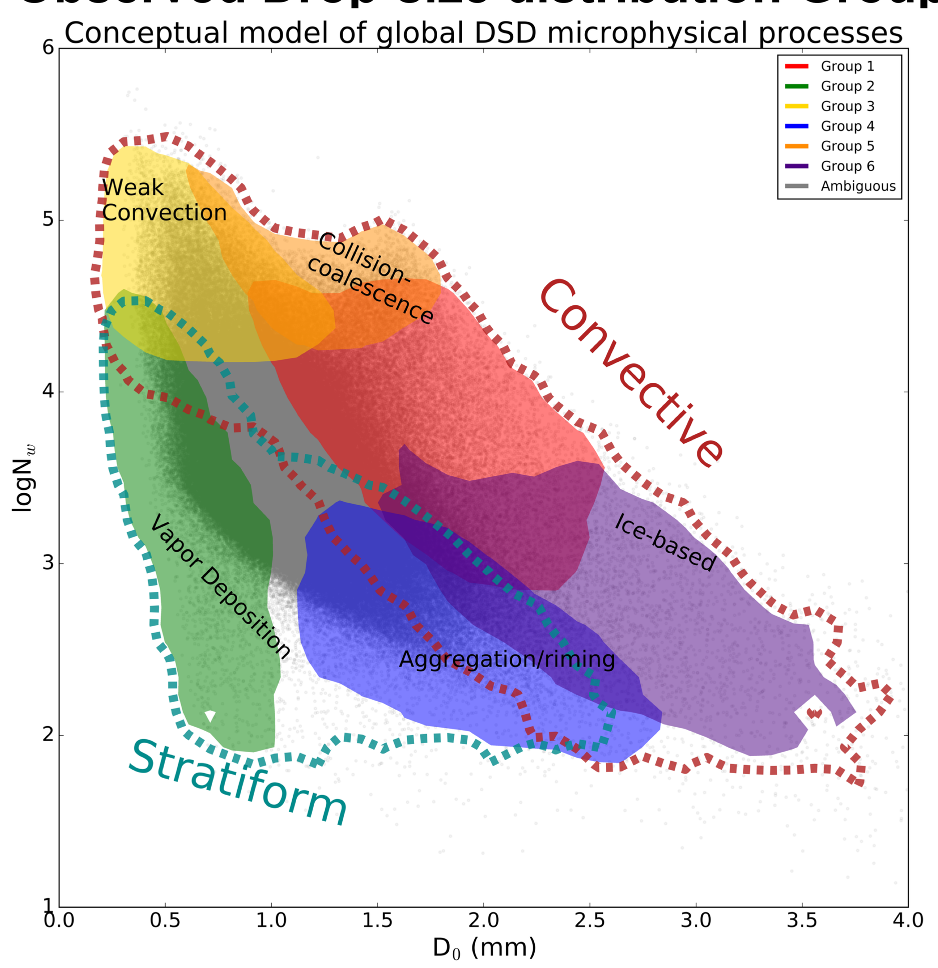
127. Understanding Microphysical Process Links to Surface Drop-Size Distributions

B. Dolan, S. Saleeby, B. R. Fuchs, S. A. Rutledge, and S. van den Heever
Department of Atmospheric Science, Colorado State University, Fort Collins, CO

Background and Motivation

Observed Drop-size distribution Groups

Conceptual model of global DSD microphysical processes



- Principal Component Analysis of 13 disdrometer datasets, 350000 raining minutes
- *Same modes of variability observed everywhere*
- Six consistent, repeatable groups found using thresholds on PC values resulting from first two empirical orthogonal functions (EOF) of PCA
- High resolution vertical cross-sections from coincident radar observations showed these six groups are consistent with:
  - Convection: weak, warm rain, ice-dominated
  - Stratiform: vapor deposition, aggregation

