Research Scanning Polarimeter (RSP) Level 2 aerosol files

Document version: 1
Data version: R0
Date: 14 July, 2020

Contributors: Bastiaan van Diedenhoven, Snorre Stamnes, Brian Cairns

Table of Contents

1. Introduction

Aerosol properties are inferred from RSP's measurements of multi-angle total radiances and polarized radiances. Details of the retrieval approach are described by Stamnes et al. (2018; Appl. Opt., doi:10.1364/AO.57.002394.). A notable update to the algorithm is that aerosol layer height is now also retrieved from the RSP data.

2. Data contents and usage

The data structure and variables are listed in the appendix. Note that the aerosol files are *not* compatible with CAMP2EX-RSP1-L1B_P3B, CAMP2EX-RSP1-L1C_P3B or CAMP2Ex-RSP1-SPNCirrusMask_P3B files.

The variable rsp_time contains the times in UTC decimal hours of the day of acquisition (i.e., between 0 and 24). Note that is different from the CAMP2Ex convention (which is UTC decimal hours starting at the day of take-off, running past 24h).

The algorithm infers aerosol optical properties at 555 nm (assuming spectrally invariant refractive indices). However, for the relevant variables, results are calculated and reported at other wavelength of RSP, namely 410, 469, 555, 670, 864, 1594, 2264 nm, in addition to common lidar wavelength, namely 355, 532 and 1064 nm.

Properties of both a fine mode and a coarse mode aerosol are retrieved (or assumed) and reported in the file. For relevant parameters, the values corresponding to the total particle size distribution (PSD) is (also) reported.

In addition to aerosol properties, ocean surface properties are retrieved and reported in the files using the ocean model from Chowdhary et al. (2006; Appl. Opt., doi:10.1364/AO.45.005542).

Aerosol parameters are listed in the table below:

Aerosol variable name prefix	**description**	**Units**	**Fine mode**	**Coarse mode**	**Total PSD**	**555 nm**	**All wls**
aerosol_tau	Total column optical depth	None	√	√	√	√	√
aerosol_reff	Effective radius	µm	√	√	√	n/a	n/a
aerosol_veff	Effective variance	None	√	√	√	n/a	n/a
aerosol_ssa	Single scattering albedo	None	√	√*	√	√	√
aerosol_real	Real part of refractive index	None	√	√*		√	

aerosol_imag	imaginary part of refractive index	None	√	√*		√	
aerosol_top_height	Top height of aerosol layer	m			√	n/a	n/a
aerosol_N	Number concentration	cm^{-3}	√	√		n/a	n/a
aerosol_ext	Extinction cross section	μm^2	√	√			√
aerosol_p180	Phase function at 180˚	/sr	√	√			√

* coarse mode refractive indices are not retrieved, but assumed to be 1.01 times that of water to represent hydrated sea salt (marine) aerosols.

Surface parameters are listed in the table below:

Surface variable name prefix	**description**	**Units**	**555 nm**	**532 nm**
surface_kd	Ocean diffuse attenuation coefficient	m^{-1}	√	√
surface_bbp	Ocean hemispherical backscatter coefficient	m^{-1}	√	√
surface_chlorophyll	Chlorophyll-a concentration	mg/m^3	n/a	n/a
surface_windspeed	Surface windspeed (Cox-Munk)	m/s	n/a	n/a

3. Notes on availability, biases and uncertainty

The RSP measurements were horizontally averaged over 20 scans or ~17 seconds.

Only data that is cloud free over 40 scans or ~33 seconds is accepted.

Only retrievals for which the final normalized cost function is below 0.15 are accepted. This normalized cost function threshold filters out data where the forward model simulations are not able to represent the observations, for example in situations with substantial non-spherical particles present and data substantially affected by clouds above and below the aircraft.

Any influence of clouds (or aerosols) above the aircraft cannot be excluded, although the cost function filter is expected to filter out most of the affected observations. Use of an above-aircraft cloud flag may be advisable.

