30-day hindcast experiments with the uncoupled CICE ice model

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AMS 2017 Seattle, WA

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- Goal: **test** stand-alone CICE V5 from Los Alamos National Laboratory for **NOAA's** Next Generation Global Prediction System

- Experiments: month-long global runs for each month in 2015

- Comparison with CFSR, NCEP analysis & RASM-ESRL

- Atmospheric forcings:

    1° & 0.2° 6 hourly CFSR (sw/lw radiation, t2m, q2m, prcp, surface wind)
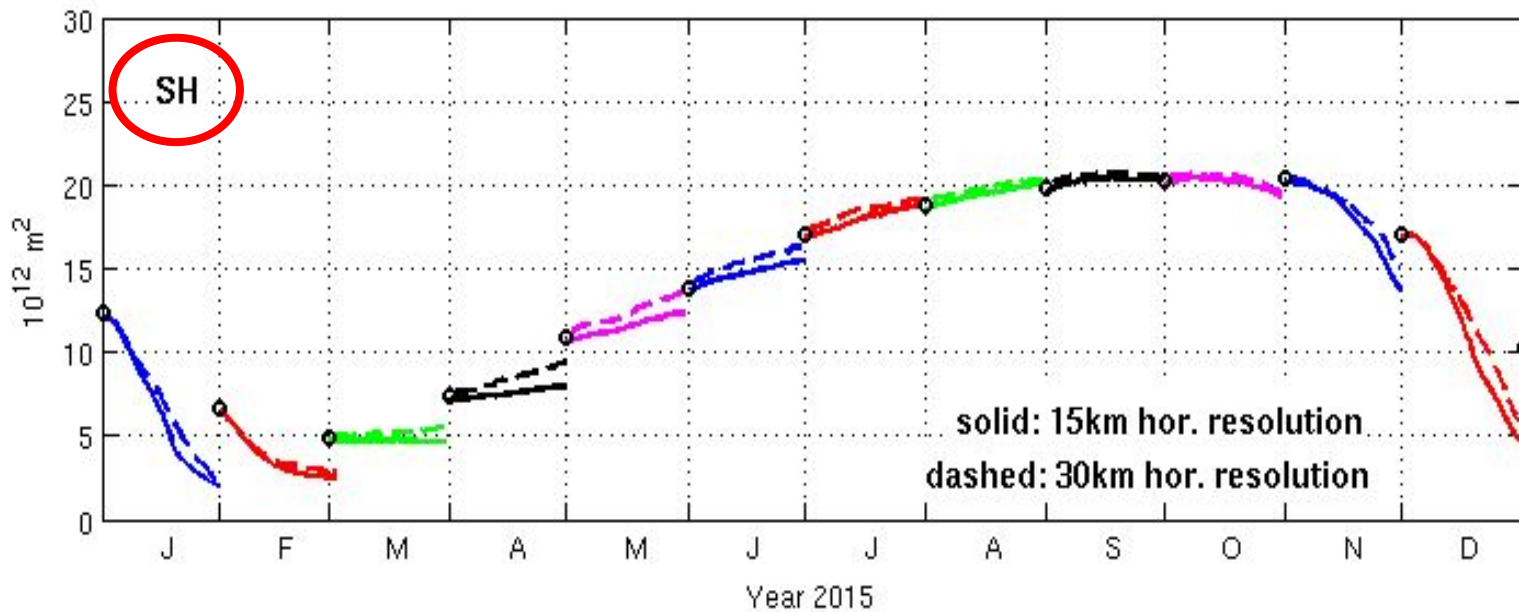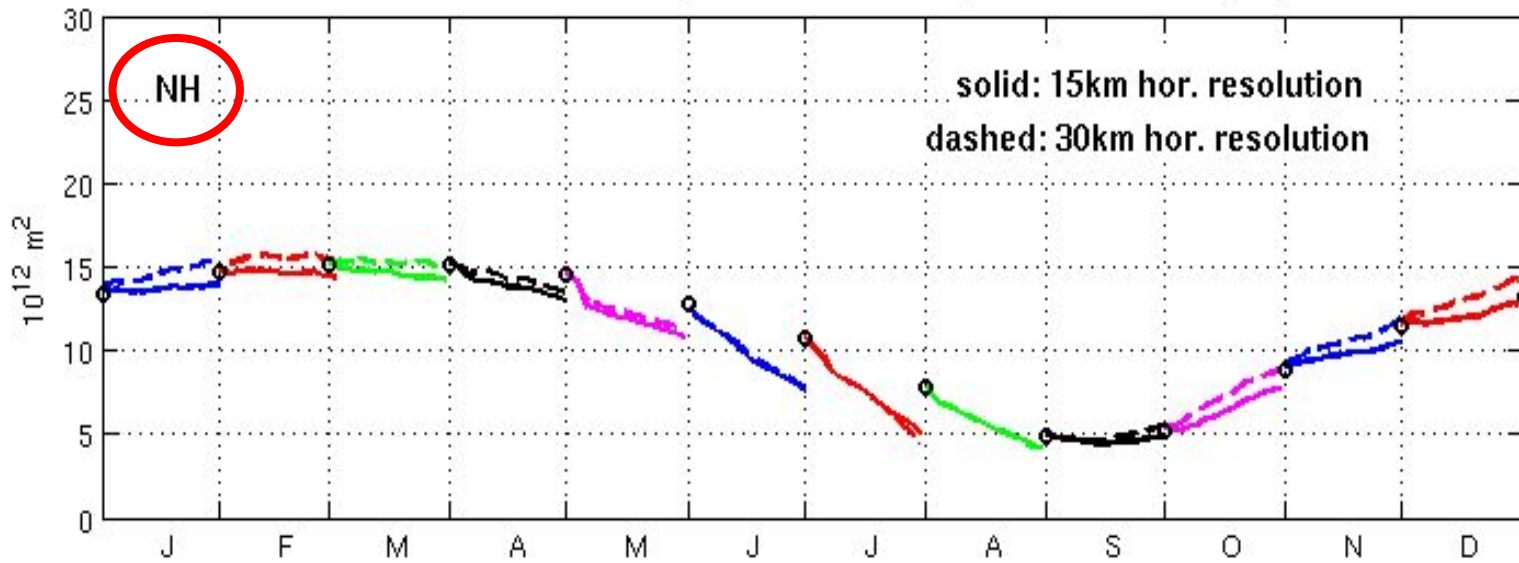
- Oceanic forcings:

    1° & 0.5° 6 hourly CFSR (sst, sss, mixed layer depth, surface current)

- Initial conditions: CFSR

- Horizontal resolution: 30km & 15km at North Pole, tripolar map projection (polar singularities shifted to land)

Ice extent from CICE5 1-month simulations with 15km and 30km horizontal resolution, where 'o' represents initial values obtained from CFS reanalysis.

Comparing to CFSR, ice melts too fast in melting seasons, but CICE does a good job in freezing seasons in both hemispheres.

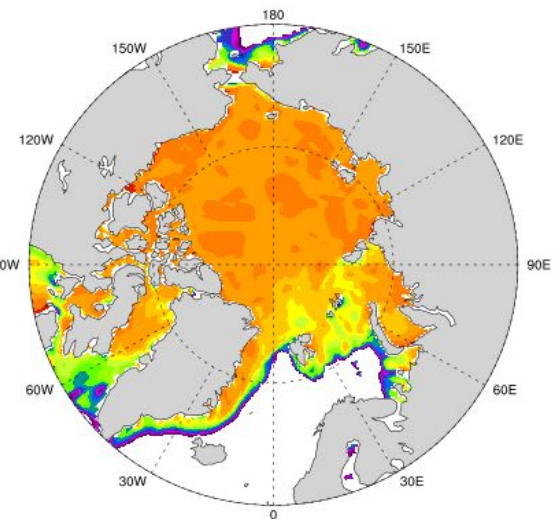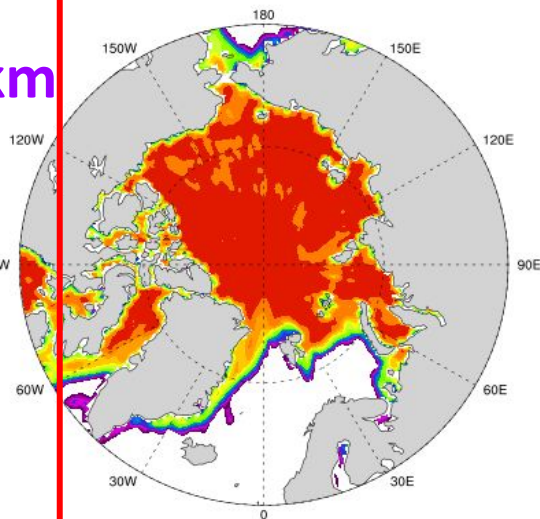**CFSR** · **Ice Area** · **CICE (31days)** · **Ice Edge (15%) Error: pos neg**
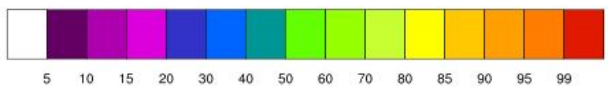
IC: Jan01
Valid: Feb01

30km

15km

CFSR Feb01 (30km res)

Ice Area (%, 30km res) Valid Feb01 (IC=Jan01)
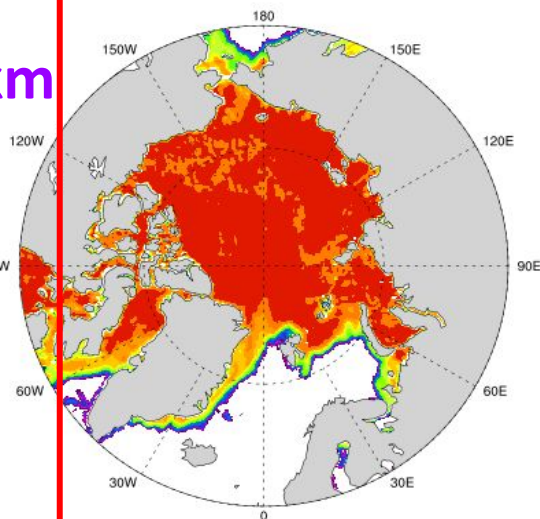
Ice Edge Error (30km res) Feb01 (IC=Jan01)

CFSR Feb01 (15km res)

Ice Area (%, 15km res) Valid Feb01 (IC=Jan01)

Ice Edge Error (15km res) Feb01 (IC=Jan01)

