

Aerosol Optical Depth Best Estimate Value-Added Product Report

(formerly named Quality Control Aerosol Optical Depth)

E Kassianov
Y Shi
L Riihimäki
G Gibler

E Cromwell
J Monroe
C Flynn

September 2023



DISCLAIMER

This report was prepared as an account of work sponsored by the U.S. Government. Neither the United States nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

Aerosol Optical Depth Best Estimate Value-Added Product Report

E Kassianov, Pacific Northwest National Laboratory (PNNL)
E Cromwell, PNNL
Y Shi, PNNL
J Monroe, National Oceanic and Atmospheric Administration
L Riihimaki, Cooperative Institute for Research in Environmental
Sciences
C Flynn, University of Oklahoma
G Gibler, PNNL

September 2023

How to cite this document:

Kassianov, E, E Cromwell, Y Shi, J Monroe, L Riihimaki, C Flynn, and G Gibler. 2023. Aerosol Optical Depth Best Estimate Value-Added Product Report. U.S. Department of Energy, Atmospheric Radiation Measurement user facility, Richland, Washington. DOE/SC-ARM-TR-247.

Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AERONET	Aerosol Robotic Network
AOD	aerosol optical depth
AODBE	Aerosol Optical Depth Best Estimate Value-Added Product
AODBE2CH	Aerosol Optical Depth Best Estimate 2-Channel
AODBE5CH	Aerosol Optical Depth Best Estimate 5-Channel
ARM	Atmospheric Radiation Measurement
CDF	cumulative distribution function
CF	Central Facility
CSPHOT	Cimel sunphotometer
EF	Extended Facility
MFRSR	multifilter rotating shadowband radiometer
NASA	National Aeronautics and Space Administration
NIMFR	normal incidence multifilter radiometer
QC	quality control
QCAOD	Quality Control Aerosol Optical Depth Value-Added Product, former name of AODBE VAP
SGP	Southern Great Plains
StDv	standard deviation
VAP	value-added product

Contents

Acronyms and Abbreviations	iii
1.0 Introduction	1
2.0 Algorithm and Methodology	2
3.0 Input Data	3
4.0 Output Data	3
5.0 Summary	7
6.0 References	8
Appendix A – Datastream Variables	A.1

Figures

1 Time series of daily-averaged AOD at 500-nm wavelength obtained from four ground-based instruments for a 21-yr period (1997-2018): MFRSR C1 (a), MFRSR E13 (b), NIMFR (c), and CSPHOT (d).	2
2 Daily-averaged combined AOD obtained from four individual AODs (Figure 1).	4
3 Example of time series of the combined AOD (green) and its four individual components (red, blue, wine, and cyan) during 3-h period for a given day (May 11, 2008).	5
4 Frequency and cumulative distribution function (CDF) of the daily-averaged combined AOD as a function of the standard deviation (StDv).	6
5 Number of days (or temporal coverage) for the combined AOD and its four components obtained for a small (0.01) value of the StDv threshold.	6

Tables

1 Parameters of linear regressions obtained for six AOD pairs for a given day (May 11, 2008): number of points (N), square of correlation coefficient (R^2), slope, and mean difference (bias).	5
2 Parameters of linear regressions obtained for six pairs of daily-averaged AODs at 500-nm wavelength for a 21-year period (1997-2018) and small (0.01) value of the StDv threshold: number of days (N), square of correlation coefficient (R^2), slope, and mean difference (bias).	7
3 The same as Table 2, except for different value (0.02) of the StDv threshold.	7
4 aodbe2ch.c1 datastream variables and descriptions.	A.1
5 aodbe5ch.c1 datastream variables and descriptions	A.3

1.0 Introduction

Four aerosol optical depth (AOD) products are offered by four collocated ground-based instruments deployed at the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility's Southern Great Plains (SGP) observatory (SGP Central Facility 1 [C1] and Extended Facility 13 [E13]) for more than two decades. Two of these instruments, the multifilter rotating shadowband radiometers (MFRSRs C1 and E13), are sensors with horizontal hemispherical receivers shaded by rotating shadowbands (Hodges and Michalsky 2016). The other two instruments, the normal incidence multifilter radiometer (NIMFR; Hodges and Michalsky 2016) and the Cimel sunphotometer (CSPHOT; Gregory 2011), are sensors with a sun-pointing design. The CSPHOT is part of the National Aeronautics and Space Administration (NASA) Aerosol Robotic Network (AERONET; Holben et al. 1998) and CSPHOT operation and scheduling differs from operation of the ARM-supported radiometers. The distinct designs of these four instruments and types of data processing determine the instrument-dependent continuity, quality, and resolution of the corresponding AOD products.

The four AOD products outlined above are used as input for the Aerosol Optical Depth Best Estimate (AODBE) value-added product (VAP) family at the SGP observatory. It should be emphasized that the ARM user facility has several established and temporal sites with a variable set of instruments for AOD measurements worldwide. Thus, the number of AOD products used as input for the AODBE VAP can be site dependent. The AODBE VAP can handle a variable set of AOD products. Currently, there are two variants of the AODBE VAP released to production, the Aerosol Optical Depth Best Estimate 2-Channel (AODBE2CH) and the Aerosol Optical Depth Best Estimate 5-Channel (AODBE5CH). Other variants of the AODBE VAP family, involving a greater number of wavelengths (7-channel), are in development.

