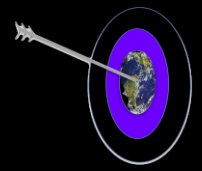

Level-1 and Atmosphere Archive & Distribution System / Distributed Active Archive Center



Dark Target



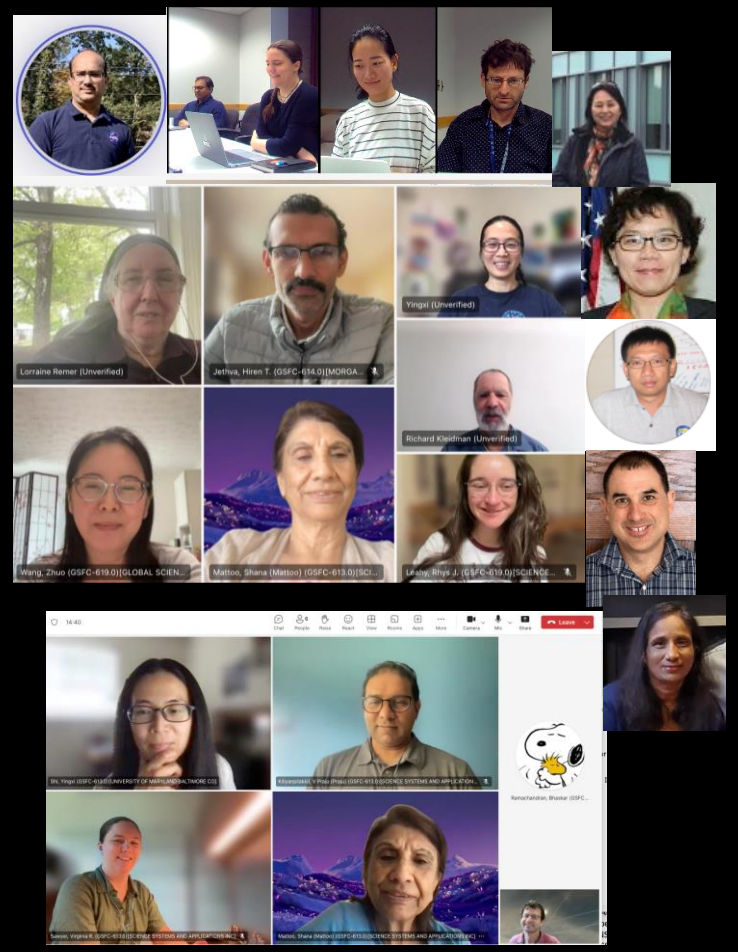
# Introduction to NASA's GEO-LEO "Dark Target" Aerosol Data Products

Robert Levy (NASA/GSFC Code 613)

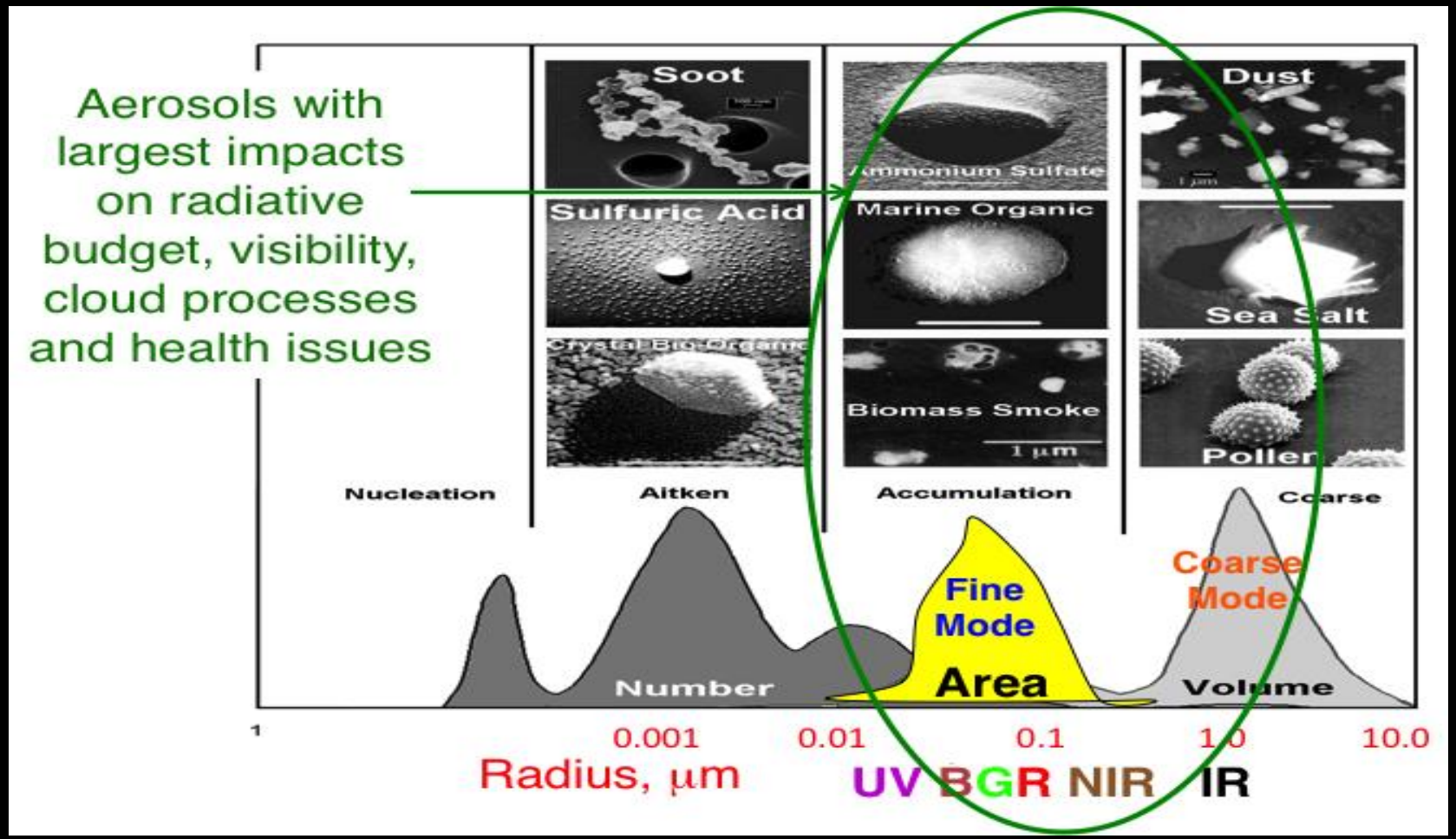
June 10, 2024

# Lots of contributions

- GSFC 613/Climate and Radiation Lab: S. Mattoo, Y. R. Shi, V. R. Sawyer, V. P. Kiliyanpilakkil & M. Kim
- GSFC 619/Terrestrial Information Systems Lab: B. Ramachandran, J. Wei, Z. Zhang, *et al*
- GSFC 618/Biospheric Science Lab: P. Gupta
- University of Maryland-Baltimore County (UMBC): L. Remer
- U. Wisconsin-Madison/Space Science and Engineering Center (SSEC): M. Oo, R. E. Holz, *et al*
- NOAA/NESDIS/STAR: S. Kondragunta, H. Zhang, *et al*.
- GSFC/Interns: S. Zhao, N. Gutkin



# Aerosol size and optical properties




- Aerosols are fine particles of solid or liquid suspended in a gas, like our atmosphere.
- Aerosols come from both natural sources such as dust, sea salt, and volcanoes and man-made sources such as automobile and power plant emissions. Forest fires and crop burning, also known as biomass burning, can be natural and/or man-made.

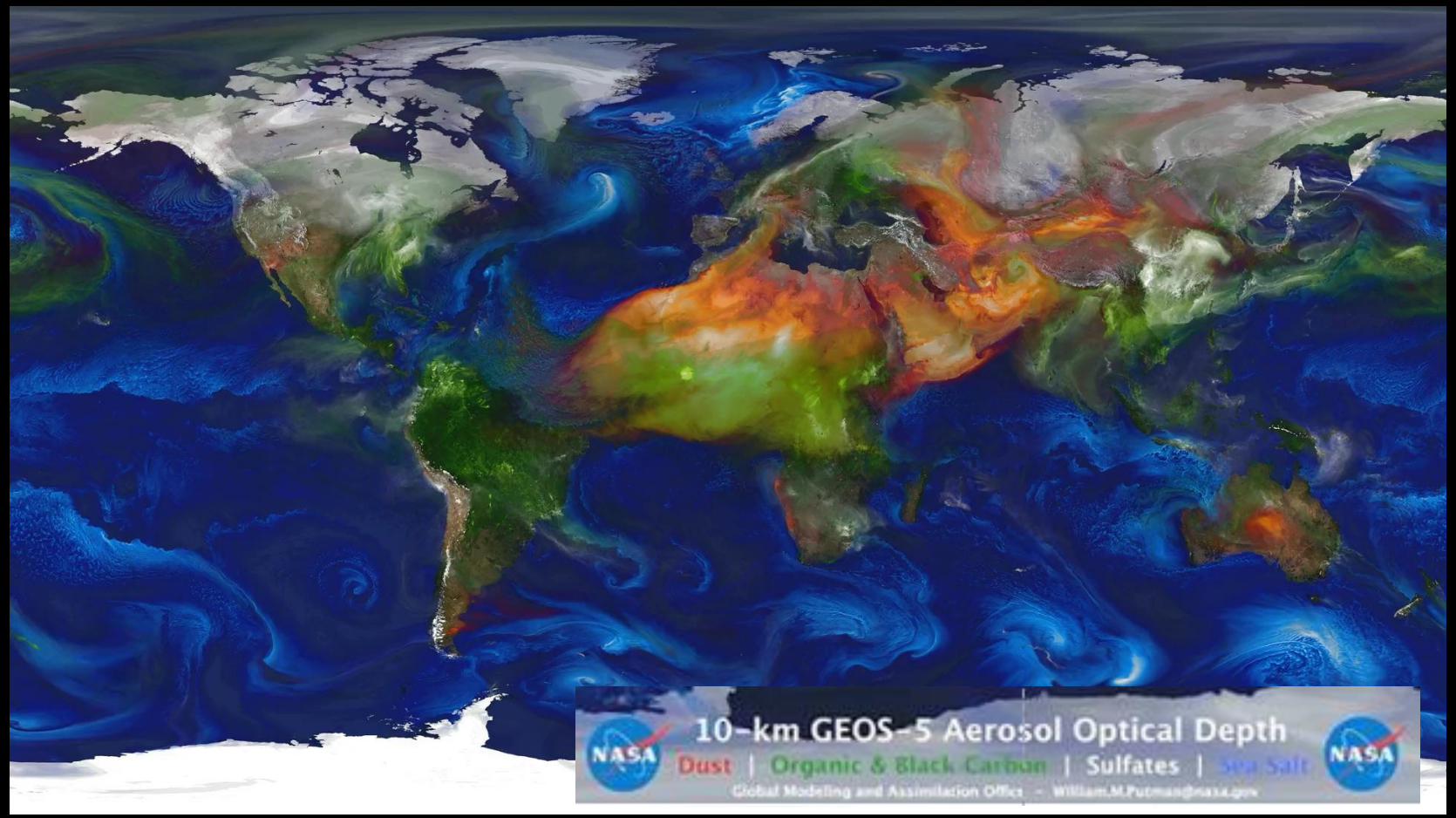
(https://darktarget.gsfc.nasa.gov/why-study-aerosols)

# Why do we care about aerosols?

- They affect visibility
- They affect human health and morbidity
- They enable clouds and precipitation
- They have roles in Earth's chemistry (carbon, sulfate, etc)
- They have roles in biology (e.g. transport nutrients)
- They directly impact the radiative budget
- They are both natural and manmade
- They are inhomogeneous in space and time
- Their distributions are changing
- The science of aerosols is truly "interdisciplinary"

- **We need datasets that characterize climatology , trends and variability**

# This is a model of aerosols around the world




- People impacted by poor air quality can benefit from better modeling, forecasting and assimilation research to understand how aerosols are transported
- Can we help people know when poor air quality is headed their way?

Can we “observe” any of these global aerosols?

# We can see aerosol from space! MODIS

Haze over the Ganges/Bay of Bengal (4 December 2001)

Smoke from Canada into USA (8 July 2002)

http://earthobservatory.nasa.gov

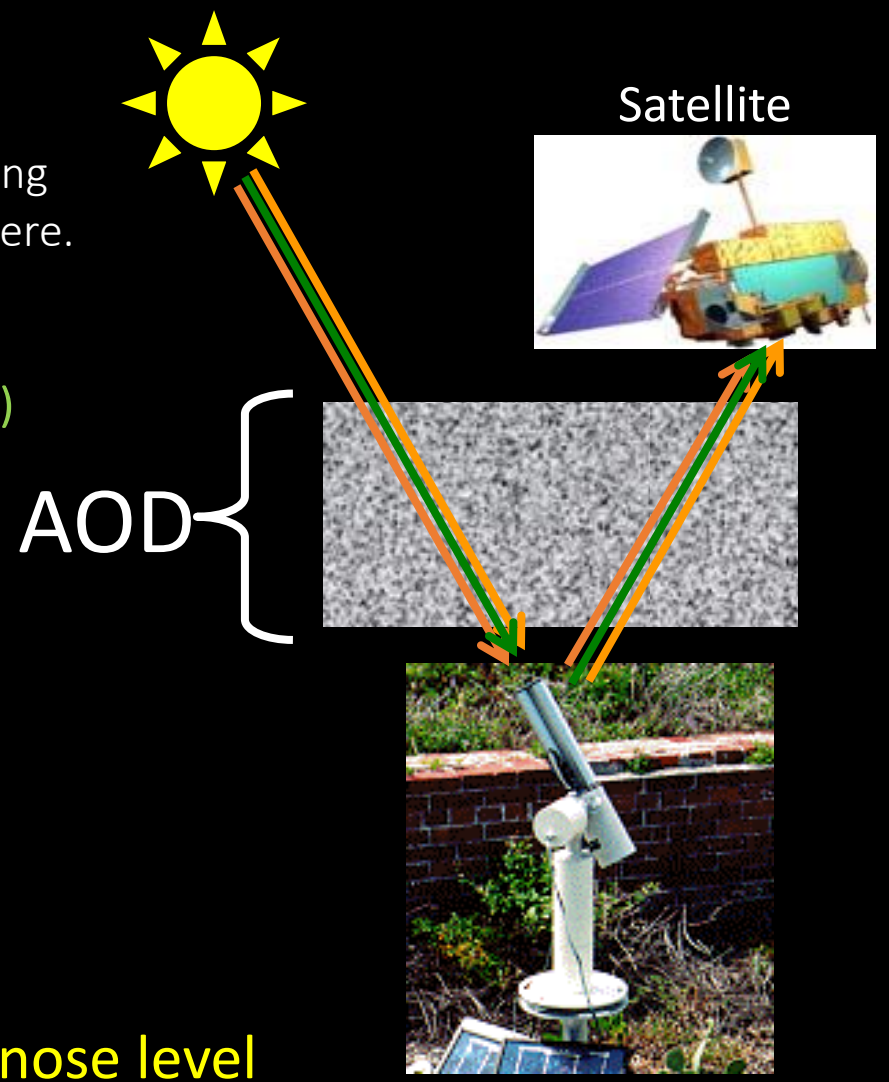
# Passive Remote Sensing of AOD

*Optical Depth* is related to the quantity of light *I* removed from a beam by scattering and absorption (the sum is known as extinction) during its path through atmosphere.

