Arctic and Antarctic Sea Ice State in CESM2 and the impact of clouds

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NCAR | CLIMATE & GLOBAL DYNAMICS

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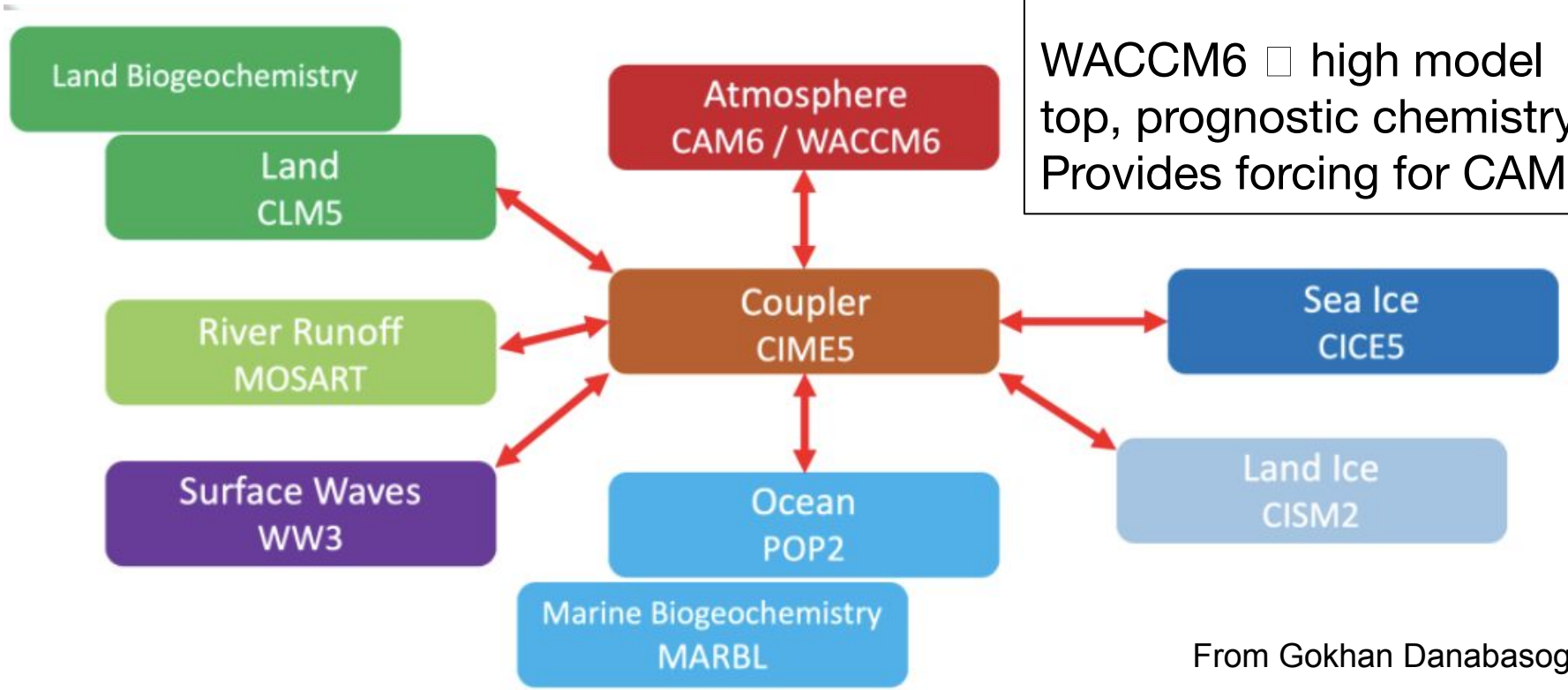
CESM2 configuration

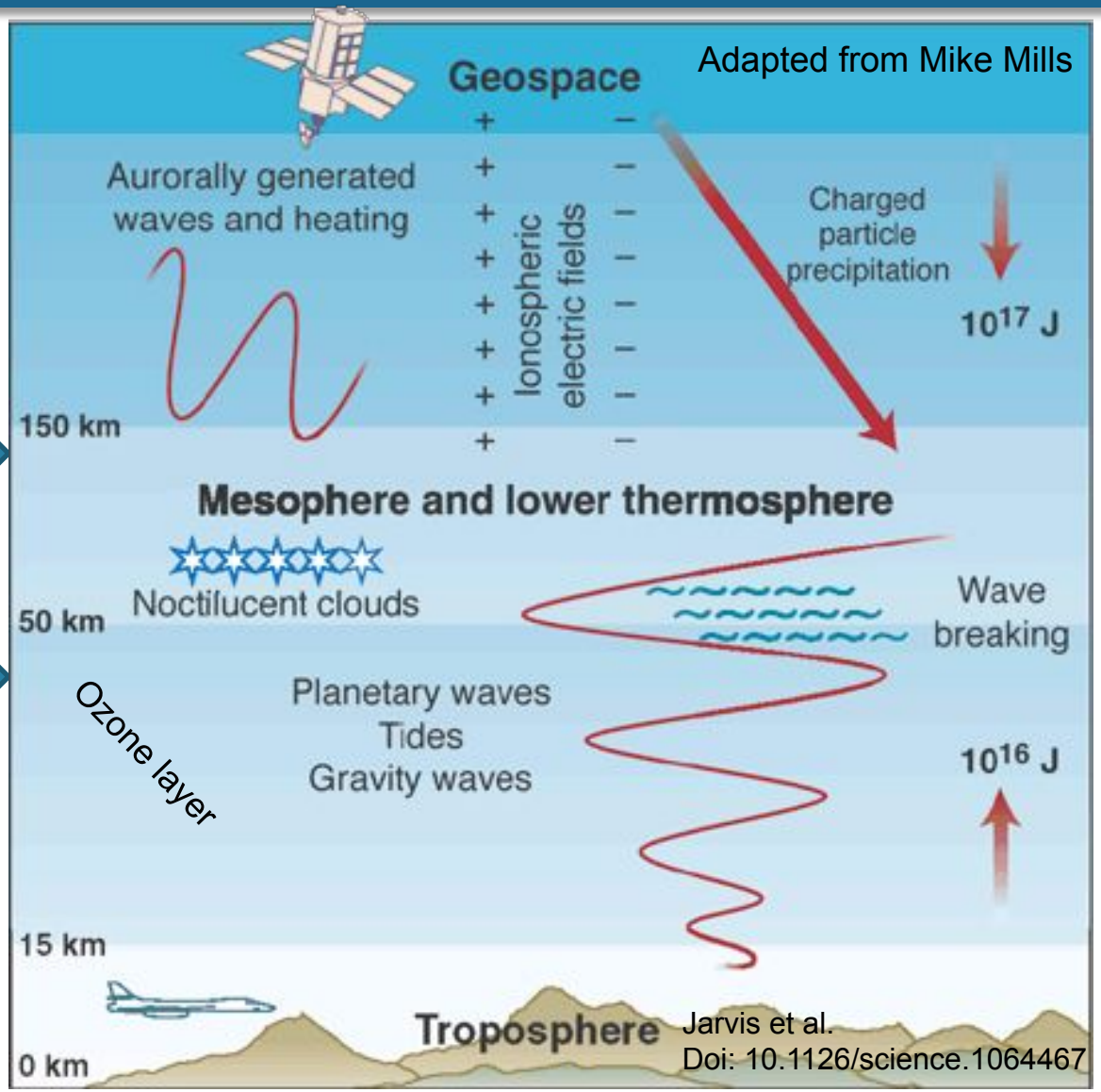
CAM6 □ low model top, simple chemistry

WACCM6 □ high model top, prognostic chemistry. Provides forcing for CAM.



