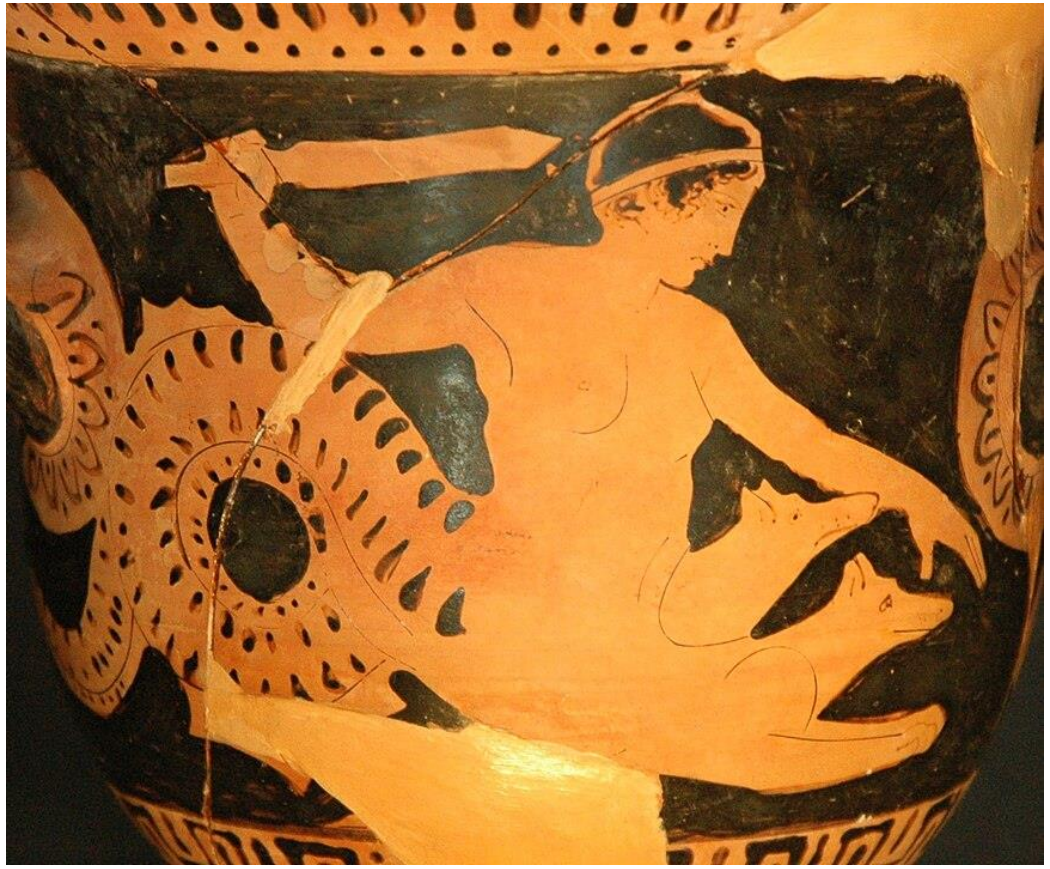
Recent airborne work with the NPS/CIRPAS Twin Otter

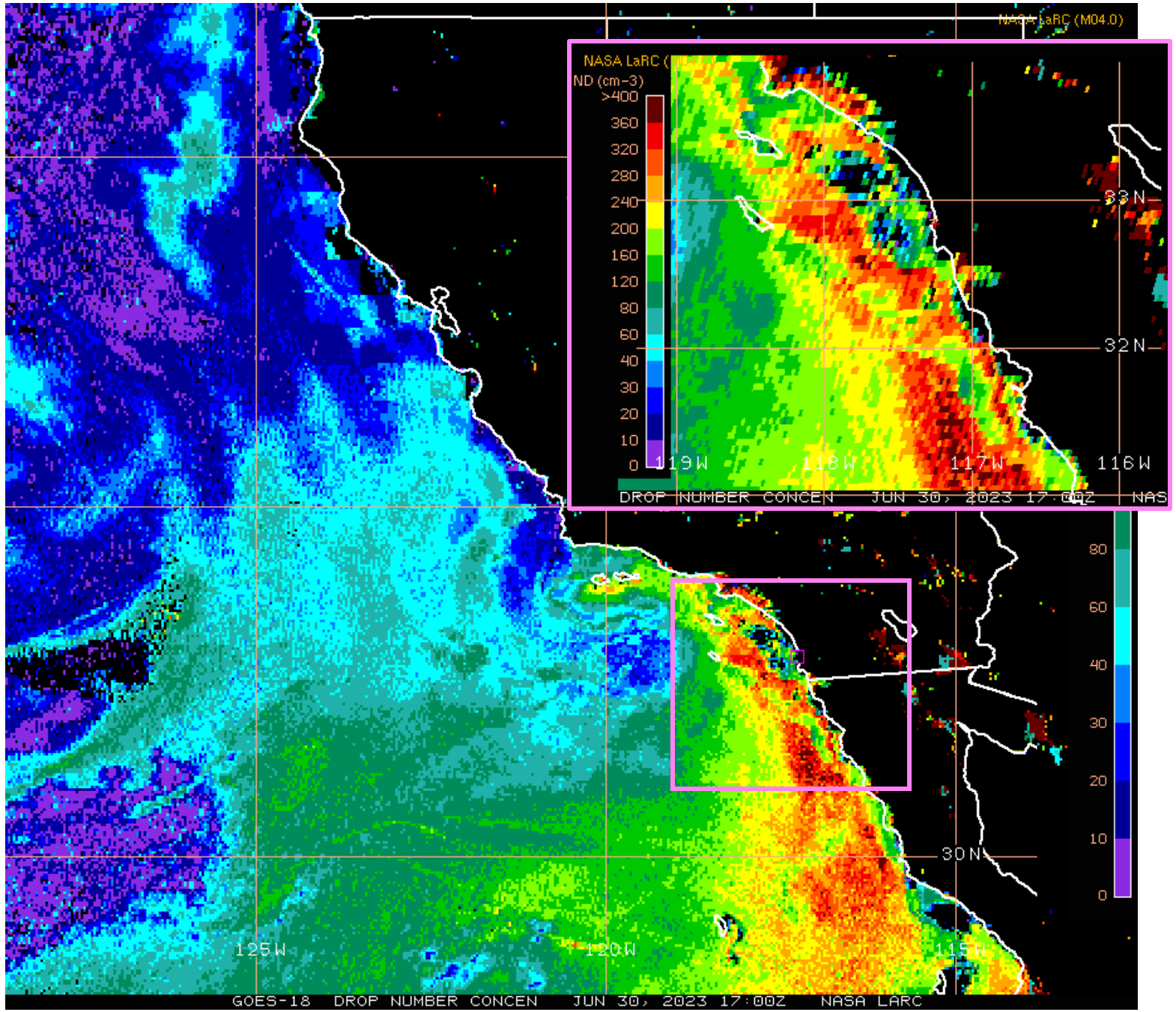
Mikael Witte

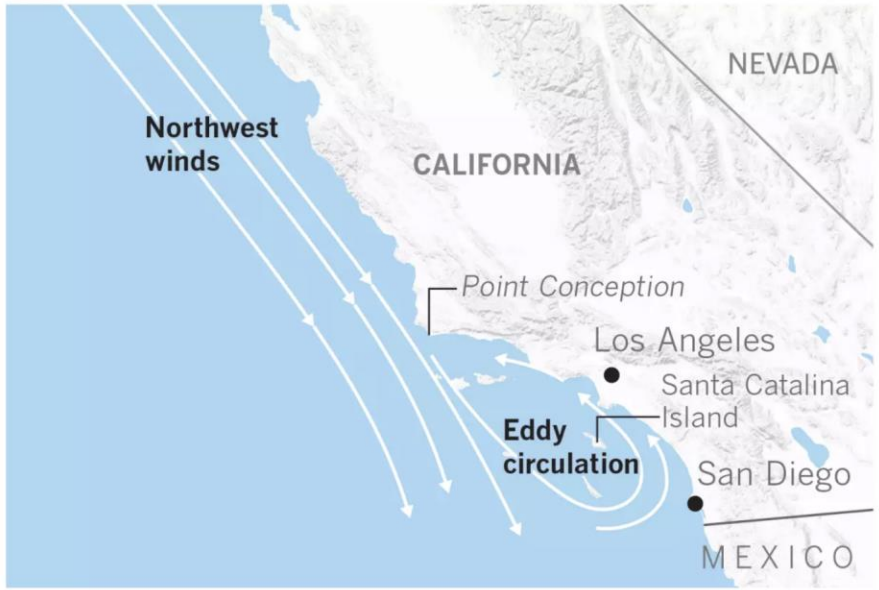
UNOLS SCOAR Meeting | 28 Feb 2025

SCILLA:

Southern California Investigation of Low clouds and Land Aerosol

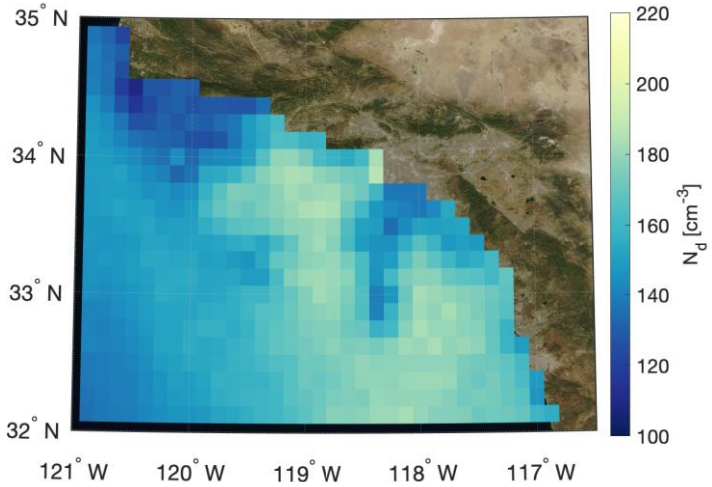






Eddies off the Southern California coast act like miniature low-pressure systems and can spin low clouds and drizzle into the L.A. Basin. (Paul Duginski / Los Angeles Times)

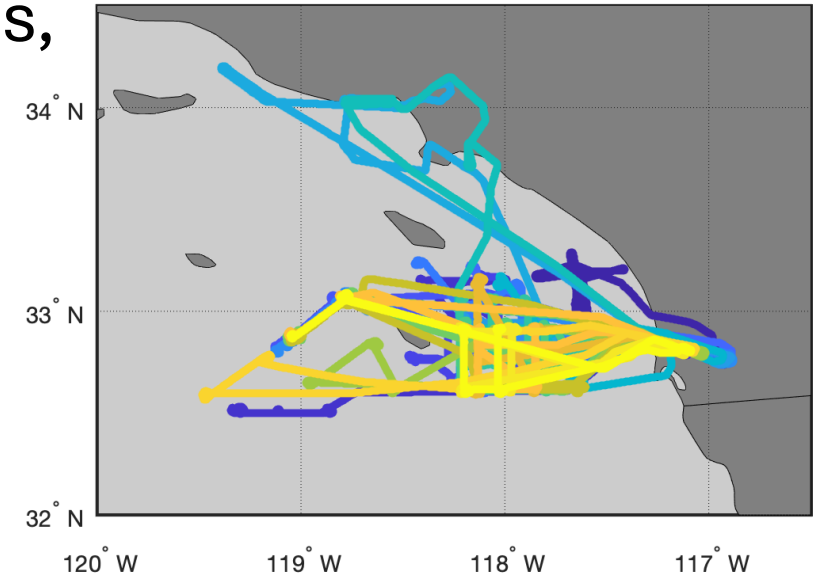
Aqua MODIS mean N_d,
1/8°, May 1-July 15, 2008-2022



SCILLA:

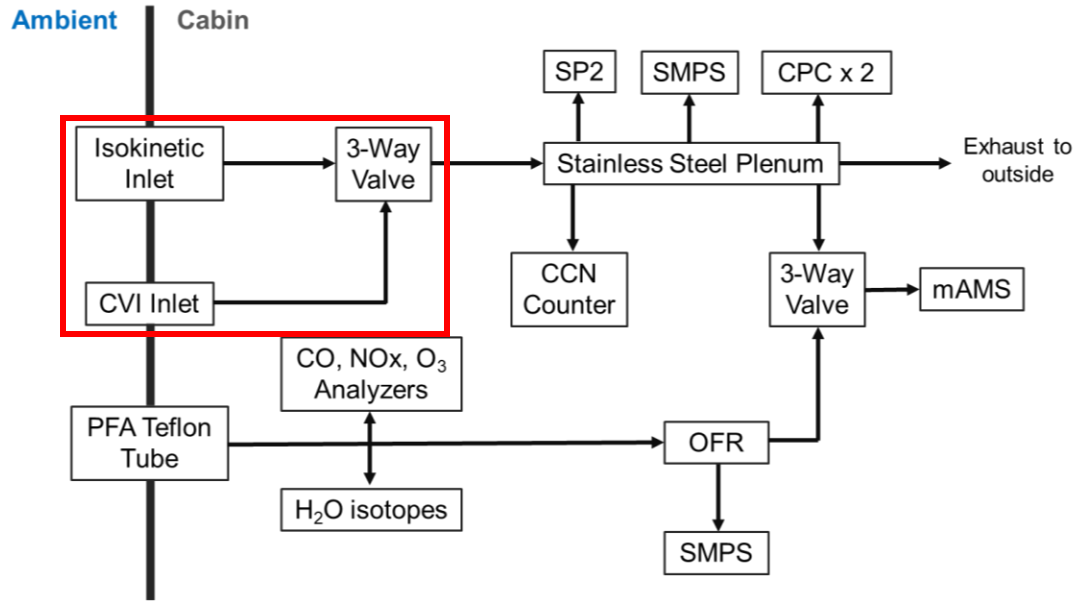
Southern California Investigation of Low clouds and Land Aerosol

- Airborne experiment flown with NPS/CIRPAS Twin Otter
- 21 research flights between 6-30 June 2023
- Flights mostly sampled near San Clemente Island with an additional 2 flights to sample LA outflow
- Sampling focus on aerosol/cloud microphysics, aerosol composition, and trace gases



Instrumentation

Aerosol/chemistry:

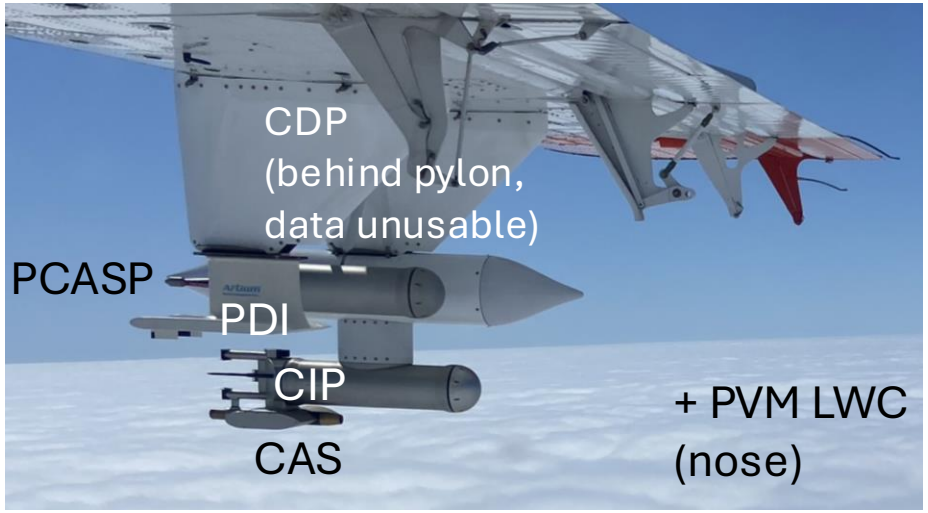


+ CIRPAS ultrafine and water CPCs (isokinetic inlet)

