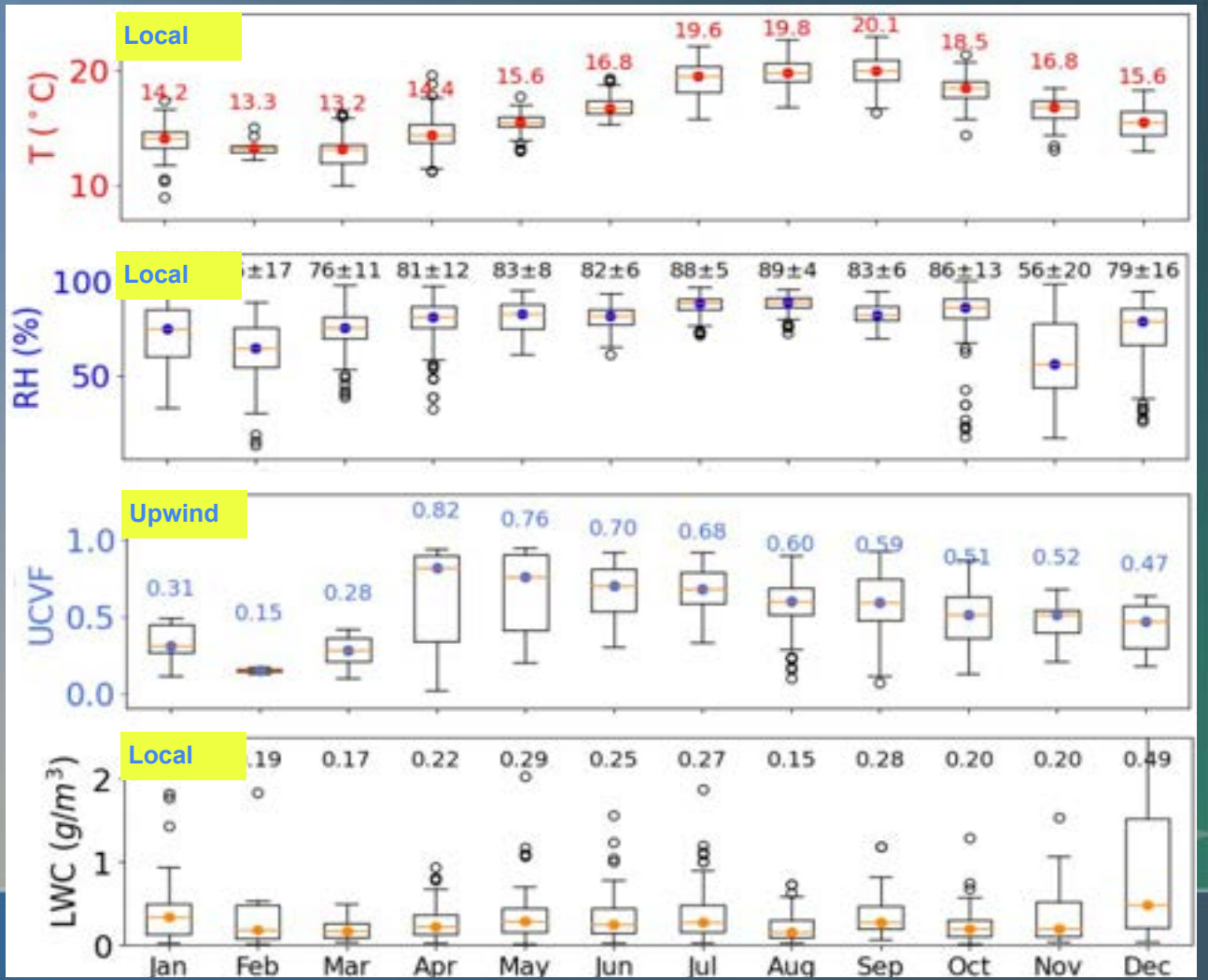
# Lightning Slides

## ARM/ASR PI Meeting Breakout Discussion

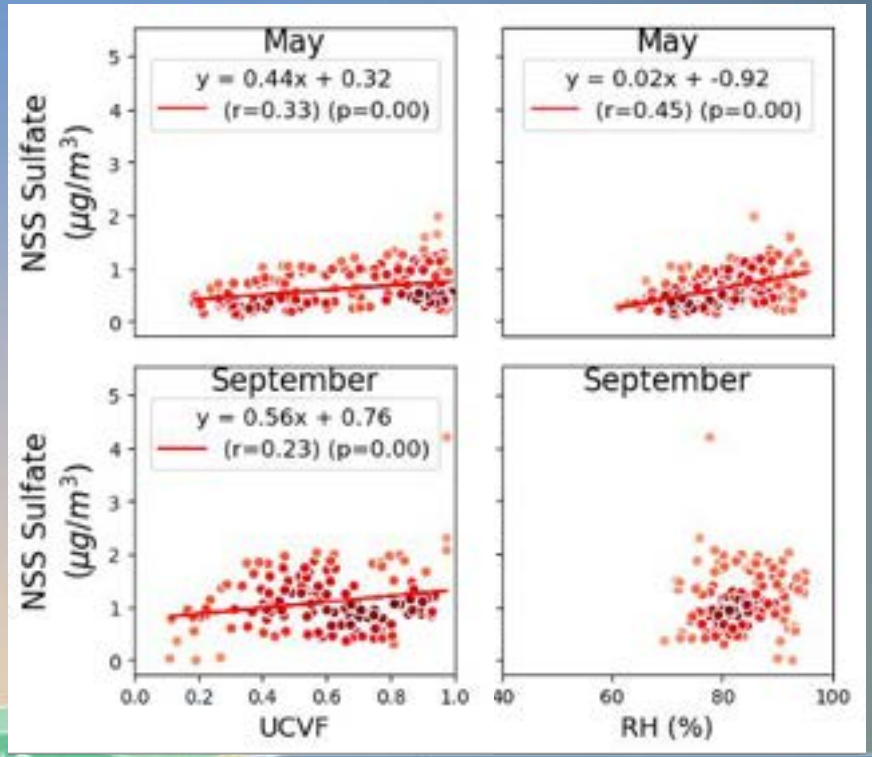
U.S. DEPARTMENT OF ENERGY | ASR Atmospheric System Research | ARM

# Climatology of Local and Upwind Meteorology and Clouds

**UCVF=1-CBH/CTH**
for 24h upwind



# Site-Specific Process Correlations Explain Variability for Regional Contributions – Compare to Global Models?




**Co-located variables indicate regional process contributions, explaining only some of the variability.**

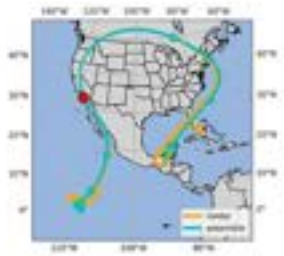
- **Retrieving similar variables from global models should explain similar amount of variability.**
- **Future work with site-specific sampling of global models could be applied to other ARM sites.**