The main goal of the AODBE VAP family is to generate a combined AOD with high quality, enhanced continuity, and fine temporal resolution. An initial variant (AODBE2CH) is used to generate the combined AOD at two wavelengths (500 and 870 nm) with 1-min resolution and is performed for a 21-yr period (1997–2018). The next variant (AODBE5CH) is used to generate the combined AOD at five wavelengths (415, 500, 615, 675, and 870 nm) with 1-min resolution for a 24-yr period (1997–2021). These products address major challenges associated with varying data quality and resolution mismatch of the individual AOD products. Also, uncertainty assessment of the combined AOD is made and its relevance for user-specified needs is discussed. Two variants outlined above have the same algorithm and methodology (section 2). Moreover, these variants have the same input data (section 3) and identical combined AODs (section 4) at two wavelengths (500 and 870 nm). Thus, only the initial variant (AODBE2CH) with suitable comments regarding AODBE5CH is considered below.

AODs offered by the ARM-supported measurements (two MFRSRs and NIMFR) incorporate the automated quality control (QC) tests. Only “good” data indicated by these tests (two MFRSRs and NIMFR) are used for generation of the combined AOD. Also, this generation involves “quality-assured” (Level 2.0) CSPHOT data provided by the most recent AERONET-supported Version 3 (V3), which has an improved cloud screening in comparison with its predecessor (Giles et al. 2019).

The automated QC tests are very useful for preliminary analysis of data quality. However, these tests occasionally are unable to detect “incorrect” data. For example, several NIMFR AODs, which successfully passed the automated QC tests, can exceed substantially those provided by the other three

instruments (Figure 1). These “incorrect” NIMFR AODs (e.g., summer of 2003) have a weak spectral dependence, which likely indicates cloud contamination.

Figure 1 also reveals that the individual time series have gaps, which are likely associated with the instrument-dependent data quality issues and the required upgrades and replacements of the ground-based instruments. Duration of these gaps is instrument-dependent and can be substantial (from several weeks to several months). The NIMFR AOD record with many detached parts has the longest durations of gaps (up to several years) compared with the AOD time series offered by the other three instruments. In contrast, the MFRSR AOD records show the best continuity.

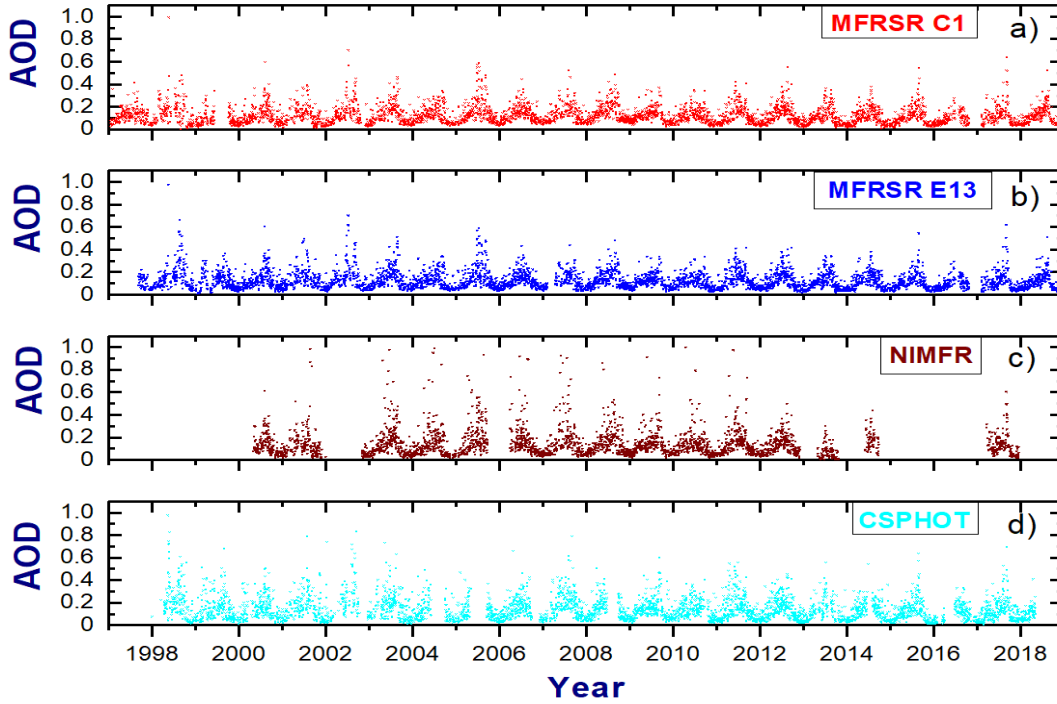


Figure 1. Time series of daily-averaged AOD at 500-nm wavelength obtained from four ground-based instruments for a 21-yr period (1997–2018): MFRSR C1 (a), MFRSR E13 (b), NIMFR (c), and CSPHOT (d). The included time series exhibit similar seasonal patterns with large and small AOD values during summer and winter, respectively. Note that the strong seasonal variability of AOD at the SGP site has been documented previously (e.g., Michalsky et al. 2010).

