

ARCSIX Merged Aerosol Size Distribution

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1.0 Data Set Overview

These measurements were part of the Arctic Radiation-Cloud-Aerosol-Surface Interaction eXperiment (ARCSIX). The overarching goal of ARCSIX is to quantify the contributions of surface properties, clouds, aerosol particles, and precipitation to the Arctic summer surface radiation budget and sea ice melt during the early melt season (May through mid-July). Four aerosol sizing instruments: Fast Integrated Mobility Spectrometer (FIMS), Ultra-High Sensitivity Aerosol Spectrometer (UHSAS), Portable Optical Particle Spectrometer (POPS), and Aerodynamic Particle Sizer (APS) were deployed during the ARCSIX campaign to measure aerosol size distributions of different size ranges. PI Perkins's group developed a method to merge the individual instrument size spectra into a single, continuous aerosol size distribution product. This archive is for the merged aerosol size distribution product generated from the ARCSIX aircraft observations.

2.0 Instrument and Algorithm Description:

FIMS, UHSAS, POPS, and APS provide complementary coverage of the aerosol size spectrum during ARCSIX, spanning from ultrafine particles to the coarse mode. FIMS measures number size distributions for roughly 10–600 nm particles based on electrical mobility diameter. UHSAS covers the accumulation mode at approximately 60–1000 nm using laser light scattering to report an optical diameter. POPS extends optical sizing into larger particles, about 140–3000 nm, also via single-particle light scattering. The APS captures the coarse mode over 0.53–5.66 μm by measuring aerodynamic diameter using time-of-flight. Additional information about these measurements can be found in their archived datasets and associated documentation (NASA, 2025).

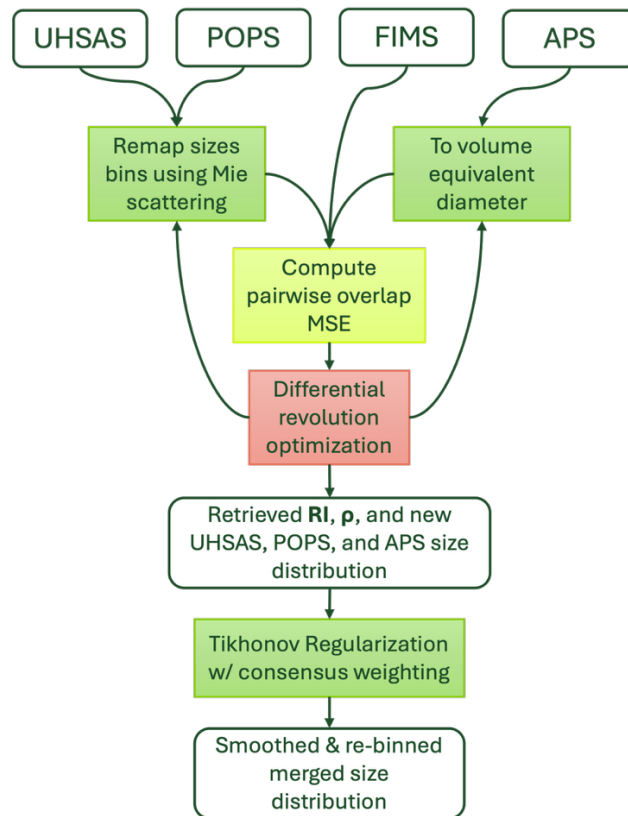


Figure 1 Workflow for merging UHSAS, POPS, FIMS, and APS aerosol size distributions.

The multi-instrument aerosol size distributions are merged using a physically based workflow that converts optical and aerodynamic diameters to a common volume equivalent diameter and combines the resulting $dN/d\log D_p$ spectra on a shared grid (Fig. 1). UHSAS and POPS optical bins are converted using Mie-scattering lookup tables parameterized by effective real refractive indices, while APS aerodynamic bins are converted using an effective particle density under a spherical-particle assumption. FIMS is treated as the reference: its mobility diameter is taken as a proxy for volume-equivalent diameter over the FIMS size range.

