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Formation of tornado-like vortices in Coriolis-centrifugal convection

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Isosurfaces of the temperature field with strong centrifugal forces and weak Coriolis forces, generating a tornado-like vortex.

Buoyancy and rotationally driven flows are ubiquitous in nature and they play an important role in a wide range of geo- and astrophysical phenomena. Rotating Rayleigh-Bénard convection, a fluid layer heated from below, cooled from above and rotated around its vertical axis, serves as an idealized model system for the underlying flow physics. In most studies, rotation has only been considered in terms of the Coriolis force, whereas the centrifugal force has been neglected. However, in doing so, one misses out on fascinating physics. We have recently developed novel theoretical arguments for characterizing rotating convective turbulence including the full inertial term, i.e., both Coriolis and centrifugal forces (Horn & Aurnou, Phys. Rev. Lett. 120, 2018). We found that in Coriolis-centrifugal convection storm-like structures can develop, ranging from eyes and secondary eyewalls found in hurricanes and typhoons, to concentrated helical upflows characteristic for tornadoes. Here, I will mainly focus on the tornado-like vortices. These vortices are not only self-consistently generated, but also exhibit the physical and visual features of type I tornadoes, i.e. tornadoes that form within mesocyclones contained in supercell thunderstorms. Hence, our studies revealed that centrifugal buoyancy is, in fact, highly relevant for the understanding of these geophysical vortices, and, thus, more important than previously thought.

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