

Annual reporting format 2016: Nordic Centre of Excellence

Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)

(01.01.2016-31.12.2020)

Original Project Aims:

- 1) To improve Arctic climate prediction by using innovative methods to capture both anthropogenic and natural factors in global and high-resolution regional models.*
- 2) To increase understanding and reduce uncertainties regarding how changes in climate interact with multiple societal factors including the development of local and regional adaptation measures*
- 3) To supply this knowledge as potential “pathways to action” to the specific Arctic regions singled out for special focus in the project.*

The project is led by the Nansen Environmental and Remote Sensing Centre (**NERSC**) and Co-led by the Stefansson Arctic Institute (**SAI**). Project members are drawn from: the University of Bergen (**UiB**); the Danish Meteorological Institute (**DMI**); the Swedish Meteorological and Hydrological Institute (**SMHI**); and the University of Iceland (**UoI**).

International and associated partners are from the Alfred Wegener Institute for Polar and Marine Research (**AWI**); the Conservation of Arctic Flora and Fauna (**CAFF**) Institute of Applied Physics of the Russian Academy of Science (**IAPRAS**); Institute of Arctic and Alpine Research (**INSTAAR**); the Institute of Oceanology, Russian Academy of Science (**IORAS**); Norwegian Institute for Air Research (**NILU**); National Snow and Ice Data Centre (**NSIDC**); Nansen-Zhu International Research Centre, China (**NZC**); Royal Roads University (**RRU**); University of California, Irvine (**UCI**); University College London (**UCL**); Arctic University of Norway (**UiT**);

Design and Methods:

ARCPATH will collect, assemble, and analyse a wide variety of different data sets and information for the project with a focus on local communities in Iceland, Norway and Greenland. Data include: historical records; observational data; socio-ecological data; and marine-mammal data. ARCPATH methods will include the use of: i) Earth System Models - the Norwegian Climate Prediction Model (NorCPM) and the European ESM (EC-Earth) Model with data assimilation from oceans and sea ice in order to perform global climate predictions; ii) Regional Arctic Climate Models to perform Arctic climate predictions; iii) ARCPATH will also use quantitative economic modelling, supported by qualitative interviews. The quantitative modelling will follow the Economics of Ecosystems and Biodiversity (<http://www.teebweb.org/>) ecosystem services economic modelling framework, where provisioning services will be quantified using market prices. Regulating services will rely on damage or avoided cost and replacement cost methods, and cultural services will rely on survey-based methods.

ARCPATH will use proven ethnographic research methods to solicit community insights concerning local changes, and to document how people are adapting/adjusting to these changes and impacts. The main research methods will involve: participant observation, semi-structured and specialist interviews, official documents and surveys. ARCPATH includes seven interlinked workpackages: WP1: *Arctic Linkages: Climate, Environmental Change, and Human Eco-Dynamics*; WP2: *Improved Global Climate Prediction by Initialization of Arctic Sea Ice and Sea-Surface Temperatures*; WP3: *Arctic Climate Predictions and Regional Downscaling*; WP4: *Climate, Socio-Ecological Systems, Cetaceans and Tourism*; WP5: *Responsible Governance, Security and Abrupt Climate Change in North Atlantic Arctic Coastal Communities*; WP6 *Project Synthesis*; WP7: *Project Management and Dissemination*.

Practical changes to original plan:

There are no significant practical changes to the original research plan.

Personnel of the Centre:

Please refer to Table 1.

Detailed Research Progress:

WP1: Arctic Linkages: Climate, Environmental Change, and Human Eco-Dynamics. (SAI, UiB, UoI; DMI; NSIDC). For WP1 ARCPATH aims to use historical data to build a comprehensive picture regarding how climatic fluctuations have influenced marine ecosystems, fisheries, and society in the past. These data sources include previously untapped climate data, fish stock and marine-mammal data coupled with records of social change. Extensive high-resolution data available for Iceland have already been acquired, but have not been fully analysed. Data for Greenland and northern Norway have been located, and will be acquired and then analysed for ARCPATH.

Work during this first year of the ARCPATH project has been undertaken primarily at SAI with a focus on the historical data for Iceland as outlined in Task 1.1. in the project description. This is: *To extend the historical climate record for Iceland to ca. AD 1700, and improve its quantification in terms of temperature and sea-ice variations through comparisons of historical, instrumental, and proxy data.* The main focus has been on the historical records. Although the project aim is to extend the climate record for Iceland back to AD 1700, in order to provide a longer context period for analyses of present and future climate change the period from AD 1600 to ca. 1900 has been considered. A general overview of the historical sources indicates that there was a great deal of climatic variability during this period. An important task for the coming year will be the construction of temperature indices and the refinement of a sea-ice index. The primary focus for this year has been on sea-ice variability.

The early and latter decades of the seventeenth century were years with much ice present. From ca. 1640 to ca. 1680 there appears to have been little sea ice off Iceland's coasts. During the period 1600 to 1850, the decades with most ice present were probably the 1780s, early 1800s and the 1830s. From 1840 to 1855 there was virtually no ice off the Icelandic coasts. From that time to 1860 there was frequent ice again, although the

incidence does not seem to have been as heavy as in the earlier part of the century. Further clusters of sea-ice years occurred again from ca. 1864 to 1872. The 1880s, specifically the period from 1881 to 1888, were unusually severe climatically, and they have come to be known as the “Dire Years”. Sea ice was present in 1881, 1882, 1883, 1886, 1887 and 1888. Some sea-ice years occurred in the 1890s, but far less than in the 1880s. From 1900 onwards sea-ice incidence falls off dramatically.

Work undertaken by SAI for Work Packages 4 and 5 is discussed below.

WP2: Improved Global Climate Prediction by Initialization of Arctic Sea Ice and Sea-Surface Temperatures. (UiB; NERSC; DMI; SMHI; IORAS; UCI; IAPRAS; NZC; AWI.) During this first year of the project, NERSC and UiB partners have used the Norwegian Climate Prediction Model that is based on the Norwegian Earth System model and the Ensemble Kalman Filter. The assimilation provides combined updates for the isopycnal ocean model and the multi-category sea-ice model (CICE4.0) of NorESM where the atmosphere is left unchanged.

In order to allow an in-depth assessment of the impact of assimilating sea-ice observations, we use an observing system simulation experiment (OSSE or perfect twin experiments) - i.e., synthetic observations are generated with the same model taken at a different time. An OSSE allows for an in-depth validation against all state variables (also across the sea-ice compartment). It also provides a controlled experiment affranchised of model bias that raises different issues. We have first focused on assimilation of synthetic ice concentration that represents the main source of available observations in the Arctic.

A configuration of the data-assimilation system that shows remarkable reduction of error for ice concentration and thickness (in each category) has been derived. There has also been a reduction of error in the ocean mixed layer and in the snow. The results are robust for an assimilation period of a 10-year period, suggesting that the scheme introduces little drift. A manuscript regarding these findings is currently in preparation.

