Zonal-mean atmospheric response to future Arctic sea ice loss: The role of ocean-atmosphere coupling

Bob Tomas
Clara Deser and Lantao Sun (CAS)

(submitted to *J. Climate*)

3 pairs of simulations, nominally 1° horizontal resolution all components

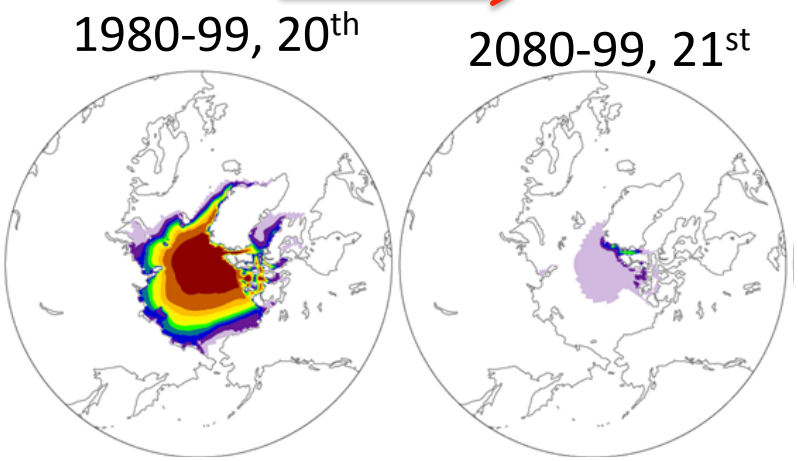
Description	Model Configuration	Responses
6 member RCP8.5 ensemble 2080-99 (late 21st century)	Fully coupled (all component models active), forced with projected GHG's and "observed" radiative forcings	Δ (RCP8.5) climate response to increased GHG's
6 member historical ensemble 1980-99 (late 20th century)		
Late 21st century Arctic sea ice	Active atmosphere and land only, sea ice and and SST prescribed as boundary conditions, GHG @ 2000	Δ (ICE_atm) atmosphere response to projected Arctic sea ice changes, uncoupled framework
Late 20th century Arctic sea ice		
Late 21st century Arctic sea ice	Fully coupled but with ice model forced to mimic late 21st and 20th century Arctic sea ice GHG @ 2000	Δ (ICE_coupled) atmosphere/ocean response to projected Arctic sea ice changes, fully coupled framework
Late 20th century Arctic sea ice		

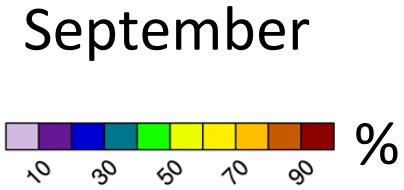
Role of active ocean in atm response to Δice

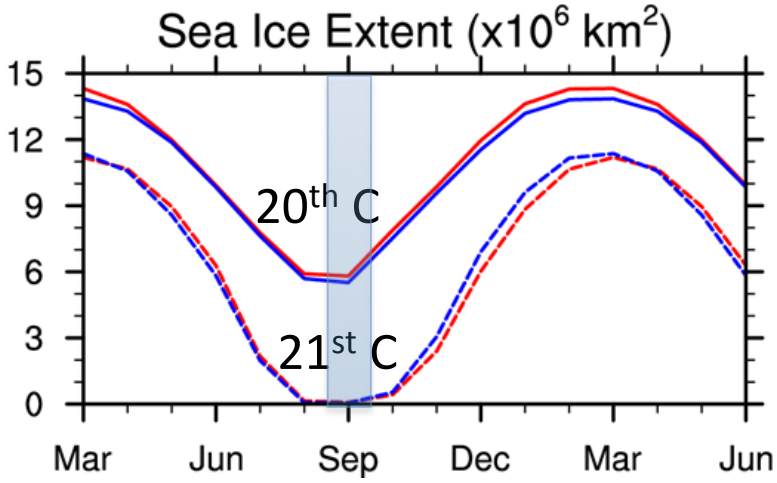
Role of Δice in full RCP8.5 atm response

