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Sensitivity of idealised baroclinic waves to mean atmospheric temperature and meridional temperature gradient changes

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The sensitivity of idealised baroclinic waves to different atmospheric temperature changes is studied. The temperature changes are similar to those which are expected to occur in the Northern Hemisphere with climate change: 1) uniform temperature increase, 2) decrease of the lower level meridional temperature gradient, and 3) increase of the upper level temperature gradient. Three sets of experiments are performed, first without atmospheric moisture, thus seeking to identify the underlying adiabatic mechanisms which drive the response of extra-tropical storms to changes in the environmental temperature. Then, similar experiments are performed in a more realistic, moist environment, using fixed initial relative humidity distribution. Warming the atmosphere uniformly tends to decrease the kinetic energy of the cyclone, which is linked to a weaker capability of the storm to exploit the available potential energy of the zonal mean flow. Unsurprisingly, the decrease of the lower level temperature gradient weakens the resulting cyclone regardless of the presence of moisture. The increase of the temperature gradient in the upper troposphere has a more complicated influence on the storm dynamics: in the dry atmosphere the maximum eddy kinetic energy decreases, whereas in the moist case it increases. We also investigate the conversions from the available potential energy of the zonal mean flow to eddy available potential energy and kinetic energy. This analysis suggests that the slightly unexpected decrease of eddy kinetic energy in the dry case with an increased upper tropospheric temperature gradient originates from the weakening of the meridional heat flux by the eddy.