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The motion of Hurricane-like vortices determined by multi-scale interactions between the mesoscale vortex flow and its large-scale environment: a theoretical model

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Research in recent years have shown that multi-scale processes play a nontrivial role in tropical cyclone development, motion and structure. For example, important multi-scale processes that determine these vortex features arise from interactions between the vortex flow itself, its environmental flow, the Coriolis force due to the earth's rotation and diabatic effects as a consequence of moisture conversion processes occuring in convective cloud systems. Concerning the vortex motion it is well known that the large-scale environmental flow acts as a steering flow. Beta-gyres arising from interactions between the vortex flow and the earth's vorticity field contribute to a deviation of the storm track from the steering flow. Interactions between mesoscale vortices and small scale convective systems are assumed to be responsible for the tendency of tropical cyclones to meander about a mean path, which can be seen in long-range observations based on modern satellite techniques. The structure and intensity changes of tropical cyclones strongly depend from both diabatic effects and the environmental flow. For instance, it is observed that an unfavourable condition for a hurricane to develop or survive is given by a strong vertical shear in the environmental flow. One common explanation for this is that the dispersion of heat as a consequence of disruption of organized pattern of convection by strong winds aloft is responsible for a weakening or limiting of the development of mature storms.

We present a threedimensional model to describe the motion and structure of Hurricane strength H1/H2 vortices. From a theoretical point of view this model gives deeper insight how the mesoscale structure of the vortex itself affects the synoptic scale vortex motion and vice versa, while taking the influence of a vertically sheared environmental flow and diabatic effects due to moisture conversion processes into account. The derivation of the model equations is based on matched asymptotic expansions which have been carried out within the framework of an unified approach to meteorological modelling developed by Klein (2004).

Klein, R. (2004): An Applied Theoretical View of Theoretical Meteorology. in: Applied mathematics Entering the 21st century; Invited talks from the ICIAM 2003 Congress. SIAM Proceedings in Applied Mathematics, vol. 116