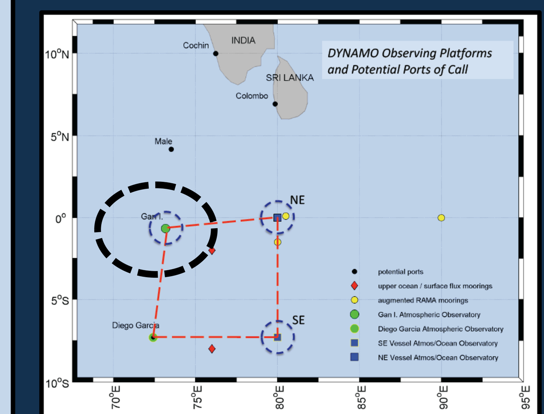
Observing, Quantifying, and Understanding Convective Organization: Insights from DYNAMO

Angela K. Rowe, Robert A. Houze, Jr., Wei-Yi Cheng, Daehyun Kim, and Stacy Brodzik
University of Washington, Seattle, WA

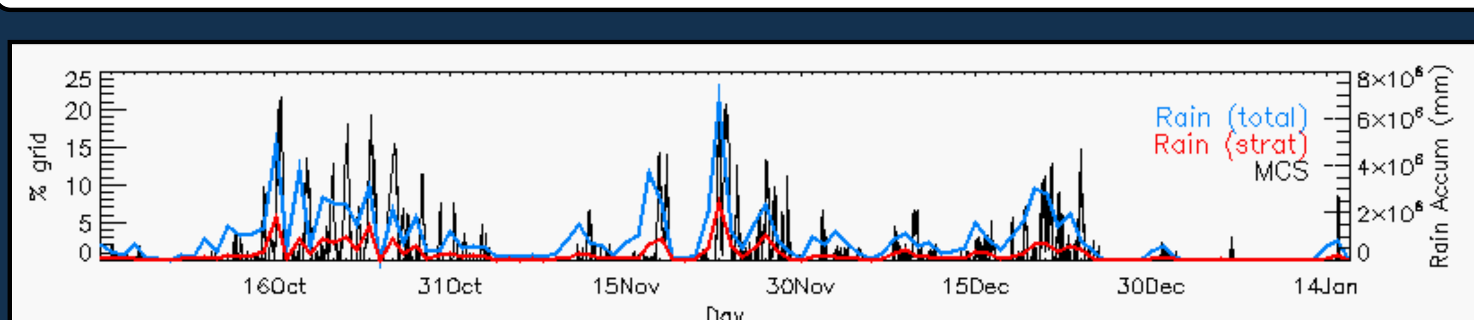
1. Introduction

During the 2011-12 DYNAMO field campaign, the NCAR dual-polarization S-band radar (S-PolKa) observed three active MJO events separated by suppressed periods. Insights into convective evolution during both suppressed and active periods have been possible using nearly continuous S-PolKa data. Analyses highlight various organizational modes of convection, including bursts of rainfall activity from mesoscale convective systems (MCSs) during which microphysical processes evolve in connection with synoptic-scale wave passages. Recent work using S-PolKa data shows an effective mechanism for quantifying convective organization revealing distinct modes of clustering during the major rain events. These results are described here, and highlight future needs for better understanding and representing important feedback mechanisms associated with convective organization.

