Monday 16th May
Session 1 – FOCUS on Climate-Biosphere Interactions

The WUN-ACE palaeovegetation initiative: high-latitude vegetation response to climate change

M.Edwards, School of Geography, University of Southampton, Highfield, Southampton SO17 1BJ

It is well documented that the high northern latitudes are both sensitive to climate change and a source of major feedbacks to the global climate system. Modern studies suggest that there are considerable differences among land-surface properties; variability is related not only to differences between forest and tundra but also to differences among tundra (and forest) vegetation types. Over the last glacial-interglacial cycle (21,000 yr BP to present), climate changes occurred of the magnitude anticipated for future anthropogenic climate change, and they were accompanied by major changes in vegetation cover. It is important, therefore, that attempts to model the arctic system address not only the recent past and the future, but longer timescales. This requires adequate documentation of the nature and timing of past vegetation. The WUN-ACE palaeovegetation initiative represents a collaboration among palaeoecologists to produce an extensively documented palaeovegetation research dataset, including a definitive set of maps of high-latitude vegetation cover from 21,000 yr BP to present. A key application of the mapped data will be the evaluation of the performance of climate models in simulating high-latitude climates. The recently completed PAIN project (Pan-Arctic Initiative) demonstrated the utility of this approach for 6000 and 21,000 yr BP, which are key times used for data-model comparisons by the climate modelling community.

The database will draw on both fossil pollen and plant macrofossil records. Macrofossil data allow for more detailed reconstructions, both spatially and taxonomically, than does pollen alone. An example of this is the reconstruction of structurally ambiguous vegetation during the Late Glacial and Early Holocene of Beringia.

Paleovegetation Mapping in North America: Scaling from Taxa to Biomes

John W. Williams, Department of Geography, University of Wisconsin
jww@geography.wisc.edu

Since the conclusion of the Biome6000 project, several groups have continued to pursue paleovegetation mapping at sub-continental to continental scales; in the 1ACE area of interest (>40°N) notable efforts include the PAIN (Bigelow et al. 2003) and CAPE (CAPE Project Members 2001)projects and, in North America, the work by myself and colleagues. Dataset development, quality-control decisions, and methodological innovation have largely proceeded in parallel, hindering synthesis among groups and regions. The 1ACE effort offers the opportunity to integrate datasets and standardize methods, with the larger goal of providing high-quality paleovegetation benchmarks for the earth system modeling community.

Post Biome6000 efforts by myself and colleagues have focused upon 1) creating research-quality datasets of fossil pollen abundances for North America, interpolated to 500-year time slices from 21 ka to present, and 2) developing paleovegetation reconstructions at ecological levels spanning taxa, plant functional types, and biomes (Williams et al. 2004). The fossil pollen dataset consists of 759 sites drawn from the NAPD, BDPMQ, PALE/PARCS, and individual records. Novel quality-control indices were used to filter records with poor dates and/or pollen sampling resolution. Vegetation maps from this data show that vegetation distribution was relatively stable during the full glacial (21-17 ka) and mid- to late-Holocene (7-0.5ka) but changed rapidly during the late-glacial period and early Holocene (16-8ka). The late-Pleistocene suite of biomes is clearly distinct from the Holocene set, both in its distribution and internal composition.

Additionally, we have developed reconstructions of fractional tree cover and leaf area (LAI) for the late Quaternary, by applying analog-based methods to a North American surface pollen dataset comprising over 4500 samples and modern tree cover and LAI datasets derived from the AVHRR and MODIS sensors (Williams 2003, Williams and Jackson 2003). These reconstructions show a widespread increase in fractional tree cover and LAI since the last glacial maximum, Holocene shifts in the prairie-forest border, and the infilling of the western boreal forest during the early to middle Holocene. The reconstructions complement biome-based approaches and should be useful for evaluating GCM's coupled to dynamic global vegetation models.

