Electronic Supplementary Material (ESI) for Environmental Science: Atmospheres.

Supplementary materials: A national crowdsourced network of low-cost fine particulate matter and aerosol optical depth monitors: Results from the 2021 wildfire season in the United States

Contents of this file

Text S1: Summary of CEAMS quality control results

Of the 192 sample logs received at the conclusion of the study, 140 (72.9%) completed at least 76.8 hours (75%) of the prescribed 96-hour runtime. Of the prematurely terminated samples, 30 (57.7%) had a depleted battery, 14 (26.9%) were manually turned off by the operator via the pushbutton, and 8 (15.4%) failed due to an unknown electrical or mechanical error. In Fig. 2, we provide the distribution of CEAMS runtimes, colored by the failure mode.

Compared with our prior laboratory reliability testing (Wendt et al., 2021), fewer AMODv2s completed their full runtime. In our laboratory testing (Wendt et al., 2021), 75.0% of the samples completed their prescribed runtime, compared with 72.9% in the CEAMS network. However, relatively similar proportions of samplers failed due to battery depletion (64.0% for laboratory and 57.7% for CEAMS) and unspecified electrical or mechanical failure (9% for laboratory and 15.4% for CEAMS). The difference in overall performance can then be partially explained by user-initiated pushbutton shutdowns, which did not occur in the laboratory testing. We received explanations for why some samples were manually shut down prematurely including concern over inclement weather, concern over theft from relatively insecure positions, and choosing to move the device to a new location mid-sample. Further study on participant interactions with the samplers is the subject of ongoing work.

We applied additional quality-control analyses to specific AOD and $PM_{2.5}$ measurements. With respect to AOD, the AMODv2 reported either a triplet average of AOD measurements or a unique error code at every 20-minute mark throughout the day. Unique error codes were provided for measurements initiated at night (no execution of tracking protocol), those that never achieved alignment with the sun, those with incomplete triplets, and those identified as cloud-contaminated. Across all wavelengths, 981 AOD measurement attempts did not complete a full triplet of measurements. The number of triplets screened for clouds and those marked as valid varied by wavelength. There were 1,915; 1,813; 1,892; and 2,490 triplets marked as cloud-contaminated for 440 nm, 500 nm, 675 nm, and 870 nm channels, respectively. There were 3,658; 3,760; 3,681; and 3,083 triplets marked as valid for 440 nm, 500 nm, 675 nm, and 870 nm channels respectively. We accounted for discrepancies with the 870 nm channel by including triplets that were valid for the remaining three wavelengths.

Compared with our prior laboratory validation work (Wendt et al., 2021), a higher proportion of measurement triplets were marked as valid for all wavelengths in our crowdsourced CEAMS campaign. In our prior study, 33.0%, 34.0%, 35.0%, and 33.0% of triplet attempts were marked as valid for 440 nm, 500 nm, 675 nm, and 870 nm channels, respectively (Wendt et al., 2021). In the present study, 55.8%, 57.4%, 56.2%, and 47.0% of triplet attempts were marked as valid for 440 nm, 500 nm, 675 nm, and 870 nm channels, respectively.

Table S1. Correlations and number of observations (N) for each wavelength by smoke or no smoke day designation. Table is a companion to Figure 4 in the main text.

	440 nm		500 nm		675 nm		870 nm	
	R^2	N	R^2	N	R^2	N	R^2	N
No Smoke	0.94	88	0.90	88	0.79	88	0.88	32
Smoke	0.99	52	0.99	52	0.98	52	0.85	41

