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Oral Abstracts - Session 1

UK SCIENCE AND INNOVATION NETWORK

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International collaboration is essential to maintain the excellence of UK science and innovation. International partnerships offer access to funding, infrastructure, data and services at a scale and scope beyond the reach of the UK acting in isolation. The benefits of international exposure are reflected in the fact that UK research with international partners has 47% more impact than research conducted solely in the UK.[1]

Promoting such partnerships was the motivation for creating the UK Science and Innovation Network (SIN). The Network is managed jointly by the Foreign and Commonwealth Office (FCO) and the Department for Business, Energy and Industrial Strategy (BEIS). It consists of approximately 90 staff located at the UK's diplomatic missions in about 30 countries. Its main role is to build partnerships and collaborations essential to maintaining the excellence of the UK's research base and the competitive advantage of its innovative businesses, for filling capability gaps and for ensuring value by leveraging international resources.

SIN's activity is guided by a global strategy, setting out four strategic objectives: the promotion of prosperity, security and international development, and projecting the UK's soft power influence. The global strategy also sets out the Network's sectoral priorities. These include supporting polar science, a sectoral priority which is a particular focus for SIN teams based in Russia, Canada, Japan and the Nordic countries. A current example of the activities supported by SIN is the growing collaboration with the Russian Arctic science community under the UK-Russia Year of Science and Education 2017. The Year of Science provides scope for increasing the visibility of the UK's Arctic research and stepping up bilateral scientific cooperation. To fulfil these objectives the SIN team in Russia is already supporting joint workshops, conferences and projects with a wide network of UK and Russian partners. With BEIS and the NERC Arctic Office it is keen to develop further activities to be included in the Year of Science and beyond.

The UK Arctic Science conference offers the potential to enhance links between SIN (globally, not just in Russia) and the UK Arctic science community. It will enable the two sides to share opportunities for prospective engagement, including potentially access to support. This could include consideration of possible collaborations in the context of the Agreement on Enhancing International Arctic Science Cooperation concluded in May 2017. SIN teams and the NERC Arctic Office are already working closely to maximise the impact of UK-based scientists in the Arctic. We understand that the Arctic Office is putting in an abstract concerning the development of the UK's international Arctic presence and connected activity. There may be positive links with the activity of SIN teams working on Arctic science.

[1] Measured by relative impact of publications.

BLUE-ACTION: TRANSLATING ADVANCES IN ARCTIC CLIMATE SCIENCE TO CLIMATE SERVICES ACROSS THE NORTHERN HEMISPHERE

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Weather and climate prediction in the Arctic and northern regions is inherently challenging and year-on-year and decadal variability makes it difficult to detect reliable signals of change. Changes in Arctic climate and weather patterns also influence Northern Hemisphere weather and climate, and potentially other climate systems worldwide. In an increasingly globalized world decision-makers from all sectors need to access to more reliable scientific knowledge and improved climate and weather information across regional boundaries to address forthcoming social and economic challenges posed by a changing climate.

In response, the H2020 funded Blue-Action project aims to deliver improved modelling, prediction, and forecasting of Arctic climate change and its impact on Northern Hemisphere climate, weather, and extreme weather events, in line with key stakeholder needs. However, activities across the academic, business, policy, and public communities are often largely disconnected, or followed a linear, 'scientist-tells-end-user' pathway, limiting opportunities for true co-creation of outcomes and real innovation. Enabling better co-creation of climate services is central to Blue-Action's approach.

To illustrate pathways by which knowledge is transformed from complex climate model output to relevant, user-specific climate services, we highlight five case studies where climate scientists are working collaboratively with user groups to develop targeted and relevant climate services based on newly improved climate data. We discuss new ways to establish a two-way dialogue around climate science, climate services, and end-user needs between academics, the policy community, businesses, NGOs, indigenous groups, and other relevant stakeholders to understand each other's needs, as well as our limitations.

AN ANCIENT DNA RECORD OF 25,000 YEARS OF ARCTIC PLANT COMMUNITY DYNAMICS

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Ancient DNA (aDNA) recovered from sediments in the Arctic and Subarctic has proved a useful new tool for studying change in terrestrial ecosystems over time. The preservation of extra-cellular (i.e. "environmental") DNA fragments appears to be enhanced by cold temperatures, for example, as found in sediments affected by permafrost or in lake sediments. While the focus of work to date that uses aDNA retrieved from sediments has been vascular plants, information on bryophyte, invertebrate and vertebrate taxa has also been retrieved from sites in northern regions. As with any new sub-field there is a need for further methodological standardization and a clearer understanding of the origin, transport and preservation (taphonomy) of ancient environmental DNA. Modern calibration work in arctic Norway has shown that soil-derived DNA records highly local plant assemblages at a scale of a few metres(1, 2); this scale is presumably reflected in DNA data from Siberian yedoma (ice-rich silt) deposits (e.g.,(3)). How DNA is recruited to lake sediments less well understood, but a range of success of DNA retrieval may be related to features such as sediment quality, catchment size, and inflowing streams. Currently, the most widely used approach for plant identification via DNA uses a "metabarcoding" approach with high-throughput sequencing. Simultaneous taxonomic identification of multiple DNA templates can be achieved using short (10-150 base pairs), but informative, DNA sequences linked to a catalogue created for the regional flora. We applied this technique to a sediment core from a glacial finger lake, (Bolshoi Schuchye) in the Polar Ural Mountains. The record covers the past 25,000 years, over which time cosmogenic exposure dating suggests the Polar Urals were largely ice-free(4). The lake has a large and topographically complex catchment and clay-rich sediments, both of which may contribute to the rich DNA flora obtained. We obtained nearly 12 million sequence reads of 167 plant taxa from 153 lake-sediment samples. DNA data show several features that pollen spectra would probably fail to detect, e.g., a turnover in grass genera over the transition to the Holocene, the persistence of a diverse arctic-alpine forb flora into the Holocene, and a diverse and variable bryophyte flora through time. The large dataset produced by this technique lends itself to novel numerical analysis. An initial examination of the temporal progression of nestedness in community composition and turnover among plant functional groups reflects shifting plant strategies and species interactions in response to major regional environmental changes.

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(3) Willerslev E et al. 2014. Fifty thousand years of Arctic vegetation and megafaunal diet. Nature 506: 47–51.
(4) Mangerud et al., 2008. Glaciers in the Polar Urals, Russia, were not much larger during the Last Global Glacial Maximum than today. Quaternary Science Reviews 27: 1047–1057.

ARCTIC SEA ICE LOSS: A NEED FOR MULTI-SECTORIAL COLLABORATION

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One of the most visible aspects of climate change is the dramatic loss of Arctic sea ice; both sea ice extent and thickness. The striking loss of sea-ice over all seasons reflects profound changes in the Arctic system. These climate driven changes bring with it environmental, socio-economic, and geopolitical consequences, as well as opportunities and possibilities. To better understand the impact of sea ice loss a multi-sectorial approach is needed. This innovative multi-sector approach to sea ice loss has gained traction over recent years as it transcends disciplinary boundaries, advances knowledge of Arctic change within a regional and global context, has a sharp eye to policy-relevance, and builds strong partnerships with northern communities. We present results from two such multi-sectorial research programmes: The EU funded ICE-ARC programme and the US funded MIZ programme.

Oral Abstracts - Session 2

QUANTIFYING SEA ICE CARBON UPTAKE WITHIN POLAR ECOSYSTEMS

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The structure and functioning of polar food webs is, to a large extent, controlled by the availability of organic carbon from two distinct sources; sea ice algae and phytoplanktic algae. Traditionally, the incorporation of these resources within food webs has been investigated by measuring stable carbon isotopes (δ13C) within animal tissue. However, in practice, carbon stable isotope end-member values considered representative of sea ice and phytoplanktic organic carbon can be difficult to establish, varying both temporally and spatially.

The 'H-Print', a relatively novel method, differentiates between carbon derived from sea ice and phytoplankton, providing clearly defined end-members for use in food web analysis. Calculated from the analysis of a suite of algae biomarkers (Highly branched isoprenoids), including some that are unique to sea ice algae, the H-Print has been successfully applied across all trophic levels in the Arctic from zooplankton to polar bears. An overview of the recent developments and applications, including calibration, of the H-Print are presented and discussed.

ARCTIC AND SUB-ARCTIC DUST SOURCES AND TRANSPORT PATHWAYS

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Estimates from field studies, remote sensing and modelling all suggest around 5% of global dust emissions originate in the high latitudes (≥50°N and ≥40°S), a similar proportion to that from the USA (excluding Alaska) or Australia. This paper identifies contemporary sources of dust within the Arctic and sub-Arctic and their role within local, regional and hemispherical environmental systems. Examples from Alaska, Iceland and Greenland are used to demonstrate that dust emissions are closely-coupled to glacio-fluvial dynamics and snow cover and that dust originating at high latitudes often stays within the Arctic region. The relative timing of dust inputs to Arctic terrestrial, cryospheric and marine systems determine its short to medium term environmental impact.

SEA ICE ROUGHNESS: THE KEY FOR PREDICTING ARCTIC SUMMER ICE ALBEDO

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The ICESat operational period 2003–2008 coincided with a dramatic decline in Arctic sea ice—linked to prolonged melt season duration and enhanced melt pond coverage. Although melt ponds evolve in stages, sea ice with smoother surface topography typically allows the pond water to spread over a wider area, reducing the ice-albedo and accelerating further melt. This understanding motivated simulations of melt pond distributions on statistically derived topographies, to examine how a decrease in the roughness of the pre-melt topography increases the fractional melt pond coverage during summer. We developed this theory into a quantitative relationship between premelt sea ice surface roughness and summer sea ice albedo. Our method, applied to ICESat observations of the end-of-winter sea ice roughness, can account for 85% of the variance in advanced very high resolution radiometer (AVHRR) observations of the summer ice-albedo. An Arctic-wide reduction in sea ice roughness from 2003 to 2008 explains a drop in ice-albedo that resulted in a 16% increase in solar heat input to the sea ice cover, which represents ten times the heat input contributed by earlier melt onset timing over the same period.

ECOSYSTEM-BASED APPROACH: DOES IT ACTCUALLY WORK IN THE ARCTIC REGION CONSERVATION SCIENCE AND POLICY?

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Co-adaptation of ecosystem terminology and selective concepts in governance vocabularies of concerned organisations and fora (Arctic council, UN...) is now perceived as natural and inseparable from the conservation rhetoric at many levels of Arctic governance. But is this approach actually realised in the Arctic region field studies and national conservation mechanisms? Does it yield comprehensive and exchangeable data across the circumpolar North or do we keep relying on isolated and irregular proxies? Building up on the 5 year experience of the Terrestrial CBMP CAFF group, which revealed the obstacles in employing ecosystem approach, the study analysed research strategies for arctic bird species in the Western half of the Russian Arctic and evaluated them on the basis of ecosystem approach use. Then it analysed and compared existing management and conservation strategies in the way they converge, diverge and interact with the research output. The study found that the ecosystem approach, though theoretically superior, is largely unrealistic in remote, poorly understood, challenging and underfunded areas of research in the Russian Arctic and, perhaps, further afield. The targeted species approach has been used by scientists and its output deployed by the state and industry alike as a proxy for environmental health of the area. The research found that ecosystem approach appears to be very difficult to execute when we are dealing with terrestrial ecosystems including dozens of vertebrate species with complicated behavioural patterns.

NUTRIENT RECYCLING FROM ARCTIC OCEAN PORE WATERS

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The availability of macronutrients (N, P, Si) is one of the main factors controlling primary productivity in the ocean and, in turn, the sequestration of atmospheric CO2 into plankton biomass and ultimately into the sediments. An important source of nutrients to the oceans is the seafloor, where organic material is decomposed by microorganisms and dissolved forms of N, P and Si are released into the surrounding pore waters, from where they are recycled back into the overlying water by diffusion and/or advection. In the Arctic Ocean, our knowledge about this benthic nutrient source to the water column is quite limited, but it can be assumed that with increasing temperature and light availability following the ongoing sea ice retreat, organic matter export to the seafloor may increase, and with it the benthic fluxes of macronutrients. Here we present nutrient flux data for various parts of the Arctic Ocean, based on three RV Polarstern expeditions in 2008, 2012 and 2015, and an RRS James Clark Ross expedition in 2017. Available data indicate that deep-water sites in the central and western Arctic Ocean show some of the lowest Si fluxes observed globally. This is probably related to general low productivity of biosiliceous plankton in this oligotrophic environment and partial biosilica dissolution in the water column. In contrast to higher Si fluxes calculated in the Canadian Archipelago, nutrient fluxes are low as well north of Svalbard and on the Yermak Plateau, despite shallower water depths (~500-2,000 m). Data from the shallow (<500 m) central and northern Barents Sea will be generated within the next months. We will put these data into the context of available compilations in the literature and provide a better understanding of benthic fluxes of macronutrients in Artic sediments.

