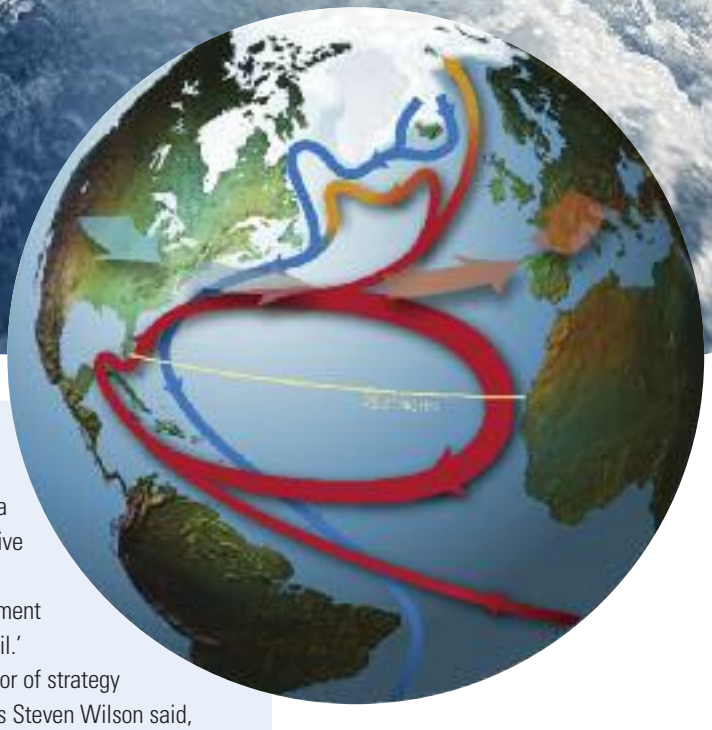
Climate system

Improving predictions, reducing and quantifying uncertainty



Rapid climate change

Until 2007, scientists had no precise knowledge about the daily, weekly and monthly variability of the Atlantic Meridional Overturning Circulation, or Atlantic Heat Conveyor – the ocean circulation that contributes to north-west Europe's temperate climate.

All that changed when two landmark papers from NERC's Rapid Climate Change programme were published in the same issue of the American journal *Science*. The papers were based on an array of scientific instruments across the Atlantic Ocean between North Africa and Miami. For the first time, scientists could say with confidence that the average strength of the conveyor from 29 March 2004 to 31 March 2005 was 18.7 Sverdrups*.

John Church, the former chairman of the Joint Scientific Committee of the World Climate Research Programme, described the programme as 'a bold new initiative led by the UK Natural Environment Research Council.'

NERC's director of strategy and partnerships Steven Wilson said, 'Funding this project was high risk as nothing like it had ever been done before. But it has paid off and is providing some spectacular results.'

- The journal *Nature* listed both papers in its top ten papers for 2007.
- Temporal variability of the Atlantic Meridional Overturning Circulation at 26.5°N. *Science*, 2007.
- Flow compensation associated with the Meridional Overturning Circulation at 26.5°N in the Atlantic. *Science*, 2007.

**1 Sverdrup = a million cubic metres per second.*

Clouds and climate change

Cloud-cover change in a warmer world is one of the major uncertainties in climate research. Scientists from the National Centre for Atmospheric Science and the Met Office Hadley Centre have discovered that carbon dioxide can alter cloud cover on timescales of days to months – not just decades, as previously suggested.

Jonathan Gregory, based at the University of Reading, has found that, contrary to previous research, cloud cover is not linked only to the relatively slow pace of global climate change. If greenhouse warming changes the stability of the lower atmosphere, this could quickly inhibit atmospheric convection and so cloud formation.

Jonathan said, 'If we can tease this faster response from observations and properly account for it, which can be more significant than the slower response from the oceans, this may help improve models more rapidly, reducing a major uncertainty.'

Ozone destruction over Atlantic

State-of-the-art global atmospheric models are underestimating the loss of low-level ozone in the tropical Atlantic by around 50 per cent due to the action of halogens (for example, bromine and iodine) in the air, say scientists from the Universities of York and Leeds and the National Centre for Atmospheric Science (NCAS).

