Development of AusCOM: The Australian Climate Ocean Model Using the OASIS3.2-5 Coupler

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What is AusCOM?

- AusCOM (Australian Climate Ocean Model) is
an 'IPCC-class' coupled ocean-sea ice model
that the Australian climate sciences community (including the Bureau of Meteorology, CSIRO and Universities) has been working together to develop for climate research and applications.

- AusCOM and its coupling framework is
one of the core parts of ACCESS
(the Australian Community Climate and Earth System Simulator) Specifically, the ACCESS model is built by coupling the UK Met Office atmospheric model UM (Unified Model), and other sub-models as required, to AusCOM.

The ACCESS/AusCOM System
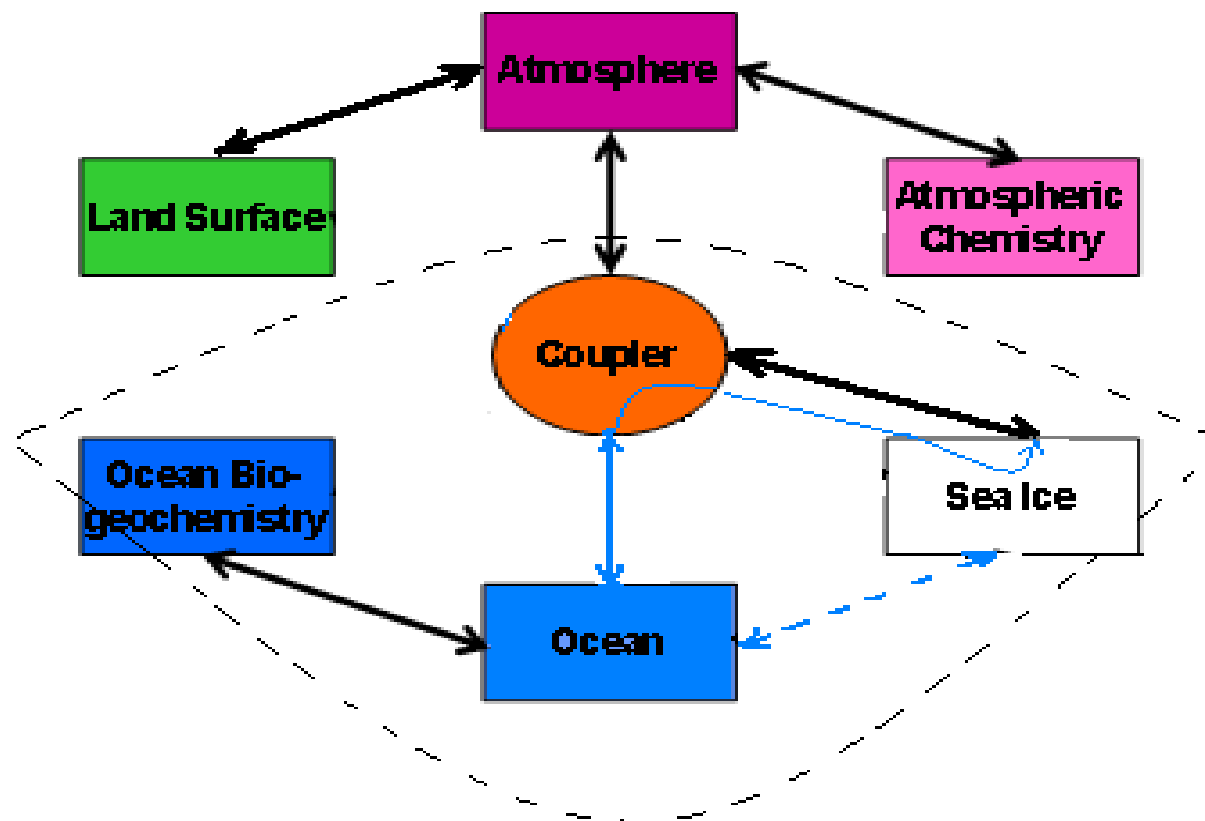
AusCOM model components

- **MATM :** an atmospheric data model
    Providing the ocean-sea ice system with atmospheric forcing (NCEP2, ECMWF ERA40, and WGOMD-CORE/CORE2 etc.).
    Grid: depending on the forcing data (e.g., T62 Gaussian grid for NCEP)

- **MOM4:** the GFDL ocean model most recent version 4p1
    Grid: global tripolar . Resolution: 360 x 300 x 46
    Longitudinal: uniform $1°$;
    Latitudinal: Equatorial meridional refinement: 1/3 degree from 10S to 10N;
    Mercator grid in Southern Ocean: 1 degree at 30S to 0.25 degree at 78S
    vertical: 46 levels covering 0-5050 m with a resolution ranging from 5 m at the surface to 250 m for the abyssal ocean.

- **CICE:** the LANL sea ice model v4.0, adapted with the same horizontal grid as the ocean model (for practical and scientific reasons).

- **OASIS3.2-5:** the numerical coupler, in charge of all data flows (coupling) between sub-models, and controls model synchronization.

The AusCOM MOM4p1 and CICE4 horizontal tripolar grid with its latitudinal grid spacing
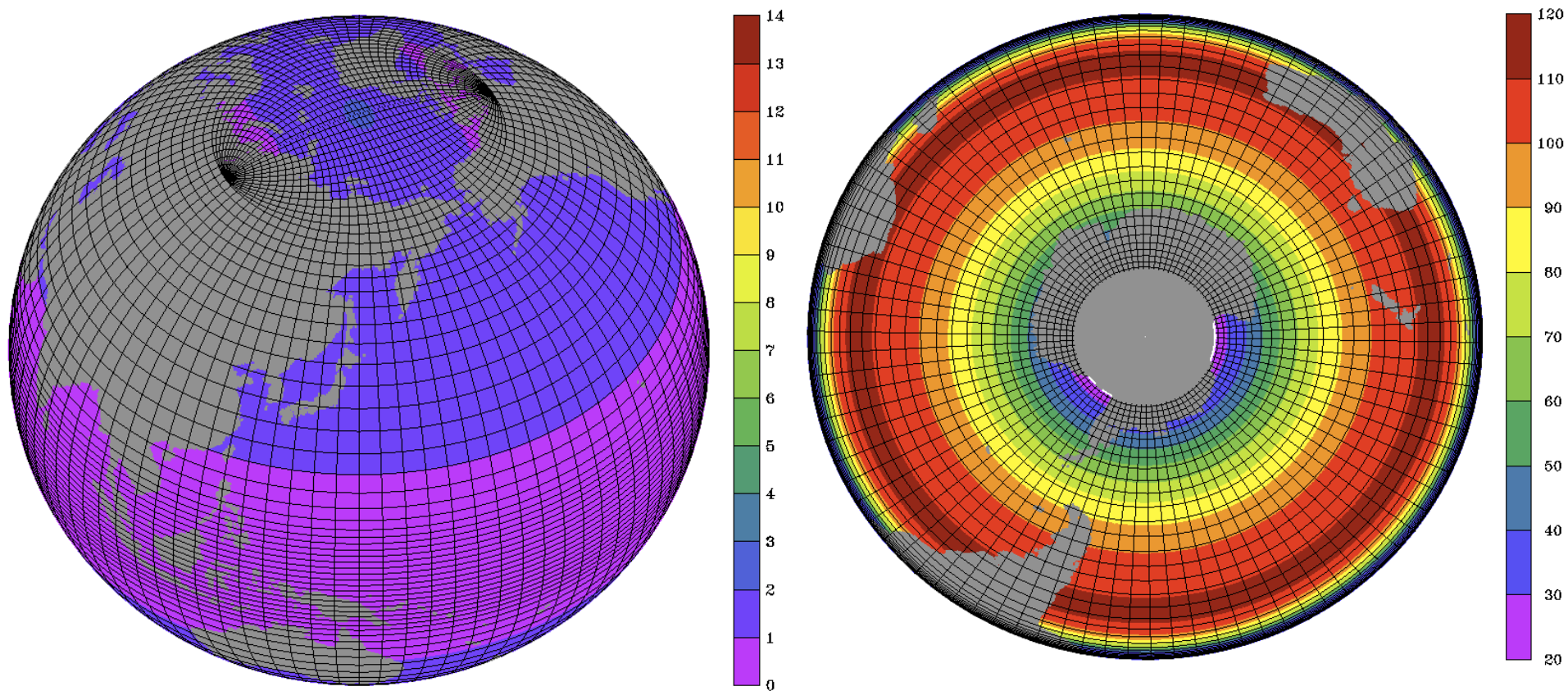
Coupling Fields I: Atm➡Ice

