Coupling HYCOM to CICE via the NCAR Coupler

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OUTLINE

- Coupled Model Frame and Sub-Model Configurations
- Coupling Approach
- Preliminary Results

  (Inter-comparison for HYCOM-CICE coupled, POP-CICE coupled, and HYCOM Standalone models)

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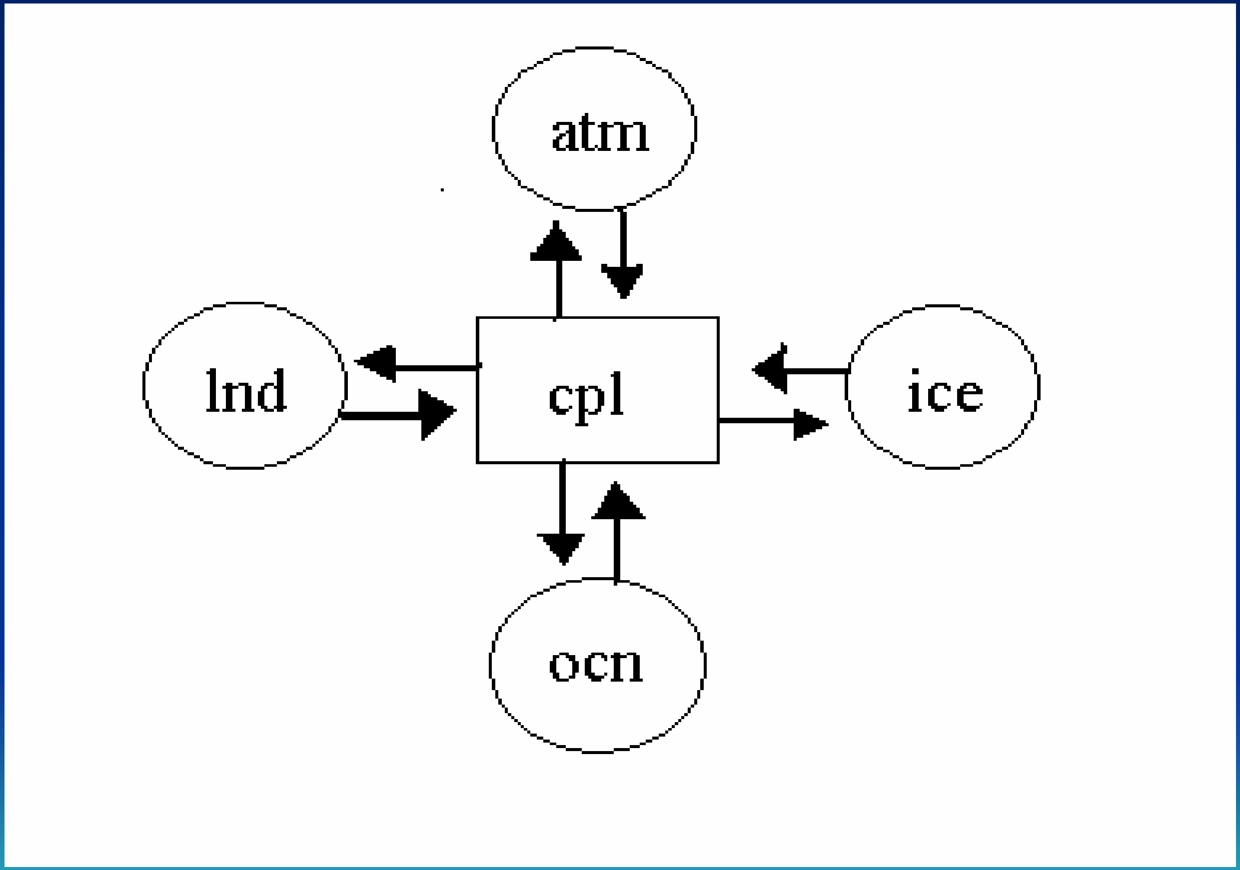
Coupled Model Frame



Ocean Model Configuration

- **Horizontal Grids:**

The NCAR Coupler requires the ocean and ice models share a common horizontal grid. Two different resolutions are officially supported in CCSM2: gx1v3 (higher resolution) and gx3v4 (lower resolution), both having the North Pole displaced in Greenland.

We use a slightly earlier version of the latter, which has 100 x 116 meshes, also called bi3/gx3v2m grid) for the practice. Its longitudinal resolution is 3.6 degrees, latitudinal resolution is variable, with the finest resolution of about 0.9 degrees near the equator.

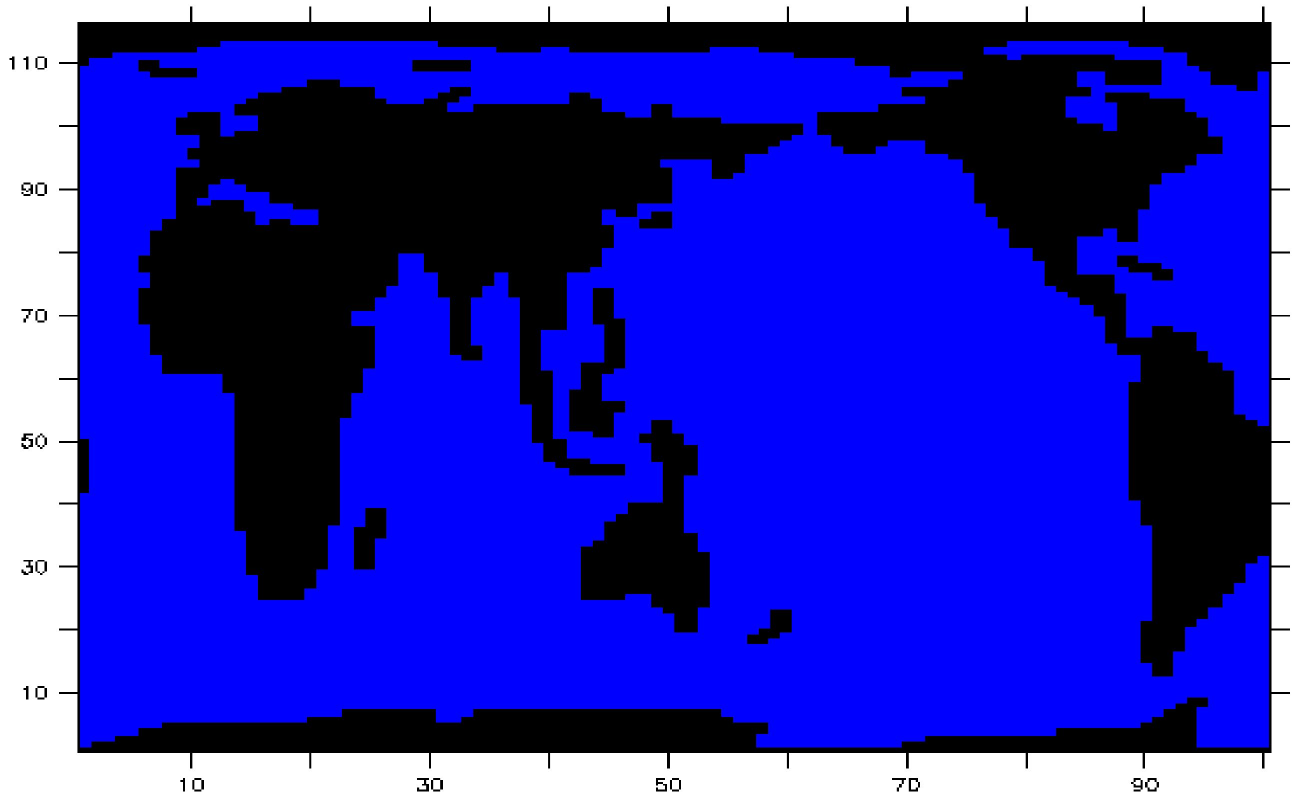
- **Vertical Resolution:**

HYCOM – 16 layers (using σ_2 as vertical coordinate in the ocean interior. Coordinate surfaces level off to become constant-depth surface wherever the isopycnals follow outcrop at the sea surface);

POP -- 25 levels, with level thickness monotonically increasing from 12 m for the surface layer to about 450 m for the deepest layer.

