High Resolution CESM: Coupled Ocean/Ice Simulations using CORE Forcing

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Ultra High Resolution Global Climate Simulation to Explore and Quantify Predictive Skill for Climate Means, Variability and Extremes

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Experimental Plan and Status

- Initial state exploration, sensitivity
  - 0.1° forced POP-CICE, 24 years completed. Use for initialization of high resolution preindustrial and present day transient simulations.
- T341 Experiments
  - T341/0.1° POP-CICE preindustrial (CAM4 physics): 43 years completed
- CAM-SE Experiments
  - 0.25°/0.1° POP-CICE preindustrial (CAM4 physics): evaluated against T341.
  - CAM-SE used for all future work, including ensemble of late 20th century/ early 21st century transients
- T85 Comparative Experiments.
  - T85/x1° POP-CICE preindustrial for comparison to “standard” CCSM 4 release
  - Ensemble of late late 20th century/ early 21st century transients to test initialization strategy.

Specific Project Goals

1. Use a suite of 1.0° POP/CICE simulations (gx1v6 grid) in the CESM framework run with CORE2 IAF (1970-2009) to provide guidance for the global 0.1° POP/CICE set-up.

2. Perform a multi-decadal (1970-2009) global 0.1° ocean/ice simulation, using POP and CICE in the CESM framework, forced with interannually varying atmospheric reanalysis fluxes (CORE2 IAF).

3. Provide restarts from (2) as initial fields for CESM T341 and CAM-SE simulations. Use (2) as a measure of "truth" to validate ocean/ice in fully-coupled CESM.

Delta–Eddington: Multiple Scattering Parameterization for Solar Radiation Transfer in Snow/Ice (Briegleb and Light, 2007)

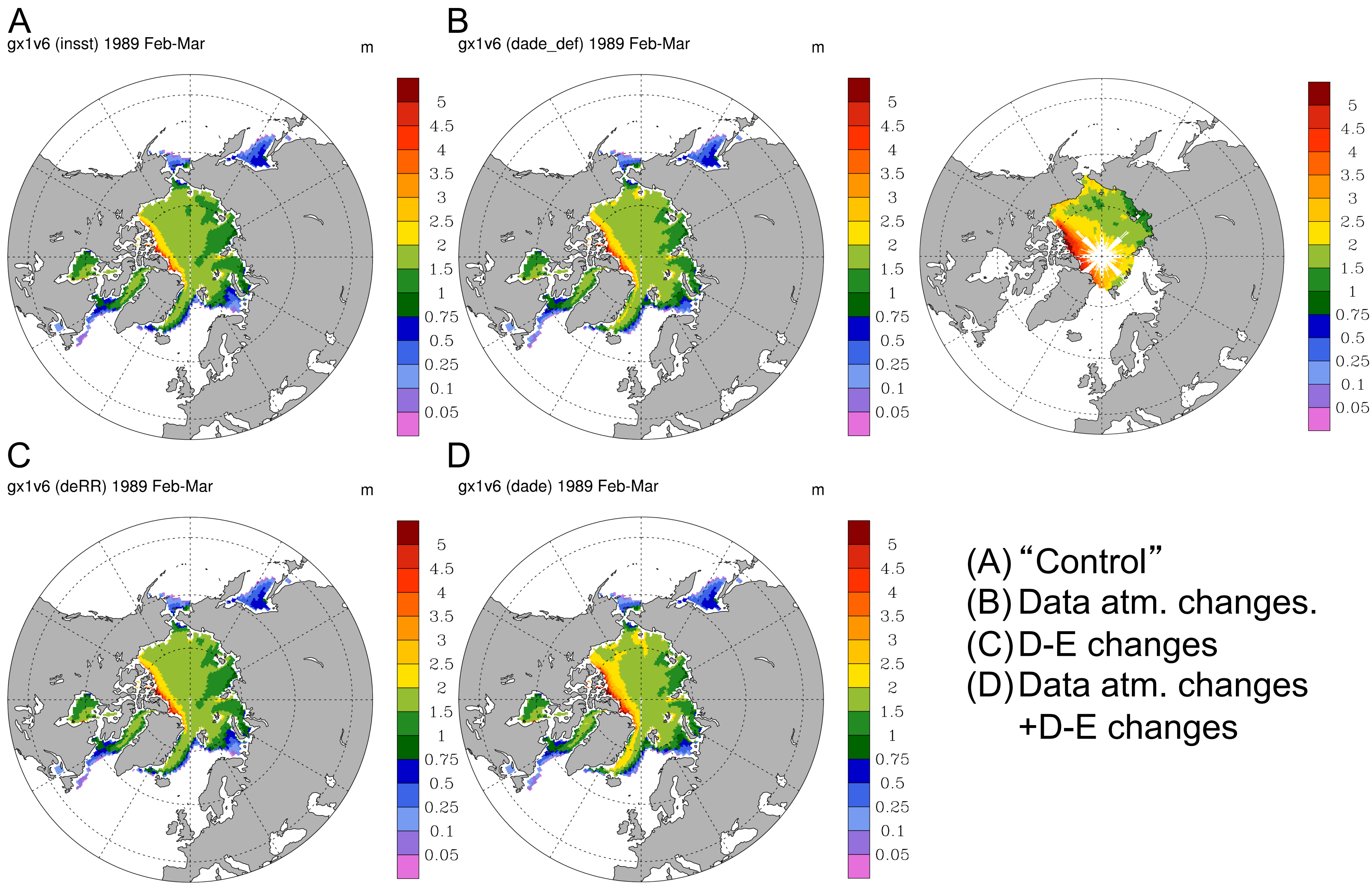
Parameters:

- dT_mlt_in and rsnw_mlt_in determine end points of the linear increase in snow grain size during melt.
- dT_mlt_in: temperature threshold at which melt begins.
- Rsnw_mlt_in is the maximum snow grain radius at 0°C. Range is 10-2500 μm.
- Standard settings are:
  - dT_mlt_in=1.5
  - Rsnw_mlt_in = 1500 μm
- For CORE2 data atmosphere we are using:
  - dT_mlt_in=1
  - Rsnw_mlt_in = 1000 μm
  - Delays the melt until -1°C and the snow grains grow to a maximum of 1mm in size.
- The smaller the snow grain radius the higher the albedo.

