Maritime Aerosol Network (MAN) – An AERONET Network

(Technical Document – February 2026)

1. Introduction and Background

Atmospheric optical properties over the oceans were not well studied until the mid-sixties of the 20th century. Remarkable progress has been made since then in our understanding of aerosol generation, evolution, transport, the way aerosol particles act as cloud condensation nuclei, affect microphysics of clouds and their ability to precipitate. Substantial radiative effects of sea-salt aerosol, better understanding of the climate change forcing by aerosols, combined with very few systematic measurements over the oceans [Smirnov et al. 2002], especially in the South Ocean, created a demand for more data acquisition. Therefore, the Aerosol Robotic Network (AERONET) [Holben et al. 1998] established a few new island aerosol automated sunphotometer sites in the South Indian Ocean, however, large areas south of 35º S still have no or limited coverage. On other hand ship-based measurements can at least partly fill the gap which exists in our knowledge of the global aerosol distribution over the oceans.

Ship-based measurements of columnar aerosol optical properties are extremely valuable for several important reasons. First, not all areas of the World Ocean can be studied from islands therefore ship-based measurements are the only source of in-situ data for such regions (e.g. areas south from the "roaring forties" in the South Atlantic). Second, it is not clear to what extent an island, acting as a local perturbator and/or source of aerosol, can alter aerosol optical properties. Finally, ship-based data can be advantageously used for validation of global aerosol transport model simulations and satellite retrievals. Certain steps in these directions have been made and hopefully will continue [Liu et al. 2004; Knobelspiesse et al. 2004; Smirnov et al. 2006].

NASA Goddard's Sensor Intercomparison for Marine Biological and Interdisciplinary Ocean Studies (SIMBIOS) project operated a successful ship-based handheld sun photometer measurement campaign from 1999 to 2002 (Knobelspiesse, 2004). Overall, 458 measurement days spanning a 6-year project duration period (1997–2003) were acquired. This was considered quite successful, such that NASA leadership made the decision that no more data is required to validate ocean color algorithms, basically terminating the program. Several Atlantic transects contributed to more dense data coverage close to the equator with very little data collected north of 45ºN and south of 30ºS. Measurements in the Indian Ocean showed high turbidity near the Indian peninsula. However, those measurements were limited to the northeast monsoon season, when continental pollution is transported from the Indian subcontinental region to the Arabian Sea and Indian Ocean. The eastern part of the Indian Ocean and areas south of 30_S were not covered and lacked any data from oceanic ships. Data acquisition efforts in the coastal areas were concentrated on the east coast and West Coast of the United States. Very few data (almost none) were available for inland seas (Mediterranean, Baltic, Black, Persian Gulf) and other coastal areas, except for the region near the coast of Japan intensively studied during the ACE-Asia experiment, though within a limited timeframe (March–April 2001).

Clearly the ocean color community recognized that more data is needed and thus AERONET project attempted to pick it up. SIMBIOS employed up to 12 hand-held sun photometers on research ships of opportunity. These instruments remained unused since 2002 and AERONET suggested reopening this network in 2006 and affiliating it with the AERONET protocols and calibrations and expanding the ships of opportunity to research, foreign, and military vessels.

Aerosol optical depth (AOD) is an atmospheric optical parameter critical for various applications ranging from Earth radiative balance computations to ocean color studies, from understanding of global aerosol distribution to aerosol remote sensing from space and global aerosol transport modelling. A brief history of the ship-based aerosol optical depth studies over the oceans spanning over 50 years was presented by Smirnov et al. (2002). Long-term island based comprehensive AOD measurements, which seemed to be a luxury for various applications in the 1980s, do not satisfy contemporary needs of remote sensing and modelling research.