Arctic Sea Ice Concentration

RCP8.5 GHG

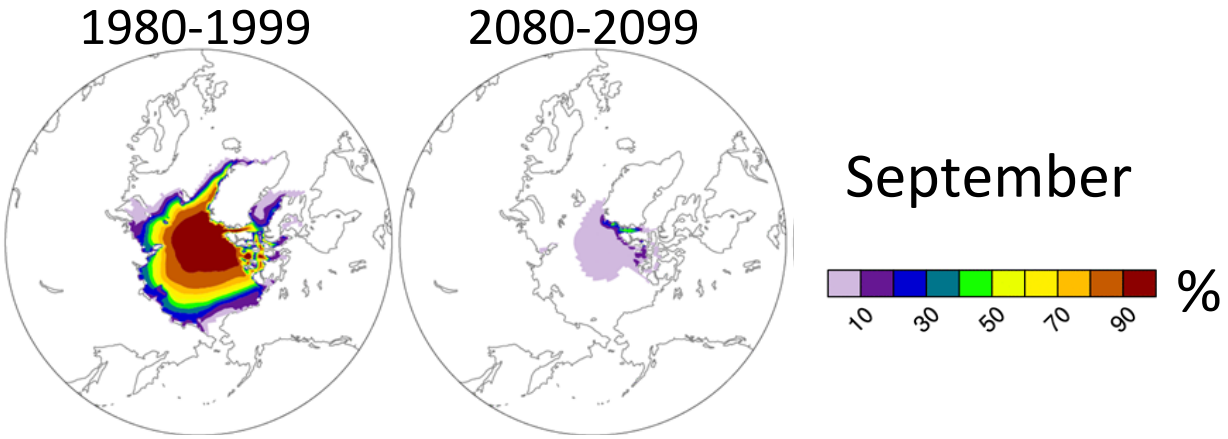


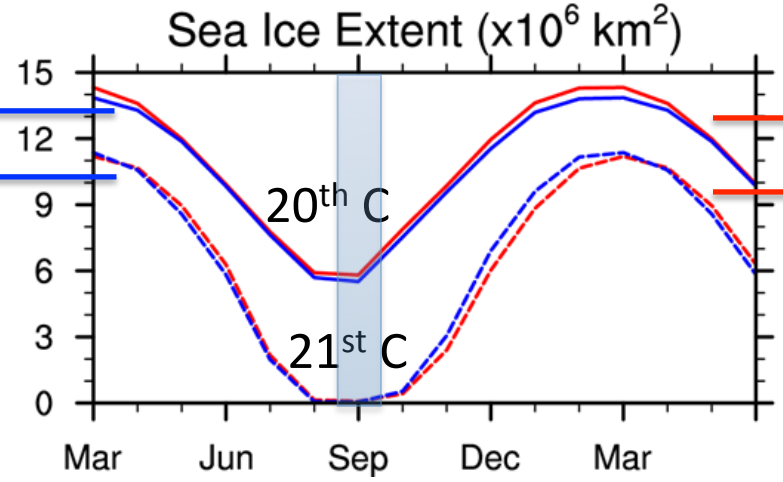




CESM (1°) Arctic Sea Ice Concentration

RCP8.5 GHG





