Sea Level Research Workshop

"Sea-Level Change: Earth System Feedbacks"

Bjerknes Centre for Climate Research (BCCR), Bergen, Norway – 12th October 2020

Workshop Minutes

Welcome and Introduction

Antonio Bonaduce (NERSC) opens the day by welcoming all the participants. He starts by stating the purpose of the workshop: foster the collaboration between the partners of the Bjerknes Center, which offers the optimal scientific framework to develop innovative sea-level research activities and set up a Sea Level Research Group (SLRG). He goes through the agenda of the workshop, and he recalls COVID-19 recommendations.

Overview

Antonio gives a brief overview of sea-level research studies based on observations, models, and the synergy between these two approaches. He emphasizes that sea-level is a key climate indicator and that the ocean has larger inertia to the changes of radiative forcings compared to the atmosphere, which leads to long-lasting responses of sea-level to climate change. He underlines the valuable contributions of in-situ and remote-sensing observations, ocean modeling, reanalyses, and observing system experiments to the understanding of global and regional sea-level at the different temporal and spatial scales of variability. The take-home message is that the combination of different approaches can contribute to: - the understanding of the unresolved feedback of the Earth system to sea-level variability; - minimize uncertainties; - design the future of sea-level research during the next decades, supported by innovative analysis methods (e.g. AI-based methods).

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Øyvind Breivik (Bjerknes Center; UiB) asks about the regional sea-level trend spatial variability.

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Antonio replies that sea-level trend variability can be associated with the signature of mesoscale features of the ocean circulation.

Session 1: Observation-based studies

John Inge Svendsen (UiB)

John Inge opens the session with a presentation about the sea-level history along the west coast of Norway. The research activities develop within the framework of the "Quantifying past and future sea-level change in Norway" (QUANTSEA) Project, which is led by NGU (Geological Survey of Norway) and includes activities on salt marshes, isolation basins, and glacial isostatic adjustment (GIA) modeling. The aim of the project is to a 3D reconstruction of the changing Norwegian coastline.

Roshin P. Raj (NERSC)

Roshin gives a talk about sea level budget closure in the Arctic. He mentioned that the research activities were developed during the Sea Level Budget Closure (SLBC) Climate Change Initiative (CCI) funded by the European Space Agency (ESA). He underlines that a proposal was submitted this year to the Norwegian Research Council to further investigate the atmospheric drivers of the discrepancies/similarities observed between the sea level signals in the Nordic Seas and in the Beaufort Gyre.

Stephen Outten (NERSC)

Stephen gives a presentation about sea level extremes, based on extreme value analysis and partitioning the storm surge and tidal contributions. He stressed the point that the events with the longest return-period were exceeded already twice during the last 30 years.

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John Inge asks about possible fingerprints of tidal extremes in the sediment samples collected along the western Norwegian Coast (laminar layers). Stephen replies that it would be an interesting proxy, even though in principle tidal extremes and sediment deposition should act over different temporal scales.

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Øyvind and Ole Joan Aarnes (Norwegian Meteorological Institute) say that they are involved in the "Storm Risk" Project, which develops activities that overlap with those presented by Stephen.

Session 2: Model-based studies

P. Langebroek (NORCE)

Petra underlines that the inertia in ice-sheets is even larger than in the ocean, and that ice-sheets are the primary drivers of mass induced sea-level rise. She gives examples of ice-sheet modelling activities at the Bjerknes Center, focusing the attention on basal hydrology (RISES and SWItchDyn Projects), ice-shelf interaction (TiPPACS Project); - and ice sheet – climate interactions (Ines KeyCLIM Project) which represent key areas to improve ice sheet projections.

O. J. Aarnes (Norwegian Meteorological Institute)

He speaks about activities developed within the StormRisk project, which includes risk assessments of the combined effect of waves and water level. He emphasizes that storm damage is the largest component of loss claims related to natural hazards. The project aims to combine model-based information (high resolution wave and storm surge models) and in-situ observations to defining the vulnerability of target areas (present and future settlements) considered also their position and orientations.

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B. Backenbeg (Deltares) sends a link to the Global Storm Surge Information System (GLOSSIS; https://www.deltares.nl/en/projects/global-storm-surge-information-system-glossis/), which can represent a good framework for collaborations.

Noel Keenlyside (UiB/NERSC); Vandhna Kumar (UiB)

Noel introduces the infrastructure Norwegian Climate Prediction Model (NorCPM) and gives examples of how the Climate Prediction Unit at the Bjerknes Center can contribute to sea-level studies providing long-term coupled reanalysis, seasonal and multi-years predictions.

