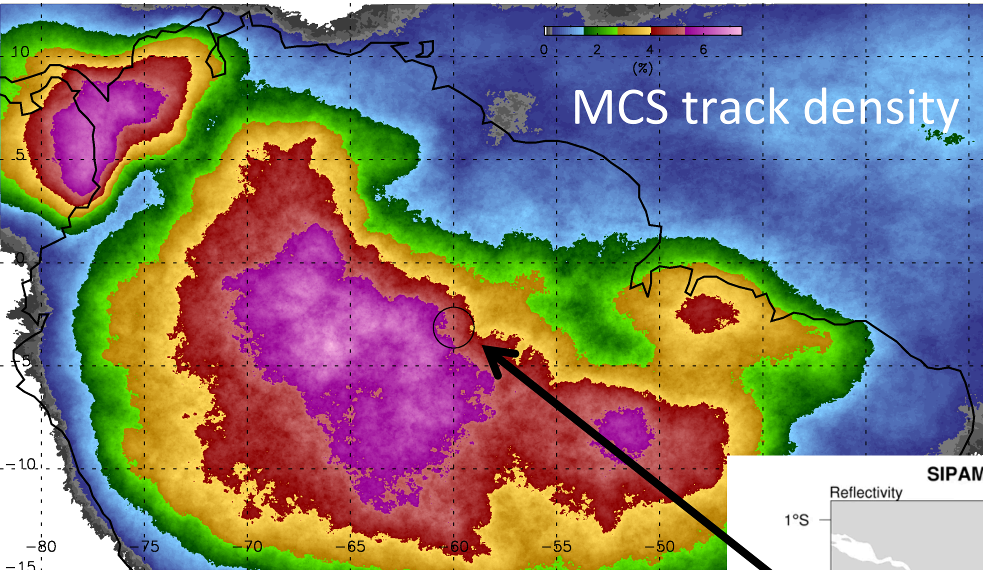
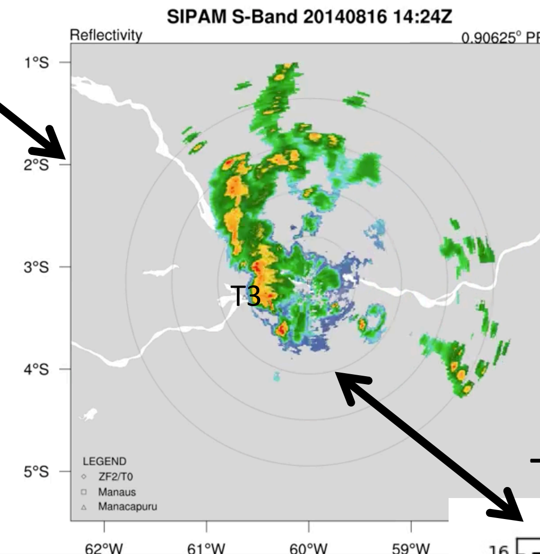
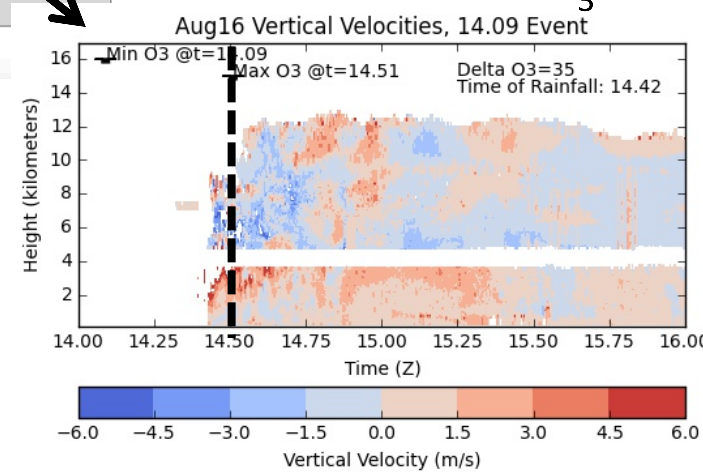
Multi-scale convective interactions during GoAmazon2014/5

