Danish National Research Foundation

CENTRE FOR ICE AND CLIMATE

Revisiting Kawase and McDermott

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with
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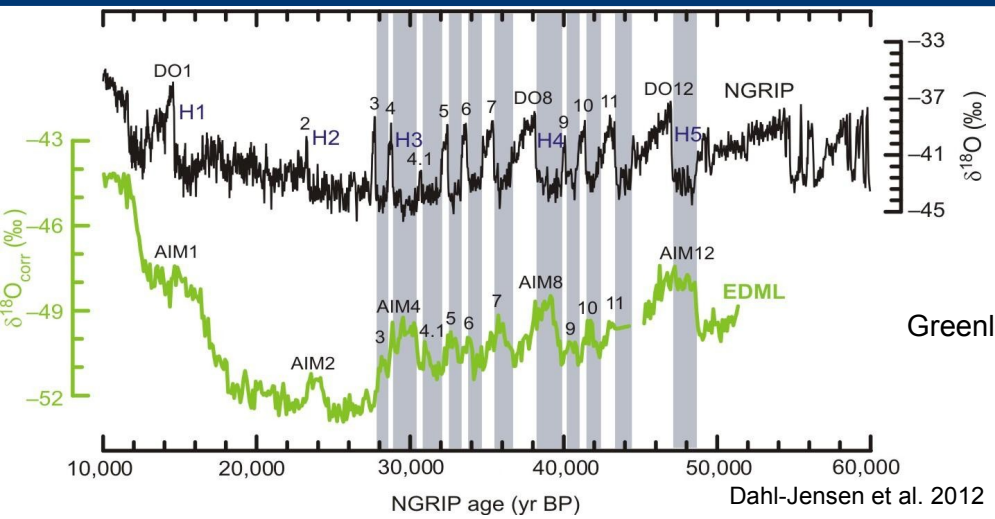
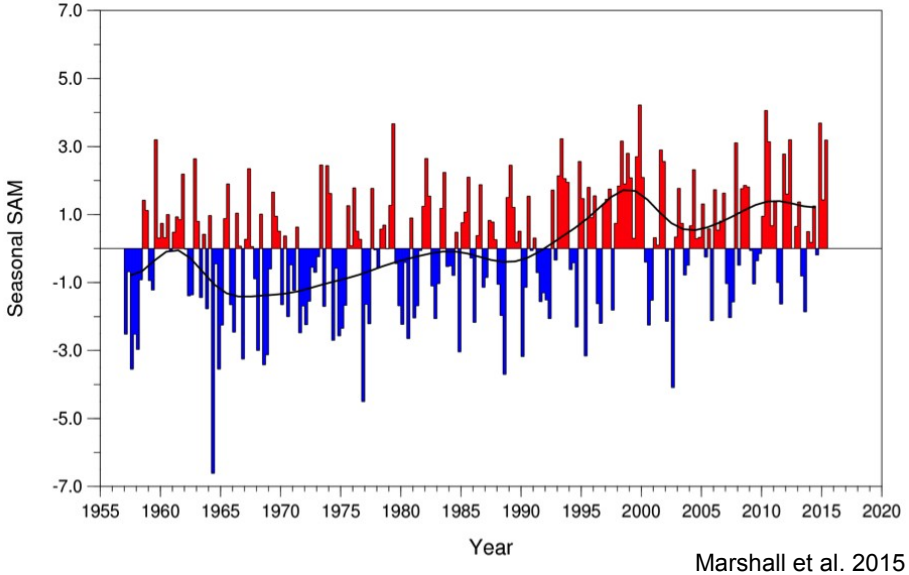
One of our Problems ...