CIRPAS facility:

- Thermodynamics (T, q_v)
- 3D winds/turbulence
- Up/down SW/LW radiation

Microphysics:



SCILLA Central Hypothesis

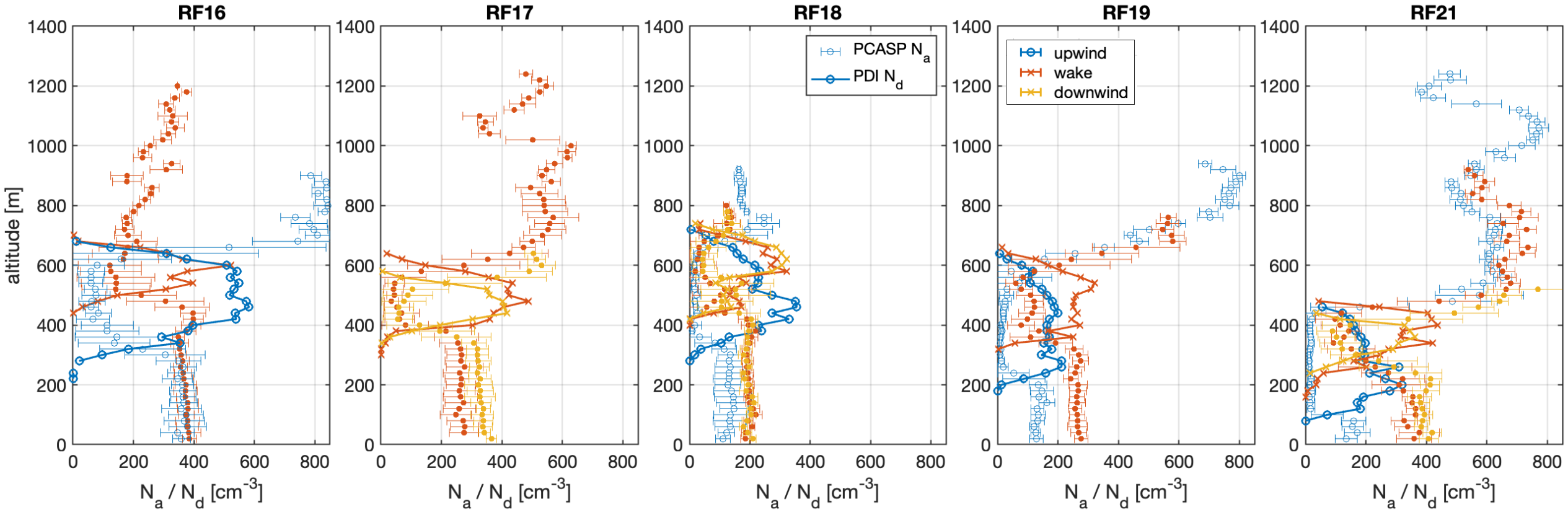
- **High cloud N_d in PBL clouds over the Southern California Bight** is caused by a combination of **horizontal transport of continental aerosol in Catalina eddies** and **vertical transport due to island wake shear**

H0. (null) High N_d inferred from satellite remote sensing is an artifact (i.e., it's a product of deficiencies/errors in retrieval algorithms)

H1. Continental aerosol is transported in the lower free troposphere from the Los Angeles basin and environs over the Bight to the southern Channel Islands (Santa Catalina & San Clemente) via shallow mesoscale circulations (Catalina eddies)

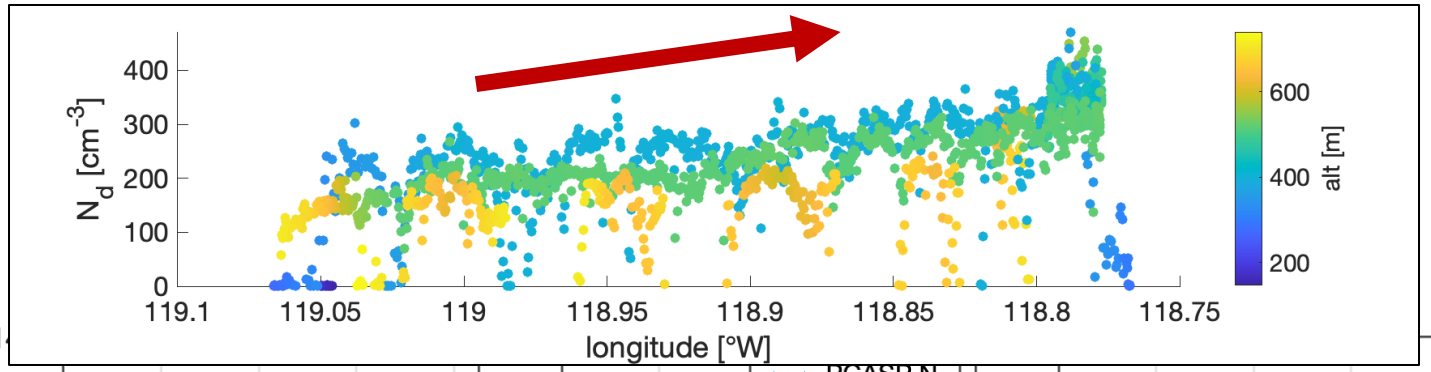
H2. Shear-driven turbulence induced by island wakes transports aerosol from the free troposphere into the cloud layer despite a PBL-topping inversion

