

Credit: TROPOMI, ESA, Copernicus, KNMI



# High Resolution Aerosol Data

Pawan Gupta, and Melanie Follette-Cook

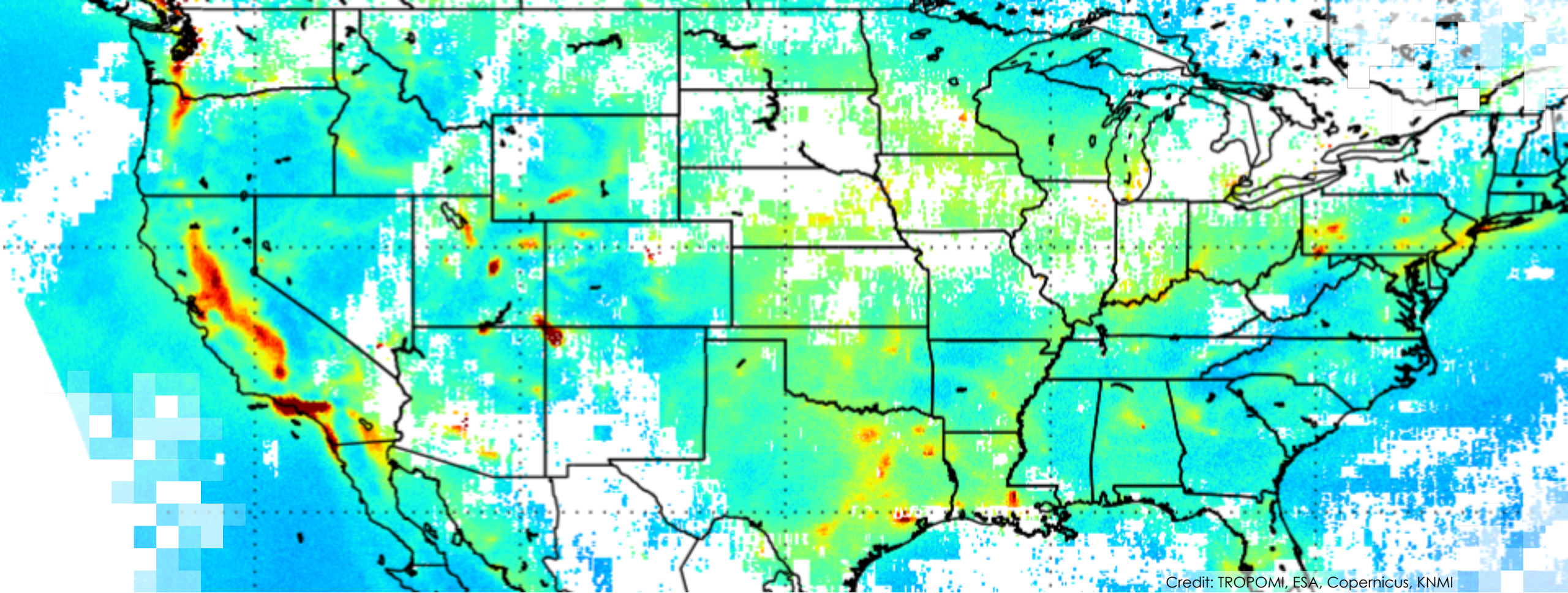
Application of Satellite Observations for Air Quality and Health Exposure, October 9-11, 2019

# Objectives

1. Gain knowledge of and ability to access available aerosol products from NASA sensors
2. Understand aerosol data format and variables

# Aerosol Data

- MODIS Terra & Aqua
  - Dark Target Aerosols
    - 10 km<sup>2</sup>, 3 km<sup>2</sup>
  - Deep Blue Aerosols
    - 10 km<sup>2</sup>
  - MAIAC Aerosols
    - 1 km<sup>2</sup>
- VIIRS-NPP
  - Deep Blue Aerosols (operational)
  - 6 km<sup>2</sup>



Know your Data

# Understanding a MODIS File Name

## Level 2, 10 km, Aerosol Product

### Product Name

- Terra: MOD04
- Aqua: MYD04

### Time

File processing information

**MOD04\_L2.A2001079.0255.061.2006289012028.hdf**

### Date

- Year
- Julian Day

### Collection

HDFLook, Panoply, IDL, Python, Fortran, MatLab, and more can be used to read the data

# Understanding a MODIS File Name

## Level 2, 3 km, Aerosol Product

### Product Name

- Terra: MOD04
- Aqua: MYD04

### Time

File processing information

**MOD04\_3K.A2001079.0255.061.2006289012028.hdf**

### Date

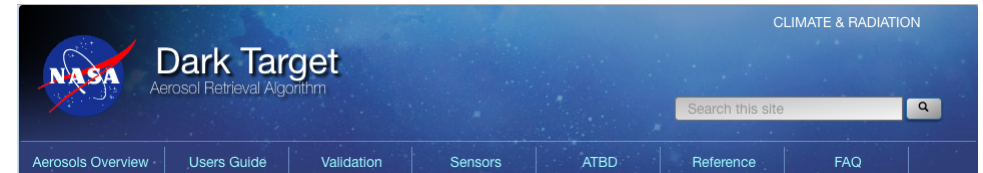
- Year
- Julian Day

### Collection

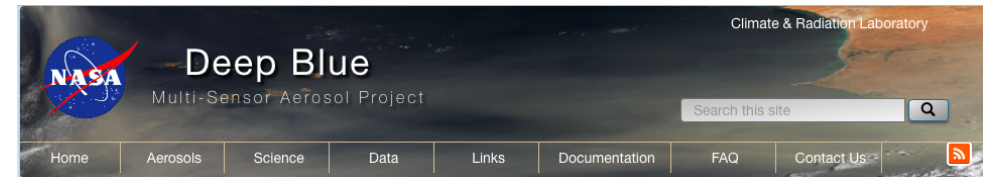
HDFLook, Panoply, IDL, Python, Fortran, MatLab, and more can be used to read the data

