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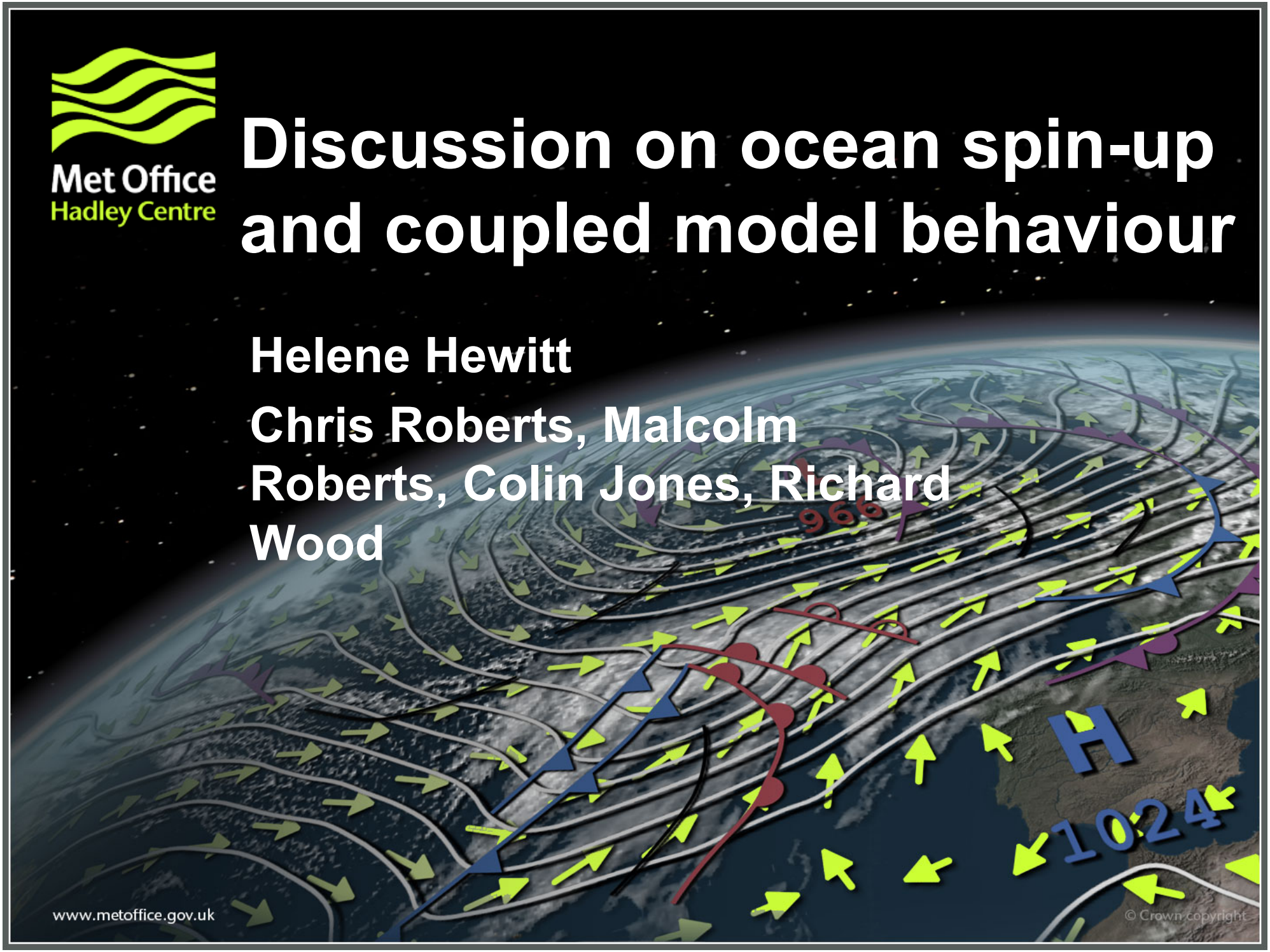
Discussion on ocean spin-up and coupled model behaviour

Helene Hewitt

Chris Roberts, Malcolm Roberts, Colin Jones, Richard Wood



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Outline

- Background
  - *Ocean spinup is on multicentennial timescale*
  - *Important for biogeochemistry*
- CMIP protocol
  - *Dog's breakfast!*
  - *HiResMIP :Impact of resolution*
- Ocean models to support coupled prediction
  - *Will OMIP/CORE runs indicate model behaviour?*
- Possible future strands
  - *CMIP6*
  - *Other approaches*

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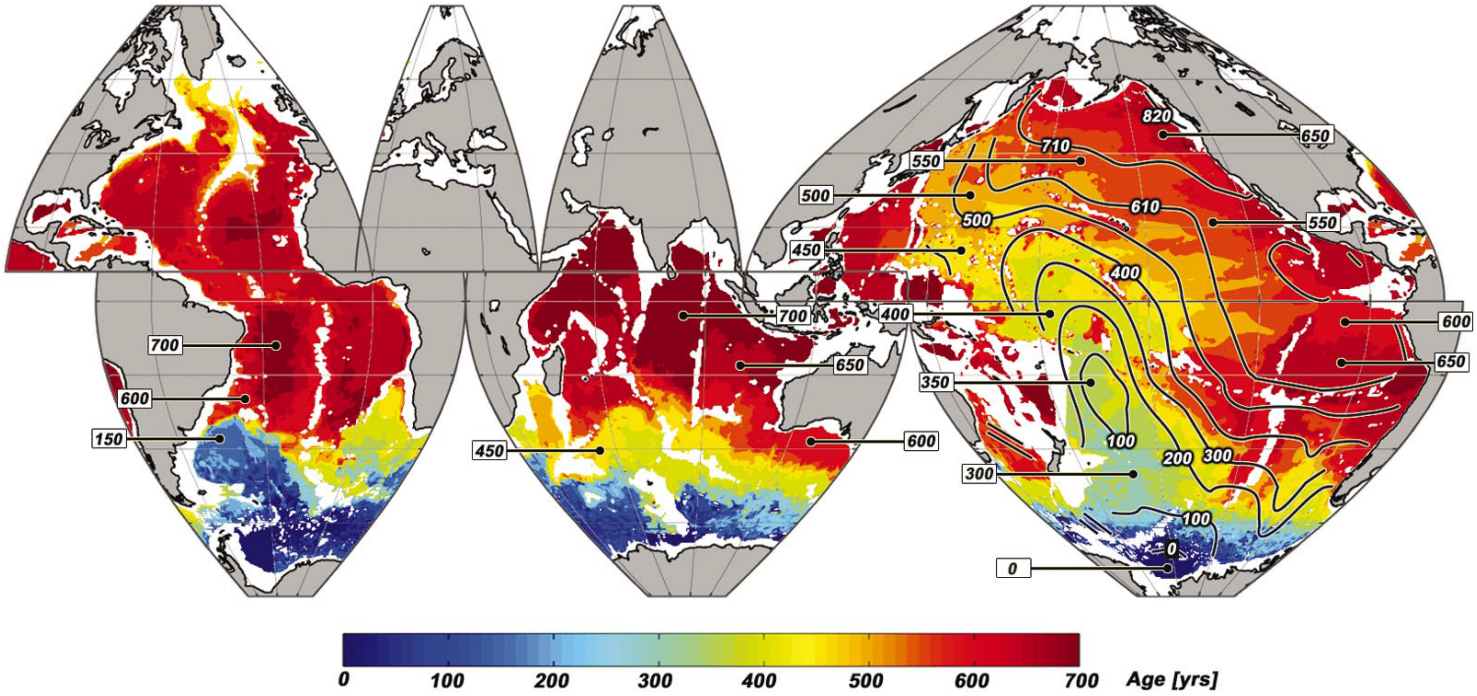
Ventilation timescales



