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

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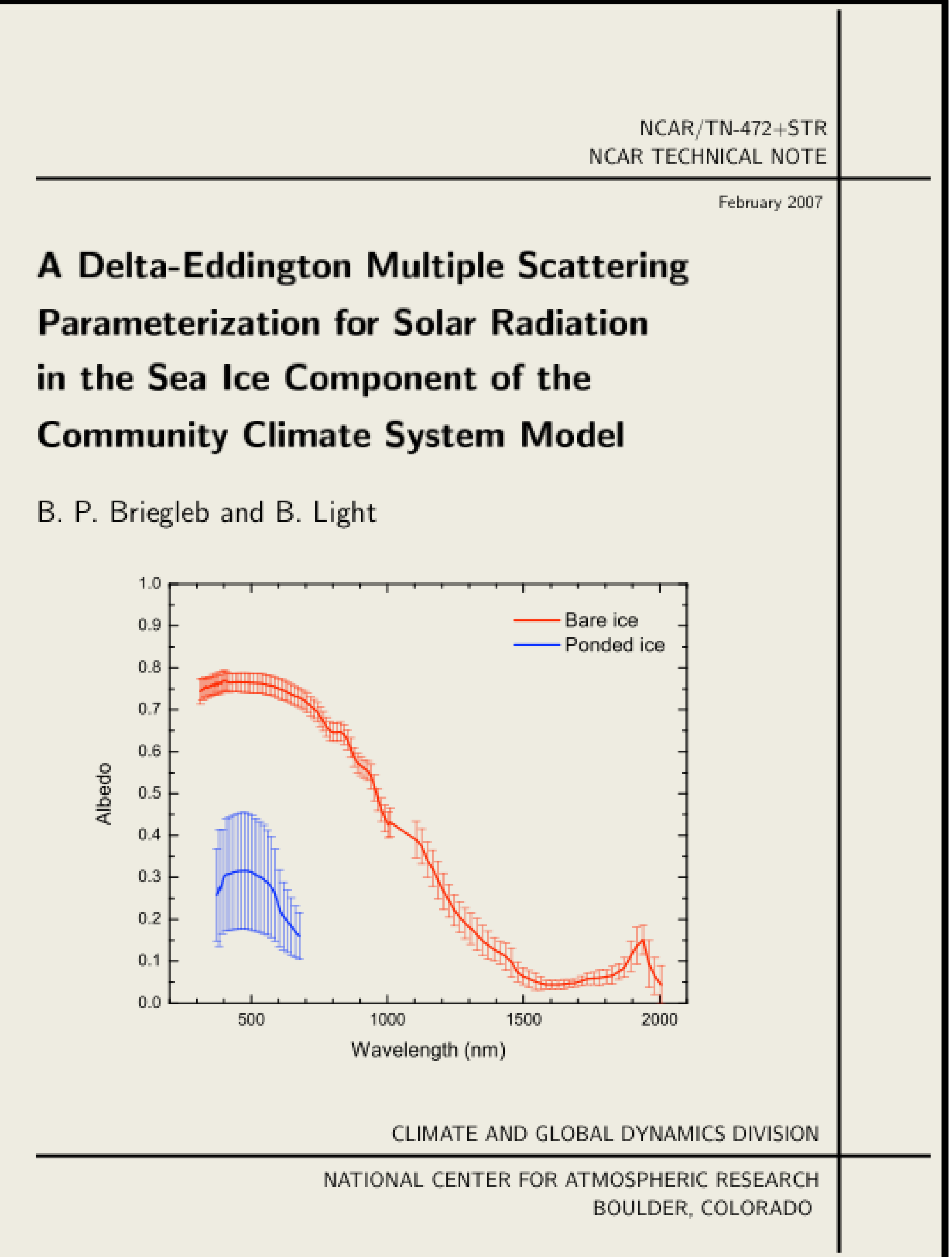

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NCAR TECHNICAL NOTE

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A Delta-Eddington Multiple Scattering Parameterization for Solar Radiation in the Sea Ice Component of the Community Climate System Model

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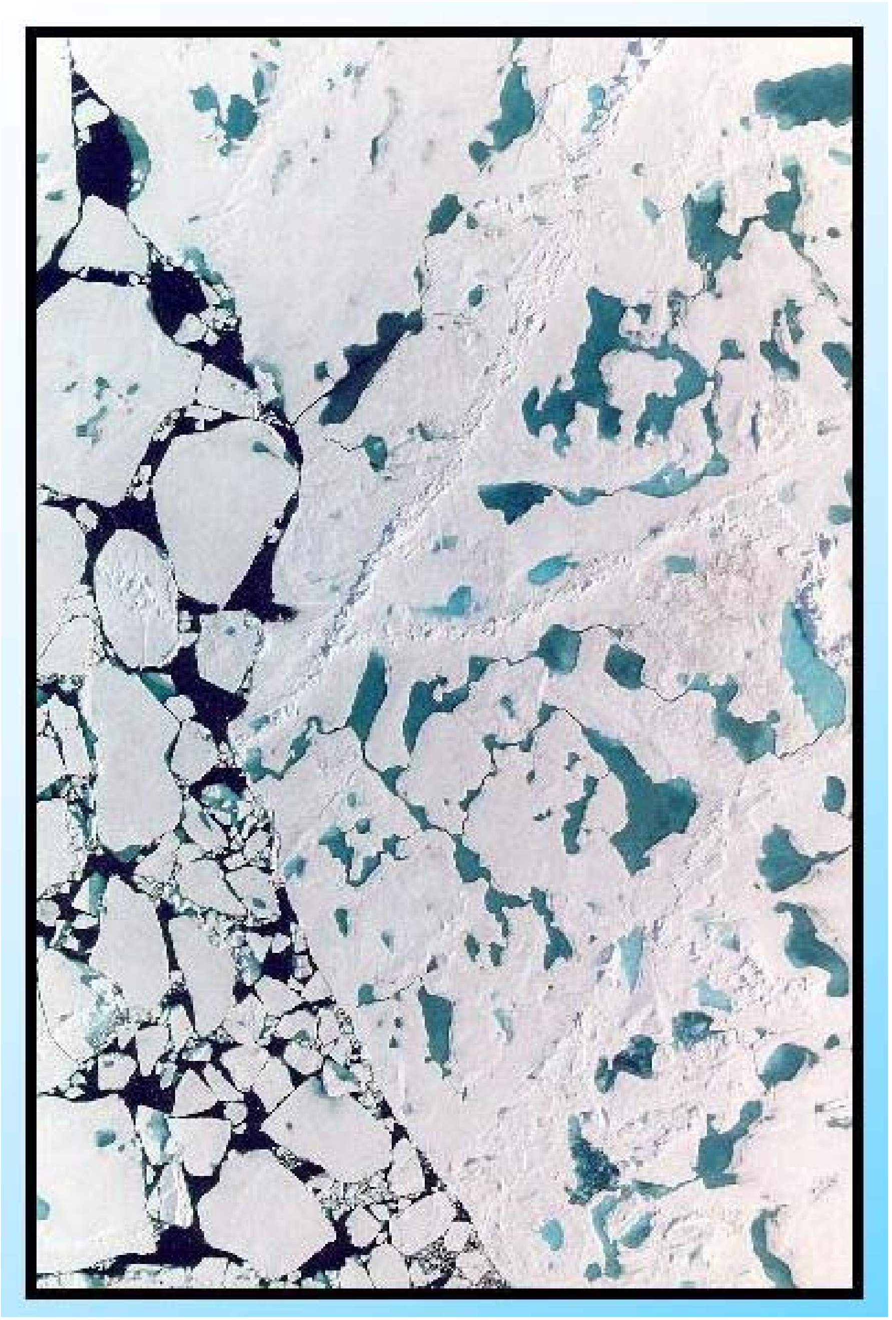
New Solar Radiation parameterization introduced in 2007

