Advancing Field Campaign Quality Assurance Through Closure of In-Situ and Remote Sensing Data Sets

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SCIENCE OBJECTIVE

Improve closure assessments of in situ and remote sensing field campaign aerosol particle data sets **by performing apples-to-apples comparison of NASA ACTIVATE's High Spectral Resolution Lidar – generation 2 (HSRL-2) and Research Scanning Polarimeter (RSP) remote sensors with in-situ instruments.**

MOTIVATION

Airborne field campaigns use instruments onboard aircraft to measure aerosol microphysical and optical properties to characterize climate and air quality phenomena.

Essential to reconcile instrument observations through verification or "closure" with models or between platforms themselves (i.e., in-situ instruments vs remote sensors).

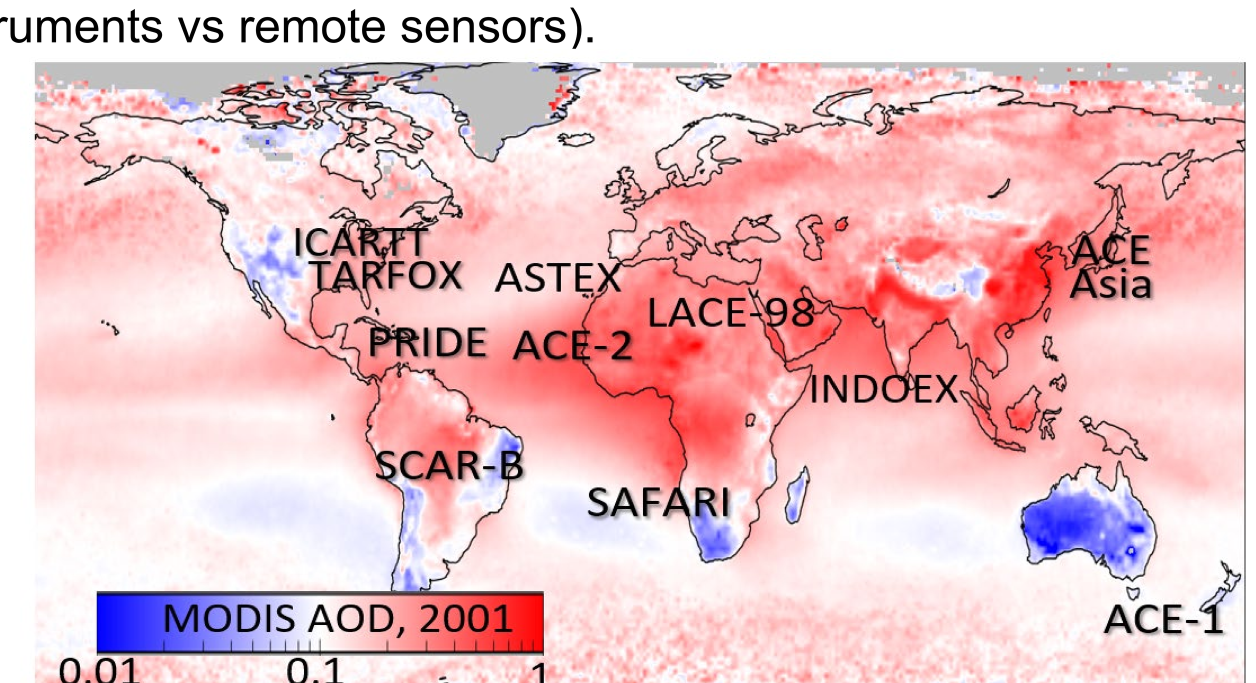

Figure 1: Early closure efforts for validation of MODIS aerosol optical depth (AOD) data (Reid et al., 2022).

In-situ instruments measure aerosol particles in controlled relative humidity (RH) environments while remote sensors perform their retrievals without altering the state of the aerosol particle (i.e., ambient) → data sets not comparable.

FIELD CAMPAIGN DESCRIPTION

NASA's Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE) uses a spatially-synchronized, joint-flight approach to study marine boundary layer dynamics of the Northwest Atlantic Ocean.

