Drowning by Numbers: Progress Towards CCSM 4.0

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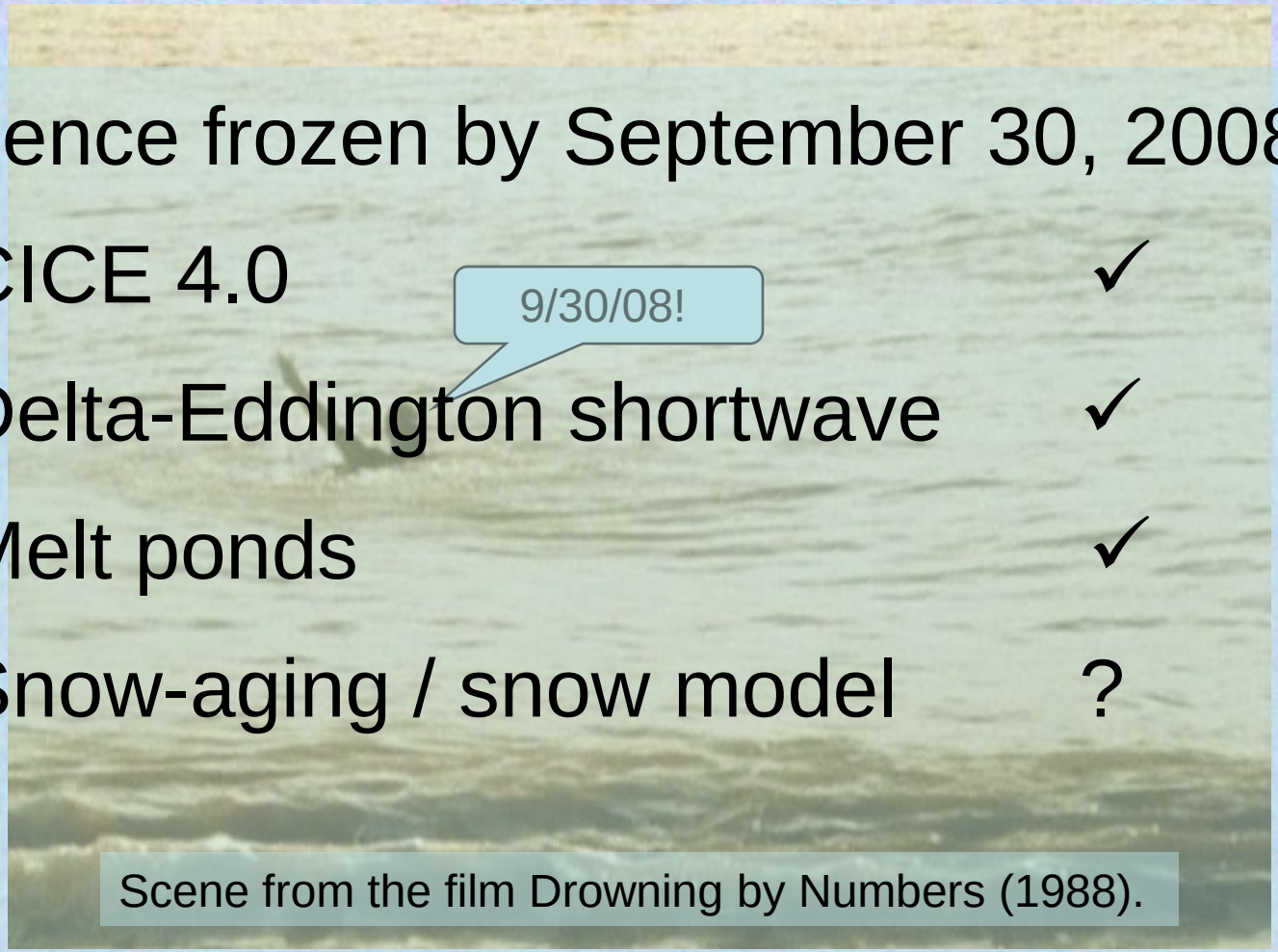
PCWG plans for CCSM 4.0

