Surface-through-Vertical Observational Analysis of ARM data

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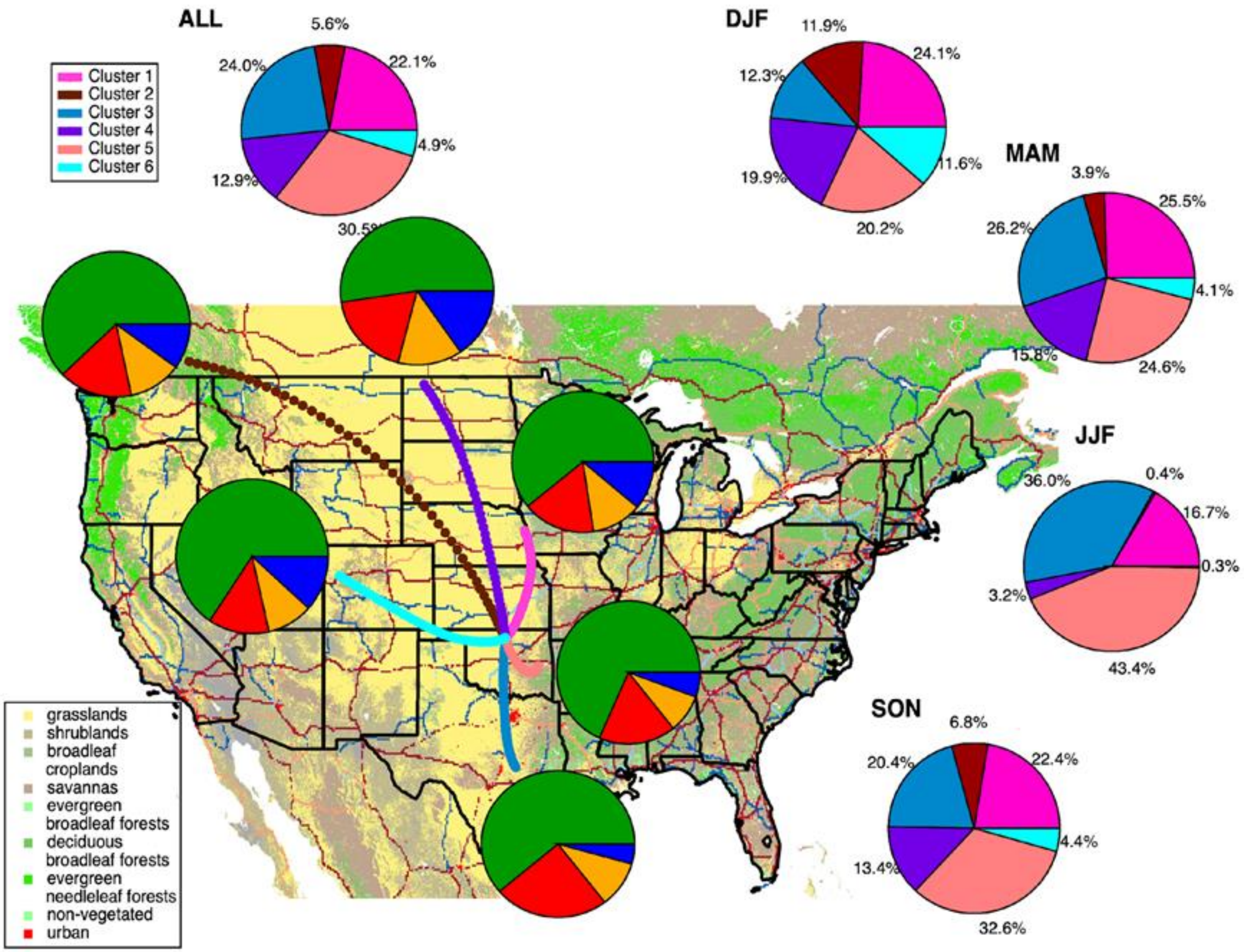
ARM AMSG Meeting, July 9, 2024

Sample workflow for atmospheric aerosol regime classification



ALL
5.6%
22.1%
24.0%
4.9%
12.9%
30.5
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
DJF
11.9%
24.1%
12.3%
19.9%
11.6%
20.2%
MAM
3.9%
25.5%
26.2%
4.1%
15.8%
24.6%
JJF
36.0%
0.4%
16.7%
0.3%
3.2%
43.4%
SON
6.8%
20.4%
22.4%
4.4%
13.4%
32.6%
grasslands
shrublands
broadleaf croplands
savannas
evergreen broadleaf forests
deciduous broadleaf forests
evergreen needleleaf forests
non-vegetated
urban

AOS Data Sources

- ACSM bulk aerosol composition
- ACSM PMF-derived OA composition
- Measured and derived optical properties (scattering, absorption, extinction, Angstrom exponents, SSA)
- CCN activated fractions
- SMPS size distributions, total number and volume
- Trace gases: O_3, SO_2
- Meteorology: temperature, pressure, RH, rain rate, wind speed and direction

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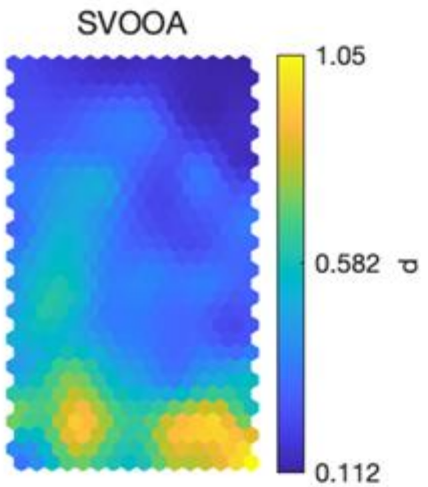
Categorization by Self-Organizing Map



