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Baltic Earth - Gulf of Finland Year 2014 Modelling Workshop

Modelling as a tool to ensure sustainable development of the Gulf of Finland-Baltic Sea ecosystem

Finnish Environment Institute SYKE, Helsinki, 24-25 November 2014

Programme, Abstracts, Participants

SYKE

Gulf of Finland Year 2014

Baltic Earth
Earth System Science for the Baltic Sea Region

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Photo credits:

Front page: The Gulf of Finland on 15 March 2002. The eastern Gulf still is covered with ice, but phytoplankton has started to bloom at the Estonian coast. Moderate-resolution Imaging Spectroradiometer (MODIS), flying aboard NASA's Terra satellite. Image courtesy Jacques Descloitres, MODIS Land Rapid Response Team at NASA GSFC.

Inside: An aerial photo of the lighthouse and pilot station of Harmaja. A pilot boat returning from its mission in July 2013. Image by Heli Vilmi / Image bank of the Environmental Administration of Finland.

Baltic Earth - Gulf of Finland Year 2014 Modelling Workshop

Modelling as a tool to ensure sustainable development of the Gulf of Finland-Baltic Sea ecosystem

A scientific workshop in support of the Gulf of Finland Declaration

Finnish Environment Institute SYKE, Helsinki
24-25 November 2014

Co-Organized by

SYKE

Gulf of Finland Year 2014

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Baltic Earth
Earth System Science for the Baltic Sea Region

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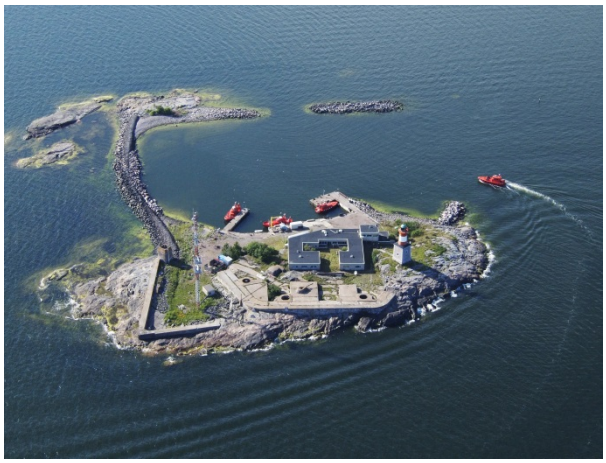
Find up-to date information on the Baltic Earth website: www.baltic-earth.eu/GoFWorkshop2014

Idea



The scientific themes of the Gulf of Finland Year 2014 (bio- and geodiversity, maritime spatial planning, maritime safety especially in winter conditions, fish and fisheries and ecosystem health) fit very well with the Grand Challenges of Baltic Earth programme, as they relate to natural and anthropogenic impacts on the biogeochemistry and ecosystem of the Gulf of Finland. In both programs, modelling is an important tool to study different processes and the linkages between them.

The workshop is organized back-to-back with the trilateral Finnish-Estonian-Russian Forum for the investigations of the Gulf of Finland ecosystem.

Issues to be covered

To assess our common knowledge of modelling various processes in the Gulf of Finland, Baltic Sea, the joint Baltic Earth-Gulf of Finland Year 2014 Workshop will cover the following modelling issues:

- the role of physical forcing on the GoF ecosystem
- biogeochemical modelling of the Baltic Sea (Gulf of Finland)
- effects of climate change on (Gulf of Finland) ecosystems
- eutrophication and cost-effective nutrient load reduction
- natural and anthropogenic hazards like coastal erosion, cyclonic storms, oil spills and other accidents and their impacts on ecosystems

Linkage to the Gulf of Finland Declaration

An important goal of the workshop is to inform decision-makers of our main knowledge gaps concerning the listed themes, and to discuss with them possible actions to be carried out to ensure a sustainable development of our Gulf of Finland in the future. Now is a suitable time for such a dialog.

One of the key results of the Thematic Year will be the Gulf of Finland Declaration, signed by the Ministers of Environment of Finland, Russia and Estonia in early 2015. In the Declaration, the most important actions to substantially and quickly improve the state of the Gulf will be listed. It is important that the scientific opinion of the entire Baltic Sea research community will be taken into account. The participation of representatives of the involved Ministries in this workshop is envisaged.

The Workshop

The Baltic Earth Gulf of Finland Workshop features invited keynote lectures, breakout working groups on different topics, a poster session and a summary section.

The workshop on Monday 24 and Tuesday 25 November is organized back to back to the joint Finnish-Estonian-Russian Trilateral Forum which is a two-day event (26-27 Nov).