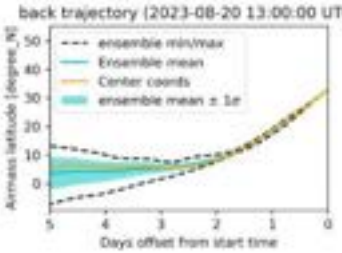
*What models would be appropriate?*

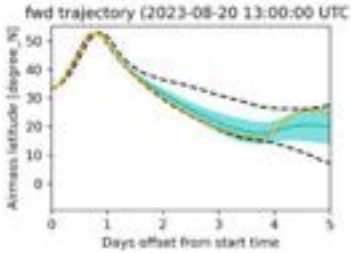
# ARMTRAJ (Trajectory Datasets) for EPCAPE

- **Four types of trajectory datasets for EPCAPE (figures from Silber et al., GMD, 2025)**

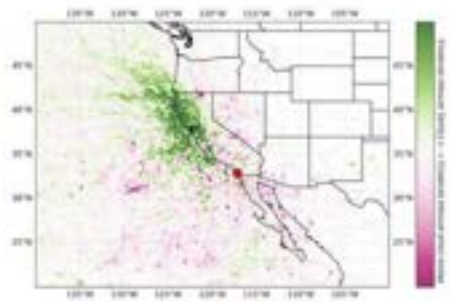
**Liquid (supersaturated) layers**



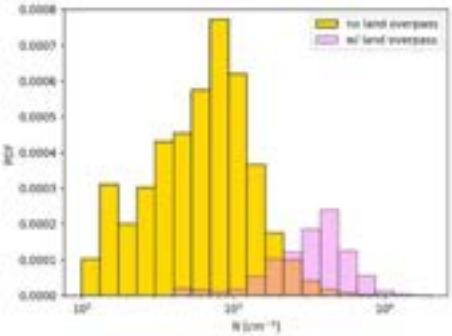


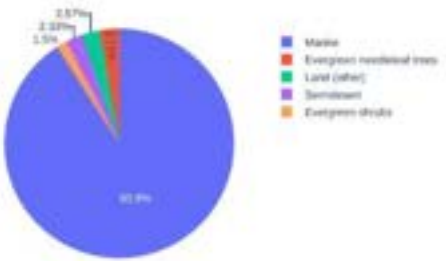

**Cloud decks**



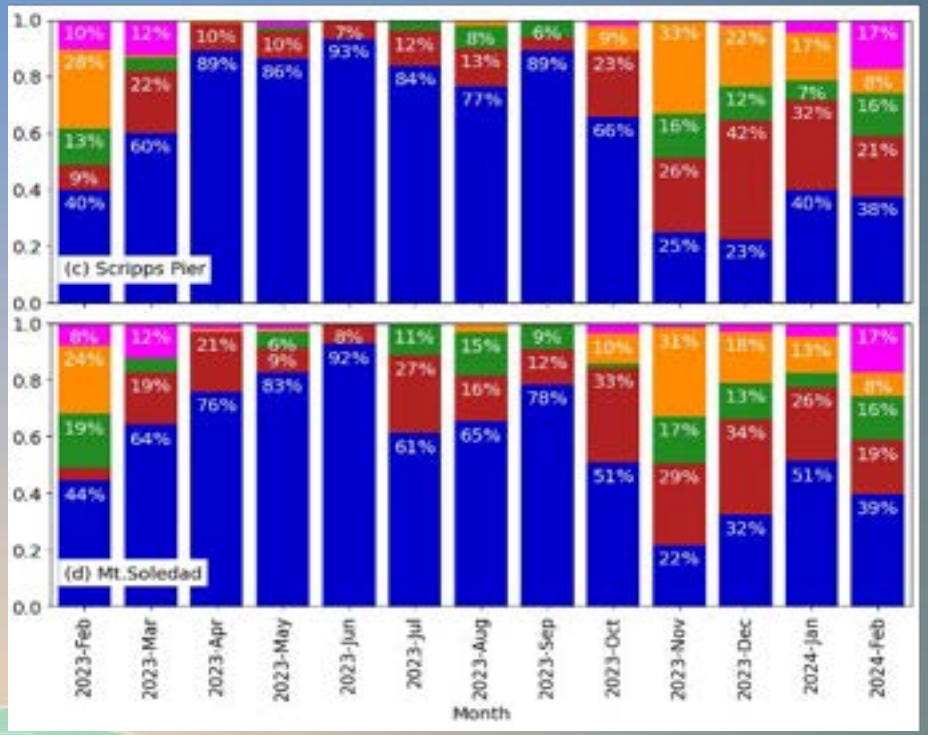
**Surface (aerosol)**

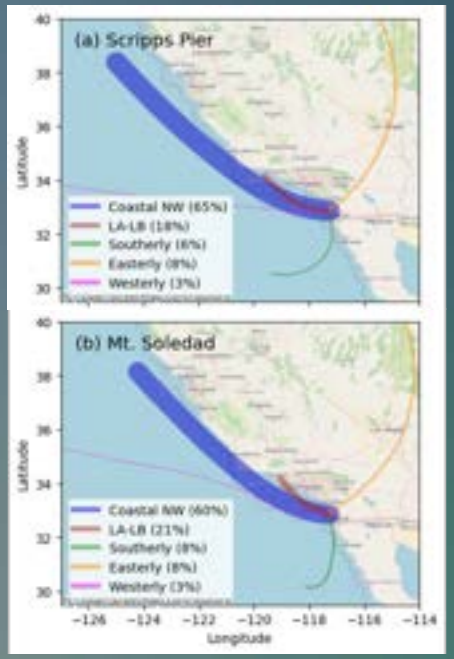



**PBL**



# Back Trajectories during EPCAPE



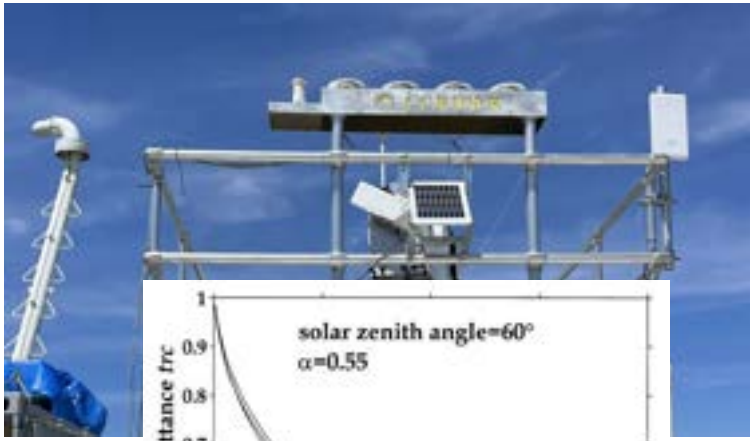



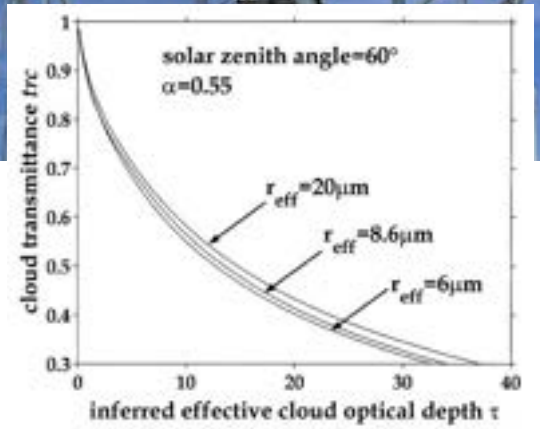

Five clusters indicate source regions for aerosols and clouds; Discuss consistency.

