Determination of Aerosol Optical Depth (AOD),
For Yankee Environmental Systems[1]
Multi Filter Rotating Shadow-band Radiometer
head number 550 (MFRSR-550)
During the period 2010 through 2020.

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This document consists of four parts and applies to the Yankee MFRSR-550.
1) A short description of the calibration process.
2) Sample calibration plots.
3) Tables of Top Of Atmosphere values for years 2010 through 2020.
4) A comparison to available coincident Aerosol Robotic Network (AERONET) values during the years 2010 through 2020.

Reference 1. https://www.yesinc.com/resource/products/solarradiation/mfr-7ds.pdf

Determination of Aerosol Optical Depth (AOD).

Aerosol optical depth is a measure of the extinction of a narrow band (approximately 10nm) irradiance from the sun. To make AOD determinations the extraterrestrial irradiance, Also known as Top Of Atmosphere (TOA) or Voltage at atmospheric path length of zero (V0) must first be determined.   These measurements are usually recorded as the raw voltages returned by the instrument which is being used. The V0 are determined by Langley extrapolation. The Yankee MFRSR-7 measures at the following seven wavelengths ~415nm, ~500nm, 615nm, ~673nm, 870nm. and ~940nm.

A Langley extrapolation is preformed by plotting the natural log of the narrowband irradiance, usually the raw voltage from the instrument, on the vertical axis versus airmass on the horizontal axis.   An airmass of 1 is defined as directly over head. Air mass is not a simple trigonometric function due to the curvature of the earth atmospheric system. The airmass used here is the approximation of Kasten and Young from 1989. REFERENCE? Here irradiance measurements are taken over an airmass of range of 2 to 5.2. An extrapolation is then made to the zero air mass irradiance value. The irradiance at zero airmass it taken as the V0 value.

Often V0 determinations are made high on a high mountain under clear skies, this is not possible for us, additionally filters degrade over time, thus requiring continuous monitoring of the Vo values. We have preformed V0 extrapolations over a period of about 10 years.   Filters have been applied to the TOA measurements to get the most stable and useable measurements. Data filter requirements are, a minimum airmass range of 1.5, a minimum of 50 points in the Langley fit, a running stability requirement, and residuals with respect the fit line of less than 0.006. An example of a Langley fit is shown in Figure 1.

Figure 1. An example of a Langley fit and extrapolation to zero air mass. The top left most plot shows all the raw data. The top middle plot shows the data after stability requirements and residual requirements have been applied. The top right plot shows data after an iterative removal of residuals have been applied. The data presented here is for the ~672nm channel for the date 2016-10-24.
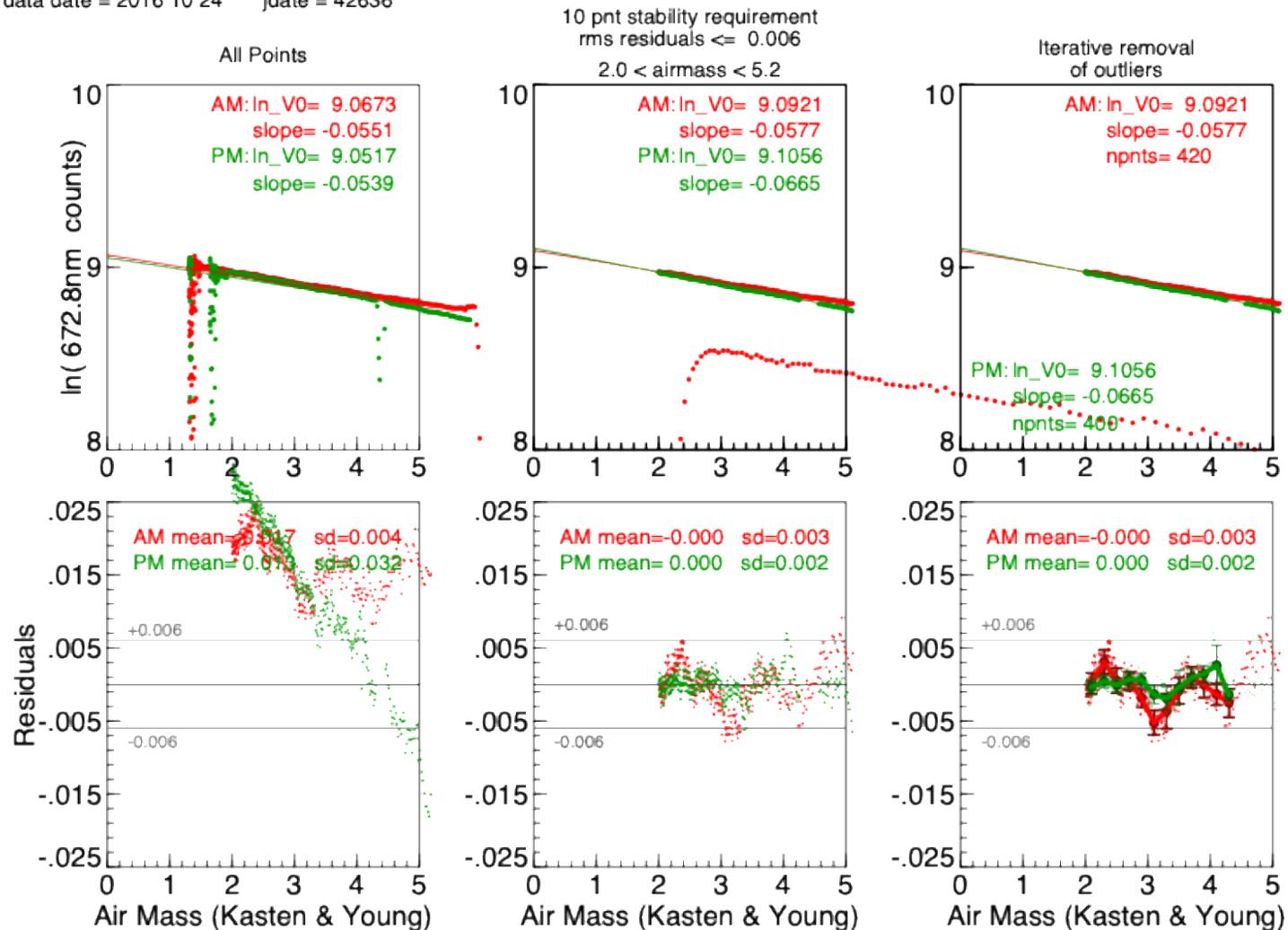
For each wavelength (415nm, 500nm, 615nm, 673nm, 870nm, and 940nm) fits have been made to the 10-year data set. The ten-year data set has been broken into intervals separated in September 2015. Points outside two standard deviations of an initial fit have been removed, and a new fit line has been determined. An example for the 676nm case is shown in Figure 2.

