Impact of Melt Ponds and Delta-Eddington Shortwave Radiation in CCSM: Towards CCSM 4.0

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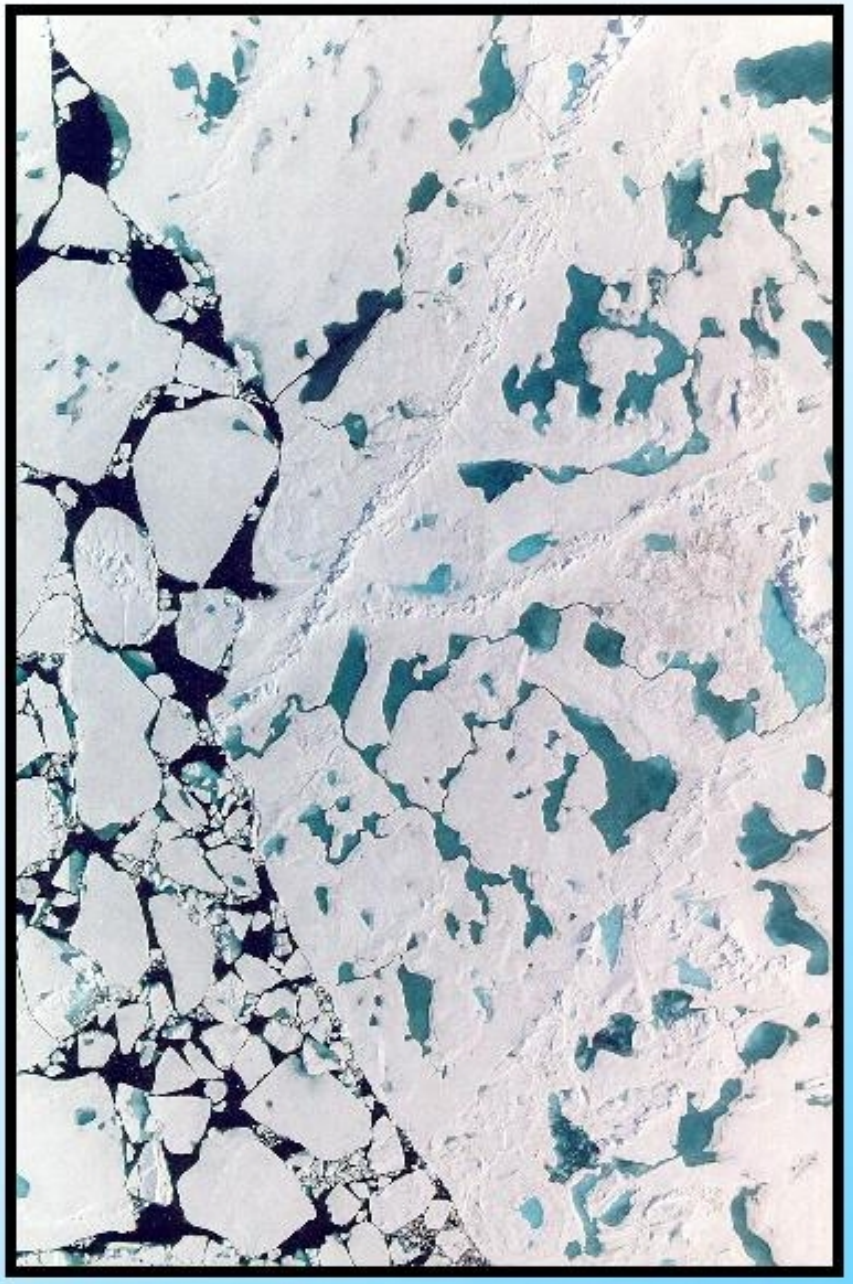
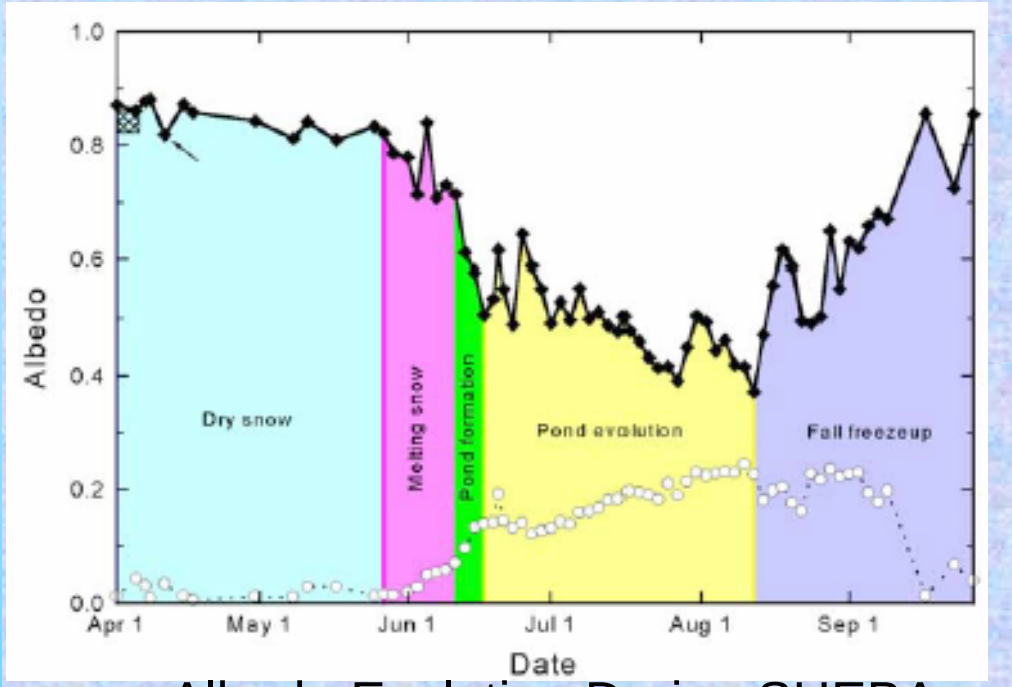
PCWG plans for CCSM 4.0

