCES IN FISHERIES APPLICATIONS OF REMOTE SENSING

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During the past four decades, the fisheries productivity of the world has been declining due to pressures from overfishing, habitat change, pollution, and climate change. Sustainable use of marine resources requires effective monitoring and management of the world's fish stocks. Remote sensing techniques are being used to help manage fisheries at sustainable levels, while also guiding fishing fleets to locate fish schools more efficiently. Fish tend to aggregate in ocean areas that exhibit conditions favored by specific fish species. Some of the relevant oceanographic conditions, such as sea surface temperature, ocean color (productivity), and oceanic fronts, which strongly influence natural fluctuations of fish stocks, can be observed and measured by remote sensors on satellites and aircraft. The remotely sensed data are provided in near-real time to help fishermen save fuel and ship time during their search for fish; to modelers who produce fisheries forecasts; and to scientists who help develop strategies for sustainable fisheries management. This paper presents an overview of how acoustic, optical, and radar sensors on ships, satellites, and aircraft are used with forecast models to improve the management and harvesting of fisheries resources.

CHANGES IN THE MORPHOLOGY OF FUCUS VESICULOSUS ALONG THE COASTAL SEA OF ESTONIA

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In this study we examined differences in the morphology of Fucus vesiculosus along salinity gradient. Samples of bladder wrack plants were collected in summer and in autumn 2013 by SCUBA diving from four locations on the Estonian shore.

ONLINE SYSTEM FOR MONITORING AND FORECAST OF SHIP RESISTANCE IN ICE, SUPPORTING WINTER NAVIGATION IN THE BALTIC SEA

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Winter navigation occurs mostly in ice channels, which icebreakers break into fast or drift ice. Every ship proceeding in such an ice channel experiences ice resistance, which influences the ship speed. The first task to create an online system to support wintertime navigation and develop the technology for in situ measurements of the ice resistance. The measurement technology was based on the understanding that in different ice conditions the interaction of ice with the ship hull results in a vibration of the ship hull of differing intensity. The vibration could be taken as a measure of ship resistance in ice. The Estonain Maritime Administration's EVA-316 icebreaker was instrumented and vibrations of the ship hull were recorded by means of acceleration sensors in 3 directions. The acceleration data and ship position were transferred in real time to the Marine Systems Institute's FTP server. Next, after a preliminary analysis of data, the ice resistance index was calculated. The comparison of the acquired ship hull vibration data with satellite ice images showed that the obtained data well distinguish the open water and ice conditions. A successful attempt was made to relate the ice resistance index to the relevant forcing parameters like wind speed and direction. We concluded that the wind direction and especially the angle between the wind direction and ship course were important factors in determining the ship resistance in the ice channel. The recorded data on the ship hull vibrations together with the ship speed and course form a dataset which enables us to assign a specific rank for the severity of ice conditions for the ice channel in which the ships operate. In order to supply the system with forecasting skill, a fuzzy logic relational scheme was defined, applied, and validated. The online system to show the in situ ice resistance and its forecast was designed and realised for the fairway into Pärnu Port, Gulf of Riga, the Baltic Sea.

THE ROLE OF THE BAROTROPIC WATER EXCHANGE IN THE FORMATION OF THE BALTIC SEA LEVEL SPECTRUM

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The low-frequency sea level spectrum in the Baltic has been analyzed based on long-term time series of sea level data (15-124 years) from three tide gauge stations in the Baltic Sea and two in the North Sea. The principal periodicities detected in the spectrum are seasonal and tidal oscillations, including the pole tide with a period of about 14 months. A cross-spectral analysis has been applied to estimate the frequency response of sea level oscillations in the Baltic Sea relative to the North Sea. It is demonstrated that the basic factor in the formation of the low-frequency sea level spectrum in the Baltic Sea is the barotropic water exchange through the Danish Straits. The limited throughput of these straits plays the role of a natural low-pass filter for the sea level variations: High frequency sea level variations from the North Sea are effectively damped, while the low frequency signal can pass through into the Baltic Sea almost undisturbed. A simple model of the barotropic water exchange used in the study enables us to estimate the parameters of the filter. It is shown that the cut-off frequency is about 0.014 cpd (74-day period): The energy of sea level oscillations at this frequency is reduced by one-half after their penetration into the Baltic Sea.

ESTIMATING TOTAL PHOSPHORUS IN THE GULF OF FINLAND IN THE NORTH-WESTERN REGION OF RUSSIA USING LANDSAT TM SATELLITE IMAGERY

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Application of remote sensing data from Landsat TM provides a wide range of opportunities to determine the level of total phosphorus (TP) in the Gulf of Finland. This method was originally described by Wu et al. [Andersson, 2012; C. Wu et al. 2010].

The research shows that division of band TM1 by band TM3 of Landsat TM can provide good estimation results of Secchi Depth [Andersson, 2012; C. Wu et al. 2010]. There are also studies that suggest that TM1 of Landsat TM can be a good predictor for calculating Secchi Depth [Andersson, 2012; C. Wu et al. 2010]. Chl-a content in the water can be estimated using the ratio of TM2 and TM3 of Landsat TM [Andersson, 2012; Hanan Farag et al. 2011]. There are several studies which described a strong linear relationship between Chl-a and TP [Malve O. & Qian S. 2006].

The results suggest that the calculation of Secchi Depth, Chl-a and TM1 Landsat sensor TM can describe the level of TP [Andersson, 2012; C. Wu et al. 2010]. This method uses the ratio of bands TM1/TM, TM2/TM3, TM3/TM2 and TM1 values from Landsat TM [Andersson, 2012; Hanan Farag et al. 2011; C. Wu et al. 2010].

Application of the model for the Gulf of Finland has shown that it is able to explain about 65% of the variance in the simulated values for TP. For further research it is necessary to collect more ground-based measurements [Andersson, 2012; Hanan Farag et al. 2011], which will be consistent in time with the information registered from satellites, and to collect more climate statistics and temporal factors that may have an impact on the results.

Keywords: Remote sensing; Landsat TM; Total Phosphorus; Chlorophyll-a; Eutrophication; Gulf of Finland.

COMPARISON OF WIND WAVE PROPERTIES IN NEVA BAY AND THE CURONIAN LAGOON BASED ON MODELED DATA

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Properties of wind-generated waves were studied in the Neva Bay and Curonian Lagoon of the Baltic Sea under typical and extreme meteorological conditions. The coasts of these enclosed shallow (average depths of ~3.6 m and ~3.8 m, respectively) water areas of different shapes (Curonian lagoon – 90x15 (on average) km, Neva Bay – 21x15 km) which have great development potential (a number of big ports in Neva Bay and the Klaipeda Port and UNESCO national natural reserve on the Curonian Spit) are continuosly affected by erosion processes.

Wave properties were obtained by means of the SWAN model. The calculations were performed based on the wind measurements recorded at the marine and onshore observation sites and recent hydrographic survey.

Results show that the significant wave height in both water areas under typical mild winds (7 m/s) does not reach 0.5 m. Moderate winds (11 m/s) develop waves up to 0.7-0.8 m whereby a distinct fetch dependence takes place in the Curonian Lagoon as well as in the Neva Bay. Stormy winds (>19 m/s) produce waves up to 1.2-1.5 m in both basins. Most of the storms come from the W-SW directions and are usually accompanied by substantial surge (in extreme cases >2 m in Neva Bay and >1.5 m in Curonian lagoon). Sea level rise increases the wave height by 0.5 m in both regions. During severe storms (>26 m/s) the largest developed waves exceed 2 m with a relatively short period (4-5 s). In general, impact caused by surge affects the spatial distribution of the highest waves, allowing their propogation in the surf and coastal zone.

Despite the basin dimensions and shape the properties of wind-generated waves are similar for the Curonian lagoon and Neva Bay.

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PYCNOCLINE VARIATIONS IN THE BALTIC SEA AFFECT BACKGROUND CONDITIONS FOR INTERNAL WAVES

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The vertical structure of the Baltic Sea water masses (and especially the main halocline and pycnocline depths) has undergone significant changes within recent decades. These variations in vertical stratification may substantially influence the dynamics of this water body by changing the conditions for generation and propagation of internal waves. The changes involve, but are not limited to, properties of single internal waves, their propagation pathways, regions of breaking and associated areas of intense mixing, and resuspension of bottom sediments.

We evaluate average kinematic and nonlinear parameters that govern the field of long, high-frequency weakly nonlinear internal waves in the framework of the Gardner equation. The calculations are performed using hydrographic data calculated by the Rossby Centre Ocean circulation model (RCO) for the entire Baltic Sea for 1961–2005, with a horizontal resolution of 2 nautical miles. The focus is on changes in the nonlinear wave regimes, wave polarities, and limiting amplitudes of solitary internal waves. Extension of the effects of changes in the stratification is demonstrated by means of comparison of the parameters in question in 1975 (characterising the situation when strong inflows were frequent) and 1995 (when inflows were weak and rare). The spatial and seasonal distributions of the listed wave parameters differ considerably for these years. The differences are evident in all seasons and for almost the entire sea. The largest change is a shift in the possible nonlinear wave regime (e.g. (dis)appearance of probable breather generation, polarity change and/or transition from one family of soliton solutions to another) over large sea areas. The typical areas where the internal waves alter their appearance (through adjustment, transformation, or breaking) are largely different due to changed background conditions. In particular, areas with intense breaking of internal waves have also been shifted over the two decades.

LARGE-SCALE MAPPING OF SHALLOW WATER BENTHIC HABITATS AND BATHYMETRY IN THE COASTAL WATERS OF THE BALTIC SEA BY MEANS OF AIRBORNE HYPERSPECTRAL REMOTE SENSING

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Extensive areas of Estonian coastal waters are just a few meters deep. Both ice and wave action change these underwater landscapes relatively rapidly. These areas are practically inaccessible to hydrographic ships and therefore most of the nautical charts of shallow coastal areas have not been renewed since the beginning of the fifties. On the other hand, there is also a need for mapping benthic habitats and changes in them because the changes reflect the ecological state of these coastal waters. Many of the areas are also hardly accessible to in situ mapping and these works are very time consuming and labour intensive. The Estonian Marine Institute has recently acquired a hyperspectral airborne imager and carried out the first extensive mapping campaign in the Väike väin area. In our presentation, we will demonstrate the capabilities and limitations of the hyperspectral sensor in mapping water depth, and the extent and type of both underwater vegetation (macroalgae, higher order plants and seagrasses) and coastal vegetation (reeds).

THE NEW MARINE MULTIPURPOSE RESEARCH PLATFORM ON UTÖ, THE SW COAST OF FINLAND

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Atmospheric research has developed a concept of focused, multidisciplinary, automated observation platforms with continuous high time resolution observations. This approach, incorporating state-of-the-art equipment, has enabled research on physical, chemical, and biological processes, as well as seasonal variability, and has revealed new, previously unknown phenomena, especially when individual stations are utilized as a coordinated network. New technical and engineering solutions allowing such an approach are also planned on marine research through projects like the US Ocean Observatories Initiative (OOI), European Multidisciplinary Seafloor Observatory (EMSO), and Japanese DONET.

On the Baltic Sea, the Finnish Meteorological Institute and Finnish Environment Institute are currently constructing a combined atmospheric and marine research station at Utö Island on the outer edge of the Archipelago Sea (59º 46'50N, 21º 22'23E, http://en.ilmatieteenlaitos.fi/uto). Focus on new developments centers especially on marine GHGs as a part of pan-European ICOS (Integrated Carbon Observing System) infrastructure.

Observations at Utö Island include:
Marine observations: current and surface waves, ice-cover radar, T-S-O2 at different depths, chlorophyll, cyanobacteria, turbidity, primary productivity, pCO2, nutrients and ship traffic (AIS).

Atmospheric observations: T, WS, WD, visibility, cloud height, BL wind profiles and turbulence, weather camera, aerosol particle size distributions, aerosol scattering and absorption, SO2, NOx, CO, O3, CO2, CH4, sea-atmosphere CO2, and heat flux.

The new research station, featuring cost-efficient logistics and good existing infrastructure, will facilitate diverse process studies, seasonal variability, instrument development and climate change studies in a variety of fields, including gas and energy exchange through the sea surface, BGC dynamics and modeling, marine biology, underwater optics and acoustics, wind power production, shipping emissions, and marine weather forecasting.

PROPERTIES OF AN ENSEMBLE OF PROJECTIONS OF EXTREME WATER LEVELS NEAR TALLINN

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Estimates of extreme water levels and their return periods are commonly very sensitive with respect to the particular method in use and depend substantially on the set of underlying data. This variability is additionally enhanced by a nonlinear course in the long-term water level time series (e.g. owing to a gradual increase in the sea level) and decadal variations in the properties of the strongest storms (e.g. wind direction in such storms) and associated surges. The solution is often sought using a combination of relatively short-term sets of recorded water level, numerical modelling and various statistical distributions of extreme values. We make an attempt to create a more reliable projection of extreme water levels and their return periods by means of constructing an ensemble of such estimates corresponding to different methods and underlying datasets. These methods are applied to (i) long-term measured local water level within different time intervals, (ii) a synthetic dataset generated by merging measured water levels at Tallinn with a hindcast performed using the HIROMB model, and (iii) water level time series calculated using the Rossby Centre Ocean Model (Swedish Hydrological and Meteorological Institute) for 1961–2005. The estimates are constructed for a nearshore area representative of Tallinn Bay. The spreading of different projections is generally homogeneous and, as expected, increases with the increase in the return period. The ensemble contains no obvious outliers and no projection has a substantial bias for all return periods. The described features suggest that an ensemble average over the set of projections may provide an adequate projection of extreme water levels and their return periods.

MANIFESTATION OF SHIP WAKES IN SATELLITE IMAGES IN PERIODS OF INTENSE ALGAE BLOOM

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The work addresses issues related to manifestation of moving ships' wakes in satellite images of the sea surface under conditions of intense algae bloom. The experimental part of the work was based on synthetic aperture radar images of the sea surface obtained by ASAR Envisat and SAR ERS-2. Additional data were provided by OLI Landsat-8, ETM+ Landsat 7 and TM Landsat 5 scanning radiometers, as well as Aqua/Terra MODIS and Envisat MERIS sensors.

Radar image patterns of ship wakes are generally assumed to have a definite structure with a typical length of less than 10 kilometers. The structure obeys the law of expansion and has the central low backscatter part confined within V-shaped wake lines.