*See Silber et al. (2024); Han et al. (submitted).*

# Clouds and Climate Remote Integrated Deployment of Radiometers (CC-RIDER)

A Multifilter Radiometer Suite for Cloud Properties
Deployed on Mt Soledad 19 APR 2023-14 FEB 2024






The radiative transfer retrieval challenge
(Fitzpatrick et al., 2004, *J. Clim.*)

**Eppley Total Ultraviolet Radiometer**

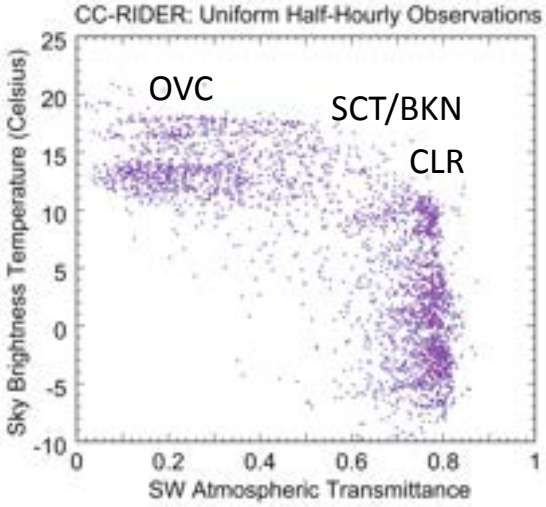
- Cloud conservative scattering optical depth

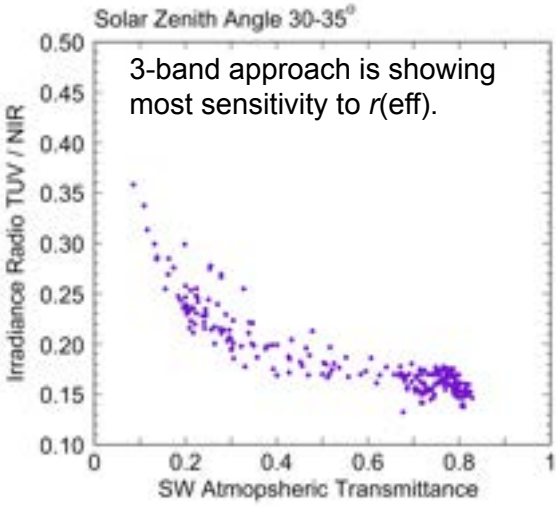
**Pyranometers (primary and backup) and Pyrgeometer**

- Shortwave and Longwave downwelling flux

**Pyranometer with 780-nm long pass filter**

- Near-IR sensitivity to cloud properties and ACI

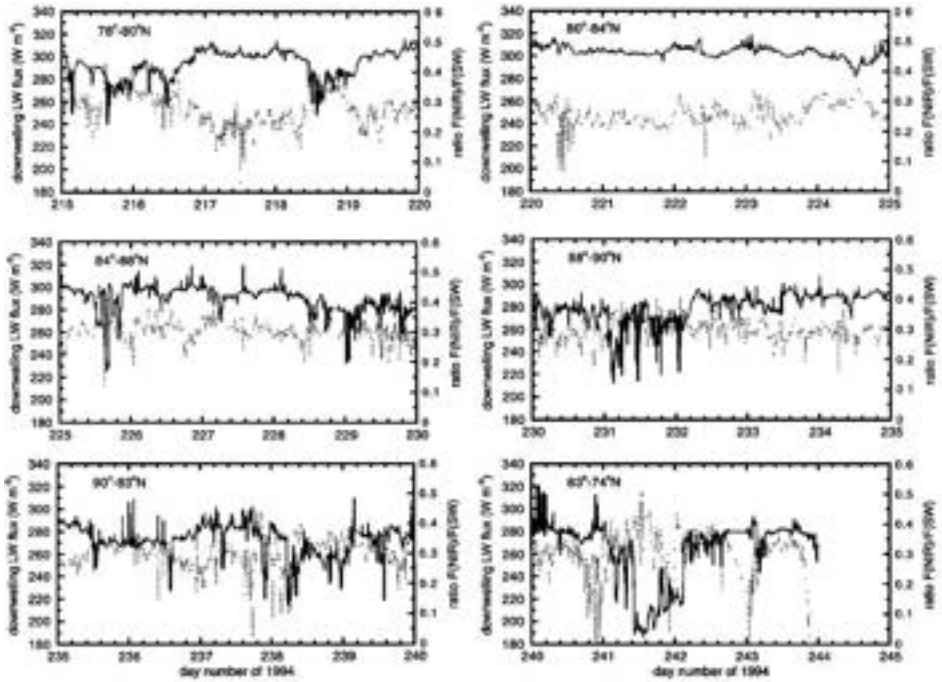


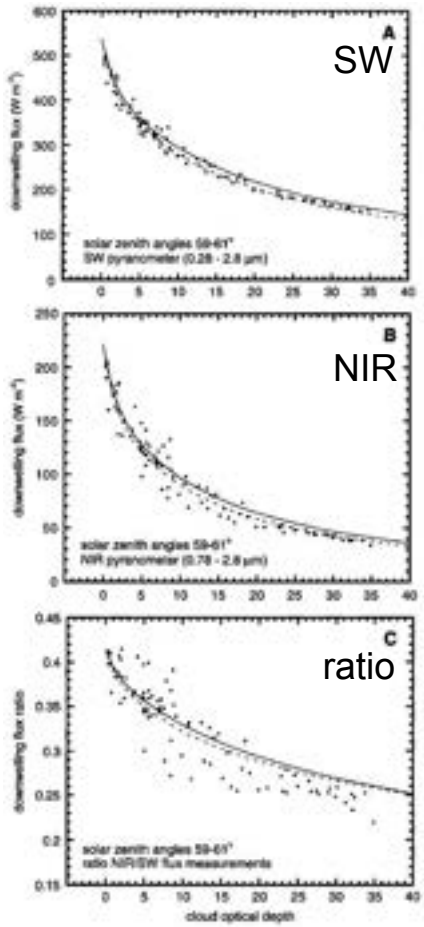



# Clouds and Climate Remote Integrated Deployment of Radiometers (CC-RIDER)

## Original Deployment with 1994 Arctic Ocean Section

USCGC *Polar Sea* at the North Pole




- Dotted curve shows flux ratio (NIR)/(full SW), solid is LW.
- Wide variability in flux ratio due to IWC influence.
- I was too young and stupid to fully appreciate and analyze this (Lubin & Simpson, 1997, *JGRd*).

