Arctic Natural Climate and Environmental Changes and Human Adaptation: From Science to Public awareness (SciencePub)

Norwegian Partner institutions:
Geological Survey of Norway (NGU), University of Tromsø (UiT), Norwegian Polar Institute (NPI), Norwegian University of Life Sciences (UMB), University of Bergen (UiB), Science Centers (Vitensenter) Tromsø, Trondheim and Bergen (SC), Oslo University College, Faculty of Journalism (UOC).

1 OBJECTIVES AND RATIONALES

The proposed project will:

- Advance our fundamental knowledge on natural climate and environmental change in the Arctic by improving system understanding and quantifying certain climate components
- Advance our understanding of human adaptation strategies to past rapid and large-scale changes in the physical environment
- Generate public outreach strategies that will leave a lasting legacy of increased public awareness of the natural environmental systems of the Arctic

1.1 Rationales

Climate models predict that a global warming of 1-5 ^{o}C will occur during the next century as a result of projected increases in atmospheric content of greenhouse gases. Warming in the Arctic is expected to be larger than the global mean. However, underlying natural climate variations are not adequately taken into account, and reliable predictions are hampered by lack of data on time scales longer than instrumental records. Arctic climate change takes place in a complex interplay between land, ice sheets, ocean and atmosphere in a manner inadequately understood. During the younger part of the Earth`s history, Arctic environment and climate was characterized by extreme shifts between cold glacial and milder non-glacial periods. Today, there are signs of decreasing sea ice cover, and increasing ocean and air temperatures, i.e. the present warm period moves towards even warmer conditions. Climate models disagree on the relative amount of warming to be expected, and natural variability adds further to this uncertainty. The changes in the Arctic are likely to have global to local effects that will challenge human society. In order to describe and understand the full range of natural climate system behaviour, paleoclimate archives must be studied. The underlying philosophy of this proposal is that increased knowledge of past natural changes of the physical environment, and the human adaptation to these changes is essential for the planning of future management strategies that governments will have to make.

Climate changes during the last glacial cycle had significant impact on the physical environment as well as the marine and terrestrial ecosystems. Influx of warm water into the North Atlantic has been of major importance for ameliorated land conditions, as well as for nourishment of ice sheets during colder periods. The decay of ice sheets had profound impact on ocean circulation and sedimentation through the release of melt-water and icebergs. During cold extremes, the large northwards draining Russian rivers were deflected to the south in front of the advancing glaciers and huge ice-dammed lakes formed, larger than any present fresh-water body on Earth. At the same time, the source of precipitation was reduced because of less influx of warm Atlantic water. In periods of warming the situation was reversed; precipitation increased, the huge lakes emptied into the Arctic seas, and the rivers were rerouted towards the north. These changes had an immense impact on oceanic circulation and distribution of heat to the adjoining land mass.

The history of human colonization of northern Eurasia begins in the last deglaciation period. The rapidly changing environments presented major challenges for the small hunter-gatherer groups that moved northwards along the Norwegian coast and from the Baltic region. Given the lack of historical analogues from similar contexts, our understanding of post-glacial human adaptations must be pieced together using reconstructions of the physical environment and theoretical models of dispersed highly mobile hunter-gatherer populations. These people brought with them a broad selection of economic skills established in more southerly environments, including abilities to cope with unpredictability and new challenges regarding both land- and sea resources.

An educated public accept environmental management policies better than an uneducated one. Science-based, objective information is crucial for environmental management, as well as for increasing public awareness of the delicate Arctic natural systems. Our vision is to involve journalists directly in this project for this component to continue beyond the duration of this project. We will (1) train journalism students about the natural climate changes in the north and the human adaptation to environmental changes through their active participation in the project; and (2) make exhibitions for pupils and students about sea-land interaction, the ice sheets growth and decay, and the human colonization of the north.

1.2 Strategic objectives

SciencePub will: 1) Assemble paleoclimate data through two intensive field/cruise seasons for further studies in the project. 2) Strengthen Norwegian expertise on the Arctic environment by networking key Norwegian scientists and institutions. 3) Develop close cooperation to key international research programmes and international collaborators, with a specific focus on strengthening ongoing collaboration with Russian scientists. 4) Recruit and train a new generation of polar scientists with expertise on the European Arctic, Svalbard and the adjacent oceans. 5) Pursue the multidisciplinary links between natural history and archaeology to explore the history of human adaptation to rapid changes in the physical environment. 6) Implement a public outreach program to raise public awareness of Arctic environmental change. 7) Develop a network between the information departments at the partner institutions and several Science Centres (Vitensentre) to build structures focused on Arctic science that will live beyond the IPY period. 8) Contribute to training of science journalists by hosting journalism students in the project, and on its expeditions.