ERA5 PBL winds, 6/26-6/30, 1700 UTC



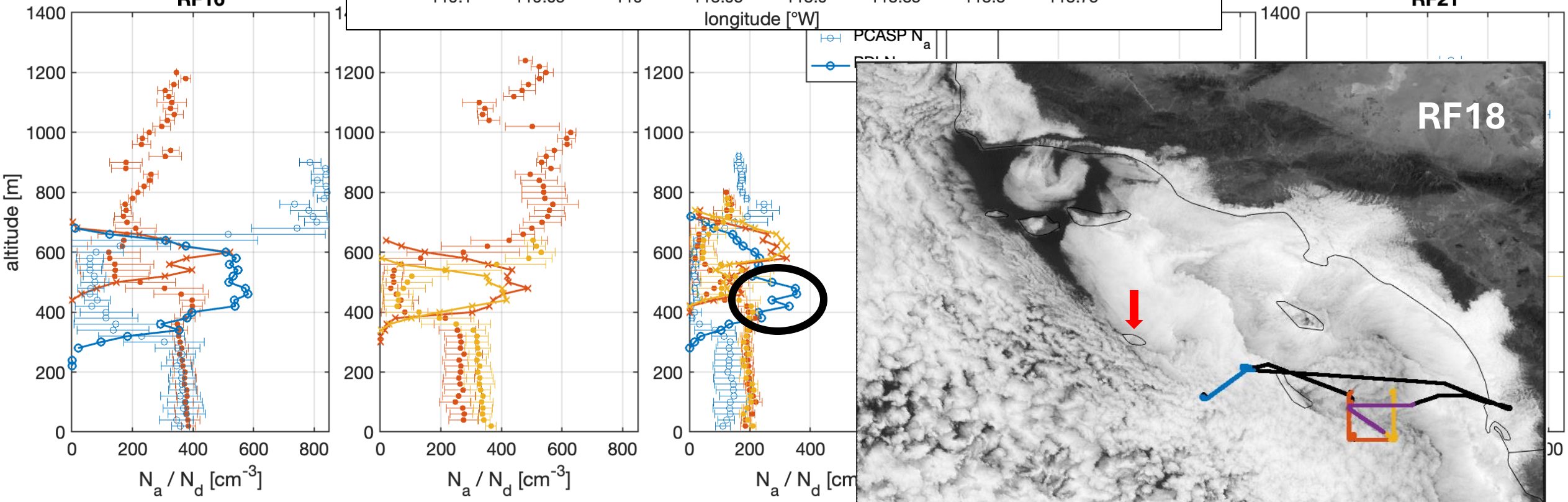
Open o: upwind of SCI

Closed •/x: downwind



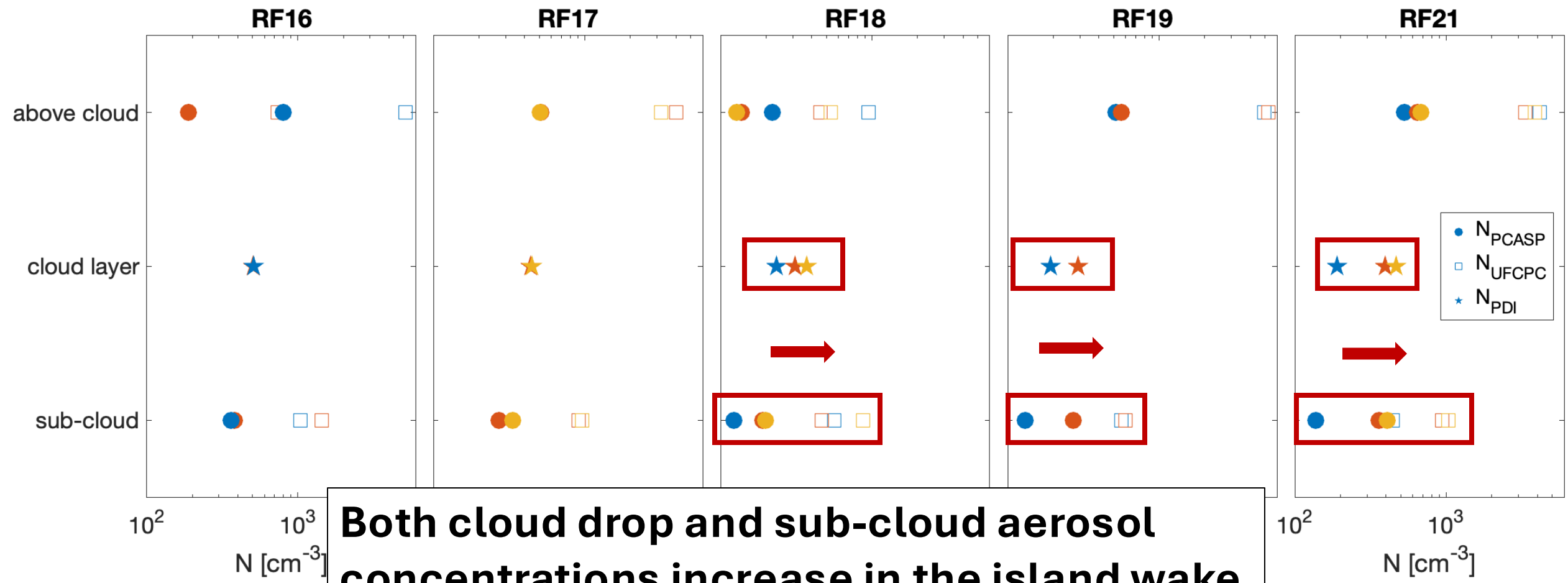
RF16

RF21

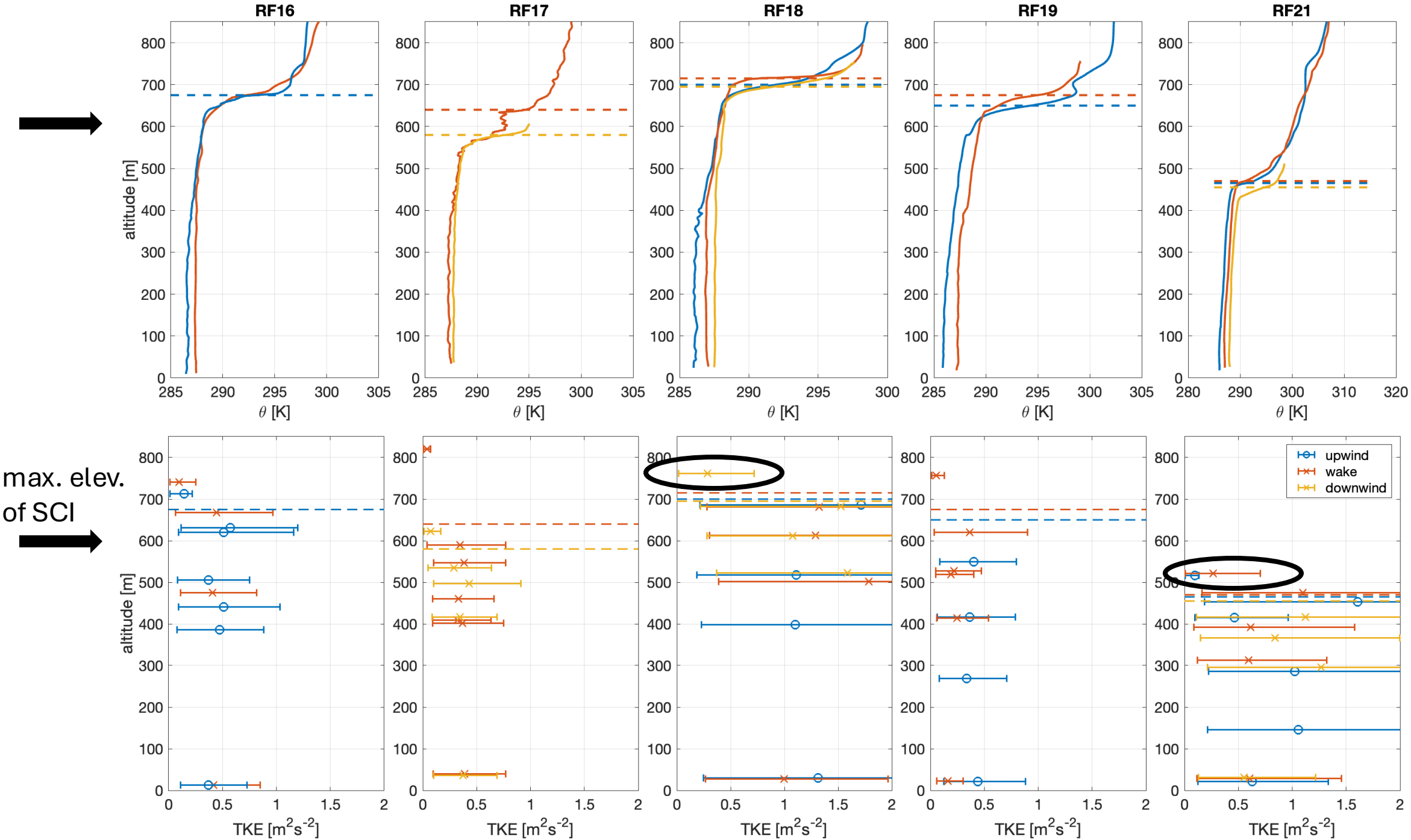


