EPCAPE

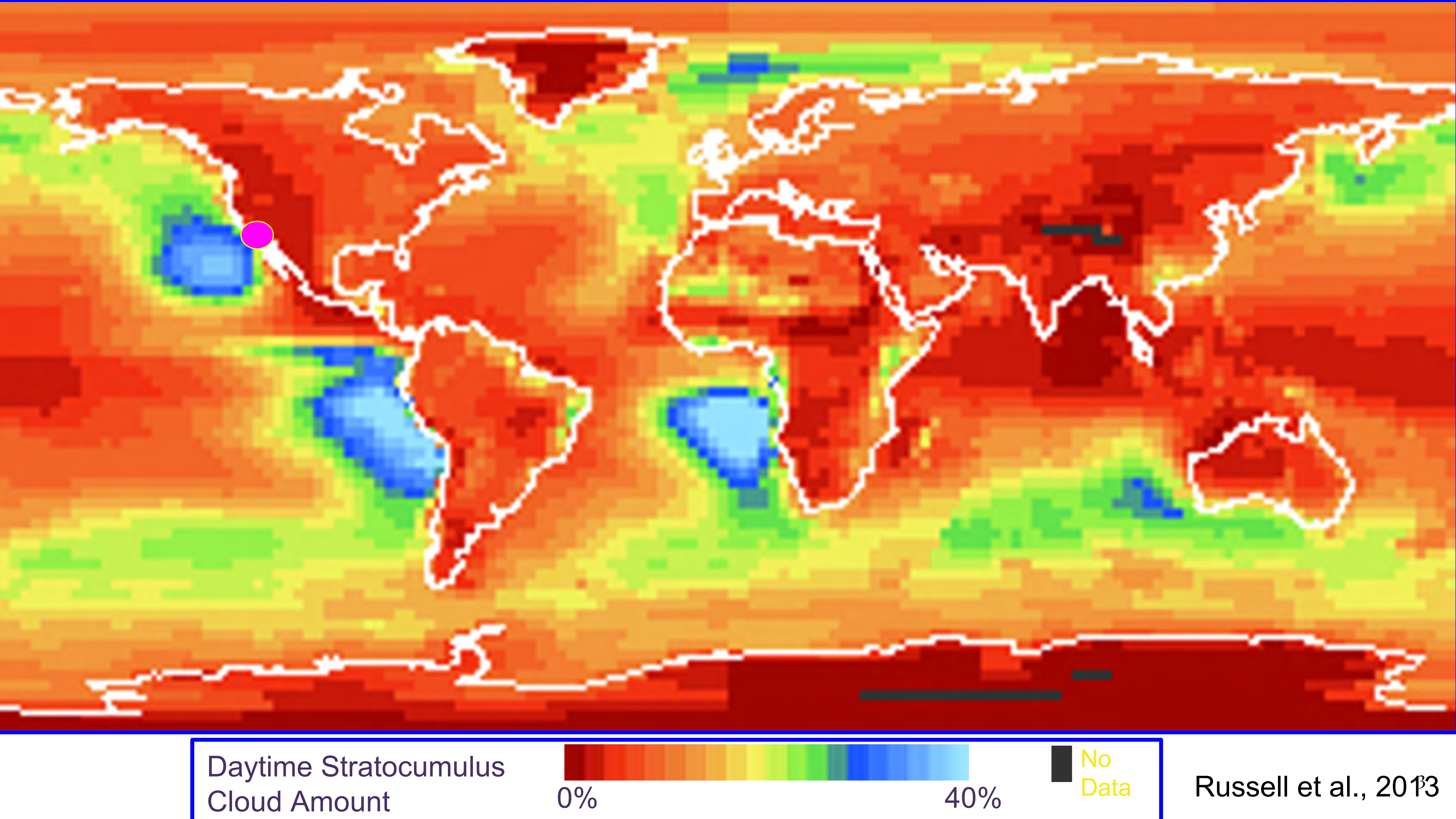
Eastern Pacific Cloud Aerosol Precipitation Experiment
DOE ARM AMF1 Deployment: February 2023 - February 2024
La Jolla, California: Scripps Pier and Mt. Soledad

Lead Scientist Lynn Russell: lmrussell@ucsd.edu

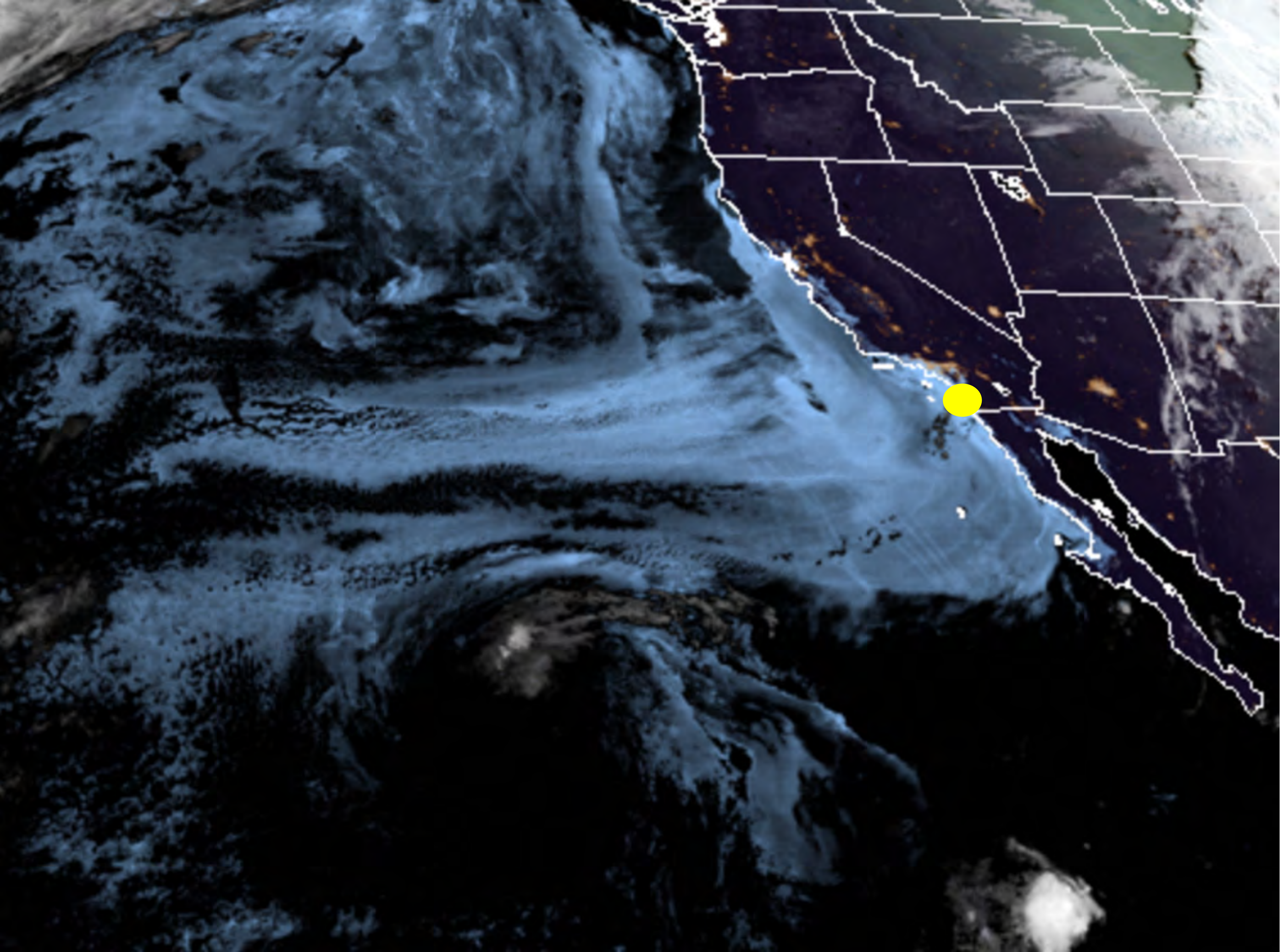
https://www.arm.gov/research/campaigns/amf2023epcape

EPCAPE Co-Investigators (Science Team is open to new researchers)

Dan Lubin, Scripps Institution of Oceanography, UCSD
Israel Silber, Pennsylvania State University
Ed Eloranta, University of Wisconsin
Johannes Muelmenstaedt, Pacific Northwest National Laboratory
Susannah Burrows, Pacific Northwest National Laboratory
Allison Aiken, Los Alamos National Laboratory
Die Wang, Brookhaven National Laboratory
Markus Petters, North Carolina State University
Mark Miller, Rutgers University
Andy Ackerman, Goddard Institute of Space Studies
Ann Fridlind, Goddard Institute of Space Studies
Mikael Witte, Joint Institute for Regional Earth System Science and Engineering, UCLA
Matt Lebsock, Joint Institute for Regional Earth System Science and Engineering, UCLA
David Painemal, Langley Research Center
Rachel Chang, Dalhousie University
John Liggio, Environment and Climate Canada
Michael Wheeler, Environment and Climate Canada



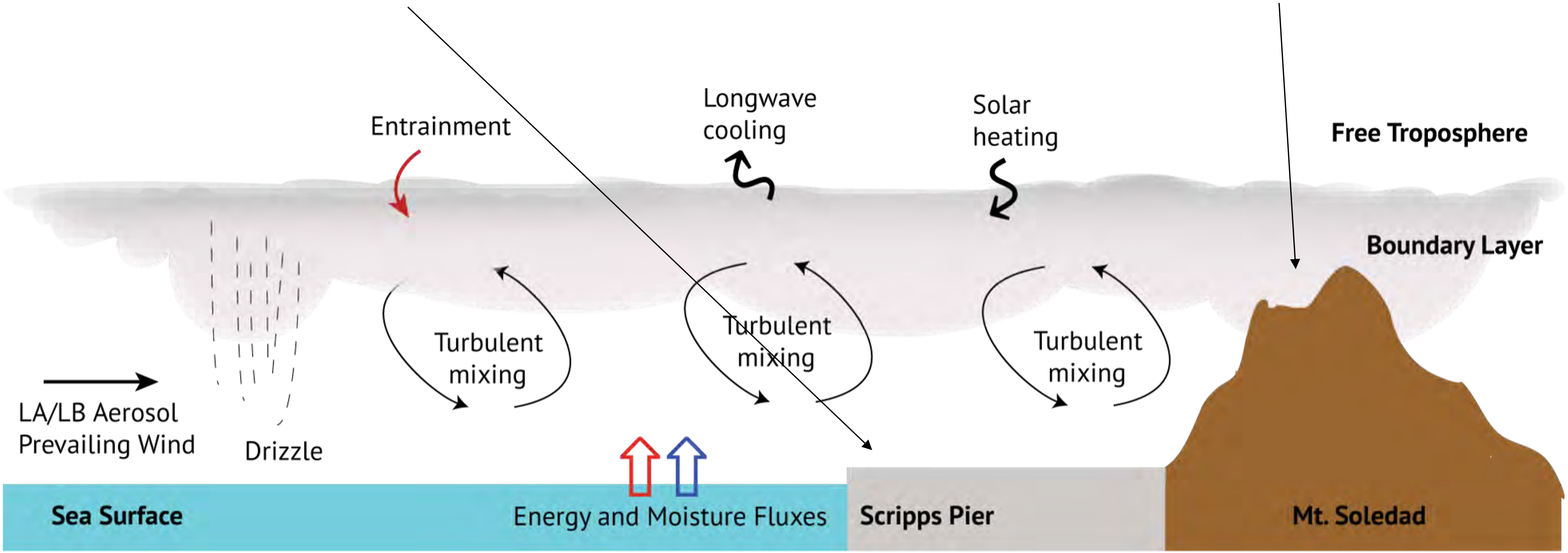
Russell et al., 2013



EPCAPE: DOE-AMF1, NSF-Soledad, ECC

AMF 1
in-situ aerosol measurements + remote sensors

EPCAPE-CCC
size distributions, detailed aerosol chemistry, comprehensive CCN measurements, CDNC estimates