(same/similar topography and land mask)

Land mask of gx3v2m grid



Coupling Approach

- The NCAR coupler controls the execution and time evolution of the whole system by synchronizing and controlling the flow of data between components;
- It communicates interfacial fluxes (and some state variables if needed) between the sub-models while insuring the conservation of fluxed quantities.

  (Synchronization and communication are conducted by MPI.)
- Communication between Ocean model and the coupler:

  7 variables sent to coupler:

  SST, SSS, u, v, dh/dx, dh/dy (surface slope), and Q*.

  Q*: potential heat flux for ice formation/melting, obtained by adjusting the surface layer T (and S) for alleviating subfreezing (i.e., ice formation) or melting the existing sea ice.

  14 variables received from coupler:

  P, ico, taux, tauy, netsw, sh, lwup, lwdn, melthf, salfx, prcp, evap, meltwf, and runoff.

- Coupling Frequency: once per day (hard-coded).

Experimental Design

- ***Land+Atm*** ➔ **Iatm data model (T62 Gaussian Grid 194x92) NCEP reanalysis 1979-1988 4-time daily (10-year cycle)**

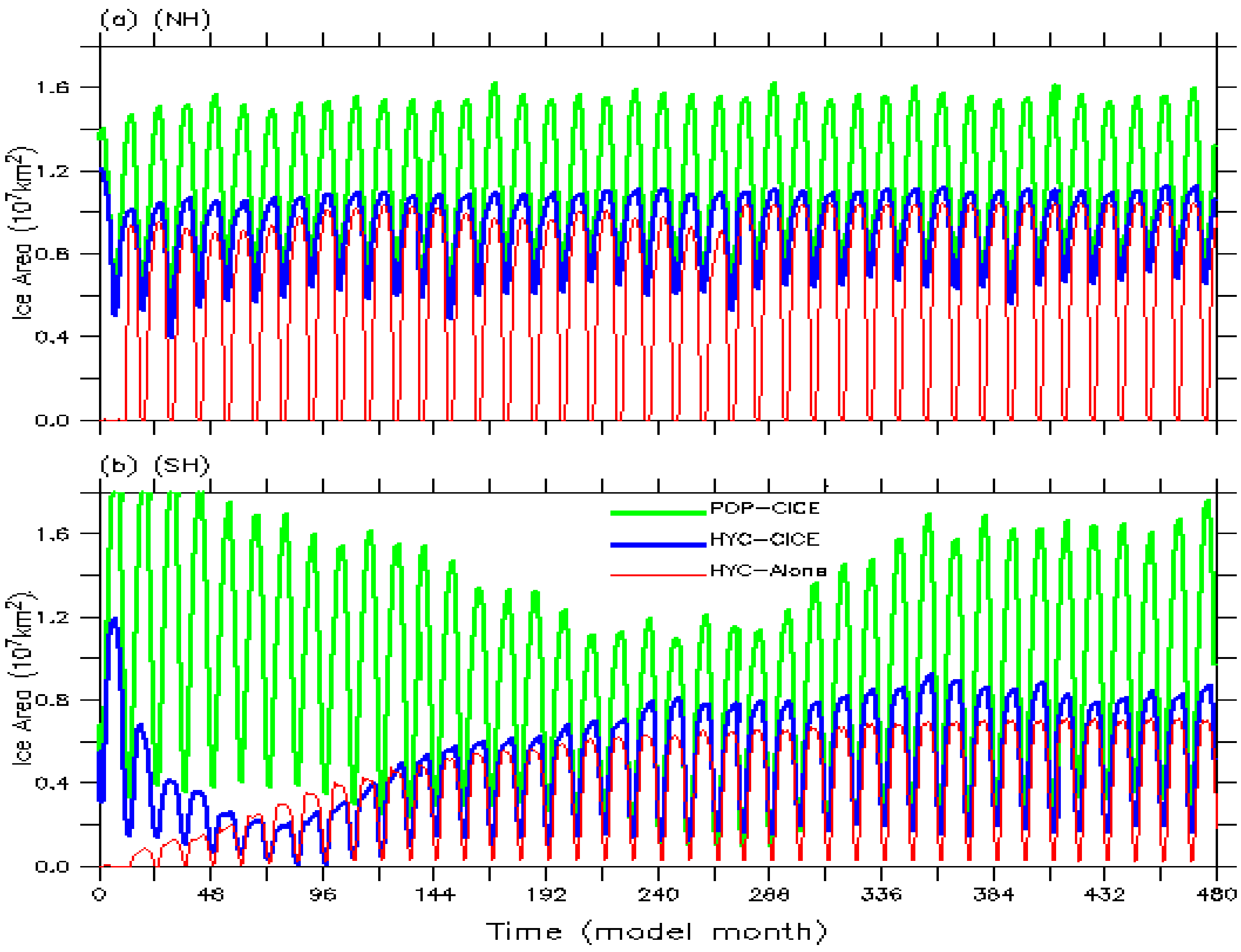
- ***Ocean Initialization:*** **Levitus climatology**

- ***Integration duration:*** **40 years for all three runs (pop-cice, hyc-cice, hycom alone).**

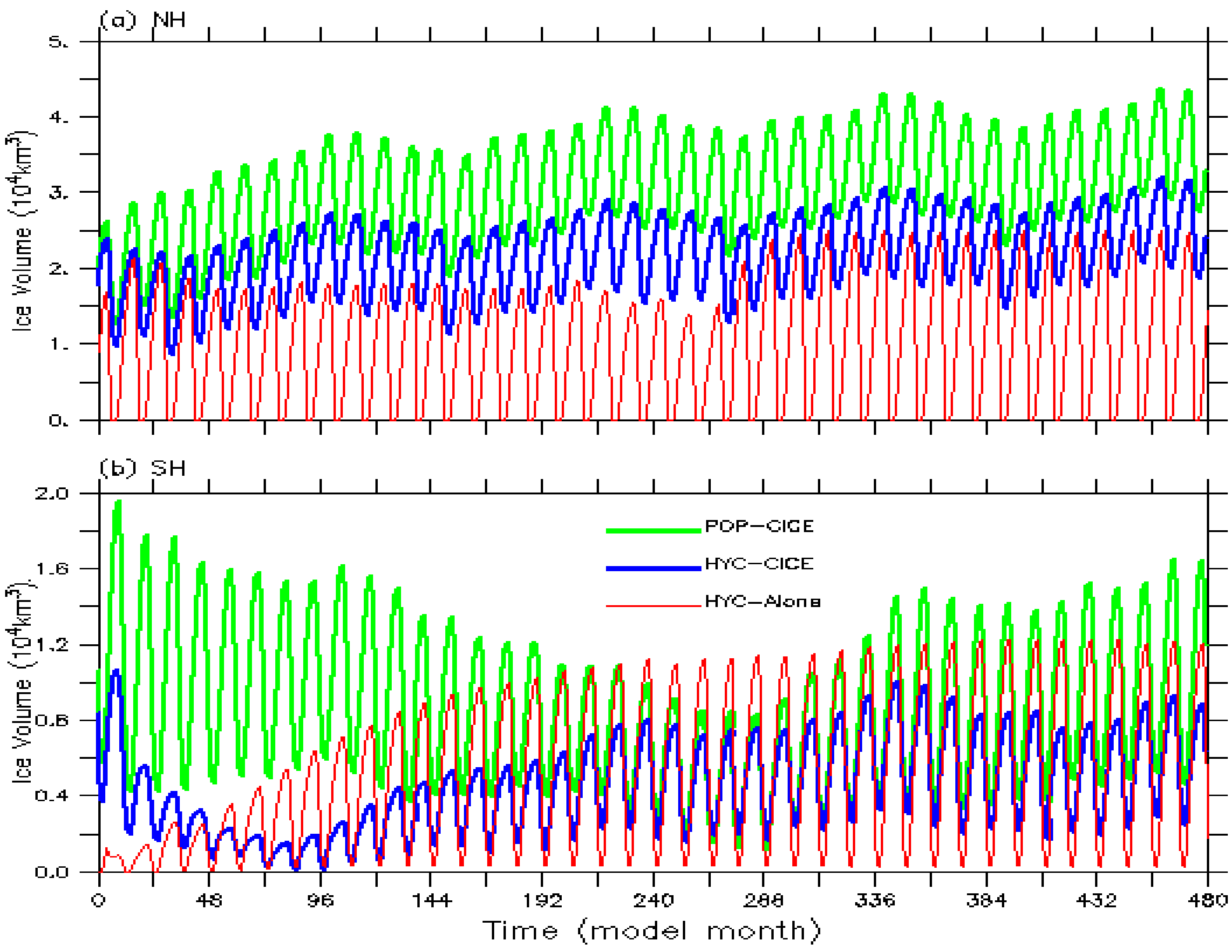
- ***Relaxation:*** **No relaxation for any of the three runs**