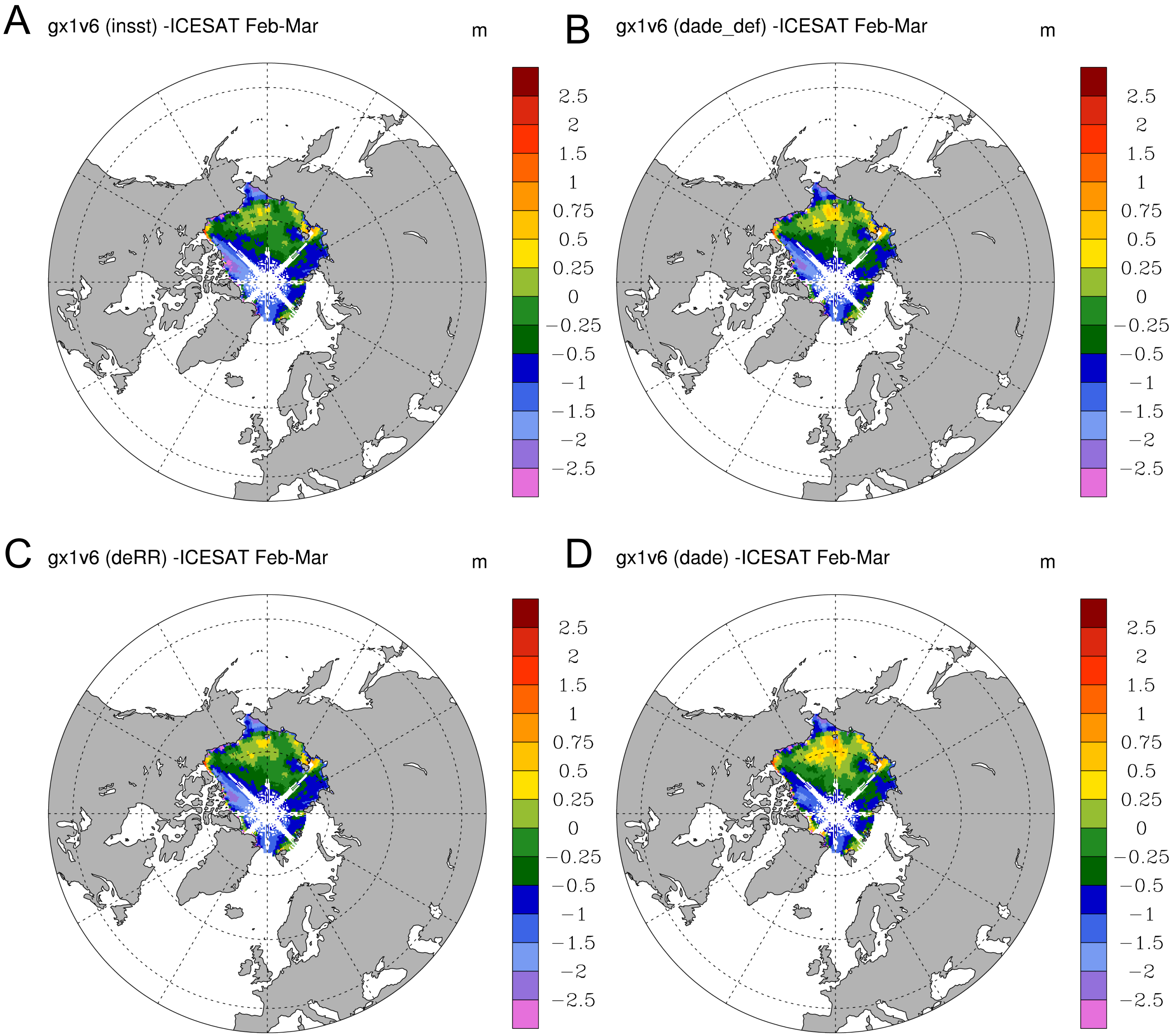
Run: POP-CICE (Gx1v6)	Experiment (all use Delta-Eddington)	Initial Ice	Surface Forcing
A	"Control" rsnw_melt_in=1500 dT_melt_in=1.5	Prescribed initial ice.	CORE IAF
B	Seasonal cycle adjustments to LWDN and air temp in Arctic in data atm (based on Sheba and Maykut82 data). rsnw_melt_in=1500 dT_melt_in=1.5	Prescribed initial ice.	CORE IAF
C	rsnw_melt_in=1000 dT_melt_in=1.0	Prescribed initial ice	CORE IAF
D	Seasonal cycle adjustments to LWDN and air temp in Arctic in data atm. & rsnw_melt_in=1000 dT_melt_in=1.0	Prescribed initial ice	CORE IAF

