Lagrangian analysis of the thermodynamic cycle of tropical cyclones in vertical shear

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Vertical shear of the environmental wind is a major factor for intensity and structural changes of tropical cyclones. The processes that govern these changes are still poorly understood and predicting intensity change of tropical cyclones remains a challenge for operational forecasters. Based on idealised numerical experiments, this work aims to advance our fundamental understanding of tropical cyclone – vertical shear interaction.

Recent research has strengthened the long-standing hypothesis that the frustration of the storm's thermodynamic cycle by intrusion of low-entropy, environmental air is the major constraint on intensity for storms in vertical wind shear. The different pathways through which environmental air enters the tropical cyclone circulation, however, have not been examined in detail yet. In particular, it is an open question to what extent different pathways contribute to the frustration of the thermodynamic cycle.

Here, an extensive trajectory analysis using model data with high temporal resolution is presented. The analysis emphasizes the pronounced asymmetric structure of sheared storms. In particular, the inflow layer exhibits a distinct wave number 1 pattern with trajectories entering the inner-core updrafts preferentially in the downshear and downshear-left quadrants. Thermodynamic properties are evaluated along the individual trajectories that pass through the inner-core updrafts. From these trajectories, the three-dimensional thermodynamic cycle of the model storm is constructed. For comparison with a recently-developed axisymmetric, steady-state theory, a second thermodynamic cycle is derived from the quasi-steady, azimuthally averaged storm structure. Preliminary results indicate distinct differences between these two thermodynamic cycles. This presentation will discuss the differences in more detail.