COAPEC

Improved Understanding of the Coupled Climate System

The COAPEC core team: Helen Snaith[1], Bablu Sinha[1], Alan Iwi[2] and Emily Black[3]

[1]Southampton Oceanography Centre, Southampton, SO14 3ZH
[2]Rutherford Appleton Laboratory, Oxon, OX11 0QX
[3]Centre for Global Atmospheric Modelling, University of Reading, RG6 6BB

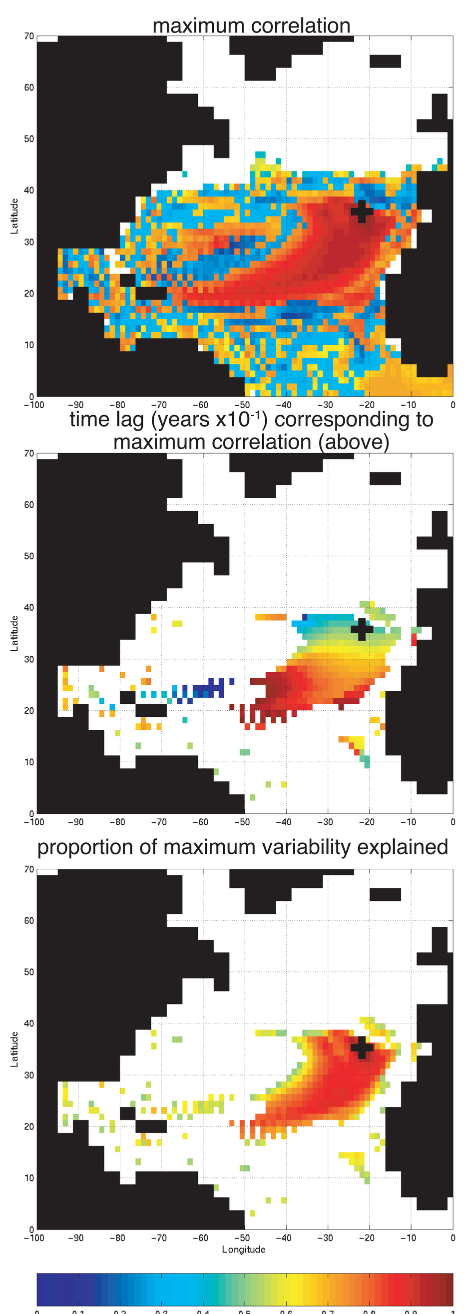
http://coapec.nerc.ac.uk
h.snaith@soc.soton.ac.uk

Under its COAPEC (Coupled Ocean Atmosphere Processes and European Climate) directed-science programme, NERC has funded 20 projects and 14 studentships, to address 5 key research themes (see right).
This poster highlights just a few of the results so far.

Decadal Climate Variability

Investigations of decadal variability of the North Atlantic climate system include research at ESSC, Reading (contact Keith Haines - kh@mail.nerc-essc.ac.uk). Results from the Hadley Centre's coupled climate model, HadCM3 (right), show a spatial lag correlation and regression of 14-15˚C water thickness anomalies below the winter mixed layer base, relative to the thickness anomalies at a point (+). This point corresponds to peak variability of the 14-15°C water layer.

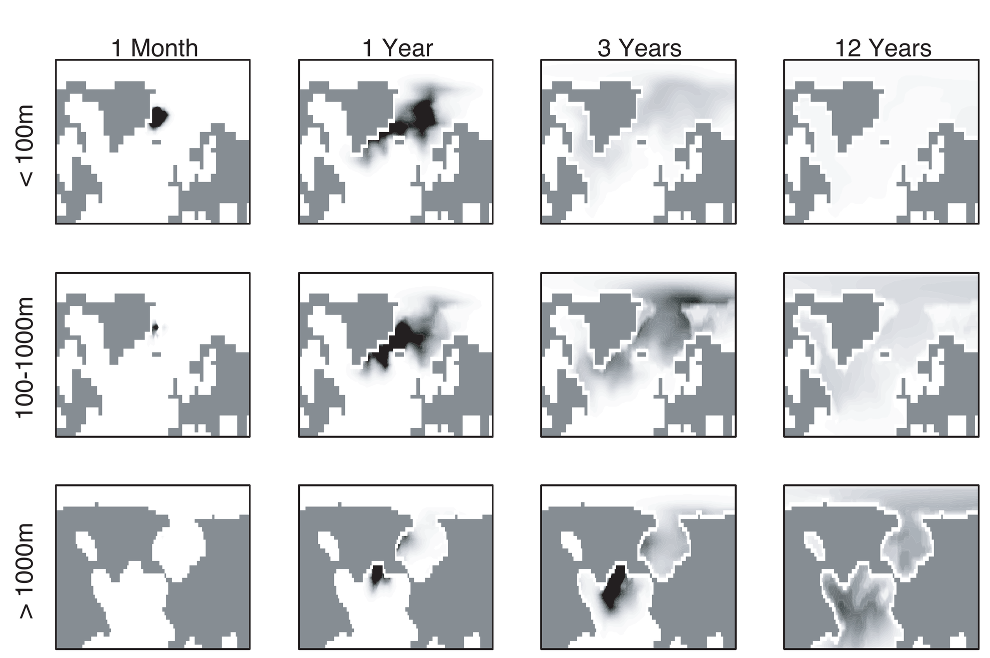
High correlations are found at lag times of up to 10 years and the explained thickness variance at remote sites can still be as high as 80%. Other results show the thermodynamic decay to these water anomalies by conversion to adjacent thermal classes. Re-entrainment into the mixed layer also occurs but so far impacts on the atmosphere have not been found.