Citations

Bigelow, N. H., L. B. Brubaker, M. E. Edwards, S. P. Harrison, I. C. Prentice, P. M. Anderson, A. A. Andreev, P. J. Bartlein, T. R. Christensen, W. Cramer, J. O. Kaplan, A. V. Lozhkin, N. V. Matveyeva, D. F. Murray, A. D. McGuire, V. Y. Razzhivin, J. C. Ritchie, B. Smith, D. A. Walker, K. Gajewski, V. Wolf, B. H. Holmqvist, Y. Igarashi, K. Kremenetskii, A. Paus, M. F. J. Pisaric, and V. S. Volkova. 2003. Climate change and Arctic ecosystems I. Vegetation changes north of 55ºN between the last glacial maximum, mid-Holocene and present. Journal of Geophysical Research-Atmospheres **108**:8170.

CAPE Project Members. 2001. Holocene paleoclimate data from the Arctic: testing models of global climate change. Quaternary Science Reviews **20**:1275-1287.

Williams, J. W. 2003. Variations in tree cover in North America since the Last Glacial Maximum. Global and Planetary Change **35**:1-23.

Williams, J. W., and S. T. Jackson. 2003. Palynological and AVHRR observations of modern vegetational gradients in eastern North America. The Holocene **13**:485-497.

Williams, J. W., B. N. Shuman, T. Webb, III, P. J. Bartlein, and P. L. Leduc. 2004. Late Quaternary vegetation dynamics in North America: Scaling from taxa to biomes. Ecological Monographs **74**:309-334.

Tertiary palaeoclimates of the Arctic from fossil plants

Jane Francis, Earth & Environment, University of Leeds

The Arctic region has a rich fossil record that records terrestrial climate conditions through the Tertiary but this dataset has yet to be fully compiled and exploited. Fossil plants in particular provide evidence for high latitude ecosystems and climates from the early Palaeogene to Neogene. One of the best known floras is the Eocene flora of the Canadian High Arctic. Layer upon layer of fossil forests are preserved in exceptional conditions on Axel Heiberg and Ellesmere islands. *In situ* tree stumps have allowed the forest floor to be reconstructed and high levels of forest productivity to be deduced. Fossil leaf litter layers over 1 metre thick contain mummified leaves and seeds, dominated by the conifer dawn redwood (*Metasequoia*) but also present are remains of pines, spruce, cypress, hickory, alder, sycamore, and more. Sedimentary evidence indicates that the plants were growing in swampy conditions on the floodplains of a large river system but were intermittently and repeatedly covered with silt-bearing floodwaters that capped the forest layers. The climate was warm to cool temperature without freezing winters and mean annual temperatures of ~9°C, even at palaeolatitudes of 80°N. The forests were also home to a rich fauna of snakes, tortoises, alligators, and a variety of primitive mammals

Session 2 – FOCUS on Land-Ocean Interactions

Proposal for PMIP2/1ACE Paleo-hosing Model Intercomparison Project (PhMIP)

Michael Schlesinger, Climate Research Group, Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign
(schlesin@atmos.uiuc.edu)

Simulations of potential future greenhouse-gas (GHG) induced climate change by coupled atmosphere-ocean general circulation models (AOGCMs) have shown that it is possible to slowdown or even collapse the Atlantic thermohaline circulation (ATHC) by the GHG-induced addition of freshwater and heat to the North Atlantic Ocean.

The ATHC currently transports poleward about 1 petawatt (10^15 W) of heat, that is, a million billion Watts. Since human civilization currently uses 10 terawatts of energy, the heat transported by the ATHC could run 100 earth civilizations. Conversely, 1% of the heat transported by the ATHC could supply all of humanity's current energy use.

A slowdown or collapse of the ATHC would result in a relative cooling of Greenland, the North Atlantic Ocean and Europe which could partially cancel or even reverse the sign of the GHG-induced warming there. Such cooling is evident in the paleoclimatic temperature record due to Heinrich events, the Younger Dryas and the 8.2 ka event.