(1) 2m air temperature
(2) 2m air specific humidity
(3) 10m zonal wind speed
(4) 10m meridional wind speed
(5) short wave radiation down
(6) long wave radiation down
(7) rainfall
(8) snowfall
(9) surface air pressure
(10) river runoff

Coupling Fields II: Ice ➔ Ocean

(1)   Wind/ice-ocean stress (i direction)
(2)   Wind/ice-ocean stress (j direction)
(3)   Fresh water flux (prec + ice form/melt associated waterflux)
(4)   Salt flux
(5)   Ice melt heat flux
(6)   Short wave radiation (penetrating)
(7)   Long wave radiation
(8)   Latent heat flux
(9)   Sensible heat flux
(10)   Air (+ sea ice) pressure
(11)   Runoff (from ATM, unaltered)

Some of them are the ice model products and some are diagnosed in ice model based on the air-sea interfacial condition using standard formula (see CICE user guide for details)

All fluxes are weighted using ice fraction where appropriate.

Coupling Fields III: Ocean➜Ice

(1) SST
(2) SSS
(3) SSU
(4) SSV
(5) SSLx: sea surface gradient (i)
(6) SSLy: sea surface gradient (j)
(7) PFMICE: potential ice form/melt heat flux

*pfmice is diagnosed using a scheme adapted from the NCAR CCSM ocean model component (LANL POP).

Coupling Fields IV: Ice➜Atm

(1) SST/IST

*This ice➜atm data passing is actually NOT necessary in AusCOM since the atmospheric component is not an active model. We do it to mimic a fully coupled model data exchange process.

Code structure for coupling: ATM

```
(initialisation)
time_sec = 0

DO icpl = 1, num_cpl            !coupling loop

   call from_ice(time_sec)

   do itap = 1, num_atm            !time loop within each cpl int
       (model calculation)
       time_sec = time_sec + dt
   end do

   call into_ice(time_sec – dt)    !using "lag=+dt"

END DO

(finalisation)
```

Code structure for coupling: ICE

(initialisation)

call get_restart_o2i('o2i.nc')   !o2i and i2o fields are saved at the end of last run
call get_restart_i2o('i2o.nc')   !or pre-processed (for initial run)

 time_sec = 0

DO icpl_ai = 1, num_cpl_ai   !begin A <==> I coupling iterations

   call from_atm(time_sec)

   Do icpl_io = 1, num_cpl_io   !begin I <==> O coupling iterations

      call into_ocn(stimestamp_io)   !No lag for I⇔O coupling

      do itap = 1, num_ice_io   ! cice time loop within each I2O coupling interval
         (call ice_step)
          time_sec = time_sec + dt
      enddo

      call from_ocn(time_sec)

   End Do

   call into_atm(time_sec – dt) !using 'lag=+dt'

END DO

(save i2o fields for use at the beginning of next run)

(finalisation)

Code Structure for Coupling: OCN

(initialisation)
time_sec = 0

DO icpl = 1, num_cpl !coupling loop

  call from_ice(time_sec)

  do itap = 1, num_ocn   !time loop within each cpl int
    (model calculation)
    time_sec = time_sec + dt
  end do

  call into_ice(time_sec)   !No lag for I⇔O coupling

END DO

(save o2i fields for use in ice model at the beginning of next run)

(finalisation)

Test Experiments—Model Validation

A number of runs have been conducted on the NEC SX6 machine and the NCI Altix Clusters (AC) using different atmospheric forcing datasets (NCEP2, ERA40, WGOMD-CORE, and CORE2, most of the forcing fields are of 4 times daily) to test the performance of AusCOM.

We examine model performance in terms of key global parameters important to climate studies. These include the meridional overturning streamfunction, global mass transport through key straits, watermass properties , and the seasonality of sea ice thickness and areal concentration. A realistic simulation under climatological and interannually varying atmospheric forcing is a key indicator of expected performance of AusCOM and the fully coupled ACCESS model.

A "spin-up" run (core-00) will be examined for the purpose of model validation (I);

Two inter-annual forcing runs (core-01, core2-02) are also examined for model validation (II).