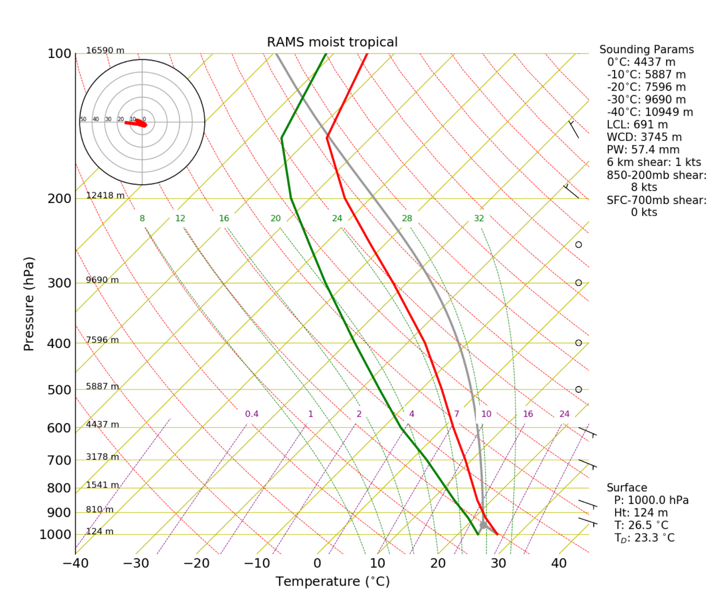
- What microphysical processes contribute to this variability?
- Do models accurately reproduce these observed modes of variability?

Approach

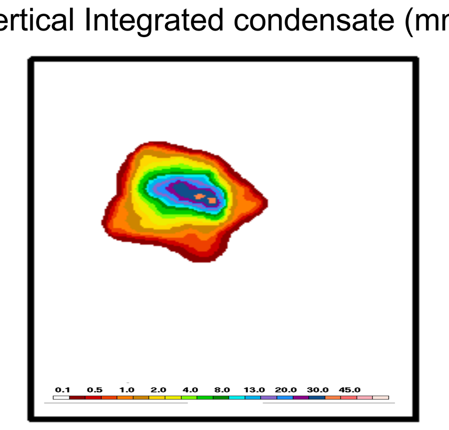
- RAMS mesoscale model with bin-emulating two moment bulk microphysics scheme
- Two idealized simulations from "moist tropical" environment and an intense mid-latitude super cell
- Assumed gamma shape parameter of μ=2
- Convert surface rain mixing ratios and number concentrations into median drop diameter (D_0) and normalized number concentration (N_w) to compare to disdrometer observations
- Compare to observations of similar storm types from Manus Island (tropical west pacific, ~3 years of data) and SGP (Oklahoma, ~5 years of data)

RAMS "Moist Tropical"

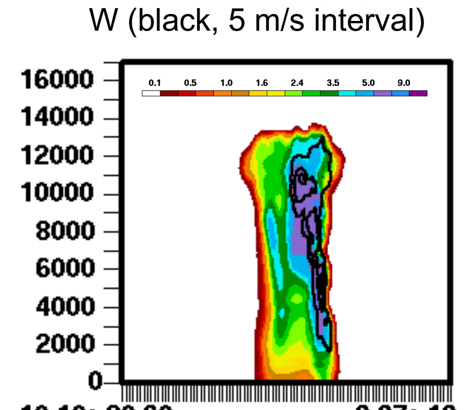
- 350x350x108, 250 m x250 m x 50 m-stretched grid
- Initialized with Dunion (2011) Moist tropical Sounding
- ~3 hours



Vertical Integrated condensate (mm)

