Convective Processes Working Group

<u>Co-chairs</u>

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Joint ARM User Facility and ASR PI Meeting

Rockville, MD

Tuesday, June 11, 2019

Photo by Jason Tomlinson

Mission

The mission of the Convective Processes Working Group is to document from observations and modeling, and thereby develop understanding of, the dynamical, thermodynamic, microphysical, and radiative processes that together determine the evolution of (deep) convective cloud systems from formation to dissipation, and to translate this understanding into methods for representing convective cloud processes in numerical weather and climate models.

Research Themes

Convective System Transitions

- Shallow to Deep (Liquid to Ice, Entrainment, Cold Pools)
- Mesoscale Organization (Life Cycle, Cold Pools)

Vertical Velocity

- Expanding Observational Retrievals
- Two-way Interactions with Microphysics and Surrounding Environment

Aerosol-Cloud Interactions

- Liquid and Ice Microphysical Effects
- Cloud Dynamical Effects

Parameterization Development

- Convective/Stratiform/Anvil Spatiotemporal Life Cycle
- Microphysics
- Turbulence

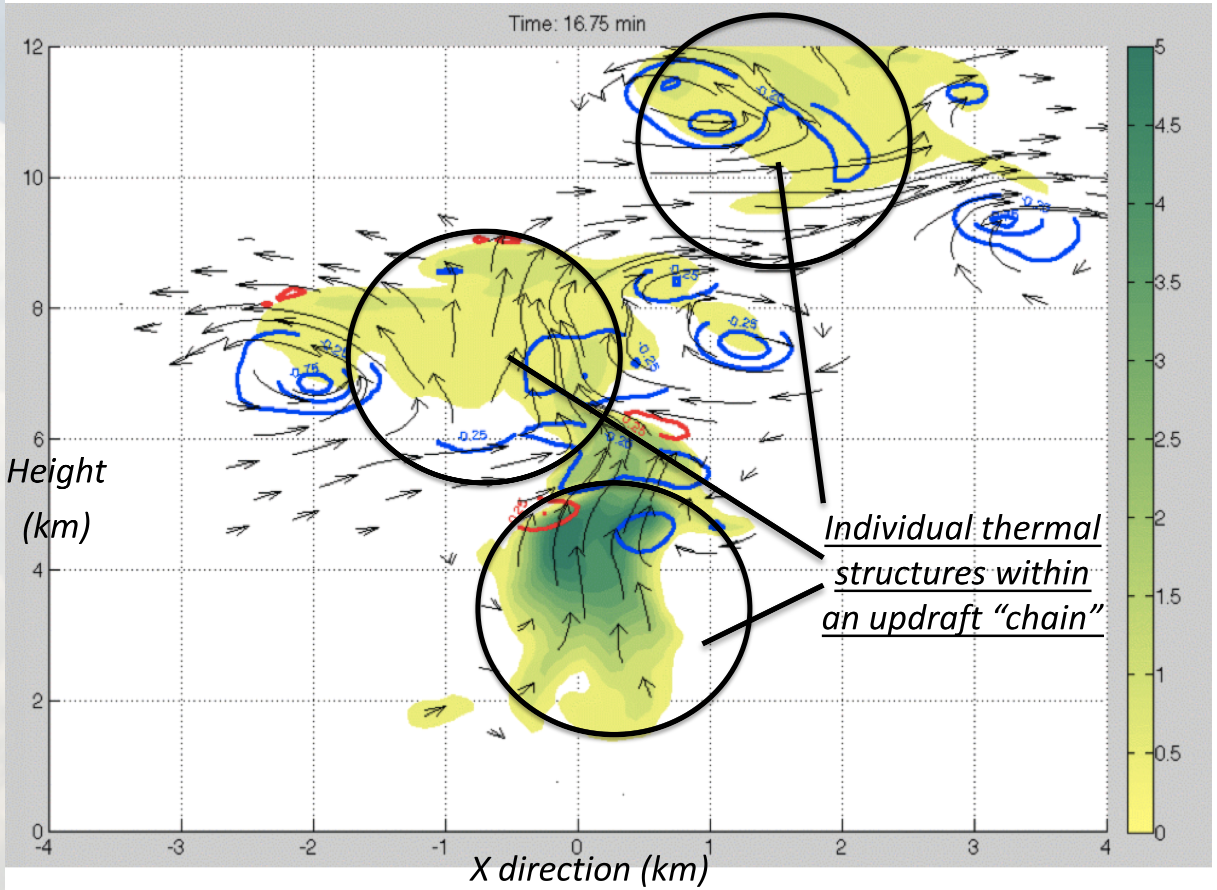
Working Group Research Topics

Categorized Convective Processes Abstracts (#)