Ice Thickness (m): POP-CICE gx1v6 for Feb-Mar 1989

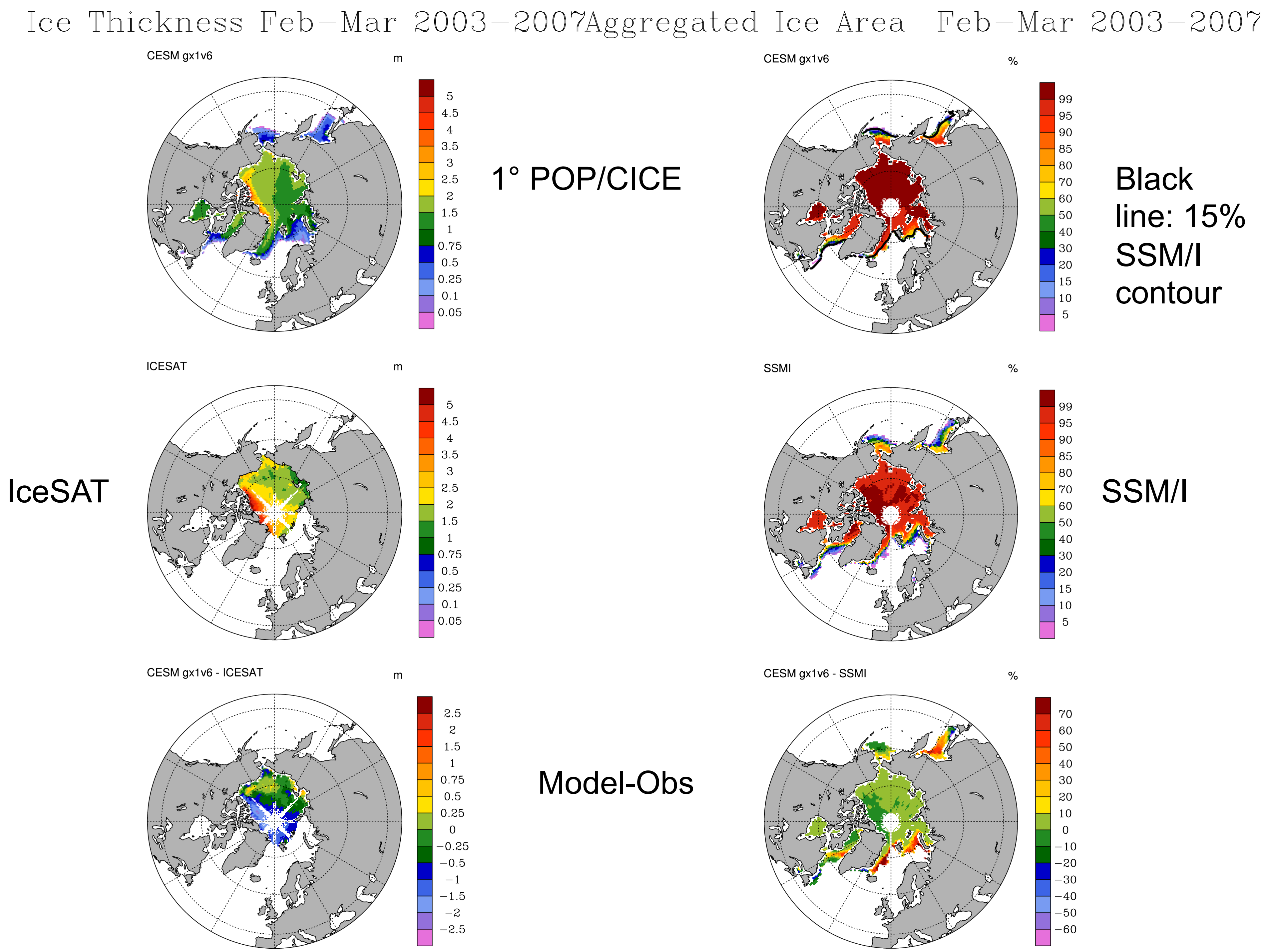
ICESAT Feb-Mar 2004-2008



Ice Thickness Differences (m): POP-CICE gx1v6 Feb-Mar 1989 – IceSAT Feb-Mar 2004-2008.



(A) "Control"
(B) Data atm. changes.
(C) D-E changes
(D) Data atm. changes +D-E changes



Ice Thickness Feb–Mar 2003–2007
Aggregated Ice Area Feb–Mar 2003–2007
CESM gx1v6
m
5
4.5
4
3.5
3
2.5
2
1.5
1
0.75
0.5
0.25
0.1
0.05
1° POP/CICE
CESM gx1v6
%
99
95
90
85
80
70
60
50
40
30
20
15
10
5
Black line: 15% SSM/I contour
ICESAT
m
IceSAT
SSMI
%
SSM/I
CESM gx1v6 - ICESAT
m
2.5
2
1.5
1
0.75
0.5
0.25
0
−0.25
−0.5
−1
−1.5
−2
−2.5
Model-Obs
CESM gx1v6 - SSMI
%
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60

Global 0.1° POP/CICE

- CESM framework (1.03/1.04) on Hopper at NERSC.
- Years 1970-1994 to date, will continue through 2009.
- Forcing: CORE2 data atmosphere.
- 0.1° tripole grid for both POP and CICE.
- Sensitivities: initial ocean and ice conditions, NY or IAF forcing
- Solar radiation transfer parameterization for sea-ice/snow was CCSM3 default for 1970-1979 (model spin-up period).
- Switched to D-Edd (dt_mlt_in = 1, and rsnw_mlt_in = 1000) at the end of 1979. This delays the melt until -1°C and the snow grains grow to a maximum of 1mm in size.
- Also changes LWDN and air temperature in CORE2 at end of 1979.

