A TURBULENCE STATISTICAL ANALYSIS OF SIMULATIONS OF TROPICAL CYCLOGENESIS

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Abstract

In a numerical study of tropical cyclogenesis, Montgomery *et al* [1] focused on the problem of how a mid-level mesoscale convective vortex (MCV), a frequent by-product of mesoscale convective systems during summertime conditions over tropical oceans, may be transformed into a surface-concentrated (warm core) tropical depression. The simulations demonstrated an upscale cloud/mesoscale mechanism for building the incipient tropical storm vortex. Within the convectively unstable and cyclonic-vorticity rich environment of the initial MCV embryo, horizontally small-scale warm-core updrafts possessing intense cyclonic vorticity in their cores ("vortical hot towers"; VHTs) emerged spontaneously as the dominant coherent structures. By continuity, downdrafts come bundled with updrafts. Updrafts and downdrafts are vortical and hence have helicity: cyclonic updrafts and anticyclonic downdrafts have positive helicity, while cyclonic downdrafts and anticyclonic updrafts have negative helicity.

Levina and Montgomery [2,3] calculated and analyzed helical characteristics of the Montgomery *et al* [1] numerical experiments. They demonstrated how the VHTs work to form a strong secondary circulation, generate helicity and provide the linkage of the tangential and overturning circulation. By means of a quantitative analysis, they suggested that the linkage provides a positive energy feedback between the two circulations. The results support the hypothesized model of a large-scale, helical-vortex instability that operates over the ocean in which sufficient moisture fluxes maintain convective instability. This perspective of large-scale helical development as articulated by these authors is complementary to and consistent with the rotating convection paradigm for tropical cyclone intensification by Montgomery and Smith [4]. The emphasis on helicity as an important characteristic of intensifying and sustaining large-scale vortex disturbances in the atmosphere due to energy transfer from small-scale helical convective turbulence (*turbulent vortex dynamo*) was proposed several years ago by Moiseev *et al* [5, 6].

Tropical cyclones are self-organized coherent structures, but also three-dimensional and turbulent. The self-organization is contrary to a classical three-dimensional turbulence interpretation. The coherence may be due to upscale energy transfer, as proposed in the turbulent vortex dynamo hypothesis, or some other reason. In order to advance understanding, we are investigating the Montgomery *et al* experiments using statistical tools from turbulence theory (namely, probability distributions of velocity and helicity increments and their moments). The statistics will be used to characterize tropical cyclogenesis and intensification and further appraise the hypothesis of the turbulent vortex dynamo.

References

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