Black Carbon Measurements over the Los Angeles Basin during CalNex

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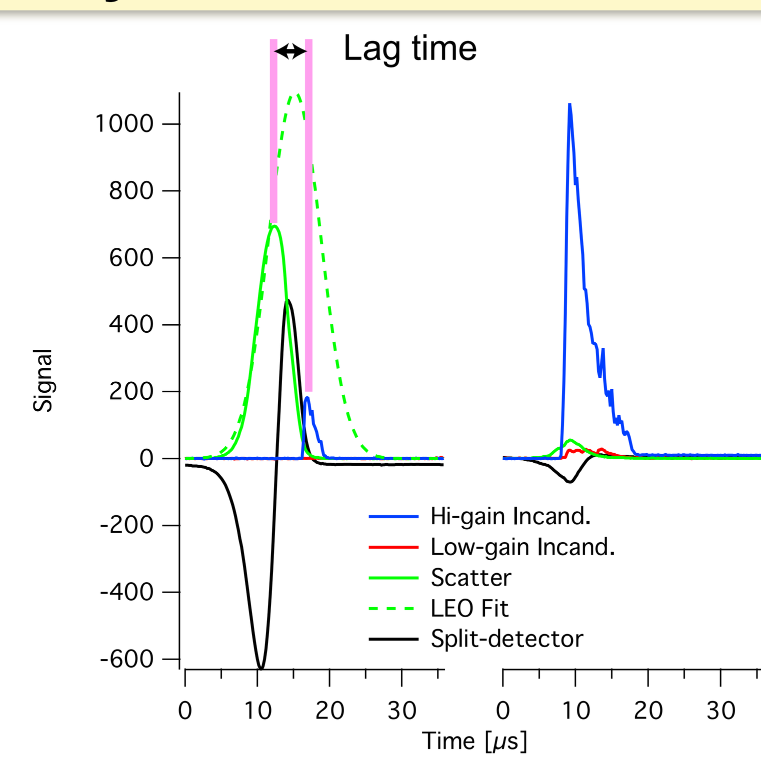
Introduction & Sampling Methods

The CalNex field campaign aimed to study both the short-term air quality and the longer-range climate change effects of pollutants in the Los Angeles Basin and the Southern San Joaquin Valley. Characterizing black carbon (BC) aerosol fits both of these goals, as BC aerosol is closely tied to anthropogenic sources and, due to its heating potential as a light absorbing particle, has important effects on climate. In this study, we aim to characterize the BC-containing aerosol observed during CalNex.

The CIRPAS Twin Otter completed 18 flights during the month of May, 2010. Three flights probed the San Joaquin Valley, while the other 15 flights focused on characterizing the aerosol in the LA Basin and its two main outflow regions, the El Cajon Pass to the northeast and the Banning Pass to the east. Sampling took place at about 1000 feet above ground level throughout the Basin at an airspeed of about 50 m/s. The payload onboard the Twin Otter was focused on aerosol instrumentation.