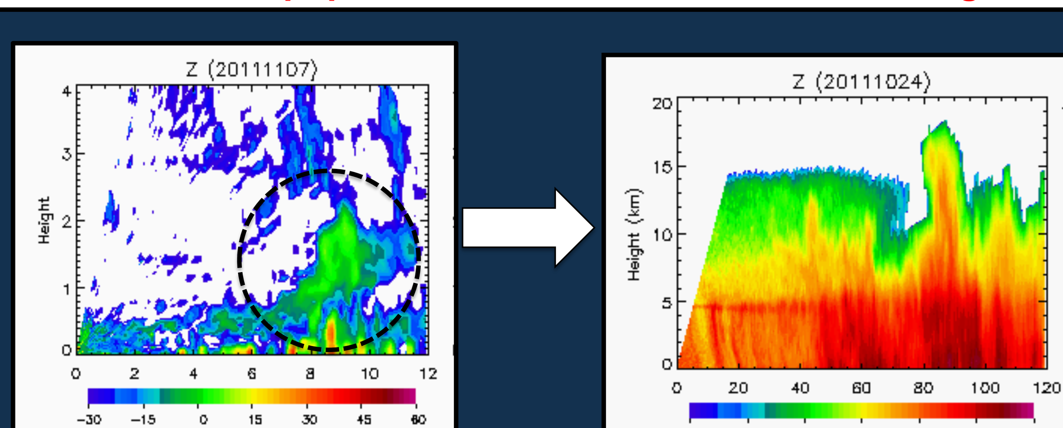


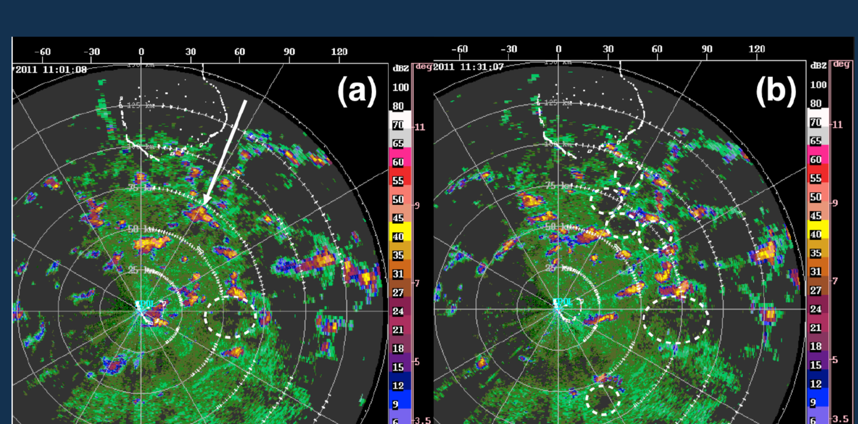
2. Suppressed MJO periods

S-PolKa observed three MJOs during DYNAMO with active periods (MCSs) separated by suppressed periods (less rainfall)



How does the cloud population evolve toward one containing MCSs?



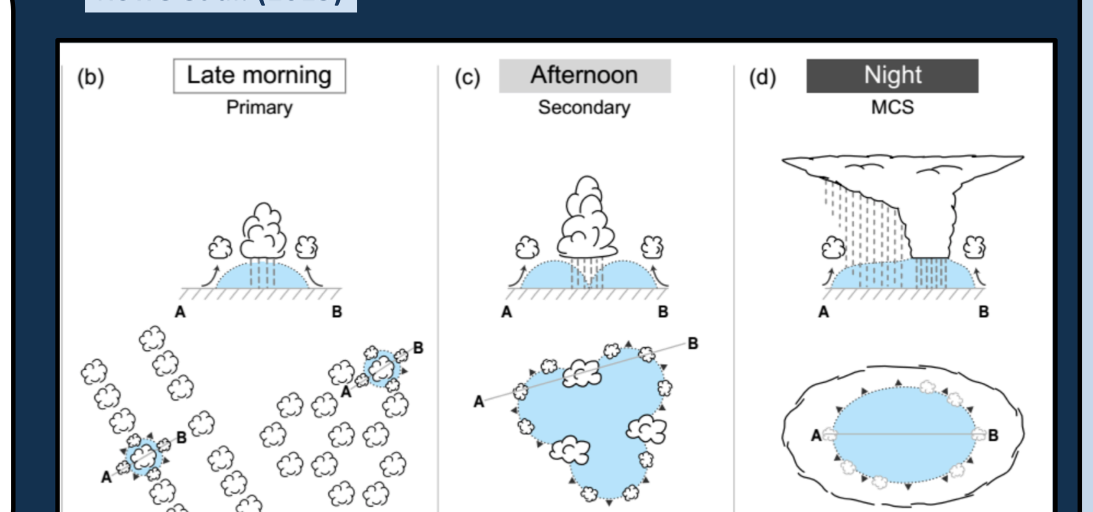


Importance of convective boundary layer rolls and cold pools

- Early in suppressed period, nonprecipitating clouds formed in shear-parallel lines along boundary rolls in early morning
- By afternoon, some clouds began to precipitate, producing cold pools that served as focused secondary initiation