The portion that is due to aerosols is known as *Aerosol Optical Depth (AOD).*
AOD is "wavelength dependent", but is commonly reported in mid-visible (*0.55 μm*)

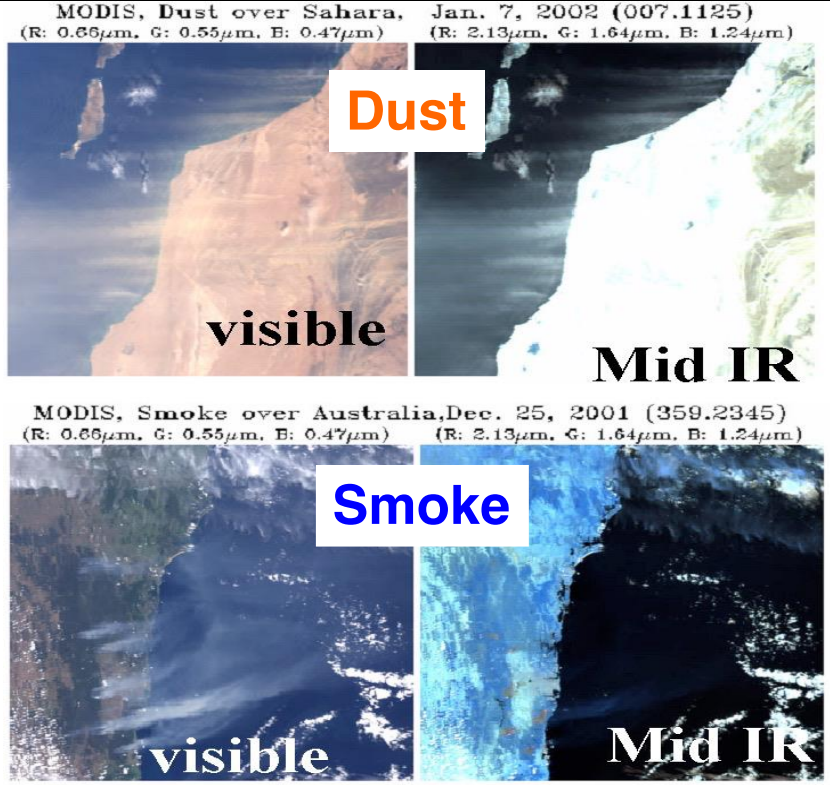
- AOD measured using a sunphotometer at the surface
  - Ground reflectance negligible
  - Extinction is measured

- AOD can be estimated from a passive sensor on a satellite
  - Ground reflectance NOT negligible
  - Satellite only observes the light scattered portion (must assume absorbed portion).




Note: AOD represents the "ENTIRE" atmosphere, not just at nose level

# So…. what is the Dark Target (DT) algorithm?

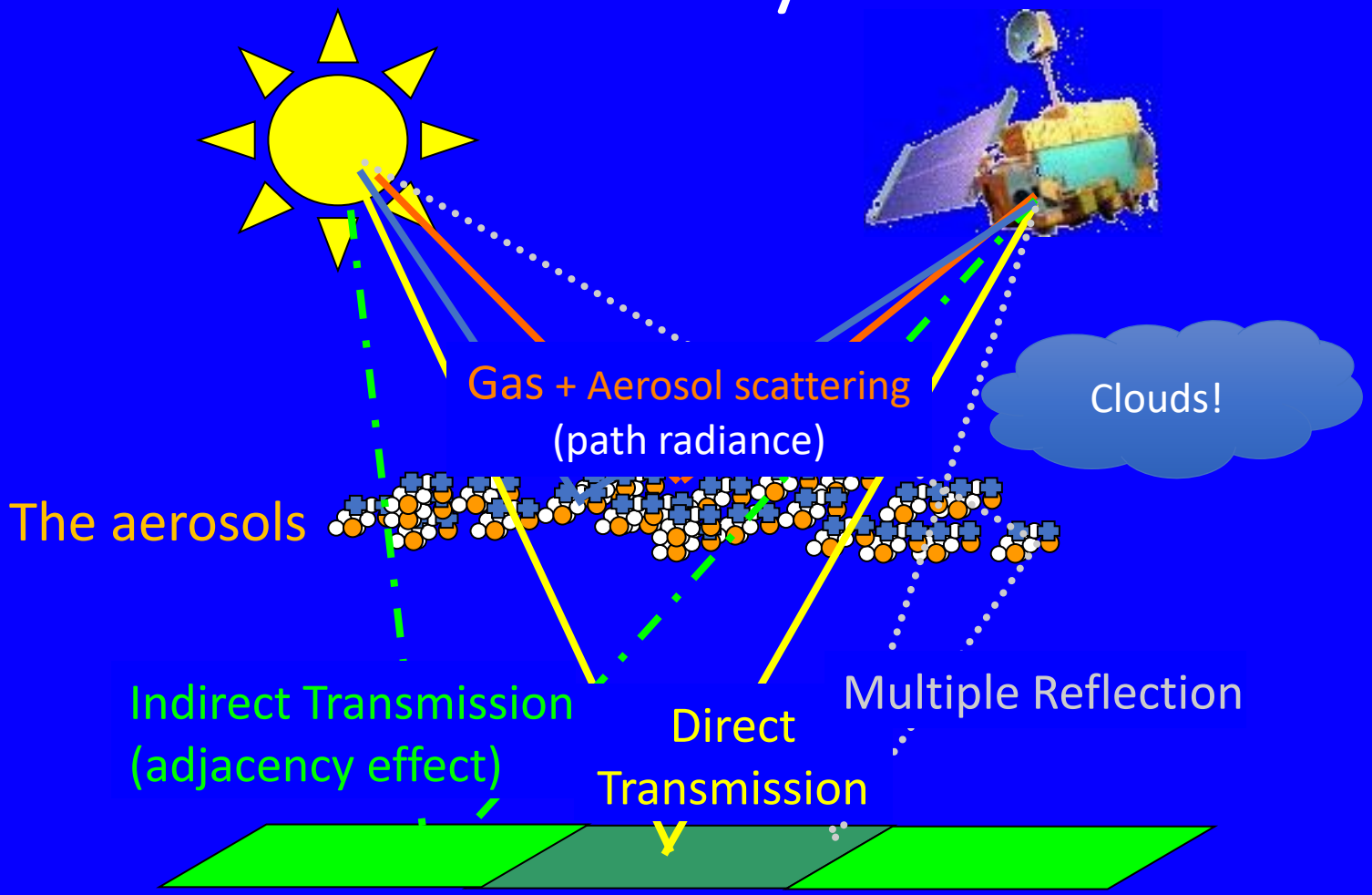



"Big" particles (e.g. Dust) reflect in IR
"Small" particles (smoke/pollution) do not.

- Relies on surfaces (or "targets") that are ***dark***, which offer a contrast to the aerosol above.
  - Open ocean is dark in near-infrared wavelengths
  - Dense Dark Vegetation (DDV) is dark in some visible and shortwave infrared wavelengths
- "bright surfaces" such as deserts and ice/snow are not suitable - therefore there are other algorithms/products that are more appropriate. (Deep Blue, MAIAC, etc.)
- DT requires "clear sky" (no clouds), and to be far from "sun glint" (specular reflection). Also doesn't work at night.

Y. Kaufman, D. Tanré, L. Remer, J.V. Martins *et al.*

# DT must account for many factors

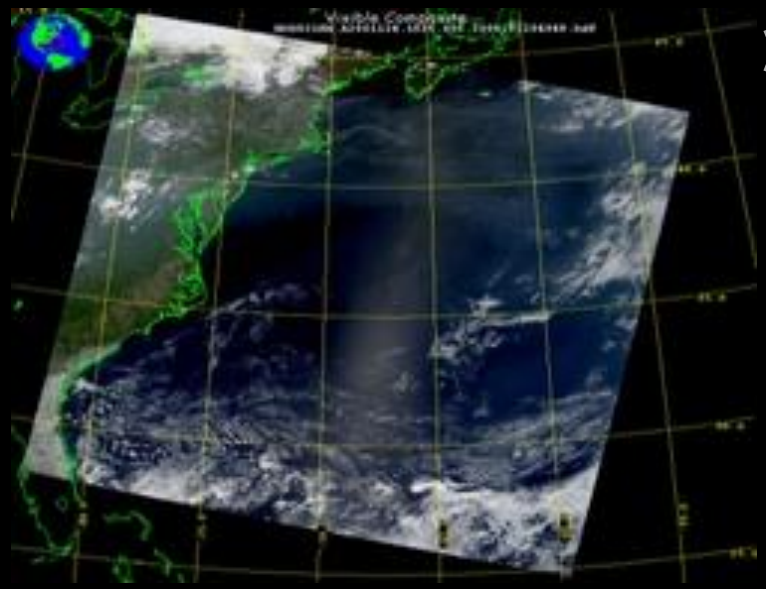


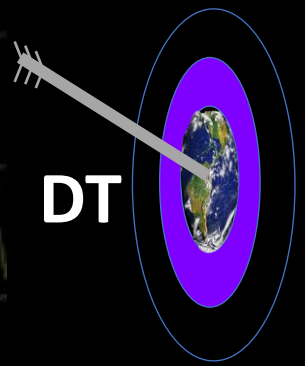

1) Aerosol properties
2) The surface
3) Rayleigh scattering
4) Gas absorption
5) 3-D reflective processes

***6) Cloud masking!***

## What a sensor observes

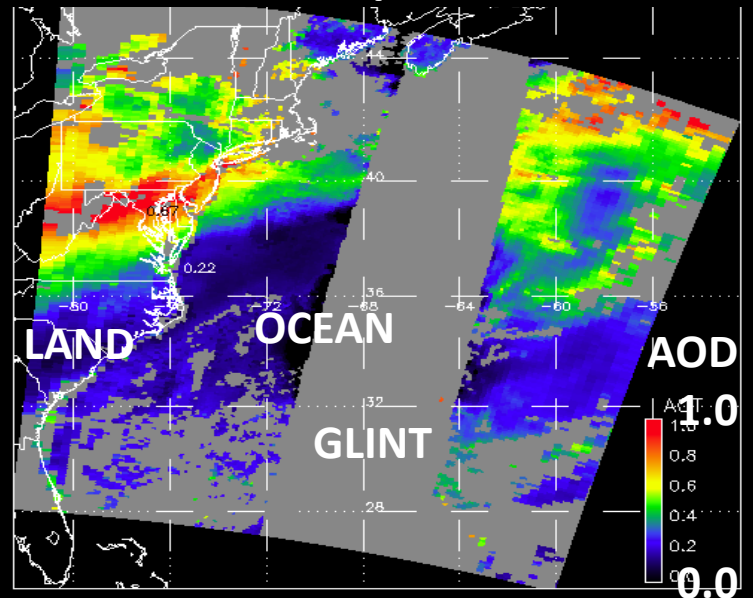
**May 4, 2001; 13:25 UTC**
**Level 1 "reflectance"**






## Attributed to aerosol (AOD)

**May 4, 2001; 13:25 UTC**
**Level 2 "product"**




# Dark Target Product (Level 2)

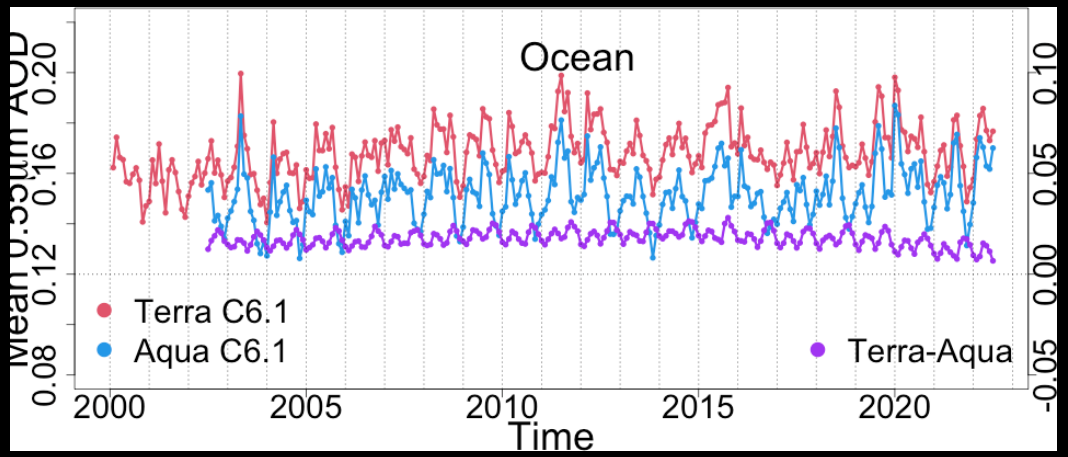
- Established by Kaufman, Tanré, Remer, et al (1997)
- Modified by Remer, Levy, Gupta, Sawyer, Shi et al (2005, 2010, 2013, 2015, 2020, etc.)
- Continuous "validation" compared to sunphotometers