Dahl-Jensen et al. 2012

Greenland and Antarctica temperature records based on icecore isotopes

Southern Annular Mode Index



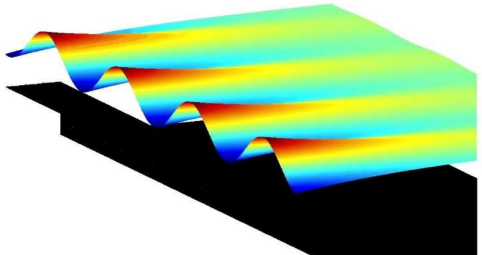
Marshall et al. 2015

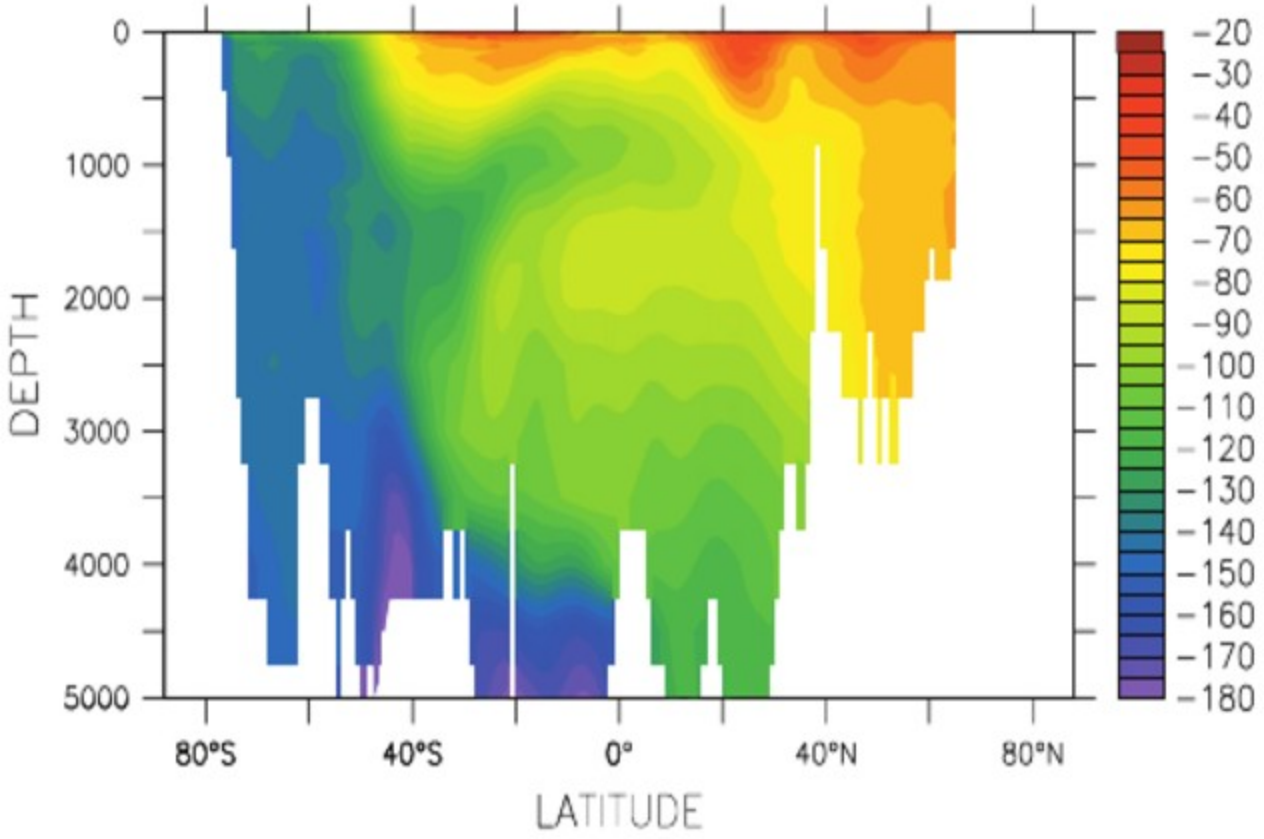
Outline

What are mechanisms for inter-hemispheric transmission of climate signals?

Today's focus is on Toggweiler & Samuels 1995 as one possible mechanism.