During this first year, UiB and NERSC have focused on understanding the mechanisms for early-twentieth century warming of the Arctic. Although data are limited, the warming during this period is thought to be comparable to the most recent warming. We performed partial coupled simulations with the Norwegian Earth System Model (NorESM) in which surface wind stress was prescribed from the 20th century reanalysis. Complementing previous studies, we find that the Pacific Decadal Oscillation contributed significantly to the early twentieth-century warming, and may have offset some of the recent observed warming. This work is being prepared for publication.

DMI has worked on establishment of the EC-Earth decadal forecast system. This system will consist of the new version (3) of the EC-Earth model prepared for CMIP6 (Climate Model Intercomparison Project – Phase 6), the ocean initialisation using anomaly initialisation and the sea-ice initialisation using the Ensemble Kalman Filter (EnKF). The new model has adopted many new features as well as new modules that improve the representation of the atmosphere, ocean and sea ice. The model configuration is also different from the earlier versions with higher horizontal and vertical resolution for both atmosphere and ocean. DMI has been working together with SMHI and other European partners in the EC-Earth consortium to jointly develop the EC-Earth3. DMI will use the model to perform the coordinated experiments to

contribute to the CMIP6 and CMIP6 endorsed inter-comparison projects, including the Decadal Climate Projections Project (CMIP6-DCPP).

SMHI has worked on finalizing the new version 3.2 of the global coupled model EC-Earth, which will be used for the decadal predictions in WP2 (standard resolution) and WP3 (high resolution). The new model version is stable in low and high resolution but some fine tuning remains. A new sea-ice albedo parameterization has been implemented. This gives a more realistic simulation of the sea-ice distribution in the Arctic. This is important with respect to the predictive skill which is carried by the sea ice.

Twin simulations with the standard resolution version (T255 – in the atmosphere and around 1° in the ocean) and the high resolution version (T511, ca 0.25° in the ocean) have been performed to test the impact of high resolution. The simulations are 60 years long and used constant present-day forcing. The results indicate a more realistic placement of the North Atlantic Current and more regional details in the North Atlantic Ocean in the high resolution version. The mixing, particularly in the Labrador Sea, is enhanced, which leads to a more realistic simulation of the Atlantic Meridional Overturning Circulation (AMOC) in the high resolution version. This is potentially important for the decadal predictability since the AMOC is the largest source for decadal predictability in the North Atlantic Ocean and surrounding land areas.

WP3: Arctic Climate Predictions and Regional Downscaling. (SMHI; DMI; SAI; IORAS; NZC). Preparatory work for the planned regional downscaling of the decadal predictions in WP3 has been undertaken. The regional ocean model MITgcm has been prepared for the dynamical downscaling experiments.

WP4: Climate, Socio-Ecological Systems, Cetaceans and Tourism. (UoI, SAI, DMI). The University of Iceland's Centre (UoI) in Húsavík together with DMI have initiated analyses of the relationships between climate and the migration patterns of dolphins and blue whales. Data exist for dolphins from 1999 to 2013 and for blue whales from 2000 till 2016. We have obtained temperature data from stations in Reykjavík and Grímsey. Efforts are under way to compare these station data with gridded temperature products such as E-OBS, HadCRUT, and GISTEMP to validate data quality and fill data gaps.

In the summer of 2016 the international corporation PCC BakkiSilicon hf began to build a silicon metal production plant at Bakki close to Húsavík. This will mean greatly increased ship traffic to Húsavík harbour through the adjacent Skjálfandi Bay. Underwater noise due to explosions from the construction of a new tunnel and also from dredging activity associated with work to enlarge the Húsavík harbour was measured.

During 2016 sounds were recorded of harbour porpoises and white-beaked dolphins. More recordings will be made in the summer of 2017 and comparisons of changes from previous recordings will be made. Sightings and photo-identification of all cetacean species were conducted in Skjálfandi Bay by students and interns as has been done in previous years. The sighting data show a decline of the white-beaked dolphins in the southwestern part of Iceland, possible due to climate change. The sighting data also show a change in the distribution of blue whales. From 2000 to 2004 these giants were observed every year off western Iceland. They appeared in the northeast of Iceland in the summer of 2004. They were sighted from the whale-watching boats starting from Húsavík and were viewed there every year (2004-2016) except 2005. This change of distribution might be because of climate change. At the present time, 172 different

individual blue whales (based on photo-identification of the whales) are registered for the Skjálfandi Bay area in a catalogue published in 2016.

An underwater loudspeaker was tested in October in Keflavík harbour. This loudspeaker is supposed to mimic a marine vibrator. It has been suggested that marine vibrators should be used instead of airguns as they are likely to be less noisy and less harmful for the environment. It is planned to test this loudspeaker in Húsavík in the summer of 2017 while blue whales are in the bay and to ascertain any effects on their behaviour.

The Institute of Sustainability Studies at the University of Iceland leads task 4.4. This task involves assessing the tradeoffs between different ecosystem services derived from the multifaceted importance of cetaceans (including cultural importance) using the Common International Classification of Ecosystem Services (CICES) framework for ecosystem services and state-of the art economic-evaluation methods (stated and revealed preferences). In the year 2016, preparation was undertaken for the ecosystem services and economic assessments. This took the form of two literature reviews (working papers) and the selection of case-study sites in northern Norway and northern Iceland. The first of the literature reviews focused on the published literature regarding assessments of ecosystem services in the Arctic. The second one focused on the economic importance of the ecosystem services derived from cetaceans. These reviews revealed a gap in the literature on the economic value of Arctic ecosystem services as well as a gap in the literature on the wider economic and cultural importance of cetaceans.

Economic use and non-use values will be evaluated from the identified ecosystem services and relative economic importance derived. Researchers from UoI will collaborate with employees at the Joint Research Center (JRC) of the European Union that focuses on assessing ecosystem services within the Mapping and Assessing of Ecosystems and their Services (MAES) project.

SAI undertook fieldwork in Húsavík during the summer of 2016 and gathered valuable information on local perceptions and conflicting interests relating to use of marine spaces in Skjálfandi Bay adjacent to Húsavík. This will be useful for further work in collaboration with community plans to set up a Marine Protected Area. (This is discussed further under WP5).

A trip to Greenland and Ittoqqortoormiit (Scoresbysund) had to be cancelled due to unforeseen circumstances. However, valuable information on environmental and social change has been gathered by visits of key Greenlandic informants to Iceland, thus laying the ground for intensive fieldwork in 2017.