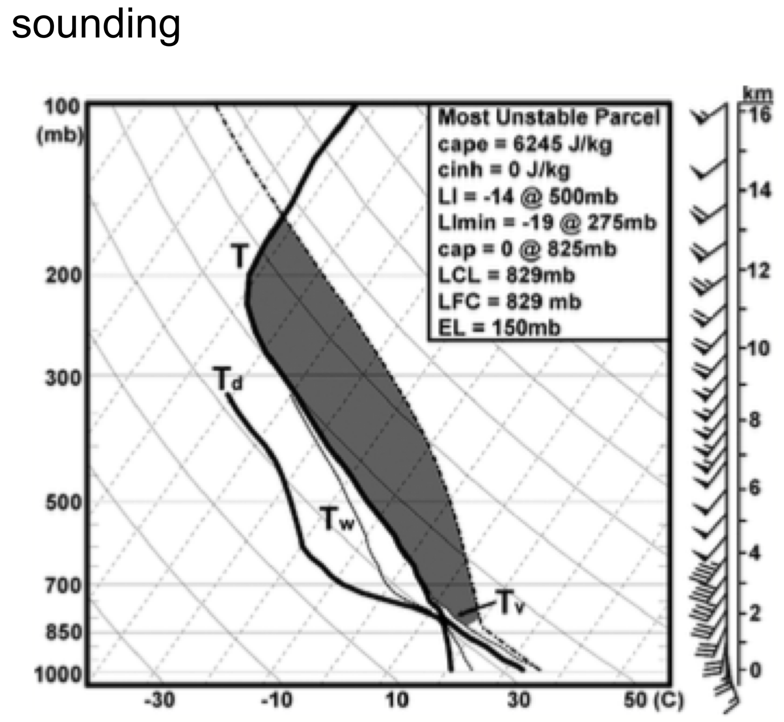


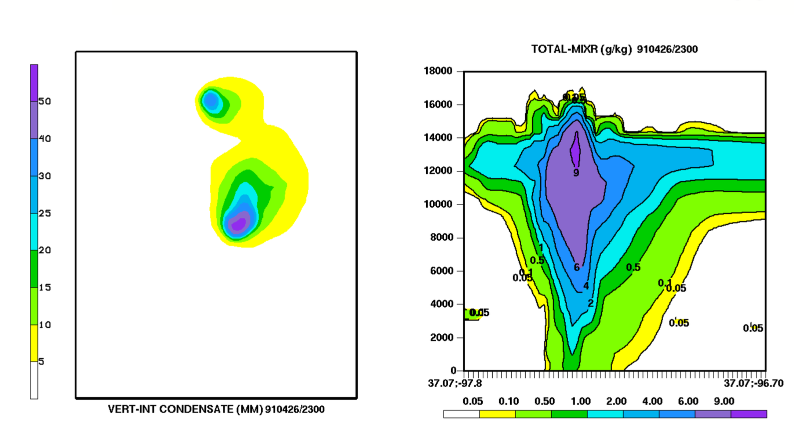
Total –MixR (g/kg)
W (black, 5 m/s interval)



RAMS "Supercell"

- 100x130x39, 1.5 km x1.5 km x 100 m-stretched grid
- Initialized with modified Weisman and Klemp (1982) convective sounding
- ~2 hours