- the TS hypothesis in a full GCM
- three caveats:
  - diapycnal mixing → new parameterization
  - mesoscale eddies
  - coastal waves → eddy resolving OGCM





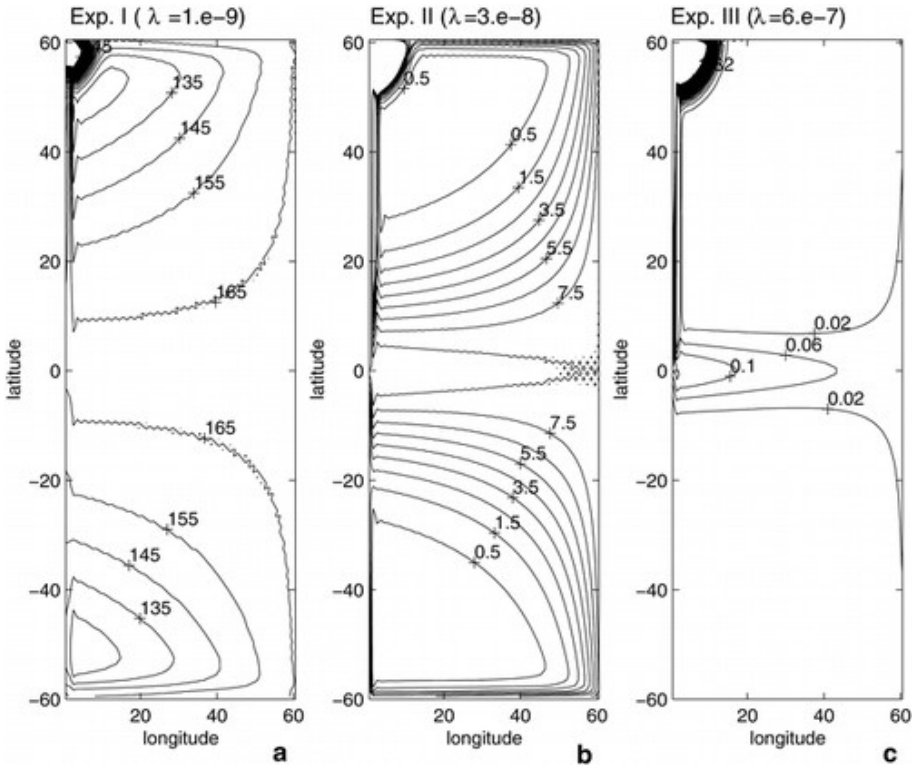
Radiocarbon along 28W (Key et al. 2004, based on WOCE)

Signal Propagation across Equator

30 yr 1 yr 1 month

Kawase '87

AMOC ~ ???



Stommel '61

AMOC ~ density gradient

Greatbatch and Lu 2003

Theory and idealized studies:
(numerical) dissipation timescale determines solution