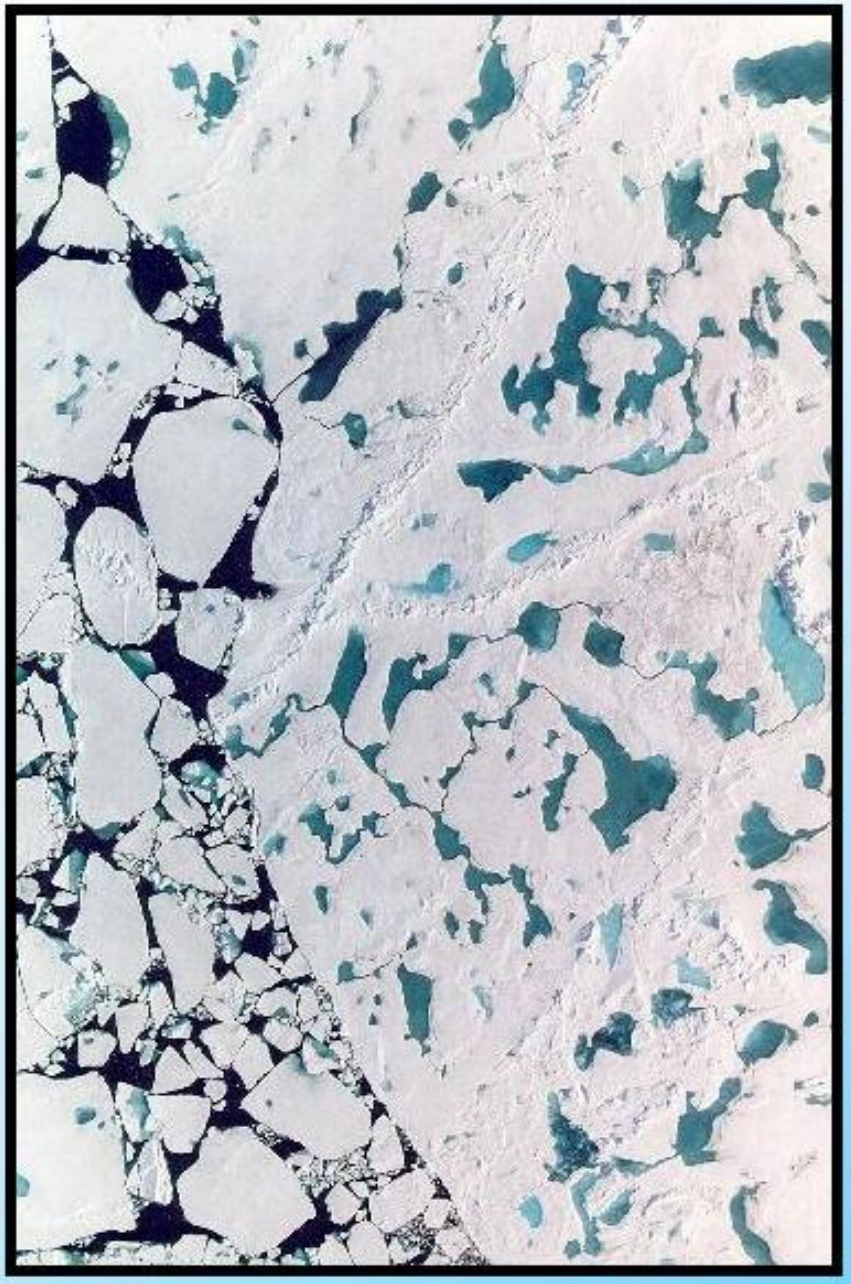
Science frozen by September 30, 2008.

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

9/30/08!

