Evaluation of Arctic climate simulations from CCSM4, CMIP5 and RACM

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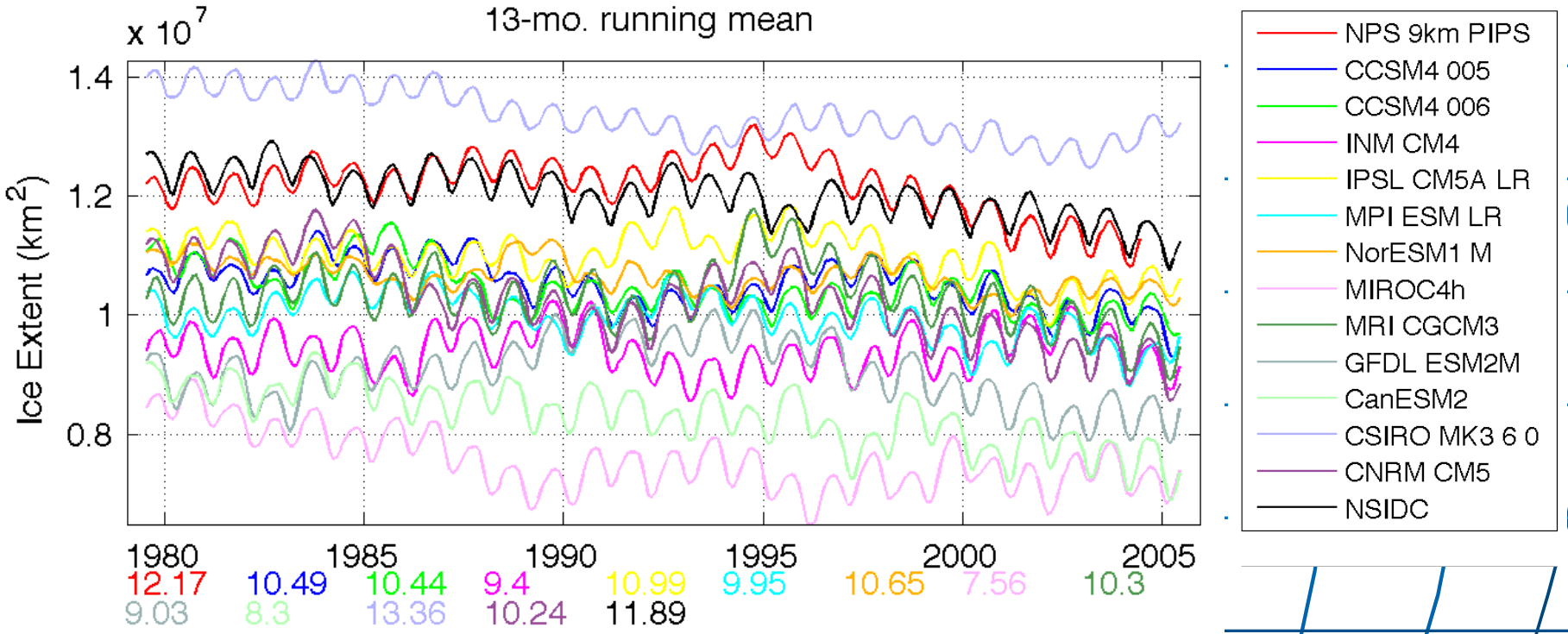
CMIP5 Ice Extent – 13-month running mean

(10^7 km^2; >15%, >0.5m)



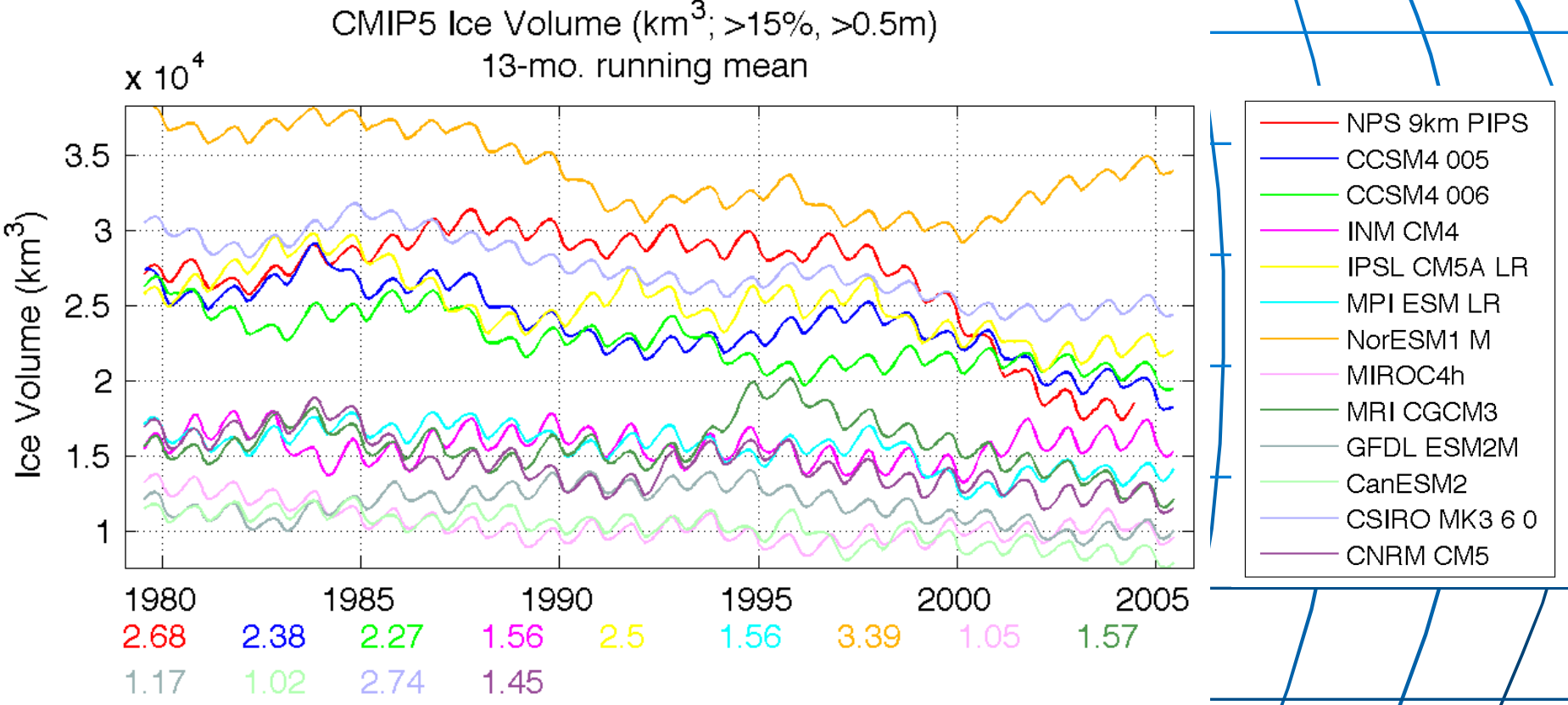
1979-2005 NSIDC mean: 11.89 mln km^2

1979-2005 mean CMIP5 range: 7.56 – 13.36 mln km^2

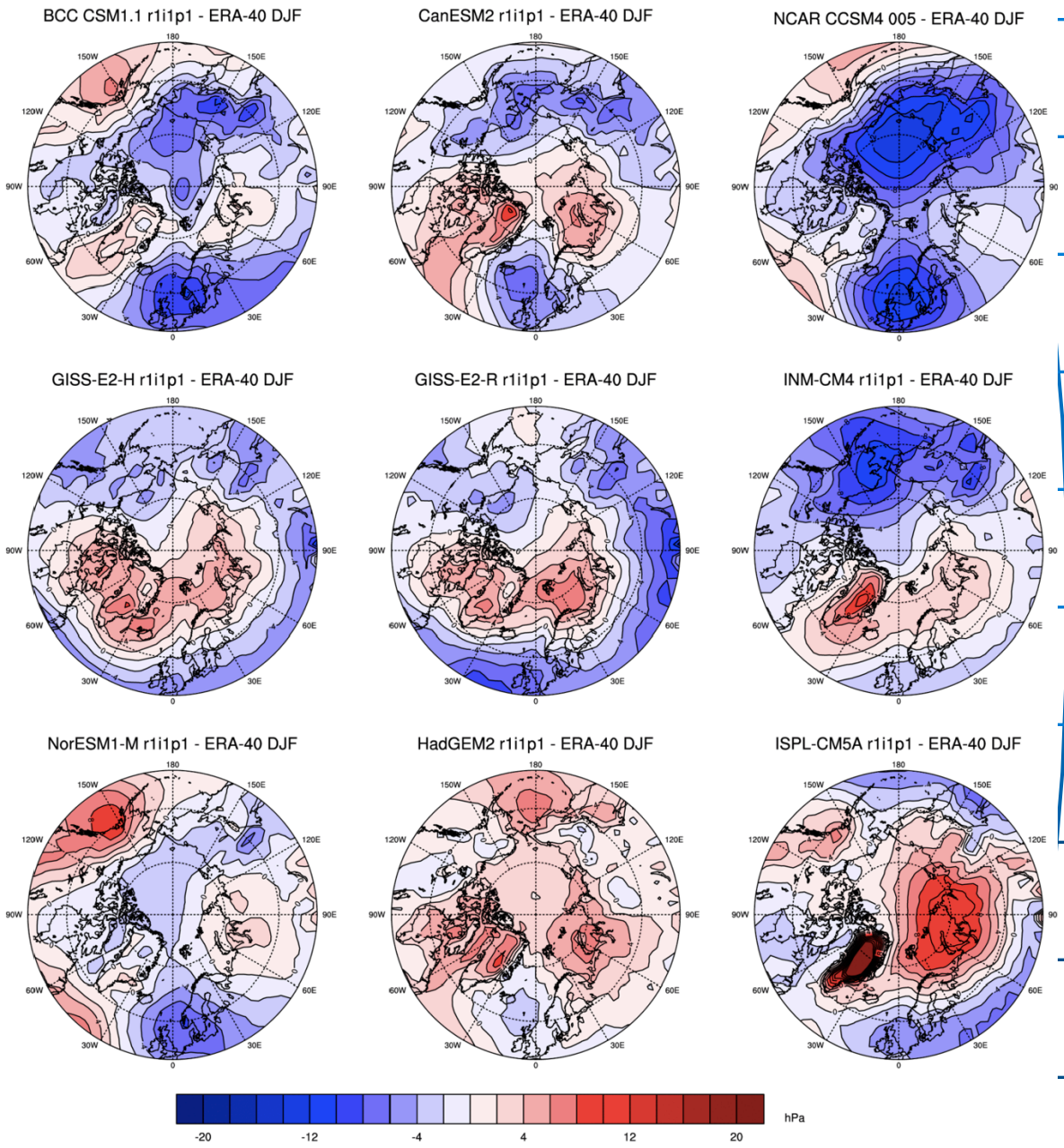
1979-2005 CCSM4 005/006: 10.49/10.44 mln km^2

CMIP5 Ice Volume – 13-month running mean

(10^4 km^3; >15%, >0.5m)