# MODIS Aerosol Parameters (SDS) – Deep Blue & Dark Target

- Optical\_Depth\_Land\_and\_Ocean
  - Retrieved using Dark Target Algorithm
  - Only high quality data
    - Over land QA = 3
    - Over ocean QA = 1, 2, 3
  - 10 km and 3km
- Quality\_Assurance\_Land
  - Quality flag associated with DD product
- Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_Best\_Estimate
  - 10 km
- Dark\_Target\_Deep\_Blue\_Optical\_Depth\_550\_Combined
  - Deep Blue & Dark Target Algorithm Merged Product
  - 10 km only



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



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

# MAIAC Data

- Collection 6 MAIAC product released in May 2018
- MCD19A2 – AOD, aerosol type, Smoke Plume Height at 1km<sup>2</sup>
- Data files – tiles of 10x10 deg.
- MCD19A2.A2019259.h11v04.006.2019261035902.hdf

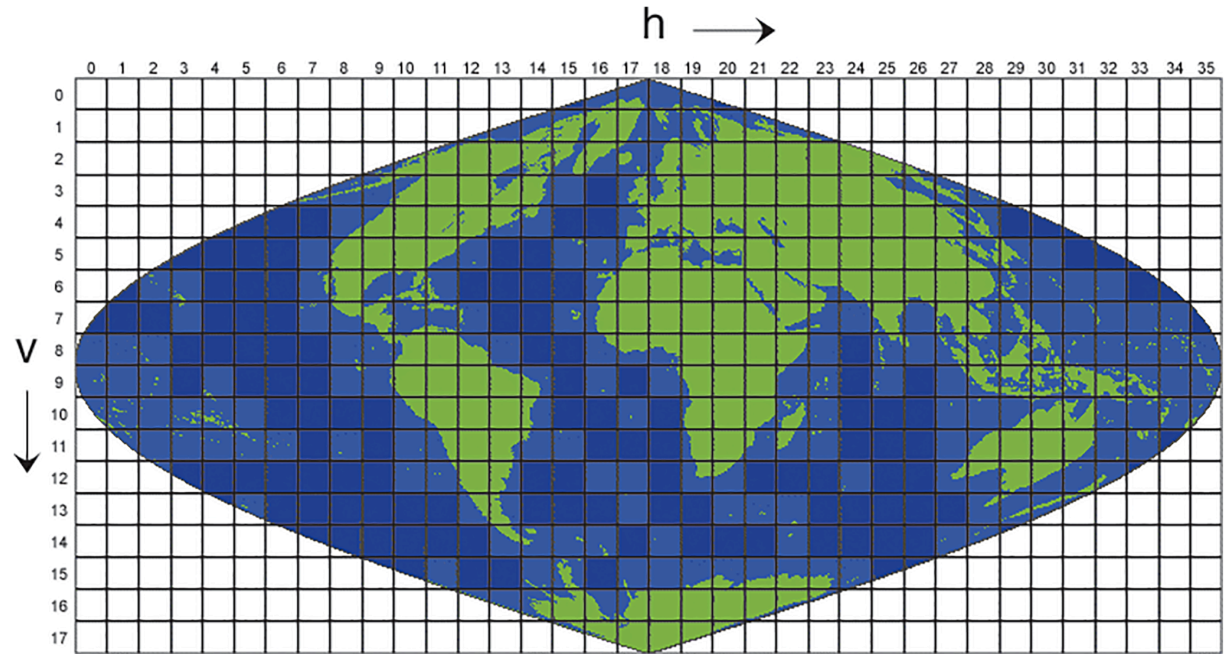


Image Credit: Lyapustin, A., Wang, Y., Korkin, S., & Huang, D. (2018). MODIS Collection 6 MAIAC algorithm. *Atmospheric Measurement Techniques*, 11(10), 5741–5765. <https://doi.org/10.5194/amt-11-5741-2018>