Sen Gupta and England, 2004

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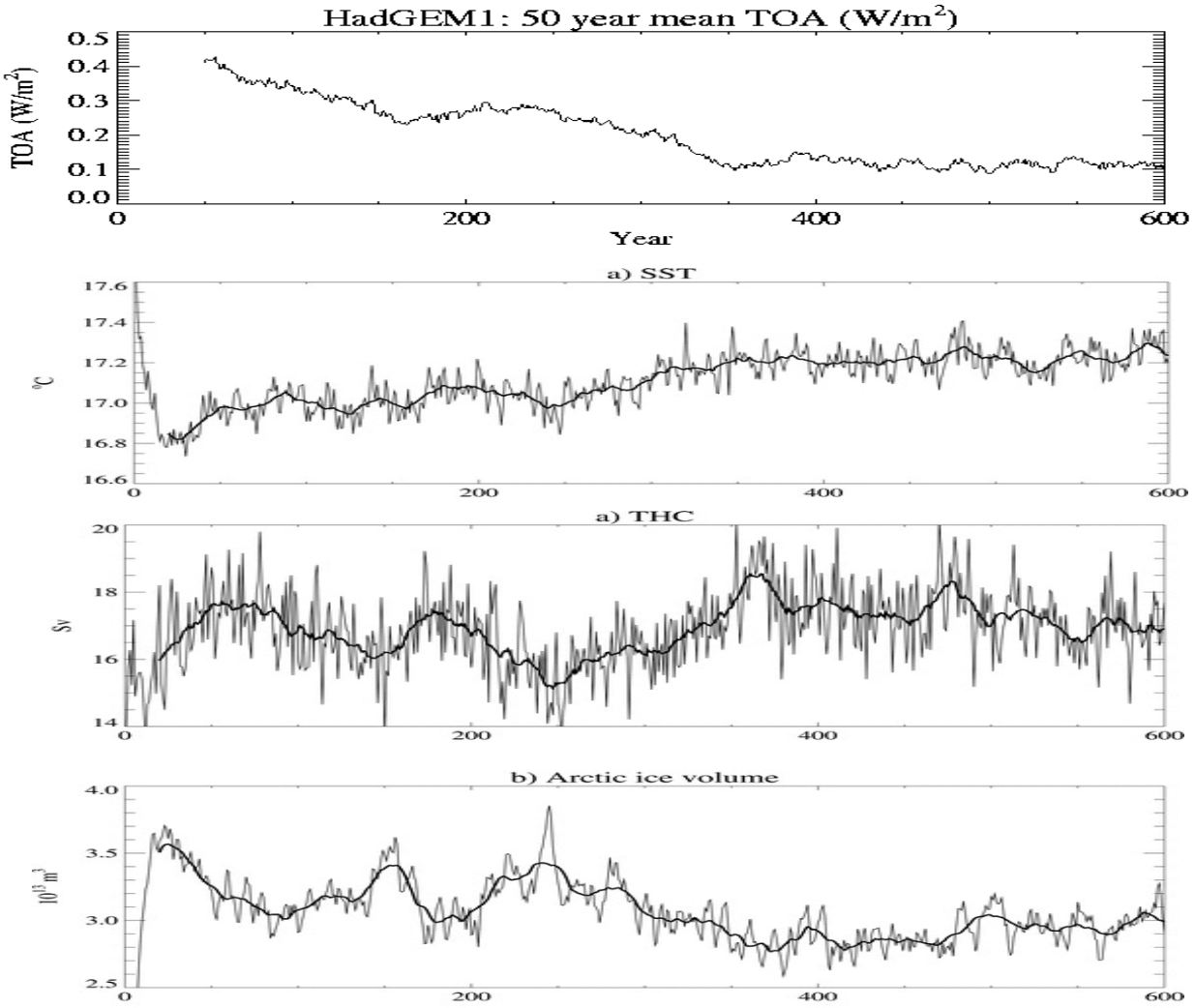
Coupled spin-up