- CICE 4.0 ✓
- Delta-Eddington shortwave ✓
- Melt ponds ✓
- Snow-aging / snow model ?



Sea Ice Melt Ponds

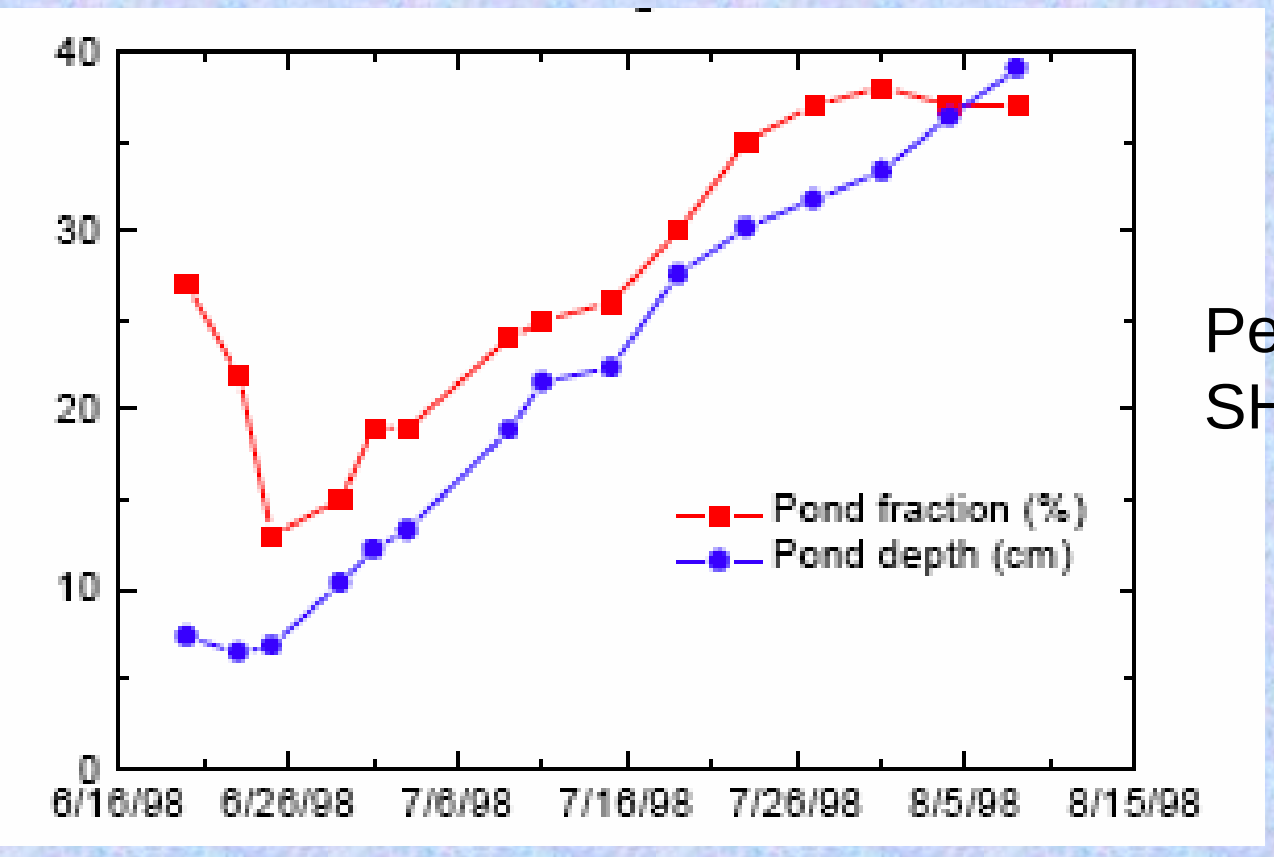
- Ponds are prevalent on sea ice
- Influence surface albedo and ice mass budget
- Code has been added to explicitly simulate melt ponds and their albedo effects