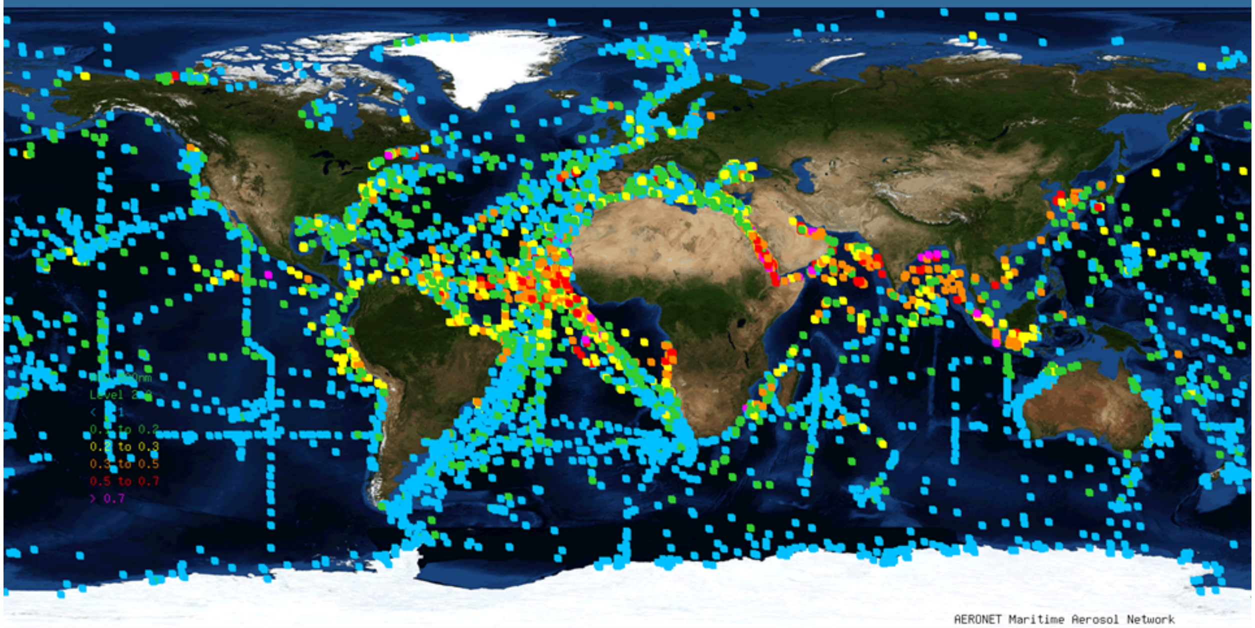
Establishment of Maritime Aerosol Network (MAN) as a component of AERONET allowed to improve our knowledge of aerosol optical properties over the oceans and fill existing data gaps in various oceanic areas. MAN deploys a hand-held sunphotometer (Microtops II) for spectral AOD measurements aboard vessels of opportunity. MAN follows the AERONET calibration and data processing standards and procedures, which ensure the highest data quality and internationally recognized standards. Data collection over world oceans, spanning now for over 20 years put together a public web-based archive which currently consists of almost 800 cruises and more than 10000 measurement days (https://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network_v3.html).

The data collected under MAN made many important contributions, specifically enhancing our knowledge and understanding of atmospheric aerosols over the oceans (e.g. Jaegle et al., 2011; Smirnov et al., 2012; Sayer et al., 2012; Levy et al., 2013; Witek et al., 2013; Toth et al., 2013; Limbacher and Kahn, 2014; Kolmonen et al., 2015; Sayer et al., 2017; Randles et al., 2017; Witek et al., 2019; Perez-Ramirez et al., 2019; Bian et al., 2019; Kinne, 2019; Wang et al., 2021; Reid et al., 2022; Zheng et al., 2026). Over the years, MAN provided critical, accurate in-situ AOD measurements serving as gold standard for ground truth to validate satellite retrievals and model simulations, specifically in Southern and Arctic Oceans. MAN made a remarkable progress increasing number of cruises per year to several dozens, expanding data collection to the areas that previously had no coverage and providing opportunities for international collaboration.

Data collection over World Oceans, spanning now for 20 years, has been successful because of close collaboration among various government institutions and universities in the US, UK, Germany, France, Spain, Poland, Canada, Russia, Saudi Arabia, Italy, South Africa, Namibia, Australia, and New Zealand.

Within MAN framework data acquisition was extended to the areas that previously had very little or no coverage at all and thus provided an important reference point in aerosol optical studies. MAN represents an important strategic sampling initiative and data acquisition from ships of opportunity complements island-based AERONET measurements. The data archive can help with understanding discrepancies between measurements and simulations for certain areas of the World

Ocean. The program exemplifies mutually beneficial international, multi-agency effort in atmospheric aerosol optical studies.



	2006	2010	2012	2014	2016	2018	2019	2023	2025
Cruises completed	2	76	147	268	356	510	579	675	791
Measurement days	63	1612	2950	4550	6040	7450	9260	9775	>10^4

Figure 1. Maritime Aerosol Network global coverage: cruise tracks and daily averages of aerosol optical depth (Level 2.0) are shown (squares are colored with respect to AOD values, i.e. blue – AOD<0.10, green – 0.10<AOD<0.20, yellow – 0.20<AOD<0.30, orange – 0.30<AOD<0.50, red – 0.50<AOD<0.70, purple - AOD≥0.70).

The AERONET is a very successful project that started over 30 years ago. One of points of success is well-documented data quality control and calibrations processes, which are traceable and accepted by the global scientific community. This technical memo is an attempt to documents MAN in great details following AERONET standards.

2. Calibration

The Microtops II sun photometer is a handheld device specifically designed to measure columnar optical depth and water vapor content. The direct sun measurements are acquired in five spectral channels within the spectral range 340-1020 nm. The standard available channels are 380, 440, 675, 870 and 936 nm. Additional channels can be requested from the manufacturer. The bandwidths of the interference filters vary from 2–4 nm for UV channels to 10 nm for visible and near-infrared channels. Detailed description of the sunphotometer and types of errors involved can be found in Knobelspiesse et al. [2004]. The estimated uncertainty of the optical depth in each channel does not exceed plus or minus 0.02 (Knobelspiesse et al., 2004), which is slightly higher than the uncertainty of the AERONET land instruments as shown by Eck et al. [1999]. A GPS is required to connect with the sunphotometer to obtain the time of measurements and geographical position of the ship.