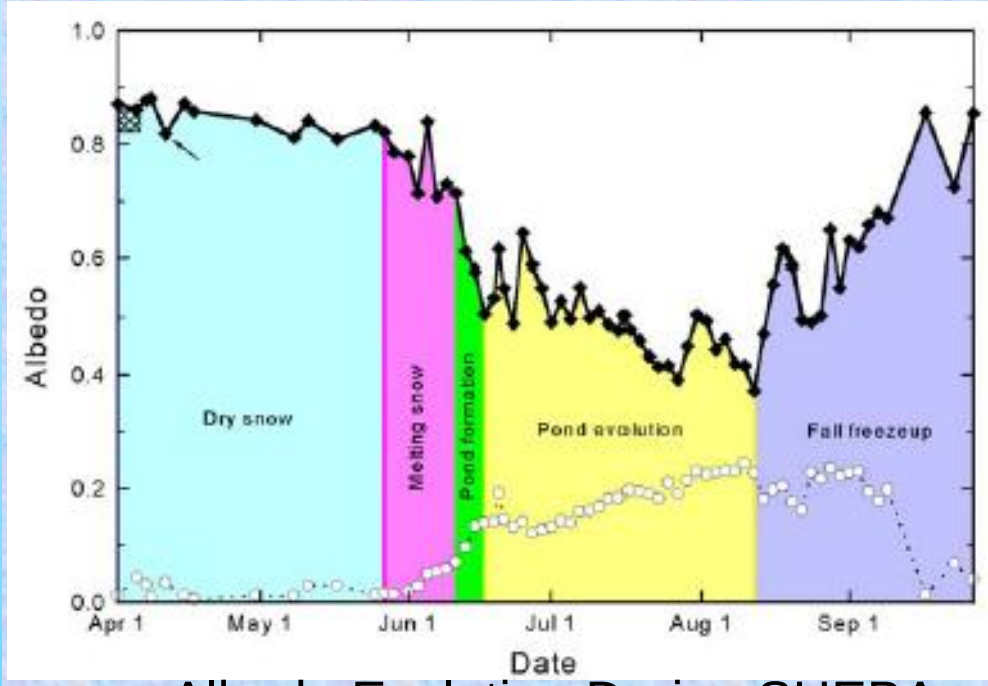


Scene from the film Drowning by Numbers (1988).



Sea Ice Melt Ponds

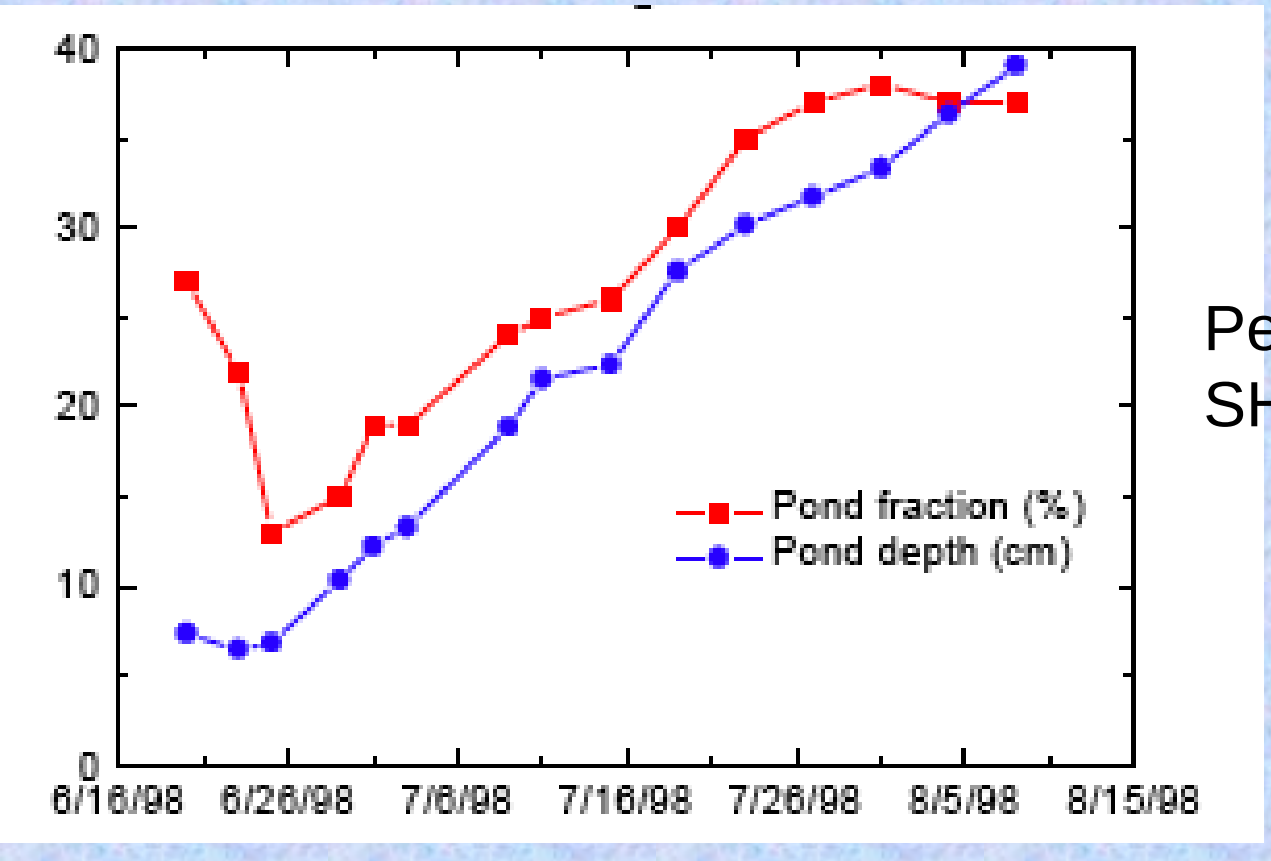
- Ponds are prevalent on sea ice
- Influence surface albedo and ice mass budget
- Code has been added to explicitly simulate melt ponds and their albedo effects