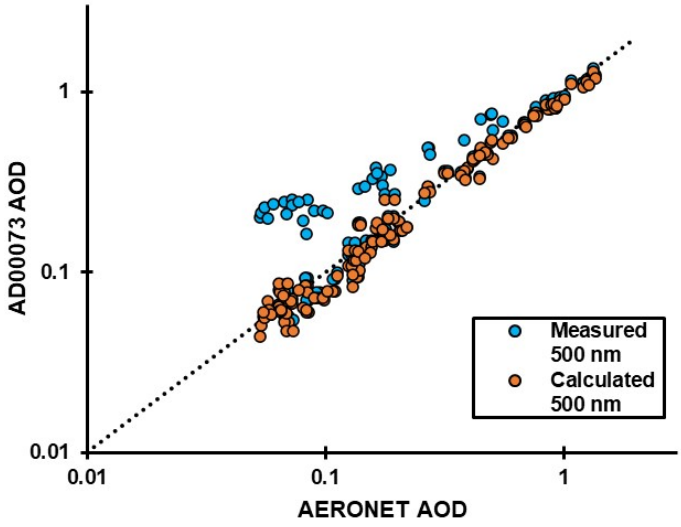

Figure S1. Scatter plot of the raw measured (blue) AOD at the 500 nm wavelength from the AD00073 unit compared to a nearby AERONET AOD and the AOD calculated (orange) using the Angstrom exponent from the 440 and 675 nm wavelengths.

