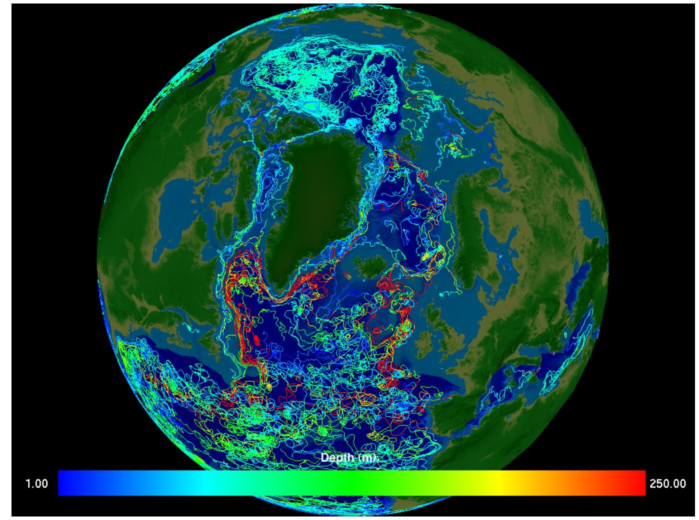
Initial Results from Fully Coupled High-Resolution ACME V0.1



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Rockville, MD

Goal of ACME V0 Simulations

Use an existing climate model to provide a baseline for comparisons with next generation ACME simulations.

In particular, focus on simulations where oceanic and atmospheric mesoscale phenomena with scales of 10s and 100s of kilometers, respectively, are largely resolved.

ACME V0.1 1850 Pre-Industrial Control Simulations

Community Atmosphere Model 5 – Spectral Element (CAM5-SE)/Community Land Model 5 (CLM5) & Parallel Ocean Program (POP2.0)/CICE4.0

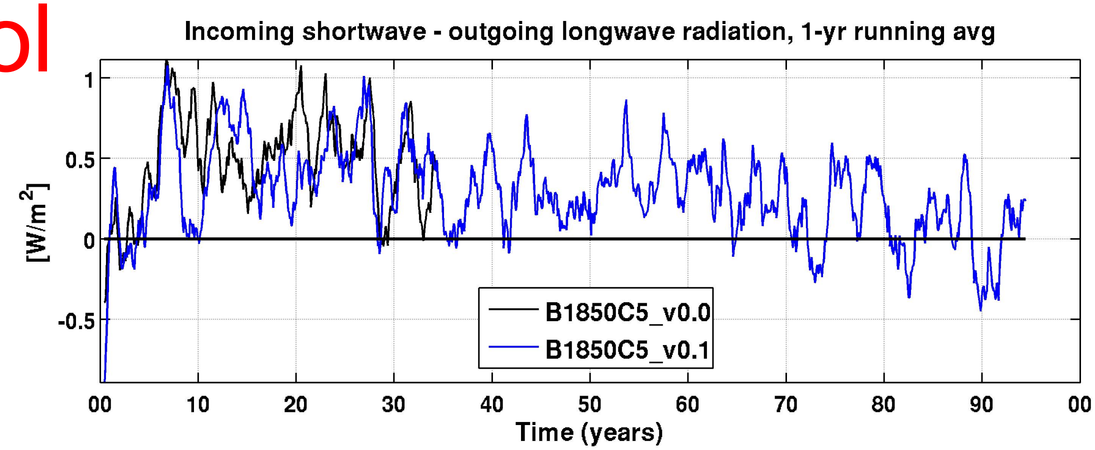
1. 0.25° CAM5/CLM5 and 0.1°, 42 level POP/CICE: 100+ yrs.
2. ~1° CAM5/CLM5, 1°, 62-level POP/CICE: 180 yrs

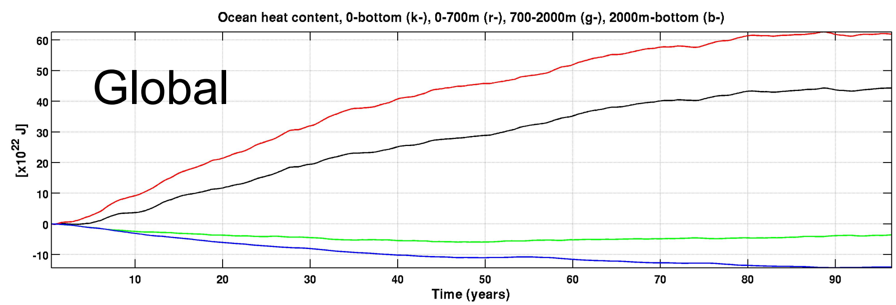
- Initial Conditions: Atmospheric reanalysis-forced POP/CICE restarts from 1 January of 1973 to allow for the adjustment of the initial transients but avoiding drift due to reanalysis forcing. POP/CICE was initialized from rest & WOCE climatology in January 1970 and was forced with CORE-II interannually-varying fluxes (IAF).

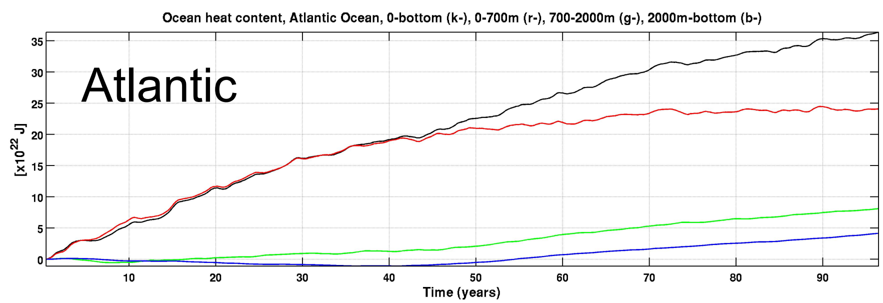
- “Tuned” in coupled mode to achieve an acceptable top of atmosphere (TOA) radiation balance.

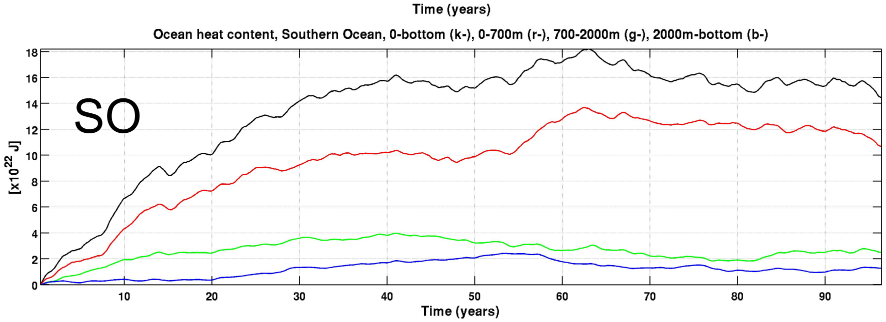
ACME V0.1: High-Resolution 1850 Pre-Industrial Control

TOA net radiation
(Wm^{-2})





