

NASA Atmospheric Composition Ground Networks Supporting Air Quality and Climate Applications

Part 2: Hands-On Analysis of AERONET Data

Carl Malings (Morgan State University), Pawan Gupta (NASA Goddard Space Flight Center), & Petar Grigorov (Science Systems & Applications, Inc.)

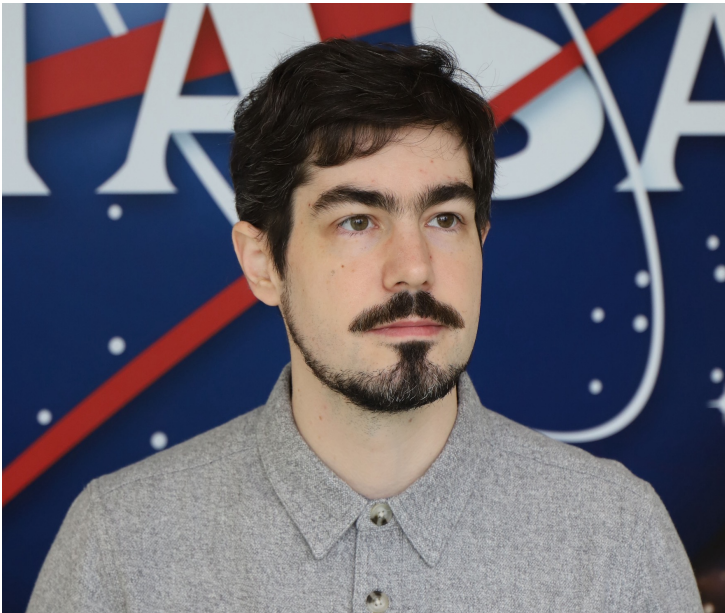
August 13, 2024



Part 2 – Trainers

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Part 2 Objectives

By the end of Part 2, participants will be able to:

- Access relevant AERONET data for given locations and application purposes.
- Compare and jointly analyze AERONET and satellite aerosol data products for a given location and time.



Review of Prior Knowledge

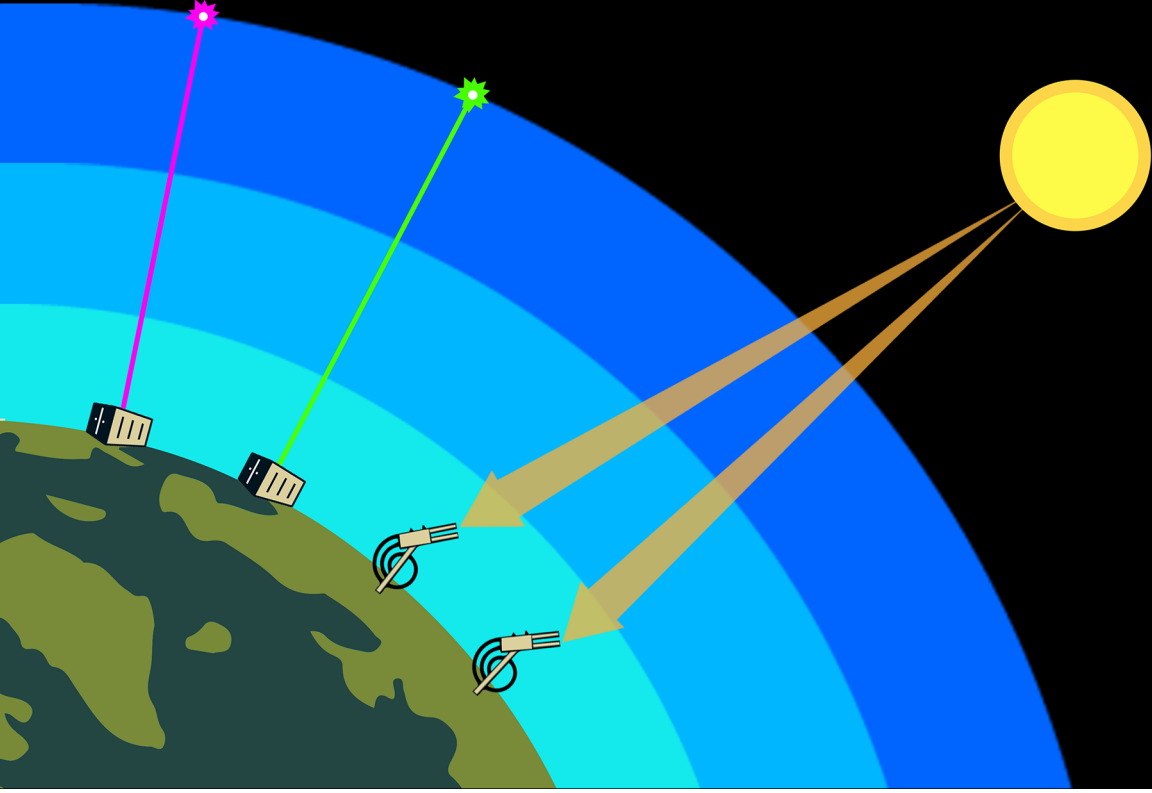
Network	Type	Primary Measurands	Number of Sites	Vertical Coverage
AERONET	Passive	Aerosols (Optical, Microphysical, Radiative)	~600 active	Total Column



How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.





Part 2:
Hands-On Analysis of AERONET Data

Outline



AERONET Webpage



Site Information



Data Display



Data Download



Alternative Tools



GitHub – Jupyter Notebooks



Live Demonstration



Tour of AERONET Website

<https://aeronet.gsfc.nasa.gov/>

AERONET Components Pages

Information Buttons:

- Data Access and Dissemination Tools
- Troubleshooting Manuals and Shipping Information
- Data Transfer and Relational Database
- Site Information Pages (photos, contacts, site description, etc.)
- System Overview (measurements, operation calibration, data)

The screenshot shows the AERONET website homepage. At the top left is the NASA logo and "GODDARD SPACE FLIGHT CENTER". At the top right is a link "+ Visit NASA.gov". The main header features the "AERONET" logo in large blue letters and "AEROSOL ROBOTIC NETWORK" below it, with a background image of a sun photometer. Below the header is a navigation bar with five buttons: "+ AEROSOL OPTICAL DEPTH", "+ AEROSOL INVERSIONS", "+ SOLAR FLUX", "+ OCEAN COLOR", and "+ MARITIME AEROSOL". Below this bar is a yellow banner with the text "For receiving updates on AERONET - subscribe to the mailing list by sending an email to aeronet-join@lists.nasa.gov". Below the banner is a blue sidebar menu with the following items: "-Home", "Home", "+ AEROSOL/FLUX NETWORKS", "+ CAMPAIGNS", "+ COLLABORATORS", "+ DATA", "+ LOGISTICS", "+ NASA PROJECTS", "+ OPERATIONS", "+ PUBLICATIONS", "+ SITE INFORMATION", "+ STAFF", and "+ SYSTEM DESCRIPTION". The main content area contains text about the AERONET program, its components, and data availability.

AERONET Webpage Overview

Data Buttons:

- Data Visualization
- Data Mapping
- Data Downloading
- Climatology Tables
- Accessing Web API (Web Service)

Site Lists:

- Display list of AERONET sites along with some key site information
- Can choose format and/or time frame

AERONET DATA ACCESS

DATA VISUALIZATION

- + Synergy Tool
- + Map Explorer

AEROSOL OPTICAL DEPTH (V3)-SOLAR

- + Data Display
- + Download Tool
- + Download All Sites
- + Climatology Tables
- + Web Service

AEROSOL INVERSIONS (V3)

- + Data Display
- + Download Tool
- + Download All Sites
- + Web Service

SOLAR FLUX

- + Data Display

OCEAN COLOR

- + V3 Data Display
- + V3 Web Service
- + Download All Sites

LUNAR AOD (V3) - PROVISIONAL

- + Data Display
- + Download Tool
- + Download All Sites
- + Web Service

ZENITH RADIANCE (V3)

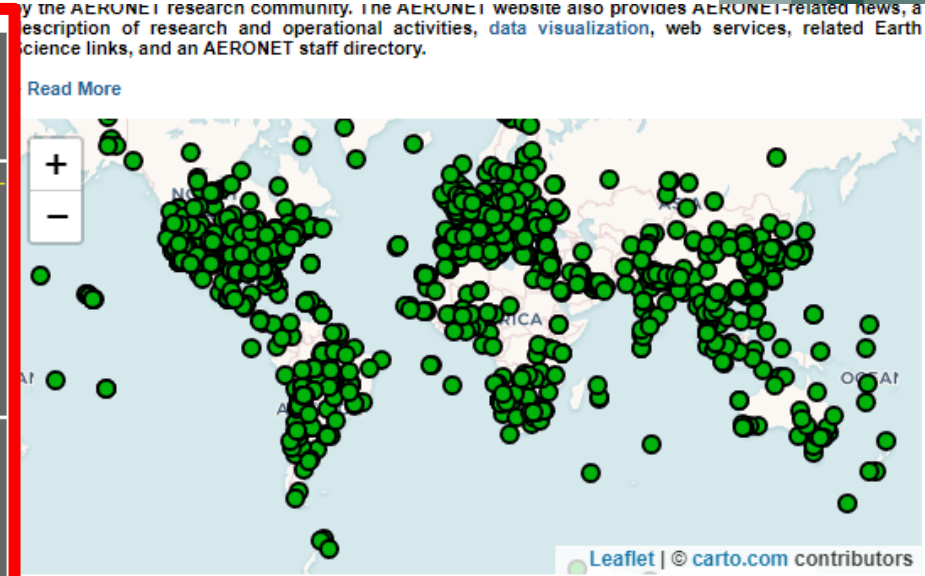
- + Web Service

CLOUD MODE (V2) - PROVISIONAL

- + Data Display

AERONET Site Lists (V3)

- + Text Format
- + Google Earth Format
- + All Lists



ANNOUNCEMENTS

10 June 2024
Visualize AERONET Data in NASA Worldview

We are happy to report that AERONET data are now visible on NASA's Worldview application. This open source code app from the Earth Observing System Data and Information System (EOSDIS) provides the capability to interactively browse over 1000 global, full-resolution satellite imagery layers and then download the underlying data. Many of the imagery layers are updated daily and are available within three hours of observation. Four of those layers represent AERONET's Aerosol Optical Depth 500nm (Near Real-Time and Daily) and Angstrom Parameter 440-870nm (Near Real-Time and Daily) data.

