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The sensitivity of the isentropic slope in a primitive-equation dry model

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It has long been noted that the extratropical troposphere has a well defined isentropic slope, such that the characteristic isentrope leaving the subtropical boundary layer reaches the tropopause in polar latitudes. This typical isentropic slope is very robust in both hemispheres and throughout the seasonal cycle.

Early theories attributed the robustness of the extratropical isentropic slope to baroclinic adjustment, i.e. to the baroclinic neutralization of the troposphere by the eddies. However, the baroclinic-adjustment constraint has been shown to fail in full-physics GCM experiments, and in idealized moist GCMs when perturbing the moisture content. In contrast, recent experiments by Schneider and others have suggested that the isentropic slope is very strongly constrained in idealized *dry* GCMs, even when strongly perturbing the heating.

In this study, we investigate the sensitivity of the isentropic slope in an idealized dry GCM similar to Schneider's. It is shown that the robustness of the isentropic slope in the dry model is not universal, but depends on the form of the heating. The key issue is how the gross stability changes: this affects whether only the energy transport increases with the heating, or the isentropic mass flux increases as well. These results may help explain the failure of the baroclinic-adjustment constraint in models with more sophisticated heating formulations than Newtonian heating, in particular when moisture is present.