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An unified approach to meteorological modelling based on multiple-scales asymptotics

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Abstract. In 2003, the author suggested a mathematical framework for the derivation of reduced meteorological models at a Mathematics conference (5th ICIAM, Sydney, Australia), (Klein, 2004). The framework consists of (i) non-dimensionalization of the 3-D 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 Keller (1951), 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 3-D compressible flow equations on the rotating sphere. The framework's potential fully shows in multiscale interaction studies such as Klein (2006), 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 (Mikusky, 2007), large-scale stratocumulus cloud decks, and planetary-synoptic scale interaction models which should be relevant for Earth System Models of Intermediate Complexity (EMICs). Here we summarize the general framework and use the example of quasi-geostrophic theory to demonstrate its application.

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