t0.1v2 CESM vs ICESAT   t0.1v2 CESM vs ICESAT

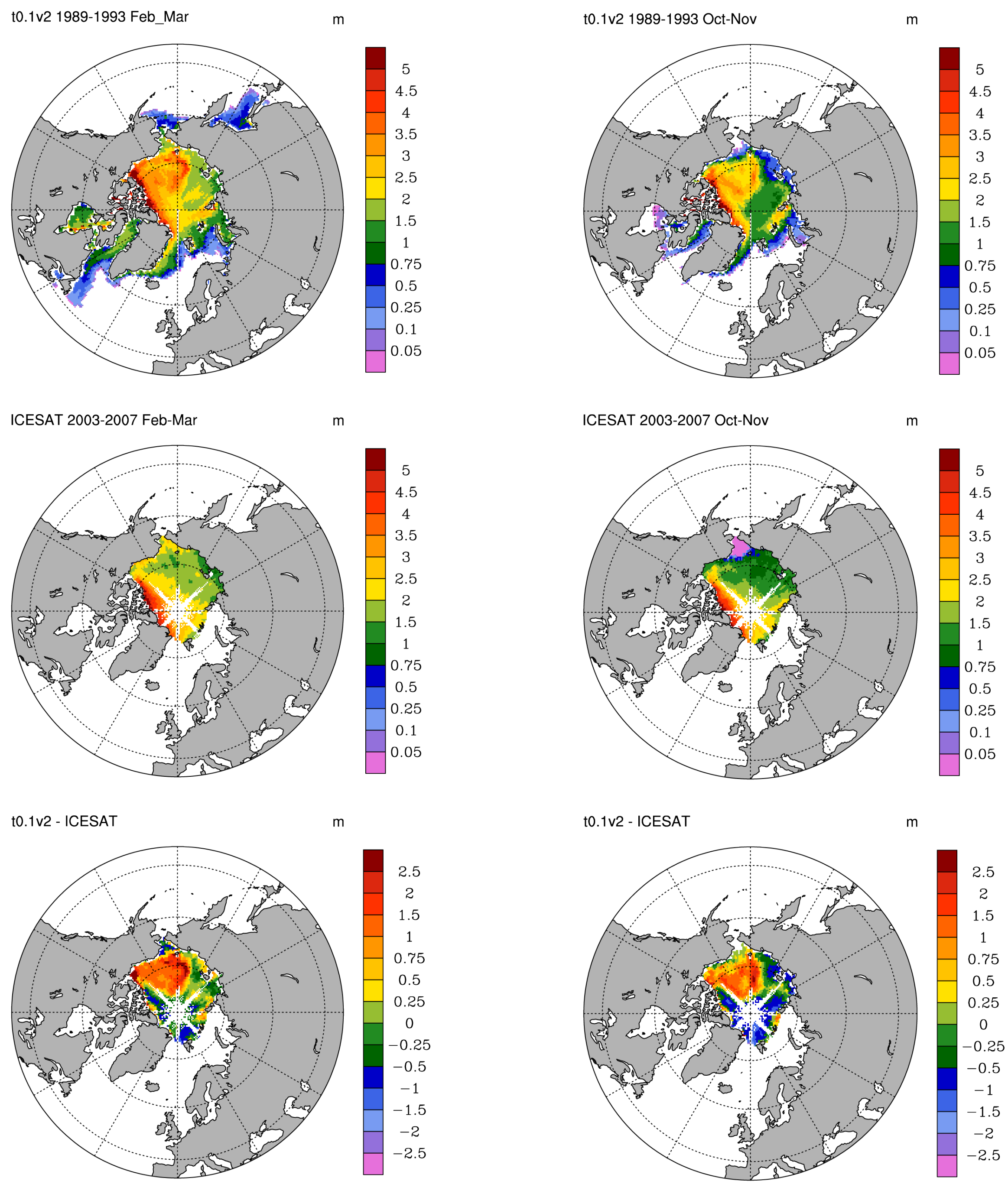
Feb-Mar
1989-1993

Oct-Nov
1989-1993

0.1° POP/
CICE

IceSAT

Model-Obs



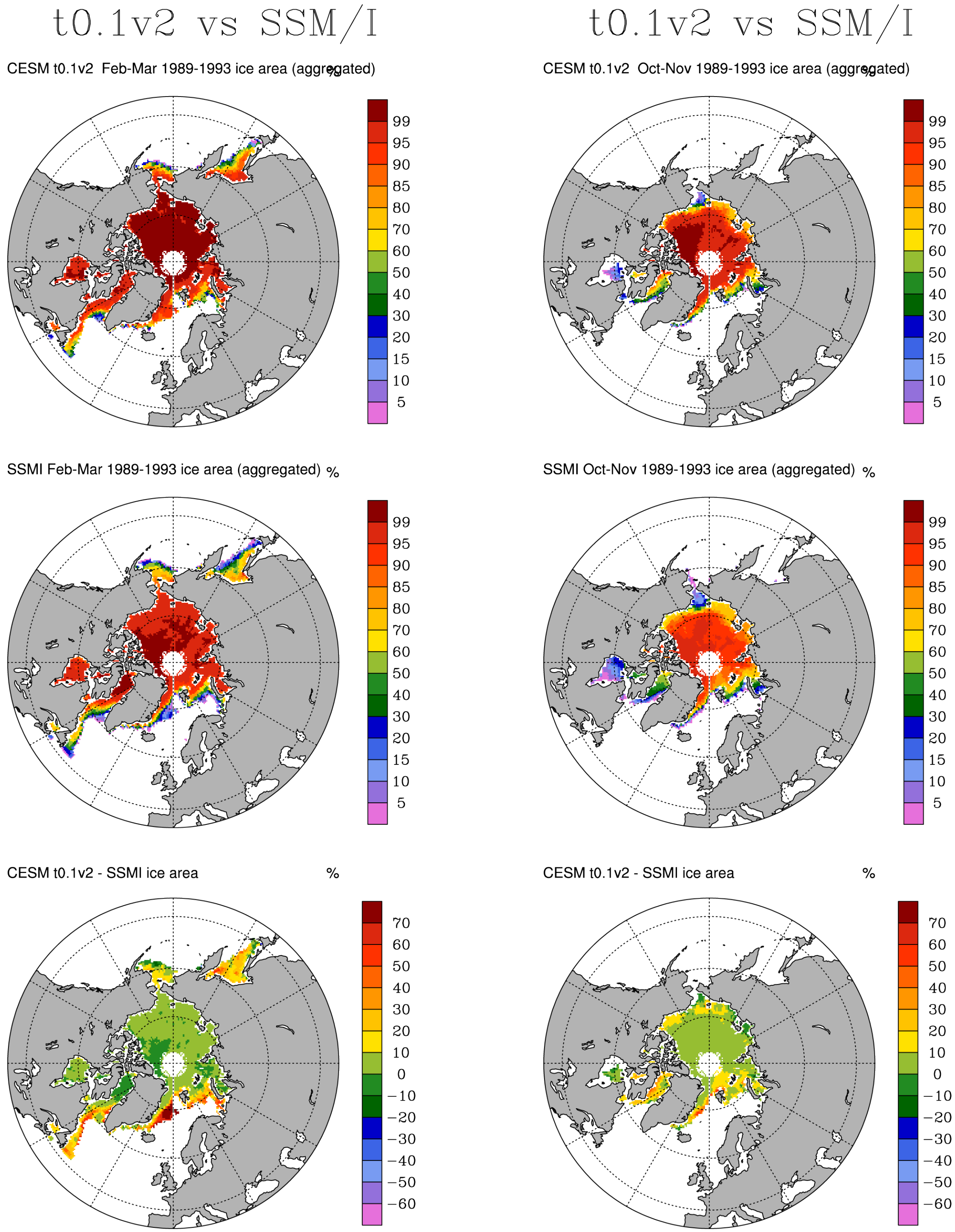
Feb-Mar
1989-1993

0.1° POP/
CICE

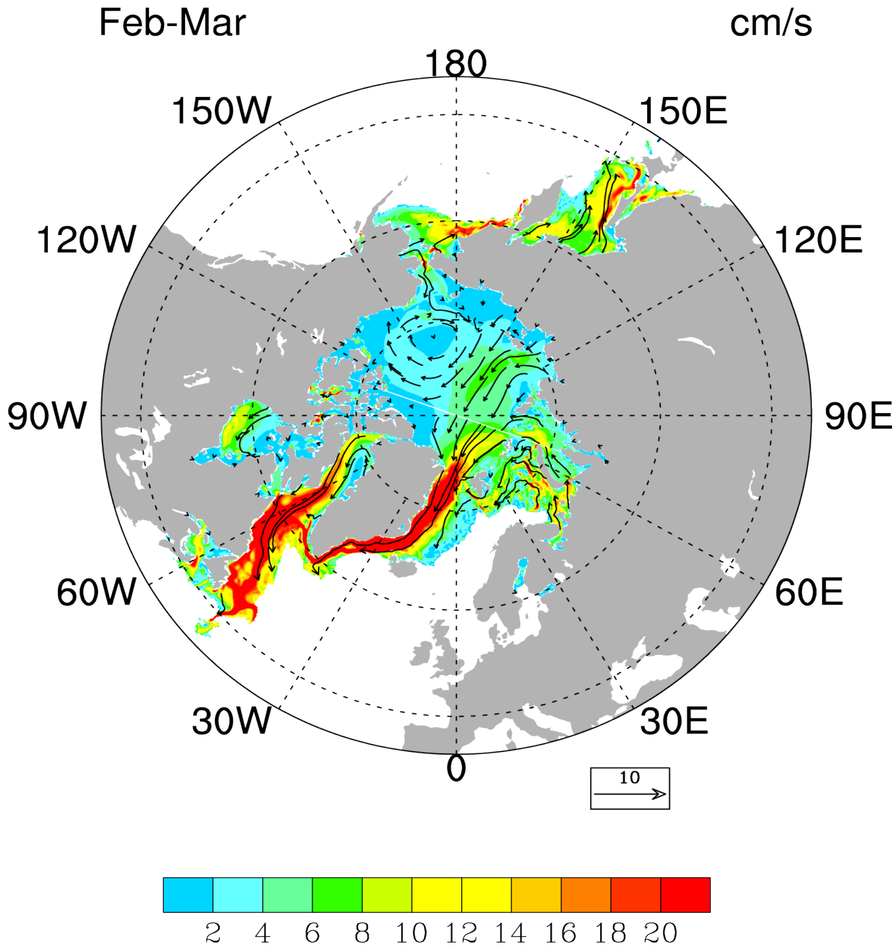
SSM/I

