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.


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.
<table>
<thead>
<tr>
<th>Run: POP-CICE (Gx1v6)</th>
<th>Experiment (all use Delta-Eddington)</th>
<th>Initial Ice</th>
<th>Surface Forcing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>“Control”</td>
<td>Prescribed initial ice.</td>
<td>CORE IAF</td>
</tr>
<tr>
<td></td>
<td>rsnw_melt_in=1500 dT_melt_in=1.5</td>
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<tr>
<td><strong>B</strong></td>
<td>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</td>
<td>Prescribed initial ice.</td>
<td>CORE IAF</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>rsnw_melt_in=1000 dT_melt_in=1.0</td>
<td>Prescribed initial ice</td>
<td>CORE IAF</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>Seasonal cycle adjustments to LWDN and air temp in Arctic in data atm. &amp; rsnw_melt_in=1000 dT_melt_in=1.0</td>
<td>Prescribed initial ice</td>
<td>CORE IAF</td>
</tr>
</tbody>
</table>
Ice Thickness (m): POP-CICE gx1v6 for 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

(A) “Control”
(B) Data atm. changes.
(C) D-E changes
(D) Data atm. changes +D-E changes
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.
Feb-Mar 1989-1993

0.1° POP/CICE

Oct-Nov 1989-1993

IceSAT

Model-Obs
0.1° POP/CICE

Feb-Mar 1989-1993

Oct-Nov 1989-1993

SSM/I

Model-Obs
Ice Drift (LHS) and Volume Dynamic (upper) and Thermodynamic (lower) Ice Tendencies for Feb-Mar 1989-1993 from 0.1° POP/CICE.
North. Hem. Ice Drift Buoy Data 1990-1993

North. Hem. 0.1° POP/CICE Ice Drifts 1990-1993
Co-located/coincident with buoy data

NH: <80°N

NH: <80°N
Meridional Overturning Circulation (Sv): 0.1° POP/CICE

(b) tx0.1v2: GL. MOC (Sv) YY1989–1993

(d) tx0.1v2: ATL. MOC (Sv) YY1989–1993
Both use D-Edd standard settings.

Both initialized from 0.1° POP/CICE.

Ice Thickness (m)

ne120_f02_t12_B1850a (FM) 0006-0010

Ice Sat (FM) 2001-2005

Ice Thickness (m)

t341f02.B1850dEdd (FM) 0007-0011

Ice Sat (FM) 2001-2005
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: $dT_{mlt\_in}=1$, $Rsnw_{mlt\_in} = 1000 \mu m$ 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).