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The Effect of the Surface Friction on the development of the Tropical Cyclone

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The effect of the surface friction on the development of the tropical cyclone is an interesting problem. On the one hand, the surface friction dissipates kinetic energy and tends to weaken the vortex. On the other hand, the boundary-layer pumping induced by the friction exports the moisture and heat to the free atmosphere and to facilitate the development of the cyclone. The numerical result of Rosenthal (1971) and the theoretical analysis of Emanuel (1995) indicate that the spin-up time of tropical cyclone varies inversely with the intensity of the surface friction. On the contrary, Craig and Gray (1996) shows that, in the first 40 hours, the decrease of the central pressure of the cyclone is not sensitive to the surface friction. In this work, the effect of the surface friction on the tropical cyclone is re-evaluated with the axisymmetric, no-hydrostatic model developed by Rotunno and Emanuel (1987).

Numerical results show that, in agreement with Rosenthal (1971) and Emanuel (1995), the strong surface friction leads to rapid development of the tropical cyclone. The reason is that the large CAPE is necessary for the initial development of the tropical cyclone. The surface friction accelerates the formation of the unstable stratification in the low-level of the tropical cyclone and results in rapid growth of CAPE. This explanation is different to that given by Rosenthal (1971), which ascribes the dependence of the spinup of the vortex on the surface friction to the CISK mechanism.

Furthermore, it is found that the sensitivity of the development of the tropical cyclone to the surface friction depends on the stratification of the environmental atmosphere. In the case that the stratification of the environment is neutral, the development of tropical cyclone is sensitive to the surface friction. However, in the unstable case, the impact of the surface friction on the development of the tropical cyclone is not very significant. In the unstable environment, the atmosphere has enough CAPE to support the initial development of the cyclone. While, in the neutral case, the system must, firstly, accumulates enough CAPE by extracting heat from the ocean. As stated above, such a process is accelerated by the surface friction. Hence, the development of the tropical cyclone in the neutral condition is more sensitive to the surface friction than that in the unstable case.

Keywords: surface friction; tropical cyclone; CAPE

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