The Real World

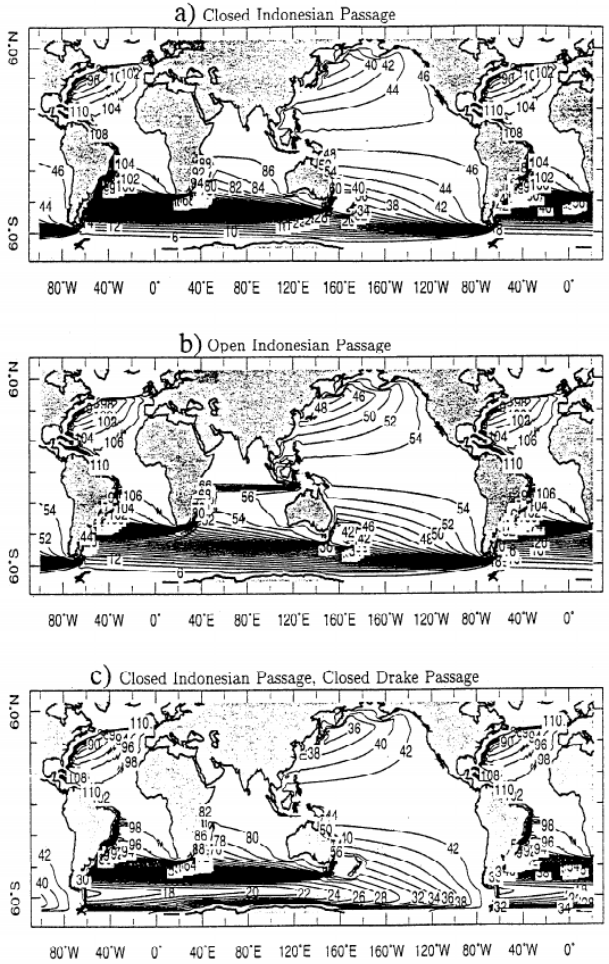
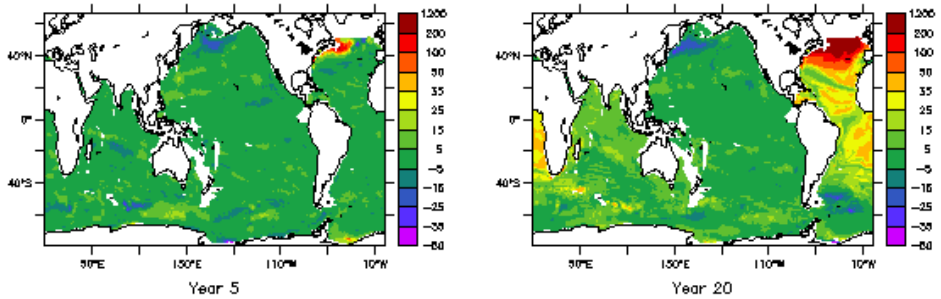
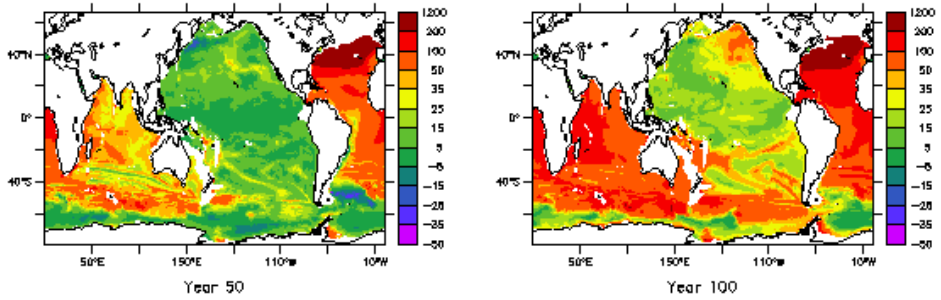


Figure 2. The displacement of the thermocline (m) induced by NADW source of 10 Sv.