Model-Obs

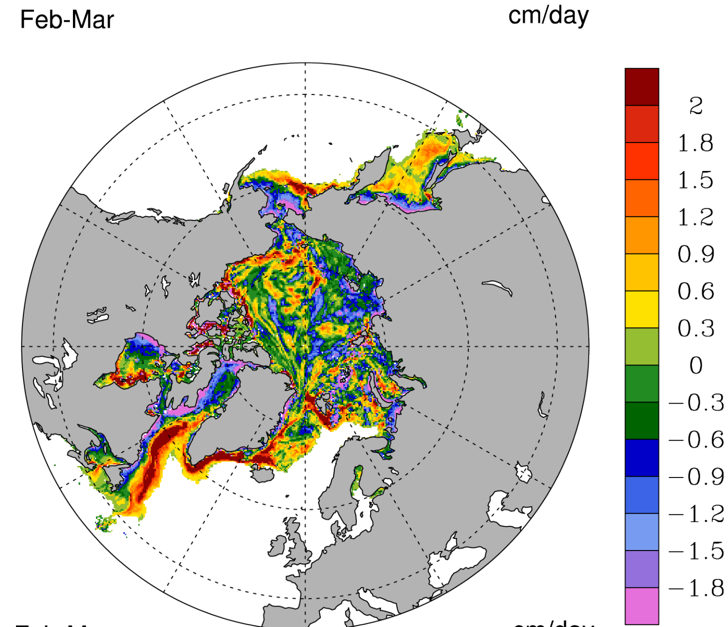
Oct-Nov
1989-1993

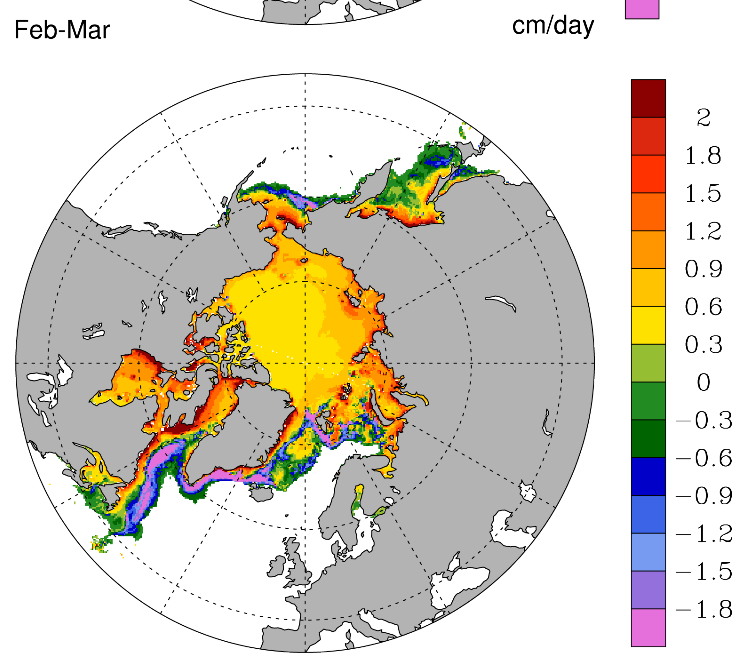


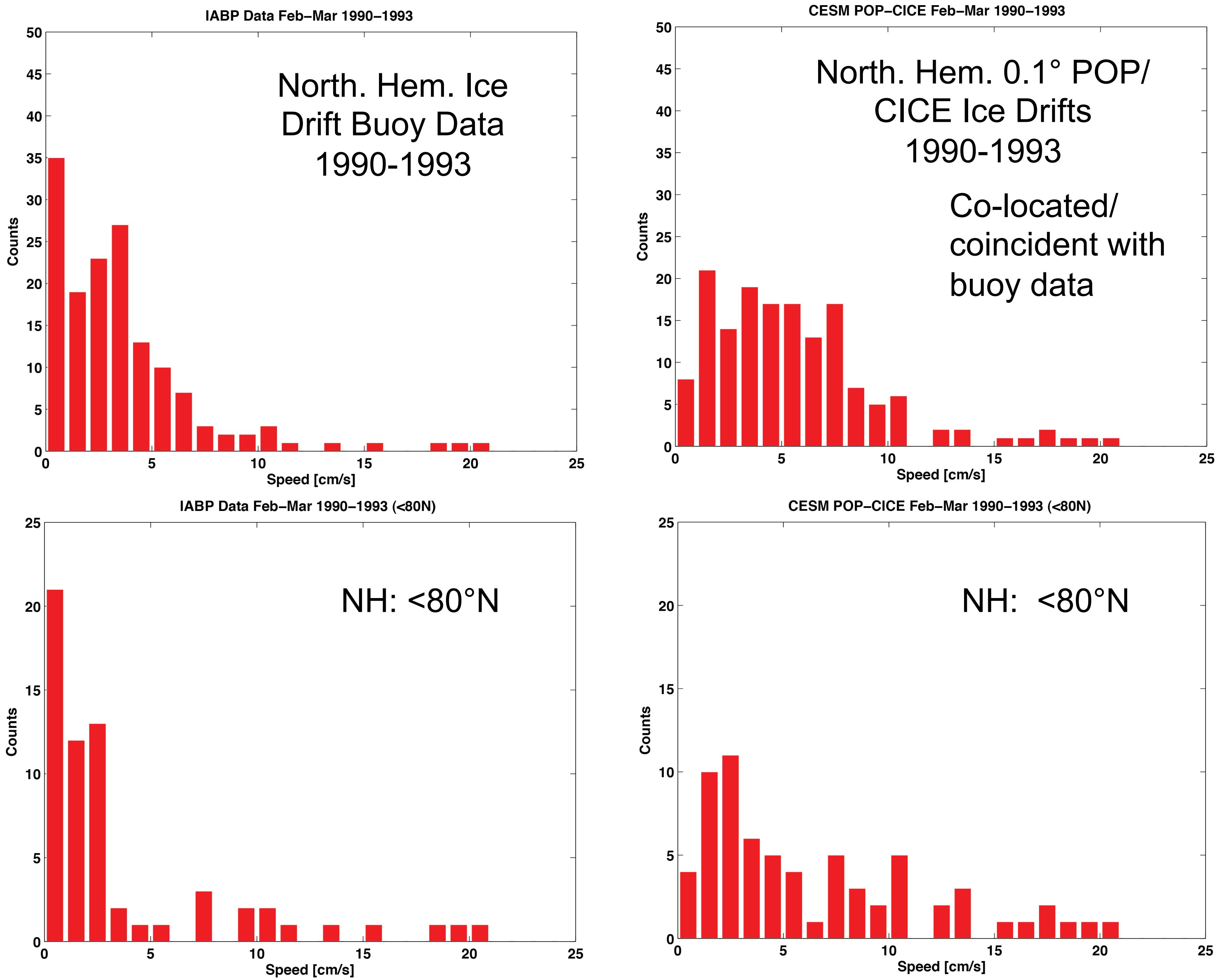
Ice Drift (LHS) and Volume Dynamic (upper) and Thermodynamic (lower) Ice Tendencies for Feb-Mar 1989-1993 from 0.1° POP/CICE.