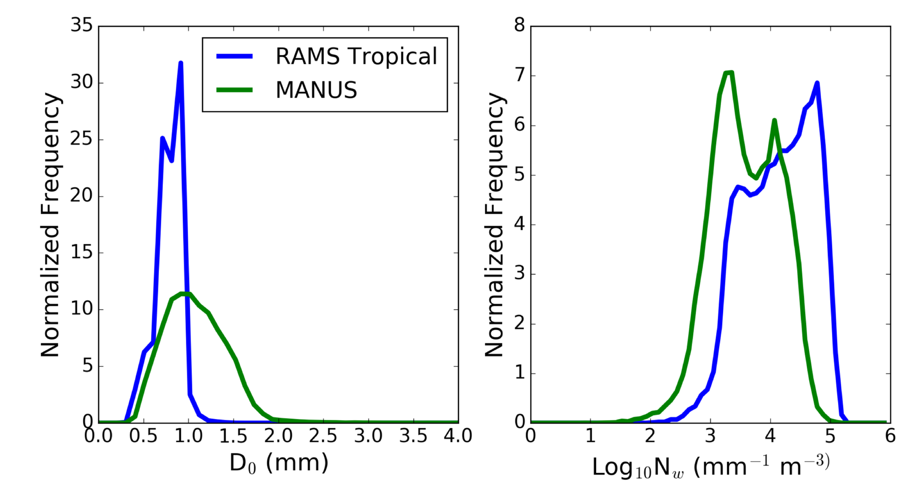


Acknowledgements

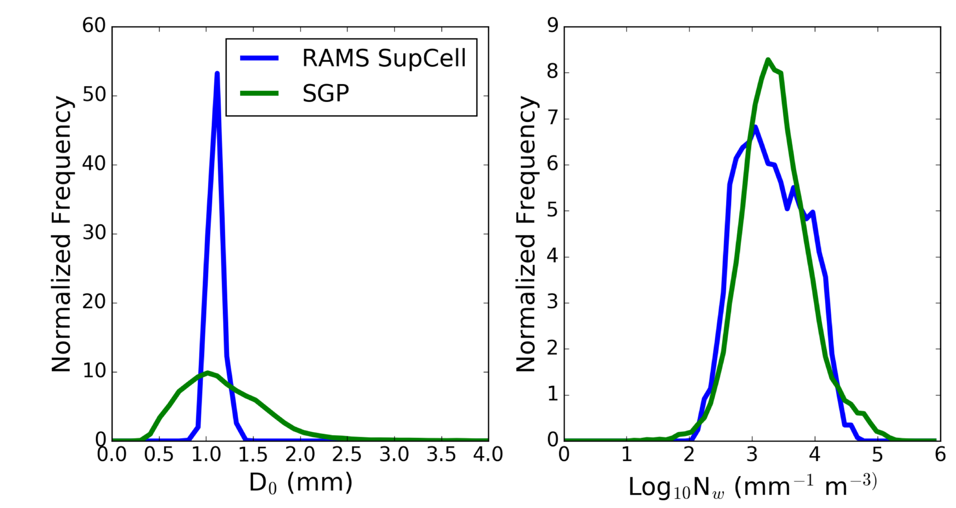
This work is supported by DE-0000000SC17977.

Preliminary Results

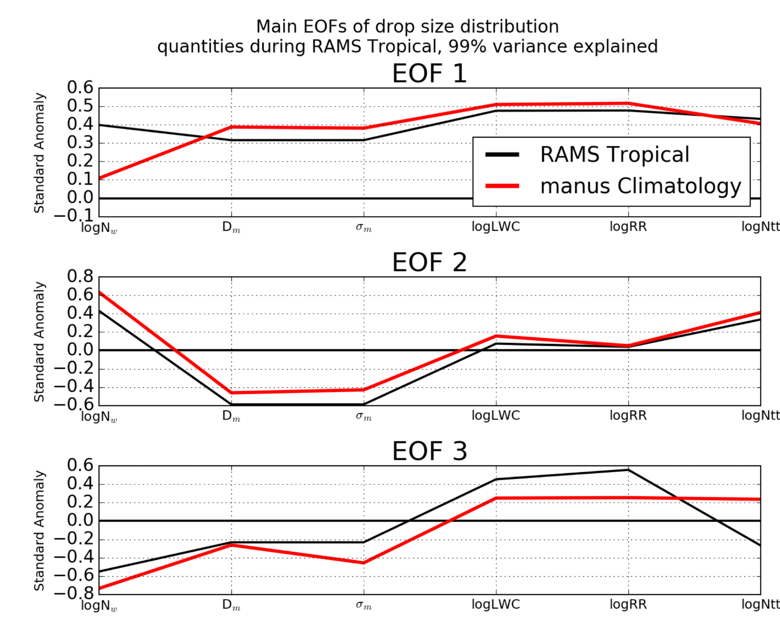
"Moist Tropical"