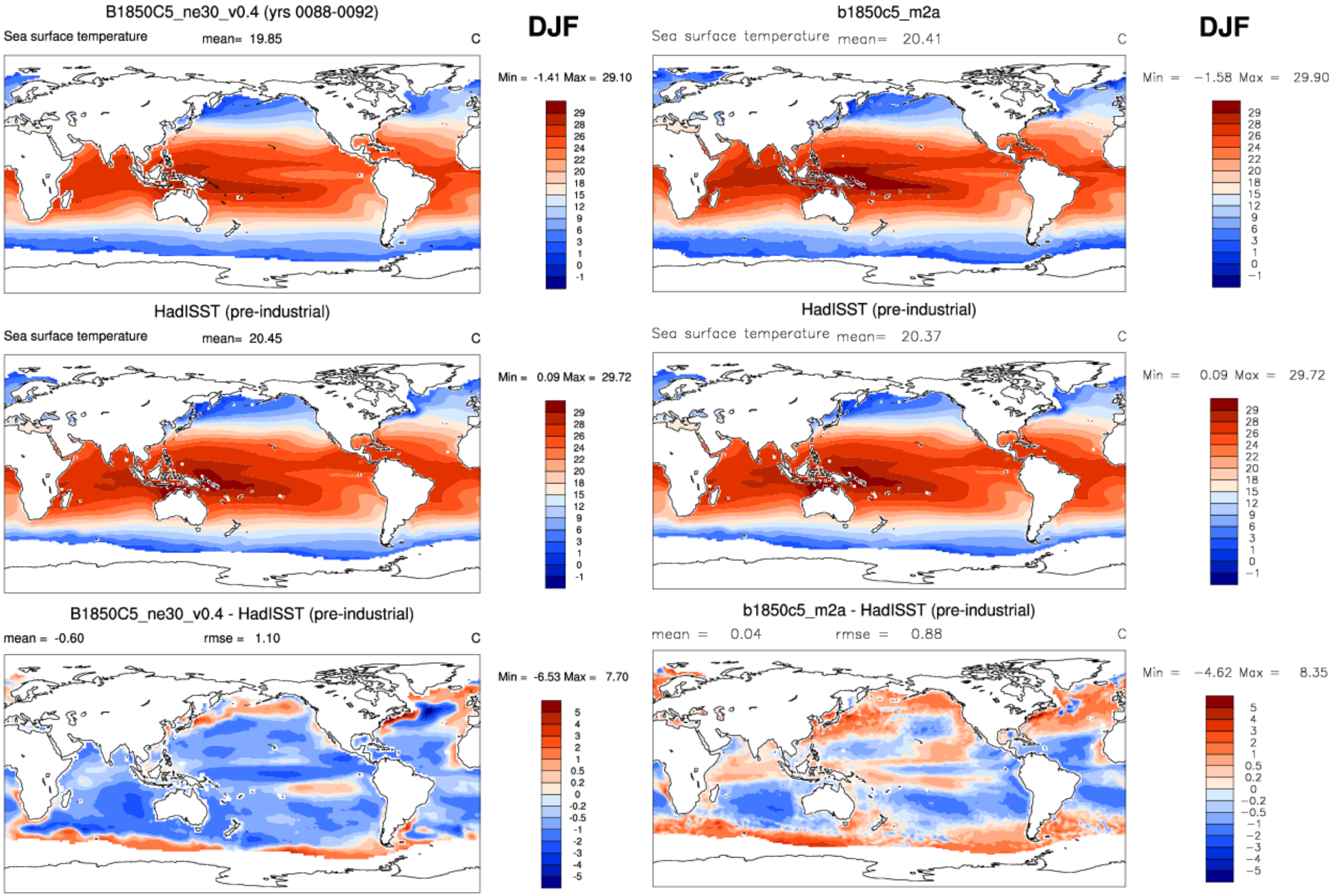




Annual time series of global, Southern Ocean, & Atlantic Ocean heat content (J) relative to year 1 annual average.

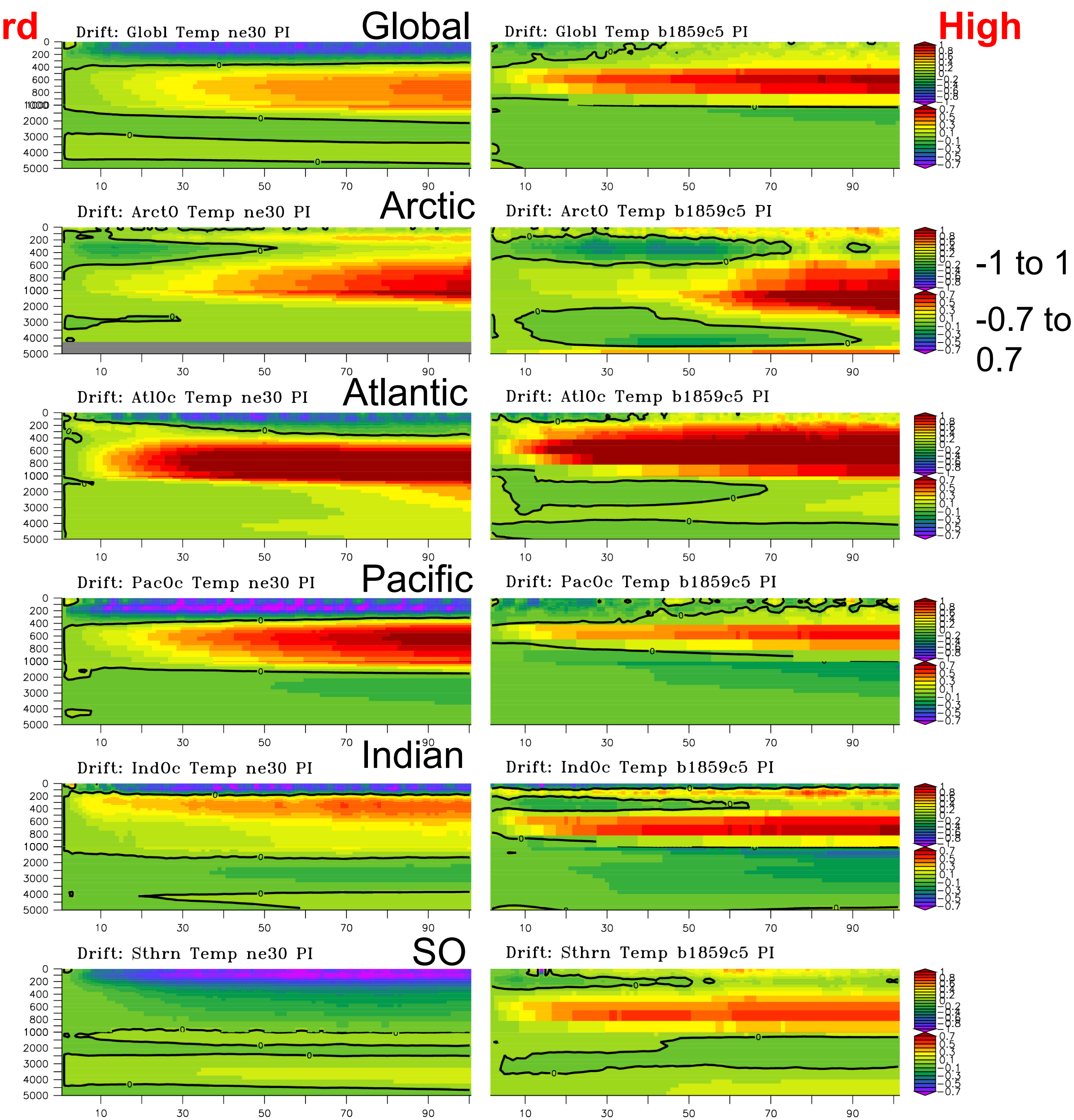
Black: total depth, red: 0=700 m
Green: 700-2000m; blue: 2000-bottom

SST biases (°C): DJF mean for V0.1 1850 PI controls (years 88-92): low (left) and high resolution (right). Observations are HadISST/OI.v2 1870-1900.