WP5: Responsible Governance, Security and Abrupt Climate Change in North Atlantic Arctic Coastal Communities. (SAI; UoI; INSTAAR, RRU, NSIDC, UiT). In the start-up phase of WP5 partners have been occupied with establishing the necessary contacts and networks, as well as recruiting research capacity to the project where gaps in expertise have been identified. WP5 forms a corollary to WP4, and focuses on the same research locations. As there is much overlap between the two work packages many of the activities undertaken have been relevant for them both and mutually strengthening. Although they are closely linked it is felt that keeping them separate for conceptual purposes will help to maintain the specific focus of each.

Of relevance for both WP4 and 5 is the fact that colleagues at SAI and UoI Húsavík are taking part in a process which may lead to the establishment of the first Marine Protected Area (MPA) in Skjálfandi Bay in northern Iceland. As noted also in the discussion for WP4, the bay is experiencing greatly increased and complex pressures due to both environmental change and also human activities, including industrial megaprojects, marine tourism and fishing interests.

This concept of the establishment of an MPA was further discussed in Húsavík in the summer 2016 and an additional meeting was held in Húsavík in September 2016 with Óli Halldórsson, Director of Húsavík Academic Centre and Chair of the Town Council of the local municipality, and Sif Jóhannesdóttir, Director of the District Cultural Centre in Húsavík. The Húsavík Academic Center received funding to create a marine spatial planning map of all users of Skjálfandi Bay and the next step will be to arrange a public meeting for all partners using the Bay.

An exciting development for WP4 and 5 is that two young researchers will be joining us as Associated Scientists. Dr Catherine Chambers (Associate Scientist, Stefansson Arctic Institute and the University Centre of the Westfjords) is an anthropologist (PhD from the University of Alaska, Fairbanks) and an expert in Icelandic and Arctic coastal communities and social aspects of fisheries governance, in particular how management systems influence the options of young people to enter fishing and gain access to resource rights. She will make a valuable contribution to the better understanding of different pathways to community resilience and sustainability and help ARCPATH provide policy relevant results relating to young people's futures in coastal communities. Gunnar Már Gunnarsson (Researcher, Stefansson Arctic Institute) has an MPhil in Polar Studies, from the Scott Polar Research Institute, University of Cambridge and an MA in Medieval Studies, University of Iceland. Gunnar Már is an expert in the cultures and history of East Greenland and the North Atlantic Arctic.

WP6: *Project Synthesis*. (SAI, NERSC, RRU, UiT).

As the project is only in its first year, there are no specific synthesis results to report, other than that there are many promising developments for the generation of new cross-cutting insights and concepts.

Nordic added value the project brings: 1) scientifically; 2) for the consortium; 3) for stakeholders:

A major goal of the ARCPATH project is to combine improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions in order to supply new knowledge on Arctic "pathways to action". Such a cross-disciplinary project would not be possible without the combined multi-disciplinary expertise of team members. This includes: climatology (regional and global modelling; dynamic downscaling; historical climatology); environmental science; environmental economics; oceanography and cryosphere research; marine and fisheries biology; fisheries management; anthropology; governance systems; human eco-dynamics; and traditional ecological knowledge (TEK). Being able to draw on all these disciplines will create the synergistic environment needed to address the serious issues currently facing northern societies. Because of the collaboration between colleagues in different Nordic countries, and because of the focus of the project on Arctic "pathways to action" ARCPATH brings true Nordic value scientifically, for the consortium, and for

stakeholders. The NordForsk NCoE call thus provides a unique chance for Nordic colleagues from all these disciplines to create a true "Centre of Excellence".

Demonstrate how the Centre has facilitated and developed cooperation with non-Nordic research groups within Arctic research:

The Centre has a very strong international component with active research partners drawn from: Canada, the USA, China and Russia. Some of these attended the ARCPATH start-up meeting held in Bergen in May 2016 and the first annual meeting held in Copenhagen in October 2016. Joint presentations with international partners have also been made. In addition, the project will further strengthen international cooperation with non-Nordic research groups via planned mobility grants for student exchanges.

Discuss: (a) cross-disciplinarity aspects of the work undertaken; (b) gender perspectives in the research; (c) contribution to open science; and (d) the contribution of users of research results (industry, policymakers, local communities etc.,) to the Centre at this stage:

(a) A key element of the ARCPATH project is its cross-disciplinarity. As noted above, we draw on disciplines from both the natural and the social sciences. All Work Packages contain some element of cross-disciplinarity. Thus, for example, WP1 combines hard science climate data with historical records of climate and marine-mammal variability. While WP 2 and 3 focus heavily on natural science climate data, they form the backbone for knowledge regarding Arctic "pathways to sustainability". WPs 4 and 5 are highly cross-disciplinary considering elements relating to climate change, marine-mammal biology, fisheries governance systems and tourism. WP 6 focuses on project management and WP 7 on synthesis whereby all the different strands and key elements of the project will be used to illuminate each other.

(b) In recent decades a very noticeable trend has been seen in almost all Arctic regions: that young women leave their communities in order to find work and education elsewhere. Of relevance here is the growth of whale-watching tourism. Thus, for example, from around the last decade of the twentieth century, Arctic whale watching has grown enormously in popularity among visitors to Iceland and other Arctic and sub-Arctic regions. This growth has been in line with the ever-increasing numbers of tourists coming to Iceland. (Since 2010 the increase has been over 20% per year.) Growth in jobs in the tourism industry, not least with regard to whale watching may enhance opportunities for women and make them more likely to stay in their communities. As a recreational and cultural activity, whale watching thus meshes with ecosystem dynamics and can be of great importance for regions struggling to develop and diversify their economy and social conditions. Gender considerations will be one of the focus research areas of ARCPATH.

(c) The ARCPATH Centre will contribute to improved access of scientific data through peer-reviewed and popular publications, presentations at conferences, public lectures and schools, and via software and educational material that will bring new information to debates on current Arctic issues. The webpage of the centre is well developed (<http://www.ncoe-arcpath.org>) and the project has a striking and evocative logo designed by a female artist from Húsavík. Supported by the Centre and the following fund (E-ARCPATH), the webpage will serve as an important and central point regarding contributions to open science.

(d) Regarding the contribution of users of research results, as noted above, colleagues at SAI and UoI Húsavík have discussed the idea of Skjálfandi Bay becoming a marine protected area (MPA). This has been discussed with the local community and other potential users. Discussions were held in Húsavík in the summer of 2016 as noted above in the discussions regarding WPs 4 and 5. The Húsavík Academic Center received funding to create a marine spatial planning map of all users of Skjálfandi Bay and the next step will be to arrange a public meeting for all partners using the Bay.

Any difficulties encountered - e.g. in staffing, access, data analysis etc., how these have or are being addressed and if they are expected to have an impact that requires updating/reviewing the initial objectives:

There are no significant difficulties encountered. However, as the project funding announcement was in December 2015 and commencement of the project had to be in January 2016 there were inevitably some delays in starting and it was not possible to have a first meeting until April 2016. Nevertheless, there is, at this stage, no need to update/review the initial objectives.

