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Tropical Oceanic Mesoscale Cold Pools in High-Resolution Global Icosahedral Nonhydrostatic (ICON) Model from DYAMOND

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In the recent years, global kilometer-scale convection-permitting models have shown promising results in producing realistic convection and precipitation. In this study, a 2.5 km global Icosahedral Nonhydrostatic (ICON) model simulation ran for 40 days (06 UTC 01 Aug – 23 UTC 10 Aug 2016) from Dynamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains (DYAMOND) initiative was used to identify thermal cold pools (using virtual temperature) over tropical oceans. In addition to examining cold pool variability, variables such as vertical wind shear (0-600 hPa and 0-300 hPa), relative humidity, convective available potential energy (CAPE), column water vapor and surface fluxes corresponding to each cold pool were analyzed. Grid-point linear regression was applied to identify relationships between these variables and cold pool size and intensity. It was found out that there is a statistically significant regional variability in the relationships between cold pool properties and their environments across the global tropics, and cold pool size and intensity have quite different dependence on the various variables considered. Unsupervised machine learning algorithm was then applied to geospatial linear regression to identify coherent patterns explaining multi-modal feedback between cold pools and their mesoscale environments.

Previous studies have hypothesized that although accurate characterization of cold pool diurnal cycle is essential to resolve realistic deep convection in the current generation climate models, our lack of understanding of feedbacks between cold pools and convection leads to distorted diurnal cycle of precipitation. NASA's RapidScat satellite was in a non-sun-synchronous orbit for 2014-2016 and thus was able to resolve diurnal cycle. Garg et al. (2020) gradient feature technique was applied on RapidScat's winds to identify cold pools and observe their diurnal cycle of number, size, precipitation and associated convective system properties. Once an observed perspective of cold pool diurnal cycle is obtained, Fourier analysis was used on all the cold pool-associated variables in ICON simulation to obtain the diurnal phase and amplitude. The simulated diurnal cycle of cold pool number, size, precipitation, and other variables were observed to be similar as RapidScat. In this way, this study creates a holistic overview of cold pool-convection-precipitation-storm environment relationships using high-resolution CRM from DYAMOND and satellite observations.