Banks et al., 2007

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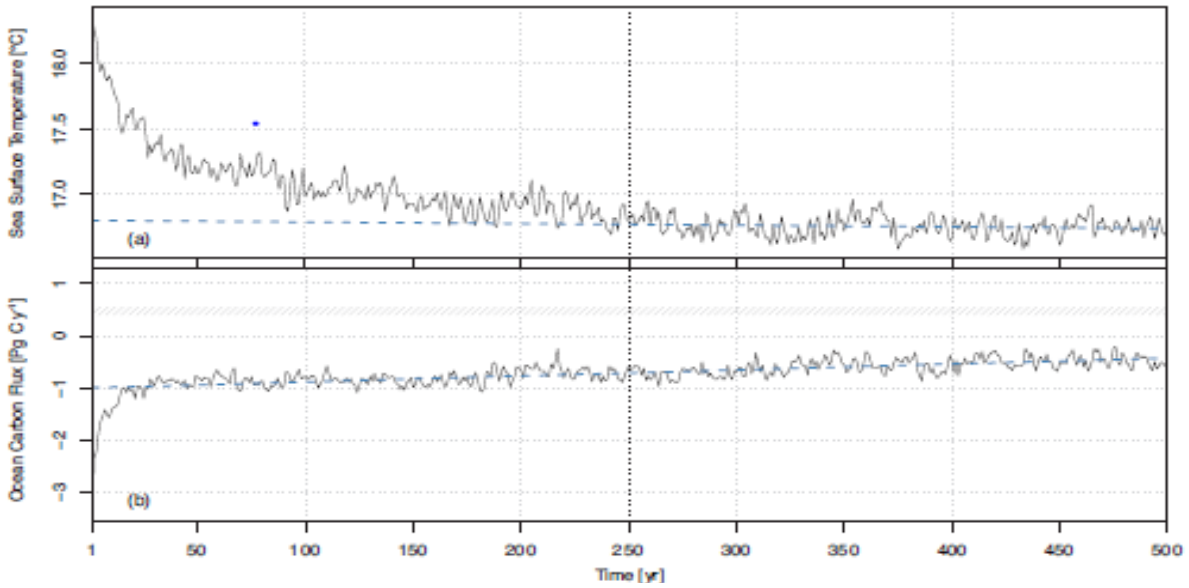
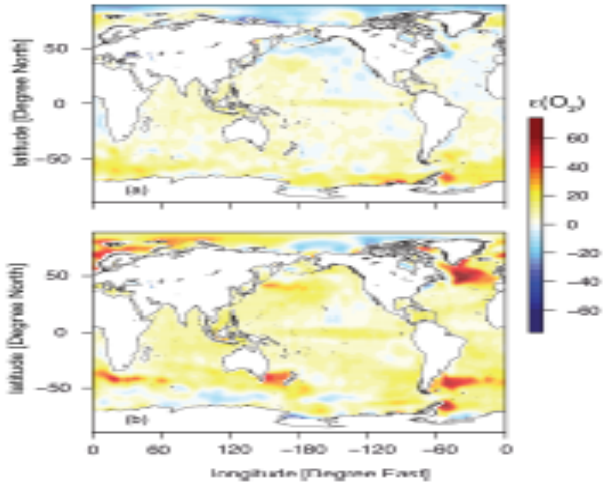
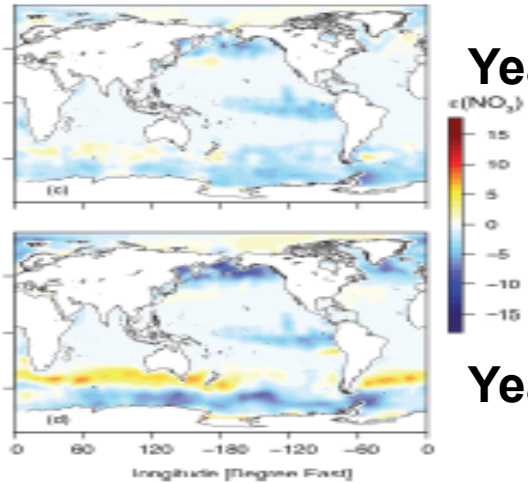
Important for biogeochemistry







Year1 bias

Year500 bias

Oxygen

Nitrate

Seferian et al., 2015

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Why do we care about spin-up?

• Drift from initial conditions to be as small as possible – short-range forecasts (data assimilation), sea ice, biogeochemistry

•Separate mean state and variability from drift

• Coupled model in radiative balance so global ocean heat content not drifting

• Other?

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CMIP Protocol

- Eyring et al., 2015:
  - *'An initial climate "spin-up" portion of a control simulation, during which the climate begins to come into balance with the forcing, is usually performed and discarded. The length of this "spin-up" period is model and resource dependent.'*

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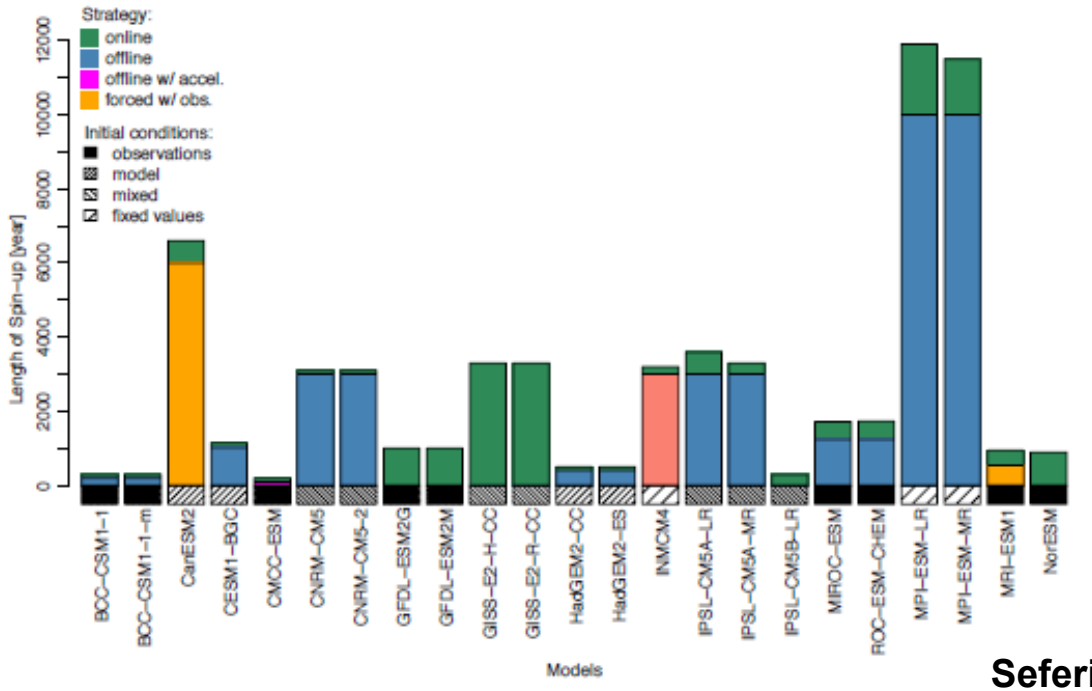
Spin up strategies

Best performing models (may) have shortest spin ups



Seferian et al., 2015

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Different spin-up for different models in same model family!