Changes introduced or envisaged in the research objectives or design:

There are no changes introduced or envisaged in the research objectives or design during the first project year.

An updated schedule of milestones and/or timetable, including major impact products, supported by a commentary on any future risks or anticipated slippage):

There are no changes in milestones and/or timetable during the first project year.

Governance:

The aspect of governance relates to WP 6 which concerns project management and dissemination. The ARCPATH Centre is led by the project leader and co-leader. The management group of the centre consists of the project leader, co-leader and the other work-package leaders. This means that there are four members from the natural sciences and two from the social sciences. Members are drawn from three different Nordic countries (Norway, Sweden and Iceland) and the gender balance is also addressed. The management group is responsible for promoting and facilitating cooperation between the partners in the Centre. Where necessary, decisions regarding the Centre will be taken according to a majority vote. In the event of a tie regarding a decision, the project leader will have an extra deciding vote (in consultation with the co-leader).

An Advisory Board (AB) consisting of highly-qualified colleagues from both natural and social science disciplines has been set up for the centre. The role of the AB is to provide advice and support to better achieve project goals. The AB consists of: Professor Cecilia Bitz, University of Washington, USA; Dr Burkhardt Rockel, the Helmholtz-Zentrum Geesthacht Institute for Coastal Research; Professor Lawrence C. Hamilton, Professor of Sociology at the University of New Hampshire, USA; and Professor Michael Bravo, Fellow of Downing College, and Senior Lecturer, Department of Geography, University of Cambridge, and Head of the Circumpolar

History and Public Policy Research Group at the Scott Polar Research Institute, Cambridge.

Highlights of the Research:

Research undertaken by SAI has established significant detail regarding variability of sea ice reaching the coasts of Iceland in the past. The general view of the past climate of Iceland has been that the period 1600 - 1900 was more or less uniformly bad, with heavy sea-ice incidence, except for a few short and insignificant warm spells. However, a scrutiny of Icelandic historical sources seem to indicate that there was, in fact, a great deal of climatic variability from early times to the present day.

Complementing previous studies, it is found that the Pacific Decadal Oscillation contributed significantly to the early twentieth-century warming, and may have offset some of the recent observed warming. This work is being prepared for publication. Preparatory work for the planned regional downscaling of the decadal predictions in WP3 has been undertaken. The regional ocean model MITgcm has been prepared for the dynamical downscaling experiments. NorCPM demonstrates skills against independent measurements: sea surface height, heat and salt content, in particular in the Equatorial and North Pacific, the North Atlantic, Subpolar Gyre (SPG) region and the Nordic Seas by only assimilating the sea surface temperature (Counillon *et al.*, 2016, Tellus).

The University of Iceland's Centre (UoI) in Húsavík together with DMI have initiated analyses of the relationships between climate and the migration patterns of dolphins and blue whales. UiB and NERSC have focused on understanding the mechanisms for early-twentieth century warming of the Arctic. Although data are limited, the warming during this period is thought to be comparable to the most recent warming.

SAI also undertook fieldwork in Húsavík during the summer of 2016 and gathered valuable information on local perceptions and conflicting interests relating to use of marine spaces in Skjálfandi Bay. This will be useful for further work in collaboration with community plans to set up a Marine Protected Area. ARCPATH intends to participate, as a scientific partner, and in an advisory capacity in this significant initiative to establish an MPA. This is a local grassroots project of perceived urgency. If successful it could become a major result and deliverable of the ARCPATH project, apart from the scientific empirical and theoretical value in terms of research.

Key Findings:

- Significant detail has been established regarding variability of sea ice reaching the coasts of Iceland in the past (established).
- High resolution decadal predictions lead to an improved representation of the North Atlantic Current system and the Atlantic Meridional Overturning Circulation (AMOC) which potentially improves the decadal predictability in the Nordic Seas and the Arctic (anticipated).

- The Pacific Decadal Oscillation is likely to have contributed to the early-twentieth century warming of the Arctic, and could influence the speed of changes in Arctic climate during the next decades (anticipated).
- Analyses of the relationships between climate and the migration patterns of dolphins and blue whales suggest a strong climatic influence (anticipated).

Warrant:

A major goal of the ARCPATH project is to combine improved regional climate predictions with enhanced understanding of environmental, societal, and economic interactions in order to supply new knowledge on Arctic "pathways to action". This cross-disciplinary project is possible because of the combined multi-disciplinary expertise of team members. This includes: climatology (regional and global modelling; dynamic downscaling; historical climatology); environmental science; environmental economics; oceanography and cryosphere research; marine and fisheries biology; fisheries management; anthropology; governance systems; human eco-dynamics; and traditional ecological knowledge (TEK). Being able to draw on all these disciplines will create the synergistic environment needed to address the serious issues currently facing northern societies.

Team members represent the following leading institutes in several different Nordic countries: the Nansen Environmental and Remote Sensing Centre (NERSC), the University of Bergen (UiB), the Arctic University of Tromsø (UiT), and the Norwegian Institute for Air Research (NILU) from Norway; the Danish Meteorological Institute (DMI); the Swedish Meteorological and Hydrological Institute (SMHI); and from Iceland, the Stefansson Arctic Institute (SAI) under the Ministry of the Environment, and the Institute of Economic Studies, and the Research Centre in Húsavík, both under the auspices of the University of Iceland (UoI). The team members, as well as the international collaborators, are leaders in their fields and have an excellent track record of many successfully completed projects. They thus have all the necessary multi-disciplinary expertise to achieve ARCPATH goals.

Researcher Mobility:

Please refer to Table 2.

Researcher Training and Education:

Please refer to Table 3.

Output and Dissemination:

Please refer to Table 4.

Meetings and Networking:

The ARCPATH start-up meeting was held in Bergen at the NERSC Nansen Environmental and Remote Sensing Centre in April 2016 and the first annual meeting was held at the Danish Meteorological Institute in October 2016. Planning is under way

for the second annual meeting which will be held in Reykjavík in October 2017. Team members have contributed to several conferences and networking meetings in 2016. Highlights have been: a presentation on ARCPATH by Astrid Ogilvie at the Arctic Workshop held in April 2006 in Boulder, Colorado; presentations by Níels Einarsson and Marianne Rasmussen at the third Whale Congress in Húsavík in June; a presentation by Edward Huijbens on ARCPATH and tourism issues in Akureyri in May and at an international Polar Tourism Research Network conference in Raufarhöfn, northeast Iceland, in August; a panel presentation at the prestigious Arctic Circle conference held in Reykjavík in October 2016 involving Níels Einarsson and Astrid Ogilvie among others; a presentation was given by Marianne Rasmussen at the Arctic Circle conference and at the fifth joint meeting between the Accoustical Society of America and the Japanese Accoustical Society in December 2016 in Honolulu, U.S.A.; Yongqi Gao gave an invited presentation at the European Open Science Forum in July 2016 in Manchester, UK; Madlen Kimmritz gave presentations in Norway, China, the UK and the USA.