Figure 2. An example of a five-year fit to the TOA values for the 676nm case. Points outside two standard deviations (marked with the letter X) of an initial fit have been removed and a new fit line has been determined. There appears to be a discontinuity at about September of 2015. It is believed this was caused by shipping the MFRSR to Davos Switzerland for a temporary filter radiometer intercomparison.
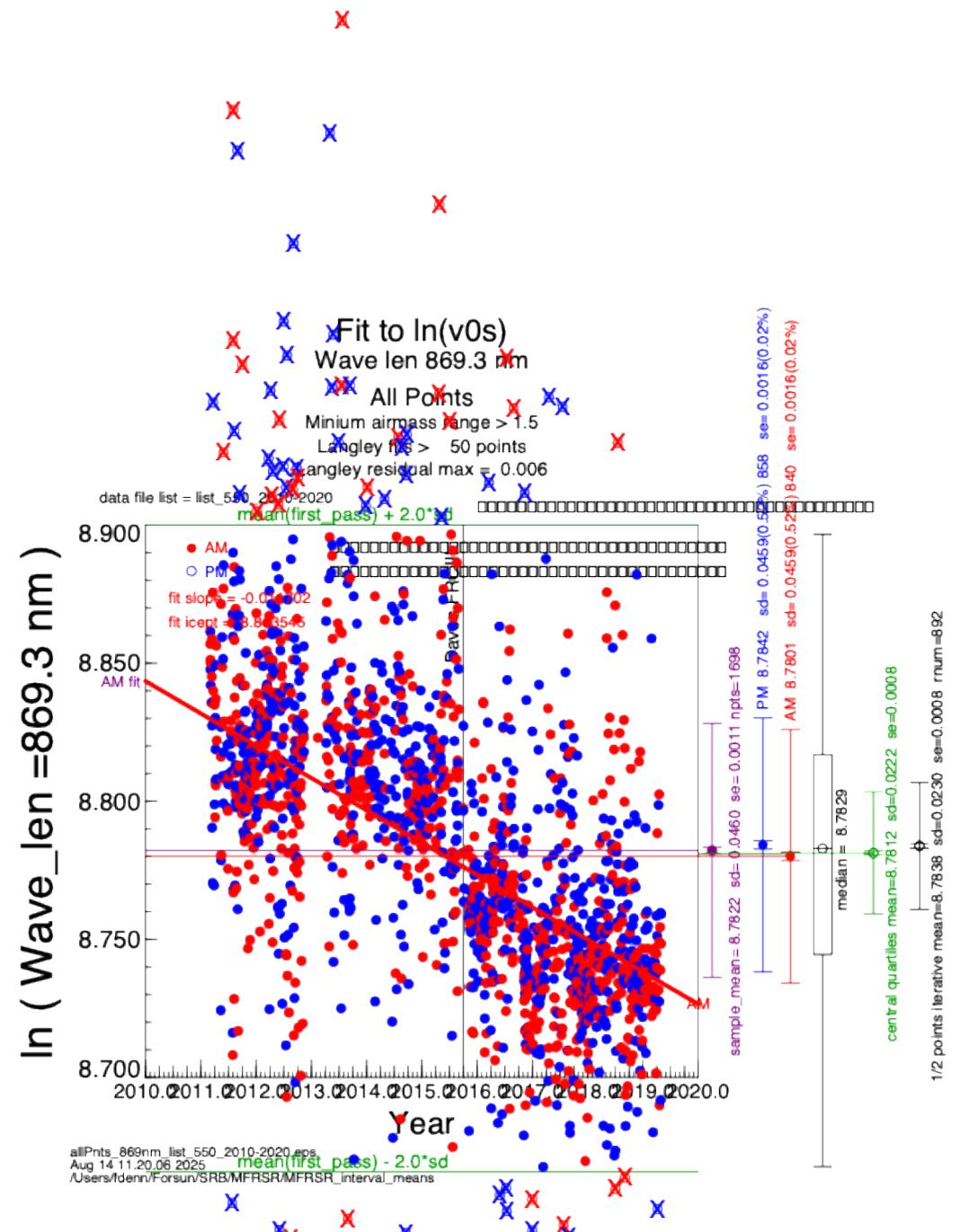
Tables 1 through 12 show the monthly V0 values derived from the multi year fit.

