2nd Baltic Earth Conference, Helsingor, 11-15 June 2018

Session Summaries

These are short summaries by the session conveners, how they have experienced the sessions from their perspective. Further information on the presentations can be found on the presentations page, where most presentations are available as pdf on a password protected page (access infos are provided by the International Baltic Earth Secretariat on an individual basis), and the extended abstracts in the conference proceedings.

Session A: Salinity dynamics

Conveners: Andreas Lehmann and Urmas Lips

The salinity in the Baltic Sea is not only a topic of physical oceanography, it involves the complete water and energy cycle. It is also a primary factor (driver) controlling the ecosystems of the Baltic Sea. The salinity dynamics is controlled by net precipitation, river runoff and the water mass exchange with the North Sea with outflow of the Baltic Sea due to freshwater surplus and a compensating inflow of higher saline waters from the Kattegat in deeper layers, strongly controlled by the prevailing atmospheric forcing conditions. First studies of future development indicate up to 2-3 g/kg decrease in salinity due to the expected increase in precipitation to the end of the century. Since the Baltic Sea ecosystem has adapted to the present salinity regime, expected changes would exert enormous stress on marine fauna and flora with associated negative social-economic consequences for the Baltic Sea countries. However, the present understanding of salinity changes is still very limited, and future projections of the salinity evolution are rather uncertain. More detailed investigations on regional precipitation patterns (runoff), atmospheric variability (wind), saline water inflows, the exchange between the sub-basins and turbulent mixing processes are still needed. Furthermore, there is also a need for new climate projection simulations with improved atmospheric and oceanographic (coupled) model systems.

Since BACC II which was published in 2015, collecting mostly research results until 2012, there have been new research on salinity dynamics of the Baltic Sea, stimulated by Baltic Earth. Especially after the recent major Baltic inflow in December 2014, a number of new studies emerged. The research focused on key topics such as: the interrelation between decadal climate variability and salinity, the

water mass exchange and major Baltic inflows and the associated atmospheric conditions, salinity variability and fluxes on different scales (detection and attribution to climate change), changes in the salt budget, and associated changes in the circulation of the Baltic Sea. These topics are still valid for future research since we still can ask questions like: Do we understand the dynamics of the present-day salinity distribution, can we predict major salt water inflows?

One of the main themes discussed at the conference was the water exchange with the North Sea through the Danish Straits including major Baltic inflows. There has been a revision of the definition of major Baltic inflows, better to term them Large Volume Changes (LVCs) or barotropic inflows. It has been shown that over recent decades no significant trend in barotropic inflows could be detected, contradicting the negative trend in MBIs. However, long-term observations of temperature and salinity (in a temporal scale of a few decades) revealed an increasing temperature trend and a decreasing trend in salinity at the surface, but an increasing trend in deeper layers associated with an increasing stratification. Additionally, the atmospheric forcing responsible for major Baltic inflows has been investigated and related to barotropic inflows. The Atlantic Multidecadal Oscillation (AMO) could be associated with temperature variability of the Baltic Sea on long timescales. On shorter timescales, the North Atlantic Oscillation (NAO) is one of the main drivers of temperature variation at the Baltic Sea surface, especially during winter. Furthermore, barotropic inflow characteristics have been investigated with respect to salinity. It could be demonstrated that for highly saline inflows, specific atmospheric conditions are necessary, whereas river runoff only plays a minor role. The effect of rising sea level on barotropic inflows with respect to an enhanced salt flux has also been discussed. The effect of brine release on vertical mixing/convection has been investigated in a numerical model study. However, the brine release during sea ice formation of the very brackish northern areas is rather small, it is not strong enough to lead to effective deep water formation even in the weakly stratified northern areas of the Baltic Sea. The inter-sub-basin water exchange during MBI events has been studied by a numerical model with very high spatial and horizontal grid resolution. Especially, the salt flux downstream into the Baltic Proper, the Gulf of Finland and Gulf of Bothnia could be increased improving the salt deficit often found in coarser grid numerical model studies.

The Slupsk Channel is a critical region of the central Baltic Sea as the water mass exchange between the Bornholm Basin and the eastern Gotland Basin as well as the Bay of Gdansk is strongly controlled by entrainment and vertical mixing. New measurements with high spatial resolution classify the Slupsk sill overflow as mixing hot spot for the eastward propagating saline deep water. The distribution of benthic foraminifera could be associated with the distribution of saline bottom water in the southeastern Baltic Sea. For future applications, this information could be used to reconstruct saline inflows into the southeastern basin.