The AOGCM simulations, however, display large differences in the change in intensity of the ATHC and in the resulting climatic changes. Simulations performed by the Coupled Model Intercomparison Project (CMIP) of the present-day climate in which freshwater is purposefully added to the surface of the North Atlantic Ocean (hosing) also show a wide range of changes in ATHC intensity and resulting climate change. Clearly, all the models cannot be correct, but all could be wrong.

Because of the importance to humanity of accurately projecting the changes in the ATHC and consequent climate changes, both resulting from greenhouse gases anthropogenically added to the atmosphere, it is proposed to carry out under the auspices of PMIP2 (a) and 1ACE (b), a Paleo-hosing Model Intercomparison Project (PhMIP).
In PhMIP the participating AOGCMs would simulate the climatic changes resulting from a 'realistic' addition of freshwater to the North Atlantic Ocean at the onset of the Younger Dryas, 13ka, and their results would be compared with paleoclimatic data to evaluate and assess the performance of the models.

(a) Paleoclimate Model Intercomparison Project 2
(b) Worldwide Universities Network Arctic Climate and Environment initiative

Tuesday 17th May

Session 3 – FOCUS on Climate-Chemistry Interactions

The WUN ACE Research Stream on Climate-Chemistry Interactions

Donald J. Wuebbles, Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801

Atmospheric pollutants and biogeochemical cycles have important impacts on the climate of the Arctic. While the dramatic changes in climate occurring in the Arctic are thought to be particularly related to human activities at the global scale, local/regional effects on atmospheric chemistry and biogeochemistry are also having a significant influence. However, the extent of these impacts and interactions in the Arctic are still poorly understood. The research stream on Climate-Chemistry Interactions is aimed at improving the understanding of the interactions between atmospheric chemistry, biogeochemical cycles, and climate processes in the Arctic. Our goal is to establish coordination between U.S., U.K. and other WUN universities towards studying key issues where existing programs do not adequately mesh the capabilities and range of expertise that ACE can establish through these international relationships. In particular, the Climate-Chemistry Interactions stream will be based around coordination of modeling and measurement capabilities towards studies of atmospheric chemistry, biogeochemical cycles, and climate. The purpose of this meeting is to define particular focal areas for ACE research. I will focus in on one of these, current and potential pollutant effects on the Arctic, in my presentation. This and other potential ACE initiatives will be discussed in other presentations.

Martyn Chipperfield

Institute for Atmospheric Science, School of Earth and Environment,
University of Leeds

Stratospheric ozone in the Arctic is subject to the same chemical loss processes as the Antarctic. However, the large interannual variability in Arctic meteorology causes a large modulation in the winter/spring loss. Some warm winters see no ozone loss while cold winters, such as 2004/5, see local depletion of around 70% near 20km. The total ozone column (the critical factor for UV flux) is also strongly modulated by transport and the dynamics of the polar vortex. A stable polar vortex, which contributes to cold temperatures and larger chemical loss, also results in less dynamical increase in column O3. In the future, climate change might impact on both of these processes. Despite reductions in stratospheric chlorine and bromine we may see a continued decreased in Arctic ozone in cold winters.

I will discuss some current issues in our understanding of the Arctic ozone layer and how it is expected to evolve. I will also discuss known correlations between the stratosphere and tropospheric meteorology (i.e. the northern annular mode). I may also discuss some links with tropospheric chemistry.

