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An Unified Approach to Meteorological Modelling based on Multiple-Scales Asymptotics

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In 2003, the author suggested a mathematical framework for the derivation of reduced meteorological models at a Mathematics conference (5th ICIAM, Sydney, Australia), /1/. The framework consists of (i) non-dimensionalization of the 3D compressible flow equations on the rotating sphere, (ii) identification of *universal* non-dimensional parameters, (iii) distinguished limits between these and additional problem-specific parameters, and (iv) multiple scales expansions in the remaining small parameter ϵ. This parameter may be interpreted as the cubic root of the centripetal acceleration due to the Earth's rotation divided by the acceleration of gravity, see also /2/, eq. 10. For the mojority of reduced models of theoretical meteorology that we have come across, the approach allowed us to generate systematic derivations starting directly from the 3D compressible flow equations on the rotating sphere. The framework's potential fully shows in multiscale interaction studies such as /3/, in which we incorporated bulk microphysics closures for moist processes and derived scale interaction models for deep convection. Currently, we study the structure, evolution, and motion of Hurricane strength H1/H2 vortices, /4/, large-scale stratocumulus cloud decks, and planetary-synoptic scale interaction models which should be relevant for Earch System Models of Intermediate Complexity (EMICs). The presentation will summarize the general framework and use the mentioned recent examples to demonstrate its application to specific scale interaction problems.

/1/ R. Klein, in: SIAM Proceedings in Applied Mathematics 116 (2004)
/2/ J.B. Keller, L. Ting, http://www.arxiv.org/abs/physics/0606114
/3/ R. Klein, A.J. Majda, Theor. Comput. Fluid Dyn. 20 (2006), 525-551
/4/ E. Mikusky, Ph.D.-Thesis, Hamburg University, submitted Dec. (2006)