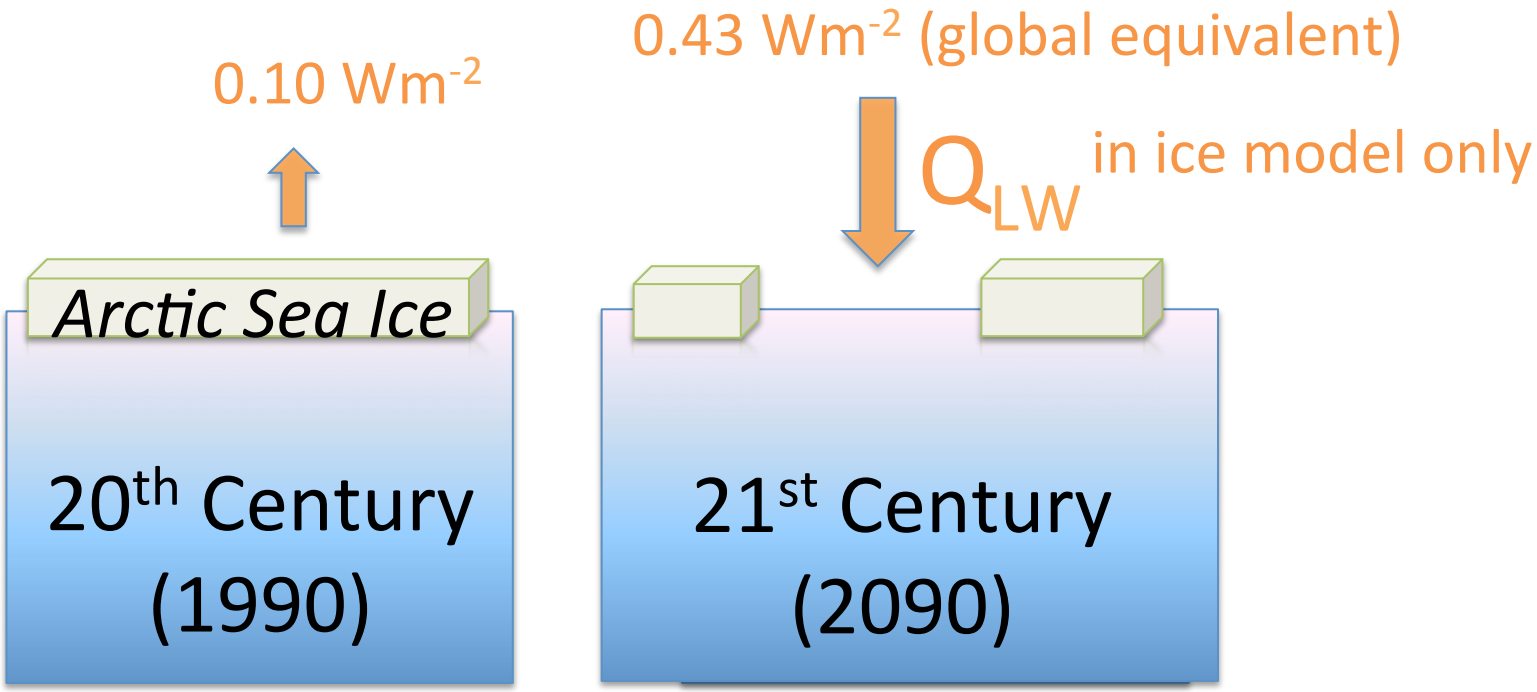
ICE_coupled
(360 years)

ICE_atm
(260 years)

Discard first 100 years as the system adjusts (AMOC)

Artificially controlling Arctic sea ice in CESM

(GHG fixed at year 2000)