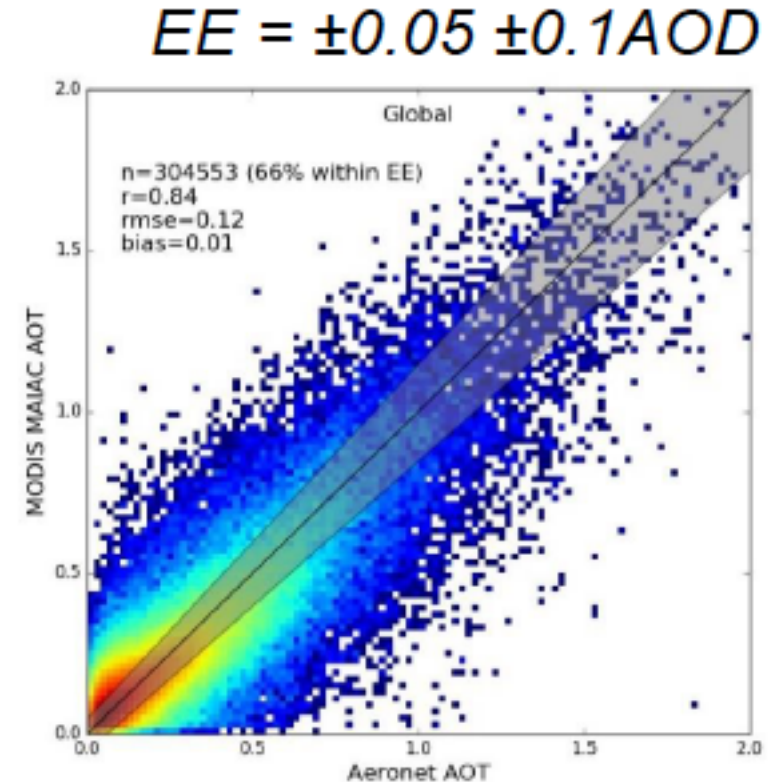
# MAIAC Validation & Data Access

- Operational Data Access
  - <https://ladsweb.modaps.eosdis.nasa.gov/>
- Near Real Time Data Access
  - <https://nrt3.modaps.eosdis.nasa.gov/archive/allData/6/MCD19A2N/2019/272>

More details – Lyapustin et al., 2018

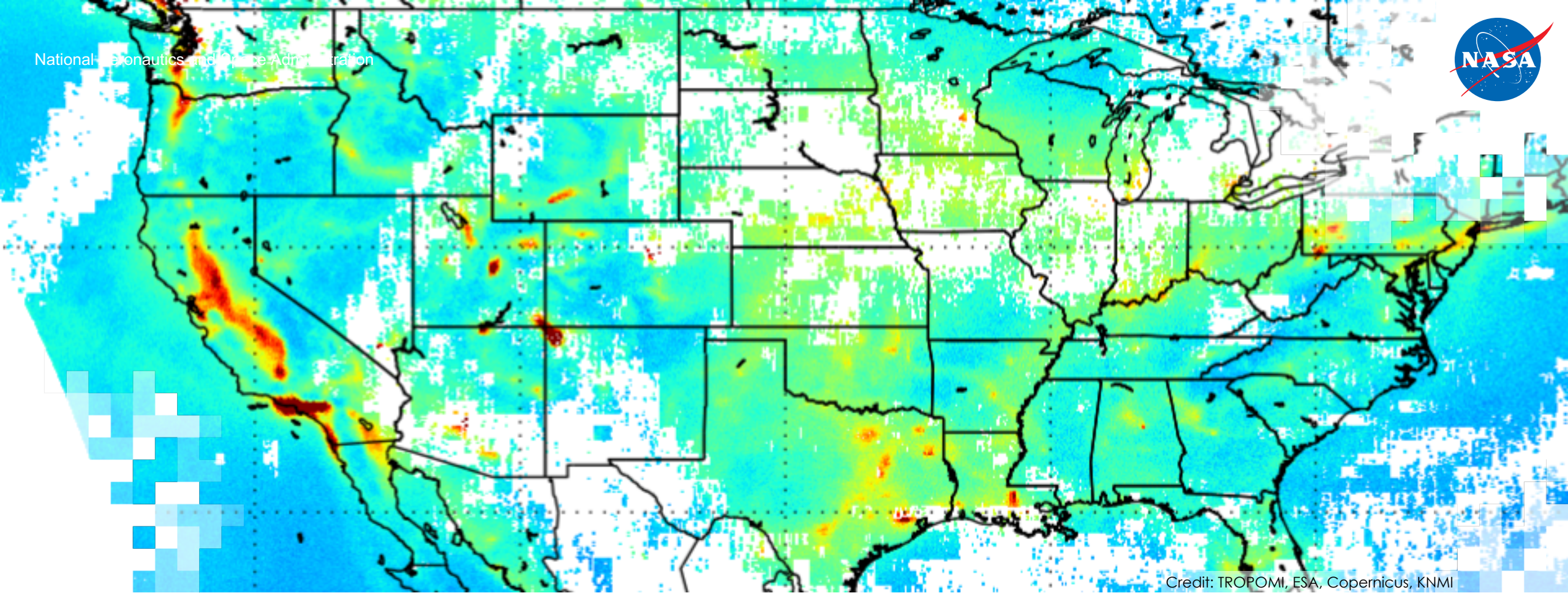
<https://www.atmos-meas-tech.net/11/5741/2018/>

Lyapustin et al., 2018



# VIIRS Deep Blue Aerosols

- Level 2 – 6x6 km<sup>2</sup>
- Level 3 – 1x1 degree (Daily, Monthly)
- NetCDF4 format
- 6 minute granule file
- Data Access - <https://ladsweb.modaps.eosdis.nasa.gov/>
- Filename
  - AERDB\_L2\_VIIRS\_SNPP.A2015272.1806.001.2018324161319.nc
  - Aerosol\_Optical\_Thickness\_550\_Land\_Ocean\_Best\_Estimate
  - Aerosol\_Optical\_Thickness\_550\_Land\_Ocean
  - Aerosol\_Optical\_Thickness\_QA\_Flag\_Land
  - Aerosol\_Optical\_Thickness\_QA\_Flag\_Ocean



