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
PIOMAS mean ice volume for 1979-2005 is $2.18 \times 10^4$ km$^3$

CMIP5 Ice Volume – 13-month running mean

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

CMIP5 Ice Volume (km$^3$, >15%, >0.5 m)

13-mo. running mean

PIOMAS mean ice volume for 1979-2005 is $2.18 \times 10^4$ 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)
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

Oct-Dec 1998

Oct-Nov 2003-2008

Kwok & Rothrock 2009

Oct-Nov 1998

Oct-Nov 2004

NPS 9-km Ice-ocn model

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

CCSM4 006

CCSM4 005

NPS NAME

NCAR CCSM4 005 (Sep 1997 - Sep 2003)

NCAR CCSM4 006 (Sep 1997 - Sep 2003)

NPS NAME (Sep 1997 - Sep 2003)

Masłowski et al., 2012 in press
Net Volume and heat flux across the Barents Sea Opening in CCSM4 and NAME models
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

Fram Strait Volume Flux (positive direction is South)

Fram Strait Heat Flux (Tref=Tfreeze; positive direction is South)
Net Volume and heat flux through Bering Strait in CCSM4 and NAME models

Bering Strait Volume Flux (positive direction is North)

Bering Strait Heat Flux (Tref=Tfreeze; positive direction is North)
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
Observations

<table>
<thead>
<tr>
<th></th>
<th>NAME: POP/CICE</th>
<th>CCSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fram Strait (Inflow)</td>
<td>6.8 Sv / 36 TW</td>
<td>6.9 Sv / 45 TW</td>
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<tr>
<td>FJL – NZ (Net)</td>
<td>NA / Near zero</td>
<td>2.6 Sv / 2.2 TW</td>
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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
• 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