

# Trace Gas Data Access, Tools, and Analysis

Melanie Follette-Cook and Pawan Gupta

Satellite Remote Sensing of Dust, Fires, Smoke, and Air Quality, July 10-12, 2018





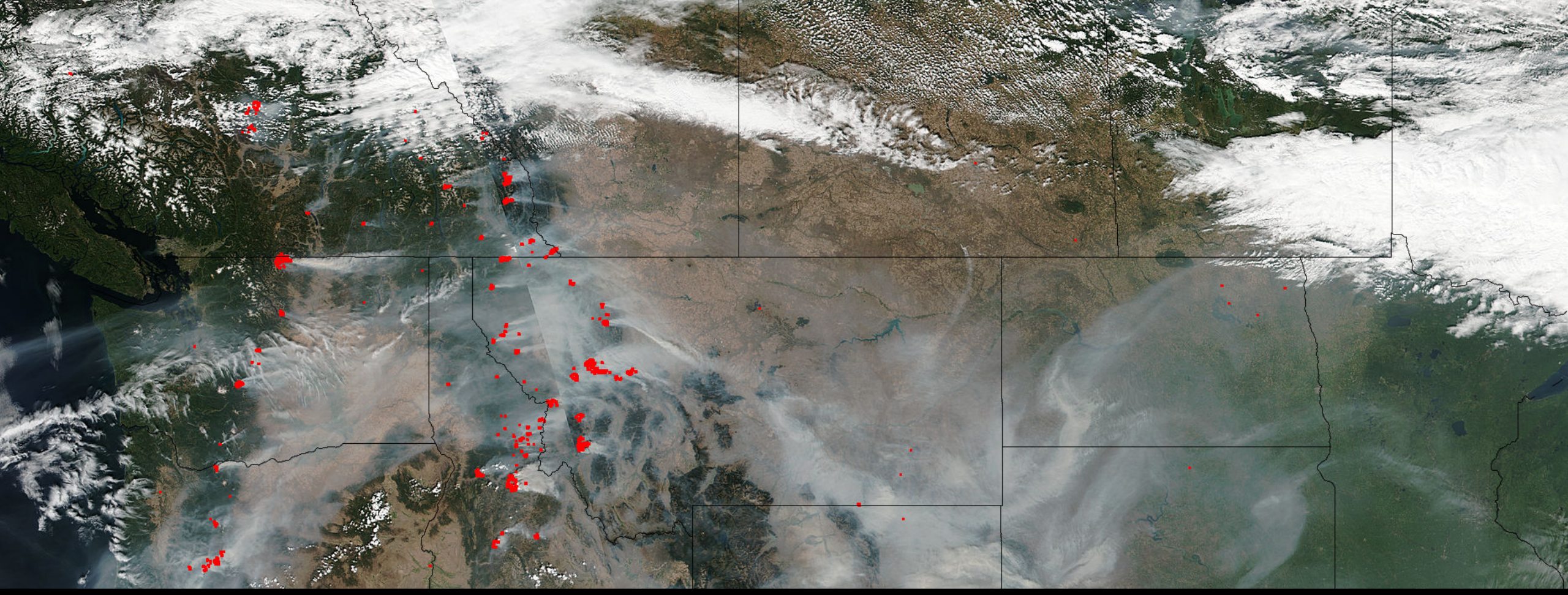
# Learning Objectives

By the end of this training, you will be:

- able to navigate the NASA Air Quality website, which currently features OMI NO<sub>2</sub>
- familiar with OMI Level 3 NO<sub>2</sub> and SO<sub>2</sub> data products and the online visualization and access tool, Giovanni
- able to download Level 2 and 3 data using Earthdata