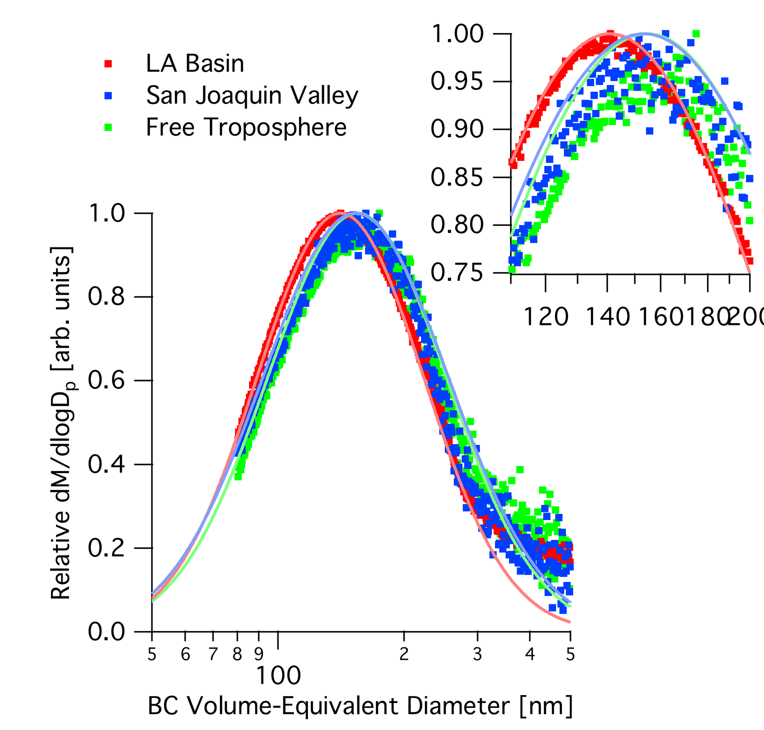
Single-particle black carbon number, mass and mixing state were measured with a Droplet Measurement Technologies Single Particle Soot Photometer (SP2), previously described by Stephens et al., 2003 and Baumgardner et al., 2004. BC mass was calibrated with glassy carbon spheres and the scattering signal was calibrated with dioctyl sebecate and interpreted with a Mie scattering model tuned to the detectors on the SP2.

Data Analysis Methods



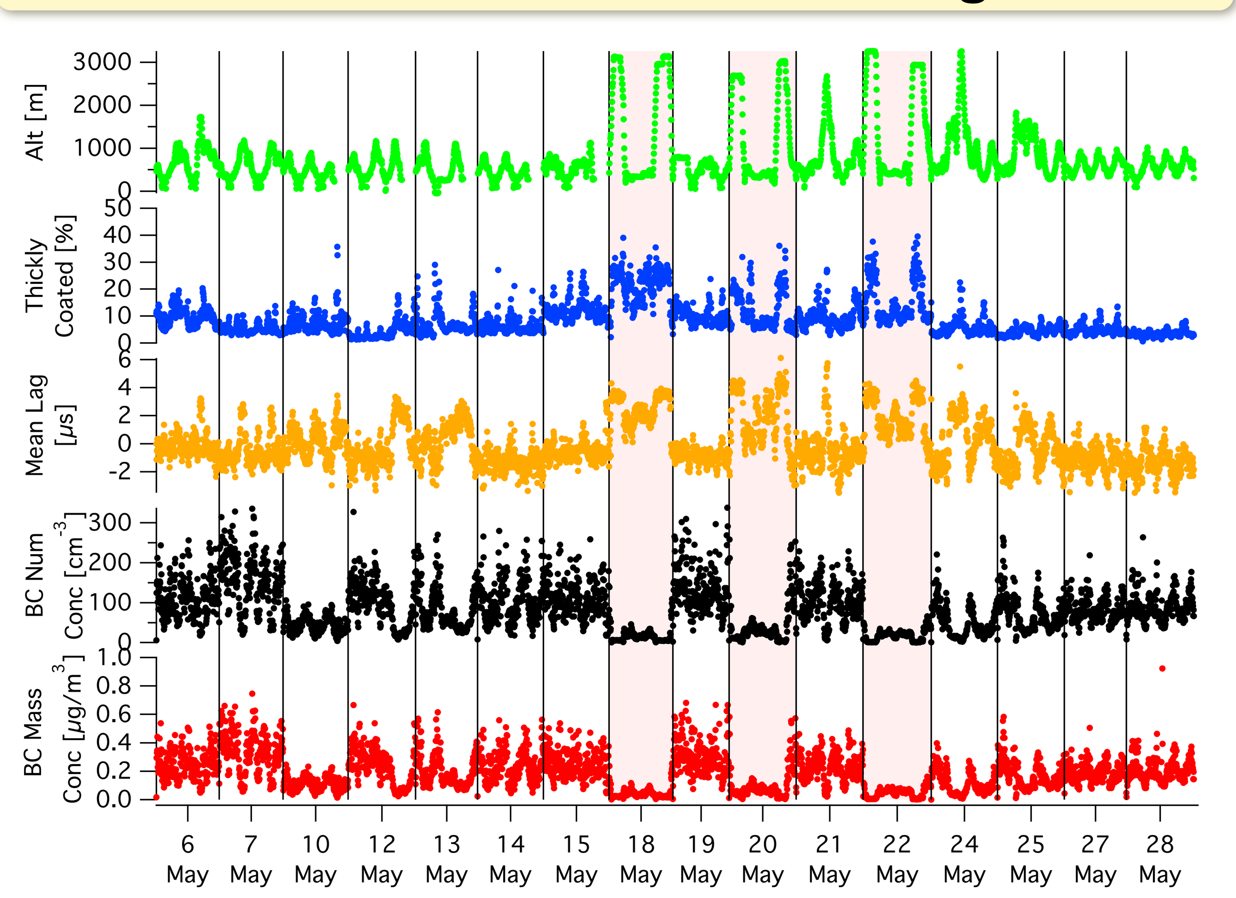
Single-particle spectra for two different particles. On the right is an uncoated, large (173 nm volume-equivalent diameter) BC particle. The scattering peak coincident with the incandescent peak is the scattering from the BC particle itself and is not indicative of a coating on the particle. On the left is a thickly coated (323 nm optical diameter), small (96 nm volume-equivalent diameter) BC particle. For particles with coatings that evaporate, the leading-edge only (LEO) fit of the scattering signal is done to ensure proper sizing.