Huang et al. 2000 (see left):
global shallow water model

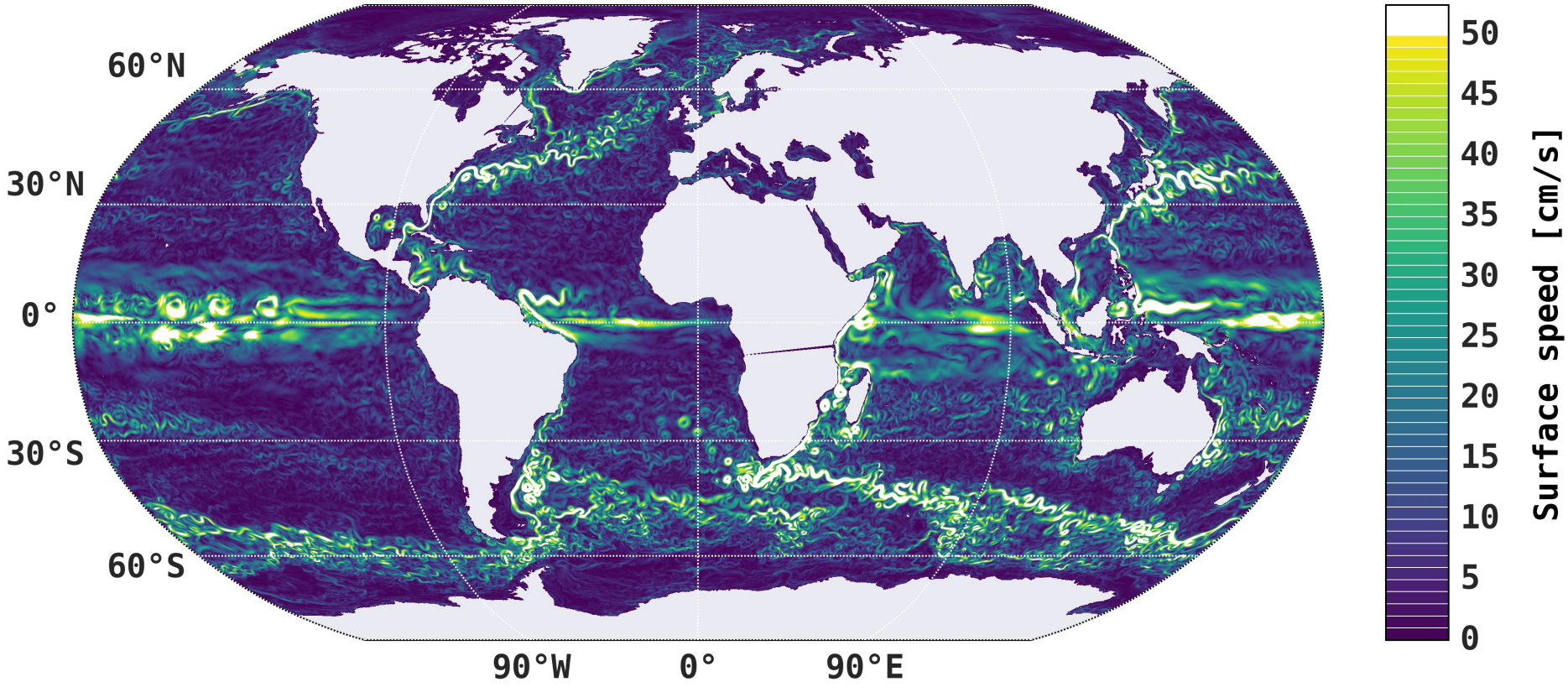


difference of sigma–28 depth



based on 40 fully coupled CESM ensemble members