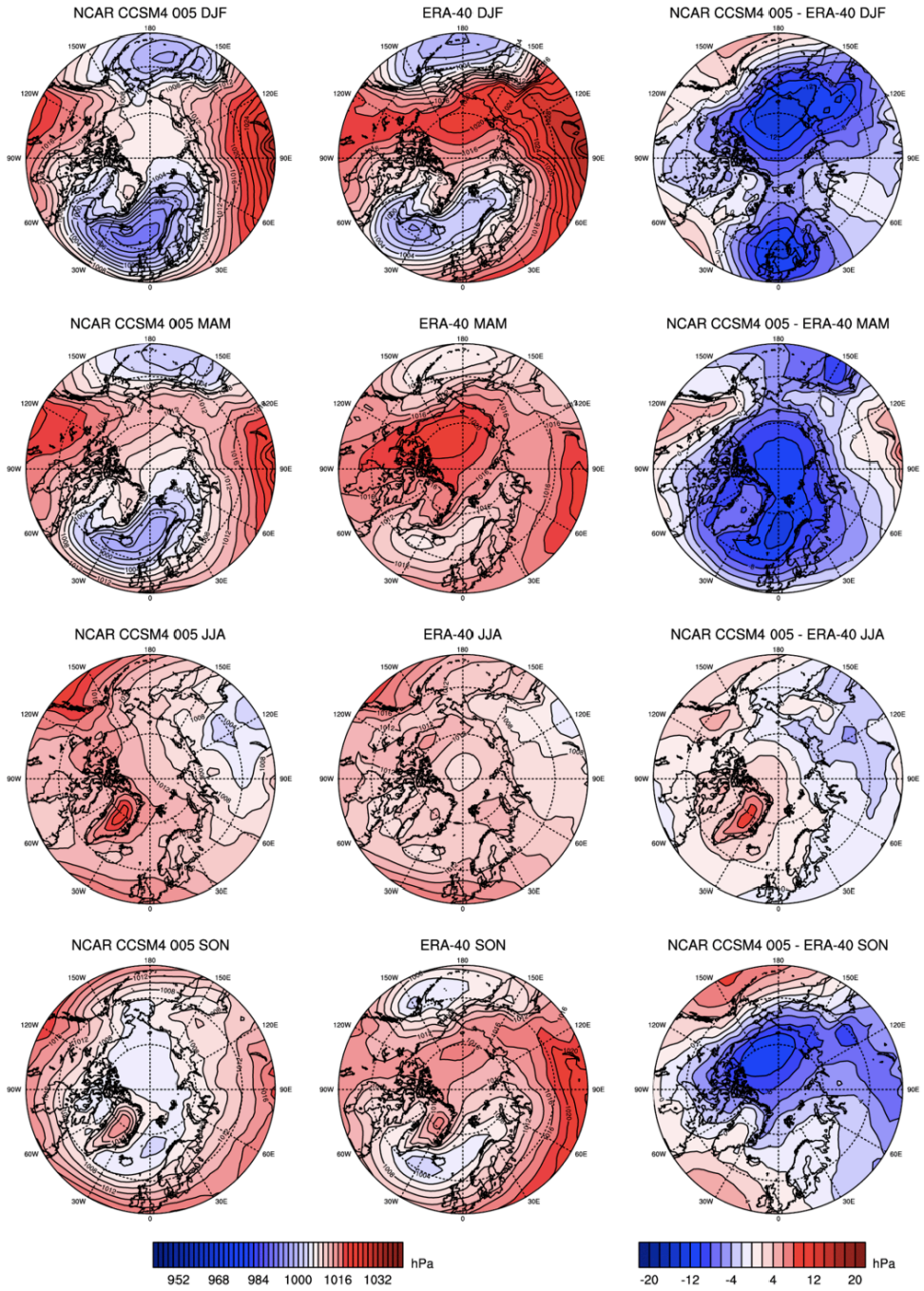


PIOMAS mean ice volume for 1979-2005 is 2.18 x 10^4 km^3



Difference in winter mean (1979-2002) SLP for nine CMIP5 GCMs and EAR-40

Maslowski et al., 2012 in press

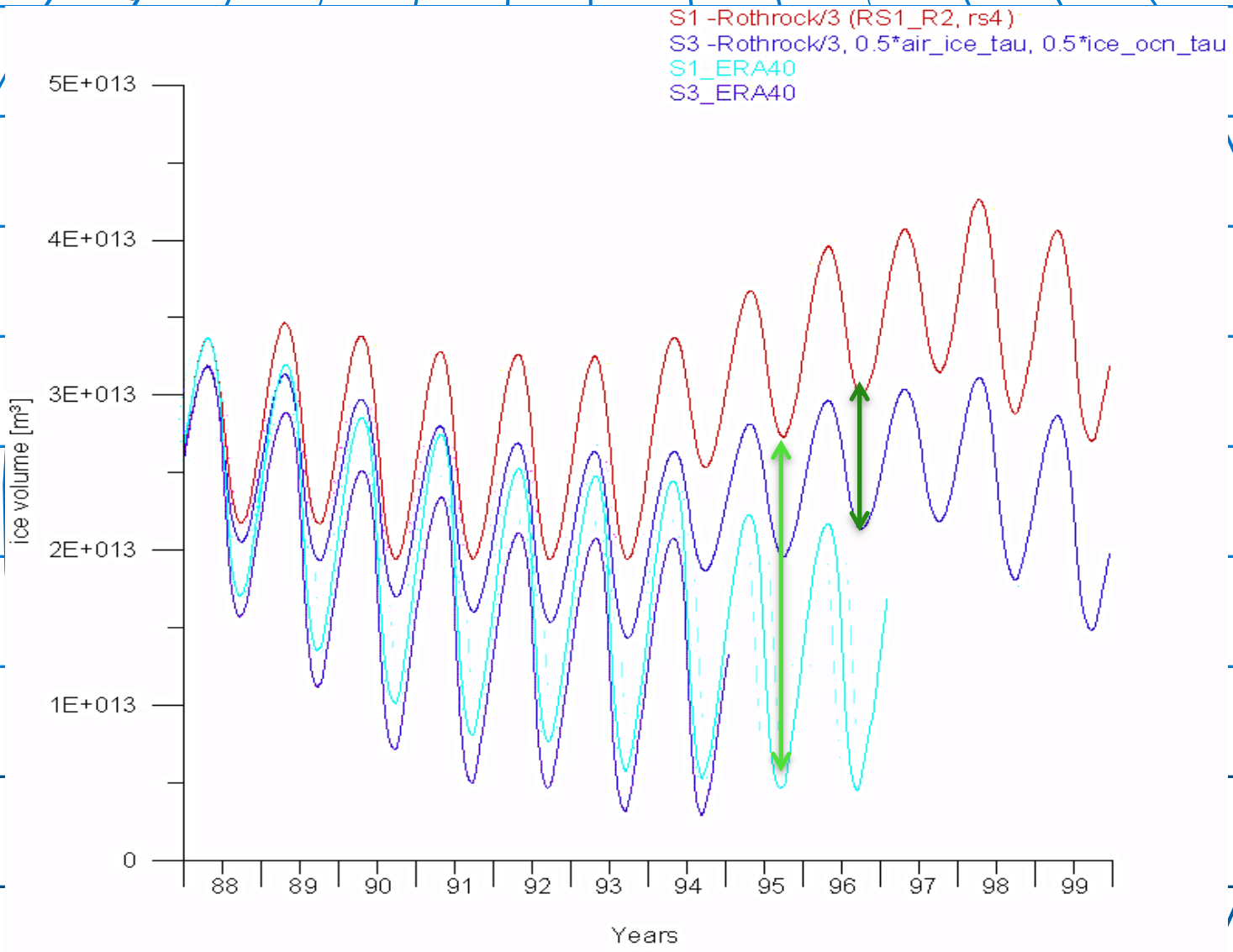


Seasonal mean (1979-2002) SLP for a CCSM4 ensemble member (left column), ERA-40 (middle) and the Difference between the two (right column).

Adopted from de Boer et al. (2012)

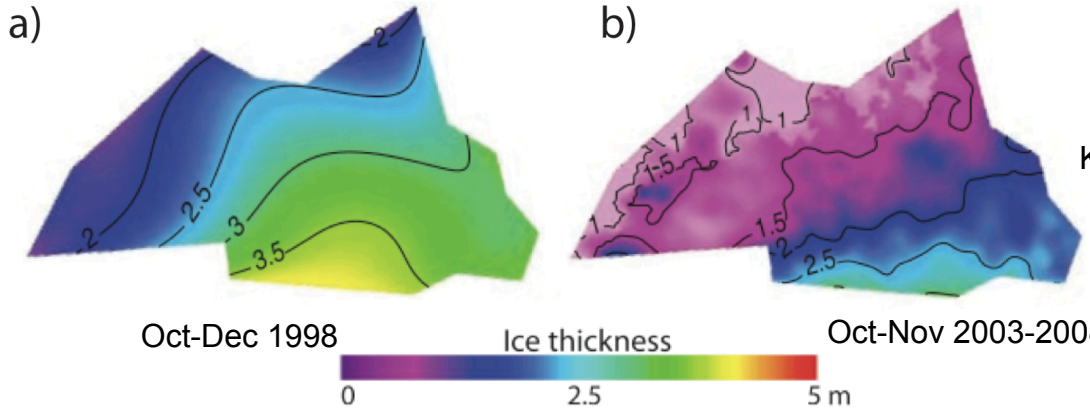
Maslowski et al., 2012 in press

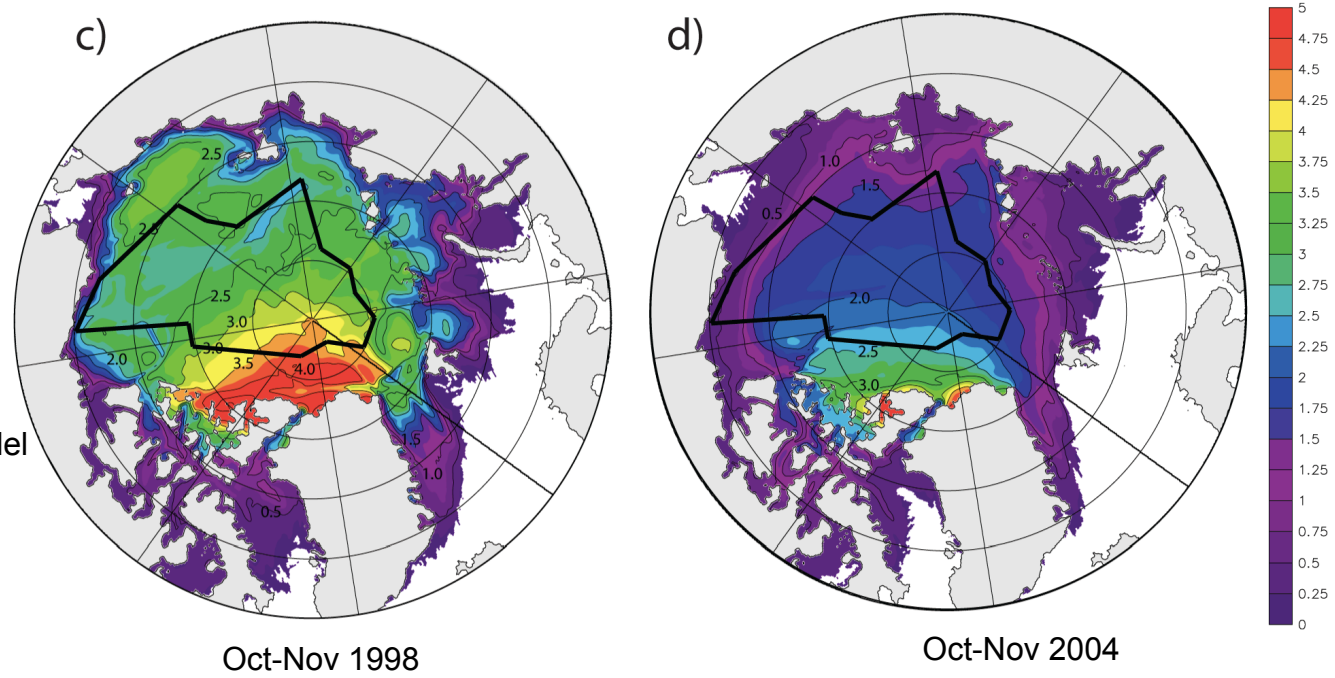
Sensitivity of modeled sea ice thickness/volume