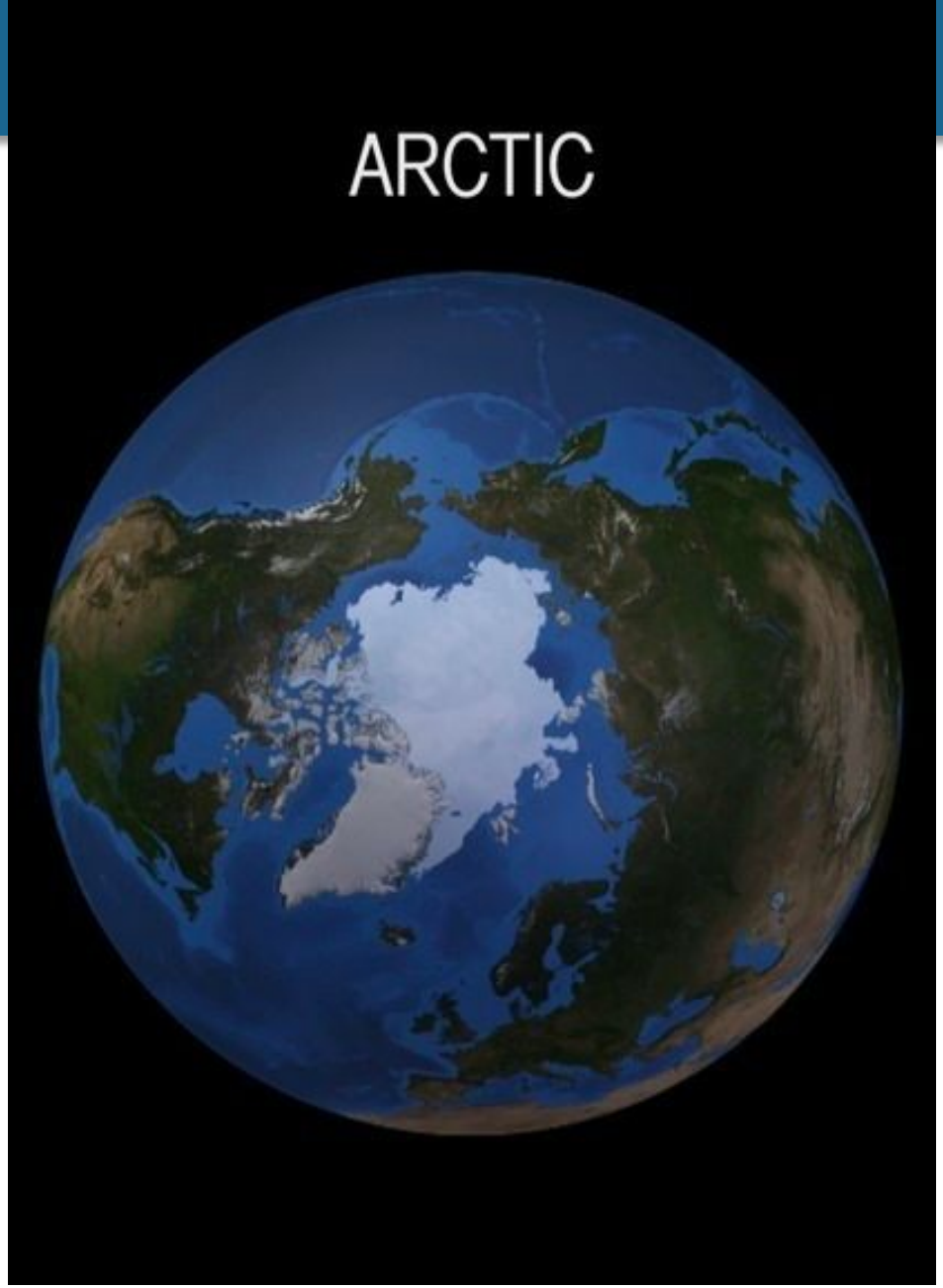
From Gokhan Danabasoglu

Atmospheric Structure

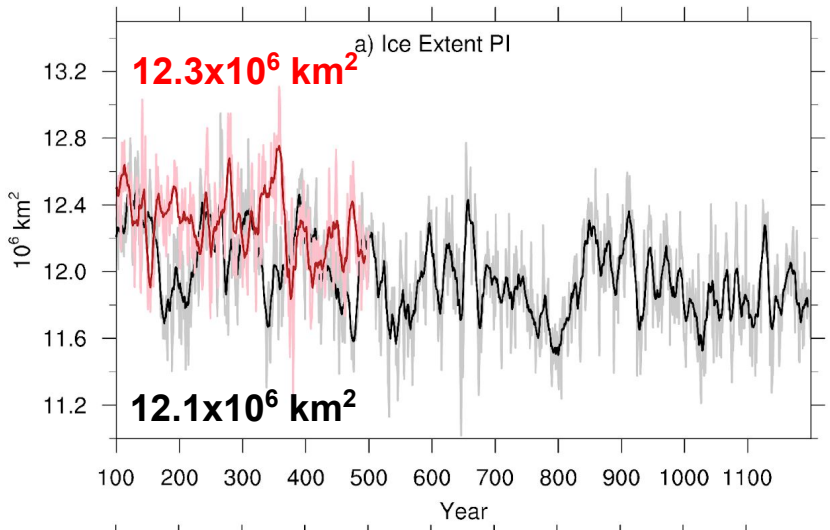


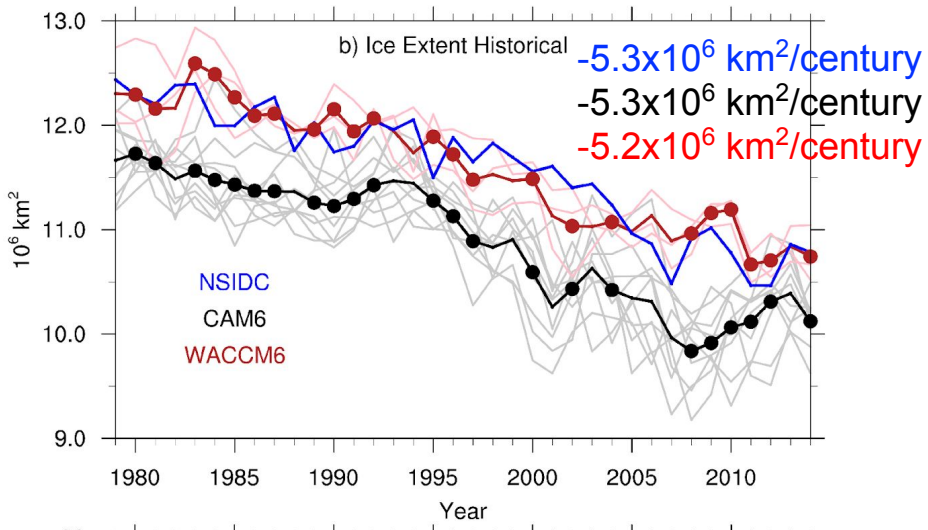
WACCM top
70 levels

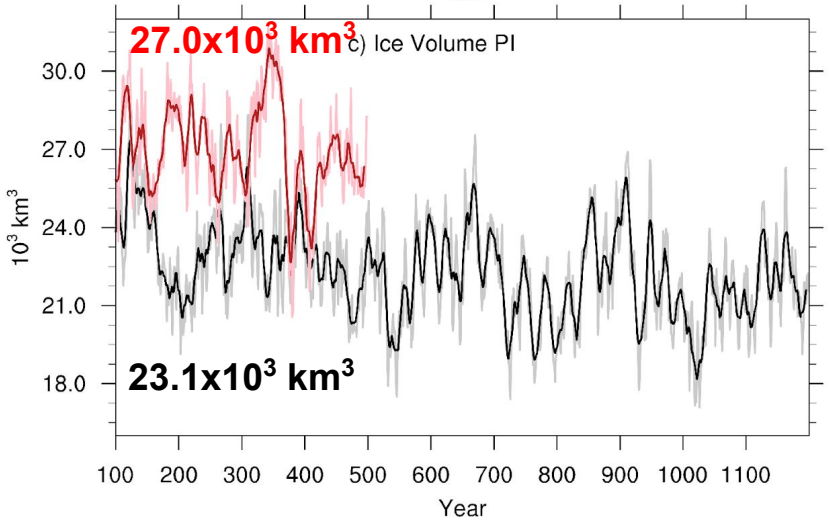
CAM top (40km)
32 levels

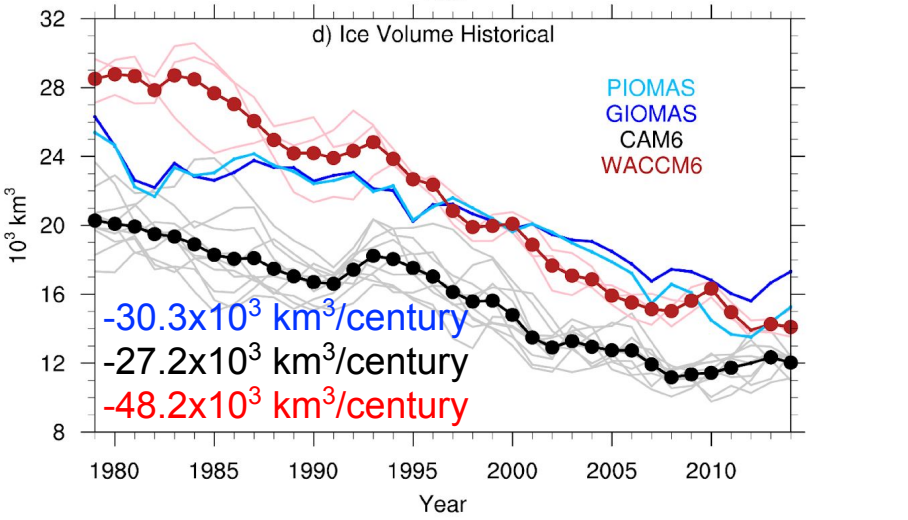

ARCTIC

Arctic mean sea ice extent and volume differ

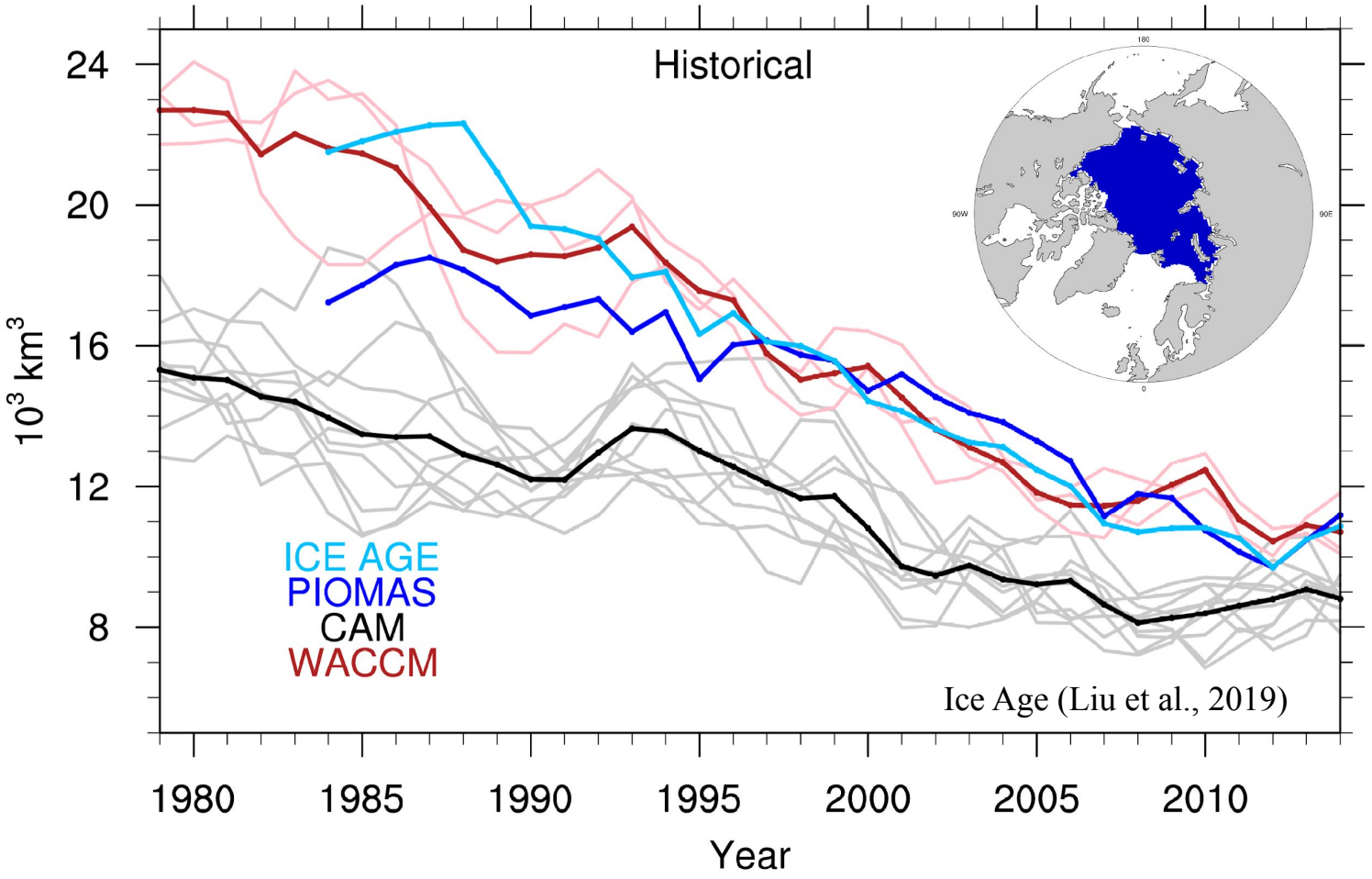




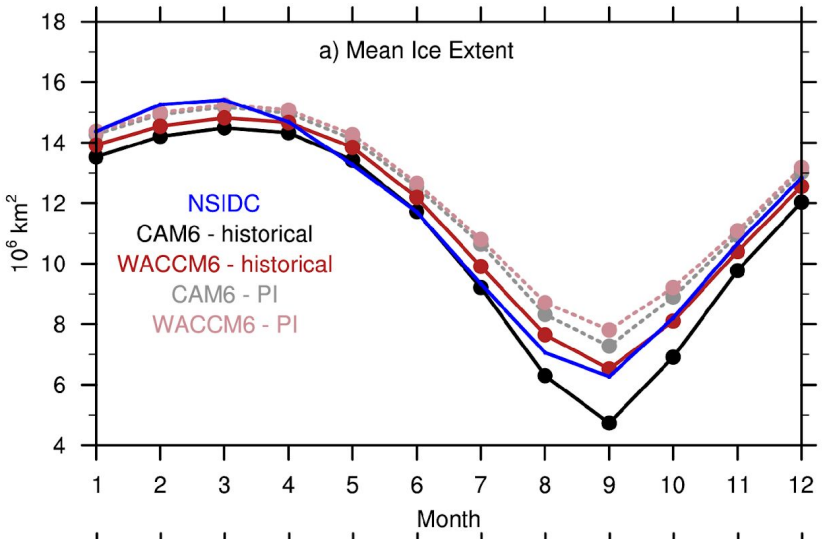


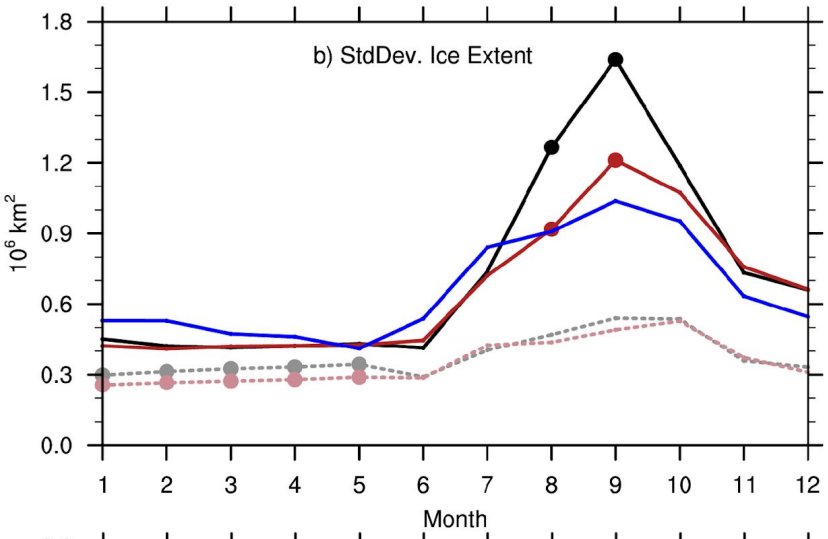


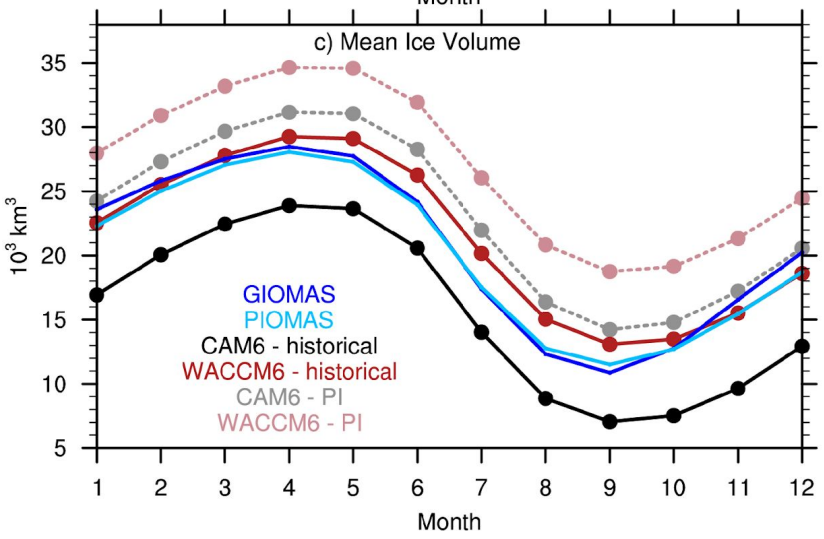
Compared to new Ice Age derived volume, WACCM fits well

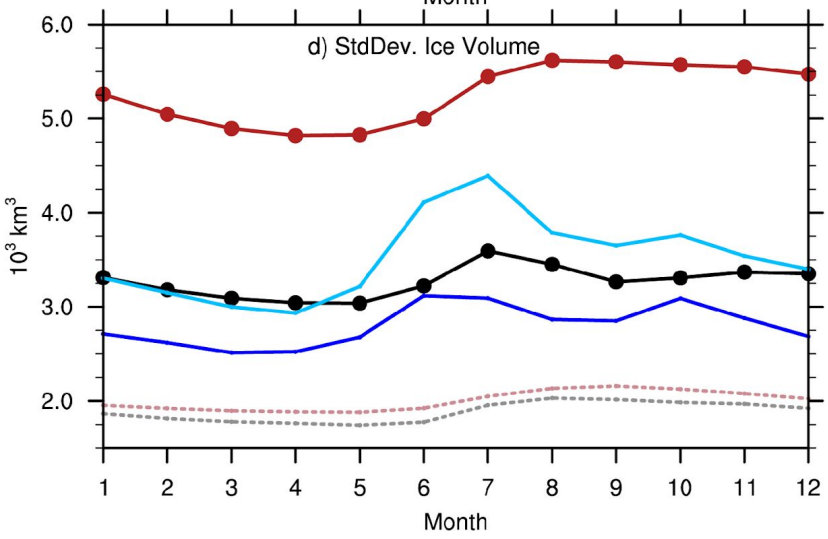


Arctic seasonal cycles



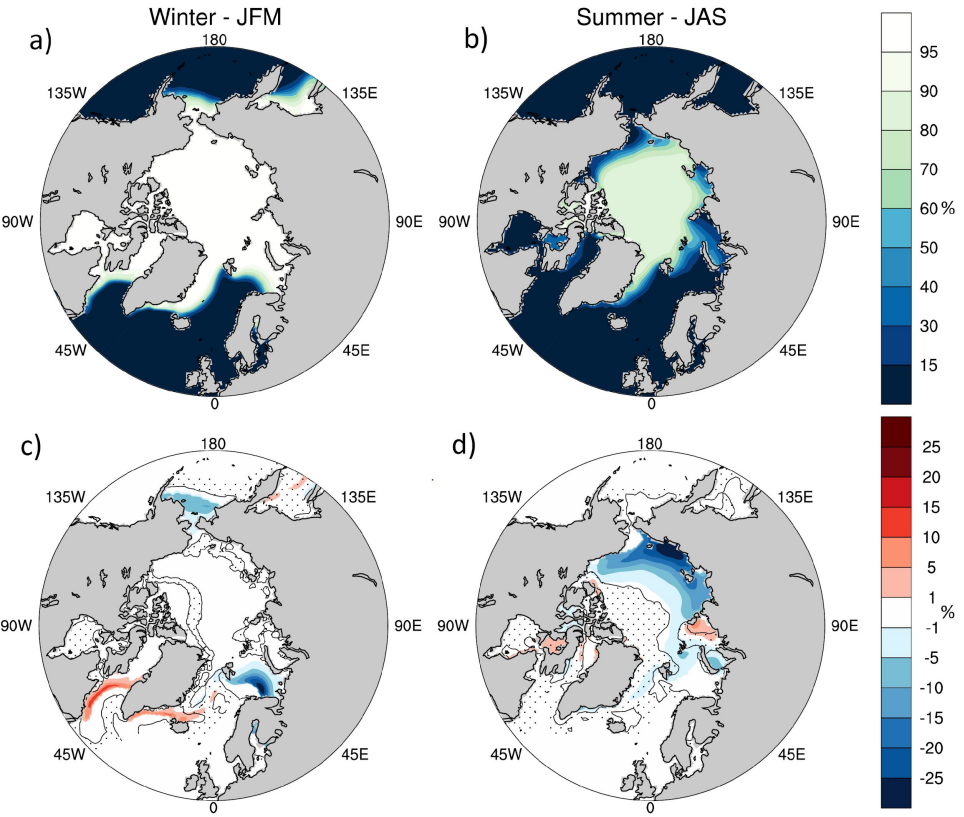






Sea ice summer concentration differences are largest near Siberian Sea

Preindustrial (years 100-500)

