ATM S 559 Homework 2: Part 2

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This is a discussion on the impact on SOM and SST runs of CCSM4 of flattening Antarctic topography. The SOM and SST cases are compared and contrasted by looking at diagnostics. Aside from the expected increased heating of Antarctica, there is a notable shift in heat transfer and precipitation to the north.

Introduction and Overview

This is a comparison of a small set of diagnostics from the Flat Antarctica SOM and SST CCSM4 cases run in homework 2 part 1. In the analysis, the topography of Antarctica was reduced to 5% of its nominal height to observe resulting changes in climate.

Comparing and Contrasting SOM and SST Results

Surface Temperature

Looking at Figure 1, the flat Antarctica cases both warm near the south pole. The SOM and SST agree fairly closely in magnitude and show an increase in surface temperature of about 12 K from 60°S to 90°S latitudes. The SOM shows a slight decrease in temperature away from Antarctica, possibly due to the assumptions makes regarding energy fluxes at the surface.

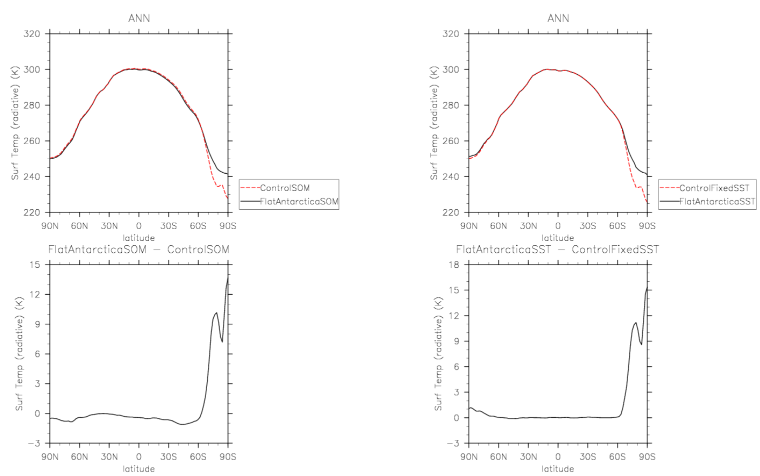

Figure 1: TS for SOM (left) and SST (right) cases.

Surface Pressure

A similar trend is shown for pressure in Figure 2, where a flat Antarctica experiences a roughly 300 millibar pressure decrease in the SOM and SST model runs. It's interesting that the jump in temperature and drop in pressure are so sharp at the 60°S latitude.

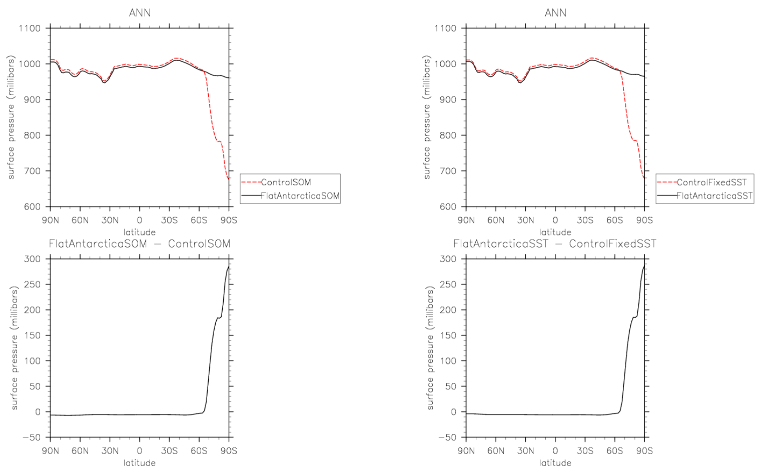

Figure 2: PS for SOM (left) and SST (right) cases.