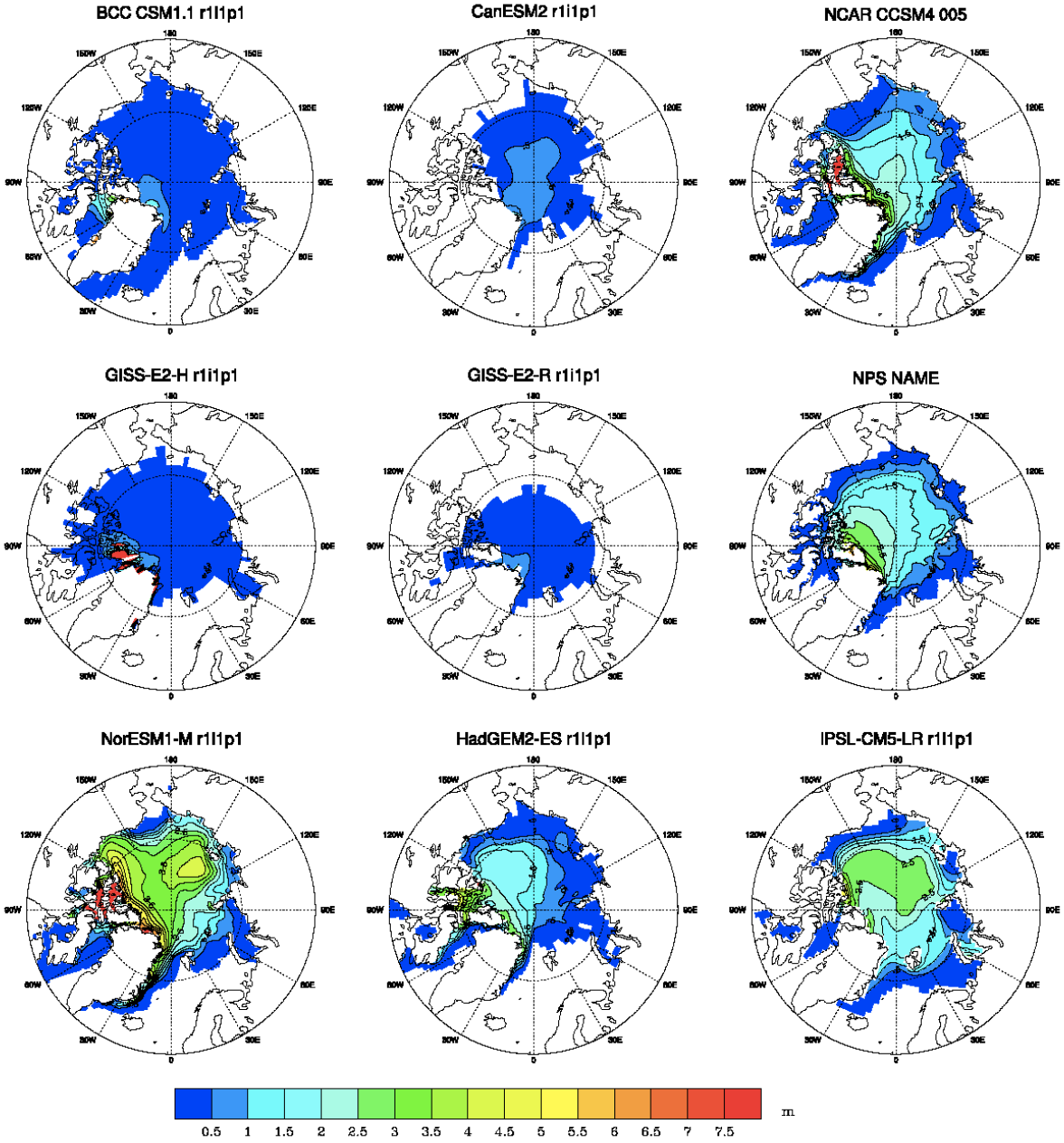
Different atmospheric forcing / sea ice parameterizations yield large changes in sea ice volume within a decade

Comparison of Arctic sea ice thickness before and after 2000





Maslowski et al., 2012 in press

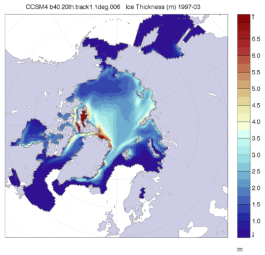


CMIP5 September mean (2000-2004) sea ice thickness (m) distribution

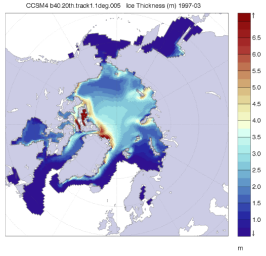
Maslowski et al., 2012 in press

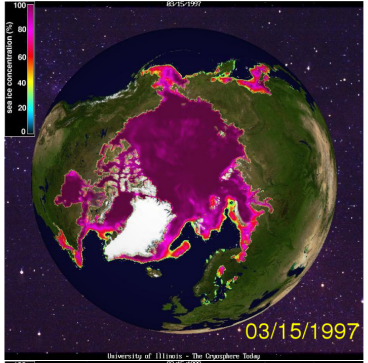
Sea Ice Thickness: CCSM4 & NPS models

CCSM4 b40.20th.track1.1deg.006
Ice Thickness Mar 1997

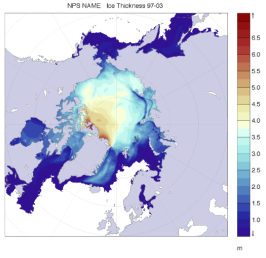


CCSM4 b40.20th.track1.1deg.005
Ice Thickness Mar 1997

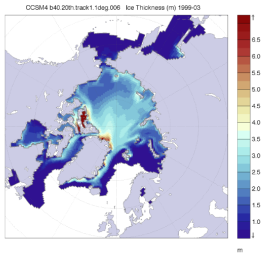




PIPS Ice Thickness Mar 1997



CCSM4 b40.20th.track1.1deg.006
Ice Thickness Mar 1999



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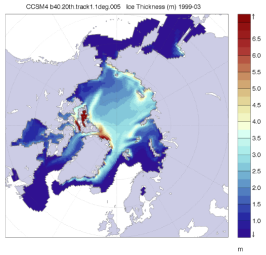
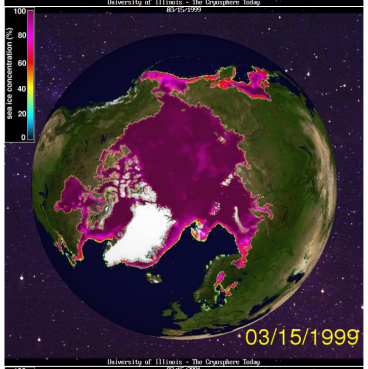
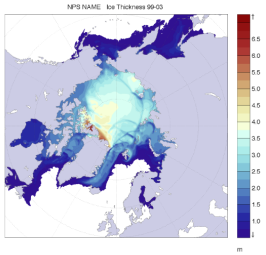
Ice Thickness Mar 1999





PIPS Ice Thickness Mar 1999



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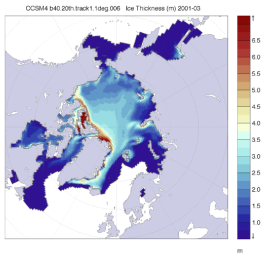
Ice Thickness Mar 2001



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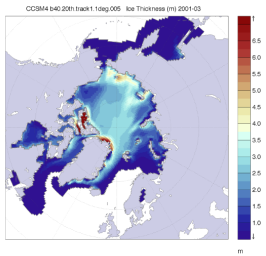
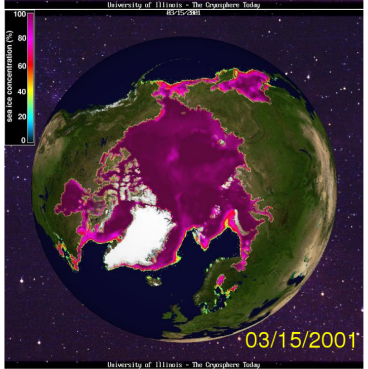
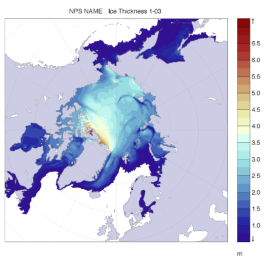
Ice Thickness Mar 2001