Each Microtops instrument is calibrated against an AERONET master-CIMEL sun/sky radiometer at NASA AERONET calibration facility located at NASA Goddard Space Flight Center (GSFC). The AERONET master is calibrated from morning Langley plot measurements at Mauna Loa observatory in Hawaii. As a rule, we put a master-CIMEL in a manual mode that enables it to take direct sun measurements every 30 seconds. The Microtops then takes 15-20 consecutive measurements within an approximately 3–5-minute interval, colocated with master-CIMEL. It is highly desirable to make inter-calibration measurements in the clear (with AOD at 500 nm less than 0.25) and stable atmospheric conditions (alsmot constant optical depth at 500 nm) to ensure accurate and stable results (Holben et al., 1998). Figure 2 presents (as an example) calibration window that indicates that standard deviation of the AOD in Cimel master during the calibration process is less than 0.005. AOD and their standard deviations are shown for the master-instrument (top) and calibrated Microtops (bottom) for a period of several minutes. New and old "extraterrestrial signal constants" are displayed for each spectral channel. The last two columns indicate the temporal change in calibration coefficients (in %) and corresponding optical depth differences. Aerosol optical depth is retrieved by applying the AERONET processing algorithm (Version 3) to the raw data.

Our calibration procedure consists of the following three steps:

1) Firstly, we calibrate the unit with instrument (i.e. Mirotops) optical windows "as is", - this is considered post deployment calibration.
2) Then we clean windows,
3) and finally, we calibrate it with "clean" windows- this is considered pre-deployment calibration. The instrument is then ready for next field deployment.

The intercalibration of Microtops performed with "clean" (step 3 - pre-deployment) windows and "dirty" (step -1 post-deployment) windows and a linear change in calibration with time was assumed in the interpolation between the two calibrations. Very rarely during the cruise does the front window get dirty (because of the mist, dust aerosol or sea salt deposits) and window cleaning is warranted at sea. In this case we take readings in stable atmospheric conditions before window cleaning and immediately after. We presume that atmospheric optical properties did not change within those 2-3 minutes that are required for careful cleaning and that after cleaning calibration coefficients return to their pre-deployment values. Thus, we can apply linear interpolation for those two time periods with the time break after cleaning at sea.

Calibration coefficients, information about calibration dates and when microtops was shipped and received and returned, all recorded in AERONET database.

All information about calibrations, window cleaning, instrument shipments etc. is retained in the MAN relational database (RDB). Figure 3 presents a spreadsheet of the Microtops instrument pool status as of December 2025. The spreadsheet provides information on the instrument's status,