25 April 2024
AERONET System - Planned Maintenance

Dear AERONET colleagues, partners, and data users. On **May 8th, 2024**, the AERONET system will be upgraded from CentOS 7 to Oracle Linux 8. This means that the server, including website and relational database, will be down for most of the work day while we are migrating and synchronizing our data. Note that instruments will still be operational and we do not expect any data loss. We appreciate your patience!

18 March 2024
AERONET Science and Application Exchange

Mark your calendars! We are excited to announce the upcoming AERONET science and application exchange, to be held on **Sep 17-19, 2024, in College Park, MD, USA**. This will be an in-person meeting only.

The exchange will bring together the global AERONET community to discuss and collaborate on topics related to the AERONET system. Such topics include, scientific development, data products, instrument calibration, research and application. This is also a wonderful opportunity to celebrate AERONET's 30 years of success in atmospheric aerosol measurements. We will have a mix of invited talks, contributed talks, and poster presentations, as well as ample opportunity for networking.

More information on Registration, Important Dates, Abstract Guidelines, and Accommodations can be found [here](#)

Sample List – Active Sites

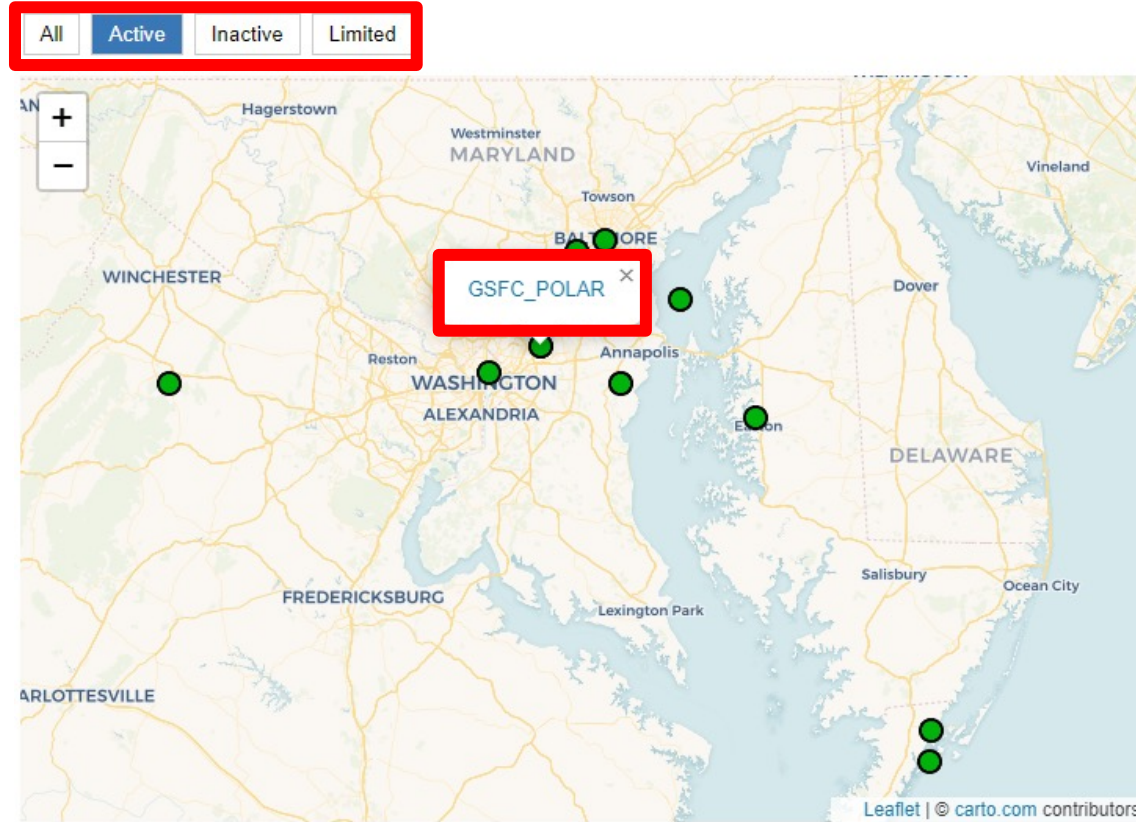
https://aeronet.gsfc.nasa.gov/aeronet_locations_v3.txt

- Contains:
 - Site Name
 - Coordinates
 - Elevation
- Features months with available data
 - 1 = Data Exists
 - 0 = No Data
- Can also generate list of sites for specific year, starting 1993
- Can download as plain text file, or compressed KMZ file for Google Earth

```
AERONET_Data_List,Site_Num=0,Date_Generated=22:07:2024,Months_Available_for_Year=0,
Site_Name,Longitude(decimal_degrees),Latitude(decimal_degrees),Elevation(meters),J
Tucson,-110.953003,32.233002,779.000000,1,1,1,0,0,1,1,0,0,0,0,0
GSFC,-76.839833,38.992500,87.000000,1,1,1,1,1,1,1,0,0,0,0,0
Wallops,-75.471950,37.932850,37.000000,1,1,0,0,1,1,1,0,0,0,0,0
Waskeiu,-106.069578,53.914386,569.000000,1,1,1,1,1,1,1,0,0,0,0,0
Key_Biscayne,-80.163330,25.731966,10.000000,1,1,1,1,1,1,1,0,0,0,0,0
Sevilleta,-106.885002,34.354721,1477.000000,1,1,1,1,1,1,1,0,0,0,0,0
Bonanza_Creek,-148.316269,64.742805,353.000000,0,0,0,1,1,1,1,0,0,0,0,0
Mauna_Loa,-155.576755,19.536006,3402.000000,1,1,1,1,1,1,1,0,0,0,0,0
Lille,3.141667,50.611667,60.000000,1,1,1,1,1,1,1,0,0,0,0,0
Missoula,-114.083336,46.916668,976.000000,1,1,1,1,1,1,1,0,0,0,0,0
Capo_Verde,-22.935499,16.732500,60.000000,1,1,1,1,1,1,1,0,0,0,0,0
UCSB,-119.845360,34.415428,33.000000,0,1,1,1,1,1,1,0,0,0,0,0
SERC,-76.555795,38.888901,36.500000,1,1,0,0,1,0,0,0,0,0,0,0
La_Jolla,-117.251130,32.868460,80.000000,1,1,1,1,1,1,1,0,0,0,0,0
Barcelona,2.112060,41.389250,125.000000,1,1,1,1,1,1,1,0,0,0,0,0
SEDE_BOKER,34.782222,30.855000,480.000000,1,1,1,1,1,1,1,0,0,0,0,0
CARTEL,-71.931330,45.379754,251.000000,1,1,1,1,1,1,1,0,0,0,0,0
Toronto,-79.470000,43.790000,186.000000,1,1,1,1,1,1,1,0,0,0,0,0
Banizoumbou,2.665190,13.546930,274.000000,1,1,1,1,1,1,1,0,0,0,0,0
Ascension_Island,-14.414722,-7.976389,30.000000,1,1,1,1,1,1,1,0,0,0,0,0
Barrow,-156.665000,71.312200,8.000000,0,1,1,1,1,1,1,0,0,0,0,0
REUNION_ST_DENIS,55.484740,-20.901390,93.000000,1,1,1,1,1,1,1,0,0,0,0,0
Rame_Head,-4.219809,50.317132,105.000000,1,0,0,1,1,1,1,0,0,0,0,0
BONDVILLE,-88.371944,40.053333,212.000000,1,1,1,1,1,1,1,0,0,0,0,0
MISR-JPL,-118.174390,34.199000,367.000000,1,1,0,0,0,0,1,0,0,0,0,0
Bratts_Lake,-104.713013,50.204238,586.700000,1,1,1,1,1,1,1,0,0,0,0,0
Dalanzadgad,104.419167,43.577222,1470.000000,1,1,1,1,1,1,1,0,0,0,0,0
Izana,-16.499060,28.309320,2401.000000,1,1,1,1,1,1,1,0,0,0,0,0
Teide,-16.639000,28.270000,3555.000000,1,1,1,1,1,1,1,0,0,0,0,0
Sioux_Falls,-96.625991,43.736481,505.000000,1,1,1,1,1,1,1,0,0,0,0,0
Egbert,-79.781414,44.231543,264.000000,1,1,1,1,1,1,1,0,0,0,0,0
Ispra,8.626700,45.803050,235.000000,1,1,1,1,1,1,1,0,0,0,0,0
Mainz,8.300000,49.999000,150.000000,0,0,1,0,1,0,0,0,0,0,0,0
Brookhaven,-72.884700,40.866000,37.000000,1,1,1,1,1,1,1,0,0,0,0,0
Saturn_Island,-123.128177,48.775252,193.000000,1,1,1,1,1,1,1,0,0,0,0,0
Ilorin,4.674500,8.484100,400.000000,1,1,1,1,1,1,1,0,0,0,0,0
Dongsha_Island,116.728833,20.698556,5.000000,1,1,1,1,1,1,1,0,0,0,0,0
Arica,-70.313333,-18.471667,25.000000,1,0,1,1,1,1,1,0,0,0,0,0
MCO-Hanimaadhoo,73.183183,6.776350,13.000000,1,1,1,1,1,1,1,0,0,0,0,0
NASA_LaRC,-76.378640,37.104960,5.000000,1,1,1,0,1,1,1,0,0,0,0,0
Pickle_Lake,-90.217500,51.449444,393.000000,1,1,1,1,1,1,1,0,0,0,0,0
IMAA_Potenza,15.723700,40.601254,770.000000,1,1,1,1,1,1,1,0,0,0,0,0
Skukuza,31.587500,-24.991700,265.000000,1,0,0,1,1,1,1,0,0,0,0,0
TABLE_MOUNTAIN_CA,-117.680000,34.380000,2200.000000,0,1,1,1,1,1,1,0,0,0,0,0
Mexico_City,-99.181667,19.333611,2268.000000,1,1,1,1,1,1,1,0,0,0,0,0
```

