Atmospheric response to the 2007 sea ice loss in CAM3.5 and CAM4

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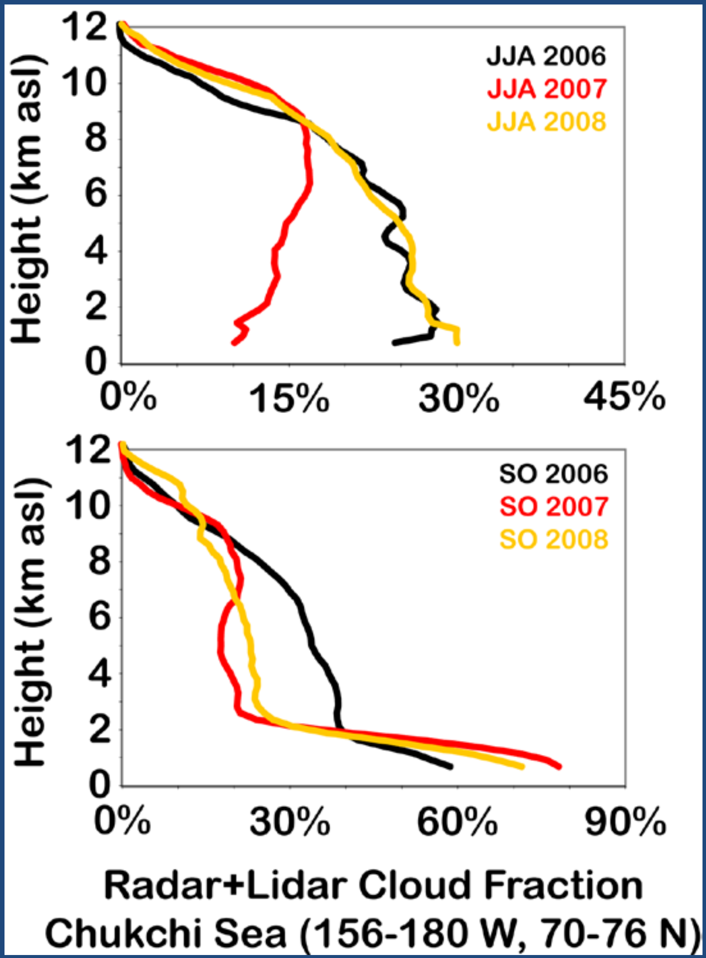
Observations reveal no summer cloud response to sea ice loss, but low cloud increases during early fall.

Kay and Gettelman (2009)



What is the atmospheric response to sea ice loss in CAM?
Does the modeled cloud response match the observations?