2.0 Algorithm and Methodology

The combined (or best-estimate) AOD is calculated by retrieving AOD measurements at 500 nm and 870 nm wavelengths from the four input sources. The corresponding AOD measurements at five wavelengths (415, 500, 615, 675, and 870 nm) are used for the AODBE5CH variant. Then, each AOD measurement is averaged to a 1-min time scale. For a given minute, the average AOD value is calculated from 0 seconds (inclusive) to 60 seconds (exclusive). During the averaging, any time sample with the following is not used for averaging:

1. a non-zero QC value

2. AOD value is less than 0
3. AOD value is greater than 1.

If no valid time samples are within the 1-min period, the averaged AOD value is set to the missing value (-9999). After the AOD measurements are averaged to a 1-min scale, the combined AOD value is then calculated for each minute and wavelength.

For each minute, the combined AOD value for a given wavelength is calculated by taking the average of the AOD measurements from the four 1-min averaged input sources. If one of these sources has a non-zero QC value, the AOD value is not used in the average. For the ground-based instruments considered here, this number can change from 2 (AODs are available from two instruments only) up to 4 (AODs are available from all instruments). If there are no good AOD values for a given minute, the combined AOD is set to the missing value (-9999). An AOD value is considered good if the corresponding QC value is zero.

In addition, the four 1-min averaged inputs (500-nm AOD values) are compared against each other. There are six pairs of these four inputs. For each pair, the VAP finds the time periods where its inputs have good QC. Then, a linear regression is performed for these periods. The VAP then provides the slope, root mean square deviation, and the mean bias from the linear regression.

3.0 Input Data

The four input datastreams for the AODBE VAP family are:

- MFRSR instrument located at SGP C1 (sgpmfrsraod1michC1.c1)
- MFRSR instrument located at SGP E13 (sgpmfrsraod1michE13.c1)
- NIMFR instrument located at SGP C1 (nimfraod1michC1.c1)
- AERONET v3 from SGP C1 (sgpcspotaodfiltqav3C1.a1).

For the AODBE2CH, the 500-nm and 870-nm AOD measurements are retrieved from each of the datastreams, along with their associated QC variables (qc_*). For the AODBE5CH, AOD measurements at five wavelengths (415, 500, 615, 675, and 870 nm) are retrieved from each of the datastreams, along with their associated QC variables (qc_*).

4.0 Output Data

The output of the AODBE2CH VAP is the aodbe2ch.c1 datastream. This datastream contains the four 1-min-averaged 500-nm and 870-nm AOD values and the combined 500-nm and 870-nm AOD values. The complete list of output variables is provided in Appendix A. The output of the AODBE5CH VAP is the aodbe5ch.c1 datastream. This datastream contains the four 1-min-averaged AOD values and the combined AOD values at five wavelengths (415, 500, 615, 675, and 870 nm). The complete list of output variables is also provided in Appendix A.

The combined 500-nm AOD for a 21-year period is shown in Figure 2. The unscreened “incorrect” NIMFR AODs (Figure 1c) are responsible for occasional “incorrect” values of the combined AOD (Figure 2).

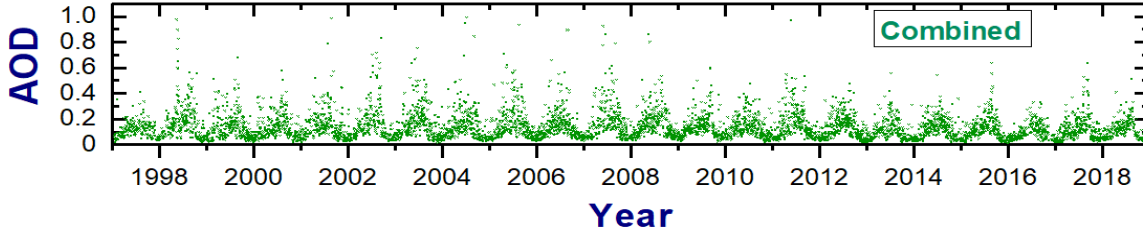


Figure 2. Daily-averaged combined AOD obtained from four individual AODs (Figure 1).

Figure 3 is an example of the combined 500-nm AOD and its four individual components for a given day (May 11, 2008). This example defines a “favorable” case where all four individual AODs are assessable and the spread between them is quite small (about 0.02 or less). To ease visual comparison of the combined and individual AODs, this example represents a “zoom in” version of their diurnal changes by selecting a narrow (3-h) temporal window. As expected, the combined AOD is located between two individual AODs with largest and smallest values and its diurnal changes follow those of the individual AODs.

Good visual agreement between individual time series (Figure 3) is supported by the basic statistics provided by the linear regressions applied to six pairs of the four individual AODs (Table 1). The six pairs are defined as follows:

1. MFRSR C1 versus CSPHOT
2. MFRSR E13 versus CSPHOT
3. NIMFR versus CSPHOT
4. MFRSR C1 versus NIMFR
5. MFRSR E13 versus NIMFR and
6. MFRSR E13 versus MFRSR C1.