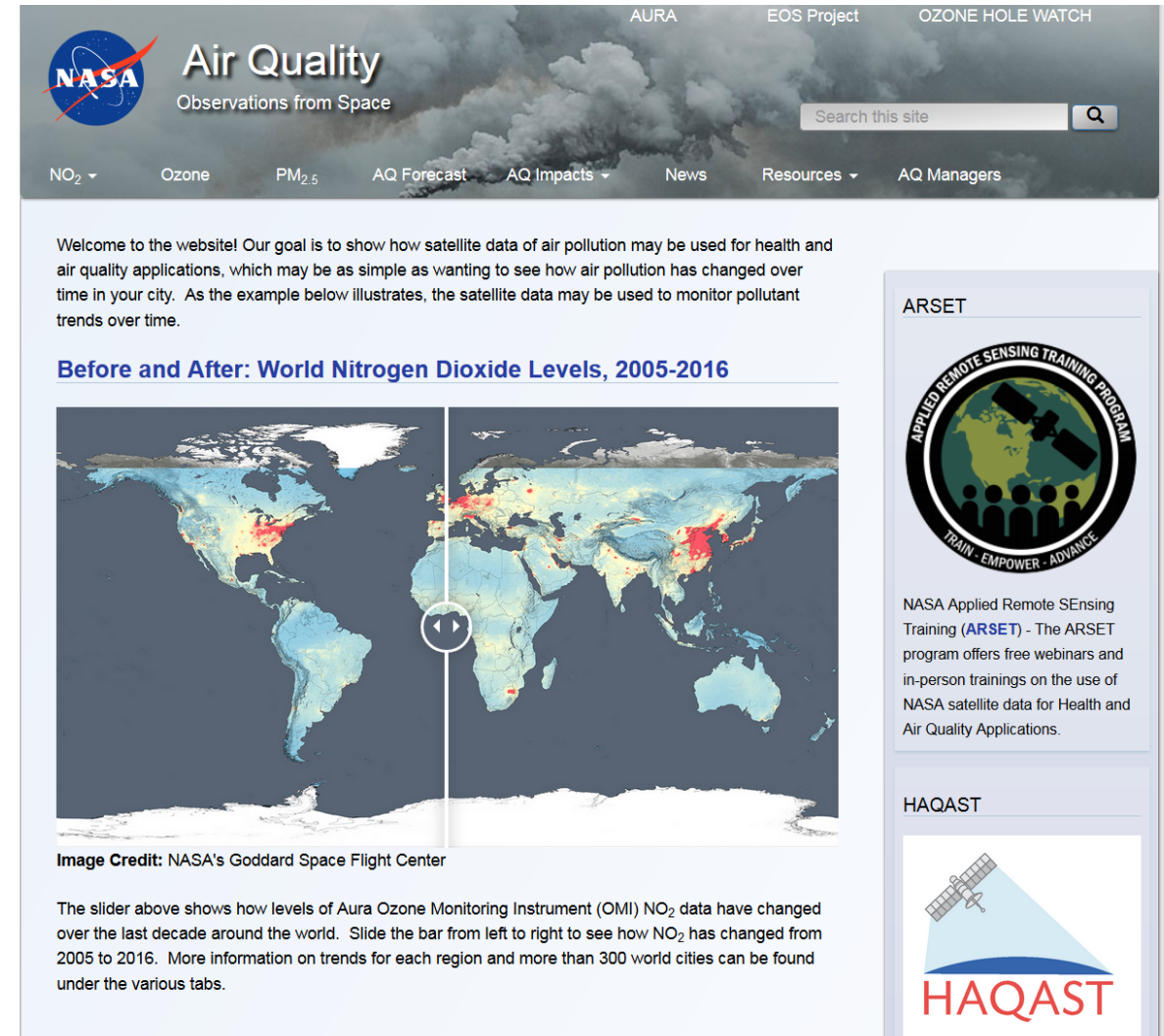


NASA Global Air Quality Website



# OMI NO<sub>2</sub>: <https://airquality.gsfc.nasa.gov>

- Download pre-made plots of OMI NO<sub>2</sub> (OMNO2d v3) for over 300 world cities
- Download OMI NO<sub>2</sub> data (ASCII, Excel – not yet, but soon) for ~300 world cities