Warms as it comes into equilibrium, so need to remove energy in the ice model

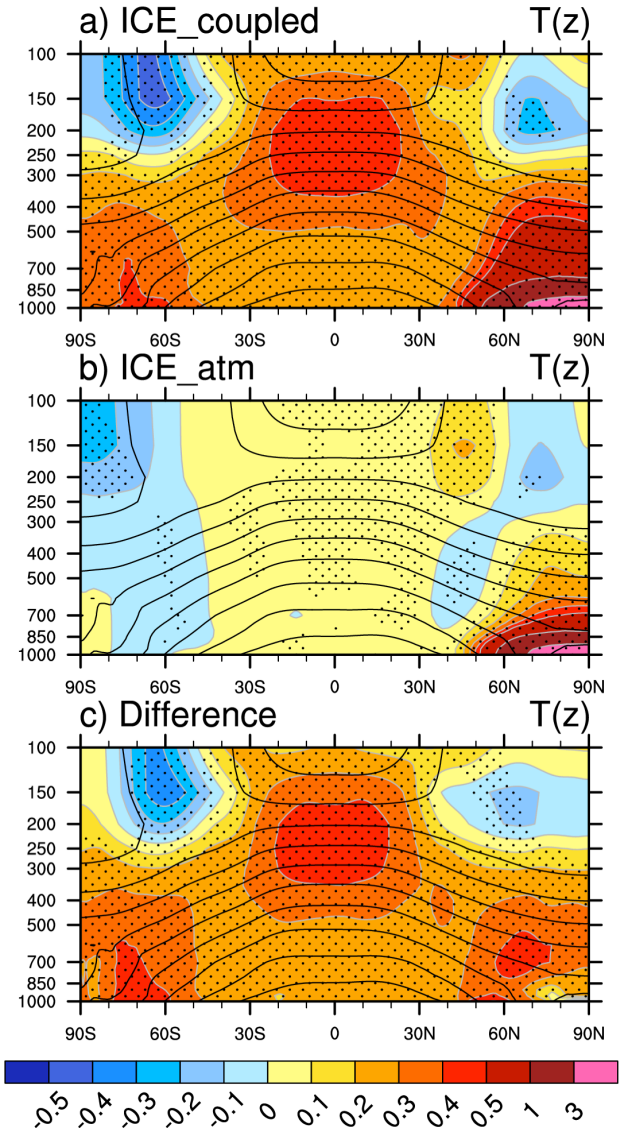
Need to add energy in the ice model to melt ice

Annual T(z) and U(z) Responses to Arctic Sea Ice Loss

Ice Coupled

Ice Atmosphere

Difference



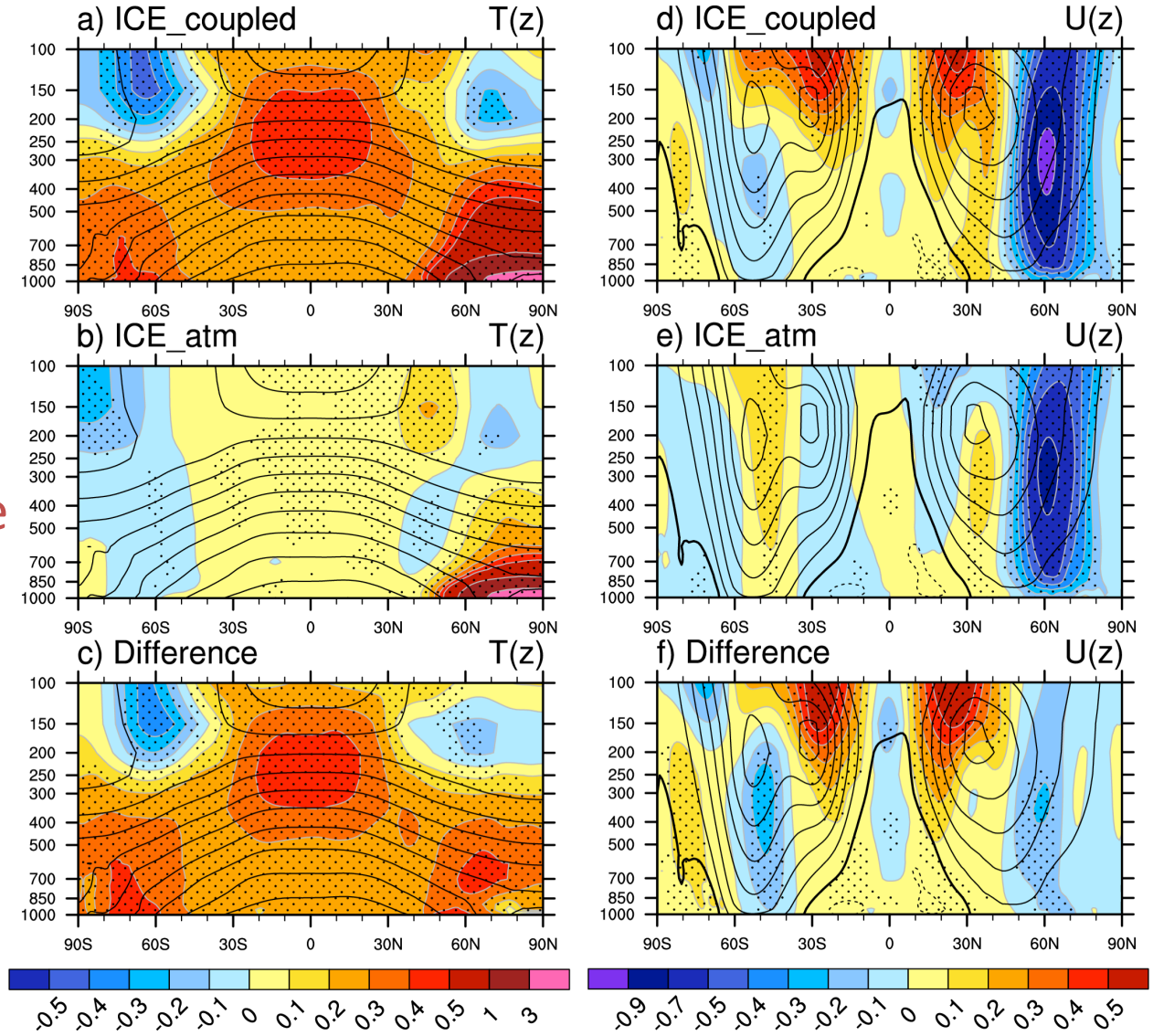
Active ocean results in global scale warming

