Forcing models with flux anomalies, a proposed MIP (FAFMIP)

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Overview of presentation

Trying to understand, and isolate, the role of the ocean in transient climate change

• Proposed MIP with coupled models – FAFMIP
  Coupled integrations with prescribed ‘overrides’ of windstress, freshwater and heat fluxes acting at the sea-surface

• Some background
  Review studies of ocean heat uptake using ocean-only models with prescribed heat flux ‘overrides’

• Conclusions
FAFMIP

• Assess spread of ocean model predictions of mean state and climate change of
  – Sea Level
  – AMOC
  – Heat uptake &
  – transient tracer and carbon uptake

CMIP6 experimental design

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Method

• Force coupled AOGC control runs with ‘overrides’
  The ‘over-rides’ are common anomalous forcing patterns obtained as ensemble-means of ‘1%CO$_2$ minus control’ CMIP5 calculations

• Proposed ‘overrides’ are:
  – surface wind stress
  – surface heat flux
  – surface freshwater flux
  – all of the above combined
  – geographically uniform heat flux anomaly
Example: ocean-only run under CORE-I forcing

Climate change experiment with a heat flux override:

- Abrupt, uniform surface forcing of $F = 4 \text{ W/m}^2$ everywhere
- Spatially-invariant radiative feedback of $\lambda = 1 \text{ Wm}^{-2}\text{K}^{-1}$

Note:
Only surface heat fluxes are perturbed
No change in winds or E-P

Marshall et al, 2014: Climate Dynamics
Temperature anomalies after 100y

Fig. 5. Temperature perturbation after 100 years of an ocean-only calculation perturbed by a uniform downwelling flux at the ocean’s surface.

Ocean-only run

CMIP5 runs

SST change in expt 4xCO2 – present day


A. Romanou – Ocean’s Carbon and Heat Uptake wrkshp, San Fran, Dec 12-14, 2014
Strong similarity between anthropogenic temperature and transient tracer in CMIP5

Sensitivity of transient tracer uptake to strength of MOC

- Experiments with CORE-I forcing and transient tracer
- Vary AMOC in two different models: GISS and MIT

Romanou et al, in prep

12/13/14
Simple model of tracer uptake

\[ A h_2 \frac{\partial C_2}{\partial t} - q(C_1 - C_2) = 0 \]

\[ C_2 = C_1(1 - e^{-\gamma t}) \quad \text{where} \quad \gamma = \frac{q}{A h_2} \]

**Inventory** = \( A h_2 C_2 = C_1 qt \) (in the limit that \( \gamma t \ll 1 \))

Simple model suggests that the tracer inventory increases linearly at a rate set by the overturning strength

*Romanou et al, in prep*
Heat uptake varies with AMOC in CMIP5 models

Figure 3. (a) Correlation between $D_{80\%}$ and $D_{AMOC}$ ($R = 0.93$, $p$ value $p < 0.01$); (b) Correlation between $D_{AMOC}$ and $M_{AMOC}$ ($R = 0.92$, $p$ value $p < 0.01$).

Kostov et al 2014, GRL
Concluding remarks

• FAFMIP will use AOGCMs, and a variety of ‘override’ forcings (heat, salt, wind)

• Coupled models are needed to represent climate feedbacks appropriately

• In ocean-only models, progress can be made using a simple air-sea feedback parameter $\lambda$

• Ocean’s MOC plays a central role in setting patterns and rates of heat and tracer uptake
MERRA Analytic Services (MERRA/AS)

CDS is storing MERRA data, a Global Modeling and Assimilation Office (GMAO) reanalysis that integrates observational data with NASA’s GEOS-5 atmosphere model, on a HADDOP cluster running the integrated Rule-Oriented Data System (iRODS). Using iRODS and Hadoop/MapReduce, MERRA/AS is able to efficiently perform operations such as calculating averages, total precipitation, temperature variation, as well as subsetting by variable, time, region, and atmospheric pressure range and provide the data to the user within several minutes. 

Access to MERRA/AS is through the CDS API

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