<u>Better physics:</u>

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

<u>More flexible</u>

- 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

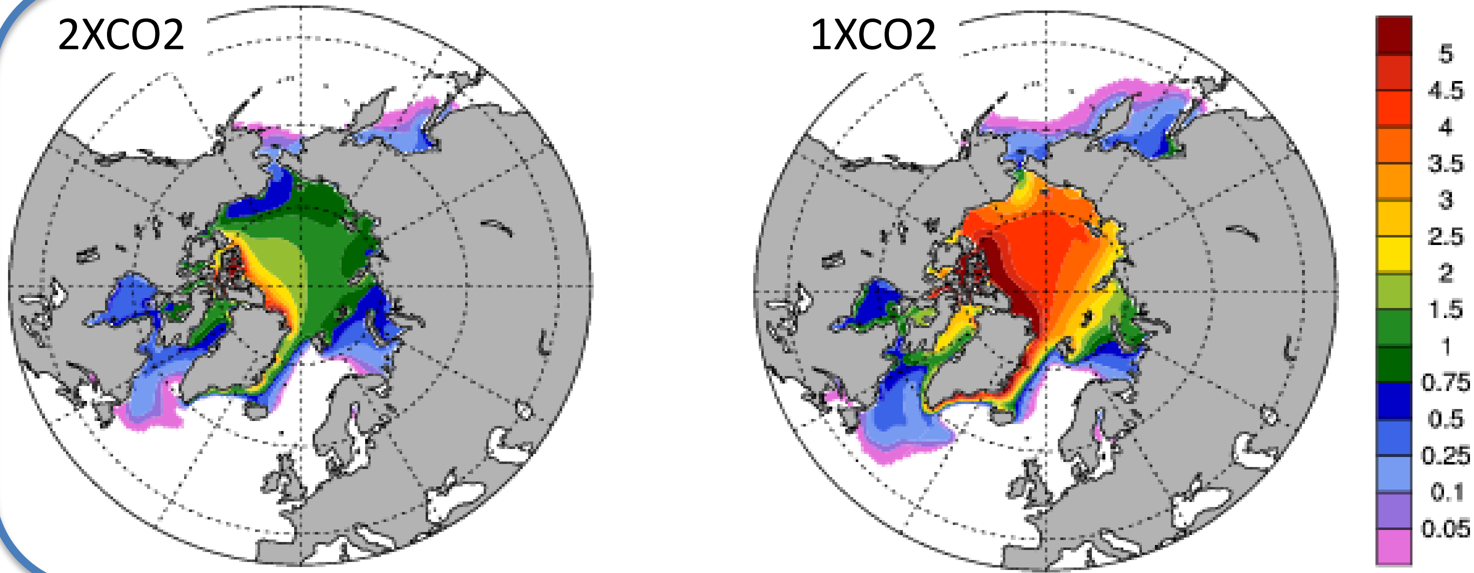
- Aerosol deposition and cycling now included.
- Account for black carbon and dust which are deposited and modified by melt and transport

What is influence of new SW capabilities on CCSM4 Polar Climate?