Oral abstracts – Session 3

NERC ARCTIC RESEARCH STATION

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The NERC Arctic Research Station supports field projects at Ny-Ålesund, Svalbard. The presentation provides information concerning Svalbard, Ny-Ålesund, NERC station equipment, facilities, travel, local research areas and the station support application system.

THE ROLE OF SEA ICE IN THE CYCLING OF PERSISTENT ORGANIC POLLUTANTS: OBSERVATIONS IN THE ARCTIC AND EXPERIMENTS IN A SEA ICE FACILITY

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Even with a warming climate, sea ice areal cover in the Arctic is extensive covering some 14.5 million km2 during the height of the Arctic winter and some 5 million km2 during the late summer minimum. This provides a large surface area for the deposition of contaminants present in the atmosphere and the interaction and entrainment of contaminants present in sea water. Field studies have demonstrated the occurrence of HCHs, PCBs and PFAS in Arctic sea ice, but processes controlling their uptake, retention and eventual release from ice are complex and intimately tied to the physical processes of ice growth and melt as well as interactions with the ice rafted snowpack and beneath ice seawater. There is some evidence that certain chemicals, particularly perfluoroalkyl acids show enrichment in sea ice relative to seawater and the release of these chemicals with ice brine (a super salty solution present in young ice) or meltwater may pose a significant exposure route to sympagic (ice-associated) organisms during seasonal thaw. Sea ice may therefore play an important role in delivering pollutants to the base of the marine foodweb. To understand chemical dynamics in sea ice we have undertaken experiments in the Roland von Glasow Sea Ice Facility. In essence this comprises a 3500 L glass tank filled with artificial seawater and the facility can be chilled to -55oC at different cooling and warming rates to promote ice growth and melt, respectively. The facility is equipped with an overhead lighting rig, tank-floor cameras and water pumps, the latter to help maintain seawater movement and provide a heat flux. The tank is fully monitored with an array of sensors and allows the collection of seawater (notably beneath ice seawater) as well as bulk ice and ice brine. Maximum ice depth is ~25 cm. An array of chemicals that have been observed in the Arctic marine system were spiked (via MeOH solution) into the seawater prior to the freeze experiments and included PCBs (#28,52), PBDEs (#47, 99), □-HCH, chlorpyrifos and endosulfan-I. Additionally, C4-12 perfluorocarboxylic and sulfonic acids were also spiked into the seawater with individual chemical concentrations in the nM range. Chemical dynamics during ice formation and growth were observed, particularly the entrainment of the chemicals in young ice and their occurrence in ice brine. Ice brine appears to play an important role in chemical retention and movement in the bulk ice. The experimental results will form the basis of a sea ice chemical fate model and the role of snow in chemical fate will be explored in future experiments by using an artificial snow layer applied to the surface of the ice.

INTER-ANNUAL VARIATION IN THE SEASONAL STRATEGIES OF ZOOPLANKTON IN A HIGH ARCTIC FJORD

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Zooplankton such as copepods adopt a variety of strategies to respond to seasonality. In the high Arctic, this seasonality is more pronounced, with the sun rising and setting for continuous periods known as the Midnight Sun and the Polar Night respectively. Behaviours such as Diel Vertical Migration (DVM) are primarily light mediated. The extreme seasonal light cycle in the Arctic challenges the classic paradigm of animals surfacing to feed and then sinking to avoid predation in response to the timing of sunrise and sunset. In the winter, copepods enter a period of hibernation known as diapause. This study investigates the timing and duration of these different strategies observed in zooplankton in response to environmental variation. Single point moorings have been installed in a high Arctic fjord (Kongsfjorden, 79N) for the last decade, sampling physical (temperature, salinity) and biological (fluorometry, backscatter from ADCPs) parameters. Eight years of this data (2007-2014) have been used to compare the inter-annual variation in the seasonal strategies of Arctic zooplankton. Lomb-scargle periodograms of backscatter data (zooplankton abundance) were used to define periods of synchronised DVM. We see that the most synchronised period of DVM in spring is centered around the equinox, suggesting a light mediated behaviour. However, the timing and duration of this synchronised period changes each year, suggesting cues and drivers other than light. Here we apply the copepod life strategy model Coltrane (Banas et al. 2016) to Kongsfjorden to investigate how the environment (temperature and prey fields) affects i) the timing of most synchronised foraging; ii) the timing of diapause; and iii) the overall success of the copepods over this eight year period. The results of this model are compared to observations from acoustics and occasional net data to identify the accuracy of timing predictions in terms of activity and spawning. Finally, we intend to interpret the effect of advection on the life cycle of Arctic copepods.

INTEGRATING SEASONAL STRATEGIES INTO MODELS OF ARCTIC PHYTOPLANKTON

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The changing Arctic environment presents a challenge to ecosystem models which seeks to reproduce observations of primary production magnitude and phenology, as well as make predictions of the future. One major difficulty in capturing these changes and their impact higher trophic levels is that the strong seasonality of polar phytoplankton, in both their physiology and behaviour, is not fully understood. Nor are seasonal strategies usually accounted for in ecosystem models. Here we develop a model of seasonality in photosynthetic parameters within populations which more accurately reflects physical observations. This description is then integrated into a larger NPZD ecosystem model which is applied to the eastern Bering Sea, and captures the timing and magnitude of the spring bloom. Seasonality in photo-parameters was established by experimentally determining photosynthesis-irradiance curves for phytoplankton communities. Samples were taken from under winter sea-ice and in open waters following ice retreat, in near-optimal spring bloom conditions. The initial slope of the photosynthesis irradiance curve, denoted α, is often called photosynthetic efficiency, and is generally expected to increase in dark-acclimated cells. However, under-ice samples were found to have lower values α, as well as the maximum growth rate μ0.A trade-off is proposed between α and maintenance respiration, a higher α leads to higher respiration costs. The proportionality is the compensation intensity, the light level at which respiration and growth are balanced. Below this point, respiration losses are greater than growth, and lower values of α become advantageous to reduce those losses. The trade-off and model of α as well as the observed seasonality of μ0 were integrated into an existing ecosystem model of the study region. In this NPZD model, seasonality in α was necessary to accurately reproduce the observed timing and magnitude of the spring bloom. Finally, we discuss how the model can be generalised to work for other sub-regions of the Arctic, beginning with the Chukchi Sea.

Oral Abstracts – Session 4

NERC ARCTIC OFFICE

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The NERC Arctic Office supports UK research in the High North; provides advice to policy makers and develops international scientific cooperation across all aspects of Arctic research. Over the course of the last year the Office has been successful in connecting UK-based researchers with new international opportunities, including through the UK-Canada Arctic Bursaries Programme and the MOSAiC International Arctic Drift Observatory. The Arctic Office is committed to widening and developing these opportunities, in partnership with the UK Arctic community. The signing of the legally binding Agreement on International Arctic Scientific Cooperation by the eight members of the Arctic Council in May 2017 marks a potentially important step change in access to the Arctic for UK-based researchers.

The proposed session will provide a focused summary of recent activity to support international cooperation; identify and share new priorities – including opportunities to influence the UK's Arctic science engagement with Russia; and to place this work in the context of wider international developments within the International Arctic Science Committee and the Arctic Council. By the end of the proposed session participants will have a strong awareness of how they can be supported by, and help shape, the work of the NERC Arctic Office; how the Office is supporting and promoting international cooperation; and to have received information about new opportunities.

We have been in discussion with colleagues from the Science and Innovation Network team in the UK Embassy in Moscow who will be attending the UK Arctic Conference. We understand that they will submit an abstract for a presentation on UK-Russia Arctic-links. We support that abstract and where there is an opportunity to synchronise the Arctic Office and SIN Moscow presentations in an appropriate session that would be welcome.

SEASONAL AND DECADAL VARIABILITY OF DUST OBSERVATIONS IN THE KANGERLUSSUAQ AREA, GREENLAND

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Arctic dust emissions have started receiving more attention in the past decade. This is because emission frequency and magnitudes are expected to increase with rising Arctic temperatures leading to a reduction in terrestrial ice masses and increases in suitable sediment for the aeolian system. Of the identified Arctic dust source regions, Greenland has received relatively little attention. Using World Meteorological Organization (WMO) dust code analysis, this study presents a 70-year record of dust events from Kangerlussuaq, west Greenland. A clear seasonal pattern of dust emissions shows increases in dust events in spring and autumn driven by effective winds and sediment supply. The decadal record suggests an increase in the magnitude, but not frequency, of dust events since the early 1990s.

LIGHT CLIMATE OF THE HIGH ARCTIC POLAR NIGHT AND ITS IMPLICATIONS FOR BIOLOGY

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Light is an ecologically important factor for both terrestrial and aquatic organisms, influencing a range of biological processes. Key aspects include intensity and spectral composition which vary over the diel cycle, as well as photoperiod which varies seasonally. Here, we discuss these and other aspects of the light climate revealed during four years of sampling on the west coast of Svalbard during Polar Night (January 2014-2017) when the sun remains 6° or more below the horizon throughout the diel period. We have made a range of atmospheric and underwater light measurements to characterize diel skylight irradiance patterns and parameterize radiative transfer models of the underwater light field. From these, we see a distinct photoperiod with a short photophase lasting several hours, and highest irradiances observed at solar noon when the sun is at its highest elevation below the horizon. The spectral composition of light varies according to the dominant source of illumination, with periods of diffuse skylight from the sun being reduced at yellow wavelengths as compared to periods dominated by moonlight. This light climate is biologically relevant, particularly for diel vertical migration of zooplankton which we show through quantitative visual models and empirical observations using autonomous platforms. Some less obvious aspects of the light climate are also evident. Specifically, there is a distinct pattern of skylight polarization at midday during the polar night which could serve as an orientation cue for birds during a time of year when visual cues are limited. Collectively, this work demonstrates that there is biologically relevant light in the Polar Night.

SUSTAINABLE HERITAGE AREAS: PARTNERSHIPS FOR ECOTOURISM

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This presentation introduces the focus and expected outcomes of a new project for accompanying the development of ecotourism initiatives in the Artic Region: SHAPE –Sustainable Heritage Areas: Partnerships for Ecotourism. The project, funded by the European Commission's Northern Periphery and Arctic Programme, works with a transnational set of sustainable heritage areas (SHAs) which are mostly located in the Artic region with diverse experiences of sustainability and regional cooperation involving stakeholders in heritage management, tourism, and governance. These SHAs are biosphere reserves or regional parks from Finland (North Karelia), Norway (Nordhordland), Greenland (Kujalleq), Iceland (Snaefellsnes Regional Park) and Scotland (Galloway and Southern Ayrshire Biosphere and Wester Ross Biosphere). Despite the many factors that make the Artic region attractive, there are many common demographic, economic, and governance challenges – and, while many of these may be exacerbated by climate change, it may also bring opportunities. Nevertheless, historical differences between stakeholders from different sectors, as well as limited cooperation and understanding of the potential of new technologies and economic models, mean that many opportunities to capitalise on natural and cultural heritage assets are not realised. The idea behind SHAPE is that, effectively implemented, innovative ecotourism initiatives that build on natural and cultural heritage assets, conserve the environment, and sustain the well-being of local people, can be a key factor in providing employment and income in rural and sparsely populated areas, while maintaining these rich assets and the fundamental qualities of traditional life. The cultural and natural heritage of these areas is fundamental to local people's sense of identity and, at the same time, represents key assets for developing ecotourism. To achieve its goals, SHAPE works to bring together stakeholders who rarely collaborate and have sometimes been in conflict (e.g. from natural/cultural heritage, agriculture, fisheries, tourism), to identify common goals for developing ecotourism initiatives and working together to realise them. Using participatory approaches based on stakeholder engagement, different methodologies and tools are developed and tested relating to the development and maintenance of effective stakeholder networks; the identification and mapping of natural and cultural assets; and the strengthening of effective governance in the SHAs. In this line, project activities in each SHA include addressing local challenges for sustainable development by mapping assets, building on existing activities, exchanging and strengthening local stakeholder knowledge through learning journeys between countries and regions and helping those who are developing ecotourism initiatives. Expected results include the development of stakeholder engagement in the SHAs involved and improvement of their governance structures and mechanism while contributing to fostering ecotourism in those areas and aiming to contribute to providing sustainable local development solutions in the Artic region.

