Parameter sweep experiments on a spectrum of cyclones
with diabatic and baroclinic processes
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A wide range of environments that prevail over the globe generate various types of cyclones such as tropical, extratropical, and hybrid cyclones. In this paper, idealized numerical experiments are used to explore a spectrum of cyclones ranging from diabatic type to baroclinic type in a parameter space consisting of three environmental factors: temperature, vertical shear, and planetary vorticity. The experiments reproduce not only typical dynamics of tropical and extratropical cyclones but also their modified dynamics which are consistent with theoretical studies; tropical cyclones are suppressed by vertical shear, while extratropical cyclones are intensified by condensational heating. The experiments also reproduce hybrid cyclones in environments with high temperature and large baroclinicity. The hybrid cyclones show multi-scale dynamics in which synoptic-scale baroclinic systems spawn smaller-scale tropical-cyclone-like convective cores. The spectrum of cyclones is found to be nonmonotonic in the parameter space because of a two-sided effect of the vertical shear: moderate shear weakens a tropical cyclone by tilting the small-scale vortex to the down-shear, while strong shear develops a large-scale vortex of an extratropical and hybrid cyclone through warm air advection from the south. The indices based on the energetics and symmetric/asymmetric structures overview the different types of cyclones in the parameter space. These parameter sweep experiments provide useful information on what environment is favorable for cyclones, particularly for intermediate environments where cyclone mechanisms are yet to be fully defined.

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