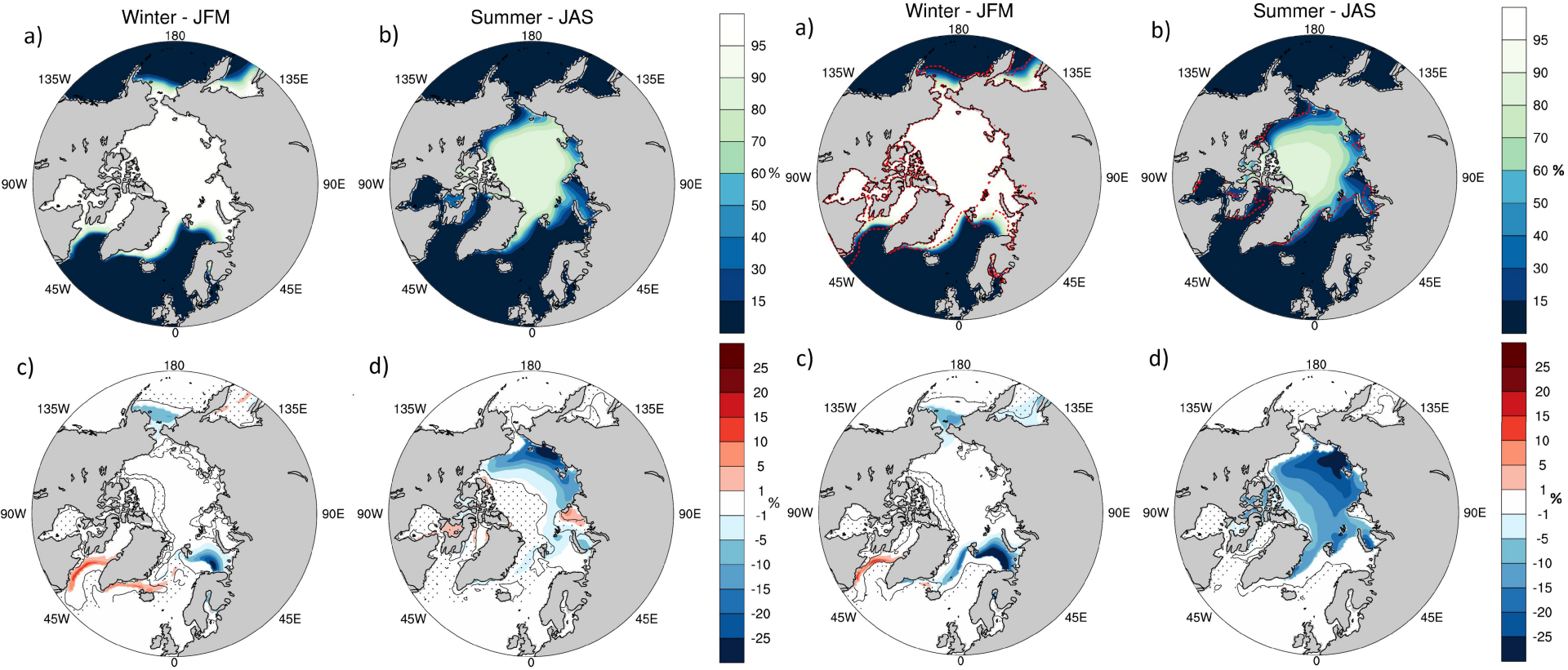


Top: WACCM
Bottom: CAM-WACCM

Sea ice summer concentration differences are largest near Siberian Sea

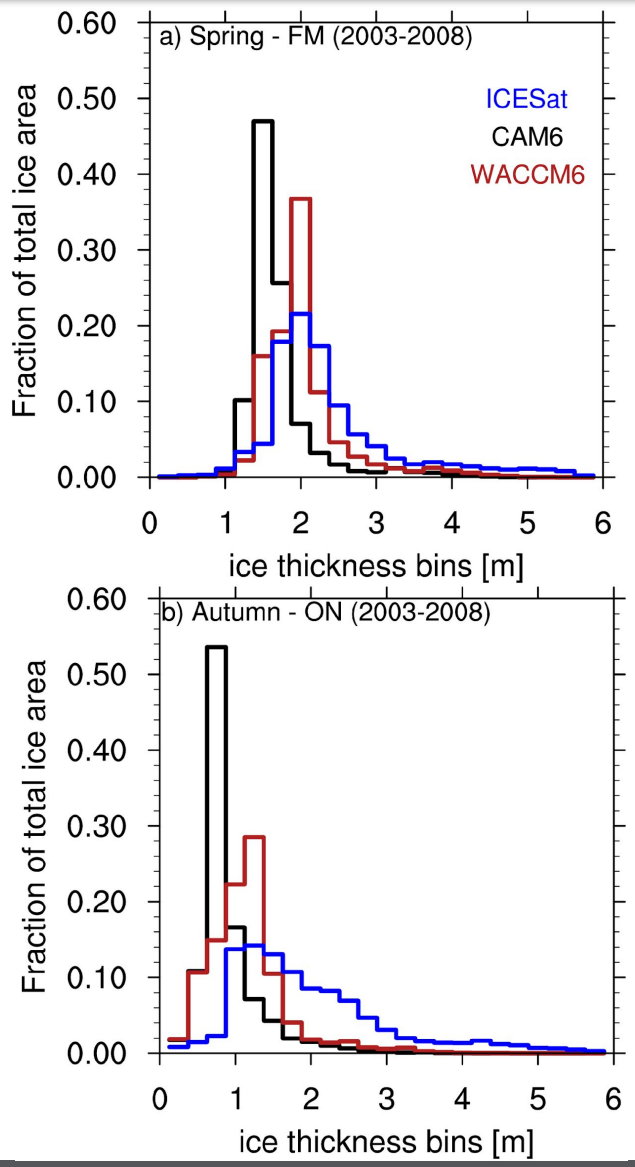
Preindustrial (years 100-500)

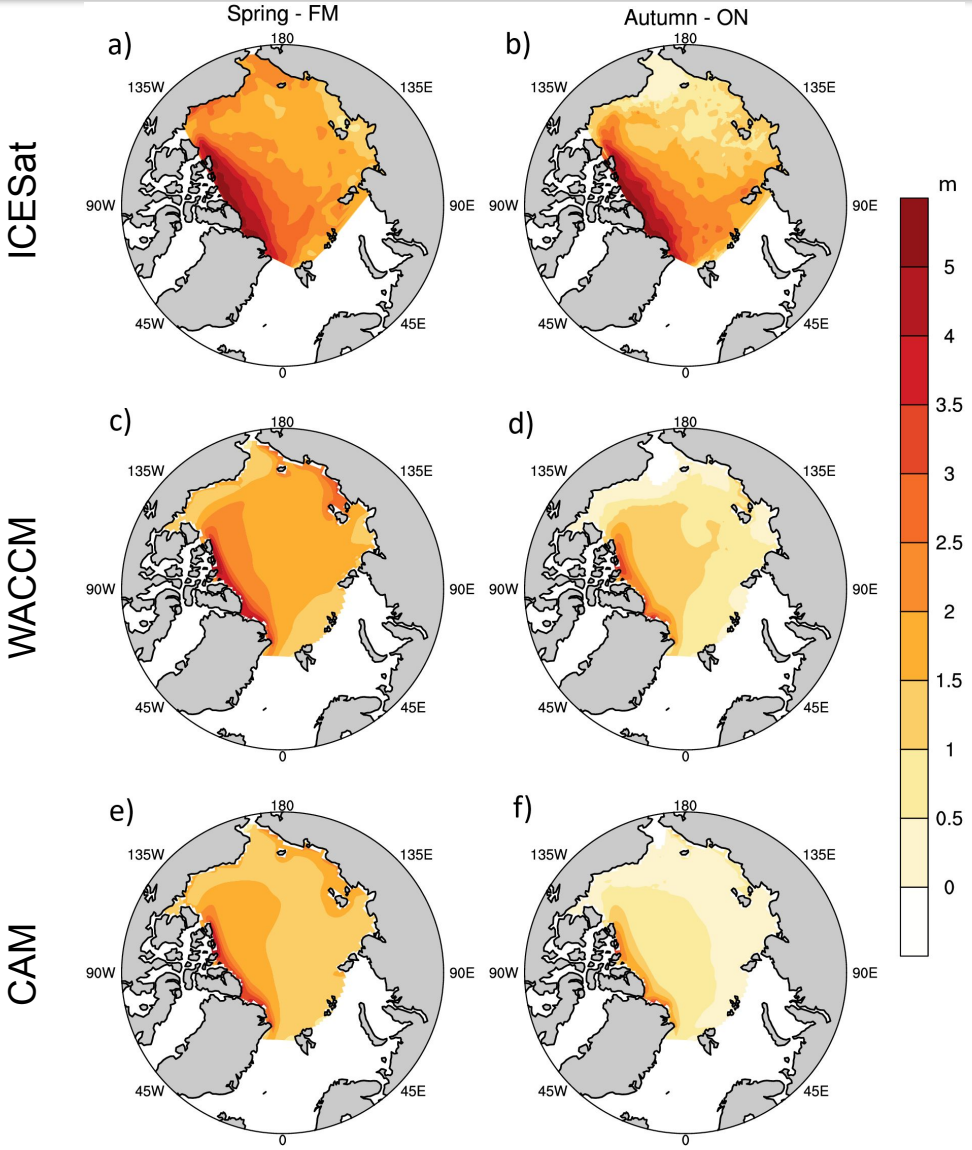
Historical (1979-2014) ensemble mean



Top: WACCM
Bottom: CAM-WACCM

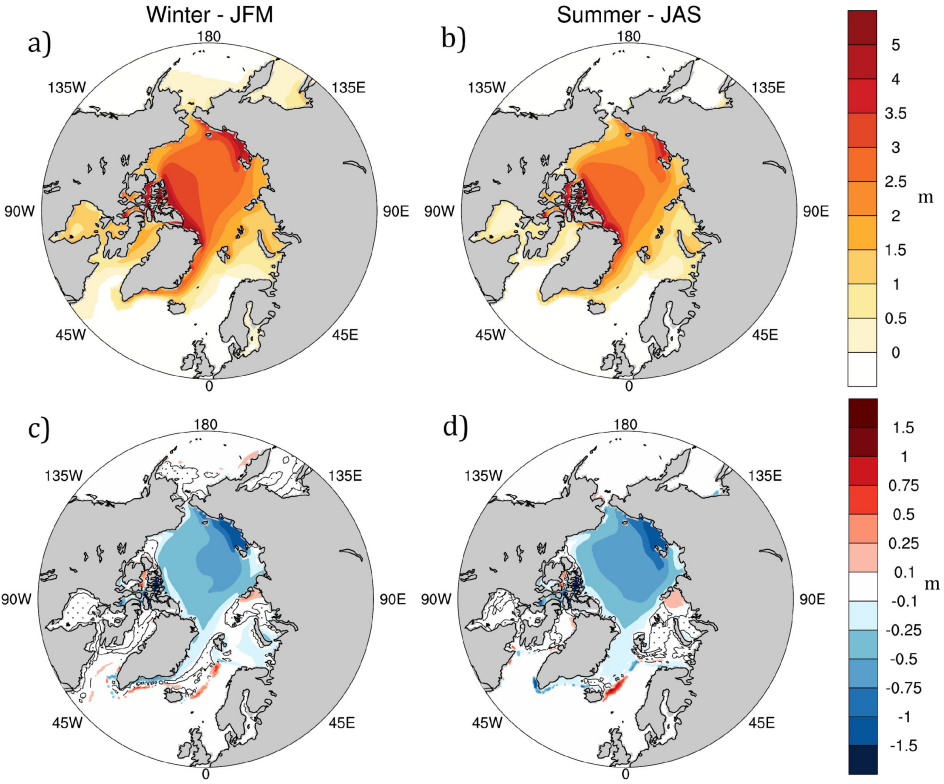
Sea ice thickness differences





Sea ice thickness differences across whole basin and persist year-round.

Preindustrial (years 100-500)



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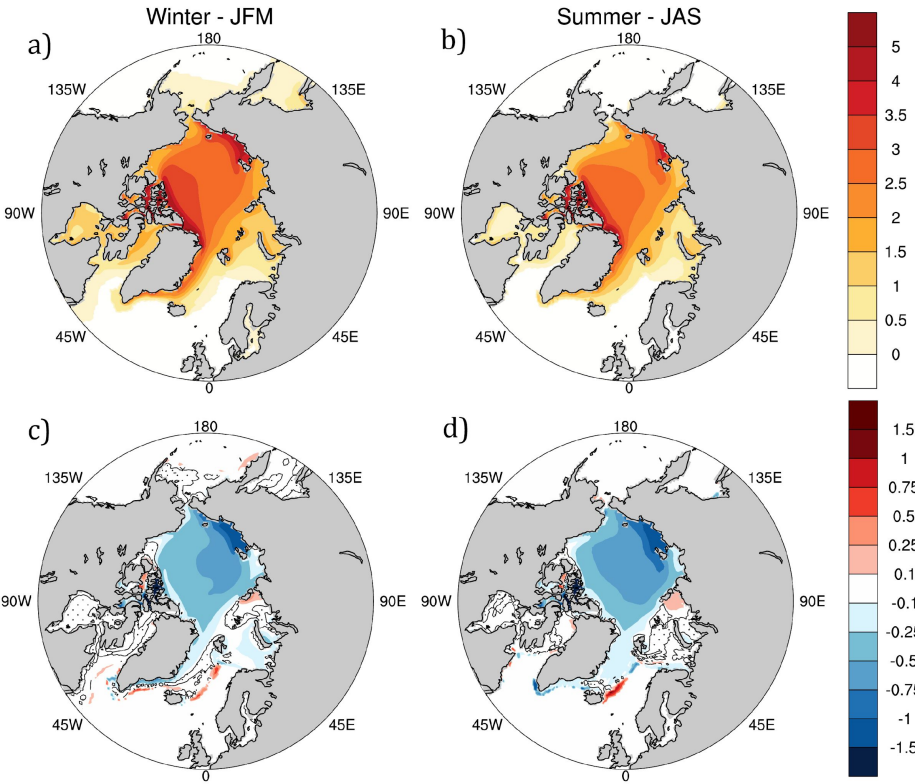
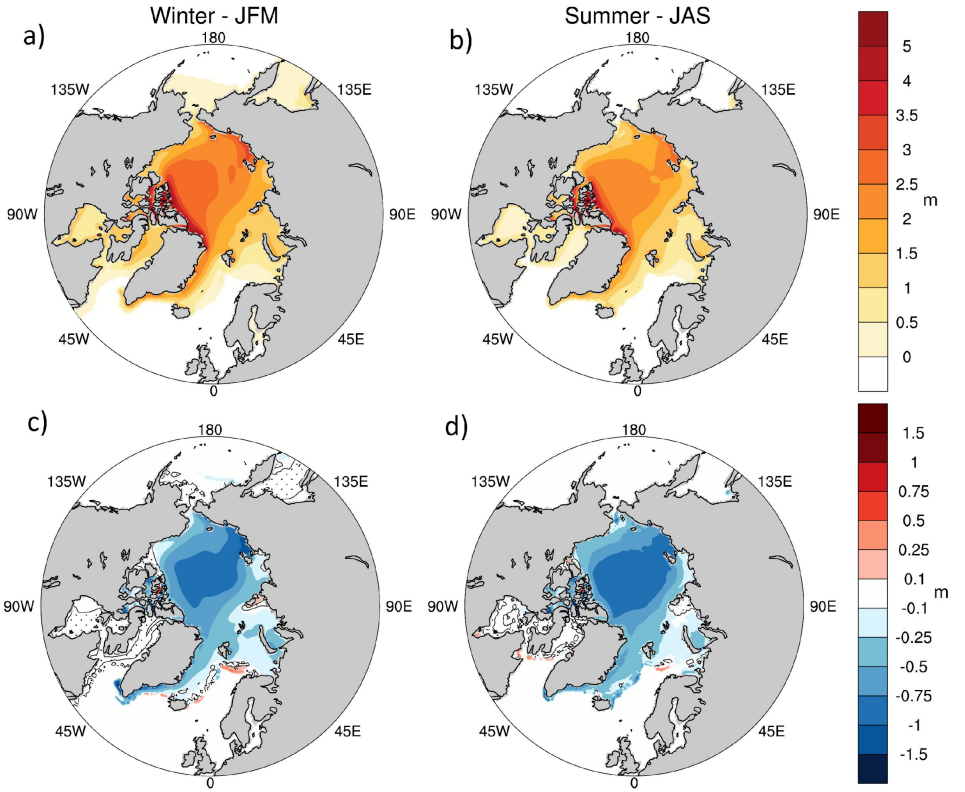
Sea ice thickness differences across whole basin and persist year-round.