The Eddy-Resolving Model



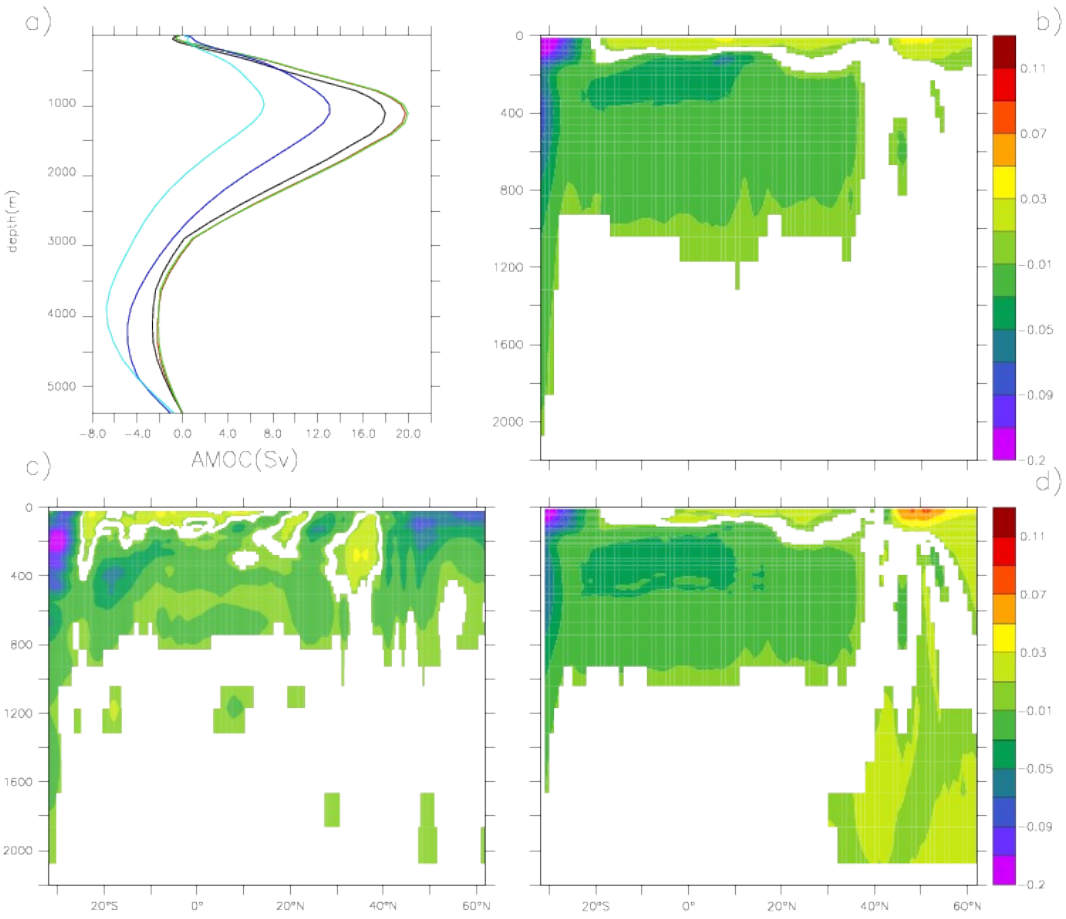
Ocean-Ice configuration of CESM (Small et al. 2014):
1/10 degree, 62 vertical layers, CORE forcing.