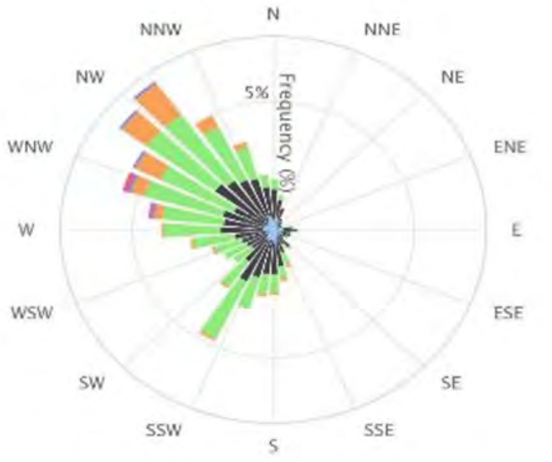


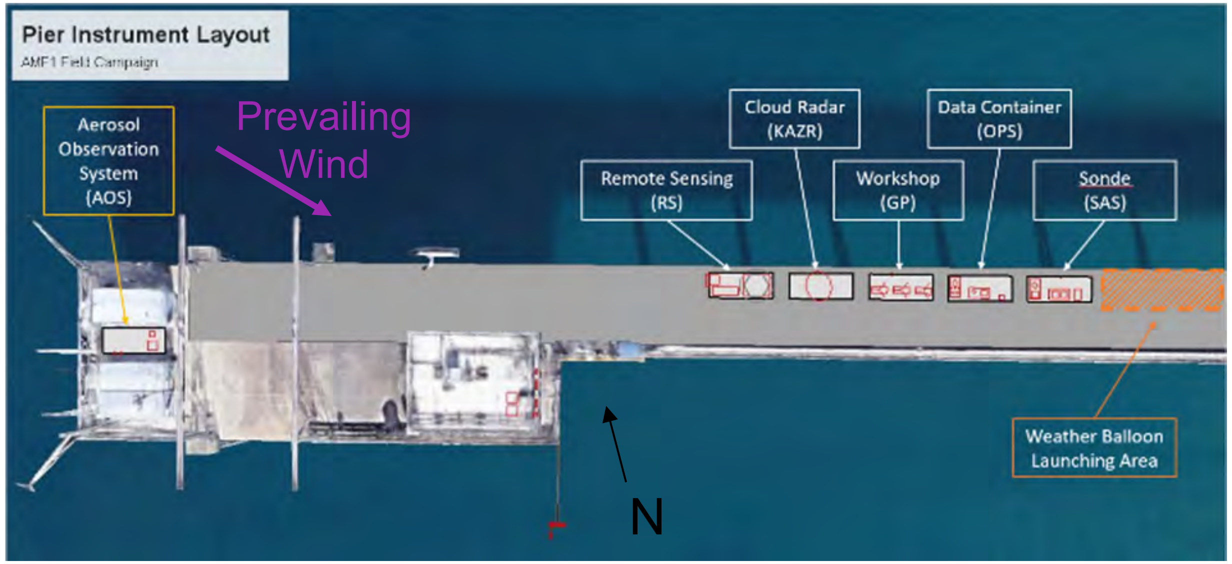
EPCAPE-CCC will provide additional information about the vertical mixing of aerosol, aerosol properties near cloud base, cloud droplet number concentrations, and in-cloud supersaturations.

Pier Deployment Site

Scripps Pier (M1)

- Scripps Oceanography Research Pier
- Main site for AMF1 facility and Balloon launches
- Shared resource, limited footprint





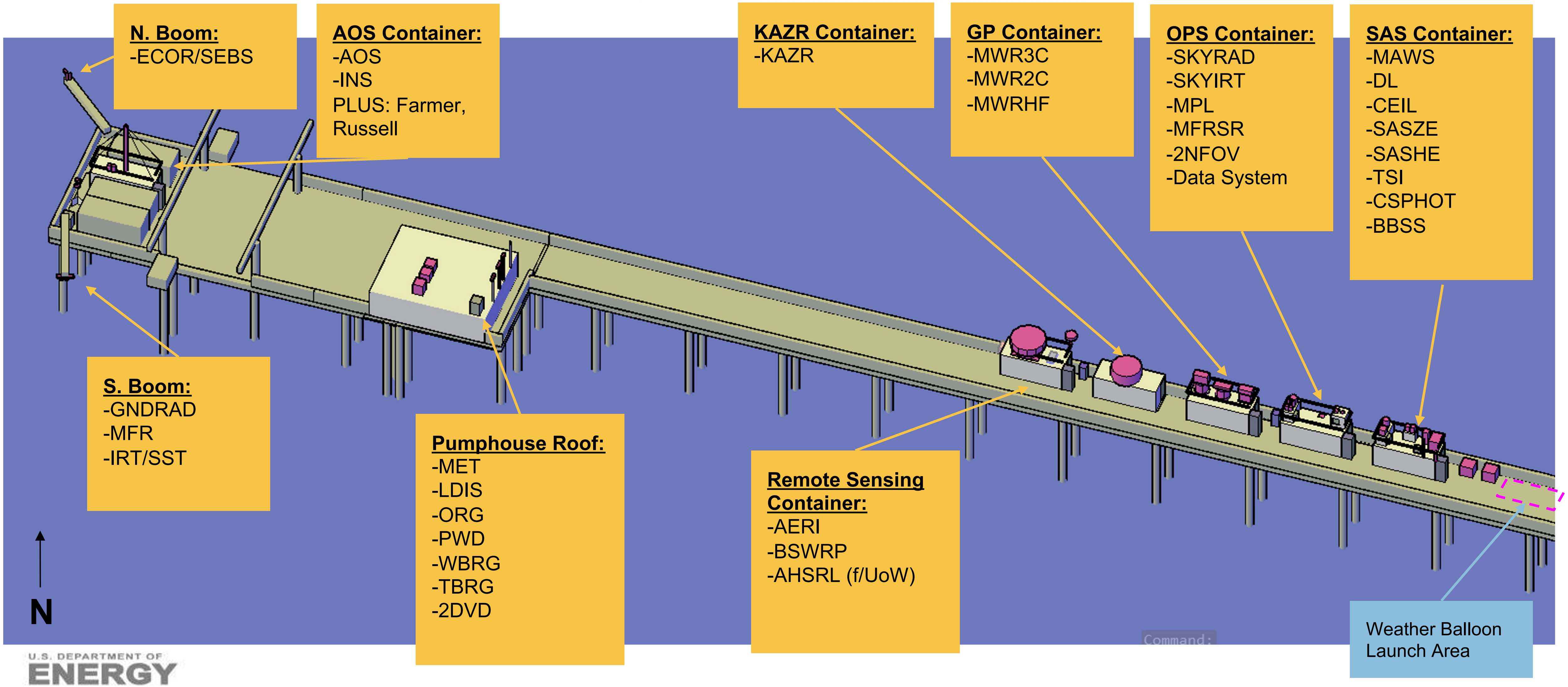
Pier Information:

- Height: 10m above mean low level water
- Width: 7 m
- Length: 330 m
- Prevailing wind NW

Main Site Layout Overview:

Scripps Research Pier, La Jolla, CA

ARM



Two sites (18m and 250m ASL) provide the ability to capture different aspects of aerosol and cloud sampling.

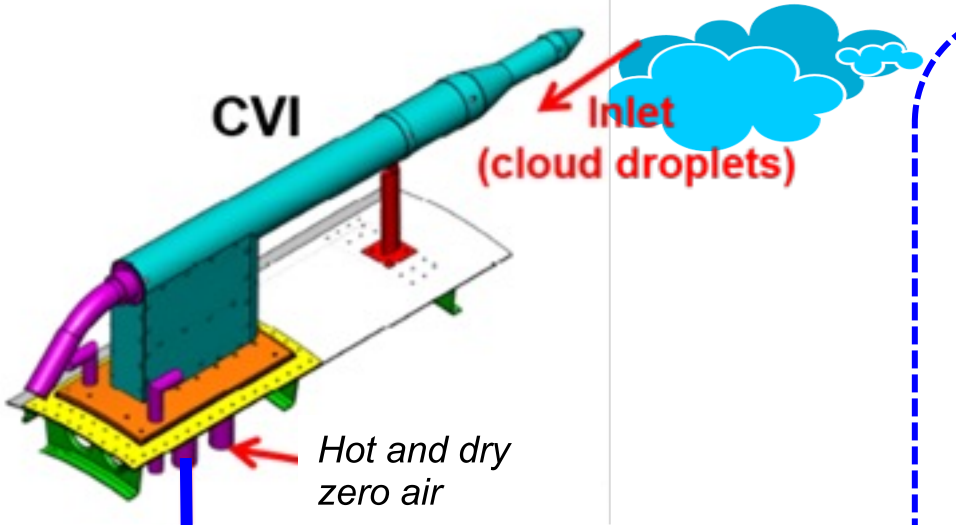
INTENSIVE EPCAPE-Chem April-June: Mt. Soledad site is frequently in cloud in May-June, allowing sampling of droplets and interstitial aerosol.