LGM Trace Gas Record Initiative

Sandy P. Harrison, BRIDGE, School of Geographical Sciences, University of Bristol, UK

The large variations of atmospheric CH_4 concentration between glacial maximum (ca 350ppb) and typical interglacial levels (ca 650-750ppb) present a challenge to our understanding of the natural regulation of the atmospheric oxidising capacity and greenhouse gas content. Contrary to early analyses, which assumed extreme restriction of wetlands at the last glacial maximum (LGM), recent attempts to model wetland distribution based on LGM climate simulations have indicated that any reduction in the wetland CH_4 source during glacial times was not sufficient, by itself, to account for the low concentration of CH_4 in the atmosphere. The small CH_4 sink in dryland soils must have been even smaller at low ambient concentrations of CH_4, low enough to challenge the survival of high-affinity methanotrophs. Thus, it is essential to seek explanations in other factors influencing the oxidising capacity of the atmosphere. To do so requires simulation of the sources, sinks and atmospheric transport and transformations of several other reactive chemical species besides CH_4.

Some preliminary modelling experiments have begun to address the numerous possibilities for such an indirect control of atmospheric CH_4. One possibility, supported by a partially-coupled GCM experiment, is that reduced tropical forest productivity and cooler tropical land temperatures suppressed production of isoprene and other volatile organic compounds, leading to a significant reduction in the tropospheric sink for OH radicals and thus an increase in the atmospheric lifetime of CH_4. Another possibility, suggested by model experiments with an interactive model of vegetation dynamics and the natural fire regime, invokes increased extent and frequency of fire in tropical savannas and grasslands providing an enhanced source of NO_x in low latitudes – another way of increasing OH concentrations. This effect was enhanced in the model by smaller C:N ratios in vegetation growing at low ambient CO_2, affecting the emission factor for NO_x while the global direct source of CH_4 due to smouldering combustion was not substantially altered.

Several novel lines of research are needed to gain a better understanding of the role of various competing or complementary processes in the natural regulation of atmospheric CH_4 and other reactive constituents. These include, at a minimum:

- Isotopic (especially $\delta^{13}C$) analysis of CH_4 in ice cores. This is approaching feasibility, and offers the potential to discriminate e.g. between changes in wetland and fire sources of CH_4 due to the widely different ^{13}C signatures of biological methanogenesis (-60 to -70$^0/_{00}$) and C_4 grass biomass (ca -12$^0/_{00}$).
- Compilation of data records globally on the occurrence of peatlands (based on the many published biostratigraphic profiles from sediment cores) and on the frequency of fire (based on charcoal records from lakes sediments). Such a compilation is needed to evaluate model simulations involving wetland area and changes in fire regime.
- A push towards next-generation Earth System Models including atmospheric chemistry, vegetation and fire dynamics, and soundly based algorithms for climatic control of biogenic emissions of key reactive species including VOCs, CO and NO_x as well as CH_4. Many of the required components exist but a major effort is needed to couple them. The ice/core record of atmospheric composition will provide a key test of the performance of such models.

Intelligent UAVs in Climate and Atmospheric Chemistry Research

Professor C Soutis, Head of Aerospace, University of Sheffield, Sheffield S1 3JD
c.soutis@sheffield.ac.uk

Mini unmanned aerial vehicles (UAVs) can be thought of as aerial robots, as six-degree-of-freedom machines whose mobility can deploy a useful payload (10-20 kg) to a remote or otherwise hazardous location where it may perform any of a variety of missions, including reconnaissance and surveillance, targeting, tagging and bio-chemical sensing. There is also a strong interest in the Climate and Atmospheric Chemistry research community for an intelligent UAV that could operate in extreme environments with increased payload capability, flying autonomy and endurance, low cost and easy to maintain and operate. UAVs are not replacements for previously manned air vehicle missions; because of their size, they will be capable of completely new missions not possible with any existing systems. Their ability to operate in constrained environments like urban canyons gives these systems a level of uniqueness unmatched by other concepts. This talk will give an overview on current developments and opportunities and how engineers could interact with climate/environmental chemistry colleagues under the WUN umbrella to develop such a flying machine.