Typical Black Carbon Mass Distributions



Typical BC mass distributions, normalized by their max. Mass distributions are found by taking histograms of the single-particle mass at 1-minute intervals, which yield the number distribution, then each bin count is multiplied by its mean mass to yield the mass distribution. A single log-normal fit to the number distribution is then used similarly to find the fit to the mass distribution. The reported mass concentrations below are found with the fitted log-normal function of the mass distribution, and these fitted values are about 30% higher than the raw measured values.

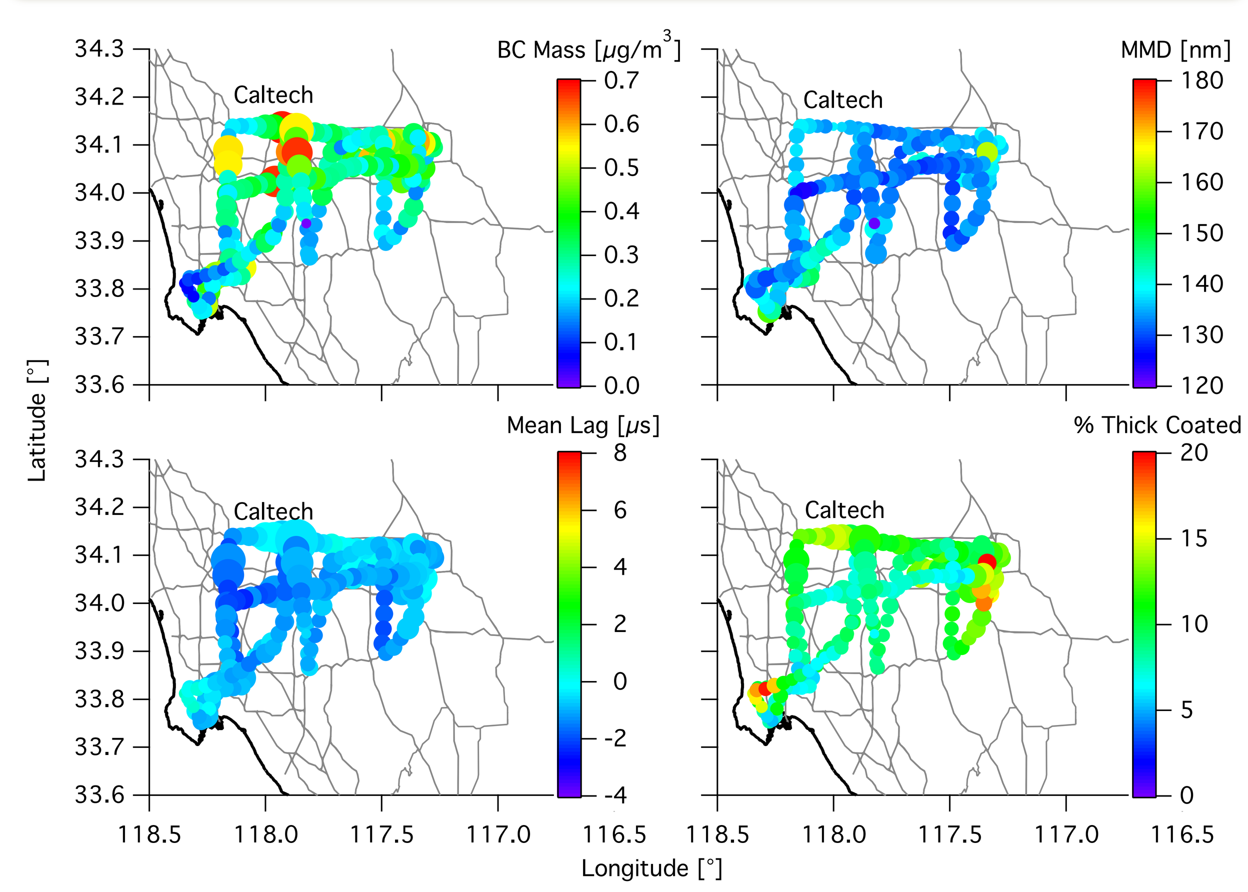
Black Carbon Observations during CalNex



All 1-minute averaged SP2 observations during CalNex. The 3 shaded flights were the trips to the San Joaquin Valley. The altitude trace is provided to highlight the few trips made above the inversion layer.