(For HYCOM standalone, surface forcing is OMIP-MPI monthly atmospheric climatology, with energy-loan ice model)

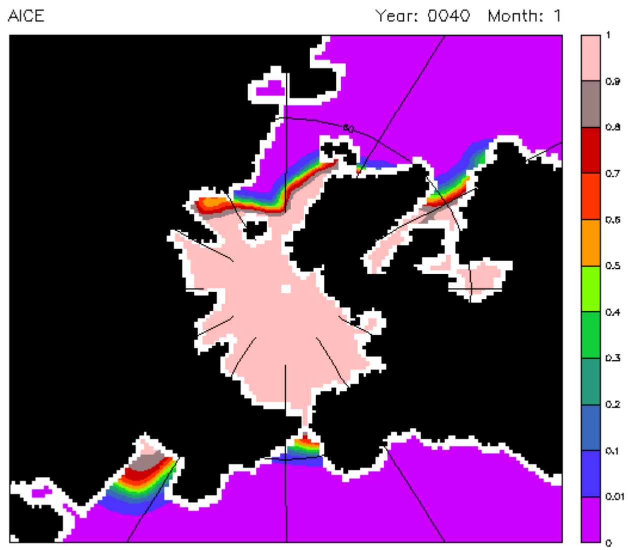
Sea ice evolution—area

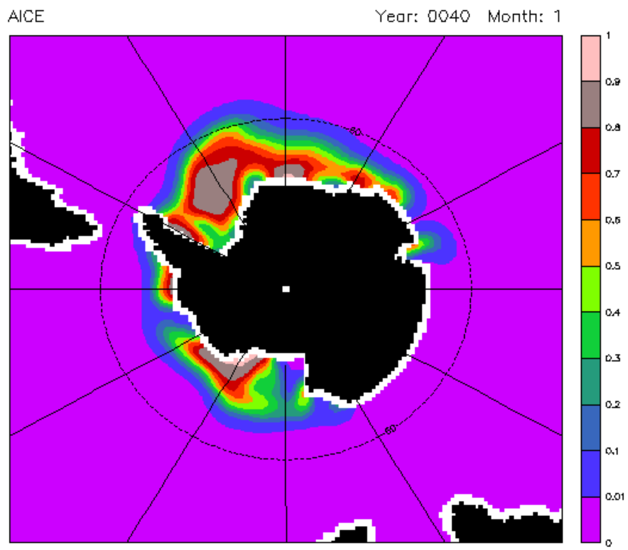


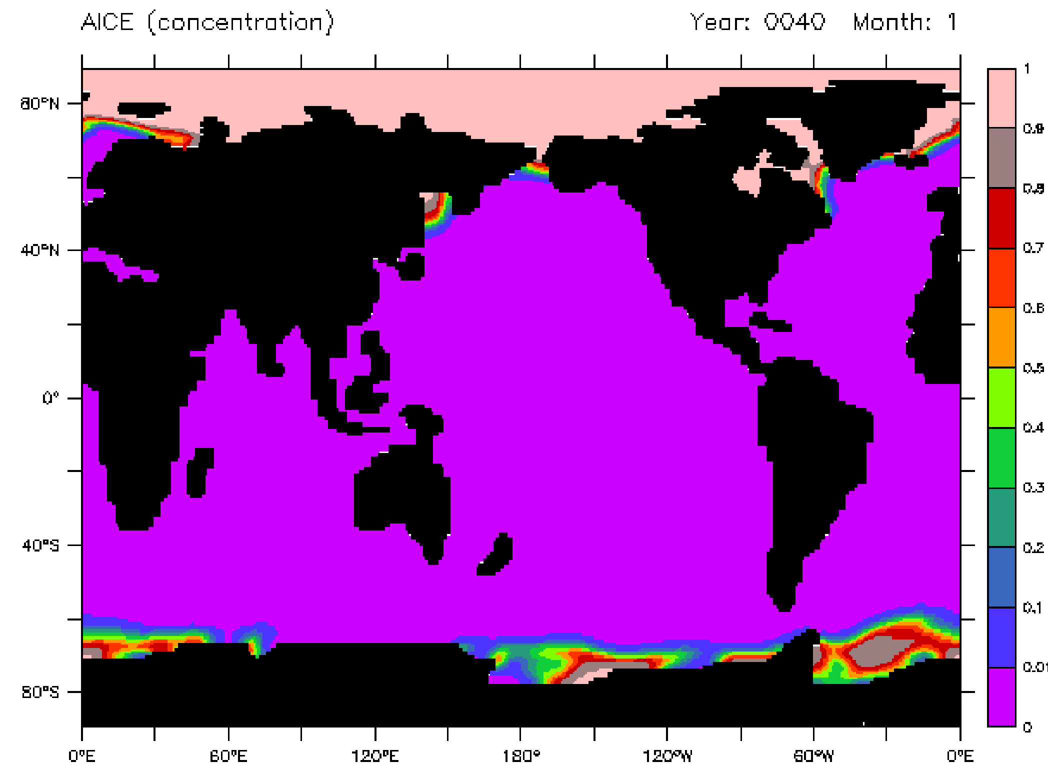