- Convective dynamics (7)
- Mesoscale organization (6)
- Microphysics (6)
- Measurements/Products (13)
- Cloud-Scale Parameterizations (2)
- GCM Parameterizations (2)

Using idealized modeling and theory to gain insight into the fundamental behavior of moist deep convection

Hugh Morrison, John Peters, Adam Varble, Scott Giangrande, Walter Hannah



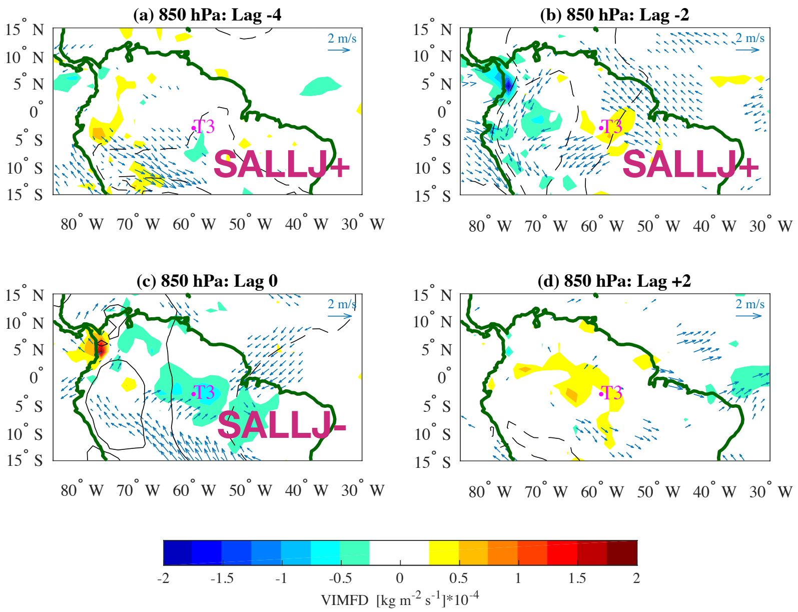
Idealized 3D LES (dx = dz = 100 m) of a growing deep convective cloud. Color contours show cloud water mixing ratio, blue and red lines are perturbation pressure, and arrows indicate flow vectors.

- LES and observations show convective structure consisting of a *series of rising thermals*, particularly for deep convection.
- This behavior fundamentally results from feedbacks between dry air entrainment, reduction of buoyancy, and flow structure.
- Strong implications for entrainment rates → e.g. pulses of large entrainment rates (~2.5 times the vertical mean) occur at the bottom of individual thermals in an updraft chain.

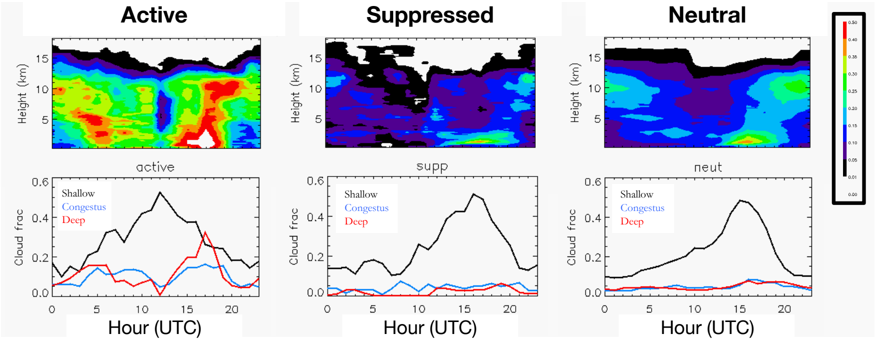
Kelvin waves over the Central Amazon During GOAmazon and Their Relationship to Localized Convection

