

# Uncertainty quantification applied to aerosol retrievals from simulated surface sun photometer and polarimetric satellite observations using GRASP

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Because surface- and satellite-based aerosol properties are retrieved quantities – with the notable exception of aerosol optical depth (AOD) measured by surface-based sun photometers – it is critical for the user community to have a quantitative understanding of the quality of these products in order to use them properly for both analysis and data assimilation. Typically, this requires reporting a pixel-level uncertainty, which can be provided by an optimal estimation (OE) retrieval or other retrieval techniques. However, there are a number of limitations in the OE-based uncertainty estimate that derive from assumptions of linearity and unknown interaction terms. An alternative, simulation-based approach for uncertainty quantification is able to directly explore these issues. The essential idea is to perform a large number of forward radiative transfer (RT) model runs varying the input parameters within the observed range of natural variability. A large set of these idealized results, with known inputs, are then presented to the retrieval algorithm which is run for each case. The result is the probability distribution of retrieval results (i.e., the actual retrieval error variance), which can then be compared to the estimated uncertainty reported by the retrieval. This Monte Carlo (MC) approach provides a quantitative check on the retrieval uncertainty.

We have developed a testbed for quantifying uncertainties in retrieved aerosol properties using the Generalized Retrieval of Aerosol and Surface Properties (GRASP) software package. This has the advantage of including both the required forward RT model and the inversion. We use Aerosol Robotic Network (AERONET) climatologies to select the range of aerosol parameters to explore, then optimize the parameter choices using experimental design approaches. We then compare the results of our MC analysis to the uncertainties reported by GRASP for a selected set of simulated sun photometer and polarimetric satellite retrieval cases.

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