However, satellite images obtained in periods of intense algae bloom during regular observations of the Black, Caspian, and Baltic Seas carry multiple instances of moving ship wakes in the form of long, narrow, bright bands of high backscatter. Estimates of the spatial and temporal characteristics of such wakes were made. They are found to be rather long-living and have lengths of dozens of kilometers. Joint analysis of SAR, VIS, and IR satellite data indicated some factors that are likely to cause the emergence of the wakes. Hypotheses to explain this phenomenon are presented.

The work was partly supported by the Russian Foundation for Basic Research (grants #13-07-12017-ofi-m-2013 and 14-05-14-05-00520).

INTERNAL WAVES IN THE SCAGERRAK STRAIT

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The work discusses two types of surface manifestations of internal waves in the Scagerrak Strait revealed in ERS-1/2 SAR and Envisat ASAR images. Internal waves of the first type are "classical" soliton trains found over the Norwegian Trench. As a rule, they propagate to the west of Cape Grenen, being induced by the interaction of tidal currents with bathymetry and seasonal upwelling.

The second type of internal waves refers to the densely packed narrow bands of alternating low and high backscatter arranged perpendicular to the coastline in a belt running along the majority of the Norwegian coast of the Skegerrak Strait. Their radar patterns are identical to those of "classical" internal wave solitons. These banded structures, however, are characterized by a larger number of bands and moderate scales. They are observed only in that region and only in winter months, obviously having no connection with periodical currents, such as tidal ones, a well-known source of internal wave generation. Possible mechanisms behind the emergence of these structures and conditions favorable for their manifestation in radar images are considered.

The work was supported by the Russian Foundation for Basic Research (grant #14-05-14-05-00520).

SATELLITE ALTIMETRY OF LARGE LAKES IN THE BALTIC BASIN

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Variability in the level of the largest lakes of the Baltic Basin is characterized by alternating periods of rise and drop, according to the altimeteric measurements of TOPEX/Poseidon (T/P) and Jason-1/2 (J1/2) satellites. Water level was calculated with the use of an algorithm for regional adaptive retracking of Sensor Geophysical Data Record databases for Lakes Ilmen, Ladoga, Onega, and Peipus. Application of this algorithm considerably increases the amount of actual data records and significantly improves the accuracy of water level evaluation. The general principles of retracking for a complex domain (a coastal zone, inland water body, etc.) are discussed. The principles are based on the calculation of signal with allowance made for the roughness of the reflecting surface, and they can be applied to different geographic regions. According to the results, temporal variability of the Lake Ilmen level is characterized by a wave with a period of 4-5 years (maximum in 2001, 2004, and 2008 and minimum in 1997, 2003, and 2008). Between 2000 and 2011, the lake level rose at a rate of 1,17±0,95 cm/yr. The level of Lake Ladoga also showed a wave with a period of 4-5 years (maximum in 1995, 1999, 2005, and 2010 and minimum in 2003, 2006, and 2009). From 1993 to 2011, the lake level was decreasing at a rate of 0,24±0,10 cm/yr. A similar wave is observed in the level of Lake Piepus (maximum in 1995, 1999, 2005, and 2010 and minimum in 1997, 2003, and 2008). During the period from 1993 to 2011, its level was rising at a rate of 1,39±0,18 cm/yr. In the interannual variability of Lake Onega's level we found a wave with a period of 15 years (maximum in 1995 and 2009 and minimum in 2003). From 1993 to 2011, the lake level was decreasing at a rate of 0,18±0,09 cm/yr. This study was supported by a series of grants from the Russian Foundation for Basic Research (Nos. 13-05-01125, 13-05-00728, 13-05-00256, and 13-01-0075).

STRATEGIC ENVIRONMENTAL ASSESSMENT AND ENVIRONMENTAL LEGISLATION FOR COASTAL ZONES OF THE RUSSIAN FEDERATION

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The development of human activities has been associated with marine and ocean coastal zones throughout time. Territorial development of economy and trade has been based in the coastal zones, for example, through harbors and approach channels, like strategic elements of trade, which are situated in the coastal areas and adjacent waters. This zone is one of the most exploited and attractive investment areas in the global economy, with a huge pressure on the environment.

The authors made a comparative evaluation of common international methods for strategic environmental assessment, their applicability to the coastal zone of the Russian Federation, and proposals for the improvement and adaptation of the described methods for Russian conditions. This paper demonstrates that the Marine Spatial Planning (MSP) (that is, zoning of marine space) tool is one way to sustainably explore the coastal zone.

In this stream, a comparison of basic Russian and Finnish laws, decrees, and other normative acts on ecological and environmental protection as neighboring and marine countries was made. The elaboration of common principles and approaches will lead to environmental conservation and sustainable environmental and ecologically friendly development of the coastal zone of the Russian Federation.

ESTIMATING LONG-TERM FLOODING RISKS ON THE FINNISH COAST

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Coastal planning requires assessments of long-term flooding risks using a method that takes into account both the short-term sea level variations and the long-term trend. We present the Finnish approach to making this assessment, which is also required by the EU floods directive. Several local and global sea level aspects have to be taken into account when sea level scenarios are defined into the future. Short-term variations in sea level are mainly related to weather phenomena. Their distribution is based on the last 30 years (1982–2011) of observation data relative to the mean sea level from the 13 tide gauges on the Finnish coast. The long-term scenarios of mean sea level are calculated by combining the most recent, regionally adjusted scenarios of global sea level rise with land uplift and long-term changes in the total amount of water in the Baltic Sea. The resulting combined distributions give estimates of future flood heights at different probability levels. Calculations are made for the years 2050 and 2100 in the N2000 height system for all the tide gauges on the Finnish coast. The lowest recommended building heights are based on the estimated water level with an exceeding frequency of 1 event / 250 years (0.4 % probability) in 2100. In addition, a site-specific freeboard (the additional height to compensate for wave action) must be estimated separately, as the wave height varies a lot along the Finnish coastline.

UTILISATION OF COASTAL RADARS IN ENVIRONMENTAL MONITORING

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Radar servers can be used to convert coastal radars to cost efficient environmental monitoring stations. The server rasterises captured raw radar data, one image per revolution, stores it and sends preprocessed data in near real time for operative and research use. This is done without interfering the normal use of the radar and with parameters that suit the monitoring purposes. Finnish Meteorological Institute receives presently data from three radars in order to follow and analyse principally local ice cover deformation but also wave fields. The monitoring range at the sites is typically 20-30 km, the update rate 2-5 seconds, and the resolution 10-30 m.

The operation principle and the capabilities of the servers are described together with the chain of processing, storage, transmission, and delivery to end users. Principal end users are icebreakers and maritime administrations that follow the opening and closing of coastal leads and the drift and closing of ship channels. Eulerian and Lagrangian ice kinematic products are generated from the image time series and used in research and validation, and to support operative use. Examples of ice parameter extraction from the radar imagery using results obtained from multi-instrument campaigns in the radar image areas are given. The imagery can also be enhanced by ship data from AIS, providing real-time information on the effect of conditions to ship performance.

Most coastal radars operate in X-band and the ice signatures in the images are usually easily identified from X- and C-band SAR images so that the classification results obtained from the coastal radar imagery can be extrapolated. The future work includes increasing the number of instrumented radars towards complete coverage and the development on rasterising algorithms for specific ice types, wave parameter retrieval and oil slick detection.

RANGE COMPENSATION IN PACK ICE IMAGERY RETRIEVED BY COASTAL RADARS

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The Finnish Meteorological Institute has instrumented coastal radars with radar servers for coastal ice field monitoring. The servers capture the radar data and processes one image per revolution with the given parameters. The image time series provide real-time high temporal and spatial resolution data on ice characteristics and are accompanied by kinematic products. The data are used in research and provided to end users, mainly icebreakers.

A basic problem in the use and analysis of radar data is that the intensity of the ice signatures decreases with range. When uncompensated, this effect decreases the usefulness of the images as a navigational aid. More importantly, compensation is required when the images are classified or quantitative ice parameters are retrieved, especially for ridging. The intensity decrease is mainly due to the physical properties of the radar, but the ice area that is shadowed by ice ridge sails also increases with distance.

The range compensation problem is approached via three different methods. The radar echo power decrease has a certain dependence on the radar properties that can be theoretically calculated or observed. Secondly, image equalisation can be based on the assumed relation between the pixel and ridging statistics, including the shadowing effect by ridge sails. Thirdly, homomorphic filtering provides an independent method on assumptions concerning the characteristics of the ice field. The three methods are compared for selected cases, and example false colour end products are shown.

COASTAL UPWELLING IN THE WESTERN BALTIC SEA – COMBINING A GLIDER SURVEY AND LONG TIME SERIES

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The first underwater glider survey in the Baltic Sea was conducted in the vicinity of the Boknis Eck (Belt Sea) time series station in July 2010. Two consecutive summer upwelling events, each lasting less than 24 hours, were recorded in high temporal and vertical resolution during a one-week survey. Generated by moderate offshore winds, both events resulted in shoaling of seasonal pycnocline and consequent decrease of surface layer temperature (up to 5 K). Only little evidence of diapycnal mixing was found for the first upwelling, and, as such, it was seen mainly as a mechanical upward and downward movement of the water column where pre-upwelling water was advected back to its original position during relaxation of the upwelling. The second upwelling event, which occurred shortly (within 24h) after the first event, was more intense and the entrainment of oxygen-deficient water in the bottom layer was observed, indicating that the upwelling event had an impact on the water column as a whole.

A comparison of wind and sea surface temperature time-series (1982-2012) data revealed that summer (June to September) upwelling at Boknis Eck occurs for wind directions between 190° to 260° and with hourly averaged wind speed exceeding 4 ms-1. For the period from 1982 to 2012 the site experienced large inter-annual variability, as the duration of upwelling-favorable wind ranged from only 8 days in 2006 to more than 28 days in 1985.

Surface (1 m depth) and deep water (below 25 m depth) anomalies of salinity and oxygen at the Bocknis Eck followed extended periods of strong upwelling-favorable wind.

PROTOTYPE AND FIRST FIELD MEASUREMENTS FOR THE MULTI-SPECTRAL VOLUME SCATTERING METER (MVSM)

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The optical volume scattering function (VSF), which describes the angular distribution of light scattered from an incident beam, is a fundamental inherent optical property of the aquatic environment. Along with the spectral absorption coefficient, VSF is one of the two inherent optical properties which describe the propagation of light in an aquatic environment. Despite its fundamental nature, there is little known about the range of variability of the VSF in the aquatic environment. One of the main reasons for this lack in the measurement data is that instruments which have been used for measuring VSF are complicated and there is no instrument commercially available that is able to take measurements of the function in a full angular range.

Tartu Observatory, in cooperation with the Interspectrum company and MHI of Ukraine, developed a prototype of a new instrument for scattering measurement - MVSM. It outperforms industrial instruments currently used to measure VSF in most parameters. It has a modern programmable multicolor LED light source, measurement angles covering a full angular range, interference filters in receiver that enable fluorescence measurements at different wavelengths, and closed measurement volume that eliminates background noise and increases sensitivity and dynamic range. The instrument has a modular design with a 32-bit microcontroller in every module; the software in the modules executes the SafeRTOS operating system under certified real-time, allowing safe and robust multitasking as well as fast multiprocessor communication between modules.

In September 2014 the comparison measurements were carried out in Sevastopol, Ukraine. A set of scattering measurements were carried out in a laboratory with pure water and with the water mixed with 5 μm solid particles. Results of the measured (VSF) and model-calculated VSFs for 5 wavelengths are presented in the poster presentation, as well as results of scattering measurements in marine water, carried out on 18-19 September in the Black Sea.

CORRECTING TIDE GAUGE SERIES DUE TO LAND UPLIFT AND DIFFERENCES BETWEEN NATIONAL HEIGHT SYSTEMS OF THE BALTIC SEA COUNTRIES

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Different types of tide gauges (TG) are used to monitor the sea level dynamics around the Baltic Sea. They are usually connected to a national levelling network and several of them are linked to regional networks (e.g. Baltic Operational Oceanographic System). The sea level readings are used for nautical navigation, modelling, and forecasting of sea level changes. Long-term and historical sea level series are also useful in studying regional land uplift/subsidence or calibrating satellite altimetry data. Both tasks require precise knowledge of inter-connections between height systems of countries surrounding the same sea.

Presently, however, six different height reference systems are in official use in the Baltic Sea countries. Even though all of these systems are based on mean sea level (MSL) observations averaged over different time periods, different reference TG and tidal systems have been adopted for national height systems. The differences in national height systems between the countries around the Baltic Sea can reach up to 20 cm. Overlooking this yields undesirable systematic biases between regional TG data series. Additionally, the entire Fennoscandia is affected by land uplift at the maximum velocity rate +10 mm yr-1 due primarily to the viscoelastic response of the solid earth resulting from the de-glaciation of the Pleistocene ice sheets. Over a time span this causes notable distortions of height system realisations even within a country; therefore, the land uplift corrections should be also taken into account in sea level series. A case study in the West-Estonian Archipelago involves the recently developed land uplift model, EST2013LU, which is based on repeated high-precision levelling data from 1933 to 2013. In addition, connections between historical and contemporary TG series are analysed. The results reveal that discrepancies due to the obsolescence of a national height system may cause discrepancies in series of nearby located tide gauges up to 3 cm.

DETERMINING SEA SURFACE TOPOGRAPHY BY GNSS SURVEYS ON ICE

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Sea surface topography (SST), the difference between the geoid and sea surface height (SSH), is requested for many marine applications. The SST is used to analyse the currents' streaming and variation of salinity. Globally, SST can be roughly determined using satellite altimetry and oceanographic data; however, in coastal areas, the accuracy and spatial resolution of these methods are rather low. Accordingly, issues related to enhancing SST resolution and accuracy with GNSS (Global Navigation Satellite Systems) measurements are explored in this study.

A practical case study tackles profile- and point-wise GNSS measurements for determining SST that were carried out on the ice surface of the West-Estonian Archipelago, the Baltic Sea. Profile-wise GNSS measurements were processed on official ice roads (all together 50 km) between the mainland and two major islands (Saaremaa and Hiiumaa). The GNSS profiles were complemented with GNSS point-wise measurements scattered (1 point per 25 km2) all over the Väinameri Basin. The GNSS-derived SSH, which is the difference between the ellipsoid and sea surface, was corrected with ice freeboard and corrections due to offsets of instantaneous sea level height values from the mean sea level. For calculating SST from the GNSS-derived and corrected SSH, a recent high-resolution (1' x 2') gravimetric geoid model GRAV-GEOID2011 was used. The estimated SST was compared with the global SST model DTU10MDT and with an earlier regional SST model in the Väinameri Basin.