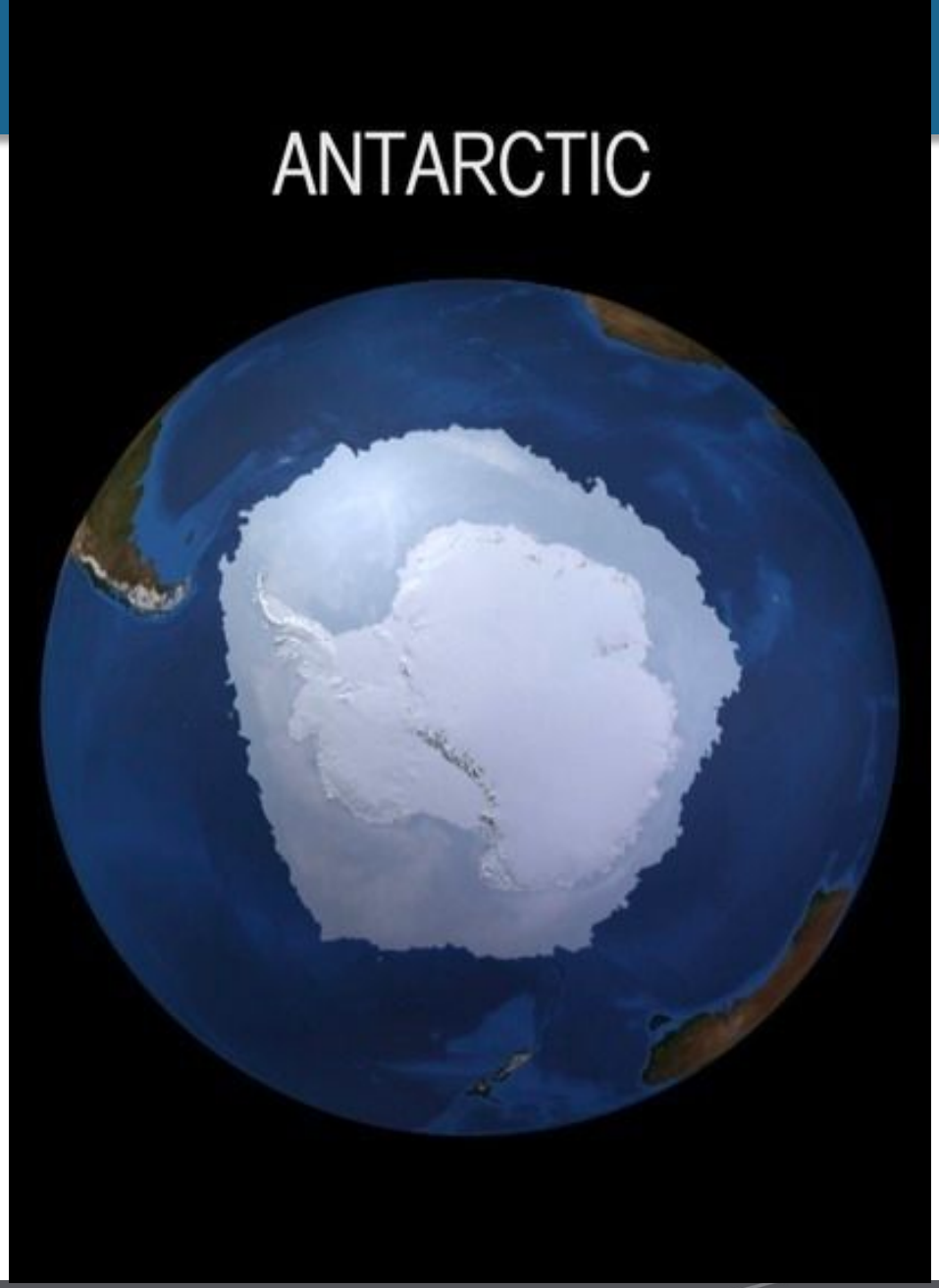
Preindustrial (years 100-500)

Historical (1979-2014) ensemble mean

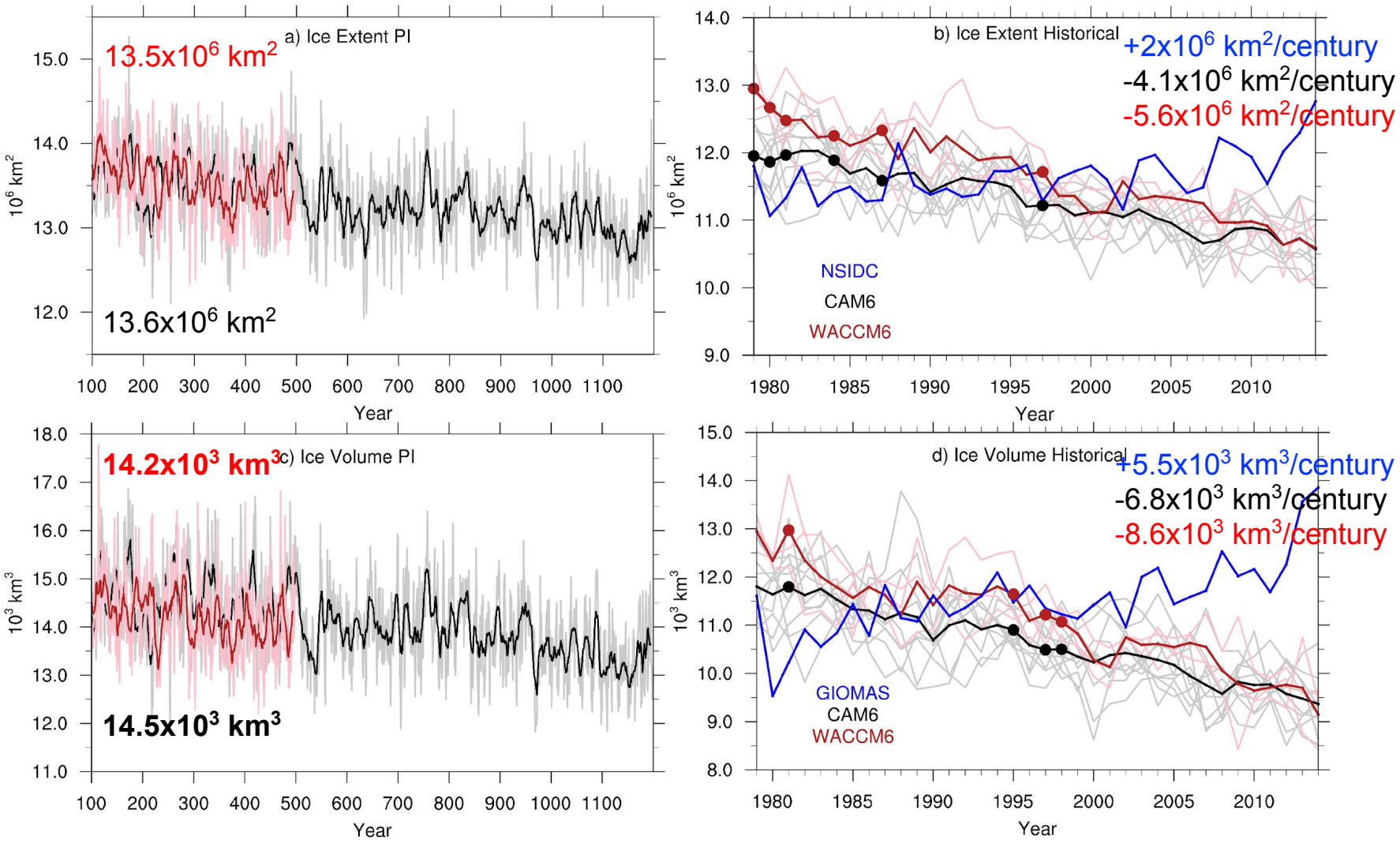




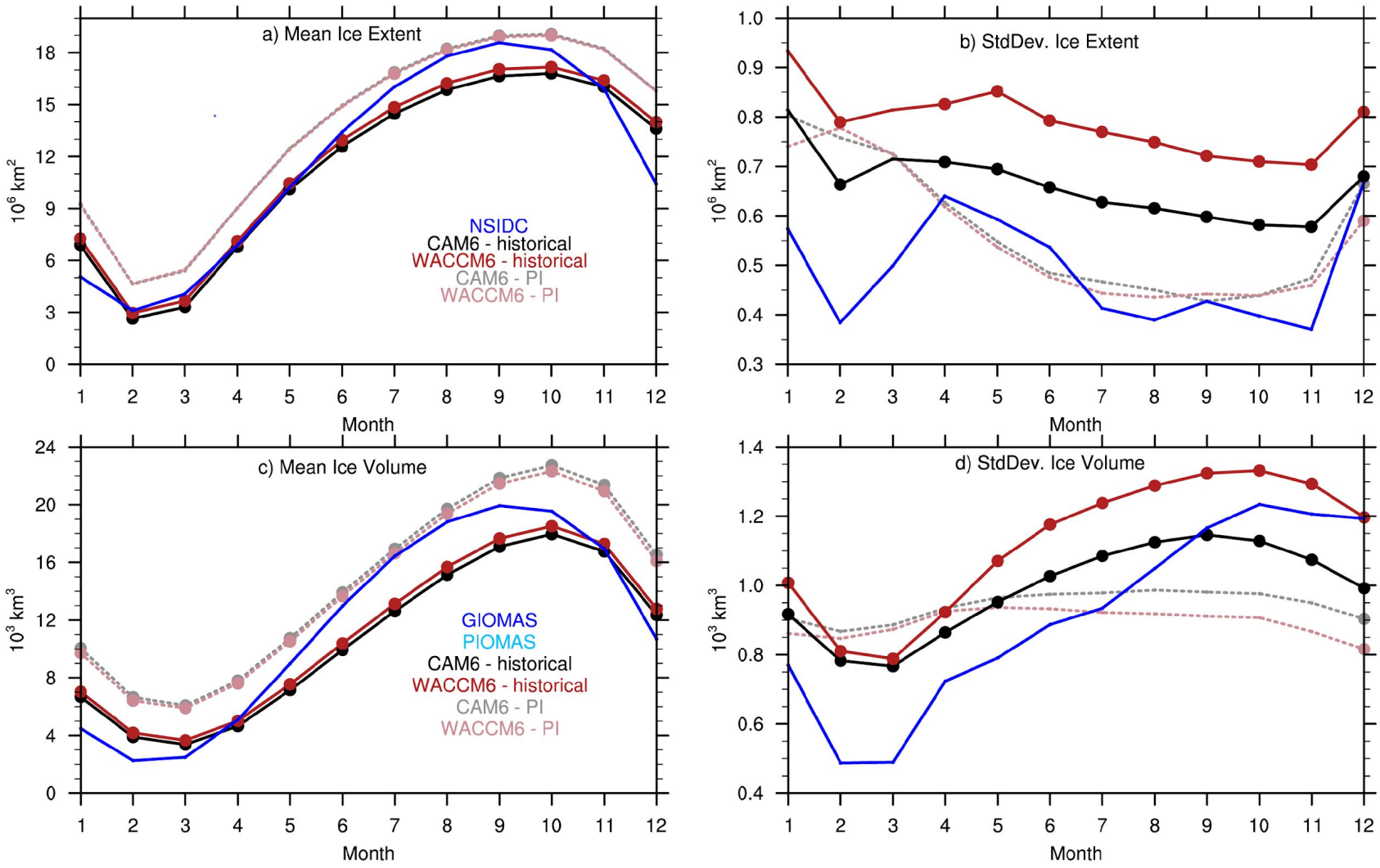
Top: WACCM
Bottom: CAM-WACCM


ANTARCTIC

Antarctic mean sea ice extent and volume are similar



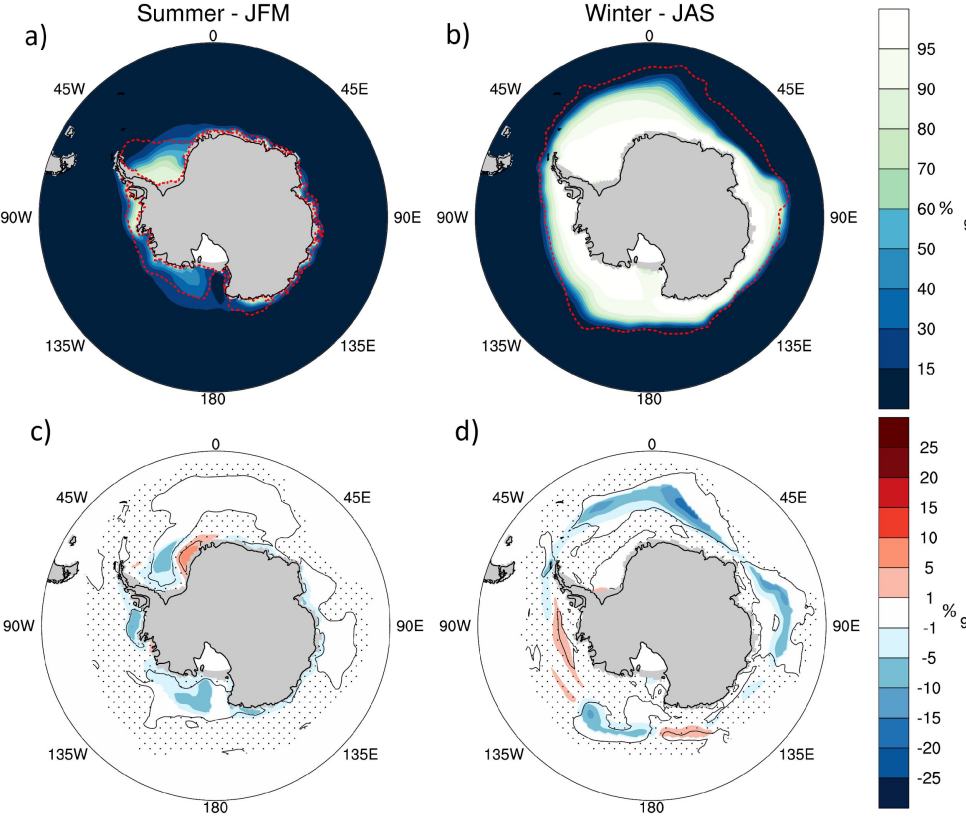
Antarctic seasonal cycles are very similar