Meetings with high-level officials at the Icelandic Ministry for the Environment and Natural Resources were held by Níels Einarsson and meetings with high-level officials at the Icelandic Ministry of Education and Science were held by Níels Einarsson and Embla Eir Oddsdóttir. For further specific details of meetings and networking please refer to Table 5.

An ARCPATH meeting of Icelandic participants was held at the Stefansson Arctic Institute in August 2016 and a working dinner meeting of ARCPATH participants and key partners was held in conjunction with the Arctic Circle (AC) conference in Reykjavik in October (<http://arcticcircle.org/>). At the AC, in collaboration with Kerry Koepping, photographer, of the Institute of Arctic and Alpine Research at the University of Colorado in Boulder, and the Arctic Arts project, a session was organised entitled: "To See Things Differently: The Education of Mid-Latitude Countries on Climate Change through Art and Science" highlighting the ARCPATH project, and referring to central ARCPATH paradigmatic messages. Panel participants were ARCPATH members Níels Einarsson and Astrid Ogilvie and also Kerry Koepping, as well as Elizabeth Ogilvie, a noted Scottish environmental artist. One fortunate result of this session and meetings is that we are now in an exciting discussion with Elizabeth Ogilvie with planned ARCPATH collaboration. Elizabeth has worked extensively with climate change, ice and impacts of changes on people in the Arctic. We are exploring way of collaborating with her in terms of an exhibit that would disseminate ARCPATH deliverables in a sophisticated form for public enlightenment and education.

In terms of synergy with other projects, the "Arctic Youth and Sustainable Futures Project" is noteworthy. This is led by the Stefansson Institute (by Drs Joan Nyman Larsen and Jón Haukur Ingimundarson) and is funded by the Nordic Council of Ministers. Several of the Icelandic ARCPATH members are also involved in this project which is likely to be an excellent partner.

Infrastructure and Data Policy:

During the first year of the ARCPATH project, partners have used their institutional and/or national infrastructures to compile climate and marine data from both historical archives and new field experiments, assimilate data into global and regional climate

models, and to perform initial analyses of observational data and model projections. Partners within the same country can share national infrastructure resources if the respective institutional/national data policies permit, while partners from different countries have shared common configurations of models ensuring compatibility between the two prediction systems used in ARCPATH.

ARCPATH will, as part of its Open Science pilot, establish a data catalogue offering open access to datasets generated in the project. This pilot will adhere to standard metadata and data formats for geo-scientific datasets, in line with recommendations from INSPIRE and EC for the Open Pilot for Research Data in H2020. For the implementation of the data catalogue, ARCPATH will draw upon standards and tools to be developed in the H2020 INTAROS (Integrated Arctic Observing System) project which started 1 December 2016 and is coordinated by NERSC. When initial standards and tools have been agreed, tentatively in the second half of 2017, the ARCPATH data catalogue will be set up and populated with a first set of metadata records. The metadata will, among others, include description of parameters, units, accuracy, data licenses and links for data access. The datasets themselves will be stored at the data owner's infrastructure or in a national or international spatial data infrastructure.

Progress and Contributions towards Programme Aims:

a) To strengthen the Nordic region's position within educational research in Europe and beyond;

ARCPATH will recruit graduate students at the PhD level (Icelandic partners are in the process of recruiting two PhD positions) and Post Doctoral positions. Two in-kind Post Doctoral positions at NERSC, one Post Doctoral position at UiB, and two Post Doctoral positions at SMHI are in place. SAI is in the process of employing one Post Doc. All these efforts will help to strengthen the Nordic region's position within educational research in Europe. ARCPATH members will organise two summer schools. One will be held in 2018 in Bergen and another will be held in 2019 in Iceland. ARCPATH will also be active in other summer schools (e.g, the biennial Nansen-Zhu Summer School, see <http://nzc.iap.ac.cn/summer2016>).

(b) To contribute to a knowledge-based policy for the educational sector in the Nordic countries by analysing issues of substantial importance and relevance to both the sector itself, policy makers and researchers;

ARCPATH research is of great educational relevance in the Nordic countries, both because of the global significance of its Arctic research, and also because of its novel approach and focus that aims at providing policy relevant and robust knowledge that will directly benefit Arctic residents. Research results will have clearly defined socio-economic relevance to the national interest of Nordic countries, and these will be disseminated to policy makers and stakeholder groups. ARCPATH will facilitate planning adaptation strategies, and will also take advantage of new opportunities to reduce environmental and economic risks. ARCPATH brings together a strong team, leaders in their respective fields, experienced in collaborative studies, and situated at institutions in the forefront of Arctic research. The combined multi-disciplinary expertise of team members, covering climate and social sciences, and extending from marine biology to environmental economics, will create the synergistic environment

needed to address the crucial issues facing northern societies. Through the training of young scientists, ARCPATH will help secure the long-term capacity in this field in the Nordic regions.

(c) to disseminate the results to a wide array of stakeholders in the Nordic region and internationally;

Early results of the ARCPATH project were disseminated to stakeholders in the Nordic regions during the first annual meeting in 2016. Further results will be disseminated via a specific workshop to be held after the annual scientific meeting in 2017. Further to this, results will be disseminated through meetings attended by the international collaborators from Canada, China, Russia and USA, specifically through projects such as the EU H2020 INTAROS, Blue-Action and Belmont/JPI InterDec) and through various international conferences (e.g., the Arctic Circle; Arctic Frontiers; the Arctic Science Summit Week; the International Conference on Climate Service). In particular, the National Marine Environmental Forecast Centre (NMEFC) in China will collaborate with ARCPATH. The project's webpage (<http://www.ncoe-arcpaht.org>) will serve as a 'permanent' base for dissemination purposes.

Impact Strategies and Plans:

ARCPATH will invite representatives from industry, policy makers and local communities to meetings and keep them updated concerning centre developments in the annual and other meetings and the planned summer schools. In order to ensure that ARCPATH activities are firmly anchored in society and are of benefit and relevance to Arctic inhabitants, and of policy relevance to decision makers, the project will actively seek the involvement of a wide range of users and stakeholders, from local communities to commercial companies to national policy making authorities. Regarding the development of the project there is close collaboration with the Whale Museum in Húsavík, as well as with one of the leading whale-watching companies which has operations both in northern Iceland, as well as in Scoresbysund (specifically the Kangertittivaq fjord region) in East Greenland, and most recently off the island of Kvaløya in Tromsø. Further to this there is collaboration with the regional labour union *Framsýn* which represents fishermen and fish workers throughout northeastern Iceland. Icelandic authorities involved are the Ministry for the Environment and Natural Resources, and Members of Parliament from the northeast constituency. ARCPATH will also cooperate with the projects EU H2020 INTAROS and Blue-Action and Belmont/JPI InterDec and with other NCoEs to strengthen synergy and research impacts. Furthermore, the ARCPATH centre has established excellent contacts with the National Marine Environmental Forecast Centre in China (a Chinese national forecast provider for the Arctic).