During recent years, the stock of observational data has been increased considerably, sophisticated statistical methods have been used to combine and interpolate between irregular spaced observational data to gridded data sets, which can further be used for detailed process analytics and verification or data assimilation into hydrodynamical models. However, observational data are still distributed between different data bases and research institutes. A common open access data base is urgently needed to fulfill present-day requirements for interdisciplinary data analysis and data science.

Session B: Land-sea-atmosphere biogeochemical feedbacks

Conveners: Gregor Rehder and Karol Kulinski

The session was opened by a solicited talk of Beata Szymczycha, who gave a review on the importance of submarine groundwater flow (SGD) on a global perspective and in the Baltic before addressing her

research on a deep SGD site in the Gulf of Gdansk, more than 70 km off shore. Apart from deriving clear proof of SGD from major ion analysis, pockmark structures were interpreted as indication for gas (methane) release at the site, supported by hydroacoustic data. The second talk by Moa Edman introduced the results of a data-validated model tailored to estimate the nutrient retention along the Swedish coastline. The results suggest a mean nutrient retention of 50-70%, with large regional differences. It was highlighted that in some areas the nutrient retention was higher than 100%, suggesting that these areas act as a sink for nutrients from the open Baltic Sea. The subsequent talk by Bernd Schneider presented a carbon-based mass balance approach for the mineralization of organic matter in the central Gotland Basin, emphasizing the importance of considering diapycnical mixing. The results suggest an oxygen demand per CO_2 release above the Redfield ratio, and does not support accelerated oxygen consumption over the last decade. In the final talk before the coffee break, Karol Kuliński reported on progress in the current understanding of the carbon system and acid-base system of the Baltic Sea. Highlighted new findings include a considerable increase in alkalinity over the last 2.5 decades, an anomaly contribution of borate alkalinity to total alkalinity, and better defined alkalinity-salinity trends for some of the major southern rivers (for the latter, see also Poster by Hammer et al.).

The coffee break was used for a short interview with Jens Müller, who attempts to get new insights in the dynamics of the summer bloom in the central Baltic Sea and the representativeness of pCO_2 data gathered by the voluntary observing ship Finnmaid, by doing research from a sailing vessel. The project Bloomsail, which is embedded in the BONUS INTEGRAL project, was well received by the Baltic Earth Science community, who followed Jens Müller's explanation of the approach eagerly while enjoying a cup of coffee or tea.

In the second part of the session, important contributions were from the studies related to the BONUS INTEGRAL project. From the overview given by the project coordinator, Gregor Rehder, the audience was informed about the project structure, rationale, major goals and first results. The project focuses on the parametrization and quantification of the air/sea fluxes of the greenhouse gases (CO_2, CH_4, N_2O) in the Baltic Sea and understanding the CO_2 system dynamics, including the aspects of ecosystem productivity and acid-base balance. An interesting talk was given also by Anja Eggert, who showed results from a study towards an understanding of the post-spring bloom in the Baltic Sea. This study gave new insights into the nutrient dynamics in that period of the year. Still, however, the question on the nitrogen source in the productive, euphotic layer of the open Baltic Sea waters remains. Anna Rutgersson reported on CO_2 fluxes measured by the eddy covariance method on the Östergarnsholm station. This study is an important contribution toward parametrization of the air/sea CO_2 exchange in the Baltic Sea. The session ended with the presentation given by Wenyan Zhang, who showed the importance of benthic organisms for the organic carbon burial in the bottom sediments of the North Sea and Baltic Sea. The oral presentations in this session were complemented by 12 high quality poster presentations, with significant contributions from young scientists.