The first row is a description of the file.

The second row displays column headings.

The next 12 lines are the monthly V0 values.

   The first two columns are year and month.

   The next seven columns are the monthly V0 data values.

   The next 7 columns are the standard deviations, of the means. T

   The final 7 columns are the number of points in the mean.

After the TOA data there is a blank line, followed by some lines that describe the data file.

Table 1. TOA values for year 2010.

TOA_SP02_interval_means_fit_2010 fit to values 2010 through 2015 September

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200   (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	std 1	std 2	std 3	std 4	std 5	std 6	std 7	n1	n2	n3	n4	n5	n6	n7
2010	1	0.000	9.304	8.652	8.518	9.135	8.821	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	2	0.000	9.303	8.651	8.518	9.134	8.821	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	3	0.000	9.302	8.651	8.517	9.134	8.821	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	4	0.000	9.301	8.650	8.516	9.133	8.821	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	5	0.000	9.300	8.649	8.516	9.133	8.820	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	6	0.000	9.299	8.648	8.515	9.132	8.820	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	7	0.000	9.299	8.647	8.514	9.132	8.820	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	8	0.000	9.298	8.646	8.513	9.131	8.820	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	9	0.000	9.297	8.645	8.513	9.131	8.819	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	10	0.000	9.296	8.644	8.512	9.130	8.819	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	11	0.000	9.295	8.643	8.511	9.130	8.819	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2010	12	0.000	9.294	8.642	8.511	9.129	8.819	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0

Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-09

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Table 2. TOA values for year 2011.

TOA_SP02_interval_means_fit_2011

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200							(year, month, 7-means, 7-std_devs, 7-npoints_in_mean)							
2011	1	0.000	9.294	8.641	8.510	9.129	8.819	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	2	0.000	9.293	8.640	8.509	9.128	8.818	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	3	0.000	9.292	8.639	8.508	9.128	8.818	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	4	0.000	9.291	8.638	8.508	9.127	8.818	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	5	0.000	9.290	8.637	8.507	9.127	8.818	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	6	0.000	9.290	8.636	8.506	9.126	8.818	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	7	0.000	9.289	8.635	8.506	9.126	8.817	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	8	0.000	9.288	8.634	8.505	9.125	8.817	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	9	0.000	9.287	8.633	8.504	9.125	8.817	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	10	0.000	9.286	8.632	8.503	9.124	8.817	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	11	0.000	9.285	8.631	8.503	9.124	8.816	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2011	12	0.000	9.285	8.630	8.502	9.123	8.816	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0

Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-09

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Table 3. TOA values for year 2012.