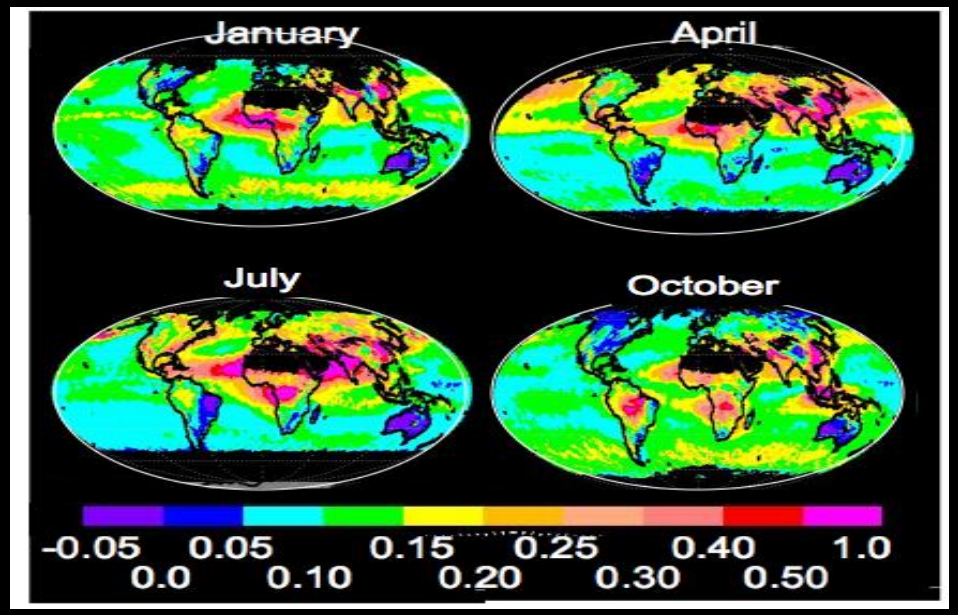
- **Requires:** Observations of spectral reflectance in selected bands between "blue" and "SWIR" wavelengths (other bands help with cloud/surface masking and filtering)
- **Retrieves:** AOD at 0.55 μm, spectral AOD (AE), cloud-cleared reflectances, diagnostics, Quality Assurance
- **Originally developed for MODIS** = Moderate-resolution Imaging Spectroradiometer.

# Dark Target applied to MODIS: What have we learned?

## = Daytime view of global aerosol system (minus the deserts and poles)

- As envisioned by Kaufman & Tanré et al.
- Maintained by the team at NASA GSFC
- Products hosted by LAADS-DAAC.
- Aggregation of the L2 product into 1°x1° grids and daily/monthly lead to Level 3 (L3).




- Two sophisticated sensors (aboard Terra since 2000 and Aqua since 2002), each with stable orbits, excellent calibration teams and validated aerosol retrieval algorithms and products.
- Small differences consistent within expected uncertainties

# Global Climate Observing System (GCOS)

requirements for **Aerosol Optical Depth (AOD)** climate data record (CDR):

| Target metric | Target |
|---|---|
| Horizontal Resolution | 5-10 km, globally |
| Accuracy | MAX(0.03 or 10%) |
| Stability / bias | <0.01 / decade |
| **Time Length** | **30+ years** |
| **Temporal Resolution** | **4 h** |

} MODIS data record (ending soon at ~25 years)

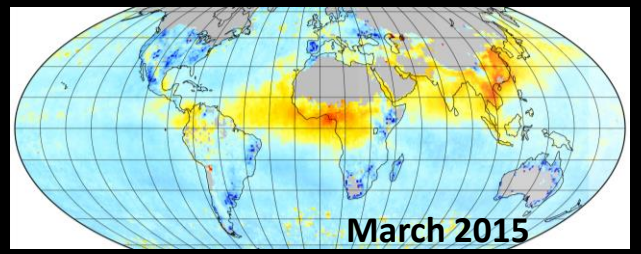
} Extend time series

} expand temporal sampling

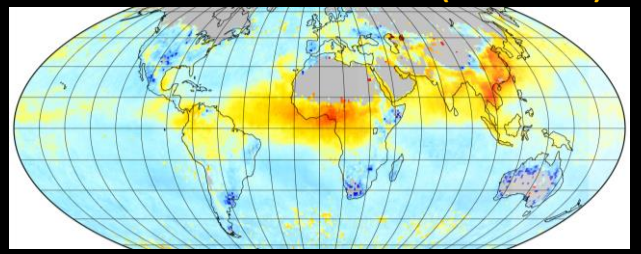
# Extend DT record with VIIRS (Visible-Near Infrared Radiometer Suite)

2000 ← MODIS → 2026

MODIS on Aqua (c. 2002)




VIIRS on Suomi-NPP (c. 2011)

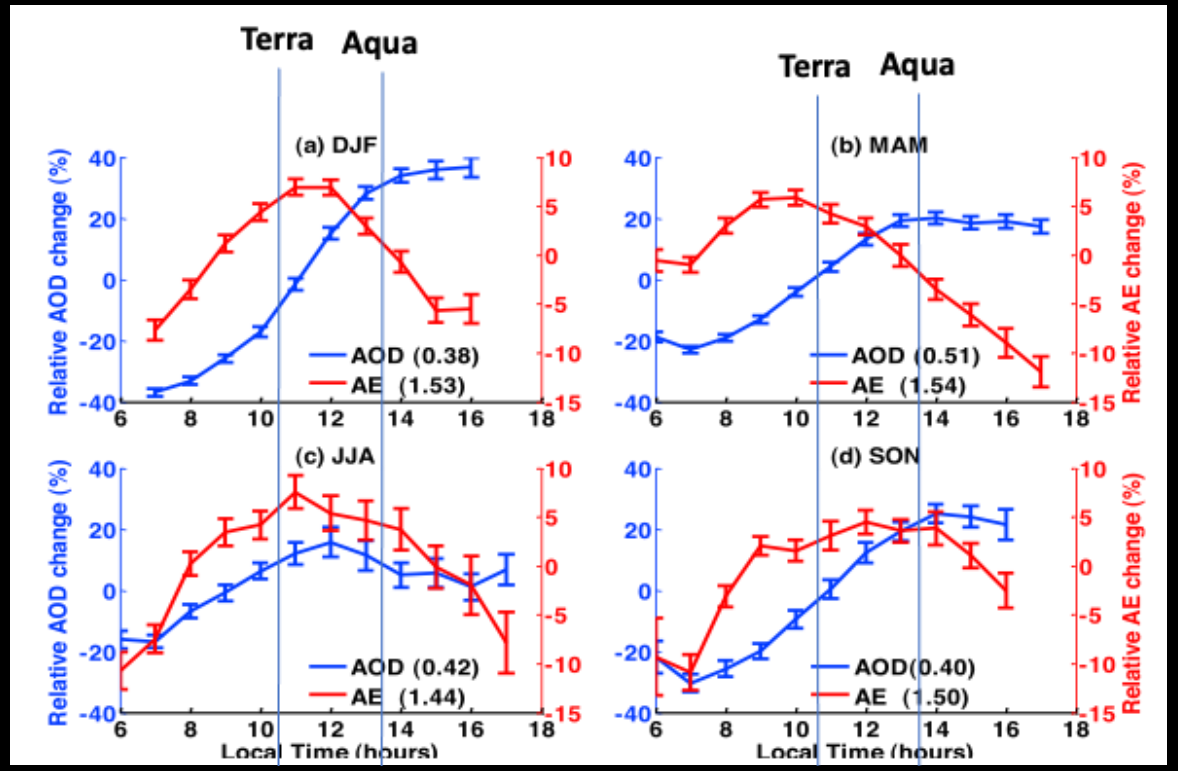


2011 ← VIIRS → 2030+

- VIIRS first launched on Suomi-NPP in 2011. Additional VIIRS sensors are on NOAA-20, NOAA21, and will be on NOAA's JPSS series thru late 2030s. MODIS→VIIRS should satisfy the multi-decadal needs of GCOS.
- Porting the DT algorithm from MODIS to VIIRS required dealing with things like "wavelength shifts" and "spatial resolution differences". Currently, there are MODIS DT products (known as "MxD04") and VIIRS DT products (known as "AERDT") that are hosted by LAADS-DAAC.
- Terra, Aqua, SNPP and the NOAA satellites are in sun-synchronous, polar Low Earth Orbit (***LEO***), such that with the wide swath of the imagers, each observes approximately once per daylight over the entire globe.

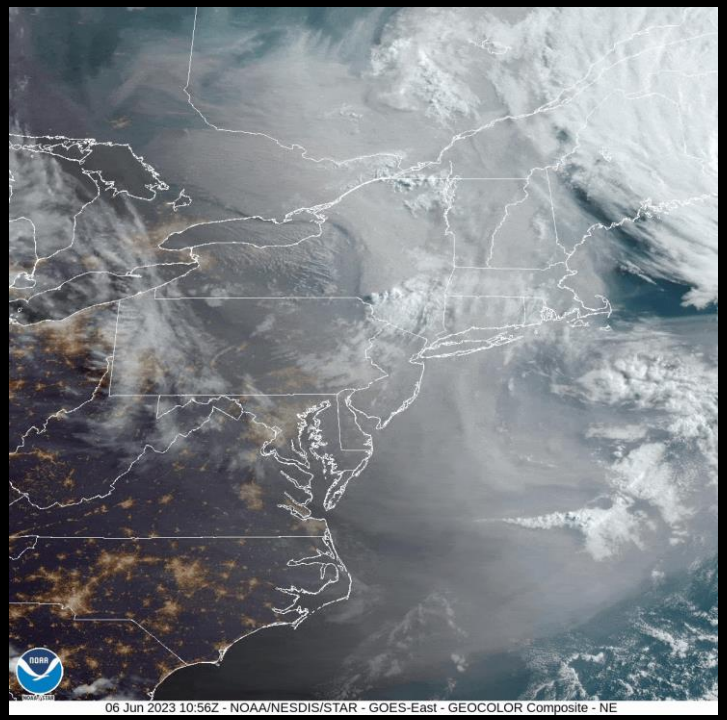
# But LEO isn't enough to satisfy GCOS <4-hour requirement:

Aerosol changes diurnally, and even more rapidly!




From: Zhang, Y., Yu, H., Eck, T. F., et al, (2012). Aerosol daytime variations over North and South America derived from multiyear AERONET measurements, *J. Geophysical Research*.

## Smoke from GOES-East




https://www.nesdis.noaa.gov/news/noaa-satellites-tracked-historic-levels-of-harmful-smoke-impacting-millions-the-eastern-us

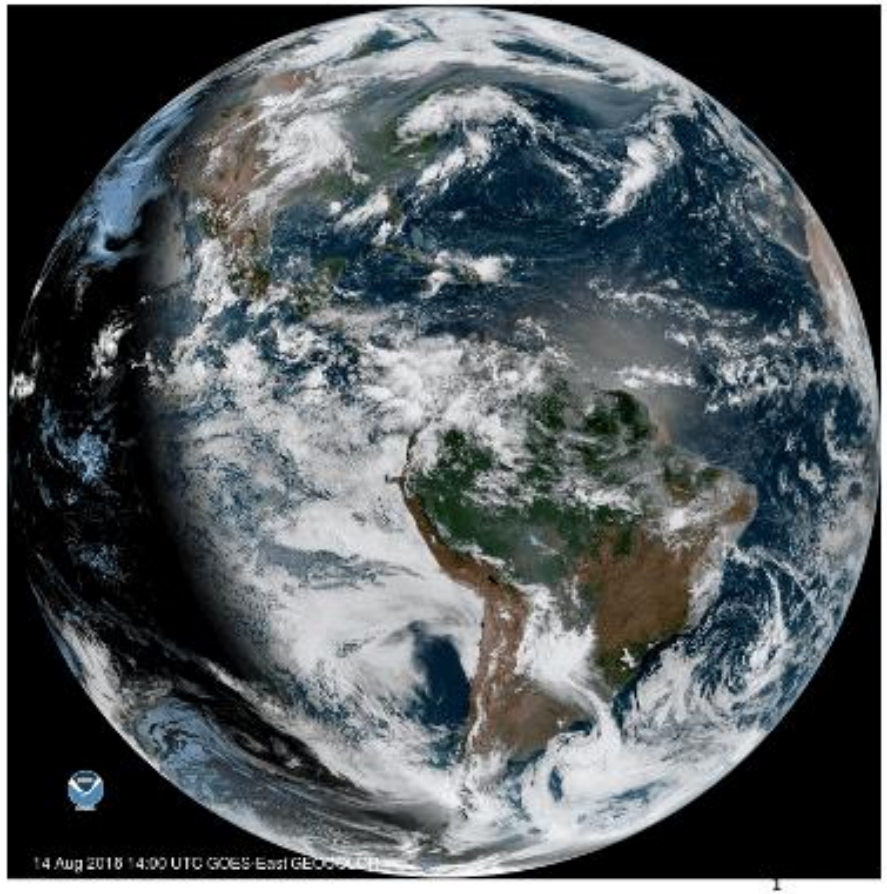
# Low Earth Orbit (LEO) & Geostationary Satellites Orbiting the Earth