The conversion parameters are retrieved independently for each time interval via a single joint optimization that minimizes a cost function constructed from pairwise discrepancies among instruments within their overlapping size ranges. The bounded optimization is solved using a population-based differential evolution algorithm.

After applying the best-fit conversions, all spectra are mapped onto a common diameter grid and combined into a single merged distribution using Tikhonov regularization. Instrument contributions are set by weights, and a consensus weighting reduces the weights of instruments that deviate strongly from the ensemble at a given diameter, producing a continuous, number-consistent size distribution that balances agreement among instruments across overlap regions.

The code for the algorithm and data processing can be accessed at: <https://github.com/bochens/SizeDistMerge>.

3.0 Data Collection and Processing:

Data from the original aerosol instruments (FIMS, UHSAS, POPS, and APS) were collected continuously in real time on the NASA P-3B and are provided as high time-resolution time series. These original measurements are used to build the merged size-distribution product. The processing starts from 5-minute windows, but the final merged records could have shorter effective periods when parts of a window are removed. For each window, in cloud sampling periods are excluded with a 10 seconds padding window. If no valid data remain after this filtering, the window is skipped and no merged record is written. Windows are also skipped unless all four instruments have usable data and each instrument meets a minimum sampling requirement, defined here by a mean nonzero sample count per size bin of at least 50.

For windows that pass these checks, the four spectra are aligned using a joint optimization that compares the instruments in aerosol volume size distributions ($dV/d\log D_p$). The optimization minimizes the mean squared difference between instruments over their overlapping diameter ranges. The effective optical-to-size conversions for UHSAS and POPS are obtained by the optimization as effective real refractive indices for each instrument, constrained to be between 1.3 and 1.8. The aerodynamic-to-volume-equivalent conversion for APS is constrained to be between 950 and 2000 kg/m^3 . The FIMS spectrum serves as the reference and only the diameters smaller or equal to 500 nm are used in the optimization.

After minimizing overlap differences and applying the conversions, the spectra are mapped onto a 200 bins grid. The final merge includes a smoothing constraint to suppress unphysical bin-to-bin noise and a consensus weighting approach that reduces the influence of instruments that deviate strongly from the ensemble at a given diameter. The baseline instrument weights used in the consensus merge are 1.0 for FIMS, 1.5 for UHSAS, 0.2 for POPS, and 2.0 for APS, with larger weights giving that instrument more influence where the instruments overlap.

4.0 Data Format:

The merged size distribution is reported in ICARTT format. The list of variables and units are given in the data file header but are repeated here. The bin edges and bin means are log10 spaced and stored in OTHER_COMMENTS.

Variable	Units	Standard_Variable_Name	Description
Time_Start	seconds	Time_Start	Seconds from 00:00 UTC at start of chunk
Time_Stop	seconds	Time_Stop	Seconds from 00:00 UTC at stop of chunk
Time_Mid	seconds	Time_Mid	Seconds from 00:00 UTC at mid-point of chunk