TOA_SP02_interval_means_fit_2012

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200 (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	7-means							7-std_devs							7-npoints_in_mean						
		0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	412.400	495.800	614.100	672.800	869.300	938.200
2012	1	0.000	9.284	8.629	8.501	9.123	8.816	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	2	0.000	9.283	8.628	8.500	9.122	8.816	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	3	0.000	9.282	8.628	8.500	9.122	8.816	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	4	0.000	9.281	8.627	8.499	9.122	8.815	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	5	0.000	9.280	8.626	8.498	9.121	8.815	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	6	0.000	9.280	8.625	8.498	9.121	8.815	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	7	0.000	9.279	8.624	8.497	9.120	8.815	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	8	0.000	9.278	8.623	8.496	9.120	8.815	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	9	0.000	9.277	8.622	8.495	9.119	8.814	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	10	0.000	9.276	8.621	8.495	9.119	8.814	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	11	0.000	9.276	8.620	8.494	9.118	8.814	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2012	12	0.000	9.275	8.619	8.493	9.118	8.814	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0

Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-09

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Table 4. TOA values for year 2013.

TOA_SP02_interval_means_fit_2013

year mn 0.000 412.400 495.800 614.100 672.800 869.300 938.200 (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	412.400	495.800	614.100	672.800	869.300	938.200
2013	1	0.000	9.274	8.618	8.493	9.117	8.813	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	2	0.000	9.273	8.617	8.492	9.117	8.813	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	3	0.000	9.272	8.616	8.491	9.116	8.813	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	4	0.000	9.271	8.615	8.490	9.116	8.813	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	5	0.000	9.271	8.614	8.490	9.115	8.813	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	6	0.000	9.270	8.613	8.489	9.115	8.812	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	7	0.000	9.269	8.612	8.488	9.114	8.812	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	8	0.000	9.268	8.611	8.488	9.114	8.812	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	9	0.000	9.267	8.610	8.487	9.113	8.812	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	10	0.000	9.266	8.609	8.486	9.113	8.811	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	11	0.000	9.266	8.608	8.485	9.112	8.811	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2013	12	0.000	9.265	8.607	8.485	9.112	8.811	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0

Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-10

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Table 5. TOA values for year 2014.

TOA_SP02_interval_means_fit_2014

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	(year, month, 7-means, 7-std_devs, 7-npoints_in_mean)													
2014	1	0.000	9.264	8.606	8.484	9.111	8.811	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	2	0.000	9.263	8.605	8.483	9.111	8.811	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	3	0.000	9.262	8.604	8.483	9.110	8.810	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	4	0.000	9.261	8.604	8.482	9.110	8.810	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	5	0.000	9.261	8.603	8.481	9.109	8.810	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	6	0.000	9.260	8.602	8.480	9.109	8.810	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	7	0.000	9.259	8.601	8.480	9.108	8.810	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	8	0.000	9.258	8.600	8.479	9.108	8.809	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	9	0.000	9.257	8.599	8.478	9.107	8.809	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	10	0.000	9.257	8.598	8.478	9.107	8.809	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	11	0.000	9.256	8.597	8.477	9.106	8.809	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0
2014	12	0.000	9.255	8.596	8.476	9.106	8.808	0.000	0.000	0.030	0.047	0.050	0.046	0.035	0.000	0	55	299	431	453	428	0

Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-09

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Table 6. TOA values for year 2015 months 1 through 9.