Annual T(z) and U(z) Responses to Arctic Sea Ice Loss

Ice Coupled

Ice Atmosphere

Difference



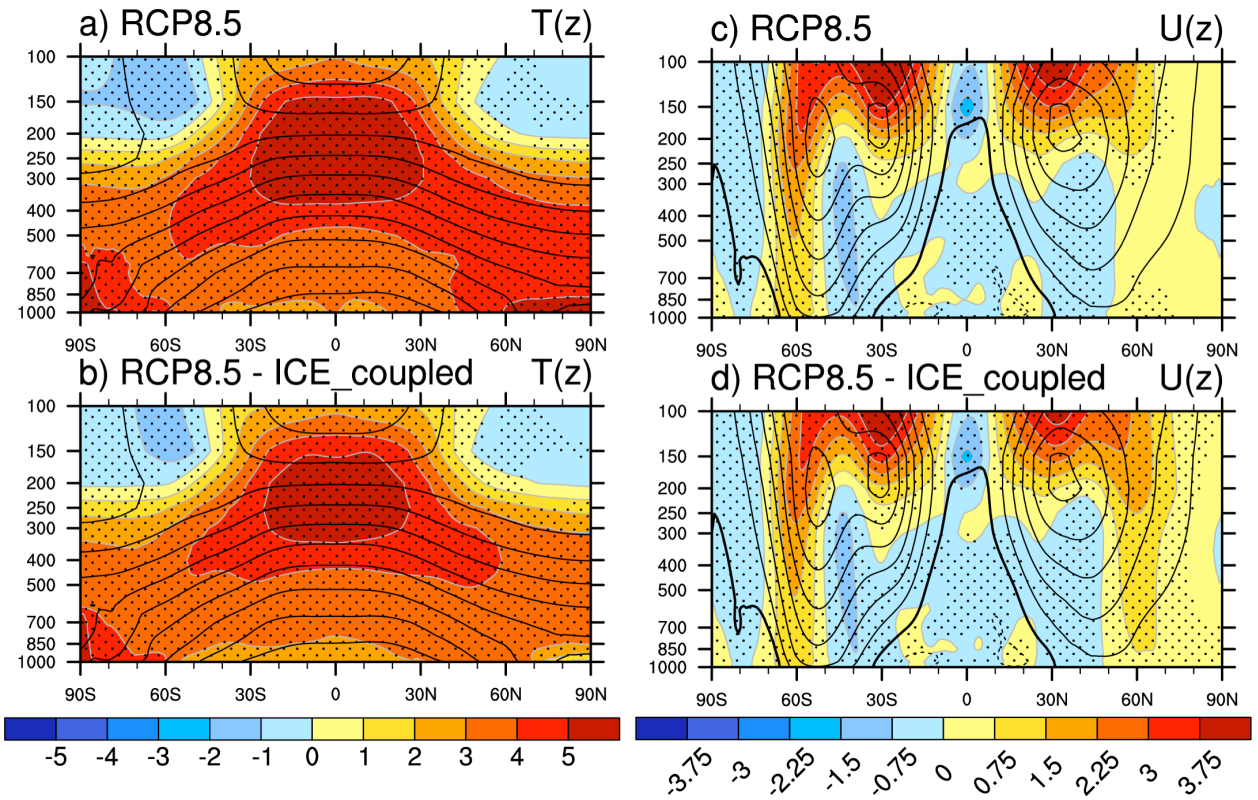
Both ice simulations have an equatorward shift in the jet