VARIATIONS OF INHERENT OPTICAL PROPERTIES IN THE UPPER MIXED LAYER AND UNDER THE THERMOCLINE ON THE NW COAST OF ESTONIA

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The study of vertical profiles of inherent optical properties (attenuation, absorption, and scattering coefficient), together with salinity and temperature measurements, was performed in July 2013 along the NW coast of Estonia. The current meter and pressure sensor for wave measurements was deployed from July 4th to July 31st near Pakri Peninsula. Water samples were taken from the upper mixed layer and under the thermocline for determination of total suspended matter (TSM) and chlorophyll a (Chl a) concentration. The local wind regime was favourable for formation of downwelling along the NW coast of Estonia in July 2013, which was also confirmed from MODIS SST images from July 2013. As a result of downwelling, at the time of the field campaign at several stations the thermocline was present at a depth of 15-20 meters. The concentration of TSM determined from water samples taken at the surface layer varied from 1 to 4.8 mg/L, and under the thermocline the TSM varied from 0.2 to 1.2 mg/L. The Chl a concentration varied from 1.67 to 10.9 µg/L at the surface layer and from 0.24 to 0.59 µg/L under the thermocline. A sharp decrease in total attenuation, absorption and scattering coefficient was observed under the thermocline at all stations where vertical stratification was present. While in the upper mixed layer the scattering was more dominant, under the thermocline the absorption became dominant. For describing the changes in specific inherent optical properties (SIOP), we calculated the TSM specific scattering coefficient and Chl a specific absorption coefficient under the thermocline and in the surface layer. The average TSM specific scattering coefficient under the thermocline was 0.8 m2 g-1 (SD 0.5) while in the surface layer it was 0.5 m2 g-1 (SD 0.18) at the stations studied. The average Chl a specific absorption coefficient at 440 nm was 1.3 m2 mg−1 (SD 0.28) under the thermocline and 0.18 m2 mg-1 (SD 0.06) in the surface layer. Remote sensing reflectance was calculated from the vertical profiles of IOPs.

METHODS AND RESULTS FROM STATISTICAL ANALYSIS OF BALTIC SEA MONITORING DATA OBTAINED BY THE ALG@LINE SYSTEM

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This report presents a statistical analysis of sea water temperature and salinity measurements implemented within the framework of the Alg@line project. The specifics of this information include measurements are performed at a depth of 5 m with temporal discreteness of about 20 sec and spatial resolution of 200-250 m. In our statistical analysis we will take an ensemble of realizations in the space of the desired configuration. Measurement data obtained from the Helsinki–Lübeck route were used in this work; the cruises are quasi–regular: Their average duration is about 26 hours, the section's length L=1132 km, vessel speed in some areas is a random variable, and sailing schedules have seasonal and inter-annual changes. Due to the cruises' "regularity," in pattern space it becomes possible to split the ensemble of "spatial field inhomogeneity and its temporal variability" into algebraic field inhomogeneity and polycyclicity of its variability (in daily, synoptic, seasonal and inter-annual ranges). The dimensionality reduction of two-dimensional space (ri, ti) in one-dimensional space is achieved due to dependence ri =cti, where (ri, ti) are fixed; c – ship speed – is the random variable. This enables to use of the theory of almost periodically correlated random processes for data analysis (Dragan, Rozhkov, Yavorskiy. Methods of probabilistic analysis of oceanographic processes rhythmics. Gidrometeoizdat,1987). In the report, the concept "rhythmics" uses in terms of cruises "regularity" and diurnal temperature variation of water, hence the daily rhythm should be analyzed in the astronomical time. Stochasticity has a different meaning depending on the selected probabilistic model. The probabilistic model can be represented as: $\xi(r,t) = \sum ak(t)\varphi k(r)$, where ak(t) is the stochastic process, and φk(r) the basis. The analysis results are presented in the report in the following form: TS-diagrams typical for cruises, spatial TS-trends, parameters of the temperature daily rhythmic, and synoptic variability parameters, considering its seasonal modulation.

SPATIAL VARIABILITY IN THE LOCATION OF THE BOUNDARIES OF THE COLD INTERMEDIATE LAYER AND ITS THICKNESS IN THE BALTIC SEA IN SPRING 2006

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The south-north (along the major axis of the sea) variability of the upper and lower boundaries of the cold intermediate layer (CIL) is analyzed on the basis of field measurement data obtained at the end of April to early May 2006 in expeditions of Russian and German research vessels in the northern and southern parts of the Baltic proper. The boundaries were defined as levels of the highest vertical gradients of water temperature at CTD profiles: thermocline for the upper boundary and anti-thermocline, located close to permanent pycno/halocline, for the lower boundary. Mean depth for the location of the upper CIL boundary (thermocline) was found to be 25 m ± 3 m (with variations from 11 m to 41 m), and of the lower boundary 60 m ± 8 m (variations from 36 m to 71 m). Average thickness of the CIL amounted to 35.5 m ± 4.6 m (from 22 m to 57 m). The most remarkable feature of the CIL is the highest variability of the depths of the boundaries from station to station (which could be more than 30 m per 70-80 km) rather than from south to north. No obvious south-north trend is detected. This speaks in favor of the independence of processes for the CIL formation at every particular location - as opposed to the idea of existence of general sea-scale transport of cold intermediate waters from some common source.

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MODELING OF SEDIMENT RESUSPENSION IN NEVA BAY DURING STRONG WIND EVENTS

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Wind waves play the major role in the resuspension of bottom sediments in coastal areas; however, the available results of field observations imply that only consideration of the combined effect of currents and wind waves can give correct model estimates of resuspension intensity. In the present study, a three-dimensional circulation model of Neva Bay (Gulf of Finland, Baltic Sea) was used to simulate resuspension of the bottom sediments due to currents and wind waves. The characteristics of wind waves are calculated from the SWAN wave model. They are then used to calculate the bottom shear stress resulting from the nonlinear wave-current interaction. The resuspension model takes into account the difference in physical characteristics of two main bottom sediments in Neva Bay: sand and silt, with a possibility to also allow for the presence of clay fraction. The variable sinking velocity of suspended particles is used, with account being taken of the effects of settling velocity reduction due to high concentrations called hindered settling, and flocculation. The model also takes into account cohesion and packing effects of the bottom sediments. Satellite images with TSM data were used to calibrate the resuspension model. We also present the results of model runs aimed at estimating the intensity and frequency of resuspension events during extremely strong winds over the Neva Bay.

REMOTE SENSING FOR COASTAL ECOSYSTEM-BASED MANAGEMENT PROCESS IMPLEMENTATION ON THE ROMANIAN BLACK SEA COASTAL ZONE

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The marine and coastal spatial data and information management actions within the Romanian research and development institutions, formed toward implementation of coastal ecosystem-based management standards, include an RS data validation QC-QD procedure and Web-GIS services. The RS and GIS complementary actions, among other areas, are developed in order to provide a modern scientific and technical instrument toward extension of an operational informational system.

The paper presents specific national consortium actions that are developed as implementing activities of the international/European RS applications to coastal complex water studies development, including calibration and validation of RS algorithm extensions and Web-GIS systems/services as support tools for the ICZM implementation process in the Romanian Black Sea area.

The results presented in this work are related to the developments of a Marine and Coastal GIS able to accommodate data exchange and integration from several sources, which when associated in databases, can constitute the engine of a dynamic and efficient decision system within the Romanian Coastal Zone.

THE SPATIAL AND TEMPORAL VARIABILITY OF THE BALTIC SEASONAL SEA-LEVEL OSCILLATIONS

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Seasonal annual (Sa) and semiannual (Ssa) oscillations are the dominant feature of the long-period sea-level variability in the Baltic Sea. Long-term records of mean monthly sea level observations from the PSMSL database were used to estimate their amplitudes and phases, and to examine the spatial and temporal (year-to-year) changes. It was found that these changes were quite significant during the 19th and 20th centuries, and highly correlated with similar changes in the North Sea. Climatologically averaged amplitudes and phases of seasonal constituents have been estimated for 70 tide gauges along the coast of the Baltic Sea. The annual harmonic was found gradually increasing from the entrance (Danish Straits) to the northeast part of the sea. The maximum amplitude of 12 cm was observed at the head of the Gulf of Bothnia.

THE STORMINESS AND WIND WAVE CLIMATE IN THE BALTIC SEA: SIMULATION USING THE SWAN MODEL

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In this study to estimate decadal and interannual changes of the wave fields for the entire Baltic Sea, the third generation spectral wind-wave SWAN model and the data fields of wind Reanalysis NCEP/NCAR were used. The parameters of the wave fields, such as significant wave heights and periods, were simulated for the period of 1948–2013.

Regime average and extreme maximum and minimum characteristics of wind waves for the Baltic Sea were calculated and analyzed. Such extreme characteristics as the wave height possible once in 100 years and wave heights with 0.1, 1, 3 and 5% probability were calculated. Storm situations were detected and their seasonal, interannual, and decadal variability were analyzed. Their extreme cases were identified and estimated.

The results were compared with instrumental data from the Swedish buoys, with the results of operational regional models and those of other similar studies. The correlation between simulated and instrumental data was high enough (about 0.8) to use SWAN for the Baltic Sea. The general trend for storminess is up, with a decrease in storm quantity at the end of 60s and at the end of 80s. The period for the increase in storminess is about 20 years.

STATISTICAL PROPERTIES OF COASTAL UPWELLING IN THE SE BALTIC SEA

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Satellite SST maps allow monitoring of the main spatiotemporal characteristics of mesoscale frontal features associated with the coastal upwelling in the SE Baltic, influencing coastal and lagoon ecosystems. This study is aimed at describing the statistical properties of coastal upwelling events in the SE Baltic Sea, based on Terra/Aqua Moderate Imaging Spectrometer (MODIS) infrared imagery for the period of 2000–2013. In the study period, 34 upwelling events were recorded in the SE Baltic Sea, and the study showed that half of them had a significant effect on the Curonian Lagoon SST regime. Main statistical parameters were calculated: SST gradients, SST differences, the front length, and the total affected upwelling area.

Special attention was focused here on the Curonian Lagoon SST regime because during intensive upwelling strong inflows of marine waters to the lagoon are registered. The inflow of relatively cold, saline, and nutrient-rich waters has a big influence on the sensitive ecosystem of the Curonian Lagoon. The study showed that in most cases cold upwelling waters spread to the Curonian Lagoon via Klaipeda Strait, about 5-15 km, but during really intensive upwelling cases (e.g., July 2006) the affected area lasted up to 40 km from Klaipeda Strait to the lagoon and covered almost 200 km2 of water area. The hydrometeorological conditions causing this water mass exchange are also analysed.

WIND TRANSFORMATION IN THE COASTAL ZONE BASED ON SAR OBSERVATIONS

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Analysis of wind transformation in the coastal zone of the Gulf of Finland using ENVISAT synthetic aperture radar (SAR) data is presented. In total, more than 25 SAR images covering various scenarios of wind field transformations are considered. The advantage of SAR data is their ability to resolve small-scale wind field features (with spatial resolution of 150 meters and larger) caused by wind transformation, due to abrupt change of the surface roughness and surface temperature at the land-sea transition. Several "typical" cases of wind transformation in various meteorological conditions and the atmospheric stratifications are considered and interpreted. The data are analyzed using a semi-empirical model of the atmospheric boundary layer transformation. The relevance of observed phenomena to the offshore wind energy resource assessment is discussed.

THE OCEAN COLOUR CLIMATE CHANGE INITIATIVE: SPECIFIC REMOTE SENSING ALGORITHM FOR THE BALTIC SEA

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The Ocean Colour – Climate Change Initiative (OC-CCI) of the European Space Agency (ESA) aims to create a long-term, consistent, error-characterized time series of ocean colour products for use in climate change studies. We developed an algorithm for the remote sensing of the Baltic Sea in accordance with the requirements of the OC-CCI. The algorithm takes into account the specific bio-optical properties of the region, such as chlorophyll-specific absorption, surface blooms of cyanobacteria, suspended matter concentration, and Gelbstoff absorption. The procedure, which is used to determine inherent optical properties and different concentrations from remote sensing reflectance, is an artificial Neural Network (NN). A comparison of the OC-CCI standard chlorophyll and NN chlorophyll is provided.

THE MAIN CHARACTERISTICS OF STORMY WINDS ON THE LITHUANIAN SEASHORE, 1991-2013

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High wind speeds across Europe are generally associated with extratropical cyclones. Storms can do widespread damage to ecosystems, property, and society. Coastal regions are not only exposed to the wind force but to storm surges and wind waves in the wake of storms as well. Stormy winds are the main drivers of the coastal processes. The Lithuanian coast is exposed to the all-predominant westerly wind directions. In the last few decades, intensification of the erosion processes have been noticed on the Lithuanian coast. Increases in the storminess in Northern Europe were determined as the main reason for it. In this study, stormy wind characteristics of the Lithuanian Baltic Sea coasts in 1991-2013 were analysed.

Wind data were used from the Lithuanian Hydrometeorological Service (LHS) under the Ministry of Environment, Klaipėda station. Stormy winds were considered to be those with speeds over 25 m/s. During the study period, 52 storm cases were noted. The predominant stormy wind directions were south-western (35% of cases), western winds (26%) and southern winds (20%). The strongest winds were noticed on 1999-12-04 during the storm ‘Anatolijus’ and they reached 38 m/s. During this storm, the predominant wind direction was from the west and south-west. Mean storm duration in the period analysed is 18 h. The longest storm lasted 23 housr. It should be noted that according to the trend analysis, the annual mean of wind velocity in the research period was decreasing. At the same time, the number of storm events on the south-eastern coast of the Baltic Proper has also decreased.

Although in most cases Baltic Sea storms reach Lithuanian coasts from the south-west, the strongest storms are from the north-west. Over the last decade, storms from the west and south-west directions increased by 5 times. During this period, an increase of short storms were observed during summer and long-lasting storms were observed in winter.