optimization_best_cost	none	DataQuality_OptimizationCost_Merged_BestCost	Optimization best cost (unitless)
warning_high_cost	none	DataQuality_WarningFlag_Merged_HighCost	0/1 QC warning: optimization_best_cost exceeds threshold
warning_merged_gt10_diff_from_cpc	none	DataQuality_WarningFlag_Merged_Gt10nmVsCPC	0/1 QC warning: merged-vs-CPC outlier (quadlog metric)
retrieved_uhsas_n_fit	none	Aerosol_RefractiveIndex_Insitu_Merged_UHSASnFit	Effective real refractive index for UHSAS used in merge optimization (EXPERIMENTAL/DIAGNOSTIC)
retrieved_pops_n_fit	none	Aerosol_RefractiveIndex_Insitu_Merged_POPSnFit	Effective real refractive index for POPS used in merge optimization (EXPERIMENTAL/DIAGNOSTIC)
retrieved_aps_density	kg m ⁻³	Aerosol_ParticleDensity_Insitu_Merged_APSDensityFit	Effective particle density for APS used in merge optimization (EXPERIMENTAL/DIAGNOSTIC)
DNLOG_001	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_001	Merged dN/dlog10(Dp) for bin 001
DNLOG_002	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_002	Merged dN/dlog10(Dp) for bin 002
DNLOG_003	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_003	Merged dN/dlog10(Dp) for bin 003
DNLOG_004	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_004	Merged dN/dlog10(Dp) for bin 004
DNLOG_005	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_005	Merged dN/dlog10(Dp) for bin 005
DNLOG_006	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_006	Merged dN/dlog10(Dp) for bin 006
DNLOG_007	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_007	Merged dN/dlog10(Dp) for bin 007
DNLOG_008	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_008	Merged dN/dlog10(Dp) for bin 008
DNLOG_009	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_009	Merged dN/dlog10(Dp) for bin 009
DNLOG_010	#/cm ³	Aerosol_NumberSizeDistribution_Merged_DNLOG_010	Merged dN/dlog10(Dp) for bin 010

DNLOG_011	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_011	Merged dN/dlog10(Dp) for bin 011
DNLOG_012	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_012	Merged dN/dlog10(Dp) for bin 012
DNLOG_013	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_013	Merged dN/dlog10(Dp) for bin 013
DNLOG_014	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_014	Merged dN/dlog10(Dp) for bin 014
DNLOG_015	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_015	Merged dN/dlog10(Dp) for bin 015
DNLOG_016	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_016	Merged dN/dlog10(Dp) for bin 016
DNLOG_017	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_017	Merged dN/dlog10(Dp) for bin 017
DNLOG_018	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_018	Merged dN/dlog10(Dp) for bin 018
DNLOG_019	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_019	Merged dN/dlog10(Dp) for bin 019
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DNLOG_021	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_021	Merged dN/dlog10(Dp) for bin 021
DNLOG_022	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_022	Merged dN/dlog10(Dp) for bin 022
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DNLOG_135	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_135	Merged dN/dlog10(Dp) for bin 135
DNLOG_136	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_136	Merged dN/dlog10(Dp) for bin 136

DNLOG_137	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_137	Merged dN/dlog10(Dp) for bin 137
DNLOG_138	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_138	Merged dN/dlog10(Dp) for bin 138
DNLOG_139	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_139	Merged dN/dlog10(Dp) for bin 139
DNLOG_140	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_140	Merged dN/dlog10(Dp) for bin 140
DNLOG_141	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_141	Merged dN/dlog10(Dp) for bin 141
DNLOG_142	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_142	Merged dN/dlog10(Dp) for bin 142
DNLOG_143	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_143	Merged dN/dlog10(Dp) for bin 143
DNLOG_144	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_144	Merged dN/dlog10(Dp) for bin 144
DNLOG_145	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_145	Merged dN/dlog10(Dp) for bin 145
DNLOG_146	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_146	Merged dN/dlog10(Dp) for bin 146
DNLOG_147	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_147	Merged dN/dlog10(Dp) for bin 147
DNLOG_148	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_148	Merged dN/dlog10(Dp) for bin 148
DNLOG_149	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_149	Merged dN/dlog10(Dp) for bin 149
DNLOG_150	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_150	Merged dN/dlog10(Dp) for bin 150
DNLOG_151	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_151	Merged dN/dlog10(Dp) for bin 151
DNLOG_152	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_152	Merged dN/dlog10(Dp) for bin 152
DNLOG_153	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_153	Merged dN/dlog10(Dp) for bin 153
DNLOG_154	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_154	Merged dN/dlog10(Dp) for bin 154
DNLOG_155	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_155	Merged dN/dlog10(Dp) for bin 155
DNLOG_156	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_156	Merged dN/dlog10(Dp) for bin 156
DNLOG_157	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_157	Merged dN/dlog10(Dp) for bin 157