2 PROJECT MODULES AND STUDY AREA

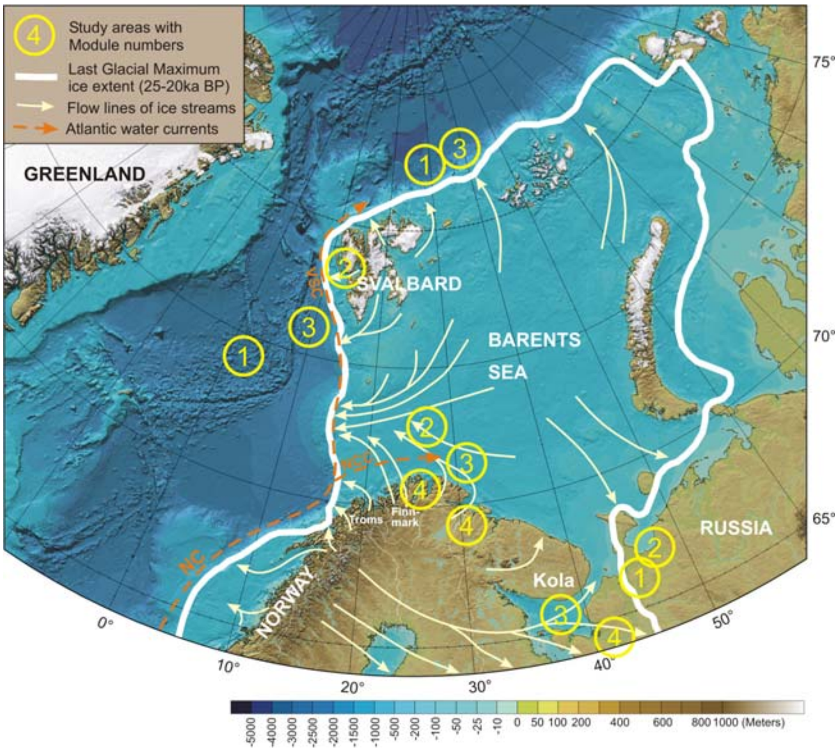

Fig. 1 *The study area with the extent and flow of the latest ice sheet. Interglacial Atlantic Water surface currents include: NC= Norwegian Current, NCC= North Cape Current, WSC= West Spitsbergen Current. The approximate working areas for the different modules are indicated.*

This project is the Norwegian coordinated contribution to the IPY endorsed APEX program (# 39). It will focus on the European Arctic region, including the Polar North Atlantic Ocean (> 70^{O}N), Svalbard and adjoining continental margin, coastal areas of northernmost Norway, the Barents Sea and NW Russia (Fig. 1). The northwest oceanic region is climatically sensitive (e.g. mixing of warm Atlantic and cold polar waters, removal of CO_2 from the atmosphere, large variations in sea- ice cover). The southeast area is a key area to understand the continental-scale change that occurred in the hydrologic cycle with river drainage totally shifting between glacial and non-glacial periods. Five interconnected, multidisciplinary and cross-institutional modules are instrumental to reach the goals (Fig. 2). Module 1 focus on development of new and improvement of existing climate proxies in order to reconstruct past changes in the physical environment, which are the goals of Modules 2 and 3. Module 4 will focus on human colonization at the end of the last glacial. This module is both an "end user" of results from modules 1-3, and through interaction, a generator of knowledge on human adaptation strategies, that may prove relevant when facing future changes. The public outreach (Module 5) is integrated into all other activities and stages of the project.