Setup of core-00 (on AC):
• CORE normal year forcing; No SST relaxation;
• IC: Levitus winter T and S climatology;
• dt_ocean = dt_ice = 1 hour, dt_coupling = 6 hours;
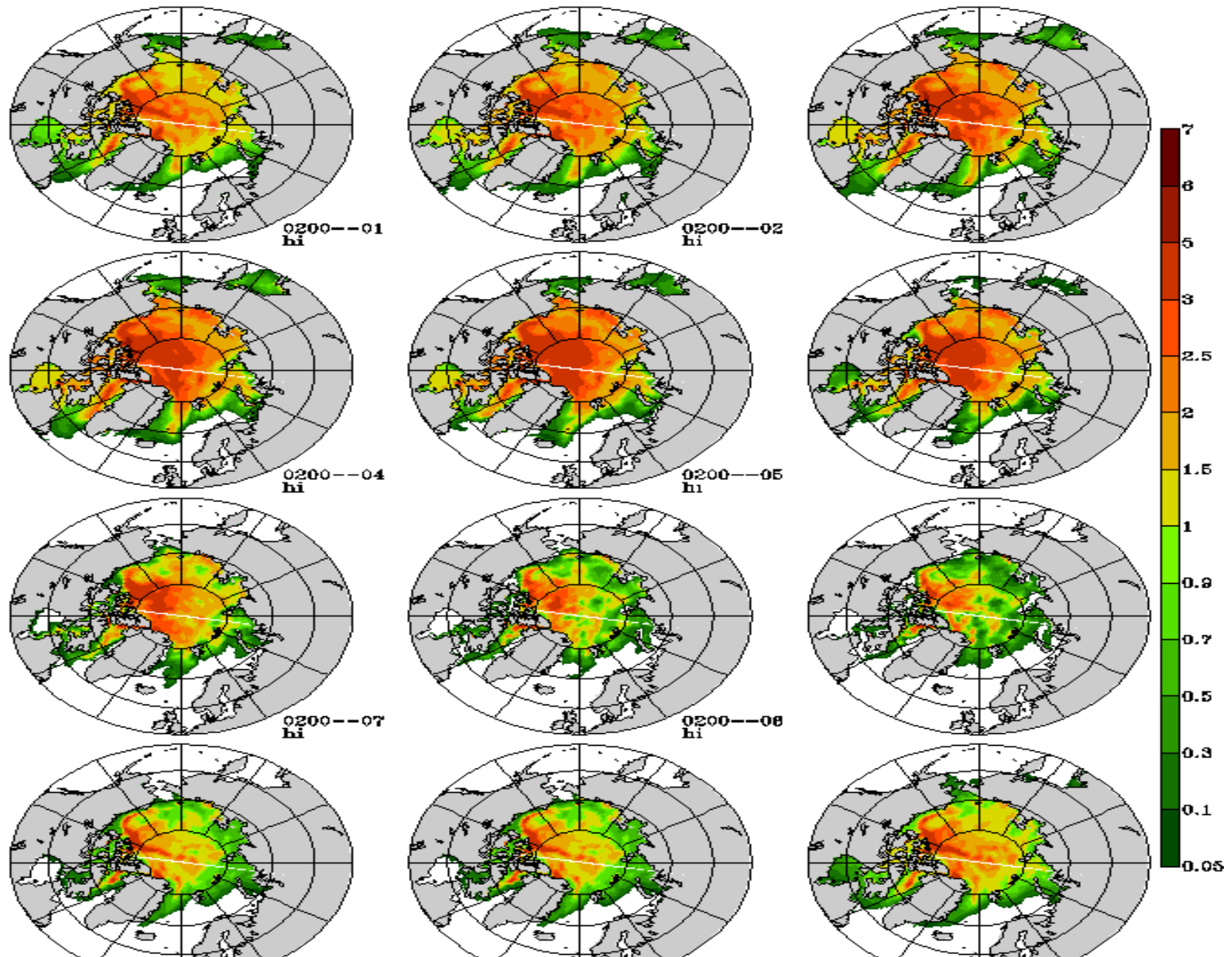• Yearly run, 200 years