Global & basin-averaged drift of annual mean potential temperature (°C) as a function of depth and time for standard (left) and high (right) resolution V0.1 1850 PI control simulations.

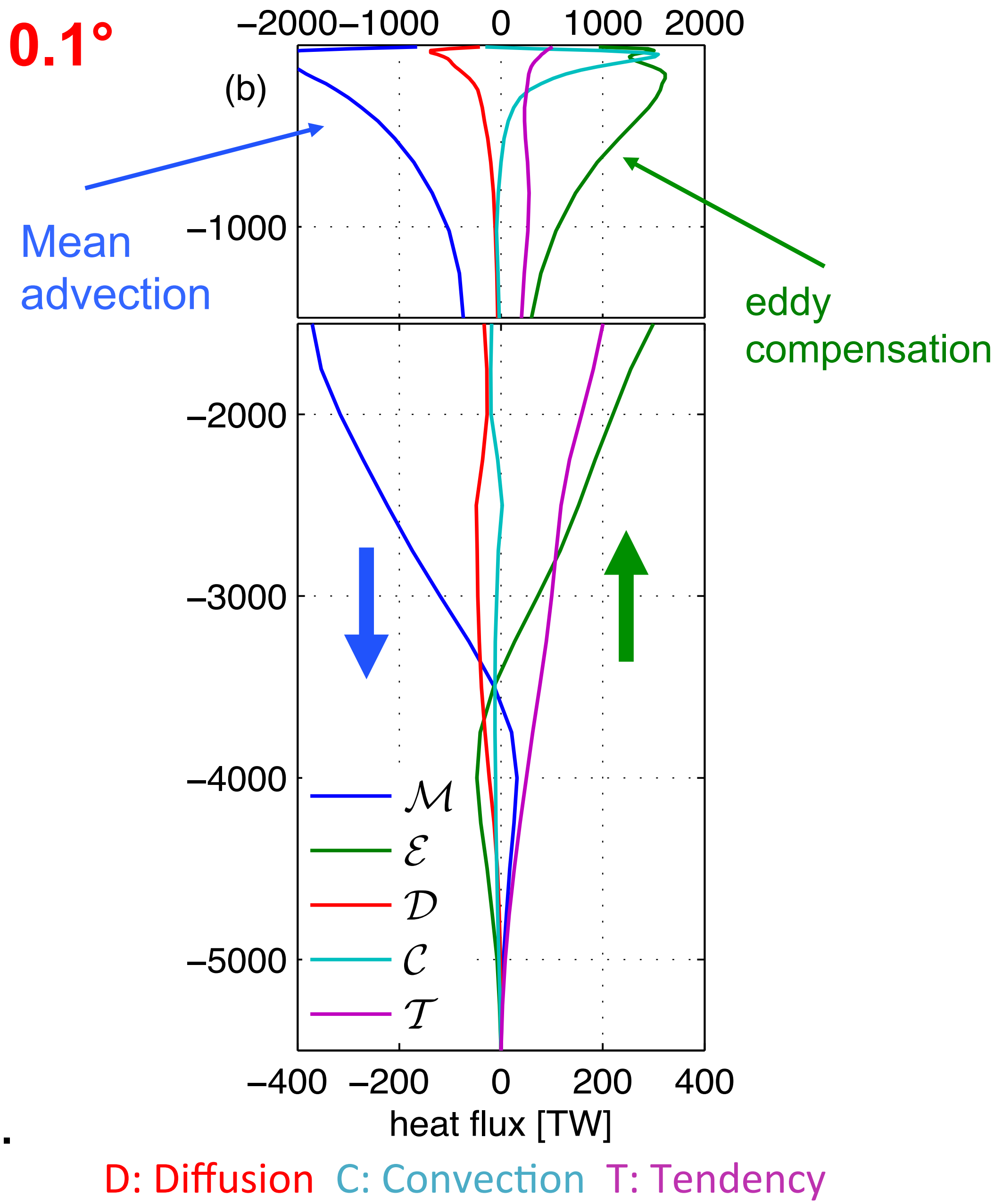
Drift is defined relative to the annual mean of the first year of the simulations.



Global ocean vertical heat flux budget from global 0.1° POP (Wolfe et al. 2008)

- Mesoscale eddies act to transport heat upward (green) such that they partially compensate the downward heat transport from the time-mean currents (blue).

- Positive values: upward heat transport (upward arrows).
- Negative values from downward heat transport.

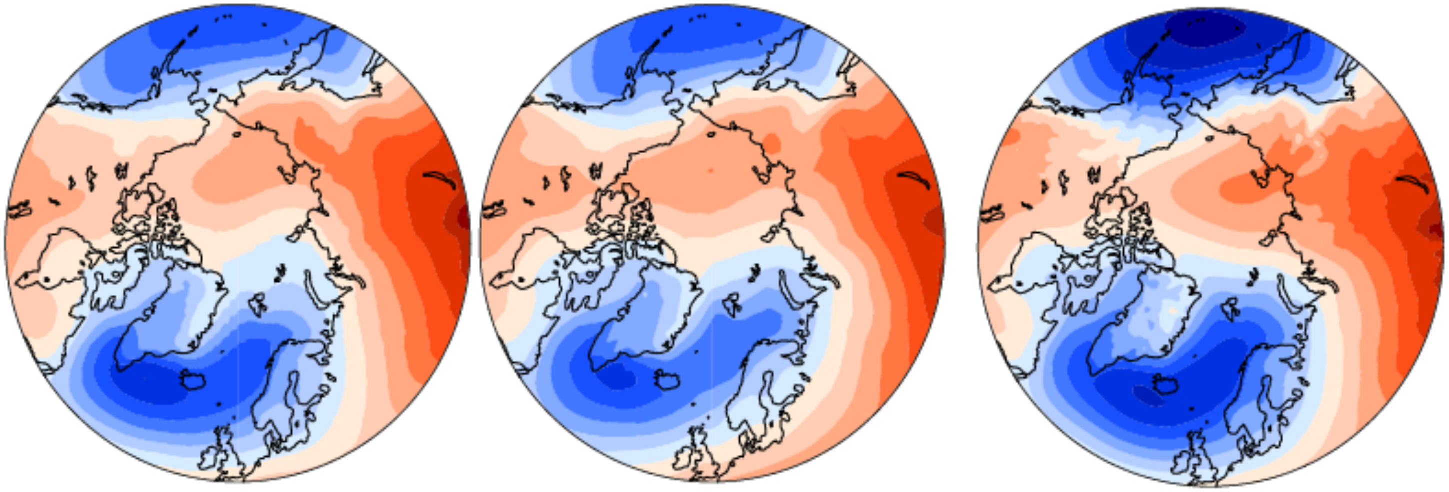


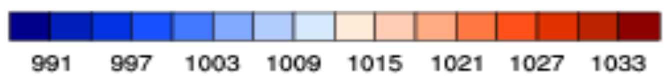
NH Winter (DJF) Sea-Level Pressure (mb)