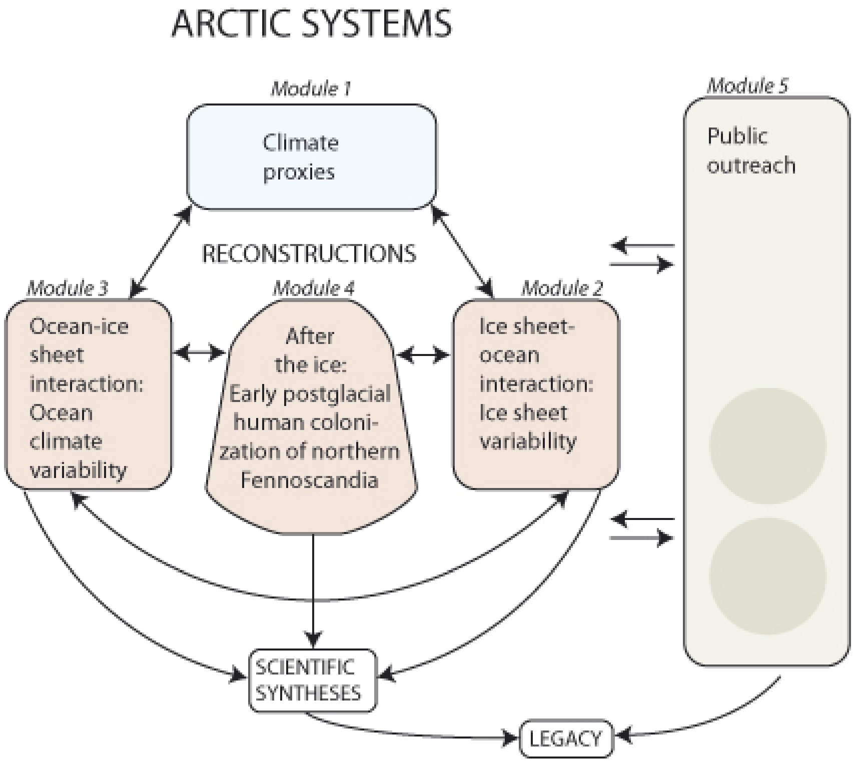

Fig. 2 *Project structure of SciencePub showing modules, links and end products.*

Module 1. Develop and strengthen climate proxies

NPI Dorthe Klitgaard Kristensen (Module leader),NGU Maria Jensen (Co-leader), UiT

- Develop precipitation proxy
- Improve sea ice/ocean temperature proxies

Precipitation proxy: Eilertsen *et al*. (2005), showed that anomalous thickness variations in Holocene tidal rhythmites from northern Norway correlate closely to modern hydrography and suggested that discharge is reflected in bed thickness. We propose to test and further develop this technique on a *c.* 20 m thick succession of 60,000 years old tidal rhythmites from the Mezen River mouth and Chyoshskaya Bay, which have a regional distribution in NW Russia (Jensen *et al*. 2006). The study will depend on the quantitative knowledge gained from the monitoring program in the present Mezen River system.

Ocean temperature proxy: Due to incomplete modern training sets at high latitudes, poor sample quality and unsuitable sample preparation techniques (Pflaumann *et al*. 2003), quantitative reconstructions of surface and sub-surface ocean temperatures below 5°C are questioned. In conjunction with international partners in WARMPAST (IPY # 36, see section 6) we aim to improve the modern calibration sets for planktonic and benthic foraminifera, diatoms, dinocysts, foraminiferal Ca/Mg-ratios, oxygen and carbon isotopes by taking undisturbed sediment-water interface samples with a multi-corer and calibrating with in situ CTD measurements. A suit of transfer functions (I&K, WAPLS, ML) will be tested to identify the best suitable statistical method for reconstruction of quantitative ocean temperatures (Telford *et al.* 2004). We will focus on three proxies: 1) Planktonic foraminfera in the 100 μm fraction. The largest modern training set for planktonic foraminifera at high latitudes represents the >150 μm fraction and are dominated by one species, *N. pachyderma* (sin) (Pflaumann *et al*. 2003). However, the >100μm contains a more diverse fauna (Carstens *et al*. 1997) and thus is better suited for reconstructing the cold temperatures in the upper 200 m of the water column. The use of benthonic foraminifera temperature reconstructions on arctic shelf seas (Sejrup *et al.* 2004) will be further refined. 2) Diatoms are useful indicators for SST in the Nordic Seas (Koç *et al.* 1993; Andersen *et al.* 2004). However, in order to improve reconstructions of the colder temperatures, a better training set from the polar north Atlantic is required. 3) Dinoflagellates. Studies from the Arctic shelf of Eurasia have shown that there is a close relation between the distribution of microfossils in the surface sediments and the characteristics of the overlying water column (Polyakova *et al*. 2003; Grøsfjeld *et al*. 2006). By applying the planned training set, and surface and core samples from the White Sea we will improve proxies for fluxes in salinity, sea ice cover and river discharge.