Site Information Map Interface

https://aeronet.gsfc.nasa.gov/new_web/site_info_v3.html



Latitude: 37.854729, Longitude: -78.219910

GSF Search Reset

- GSFC
- GSFC_POLAR

Chesapeake_Bay(39.1N, 76.3W) [Annapolis, MD]	Easton-MDE(38.8N, 76.1W)	GSFC(39.0N, 76.8W) [GSFC, Greenbelt, MD]
GSFC_POLAR(39.0N, 76.8W) [GSFC, Greenbelt, MD]	Howard_Univ-IRB(38.9N, 77.0W) [Washington, DC]	MD_Science_Center(39.3N, 76.6W) [MD Science Center, Baltimore, Maryland]
NEON_SCBI(38.9N, 78.1W) [Front Royal, VA]	NEON_SERC(38.9N, 76.6W) [Edgewater, MD]	SERC(38.9N, 76.6W) [SERC, Annapolis, Maryland]
UMBC(39.3N, 76.7W) [UMBC, Maryland]	Wallops(37.9N, 75.5W) [Wallops Island, Virginia]	WFF_X-75_Sci_Obs(37.8N, 75.5W)

GSFC (GSFC, Greenbelt, MD)

Coordinates: 38.99250° N, 76.83983° W
Elevation: 87.0 m



Image 1 - A view of the AERONET calibration platform



Site Description

This site is located on top of the building that houses the AERONET program at NASA's Goddard Space Flight Center. Here AERONET staff monitor aerosols locally and also calibrate instruments from around the world.

Contact Information

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Responsible Institution(s):	<ul style="list-style-type: none"> • NASA--National Aeronautics and Space Administration • http://www.nasa.gov



AERONET Data Display Interface

https://aeronet.gsfc.nasa.gov/new_web/draw_map_display_aod_v3.html

- Similar functionality to the Site Info Mapper
- Used for solar/lunar AOD and inversion products, as well as water-leaving radiances

Additional Functionality:

- Filter based on site activity, level of data, and time using dropdown menus
- On-click popup container with link to data display page (example below)

Level 1.5 Data: The following data are cloud cleared and quality controls have been applied but these data may not have final calibration applied.

Active Status: Total Data (Years): AOD Level: Year: Month: Day:

Data Display Controls

AERONET AOD Data Product:
 AOD
 Water Vapor
 440-870 Angstrom
 SDA Fine/Coarse AOD
 SDA Fine Mode Fraction

AOD Level (2024): Level 1.0 Level 1.5
 Data Format: All points Daily averages
 Triplet Variability (All Points Only): Off On

SELECT CHARTS FOR LARGER IMAGES

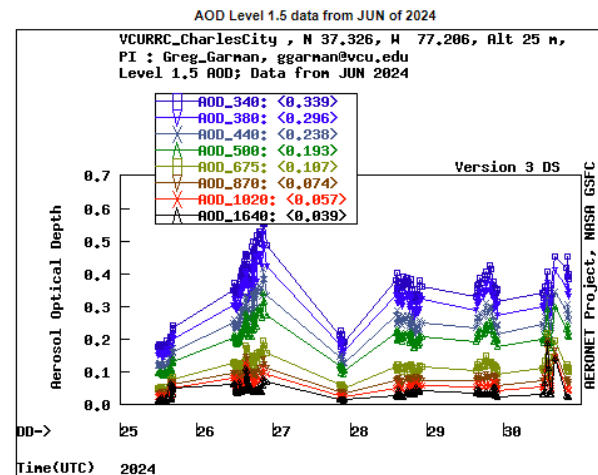
Choose year:
 Choose month of 2024:

Related Product Availability for VCURRC_CharlesCity (select each day below):

- Show Terra MODIS
- Show Aqua MODIS
- Show VIIRS
- Show Diagnostic Charts

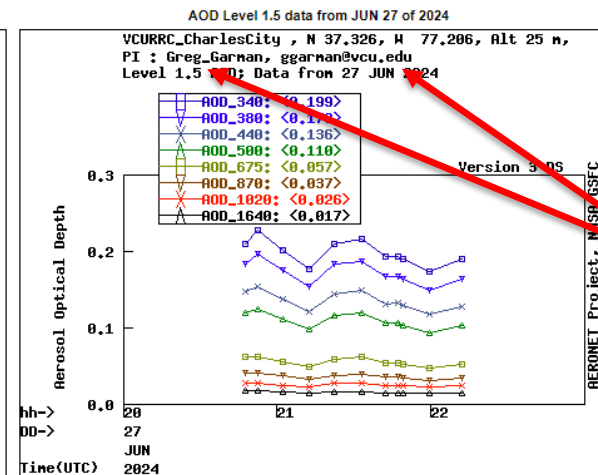
Choose day of JUN 2024

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30						



AERONET DOWNLOAD

- AOD Level 1.0
- SDA Level 1.0
- AOD Level 1.5
- SDA Level 1.5
- More AERONET Downloadable Products...



AERONET DOWNLOAD

- AOD Level 1.0
- SDA Level 1.0
- AOD Level 1.5
- SDA Level 1.5
- More AERONET Downloadable Products...

N, 76.3W)	Easton-MDE(38.8N, 76.1W)
D)	
I, 76.8W)	Howard_ Univ-IRB(38.9N, 77.0W)
, MD)	[Washington, DC]
76.4W)	NEON_MLBS(37.4N, 80.5W)
	[Charlottesville, VA]
5.5W)	
rginia)	

Hyperlinks are constructed with dropdown selections.



AERONET Data Download Interface

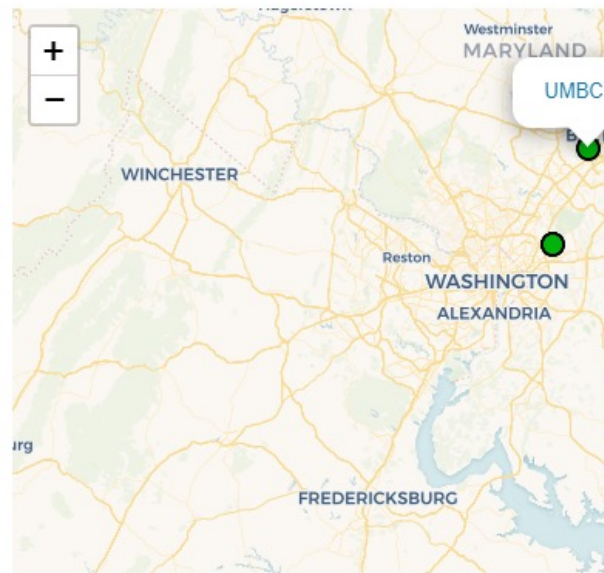
https://aeronet.gsfc.nasa.gov/new_web/webtool_aod_v3.html

Used for solar/lunar AOD and inversion products

Additional Functionality:

- Filter based on activity, region, country/province, and site using dropdown menus
- On-click popup container with link to download data for the selected site

Active Status: Region Selection: Country/Province:



Latitude: 39.553692, Longitude: -78.093567

Chesapeake_Bay(39.1N, 76.3W) [Annapolis, MD]	Easton-MDE(38.8N, 76.1W)	[GSFC, Greenbelt, MD]
GSFC_POLAR(39.0N, 76.8W) [GSFC, Greenbelt, MD]	MD_Science_Center(39.3N, 76.6W) [MD Science Center, Baltimore, Maryland]	NEON_SERC(38.9N, 76.6W) [Edgewater, MD]
SERC(38.9N, 76.6W) [SERC, Annapolis, Maryland]	UMBC(39.3N, 76.7W) [UMBC, Maryland]	

Click Geographic Region, Country/State or AERONET Site to change site selection:

Geographic Region: United_States_East
Country/State: Maryland
AERONET Site: UMBC

Download Data for UMBC

Select the start and end time of the data download period:

START: Day/Month/Year
1 JAN 2009
END: Day/Month/Year
31 DEC 2024

Data Descriptions

Data Units

Note: Data are not available if the data type is italicized

Select the data type(s) using the corresponding check box:

Direct Sun Products	Select
Aerosol Optical Depth (AOD) with Precipitable Water and Angstrom Parameter	Level 1.0 <input type="checkbox"/> Level 1.5 <input type="checkbox"/> Level 2.0 <input type="checkbox"/>
Total Optical Depth based on AOD Level*	Level 1.0 <input type="checkbox"/> Level 1.5 <input checked="" type="checkbox"/> Level 2.0 <input type="checkbox"/>
Spectral Deconvolution Algorithm (SDA) Retrievals -- Fine Mode AOD, Coarse Mode AOD, and Fine Mode Fraction	Level 1.0 <input type="checkbox"/> Level 1.5 <input checked="" type="checkbox"/> Level 2.0 <input type="checkbox"/>
Data Format	
<input type="radio"/> All Points <input checked="" type="radio"/> Daily Averages <input type="radio"/> Monthly Averages	



Alternative Tools: Synergy Tool

https://aeronet.gsfc.nasa.gov/cgi-bin/bamgomas_interactive

Collocates AERONET data with other surface and satellite databases (e.g., MODIS, MPLNET).