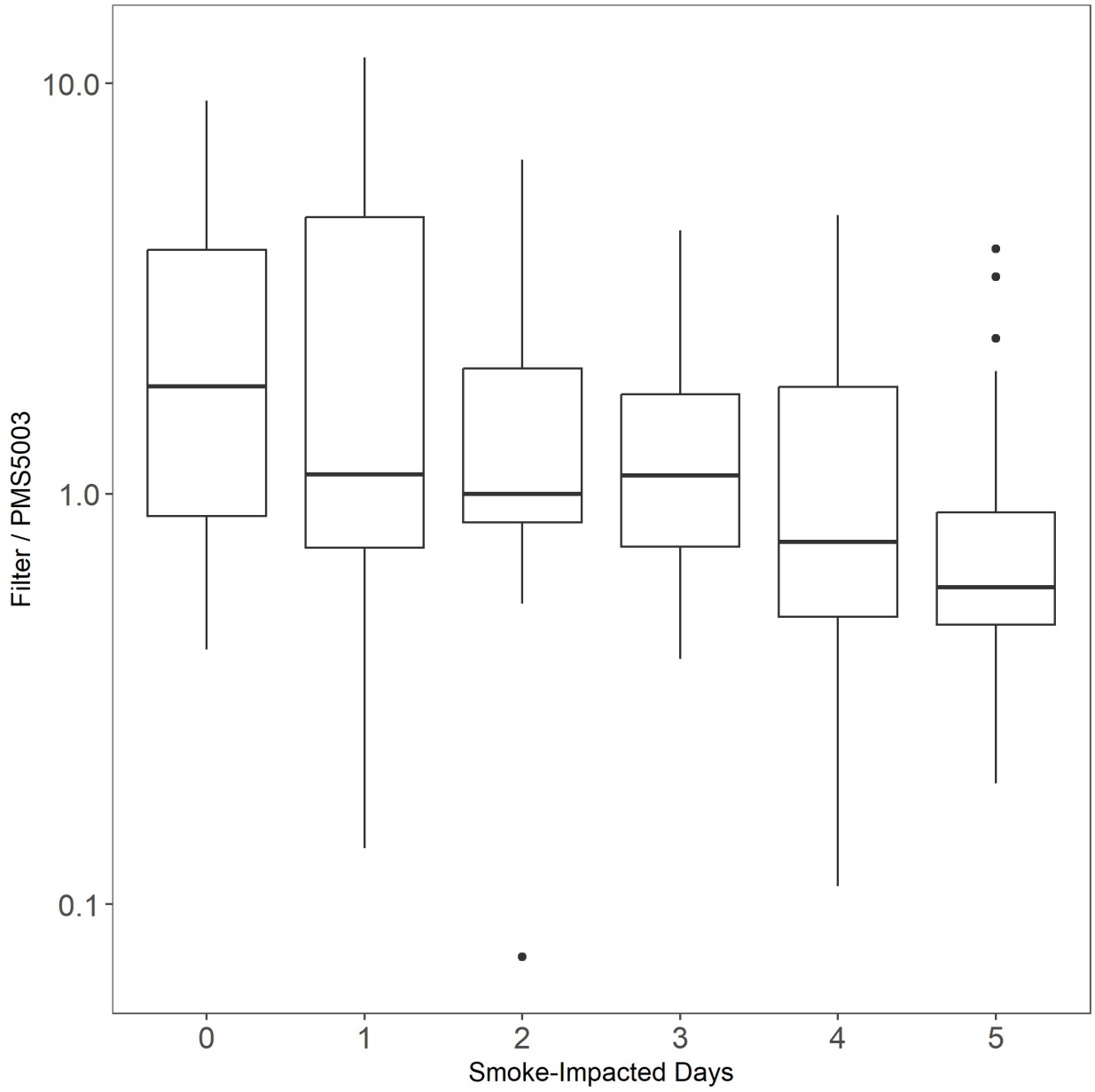

Figure S2. Box and whisker plots of how filter/PMS5003 values (i.e., Plantower scaling factors) varied with the number of smoke days for AMODv2 sampling runs. Filters with five smoke-impacted days included two partial sampling days (i.e., sampled for 12 hours on the first day, and another 12 hours on the last day, for a total of 96 hours.). Box corresponds to the 25th and 75th percentiles and whiskers extend to highest and lowest values or 1.5*IQR.

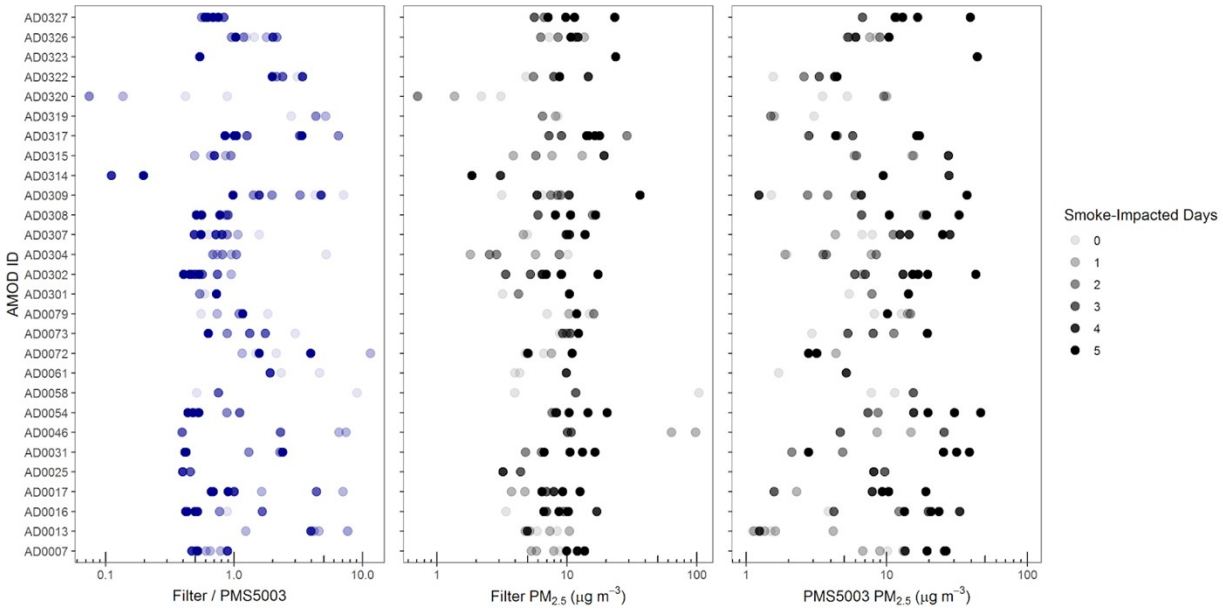

Figure S3. Distribution of filter/PMS5003 concentration ratio by number of smoke-impacted days and AMODv2 identification number. Filters with five smoke-impacted days included two partial sampling days (i.e., sampled for 12 hours on the first day, and another 12 hours on the last day, for a total of 96 hours.).