Module 2. Ice sheet-ocean interaction: Ice sheet variability
UMB Jon Landvik (Module leader), NGU Eiliv Larsen (Co-leader).

- Reconstruct ice sheet history
- Understand ice sheet control on continental ice dammed lakes, their formation and drainage into the ocean

Ice sheet – ocean interaction. The ice-sheet/ocean interplay is one of the most important system linkages in the glacial history of the Polar North Atlantic. During several periods, influx of warm Atlantic water provided moisture sources for the growth of high-latitude ice-sheets (Hald *et al.* 2001; Siegert & Dowdeswell 2004), and eustatic low sea level enabled ice sheet growth in the Barents Sea and on the shallow continental shelves. Ice-sheet disintegration released meltwater and led to ice-dammed lake outbursts, all influenced the oceanic circulation and the marine environment (Spielhagen *et al*. 2004; Svendsen *et al*. 2004). Sediment cores from the sea floor document the palaeoceanographic changes and the marine influence, and the response to ice sheet growth and decay (Module 3). Recent advances in ice-sheet reconstruction in the perimeter of the Barents Sea (Svalbard and NW Russia) show a larger complexity than previously assumed (Svendsen *et al.* 2004; Landvik *et al.* 2005; Larsen *et al.* 2006).
Ice sheet variability – our geological archives. This module focuses on understanding the ice sheet variability of the last glacial - interglacial cycle in selected areas of the European Arctic, by examining their extent, timing and the glacial dynamics. A strong emphasis will be on the interplay between the ice sheets and the ocean. The research will be closely linked to Module 3 (Ocean - ice sheet interaction) and Module 4 (Human adaptation). In cooperation with Module 3, promising glacial/deglacial successions from MIS 4 and MIS 2/1 will be targeted in both Svalbard and NW Russia. In the fjord, coast and shelf region of Svalbard, the ice sheet variability can be unlocked from stratigraphic records (Mangerud *et al*. 1998; Landvik *et al.* 1998; Landvik *et al.* 2005) and geomorphological constraints on past ice sheet elevation (Landvik *et al.* 2003). A refined reconstruction of glacier extent and timing will be developed as a base for correlation with the marine record (Module 3). Investigations will include sedimentological studies of key stratigraphies with glacial/deglacial successions, improved chronology (OSL dating, amino acid chronology), ^{10}Be exposure age dating to further develop ice sheet geometry, and ice sheet dynamics reconstructions (Landvik *et al*. 2003; Linge *et al.* 2006). In NW Russia the land and shelf region has been influenced by the Barents, the Kara and Fennoscandian ice sheets. These ice sheets had significant impact on palaeohydrology through rerouting at continental scale of fluvial drainage, formation of large ice-dammed lakes (Arkhipov *et al.* 1995, Mangerud *et al.* 2004; Larsen *et al.* 2006), succeeded by

catastrophic meltwater release to the ocean (Spielhagen *et al*. 2004). New field studies will focus on ice stream behaviour in this system through sedimentological investigations of till/sediment contacts in known stratigraphies, on timing of lake and fluvial phases and their relation to the ice sheet history. Synthesis of the deglaciation chronology and sea-level history of Finnmark, northern Norway (e.g., Sollid *et al.* 1973; Follestad 1981; Lebesbye 1983) will provide geological boundary conditions for the human immigration (Module 4).

Module 3. Ocean-ice sheet interaction: Ocean climate variability
Morten Hald UiT (Module leader), NPI Nalân Koç (Co-leader), NGU, UiB.

