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The Height of the Tropopause and the General Circulation

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We will discuss the mechanisms that determine the height of the extra-tropical tropopause. The tropopause may be regarded as the boundary between a dynamically active troposphere and a stratosphere that is more nearly in radiative equilibrium. In the extra-tropics the dynamical activity is predominantly in the form of baroclinic eddies that transport heat polewards and upwards and the height of the tropopause is largely determined by the vertical extent of the isentropic mass flux, and so is essentially the vertical extent of the baroclinic eddies themselves. In simple terms, the extra-tropical troposphere is a baroclinic boundary layer and the tropopause a front. The vertical extent of the boundary layer is influenced both by the adiabatic dynamics of the baroclinic eddies and by diabatic effects, and therefore, and as is known, both dynamical and radiative constraints must be satisfied. Various theories have been proposed for these dynamics including baroclinic adjustment and its relatives, and diffusive closures. Using an idealized primitive equation model we explore if and how the dynamical ideas can successfully predict the tropopause height and if and how the diabatic constraints limit their applicability. We find when the vertical redistribution of heat is important the radiative constraint tightly constrains the tropopause height and prevents an adjustment to marginal criticality. In contrast, when the stratification adjustment is small, the radiative constraint is only loosely satisfied and there is a tendency for the flow to adjust to marginal criticality.