NIR pyranometer (B) detects ~20 W $m^{-2}$ of ice absorption in Arctic stratiform clouds.

# Connecting Aerosol-Related Cloud Brightness to Turbulence using EPCAPE Measurements

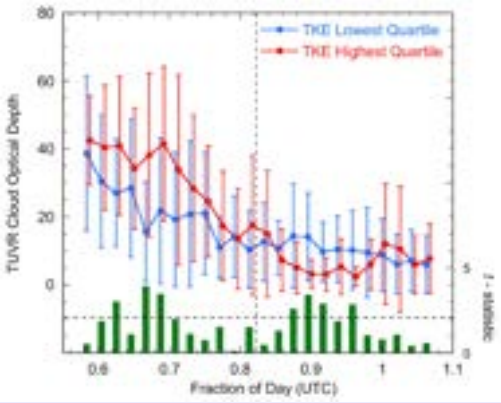
Mark A. Miller, Lynn Russell, Dan Lubin

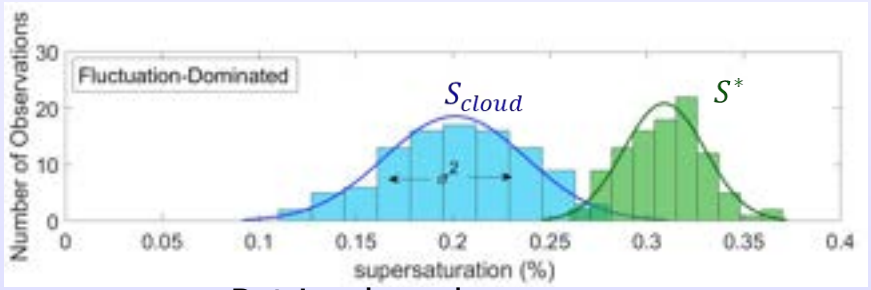
***We expect marine boundary layer cloud brightness to depend on the nature of the aerosol particles and the history of in-cloud processing through $S^*$ and local in-cloud turbulent conditions through $S$.***

H1: Are the distributions of $S$ and $S^*$ near the cloud base ***fluctuation-dominated*** and how is the ***Hoppel Minimum* (HM)** is manifested in these regimes?

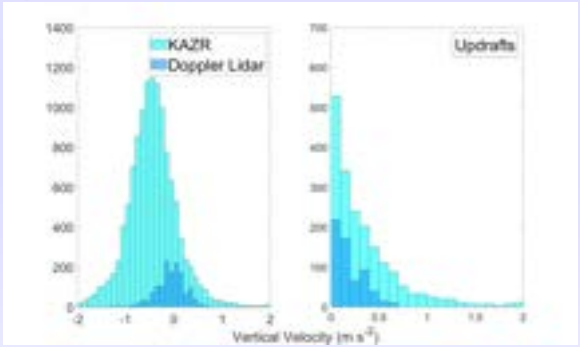
H2: Do the distributions of $S$ and $S^*$ change in response to changes in the TKE profile driven by diurnal decoupling?

Cloud Optical Depth and Turbulence

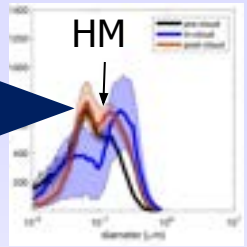



Tools




Mt. Soledad




Co: Jeramy Dedrick

Retrievals and Parameterizations

Siebert and Shaw, 2017

$$s_{qs} = \frac{a_1 w}{a_2 N_d r} = a_1 w \tau_{phase}$$

Yang et al. 2019

$$s = \frac{w}{2\pi G} \frac{\partial \ln LWC}{\partial z} \left( \frac{LWC}{\rho_l N_d} \right)^{2/3}$$

Collaborators?

Cloud Dynamics and Microphysics

# Can we detect and quantify in-cloud aerosol production from investigating cloud-drop residuals?

## Motivation/Hypothesis

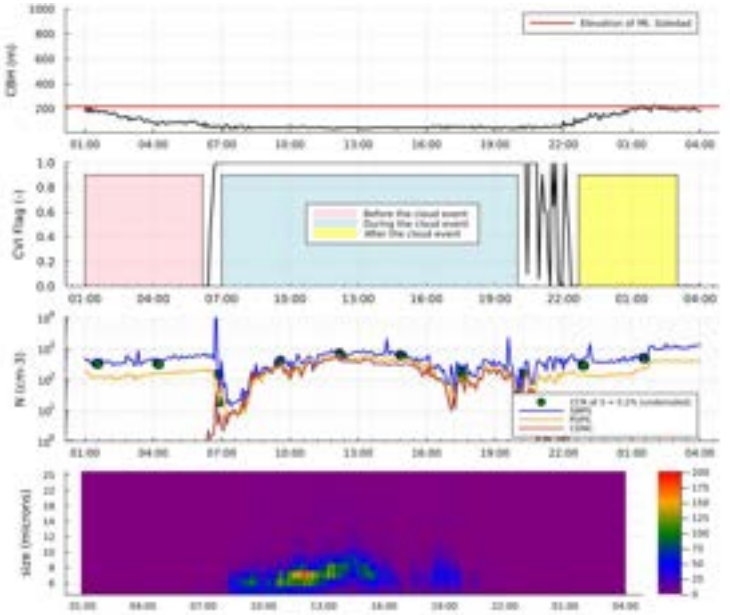
- In-cloud production of secondary inorganic and organic compounds adds to aerosol mass during cloud-processing.

## Approach

- Evaluate differences in hygroscopicity of sub-cloud aerosol and cloud-droplet residuals.