5 10 15 20 30 40 50 60 70 80 85 90 95 99
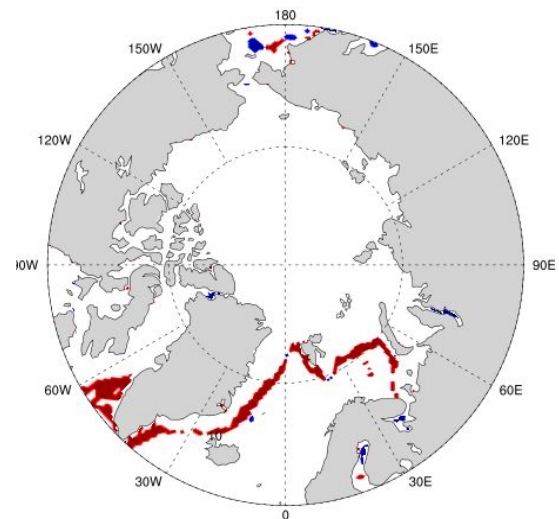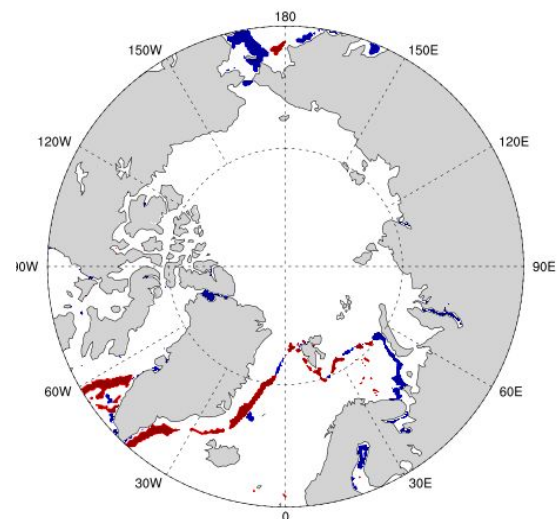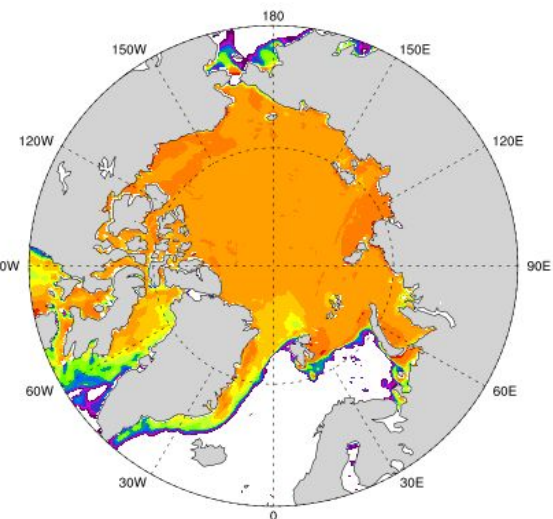
Ice area (%) from Jan 01 simulations and ice edge error on Feb 01 at 30km (upper) and 15km (lower) horizontal resolution.

Overall ice area over Arctic is lower, although the ice edge is further south.

Ice Area

CFSR **CICE (31days)** **Ice Edge (15%) Error: pos neg**

IC: Jul01
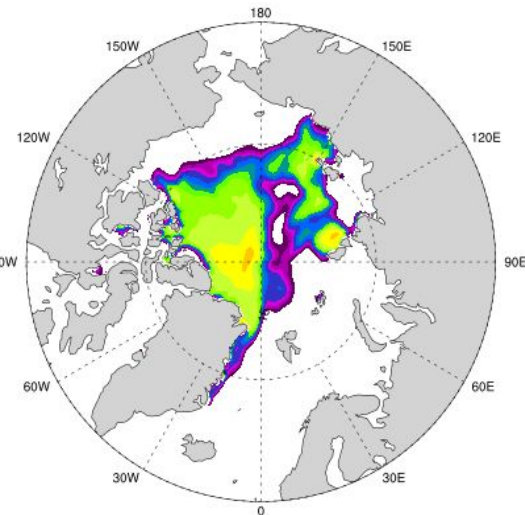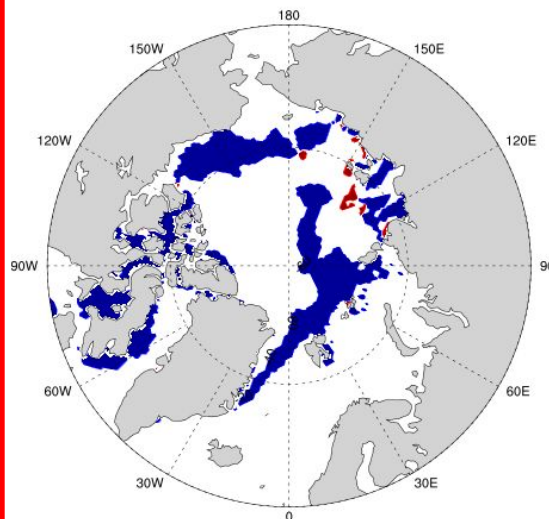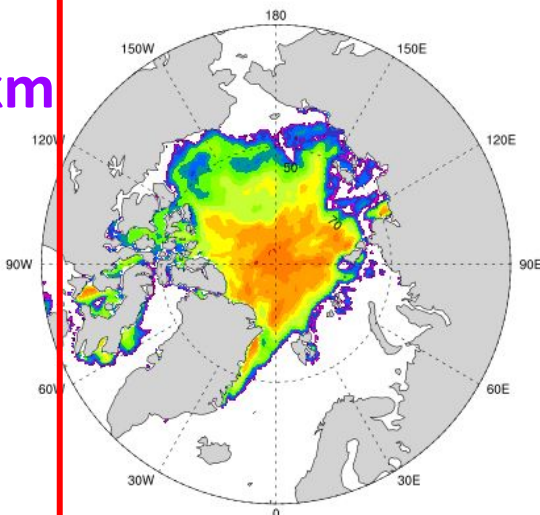**Valid: Aug01**

30km

CFSR Aug01 (30km res)

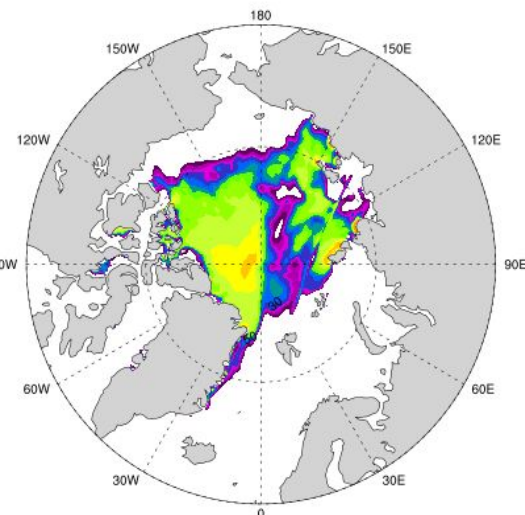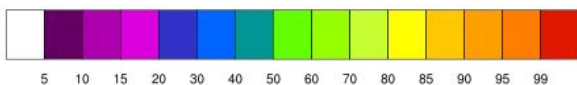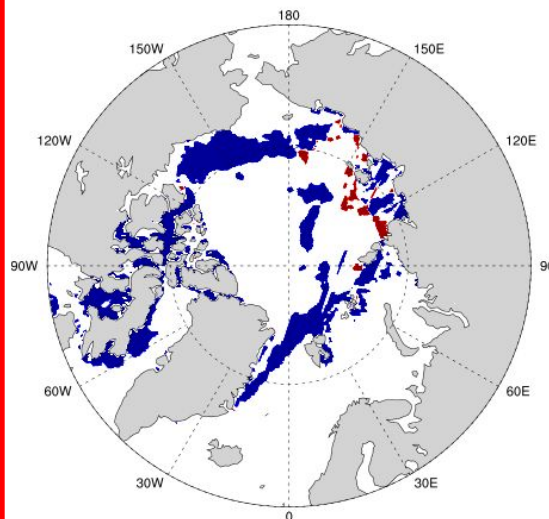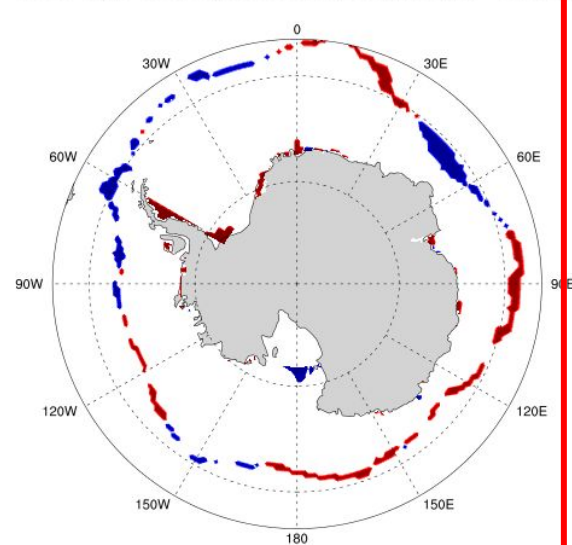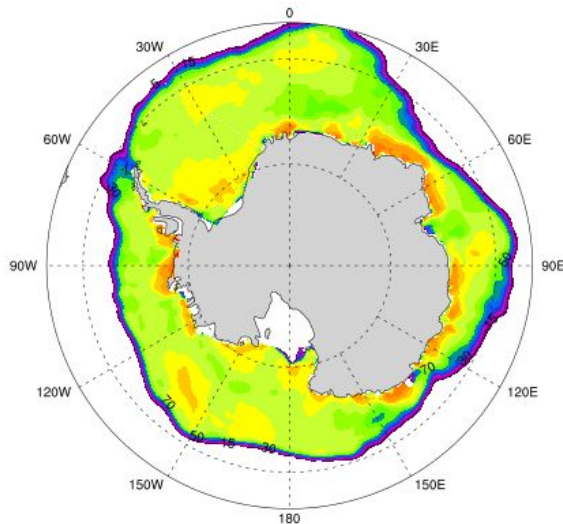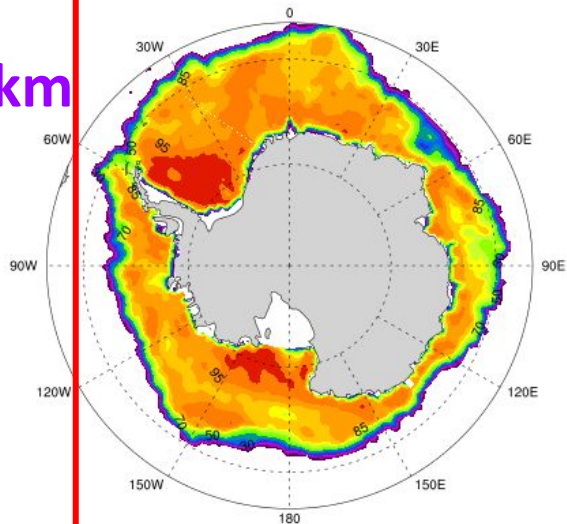Ice Area (%, 30km res) Valid Aug01 (IC=Jul01)

Ice Edge Error (30km res) Aug01 (IC=Jul01)
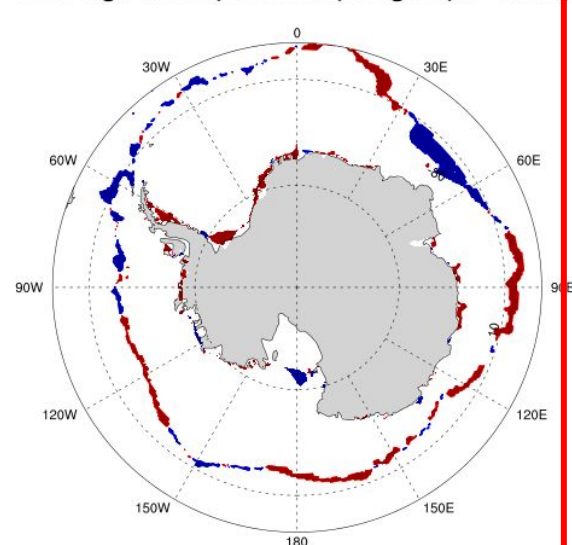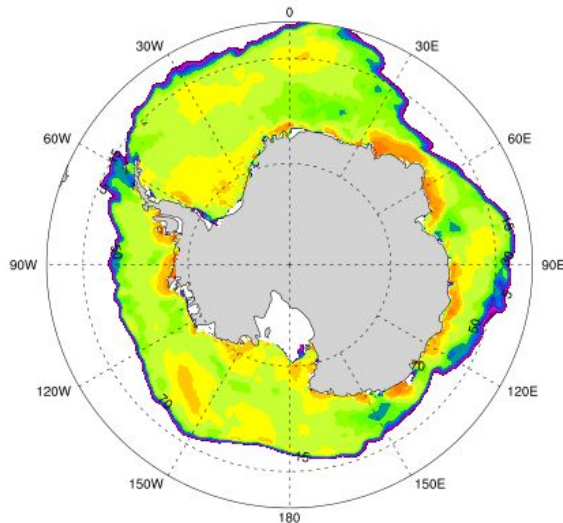
15km

CFSR Aug01 (15km res)

Ice Area (%, 15km res) Valid Aug01 (IC=Jul01)

Ice Edge Error (15km res) Aug01 (IC=Jul01)

5 10 15 20 30 40 50 60 70 80 85 90 95 99

Ice area (%) from July 01 simulations and ice edge error on Aug 01.