TOA_SP02_interval_means_fit_2015

```
year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200  (year, month, 7-means, 7-std_devs,  7-npoints_in_mean)
2015  1  0.000  9.254  8.595  8.475  9.105  8.808  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  2  0.000  9.253  8.594  8.475  9.105  8.808  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  3  0.000  9.252  8.593  8.474  9.104  8.808  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  4  0.000  9.252  8.592  8.473  9.104  8.808  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  5  0.000  9.251  8.591  8.472  9.103  8.807  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  6  0.000  9.250  8.590  8.472  9.103  8.807  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  7  0.000  9.249  8.589  8.471  9.102  8.807  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  8  0.000  9.248  8.588  8.470  9.102  8.807  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015  9  0.000  9.247  8.587  8.470  9.101  8.806  0.000  0.000  0.030  0.047  0.050  0.046  0.035  0.000  0 55 299 431 453 428 0
2015 10  0.0    0.0    0.0    0.0    0.0    0.0    0.0.   0.0.   0.0    0.0    0.0    0.0    0.0    0.0.   0 0  0  0  0  0 0
2015 11  0.0    0.0    0.0    0.0    0.0    0.0    0.0.   0.0.   0.0    0.0    0.0    0.0    0.0    0.0.   0 0  0  0  0  0 0
2015 12  0.0    0.0    0.0    0.0    0.0    0.0    0.0.   0.0.   0.0    0.0    0.0    0.0    0.0    0.0.   0 0  0  0  0  0 0
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Monthly values from a linear fit to all acceptable individual TOA values from 2010 through 2015-09

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Second interval

Table 7. TOA values for year 2015 for months 10 through 12.

TOA_SP02_interval_means_fit_2015

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	(year, month, 7-means, 7-std_devs, 7-npoints_in_mean)											
2015	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	02	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	03	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	04	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	05	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	06	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	07	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	08	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	09	0.0	0.0	0.0	0.0	0.0	0.0	0.0.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0.	0	0	0	0	0	0	0
2015	10	0.000	9.218	8.579	8.464	9.094	8.758	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2015	11	0.000	9.217	8.579	8.464	9.094	8.757	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2015	12	0.000	9.216	8.578	8.463	9.094	8.757	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

