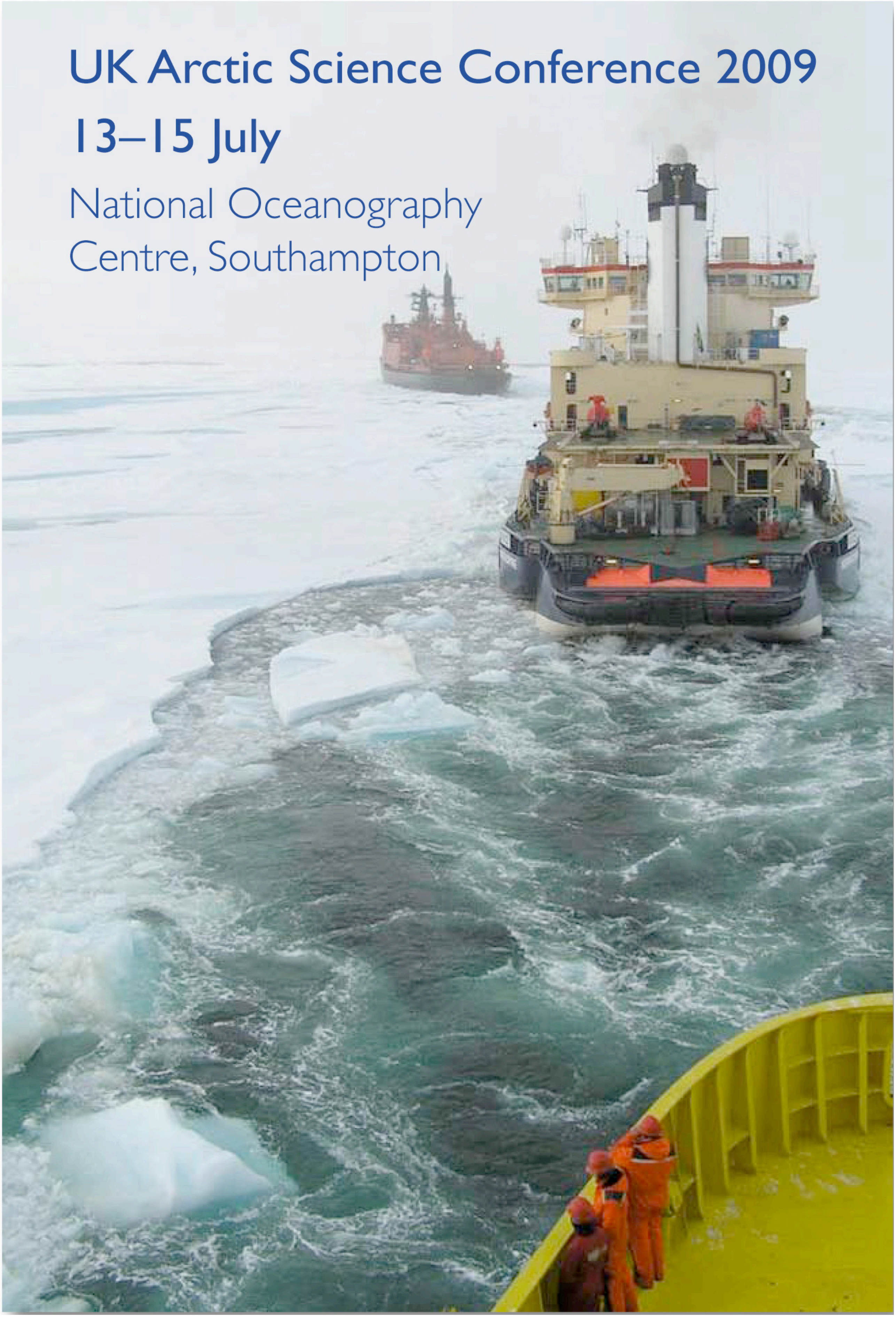
UK Arctic Science Conference 2009

13–15 July

National Oceanography
Centre, Southampton



List of Contents

Programme and Schedule of Talks

Monday 13 July 2009	13.30-13.45	*Welcome*		
	13.45-15.15	*Session 1: Physical Oceanography. Sheldon Bacon (NOCS), Chair.*		
	13.45-14.15	Bob Dickson *CEFAS*	Securing the Legacy of the International Polar Year: what have we learned, where do we go from here? (*invited*)	1
	14.15-14.30	Vladimir Ivanov *SAMS*	Atlantic Water warming accelerates Arctic Sea ice reduction?	2
	14.30-14.45	Tim Boyd *SAMS*	Eddies over the Lomonosov Ridge: Submarine-based observations of mesoscale variability in the Atlantic Water of the central Arctic Ocean	3
	14.45-15.00	Povl Abrahamsen *BAS*	Tracer-derived freshwater composition of the Siberian continental shelf and slope following the summer of 2007	4
	15.00-15.15	Clair Postlethwaite *POL*	The effect of tides on sea ice in Arctic shelf seas	5
	15.15-15.45	*Afternoon tea*		
	15.45-17.30	*Session 2: Physical Oceanography, Atmosphere and Methane. Mike Meredith (BAS), Chair.*		
	15.45-16.15	Cecilie Mauritzen *Norwegian Met. Institute, Oslo*	Arctic Observations: meeting the needs of operational ocean forecasting, climate monitoring and all the timescales in between (*invited*)	6
	16.15-16.30	Ken Carslaw *U. Leeds*	The impact of aerosol on Arctic climate change	7
	16.30-16.45	Ian Brooks *U. Leeds*	The Arctic Summer Cloud-Ocean Study – ASCOS	8
	16.45-17.00	Howard Roscoe *BAS*	Hudson Bay frost flowers: surface area and ionic content as a function of salinity and temperature, and their co-existence with wind-blown snow	9
	17.00-17.15	David Lowry *Royal Holloway*	Arctic methane sources in summer 2008	10
	17.15-17.30	Graham Westbrook *U. Birmingham*	Plumes of bubbles release methane gas from the seabed along the West Spitsbergen continental margin.	11
	17.30-19.30	Icebreaker		
Tuesday 14 July 2009	08.45-10.15	*Session 3: Terrestrial Glaciology. Tony Payne (U. Bristol), Chair.*		
	08.45-09.15	Andrew Shepherd *U. Edinburgh*	High variability in seasonal acceleration of the Greenland Ice Sheet due to routing of surface water (*invited*)	12
	09.15-09.30	Katherine Arrell *U. Leeds*	Modelling Arctic Alpine glacier runoff and floodplain dynamics	13

	09.30-09.45	Liz Morris *SPRI*	Variations in density and accumulation in the dry snow zone of the Greenland Ice Sheet	14
	09.45-10.00	Poul Christoffersen *SPRI*	Warm water in Greenland fjords triggers rapid retreat of outlet glaciers	15
	10.00-10.15	Andreas Vieli *U. Durham*	Understanding rapid dynamic changes of Greenland outlet glaciers from numerical modelling	16
	10.15-10.45	*Morning coffee*		
	10.45-12.30	*Session 4: Terrestrial Biogeochemistry and Ecology; Geosciences. Marc Reichow (U. Leicester), Chair.*		
	10.45-11.00	Stephen Sitch *U. Leeds*	Assessing the circumpolar carbon balance of Arctic tundra with remote sensing and process-based modelling approaches	17
	11.00-11.15	Lorna Street *U. Edinburgh*	Tracking the fate of carbon in Arctic moss communities using 13C isotope labelling	18
	11.15-11.30	Philip Wookey *U. Stirling*	Plant-soil interactions, positive 'priming' effects and patterns of soil carbon storage in Arctic Sweden	19
	11.30-11.45	Liane Benning *U. Leeds*	How 'on Earth' do cryophiles beat Darwin's law of 'survival of the fittest', and what does this mean for planetary exploration?	20
	11.45-12.00	Nick Kusznir *U. Liverpool*	Arctic crustal thickness and oceanic lithosphere distribution from gravity inversion	21
	12.00-12.30	Wilfried Jokat *AWI, Bremerhaven*	Geodynamic evolution of the Arctic Ocean during the Cenozoic: Challenges for geoscientific research (*invited*)	22
	12.30-13.30	Lunch		
	13.30-15.30	*Session 5: Sea ice. Daniel Feltham (CPOM-UCL & BAS), Chair.*		
	13.30-14.00	Jackie Richter-Menge *CRREL, Hanover NH*	Arctic Sea Ice: Studies of a Dynamic Environmental Indicator (*invited*)	23
	14.00-14.15	Phil Hwang *SAMS*	Sea ice variability in the Chukchi Borderland of the Arctic Ocean	24
	14.15-14.30	Adrian Turner *CPOM-UCL*	Basal ablation in Arctic models of sea ice	25
	14.30-14.45	Simon Belt *U. Plymouth*	Declining Arctic sea ice is a thing of the past	26
	14.45-15.00	Peter Wadhams *DAMTP*	Ice thickness characteristics in the Arctic Basin derived from submarine and AUV multibeam sonar	27
	15.00-15.30	Seymour Laxon *CPOM-UCL*	CryoSat and satellite observations of the polar regions (*invited*)	28
	15.30-16.00	*Afternoon tea*		
	16.00-18.00	*Session 6*	Posters (all subjects)	

	20.00 onwards	*Conference Dinner*		
Wednesday 15 July 2009	08.45-10.15	*Session 7: Marine Biogeochemistry and Ecology. Ray Leakey (SAMS), Chair.*		
	08.45-09.15	David Thomas *U. Bangor*	Sea ice biogeochemistry – implications of changing sea ice conditions (*invited*)	29
	09.15-09.30	Katya Popova *NOCS*	Physical mechanisms controlling Arctic primary productivity	30
	09.30-09.45	Alex Cunningham *U. Strathclyde*	Optical challenges in a changing Arctic Ocean	31
	09.45-10.00	Helen Findlay *PML*	Ocean acidification and climate change impacts on Semibalanus balanoides in the Arctic	32
	10.00-10.15	Geraint Tarling *BAS*	Seasonal patterns in vertical migration of marine zooplankton at high latitudes: driver and implications	33
	10.15-10.45	*Morning coffee*		
	10.45-12.30	*Session 8: Climate and Palaeo-records. Tim Minshull (NOCS), Chair.*		
	10.45-11.00	Peili Wu *Hadley Centre*	Modelling the Arctic freshwater budget	34
	11.00-11.15	Jeff Ridley *Hadley Centre*	Is decline of the Greenland Ice Sheet reversible?	35
	11.15-11.30	Jeff Blackford *U. Manchester*	Recent climate change in Arctic and peri-Arctic regions – a palaeoenvironmental perspective from peat bogs	36
	11.30-11.45	Alan Kemp *NOCS*	The seasonal cycle of the late Cretaceous Arctic Ocean	37
	11.45-12.00	Guy Harrington *U. Birmingham*	Plant richness in the early Eocene of the Canadian High Arctic	38
	12.00-12.30	Jane Francis *U. Leeds*	Arctic forests and climates in a greenhouse world: a window into our future warm world? (*invited*)	39
	12.30-13.00	*Final discussion: What next? Liz Morris (SPRI), Chair.*		
	13.00	*Meeting ends*		

List of Posters

Abstracts

Notes:

1: abstracts appear in the same order as they are listed in the programme;

2: the presenting author for each talk or poster is shown in boldface type;

3: UK institutional affiliations are given in conventional abbreviated forms while international affiliations are quoted more fully;

4: contact information for presenting authors is email address only;

5: there is one extra poster classification (*Data & Information*) that does not appear in the talks; two late submissions appear at the end, out of sequence.

Physical Oceanography: Talk – *Invited Speaker*

Securing the legacy of the International Polar Year: what have we learned, where do we go from here?

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Though climate modellers are fully aware and agreed that extreme change is passing through the ocean-atmosphere-cryosphere system of our Northern Seas, in fact many of the physical processes implicated in driving these changes may not yet be represented realistically (or at all) in climate models. As the recent ASOF volume points out, the list is quite long: '*Climate models are inherently weak in the important subtleties of deep convection, interior diapycnal mixing, boundary currents, shelf circulations (climate models have no continental shelves!), downslope flows that entrain new fluid during their descent, thin cascading overflows, delicate upper ocean stratification by both heat and salt with its strong influence on convective geography, ice dynamics…'*; all of these would seem to have at least a potential importance for the simulation and prediction of Arctic change; and the hope is that many of them would have been drawn into the observational net of the IPY.

However, it takes no great thought to realise that rather than the two-year project itself, it will be the 'legacy phase' of the IPY, sustained over years to decades, that will develop our understanding of these processes, their changes, their feedbacks and their likely climatic impacts to the point where they can be of use to climate models. Plainly, we can't continue everything. What have we *learned* in the IPY that might help us design its legacy phase? The Arctic Ocean Sciences Board has set itself the task of designing a fully-costed and internationally agreed observing plan for the IPY 'legacy phase' by the time of the post-IPY Conference in Oslo in June 2010. So we have roughly a year to decide its content. Here we describe a half-dozen examples, illustrative of the ways our ideas have changed during the IPY, that help define the scope of their task.

However that plan develops, there would be little debate among scientists that the basic need is for a plan capable of integrating national efforts to provide a freely-shared, flexible, reliable and reasonably complete ocean data set, versatile enough to spread both established and emerging technologies across the available platforms, and to ensure both the compatibility of data sets and their widespread distribution. The fear would be that national issues of sovereignty, access and logistics might instead promote a dataset whose coverage, quality, cost and accessibility would be a variable function of the country responsible.

Physical Oceanography: Talk

Atlantic Water warming accelerates Arctic sea-ice reduction?

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Unprecedented low sea-ice concentration in the Arctic Ocean observed in September 2007 suggests that the reduction of the Arctic sea-ice is going much faster than climate models predict. Multiple factors control sea ice parameters and they are neither well-documented nor well-represented in models. Probably, the most uncertain factor among the others is the amount of sensible heat from the Atlantic Water layer in the Arctic Ocean eventually affecting sea ice. Atlantic Water (AW) reaching the Arctic Ocean is considered to be the major heat source for the ocean interior. However, since after passing Fram Strait AW 'submerges' the upper waters, loosing direct contact with the atmosphere, the question whether the major amount of stored heat is released upwards affecting sea ice, or it stays in the deep being eventually flashed out of the Arctic Ocean, is a big unresolved issue. This issue became especially critical after 1991 when substantial warming in AW was recorded. Rapid reduction of the Arctic ice cover in 1990-2000s, questions possible contribution of AW heat in this process as well. We present observation-based results which demonstrate substantial heat/salt exchange between the upper part of AW and overlaying halocline water layer. Model estimations show that throughout the last few decades continuous AW warming accompanied by weakening of vertical stratification accelerated upward heat transfer from AW resulting in anomalous heat flux of 0.5 W/m2. This is the equivalent of 5 cm of annual ice-thickness loss or up to 70cm of ice thickness loss since the late 1970s.

Physical Oceanography: Talk

Eddies over the Lomonosov Ridge: Submarine-based observations of mesoscale variability in the Atlantic Water of the central Arctic Ocean

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Above the Lomonosov Ridge of the central Arctic Ocean is a frontal region between relatively warm, salty Atlantic water flowing cyclonically (anti-clockwise) along the Eurasian side of the ridge and colder, fresher water on the Canadian side. Horizontal variability of this region is examined using underway CTD data from submarine transects that were run across the ridge at fixed depth (214m) in the thermocline. Eddies of Atlantic water with length scales of order 15km are found embedded within the high gradient region on the Canadian basin side of the front near 89 deg N. Eddy location appears to be related to underlying ridge bathymetry, suggesting a role for topography in eddy formation.

Physical Oceanography: Talk

Tracer-derived freshwater composition of the Siberian continental shelf and slope following the summer of 2007

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We investigate the freshwater composition of the Arctic Ocean north of the New Siberian Islands using geochemical tracer data (delta-18O, Ba, and PO4*) collected following the extreme summer of 2007, as well as preliminary data from 2008. We find that the anomalous wind patterns which partly explained the sea ice minimum in 2007 also led to significant quantities of Pacific-derived surface water in the westernmost part of the Makarov Basin. We also find significantly larger quantities of meteoric water near Lomonosov Ridge compared with earlier years. Dissolved barium is depleted in the upper layers in one region of our study area, probably as a result of biological activity in open waters. Increasingly ice-free conditions compromise the quantitative use of barium as a tracer of river water in the Arctic Ocean.