- At Met Office for example:
  - HadGEM3 will be initialised from EN3/4 and have coupled spin-up
  - UKESM1 will
    1. run pre-industrial coupled for ~50 years
    2. offline spin-up for ~3000 years (using fluxes from pre-industrial coupled run) possibly with intermittent recoupling
    3. coupled for ~500 years before DECK runs start.

Can spin-up length be defined by criteria eg, ocean heat content, net surface ocean carbon flux?

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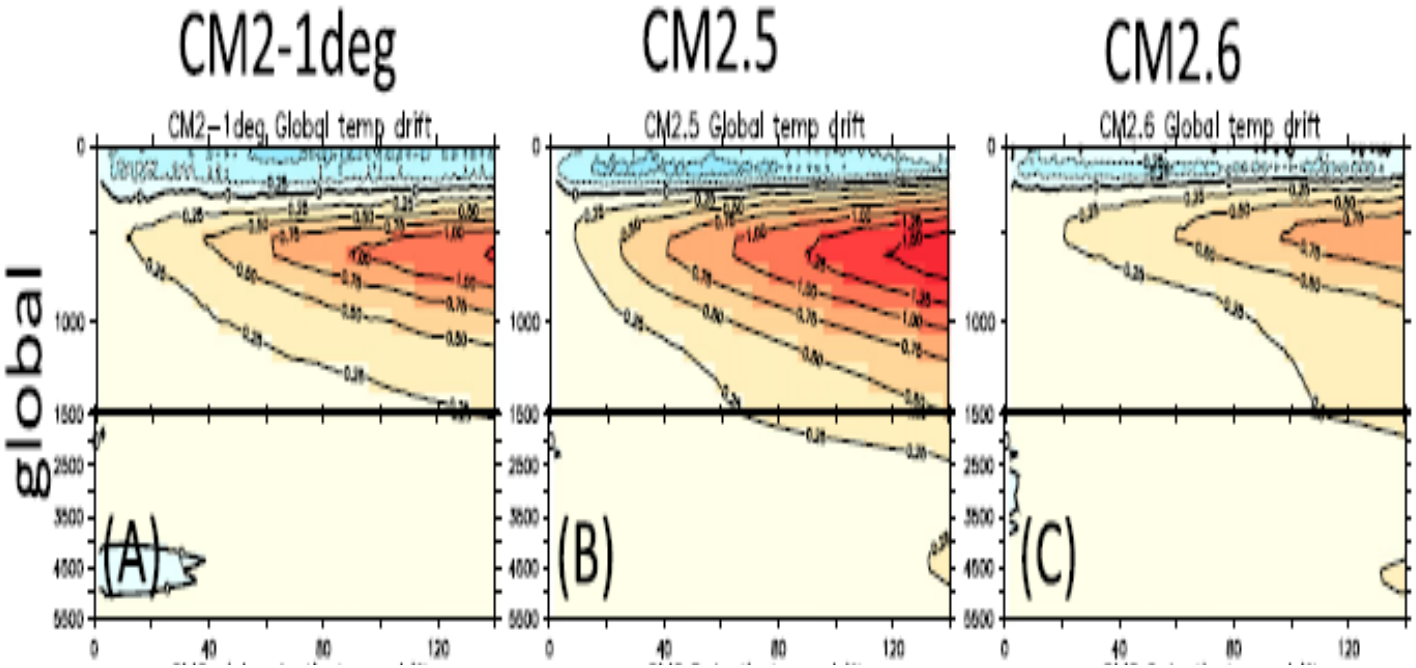
Impact of resolution



Griffies et al., 2015

HighResMIP: model resolutions should have their own coupled spin-ups (~20 years?) ...not remapped from low resolution models!

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Ocean models for coupled prediction

- Ocean modelling is relevant for short-range forecasting, seasonal-decadal prediction and climate projections and research

- Forced ocean models with data assimilation for reanalysis and initialisation of seasonal-decadal coupled prediction

- Forced ocean models in development and spin-up of coupled/ES models

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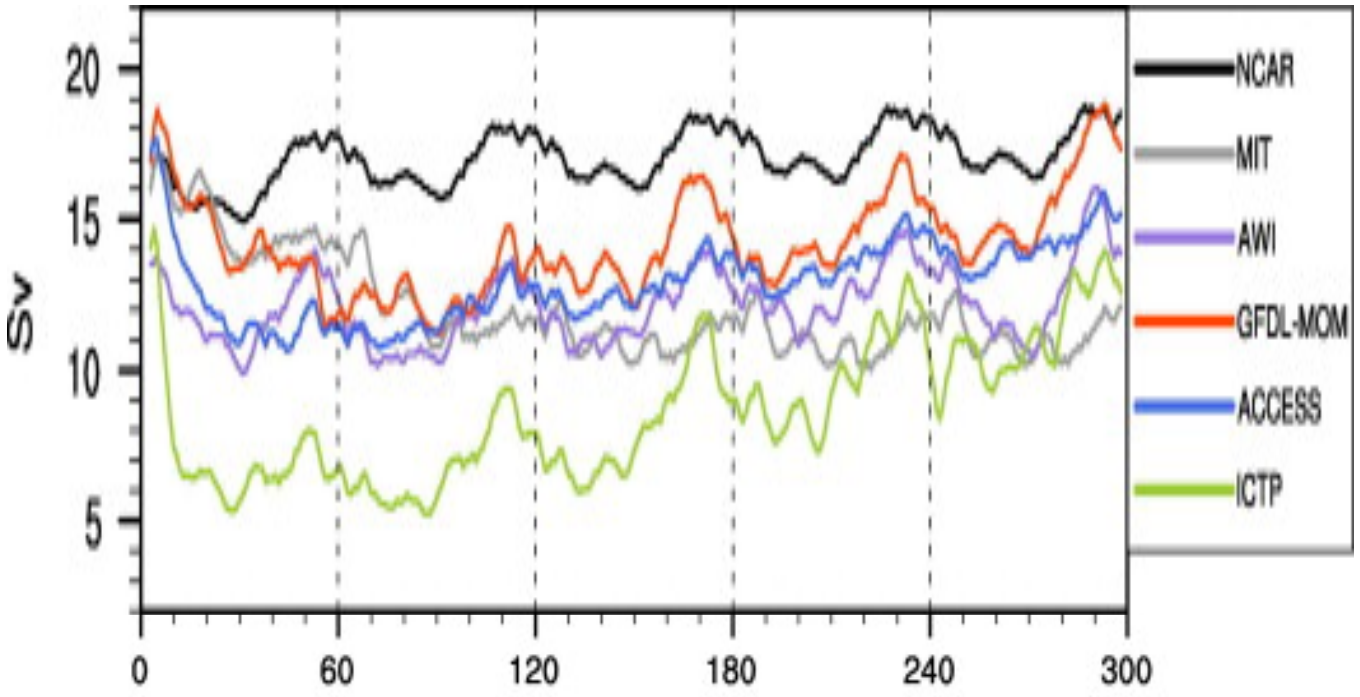
Forced ocean models