LINKING THE SYNOPTIC- AND MICRO-SCALES: HOW CAN HIGH PRESSURE SYSTEMS AFFECT MARINE CLOUD MICROPHYSICS IN THE SUB-ARCTIC?

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Long-lived mixed-phase clouds (MPCs) — containing both liquid cloud droplets and ice crystals — are commonly observed throughout the Arctic. Models on various scales are notoriously poor at reproducing the fraction and lifetime of these inherently unstable clouds due to the complex small-scale interactions which occur within them; therefore, it is imperative to improve our understanding of their interaction with, and response to, their environment. To maintain the height of these boundary layer (BL) clouds in cloud-resolving models, large-scale subsidence -- associated with high pressure systems -- is often imposed; however, the relationship between subsidence and mixed-phase cloud microphysics has not been previously studied. Using the UK Met Office Large Eddy Model (LEM), we find strong cloud microphysical sensitivities to large-scale subsidence: by enforcing BL inversion strength and reducing entrainment from above, widespread subsidence can dynamically stimulate sub-Arctic marine MPC, promoting efficient precipitation formation and a greater cloud liquid-water path. Our results therefore indicate that high pressure systems in the ocean-exposed low-, or sub-, Arctic regions have the potential to affect resident BL MPCs by enhancing their liquid fraction, thus helping to sustain them for longer against cloud glaciation.

Oral Abstracts - Session 5

NATURAL AND CULTURAL ASSET MAPPING BY PUBLIC PARTICIPATORY GIS FOR SUSTAINABLE TOURISM IN THE FAR NORTH: A FEASIBILITY STUDY IN SNAEFELLSNES REGIONAL PARK, ICELAND

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Asset mapping is an inventory of features of an area, both tangible and intangible, that have value. These assets are systematically identified, classified and analysed spatially. This paper examines asset mapping using Geographic Information Systems (GIS) as a step towards a sustainable tourism development strategy. Applications of asset maps in this field include using them to manage land use, form a strategy for linking assets for added value, and in planning for preservation and future development. First, the review of literature presents examples of natural and cultural asset mapping methods using GIS and the application of asset mapping in integrated management of parks and reserves. Concepts, tools and frameworks are covered, with specific attention given to public participatory methods. Participatory asset mapping is the collective gathering of information from community members to compile a map of local assets. It is a holistic method of mapping because it is consultative. By consulting local residents, a wealth of information on known and previously unknown assets can be gathered, including values attached to them. This information can then be transferred quantitatively into the GIS system.The focus then shifts to the applied use of asset mapping in integrated management of natural and cultural resources in Snaefellsnes Regional Park, Iceland. This is presented in the form of a feasibility study, analysing the potential scope of Public Participatory GIS use on the scale and resources that such a park has. The feasibility study is intended to bridge the gap between theory and application on a small-to-medium park scale in the Arctic and Far North.

SAVING ARCTIC ICE BY TWOMEY-LATHAM MARINE CLOUD BRIGHTENING

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Although most computer climate models predict Arctic summer ice lasting till the middle of this century, the much earlier predictions by Wadhams and Maslowski are now, unfortunately, seen to be more accurate. The problems of loss of reflectivity, the faster release of methane from permafrost, changes to the jet-stream and thermo-haline circulation will be familiar to people at this conference and look unpleasant.

It may be possible to use John Latham's idea for marine cloud brightening to save the Arctic ice. It uses the Twomey effect to increase cloud reflectivity by spraying submicron drops of filtered sea water into the turbulent marine boundary layer. This will increase the concentration of cloud condensation nuclei to give a larger number of smaller cloud drops for the same liquid water quantity. Doubling the number will increase reflectivity by over 0.05. In clean marine air, spray quantities are surprisingly small.

The paper will describe the design of unmanned, wind-driven spray vessels and a way in which we can get an everywhere-to-everywhere transfer function of side-effects, both good and bad. It will present a calculation of how many spray vessels will be needed.

MAGNITUDE AND POTENTIAL CONSEQUENCE OF MICROBIAL FLUX FROM GREENLAND ICE SHEET

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As the Greenland ice sheet melts, it expels sediments, nutrients and microbiota to downstream environments. In this study we test the hypothesis that these microbial assemblages provide a significant nutritional source to adjoining ecosystems, and that they have the potential to inoculate and inhabit their new surroundings. We investigated the abundance and community composition of bacteria and archaea as they exit the south-western portion of the Greenland ice sheet, and as they flow into a downstream fjord, using 16S rRNA gene sequencing and qPCR approaches. Sediment cores were collected from the fjord and incubated under nutrient amended anoxic conditions to test for methanogenesis and changes in community composition. We estimated that ~1.02 x 10^21 cells were transported from the sampled catchment to the downstream fjord in 2012, equivalent to 30.95 Mg of carbon. Proteobacteria were found to dominate the sequence assemblages, which were likely mostly of subglacial origin. When the release of biomass was considered relative to adjoining periglacial river flux contributors, the majority of cells entering the downstream fjord delta were found to originate from glacial melt. Microcosms were used to investigate the continued legacy of cells once deposited within anoxic delta systems. We found that methane concentrations increased within CO2/H2-amended microcosms, equivalent to production rates of ~4 pmol g−1 d−1, which was likely performed by methanogenic Methanomicrobiales- and Methanosarcinales-related organisms. A surge in the abundance of Desulfosporosinus meridiei related assemblages within CO2/H2-amended incubations was suggestive of the potential for sulphate reducing processes. Cell release from the ice sheet was found to be dependent on discharge, leading us to hypothesize that as melt from the Greenland ice sheet continues to increase as a result of climate change, so too will the release of glacial microbiota to downstream environments. Our results suggest that this will likely have a consequential impact on downstream ecosystems. In summary; studied glacial catchment releases substantial amounts of biomass throughout the melt season, which is transported to adjacent environments where it has the potential to inoculate and biogeochemically influence downstream ecosystems.

ASSESSING THE VIABILITY OF ARCTIC GAS HYDRATE EXPLOTAITION

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Gas hydrates are solid compounds where a molecule of gas is encased in a lattice of ice. Since this gas can be produced using current technology, hydrates have the potential to be a substantial unconventional source of natural gas. For many countries for whom domestic conventional sources of natural gas are limited, hydrates within their exclusive economic zone could provide an important alternative. Currently hydrates are not being commercially exploited, but there is significant interest and investment aiming to make their exploitation economically viable over the next two decades. Hydrate exploitation in the Arctic may be of particular interest, as the cold weather conditions allow hydrate to form onshore beneath existing permafrost, and offshore at relatively shallow water depths (deeper than about 350 m) when compared to lower latitudes. However, proposals for heavy industry in the Arctic are generally contentious, as the environment is relatively undisturbed by human development and at high risk from existing climate change. There appear to be few existing studies exploring whether hydrate exploitation in the Arctic could be appropriate from an economic, environmental and social viewpoint. Before any viable commercial production commences, the potential impacts across society must be considered. This project aims to evaluate the potential of gas hydrate production within the Arctic. We will numerically model several probable hydrate production scenarios on known hydrate reservoirs. The resulting magnitude and rate of gas production predicted will be used in an exhaustive analysis of the potential social, economic and environmental impacts of hydrate exploitation on an area. These impacts will be quantified using existing data and expert judgement to provide a holistic assessment of Arctic gas hydrate exploitation that varied stakeholders can use to make informed decisions. This review presents the preliminary results from this ongoing project. Potential impacts have been established using a DPSIR (Driving forces; Pressures; States; Impacts; Responses) framework. We have focussed on impacts upon: health and wellbeing, land use and access, services and infrastructure, population, employment opportunities, income and lifestyles. We plan to evaluate these impacts using multi-criteria decision analysis (MCDA), as this will allow a mixture of data types and sources to be considered simultaneously. We have also begun to model hydrate-sourced gas production of an existing hydrate reservoir in the North Slope region of Alaska using depressurisation and thermal stimulation. We have hypothesised a potential production regime using information from prior scientific testing of the technique. These modelling results will eventually be incorporated into the MCDA, as well as evaluation of the range of possible environmental impacts. Going forward, a greater selection of sites where hydrate exploitation may occur in future will be explored. These sites have been chosen to provide a representative sample of the Arctic. Overall this is building towards an assessment of to what extent hydrate exploitation can be considered beneficial to a range of different stakeholders.

Oral Abstracts - Session 6

ON THE ROLE OF AMMONIA IN ARCTIC AEROSOL NUCLEATION AND CLOUD FORMATION

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This study investigates the importance of ammonia in Arctic aerosol nucleation and the formation of cloud condensation nuclei (CCN) at high-latitudes. The importance of atmospheric nucleation processes to summertime Arctic aerosol concentration has been frequently noted at ground-stations, during campaigns and within models (which typically predict that the majority of aerosol in the Arctic summertime boundary layer derives from nucleation). However, as nucleation mechanisms in global models have increased in complexity (improving model skill globally) our skill in the Arctic has generally decreased. This decrease in model skill is likely due to a lack of organic compounds (monterpenes etc.) in the modelled high Arctic which have been identified as a key component in atmospheric nucleation in the mid-latitudes and thus incorporated into many global nucleation parametrisations. Recently it has been suggested that ammonia (also identified as a potentially important component in atmospheric nucleation) may control nucleation processes in the Arctic. However, the source (or sources) of Arctic ammonia remain unclear. Here, we use modelling, long-term aerosol in-situ observations, high resolution sea-ice satellite observations and new emission inventories to investigate the link between ammonia sources (including bird colonies, sea-ice melt and open ocean in the marginal ice zones) and nucleation events in the mid-to-high Arctic, and thus quantify the importance of individual ammonia sources to Arctic-wide CCN and cloud droplet populations.

CIRCADIAN TIME-KEEPING IN MARINE ZOOPLANKTON

Last, K. S. [1], Berge, J.[2,3], Brierley, A.[4], Cohen, J.[5], Cottier, F.[1], Daase, M.[2], Dumont, E.[1], Johnsen, G.[3,6], Häfker, N. S.[7,8], Hüppe, L.[8], Hobbs, L.[1,10], Meyer, B.[7,8,9], Pond, W.[1], Soreide, J.[3], Teschke, M.[7], Wilcockson, D.[11]

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In extreme high latitude marine environments that are without perceptible solar illumination in winter, light-mediated patterns of biological activity have historically been considered non-existent. However, recent evidence has shown that diel or lunar vertical migrations (DVM and LVM respectively) of zooplankton frequently occur throughout the Polar Night and are common across the Arctic Ocean. The extent of migrations suggests that the behaviour is highly conserved and adaptive in avoiding visually mediated predation, yet the lack of environmental light, believed to drive migrations, provides us with a paradox. Could there be an alternative cue in extreme light limiting environments? We present tantalising data from behavioural, physiological and genetic studies on the two main Arctic zooplankton groups, copepods and krill, suggesting that the circadian clock provides temporal information in the absence of environmental cues. From rhythms in swimming behaviour to visual sensitivity, respiration and gene expression, multiple lines of evidence suggest endogenous genetic control of diel activity. DVM constitute the largest, by biomass, daily migration on the planet, structuring biogeochemical cycles and spatially influencing higher trophic levels such as fish and mammals. Here we suggest that the circadian clock is, quite possibly, central to this process.