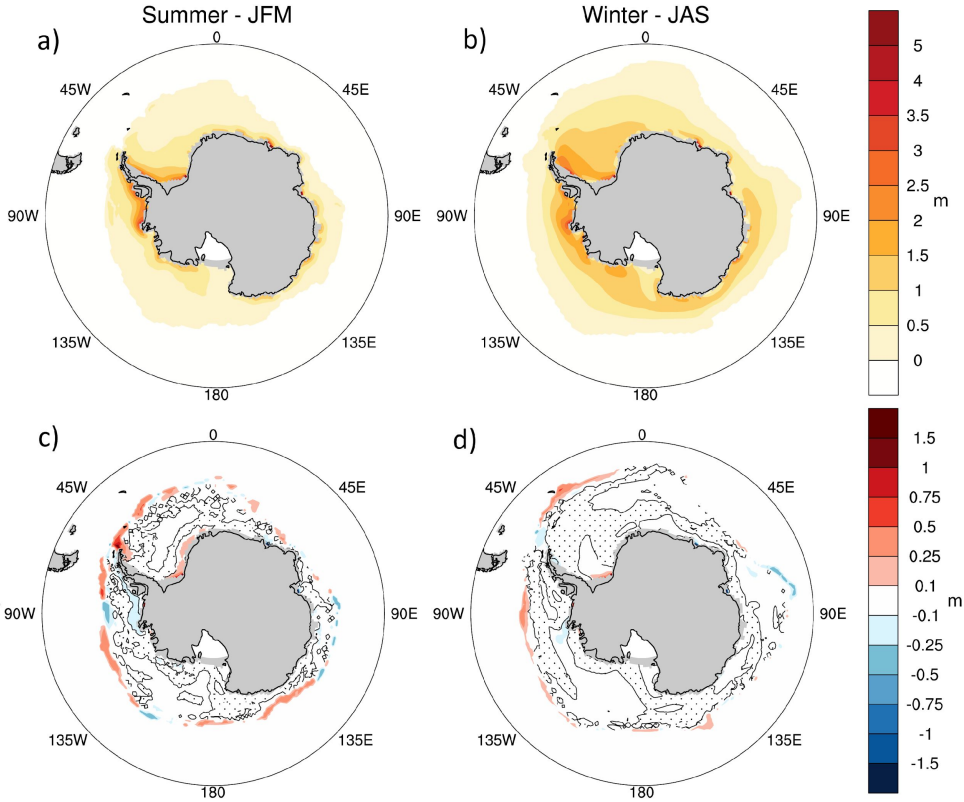


Antarctic Spatial Differences

Sea Ice Concentration
Preindustrial (years 100-500)

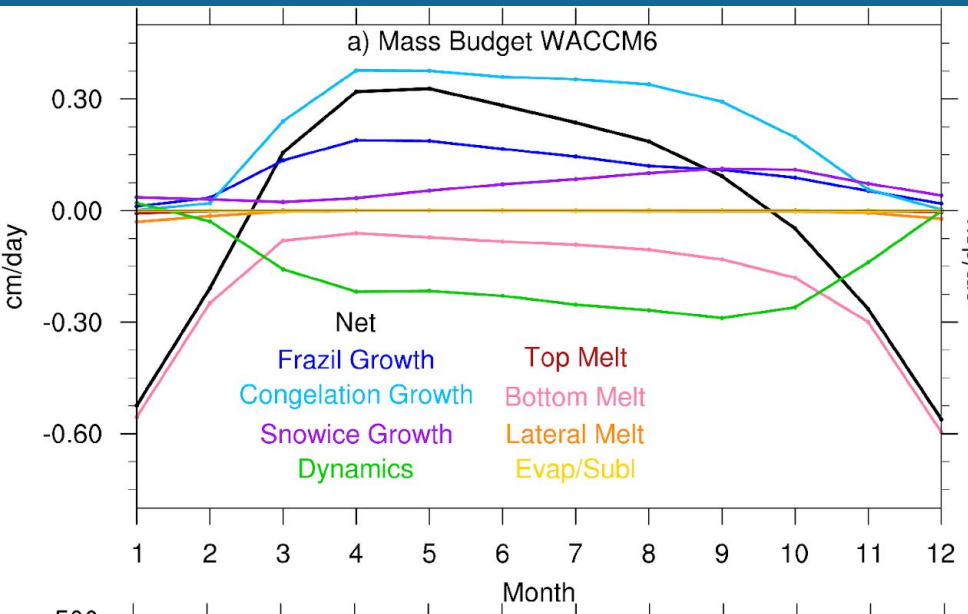
Sea Ice Thickness
Preindustrial (years 100-500)

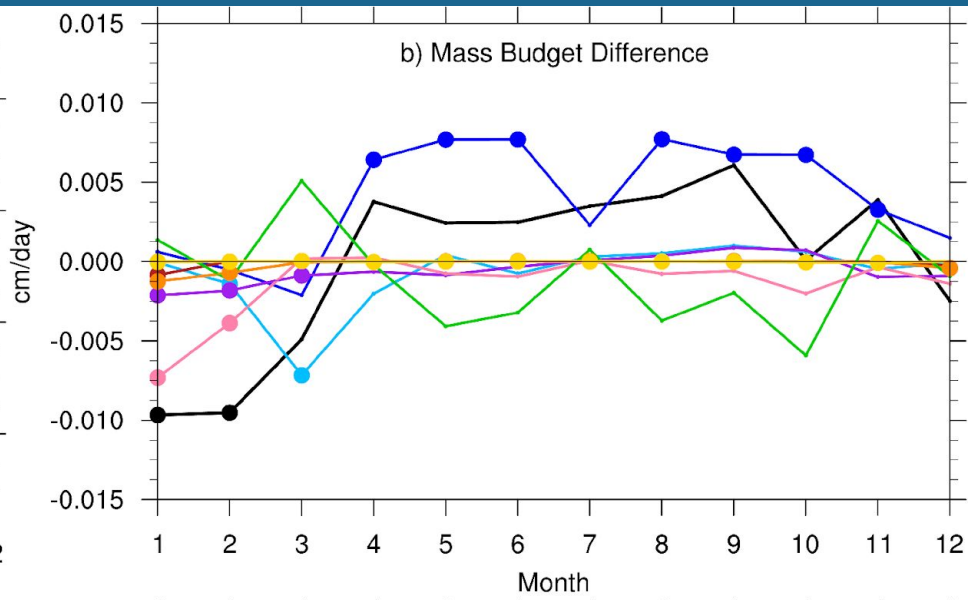


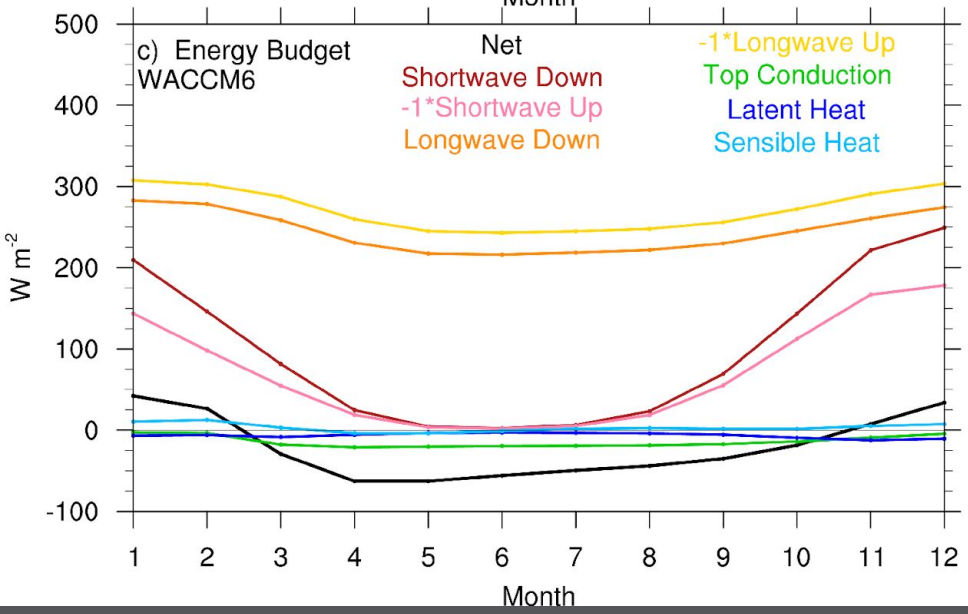


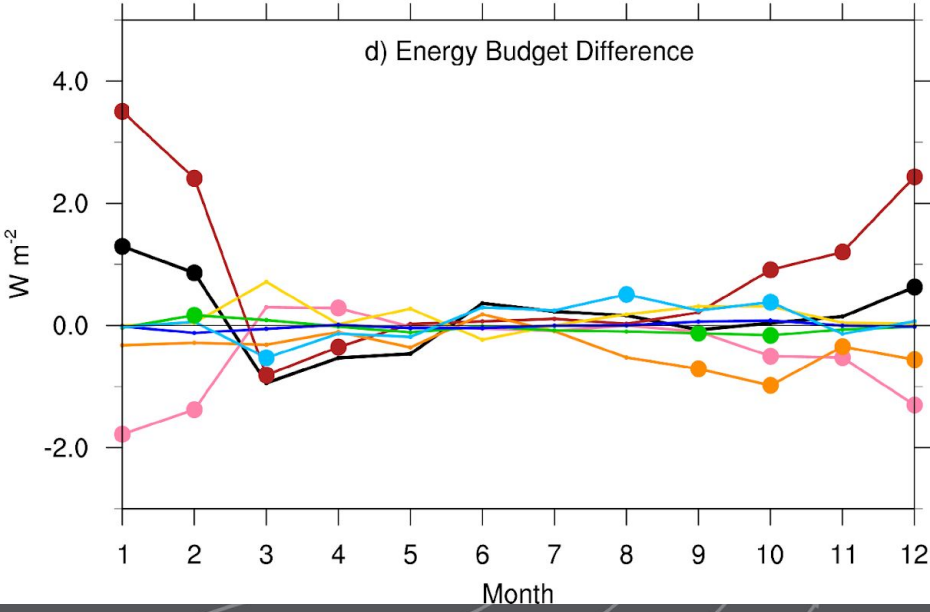
Top: WACCM
Bottom: CAM-WACCM

There are some differences in Antarctic mass and energy budget

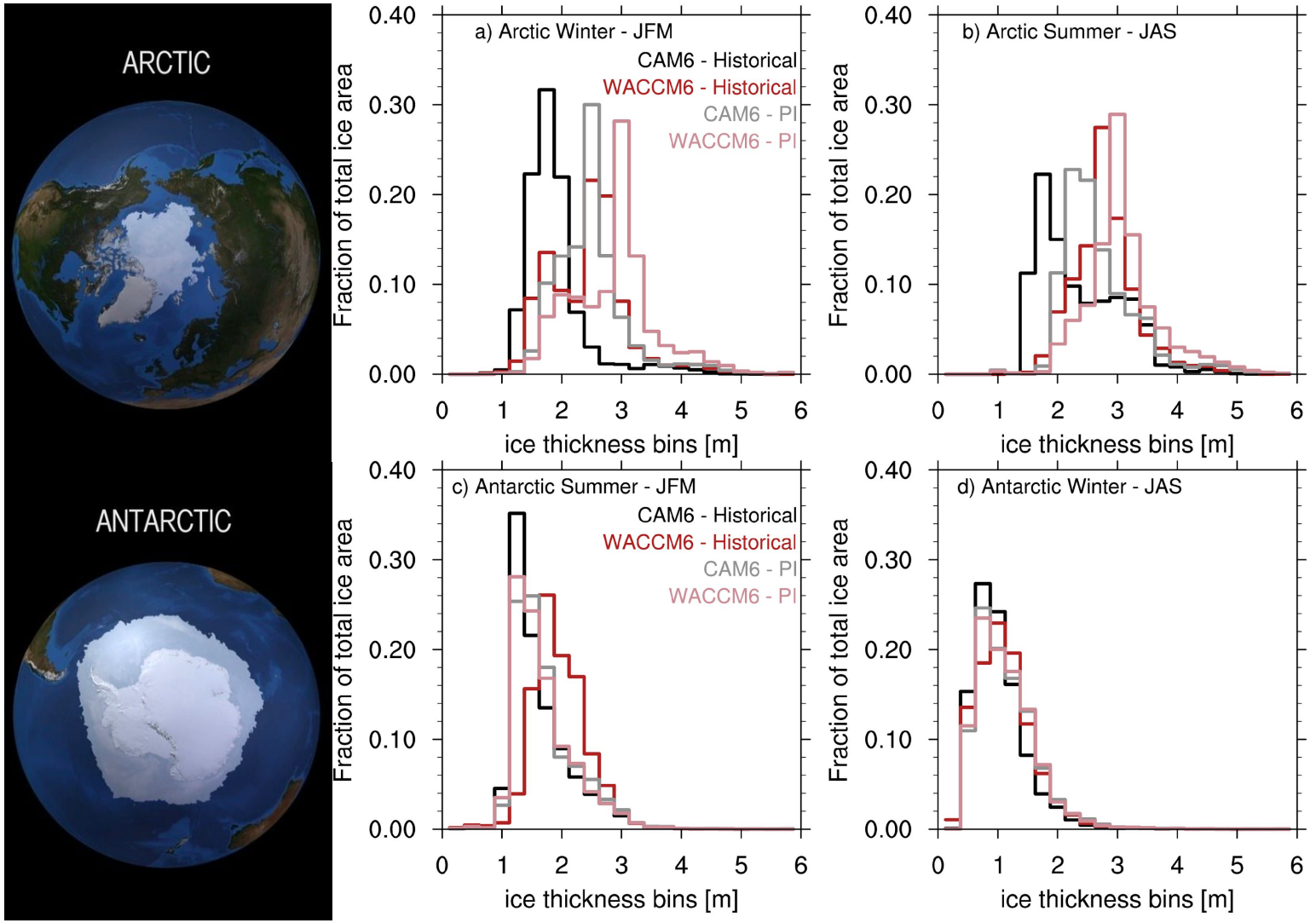








Why is the Arctic sea ice thickness so different in CESM2 configurations while the Antarctic thickness is not?