Physical Oceanography: Talk

The Effect of Tides on Sea Ice in Arctic Shelf Seas

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General Circulation Models used to predict future climate do not generally include tides in the ocean physics. We investigate the impact tides have on sea ice distribution and dense water formation in the Barents and Kara Seas using a dynamic/thermodynamic sea ice model (CICE) coupled to a coastal ocean model (POLCOMS). Sea ice can be modulated by tides in several ways. Tidal mixing can hinder ice growth or even cause melting, as oceanic heat is transported upwards. Indeed melting increases throughout the domain when tidal forcing is added to the model. A layer of fresh melt water can inhibit convection. Additionally the ebb and flow of the tide can cause sea ice to pile up (in areas of convergence) or separate (in areas of divergence). Thicker, piled up ice thermally insulates the ocean from the atmosphere and thus further ice production becomes less likely. Conversely, areas of open water exposed as the tides pull the ice cover apart, start to produce dense water as brine is rejected from newly formed sea ice. The latter process occurs in the model in several shallow, tidally active locations and has a significant impact on the salinity of the underlying water column along the Russian coast.

Physical Oceanography: Talk – *Invited Speaker*

Arctic Observations: meeting the needs of operational ocean forecasting, climate monitoring and all the timescales in between

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An "ocean observing system" - the oceanic equivalent to an atmospheric observing system - is practically non-existent at any latitude. The need for one has never been so strong as to make it economically viable, until in recent years, when the realization that ocean circulation plays an important role in climate has become generally accepted. Presently, many traditional oceanic sections are repeated regularly through international cooperation. And hundreds of automated monitoring floats drift in the world oceans transmitting information about the subsurface ocean real-time to the modelling centers, to be merged with remote sensing information to make better estimates and predictions of ocean circulation. During the International Polar Year we have seen the polar equivalents – profiling CTDs anchored in the sea ice – successfully delivering real-time information of the Arctic Ocean. These high latitudes are essential to the climate system, primarily due to the ice-climate feedback. And precisely because of that feedback mechanism, high-quality short-term forecasting of weather, ice and current conditions will increasingly be in demand. The questions touched upon in this talk are basic: What *is* an observing system, and what is it to observe?

Atmosphere & Methane: Talk

The Arctic Summer Cloud-Ocean Study – ASCOS

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Caroline Leck	U. Stockholm
P. Ola G. Persson	NOAA
Matthew Shupe	U. Colorado
Cathryn E. Birch	U. Leeds
Barbara Brooks	U. Leeds
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The Arctic is a region of great sensitivity to climate change but is poorly represented by global climate models. The sensitivity arises due to a number of feedback mechanisms that amplify changes to Arctic climate; uncertainty in the models arises from a poor understanding of the details of these feedback processes, and from a dearth of observations upon which to base parameterizations specific to the unique Arctic environment. Low level stratiform clouds are particularly poorly represented; existing models struggle to reproduce their extent and properties. The Arctic Summer Cloud-Ocean Study (ASCOS) is an international, interdisciplinary field study investigating the myriad processes that control the near-ubiquitous summertime arctic stratus clouds. A month long field campaign took place in August 2008, based around the icebreaker Oden. Measurements included extensive in-situ micrometeorology: surface layer flux profiles from two masts, sodar measurements of boundary layer structure and wind profiles, full surface energy balance, and tethered balloon profiles of mean and turbulent quantities up to about 700m. Turbulent fluxes were also measured below the ice, along with ocean microstructure profiles down to 500m. Aerosol properties and gas-phase chemistry were measured from container labs on board Oden, and intermittently from sites on the ice, from the tethered balloon, and from a helicopter. Marine bio-chemistry measurements were made at an open-lead site 2km from the ship. Cloud properties were measured with a wide range of remote sensing retrievals. A separate, but coordinated project - Arctic Mechanisms of Interaction between the Surface and Atmosphere (AMISA) - made in-situ airborne measurements of cloud microphysics, aerosol, and radiative properties above, within, and below cloud from the NASA DC8 research aircraft. The University of Leeds formed the core of the boundary layer measurement programme on the ice, and contributed to aerosol measurements both on Oden and the DC8. An overview of the ASCOS project will be presented. Further details of ASCOS can be found at www.ascos.org.

Atmosphere & Methane: Talk

The impact of aerosol on Arctic climate change

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Aerosols have a substantial but very uncertain influence on Arctic climate. A recent study published in Nature suggests that 2/3 of the recent Arctic warming could be due to aerosol. In a phenomenon known as Arctic haze high concentrations of aged particles consisting mainly of sulphate, black carbon (BC), organic carbon, and nitrate enter the Arctic atmosphere in winter and spring and accumulate due to strong surface temperature inversions and low scavenging rates. Multi-year observations suggest changes in short and long-wave radiation of several Wm^{-2}. In addition, deposition of BC on snow and ice reduces the albedo and has been shown to increase surface temperatures by as much as 1.6 K. Furthermore, future changes in sea ice will alter DMS emissions and affect local aerosol formation.

We review recent studies of the impact of aerosols on Arctic climate and the status of models used to simulate them. Global models such as the UK Chemistry and Aerosol (UKCA) chemistry-climate model in the Unified Model are ideal tools to calculate aerosol effects, but substantial uncertainties exist. We will show simulations of the aerosol transport to the Arctic including an analysis of the aerosol microphysics and optical depth from high latitude research stations. The results show that the aerosol in the Arctic is very dependent on the wet scavenging processes during long range transport.

The UK is well placed to study the impact of air pollution on the Arctic. The new UKCA model will soon be embedded in the QUEST Earth system model to study the coupling of aerosols, clouds, radiation, black carbon deposition and the ice albedo. The opportunities will be briefly discussed.

Atmosphere & Methane: Talk

Hudson Bay frost flowers: surface area & ionic content as a function of salinity & temperature, and their co-existence with wind-blown snow

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Frost flowers are important to polar tropospheric chemistry because they are a potential source of sea-salt aerosol from which reactive bromine compounds can form, which then catalytically remove surface ozone. Frost flowers were observed and collected on Hudson Bay in 2008, and their specific surface area was measured at a site close to their collection point, using the so-called BET method. The range of values was 63 to 299 $cm^2\ g^{-1}$, similar to that of earlier work by others despite our much colder conditions. Our correlation of results with growth time and chemistry reveals the factors responsible for this wide range of surface area values: longer growth time leads to larger areas at lower temperatures. We also measured the ionic content of melted frost flowers, together with any nearby brine and the local seawater. The relationship between growth time and salinity varied spatially due to a nearby fresh-water river and to tidal effects at the coast. Ionic enrichment affects frost flowers' contribution to atmospheric chemistry, and we found it depended heavily on location, growth time and temperature. No significant enhancement or depletion of bromide was detected. The low surface area amplification of frost flowers plus their structural rigidity suggest their direct effect on sea salt mobilization and halogen chemistry may be less than previously thought, but their ability to salinate wind-blown snow may increase their indirect importance.

Atmosphere & Methane: Talk

Arctic Methane Sources in Summer 2008

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The Arctic contains vast quantities of stored methane and emissions from these sources are very sensitive to temperature change. Warming of the Arctic will increase methane emissions from sources such as wetlands and clathrate, producing a feedback effect. 2007-2008 saw an increase in global methane concentrations and increased emissions from the Arctic may have contributed to the rise. Stable isotopic analysis of atmospheric methane ($\delta^{13}C$), together with back trajectory analysis of the air masses sampled can be used to obtain isotopic signatures of the major source regions, and help in identification of changing sources. By determining the incremental mixing ratio and change in $\delta^{13}C$ of CH_4 in air coming from a chosen sector, compared with regional background, the signature of the methane source(s) can be calculated. Methane $\delta^{13}C$ has been measured in ambient air samples collected every two weeks at the Zeppelin station in Spitsbergen since July 2007. Samples were also collected daily at the station throughout the summer of 2008. Weekly sampling at the Pallas Sammaltunturi station in northern Finland began in August 2008. Source studies have been carried out in addition to the ambient measurements to identify the methane isotopic signature of Arctic sources. Recently these have included wetland studies in Pallas, Finland and Ny-Ålesund, Spitsbergen and studies of methane hydrate release during a research cruise off the west coast of Spitsbergen. These complement earlier source study experiments on gas fields and wetlands in the Ob River region of Siberia. The highest atmospheric methane mixing ratios measured in ambient air samples from Spitsbergen during the summer of 2008 were measured when 5-day air mass back trajectories had passed over Siberia. Methane in these samples was relatively depleted in ^{13}C. For example air masses that had passed over the Ob River gas field area had a methane $\delta^{13}C$ source signature of -61 ± 3 ‰. This is likely to originate from mixing between methane derived from gas (around -49 ‰) and wetland (around -67 ‰). Continued monitoring of $\delta^{13}C$ of Arctic methane is vital to monitor changes in emission from sources within this highly sensitive region, particularly as recent warming is increasing emissions from natural sources.

Atmosphere & Methane: Talk

Plumes of bubbles release methane gas from the seabed along the West Spitsbergen continental margin

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Heiko Pälike	NOCS
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Over 250 plumes of gas bubbles have been discovered emanating from the seabed of the West Spitsbergen continental margin, at and above the upper limit of the gas hydrate stability zone (GHSZ), at depths of 150-400 m. Some plumes extend upward to within 50 m of the sea surface. The gas is predominantly methane, and seismic reflection data indicate free gas beneath the plume field. A 1°C warming of the northward-flowing West Spitsbergen current over the last thirty years is likely to have increased the release of methane from the seabed by reducing the extent of the GHSZ, causing the liberation of methane from decomposing hydrate. If this process is widespread along Arctic continental margins, the methane released could be a large proportion of global methane flux. Methane released from gas hydrate in submarine sediments has been invoked as an agent of past climate change, yet comparatively little is known about methane fluxes in the present-day marine environment. At present, very little of the methane released in the plumes appears to reach the atmosphere.

Terrestrial Glaciology: Talk – *Invited Speaker*

High variability in seasonal acceleration of the Greenland Ice Sheet due to routing of surface water

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Although satellite and ground-based observations show that fluctuations in melting at the surface of the Greenland Ice Sheet (GrIS) trigger changes in ice sheet motion, the effect is least pronounced at marine-terminating sectors of the ice sheet and, in places, the magnitude of seasonal velocity changes has diminished over the past decade in the face of increased melting. In consequence, the extent to which changes in climate expected over the course of the 21st century will increase the flow and sea level contribution of the GrIS remains uncertain. Here we use interferometric synthetic aperture radar data to show that the pattern of summertime ice speedup is highly non-uniform - extending in places to over 100 km inland - and is intimately linked to the routing of supra-glacial water. The magnitude of seasonal flow variations is positively correlated (r=0.78) with runoff generated within overlying surface hydrological catchments. During late summer, ice beneath the largest catchments flows on average 48 % faster than in winter; beneath smaller catchments the speedup is much less pronounced. Our findings provide a basis for modelling the dynamical response of the GrIS as the degree of melting at the surface evolves – a process that has been often considered for Alpine glaciers - and suggest that ground-based experiments to study seasonal velocity fluctuations should be sited with care to avoid sampling areas which exhibit modest variability.

Terrestrial Glaciology: Talk

Modelling Arctic Alpine glacier runoff and floodplain dynamics

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Arctic glacial and proglacial systems are complex product of cryospheric and fluvial processes. They are highly dynamic and very sensitive to climate change, which is predicted to cause air temperature warming in the Arctic of 2-3 times higher than the global average (Schiermeier, 2006). The Arctic also exhibits strong seasonal cycles in meltwater runoff and physicochemical characteristics, these properties make Arctic glacial and proglacial systems ideal sites for recognising climate change effects on glaciers, landscapes, hydrology and ecology. Such recognition can be directly through meltwater fluxes, and indirectly through river channel morpho-dynamics. Previous attempts to quantify these integrated proglacial systems have adopted a modelling approach and have treated glacial, hydrological and geomorphological components strictly as separate entities, thereby limiting our understanding of these system interactions. Currently, no holistic integration of models of snow and ice melt production, proglacial meltwater routing and hydraulics, has been attempted. This requires immediate attention because changes in rates and scales of climatic, glacial and hydrological processes are predicted to accelerate (IPCC, 2007). We suggest that development and validation of linked climate-driven glacial and hydrological models will permit more accurate quantification of the sensitivity of these systems to climatic change. In particular we will consider how climatic perturbations are propagated through these coupled systems. The first part of this project has opportunistically utilised 100 years of intermittent glaciological observations and ~ 75 years of continuous weather observations at Kårsaglaciären, arctic Sweden to characterise historical glacier and proglacial system changes. For model parameterisation and validation we have made intensive field measurements including installation and maintenance of an automatic weather station (AWS), high resolution topographic surveys of the active upper Kårsajåkka channel and continuous measurements of spring and summer stream temperature. In March 2008 and March 2009 we have measured the end-of-winter snow surface, snow depth to end-of summer ice surface, snow density variations and ice depth to bedrock via a GPR survey, all on Kårsaglaciären. Our preliminary results from this first part of the project show a dramatically declining glacial extent, ice surface downwasting, a shift in the position of the dominant accumulation area and thus a reduced ice volume. We suggest that coincident with these changes has been a change in the glacier's thermal regime and consequent flow dynamics.

References

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Schiermeier, Q., 2006: Arctic ecology: On thin ice. *Nature* **441** 146-147.

Terrestrial Glaciology: Talk

Variations in density and accumulation in the dry snow zone of the Greenland Ice Sheet

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Uncertainty in the trend in spatially averaged land ice mass measured by satellite altimeters arises from short-term fluctuations in accumulation and near surafce density. Quantifying this uncertainty requires an understanding of the spatial correlation of these fluctuations, and is one of the objectives of the cal/val activities in support of CryoSat. This paper describes measurements of surface elevation and density made during successive traverses of the dry snow zone in central west Greenland, along the EGIG line and north to Summit station. From these data the spatial covariance of elevation change has been determined for the periods between Spring 2004, Autumn 2004, Spring 2006 and Summer 2006, and the contributions to this covariance from accumulation, surface density and compaction quantified.

Terrestrial Glaciology: Talk

Warm water in Greenland fjords triggers rapid retreat of outlet glaciers

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Fjord-terminating outlet glaciers in Greenland fluctuate at both seasonal and interannual timescales. Recent observations and numerical modelling indicate that changes in terminus position and speed are triggered at the calving ice front, but it is not clear why these changes are occurring and how they may relate to Arctic warming. We have used hydrographic datasets from Kangerdlugssuaq Fjord and the adjacent East Greenland seas in 1993 and 2004 to show major differences in water compositions. To elucidate the glacial response to ocean warming, which is up to 4°C inside the fjord, we examined satellite-derived sea-surface temperatures and margin positions for Kangerdlugssuaq Glacier since 1985. We found that the glacier fluctuates seasonally and that a rapid change occurred when the seasonal cycle was superimposed by a stepped change in water temperature. It is possible that the decay of sea ice defines the onset of calving seasons where retreat occurs because the rate of calving exceeds the speed of ice. Consecutive years with calving seasons prolonged by mild winters and warm summers may explain why marine outlet glaciers in southeast Greenland have retreated and discharged synchronously in recent years.