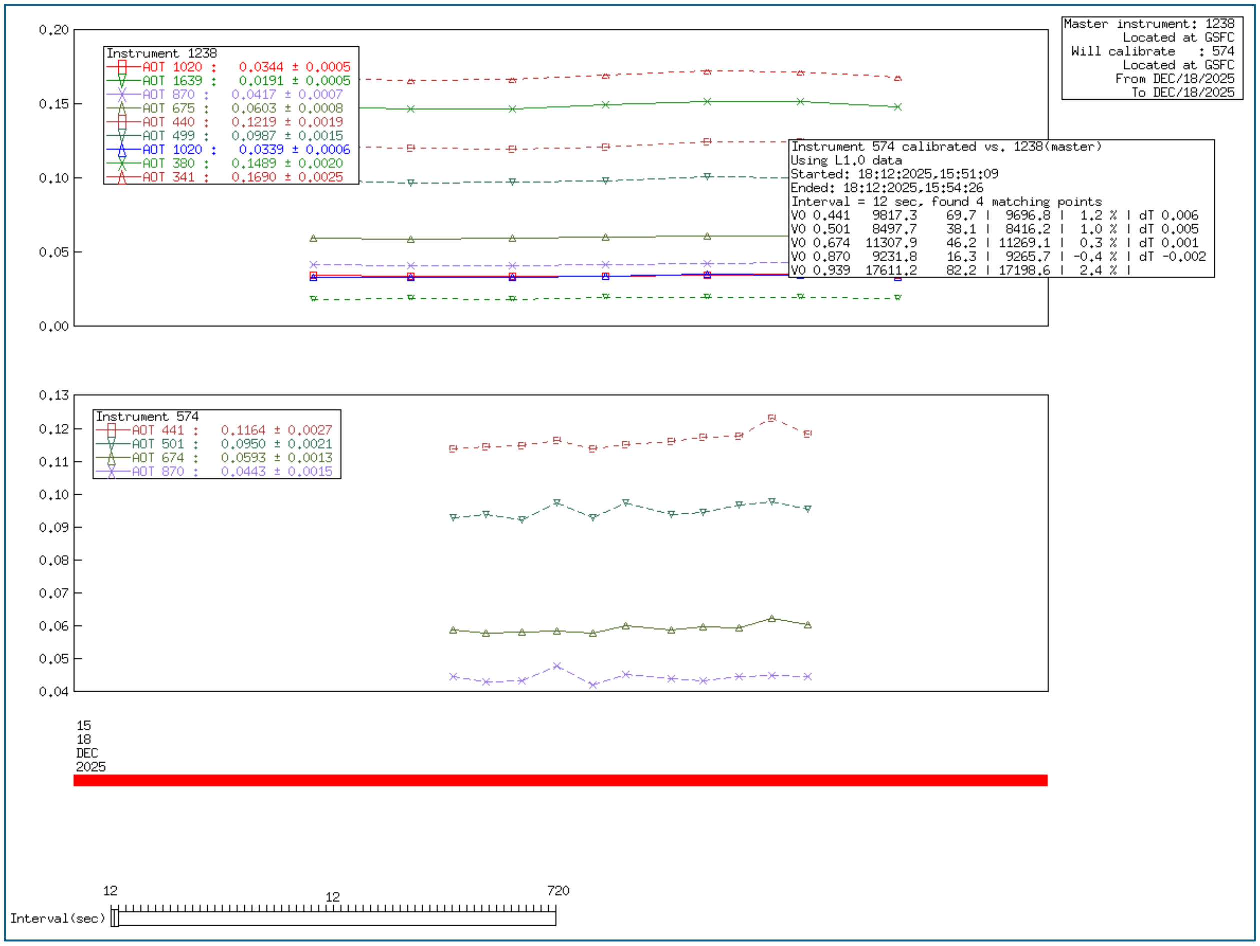


Figure 2. The intercomparison window on Demontrat which allows computation of the calibration coefficients from a time series of AOD. Reference instrument AODs (top plot) are used with voltages from a field instrument (i.e. Microtops bottom plot) to compute calibration coefficients for a field instrument.

date it was returned from the field, filter configuration, parameters for the water vapor content retrievals, calibration dates (post-field and pre-field), maintenance remarks (cleaning, filter change etc.), shipping information, and information regarding the person responsible for the data collection.

NTERCAL TABLES: ACTIVE HISTORY SEARCH LOGOUT

Inst	S/N	Date Returned	Filters	A B Constants	Sun1	Data Status	Maint	Clean	Sun2	Shipped	Received	Contact Person	Current Status
1199	4724	8/23/2019	340, 440, 675, 870, 936	A=0.6548 B=0.574			dead			11/6/2024		Jason Kraft	GSFC
490	3769	9/10/2019	440, 500, 675, 870, 936	A=0.6928 B=0.604	X				X				GSFC
488	3774	10/31/2019	440, 500, 675, 870, 936	A=0.6928 B=0.604				X	X				GSFC
578	3760	1/28/2020	340, 440, 675, 870, 936	A=0.6548 B=0.574	X			X	X				GSFC
503	3763	8/2/2021	380, 440, 675, 870, 936	A=0.6548 B=0.574					X			Rob Levy	GSFC
1393	28789	12/6/2022	380, 440, 675, 870, 936	A=0.6548 B=0.574					X				GSFC
1394	28790	12/6/2022	380, 440, 675, 870, 936	A=0.6548 B=0.574					X				GSFC
1395	28791	12/6/2022	380, 440, 675, 870, 936	A=0.6548 B=0.574					X				GSFC
1396	28792	12/6/2022	380, 440, 675, 870, 936	A=0.6548 B=0.574					X				GSFC
173	22498	5/4/2023	380, 440, 675, 870, 936	A=0.6548 B=0.574	X			X	X				GSFC
478	4074	8/8/2024	340, 380, 440, 500, 870					X	X			Gordon Labow	GSFC
1198	4740	11/5/2024	440, 500, 675, 870, 936	A=0.6548 B=0.574			dead						GSFC
261	22500	12/26/2024	380, 440, 675, 870, 936	A=0.6548 B=0.574	X			X	X				GSFC
698	19746	1/14/2025	380, 440, 500, 675, 870		X			X	X				GSFC
685	16825	1/23/2025	380, 440, 675, 870, 936	A=0.6571, B=0.6032	X			X	X				GSFC
1514	3757	3/3/2025	380, 440, 870, 936, 1020	A=0.6548 B=0.574					X				GSFC
473	5395	5/13/2025	440, 500, 675, 870, 936	A=0.6597 B=0.5899			dead						GSFC
686	16826	5/27/2025	380, 440, 675, 870, 936	A=0.6569, B=0.6065	X			X	X				GSFC
573	13911	6/2/2025	440, 500, 675, 870, 936	A=0.6074 B=0.6273	X			X	X				GSFC
687	16827	6/9/2025	380, 440, 675, 870, 936	A=0.6537, B=0.6089	X			X	X				GSFC
480	3777	7/28/2025	340, 380, 440, 500, 870		X			X	X				GSFC
472	3765	8/18/2025	440, 500, 675, 870, 936	A=0.6749 B=0.6024	X			X	X				GSFC
891	19747	11/26/2025	380, 440, 500, 675, 870		X			X					GSFC
475	3770	12/2/2025	440, 500, 675, 870, 936	A=0.6928 B=0.604									GSFC
477	3776	12/10/2025	340, 380, 440, 500, 870		X			X					GSFC
587	3656	12/10/2025	440, 675, 870, 936, 1020	A=0.6749 B=0.6024	X			X				Sherwin Lander	GSFC
676	4077	12/10/2025	380, 440, 500, 675, 870		X			X				Mike Ondrusek	GSFC
677	8470	12/10/2025	380, 500, 675, 870, 1020		X			X				Alex Gilerson	GSFC
571	12609	12/16/2025	380, 440, 675, 870, 936	A=0.6055 B=0.6278									GSFC
683	16823	12/16/2025	380, 440, 675, 870, 936	A=0.6576, B=0.6027	X			X					GSFC
574	13912	12/16/2025	440, 500, 675, 870, 936	A=0.6306 B=0.6192	X								GSFC