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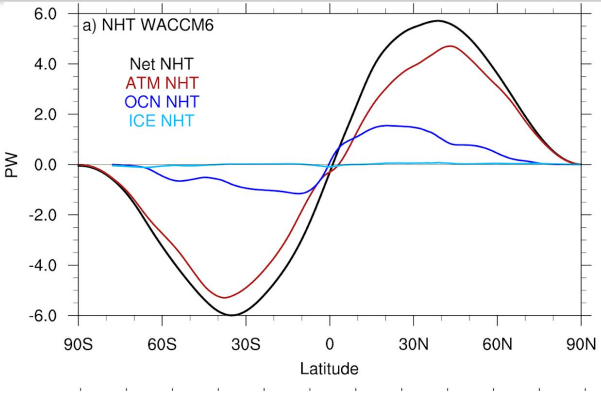
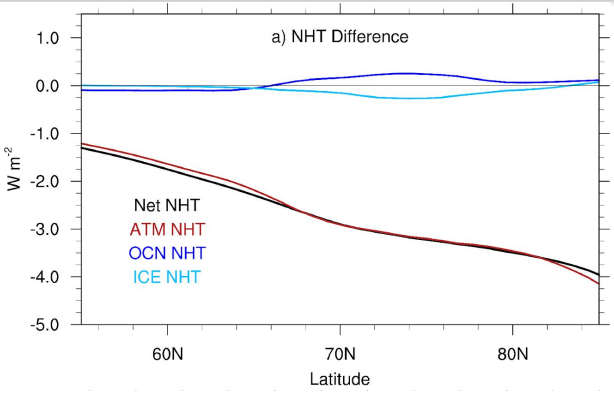
Northward Heat Transport is not significantly different



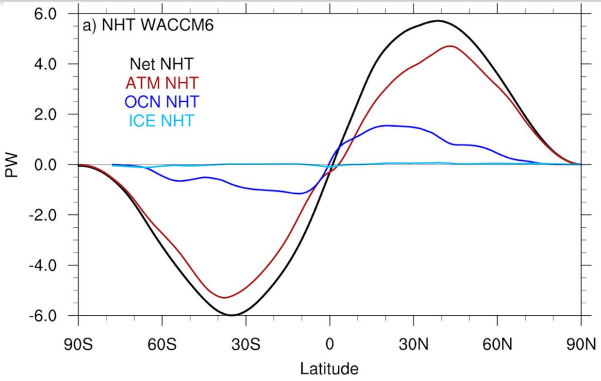


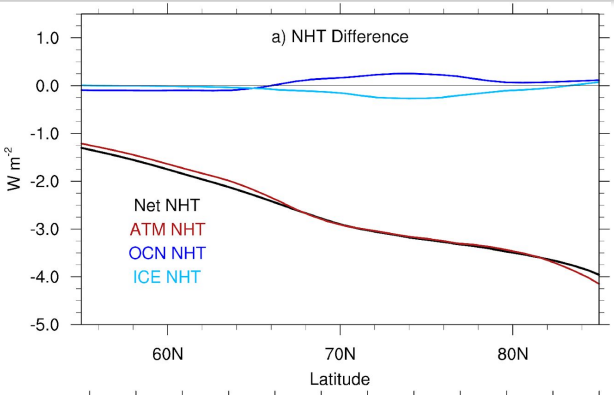
Left:
WACCM

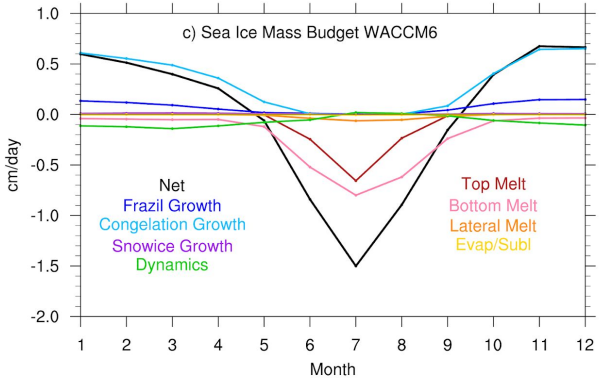
Right:
CAM-WACCM

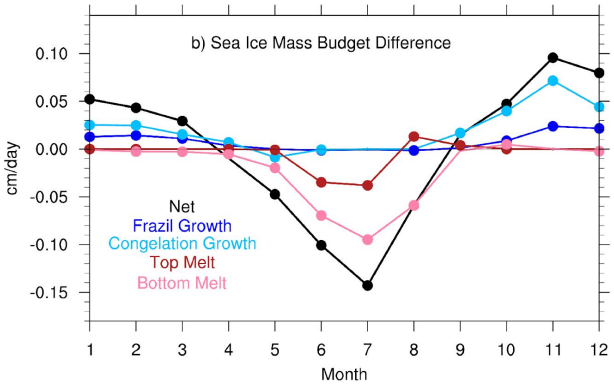
Month

Ice Mass budget differs significantly







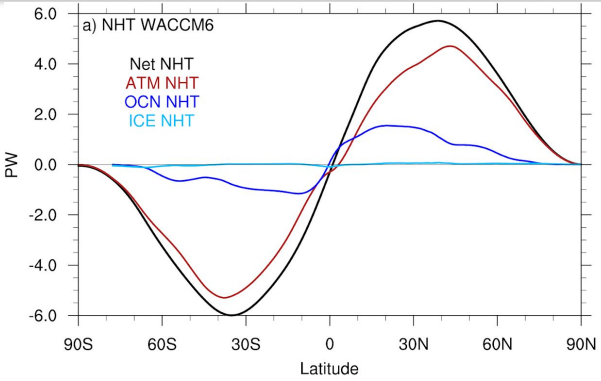


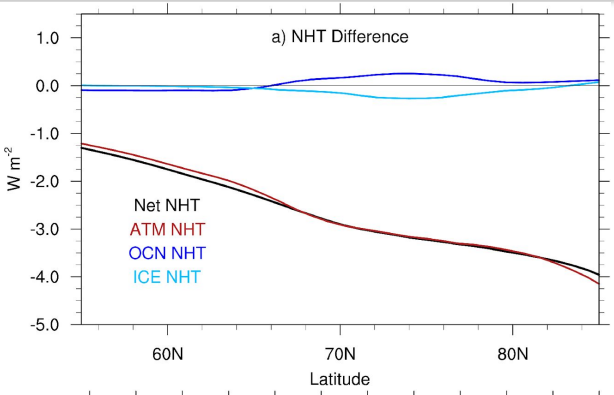
Left:
WACCM

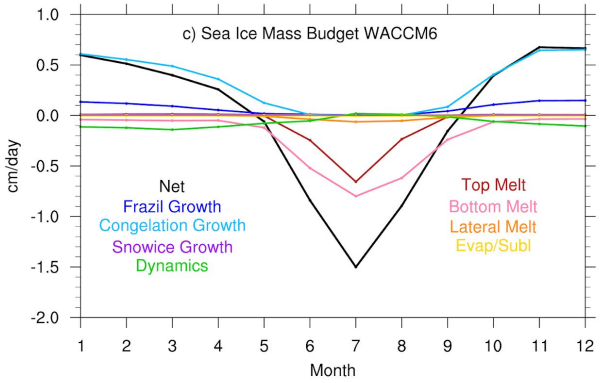
Right:
CAM-WACCM

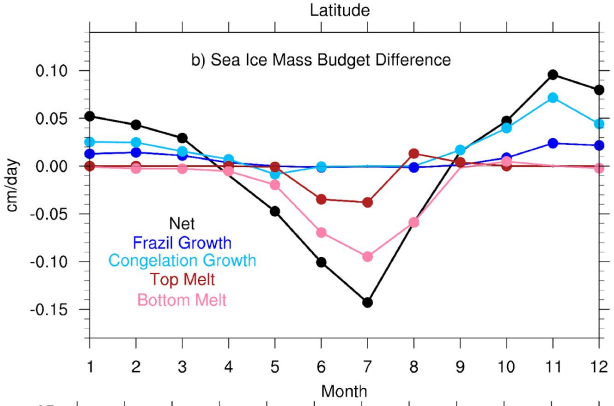
Month

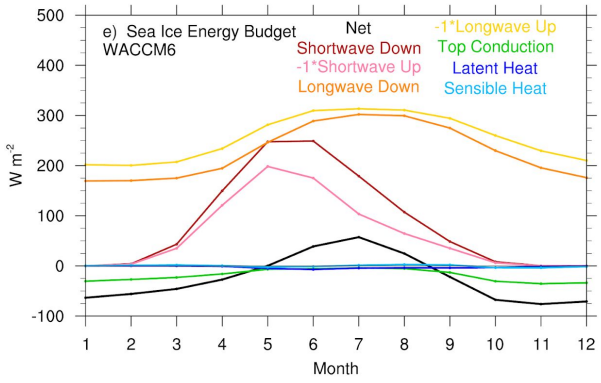
Shortwave radiation differs significantly

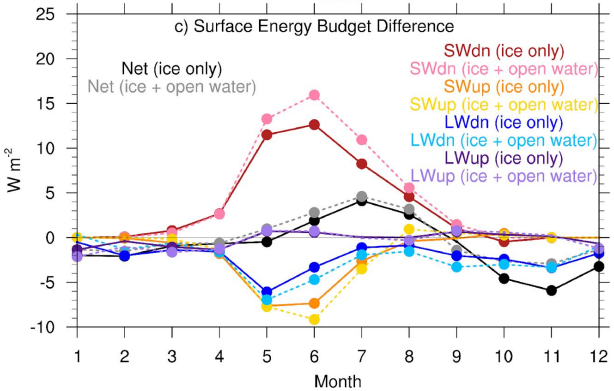










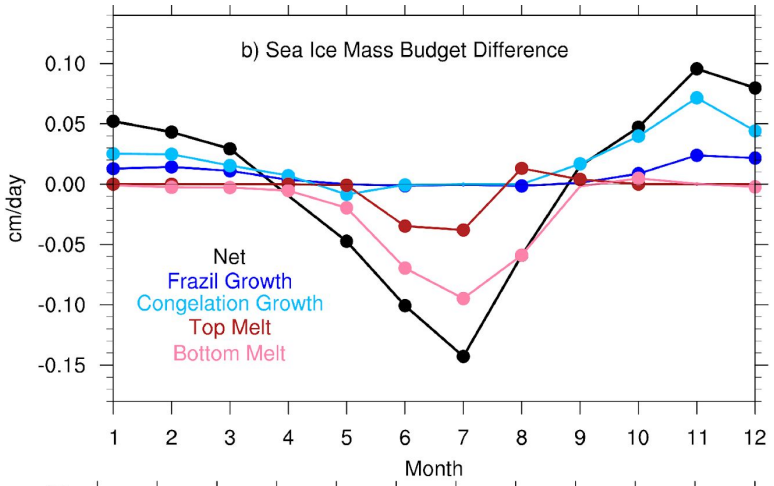


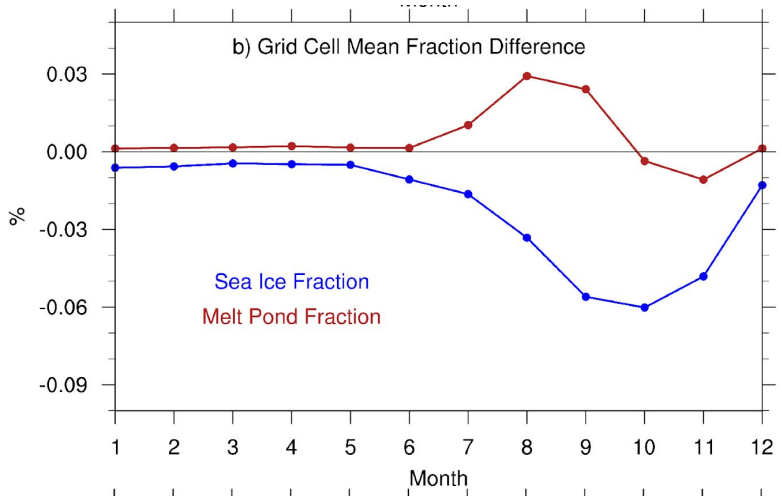
Left:
WACCM

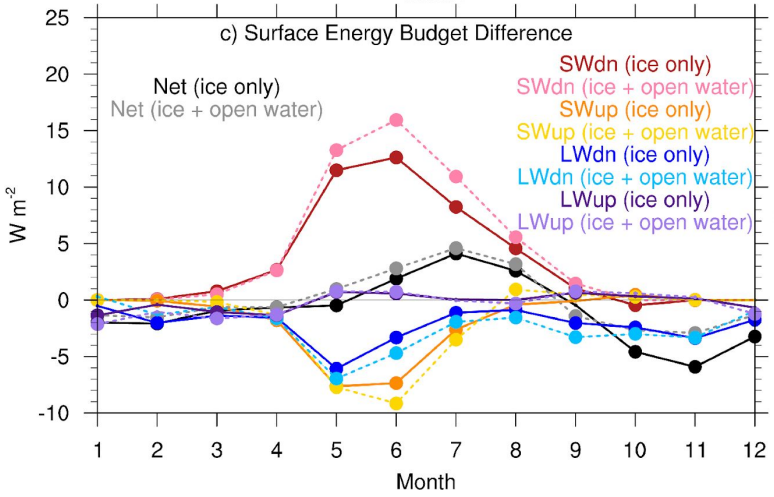
Right:
CAM-WACCM

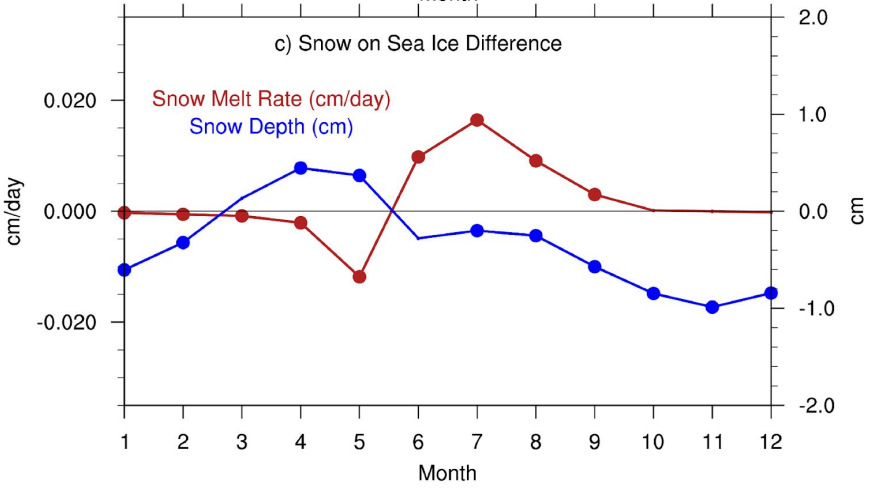
Spring radiation differences to to surface snow melt, then differences in sea ice melt trigger albedo feedback.

