2015-report from the board

VISION
The vision of the Nansen Center is to serve the society through advancing knowledge on the marine environment and climate system in the spirit of Nobel Laureate and humanist Fridtjof Nansen.

The main research areas of the Nansen Center include:

- Climate processes, variability and change
- Arctic and Marine remote sensing
- Ocean modelling, data assimilation and forecasting
- Societal impact of global change

ORGANIZATION
The Nansen Center was founded in 1986 as an independent non-profit research foundation affiliated with the University of Bergen, Norway. The Nansen Center conducts climate and environmental research projects funded by research councils, the European Commission, space agencies, national and international government agencies, as well as private donations, in cooperation with business and industry. The Nansen Center is a national environmental research institute and receives basic funding from the Ministry of Climate and Environment through the Research Council of Norway.

As a national environmental research institute, the Center has strengthened its expertise through institutional strategic programs within studies of regional climate change, including studies of sea level change and local air quality in urban areas. Operational oceanographic studies and services in the Arctic, focusing on integrating observations and the development of ocean and sea ice modelling and forecasting. Climate studies with a focus on teleconnections and coupling between the Arctic and monsoon systems in India and China, as well as integrated multidisciplinary climate and environmental research. Over the last 30 years the Nansen Center has built up extensive knowledge on the development and application of satellite-based Earth observation (EO) data. In particular the Center aims at being a national resource for knowledge of EO research within marine, cryosphere and climate studies. An increased focus on cross-disciplinary research cooperation and synergies between existing scientific disciplines has strengthened the scientific expertise of the Center. The establishments of nine thematic research groups within the Center has strengthened the scientific and international research capacity of the Center.

VISION

The staff at the Centre originates from 24 countries worldwide.

SPECIAL TERTIAL PRODUCTION
During 2015 the scientific staff published 49 scientific articles in international peer-reviewed journals which are registered in the Norwegian Science Index (NVI). Three published articles were not eligible for the NVI. This is nine fewer scientific NVI articles than were published in 2014. In addition there were 43 conference proceedings and presentations, 20 technical and other reports, as well as four communications or chronicles published - in total there were 119 publications. In 2015 the Ministry of Education and Research changed the regulations for the calculation of institutional NVI publication scores. The new regulations favour multi-institutional and international co-authorship and cooperation, which turned out to be favourable to the overall NVI-publications score for the Center.

One PhD student defended her dissertation at the University of Bergen in 2015:

- Dr. Mary Swapna George: Modelling and observations of upwelling along the southwest coast of India and its intrusion into the Bay of Bengal, during summer monsoon. Supervisors at the Nansen Center: O.M. Johannessen and L. Bertino.

Three students have passed their Master exams at the University of Bergen after completing their studies at, and with supervision from scientists at, the Nansen Center (see page 11).

The Center actively engages in public outreach through the press, television and popular science lectures. At least 95 media reports about our research results and scientists have been registered in 2015. Many of these media reports have been associated with the GC Rieber Climate Research Institute, the Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography and Department for Polar and Environmental Research.

The premises and working environment are very satisfactory – both in the main office in Longyearbyen and the premises of the 2015 polar drift station, where Prof. Yngve FRAM reports have been associated with several high air pollution events during fall 2015. The GC Rieber Fund and the Board, the administration and the employees, through the Working Environment Committee (AMU) have focused on health, environment and safety (HMS) in 2015. Absence due to sickness was 4.46% of the total work effort, which is an increase from 3.58% in 2014. The Center has a defined environmental policy and the Board concludes that the activities do not pollute or in any other way harm the environment.

Cover page: The Arctic sea-ice concentration mid-September 2008 as simulated with the neXtSIM sea-ice model developed at the Nansen Center. Courtesy: Einar Ørn Ölason and A7Print.
major Norwegian climate reports commissioned by the Directorate of Environment in 2015 – Climate in Norway in 2100 and Sea Level Change for Norway, Past and Present observations and Projections to 2100. Both reports attracted significant media attention when they were launched during fall 2015 and in particular the sea level report was important for the Nansen Center.

The Nansen Center participated in Forskningsdagene 2015 with the exhibition From physics to food in the oceans. The exhibition was at Festplassen and was visited by about 2000 school students and 6000 other visitors. The movie Svalbard – Arctic seasons was also frequently shown to visitors to the Center in our cinema.

