Geophysical Research Abstracts, Vol. 9, 05330, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05330

Model equations for atmospheric motions on planetary scales

S. Dolaptchiev (1) and R. Klein (1,2)

(1) Potsdam Institute for Climate Impact Research (PIK), Germany, (2) FB Mathematik & Informatik, Freie Universität Berlin, Germany. (Stamen.Dolaptchiev@pik-potsdam.de)

A considerable part of the atmospheric variability exhibits spatial structures on a planetary scale, i.e., on scale of the order of the earth's radius. Reduced model equations capturing the relevant physical processes on these large scales are potentially useful in the construction of earth system models of intermediate complexity (EMICs) for long-term climate simulations. Here we present such reduced equations that account for multiscale planetary-synoptic interactions. Specifically, we consider the planetary spatial scale with a corresponding advective time scale of the order of ten days, and the characteristic length and time scales of the synoptic eddies ($1,000\,\mathrm{km}; 1\,\mathrm{day}$). The derivations are based on the unified multiple-scales asymptotic approach proposed in [2] (see also [1, 3]). We examine two different flow regimes.

In the first regime, we assume horizontal velocities of the order of $10\,$m/s and relatively weak background potential temperature variations comparable in magnitude to those adopted in classical quasi-geostrophic theory. The resulting equations may be considered as the anelastic analogon of Pedlosky's equations [4] for incompressible large scale motions in the ocean. Additionally we derive a vorticity transport equation on the ten day time scale, which determines the barotropic component of the pressure. This component can be calculated from the classical planetary geostrophic (PG) equations only if some source terms are added, e. g. friction and surface wind stress. Such an approach is applicable to the ocean but not to the atmosphere and the vorticity transport equation gives a possibility to use PG type equations for atmospheric dynamics on the planetary scale.

Motivated by the observed equator-to-pole temperature differences, we consider in the second regime systematically larger meridional variations of the background potential temperature. Through thermal wind balance, these variations imply zonal velocities of the order of the jet streams $(\sim 100\,\mathrm{m/s})$. Because of advection by these large velocities, new planetary-synoptic interactions arise in this regime on the fast (synoptic) time scale. The potential vorticity (PV) equation for the planetary-scale dynamics now has additional terms, such as an advection term for relative vorticity and averages over the synoptic eddy fluxes, which are absent in the PG-type equation obtained in the first regime.

After studying the relevance of the two regimes to the atmosphere, the next step will be to incorporate orography and diabatic source terms in the models. The arising vorticity transport equations, similar to the one discussed above, suggest themselves as prognostic alternatives to the temperature-based diagnostic closure for the barotropic pressure component used in the CLIMBER EMIC, [5].

References

[1] Majda, A. and Klein, R., *Systematic multi-scale models for the tropics*, J. Atmos. Sci. **2** (2003), 393–408.

[2] Klein, R., *An Applied Mathematical View of Meteorological Modelling,* in: Applied Mathematics Entering the 21st century; Invited talks from the ICIAM 2003 Congress. SIAM Proceedings in Applied Mathematics, **116**, (2004)

[3] Klein, R. and Majda, A., *Systematic multiscale models for deep convection on mesoscales*, Theor. & Comput. Fluid Dyn. **20** (2006), 525–551.

[4] Pedlosky, J., *The Equations for Geostrophic Motion in the Ocean*, J. Phys. Ocean. **14** (1984), 448–455.

[5] Petoukhov, V., Ganopolski, A., Brovkin, V., Claussen, M., Eliseev, A., Kubatzki, C. and Rahmstorf, S., *CLIMBER-2: A Climate System Model of Intermediate Complexity. Part I: Model Description and Performance for Present Climate,* Clim. Dyn. **16** (2000), 1–17.