The screenshot shows the NASA Air Quality website interface. At the top, there's a navigation bar with links for AURA, EOS Project, and OZONE HOLE WATCH. The main header features the NASA logo and the text "Air Quality Observations from Space". Below this is a search bar and a menu with options like NO<sub>2</sub>, Ozone, PM<sub>2.5</sub>, AQ Forecast, AQ Impacts, News, Resources, and AQ Managers. The main content area includes a welcome message and a section titled "Before and After: World Nitrogen Dioxide Levels, 2005-2016" which displays a world map with a slider to compare data from 2005 and 2016. To the right, there are two sidebar boxes: "ARSET" (Applied Remote Sensing Training Program) and "HAQAST" (Health and Air Quality Applications Training).

**ARSET**  
APPLIED REMOTE SENSING TRAINING PROGRAM  
TRAIN - EMPOWER - ADVANCE

NASA Applied Remote Sensing Training (ARSET) - The ARSET program offers free webinars and in-person trainings on the use of NASA satellite data for Health and Air Quality Applications.

**HAQAST**  
HAQAST





# OMI NO<sub>2</sub>

- There are several ways to get OMI NO<sub>2</sub> trend data for a city or region

The screenshot shows the NASA Air Quality website interface. At the top, there is a navigation bar with links for AURA, EOS Project, and OZONE HOLE WATCH. The main header features the NASA logo and the text "Air Quality Observations from Space". A search bar is located on the right side of the header. Below the header, there is a menu with options: NO<sub>2</sub>, Ozone, PM<sub>2.5</sub>, AQ Forecast, AQ Impacts, News, Resources, and AQ Managers. The NO<sub>2</sub> menu is expanded, showing options for World Cities, World Regions, US Power Plants, and Before/After Maps. The "World Cities" option is circled in red. The main content area displays a world map titled "Before and After: World Nitrogen Dioxide Levels, 2005-2016". The map shows a color scale representing NO<sub>2</sub> levels, with a slider below it. The text below the map reads: "Image Credit: NASA's Goddard Space Flight Center" and "The slider above shows how levels of Aura Ozone Monitoring Instrument (OMI) NO<sub>2</sub> data have changed over the last decade around the world. Slide the bar from left to right to see how NO<sub>2</sub> has changed from 2005 to 2016. More information on trends for each region and more than 300 world cities can be found under the various tabs."

## ARSET



NASA Applied Remote Sensing Training (**ARSET**) - The ARSET program offers free webinars and in-person trainings on the use of NASA satellite data for Health and Air Quality Applications.