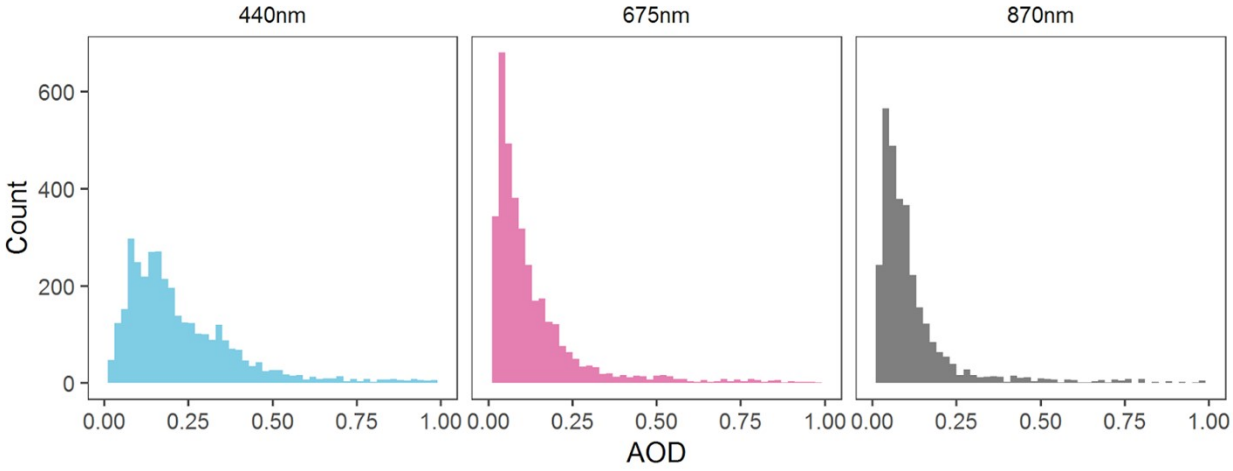

Figure S4. Distribution of valid AOD measurements in CEAMS campaign by wavelength.

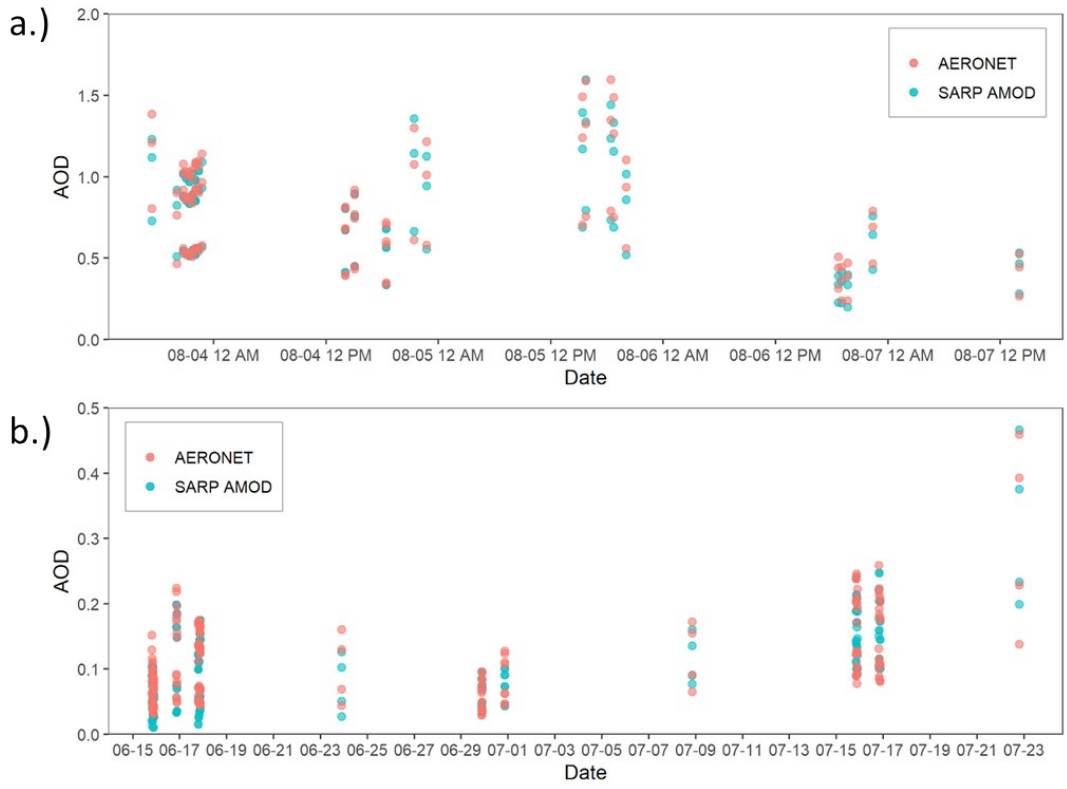

Fig S5. Time series of AOD measured at paired SARP AMOD site and nearby AERONET. Panel a) is for AMOD ADo323 and the Missoula AERONET site; panel b) is for AMOD AD0007 and the Georgia Tech AERONET site. The time series has been sampled to times when both locations had valid AOD550nm measurements.