Sea ice evolution—volume



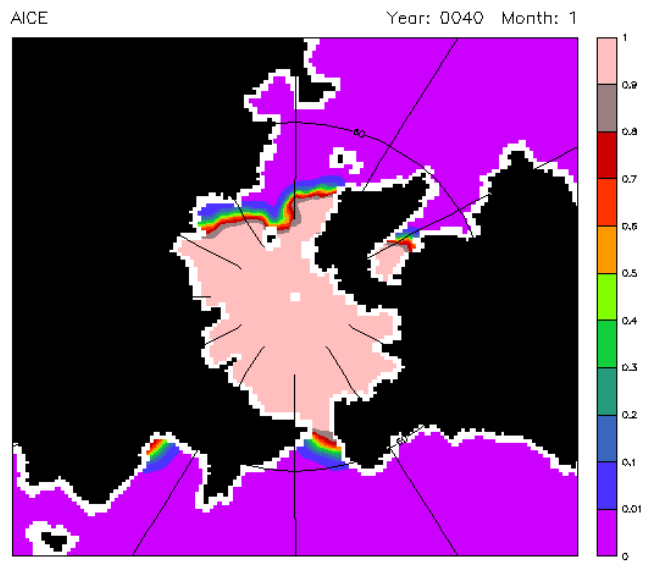
Monthly Sea Ice: POP coupled

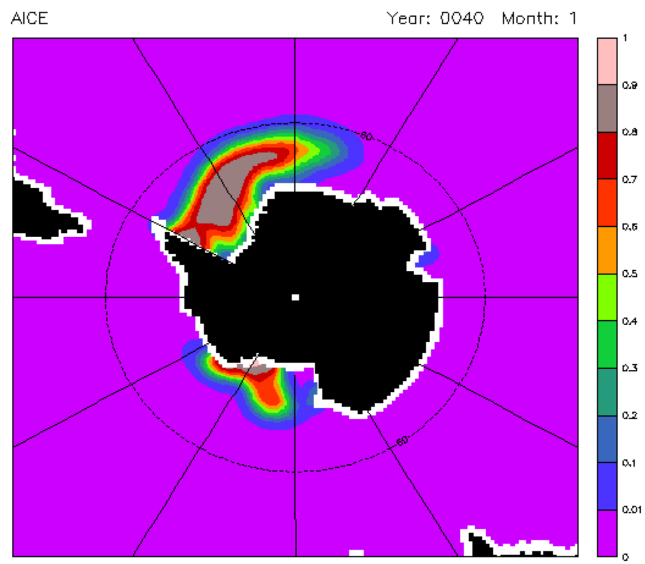


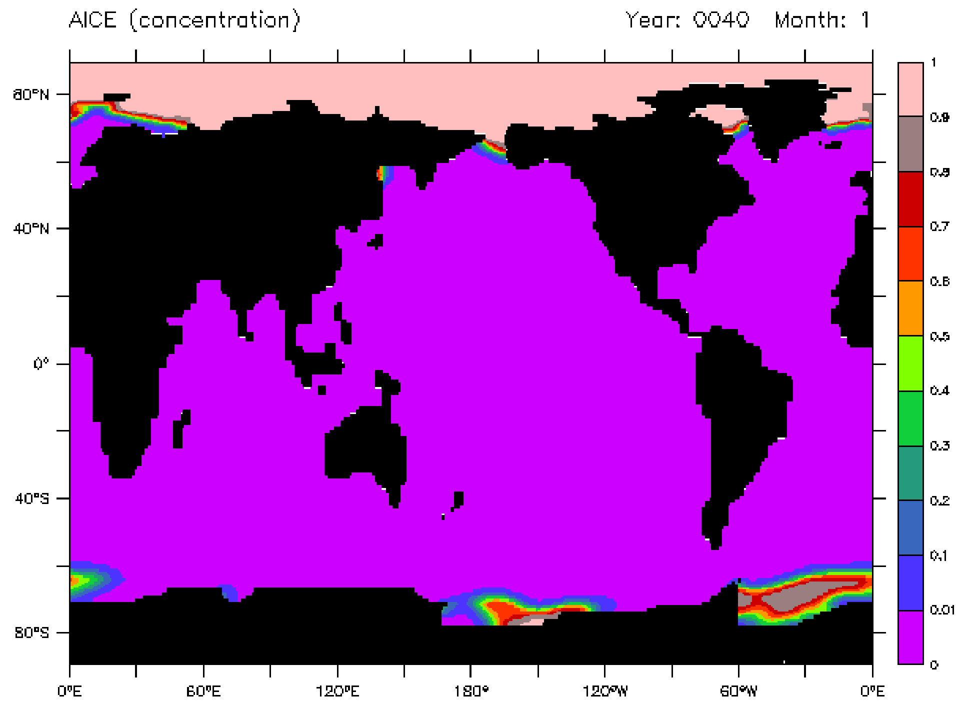




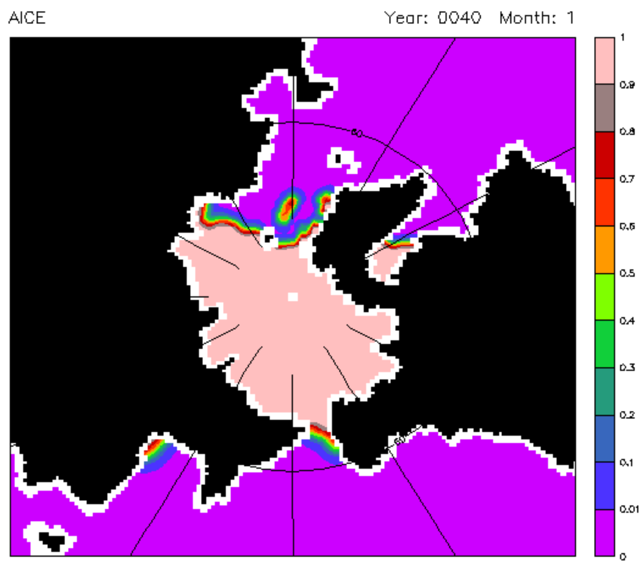
Monthly Sea Ice: HYC coupled

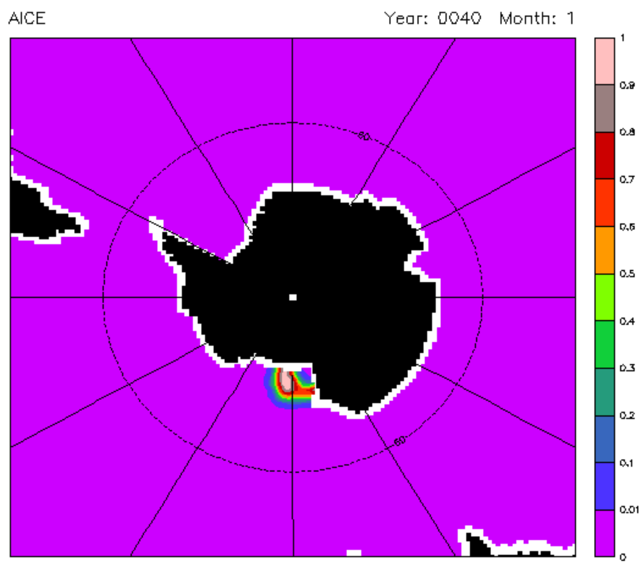


