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Circulation sensitivity to heating in a simple model of baroclinic turbulence

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In this presentation we discuss the sensitivity of the equilibrium state of an idealized two-level primitive equation model on the form and strength of the heating. We compare two different versions of the model, forced using two different heating formulations: a standard model forced by Newtonian cooling and a "prescribed heating model", in which the net heating reaching the lower level is prescribed. To interpret the results, it is useful to distinguish between two facets of the heating: the differential heating, defined as the meridional heat transport from low to high latitudes in the model, and the vertical destabilization, or heat transport from the lower to the upper troposphere. While the differential heating is always internally determined (in both heating formulations), the vertical destabilization is internally determined in the Newtonian cooling model but prescribed from the outset in the model forced from below.

An important constraint for understanding the results is that, when the eddies are quasi-adiabatic, the eddy mixing slope should scale as the isentropic slope. This implies that the isentropic slope is ultimately constrained by the structure of the heating, and in particular by the ratio between vertical destabilization and differential heating. Consistent with this, the criticality always decreases (i.e., the isentropic slope always flattens) with increasing differential heating in the model forced from below. In contrast, the criticality may either increase or decrease with increasing differential heating in the Newtonian forcing model, depending on whether the vertical destabilization -internally determined now- increases faster or slower than the differential heating. When they change proportionally, the criticality is relatively insensitive to the external heating.