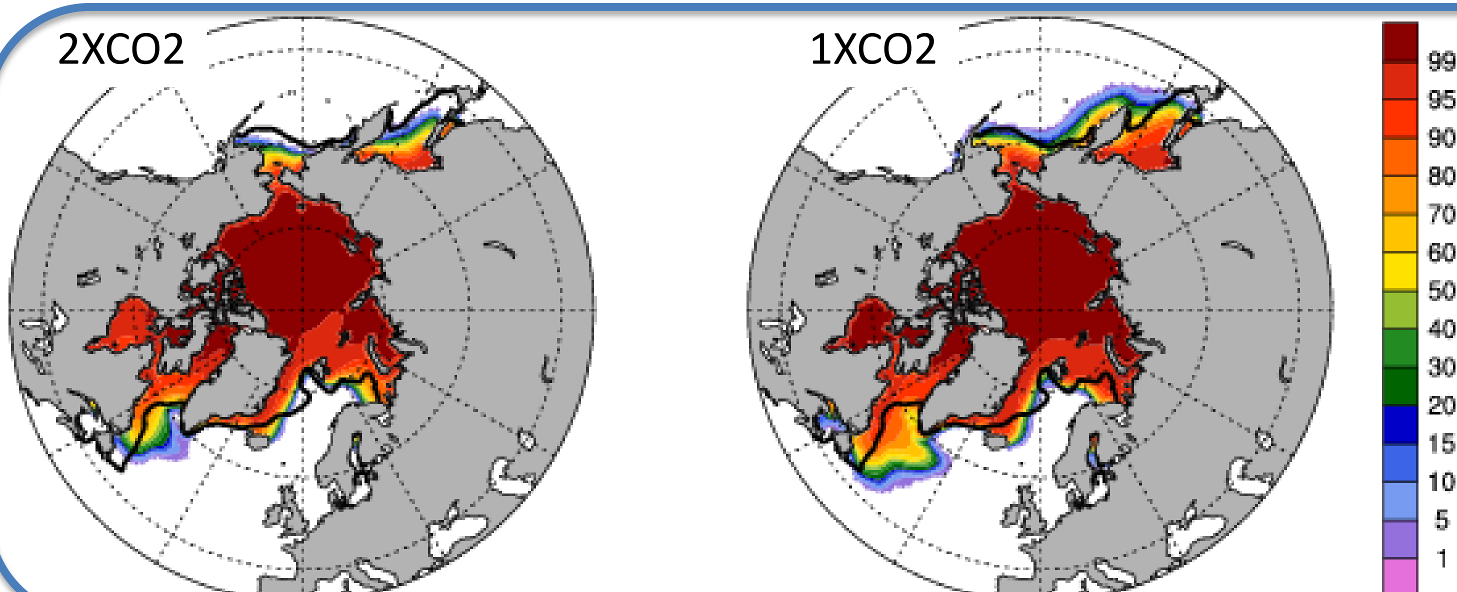
Model Simulation	CO_2 level
Control	1xCO_2
No Aerosols	1xCO_2
No Ponds or Aerosols	1XCO_2
Control	2xCO_2
No Aerosols	2xCO_2
No Ponds or Aerosols	2XCO_2

SOM integrations at 2°/gx1, ~60 Years in length

Control Integrations (2°/gx1 SOM)