Potential Media Stories:

It is likely that, as the project develops, stories regarding changes in whale migrations could well be of great interest, as well as stories regarding all aspects of Arctic change. The potential establishment of a Marine Protected Area in Skjálfandi Bay, one of our research areas, could also be of great general interest.

Supplementary Funding:

In order to strengthen user engagement and the communication of project results, ARCPATH will establish inter-project liaisons with the newly funded EU H2020 projects (INTAROS, Blue-Action), where ARCPATH partner institutions are also involved. ARCPATH will also be active in communicating with the other NCoEs supported by NordForsk.

Programme Evaluation:

The ARCPATH project has received valuable comments and advice from members of the Advisory Board. Examples are from Professor Larry Hamilton of the University of New Hampshire and Dr Burkhardt Rockel from the Helmholtz-Zentrum Geesthacht. Following ARCPATH's annual meeting in 2016, Professor Hamilton commented as follows: 'The ARCPATH initiative brings together a range of scholars from different disciplines, with ambitious goals to analyse (and develop policy from) linkages between climate change and societal activities in the Arctic. While regional, decadal-scale climate predictions present significant scientific challenges in themselves, the crux of this project will lie in characterizing relationships between climate change and society. That is an important, exciting goal that I strongly endorse.' Similarly, Dr Burkhardt Rockel commented, 'As Lone Jessen from NordForsk pointed out, the proposal for ARCPATH got an excellent review though the reviewers find its goals very ambitious and challenging. I can fully support this view which I got when reading the ARCPATH proposal in preparation to the Copenhagen meeting. During the meeting I got the impression that the project is well organized and the participants are highly motivated. Moreover, the participants are not just trapped in their own discipline but are open and interested also in the other parts. This is the basis for mastering the challenges in ARCPATH. Nevertheless, the different disciplines are in different work packages. Since there are interactions defined (deliverables from one work package is used by another one) I strongly recommend to keep constant discussion between the WPs'. These comments are very welcome and are much in line with the plans and intentions of ARCPATH members who are very familiar with the running of large interdisciplinary projects

Requests for Programme support:

ARCPATH members are extremely grateful for the support from NordForsk for this interdisciplinary, international project that considers pathways to resilient, sustainable societies in the context of climate and socio-economic change in the Arctic.

Table 1: Personnel of the Centre

List the names of the research team leaders involved in the NCoE. Please give the number of other researchers and students who have worked within the project. Also, please indicate the number persons in each category as listed (number of, number of person years in total and the number of person years paid by the NCoE).

Name of the research team leader	Host Institution
Dr Yongqi Gao	Nansen Environmental and Remote Sensing Center, Norway
Dr Torill Hamre	Nansen Environmental and Remote Sensing Center, Norway
Prof. Noel Keenlyside	University of Bergen, Norway
Dr Astrid Elisabeth Ogilvie	Stefansson Arctic Institute, Iceland
Dr Níels Einarsson	Stefansson Arctic Institute, Iceland
Dr Marianne H. Rasmussen	The Research Center in Husavik, University of Iceland, Iceland
Prof. Brynhildur Daviðsdóttir	Institute of Economic Studies, University of Iceland, Iceland
Dr Torben Koenigk	Swedish Meteorological and Hydrological Institute, Sweden
Dr Markus Meier	Swedish Meteorological and Hydrological Institute, Sweden
Dr Shuting Yang	Danish Meteorological Institute
Prof. Ke Fan	Institute of Atmospheric Physics, Chinese Academy of Sciences, China
Prof. Leslie King	Royal Roads University, Canada
Prof. James R. McGoodwin	University of Colorado, USA
Prof. Sergey K. Gulev	P.P. Shirshov Institute of Oceanology, Russian Academy of Science, Russia

	Number of Persons	Person years in Total	Person years paid by the NCoE
Professors and associate professors	6	1.625	0
Senior researchers (other than above)	9	2.95	0.98
Postdoctoral researchers	5	1.82	0.64
Postgraduate students	0	0	0
Other academic personnel	4	0	0
Auxiliary personnel (office, technical, other personnel)	3	0.06	0.06

Table 2: Researcher mobility

Please specify research stay abroad as well as visits by foreign researchers. Here mobility is defined as a stay abroad of at least 2 weeks duration.

Name, job title, organisation	Site of work	Purpose of visit	Duration of visit	Comments, output of the visit
Per Pemberton, Researcher, SMHI	Geophysical Institute University of Bergen	Invited guest researcher developing new methods to diagnose water mass transformations in Nordic Seas/Arctic Ocean	2 weeks October 2016	A collaboration to study how the water mass transformations in the Nordic Seas/Arctic Ocean contribute to the overturning/estuarine circulation was initiated. A manuscript is being prepared.

Table 3: Researcher training and education

Please list courses organized. Specify the number of students participating (own students, and other students) and number of ECTS points gained in the courses. In addition, the number of PhD and Post Docs, both national and international is asked for.

Course (name of course, institution, person responsible)	Own Students	Other students	Number of ECTS points
Marine mammal summer course, UoI Húsavík, Marianne Rasmussen http://rannsoknasetur.hi.is/summer_course		22	2

How many PhDs and Post Docs are recruited in Nordic countries (specify the country) and how many are recruited internationally?

Number of PhD students recruited in Nordic countries (specify the country)	In recruitment
Number of PhD students recruited outside Nordic countries	In recruitment
Number of Post Docs recruited in Nordic countries (specify the country)	Sweden (SMHI): 1
Number of Post Docs recruited outside Nordic countries	Norway (NERSC:2; UiB:1): 3 Sweden (SMHI): 1

Specify the number of PhD degrees achieved at the Centre in reporting period.

Number of PhD degree achieved	0
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Table 4: Output and dissemination

Report the output of the research, e.g. publications.

Two tables are provided. The first table is for publications, reports and outreach activities with the main activities/collaboration funded by the NCoE. The second table is for publications, reports and outreach activities where the NCoE research has contributed. Also, report the number of Open Access publications.

Please attach a complete publication list – To the extent possible, please indicate direct publication linked to the work of the centre.

N.B. All presentations were oral.