Terrestrial Glaciology: Talk

Understanding rapid dynamic changes of Greenland outlet glaciers from numerical modeling

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Recent rapid dynamic changes of Greenland's outlet glaciers raised concerns over the contribution to future sea level rise. These dynamic changes seem to be linked to the warming trend in Greenland, but the mechanisms that link climate and ice dynamics are poorly understood, and current numerical models of ice sheets are not able to simulate these changes realistically. These dynamic changes therefore provide major uncertainties in the predictions of mass loss from the Greenland ice sheet. We developed a numerical ice-flow model that reproduces the observed rapid changes in Helheim Glacier, one of Greenland's largest outlet glaciers. Our simulations show that the ice acceleration, thinning and retreat begin at the ocean terminating calving front and then propagate rapidly upstream through dynamic coupling along the glacier. We find that these changes are unlikely to be caused by basal lubrication through enhanced surface melt from the recent atmospheric warming. The modelling further shows that such tidewater outlet glaciers are extremely sensitive to changing boundary conditions at the calving terminus and dynamically adjust extremely rapidly. This implies that the recent rapid mass loss of Greenland's outlet glaciers may reflect short-term variations in climate or ocean conditions and should not be extrapolated into the future.

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk

Assessing the circumpolar carbon balance of arctic tundra with remote sensing and process-based modelling approaches

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John Kimball	U. Montana, USA
Nicola Gedney	Met Office Hadley Centre, UK
John Gamon	California State University, USA
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Here we review the current status of using remote sensing and process-based modeling approaches to assess the contemporary and future circumpolar carbon balance of Arctic tundra, including the exchange of both carbon dioxide and methane with the atmosphere (Sitch et al., 2007). Analyses based on remote sensing approaches that use a 20-year data record of satellite data indicate that tundra is greening in the Arctic, suggesting an increase in photosynthetic activity and net primary production. Modelling studies generally simulate a small net carbon sink for the distribution of Arctic tundra, a result that is within the uncertainty range of field-based estimates of net carbon exchange. Applications of process based approaches for scenarios of future climate change generally indicate net carbon sequestration in Arctic tundra as enhanced vegetation production exceeds simulated increases in decomposition. However, methane emissions are likely to increase dramatically, in response to rising soil temperatures, over the next century. Key uncertainties in the response of Arctic ecosystems to climate change include uncertainties in future fire regimes and uncertainties relating to changes in the soil environment. These include the response of soil decomposition and respiration to warming and deepening of the soil active layer, uncertainties in precipitation and potential soil drying, and distribution of wetlands. While there are numerous uncertainties in the projections of process-based models, they generally indicate that Arctic tundra will be a small sink for carbon over the next century and that methane emissions will increase considerably, which implies that exchange of greenhouse gases between the atmosphere and Arctic tundra ecosystems is likely to contribute to climate warming.

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk

Tracking the fate of carbon in Arctic moss communities using ^{13}C isotope labeling

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Significant temperature rise in the terrestrial Arctic will influence the carbon (C) cycle, through effects on plant growth and soil decomposition. Loss of Arctic soil C could result in a dangerous feedback on global climate warming. The ABACUS project aims to further our ability to predict the size and direction of shifts in Arctic C balance through developing ecosystem models of C exchange between atmosphere, vegetation and soils. A key component is quantifying the fraction of photosynthetically fixed C (Gross Primary Productivity, GPP) that is respired by plants (autotrophic respiration, RA) versus that incorporated into plant tissues as growth (Net Primary Productivity, NPP). Current models typically assume NPP is 50% of GPP, but this is largely based on evidence from ecosystems dominated by vascular plants. Nonvascular plants (bryophytes - the mosses and liverworts) are a ubiquitous component of vegetation in Arctic ecosystems. They have a fundamentally different physiology to higher plants; being unable to actively regulate tissue water content and lacking true roots, stems or storage organs. It is likely therefore that bryophyte respiratory costs, and therefore NPP:GPP ratios, differ from vascular plants.

We used ^{13}C isotope labelling to determine the NPP:GPP ratio and turnover time of C in moss communities in Swedish sub-Arctic tundra. We tracked assimilated ^{13}C in Sphagnum fuscum and Polytrichum strictum, two contrasting moss species, following a 3-hour fumigation under 95% atom enriched $^{13}CO_2$. We present data on the isotopic enrichment in moss tissue as well as in respired CO_2 (measured by a field-deployed mass spectrometer) over time following pulse labelling. Our results show clear differences between species in the relative amounts of assimilated C returned to the atmosphere through respiration versus that stored as biomass through growth. About 75% of gross C uptake remained in S. fuscum tissues 5 days after labelling, whereas in P. strictum tissues only about 30% remained. The mean residence time of assimilated C in S. fuscum was longer at about 5 days compared to around 3 days for P. strictum. Our results emphasis the importance of moss species composition in Arctic C dynamics.

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk

Plant-soil interactions, positive 'priming' effects and patterns of soil C storage in arctic Sweden

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With global warming predicted to alter the distribution of different plant communities across the planet, it is extremely important to improve our understanding of how the whole plant-soil system controls patterns of soil C storage. In arctic Sweden, as one moves from mountain birch forest into the surrounding tundra-heath, the amount of C stored below ground increases as the organic soil horizon deepens. Over the coming decades, the treeline is expected to advance, making it important to understand how soil C cycling is controlled in these ecosystems. During the mid-20th Century, nuclear weapons testing released ^{14}C into the atmosphere, providing a global tracer that can age the CO_2 released from plants and soils. We used $^{14}CO_2$ measurements to investigate whether the age of C released from vegetated plots, and clipped and trenched (CT) plots (i.e. a treatment which limits the input of recently-fixed C), changed with seasonal shifts in plant activity and temperature. On the heath the mean age of C respired from the control plots ranged from 4 to 6 years old, while the CO_2 released from the CT plots was older, ranging from 5-11 years old. In the forest, the mean age of C respired from the control plots ranged from 1 to 6 years old, with the CO_2 released from the CT plots again being older (4-9 years old). Therefore, overall, the C respired from the heath system was slightly older. At the tundra-heath site, as expected the difference in the age of C respired from the control and CT plots was greatest mid-season, during the period of peak photosynthesis, reflecting the contribution of recently-fixed C in the control plots. In contrast, in the birch forest, the difference between the two plot types in terms of the age of respired CO_2 was smallest mid-season, despite plant activity in this ecosystem also peaking at this time. To explain this result, in the vegetated birch forest plots, the decomposition of older, ^{14}C-enriched soil C must have been stimulated mid-season. Such positive 'priming' effects may explain the thinner organic horizon in the forest, and leads to the suggestion that tree encroachment into the heath could increase the decomposition of older organic matter resulting in an overall loss of soil C.

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk

How 'on Earth' do cryophiles beat Darwin's law of 'survival of the fittest' and what does this mean for planetary exploration?

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Life flourishes in the most extreme terrestrial environments and extant or extinct microbial life is the target for future NASA and ESA "Search for Life" missions to Mars. Cold-loving extremophile microorganisms (cryophiles) in Arctic glacial ice and on snowfields have developed very specialized protective pigments (UV-radiation screening or light harvesting pigments) and antioxidants (e.g., xantophyls) that help them shield the chloroplast from high UV radiation, and allows them to survive large temperature and pH fluctuations, nutrient depletion as well as repeated desiccation of thaw-freezing cycles. These adaptations are relevant for understanding the survival and preservation potential of biomarker molecules in endolithic consortia in both modern and ancient terrestrial rocks as well as deep ice cores (i.e, Antarctica or Greenland) and these adaptive strategies are important for guiding the "Search for Life" missions to the water-ice-rich regions of Mars or Europa. Here we present spectroscopic, microscopic, isotopic and molecular organic chemical and microbiological data of glacial ice and snowfield microbial communities from studies carried out in Svalbard (80˚N) as part of the Arctic Mars Analogue Svalbard Expeditions (AMASE).

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk

Arctic Crustal Thickness and Oceanic Lithosphere Distribution from Gravity Inversion

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The ocean basins of the Arctic formed during the Late Jurassic, Cretaceous and Tertiary as a series of small distinct ocean basins leading to a complex distribution of oceanic crust, thinned continental crust and rifted continental margins. The spatial evolution of Arctic Ocean basin geometry and bathymetry is critical for understanding the palaeo-oceanography and ocean gateway connectivity of this important region and its influence on global climate. Unfortunately the plate tectonic history of the Arctic, and the Amerasia Basin and Arctic-Pacific ocean gateway in particular, is poorly understood and hinders our understanding of Arctic palaeo-oceanography during the Cretaceous and Tertiary. Using gravity anomaly inversion we have produced the first comprehensive maps of crustal thickness and oceanic lithosphere distribution for the Arctic region. Using these we can begin to predict the development of Arctic bathymetry with time however much uncertainty remains. While geophysics provides remote sensing indications of crustal thickness, ocean-continent transition location and oceanic lithosphere distribution of the Arctic, progress in understanding the relationship between the tectonic, palaeo-oceanographic and palaeo-climate histories of the Arctic requires coordination of geophysical, geological and oceanographic research and collaboration between scientists with these different skills.

Our research addresses the determination of crustal thickness, continental lithosphere thinning factors and ocean-continent transition location for the Amerasia and Eurasian Basins of the Arctic using a new gravity inversion method which incorporates a lithosphere thermal gravity anomaly correction (Greenhalgh & Kusznir, GRL, 2007; Chappell & Kusznir, GJI, 2008). We use crustal thickness and continental lithosphere thinning factor maps, determined by inversion of the NGA (U) Arctic Gravity Project and IBCAO bathymetry data to predict the distribution of oceanic lithosphere and ocean-continent transition (OCT) location for the Amerasia and Eurasia Basins.

The resulting gravity inversion predictions of crustal thickness, OCT location and oceanic lithosphere distribution are then used to test plate tectonic reconstructions of the Amerasia Basin (Alvy, Gaina, Kusznir & Torsvik, EPSL, 2008) which may be used to predict palaeo-oceanographic templates, palaeo-bathymetries and Arctic ocean gateway history. Our gravity inversion predicts thin crust and high continental lithosphere thinning factors in the Makarov, Podvodnikov, Nautilus and Canada Basins consistent with these basins being oceanic or highly thinned continental crust. Larger crustal thicknesses, in the range 20 - 30 km, are predicted for the Lomonosov, Alpha and Mendeleev Ridges. Moho depths predicted by gravity inversion compare well with estimates from the TransArctica-Arctica seismic profiles for the Podvodnikov and Makarov Basins, and the Lomonosov Ridge. Outside the main oceanic Amerasia and Eurasia Basins, locally thinner crust is predicted in the Laptev Sea and North Chukchi Basins. A triangular region of thinner crust is also predicted in the region of the East Siberian Sea Basin and separated from the Podvodnikov Basin by thick crust under the De Long Massif. There is the intriguing possibility that these basins may be underlain by very thin continental crust or oceanic crust. The presence of very thin continental or oceanic crust under the North Chukchi Basin, Laptev Sea and East Siberian Sea Basin would have major implications for understanding the Mesozoic and Cenozoic plate tectonic history of the Siberian and Chuchki margins of the Amerasia Basin.

Terrestrial Biogeochemistry and Ecology; Geosciences: Talk – *Invited Speaker*

Geodynamic evolution of the Arctic Ocean during the Cenozoic: Challenges for geoscientific research

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The Cenozoic evolution of the Arctic Ocean is closely related to two tectonic events: the rifting of the Lomonosov Ridge from the Siberian Shelf, and the opening of the Fram Strait. The duration of the rift phase between the Lomonosov Ridge and the shelf is poorly constrained by marine data, and is difficult to describe. The drift of the ridge, however, is well documented by seafloor spreading anomalies in the Amundsen and Nansen basins. During most of the basin formation the spreading was ultra slow, as indicated by magnetic and seismic data. The only scientific deep drill hole in the central Arctic is located on the ridge. Analyses showed that the environment between 55 and 45 Ma was completely different to what we observe today: e.g., surface water temperatures were well above 20°C in the summer. Unfortunately, the drilling information is not complete in describing the transition from the warm Arctic to the present day situation. Thus, the role of the Fram Strait opening some 15 Ma between North Greenland and Svalbard is speculative. Coring information indicates that around 17 Ma the Arctic Ocean became ventilated, which can be related to the final formation of a deep water connection in the Fram Strait. Geophysical data furthermore indicate that most likely before that tectonic event shallow water connections existed in the Fram Strait to allow limited water exchange: e.g. across the Yermak Plateau.

In order to address these problems continued broad research activities are necessary, including deep drilling during the next decade.

Sea Ice: Talk – *Invited Speaker*

Arctic Sea Ice: Studies of a Dynamic Environmental Indicator

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Recent changes in the extent and composition of the Arctic sea ice cover provide some of the most dramatic evidence of global warming. This presentation will concentrate on the current state of the sea ice cover in the context of historic trends and forecasts of future change. It will consider the confluence of events that led to the abrupt decline in the extent and composition of the ice cover in the summer of 2007 and the reasons behind the projections of continued loss in the foreseeable future. The extensive impacts of these remarkable changes will be discussed, ranging from the global environment to the diverse communities that call the Arctic home to adventure tourism. The presentation will conclude with a virtual field trip to an Arctic ice camp, sharing the adventure involved in studying one of nature's bellwethers.

Sea Ice: Talk

Sea ice variability in the Chukchi Borderland of the Arctic Ocean

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Over the past two decades, the Arctic sea ice has declined been in both extent and thickness. Until 1995 the strongest negative trend in sea ice concentration mostly occurred in the East Siberian Sea. This was attributed to dominant positive phase of winter Arctic Oscillation (AO) index during 1989-1995 and the associated changes in sea ice dynamics. Since 1995, the centre of strong negative trend in September sea ice concentration has shifted from the East Siberian Sea to the Chukchi Borderland (CBL) region. The possible causes for this shift are (i) changes in atmospheric circulation, (ii) advection of ocean heat flux from Pacific and Atlantic based waters, (iii) enhanced solar heating of the upper ocean, and (vi) low-level clouds. It appears that all these factors contributed to the negative sea ice trend in the CBL region, but it is not clear which mechanism is most dominant or how the interaction and feedback mechanisms between the atmosphere, sea ice and ocean play out. Here we present the year-to-year variability of sea ice parameters (concentration, breakup/freeze dates and ice motion) and how the sea ice variability can be interpreted in the context of atmospheric/oceanic variability in the CBL region, which provides an insight into possible forcing mechanisms.

Sea Ice: Talk

Basal ablation in Arctic models of sea ice

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Basal ice ablation of Arctic sea ice during the summer is of critical importance in determining sea ice extent and thickness. We investigate the effect that an improved formulation of basal ice ablation has on model predictions of average sea ice thickness. In this new formulation the ice-ocean interface temperature is allowed to vary and the rate limiting effect of salt diffusion near the interface is taken into account. The importance of the improved physics is investigated with fifty year simulations of a sea ice model. Basal ablation depends upon the ratio of turbulent transfer coefficients of heat to salt; it is found that for conservative values of this ratio the improved basal ablation formulation results in a ~7% increase in average ice thickness, while for larger values of this ratio the increase in average thickness can reach ~13%.

Sea Ice: Talk

Declining Arctic sea ice is a thing of the past

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Guillaume Masse	U. Plymouth/CNRS Paris
Lindsay Vare	U. Plymouth
Thomas Brown	U. Plymouth
Steve Rowland	U. Plymouth
John Andrews	INSTAAR, Colorado, USA
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The recent decline in Arctic sea ice cover over the last 30 years has attracted significant media and scientific attention worldwide. Despite this, relatively little is known about the longer term palaeo sea ice record, although the results from proxy-based studies are starting to emerge. In Plymouth, we have been focusing our attention on the application of a novel biomarker approach to the elucidation of sea ice records for the last 30 kyr for locations across the Arctic. The biomarker is a mono-unsaturated highly branched isoprenoid lipid, termed IP25, that is made specifically by sea ice diatoms during the Spring bloom and is deposited in Arctic marine sediments upon ice melt. IP25 is straghtforward to detect by mass spectrometric methods and appears to be stable in sediments. No other biomarker has these attributes.

This presentation will consist of an introduction to the IP25 proxy, together with recent case studies that show how we have used it in conjunction with other climate proxies to provide palaeo sea ice records for the Canadian Arctic, North and West Iceland, the Barents Sea and Fram Strait . The data provide evidence for significant temporal and spatial variability in the sea record, information that is likely to be key for future climate modelling studies.

This NERC-funded project has benefited from extensive international collaboration with other European and North American (IPY) projects.