Active ocean results in a global responses

Arctic Sea Ice Loss Contribution to RCP8.5 Response

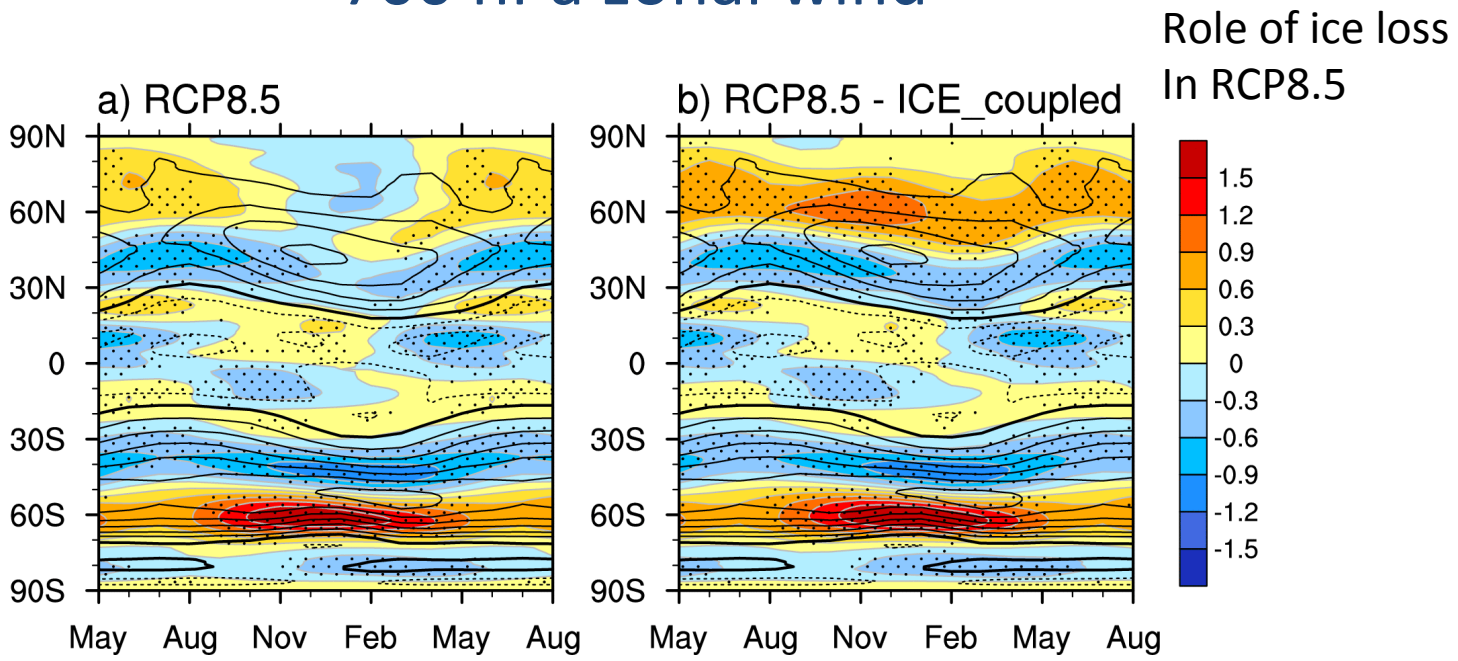
RCP8.5

Difference



Greater hemispheric symmetry in the absence of Arctic sea ice loss

Arctic Sea Ice Loss Contribution to RCP8.5 Response
700 hPa zonal wind