**Imager in LEO Orbit (MODIS on Aqua)**

LEO takes a full day to orbit the globe
GEO observes one place all day

Animations from: https://arset.gsfc.nasa.gov

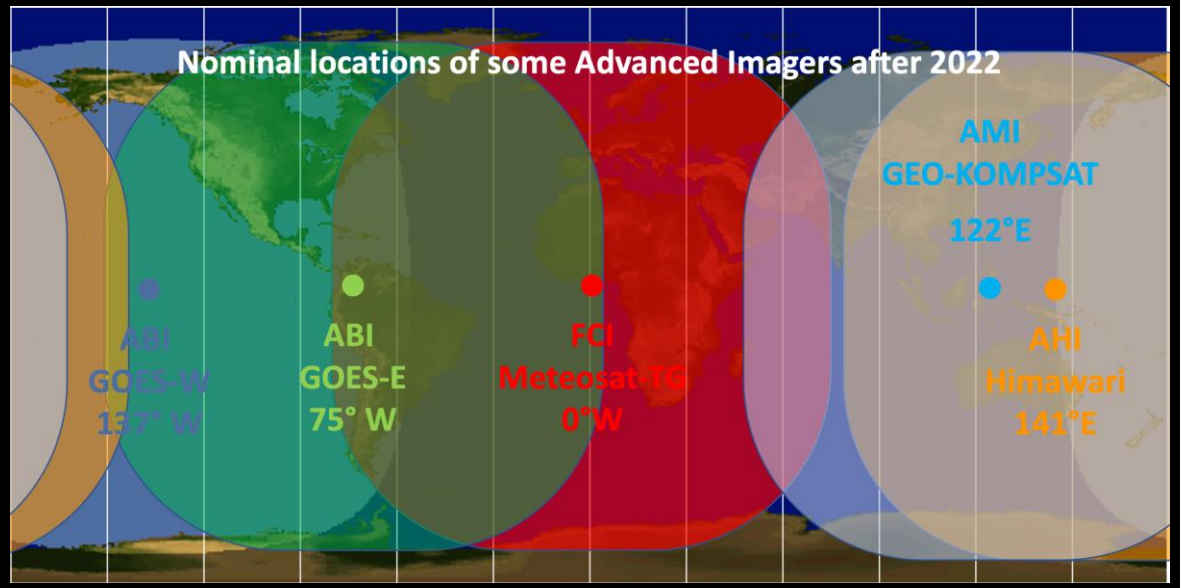
**Imager in GEO Orbit (ABI on GOES-East)**




Animations from: https://arset.gsfc.nasa.gov

# Expand DT record by using GEO sensors!

Modern (Third Generation) imagers have nearly the spectral/spatial capabilities of our LEO



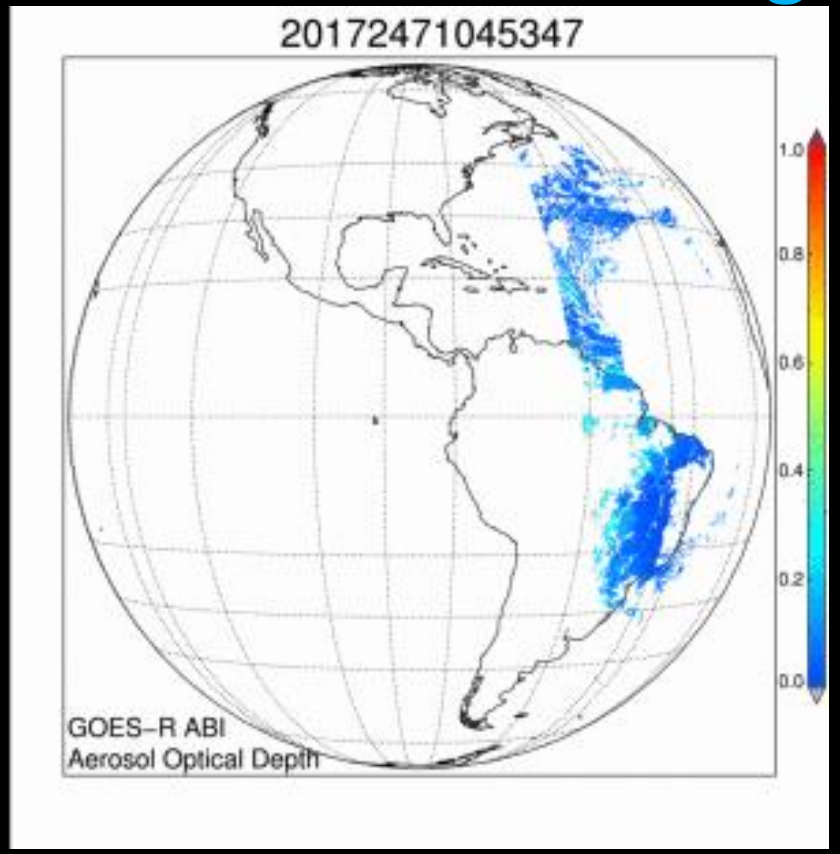

AHI = Advanced Himawari Imager (Japan)
ABI = Advanced Baseline Imager (U.S.)
AMI = Advanced Meteorological Imager (Korea)
FCI = Flexible Combined Imager (Europe)

Wavelength Bands and Spatial Resolution

| | MODIS | VIIRS | AHI | ABI |
|---|---|---|---|---|
| Blue | 0.47/0.5 | 0.49/0.75 | 0.47/1.0 | 0.47/1.0 |
| Green | 0.55/0.5 | 0.55/0.75 | 0.51/1.0 | |
| Red | 0.66/0.25 | 0.67/0.75 | 0.64/0.5 | 0.64/0.5 |
| NIR | 0.86/0.25 | 0.86/0.75 | 0.86/1.0 | 0.86/1.0 |
| NIR | 1.24/0.5 | 1.24/0.75 | | |
| Cirrus | 1.38/0.5 | 1.38/0.75 | | 1.38/2.0 |
| SWIR | 1.61/0.5 | 1.61/0.75 | 1.61/2.0 | 1.61/1.0 |
| SWIR | 2.11/0.5 | 2.25/0.75 | 2.25/2.0 | 2.25/2.0 |

**The future: A *coordinated* GEO-Ring**

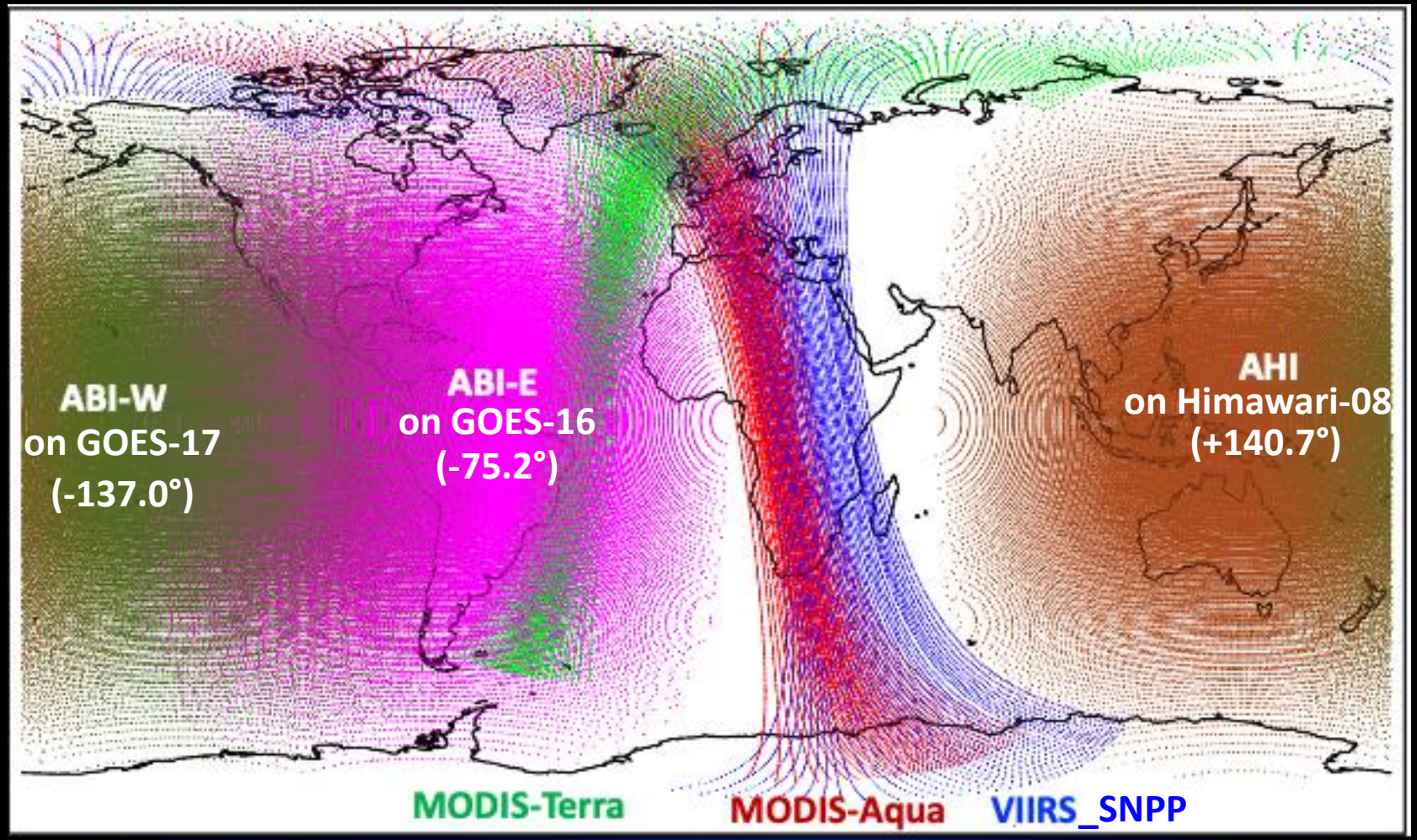
# RGB and (our first DT retrieval!) AOD from ABI for Sep 4, 2017 Canada/Washington fires and Brazil smoke mega-events




Looks pretty good! Even with the glint hole ±(40° from specular reflection) and some issues near clouds.

Also note this was GOES-16 before it became GOES-East, and that images were taken every 15 minutes

# Can we apply DT to different platforms and combine into a single product?



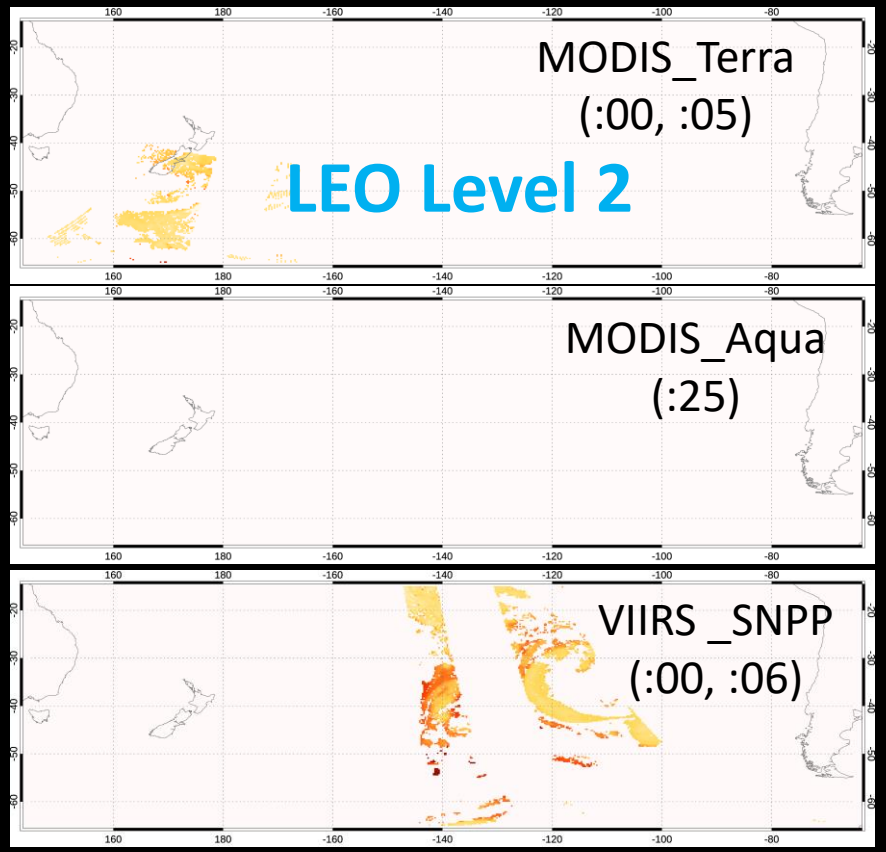

Circa 2017

# "Adding high temporal resolution to the global long-term aerosol data record: A synergy of LEO and GEO":

## A proposal to MEaSUREs-2017

Main tasks:

1) Develop Level 2: Use a modified DT algorithm to create Full-Disk (FD) Level 2 (L2) aerosol products for each GEO sensors (ABI16, ABI17 and AHI8), every 10 mins. Also, modify the algorithm for MODIS and VIIRS so that we have a *consistent Level 2 retrieval* from all sensors (data formats, product variables, etc.).
2) Merge for Level 3: Adopt a gridding system and infrastructure to ingest and aggregate the L2 retrievals from both GEO and existing LEO (MODIS+VIIRS). Determine weightings to create "best of" products on these grids.
3) Archive data: Archive both the L2 disks and L3 aggregations. Effort includes developing appropriate file format, as well as documenting/meta-data.
4) Communicate: Develop tool(s) to visualize the LEO/GEO products separately as well as their merging. Develop presentations and organize workshops for users.
5) Science: Use these new products to help answer science questions related to aerosol transport and variability