Proposes sampling from CVI and Isokinetic Inlet at Mt. Soledad

Instrument	Contact	Description	Inlet
Brechtel Counterflow Virtual Impactor (CVI)	Wheeler	Evaporates cloud droplets and provides residual particles to other instruments	N/A
Brechtel Differential Mobility Analyzer (DMA)	Russell	Number distribution of particles (0.02-0.9 um)	Switched
*DMT Cloud Condensation Nuclei (CCN) Counter	Petters	CCN number concentration and supersaturation spectra of particles for 0.07-0.6% supersaturation	Switched
Mini Handix CCN (5)	Petters	CCN number concentration and supersaturation spectra of particles for 0.1-1% supersaturation	Both
Printed Optical Particle Spectrometer (POPS)	Petters	Aerosol number distribution (0.15-3 um)	Switched
TSI Aerodynamic Particle Sizer (APS)	Russell	Number distribution of particles (0.5-10 um)	Isokinetic
Aerodyne High-Resolution Aerosol Mass Spectrometer (HR-AMS) with Event Trigger (ET)	Russell	NR organic, sulfate, nitrate, chloride, ammonium mass fragment concentrations (0.07-0.8 um) every 5 min	Switched
DMT Single-Particle Soot Photometer (SP2)	Wheeler	BC mass and number distribution (0.08-1 um)	Switched
Aerodyne Iodide Chemical Ionization Mass Spectrometer (CIMS)	Liggio	Gas-phase compounds	Switched
Fog Droplet Monitor	Chang	Number size distribution of fog (cloud) droplets	N/A
DMT Photoacoustic Extinctiometer (PAX)	Lee	BC concentration, aerosol light scattering and absorption coefficients	Switched
*Direct-to-Liquid Cloud Droplet OH Burst (DtL-OH)	Paulson	Hydroxyl radical formation by particles using direct-to-liquid sampling and fluorescence	Switched
*Filters for transition metals and OH burst	Paulson	Soluble metals by ICPMS and OH burst	Switched
Filters for FTIR and XRF	Russell	Organic functional group and element concentrations	Both

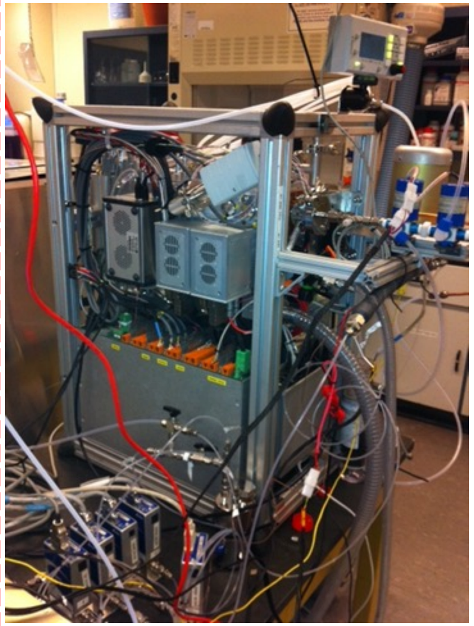
Cloud droplet gas & particle residuals via CVI and CIMS

J.Liggio | J. Wentzell | M. Wheeler | A. Lee



Science Objectives:

- Improved understanding of composition of water soluble organics within cloud droplets (CIMS)
- Organic gas-cloud droplet partitioning and/or chemistry (CIMS) – can we measure processing of organics consistent with "OH bursts"?
- Impact of cloud processes on the formation of brown carbon (PAX)



HR-ToF-CIMS

Evaporated organic gases

Cloud droplet residuals

gas gas gas gas gas gas gas gas gas

PM residuals

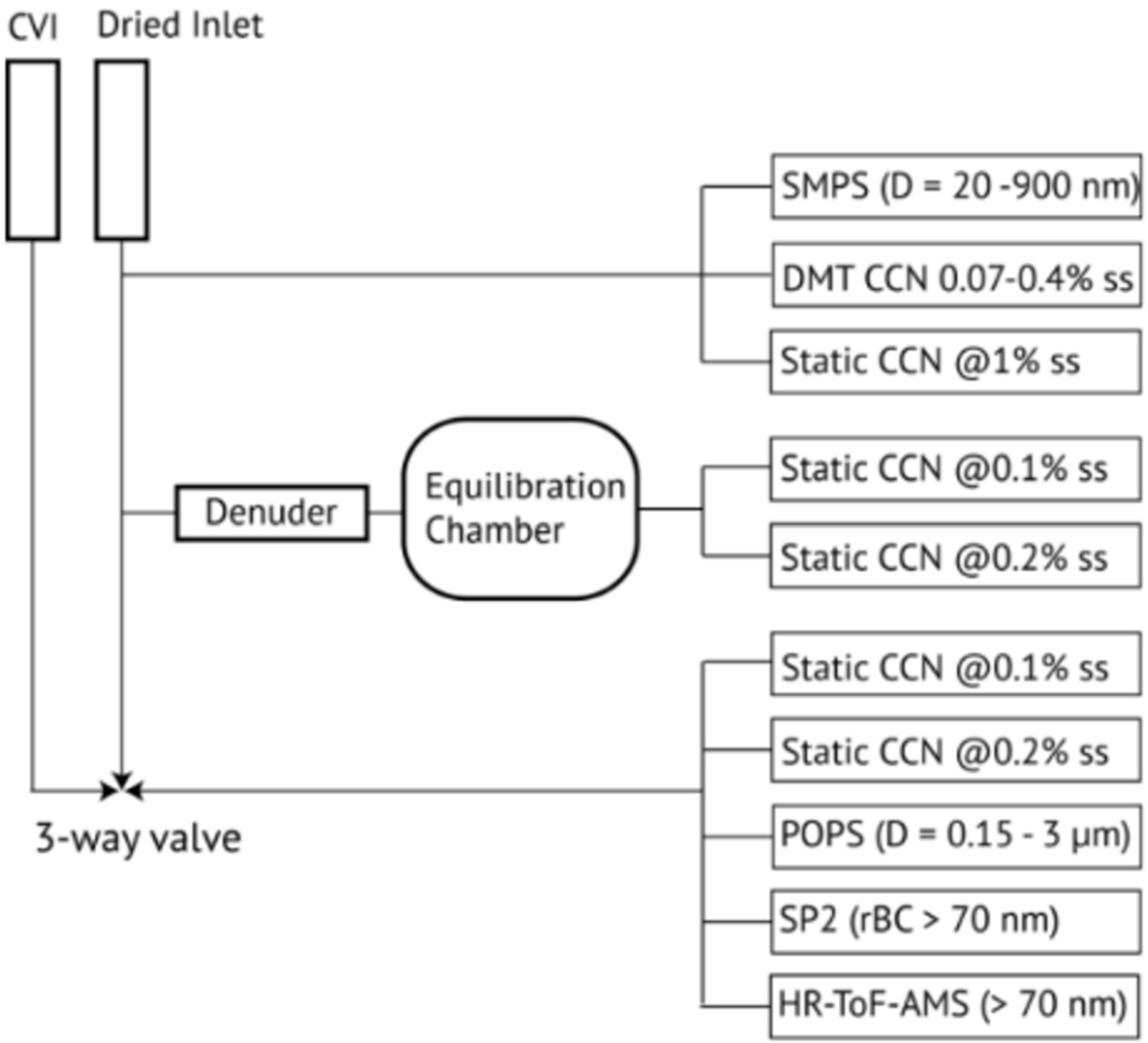
- Iodide ionization ($I^-\cdot(H_2O)_n + M \rightarrow I^-\cdot(M) + n\,(H_2O)$ where n=0,1,2..)
- Oxidized organic gases (organic acids, org-nitrates, etc..)
- Inorganic Nitrogen (N_2O_5, HNCO, HONO)
- <10 ppt DL in 1 sec for many species

SP2 (BC)

PAX (BrC)

Other PM instruments (**HR-ToF-AMS, CPC, CCN, etc…**)

Effect of gas phase is evaluated by contrasting denuded and undenuded CCN at multiple supersaturations (Petters, NCSU)



Broken Clouds on 26 September 2022 at Soledad

https://www.arm.gov/research/campaigns/amf2023epcape

EXTRA SLIDES

Broken Clouds on 24 September 2022 at Soledad

EPCAPE
Eastern Pacific Cloud Aerosol Precipitation Experiment

https://www.arm.gov/research/campaigns/amf2023epcape

EPCAPE

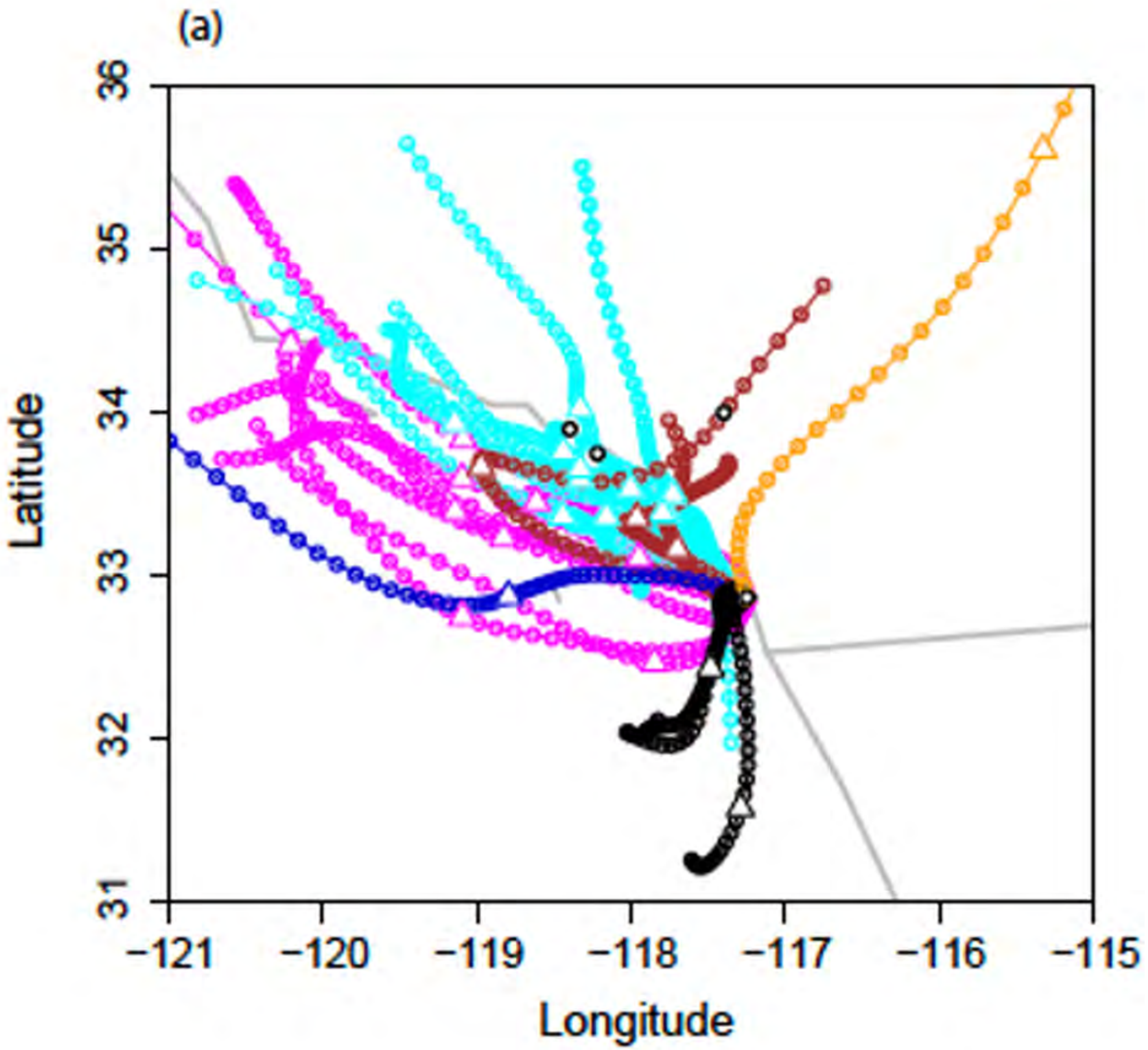
Eastern Pacific Cloud Aerosol Precipitation Experiment