Sea Ice: Talk

Ice thickness characteristics in the Arctic Basin derived from submarine and AUV multibeam sonar data

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Multibeam sonar, as fitted to the UK submarine "Tireless", to the Autosub AUV and to smaller AUVs, has provided a new view of Arctic sea ice in which the full 3-D topography is revealed. This also demonstrates the accelerated melt of ridged ice as compared to undeformed ice in the general thinning and retreat of the ice cover which has been mapped by UK submarines over the past 38 years. We review the insights which this new tool has provided into the morphology and thermodynamics of Arctic sea ice.

Sea Ice: Talk – *Invited Speaker*

CryoSat and satellite observations of the polar regions

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Earth observation satellites provide the only means to obtain wide area, synoptic and continuous observations of the Earth's polar regions. Passive microwave sensors have provided observations of the polar regions for moire than 30 years revealing a steady decline in Arctic ice extent and increased melting of the Greenland ice cap. Synthetic Aperture Radar (SAR) data has provided information on sea ice motion and deformation and on the dynamic motion of glaciers and ice streams. The most recent techniques concern the use of satellite altimeters determination of changes in ice elevation and sea ice thickness, for the first time allowing us to constrain the mass balance of the Earth's polar ice masses. We review the strengths and limitations of these techniques and and show how in-situ and airborne data are critical in reducing uncertainties in measurements of the polar regions. We will also describe new and forthcoming missions, including Cryosat, which promise to provide an unprecedented view of the Earth's polar ice masses in the near future.

Marine Biogeochemistry and Ecology: Talk – *Invited Speaker*

Sea ice biogeochemistry - implications of changing sea ice conditions.

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Sea ice is an ephemeral feature both of the polar regions and also of seas such as the Baltic, Caspian and Okhotsk. At its maximum extent it covers 13% of the Earth's surface area, making it one of the major biomes on the planet similar, in terms of areal extent, to that of deserts and tundra. Underneath the snow lies a unique habitat for a group of organisms that are encased in an ice matrix dominated by low temperatures, concentrated brines and low light. Survival in these conditions requires a complex suite of physiological and metabolic adaptations. In fact sea ice organisms thrive in the ice, and their prolific growth gives them a fundamental role in Polar ecosystems. Adaptations to life within the ice matrix will be discussed within a framework of the implications of a potential reduction in sea ice cover in the Arctic.

Marine Biogeochemistry and Ecology: Talk

Physical mechanisms controlling Arctic primary productivity

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Until recently, the Arctic Basin was generally considered to be a biological desert and essentially escaped the attention of global or even basin-scale ecosystem modelling efforts. However, due to anthropogenic climate change, the Arctic Ocean's sea-ice cover is undergoing an unexpectedly fast retreat, and is exposing increasingly large areas of the basin to sunlight. As indicated by existing Arctic phenomena such as ice-edge blooms, this decline in sea-ice is liable to encourage pronounced growth of phytoplankton in summer and poses pressing questions concerning the future of Arctic ecosystems and brings modelling these to the centre of attention. The Arctic Ocean is an area where physical factors play a disproportionately significant role in plankton productivity compared with the rest of the World Ocean. As these factors are strongly responding to climate change, here we analyse the results from simulations of the ¼ degree resolution global ocean NEMO model coupled with the MEDUSA biogeochemical model, with a particular focus on the Arctic basin. We show that a substantial part of the variability of primary production can be explained by three physical factors: (i) maximum penetration of the winter mixing, which determines an amount of nutrients available for the primary production; (ii) upwelling rate, which provides an additional source of nutrients in localised areas and will potentially accelerate in future with further retreat of the sea ice beyond the shelf break; (iii) short-wave radiation at the ocean surface which controls the magnitude of the phytoplankton blooms.

Marine Biogeochemistry and Ecology: Talk

Optical Challenges in a Changing Arctic Ocean

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It is almost a truism to state that Arctic ecosystems are driven by strong seasonality in the availability of solar radiation, and that the marked reduction in summer ice cover forecast over the next decade will have profound effects on marine primary productivity. What is rather less appreciated, however, is the expectation that significant changes will occur in the inherent optical properties of the extensive shelf waters of the region in response to increased fluxes of suspended sediment and organic material from river basins. There are several reasons why it is important to quantify these changes. First, variations in water colour and turbidity have significant effects on the spectral quality of the underwater light climate and on the depth of the euphotic zone. Second, changes in the depth of penetration of ultra-violet radiation and in the rate of photo-oxidation of dissolved organic compounds will introduce significant unknowns into calculations of local carbon balances and air-sea gas fluxes. Third, changes in optical characteristics have significant implications for the viability of optical remote sensing of the Arctic Ocean. These waters already fall into the problematic Case 2 category for which standard ocean colour inversion algorithms (based on statistical regressions on global data sets) are known to perform poorly. Alternative, physics-based approaches to the inversion problem rely heavily on accurate knowledge of the specific inherent optical properties in the region of interest, and relevant measurements in Arctic waters are extremely rare. A rather more speculative hypo thesis suggests that changes in underwater visibility may alter the dynamics of competition between visual and non-visual predators and bring about shifts in the dominant organisms in higher trophic levels. This talk will review existing knowledge of the optical characteristics of Arctic waters and identify topics which urgently need to be addressed. It will also use results from numerical radiative transfer modelling to predict the scale of the changes that might be anticipated and to assess their implications for both remote sensing and marine primary productivity.

Marine Biogeochemistry and Ecology: Talk

Ocean acidification and climate change impacts on Semibalanus balanoides in the Arctic

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The barnacle Semibalanus balanoides is a major space occupier on rocky shores in Northern Europe and hence changes in its population ecology will have a major influence on other species. It is limited at the northern edge of its distribution by the ice-edge (and is hence found on Svalbard) and is restricted at the southern edge of its distribution by temperature. Here we present results from experiments on the temperature and carbon dioxide effects on S. balanoides cyprid and post-larvae growth, development and survival. Laboratory experiments from southern populations (Plymouth, UK) indicate that while increases in temperature impacted survival of post-larvae, increased CO_2 additionally delayed the metamorphosis of cyprids thereby increasing their exposure to desiccation. In contrast laboratory experiments on northern populations (Ny-Ålesund, Svalbard) indicate that there was very little impact from either elevated temperature or CO_2 on survival or the mineralogy of their shells but growth was significantly slowed by elevated CO_2 alone and by an interaction of temperature and increased CO_2. These results highlight that there may be profound interpopulation differences at the opposite range edges of a species geographic distribution.

Marine Biogeochemistry and Ecology: Talk

Seasonal patterns in vertical migration of marine zooplankton at high-latitudes: drivers and implications

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Margaret Wallace	Gatty Marine Laboratory, U. St. Andrews
Finlo Cottier	SAMS
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Polar oceans are major carbon sinks and the diel vertical migration (DVM) of zooplankton in these environments can contribute to the export of carbon through respiration and deposition of faecal pellets below the mixed layer. DVM is principally controlled by the day/night light-cycle and the extreme seasonality of this cycle at high latitudes can result in major alterations to DVM patterns over the course of the year. We investigated seasonality in DVM in the Svalbard archipelago using data from moored acoustic Doppler current profilers (ADCPs), in conjunction with net and sediment trap samples. Almost two years' worth of data (2006-08) were collected from two closely spaced fjords, of which one was seasonally ice-covered and the other, constantly ice-free. In both fjords, a synchronised movement of individuals was resolved in the backscatter data during spring and autumn, comprising of an ascent at dusk and a descent at dawn. Such synchronised movements almost disappeared during winter (continuous darkness) and mid-summer (continuous light). However, vertical velocity data revealed unsynchronised movements of individuals during mid-summer. Switches between different modes of DVM over the course of the year differed in their timing between the two fjords. In particular, the period of summertime asynchrony was almost 2 months longer in the ice-covered compared to the ice-free fjord. The melting of ice in the former fjord in the early autumn also disrupted the pattern of DVM considerably. The study provides evidence that the duration of ice cover can affect the seasonal cycle of DVM in Arctic environments, with likely consequences to the transport of carbon to depth

Climate and Palaeo-records: Talk

Modelling the Arctic Freshwater Budget

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I will review the current status of the freshwater budget simulated by coupled climate models in comparison to observational estimates. This will cover ocean freshwater storage and transport, river discharges and surface precipitation and evaporation. I will also try to highlight some issues relating to the robustness and uncertainties in future climate projections for the Arctic using the Hadley Centre's QUMP simulations.

Climate and Palaeo-records: Talk

Is decline of the Greenland ice sheet reversible?

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A series of simulations of the Greenland ice sheet coupled to a global climate model (HadCM3) have been conducted to investigate the recovery of the ice sheet from various states of decline. We find that that there are several stable states for the ice sheet under forcing from pre-industrial CO_2. Ice sheet volume trajectory followed depends on its initial state of decline. A threshold for full recovery of the ice sheet is passed if more than 15% of the ice volume is lost.

Climate and Palaeo-records: Talk

Recent climate change in arctic and peri-arctic regions- a paleoenvironmental perspective from peat bogs

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Central Alaska is currently seen as a global warming hotspot, with both modelled and measured warming rates among the most rapid in the world. This has significant implications for permafrost melting, ecosystem responses and carbon budgets. However, the palaeoclimatic record from most of Alaska on the critical decadal-century timescales is limited, and high resolution, quantified data are needed to put current changes into a historical perspective - how unusual is the current trend? Have there been past events with comparable rates of change? The aim of this paper is to review recent developments in peat-based palaeoclimate research in Alaska, which has seen the development of a testate amoebae species-environment model for Alaskan mires (Payne et al. 2006) and its application (Payne and Blackford 2008a).

In addition, recent developments in tephrochronology from the region allows precise correlation and accurate dating of the records (Payne et al. 2008; Payne and Blackford 2008b). Combined volcanic and climatic forcing of mire development has been illustrated (Payne and Blackford 2008c). Longer records from Faroes, Iceland and Greenland suggest a periodicity in peat response to climate forcing, and these will be described and analysed (Ellershaw, 2004; Blackford and Ellershaw, 2006). Unpublished data from central Alaska will be presented, showing significant fluctuations in mire wetness over century timescales. Overall, these data suggest (1) that climatic instability and rapid change characterise the late Holocene, (2) methods exist to extend this data set around the arctic regions, and (3) bog records can be combined with other proxy records to better understand climatic variability and climate-ecosystem linkages.

Climate and Palaeo-records: Talk

The Seasonal cycle of the late Cretaceous Arctic Ocean

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Laminated marine sediments represent a "palaeo-sediment trap" that provide the opportunity to reconstruct the seasonal cycle of production and flux from ancient seas. US and Canadian expeditions to floating ice islands in the Arctic between (1964-1983) recovered shallow buried laminated diatomaceous sediments from the Alpha Ridge of the Arctic Ocean. A new study of these cores using electron microscope techniques reveals the seasonal cycle of the Arctic Ocean during the greenhouse period of the late Cretaceous. Seasonal primary production was dominated by diatom algae but was not related to upwelling as previously hypothesised. Rather, production occurred within a stratified water column, involving specially adapted species in blooms resembling those of the modern North Pacific Subtropical Gyre, or those indicated for the Mediterranean sapropels. With elevated CO_2 levels and warming currently driving increased stratification in the global ocean this stratified-adapted style of production may become more widespread. Our evidence for seasonal diatom production and flux testify to an ice free summer, but thin accumulations of terrigenous sediment within the diatom ooze are consistent with the presence of intermittent sea ice in the winter, supporting a wide body of evidence for low Arctic late Cretaceous winter temperatures rather than recent suggestions of a 15°C mean annual temperature at this time.

Climate and Palaeo-records: Talk

Plant richness in the Early Eocene of the Canadian High Arctic

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Tundra regions of the high Arctic contain specialised plant communities that will undergo substantial fragmentation and extinction in the face of current and predicted future global warming. This will be accompanied by migration and geographic range expansions of lower latitude, temperate vegetation types. But the potential biodiversity of a greenhouse-warmed Arctic is unknown and the only records which provide biodiversity estimates of a greenhouse Arctic with which to test modelling assumptions are from the geological past. So under optimal climate conditions, how many plant species can the Arctic support? Here we use pollen records to show that plant richness in the globally warm Early Eocene (~54-52 Ma) in the high Arctic (Stenkul Fiord, Ellesmere Island, ~78°N) was approximately the same as that at mid-high latitudes in Wyoming, USA (44-47°N) but floras were assembled from different taxa not shared with North America or Europe. Results indicate that the Arctic regions are capable, under equable greenhouse climate conditions, of supporting a vegetation type similar in richness to present-day warm-temperate North America but not one that is winnowed from richer, lower latitude floras. Arctic floras in the early Cenozoic may be sourced predominantly from Asia. Alternatively, cosmopolitan plant species are present alongside plants that evolved in the Arctic regions. Apparent endemism may be due to (a) lack of knowledge on Asian plant occurrences, or (b) the vast geographic area present in the high Arctic coupled with prolonged equable climates which facilitated diversification of geographically widespread plant families.

Climate and Palaeo-records: Talk – *Invited Speaker*

Arctic forests and climates in a greenhouse world: a window into our future warm world?

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Fifty million years ago during the Eocene the climate was globally warm with atmospheric CO2 levels much like those predicted for our future warm world. Polar regions were free of permanent ice caps and were covered with forest vegetation, now preserved in the rock record as fossil plants. In the northern high latitudes in the Canadian Arctic broad-leaved deciduous forests were dominated by the deciduous conifer dawn redwood (Metasequoia) along with pines, spruce and larch. Flowering trees such as alder, birch, and hickory were also present, along with ginkgo and katsura. On Svalbard a fossil flora dominated by large birch leaves has been recovered, including also Metasequoia and the flowering tree katsura (Cercidiphyllum). Animals such as turtles, primitive horses and large browsing hippo-like mammals called Coryphodon lived in swamp-like environments. Climate signals in fossils and sediments indicate that this polar region experienced summers with relatively high temperatures (~24 °C) and with winter temperatures that remained mild, even as far as 80°N. As the present Arctic Sea ice melts are we looking forward to a tropical Arctic once again?

Physical Oceanography: Poster

The North Atlantic Inflow into the Arctic Ocean

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North Atlantic Water (NAW) plays a central role in the ocean climate of the Nordic Seas and Arctic Ocean. Whereas the pathways of the NAW in the Nordic Seas are mostly known, those into the Arctic Ocean are yet to be fully understood. To elucidate these routes the results of a high-resolution global coupled ice-ocean model are used. We demonstrate that in 1989 - 2004 the NAW inflow was equally divided between the Fram Strait and Barents Sea. Two mode waters in the Barents Sea branch are identified: a halocline water produced by surface cooling at shallow convective sites in the northern Barents Sea, and bottom water formed from NAW in the southeastern Barents Sea via full-depth convection and mixing. These two modes continue into the Nansen Basin along two separate routes: one through the northern Barents Sea shelf, and the other through the southeastern Barents Sea. Based on model transformation rates of the NAW and halocline waters, less than half of the NAW coming into the Nordic Seas reaches the Arctic Ocean relatively unmodified, the rest of it will have been modified in the Barents and Kara Seas with a large fraction re-circulating into the North Atlantic. The contribution of the Arctic Boundary Current in the Laptev Sea to the Eurasian Basin halocline was examined using model and observational data. The results suggest a double-core current: a conventional Atlantic Water (AW) flow, and a shelf break current, with a strength almost half of the AW flow, bringing light Barents Sea waters into the Arctic Ocean. Barents Sea wind forcing is the main driver of the shelf break current, through Ekman drift and potential vorticity inflow mechanisms. The model results show (i) the halocline loss in the Laptev Sea through intensive mixing and export, and (ii) that both advective and convective renewal of the Eurasian Basin halocline have a timescale of ca. 26 years.

Physical Oceanography: Poster

A UK marine observatory in the Arctic: Physical and biogeochemical shelf processes.