Standard Resolution
1 deg /1 deg

Observations
JRA 25

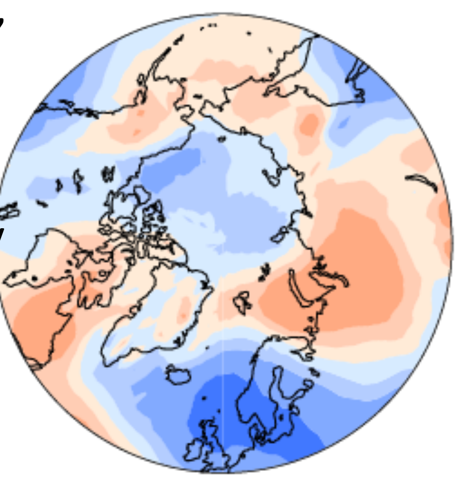
High Resolution
.25 deg /.1 deg

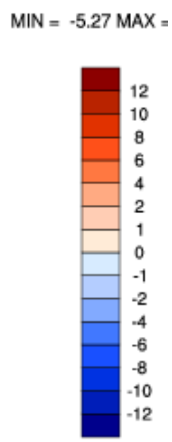




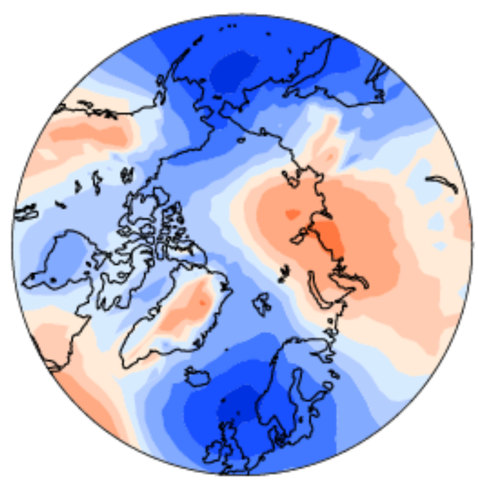
1 deg. - JRA

Good Pattern,
Gradients a little too smooth-> Sfc Winds slightly Too weak





.25 deg./.1 deg - JRA

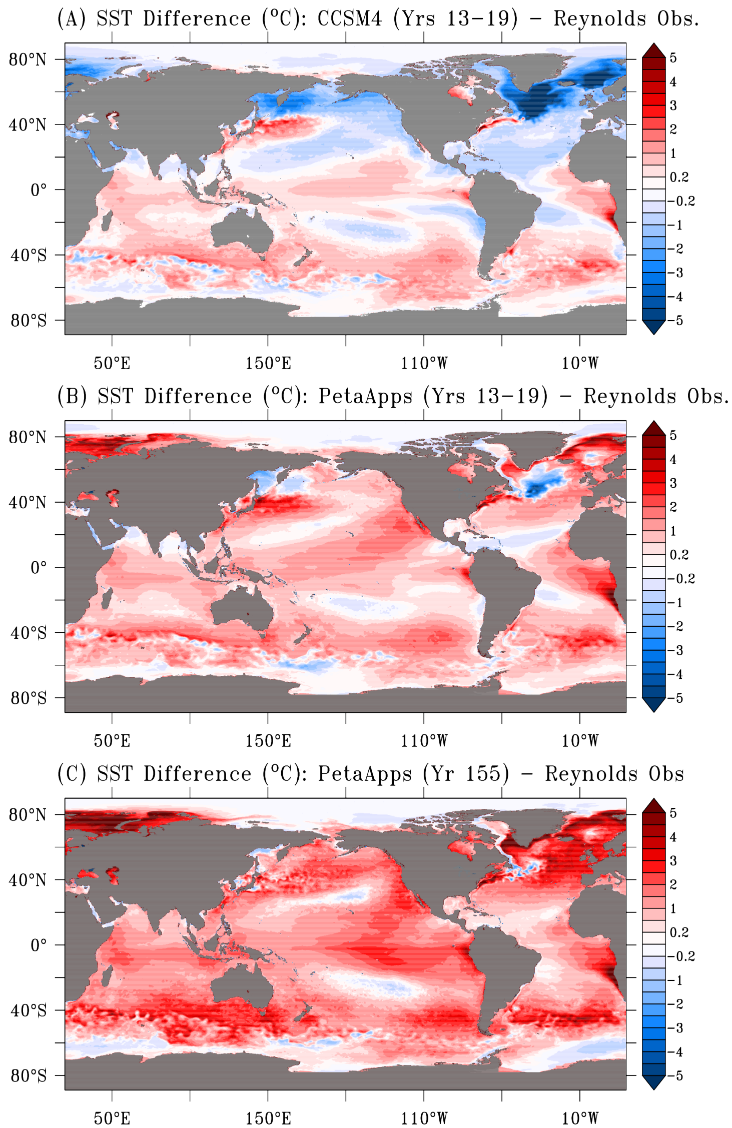


Good Pattern,
Gradients too sharp-> Sfc Winds Too Strong

Sensitivity to Initial Conditions: CCSM3.5 1990 Controls

ATLAS: 0.1° POP/CICE & 0.25° CAM/CLM
PetaApps: 0.1° POP/CICE & 0.5° CAM/CLM

SST Biases:



(A) ATLAS SST – Reynolds SST (Yrs 13-19)

Initialized from 2 yr CCSM4 using 0.1° POP/CICE and 0.5° CAM/CLM. (McClean et al., 2011, OM)

(B) PetaApps SST – Reynolds SST (Yrs 13-19).

Initialized from multi-century CCSM3 Pre-industrial control interpolated to high resolution grid. (Kirtman et al., 2012, Clim. Dyn.)

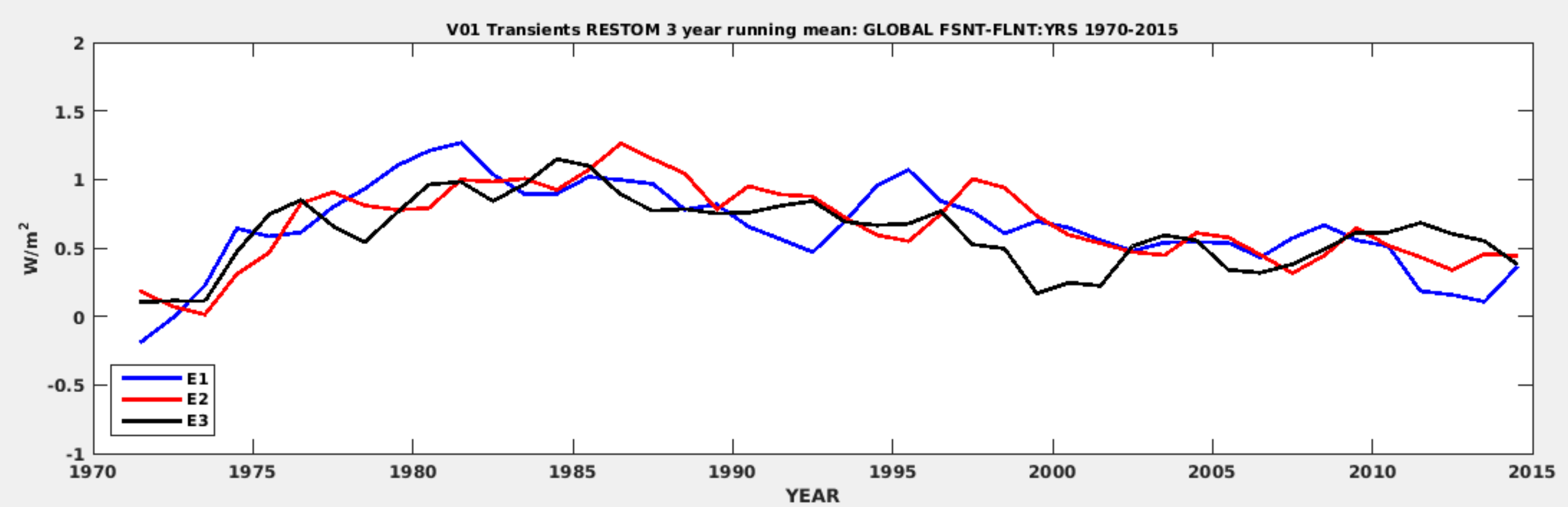
(C) PetaApps SST – Reynolds SST (Yr 155)