Absence of poleward shift of NH winter westerlies in RCP8.5 due to offsetting influences of GHG increase and Arctic sea ice loss

Conclusions

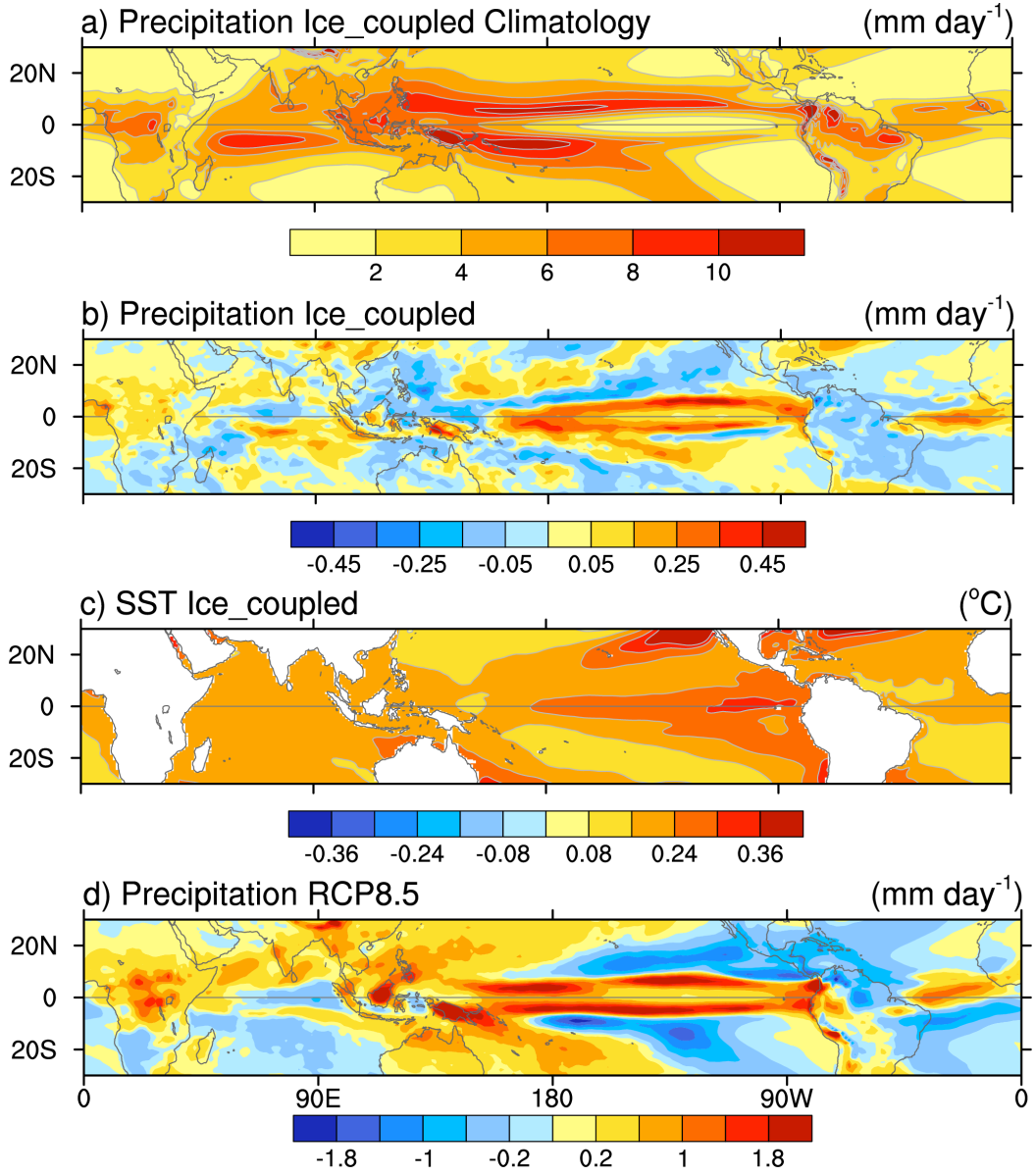
We were able to simulate the atmosphere/ocean response to projected 21st century Arctic sea ice loss in fully coupled simulations