Danabasoglu et al. (2014)

- These experiments are of particular value for those interested in using OGCMs to understand ocean and climate variability.
- For initialised experiments, arguably more interested in drift away from initial state (observations)

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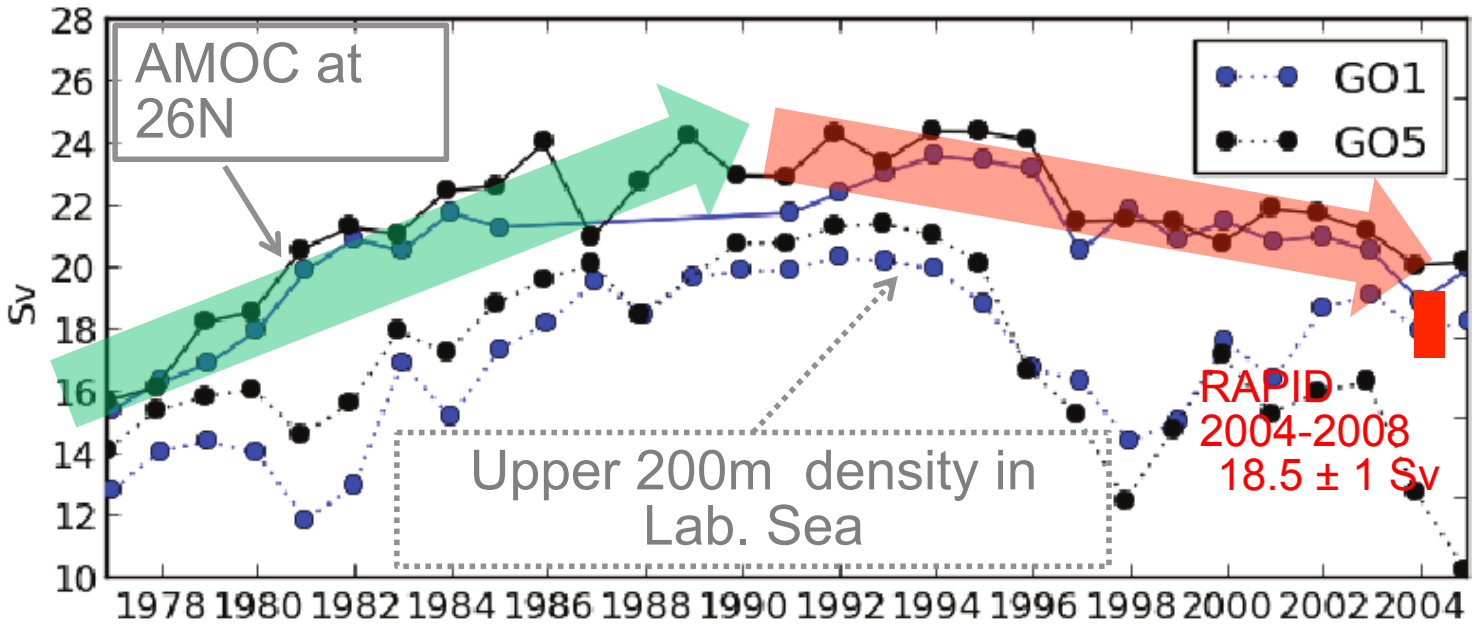
AMOC example (C Roberts)



Megann et al. (2004)

Decadal changes in AMOC linked to changes in Labrador Sea density.

8 Sv increase from 1976 to 1990.

4 Sv decrease from 1990-2004.

Similar changes in GO1 and GO5.

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Removing drift is critical to the understanding of mechanisms