## Collaborative Opportunities

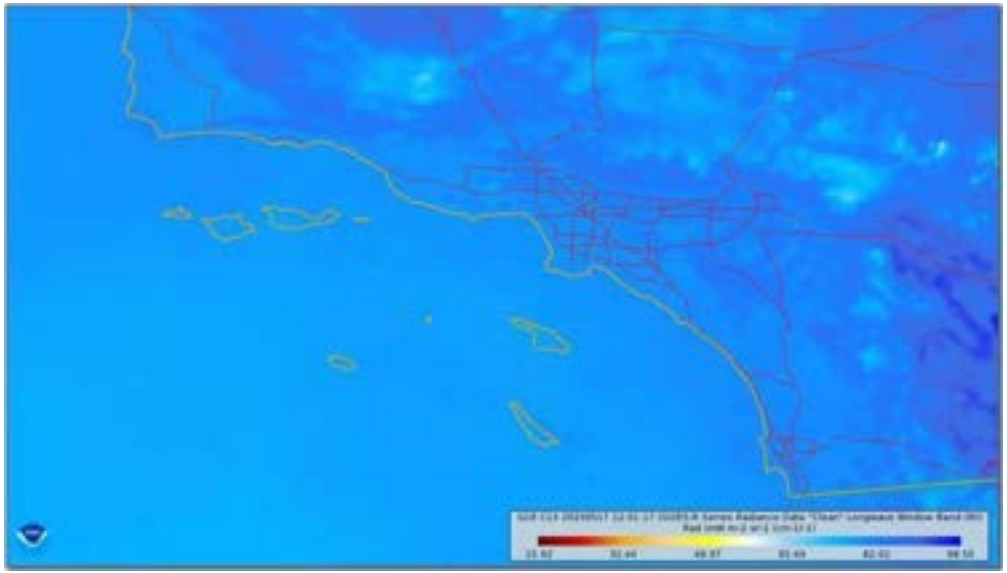
- Cross-correlation between the hygroscopicity results and any available tracers for cloud processing.
- Cross-correlation between hygroscopicity and aerosol mass-spectrometer data.
- Estimates of in-cloud lifetime for each cloud event.
- Model estimates of expected in-cloud aerosol production versus time (Feb through August).
- ...?



- **Cloud droplet spectra and aerosol spectra (SMPS > 30 nm, POPS > 150 nm) and size-resolved CCN before during and after a cloud event.**
- **Aerosol properties were sampled behind a CVI-Inlet to study cloud drop residuals.**

[Main Dataset: Cloud Condensation Nuclei and Printed Optical Particle Spectrometer Measurements at Mt. Soledad during EPCAPE 2023-24; Ravichandran/Petters et al., UC Riverside ]