AERONET DATA SYNERGY TOOL

+ AERONET + MODIS + BACK TRAJECTORY + MPLNET + GOCART + GIOVANNI

Select the above buttons to find information for products provided by this data display

MODIS Rapid Response images have transitioned to NASA Worldview

Master Controls

Initial Date: Year 2024 Month JAN Day 1

Enter Site Name: [GSFC - Additional Site Information](#)
38.992500° N, 76.839833° W
Elevation: 87m

Change Site

Surface Data	Satellite Retrievals	Model Output
AERONET (V3 unless noted)	<input type="checkbox"/> NASA Worldview	<input type="checkbox"/> GSFC Back Trajectory
<input type="checkbox"/> AOD (Solar)		<input type="checkbox"/> HYSPLIT Trajectory
<input type="checkbox"/> Inversions (Almucantar)		<input type="checkbox"/> NOGAPS Weather
<input type="checkbox"/> Inversions (Hybrid)		
<input type="checkbox"/> Ocean Color		
<input type="checkbox"/> SDA Retrievals		
<input type="checkbox"/> Cloud Mode Retrievals - (V2,Provisional)		
<input type="checkbox"/> SolRad-Net Flux (V2)		<input type="checkbox"/> Select All
MPLNET		
<input type="checkbox"/> Backscatter and Extinction		

Change Image Size: Small Large

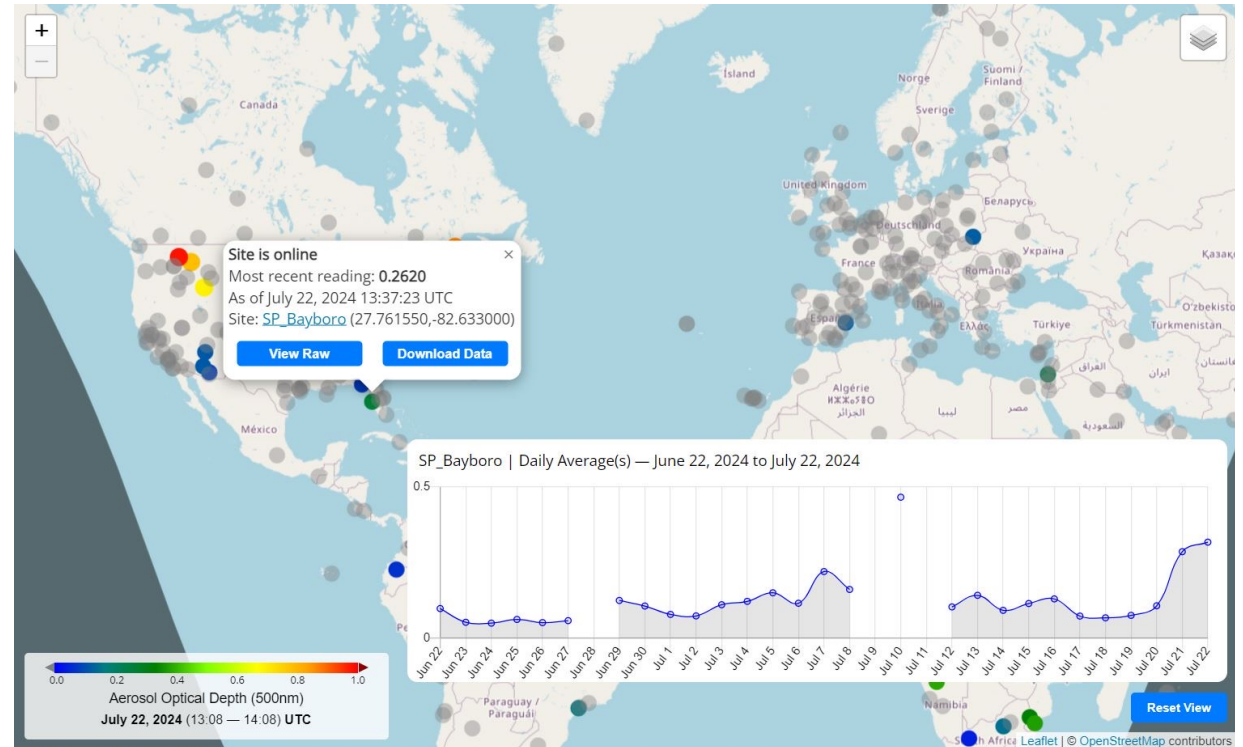
+ Data Synergy Tool: [Ilya Slutsker](#)



Alternative Tools: AERONET Map Explorer

https://aeronet.gsfc.nasa.gov/new_web/aeronet_map_tool/index.html

- Obtains AERONET data from Web API and plots them either in near-real time or as daily averages.
- Popup containers show site activity, most recent reading with timestamp, as well as time-series.
- Ability to select channel, site, mode, day/time, as well as to download the data.



AERONET Data in NASA Worldview

The screenshot displays the NASA Worldview interface with the following components:

- Search Bar:** "Search for places or enter coordinates" with a search icon and a notification badge.
- Layers Panel (Left):**
 - Layers: OpenStreetMap contributors, Natural earth
 - Coastlines / Borders / Roads: OpenStreetMap contributors
 - Coastlines: OpenStreetMap contributors
 - Angstrom Parameter 440-870nm (Daily): AERONET, Inactive Site, Angstrom Parameter (color scale: <math>< 0.0</math> to ≈ 2.5)
 - Aerosol Optical Depth 500nm: AERONET, Inactive Site, Aerosol Optical Depth (color scale: <math>< 0.0</math> to 5.0)
 - Angstrom Parameter 440-870nm (Near Real-Time): AERONET, Inactive Site
 - Buttons: + Add Layers, Start Comparison
- Map:** Satellite view of Earth with numerous colored dots representing AERONET sites. A scale bar shows 2000 km and 2000 mi. Coordinates: 47.7642°N, -34.7239°W, EPSG.
- Layer Information Panel (Right):**
 - Reset AERONET
 - Showing 4 out of 1125
 - COVERAGE:** Always Available (2), Available 2024 AUG 01 (2)
 - CATEGORY:** Air Quality (4), Ash Plumes (4), Atmosphere (4), Dust Storms (4), Fires (4), Smoke Plumes (4)
 - MEASUREMENTS:** Aerosol Optical Depth (4)
 - SOURCE:** AERONET (4)
 - PERIOD:** No matches.
 - DAY/NIGHT:** No matches.
 - DAAC/SIPS:** No matches.
 - IMAGERY TYPE:** Vector (4)
- Layer Details (Bottom Right):**
 - Angstrom Parameter 440-870nm (Near Real-Time) AERONET
 - Angstrom Parameter 440-870nm (Near Real-Time) AERONET
 - Aerosol Optical Depth 500nm (Daily) AERONET
 - Angstrom Parameter 440-870nm (Daily) AERONET
 - Remove Layer button
 - Temporal Coverage: 1992 JAN 01 00:00Z - Present
 - Text: "The AERONET Angstrom Parameter 440-870nm (Near Real-Time) layer provides the Angstrom parameter from the Level 1.5 data for AERONET ground-based remote sensing aerosol network sites. The angstrom parameter provides additional information related to the aerosol particle size (larger the value, the smaller the particle size). Values <math>< 1</math> suggest optical dominance of coarse particles (e.g. dust) and values > 1 suggest optical dominance of fine particles (e.g. smoke)."
 - Text: "The angstrom parameter is calculated for all available wavelengths within the Angstrom parameter range. For example, the Angstrom 870-440nm includes the 870, 670, 500 and 440 nm AOD data. A special case for a polarized instrument is Angstrom 870-440nm which only includes 870, 670 and 440 nm AOD data (polarized instruments do not have
- Time Display (Bottom):** 2024 JUL 02 09:38Z, 60 MINUTE, playback controls, and a timeline from 1:00 to 12:00.

Available Layers



The Web API – Explanation of Variables and Sample Data File

https://aeronet.gsfc.nasa.gov/print_web_data_help_v3_new.html

Table 2: Explanation of Data Types for the Web Service

Data Types	Explanation
AOD10	Aerosol Optical Depth Level 1.0
AOD15	Aerosol Optical Depth Level 1.5
AOD20	Aerosol Optical Depth Level 2.0
SDA10	SDA Retrieval Level 1.0
SDA15	SDA Retrieval Level 1.5
SDA20	SDA Retrieval Level 2.0
TOT10	Total Optical Depth based on AOD Level 1.0 (all points only)
TOT15	Total Optical Depth based on AOD Level 1.5 (all points only)
TOT20	Total Optical Depth based on AOD Level 2.0 (all points only)

AERONET Data Download (Version 3 Direct Sun)

AERONET Version 3;
 Version 3: AOD Level 1.5
 The following data are cloud cleared and quality controls have been applied but these data may not have final calibration applied. These data may change.
 Contact: PI=Pawan_Gupta_and_Elena_Lind; PI Email=pawan.gupta@nasa.gov_and_elena.lind@nasa.gov
 AERONET_Site.Date(dd:mm:yyyy).Time(hh:mm:ss).Day_of_Year.Day_of_Year(Fraction).AOD_1640nm.AOD_1020nm.AOD_870nm.AOD_865nm.AOD_779nm.AOD_675nm.AOD_667nm.AOD_620nm.AOD_560nm.AOD_555nm
 870_Angstrom_Exponent.380-500_Angstrom_Exponent.440-675_Angstrom_Exponent.500-870_Angstrom_Exponent.340-440_Angstrom_Exponent.440-675_Angstrom_Exponent[Polars].Data_Quality_Level.AERONET_Instrument_Number.AERONET_Site_Name.Site_Latitude(Degrees).Site_Elevation(m).Solar_Zenith_Angle(Degrees).Optical_Air_Mass.Sens
 GSFC.01:07:2024.10:38:13.183.183.443206.0.003819.0.010138.0.012266.-999.000000.-999.000000.0.015941.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.025779.-999.00
 GSFC.01:07:2024.10:41:43.183.183.445637.0.003770.0.010067.0.012117.-999.000000.-999.000000.0.015618.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.025406.-999.00
 GSFC.01:07:2024.10:43:44.183.183.447037.0.003741.0.009926.0.011870.-999.000000.-999.000000.0.015358.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.024923.-999.00
 GSFC.01:07:2024.10:45:55.183.183.448553.0.003631.0.009804.0.011828.-999.000000.-999.000000.0.015381.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.025299.-999.00
 GSFC.01:07:2024.10:50:48.183.183.451944.0.003637.0.009646.0.011965.-999.000000.-999.000000.0.015683.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.025876.-999.00
 GSFC.01:07:2024.10:56:39.183.183.456007.0.003599.0.009483.0.011658.-999.000000.-999.000000.0.015397.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.025603.-999.00
 GSFC.01:07:2024.11:01:43.183.183.459525.0.003792.0.009837.0.012185.-999.000000.-999.000000.0.016010.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.026751.-999.00
 GSFC.01:07:2024.11:03:43.183.183.460914.0.003980.0.009974.0.012396.-999.000000.-999.000000.0.016309.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.027136.-999.00
 GSFC.01:07:2024.11:06:43.183.183.462998.0.003847.0.009746.0.012160.-999.000000.-999.000000.0.015996.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.026799.-999.00
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 GSFC.01:07:2024.11:13:44.183.183.467870.0.004099.0.009866.0.012270.-999.000000.-999.000000.0.015996.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.026231.-999.00
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 GSFC.01:07:2024.14:01:44.183.183.584537.0.007485.0.015712.0.020976.-999.000000.-999.000000.0.029147.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.048563.-999.00
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 GSFC.01:07:2024.14:11:44.183.183.591481.0.006096.0.012981.0.018637.-999.000000.-999.000000.0.025971.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.043016.-999.00
 GSFC.01:07:2024.14:26:44.183.183.601898.0.006011.0.011930.0.017256.-999.000000.-999.000000.0.022939.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.037948.-999.00
 GSFC.01:07:2024.14:31:45.183.183.605382.0.005633.0.012334.0.017011.-999.000000.-999.000000.0.022784.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.037660.-999.00
 GSFC.01:07:2024.14:36:44.183.183.608843.0.005411.0.011664.0.017181.-999.000000.-999.000000.0.022368.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.037905.-999.00
 GSFC.01:07:2024.14:41:44.183.183.612315.0.004864.0.010858.0.015769.-999.000000.-999.000000.0.020729.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.034053.-999.00
 GSFC.01:07:2024.14:46:45.183.183.615799.0.004981.0.010924.0.016425.-999.000000.-999.000000.0.021695.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.035145.-999.00
 GSFC.01:07:2024.14:56:44.183.183.622731.0.006173.0.012794.0.018055.-999.000000.-999.000000.0.023921.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.039722.-999.00
 GSFC.01:07:2024.15:01:46.183.183.626227.0.005885.0.013215.0.018424.-999.000000.-999.000000.0.024427.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.039910.-999.00
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 GSFC.01:07:2024.15:11:44.183.183.633148.0.005856.0.012327.0.018448.-999.000000.-999.000000.0.024350.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.-999.000000.0.040537.-999.00