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Stig Falk-Petersen	Norwegian Polar Insitute
Vigdis Tverberg	Norwegian Polar Insitute
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Observations of the Arctic marine environment have unraveled the close coupling between the physical processes and the biological systems. The Scottish Association for Marine Science, working with Norwegian institutes, has maintained a near-continuous capacity for moored observations around Svalbard since 2002. The main focus, funded through Oceans 2025, has been on Kongsfjorden (Atlantic influenced) with identical deployments being made in Rijpfjorden (Arctic influenced). Data from these deployments has included physical, biological and geochemical parameters enabling interdisciplinary studies of shelf-fjordic processes on timescales ranging from daily to inter-annual. Here we outline some of the key scientific advances that have emerged from this bi-lateral, multi-discipline approach to arctic marine research. Specifically, we show the potential for exploiting these observations into a Pan-Arctic view of the marine system. Ultimately we aim to exploit these datasets across a range of Arctic marine projects with international research groups to answer questions on shelf-basin interactions and responses.

Physical Oceanography: Poster

Stable Isotopes a Tracer for Freshwater additions to the East Greenland Current and the East Greenland Coastal Current

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Observations over the last decade suggest both a thinning of the Arctic sea-ice cover (Rothrock et al., 1999; Laxon et al., 2003) and a dramatic reduction in its spatial extent (Comiso, 2002; Stroeve et al., 2005). We detect a positive change of ~10 ‰ between 2004 and 2005 in the stable oxygen isotope composition of the net freshwater component in the East Greenland Current (EGC) and East Greenland Coastal Current (EGCC), key carriers of freshened surface waters out of the Arctic. This isotopic signal is unique since at least the early 1960s and we show that it reflects a remarkable increase in the sea-ice melt water transport within these currents. Our findings suggest that a large proportion of the sea-ice meltwater resulting from the rapid reduction of Arctic sea-ice is exported from the Arctic via the EGC/EGCC into the northern North Atlantic. Additionally it appears that this sea-ice meltwater export is not in phase with atmospheric circulation regimes such as the North Atlantic Oscillation and the Arctic Oscillation. These findings might have important ramifications for the global thermohaline circulation (e.g. Rahmstorf, 2005).

Physical Oceanography: Poster

Impact of freshwater ice melt on surface circulation in the Barents and Kara Seas

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The surface circulation currents in the Barents and Kara Seas are presently not well known due to the area previously being covered in ice. However, during this century there will be no September sea ice in the Arctic; it is melting at a faster rate than expected as indicated by recent observations, causing rapid implications on circulation. The aim of this study is to investigate the surface circulation in the Barents and Kara Seas and to determine the changes of the water column structure by using a limited number of Argo floats, archived CTD measurements and remotely sensed data. The implications of increased freshwater input upon circulation are to be identified; it is hypothesized that the surface circulation velocity will increase with increased freshwater input.

Physical Oceanography: Poster

Mapping ocean structure at the mesoscale

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Seismic oceanography offers, for the first time, the ability to visualise boundaries and gradients in the water column with unprecedented lateral resolution. These data provide the link between models and reality as typically sampled by conventional oceanographic surveys. Examples will be shown of seismic data (and corresponding physical oceanography data) from: 1) the Faroe-Shetland channel which maps the mixed water boundary between the deep Nordic Sea water and the upper North Atlantic water; 2) intrusions and staircases associated with an eddy with examples from the Gulf of Cadiz; 3) major fronts in the South Atlantic; and 4) dense bounded flows with example from the southern Adriatic. In each case the new information about the spatial relationships provide new insights and understanding into mesoscale ocean processes.

Physical Oceanography: Poster

Arctic outflows in the western North Atlantic subpolar gyre

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The western subpolar region, encompassing the Labrador Sea, the Eirik Ridge and the southwest Irminger Sea, contains all the major shallow and deep Arctic outflows. The outflows are concentrated in the boundary currents that trace the outer edges of the basins. Results from a fieldwork programme from 2005 to 2008 show that the pathways are more complex than previously thought, describing a new route for shallow Arctic freshwater into the interior of the subpolar gyre. Synoptic and long-term velocity measurements are used to provide volume transport and freshwater flux estimates for the shallow and deep outflows.

Physical Oceanography: Poster

Seasonal Variability of the Nordic Seas Circulation

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The Nordic Seas are the regions of exchanges between the Arctic and the Atlantic oceans. Furthermore, they are the regions of deep-water formation. By providing a substantial part of the source waters for North Atlantic Deep Water the Nordic Seas influence the global thermohaline circulation. Therefore, an understanding of the Nordic Seas circulation and its variability is needed to determine how changes in the high latitude climate affect the global thermohaline circulation and the regional climate. Although the summer circulation in the region is known from in-situ and other measurements, knowledge about the winter circulation is limited because of the unavailability of data from the ice-covered seas. However, Peacock and Laxon (2004, J Geophys Res, 109, C07001) showed that it is possible to derive sea surface height anomaly from satellite altimeter in the ice-covered seas. The study presents this novel satellite-altimeter data derived from ice-covered seas combined with altimeter records from the open ocean. Envisat altimeter data for a six-year long period, beginning in October 2002, has been used and corrected by applying a set of relevant geophysical corrections. Seasonal variability of the sea surface height anomaly is presented.

Physical Oceanography: Poster

Deep ocean time-series observations in the Norwegian Sea

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EuroSITES (www.eurosites.info) is a 3 year European FP7 Collaborative Project which will integrate and enhance 9 European deep ocean observatories towards a multi- and inter-disciplinary network encompassing the full water column to the seafloor and subseafloor. Coordinated by the National Oceanography Centre Southampton, integration will be achieved through enhancement and standardization of existing in situ infrastructure through best practice and common data management. Geographical coverage of the Eulerian network spans from the Subtropical Atlantic to the Mediterranean and Norwegian Seas. A key site within the network is Ocean Weather Ship Station (OWS) M in the Norwegian Sea (66°N, 02°E). Having performed daily oceanographic measurements since 1 October 1948, this site presents the longest existing homogeneous time series from the deep ocean. The location of the time-series site has proved to be strategic for studying trends and changes in the Atlantic inflow and the Norwegian Sea Deep Water. 60 years of hydrographical time series data have provided a fascinating glimpse of the delicacy-of-balance of deep exchanges between the Norwegian Sea and the surrounding seas. The upper 1000 m has experienced a strong freshening since the arrival of the Great Salinity Anomaly in the 1970s. During the recent years the salinity and temperature of the Atlantic water entering Arctic have also increased. These compelling results support the case for sustained, integrated long-term times-series in the Norwegian Sea and the Arctic region. Within the EuroSITES project (2008-2011) Station M will enhance the current infrastructure with a sub-surface mooring to complement the existing sampling carried out from the OWS Polarfront. Future plans include the addition of biogeochemical sensors to measure parameters including chl-a, nitrate, CO_2 and pH. In addition, EuroSITES is working with existing initiatives in the Arctic e.g. the HAUSGARTEN observatory and the ACOBAR FP7 project to extend the integrated network to include the Arctic and in particular the Fram Strait.

Physical Oceanography: Poster

Vertical Mixing at Intermediate depths along the Arctic Ocean boundary

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Microstructure and hydrographic observations, during September 2007 in the boundary current on the East Siberian continental slope, document upper ocean stratification and along-stream water mass changes. A thin warm surface layer overrides a shallow halocline characterized by a 40-m thick temperature minimum layer beginning at about 30 m depth. Below the halocline, well-defined thermohaline diffusive staircases extended downwards to warm Atlantic Water intrusions found at 200-800 m depth. Observed turbulent eddy kinetic energy dissipations are extremely low (<10 microWatts per cubic meter), such that double diffusive convection dominates the vertical mixing in the upper-ocean. The diffusive convection heat fluxes are an order of magnitude too small to account for the observed along-stream cooling of the boundary current. Our results implicate circulation patterns and the influence of shelf waters in the evolution of the boundary current waters.

Physical Oceanography: Poster

The effect of bathymetry on the propagation of Atlantic water anomalies

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The barotropic and baroclinic response of an idealised Arctic Ocean model to the introduction of anomalies in the depth and thickness of the Arctic Atlantic layer is examined. The model domain is a circular basin where shelves of arbitrary depth and width, as well as ocean ridges, can be introduced. The model configuration is based on NEMO 3 with a horizontal resolution of 10 km. It includes a free surface and an initial 2-layer stratification derived from World Ocean Atlas 2005 data. The model has been validated by reproducing laboratory experiments (Wake et al., 2004) and analytical solutions of simple linear problems.

Physical Oceanography: Poster

Eddy length scales and the Rossby Radius in the Arctic Ocean

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Stratification is weak in the Arctic Ocean, so the first-mode internal Rossby radius, the length scale of eddies, is typically 5-15km, instead of the 30-50km characteristic of the mid-latitude ocean. Current oceanic general circulation models (OGCM's) have at best a resolution of 0.1° ~10km. Given that two gridpoints per eddy radius are thought necessary to adequately resolve the eddies, and one gridpoint to 'permit' eddies, it is important to know the field of the Rossby radius so that we know where the ocean models will describe the eddy field adequately and where they will not. Here we present fields of the Rossby radius over the Arctic. We find relatively large Rossby radii over the central Arctic, ~15km, but much smaller values over the continental slopes and the shelves.

Physical Oceanography: Poster

Dissolved nutrient distribution in the Laptev and East Siberian Seas during the two record ice free years of 2007 and 2008

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Two oceanographic cruises to the Laptev Sea and Eastern Siberian Sea were conducted during the record ice-free years of 2007 and 2008 (September and October respectively) as part of the NERC-funded Arctic Synoptic Basin-wide Oceanography programme. We address the question of whether nutrient distributions in 2007 and 2008, within these regions, are consistent with current predictions of Arctic Ocean warming via the increased influence of Atlantic Water. In order to investigate this, water mass and nutrient distributions were evaluated using potential temperature - salinity (θ-S) plots and an Optimum Multiparameter Analysis (OMP), which were then compared with historical data. N to P ratios of 18.6 and 16.9 for 2007 and 2008 respectively are consistent with a ratio of 17.5 reported in the literature as characteristic of the Atlantic Water. However, vertical sections reveal nutrient isolines being shallower than historical data and preliminary OMP results show a stronger presence of the Atlantic Water, which would suggest a slight thickening of this water mass by approximately 50 m. Whether these observations show part of the normal variability or reflect changes currently taking place in the Arctic requires further analysis.

Physical Oceanography: Poster

Towards a pan-Arctic Ocean inverse model

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As the integrated Arctic Ocean Observing System (iAOOS) is getting established, we have much better observations across the main gateways of the Arctic Ocean (Davis, Fram and Bering straits, and Barents Sea Opening). We are able to enclose the Arctic ocean using these hydrographic sections for a certain period. We are trying to estimate oceanic fluxes through these gateways by using inverse techniques applied to hydrographic, moored current meter and other available data in summer 2005. We will show the preliminary model diagnostics of ocean circulation and associated heat and freshwater fluxes.

Atmosphere and Methane: Poster

Ice-Cloud Coupling in the Central Arctic Ocean – Measurements from the ASCOS Campaign

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Joseph Sedlar	U. Stockholm
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The atmospheric boundary layer over the central Arctic Ocean is usually shallow and near-neutral or weakly stable during the summer months. Shallow stratiform clouds and fog are near-ubiquitous features. Turbulent coupling between the surface and the cloud layer is often weak and sporadic or non-existent. The Arctic boundary layer and clouds are very poorly represented in models, in part due to a lack of basic understanding of the unique nature of some of the physical processes in the Arctic environment. A central goal of the Arctic Summer Cloud-Ocean Study (ASCOS) programme is to better understand the processes that control the formation, properties, and dissipation of Arctic stratus. Here we will present some of the measurements of boundary layer structure, surface fluxes, and cloud properties obtained during the ASCOS field campaign during August 2008 along with some comparisons to forecast fields from the Met Office Unified Model.

Atmosphere and Methane: Poster

Seismic imaging of gas hydrate and free gas based on ocean bottom seismometer data along the continental margin of Western Svalbard

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The stability of shallow gas hydrates in the Arctic region is expected to be affected by the warming of the bottom-water in the next decades. It is, therefore, important to evaluate how the gas hydrate systems will react to future increases in bottom-water temperature and the impact on climate of the spatial and temporal variability of the release of methane from these reservoirs. As part of the International Polar Year initiative, a multidisciplinary marine expedition was carried out in August-September 2008 along the continental margin west of Svalbard in the Arctic Ocean. One of the objectives was to investigate the extent of the gas hydrate stability zone (GHSZ) along the continental slope and the quantity of methane present from the geophysical properties of methane hydrate- and gas-bearing sediments. 13 ocean-bottom seismometers (OBS) were deployed on 5 representative sites along and across the continental margin as part of the project. The high frequency airguns were fired at 5-s intervals, concurrently with the acquisition of multi-channel seismic reflection profiles. The OBSs were equipped with a 3-component 4.5 Hz geophone package and a broadband hydrophone; the data-loggers were operated at 1 kHz sample rate. The OBS experiments were designed to recover P- and S-wave velocities to depths of a few hundreds metres below the seabed in order to estimate the amount of hydrate in the region. The data show clearly recorded P reflections at short offsets, as well as refracted arrivals at larger offsets, from depths up to 2 kilometres below the seabed. The P-wave velocities were modelled for two sites located above and below the upper limit of GHSZ, using a ray tracing and forward modelling method. The resulting velocity model for the site below the upper limit of the GHSZ indicates the presence of a low velocity zone (1.60 km/s) about 160 m below the seabed which is interpreted as a free gas reservoir. However, no clear bottom simulator reflector (BSR), i.e. acoustic contrast between the gas hydrates and free gas, has been recognised yet for this site. The velocity model for the second site above the upper limit of the GHSZ indicates high velocity compact sediments with no clear evidence for free gas or gas hydrates. Further modelling of the P- and S-wave velocities will provide a better understanding of the sub-seabed distribution of the seismic properties from which the amount of hydrate present in the sediment can be estimated and features indicative of its presence recognised.

Atmosphere and Methane: Poster

Evidence for the emission of reactive halocarbons from open leads in Arctic sea ice during COBRA

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Recent observations of reactive halogens in the Antarctic atmosphere show that polar sources are significant. In the upper troposphere, photooxidation of organobromine compounds (such as $CHBr_3$, CH_2Br_2 and $CHBr_2Cl$) produces reactive bromine, which contributes to the reduction of ozone. Short-lived organobromine compounds and their oxidation products may also be delivered to the stratosphere through rapid convection from the marine atmospheric boundary layer. In the atmospheric boundary layer, reactive iodine has been implicated in ozone depletion and particle formation processes, which impact both the oxidative and radiative capacity of the atmosphere and may thus affect climate. However the precursors of reactive iodine are currently unknown. Due to their rapid photolysis within the boundary layer, very short lived halocarbons (mono-, di- and tri-halogenated organics) containing iodine are a possible source. Current research suggests both biotic and abiotic sources of halocarbons in polar regions. During the COBRA (Impact of COmbined Bromine and Iodine Release on the Arctic atmosphere) campaign on the east coast of Hudson Bay (55.30°N, 77.73°W) during Feb-Mar 2008, measurements in air suggest these gases are predominantly vented from open leads. Measurements made in sea-ice show that elevated iodide and halocarbon concentrations at the bottom of the ice, where chlorophyll-a levels are also highest, suggesting biological production of reactive halocarbons on the bottom of sea-ice may occur.