For example, the square of correlation coefficient (R^2) exceeds 0.92 for all pairs (Table 1). The slope is relatively small (~ 0.8) and large (~ 1.0) for the first three and last three pairs, respectively (Table 1). It should be emphasized that sample size for the first three pairs ($N \leq 44$) is about 10 times smaller than that for the last three pairs ($N \leq 438$). Therefore, the difference between slopes obtained for the first and last three pairs can be attributed, at least in part, to the substantial difference between sample sizes.

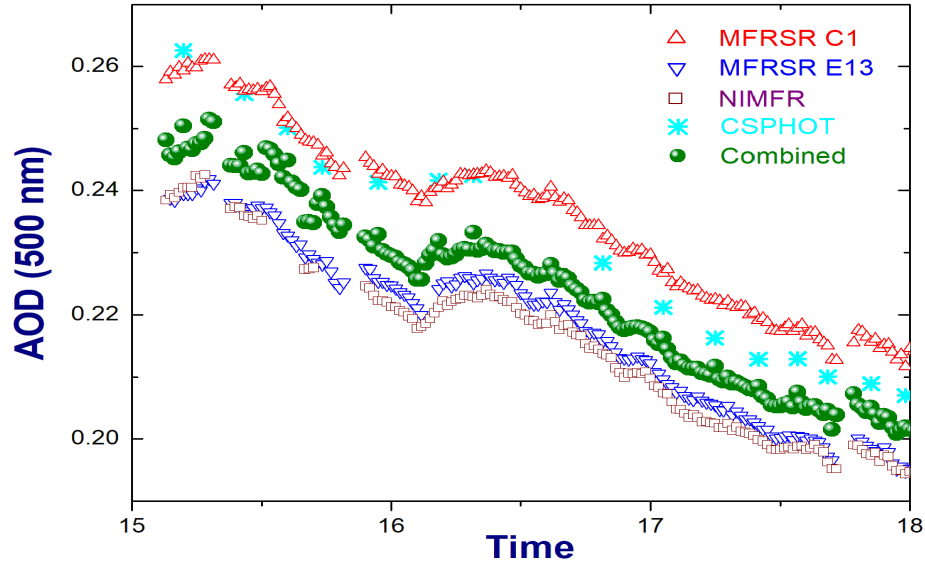


Figure 3. Example of time series of the combined AOD (green) and its four individual components (red, blue, wine, and cyan) during 3-h period for a given day (May 11, 2008).

Table 1. Parameters of linear regressions obtained for six AOD pairs for a given day (May 11, 2008): number of points (N), square of correlation coefficient (R^2), slope, and mean difference (bias).

AOD pair	N	R^2	Slope	Bias
1	44	0.952	0.845	0.007
2	38	0.989	0.796	-0.011
3	34	0.986	0.810	-0.013
4	382	0.926	1.01	0.02
5	355	0.984	0.986	0.002
6	438	0.943	1.044	0.019

Both range and standard deviation (StDv) of the combined AOD are calculated for describing its temporal variability. The latter can be viewed as an uncertainty of the combined AOD. Large (>0.05) values of the calculated StDv represent rare events ($\sim 3\%$ of time) (Figure 4) that include days with occasional “incorrect” AODs (Figure 2). An appropriate selection of the StDv threshold can remove them easily. For example, by choosing a small (0.01) threshold, one can preserve the distinct seasonal pattern of the combined AOD (Figure 2) but eliminate days with “incorrect” AODs. We emphasize that the StDv (or uncertainty) of the combined AOD does not exceed the prescribed uncertainties (0.01-0.02) of the individual AODs for most cases ($\sim 90\%$ of time) (Figure 4). Different applications of the combined AOD may have different user-specified requirements in terms of acceptable uncertainty. Statistics of the StDv (Figure 4) offer an opportunity to accomplish these goals.

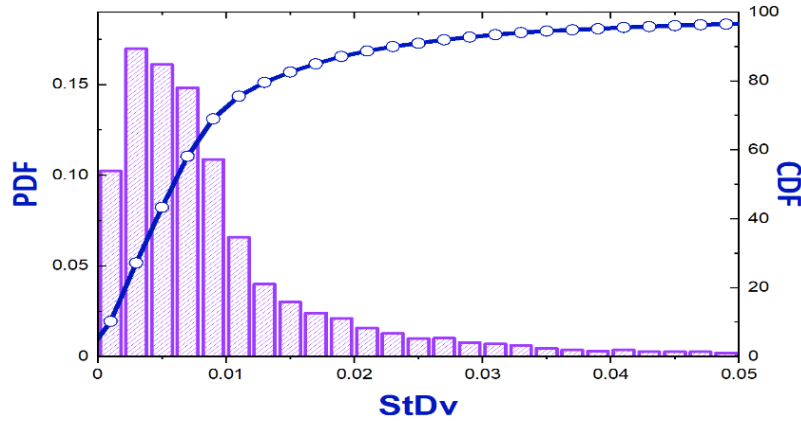


Figure 4. Frequency and cumulative distribution function (CDF) of the daily-averaged combined AOD as a function of the standard deviation (StDv).