DNLOG_158	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_158	Merged dN/dlog10(Dp) for bin 158
DNLOG_159	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_159	Merged dN/dlog10(Dp) for bin 159
DNLOG_160	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_160	Merged dN/dlog10(Dp) for bin 160
DNLOG_161	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_161	Merged dN/dlog10(Dp) for bin 161
DNLOG_162	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_162	Merged dN/dlog10(Dp) for bin 162
DNLOG_163	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_163	Merged dN/dlog10(Dp) for bin 163
DNLOG_164	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_164	Merged dN/dlog10(Dp) for bin 164
DNLOG_165	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_165	Merged dN/dlog10(Dp) for bin 165
DNLOG_166	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_166	Merged dN/dlog10(Dp) for bin 166
DNLOG_167	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_167	Merged dN/dlog10(Dp) for bin 167
DNLOG_168	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_168	Merged dN/dlog10(Dp) for bin 168
DNLOG_169	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_169	Merged dN/dlog10(Dp) for bin 169
DNLOG_170	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_170	Merged dN/dlog10(Dp) for bin 170
DNLOG_171	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_171	Merged dN/dlog10(Dp) for bin 171
DNLOG_172	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_172	Merged dN/dlog10(Dp) for bin 172
DNLOG_173	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_173	Merged dN/dlog10(Dp) for bin 173
DNLOG_174	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_174	Merged dN/dlog10(Dp) for bin 174
DNLOG_175	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_175	Merged dN/dlog10(Dp) for bin 175
DNLOG_176	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_176	Merged dN/dlog10(Dp) for bin 176
DNLOG_177	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_177	Merged dN/dlog10(Dp) for bin 177
DNLOG_178	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_178	Merged dN/dlog10(Dp) for bin 178

DNLOG_179	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_179	Merged dN/dlog10(Dp) for bin 179
DNLOG_180	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_180	Merged dN/dlog10(Dp) for bin 180
DNLOG_181	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_181	Merged dN/dlog10(Dp) for bin 181
DNLOG_182	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_182	Merged dN/dlog10(Dp) for bin 182
DNLOG_183	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_183	Merged dN/dlog10(Dp) for bin 183
DNLOG_184	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_184	Merged dN/dlog10(Dp) for bin 184
DNLOG_185	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_185	Merged dN/dlog10(Dp) for bin 185
DNLOG_186	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_186	Merged dN/dlog10(Dp) for bin 186
DNLOG_187	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_187	Merged dN/dlog10(Dp) for bin 187
DNLOG_188	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_188	Merged dN/dlog10(Dp) for bin 188
DNLOG_189	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_189	Merged dN/dlog10(Dp) for bin 189
DNLOG_190	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_190	Merged dN/dlog10(Dp) for bin 190
DNLOG_191	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_191	Merged dN/dlog10(Dp) for bin 191
DNLOG_192	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_192	Merged dN/dlog10(Dp) for bin 192
DNLOG_193	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_193	Merged dN/dlog10(Dp) for bin 193
DNLOG_194	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_194	Merged dN/dlog10(Dp) for bin 194
DNLOG_195	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_195	Merged dN/dlog10(Dp) for bin 195
DNLOG_196	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_196	Merged dN/dlog10(Dp) for bin 196
DNLOG_197	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_197	Merged dN/dlog10(Dp) for bin 197
DNLOG_198	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_198	Merged dN/dlog10(Dp) for bin 198
DNLOG_199	#/cm3	Aerosol_NumberSizeDistribution_Merged_DNLOG_199	Merged dN/dlog10(Dp) for bin 199

DNLOG_200	#/cm3	Aerosol_NumberSizeDistributio n_Merged_DNLOG_200	Merged dN/dlog10(Dp) for bin 200
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5.0 Data remarks

Data are not continuous; records are listed in chronological order. Time_Start, Time_Stop, and Time_Mid define each averaging interval. Each record reports the merged aerosol number size distribution (DNLOG_###) for that time interval along with merge diagnostic variables (optimization_best_cost and QC warning flags; retrieved parameters where included).

6.0 References

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