PI: Courtney Schumacher,
Texas A&M University





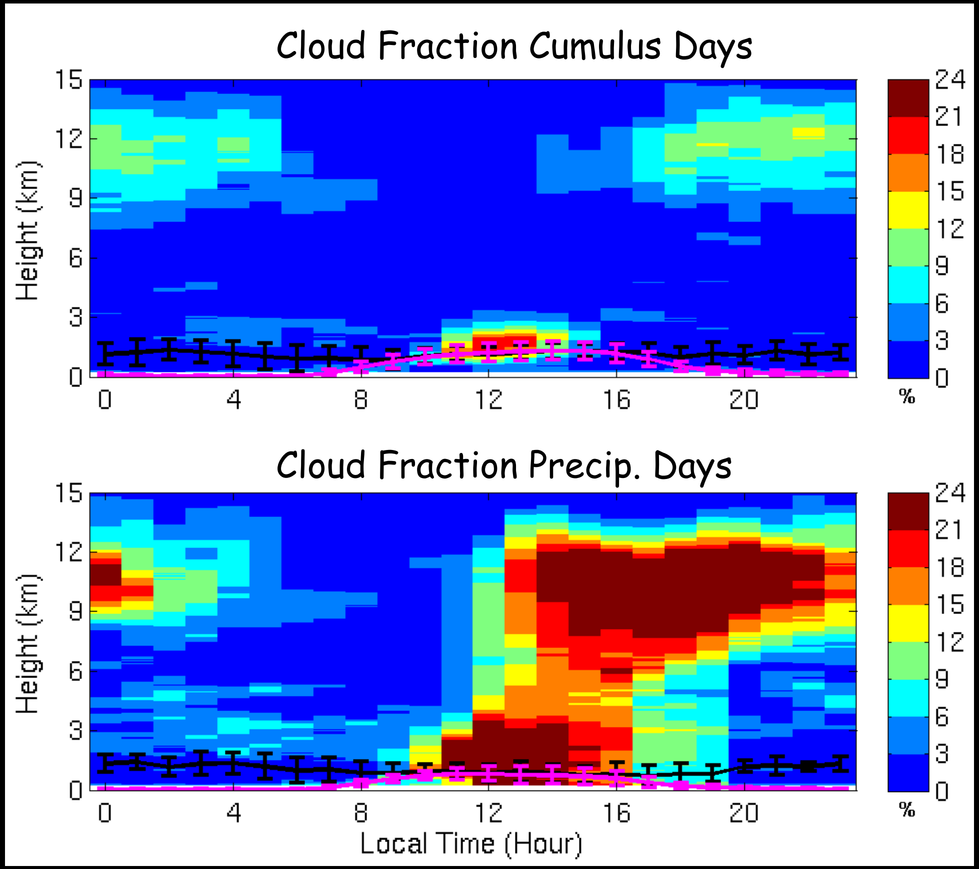
Time of max surface O_3



- MCSs have preferential regions of formation and propagation over the Amazon
- MCS impacts can be felt on the large scale via rain and transports of heat, moisture, and momentum
- MCSs also play an important role in chemistry transport

Controls of precipitation during the Amazonian dry season

Ghate, V. P., and P. Kollias, 2016: On the controls of daytime precipitation in the Amazonian dry season. *J. Hydrometeor.*, **17**, 3079-3097



Motivation and Objectives:

- Challenging for GCM to accurately simulate the rainfall during the Amazonian dry season, which has a significant impact on the rainforest.
- What factors control the daytime transition from shallow-to-deep convection? And what causes the number of rain events to decrease during the dry season?

Approach:

- Use data from the GO-Amazon field campaign and contrast the diurnal cycles of days with and without precipitation.
- Study the progression of key variables during progression of the dry season.

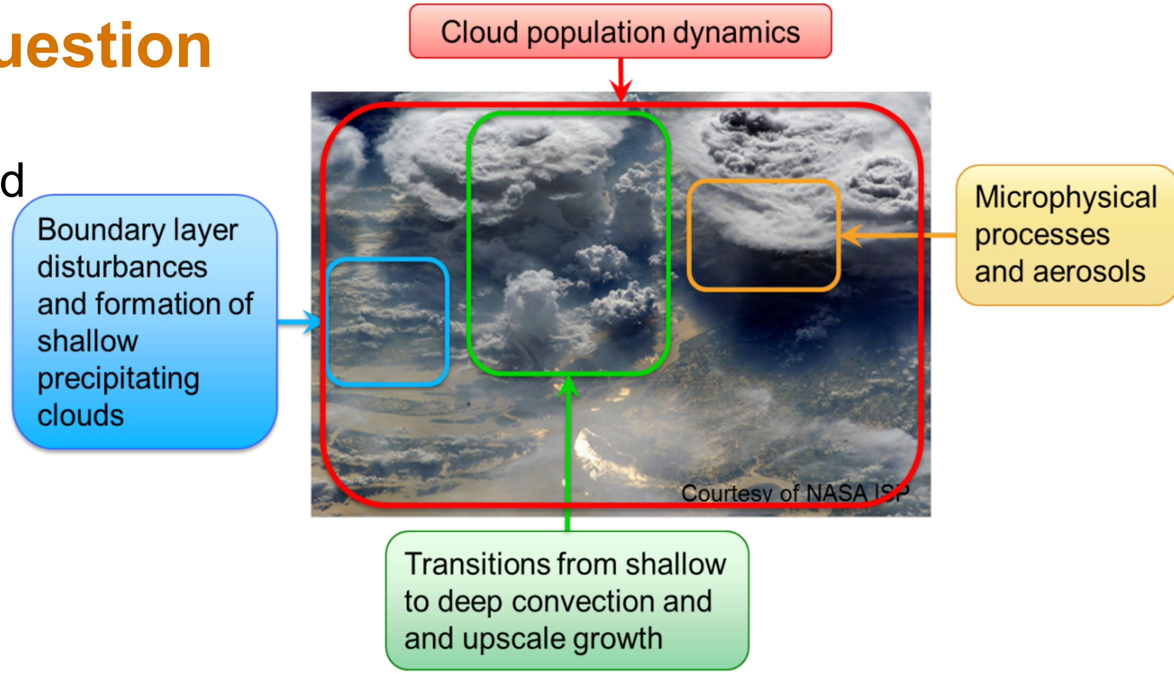
Key Results:

- Precipitation days had higher moisture above the BL compared to cumulus days, while it had lower LCL and surface sensible heat flux. → *Less CINE and lower entrainment*
- Decrease in precipitation during the progression of dry season mainly due to decrease in propagating squall lines. → *Dry season precipitation controlled by non-local factors like moisture advection and squall lines*

Research on convective transitions at PNNL

Overarching Science Question

- What are the key processes that control transitions in cloud populations?
- How do these processes and transitions collectively shape the evolution of the cloud populations?