Estimated uncertainties are listed in the table below (from Stamnes et al. 2018). For the further discussion on uncertainties we refer to Stamnes et al. (2018). The diagonals of the posterior error covariance matrix represent the uncertainties of each retrieval parameter, and are reported in the variable /Serr_diag. These uncertainties are currently underestimated because RSP data is hyper-angular and correlated, which is not currently taken in account. This issue will be fixed in a future update.

Table 2. Aerosol Uncertainty Targets for One Standard Deviation (1σ)[a]

Param.	Description	1σ Desired Uncertainty	RMSD (Simulated)
τ_{555f}	fine-mode optical depth at 555 nm	0.02	0.0427 (0.0372)[b]
$r_{\mathrm{eff},f}$	fine-mode effective radius	0.015 μm	0.0196 μm
$v_{\mathrm{eff},f}$	fine-mode effective variance	0.05	0.0487
r_{nf}	fine-mode real part	0.02	0.0293
SSA_f	fine-mode SSA	0.02	0.0209
τ_{555c}	coarse-mode optical depth at 555 nm	0.02	0.0132
$r_{\mathrm{eff},c}$	coarse-mode radius	0.15 μm	0.148 μm
$v_{\mathrm{eff},c}$	coarse-mode effective variance	0.05	0.0669
CHL	chlorophyll concentration	0.7 mg/m^3	2.59 mg/m^3
v	Wind speed	0.5 m/s	0.501 m/s

[a]Assumption: aerosol optical depth $\tau_{555f} \geq 0.05$ and $\tau_{555c} \geq 0.02$, otherwise uncertainty targets become difficult to meet. The effective radius is a function of the mode radius r_n and the mode width σ_g [Eq. (9)]. The effective variance is a function of the size distribution mode width σ_g only [Eq. (10)]. The root-mean-square deviation (RMSD) for the simulated retrievals presented in this paper are provided in the fourth column.

[b]RMSD versus HSRL-1 total (fine and coarse) AOD at 532 nm from SABOR. Non-spherical aerosols such as dust are not included in the present retrieval, but can be detected and avoided by using HSRL-1 aerosol depolarization measurements.

Appendix: data structure and variables

group	/
dataset	/000-README
dataset	/Serr_diag
dataset	/Serr_total
dataset	/Serr_total_diag
dataset	/aerosol_N_c
dataset	/aerosol_N_f
dataset	/aerosol_imag_c_555

dataset /aerosol_imag_f_555
dataset /aerosol_kext_c
dataset /aerosol_kext_f
dataset /aerosol_p180_c
dataset /aerosol_p180_f
dataset /aerosol_real_c_555
dataset /aerosol_real_f_555
dataset /aerosol_reff_c
dataset /aerosol_reff_f
dataset /aerosol_reff_total
dataset /aerosol_ssa_c
dataset /aerosol_ssa_c_555
dataset /aerosol_ssa_f
dataset /aerosol_ssa_f_555
dataset /aerosol_ssa_total_555
dataset /aerosol_tau_c
dataset /aerosol_tau_c_555
dataset /aerosol_tau_f
dataset /aerosol_tau_f_555
dataset /aerosol_tau_total_555
dataset /aerosol_top_height
dataset /aerosol_veff_c
dataset /aerosol_veff_f
dataset /aircraft_altitude
dataset /aircraft_lat
dataset /aircraft_lon
dataset /aircraft_pitch
dataset /aircraft_roll
dataset /aircraft_yaw
dataset /atmos_water_vapor_column_amount
dataset /cloud_top_height
dataset /output_channels
dataset /retrieval_normalized_cost_function_data
dataset /retrieval_normalized_cost_function_total
dataset /rsp_relative_azimuth
dataset /rsp_solar_zenith
dataset /rsp_time
dataset /surface_Kd_532
dataset /surface_Kd_555
dataset /surface_bbp_532
dataset /surface_bbp_555
dataset /surface_chlorophyll
dataset /surface_windspeed