Setup for core-01 and core2-02(on SX6):
• Same as core-00 but with inter-annual CORE forcing covering period 1979~2004.
• Core-01 has weak SST relaxation;
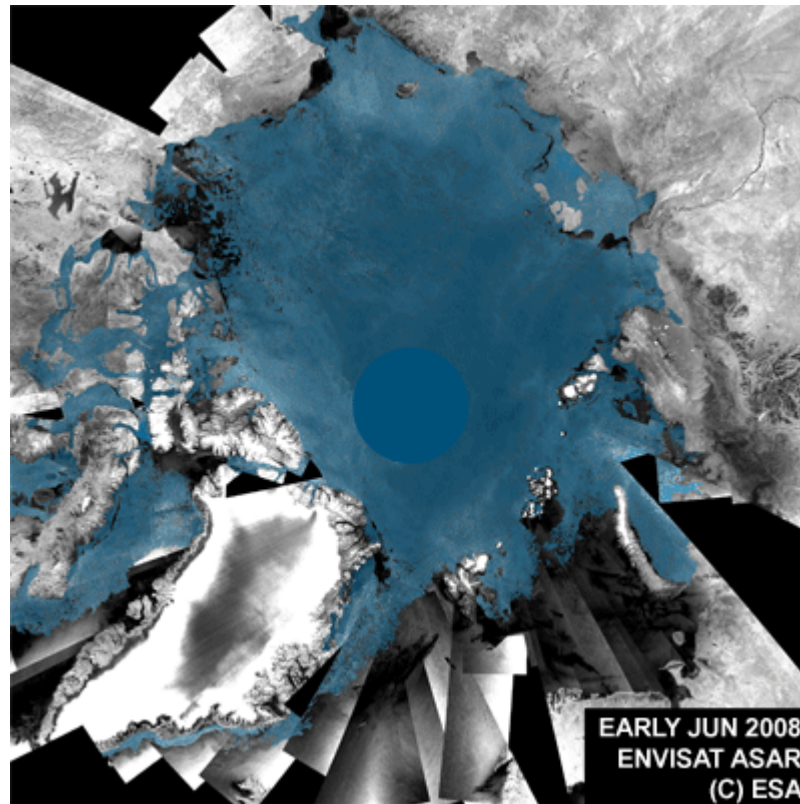• Core2-02 has no SST relaxation.
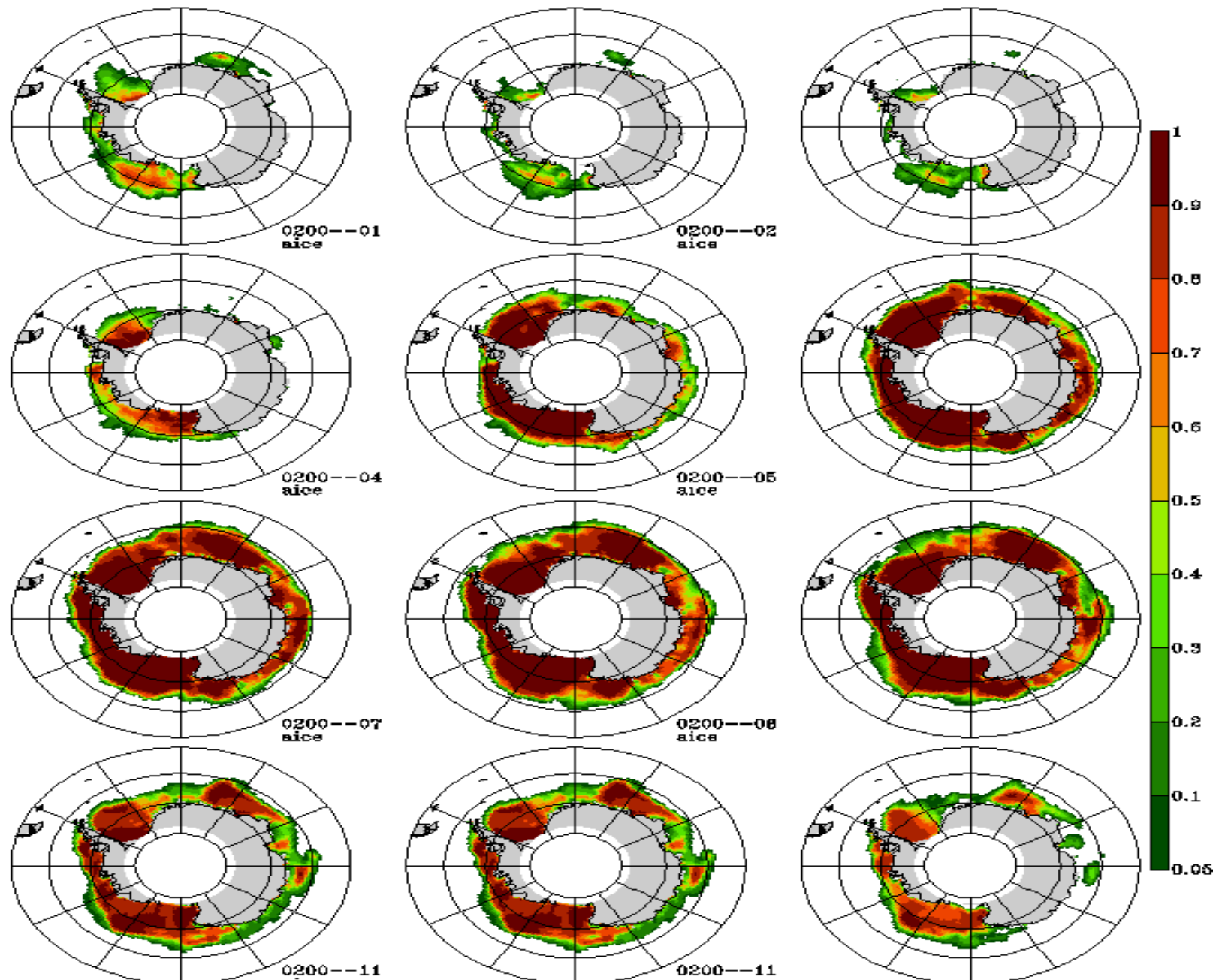
Model validation (I): NH sea ice (year 200)
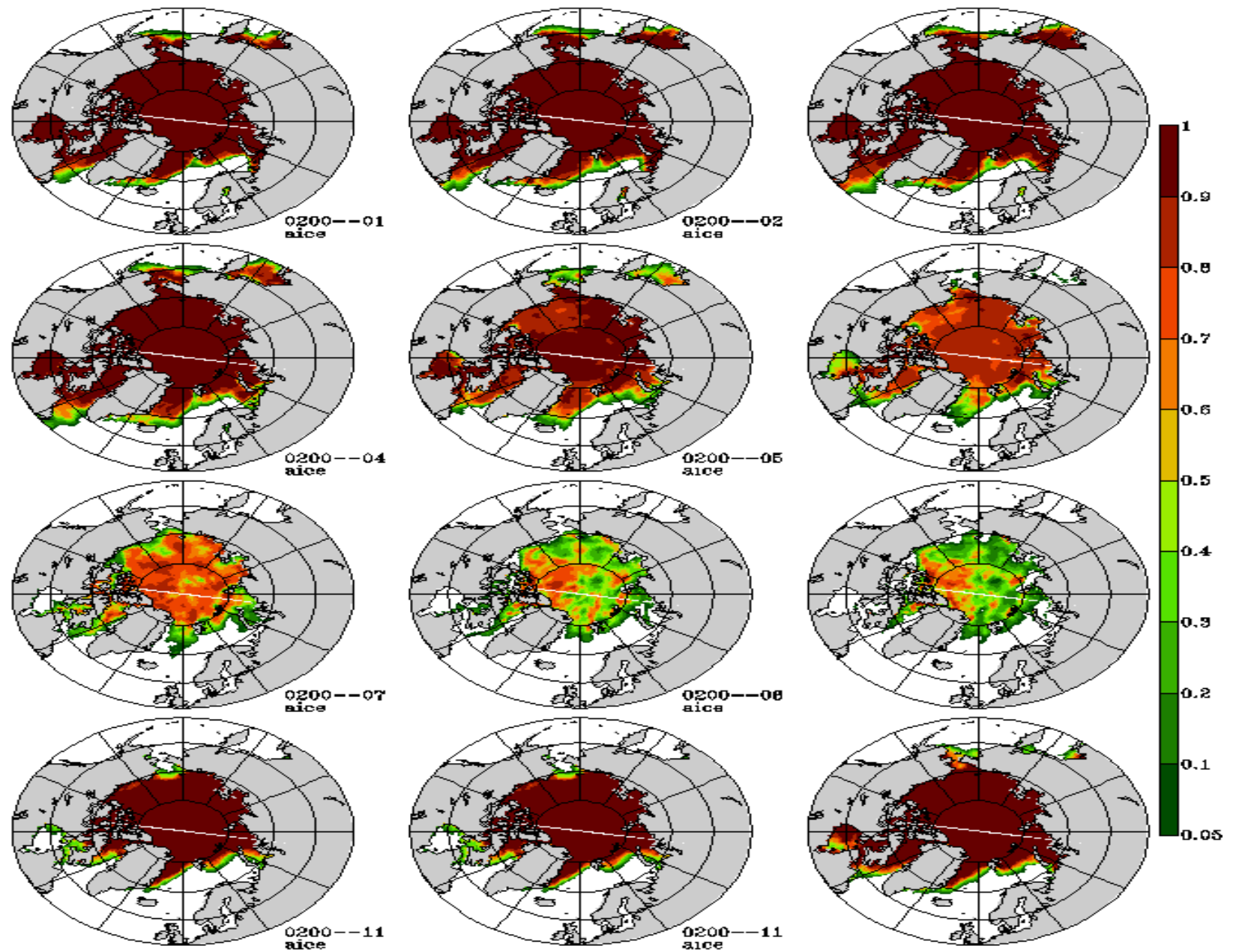
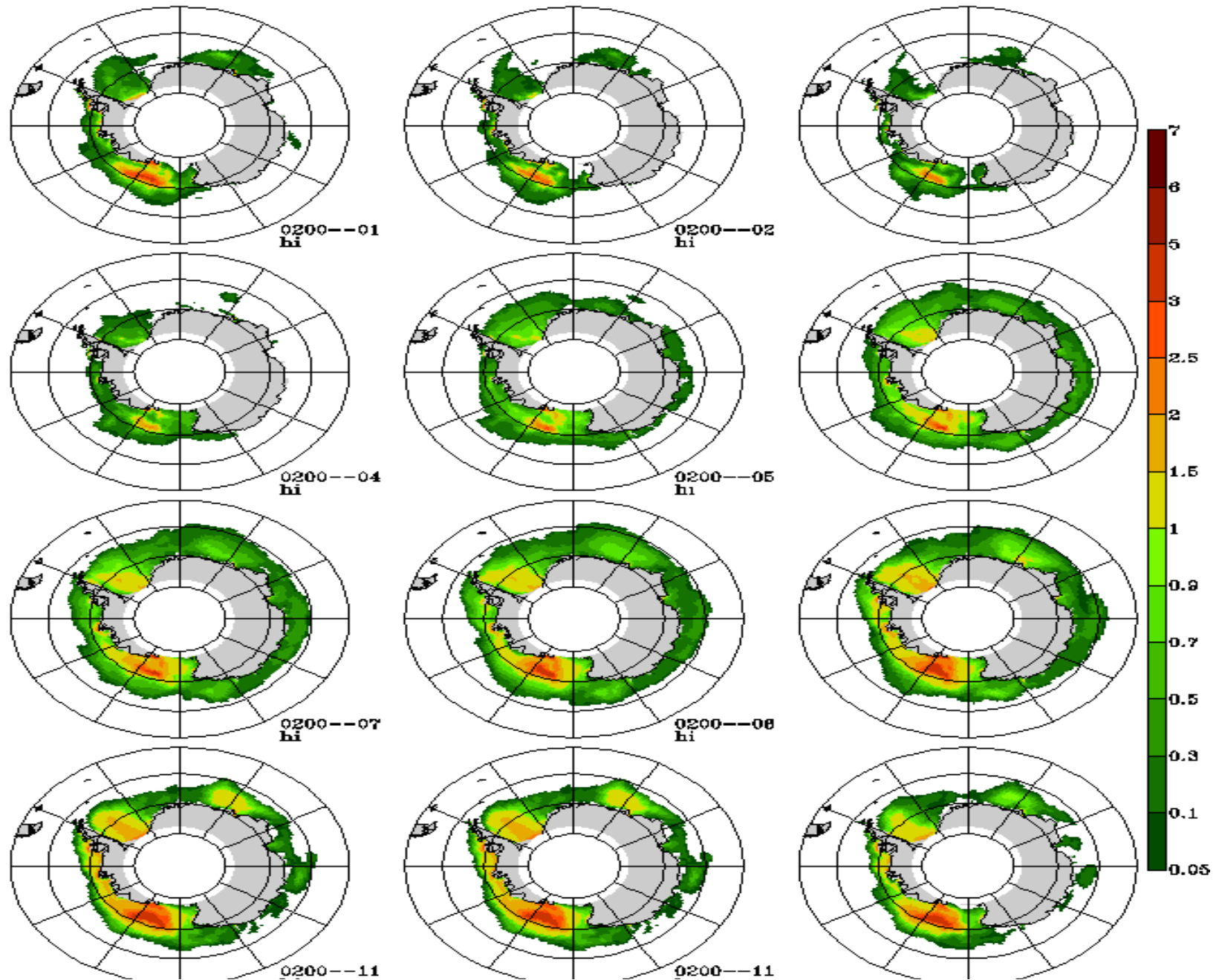# Model validation (I): NH sea ice (year 200)