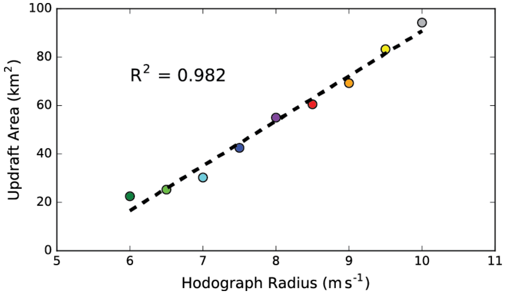
Current activities

Observational and **high resolution modeling** studies of

- Boundary layer rolls over **SGP**.
- Shallow to deep convection transitions over **Amazon**
- Stochastic cloud population modeling over **Darwin**
- Aerosol impacts on deep convection over **SGP** and **Amazon**

"A Bottom-up Approach to Improve the Representation of Deep Convective Clouds in Weather and Climate Models", Trapp, Lasher-Trapp, Nesbitt, UIUC

- **Overarching objective**: to understand how convective-storm updrafts, downdrafts, and cold pools are inter-related, and how these three convective components are modulated by external and internal factors
  - *current focus is on MC3E-type environments, as on 23 May 2011*
- Using idealized simulations, we find that environmental vertical wind shear exerts a large control on updraft-core width, especially for wind hodographs that are curved



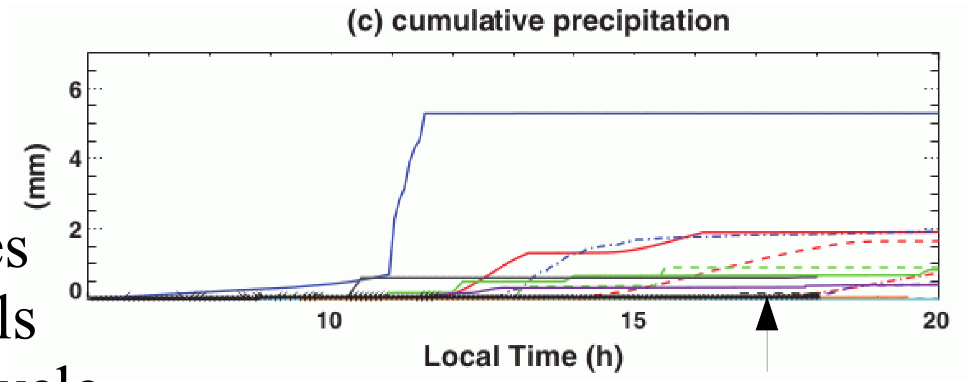
increases in updraft-core width are accompanied by increases in downdraft-core width and increases in cold-pool depth/area

this strong inter-relationship is modulated by the representation of microphysical processes

- **Ongoing**: microphysical-process assessment, observational analyses

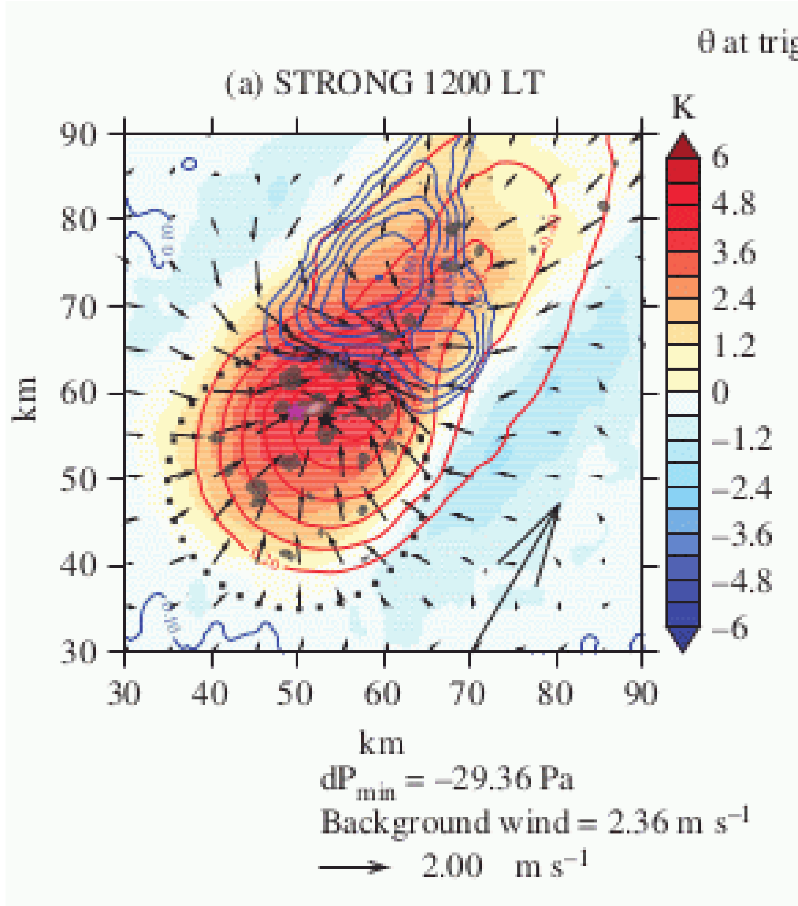
Initiation of daytime moist convection in the Tropics

F. Couvreux, N Rochetin, F. Guichard,C Rio



Current studies :

- Still a challenge for models
- Obs & LES : role of surface heterogeneities
- Interaction between breeze and BL thermals
- Tracking of the cold pools in LES=> life cycle