Yolande Serra and Angela Rowe

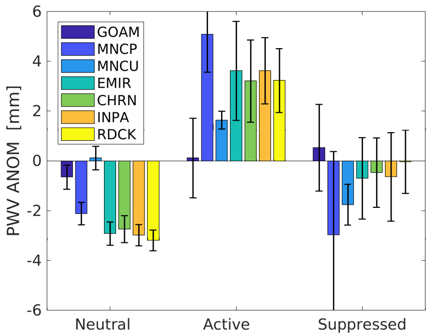
Kelvin wave integrated moisture flux divergence and wind at 850 hPa



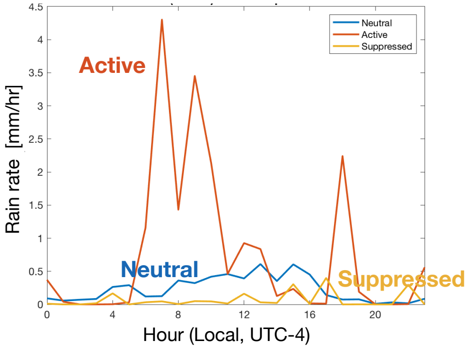
Kelvin wave cloud fraction diurnal cycle



Kelvin wave PWV



Kelvin wave rainfall diurnal cycle



Kelvin waves are active over the Central Amazon during the wet season (Nov-April) and are found to feedback on the seasonal cycle over this region in two ways:

1. Suppressed phase: Surface shortwave forcing at T3 is strong and balanced by sensible heat flux, which increases the surface high pressure and thus strengthens the SALLJ, producing low-level moisture divergence anomalies and suppressing convection (Lag -4 to Lag -2, SALLJ+).
2. Active phase: The surface cools and moistens, reducing surface high pressure and contributing to low-level moisture convergence anomalies, which weakens the SALLJ and favors large-spread convection (Lag 0, SALLJ-).

Local impacts on rainfall, column precipitable water vapor (PWV) and cloud development are significant and illustrate the importance of Kelvin waves on local convection over the Central Amazon.

Factors Contributing to Simulated Stratiform Precipitation Biases and Variability

Objective

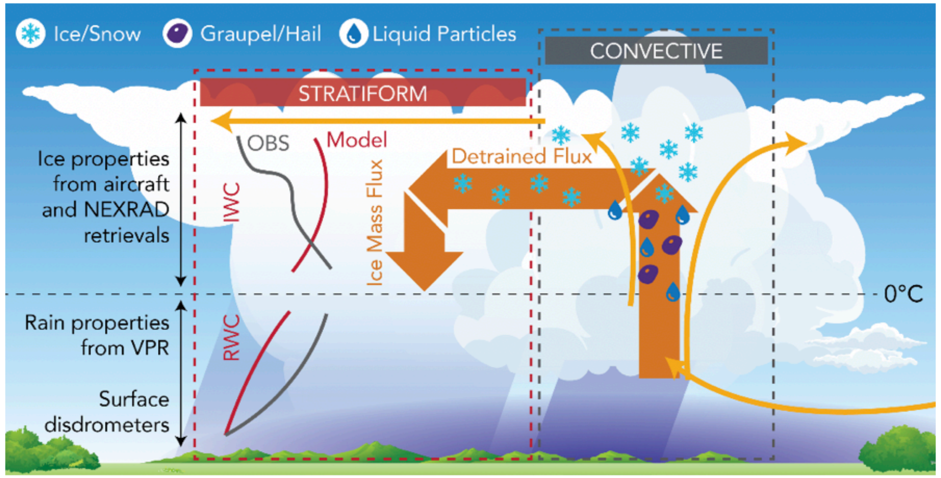
- Examine model biases and variability for various cloud microphysics schemes, and identify major factors and processes leading to those differences.

Approach

- Use high-resolution (1-kilometer) model simulations of a well-observed squall line mesoscale convective system from the MC3E field campaign with eight microphysics schemes
- Systematically evaluate simulated stratiform precipitation properties with radar and in situ aircraft measurements
- Build a systematic approach to evaluate the vertical evolution of hydrometeor properties.