Overall, too much ice depletion in summer.

CFSR **Ice Area** **CICE (31days)** **Ice Edge (15%) Error: pos neg**

30km

15km

IC: Jul01
Valid: Aug01

CFSR Aug01 (30km res)

Ice Area (%, 30km res) Valid Aug01 (IC=Jul01)
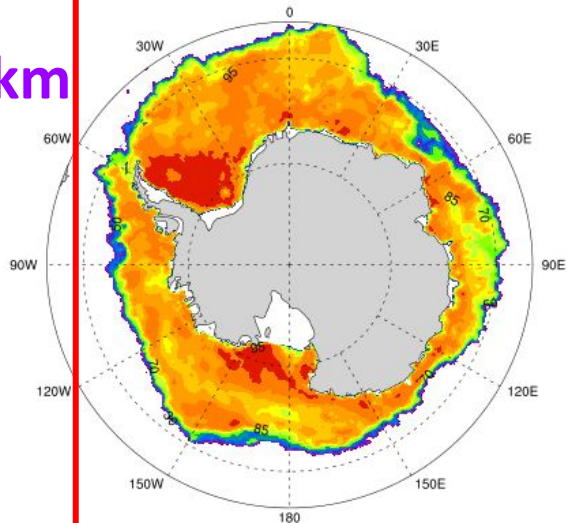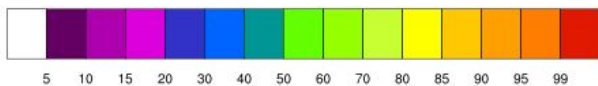
Ice Edge Error (30km res) Aug01 (IC=Jul01)

CFSR Aug01 (15km res)

Ice Area (%, 15km res) Valid Aug01 (IC=Jul01)

Ice Edge Error (15km res) Aug01 (IC=Jul01)

Ice area (%) in July 01 simulations and ice edge error on Aug 01.

The simulated ice edge is close to CFSR, but ice area is smaller.

5 10 15 20 30 40 50 60 70 80 85 90 95 99

CFSR **Ice Area** **CICE** (31days) **Ice Edge (15%) Error: pos neg**
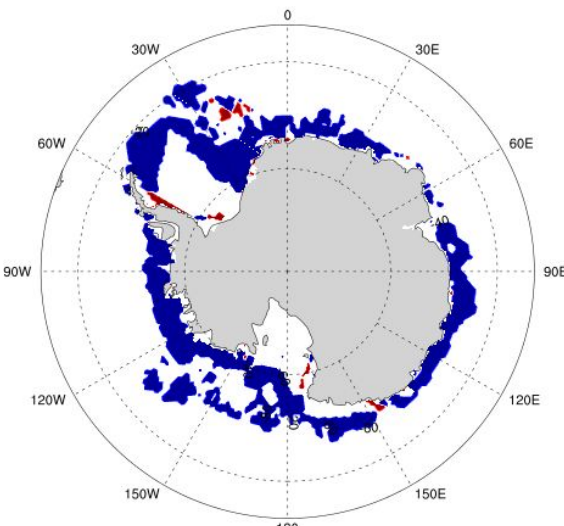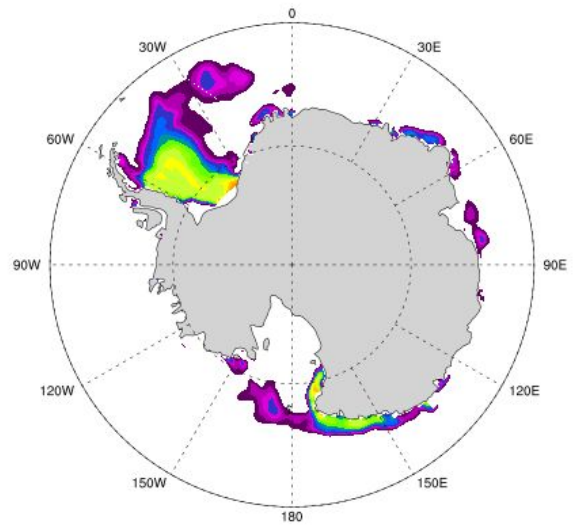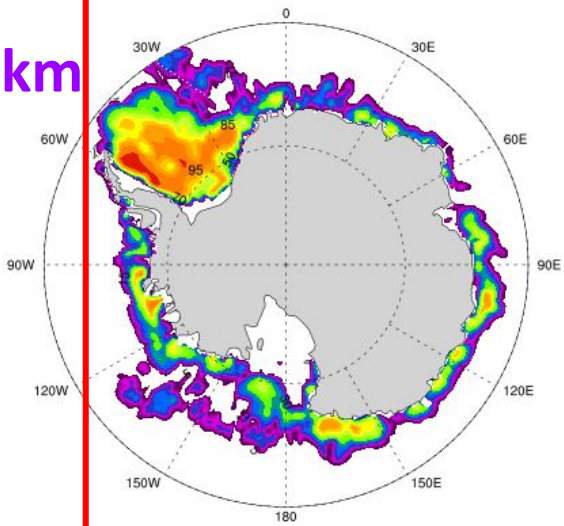
IC: Jan01
Valid: Feb01

30km

15km

CFSR Feb01 (30km res)

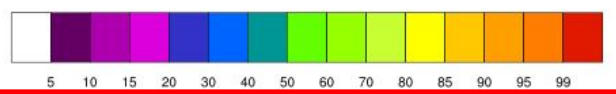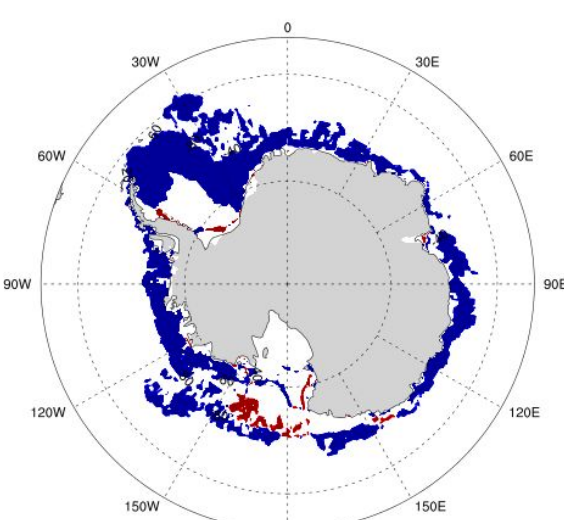Ice Area (%, 30km res) Valid Feb01 (IC=Jan01)
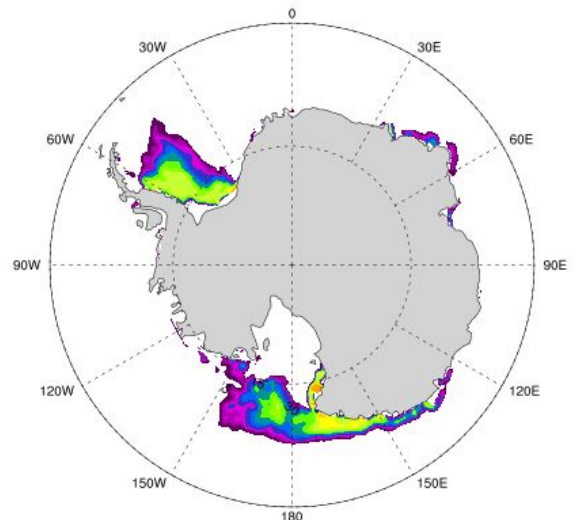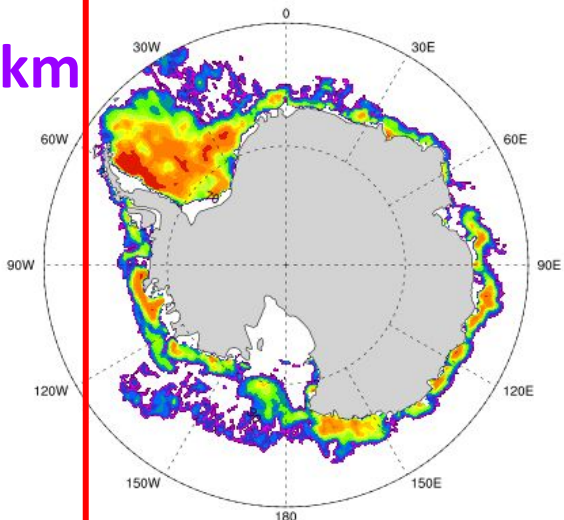
Ice Edge Error (30km res) Feb01 (IC=Jan01)

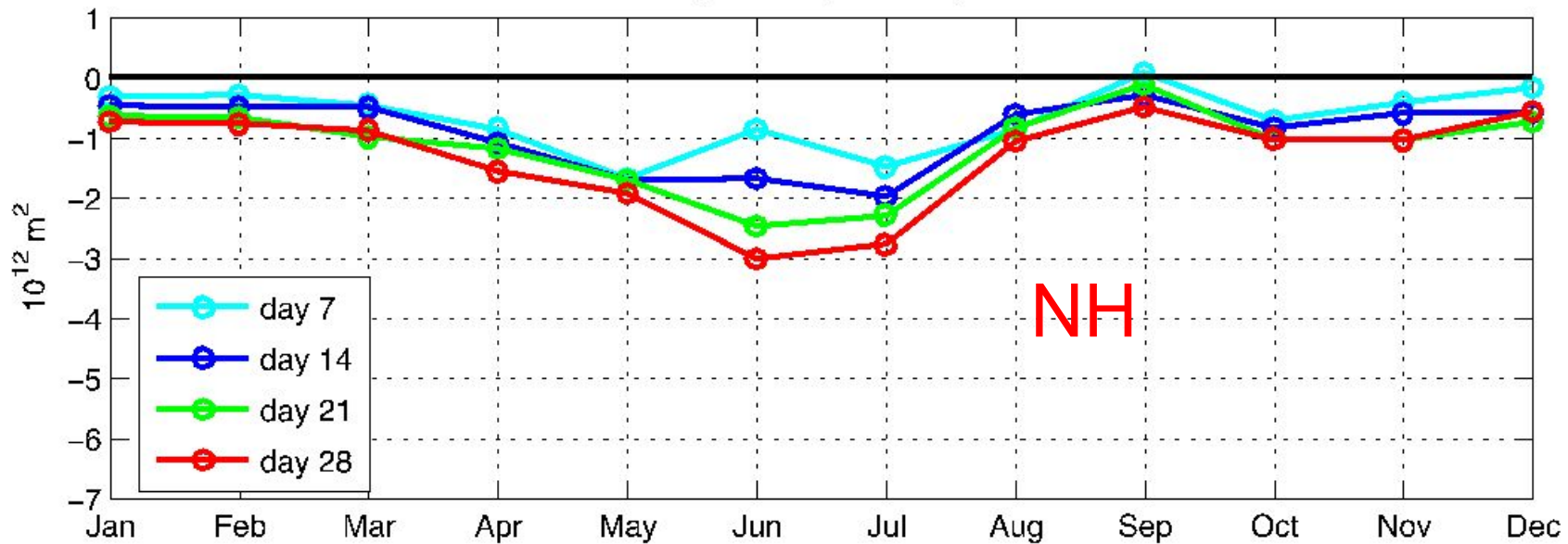CFSR Feb01 (15km res)