3-day means, 1 Tb/day, 0.1 yrs/day on 4096 cores at FSZ Juelich

Comparing coarse and eddy permitting models.

AMOC @ 30N

1/10 Control
1/10 high SO,yr 17
1 deg. Control
1 deg 17/50 yrs



zonally averaged change in Atlantic density
x 1, after 17 years

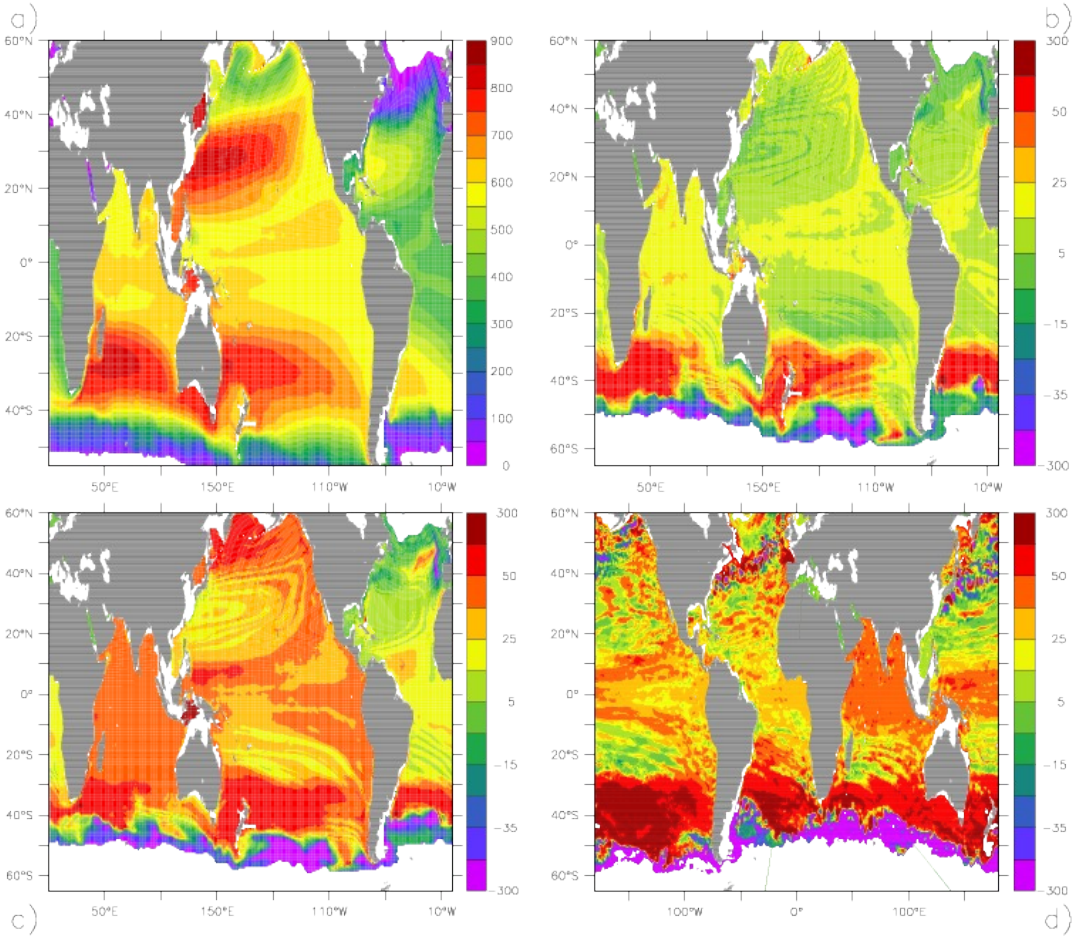
zonally averaged change in Atlantic density
x 1/10, after 3 (!) yrs

