Exploring ground-based aerosol optical properties to improve satellite estimates of surface particulate matter concentrations

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Estimates of surface-level particulate matter (PM) concentrations from satellites, essential to complement surface network observations over extra-urban regions, mainly rely on the observed aerosol optical depth (AOD). Therefore, it is crucial exploring how column and profile optical properties are related to aerosol concentrations. Since this can be best achieved by using ground-based observations, we analyzed collocated observations of fine particulate matter (PM2.5), ambient black carbon (BC) as well as columnar aerosol optical properties from a skyradiometer and aerosol extinction profiles from multi-axis differential optical absorption spectroscopy (MAX-DOAS), with an emphasis on the ultraviolet (UV) spectral region. After accounting for the influence of the humidity and the different aerosol extinction profiles, we found that the partial column (i.e., the lowest 1 km layer) of the fine fraction aerosol optical depth ($fAOD_{pc}$), obtained by combing skyradiometer and MAX-DOAS retrievals, reproduced the variability of the PM2.5 better than the columnar fAOD. In the same way, although BC dominates the total absorption in the near-infrared (NIR) spectral range, we showed that the partial column aerosol absorption optical depth ($fAAOD_{pc}$) at UV wavelengths was related to the BC variability better than the corresponding column-based estimates. The observed relationship between the $fAAOD_{pc}$ and an estimated BC partial column was reproduced from Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) and resulted in an estimate close to a reasonable BC mass absorption cross-section. Overall, our results point to a right consistency among the used datasets and between them and MERRA-2, stress the well-known sensitivity to the aerosol absorption in the UV spectral region, and highlight the efficacy of combined MAX-DOAS & skyradiometer observations. We expect that these findings will allow a more in-depth evaluation of satellite estimates of surface particulate matter concentrations.

Keywords: aerosol, remote sensing, skyradiometer