Ventilation and Propagation of Isothermal (14-15°C) Layer Thickness Anomalies

Work at UEA and Sheffield has asked: are "Great Salinity Anomalies" advective? (contact Grant Bigg - grant.bigg@sheffield.ac.uk)

"Great Salinity Anomalies" (GSAs) have been observed to propagate around the North Atlantic sub-polar gyre in recent decades (Dickson *et al.*, 1988; Belkin *et al.*, 1998; Belkin, 2004). Their propagation speeds and salt deficits have led to the interpretation that the propagation is advective in origin. Similar anomalies have been seen in HadCM3, but when these modelled anomalies are marked with passive tracers, the model tracers fail to advect with the upper layer salinity anomaly, but instead end up mainly in the northern North Atlantic at depths below the mixed layer (see right). This suggests that, in HadCM3 at least, the movement of salinity anomalies around the sub-polar gyre is not dominated by advection (although it clearly is locally). It is also clear that vertical mixing is not responsible as the salinity anomalies are also seen to move around the sub-polar gyre in the depth averaged salinity, so anomalies in either the oceanic currents and their associated advection of salt, or surface fresh water fluxes, must be responsible.



Mean evolution of 12 passive tracers released in the East Greenland Current during the initiation of a GSA event in HadCM3.

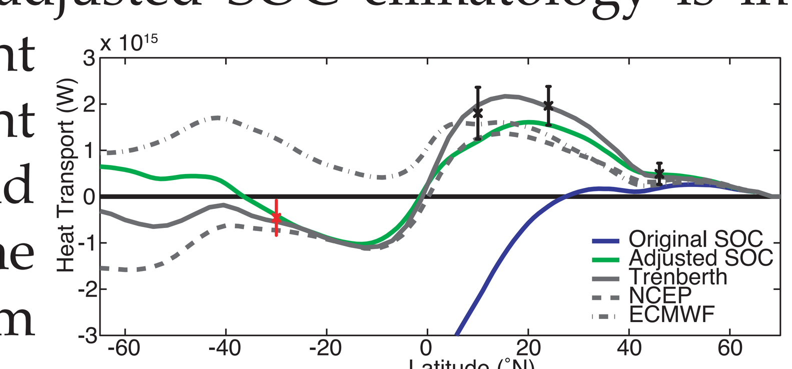
COAPEC's 5 key Research Themes:

- What are the observed characteristics of seasonal-to-decadal climate variability in the Atlantic Sector?
- How do the mean climate and climate variability in the Atlantic Sector simulated by a Coupled General Circulation Model differ from that observed? How do we correct model deficiencies?
- What are the physical mechanisms that determine the mean climate and seasonal-to-decadal climate variability in the Atlantic Sector?
- What processes determine the predictability of climate fluctuations in the Atlantic-European region?
- Bridging the gap between scientific output and societal needs.

Surface Fluxes

Underpinning research into observational datasets has resulted in improvements to the Southampton Oceanography Centre (SOC) surface flux climatology (contact Simon Josey - sxj@soc.soton.ac.uk).

The global mean net ocean heat gain of 30 Wm^{-2} in the SOC flux climatology has been addressed using inverse analysis with 10 hydrographic heat transport measurements as constraints. The preferred analysis solution results in an adjusted version of the climatology for which the global mean net heat flux is -2 Wm^{-2}. The implied ocean heat transport in the adjusted SOC climatology is in good agreement with independent estimates, including a more recent hydrographic value at 32°S and residually derived fluxes (see right). The new fields are available from http://www.soc.soton.ac.uk/JRD/MET/coapec.php and further details of the research can be found in Grist and Josey (2003).