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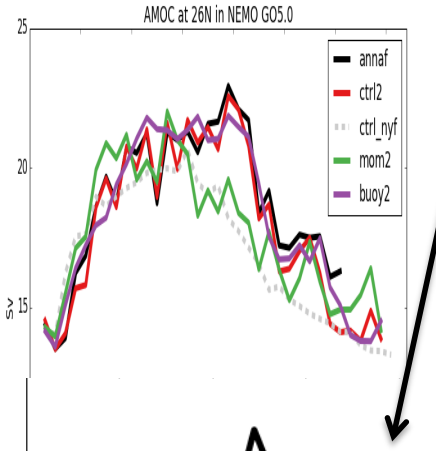
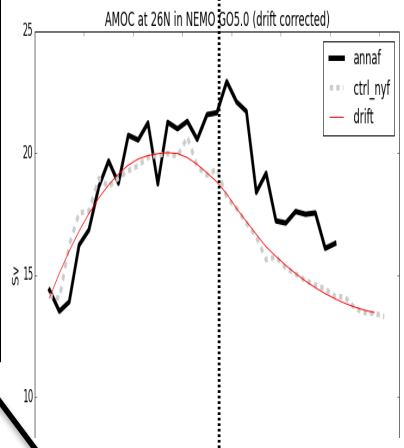
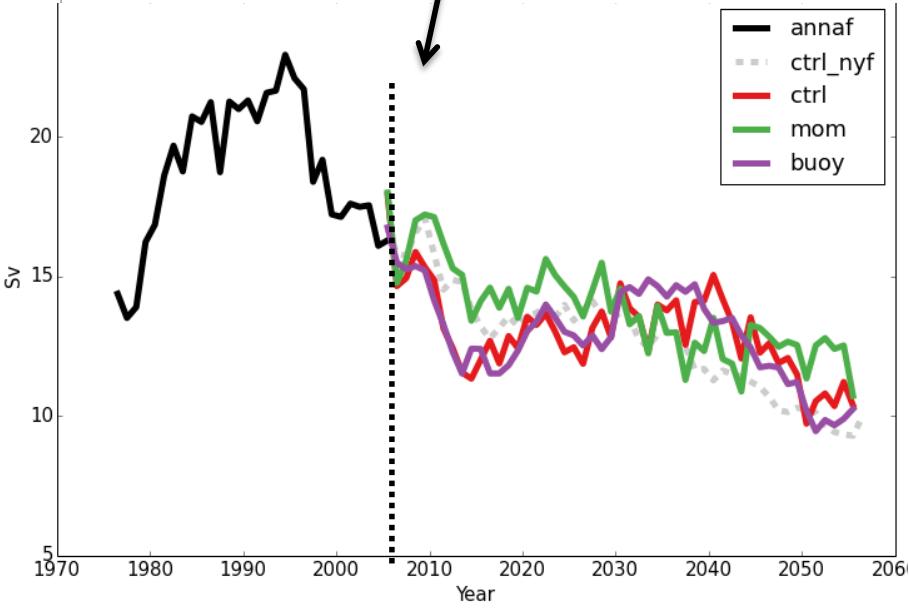
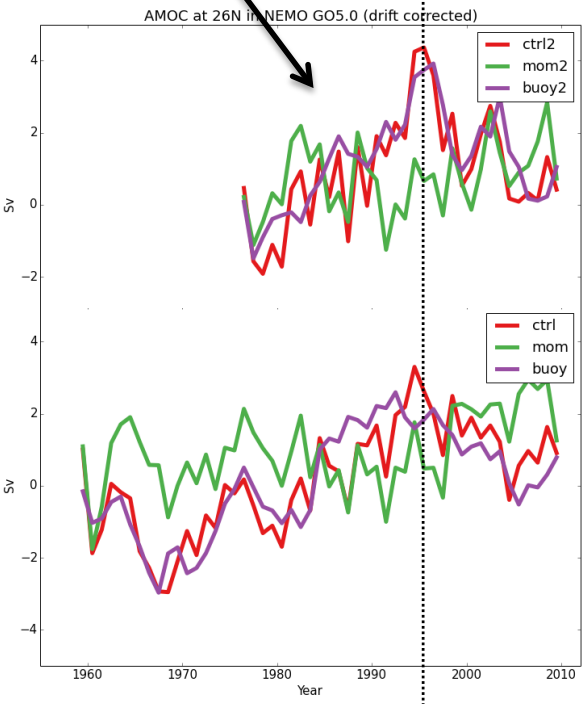


Variability depends on initial state

Removing non-linear drift with NYF shows more similar behaviour







Repeated CORE-II forcing 1959-2009

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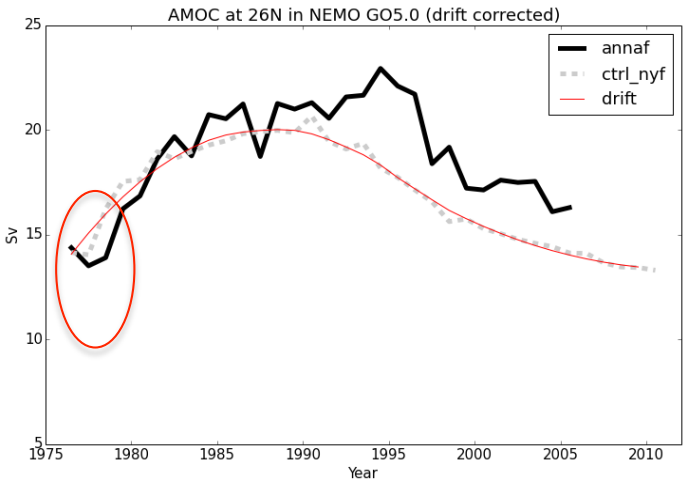
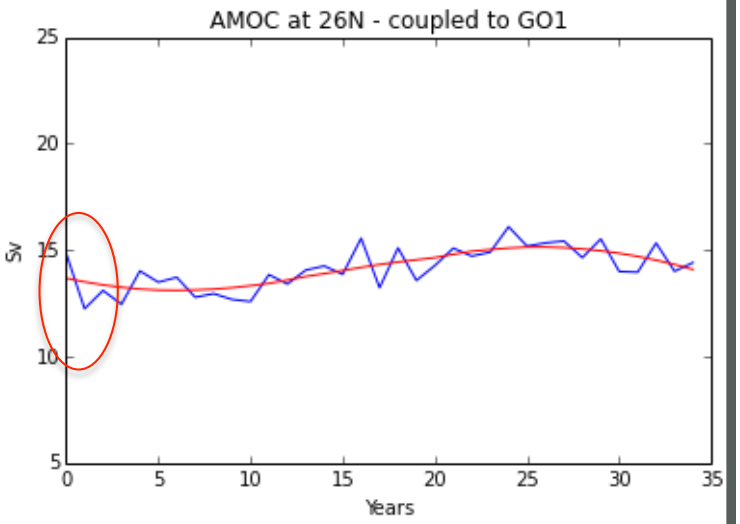
Are forced runs indicative of coupled state?

