Geophysical Research Abstracts
Vol. 20, EGU2018-6120, 2018
EGU General Assembly 2018

Forced stationary waves in the planetary geostrophic equations on the sphere

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The classical quasi-geostrophic theory is not appropriate for describing planetary scale atmospheric motions in mid-latitudes since large variations of the Coriolis parameter f and horizontal variations of the background stratification have to be considered. In this case asymptotic analyses reveals that the planetary geostrophic equations (PGE) are more suitable for describing the dynamics. Here we present numerical simulations of the PGE on the sphere for a Boussinesq fluid. In particular, we study stationary waves forced by azonal temperature perturbations. The singularity of the PGE at the equator (where f vanishes) is avoided by including vertical diffusion in the tropics. Similar diffusion is incorporated in other idealized models of the atmosphere, e.g., the Held & Hou model of axisymmetric circulation. It is shown that the momentum fluxes due to stationary waves are comparable in magnitude to the one resulting from the mean meridional circulation, which in this case is controlled by the diffusion. The structure of the forced waves can be understood in terms of a linear model, constructed by linearizing the PGE around the zonally symmetric relaxation wind profile. In addition, analytical solutions for a constant wind profile are discussed.