- Inflow of Atlantic water during warm extremes
- Quantification of sea surface temperatures critical for growth and decay of ice sheets
- Oceanic response to ice-dammed lake drainage and ice sheet break-up

Ocean – ice sheet interaction. The last glacial - interglacial period in the Polar North Atlantic region was characterized by high amplitude, millennial scale variations in climate and water masses (Bauch *et al*. 2001; Hald *et al*. 2001; Rasmussen & Thomsen 2004; Spielhagen *et al*. 2004). This variation had a large impact on the growth and decay of the Svalbard Barents and northern Fennoscandian ice sheets (Knies *et al*. 1999; Spielhagen *et al*. 2004). Glacial build-up phases and subsequent deglaciations were associated to influx of "warm" Atlantic Water during e.g. the last glacial maximum and during marine isotope stage, MIS 4. These periods were followed by oceanic cold extremes associated with meltwater, perennial sea-ice cover and inert oceanic circulation (Hald *et al*. 2001; Knies *et al*. 2003).
Hypotheses and testing. This module will focus on the following hypotheses/problems: 1) There are indications that warming is under way in the Arctic and climate models predict that Arctic warming may be as much as twice the global mean (IPCC 2001). 2) An "inverse" relationship between influx of Atlantic Water through the North Cape Current (NCC) and the West Spitsbergen Current (WSC), predicted in modeling experiments (Laurantin 2004), is linked to large-scale atmospheric circulation (North Atlantic Oscillation and Arctic Oscillation). This circulation has implications for sea-ice distribution, ocean temperatures and precipitation and thus glaciation in the Barents region. 3) Ocean boundary conditions for respectively growth and decay of large ice sheets are linked to inflow of Atlantic Water (Hebbeln *et al*. 1994). 4) Abrupt outbursts of freshwater from glacier ice, ice dammed lakes (Mangerud *et al.* 2004) and rivers may cause rapid and dramatic changes in ocean circulation and climate in the future (Rahmstorf 2003) mimicking the past (Clark *et al.* 2001). Hypotheses 1 and 2 will be tested in paleoclimate-records reflecting the WSC and NC during the late glacial-Holocene. This history of NCC is also directly relevant for human colonization in coastal Finnmark (Module 4). To elucidate hypothesis 3 we aim to quantify sea surface temperatures and salinity during well known glacial - deglacial sequences during MIS 4 and, MIS 2/1. Hypothesis 4 will be tested by studying sediments from the last glacial cycle reflecting the effects on the ocean circulation from freshwater release from the large ice dammed lakes and rerouting of river drainage in NW Russia (Kvasov 1979; Larsen *et al.* 2006). The investigations regarding 3 and 4 will rely on multi-proxy studies of high-resolution sediment cores from the continental slope off western and northern Svalbard. Detailed acoustic investigations and sediment core pilot studies during the last decades (Vanneste *et al.* 2005) allow for a goal-oriented coring program.
Application of Climate proxies and chronology. SST will be reconstructed using the improved transfer functions (cf. Module 1) in combination with oxygen isotopes. Chronology will be based on ^{14}C, isotope-, magneto- and tephra stratigraphy. There is a large potential to apply tephra for the last 130 ka, as a number of regional tephra layers are known from eruptions in Iceland, Italy and Germany. Some of these are regional markers (Grønvold *et al*. 1995; Hajdas *et al.* 1995; Birks *et al*. 1996; Lacasse *et al*. 1996; Frontval *et al*. 1998; Fedele *et al*. 2003). Tephra stratigraphy has yet to be established for the high-latitude target areas proposed here. When better established, this tool may contribute to improve ocean-land correlation in the Arctic areas (e.g. Haflidason *et al*. 2000; Lacasse, 2001; Fedele *et al*. 2003). Based on long experience from the area we can now identify core locations with a much better time resolution (century to sub decadal) compared to earlier investigations. In summary, this will reduce the uncertainties in the reconstructions both in time and space. The data will be reproduced at a format directly applicable for climate modeling experiments to be conducted through WARMPAST.

Module 4. After the ice: Early postglacial human colonization of northern Fennoscandia.
UiT Hans Peter Blankholm (Module leader), NGU Astrid Lyså (Co-leader), UMB, NPI.

- Human response to ice sheet variability as boundary conditions for early settlement
- Human response to sea level and temperature changes
- Generate new integrated models for human pioneer adaptations and settlement
- Improve ability to identify new early Holocene localities

