# Update on Perturbed Physics Ensembles

Ben Booth, B. Bhaskaran, Kate Brown, Mat Collins, Glen Harris, James Murphy, David Sexton, Mark Webb

Hadley Centre for Climate Prediction and Research, Met Office, Exeter, UK

Slab-Model Ensemble Simulations

- 128 HadSM3 (atmosphere-slab ocean model) ensemble with parameters perturbed simultaneously
- Additional simulations underway to explore more of parameter space
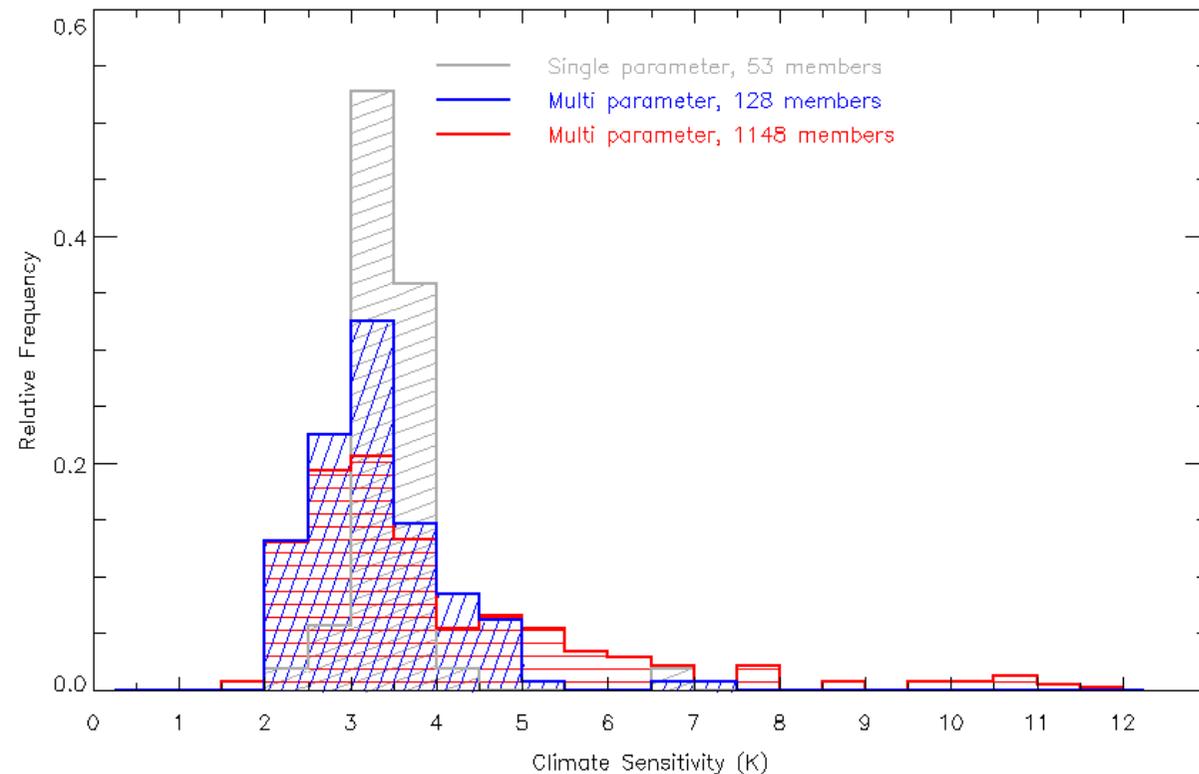
Murphy et al., 2004
Webb et al., in press
Stainforth et al., 2005

