RAPID International Science Conference 24th - 27th October, 2006

Summary briefing note

NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

The RAPID science community and fellow international experts met in Birmingham recently to discuss latest findings, thoughts and issues on abrupt climate change, with particular attention to historical, present and future states of the Atlantic Ocean circulation. This briefing note summarises key findings from the meeting as presented under three of the conference themes.

Theme 1: Is the Atlantic meridional overturning circulation[1] changing?

Harry Bryden (National Oceanography Centre, Southampton, UK) followed up his work last year[2] by presenting the first full-year (2004) time series recovered from the **RAPID Atlantic moorings across 26 degrees north[3]**. Although too short a time series to infer any long-term trend one enigmatic reported feature is the disappearance of the deep-ocean return leg of the Atlantic thermohaline circulation[1] from the instrument readings for a period of about 15 days in November 2004. More data and analysis is needed to clarify whether this indicated a temporary halt in the circulation, or geographical re-arrangement of the system.

Bogi Hansen (Faeroese Fisheries Laboratory, Faeroe Isles) presented results from farther north demonstrating that during the past decade the volume of deep water flow

from the Arctic into the Atlantic Basin, through the **Faeroe Bank Channel** (the most important source of the return leg of the thermohaline circulation) has remained constant. These results apparently indicate that the downward trend[4] evident in the same flow from 1950 - 1999, a further indication that the entire system may have been slowing down during the 20th century, has stabilised. There is also evidence that the saltiness of this water has increased from 1995 – 2005.

Theme 2: What does the past tell us about rapid climate change?

Eric Wolff (British Antarctic Survey, UK) summarised work relating to previous incidents of abrupt climate change that the planet, and in particular the northern hemisphere, has experienced with reference to **'Dansgaard-Oeschger' events** – periods of anomalously warm temperatures that seem to have punctuated the previous glacial era. Advances in data analysis techniques have shown how the warming associated with these event is exceptionally rapid – for instance regions of Greenland warming between 8-15 deg C in as little as 40 years. The cooling phases are shown to be less rapid. Interestingly there is also evidence to suggest that changes of an *opposite* sign occur simultaneously in Antarctica.

Improved data analysis techniques have also been able to further elucidate the so-called **8.2 ky event** – a cooling episode approximately 8200 years before present (b.p.) during the transition from the previous glacial era to the present inter-glacial state. Improved techniques have been able to identify the timing of this event with unprecedented accuracy – a general 150-year cool episode with a central cooling event lasting 69 years centred around 8290 years b.p. This event is associated with the catastrophic release of fresh meltwater from the ancient Lake Agassiz in North America, slowing the Atlantic thermohaine circulation.

Mark Chapman (University of East Anglia, UK) presented research indicating that the at main 8.2 ky event appears to have been preceded by an additional cooling event occurring at **8490 years b.p**.[5] coinciding with the *initial* freshwater discharge from Lake Agassiz, - with the later 8290 years b.p. event representing the culmination of the episode.

Theme 3: The thermohaline circulation, climate and weather in the 21st century

Johann Jungclaus (Max Planck Institute for Meteorology, Germany) presented results from climate model simulations performed by **Daniela Jacob** and colleagues depicting **how European climate may respond to a weakening of the Atlantic thermohaline circulation**. In these experiments a high-resolution model covering Europe was embedded into a conventional global climate model, subjected to a 50% reduction in the present-day strength of the thermohaline circulation. As a result of these changes European climate changed significantly – with an increased tendency for **Atlantic airflows** to influence the region, especially during winter. In a normal situation, this would mean warmer temperatures, with maritime air moderating cold continental air, but after the circulation slow down the maritime air is cooler – therefore the effect is to cool temperatures over Europe. A further notable change is the increase in the number of **snow days** (days with more than 3cm of water equivalent lying snow) over the UK – anything up to 25 – 50 days per winter, compared with under 10 days for the normal climate. It is important to remember that these results do *not* incorporate a background global warming – rather show how a non-greenhouse climate might respond[6].

Till Kuhlbrodt (Potsdam Institute for Climate Impact Research, Germany) presented results from a further set of experiments which do incorporate greenhouse warming, showing how slowing of the thermohaline circulation in a warming world effects both **regional temperature** and, significantly, **sea level rise**. Depending on how sensitive the Greenland Ice Sheet melting rate is to global warming, the thermohaline circulation slows, in this model, to between 10% and 85% of normal strength. In the extreme case, this dampens the global warming change over parts of Scandinavia by up to 3.1 deg. C. The effect on the simulated hemispheric average temperature is less – a 0.7 deg. C dampening, or lower if less Greenland melting occurs (and hence more moderate slowing of the thermohaline circulation). With respect to sea level rise, often overlooked in impact studies, an exacerbated slowing of the thermohaline circulation resulted in an **additional 50cm rise** in mean sea level around parts of the European coast, over and above the rise already caused by direct global warming in the particular model used for these experiments. These additional changes can be related to changes in water mass distribution in the Atlantic basin as a result of the decreased sinking activity that usually occurs in the high latitude Atlantic.

Thierry Fichefet (Universite Catholique de Louvain) also discussed the topic of **Greenland Ice Sheet melt rates** and their capacity to influence the Atlantic thermohaline circulation, building on recent observations that the ice sheet is melting at an unprecedented rate – despite some mass increase in central regions. The critical threshold remains 3 deg. C– if global mean temperatures were to exceed this value then complete elimination of the ice sheet can be expected. Experiments using an intermediate complexity earth model showed how even the total melting of the ice sheet did not halt the thermohaline circulation – but rather caused a slowdown, in this particular model.

Panel Discussion – what does society want to know about rapid climate change?

RAPID delegates also heard from representatives from the financial risk management sector **(Steven Jewson, Risk Management Solutions, UK)**, the **UK Department of the Environment and Rural Affairs** (**Cathy Johnson**) and the **UK Climate Impacts Programme** (**Roger Street**) concerning the value of science produced by the RAPID community to the public and private sector arenas. One concurrent opinion was the value of probability-distribution type climate predictions to the user community, providing information on the range of likely future states, and their associated probabilities. RAPID continues to fund research into techniques for developing probabilistic forecasts of future thermohaline circulation strengths, and heard from **Peter Challenor (National Oceanography Centre, Southampton)** in the final session, outlining plans to produce initial, first stage forecasts of these types.

Craig J Wallace, RAPID Knowledge Transfer
c.wallace@noc.soton.ac.uk

Notes:

1: The terms 'Atlantic merdional overturning circulation' and 'Atlantic thermohaline circulation' can both be used to describe the circulation characteristics of the Atlantic Ocean that give rise to the vast northwards surface transport of heat, of which the Gulf Stream and North Atlantic Drift are both components.

2: Bryden et al., 2005, Nature, 438, 655 – 657, on the slowing of the Atlantic meridional overturning circulation since 1957.

3: RAPID maintains a distributed monitoring system at three locations across the Atlantic Ocean at a latitude of 26 degrees north – the optimal location for monitoring the structure of the basin-wide circulation.

4: See Hansen et al., 2001, Nature, 441, 927 - 930.

5: See Ellison et al., 2006, Science, 312, 1929 – 1932.

6: See Jacob et al., 2005, Geophysical Research Letters, doi: 10.1029/2005GL023286,2005 for detailed experiment details.