# Supplement of:

# Assessing uncertainties of a geophysical approach to estimate surface fine particulate matter distributions from satellite observed aerosol optical depth

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**S1. Satellite-derived $PM_{2.5}$ in DJF, MAM, and SON**

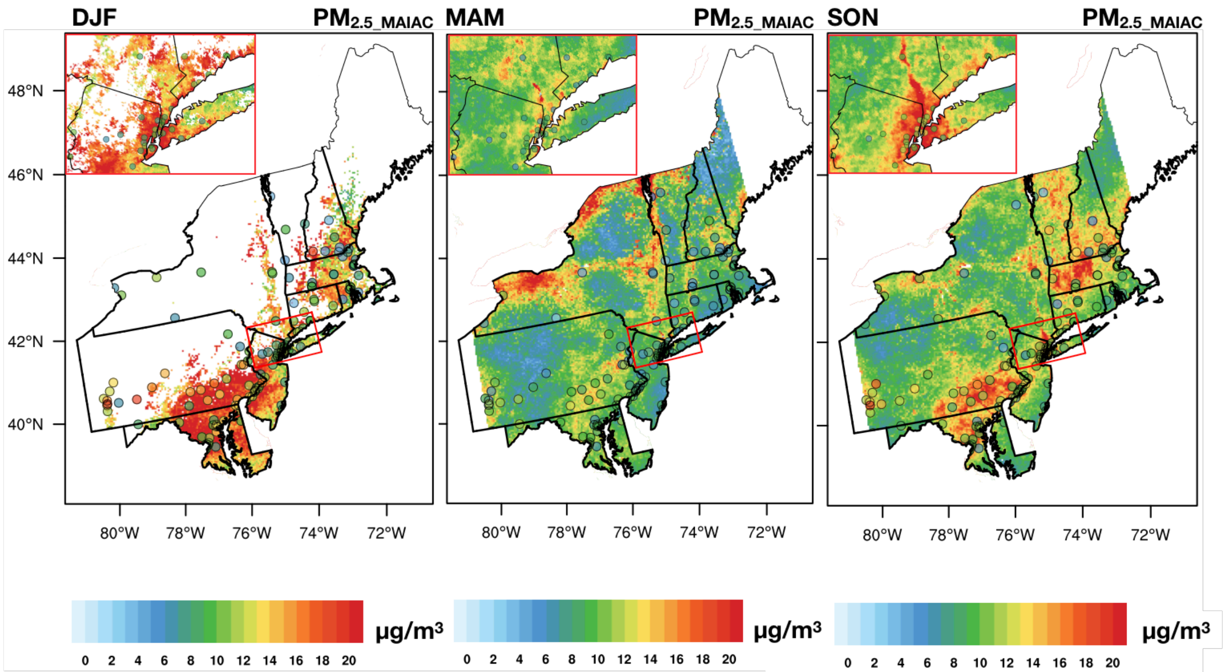


Figure S1 Seasonal average satellite-derived $PM_{2.5}$ ($PM_{2.5\_MAIAC}$) overlaid with ground-based AQS observations over the Northeast USA with zoom-in maps over the New York City region in the upper left corner. The satellite-derived $PM_{2.5}$ are calculated as the product of MAIAC AOD and CMAQ modeled $PM_{2/5}$/AOD relationship without any further constraints.

**S2. Choice of hygroscopic growth functions**

Figure S1a and b compare the hygroscopic growth factor *f*(RH) of OC and SNA with RH using the κ parameter (Petters and Kreidenweis, 2007), the IMPROVE algorithm (Malm et al., 1994), and the Chin et al. (2002) approach based largely on the OPAC. Using κ to parameterize hygroscopic growth factor generally gives low *f*(RH) at low to median RH < 60%, and rapid growth with RH at high RH>80%. In comparison, the IMPROVE algorithm, which is used for on-line calculation of AOD in the CMAQ (Roy et al., 2007), assumes no hygroscopic growth for OC, but a rapid growth for SNA, which increases by more than a factor of 5 at RH>90%. Chin et al. (2002), on the other hand, suggest a slow growth rate with RH, but high *f*(RH) at low to median RH (RH<80%) for both OC and SNA. Using the IMPROVE instead of κ parameter leads to an overall smaller $PM_{2.5\_MAIAC}$ (mean difference = -9.5 μg/m$^3$), but underestimate of $PM_{2.5}$ compared with AQS observations. Using the *f*(RH) from Chin et al. (2002) also leads to an overall decrease of $PM_{2.5}$ (-2.5 μg/m$^3$), with largest decrease in DJF (-4.1 μg/m$^3$), reflecting the large discrepancy between the Chin et al. (2002) approach and the κ parameter for dry environments.