Programme

Day 1: Monday 24 November

Overall introduction

11.00 Opening and The Gulf of Finland Year Declaration
Martti Poutanen, Finnish Ministry of Environment of Finland

11.20 The scientific goals of the Gulf of Finland Year and linkages to Baltic Earth
Kai Myrberg, SYKE, Finland

Scientific talks

11.50 General physical forcing of the Gulf of Finland area, and how the forcing affects the ecosystems
Urmas Lips, Tallinn University of Technology, Estonia

12.10 Eutrophication and cost-effective nutrient load reductions (BSAP)
Bo Gustafsson, Baltic Nest Institute, Sweden

12.30 Biogeochemical modelling of the Baltic Sea and related challenges
Markus Meier, SMHI, Sweden

12.50 Lunch

13.50 Major natural hazards in the Gulf of Finland
Tarmo Soomere, Tallinn University of Technology, Estonia

14.10 Major human threats in the Gulf of Finland (oil spills, shipping accidents)
Pentti Kujala, Aalto University, Finland

14.30 The effects of climate change to the Gulf of Finland ecosystem
Markku Viitasalo, SYKE, Finland

14.50 Coffee

15.20 Discussion and division to working groups

15.40 Workshops devoted to the Gulf of Finland Declaration

Thematic groups

A. Cost-effective nutrient load reductions, main findings
B. Preventive methods and forecasting of oils spills and other marine accidents, new methods
C. The impacts of climate change on physics and biogeochemistry, main effects

Questions to be answered:

1. What is our knowledge of the environmental state of the Gulf now? How vulnerable is the Gulf towards anthropogenic impacts?
2. Which fundamental research gaps are there and what kind of new scientific innovations/modelling tools do we need in Gulf of Finland studies in the future to learn more about the ecosystem functioning?
3. What is our message to decision makers? What should our common research and modelling efforts be directed to in order to support environmental protection activities?

Recommendations to the Declaration: How can the state of the Gulf be improved rapidly and cost-effectively? Which concrete actions do our modelling results indicate?

18.00 Poster Session

19.00 Grand Evening Party (with Poster Session)

21.00 Helsinki by Night

Day 2: Tuesday 25 November

09.00 Finalizing the work of the Thematic Groups

10.30 Coffee

11:00 Wrapping-up the main findings and discussion

12.00 Closure

Oral presentations

(in sequence of presentation)

Eutrophication and cost-effective nutrient load reductions (BSAP)

Bo Gustafsson
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During the 20th century the Baltic Sea faced tremendous change in the nutrient state. The naturally quite oligotrophic sea faced massive increase in supply from land and atmosphere. Awareness of eutrophication problems in society has led to increased efforts to curb emissions, beginning with sewage treatment, but nowadays also measures are implemented to curb emissions from other sectors as well, such as agriculture, industrial and combustion sources. However, the time-scales of recovery are quite long, primarily because of large deposits of bioavailable nutrients in the sediments, and that makes it difficult to monitor progress in the Baltic Sea environment. As measures have become increasingly expensive for the society, there is an increased demand from society for predictions on how large the necessary reductions have to be in order to achieve a non-eutrophied sea. Within the framework of the HELCOM Baltic Sea Action Plan (BSAP), we have calculated the necessary reductions and provide a set of estimates of maximum allowable inputs. The calculations were performed with the coupled physical-biogeochemical model BALTSEM. In this presentation, a brief overview will be given on the modeling work that led to these maximum allowable inputs.

Major natural hazards in the Gulf of Finland

Tarmo Soomere
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The water masses of the Gulf of Finland often severely react to several important global and local (mostly atmospheric) drivers of natural hazards. Fortunately, the impact of global sea level rise is compensated here by the postglacial uplift of most of the Gulf. The direct wind impact leads to severe wind waves, extensive wave set-up and run-up and exceptionally high storm surges. While the extreme wave heights here are commensurable with the size of this water body, its eastern end hosts the highest storm surges in the entire Baltic Sea basin. In many occasions indirect effects of atmospheric drivers such as generation of long waves (meteorological tsunamis) or export of saltier water from the bottom layers of the Gulf may substantially modify the usual behaviour or development of its surface, coast and seabed. Specific features of wave generation and propagation such as strong winds blowing obliquely with respect to the Gulf or the associated phenomenon of slanted fetch may give rise to windseas and swells that approach the coast from unexpected directions. As the strongest winds often blow from directions from where the winds generally have a low frequency of occurrence, many coastal sections are only infrequently affected by high or long waves. These sections may seem stable but are heavily damaged when a strong storm generates waves from unusual directions or of unusual length. The elongated shape of the gulf indicates that

even small changes in the directional structure of driving forces may lead to drastic reactions of certain parts of the Gulf, for example, to the instability of sandy coasts in the eastern Gulf of Finland. The complexity of the dynamics of the Gulf of Finland renders the development of projections of the potential impact of climate changes on this water body a particular challenge.

Poster presentations

(alphabetically)

Poster 1

Circulation changes in the Baltic Sea during the 20th and 21st century

Byoung Woong An and Jari Haapala
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Circulation in the Baltic Sea persists for most of the year and is mainly determined by local driving forces, e.g. winds and river runoff. Therefore, changes in atmospheric forcing can directly affect the subsurface water masses and circulation by different mechanisms. This study describes variations of subduction and ventilation mechanism of the water mass in the Baltic Sea in terms of the balance of vorticities. This study also has computed the Lagrangian trajectories for mapping the mean flow and dispersion properties using Ariane (http://stockage.univ-brest.fr/~grima/Ariane/). The numerical model used in this study has a 2 nautical mile horizontal resolution, and it uses observed river runoff and atmospheric forcing downscaled using RCA, and covers the years 1961-2007. For the 21st century projection, the IPCC SRES A2 scenario was used.