AERONET Data Download (Version 3 Direct Sun)
https://aeronet.gsfc.nasa.gov/cgi-bin/print_web_data_v3

The following tables and examples show how to use the AERONET web data service for Version 3 products.

Table 1: Explanation and Values for Mandatory and Optional Web Service Parameters

Mandatory Parameters	Explanation	Values
year,month,day	Starting time moment (year= 1992 to present), (month=1 to 12), (day = 1 to max num, depends on month)	Year: 1993 to present (must be 4-digits) Month: 1 to 12 Day: 1 to max_day_of_month
AVG	Data Format	All points: AVG=10 Daily average: AVG=20
[data_type]	Data Types (See Table 2)	[data_type]=1
Optional Parameters		
year2,month2,day2	Ending time moment**	Year: 1993 to present (must be 4-digits) Month: 1 to 12 Day: 1 to max_day_of_month **if year2, month2, and day2 are omitted, then the current day is assumed
hour, hour2	Specified beginning (hour) and ending hour (hour2)	Hour: 0 to 23 if not specified, then the hour is set to zero; time2 is incremented to next day and hour2=0
site	AERONET site name	Exact match of AERONET database name If none specified, then all sites are searched for data during the time interval specified AERONET Site Name List
lat1,lon1,lat2,lon2	Bounding Box **	lat1,lon1 - Lower Left lat2,lon2 - Upper Right **values must be in decimal degrees (including the decimal)
lunar_merge	Enable Lunar AOD (Provisional) Only Download	0 - No Lunar 1- Lunar Data (Provisional)
ldp_year,		Year: 1993 to present (must be 4-digits)
ldp_month,	Request data records after user specified date based on the last processing date of the record **	Month: 1 to 12
ldp_day		Day: 1 to max_day_of_month ** All Points format only
if_no_html	Determine whether html formatting is printed	0 - HTML formatting printed (default) 1 - No HTML formatting printed






AERONET GitHub Codes

<https://github.com/pawanpgupta/AERONET/tree/Python>

1. Reads Aerosol Optical Depth (AOD) data from Web API, and plots values on a world map. The results can be either daily averages, hourly averages, or total average over specified time frame.
2. Works similarly to Ex. 1, but with an interactive twist: dynamic plots with sliders and animations with play/pause/stop buttons,
3. Works similarly to Ex. 1, but instead reads AERONET Inversions data from Web API.
4. Reads AOD data from Web API, and produces a variety of plots, including time-series, calendar plot, tile plots, yearly averages with regression line.

Materials for ARSET Training - visualizing AERONET data. This repository contains materials for reading and mapping AERONET data, as well as producing time-series plot. Scripts require input from user such as time range, coordinates, level data, averaging type, product/channel. AERONET's Web API is used for extracting the data. An additional script collocates AERONET's ground based measurements with VIIRS satellite aerosol measurements and produces a scatter plots. Similar input parameter are used as the Web API codes.

Materials

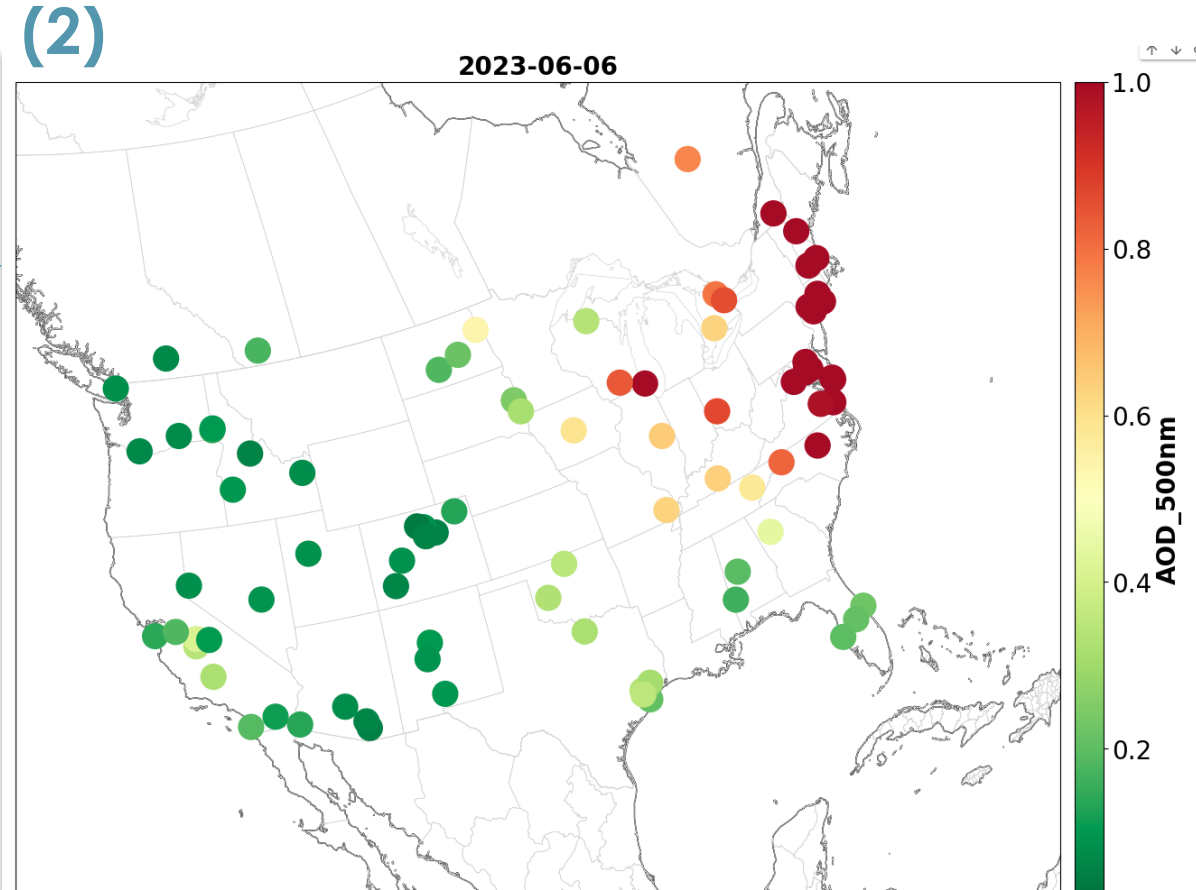
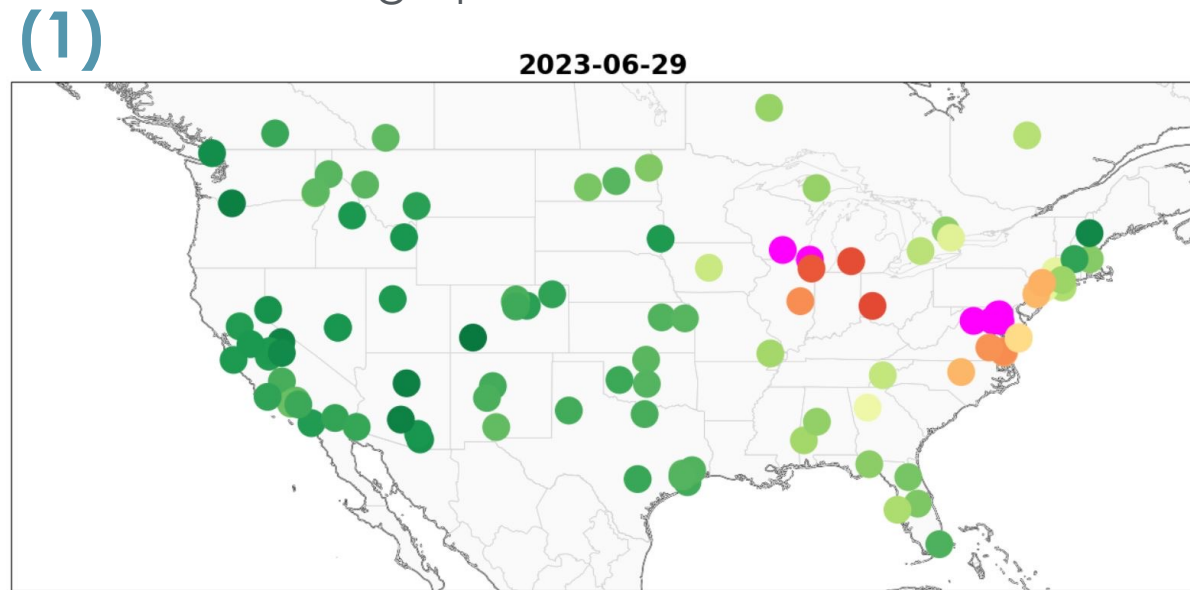
Lecture Topic	Interactive Link
1. Read and Map AERONET Data (AOD)	 Open in Colab
2. Read and Map AERONET Data (AOD - Interactive)	 Open in Colab
3. Read and Map AERONET Data (Inversions)	 Open in Colab
4. AERONET Time Series Plots	 Open in Colab
5. VIIRS - AERONET Comparison	 Open in Colab