During the DISCOVER-AQ Baltimore-Washington D.C. field campaign, light extinction was measured at dry, ambient, and wet conditions, providing an opportunity to evaluate the parameterization of hygroscopic growth. The gamma (γ) factor, which is used to represent the hygroscopic growth factor for light scattering of all aerosols, is defined as:

$$\gamma = \frac{\ln{(SC_{amb}/SC_{dry})}}{\ln{((100-RH_{dry})/(100-RH_{amb}))}} \quad (9)$$

where $SC_{amb}$ is the scattering coefficient for the ambient environment, and $SC_{dry}$ is the scattering coefficient measured in a slightly heated airstream with a lower RH than ambient RH. We calculate the γ from both DISCOVER-AQ observations and CMAQ simulations with different parameterizations for *f*(RH). For CMAQ simulation, we use a constant RH = 20% to represent the dry condition. We find that the γ factor calculated from the κ parameter agrees best with observations in terms of the distribution (Fig. S1c), suggesting that the κ parameter best characterize the growth factor function, at least for the conditions sampled by DISCOVER-AQ. Both IMPROVE and Chin et al. (2002) overestimate γ by factors of 3 and 5 respectively.

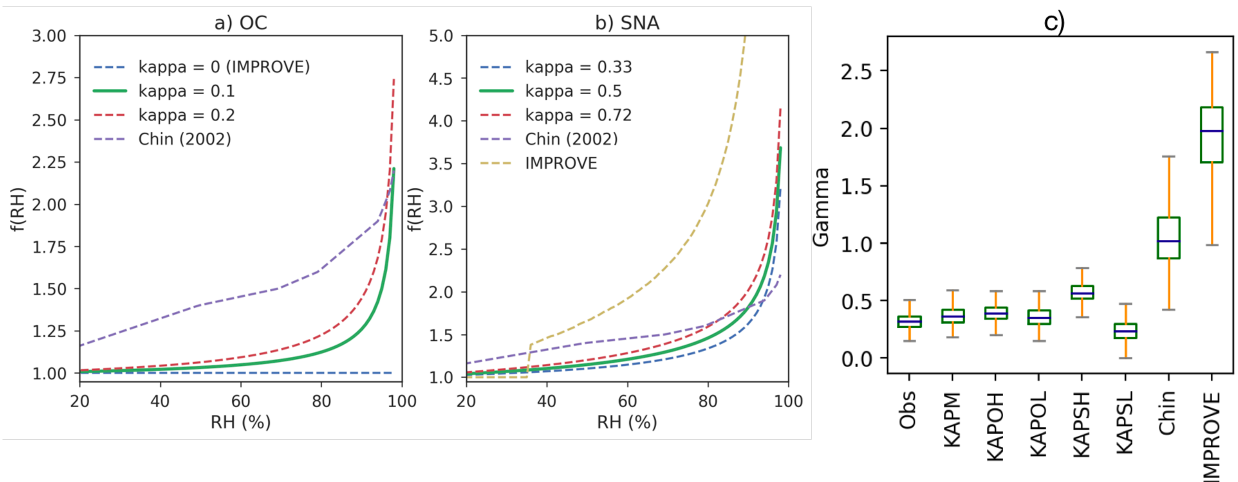


Figure S2 Hygroscopic growth factor of: a) OC and b) SNA as a function of relative humidity using different functions including the κ parameter with different values, IMPROVE algorithm (Hand and Malm, 2006), and the Chin et al. (2002) approach. c) Comparison of the gamma factor from CMAQ derived by using different functions for hygroscopicity (KAPM: κ used in default run of FlexAOD; KAPOH: high κ for OC; KAPOL: low κ for OC; KAPSH: high κ for SNA; KAPSL: low κ for SNA) vs. that observed from DISCOVER-AQ 2011 Baltimore-Washington D.C. aircraft campaign (Obs).

