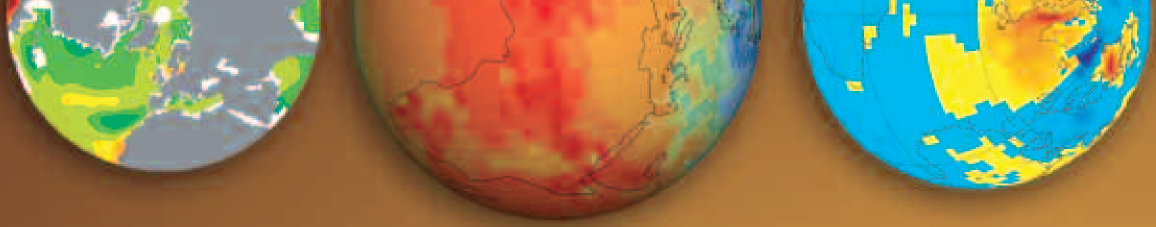


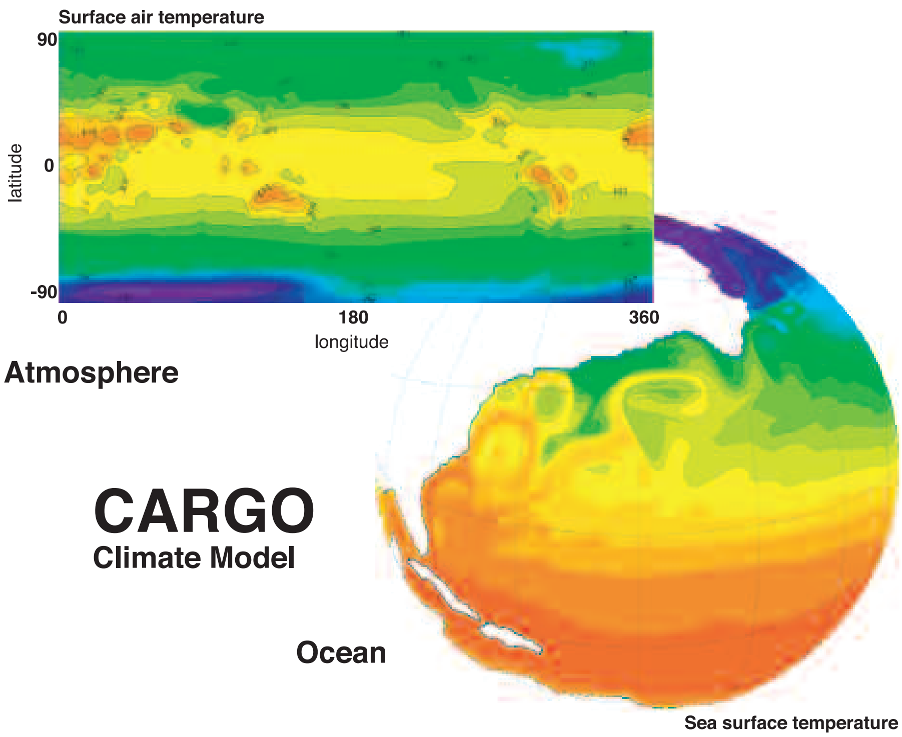
Oceans & Atmosphere

New climate models developed within COAPEC

COAPEC project investigators were encouraged to use existing coupled models, such as the Hadley Centre's coupled Climate Model HadCM3, for their research. However, they also undertook some model development in order to achieve COAPEC objectives. The Core Team members were particularly active in working with researchers to develop models that are now generally available to the scientific community.

The Hadley Centre's HadCM3 climate model was the state-of-the-art climate model for much of the COAPEC programme. The Hadley Centre made 1,000 model years of data from HadCM3 available to COAPEC researchers. However, investigations into the mechanisms that determine the climate's variability and predictability required models to be run with different parameters than were used for this control run, or using different representations of physical processes such as mixing. We realised that existing models could not allow us to carry out all of the experiments needed for these investigations. In addition, relying on a single model would restrict our understanding to the specific representation of the climate system used in that model.