Sample Output – Read and Map AERONET Data

- Code produces spatial patterns of aerosol optical depth (AOD) at a specified wavelength.
- User can select date range, region, wavelength AOD, and averaging type to display.
- Two projections are used when plotting the AOD:
 1. Plate Carrée
 2. Orthographic

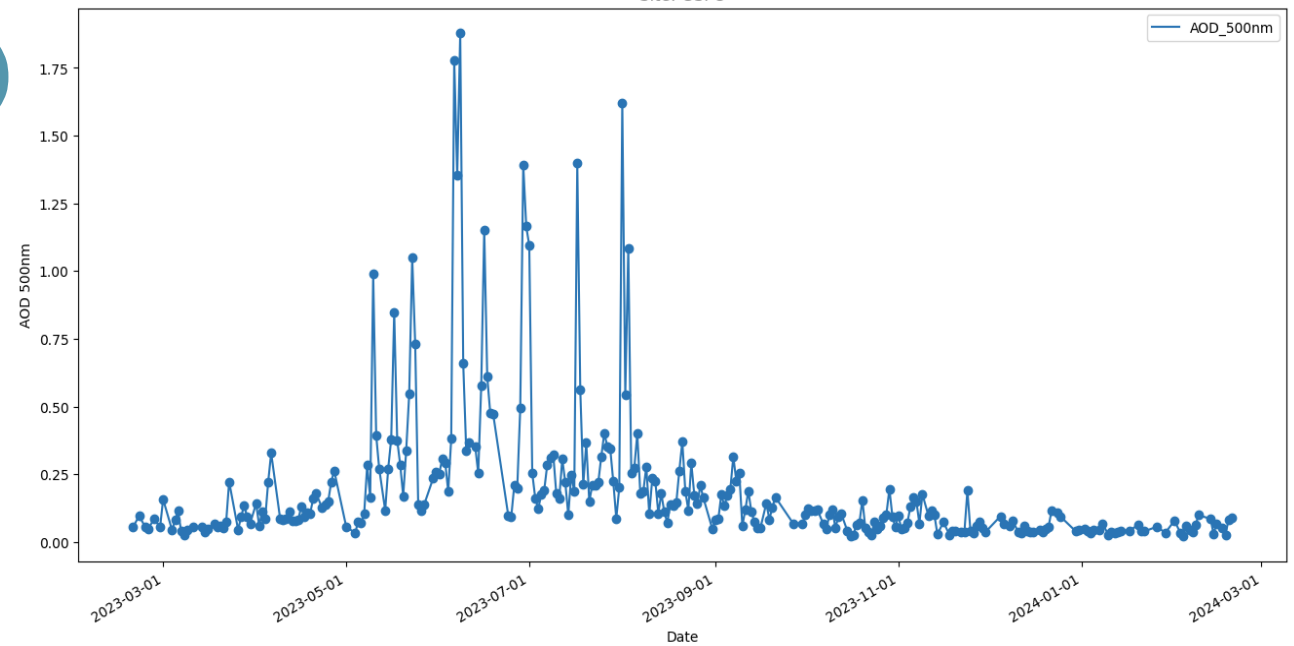
- (1)
1. Plate Carrée
2. Orthographic



Sample Output – AERONET Time Series Plots

- Identical functionality as the Read and Map code – data is being read from Web API.
- Code produces a variety of time plots, both for short-term and long-term trends.
- Input parameters include site, date range, averaging type, AOD channel, level data.
- Featured Visuals:
 - Time-Series Graph (1)
 - Tile Plot (2)
 - Calendar Plot (3)
 - Annual Variability Plot (4)

(1)



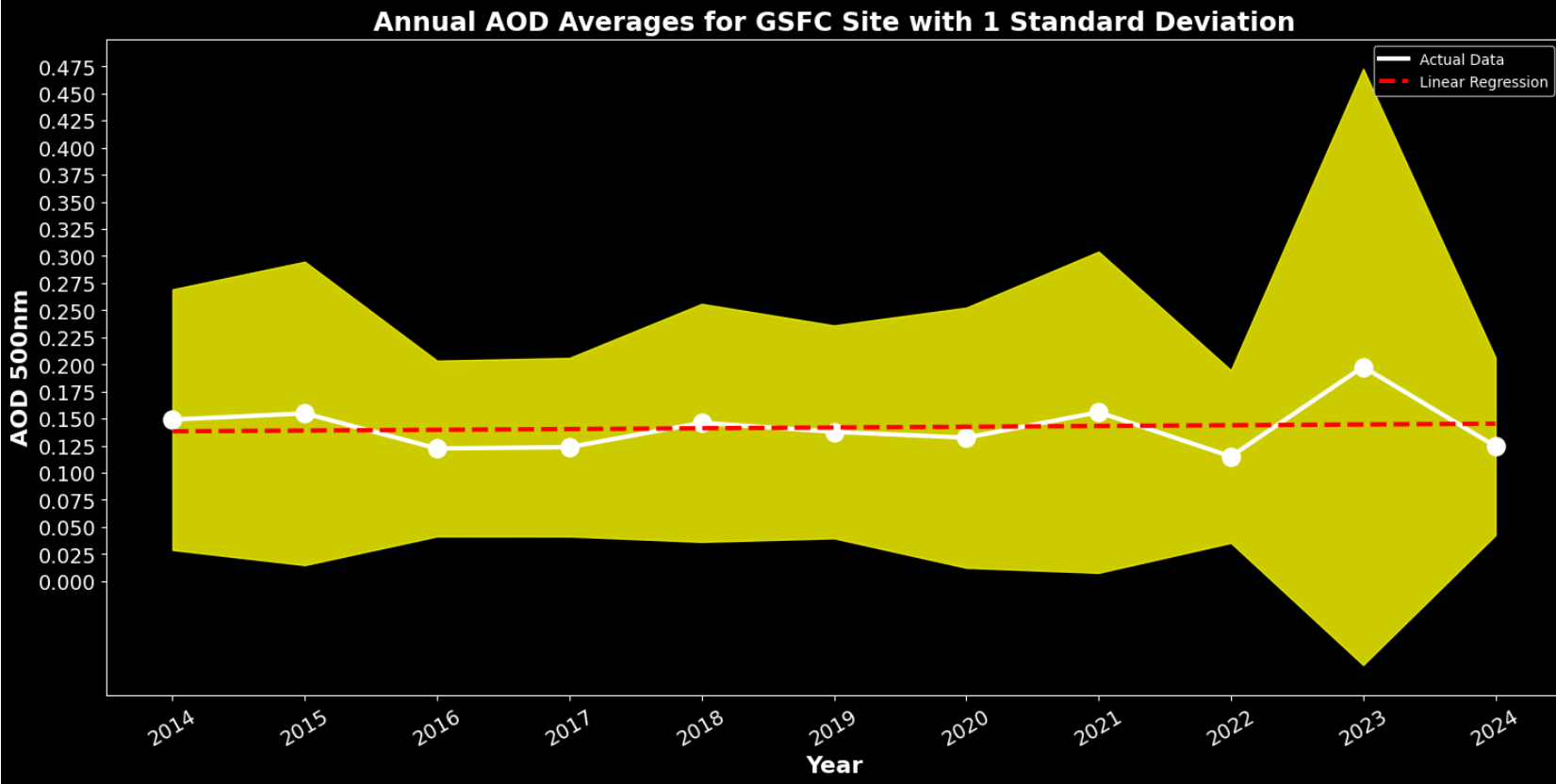
(2)