**S3. Impacts of different assumptions for the size distribution on the satellite-derived $PM_{2.5}$**

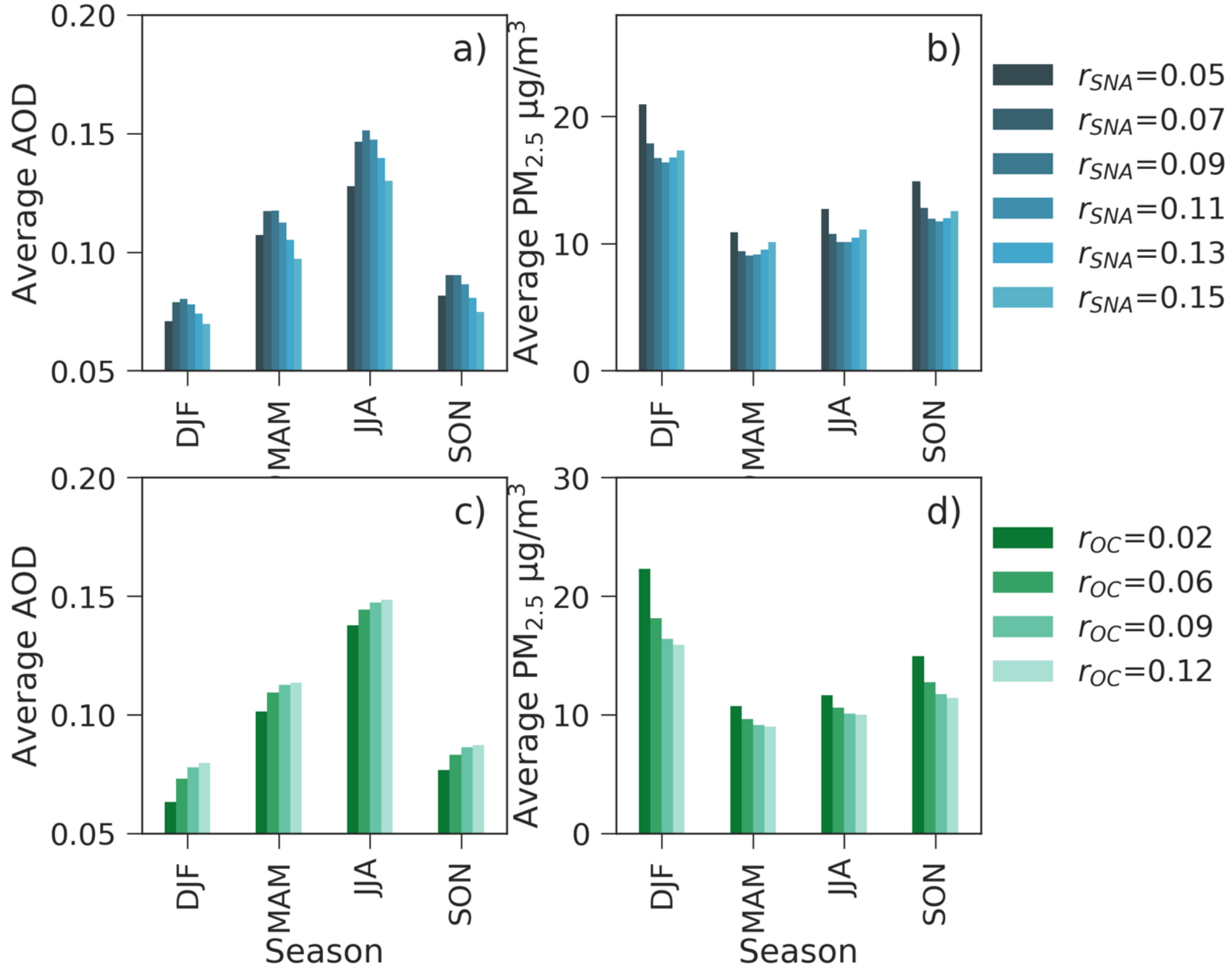


Figure S3 Seasonal average (left) $AOD_{CMAQ}$ and (right) $PM_{2.5\_MAIAC}$ using different modal radii for SNA (top) and OC (bottom).

# References


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