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A climatology of trade cumulus cold pools and their link to mesoscale cloud organization

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We present a climatology of trade cumulus cold pools and their associated meteorological perturbations based on ten years of in-situ and remote sensing data from the Barbados Cloud Observatory. Cold pools are identified by abrupt drops in surface temperature, and the mesoscale organization pattern is classified by a neural network algorithm based on GOES-16 infrared images. We find cold pools to be ubiquitous in the winter trades —they are present about 5% of the time and occur on two-thirds of days. Stronger temperature drops (dT) are associated with deeper clouds, stronger precipitation, stronger downdrafts and humdidity drops, stronger updrafts and wind gusts in the front, and larger cloud cover compared to weaker dT. The downdraft strength together with the cold-pool duration explains variability in dT very well (Multiple R^2=0.53).

The mesoscale organization pattern has a strong influence on the occurrence frequency of cold pools. Fish has the largest cold-pool fraction (13% of time), followed by Flowers and Gravel (10.4% and 7.4%), and lastly Sugar (1.7%). Fish cold pools are also significantly stronger and longer-lasting compared to Flowers and Gravel cold pools. The daily cycle of the occurrence frequency of Gravel, Flowers, and Fish can explain a large fraction of the daily cycle in the cold-pool occurrence, as well as the pronounced extension of the daily cycle of shallow convection into the early afternoon by cold pools. Overall, we find cold-pool periods to be ~90% cloudier relative to the average winter trades. Also the wake of cold pools is characterized by above-average cloudiness, suggesting that mesoscale arcs enclosing broad clear-sky areas are rather the exception than the rule. Better understanding how cold pools interact with and shape their environment could therefore be valuable to understand cloud cover variability in the trades.

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