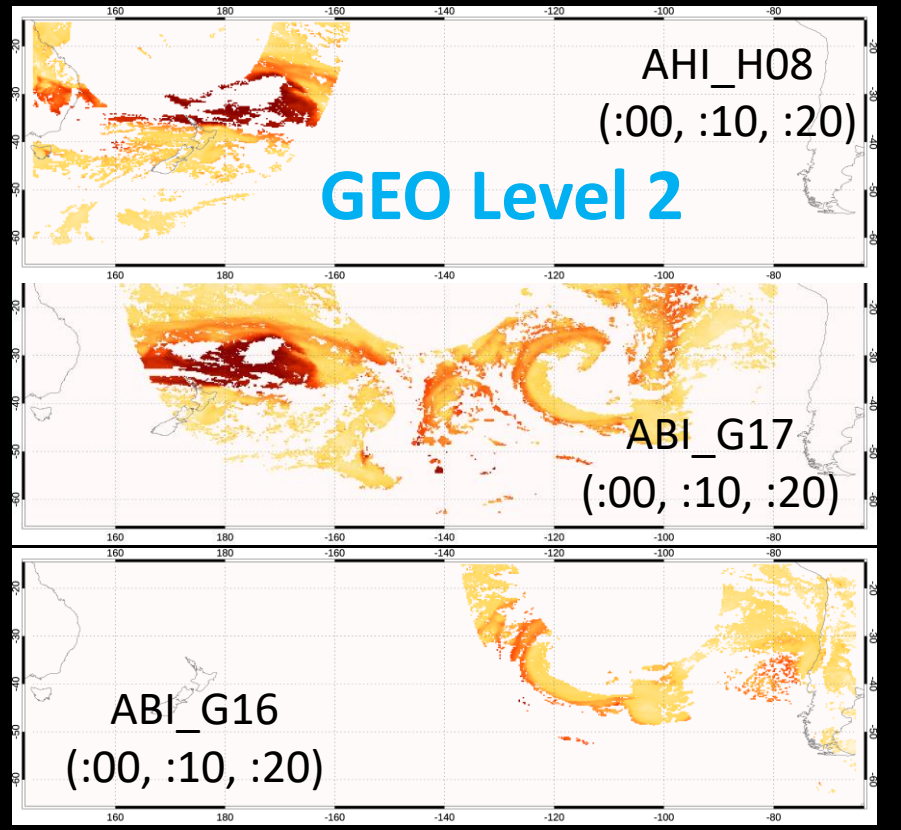



## Case study: Australia bushfires on January 5, 2020

All Level 2 AOD retrievals
21:00 – 21:29 UTC

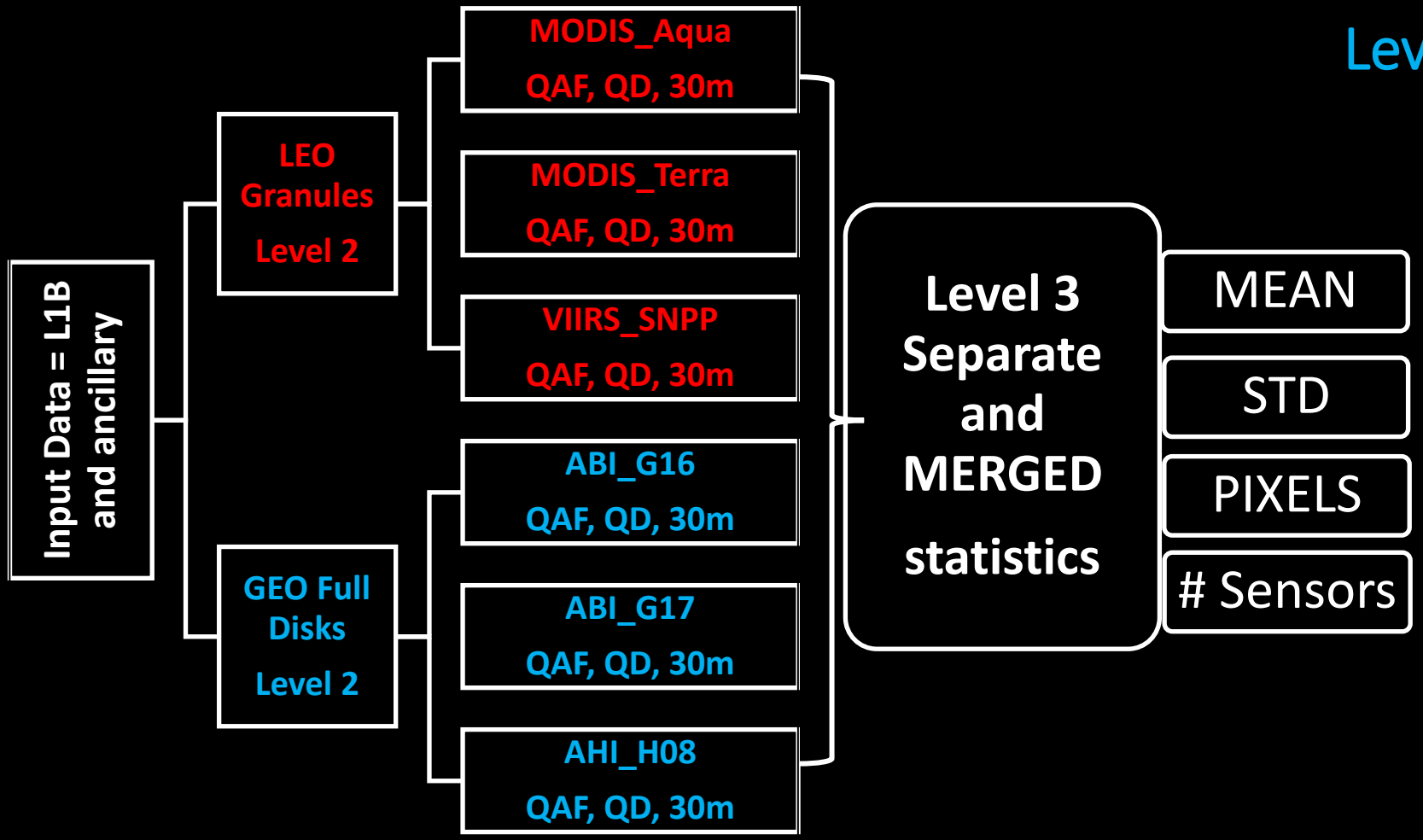
AOD

0.01 0.03 0.1 0.3 1.0 3.0




**All L2 retrievals are *consistent***

- Algorithm uses the same physics for each sensor.
- Denoted ***XAERDT_L2*** to indicate divergence from MODIS/*MxD04_L2* and VIIRS/*AERDT_L2* standard products.
- Reported variables are same for each sensor
- All files in “NetCDF4” format

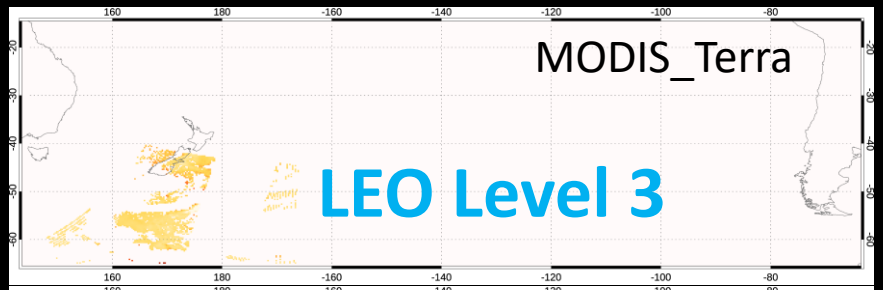



# Level 2 to Level 3

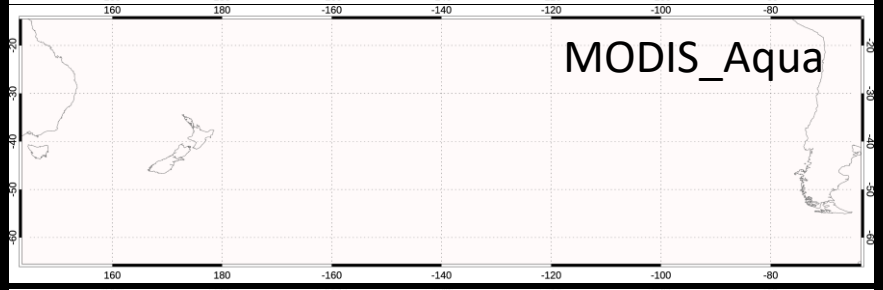
- QAF = Quality Filtering
- QD = 0.25° x 0.25°
- HH = Half Hourly

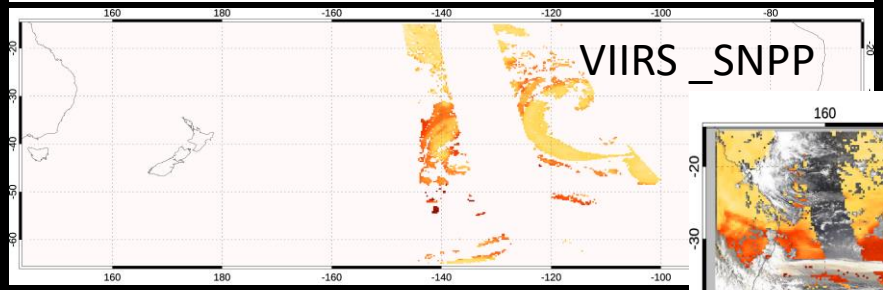
- Variables in Level 3
  - AOD (at 0.55 μm)
  - Angles