Albedo Evolution During SHEBA
(Perovich et al. 2002)

Melt Pond Parameterization

- Accumulate 10-15% of snow and surface ice melt into pond volume.
- Compute pond area/depth from simple empirically-based relationship.
- Currently no change in fresh-water exchange.
- Pond volume is advected as a CICE tracer.
- Change in albedo depends on pond fraction and / or depth.



Perovich et al. 2003
SHEBA observations

Pond Volume = Pond Fraction X Pond Depth

Pond Depth = 0.8 X Pond Fraction

Delta-Eddington Shortwave Radiation

- Briegleb and Light, 2007.
- New shortwave radiation scheme that computes albedos based on inherent optical properties of sea ice, snow, and ponds.
- Albedos are “tuned” by adjusting snow and ice properties based on a standard deviation from SHEBA observations and offline RT calculations.

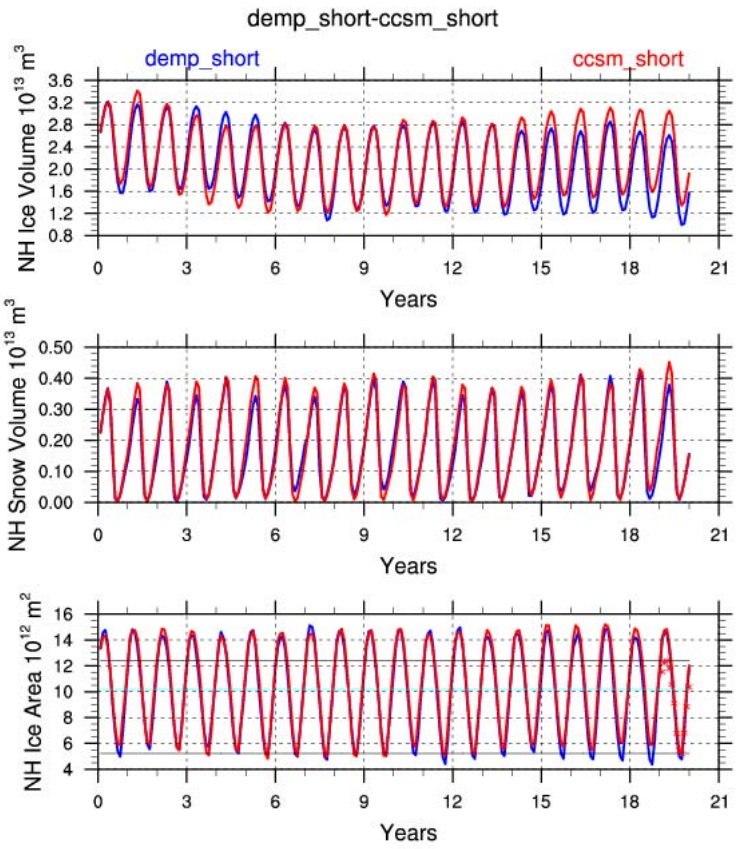
Previous Experiments

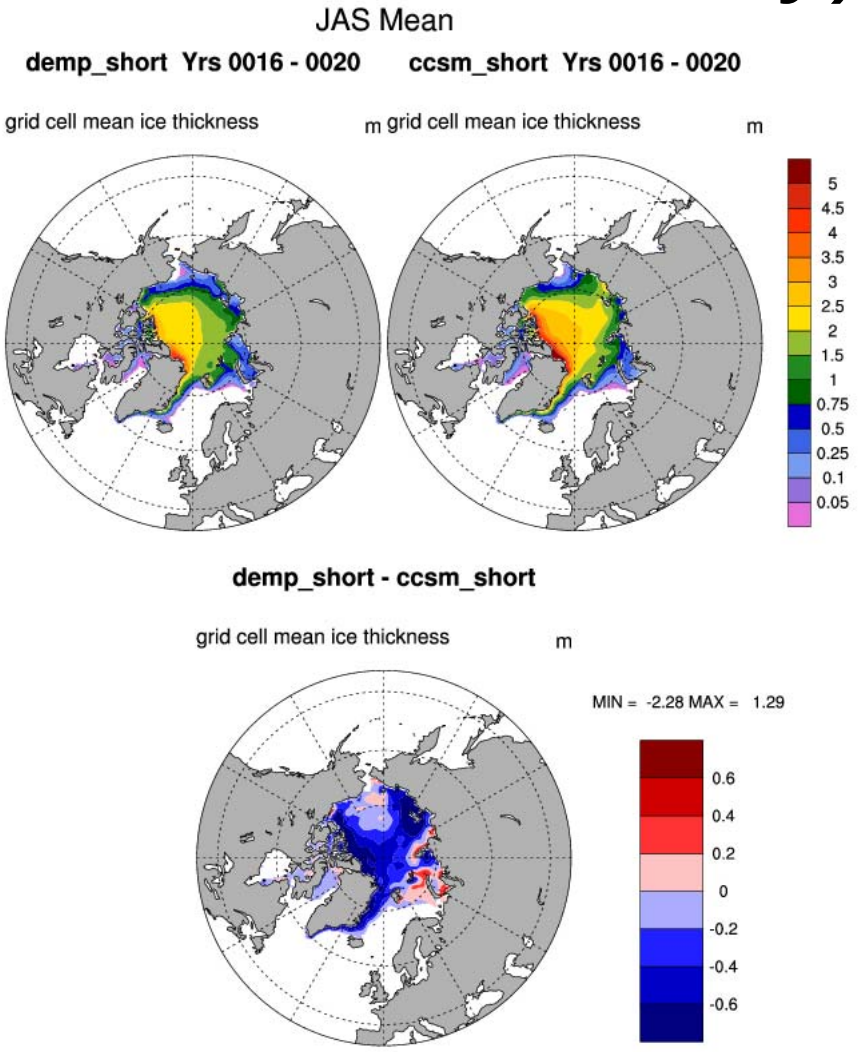
- CCSM 3.0 experiments with and without melt ponds showed a strong sensitivity to the prescribed runoff fraction.
- DE requires a melt pond fraction and depth (prescribed by default).
- Experiments comparing DE vs CCSM shortwave (without explicit ponds) showed generally thinner ice.

CCSM 3.5 Experiments (atm-ice-som)

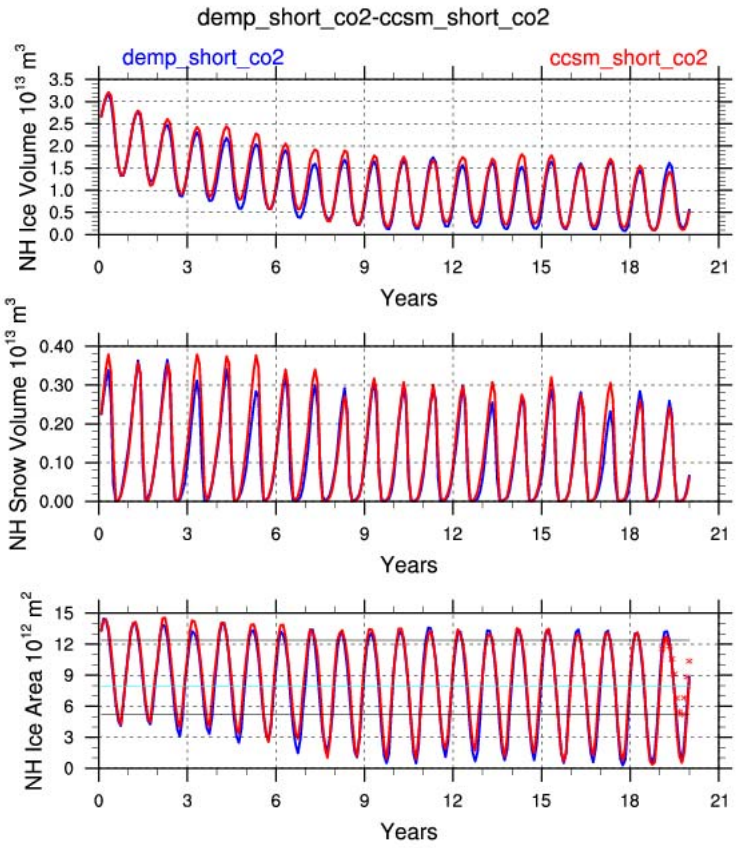
	1 x CO2	2 x CO2
No MP	ccsm_short	ccsm_short_co2
MP	demp_short demp_short2	demp_short_co2 demp_short_co2b