Chemistry of the Antarctic Boundary Layer and the Interface with Snow (CHABLIS)

Dwayne Heard, University of Leeds

OH and HO2 radical measurements have been made over a 6 week period during January and February 2005 at The British Antarctic Surveys' Halley Research Station on the Brunt Ice shelf, Antarctica (75.58oS; 26.57oW). The instrument was deployed as part of the Chemistry of the Antarctic Boundary Layer and the Interaction with Snow (CHABLIS) summer intensive field campaign. During the campaign, a wide range of other species were measured, including O3, CO, NOx, Non-methane Hydrocarbons, HCHO, Σ{HO2 + RO2}, inorganic, and organic peroxides, alkyl nitrates, alkyl halides, BrO, IO, NO3, dew point, j(O1D) and spectrally resolved total radiation. These measurements, together with OH and HO2 measurements, allow a detailed study of the fast photochemistry of the Antarctic boundary layer to be carried out. Preliminary results and analysis will be presented, together with an overview of the aims and objectives of the CHABLIS project.

Session 4 – FOCUS on Climates and Environments of Deep Time

Towards Palaeo-ACE (*pACE*)

Henk Brinkhuis, Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands
email H.Brinkhuis@bio.uu.nl
web http://www.bio.uu.nl/~palaeo/Personeel/Henkb.htm

Broadly, the aim of a ***pACE***- subprogram of ACE could be formulated as

"*to understand the palaeoenvironmental, palaeobiological and palaeoclimatological evolution of the Arctic and northern circumpolar regions over geological timescales, using a combination of modelling tools and field-data, which draw on expertise, data, equipment and infrastructure uniquely available at the WUN nodes…*"

Components of *pACE*. The program should be based on the interactive linking of field data ('observations') with e.g., biogeochemical and paleoclimate modeling. Although we may consider the entire geological record, it is here suggested to initially focus on climatologically key time slices such as the mid Cretaceous, early Eocene, and mid Miocene greenhouses, and (the) transition(s) to icehouse Earth. Components of the sub-program may thus be Arctic, and/or NH high latitude:

- Integrated chronostratigraphy (bio, magneto, chemo, etc)
- Tectonic & palaeogeographic evolution
- Palaeoceanographic evolution,
- Palaeoclimatic evolution,
- Palaeovegetation, reconstructions
- Cryosphere evolution and dynamics

These components should be developed typically on long term (~1 Ma), or shorter (orbital) time scales.

A first step may be to produce shortlists of (1) existing expertise, (2) past and ongoing palaeo-Arctic projects, or (3) past and ongoing projects that can somehow be related to long term Arctic palaeoenvironmental evolution. A second step may be to then produce an inventory of already related or relatable projects, and the potential basis of exchange of e.g., ideas, students, staff, materials, and any other form of scientific cooperation, and eventually the formulation of new integrated WUN, or other research projects.

From Greenhouse to Icehouse: Marine and Terrestrial Palynological Evidence for Climatic and Oceanic Change Through the Cenozoic of the Arctic

Jonathan P. Bujak[1] & Henk Brinkhuis[2]
[1] Bujak Research International, 105 North Park Drive, Blackpool FY3 8NE, UK; email: jonathan@bujakmudge.com
[2] Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands; email H.Brinkhuis@bio.uu.nl

The marine and terrestrial biotas of northern Alaska and the Canadian Beaufort Mackenzie Basin (BMB) are intimately linked to changes in the climate and oceanography of the region. These changes can be reconstructed using palynological data from surface sections and numerous exploration wells drilled in the region over the past 30 years. During the Late Triassic to Early Eocene, marine dinoflagellate cyst (dinocyst) and terrestrial miospore (pollen and spore) palynomorphs were diverse and abundant across the region, reflecting the presence of a relatively warm and productive polar ocean that was fringed by extensive forests. The region was heated by northward-flowing Pacific currents, but lay north of the Arctic Circle and had seasonal 24 hour winter darkness and summer daylight. No modern analogue exists for this environment. A dramatic change occurred at the end of the Early Eocene as global climate shifted from the greenhouse towards the modern icehouse world. This had a particularly strong effect in high latitudes. A succession of major extinction events reflected falling sea and air temperatures in the Arctic and progressively eliminated marine and terrestrial species from the region. These events can be correlated with Eocene cooling steps known from the North Atlantic, where they had a milder effect, and provide a chronostratigraphic link between the regions. By Oligocene time the Arctic populations were strongly impoverished, but Miocene warming permitted the immigration of cold-temperate species including marine dinoflagellates and terrestrial angiosperms. Following this warm phase, the marine and terrestrial populations became increasingly restricted as air and water temperatures fell during the Plio-Pleistocene, leading to the modern highly endemic Arctic biotas.