Atmosphere and Methane: Poster

Trace Gases from Firn Air: UEA Atmospheric Chemistry Group

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This poster presentation will be looking at results obtained by the Atmospheric Chemistry Group: University of East Anglia (UEA). The group has been making measurements on a suite of trace gases extracted from firn air samples. These experiments have produced data sets of atmospheric concentration, for a number of trace gases that reach back to around the middle of the last century. Firn is defined as 'old' snow that has been recrystalized into a more dense substance. Firn can be distinguished by its density which is greater than 0.55 g cm^{-3} compared to 'fresh' snow which has a density of about 0.1 g cm^{-3}. Air is then able to diffuse through this permeable layer. This air is then extracted at increasing depth to give a record of the past composition of the atmosphere. The major trace gases measured are the chlorofluorocarbons (CFCs), the hydrochlorofluorocarbons (HCFCs), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and other organic Halogens. These gases are important because of their Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) as well as their significance in other atmospheric chemistry reactions. These results will help us refine our understanding of the amount, distribution and changes in the chemical makeup of the atmosphere. Here we will present data sets obtained from firn air collected by two drilling projects. Firstly the North Greenland Ice core Project (NGRIP project), located at 75.1°N and 42.3°W, where the firn air was extracted during the northern summer of 1999. The second drilling project analyzed was the North Greenland Eemian Ice drilling project (NEEM project), located at 77.5°N 51.1°W, where the firn air was extracted during the northern summer of 2008. Both sets of measurements were analyzed on a gas chromatography - mass spectrometer (GC-MS) facility based at the UEA. Comparison between these two firn columns will highlight the major changes in atmospheric concentration since the middle of the last century as well as the recent trends.

Atmosphere and Methane: Poster

Dissociation of Arctic gas hydrates: Effects on ocean chemistry

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A recent expedition to the Arctic Ocean off the western coast of Svalbard has recorded the presence of more than 250 plumes of gas bubbles, close to the landward limit of the gas hydrate stability zone. Water column measurements show that bottom waters in this area are enriched in dissolved methane (by up to a factor of 60 above background), while surface waters have dissolved methane concentrations that are close to those recorded at the background site. Levels of dissolved oxygen are slightly reduced in waters that have high methane concentrations, presumably because of methane oxidation which produces carbon dioxide. On the same expedition, gas hydrate was discovered at two locations in deeper waters within the gas hydrate stability zone. Porefluid chemistry suggests that, in most cases, methane produced by dissociation of gas hydrate is consumed within the sediment column by anaerobic oxidation processes.

Atmosphere and Methane: Poster

Polar boundary layer ozone depletion events and their link to blizzards, blowing snow and changes in sea ice

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Boundary layer ozone depletion events (ODEs) are well known phenomena that occur in both polar regions in springtime. During an event, ozone mixing ratios can fall to below instrumental detection limits within a few minutes and remain suppressed for several days. The ozone destruction is driven by halogen gases, in particular bromine, which has a source associated with sea ice. The mechanism whereby bromine from sea water is liberated into gaseous catalyst is not well understood, nor are the environmental conditions that favour ODEs. Observations are generally limited to coastal sites simply because of the difficulties associated with accessing the sea ice zone in spring. From the observations, it is generally believed that ODEs are favoured by low wind conditions, in which a stable boundary layer enables emissions to build up, thus exacerbating destruction reactions. Events observed during strong winds are generally assumed to be associated with transported of depleted air masses. However, recent modelling work, together with observations made in Antarctica, challenge this view. The modelling work suggests that blowing snow is a source of sea salt aerosol from which bromine can be liberated; the observations report an active ODE, coincident with elevated mixing ratios of bromine monoxide (from satellite measurements) where it was clearly extremely stormy. As yet, such a scenario has never been reported for the Arctic. We use satellite images of BrO together with ECMWF re-analyses, to probe links between severe low pressure systems (with high wind speeds and blowing snow) and areas with high concentrations of BrO for both Antarctica and the Arctic. The results provide considerable insight into the mechanisms driving ODEs, and raises questions concerning future halogen and surface ozone budgets given likely changes to sea ice, particularly in the Arctic.

Atmosphere and Methane: Poster

Investigating long-range transport of pollution to the Arctic troposphere using aircraft observations and a global chemical transport model

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Surface temperatures in the Arctic have increased more than in any other region over the past few decades. A better understanding of the processes governing this warming, including the role of short-lived greenhouse gases, is therefore urgently required. During summer 2008, the POLARCAT campaign aimed to collect an extensive gas-phase and aerosol dataset within the Arctic troposphere, which will aid the evaluation of our understanding of oxidant photochemistry and aerosol processing in the region. Previous comparisons of global chemical transport models have shown that they exhibit large variability in their Arctic chemical budgets, indicating that the processes controlling Arctic tropospheric composition are not well understood or represented within models. Here, we will use new trace-gas observations from the French ATR and German DLR Falcon aircraft during the POLARCAT experiment to evaluate the ability of a global chemical transport model (TOMCAT) to simulate the summertime transport of pollutants to the Arctic, and their impact on oxidant budgets. In particular, we aim to quantify the impact of anthropogenic and biomass burning sources on the Arctic tropospheric ozone budget. Initial results show that the model underestimates observed concentrations of CO, which has led to a re-evaluation of the different sources of CO to the region. Model performance in the Arctic is highly sensitive to the treatment of boreal biomass burning emissions. Boreal biomass burning plumes were sampled frequently over the course of the campaign therefore accurate representation of emission injection heights and fire locations is essential. Model CO is improved with real-time satellite derived daily biomass burning emissions, however large uncertainties in these emissions result in large variability in the Arctic CO budget. We will also present results on the ability of the model to capture pollution transport pathways to the Arctic and contributions to the oxidant and NOy budgets from different sources.

Atmosphere and Methane: Poster

Has climate change affected the shallow marine gas hydrates in the Arctic? A multichannel reflection seismic survey to document the evidence offshore Svalbard

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A likely result of global climate change is warming of ocean bottom sediments and resulting destabilisation of marine gas hydrate, which could lead to the release of methane into the ocean and atmosphere. One site in the Arctic which has shown prominent effects of recent warming is Svalbard, Northern Europe. In order to document the impact of recent warming on the gas hydrate within shallow marine sediments, a multi-disciplinary cruise on RRS James Clark Ross was conducted offshore Svalbard in August-September 2008. During this cruise we collected multichannel high resolution seismic reflection data (1 ms sample interval and 3.125 m common mid-point spacing), side-scan sonar data, and multi-beam bathymetry data from this region. The specific objectives of the cruise included: (1) to outline the shallow structures of the gas hydrate stability zone including shallow fluid flow areas, to ascertain the potential impact of gas hydrate instability; (2) to investigate the distribution and character of potential sea-floor failures (slides) and their relationship to gas hydrate deposits. We present initial results from a subset of the profiles which have been processed. In these profiles, we identify (i) bottom-current controlled processes like contourites and sediment waves on the slopes and glacial debris flow in the shallow shelf, (ii) palaeo-slope failures draped by later hemipelagic sediments and contourites, (iii) gas clouds and gas chimneys, (iv) bottom simulating reflectors as a proxy for the base of gas hydrates. Future study aims at mapping the sedimentary structures, slope failures in a regional scale, classification of the fluid migration features and understanding the possible link between hydrate dissociation, slope failure and approximate timings with relation to the sedimentation history.

Atmosphere and Methane: Poster

Isotopic characterisation of Seasonal Methane Emissions from a Finnish Arctic Wetland

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Arctic wetlands are a major source of methane to the atmosphere. To identify the contribution from this source to the global methane budget, the isotopic signature of wetland emissions needs to be known.

In August 2008 and May 2009, diurnal air sampling campaigns were carried out at Lompolojänkkä, a Finnish aapa mire, to determine its methane emission signature ($\delta^{13}CCH_4$). Air samples were also collected at a nearby forest station, Kenttärova, and hilltop station, Sammaltunturi, to provide comparisons with local background air. These three stations (run by the Finnish Meteorological Institute) are within the Arctic Circle and contribute to the Global Atmospheric Watch network. The 'diurnal' technique has significant advantages over conventional chamber measurements, as they show a representative source signature of the wetland rather than sampling local micro-environments, and they measure the emissions directly in air, after leaving the wetland.

Keeling plot analyses of air collected during the diurnal sampling campaigns at Lompolojänkkä show a representative wetland-wide stable carbon isotope source signature of -68.8 ± 0.6 ‰ in mid to late summer and -66.3 ± 0.6 ‰ during the spring melt. Over the winter months, any methane produced in the wetland is trapped beneath the snow and is used as a substrate by methanotrophic bacteria, which act at a reduced rate in colder conditions and, subsequently, cause only a small shift in the source signature of the leftover methane. This methane is then emitted during the spring melt.

The highest emissions of methane during the May 2009 diurnal sampling campaign were seen during the temporary refreezing of the wetland, when overnight temperature suddenly plummeted. This indicates that a significant portion of the 'burst' of methane observed during the spring melt period occurs due to freezing of the wetland.

Arctic wetlands may already be responding strongly to Arctic warming. Methane is a potent greenhouse gas and there is thus a likelihood of feedback - the warming feeding the warming, as the summer season becomes lengthier.

Atmosphere and Methane: Poster

Methane release from gas hydrate on the Western Svalbard continental margin since the last glacial maximum

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The release of methane from gas hydrate at continental margins has been proposed as a positive feedback mechanism in past climate warming. Improving understanding of how hydrate systems have responded to warming and sea level change since the last glacial maximum will help predictions of their behaviour in the future. Predictions of the changing hydrate stability field on the continental shelf of west Svalbard since 20ka are presented. The behaviour of the system has been controlled by local sea level change, and variable flow of Atlantic waters, changing the temperature profile within the water column. The West Spitsbergen Current (WSC) flows northwards along the Svalbard margin, transporting heat to the Arctic, and making this area particularly sensitive to changes in ocean circulation. Ocean warming will cause the hydrate stability zone to retreat down slope leading to dissociation of hydrate that is no longer in the stability zone. Modelling is used to determine the factors governing how fast the hydrate stability zone will retreat and the rate of hydrate dissociation.

Terrestrial Glaciology: Poster

Seasonal evolution of supra-glacial lake volume from ASTER imagery

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Water stored in and released from supra-glacial lakes is an important factor when considering the seasonal and long-term evolution of the Greenland Ice Sheet. Here, we use a radiative transfer model to estimate changes in the depth and volume of a supra-glacial lake on the surface of Jakobshavn Isbrae in western Greenland between 2002 and 2005. When compared to estimates of the lake depth determined from airborne LiDAR observations, we estimate that the root mean square departure of the modelled lake depths was 0.3 m during cloud-free conditions. The maximum lake area, depth, and volume, were 3.4 km^2, 9.6 ± 1.0 m, and 18.6 ± 3.7 x 10^6 m^3, respectively. When sequenced according to the number of positive degree days (PDD's) accumulated prior to each image, we observe the lake volume to evolve in three distinct phases. At the start of the melting season, the rate of filling is slow; after approximately 80 PDD's the rate of filling increases by a factor ~ 3, and after approximately 125 PDD's the lake drains rapidly. We estimate that the lake drains at a minimum rate of 2.66 ± 0.53 x 10^6 m^3 day^{-1} over a six day period.

Terrestrial Glaciology: Poster

Potential of borehole optical televiewing for determining the 3d structure of glaciers: case study of Midre Lovènbreen, Svalbard

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The principles and operation of borehole optical televiewing (OPTV) are presented, and the potential glaciological applications of the technique are summarized. These include full 3d structural and facies mapping as well as virtual ice core recreation and (actual) ice core orientation. Details of the application of the technique to investigations of glacial sediment transfer are illustrated with reference to a case study from the frontal zone of Midre Lovènbreen, Svalbard. Here spatial interpolation between eight borehole OPTV logs reveals eight separate structural features: (i) primary stratification; (ii) longitudinal foliation; (iii) transverse fracture traces; (iv) arcuate shear planes; (v) oblique fractures; (vi) large-scale lateral folds; (vii) medium-scale horizontal folds; and (viii) small-scale horizontal folds. OPTV reveals basally derived englacial sediment layers intercalated within primary stratification, elevated into near-vertical planes around a central fold axis by large-scale lateral folding. Supraglacial longitudinal debris ridges are classified into two types on the basis of their morphology and association with glacier structure. Type-I debris ridges are formed by the exposure of large-scale lateral fold-axes at the glacier surface in response to the convergence of multiple flow units into a narrow ice tongue. Type-II debris ridges, in contrast, undergo secondary deformation by small-scale horizontal folding in association with vertical displacements across arcuate shear planes in response to longitudinally compressive stresses at the glacier terminus.

Terrestrial Glaciology: Poster

Has dynamic thinning switched off in south-east Greenland?

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Following a relatively stable period during the 1990's, dramatic changes have been reported for many tidewater outlets in the south-eastern part of the Greenland Ice Sheet (GrIS). Results from measurements using the GRACE (Gravity Recovery and Climate Experiment) mission clearly identified the south-eastern part of the GrIS as having the highest rates of mass loss (1, 2). Two of the major outlet glaciers in this area, Helheim and Kangerdlugssuaq, accelerated by about 100 % and 40 %, respectively, and their calving fronts retreated by several km (3). Retreat and acceleration occurred in two phases during summer 2003 and 2005 at Helheim, and in a single period between late 2004 and early 2005 at Kangerdlugssuaq. Further south widespread glacier acceleration between 1996 and 2005 affected most of the outlet glaciers (4). In all Greenland's mass loss was calculated to have doubled in the period (4). Increased discharge due to thinning in the marginal areas, coupled to rapid changes in ice dynamics and synchronous retreat of their calving front positions, led to speculations that the GrIS had crossed a "tipping point" induced by global warming. However, subsequent studies showed that during summer 2006 Helheim and Kangerlugssuaq had simultaneously slowed down and their thinning had stopped. Because variability in the ice sheet's mass loss results mostly from the SE Greenland sector, further understanding of the nature, distribution, and controls of dynamic change in this region is essential. In order to examine the extent of the dynamic changes and to identify their cause we used satellite data to measure glacier surface elevation and calving front positions of 24 outlets of 14 major tidewater terminating glaciers, as well as speeds of 9 outlets in SE Greenland. We concentrate on the region where the GRACE data show highest rates of mass change and our data cover the period during and after the cessation of fast flow and thinning at Helheim and Kangerdlugssuaq (2004-2008).

We used digital elevation models (DEMs) extracted from ASTER stereo-satellite images to measure elevation changes near the glacier margins. Further, we used cross-correlation tracking from ASTER, Landsat 7, and ENVISAT-ASAR data, as well as repeated airborne lidar profiles to derive glacier flow speed estimates. For the first time, we will characterise multi-decadal glacier changes for the whole south-eastern part of Greenland aiming to answer the questions: (i) Has mass loss slowed in the whole of the south-east of Greenland and dynamic thinning switched off? (ii) What are the controls of SE Greenland glacier dynamics?

(1) Chen JL, Wilson CR, Tapley DB, *Science* **313** 1958 (2006).
(2) Velicogna I Wahr J, *Science* **311** 1754 (2006)
(3) Luckman A, Murray T, de Lange R, Hanna E, *Geophys. Res. Lett.* **33** L03503 (2006).
(4) Rignot E, Kanagaratnam P, *Science* **311** 986 (2006).

