A Role of Vortical Hot Towers in Providing the Vortex Dynamo in the Atmosphere

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We are going to discuss a crucial role of rotating moist convection in the tropics (Vortical Hot Towers - VHTs), discovered and substantiated in pioneering works on near-cloud-resolving numerical simulation of tropical cyclogenesis (Hendricks et al., 2004, *JAS*; Montgomery et al., 2006, *JAS*), in providing the turbulent vortex dynamo during tropical cyclone (TC) formation.

The theoretical hypothesis on the turbulent vortex dynamo (Moiseev et al., 1983, *JETP*) suggested a large-scale vortex structure formation as a result of inverse energy cascade in helical hydrodynamic turbulence with the broken mirror symmetry. Based on it, a hypothetical scenario for intensification and sustaining of large-scale vortex disturbances in the atmosphere due to energy transfer from small-scale helical convective turbulence was proposed and illustrated by giving theoretical estimates for conditions of TC formation (Moiseev et al., 1983, *Doklady*). In latter paper, the authors proceeded from the assumption that a developed TC is an intense mesoscale atmospheric vortex, in which the main component of velocity lies in a horizontal plane. The powerful tangential circulation is superimposed on a weaker transverse circulation formed by the radial and vertical velocity components (in the cylindrical coordinates). Meanwhile, the transverse circulation is of crucial importance for the existence of such vortical system as a whole and ensures an energy supply from the ocean. Following the proposed hypothesis, the effect of the vortex dynamo should generate a linkage of air streamlines, i.e. the helical structure of the large-scale flow and produce the positive feedback providing the mutual intensification of both circulations. In the rotating Earth’s atmosphere, a link is evident between the transverse and tangential circulation: it is provided by the action of the Coriolis force on the horizontal velocity. However, at that time, it was completely unclear how the second link might be formed between the tangential and transverse circulation that is needed to close the feedback loop for the vortex dynamo effect.

New knowledge on vortical convection makes this feazible. We show how the interaction of moist convection with vertical wind shear observed in natural atmospheric conditions can be interpreted in terms of the mathematical model of the vortex dynamo in a convective system (Levina et al., 2000, review in *Advances in Fluid Mechanics*). A process of generation of the linkage of horizontal and vertical vortex lines observed during such interaction on cloud scales is examined as well as the formation of the linkage of circulations on the vortex system-scale. The process can be quantified by helicity of the velocity field, which is a measure of the degree of linkage (Moffatt, 1969, *JFM*). We examine the helicity and kinetic energy evolution and demonstrate that the linkage of primary tangential and secondary transverse circulation formed on mesoscales is ensured by a population of VHTs of different size and intensity. This time moment is diagnosed based on the kinetic energy: when a mutual intensification of both circulations starts and the nascent TC becomes energy-self-sustaining. Throughout the TC lifetime, VHTs act as dynamical “staples” providing the linkage of circulations. Thus, the positive feedback loop linking the tangential and transverse circulation is realized through VHTs.
Finally, an analogy is traced between the role of interaction 'moist convection –vertical wind shear' in creating the vortex dynamo in the atmosphere and the role of the mean electromotive force providing the MHD dynamo in electrically conducting media.
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