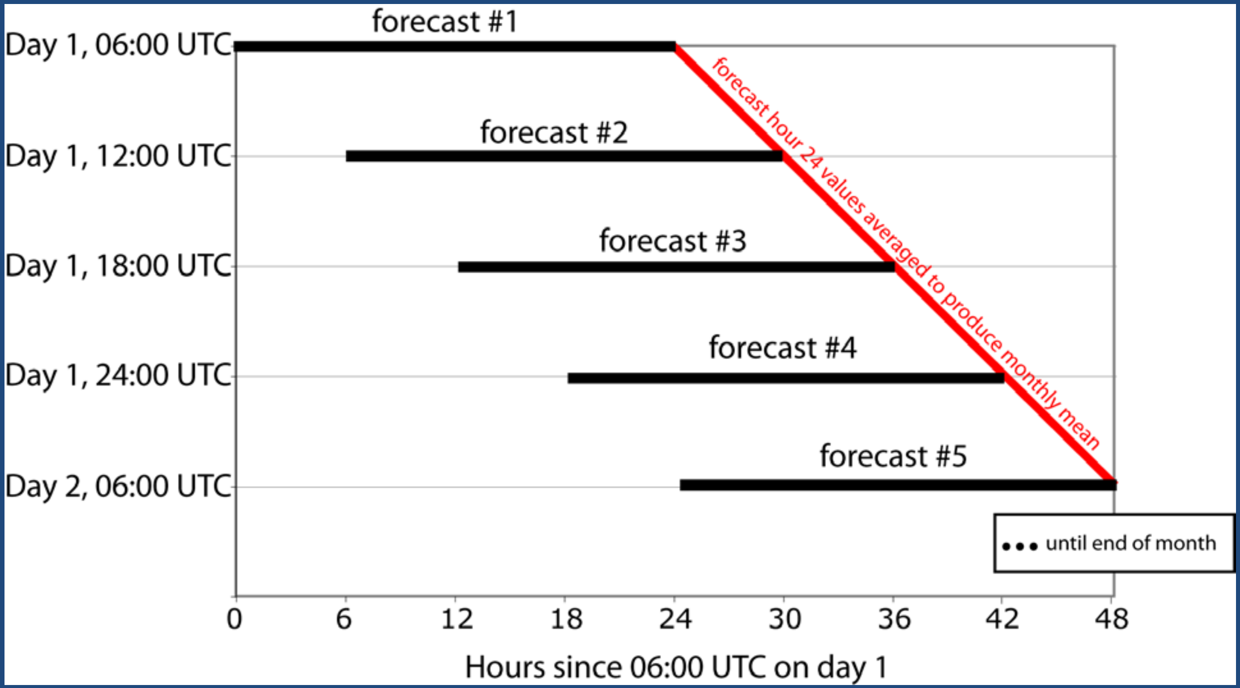
CAM-DART sea ice project

CAM = Community Atmosphere Model, version 3.5 OR version *4*
DART = Data Assimilation Research Testbed

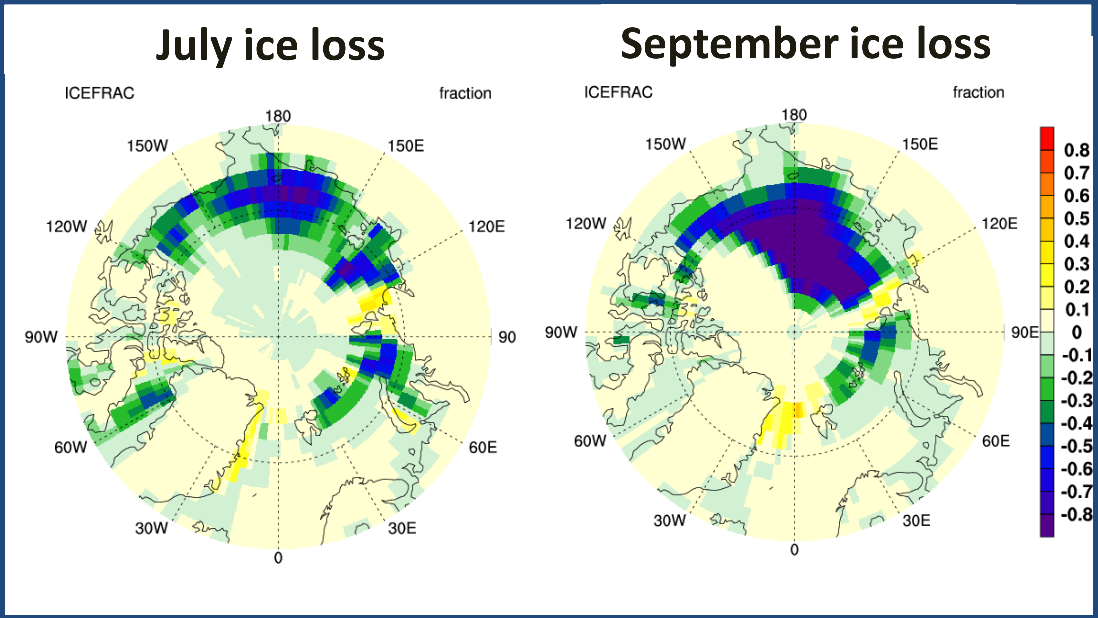
Steps:

1) Run DART-CAM assimilation
2) Run 24-hour CAM forecasts with climo or observed SST/sea ice
3) Average CAM forecasts to make monthly mean

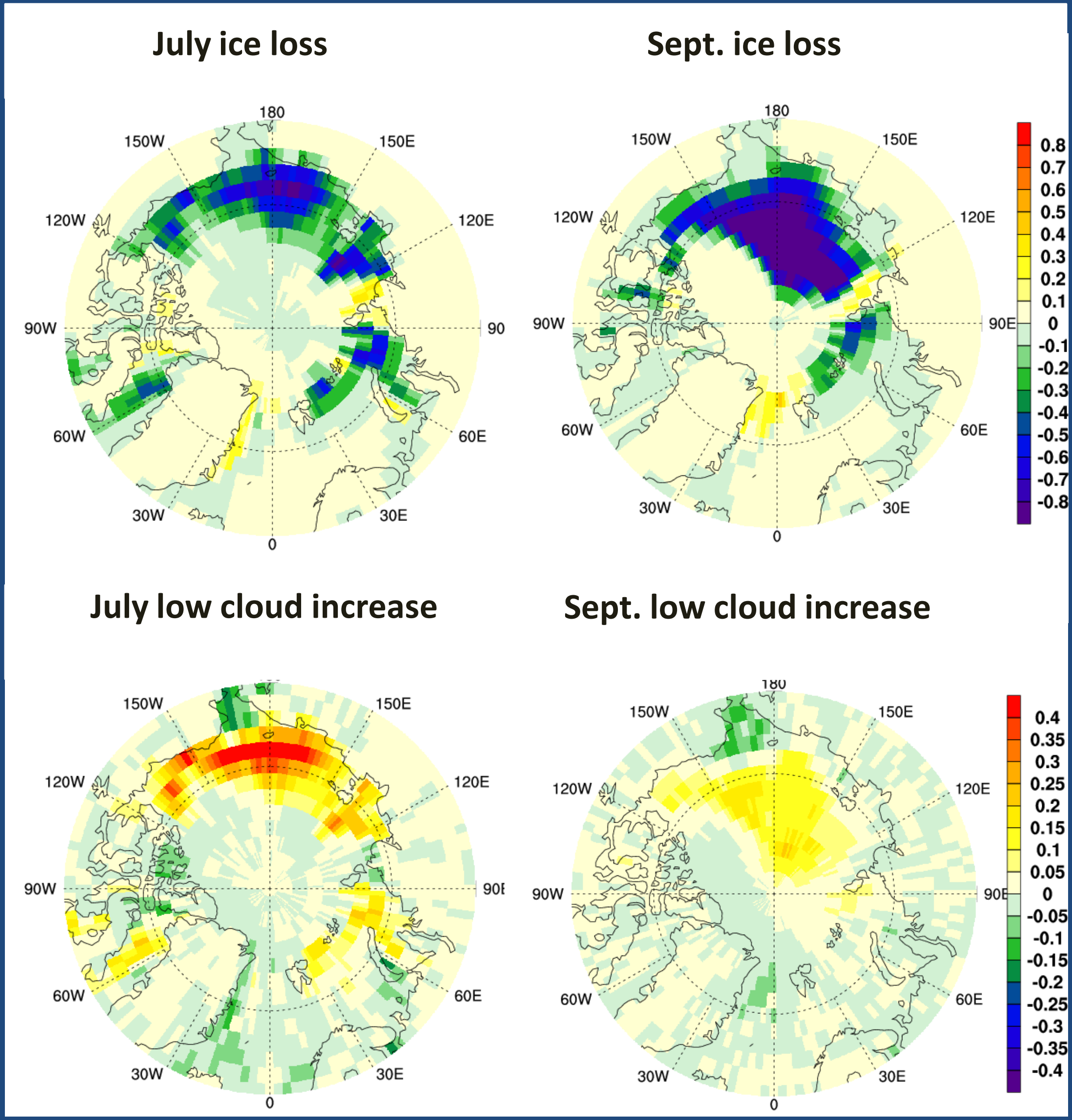
Example of forecast cycle and averaging