Albedo Evolution During SHEBA
(Perovich et al. 2002)

Melt Pond Parameterization

- Accumulate 15-65% of snow, surface ice melt, and rain into pond volume, depending on ice fraction.
- Pond fraction is reduced by snow fraction.
- 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

Runoff fraction = 0.85 - 0.5 * Ice 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.

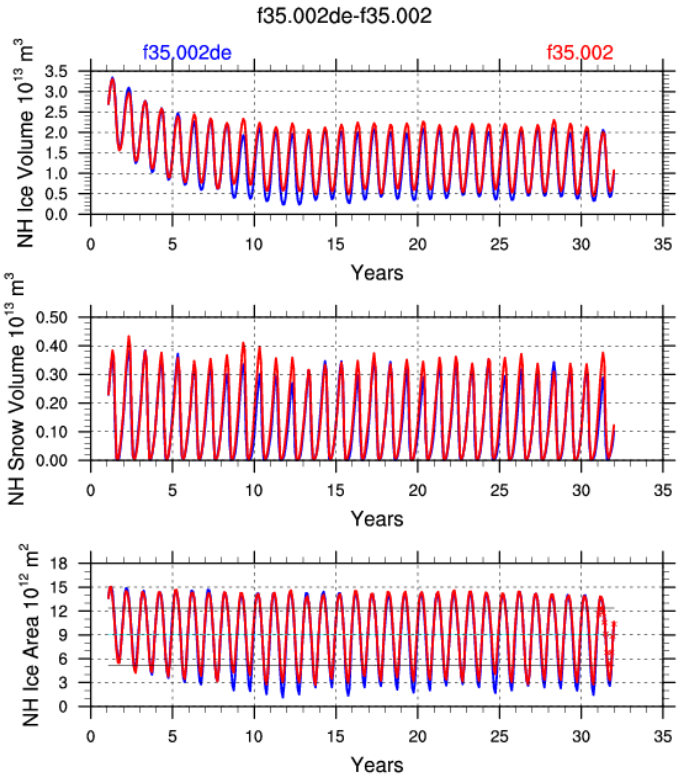
Previous Experiments

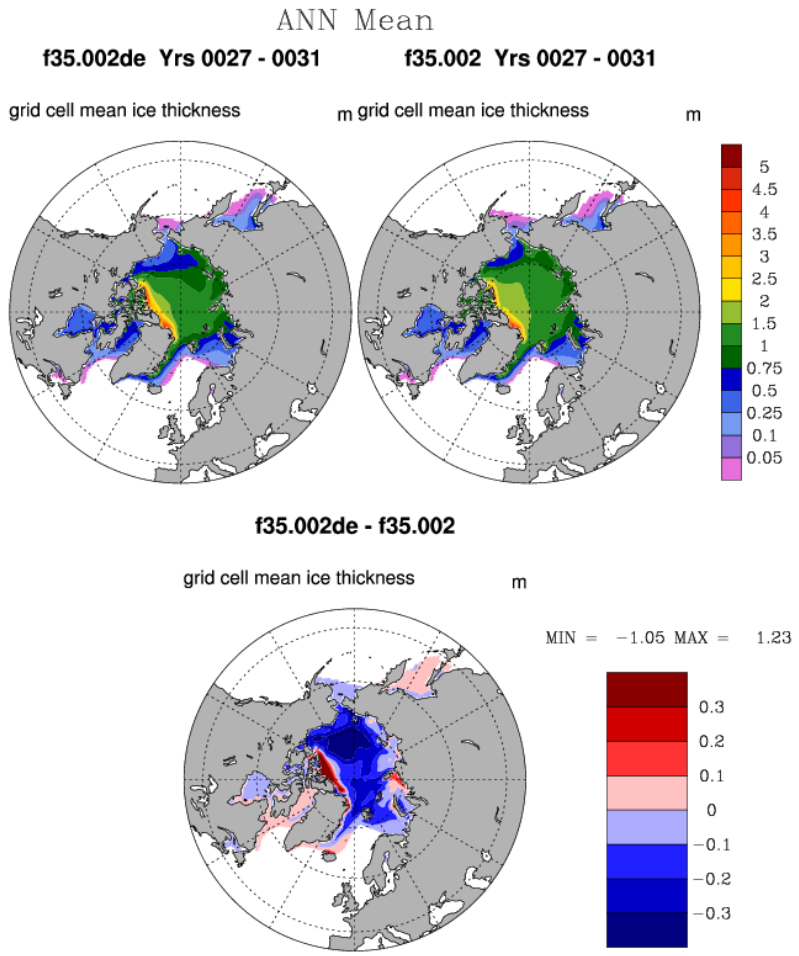
- CCSM 3.0 experiments with and without melt ponds showed a strong sensitivity to the prescribed runoff fraction.
- DE requires a melt pond fraction and depth (prescribed by default).
- Experiments comparing DE vs CCSM shortwave (without explicit ponds) showed generally thinner ice.
- Need to include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