# Australia bushfires Jan 5, 2020 @21:00




LEO Level 3

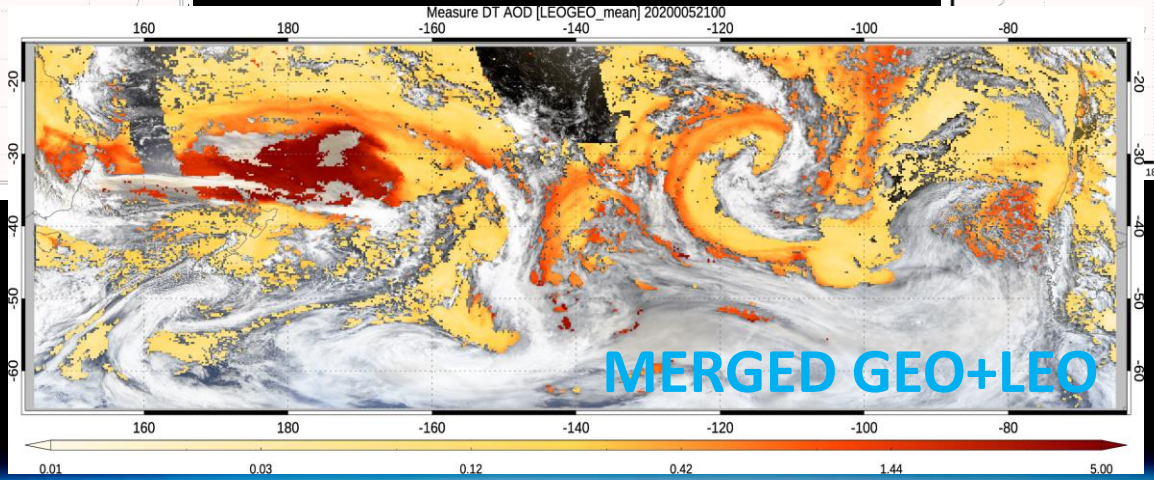


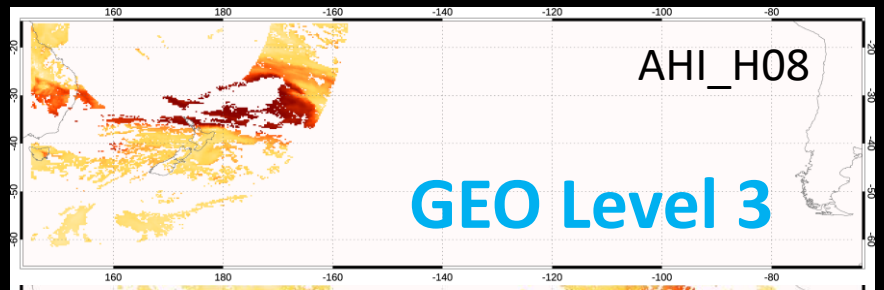




Australia

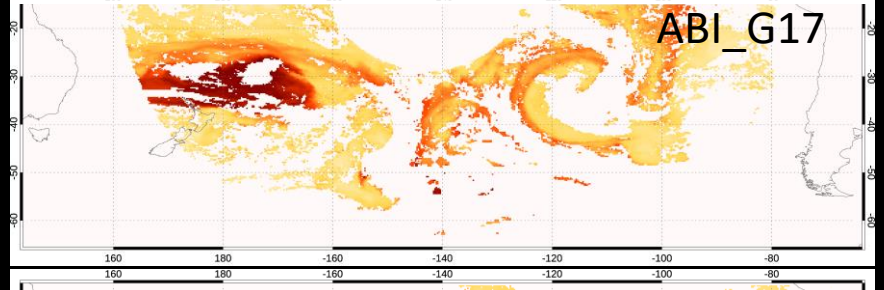
AOD

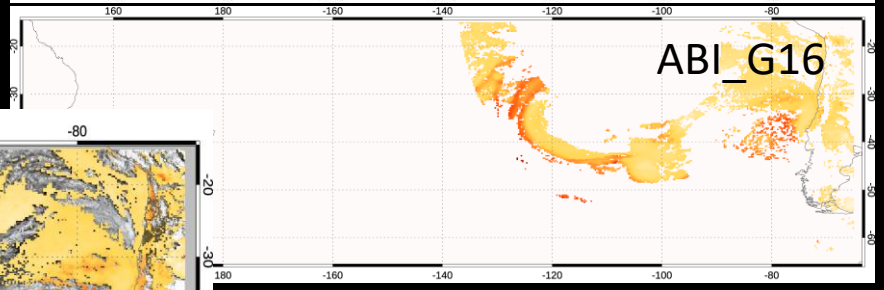
0.01 0.03 0.1 0.3 1.0 3.0



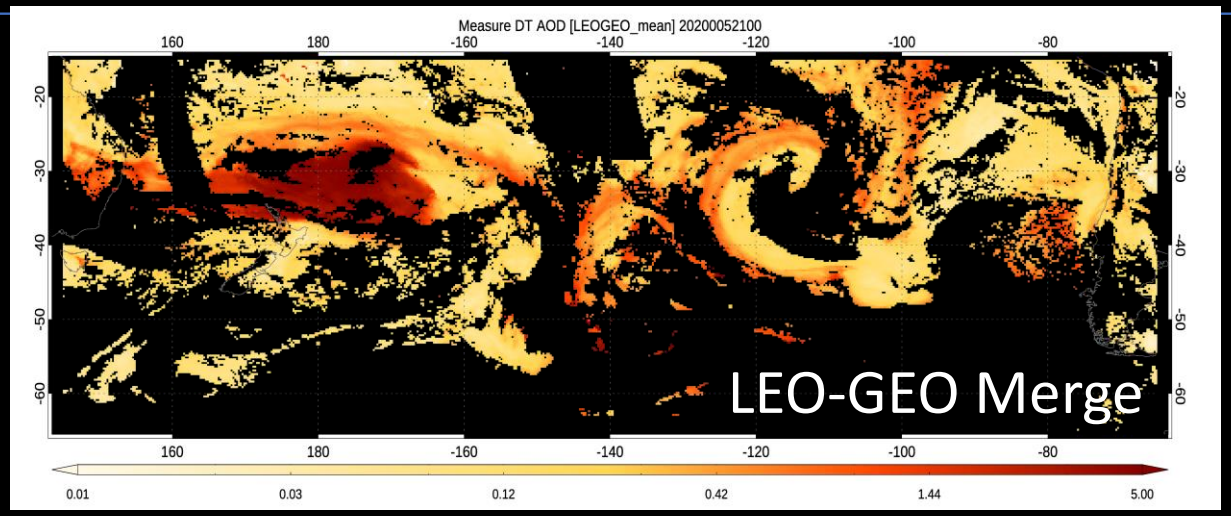




GEO Level 3

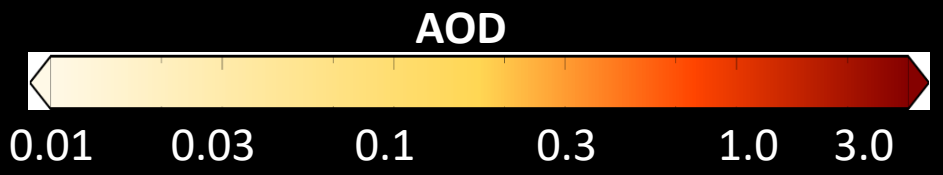


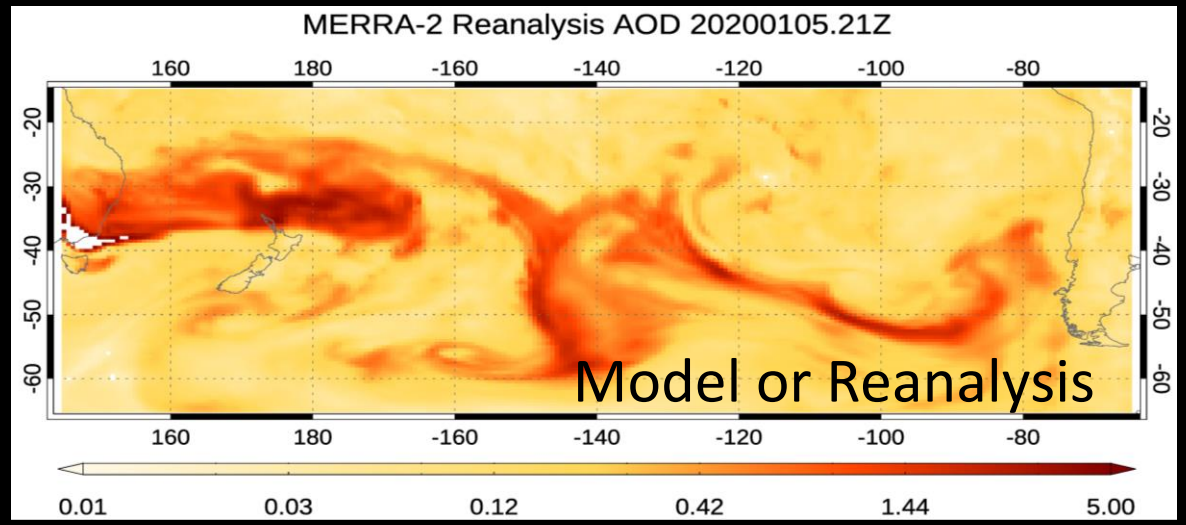




S. America



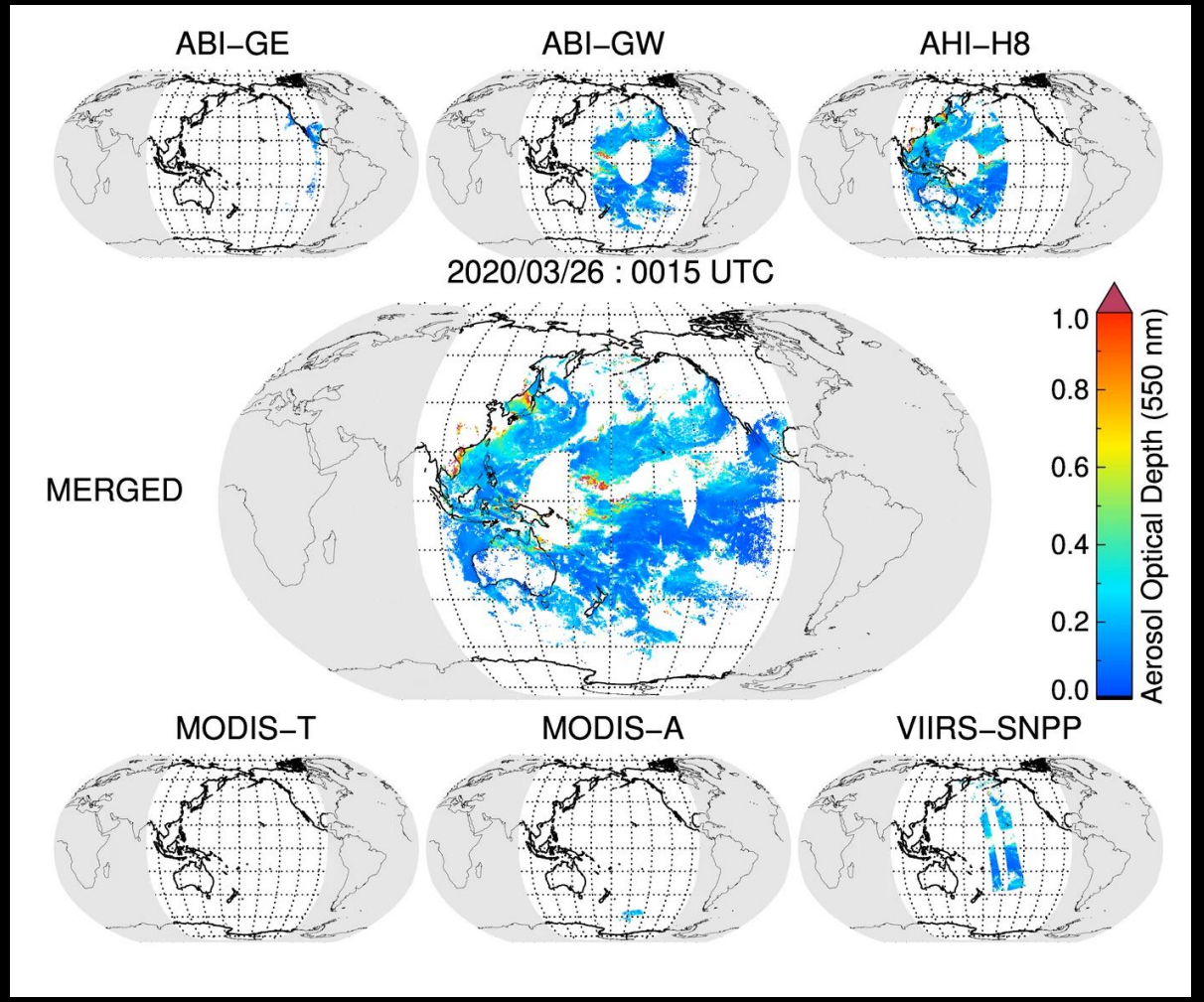

# Australia bushfires of January 2020
# 5 Jan 21:00 – 21:29 UTC
# compare observations and models



# XAERDT:

- Uses DT-package on many machines
- Level 2: 6 sensors (nadir resolution)
  - MODIS_Terra (10 km)
  - MODIS_Aqua (10 km)
  - VIIRS_SNPP(6 km)
  - ABI_G16 (10 km)
  - ABI_G17 (10 km)
  - AHI_H08 (10 km); Thru 13 Dec 2022
  - AHI_H09 (10 km); After 13 Dec 2022
- Level 3:
  - HH = 30-minute intervals
  - QD = Global 0.25° x 0.25°




Level 2 data for 2019-2022 available! Level 3 almost

EARTHDATA Other DAACs Feedback

About LAADS Data Learn Login

Home › Alerts & Issues › GEO-LEO Dark Target Aerosol data products suite available

# GEO-LEO Dark Target Aerosol data products suite available

| Platform | G16,G17,H8,SNPP,N20,Terra,Aqua |
|---|---|
| Instrument | ABI,AVI,VIIRS,MODIS |
| Source | MODAPS, LAADS |
| Issue | Alert |
| Last Updated | 2024-04-03 15:10:00 |
| Start | 2024-04-03 15:00:00 |
| End | 2024-07-01 00:00:00 |
| Description | NASA's Level-1 and Atmosphere Archive & Distribution System Distributed Active Archive Center is pleased to announce the release of the GEO-LEO Dark Target Aerosol data products suite. The Geostationary Earth Orbit (GEO) - Low-Earth Orbit (LEO) Dark Target Aerosol is a suite of global aerosol products both from geostationary and low-earth orbit satellites for a three-year timespan between January 2019 and December 2022 that shows aerosol movement across the globe every ten minutes. |

https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/applications/geoleo/

https://www.earthdata.nasa.gov/learn/webinars-and-tutorials/laads-geo-leo-06-10-2024

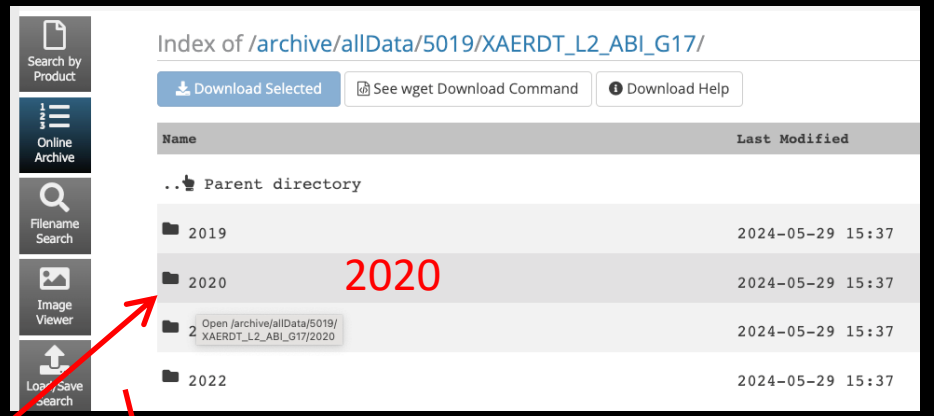
# Grabbing a L2 file via the archive: ABI_G17 from 5 Jan 2020 (Day 005) @ 21:00 UTC

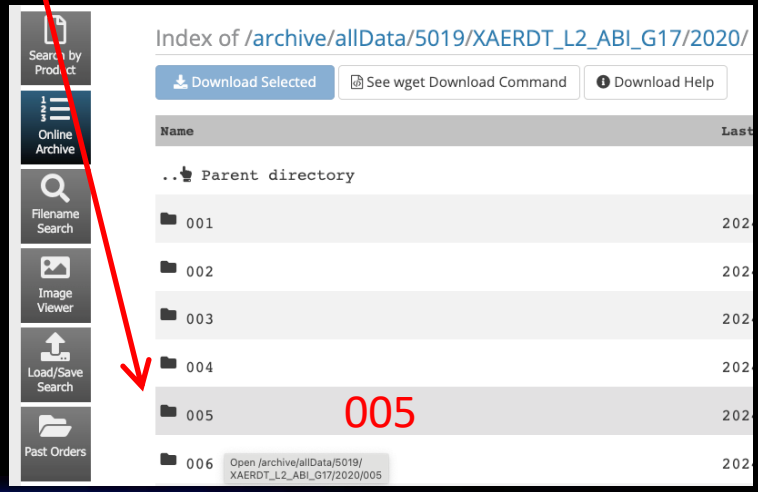
Starting here: *https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/applications/geoleo/#output-products*

## Output products

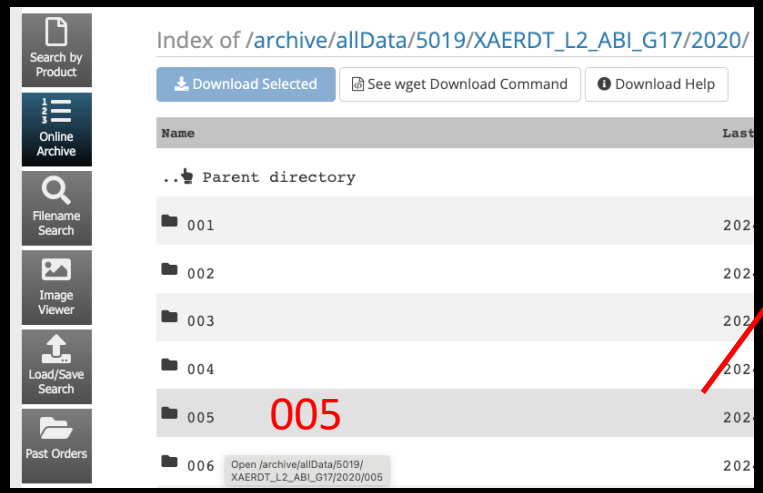
| Platform | Sensor | Temporal Resolution | Spatial Resolution | Product |
|---|---|---|---|---|
| GOES-16 | Advanced Baseline Imager (ABI) | 10 min. (15 min. before April 2019) | 10 km | XAERDT_L2_ABI_G16 |
| GOES-17 | Advanced Baseline Imager (ABI) | 10 min. (15 min. before April 2019) | 10 km | XAERDT_L2_ABI_G17 |
| Himawari-8 | Advanced Himawari Imager (AHI) | 10 min. | 10 km | |
| Himawari-9 | Advanced Himawari Imager (AHI) | 10 min. | 10 km | |
| SNPP | Visible-Infrared Imaging Radiometer Suite (VIIRS) | 6 min. | 6 km | XAERDT_L2_VIIRS_SNPP |
| NOAA-20 | Visible-Infrared Imaging Radiometer Suite (VIIRS) | 6 min. | 6 km | XAERDT_L2_VIIRS_NOAA20 |
| Terra | Moderate-resolution Imaging Spectroradiometer (MODIS) | 5 min. | 5 km | XAERDT_L2_MODIS_Terra |
| Aqua | Moderate-resolution Imaging Spectroradiometer (MODIS) | 5 min. | 5 km | XAERDT_L2_MODIS_Aqua |
| Merged | Merged Level-3 | 30 min. | 0.25° | XAERDT_L3_MEASURES_QD_HH |

