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Planetary geostrophic Boussinesq dynamics: barotropic flow, baroclinic instability and forced stationary waves

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Motions on planetary spatial scales in the atmosphere are governed by the planetary geostrophic equations. However, not much attention has been paid to the interaction between the baroclinic and barotropic flow within the planetary geostrophic scaling. This is the focus of the present study by utilizing planetary geostrophic equations for a Boussinesq fluid supplemented by an asymptotically derived evolution equation for the barotropic flow. The latter is effected by meridional momentum flux due to baroclinic flow and drag by the surface wind. The barotropic wind on the other hand affects the baroclinic flow through buoyancy advection. By relaxing towards a prescribed buoyancy profile the model produces realistic major features of the zonally symmetric wind and temperature fields. We show that there is considerable cancelation between the barotropic and the baroclinic surface zonal mean zonal wind. The linear and nonlinear model response to steady diabatic zonally asymmetric forcing is investigated. The arising stationary waves are interpreted in terms of analytical solutions. We also study the problem of baroclinic instability on the sphere within the present model.

Reference: Dolaptchiev, S. I., Achatz, U. and Th. Reitz, 2019: Planetary geostrophic Boussinesq dynamics: barotropic flow, baroclinic instability and forced stationary waves, Quart. J. Roy. Met. Soc., 145: 3751-3765.

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