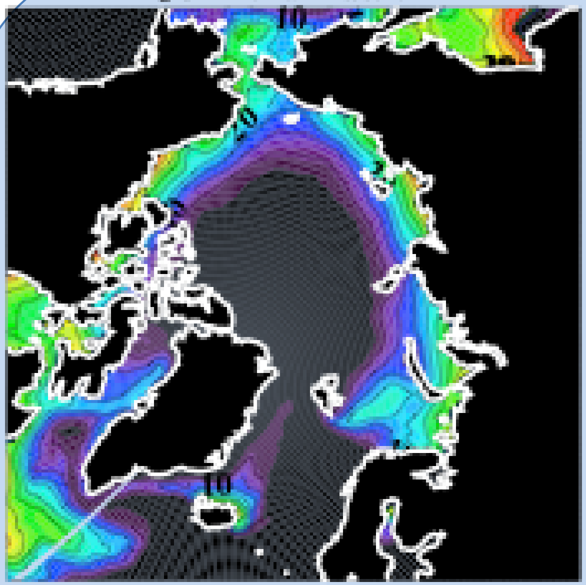
Annual Mean Ice Thickness



JFM Ice Concentration

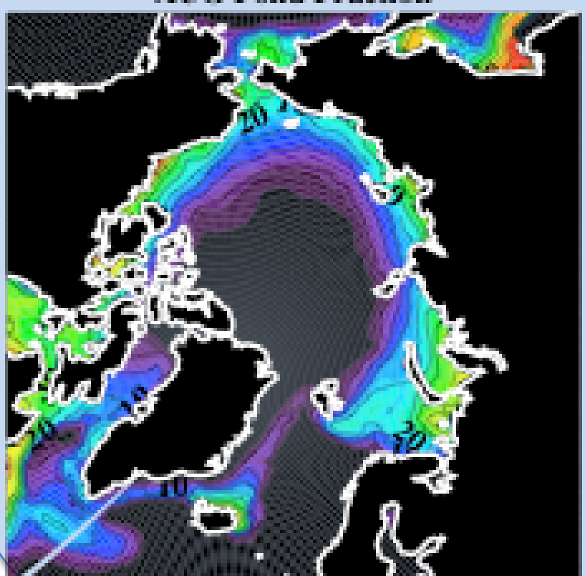
Control Integration – Pond Simulation

JUL Pond Fraction



July

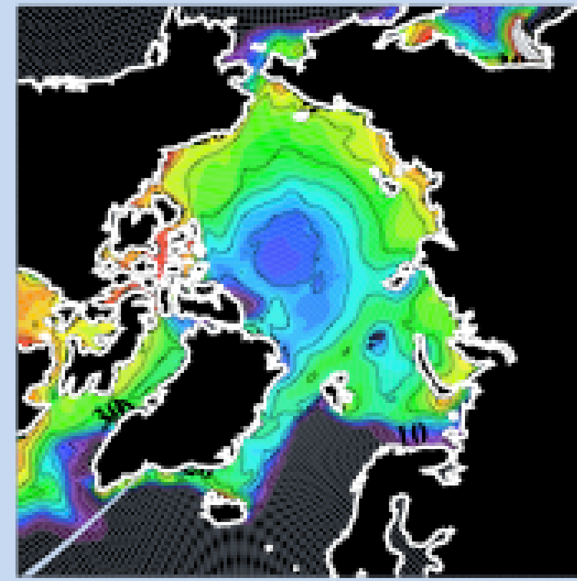
AUG Pond Fraction



August

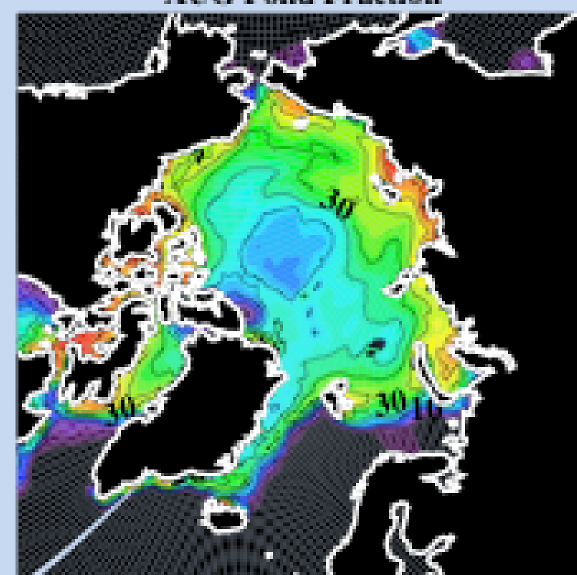
1XCO2 Run

JUL Pond Fraction



July

AUG Pond Fraction



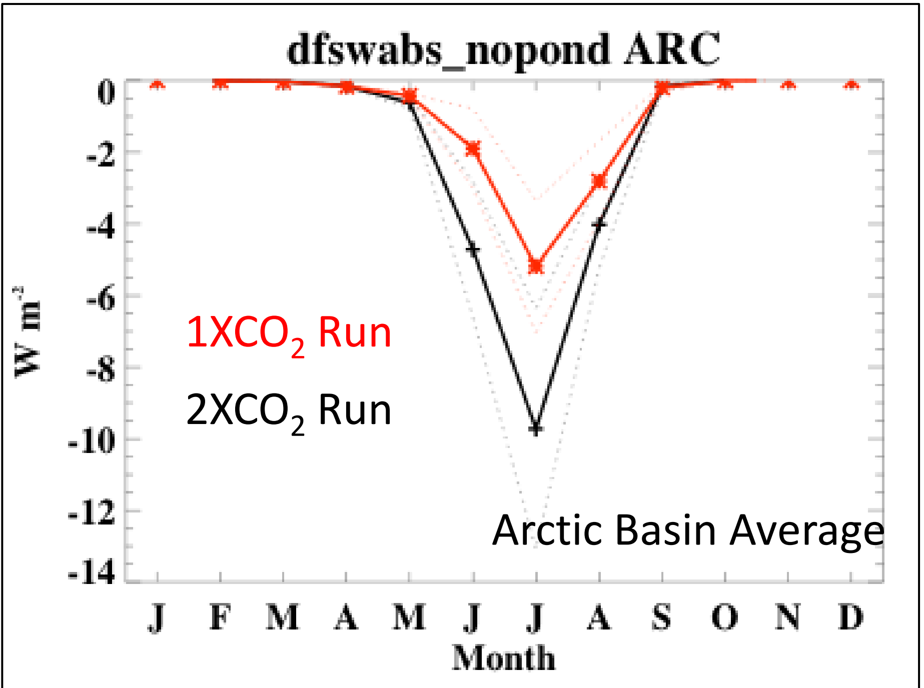
August

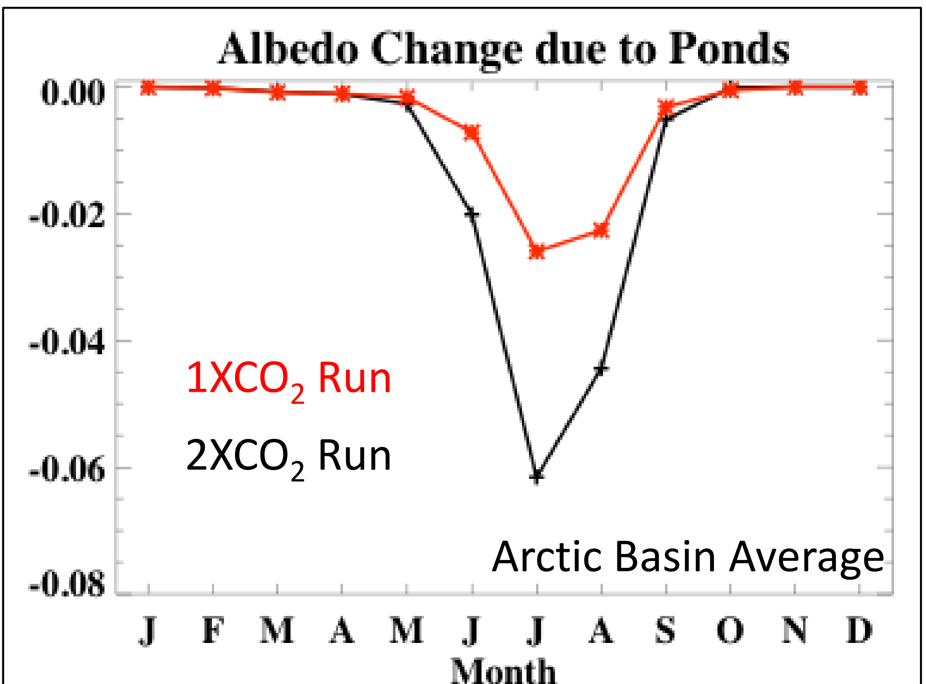
2XCO2 Run

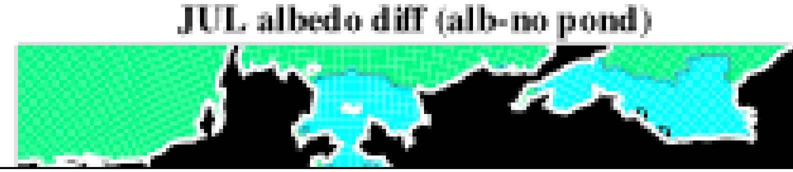
Assessing radiative impacts of ponds/aerosols