## HAQAST



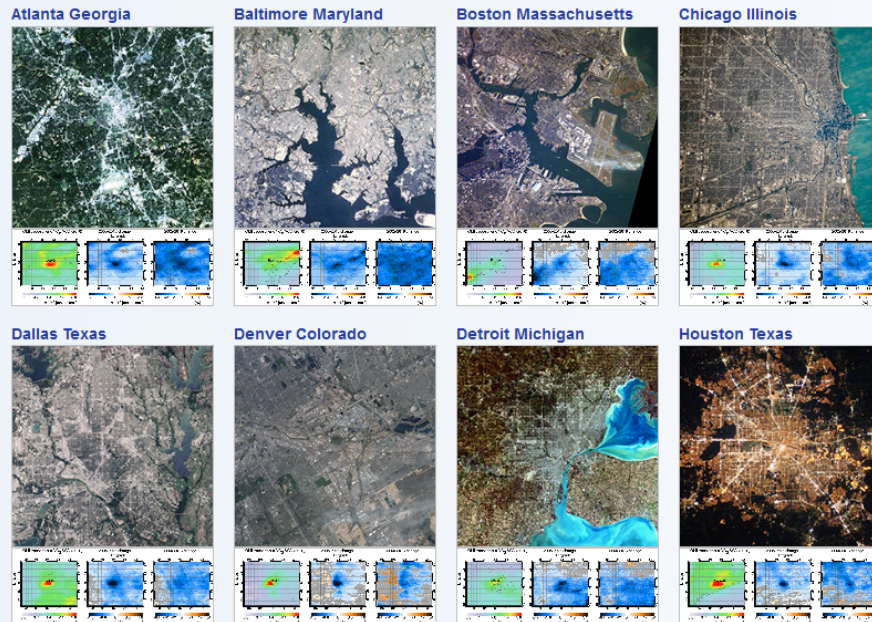


# OMI NO<sub>2</sub>: US Cities



## Nitrogen Dioxide Trends for US Cities

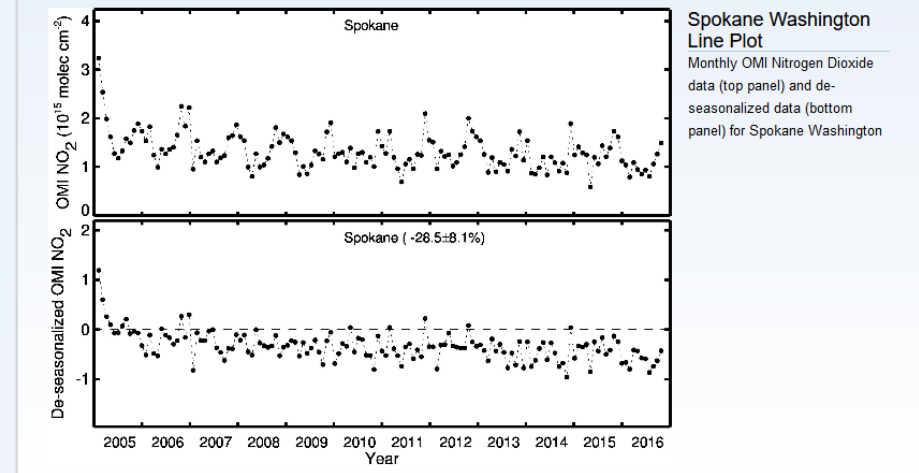
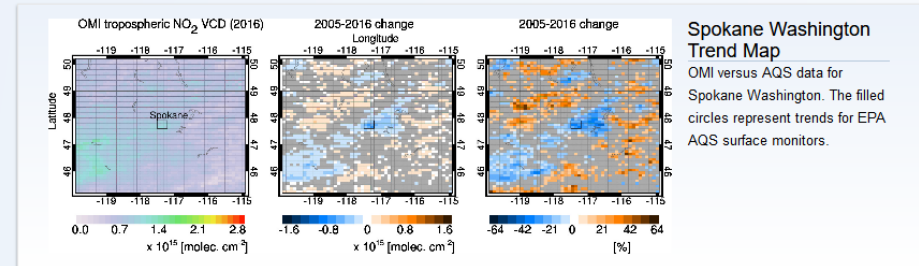
Browse the Top 20 US Cities. There are ready-made plots that you can download. **The correspondence is generally great between variations and trends in OMI NO<sub>2</sub> levels and EPA Air Quality System (AQS) "nose-level" NO<sub>2</sub> data.** Check out our recent paper (Lamsal et al., 2015).