Understanding the drivers of uncertainty

LW cloud feedback (W/m²/K)
SW cloud feedback (W/m²/K)
Net cloud feedback (W/m²/K)
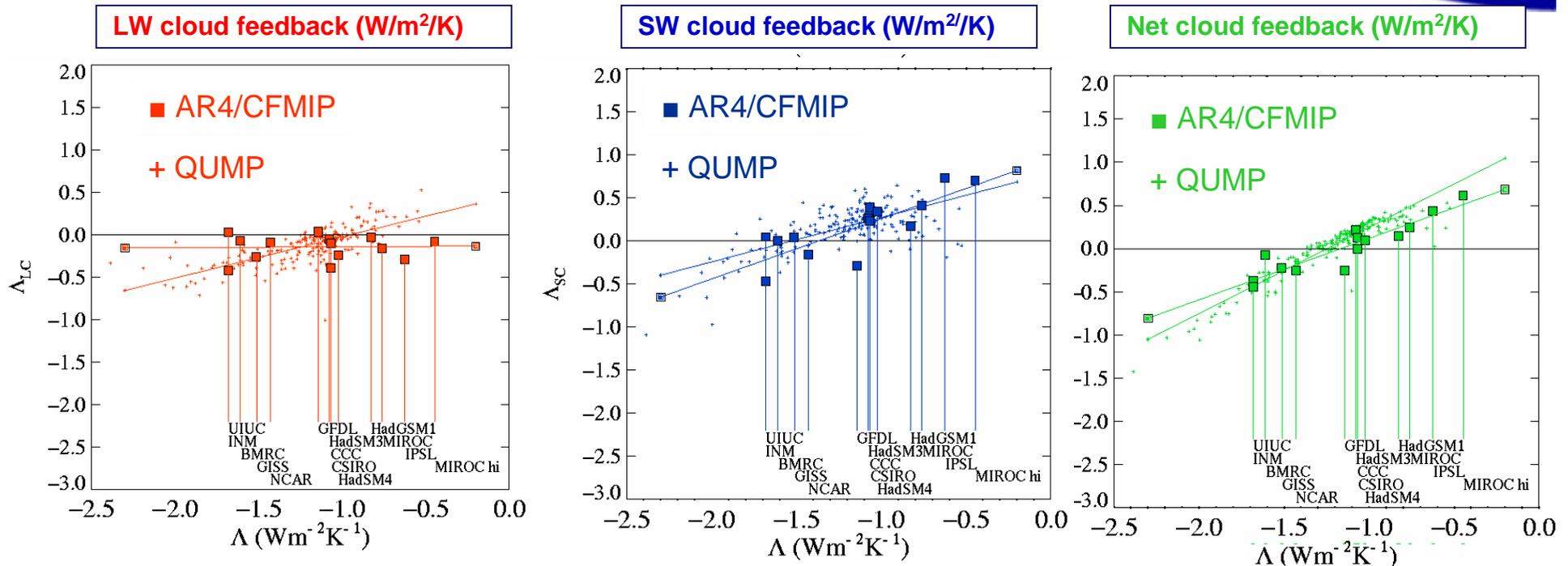
- QUMP spans 80% or more of the range in global cloud feedbacks seen in other models
- The largest spread in net cloud feedback comes from areas dominated by changes in low level cloud amount
- Used to inform the implementation of the discrepancy term

Webb et al 2006, Climate Dynamics, in press
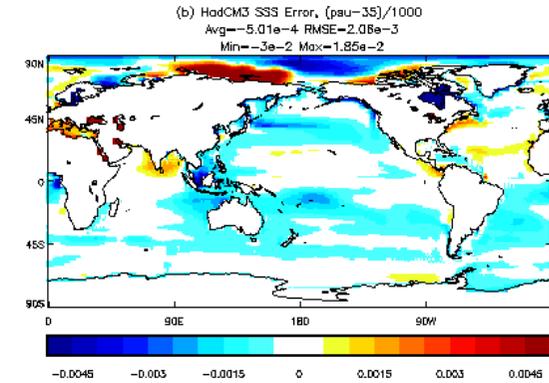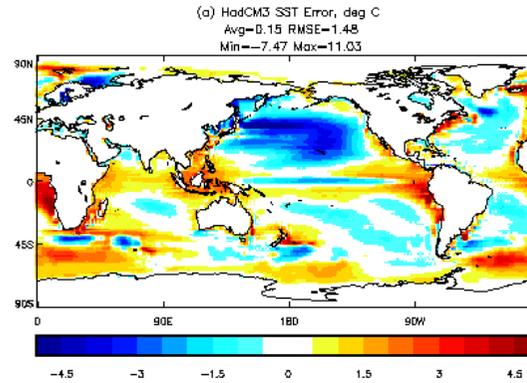
HadCM3 Ensembles

