The Response of Tropical Precipitation to the Extratropical Thermal Forcing

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Many recent paleoclimatic studies, both observational and modeling, have pointed to the influence of high latitudes on the tropical precipitation. To develop a better understanding of what controls this tropical response, we examine the response of tropical precipitation to extratropical thermal forcing using idealized and comprehensive atmospheric GCMs, in an aqua-planet configuration coupled to a slab ocean. Heat is subtracted from poleward of 40°N and simultaneously added to poleward of 40°S, equivalent to an imposed southward cross-equatorial heat flux in the ocean.

We find a close relationship between the magnitude of the tropical precipitation response and the degree of compensation between the imposed oceanic flux and the resulting response in the atmospheric energy transport. The idealized model produces a low level of compensation of about 25%, which can be predicted from an energy balance model. This supports the claim that the low level of compensation is expected if the primary communication between the extratropics and the Hadley cell is through eddy fluxes of moist static energy. A simple theory is developed that predicts the precipitation response and its sensitivity to the convection scheme parameter, which results from different values of the gross moist stability.

In a comprehensive GCM, all cases show a much greater shift of the ITCZ than in the idealized model, related to the fact that the compensation of the implied oceanic transport by the atmospheric energy transport is much larger due to positive cloud and water vapor feedbacks that amplify the imposed extratropical thermal forcing.