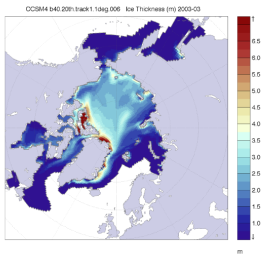




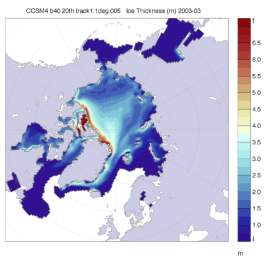
PIPS Ice Thickness Mar 2001

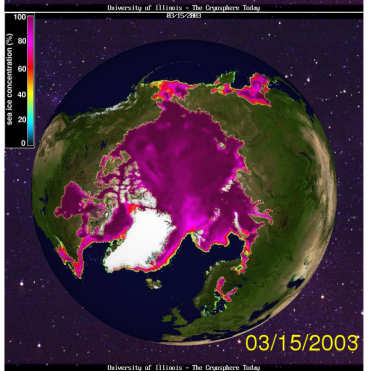


CCSM4 b40.20th.track1.1deg.006
Ice Thickness Mar 2003

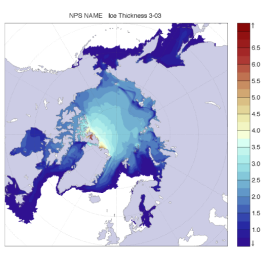


CCSM4 b40.20th.track1.1deg.005
Ice Thickness Mar 2003

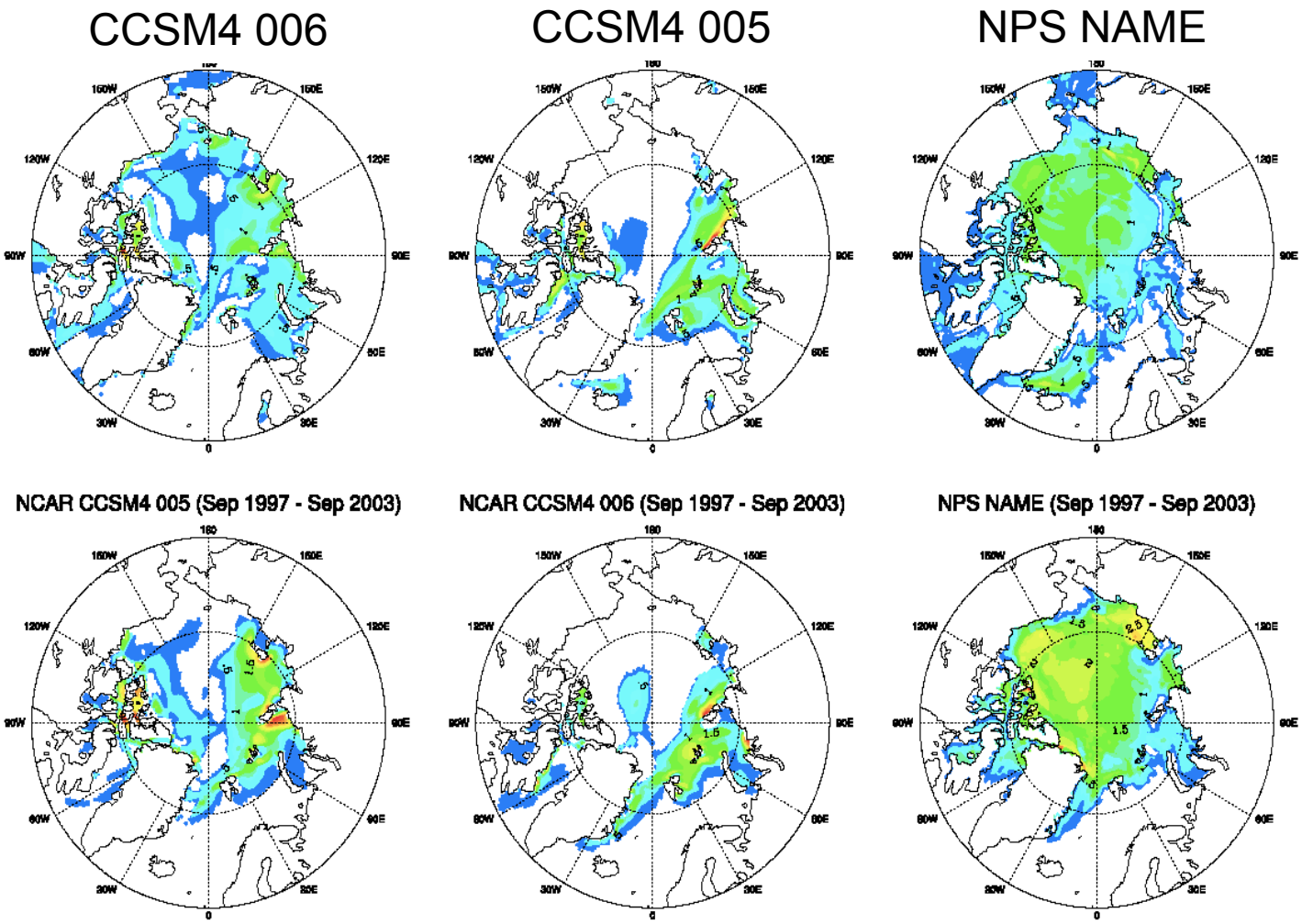




PIPS Ice Thickness Mar 2003

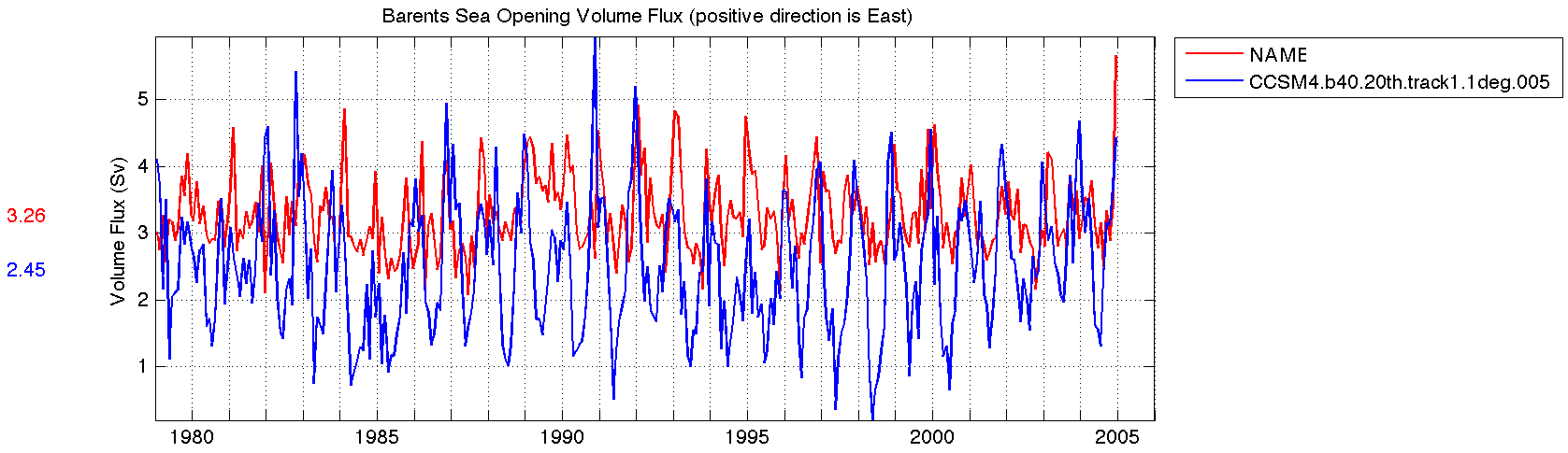


Sea Ice Thickness difference between 1997 and 2003 during March (top) and September (bottom)