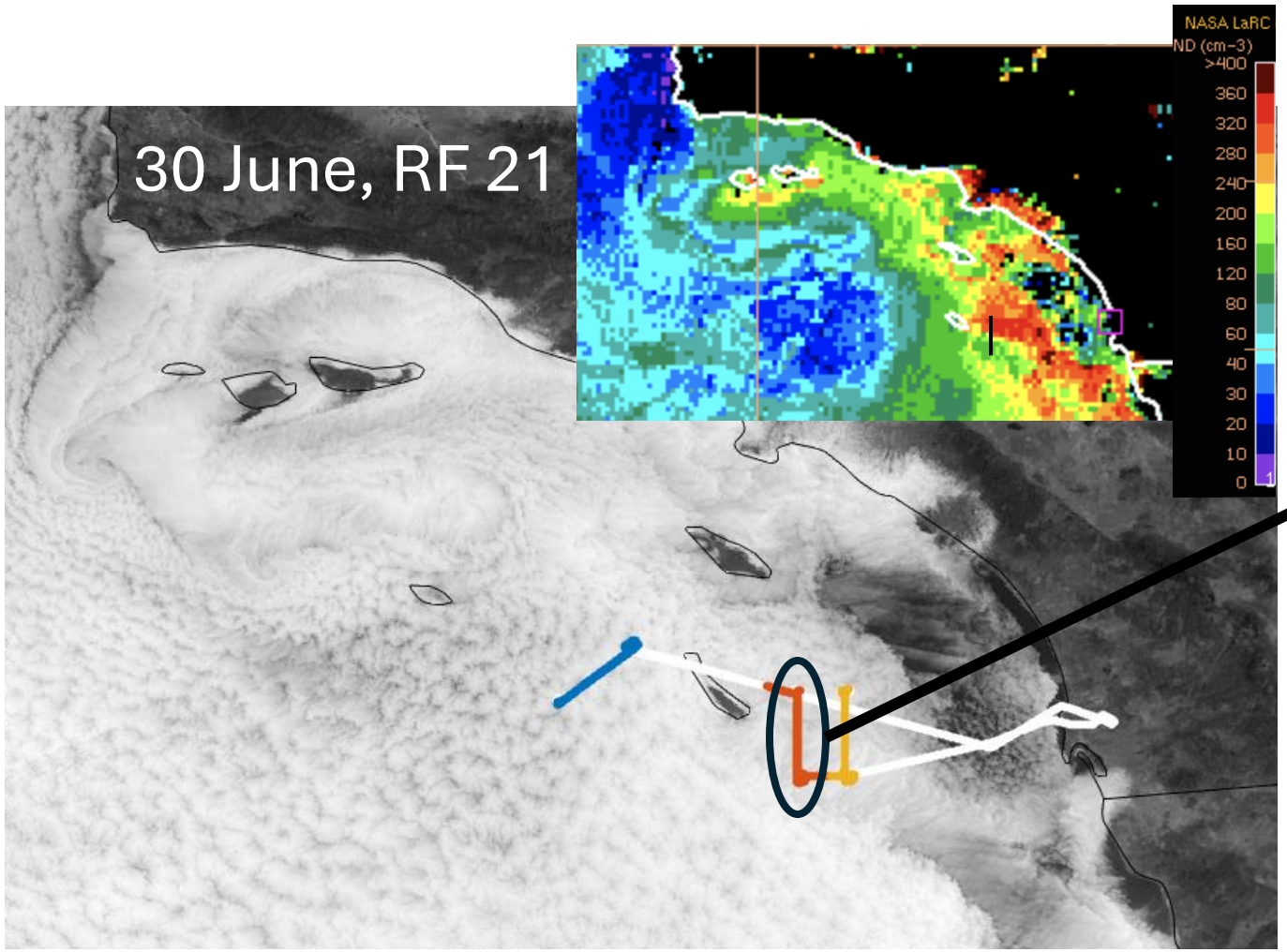
Open o: upwind of SCI

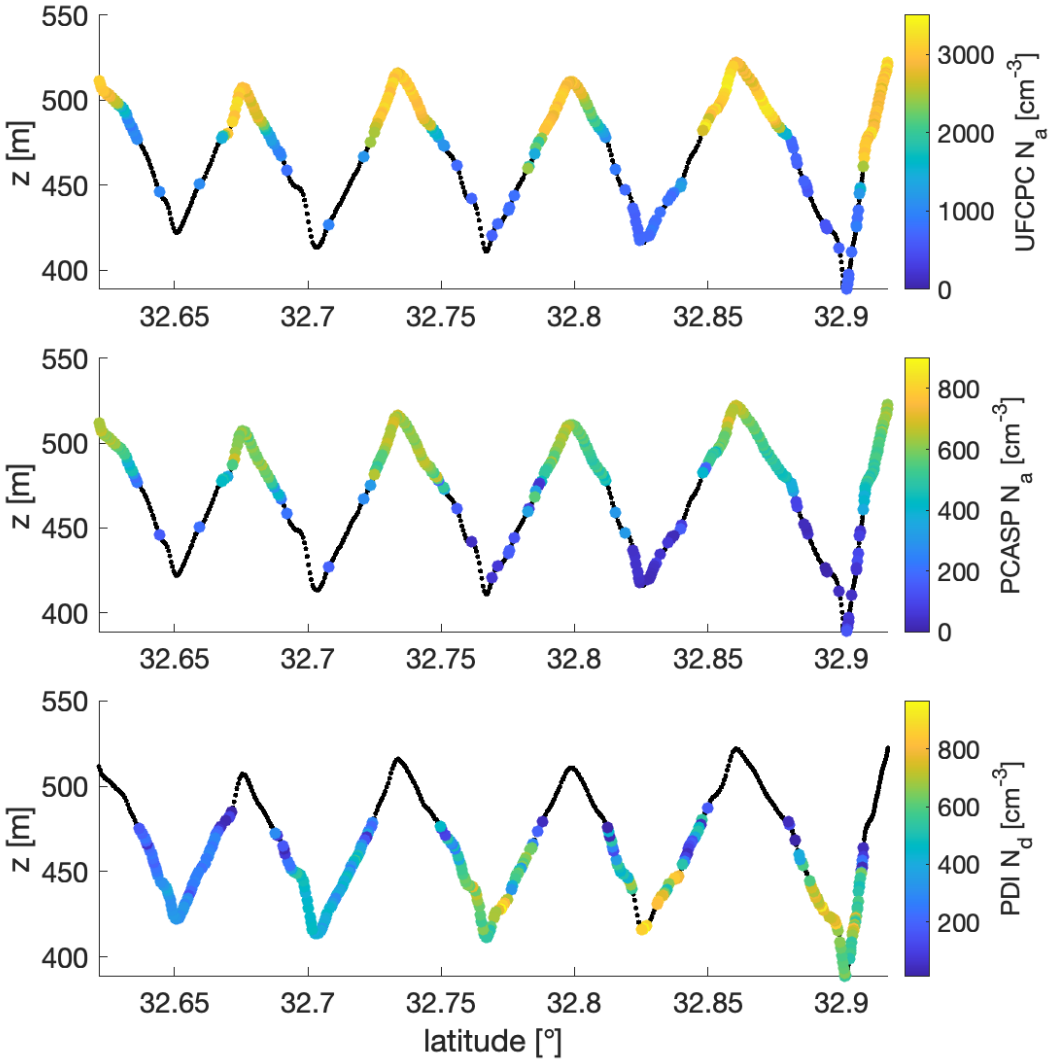
Closed •/x: downwind



Both cloud drop and sub-cloud aerosol concentrations increase in the island wake during mature Catalina eddy conditions