Outreach and Dissemination main activities/collaboration funded by the NCoE

<p>Peer reviewed scientific publications / of which Open Access</p> <p>Chambers, Catherine, Einarsson, Níels and Karlsdóttir, Anna. <i>Small-scale fisheries in Iceland: Local voices and global complexities</i>. In: Pascual, J., Pita, C. and Bavinck, M. (Eds.) <i>Small-Scale Fisheries in Europe: Status, resilience and governance</i>. Springer (SAI contribution). In press.</p> <p>Huijbens, E. and Einarsson, N. 2016. Feasting on friends: Whales, puffins and tourism in Iceland. In: Appstate, C. (Ed.): <i>Animals as Food: Ethical Implications for Tourism</i>. <i>Research in the Ethics of Tourism</i> series published by Routledge. Peer review /open access (SAI contribution). In press.</p>	1
<p>Non peer-reviewed publications / of which Open Access</p> <p>Ogilvie, A.E.J., Einarsson, Níels, Gao, Yongqi, Keenlyside, Noel, Rasmusson, Marianne, H. 2016. <i>Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)</i>. 46th International Arctic Workshop, Program and Abstracts 2016. Institute of Arctic and Alpine Research (INSTAAR), University of Colorado at Boulder, 50-52 (SAI contribution).</p>	1
<p>Reports</p>	0
<p>Publications for the public</p>	0
<p>Invited conference presentations</p> <p>Counillon F. , Keenlyside, N., Wang Y., Kimmritz, M. and Bethke, I. 2016. <i>Reanalysis and climate prediction with the Norwegian Climate Prediction Model</i>. Invited speaker at Nansen-Zhu Summer School, Climate teleconnections and</p>	2

<p>predictions, Wuhan, 14 October 2016 (NERSC contribution).</p> <p>Counillon F, Kimmritz, M. and L. Bertino. <i>Application, Data assimilation: a perspective from Norway</i>. Invited speaker at Sea Ice Thickness Workshop, National Centre for Atmospheric Research (NCAR), Boulder, Colorado, 15 November 2016 (NERSC contribution).</p> <p>Kimmritz, M. 2016. Invited speaker at Nansen-Zhu Summer School, Climate teleconnections and predictions, Beijing, China, 10/2016 (NERSC contribution).</p> <p>Kimmritz, M. 2016. Invited speaker at Sea Ice Thickness Workshop at NCAR, Boulder, USA 11/2016 (NERSC contribution).</p>	
<p>Conference presentations (all oral)</p> <p>Counillon, F., Keenlyside, N., Wang Y., Kimmritz, M. and Bethke, I. 2016. <i>Reanalysis and climate prediction with the Norwegian Climate Prediction Model</i>, Data Analysis and Modelling in Earth Sciences Workshop, Hamburg, 28 September 2016 (NERSC contribution).</p> <p>Counillon, F., Keenlyside, N., Kimmritz, M., Wang Y., and Bethke, I. 2016. <i>Reanalysis and climate prediction with the Norwegian Climate Prediction Model</i>, International Workshop on Coupled Data Assimilation, Toulouse, 20 October 2016 (NERSC contribution).</p> <p>Einarsson, Níels. 2016. (Presenter and Session Organiser). <i>Fishing rights and financial capitalism in the Arctic: From common property to private ownership assets</i>. Session title: <i>Closing the marine commons as a tool of resource governance: Inevitable developments and alternative solutions</i>. Nordic ruralities conference, University of Akureyri, Akureyri 24 May, 2016 (SAI contribution).</p> <p>Einarsson, Níels. 2016. Introduction, Chair, and Moderator. Panel on The Educating of Mid-Latitudinal Countries on Climate Change through Art and Science: “<i>To See Things Differently</i>” organized by Kerry Koepping, Arctic Arts Project. Arctic Circle Conference, Harpa, Reykjavik, Iceland, 7-9 October, 2016 (SAI contribution).</p> <p>Einarsson, Níels and Nielson, Alison. 2016. <i>Fishing communities in the age of financial capitalism: From the Arctic to the Azores</i>. Undisciplined Environments: International Conference of the European Network of Political Ecology (ENTITLE) Stockholm, Kungliga Tekniska Högskolan, 21 March 2016 (SAI contribution).</p> <p>Einarsson, Níels and Ogilvie, A.E.J. 2016. <i>Sea ice, Climate, and Resource Governance in a Northern Community: The Case of Grímsey Island, Iceland</i>. Conference on Anthropology, Weather and Climate, British Museum, London, 28 May 2016 (SAI contribution).</p>	

