Recent Arctic Climate Modeling at GFDL

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Background

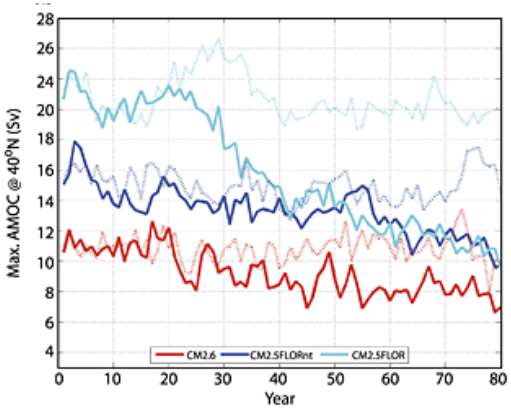
- MCM -> CM2 -> ESM2/CM3 -> ESM4/CM4*

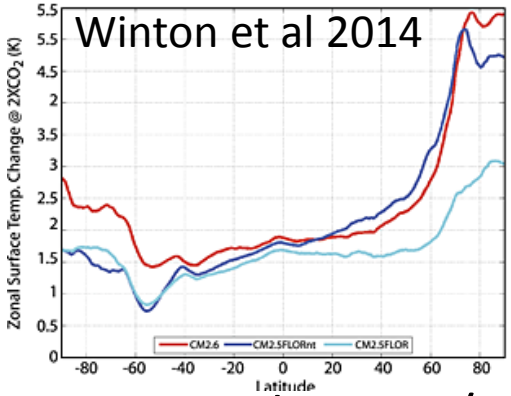
- CM4 uses SIS2 sea ice – CICE-like thermodynamic structure & radiation; EVP dynamics on C-grid

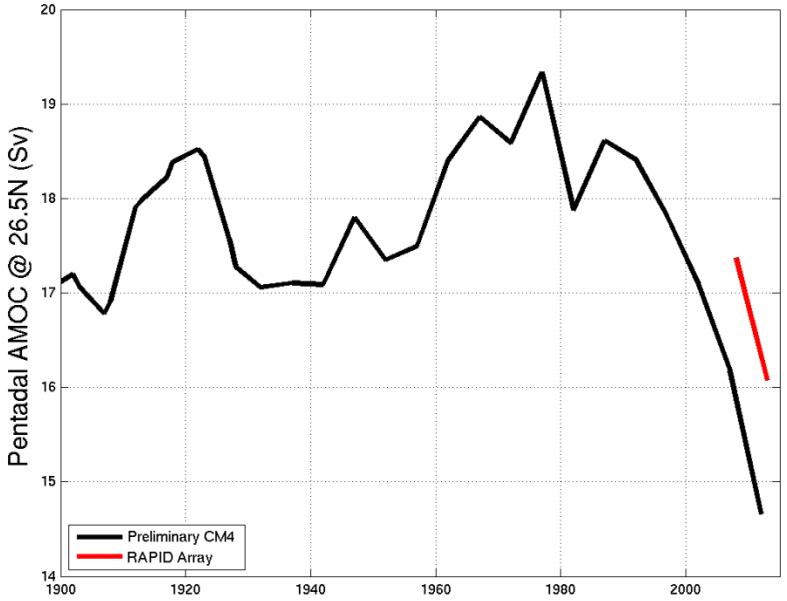
- CM4 development cycle has had an increased focus on the model's sensitivity characteristics

* all "CM4" results shown are *preliminary* and intended to be illustrative

AMOC decline mitigates Arctic warming



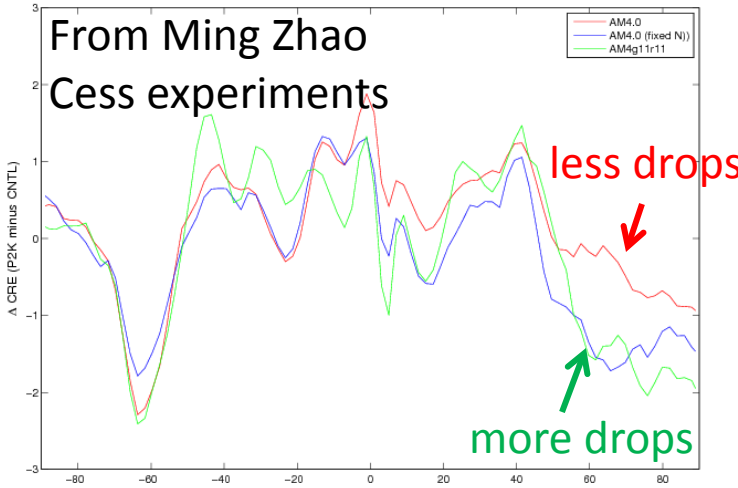


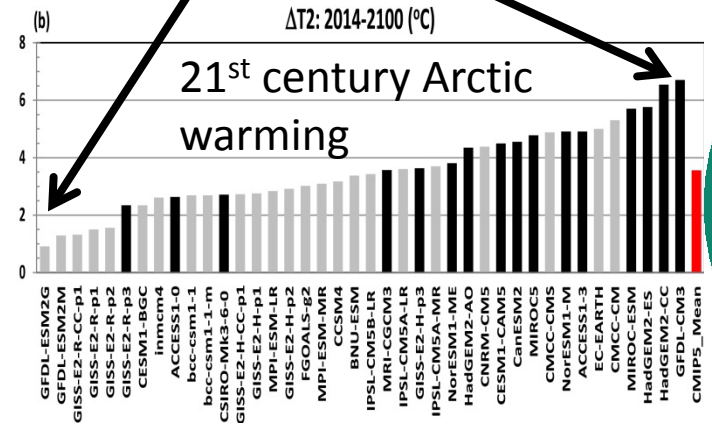


- Decreased AMOC/reduced OHT response reduces Arctic warming
- AMOC and AMOC decline magnitudes are related -> obs constraint
- Success: reasonable simulation of AMOC magnitude
- Challenges: ocean heat transport is still too low, NADW too shallow, overflows lacking despite MOM6's Lagrangian vertical coordinate.

