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Measuring Convective Mass Fluxes Over Tropical Oceans

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Deep convection forms the upward branches of all large-scale circulations in the tropics. Understanding what controls the form and intensity of vertical convective mass fluxes is thus key to understanding tropical weather and climate. These mass fluxes and the corresponding conditions supporting them have been measured by recent field programs (TPARC/TCS08, PREDICT, HS3) in tropical disturbances considered to be possible tropical storm precursors. In reality, this encompasses most strong convection in the tropics. The measurements were made with arrays of dropsondes deployed from high altitude. In some cases Doppler radar provided additional measurements. The results are in some ways surprising. Three factors were found to control the mass flux profiles, the strength of total surface heat fluxes, the column-integrated relative humidity, and the low to mid-tropospheric moist convective instability. The first two act as expected, with larger heat fluxes and higher humidity producing more precipitation and stronger lower tropospheric mass fluxes. However, unexpectedly, smaller (but still positive) convective instability produces more precipitation as well as more bottom-heavy convective mass flux profiles. Furthermore, the column humidity and the convective instability are anti-correlated, at least in the presence of strong convection. On spatial scales of a few hundred kilometers, the virtual temperature structure appears to be in dynamic balance with the pattern of potential vorticity. Since potential vorticity typically evolves on longer time scales than convection, the potential vorticity pattern plus the surface heat fluxes then become the immediate controlling factors for average convective properties. All measurements so far have taken place in regions with relatively flat sea surface temperature (SST) distributions. We are currently seeking funding for a measurement program in the tropical east Pacific, a region that exhibits strong SST gradients and correspondingly great diversity in the forms of convection. Given the strong boundary layer flows induced by the SST gradients in this region, we hope to determine whether the patterns of convective mass flux seen in other regions persist there.