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# Download MODIS Aerosol Data

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# Data Sets to Download

- <https://go.nasa.gov/2oFiADP>
- July 29, 2019
- Geographical Boundary
  - W: -129.4°, N: 45.7°, E: -108.2°, S: 27.5°
- Products
  - MYD04\_L2, MYD04\_3K
  - MOD04\_L2, MOD\_3K
  - MCD19A2
  - AERDB\_L2\_VIIRS\_SNPP

# Step 1: Visit <https://urs.earthdata.nasa.gov/users/new>



## EARTHDATA LOGIN

### Register for an Earthdata Login Profile

#### Profile Information

**Username:** •

**Password:** •

**Password Confirmation:** •

• Required field

#### Username must:

- Be a Minimum of 4 characters
- Be a Maximum of 30 characters
- Use letters, numbers, periods and underscores
- Not contain any blank spaces
- Not begin, end or contain two consecutive special characters( . \_ )

#### Password must contain:

- Minimum of 8 characters
- One Uppercase letter
- One Lowercase letter
- One Number


















# Step 2: Add LAADS Web to your Applications

- Login to Earthdata
- Click on **My Applications**
- Click on **Approve More Applications**
- Look for LAADS Web in the list or search
- Add LAADS Web to your applications

You should see LAADS Web in your list of approved applications

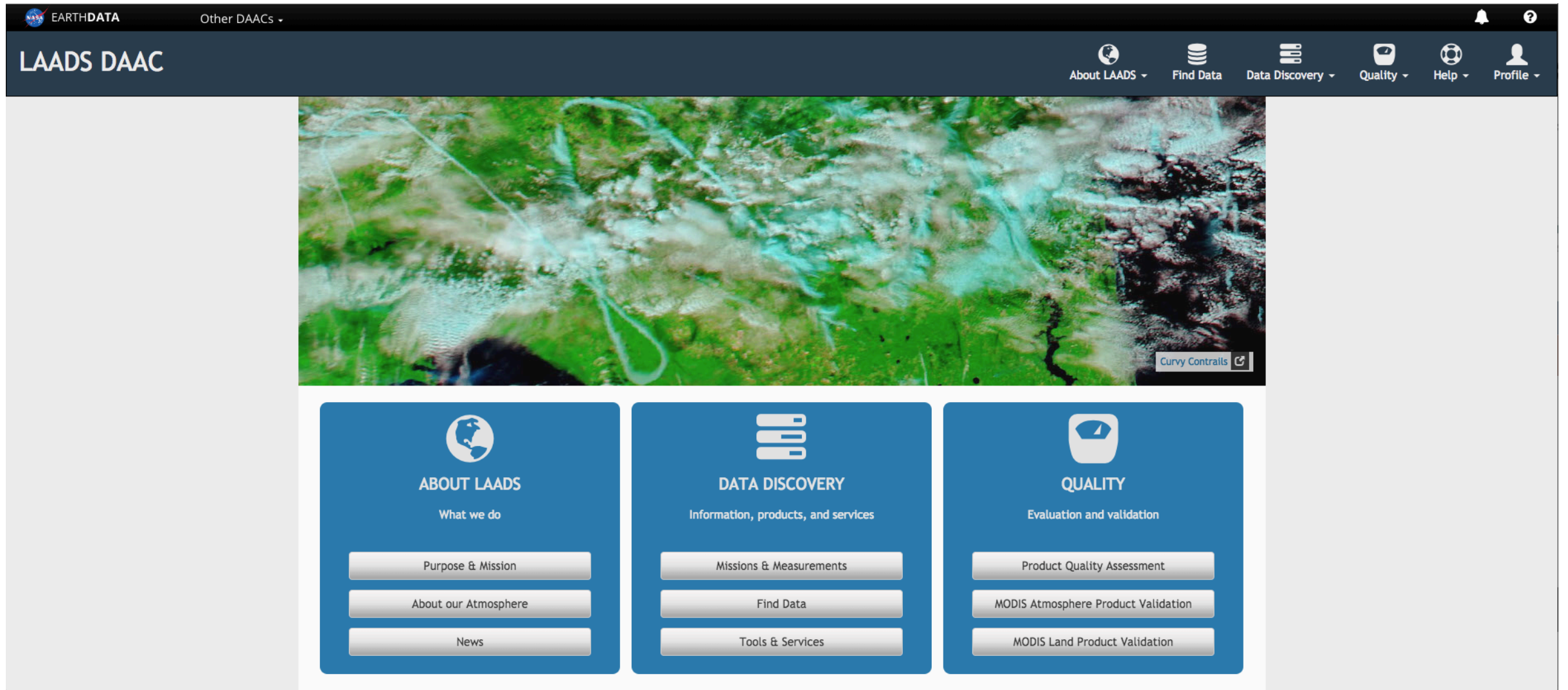
## Approved Applications

Applications that use your Earthdata Login profile for authentication.