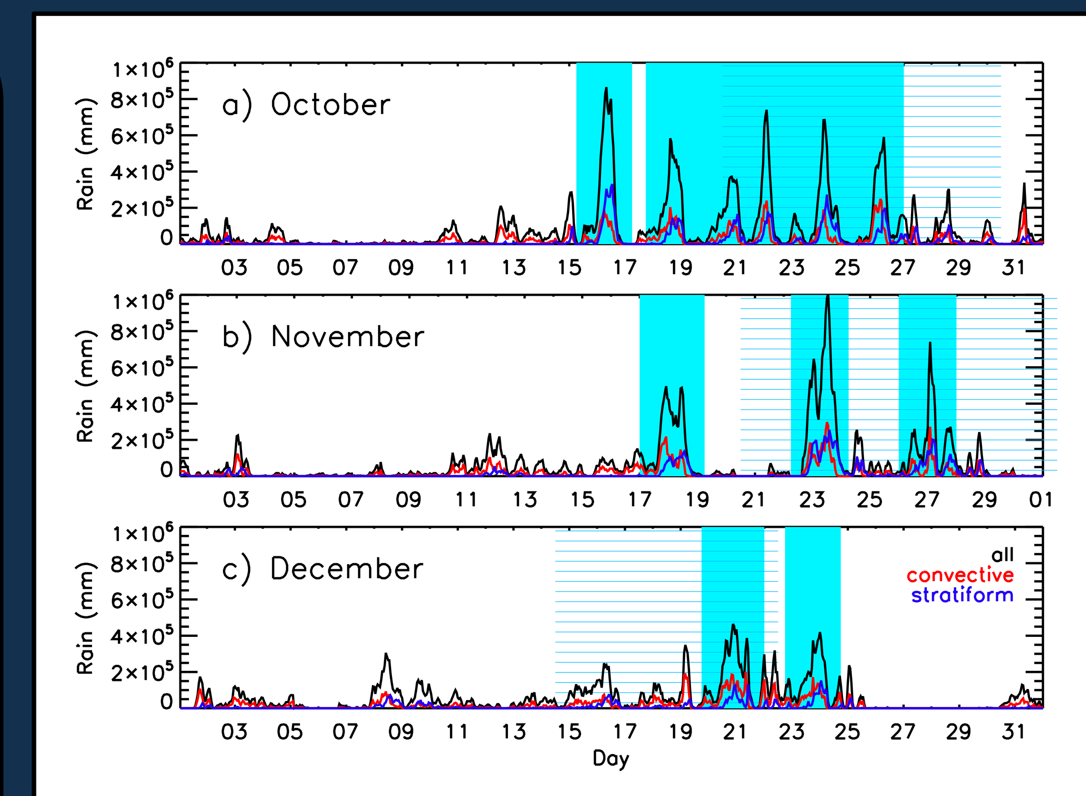
- Through combined observational (Rowe and Houze 2015) and modeling (Feng et al. 2015) studies, found that with increasing moisture, deeper convection formed and merged along intersecting cold pool boundaries with upscale growth into overnight MCSs during transition to active periods

Rowe et al. (2015)