CAM3.5 atmospheric response to sea ice loss

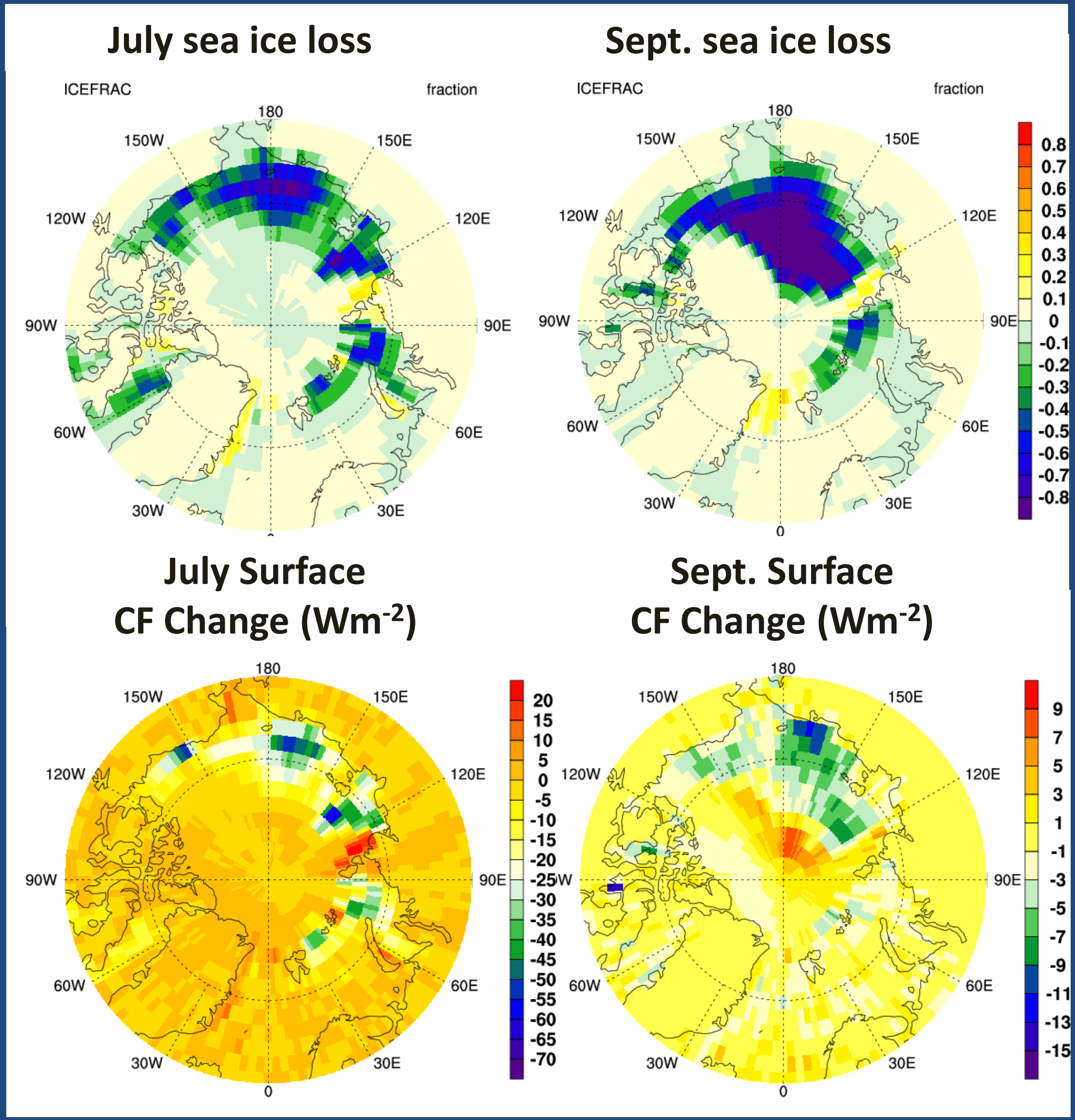


Cloud response to sea ice loss in CAM3.5



CAM3.5 forecasts have low cloud increases over newly open water in both July and September.