LONG-TERM VARIABILITY OF MEAN ANNUAL SEA LEVEL ON THE EASTERN BALTIC COAST

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The long historical series of water level (in the Baltic Reference System) observations in Baltiysk and Kronstadt for the period of 1840-2005 were used to analyze a long-term trend and the features of the interannual sea level variations. Yearly mean water level in Kronstadt is permanently higher than in Baltiysk, but significantly sustained reduction of this difference to the end of the past century was found, for example, from 21 cm to 10 cm, and 5 cm on average for the periods of 1841-70, 1961-90, and 1991-2005, respectively. A significant difference in the rate of growth was estimated not only for the whole period (1.7 mm/year at Baltiysk and 0.5 mm/year at Kronstadt), but also for sub-intervals, especially after 1990 (8.6 mm/year in Baltiysk, 1.1 mm/year in Kronstadt). This could be a consequence of the significant land subsidence in the southern part of the coast (Baltiysk) and its uplift in the Gulf of Finland, where this rise offsets to some extent the increase of water level due to global warming. Another reason could be a significant change in the wind and air pressure regime. Additional analysis of the mean values of sea levels (in the Baltic Reference System) at the Lithuania (Klaipeda, Liepaja) and Latvia (Ventspils, Tallinn) gauges for 1901-1990 averaged over the ten-year and thirty-year intervals showed that the most significant sea level rise on the coast from Baltiysk to Kronstadt was observed in 1981-90 (Baltiysk - 8.8, Klaipeda - 6.9, Liepaja - 7.3, Ventspils - 7.4, Kronstadt - 7.9 mm/year), except Tallinn (1.3 mm/year). This suggests that the primary components of the multi-year variability in sea level on the eastern shore of the Baltic Sea are determined by the influence of common climatic conditions, particularly atmospheric transfer from the Atlantic.

MULTIDECADAL ENSEMBLE HINDCAST OF WAVE FIELDS IN THE BALTIC SEA

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Several versions of the Baltic Sea wave climate are reconstructed by means of the WAM spectral wave model with a resolution of about 3 nautical miles. This model (optionally covering different different frequency ranges) is forces with two versions of wind fields and with and without information about sea ice. The wave fields are calculated for 1956–2009 (54 years) using high-resolution COSMO wind hindcast and for slightly adjusted geostrophic wind fields from the Swedish Meteorological and Hydrological Institute database for 1970–2007. The runs are performed in parallel with and without ice information. We provide a comparison of spatial distributions of the main climatological parameters (average wave heights, higher quantiles of wave heights, etc.; formal trends of these quantities) for these runs. All simulations replicate the well-known features of the Baltic Sea wave climate, such as the moderate average wave heights, extensive intermittency of wave properties and substantial spatial anisotropy of typical and extreme wave heights, with the relatively severe wave climate in the eastern parts of the Baltic Proper and its subbasins. The simulations also indicate widespread differences in the long-term behaviour of average wave heights and higher quantiles of the wave heights in different sea areas. The hindcasts reasonably replicate interannual variability in the wave heights and provide a fair portrayal of typical wave periods, but are clearly less representative in terms of wave propagation directions and especially in terms of the rotation of these directions.

EUROPEAN MARINE OBSERVATION DATA NETWORK - EMODNET PHYSICS

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The physics preparatory action (MARE/2010/02 - Lot [SI2.579120]) had overall objectives to provide access to archived and near real-time data on physical conditions as monitored by fixed stations and Ferrybox lines in all the European sea basins and oceans, and to determine how well the data meet users' needs.

The existing European Marine Observation and Data Network (EMODnet) Physics portal, www.emodnet-physics.eu, includes systems for physical data from the whole of Europe (wave height and period, temperature of the water column, wind speed and direction, salinity of the water column, horizontal velocity of the water column, light attenuation, and sea level) provided mainly by fixed stations and Ferry-box platforms, discovering related datasets (both near real-time and historical datasets), viewing and downloading the data from about 470 platforms.

It is based on a strong collaboration between EuroGOOS member institutes and its regional operational oceanographic systems (ROOSs), and brings together two marine, but different, communities: the “real-time” ocean observing institutes and centers and the National Oceanographic Data Centres (NODCs) that are in charge of archived ocean data validation, quality checks, and continuous update of data archives for marine environmental monitoring.

EMODnet Physics is a Marine Observation and Data Information System that provides a single point of access to near real-time and historical archived data. It provides data access to any relevant user, and is aimed at attracting new data holders and providing better and more data. With a long-term vision for a sustained pan-European Ocean Observation System EMODnet Physics is supporting the coordination of the EuroGOOS ROOSs and the empowerment and improvement of their observational and data management infrastructure.

The presentation will show how to exploit the EMODnet portal and access the metadata and in situ data of connected platforms.

BALTIC SEA MODELLING AS A TOOL FOR THE STUDY OF PAST CLIMATES

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During the past decade a strong improvement has taken place regarding data availability in the form of gridded data sets, long-term data series, and proxy data. Large amounts of information are now available and open up the need to use methods for analysing and synthesising this information. Baltic Sea modelling is such a method that can bring together an enormous amount of information. The strength of the method is that it allows us to evaluate available information against independent information. For example, meteorological data can be evaluated by salinity. Some different global reanalysations of meteorological data with decadal time resolution are freely available from, for instance, the ECMWF products such as ERA40. These data have been used in several Baltic Sea applications together with the gridded data sets available through SMHI (BALTEX hydrology data centre). From these forcing data, Baltic Sea modelling has generated new marine gridded physical-biochemical data sets. These model data sets are regularly validated and cover at present the time period of 1958-2012. Longer time periods, several centuries long of gridded data sets with pressure and temperatures, have been constructed for Europe running from 1500 AD up to now. These data, together with other long-time data sets, have been used to characterise and model the Baltic Sea during the studied period of 500 years. In these presentations, examples of model reconstructions will be illustrated showing variations of river runoff, sea ice, temperatures, salinity and hypoxia. The work to understand the past Baltic Sea climate conditions can be seen as a large puzzle in which humanist researchers and scientists of many disciplines can piece together a picture of the past and climates. Baltic Sea modelling can bridge the different disciplines and by making the model reconstruction freely available (upon request from the present author) the data sets may hopefully improve this communication.

SHORT-TERM MONITORING OF THE NORTH-WEST COASTS OF THE GULF OF OMAN USING BOTH SATELLITE IMAGES AND A NUMERICAL MODEL

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This investigation, which involved the use of both satellite images and a simulation model, focuses on the effect of the hydrodynamics of a sea on the classification of the adjacent coastal area. The area selected for this study comprises the north-west coasts of the Gulf of Oman, with a total area of about 326979.5 hectares.

Mike 21 was employed to simulate the hydrodynamics of the Gulf of Oman, and the Aster images of the Terra satellite for 2005 were used to categorise the adjacent coastal area by applying Shepard's classification.

Coastal classification of the area shows that most of the area is dominated by the primary coasts, formed mostly by non-marine agents. The secondary coasts which are shaped primarily by marine processes cover just 7% of the total area, with the salt marshes being the most dominant one.

Wind, wave, and tidal conditions of the area were considered for a period of 15 years, from 1993 to 2008. In studying the hydrodynamic of the Gulf of Oman, it was found that the calm nature of the currents in the vicinity of these coasts rarely exceeds 1 m/s, which is the main reason for the predomination of the primary agent.

BALTIC SEA BATHYMETRIC DATABASE

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An introduction to the Baltic Sea Bathymetric Database

This is a cooperative project between most countries around the Baltic Sea, the aim of which is to develop and maintain a bathymetric database of the Baltic Sea.

The project has been financed by the EU and is developed under the umbrella of the BSHC (Baltic Sea Hydrographic Comission).

Data from the database can be viewed at www.bshc.pro and can be downloaded for free.

The current resolution of the database is 500 m where such data exist and are available due to political restrictions.

This is much better than the previous situation before, in which only very low-resolution GEBCO and ETOPO data were available.

HISTORICAL ANALYSIS OF THE OCCURRENCE OF METEOTSUNAMIS ON THE FINNISH COAST

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Several small meteotsunamis, meteorologically induced tsunami waves, have been observed during recent summers (2010-2012) in different places along the Finnish coastline. The phenomenon is not unprecedented on the Finnish coast, but no reports of its occurrence have been received by Finnish sea level researchers for decades. The research presented here aims at studying temporal changes in meteotsunami occurrence in Finland.

A major limitation for studying such local and short-lived events (wave periods ranging from a few minutes to two hours) is the crude spatial and temporal resolution of sea level and meteorological data. To overcome this limitation, we have examined archived tide gauge paper recordings, in which the sea level has been plotted as a continuous curve. The recordings have been examined from two tide gauges in the Gulf of Finland, Hanko and Hamina, for the time periods of 1922-1979 and 1928-1979, respectively.

By visual inspection of the paper recordings and digitising the promising events it is possible to detect rapid sea level variations, which are invisible in the standard 4-hour or 1-hour digital sea level data. Their atmospheric origin is confirmed by examining archived barograms from nearby coastal stations for sudden changes in air pressure. Results show no clear trend in the frequency or intensity of meteotsunamis on the Finnish coast, but there is periodicity in their occurrence.

THE CHARACTERISTICS OF SEAFARING LABOUR

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In the maritime industry, seafaring labour is the most important part of the process of shipping production – just as much as the factory worker on land. However, due to the fact that it is not possible for the most part to compare seafaring occupations with those on land, the seafaring labour also differs greatly from that of shore-based workers. On the one hand, the seafarer's profession is still one of the most complex and dangerous jobs, with unmatched rates of intrinsic hazards, while on the other hand, the ship is not only the special instrument of seafaring labour, but also the residence where the seafarer works, lives, sleeps, and socialises. All of these characteristics determine that the policies and practices with respect to the seafarer differ from those in the shore-based industry. This article discusses a number of characteristics of seafaring labor from the perspective of mode of production and labor process.

MERIS DATA FOR MONITORING OF SMALL- AND MEDIUM-SIZED HUMIC SWEDISH LAKES

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According to the Water Framework Directive (WFD), all lakes larger than 50 ha (0,5 km2) should be monitored on a regular basis. In Sweden, chlorophyll a is one of the parameters used to classify the phytoplankton status of a lake and CDOM is used to define the lake type. Also, time series of CDOM is of environmental interest to be able to study the brownification of lakes. The possibility to use satellite-based information (ENVISAT – MERIS) to measure and monitor the water quality status of Lake Bolmen and surrounding smaller lakes (>2 km2) has been investigated. The work was focused on chlorophyll a and CDOM, and data from 83 lakes in the investigated region has been analysed. In general, chlorophyll levels between 0-10 ug/l and aCDOM(442) between 3-10 m-1 prevail in these lakes, but also more extreme levels of chlorophyll around 50 ug/l and aCDOM around 20 m-1 exist. Data from 5 years (2007-2011) has been analysed together with existing field data from approximately 20 lakes. The results indicate that good water quality estimates, especially for chlorophyll, could be generated for lakes larger than 2-3 km2. This means that not all lakes required by the WFD can be possible to monitor using MERIS and future Sentinel-3-OLCI data, but that a significant contribution to the present and future monitoring program should be possible by adding earth observation data.

AN ESTIMATE OF THE IMPACT OF VESSEL WAKES ON COASTAL PROCESSES: A CASE STUDY FOR AEGNA, ESTONIA

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The purpose of the study is to quantify the intensity of coastal processes influenced by wakes from fast ferries on the coast of Aegna Island in Tallinn Bay. During the windy season (Sept–March) sediment transport in the study site is mainly driven by wind waves to the east. In the calm season (April–Aug), a substantial amount of sediments is moved by vessel wakes to the west. The existing sediment structure thus reflects a balance of these drivers. To evaluate the impact of vessel wakes, we performed experiments in the calm season (June–July 2013) when small amounts of finer sediment may have been affected by low wind waves, but the majority of gravel and pebbles were set into motion, if at all, by vessel wakes. The idea was to track how waves relocate painted gravel, pebbles, and cobbles. Sediments for the experiment were sorted by fractions of coarse gravel (1–2.5 cm), pebbles (2.5–5 cm) and cobbles (5–10 cm). Stones from each fraction were painted in a different color. The painted stones (totaling a few thousand) were laid along a straight line (normal to the waterline) to the subaerial beach until the observed highest wave run-up line and in batches at different depths (0.5–10 m). A portion of the stones was rapidly covered by finer sediment. The location of each painted stone visible in the swash zone was positioned daily with the RTK-GPS device for 9 days and once after three months in October. The volume of the sediment brought into motion by vessel wakes was evaluated based on the location of identified painted stones. The motions are expressed in terms of the dispersion of each fraction, relocation of the center of mass of painted sediment clusters and skewness of the distribution of painted stones, calculated on daily basis for each fraction for nine subsequent days. Simultaneous measurements of vessel wakes in the nearshore made it possible to relate the properties of sediment transport with the properties of incoming waves.

ONLINE AND IN SITU KINETICS STUDIES OF BIOFILM FORMATION ON SOLID MARINE SUBMERGED SUBSTRATA BY CONTACT ANGLE WETTABILITY AND MICROSCOPIC TECHNIQUES

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The characterization of wetting properties (by contact angles CA) of several undersea artificial (glass plates) and natural (stones, sand layers, soft-bottom structures, aquatic macrophytes, sediments) solid substrata in Baltic Sea brackish waters (Gulf of Gdansk) were performed. The apparent surface free energy γSV and other interfacial interaction parameters: 2D film pressure Π, work of adhesion WA, and of spreading WS; dispersive term γSVd of γSV were derived from CAH approach developed by Chibowski (2003) with only three measurable quantities – surface tension of the probe liquid γLV and its advancing ΘA and receding ΘR contact angle hysteresis (= ΘA- ΘR). The most useful technique to measure in situ CAs giving reproducible and accurate values turned out to be a captive bubble method, for fully hydrated interfacial layers of highly hydrophilic and porous nature met at the seabed. Since the outermost surface of the submerged substrate is sensed with the presented CA captive bubble technique (captive bubble syringe set-up + a USB microscope system was assigned to field work), surface evolution of the formed biofilm structure can be monitored online at different stages of its formation, from seconds to weeks (macrofouling). Increasing CAH increases the adhesion between the liquid and substratum. In addition to surface free energy, other factors, including surface charge, surface roughness, temperature, contact time and fluid shear flow velocity also have significant influence on the adhesion of biofouling. Views of the glass biofouled slides taken with a confocal scanning laser microscopy allowed 3D biofilm architecture on glass to be visualized and quantified. The evolution of the wettability parameters allowed identification of the particular biofilm states: best release properties, maximum organic matter accumulation, and mature film dispersion. The presence of adsorbed organic matter layer led to the surface hydrophobization (CA↑, γSV ↓,WA↓, WS more negative).