The findings are significant because halogen reactions remove ozone, a greenhouse gas, and increase levels of hydroxyl radicals. This in turn accelerates methane removal, the third most abundant greenhouse gas in the atmosphere.

Director of the NCAS Composition programme Alastair Lewis said, 'While the results from this study could be interpreted as a good-news story – greenhouse gases are destroyed over the ocean in greater quantities than previously thought – the research shows that this remote region cannot be taken for granted. Just a small increase of nitrogen oxides in the air, from shipping or longer-range transport of pollutants, could tip the balance from a sink region to a source for low-level ozone.'

The results come from the first full year of measurements from the recently established NERC-funded Cape Verde Atmospheric Observatory.

■ Extensive halogen-mediated ozone destruction over the tropical Atlantic Ocean. *Nature*, 2008.

Uncertainty over climate proxies

Researchers at the Open University have direct evidence that variations in the magnesium/calcium ratio (Mg/Ca) within tiny shells of marine plankton are not controlled by changes in seawater temperature as the plankton move up and down the water column.

This means that the Mg/Ca ratio of the shell is mainly regulated by the organism itself. The Mg/Ca ratio of shells is often used as a proxy for past ocean temperatures and so for past climate.

It is now clear that scientists need a better understanding of this biological process to define precisely the relationship between temperature and shell Mg/Ca ratio, which is crucial for reconstructing past climates and predicting future climates. The researchers based their study on material recovered from one of NERC's long-term ocean-monitoring stations.

Ozone halts CO_2 absorption

Rising levels of low-level ozone from industrial emissions will significantly hamper plants' ability to absorb CO_2, causing more of the greenhouse gas to accumulate in the atmosphere than previously estimated, according to research in the journal *Nature*.

The research, a collaboration between scientists at the Met Office, the Centre for Ecology & Hydrology and the University of Exeter, shows that this indirect effect of low-level ozone on climate could be at least as great as ozone's direct effect as a greenhouse gas.

The team's global model projects that between the years 1901 and 2100, gross primary productivity on land may decrease 14-23 per cent owing to plant ozone damage. Until now this factor has not been included in climate projections.

Peter Cox from the University of Exeter and director of the NERC Climate and Land Surface Systems Interaction Centre said 'Policies to limit increases in near-surface ozone must be seen as an even higher priority.'

■ Indirect radiative forcing of climate change through ozone effects on the land-carbon sink. *Nature*, 2007.

Monsoon shifts

India will see significantly more days of heavy rainfall as global carbon dioxide levels approach double pre-industrial levels, increasing the likelihood of damaging floods.

Researchers from the National Centre for Atmospheric Science (NCAS) say that, at the same time, cycles of very wet and less wet monsoon behaviour are likely to become more intense with more pronounced dry spells. This will have serious effects on agricultural productivity.

Related work at NCAS has also shown that short-lived but important surface temperature variations in the Indian Ocean may contribute to floods and droughts during the Indian summer monsoon, depending on their strength and location.

Director of the NCAS Climate programme Julia Slingo said, 'These studies using the Met Office Hadley Centre's climate model are giving us new and very important results for working out what will happen to the Indian Monsoon in the next few decades.'

The latest report from the UN's Intergovernmental Panel on Climate Change indicated this was a major area of uncertainty in climate prediction.

Prasanta Biswas/Majority World/Still Pictures

Climate models fail to represent observed tropical rainfall trends

Since 1979, rainfall in the tropics increased rapidly in moist regions and decreased in already dry regions, according to research in the journal *Geophysical Research Letters*.

The size of the changes is substantially larger than state-of-the-art climate models predict. Environmental Systems Science Centre scientists and researchers at the University of Miami say this has important implications for future predictions; the reliability of satellites and other measuring systems; and how researchers monitor the global water cycle.

■ Large discrepancy between observed and simulated precipitation trends in the ascending and descending branches of the tropical circulation. *Geophysical Research Letters*, 2007.