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Satellite Mapping of PM2.5 Episodes in the Wintertime San Joaquin Valley: A "Static" Model Using Column Water Vapor

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Abstract. The use of satellite Aerosol Optical Thickness (AOT) from imaging spectrometers has been successful in quantifying and mapping high PM2.5 (particulate matter mass < 2.5 µm diameter) episodes for pollution abatement and health studies. However, some regions have high PM2.5 but poor estimation success. The challenges in using Aerosol Optical Thickness (AOT) from imaging spectrometers to characterize PM2.5 worldwide was especially evident in the wintertime San Joaquin Valley (SJV). The SJV's attendant difficulties of high-albedo surfaces and very shallow, variable vertical mixing also occur in other significantly polluted regions around the world. We report on more accurate PM2.5 maps for the whole-winter period in the SJV, Nov 14, 2012–Dec 11, 2013. Intensive measurements by including NASA aircraft were made for several weeks in that winter, the DISCOVER-AQ California mission.

We found success with a relatively simple method based on calibration and checking with surface monitors and a characterization of vertical mixing, and incorporating specific understandings of the region's climatology. We estimate PM2.5 to within ~ 7 µg m^{-3} RMSE and with *R* values of ~ 0.9, based on remotely sensed MAIAC (Multi-Angle Implementation of Atmospheric Correction) observations, and that certain further work will improve that accuracy. Mapping is at 1 km resolution. This allows a time sequence of mapped aerosols at 1 km for cloud-free days. We describe our technique as a "static estimation". Estimation procedures like this one, not dependent on well-mapped source strengths or

on transport error, should help full source-driven simulations by deconstructing processes. They also provide a rapid method to create a long-term climatology.

Essential features of the technique are (a) daily calibration of the AOT to PM2.5 using available surface monitors, and (b) characterization of mixed-layer dilution using column water vapor (CWV, otherwise "precipitable water"). We noted that on multi-day timescales both water vapor and particles share near-surface sources and both fall to very low values with altitude; indeed, both are largely removed by precipitation. The existence of layers of H_2O or aerosol not within the mixed layer adds complexity, but mixed-effects statistical regression captures essential proportionality of PM2.5 and the ratio variable (AOT/CWV). Accuracy is much higher than previous statistical models, and can be extended to the whole Aqua-satellite data record. The maps and time-series we show suggest a repeated pattern for large valleys like the SJV — progressive stabilization of the mixing height after frontal passages: PM2.5 is somewhat more determined by day-by-day changes in mixing than it is by the progressive accumulation of pollutants (revealed as increasing AOT).