MICROBIAL POPULATION CHANGES IN THE POLLUTED COASTAL SEDIMENTS OF THE GULF OF FINLAND, BALTIC SEA

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Microorganisms play a primary role in regulating biogeochemical systems in marine environment. The impact of pollution on the microbial community includes alterations in the abundance, diversity and physiology of microorganisms, which affect the biogeochemical cycles and productivity of the aquatic ecosystem. Heavy metal contamination in the Gulf of Finland has become a serious environmental problem, due to the direct and long-lasting impact on the ecosystem's functioning. Investigation of the distribution of microorganisms in the polluted environment is of great importance for gaining a better understanding of the aquatic ecosystem. This study has been undertaken to characterize the microbial population and ecological changes regulated by pollution pressure in coastal sediments of the Eastern Gulf of Finland, Baltic Sea. The culturable bacterial population showed a significant spatial variation and ranged between 105-108 CFU g-1 dry weight of the sediment. The number of total heterotrophic culturable bacteria showed an increase from the northern to southern part of the coast and was found to be highest in the Neva Bay. There was no significant pattern of fungal distribution within the sediment samples. The long-term accumulation of heavy metals in sediments of the Gulf of Finland provides the microbial community time to adapt to these contaminants. The study revealed high heavy metal concentration and a high number of metal-tolerant microorganisms in sediment samples. It is observed that fungi were the predominant group among metal-tolerant microorganisms compared to bacteria. Reduced microbial diversity was found in contaminated sediments. The results suggest that exposure to heavy metals has a negative effect on the culturable heterotrophic microbial community in sediments. Changes in the structure of this important component of the microbial assemblages have the potential to impact the biogeochemical cycling and trophic relationships of the aquatic ecosystem profoundly.

ANALYSIS OF HISTORICAL MERIS AND MODIS DATA TO EVALUATE THE IMPACT OF DREDGING ON MONTHLY MEAN SURFACE TSM CONCENTRATION

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We studied the changes of TSM distribution in the Estonian coastal sea with a special focus on Paldiski Harbour in Pakri Bay. Pakri Bay is an environmentally sensitive area: Most of the bay is covered by a Natura 2000 Special Protection Area. The purpose of the current study was to examine the suitability of remote sensing data to detect the turbidity differences caused by dredged sediments and to evaluate the impact of the monthly mean dredging amount on the surface TSM concentration retrieved from satellite images. The MERIS Full Swath Geo-located (FSG) products with 300 m resolution and MODIS band 1 data with 250 m resolution from years 2006-2010 were used in the analysis. MERIS images were processed using the Case-2 water processors available in BEAM software. Outputs of C2R and FUB processors were validated with in situ measurements of TSM at the time of dredging operation. Analysis showed reliable correlation between satellite data and in situ TSM measurements: r2 was 0.51 for the FUB processor and 0.61 for the C2R processor. For conversion of MODIS band 1 (B1) reflectance data to TSM concentration an empirical algorithm was established. Firstly, we used "dark pixel" methodology for correction of atmospheric disturbances. Using the whole dataset, a statistically reliable correlation (r2=0.43) between TSM from water sample and MODIS B1 reflectance was obtained. The monthly average TSM maps in the harbour region were calculated from MERIS and MODIS data using validated conversion algorithms in order to describe TSM variability at the time of the dredging period. For analysis of environmental impact, we calculated the differences between monthly mean maps from the dredging period (2008) versus non-dredging period (monthly mean 2006-2010). The estimated area in km2 affected by dredged sediments was 0,91 from MERIS images and 3,25 from MODIS images in July, 0,61 from MERIS images and 1,5 from MODIS images in August, and 0,92 from MERIS images and 1 from MODIS images in September.

CHARACTERIZATION OF THE EXTENT OF ICE COVER FROM MODIS IMAGERY DURING DIFFERENT WINTER SCENARIOS IN THE GULF OF RIGA, BALTIC SEA

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The Baltic Sea is well known for seasonal ice cover. The current study is focused on the Gulf of Riga, which is located in the eastern part of the Baltic Sea. Previous studies have shown that the ice conditions in the Gulf of Riga can vary significantly from year to year, depending on the weather conditions. Depending on the year, the ice cover season starts between late November and middle January. The length of the ice season, which can last until late April, is in the range of 3-5 months. In addition to interannual ice cover variations, there are significant spatial variations between different gulf areas.

The use of remote sensing methods enables us to monitor the ice extent during different winter scenarios. Although during the last years the emphasis in operational ice remote sensing has been on exploiting the capabilities of active sensors (e.g. SAR), the optical imagery can provide valuable information as well. Data from Moderate Resolution Imaging Spectroradiometer (MODIS) can be used for monitoring ice extent and for characterization of average winter conditions. We used MODIS data from the visible range channels of the spectrum with 250 m resolution (620 – 670 nm; 841 – 876 nm) to detect ice extent in the Gulf of Riga (Baltic Sea). In total, 366 images were used for ice extent detection.

After processing all of the 366 images, the average ice cover maps for different months and years were calculated. The ice cover probability maps were calculated which showed the percentage of time that each pixel was covered by ice. Based on the negative degree days, calculated from the data obtained at the Kihnu meteorological station, the winter scenarios were defined. If the sum of negative degree days (ºC day) is above 400, then the winter was considered to be severe (2003, 2006, 2010 and 2011). In case of moderate (2004 and 2005) winters the corresponding value was between 200 and 400 and for mild (2007, 2008 and 2009) winters the sum of negative degree days was below 200.

A COMPARISON OF SEA LEVEL SPECTRA AND ENERGY PARTITIONING IN THE BALTIC SEA VERSUS THE NORTH SEA AND PACIFIC OCEAN

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Sea level oscillations are arguably the most important indicator for characterizing dynamical processes in oceanic basins. The focus of our study is to compare spectral distributions and energy partitioning for sea level oscillations with periods of a few hours to several decades in three major basins: the semi-enclosed Baltic Sea, and the open-ocean North Sea and North Pacific Ocean. For this purpose, we have used long-term hourly sea level records for various sites in the Baltic Sea, on the SW coast of the North Sea, and in the NE Pacific. Records from some sites in these basins are more than 100 years long. For the two open ocean basins tides are the most energetic processes and are responsible for about 88% of the total energy in the North Sea and ~94% in the NE Pacific. In the Baltic Sea, tides are negligible (~0.3%). Tides were calculated and subtracted from the records. Non-tidal (residual) sea level variability is shown to occur over a wide range of spatial and temporal scales, ranging from hourly and diurnal variations forced by coastal winds and atmospheric pressure fluctuations, to climate-scale variations associated with changing sea and ocean volumes. Residual oscillations in the North Sea are 4-5 times stronger than in the two other basins, mainly because of large sea level oscillations forced by high atmospheric activity in this region. We have partitioned the sea level energy distribution according to various time scales: specifically, tidal, mesoscale, synoptic, seasonal and long-period (climatic). Spectral analysis reveals that relatively short period processes (periods < 3 months) are generated within the Baltic Sea itself and are almost unaffected by external oscillations. In contrast, processes with periods greater than 3 months are induced by the oscillations arriving from the North Sea. Thus, the Danish Strait acts as a low-pass filter, strongly suppressing high-frequency processes but allowing low-frequency processes to pass through freely.

BALTIC EARTH - REGIONAL EARTH SYSTEM SCIENCE FOR THE BALTIC SEA REGION

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The goal of Baltic Earth is to achieve an improved Earth system understanding of the Baltic Sea region. Baltic Earth is the successor to BALTEX, which was terminated in June 2013, after 20 years and two successful phases. The research components of BALTEX continue to be relevant, but now have a more holistic focus encompassing processes in the atmosphere, on land, and in the sea, as well as processes and impacts related to the anthroposphere. Specific interdisciplinary research challenges have been formulated by the Baltic Earth Interim Science Steering Group to be approached by the new programme in the coming years. The continuity in basic research fields, structure (secretariat, conferences, publications) and the international network (people and institutions) is symbolised by the logo, which is similar but still distinctly different from the BALTEX logo.

A major means of achieving the goals of Baltic Earth will be scientific assessments of particular research topics to be prepared by expert groups. Similar to the BACC approach, the assessments shall help to identify gaps and inconsistencies in the current knowledge. A Baltic Earth Science Plan will be established by mid-2014, with a definition of core research questions, so-called "Grand Challenges". These currently include:

1. Salinity dynamics in the Baltic Sea
2. Land-Sea biogeochemical feedbacks in the Baltic Sea region
3. Natural hazards and extreme events in the Baltic Sea region
4. Understanding sea level dynamics in the Baltic Sea
5. Understanding regional variability of water and energy exchanges

Baltic Earth will be committed to educational activities with the establishment of regular Baltic Earth Summer Schools, the first of which is intended to take place in 2015. The first dedicated Baltic Earth Conference is planned for 2016.

"Products" of Baltic Earth will include:

→ Conferences
→ Workshops
→ Assessment Projects
→ Research Projects
→ Summer Schools

REMOTE SENSING OF SHORTWAVE SOLAR RADIATION AND NEAR-SURFACE AIR TEMPERATURE CHANGES IN THE SOUTH-EASTERN BALTIC

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The main aim of this work is to determine shortwave solar radiation and near-surface air temperature changes in the south-eastern Baltic region during 2000-2013 using satellite data and remote sensing methods. The amount of solar radiation that reaches the Earth's surface (both land and sea surfaces) and its atmosphere defines the local temperatures and meteorological conditions, and may indicate climate change processes in the environment systems. Therefore, solar radiation reaching the Earth is the main energy source governing the surface temperature dynamics, both on land and in the ocean. While the grid of meteorological stations measuring solar radiation is rather sparse, satellite remote sensing data can be effectively used instead. However, the latter should also be treated carefully, taking into account signal absorption, atmospheric clarity, cloud coverage, etc. In this work, Terra and Aqua, MODIS, and AIRS data of a 15 x 15 km resolution was used to evaluate the incoming shortwave solar radiation and near-surface air temperature in the south-eastern Baltic. Space-derived estimates were then compared with regular observations taken at the meteorological stations. The results of the work demonstrate fairly how CM SAF satellite data could be applied for the coastal climate zone indication, breeze dynamics research, and cartography of the entire Baltic region.

ESTIMATION OF WAVE FIELD PARAMETERS FROM SAR IMAGERY IN THE BALTIC SEA

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The current study is focused on detection of wave field parameters from SAR imagery in the Baltic Sea. The study is carried out over the Baltic Sea region, where common SW and W winds induce steep waves with shorter wavelengths compared to ocean waves. As TerraSAR-X data has high spatial resolution (0.75 – 1.5 m per pixel) compared to previous SAR sensors (e.g. ENVISAT/ASAR), it enables detection of the two-dimensional wave spectrum even in the Baltic Sea.

The main objective of this work was to demonstrate the capability of detecting wave field parameter from TerraSAR-X imagery in the Baltic Sea. The wave field parameters obtained from SAR imagery were compared with in situ measurements and the SWAN wave model.

The comparison showed significant correlation between SWAN- and SAR-derived wave propagation direction ($r = 0.84$; rmsd = 34.4˚) and wavelengths ($r = 0.86$; rmsd = 11.8 m). The peak period was also calculated from SAR-based 2D wavenumber spectrum and compared with SWAN results (rmsd = 1.27; $r = 0.81$). The comparison of SAR-based wave field information with buoy measurements also showed good agreement in case of wave propagation direction ($r = 0.88$ and rmsd =45˚) and mean wave period.

Case studies showed that SAR data enables detection of land shadow effects and small-scale wave field variations in the coastal zone.

TRANSFORMATION AND RUN-UP OF LARGE-AMPLITUDE NONLINEAR WAVES FROM HIGH-SPEED FERRIES IN THE COASTAL ZONE OF THE BALTIC SEA

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It is known that high-speed vessels may induce large-amplitude waves at the sea surface. In the coastal zone, these waves may also be amplified due to effects of wave shoaling, refraction, and diffractio,n and can form a type of freak waves. These large waves are especially hazardous in the nearshore region, where they result in significant near-bottom velocities, induce bed sediment transport, and cause significant geomorphic change to the beach.

In this work, we focus on the highly nonlinear effects of transformation and run-up of waves induced by fast ferries in the coastal zone of Tallinn Bay, the Baltic Sea. The study is based on experimental data, which were collected in June-July 2013 in the coastal zone of Aegna Island. The experimental set included two LOG_aLevel® downlooking ultrasonic echosounders from General Acoustics located at a distance of 20 m and 100 m from the shore and video and manual measurements of wave run-up on a beach. All this allows us to study the transformation and run-up of the wake as a wave group and of each particular wave in detail. The data from measurements are also compared with the results of numerical simulations of wave propagation computed with the use of the CLAWPACK software package.

RUN-UP OF LARGE STORM WAVES ON ESTONIAN COASTS OF THE BALTIC SEA

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Analysis of maximal inundation of Estonian coasts on the Baltic Sea has been conducted based on 35-year wind wave simulations with a WAM model forced by COSMO winds in the presence of ice. The maximal significant wave heights and corresponding periods were found for 18 beach profiles selected along the Estonian Baltic Sea coast nearest to the shoreline point, which usually corresponded to water depth about 10 to 20 m and distances of up to 8 km from the shore. Run-up of waves with the same heights and periods on Estonian beaches of real topography taken from geological field surveys and combined with Google maps, where needed, was calculated in the shallow water theory framework using the CLAWPACK software package (www.clawpack.org).

We considered the case in which monochromatic waves of corresponding wave height and period were approaching the coast. To do so, we used boundary conditions of wave-makers located offshore and generating regular waves. Time and space steps during all calculations of wave run-up remained constant (1 m and 1 s respectively). The maximum wave run-up corresponded to the run-up of the first wave and wave set-up formed by the run-up of high-amplitude waves was observed.

SPATIAL-TEMPORAL ANALYSIS OF HYDROPHYSICAL DATA USING MULTIPLE LINEAR MODELS

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The subjects of this research are the surface layer hydrophysical parameters and their spatial-temporal statistical models in the south-eastern Baltic Sea. We analyze water salinity, water temperature, and ice phenomena data collected in the period of 1993-2013. The Center of Marine Research in Klaipėda (Lithuania) provided us with the data. The purpose of this research is to differentiate time layers to construct optimal parametric spatial trend and spatial distribution (semivariogram) models, and to use the constructed models for ice formation statistical dependence on water salinity and temperature research, as well as to interpolate and to make predictions using different linear prediction models (kriging).

INTER-ANNUAL VARIATIONS AND TRANSVERSE PATTERNS OF THE SPRING BLOOM IN THE GULF OF FINLAND IN 2009–2012

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In order to gain a better understanding of spring bloom dynamics in the Gulf of Finland, comprehensive measurements were carried out from March to the end of May from 2009 to 2012. High-resolution measurements enable bloom dynamics to be followed from the basin/seasonal scales to the mesoscale. The spatial variability of the bloom, and partly the inter-annual variations, can be related to the mesoscale processes that influence vertical transport of nutrients and development of stratification.