Earthdata Feedback Module	
Earthdata Website	
Earthdata Code Collaborative	
Metadata Management Tool	
Earthdata Search	 
MISR Order and Customization Tool Production test site	 
NASA GESDISC DATA ARCHIVE	 
<b>LAADS Web</b>	  
SEDAC Website	 
LP DAAC Data Pool	 



# Step 3: Login at <https://ladsweb.modaps.eosdis.nasa.gov/>



The screenshot shows the LAADS DAAC website homepage. At the top left is the NASA EarthData logo and a link to "Other DAACs". The main header "LAADS DAAC" is on the left, and navigation icons for "About LAADS", "Find Data", "Data Discovery", "Quality", "Help", and "Profile" are on the right. A large satellite image of a forest with cyan overlays is the main visual. Below it are three blue panels: "ABOUT LAADS" (What we do) with links for Purpose & Mission, About our Atmosphere, and News; "DATA DISCOVERY" (Information, products, and services) with links for Missions & Measurements, Find Data, and Tools & Services; and "QUALITY" (Evaluation and validation) with links for Product Quality Assessment, MODIS Atmosphere Product Validation, and MODIS Land Product Validation.



# Step 4: Click on “Find Data”

The screenshot shows the LAADS DAAC website interface. At the top, there is a dark blue header with the NASA EARTHDATA logo on the left, a dropdown menu for 'Other DAACs', and navigation icons for 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. Below the header is a large satellite image of a landscape with a 'Curvy Contrails' watermark. The main content area features three blue panels. The first panel, 'ABOUT LAADS', includes buttons for 'Purpose & Mission', 'About our Atmosphere', and 'News'. The second panel, 'DATA DISCOVERY', includes buttons for 'Missions & Measurements', 'Find Data' (highlighted with a red box and a mouse cursor), and 'Tools & Services'. The third panel, 'QUALITY', includes buttons for 'Product Quality Assessment', 'MODIS Atmosphere Product Validation', and 'MODIS Land Product Validation'.





# Step 5: Make a Product Selection - Select Sensor

The screenshot displays the LAADS DAAC web interface. At the top left is the NASA logo and the text 'LAADS DAAC'. The top right contains navigation links: 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. Below the header is a progress bar with five steps: '1 PRODUCTS', '2 TIME', '3 LOCATION', '4 FILES', and '5 REVIEW & ORDER'. The 'PRODUCTS' step is active. Below the progress bar, there are status indicators: 'No products selected.', 'No date selected.', 'No location selected.', and 'No files selected.', along with a 'reset' button. A search bar on the right contains the text 'keyword'. A dropdown menu is open under the 'PRODUCTS' step, listing various sensors: 'Select a Sensor', 'Multiple (Ancillary Data)', 'MERIS:Envisat', 'MODIS:Aqua' (highlighted), 'MODIS:Combine Terra-Aqua', 'MODIS:Terra', 'OLCI:ESA-Copernicus-Sentinel-3A', 'SLSTR:ESA-Copernicus-Sentinel-3A', 'VIIRS:Suomi-NPP', and 'All Sensors'. The left sidebar contains icons for 'Search by Product', 'Online Archive', 'Filename Search', 'Image Viewer', 'Load/Save Search', and 'Past Orders'.



# Step 5: Make a Product Selection - Data Collection

The screenshot shows the LAADS DAAC web interface. At the top, the NASA logo and 'LAADS DAAC' are visible. The navigation bar includes 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. The main navigation tabs are '1 PRODUCTS', '2 TIME', '3 LOCATION', '4 FILES', and '5 REVIEW & ORDER'. Below the tabs, status indicators show 'No products selected.', 'No date selected.', 'No location selected.', and 'No files selected.', with a 'reset' button. A search bar contains the text 'keyword'. A dropdown menu is open for 'MODIS:Aqua', listing various collections. The selected item is '6 - MODIS Collection 6 - Level 1, Atmosphere, Land'. The main content area shows a list of products under the 'All' collection, including 'MYD00F', 'MYD01', 'MYD021KM', 'MYD02HKM', 'MYD02OBC', 'MYD02QKM', 'MYD02SSH', 'MYD03', 'MYD04\_3K', and 'MYD04\_L2'. Each product entry includes its name and a brief description.

**MODIS:Aqua**

- Select a Collection
- 4 - MODIS Collection 4 - Atmosphere Full Mission
- 4.1 - MODIS Collection 4.1 - Land Surface Temperature
- 5.1 - MODIS Collection 5.1 - Selected Atmosphere and Land
- 6 - MODIS Collection 6 - Level 1, Atmosphere, Land**
- 61 - MODIS Collection 6.1 - Level 1, Atmosphere, Land

MODIS Terra, Aqua [7]

**Atmosphere [12]**

- Aerosol [2]
- Water Vapor [1]
- Cloud Properties [1]
- Atmosphere Profiles [2]
- Cloud Mask [2]
- Joint L2 Atmosphere Product [1]
- L3 Atmosphere Product [3]

**Land [29]**

- Radiation Budget Variables [16]**
  - Land Surface Reflectance [7]
  - Land Surface Temperature & Emissivity [9]
- Ecosystem Variables [9]**
  - Vegetation Indices [6]
  - LAI & PAR [1]

**All**

Collection ( 6 - MODIS Collection 6 - Level 1, Atmosphere, Land )

