

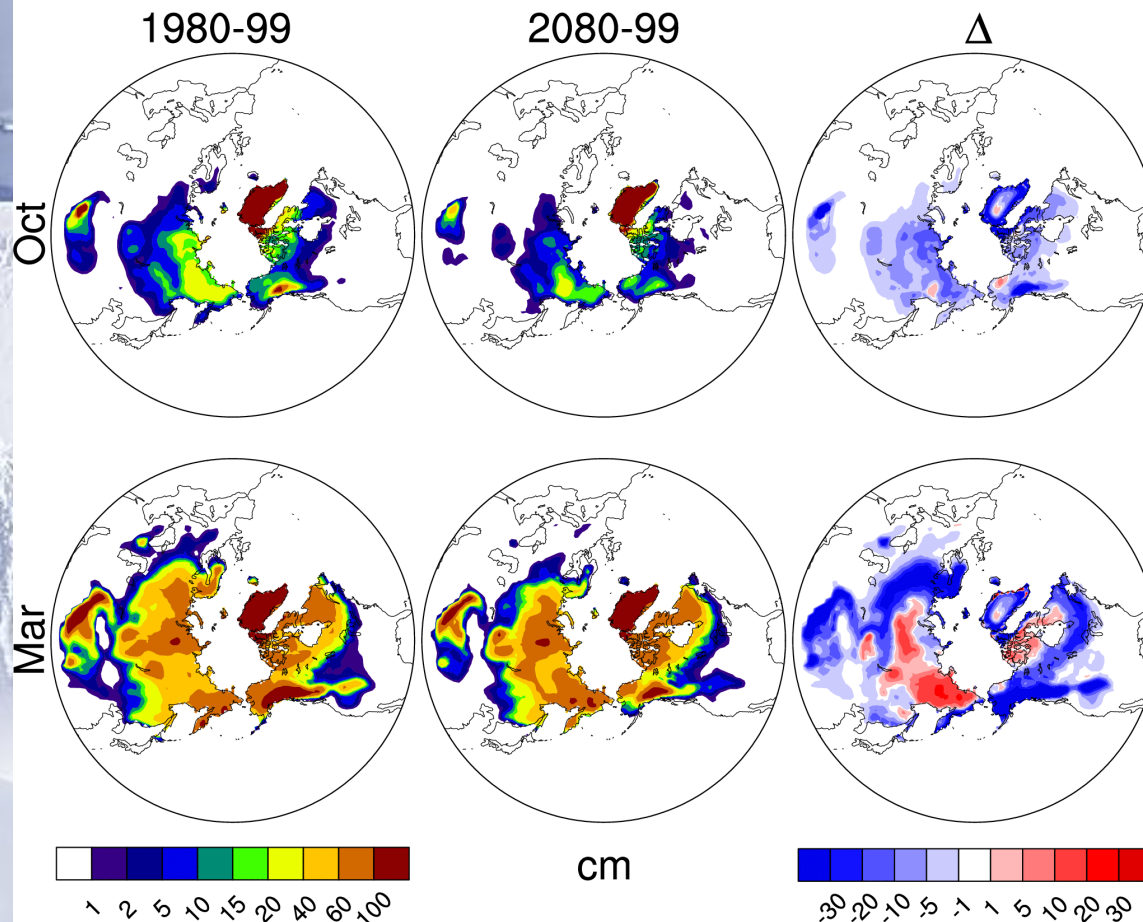
Projected changes in land snow cover:

How will they effect the climate?

Step 0.1: Getting a “reasonable” simulation

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CCSM3 A1B snow depth(cm LWE): Present and Future



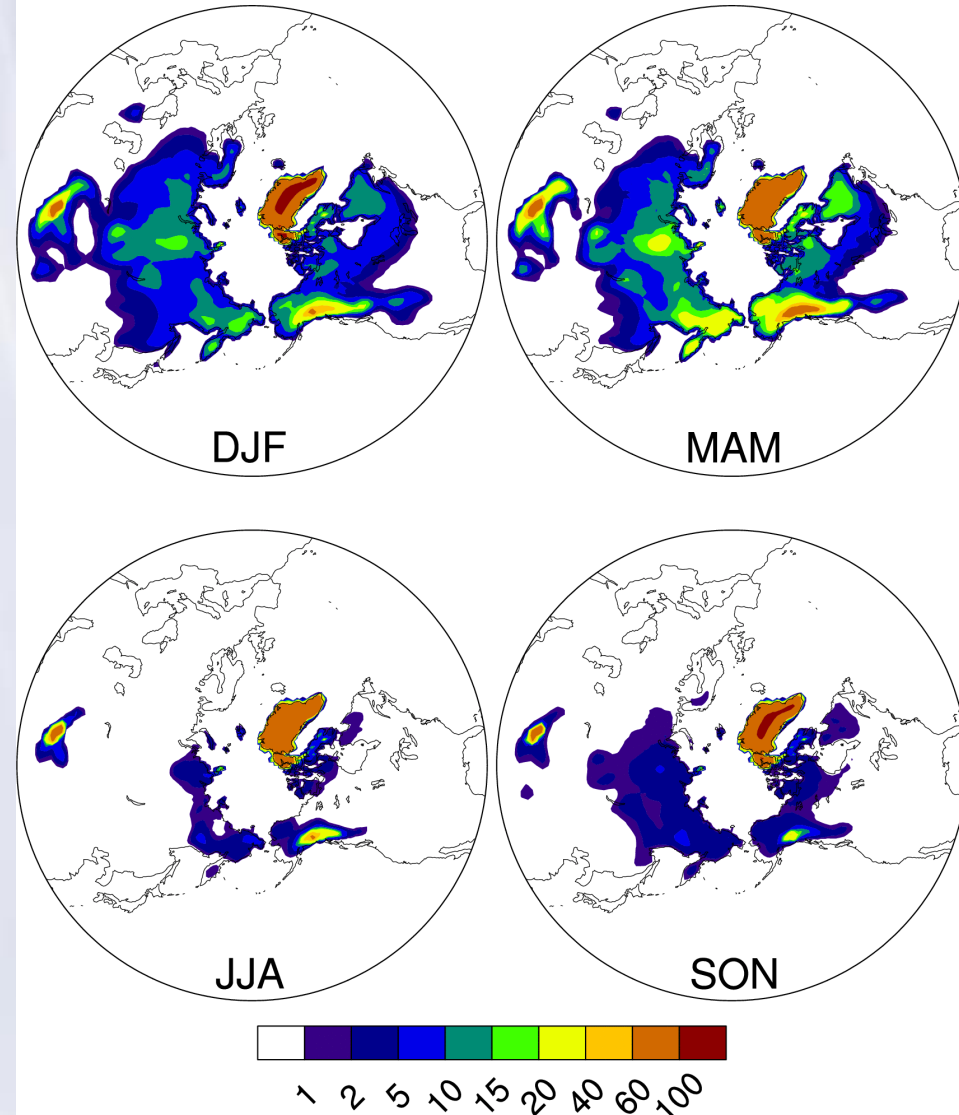
Methodology:

Take monthly averaged snow from CCSM3 A1B scenarios (1980-99 and 2080-99) and impose snow depth, water content and age into land model with active atmosphere (T-85), data ocean and ice

Today's presentation, Step 0.1: Compare imposed snow experiment with control experiment with prognostic snow (active land) for 1980-99

Seasonal Snow Forcing

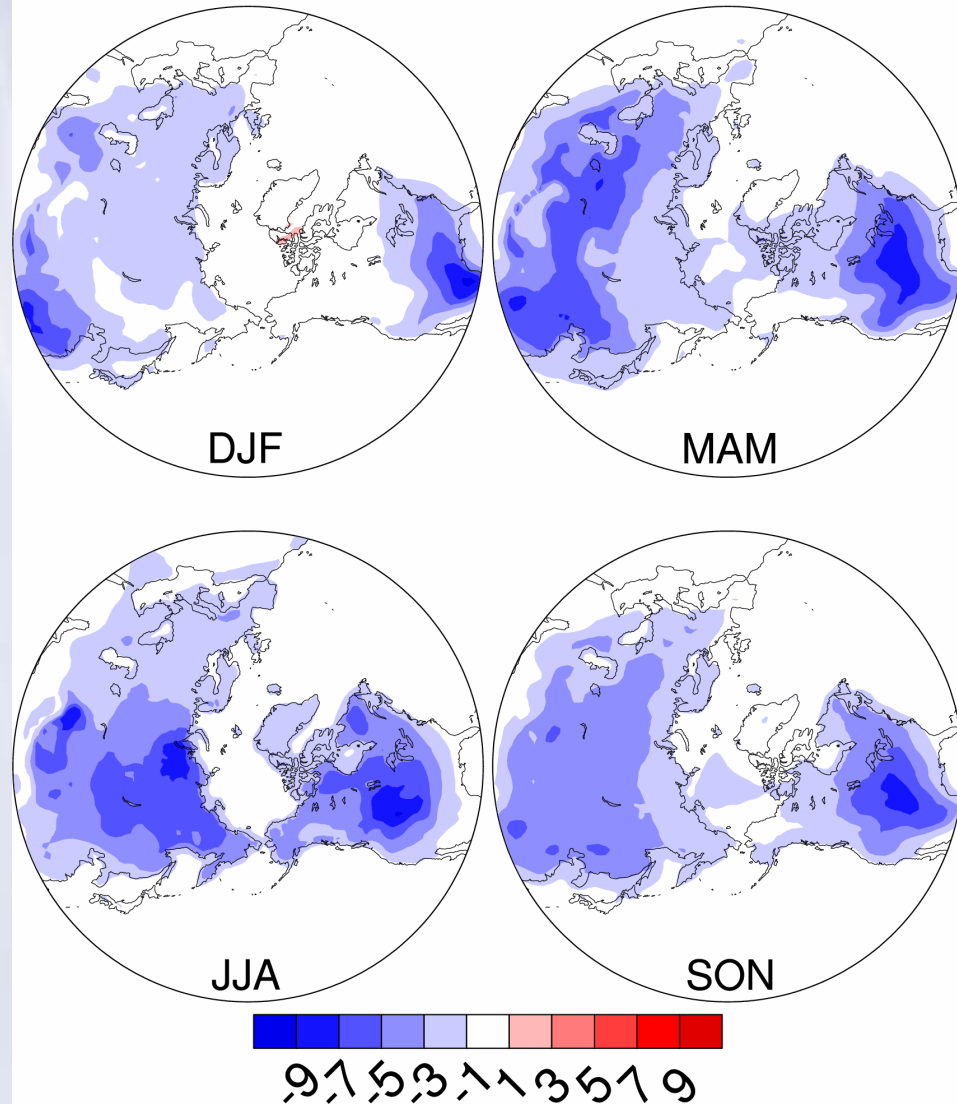
A1B CCSM3 1980-99 Snow Depth (LWE cm)



Result: Imposed snow experiment is colder (up to 5-10° C) than prognostic snow; all seasons