- Need coupled model experiments to capture time-dependent climate change
- A 17 member ensemble of HadCM3 (atmosphere-dynamic ocean) experiments with perturbed atmosphere, surface and sea-ice parameters

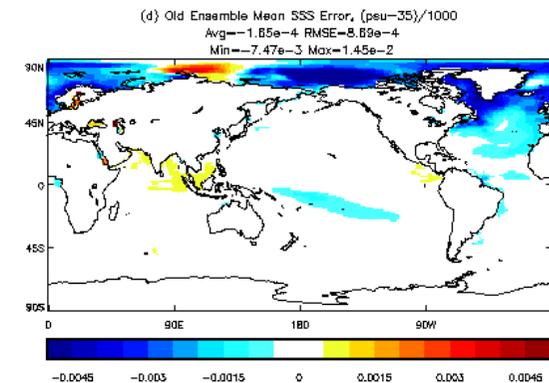

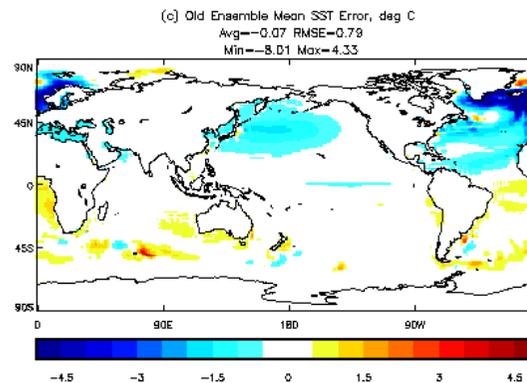Collins et al., Clim. Dyn. in press
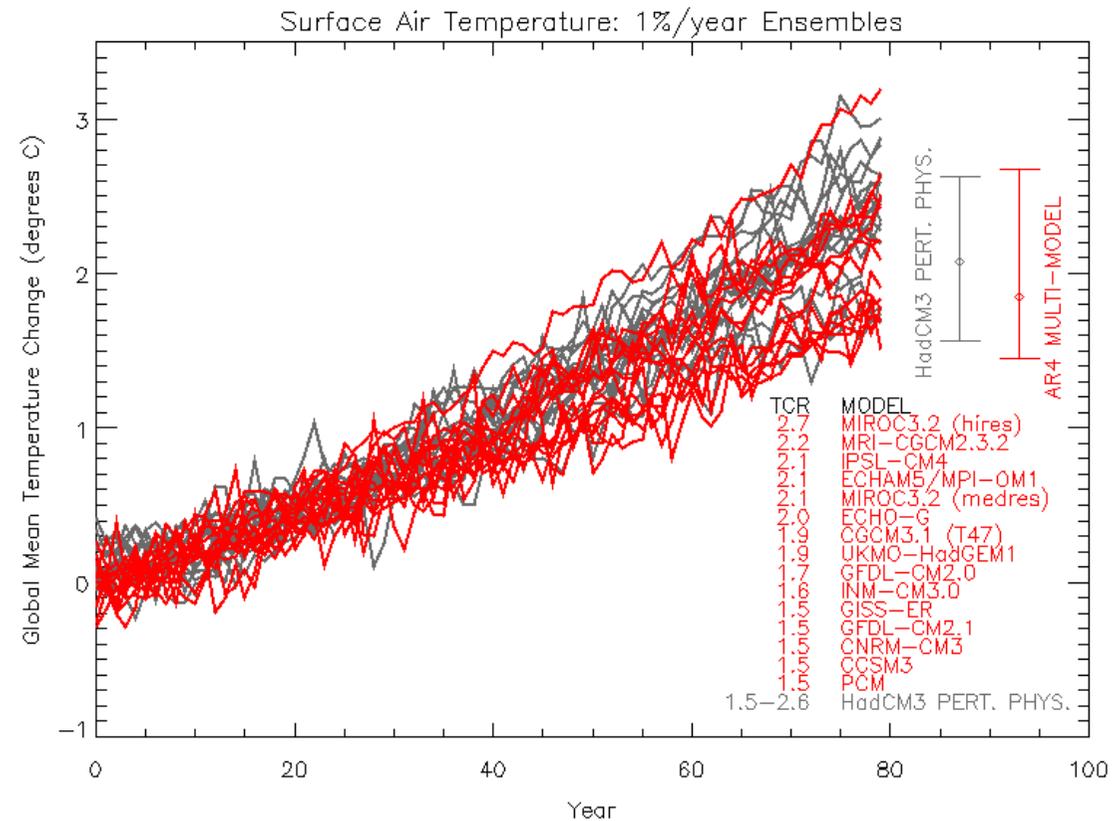
New Ensemble with Reduced SST/Salinity Biases