Future work :

- Contrasting different tropical environment
- Identifying the impact of the shallow convection regime on the initiation of deep convection
- Modifying the triggering of the deep convection parameterization to take into account the surface heterogeneities

METEO FRANCE

Diagnosing Raindrop Evaporation, Breakup & Coalescence

Liquid water content: $q = N_t \sum G(D_m, \mu; D) D^3 \Delta D$ [g m^{-3}]

Take the 10*logarithm of both sides:

$$q^{dB} = N_t^{dB} + D_q^{dB} \quad \text{[dB]}$$

Objective

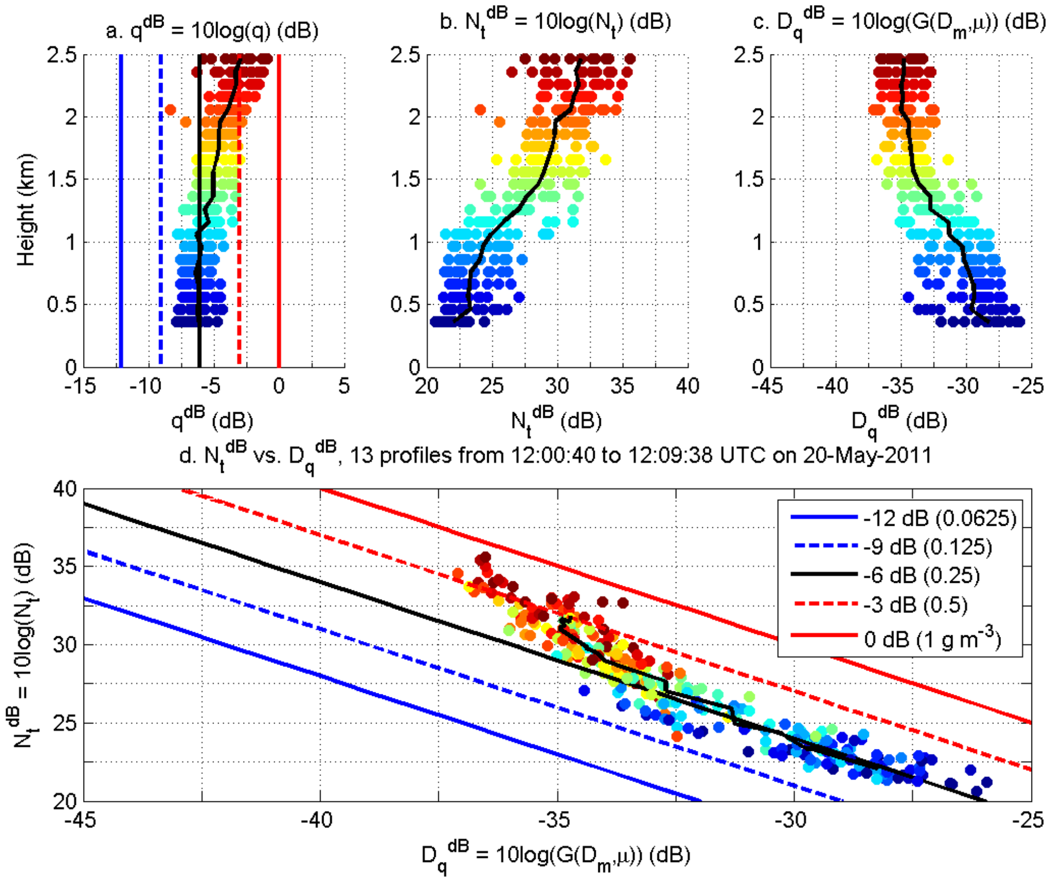
- Diagnose raindrop evaporation, breakup, and coalescence using the vertical change in rainfall parameters

Approach

- *Vertical Decomposition Diagrams* express rainfall parameters in logarithmic units:
  - q^{dB}: *liquid water content*
  - N_t^{dB}: *total number concentration*
  - D_q^{dB}: *characteristic raindrop size*
- *Evaporation* & *accretion* subtract or add mass as diagnosed by changes in q^{dB}
- *Breakup* & *coalescence* redistribute mass as diagnosed by compensating changes in N_t^{dB} and D_q^{dB}

Impact

- *Vertical Decomposition Diagrams*:
  - Useful for observations & models
  - Identify mass- or size-modifying rain microphysics processes



Vertical Decomposition Diagram during stratiform rain over SGP.

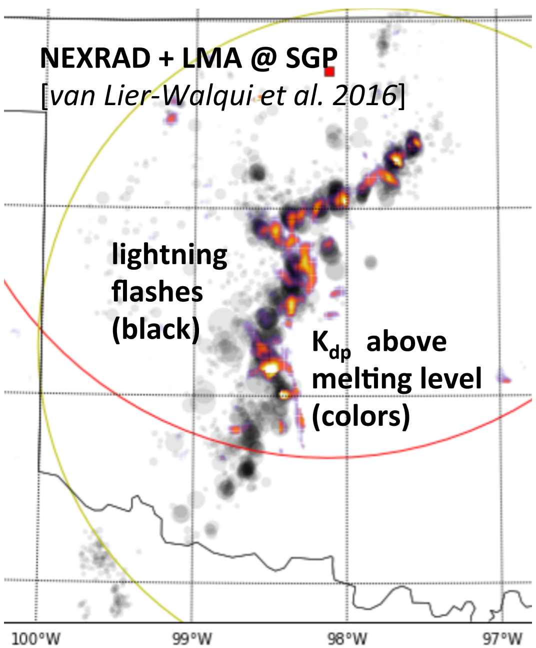
C. R. Williams, 2016: Reflectivity and liquid water content vertical decomposition diagrams to diagnose vertical evolution of raindrop size distributions. *J. Atmos. Oceanic Technol.* **33**, 579-595, doi: 10.1175/JTECH-D-15-0208.1

Happy π-day!