- 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







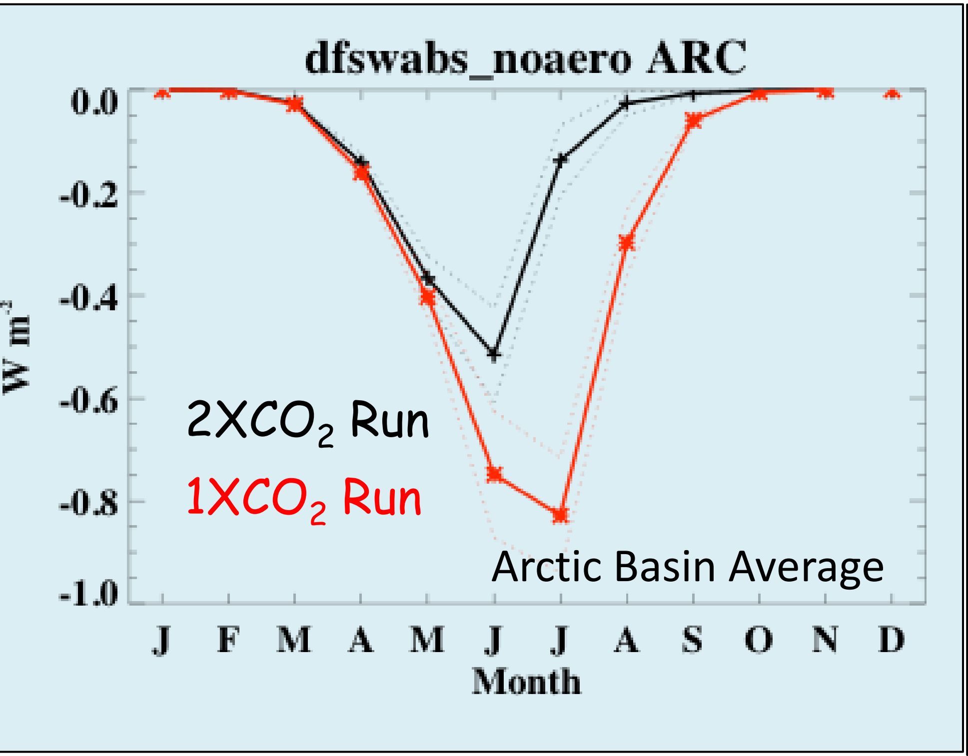
Ponds result in 5-10 W/m^2 increase in SW absorption over Arctic basin for July

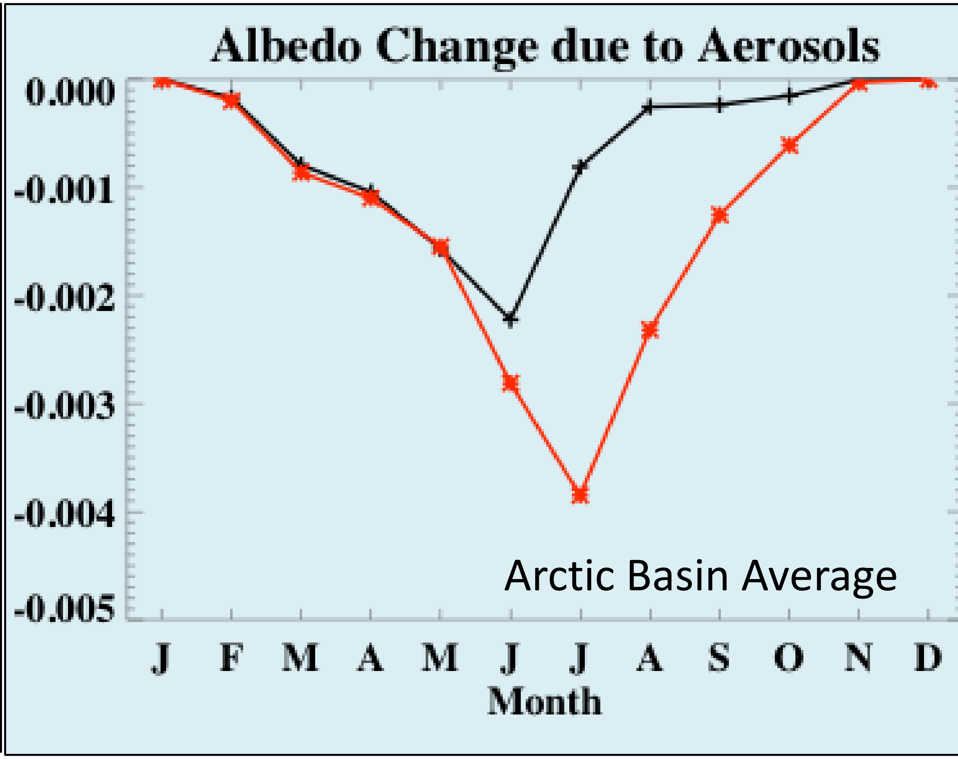
Pond impact is larger in 2XCO2 simulation.

- 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,

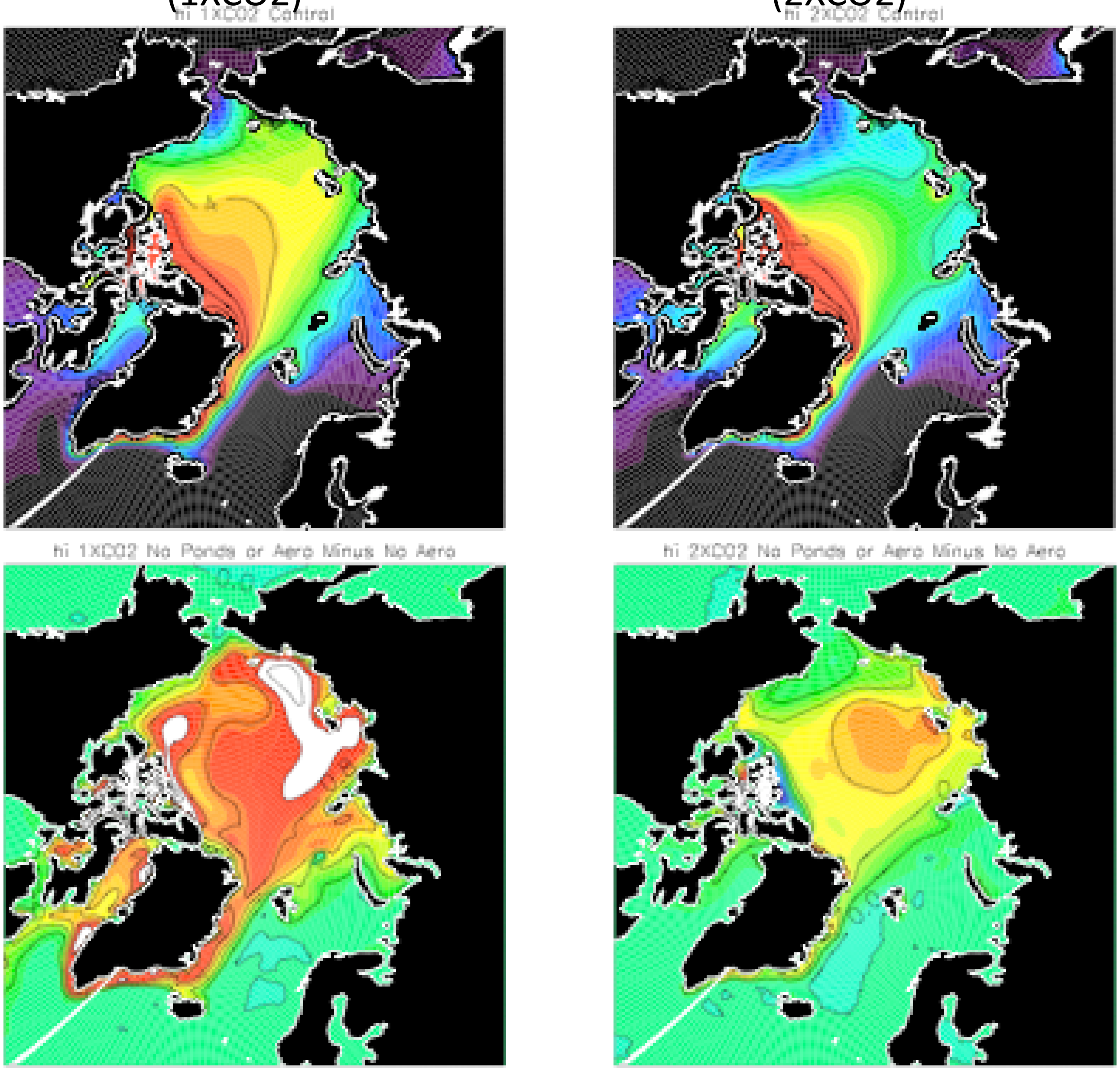
- albedo impact is small
- <1 W/m2 increase in absorbed SW