Ice Area (%, 15km res) Valid Feb01 (IC=Jan01)

Ice Edge Error (15km res) Feb01 (IC=Jan01)

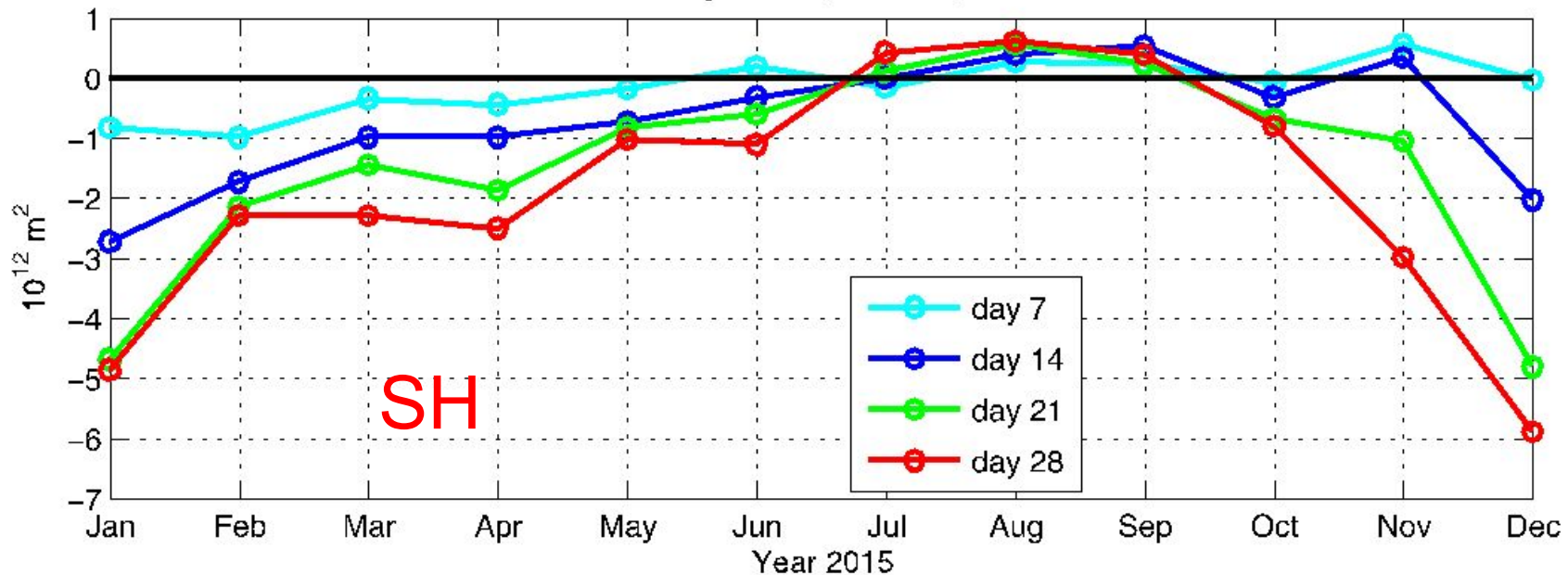5 10 15 20 30 40 50 60 70 80 85 90 95 99

Ice area (%) in Jan 01 simulations and ice edge error on Feb 01 at 30km (upper) and 15km (lower) horizontal resolution.

Overall there is too much melting (ice area is lower and ice edge is too far poleward).

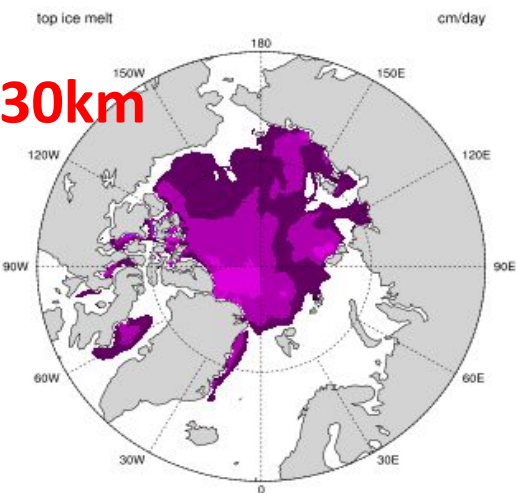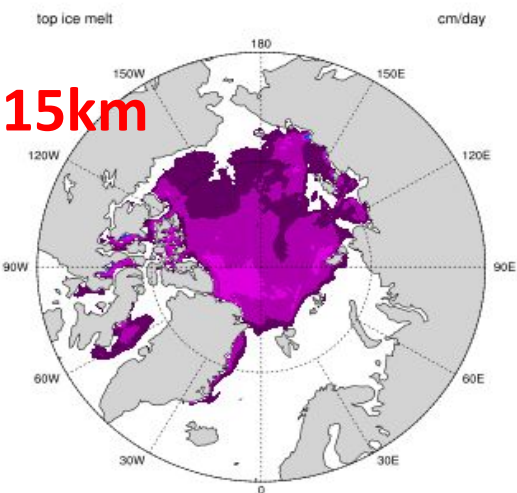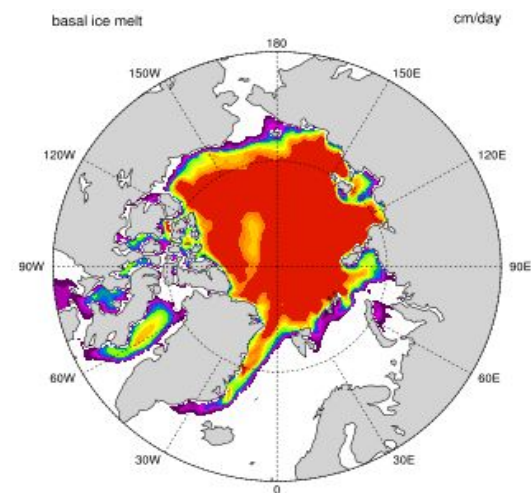Ice edge error at 1-4 week lead time. Error is largest in melting season: ice melts too fast in early summer
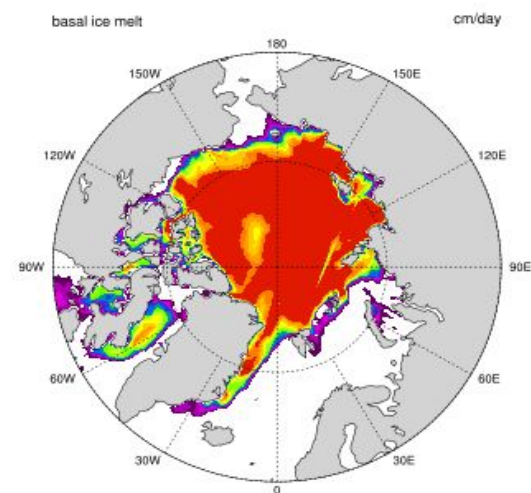
top melt

basal melt (cm/day)

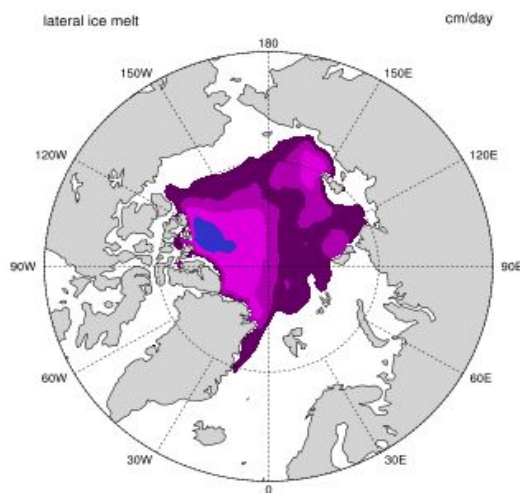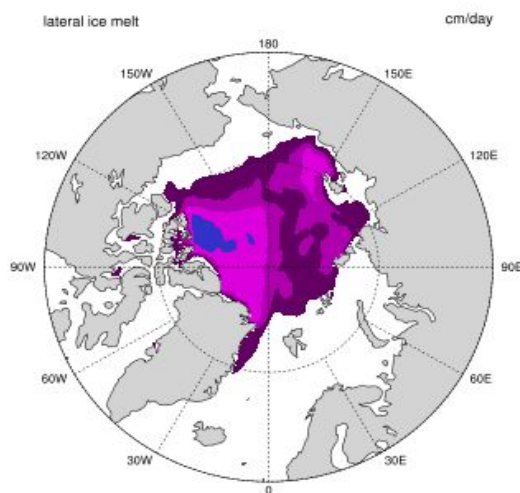# lateral melt

30km

top melt (15km res)

basal melt July (IC=Jul01)

lateral melt

15km
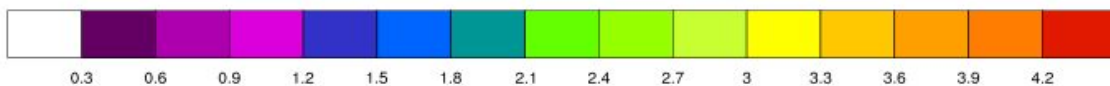
IC: Jul 01

Melting in July: most is basal at both 15km & 30km resolution.

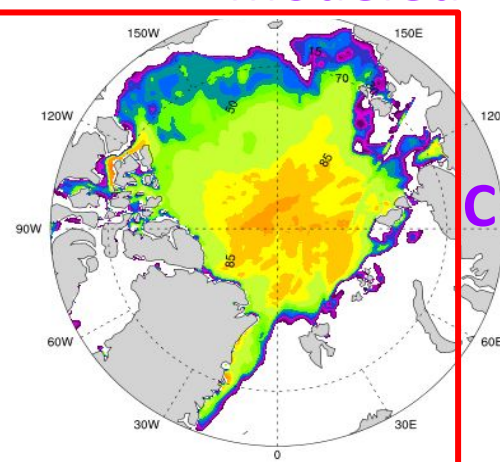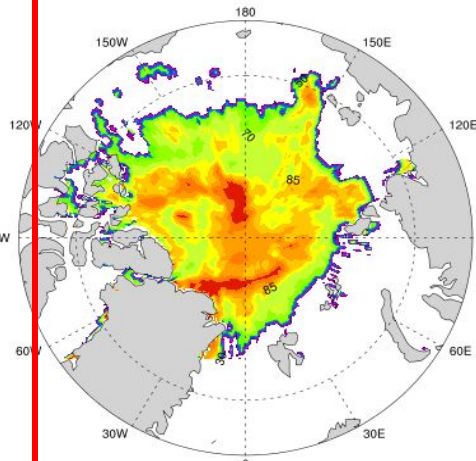**ana** **Ice Area** **modeled** **Ice Edge Error**