AN ARCTIC OCEAN DOUBLE OVERTURNINNG DIAGNOSED FROM BOUNDARY OBSERVATIONS

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The Arctic Ocean has a significant effect on global ocean circulation because it provides sources of both dense and light waters to the North Atlantic. The processes affecting formation of water masses within the Arctic, however, remain poorly understood because of the sparsity of measurements available for the region. For the first time, we use data derived from quasi-synoptic hydrographic observations across the main Arctic gateways (the Bering Strait, Davis Strait, Fram Strait and Barents Sea Opening) to diagnose water mass transformations in the Arctic interior. We see a double overturning circulation in density space. In the upper cell, around 1.8 Sv of in-flowing Atlantic Water experiences freshening through mixing with fresher Arctic surface waters. The lower cell involves the densification of a further 1.5 Sv of Atlantic Water, which we account for through surface buoyancy fluxes driven by heat loss on the Barents Shelf, calculated from ERA-Interim reanalysis data. Turbulent diffusivities of order 10-5 m2 s-1 are implied by the water mass transformations when averaged over the Arctic Basin. These are an order of magnitude larger than observations of turbulent microstructure made around the Siberian shelf, indicating that other sources and sinks of buoyancy are important.

EVALUATING SPATIOTEMPORAL DIFFERENCES IN METHANE FLUXES ON THE NORTH SLOPE OF ALASKA VIA EDDY COVARIANCE FOOTPRINT MODELLING

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Arctic permafrost soils store 1300-1370 Pg of organic carbon, twice the current atmospheric stock. This region is warming at approximately 1°C per decade, and permafrost soils could lose 381-616 Pg C by 2300, with a large portion potentially being released as the potent greenhouse gas methane (CH4). Despite intensive investigation, uncertainty estimates of CH4 emissions have changed little since the first estimates in 1974. Two main difficulties in creating a baseline flux estimate is the region's remote nature and the high spatiotemporal variability in methane fluxes. This project examines fluxes from three eddy covariance sites in Barrow, Alaska by applying the Kormann and Meixner (2001) footprint model to investigate the spatio-temporal variability. A LiDAR digital elevation model collected by NGEE Artic at a very fine resolution (0.25m) and WorldView2 data have been used to give quantitative metrics for vegetation and microtopographic differences over these three sites. Preliminary results show significant differences (p-value < 0.05) in CH4 emission patterns in the footprints that could bias flux estimates by 20%. Furthermore, the pattern of footprint variability shows divergent spatial patterns between summer and winter fluxes. The largest mean summer fluxes were observed in a low lying sedge-dominated drained lake basin (7.74 mg CH4 m-2 day-1) with the less degraded, more polygonal area having an average flux of (5.82 mg CH4 m-2 day-1). In the winter "zero curtain" period, the pattern reversed with higher fluxes coming from the polygonal area (3.58 mg CH4 m-2 day-1) and slightly lower fluxes (3.35 mg CH4 m-2 day-1) observed from the lake basin. This highlights that flux drivers differ by season and that these dynamics should be considered for estimating annual and regional fluxes.

INVESTIGATING THE RESPONSE OF A POLAR FJORD TO OCEANIC, ATMOSPHERIC AND FRESHWATER CHANGE

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Fjords are critical components of the polar environment, acting to shape and moderate the exchanges between the oceanic and glacial systems. To investigate the response of polar fjords to changing forcing, we use a three-layer box model that simulates restricted exchange to the coastal ocean. The model is coupled to a simple sea ice model and incorporates brine rejection. The impacts of rising ocean temperatures (OTs), surface air temperatures (SATs), and freshwater discharges on fjord dynamics and sea ice processes around Svalbard are investigated. We find that over two decades, rising OTs cause sea ice to decline to zero; rising freshwater discharges, however, do not affect sea ice growth during the same time period but do cause an enhanced estuarine exchange between fjord and shelf. Ocean-to-atmosphere surface heat flux increases with rising OTs, indicating that the loss of sea ice as a result of rising ocean temperature could be driving the recently-observed rising SATs around Svalbard.

Oral abstracts - Session 7

DOES COMPETITION LIMIT THE GROWTH AND CLIMATE SENSITIVITY OF TUNDRA SHRUBS?

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As the Arctic warms, plants grow taller and faster, and colonise places where they could not previously survive. Shrub species are especially responsive and have become more abundant in the tundra over the last half-century. However, the speed and degree of change in tundra plants vary greatly among sites. This could be in part due to local limitations like plant-plant competition for light, water and nutrients. Neighbour removal experiments are a useful method to investigate biotic interactions: increases or decreases in the growth or performance of focal plants after removal indicate competitive or facilitative interactions, respectively. We took advantage of a past canopy removal experiment (2007-2009) to test for the effect of competition on the growth of tundra willows (Salix spp.) in the alpine tundra of the Kluane region (Yukon Territory, Canada). We hypothesised that the removal of above-ground vegetation would result in a release from competition for neighbouring shrubs, leading to greater growth (wider annual growth rings in the woody stems) and higher sensitivity to the regional climate (higher correlations between ring width and summer temperature). Radial growth in focal shrubs did not increase in years following the removal of competitors. The climate sensitivity of growth (correlation between annual growth and monthly climate variables) became slightly stronger in the post-removal period, but these trends were mirrored in control plots, suggesting that all shrubs were likely responding to changing climatic conditions at the site. Overall, we could not find support for a strong effect of biotic interactions in this canopy removal experiment. However, below-ground competition deserves further attention, as most tundra biomass is found beneath the soil surface.

A YEAR IN THE LIFE OF THE MINUTIAE IN A CHANGING ARCTIC OCEAN

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As the global climate changes, the higher latitudes are seen to be warming significantly faster and it is likely - if not already apparent - that the Arctic biome will experience considerable shifts in ice melt season length and permafrost thawing, leading to changes in photoirradiance and in the freshwater and terrigenous inputs to the marine environment. The exchange of nutrients between Arctic surface and deep waters and their biogeochemical cycling throughout the water column is driven by the seasonality of some of the most extreme environmental changes on the planet. The impacts, however, of the current global climate transition period on the biodiversity and its continued nutrient cycling within the Arctic Ocean are not yet known. To determine seasonal variation in the microbial flora and fauna of the deep water column, samples were collected from a 1000m depth profile in the seas around the Western coasts of the Svalbard archipelago throughout the polar year. High-throughput sequencing of tag amplicon and shotgun metagenomes were used to monitor microbial diversity and function in both the epipelagic surface waters (defined by the diametric diurnal conditions of the polar summer and winter) and the relatively invariable and permanently dark mesopelagic depths. In epipelagic surface waters (<200m depth), seasonal diversity varied significantly, with light and the corresponding annual phytoplankton bloom pattern being the primary drivers of change during the late spring and summer months. In the mesopelagic ocean deeps (>200m), seasonality subsequently had much less effect on biodiversity. Interestingly, species richness consistently increased down through the water column, with the deepest darkest waters containing the greatest diversity. The phenomenon of the polar phytoplankton blooms, followed by the successional explosion of heterotrophic bacterial populations, also seemingly spurs the annual disappearance of the ancient and chemolithoautotrophic marine Archaea from surface waters. During the winter darkness, these venerable microbes feast upon the summer fruits of the phytoplankton photosynthesis, replenishing surface waters with nutrients which fuel the next spring bloom, essentially yin to the phytoplankton's yang. However, should suggested models of a freshening Arctic be correct, surface Arctic basin waters in a warming world may become increasingly stratified, such that the vertical flux of nutrients between deeper waters and the epipelagic zone may be much reduced; primary productivity would consequently be lessened and this annual biogeochemical cycle, so essential for Arctic Ocean productivity, would inevitably be disrupted. Given the significance of the annual phytoplankton bloom pattern on prokaryote diversity in Arctic waters, any changes to bloom dynamics resulting from accelerated global warming will likely have major impacts on surface marine microbial communities, those impacts inevitably trickling down into deeper waters...

EXPLORATION OF ARCTIC AND ANTARCTIC SEAWEED BIODIVERSITY IN THE CONTEXT OF POLAR CLIMATE CHANGE

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Polar regions are hotspots of climate change, which inevitably also affects seaweed biodiversity by sea ice recession, increased iceberg scouring, and increased inputs of glacial melt water, all of which can have major impacts on phytobenthic communities. However, any studies of the polar phytobenthos in this context confront major challenges in terms of (1) scarce historic baseline datasets and (2) environmental and logistical constraints for scientific collections, and in situ observations by diving. This paper presents highlights from our expeditions to northern Baffin Island (Canadian Arctic, 2009) and Adelaide Island (Antarctica, 2010-2011) which assessed the biodiversity of seaweeds and associated eukaryotic pathogens at established study sites. Our dataset provides a baseline inventory for future work assessing impacts of the currently ongoing changes in the Arctic and Antarctic marine environment. In both cases, diving surveys and collections of macroscopic algae were complemented by applying the Germling Emergence Method and DNA barcode sequencing of the live isolates obtained from substratum samples.- We present a baseline seaweed species checklist for northern Baffin Island in the Arctic and southern Adelaide Island / northern Marguerite Bay in the Antarctic, respectively, reporting numerous new records of seaweed taxa and associated pathogens. The paper also discusses implications for establishing baseline inventories and managing safe and scientifically productive diving operations in remote polar locations.

CAN WE DETECT CHANGES IN ARCTIC ECOSYSTEMS?

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Due to unprecedented rates of environmental change, the Arctic is now a crucible of multiple concurrent stressors. Understanding how food webs are being reshaped over different spatial and temporal scales in response to these stressors is crucial in addressing the impacts of future change on biodiversity and ecosystem services. Stable isotopes of nitrogen (14N, 15N) and carbon (12C, 13C) have the potential to be important food web tracers due to the isotopic discrimination in 15N by ~ 2-5 per mil (‰) and 13C by <1‰ with each trophic transfer. This approach provides quantitative information on trophic position and food chain length. However, the isotopic signal recorded at each trophic level is sensitive to the 15N and 13C at the base of the food web, termed the 'isoscape'. Particulate organic material (POM) makes up the bulk of the isoscape and is itself underpinned by primary producers, whose 15N and 13C value is controlled by bottom-up factors, specifically (a) the 15N and 13C of the dissolved nutrient and carbon sources, (b) the magnitude of N and C sources and (c) isotope fractionation during N and C phytoplankton assimilation. All are likely to vary in response to environmental change in the Arctic. Determining the inferred trophic position of an Arctic predator, such as pelagic-feeding seals, and food chain length from 15N and 13C tracers could be problematic for two reasons. Firstly, the strong spatio-temporal gradients in the isoscape across the Arctic must be constrained to accurately quantify predator position. Secondly, if predators migrate and forage widely, they are exposed to a variety of isoscapes. For example, the 15N value of nitrate varies by up to 2 to 3‰ between the Atlantic and Pacific inflows, which is equivalent to one trophic position from a food web perspective. Equally, the 13C baseline will lighten due to ongoing uptake of 13C-deplete anthropogenic CO2 and its transport into the Arctic from the Atlantic and Pacific, directly affecting the 13C signal in predators. Indeed, there are many examples of the sensitivity of the 15N and 13C of predators to a changing isoscape. The goal of ARISE, a NERC-funded Changing Arctic Ocean project, is to develop a new framework to detect and attribute changes to Arctic food webs during periods of decadal change. Rather than evaluate an entire ecosystem, the ARISE project will take a specific focus on the base of the food web and two species of pelagic-feeding ice-dependent predators, the harp seal (Pagophilus groenlandicus) and the ringed seal (Phoca hispida), which are excellent 'indicator species' of food web functioning. Due to their wide Arctic distributions, long-range migrations and thus substantial time spent at sea, as well as flexible foraging patterns, these seals are exposed to multiple stressors across the Arctic region and so are excellent candidates for this study. Our goals will be achieved by benchmarking novel food web tracer techniques to the underlying changes in the isoscape and seal foraging behaviour using observational and modelling techniques. We will project will be underpinned by a seasonally resolved, pan-Arctic fieldwork programme as well as access to the best available archive samples of seal teeth, allowing a pan-Arctic, multi-decadal perspective on the impact of environmental change on Arctic foodwebs.