Differences:
CAM-WACCM

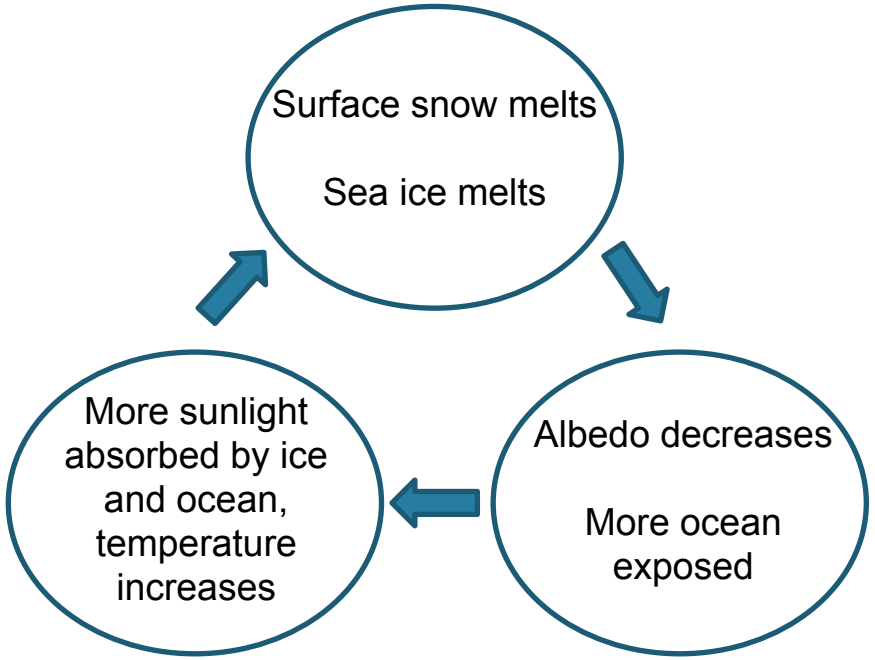




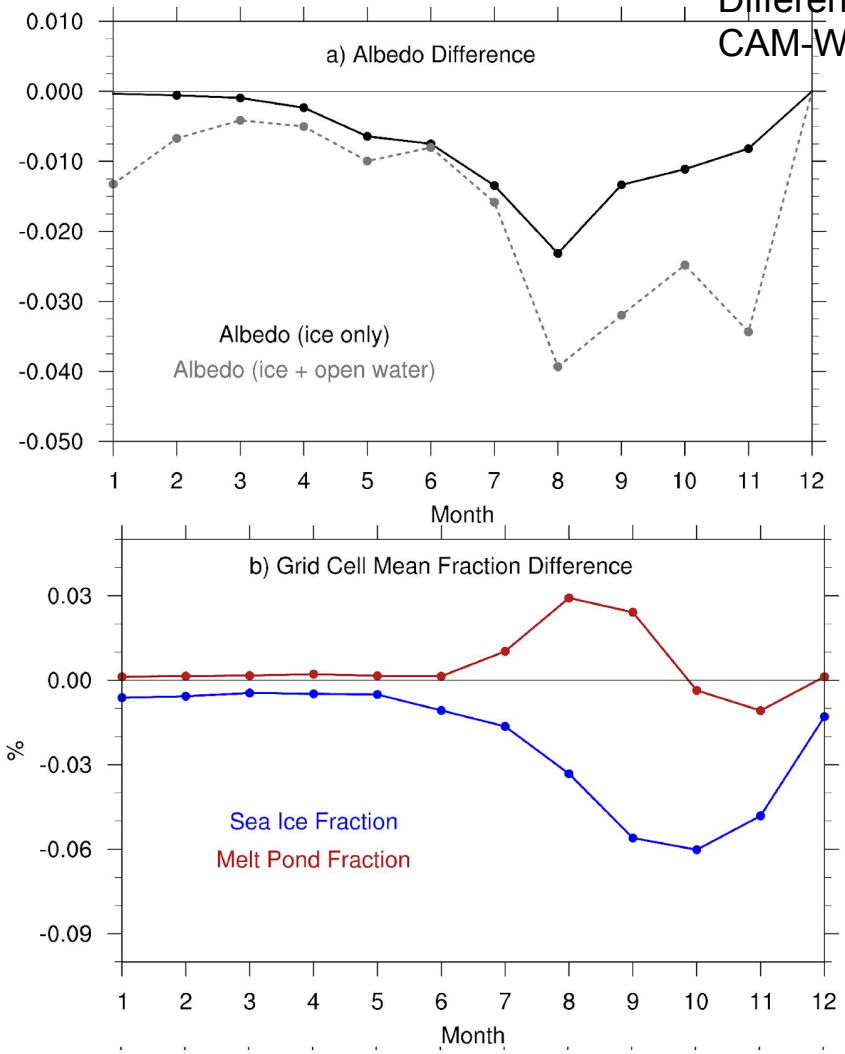




The surface albedo feedback begins to diverge



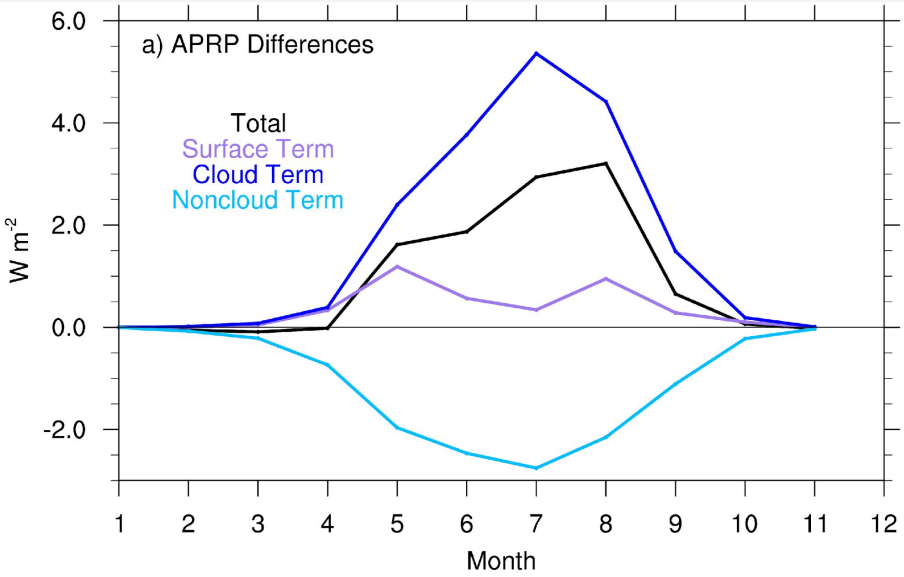
Differences: CAM-WACCM



The cloud differences are larger than the surface albedo differences

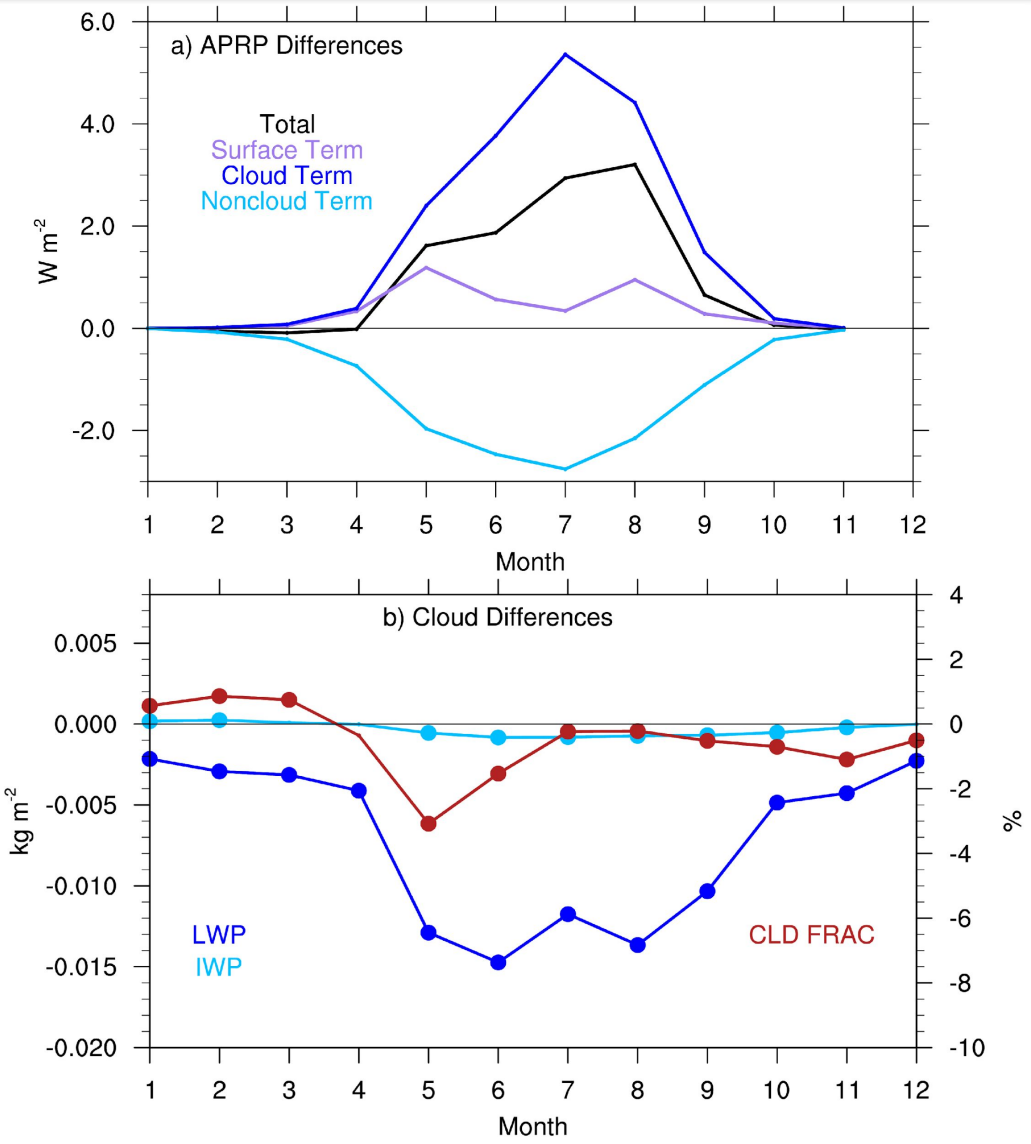
Surface albedo feedback +
 CAM has larger surface albedo feedback