CFSR
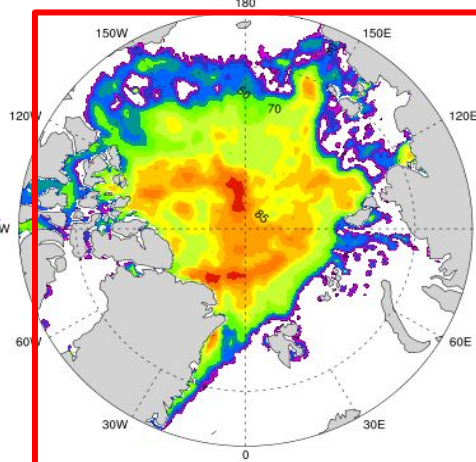
CICE
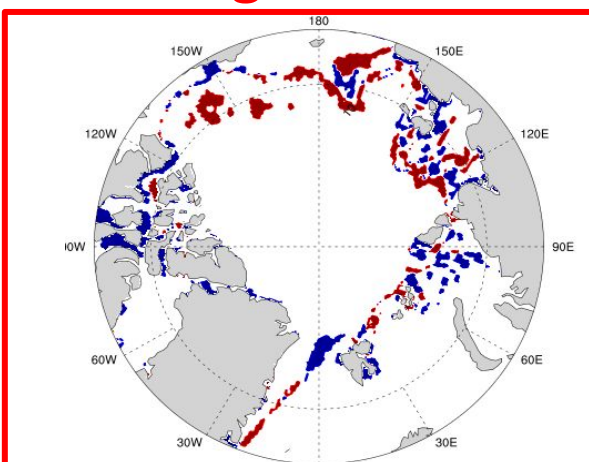
GFS Aug10
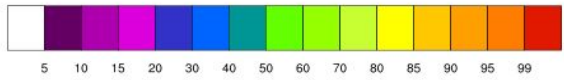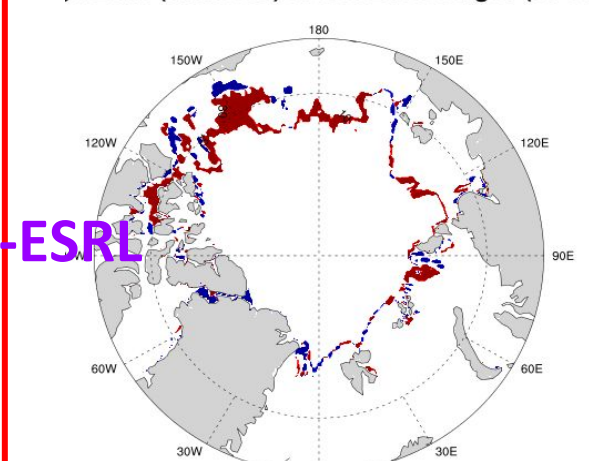
Ice Area (%, 10km res) RASM-ESRL Valid Aug10 (IC=Aug01)

ge Error (10km res) RASM-ESRL Aug10 (IC=Aug01)

GFS

RASM-ESRL

IC: Aug01
Valid: Aug10

5 10 15 20 30 40 50 60 70 80 85 90 95 99
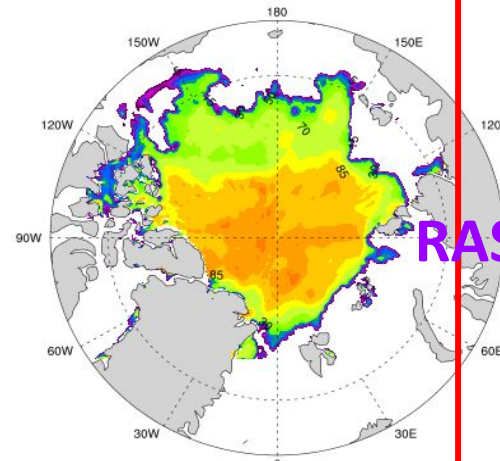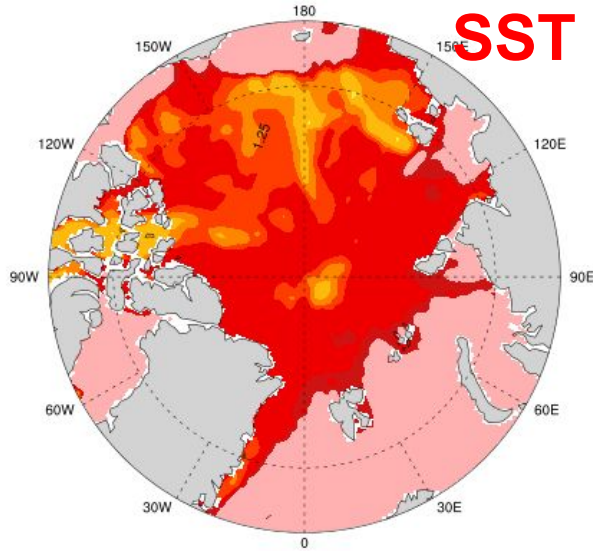
Regional Arctic System Model (RASM; Maslowski et al. 2012)
- WRF atmospheric model
- The Los Alamos National Laboratory CICE mixed layer ocean and sea ice model
- NCAR CLM2 land surface model

Valid Aug 10

CICE

RASM-ESRL

SST Difference

SST (30km res) CFSR minus OISST Aug10 (IC=Aug01)
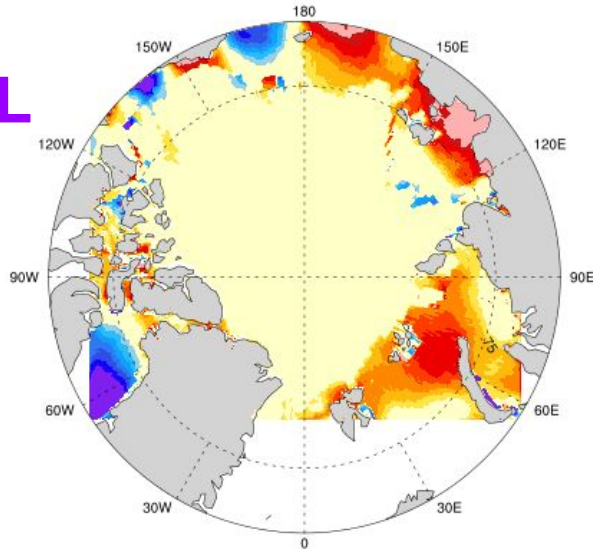
SST (10km res) RASM-ESRL simulated minus GFS Aug10 (IC=Aug01)
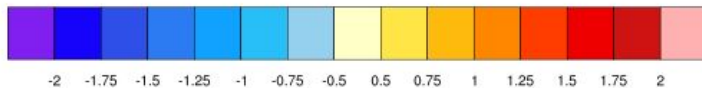
Upper: CFSR SST minus NOAA Optimum Interpolation SST V2*: the former is more than 1° warmer over most of the Arctic cap, responsible for excessive summer melting (see next slide)

Lower: RASM-ESRL SST minus GFS. The former is warmer by >1° only at the boundary.

* OISST2; Reynolds et al. 2002

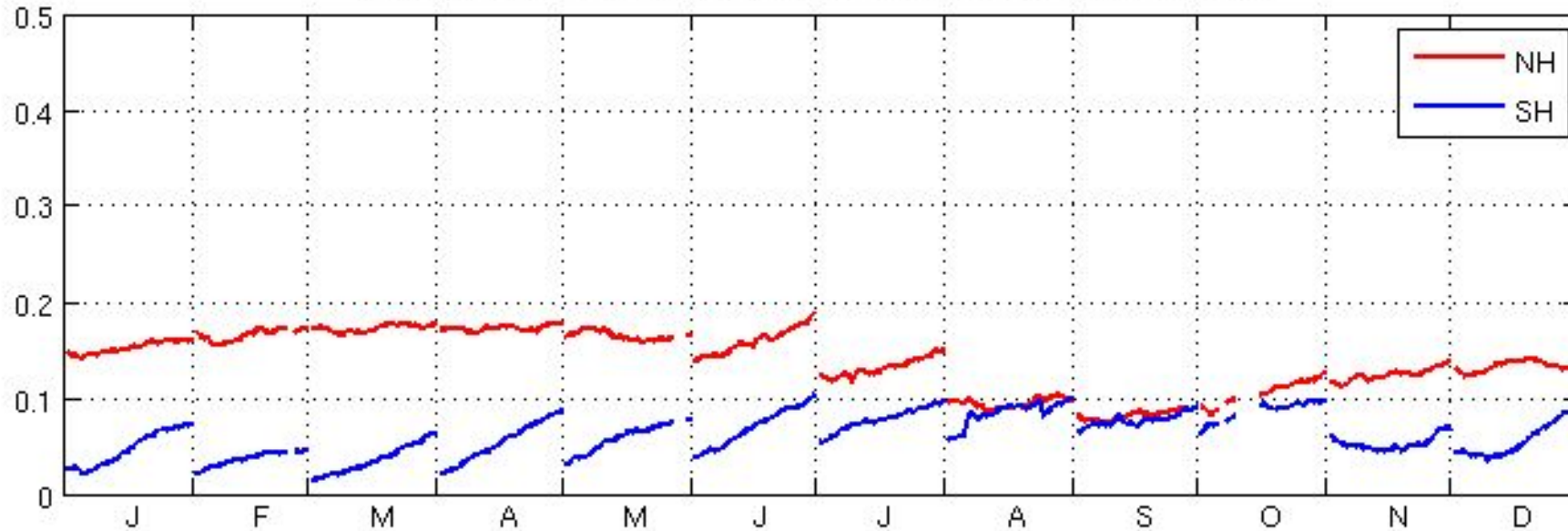Ice Extent from CICE5 30day Simulations at 30km w. SST from OISST & CFSR (o = initial time/reanalysis)
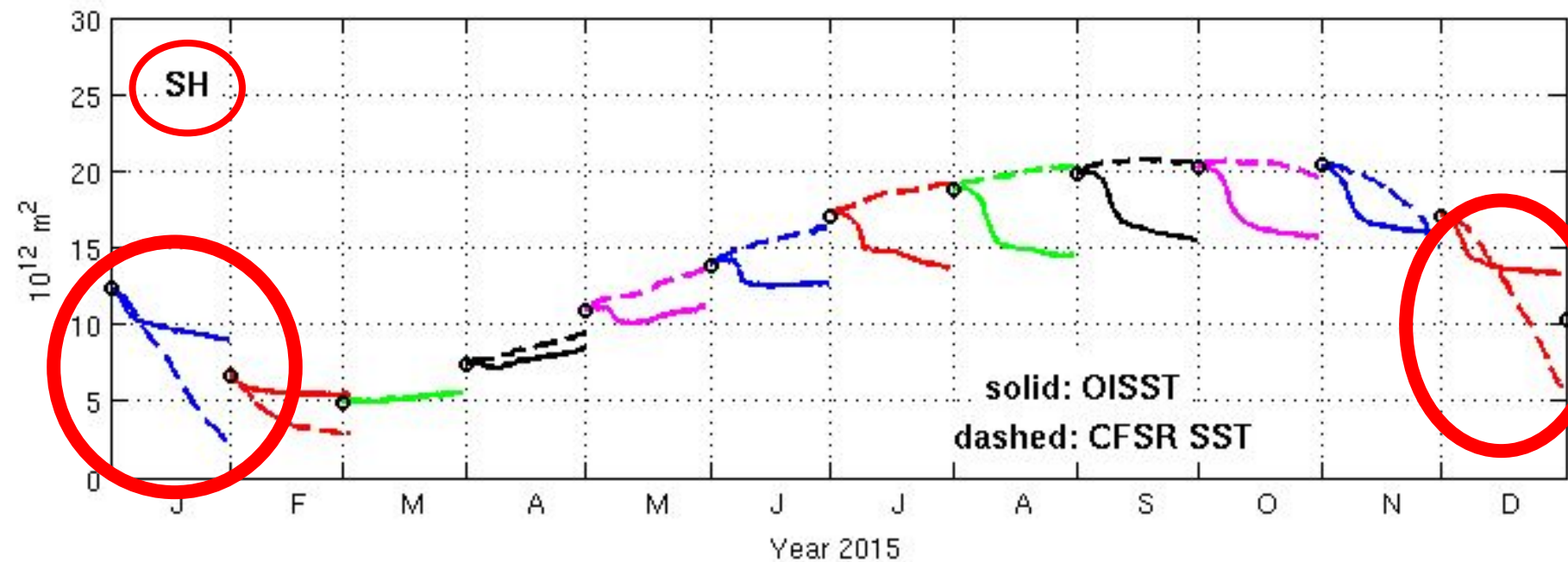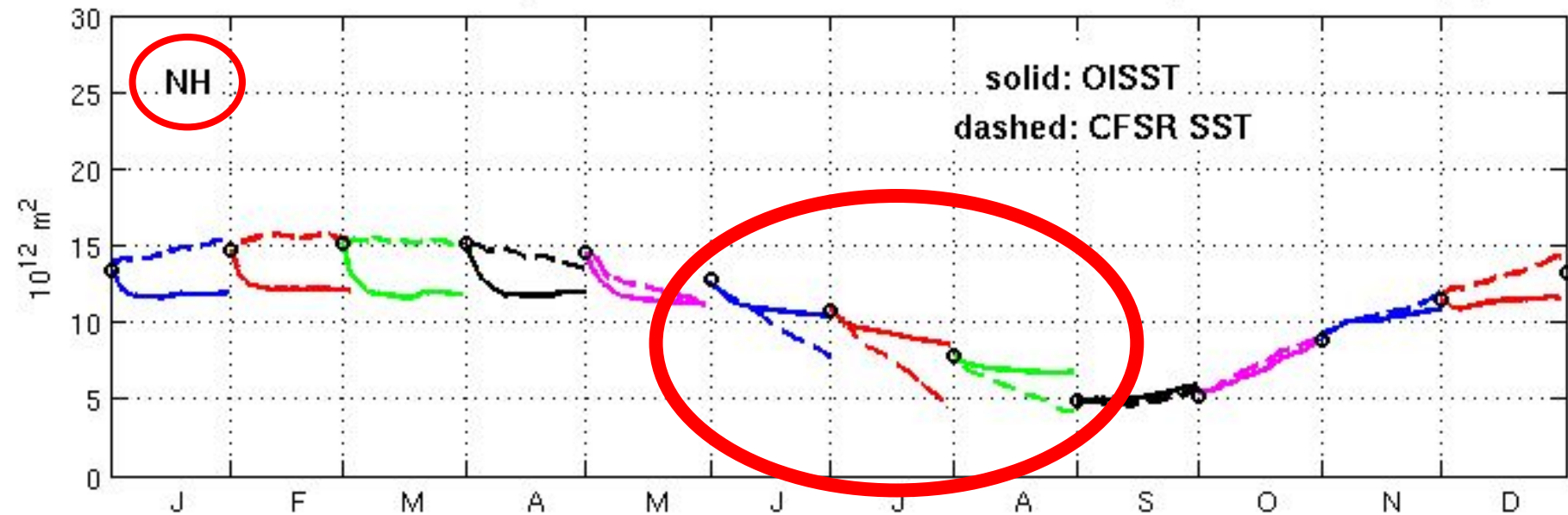
When CICE is forced by NOAA OISST V2 SST (solid) instead of CFSR SST (dashed), and other forcings remain the same, the excessive melting in summer is gone.