Logo by Jeep Maneenoi.

Back trajectories from Scripps Pier

In August-September (2009), most trajectories to Scripps pier were associated with northwesterlies, many of which passed near the ports of Los Angeles and Long Beach.

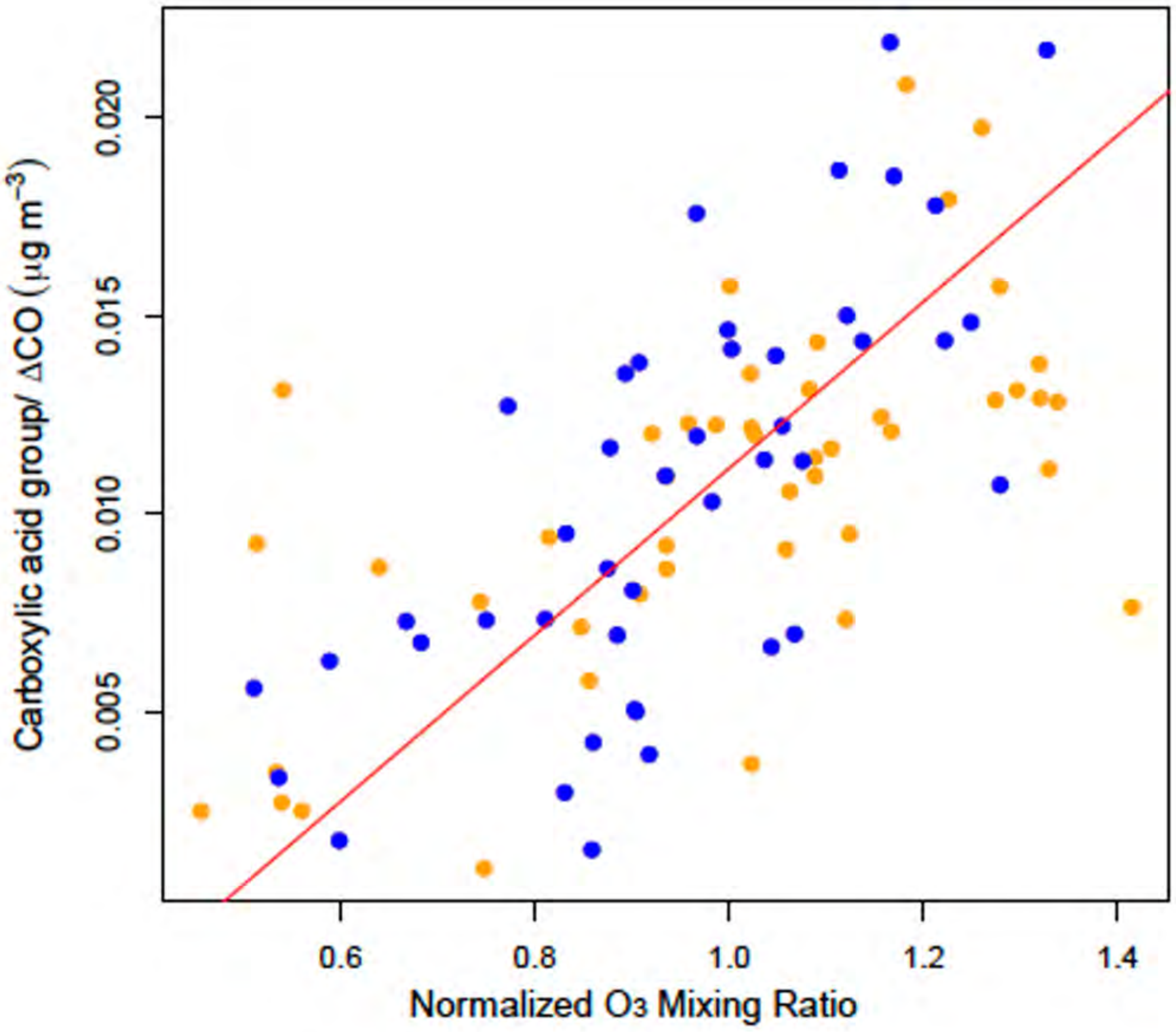
Liu, S., Day, D. A., Shields, J. E., & **Russell**, L. M. (2011). Ozone-driven daytime formation of secondary organic aerosol containing carboxylic acid groups and alkane groups. *Atmospheric Chemistry and Physics*, *11*(16), 8321–8341. https://doi.org/10.5194/acp-11-8321-2011



Photochemical Aerosol at Pier

- Correlation of normalized carboxylic acid group mass concentration and normalized O_3 mixing ratio (by campaign average) for the "Afternoon High" (orange) and "Noon High" (blue) days.
- The correlation coefficient is 0.7.

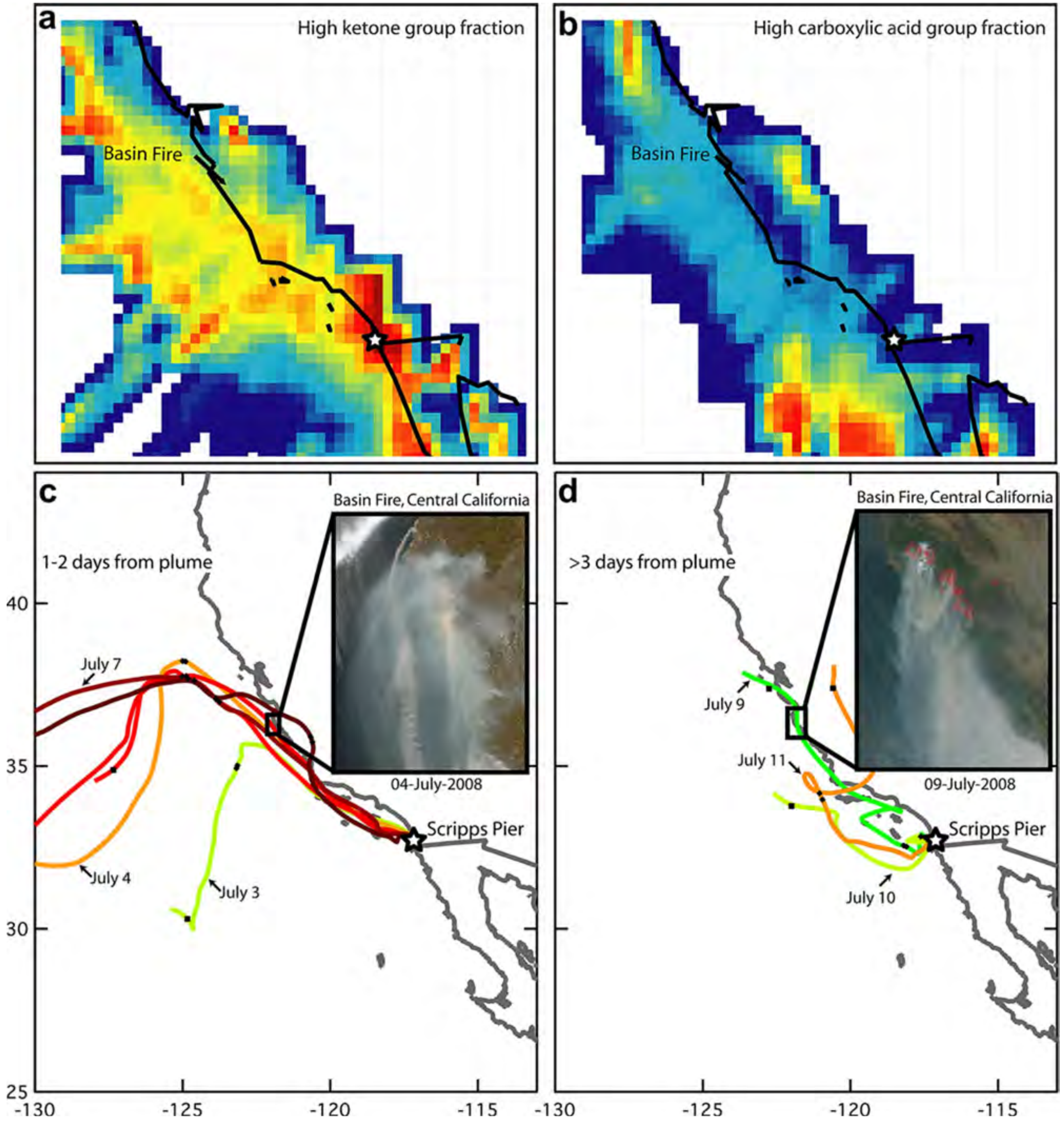
Liu et al., 2011, *ACP*.



Coastal Transport

Multi-day transport (July 2008) over the ocean provides opportunities to characterize photochemistry and cloud chemistry *in situ*.