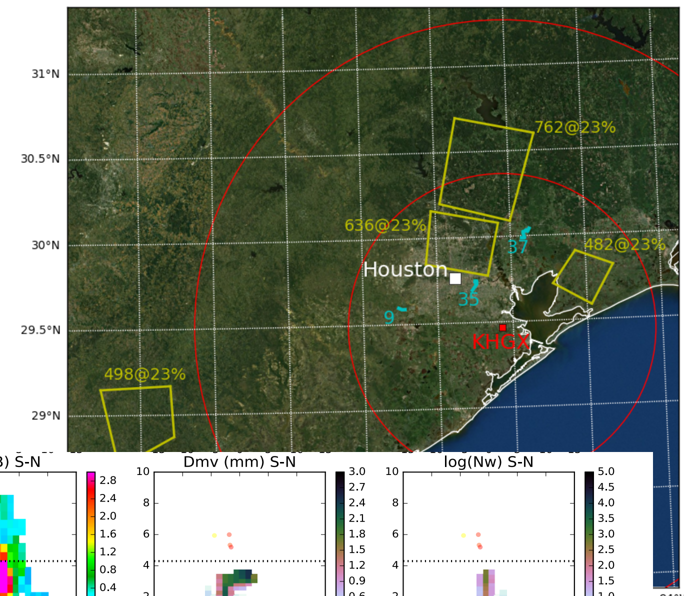
Convective updraft microphysics—from MC3E to...Houston?

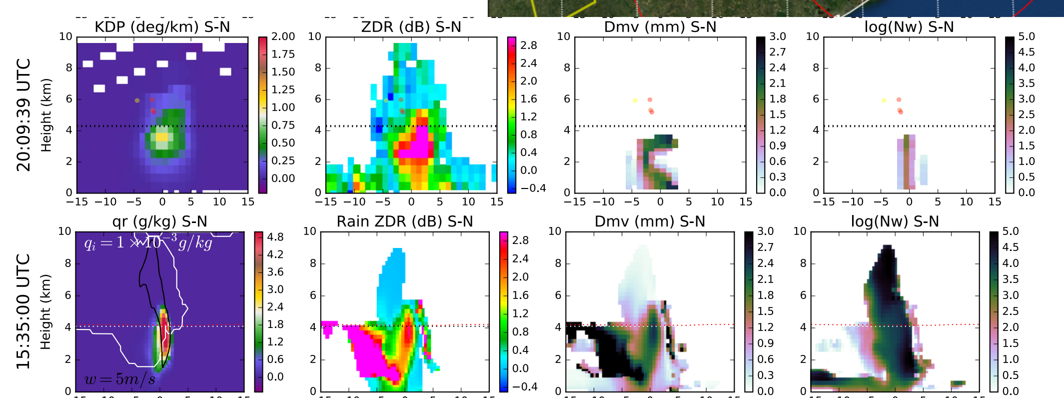
- **Problem**
  - simulations of convective updraft microphysics and dynamics remain very poorly constrained
- **MC3E findings**
  - polarimetric radar can very well be used to both locate and "see inside" updrafts [*van Lier-Walqui et al. MWR 2016*]
  - surprising 20 May case evidence of warm-temperature ice multiplication similar to that commonly seen during HAIC-HIWC [*Fridlind et al. ACPD 2017*]

- **iLEAPS/GEWEX ACPC group proposal**
  - isolated updraft cell tracking study using polarimetric radars and ground-based aerosol measurements
  - Houston region provides robust aerosol perturbation and dynamic susceptibility under onshore flow



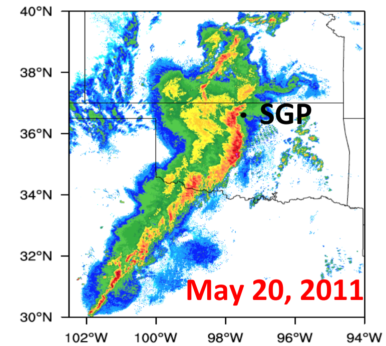
NEXRAD + LMA @ Houston
[*van Lier-Walqui, Fridlind, Ryzhkov, Zhang, Rosenfeld, Quaas, et al. ACPD in prep.*]