<b>MYD00F</b> MODIS/Aqua Level 0 Raw Instrument Packets (5 minutes)	i
<b>MYD01</b> Level 1A Scans of raw radiances in counts	i
<b>MYD021KM</b> Level 1B Calibrated Radiances - 1km	i
<b>MYD02HKM</b> Level 1B Calibrated Radiances - 500m	i
<b>MYD02OBC</b> Level 1B Onboard Calibrator/Engineering Data	i
<b>MYD02QKM</b> Level 1B Calibrated Radiances - 250m	i
<b>MYD02SSH</b> MODIS/Aqua Level 1B Subsampled Calibrated Radiances 5km	i
<b>MYD03</b> Geolocation - 1km	i
<b>MYD04_3K</b> MODIS/Aqua Aerosol 5-Min L2 Swath 3km	i
<b>MYD04_L2</b> MODIS/Aqua Aerosol 5-Min L2 Swath 10km	i



# Step 5: Make a Product Selection – Data Product

The screenshot displays the LAADS DAAC web interface. At the top, the NASA logo and 'LAADS DAAC' are visible. The navigation bar shows five steps: 1. PRODUCTS (active), 2. TIME, 3. LOCATION, 4. FILES, and 5. REVIEW & ORDER. Below the navigation bar, there are status indicators: 'No date selected.', 'No location selected.', and 'No files selected.', along with a 'reset' button. The main content area is divided into a sidebar on the left and a main panel on the right. The sidebar contains search filters: 'All [57]', 'Level-0 / Level-1 [7]', 'Atmosphere [12]', 'Aerosol [2]', 'Water Vapor [1]', 'Cloud Properties [1]', 'Atmosphere Profiles [2]', 'Cloud Mask [2]', 'Joint L2 Atmosphere Product [1]', 'L3 Atmosphere Product [3]', 'Land [29]', 'Radiation Budget Variables [16]', and 'Ecosystem Variables [9]'. The 'Aerosol' category is selected. The main panel shows a search bar with the text 'Aerosol' and a 'keyword' input field. Below the search bar, two product entries are listed: 'MYD04\_3K' (MODIS/Aqua Aerosol 5-Min L2 Swath 3km) and 'MYD04\_L2' (MODIS/Aqua Aerosol 5-Min L2 Swath 10km). Both products are highlighted in green, indicating they are selected. A mouse cursor is pointing at the 'MYD04\_L2' entry. The bottom right corner of the interface features a 'Clear Selected Products' button.



# Step 6: Select Time

LAADS DAAC

About LAADS Find Data Data Discovery Quality Help Profile

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

Products (Collection) No date selected. No location selected. No files selected. reset

MODIS:Aqua Select a Collection

Products (Collection) Add product MYD04\_3K (6) MYD04\_L2 (6)

Aerosol Collection ( 6 - MODIS Collection 6 - Level 1, Atmosphere, Land ) keyword

Clear Selected Products

All [57]

Level-0 / Level-1 [7]

MODIS Terra, Aqua [7]

Atmosphere [12]

Aerosol [2]

Water Vapor [1]

Cloud Properties [1]

Atmosphere Profiles [2]

Cloud Mask [2]

Joint L2 Atmosphere Product [1]

L3 Atmosphere Product [3]

Land [29]

Radiation Budget Variables [16]

Land Surface Reflectance [7]

Land Surface Temperature & Emissivity [9]

Ecosystem Variables [9]

Vegetation Indices [6]

LAL & PAR [1]

Click on the next arrow on the right, or click on the TIME tab



# Step 6: Select Time

The screenshot shows the LAADS DAAC search interface. The navigation bar at the top has five steps: 1 PRODUCTS, 2 TIME, 3 LOCATION (highlighted with a red circle and a mouse cursor), 4 FILES, and 5 REVIEW & ORDER. Below the navigation bar, there are three status bars: '2 products selected' with a date range of '2017-10-08 .. 2017-12-09', 'No location selected.', and 'No files selected.' with a 'reset' button. The main content area is divided into two panels. The left panel has a 'Date Range' section with a 'Date Range' button (highlighted with a red circle and a mouse cursor) and a 'Single Date' button. Below this is a 'Display as:' dropdown set to 'YYYY-MM-DD', and two date pickers showing '2017-10-08' and '2017-12-09'. An 'Add Date' button is also highlighted with a red circle and a mouse cursor. The right panel has a 'Date Selection:' section with a 'Clear All' button and a date range '2017-10-08 .. 2017-12-09' with edit and delete icons. At the bottom, there is a 'Coverage Selection:' section with two radio buttons: 'Day' (checked) and 'Day-Night Boundary'. Explanatory text for each option is provided: '(granules contain day data only)' for 'Day' and '(granules contain data over the seasonal, latitude boundary between day and night)' for 'Day-Night Boundary'.

- Select **Date Range** or **Single Date**
- Click **Add Date**
- Click **Location**



# Step 7: Select a Location or Region

LAADS DAAC

Search by

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

2017-10-08 .. 2017-12-09 W: -123.7°, N: 38.4°, E: -120.6°, S: 35.9° No files selected. reset

Lat: 36.71°, Lon: -119.86°

**SELECT AREA OF INTEREST**

- World
- Countries
- Tiles
- Validation Sites
- Draw Custom Box (Classic)**  
Draw box on the map. Panning is disabled.
- Enter Coordinates

Current selection:  
W: -123.7°, N: 38.4°, E: -120.6°, S: 35.9°

- Select **Draw Custom Box (Classic)**
- Draw a box over the Bay Area, California
- Click the **next** arrow
- The program will start searching data