Session C: Natural hazards and high impact events

Conveners: Martin Stendel and Joanna Wibig

The session was dominated by oceanographic issues starting from storm surges analysis consisting of case studies (extratropical storm Axel in January 2017), atmospherical drivers (cyclones), power impacts to the coast and modelling efforts with regional hydrodynamic models for reliable prediction of water level. This topic was also investigated through analysing of waves and strong wind events. It was often done using the global or regional reanalyses, which were validated against independent wind and sea level pressure observations at stations located at the coast or on offshore research platforms. It was shown that global reanalyses are able to reproduce the storms that have longer

duration, but they fail in reproducing fast moving or very strong storm events. Fast moving events are better reproduced by regional or local reanalyses. The usability of ERA5 reanalysis with high temporal and spatial resolution for high impact events investigation was assessed in the Baltic Earth region in the other paper. The atmospheric circulation as a factor favoring storms and significant wave heights was investigated using the NAO, AO and Scand indices. One presentation was devoted to modelling of wave impact on coastal infrastructure. Rogue waves climatology in the southern North Sea was also presented. This presentation was seen as a best young researcher oral presentation during the conference.

All above described subjects are well interlinked with sea level extremes issue which was also considered in a few presentations. In one of them, a non-stationary approach to extreme value modelling of sea surface height was introduced. The GEV model with linear trends in the location and scale parameters was used, indicating a strong increase in the most intense extremes as well as in medium and low-range extremes in the Gulf of Riga. The analysis of the temporal variability of sea level along German Baltic Sea coast has shown that the highest values were observed in the decade 1981-1990. The factors favoring the high water events in the Odra River mouth were also investigated. Possibilities of reproduction of extreme water levels in the North and Baltic Seas using the coupled ocean-atmospheric climate model (MPI-OM) were assessed in the other one.

Among the oceanographic presentations there was also one concerning strong currents in two narrow straits in the Finnish Archipelago Sea and the other presenting simulations of possible tsunami effects of Chelyabinsk-like meteorite drop in the Baltic Sea. A COHERENT project was also presented, which is devoted to reinforce adaptation processes and risk and hazard management in the coastal region. Its output includes an adaptation/decision making software toolkit allowing for costs analysis of the adaptation to severe storm-surge events, warning system and hazard management.

The topic C was dominated by oceanographic presentations, but a few climatological issues were analysed also. Among them the strongest attention was put on droughts. They were analysed in the context of drivers as well as changes related to warming. It was shown that in the southern and eastern part of Baltic Earth the danger of more frequent and intense droughts is relatively high. The other climatological presentations concern extreme precipitation events and snow cover temporal variability in Estonia.

The open discussion was dominated by issues related to reanalysis data and possibilities of making use of them in different applications. How reliable they are? Can we harness them for climate change detection?

Session D: Sea level dynamics, coastal morphology and erosion

Conveners: Kai Myrberg and Ralf Weisse

Session D was devoted to study various coastal processes like sea level dynamics, coastal morphology and erosion. While some presentations addressed issues from user perspectives, the majority of talks and posters addressed issues from a natural science perspective. Extreme sea levels, spatial and temporal features of their variability, and disentangling contributions from processes such as seiches or changes in volume of water in a basin appeared to be a thematic priority. Comparison and validation of measurement techniques for waves or coastal processes, or altimetry-derived sea level trends were other issues addressed in this session. From a user perspective, municipality needs on climate change sea level information and mitigation measures on coastal erosion were elaborated.

The session started with the solicited paper of Kevin Parnell. His topic was beach nourishment. It is a common response to coastal erosion, building the beach profile to repair past erosion and increase each resilience to future high-energy events. The Gold Coast in Australia was taken as an example. This nourishment project has provided lessons with respect to building natural morphologies to promote both short-term and long-term benefits. The talk by Ralf Weisse et al. was devoted to study extreme storm tides that are both, highly unlikely but still physically possible and that may be linked with extreme consequences. Preliminary analyzes suggest within the data considered so far unprecedented storm tides exist that may bear potential for amplification. The latter still needs to be investigated in detail. Potential consequences will be assessed based on narrative scenarios developed under participation of local and federal stakeholders. The paper by Madsen et al. studied sea level change from the point of view of municipality needs. The work will further feed in to and support the newly financed Danish Climate Atlas, which will focus on developing authoritative climate change information for the Danish municipalities, among other things specifically on storm surges. Eelsalu et al. investigated inter-annual coastal processes in Estonia. The combination of airborne and terrestrial laser scanning offers high-quality data that gives a reliable insight to the internal structure of beach processes. The coastal processes are actively distributing sand in the alongshore direction in the study area. The process is non-stationary: during some years the subaerial beach gains sand while in other years sediments are carried away.

