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Relative importance of tropopause structure and diabatic heating for baroclinic instability

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Many weather and climate models fail to represent the sharp vertical changes of vertical wind shear and stratification near the tropopause. This discrepancy results in errors in the horizontal gradient of potential vorticity (PV), which acts as a wave guide for Rossby waves that highly influence surface weather in midlatitudes. In an idealised quasi-geostrophic model developed from the Eady model, we investigate how variations in vertical wind shear and stratification near the tropopause affect baroclinic growth. Comparing sharp and smooth vertical profiles of wind shear and stratification across the tropopause for different tropopause altitudes, we find that both smoothing and tropopause altitude have little impact on the growth rate, wavelength, phase speed, and structure of baroclinic waves, despite a sometimes significant weakening of the maximum PV gradient for extensive smoothing. Instead, we find that baroclinic growth is more sensitive if the vertical integral of the PV gradient is not conserved across the tropopause. Furthermore, including mid-tropospheric latent heating highlights that errors in baroclinic growth related to a misrepresentation of latent heating intensity are typically much larger than those associated with the correct representation of vertical wind shear and stratification in the tropopause region. Our results thus indicate that the correct representation of latent heating in weather forecast models is of higher importance than adequately resolving the tropopause.