CCSM 3.5 Experiments (atm-ice-som)

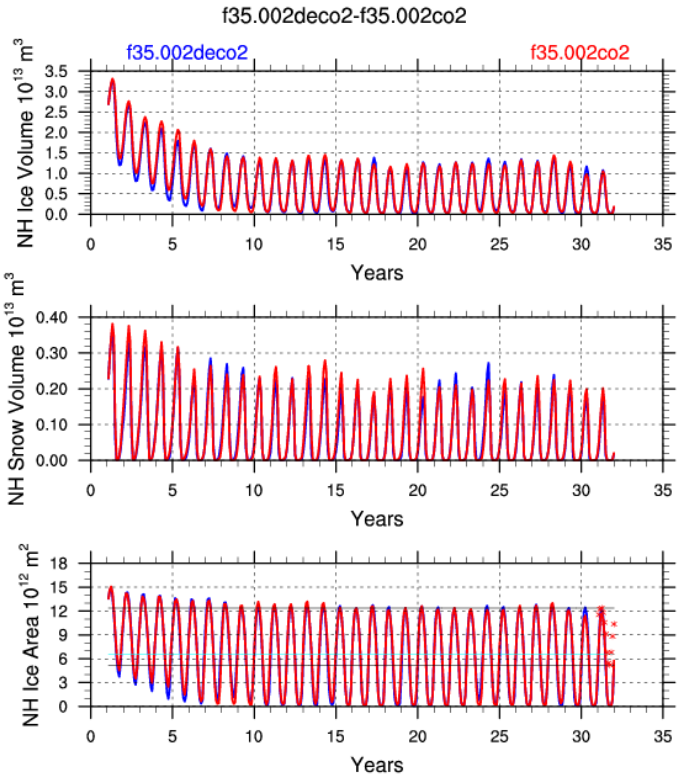
	1 x CO2	2 x CO2
No MP	f35.002	f35.002co2
MP	f35.002mp f35.002de	f35.002mpco2 f35.002deco2