Plots are available for select cities

### Spokane Washington

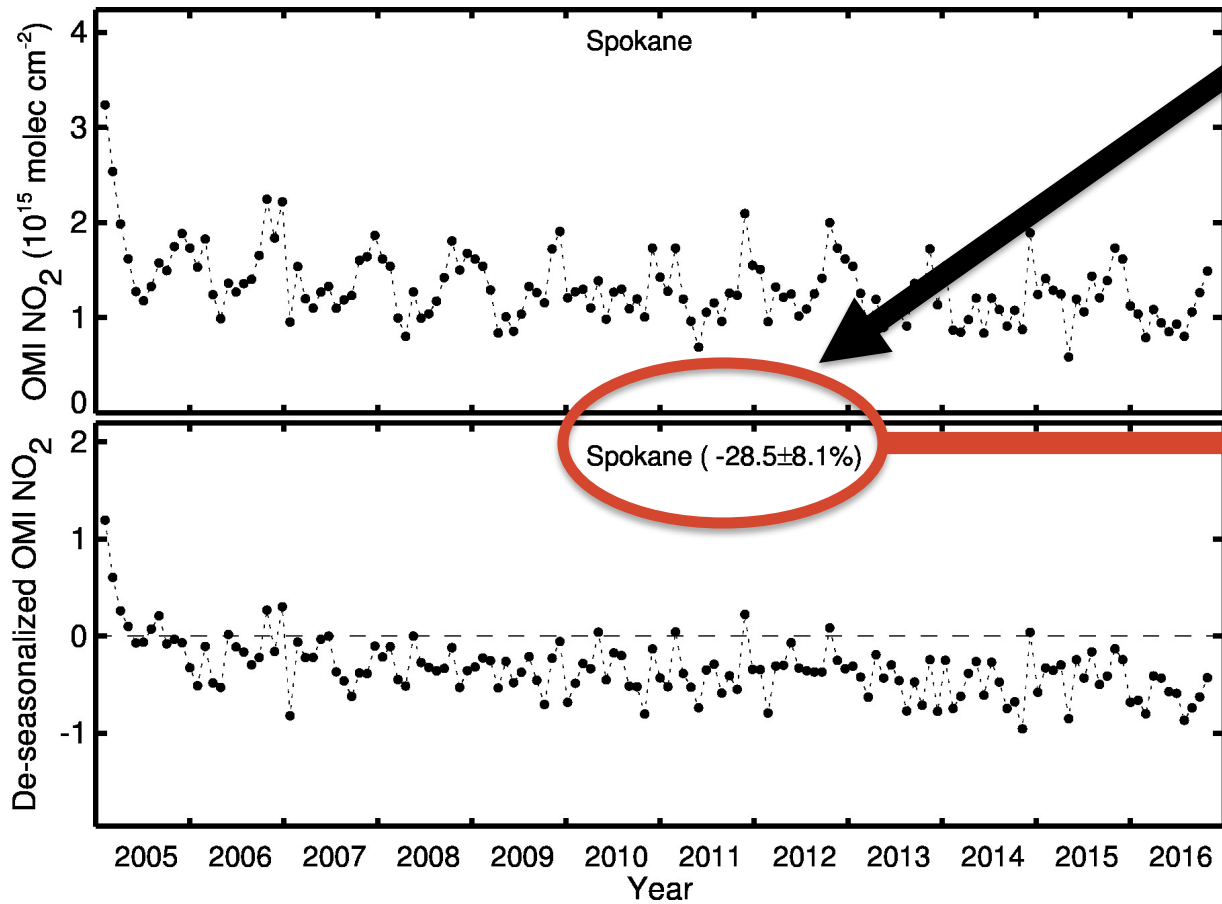
Change in NO<sub>2</sub>: -28.54  
 2016 Avg. NO<sub>2</sub>: 1.80 (1e15 molec cm<sup>-2</sup>)