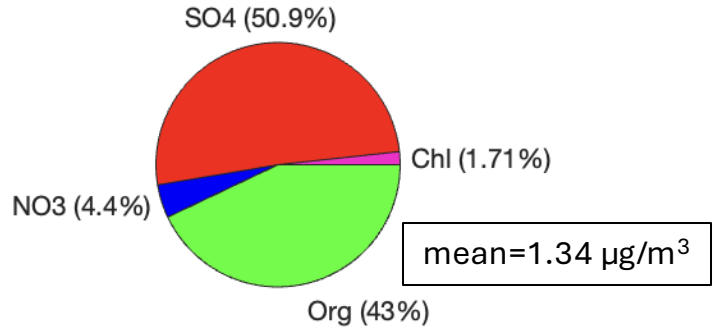
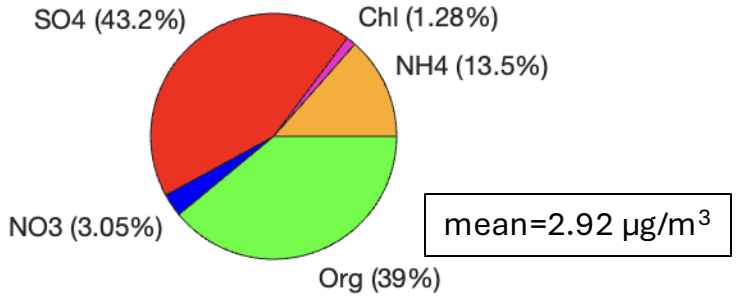
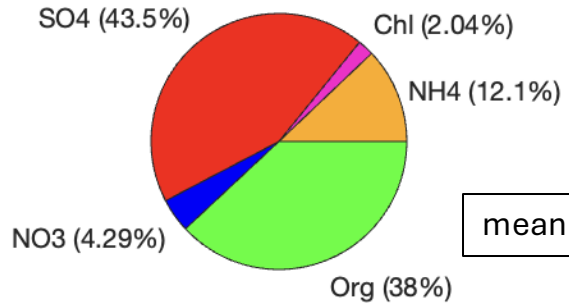
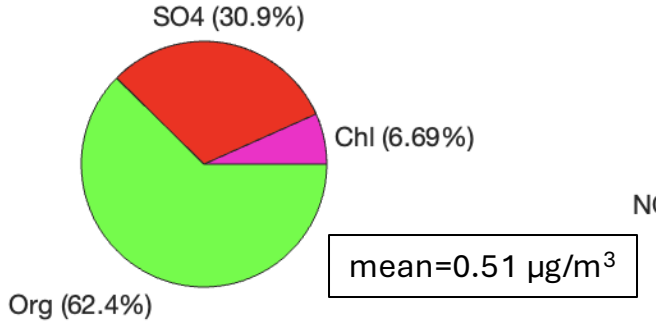
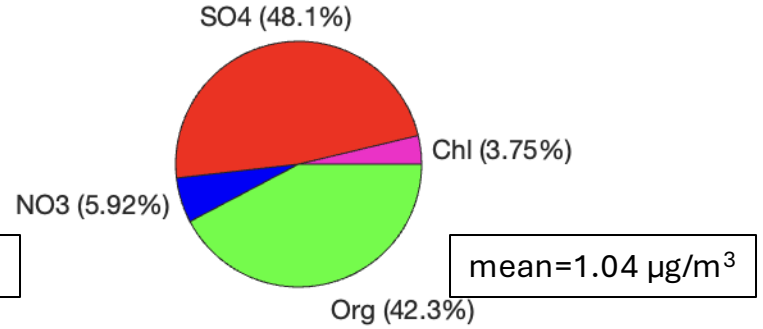
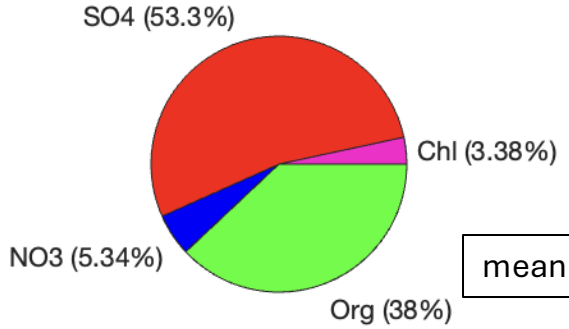
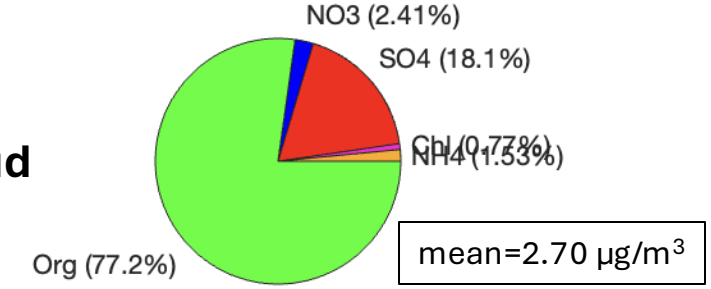
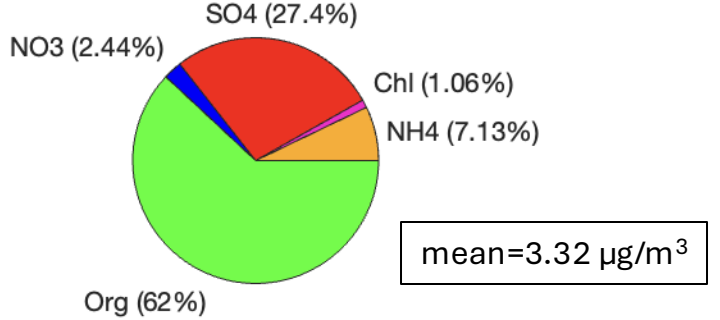

RF16
RF17
RF18
RF19
RF21
altitude [m]
θ [K]
TKE [m²s⁻²]
upwind
wake
downwind
max. elev. of SCI


30 June, RF 21
NASA LaRC
ND (cm-3)
>400
360
320
280
240
200
160
120
80
60
40
30
20
10
0


z [m]
550
500
450
400
32.65
32.7
32.75
32.8
32.85
32.9
UFCPC N_a [cm^{-3}]
3000
2000
1000
0
PCASP N_a [cm^{-3}]
800
600
400
200
0
PDI N_d [cm^{-3}]
800
600
400
200
latitude [°]

Is aerosol composition consistent w/transport?

RF21

	Upwind	Wake	Downwind
Surface	 mean=1.34 µg/m^3	 mean=2.92 µg/m^3	 mean=3.06 µg/m^3
Mid-cloud CVI	 mean=0.51 µg/m^3	 mean=1.04 µg/m^3	 mean=1.19 µg/m^3
Above cloud	 mean=2.70 µg/m^3	 mean=3.32 µg/m^3	

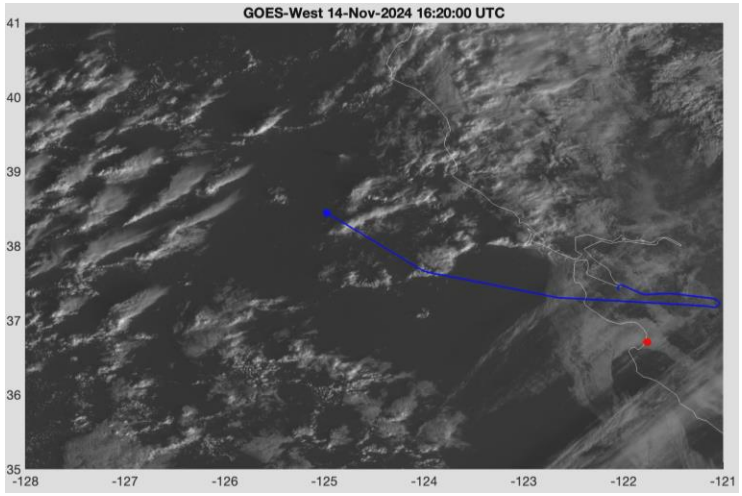
AMS data from B. Ries and R. Bahreini, UCR

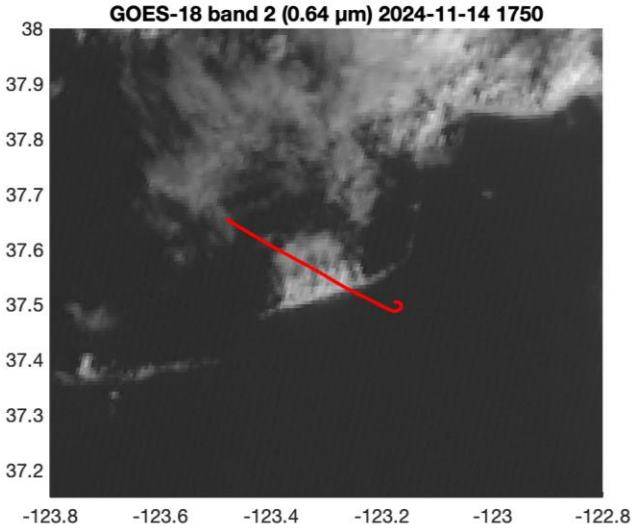
SCILLA Summary

- Enhanced aerosol number, cloud number, and cloud drop residual mass concentrations were observed in the wake of San Clemente Island during a multi-day Catalina eddy event
- Vertical transport is likely driven by wake-induced shear as evidenced by “large” TKE above inversion height
  - Time-series view shows that entrainment of free tropospheric aerosol into the boundary layer is highly localized/spatially intermittent
- Horizontal transport story is more complicated
  - Back trajectories suggest combination of long-range transport (from Bay Area?) and more “local” transport from SoCal/LA Basin
  - Using aerosol physiochemical properties to fingerprint source regions