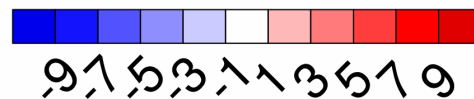
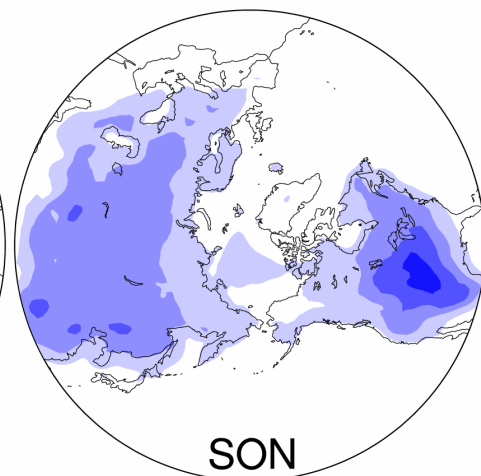
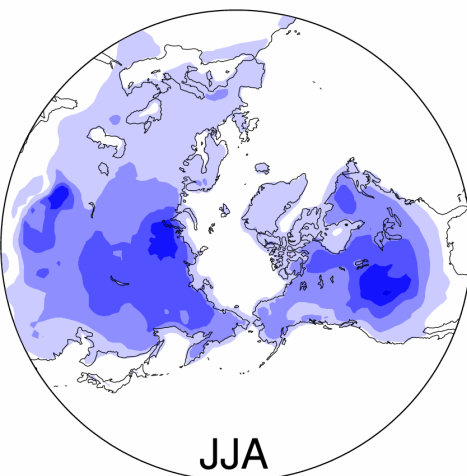
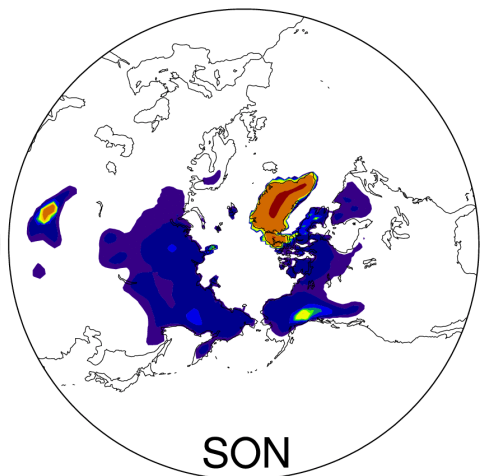
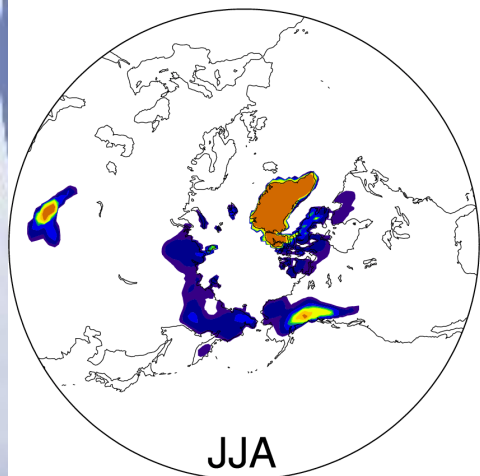
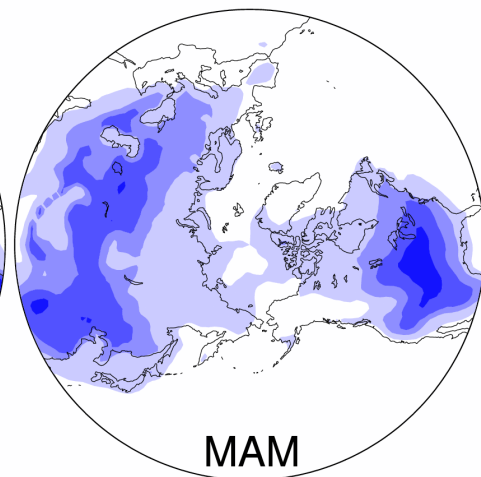
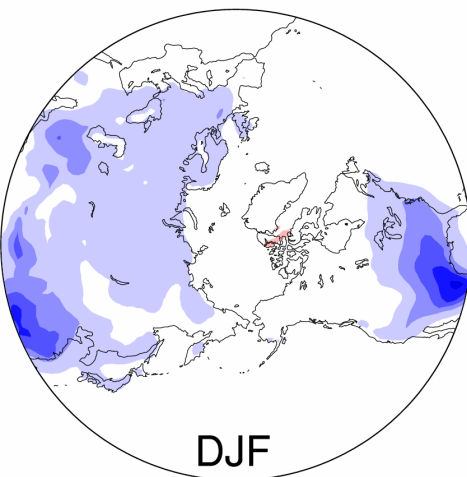
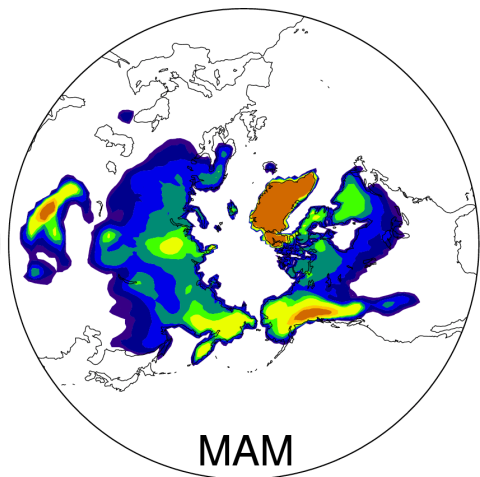
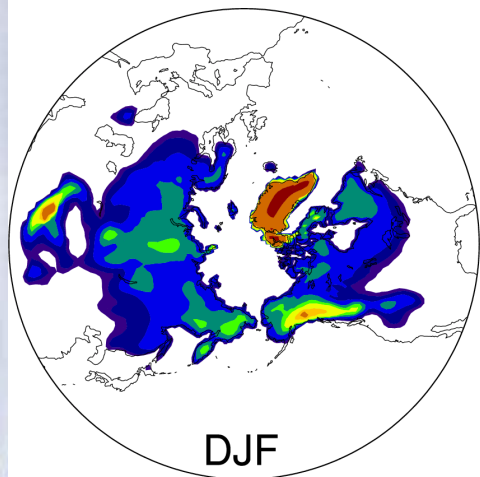
Large near surface T anomalies mostly associated with mean snow < 1-2 cm; in some cases very small amounts of snow

