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Stability, Convection and Resolution: Understanding Vertical Motion in Modeled Extratropical Cyclones

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The warm sector in a developing extratropical cyclone is a region with ample vertical motion and precipitation. While most of the lifting of air masses within this region is driven by a response to baroclinic instability, convection is also active. The current analysis examines the interaction between these two types of vertical motion in numerical models in an effort to better understand general circulation model's (GCM's) projected changes in extratropical cyclones with global warming. First, cyclone-centered diagnostics are used to analyze the cloud field perpendicular to the warm front in a GCM. The analysis shows that the model's convection scheme is very active in the equatorward region of the warm sector. The convective mixing of heat acts to decrease the model relative humidity and cloud fraction, making the modeled cloud field biased low. Given this result, a proxy for warm sector convective activity is created based on the fraction of precipitation generated by the convection scheme. This cyclone-relative metric is examined in a numerical integration of an idealized extratropical cyclone, as well as a regional climate model. These models are analyzed at multiple resolutions, with the convective activity metric being compared to storm intensity and intensification rates. The analysis is then repeated using mean state temperature and moisture profiles meant to represent global warming, and the results are linked to the modeled vertical stability.