ICE COVER DETERMINATION FOR LAKES OF THE BALTIC AND WHITE SEA BASINS ON THE BASIS OF JASON-2 SATELLITE OBSERVATIONS

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This work aims at development of a simple method for distinction between open water and ice cover on the basis of the geophysical data record (GDR) of altimetry satellite Jason-2 for large and medium-sized freshwater inland water bodies. The method is applied to the following lakes: Ladoga, Onega, Vygozero, and Segosero. The method for ice-water discrimination based on the data of altimetry satellites was initially developed for the Topex/Poseidon satellite and was successfully applied to the Caspian, Aral, and other seas, as well as Lake Baikal. This method was based on the joint analysis of two parameters: the backscatter coefficient at 13.6 GHz and the average value of the brightness temperature values at 18 and 37 GHz. It is shown that the method works well for large water bodies such as Lakes Ladoga and Onega and experiences significant difficulties for medium-sized water bodies, such as Vygozero and Segosero, due to the small amount of valid data on the backscattering coefficient, which is caused by the influence of the land on the shape of the reflected altimetry pulses. For the medium water basins, a more productive method is based on analysis of the difference in brightness temperatures of land and water. Along-track variation of the average brightness temperature at 18.7 and 34 GHz for cycles 1-179 of Jason-2, constructed for winter and summer periods, showed that the difference in brightness temperatures of land and water strongly reduced when the water freezes. We constructed time series of brightness temperature differences and demonstrated that these dependencies have a pronounced seasonal variation for all lakes considered. The transition from summer values (open water) to winter values (ice) is sharp enough, which allowed us to determine sufficiently accurately the date of freezing for the lakes.

CONNECTION BETWEEN INTERNAL WAVE ACTIVITY AND OUTER SHELF AND SLOPE CIRCULATION DURING WINTER 2012 OFF LONG BAY (SE US)

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A cross-shelf moored array, shipboard current profiler observations, and glider observations were collected over the first few months of 2012 as part of a study of wintertime phytoplankton blooms off the coast of northern South Carolina, United States. The combined dataset is examined to document the subtidal circulation in the region inshore of the offshore deflection of the Gulf Stream and its influence on the onshore propagating internal wave field. Meanders of the Gulf Stream indirectly forced the outer shelf flow through formation of filaments off the meander crests that moved along the upper slope. Several filaments exhibited unusually strong flow and moved equatorward, displacing ambient waters, and inhibiting onshore internal waves propagation. Times of poleward flow along the shelf led to opposite thermocline tilts over the upper slope and increased internal wave activity on the shelf.

CLIMATIC CHANGE OF THE BALTIC SEA LEVEL AND SEA SURFACE TEMPERATURE BASED ON SATELLITE ALTIMETRY AND RADIOMETRY

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For the period from January 1993 to June 1994, the Baltic Sea level (BSL) dropped at a rate of -18.39±2.31 cm/yr. In the next six months (until December 1994) there was a rise in its rate (+39.28±4.02 cm/yr). A short period of sharp drop in BSL at a rate of 29.40±3,72 cm/yr was observed from December 1994 to January 1995. Then, from January 1995 to November 1998, it rose again at a rate of +7.44±0.65 cm/yr, and from November 1998 to November 2002, the BSL dropped at a rate of -5.53±0,32 cm/yr. Then, from November 2002 to January 2005 the BSL rose at a rate of +12.25±1.71 cm/yr. A short period of sharp drop in BSL at a rate of -15.40±3,72 cm/yr was observed from January 2005 to March 2006. The maximum rate of sea level rise at 66.02±0,83 cm/yr was obtained from March 2006 to January 2008, and from January 2008 to February 2010 BSL dropped at a rate of -7.25±0.32 cm/yr. Until now the Baltic Sea level has risen at a rate of +13.80±1.37 cm/yr.

On average in 1993-2012, the Baltic Sea dropped at a rate of 0.35±0.07 cm/yr. In this time period sea surface temperature (SST) rose also at a rate of +0.07±0.03 °C/yr according to remote sensing data.

IN SITU MEASUREMENTS OF CARDIAC ACTIVITY DYNAMICS IN INDIGENOUS MACROBENTHIC INVERTEBRATES FOR WATER QUALITY BIOINDICATION

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One of the prospective tasks for the maintenance Baltic Sea ecological safety is the development of technology for conducting bioindication and ecological assessment of studied areas differing in anthropogenic impact. This approach could be realized on the basis of the bioelectronic method (Kholodkevich et al., 1999) for monitoring cardiac activity (heart rate) in indigenous invertebrates species, taking into account that cardiac activity is an integrated measure of the health state of the species inhabiting the studied areas. An objective for future investigation could be to establish the links between the content of hazardous contaminants in tissues of the indicators' species and selected physiological and behavior traits. Such data could be used as a bridge between hazardous substances and their biological effects on organism functioning, and lead to support for biomonitoring in Baltic Sea regions of special concern to emerging agents listed in HELCOM CORESET.

The necessity of online monitoring to reveal the localities of ecological impact and determination of rapid extreme changes in environmental water quality is obvious. It is known that ecological risk for the ecosystem in emergency situations is accompanied by changes in the hydrobiotic community. This fact determines the active bioindication methods to be used based on bioelectronic testing of indigenous hydrobionts.

The principle possibility for the applicability of bioelectronic systems together with Ferry Box systems and automatic monitoring buoys is discussed.

ON WAVE DAMPING DUE TO CRUDE OIL FILM: THEORY AND LABORATORY EXPERIMENTS

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Damping of surface waves due to oil films of finite thickness is a very important problem for development of remote sensing methods of oil spill monitoring. Damping of gravity-capillary waves has been analyzed numerically and the role of physical parameters for oil films (volume viscosity, surface and interfacial tension, surface and interfacial viscosity and elasticity, and film thickness) on the value of the damping coefficient was analysed in the framework of the two-layer fluid model. The calculated damping coefficient was compared with an approximate analytical solution for thin films and possibilities of its use were discussed. The results have been applied to describe data from our laboratory experiments on wave damping due to crude oil films in a wide wave frequency range. Physical parameters of oil films were estimated when tuning the film parameters to fit theory to the experimental dependencies of the damping coefficient on film thickness. The peculiarity of the dispersion equation obtained in the experiments - non-monotonic dependence of the wave number of gravity-capillary waves on their frequency - was explained. The crude oil films can be characterized by a complex viscoelasticity coefficient with large real part (the film elasticity parameter). The experiments were performed at different temperatures, and dependence of oil film physical parameters on temperature conditions was detected. The experiments showed that the wave damping coefficient in the presence of thin films depends weakly on temperature, while the wave damping due to thick films strongly increases when the temperature decreases because of the volume oil viscosity growth. Radar and optical contrasts of oil slick images on the sea surface were estimated and compared with field experimental data.

STORM SURGES IN THE BALTIC SEA AND THE SEA OF OKHOTSK: A COMPARISON OF STATISTICAL PROPERTIES AND FORMATION CONDITIONS

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Storm surges flooding coastal areas are mainly caused by the passage of deep cyclones. They present a significant threat to human settlements on the coasts of both the Baltic Sea and the Sea of Okhotsk. In the Baltic Sea, the most dangerous surges are observed in the Gulf of Finland and in the Gulf of Riga; the formation of strong surges in these areas is mostly associated with westerly winds.

In the Sea of Okhotsk, the region most affected by storm dangerous surges is the shallow Sakhalinsky Bay, which is located between the mainland and the northern part of Sakhalin Island. The maximum surge height was observed in the port of Moskalvo in 1971 (2.7 m is the highest surge ever recorded in the Far East of Russia). The formation of significant surges is mainly caused by sustained northerly or northwesterly winds typically associated with a deep cyclone in the central part of the sea. Dangerous surges also occur on the Okhotsk coast of the Kuril Islands, and on the west coast of the Kamchatka Peninsula.

In this study we collected and examined coastal tide gauge observations in the Baltic Sea and in the Sea of Okhotsk. We estimated statistical parameters of surges at various coastal stations and analyzed their spatial variations. The surge height distribution for different threshold values was compared with the Poisson law. One of the most important tasks of our study was to identify, for both regions, the cyclone trajectories responsible for the most dangerous surges.

We also estimated the relative contribution of atmospheric pressure and wind velocity components in surge generation for various coastal regions. Tides are negligibly small in the Baltic Sea, but in the Sea of Okhotsk they are substantial; thus, for the latter basin we estimated the influence of tides on the formation of extreme surge heights. Furthermore, for large gulfs and bays in the Baltic Sea and the Sea of Okhotsk we evaluated the role of low-frequency resonant oscillations in producing destructive surges.

VARIETY AND VULNERABILITY OF ORNITHOFAUNA IN THE EASTERN PART OF THE GULF OF FINLAND IN THE «NORDSTREAM» MARINE GAS PIPELINE ZONE

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Within the framework of monitoring of the «Nordstream» Project, in 2010–2013 observations on bird migrations and reproduction / nesting were carried out on the gas-pipeline corridor in the Russian sector of the Gulf of Finland (Baltic Sea). Migration activity was studied in the coastal zone of Fiskar, Sommers, Nerva, Moschny, Seskar, Bolshoy and Maliy Tutters, the Gogland Islands, and in Portovaja Bay on the northern coast of the Gulf of Finland. Information about the nesting populations was collected during regular route observations on these islands. It was found that the gas-pipeline construction did not effect the basic characteristics of functioning, dynamics, and reproduction of the ornitocenosis in the Russian part of the Gulf of Finland. The disturbance factor was observed in Portovaja Bay in the form of decreasing the number of nesting ducks. Rare and protected species of the ornitofauna are not affected by the pipeline construction. An expansion in the number of cormorants and eiders was observed in the research area. It was shown that for assessment of the pipeline's influence on the ornitofauna only species which are ecologically connected with the water environment and the coastal zone biotopes can be used. The typical species of Baltic marine fauna are in this group, as well as the species which are connected with freshwater lakes but using the marine coastal zone as a place of relaxation and feeding during the migration period.

DISTRIBUTION OF ZOOBENTHIC COMMUNITIES ACCORDING TO ENVIRONMENTAL CONDITIONS IN THE LAHEPERE BAY REGION

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This paper is based on an analysis of zoobenthic communities from Lahepere Bay of the Estonian coastal sea and its region up to the Estonian economic zone. The samples were collected on 3-4 July of 2013 from fifteen stations using Van Veen grab with an opening area of 0.1 m². From three stations no zoobenthos was found, due to an oxygen deficit in the near bottom layer. Bottom macrofauna was identified to the species level; abundance and dry biomass were also determined.

In deeper areas of the study (57-73 m) only two to four species were found in each sampling station, whereas key species included Macoma balthica, Halicryptos spinulosus, and Marenzelleria neglecta. At a depth range of 43-57 m the species composition consisted of five to seven species, including the key species Monoporeia affinis and Bylgides sarsi in addition to the previous. Shallower stations (12-34 m) had up to 17 species in one community, and key species included bivalves.

The results showed that zoobenthic communities were more diverse in the shallow Lahepere Bay with a coarse sediment type. The sediment type changed from gravel (even rocks) and sand to mud or clay from the southern part of the Lahepere Bay towards the open sea area.

SEA ANIMALS AS A REMOTE SENSING TOOL IN THE SERVICE OF MARINE RESEARCHERS

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Recent technological developments have increased opportunities to explore ecosystems without substantial interference. Attempts to obtain information on marine animals has led to the creation of clever bio-logging devices that obtain multidimensional information about the environment. The logger sensors are often not limited only to determing location; therefore, to get more diverse information from the logger, sensors describing various environmental parameters can be added, which may include, e.g., temperature, salinity, and chlorophyll a.

Recently, there has been an increase of interest in these methods of data collection.The main reasons for this are poor location of research areas, a large study area, presence of a suitable animal platform species, a large amount of high-quality information at once, and cost effectiveness. Such methods are used massively in the high latitudes. The work of autonomous buoys are hindered by ice in the Arctic and currents in the Antarctic. At least 70% of CTD (conductivity-temperature-depth) data is collected by elephant seals. The hooded seal is used to collect CTD in addition to the data that is gathered by ships and buoys. Gray and harbor seals were used to map shelf areas in Ireland. Various of fluorometers has been tested and the first of such data was collected by an elephant seal.

The Baltic Sea is highly suitable for use of such applications in many aspects. The Baltic is shallow and divided, which makes the work of other autonomous devices complicated. There are two mammal species, the gray and ringed seal, with relatively stable movement patterns whose habitat use covers the entire sea relatively evenly. It is rather easy to catch them and they are able to gather data 24 hours a day. The majority of the coast is covered by GSM network, which enables the transmission of large amounts of detailed data. CTD data from ringed seals in Estonia was used to investigate the possibilities for creating temperature maps. It is possible to correct models at medium and deep water layers.

RFLEX SHIPBORNE REMOTE SENSING FROM SHIPS-OF-OPPORTUNITY ON THE BALTIC SEA

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Reliable in situ validation data are an important component to validation of aquatic remote sensing products, particularly when the water body has complex optical properties such as in coastal seas and estuaries. Above-surface remote-sensing reflectance (Rrs) can be collected both from offshore moorings and ships. The use of moving ships with regular routes adds a spatial component to the new observation layer.

We present results from our operational Rrs recording platforms on the Baltic Sea from research cruises and the first year of routine operations. Rrs are collected during sunlit hours at 15-s intervals at continuously optimized azimuth angles, and subsequently corrected for surface reflectance and sunglint, yielding 20-60% of measurements passing automatic quality control, depending on illumination conditions, or up to 1000 samples per day on the Finland-Germany transect. Continuous in situ Rrs¬ helps to identify atmospheric correction problems as well as near-surface cyanobacteria blooms in summer.

Development of the Rflex automated reflectance unit has been supported by EU FP7 projects PROTOOL (www.protool-project.eu) and WaterS (www.mywaters.eu). Rflex hardware description, free software, documentation, and computer code for Rrs signal processing can be obtained through sourceforge.net/p/rflex/wiki/Home/. The upcoming FerryScope (BONUS) project aims to make the operational Rrs observations openly available for remote sensing image calibration and algorithm development.

FORECASTING GLOBAL TEMPERATURES: MISSING THE POINT

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During the past five decades, global air temperatures have been warming at a rather high rate, resulting in scientific and social concern. However, the warming rate changes with time. Global surface temperature records show a persistent stabilization since the beginning of the 21st century, the so-called hiatus. We try to elucidate the consequences of the hiatus on forecasting global temperatures for the 21st century. We analyze measured and modeled data on global mean surface air temperature, covering the last 160 years using spectrum techniques. The spectrum analysis of the measured data shows a strong secular trend (ST) and a clear multidecadal sinusoidal oscillation (MDV).