Aerosol impact is larger in 1XCO2 simulation.

- Less surface melt results in less meltwater scavenging of aerosols.

Influence of ponds on simulated sea ice

(1XCO2) (2XCO2)



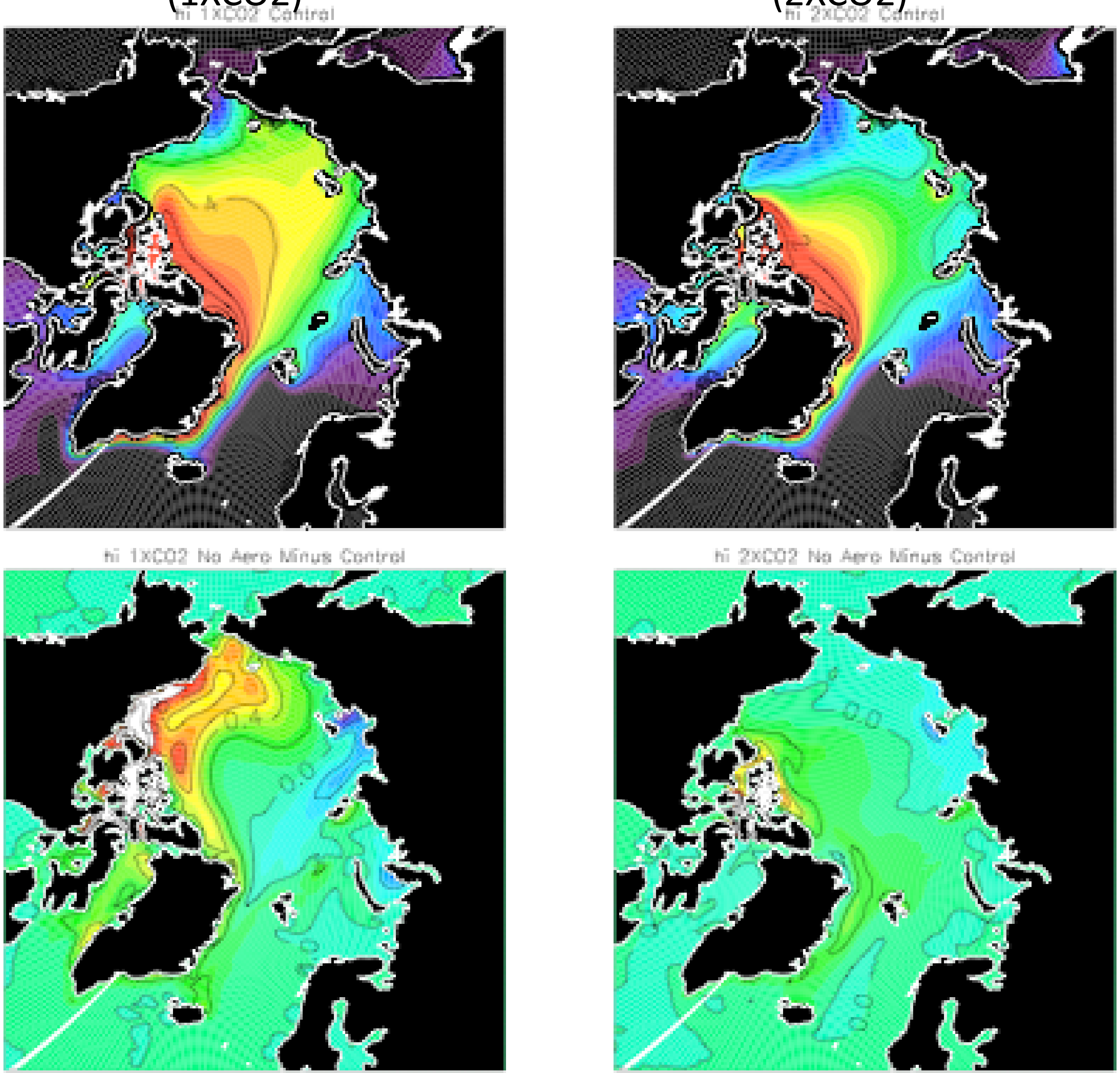
Annual Ice Thickness

Control Runs (2°/gx1 SOM)

Model Runs No Ponds & Aerosol Run Minus No Aerosol Run

Influence of aerosols on simulated sea ice

(1XCO2) (2XCO2)