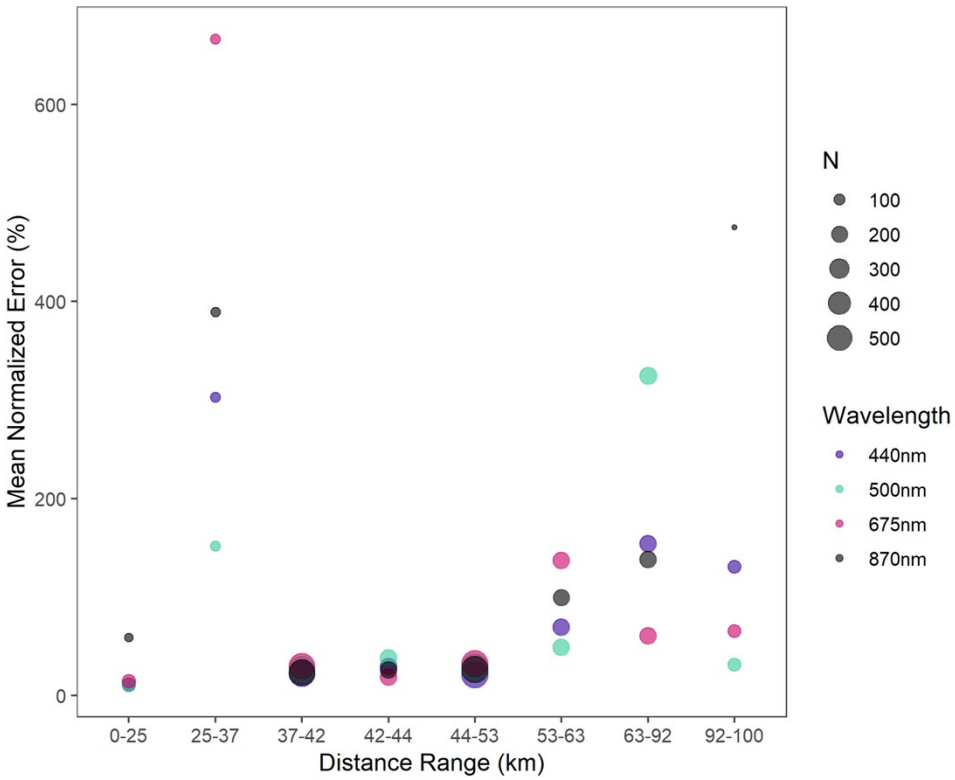

Figure S6. SARP vs. AERONET mean normalized error as a function of distance separating SARP and AERONET monitors.

