Including Ocean Model Uncertainties in Climate Predictions

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Talk Outline:

- **Probabilistic Climate Forecasts**
- **A recipe book of perturbations**
- **Current Investigations**

Attaching Probabilities

Probabilistic weather prediction is well established.

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DEMETER: 6 European GCMs used for seasonal forecasting

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Multi model ensemble required

Perturbed Models

- Only a small amount of independent models in world (e.g. 18 in IPCC)
- Climate*prediction*.net creates many models from HadAM3
- Uses home PC's to perform the integrations
- Currently uses a 'slab' ocean

An Ocean Model

- Required to accurately model transient behaviour
- Will have its own uncertainties
- Requires even more computing power
- Create new models by perturbing the parameters within sub-grid parameterisations

Selection of Perturbations

- Hundreds of possible perturbations
- Shortlist obtained from literature
- Ranges from observational uncertainty or from oceanographers – rather than climate scientists
- Restrict analysis to those with large climate effects
- Determined top 3 perturbations

Isopycnal Diffusivity

- Diffusion along lines of constant density
- Important in vertical heat transfer in high latitudes
- Diffusivity different at surface and depth
- Same value used in HadCM3 for whole ocean
- Values used are an observation for the surface, an observation at depth and a mid range value (standard HadCM3)

Kraus & Turner Mixed Layer

- Wind Mixing Energy,

$$W = \lambda \rho_w \left(\sqrt{\frac{\rho_a C_D}{\rho_w}} |V| \right)^3$$

- λ is an artificial scaling factor because V is the wind speed at 10m, not at the ocean surface.
- Decay with depth also a factor.

- Perturb λ and depth scale, d, simultaneously to get different realisations of the Mixed layer

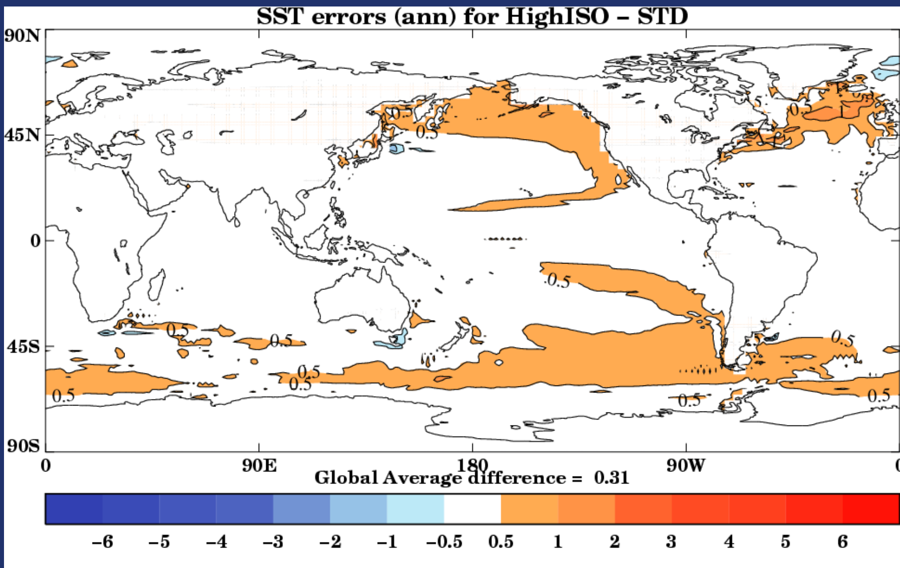
Vertical Diffusivity

- Models vertical mixing due to eddies
- Strength of the mixing changes with depth
- Range chosen from a selection of observations
- Does not affect mixed layer as that is mixed using Kraus – Turner model
- Applied as a background diffusivity in Pacanowski and Philander scheme.