TOA values derived from toa values starting November 2015 through about May 2020

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Table 8. TOA values for year 2016.

TOA_SP02_interval_means_fit_2016

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200 (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	1	0.000	9.215	8.577	8.463	9.093	8.756	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	2	0.000	9.214	8.577	8.462	9.093	8.756	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	3	0.000	9.213	8.576	8.462	9.093	8.755	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	4	0.000	9.212	8.575	8.462	9.092	8.755	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	5	0.000	9.210	8.575	8.461	9.092	8.754	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	6	0.000	9.209	8.574	8.461	9.092	8.754	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	7	0.000	9.208	8.573	8.460	9.092	8.753	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	8	0.000	9.207	8.573	8.460	9.091	8.753	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	9	0.000	9.206	8.572	8.460	9.091	8.752	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	10	0.000	9.205	8.571	8.459	9.091	8.752	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	11	0.000	9.204	8.571	8.459	9.090	8.751	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2016	12	0.000	9.203	8.570	8.458	9.090	8.751	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

Monthly values from a linear fit to all acceptable individual TOA values from 2015-10 through 2020

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Table 9. TOA values for year 2017.

TOA_SP02_interval_means_fit_2017

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200 (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	std1	std2	std3	std4	std5	std6	std7	n1	n2	n3	n4	n5	n6	n7
2017	1	0.000	9.202	8.569	8.458	9.090	8.750	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	2	0.000	9.201	8.568	8.458	9.090	8.750	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	3	0.000	9.200	8.568	8.457	9.089	8.749	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	4	0.000	9.199	8.567	8.457	9.089	8.749	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	5	0.000	9.197	8.566	8.456	9.089	8.748	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	6	0.000	9.196	8.566	8.456	9.088	8.748	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	7	0.000	9.195	8.565	8.456	9.088	8.747	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	8	0.000	9.194	8.564	8.455	9.088	8.747	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	9	0.000	9.193	8.564	8.455	9.088	8.746	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	10	0.000	9.192	8.563	8.454	9.087	8.746	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	11	0.000	9.191	8.562	8.454	9.087	8.745	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2017	12	0.000	9.190	8.562	8.454	9.087	8.745	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

