# Comparative Study of AOD and $PM_{2.5}$ Relationship with Different Mixing Layer Heights during DISCOVER-AQ Field Campaigns


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## Data

### Airborne HSRL measurements

HSRL is a compact and robust – designed sensor onboard small aircraft such as the NASA Langley King Air B200 when deployed in DISCOVER-AQ field experiments. The HSRL instrument is an innovative technology that is similar to radar; however, with lidar, radio waves are replaced with laser light. Lidar allows researchers to see the vertical dimension of the atmosphere, and the advanced HSRL makes measurements that can even distinguish among different aerosol types and their sources. The HSRL technique takes advantage of the spectral distribution of the lidar return signal to discriminate aerosol and molecular signals and thereby measure aerosol extinction and backscatter independently. It measures aerosol backscatter and depolarization at 0.532 and 1.064 μm and aerosol extinction at 0.532 μm.

### DRAGON sunphotometer observations

A large number of AERONET sunphotometers deployed intensive field campaigns such as DISCOVER-AQ in BWC (Baltimore Washington Corridor; July 2011), SJV (San Joaquin valley; January 16 –February 4, 2013), Houston Metropolitan Region (September 2013). The DRAGON (Distributed Regional Aerosol Gridded Observation Networks) covers 6,500, 22,000, 14,000 $km^2$, in BWC, SJV, HMR, respectively.

### Surface in-situ $PM_{2.5}$ and meteorological measurements

Hourly $PM_{2.5}$ (Particulate Matter with aerodynamic diameter ≤2.5 μm), relative humidity (RH), wind speed, wind direction, and surface temperature. Measurements of three (Beltsville, Edgewood, Fair Hill), four (Bakersfield, Fresno, Clovis, Porterville), and four (Clinton, Aldine, Deer Park, Galveston) surface stations, along with corresponding DRAGON and HSRL observations, serve the baseline relationship for satellite AOD retrievals.

### Reference


Chu D. A., Richard Ferrare, James Szykman, Jasper Lewis, Amy Scarino, Jennifer Hains, Sharon Burton, Gao Chen, Tzuchin Tsai, Chris Hostetler, John Hair, Brent Holben, James Crawford, Regional Characteristics of the Relationship between columnar AOD and surface $PM_{2.5}$: Application of lidar aerosol extinction profiles over Baltimore-Washington Corridor during DISCOVER-AQ, Atmos. Environ., 10.1016/j.atmosenv.2014.11.034.


## Approach

$$\tau_{a,0.55\mu m} = \int_0^{TOA} \rho(z)\, \sigma^{ext}_{0.55\mu m}(z)\, dz$$

Assumption 1: homogeneously mixed within mixing layer height

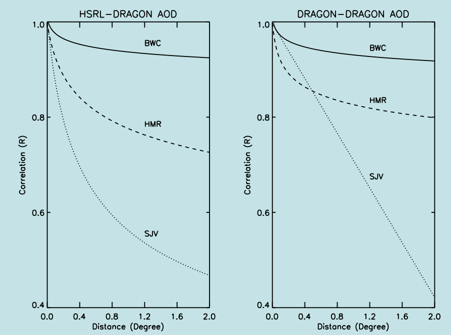
$$PM_{2.5} \approx \frac{\tau_{a,0.55\mu m}}{[f(RH)\sigma^{ext}_{dry,0.55\mu m}]_{surface}\, L_{mix}}$$

Assumption 2: $L_{mix}$ = HLH where HLH is derived by the sum of planetary boundary layer height (PBLH) and scale height (H); scale height is derived by assuming exponential decrease of extinction with height above PBL

$$PM_{2.5} \approx \frac{\tau_{a,0.55\mu m}}{[f(RH)\sigma^{ext}_{dry,0.55\mu m}]_{surface}\, HLH}$$

Where $\tau_{a,0.55\mu m}$ is AOD at 0.55 μm wavelength; ρ(z) is aerosol mass concentration (μg/$m^3$); is aerosol extinction cross section per unit mass ($m^2$/μg) at 0.55 μm; f(RH) is hygroscopic growth factor; $\sigma^{ext}_{0.55\mu m}$ aerosol extinction cross section per unit mass at surface relative to dry particles at 0.55 μm wavelength; $L_{mix}$ is aerosol mixing layer height (km); HLH is estimated haze layer height.

## Spatial Variability of AOD




- Fitted (power or linear) functions on correlation vs. distance (km) with respect to HSRL-DRAGON and DRAGON-DRAGON
- More isolated pollution emission in SJV as opposed to HMR and BWC
- Large differences shown in SJV due to coarser distribution of sunphotometers