Cloud-Resolving Model Intercomparison of a MC3E Squall Line Case

Led by Jiwen Fan, Adam Varble, and Hugh Morrison



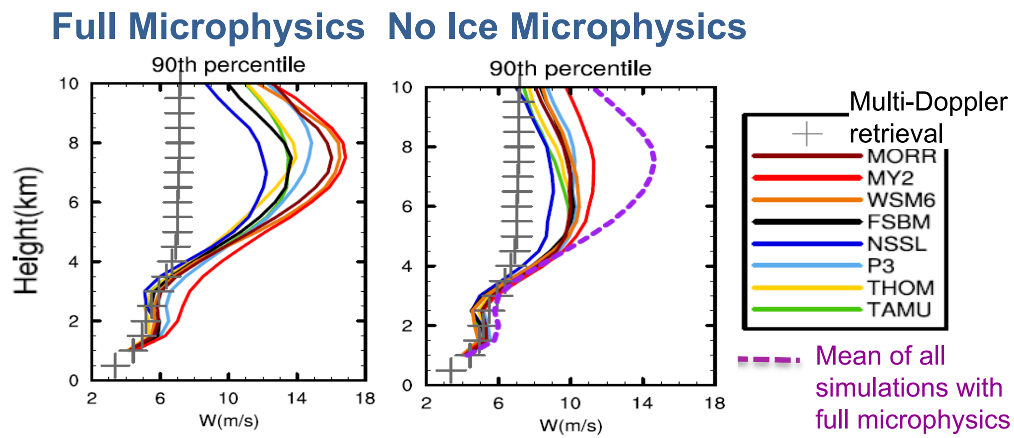
Objectives

- Examine the dominant factors responsible for processes/factors leading to the large spread of CRM deep convection simulations and simulated aerosol impacts.

Approach

- Perform high-resolution (1 km) simulations with different microphysics schemes including 1-moment bulk, 2-moment bulk, and bin microphysics.
- Employ the “piggybacking” approach to separate microphysical effects from the feedback to dynamics.

Working on: (1) the factors leading to underestimation of stratiform precipitation and area; (2) separating microphysical effects from the feedback effect on dynamics. **Comparison on aerosol impact is planned.**



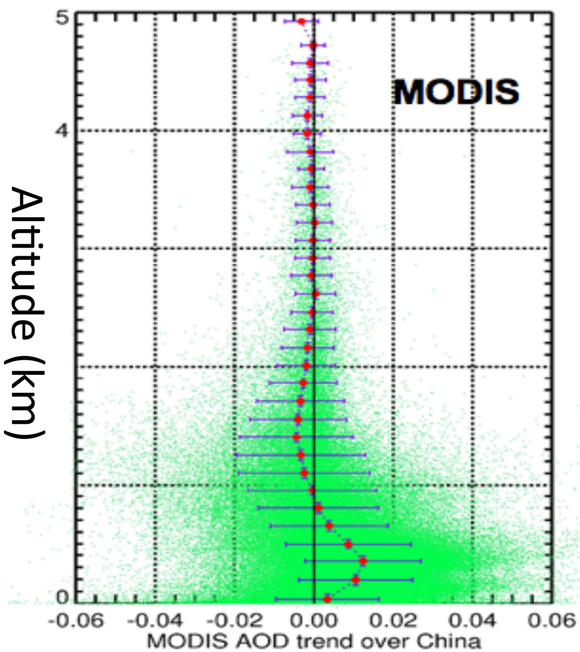
Key points

- Simulations overestimate convective intensity, and underestimate stratiform precipitation and area.
- Large spread of updraft velocity corresponds with the spreads in both low-level pressure perturbation gradient mainly determined by cold pool intensity and buoyancy mainly by latent heating.
- Ice microphysics parameterization majorly contribute to the large spread of updraft intensity.

