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Polar vortex regimes in a simple general circulation model

Roland Walz[1], Hella Garny[1,2], and Thomas Birner[1,2]
[1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institut für Physik der Atmosphäre, Weßling, Germany (roland.walz@dlr.de)
[2]Meteorological Institute, Ludwig-Maximilians-Universität München, München, Germany

A dry dynamical-core model is used to investigate the regime behavior of the polar vortex under the influence of tropical upper-tropospheric warming. Up to 5 K temperature increase in this region, the polar vortex strength and variability hardly changes. Only for temperature increases above 8 K the polar night jet speeds up by approximately 20 m s^{-1} and the probability of sudden stratospheric warmings is strongly reduced.

A comparison of climatological-mean differences of the zonal-mean zonal winds between the two regimes and the first empirical orthogonal function of the zonal-mean zonal wind closest to the regime transition at around 7.5 K temperature increase reveals that the system oscillates between both regimes at the regime transition. Every regime is present for a long time accounting for the peaked autocorrelation time scale being distinctive of a regime transition. From a dynamical point of view the strong polar vortex regime is characterized by less negative Eliassen-Palm (EP) flux divergence in the stratosphere and an equatorward refraction of EP flux in the midlatitudes compared to the weak polar vortex regime.

In order to quantify the influence of the polar vortex on the tropospheric circulation during tropospheric warming, another set of tropical upper-tropospheric heating simulations without a polar vortex is performed. This reveals that the latitudes of the tropospheric jets in both sets of simulations coincide for tropical upper-tropospheric warmings up to 5 K, or equivalently, when the polar vortex is in its weak regime. However, when the polar vortex starts to transition to the strong regime, i.e. for tropospheric warmings above 5 K, the poleward contraction of the tropospheric jet is strongly enhanced compared to the set of simulations without polar vortex.