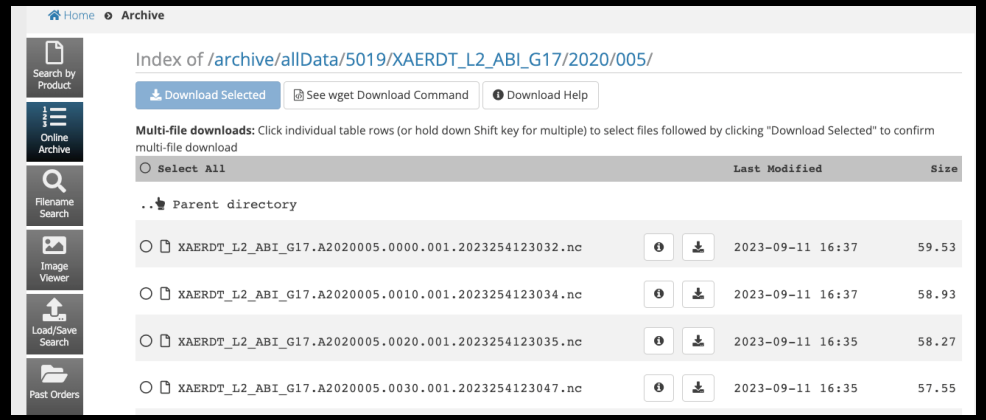
XAERDT_L2_ABI_G17 ▾
- Product Details
- Order Data
- Direct Download



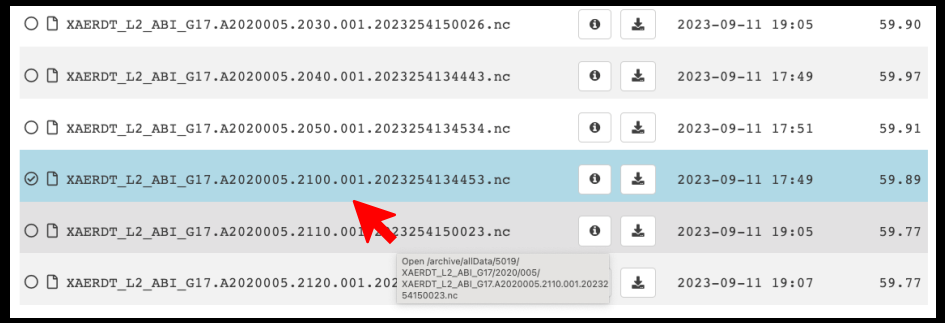



# Grabbing a L2 file via the archive: XAERDT_L2_ABI_G17_2020005.2100




Scroll down



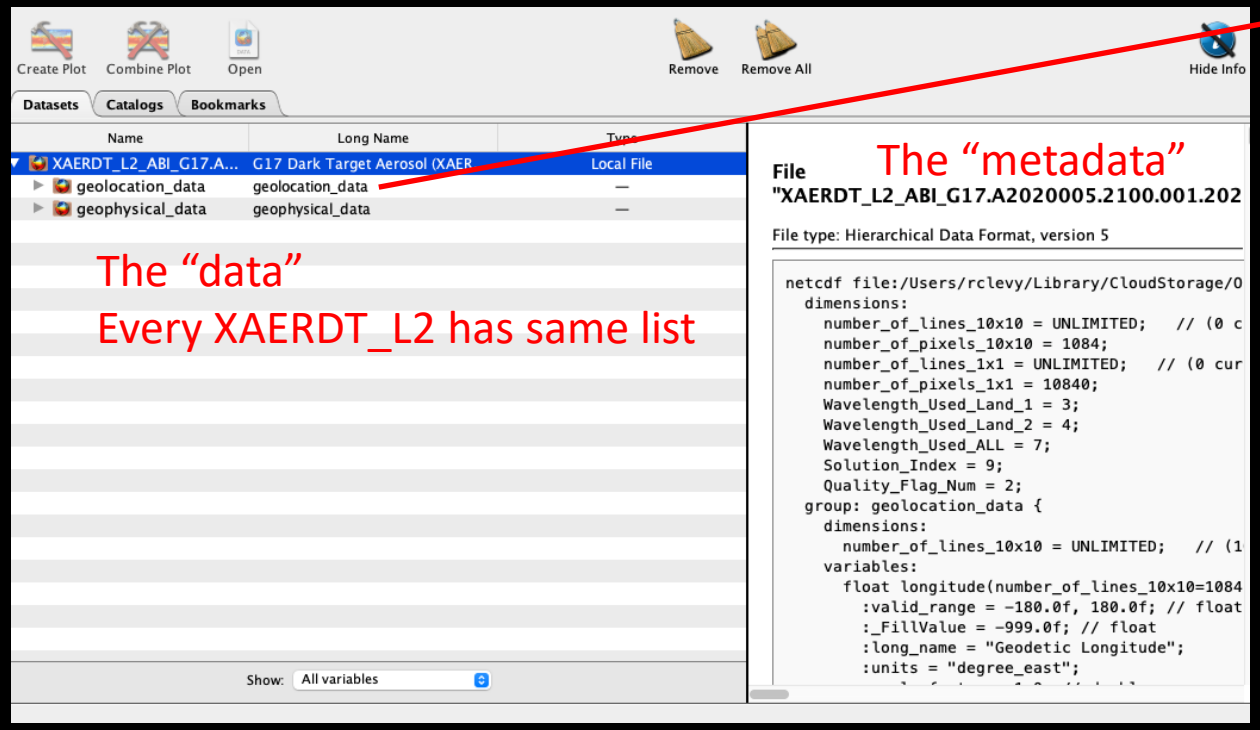

XAERDT_L2_ABI_G17.A2020005.2100.001.2023254134453.nc

XAERDT_L2_SENSOR_PLATFORM.AYYYYDDD.HHMM.VVV.yyyydddhhmmss.nc

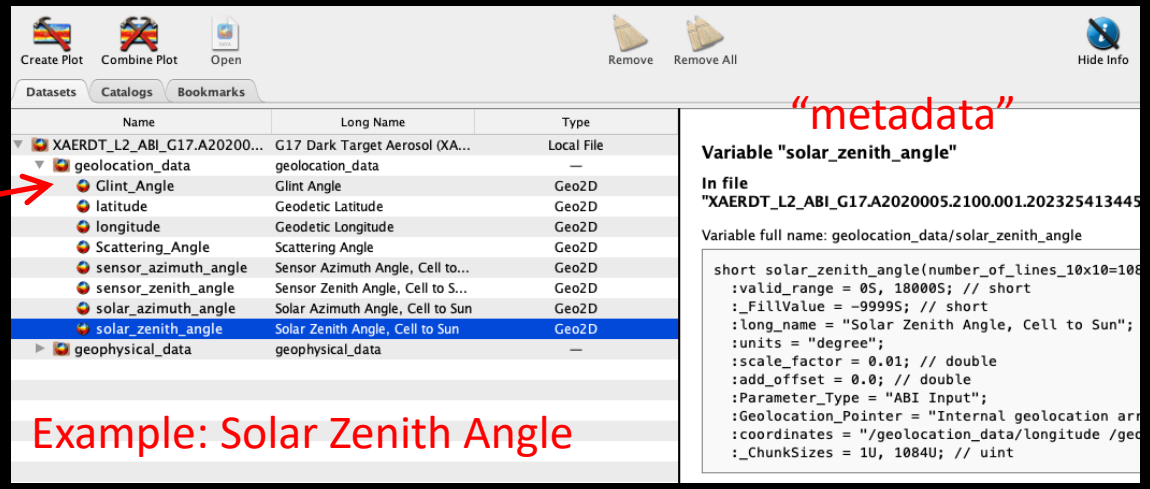
Level-1 and Atmosphere Archive & Distribution System / Distributed Active Archive Center

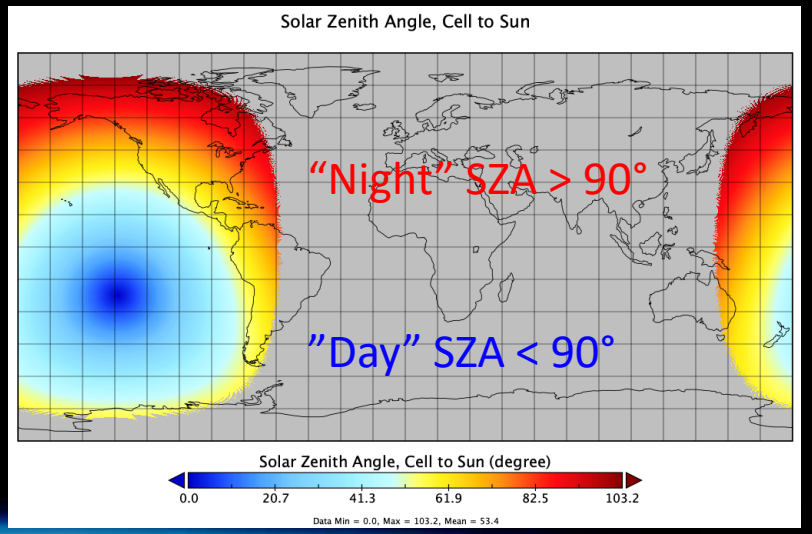
Dark Target

# What's in the NetCDF4 XAERDT_L2 file? (Using a free tool called Panoply)




"geolocation data"




XAERDT_L2_ABI_G17.A2020005.2100.001.2023254134453.nc

# What's in each L2 file?

"geophysical data": All XAERDT_L2_Sensor_Platform*.nc files have the same list

| Name | Long Name | Type |
|---|---|---|
| XAERDT_L2_ABI_G17.A2020005.2100.001.2023254134453.nc | G17 Dark Target Aerosol (XAERDT_L2_ABI_... | Local File |
| geolocation_data | geolocation_data | — |
| geophysical_data | geophysical_data | — |
| Aerosol_Cldmask_Land_Ocean | Aerosol Cloud Mask at native resolution 0 = ... | 2D |
| Aerosol_Cloud_Fraction_Land | Cloud fraction from Land aerosol cloud mask... | Geo2D |
| Aerosol_Cloud_Fraction_Ocean | Cloud fraction from Ocean aerosol cloud mas... | Geo2D |
| Aerosol_Type_Land | Aerosol Type: 1 = Continental, 2 = Moderat... | Geo2D |
| Angstrom_Exponent_1_Ocean | Calculated Angstrom Exponent for 0.55 vs 0... | Geo2D |
| Angstrom_Exponent_2_Ocean | Calculated Angstrom Exponent for 0.86 vs 2... | Geo2D |
| Asymmetry_Factor_Average_Ocean | Inferred Asymmetry Factor for average soluti... | Geo2D |
| Average_Cloud_Pixel_Distance_Land_Ocean | Average Distance (number of pixels) to near... | Geo2D |
| Backscattering_Ratio_Average_Ocean | Inferred Backscattering Ratio for average sol... | Geo2D |
| Cloud_Pixel_Distance_Land_Ocean | Distance (number of pixels) to nearest pixel i... | 2D |
| Corrected_Optical_Depth_Land | Retrieved AOT at 0.47, 0.55, 0.63, 2.24 mi... | Geo2D |
| Effective_Optical_Depth_Average_Ocean | Retrieved AOT for average solution at 0.47, ... | Geo2D |
| Effective_Radius_Ocean | Effective Radius at 0.55 microns | Geo2D |
| Error_Flag_Land_And_Ocean | Error code 1-26. Layer 1 ocean, Layer 2 lan... | Geo2D |
| Fitting_Error_Land | Spectral Fitting error for inversion over land | Geo2D |
| Image_Optical_Depth_Land_And_Ocean | AOT at 0.55 micron for both ocean (Average... | Geo2D |
| Land_Ocean_Quality_Flag | Quality flag for land and ocean aerosol retrie... | Geo2D |
| Land_Sea_Flag | Land Sea Flag(based on MOD03 Landsea ma... | Geo2D |
| Least_Squares_Error_Ocean | Residual of least squares fitting for inversion ... | Geo2D |
| Mass_Concentration_Land | Estimated Column Mass(per area) using assu... | Geo2D |
| Mass_Concentration_Ocean | Estimated Column Mass (per area) using ass... | Geo2D |
| Mean_Reflectance_Land | Mean reflectance of pixels used for land retri... | Geo2D |
| Mean_Reflectance_Ocean | Mean reflectance of pixels used for ocean re... | Geo2D |
| Number_Pixels_Used_Land | Number of pixels used for land retrieval at 0... | Geo2D |
| Number_Pixels_Used_Ocean | Number of pixels used for ocean retrieval at ... | Geo2D |
| Optical_Depth_By_Models_Ocean | Retrieved AOT (at 0.55 micron) partioned by... | Geo2D |
| Optical_Depth_Land_And_Ocean | AOT at 0.55 micron for both ocean (Average... | Geo2D |
| Optical_Depth_Large_Average_Ocean | Retrieved AOT of large mode for average sol... | Geo2D |
| Optical_Depth_Ratio_Small_Land | Fraction of AOT contributed by fine dominate... | Geo2D |
| Optical_Depth_Ratio_Small_Ocean_0p55micron | Fraction of AOT (at 0.55 micron) contributed... | Geo2D |
| Optical_Depth_Small_Average_Ocean | Retrieved optical thickness for fine mode (Av... | Geo2D |
| PSML003_Ocean | Inferred column number concentration (num... | Geo2D |
| STD_Reflectance_Land | Standard deviation of reflectance of pixels us... | Geo2D |
| STD_Reflectance_Ocean | Standard deviation of reflectance of pixels us... | Geo2D |
| Surface_Reflectance_Land | Estimated Surface Reflectance at 0.47, 0.63,... | Geo2D |
| Topographic_Altitude_Land | Averaged topographic altitude (in km) for Land | Geo2D |
| Wind_Speed_GMAO_Ocean | Wind Speed based on GMAO reanalysis for O... | Geo2D |

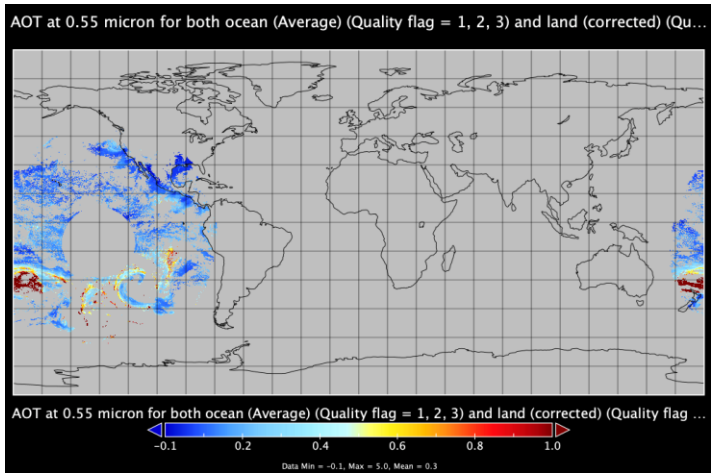
**Variable "Optical_Depth_Land_And_Ocean"**

**In file "XAERDT_L2_ABI_G17.A2020005.2100.001.2023254134453.nc"**

Variable full name: geophysical_data/Optical_Depth_Land_And_Ocean

```
short Optical_Depth_Land_And_Ocean(number_of_lines_10x10=1084, number_of_pixels_10x10=1084);
  :valid_range = -100S, 5000S; // short
  :_FillValue = -9999S; // short
  :long_name = "AOT at 0.55 micron for both ocean (Average) (Quality flag = 1, 2, 3) and land (corrected) (Quality flag = 3)"
  :units = "None";
  :scale_factor = 0.001; // double
  :add_offset = 0.0; // double
  :Parameter_Type = "Output";
  :Geolocation_Pointer = "Internal geolocation arrays";
  :coordinates = "/geolocation_data/longitude /geolocation_data/latitude";
  :_ChunkSizes = 1U, 1084U; // uint
```

## Optical_Depth_Land_And_Ocean




This is our primary *Quality_Assurance_Filtered (QAF)* output.