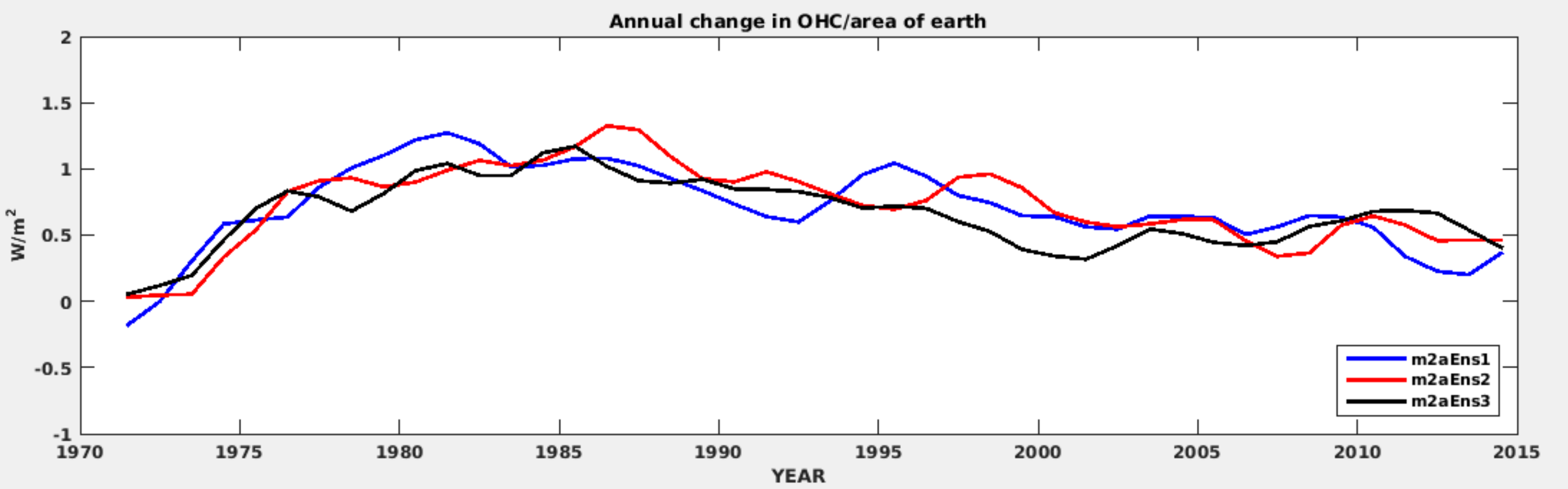
PetaApps output courtesy, B. Kirtman (U. Miami)

Idealized 1970-2010 climate change: High Resolution

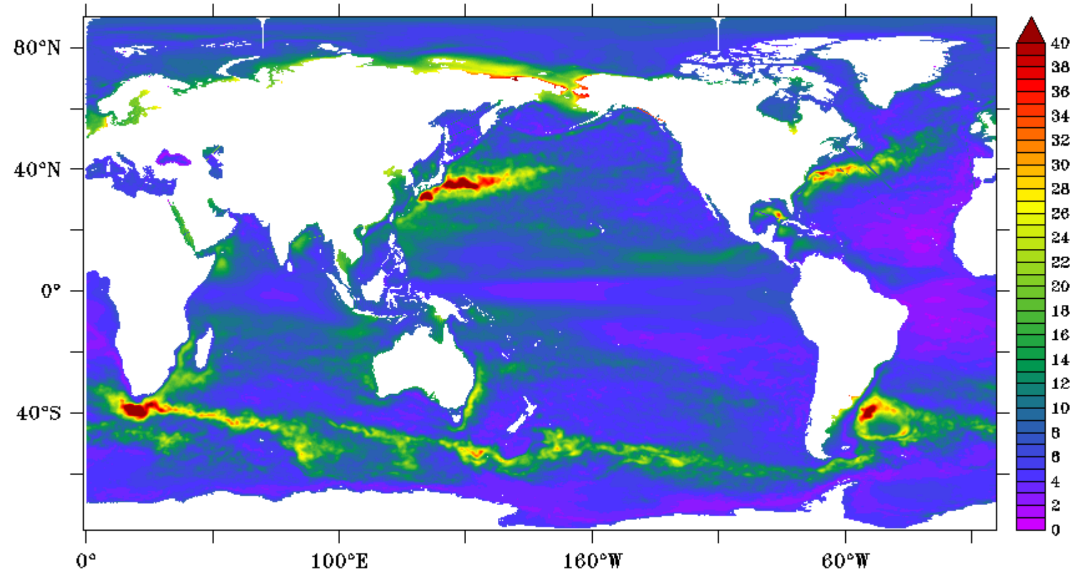
- Three-member ensemble of present day transients (1970-2010)
- Initial Conditions: ocean and sea ice from an atmospheric reanalysis-forced 0.1° POP2/CICE4 simulation configured in the same framework as fully coupled V0.1. This simulation was started in 1948.
- These ICs are from the late 1960's and early 1970s (depicting different phases of large-scale climate modes), so 20+ years of POP/CICE spin-up.
- We then force the coupled model with repeating 2000 forcing (no volcanoes). Referred to as V0.1 PDs.
- Branch off Year 90 of the1850 PI control since it reached a roughly quasi-steady state (not thermodynamic equilibrium) and force with repeating annual 2000 forcing (no volcanoes) – underway, so not discussed here.