HadCM3 – Obs
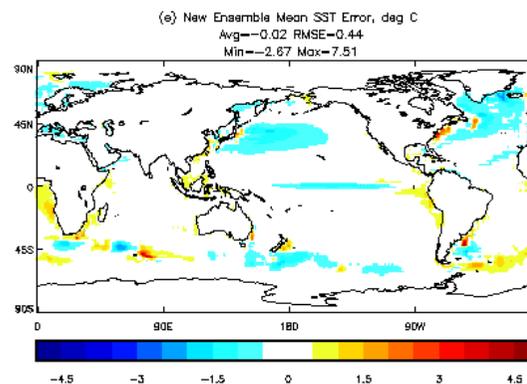
Flux-adjusted – Obs
(Collins et al. 2006)

New flux-adjusted -
Obs

- Old ensemble (grey)
- New ensemble (black)
- HadCRUT observed series (red)

- Slightly wider range of feedbacks explored in new ensemble

Historical+A1B Ensembles
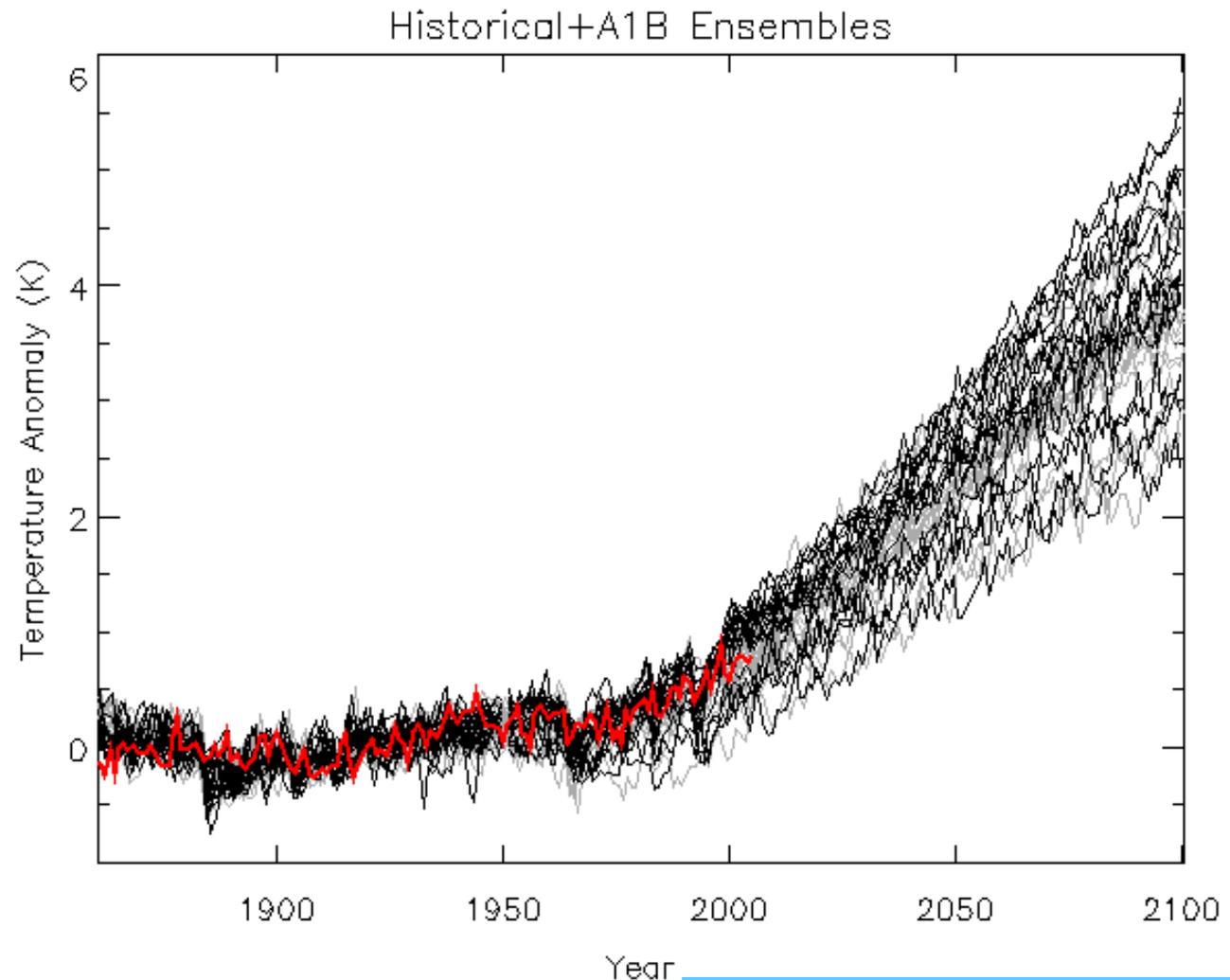
Glen Harris, Ben Booth

Ocean Parameter Perturbation Experiments

Global Mean Temperature

Changing these ocean parameters has little effect on the rate of time-dependent climate change

Collins, Brierley, MacVean, Booth and Harris, submitted to J. Clim.