Precipitation Rates

The precipitation rates for the SOM and SST runs look very similar to each, and they do not differ much from the control runs. In Figure 3, both show an increase in precipitation rate of of 0.2 mm/day, which would translate to a roughly 36% increase in total precipitation for Antarctica. The SOM case shows a northward shift in precipitation in the tropics. This might be because the SOM lacks the simulation of ocean transport that SST has (albeit crude). The SOM assumptions do not capture energy fluxes at the ocean surface as well as the SST does.

Top of Model Atmosphere Radiation Fluxes

Figure 4 shows the TOM atmosphere net shortwave radiation fluxes for the SOM and SST cases, with the SOM case displaying a larger decrease in net flux away from Antarctica. This again seems like the result of the SOMs lack of ocean dynamics.

Meridional Streamfunction

Figure 5 shows the SOM and SST meridional streamfunction plots. The northward shift in precipitation is linked to the northward shift of tropical cells in the SOM. Frierson [1] explains this as heat release

[1] Dargan MW Frierson, Yen-Ting Hwang, Neven S Fučkar, Richard Seager, Sarah M Kang, Aaron Donohoe, Elizabeth A Maroon, Xiaojuan Liu, and David S Battisti. Contribution of ocean overturning circulation to tropical rainfall peak in the northern hemisphere. *Nature Geoscience*, 6(11):940–944, 2013

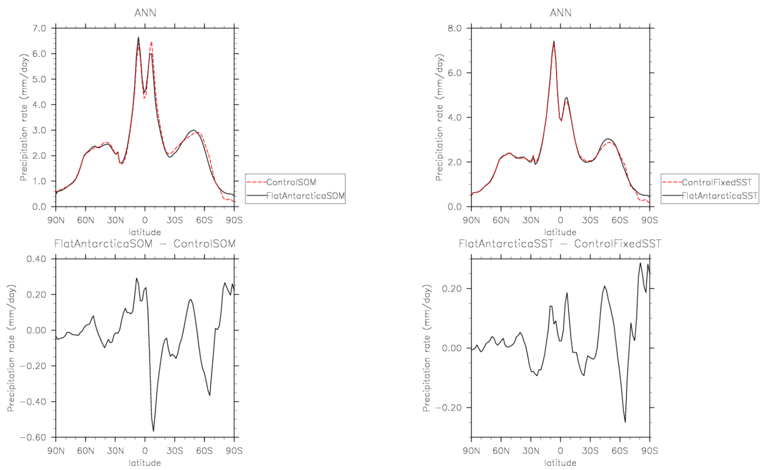

Figure 3: Precipitation rate for SOM (left) and SST (right) cases.

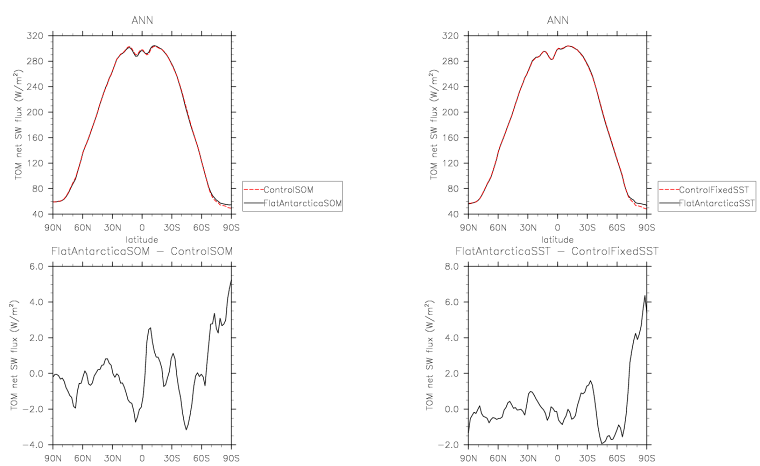

Figure 4: TOM net SW flux for SOM (left) and SST (right) cases.

from the ocean to the atmosphere in the northern hemisphere. The atmospheric response is moisture transport in the opposite direction of energy transport, in our case, the moisture moves north. Figure 6 shows the meridional streamfunction from the tall Arctic SOM case. If I'm interpreting it correctly, it shows a similar shift in moisture transport to the north, suggesting that adding topography to the Arctic has a similar impact on forcing as flattening Antarctica.