Impact

- Study explained the underestimation of stratiform precipitation rates by models: opposite to observations, simulated ice water content decreased as it approached the melting level
- Study illustrated the role of convective microphysics in determining stratiform properties and the need for greater measurements of convective regions within storms.



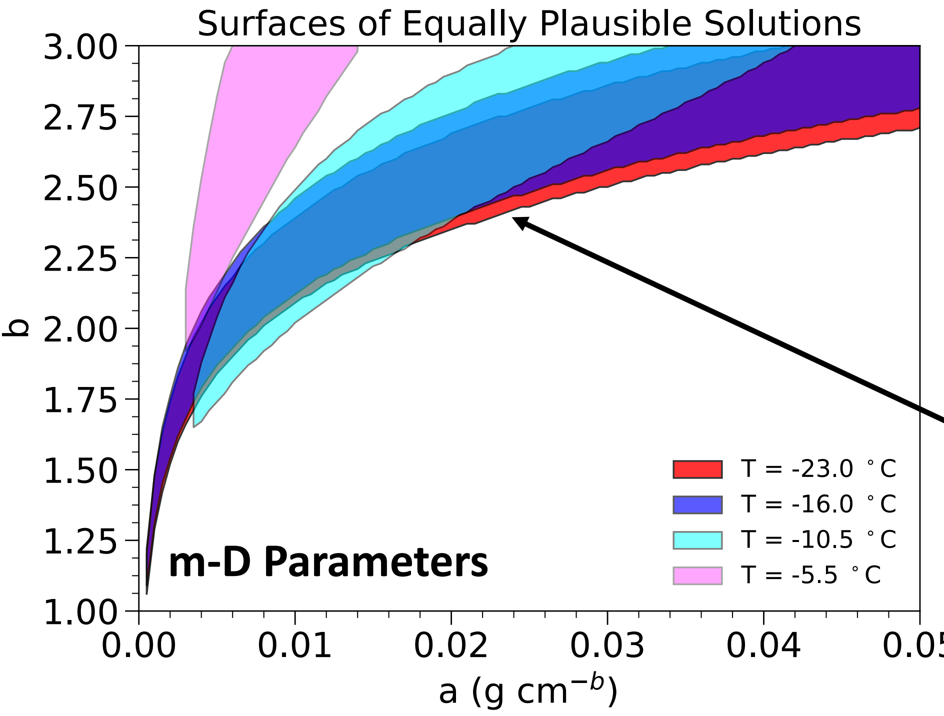
Simulations overestimated ice water content (IWC) above 7 kilometers but produced a decreasing trend approaching the melting level, opposite of aircraft observations from the Midlatitude Continental Convective Clouds Experiment (MC3E). This led to a general underestimation of rain water content at low atmosphere. Also, the detrained condensate properties from convective region significantly controlled large variability in simulated stratiform precipitation properties.

Han B, J Fan, A Varble, H Morrison, CR Williams, B Chen, X Dong, SE Giangrande, A Khain, E Mansell, JA Milbrandt, J Shpund, and G Thompson. 2019. "Cloud-Resolving Model Intercomparison of an MC3E Squall Line Case: Part II. Stratiform Precipitation Properties." *Journal of Geophysical Research: Atmospheres* 124(2):1090–1117, https://doi.org/10.1029/2018JD029596.

Developing Stochastic Representations Using In-situ Data: Results from MC3E

- **Motivation:** Parameters from mass-dimension (*m-D*) relations & gamma parameters from particle size distributions (PSDs) **vary based on temperature & other environmental factors**

