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A multi-scale model for the planetary and synoptic motions in the atmosphere

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A reduced asymptotic model valid for the planetary and synoptic scales in the atmosphere is presented. The model is derived by applying a systematic multiple scales asymptotic method to the full compressible flow equations in spherical geometry (Dolaptchiev & Klein, 2013). The synoptic scale dynamics in the model is governed by modified quasi-geostrophic equations which take into account planetary scale variations of the background stratification and of the Coriolis parameter. The planetary scale background is described by the planetary geostrophic equations and a new closure condition in the form of a two-scale evolution equation for the barotropic component of the background flow. This closure equation provides a model revealing an interaction mechanism from the synoptic scale to the planetary scale.

To obtain a quantitative assessment of the validity of the asymptotics, the balances on the planetary and synoptic scales are studied by utilizing a primitive equations model. For that purpose spatial and temporal variations of different terms in the vorticity equation are analyzed. It is found that for planetary scale modes the horizontal fluxes of relative and planetary vorticity are nearly divergence free. It is shown that the results are consistent with the asymptotic model.

Dolaptchiev, S. I. and Klein, R., 2013, A multi-scale model for the planetary and synoptic motions in the atmosphere, J. Atmos. Sci., 70, 2963-2981