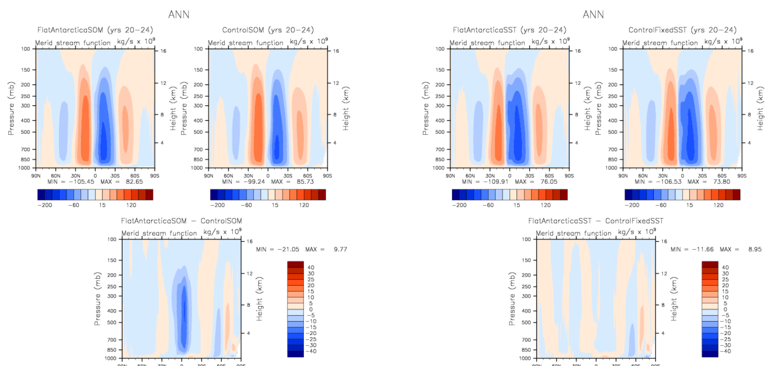

Figure 5: Meridional streamfunctions for SOM (left) and SST (right) cases.

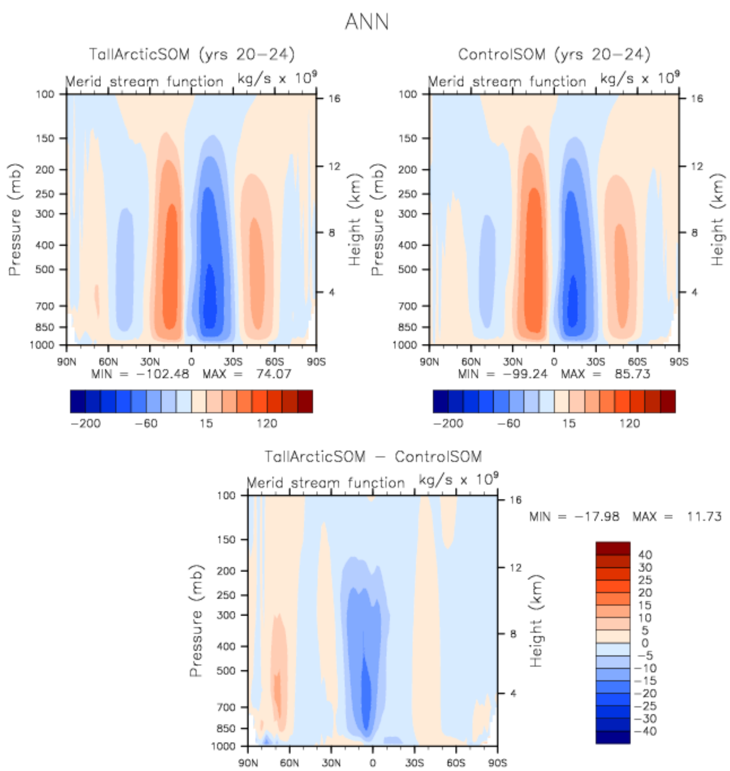

Figure 6: Meridional streamfunctions for SOM tall Arctic case.

Summary and Conclusions

The shift northward of precipitation was counter intuitive, however, explanations of the physics at play from the literature[2] make sense. Reduced energy fluxes over Antarctica must be balanced, and this balance is achieved through a shift in the ITCZ.

[2] Hansi KA Singh, Cecilia M Bitz, and Dargan MW Frierson. The global climate response to lowering surface orography of antarctica and the importance of atmosphere–ocean coupling. *Journal of Climate*, 29(11):4137–4153, 2016

References

[1] Dargan MW Frierson, Yen-Ting Hwang, Neven S Fučkar, Richard Seager, Sarah M Kang, Aaron Donohoe, Elizabeth A Maroon, Xiaojuan Liu, and David S Battisti. Contribution of ocean overturning circulation to tropical rainfall peak in the northern hemisphere. *Nature Geoscience*, 6(11):940–944, 2013.

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