# Example cloud event: 05/17 - 05/18 - 1:00 to 3:00

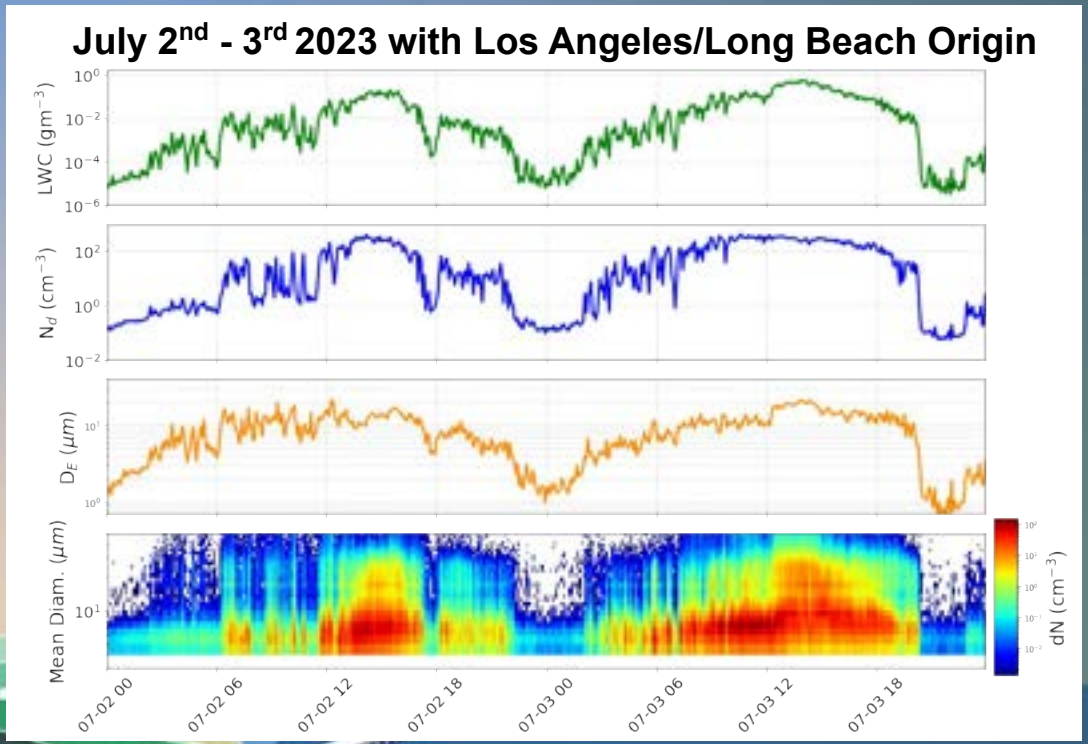


# GOES-W satellite imagery corroborates with in situ cloud droplet measurements from Mt. Soledad

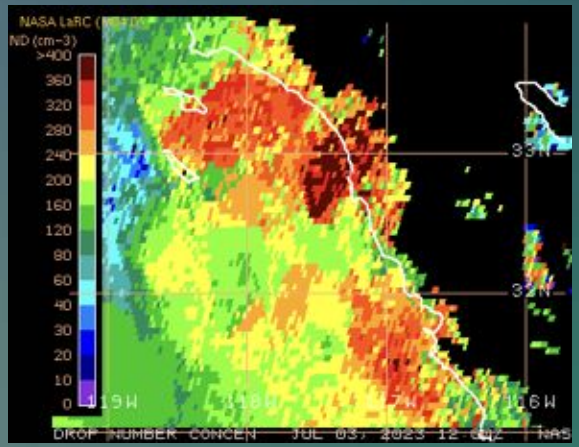


DALHOUSIE UNIVERSITY

## July 2nd - 3rd 2023 with Los Angeles/Long Beach Origin

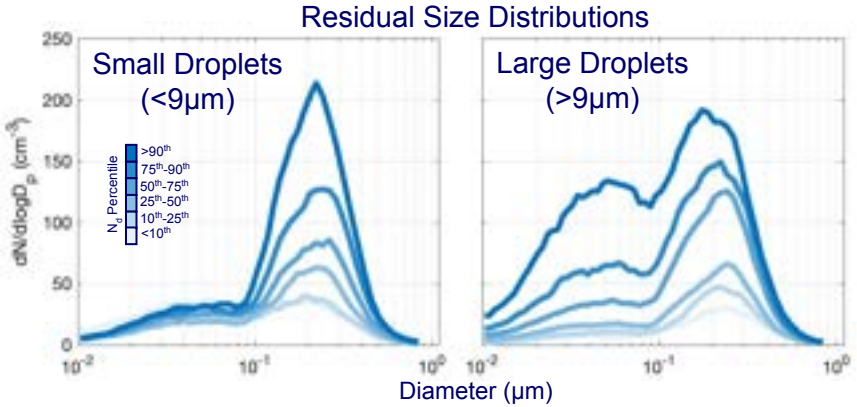


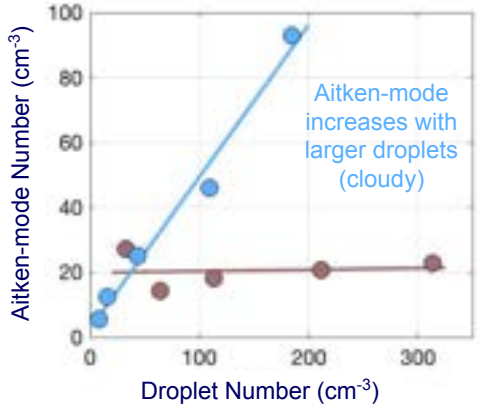

## July 3rd 12:00 UTC



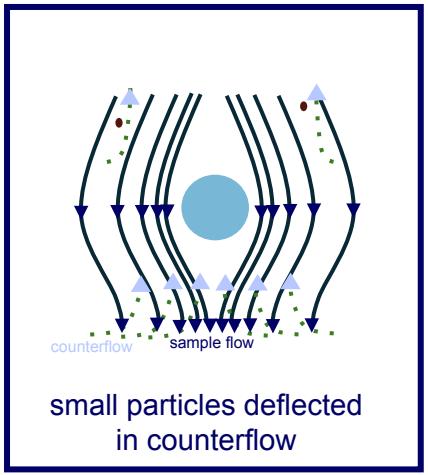

How well does the satellite-retrieved cloud LWC and $N_d$ agree with in situ droplet concentrations?

# CVI Operation and Efficiency

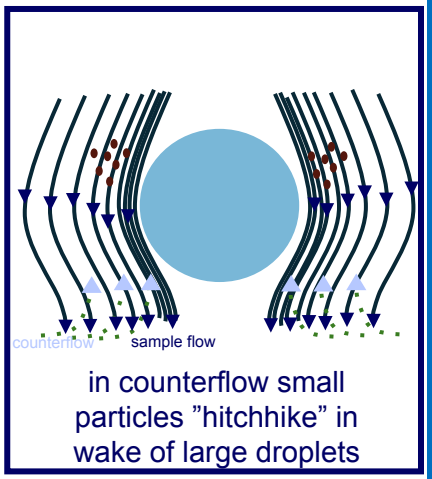



Aitken-mode unchanged for increases in small droplets (hazy)




small particles deflected in counterflow



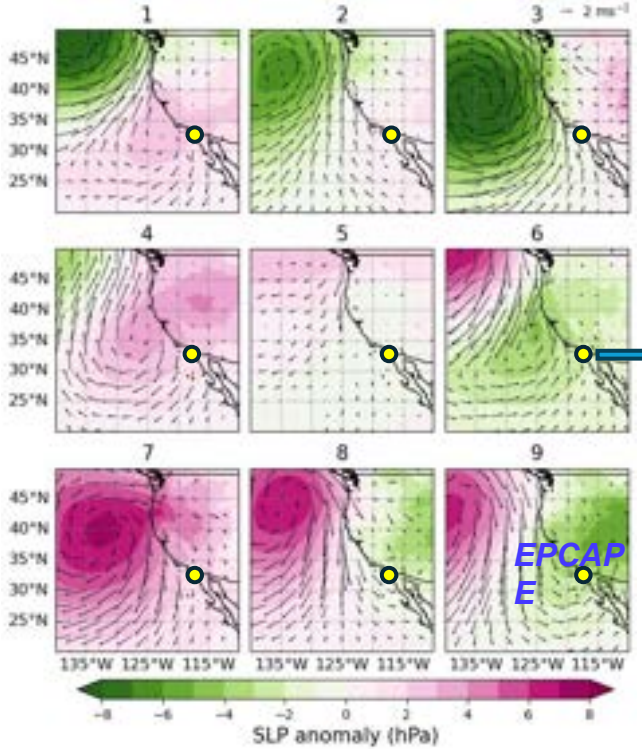

in counterflow small particles ”hitchhike” in wake of large droplets

In cloudy conditions, Hoppel minimum represents critical size of residual aerosol activated in >9μm droplets.

# Atmospheric regimes and drivers of cloud variability and aerosol-cloud-radiation interactions over the coastal northeast Pacific

Seethala Chellappan, David Painemal, Mandy Thieman, William Smith Jr. (NASA LaRC Team, DE-FOA-0002850)

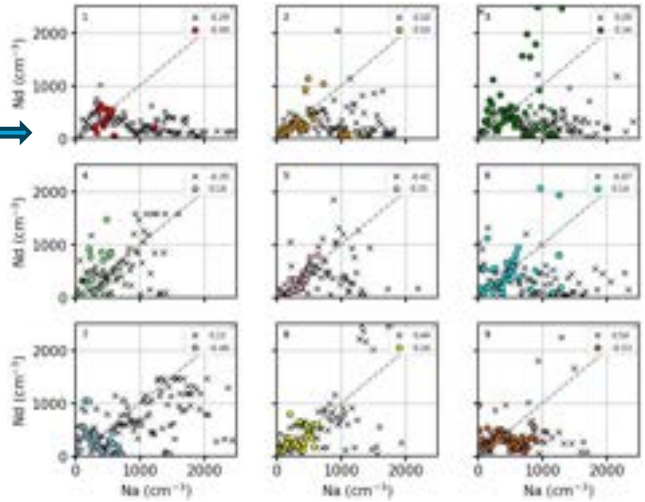
***Synoptic regimes based on Self Organizing Maps (SLP and 975 hPa winds)***




## Objectives

- Understand the control of coastal meteorology over cloud variability and aerosol transport at the EPCAPE site.
- Isolate the cloud response to aerosol concentration from the control of environmental factors through the use of atmospheric regimes.
- Determine magnitudes of aerosol-cloud interactions and cloud adjustments.