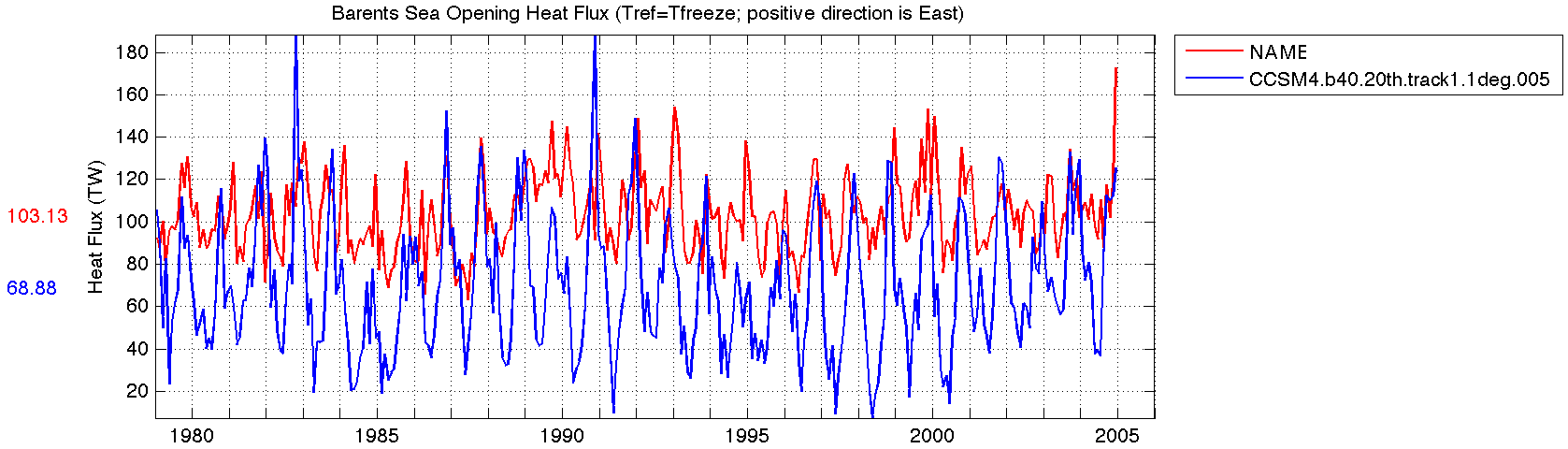
Maslowski et al., 2012 in press

Net Volume and heat flux across the Barents Sea Opening in CCSM4 and NAME models



3.26

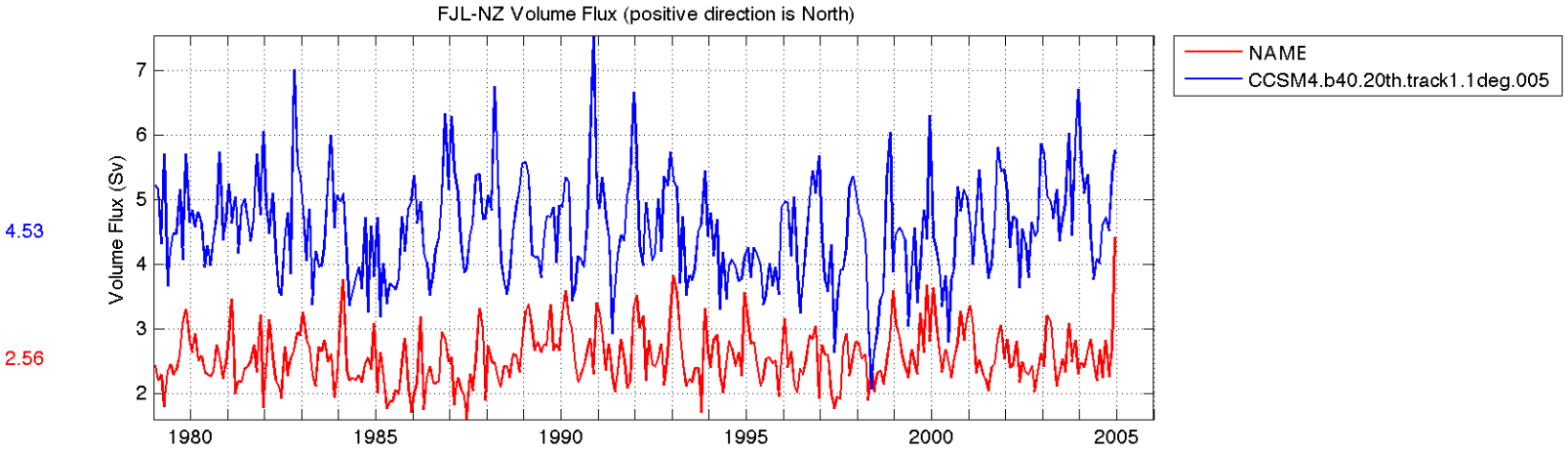
2.45

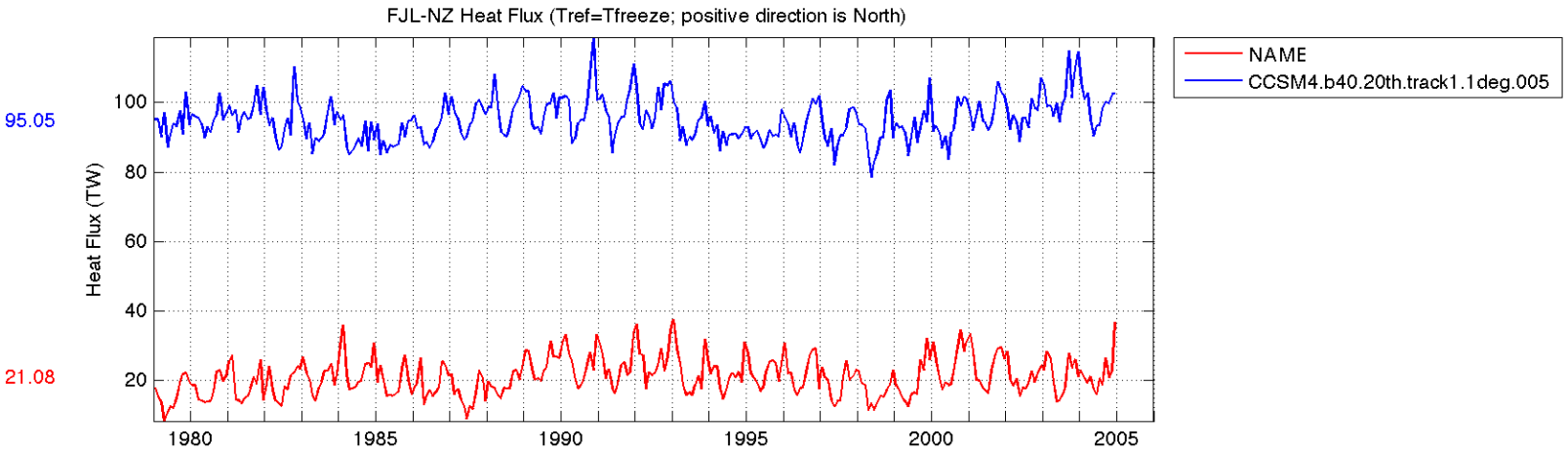


103.13

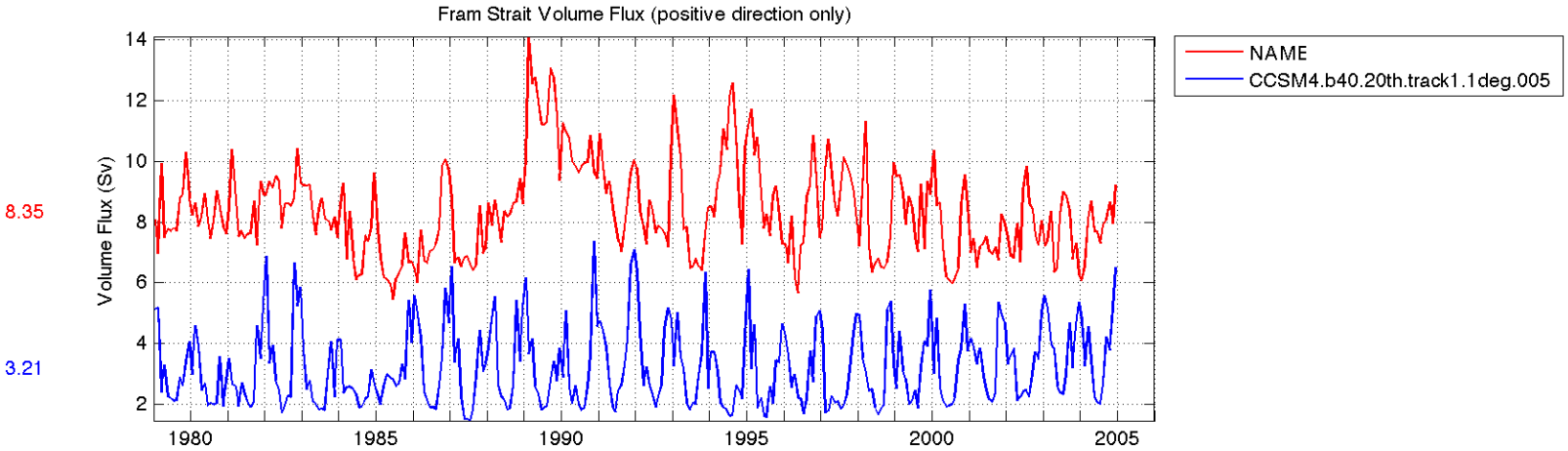
68.88

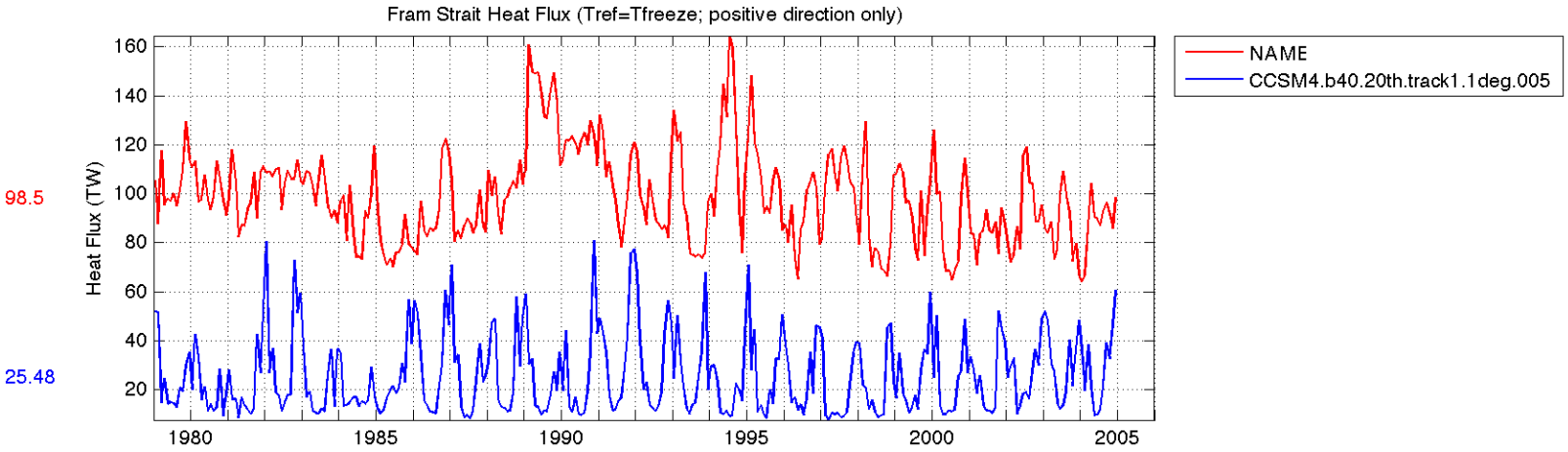
Net Volume and heat flux out from the Barents/Kara Sea in CCSM4 and NAME models