Figure 5 contrasts temporal coverages obtained for both individual and combined AODs and demonstrates two important points. First, coverage of the combined AOD is comparable with those obtained for two MFRSR AODs, mostly due to their greater continuity compared to AODs provided by the other two (NIMFR and CSPHOT) instruments (Figure 1). Second, coverage of the combined AOD is substantially greater than that for the NIMFR AOD and for the CSPHOT AOD. This coverage difference is about 80% and 40% for the NIMFR AOD and CSPHOT AOD, respectively. Several factors, such as large gaps in the NIMFR AOD and CSPHOT AOD data sets, and their partial overlaps (Figure 1), impact this difference.

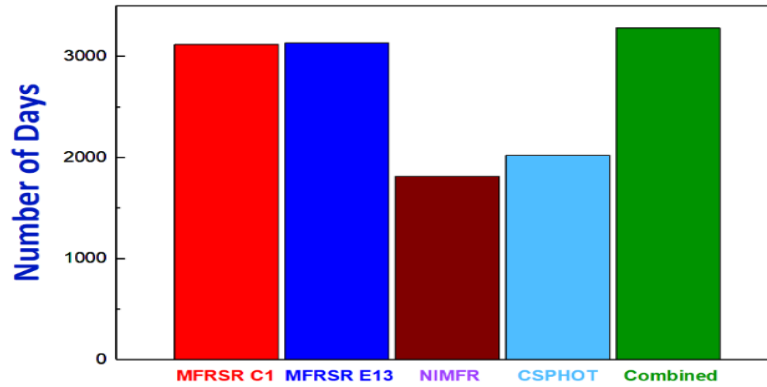


Figure 5. Number of days (or temporal coverage) for the combined AOD and its four components obtained for a small (0.01) value of the StDv threshold.

Tables 2 and 3 illustrate level of agreement between individual AODs as a function of the StDv threshold and include six pairs of four individual AODs. The obtained statistics suggest that the small (e.g., ≤ 0.02) spectrally independent StDv threshold can be used to pick up days where all individual AODs are consistent with each other. Certainly, the required level of agreement between individual AODs depends on user-specified needs and an appropriate selection of the StDv threshold can address these needs. Such selection could include a wavelength-dependent threshold and/or its normalized version if needed.

Table 2. Parameters of linear regressions obtained for six pairs of daily-averaged AODs at 500-nm wavelength for a 21-year period (1997-2018) and small (0.01) value of the StDv threshold: number of days (N), square of correlation coefficient (R^2), slope, and mean difference (bias). The AOD pairs are the same from Table 1.

AOD pair	N	R^2	Slope	Bias
1	2184	0.973	0.967	-0.003
2	2201	0.974	0.949	-0.002
3	1363	0.981	0.973	0.003
4	1727	0.986	0.997	-0.007
5	1721	0.988	0.992	-0.005
6	3006	0.989	0.978	0.001

Table 3. The same as Table 2, except for different value (0.02) of the StDv threshold.

AOD pair	N	R^2	Slope	Bias
1	2865	0.951	0.942	-0.001
2	2890	0.950	0.920	0.001
3	1860	0.953	0.950	0.005
4	2302	0.979	1.000	-0.008
5	2299	0.981	0.991	-0.006
6	3812	0.984	0.972	0.001

5.0 Summary

An initial version of the AODBE VAP, AODBE2CH, generates the combined AOD at two wavelengths (500 and 870 nm) with high temporal resolution (1-min) for a 21-yr period (1997-2018) by merging available individual AOD products. The next version of the AODBE VAP, AODBE5CH, generates the combined AOD at five wavelengths (415, 500, 615, 675, and 870 nm) with high temporal resolution (1-min) for a 24-yr period (1997-2021) by merging available individual AOD products. These products are provided by four ground-based instruments (MFRSR C1, MFRSR E13, NIMFR, and CSPHOT) deployed at the ARM SGP observatory (C1 and E13). However, filling the data gaps with unavailable individual AODs is not considered. This initial version also provides uncertainty of the combined AOD. This uncertainty information would be beneficial for a wide range of cross-cutting applications, such as an effective screening of occasional events with poor-quality data and identification of periods when individual AOD products are in good agreement. Contrasting the combined AOD and its individual components reveals that the combined AOD has an extended temporal coverage (e.g., up to 40% relative to the CSPHOT AOD), while uncertainty of the combined AOD does not exceed the prescribed uncertainties (0.01-0.02) of the individual AODs for most cases ($\sim 90\%$ of time). Thus, the generated combined AOD preserves the advantages of the individual AODs (high data quality) and reduces their disadvantages (detached parts of the data time series).