**AWARDS**

Nansen Center scientist Dr. Richard Davy received the Outstanding Young Scientist Award from the European Geophysical Union in May 2015 for his atmospheric research.

**INTERNATIONAL ACTIVITIES**

Cooperation within Europe is an important part of research activities at the Center. In 2015 the Center participated in 11 projects funded by the European Commission, and acted as coordinator for two of these projects.

The European Commission launched in 2015 the Copernicus Marine Environment Monitoring Service (CMEMS). The Nansen Center has, in cooperation with the Meteorological Institute and the Institute of Marine Research, obtained the contract to operate the CMEMS Arctic Marine Forecasting Center (AMFC) until 2021. The contract is a major milestone in the development of operational oceanography at the Center. AMFC delivers weekly ocean and sea ice forecasts based on in situ measurements, satellite Earth observation data and the coupled modelling and data assimilation system ToPAZ that has been developed at the Nansen Center over many years.

The Center is also coordinating two Nordic Centers of Excellence: EmbLa: Ensemble-based data assimilation for environmental monitoring and prediction focusing on developing the operational use of data assimilation in environmental research and modelling (started in 2014) and ARCPATCH: Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies, focusing on responsible and sustainable development under future climate change, which was approved late in 2015.

The Nansen Center is a partner in EuroGOOS and leads the Arctic activities (ArcticROOS), which focus on the development and implementation of operational observing and forecasting systems for the Arctic Ocean. Key information products are distributed through the ArcticROOS portal - www.arctic-roos.org, including daily updates of sea ice extent and concentration derived from Earth observation satellites, providing records of the sea ice variability since 1978. The basic funding has been used to improve the operations of this sea ice information service for the Arctic Ocean.

The Nansen Group comprises five international research centres in Russia, India, China, South Africa and Bangladesh. This research group is a very important research and knowledge network and “human capital” for the Nansen Center in Bergen. A total of 220 people including 75 PhD students are employed and affiliated with the Nansen Centers. The cooperation within the Nansen Group has resulted in several joint research projects, joint publications, exchange visits of scientists and students, as well as extensive exchange of knowledge and capacity-building across borders. The Nansen Centers in Russia (NIERSC) and India (NERCI) successfully completed the coordination of their respective major FP7 INCO-LAB projects funded by the European Commission – “European-Russian Centre for cooperation in the Arctic and Sub-Arctic environmental and climate research (EuRUCAS)” and “India-European research facilities for studies on Marine Ecosystem and climate in India (INDO-MARECLIM)” in 2015. In 2015 the Ministry of Education and Research launched their new international strategy, panoramafrica, for cooperation on higher education and research for 2016-2020, which includes four of the countries with international Nansen Centers as well as Japan and Brazil.

The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers. The foundation, Nansen Scientific Society, where Ola M. Johannessen is the President, has funded 10 Nansen Fellowship stipends at the international Nansen Centers.
dation has funded several exchange visits to the Nansen Center in Bergen for students and young scientists from China, India, Russia, South Africa and Bangladesh. One PhD candidate in the Nansen Group defended her PhD. dissertation with support from the Society in 2015. Furthermore, the Society has supported publication of 12 scientific papers in international scientific journals, 17 conference reports and 37 oral presentations at scientific conferences in 2015.

**The Svalbard Office**

The Nansen Center’s office in the Svalbard Research Park, Longyearbyen, contributes to strengthening Arctic research activities at the Center. Several research projects related to oceanography and sea ice research at the Center are conducted in the Svalbard region. One PhD student is permanently located at the office in Longyearbyen and several scientists and students have used the office during 2015. This presence is strengthening research cooperation with, and education at, UNIS and other institutions in Svalbard. In cooperation with the Norwegian Scientific Academy for Polar Research (NVP), UNIS and the Nansen Center the interdisciplinary PhD and Post-doc research school Arctic Ocean Governance as a Multifunctional Challenge was hosted at Isdammern in August 2015. The 18 young scientists that participated published the results of the research school in the scientific peer review article Assessing the added value of the recent declaration on unregulated fishing for sustainable governance of the central Arctic Ocean (Shephard et al, 2016) in the journal Marine Policy.