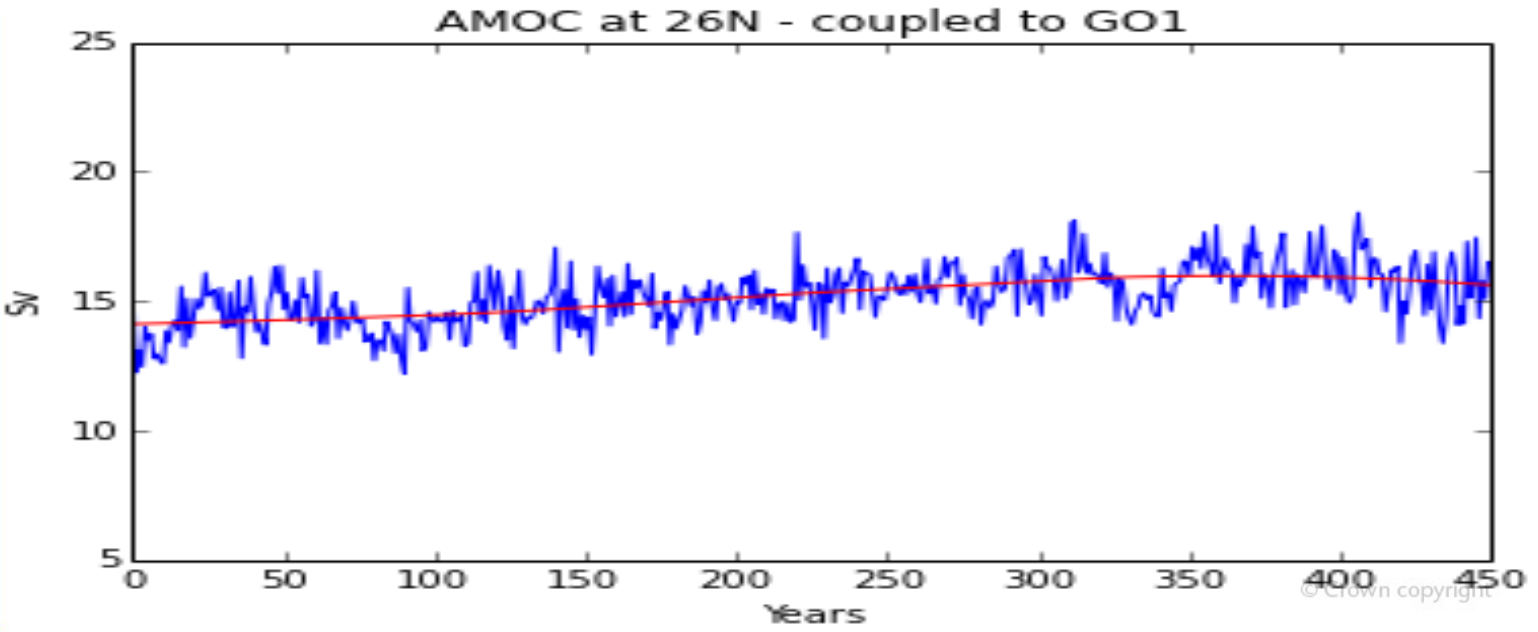
In short runs, coupled and forced AMOC behaviour different

Focus on initial drift?

Is variability too low in coupled experiments?







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Improve biases using short range/seasonal forecasts?

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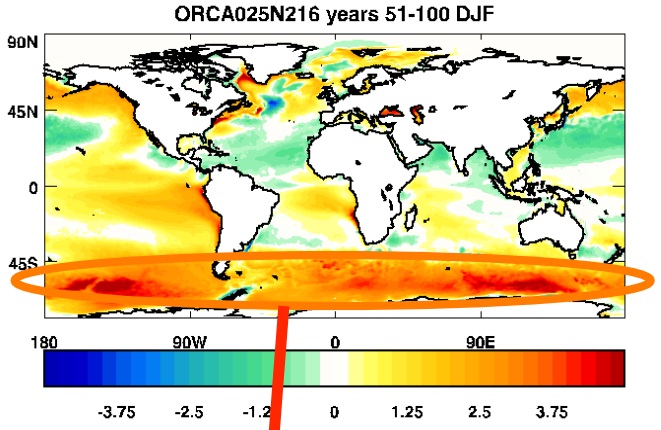
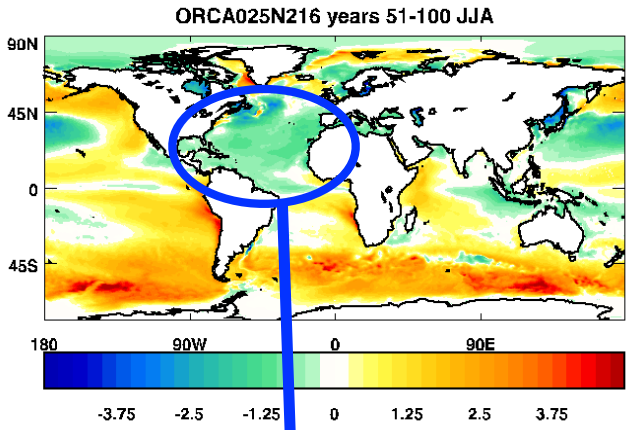
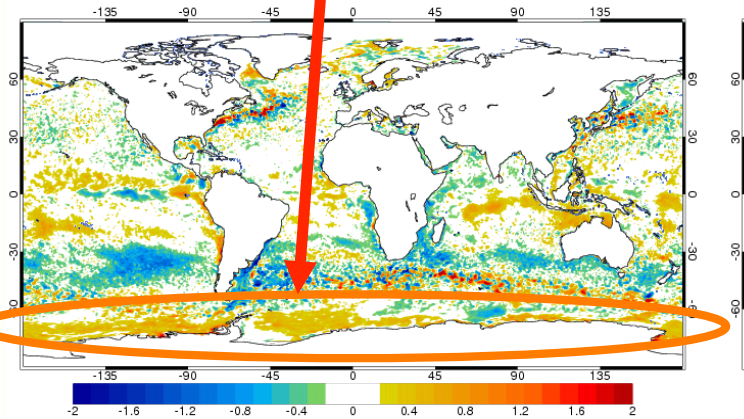
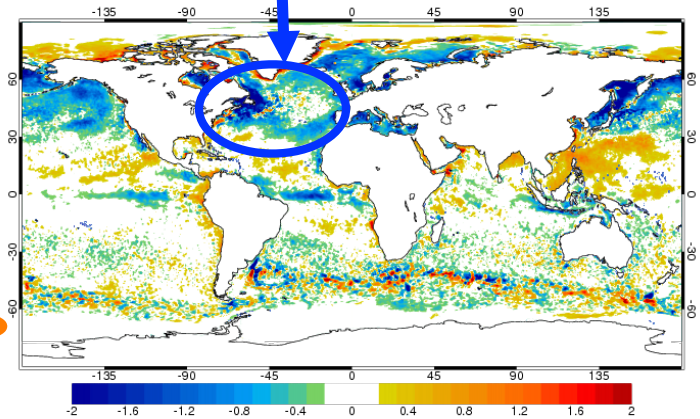
Climate: 50 yr mean





Coupled NWP: Day 14





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Possible future strands

- CMIP context:
  - Ask groups to ensure that ocean spin-up is archived and documented (Eyring paper?)
  - Propose criteria for determining sufficient length of spin-up (Who?)
  - Intercomparison of OMIP, CMIP DECK and HighResMIP across the models: How indicative is the OMIP simulation both in terms of physics and biogeochemistry of the coupled state? How realistic is the variability? (This group?)
  - Compare an offline spin-up with a coupled spin-up – different attractor depending on surface forcing? (in slow time? Who?)