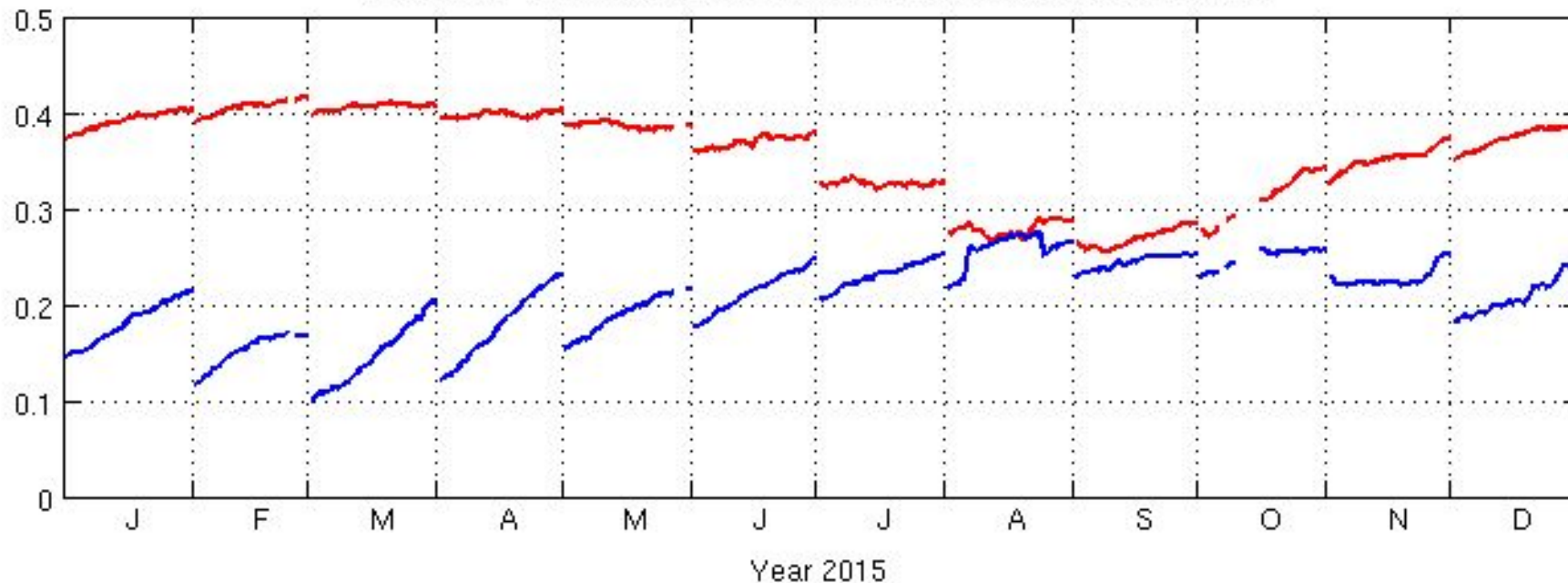This suggests that CFSR SST is responsible for the excessive summer melting.

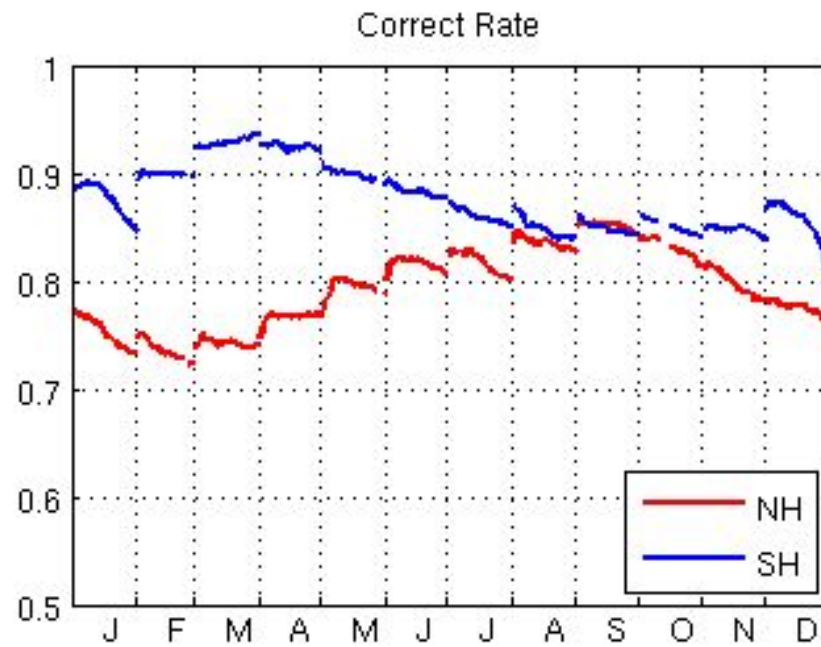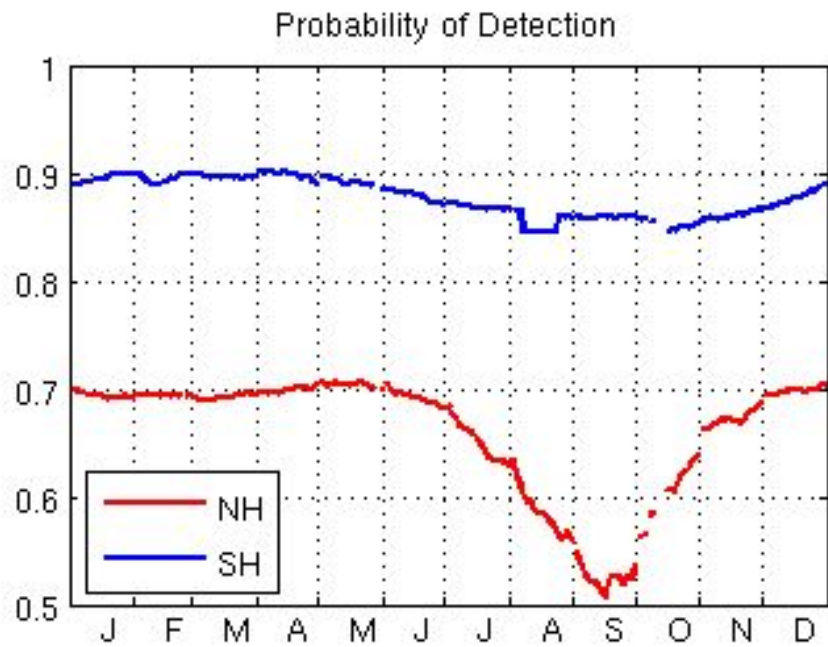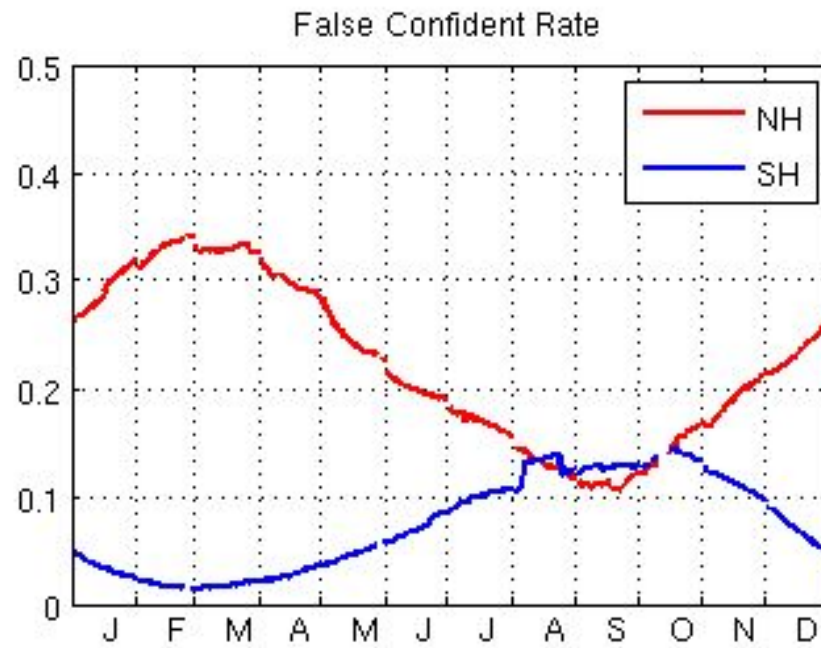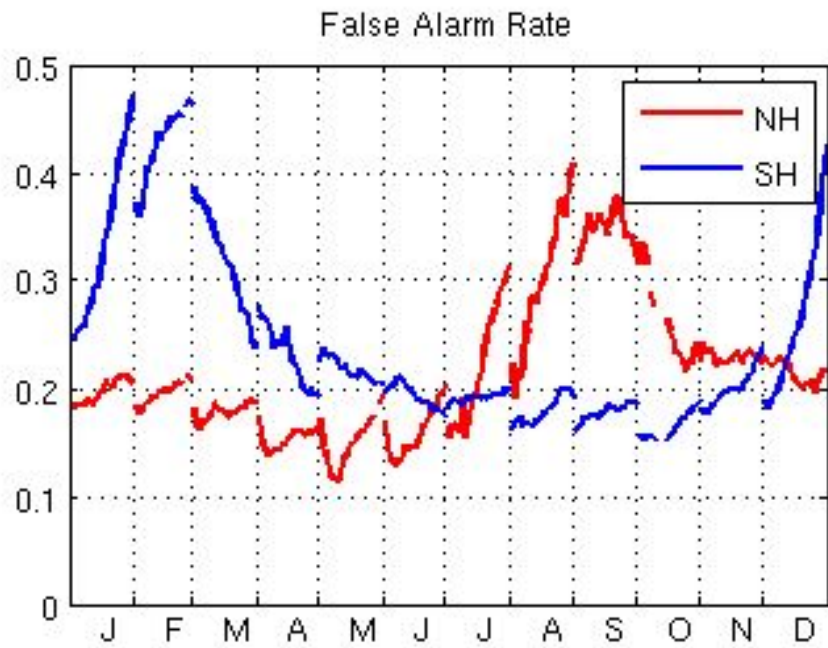**Bias** — Bias in Ice Concentration from CICE5 30day Simulations at 30km res