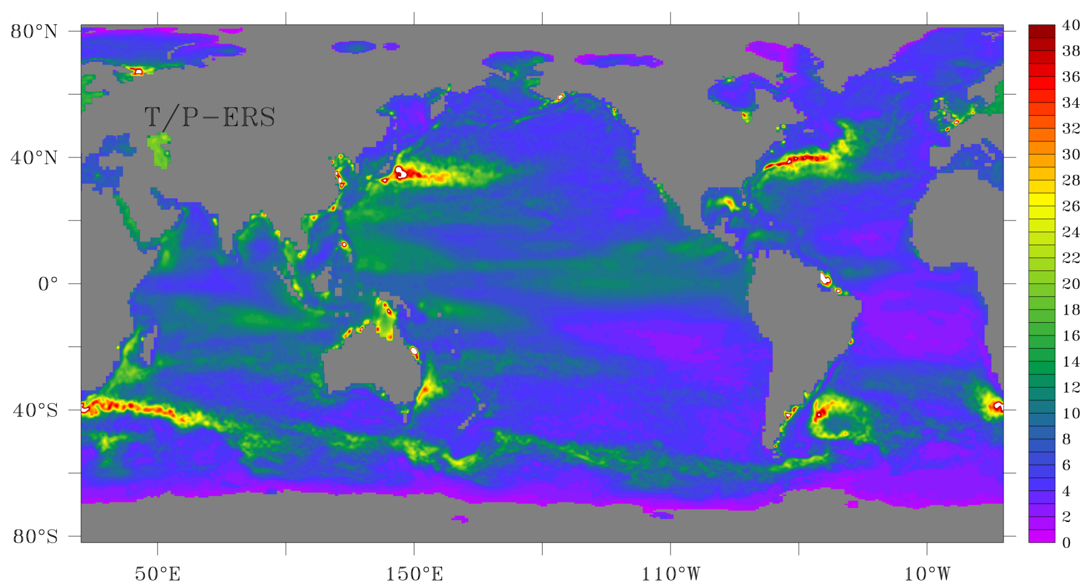
TOA net radiation (Wm^{-2}) (upper) and annual change of global-averaged ocean heat content/area of the earth (lower) for three V0.1 PDs.



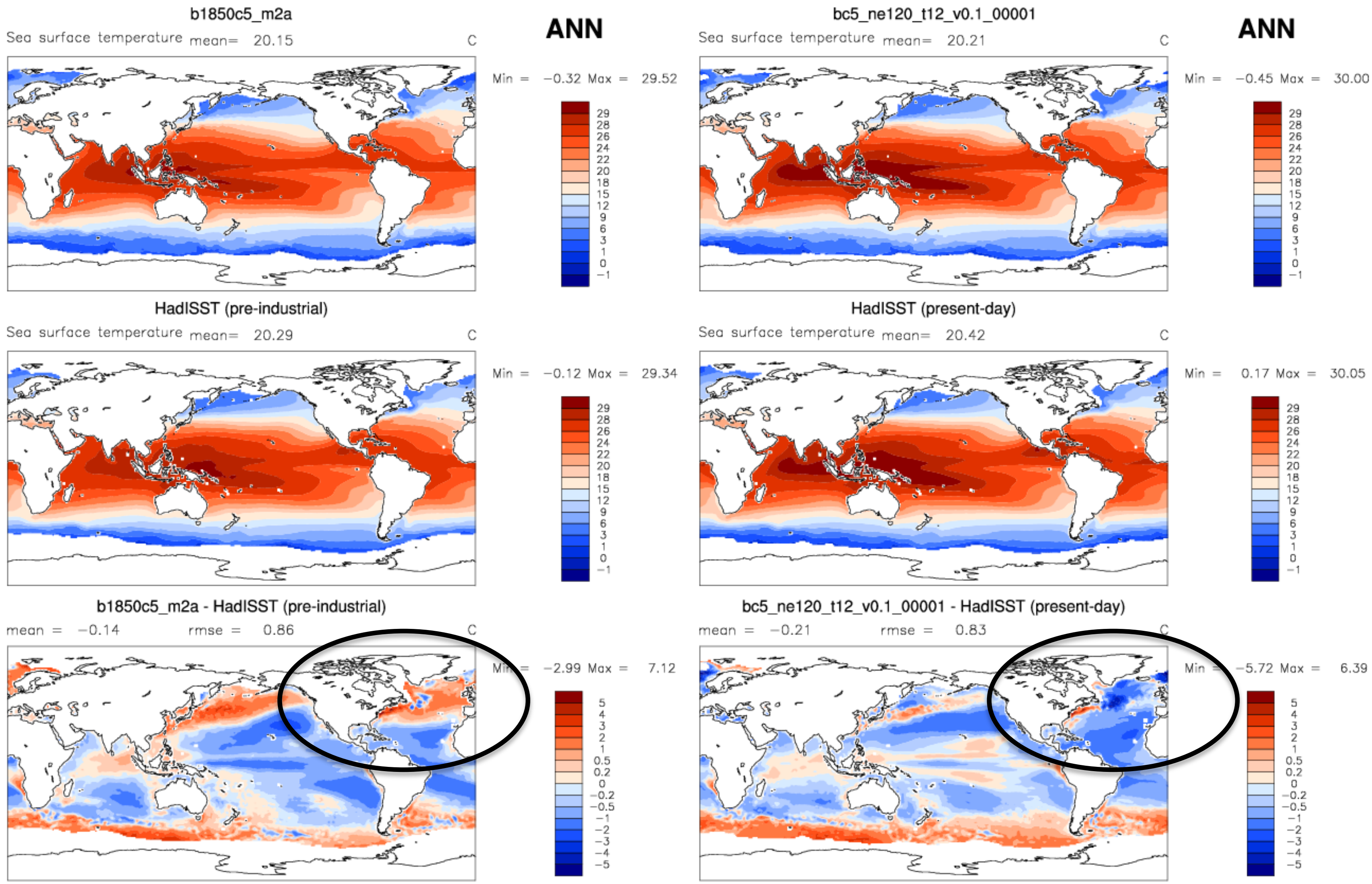


RMS sea surface height anomaly SSHA (cm) for V0.1 PD_01 (upper) and TOPEX/Poseidon/ERS observations (lower).