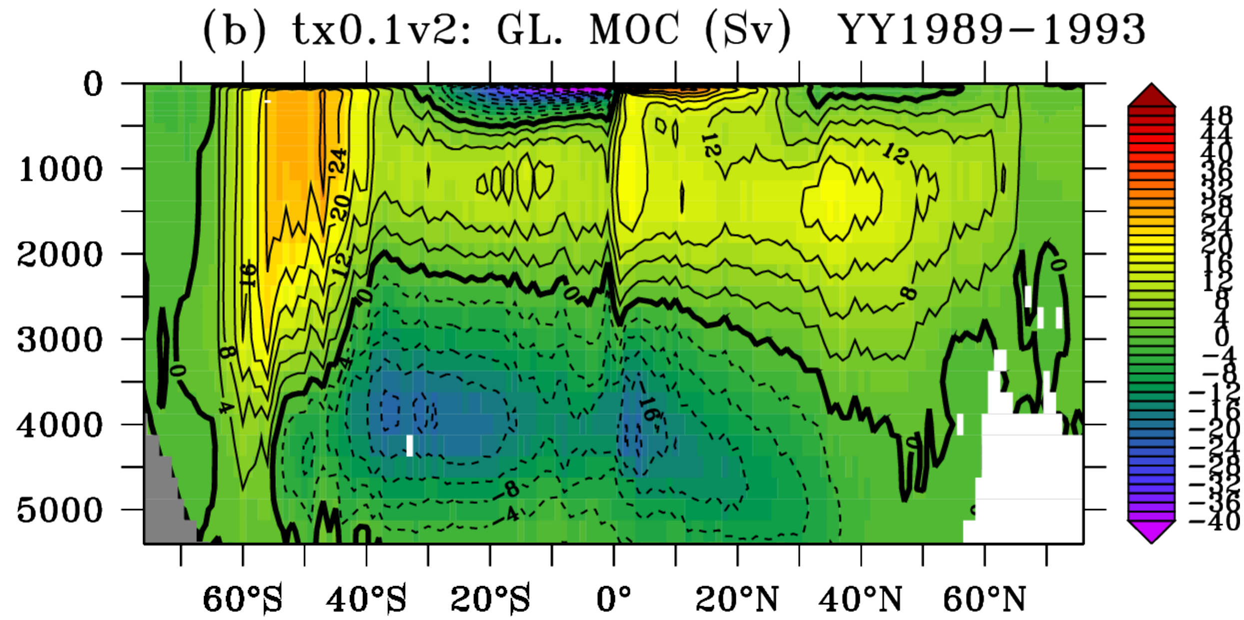
Magnitude of ice drift vectors (cm/sec)

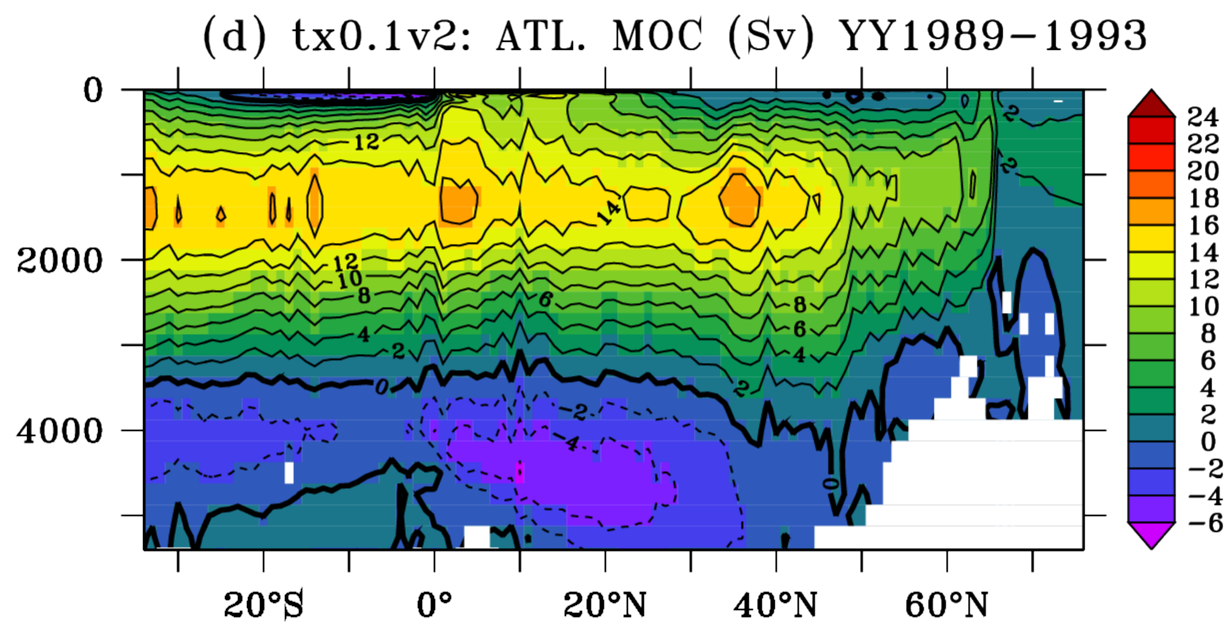





IABP Data Feb–Mar 1990–1993
North. Hem. Ice Drift Buoy Data 1990-1993
Counts
Speed [cm/s]
CESM POP–CICE Feb–Mar 1990–1993
North. Hem. 0.1° POP/ CICE Ice Drifts 1990-1993
Co-located/ coincident with buoy data
Counts
Speed [cm/s]
IABP Data Feb–Mar 1990–1993 (<80N)
NH: <80°N
Counts
Speed [cm/s]
CESM POP–CICE Feb–Mar 1990–1993 (<80N)
NH: <80°N
Counts
Speed [cm/s]

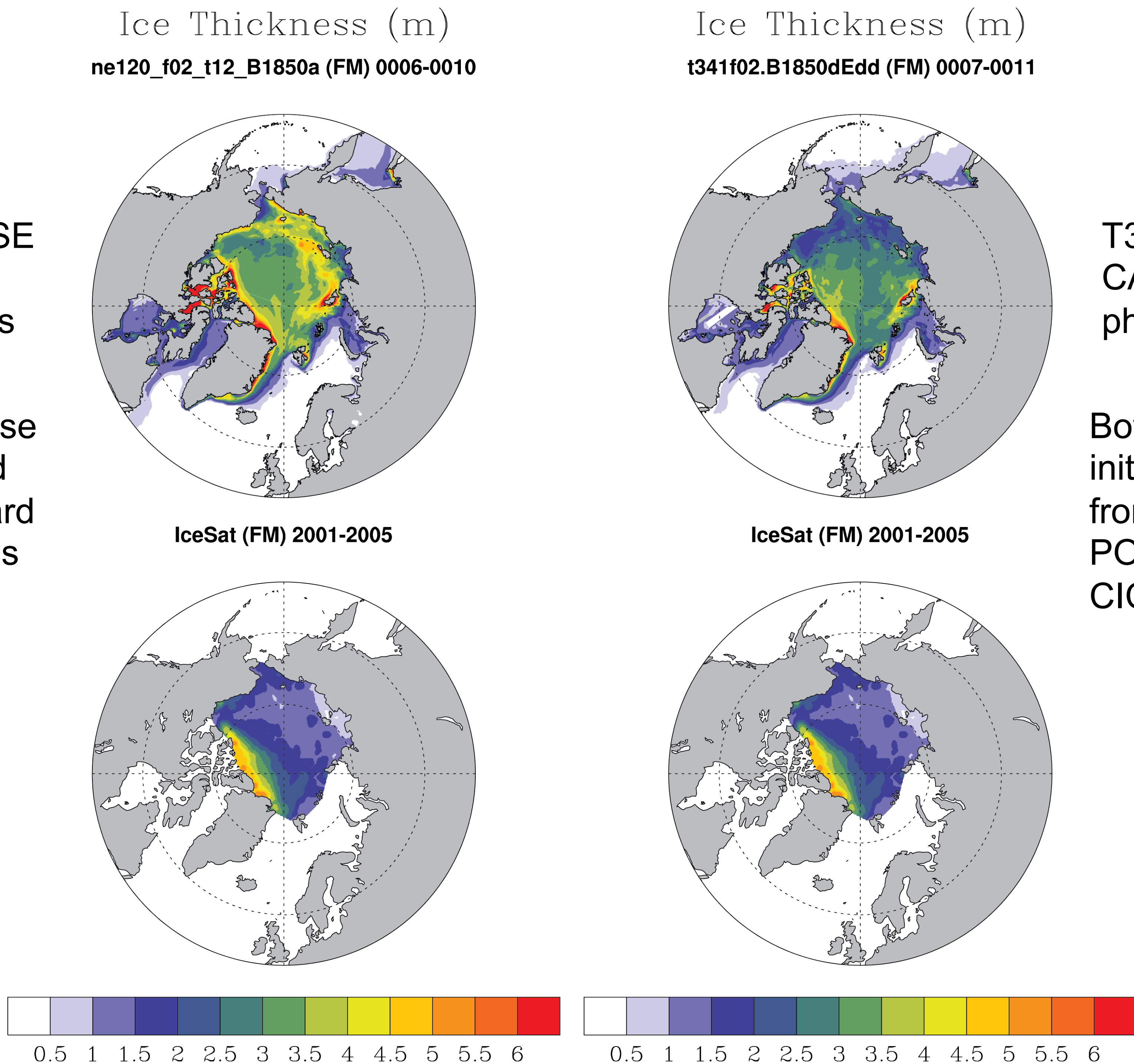
Meridional Overturning Circulation (Sv): 0.1° POP/CICE