Figure 3. Intercalibration table of the Microtops pool

3. Measurement Protocol and Procedure

The measurement protocol requires an operator taking 6-10 consecutive measurements (it takes about a minute for a GPS to lock the position and slightly over a minute to complete the sequence for all filters) when the solar disk is free of clouds. It is important to note that observers are relied upon to decide when the sun is unobscured by clouds (based on visual assessment only) and to only take measurements for those conditions. An automated cloud screening is also applied during the data processing. Depending on the sky conditions, measurements should be repeated several times (or at regular interval) during the day.

Measurement points are grouped temporally into series. If the interval between two points in a measurement sequence is more than two minutes, then these points are placed into different series (Fig. 4). A series can have one or more instantaneous measurement points (typically five or more). All the points in a series are averaged to get single measurement data point. A sequence of means of individual series in a day can be used to compute the daily average.

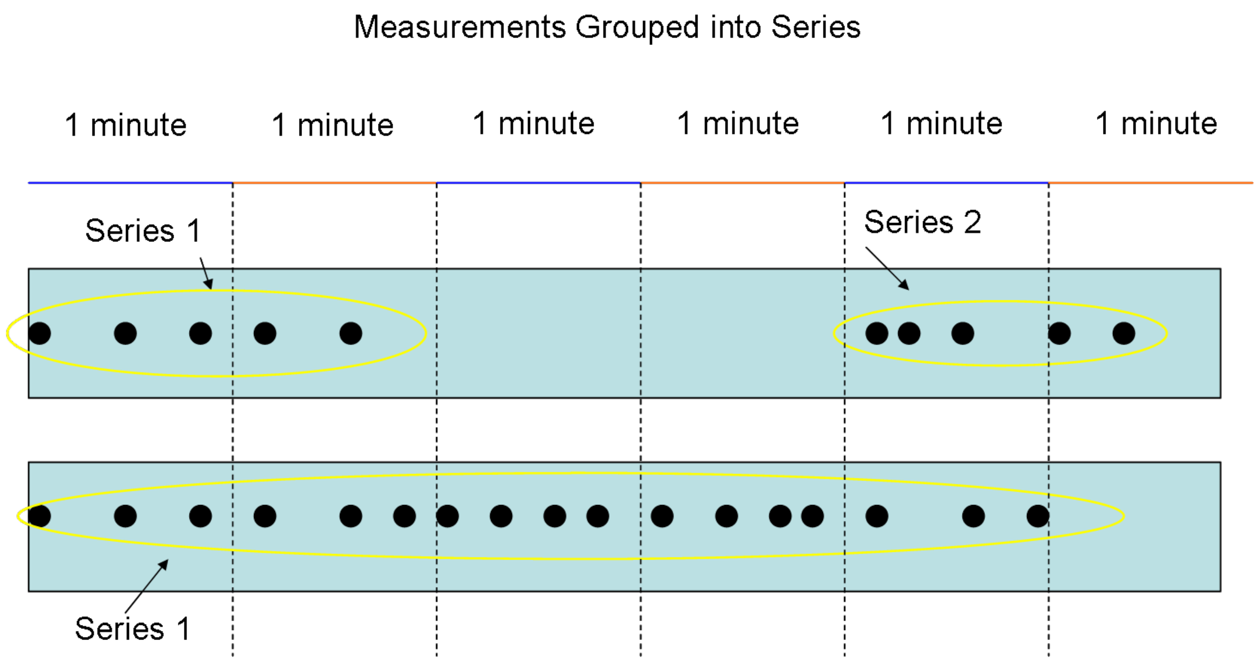


Figure 4. A schematic of measurement series and grouping arrangement to calculate a point measurement.

All initial parameters required for measurements are pre-installed in the GPS and Microtops, so there is no need to change anything. The operator should perform following task to take measurements:

1. Connect GPS and Microtops
2. Turn GPS ON
3. Turn Microtops ON and wait till the Main screen shows up.
4. When GPS locks the position, it will update the date and time in Microtops and Microtops will beep twice.
5. Open the lid on Microtops.
6. Aim at the Sun and get a spot on target (in the central circle).
7. Push SCAN
8. When SCAN (8-10 seconds) is complete Microtops beeps once.
9. Do SCAN 6-10 times.
10. Close the lid and turn Microtops and GPS OFF.

Each SCAN takes about 8-10 seconds, so 6-10 scans will take about 2 minutes plus some time for a GPS to lock a position. Microtops should always be in the shipping case except for the measurements. The internal memory can keep about 700 readings.