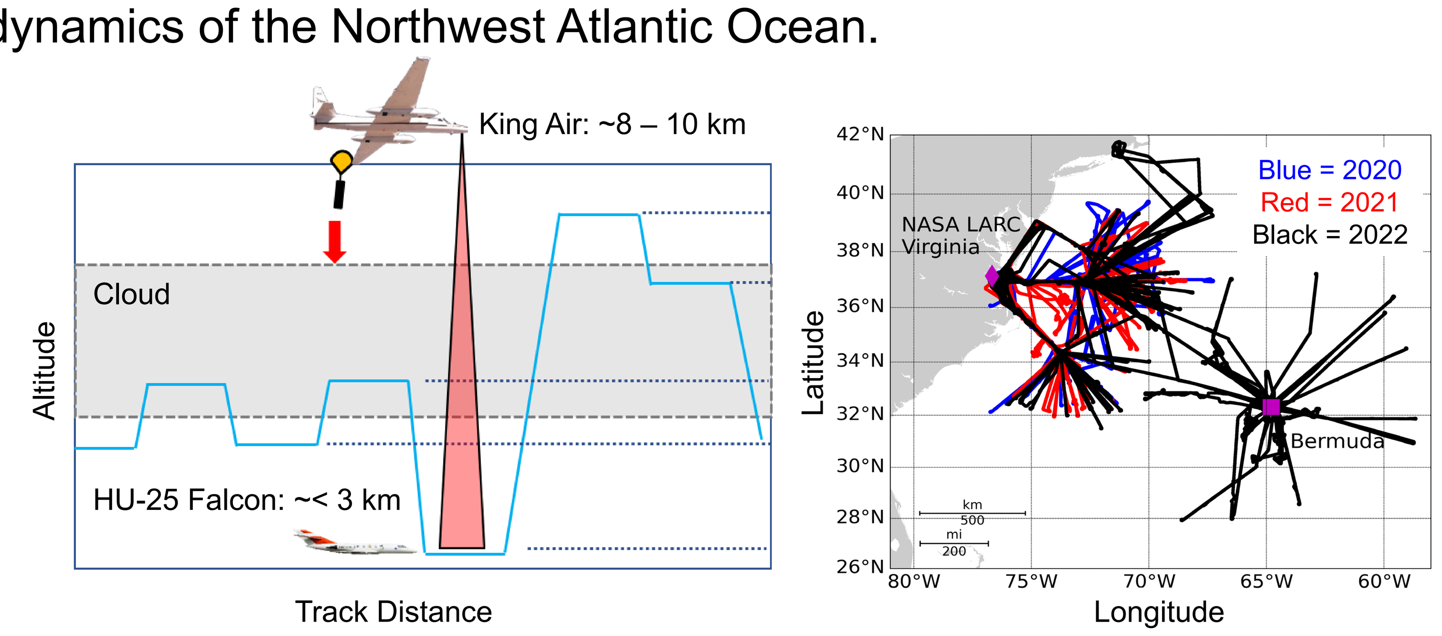

Figure 2: a) ACTIVATE's joint-flight approach which deploys low-flying HU-25 Falcon that houses in-situ instruments and high-flying King Air that houses HSRL-2 and RSP remote sensors and b) flight tracks of all 179 ACTIVATE flights from 2020 to 2022.

WHAT IS ISARA?

Based on Modeled optical properties of ensembles of aerosol particles (MOPSMAP) Fortran package (Gasteiger and Wiegner, 2018), which uses Mie theory or other methods (e.g., T-matrix method, discrete dipole approximation) to calculate **ambient in-situ** aerosol microphysical and optical properties at user-specified wavelengths **separately for fine-mode and coarse-mode aerosol particles**.

