Purpose
Talk

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Title
Potential vorticity diagnostics to quantify the role of latent heating for extratropical cyclone dynamics in a warmer climate

Abstract
Latent heating (LH) due to cloud formation can substantially amplify the intensification of extratropical cyclones. The expected increase of the atmospheric moisture content due to ongoing emissions of anthropogenic greenhouse gases is going to increase the potential for LH in cyclones. How this increase may affect both individual cyclones and the storm track as a whole is still unclear. Here, we investigate the role of LH for cyclones in two conceptually different sets of idealized climate change simulations. To this end, we use a diagnostic method that explicitly quantifies the contribution of LH to the lower-tropospheric potential vorticity (PV) anomaly of a cyclone, which is strongly coupled to cyclone intensity and the associated impacts in terms of surface weather. First, we apply this PV diagnostic to regional surrogate climate change simulations of 12 Northern Hemisphere cyclones in a spatially homogeneously warmer climate, in which only the atmospheric moisture content increases but no changes in baroclinicity occur. We demonstrate that enhanced LH can largely but not fully explain the substantially varying changes in the dynamics, intensity, and impacts of these cyclones. Second, we use a set of idealized aquaplanet GCM simulations of very cold to very warm climates, in which changes in the atmospheric moisture content are accompanied by changes in the meridional and vertical temperature structure. Applying our PV diagnostic to the cyclones from these simulations demonstrates that cyclone intensity increases with warming due to the continuous increase in LH, reaches a maximum in climates warmer than present-day, and decreases beyond a certain warming once the increase of LH is overcompensated by the counteracting reduction in mean available potential energy. Because of their substantially stronger increase in LH, the most intense cyclones reach their maximum intensity in warmer climates than moderately intense cyclones with weaker LH.