Ocean Parameter Ensemble

- **Perturbations to key parameters in the ocean component**
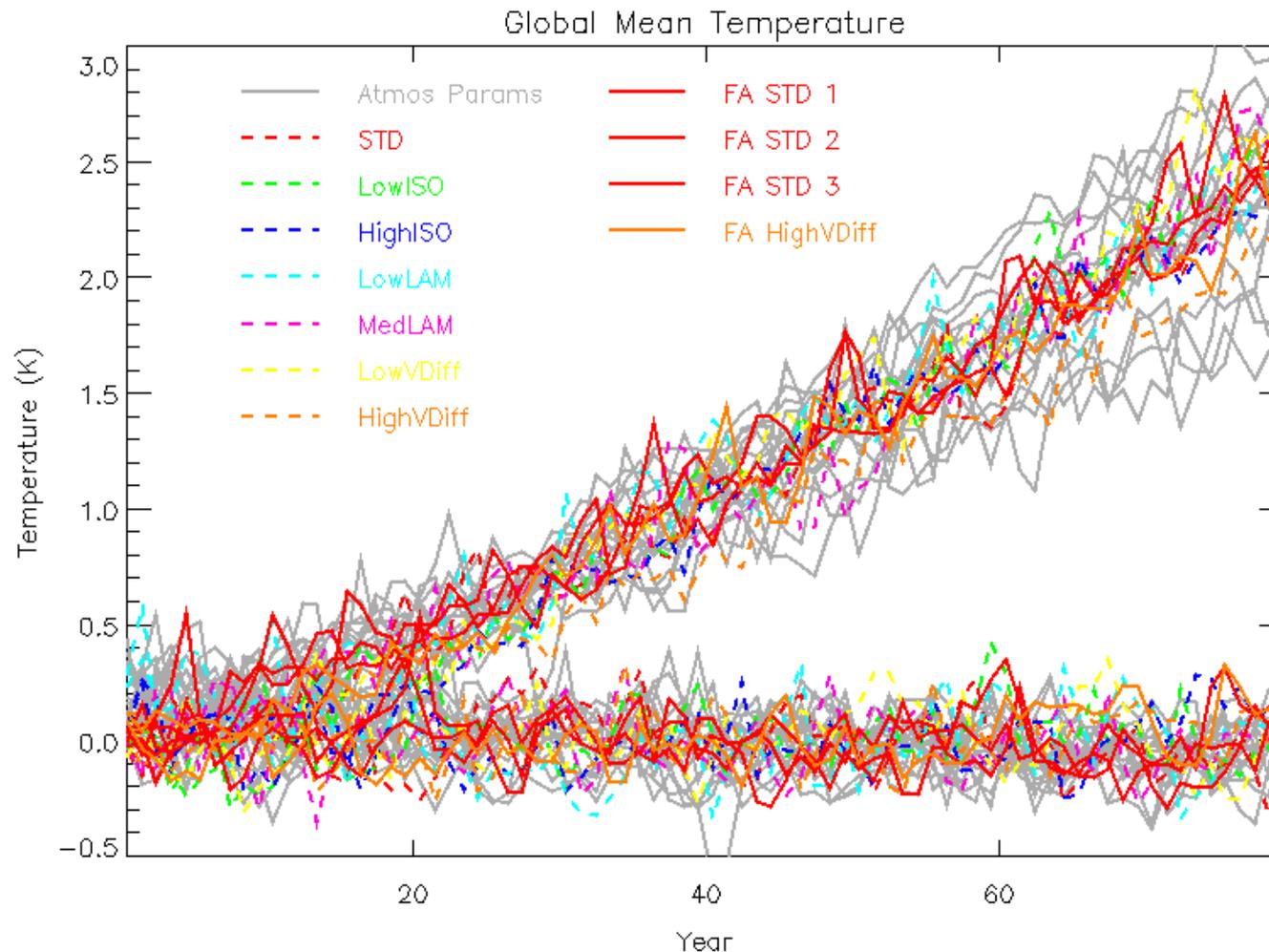
  1. Horizontal diffusion of heat and momentum

  2. Gent and McWilliams + Visbeck scheme

  3. Vertical diffusivity

  4. Mixed layer scheme (Quadratic/Full Large scheme)

  5. Marginal sea outflow

  6. Water type

- **16 members (+standard) Latin Hypercube design**

Mat Collins, Chris Brierley

Sulphur-Cycle Parameter Ensemble

- Perturbations to key parameters controlling the HadCM3 sulphur-cycle representation

  1. Background volcanic emission scaling

  2. Scavenging rate of SO4 by large-scale and convective rain

  3. Background minimum cloud droplet number of continents

  4. Particle size distribution for Aitken mode

  5. Particle size distribution for Accumulation mode

  6. Level for high-level sulphur emissions

- 16 member (+standard) Latin Hypercube design

Ben Booth, Hadley S-cycle Group

Carbon-cycle Parameter Perturbations

- Have been setting up a carbon-cycle version of HadCM3 with 1.25°x1.25⁰ horizontal ocean resolution
- Currently in spin-up phase
- Plan to perturb parameters in the terrestrial carbon cycle component only