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Clustering by k-medoids

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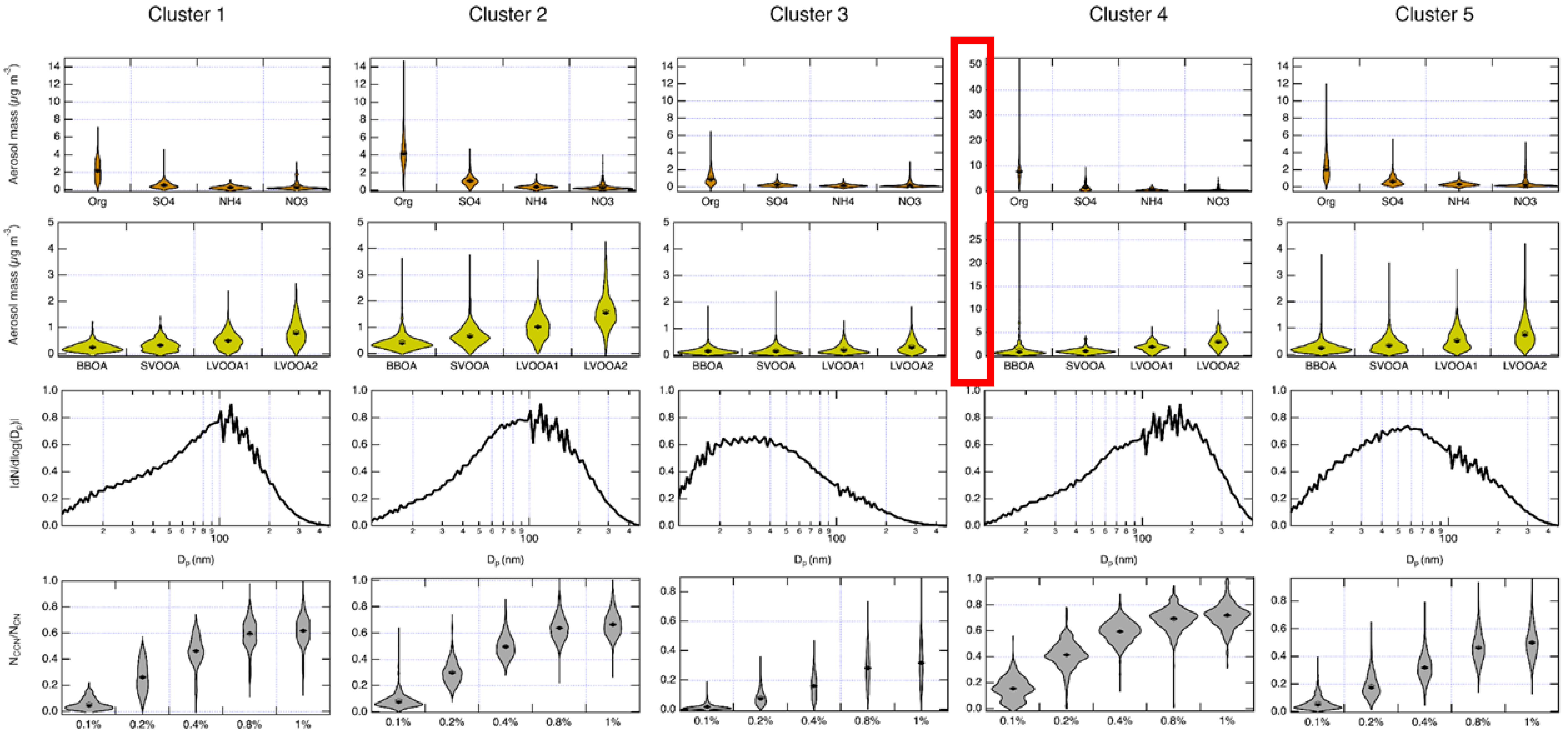
Atmospheric regime clusters

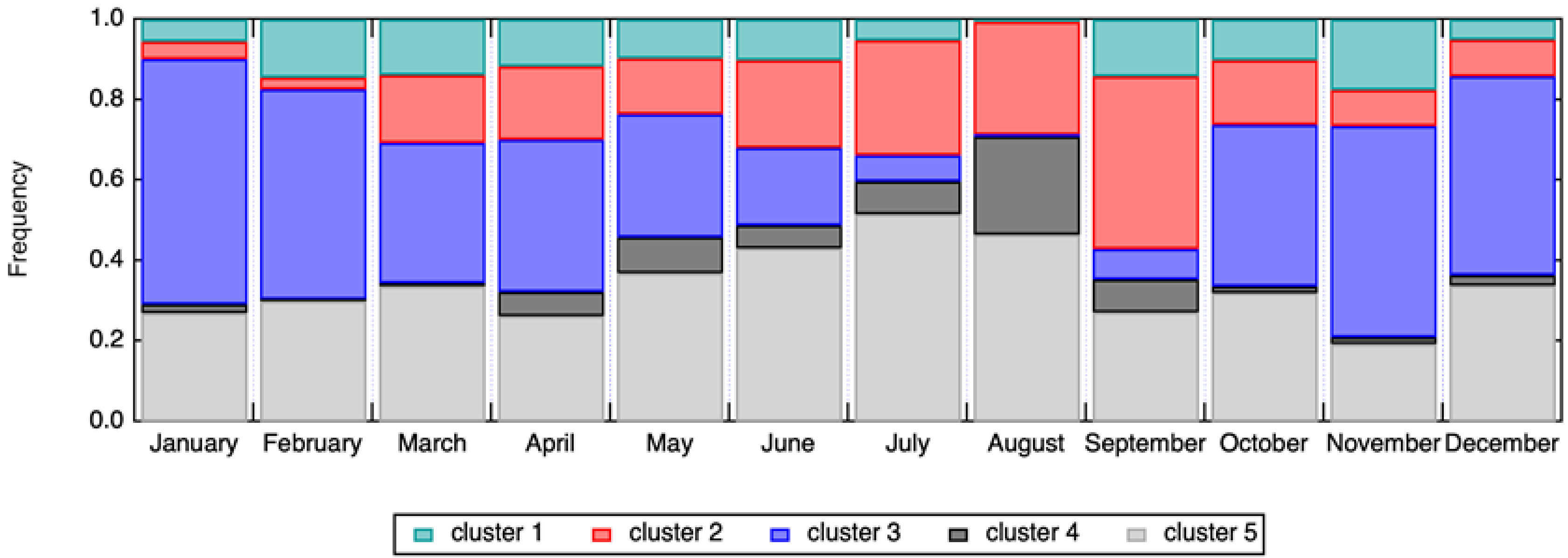
Analysis of seasonal behavior, HYSPLIT back-trajectories, etc.