Cloud forcing (CF) changes due to sea ice loss



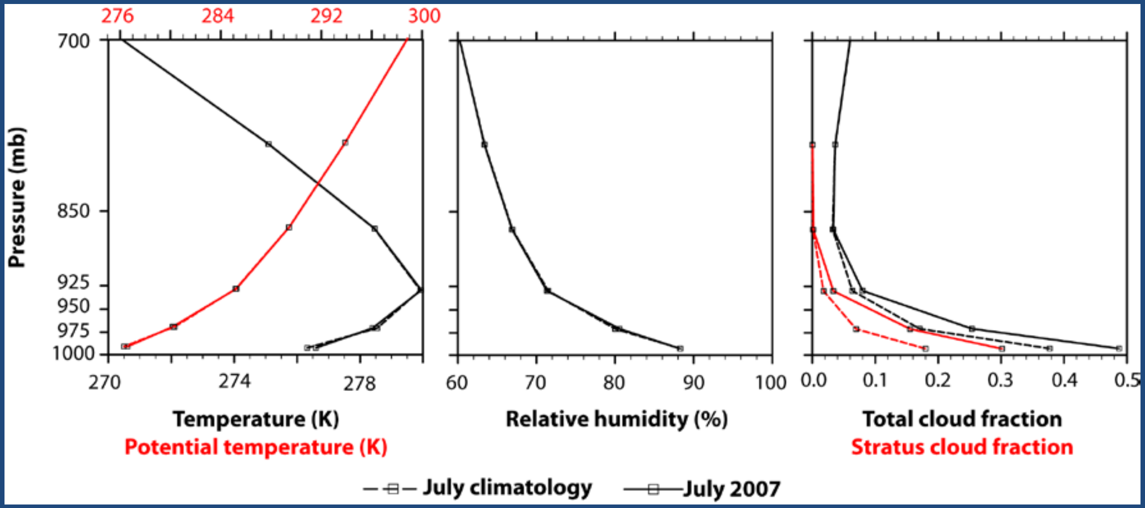
Avg. CF change in grid cells with sea ice loss

	July	September
TOA	-22.7 Wm^{-2}	-5.5 Wm^{-2}
Surface	-18.9 Wm^{-2}	-1.6 Wm^{-2}

STRONGER NET COOLING IN BOTH MONTHS

What processes explain the cloud increases over newly open water?

Profiles over CAM grid cells with sea ice loss



July cloud increases result because stratus clouds are only diagnosed over the open ocean. (!)

A quick fix for CAM3.5?