# Step 8: Files

The screenshot shows the LAADS DAAC interface. At the top, there are navigation tabs: 1 PRODUCTS, 2 TIME, 3 LOCATION, 4 FILES (selected), and 5 REVIEW & ORDER. A red circle highlights the right-pointing arrow icon in the REVIEW & ORDER tab. Below the tabs, there are filters for products (2 selected), time (2017-10-08 to 2017-12-09), location (W: -123.7°, N: 38.4°, E: -120.6°, S: 35.9°), and files (236 selected). A red circle highlights the 'Select All' button in the file selection area. Below the filters is a table of files with columns: Filename, Product (collection), Image, Date / Time, and Download. A white text box with a black border is overlaid on the table, containing the following instructions:

- Click **Select All**
- Click the Next Arrow

Filename	Product (collection)	Image	Date / Time	Download
MYD04_3K.A2017281.2105.006.2017282153727.hdf	MYD04_3K (6)		2017-10-08 21:05:00	11 MB
MYD04_L2.A2017281.2105.006.2017282154132.hdf	MYD04_L2 (6)		2017-10-08 21:05:00	5 MB
MYD04_3K.A2017282.2150.006.2017283153744.hdf	MYD04_3K (6)		2017-10-09 21:50:00	10 MB
MYD04_L2.A2017282.2150.006.2017283153836.hdf	MYD04_L2 (6)		2017-10-09 21:50:00	3 MB
MYD04_3K.A2017282.2145.006.2017283153759.hdf	MYD04_3K (6)		2017-10-09 21:45:00	9 MB
MYD04_L2.A2017282.2145.006.2017283153915.hdf	MYD04_L2 (6)		2017-10-09 21:45:00	3 MB
MYD04_3K.A2017282.2010.006.2017283154914.hdf	MYD04_3K (6)		2017-10-09 20:10:00	7 MB
MYD04_L2.A2017282.2010.006.2017283155401.hdf	MYD04_L2 (6)		2017-10-09 20:10:00	4 MB
MYD04_3K.A2017283.2050.006.2017284154548.hdf	MYD04_3K (6)		2017-10-10 20:50:00	10 MB
MYD04_L2.A2017283.2050.006.2017284155153.hdf	MYD04_L2 (6)		2017-10-10 20:50:00	5 MB
MYD04_3K.A2017284.2135.006.2017285155249.hdf			-10-11 21:35:00	16 MB
MYD04_L2.A2017284.2135.006.2017285155410.hdf			-10-11 21:35:00	4 MB
MYD04_3K.A2017285.2215.006.2017286165521.hdf			-10-12 22:15:00	9 MB
MYD04_L2.A2017285.2215.006.2017286165605.hdf			-10-12 22:15:00	3 MB
MYD04_3K.A2017285.2040.006.2017286165607.hdf	MYD04_3K (6)		2017-10-12 20:40:00	9 MB
MYD04_L2.A2017285.2040.006.2017286170047.hdf	MYD04_L2 (6)		2017-10-12 20:40:00	5 MB
MYD04_3K.A2017286.2125.006.2017287160915.hdf	MYD04_3K (6)		2017-10-13 21:25:00	11 MB



# Step 9: Submit Order

The screenshot shows the 'REVIEW & ORDER' step of the LAADS DAAC data submission process. The interface includes a top navigation bar with the NASA logo and 'LAADS DAAC' text, and a secondary navigation bar with links for 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. Below this is a progress indicator with five steps: 1. PRODUCTS, 2. TIME, 3. LOCATION, 4. FILES, and 5. REVIEW & ORDER (highlighted). A summary bar shows '2 products selected', the time range '2017-10-08..2017-12-09', location coordinates '-123.7, 38.4, -120.6, 35.9', and '236 files selected'. A 'reset' button is also present.

The main content area is divided into two columns. The left column, titled 'Files Summary:', contains two entries for 'Collection 6':

- MYD04\_3K** (Collection 6) [ 2017-10-08 21:05:00 .. 2017-12-09 21:15:00 ]  
The order will generate 118 files. Total: 118 files ✖
- MYD04\_L2** (Collection 6) [ 2017-10-08 21:05:00 .. 2017-12-09 21:15:00 ]  
The order will generate 118 files. Total: 118 files ✖

The right column contains three blue buttons: 'Apply Post-Processing', 'Select Delivery Method', and 'Add another search'. Below these is a grey bar stating 'The order may generate as many as 236 files.' At the bottom right, a green 'Submit Order' button is highlighted with a red circle and a mouse cursor.