Poster abstracts

List of posters (*In alphabetical order*)

First Name	Surname	Affiliation	Title of abstract
Keechy	Akkerman	Loughborough University	Separating limnological/nutrient supply from regional climatic effects on aquatic production: a paired-lake study in SW Greenland
Tom	Bradwell	University of Stirling	Increased North Atlantic dust deposition linked to Holocene Icelandic glacier fluctuations
Thomas	Brown	Scottish Association for Marine Science	High contributions of sea ice derived carbon in polar bear (Ursus maritimus) tissue
Alison	Cook	Durham University	Multi-decadal frontal change rates of tidewater glaciers in the Canadian Arctic Archipelago
Veronica	Coppolaro	University of Florence/ Alfred Wegener Institute (AWI)	Under-ice topography and sea ice draft measurements with a multibeam sonar mounted on a remotely operated vehicle
Finlo	Cottier	Scottish Association for Marine Science	Arctic Productivity in the Seasonal Ice Zone -Arctic PRIZE
Nick	Cox	NERC Arctic Research Station, British Antarctic Survey	NERC Arctic Research Station
Emma	Dodd	University of Leicester	A Combined Surface Temperature Dataset for the Arctic from MODIS and AVHRR
Anna	Gebruk	University of Edinburgh and LMSU Marine Research Centre, Russia	Revealing food resources of the Atlantic walrus in the Pechora Sea
Sophie	Green	British Geological Survey	International Ocean Discovery Program Expedition 377 Arctic Ocean Paleoceanography
Hannah	Griffith	University of Exeter	An investigation into the relationship between the North Atlantic Oscillation and Arctic temperature changes since 1880.
Calum	Harvey-Scholes	University of Exeter	On reflection: An investigation into the relationship between Northern Hemisphere energy flux and snow cover extent.
Jade	Hatton	University of Bristol	Subglacial weathering controls silicon isotope composition of Greenland Ice Sheet meltwaters
Laura	Hobbs	Scottish Association for Marine Science	The UK Polar Network: representing early career Polar scientists
Georgia	Hole	University of Oxford	Out of the Woods – Driftwood Provenance as a Proxy for Holocene Arctic Sea Ice Dynamics
John	Howe	Scottish Association for Marine Science	AUV observations of tide-water glacial environments, western Svalbard.
Hazel	Jones	University of Manchester	Airborne aerosol and cloud observations from the European Arctic
Elizabeth	Kirk	Nottingham Trent University	Law and Governance in a Dynamic Marine Environment
Daria	Mishina	Webster University of Vienna	ARCTIC TOURIST TAXATION OR ARCTIC CHARITY?

First Name	**Surname**	**Affiliation**	**Title of abstract**
Bhavani	Narayanaswamy	Scottish Association for Marine Science	Arctic PRIZE: - Spatial and temporal changes in the megafaunal community composition in the Barents Sea
David	Pond	Scottish Association for Marine Science	Copepod- Diatom interactions in a changing Arctic(DIAPOD)
Marie	Porter	Scottish Association for Marine Science	Gliders in the seasonal ice zone of the Barents Sea: Initial results and lessons learnt
Clay	Prater	Loughborough University	Effects of locally-derived glacial dust deposition on low nutrient lakes in West Greenland
Kassandra	Reuss-Schmidt	University of Sheffield	Evaluating Spatiotemporal Differences in Methane Fluxes on the North Slope of Alaska via Eddy Covariance Footprint Modelling
Heidi	Sevestre	St Andrews University	Surges of tidewater glaciers initiated at the terminus: observations and mechanisms
Luke	Storrie	University of Southampton / Norwegian Polar Institute	Determining the species assemblage and habitat use of cetaceans in the Svalbard Archipelago, based on recorded observations from 2002-2014
Maud	van Soest	Loughborough University	Biogeochemical impacts of dust deposition on Arctic soils
Cath	Waller	University of Hull	Preliminary biodiversity assessment of West Greenland intertidal habitats
Yuanyuan	Zhang	Beijing Normal University	Error assessment of multi-source satellite-derived sea ice leads products

Abstracts

(In alphabetical order)

SEPARATING LIMNOLOGICAL/NUTRIENT SUPPLY FROM REGIONAL CLIMATIC EFFECTS ON AQUATIC PRODUCTION: A PAIRED-LAKE STUDY IN SW GREENLAND

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Arctic aquatic ecosystems are nutrient-limited and are therefore affected by the recent anthropogenic disruption of biogeochemistry as much as by climatic changes. The impacts of these processes are difficult to predict and separate due to collinearity in external drivers (e.g. climate, nutrients, catchment changes), inherent ecosystem complexity and a wide range of in-lake processes (e.g. thermal stratification, nutrient recycling, species competition) that respond differentially to external forcing. Sediment records can be used to determine natural responses to past climate forcing, but it remains difficult to separate local from regional processes and it is still unclear to what extent climate drives ecological change and production in lakes. Here, we aim to separate local (in-lake, nutrient supply) from regional (climate) controls by using a multi-proxy palaeolimnological paired-lake study, where the two adjacent sites differ in morphometry and lake depth but reflect the same regional climate forcing. The two lakes (SS2, SS1590) are located near Kangerlussuaq in Southwest Greenland, a well-studied, lake-rich region that allows the research to be placed in a wider regional context. A range of proxies from sediment cores covering the last 6500 years were analysed in order to reconstruct shifts in primary producers during key climatic changes (Neoglacial cooling, MCA and Little Ice Age) and were combined with stable isotopes, dust records and independent palaeoclimate data. The two lakes exhibit very similar increases in diatom production associated with Neoglacial cooling (from ~3800 cal yr BP), suggesting that regional nutrient supply was important, but there are differences in diatom community structure between the two lakes. Lake morphometry controlled the lakes' responses to warming during the MCA with increased evaporation and reduced hydrological connectivity; strengthened thermal stratification resulted in unambiguous increases in pigment records of anoxia (purple sulphur bacteria) and associated shifts in chironomid assemblages at the deeper site. This study highlights the complexity of ecological changes over centennial timescales and emphasizes the importance of nutrient supply, limnological controls on community structure and aquatic production rather than direct climate forcing.

INCREASED NORTH ATLANTIC DUST DEPOSITION LINKED TO HOLOCENE ICELANDIC GLACIER FLUCTUATIONS

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There is strong evidence that mineral dust concentrations in the atmosphere fluctuate in sympathy with glacial-interglacial climate, with increased dust deposition occurring during major cold phases (stadials) over the last ~100 ka. Importantly, dust deposition in Polar regions can affect the surface mass balance of snow and ice sheets via a positive feedback between ice albedo and melt rates. On shorter sub-millennial timescales however, the link between atmospheric dust concentrations and ice-sheet fluctuations remains enigmatic. We address this question using sedimentological, geochemical and isotopic analyses of high-resolution peat sequences from northern Scotland – natural terrestrial archives of atmospheric dust and ash. We find a strong temporal association between peaks in minerogenic dust and the timing of Holocene glacier fluctuations in Iceland. A marked peak in increased dust deposition, c. 2.5-3.0 ka BP, in a high-resolution peat core from Caithness occurs against a backdrop of low dust deposition in the preceding and subsequent millennia (i.e. 5.0-3.0 ka and 2.5-1.5 ka BP); whilst a second marked dust peak occurs between 0.5-0.2 ka BP. Similar dust peaks, of different magnitude, are also seen in peat records from sites on Shetland ~200 km to the northeast during the same time intervals centred around c. 2.5-3.0 ka BP and at 0.5-0.2 ka BP – reinforcing this temporal pattern. Sedimentological and geochemical analyses, coupled with previous tephrochronological studies, show that neither of these time intervals relate to specific volcanic events. Instead, we suggest these major dust peaks reflect enhanced availability of silt-sized material sourced from the extensive glacial outwash plains (sandar) of southern Iceland and transported by strong winds during the Neoglacial and Little Ice Age glacier advance-retreat cycles. This work highlights the wider role of dynamic sub-Polar glaciers and their meltwater systems in producing large volumes of iron-rich fine-grained material for aeolian transportation to the high-latitude North Atlantic Ocean and its terrestrial margins.

HIGH CONTRIBUTIONS OF SEA ICE DERIVED CARBON IN POLAR BEAR (URSUS MARITIMUS) TISSUE

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Polar bears (Ursus maritimus) utilise Arctic sea ice as a physical habitat. Consequently, conservation assessments of polar bears identify the ongoing reduction in sea ice to represent a significant threat to their survival. However, the additional role of sea ice as a potential, indirect, source of energy to bears has been overlooked, likely due to the paucity of available data. Here we used the biomarker-based H-Print approach to show that sympagic, rather than pelagic, carbon contributions dominated the marine component of polar bear diet (72-100%; 99% CI, n = 55), irrespective of differences in diet composition, as estimated by quantitative fatty acid signature analysis. The lowest mean estimates of sympagic carbon were found in Baffin Bay bears, which were also exposed to the most rapidly increasing open water season. For future ecosystems characterised by less sea ice, polar bears will not only lose some of their physical habitat, but our data suggest that they will likely also need to adapt to changes in energy sources.

MULTI-DECADAL FRONTAL CHANGE RATES OF TIDEWATER GLACIERS IN THE CANADIAN ARCTIC ARCHIPELAGO

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Recent studies of post-2000 observational data have shown variability in the dynamic ice discharge of tidewater glaciers throughout the Canadian Arctic Archipelago (CAA). Expanding this to all tidewater glaciers in the region on a decadal time scale using earlier records can help identify when glacier retreat began, and determine longer-term temporal trends in mass balance.Our study shows that over 94% of 300 tidewater glaciers in the CAA (from southern Baffin Island to Ellesmere Island, excluding those on the northern coast) have retreated since the earliest observational records (aerial photographs acquired in 1958-1960). Mean overall length change rate of the 211 glaciers in the Queen Elizabeth Islands (QEI) is -9.3 ma-1 (± 1.38 SE), and of the 89 glaciers on Baffin and Bylot Islands (BBI) is -7.1 ma-1 (± 0.72 SE). Mean frontal widths of tidewater glaciers in the QEI are greater than those on islands to the south, resulting in greater mean area loss from this region. Each glacier has ~6 frontal positions digitised from a range of image sources at approximately decadal intervals. Length change rates have been calculated across each time interval for each glacier, and results indicate a similar temporal pattern throughout the region, whereby glaciers show minimal change in early years with retreat rates slowly increasing, followed by acceleration in retreat rates since the early 2000s. A similar trend (at differing magnitudes) has been observed within each latitudinal degree band, and for glaciers of differing frontal widths. Further observations of glacier changes and spatial and temporal correlations with ocean temperatures are shown on the poster.

UNDER-ICE TOPOGRAPHY AND SEA ICE DRAFT MEASUREMENTS WITH A MULTIBEAM SONAR MOUNTED ON A REMOTELY OPERATED VEHICLE

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Sea ice plays a major role in the Arctic climate as it represents the interface between the arctic ocean and the atmosphere but it is also important for the whole global energy budget. Climate change has caused a drastic rise in air temperature during the last decades that has led to a rapid sea ice decline. Until now, sea ice retreat and thinning is underestimated and poorly represented by climate models because many processes are not yet well understood. Further observations of sea ice thickness and extent are required in order to understand the key processes that lead to sea ice transformations in both space and time. In this project the sea ice thickness of three different areas northeast of the Svalbard archipelago is investigated during the freeze-up period of September and October 2016. In this pilot project, sea ice draft measurements are conducted using an upward-looking multibeam sonar and a pressure sensor mounted on a remotely operated vehicle for under ice surveys. The data collected are processed using the hydrographic processing system "CARIS Hips"; a new processing flow has been developed to analyse the data collected by the upward-looking sonar and the pressure sensor in order to directly compute sea ice draft. Three-dimensional topographic images of the underside of the sea ice are produced together with the respective sea ice thickness maps. Also, the sea ice thickness dataset obtained from the sonar system is compared to the sea ice thickness data collected during the same surveys by an electromagnetic induction sounding based instrument. Finally, the "Freezing-degree days" model is used to assess sea ice thermodynamical growth on the data collected during the field campaign. Snow cover is taken into account in the model thanks to snow depth measurements conducted on the areas with a Magna Probe. It is found that the two instruments for measuring sea ice thickness give similar sea ice distributions and have the same vertical resolution. However, the multibeam sonar gives a better lateral resolution and it is more accurate than the electromagnetic system when measuring sea ice ridges. The assessment of sea ice thermodynamical growth is hindered by the high spatial variability of the three areas of this campaign, but the model predictions are found to be consistent with the formation of a few centimeters of new ice from open water during a survey period of four weeks. This work also suggests some improvements to the navigation of the underwater vehicle and to the script for sea ice draft calculation from multibeam sonar data. The results of this project prove that the new processing flow implemented in CARIS Hips allows for a reliable, efficient, and high resolution retrieval of sea ice draft measurements collected by an upward-looking sonar mounted on a remotely operated vehicle. The methods presented in this project can be adopted for a future year-round spatial and temporal study, necessary to fill the existing data gap during winter time in the Arctic. The use of the multibeam sonar together with the many interdisciplinary sensors mounted on the remotely operated vehicle can allow for a complete overview of the sea ice underside environment and contribute to the improvement of climate models.

