Response of the CHIME coupled climate model to two climate forcing scenarios

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 - SAT and SST
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RAPID and the UK THCMIP

RAPID project: £20 million, six-year (2001-2007) programme funded by the Natural Environment Research Council.

Now continued under RAPID-WATCH

UK THCMIP: Conduct climate change experiments using a suite of UK coupled climate models (HiGEM, HadCM3, CHIME, FORTE, FAMOUS, FRUGAL, GENIE)

Climate Experiments

Transient 1% increasing CO_2 – results in 4x pre-industrial CO2 after 140 years

0.1 Sv hosing – distributed uniformly between 50N and 70N

Data stored daily for 1 year, 5 day for 10 years, and monthly for the full experiment.

Vertical ocean coordinates and climate prediction

IPCC AR3 model intercomparison shows the effect of anthropogenic greenhouse forcing on predicted Atlantic MOC.

In most IPCC models the MOC reduces under global warming, except ECHAM4/OPYC, which has an isopycnic ocean component. Since then, a NASA GISS coupled model with a hybrid-component ocean also has a stable MOC under GHG forcing.



Relative MOC strength in coupled models under plausible emissions scenarios (from IPCC AR3)

The CHIME model

HYCOM v2.1.34 ocean

- Uses 2000 dbar reference pressure for potential density (σ_2), and applies a correction for thermobaricity.
- Spherical 1.25° x 1.25° grid south of 55°N, with bipolar grid covering Arctic (poles at 110°W and 70°E)
- Bering Strait and Gibraltar Strait open.

HadAM3 atmosphere

• $3.75^{\circ} \times 2.5^{\circ}$ resolution with 19 σ -layers.

Ice model

 Semtner thermodynamics, plus drift with ocean surface current (same as in HadCM3).

Coupling

Ocean and atmosphere coupled daily through OASIS v2.4

Global mean 1.5m surface air temperature



Decadal mean SAT change (°C)



2

CHIME



Decadal mean SST change (°C)





CHIME



Decadal mean precipitation change (mm/month)



CHIME







Reduction in ice cover (decadal mean, %)



CHIME







Decadal mean SAT change (°C) After 100 years of 0.1Sv hosing



CHIME



Decadal mean SST change (°C) After 100 years of 0.1Sv hosing



HadCM3

CHIME

CHIME

Atlantic MOC (Sv) = CM3 spin-up/control = 0.1 Sv Hosing

Time smoothed maximum

HadCM3 & HadGEM1

N. Atlantic MOC and the steric height gradient

Original figure from Thorpe et al (2001)

Temperature anomalies @ 1000m Transient 1% after 140 yrs

FORTE

Summary

- Climate Sensitivity runs complete, but still at early stage of analysis.
- Data converted to CF-1.4 compliant NetCDF.

Transient CO₂ experiment

- Decrease in MOC is about 5 Sv (similar to HadCM3).
- Global mean SAT increases linearly by 4°C over 140 years, but...
 - Regional changes, in particular over land and the Arctic show much larger responses.
- Global mean SST increases
 - Again, warming strongest in northern Hemisphere.
 - Some cooling over the Southern Ocean maybe some change in circulation?
- Reduced precipitation over Amazon & Caribbean. Major changes in tropics.
- Decrease in ice cover
 - CHIME and HadCM3 both show strong decreases in ice cover (N and S).
 - Ice cover reduction more severe in CHIME, especially in NH.

0.1Sv hosing experiment

- In CHIME the Atlantic MOC decreases initially by about 4 Sv, but recovers before hosing is removed.
- In HadCM3 the MOC decrease is similar, but doesn't recover until hosing is stopped – then overshoots.
- Very little SAT/SST change in CHIME, but HadCM3 shows North Atlantic cooling of >2°C and warming in the Nordic Seas.
- Little change outside of North Atlantic in either model.

Steric height gradient vs Atlantic MOC

- CHIME does not show any clear correlation.
- HadCM3 and FORTE do show gradients, but not the same.
- Some evidence to suggest that an E-W gradient may be better.