Monthly values from a linear fit to all acceptable individual TOA values from 2015-10 through 2020

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Table 10. TOA values for year 2018.

TOA_SP02_interval_means_fit_2018

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200   (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	std 1	std 2	std 3	std 4	std 5	std 6	std 7	n1	n2	n3	n4	n5	n6	n7
2018	1	0.000	9.189	8.561	8.453	9.086	8.744	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	2	0.000	9.188	8.560	8.453	9.086	8.744	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	3	0.000	9.187	8.560	8.452	9.086	8.743	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	4	0.000	9.185	8.559	8.452	9.086	8.743	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	5	0.000	9.184	8.558	8.452	9.085	8.742	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	6	0.000	9.183	8.558	8.451	9.085	8.742	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	7	0.000	9.182	8.557	8.451	9.085	8.741	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	8	0.000	9.181	8.556	8.450	9.084	8.741	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	9	0.000	9.180	8.556	8.450	9.084	8.740	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	10	0.000	9.179	8.555	8.450	9.084	8.740	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	11	0.000	9.178	8.554	8.449	9.084	8.739	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2018	12	0.000	9.177	8.554	8.449	9.083	8.739	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

Monthly values from a linear fit to all acceptable individual TOA values from 2015-10 through 2020

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Table 11. TOA values for year 2019.

TOA_SP02_interval_means_fit_2019

year mn   0.000 412.400 495.800 614.100 672.800 869.300 938.200   (year, month, 7-means, 7-std_devs, 7-npoints_in_mean)

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	1	0.000	9.176	8.553	8.448	9.083	8.738	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	2	0.000	9.175	8.552	8.448	9.083	8.738	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	3	0.000	9.174	8.552	8.448	9.082	8.737	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	4	0.000	9.172	8.551	8.447	9.082	8.737	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	5	0.000	9.171	8.550	8.447	9.082	8.736	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	6	0.000	9.170	8.550	8.446	9.082	8.736	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	7	0.000	9.169	8.549	8.446	9.081	8.735	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	8	0.000	9.168	8.548	8.446	9.081	8.735	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	9	0.000	9.167	8.548	8.445	9.081	8.734	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	10	0.000	9.166	8.547	8.445	9.080	8.733	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	11	0.000	9.165	8.546	8.444	9.080	8.733	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2019	12	0.000	9.164	8.546	8.444	9.080	8.732	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