4. Data Download from Instrument to Computer

The data transfer from Microptops to a computer required specific software called 'hyperterminal program' developed and provided by Solar Light Inc. manufacturing company. The software must be installed and Microtops should be connected to computer using ' ' type cable before data transfer can be performed. Figure 5 provide various screens shots of data download process by following steps below:

1. Enter a name for the Hyperterminal Session called “Microtops” and if necessary select the COM port (please choose the right COM port otherwise it will not work).
2. In port settings, set the Bits per second field to 4800 and press OK.
3. When you get a Hyperterminal screen, please push ENTER and you will see the command menu.
4. In the Hyperterminal menu, select Transfer and choose Capture text…, choose a directory and file name, click OK, and then push P (for Printer). The data will be saved in the text file in the directory you have chosen.

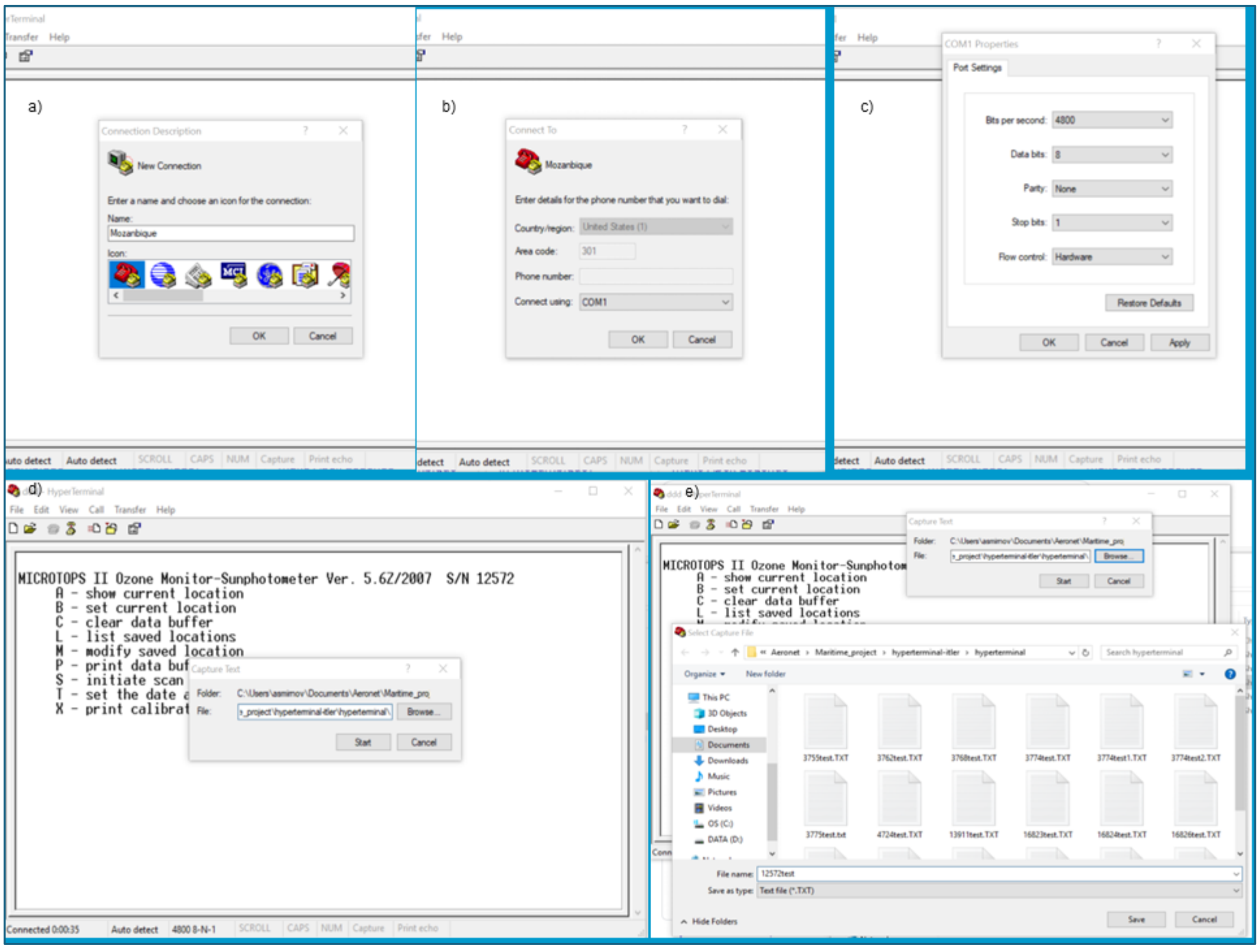


Figure 5. Importing data in a single file (ASCII format)

5. Data Processing and Products

MAN has following aerosols properties as data products:

1. Spectral AOD (5 channels within 340-1020 nm range)

2. Angstrom parameter (calculated using a least squares method within the 440-870 nm wavelength range),
3. Columnar precipitable water
4. AOD at 500 nm partitioned into fine and coarse components according to the Spectral De-convolution Algorithm (SDA) by O'Neill et al. (2001; 2003).