Terrestrial Glaciology: Poster

Regional and temporal variations in the formation of supraglacial melt ponds on the Greenland Ice Sheet

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Surface melt ponds form seasonally in the ablation zone of the Greenland Ice Sheet and they have been shown to provide the sites for the hydrofracture initiation of the moulins required for supraglacial meltwater to reach the bed of the Greenland Ice Sheet (Das et al., 2008). Studies to date have been restricted to a region of large surface lakes surrounding the Jakobshavn Isbrae catchment area (Box and Ski, 2007). However, large surface lakes also develop seasonally in other areas of the ice sheet, especially in the northern regions. We have developed a high temporal resolution dataset of lake evolution and drainage in all of the regions of the Greenland Ice Sheet where large surface lakes develop during summer. This study spans the period 2001-2008 using approximately 200 MODIS scenes per melt season per region. We show that there are significant regional differences in the supraglacial hydrology of the ice sheet, which could cause spatial variations in the role of melt water in ice dynamics across Greenland as it responds to the warming climate.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

The Gakkel Ridge: a very-low-melt-flux end-member of lithospheric accretion processes

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Studies on the ultra-slow spreading Gakkel and Southwest Indian Ridges have discovered what appears to be a novel form of plate accretion. This is characterised by long, axis-parallel lenticular ridges that appear to be mantle blocks rising directly out of the seafloor on low-angle faults in regions where seismic layer 3 is largely absent (Dick et al., Nature, 2003). These structures are essentially different both from the volcanic ridges and high angle normal faults associated with "normal", melt-rich seafloor spreading and from the oceanic core complexes that locally exhume mantle in areas of intermediate melt supply, and may represent the very-low melt flux end-member of seafloor spreading. To date these structures have only been imaged and sampled at a regional scale, so their detailed study represents an important opportunity for UK Arctic geoscience. As well as their intrinsic geodynamic interest, they provide an excellent opportunity for obtaining fresh mantle samples, and may yield hitherto unknown examples of peridotite-hosted hydrothermal activity, vent biology and microbiology. These features should be studied with tools such as Autosub 6000 and, ice permitting, Isis and oriented rock drills.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

Climate change impacts on reindeer population dynamics

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Understanding the population dynamics of reindeer/caribou (Rangifer tarandus) is important because in the High Arctic their presence converts moss and lichen dominated vegetation communities to ones dominated by grasses and sedges. Thus, Rangifer are a keystone species in this environment. However, it is unclear how their population dynamics will change under current climate change. Will generally warmer conditions, leading to earlier spring melt and higher plant productivity, result in population growth? Or will milder winters, with more occasions when temperatures rise above zero, lead to extreme icing events and population crashes? Since body weight influences both birth and survival rates, which tend to co-vary between years, we explore variation in body weight of individual Svalbard reindeer over 15 years. Body weight in April is most strongly influenced by total precipitation when temperature is above freezing in December and January, with some of the residual variation associated with population density in the previous summer. However, there was no detectable effect of either the weather the previous summer or direct measures of plant productivity. Our model of December/January weather explains birth and death rates of reindeer in our study area for 15 years prior to our series of body weight measurements. We speculate about the longer term consequences of climate change on reindeer populations and the likely succession in vegetation communities, as climate continues to warm.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

Bathymetry, Controlled Source Seismic, and Gravity Observations of the Mendeleev Ridge; Implications for Ridge Structure, Origin, and Regional Tectonics

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Multi-channel-seismic (MCS), seismic refraction, and gravity data collected over the Mendeleev Ridge from USCG Icebreaker Healy have been processed and interpreted to describe the crustal style of the ridge, as well as the structural and depositional history. These results provide constraints on the origin of the ridge, and the tectonic evolution of the Amerasian Basin. MCS images reveal two primary sediment sequences separated by an unconformity that persists across the entire Mendeleev Ridge. The basement and lower sediment sequence exhibit pervasive normal faulting. The upper sequence is laterally conformable and not effected by faulting, thus the regional unconformity dividing the two sequences is interpreted to mark the end of extensional deformation. Modeling of sonobuoy seismic refraction data reveals an upper crustal velocity structure consistent with either a volcanic rifted continental margin, or an oceanic plateau. Observed gravity anomalies collected along the MCS lines can be reproduced by a model consisting of bathymetry, sediment and basement horizons from the MCS data, and a crust of 2.86 g cm^{-3}. This result is consistent with homogeneous, mafic crust. The similar velocity and density structures of the Mendeleev and Alpha ridges is consistent with a model where the two ridges are contiguous and share a common geologic origin. Three tectonic models are presented for the origin of the Alpha Mendeleev Ridge (AMR) that satisfy constraints set by this and previous studies.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

Thermokarst lakes and feedbacks to climate change

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Thermokarst Lakes (TKLs) dominate large areas of the Arctic land surface and may expand as permafrost continues to warm and thaw. They are linked to climate change through a potentially sizeable trace-gas feedback to the carbon cycle. A combination of remotely-sensed surface and sub-surface observations, measurements of trace-gas flux, incubations of sediment, and analyses of dated permafrost-soil and lake-sediment cores will inform a quantitative model of CO_2 and CH_4 emissions from TKLs in Alaska and Siberia from the LGM to the present. Using permafrost characteristics, geomorphologic constraints and earth-system model-based projections of future climate change, we will attempt to estimate CO_2 and CH_4 emissions from TKLs during the next 100-200 years as a positive feedback to climate change. The first year's work in remote sensing on the northern Seward Peninsula, Alaska, has used a range of multi-sensor and multi-temporal satellite datasets to quantify recent changes in lake area and drainage rates and provides the basis of more accurate classifications of land-cover, including lakes, drained basins, and other forms of thermokarst terrain. A bubble-mapping approach to assessing methane flux indicates within- and between-lake patterns of flux intensity. Preliminary results indicate expansion rates are related to local topography and within-lake differences in gas flux can be linked to the structure of permafrosted ground and to lake expansion.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

Long Term Impacts Of Elevated CO_2 On Sub-Arctic Plant Communities: Acclimation?

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Results from an unique experiment investigating the long term impacts of elevated CO_2 and enhanced UV-B on a sub-arctic heath community in Swedish Lapland will be presented. Plant growth, community responses and belowground responses will be discussed and stable isotope approaches introduced.

Sea Ice: Poster

Incorporation of a new melt pond model into a GCM sea ice model component

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The Arctic sea ice cover has retreated in the past few decades: submarine data gathered from 1958 to 1976 indicates a decrease of sea ice thickness of about 1.5m (Rothrock et al, 1999) in the region of observation. Satellite observations show that the ice cover is continuing to thin (Laxon et al, 2003). In September 2005 and 2007 historical minima of sea ice extent have been observed. Melt ponds form on sea ice during the melting season and their presence affects the heat and mass balance of the ice cover. Towards the end of the melt season melt ponds cover up to 50% of the sea ice area. We have previously developed a new melt pond evolution theory and presented results of a standalone version of our model. We have now included our theory into the Los Alamos CICE sea ice model. We will present results to show the impact of the presence of a pond routine in CICE and present the results of a sensitivity study to various parameters.

Sea Ice: Poster

Recent changes in Arctic sea ice thickness from satellite altimetry

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Arctic sea ice is rapidly declining. The trend in sea ice extent between 1979 and 2006, derived from satellite observations, was -9.1 ± 1.5% per decade. The recent record minima in September 2007 and September 2008 increased this downward trend to -11.7% per decade. However, measurements of ice extent provide only tell one part of the story and to fully understand changes in the Arctic ice cover we must also understand how the ice thickness is changing. We present satellite altimetry estimates of Arctic sea ice thickness over recent winters and look at the changes in the multi-year and first-year ice cover, along with the growth of each ice category over the winter period.

Sea Ice: Poster

Snow/sea ice melt detection?

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The timing of snow/sea ice melt is a critical factor to determine the overall sea ice mass balance in the Arctic. The microwave satellite technique is often used to detect snow/sea ice melt. This technique is based on the fact that snow/sea ice physical properties closely link to electric (i.e., complex permittivity) properties and in turn microwave scattering/emission. However, there are significant discrepancies among different satellite techniques due to the complexity of this linkage during spring season. Here we present field observations that reveal some of these complex physical-electric linkages and give us insight for satellite-based technique to detect snow/sea ice melt.

Sea Ice: Poster

Novel sensor chains for the study of sea ice

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The Arctic is changing rapidly in response to global warming: in particular the sea ice cover in the Arctic Ocean has seen drastic reductions, with the lowest recorded summer minimum in 2007. Whereas satellites can readily measure the areal extent of the sea ice, it is not so easy for them to make the measurements of the ice thickness that are needed to detect changes in the total volume of the sea ice. Fortunately, the IPY has seen many programmes of in situ measurement over the last year, and there has as a result been an increased number of spot thickness measurements. To recover measurements over a period of time is more difficult, and the traditional equipment to make these measurements (the Ice Mass Balance buoy, or IMB) is expensive and cumbersome. What we have done is to develop and deploy a replacement for the IMB which is both cheap and easy to use. It consists of a flexible 6-metre chain of more than 100 miniature temperature sensors connected to a small satellite modem. The chain is easily deployed through a 2" auger hole and measures temperature changes in the ice and the neighbouring air and sea. Small heaters can also be turned on to allow the chain to determine whether it is in air, snow, ice or water. Initial results have been very encouraging and have already generated wide interest and sales to BAS and Finland. The work has been funded through the NERC ASBO-IPY consortium grant.

Sea Ice: Poster

Frazil Ice Formation in the Polar Oceans

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Cracks in the sea ice cover, known as leads, can form due to mechanical forcing and expose ocean water directly to the cold atmosphere. The formation of sea ice in these leads plays an important role in the mass balance of sea ice and the salt budget of the ocean. The formation of sea ice is a complex process, which initially involves the creation of frazil ice, then "grease ice", pancake ice and finally a layer of solid ice. This study concentrates solely on modelling the first stage, frazil ice formation. This initial stage is characterised by small millimetre-sized crystals of ice which are formed in turbulent waters. The crystals are first formed through a process of seeding. Once we have a seeded crystal the following processes occur: growth/melting, secondary nucleation and flocculation. The first is the effect the change in temperature has on the crystals either making them grow (supercooling) or melt (superheating). The last two are the effects turbulence has on the crystals. By creating collisions, we have new nucleus breaking off from larger crystals (secondary nucleation) or larger crystals breaking up into smaller crystals (flocculation). The mathematical model used will rely on the conservation of mass, momentum and thermodynamics, and will have as variables sea surface temperature, air temperature, ice concentration, air and ocean velocities.

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Sea Ice: Poster

Modeling The Sea Ice Edge

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The aim of this project is create a mathematical model of the marginal ice zone that can locate the sea ice edge. The model will incorporate the relevant physical processes and take into consideration sea and atmospheric stresses as well as the internal pressures of the broken sea ice. Sea ice components of atmosphere-ocean coupled Global Climate Models crudely parameterize processes at the edge of the sea ice cover, using rheologies from the sea ice pack rather than the broken edge. This leads to inaccuracies in calculating the location of the sea ice edge and thus the extent of the cover. So far in my research, I have examined a reduced 1 dimensional model of the sea ice momentum balance as described by Gray & Morland (1994), using scaling. My aim is to produce a model that will produce accurate solutions to the momentum balance to study the nature of the marginal ice zone. The relevant physical processes will be incorporated into the CICE sea ice model so to represent the marginal ice zone within the sea ice pack.

Sea Ice: Poster

Arctic Sea Ice Properties from Multibeam Sonar

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In March of 2007, the Royal Navy submarine HMS *Tireless* performed a gridded survey 350 km off the northern coast of Greenland during a transect of the Arctic Ocean to measure Arctic sea ice conditions. In addition to the data collected for an encompassing 6,000 km transect, over 200 km of acoustic topographic data was gathered from upward looking echosounder and multibeam sonar for this survey alone. The echosounder data show ice draft to be unchanged from an overlapping submarine cruise in April 2004, using the same sonar, while confirming ice thickness in this region to be among the highest in the Arctic Ocean. Data from the submarine's multibeam sonar covers an unprecedented length of physical distance in which pressure ridge orientation and shape, as well as concentration of ice types and thickness are examined. We briefly present results from the echosounder, next turning to the relative ease with which ridge and ice concentration statistics can be gleaned from the multibeam record, and finally report on the status of preferred ridge orientation in this region. This work was funded by ONR and MOD, and was a collaboration with the DAMOCLES project.

Sea Ice: Poster

Use of a discrete element model to study failure modes of a sea ice cover

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Sea ice can deform through propagation of fractures, delineating floes of different shape. The sea ice rheology depends on the shape and orientation of the floes. The fracture can occur through normal or shear failure. We use a discrete element model to study aggregate formation of blocks through different failure modes. The sea ice cover initially consists of polygonal floes connected by frozen joints. Once a critical amount of shear or compressive elastic deformation is reached at the joints, the joints fail. Multiple failure of the joints produce different floe shapes under different failure criteria.

Marine Biogeochemistry and Ecology: Poster

Investigating the response of coccolithophores to variable carbonate chemistry between the UK and the Arctic region around Svalbard

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The ICE CHASER cruise 23 July - 23 August 2008 gave us the opportunity to quantify the carbonate chemistry and directly measure pelagic calcification rates in a transect between the North Sea and Svalbard, and in the Arctic region north of Svalbard for the first time. The survey included, among others, an ice (ICE), a Marginal Ice Zone (MIZ) and an Arctic fjord (RIP) station. The aim of this study was to investigate in-situ coccolithophore community response to spatial variations in the carbonate chemistry and especially the calcite saturation state. Along the transect, the lowest Dissolved Inorganic Carbon (DIC) and alkalinity values were measured in the northern North Sea and in the areas covered/partially covered by ice around Svalbard. The low values in the northern North Sea were associated with freshwater input from the Norwegian shelf. The low DIC values around Svalbard were probably due to an earlier intense phytoplankton bloom and were accompanied by exceptionally low (<150 ppmv) pCO_2. Ice coverage and stratification in this area presumably limited air-sea CO_2 exchange, inhibiting the DIC and pCO_2 recovery post-bloom. As a result, calcite saturation state and pH remained relatively high. pCO_2 was particularly high (>400 ppmv) in the southern North Sea, probably due to lack of stratification, which resulted in relatively low calcite saturation state and pH values. Particulate Inorganic Carbon (PIC) and chl-α were generally higher in the North Sea and decreased with latitude. The calcification:primary production ratio (CF:PP) around Svalbard was low (average ~ 0.01-0.02). Primary productivity reached 0.7 mmol m^{-3} d^{-1} at the MIZ and RIP stations, probably due to a combination of nutrient and light availability. Calcification exhibited a response to nitrate availability and was higher at the ICE and RIP stations (50 and 6 µmol m^{-3} d^{-1} respectively). Future work will focus on identifying the coccolithophore species present in the different areas of study and assessing changes in their abundance and morphology along the transect.

Marine Biogeochemistry and Ecology: Poster

Tracking persistent chemicals in the Arctic marine system

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A twelve week sampling campaign was conducted in the Amundsen Gulf in the Canadian Arctic during March-June 2008 as part of the Canadian Circumpolar Flaw Lead project (CFL). The objective of the study was to understand the transfer of persistent chemicals between the lower atmosphere and marine surfaces, including the sea-ice snowpack and water. Measurements have been conducted for 'legacy' persistent organic pollutants (POPs), such as Polychlorinated Biphenyls (PCBs), Organochlorine Pesticides (OCPs) as well as emerging chemical contaminants such as Perfluoroalkyl Compounds (PFCs) and their precursors. Whenever possible, integrated sampling was conducted combining air, snow, ice and seawater sampling at various CFL stations. Due to the diversity of target analytes, separate sampling equipment and strategies where adopted. These were roughly distributed between 'large volume' techniques for legacy POPs, and 'low volume' sampling methods/techniques for PFCs. It is hypothesised that the snowpack serves to accumulate contaminants from the atmosphere during the colder winter period; effectively providing a contaminant 'reservoir' during spring melt and driving concentrations in surface seawater. To-date, both PCBs and OC pesticides have been detected in the marine snowpack and concentrations appear to be a function of the snow-type (grain size and density) and ambient air temperature. Initial examination of the same chemicals in the sea-ice reveals much lower concentrations with levels possibly decoupled from the overlying snowpack. PFCs data will establish the dominant transportation pathway accounting for their presence in surface waters of the Arctic Ocean as their presence especially in remote environments is related to transport with oceanic currents or to long-range atmospheric transport of precursor compounds.

Marine Biogeochemistry and Ecology: Poster

A synoptic view of phytoplankton community structure in the Arctic Ocean

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Limited accessibility for ships in the Arctic ocean has historically restricted opportunitites for in situ ocean data collection, resulting in a severe gap in our knowledge of Arctic marine ecosystems. Advances in Earth Observation satellites, however, provide a practical mechanism to observe high-latitude pelagic ecosystems throughout their summer growing season. We have developed a novel algorithm to observe phytoplankton community structure from space through the application of ocean colour radiometry. The algorithm is based on the inherent optical properties of phytoplankton and takes acoount of the large solar zenith angle at high latitudes. The algorithm was applied to arctic regions to provide, for the first time, a synoptic view of how phytoplankton community structure varies spatially and through time (seasonally and interannually). Such observations provide a significant opportunity to investigate processes influencing the Arctic pelagic ecosystem (e.g. sea ice variability, ocean circulation) and feedbacks to the global carbon cycle.