Poster 2

The Gulf Of Finland: Social and economic problems of St. Petersburg in conditions of natural environmental change

Baykova Irina[1], Kostrukova Oksana[2]
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The water area and coasts of the Gulf of Finland (Baltic Sea) show a unique cultural heritage, including world heritage monuments of UNESCO, in the important geopolitical position at the borders of Estonia, Finland and Russia.

Natural, climatic and industrial changes and their influences on the ecological condition of the water area and coastal zones of the Gulf of Finland are estimated. Technical systems, all this can cause cascade reaction of many natural systems and processes, finally, will aggravate existing and will result in occurrence of new environmental problems.

The greatest danger is represented by technological incidents which have a detrimental effect on the reliable operation of infrastructure. Ecological risks and social and economic consequences of modern change natural and technological environments in territory of a megacity Saint Petersburg and its environments.

The development of all branches of manufacturing and financial and economic activity of Saint Petersburg and its suburbs is directly or indirectly connected to forecasting of natural and technological environmental conditions. The analysis of future sustainable development of the Gulf of Finland shows that the choice of technology for tourist and recreational resources will have serious consequences for the economical and social well-being of the region.

In the conclusion, problems of adaptation to climate changing conditions and adaptation of blue and green technologies in the tourist industry are discussed.

Poster 3

Successful adaptation of agriculture to the climate change helps in mitigating the increasing nutrient loading to the Baltic Sea

Huttunen, I., Piirainen, V., Huttunen, M., Lehtonen, H., Korppoo, M. and Vehviläinen, B.
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Climate change is expected to shorten snow cover period and increase runoff especially in winter time in the watersheds draining to the Baltic Sea. We studied the combined effect of different agricultural scenarios and a climate change scenario to the nutrient (phosphorus and nitrogen) transport from Finnish watersheds to the Baltic Sea with two chained models: the economic agricultural sector model DREMFIA and the nutrient loading model VEMALA. We created three different agricultural scenarios to describe the possible future pathways for agricultural production, reflecting the level of adaptation to the climate change. The agricultural scenarios were driven by the prices of agricultural products and by agricultural policies. The land use, level of fertilization and intensity of agricultural production from the agricultural scenarios of the DREMFIA model were used as input to VEMALA to predict the changes in nutrient loading.

VEMALA is an operational nutrient loading model for Finnish watersheds which simulates runoff, nutrient processes, leaching and transport on land, in rivers and in lakes. In the VEMALA simulations, we combined the output from the three DREMFIA scenarios with the A1B mean climate change scenario. The total riverine phosphorus loading from Finnish watersheds to the Baltic Sea increased by 7%, 9% and 12% in successful (SuA), moderate (MoA) and little adaptation (LiA) scenarios, respectively. The respective increase in rivers draining to the Gulf of Finland was 12%, 14% and 16%. Also the total nitrogen loading increased in all scenarios, but not in line with the level of adaptation as in the case of phosphorus. The nitrogen loading increase was 5%, 2% and 12% to the Baltic Sea and 17%, 7% and 33% to the Gulf of Finland in SuA, MoA and LiA scenarios, respectively. The phosphorus and nitrogen balance in fields was the main driver of the nutrient loading results. Although fertilization was highest in the SuA scenario, reaching high yields due to the prolonged growing season and successful adaptation to the climate change compensated for the phosphorus and nitrogen addition. Erosion increased in all scenarios. Successful adaptation increased nitrogen loading more than moderate adaptation, because of increased production of cereals which have one of the highest specific leaching of nitrogen from the hectare.

Our results show the need for agricultural sector to adapt to the changing climate in order to mitigate the increasing nutrient loading. Unsuccessful adaptation may lead to increased nutrient balances, as poor yields are obtained despite the high fertilizer application. This, in turn, leads to

higher nutrient losses. On the other hand, in the case of successful adaptation and high yields obtained, the most erodible fields could be permanently vegetated, which would help in mitigating the increasing erosion.

With the VEMALA model we will assess which mitigation measures can reduce agricultural loading to achieve the targets of the Marine Strategy Framework Directive in coastal waters to reach good ecological status.

Poster 4

Quantification of the evolution of a small beach applying laser scanning technology

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It is often necessary to quantify the changes of the sediment volume of small beaches where the classical means of beach profiling do not provide high enough spatial resolution. We demonstrate the capacity of a laser scanning technology to characterize the intensity of coastal processes under the combined impact of wind waves and wakes generated by fast ferries. The study site is a small accumulation beach section (Russalka beach) located in the bayhead of Tallinn Bay.

