



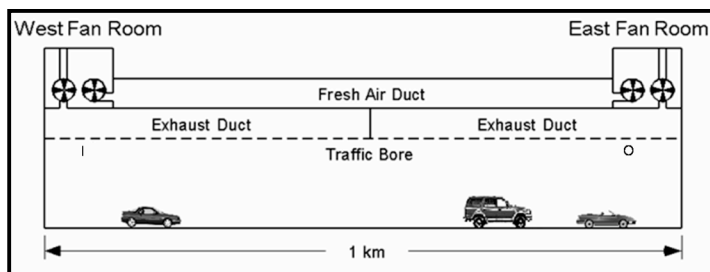
How do Vehicle Emissions Affect Climate?

The objective of this study is to measure the radiative properties of vehicle emissions in a real world situation and assess the effects of aerosol on regional climate.

It is well known that aerosols have a profound effect on regional and global climate, however, there still exist large uncertainties in the measurement of key aerosol radiative properties, such as absorption and single scattering albedo and their distribution in the atmosphere. These effects are felt directly, through direct scattering and absorption of solar radiation and indirectly by modifying cloud properties and precipitation. Single scattering albedo, the ratio of scattering to extinction, is an important metric for aerosol radiative effects and an important input into global climate models.



Heavy and light duty vehicles exiting the Caldecott Tunnel near San Francisco, CA



Schematic layout of the Caldecott Tunnel. Our instrumentation was set up in an exhaust duct which is separated from the vehicle traffic.

Measurements within the Caldecott Tunnel

The Caldecott Tunnel is a heavily-used commuter tunnel east of San Francisco. One unique feature is that heavy vehicles are restricted from bore 2 affording an opportunity to study light duty and mixed duty vehicles under real driving conditions.

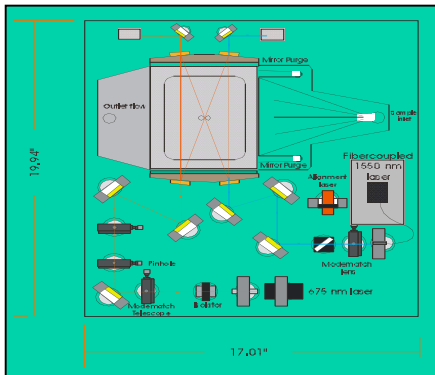
Gas phase pollutants (CO_2 , CO, NO_x) are measured at the inlet (I) and outlet (O) of tunnel. Aerosol size distribution (TSI SMPS) and optical properties (Cadenza, nephelometers) measured at outlet, just above traffic in exhaust duct. Black carbon (BC) mass is measured on filters and aethalometers.

Two tunnel bores: 1) light-duty (gasoline) vehicles and 2) mixed light-duty and heavy-duty (diesel) vehicles.

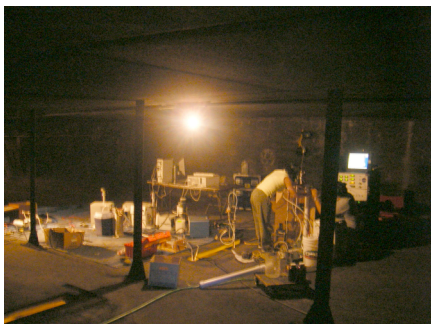
Key Findings

1. Black Carbon (BC) dominates the radiatively active aerosol, especially during peak traffic periods. The single scattering albedo during these periods approaches that of pure BC emitted from a sooting diffusion flame.
2. The mass absorption efficiency of the tunnel aerosol is about 6 gm^{-2} , which is at the low end of the range observed in the atmosphere. This suggests that the efficiency of BC emitted from trucks increases as it ages in the atmosphere.
3. The number size distribution of aerosol is dominated by freshly nucleated particles, but there is a radiatively active soot accumulation mode ($D \sim 150 \text{ nm}$) and a larger mode ($D \sim 600 \text{ nm}$) of unknown composition.

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Schematic of Cadenza.

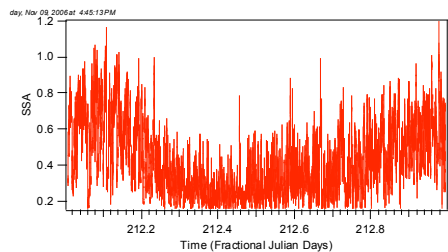
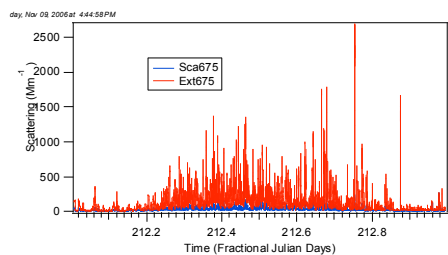
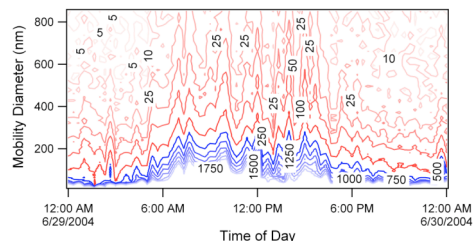


Features of Cadenza

Cadenza [Strawa et al., 2003; Strawa et al., 2006] is a new instrument that uses continuous wave cavity ring-down (CW-CRD) to measure the aerosol extinction coefficient for 675 nm and 1550 nm light, and simultaneously measure the scattering coefficient at 675 nm using a reciprocal nephelometer [Mulholland and Bryner, 1994] concept. Both measurements are made in the same optical and flow cell at exactly the same conditions with a temporal resolution of about 1 sec. Absorption coefficient is obtained from the difference of measured extinction and scattering within the instrument and single scattering albedo from their ratio.

At left: Instrumentation in the ventilation area above the tunnel traffic bore.

Below: Measurements of aerosol size distribution (top), extinction coefficient (middle), and single scattering albedo (bottom) during the day.



Observations

The measurements of optical properties show a distinct diurnal variation with peaks in the coefficients occurring during the midday commute.

The single scattering albedo during the commute periods is very close to the values for pure black carbon. Values of optical coefficients are much lower on weekends and single scattering albedo is higher as expected.

While particle concentrations and optical coefficients are very high, they are not unlike those from other tunnel studies.

The magnitude of extinction and absorption coefficients was higher in the dual use bore than in the in the light duty bore, however, the single scattering albedo appears to be lower in the light duty bore. This is a surprising result and will be investigated further.

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