ARCTIC PRODUCTIVITY IN THE SEASONAL ICE ZONE – ARCTIC PRIZE

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Arctic PRIZE is a £2.5 million project funded through the UK Natural Environment Research Council. It is a project within the NERC Changing Arctic Ocean Program that aims to understand how change in the physical environment (ice and ocean) will affect the large-scale ecosystem structure and biogeochemical functioning of the Arctic Ocean. Arctic PRIZE will run from 2017 to 2021 and focus its field campaigns in the Barents Sea, particularly focussing on processes and conditions that evolve in the seasonal ice zone. We will investigate the seasonally and spatially varying relationship between sea ice, water column structure, light, nutrients and productivity and the roles they play in structuring energy transfer to pelagic zooplankton and benthic megafauna. Arctic PRIZE will utilise robotics technologies (specifically ocean gliders and autonomous underwater vehicles) to target the critically important but under-sampled seasonal transition from winter into the post-bloom summer period. The project will also develop the predictive tools necessary to assess how the Arctic ecosystems will respond to a reducing sea ice cover. This will be achieved through a combined experimental/modelling programme. The project is embedded within international Arctic networks based in Norway and Canada and coordinated with ongoing US projects in the Pacific Arctic. A key objective of Arctic PRIZE is the forging of lasting engagement with the international Arctic research community. In particular, Arctic PRIZE is committed to the development of the next generation of Arctic researchers.

A COMBINED SURFACE TEMPERATURE DATASET FOR THE ARCTIC FROM MODIS AND AVHRR

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Surface Temperature (ST) changes in the Polar Regions are predicted to be more rapid than either global averages or responses in lower latitudes. Observations of STs and other changes associated with climate change increasingly confirm these predictions in the Arctic. Furthermore, recent high profile events of anomalously warm temperatures have increased interest in Arctic surface temperatures. It is, therefore, particularly important to monitor Arctic climate change. Satellites are particularly relevant to observations of Polar Regions as they are well-served by low-Earth orbiting satellites. Whilst clouds often cause problems for satellite observations of the surface, in situ observations of STs are much sparser. Previous work at the University of Leicester has produced a combined land, ocean and ice ST dataset for the Arctic using ATSR data (AAST) which covers the period 1995 to 2012. In order to facilitate investigation of more recent changes in the Arctic (2010 to 2016) we have produced another combined surface temperature dataset using MODIS and AVHRR; the Metop-A AVHRR and MODIS Arctic Surface Temperature dataset (AMAST). The method of cloud-clearing, use of auxiliary data for ice classification and the ST retrievals used for each surface-type in AMAST will be described. AAST and AMAST were compared in the time period common to both datasets. We will provide results from this intercomparison, as well as an assessment of the impact of utilising data from wide and narrow swath sensors. Time series of ST anomalies over the Arctic region produced from AMAST will be presented.

REVEALING FOOD RESOURCES OF THE ATLANTIC WALRUS (ODOBENUS ROSMARUS ROSMARUS) IN THE PECHORA SEA

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The Pechora Sea (SE Barents Sea) has a unique ecosystem, which is assured by the limnetic influence of the continental runoff as well as mixing of three different water masses of the Arctic and Atlantic Ocean origins. The marine ecosystem of the Pechora Sea is currently facing the growing anthropogenic pressure, caused by the offshore oil exploration, shipping and fishery. The Atlantic walrus (Odobenus rosmarus rosmarus) is an indicator species, sensitive to the health of the regional ecosystem. The trophic niche of walruses is primarily benthic infaunal bivalve molluscs, however regional diet peculiarities exist. The diet of walrus in the Pechora Sea has never been studied in detail and remains largely unknown. To assess the food resources of the Atlantic walrus in the Pechors Sea, 20 marine stations were studied in the area of walrus settlements by the Vaigach island. Seventy-three bottom grab samples of macrobenthic invertebrates were analysed as well as 16 ROV video recording and one faecal sample. One hundred ninety taxa of macrobenthic invertebrates identified in the samples. Five model maps were developed to represent the distribution of the substrates, macrobenthic biomass, abundance, types of assemblages and characterise the food resources of the walruses in the study area.

Project stages and key objectives: 1. Conducting field work (RV Kartesh, July 2016) to collect data including grab samples of macrobenthic invertebrates and ROV video recordings; 2. Assessing the composition of the benthic assemblages in the near-shore areas of the Pechora Sea where populations of walrus occur based on remote sensing and observation literature data, including invertebrate abundance, biomass, diversity and species composition; 3. Revealing food resources of the Atlantic walrus by identifying which of invertebrates have potentially important prey items and comparing to the data to local walruses' faecal content; 4. Determining whether the area contains enough food resources to sustain the population observed based on literature review of the food energy use of walruses; 5. Mapping the spatial distribution of benthic invertebrates identifying feeding resources.

Key outcomes: Macrobenthic assemblages The list of dominant species (based on the Q parameter) varies for each station, as a complex however, local macrobenthic fauna corresponds to the assemblage of bivalves Astartidae, Cardiidae with variable subdominants. The mosaic distribution pattern of macrobenthic assemblages is also mentioned in the literature (Dahle et al., 1998; Denisenko et al., 2003) and assured by the mosaic pattern of the substrate distribution shown by the ROV data. Statistical analysis of the samples showed two clusters of the stations: (1) stations that are rich in biomass (largely formed by massive bivalve molluscs) but depressed in biodiversity; (2) stations that are barren in terms of foraging recourses - reduced in average biomass, but diverse in the number of species (mostly represented by relatively small polychaetes). Foraging resources of the walruses in the research area are mainly formed by the massive bivalve molluscs, the most important are Astarte borealis, Ciliatocardium ciliatum, Nicania montagui. Interestingly, three other bivalve species are known from literature to make up the bulk of walrus diet: Mya truncata, Hiatella arctica and Serripes groenlandicus. The average biomass of the food resources in the study area is 139 ± 38 g/m2. The reachest in terms of macrobenthic biomass zone of the study area reaches the biomass value of 500 g/m2. Noticeable, the feeding ground of walruses lies beyond the protected area that the Vaigach island corresponds to. The estimate of the forage reserve amounts to 3 395 000 kg for the study area, which gives 85 of days of feeding for the population of 1000 individuals and 424 days for the population of 200 individuals. That is clearly not enough to sustain the growing population observed in the area. Three main hypotheses were formulated: (1) the water area by the Vaigach island is not main and the only feeding ground for the population observed, (2) the significant contribution to the foraging recourses is given by the species unavailable for grab sampling. Bivalve species Mya truncata and Mytilus edulis could serve as the additional food resources (Sukhotin et al., 2008, own data) as well as crustaceans noticed on the ROV video recordings, (3) the daily intake known from literature is significantly overestimated.

INTERNATIONAL OCEAN DISCOVERY PROGRAM EXPEDITION 377 ARCTIC OCEAN PALEOCEANOGRAPHY

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Paleoceanography prior to 2004, geological sampling in the Arctic Ocean was mainly restricted to near-surface Quaternary sediments. Therefore, the long-term Pre-Quaternary geological history remained poorly known. With the successful completion of the Arctic Coring Expedition - ACEX (IODP Expedition 302) in 2004, a new era in Arctic research began. Employing a novel multi-vessel approach, this first Mission Specific Platform (MSP) expedition of IODP, proved that drilling in permanently ice-covered regions is possible. During ACEX, 428 meters of Quaternary, Neogene, Paleogene and Campanian sediment on Lomonosov Ridge were penetrated, providing unique, new insights into the Cenozoic Arctic paleoceanographic and climatic history. While highly successful, the ACEX record had three important limitations. Based on the original age model, the ACEX sequence contains a large hiatus spanning the time interval from late Eocene to middle Miocene, i.e., 44.4 to 18.2 Ma. This is a critical time interval, as it spans the time when prominent changes in global climate took place during the transition from the early Cenozoic Greenhouse world to the late Cenozoic Icehouse world. Furthermore, generally limited recovery during ACEX prevented detailed and continuous reconstruction of Cenozoic climate history. Finally, a higher-resolution reconstruction of Arctic rapid climate change during Neogene to Pleistocene times, could not be reached during ACEX in 2004. In order to address these questions IODP Expedition 377 Arctic Paleoceanography (ArcOP) will return to the Lomonosov Ridge for a second MSP in 2018 to address these major gaps in our knowledge on Arctic Ocean paleoenvironmental history through Cenozoic times, and its relationship to the global climate history. The overall goal of the proposed drilling campaign is the recovery of a complete stratigraphic sedimentary record on the southern Lomonosov Ridge to meet our highest priority paleoceanographic objective, the continuous long-term Cenozoic climate history of the central Arctic Ocean. Furthermore, sedimentation rates two to four times higher than those of ACEX permit higher-resolution studies of Arctic climate change in the Pleistocene and Neogene. This poster will detail the key goals of the expedition and the planned strategy for achieving them.

AN INVESTIGATION INTO THE RELATIONSHIP BETWEEN THE NORTH ATLANTIC OSCILLATION AND ARCTIC TEMPERATURE CHANGES SINCE 1880.

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Anthropogenic radiative forcing has played a dominant role in climate changes since the 1970s. However, the relative influence of anthropogenic forcing and natural variability is not yet fully understood. Climate change since the 1970s has occurred during a period of time when the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO) have shown pronounced multidecadal variations. Hence, I study the role of variations in the NAO/AO on Arctic temperature changes since 1880. The extent to which changes in Arctic temperatures since 1970 can be attributed to corresponding variations in the NAO/AO will also be studied. NAO/AO Indices and Arctic station temperature data will be analysed using R program. Multiple datasets will be used to provide a comprehensive and novel approach to address my research question. My findings will address the knowledge gap in our understanding of how the NAO/AO has changed since 1880 with Arctic temperatures, with specific focus post-1970, and finally, if and how the NAO/AO has changed since 1970 with respect to anthropogenic climate change. This study will address one of the most urgent challenges at present (IPCC, 2013) by advancing understanding of the relationship between increasing temperature trends in the Arctic as a result of the anthropogenic rise in greenhouse gas concentrations and NAO/AO change. Ultimately, if increases in Arctic temperatures since 1970 cannot be explained by variations in the NAO/AO, then this follows the current scientific consensus that suggests that climate change since at least 1970 is predominantly, if not solely, human-induced.

ON REFLECTION: AN INVESTIGATION INTO THE RELATIONSHIP BETWEEN NORTHERN HEMISPHERE ENERGY FLUX AND SNOW COVER EXTENT.

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This study investigates the relationship between the shortwave energy flux in the Northern Hemisphere and terrestrial snow cover extent, examining the power of associated albedo feedback effects. The primary questions are: to what extent has the flux in short wave solar radiation changed due to snow cover extent? and, what is the magnitude of the snow-albedo effect? At a global level, the energy imbalance resulting from the enhanced greenhouse effect is strongest in the North Pole, largely due to a collection of powerful local feedback effects. Amongst the most powerful of these is surface (snow/ice) albedo feedback (Serreze & Barry, 2011, Global Planet Change). As snow and ice recede, darker surfaces which more readily absorb shortwave solar radiation are exposed which enhances the warming and melts more snow and ice. In the case of sea ice, the evidence suggests that since 1978 the ice-albedo feedback effect has resulted in warming equivalent to the effect of 25% of greenhouse gas emissions in that time (Pistone et al., 2014, PNAS). These changes are impacting climate, ecological and human systems around the globe. This study takes advantage of data from two remote sensing programmes: energy flux data from CERES and snow cover extent data is based on the NOAA snow climate data record. We examined these two datasets to understand the relationship between snow cover extent and energy flux, and also investigated other variables influencing the energy flux. Based on the nature of this relationship and a measurement of the change in energy flux, we estimated the magnitude of the snow-albedo feedback effect.