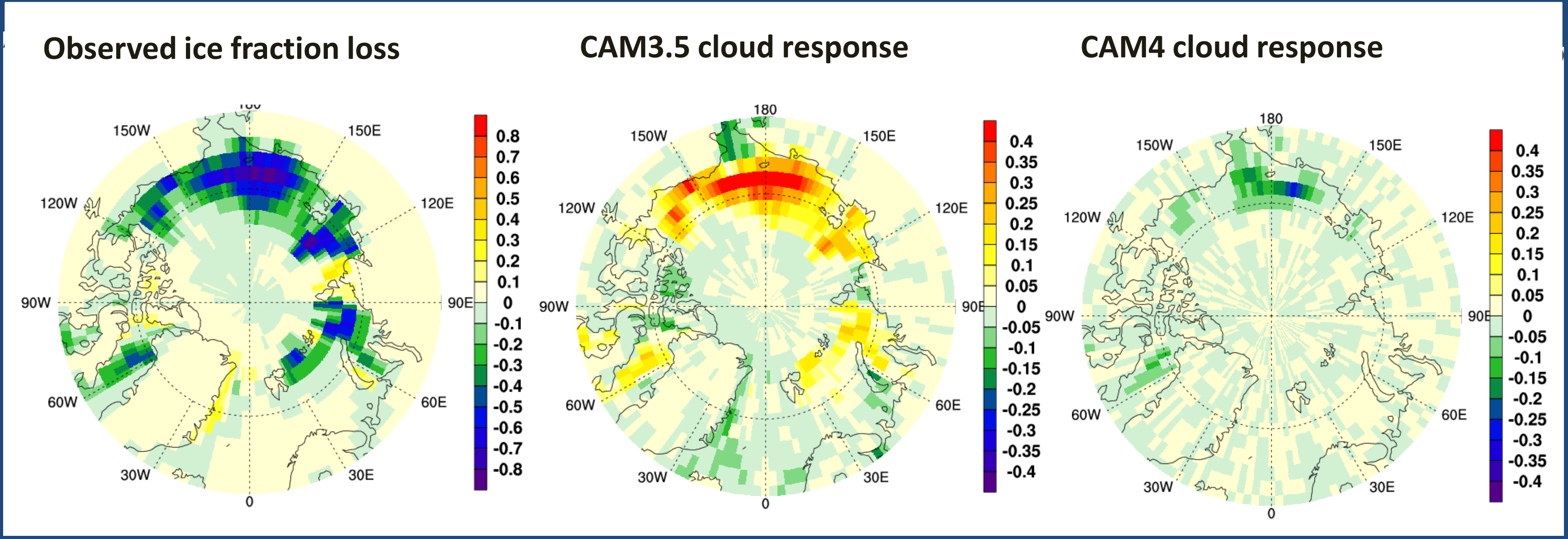
"vanilla" = unmodified CAM3.5 code

"cldmod"=CLDST diagnosed over open water AND sea ice

Net July radiation change in grid cells with sea ice loss

	vanilla	cldmod
TOA	+13.5 Wm^{-2}	+21.3 Wm^{-2}
Surface	+13.3 Wm^{-2}	+18.1 Wm^{-2}

July CAM3.5 vs. CAM4



Summary of July changes associated with sea ice loss

	CAM3.5	CLDMOD CAM3.5	CAM4
Low cloud	**+16%**	**-3%**	**-3%**
Surface albedo	**-13%**	**-14%**	**-8%**

Summary

-Observations reveal no summer cloud response to sea ice loss, but cloud increases during early fall (Kay and Gettelman, 2009).

-CAM3.5 has a built-in feedback between stratus clouds and sea ice. This feedback produces unrealistic cloud increases over newly open water in stable atmospheric regimes.

-CAM4's weak July cloud response to sea ice loss is more consistent with recent observations. Due to the albedo reductions alone:

1) Clouds have a stronger cooling influence
2) Upward SW decreases (ice albedo feedback)
3) Surface downward SW decreases (multiple scattering feedback)

-September cloud increases over newly open water in CAM3.5 are consistent with recent observations.

Implications

1) CAM3.5 has a built-in feedback between clouds and sea ice in stable atmospheric regimes. Stratus clouds increase over newly open water.

2) This feedback is NOT realistic. It is not seen in observations (Kay and Gettelman, 2009).