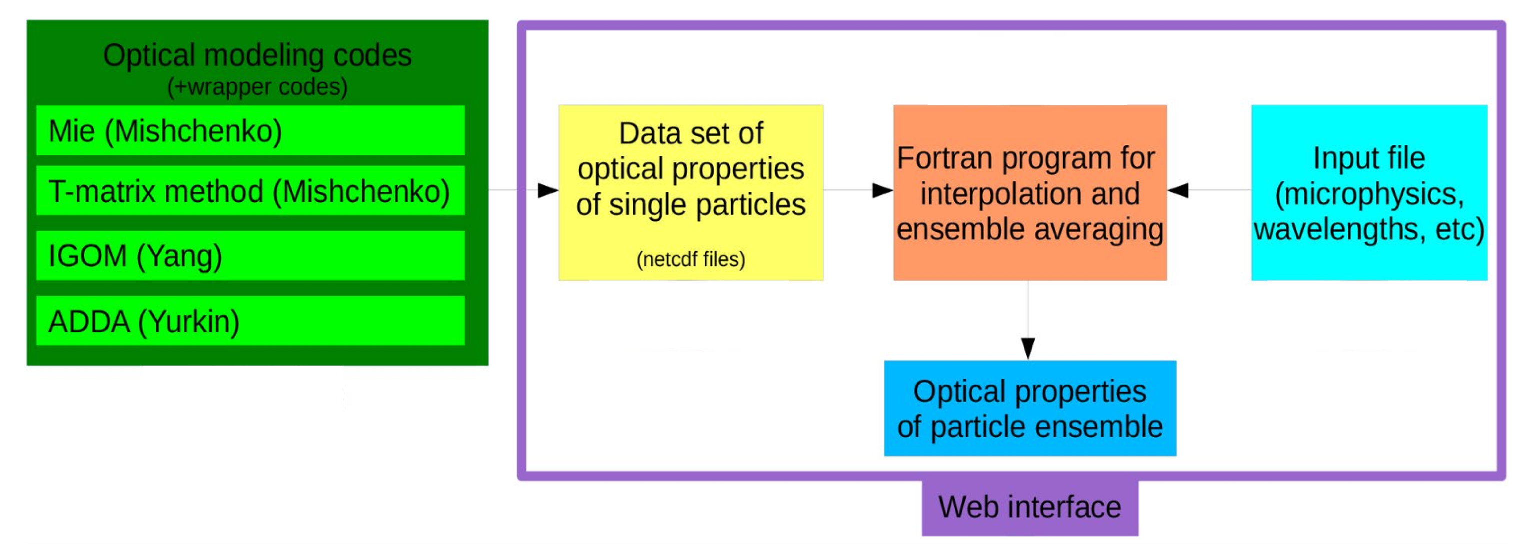

Figure 3: Flowchart of how MOPSMAP calculates optical properties of aerosol particle ensembles (Gasteiger and Wiegner, 2018).

ISARA RETRIEVAL METHODOLOGY

1) Retrieve dry imaginary refractive index (IRI) using dry resolved aerosol number concentration (n^o) with diameters from 3 – 3162 nm, MOPSMAP-calculated dry scattering and absorption coefficients (C), and dry C measured by ACTIVATE's instruments.

2) Retrieve hygroscopicity (κ) using n^o, ambient Diode Laser Hygrometer relative humidity (RH) measurements, MOPSMAP-calculated ambient scattering coefficient C, and measured ambient C.

3) Apply cloud filtering and calculate ambient extinction (ε_{532nm}), aerosol number concentration (N_a), fine-mode effective radius ($r_{eff,f}$), total effective single-scattering albedo (SSA_t)

4) Apply collocation algorithm detailed in Schlosser et al. (forthcoming) to ensure spatiotemporal proximity between in situ and remote sensing data (data filtered within 15 km spatially and 6 min temporally).

Figure 4: Flowchart of how ISARA is used to calculated ambient optical properties using ACTIVATE data.

ISARA WEBSITE

For more information on ISARA and how to use this code for your own research, please visit https://sdmitrovic.github.io/ISARA/ or scan the QR code.

