The influence of new sea ice radiation physics and associated capabilities in CCSM4

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New Solar Radiation parameterization introduced in 2007

Better physics:

• makes use of inherent optical properties to define scattering and absorption snow, sea ice and included absorbers

More flexible

• Explicitly allows for included absorbers (black carbon, dust, algae, ponds, etc.)
New radiative transfer allows for (requires) melt pond parameterization

- Only influences radiation
- Pond volume depends on surface meltwater, assuming a runoff fraction
New radiative transfer allows for:

**Included absorbers**

- Aerosol deposition and cycling now included.
- Account for black carbon and dust which are deposited and modified by melt and transport.
What is influence of new SW capabilities on CCSM4 Polar Climate?

<table>
<thead>
<tr>
<th>Model Simulation</th>
<th>CO2 level</th>
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<tbody>
<tr>
<td>Control</td>
<td>1xCO2</td>
</tr>
<tr>
<td>No Aerosols</td>
<td>1xCO2</td>
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<tr>
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SOM integrations at 2°/gx1, ~60 Years in length
Control Integrations (2$^\circ$/gx1 SOM)

**Annual Mean Ice Thickness**

2XCO2  

1XCO2  

**JFM Ice Concentration**

2XCO2  

1XCO2
Control Integration - Pond Simulation

1X CO2 Run

July

August

2X CO2 Run

July

August
Assessing radiative impacts of ponds/aerosols

• New diagnostics available to quantify radiative impacts

• Extra DE radiation computations performed which excludes ponds or excludes aerosols (for each category and surface type, so increases computational expense)

• New history file variables saved (*_noaero and *_nopond variables) from these computations
Radiative impact of ponds in control runs

Ponds result in 5-10 W/m² increase in SW absorption over Arctic basin for July

Pond impact is larger in 2XCO₂ simulation.
- More surface melting results in increased pond volume

Difference in July Ice Albedo due to Ponds
For 2xCO₂ run
Radiative impact of aerosols (in control runs)

Using 1850 Aerosol deposition,
- albedo impact is small
- <1 W/m² increase in absorbed SW

Aerosol impact is larger in 1XCO₂ simulation.
- Less surface melt results in less meltwater scavenging of aerosols.
Influence of ponds on simulated sea ice

Control Runs (2^0/9x1 SOM)

Model Runs
No Ponds & Aerosol Run Minus No Aerosol Run

Annual Ice Thickness

(1XCO2) (2XCO2)
Influence of aerosols on simulated sea ice

Annual Ice Thickness

Control Runs (2°/g×1 SOM)

Model Runs No Aerosol Run Minus Control
Conclusions

• We are assessing the influence of new SW and its associated capabilities in CCSM4 runs
• Ponds account for ~5-10 W/m2 increased SW absorption in control runs
• Aerosols account for <1 W/m2 increased SW absorption
• Influence is larger when coupled feedbacks are allowed
• Since influence varies depending on climate state, the pond/aerosol impact could affect the albedo feedback
Influence of ponds on simulated sea ice

(1XCO2) (2XCO2)

JAS Ice Concentration

Control Runs
(2°/g×1 SOM)

Model Runs
No Ponds & Aerosol Run
Minus No Aerosol Run
Influence of aerosols on simulated sea ice

JAS Ice Concentration

Control Runs
(2°/g×1 SOM)

Model Runs
No Aerosol Run Minus Control
Implications for albedo feedback