Air to sea CO_2 flux

Ben Booth, Hadley C-cycle Group
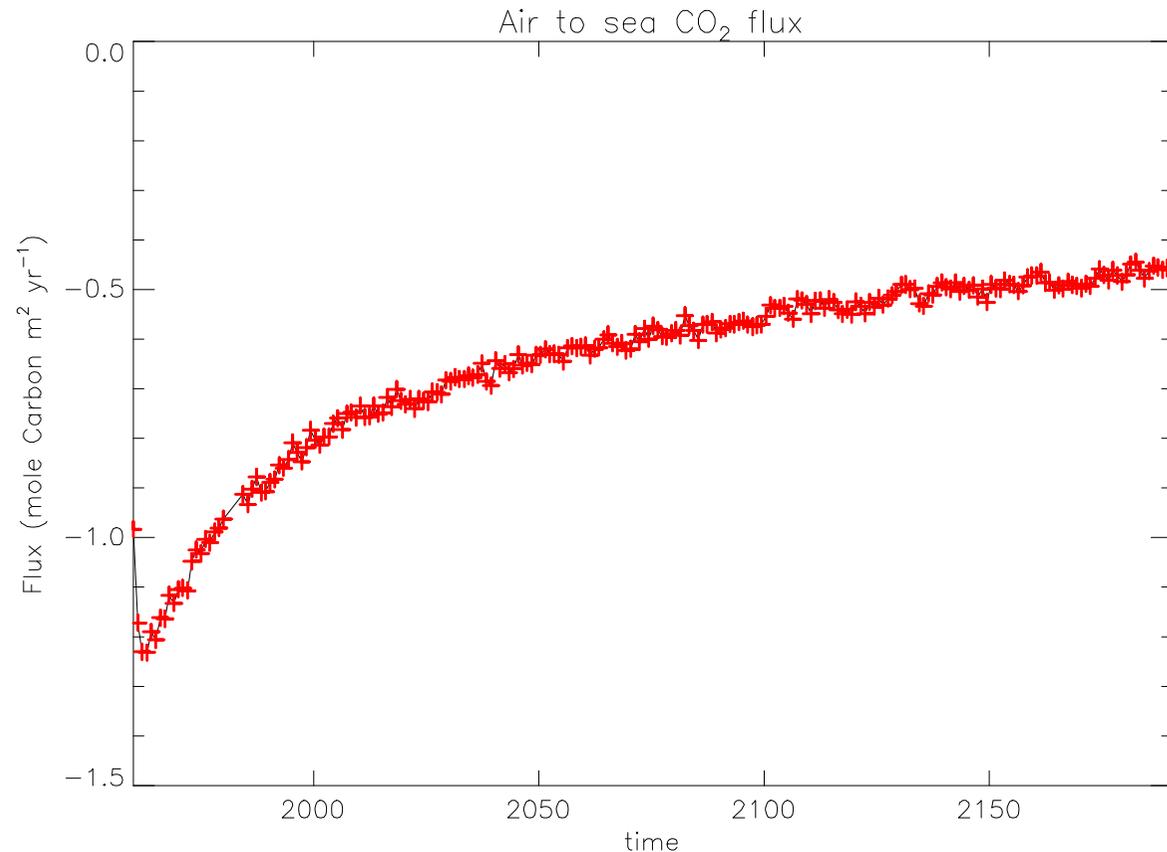
A "Cross-Validation" Ensemble

- Simultaneous perturbations made to parameters in the atmosphere, surface, sea-ice, ocean, sulphur-cycle and terrestrial carbon cycle
- To investigate interactions between uncertainties in different components and different physical and biogeochemical feedbacks
- Hopefully starting mid 2007, dependent on proceeding work and computer resources

Down-scaling to the UK and Europe

■A small number of 25km resolution HadRM3 (regional model) experiments driven by boundary forcing from the HadCM3 ensemble (1950-2100)

■Evaluating test experiment now

surface Atmos Atmospheric model land/sea mask Land=1, Sea=0
From 0/ 0/ 0 to 0/ 0/ 0

Min=0.00000
Max=1.00000

Mean=0.517545

Robin Clark, David Hassell, …