**TerraOrbit AS and CoTo AS**

The Nansen Center is the owner of the companies TerraOrbit AS and COTO AS. The common goal of these companies is to offer services for monitoring and forecasting of the environment and the oceans. The revenue of these activities will in turn contribute to scientific development in fields of benefit to society and industry. The activities in the two companies have been minimal in 2015.

**Economy**

The Nansen Center is a non-profit research foundation. The total project income in 2015 was 64,948 MNOK and the expenses were 63,997 MNOK, which gives a surplus of 0.951 MNOK. The net financial income is 0.578 MNOK. This gives an annual surplus for 2015 of 1,529 MNOK, which is transferred to equity capital. The research activities in 2015 have increased both in turnover and number of employees, however the direct expenses associated with field cruise activities were significantly less than in 2014.

The Center has a strong economy with an equity capital of 33,381 MNOK, after the transfer of the surplus for 2015. The project income in 2015 was mainly from the Research Council of Norway, several Norwegian ministries, the European Commission (EC) FP7, Horizon2020 and Copernicus programmes, European Space Agency, the Norwegian Space Centre and a small part from research cooperation with oil companies and industrial partners. The GC Rieber Funds has supported a PhD student at the GC Rieber Climate Institute with 750,000 NOK for studying and modelling of air quality in Bergen. The basic funding from the Research Council of Norway was 5,742 MNOK in 2015.

The Board confirm that the conditions for continued operations are satisfactory according to §3-3a in the accounting legislation. The annual accounts are made under this assumption, which is consistent with the long-term strategy and prognosis for the development of the Center. The Center has a strong economy.

Financial risks are primarily associated with foreign currency exchange rates. 36% of the project income is in a foreign currency, primarily Euro. The policy at the Center is to continuously assess the need for currency hedging. The Center does not have any loans. Access liquidity is according to board decision kept at a bank account. The clients are mainly public national or foreign institutions with whom the Center have had a long lasting business relation over many years, accordingly the risks associated with their credit are limited. The liquidity risk is also regarded to be very limited.

**Prospects for 2016**

Research project applications in 2016 will focus on relevant open calls to be announced by the Research Council of Norway, EC Horizon2020 and Copernicus programmes, and tenders from the European Space Agency and other funding agencies. Several scheduled H2020 calls in 2016 are particularly relevant for the expertise of the Nansen Center. Significant efforts are foreseen in the development of new applications and consortia both as project coordinator, work package leader and project partner in H2020 project applications in 2016. Increased framework for support and funding (PES2020 and STIM-EU) from the Research Council of Norway is in this respect an efficient and essential instrument. The Center also plans to apply for research and development projects of high relevance for both Norwegian public administration and business in 2016. This priority is in accordance with the conclusion of the assessment of the Norwegian environmental research institutes made by the Research Council of Norway. The assessment concludes that the Nansen Center is favourable with respect to international cooperation in research and education, the Centre publish very well compared to other environmental research institutes, but have potential for development wrt. demonstrating societal relevance through increased project activities with public agencies and authorities. Being the coordinator of the European Copernicus Arctic Marine Forecasting Center until 2021 proves both relevance and societal applications of the research activities performed at the Center.

An increase in funded research projects is expected during 2016, as well as increased expenses also associated with planned project cruise activities in the Fram Strait during summer 2016.
**EU COPERNICUS ARCTIC MARINE FORECASTING CENTRE (AMFC)**

The Copernicus Marine Environmental Monitoring Services (CMEMS) was kicked off on 1st May 2015, managed by Mercator Ocean on behalf of the EU. The Copernicus programme is a cornerstone of the European Union’s efforts to monitor the Earth and its ecosystems, whilst ensuring that its citizens are prepared and protected in the case of crises and natural or man-made disasters. Copernicus is “Europe’s eyes on Earth”. Within CMEMS, the Nansen Center leads the Arctic Marine Forecasting Center (ARC MFC) in partnership with MET Norway and IMR. NERSC further develops the TOPAZ forecasting and reanalysis system, which is exploited operationally at MET Norway, while the IMR is involved in the validation of the provided services. As such, the ARC MFC represents the most intense collaborative effort between these Norwegian institutions with a budget of 4 million Euros (corresponding to 24 person-years) over the 3 years of the first phase of CMEMS.