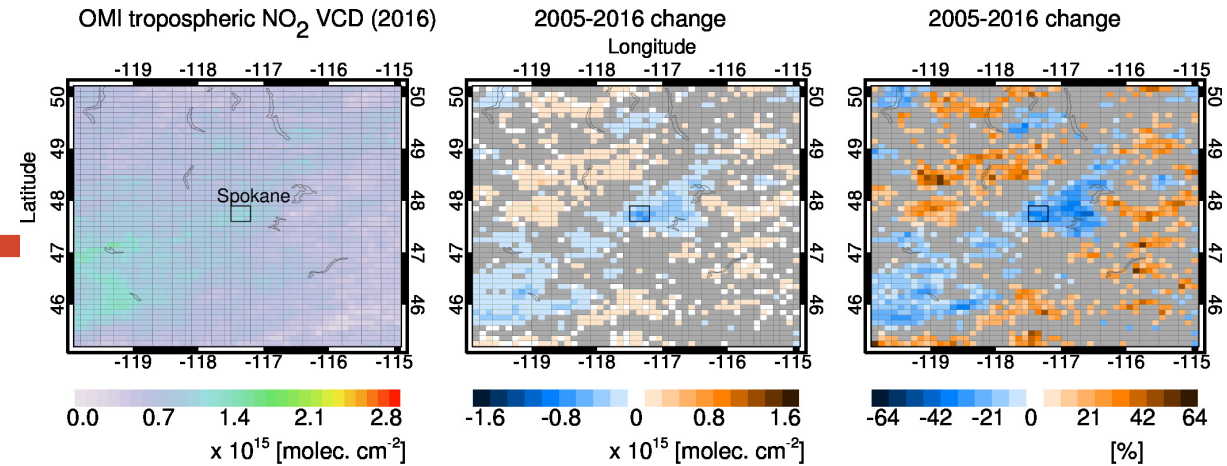


# OMI NO<sub>2</sub>: US Cities

## Spokane



Percent trend from 2005 to 2016 for the area inside the box



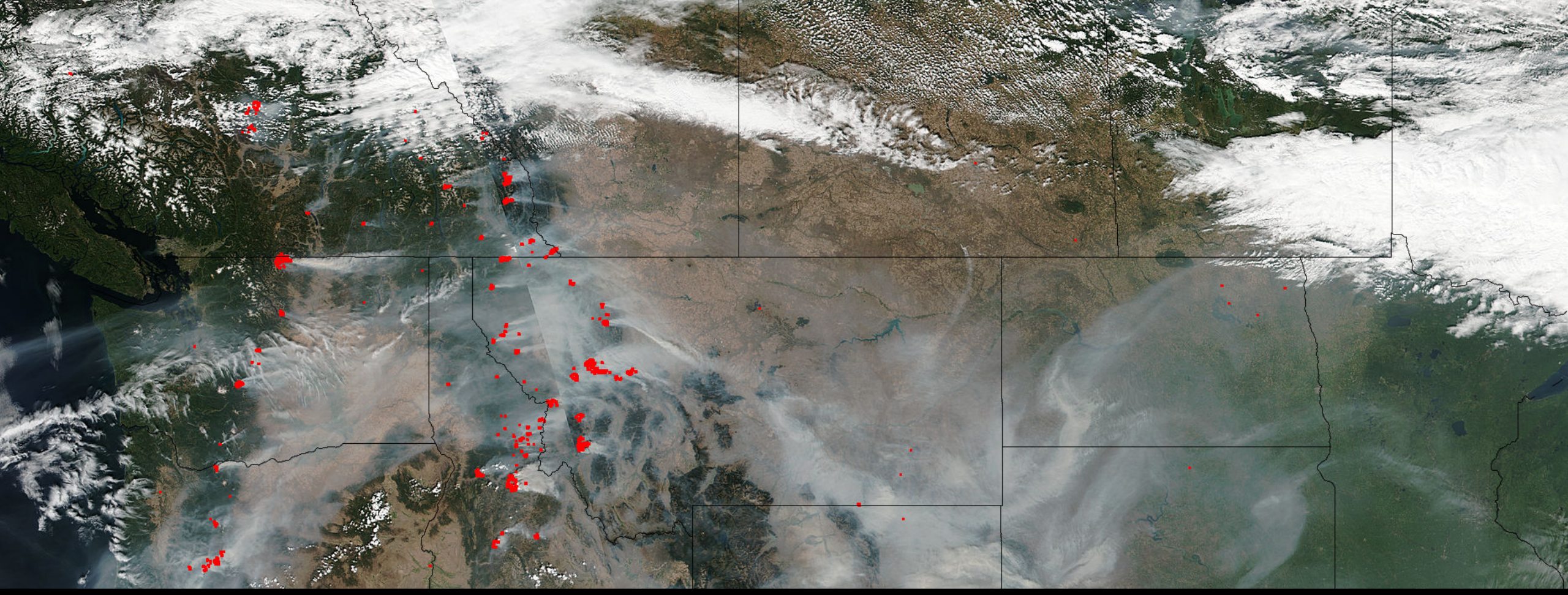


# OMI NO<sub>2</sub>: Exercise

- What is the trend in OMI NO<sub>2</sub> for your favorite city?
- Compare the trend in your favorite city to the trend in Washington, DC