Marine Biogeochemistry and Ecology: Poster

The role of sea ice dynamics in carbonate mineral production and its fate in the polar oceans

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The interaction between the marine and atmospheric carbon cycle is a critical factor in understanding climate change and the polar oceans play an important role in mediating the earth's climate, for example the polar waters provide an appreciable part of the global carbon sink. Although the interplay between biology and climate change is a major focus of current studies, less attention has been paid to abiotic drivers that may influence carbon cycling and sequestration. The recent discovery of ikaite a metastable phase of hydrated $CaCO_3$ ($CaCO_3.6H_2O$) has confirmed the presence and form of calcium carbonate in sea ice but has left us unable to assess the significance of its role in carbon cycling in polar oceans because controls on its production and dissolution in sea ice are unknown. Our intention is to find out the likely scale and location of ikaite production and determine its importance the regional carbon cycle in the ice-water-atmosphere system, including the possibility of a CO_2 drawdown from the atmosphere into the ocean upon dissolution during seasonal sea ice decay.

Marine Biogeochemistry and Ecology: Poster

Arctic phytoplankton blooms from satellite

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Spring blooms account for roughly half of annual new primary production in the Arctic Ocean, and are central to this polar ecosystem. In the southern Arctic where seasonal ice is present, they form along the ice-edge over a 20-100 km belt and follow its northward retreat as ice breaks up and melts. They exhaust quickly the nutrients in the shallow mixed layer but have a long lifetime because they are "on the move", consuming gradually the nutrients in newly ice-free water. They differ from more traditional open water blooms with respect to the nature of the water column stratification, here induced by freshwater input instead of solar heating. Ice-edge blooms exhibit an important interannual variability in magnitude, timing and blooming species, reflecting the variability in physical conditions. Recent studies based on satellite measurements of chlorophyll-a show an important increase in primary production along with the dramatic decrease of sea ice summer extent. It is attributed both to larger open water area and longer growth season. Yet the precise contribution of the bloom is not clearly understood. The present study aims at detecting ice-edge blooms in ten years of ocean colour satellite data, with emphasis on the bio-physical interactions at work. It is a necessary step to appreciate the response of the bloom to the huge freshwater input from melting of multiyear ice.

Marine Biogeochemistry and Ecology: Poster

Analysis of the bacterial and archaeal populations in Rijpfjorden, Svalbard following ice break up

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The Arctic Ocean plays a critical role in global carbon cycling, however it is also extremely vulnerable to climate change. Despite this, relatively little is known about how climate change will impact the arctic carbon cycle. Microbial populations (bacteria & archaea) form an integral part of carbon cycling in the arctic. By understanding what microbial populations are present and their biodiversity in the arctic pelagic and benthic environments, under different ice regimes (open ocean, marginal ice and ice covered), we hope to gain a better understanding of how climate change may affect carbon cycling. This work will focus on samples taken from Rijpfjorden (an arctic fjord on the north eastern tip of Svalbard) directly after break up and melting of ice in this area. Following the break-up of ice, there is an immediate increase in light penetration to the pelagic water this causes a steep increase in pelagic primary production and in turn will impact the microbial populations. A range of samples were obtained for culture-independent analysis of the bacterial and archaeal populations including sediment trap material, copepod guts and sedimentary cores. DNA extracted from the samples were profiled by genetic fingerprinting and detailed genetic information was obtained by sequence analysis. Comparative analysis of the bacterial and archaeal populations in the benthic and pelagic environments will be made and initial findings will presented here.

Marine Biogeochemistry and Ecology: Poster

Glacial inputs of iron and macronutrients to the coastal ocean: work in progress and opportunities to combine interests

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We live in a warming world in which polar regions in particular are anticipated to be impacted. Glacial retreat and enhanced melt-water discharge from land-based ice will introduce increased amounts of solute and particulate material into coastal polar seas. Of particular interest are enhancement of iron and macro-nutrient (N, P, Si) fluxes that can fuel productivity in these adjacent waters. However, whilst information exists on budgets of glacial nutrients, very little is known about their behaviour in both the pro-glacial areas and on mixing with seawater, or about the role of the interactions with glacial particles. This information is important to our ability to model the impact of discharge changes in these systems and extend this information to larger scales to thus help predict biogeochemical impacts of climate change in the future and understand changes during past climate excursions. The NERC base at Ny Ålesund (79˚N, 14˚W), in the arctic Svalbard archipelago is the hub our current land-based fieldwork, and is in easy reach of the two main glacier systems that are to be studied in the first phase of this project. These drain into the adjacent fjord, Kongsfjorden. We already have extensive knowledge of processes on and beneath the glaciers that may modify nutrient fluxes from the glacier terminus. We further plan to collect samples from drainage streams across the zone between the nose of the glacier and the fjord over the main part of the melt season, and measure changes in key parameter and in particular Fe and other nutrients. In combination with water flows we will be able to follow changes in the form (or phase) and amount of these nutrients across this pro-glacial plain. Additionally, we will follow the impact of mixing of meltwaters with adjacent coastal seawater through field measurement and laboratory experiments. In both the fjord and pro-glacial systems interactions of the nutrients with the abundant glacial particles present will be studied. It will be possible to apply this new process knowledge in other glacial systems and thus substantially improve our knowledge of the global impacts of nutrient release on polar waters in a warming world. Our aim is to compliment the main project with a study of primary productivity in the fjord and how it relates to nutrient and particle inputs. We believe that the general field of nutrient transformation and transfer from land to fjord is a fertile area for future research, given the evident climatic sensitivity of the water flux and processes in the ice-proglacial zone-estuary system. We welcome collaboration with interested interdisciplinary researchers with complimentary skills.

Climate and Palaeo-Records: Poster

Impacts of the c. 3,400 BP Aniakchak II eruption on an Arctic peatland

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The caldera-forming eruption of Aniakchak, dated to approximately 3,400 BP, is known to be one of the largest of the Holocene period, with a significant trace in Greenland ice cores, distal tephras and thick proximal deposits. In this paper we review the dates for the eruption and present new palaeoecological evidence for the impacts of the tephra on a tundra wetland, 1100km from the eruption.

Initial results suggest a hiatus in peat deposition, followed by a return of peat formation in a landscape dominated by Poaceae (grasses) and Ericaceae (heaths), before returning to a sedge (Cyperaceae) dominated wetland. During the earlier phases post-deposition, tree pollen increase in frequency, perhaps due to the underproduction of ground flora. Mites (oribatids) show a pattern of recolonisation by *Ceratozetes parvulus* and then *Hydrozetes*, demonstrating first a phase of thin organic soil and then a phase of increasingly wet and peaty conditions. Statistical analyses of the pollen and oribatid data using RDA show that the impacts of the AK tephra deposit are statistically significant, based on a model of immediate impact at the depth of tephra deposition and then continued but exponentially-diminishing impact above this.

Implications of these results are that a large proportion (perhaps 10%) of the wetlands of Alaska may have been affected by the eruption and ash deposition for a long period of time (80-120 years) and that local ecological changes were significant enough to affect the carbon balance and the ecology of this distal region. The tephra layer may have left the ground surface bare, or prevented preservation, preventing peat growth for a period of 100-200 years. However, these data relate only to a single site, and for the period immediately following the tephra deposition no environmental evidence is available due to the lack of peat accumulation.

Further studies on the dating and impacts of this and other major eruptions will constrain the impacts of volcanism on carbon budgets, arctic ecology and biodiversity.

Climate and Palaeo-Records: Poster

Increased seasonality through the Eocene to Oligocene transition in northern high latitudes

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A profound global climate shift took place at the Eocene-Oligocene transition (33.5 million years ago) when Cretaceous/early Palaeogene greenhouse conditions gave way to icehouse conditions. During this interval, changes in the Earth's orbit and a long-term drop in atmospheric carbon dioxide concentrations resulted in both the growth of Antarctic ice sheets to approximately their modern size and the appearance of Northern Hemisphere glacial ice. However, palaeoclimatic studies of this interval are contradictory: although some analyses indicate no major climatic changes, others imply cooler temperatures, increased seasonality and/or aridity. Climatic conditions in high northern latitudes over this interval are particularly poorly known. Here we present northern high-latitude terrestrial climate estimates for the Eocene to Oligocene interval, based on bioclimatic analysis of terrestrially derived spore and pollen assemblages preserved in marine sediments from the Norwegian-Greenland Sea. Our data indicate a cooling of ~5˚C in cold-month (winter) mean temperatures to 0-2˚C, and a concomitant increased seasonality before the Oi-1 glaciation event. These data indicate that a cooling component is indeed incorporated in the $\delta^{18}O$ isotope shift across the Eocene-Oligocene transition. However, the relatively warm summer temperatures at that time mean that continental ice on East Greenland was probably restricted to alpine outlet glaciers.

Data & Information: Poster

OSTIA: An operational, high resolution sea surface temperature and sea ice analysis system

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An Operational sea Surface Temperature (SST) and sea Ice Analysis system (OSTIA) has been running at the UK Met. Office since November 2006. The output is a daily, global coverage 1/20° (~6km) combined SST and sea ice concentration product based on measurements from several satellite and in situ SST data sets. Satellite-derived sea ice products from the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI-SAF) provide sea ice concentration and ice edge data to the analysis system, which are used to control SSTs at high latitudes. Accurate, high resolution SST and sea ice information on both global and regional scales is necessary for many marine applications as well as numerical weather prediction, seasonal forecasting and climate monitoring. High latitude uses of OSTIA analysis products include monitoring of sea ice extent and research into polar SST changes as well as the provision of boundary conditions for numerical modelling applications. OSTIA daily SST and sea ice products are freely available for research use. There are plans to produce a 20-year re-analysis, which will be made available as part of the MyOcean project. This is a European initiative with the aim of producing a single point of service for all European ocean forecasting products. Additionally, the same SST and sea ice data are assimilated into the Met. Office Forecasting Ocean Assimilation Model (FOAM) system, an operational deep ocean forecasting system, producing daily analyses and 5-day forecasts of sea ice variables and three-dimensional temperature, salinity and currents, with applications including seasonal forecasting and climate research.

Data & Information: Poster

The Polar Data Centre

Helen Campbell BAS
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The Polar Data Centre (PDC) is the NERC Data Centre with a mission to coordinate, and where appropriate manage, disseminate and curate NERC's polar data and information. This enables the scientific community, stakeholders and the wider world to use them effectively and to their full potential, both now and in the future. The Polar Data Centre replaced the Antarctic Environmental Data Centre in April 2009 and is based at the British Antarctic Survey, home of the newly formed NERC Arctic Office.

In many cases Arctic data are already managed by a discipline specific NERC Data Centre and the PDC will not change this. However, the Polar Data Centre will support Arctic projects producing datasets not appropriately served by one of these discipline specific data centres. As a geographically-based data centre, we also work across discipline boundaries to provide effective data links between NERC's scientific communities and the international polar community, as well as working in partnership with many international polar data centres.

This presentation gives an overview of the data centre, details recent data science projects, outlines the connections with other data centres and looks to the future of a more co-ordinated approach to Polar data management.

Data & Information: Poster

The 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 (IPY). It is the UK branch of the Association of Polar Early Career Scientists (APECS). It comprises a dedicated management committee and the membership of over 130 early career scientists, from aspiring undergraduates to current Masters and PhD students, postdoctoral researchers and recent faculty appointees. The common thread between UKPN members is an interest in the Polar Regions and a desire to coordinate networking, education/outreach and information dissemination for early career researchers during and after the International Polar Year (IPY).

The aims of UKPN are threefold:

- To provide networking between and support for early career polar researchers.
- To provide education and outreach with regards polar issues to young people.
- To provide information via newsletters and this website.

Since its establishment, the UKPN has organised networking days and workshops, where talks are presented by invited and recognised scientist and also by early career scientist. Activities planned for the the near future include the following:

- Arctic marine science workshop (12-13 October 2009, PML)
- Cryosphere workshop (4-6 November 2009, U. Sheffield)
- "Surviving Antarctica: Human innovation and endeavour" workshop (British Science Festival, U. Surrey Workshop 5-10 September 2009)
- Outreach session for school children at the International Glaciological Society (U. Northumbria, Newcastle-upon-Tyne, UK, from 27-31 July 2009).

The UKPN Education & Outreach working group promotes the inclusion of polar research in school curricula and organises events which allow pupils and students to learn more about life and research in polar regions, as well as the careers open to school leavers in similar fields. So far, UK Polar Network members have taken part in the Royal Geographical Society Explore conference, written articles for magazines, and presented information about the UKPN at international conferences.

Terrestrial Biogeochemistry and Ecology; Geosciences: Poster

The nature and timing of Arctic volcanism: constraints from the Taimyr Peninsula

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The formation and timing of emplacement of large igneous provinces and the environmental consequences these may have are currently matters of debate. Volcanism in the high Arctic may be part of the Siberian large igneous province and possibly represents parts of a plume trail. Petrogenetic models on and the timing of volcanism in the Arctic are, however, poorly constrained.

The Taimyr Peninsula of Arctic Siberia is considered to be a crucial area in which to study the relationships between continental collision and plume related rifting during the tectonic evolution of Arctic Eurasia in the Late Palaeozoic and Mesozoic (e.g. Inger et al., 1999). Basaltic lavas and intrusives (sills and dikes) supposedly correlated with the Permo–Triassic Siberian Traps are widespread on the Peninsula and folded together with Carboniferous to Permian terrigenous sedimentary rocks. $^{40}Ar/^{39}Ar$ ages on Taimyr lavas demonstrate that volcanism on the Peninsula was contemporaneous with the main stage activity of the Siberian Traps at ~250 Ma increasing the know extent of the province to the north. The precise lava ages also present a maximum age for the onset of Mesozoic fold-related deformation in South Taimyr. Timing of emplacement of intrusive rocks cannot be verified by our data with certainty but ages on high temperature steps indicate ages ~247-244 Ma. These ages are older than published (Torsvik and Andersen, 2002; Walderhaug et al., 2005) paleomagnetic and $^{40}Ar/^{39}Ar$ evidence (230-198 Ma) highlighting the requirement of a re-evaluation of timing of intrusive activity on the Peninsula.

Geochemical evidence suggests that both Taimyr lavas and intrusives were derived by large degrees of partial melting possibly at shallow depths. These magmas were subsequently crustally contaminated which is indicated by high La/Sm (>2.5) and $^{87}Sr/^{86}Sr$ (>0.706) ratios observed in some of the Taimyr samples. All samples can be correlated to the Low-Ti series of the Siberian Traps with close affinity of lavas and intrusives to the Noril'sk Nadezhdinsky and Tuklonsky suites, respectively. Radiogenic data also imply that a depleted source was likely not involved in the formation of the Taimyr igneous rocks.

Marine Biogeochemistry and Ecology: Poster

Biogeochemical studies in the sea-ice, marginal ice zone and open waters of the Arctic north of Svalbard: preliminary results from the international "Ice Chaser" Cruise (Summer 2008)

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Rapid climate-induced changes in Arctic sea-ice and water column structure will have a significant impact on the Arctic marine ecosystem and carbon cycle, and the accurate prediction of such changes is a major challenge for the Arctic marine science community. During July and August 2008 a multidisciplinary programme of observational and experimental research was undertaken on the RRS *James Clark Ross* in shelf seas to the north of Svalbard in the European Arctic. The objective of the UK-led expedition was to improve our understanding of the ecology and biogeochemistry of the region and thereby help refine models of ecosystem response to environmental change. A range of physical, chemical and biological observations and experiments were conducted in the water column and sediments at ice-covered, marginal ice zone and open water stations. Oceanographic conditions were colder than expected with extensive ice cover due to northerly winds driving pack ice into the region; the marine ecosystem was therefore characterised by typical Arctic species. Preliminary results revealed the presence of a post-bloom recycling community characterised by an active but relatively slow growing phytoplankton community, and an active microbial community which was uncoupled from the phytoplankton. Healthy populations of large herbivorous zooplankton were also found in deep waters indicting the presence of an earlier under-ice phytoplankton bloom. This poster summarises these and other preliminary findings from the expedition.

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