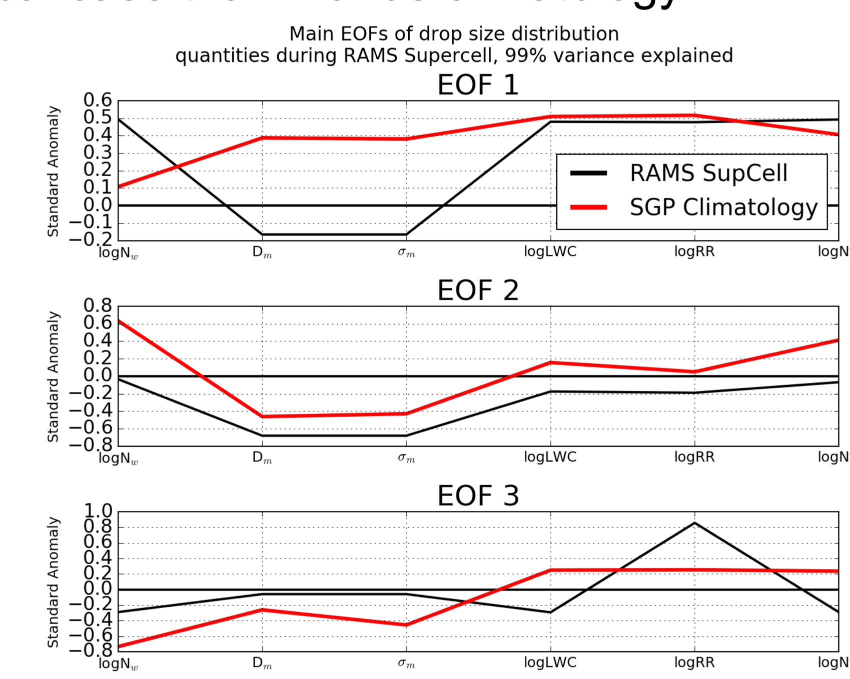
"Supercell"

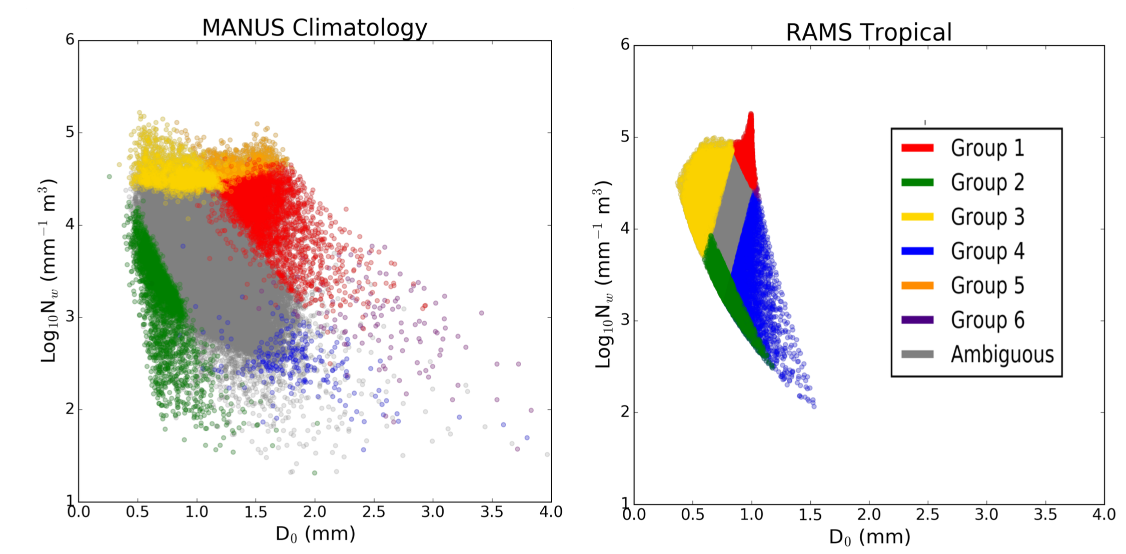


- Distributions of D_0 show these single, idealized simulations have narrower and smaller mean diameters compared to climatological DSDs from disdrometers
- Distributions of N_w relatively similar, but peak values of RAMS are higher in tropical case than Manus climatology