This analysis requires high-resolution and high-accuracy spatial data about the 3D surface of the beach area. Such data sets were obtained using the terrestrial (TLS) and airborne laser scanning (ALS) technology. The extent and distribution of erosion and accumulation spots at the Russalka beach were analyzed by means of creating and comparing of two digital terrain models of this area from scanning performed in different seasons and by different methods (ALS/TLS). These data were used to quantify rapid and spatially inhomogeneous changes to the subaerial beach, to characterize the intensity of coastal processes, to identify the changes of beach volume and to reveal several qualitative features of redistribution of sand.

The combined laser scanning technology was able to highlight relatively small changes in the shapes of coastal profiles and to identify the presence of so-called non-reflecting beach profiles and in this way to characterize more deeply the nature of the changes. This technology is thus able to provide not only crucial information about whether the beach is losing sand or recovering but also about whether enhanced danger from unexpected run-up may be expected at single sites.

Poster 5

Biogeochemical changes on the sediment-water interface due to *Marenzelleria ssp.* invasion in the eastern Gulf of Finland

Tatjana Eremina[1], Ekaterina Voloshchuk[1], Alexey Maximov[2], Vladimir Ryabchenko[3]
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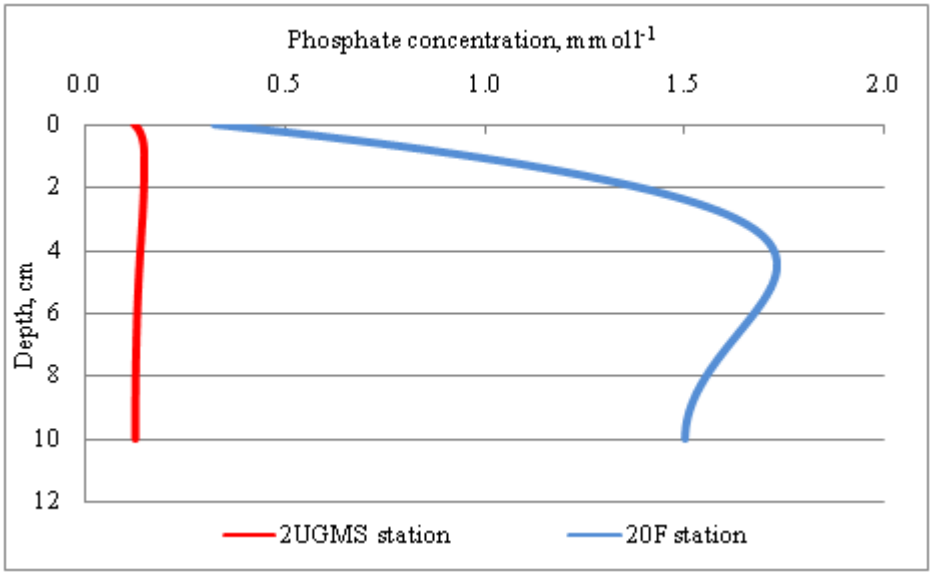
In 2008 the Eastern Gulf of Finland was invaded by hypoxic-tolerant arctic polychaete worm of the genus *Marenzelleria spp.* By 2009 *Marenzelleria spp.* became the dominant component of the soft-bottom zoobenthos. *Marenzelleria spp.* burrow into the sediments deeper than the native Baltic species, essentially affecting the exchange processes on the sediment-water interface (Karlsson et al. 2005). From the time of its invasion those polychaetes have already caused changes in plankton communities of the Eastern part of the Gulf of Finland. The worm's bioturbation and bioirrigation activity in the sediments have led to a supression of blue-green algae growth by increasing the nitrogen/phosphorus ratio. Further changes in the ecosystem of the Gulf of Finland may be observed in the future.

For a quantitative assessment of the worm's activity and its contribution to benthic layer changes, the reactive-transport model (Boudreau, 1996) was applied. The model simulates the diagenesis of nutrients (NO_3^-, PO_4^{3-}, NH_4^+), oxidants (NO_3^-, SO_4^{2-} etc.) and some metals (total Mn and Fe).

For model validation, hydrochemical data were collected in September 2013 in the eastern part of the Gulf of Finland from near bottom layer, pore water and sediments. Comparative analysis of biogeochemical changes in the bottom sediments was carried out at 2 stations in the eastern Gulf of Finland – 2UGMS (60°05.003'N; 028°43.017'E) and 20F (60°19.983'N; 027°59.969'E). A high abundance of *Marenzelleria spp.* was revealed at station 2UGMS (3912 ± 198 ind. m^{-2}) and a rather low abundance at station 20F (240±40 ind. m^{-2}). Calculated bioirrigation coefficients for these stations turned out to be 483 $year^{-1}$ and 3 $year^{-1}$, respectively.

Furthermore, according to the model estimates, bioirrigation activity of those polychaetes may lead to significant biogeochemical changes in the sediments, directly affecting phosphate concentration (see figure). Simulation results also show that in 5 years, phosphate storage at the station with high abundances of *Marenzelleria spp.* may be 11-fold less compared to the station with low worm abundances.(assuming unchanging number of polychaetes).

It is planned to take into account the impact of this *Marenzelleria spp.* invasion on the ecosystem of the Gulf in the St.Petersburg Baltic Eutrophication Model (SPBEM) – the high-resolution eco-hydrodynamic model of the Baltic Sea.