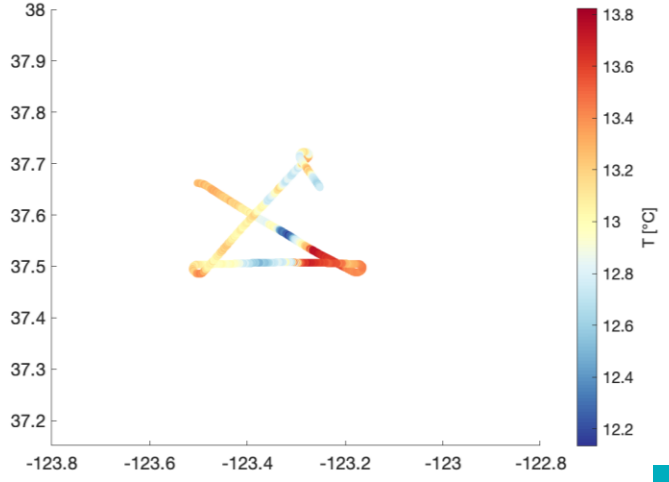
Other recent activities/stuff I’m excited about

November 14 , 2024 – Cold Pools W of SF/Marin

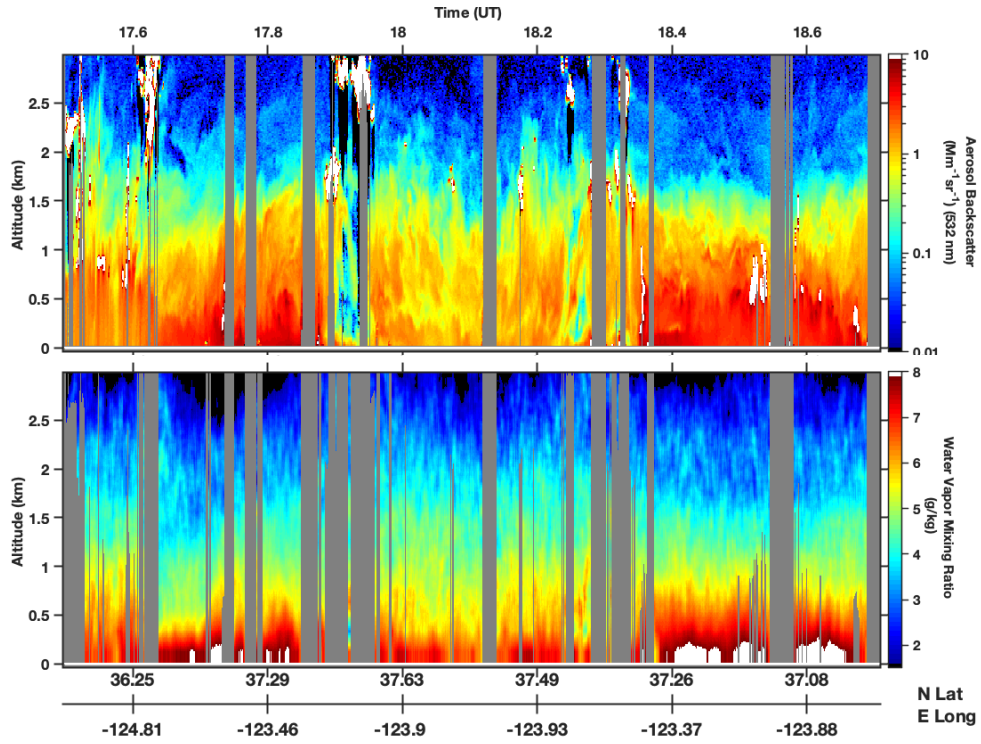




Twin Otter 30 m leg



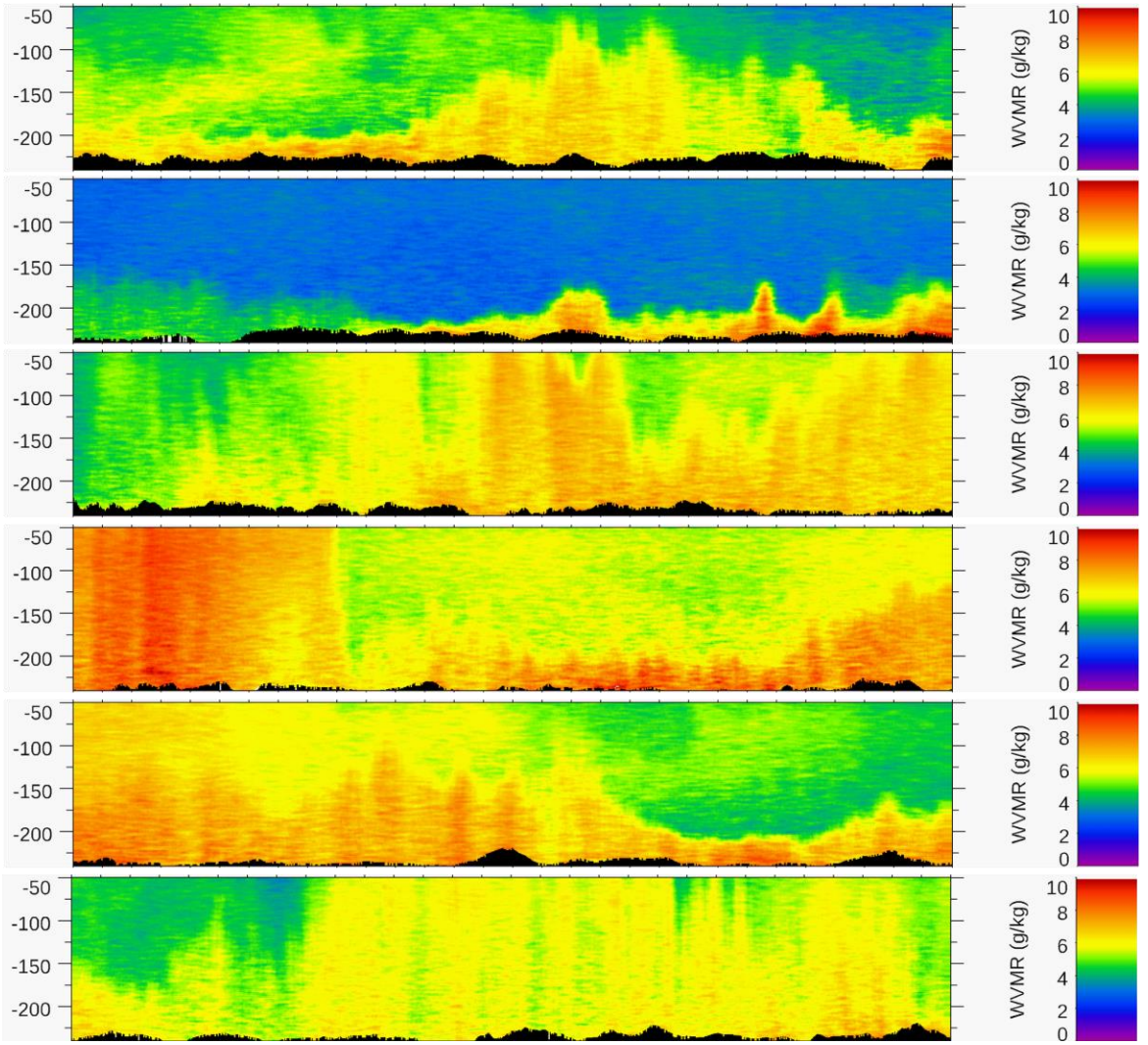
NASA G-III DIAL/HSRL (preliminary)



