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Simulations of marine boundary layer cold pools and their role in setting scales of deep tropical convection

Eric Skyllingstad (1), Carol Anne Clayson (2), and James Edson (2)
(1) Oregon State University, United States (skylling@coas.oregonstate.edu), (2) Woods Hole Oceanographic Institute

Cloud resolving large-eddy simulation is used to examine how boundary layer processes act to organize tropical deep convection. A common feature of precipitating marine convection is the formation of downdrafts and spreading cold pools of air that interact and modify the marine boundary layer. Cold pools can spread over an area much larger than the original deep convective system. As cold pools expand downwind, they increase the surface wind speed; upwind expansion causes reduced surface winds. These wind speed changes generate significant differences in the surface fluxes that affect both the cold pool lifecycle and behavior of the larger scale convective system. In this study, we test the hypothesis that scales of convection can be set by the behavior of cold pools as they combine and are modified by the surface boundary. New convection is often forced by increased vertical motion at the leading edge of cold pools or in regions where they intersect. Consequently, cold pools can influence convective organization over regions much larger than the initiating convective cloud scale. Simulations are conducted for an idealized domain with scales of $\sim$500 km with an underlying mixed-layer ocean. Initial conditions are prescribed with both uniform sea-surface temperature (SST) and a warm SST patch aligned with the wind, focusing convection over a broad region. Our experiments suggest that differential surface drag generated by vertical wind shear can lead to enhancement of preferred regions of vertical motion, leading to coherent initiation of new convective cells and clustering. Further expansion of the convective system is produced as the cold pools merge from the convective cluster. Using the model we determine that aggregate cold pool scales increase with warm SST regions, such as observed below the inter-tropical convergence zone, indicating that cold pool boundary layer interaction is key for large convective cluster formation.