Regional - large | Biogenic | Clean | Biomass burning | Regional - small

Temporal variability of the clusters

- “Clean” prevalent in winter
- “Biogenic” and “biomass burning” prevalent in the summer



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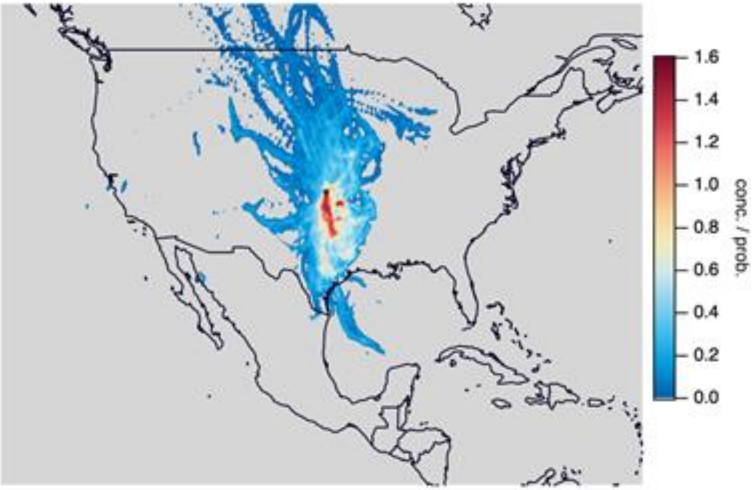
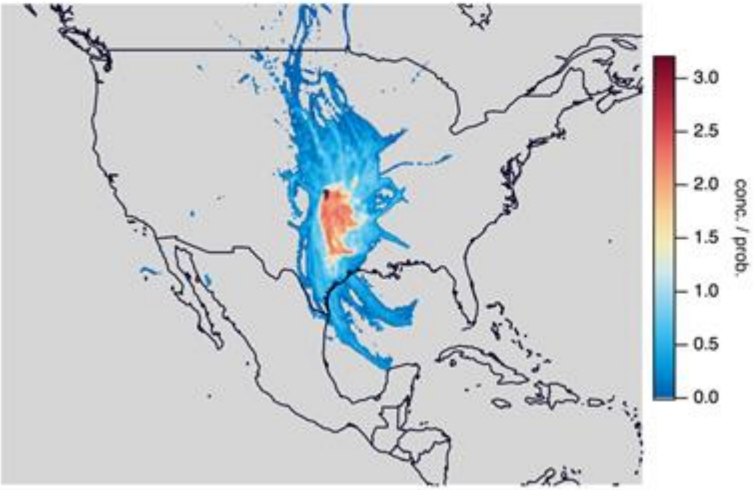
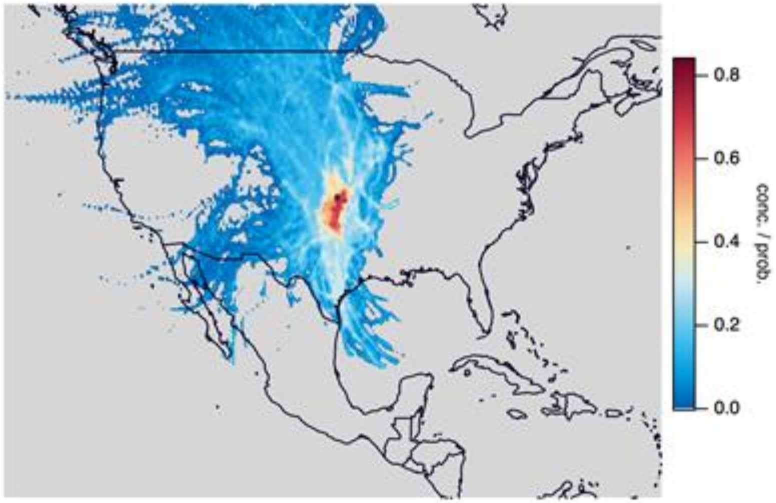
Regional - large