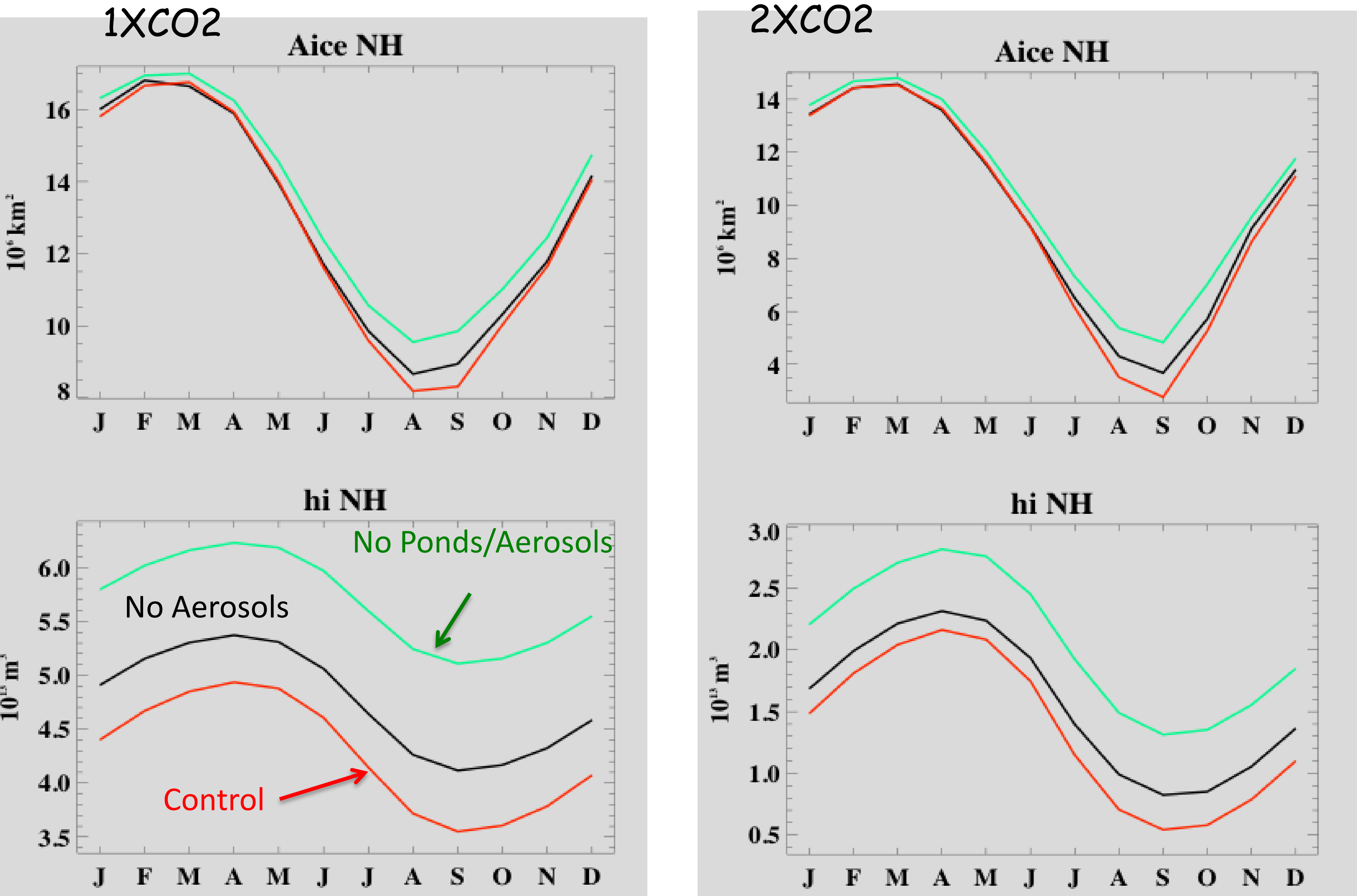


Annual Ice Thickness

Control Runs (2°/gx1 SOM)

Model Runs No Aerosol Run Minus Control

NH Sea Ice Area/Volume



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

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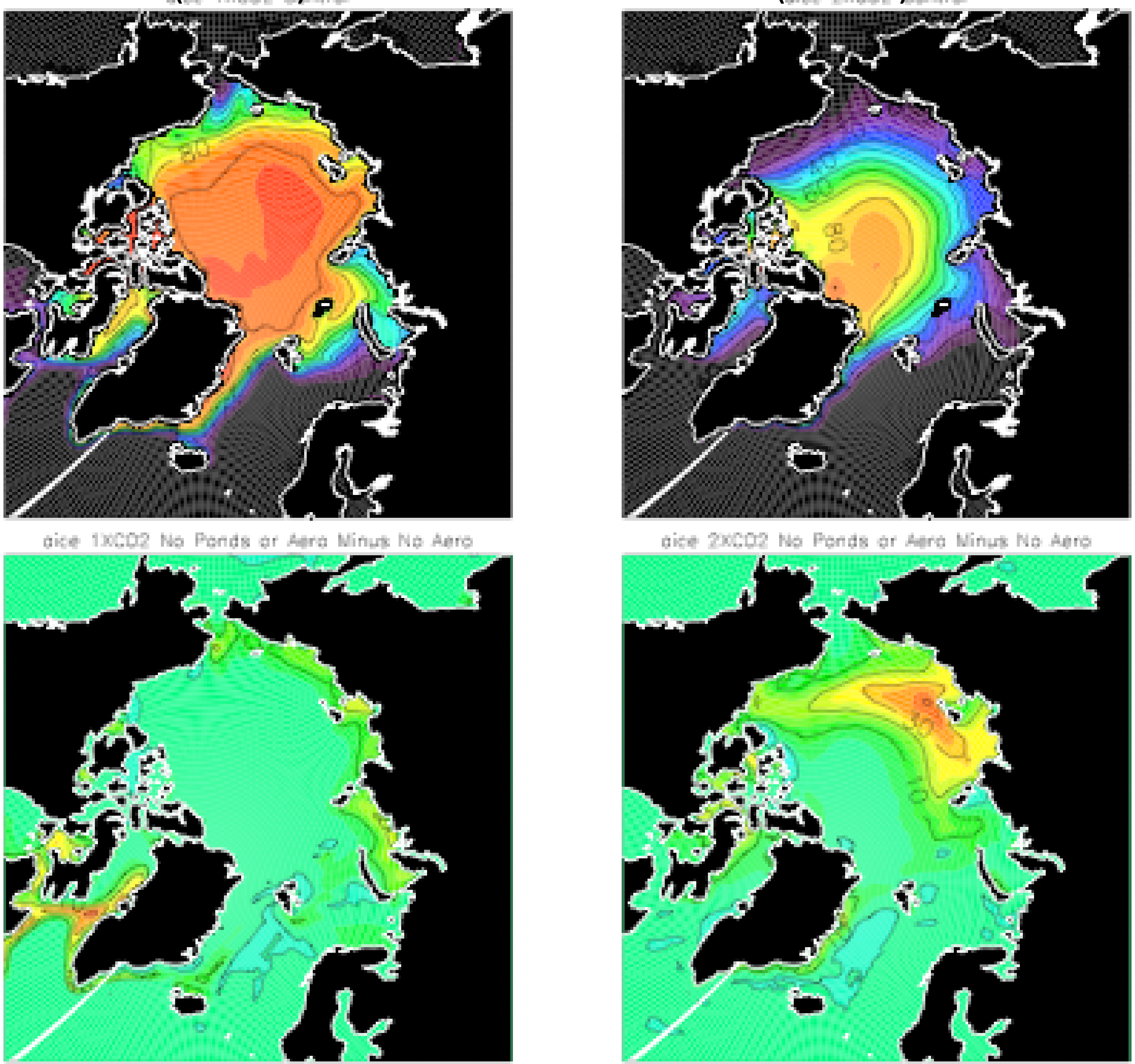
Influence of ponds on simulated sea ice