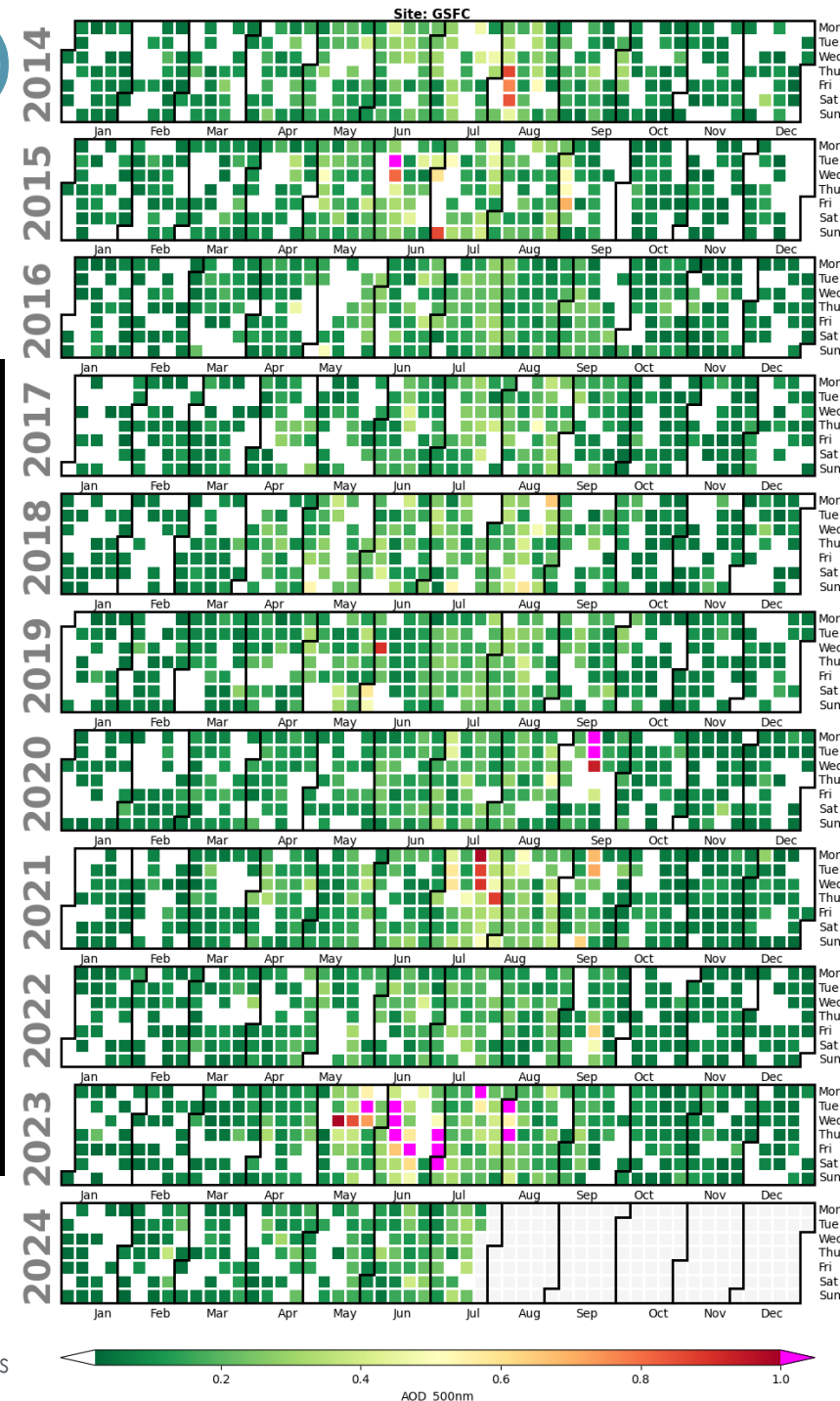
Sample Output – AERONET Time Series Plots

(4)

Annual AOD Averages for GSFC Site with 1 Standard Deviation



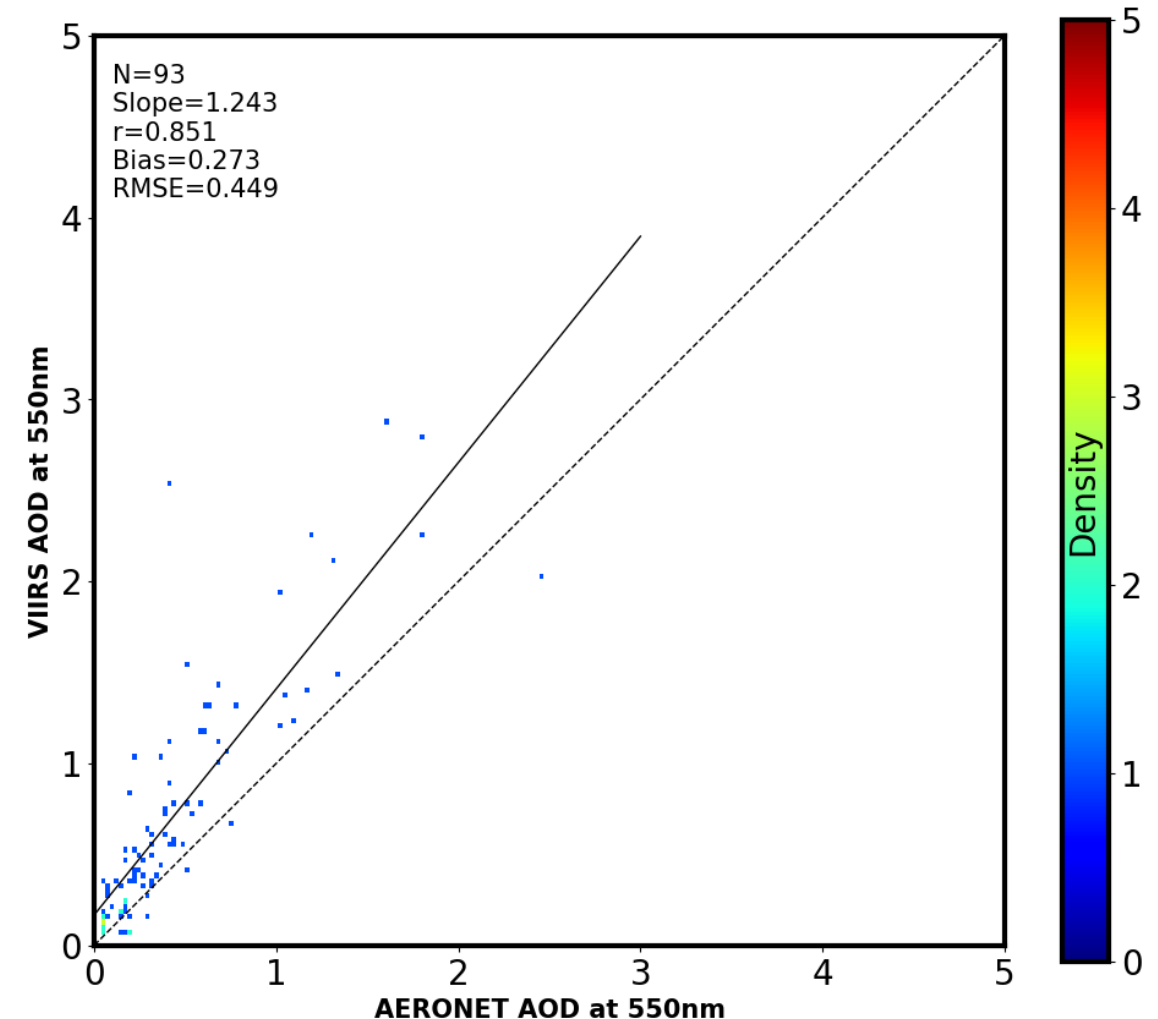
(3)



Sample Output: VIIRS – AERONET Comparison

- Code uses LAADS query file to read multiple NetCDF files from EOSDIS and retrieve AOD 550 nm data from the VIIRS satellite.
- Similar input parameters are used to access AERONET web API and retrieve AOD data for 440 nm, 500 nm, and 675 nm channels.
- Performs data collocation, where AERONET and VIIRS data are matched based on location and time.
- Functions for spatial averaging and statistical comparison are used for analysis, where AOD 550 nm for AERONET is interpolated using the 3 channels.
- Produces collocated data, as well as comparison graph.

VIIRS vs AERONET Comparison



AERONET Google Colab Codes - Preliminaries

- **Primary Requirement:** Google Account and Internet Access

Required Libraries – Cell 1

```
!pip install cartopy
!pip install --no-binary shapely shapely --force
!pip install beautifulsoup4
!pip install requests
!pip install geopandas
```

```
from bs4 import BeautifulSoup
import requests
import shutil
import numpy as np
import datetime
import pandas as pd
import geopandas as gpd
import matplotlib.pyplot as plt

import cartopy.crs as ccrs
import cartopy.feature as cfeature
from copy import deepcopy as dc
```

Connecting Local Drive to Colab Notebook – Cell 2

Permit this notebook to access your Google Drive files?

This notebook is requesting access to your Google Drive files. Granting access to Google Drive will permit code executed in the notebook to modify files in your Google Drive. Make sure to review notebook code prior to allowing this access.

No thanks

[Connect to Google Drive](#)

- See, edit, create, and delete any of your Google Drive documents ⓘ

Make sure you trust Google Drive for desktop

You may be sharing sensitive info with this site or app. You can always see or remove access in your [Google Account](#).

Learn how Google helps you [share data safely](#).

See Google Drive for desktop's [Privacy Policy](#) and [Terms of Service](#).

Cancel

Allow

Input Parameters – Cell 3

```
dt_initial = '20230615'
dt_final = '20230629'
level = 1.5
average_type = 1
vis_min = 0.0
vis_max = 1.0
feature_choice = 1
wavelength = 500
Angstrom_exp = '440-675'
long_west, long_east = -130, -65
lat_south, lat_north = 25, 50
```

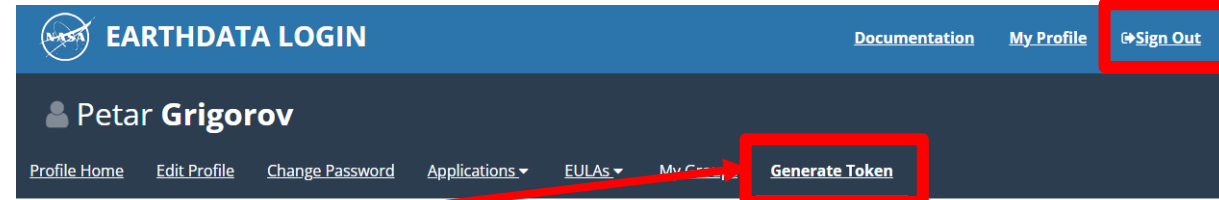


VIIRS – AERONET Collocation Code Preliminaries

(1)

- **Requirements:**

1. Earthdata Credentials:
<https://urs.earthdata.nasa.gov/>
2. Generate token.
3. Copy and place token in code (cell 6 – *auth*).
4. Ensure LAADS applications are approved for profile authentication (*Applications -> Authorized Apps*).
5. Download query file from LAADS:
<https://ladsweb.modaps.eosdis.nasa.gov/search/>.
6. Ensure LAADS and AERONET coordinate box inputs match.



(2)

Generate a Bearer Token

User tokens are a new feature in EDL and may not be supported by all EDL integrated applications.

You can generate a bearer token for federated token access sharing. Not all EDL applications support Federated token access sharing.

You may have up to 2 active tokens at a time.