The ARC MFC provides four main products, with the 3-dimensional ocean physical and biogeochemical models used both in short-term forecasts (up to 10 days) as well as in reanalysis mode over the entire satellite era. It means the following: if anyone asks the EU where the Arctic sea ice will be tomorrow, the official answer will come from a system developed over the last decades at the Nansen Center. In 2017, an Arctic wave forecast will be added to the operational service delivered by MET Norway (see Figure 1). In addition NERSC contributes a SAR-based sea ice remote-sensing product to the Ocean and Sea Ice Thematic Assembly Center (OSI TAC), another CMEMS element lead by MET Norway. CMEMS is an important milestone in a long series of EU funded research and development projects, including DIADEM, TOPAZ, Mersea-Strand1, MERSEA IP, MyOcean and MyOcean2, by taking up their developments into a common European operational service. CMEMS relies heavily on the quality of the models for ocean, sea-ice and ecosystem, as well as efficient assimilation of Earth Observations data. CMEMS offers more than just delivery data products, it also entails visualization service, regular product validation efforts.

A 24/7 operational monitoring of the production chain and a service desk answering questions and keeping users informed of upcoming changes and new service elements, and expansion of new satellite data sources from e.g. the European Sentinel satellites. CMEMS is designed to serve many public, commercial and scientific purposes including major EU policies such as the Marine Strategy Framework Directive, combating pollution, protection of marine species, maritime safety and routing, sustainable exploitation of ocean resources, climate and weather monitoring. CMEMS will strive to keep the operational service at the forefront of research and motivates the Nansen Center to carry on further methodological developments that will contribute to the evolution of the CMEMS services.

### Relevant publications:
- Tonani, Maria; Balmaseda, Magdalena; Bertino, Laurent; Blockley, Ed; Brassington, Gary; Davidson, Fraser; Drillet, Yann; Hogan, Pat; Kuragano, Tsurane; Lee, Tong; Mehra, Avichal; Paranathara, Francis; Tanajura, Clemente A.; Wang, Hui. Status and future of global and regional ocean prediction systems. Journal of operational oceanography. Publisher: The Institute of Marine Engineering, Science & Technology 2015, Volume 8.(2)

**A NORTH ATLANTIC COUPLED PHYSICAL-BILOGICAL OCEAN MODEL**

A combined state-parameter estimation was performed in a coupled physical-biological model (HYCOM-NORWECOM: Samuelsen et al., 2015) for the North-Atlantic and the Arctic oceans. The study was part of the production of a 4-year pilot reanalysis product for the EU FP7-projects MyOcean and GreenSeas. The state-parameter estimation was performed by assimilating temperature, sea-level anomaly, sea-ice and satellite-derived sea-surface chlorophyll using the Deterministic ensemble Kalman filter (DEnKF). The states of the 11-component NPZD (nutrient, phytoplankton, zooplankton, detritus) model, NORWECOM, as well as the mortality terms for the two phytoplankton and two zooplankton classes were also estimated over a full annual cycle. The mortality parameters were selected for optimization because they are
known to be uncertain in NPZD models and the parameters were allowed to vary in both space and time. Distinct spatial and temporal patterns occurred for all the parameters. By clustering the parameters, regions of similar plankton dynamics could be identified (Figure 2). In some areas, for example in the Gulf Stream region, the parameter exceeded what is commonly considered realistic values, indicating that the present model formulation cannot correctly describe this area. In the high-latitude regions, the mortality parameters retain realistic values and the modelled chlorophyll values were improved, not unexpectedly, since the model was originally developed for the Northern regions.

The resulting reanalysis produced improved model estimates during parameter optimization; it was also improved compared to independent in-situ chlorophyll. In 2010, the optimized parameters from the previous period was used in the simulation, the results for this year yields improved results compared to the free run, but the error were larger than during the estimation of parameters. However, it should be kept in mind that there was an unusually large phytoplankton bloom in the North Atlantic in 2010. The assimilation had a small impact on nutrients, but no systematic improvement or deterioration could be found, except at around 1000 meters depth where the initial adjustments during the assimilation caused an offset in nutrients that slowly reduced over time.