SUBGLACIAL WEATHERING CONTROLS SILICON ISOTOPE COMPOSITION OF GREENLAND ICE SHEET MELTWATERS

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Subglacial weathering plays a key role in global silicate weathering budgets, contributing to the cycling of silicon (Si) in terrestrial and marine systems and the drawdown of carbon dioxide from the atmosphere. Here, we present data from two Greenland glacial catchments of differing size (Leverett Glacier and Kiattuut Sermiat) to demonstrate how Si isotopes from dissolved and amorphous solid fractions (δ30DSi and δ30ASi respectively) can be used together with major ion data to assess the degree of secondary silicate weathering product formation and redissolution in subglacial environments.Both catchments have δ30DSi values lower than average riverine values (Kiattuut Sermiat 0.41‰, Leverett Glacier -0.25‰) and show a seasonal decline, which is more pronounced at Leverett Glacier. The δ30ASi values are also lighter than the bedrock (mean values KS -0.18±0.12‰, LG 0.00±0.07‰) in both catchments, indicating a secondary weathering origin. Subglacial waters from Leverett Glacier have elevated Na+ and K+ ions, indicating a dominance of silicate weathering, whilst meltwaters from Kiattuut Sermiat are dominated by carbonate hydrolysis throughout the melt season.By combining analysis of major ions ratios with silicon isotope compositions we find that differences in subglacial hydrology due to catchment size result in differing subglacial weathering regimes; subglacial waters under larger catchments have longer residence times so undergo enhanced silicate weathering and redissolution of secondary weathering products. We conclude that differing weathering regimes and subglacial hydrology between catchments need to be considered when estimating δ30Si exported into polar oceans.

THE UK POLAR NETWORK: REPRESENTING EARLY CAREER POLAR SCIENTISTS

Hobbs, L., UK Polar Network members

UK Polar Network

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The UK Polar Network was established in April 2007 as part of the 2007 – 2009 International Polar Year. We are the UK branch of the Association of Polar Early Career Scientists (APECS) and currently have over 600 members, from aspiring undergraduates to Masters and PhD students, postdoctoral researchers, and recent faculty appointees. We have three key aims. Firstly, career development - we organise workshops and mentor panels for early career scientists throughout the UK. Recent events include a Project Management workshop hosted in collaboration with the Challenger Society at both NOC Southampton and BAS. Secondly, education and outreach. This includes school visits, arranging for flags designed by schools to be sent to Antarctica each year as part of the Antarctica Day celebrations, and running events at museums, science centres, and science festivals. Our final aim is to provide early career support through a mailing list and social media to advertise opportunities and facilitate networking within the early career community both physically and online. The UK Polar Network has now been running for ten years, making it one of the oldest APECS national committees. In the upcoming year, we intend to continue our efforts to support early career scientists and would welcome new members to the committee to assist us in fulfilling our aims. Please visit our poster to find out more about our events or how you can be involved.

OUT OF THE WOODS – DRIFTWOOD PROVENANCE AS A PROXY FOR HOLOCENE ARCTIC SEA ICE DYNAMICS

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The collation of over 900 driftwood samples from across the western Arctic with spatiotemporal distribution and available provenance data has enabled the production of a high-resolution proxy-based reconstruction of Holocene Arctic Ocean surface current and sea ice dynamics. Although regionally-bounded, driftwood-based sea ice reconstruction studies suggest spatiotemporally complex past Arctic sea ice extent and movement, a large-scale compilation of Holocene Arctic driftwood had not previously been developed. Sparse driftwood in the Early Holocene (≥8.2 cal. ka BP) deglacial period was followed by increased driftwood deposition in the warmer Mid-Holocene (8.2 - 4.2 cal. ka BP); characterised by an enhanced Transpolar Drift (TPD) c.7 cal. ka BP, leading to sea ice loss through the Fram Strait. Driftwood incursion peaks show spatial E-W progression from the Eurasian Archipelagos to Greenland and the Canadian Arctic Archipelago, suggesting a progressive shift in the orientation of the TPD on centennial-millennial timescales and intermediate phases in the Arctic Oscillation. Late Holocene cooling (≤4.2 cal. ka BP) is indicated by increased influx of Picea (likely from North American) via a strengthened Beaufort Gyre (BG) which enhanced sea ice recirculation, starting in the Western Arctic and progressing eastwards. In recent millennia (<2 cal. ka BP), a more variable driftwood record alternates between BG and TPD dominance on centennial timescales. To further constrain a spatiotemporal reconstruction of variations in Holocene ocean current and sea ice dynamics, a more definitive determination of driftwood provenance is currently being built upon the current framework through radiogenic isotope tracing.

AUV OBSERVATIONS OF TIDE-WATER GLACIAL ENVIRONMENTS, WESTERN SVALBARD

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The Arctic will probably experience the most severe environmental change on Earth with an estimated annual average warming of 4 – 8°C degrees. The fjord systems of western Svalbard are highly sensitive to the present warming and are therefore very vulnerable to change. These 'natural Arctic laboratories', are influenced by both temperate Atlantic water advected from the West Spitsbergen Current as well as atmospheric input from North America, Europe and Asia. Furthermore, marine terminating glaciers locally influence many Svalbard fjords . Thus, Svalbard is an important site for investigations of polar marine environmental and climate change. The distribution and movement of glacier fronts in the Krossfjorden-Kongsfjorden region has previously been mapped using surface vessels, yet the innermost part of these fjords and the glacier front environments have not been subject to detailed bathymetric surveys. In this study, the seafloor from the inner part of a glacially-influenced fjord in Krossfjorden, the Fjortende juli bukta (the 'Fourth of July' bay), and the adjacent to the tide water Fjortende juli breen glacial front, has been mapped using an autonomous underwater vehicle (AUV) equipped with a swath sonar system, providing very high-resolution bathymetry, side-scan data and the seabed photography to document the seabed geomorphology, sediment type and benthic habitat. Preliminary bathymetric, photographic and side-scan data suggests sedimentation from subglacial meltwater dominates the ice-proximal zone whilst settling from suspension is more prevalent away from the glacier. Seabed photographs from the AUV reveal a fine-grained depositional environment with fine-grain sediments and intense bioturbation with a limited benthic species diversity. Glaciomarine systems are characterized by a dynamic climatically controlled environment and the use of autonomous and robotic vehicles can greatly aid in the monitoring of change by collecting high-resolution datasets where vessel based observations are lacking.

AIRBORNE AEROSOL AND CLOUD OBSERVATIONS FROM THE EUROPEAN ARCTIC

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The Aerosol-Cloud Coupling and Climate Interaction in the Arctic (ACCACIA) project was a NERC funded project to investigate the role of aerosols and clouds in the Arctic Climate system. The project was split into two time periods: March/April 2013 and July 2013 to enable comparison of data from different seasons. The British Antarctic Survey's MASIN Twin Otter was based at Longyearbyen, Svalbard for both campaigns. The aircraft is fitted with instruments that allow all standard meteorological parameters to be reported along with external cloud microphysics probes (CAPS-DPOL, CDP and 2DS) that provide size segregated number concentration and cloud particle habit information. Eight science flights were performed as part of the summer campaign. Flights to the north of Svalbard typically sampled mixed-phase stratocumulus layer cloud; sometimes single layer whilst for other flights was multilayer. Ice habits for these clouds were found to be primarily columns, though irregular ice was also seen and large stellar plates were seen on occasion. For these flights, the ice was found to be in patchy locations with quick transitions between phases. There was strong evidence that secondary ice particle production processes were operating in these regions. Other flights saw liquid-only clouds, where cloud droplets reached larger sizes leading to liquid precipitation. For flights that included sampling of a layer from over the Arctic sea ice to over open sea, a lifting and deepening of the cloud later was noted for several cases. We will present an overview of the summer aerosol and cloud data, and compare to previously published data from the spring campaign where cloud temperatures were colder. These clouds consisted of mostly super cooled water without the patchy glaciation observed in the summer, with little evidence of secondary ice processes.

LAW AND GOVERNANCE IN A DYNAMIC MARINE ENVIRONMENT

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As the Arctic Ocean becomes more and more ice free the oil companies, fishing industry and shipping industries operating in the Artic are and will grow in number and size. Their expansion signals threats to the marine environment from pollution to invasive species. It also gives rise to the possibility of increasing competition between the various uses and users, including traditional and local communities. Law tends to respond to problems after they arise, yet the Arctic also shows a governance system rapidly developing and responding to issues, sometimes on a precautionary basis. These responses are arising despite the lack of an obvious hierarchy of governance institutions in the marine Arctic.

This presentation will illustrate the mechanisms that enable this apparently weak and under developed governance system to both grow and take precautionary actions. In so doing it will draw out areas where further work is required to strengthen the existing laws and governance systems.

ARCTIC TOURIST TAXATION OR ARCTIC CHARITY

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The purpose of this article is to introduce a new Arctic tourism-approach: Arctic tourist taxation. In contrast to other studies, I consider whether business (especially expensive Arctic tourism) can be connected to the direct Arctic development by taxation and charity. Specifically, I focus on the needed changes in understanding Arctic tourism in general. Tourist operators and tourists need to avoid consumer attitude and need to follow the "The Golden Rule". Under the "Arctic tourism"; I analyze Arctic territories (High-Arctic, Low-Arctic and sub-Arctic territories).Using qualitative method of analysis, I find evidence of possibility to manage a "Arctic tourist taxation" as a new program of the Arctic Council or "Arctic Charity" as an independent NGO. The Arctic region has many different problems with infrastructure, education of people in the Arctic, territorial, social, and health development. Thus, I demonstrate that every Arctic tourist is able to take part in the further Arctic development.

Keywords: international tourism, taxation, charity, indigenous people, Arctic tourism.

ARCTIC PRIZE: - SPATIAL AND TEMPORAL CHANGES IN THE MEGAFAUNAL COMMUNITY COMPOSITION IN THE BARENTS SEA

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Investigating the spatial and temporal changes in the megafaunal benthic community composition at ~200 m in the Barents Sea in relation to variations in surface productivity is being addressed through WP5 of the Arctic PRIZE project. These larger benthic organisms play a number of important roles including, amongst others: nutrient sources for other organisms, substrates for a variety of other fauna, and re-distribution and re-mineralisation of organic carbon reaching the seabed. However, the functional roles of many of these megafauna are still not yet well understood. Recent studies have highlighted the importance of understanding the impact of abiotic factors on benthic communities to ascertain the influence of climatic change on the fauna, yet there have been very few studies investigating how abiotic factors impact these megafaunal communities. For example, Morata et al. looked at the response of the benthic community to different food inputs and found a dependence on early supply of food in order to function e.g. reproduction. Changes made to this input either in timing, quantity or quality may have a major impact on the functioning and resilience of the benthic community.Our objectives are: 1)To Detect spatial changes in benthic epifaunal community composition, moving from a permanently ice free region through to predominantly ice covered.2)To resolve seasonal temporal changes in the benthic mobile faunal community in response to inputs (sympagic and pelagic) of organic material to the seafloor from ice-covered to ice-free periods.To address these objectives we will use the Gavia Offshore Surveyor along set transects in the Barents Sea. Where possible the AUV will be flown over the same/similar sediment types and at the same depth boundary. In addition a time-lapse camera will be deployed in Rijpfjorden to detect the response of the mobile fauna to changes in fluxes of organic material reaching the seafloor. By combining the results across the different Arctic-PRIZE work-packages, we aim to identify significant impacts on benthic megafauna distributions as a consequence of ice retreat (seasonal and multi-year time scales) and to observe timing of biological responses to determine effective export rates to the sea bed.

COPEPOD-DIATOM INTERACTIONS IN A CHANGING ARCTIC (DIAPOD)

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Copepod species of the genus Calanus (Calanus hereafter) are rice grain-sized crustaceans, distant relatives of crabs and lobsters, that occur throughout the Arctic Ocean consuming enormous quantities of microscopic algae (phytoplankton). These tiny animals represent the primary food source for many Arctic fish, seabirds and whales. During early spring they gorge on extensive seasonal blooms of diatoms, fat-rich phytoplankton that proliferate both beneath the sea ice and in the open ocean. This allows Calanus to rapidly obtain sufficient fat to survive during the many months of food scarcity during the Arctic winter. Diatoms also produce one of the main marine omega-3 polyunsaturated fatty acids that Calanus require to successfully survive and reproduce in the frozen Arctic waters. Calanus seasonally migrate into deeper waters to save energy and reduce their losses to predation in an overwintering process called diapause that is fuelled entirely by carbon-rich fat (lipids). This vertical 'lipid pump' transfers vast quantities of carbon into the ocean's interior and ultimately represents the draw-down of atmospheric carbon dioxide (CO2), an important process within the global carbon cycle. Continued global warming throughout the 21st century is expected to exert a strong influence on the timing, magnitude and spatial distribution of diatom productivity in the Arctic Ocean. Little is known about how Calanus will respond to these changes, making it difficult to understand how the wider Arctic ecosystem and its biogeochemistry will be affected by climate change. The overarching goal of DIAPOD is to develop a predictive understanding of how Calanus in the Arctic will be affected by future climate change.