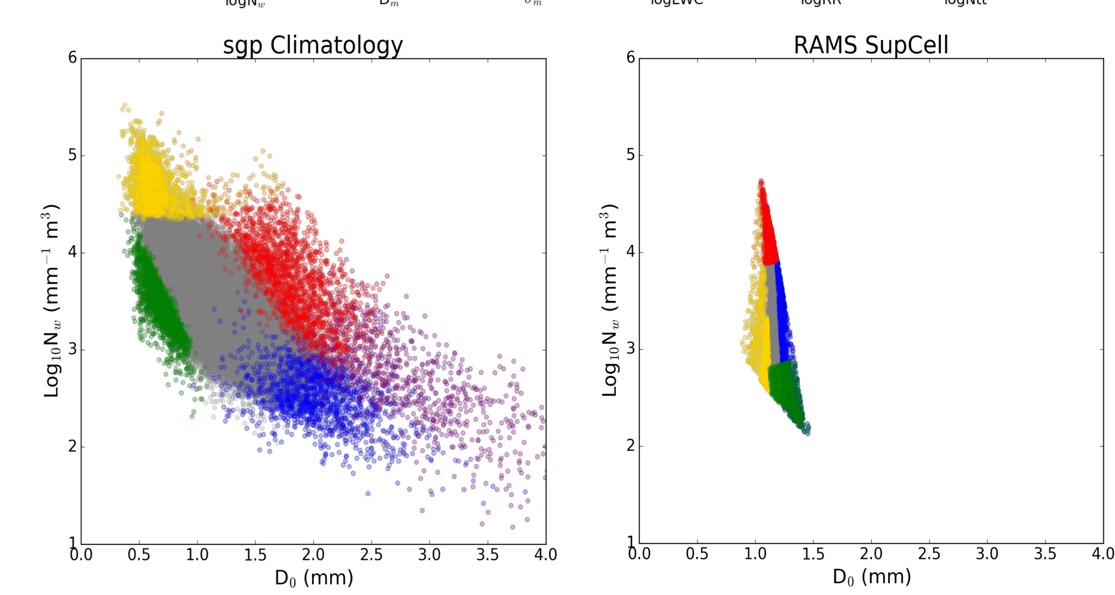


- EOFs reveal the co-variance of the six parameters in each mode
- Positive values indicate high values of given quantity compared to the normalized mean





Using thresholds on the PC values derived from the PCA, six groups are clustered based on similar characteristics and co-variability of DSD parameters



- Tropical simulation shows the same EOFs (1, 2 and 3) as Manus climatology
  - For example, EOF1 has large values of N_w, D_0, σ_m, rain rate, liquid water content and number of drops
  - EOF2 has large N_w and number of drops, but small mean sizes and σ_m
  - Same dominant modes of variability in tropical ocean are captured by simulation
  - Suggests majority of processes seen in climatological disdrometer data are captured in this idealized case

- Supercell simulation does NOT have same EOFs as SGP climatology
  - Disdrometer climatology encapsulates many different types of storms, possibly encompassing microphysical processes that may not be present in simulation of one supercell
  - Low variability in D_0 drives different EOFs (EOF1 and EOF2 are flipped compared to SGP climatology)
    - Bigger mean sized drops are absent in simulation – Why?
      - Coarse resolution or / anomalous storm?
      - Parameterizations of size-sorting, melting, drop break up?

- Results from two idealized simulations using bulk microphysics in different thermodynamic regimes show some promising results for investigating observed rainfall variability
- Important differences between disdrometer climatology and single cases
  - One simulation may not capture every mode of variability seen in a climatology of disdrometer data
  - Simulations seem to generally have smaller D_0 and lack of large D_0 compared to observations
  - Fixed μ used in bulk scheme may alter the modes of variability

Future Work

- Query a large database of simulations from different storm types, different locations to compare with global disdrometer dataset and apply PCA for more representative comparison to climatological disdrometer data
- Investigate surface rainfall parameters from bin microphysics in comparison to bulk and observations
  - Does the fixed μ assumption of bulk schemes impact the modes of variability?
- Correlate model microphysical conversion rates to surface rainfall groups
- How do assumptions about the DSD (specifically the shape parameter) impact storm microphysics and dynamics?