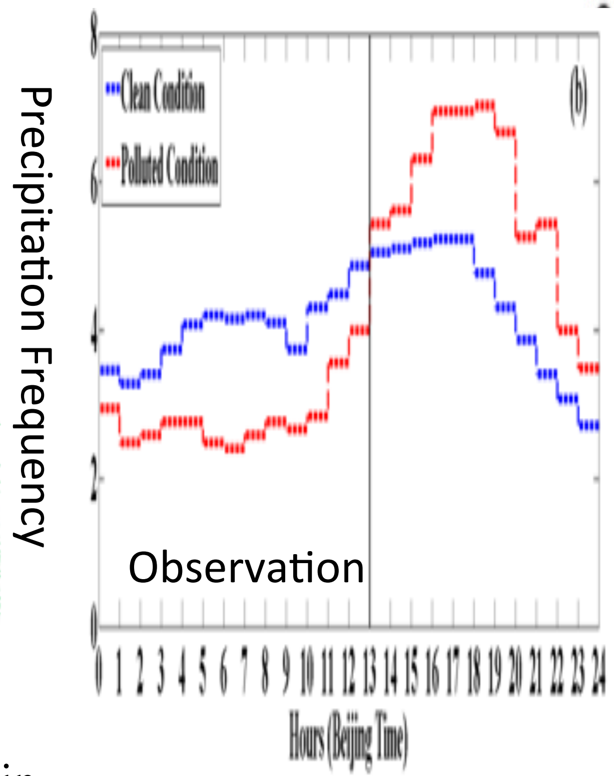
Aerosol-PBL-Convection Interactions

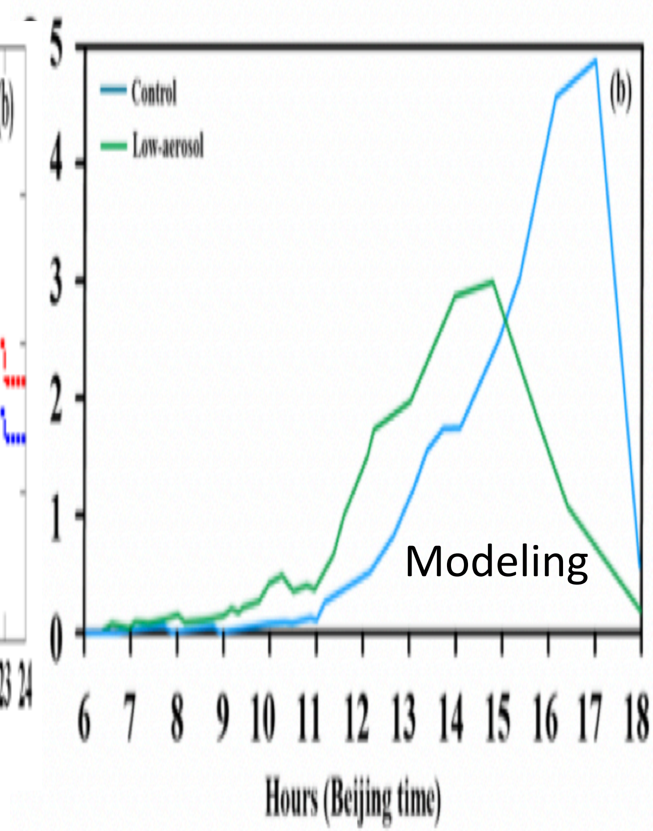
Zhanqing Li

- How do aerosol and PBL interact ?
- How does the aerosol-PBL interaction affect convection ?



10-year trend of AOD at different altitude in a basin in China: increasing in PBL but decreasing outside PBL caused by a suppression of PBL by aerosol. Dong et al. (2017, ACP)





Diurnal variations of heavy precipitation averaged for all cases over a decade in southern China under severe polluted and clean condition s

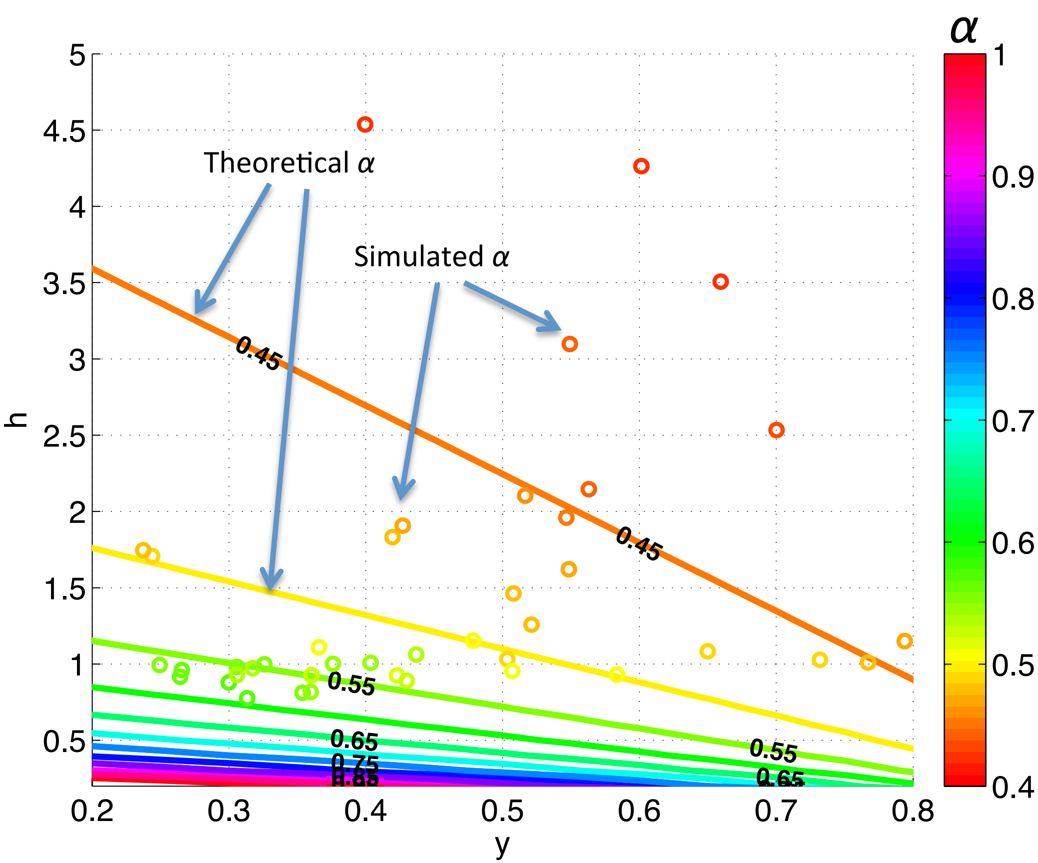
Guo et al. 2016, JGR) , Lee et al. (2016, JGR)

The ascent rate of moist convective updrafts

Hugh Morrison and John Peters

- Observational and modeling studies suggest a ratio of updraft top ascent rate and maximum vertical velocity α ~ 0.5 to 0.6 (Turner 1973, Romps and Charn 2015).

- We derive an analytic theoretical expression for α as a function of two nondimensional buoyancy-related parameters h and y. This is done by extending Hill's analytic spherical vortex model (Hill 1894), which gives α = 0.4, to include the effects of buoyancy.