Δ TREFHT imposed - prognostic



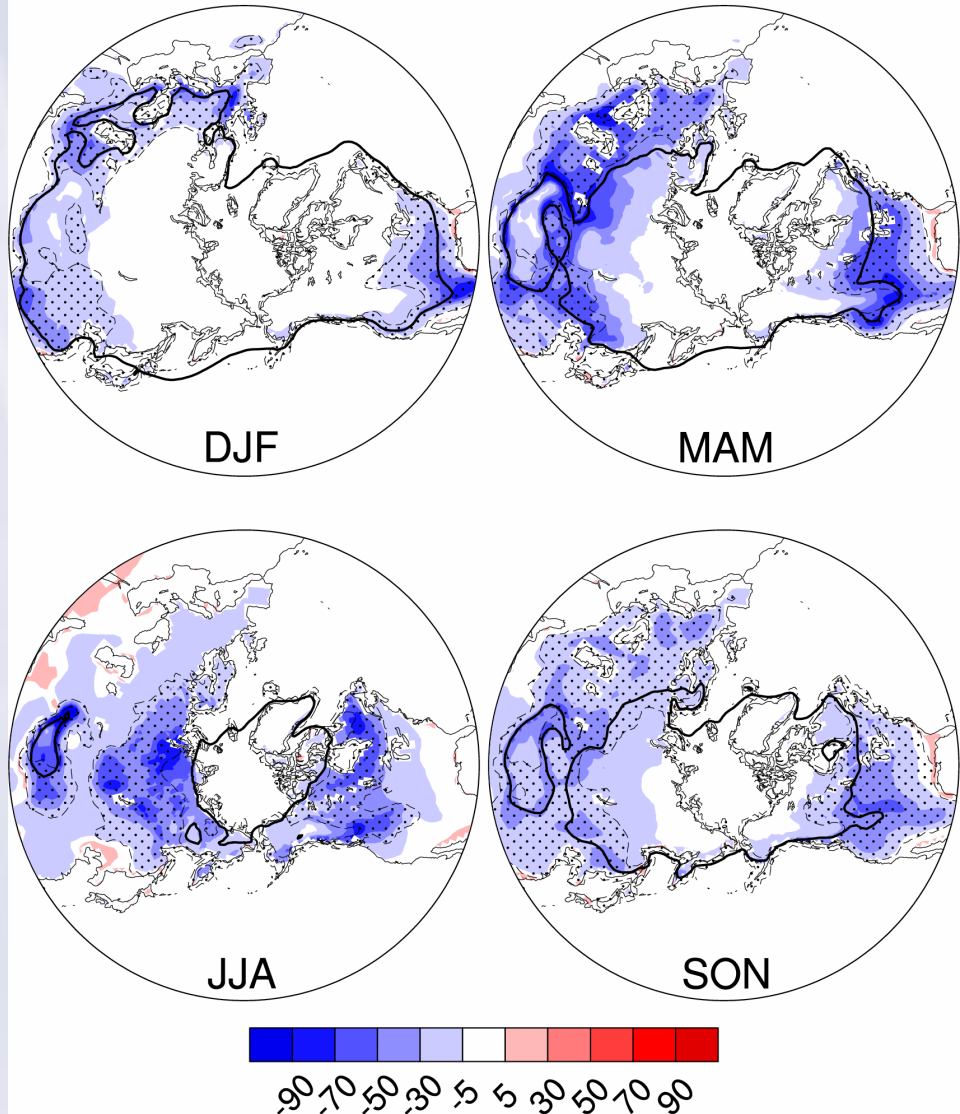
A1B CCSM3 1980-99 Snow Depth (LWE cm)