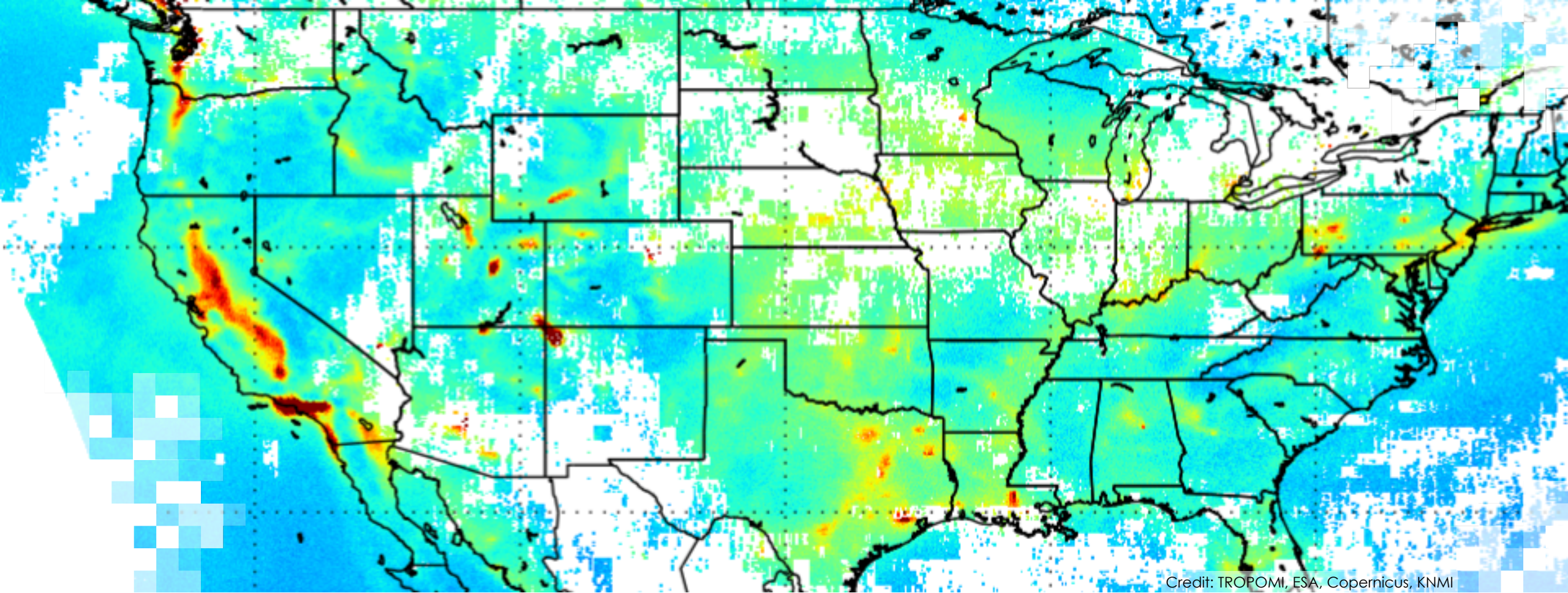




# Step 10: Download the Data

- After placing your order, check your email for order confirmation
- Follow the instructions in the email to download the data
- Save the data in your directory where you will run your python scripts





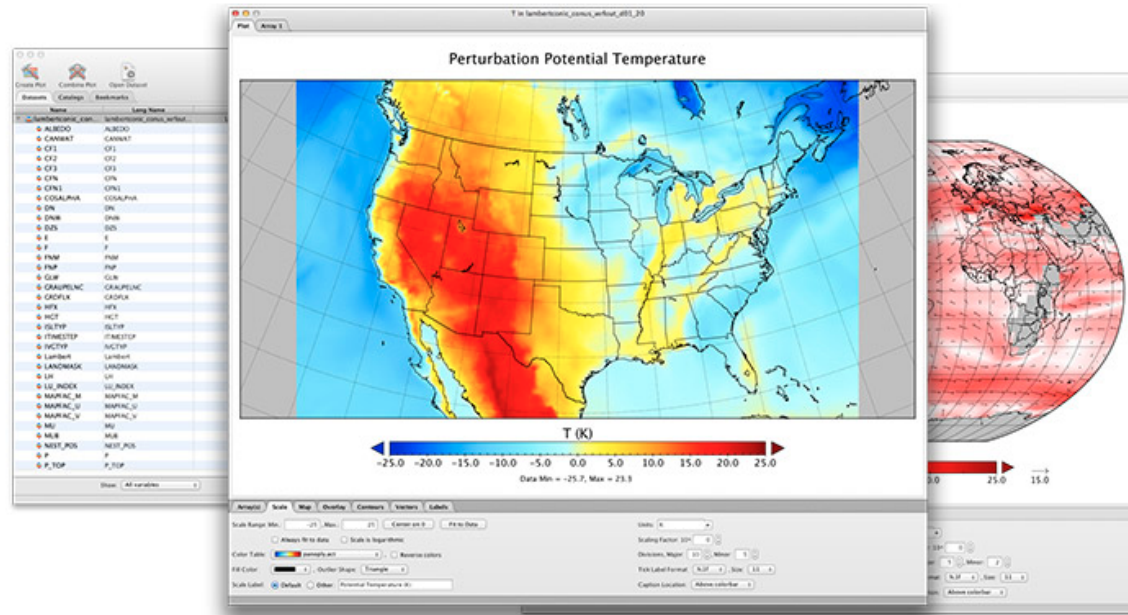
## Mapping Aerosol Data with Panoply

# Panoply

<https://www.giss.nasa.gov/tools/panoply/>

Panoply netCDF, HDF and GRIB Data Viewer

*panoply* \PAN-uh-plee\, noun: 1. A splendid or impressive array. ...



Can analyze NetCDF, HDF, GRIB, and more  
Runs on Mac, Windows, and Linux

With Panoply 4 you can:

- Plot variety of 2D and 1D arrays
- Combine two arrays in one plot by differencing, summing or averaging.
- Plot maps using any of 100+ map projections
- Change color tables, or apply your own (ACT, CPT, or RGB)
- Save plots as GIF, JPEG, PNG or TIFF bitmap images or as PDF or PS
- Export map plots in KMZ format.
- Export animations as MP4 video or as a collection of individual frame images.

