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On the sensitivities of idealized moist baroclinic waves to environmental temperature and moist convection

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The impact of cloud diabatic heating on baroclinic life cycles has been studied for decades, with the nearly universal finding that this heating enhances the system growth rate. However, few if any studies have systematically addressed the sensitivity of baroclinic waves to environmental temperature. For a given relative humidity, warmer atmospheres contain more moisture than colder atmospheres. They also are more prone to the development of deep moist convection, which is itself a major source of diabatic heating. Thus, it is reasonable to expect faster baroclinic wave growth in warmer systems. To address this question, this study performs idealized simulations of moist baroclinic waves in a periodic channel, using initial environments with identical relative humidities, dry stabilities, and dry available potential energies but varying environmental temperatures and moist instabilities. While the dry versions of these simulations exhibit virtually identical wave growth, the moist versions exhibit major differences in life cycle. Counter-intuitively, despite slightly faster initial wave growth, the warmer and moister waves ultimately develop into weaker baroclinic systems with an earlier onset of the decay phase. An energetics analysis reveals that the reduced wave amplitude in the warmer cases stems from a reduced transfer of available potential energy into eddy potential energy. This reduced energy transfer is associated with an unfavorable phasing of mid-to-upper-level thermal and vorticity anomalies, which limits the meridional heat flux.