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Nonlinear dynamics in the tropics in the shallow water approximation

Giovanni Dalu and Marina Baldi
CNR - Institute of Biometeorology, Roma, Italy (m.baldi@ibimet.cnr.it)

The dynamics in the tropics are studied by producing the full nonlinear solution and the solution in the weak temperature gradient approximation (WTG) using a hydrostatic model with one, two, and three layers in the equatorial beta-plane and in the shallow water approximation, where the frictional losses are parameterized with Rayleigh friction coefficients.

The validity of the WTG approximation is discussed and the validity of a lid as an upper boundary are discussed in relation to the frictional losses and the thermal relaxation time, using an idealized zonally symmetric model, where the fluxes by large scale eddies are neglected. Results show that the latitudinal width of the atmospheric circulation in the tropics is underestimated by the WTG approximation, while it is overestimated when a rigid lid is adopted as an upper boundary.

In addition, results show that, when the friction coefficient is smaller than the average Coriolis parameter, the latitudinal width of the circulation monotonically increases as the frictional losses increases, while, when the friction coefficient exceeds the value of the Coriolis parameter, the width of the circulation in the tropics monotonically decreases.

In the absence of friction the circulation is specular symmetric about the equator. When the frictional losses are small, as over the ocean, the latitudinal width of the circulation is smaller than the width of the corresponding circulation over land.

Finally, the perturbations induced by an off-equator diabatic source will be discussed using a nonlinear Matsuno-Gill type of model.