Geophysical Research Abstracts
Vol. 15, EGU2013-12399, 2013
EGU General Assembly 2013

Large Aspect Ratio Roll Vortices (10 km Wavelength) In Tropical Cyclone Boundary Layers: SAR Evidence and Theoretical Modeling

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Analysis of synthetic aperture radar (SAR) images of the sea surface underneath tropical cyclones shows clear evidence of organized bands of surface wind convergence and wind stress curl. These patterns are consistent with the effects of planetary boundary roll vortices, except the observed wavelengths are O(10 km), which implies the rolls have aspect ratios (wavelength/PBL depth) many times what has been commonly observed in hurricane boundary layers (typically 2.5). The tropical cyclone boundary layer is a very favorable environment for the formation of roll vortices and observations show that O(1-3 km) wavelength rolls are a very common feature. We present an extension of the Foster (2005) nonlinear theory for hurricane PBL roll formation that posits a nonlinear, wave-wave, upscale energy transfer mechanism for the formation of large aspect ratio rolls. These large-aspect ratio rolls induce a circulation that extends from the sea-surface into the storm interior above the boundary layer and modulates the smaller rolls. Implications for improving SAR surface wind retrievals, hurricane boundary layer parameterization and surface fluxes are presented.