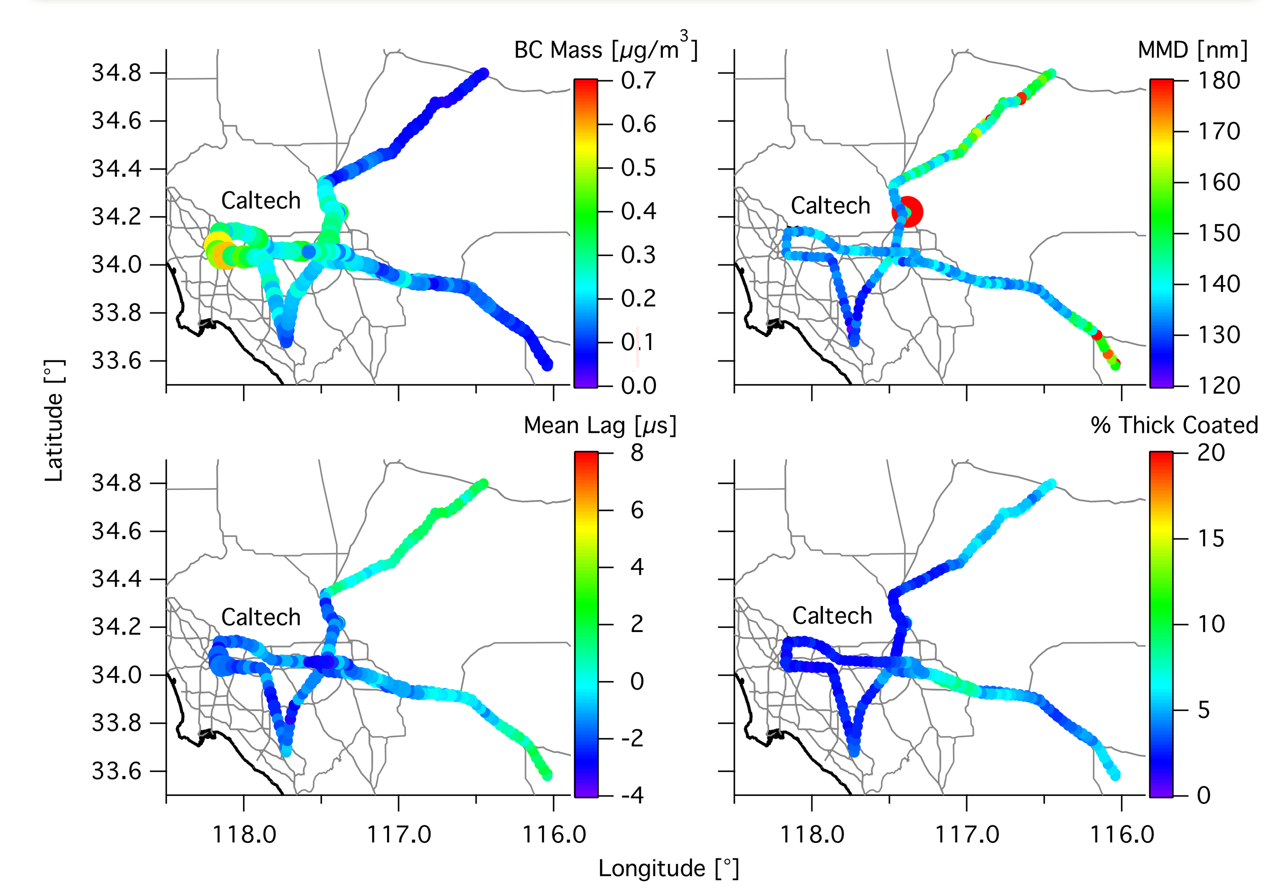
	BC Number Concentration [cm^{-3}]	BC Mass Concentration [μg/m^3]	Lag Time [μs]	Percent Thickly Coated [%]	BC Mass Fraction [%]	Mass-median Diameter [nm]
LA Basin	265	0.259	0.794	2.86	4.32	141
West LA Basin	*318*	*0.269*	*0.572*	*2.1*	*4.06*	*141*
East LA Basin	*253*	*0.225*	*0.921*	*3.66*	*3.46*	
Basin Outflows	180	0.153	1.4	2.45	6.64	145
El Cajon Outflow	*199*	*0.17*	*1.41*	*2.02*	*7.29*	
Banning Outflow	*149*	*0.127*	*1.39*	*3.13*	*5.62*	
San Joaquin Valley	68.5	0.0667	1.99	7.78	1.75	153
Free Troposphere	59.6	0.051	2.98	9.43	2.67	155

May 19, 2010



This was our second dirtiest flight overall. BC mass concentrations are highest on the northern edge of the LA Basin, a consequence of more freeways and thus emissions and of the sea breeze pushing the pollution up against the mountains. The mixing state parameters are fairly constant throughout the Basin.