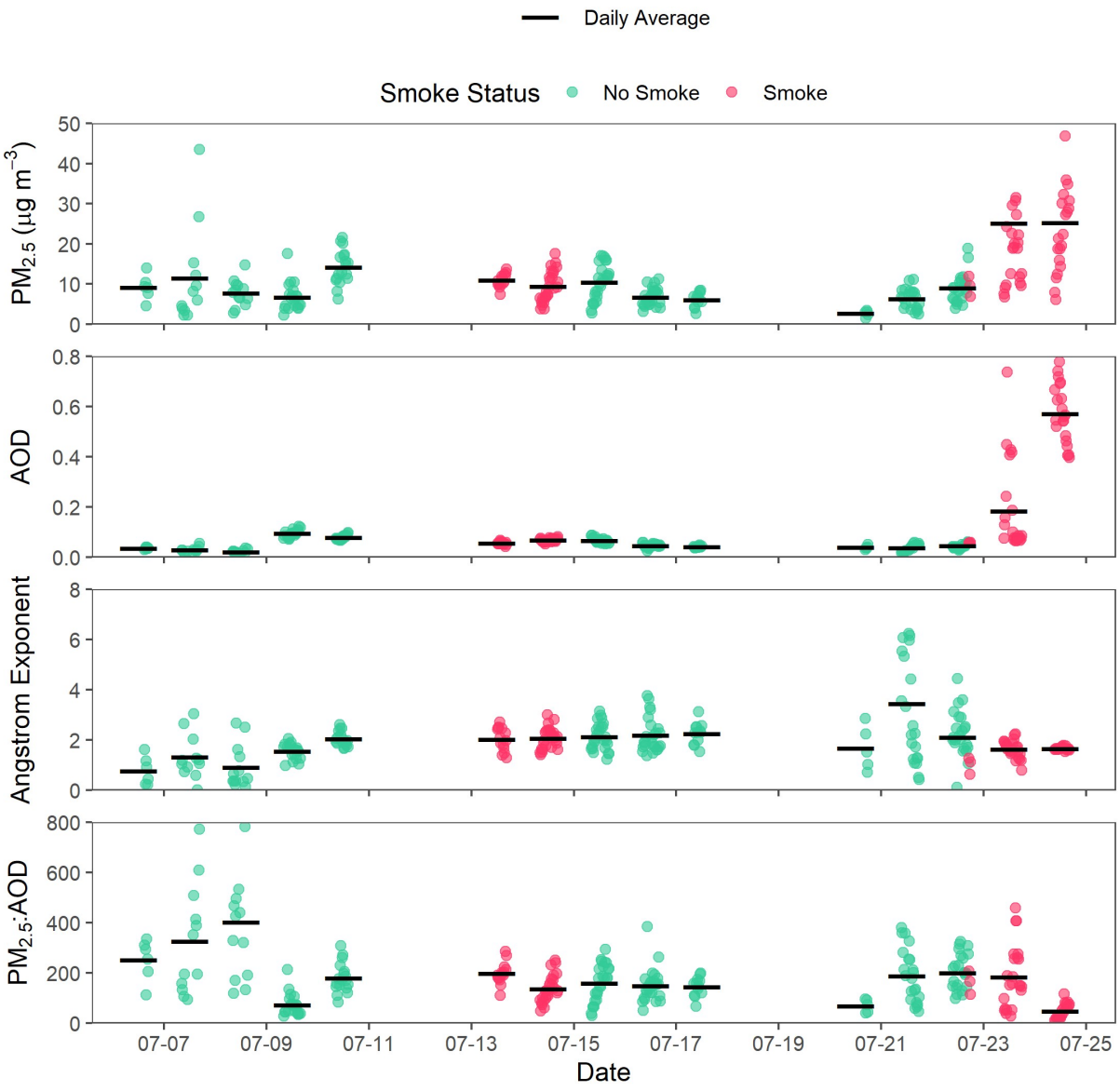

Figure S7. Time series plots of $PM_{2.5}$, AOD, Angstrom exponent, and $PM_{2.5}$:AOD from July 6, 2021 to July 24, 2021, from a CEAMS site near Sacramento, California. Note that measurements on July 12, 2022, were from a single AMODv2 started early by the CEAMS participant.