Vandhna introduces the “Mare Nullius Project” which focuses on the environmental and societal impact of sea-level rise in the Pacific Islands, where the combination of sea-level rise and erosion exposes nations to unprecedented risks. The project has a cross-disciplinary vocation and aims to combine climate science, anthropology, and law to analyze how Pacific islanders and their states (Pacific Exclusive Economic Zones) prepare for and react to, what may be the demise of their sovereign land and sea territories.

Vandhna explains that NorCPM and CMIP6 climate projections are considered in the project and her activities include: - bias reduction; - sea-level projections; sea-level predictions.

Session 3: Synergy between observations and models

Andreas Born (UiB)

Andreas shows results on improved modeling of Greenland ice-sheet, obtained through layer modeling optimized starting from data of height, depth, thickness, flow and change of sea ice, glaciers, and ice sheets collected during the NASA Operation IceBridge (>10 years survey). This is implemented into the Bergen Snow Simulator (BESSI), used for running ice-sheet numerical simulations of the present (ERA-Interim) and future climate (CMIP6). He shows results about the sensitivity of surface mass balance (SMB) to the warming and underlines that approximating the interannual variability with climatological averages can lead to errors (up to 40 %) in the SMB.

William Helland-Hansen (UiB)

William starts his talk about the coastal changes during the 21st century showing the COASTER web portal (http://www.geo.uib.no/coaster) which provides a global view on coastal transgression and regression taking into account climate-driven sea-level changes (CMIP5 scenarios), vertical land movements (e.g. subsidence), sediments supply and distribution.

In this sense, he says that the project proposal “Coastal Change in the 21st Century (CC21)” was submitted (but unfortunately not funded) to quantify how the sea-level change, vertical land movements, sediment supply, and distribution combined with the human activity affect coastal change in the 21st century.

The CC21 proposal includes the use of machine learning methods to detect coastal changes from satellite images all over the globe and the creation of interactive applications to visualize probability-conditioned shore-line changes through the 21st century.

Jiping Xie (NERSC)

Jiping starts his presentation about sea level in the Arctic Ocean Reanalysis, showing the infrastructure of the Arctic Monitoring and Forecasting Center (ARC MFC) which includes ocean circulation, and biogeochemical and wave models, data assimilation, in-situ and remote sensing observation. He describes the metrics (spread reduction factor) used to assess the impact of the observing systems into the Arctic Ocean Reanalysis. He underlines that the sea-level signals in the Arctic ocean reanalysis are in agreement with those retrieved from a global ocean reanalysis. He says that a key issue for assimilating sea-level remote-sensing observations relies on the mean sea surface considered to obtain the sea-level anomalies. Furthermore, he underlines that improving our understanding of the differences between the sea-level signals in ocean reanalysis and in-situ data (tide gauge) would reduce the uncertainty of the sea level estimates in the Arctic Ocean.

Session 4: Projections

Heiko Goelzer (NORCE)

Heiko presents results about the future sea-level contribution of the Greenland ice sheet. Those come from an ensemble multimodal study contributing to the Ice Sheet Model Intercomparison Phase 6 (ISMIP6). Model simulations in ISMIP6 rely still on CMIP5 projections, due to delays in the delivery of CMIP6 projections. He shows that ice-sheet contributions to sea-level rise stabilize towards the end of the century (~32 mm) under a mitigation scenario (RCP2.6), while a steep growth is observed (up to ~90 mm) considering a severe emissions scenario (RCP8.5). The largest uncertainty is associated with the ice-sheets in the south-western basin, characterized by the largest mass loss. He underlines that the largest gap in our knowledge is about the physical understanding and implementation of the calving process, i.e. the interaction of the ice sheet with the ocean.

Furthermore, he gives a brief overview of the Antarctic projections. He focuses on the contributions of the: - western and eastern ice sheets, which are the most vulnerable areas to global warming; - Antarctic Peninsula where the ice shelf collapse could have large sea-level contributions (28 mm). He says that sources of uncertainty rely on how to convert climate model output into ice sheet forcings.

Kristin Richter (NORCE)

Kristin speaks about the sea-level projections for Norway, based on the “Klima i Norge” report on “Sea level changes for Norway”, issued in 2015. The reports show sea-level projections for more than 250 coastal municipalities in Norway, considering the low, medium, and high emissions scenarios from CMIP5. She shows results in Oslo and Stavanger, where the largest contributions derive from Antarctica, steric, dynamic, and vertical land movements. She also shows results on sea-level extremes changes, which are updated every 5 years by the Norwegian Mapping Authority (Kartverket). She underlines the possibility of updating the next report in 2023, considering: -CMIP6 forcings; -high-resolution models and/or downscaling; -model weighting according to model performance; sea-state contributions; changes in tidal regimes; - drivers of changes in extreme coastal water levels; scenarios beyond 2100.