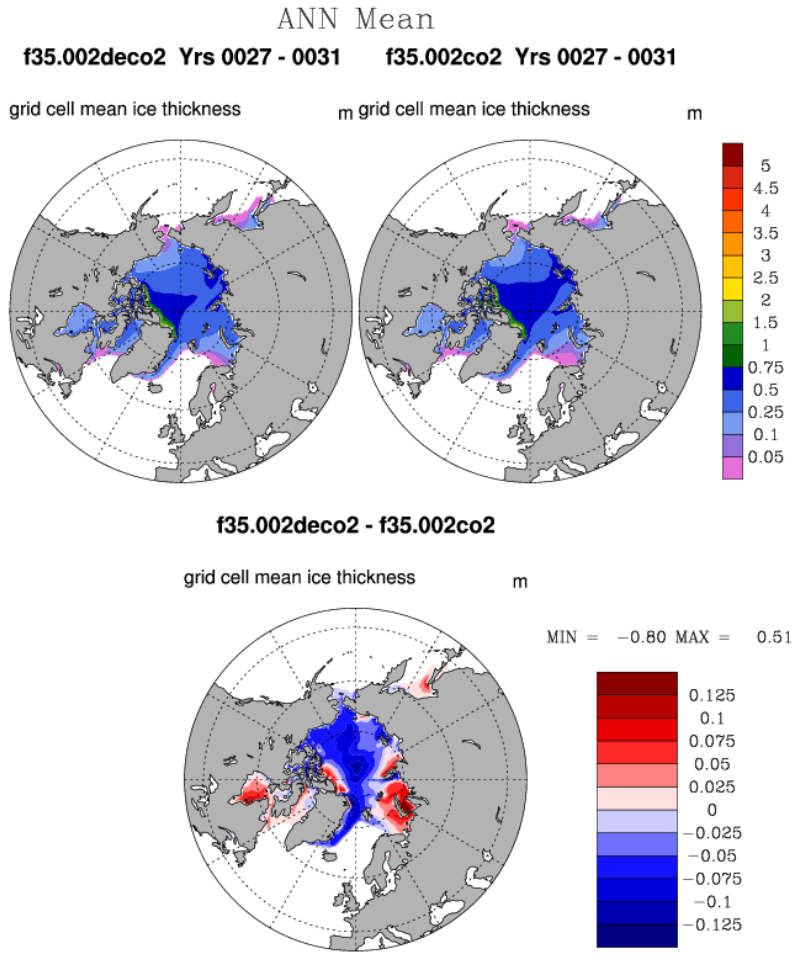
Results
(Radiation / Melt Ponds - Present Day)