Annual Mean Surface NO<sub>2</sub> Estimates

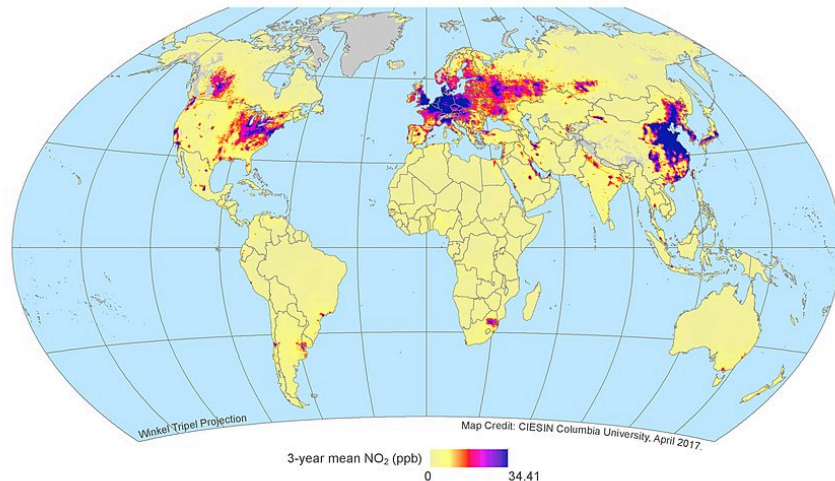


# GOME, SCIAMACHY, GOME-2 Annual Mean Surface NO<sub>2</sub>

<http://sedac.ciesin.columbia.edu/>

- Download data and pre-made images of surface NO<sub>2</sub> inferred from satellite observations

Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO<sub>2</sub>) Grids from GOME, SCIAMACHY and GOME-2, 2010-2012  
Satellite-Derived Environmental Indicators



The Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO<sub>2</sub>) Grids from GOME, SCIAMACHY and GOME-2 are part of the Satellite-Derived Environmental Indicators collection. This data set represents a series of three-year running mean grids (1996-2012) of ground level Nitrogen Dioxide that are derived from Global Ozone Monitoring Experiment (GOME), Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) and Global Ozone Monitoring Experiment-2 (GOME-2) satellite retrievals. This map displays 3-year mean satellite-derived NO<sub>2</sub> concentrations measured in parts per billion (ppb) at a spatial resolution of 6 arc-minutes (0.1 degree or approximately 10 km at the equator) for the years 2010 to 2012.

Center for International Earth Science Information Network  
EARTH INSTITUTE | COLUMBIA UNIVERSITY

Data Source: Geddes, J.A., R.V. Martin, B.L. Boys, and A. van Donkelaar. 2017. Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO<sub>2</sub>) Grids from GOME, SCIAMACHY and GOME-2. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <https://doi.org/10.7927/H4JW8BTT>.

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**SOCIOECONOMIC DATA AND APPLICATIONS CENTER (SEDAC)**  
A Data Center in NASA's Earth Observing System Data and Information System (EOSDIS) — Hosted by CIESIN at Columbia University

Search SEDAC... Data [Q] [User Icon]

DATA MAPS THEMES RESOURCES SOCIAL MEDIA ABOUT HELP

DATA SETS  
DATA COLLECTIONS  
FEATURED DATA USES  
DATA CITATIONS  
CITATIONS DATABASE

In the Spotlight  
Map Gallery

India Winter Cropped Area, 2016  
A new map collection featuring annual winter cropped area for India (2001-2016).