All products have three data quality levels same as standard AERONET version 3: Level 1.0 (unscreened), Level 1.5 (cloud-screened), and Level 2.0 (cloud-screened, quality assured with final calibration and manual inspection). In general, after final calibration (post field) the values of spectral AOD at Level 1.5 match those at Level 2.0 except for a few possible cloud contaminated outliers that are manually removed. Additional quality assuarance are added to the SDA products, which are more complex. We would like to point out that the SDA data- QA criteria were empirically determined and were tested on various subsets of different aerosol types. These tests were carried out for various optical conditions across the AERONET database and for the entire MAN dataset. We would like to emphasize that those criteria are in line with the AERONET SDA products however fine and coarse aerosol optical depth partition products for MAN have additional quality checks.

All products are available on the MAN web page, which is a part of the AERONET web site. A public domain web-based archive dedicated to the network activity can be found at: https://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network_v3.html .

The following criteria are examined for cloud and pointing errors:

- within a series, the minimum aerosol optical depth for each point is identified at each wavelength (τ_{ai}^{min}).
- if the difference (τ_{ai} - τ_{ai}^{min}) for each spectral channel is less than the maximum of {τ_{ai}^{min} *0.05, 0.02}, then that point within a series is considered cloud-free and pointing error free.
- If the above screening removes all but one point from a series, then an additional criterion below is applied to the spectral channels:
- if the Angstrom parameter computed using all available channels between 440 and 870 nm is greater than -0.1, then the point is considered cloud and pointing error free.

The Level 1.5 data series are raised to Level 2.0 (quality-assured) series after final calibration values are applied, spectral channels are evaluated for filter degradation and other possible instrumental problems or data anomalies; and manual data inspection is completed for possible cloud contaminated outliers.

SDA Retrievals:

The AOD processing includes the spectral de-convolution algorithm (SDA) described in O'Neill et al. (2003). This algorithm yields fine (sub-micron) and coarse (super-micron) AODs at a standard wavelength of 500 nm (from which FMF, the fraction of fine mode to total AOD can be computed). The algorithm fundamentally depends on the assumption that the coarse mode Angstrom exponent and its derivative are close to zero. Its advantage lies in the fact that it produces useful indicators of aerosol size discrimination at the frequency of extinction measurements.

The key output products of the SDA are all computed at a reference wavelength of λ = 500 nm. These products include the AOD (τ_a, using the nomenclature of O'Neill et al., 2003), the spectral derivative of the AOD (α) and the spectral derivative of a (α'). These three "generic" products are employed in the SDA to compute the principal SDA output products of fine mode aerosol optical depth (τ_f), the spectral derivative of the fine mode aerosol optical depth (α_f), the spectral derivative of α_f (α'_f), the fine mode fraction ($\eta = \tau_f / \tau_a$) and the coarse mode optical depth ($\tau_c = \tau_a - \tau_f$). Note that spectral derivatives can be evaluated at 500 nm (in a differential calculus sense) because we fit the input AERONET AODs with a second order spectral polynomial.

The spectral derivatives α and α_f represent, respectively, (i) a generic Angstrom exponent containing information on the combined size contributions of fine and coarse mode aerosols (very strongly related to the typical multi-wavelength-regression Angstrom exponent while not being spectrally diluted in terms of allowing the extraction of higher orders of spectral curvature information) and (ii) size information specific to the fine mode size distribution. The theoretical underpinning of the SDA technique is that the aerosol world is assumed to be bimodal; not always true, but it is a hypothesis of surprisingly universal applicability (when it is not true it clearly produces an optically equivalent bimodal representation of the real aerosol world; not unlike the more primitive but indisputably relevant regression Angstrom exponent reduces the aerosol world to straight lines in log AOD versus log λ space).

The SDA retrievals utilize the AERONET AOD (Level 1.0, 1.5, and 2.0) products. Level 1.0 SDA products do not apply any restrictions. However, Levels 1.5 and 2.0 SDA impose additional criteria depending on the number of wavelengths, spectral range and air mass dependence of AOD for each wavelength as well as logic to remove outliers.

Criteria for Level 1.5 SDA retrievals:

- At least three wavelength combinations must include 440 and 870nm with either 490, 500 or 675nm.
- The AOD for each channel must be greater than or equal to 0.02/m, where m is the optical air mass.
- Outliers are removed according to the following criterion:
- $Abs(AOD_{500nm}-AOD_{SDA500nm})>(0.02+AOD_{500nm}*0.005)$
- If within the series any tau_fine or tau_coarse is beyond tau_mean plus/minus 2*stdev for the series we eliminate this measurement.

Criteria for Level 2.0 SDA retrievals:

- At least four wavelengths must be included for input. The spectral range must be bounded by 380 and 870nm with at least two additional wavlengths between the bounds (e.g., 440, 500, 675nm). The three channel combination of 380, 500, and 870nm will also be accepted.
- The AOD for each channel must be greater than or equal to 0.02/m, where m is the optical air mass.
- Outliers are removed according to the following criterion:
- $Abs(AOD_{500nm}-AOD_{SDA500nm})>(0.01+AOD_{500nm}*0.005)$

- If within the series any tau_fine or tau_coarse is beyond tau_mean plus/minus 2*stdev for the series we eliminate this measurement.