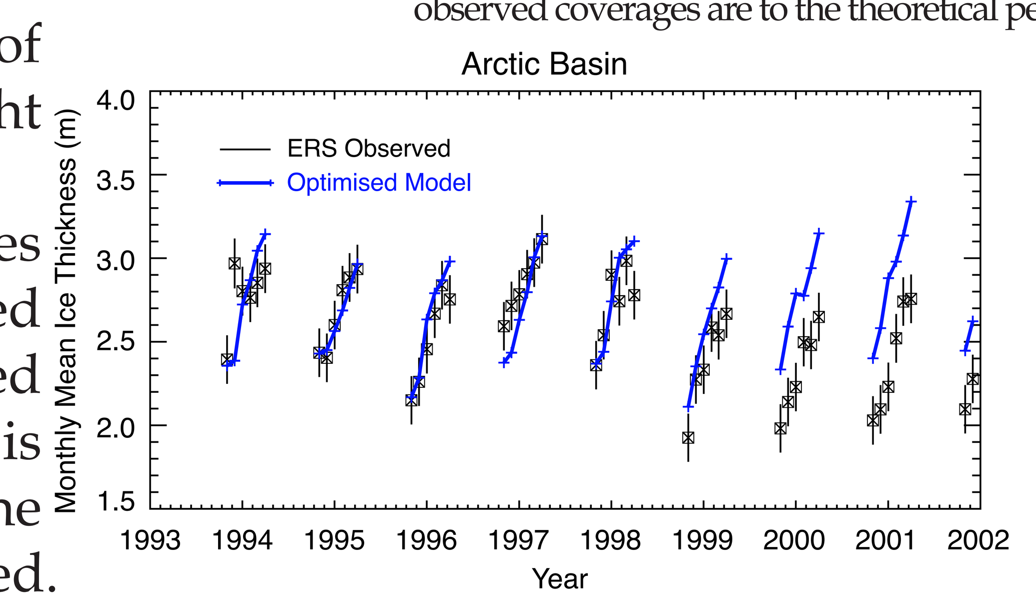
Global Ocean heat transport calculations. Black crosses indicate some of the hydrographic heat transport estimates used as constraints. The red cross is based on a more recent hydrographic estimate at 32°S.

Model Development

The development of climate models to investigate coupled interactions is central to COAPEC. The CHIME model incorporates a hybrid co-ordinate ocean model, whilst a coupled Quasi-Geostrophic model allows investigations of the influence of high resolution ocean features. New sea ice data at the Centre for Polar Observations and Modelling (CPOM) have been used to validate improved sea-ice models for climate modelling (contact Paul Miller - pm@cpom.ucl.ac.uk).

Winter ice thickness data from ERS satellite data (Laxon *at al.*, 2003) highlighted the inability of current climate models, either global or Arctic only, to reproduce the observed high interannual variability of Arctic sea ice thickness. These data, with sea ice area and velocity estimates, were used to examine in fine detail the performance of a state-of-the-art sea ice model, improve model predictions of thickness, area and velocity simultaneously and highlight aspects of models in need of further improvement.

Shown here are observed monthly-mean ice thicknesses for all winter months from 1993 - 2001 and modelled values from the optimised sea ice model. Mean observed thickness (standard deviation) over the whole period is 2.78m (0.88m), while the model gives 2.72m (0.96m). The worsening agreement seen after 1999 is being investigated.



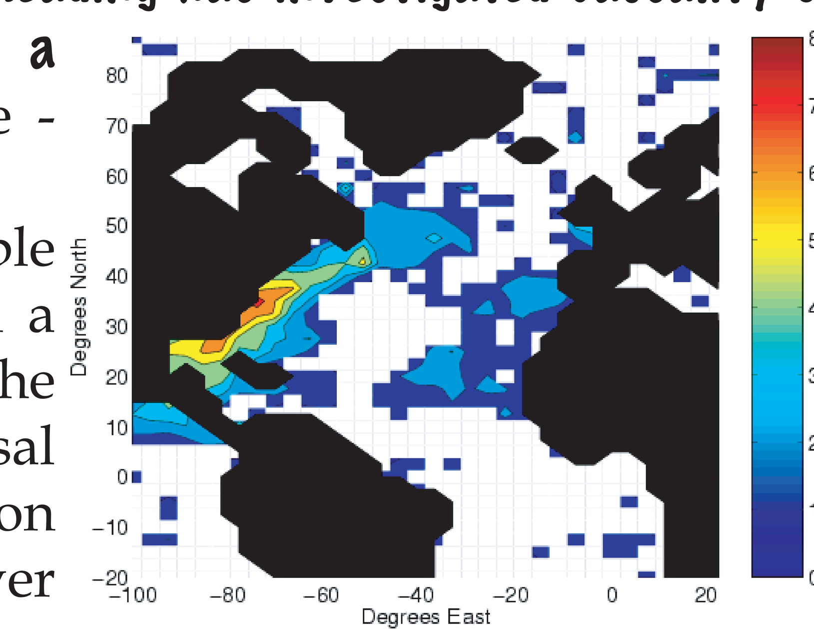
Mechanisms Determining Variability

Several research projects at Reading have looked at a variety of mechanisms for variability, including the role of Bjerknes compensation in energy transport variability (Shaffrey, Thursday), **multi-season memory in the Atlantic Ocean** (George, Thursday) **and the relationship between atmospheric blocking and the North Atlantic Oscillation** (Tyrlis, Friday).