The observed acceleration of the warming during the period from 1970 to 2000 therefore appears to be caused by a superimposition of anthropogenic-induced warming (~60%) with the positive phase of a multidecadal oscillation (~40%), while the recent slowdown (hiatus) of this tendency is likely due to a shift in the MDV phase. The proposed tipping point in the climate system around the 1980s could be a misinterpretation of the accelerated warming caused by the natural oscillation. Most current-generation global circulation models (CMIP5) do not reproduce this MDV and are missing the hiatus in their simulations. Therefore, it is less likely that these models could correctly forecast the temperature evolution during the coming decades. Forecasting based on the analyzed ST and MDV dynamics reproduces indeed the present hiatus and results, in comparison to CMIP5 forecasts, in much lower temperature increases for 2100 of less than 1° C. Global mean air temperatures could even decrease for the next 2-3 decades. We conclude that firstly investment in model development and in model validation should be increased to achieve realistic hindcasts, especially capturing the hiatus and closing the “black hole” in Earth’s energy balance, before focusing again on forecasting.

ON THE MECHANISMS OF DANGEROUS SEA LEVEL RISE IN THE EASTERN PART OF GULF OF FINLAND AND POSSIBLE REASONS FOR INCREASE IN THEIR FREQUENCY IN THE SECOND HALF OF THE 20TH AND THE BEGINNING OF THE 21ST CENTURIES

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Conventional now an identification of Neva flood waves as long gravity waves is refuted. Comparison of the estimated characteristics of Neva floods with theoretical dispersion relations of different types of long waves is carried out. This comparison and the results of an analysis of the meteorological information and previously performed numerical experiments on the Baltic Sea hydrodynamic model show that Neva flood waves are identified as baroclinic topographic waves which may be generated in the result of resonance between anemobarical forces in the atmospheric cyclones and eigenmodes of the Open Baltic Sea–Finnish Bay system. Results of theoretical studies are confirmed by results of analysis of instrumental measurements of hydrometeorological characteristics during the formation of dangerous level rises in the east of the Gulf of Finland. It is shown that, despite the storm conditions, in these periods pronounced stratification persists. On the baroclinic nature of flood's wave indicates significant changes in the currents dispersion with depth, when changing their directions are reversed, as it occurs in the first baroclinic mode of waves. The direction of major axes for the ellipses of the standard deviation is not oriented along the isobath, as it should be in the long gravity waves, and elongated across the bottom topography contours, which is typical of gradient-vorticity waves, which belong to the class of horizontal shear waves. It is hypothesized that the observed increase in the frequency of dangerous sea level rises in the eastern part of the Gulf of Finland may be associated with interannual variability of baroclinic conditions. This hypothesis is tested by methods of statistical analysis of interannual changes in thermohaline conditions and cases of flooding.

ON THE VERTICAL STRUCTURE OF THE LOW-FREQUENCY OSCILLATIONS OF CURRENTS IN THE GULF OF FINLAND

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The aim of this study was to determine the depths which were most influenced by low-frequency motions and to reveal the processes behind the observed distribution of kinetic energy. The long-term records of five bottom-mounted ADCP deployed along the Gulf of Finland (GoF) in different regions were studied. Two ADCP of five were deployed along the thalweg of the gulf in the same time period (winter 2011/2012), while the remaining three were located closer to the southern coastal slope of the GoF. Those ADCP were deployed at different time periods. It was found that in many cases the low-frequency oscillation of currents, not found in the surface layer, was a dominant phenomenon below the pycnocline. The maximum amplitudes of those motions were observed sometimes directly near the bottom and sometimes in the middle of the bottom layer (the layer below the pycnocline). Still, time periods were also observed when the low-frequency variability did not exist. The frequency of oscillations varied by region in the GoF and therefore the role of bottom topography in determination of the frequency of oscillations could be expected. Furthermore, a hypothesis that some of the observed low-frequency oscillations were bottom-trapped topographic waves was proposed. The varying wind conditions were expected to be a source of energy for these periodic processes. Under ice cover, the current variability in low-frequency range was not observed. For comparison, model results of bottom-trapped topographic waves for one region of the GoF were shown. Vertical distribution of the amplitudes of measured currents in some cases was similar to the modelled ones, but in many cases a more complicated pattern was observed.

THE IMPACT OF A PORT ON THE SURROUNDING SHORES BASED ON 10 YEARS OF MONITORING RESULTS: PORT OF SILLAMÄE CASE STUDY (GULF OF FINLAD, BALTIC SEA)

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The main purpose of the paper is to discover the impact of a port establishment on changes in the shorelines and sediment budget in the vicinity of Sillamäe town. The study is based on analysis of the changes in shoreline positions, scarp edges, and shore profiles measured between 2004-2013. The measurements were carried out using RTK-GPS (accurate to within 1–2 cm), handheld GPS (accurate to within 3 m), and a Leica level. Ortophotos and archived photographs of the study area were also used. In addition, wave conditions have been studied both by field observations and model hindcasts along the northerly exposed relatively straight coastal section between Letipea Peninsula and Sillamäe.

The results suggest that either a stable geomorphic state or a slow accumulation prevailed along the studied coast. After stronger storms, occasional erosion events were registered in several sections of the study site. However, these changes were mostly temporary and a stable state was usually restored soon after the erosion event. Changes in sediment quantities (both in accumulation and erosion) were mostly small, or less than 2 m3 per year and shoreline meter. Bigger changes associated with greater storms occurred during the two-year period in 2004-2006, when sediment quantities declined by about 19%, and in 2011, when sediment quantities grew 34% on one profile.

Unlike the westerly exposed coasts of Estonia, both storminess and wave heights have slightly decreased at Sillamäe since the 1960s. However, over the period of 2003-2013, this decreasing trend has again turned into a mild rise. Nevertheless, we could not register an increasing trend in shore processes over the same period, nor were we able to register any negative impacts that can be associated to the port development. Moreover, the slightly increasing trend in wave parameters and continuously stable state in shore processes might even indicate a positive impact of the port on the shores surrounding Sillamäe.

ANALYSIS OF SURFACE CURRENT PROPERTIES IN THE GULF OF FINLAND USING DATA FROM SURFACE DRIFTERS

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The accurate prediction of currents in the ocean surface layer is of importance for many applications, such as environmental monitoring, offshore commercial operations, and shipping safety. Numerical models can be used to obtain such predictions, but in most sea areas the availability of current observations remains scarce.

We report results of field experiments involving passive surface drifters in the Gulf of Finland, with the purpose of characterizing the mesoscale and sub-mesoscale flow dynamics and spreading rate. A total of 52 deployments of surface drifters were made in 2011 and 2013, with duration of drift lasting from 1 to 35 days. The individual tracks produced a velocity distribution with a mean value close to 0.1 m/s, with close resemblance to the Rayleigh distribution. A Lagrangian integral time scale was calculated based on the auto-correlation of the drifter velocity, revealing that the persistency of movement was less than 10 hours for most tracks, but in some cases reaching up to 20 hours.

Analysis was also made for the relative dispersion of drifter clusters. At small separation scales the speed of drifter separation appears to follow the Richardson Law, where the relative diffusivity increases as the separation distance to the 1/3 power. However, a transition takes place with separation distances from 2.5 to 5 km, after which the relative diffusivity decreases with increasing separation distance. These results point to the complexity of the underlying surface current fields, and indicate what scales must be resolved in numerical models in order to obtain reliable predictions for surface currents in the Gulf of Finland.

WIND PATTERNS IN LAKE PEIPSI: HINDCAST AND IN SITU DATA

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Long-term wind patterns in the North-Eastern part of Europe are studied by means of in situ measurements and numerical modelling. The measured values overestimate the magnitude of wind speed by a factor of two. Interestingly, wind direction is fairly reconstructed.

ROGUE WAVES IN LITHUANIAN WATERS

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Favorable conditions for crossing seas in the Lithuanian waters (Baltic Sea) are investigated. Two-dimensional wave spectrum in the Baltic Sea is studied based on a multi-decadal wave hindcast (1957-2009) under the WAM model. The spectrum contains 24 directions (from 7.5° to 352.5°), and the energy of wave components are approximated using 40 frequencies (from 0.042 Hz to 1.7 Hz). The characteristics of rogue waves are explained under the Kadomtsev-Petviashvili equation. The multi-decadal hindcast reveals a relatively high presence of two-peak systems.

SOME FEATURES OF BOTTOM SALTY WATER FORMATION IN THE ARKONA BASIN BY MODEL RESULTS

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A mathematical model of the bottom saline water formation in the Arkona Basin during the North Sea water inflow is presented. The model includes a system of hydrostatic equations for motion, the continuity equation, transport equation, and equation of state. The salt water inflow through the Strait of Zund is modeled by setting the strait periodic changes in flow with a period of 10 days and water salinity of 20%. The initial salinity of the Arkona Basin is about 10%. Results showed a significant role of baroclinic currents in the formation of bottom saline waters in Arkona Basin during the North Sea water inflow.

WAVE FORECASTING IN COASTAL ARCHIPELAGOS

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The Archipelago Sea, located between the Gotland Sea and Bothnian Sea, has countless small islands. The southern edge of the Archipelago Sea is also characterized by shoals that cause wave refraction and depth-induced wave breaking. To assist safe and efficient shipping in this area, wave forecasts with resolutions high enough to solve the islands and small-scale features in bathymetry are needed. At the Finnish Meteorological Institute (FMI,) the WAM wave model was implemented in the Archipelago Sea with 0.1 nmi and 0.5 nmi resolution. A comparison of the wave model results against measurements made in the Archipelago Sea in September 2010 showed the 0.1 nmi resolution grids and 0.5 nmi grids using additional grid obstructions to account for wave energy attenuated by the unresolved islands, and were able to simulate the wave field inside the Archipelago Sea with sufficient accuracy. It was also shown that the wave energy attenuates rapidly when it enters the archipelago and inside the Archipelago Sea the wave field is mainly dominated by local wind waves. To further evaluate the accuracy of the wave forecast in this area and to estimate the properties of the wave field inside the archipelago, a-posteriori forecasts were made for summer 2013 using wind forcing from Fm I's NWP system, HIRLAM. In addition, wind forcing from the higher-resolution NWP system, HARMONIE, is tested. Significant wave height, peak wave period and direction are compared against wave measurements made at FMI's Utö measurement station between May and October 2013.

UPWELLING-RELATED SEA SURFACE TEMPERATURE AND CHLOROPHYLL VARIABILITY STUDIED FROM REMOTE SENSING IMAGERY IN THE GULF OF FINLAND

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The current study focuses on studying the sea surface temperature (SST) and chlorophyll a (Chl a) variation from remote sensing imagery and ship of opportunity data in the context of upwelling events in the Gulf of Finland.

We propose a method for using operational ship of opportunity temperature data at a fixed depth for bias correction of satellite sea surface temperature (SST) maps. The bias-corrected SST imagery from MODerate Resolution Imaging Spectroradiometer (MODIS) and Advanced Along-Track Scanning Radiometer (AATSR) sensors were used to calculate mean upwelling characteristics in the Gulf of Finland (Baltic Sea). Firstly, we determined that the operational flow through temperature data at a 4-m depth can be used for validation of satellite SST in cases of wind speed over 5 m s–1. The composite SST maps were calculated from bias-corrected images collected during upwelling events in the Gulf of Finland in 2000–2009. Mean upwelling characteristics were estimated from composite maps for both the northern and southern coasts of the Gulf of Finland.

The Chl a concentration obtained from MERIS data using the FUB Case 2 waters processor was well correlated with in situ Chl a (r2=0.67), but was underestimated on average by 25%. Spatio-temporal variability of Chl a caused by upwelling events in the Gulf of Finland was investigated using MERIS (MEdium Resolution Imaging Spectrometer), MODIS, and in situ data. Case studies showed that the spatio-temporal variability of Chl a was influenced by coupled upwelling events. Comparison of the upwelling areas in the SST images and post-upwelling high Chl a areas in MERIS images showed structural similarities.

AN ASSESSMENT OF WIND ENERGY RESOURCES IN THE GULF OF RIGA USING IN SITU MEASUREMENTS, SAR IMAGERY, AND HIRLAM/BALTAN65+ MODEL DATA

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Wind speed and related mean annual energy yield by wind turbine are the cornerstones for suitability assessments of wind energy development in the Gulf of Riga area. The objective of the current study was to retrieve marine wind information by use of coastal wind measurements, high-resolution remote sensing data, and operational atmosphere model.

Long-term coastal meteorological observations (1981-2010) were used to model the wind fields by WAsP software (Wind Atlas Analysis and Application Program). WAsP uses topographical inputs, along with on-site meteorology data, to project wind field parameters over pre-defined grid nodes (node interval of 1 km in this study).

Also, space-borne SAR (Synthetic Aperture Radar) images were used to retrieve high-resolution (75 m) wind fields at the 10-m level by implementing a CMOD5 algorithm on 800 ENVISAT/ASAR images (years 2007-2010).

Wind field parameters covering 1981-2010 were calculated using data from two different model fields: the High-Resolution Limited Area Model (HIRLAM) from 2007-2010 and BaltAn65+ regional reanalysis database, comprising meteorological data of the Baltic Sea region for the time period of 1981–2005.

Maps of marine wind field parameters (1 km resolution) from in situ measurements, remote sensing and model reanalysis data were calculated covering the entire Gulf of Riga. The following parameters at a 10-m height were calculated for different timeframes and data sources: mean monthly wind speed, mean annual wind speed, mean monthly energy density, Weibull scale parameter (A), and Weibull shape parameter (k).

The analysis of results showed that the average wind field over the Gulf of Riga is rather uniform, except in the distinct zones of wind speed reduction along the coastline. The wind speeds are higher in the northern part of the gulf. The coastal zones of wind gradient are wider at the western coast of the Gulf of Riga, and the effect of islands cannot be neglected. The wind speed has distinct seasonal differences.

SPATIO-TEMPORAL VARIABILITY OF THE PLUME IN THE LITHUANIAN BALTIC SEA COASTAL WATERS

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This study aims to assess the patterns of coastal plume distribution in the Lithuanian Baltic Sea coastal waters with the application of the remote sensing technique during the intensive vegetation period (June-September). The analysis of the summer plume area was based on long-term salinity data, in situ measurements, and satellite images. The long-term 1992-2007 salinity data from August originating from the national monitoring program performed by the Department of Marine Research, Environmental Protection Agency were analysed. In situ chlorophyll a, coloured dissolved organic matter (CDOM), total suspended matter (TSM), and salinity data were collected during five field surveys carried out in July, August, and September in 2010 and in August in 2011 in the SE Baltic Sea coastal waters. Analysis of plume spatial distribution was based on MERIS FR for the period of 2005-2011. In total, 147 images for the summer period were analysed. Mean salinity of the plume waters was significantly lower than the salinity of Lithuanian Baltic Sea coastal waters and highly correlated with the absorption of CDOM. According to this relationship, a threshold CDOM value (0.408 1/m) indicating the plume waters was determined. Plume area in the Lithuanian Baltic Sea coastal waters covers the whole territorial sea, but is mainly directed towards the mainland coast to the north. During the intensive vegetation period of 2005-2011, two-thirds of all investigated cases (64%) in the fresh estuarine waters were directed towards the mainland coast to the north, north-west and west of the Klaipėda Strait, thus covering a two-fold smaller area of the sea, while in 20% of all investigated cases the estuarine water masses were directed south-east, southwards. The main environmental factors driving the spatial distribution of the plume were river discharge and wind.