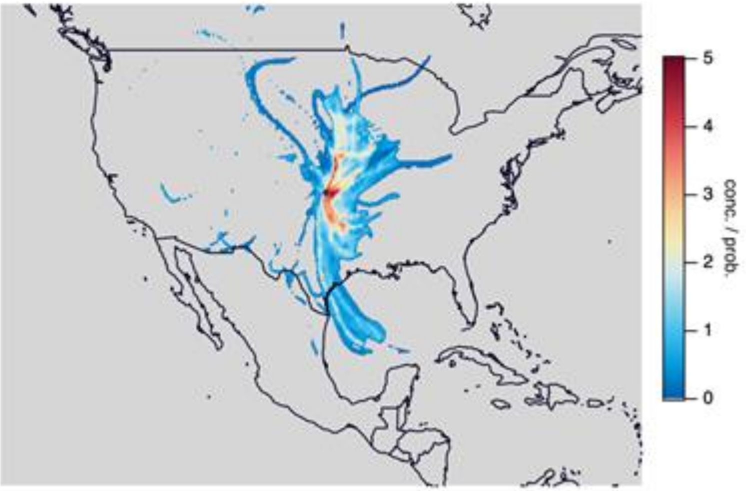
Biogenic



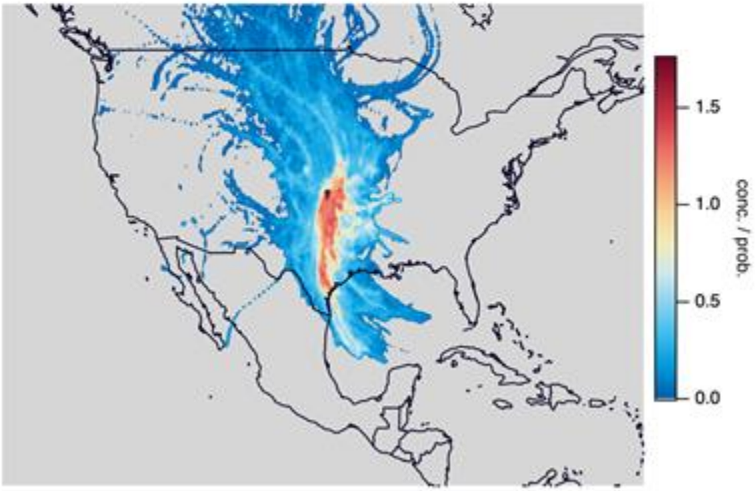
Clean



Biomass burning



Regional - small



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Connecting ARM aerosol measurements with the boundary layer and clouds

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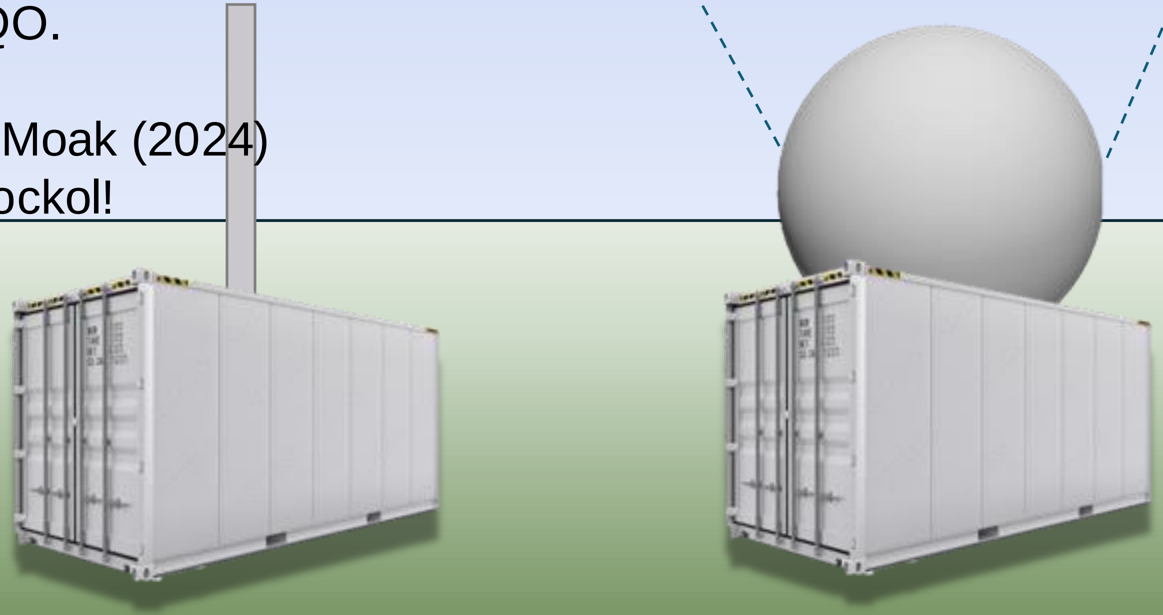
Linking AOS-measured aerosol properties to boundary layer clouds

- Goal is to identify conditions in which AOS-measured aerosol is representative of the boundary layer CCN.

- For now, we analyze SGP data collected in 2019.

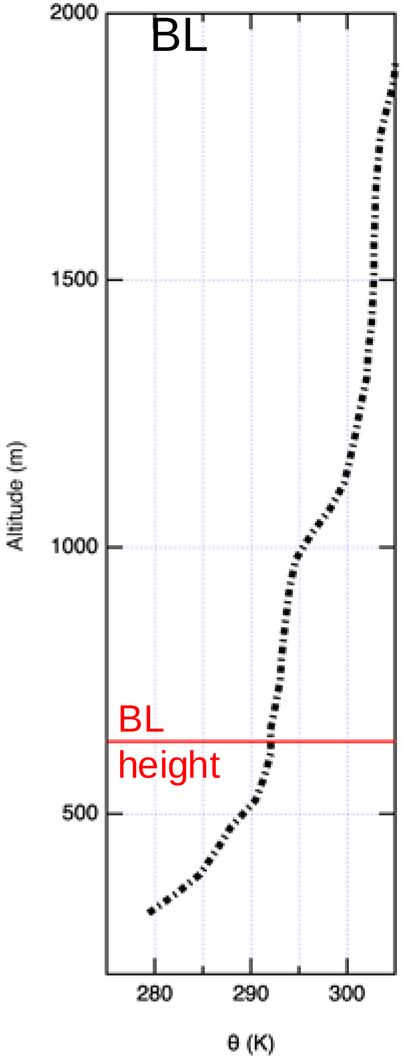
- This will enable comparisons between cloud-processed and not cloud-processed particle populations. *Chemical signatures of aqueous processing*

- A lot of this was done by University of Oklahoma students, under a new collaboration between our group and ARM DQO.
    - Reese Mischler (2023)
    - Tristen Anderson, Lucas Bush and Dane Moak (2024)
    - Huge thanks to Ken Kehoe and Alyssa Sockol!