Early Post Glacial human colonization and adaptation. Biologically modern humans colonized the southern Eurasia periglacial zone during the Middle Weichselian (40,000-30,000 BP), expanded into the Russian Arctic west of the Urals *c.* 39-36,000 BP (Pavlov *et al*. 2001), and to the edge of the Arctic Ocean in central Siberia *c.* 27,000 BP (Pitul'ko *et al*. 2004). The Scandinavian Ice Sheet prevented colonization of southern Fennoscandia until 12-10,000 BP, but by 9500 BP humans had entered the northernmost coastal region of Norway (Hesjedal *et al*. 1996), and traces of early Holocene (Preboreal) settlement have recently been found in the northern interiors of Finland and Sweden (Olofsson 2003; Rankama & Kankaanpää 2005). Svalbard was not occupied until early historical time.
Models for northern Fennoscandia. Most archaeologists see the colonization of northern Norway as occurring along the coast from the south, although new palaeoenvironmental reconstructions (Møller 1996; Demidov *et al*. 2006) have raised the possibility of an eastern route via Kola. Additional routes could be postulated from the Gulf of Bothnia through northern Finland (Rankama 2003) and from Swedish Norrland across the mountains (Blankholm 2004). Some archaeologists have linked the northward settlement expansion to specialized hunters following the shifting migrations of reindeer herds, while others have attributed the rapid movement to the utilization of marine resources. Low-level resolution of both environmental and archaeological records has until recently hampered detailed insights, in particular on how the colonization was related to rapid climate change. However, with chronological resolution of 2-300 years both within archaeological and geological research, it is now possible to investigate these issues and dynamics in more detail. The key hypothesis is that the pioneers were successful because of skilful diversified economic and adaptive strategies involving land-, riverine-, and (increasingly) marine resources. Economic diversity may prove a success factor to cope with rapid environmetal changes in the future as it has been in the past, e.g. 10,000 years ago at lower latitudes (Blankholm 1996), and also during the Little Ice Age with Finnish immigration to Finnmark.
Approach. The deglaciation and sea level changes at the late glacial- early Holocene transition in northern Russia – Finnmark is relatively well constrained (Marthinussen 1960; Sollid *et al.* 1973; Gataullin *et al.* 2001; Corner *et al.* 2001; Demidov *et al*. 2006), and together with a high-resolution marine climate record (Module 3) this will form part of the basis for assessing the physical conditions during early colonization. i) The Quaternary science data from Modules 2 and 3 will be integrated with the archaeological database in order to provide more robust models on human response to ice sheet variability and the associated accessibility to land and sea. Concurrently, newly investigated archaeological sites on river-, lake-, and marine terraces will provide valuable feed-back to Modules 2 and 3. ii) Modules 2 and 3 will also provide the basis for more precise, preliminary models of how the pioneers responded to rapid changes in sea level and temperatures. iii) The new knowledge and evidence of climatic, geological, and general ecological processes will provide for predictive models for the location of new early Holocene localities and settlements. iv) The above will be used to generate new integrated models, including social aspects, for the human pioneer adaptations and settlement.

Module 5. Public outreach
NGU Gudmund Løvø (Module leader), OUC Thore Roksvold (Co-leader), NPI, UiB, UiT, UMB, Science centers in Tromsø, Bergen and Trondheim (SC)

- Improve public awareness on natural environmental changes in the Arctic
- Contribute to a lasting legacy of the IPY research efforts

Science for the society. Dissemination of research results to the public has commonly been neglected by the scientific community. Improved communication between the public and the scientific community is a major challenge for the future. Up-to-date scientific results on Arctic research are a prerequisite for proper environmental management as well as political decisions on both national and multi-national levels. Our challenge is to raise the level of public and political awareness regarding the natural environmental change in the Arctic.

Outreach strategy and legacy. A main goal is to communicate knowledge on Arctic environmental change to the younger generation. We will promote public outreach by establishing a fully integrated project module with this focus. The module networks information officers at all partner institutions. Thus, the public outreach will be an ongoing activity carried out from the initiation of the project. Such a structure relates professional journalists directly to the scientific activity at the partner institutions. This strategy will improve communication between information officers and scientists on Arctic subjects, and we expect this cooperation to build relations beyond the IPY period. For the legacy of the IPY effort, we will also highlight the training of science journalists by their participation in field work and expeditions, and the exhibitions at the Science Centres.

Outreach products. Exhibitions aimed at primary and secondary school level will be developed in collaboration with the Science Centers in Tromsø, Trondheim and Bergen. The results of the projects and the experiments will also be presented to a broad audience including pupils and students at different locations in Norway during 'Forskningsdagene' (www.forskningsdagene.com) and at Polaria in Tromsø (www.polaria.no), and to the Russian public through Russian collaborators.