Palaeogene pollen floras from the Canadian Arctic

Guy Harrington, School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, B15 2TT
g.j.harrington@bham.ac.uk

The Canadian Arctic yields many well exposed sections that are conducive for palynological research. Previous palaeobotanical and palynological investigations have yielded abundant data from the globally warm late Cretaceous (>70 Ma) – Eocene (35 Ma). A critical problem that affects the utility of these studies is that (a) the age of sediments is subject to great uncertainty, and (b) the palynogical data are frequently not dated independently. One important interval is the Palaeocene–Eocene Thermal Maximum (PETM) which marks the Palaeocene–Eocene boundary (55 Ma). It is the subject of intense interest because climate warmed globally by 6-8 °C in about 10 ky. Previous research has shown that the Palaeocene–Eocene boundary is marked in the pollen record by the permanent introduction of several pollen morphotypes. Fifty-two pollen samples (collected by Ben le Page) from Stenkul Fiord (Ellesmere Island, Canada, c. 78°N) show a diverse vegetation type of >70 different pollen morphotypes in the Late Palaeocene-Early Eocene interval. Composition of this arctic vegetation type is totally different from lower latitude warm-temperate regions such as North Dakota and Wyoming during the same time interval. Pollen results show that major changes in vegetation accompany the transition from what is conventionally termed the "Palaeocene" into "the Eocene". This is noted by the introduction of 26 morphotypes. There is no extinction. A change from gymnosperm dominated assemblages to those dominated by angiosperms is also evident. However, the pattern of floral change is most similar to that from the early Eocene (c.53 Ma) into the Early Eocene Climatic Optimum (EECO – 53-51 Ma). Floral change is *completely* different to that observed across Palaeocene–Eocene sections that have robust chronological support. Hence pollen data suggest that either the PETM had no lasting impact on vegetation or that the earliest Eocene is missing from Stenkul Fiord. My research has also prompted several broader questions that I would like to investigate – How can fossil pollen from deep-time contribute to meaningful climate modelling? How sensitive are plant communities in greenhouse climates to rapid warming? What factors account for the uniqueness of the Arctic flora and does this vary over time?

The Transition from Greenhouse to Icehouse: Paleosols and Paleoclimate Modeling of the Paleocene Arctic

Timothy White and David Pollard, Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA 16802

This project will use a two-pronged data and modeling approach to understand the transition from a warm greenhouse to icehouse state in the Eocene Arctic. The data phase will consist of (i) analysis of oxygen isotopic records of paleoprecipitation derived from early Eocene paleosol siderite spherules, obtained in the circum Arctic region focused on Alaska and Arctic Canada, and (ii) continued description and sampling of Paleogene shallow-marine strata in Alaska from which a new record of the presence of lonestones and glendonites has been obtained. The modeling phase will use coupled 3-D global climate and dynamical ice-sheet models with water isotopic capability to (i) better understand oxygen isotopic distribution in the early Eocene, and, (ii) investigate whether or not glaciers may have been present in the Northern Hemisphere during the Eocene, a time most often considered to have been warm.