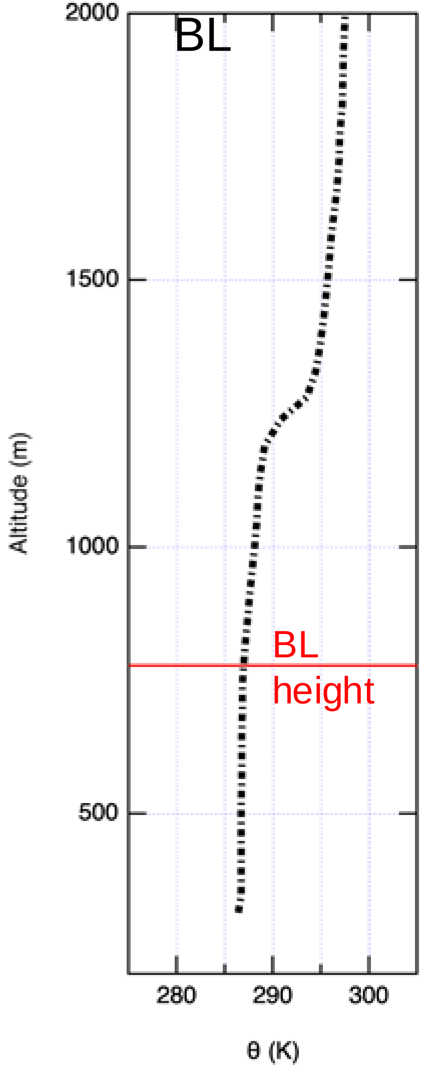


Step 1: Use radiosonde profiles to identify neutral boundary layer conditions

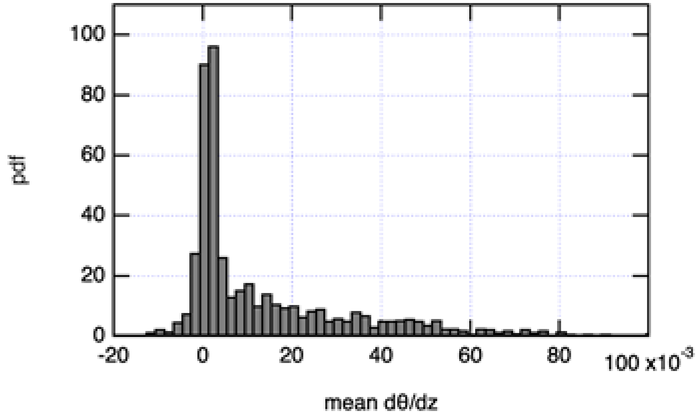
Stable BL

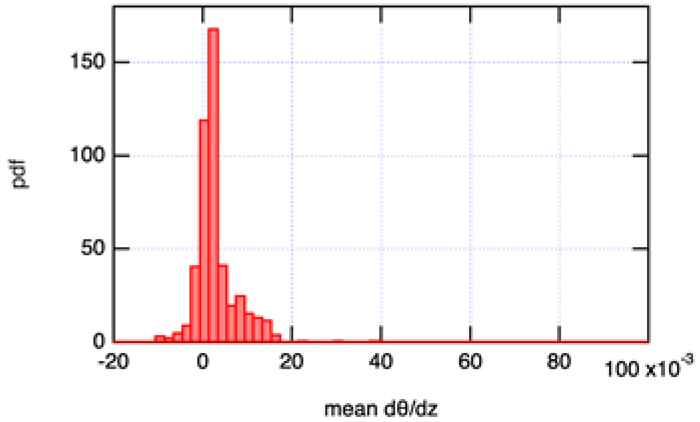


Neutral BL



Potential temperature lapse rate: all 2019 radiosonde launches



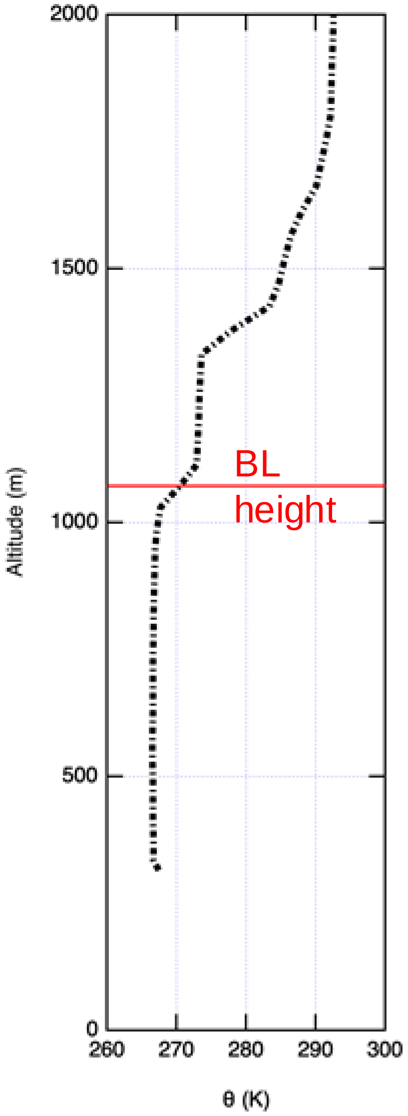


Potential temperature lapse rate: neutral BL cases

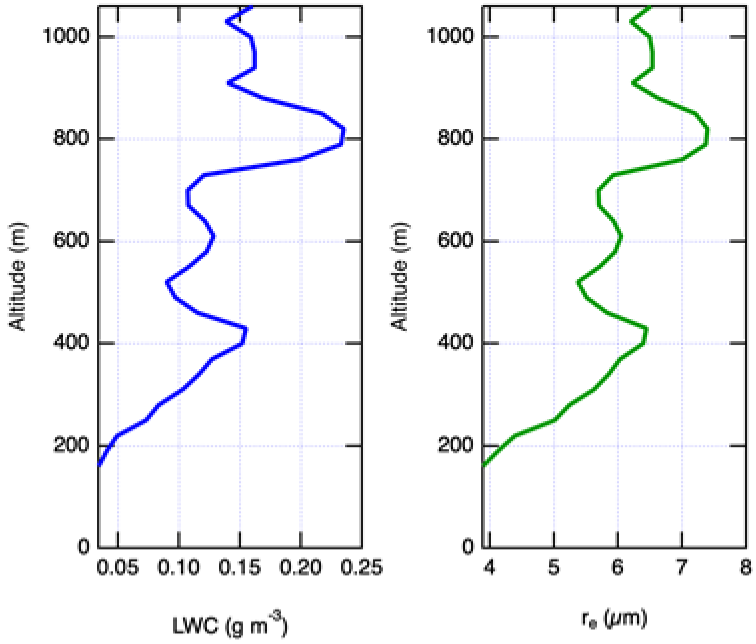
- From the ARM radiosonde profiles, select those with neutral BL flag (Liu & Liang method).