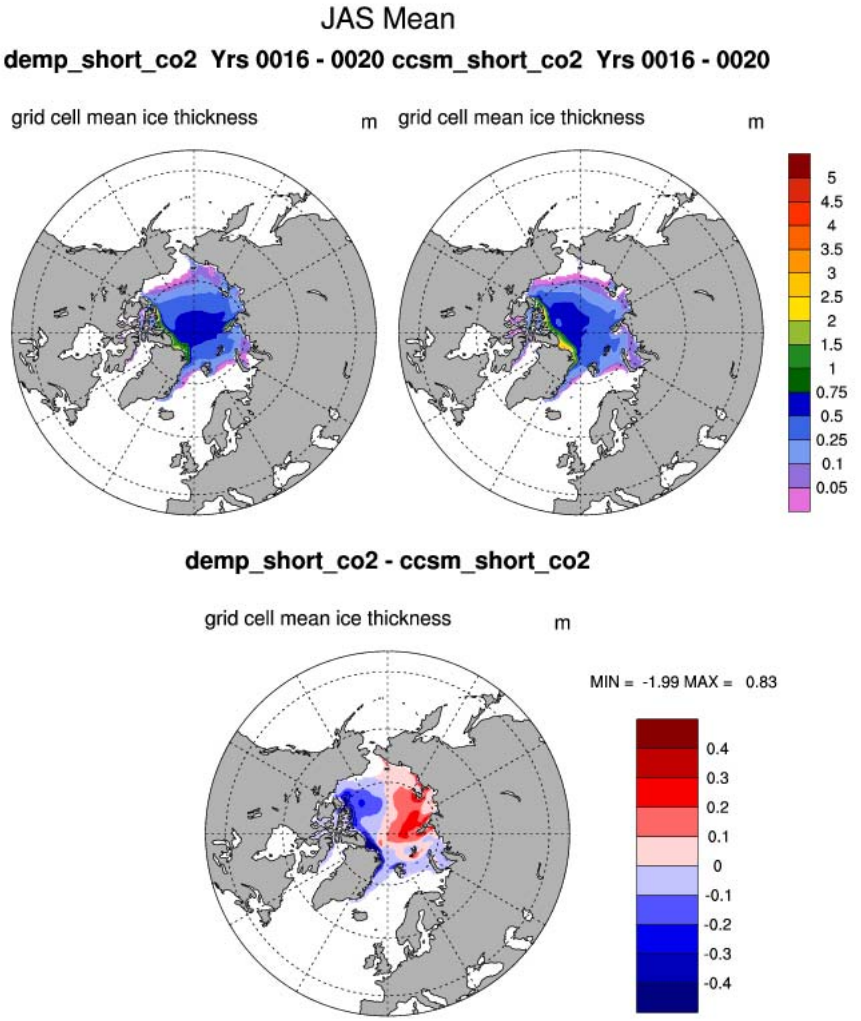
Results
(Radiation / Melt Ponds - Present Day)





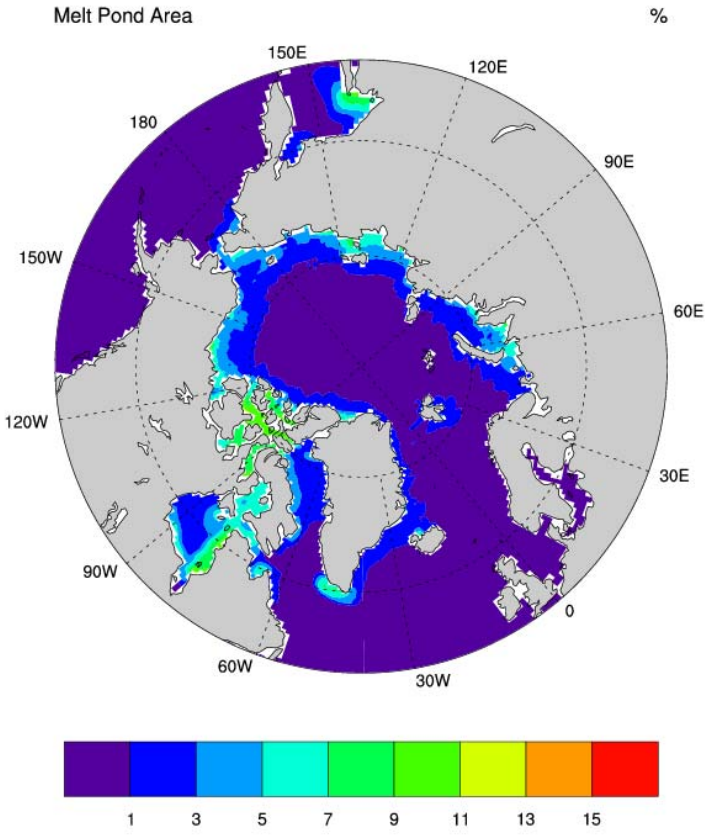
Results
(Radiation / Melt Ponds - Future)