Vertical profiles of phosphate concentration in the pore water of the sediments at stations 2UGMS and 20F in 5 years of the model running.

Poster 6

Continuous measurement of water quality using navigational buoys in Helsinki sea area

Kari Kallio[1], Antti Lindfors[2], Emil Vahtera[3] and Seppo Virtanen[4]

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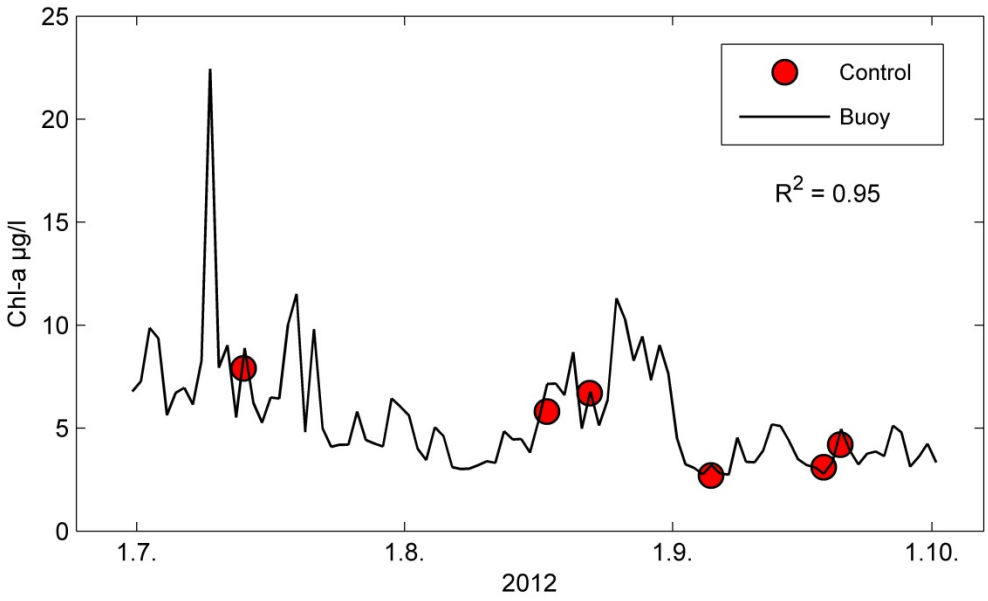
We tested automatic sensors near Helsinki in 2012 and 2013. The measurements were conducted on navigational spar buoys with a diameter of 50 cm. The system was developed by Luode Consulting Oy and MeriTaito Ltd. The sensors, manufactured by YSI, were placed at about 2 m depth and they collected data with 1 h interval. The sensors measured chlorophyll *a* and phycocyanin fluorescence, turbidity, temperature and conductivity. Data was sent via GSM network to a web-server twice a day.

Reference samples were taken twice a month and laboratory results were used the calibration of the sensor measurements. The sensors were cleaned manually once a month. The estimation accuracies were: Chl-a (R^2 0.72-0.87), turbidity (R^2 0.47-0.95), temperature (R^2 0.95-0.99) and salinity (R^2 0.83-0.99).

The buoy results have been used for the validation of satellite image products (Chl) and as an aid in ecological classification according to the Water Framework Directive. Other possible applications include reporting of algal situation, validation of models (physical and biological) and monitoring the impact of local activities such as waste water discharges, dredging and dumping of dredged material, and discharges of cooling sea water from power plants. The buoys also support process studies and measurements can be used in data assimilation and in optimization of routine sampling (frequency, timing). The locations of the future buoys and their combined use with other information sources and models should be carefully planned before their installation.



Chl-a results of Helsinki buoy (Torra Lövö) in 2012.

Poster 7

Towards an operational ecosystem model for the North and Baltic Sea

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A good knowledge of the current status of the marine environment is important for different purposes. Data are needed e.g. for management strategies like the Marine Strategy Framework Directive, the Baltic Sea Action Plan, conventions like OSPAR and HELCOM, for fisheries and for touristic activities.

Germany is connected to the North Sea and the Baltic Sea, which are interconnected via Skagerrak and Kattegat and hold very different physical and biological properties. Therefore, the Federal Maritime and Hydrographic Agency (BSH) has to provide information for two different sea regions.

The presented work is the result of the national DeMarine2 project which develops prototypes of downstream services for the COPERNICUS program. The aim of this subproject is the implementation of a combined modelling and data assimilation system to provide comprehensive data products of the marine environment of the North and Baltic Sea consisting of physical and biogeochemical information.

Therefore, the ecosystem model ERGOM is coupled to the circulation model HBM (HIROMBBOOS-Model) and is applied to the whole North and Baltic Sea area. In the calibration phase, the model is simulating the year 2008 as a reference. At the current stage, the model can represent the cyanobacteria bloom in the Baltic Sea and the spring bloom of diatoms, as well as the general chlorophyll distribution. Some nutrients like nitrate are represented quite well and the model is showing good results for SST and salinity distributions.