6.0 References

Giles, DM, A Sinyuk, MG Sorokin, JS Schafer, A Smirnov, I Slutsker, TF Eck, BN Holben, JR Lewis, JR Campbell, EJ Welton, SV Korkin, and AI Lyapustin. 2019. “Advancements in the Aerosol Robotic Network (AERONET) Version 3 database – automated near-real-time quality control algorithm with improved cloud screening for Sun photometer aerosol optical depth (AOD) measurements.” *Atmospheric Measurement Techniques* 12(1): 169–209, <https://doi.org/10.5194/amt-12-169-2019>

Gregory, L. 2011. Cimel Sunphotometer (CSPHOT) Handbook. U.S. Department of Energy. DOE/SC-ARM-TR-056, https://www.arm.gov/publications/tech_reports/handbooks/csphot_handbook.pdf

Hodges, GB, and JJ Michalsky. 2016. Multifilter Rotating Shadowband Radiometer Instrument Handbook with subsections for derivative instruments: Multifilter Radiometer (MFR) Normal Incidence Multifilter Radiometer (NIMFR). U.S. Department of Energy. DOE/SC-ARM-TR-144, https://www.arm.gov/publications/tech_reports/handbooks/mfrsr_handbook.pdf

Holben, BN, TF Eck, I Slutsker, D Tanré, JP Buis, A Setzer, E Vermote, JA Reagan, YJ Kaufman, T Nakajima, F Lavenu, I Jankowiak, and A Smirnov. 1998. “AERONET – A federated instrument network and data archive for aerosol characterization.” *Remote Sensing of Environment* 66(1): 1–16, [https://doi.org/10.1016/S0034-4257\(98\)00031-5](https://doi.org/10.1016/S0034-4257(98)00031-5)

Michalsky, JJ, JA Schlemmer, WE Berkheiser, JL Berndt, LC Harrison, NS Laulainen, NR Larson, and JC Barnard. 2010. “Multiyear measurements of aerosol optical depth in the Atmospheric Radiation Measurement and Quantitative Links programs.” *Journal of Geophysical Research – Atmospheres* 115(D11): 12099–12107, <https://doi.org/10.1029/2001JD900096>

Appendix A

Datastream Variables

The tables below list variable names and descriptions for each datastream. Variable names in bold are the primary variables of the datastream.

Table 4. aodbe2ch.c1 datastream variables and descriptions.

Variable name (dimension)	Description
aod_cimel_500 (time)	Aerosol Optical Depth at 500 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_500_goodfraction (time)	Metric goodfraction for variable aod_cimel_500.
aod_cimel_870 (time)	Aerosol Optical Depth at 870 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_870_goodfraction (time)	Metric goodfraction for variable aod_cimel_870.
aod_nimfr_500 (time)	Aerosol Optical Depth at 500 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_500_goodfraction (time)	Metric goodfraction for variable aod_nimfr_500.
qc_aod_nimfr_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_870 (time)	Aerosol Optical Depth at 870 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_870_goodfraction (time)	Metric goodfraction for variable aod_nimfr_870.
qc_aod_nimfr_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the nimfraod1mich.c1 datastream.
aod_mfrsr_500 (time)	Aerosol Optical Depth at 500 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_500_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_500.
qc_aod_mfrsr_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_870 (time)	Aerosol Optical Depth at 870 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_870_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_870.

Variable name (dimension)	Description
qc_aod_mfrsr_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_500 (time)	Aerosol Optical Depth at 500 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_500_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_500.
qc_aod_mfrsr_additional_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the additional mfrsraod1mich.c datastream.
aod_mfrsr_additional_870 (time)	Aerosol Optical Depth at 870 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_C1_additional_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_870.
qc_aod_mfrsr_additional_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the additional mfrsraod1mich.c1 datastream.
aod_be_500 (time)	AOD best estimate at 500 nm. Mean of any AOD points considered good.
qc_aod_be_500 (time)	Quality check results on variable: AOD best estimate at 500 nm. Mean of any AOD points considered good.
aod_be_500_random_uncertainty (time)	Standard deviation of data points used in aod_be_500 when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_500_quadrature_uncertainty (time)	Quadrature of uncertainty values used in aod_be_500.
aod_be_500_range (time)	Range of AOD values (max-min) used in aod_be_500.
source_aod_be_500 (time)	Source for variable: AOD best estimate at 500 nm. Mean of any AOD points considered good.
aod_be_870 (time)	AOD best estimate at 870 nm. Mean of any AOD points considered good.
qc_aod_be_870 (time)	Quality check results on variable: AOD best estimate at 870 nm. Mean of any AOD points considered good.
aod_be_870_random_uncertainty (time)	Standard deviation of data points used in aod_be_870 when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_870_quadrature_uncertainty (time)	Quadrature of uncertainty values used in aod_be_870
aod_be_870_range (time)	Range of AOD values (max-min) used in aod_be_870
source_aod_be_870 (time)	Source for variable: AOD best estimate at 870 nm. Mean of any AOD points considered good.
daily_R2_500 (ncomparisons)	Square of correlation coefficient between two variables for 500 nm.