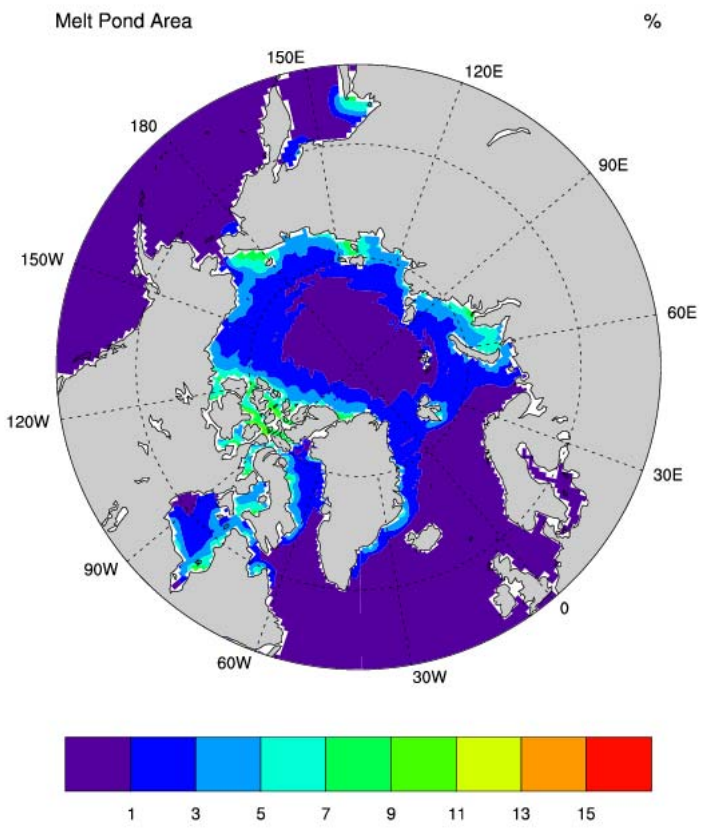


Results
(Melt Ponds - Future vs Present)

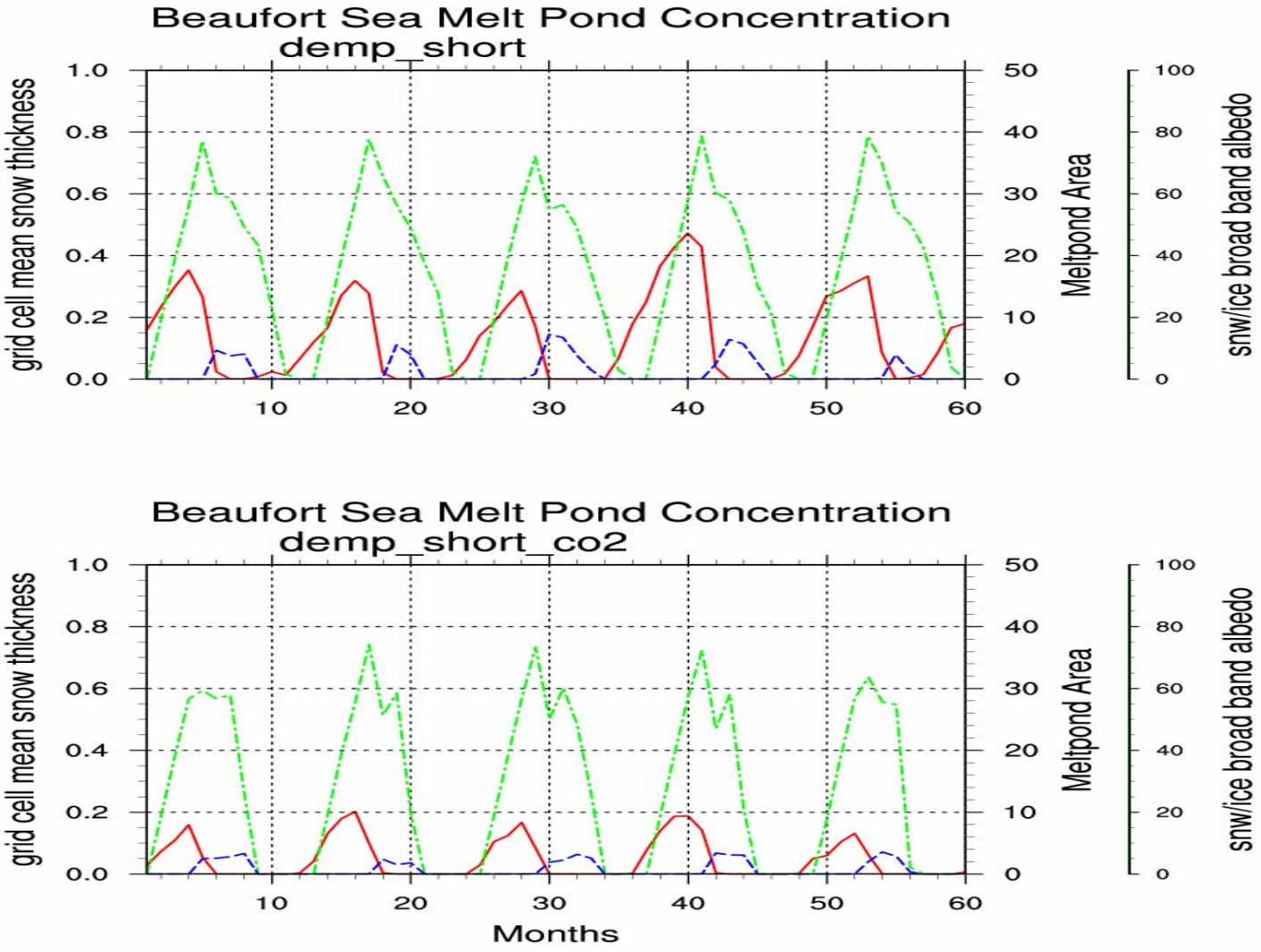
Melt Pond Concentration JAS Mean - demp_short