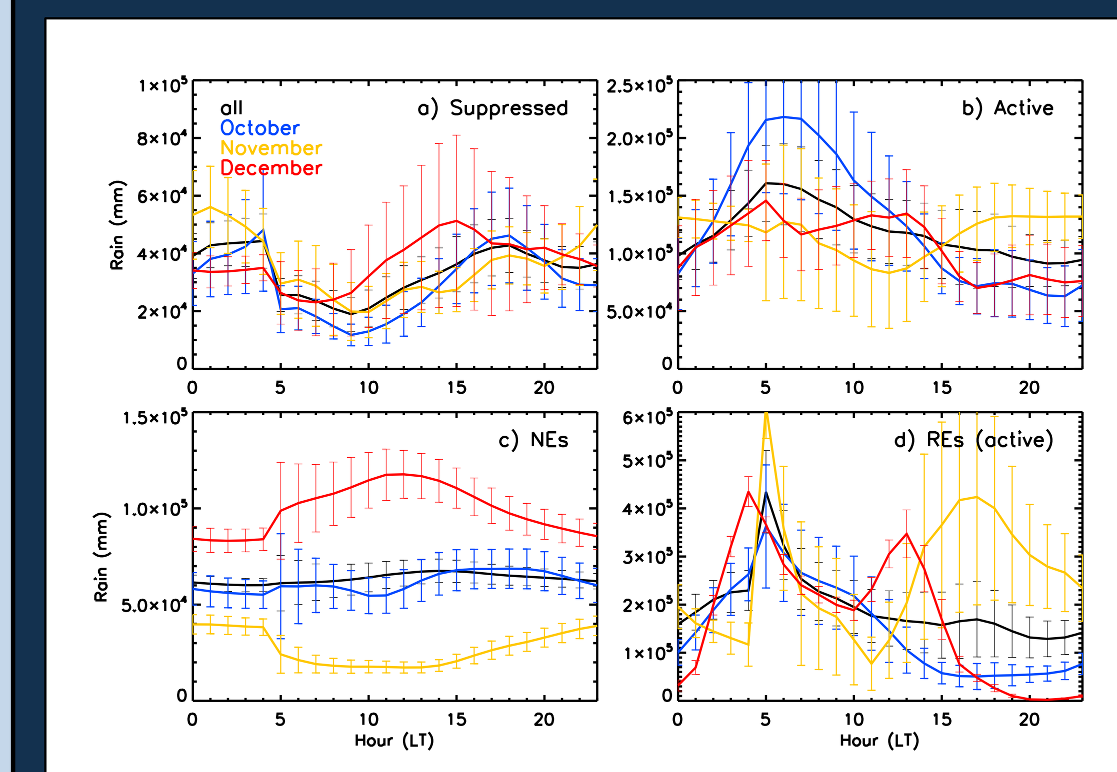


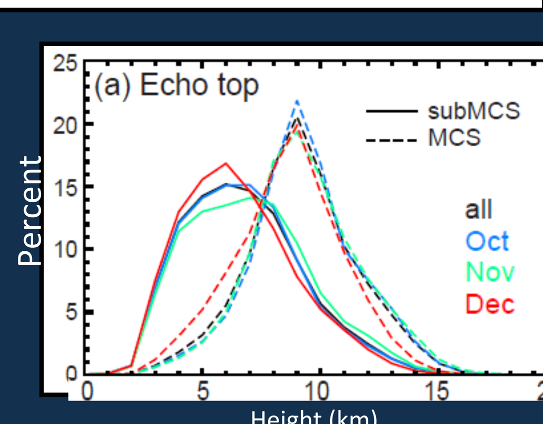
3. Active MJO periods

- During active MJO periods, MCSs mostly responsible for rainfall and occurred within 2-4-day bursts (Zuluaga and Houze 2013; Rowe et al. 2019)
- During **2-day rain events**:
  - shallow convection transitions to deep convection under unstable conditions
  - eventually grow to wide convective entities as rainfall and large-scale vertical motion with pronounced low-level convergence
  - Then to broad stratiform regions with periods of embedded convection



Rowe et al. (2019)





Differences between active periods

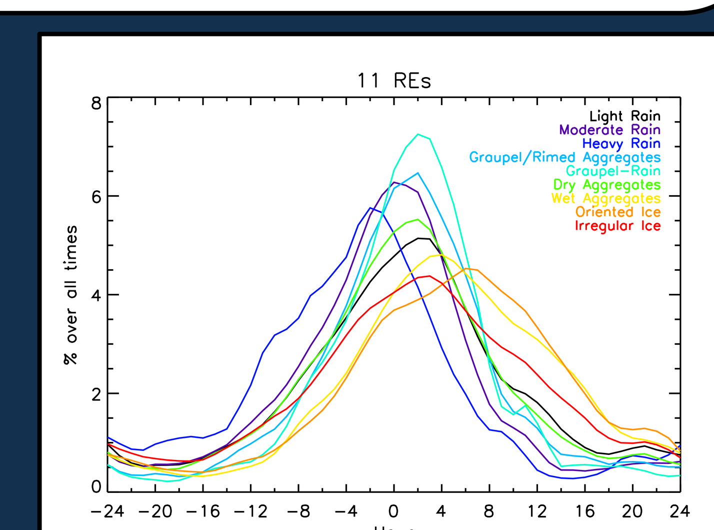
- Taller echo tops during Oct/Nov compared to Dec
- Different modes of convective organization: Oct/Nov – embedded convection following Yamada et al. (2010); Dec – squall lines

- Diurnal cycle, which dominates timing and evolution of systems during MJO suppressed periods, played a role during quasi-2-day October rain events with statistically significant early morning peak in rainfall
- Strong Kelvin wave activity during November MJO strongly influenced timing of convective systems leading to rainfall maxima with widespread echo during the afternoon
- Varying diurnal cycles not only between months but between rain events (REs) and non-rain events (NEs) during active periods

