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INVESTIGATING ENVIRONMENTAL CONTROLS ON TROPICAL MESOSCALE CONVECTIVE SYSTEM LIFECYCLES

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1. SUMMARY

Tropical mesoscale convective systems (MCS) are some of the most intense and frequent precipitating systems occurring throughout the year, contributing up to more than 50% of the annual rainfall across the tropics (Nesbitt et al. 2006). However, multi-scale interactions between MCSs and their environments are not well understood, likely leading to model biases in precipitation and cloud properties. Motivated by the need to reduce uncertainty in prediction of future hydrological cycle changes, which will depend greatly on the improvement of our understanding of the dominant rain producing systems in the tropics, our guiding research questions are: (1) What are the thermodynamic controls on tropical MCS lifecycle (growth, maturity, and decay) and lifetime?, and (2) How do oceanic cold pools (strength and size) modify the MCS lifecycle? Our study invokes observational data from multiple platforms to identify the dominant thermodynamic controls on MCS lifecycle. Remotely sensed data (GPM, AIRS/Aqua), reanalyses (ERA-5), and surfaced-based (PMEL buoy) data are being used to answer science questions pertaining to MCS and cold pool dynamics. MCS lifecycle is quantified using Tracked IMERG Mesoscale Precipitation System data (TIMPS; Rajagopal et al. 2023). Each system is spatiotemporally tracked, providing statistics on precipitation rate, area, and lifetimes. We show how estimates of buoyancy evolve with MCSs in space and time, for growth, mature, and decay stages.

Our preliminary results suggest that before MCSs are detected, an increase in column moisture and environmental buoyancy can be detected up to 24 hours beforehand; however, this increase is observed over a shorter period for MCSs occurring over land. Additionally, we show storm-centric spatial composites of moisture and temperature perturbations that suggest a significant downdraft cooling near surface with enhanced buoyancy surrounding it. Rotational composites of these perturbations show evidence that MCS directions of motion may be driven by local perturbations in the thermodynamic environment. This work is the first demonstration of AIRS's ability to capture key thermodynamic perturbations surrounding MCSs, indicating that AIRS too can be used to investigate cold pool-MCS interactions.

Secondly, the study delves into understanding the role of cold pools in modulating MCS lifecycles. We collocate the dataset developed in the previous task with buoy data to obtain a broader understanding of cold pool intensity and spatial extent. To quantify the potential for cold pools to modulate updraft buoyancy and MCS longevity, creation of a cold-pool expansion metric as a function of cold pool strength and extent is underway. An extensive multi-platform database consisting of satellite-derived MCSs and their tracked lifecycle information, collocated with buoy and reanalysis data, and AIRS thermodynamic profiles will be created, analyzed, and publicly shared with the earth-science community. This work aims to inform revisions to current parametrizations of moist convection across scales and support MCS parameterization efforts.

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2. ABBREVIATIONS

GPM: NASA's Global Precipitation Measurement Mission; IMERG: Integrated Multi-satellite Retrievals for GPM; AIRS: Atmospheric Infrared Sounder on NASA's Aqua satellite; ERA-5: European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5; PMEL: Pacific Marine Environmental Laboratory under the National Oceanic and Atmospheric Administration.

3. REFERENCES

1. Nesbitt, S. W., Cifelli, R., & Rutledge, S. A. (2006). Storm morphology and rainfall characteristics of TRMM precipitation features. *Monthly Weather Review*, *134*(10), 2702-2721.
2. Rajagopal, M., Russell, J., Skok, G., & Zipser, E. (2023). Tracking mesoscale convective systems in IMERG and regional variability of their properties in the tropics. *Journal of Geophysical Research: Atmospheres*, *128*(24), e2023JD038563.