Step 2: Cloud properties during neutral BL conditions

ARM radiosonde product



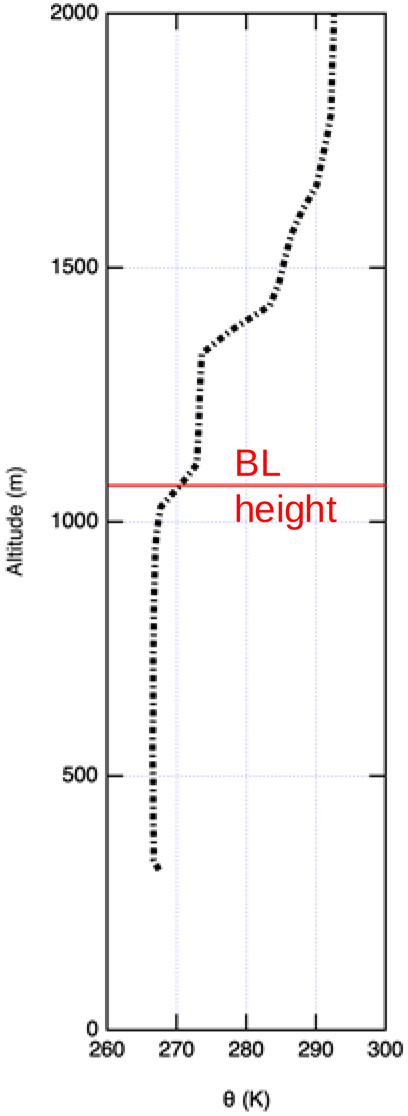
KAZR microbase product

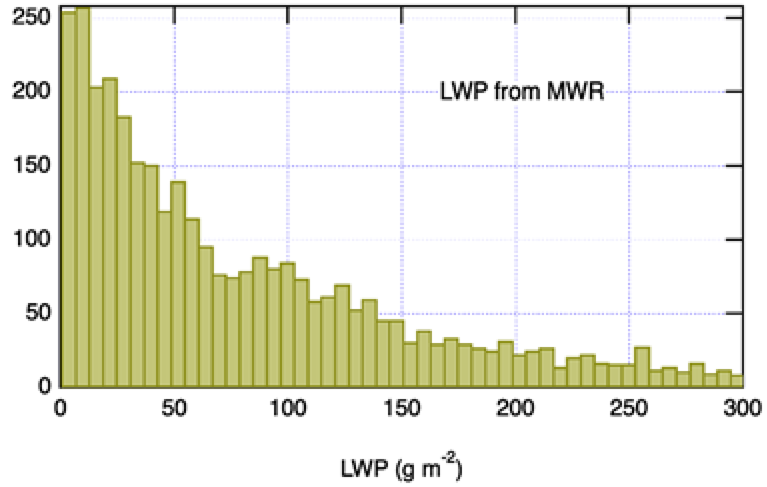


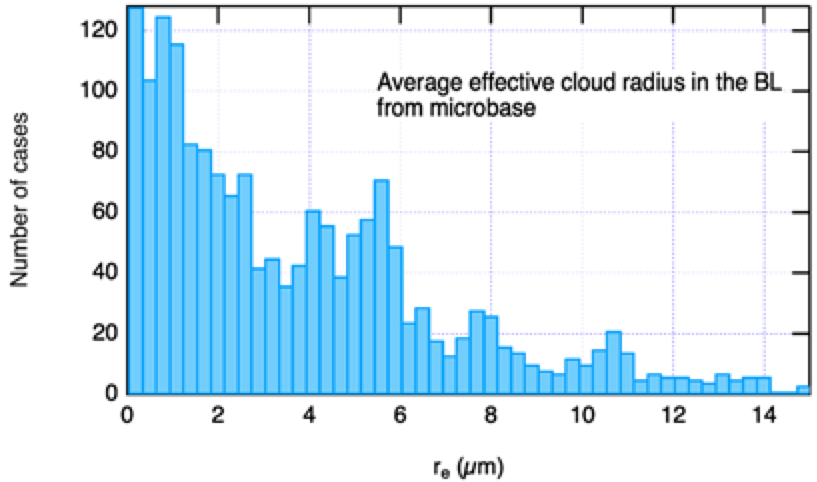
- From step 1, for identified neutral BL profiles, take times +/- 90 minutes around the radiosonde profile (assume the neutral BL condition persists for 3 hours), and partition AOS datasets and microbase microphysical datasets into time periods corresponding to neutral boundary layer conditions.
- For microbase LWC and equivalent droplet radius profiles, retain only altitudes < BL height.
- Filter out precipitation and clear sky conditions
- Use the ARSCL product to filter out multilayered clouds (we want single cloud layer, ideally contained mostly in the boundary layer)

