Aerosol Retrievals and PM2.5 concentration estimations from Nephelometers using GRASP Algorithm and machine learning method

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This study demonstrates the capability of characterizing aerosol optical and microphysical properties as well as estimating PM2.5 concentration using measurements from different types of nephelometers developed by AirPhoton using GRASP (Generalized Retrieval of Aerosol and Surface Properties) algorithm in combination with machine learning method.

The 3-wavelength polarized imaging nephelometer (PI-Neph) allows the accurate measurement of phase function and degree of polarization, while the 3-wavelength integrating nephelometer (IN-Neph) measures forward and backward scattering, with the capability to adjust the size bin cut-offs by controlling inlet flow rate. GRASP algorithm is a next generation open-source algorithm developed for aerosol retrievals which has been applied in diverse in-situ and airborne instruments such as sun-radiometer, lidar, satellite sensors etc. [3,4,5] In our study, the capability of GRASP for advanced aerosol characterization from different types of nephelometers have been demonstrated.

For PI-Neph [2], aerosol optical and microphysical properties were retrieved with high accuracy for both synthetic data and real measurement data obtained in Granada, Spain. For IN-Neph, the results have shown that the aerosol size distribution and refractive index can be retrieved with reasonable accuracy while size-bin cut-off information is provided. The IN-Neph with PM2.5 and PM10 size-cutoffs with high temporal resolution were deployed over SPARTAN network together with sampling stations as well as other instruments. By combining gravimetric measurements from sampling station filters and nephelometer measurements, SPARTAN has estimated hourly PM2.5 which has been validated against tapered-element oscillating microbalance (TEOM) measurements and shown reasonable agreement with correlation of 0.79 [1]. In this study, we combined the GRASP algorithm with a machine learning (ML) method, gradient boosting (GB), to estimate PM2.5 mass concentrations from IN-Neph measurements from the SPARTAN network. The comparison between GRASP/ML retrieved PM2.5 concentrations with SPARTAN PM2.5 hourly estimates has shown good consistency and this new method also offers additional

retrieved parameters such as aerosol refractive index which provide a better understanding of the aerosol types over monitoring sties.

References

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