Discussion on ocean spin-up and coupled model behaviour

Helene Hewitt
Chris Roberts, Malcolm Roberts, Colin Jones, Richard Wood
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
Ventilation timescales

Sen Gupta and England, 2004
Coupled spin-up

HadGEM1: 50 year mean TOA (W/m²)

a) SST

b) THC

b) Arctic ice volume

Banks et al., 2007
Important for biogeochemistry

Year 1 bias

Year 500 bias

Oxygen

Nitrate

Seferian et al., 2015
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?
• 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.’
Spin up strategies

Best performing models (may) have shortest spin ups

Seferian et al., 2015
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?
Impact of resolution

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

Griffies et al., 2015
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
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)
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.

Megann et al. (2004)
Removing drift is critical to the understanding of mechanisms.

Variability depends on initial state.

Removing non-linear drift with NYF shows more similar behaviour.

Repeated CORE-II forcing 1959-2009
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?
Improve biases using short range/seasonal forecasts?

Climate: 50 yr mean

Coupled NWP: Day 14

Tim Johns
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?)
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?
Discuss....
Ocean adjustment in HadGEM1