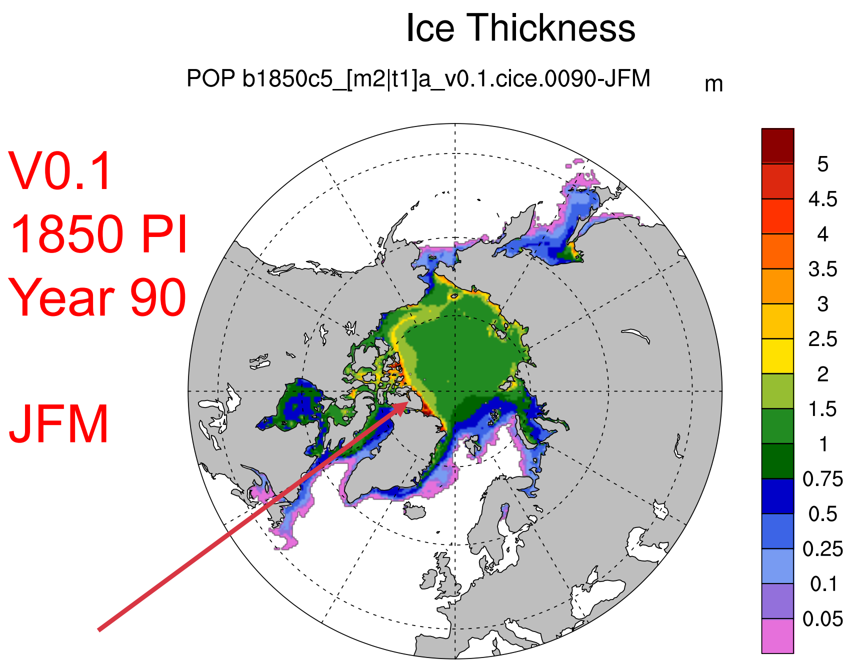


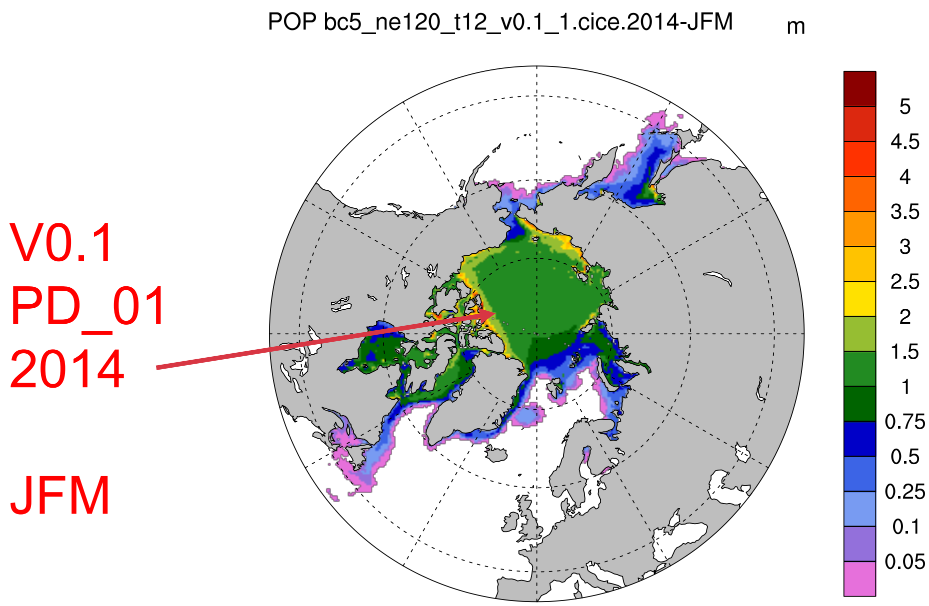


SST biases (°C): annual mean for V0.1 PI control (years 93-97) (left) and V0.1 PD_01 2006-2010. Observations are PI & PD.