Despite the calibration and validation effort, the model is still a simplification of the real system. To account for potential uncertainties and provide best estimates a data assimilation scheme is applied to combine (satellite) data and model simulations. The data assimilation already led to further improvement in the representation of SST and salinity.

We will show results from the calibration phase in comparison with observations, some of the improvements due to data assimilation and results of the pre-operational test-phase, in which the model runs daily to produce a 48 hour forecast.

Poster 8

Atmospheric circulation patterns forcing large water volume changes of the Baltic Sea

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The salt budget of the Baltic Sea is determined by a balance between saline inflow from the Kattegat and brackish water outflow from the Baltic through the Danish Straits. River runoff and precipitation cause dilution while evaporation acts in the opposite direction. Ice formation and melting act as evaporation and precipitation, respectively, but have no influence on an annual timescale. Generally, during dry periods the mean salinity of the Baltic Sea increases while during wet periods a decrease will happen. These long-term changes are overlaid by the atmospheric-driven water exchange between North Sea and Baltic Sea. The salinity and the stratification in the deep basins are linked to the occurrence of Major Baltic Inflows (MBIs) of higher saline water of North Sea origin, which occur sporadically and transport higher saline and oxygenated water to deeper layers. These major inflows are often followed by stagnation periods with no strong saline inflows, during which the permanent halocline weakens, even disappears in some basins, and extended areas of oxygen deficiency develop in those regions where the salinity stratification remains. Since the mid-1970s, the frequency and intensity of MBIs have decreased. They were completely absent between February 1983 and January 1993. However, in spite of the decreasing frequency of MBIs, there was no obvious decrease in the frequency of larger volume changes (LVCs) of the Baltic Sea.

Strong inflows leading to LVCs are associated with certain sequences of atmospheric flow patterns over the larger North Atlantic/North European region. We studied the atmospheric circulation forcing of LVC-s by two different approaches: Eulerian and Lagrangian. Lamb automated weather types or synoptic weather types were used as Eulerian approach and the tracks of cyclones that cause the changing circulation patterns as Lagrangian approach. Mean sea level pressures from NCEP/NCAR and ERA Interim SLP reanalysis data for the period 1950-2013 were used as initial data. Our results confirm that about a month before the main inflow over the Danish Straits prevail eastern air flow with anticyclonic vorticity what turns to strong western/northwestern flow. From the other side we show, that most effective inflows occur if deep cyclones follow a certain pathway over the Baltic Sea area.

This work is a contribution to the Earth system research network for the Baltic region ''Baltic Earth''.

Poster 9

Detect and Estimate the Impact of the Positive Phase of the North Atlantic Oscillation (NAO+) index on the Mean Sea Level Variability in Winter Condition at the Finland Gulf: Approximate Solutions

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Mean sea level variability at the Gulf of Finland is considered to be the indicators of the atmospheric processes influenced by the North Atlantic Oscillation (NAO). Both winter months (December, January, February) and winter DJF season (average of December, January, February months) means of 3 long-term data station series of the mean sea level and the (NAO) indices were analyzed for different spans, and in term of winter DJF season only for the period 1977 through 1994. This study is dictated for: 1) Detect the exclusive impacts of the positive phases of the (NAO) indices on the mean sea levels by estimating the linear correlation coefficient using Pearson's Correlation technique. 2) Modeling the interrelations between the mean sea levels and (NAO) indices by estimating the linear regression models using Ordinary Least Square (OLS), Generalized Least Square Error Minimization (GLS) and Robust Standard Errors (RSE) methods. Both for manifesting the impact of the positive phase of (NAO) index. 3) Estimating the linear trend coefficient in the mean sea level time series in different spans by using (OLS), (GLS) and Theil-Sen methods, for manifesting the contribution of the positive phase of (NAO) index. 4) Estimating the new time series for the mean sea level from the linear regression equations, over the period 1977 through 1994 in winter season. 5) Estimating the linear trend coefficient in the new time series of the mean sea level (that calculated from the point no. 4), what configured by the influence of the positive phase (NAO) index for the period 1977 through 1994 in winter DJF season by using (OLS), (GLS) and Theil-Sen methods. Mean sea level are mainly influenced by the positive phase of (NAO) index at a specific station, that's where, the positive phase of the (NAO) index manifest its impact on the mean sea level and its contribution in the related configured trends for different spans. Also, this phase manifest its impact on the mean sea level and in the configured trend in winter DJF season over the period 1977 through 1994. The highest values of correlations were in January for different spans and in winter season for the period 1977-1994, referring to the highest westerly winds, air temperature, precipitation and the atmospheric circulation. Whereas, the connection between individual mean sea level stations and (NAO) index may be heterogeneous in time and in position for different spans. Highest trends were in winter DJF seasons for the period 1977 to 1994 with similar values at the different station caused comparatively higher sea level in the studied stations at the Finnish coast in the Finland Gulf. Insignificant trend referring to the mean sea level fluctuation might be under the influence of occurrence of the lasting multi-decadal wet and dry periods and might correspond with the similar large random component that found in the North Atlantic Oscillation spectrum through the entire spans. Positive trends in winter mean sea level can be explained by milder winters during this period (1977 through 1994). Whereas, the negative trends in winter mean sea level for different spans, can be explained by influence of the vertical crustal movement at the Finnish coats. The positive phase of (NAO) index has linear and non-linear relations with impacted river discharge, in which, this impact played a rule in the patterns of regional mean sea level changes in terms of time and space at the Gulf of Finland.