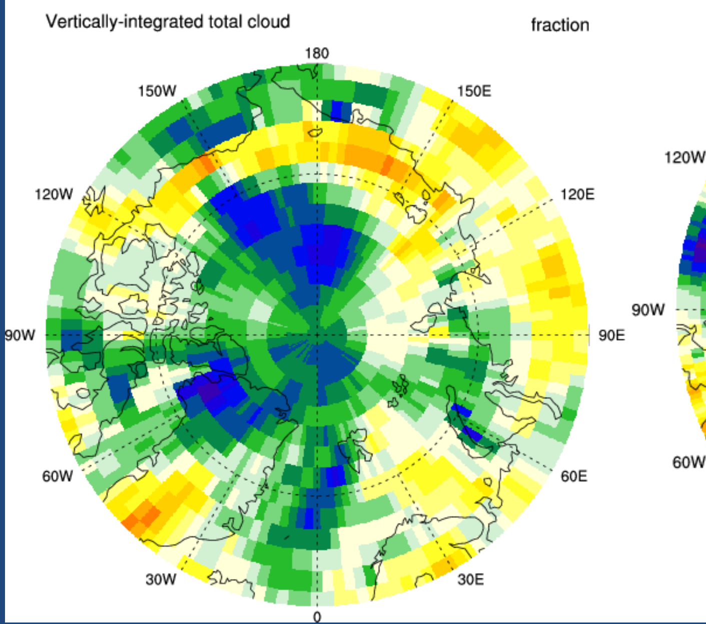
A detailed comparison of changes resulting from sea ice loss

	VANILLA CAM3.5	CLDMOD CAM3.5
Low cloud	+16%	-3%
Surface albedo	-13%	-14%
TOA CF (Wm^{-2})	-22.7	-15.8
Surface CF (Wm^{-2})	-18.9 *SW -25.3 LW +6.4*	-17.7 *SW -17.1 LW -0.5*
Surface shortwave fluxes (Wm^{-2})	Net: +15.0 Down: -23.7 Up: -38.7	Net: +24.0 Down: -9.8 Up: -33.8