The discussion focused on the state of our understanding with respect to making inferences about the future. A gap seems to appear in linking observed and future erosion and coastline change with the effects of rising mean and changing extreme sea levels. Although some of the longest tide gauge records can be found in the Baltic Sea, a point for even longer historic digitized time series was made. Stronger linkage Baltic Earth with other communities working on global and regional sea levels was considered as an advantage. It was also noted that a relatively large number of papers has been published recently about sea level changes but there are few new papers on mean sea levels which is a very important topic while thinking e.g. about climate change.

Session E: Regional variability of water and energy exchanges

Conveners: Piia Post and Irina Danilovich

The session was devoted to the Baltic Earth Grand Challenge dealing with atmospheric circulation, climate, the water regime, ecological status and methods of their study and assessment. The session included 16 presentations, 8 oral and 8 posters. Two presentations were devoted to remote sensing methods in weather studies, 4 presentations were about atmospheric circulation patterns over the Baltic Sea, and 4 presentations described the interaction between the atmosphere, weather and sea water in the Baltic Sea region; others were inland hydrological studies.

The discussion concluded the following:

More then a third of the presentations were about the hydrological regime and rivers. This proportion has increased since previous conferences. At the same time, there were less contributions about the energy topic of the Grand Challenge. There were some suggestions to divide the GC into sub-sections to get more attention on the energy budget issues in the Baltic Sea area, but it was finally agreed that the water-energy exchange is a complicated system which should remain as one study object.

This topic has been the central study for many years in the BALTEX and Baltic Earth programmes. Currently, the study object is under development and needs further efforts of researches within the Baltic Earth community.

Session F: Multiple drivers of regional Earth system changes

Conveners: Anders Omstedt and Marcus Reckermann

During the session, 8 presentations were given and during an open discussion these and more general questions were discussed. The presentations covered aspects such as land-use climate forcing during the Holocene, impacts of societal and climate change on nutrients loads, variability in nutrient and oxygen concentrations, shipping and the environment, temperature changes since 1850 and the importance of physical oceanography for the Marine Strategy Framework.

In general, more studies are now directed towards multiple drivers. Baltic Earth will arrange a workshop in the coming autumn related to this topic. The topic opens up complex questions related to detection and attribution, and it was suggested that inspiration from similar multiple drivers' studies in medicine could be sought, where large databases are available and detection and attribution of human health problems is in focus. The Multiple Drivers topic also opens up the need for improving our communication with society.

Session G: Regional climate system modelling

Convener: Stefan Hagemann

The two morning sessions were preceded by an enlightening overview on the history of climate science in the Baltic Sea region. The topical session G on regional climate system modelling included presentations on various useful datasets [The UERRA regional reanalysis for Europe, and the Baltic and North Seas Climatology (BNSC)], introduction of coupled system models (IOW) or some of their components [assessment of several ocean models in the Baltic Sea, and the high-resolution hydrological discharge (HD) model of the GCOAST system], and a discussion of results on specific sub-topics. The latter comprised a history of projected changes and their spread from the various regional climate model ensembles since the PRUDENCE project, projected changes in Baltic Sea upwelling, and the assessment of the role of trends in the occurrence of Großwetterlagen on the ongoing climate change in Estonia.

The discussion started with the question on which observational data are still missing or underrepresented. Here, the desire for gridded data of surface energy fluxes was mentioned, i.e. turbulent energy fluxes over the Baltic Sea surface. Moreover, inventories of existing data from the social sciences are missing to bridge the gap within Baltic Earth. Links of available observation data sets are desired to be listed on the website of the Baltic Earth Program.

Further, for paleoclimate studies over the Baltic Sea catchment, information of high resolution paleoclimate simulations was requested, but it was noted that at present, only coarse resolution data from global climate models do exist (e.g. at HZG (Eduardo Zorita) or MPI-M (Victor Brovkin).

With regard to coupled system modelling, Ha Hagemann reported shortly from the respective working group meeting on Tuesday about two ongoing activities of (1) available climate projection ensembles analysis and (2) new coordinated experiments setup.

The discussion ends up with statements of steering group members that the sessions throughout the conference should not always follow the topic order in alphabetical sequence. This is strongly supported by topic G as this would mean that it is not always them who will end up on Friday.