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A Quantitative Assessment of the Impact of Increase in CO2 Concentration on Baroclinic Instability

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Interaction between CO_2 and atmospheric radiation plays a significant part in changing horizontal and vertical temperature distributions through which it can affect the mid-latitude atmospheric dynamics. The baroclinic instability, which is the source of large-scale eddy formation in mid-latitudes, depends on meridional and vertical eddy fluxes of heat. In addition, the eddy available potential energy, which comes from the mean available potential energy, relies on meridional temperature gradient and provides eddy growth by conversion to eddy kinetic energy. The aim of this study is to determine how the amount of CO_2 concentration present in the atmosphere affects the baroclinic instability and formation of large-scale eddies in mid-latitudes. In contrast with what is common in climatological studies, the response of atmospheric flows to CO_2 radiative effects has been investigated for a short period relevant for the duration of baroclinic instability. For this purpose, the RRTMG radiative parameterization scheme has been coupled with the DCASL dry dynamical core. The Jablonowski–Williamson test is used to carry out baroclinic instability simulations for five cases with the same initialization but different CO_2 concentrations (0, 250, 500, 750 and 1000 ppm). The impacts of different CO_2 concentrations on eddies growth, mean flow and eddy-mean flow interaction are discussed. Results show that increase in the concentration of CO_2 decreases the meridional temperature gradient and thus reduces the eddy kinetic energy at lower atmospheric levels. Also, increase in CO_2 concentration has a considerable impact on the growth rate, meridional and vertical eddy propagation and jet intensification. It is also interesting to note that the CO_2 radiative impacts on baroclinic instability are saturated at 750 ppm.