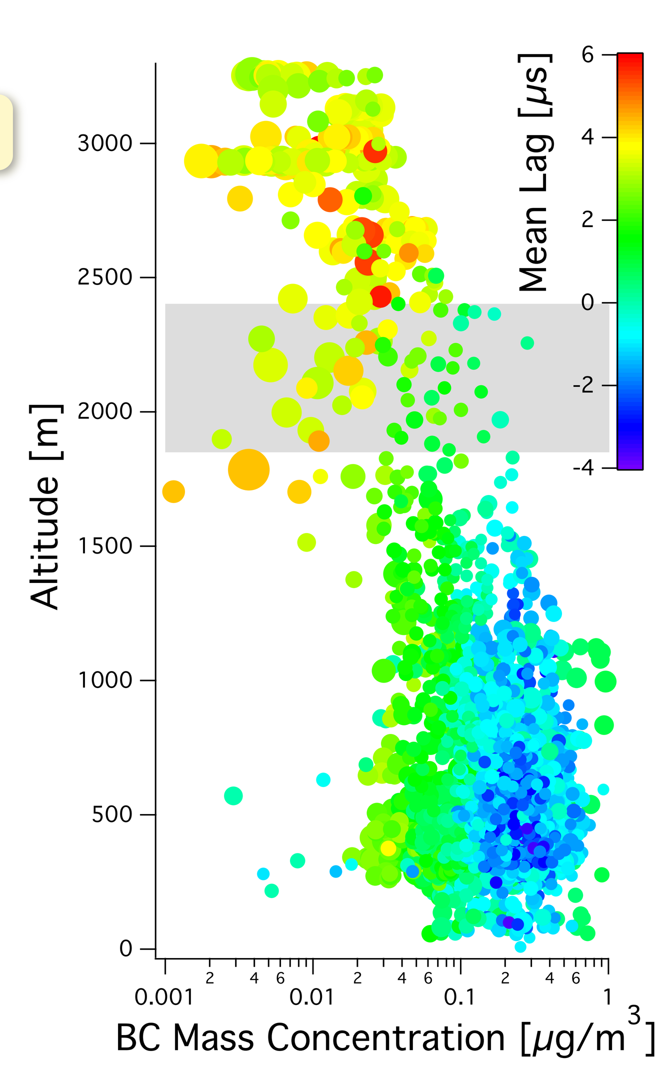
May 25, 2010



This flight was typical of our observations of the contrast between the LA Basin and the Basin's outflow regions. The mixing state parameters, mean lag time and percent thickly coated, remain relatively constant within the LA Basin and only see significant changes in both outflow regions.

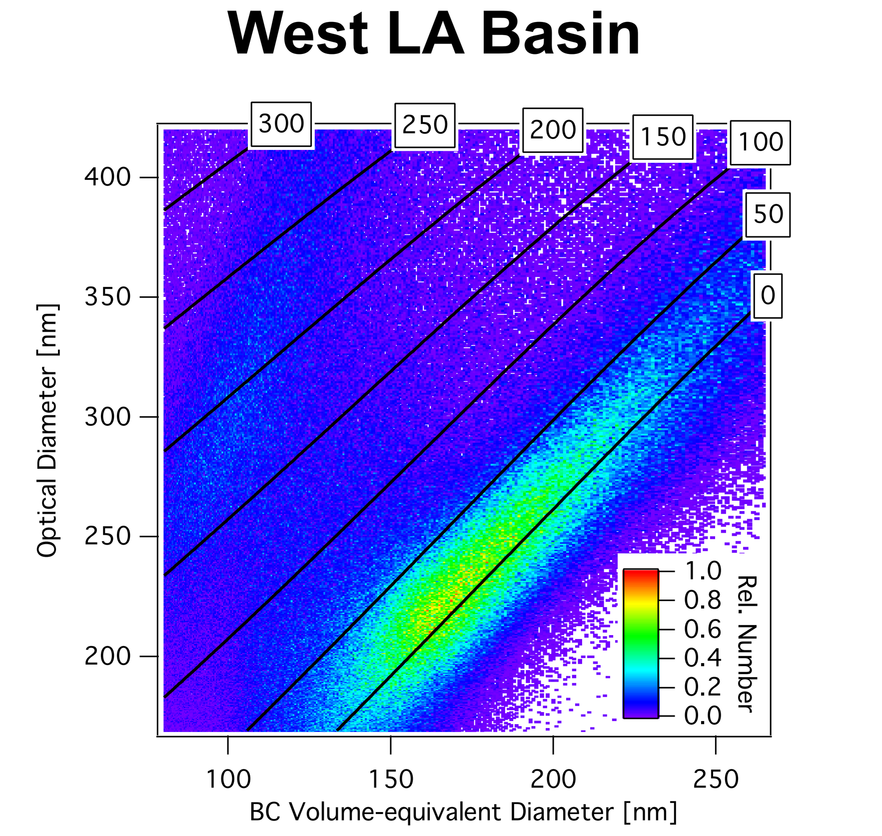
Vertical Distribution of Black Carbon

BC variation with altitude for one-minute resolution data for all flights. The size of the markers are proportional to the percent of detectable BC particles "thickly coated". The gray-shaded region of the plot denotes the range of observed inversion layers on these flights.