NH sea ice cover -- Observation
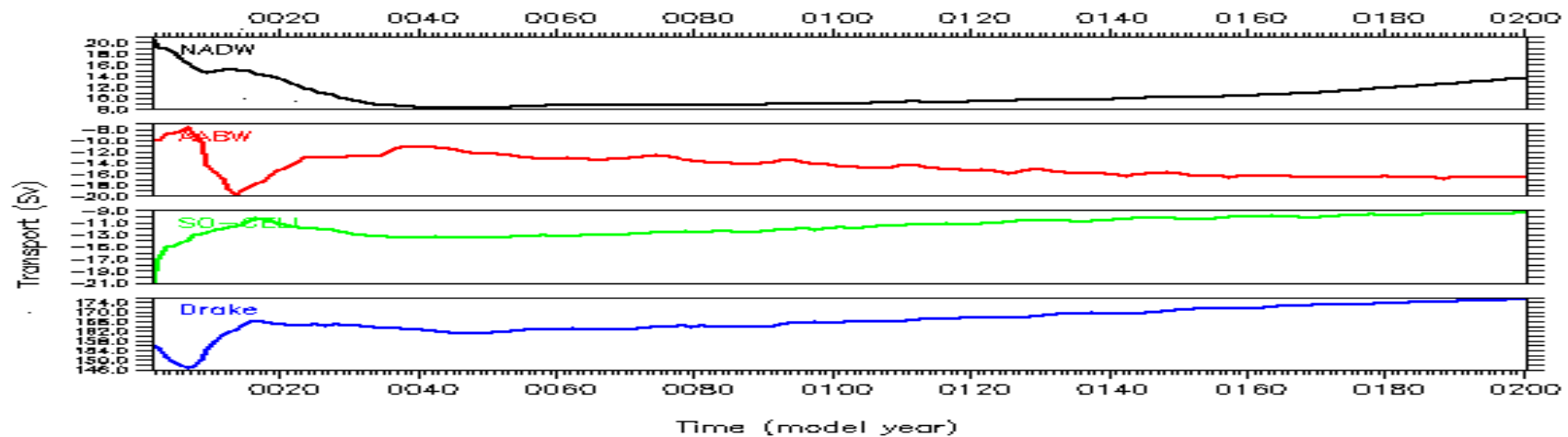

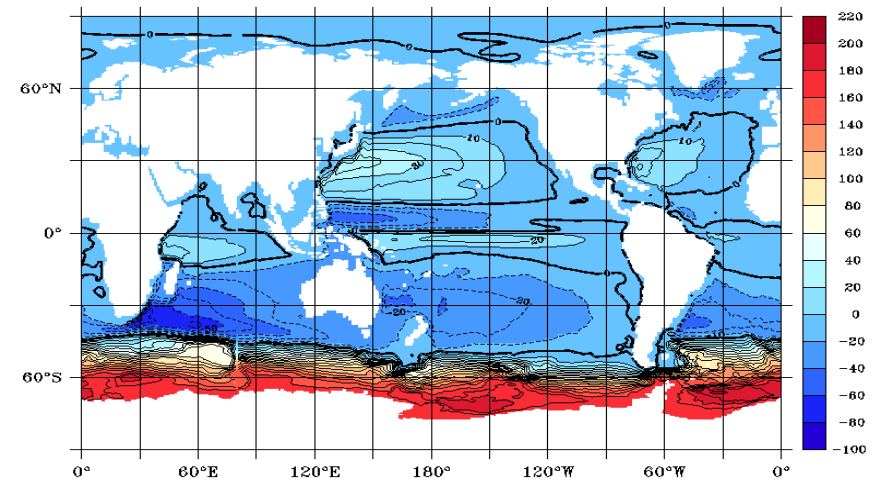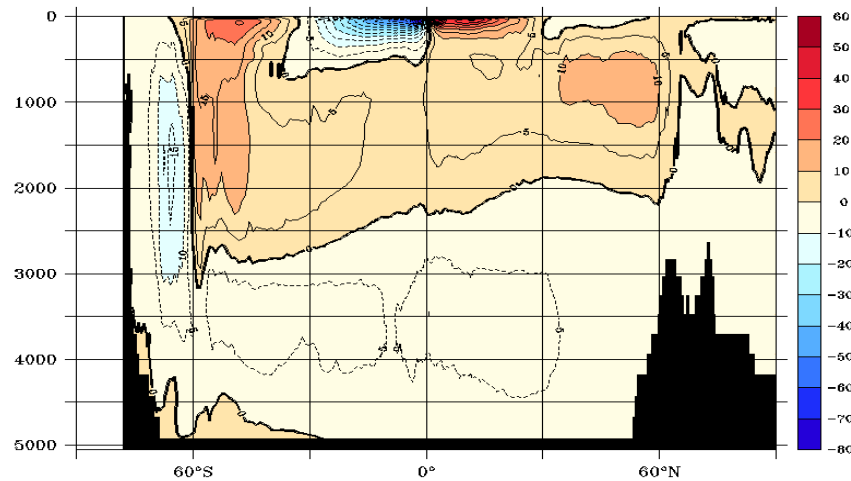EARLY JUN 2008
ENVISAT ASAR
(C) ESA