Step 2: Cloud properties during neutral BL conditions

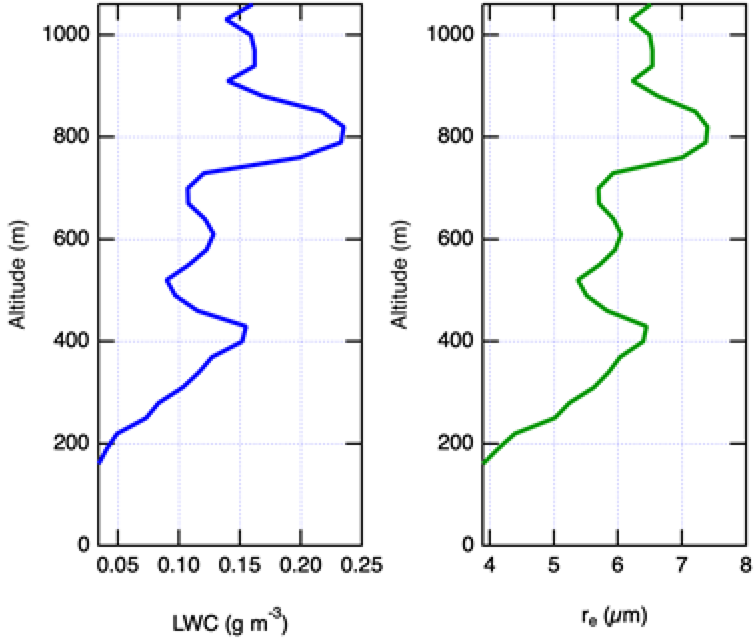
ARM radiosonde product







KAZR microbase product



Step 4: Quantifying ACI at SGP

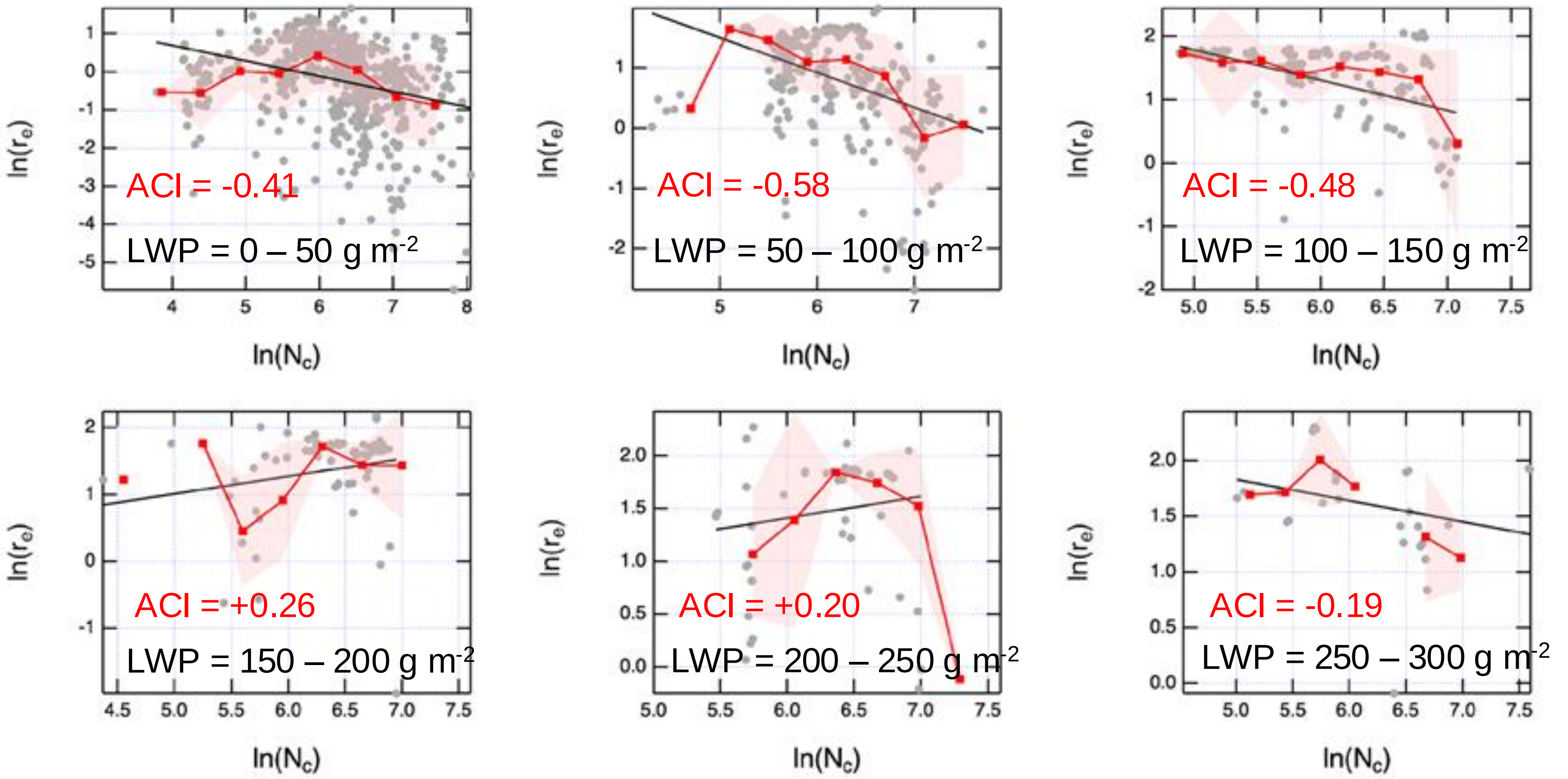
$$ACI_\tau = \frac{\partial \ln \tau_d}{\partial \ln \alpha}\bigg|_{LWP} \quad 0 < \mathrm{ACI}_\tau < 0.33 \qquad (1a)$$