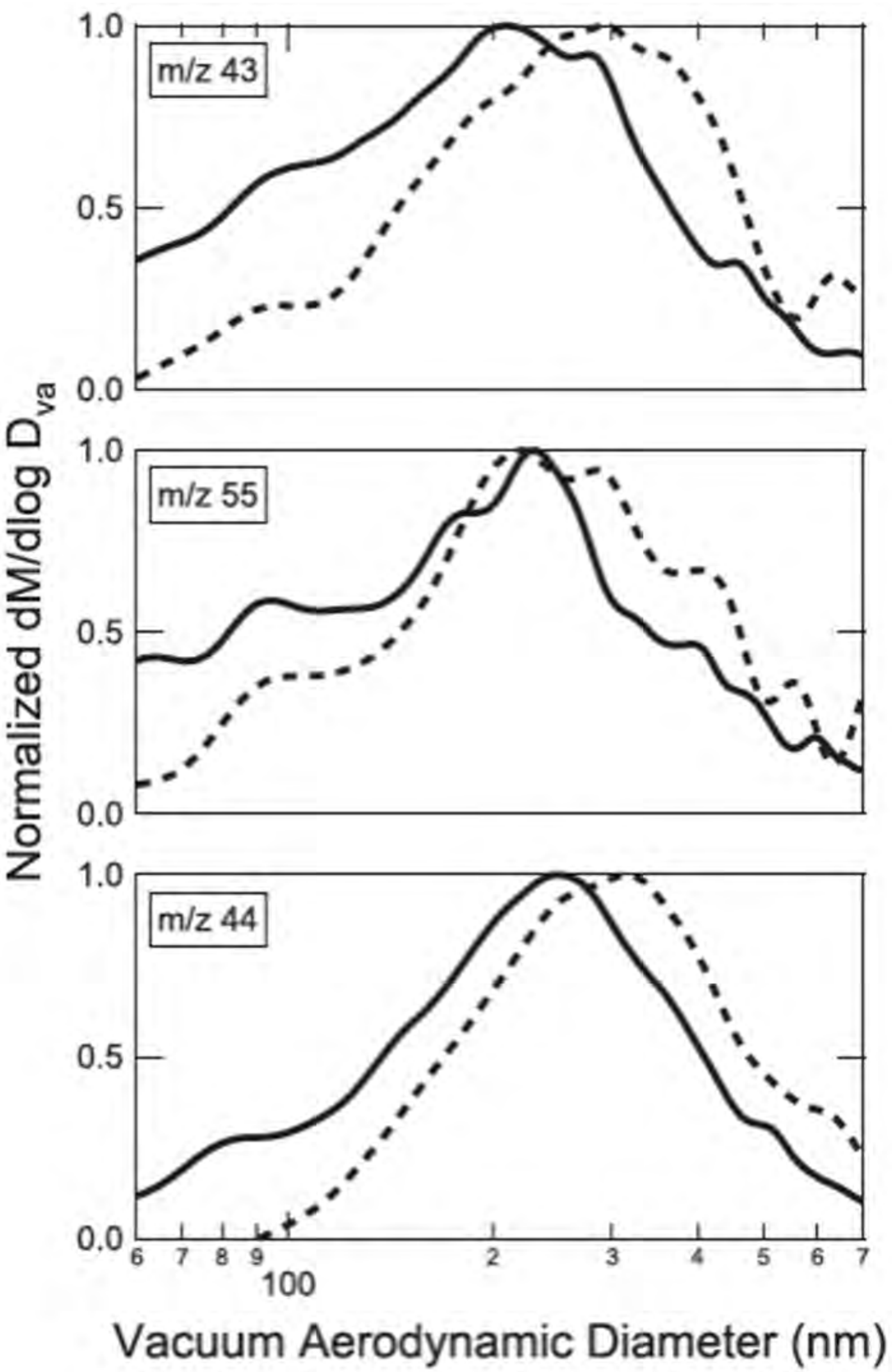
Wildfires provide large, intermittent sources as well as clear satellite signatures.

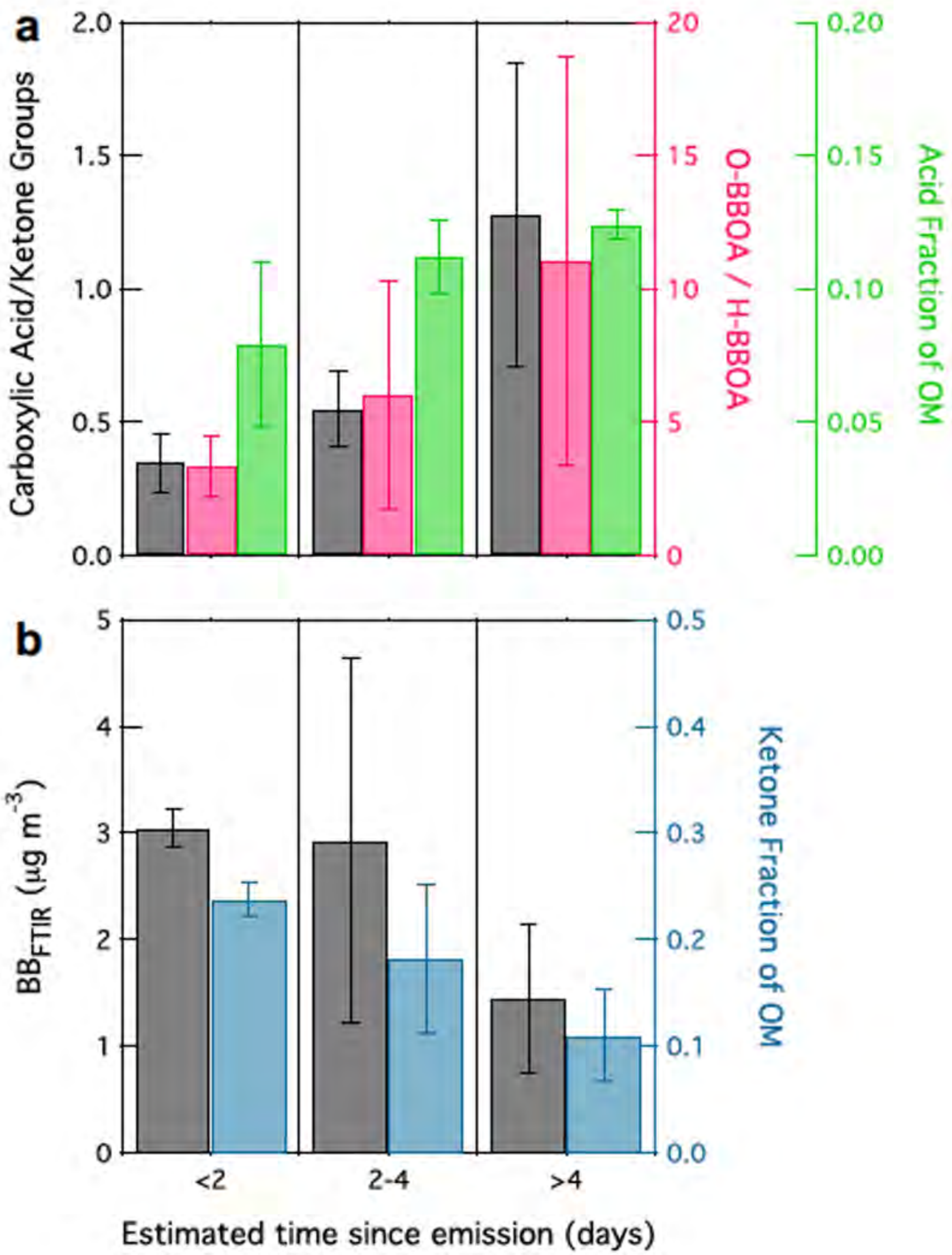


Hawkins, L. N., & **Russell**, L. M. (2010). Oxidation of ketone groups in transported biomass burning aerosol from the 2008 Northern California Lightning Series fires. *Atmospheric Environment*, *44*(34), 4142–4154. https://doi.org/10.1016/j.atmosenv.2010.07.036

Wildfire Emissions

- Organic composition shows increased oxidation with time.
- Size of oxidized organics also increases.

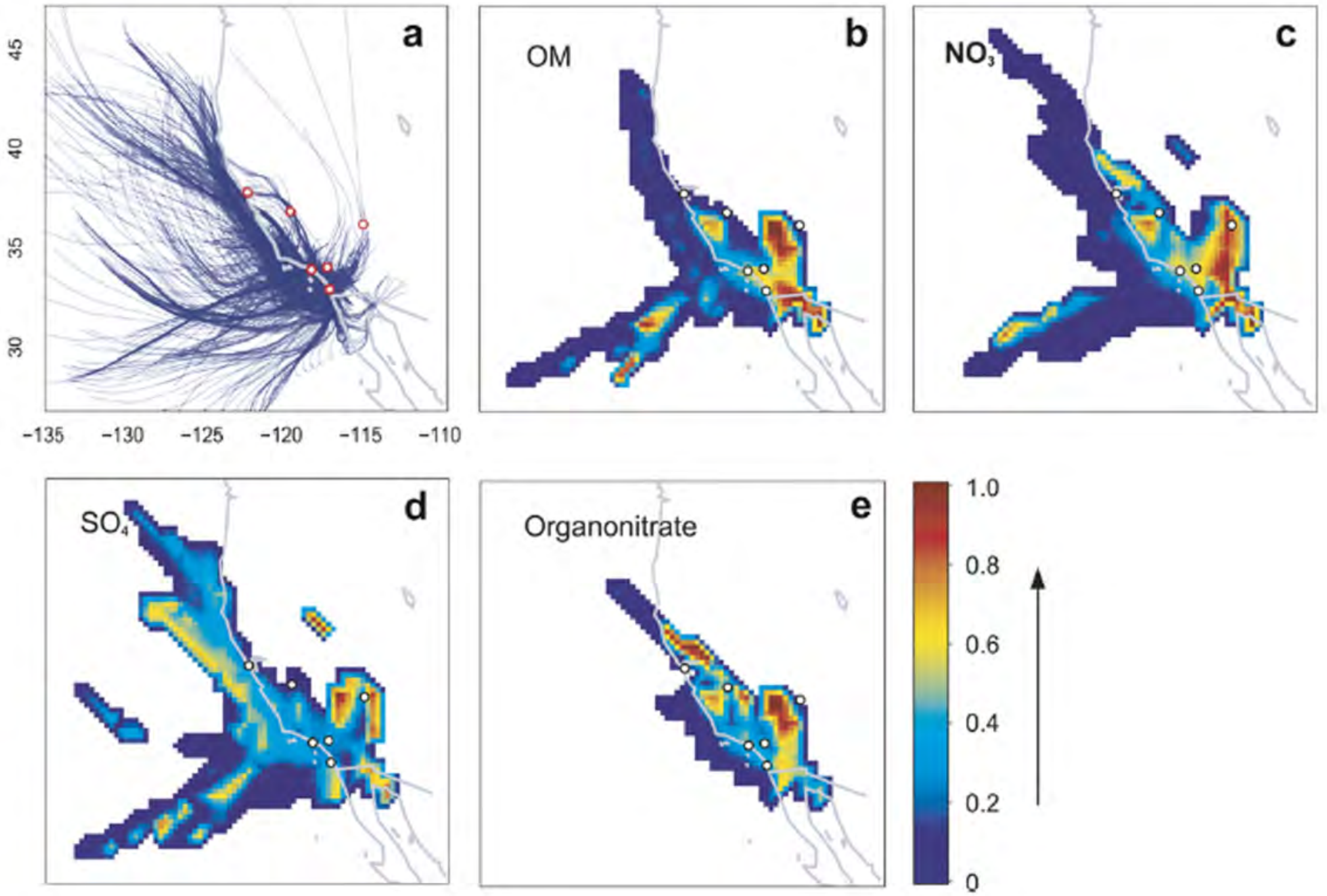




Hawkins and Russell, 2010, *AtmEnv.*

Inland Agricultural Emissions

In February-March (2009), Scripps pier received frequent air masses from the eastern LA basin (Riverside).