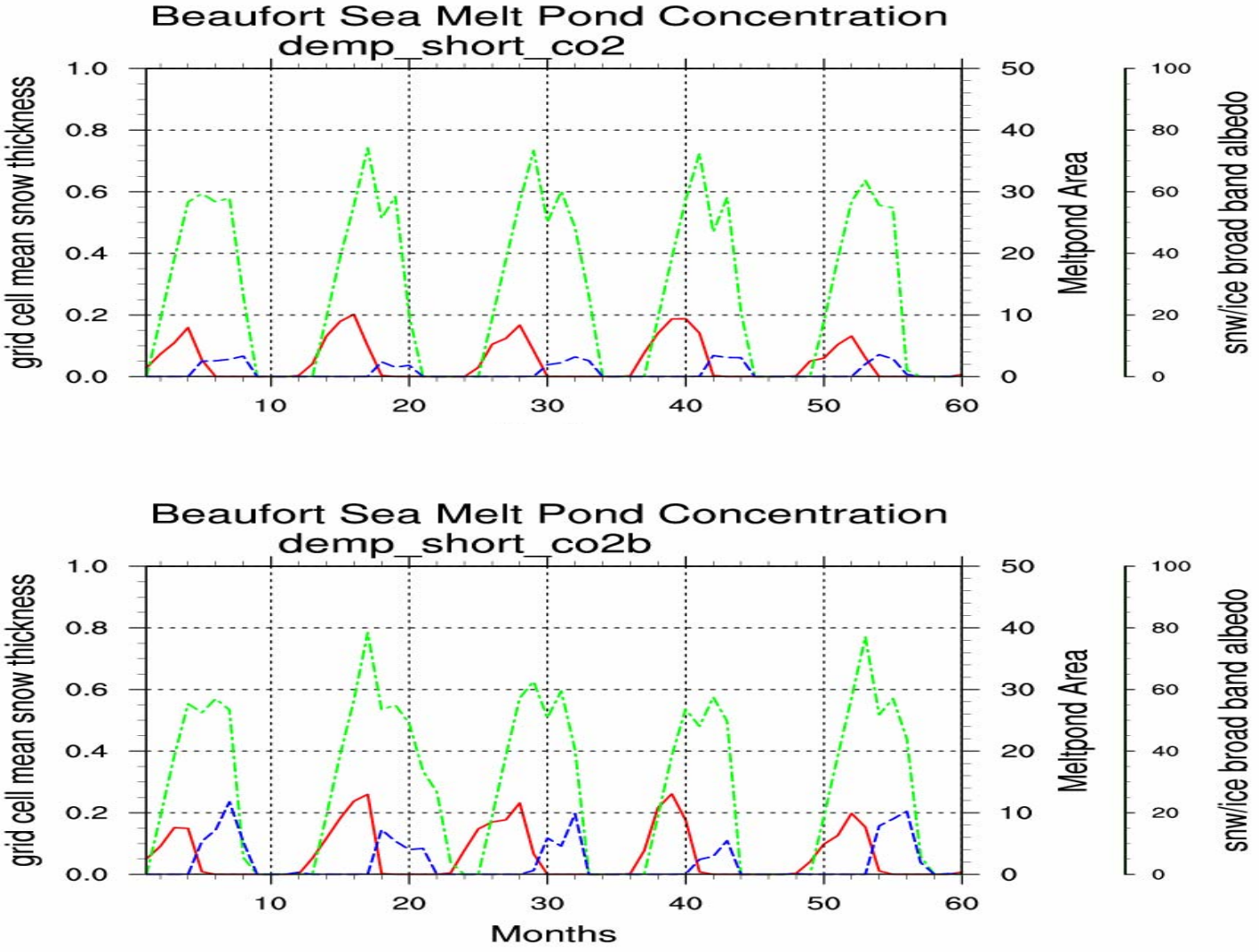
Melt Pond Concentration JAS Mean - demp_short_co2