The token can then be passed into an application by using an **Authorization: Bearer** header

The token will only authorize for applications that are EDL compliant and do not have unapproved EULAs

Expires on 09/29/2024	SHOW TOKEN	
Expires on 09/29/2024	SHOW TOKEN	

[GENERATE TOKEN](#)

```
download_path = working_directory + "AERDT/"
if not os.path.exists(download_path):
    os.makedirs(download_path)

#auth = {"Authorization": "Bearer eyJ0eXAiOiJKV1QiLCJvcmlnaW4iOiJFYXJ0aGRhdGEgTG9"}
auth = {"Authorization": "Bearer eyJ0eXAiOiJKV1QiLCJvcmlnaW4iOiJFYXJ0aGRhdGEgTG9"}
```

(3)



VIIRS – AERONET Collocation Code Preliminaries (LAADS Applications)

- Select “Applications > Authorized Apps”
- Select “Approve More Applications”
- Search “laads”
- Select “Authorize”

(4)

EARTHDATA LOGIN [Documentation](#) [My Profile](#) [Sign Out](#)

Petar Grigorov

[Profile Home](#) [Edit Profile](#) [Change Password](#) **Applications** [EULAs](#) [My Groups](#) [Generate Token](#)

Authorized Apps

Approved Applications

Applications that use your Earthdata Login profile for authentication.

Earthdata Feedback Module	?
Earthdata Code Collaborative	?
Earthdata Website	?
CMR SSO APP for EDL in PROD	?
LAADS DAAC Cumulus (PROD)	✎ ✕
Metadata Management Tool	?
LAADS Web	✎ 👤 ✕
APPROVE MORE APPLICATIONS	



1 PRODUCTS 2 TIME 3 LOCATION 4 FILES 5 REVIEW & ORDER

AERDT_L2_VIIRS_SNPP (5200) 2024-07-16 ... 2024-07-31 W: 65°, N: 35°, E: 130°, S: -10° No files selected. reset

All Sensors All Standard Collections All [511]

Level-0 / Level-1 [34]

MODIS Terra, Aqua [14]

VIIRS Suomi NPP [9]

OLCI ESA Copernicus Sentinel-3A [2]

SLSTR ESA Copernicus Sentinel-3A [1]

OLCI ESA Copernicus Sentinel-3B [2]

SLSTR ESA Copernicus Sentinel-3B [1]

MERIS Envisat [5]

Atmosphere [58]

Aerosol [20]

Water Vapor [5]

Cloud Properties [14]

Atmosphere Profiles [2]

Cloud Mask [5]

L2 Joint Atmosphere Product [2]

L3 Atmosphere Product [8]

VIIRS+CrIS Fusion [2]

Airborne [4]

MAS_eMAS [4]

Land [158]

Radiation Budget Variables [117]

Land Surface Reflectance [22]

Land Surface Temperature & Emissivity [18]

BRDF & Albedo [77]

Frequency Variables [18]

All Standard Collections

AERDB_D3_VIIRS_NOAA20
VIIRS/NOAA20 Deep Blue Level 3 daily aerosol data, 1x1 degree grid

AERDB_D3_VIIRS_SNPP
VIIRS/SNPP Deep Blue Level 3 daily aerosol data, 1x1 degree grid

AERDB_L2_VIIRS_NOAA20
VIIRS/NOAA20 Deep Blue Aerosol L2 6-Min Swath 6 km

AERDB_L2_VIIRS_SNPP
VIIRS/SNPP Deep Blue Aerosol L2 6-Min Swath 6 km

AERDB_M3_VIIRS_NOAA20
VIIRS/NOAA20 Deep Blue Level 3 monthly aerosol data, 1x1 degree grid

AERDB_M3_VIIRS_SNPP
VIIRS/SNPP Deep Blue Level 3 monthly aerosol data, 1x1 degree grid

AERDT_L2_VIIRS_NOAA20
VIIRS/NOAA20 Dark Target Aerosol 6-Min L2 Swath 6 km

✓ AERDT_L2_VIIRS_SNPP
VIIRS/SNPP Dark Target Aerosol L2 6-Min Swath 6 km

AMSL1B
Autonomous Modular Sensor (AMS) Calibrated, Geolocated Radiances L1B Data

AMSL2I
Autonomous Modular Sensor (AMS) Level 2 Ice Phase Data

AMSL2W
Autonomous Modular Sensor (AMS) Level 2 Water Phase Data

CLDCR_L2_VIIRS_SNPP
VIIRS/SNPP Cirrus Reflectance 6-min L2 Swath 750m

CLDMSK_L2_MODIS_Aqua
MODIS/Aqua Cloud Mask 5-Min Swath 1000 m (Aqua MODIS)

CLDMSK_L2_VIIRS_NOAA20
VIIRS/NOAA20 Cloud Mask 6-Min Swath 750 m (NOAA20 VIIRS)

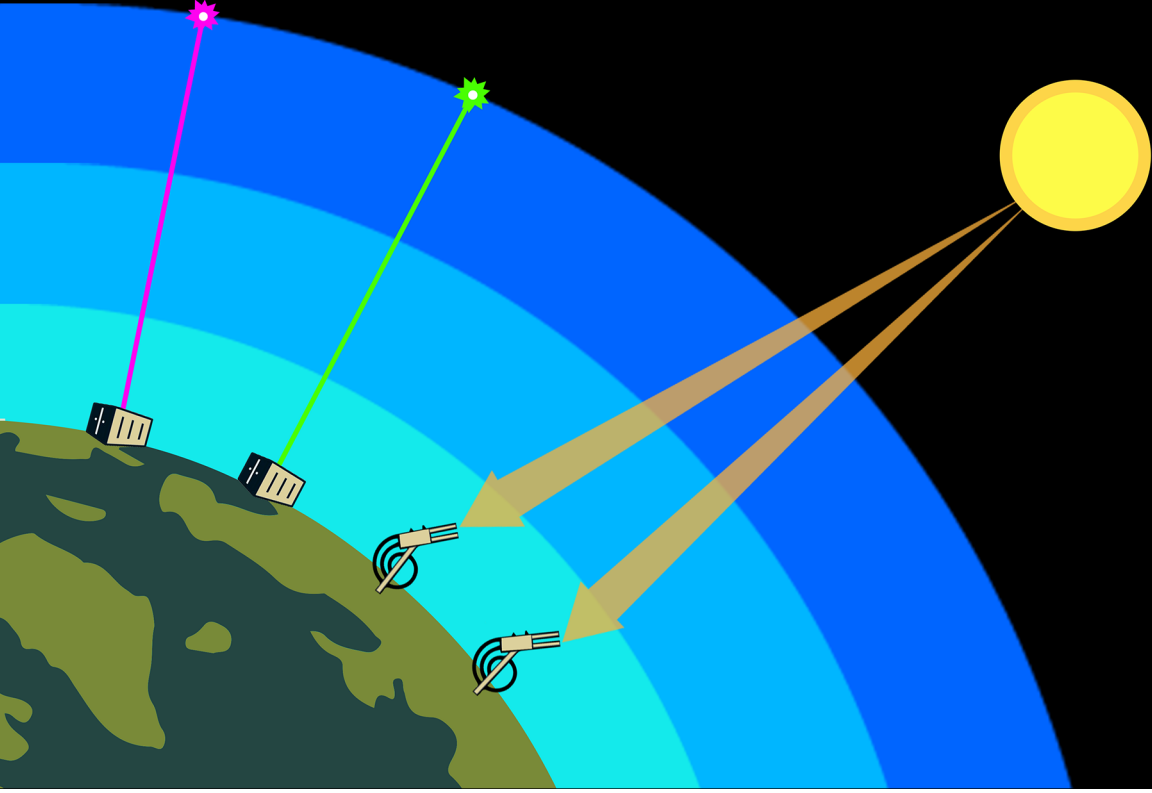
(5) VIIRS – AERONET Collocation Code Preliminaries (Query File)

- Select Product: AERDT_L2_VIIRS_SNPP
- Select Timeframe
- Specify Coordinates
- Download list of files as .csv, do not download the files themselves
- Ensure coordinates match for proper collocation (cell 7)

(6)

```
# Defining Global Variables
level =15 # AERONET data level --- 15 for Level 1.5
#average_type=2 #daily (1), hourly (2), timeavg (3)
AOD_min=0.0
AOD_max=1.0
long_west,long_east,lat_south,lat_north = 65., 130., -10., 35.
```





Part 2:
Summary

Summary

Network	Type	Primary Measurands	Number of Sites	Vertical Coverage
AERONET	Passive	Aerosols (Optical, Microphysical, Radiative)	~600 Active	Total Column

- There are many ways to access and analyze AERONET data:
 - The [AERONET website](#) links to interactive site maps, data visualizations, and download tools.
 - The [data synergy tool](#) allows comparison with satellite data and other ground networks.
 - The Web API allows programming languages to access data automatically.
 - The [AERONET GitHub](#) page includes examples of code to access data using the Web API.



Acknowledgments

- AERONET Team
- AERONET Site PIs
- AERONET Site Managers
- NASA HQ
- International Partners



Looking Ahead to Part 3

- We will learn about Pandora, another ground-based passive remote sensor.
- Pandora complements AERONET with information on trace gases like ozone and nitrogen dioxide.



Homework and Certificates

- **Homework:**
 - One homework assignment
 - Opens on 08/22/2024
 - Access from the [training webpage](#)
 - Answers must be submitted via Google Forms
 - **Due by 09/05/2024**
- **Certificate of Completion:**
 - Attend all five live webinars (attendance is recorded automatically)
 - Complete the homework assignment by the deadline
 - You will receive a certificate via email approximately two months after completion of the course.



Contact Information

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- aeronet-join@lists.nasa.gov

- [ARSET Website](#)
- Follow us on Twitter!
 - [@NASAARSET](#)
- [ARSET YouTube](#)

Visit our Sister Programs:



[DEVELOP](#)



[SERVIR](#)



Resources

- [AERONET Website](#)
 - [AERONET Site Information Map](#)
 - [AERONET Data Display Interface](#)
 - [AERONET Data Download Interface](#)
 - [AERONET Data Synergy Tool](#)
 - [AERONET Map Explorer](#)
 - [AERONET GitHub](#)





Thank You!