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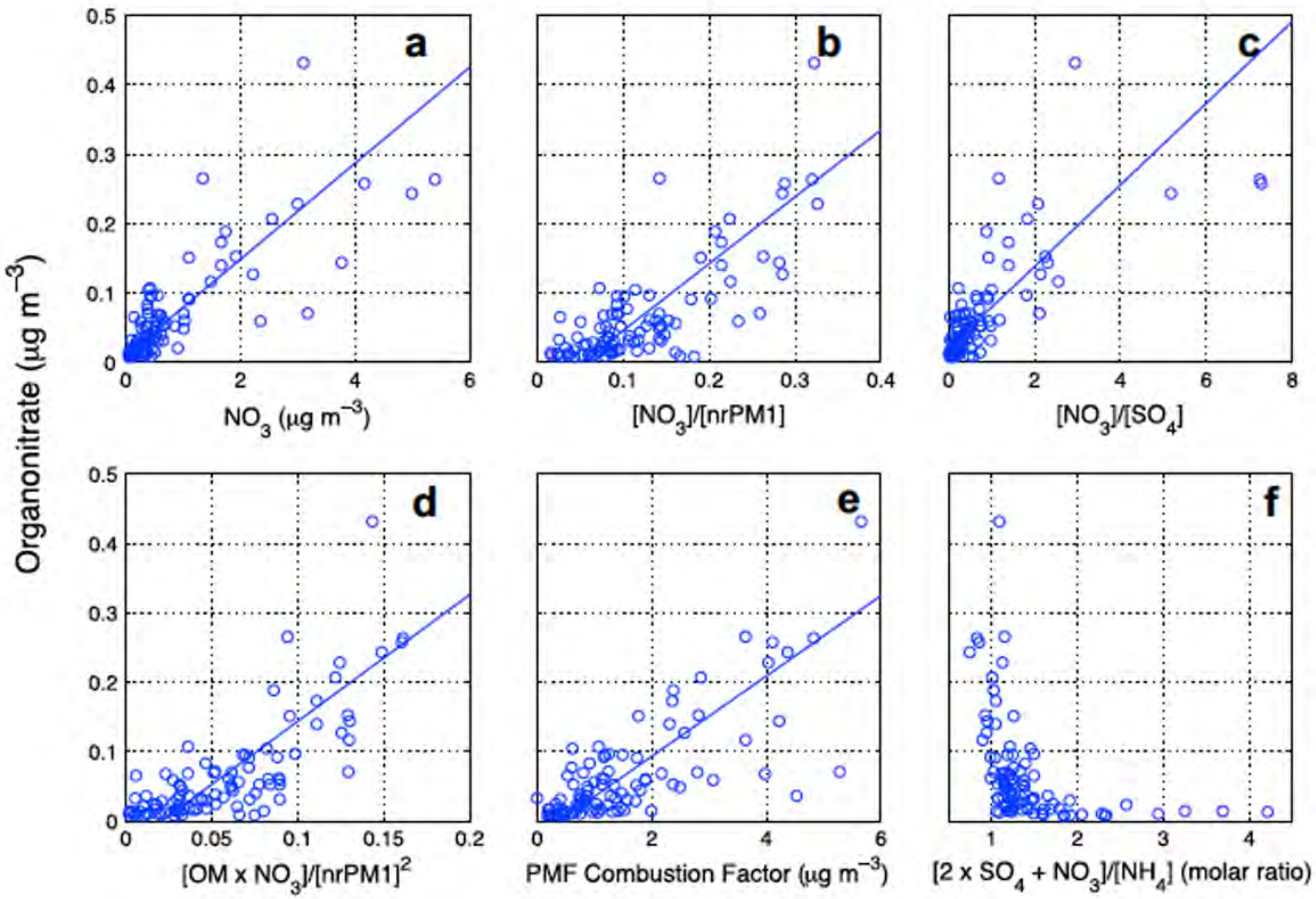
Day, D. A., Liu, S., **Russell**, L. M., & Ziemann, P. J. (2010). Organonitrate group concentrations in submicron particles with high nitrate and organic fractions in coastal southern California. *Atmospheric Environment*, *44*(16), 1970–1979. https://doi.org/10.1016/j.atmosenv.2010.02.045

Organonitrate and Nitrate Components

- High nitrate associated with agriculture emissions from eastern LA basin.
- Organonitrate from FTIR and AMS were correlated with nitrate, much of which was associated with combustion emissions from vehicles.