We will contribute to the education of research journalists by involving students from the Faculty of Journalism, Oslo University College in fieldwork, and to present science results as part of their curriculum. This will be organized through the faculty's master program in science journalism, bachelor course in science writing, and bachelor course in information and communication.

Through this network of information officers, we will establish and maintain SciencePub's web pages, and produce and publish popularized articles and presentations in newspapers/journals, on national/ local radio and TV-networks, on relevant web sites (e.g. the national popular website for research www.forskning.no) and on partner institutions web-sites.

3 PROJECT TEAM AND MANAGEMENT

SciencePub has assembled a team of researchers and public outreach experts from nine institutions: Geological Survey of Norway (NGU), University of Tromsø (UiT), Norwegian Polar Institute (NPI), Norwegian University of Life Sciences (UMB), University of Bergen (UiB), Science Centres (Vitensenter) Tromsø, Trondheim and Bergen, Oslo University College, Faculty of Journalism (UOC). The research team include the following scientists: NGU: Eiliv Larsen, Achim A. Beylich, Raymond Eilertsen, Kari Grøsfjeld, Maria Jensen, Jochen Knies, Astrid Lyså, Dag Ottesen. UiT: Hans Peter Blankholm Morten Hald, Bryan Hood, Tine Rasmussen, NPI: Dorthe Klitgaard Kristensen, Nalân Koç. UMB: Jon Landvik, Sylvi Haldorsen. UiB: Haflidi Haflidason, Hans Petter Sejrup. The research team comprises scientists that play key roles in marine and terrestrial environmental and palaeoenvironmental research in the polar region of Eurasia. SciencePub will draw on, and further develop, the expertise of this cross-institutional network. Especially, we aim at strengthening the integration of Norwegian ocean-land climatic research. As shown by the publication records (see attached CV's with publications), all partners of SciencePub have a history of strong international collaboration. The public outreach team includes experts from the public relation departments at NGU: Gudmund Løvø. UiT: Torgunn Wærås. NPI: Gunn Sissel Jaklin. UMB: Aase Vallevik Hjukse. UiB: Margareth Barndon and experts from the Science Centers in Tromsø: Tove Marienborg. Trondheim: Atle Kjærvik. Bergen: Asle Moldestad. The Faculty of Journalism, Oslo University College is represented with Thore Roksvold, Egil Fossum, and Harald Hornmoen. The public outreach team consists of professional and experienced journalists, information officers and information managers. The group has a broad network in the media and is for many years used to popularize and present research.

The project will be coordinated by professor Eiliv Larsen, and with secretariat at NGU. He will lead the project steering committee composed of him and the five module leaders. The co-ordination secretariat will undertake the daily running of the project including economy and reporting, assist and co-ordinate meetings, popular scientific papers and syntheses. The steering committee will be the responsible body for the project both with respect to scientific and economic priorities. The module leaders have the main responsibility for follow-up, co-ordination and reporting from each module. The organization structure of SciencePub aims to strengthen integration between the different disciplines and expertise represented by the various groups involved.

4 LOGISTICS, METHODOLOGIES AND DATA

Cruises and fieldwork. The project has access to the only two ice strengthened research vessels in Norway, R/V "Jan Mayen" of the University of Tromsø and the R/V "Lance" of the Norwegian Polar Institute. Terrestrial fieldwork will be carried out in northwest Svalbard and a clustering of potential sites in the Kongsfjorden area enables cost efficient use of logistic support for the Norwegian Polar Institute Sverdrup Station in Ny Ålesund. In NW Russia, the fieldwork will be effectively carried out through well established collaboration with Russian partners (cf. chapter 6). The archaeological fieldwork will take place in Finnmark and will involve the excavation and surveying of selected key-sites and areas.
Methodologies. The project has access to modern instruments and laboratory facilities at the partner institutions including: advanced instruments for sediment logging, geochemical, lithological and micropaleontological analysis. The chronological methods include ^{14}C, optical stimulated luminescence, amino acid racemization, exposure age dating and tephra chronology, stable oxygen and carbon isotope stratigraphy, biostratigraphy (foraminifera, diatoms and dinoflagellates), IRD analyses, foraminiferal Ca/Mg, transfer functions.
Data. SciencePub will follow the general IPY data policy. Sediment samples will be stored at modern cooling facilities at the partner institutions. Digital data will be archived, published and distributed through the World Data Centre for Marine Environmental Sciences (WDC-MARE) using the information system PANGAEA (http://www.pangaea.de) and the MAREANO (http://www.mareano.no/). PANGAEA (Bremen, Germany) supports publishing, distributing and archiving data related to the marine environment, to climatic variability and to the solid earth while MAREANO, located at the project coordinator institution, supports the Norwegian Sea and Margin archiving of data.