Δ TREFHT imposed - prognostic



LW+LH+SH

$\Delta\text{THFLX} + \text{FSNS}$, imposed snow Wm^{-2}



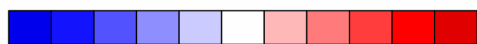
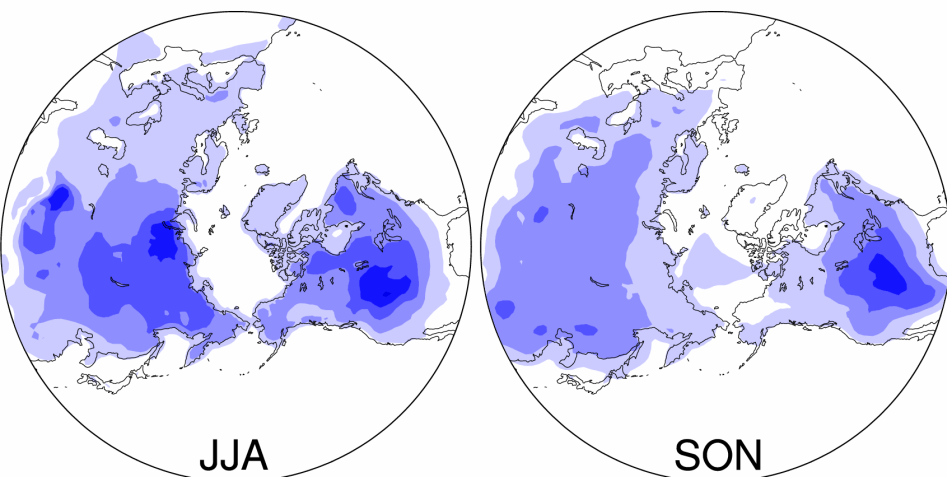
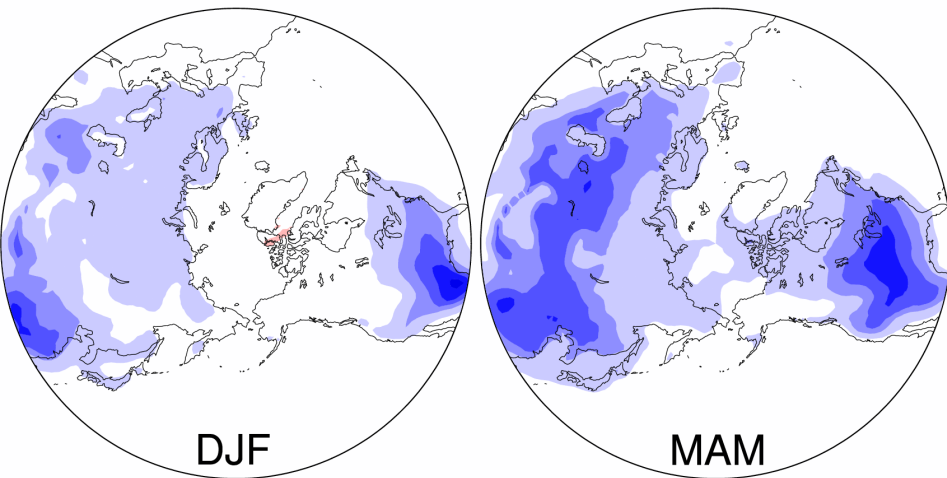
Result: sizable surface heat flux anomalies (mostly sensible + latent) associated < 1cm mean snow (stippled) and near or above mean freezing (0°C contour)

In most cases, ΔTHFLX closely associated with the maximum temperature anomalies

We put in snow; atmosphere melts it; we put it back.

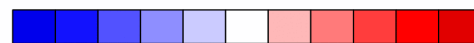
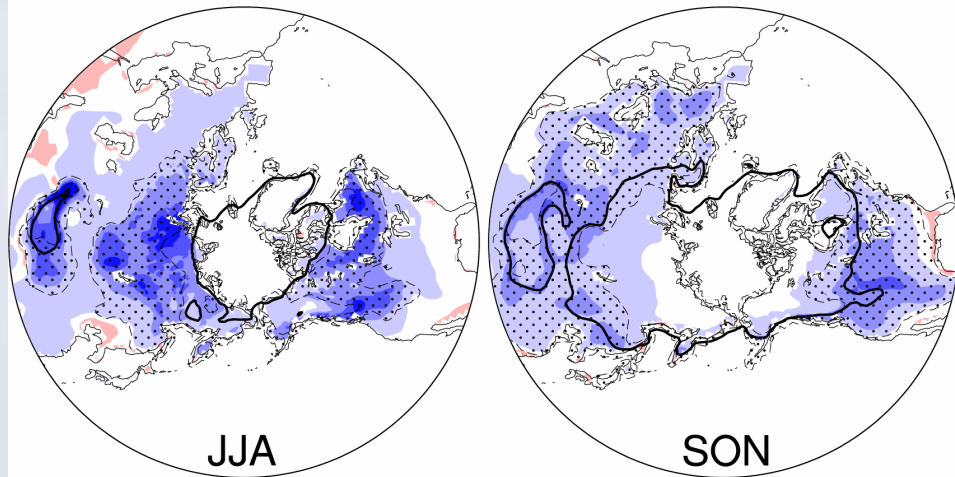
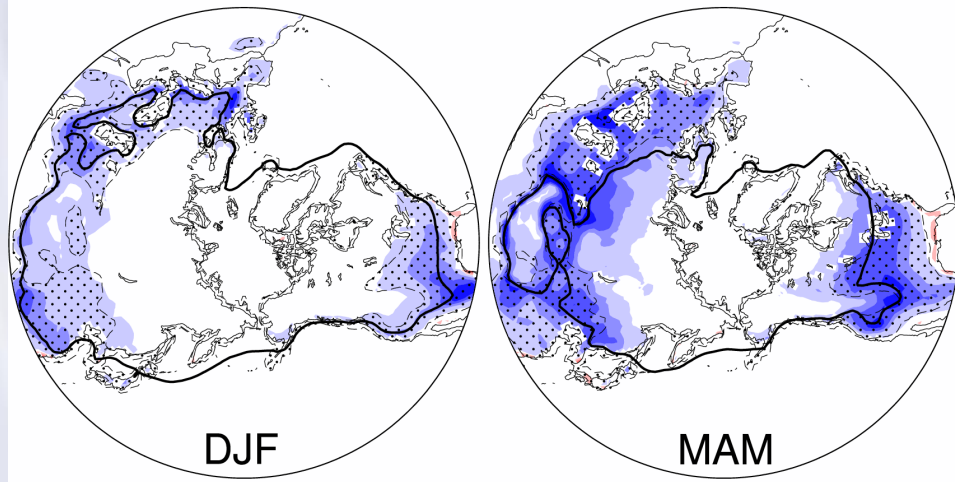
Unavoidable in any type of imposed BC experiment but can we do better?