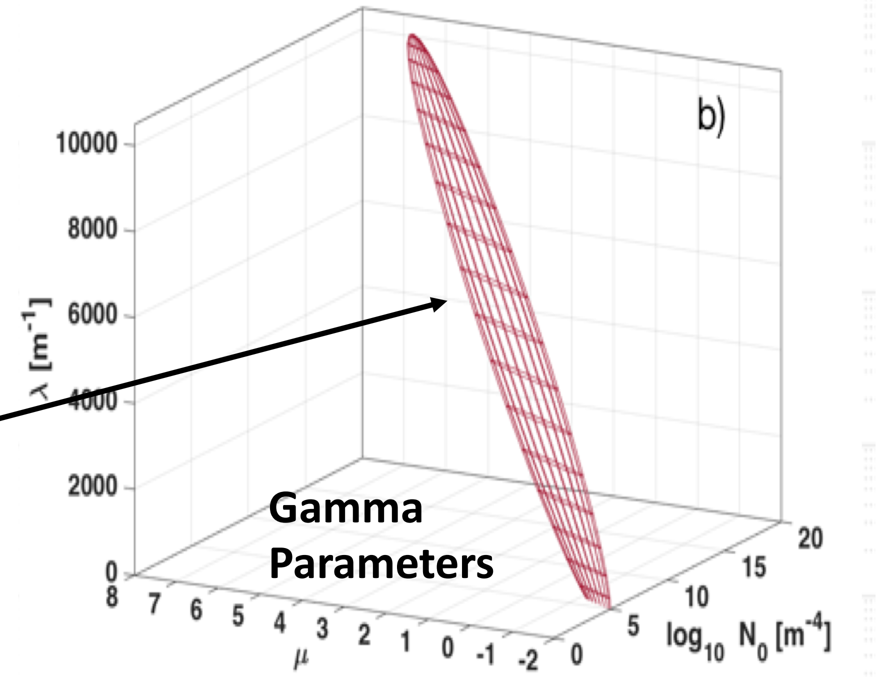
- **Goal:** Improve model representation of empirical parameters by **implementing stochastic parameterization** utilizing **range of equally-realizable solutions** from parameter phase space



Solutions determined from χ^2 minimization technique **considering uncertainties** in measurements and statistical counting of particles

Parameters within bounded region can be **chosen stochastically for use in models**

See posters by Finlon et al. (A2 #75) & Stanford et al. (A2 #74)



Sessions/Talks

Monday

1:30-3:30 PM	Cloud, Aerosol, and Complex Terrain Interactions (CACTI) field campaign [Salon C]
4:00-6:00 PM	Process-driven sampling strategies for ARM instruments [Brookside]

Tuesday

11:45 AM-12:00 PM	Investigation of precipitation processes with RAMS and observations *Brenda Dolan, Colorado State University*
12:00-12:15 PM	Updraft and downdraft core kinematics of mesoscale convective systems through observations and idealized simulations *Die Wang, Brookhaven National Laboratory*
12:15-12:30 PM	Taranis: Advanced Precipitation and Cloud Products for ARM Radars *Joe Hardin, Pacific Northwest National Laboratory*
1:30-3:30 PM	LASSO update and discussions [White Flint]
3:30-5:00 PM	Poster A1: Convective clouds, including aerosol interactions [Salon AB]

Wednesday

10:30 AM-12:30 PM	TRacking Aerosol Convection interactions ExpeRiment [White Flint]

Thursday

8:50-9:15 AM	Cloud, Aerosol, and Complex Terrain Interactions (CACTI) field campaign *Adam Varble, Pacific Northwest National Laboratory*
1:30-4:00 PM	Convective Processes Working Group [Brookside]

Thursday CPWG Session Agenda

1:30-1:40	Working group overview (Adam Varble)
1:40-2:15	Review of breakout sessions, recent/future field campaigns, and posters (Adam Varble/Mike Jensen)
2:15-2:25	LLNL SFA (Steve Klein)
2:25-2:40	BNL SFA (Mike Jensen)
2:40-3:00	PNNL SFA (Samson Hagos)
3:00-3:20	Discussion of pre-meeting survey questions

- Does the research ongoing in ASR reflect overarching critical needs for improving understanding and model representation of deep convective processes? Do upcoming ARM field campaigns and IOPs? Why or why not?
- Can communication and collaboration between ASR projects, both lab and non-lab, be improved for mutual benefit, and if so, how? As an example, should we organize specific focus groups with dedicated breakouts and/or regular telecons?

Thursday CPWG Session Agenda

3:20-3:35	Review of relevant ARM products and plans (Scott Collis)
3:35-3:55	Discussion of pre-meeting survey questions

- Which observations and products are most needed (currently existing or not) to make progress on improving understanding and model representation of deep convective processes? Are these adequately provided by ARM or another agency?
- Are existing ARM data and products easy to access and understand? Is ARM data quality and availability sufficient for your needs? Do you have any recommendations for improvement in these areas?

3:55-4:00	Wrap-Up