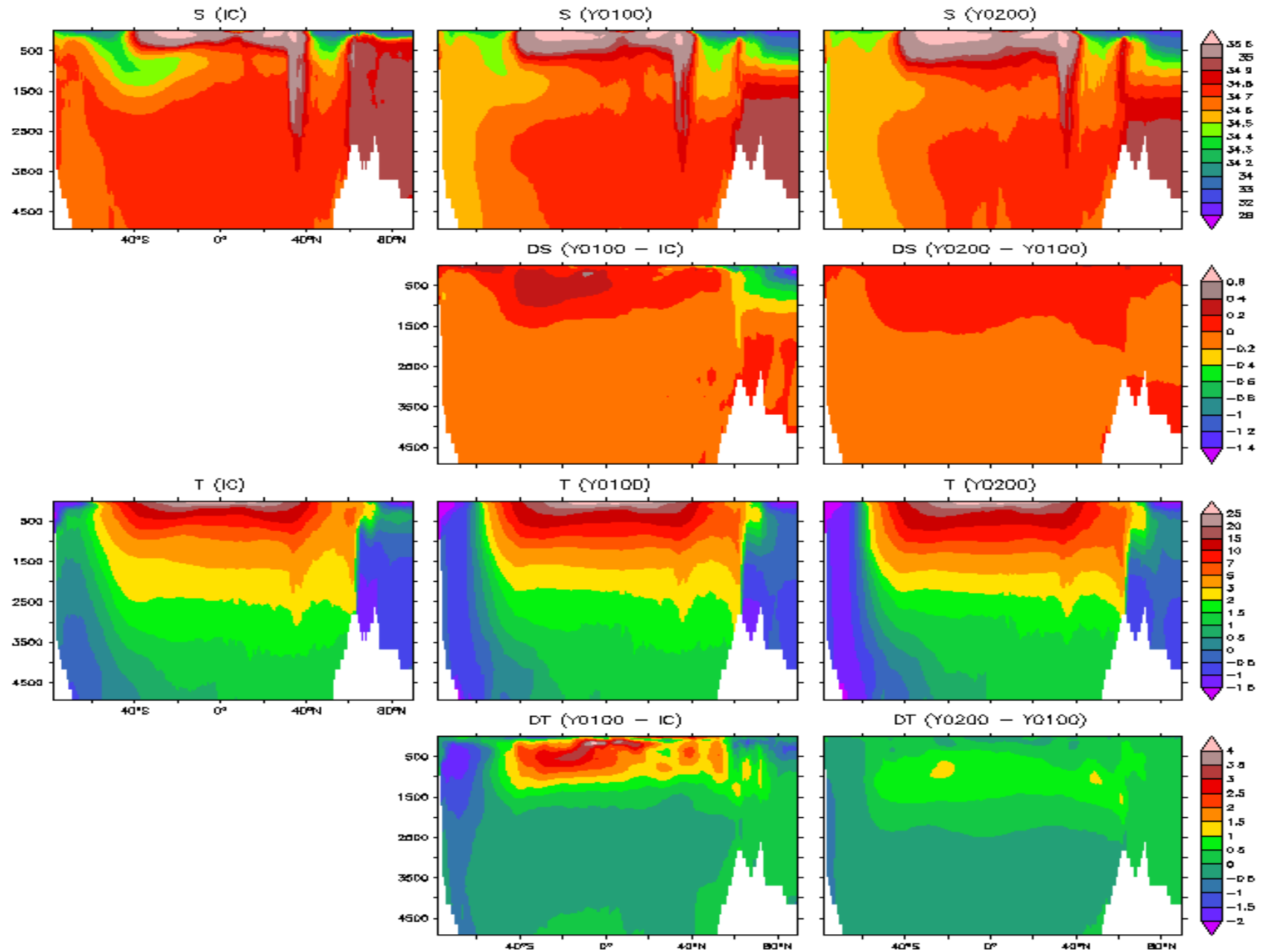# Model validation (I): SH sea ice (year 200)

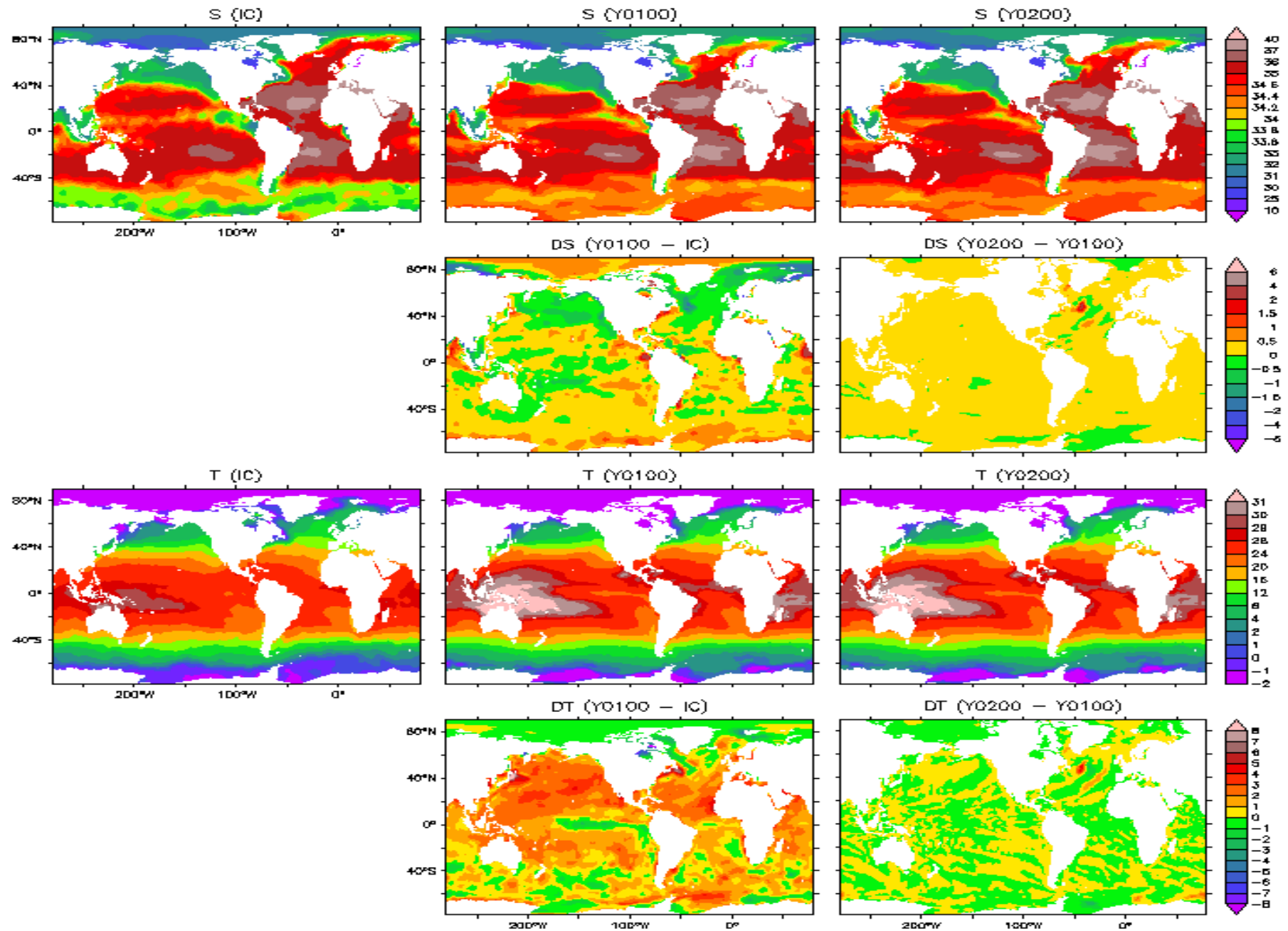# Model validation (I): SH sea ice (year 200)