Δ TREFHT imposed - prognostic

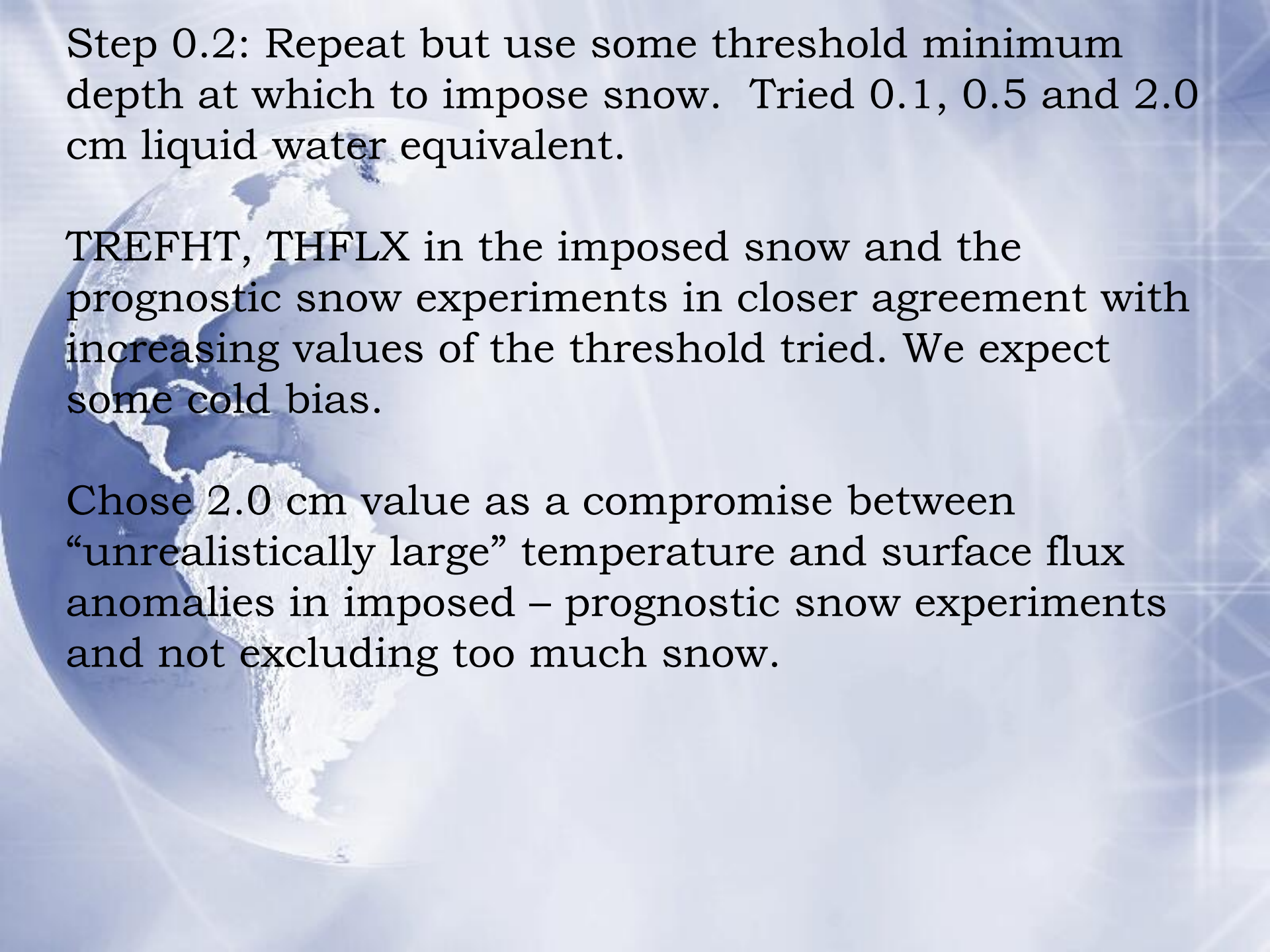


9 7.5 6 4.5 3 1.5 0 1.5 3 4.5 6 7.5 9

Δ THFLX+FSNS, imposed snow Wm^{-2}



90 75 60 45 30 15 0 15 30 45 60 75 90

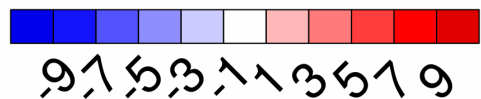
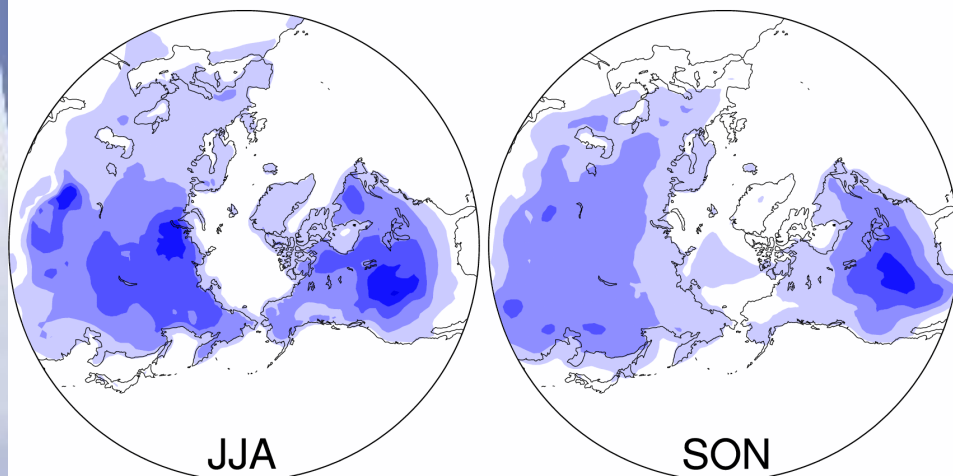
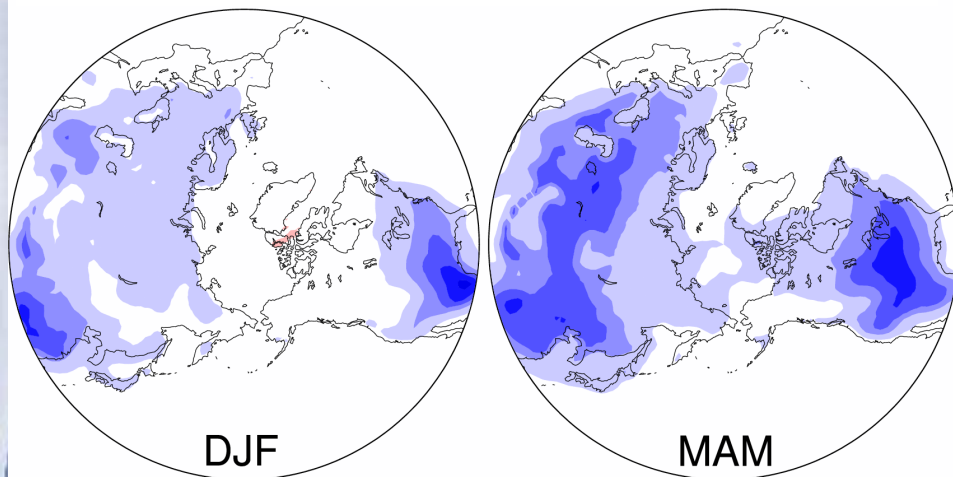