Relevant publications:

SEA ICE MODELLING: neXtSIM AND neXtSIM-F

In 2015, a new high resolution sea-ice forecasting platform named neXtSIM-F was developed, based on the neXtSIM sea ice model. neXtSIM is a Lagrangian sea ice model that uses a new mechanical framework (the elastic-to-brittle rheology) to simulate the complex dynamical response of sea ice to the winds and ocean currents, the occurrence of cracks, leads and ridges in the sea ice pack. The platform has been set up to cover the Barents and Kara Seas at a 3km horizontal resolution (Figure 3). neXtSIM-F has been running in near-real time over 9 months from fall 2015, using as forcing the weather forecasts provided by ECMWF and ocean forecasts provided by the Copernicus Marine and Environmental Monitoring System (ARC MFC). The neXtSIM-F forecasts illustrations and description of the platform are available on the web at https://nextsim.nersc.no. Near-real time evaluation of the neXtSIM-F performance with respect to sea ice drift forecast was conducted against the OSI SAF sea ice drift observation and can be viewed at ftp://ftp.nersc.no/pub/Philipp/forecast_eval.

In the meantime, the development of neXTSIM has reached a new level, with the inclusion of a thermodynamic model in addition to the dynamic model, making neXTSIM ready to be coupled to an ocean/atmospheric model. The performance of neXTSIM with respect to sea ice deformation scaling properties, drift statistics, sea ice extent and volume has been assessed and the results compiled for reporting in a scientific publication.

Also, experimental work has been done on water wave transmission by an array of floating disks. This work is an important contribution to the development of the wave-in-ice (WIM) model we are pushing at NERSC, and towards its future inclusion into the neXTSIM sea ice model in order to study sea ice-ocean processes in the Marginal Ice Zone.

Relevant publications:
• Bouillon, S.; Rampal, P.: Presentation of the dynamical core of neXTSIM, a new sea ice model. Ocean Modelling 2015, Volume 91.

Figure 4. (a) A subset of the original SAR image (backscatter) on the 8 March 2009; (b) respective classified SAR image (red – lead, blue – ice) with (a) as background; (c) AMSR-E lead fraction in per cent with (a) as background.

SATELLITE-DERIVED SEA ICE LEAD FRACTION IN THE ARCTIC OCEAN

Leads within consolidated sea ice control heat exchange between the ocean and the atmosphere during winter, thus constituting an important climate parameter. These narrow elongated features occur when sea ice is forming under the action of wind and currents, reducing the local mechanical strength of the ice cover, which in turn impact the sea ice drift pattern. This creates a high demand for a high quality lead fraction (LF) data set for sea ice model validation, initialization, and for the assimilation of such data in regional ice-ocean models. In this context, an available LF data set retrieved from satellite passive microwave observations (Advanced Microwave Scanning Radiometer Earth Observing System, AMSR-E) is of great value, which has been providing pan-Arctic light and cloud-independent daily coverage since 2002. In a study performed at the Nansen Center errors in the data set are quantified using accurate LF estimates retrieved from Synthetic Aperture Radar (SAR) images employing a threshold technique (Figure 4). A consistent overestimation of LF by a factor of 2–4 is found in the AMSR-E LF product. It is shown that a simple adjustment of the upper tie point used in the method to estimate the LF can reduce the pixel-wise error by a factor of 2 on average. Applying such an adjustment to the full data set may thus significantly increase the quality and value of the original data set.

Relevant publication:
• Ivanova, N., Rampal, P., and Bouillon, S.: Error assessment of satellite-derived lead fraction in the Arctic, The Cryosphere, 10, 585-595.

MODEL ERRORS IN DATA ASSIMILATION

One of the main aspects that lead to the success of the Ensemble Kalman Filter (EnKF) was its ability to account for model errors while “perfect model” data assimilation methods had to blame all the discrepancies on either the observations or the initial state. Considerable attention has been drawn on the negative effects of representing observation errors by random perturbations, and their partial remediation by square root analysis schemes. However, limited efforts have been devoted to eliminate the need for simulated random model perturbations in the EnKF. Raanes et al. (2015) have therefore suggested three methods, which outperform the existing ones in either a linear or a non-linear
In HORIZON 2020 (granted in 2016).