RMSE — RMS in Ice Concentration from CICE5 30day Simulations at 30km res

Based on ice area (%) against the NCEP operational ice area analysis (1/12º), masked points climatologically never have sea ice (SST > 2º). 30 day simulations at 30km resolution

Based on ice extent against the NCEP operational ice extent analysis (1/12º), masked points climatologically never have sea ice (SST > 2º). 30 day simulations at 30km resolution

Summary

- Stand-alone global CICE V5 has been tested at 30 day time scale for implementation in NGGPS
- Driven by 6-hourly CFSR atmospheric and oceanic forcings, with CFSR initial conditions
- Overall ice edge is close to CFSR, but too far poleward in summer in both hemispheres
- Excessive summer melting occurs in both hemispheres
- Most melting is basal, suggesting error in SST; when CFSR SST is replaced by NOAA OISST V2, **there is no more excessive summer melting**
- Despite SST error, the CICE5 skill is relatively high
- Adoption of CICE V5 in the coupled NGGPS will require joint calibration of the various components (atmosphere-ocean-ice)
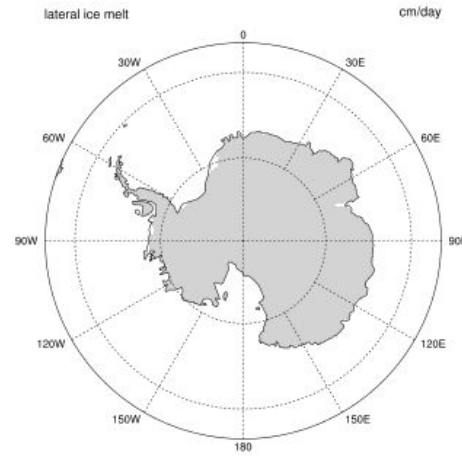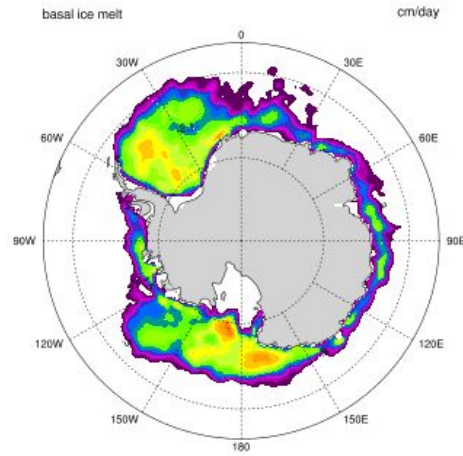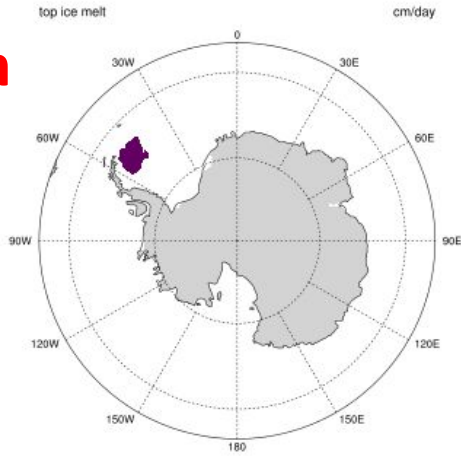
Backup slides

Jan

top melt   **basal melt (cm/day)**   **lateral melt**
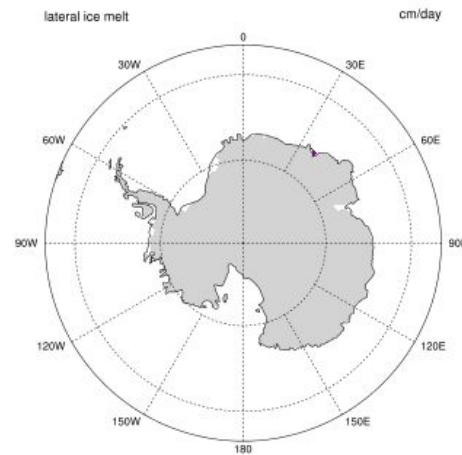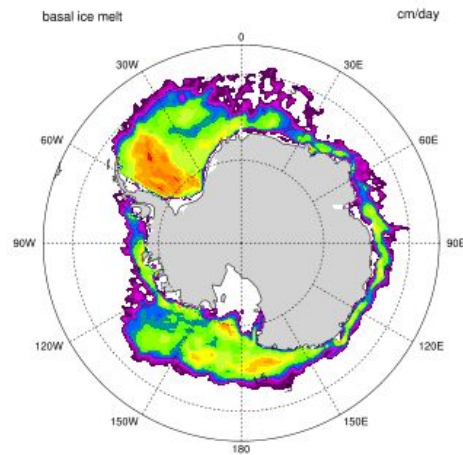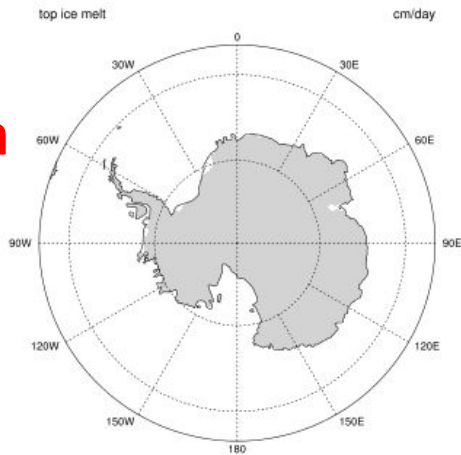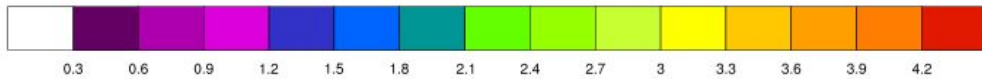
30km

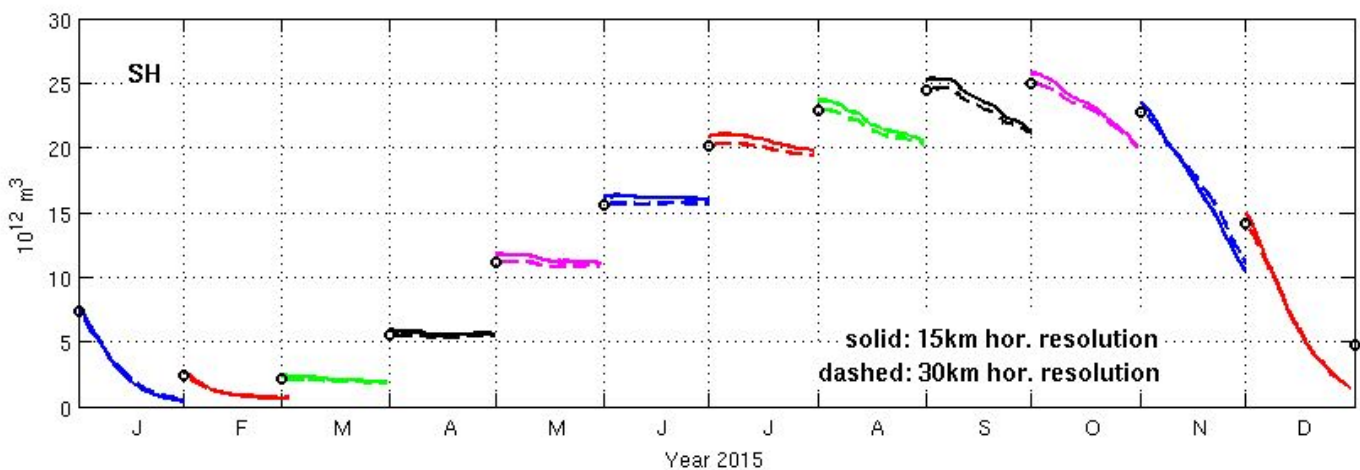**15km**

Almost all melting is at basal at both 15km & 30km resolution.

Ice Volume from CICE5 30day Simulations w. CFSR (o = initial time/reanalysis)
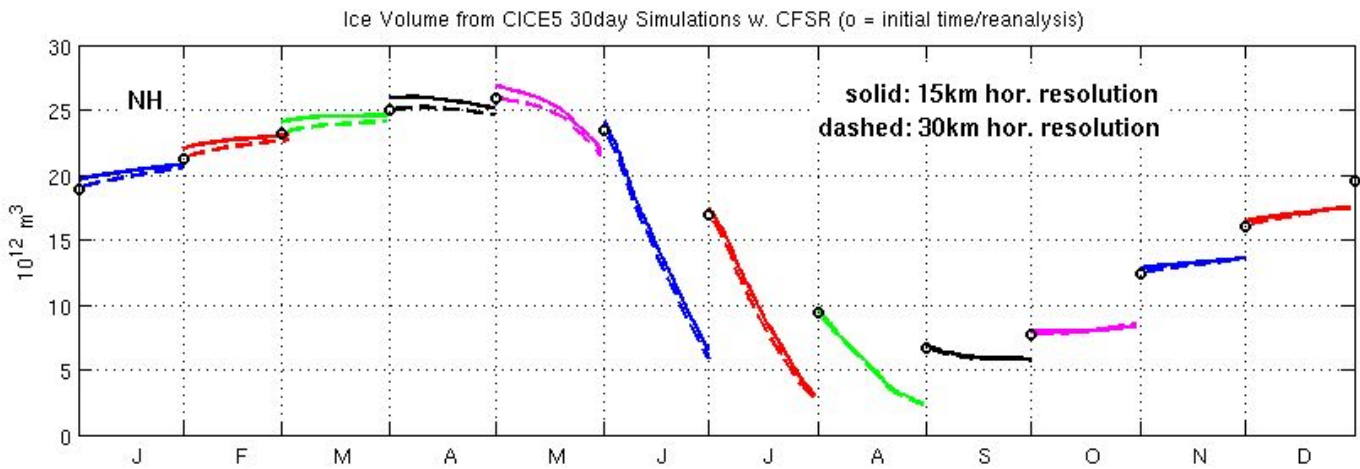
Ice volume from CICE5 1-month simulation with 15km and 30km (at North Pole). Horizontal resolution is shown for both hemispheres, where 'o' represents initial values which are CFS reanalysis.