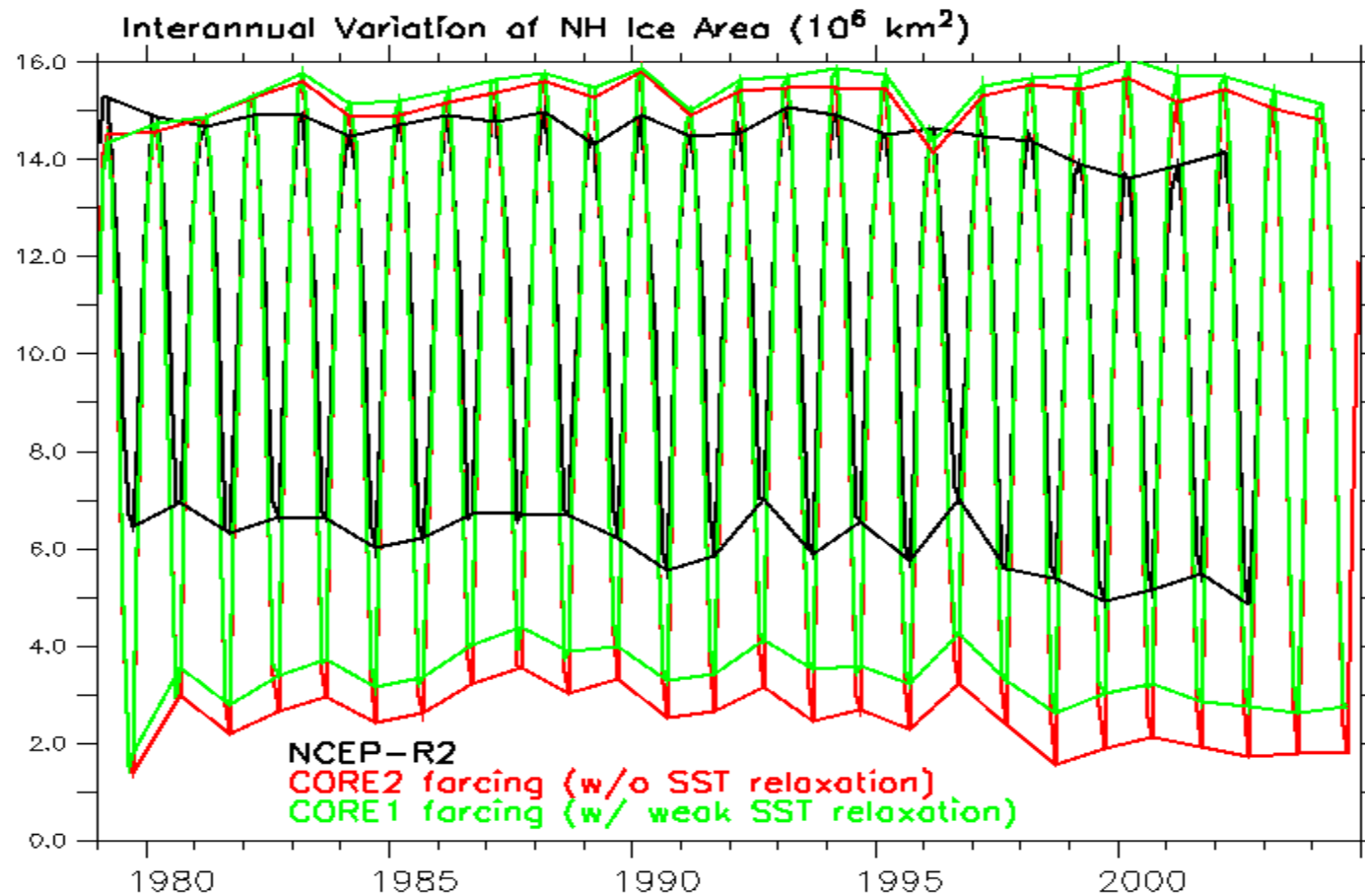# Model validation (I): Global Ocean Water mass transports