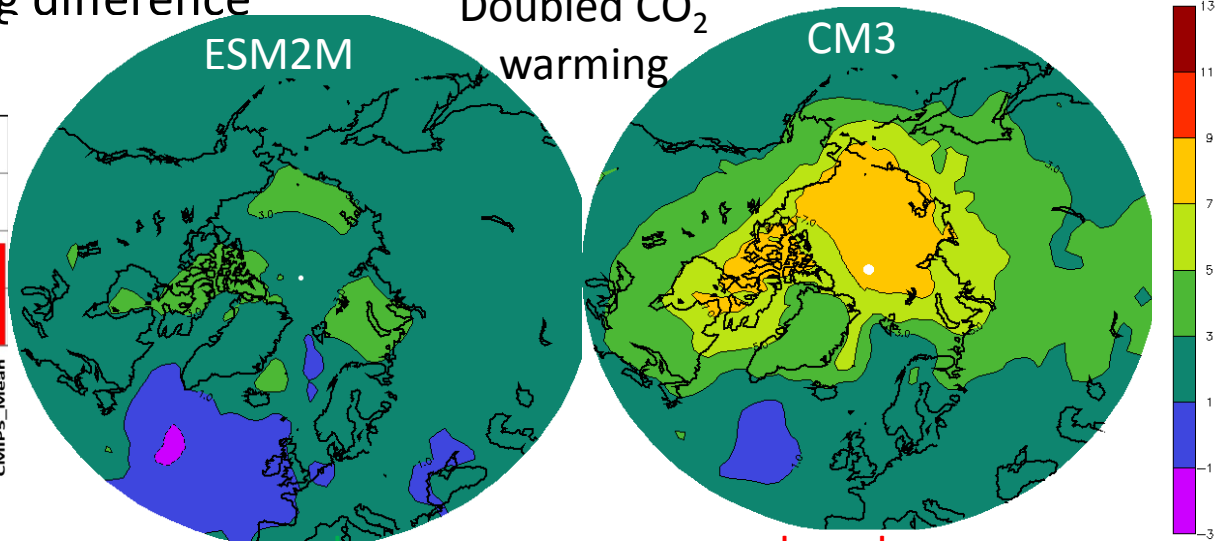
Increased cloud drop number density simulation reduces Arctic warming

- Feedback difference manifests in climate model sea ice sensitivity (~35% more NH sea ice loss per deg. warming with "red" atmosphere relative to "green")
- Challenge: observational constraints on cloud drop number density
- Success: progress toward understanding large CM2/CM3 Arctic warming difference

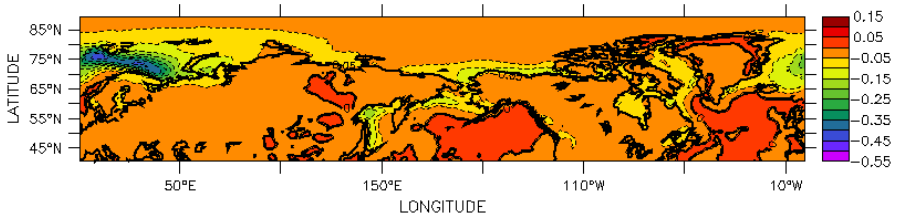




Chylek et al 2016

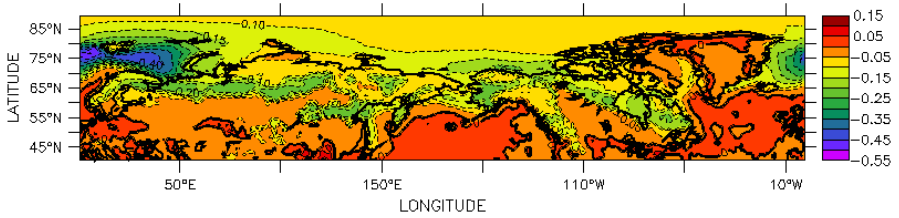


Vegetation feedback increases Arctic warming: Boreal forest invades tundra



Delta–Surf. Albedo – Static Veg.

Surface albedo change at doubled CO_2 in 1%/year CO_2 increase experiment



Delta–Surf. Albedo – Dynamic Veg.

- Ice/albedo feedback mediated by vegetation snow masking
- Vegetation response increases warming and sea ice decline
- Success: incorporation of important vegetation feedback
- Challenges: process realism, observational constraints

Summary of Challenges

- AMOC simulation: deep overflows, NADW biases
- Arctic cloud drop count density feedback: observational constraints, process understanding
- Arctic vegetation feedback: process representation and observational constraints