*Manuscript in preparation to be submitted to ACP in spring.*



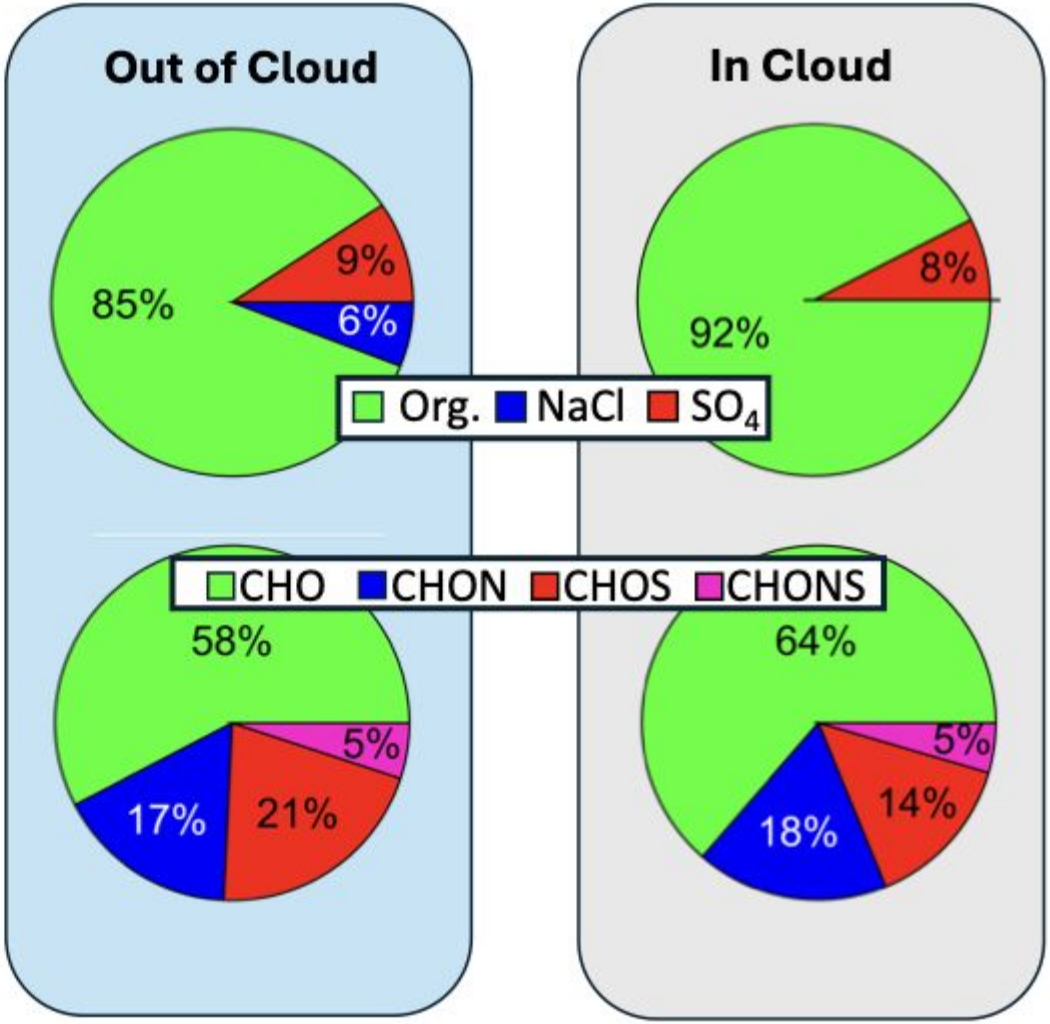

***Relationship between ARM Aerosol Concentrations and Cloud Droplet Number Concentrations at Scripps Pier for different atmospheric regimes***

**VAPs request:**

1. Cloud Optical Depth (SPHOTCOD) from Cimel Sunphotometer
2. Drizzle/Precipitation Rate from Ka band Zenith Radar (KAZR)

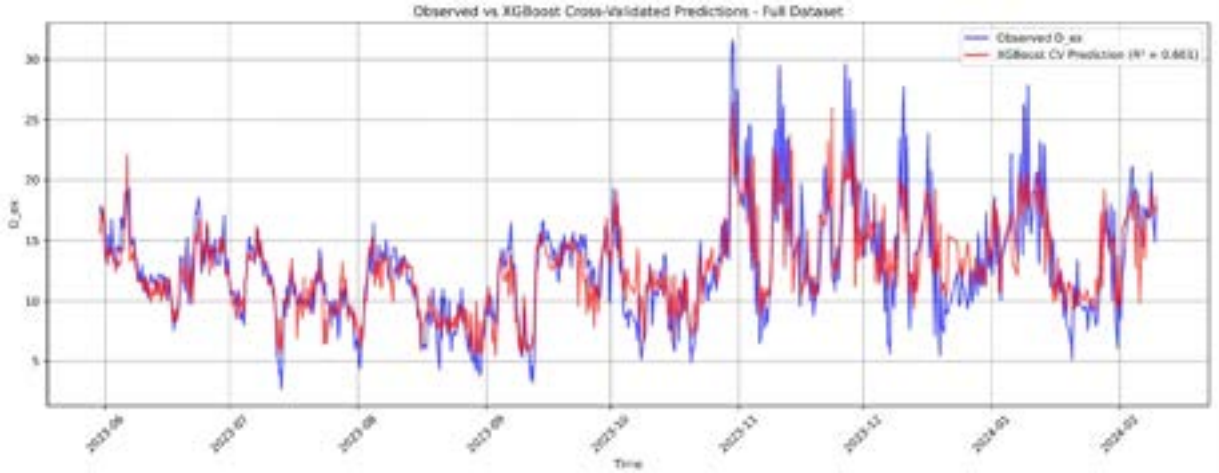
# Studying the impact of cloud processing on ultrafine aerosol composition (UC Irvine)

- Ultrafine particle composition was measured on Mt. Soledad using TDCIMS
- We compared composition of particles with similar origin (coastal air) when site was in-cloud to out of cloud.
- During periods in-cloud, ultrafine particles were missing NaCl that was present in out-of-cloud particles.
- Speciated organics were showed reductions in organosulfates and correspondingly higher oxidized organics.



# Understanding Water Vapor Isotopic Composition in Coastal Air Masses: An Information Theory Perspective

- **Nonlinear Controls:** Information theory captures complex relationships in water isotopes, revealing patterns missed by linear models.
- **Marine vs. Continental Differences:**
  - **Marine air:** Just **2 variables (RH & geopotential height)** explain **76% of isotopicvariability**.
  - **Continental air:** More complex interactions, with multiple variables explaining **<41%**.
- **Sea Surface Temperature (SST): Limited direct impact (7**




**Machine Learning Validation:** Gradient boosting confirms information theory results, achieving an **$R^2$ of 0.77** for marine air and **0.63** for continental air.

## Implications

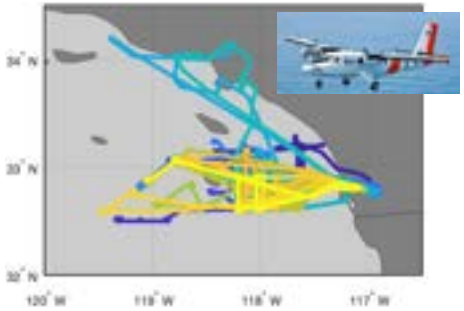
- **D-excess is shaped by both local and large-scale processes.**
- **Marine environments follow simpler rules, while continental influences introduce complexity.**
- **Information theory provides a robust framework for studying atmospheric water cycle dynamics.**

**EPCAPE-ISO: Measurements of water vapor isotopic composition during EPCAPE**

**PI: Joe Galewsky, University of New Mexico, galewsky@unm.edu**

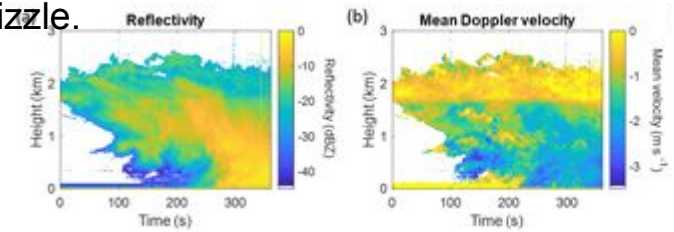
# Opportunities for EPCAPE-SCILLA collaboration