CAUSES OF THE SHORT-TERM SHORELINE MOVEMENT AFTER BEACH REPLENISHMENT IN THE SE BALTIC SEA

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The coastal zone is a dynamic, complex, and vulnerable environment, the changes to which have significant economic and social impact. Lithuania has a short (only 90.6 km long) stretch of the SE Baltic Sea coast, and part of it has high recreational value. One of these sectors is Palanga Beach, which has turned into an erosive coast during last decades of the 20th century. To prevent further beach loss, it was decided to apply beach nourishment for the damaged section. After beach replenishment (early spring of 2012), Palanga Beach became wider on average by 43 meters, and in total 290000 m3 were added. In this work, short-term shoreline changes as consequence of water level and sediment volume changes were analysed.

Beach profiling in 30 profiles (every 100 m) were performed from 2012 06 01 until 2013 12 30 in a 3-km section of Palanga Beach. Profiling was performed using a Leica 900 dual-band GPS receiver. Sand volume and shoreline position movement calculations were made using ArcMapTM and DSAS 4.0 software, respectively. A field survey was performed once per week, and on the same day actual shoreline position was measured. Sea water level data were collected from the Palanga hydrological monitoring station (Marine Research Department, at the EPA).

Sand redistribution after beach replenishment is mainly performed by the eolian processes and water level changes. During the study period, the sea level change was ~45 cm (-18.6 ÷ 26,4cm). It was found that increasing the sea water level does not produce shoreline retreat in the entire study area: In the accumulative zone the shoreline still moves seawards, and in the erosive beach sectors, even during low sea water, the shoreline moves inland.

Accumulative and erosive shore sectors were indicated in the study period. In erosive sectors, the shoreline moved inland by 40 m over 1,5 years (Total loss of the sediment in these sectors was 130 m3). At the same time, accumulative sectors collected 44 m3 of sand in 1,4-km-long coastal sectors, and the shoreline moved by approximately 10 m.

ECOLOGICAL STATE ASSESSMENT OF KOPORSKAYA BAY USING A CHEMICAL AND BIOLOGICAL MONITORING DATABASE

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Created by IEG RAS, the database of hydrochemical and hydrobiological samples in the 30-km zone of Leningrad NPP offers information for assessing the ecological state of Koporskaya Bay as a cooling pond of Leningrad NPP and evaluation of adequate strategies for water body development.

Ecological monitoring is required to cover a number of 'water quality elements', including physical, hydro-morphological, biological, and chemical parameters. Standard chemical monitoring delivers important information on chemical levels for many pollutants, but it fails to provide any information on the toxicity of water samples. Quantity and biomass changes in environmental occupied flora and fauna populations are indicators for water pollution assessment. Whole organisms collected at points at the same time as chemical samples were used in standardized toxicity tests.

Coastal zones and estuaries, especially in industrial areas, are widely regarded as naturally stressed ecosystems where biota can accommodate or adapt to the dynamic physical and chemical conditions. The effects of warm water discharge from Leningrad Nuclear Power Plant (Leningrad NPP) on the physical, chemical, and biological properties of a natural water pond (Koporskay Bay, Gulf of Finland) were studied during the period of 2010–2014.

Water samples for chemical and biological analyses and fish assemblages were collected within the vegetation period (from May to September) every 1.5–2 months and once a year in the winter period.

Observations have shown an increase of phosphates, nitrates, and suspended matter in water during the summer period, a decrease of benthic and plankton community biodiversity in the vicinity of discharge channels of NPP, and a change in fish assemblages of the Koporskaya Bay during the last 3 years. The datebase created by IEG RAS would be a useful tool for assessing the ecological state of this cooling pond during construction and exploitation of Leningrad-2 NPP.

ASSESSMENT OF THE NUCLEAR INDUSTRY'S IMPACT ON COASTAL ECOSYSTEMS IN KOPORSKAYA BAY, GULF OF FINLAND

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Use of marine waters for cooling purposes in the power industry leads to environmental degradation and thermal and chemical pollution in the coastal zone. This study focuses on the non-radioecological impact of the nuclear industry (including nuclear power plants, enterprises specializing in treatment and utilization of radioactive raw materials, depositories of radioactive waste products and urban areas) on the coastal ecosystems in the Baltic Sea region. A new nuclear power plant (Leningradskaya NPP-2) is to be built here on the shores of Koporskaya Bay.

A numerical 3D hydrodynamic model of the water circulation and ice evolution of Koporskaya Bay (based on the Princeton Ocean Model) was applied to assess the modern NPP thermal impact on the ecosystems. Comparison of model results with field observations and remote sensing data indicates the capability of the model to predict future changes on seasonal and annual time scales. Model results were coupled with hydrobiological field data and an assessment of NPP influence on phytoplankton, zooplankton, benthos, and fish.

A strong ecological effect on marine biota occurs in the vicinity of discharge channel outlets of the NPP, where organisms are “shocked” by high temperatures, especially during the winter period. At the same time, additional discharges of cooling water from the new NPP will not lead to critical changes in the thermal regime and biota because of the usage of a cooling tower during the technological process. Thus, coupling of hydrodynamic modeling results with field observations allowed us to develop a scientific basis to assess the biological effects of nuclear power plant usage in the Baltic region.

ANALYSIS OF THE LIFETIME OF EDDY STRUCTURES

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Turbulent surface current motion is characterized by a complex field of eddies or vortices interspaced by meanders, fronts, and filaments. Eddies are generally more energetic than the surrounding currents, and play an important part in transport of heat, mass, and momentum, as well as biological and chemical agents, from their area of generation to areas where they disintegrate. The detection of eddies from field measurements has been carried out in several research programs over the last 40 years.

When analyzing instantaneous flow fields, e.g., satellite images, there are two main groups of methods available for eddy detection. Detection methods based on physical quantities depend on local variations in some quantity, such as pressure or vorticity. Relatively strong gradients are required to be reasonably sure that the anomaly represents a persistent structure, so these methods tend to detect the strong, dominant vortex field. Another method depends on the geometric properties of streamlines, in which case the curvature of the streamline is indicative of vortex structures. An eddy structure is detected if a streamline undergoes a rotation of $\pm 2\pi$ and the endpoint after rotation is close to the starting point. In the present paper, we use a hybrid method based on both a physical and a geometrical detection to examine the existence of eddies in simulated velocity fields. The aim of this study is to analyze the lifetime of these eddy structures.

VARIATIONS OF WAVE-DRIVEN SEDIMENT FLUX ALONG THE EASTERN BALTIC SEA REFLECTING THE CHOICE OF WIND DATA

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Sedimentary coasts along the eastern Baltic Sea express a delicate balance between the impact of waves approaching from two predominant directions (south-west and north-north-west) and therefore are sensitive to any changes in wave activity, including a change in the approach direction or balance between waves from these directions. Consequently, any variations in wave properties are likely reflected in the intensity and possibly direction of coastal processes. We analyse the sensitivity of patterns and magnitude of alongshore sediment along the eastern Baltic Sea by means of comparison of the net and bulk transport, evaluated using two different wave model runs. The study area stretches from the Sambian (Samland) Peninsula (Kaliningrad region) up to Pärnu Bay (Estonia). This is the longest connected domain of sedimentary coasts on the Baltic Sea. The properties of wave-driven sediment flux were evaluated using the Coastal Engineering Research Centre (CERC) wave energy flux model. The input wave properties (hourly time series of the significant wave height, peak period, and wave direction with a spatial resolution of about 5.5 km) were simulated using the third generation spectral wave model, WAM. We compare the output of two simulations for 1970–2007: (1) a run forced by adjusted geostrophic winds from the Swedish Meteorological and Hydrological Institute without ice information, and (2) another run that used simulated winds from the atmospheric regional model COSMO-CLM 4.8 and accounted for the presence of ice. Both runs reproduced the well-known counter-clockwise sediment motion along the study area, with a few quasi-stable reversals and occasional short-time reversals, and several major areas of sediment flux divergence and convergence. Larger variations became evident in bulk and net transport rates in certain coastal segments.

TIDES IN THE GULF OF FINLAND

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New estimates of the amplitudes and phases of up to 86 tidal constituents were obtained using the least-squares method at 21 stations in the Gulf of Finland. The long-term hourly sea level data mostly over 1977-2010 were used. The new co-tidal charts of M2, S2, K1 and O1 tides are presented. For completeness at 9 stations, the seasonal variability of the M2 tide was determined. Inter-annual variability of the M2 tide and K1 tide at these stations is also examined.

CURRENT MEASUREMENT BY DIFFERENTIAL ACOUSTIC TRAVEL-TIME REVIEWED

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Since 1977 papers have been published and talks presented about measurement of fluid flow by differential acoustic travel-time. The technique is older than these publications but a compilation of these will serve as a research source for understanding the development of the technique through 2014. The earliest papers describe the differential acoustic travel-time technique as applied to a free-fall shear meter and then to a boundary layer array. Next are the benthic boundary layer studies that gave rise to the BASS tripods and their application to the deep-sea sediment transport problem. Deep-sea applications transitioned to shelf depths and the combination of waves and current in estimates of bottom stress. Studies of the upper boundary layer used bottom tripods suspended from surface floats or mounted on tower legs to study air-sea interaction and mixing under waves in the surface boundary layer. Free drifting velocity sensing arrays were deployed to study internal diapycnal mixing. There are a series of papers about Richardson number measurements from RiNo floats. Finally, the development of a compact single-point sensor based upon the differential acoustic travel-time technique is described in papers that progress through analyses of performance and enhancements, as well as applications of the Modular Acoustic Velocity Sensor, MAVS.

SURFACE DRIFTER EXPERIMENT ON THE LITHUANIAN COAST OF THE BALTIC SEA

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Only a few short-term drifter experiments have been performed in the uppermost 1–2-m-thick layer of the Baltic Sea so far, according to Soomere (2011), and most of them were carried out in the Gulf of Finland. The most recent publication presents results of surface drifter (SVP-B type) deployment in the Baltic Proper (Kjellsson and Döös, 2012).

In November 2013 the first short-term surface drifter experiment was carried out on the Lithuanian coast in the southeastern part of the Baltic Sea. The drifters developed by PTR Group (Soomere, 2011) were used. Three drifters were deployed from the scientific research low draft vessel "Vėjūnas" at the location which is about 2 km from the coast of Giruliai town to the north of the Klaipeda Strait. During the period of observation, the drifting direction changed about 5 times by more than 90 deg, mainly due to changes in the mean wind direction. After seven days the drifters reached the coast approximately 30 km to the south of the Klaipeda Strait. The dispersion and other relevant parameters were evaluated.

Soomere T., Viidebaum M. and Kalda J. On dispersion properties of surface motions in the Gulf of Finland. Proceedings of the Estonian Academy of Sciences, 2011, 60, 4, 269–279.

Kjellsson J. and Döös K. Surface drifters and model trajectories in the Baltic Sea. Boreal Environment Research, 2012, 17, 447–459.

FEATURES OF SUMMERTIME CIRCULATION IN THE GULF OF RIGA (A NUMERICAL SIMULATION)

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A regional, 0.5 n.m. and 20 sigma layer grid model of the Gulf of Riga (GoR) was implemented based on the Princeton Ocean Model code, with initial conditions and atmospheric forcing taken from HIROMB and HIRLAM output. A basic run that covers an ice-free period of May 1–December 31, 2012, brought the following results:
- the mean summertime surface circulation in GoR displays a whole-basin anticyclonic gyre with more intense currents in the western half of the gyre;
- two seasonal currents are identified: the Northern Longshore Current (NLC) in the western part of GoR and the Southern Subsurface Longshore Current in the eastern part of GoR;
- in the cold part of the year (when seasonal pycnocline is absent), the anticyclonic gyre in GoR is replaced by a cyclonic gyre.

The seasonal change in sign of the whole-basin surface circulation in GoR is likely controlled by the NLC, a baroclinic jet-like current formed along the western shore in the summer, due to the prevalence of southwesterly, upwelling-favored winds, and the presence of seasonal stratification that can be approximated as a two-layer vertical structure; this baroclinic jet disappears in winter due to the absence of seasonal pycnocline.

EQUILIBRIUM BEACH PROFILE FORMATTING PECULARITIES OF THE LITHUANIAN COAST

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Lithuania, as a marine state, has a relatively small marine coastline. 51,03 km covers the Curonian spit, while the mainland covers only 38,49 km (Zilinskas 2011). This shorter shoreline strip has a different anthropogenic load scale. The largest part of it goes to recreational activities and infrastructure development; therefore, the trend of Lithuanian beaches has very important economic value.

In recent decades, the constantly changing hydrometeorological situation affects the development of the beach and its stability. Over the last 20 years alone, eroded coast worldwide has risen up to 70% (Zhang 2004). Similar changes are observed on the coast of Lithuania: 50 years ago accumulation processes prevailed in most sections of the coast, but recent studies (Zilinskas 2008) have shown that erosion processes have become dominant. This change is easy to notice by analyzing cross-shore profiles, keeping in mind that the beach directly experiencing the impact of the waves is the most sensitive element of the sandy coast (Jarmalavicius 2011). Therefore, the slightest changes in coast-forming factors are reflected in equilibrium beach profile formation. The hypothesis behind the equilibrium beach profile is that beaches respond to wave forcing by adjusting their form to an "equilibrium" or constant shape attributable to a given type of incident wave and or sediment characteristics. Thus, by studying equilibrium beach profile changes it is possible to indicate the changes in processes which determine morphological features of the coast.

This paper analyzes the features of the Lithuanian equilibrium beach profile. The data was collected by measuring the beach from the dune peak to a depth of 0.5 meters with a dual-frequency GPS receiver, while the single-beam echo sounder was used to measure the submarine part up to 10 meters deep. This research will determine potential areas for profile changes and will allow classification of investigational area into potentially vulnerable areas.

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