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She asks the audience about tidal modelling activities.

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Laurent Bertino (NERSC) replies that a Nansen Center ex-student could be a good contact (M. Hart-Davis), and provides a reference to a relevant study about tidal secular trends (Muller et al.,2011; doi:10.1029/2010JC006387).

Session 5: Innovative methods

K. Malde (Institute of Marine Research) gives an overview about machine learning methods in marine science, focusing the attention on marine biology. He speaks about supervised and unsupervised methods for automatic identification, both species-specific (fish stock assessment) and individual-specific (e.g. facial recognition in salmons). He continues speaking about age classification based automatic recognition applied to otoliths and fish scales.

He says that those methods could apply also for different kinds of data, and that data abundance is often a constraint.

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O. Breivik asks about machine learning methods that can be applied to non-formatted data, referring to coastal damaged data which enters in the joint probabilities considered for extreme events (surge and wave heights) in the StormRisk Project.

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K. Malde answers that unsupervised machine learning methods can represent a valuable approach.

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A. Bonaduce asks about unsupervised methods applied to unlabelled data: e.g. clustering. He says that data are available both from observations and geophysical models, and it would be interesting to develop collaborations.

Discussion

Nele Meckler (UiB) chairs the Session.

Tore Furevik (BCCR)

Tore introduces the discussion by talking about the importance of sea-level research and its relevance at Bjerknes Center (Phase III). He argues about the research themes (Climate, Hazards, Polar, Carbon), research fundings, and internal projects at the Bjerknes Center. He underlines that the Bjerknes Center during its next phase (from 2022) will continue to: - do groundbreaking research; - play an important role on the international scene; - contribute to the low emission and resilient society; -be active in research training and teaching. He mentions important resources for research fundings: -Norwegian government; -Norwegian Research Council; -Trond Mohn Foundation; -Horizon Europe; -European Research Council (ERC).

He underlines the importance of sea-level research at the Bjerknes Center (~150 scientific papers), where all the cross-disciplinary skills to address this challenging topic are well represented, such as : - Glacier reconstruction; Ice Sheet Contributions; Global and Regional Sea-level Changes; Earth System Modelling and Climate Predictions; Remote Sensing, in-situ observations and fieldwork. He emphasizes that setting up a Sea Level Research Group (SLRG) at the Bjerknes Center is “a great idea!”.

He says that the SLRG could be a cross-disciplinary subgroup of other research themes at the Bjerknes Center.

He mentions internal lines of fundings for short term activities: - Fast Track Initiative (1 year - 100-300 KNOK); - Synthesis Projects (1 year - 1-1.5 MNOK).

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John-Inge points out that this group does not have expertise in isostatic modelling and that collaboration with the Mapping Authority (Kartverket) is essential. He also mentions that there is no national database for paleo observations of sea level. This information is for example requested by solid-earth/GIA modellers.

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Nele suggests projecting the planning of future common activities into research proposals, to avoid fragmentation and to start having common objectives (and deadlines). She recalls the experience done in the past with the idea of having a research group focused on “Tipping Points”, which vanished because of a lack of activities planned to achieve common objectives.

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Elaine McDonagh (NORCE) suggests to look at the presentation given by Kristin and start talking about research priorities regarding the list of activities relevant to the next “Klima i Norge” report (2023) about Sea Level Changes in Norway.

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Kristin says that it is a good idea to recall that list, and that to this extent it is also important to create/keep contents with the Norwegian Mapping Authority (Kartverket). She also underlines that the strategy for the new “Klima i Norge” report is not clear yet, and it is not sure that sea-level changes will be addressed in a dedicated report as in the past.

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Andreas suggests planning “large breadth” activities, instead of multiple small studies which, according to previous experience, can lead to fragmented efforts.

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Antonio suggests to follow a comprehensive approach since activities realized to address specific topics can be propaedeutic for others: e.g. forthcoming observations can contribute to improving the accuracy of ocean state estimates (e.g. ocean reanalysis), which in turn can represent optimal initial conditions for reducing uncertainties of sea-level projections (e.g. CMIP6).

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Johnny Johannessen (NERSC) gives input about the way to follow to successfully set up the Sea Level Research Group. He suggests to go step by step, collecting first the inputs of the participants as outcomes of the workshop, that should be capitalized into a workshop report, which should be followed by an implementation strategy for the research group.

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Nele closes the Session thanking the participants for their valuable comments.