Each of the new models has a specific niche in coupled research. In some cases, we have developed different models to address similar issues, but the models represent parts of the climate system in very different ways. For example, we have developed two models to help us understand how small scale ocean features influence interactions between the ocean and the atmosphere. Each model runs a high-resolution ocean but represents the ocean dynamics very differently.



CHIME
National Oceanography Centre, Southampton

CHIME - the Coupled Hadley-Isopycnic Model Experiment – is a new IPCC class coupled climate model. CHIME uses the same atmosphere and ice component models as HadCM3. It also has similar horizontal resolution for the ocean, but it represents the ocean's vertical structure very differently. This formulation follows isopycnic (constant density) surfaces, rather than fixed depths. We expect it to more accurately represent the ocean, eg. by preserving water mass properties better. This new model means that the UK no longer relies on predictions from a single type of model.

FORTE
National Oceanography Centre, Southampton

FORTE is an intermediate complexity model, sitting between high end (IPCC-class) climate models such as HadCM3 and CHIME, and reduced physics or box models. FORTE is used to investigate fundamental climate processes and to test hypotheses, as it runs ten times faster than other primitive-equation based climate models. This allows for long integrations and large ensembles. COAPEC researchers used it to underpin investigations ranging from the relative effects of mountains and ocean on European climate, to the ocean's influence on atmospheric storm tracks.

C-Goldstein
National Oceanography Centre, Southampton

C-GOLDSTEIN is an Earth system model of intermediate complexity. It efficiently addresses coupled processes involving the atmosphere, ocean and sea-ice. C-GOLDSTEIN includes a fully 3D frictional geostrophic ocean component, but retains high integration efficiency (20,000 years of integration run in about a day on a PC). We coupled a frictional geostrophic ocean to a simple energy moisture balance model of the atmosphere and a standard thermodynamic model of sea-ice. We later coupled it to a low-resolution general circulation model of the atmosphere and an elastic-viscous-plastic model of sea-ice rheology. The original C-GOLDSTEIN model proved versatile in studies for which we needed several ensembles of 100-1000 simulations.

Q-GCM (Quasi-Geostrophic Coupled Model)
National Oceanography Centre, Southampton

The coupled models used to predict our climate have long possessed enough grid points to describe the natural atmospheric length scale (about 1000km), so that the atmosphere in the models has realistic variability. However, the models lack enough grid points to describe the ocean's natural length scale (about 30km). This means the models' oceans have far less variability than researchers have observed. Does this matter? Could the real ocean's natural variability play a role in decadal climate variability, and if so, how? We do not yet have the computing power to fully answer this question, but we do a good job with slightly simplified models. We developed the Quasi-Geostrophic Coupled Model, a quasi-geostrophic representation of the ocean, coupled to a quasi-geostrophic atmospheric model, to answer these questions.

CARGO (Coupled Atmosphere - Reduced Gravity Ocean)
University of Reading

We developed CARGO to determine how better-resolved small-scale oceanic features such as western boundary currents, geostrophic eddies and Kelvin waves affect the coupled climate system. CARGO is an atmospheric general circulation model (the Reading Intermediate General Circulation Model at T31 resolution) coupled to a reduced-gravity model of the Atlantic (with between 1/6 and 1/12 degree lateral resolution); climatological sea surface temperatures are prescribed over the remainder of the oceans. We are using CARGO to study how a weakened Atlantic overturning circulation affects the atmosphere.

HOPE – Stochastic
Rutherford Appleton Laboratory

We developed a hybrid coupled climate model to investigate seasonal predictability of Western-European climate. This model comprised a fully dynamical ocean (HOPE) and an atmosphere consisting of: a regressive model, driven by underlying sea surface temperature and a stochastic model, driven by a representation of internal atmospheric variability. The hybrid coupled climate model reproduced the same geographic annual variability of sea surface temperature as the model it was derived from. Like previous models of its kind, the hybrid coupled climate model produced less interannual variability than the forced HadAM3 runs.

Sea surface temperature from Q-GCM.