Step 0.2: Repeat but use some threshold minimum depth at which to impose snow. Tried 0.1, 0.5 and 2.0 cm liquid water equivalent.

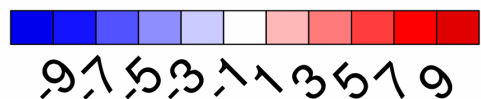
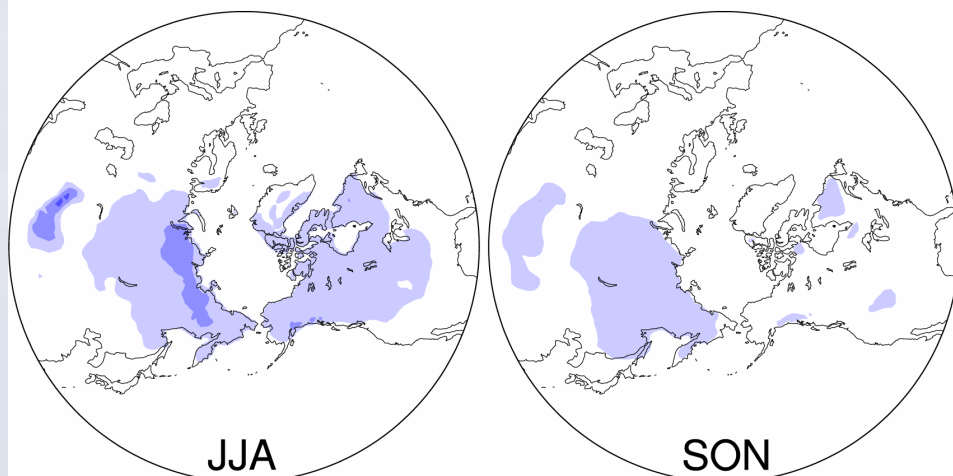
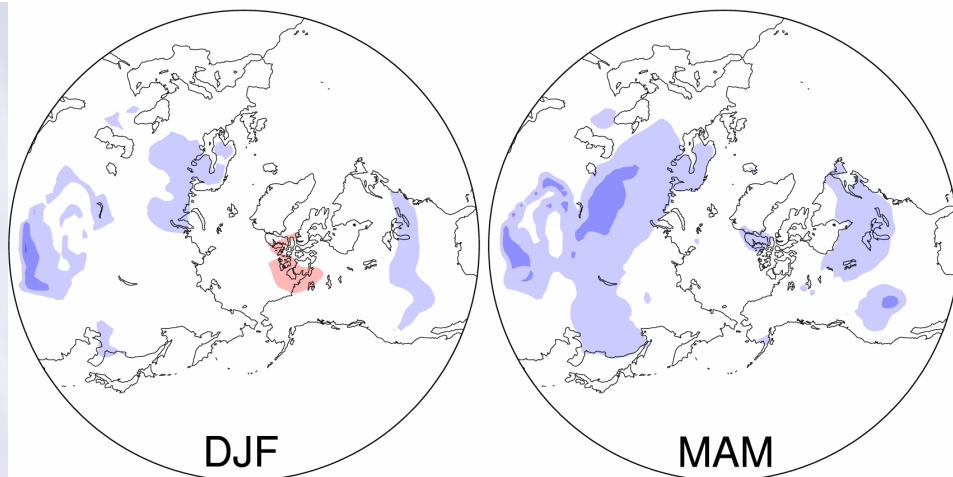
TREFHT, THFLX in the imposed snow and the prognostic snow experiments in closer agreement with increasing values of the threshold tried. We expect some cold bias.

