Optical Depth Feedback in CFMIP1

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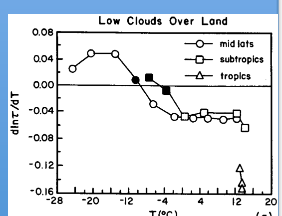
Background

Previous research using satellites and in situ observations has suggested that the optical depth of low clouds increases along with cloud temperature in the high latitudes (Somerville and Remer, 1984; Tselioudis et al., 1992), which leads to a negative feedback, while tropical clouds show decreased opacity with warmer temperatures. Can this behavior be replicated by climate models, and can they help us understand why clouds in different regions respond differently? We also examine if the feedback seen in short-term variability (days to years) provide information on century-scale feedbacks.

Data

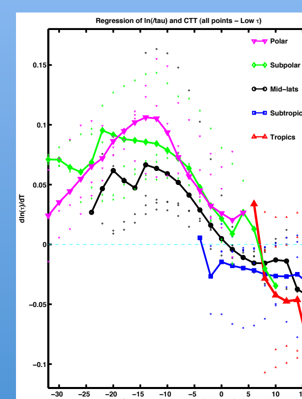
Climate model output from the Cloud Feedback Model Intercomparison Project (CFMIP) control and $2xCO_2$ runs for 8 different climate models.



from Tselioudis et al. (1992)

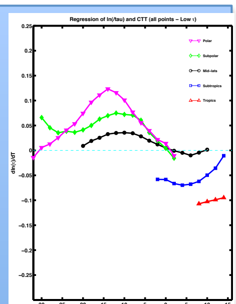
Multi-model Results

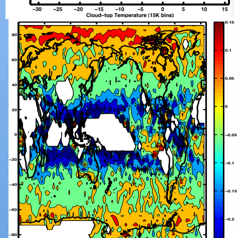
We repeat the regional analysis for each of the 8 models in the CFMIP archive that have all the necessary output retained. In the figure below, the multi-model average is the thick line, while the result for each model is shown in the smaller points. For all models, we see a consistent pattern of negative optical depth feedback for clouds in the midlatitude and polar regions, while we see a positive feedback for tropical and subtropical clouds in nearly every model. It will be important to investigate if parameterization choice can lead to a different optical thickness feedback.

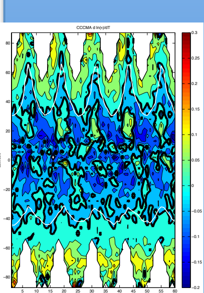


Single-model Results

The results for the control climate of the CCCMA model are shown below. This model replicates the behavior of saltellite-observed cloud properties. This model clearly demonstrates the different response of clouds at different temperatures, and in different regions. The plot below shows the feedback value averaged over latitude bands over the 5-year control integration. The solid black line represents the zero-feedback value, while the white line represents the average location of the 0°cloud temperature contour.







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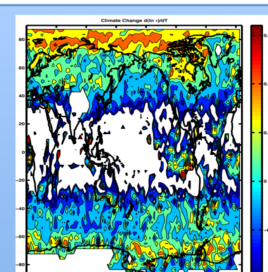
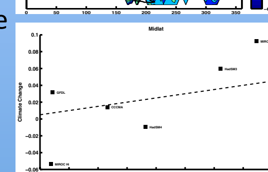
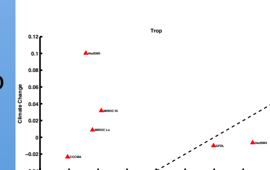
Timescale of Feedbacks

It is important to understand if the feedbacks we diagnose from present-day observations can be applied to a long-term climate change scenario. Here is the climate change feedback value, calculated as the average difference in optical thickness, divided by the average cloud temperature change for each location. By averaging over different regions, we can compare the control climate response of optical thickness to that predicted in a climate change scenario.







References

Somerville, R.C.J. and L.A. Remer, 1984. *J. Geophys. Res.*, 89, 9668-72.

Tselioudis, G., W.B. Rossow and D. Rind, 1992. *J. Clim.*, 5, 1484-95.