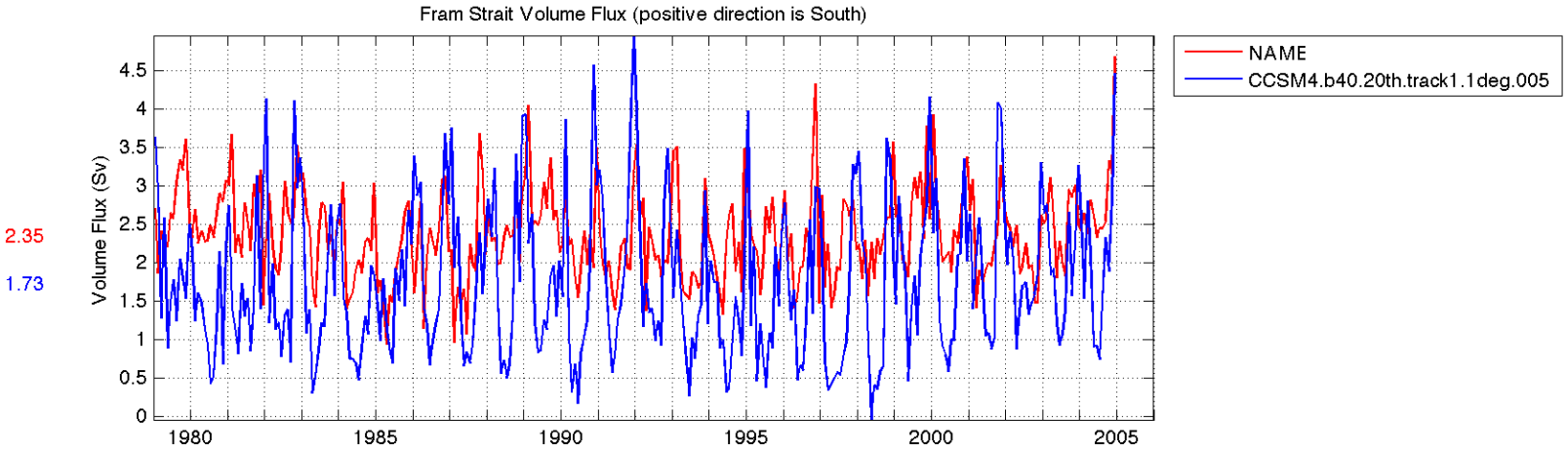


Northward Volume and heat flux through Fram Strait in CCSM4 and NAME models



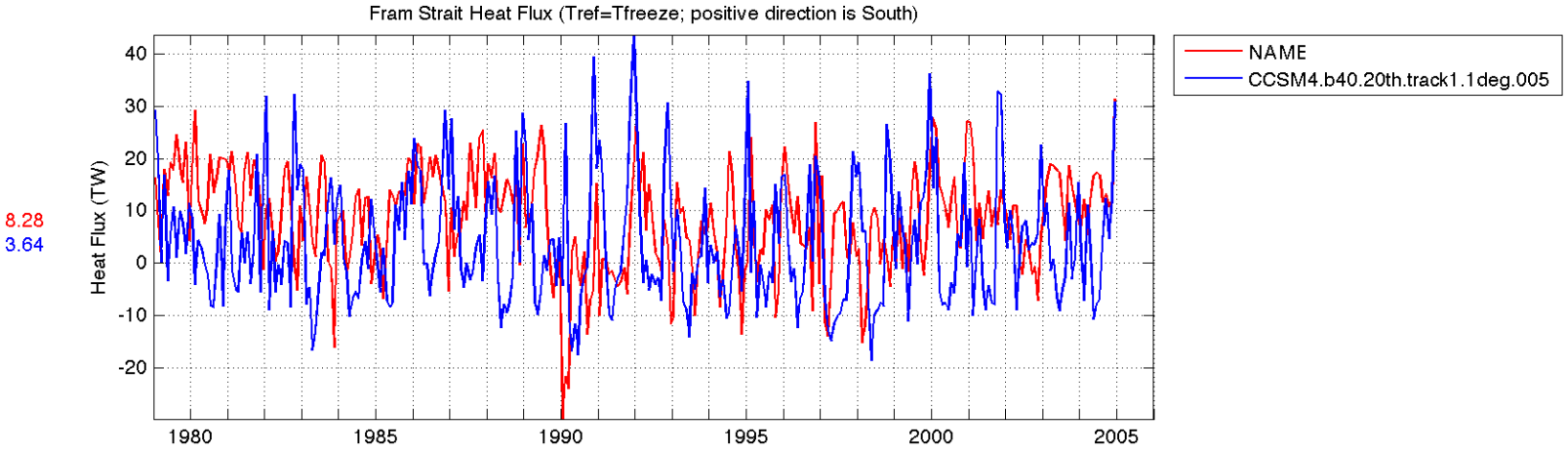


Net Volume and heat flux through Fram Strait in CCSM4 and NAME models



2.35

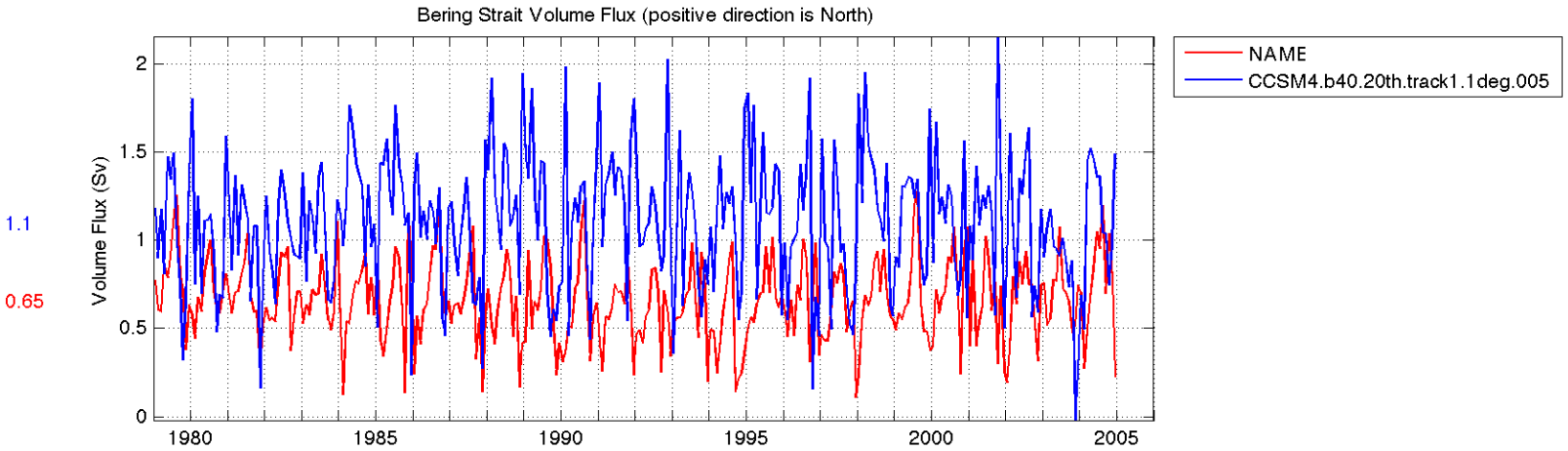
1.73

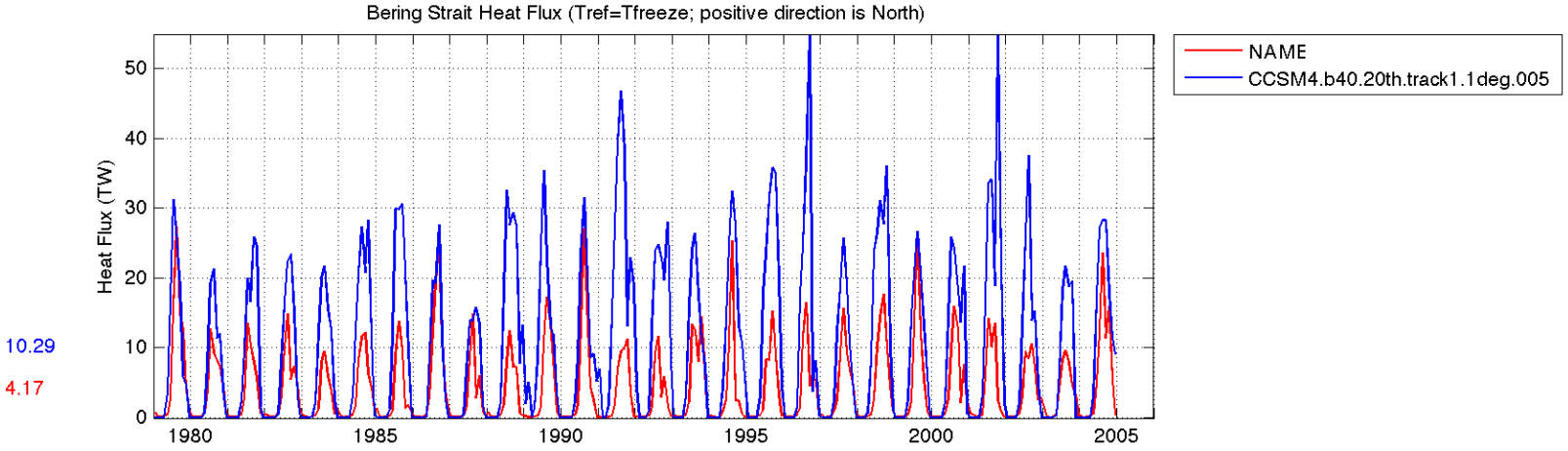


8.28

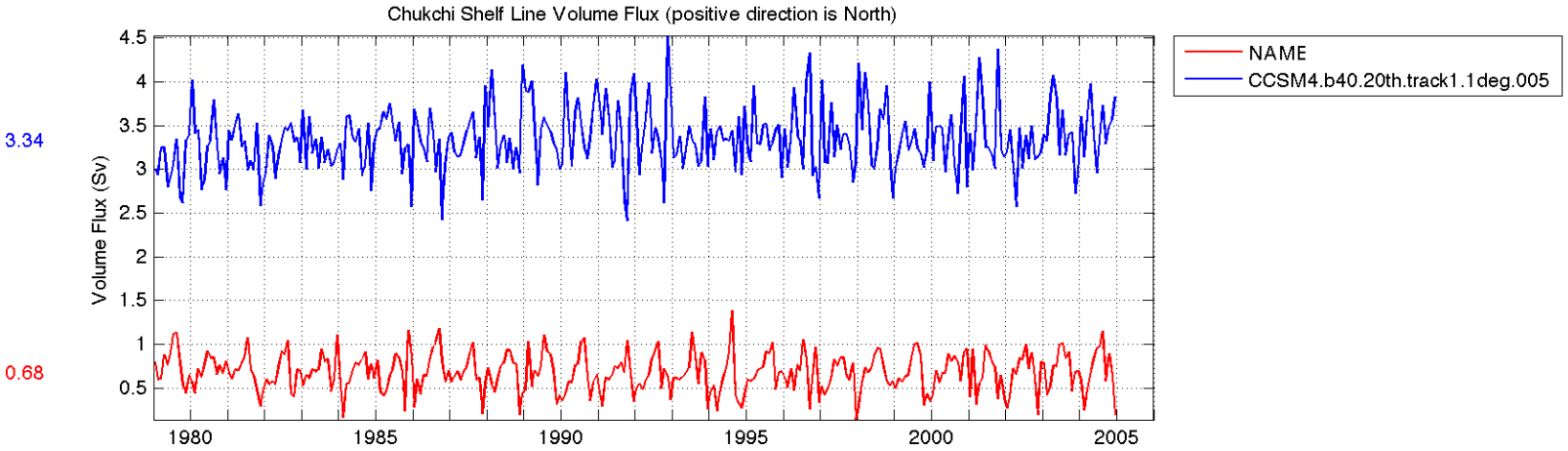
3.64

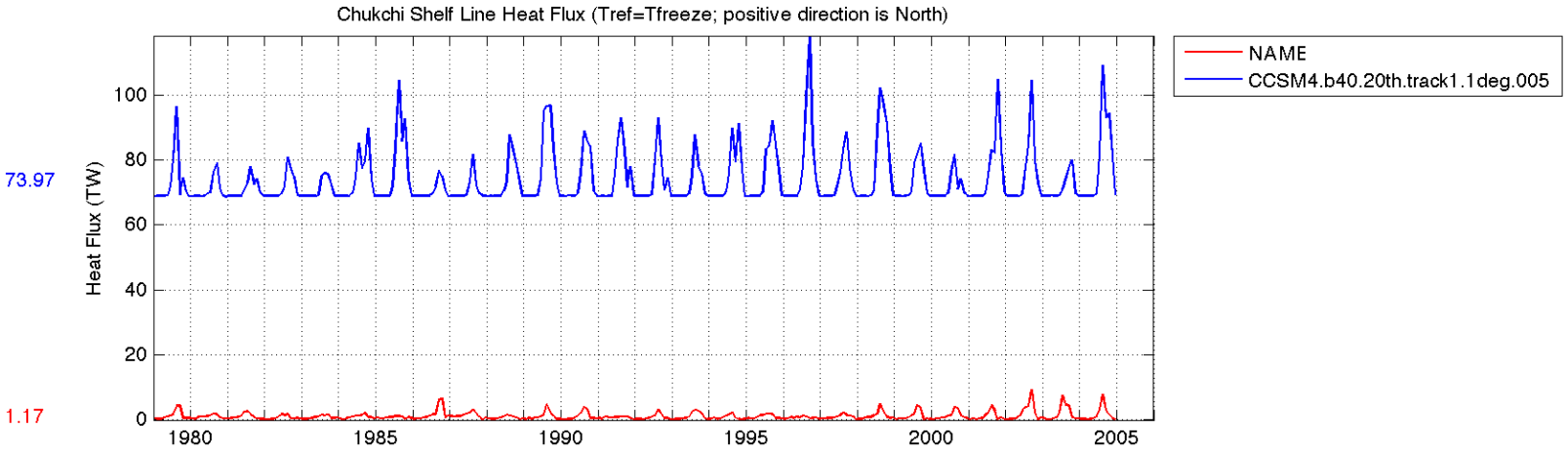
Net Volume and heat flux through Bering Strait in CCSM4 and NAME models



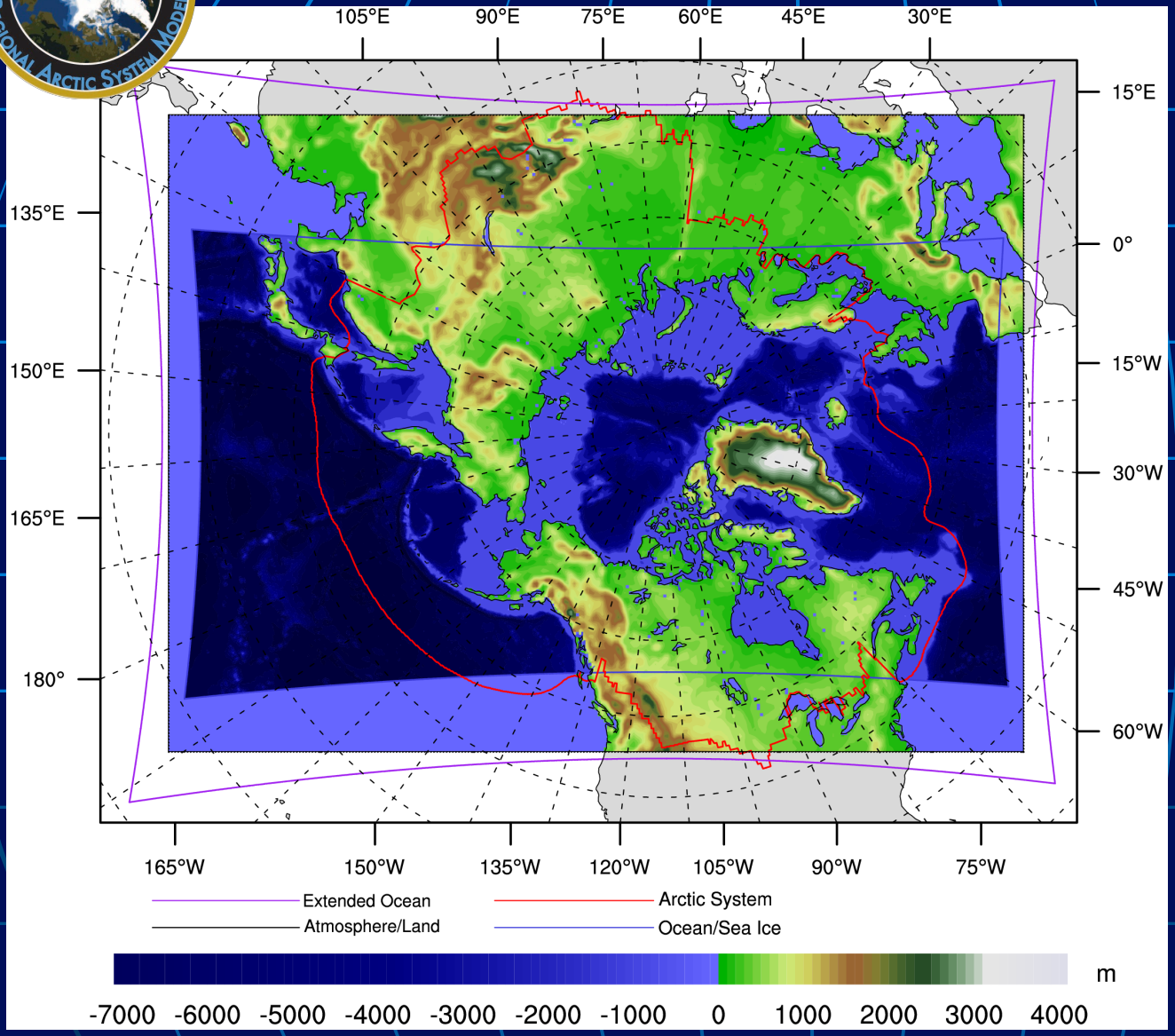


Net Volume and heat flux out from the Chukchi / East Siberian Sea in CCSM4 and NAME models





RACM/RASM Domains for Coupling and Topography



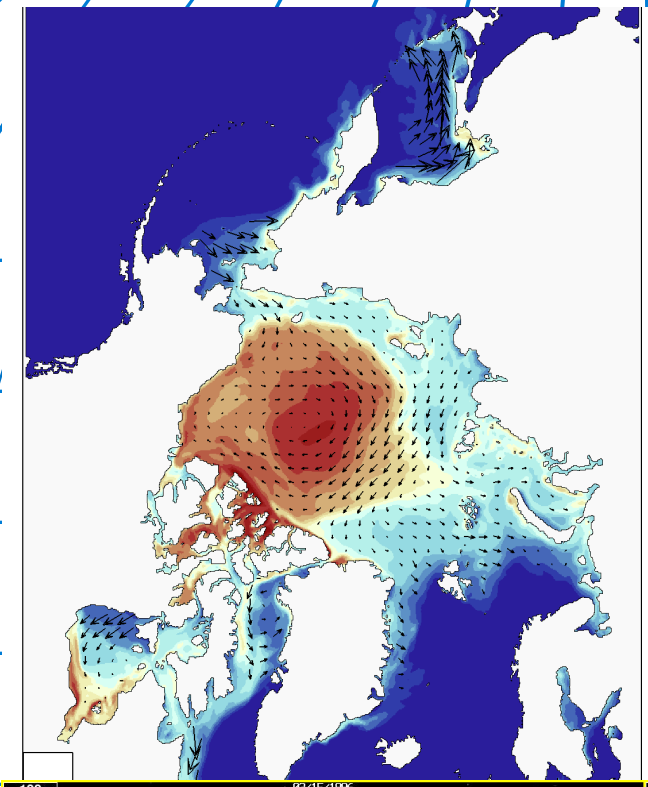
Pan-Arctic region to include:

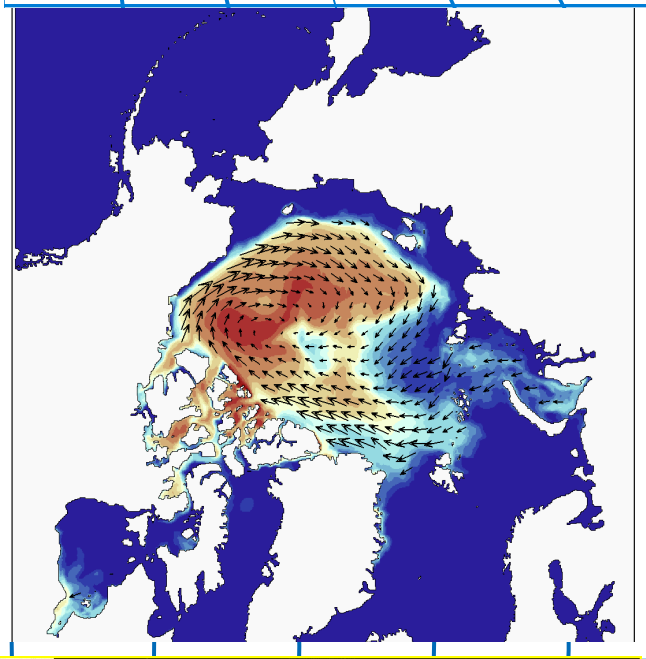
- all sea ice covered ocean in the northern hemisphere
- Arctic river drainage
- critical inter-ocean exchange and transport
- large-scale atmospheric weather patterns (AO, NAO, PDO)

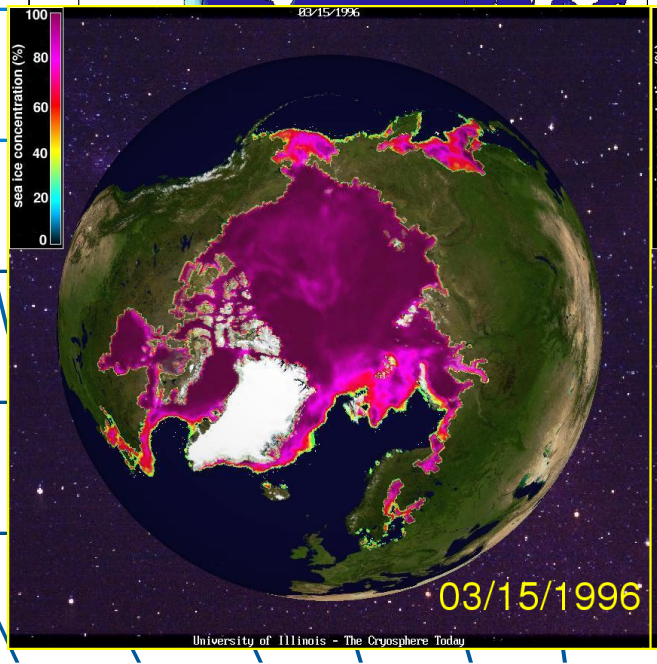
The Arctic System domain (red line) after Roberts et al. (2010).

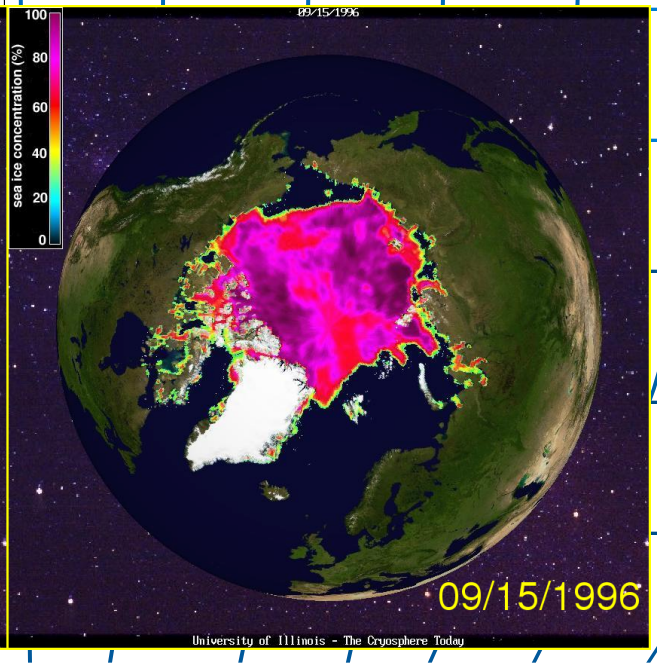
RASM pan-Arctic model domain. WRF and VIC model domains include the entire colored region. POP and CICE domains are bound by the inner blue rectangle. Shading indicates model topobathymetry.

RACM / SSM/I sea ice cover



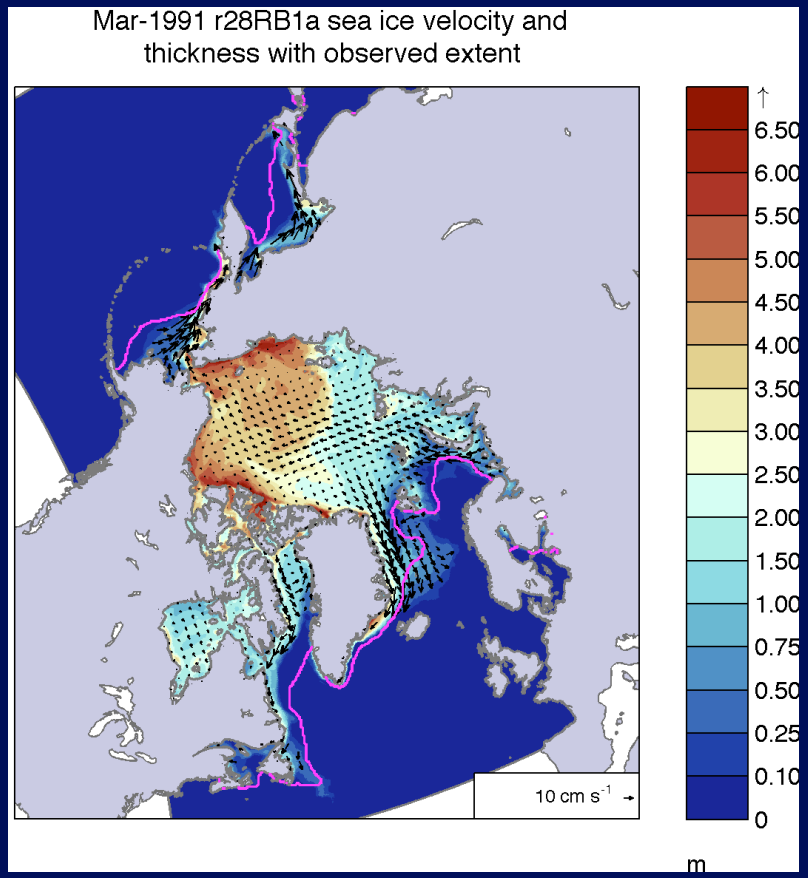




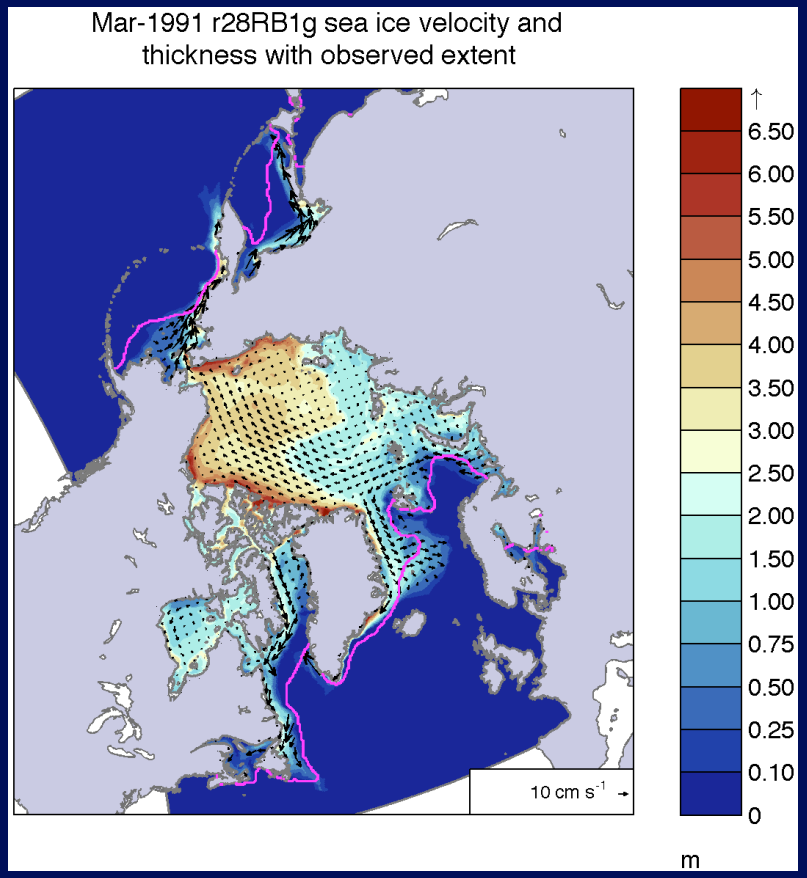


Changing EVP timestep in CICE

RACM with 20min coupling and 20 min EVP timestep



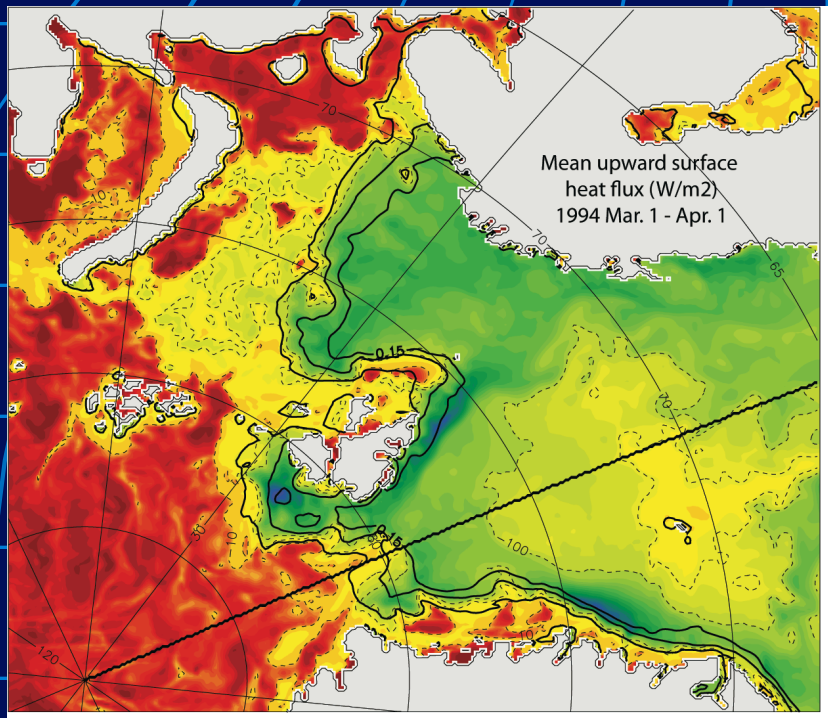
RACM with 20min coupling and 5 min EVP timestep