Lidar data courtesy of Amin Nehrir, NASA LaRC

An even finer view of vapor from Raman lidar…

- Raman lidar q_v from REDSAW over Salton Sea, May 2024
- Range gate resolution = **0.6 m**
- Similar configuration for SHIMMER campaign sampled stable BL over Monterey Bay, Dec 2024 (data not yet post-processed)
- Promising dataset for probing micro-scale structure of T/q, air-sea interactions

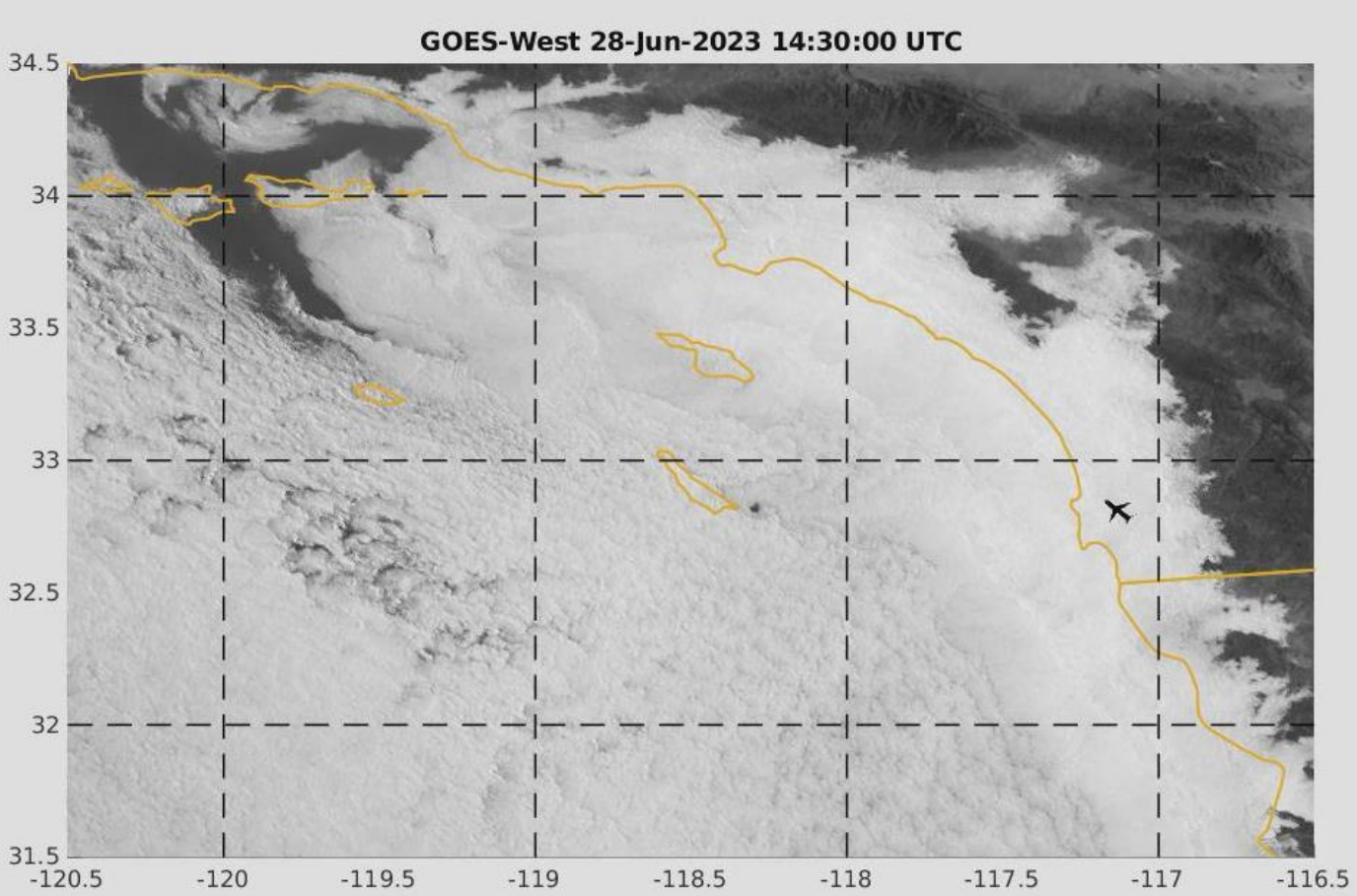


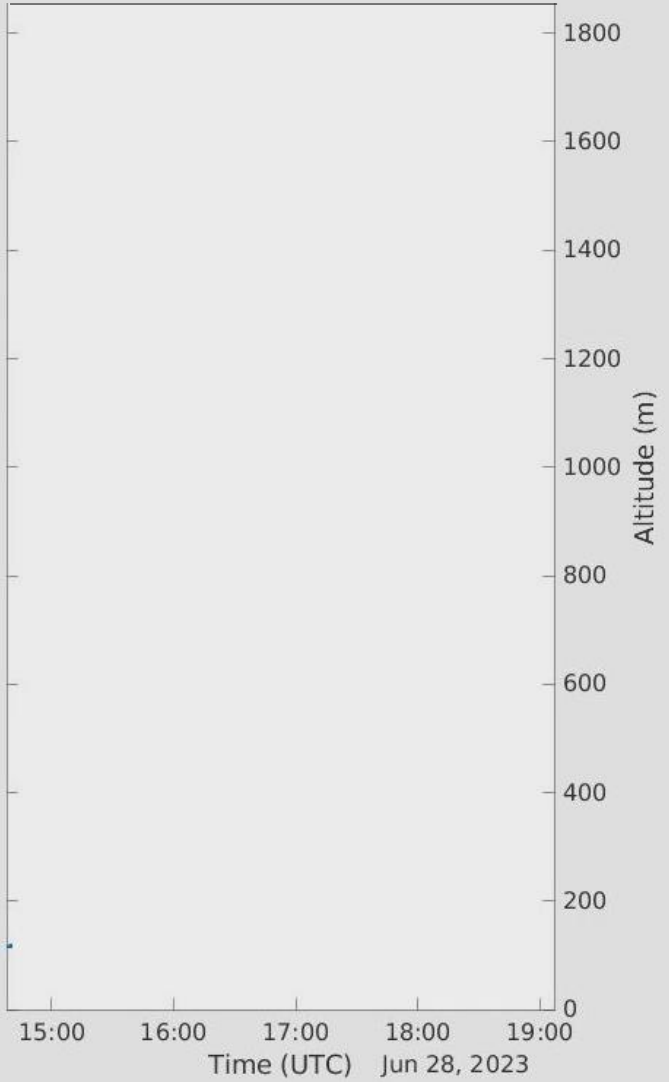
Data courtesy of Z. Wang (Stony Brook), Q. Wang (NPS)

Thanks!

SCILLA participants:

Anthony Bucholtz, Bryce Kujat, Jeff Martin,
Greg Cooper (CIRPAS)
Dongli Wang and Andrew Metcalf (Clemson)
Sierra Bollinger (NPS)
Lisa Welp (Purdue)
Roya Bahreini, Don Collins, Minghao Han,
Bradley Ries (UC Riverside)
Patrick Chuang, Mason Leandro (UC Santa Cruz)


GOES-West 28-Jun-2023 14:30:00 UTC
34.5
34
33.5
33
32.5
32
31.5
-120.5
-120
-119.5
-119
-118.5
-118
-117.5
-117
-116.5


1800
1600
1400
1200
1000
800
600
400
200
0
Altitude (m)
15:00
16:00
17:00
18:00
19:00
Time (UTC)
Jun 28, 2023

H0: Is satellite N_d well retrieved?