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On weak zonally symmetric ENSO atmospheric heating and the strong zonally symmetric air temperature response

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Satellite observations of tropical out-going longwave radiation, a proxy for deep atmospheric convection and precipitation, show that anomalous precipitation in tropical regions tends to balance zonally. For example, averaged over the 10 degrees S to 10 degrees N equatorial strip the root mean squared (RMS) zonally asymmetric component of the OLR anomalies is 25 times bigger than the zonally symmetric component. Why should this be so? We argue that the anomalous zonally symmetric precipitation is weak because it is proportional to vertical velocity which, when averaged over a constant pressure surface S from (say) 10 degrees S to 10 degrees N, is nearly zero. The horizontally averaged vertical velocity over S is small because the net horizontal geostrophic convergent flow across 10 degrees S and 10 degrees N is zero and the vertical velocity vanishes at the surface.

Even though the anomalous latent equatorial heating of the atmosphere has a zonally symmetric component about 25 times smaller than the zonally asymmetric component, the zonally symmetric and asymmetric air temperature anomalies are comparable, i.e., the tropical troposphere is extremely sensitive to zonally symmetric heating anomalies. Our analysis showed that this extreme sensitivity is due to weak damping of the dominant equatorial Kelvin and Rossby waves. For the tropical troposphere we showed that the spin down time due to surface friction is the depth of the troposphere divided by twice the surface drag coefficient times the surface wind speed. Based on this spin down time ($\approx$3 weeks) and a reasonable Newtonian cooling time of 1 month, calculations with a modified Gill (1980) model give the observed extreme sensitiv-

ity to zonally symmetric heating. These calculations are in qualitative agreement with those of Wu et al. (2001) who obtained results for a wide range of decay times. Physically the zonally symmetric response is favored because the dominant waves can travel completely around the earth without much decay.