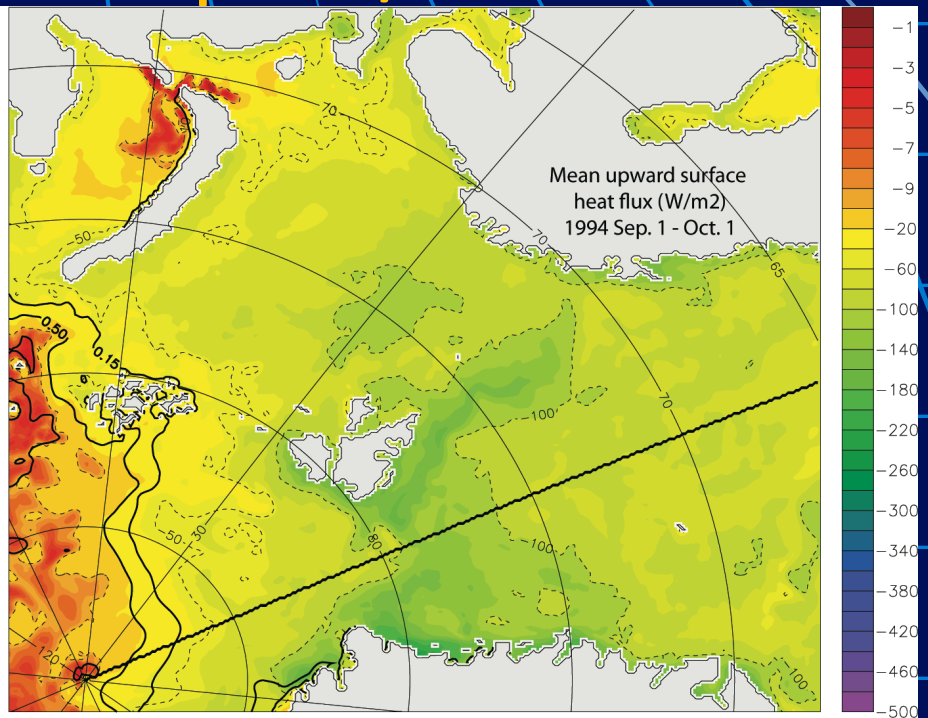


Significant improvement to sea ice thickness

Note: Ice-ocean still in spinup phase

RACM Oceanic Heat Transport / Surface Flux

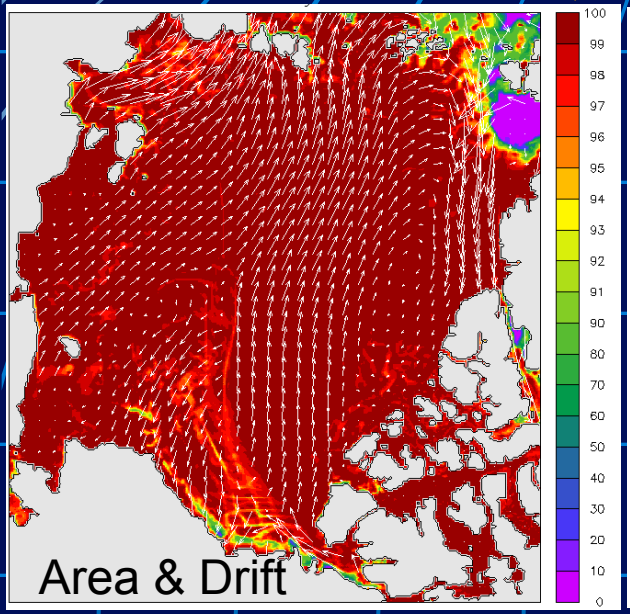


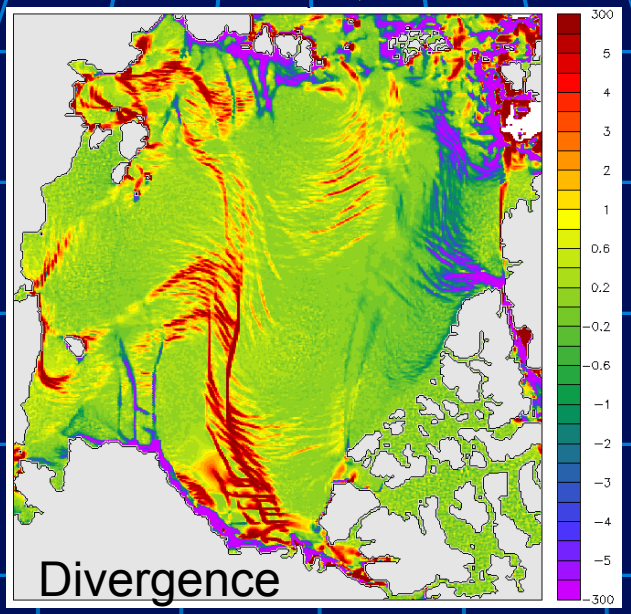


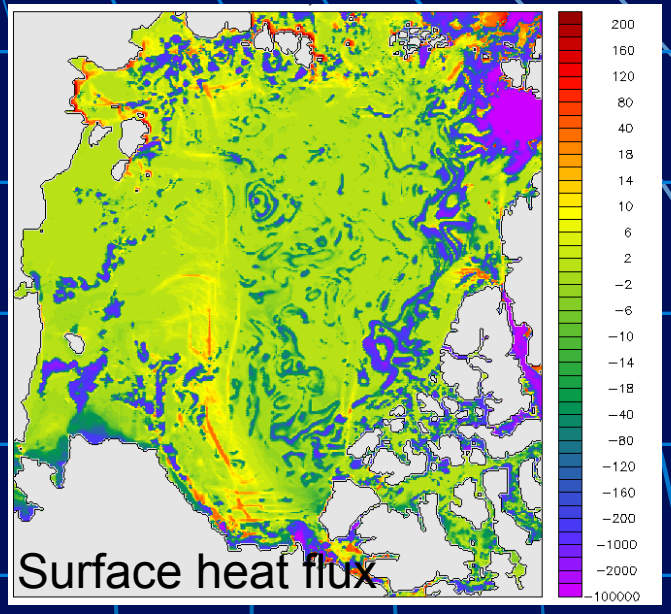
	Observations	NAME: POP/CICE	CCSM
Fram Strait (Inflow)	6.8 Sv / 36 TW	6.9 Sv / 45 TW	2.0 Sv / 17 TW
FJL – NZ (Net)	NA / Near zero	2.6 Sv / 2.2 TW	4.35 Sv / 31 TW

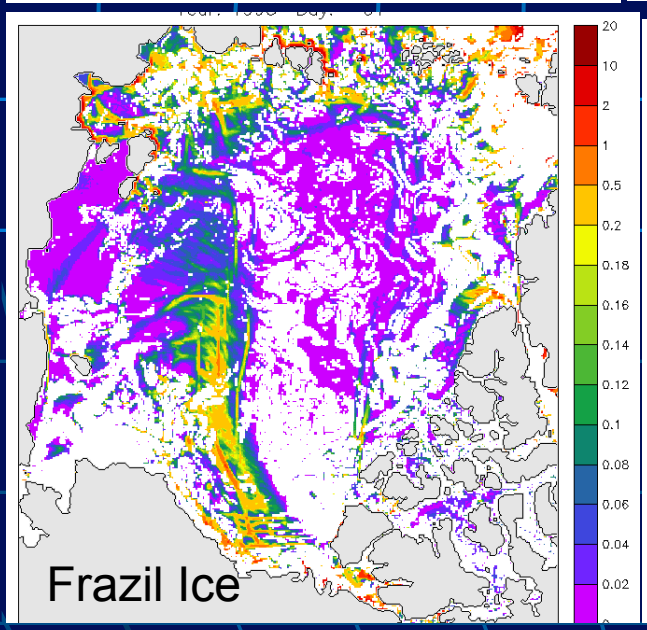
CCSM3 (b&f) transports; NAME transports (Maslowski et al., JGR, 2004)
Obs: Fram Strait – Beszczynska-Möller et al. 2011; FJL-NZ - Gammelsrod et al.,2008

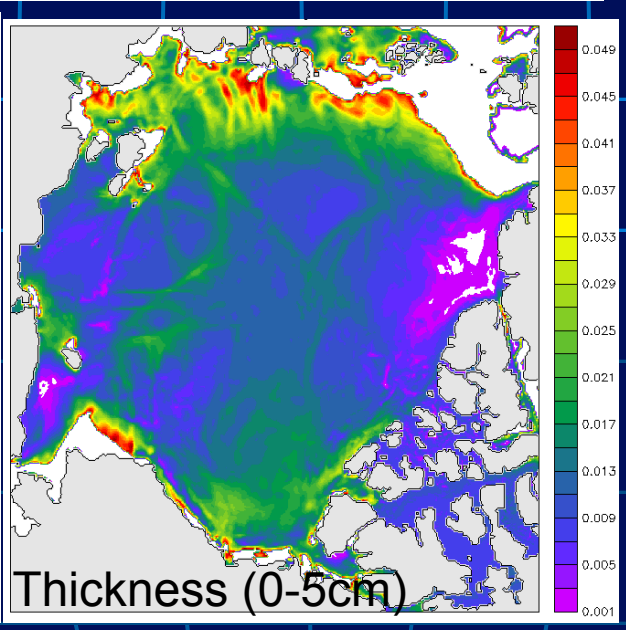
RACM sea ice drift, deformations, effect on thickness distribution

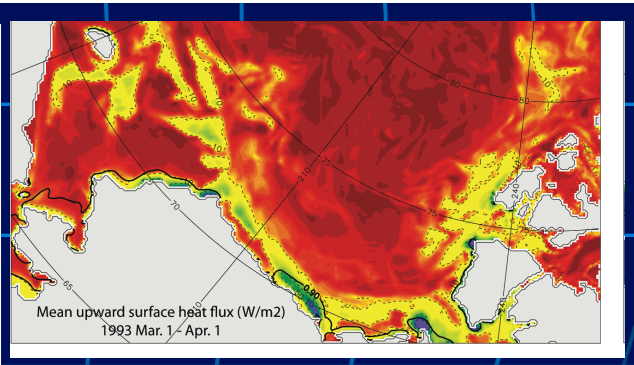


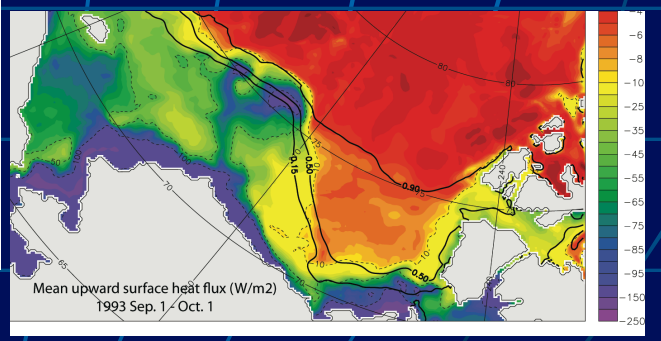












March 2, 1993, 0000Z

Summary

- CCSM4 sea ice simulations have improved (re. CCSM3)
- …but questions remain, re: e.g. arctic atmosphere
- CCSM4 sea ice thickness distribution realistic in the early 2000s but recent variability not represented
- Oceanic forcing in polar regions in CCSM4 needs improvements

- RACM has been developed and it works
- … but further evaluation / sensitivity / tuning under way
- Ice thickness distribution & variability one of the main issues for improved regional and global climate modeling … and prediction of arctic climate change