Cloud Radar and Thermodynamic Profiling to Investigate Bulk Entrainment for Tropical Deep Convective Clouds

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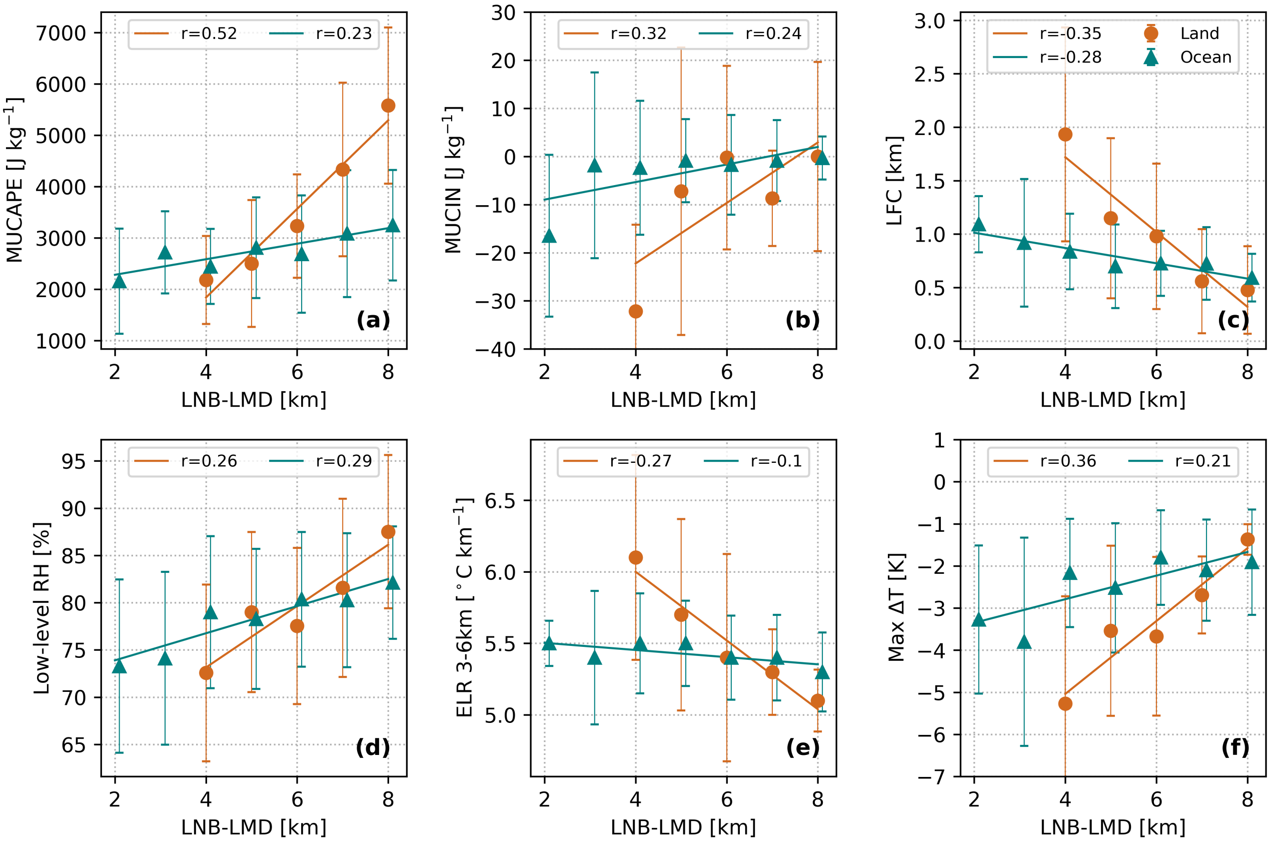
Deep convective clouds are an important driver of the global circulation and enable the transport of heat, momentum, water, and chemical species throughout the depth of the troposphere. The extent of this transport is regulated by convective updrafts, wherein updraft size and strength are controlled by buoyancy and dynamical forcing, as well as the mixing of environmental air (i.e., entrainment). The focus of this effort is on the relationship between convective parameters of interest (as estimated from close-proximity radiosonde launches) and a straightforward radar-based proxy for entrainment rate. Specifically, we define the difference between the level of neutral buoyancy (LNB; the theoretical height that a surface parcel raised above the level of free convection would reach with no mixing) and the level of maximum detrainment (LMD; cloud radar-based height of the maximum reflectivity factor in forward anvil clouds) as this proxy for bulk convective entrainment rate. For each tropical convective cloud with a well-observed forward anvil, the LNB and LMD are estimated and co-varied with several common convective indices.

Tropical deep convective clouds are drawn from the multi-year, multi-site ground and profiling (cloud radar) archives as collected by the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Facilities. Convective events span ARM fixed-site records at oceanic / maritime continental locations from the Tropical Western Pacific (Manus, Nauru, Darwin), as well as ARM Mobile Facility deployments to (oceanic) Gan Island, Maldives, and continental examples from Niamey, Niger, and Manacapuru, Brazil. From the multi-site relationships between this entrainment rate proxy and convective parameters, a key finding is that the convective available potential energy (CAPE) and low-level relative humidity explain the greatest portion of the variance for tropical continental and oceanic deep convective events.

Keywords: Deep Convection, Cloud Radar, Detrainment



r=0.52
r=0.23
MUCAPE [J kg^{-1}]
LNB-LMD [km]
(a)
r=0.32
r=0.24
MUCIN [J kg^{-1}]
LNB-LMD [km]
(b)
r=-0.35
r=-0.28
Land
Ocean
LFC [km]
LNB-LMD [km]
(c)
r=0.26
r=0.29
Low-level RH [%]
LNB-LMD [km]
(d)
r=-0.27
r=-0.1
ELR 3-6km [$^\circ$C km^{-1}]
LNB-LMD [km]
(e)
r=0.36
r=0.21
Max ΔT [K]
LNB-LMD [km]
(f)