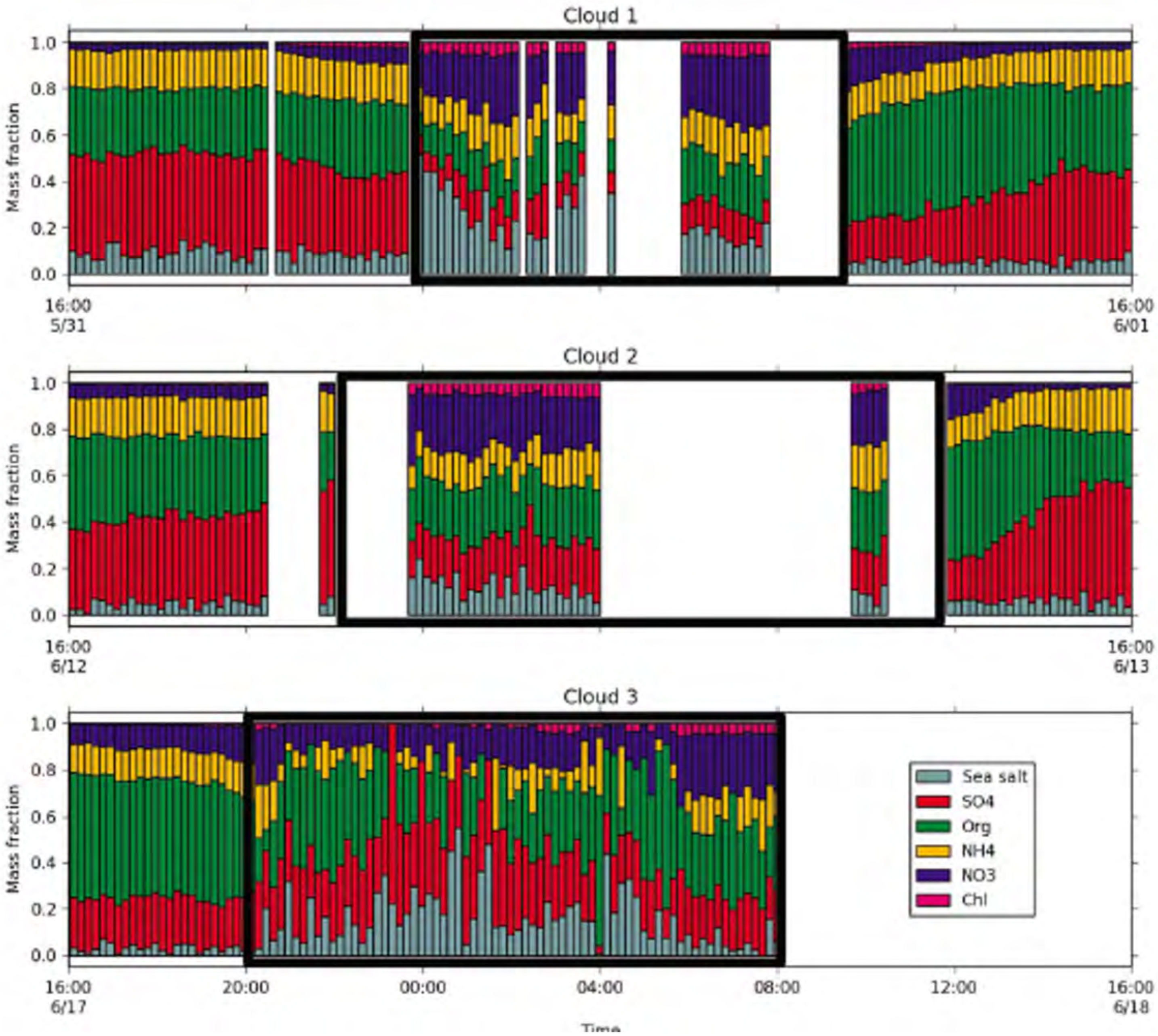
Day et al., 2010, *AtmEnv.*



Composition Changes in Cloud at Mt. Soledad

"SOLEDAD" Campaign in June 2012

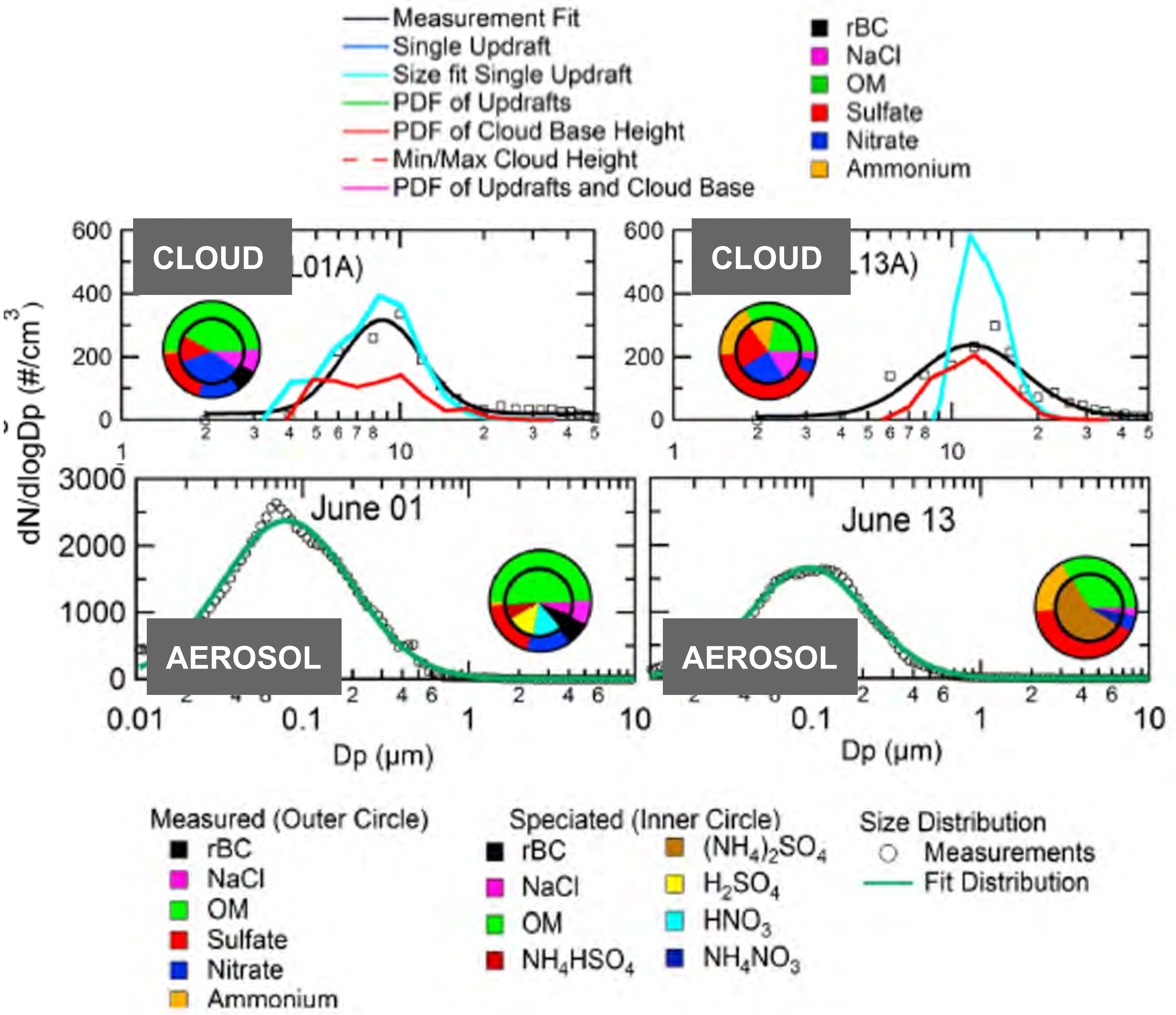
Modini, R. L., Frossard, A. A., Ahlm, L., **Russell**, L. M., Corrigan, C. E., Roberts, G. C., Hawkins, L. N., Schroder, J. C., Bertram, A. K., Zhao, R., Lee, A. K. Y., Abbatt, J. P. D., Lin, J., Nenes, A., Wang, Z., Wonaschutz, A., Sorooshian, A., Noone, K. J., Jonsson, H., ... Leaitch, W. R. (2015). Primary marine aerosol-cloud interactions off the coast of California. *Journal of Geophysical Research-Atmospheres*, *120*(9), 4282–4303. https://doi.org/10.1002/2014jd022963



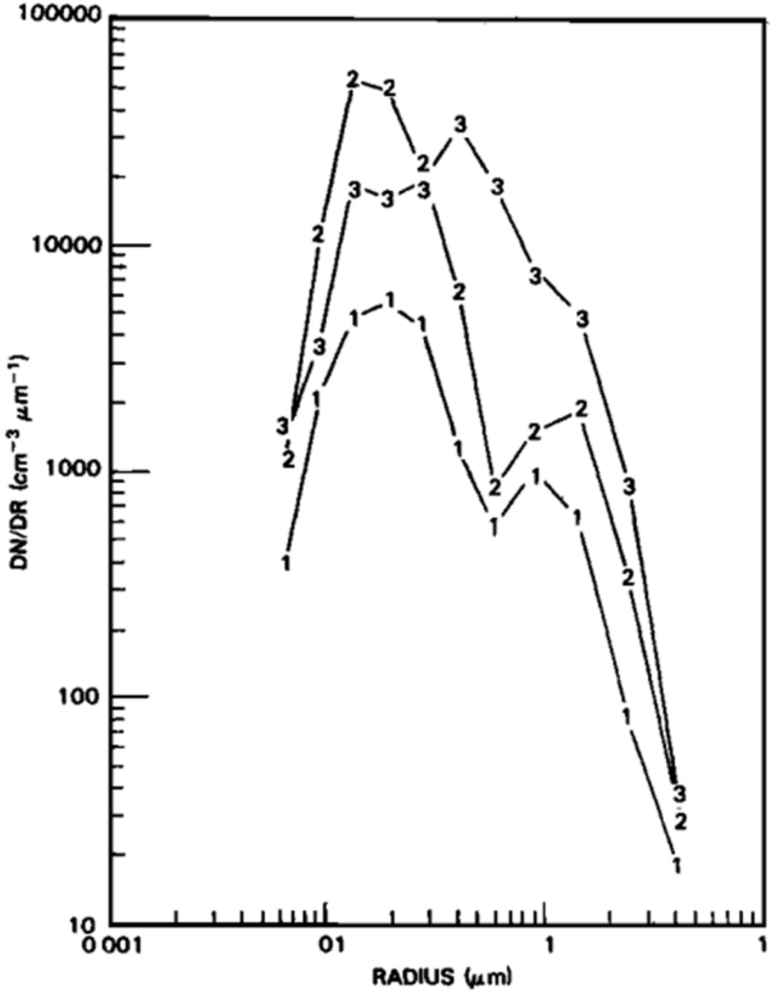
Closure of Activated Aerosol Composition

Aerosol-Cloud Parcel Modeling

Sanchez, K. J., **Russell**, L. M., Modini, R. L., Frossard, A. A., Ahlm, L., Corrigan, C. E., Roberts, G. C., Hawkins, L. N., Schroder, J. C., Bertram, A. K., Zhao, R., Lee, A. K. Y., Lin, J. J., Nenes, A., Wang, Z., Wonaschutz, A., Sorooshian, A., Noone, K. J., Jonsson, H., ... Seinfeld, J. H. (2016). Meteorological and aerosol effects on marine cloud microphysical properties. *Journal of Geophysical Research-Atmospheres*, *121*(8), 4142–4161. https://doi.org/10.1002/2015jd024595



Effect of non-precipitating clouds on the aerosol size distribution in the marine boundary layer



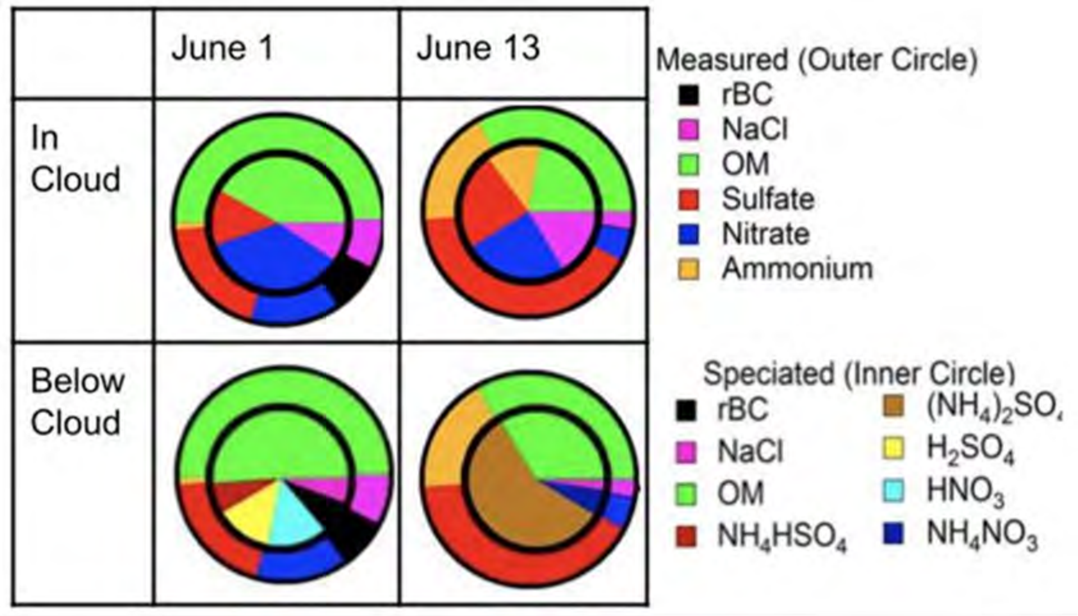
"We believe that the data and arguments presented above make a strong case for the importance of nonprecipitating clouds in forming the size distribution. Nonprecipitating cloud cycles are probably the major mechanism for accumulating mass in the 0.08 to 0.5 um size range where particles are very efficiently removed by Precipitation scavenging. **This mechanism has a tendency to produce a steep slope at sizes greater than about 0.1 um and to produce a doubly peaked distribution in geographical regions where there is no direct particle injection in the 0.04 to 0.08 um range.**"

[Hoppel et al., 1986, JGR]


Ports of Los Angeles and Long Beach
Prevailing Winds
La Jolla
Torrance
Long Beach
Anaheim
Santa Ana
Huntington Beach
Irvine
Lake Elsinore
Perris
Murrieta
Temecula
Dana Point
San Clemente
Two Harbors
Catalina Island Essential Fish Habitat...
Oceanside
Vista
Carlsbad
Escondido
Pala
San Clemente Island
San Diego

Hypotheses to be tested: Chemical Signatures of Cloud Processing

H1: The subset of the aerosol population that is activated to cloud droplets is chemically distinct from the unactivated particles, and its size-resolved chemical composition is further differentiated by adding aqueous-oxidized components that can be measured by single-particle mass fragments.