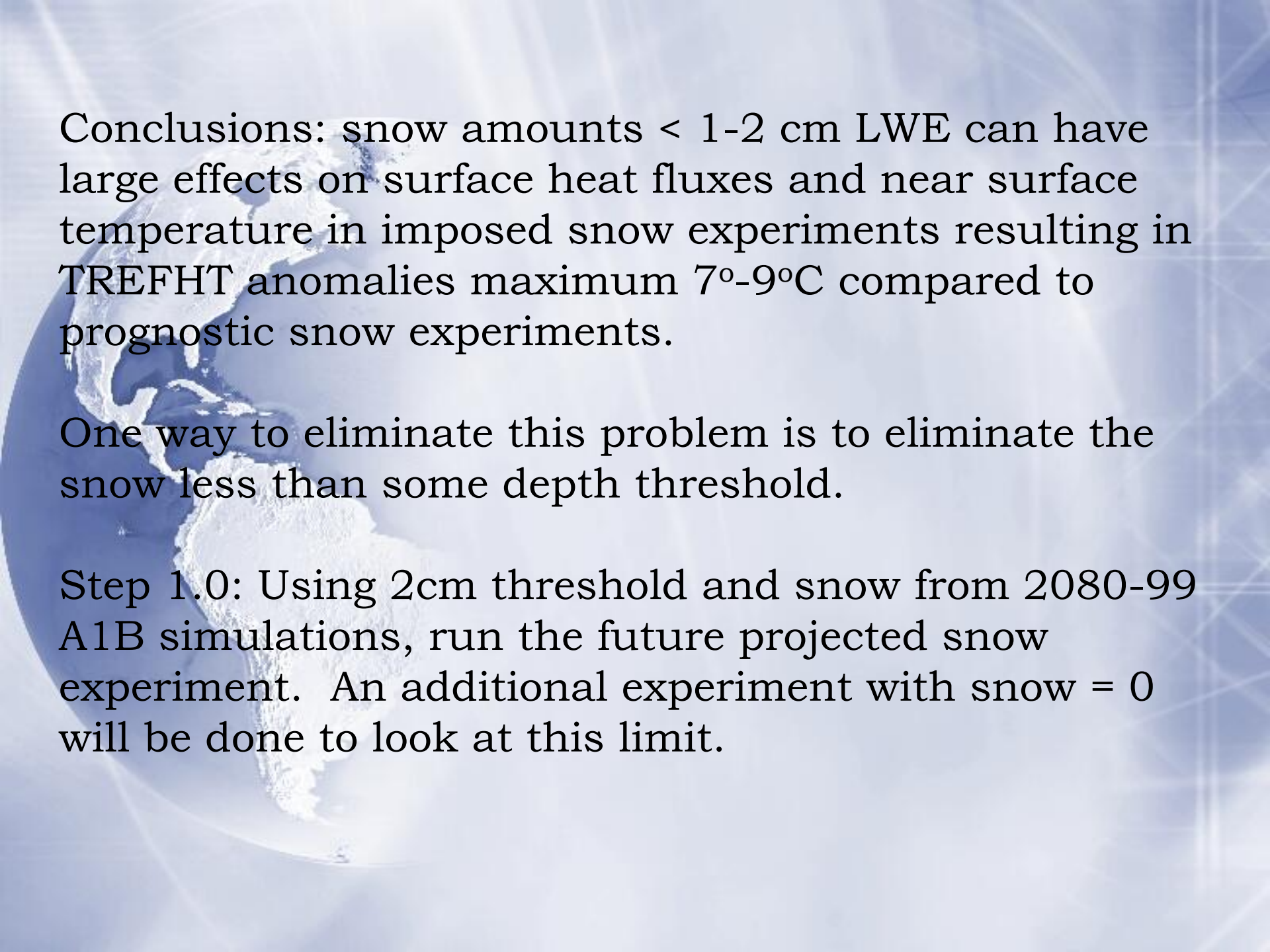
Chose 2.0 cm value as a compromise between “unrealistically large” temperature and surface flux anomalies in imposed – prognostic snow experiments and not excluding too much snow.

Δ TREFHT imposed - prognostic
no threshold



Δ TREFHT imposed - prognostic
2 cm threshold





Conclusions: snow amounts $< 1\text{-}2$ cm LWE can have large effects on surface heat fluxes and near surface temperature in imposed snow experiments resulting in TREFHT anomalies maximum $7^{\circ}\text{-}9^{\circ}\text{C}$ compared to prognostic snow experiments.

One way to eliminate this problem is to eliminate the snow less than some depth threshold.

Step 1.0: Using 2cm threshold and snow from 2080-99 A1B simulations, run the future projected snow experiment. An additional experiment with snow = 0 will be done to look at this limit.

- 1) Direct effect on local T and precipitation
- 2) Direct effect on local circulation and...
- 3) ...Indirect effect through Δ storm tracks, large scale circulation
- 4) Indirect effect, low-latitude precipitation, large-scale teleconnection patterns in tropics and mid-latitudes

Mechanisms: Through changes in the surface fluxes:

