

17 APRIL 2002 : ABRUPT CLIMATE CHANGE:THE ROLE OF THE ATLANTIC OCEAN

Professor Jochem Marotzke, Southampton Oceanography Centre - General introduction and the use of models to design a monitoring array (jym@soc.soton.ac.uk)

The ocean's thermohaline circulation (THC) is responsible for the unusually strong northward heat transport in the North Atlantic, which results in the relative mildness of western European climate. Abrupt changes in the THC are a plausible cause of observed past climate changes and might occur again in the future, but fundamental gaps exist in our understanding of the processes involved. I will outline the dynamical ideas behind, and current planning work toward, efforts to observe the Atlantic THC on a continuous basis. Such monitoring will be a prerequisite for the ultimate goal of predicting THC variability.

Professor N McCave, University of Cambridge - What can we learn from palaeo-proxies? (mccave@esc.cam.ac.uk)

We use data based on oxygen and carbon isotopes, skeletal chemistry, species abundances, organic molecules and physical properties of sediments as a basis for inferring past temperature, salinity, density, nutrients and flow speed of oceanic water masses. Some proxies also allow inference of the location of sea ice and ice volume on land. These data have shown us that there were profound and quite rapid changes in the distribution of water masses (indexed by nutrient proxies) and sea surface temperature, especially during deglaciation where large volumes of meltwater flooded the system. Recent work has shown the presence of a weak 1500 year oscillation in temperature, flow speed and ice extent in the last 10 ka, but very strong effects from 30-60 ka. Estimates of geostrophic flow suggest a 30% weakening of Gulf Stream flux in the glacial. A particular problem for recognition of spatially co-ordinated activity during rapid changes lies in precision of temporal correlation between records, and degradation of records by bioturbation.

Dr R Dickson, CEFAS, Lowestoft - Recent changes observed in the high-latitude ocean (r.r.dickson@cefas.co.uk)

Most projections of greenhouse gas induced climate change anticipate a weakened THC in the North Atlantic due to increased freshening and warming in subpolar seas, and the supposition is that this climate signal will be transferred to the deep ocean via the two overflows. However, these simulations do not yet deal adequately with many of the mechanisms believed to control the THC. Here, we review the observational evidence for long-term changes in the thermohaline circulation loop that connects the Nordic Seas with the deep North Atlantic. Two changes in particular have been reported. First an apparent weakening by 25% in the transport of the cold, dense overflow through Faroe-Bank Channel since 1950, based on a mix of direct and proxy evidence. Second, the recent evidence from long hydrographic records that the entire system of overflow and entrainment that ventilates the deep Atlantic has changed steadily in character over the

past four decades resulting in a sustained and widespread freshening of the deep and abyssal ocean. The question of ultimate cause is discussed. While the role of the amplifying NAO seems clear in these changes, there is not yet any clear evidence for the involvement of 'global change'.

Dr Robert Marsh, Southampton Oceanography Centre - Changes in surface forcing and their implications for the thermohaline circulation (rma@soc.soton.ac.uk)

The thermohaline circulation (THC) can be defined as a meridional streamfunction in density space, forced by density fluxes at the surface and within the ocean interior. A surface-forced THC strength can be diagnosed from fields of surface heat and freshwater flux. From ship-based flux estimates, it appears that this THC strength has varied considerably over the last 20 years, the densest limb notably weakening over the period (in general agreement with hydrographic observations). Dominated by heat fluxes, the THC seems to follow the North Atlantic Oscillation on interannual-to-decadal timescales. The more subtle role of freshwater fluxes - capping the surface layer and suppressing deep water formation - may play a role on multidecadal timescales. Ship-based observations and reanalysis data suggest that mid-latitude precipitation increased markedly since the 1960s, providing a possible explanation for slow, widespread freshening of upper waters and recent weakening of the THC.

Dr Richard Wood, Hadley Centre, Met Office - Modelling future changes in the thermohaline circulation and their impact on climate (rwood@meto.gov.uk)

Any major change in the Atlantic thermohaline circulation (THC) would be expected to have a significant impact on the climate of the whole Northern Hemisphere and tropics (not just western Europe as is often stated). Unfortunately the prediction of future THC changes is currently beset by considerable uncertainty. While most model projections (e.g. for the Intergovernmental Panel on Climate Change) do not suggest a collapse of the THC in the next 100 years, some models do suggest that large scale, irreversible changes are possible in response to particular scenarios of greenhouse gas increase. Three sources of uncertainty can be identified: 'scenario uncertainty' (different pathways to the same final greenhouse gas concentration can produce different final outcomes), 'initial condition uncertainty' (small changes in initial conditions, or forcing by unpredictable 'weather', can produce large changes in the THC evolution), and model uncertainty (some of the key processes are not quantitatively well enough modelled, so different models produce different results for the same forcing). To understand and reduce the current uncertainty in THC projections requires a range of modelling approaches, improved observations and careful linkage between the two. Some recent progress in this direction will be described.

Dr M Srokosz, Southampton Oceanography Centre - The rapid climate change (mas@soc.soton.ac.uk)

Palaeo data indicate that rapid climate changes (as fast as over 10-20 years) have occurred in the past, with the ocean thermohaline circulation (THC) possibly playing a

key role. Climate models suggest under greenhouse warming the THC could slow down or stop, with potentially large impacts on the climate of NW Europe. For these reasons NERC is investing £20M over the next 6 years on studies of rapid climate change, with a main (but not exclusive) focus on the role of the Atlantic Ocean's THC. The Rapid programme aims to integrate direct measurements of the THC, investigations using palaeo data and a hierarchy of numerical models (from local process to global circulation), in order to better monitor, understand and predict future changes. This talk will give a brief overview of the current status of the programme, and future plans.

Dr Helen Snaith, Southampton University - Coupled ocean atmosphere processes and european climate (hms@soc.soton.ac.uk)

The NERC Thematic Programme COAPEC started in 1999 and will run for at least five years. The goal of COAPEC is to determine the impact on climate, especially European climate, of the coupling between the atmosphere and the Atlantic Ocean on seasonal to decadal timescales. This talk will outline the five key themes of the programme science plan together with the strategy used to address them. The current status of the programme will be explained and a few preliminary results of the research carried out during the programme will be shown