Variable name (dimension)	Description
daily_npoint_500 (ncomparisons)	Number of points available for comparison between two variables for 500 nm.
daily_mean_bias_500 (ncomparisons)	Mean bias between two variables for 500 nm.
daily_slope_500 (ncomparisons)	Slope of linear regression line between two variables for 500 nm.
good_data_flag	Daily value indicating which of 4 AOD datastreams declared good for a given day.

Table 5. aodbe5ch.c1 datastream variables and descriptions

Variable name (dimension)	Description
aod_cimel_380 (time)	Aerosol Optical Depth at 380 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_380_goodfraction (time)	Metric goodfraction for variable aod_cimel_380.
aod_cimel_440 (time)	Aerosol Optical Depth at 440 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_440_goodfraction (time)	Metric goodfraction for variable aod_cimel_440.
be_aod_cimel_415 (time)	Best estimate of Aerosol Optical Depth at 415 nm based on a polynomial fit of csphotaodfiltqav3.a1 data.
aod_cimel_500 (time)	Aerosol Optical Depth at 500 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_500_goodfraction (time)	Metric goodfraction for variable aod_cimel_500.
be_aod_cimel_615 (time)	Best estimate of Aerosol Optical Depth at 615 nm based on a polynomial fit of csphotaodfiltqav3.a1 data.
aod_cimel_675 (time)	Aerosol Optical Depth at 675 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_675_goodfraction (time)	Metric goodfraction for variable aod_cimel_675.
aod_cimel_870 (time)	Aerosol Optical Depth at 870 nm from the csphotaodfiltqav3.a1 datastream.
aod_cimel_870_goodfraction (time)	Metric goodfraction for variable aod_cimel_870.
aod_mfrsr_415 (time)	Aerosol Optical Depth at 415 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_415_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_415.
qc_aod_mfrsr_415 (time)	Quality check results on variable: Aerosol Optical Depth at 415 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_500 (time)	Aerosol Optical Depth at 500 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_500_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_500.

Variable name (dimension)	Description
qc_aod_mfrsr_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_615 (time)	Aerosol Optical Depth at 615 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_615_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_615.
qc_aod_mfrsr_615 (time)	Quality check results on variable: Aerosol Optical Depth at 615 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_673 (time)	Aerosol Optical Depth at 673 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_673_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_673.
qc_aod_mfrsr_673 (time)	Quality check results on variable: Aerosol Optical Depth at 673 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_870 (time)	Aerosol Optical Depth at 870 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_870_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_870.
qc_aod_mfrsr_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the primary mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_415 (time)	Aerosol Optical Depth at 415 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_415_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_415.
qc_aod_mfrsr_additional_415 (time)	Quality check results on variable: Aerosol Optical Depth at 415 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_500 (time)	Aerosol Optical Depth at 500 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_500_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_500.
qc_aod_mfrsr_additional_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_615 (time)	Aerosol Optical Depth at 615 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_615_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_615.
qc_aod_mfrsr_additional_615 (time)	Quality check results on variable: Aerosol Optical Depth at 615 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_673 (time)	Aerosol Optical Depth at 673 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_673_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_673.

Variable name (dimension)	Description
qc_aod_mfrsr_additional_673 (time)	Quality check results on variable: Aerosol Optical Depth at 673 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_870 (time)	Aerosol Optical Depth at 870 nm from the additional mfrsraod1mich.c1 datastream.
aod_mfrsr_additional_870_goodfraction (time)	Metric goodfraction for variable aod_mfrsr_additional_870.
qc_aod_mfrsr_additional_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the additional mfrsraod1mich.c1 datastream.
aod_nimfr_415 (time)	Aerosol Optical Depth at 415 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_415_goodfraction (time)	Metric goodfraction for variable aod_nimfr_415.
qc_aod_nimfr_415 (time)	Quality check results on variable: Aerosol Optical Depth at 415 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_500 (time)	Aerosol Optical Depth at 500 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_500_goodfraction (time)	Metric goodfraction for variable aod_nimfr_500.
qc_aod_nimfr_500 (time)	Quality check results on variable: Aerosol Optical Depth at 500 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_615 (time)	Aerosol Optical Depth at 615 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_615_goodfraction (time)	Metric goodfraction for variable aod_nimfr_615.
qc_aod_nimfr_615 (time)	Quality check results on variable: Aerosol Optical Depth at 615 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_673 (time)	Aerosol Optical Depth at 673 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_673_goodfraction (time)	Metric goodfraction for variable aod_nimfr_673.
qc_aod_nimfr_673 (time)	Quality check results on variable: Aerosol Optical Depth at 673 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_870 (time)	Aerosol Optical Depth at 870 nm from the nimfraod1mich.c1 datastream.
aod_nimfr_870_goodfraction (time)	Metric goodfraction for variable aod_nimfr_870.
qc_aod_nimfr_870 (time)	Quality check results on variable: Aerosol Optical Depth at 870 nm from the nimfraod1mich.c1 datastream.
aod_be_polyfit_415 (time)	AOD best estimate at 415 nm. Polynomial best fit of any AOD points considered good.
qc_aod_be_polyfit_415 (time)	Quality check results on variable: AOD best estimate at 415 nm. Polynomial best fit of any AOD points considered good.
aod_be_mean_415 (time)	AOD best estimate at 415 nm. Mean of any AOD points considered good.