Monthly values from a linear fit to all acceptable individual TOA values from 2015-10 through 2020

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Table 12. TOA values for year 2020.

TOA_SP02_interval_means_fit_2020

year	mn	0.000	412.400	495.800	614.100	672.800	869.300	938.200	(year, month, 7-means, 7-std_devs, 7-npoints_in_mean)														
2020	1	0.000	9.163	8.545	8.444	9.080	8.732	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	2	0.000	9.162	8.544	8.443	9.079	8.731	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	3	0.000	9.160	8.544	8.443	9.079	8.731	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	4	0.000	9.159	8.543	8.442	9.079	8.730	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	5	0.000	9.158	8.542	8.442	9.078	8.730	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	6	0.000	9.157	8.542	8.442	9.078	8.729	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	7	0.000	9.156	8.541	8.441	9.078	8.729	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	8	0.000	9.155	8.540	8.441	9.078	8.728	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	9	0.000	9.154	8.539	8.440	9.077	8.728	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	10	0.000	9.153	8.539	8.440	9.077	8.727	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	11	0.000	9.152	8.538	8.440	9.077	8.727	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0
2020	12	0.000	9.151	8.537	8.439	9.076	8.726	0.000	0.000	0.027	0.036	0.040	0.036	0.029	0.000	0	95	289	382	396	408	0

Monthly values from a linear fit to all acceptable individual TOA values from 2015-10 through 2020

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A comparison to AERONET follows.

Comparisons are shown for each of the common wavelength channels 500nm, 675nm, and 870nm, for the 10-year interval, Figures 3 through 5.
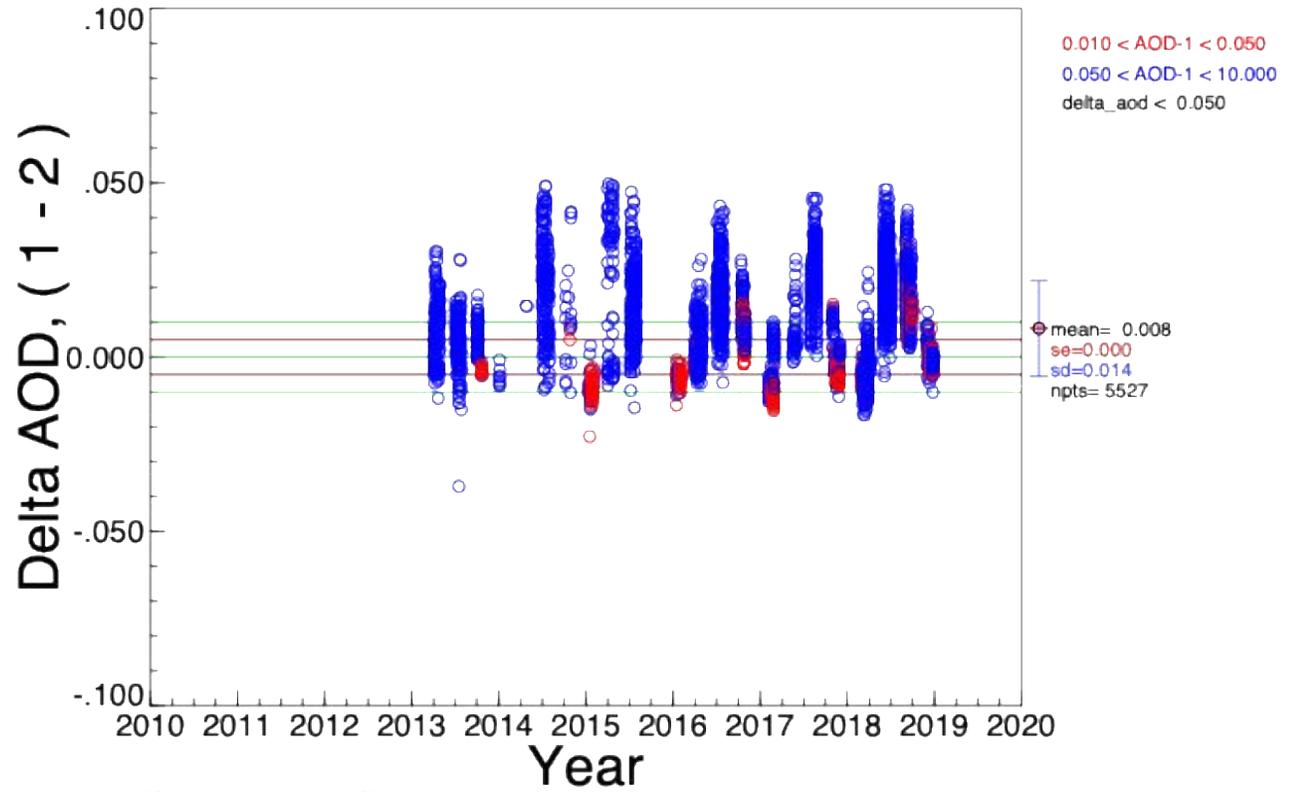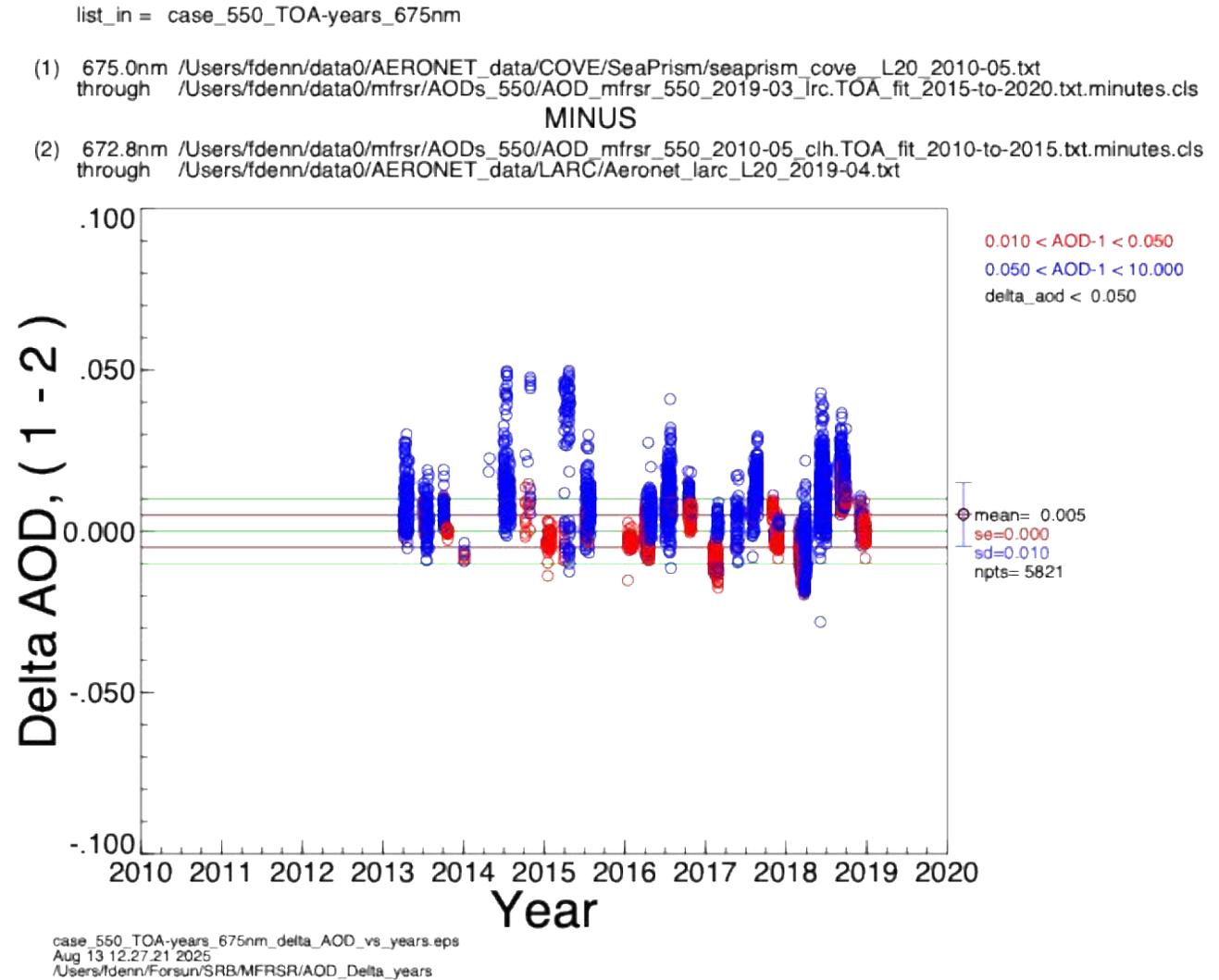
Figure 3. Differences between AERONET clear sky values and MFRSR-550, using the TOA values in this document. This is for years 2010 through 2020, for the 500nm case.

Figure 4. Differences between AERONET clear sky values and MFRSR-550, using the TOA values in this document. This is for years 2010 through 2020, for the 675nm case.
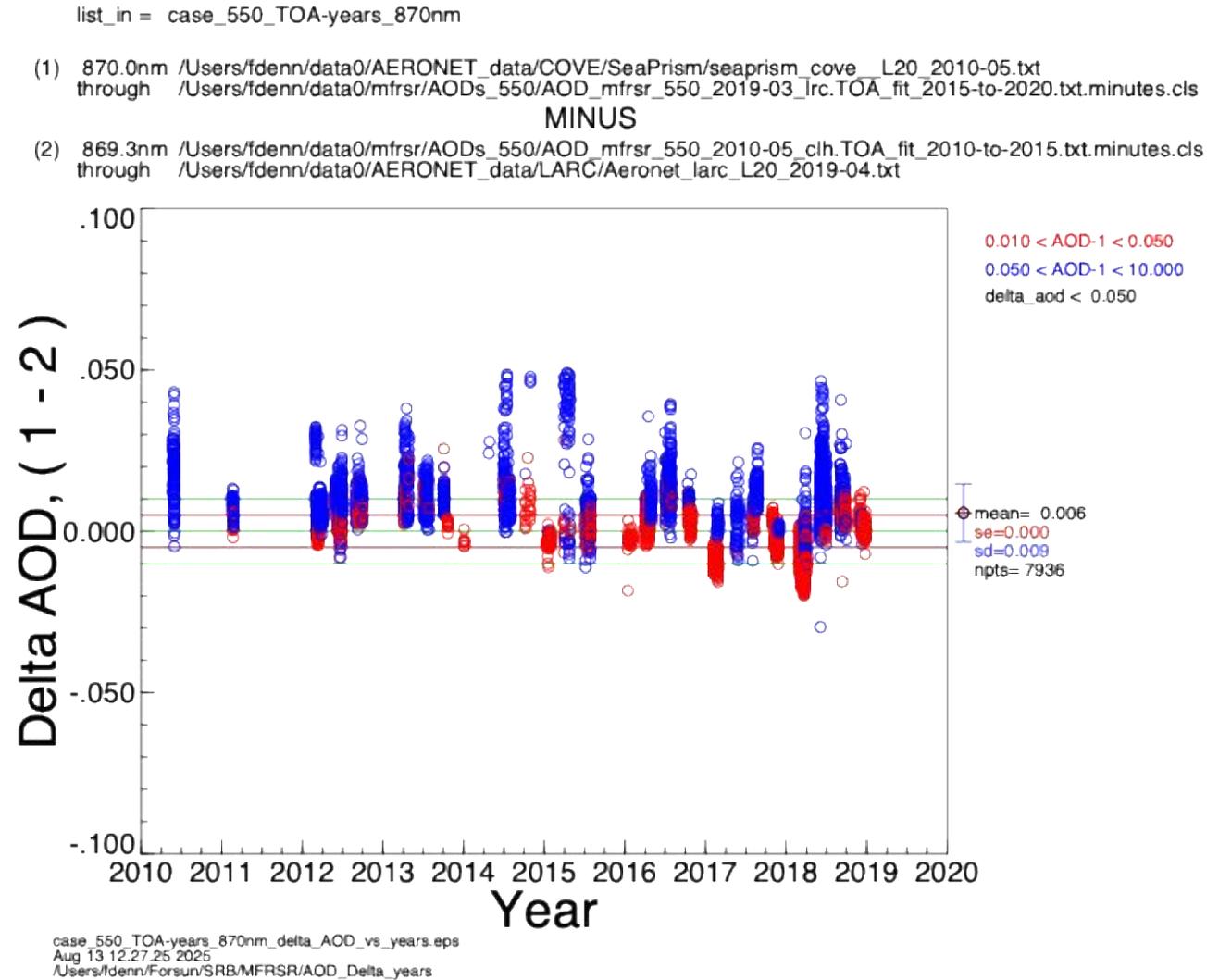
Figure 5. Differences between AERONET clear sky values and MFRSR-550, using the TOA values in this document. This is for years 2010 through 2020, for the 870nm case.

The End.