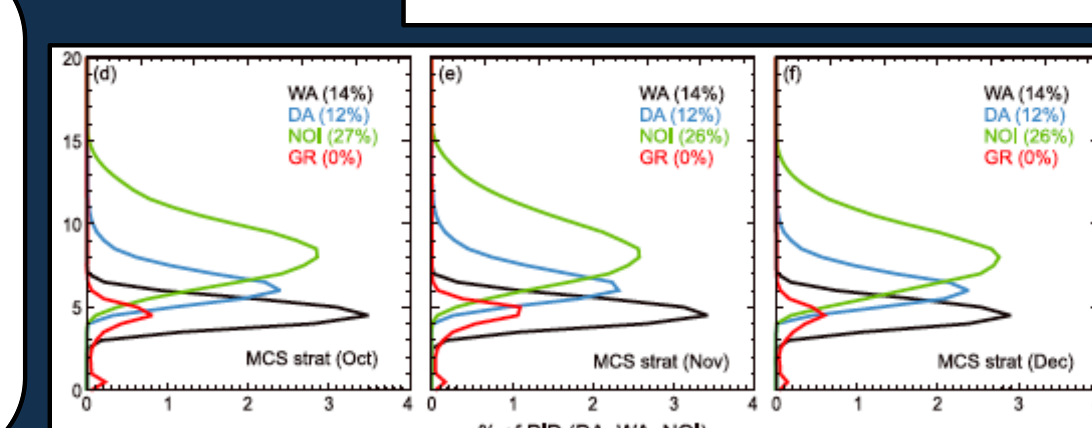
- **MJO studies that do not account for the intermittency of rainfall during active MJO phases through averaging over multiple events can lead to the misimpression that the primary rain-producing clouds of the MJO are modulated solely by the diurnal cycle**

Microphysics

- Similar profiles of ice hydrometeors in each month despite overall less stratiform and shallower convection during December
- Microphysical properties occurring in the 2-4-day rain events manifest statistically in concert with the synoptic time scales



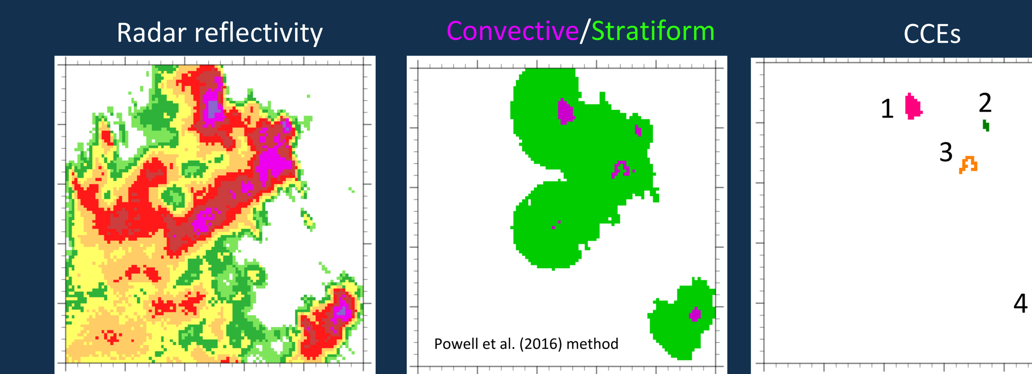
Results reinforce idea that correct simulation of MJO must take into account **synoptic, diurnal, convective, and microphysical processes** separately and distinctly in order to obtain the correct precipitation characteristics of the MJO

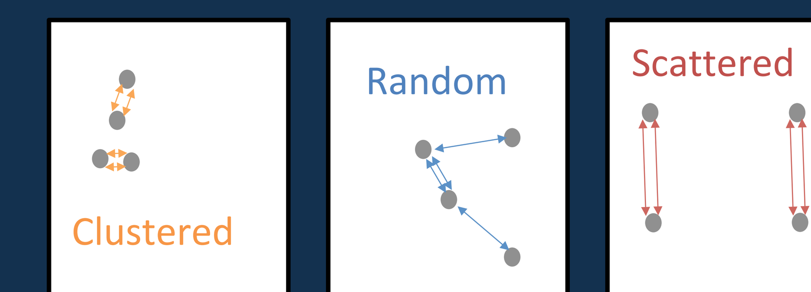


4. Convective Organization

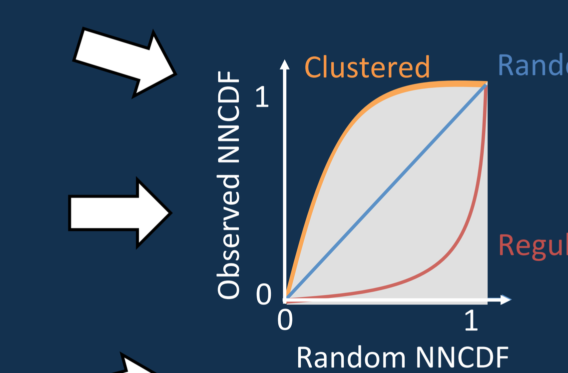
How to quantify convective organization in observations?