(1XCO2) (2XCO2)



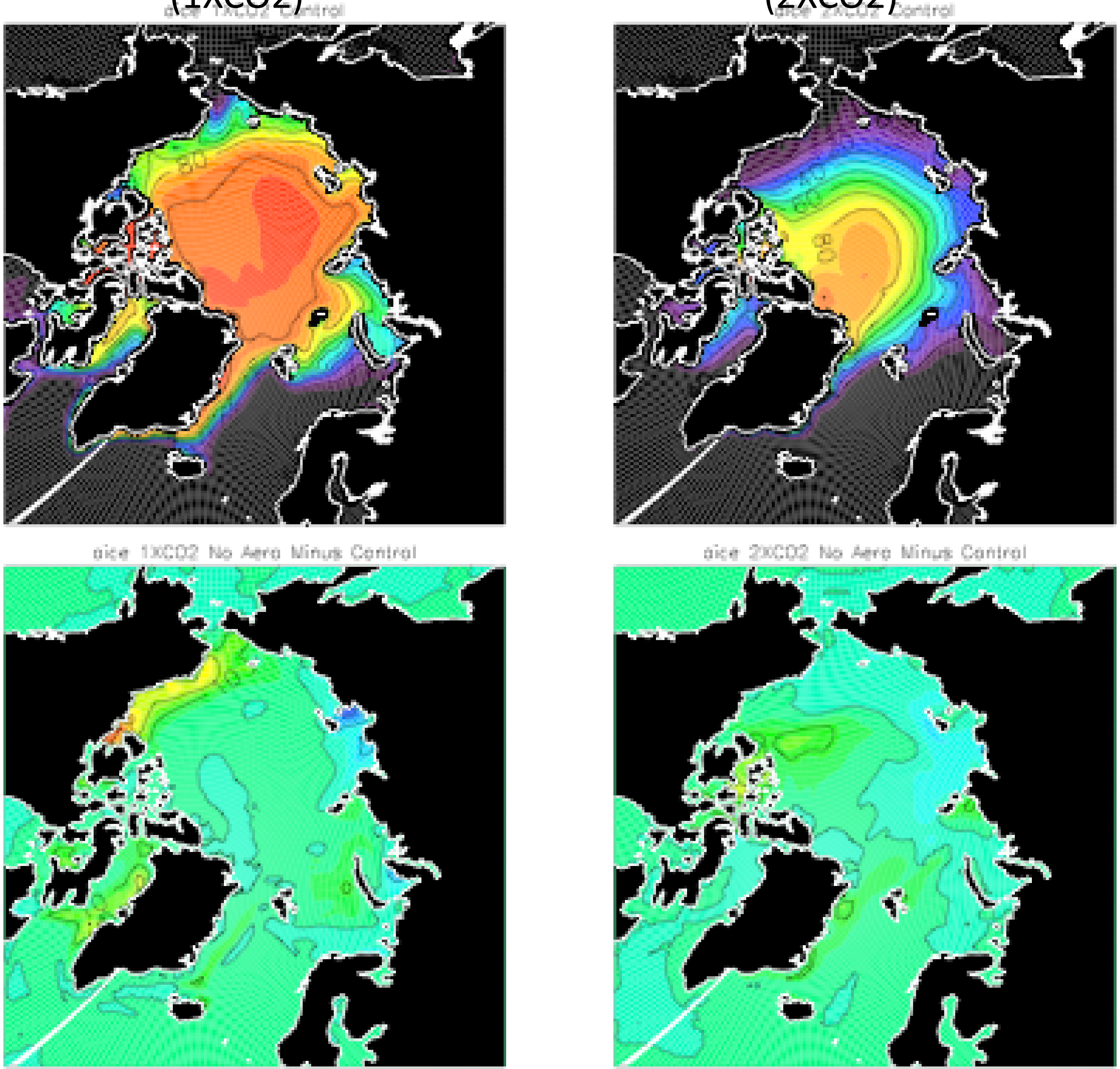
JAS Ice Concentration

Control Runs
(2^o/gx1 SOM)

Model Runs
No Ponds &
Aerosol Run
Minus
No Aerosol Run

Influence of aerosols on simulated sea ice

(1XCO2) (2XCO2)



JAS Ice Concentration

Control Runs (2°/gx1 SOM)

Model Runs No Aerosol Run Minus Control

Implications for albedo feedback