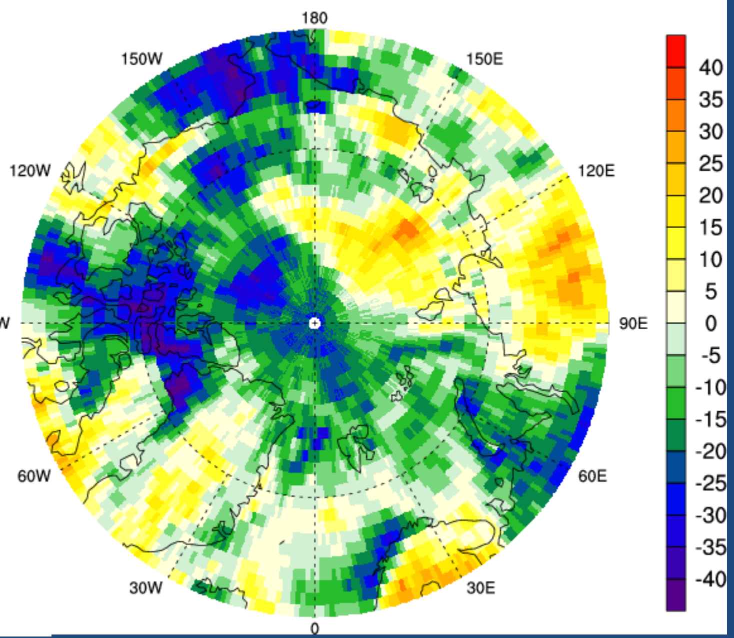
Modeled vs. observed cloud changes

July07 minus July06

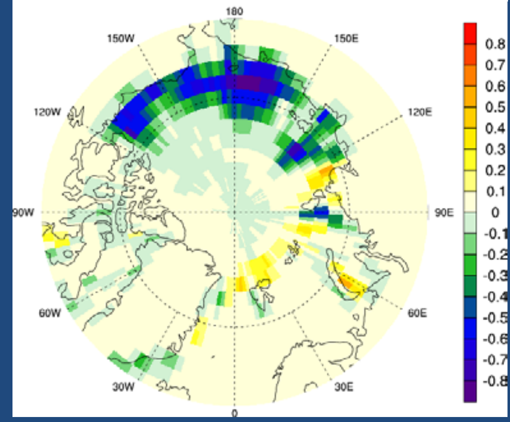
CAM Cloud Difference



MODIS Terra Cloud Difference

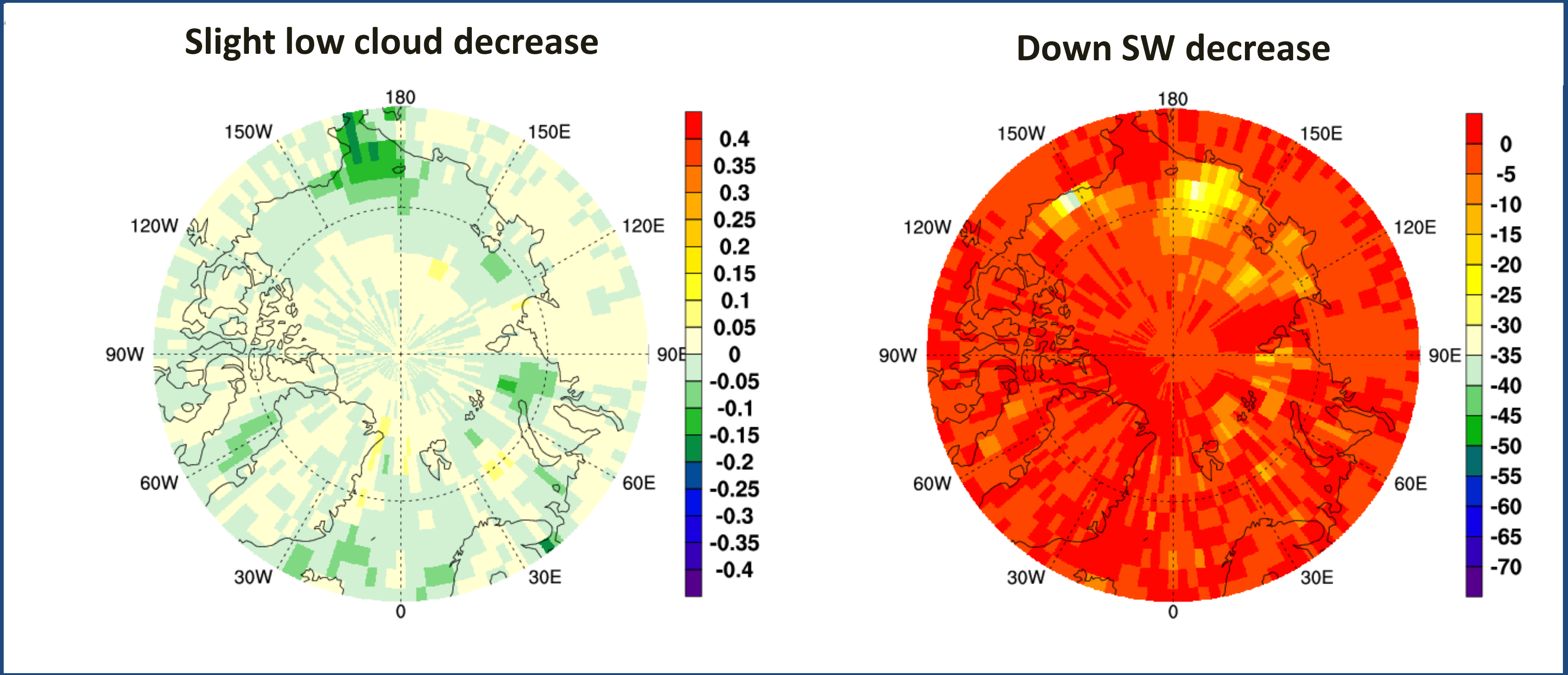


Sea Ice
Fraction Difference



CAM3.5's built in feedback between stratus cloud formation and sea ice loss is not realistic.

Surface downwelling shortwave radiation decreased over sea ice with slight cloud decreases!



The reduction in downwelling SW radiation over newly open water results from a decrease in multiple scattering between clouds and the surface.

Recent Arctic sea ice loss creates new opportunities to understand the atmospheric response to sea ice loss