Results
(Melt Ponds - Present vs Future)

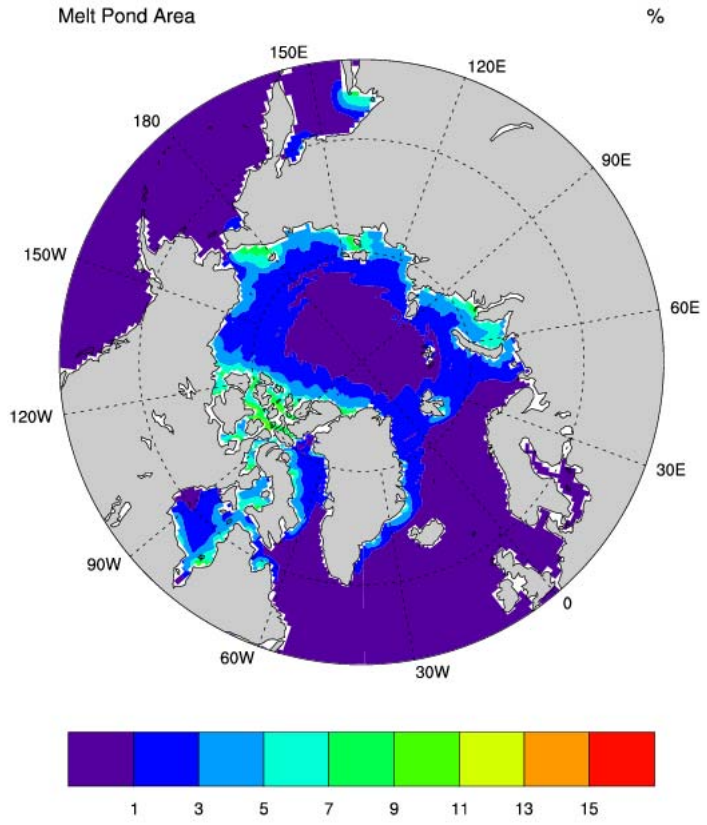


Results
(Rain, Rain, Go Away!)

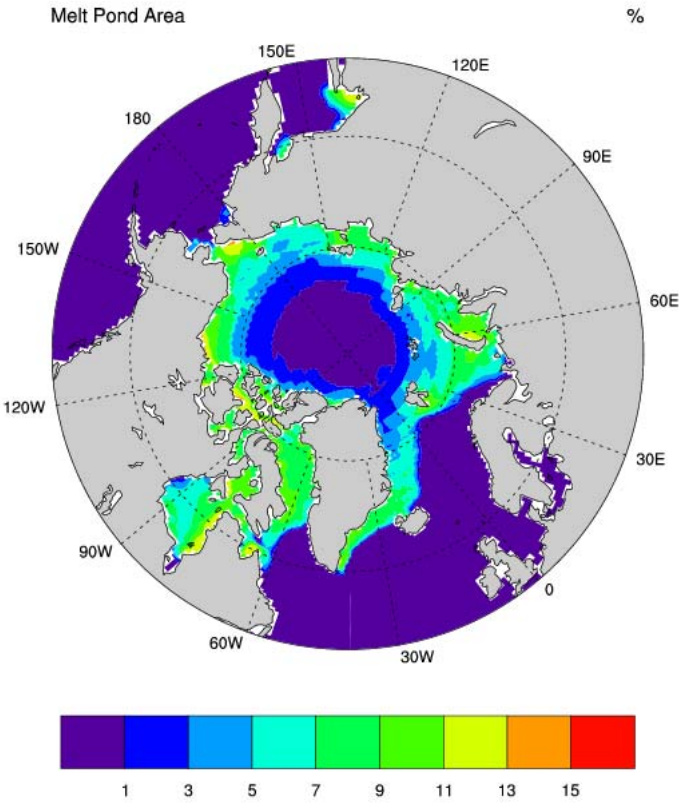


Results
(Rain, Rain, Go Away!)

Melt Pond Concentration JAS Mean - demp_short_co2



Melt Pond Concentration JAS Mean - demp_short_co2b



Summary

- Implicit melt ponds were not too bad compared to this simple explicit melt pond formulation.
- Melt ponds very sensitive to runoff fraction.
- DE can be tuned to give similar results to CCSM shortwave.
- Climate sensitivity in 2 x CO2 is similar.
- Should account for rain.

Why use Delta-Eddington and Melt Ponds?

- More physical.
- Allows for addition of soot, algae, etc.
- Handles multiple snow layers.
- Addition of snow-aging easily works with radiation.
- Interaction with more complicated melt ponds.

Work in Progress

- Sensitivity to runoff fraction.
- Fall freeze-up.
- DE performance and tuning.
- Fully-coupled runs.
- Snow aging / snow model?