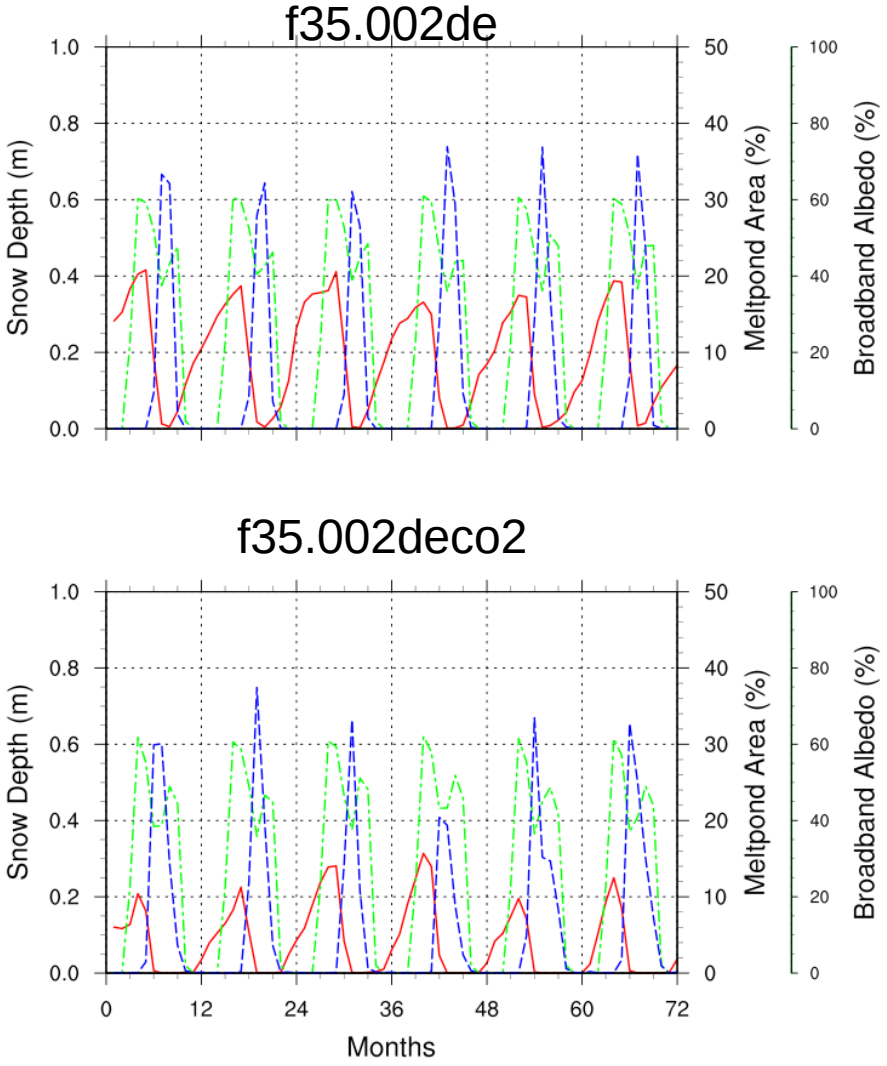


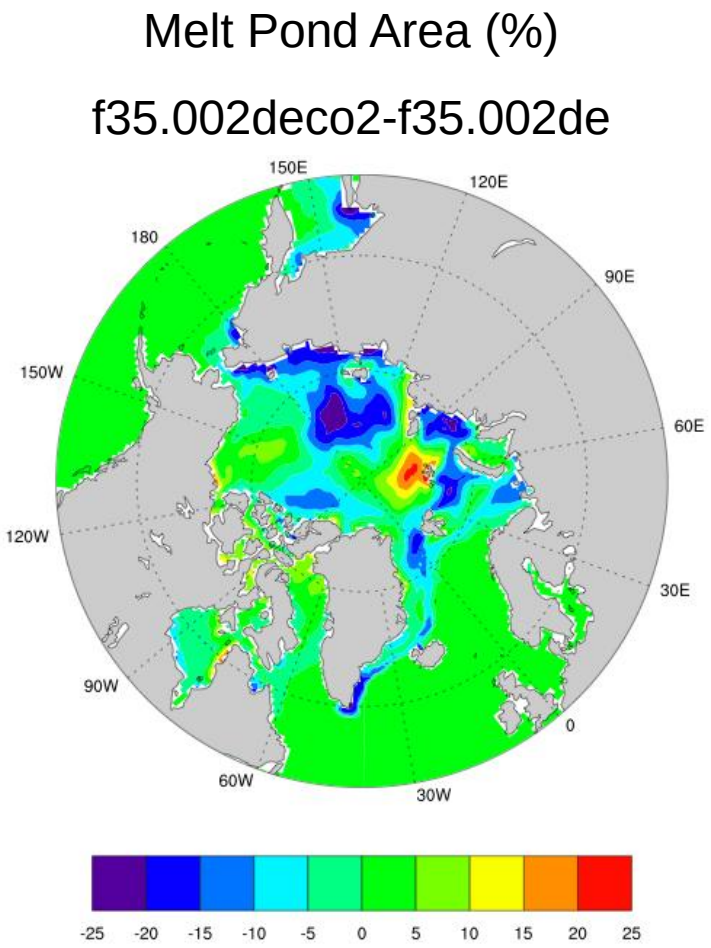
Results
(Radiation / Melt Ponds - Future)





Results
(Radiation / Melt Ponds - Present vs Future)





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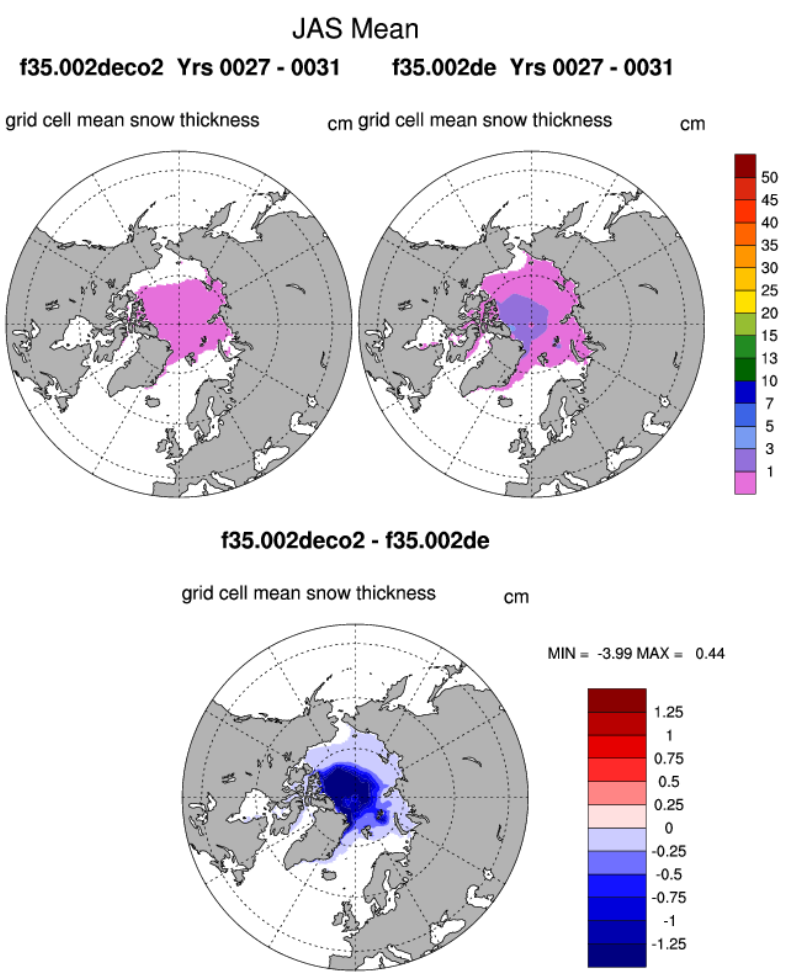