Cloud feedback –
 CAM has smaller cloud feedback



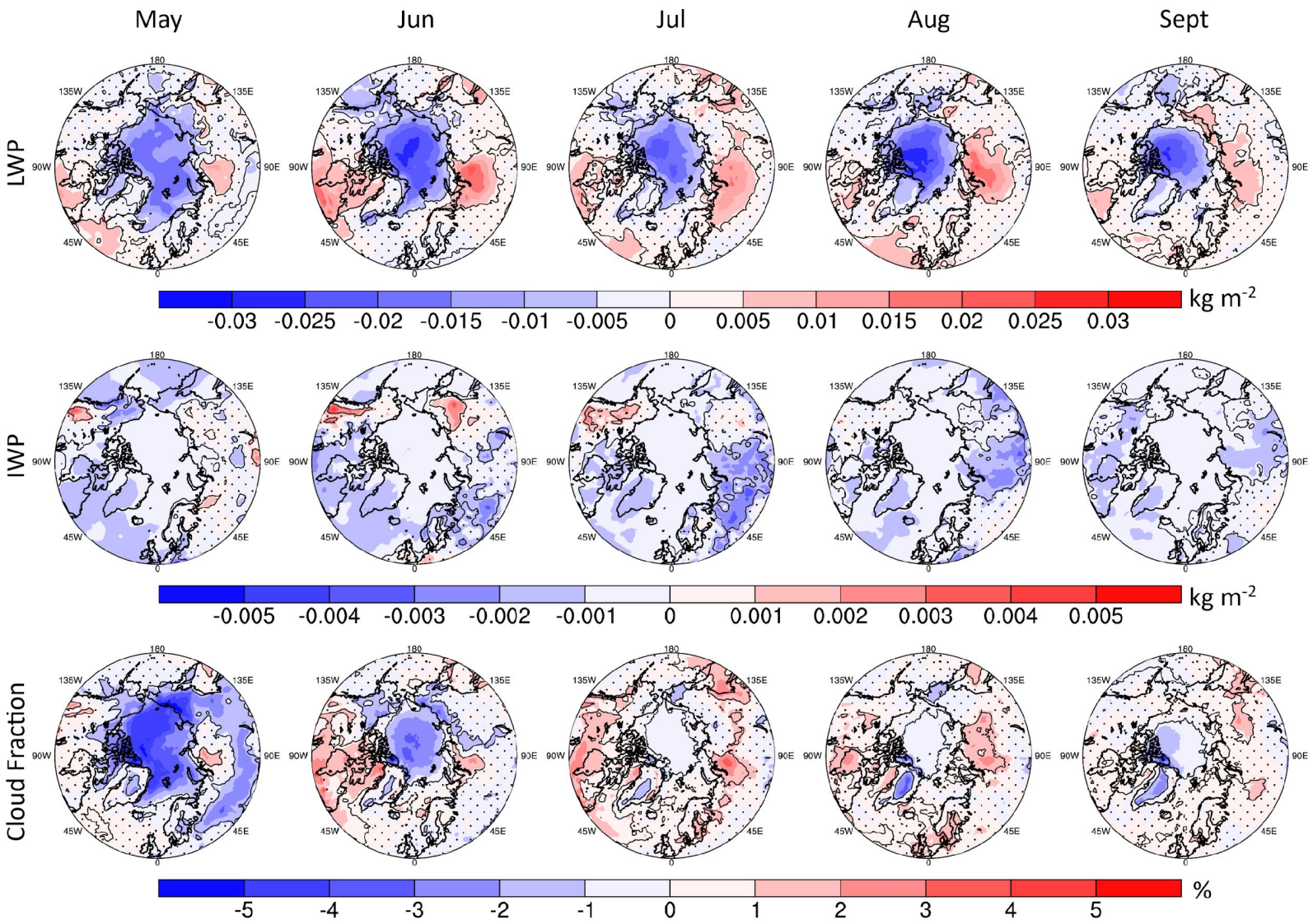
Differences:
CAM-WACCM

The liquid cloud differences are large in spring and summer

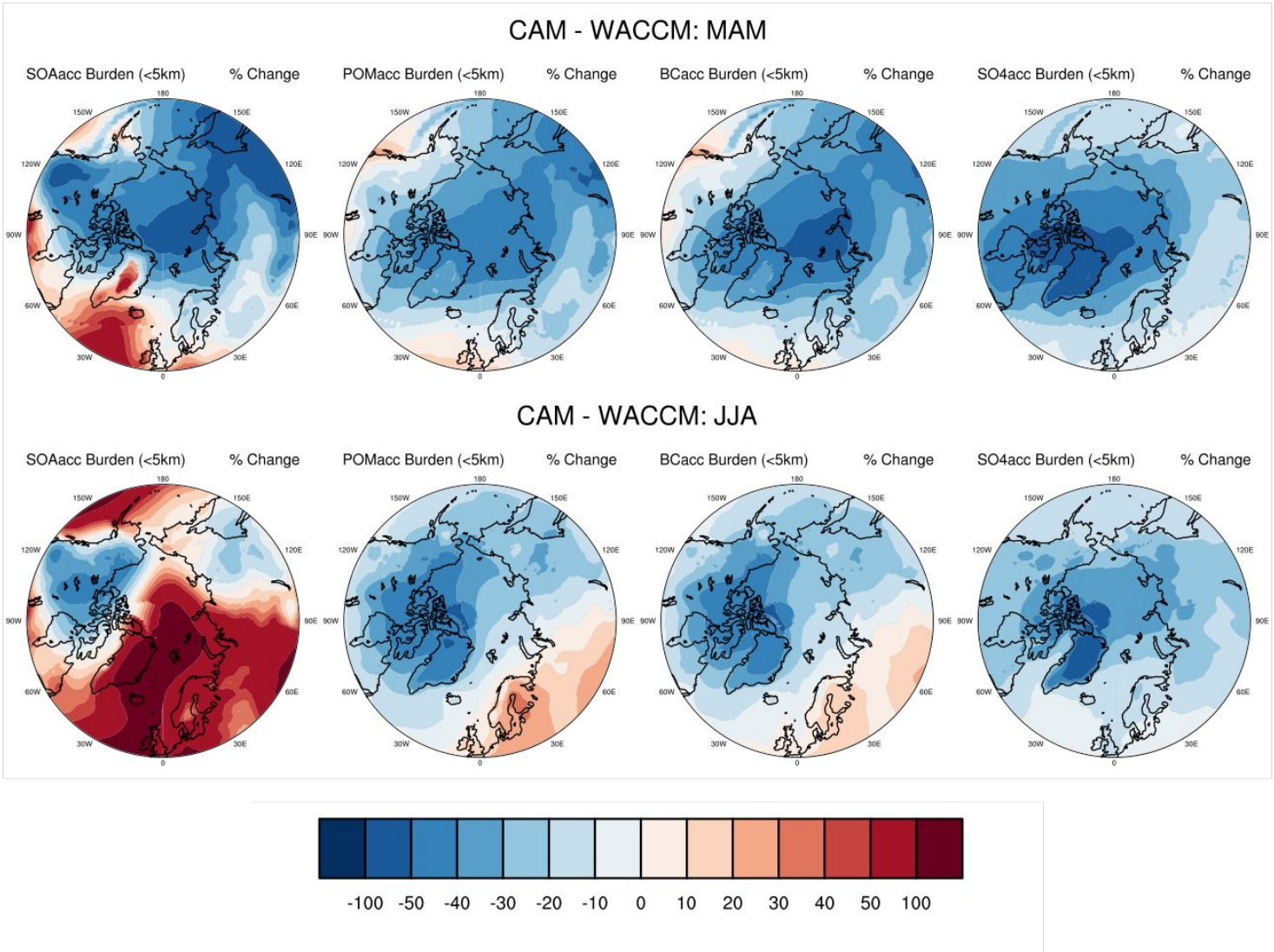


Differences:
CAM-WACCM

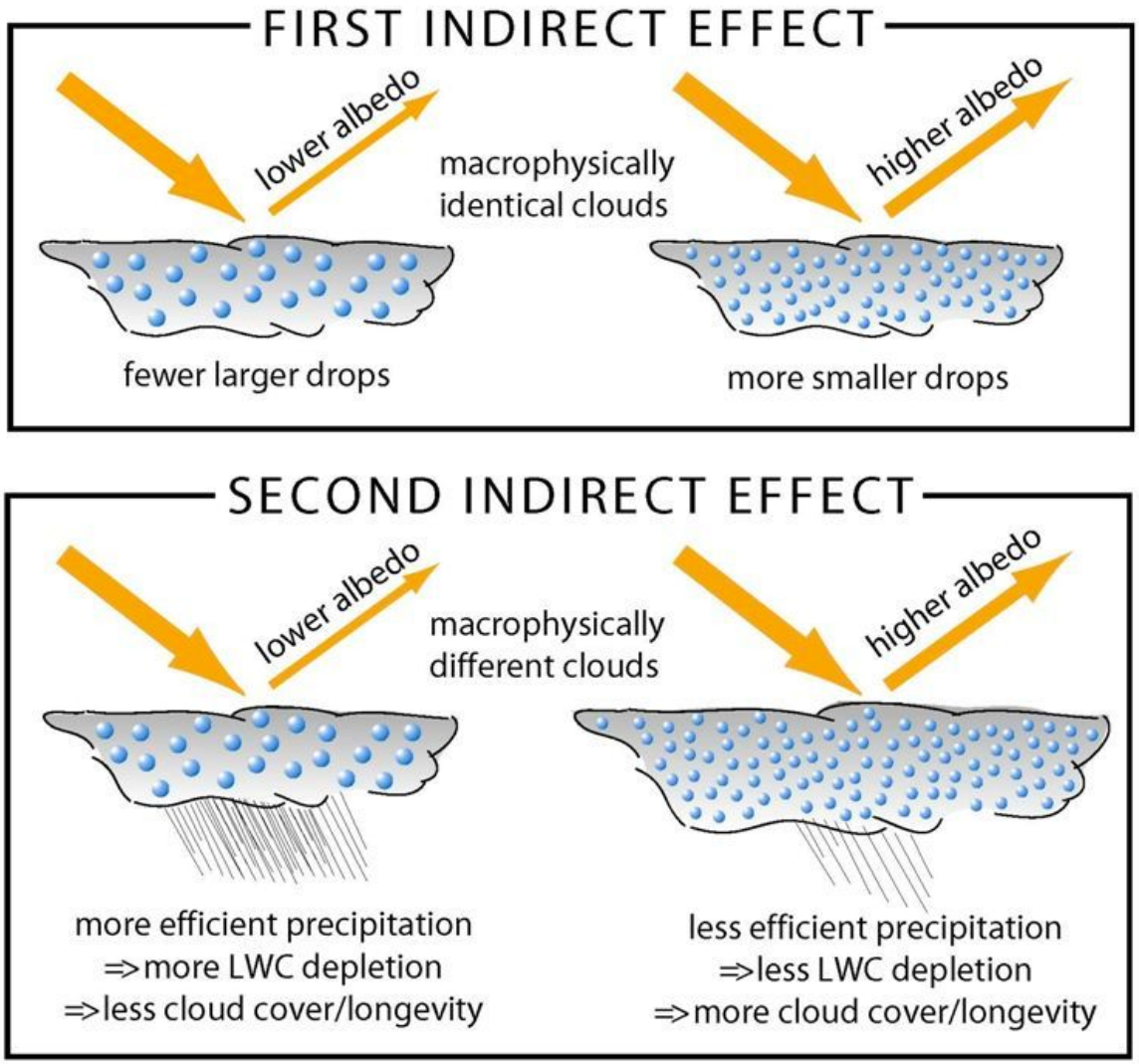
Cloud differences are largest over the sea ice



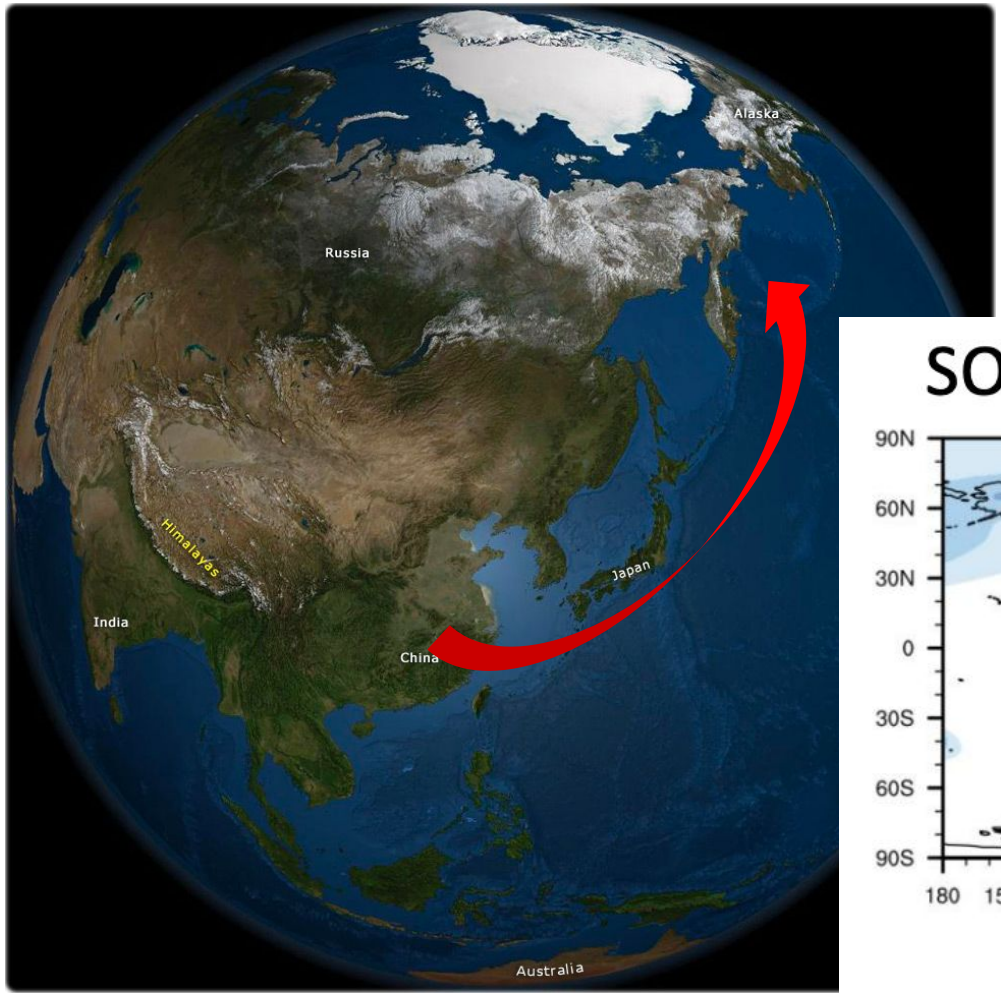
CAM has fewer aerosols



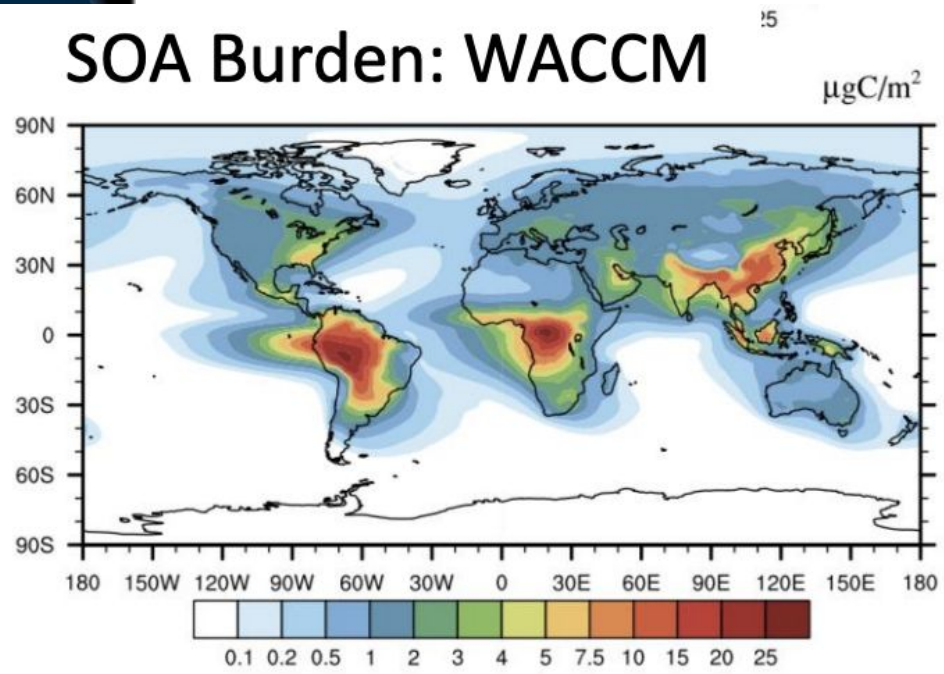
More aerosol lead to more CCN and cloud particles, which affects clouds



Aerosols are primarily produced outside the Arctic and transported there, where they are CCN

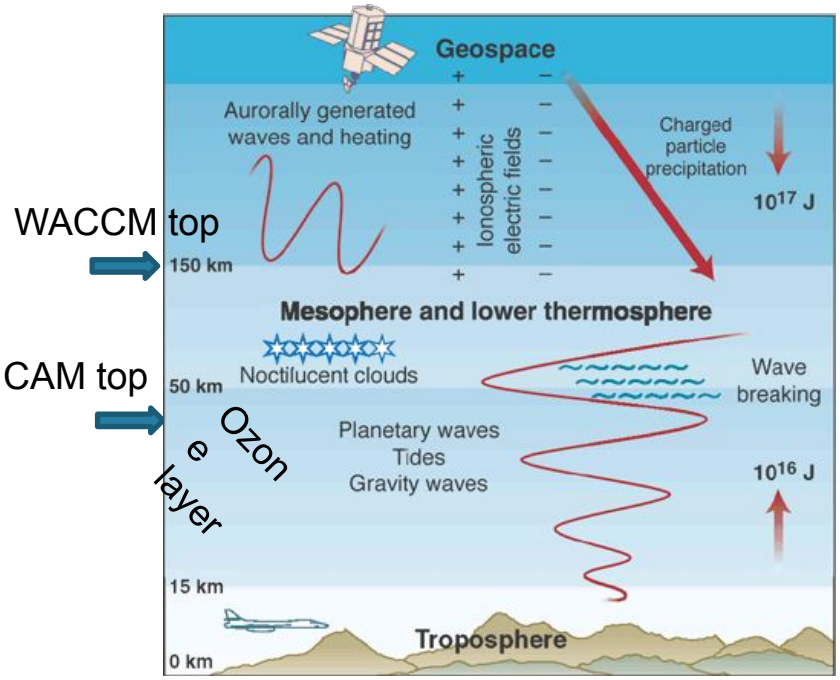


Antarctic is more pristine environment, so differences in aerosols are smaller and lead to similar atmospheric forcing for sea ice.



Some outstanding questions

- Subsequent tests with WACCM and SOA scheme turned off show similar results to CAM. □ Is there a way to run the low top model with important prognostic chemistry?
- What are the transport pathways and mechanisms for the aerosols?
- How realistic are the clouds? Are WACCM liquid cloud thicknesses reasonable?
- How realistic is this aerosol burden? Are there other aerosols (e.g. from biomass burning?) that might be missing or also important in Arctic clouds?
- Analysis is for Preindustrial □ how do aerosols, clouds, and the resulting sea ice mass and energy budgets differ in historical or future scenarios?



Conclusions

Thank you!

Questions?

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