

Aerosol Chemical Speciation profiles via Lidar and Polarimeter Synergy: From Airborne to Global Satellite Observations

Abou Bakr Merdji ^{a,*}, Juan Cuesta ^a, Anton Lopatin ^b, Fazzal Qayyum ^{a,c}, Oleg Dubovik ^d, Alaa Mhawish ^e, Richard Ferrare ^f, Sharon P. Burton ^f, Jens Redemann ^g

^a Univ Paris Est Creteil and Université Paris Cité, CNRS, LISA, F-94010 Créteil, France

^b GRASP SAS, Lille, 59800, France

^c Centre national d'études spatiales (CNES), Paris, France

^d Laboratoire d'Optique Atmosphérique, UMR 8518, Villeneuve d'Ascq, 59650, France

^e Sand and Dust Storm Regional Center, National Center for Meteorology, Jeddah, Saudi Arabia

^f NASA Langley Research Center, Hampton, VA, USA

^g School of Meteorology, University of Oklahoma, Norman, USA

**Presenting author (abou.merdji@lisa.ipsl.fr)*

We present the Aerosol Chemical Profiling (AEROCHEMPro) methodology [1], an advanced synergistic retrieval implemented within the GRASP (Generalized Retrieval of Atmosphere and Surface Properties) inversion framework [2]. Unlike traditional classification schemes, AEROCHEMPro utilizes a continuous optimization approach to resolve the detailed vertical distributions and composition of multiple aerosol modes simultaneously. From these modal properties, the method derives the vertical concentrations of six aerosol chemical components: black carbon, organic matter, inorganic salts, sea salt, quartz, iron oxide, and associated water content.

The framework's robustness is demonstrated through a two-tiered implementation approach. First, we apply the method to airborne observations from the NASA ACTIVATE campaign, utilizing the synergy between the high-spectral-resolution lidar (HSRL-2) ($2\beta+2\alpha+3\delta+1\beta_{\text{att}}$) and the Research Scanning Polarimeter (RSP). We demonstrate that the inclusion of high-spectral-resolution lidar data provides innovative observations of the vertical distribution of fine, dust, and sea salt particles, while polarimetric sensitivities to the complex refractive index enable the accurate quantitative discrimination of chemical species. Retrieved vertical profiles are validated against collocated in-situ aircraft measurements, showing high fidelity in capturing the vertical distribution of carbonaceous, inorganic salt, and sea salt aerosols.

Furthermore, we extend the application to the spaceborne synergy of CALIOP and POLDER-3/PARASOL, presenting preliminary results of aerosol chemical vertical distributions from space.

This work highlights AEROCHEMPro's capability to bridge the gap between remote sensing observables and the mass-based variables required by Chemical Transport Models (CTMs), providing a pathway for the next generation of satellite missions such as EarthCARE, PACE and 3MI.

Keywords: AEROCHEMPro; GRASP; HSRL-2; RSP; CALIOP; POLDER-3; aerosol vertical profile; chemical species.

References

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