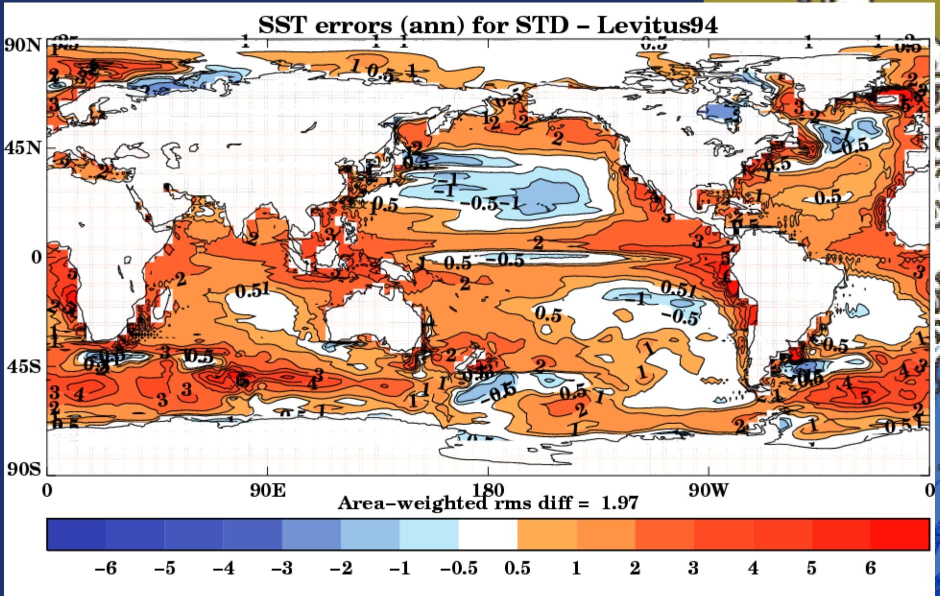
Experimental Setup

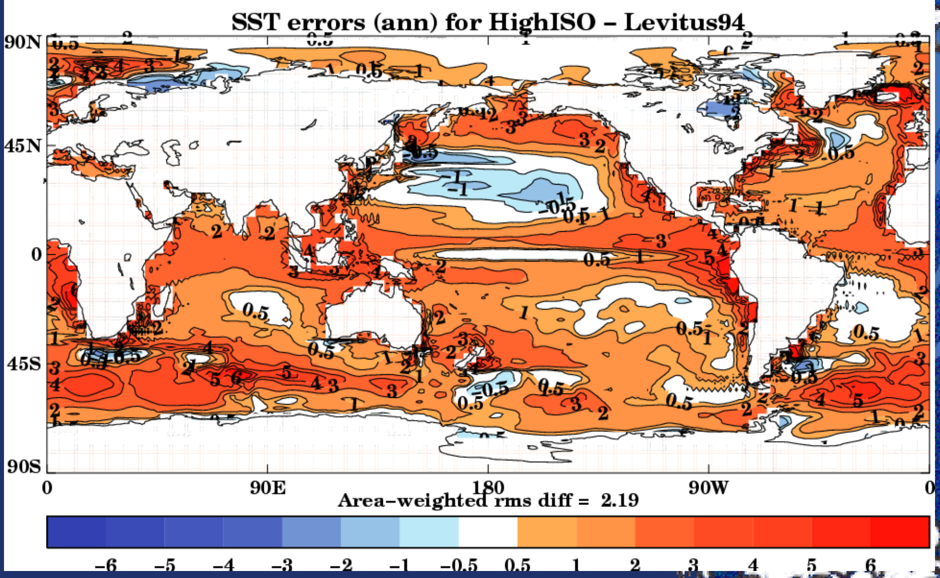
- 7 member ensemble: Standard HadCM3 and then max and min of the 3 perturbations above
- 500 year coupled spin up from Levitus observations
- 80 yr Control run
- 80 yr 1% per year CO_2 increase (CMIP)