Since 2005, acoustic observing technology has been implemented and used by the Nansen Center in combination with other observations and models to better understand the ocean and sea ice environment in the Fram Strait. Evolving from a single track acoustic system deployed in 2008, an extended acoustic system was successfully deployed in 2014 for two years operation in the Fram Strait under the UNDER-ICE NFR project with co-funding from GDF SUEZ (Figure 6).

Preparing for the data processing and analysis in 2016 a detailed technical description of the existing processing procedures of the acoustic data has been provided along with a new metadata structure for acoustic data (Geyer et al. 2015). The processing procedures are undergoing revision to facilitate for the new metadata structure and the new receiver technology used in UNDER-ICE experiment.

The main scientific activity in 2015 has been to publish results from previous experiments, ACOBAR, DAMOCLES and WIFAR projects. Six manuscripts were developed and submitted to international referee journals. These publications documents step by step the production chain of tomographic data from pre-processing of measured travel times to the inversion of those to depth-range ocean temperature observation, and finally how the acoustically derived mean temperatures can be used to validate ice-ocean models. Passive acoustic data from drifting ice stations were analysed and it was found that cavitation noise from icebreakers operating in heavy ice dominates the soundscape occasionally. A Master Thesis Estimating fin whale distribution from ambient noise spectra using Bayesian inversion (Menze, 2015) was completed based on data from the DAMOCLES experiment.

Relevant publications:


**REGIONAL SEA LEVEL VARIABILITY**

One of the activities within the ocean and coastal remote sensing group is sea level research. The use of remote sensing such as radar altimetry is an obvious element of such research, but also the regional ocean density and circulation changes is in focus. The oceanographic knowledge at the Nansen Center and in Bergen in general is put to use in studies of regional sea level variability and change. In 2015 a major effort to provide Norway with updated local and regional sea level projections was completed. Changes to mean sea level and/or sea level extremes (e.g., storm surges) will have impact on coastal infrastructure and lead to future changes in the coastal zone. These changes represent a changing exposure or risk to our society. The report Sea Level Change for Norway (Simpson et al., 2015) was produced in collaboration between the Norwegian Mapping Authority and the Nansen Center, under the auspices of the Bjerknes Centre For Climate Research in Bergen. The report synthesizes our understanding of past and present observed sea level changes for Norway, as well as projections to sea level projections up until 2100 for every coastal municipality. The primary focus is changes to mean sea level, but updated return heights for each coastal municipality in Norway, is also provided. The regional sea level projections are based on findings from the 5th IPCC Assessment Report (AR5) of the Intergovernmental Panel for Climate
Relevant publications:


APPARENT HIATUS IN GLOBAL WARMING - DYNAMICAL SOURCES AND MODELLING

In February 2015, one had an opportunity to celebrate 30 years’ anniversary of the global monthly averaged air surface temperature being at or below the long-term mean value according to the National Ocean and Atmospheric Administration (NOAA). Since the World Meteorological Organization (WMO) defines the climatological standard normal as the 30 years mean, it is now formally certified that the Earth’s climate has warmed. The warming however has not been monotonically steady. Although 2015 was a record-breaking year with the global annually averaged temperature anomaly of +0.46°C [NOAA, 2015], for more than a decade over 1998–2014, the temperatures did not increase significantly. This period has been called the apparent hiatus in global warming.

The search for physical and dynamical mechanisms for this hiatus caused hot debates among scientists, politicians and the general public. Stephen Outten and Peter Thorne of the Nansen Center, led a team to examine the hiatus mechanisms using two 30-member ensembles from the Norwegian Earth System Model (NorESM) [Outten et al., 2015 and Throne et al., 2015]. The ensembles’ surface temperature trends were found to be statistically indistinguishable over 1998–2012 despite differences in the prescribed forcings (Figure 8). According to NorESM, there is thus no evidence that forcing errors play a significant role in explaining why global climate models failed to reproduce the hiatus. In general, observations are towards the lower bound of the ensembles or, for some observational estimates, J. Geophys. Res. Atm., 120. 8

Relevant publications:


EXTRA-TROPICAL OCEAN WARMING AND WINTERTIME ARCTIC SEA ICE COVER VARIABILITY

Despite the fact that the Arctic Oscillation (AO) has reached a more neutral state and a global-warming hiatus has occurred in winter since the late 1990s, the Arctic sea ice cover (ASIC) still shows a pronounced decrease. Li et al. (2015) reveals a close connection (R = 0.5) between the extratropical winter sea surface temperature (ET-SST) and ASIC in winter from 1994 to 2013 (Figure 9). In response to one positive (negative) unit of the total variability, (a) Principal component time series of the EOF-1 of ASIC (ASIC PC-1; black dashed line) and ET-SST (ET-SST PC-1; blue solid line) in units of standard deviations, (b) Principal component time series of EOF-1 of ASIC (ASIC PC-1; blue dashed line) and sea ice cover averaged over Barents–Kara Seas (SIC-BaKa, blue solid line, in the domain of 70°–80°N, 30°–80°E), together with sea ice cover averaged over the Bering Sea (SIC-Bering, red solid line, in the domain of 66.5°–76.5°N, 160°E–150°W) in units of standard deviations. All data and indices are detrended.

Figure 9: (a) Leading EOF mode of Arctic sea ice cover (ASIC; north of 50°N) anomalies during 1994–2013 DJF, which accounts for 19% of the total ASIC variability. The EOF in (b) is the same as that in (a), except for extratropical SST (ET-SST; 20°N–70°N), for which it accounts for 26% of the total variability. (c) Correlation coefficients of the first PC of ASIC (ASIPC1; red solid line) and ET-SST (ETPC1; blue solid line) in winter from 1994 to 2013 (Figure 9). In connection (R = 0.5) between the extratropical Arctic Oscillation (AO) has reached a more neutral state and a global-warming hiatus has occurred in winter since the late 1990s, the Arctic sea ice cover (ASIC) still shows a pronounced decrease. Li et al. (2015) reveals a close connection (R = 0.5) between the extratropical winter sea surface temperature (ET-SST) and ASIC in winter from 1994 to 2013 (Figure 9). In response to one positive (negative) unit of deviation in the ET-SST pattern, the ASIC decreases (increases) in the Barents–Kara Seas and Hudson Bay (the Baffin Bay and Bering Sea) by 100–400 km². This relationship might be maintained because of the impact of warming extratropical oceans on the polar vortex. Positive mid-latitude SST anomalies in the North Pacific and North Atlantic (around 40°N) strengthen the equatorward planetary wave propagation, whereas negative high-latitude SST anomalies weaken the upward planetary wave propagation from the lower troposphere to the stratosphere. The former indicates a strengthening of the poleward meridional eddy momentum flux, and the latter implies a weakening of the poleward eddy heat flux, which favours an intensified upper-level polar stratospheric jet and a colder polar vortex, implying a stronger-than-normal polar vortex. Consequently, an anomalous cyclone emerges over the eastern Arctic, changing the ASIC by modulating the mean meridional heat flux. A possible reason for the long-term changes in the relationship between the ET-SST and ASIC is also discussed.

Relevant publication:

publications in 2015

NORWEGIAN SCIENCE INDEX-NVI PUBLICATIONS (49)
Holt, Jason; Schrum, Corinna; Cannaby, Heather; Daewel, Ute; Allen, Icarus; Artioli, Yuri; Bopp, Laurent; Butenschon, Momme; Fach, Bettina A.; Harle, James; Pushpadas, Dhanya; Salihoglu, Baris; Wallentin, Sarah L. 2016. “The Impacts of Climate change on the primary production of regional seas: A comparative analysis of five European seas. Progress in Oceanography 2016, Volume 140. p. 91-115.


Bergh, Jon Erik; Rampal, Pierre; Olsan, Einar, and Bouillon, Sylvain, 2015: Diffusion/Dispersion laws in the ice pack: a comparison between EVP and EB sea ice models and observed buoy trajectories. Deliverable D2.2 under the spacer sea ice model development in view of oilspill forecasting, OGPA RT JIP. NERSC Technical Report no. 349.

The staff of the Nansen Center gathered at Sandven Hotel in October 2015.

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