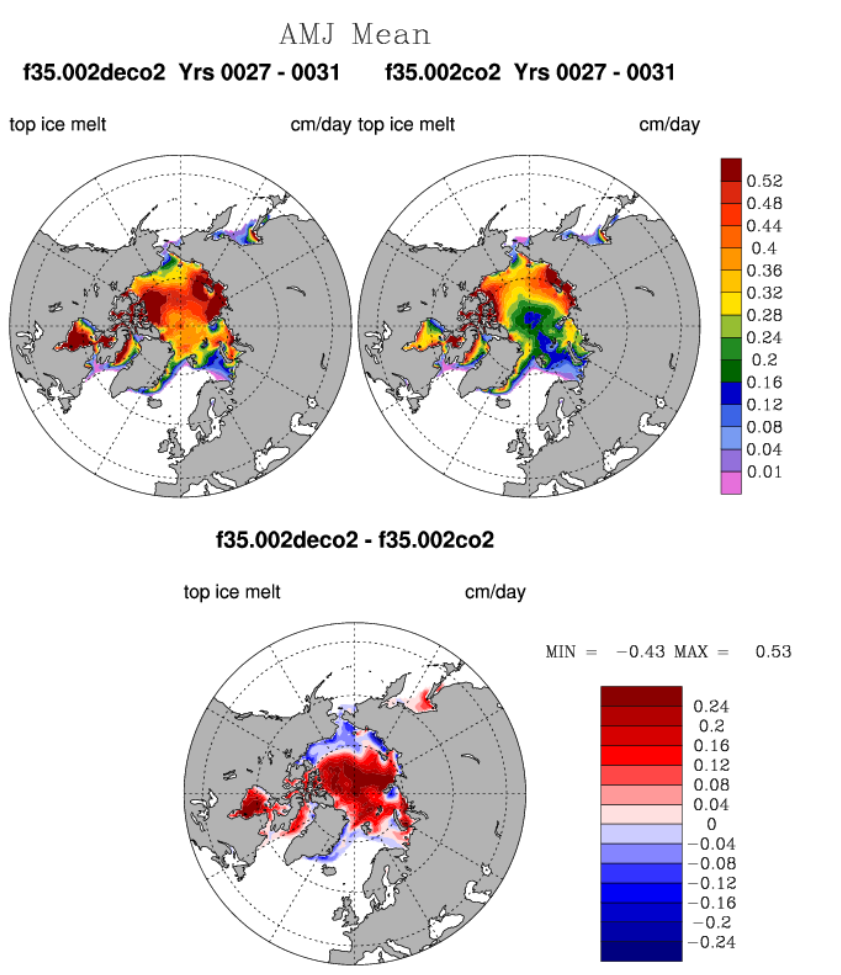

Summary

- Implicit melt ponds in CCSM3 essentially captured the basic albedo effects compared to this simple explicit melt pond formulation.
- While DE and CCSM shortwave can be tuned to give similar results, DE provides more generality.
- Climate sensitivity in all configurations is similar.
- In a 2 x CO2 world, the shift to more rain and less snow along with enhanced surface ice melt appears to mostly compensate the pond accumulation.
- Generally fewer ponds in the future, likely due to ice-fraction dependent runoff.

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

- CICE 4.0 numerical / software engineering enhancements.
- DE performance and tuning.
- Melt ponds and DE soon to be the default in CCSM4 fully-coupled runs.
- Snow aging / snow model?