Existing oxygen isotope profiles from paleosol sphaerosiderites in the early Eocene, mostly from North America including Alaska, display a pronounced south to north depletion, and are depleted relative to similar modern latitudinal distributions. These results indicate that early Eocene paleotemperatures may have been as warm as those reconstructed for the middle Cretaceous greenhouse and provide evidence for an amplified atmospheric hydrologic cycle during these episodes of extreme warmth. A discrepancy between paleosol and model-derived $\delta^{18}O$ values exists at high latitudes; the model values are substantially enriched relative to the paleosol data. We intend to explore several explanations for this discrepancy including but not limited to gathering more samples for isotopic analysis, geological issues associated with model paleogeography and paleotopography, and the use of a modeled seasonal cycle rather than mean annual values.

Historically, ice-free conditions are considered to have existed throughout much of the Eocene. Significant Antarctic glaciation is considered to have begun around the Eocene-Oligocene boundary, while the Northern Hemisphere remained essentially ice free until the Miocene or later. However, several lines of evidence indicate that Antarctic glaciation may have begun earlier, during the mid-Eocene. Furthermore, the presence of lonestones and glendonites of Eocene age in Alaska and Svalbard suggests that seasonal ice, if not glaciers, may have been established in the Northern Hemisphere at this time. The timing of these "cool climate" deposits roughly corresponds to some estimates of the initiation of Antarctic glaciation, and circumstantially suggests that Northern Hemisphere glaciation may have accompanied the development of the Antarctic cryosphere. We plan to perform systematic GCM-ice sheet simulations to help explain these data, to explore interactions between Antarctic and Arctic glaciation, and to investigate the feasibility of early Antarctic and Alaskan glaciation and the presence or absence of Arctic sea ice cover during the mid Eocene.

This work will be integrated with ongoing global studies of Paleogene climate evolution involving collaboration with others at Penn State (R. Alley, M. Arthur, T. Bralower, L. Kump), within the WUN network, and elsewhere.

Henk Brinkhuis, Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands
email H.Brinkhuis@bio.uu.nl
web http://www.bio.uu.nl/~palaeo/Personeel/Henkb.htm

& the ACEX Science Party

In September 2004, the Arctic Coring Expedition, ACEX (IODP 302) recovered a first ever semi-continuous climate record of the Arctic Ocean drilling the Lomonosov Ridge, spanning the past ~56 Ma. Initial, mainly dinoflagellate based age-assessments includes the recognition of some ~200m each of middle and late Neogene and early Paleogene deposits, with a conspicuous ~25 Ma hiatus separating these units. The laminated lower and middle Eocene is organic-rich, and the latter also contains abundant siliceous microfossils. The early – middle Eocene transition (~50-49 Ma) includes an interval containing stunning abundances of remains of the freshwater fern *Azolla* suggesting that at least episodically, fresh surface water settings characterized the Arctic Basin. Although predictions had placed the base of the sediment column at 50 Ma, palynology revealed the successful recovery of the Paleocene - Eocene transition. During this time of super-greenhouse conditions, about 55 Ma ago, the Arctic was subtropical with ultra warm surface ocean temperatures, reconstructed from dinoflagellate cysts and TEX_{86} biomarkers, of up to ~24ºC annual average, some 6ºC above background values. ACEX also penetrated into some 30m of the underlying sedimentary bedrock, confirming the hypothesis that the Lomonosov Ridge crust is of shallow-water, continental origin and of Campanian age.

Wednesday 18th May
Session 5 – FOCUS on Climate-Crosphere Interactions

The role of the cryosphere in modulating the thermohaline circulation of the Atlantic

Jonathan L Bamber[1], Jonathan Gregory[2], Tony Payne[1], Jeff Ridley[3], John Shepherd[4], Paul Valdes[1].
1 Bristol Glaciology Centre, University Bristol, BS8 1SS.
2 Dept Meteorology, University Reading
3 Hadley Centre for Climate Prediction, Exeter
4 School of Earth and Ocean Science, University Southampton.