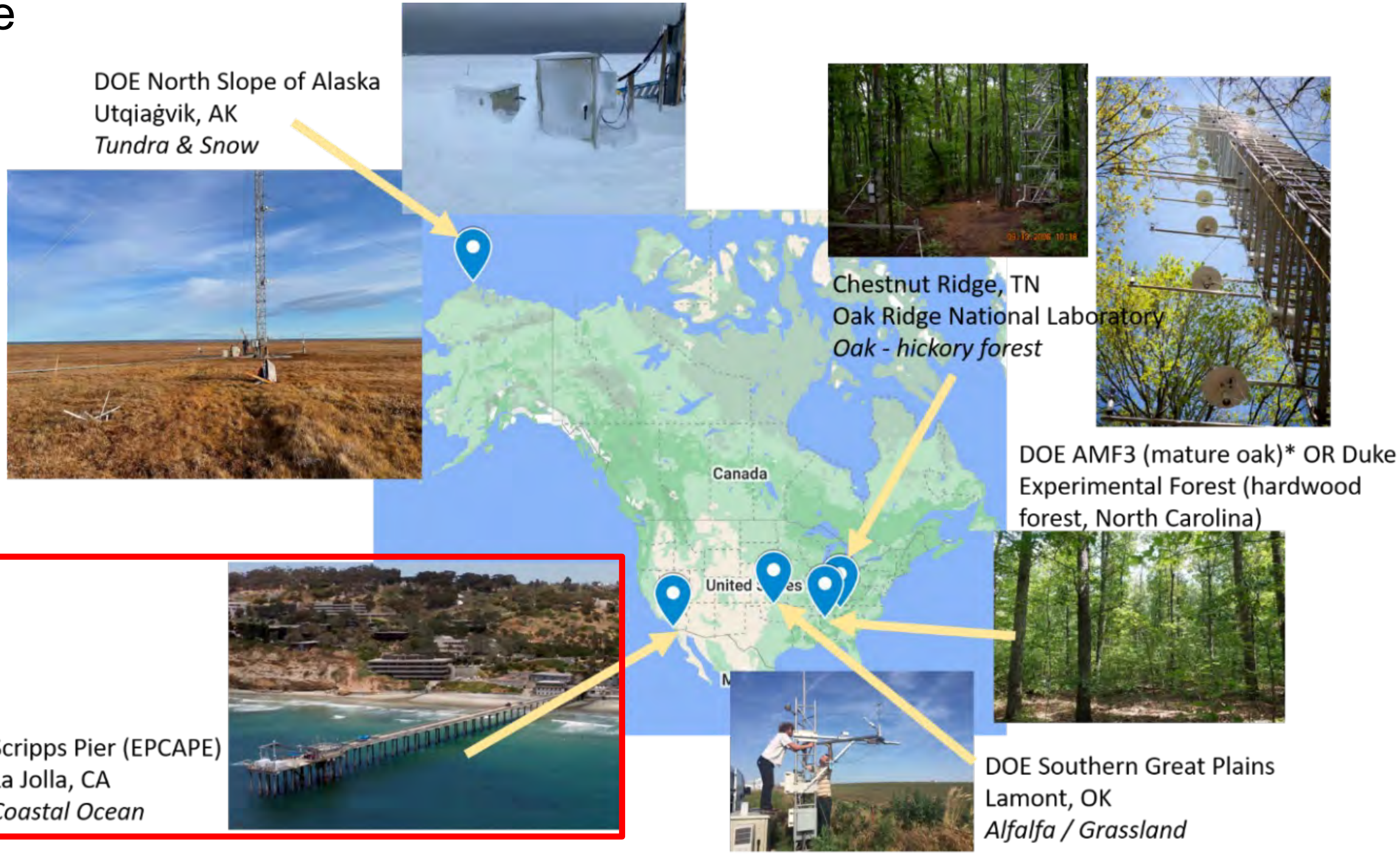
- Measured (outer circle) and simulated (inner circle) chemical composition for particles collected below cloud and in cloud.
- The simulated in-cloud droplet composition contains more nitrate, more salt, and less BC than is measured in the interstitial aerosol.
- The mixing state was unknown. Single-particle measurements of sulfate, nitrate, and carbon components are needed to accurately initialize simulations.

[Sanchez et al. 2016, JGR]

FALCON: Fluxes of AerosoL Continuous Observing Network (Farmer, CSU)

Goal: To quantify size-resolved particle fluxes at multiple sites over different surfaces to investigate underlying processes of particle deposition

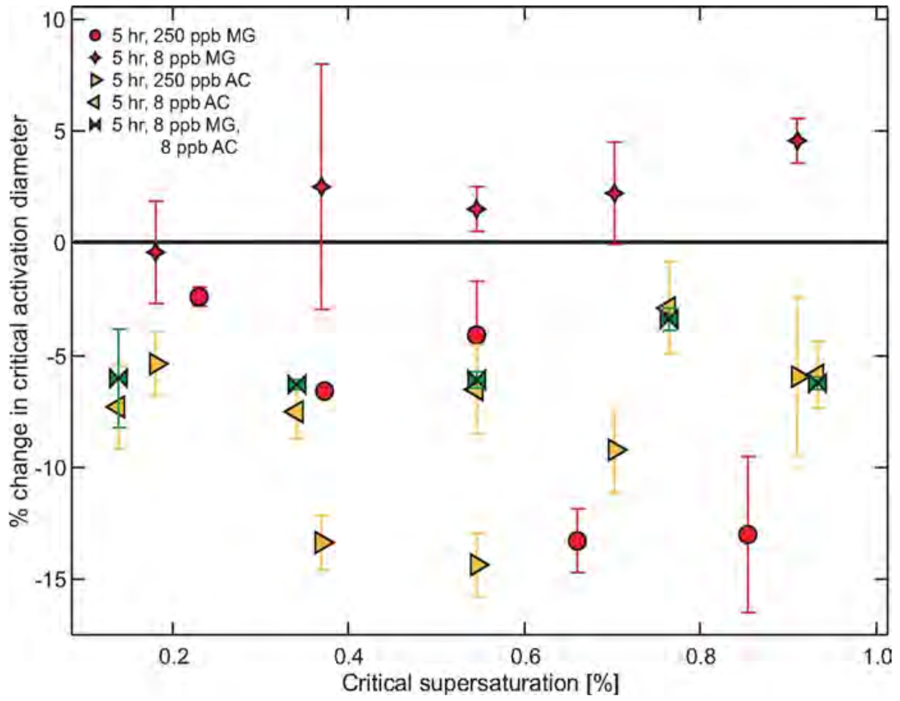
- Portable Optical Particle Sizer (POPS) measures particles 140 – 3000 nm
- Eddy covariance / wavelet flux analysis
- Scripps Pier: Spring 2023 – 2024+
- Measure particle emission deposition over coastal water



Research Team

Dr. Delphine Farmer (PI, CSU), Dr. Ethan Emerson (coPI, CSU), Dr. Joshi Ruthambara (CSU), Mr. Ricky Peña (CSU) + technical support from DOE ARM

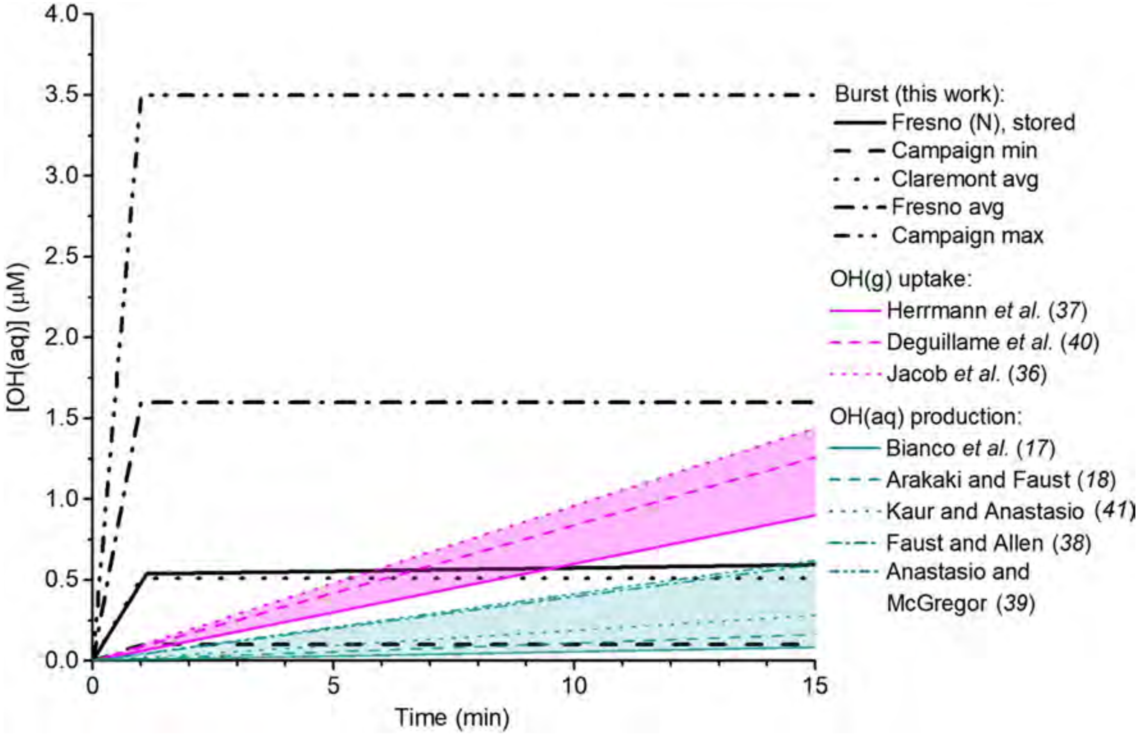
H2: Gas-phase compounds that are removed by denuding will lower the supersaturation required for activation of each particle by enhancing water solubility during the uptake process.



- Humidified ammonium sulfate aerosols were exposed to gas-phase methyl glyoxal or acetaldehyde in a Teflon reaction chamber.
- The critical dry diameters observed for each experiment as a function of instrument supersaturation are compared with the ammonium sulfate control to demonstrate the effect of organics.
- The data show a decrease in the activation diameter for particles exposed to methyl glyoxal and acetaldehyde.
- Other gases including nitric acid and semi-volatile organic vapors, such as those formed during secondary organic aerosol formation by oxidation are thought to have similar effects

[Sareen et al. 2013, PNAS]

H3: Particles with longer times between cloud cycles will produce a larger OH burst, and as a result, larger changes to particle chemical composition during cloud cycling.



[Paulson et al., 2019, Scientific Advances]

- Measured production from OH "bursts". The solid line is a typical time-resolved burst from a Fresno stored sample.
- Dashed lines represent the minimum, average, and maximum cumulative concentrations from fresh samples.
- Magenta lines: Uptake of OH(g) into droplets, based on estimates from three cloud chemistry models.
- Green lines: Measured OH(aq) production in authentic cloud and fog water samples from five previous studies