GLIDERS IN THE SEASONAL ICE ZONE OF THE BARENTS SEA: INITIAL RESULTS AND LESSONS LEARNT

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Seasonally resolved observations of the Arctic shelf seas are challenging to acquire due to ice and access. Nevertheless, preconditioning of the water from winter time through to spring prior to the onset of the spring bloom is an important, yet poorly understood evolution. Robotic platforms, particularly gliders, offer a means of acquiring such data. In July and August 2017 we planned a two week glider mission in the Barents Sea. This is one of the first glider missions in this location and it is a precursor to a large (6 gliders, 5 months) winter to summer mission in 2018 as part of the NERC Changing Arctic Ocean program.

Using this short glider mission we will not only gather high resolution hydrographic, light and ocean colour data but will gain insights into the environmental conditions that may be experienced by the glider during the longer deployments. We will test the glider in the unknown currents and extreme buoyancy conditions that are found near to melting sea ice. Consequently we will be able to plan and adapt the strategy for the 2018 mission to best utilise the conditions apparent in the Barents Sea.

Here we will show data from this early glider transect, highlighting the distribution of the water masses along the transect from the open shelf towards the marginal ice zone. Additionally we will use the high resolution data to define the mixed layer depth as it changes with distance from the ice edge, which when combined with light and colour data collected by the glider will help to inform nutrient uptake studies.

Here we show this novel data and describe the successes and difficulties of glider operations within the Barents Sea.

EFFECTS OF LOCALLY-DERIVED GLACIAL DUST DEPOSITION ON LOW NUTRIENT LAKES IN WEST GREENLAND

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Climate change is rapidly altering ecosystems worldwide with some of the clearest effects occurring in the Arctic. Glacial melting in these areas resulting from elevated temperatures can increase runoff of glacio-fluvially produced silt into periglacial environments. Some of this material is rapidly carried out to the sea through rivers, but a significant portion is deposited onto glacial outwash plains where lighter particles are deflated and subsequently transported and deposited onto adjacent areas through aeolian processes. This dust, which contains both macro- and trace-elements, thus represents a potentially important cross-system subsidy for downwind ecosystems such as lakes. Terrestrially-derived nutrients can influence elemental cycling and biological productivity in aquatic environments. However, while most previous work has focused on nutrient delivery via hydrological inputs, the effects of atmospheric dry deposition on lake ecosystems remain comparatively understudied. High-latitude lakes could be predicted to be especially sensitive to dust inputs as primary production in these environments is typically nutrient-limited. As lakes are numerous in glaciated environments and serve as hot-spots of biological activity and carbon-burial, it is important to understand how nutrient deposition may affect lake ecosystem function and community structure. This paper highlights a recently initiated multidisciplinary project characterizing aeolian inputs and examining their effects on water chemistry and microbial production in oligotrophic lakes in West Greenland located adjacent to the present ice sheet margin and which span a range of dust loadings. Data of dust elemental leaching rates along with lake nutrient concentrations are presented to characterize the effect of differences in dust deposition across the study lakes. Future work including physical and chemical dust characterization, microbial bioassays and paleolimnology will address the overall study objective of better understanding the role of aeolian processes in cross-system nutrient transport and its effects on lake ecosystems in arctic environments.

EVALUATING SPATIOTEMPORAL DIFFERENCES IN METHANE FLUXES ON THE NORTH SLOPE OF ALASKA VIA EDDY COVARIANCE FOORPRINT MODELLING

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Arctic permafrost soils store 1300-1370 Pg of organic carbon, twice the current atmospheric stock. This region is warming at approximately 1°C per decade, and permafrost soils could lose 381-616 Pg C by 2300, with a large portion potentially being released as the potent greenhouse gas methane (CH4). Despite intensive investigation, uncertainty estimates of CH4 emissions have changed little since the first estimates in 1974. Two main difficulties in creating a baseline flux estimate is the region's remote nature and the high spatiotemporal variability in methane fluxes. This project examines fluxes from three eddy covariance sites in Barrow, Alaska by applying the Kormann and Meixner (2001) footprint model to investigate the spatio-temporal variability. A LiDAR digital elevation model collected by NGEE Artic at a very fine resolution (0.25m) and WorldView2 data have been used to give quantitative metrics for vegetation and microtopographic differences over these three sites. Preliminary results show significant differences (p-value < 0.05) in CH4 emission patterns in the footprints that could bias flux estimates by 20%. Furthermore, the pattern of footprint variability shows divergent spatial patterns between summer and winter fluxes. The largest mean summer fluxes were observed in a low lying sedge-dominated drained lake basin (7.74 mg CH4 m-2 day-1) with the less degraded, more polygonal area having an average flux of (5.82 mg CH4 m-2 day-1). In the winter "zero curtain" period, the pattern reversed with higher fluxes coming from the polygonal area (3.58 mg CH4 m-2 day-1) and slightly lower fluxes (3.35 mg CH4 m-2 day-1) observed from the lake basin. This highlights that flux drivers differ by season and that these dynamics should be considered for estimating annual and regional fluxes.

SURGES OF TIDEWATER GLACIERS INITIATED AT THE TERMINUS: OBSERVATIONS AND MECHANISMS

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There have been numerous reports that surges of tidewater glaciers in Svalbard were initiated at the terminus and propagated up-glacier, in contrast with downglacier-propagating surges of land-terminating glaciers. Most of the tidewater glacier surges were poorly documented, however, and the cause of this anomalous behavior was unknown. In this study we present detailed data on the recent surges of Aavatsmarkbreen and Wahlenbergbreen, two tidewater glaciers in western Spitsbergen. High-resolution time-series of glacier velocities and evolution of surface crevasse patterns clearly show that both surges propagated up-glacier in a series of abrupt steps. Prior to the surges, the glaciers underwent strong retreat and significant steepening of their terminal zones, and in the case of Aavatsmarkbreen this can be shown to have caused a doubling of driving stress between 1990 and surge onset in 2013. We conclude that the surges developed in response to two distinct processes. 1) During the late quiescent phase, the terminal zones underwent gradual acceleration due to steepening and increasing driving stress. 2) Acceleration of the glacier termini caused surface crevasses to propagate up-glacier, allowing surface melt- and rain-water to access the bed. Upward migration of the surge velocities coincided with stepwise the expansion of the crevasse field. Despite a short-lived reactivation in the summer of 2015, the surge of Aavatsmarkbreen terminated gradually, which we interpret as the result of gradual leakage of stored water. The behavior of these glaciers can be understood in terms of the enthalpy cycle model.

DETERMINING THE SPECIES ASSEMBLAGE AND HABITAT USE OF CETACEANS IN THE SVALBARD ARCHIPELAGO, BASED ON RECORDED OBSERVATIONS FROM 2002-2014

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Understanding the ecology of cetaceans in the Svalbard Archipelago in the High Arctic is of critical importance. With its long history of whaling, and its rapidly changing physical and biological regimes, this region is likely to continue undergoing some of the most profound alterations associated with climate change. Knowledge about the habitat use of many cetacean species in this region is limited due to their highly mobile nature and difficulties in attaching tracking devices to these animals. This study used 13 years of cetacean sighting data (2002-2014) from waters around the Svalbard Archipelago, to determine key habitats for year-round resident Arctic species and seasonally resident species, and to explore spatial overlap between these groups. Maximum entropy (MaxEnt) habitat modelling and kernel density estimations were undertaken for each of the frequently observed species (over 100 observation events). Temporal changes over the study period were also investigated, to explore whether range shifts may be occurring. Fifteen cetacean species were sighted in Svalbard waters. Among the resident ice-associated cetaceans, only white whales were reported frequently; they were seen exclusively in coastal habitats, in accordance with their known use of tidal glacier fronts for feeding in this region. Narwhal and bowhead whales were rare (fewer than 30 observation events). Seasonally resident minke whales, fin whales, humpback whales, blue whales, sperm whales, and small dolphins were all seen frequently; they were observed in broad and somewhat overlapping habitats around Svalbard, with the continental slope clearly being important habitat for all of these species. Other less common seasonal residents (fewer than 50 observation events) included killer whales, northern bottlenose whales, and sei whales; harbour porpoises and long-finned pilot whales were also reported, but rarely. Shifts over the study period toward higher latitudes and into coastal environments were observed for several seasonally resident species, including minke whales, fin whales, humpback whales, and blue whales. Sperm whales, northern bottlenose whales, and sei whales were all observed further north than the previously documented ranges of these species. The observed poleward expansions are most likely linked to changes in prey abundance in Svalbard waters, which are concomitant with warming ocean temperatures and a northward retraction of the ice edge. This study provides an important baseline for the habitat use and assemblage of cetacean species in Svalbard Waters, on which future systematic studies can build.

BIOGEOCHEMICAL IMPACTS OF DUST DEPOSITION ON ARCTIC SOILS

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Arctic soils are generally limited in nutrient availability. Characteristically slow turnover rates and the gradual burial of organic matter in permafrost mean that nutrients become available to plants at very slow rates. Melting and retreating glaciers produce fine dusty material and as more land surface area will be exposed to wind action, local dust emissions are likely to increase. This aeolian input might be a source of additional nutrients to soils which could overwhelm conventional soil-forming processes. The aim of this project is to understand how Arctic soils become colonized and productive under contemporary conditions focusing on the relative importance of soil-forming processes vs dust inputs. Frisbee traps are deployed during a first field visit in April 2017 along a transect between the Greenland ice sheet and Kangerlussuaq (66˚00'N and 50˚43'20"W) with an inferred gradient of dust deposition from high near the ice to near zero 30 km west. During this field visit the amount of dust in snow layers is also documented for an estimation of deposition over the winter. The dust samplers are emptied during a second field visit in June and again in August 2017 when detailed descriptions were made of vegetation cover and existing soil profiles. Soil samples were collected for several laboratory analyses in the coming months.

PRELIMINARY BIODIVERSITY ASSESSMENT OF WEST GREENLAND INTERTIDAL HABITATS

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The Arctic is undergoing dramatic changes, including unprecedented decline in sea ice and melt of the Greenland ice sheet. These changes are likely to have significant impacts on Greenland intertidal ecosystems. We present preliminary results of intertidal biodiversity and microplastic surveys undertaken on the West of Greenland, and estimate changes in intertidal community structure by comparing our results with historical literature.

ERROR ASSESSMENT OF MULTI-SOURCE SATELLITE-DERIVED SEA ICE LEADS PRODUCTS

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Arctic sea ice is undergoing dramatic changes in the context of global climate change. Satellite observation data shows a decreasing Arctic sea ice extent about 13% every decade in recent years, accompany with an accelerate thinning. Sea ice leads as a dynamics and thermodynamic driven sea ice features, it is the important heat flux window for the ocean and atmosphere, especially during wintertime. Poor performance of model simulation and the lack of long series satellite observation data with high resolution limited our focus on characterizing and understanding the variability of Arctic sea ice leads. Hence there is a rising demand for high resolution and accuracy sea ice leads product. A daily AMSRE based product with 6.25 km spatial resolution from 2002 to 2011 and a daily MODIS based product with 1.5 km spatial resolution from 2003 to 2015 and a daily Advanced-MODIS based product with 1 km spatial resolution from 2002 to 2017 have been introduced in this passage. In this context, Synthetic Aperture Radar images are employed to quantify this three kinds of sea ice leads products. Our results highlight that the AMSRE product has a consistent overestimation in pan-Arctic, the MODIS product has a significant omission in Beaufort Sea and a remarkable misclassification in GIN (Greenland, Iceland and Norway), and the A-MODIS product adjusts the accuracy of leads discrimination and can be useful to apply in forecast model.

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