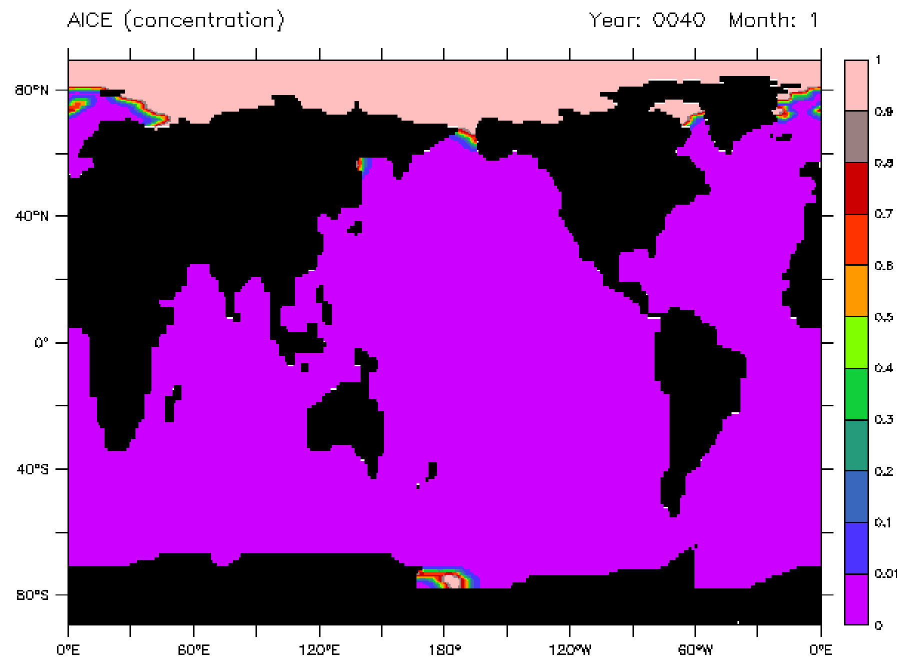




Monthly Sea Ice: HYC Alone

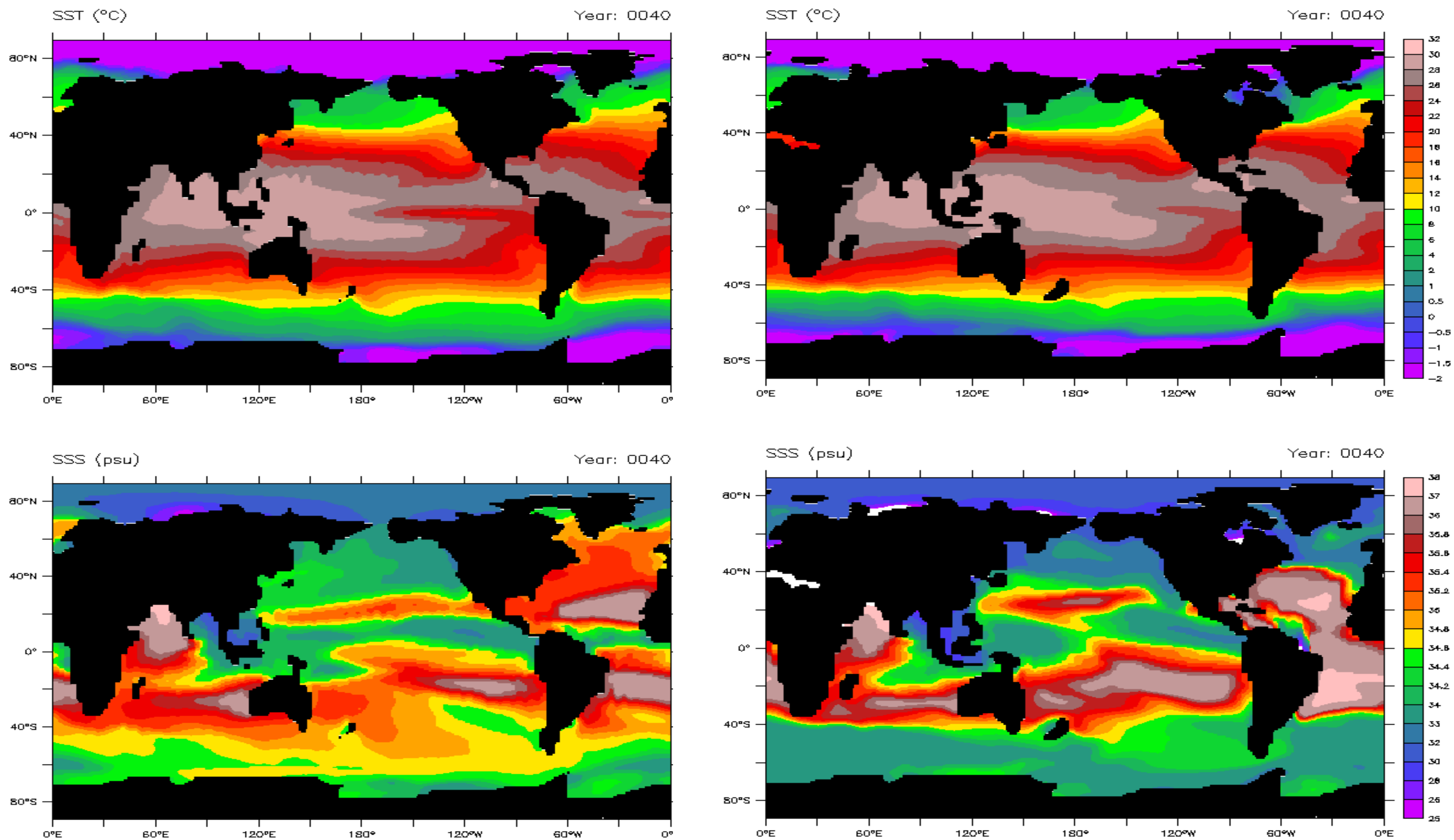






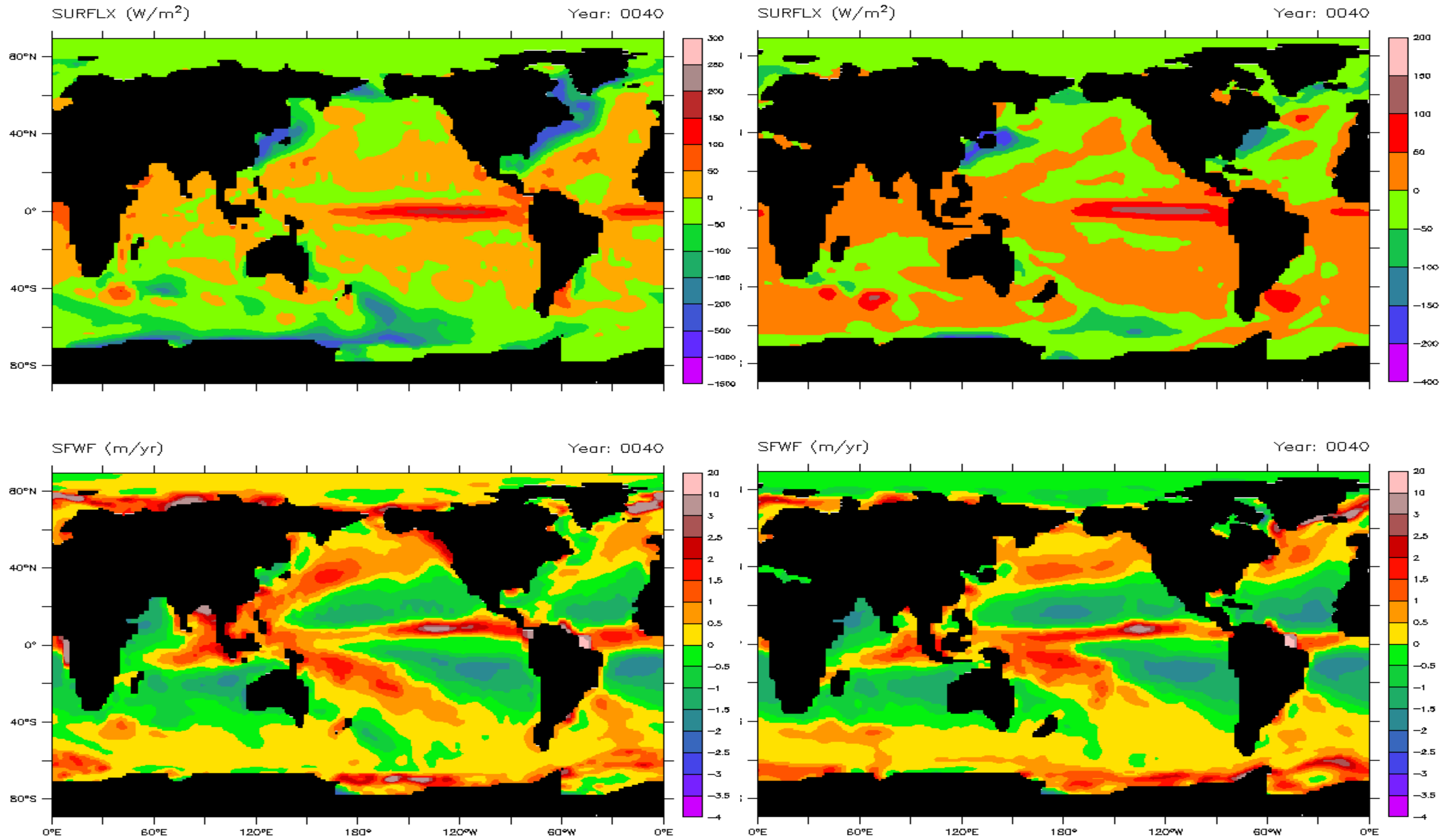
Surface Features: SST & SSS

hyc-cice pop-cice



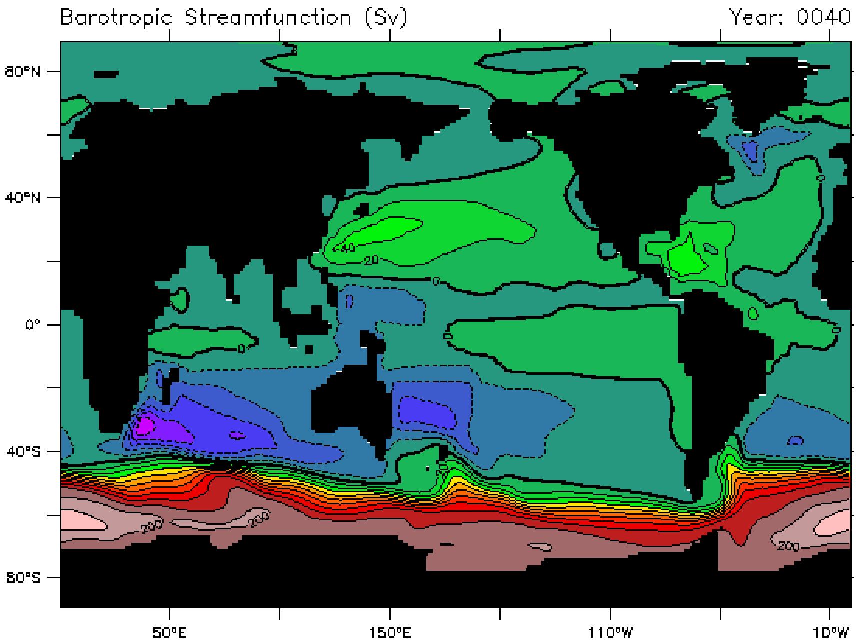