When ice and associated SST's are prescribed as lower B.C.'s, the response is confined to the vicinity of the ice loss. In contrast, the response is global with an active ocean model

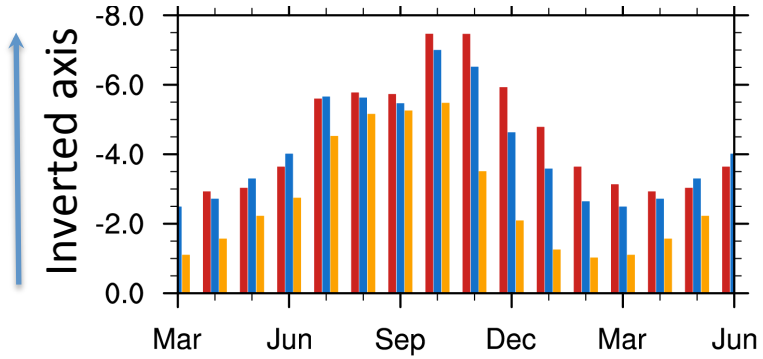
The zonal wind response to Arctic sea ice loss in both ice simulations is an equatorward shift in the mean zonal jet

This equatorward shift accounts for the absence of a winter poleward jet shift in the NH RCP8.5 simulations

Tropical Coupled Response to Arctic Sea Ice Loss



Sea Ice Loss (10^6 km^2)

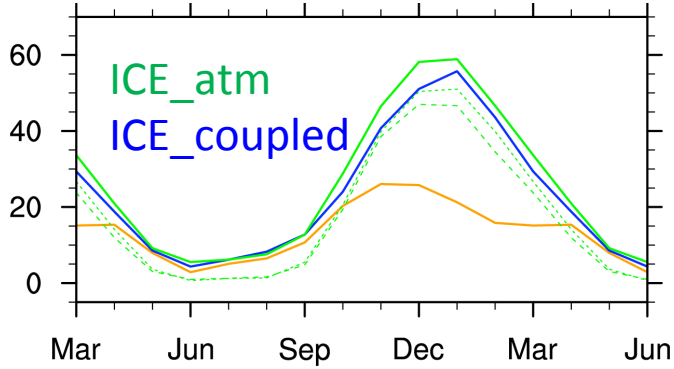


RCP8.5

Our coupled runs

Lowered albedo run

Arctic Ocean Heat Flux Response (Wm^{-2} upward)



- Maximizes in winter
- Underestimated in lowered albedo run