Large, secular changes have been observed in both runoff from Greenland and Arctic sea ice extent. Combined, these two components of the cryosphere are projected to produce a significant perturbation to the freshwater budget of the Arctic. We present here an overview and rationale behind a project aimed at investigating what impacts these changes may have on the thermohaline circulation of the North Atlantic under a warming climate. This is being achieved by coupling a suite of models that define the mass balance of land and sea ice in the Arctic into a fast Earth Model of Intermediate Complexity (EMIC) and a medium resolution fully coupled Atmosphere-Ocean GCM based on HadCM3 (called FAMOUS). The coupled ice-ocean-atmosphere models will be used to investigate, in detail, the interaction of the cryosphere with the rest of the climate system, with particular emphasis on the THC.

We discuss the development of, and early results from, the i) the ice sheet model, ii) the EMIC and iii) FAMOUS and initial testing of model performance and behaviour The surface mass balance model for the Greenland ice sheet is complete and some offline runs have been undertaken to examine interannual variability in runoff and how this compares with observations. This part of the project is being further developed within the framework of the Arctic Ocean Science Board-CLIC observing plan for IPY. A "climatology" of runoff and calving fluxes from the Greenland ice sheet from 1957-present day will be produced through a combined modelling-observational approach, which is outlined here.

Session 6 – FOCUS on Earth System Modelling

Improving GCM Simulations of Arctic Clouds

Steve Vavrus, Center for Climatic Research, University of Wisconsin

Arctic clouds exert a large influence on the surface radiation budget, substantially reducing wintertime cooling and summertime heating of the surface. The net effect of Arctic clouds during the course of the year is a warming of the surface except for a period during summer, but the precise climatic impact is a complicated function of cloud fraction, height, thickness, and water content. The presence or absence of clouds has a large impact on sea ice growth and the melting of snow and ice in polar regions. Despite their importance, polar cloudiness is a variable that climate models simulate poorly. While the latest generation of models shows some improvement over older simulations, they still display considerable spread in the simulated climatological mean Arctic cloud coverage and its annual cycle.

Fortunately, there are opportunities for improving cloud simulations in climate models. First, a few models, such as GENESIS and the GISS A/O GCM, have been able to reproduce fairly credibly certain aspects of Arctic clouds, including the annual cycle of cloud amount. Exploring why these models have more success in their polar cloud simulations provides one avenue for improving cloud parameterizations in other models. Second, it appears that the biases in many simulated Arctic climate variables (including cloudiness) in coupled models are primarily attributable to the atmospheric model component, thus narrowing the possible sources of error. Third, recently available data sets from field studies provide not only observational targets for evaluating models but also comprehensive information on cloud physics that can be used to improve cloud parameterizations in models. Fourth, there is a wealth of recently available model output from a wide range of models in the CMIP (Coupled Model Intercomparison Project) and IPCC archives, which allows detailed analysis of simulations for the present climate.

A goal of 1ACE should be to promote and utilize model simulations that better simulate Arctic clouds. I am currently working on diagnosing and upgrading the cloud parameterization used in one state-of-the-art GCM, the NCAR CCSM3. Analysis of this model indicates that some of its pronounced wintertime cloud bias is attributable to excessive moisture transport from lower latitudes, while another portion may be ameliorated by modifying the prognostic equation for cloud fraction under very dry atmospheric conditions.

Representing interactions between snow, vegetation and the atmosphere in large scale models

Richard Essery, Institute of Geography and Earth Sciences, University of Wales, Aberystywth SY23 3DB

The unique properties of snow (high albedo, high latent heat of fusion, low thermal conductivity) have strong influences on the energy balance of snow-covered surfaces and interactions with the atmosphere. Snowcover can evolve rapidly and is frequently heterogeneous, presenting challenges for large-scale modelling. Vegetation influences snow distributions by trapping falling or wind-blown snow and by modifying the

radiative and turbulent heat fluxes to snow surfaces. Problems in modelling interactions between snow, vegetation and the atmosphere will be discussed, and potential methods for addressing them will be reviewed.