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Analysis of CAPE in Intensifying Tropical Cyclones Simulated by CM1

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The transition of a tropical storm to a full blown hurricane (Typhoon) during intensification can be a source of great debate among many well respected scientists. As a result there is a lack of a comprehensive understanding of intensification. The present study aims to lessen some of the confusion by addressing the role of convective available potential energy (CAPE) in cyclogenesis. Previous work by others fail to include this due to assumptions that allow the intensification to occur under different conditions.

A series of sensitivity tests were conducted using an idealised set up in the cloud resolving non-hydrostatic model CM1. A base state provided by a Dunion sounding was used with the vortex being initialised using the Rotunno and Emanuel's scheme and the Morrison double-moment cloud microphysical scheme was adopted. All experiments employed a 2km grid spacing with 600 grid points in the horizontal and 500m grid spacing with 59 grid points in the vertical. Two sets of sensitivity tests were done where the distribution of CAPE was investigated. In the first group the base state temperature was perturbed such that the atmosphere cooled and warmed at 0.5K/km and 1K/km in the vertical direction. In the second group the value for the exchange coefficient for enthalpy was increased and decreased by a factor of 2 and 4 for both cases. Since we are only interested in the rate of intensification most results were taken at the time when the rate of intensification was the highest.

In the temperature perturbation experiments warming the atmosphere creates less than ideal conditions for cyclogenesis which results in no hurricane developing when the air was warmed by 1K/km and a very weak tropical cyclone developing when the air was warmed by 0.5K/km. As a result of this there is very little CAPE present in both cases. In contrast, cooling the air provides better conditions for cyclogenesis. The amount of CAPE is much greater when the air was cooled by 0.5K/km but the final intensity of the cyclone is not. In fact the intensification of the cyclone under both cooling conditions are very similar. The results for the second experiment group are more distinct. Although the coefficient was halved and quartered, there is still a strong cyclone present but the amount of CAPE is less. The experiment with a reduction by factor of 4 exhibits very little CAPE whereas the one where it was reduced by a factor of 2 has some but still a rather small amount of CAPE. There is a greater amount of CAPE for when the coefficient is increased by a factor of 4. Additionally, the intensification rate is also much greater. The intensification rate appears to be sensitive to the presence of CAPE. These results suggest that CAPE is a vital quantity for tropical cyclone intensification.