

Sea surface temperature and subsurface density fingerprints of the AMOC in CMIP5 models

C. Roberts (UK Met Office), F. Garry (Southampton University) and L. Jackson (UK Met Office)

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- CMIP5 models used
- What is a 'fingerprint' and why would we use it?
- Fingerprints of the AMOC in CMIP5 models
 - Control simulations
 - 1% per year CO2
- Observational fingerprints
- Conclusions



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- Models with the best MOC also have the best ρ ,T and S in the SPG
- Models with too strong MOC are too dense (warm and salty) in surface SPG and less stratified
- Models with weak MOC are too light (and fresh) in surface SPG and more stratified © Crown copyright Met Office



What is a 'fingerprint'?

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- Higher signal-to-noise ratio
- Can detect changes more quickly
- Potential to extend timeseries back in time



What makes a good fingerprint of the AMOC?

- Want a fingerprint to detect changes not high freq variability
- High signal-to-noise ratio
- Can be observed (and preferably has been observed in the past)
- Physically based metric relationship to the AMOC rather than any external forcing.

Previous fingerprints:

- SST AMO pattern
- Subsurface temperature patterns
- Subsurface ocean properties



SST correlations with AMOC

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-0.4 -0.2 0 0.2 0.4 -0.4 -0.2 0 0.2 0.4



-0.4 -0.2 0 0.2 0.4 -0.4 -0.2 0 0.2 0.4 -0.4 -0.2 0 0.2 0.4



Upper ocean density (0-800m) correlations with AMOC







-0.04

-0.02 0 0.02 0.04

30W

60M

-0.04 -0.02 0 0.02 0.04





2°S



-0.04

-0.02 0 0.02 0.04

45S

90W

60W 30W 0



Mid ocean density (800-1800m) correlations with MOC



-0.006 -0.003 0



-0.006 -0.003



0

0.003 0.006





-0.006 -0.003 0 0.003 0.006 (i) NORESM1-ME (n = 50)

(f) MPI-ESM-MR (n = 100)





0

0.003 0.006



-0.006 -0.003







0.003 0.006 -0.006 -0.003 0

30М

60W



Depth dependence of correlations in the subpolar gyre

- Normalised correlation between SPG density profile and AMOC
- Significant when values > 1
- Most models have significant correlations from 800-1800m
- In HadCM3 and CNRM-CM5 upper ocean density (<800m) is more significantly correlated to MOC.





- Labrador sea index leads MOC by 2-7 years
- Mid ocean density index leads MOC by 0-3 years in most models
- In HadCM3 and CNRM-CM5 it lags/is less significant
- SST index lags MOC by 1-5 years.





Transient experiments

• SST index doesn't always represent MOC

• SST index has a lot of noise – many other influencing factors at surface

 Lab sea and mid dens indices have less noise than SST, in particular mid dens.





Detecting a significant trend

• Time to detect a significant trend

 Mid ocean index has the fastest detection time for all models



Time to detect a significant trend in 1%CO2 experiments



Detecting anthropogenic trend

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- Time to detect a trend that is significantly different from variability in the control
- Fingerprints represent low frequency control variability of MOC. So relationship of trend to low frequency variability is similar.
- Hence we can detect changes earlier but not distinguish between forced changes and internal variability earlier using fingerprints.







- AMOC timeseries does not have a significant trend
- Mid density index has a marginally significant decreasing trend over 2004-2011



- SPG density profiles are important for MOC strength
- Across most models, interdecadal MOC variability is:
 - preceded by a signal in the Labrador sea, and in mid depths SPG density
 - followed by a signal in SST.
- SST dipole works as an MOC fingerprint in control runs (though it is noisy) but not in all models with forced scenarios.
- Mid ocean density dipole provides a good fingerprint for detecting changes in the MOC, however it *does not* distinguish between forced changes and variability.



Thanks, any questions?

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