<p>Einarsson, Níels and Ogilvie, A.E.J. 2016. Panel on People, Policy and Adaptations to Rapid Change in the Arctic, sponsored by the Institute of Arctic Studies at Dartmouth College, 4. December, discussing the role of multidisciplinary research and international collaboration for sustainability https://news.dartmouth.edu/events/event?event=41766#.WNFN01vjcs (SAI contribution).</p> <p>Einarsson, Níels and Vidal, Duarte. <i>Market-based fisheries governance, marine reserves and coastal communities: Developing interdisciplinary empirical research</i>. NILS Science and Sustainability Programme Conference, Universidade de Complutense, 26 May 2016 (SAI contribution).</p> <p>Huijbens, E.H. 2016. Tourism and socio-economic development in the Arctic in times of climate change. Oral presentation to conference: <i>Enginn er eyland: Ísland og alþjóðasamfélagið – staða og framtíð Íslendinga í samfélagi þjóðanna</i> (No Man is an Island: The Place and Future of Icelanders in Society) Akureyri, University of Akureyri, Iceland, 19 March 2016 (SAI contribution).</p> <p>Kimmritz, M. 2016. <i>On sub-seasonal prediction of Arctic sea ice using multivariate assimilation of sea-ice</i>. North Atlantic Climate (NACLIM) meeting, Exeter, 4 October 2016 (NERSC contribution).</p> <p>Kimmritz, M. 2016. Presentation at Data Analysis and Modelling in Earth Sciences, Hamburg, Germany, September 2016 (NERSC contribution).</p> <p>Kimmritz, M. 2016, Assimilating sea ice in Norwegian Climate Prediction Model, ARCPATH Annual Meeting, Danish Meteorological Institute, Copenhagen. 27-28 October 2016 (NERSC contribution).</p> <p>Kimmritz, M., Counillon, F., Gao, Y., Bethke, I., Wang, Y. and Keenlyside, N. 2016. <i>Data assimilation of sea ice within the Norwegian Climate Prediction Model</i>. SNOWGLACE meeting, Bergen, 1 December 2016 (NERSC contribution).</p> <p>Ogilvie, A.E.J. 2016. <i>Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)</i>. 46th International Arctic Workshop: <i>The Arctic's new normal: Shifting environmental baselines over decades to millennia and comparisons with the Antarctic</i>, INSTAAR, Boulder, Colorado, 3 April 2016 (SAI contribution).</p> <p>Ogilvie, A.E.J. 2016. <i>A Fleet of Silver: Literary and Historical Icescapes of Iceland</i>. Third International St Magnus Conference: <i>Visualising the North</i>, The Centre for Nordic Studies (CNS) University of the Highlands and Islands, Kirkwall, Orkney, 15 April 2016 (SAI contribution).</p> <p>Ogilvie, A.E.J., Koepping, Kerry, and Einarsson, Níels. 2016. <i>Visualising the Arctic: Change and the New Normal</i>. Third International St Magnus Conference: <i>Visualising the North</i>, The Centre for Nordic Studies (CNS) University of the</p>	
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<p>Highlands and Islands, Kirkwall, Orkney, 16 April 2016 (SAI contribution).</p> <p>Ogilvie, A.E.J. 2016. <i>The Summer of 1816 in Iceland</i>. 1816: The Year Without A Summer. Royal Meteorological Society National Meeting, Whitby Museum, Whitby, North Yorkshire, 21 May 2016 (SAI contribution).</p> <p>Ogilvie, A.E.J. 2016. <i>The ARCPATH project</i>. Sigtuna HfE Workshop, Sponsored by Sigtunastiftelsen and NIES, Sigtuna, Sweden, 9-11 September 2016(SAI contribution).</p> <p>Ogilvie, A.E.J. 2016. <i>Seeing Things Differently in Arctic Research</i>. Panel on The Educating of Mid-Latitudinal Countries on Climate Change through Art and Science: “<i>To See Things Differently</i>” organized by Kerry Koepping, Arctic Arts Project. Arctic Circle Conference, Harpa, Reykjavik, Iceland, 7-9 October, 2016 (SAI contribution).</p> <p>Ogilvie, A.E.J. 2016. WP 1: <i>Arctic Linkages: Climate, Environmental Change, and Human Eco-Dynamics</i>. ARCPATH Annual Meeting, Meteorological Institute, Copenhagen, 27-28 October, 2016. Presented by Noel Keenlyside (SAI contribution).</p> <p>Rasmussen, M. H. 2016. Photo-Identification of Whales and Dolphins. Arctic Circle conference, Harpa, Reykjavik, Iceland, 7-9 October, 2016 (UoI contribution).</p> <p>Rasmussen, M.H., Koblitz, J. and Stilz, P. 2016. Echolocation Behaviour of the Icelandic White-Beaked Dolphins (<i>Lagenorhynchus albirostris</i>) Now and Then, The Fifth Joint Meeting between the Acoustical Society of America and the Japanese Acoustical Society, Honolulu, USA, 28 November 2 December, 2016 (UoI contribution).</p>	
<p>Number of appearances in media</p> <p>Niels Einarsson. Interview in Icelandic State Radio, Channel one, 22 February 2016.</p> <p>Niels Einarsson. Interview with Norwegian State Broadcasting, NRK P2, 19 September 2016. First broadcast 1 February 2017.</p> <p>https://radio.nrk.no/serie/ekko/MDSP25002317/01-02-2017#t=33m1s</p>	
<p>Outreach and dissemination to the public</p> <p>Ogilvie, A.E.J. 2016. <i>Living in Northern Coastal Communities</i>. Invited Outreach presentation to Boulder “Sons of Norway” group. 22 January 2016 (SAI contribution).</p>	
<p>Web disseminations</p>	

Conferences arranged	
Summer courses	

Outreach and Dissemination where the NCoE has contributed

<p>Peer reviewed Publications/of which Open Access</p> <p>Counillon, F., Keenlyside, N., Bethke, I., Wang, Y., Billeau, S., Shen, M.L. and Bentsen, M. 2016. Flow-dependent assimilation of sea surface temperature in isopycnal coordinates with the Norwegian Climate Prediction Model. Tellus, A, 68, 32437, http://dx.doi.org/10.3402/tellusa.v68.32437 (NERSC contribution).</p> <p>Årthun, M., Eldevik, T., Viste, E., Drange, H., Furevik, T., Johnson, H.L. and Keenlyside, N.S. 2016. Skillful prediction of European climate rooted in the ocean, submitted (UiB contribution).</p>	Open Access
Non peer-reviewed Publications / of which Open Access	
Reports	
Publications for the public	
<p>Invited conference presentations</p> <p>Gao, Y. 2016. Meeting tomorrow's societal challenges: cross-border cooperation in Arctic research, European Open Science Forum, Manchester, U.K., July 2016 (NERSC contribution).</p>	
Conference presentations, oral/poster	
Number of appearances in media	
Outreach and dissemination to the public	
<p>Web dissemination</p> <p>1 http://www.ncoe-arcpaht</p> <p>2 http://www.svs.is/en/news/norwegian-and-icelandic-institutes-lead-a-new-nordic-centre-of-excellence-for-arctic-research</p> <p>3 http://www.bjerknes.uib.no/en/article/news/combining-climate-and-social-science-local-communities</p> <p>4 https://www.nerisc.no/news/nansen-centre-granted-one-four-new-nordic-centers-excellence-arctic-research</p> <p>5 http://www.bbc.co.uk/programmes/b05w9ljp</p>	<p>ARCPATH webpage</p> <p>SAI webpage</p> <p>BCCR webpage</p> <p>NERSC webpage</p>

<p>Conferences arranged</p> <p>Edward Huijbens (SAI) planned and hosted the 5th International Polar Tourism Research Network Conference: <i>Tourism, People and Protected Areas in Polar Wilderness</i> held at Raufarhöfn, northeastern Iceland, 29 August - 2 September 2016. There were 50 participants.</p>	<p>0</p>
<p>Summer courses</p> <p>Summer School on Climate Teleconnections and Predictions in Wuhan China (October 10-14, 2016)</p> <p>Marine Mammal summer course http://rannsoknasetur.hi.is/summer_course</p>	<p>Yongqi Gao Noel Keenlyside Francois Counillon Marianne Rasmussen</p>

Table 5: Meetings and networking

Number of workshops with invited speakers, conferences and other academic events organised by the NCoE:

Workshops

Workshop on Ensemble Kalman Filter for sea-ice data assimilation at the Danish Meteorological Institute, 26 October 2016.

Workshop with stakeholders at the Danish Meteorological Institute 28 October 2016.

Conferences

3rd Whale congress in Húsavík in June.
Niels Einarsson and Marianne Rasmussen both presented here.

Arctic Circle conference
Niels Einarsson, Marianne Rasmussen and Astrid Ogilvie presented at the Arctic Circle conference in October in Reykjavik in two different break-out sessions.

Marianne Rasmussen attended the fifth joint meeting between the Acoustical Society of America and the Japanese acoustical society in December 2016 in Honolulu U.S.A. with a talk.

Edward Huijbens presented ARCPATH and tourism issues at a conference in Akureyri in May and at an International Polar Tourism Research Network conference in Raufarhöfn, Northeast Iceland, in August.

Meetings with high level officials at the Icelandic Ministry for the Environment and Natural Resources (Niels Einarsson)

Meetings with high level officials at the Icelandic Ministry of Education and Science (Niels Einarsson and Embla Eir).