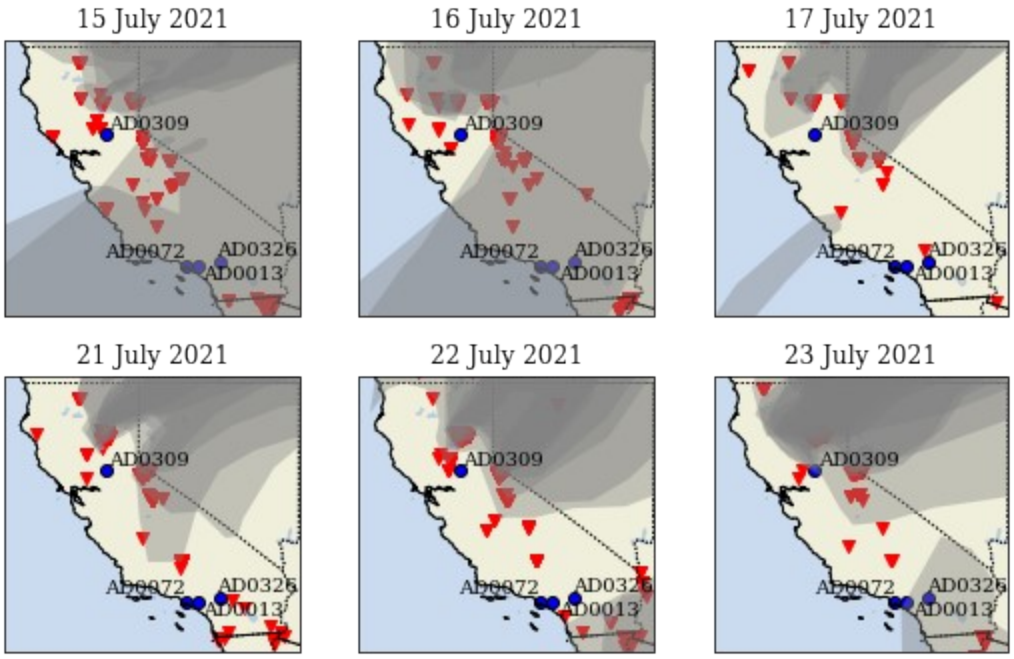

Figure S8. HMS smoke maps for selected time periods with smoke plumes denoted in gray and fire hot spots denoted by red triangles. Locations of AMODv2s in California for the campaign are labeled and noted by blue circles.

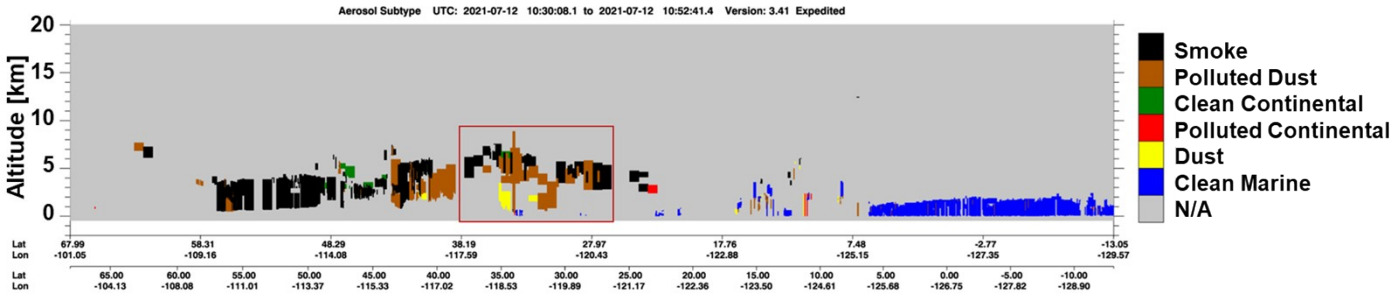

Figure S9. Curtain plot from NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) on July 12, 2021. The boxed region designated the Southern California region where CEAMS monitors were located.

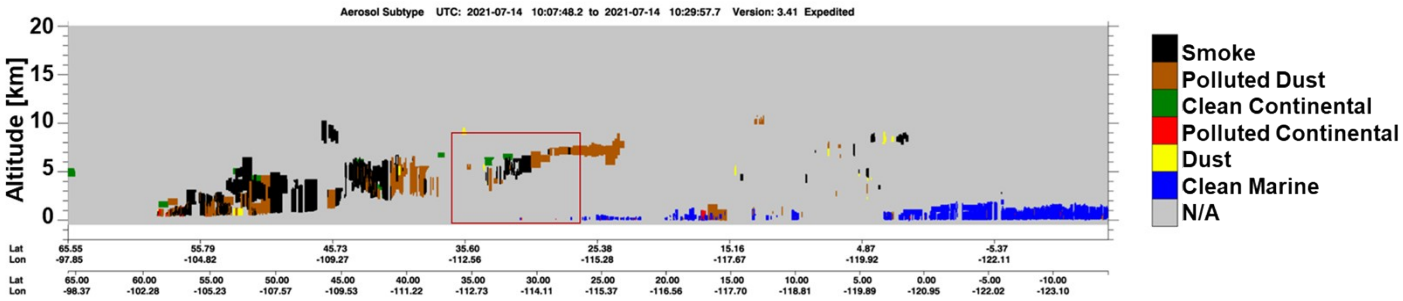

Figure S10. Curtain plot from NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) on July 14, 2021. Boxed region is for an overpass over California.