Compared to CFSR, too much ice melts too fast in melting seasons and freezes too slowly in freezing seasons in the 30km simulations based on the total ice volume. The bias appears to be smaller in the 15km simulations. This is the case for both hemispheres.

Ice Edge Error NH

Ice Edge Error SH

solid: 15km hor. res.
dashed: 30km hor. res.
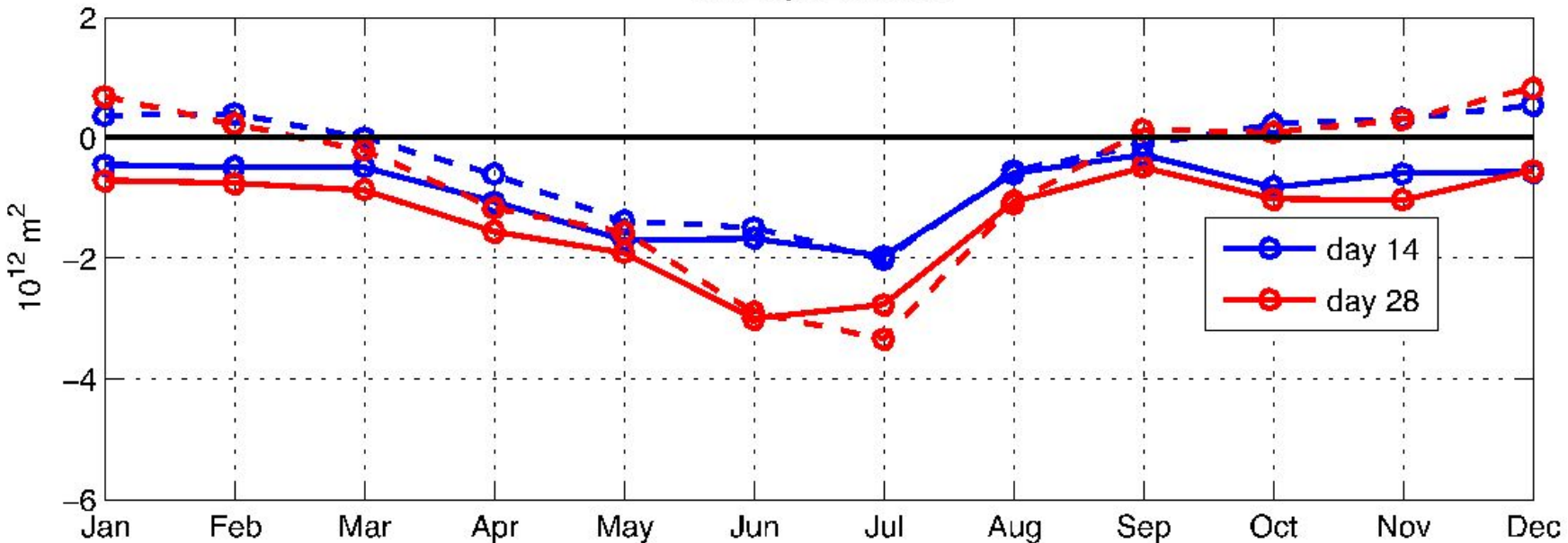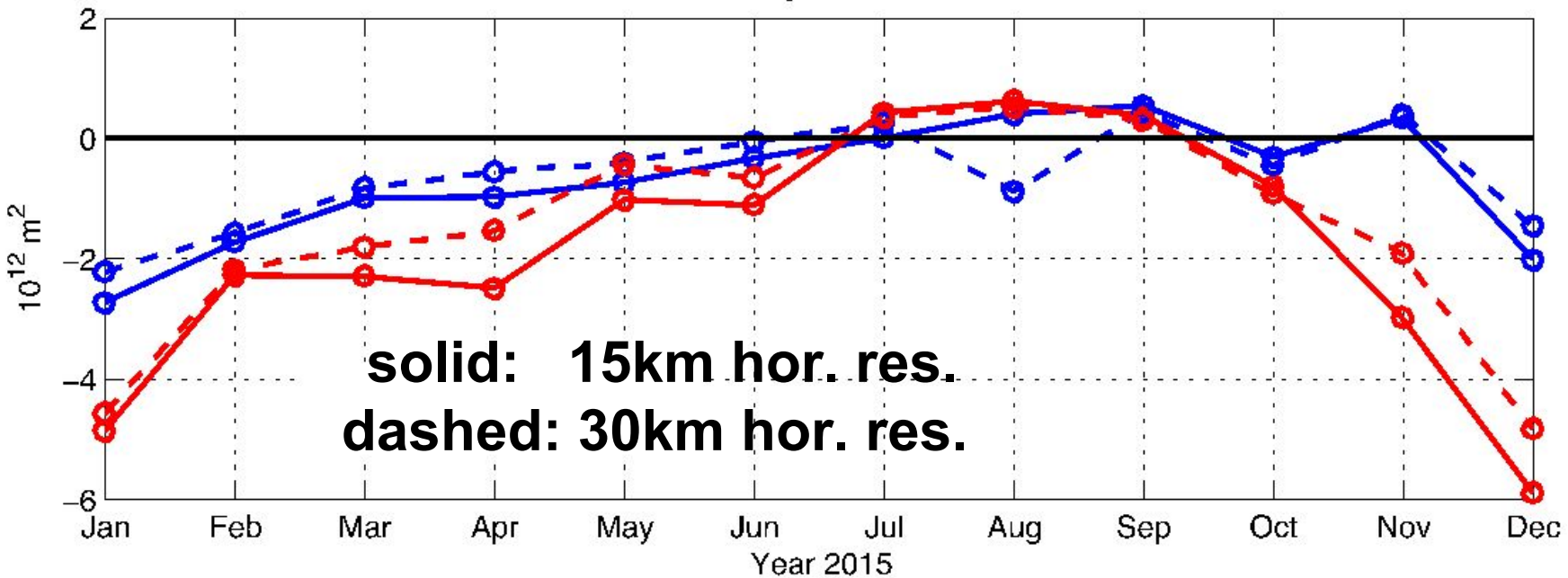
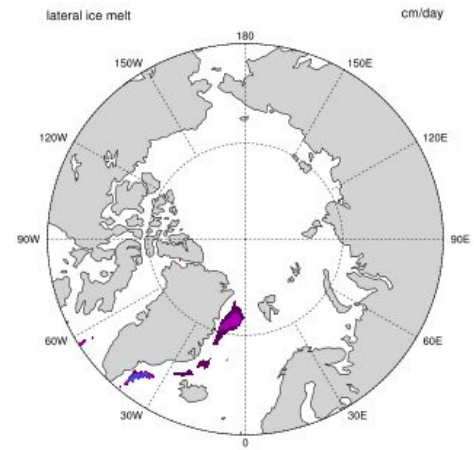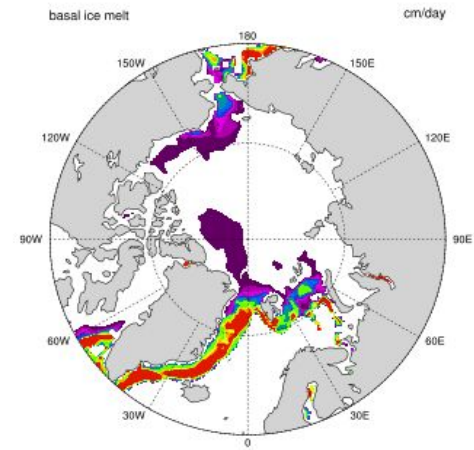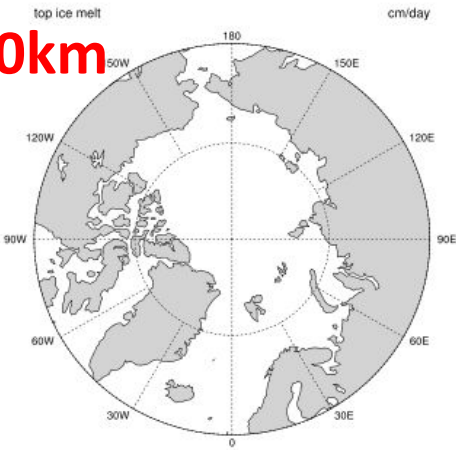Overall ice edge error is similar at 15km & 30km resolution.
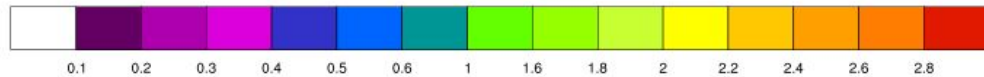
Feb01

top melt   basal melt (mm/day)   lateral melt

30km
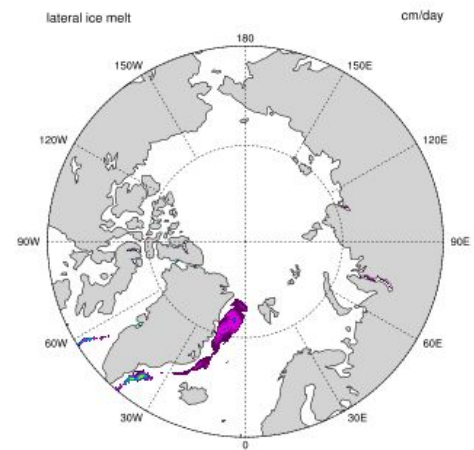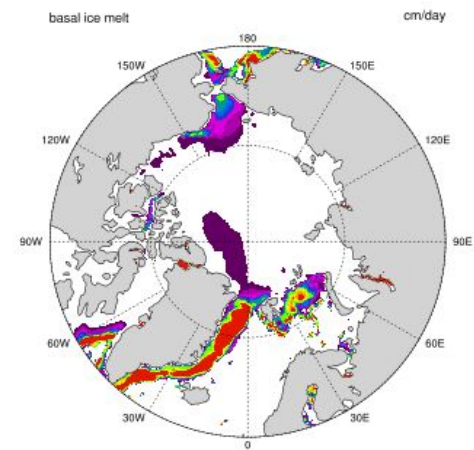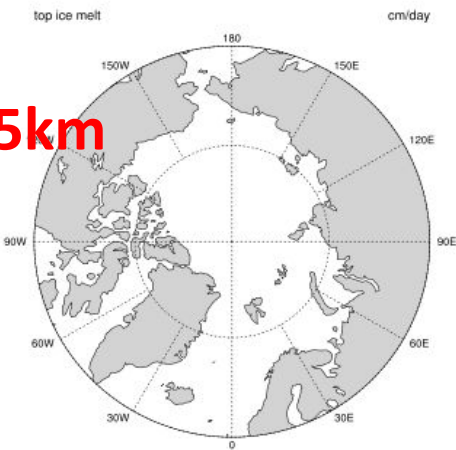
15km

Simulated NH ice coverage (%) is a little lower on Feb. 1 (page 4). The melting takes place mostly at basal during Jan.