Variable name (dimension)	Description
qc_aod_be_mean_415 (time)	Quality check results on variable: AOD best estimate at 415 nm. Mean of any AOD points considered good.
aod_be_415_random_uncertainty (time)	Standard deviation of data points used in AOD best estimates at 415 nm when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_415_quadrature_uncertainty (time)	Quadrature of uncertainty values used in AOD best estimates at 415 nm.
aod_be_415_range (time)	Range of AOD values (max-min) used in AOD best estimates at 415 nm.
source_aod_be_415 (time)	Source for variable: AOD best estimates at 415 nm.
aod_be_polyfit_500 (time)	AOD best estimate at 500 nm. Polynomial best fit of any AOD points considered good.
qc_aod_be_polyfit_500 (time)	Quality check results on variable: AOD best estimate at 500 nm. Polynomial best fit of any AOD points considered good.
aod_be_mean_500 (time)	AOD best estimate at 500 nm. Mean of any AOD points considered good.
qc_aod_be_mean_500 (time)	Quality check results on variable: AOD best estimate at 500 nm. Mean of any AOD points considered good.
aod_be_500_random_uncertainty (time)	Standard deviation of data points used in AOD best estimates at 500 nm when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_500_quadrature_uncertainty (time)	Quadrature of uncertainty values used in AOD best estimates at 500 nm.
aod_be_500_range (time)	Range of AOD values (max-min) used in AOD best estimates at 500 nm.
source_aod_be_500 (time)	Source for variable: AOD best estimates at 500 nm.
aod_be_polyfit_615 (time)	AOD best estimate at 615 nm. Polynomial best fit of any AOD points considered good.
qc_aod_be_polyfit_615 (time)	Quality check results on variable: AOD best estimate at 615 nm. Polynomial best fit of any AOD points considered good.
aod_be_mean_615 (time)	AOD best estimate at 615 nm. Mean of any AOD points considered good.
qc_aod_be_mean_615 (time)	Quality check results on variable: AOD best estimate at 615 nm. Mean of any AOD points considered good.
aod_be_615_random_uncertainty (time)	Standard deviation of data points used in AOD best estimates at 615 nm when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_615_quadrature_uncertainty (time)	Quadrature of uncertainty values used in AOD best estimates at 615 nm.

Variable name (dimension)	Description
aod_be_615_range (time)	Range of AOD values (max-min) used in AOD best estimates at 615 nm.
source_aod_be_615 (time)	Source for variable: AOD best estimates at 615 nm.
aod_be_polyfit_673 (time)	AOD best estimate at 673 nm. Polynomial best fit of any AOD points considered good.
qc_aod_be_polyfit_673 (time)	Quality check results on variable: AOD best estimate at 673 nm. Polynomial best fit of any AOD points considered good.
aod_be_mean_673 (time)	AOD best estimate at 673 nm. Mean of any AOD points considered good.
qc_aod_be_mean_673 (time)	Quality check results on variable: AOD best estimate at 673 nm. Mean of any AOD points considered good.
aod_be_673_random_uncertainty (time)	Standard deviation of data points used in AOD best estimates at 673 nm when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_673_quadrature_uncertainty (time)	Quadrature of uncertainty values used in AOD best estimates at 673 nm.
aod_be_673_range (time)	Range of AOD values (max-min) used in AOD best estimates at 673 nm.
source_aod_be_673 (time)	Source for variable: AOD best estimates at 673 nm.
aod_be_polyfit_870 (time)	AOD best estimate at 870 nm. Polynomial best fit of any AOD points considered good.
qc_aod_be_polyfit_870 (time)	Quality check results on variable: AOD best estimate at 870 nm. Polynomial best fit of any AOD points considered good.
aod_be_mean_870 (time)	AOD best estimate at 870 nm. Mean of any AOD points considered good.
qc_aod_be_mean_870 (time)	Quality check results on variable: AOD best estimate at 870 nm. Mean of any AOD points considered good.
aod_be_870_random_uncertainty (time)	Standard deviation of data points used in AOD best estimates at 870 nm when 2 or more measurements available. Standard value of 0.02 when 1 AOD variable used.
aod_be_870_quadrature_uncertainty (time)	Quadrature of uncertainty values used in AOD best estimates at 870 nm.
aod_be_870_range (time)	Range of AOD values (max-min) used in AOD best estimates at 870 nm.
source_aod_be_870 (time)	Source for variable: AOD best estimates at 870 nm.
daily_R2_500 (ncomparisons)	Square of correlation coefficient between two variables for 500 nm.
daily_npoint_500 (ncomparisons)	Number of points available for comparison between two variables for 500 nm.
daily_mean_bias_500 (ncomparisons)	Mean bias between two variables for 500 nm.

Variable name (dimension)	Description
daily_slope_500 (ncomparisons)	Slope of linear regression line between two variables for 500 nm.
good_data_flag	Daily value indicating which of 4 AOD datastreams declared good for a given day.



www.arm.gov

U.S. DEPARTMENT OF
ENERGY

Office of Science