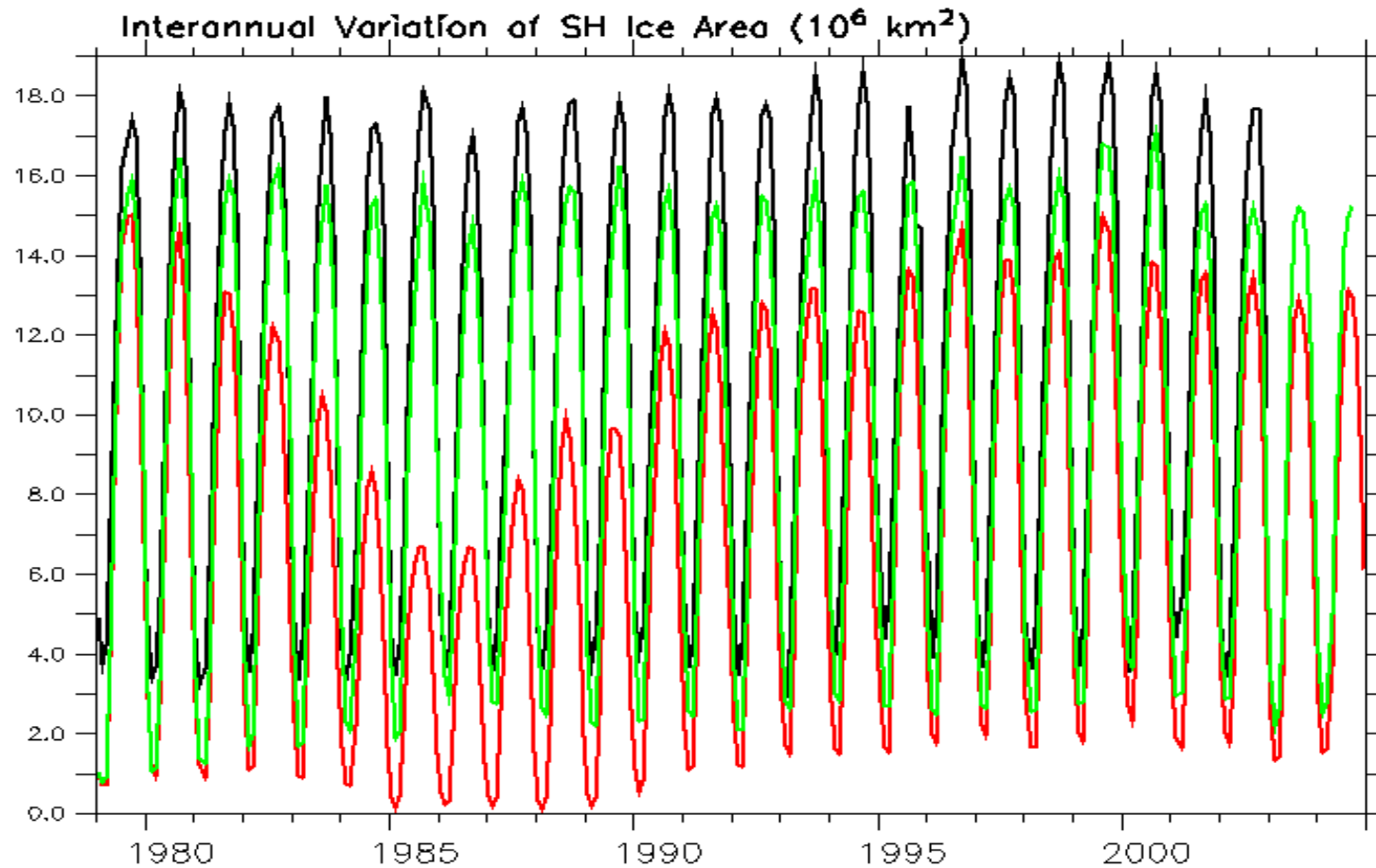# Model validation (I): Global Ocean T and S: Zonal Mean

Model validation (I): Surface Temperature and Salinity

Model validation (II): Interannual variation of the NH Sea Ice Area

Interannual Variation of NH Ice Area (10^6 km^2)

NCEP-R2
CORE2 forcing (w/o SST relaxation)
CORE1 forcing (w/ weak SST relaxation)

Model validation (II): Interannual variation of the SH Sea Ice Area

Interannual Variation of SH Ice Area (10^6 km^2)

Model validation (II): Interannual variation
of the Tropical Pacific Ocean SST and Heat Content
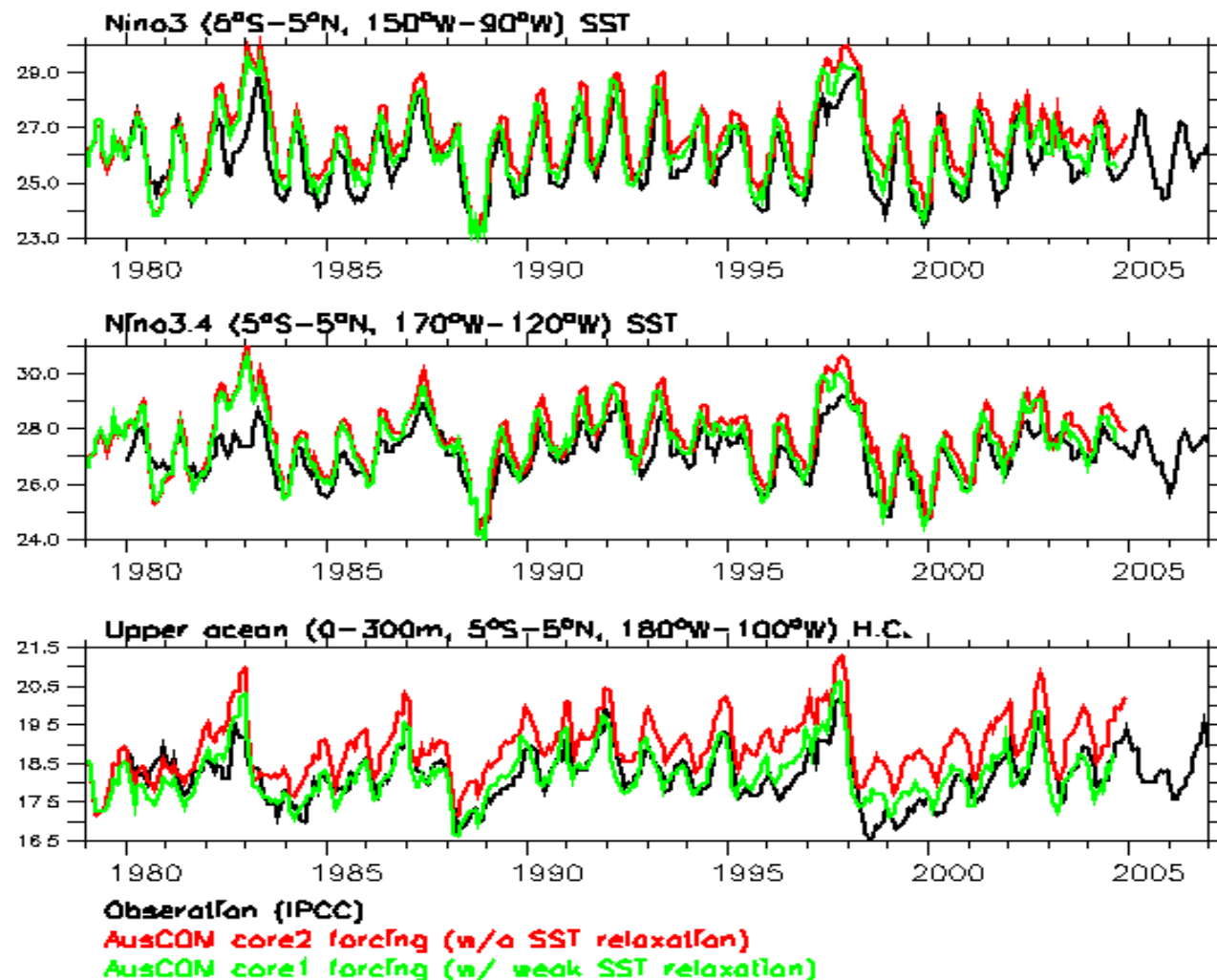
Model validation (II): Interannual variation of the Tropical Pacific Ocean SST and Heat Content Anomalies

Nino3 (6°S–5°N, 150°W–90°W) SSTA

Nino3.4 (5°S–5°N, 170°W–120°W) SSTA

Upper ocean (0–300m, 5°S–5°N, 180°W–100°W) H.C.A.

Observation (IPCC)
AusCOM core2 forcing (w/o SST relaxation)
AusCOM core1 forcing (w/ weak SST relaxation)