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Balanced vs. Radiating Responses to Diurnal Heating in Tropical Cyclone-Like Vortices in a Linear Nonhydrostatic Model

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The diurnal cycle (DC) in tropical cyclones (TCs) is a well documented phenomenon. While early studies suggested the DC in cirrus canopy area was due to a DC in eyewall convection, later studies instead attributed this to the DC of solar radiation directly affecting the cirrus canopy. In this study, we use a linear dynamical model to examine the extent to which linear dynamics can capture the DC in TCs. In particular, we explore the transition between balanced and radiating responses to diurnal heating. The heat forcing in the linear model is physically motivated by the diabetic heating output from a more realistic simulation, which illustrated the presence of a DC in moist convective heating and radiative heating in the eyewall, and a DC of radiative heating in the cirrus canopy. This study finds that the DC of heating in the eyewall produces an almost entirely balanced response, which is largely restricted to inside the RMW by the high inertial stability of the inner core. The DC of radiative heating in the cirrus canopy produces a strongly radiating response throughout the entire cyclone. Low frequency responses, of diurnal and semi-diurnal frequency, are balanced throughout much of the cyclone. High frequency responses, created at sunrise and sunset, can radiate outwards downwards as gravity waves, and can exist in the vast majority of the cyclone. Based on these results, diurnal responses are balanced in the majority of a TC and are caused by diurnal oscillations in the cirrus canopy as opposed to the eyewall.