Comparison of the analytic theoretical α (colored lines) with values directly calculated from 3D simulations using the CM1 model (colored circles), as a function of non-dimensional buoyancy parameters h and y.

h = ratio of buoyancy within thermal to the total buoyancy
y = ratio of buoyancy from thermal bottom to height of maximum vertical velocity to the buoyancy within the thermal

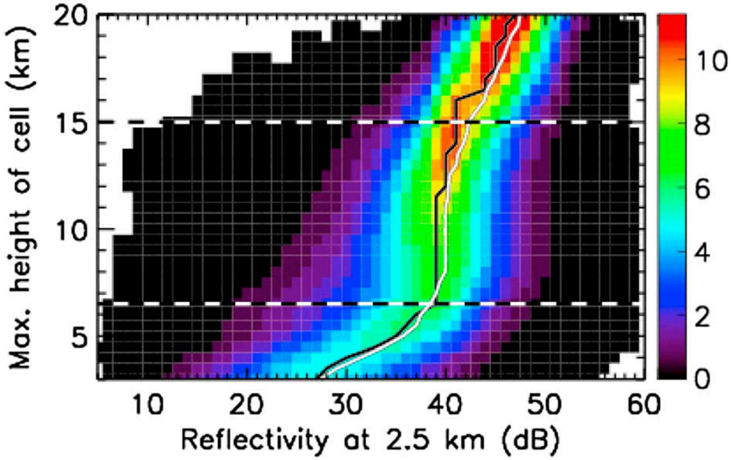
Theoretical α well match the simulated α, including the dependence on y and h.

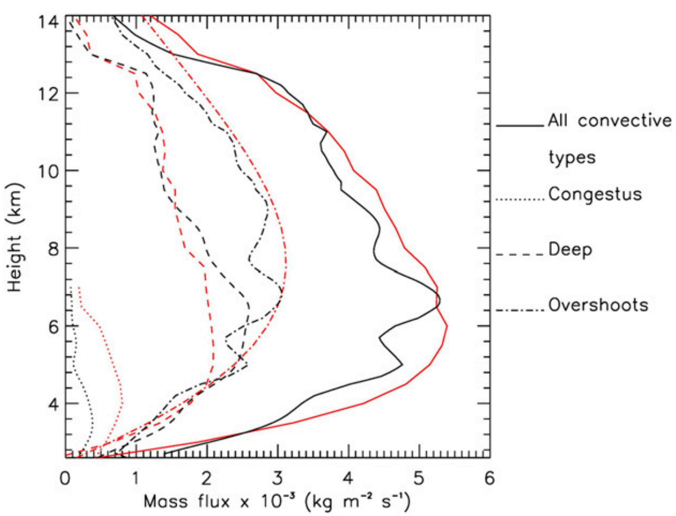
- We are interested in comparisons with observations (radar retrievals, other), for this and other recent theoretical work (Morrison 2016a,b,2017, Peters 2016).

- Implications for convection schemes.

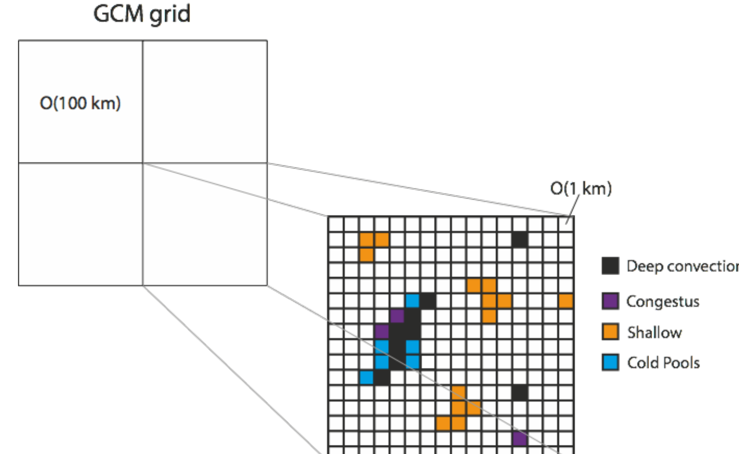
Convection Research - Jakob

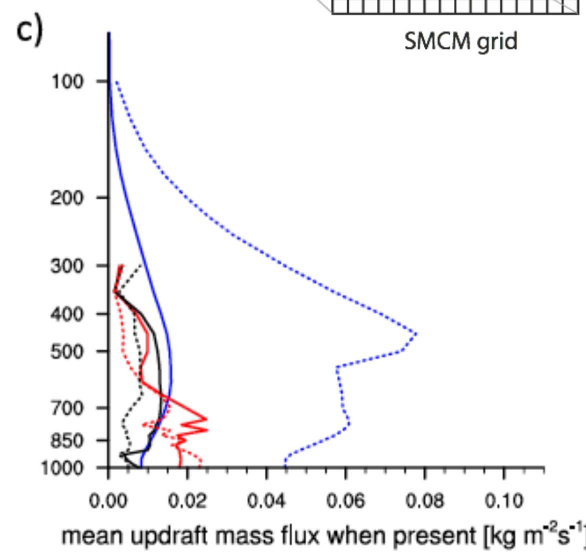
Our goal is to use radar (and other) data to support the development of a fundamentally new framework for cumulus parametrization.





Kumar et al., 2013-2017





Peters et al., 2013, 2017

CMDV-RRM

- ACME will be run in RRM mode down to ~13km of over key ARM sites.
- Science Question: Can the dynamical core + convective scheme reproduce convective organization with the mesoscale parameterization turned off?

On the topic of vertical velocities

- we agree work needs to be understanding of the limitation of applicability of these retrievals. Need Blue-team Red-team aproach (apropos Leo Donner) IOP?????

Software!

- Open-source multi-Doppler collaboration between OU/NSSL, NASA Marshall and Argonne (in that order!). https://github.com/tjlang/MultiDop
- Thanks to the Monash group (Bhupendra Raut, Christian Jakob) we are close to a Py-ART based TITAN-like tracking code.