5 RECRUITMENT

SciencePub seeks funding of 5 fellowships, 3 doctoral and 2 postdoctoral. The positions will all be announced internationally, and candidates actively searched for through our contacts. These are important recruitment positions to further strengthen Norwegian competence on Arctic palaeoenvironmental research, and to conduct the labor-intensive research. They will be integrated in the SciencePub and institutional research groups, and will participate in the international IPY/APEX/other relevant networks. We plan for a 6-12 months stay at a foreign institution for all PhD fellows and when relevant also for post docs. To ensure cross-disciplinary approaches, the fellows will actively work on syntheses and correlation of land and marine records in cooperation with the senior scientists. The fellows will be supported by the PhD Trainee School in Arctic marine geology and geophysics (AMGG) at the University of Tromsø. AMGG offers a wide specter of training courses, workshops and cruises. Recruitment positions:

- *PhD 1, UiT (Responsible: Morten Hald):* Marine paleoclimate (Modules 2, 3), modern climate proxies (module 1) and climate modeling (WARMPAST), with expertice in foraminifera and statistics.
- *PhD 2, UiT (Responsible: Hans Peter Blankholm):* Integration of archaeological and palaeoenvironmental data, and modelling of pioneer colonization, adaptation and settlement. Six months in England studying Quarternary archaeology methodology. Impact to modules 2, 3 and 4.
- *PhD 3, NPI (Responsible: Nalân Koç):* Marine paleoclimate (Module 3) and modern climate proxies (Module 1) with expertice in diatoms. Quantitative reconstructions of sea surface temperatures, statistical analysis of Arctic SST variability.
- *PostDoc 4, NGU (Responsible: Eiliv Larsen):* Time-dependant glacial and sea level modeling. Important for modules 2, 3, 4 and for project syntheses.
- *PostDoc 5, UMB (Responsible: Jon Landvik):* Stratigraphic and geomorphic studies along the west coast of Svalbard to address the character and age of the glacial/deglacial successions. Primarily module 2, with close relations to modules 3 and 4.

6 IPY LINKS AND INTERNATIONAL COLLABORATION

This project is the coordinated Norwegian contribution to APEX (Arctic Palaeoclimate and its EXtremes, IPY endorsed program #39, and ESF proposed network). APEX (http://www.apex.geo.su.se) is a large "palaeo land – sea interaction" network, clustering a number of projects focusing on Arctic climate extremes. SciencePub forms an important part of APEX by studying warm and cold extremes of the last glacial – interglacial cycle as evidenced from the Barents Sea and fringing land mass. SciencePub also contribute to WARMPAST (IPY #36, Coordinated by Hald) through studying palaeoceanographic and glacier responses, development of proxies, and by data for climate modelling.

Since 1990 members of the group have cooperated closely with Russian scientists both in developing joint projects, organizing joint cruises and field-work, and in publishing their results. We plan on having at least one 2-4 months research stays in Russia working on this project, and at least one in the opposite direction. Both through APEX and through our personal contacts in Russia the young generation of scientists will get access to this network and can develop it further. Four Russian scientists have been actively involved in developing the present proposal: Dr. Igor N. Demidov (Member of APEX steering Committee), Geological Institute, Russian Academy of Sciences, Petrozavodsk, Dr. Viktoriya Krupskaya, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, RAS, Dr. Sergei Korsun, PP. Shirshov Institute of Oceanology, RAS, Moscow, and Dr. Alexey Krylov, VNII Okeangeologia, St. Petersburg. Of great importance to access of data on the Russian side is the formal agreement of cooperation between NGU and ROSNEDRA. ROSNEDRA is the state agency that finance state research institutions, and thus are owner of data under these institutions. The agreement makes NGU their main western partner.

The team behind this proposal has a further large international network that also partly is involved in the proposed research. The legacy of international collaboration should be evident from the enclosed CV's and publication lists of the partners.

Reference lists, SciencePub application

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