We also report "Image_Optical_Depth_Land_And_Ocean" which is not filtered

Other variables relate to quality assurance, diagnostics and other "derived" quantities.

# What's in a L3 file?

Output products

| Platform | Sensor | Temporal Resolution | Spatial Resolution | Product |
|---|---|---|---|---|
| GOES-16 | Advanced Baseline Imager (ABI) | 10 min. (15 min. before April 2019) | 10 km | XAERDT_L2_ABI_G16 |
| GOES-17 | Advanced Baseline Imager (ABI) | 10 min. (15 min. before April 2019) | 10 km | XAERDT_L2_ABI_G17 |
| Himawari-8 | Advanced Himawari Imager (AHI) | 10 min. | 10 km | XAERDT_L2_AHI_H08 |
| Himawari-9 | Advanced Himawari Imager (AHI) | 10 min. | 10 km | XAERDT_L2_AHI_H09 |
| SNPP | Visible-Infrared Imaging Radiometer Suite (VIIRS) | 6 min. | 6 km | XAERDT_L2_VIIRS_SNPP |
| NOAA-20 | Visible-Infrared Imaging Radiometer Suite (VIIRS) | 6 min. | 6 km | XAERDT_L2_VIIRS_NOAA20 |
| Terra | Moderate-resolution Imaging Spectroradiometer (MODIS) | 5 min. | 5 km | XAERDT_L2_MODIS_Terra |
| Aqua | Moderate-resolution Imaging Spectroradiometer (MODIS) | 5 min. | 5 km | XAERDT_L2_MODIS_Aqua |
| Merged | Merged Level-3 | 30 min. | 0.25° | XAERDT_L3_MEASURES_QD_HH |

Available soon: And when it is, you will be able to select:

↓

Subdirectories

-YYYY

-DDD

↓

XAERDT_L3_MEASURES_HH_QD.AYYYYDDD.HHMM.VVV.yyyydddhhmmss.nc

| Name | Long Name | Type |
|---|---|---|
| XAERDT_L3_MEASURES_QD_HH.20200105.2100.V0.... | Level 3 gridded merged aerosol data ... | Local File |
| AOD_AllQA_550_ABI_G16_Mean | Mean ABI GOES-16 (GOES-R or GOES... | Geo2D |
| AOD_AllQA_550_ABI_G16_Pixels | Number of Pixel used in calculating AB... | Geo2D |
| AOD_AllQA_550_ABI_G16_STD | Standard Deviation of ABI GOES-16 (G... | Geo2D |
| AOD_AllQA_550_ABI_G17_Mean | Mean ABI GOES-17 (GOES-S or GOES-... | Geo2D |
| AOD_AllQA_550_ABI_G17_Pixels | Number of Pixel used in calculating AB... | Geo2D |
| AOD_AllQA_550_ABI_G17_STD | Standard Deviation of ABI GOES-17 (G... | Geo2D |
| AOD_AllQA_550_AHI_H08_Mean | Mean AHI Himawari-8 AOT at 0.55 mi... | Geo2D |
| AOD_AllQA_550_AHI_H08_Pixels | Number of Pixel used in calculating A... | Geo2D |
| AOD_AllQA_550_AHI_H08_STD | Standard Deviation of AHI Himawari-8... | Geo2D |
| AOD_AllQA_550_LEOGEO_Mean | Mean of gridded LEO and GEO sensor... | Geo2D |
| AOD_AllQA_550_LEOGEO_NumberOfSensors | Number of Sensors used in calculating... | Geo2D |
| AOD_AllQA_550_LEOGEO_SensorWeighting | Weighting of each sensor used in calcu... | Geo2D |
| AOD_AllQA_550_LEOGEO_STD | Standard Deviation of gridded LEO an... | Geo2D |
| AOD_AllQA_550_LEOGEO_TotalPixels | Total number of level 2 pixels from all... | Geo2D |
| AOD_AllQA_550_MODIS_A_Mean | Mean MODIS Aqua AOT at 0.55 micro... | Geo2D |
| AOD_AllQA_550_MODIS_A_Pixels | Number of Pixel used in calculating M... | Geo2D |
| AOD_AllQA_550_MODIS_A_STD | Standard Deviation of MODIS Aqua AO... | Geo2D |
| AOD_AllQA_550_MODIS_T_Mean | Mean MODIS Terra AOT at 0.55 micro... | Geo2D |
| AOD_AllQA_550_MODIS_T_Pixels | Number of Pixel used in calculating M... | Geo2D |
| AOD_AllQA_550_MODIS_T_STD | Standard Deviation of MODIS Terra AO... | Geo2D |
| AOD_AllQA_550_VIIRS_SNPP_Mean | Mean SNPP VIIRS AOT at 0.55 micron ... | Geo2D |
| AOD_AllQA_550_VIIRS_SNPP_Pixels | Number of Pixel used in calculating SN... | Geo2D |
| AOD_AllQA_550_VIIRS_SNPP_STD | Standard Deviation of SNPP VIIRS AOT ... | Geo2D |

**File "XAERDT_L3_MEASURES_QD_HH.20200105.2100.V0.20240312.nc"**

File type: Hierarchical Data Format, version 5

```
netcdf file:/Users/rclevy/Library/CloudStorage/OneDrive-NASA/My_Presentations/LAADS_GEOLEO_Webin
  dimensions:
    time = UNLIMITED;   // (1 currently)
    lat = 720;
    lon = 1440;
    sensor = 6;
  variables:
    float time(time=1);
      :long_name = "time";
      :calendar = "standard";
      :units = "minutes since 2020-01-05 21:00:00";
      :_ChunkSizes = 1024U; // uint

    float lat(lat=720);
      :_FillValue = -9999.0f; // float
      :valid_range = -90.0f, 90.0f; // float
      :standard_name = "latitude";
      :long_name = "Geodectic Latitude";
      :units = "degrees_north";
      :scale_factor = 1.0; // double
      :add_offset = 0.0; // double
      :Parameter_Type = "Equal angle grid center location";
```

# What's in a L3 file?

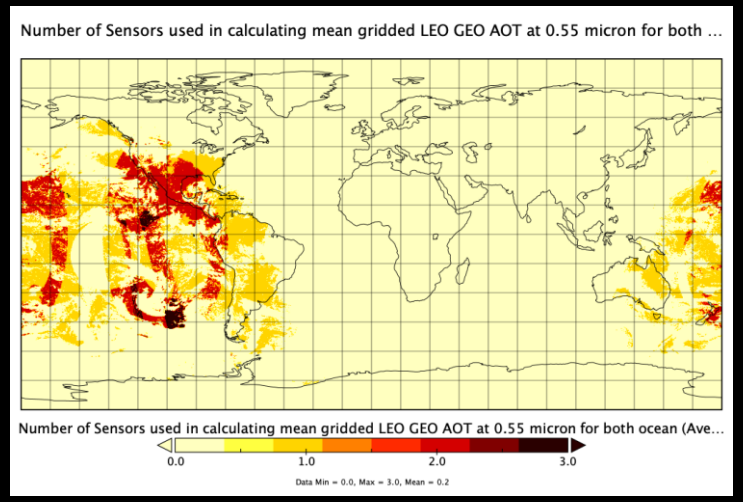
XAERDT_L3_MEASURES_HH_QD.AYYYYDDD.HHMM.VVV.yyyydddhhmmss.nc

| Geophysical / Geolocation | Sensor(s) | Statistic(s) | Notes |
|---|---|---|---|
| AOD_AllQA_550<br>AOD_FilteredQA_550 | MODIS_T, MODIS_A, VIIRS_SNPP<br>ABI_G16, ABI_G17, AHI_H08/H09* | Mean, Pixels, STD | AllQA from Level 2: Image_Optical_Depth_Land_And_Ocean<br>FilteredQA from Level 2: Optical_Depth_Land_And_Ocean |
| AOD_AllQA_550<br>AOD_FilteredQA_550 | LEOGEO | Mean, Pixels, STD,<br>NumberOfSensors,<br>SensorWeighting,<br>Total_Pixels | AllQA from Level 3: AllQA_550_Sensor_Platform<br>FilteredQA from Level 3: AllQA_550_Sensor_Platform<br><br>(e.g. calculated from the sensor-specific quantities) |
| Scattering_Angle<br>Sensor_Zenith | MODIS_T, MODIS_A, VIIRS_SNPP<br>ABI_G16, ABI_G17, AHI_H08/H09* | Mean, Pixels, STD | From Level 2: Scattering_Angle<br>From Level 2: Sensor_Zenith_Angle |
| Lat<br>Lon | | | Centers of 0.25° boxes |
| Land_Sea_Mask<br>Topographic Altitude | | | Derived from MODIS products |
| Solar_Zenith | | | Computed from lat, lon, and center time (e.g. HH:15 or HH:45) |

# What's in a L3 file?

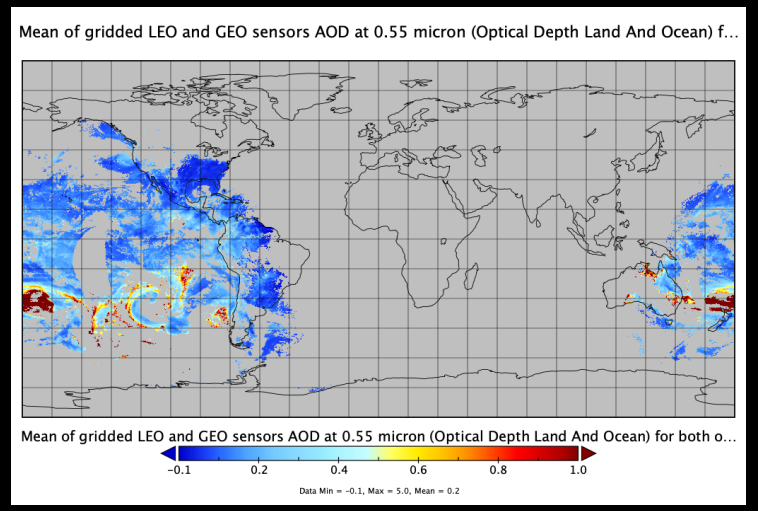
XAERDT_L3_MEASURES_HH_QD.A2020005.2100.VVV.yyyydddhhmmss.nc

## AOD_FilteredQA_550_NumberOfSensors



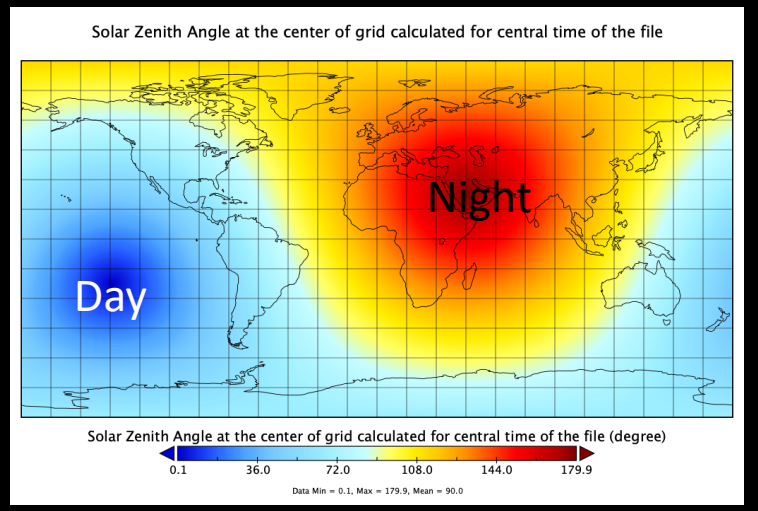

Noting up to three sensors at a given location for this time

## AOD_FilteredQA_550_Mean




Based in the Level 2 variable Optical_Depth_Land_and_Ocean

## Solar_Zenith




Note where retrievals occur during day

# Demonstration on How to Access the GEO-LEO DT Data

LAADS DAAC

Earthdata Search

# How to Access GEO-LEO DT Data

## LAADS DAAC

- https://ladsweb.modaps.eosdis.nasa.gov/search/

## Earthdata Search

- https://search.earthdata.nasa.gov

# Questions?