Surface Features: Net H/FW Fluxes

hyc-cice **pop-cice**

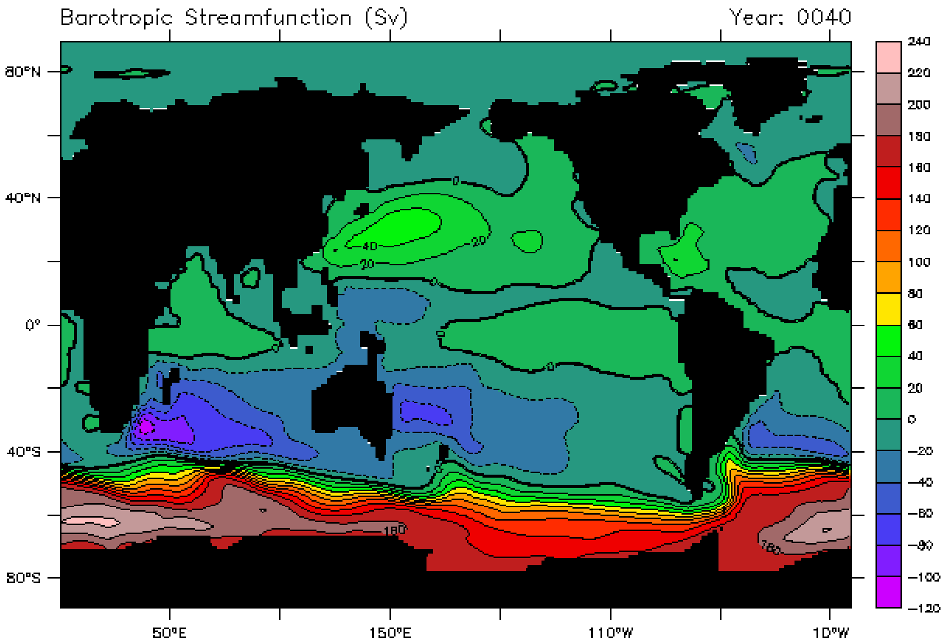


Barotropic Streamfunction

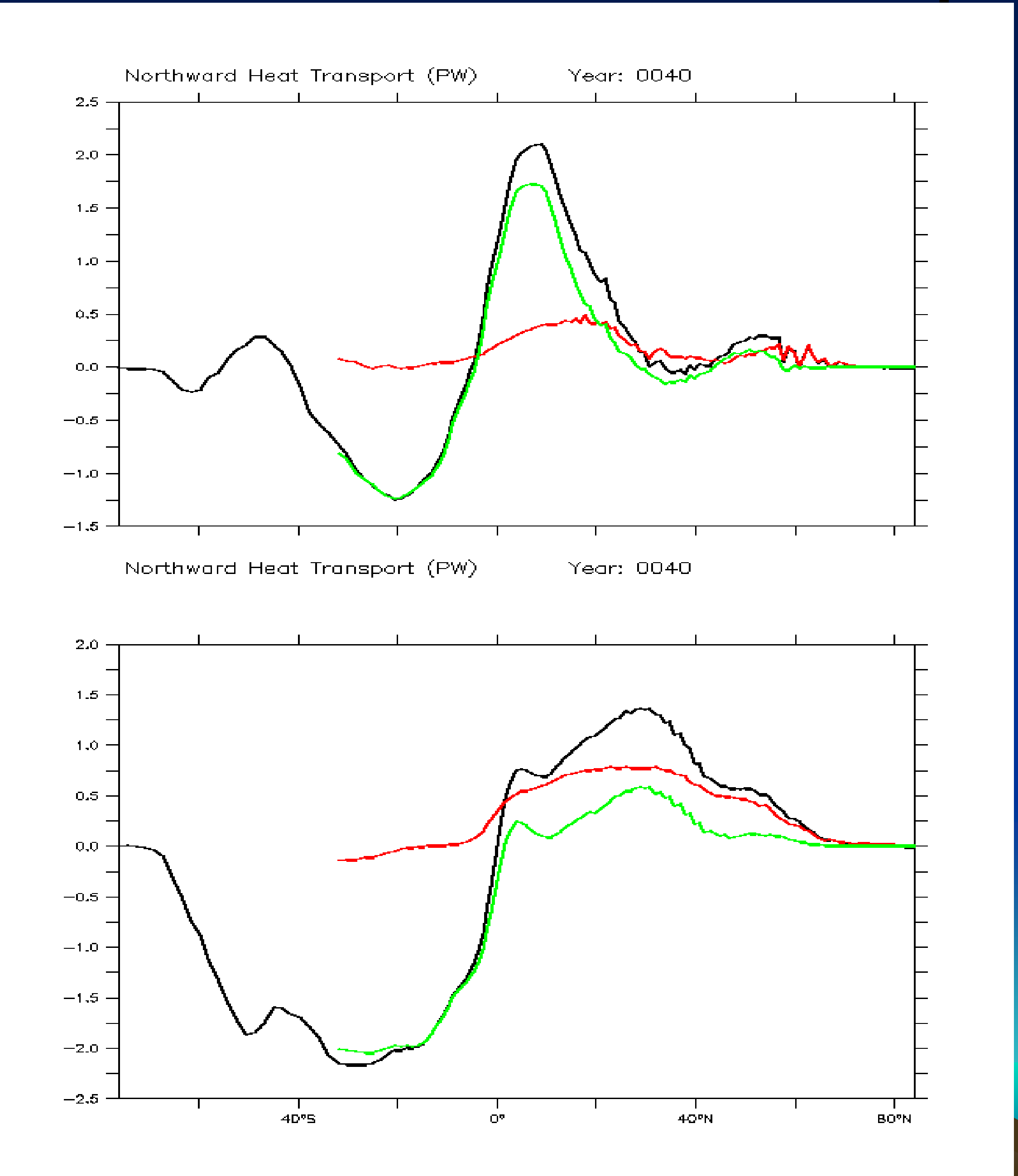
hycom-alone



hycom-cice

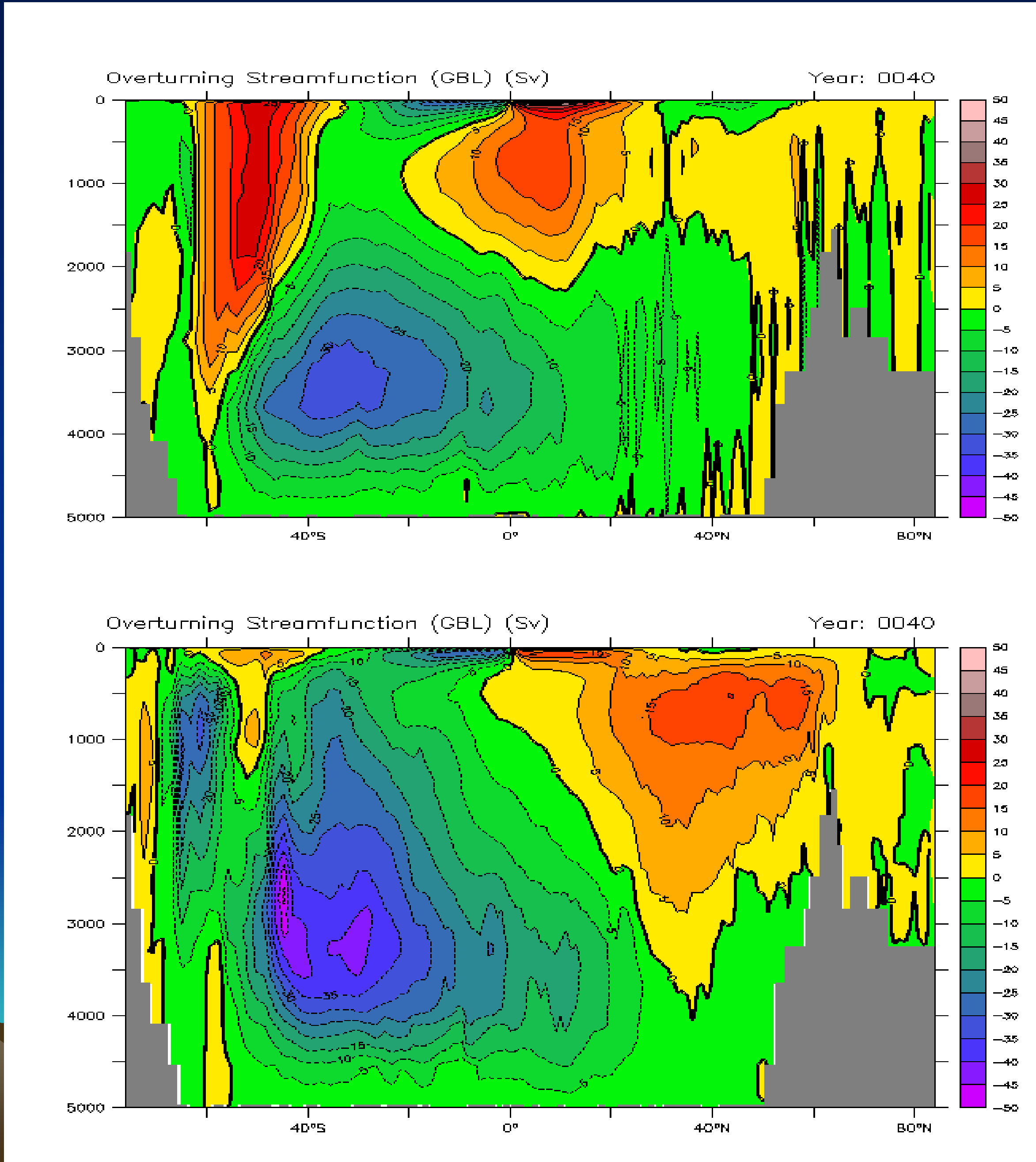


Northward heat transports:



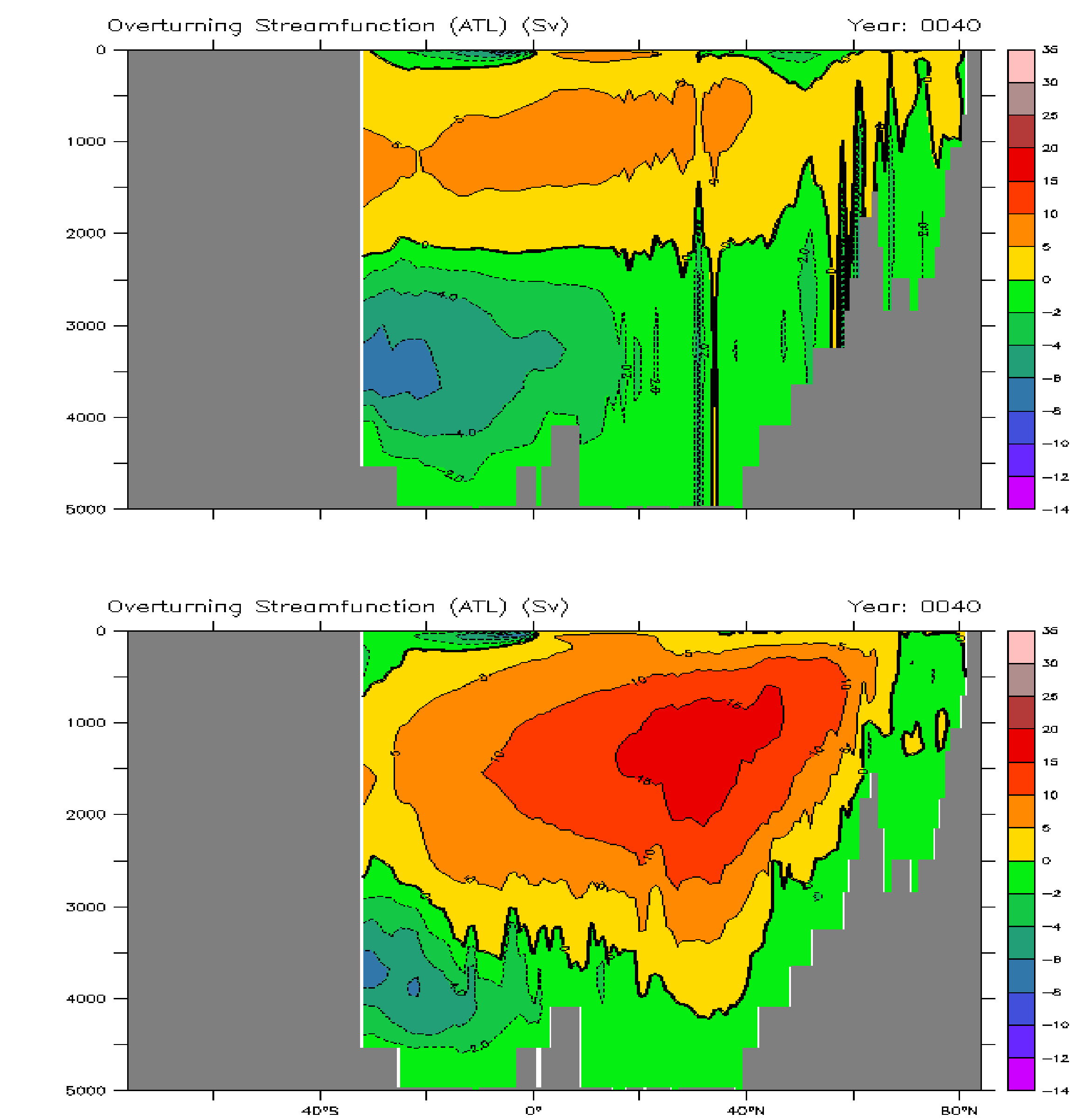
- POP cpld
- HYC cpld

Global Ocean Overturning



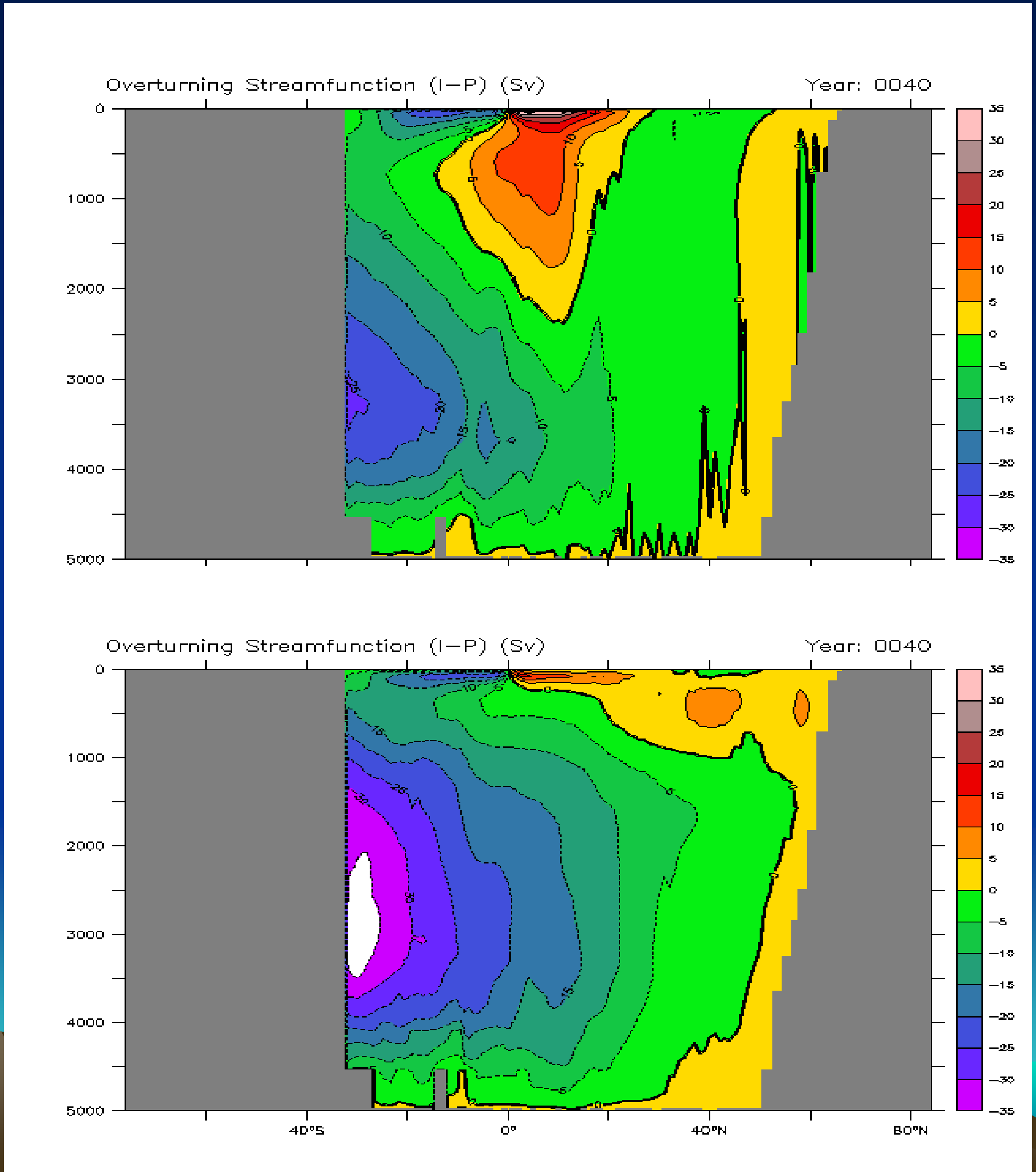
- POP cpld
- HYC cpld

Atlantic Overturning



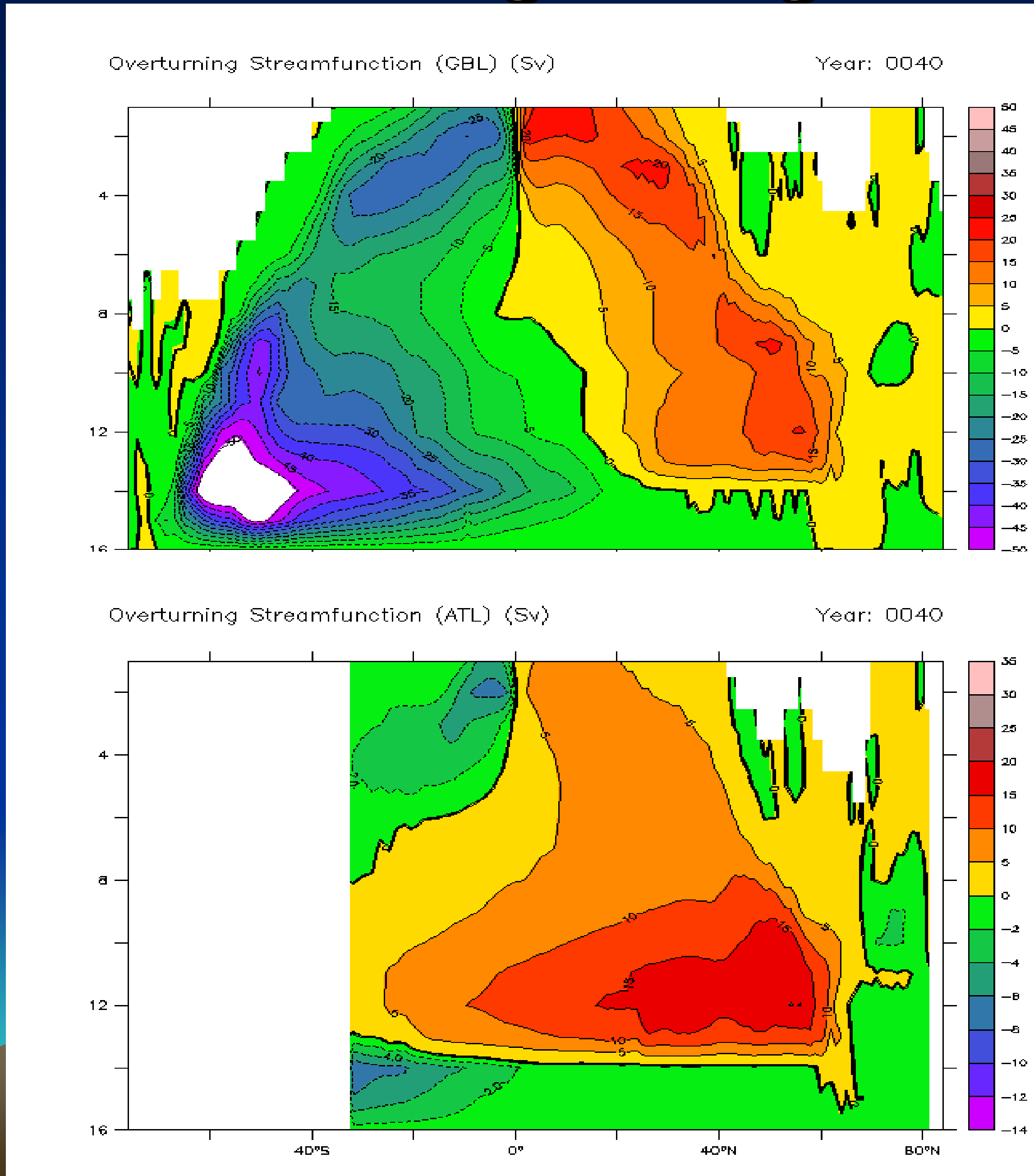
- POP cpld
- HYC cpld

Indian-Pacific Overturning



- POP cpld
- HYC cpld

Overturning in sigma space



- **HYCOM coupled (Global Ocean)**
- **HYCOM coupled (Atlantic Ocean)**

Concluding Summary

- HYCOM-CICE coupled model (in the CCSM2 frame) works (pretty well?). Coupled model sea ice simulation has been significantly improved compared to the standalone HYCOM. Furthermore, all the major dynamic features in the uncoupled hycom are well maintained in the coupled model.

- Under the same coupling frame, HYCOM represents more realistic thermohaline circulation than POP, especially the Antarctic Bottom water Formation (AABWF) and the North Atlantic Deep Water Formation (NADWF).

- We can move on towards our next target: fitting HYCOM 2.1 2-degree global model into the CCSM frame (then the 0.72 degree, and fully coupled, should the need arise …).

Acknowledgements

- All integrations have been conducted on the NCAR IBM sp3/sp4 machines
- The remapping and oceanic transports computation softwares are kindly provided by Dr. Mats Bentson.

THANK YOU