Poster 10

Quantification of the impact of vessel wakes on the transport of coarse sediment

Katri Pindsoo, Maris Eelsalu, Tarmo Soomere
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During the last decades wakes from fast ferries have become a new hydrodynamic forcing factor. They may considerably impact sediment transport at the coasts in the vicinity of waterways of semi-sheltered seas. The major reason for concern is that some properties of vessel wakes may differ from the typical properties of wind waves approaching the affected coastal segments. Waves with unusual properties may lead to significant changes to the reaction of the shores. The aim of this study is to demonstrate that vessel wakes can be the predominant driver of coarse sediment on medium-energy shores.

The study area is a small gravel and shingle beach on the island of Aegna in the Gulf of Finland, the Baltic Sea. Waves from fast ferries (that pass this beach at a distance of 2.7 km) are often up to 1 m high. These waves approach the coast from a direction from where wind waves of comparable height never approach. To identify the specific influence of vessel wakes, we observed the motion of selected coarse sediments in the calm season, June–July 2013. Sediments were separated into fractions of coarse gravel (1–2.5 cm), pebbles (2.5–5 cm) and cobbles (5–10 cm). A few thousand painted sediment clasts were lined up in the swash zone across the waterline from the depth of 0.5 m until the highest run-up (about 1.3 m above the sea surface). The location of visible sediment clasts was tracked with a RTK-GPS device with an accuracy of 1–2 cm for nine subsequent days. Additional measurements were carried out in October 2013 and in May 2014.

The rate of the relocation of the center of the mass and dispersion of each fraction and the fastest moving coarse sediments were evaluated daily. The results revealed that less than 1 m high vessel wakes are able to relocate coarse sediments (incl. cobbles) to remarkable distances and therefore may considerably reshape gravel and shingle beaches with a limited amount of sediments. During the relatively calm season in spring and summer a substantial amount of coarse sediments is driven to the west by vessel wakes. Close to the waterline small amount of sediments are still carried to the east by wind waves. Also some random cross-shore transport was generated by vessel wakes that exerted the highest run-up. Therefore sediment transport at the beach in question tends to have a cyclonic pattern. In the windy season (autumn and winter) sediment transport is mainly driven by wind-waves to the east. The existing sediment structure reflects a balance of the impact of the two wave systems.

Poster 11

A study of biotransformation forms of nitrogen, phosphorus and the oxygen dynamics in Neva Bay waters based on a spatially inhomogeneous simulation model

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The aim of the work: to explore the most important patterns forming of stocking and features of the long-term dynamics of forms N and P in the Neva Bay (NB) Gulf of Finland through numerical experiments on spatially inhomogeneous simulation model ecosystems NB. The emphasis was done on the study of the natural cycle of N and P forms, the impact on the dynamics of their hydrological regime and anthropogenic stress.

The model includes several basic blocks. The hydraulic block calculates unsteady, spatially inhomogeneous and vertically averaged field of flow; the hydrothermal block calculates the values of photoperiod, the components of the heat of balance and temperature regimes of the water body, the hydrooptical block – optical characteristics of the aquatic environment. The biochemical block reproduced results of joint biotransformation forms N and P, which come in the Neva Bay from sewage and river runoff, as well as the interaction of the variables under the combined effect of natural and anthropogenic factors. This block includes: concentration of dissolved fractions of organic N and P; mineral forms of P and N – ammonium, nitrite and nitrate, suspended forms of N and P – composed of detritus, aquatic biomass – heterotrophic bacterioplankton, phytoplankton, zooplankton and protozoa, as well as dissolved oxygen in the water. The modeling suggests draw good a conclusion about qualitative and quantitative accordance of model calculations with long-term results of observations.

The calculations showed that the content of the N and P in the water of the Neva Bay can not limit of increasing of bioproductivity of they area of water. The contribution of primary production of phytoplankton in the overall intake of organic matter is low. The simulation results and data of observations indicate that the main reason for the intensive development of heterotrophic microorganisms in the waters of the Neva Bay – a significant inflow of allochthonous organic matter from the external sources.

Poster 12

On the origins of cyclones entering the Baltic Sea region

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Changes in cyclonality are one of the major reasons for climate warming tendencies in the Baltic Sea region over the last decades as in winter the trajectories of the Atlantic cyclones have shifted northwards, bringing along relatively warmer air masses from the ocean (Sepp et al. 2005). Since cyclones are important not only from the viewpoint of air temperature changes, but they produce atmospheric forcing to the sea surface causing substantial sea level changes and mixing, bring along wind storms and precipitation, then it is important to know if in addition to track changes there have been also other changes in the characteristics of cyclone life cycle in the Baltic Sea region.