The effect of a perturbation on the control climate



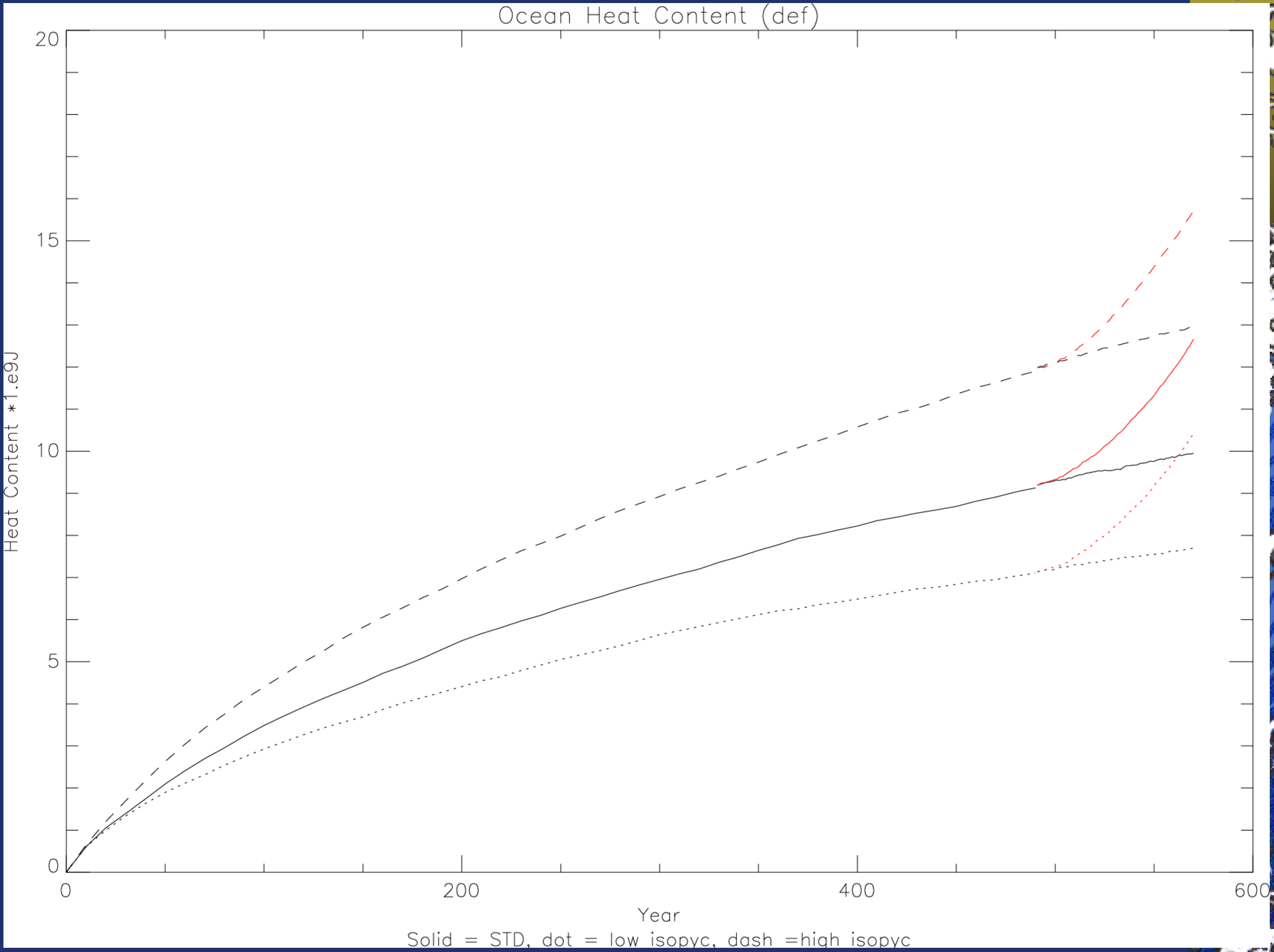
The change in SST due to increased Isopycnal Diffusivity





The Difference between observations and the standard model (top) and the member with increased isopycnal diffusion (bottom)

Ocean Heat Content for Standard model and perturbed Isopycnal models



Future Work

- *Determine ensemble-wide properties*
- *Investigate the effects and linearity of the individual perturbations on the control climate to gain understanding about the physical process*
- *Investigate the effects on the global warming signal to estimate how much uncertainty is contained in the parameter*