

Testing Extensions of Our Quantitative Daily of San Joaquin Wintertime Aerosols Using MAIAC and Meteorology without Transport/Transformation Assumptions

ABSTRACT:

The Western US and many regions globally present daunting difficulties in understanding and mapping PM_{2.5} episodes. We evaluate extensions of a method independent of source-description and transport/transformation. These regions suffer frequent few-day episodes due to shallow mixing; low satellite AOT and bright surfaces complicate the description. Nevertheless, we expect residual errors in our maps of less than 8 $\mu\text{g}/\text{m}^3$ in episodes reaching 60–100 $\mu\text{g}/\text{m}^3$; maps which detail pollution from Interstate 5.

Our current success is due to use of physically meaningful functions of MODIS-MAIAC-derived AOD, afternoon mixed-layer height, and relative humidity for a basin in which the latter are correlated. A mixed-effects model then describes a daily AOT-to-PM_{2.5} relationship. (Note: in other published mixed-effects models, AOT contributes minimally.

We seek to extend on these to develop useful estimation methods for similar situations. We evaluate existing but more spotty information on size distribution (AERONET, MISR, MAIA, CALIPSO, other remote sensing). We also describe the usefulness of an equivalent mixing depth for water vapor vs meteorological boundary layer height. Each has virtues and limitations. Finally, we begin to evaluate methods for removing the complications due to detached but polluted layers (which don't mix to the surface) using geographical, meteorological, and remotely sensed data.

Several regions in the Western United States present daunting difficulties in the characterization of particulate pollution episodes and resultant health effects. Prominent features are: frequent wintertime pollution episodes, atypical composition of the aerosols, very thin mixed layers, and complex surface bidirectional reflectance of bright surfaces. Consequently, wintertime high pollution is associated with marginally retrieval aerosol optical thickness (AOT).

We will explain our success in quantifying and mapping episodes of PM_{2.5} using broadly available observations constructed with physically meaningful functions of MAIAC-derived AOD, afternoon mixed-layer height, and relative humidity on a large-regional basis (e.g. most of California's San Joaquin Valley). We seek to extend on these to develop useful estimation methods for similar situations. We evaluate existing but more spotty information on size distribution (AERONET, MISR, MAIA, CALIPSO, other remote sensing). We also describe the usefulness of an equivalent mixing depth for water vapor vs meteorological boundary layer height. Each has virtues and limitations. Finally, we begin to evaluate methods for removing the complications due to detached but polluted layers (which don't mix to the surface) using geographical, meteorological, and remotely sensed data.

Our initial work pictured daily maps of PM_{2.5} for San Joaquin Valley (SJV). NASA's DISCOVER-AQ airborne measurements (Jan-Feb, 2013) allowed additional insights for two full pollution episodes. (Chatfield et al., 2017) We used the uniquely relevant MAIAC method for AOT from MODIS (at 1 km x 1km), along with high-accuracy meteorological mixed-layer heights. Results do not depend on the geographical description of source locations or transport. These could be called "near data" in the sense that they can guide transport models.

Aerosol features reflecting emissions along Interstate 5 and other highways are visible when air flow is along the road. Available airborne describe region-wide effects of varying size distribution and composition. Noting that the maximum PM_{2.5} concentrations in SJV reached 60–100 micrograms per cubic meter, an estimated residual error is ca. 8 $\mu\text{g} / \text{m}^3$ is sufficient to outline unexplored basic processes and sources.

A warning about the use of AOT! There is good prediction using a very simple random effects model which ignores AOT and describes regional variability by day but valid for a whole region. It is more informative than AOT! AOT dependence adds only marginally in random effects models whose success has been reported. However, when physically based day-by-day predictive variables (mixed-layer depth and particle sizes) are included. AOT then shows useful explanatory power in the random effects regression.

MODIS: MODerate-resolution Imaging Spectrometer. MAIAC: Multiple-Angle Implementation of Atmospheric Correction. MAIA: Multi-Angle Imager for Aerosols, the

“Lyapunov” method..DISCOVER-AQ: Deriving Information on Surface Conditions from
Column and VERTically Resolved Observations Relevant to Air Quality