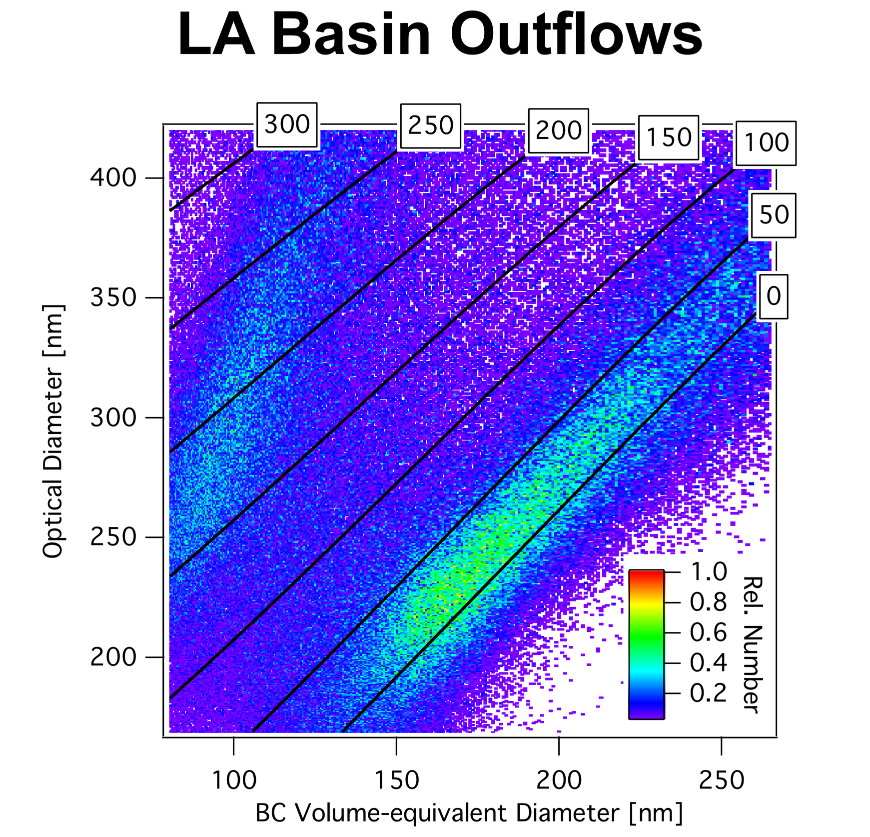


Mixing State of Black Carbon Particles

West LA Basin



LA Basin Outflows



Mixing state plots of all particles measured in two locations, the source-rich Western LA Basin and the aged Basin outflow regions. The optical diameters are derived from the leading-edge only fits of the scattering signal and assuming a refractive index of 1.5 - 0.0i. The solid lines are a core-and-shell Mie model with the core diameter equal to the BC volume-equivalent diameter on the x-axis and a shell thickness in nm indicated by the boxes. The assumed refractive index of the core is 1.95 - 079i (Bond & Bergstrom, 2006) and of the shell is 1.5 - 0.0i.

Implications

Within the LA Basin, patterns emerge in the BC mass concentration (more mass on the north side of the Basin), but the coating parameters of lag time and percent thickly coated are relatively uniform. In regards to the coating parameters, day-to-day variation seems more important.

The LA Basin outflow regions both exhibit evidence of increased coatings on the BC particles. Dilution in these outflows clearly lowers the BC mass concentration, but the mass fraction of BC increases in these regions. This is evidence of the other major aerosol components evaporating relative to the BC.

The vertical distribution of BC shows the decrease in concentration with altitude coupled with an increase in coating thicknesses. We expect more aged aerosol above the inversion layer, and indeed do see evidence of that in the nature of the BC particles.

The mixing state of BC clearly evolves from the source-rich LA Basin to the outflows. A clear increase in the number of thickly coated small BC particles is apparent relative to main mode of BC particles.

Acknowledgements

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