- Flights sampled PBL/LFT upwind of EPCAPE (50-150 km W of Pier)
  - Many flights overpassed Pier, but no dedicated sampling
- Broad range of aerosol and trace gas measurements:
  - Non-refractory aerosol composition (AMS; R. Bahreini, UCR)
  - Aerosol size distribution (SEMS, PCASP; A. Metcalf, Clemson)
  - Secondary aerosol formation (OFR; D. Collins, UCR)
  - Refractory particle characterization (SP2; A. Metcalf, Clemson)
  - $H_2O$ isotopes (L. Welp, Purdue)
  - $NO_x$, $CO_2$, $O_3$ concentrations (D. Collins, A. Metcalf)
  - CVI for sampling of drop residuals
- Plus detailed in situ cloud/drizzle DSD, turbulence, radiation, and thermodynamic measurements
- Merged 1 Hz measurements uploaded as PI product to ARM Archive, 10 Hz and sub-1 Hz data (AMS, SEMS) to be uploaded in next month or two
- Contact Mikael Witte (mikael.witte@nps.edu) for more info



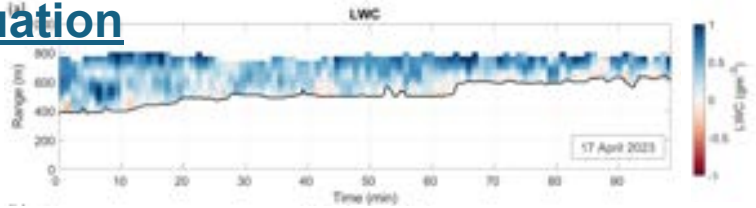
## G-band Radar Demonstration for Microphysics (PI: Matt Lebsock)

- Small field campaign: March – April (2023)
- Goal: demonstrate the utility of G-band Doppler radar for measuring cloud and drizzle.



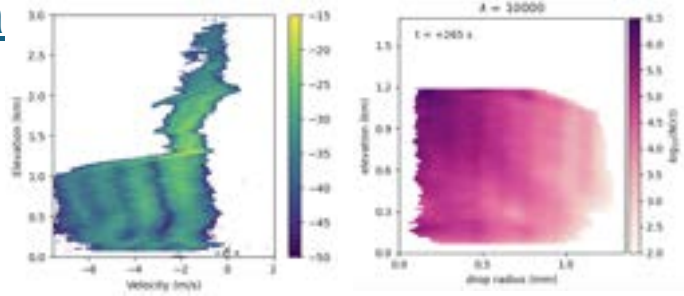

Socuellamos, et al.,
https://doi.org/10.5194/essd-16-2701-2024.

## Profiling cloud LWC with G/Ka band differential attenuation




Socuellamos et al.
https://doi.org/10.5194/amt-17-6965-2024.

## Profiling raindrop DSD with G-band Doppler Spectra

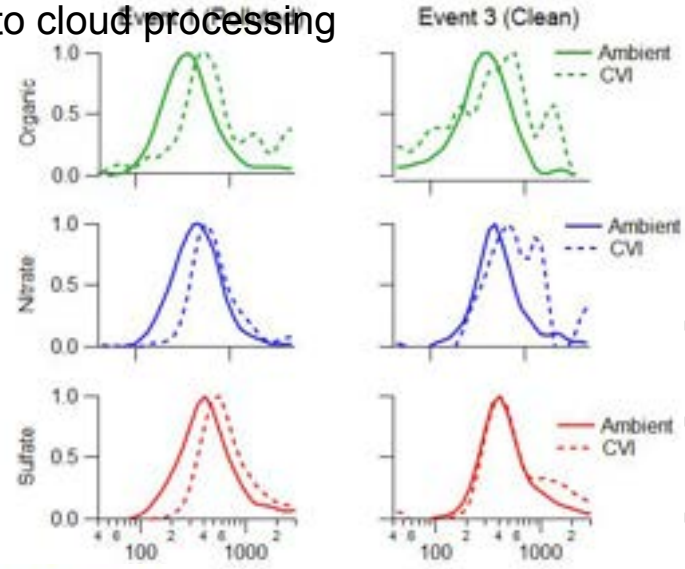


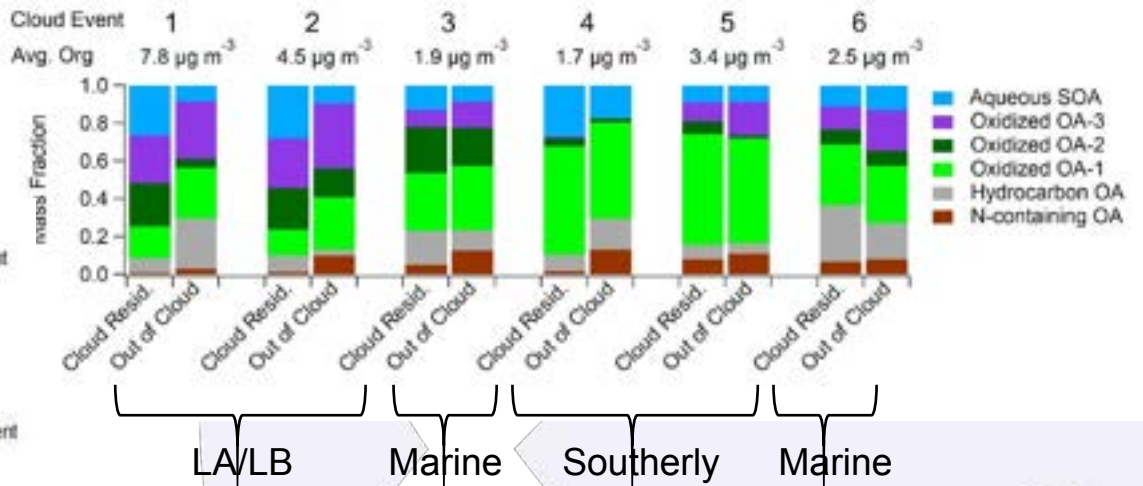

Yurk et al.,
Vertical Wind and Drop Size Distribution Retrieval with the CloudCube G-band Doppler Radar, in review

# In-Cloud Sampling at Mt. Soledad

Ryan N. Farley, Kyle Gorkowski, James Lee, Katherine Benedict, Abu Sayeed Md Shawon, Nevil A. Franco, Manvendra Dubey, Allison C. Aiken

- Sampled from Oct-Nov 2023
- Positive Matrix Factorization identified an aqueous phase secondary organic aerosol related to cloud processing




- Los Alamos AMS had a **$PM_{2.5}$ inlet,** instead of the typical $PM_1$ inlet.
- A clear shift was seen to larger particle sizes when sampling behind the CVI
- 20-50% of aerosol mass was seen between 1 and 2.5μm in the cloud residuals

# Discussion Questions

(1) What relationships exist between mesoscale variations in cloud structure, the cloud top radiation budget, and maximum supersaturation?

(2) How is aerosol processing by clouds, as indicated by the Hoppel Minimum, related to the cloud top radiation budget?