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Possible future strands

- Other approaches:
  - Explore initial drifts and links to longer term biases (via assimilation increments?) – improve model fidelity to reduce spin-up
  - Can we initialise biogeochemistry better to reduce spin-up requirements? Newton-Krylov method?
  - Look at using normal year to remove drifts in forced models?

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Discuss….

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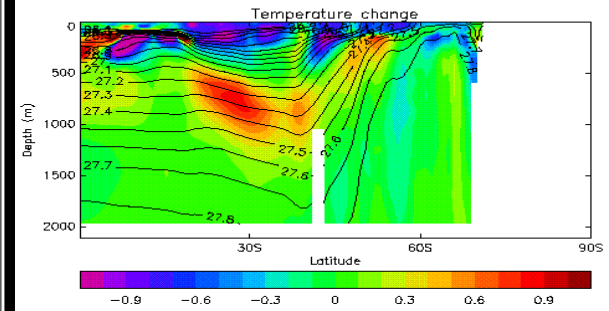
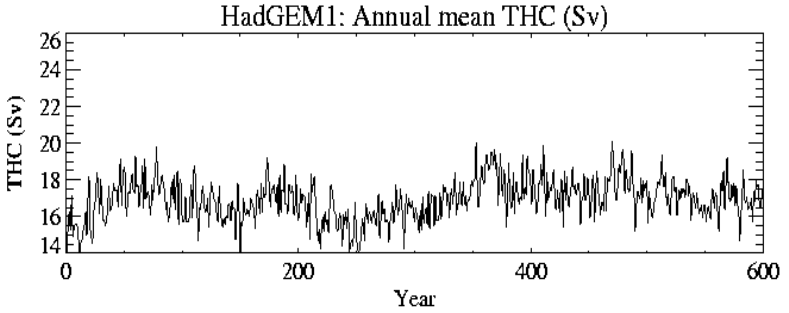
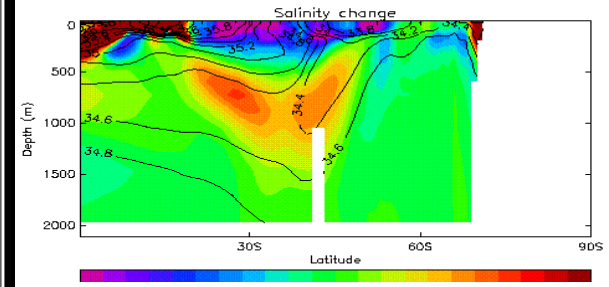
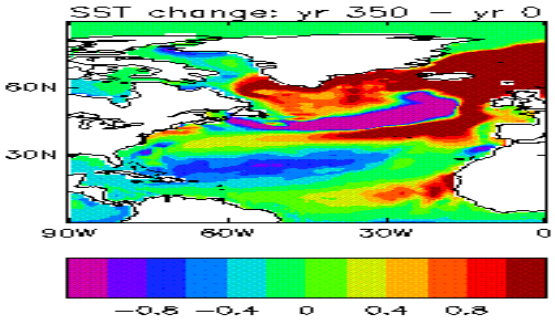
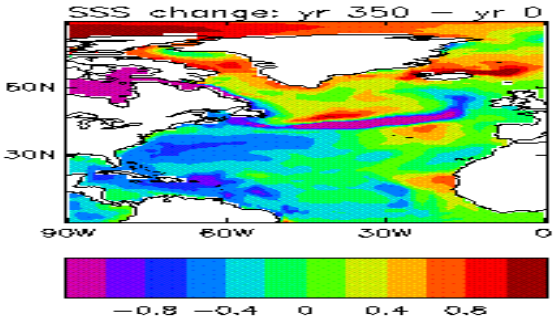
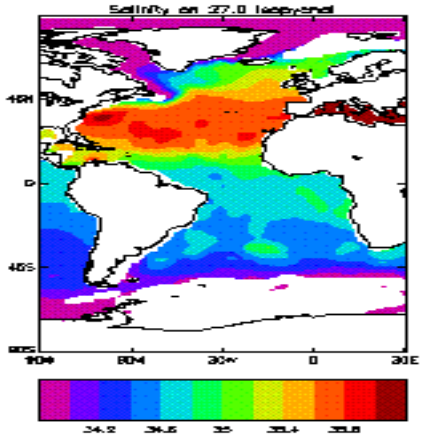
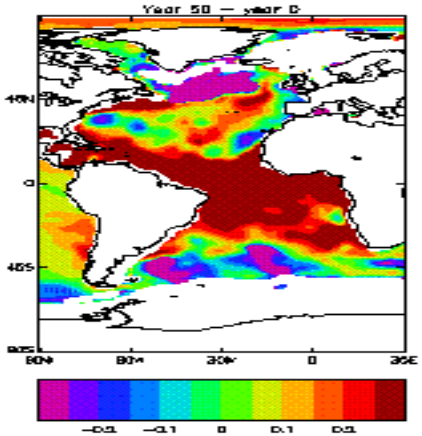
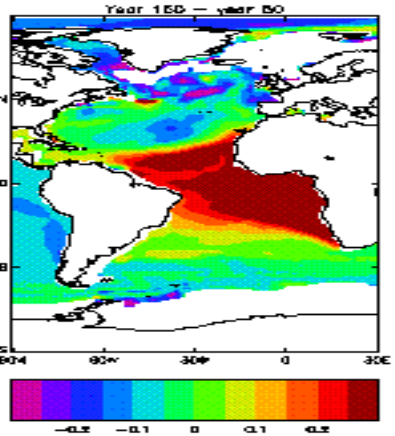
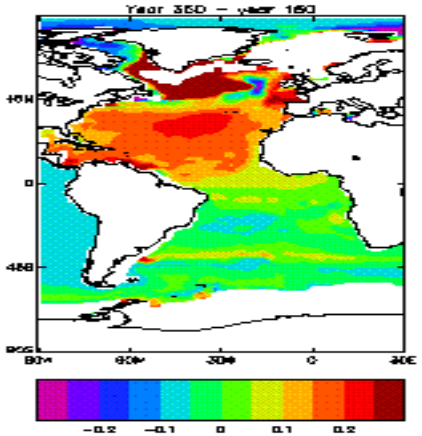
Ocean adjustment in HadGEM1

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