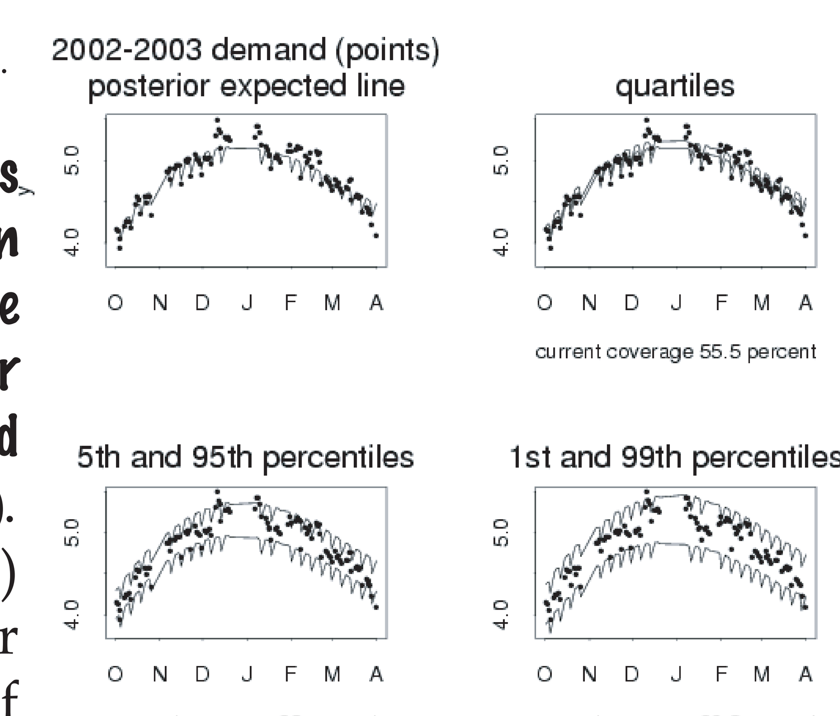
Predictability

COAPEC has investigated many issues regarding climate predictability. The ClimatePrediction.net experiment (talks on Thursday and computer demonstration) **uses ensembles to investigate parameter space, whilst Emily Black has investigated the predictability of the Summer 2003 heatwave** (see poster). **A student project at the University of Reading has investigated causality of ocean-atmosphere interactions in a complex GCM** (contact Tim Mosedale - t.j.mosedale@reading.ac.uk).

Granger causality tests on a simple VAR model fit to daily data from a control HadCM3 simulation show the region where the local SST is causal for the NAO index. In this region knowledge of the values of SST over the previous few days is of predictive value for the NAO index, suggesting that this region is key to the influence of the ocean on the large-scale atmospheric flow. The coloured grid points show significance at the 95% level for the causal effect of SST on the NAO.



Another project at the University of Reading is investigating the use of seasonal forecasts for the UK Energy Sector (contact Sergio Pezzuli - s.pezzulli@reading.ac.uk).



Observed demand (points), posterior mean and other selected percentile trajectories. Note how close the actual observed coverages are to the theoretical percents

Electricity forecasts are currently based on climatology by means of a Bayesian model. This allows production of the "posterior" probability distribution for any quantity of interest, like the entire trajectory, the winter mode or the economical value of any particular business strategy. Seasonal forecasts have insufficient skill to be if use yet, but short term forecasts show positive impacts.

References

Belkin, I.M., S. Levitus, J. Antonov and S.-A. Malmberg (1998) "Great Salinity Anomalies" in the North Atlantic, Prog. Oceanogr., **41**, 1-68, .

Belkin, I.M. (2004) Propagation of the "Great Salinity Anomaly" of the 1990s around the northern North Atlantic, Geophys. Res. Lett., **31**, L08306, doi:10.1029/2003GL019334.

Dickson, R.R., J. Meincke, S.-A. Malmberg and A. J. Lee (1988) The "Great Salinity Anomaly" in the northern North Atlantic, 1968-1982, Prog. Oceanogr., **20**(2), 103-151.

Grist, J. P. and S. A. Josey (2003). Inverse analysis adjustment of the SOC air-sea flux climatology using ocean heat transport constraints. *J. Climate*, **16**, 3274-3295.

Haines, K. and C. P. Old. Diagnosing natural variability of the North Atlantic water masses in HadCM3. *J. Climate*, In Press.

Laxon, S., N. Peacock and D. Smith (2003). High interannual variability of sea ice thickness in the Arctic region. *Nature*, **425**(6961), 947-950.