- Convective properties → Contiguous Convective Echoes (CCEs)
- Spatial clustering as proxy for convective organization

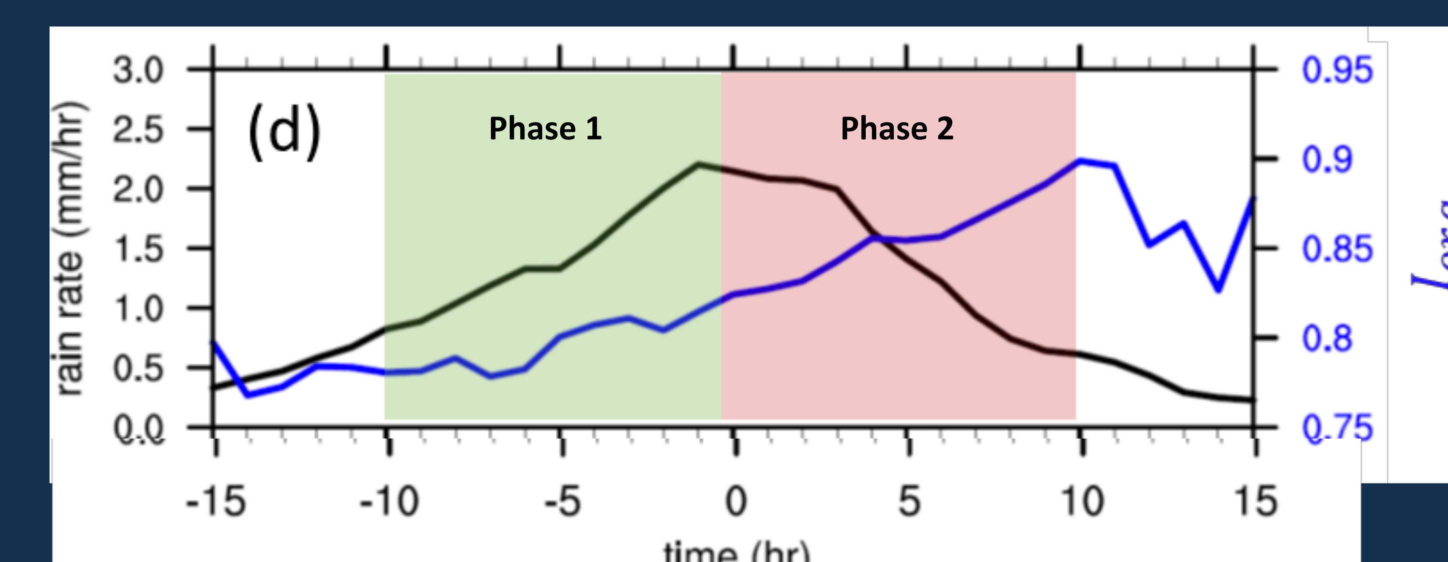




Iorg: scalar metric of convective clustering (Tompkins and Semie 2017)



Cheng et al. (2019)



Phase 1

- Developing stage
- Number of CCEs **increases**
- **Before** widespread stratiform

Phase 2

- Decaying stage
- Number of CCEs **decreases**
- **After** the **stratiform** develops

5. Conclusions and Looking Forward

- Through a sensitive, dual-polarization radar (S-PolKa), the evolving cloud population during MJO events could be evaluated. Results highlight various organizational modes of convection from early organization of nonprecipitating clouds along boundary layer rolls to the large MCSs characteristic of the active period.
- An effective mechanism for classifying convective organization reveals two distinct phases of clustering during major MJO rain events that are being further investigated related to cold pool-updraft feedbacks and mesoscale circulations.
- This research highlights the need to better understand and represent these feedback mechanisms and their role in convective organization, emphasizing the need for for high-quality combined measurements of the following over both ocean and land:
  - Properties of cold pools
  - Ice-phase microphysics (variations in types of MCSs, influence on latent/radiative heating)
  - Mesoscale organized flow patterns (coincident observations of vertical velocity and hydrometeors)
  - Environmental conditions (across multiple scales)
- Observations from recent RELAMPAGO-CACTI field campaign valuable for understanding of convective lifecycle including rapid upscale growth, coincident kinematic and microphysical observations along with cold pool properties

E-mail: akrowe@atmos.uw.edu
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