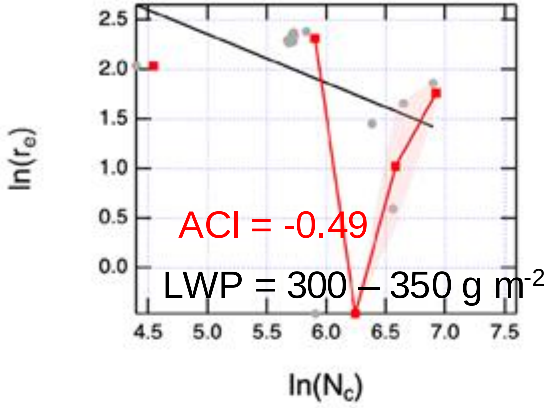
$$ACI_r = -\frac{\partial \ln r_e}{\partial \ln \alpha}\bigg|_{LWP} \quad 0 < \mathrm{ACI}_r < 0.33 \qquad (1b)$$

$$ACI_N = \frac{d \ln N_d}{d \ln \alpha} \quad 0 < \mathrm{ACI}_N < 1.0 \qquad (1c)$$

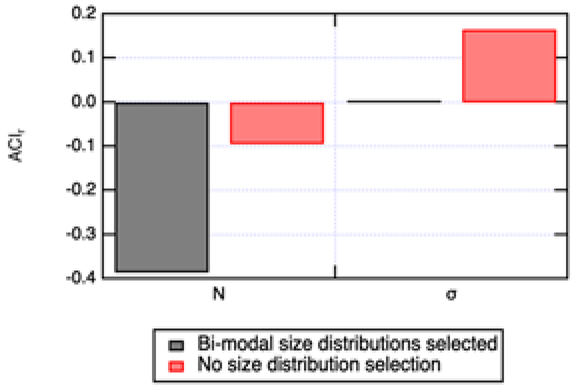
$$ACI_\tau = -ACI_r = \frac{1}{3} ACI_N \qquad (1d)$$

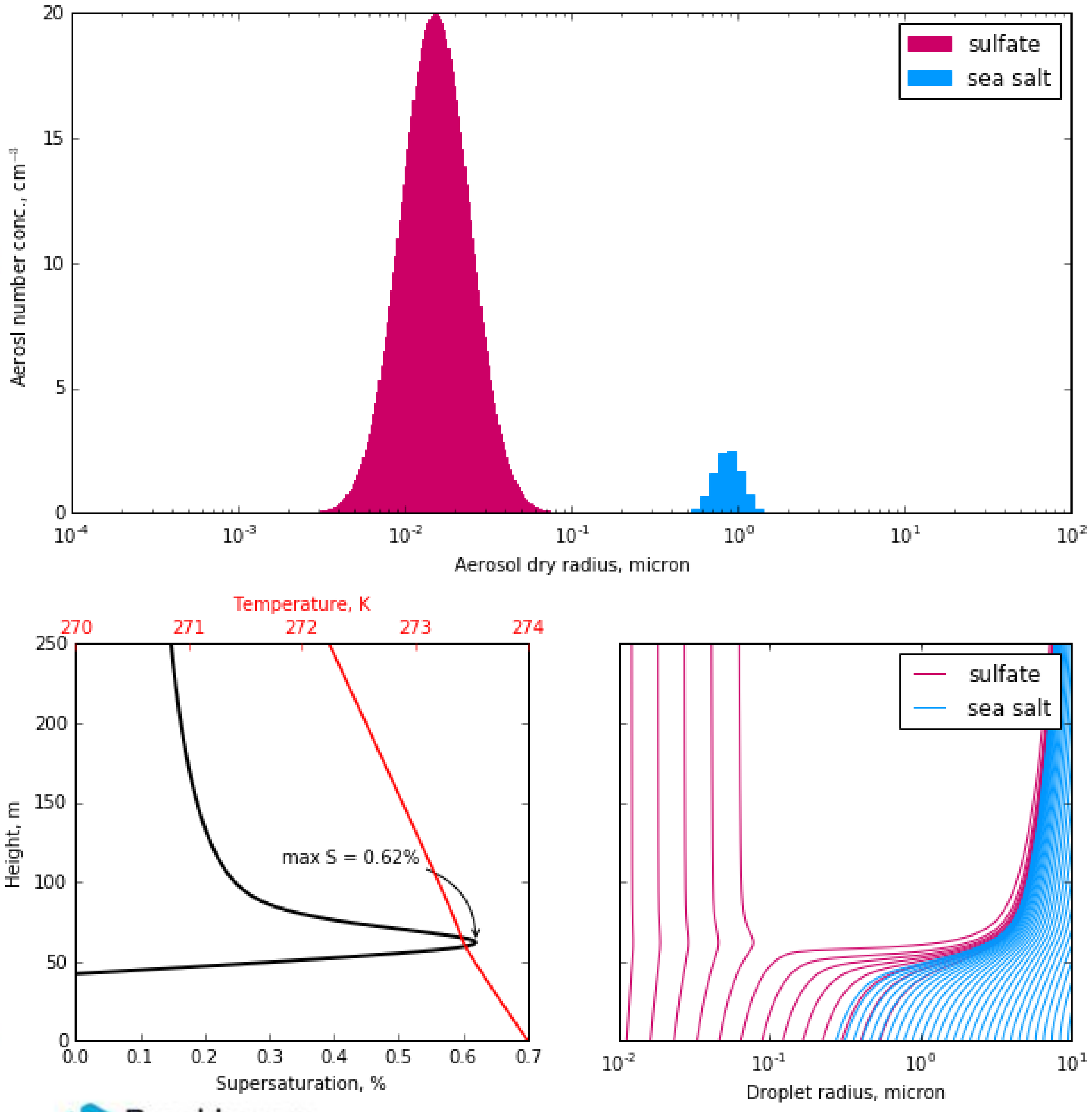
- Hypothesis: in steps 1-2, we identified cases in which aerosols interact with clouds. If we did this correctly, we can apply the methods from McComiskey et al. (2009) to quantify ACI relationships.
- The microbase product does not have cloud droplet number, but can use equivalent radius and equation 1b.





Average ACI$_r$ = -0.386





- This year, the students are adding a modeling component:
- We implemented a 0D adiabatic parcel model on ARM's Jupyter workbench
- The goal is to enable automatic ingest of ARM aerosol size distribution and kappa data into the model
- We will be able to then compare the model output to the radar-sensed cloud properties