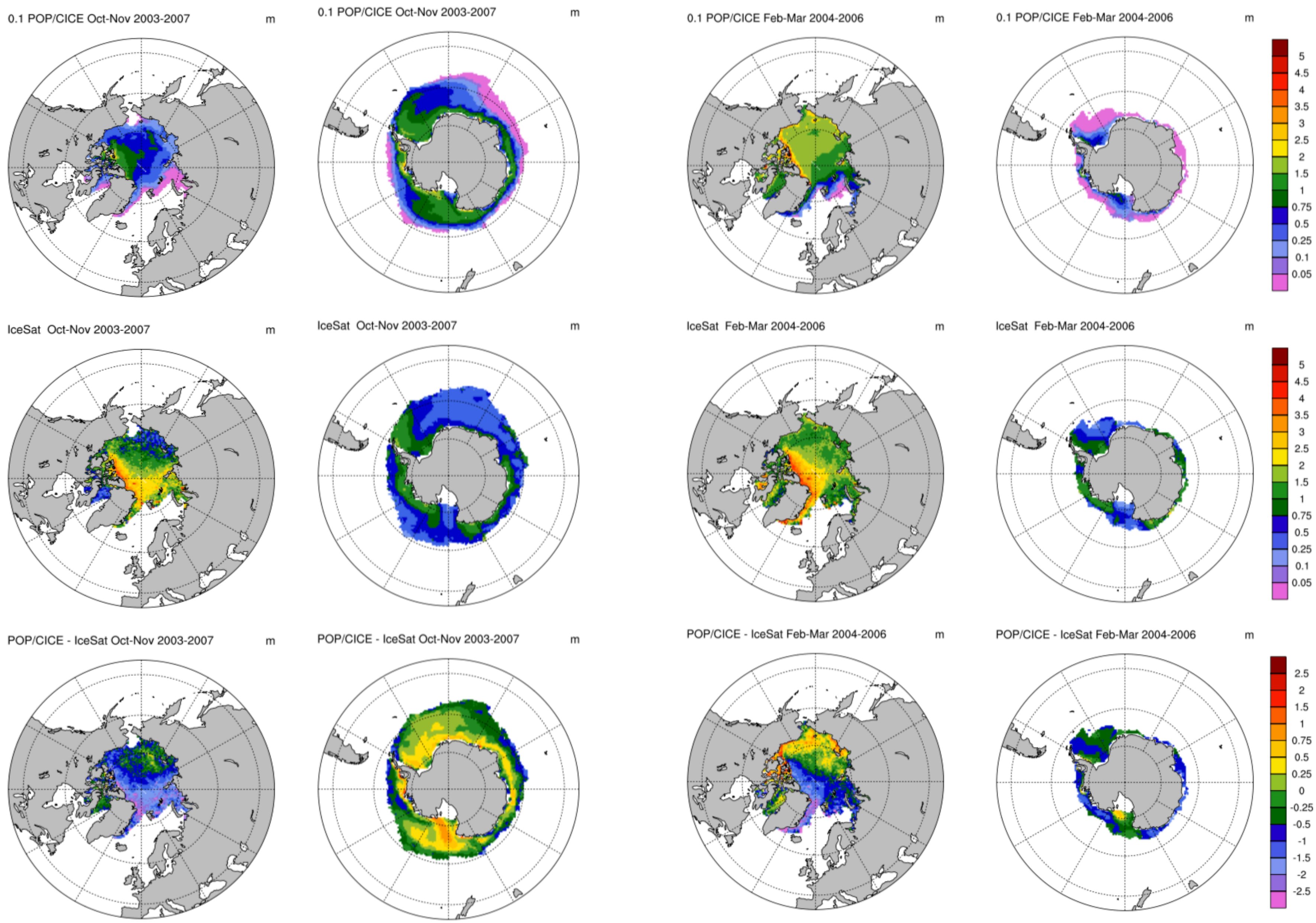


Ice Thickness JFM

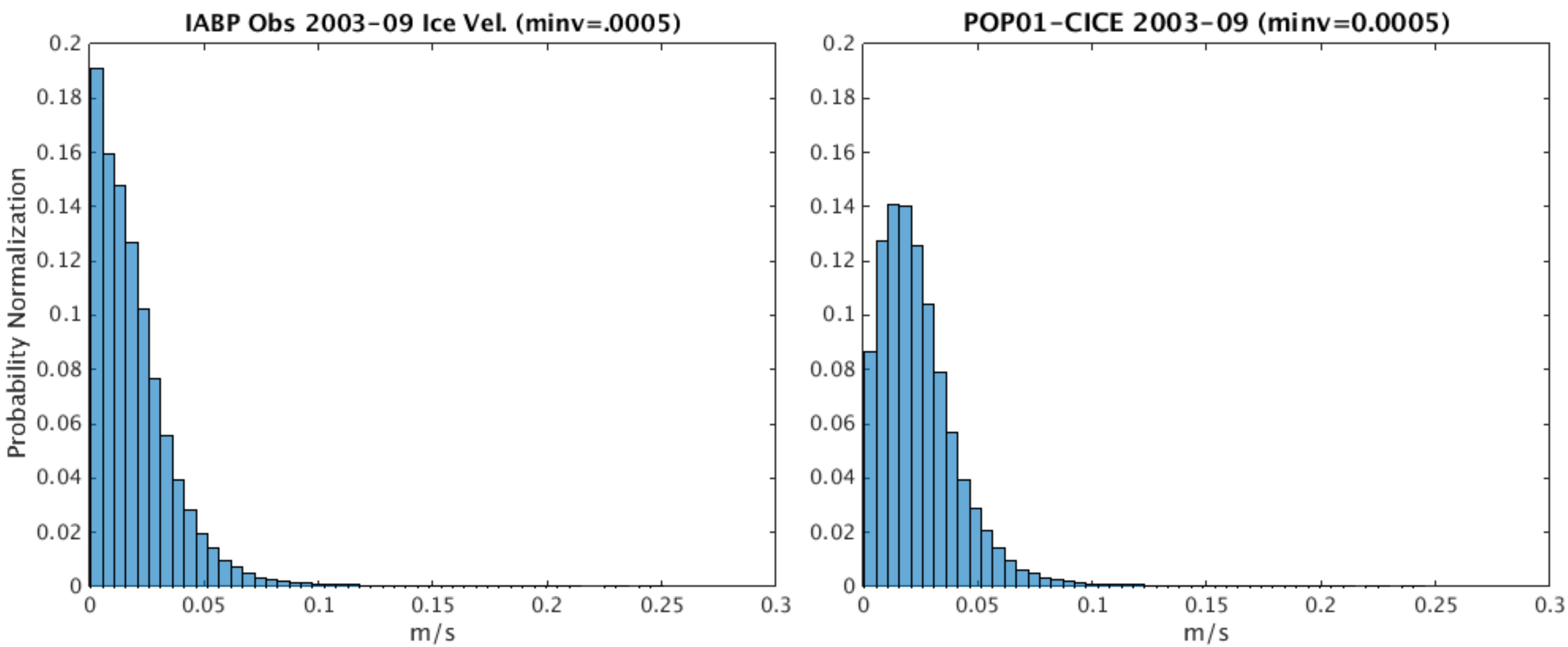




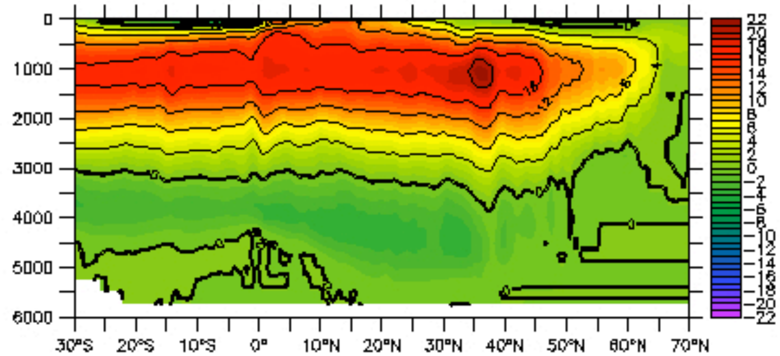
Ice Thickness (m): 0.1° POP/CICE (top), ICESat (middle), model-obs. (lower) for Oct-Nov 2003-2007 (left) & Feb-Mar 2004-2006 (right)



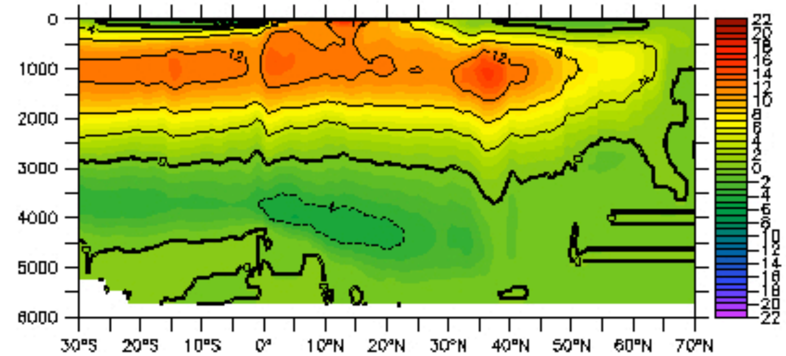
PDFs of sea ice drift from the International Arctic Buoy Programme (IABP) data (left) and 0.1° POP/ CICE (right) for 2003-2009



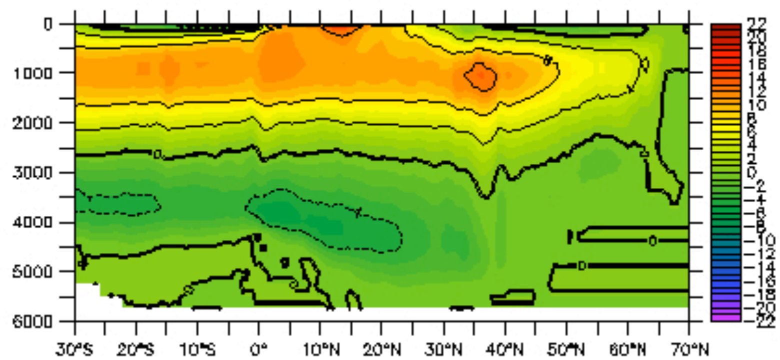
ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (SV)



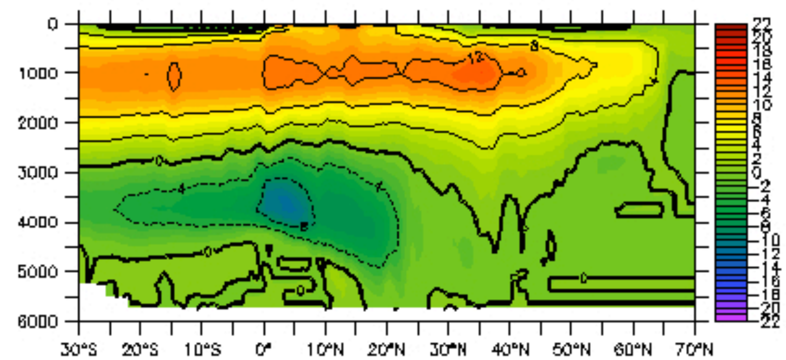
Preindustrial (years 70-79)



Present Day #1 (years 20-29)



Present Day #2 (years 20-29)



POP-CICE CORE2 (years 40-49)

Conclusions

- High (H) and standard (S) resolution V0.1 1850 pre-industrial control simulations were run for 100+ years. Warm biases were found in the upper 1000m at both resolutions.

- Upward vertical eddy heat fluxes may be significantly compensating for the downward mean advection of heat i.e. North Pacific.

- Adjustment from forced high-resolution ocean/ice model initial states to 2000 forcing, shows promise in capturing change from 1970-2010..

- Arctic sea ice using 2000 forcing becomes unrealistically thin. Excessive sea ice melt is likely responsible for the weak AMOC.

Continuing High-Resolution V0.1 Simulations

1. Continuation of the 1850 PI run

2. Branch at year 90 of the 1850 simulation and then use Approximate Present-Day (APD) forcing.

3. Start a new run with the APD forcing using an the same initial state used to initialize the 1850 run (short CORE forced ice/ocean simulation).

4. Same as 2, except branched from year 20.