The cyclones data base of Gulev et al (2001) gives us opportunity to check it, as it consists geographical coordinates, time and sea level pressures (SLP) of low pressure centres in the Northern Hemisphere for the period 1948-2010 from the NCEP/NCAR reanalysis.

We filtered out from a database of cyclones (Gulev et al. 2001) the lows with average SLP < 1000 hPa that formed outside of and entered into the 1000 km radius circle centred at 58.75°N 25.5°E (ring in Fig 1). The total number of such incoming cyclones during the period was 2185. We study here temporal changes of following properties of incoming cyclones: the number of cyclones formed in various areas (in 12 clusters by *k*-means method); their duration; their SLP characteristics (mean and minimum SLP, also SLP in the formation point). The period was divided into three 21-year sub-periods and changes in the formation areas were compared visually.

The results of the present study can be concluded as follows: the number of cyclones entering the Baltic region has not changed during the period, but the lows have generally become deeper and, therefore stronger. There has been no redistribution of cyclones among clusters.

It is important to note that the incoming cyclones have not started forming as stronger cyclones, but rather, the decreasing trends of mean and minimum SLP are caused by changes in other parts of the cyclones' life cycle. This means that the lows receive additional energy from the atmosphere or the ocean in areas far away from their formation points. It may be assumed that this extra energy forces the cyclones to use different trajectories (Sepp et al. 2005) than before.

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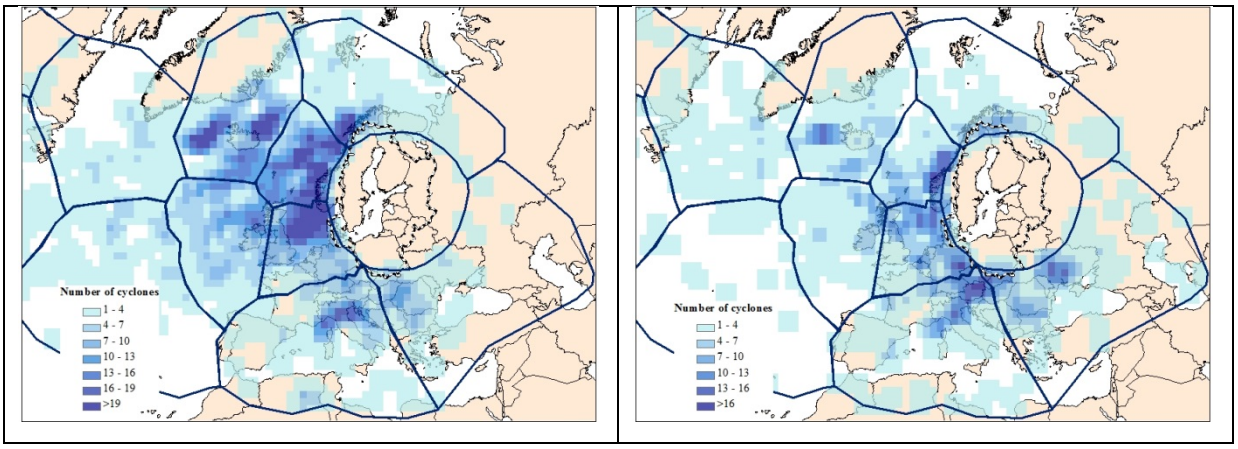

Main formation areas of cyclones entering the Baltic Sea region in the cold half–year (left) and the warm half–year (right) during 1948–2010. Numbers are for the whole period per 10000 km^2 areas.

Poster 13

Sediment core studies can provide realistic scenarios for modelling extreme storm events

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Climate change is predicted to result in stronger and more unpredictable storms that have the potential to change the erosion and accretion of coasts and shallow sea areas, leading to adverse effects such as the loss of habitats and property (e.g. Krarup Leth et al. 2013). Storm influence on coasts and seafloor is particularly strong in areas such as the Baltic Sea, where the tidal energy is negligible, and the sea level is predominantly controlled by wind and atmospheric pressure.

Previous storm impacts on coastal areas can be explored by studying the fine structure of sediment cores for features indicating sediment reworking and event deposition (Virtasalo et al. 2011). A recent study infers recurrent episodic erosion and thin mud bed deposition from storm-induced flows in the easternmost Gulf of Finland (Virtasalo et al. 2014). The extreme storms take place on average every 30 years, which is on the same temporal scale with the strong interdecadal variability of storminess in Fennoscandia in connection to the winter NAO (The BACC Author Team, 2008; Bärring and Fortuniak, 2009).

Detailed studies of storm-emplaced sediment beds in X-radiographs of long sediment cores have the potential to provide important new understanding of the recurrence intervals and severity of extreme storm events, and their natural variability, during the past decades to centuries in the Baltic Sea basin. The cores need to be accurately dated by combining independent techniques such as ^{137}Cs, ^{210}Pb, AMS-^{14}C and paleomagnetic correlation. Sediment core studies of past storminess can provide realistic scenarios for the wave and current modeling of the impacts of extreme storm events, as well as background data for model validation.

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