… like above, but after 50 years.

The Atlantic after a 50% increase in Southern Ocean winds.

The Sigma27 Isopycnal

depth in
x1 control



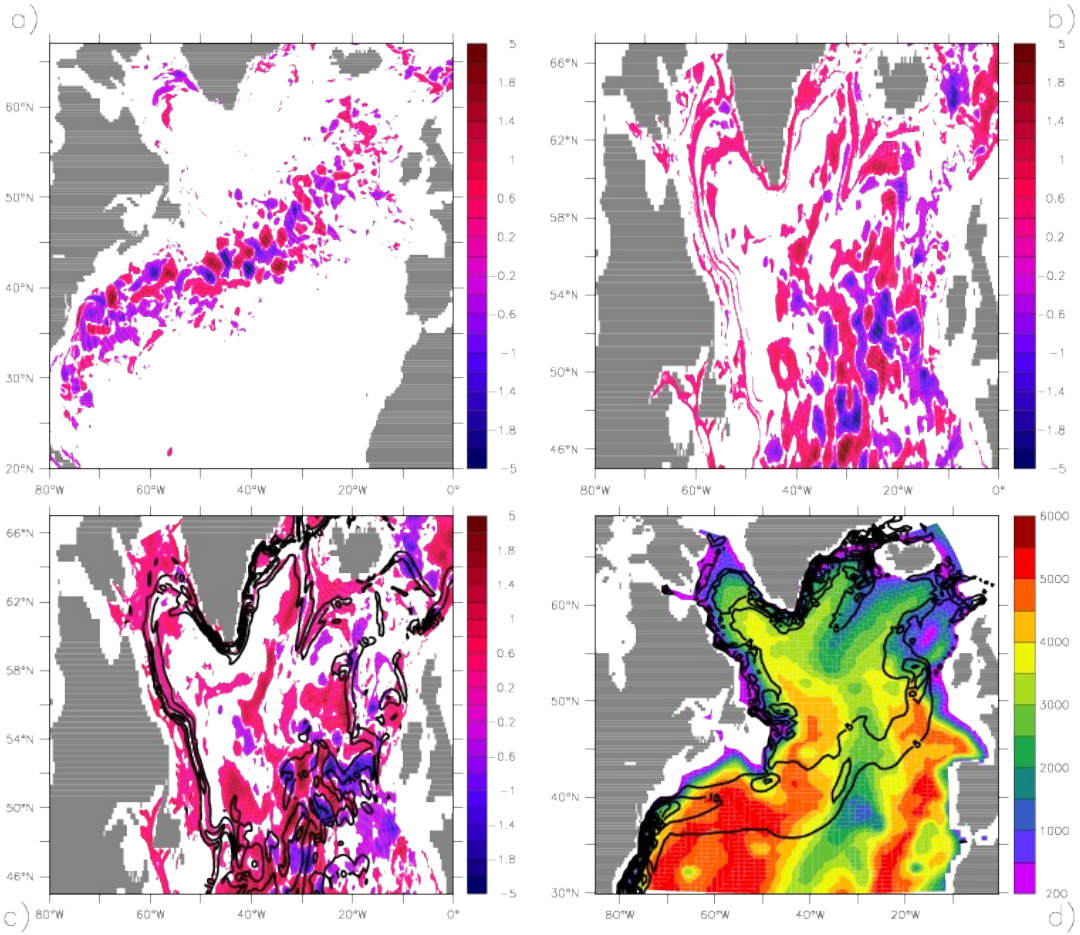
change in
depth for x1
after 17 yrs

change in
depth for x1
after 50 yrs

like above
but for x 1/10

Density in x1/10 @ 200 m depth.

difference
one year after
increasing
S. O. winds



as in left but
after 2 years

as above but
after 3 yrs

contour lines:
flow speed
10 cm/s interval

topography
and 200m flow
speed in x1,
5 cm/s intervals

Veros

https://github.com/dionhaefner/veros

The Versatile Ocean Simulator

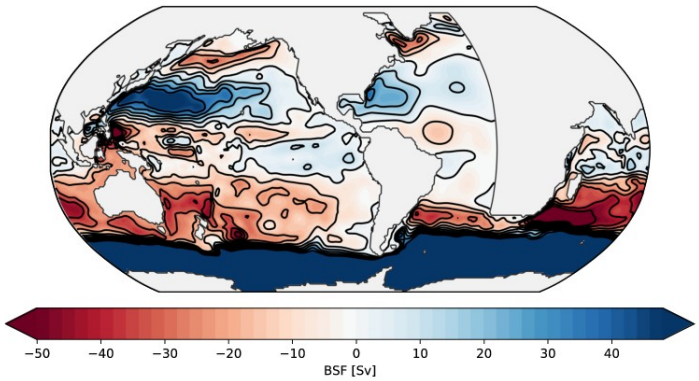
Vision

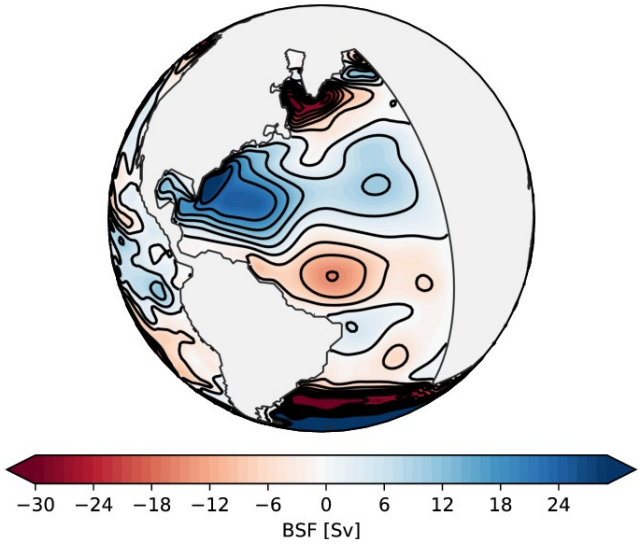
Swiss army knife of ocean modeling:

- modern code that is readable, adaptable, verifiable
- runs efficiently on your laptop, gaming PC, or small cluster
- supports both idealized and realistic configurations

Implementation

- written in pure Python!
- based on pyOM2
- NumPy for small models, switches to Bohrium backend for large setups





Results

- stronger Southern Ocean winds lead to a global deepening of isopycnals that is mostly independent of resolution

- the Atlantic subpolar gyre is exceptional, because buoyancy anomalies only enter it in the eddy permitting model

- accurate representation of eastern boundary currents is key

- next steps will require a more idealized set-up