RESULTS

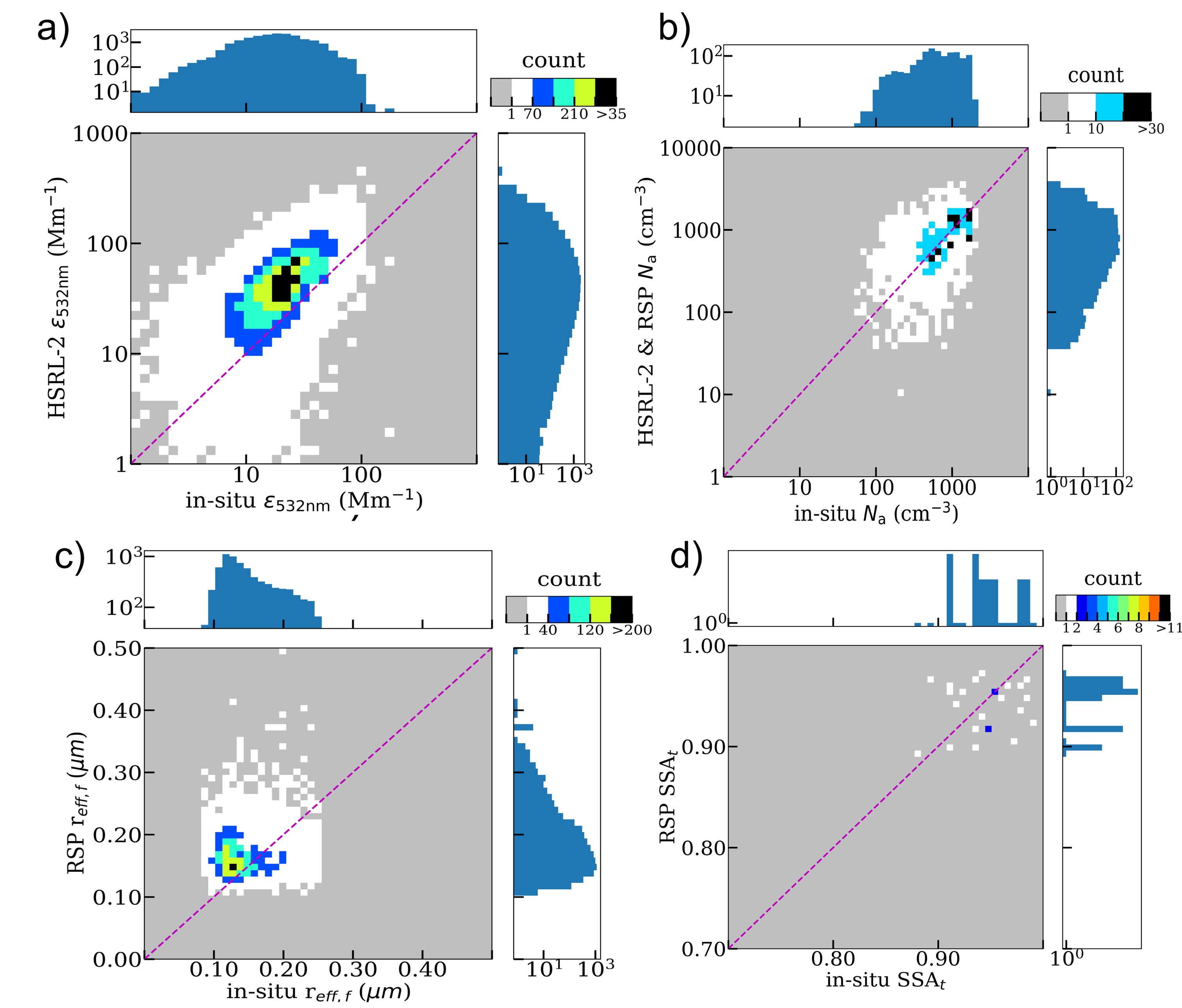

Figure 5: Comparisons of a) HSRL-2 extinction (ε_{532nm}), b) HSRL-2 – RSP aerosol number concentration (N_a), c) RSP fine-mode effective radius ($r_{eff,f}$), and d) RSP total effective single-scattering albedo (SSA_t) to equivalent ISARA-modelled in-situ values using all ACTIVATE 2020 – 2022 flight data.

	ε_{532nm}	N_a	$r_{eff,f}$	SSA_t
NMAD (%)				

CONCLUSIONS AND FUTURE WORK

Takeaway: ISARA-modelled values compare better with HSRL-2 ε_{532nm} and HSRL-2 + RSP N_a (? and ? % agreement, respectively) than with RSP $r_{eff,f}$ and SSA_t (agree within ? And ? %).

Next steps: Investigate difficulties in RSP comparisons (i.e., explore effects of strongly-absorbing particles), calculate coarse-mode effective radius and perform closure.

ACKNOWLEDGEMENTS

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