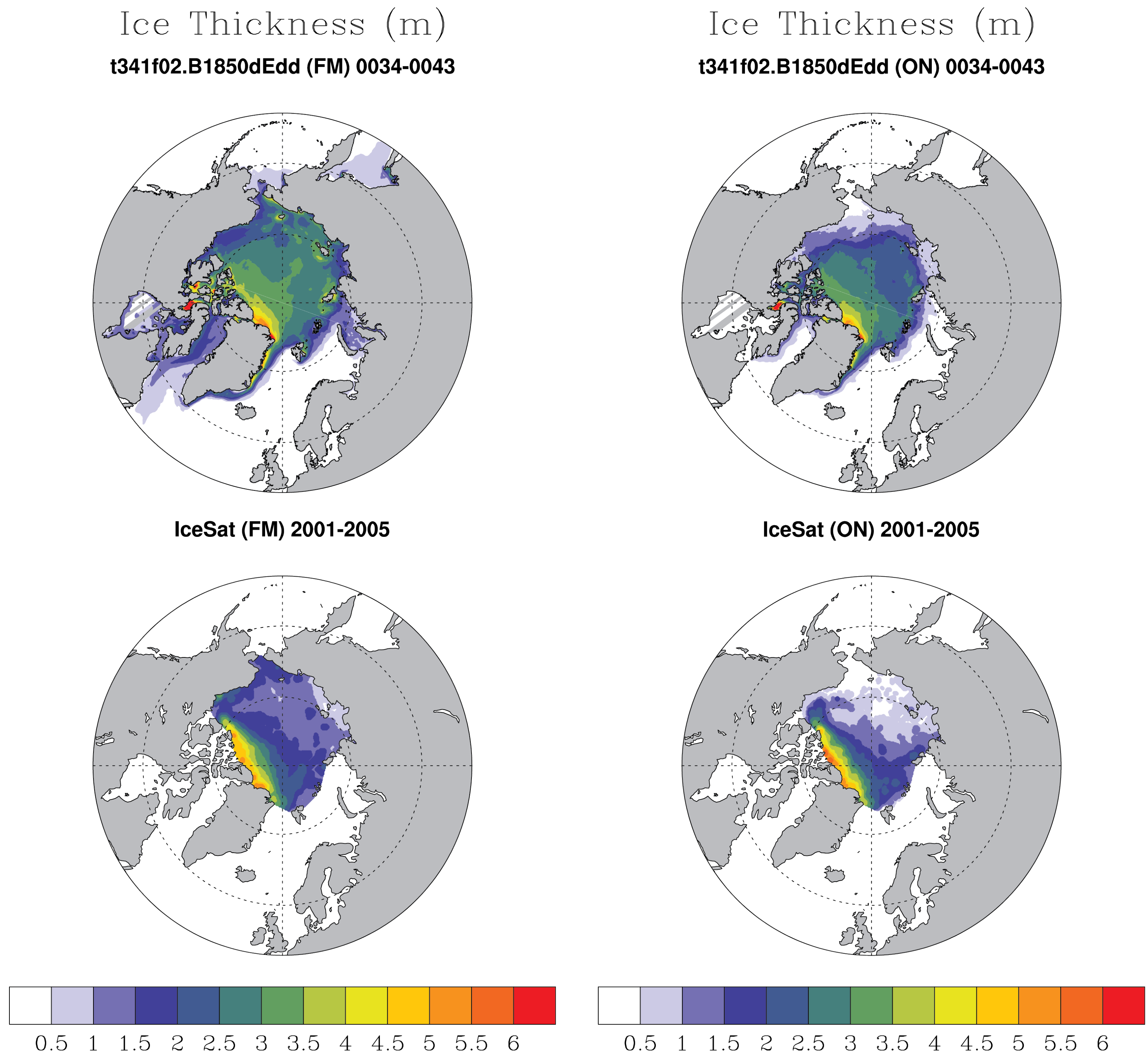
CAM-SE
CAM4
physics

Both use
D-Edd
standard
settings

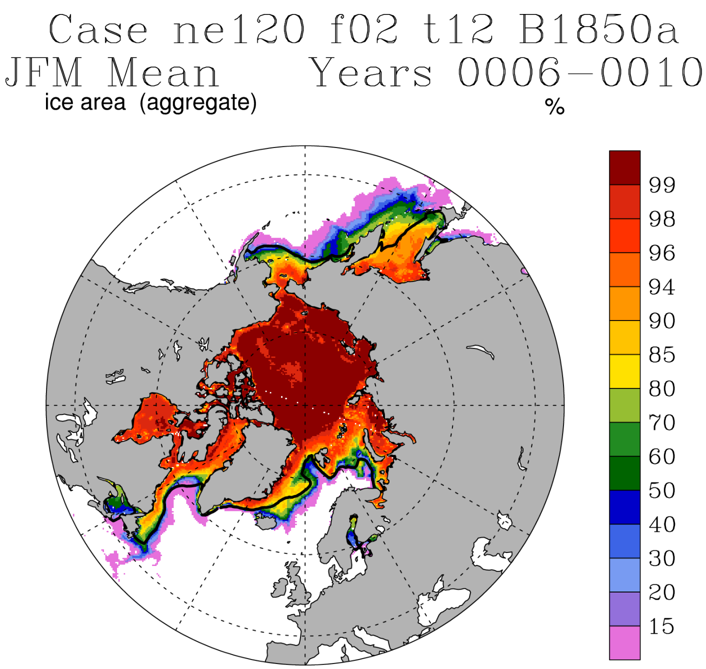


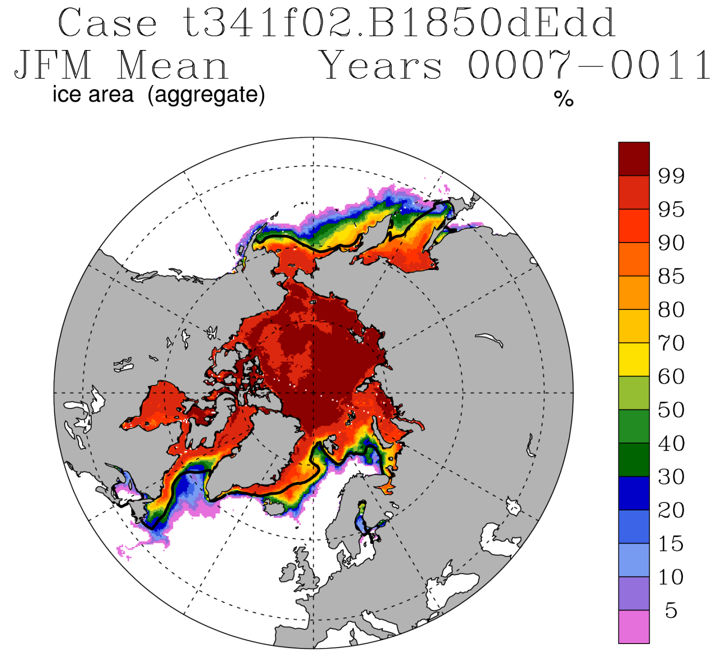
T341
CAM4
physics

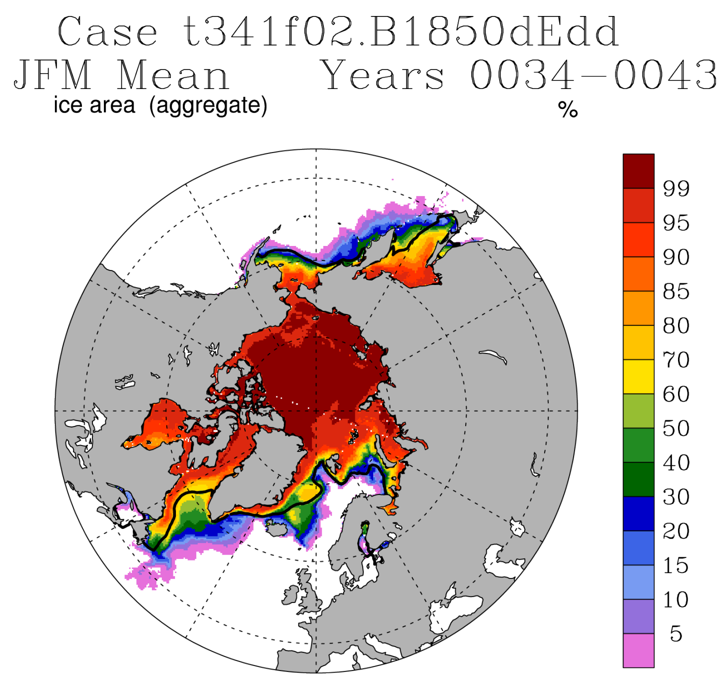
Both
initialized
from 0.1°
POP/
CICE


Ice Thickness (m)
t341f02.B1850dEdd (FM) 0034-0043
Ice Thickness (m)
t341f02.B1850dEdd (ON) 0034-0043
IceSat (FM) 2001-2005
IceSat (ON) 2001-2005
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6

Ice Concentration (%) for CAM-SE (LHS) and T341 (RHS) CESM Simulations







Black line is 15% concentration contour from SSM/I

Conclusions

- 1° POP/CICE (gx1v6) sensitivity studies using CORE2 IAF show the most realistic Arctic ice thicknesses relative to IceSAT using D-Edd parameters: dT_mlt_in=1, Rsnw_mlt_in = 1000 µm and seasonal cycle adjustments to LWDN and air temperature in CORE2.

- In Feb-Mar & Oct-Nov 1989-1993, climatological ice thickness biases in 0.1° POP/CICE are 0.5-1 m too thin to the north of the Canadian Archipelago and in the western Arctic.

- 0.1° POP/CICE has more occurrences of fast ice drifts relative to IABP observations both in the Arctic and south of 80°N. Erroneous export of sea ice via the East Greenland and Labrador Current will result in erroneous freshwater export to the North Atlantic, impacting the AMOC.

- Early results from CAM-SE (CAM4 physics) indicate more realistic Arctic ice distributions and thickness than in T341 (CAM4 physics).