For each cruise we generate a map, where in a compact graphic form (filled squares), daily averages at a wavelength of 500 nm and the ship's track are shown. Data files are available in the following form: instantaneous measurements (Level 1.0), instantaneous measurements (Level 1.5), series (groups) of measurements (Level 1.5), and daily averages (Level 1.5). Ship tracks are available in the form of geospatial Google Earth files and mapped daily averages at various wavelengths are available in the same compressed file. Cruise notes (if any) made by the operators and any other complimentary information (meteorological, satellite, sky photos from a fish-eye camera, etc.) are available also. Upon completion of the Quality Assurance process the data archive will be complemented by the Level 2.0 series and daily averages.

6. MAN Data Policy

The whole process of instrument calibration, shipment to the ship, data collection at sea, shipment back to GSFC for the post-field calibration, calibration, maintenance, data processing, cloud screening and quality assurance, web site posting and updates, is a very lengthy, time and labor-consuming procedure. The MAN data usage policy emphasizes that the public domain data are contributed by the Maritime Aerosol Network (MAN), a component of the International AERONET Federation; each cruise has Principal Investigators (PIs) responsible for instrument deployment, maintenance and data collection, and the PIs have priority use of the data collected during the ship cruise and are entitled to be notified when using their cruise data. Also, we believe that due to the research and development phase characterizing Maritime Aerosol Network, offering co-authorship to Principal Investigators would be an expected sign of courtesy, however it is not a requirement.

7. **Potential Future Instrumental Improvements**

Based on our experience and experience of our collaborators nationally and overseas several specific points can be outlined regarding the instrumentation.

- Current design of the front window makes it difficult to clean it.
- Accumulated sea-salt and/or dust usually concentrate in the corners, i.e. in front of the first and last filters.
- To make cleaning easier it would be beneficial to have a flat front window surface (in other words glass and frame should be at the same level).
- A lid padding is an extra source of contamination for the front window. No lid padding is necessary.
- Microtops – PC serial port. Should be changed to USB or USB-C to avoid an adapter.
- Previously a simple interface to download an ASCII file was available via HyperTerminal under Windows XP. Currently it does not exist anymore and for Windows7-11 we are using some built-in-house program. It would be nice to have a software recommendation for PC and Mac users. As an alternative the Bluetooth and cellular options should be added to download the data to a pc directly.

  Integrated GPS. It is necessary to have a GPS integrated within the unit.

8. Summary

AOD is an atmospheric optical parameter critical for various applications ranging from Earth radiative balance computations to ocean color studies, from understanding of global aerosol distribution to aerosol remote sensing from space and global aerosol transport modelling. Long-term island based comprehensive AOD measurements, which seemed to be a luxury for various applications in the 1980s, do not satisfy contemporary needs of remote sensing and modelling researchers.

AERONET provides the scientific community with high quality data on atmospheric aerosol optical properties. Validation of satellite retrievals and aerosol global modelling (Randles et al., 2017) would not be possible without information from hundreds of AERONET sites around the globe. However, over the oceans AERONET coverage is limited to several island and coastal sites. Therefore, the establishment of the MAN as a component of the AERONET (Smirnov et al., 2009) has been a key step towards meeting this data need. This program enables individual investigators to perform observations with calibrated instruments on research vessels, providing a singularly unique at-sea dataset unavailable from any other source.

MAN started regular data acquisition in November 2006 after two pilot projects were conducted (in 2004 and in the winter of 2005–2006). Since then, ship cruises continued accumulating data, with over 10000 days of measurements as of December 2025. Collected data make an important contribution, enhance our knowledge, help better understand aerosols over the oceans and fill existing data gaps in various oceanic areas.

MAN observations collocated with MODIS Terra, MODIS Aqua, MISR, POLDER, SeaWIFS, OMI, and CALIOP spaceborne aerosol products allowed to investigate regional and latitudinal biases in the satellite data (Kahn et al., 2010; Smirnov et al., 2011; Levy et al., 2013; Toth et al., 2013; Witek et al., 2013; Smirnov et al. 2017; Sayer et al., 2018). Because of different spatial-temporal characteristics of the analyzed products, the number of MAN data points collocated with spaceborne retrievals varied between thousands of matchups for MODIS to dozens for CALIOP. Despite these unavoidable sampling biases, latitudinal dependencies of AOD differences for all satellite sensors helped to determine whether satellite retrievals are within claimed uncertainty boundaries and showed where biases exist and corrections are needed.

MAN provides high quality data for various PACE validation cruises. In the last two years MAN supported validation campaigns over Gulf of America, Great Lakes and off West coast of the US. This became possible owing to a close collaboration with the PACE team, US Naval Research Laboratory, NOAA, University of California at Santa Barbara, University of California Santa Cruz and Cleveland State University.

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