Gridded Population of the World (GPW), v4  
India Data Collection  
Population Dynamics

Featured Data Sets  
Global Man-made Impervious Surface (GMIS) Dataset From Landsat, v1 (2010)  
Global High Resolution Urban Data from Landsat

Overview Download Documents (2) Maps  
To provide high spatial resolution estimates of global man-made imperviousness for the target year 2010, derived from global 30m Landsat satellite data and a companion dataset to the Global Human Built-up And Settlement Extent

Global Human Built-up And Settlement Extent (HBASE) Dataset From Landsat, v1 (2010)  
Global High Resolution Urban Data from Landsat

Overview Download Documents (2) Maps  
To provide high spatial resolution estimates of global urban extent derived from global 30m Landsat satellite data for the target year 2010 and a companion dataset to the Global Man-made Impervious Surface

News  
Population Data, Hazard Exposure, and Sustainable Repositories Addressed in Three DC Area Talks  
New Report Ranks Nations' Environmental Performance, Reveals Trends  
CIESIN Staff Honored for Ten Years of Service  
Earth Science Data Experts Hold Joint Meetings in Maryland





# GOME, SCIAMACHY, GOME-2 Annual Mean Surface NO<sub>2</sub>

<http://sedac.ciesin.columbia.edu/>

- Download data of surface NO<sub>2</sub> inferred from satellite observations from 1996 to 2012
  - Download GeoTIFF files
  - Download ASCII and HDF files from [http://fizz.phys.dal.ca/~atmos/martin/?page\\_id=232](http://fizz.phys.dal.ca/~atmos/martin/?page_id=232)

The screenshot shows the SEDAC website interface. At the top, the NASA logo and the text "SOCIOECONOMIC DATA AND APPLICATIONS CENTER (SEDAC)" are visible, along with the tagline "A Data Center in NASA's Earth Observing System Data and Information System (EOSDIS) — Hosted by CIESIN at Columbia University". A navigation bar includes links for DATA, MAPS, THEMES, RESOURCES, SOCIAL MEDIA, ABOUT, and HELP. Below this, the page title is "Satellite-Derived Environmental Indicators". The main content area is titled "Global 3-Year Running Mean Ground-Level NO<sub>2</sub> Grids from GOME, SCIAMACHY and GOME-2, v1 (1996–2012)". A "Data Download" button is highlighted with a red circle. To the right, there is a world map showing ground-level NO<sub>2</sub> concentrations from 1996-1998. The abstract describes the data as a series of three-year running mean grids of ground level NO<sub>2</sub> derived from satellite retrievals of GOME, SCIAMACHY, and GOME-2. The recommended citation is provided at the bottom.

**Collection Overview**

Data Sets (7)

Global 3-Year Running Mean Ground-Level NO<sub>2</sub> Grids from GOME, SCIAMACHY and GOME-2, v1 (1996–2012)

Show All...

Map Gallery (48)

Map Services (11)

Citations

Global 3-Year Running Mean Ground-Level NO<sub>2</sub> Grids from GOME, SCIAMACHY and GOME-2, v1 (1996–2012)

Set Overview **Data Download** Maps Map Services Documentation Metadata

**Purpose:**

To provide a continuous surface of NO<sub>2</sub> concentrations for health and environmental research.

**Abstract:**

The Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO<sub>2</sub>) Grids from GOME, SCIAMACHY and GOME-2 represent a series of three-year running mean grids (1996–2012) of ground level NO<sub>2</sub> that were derived from Global Ozone Monitoring Experiment (GOME), Scanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY) and Global Ozone Monitoring Experiment-2 (GOME-2) satellite retrievals. For each satellite-derived NO<sub>2</sub> source, the relationship between satellite observations of tropospheric NO<sub>2</sub> column densities and the NO<sub>2</sub> concentrations at ground level relevant to human exposure is simulated, using the Goddard Earth Observing System chemical transport model (GEOS-Chem) to produce a mean NO<sub>2</sub> concentration raster grid. The grid cell resolution is six arc-minutes (0.1 degree, or approximately 10 km at the equator) covering the global land surface.

**Recommended Citation(s)\*:**

Geddes, J.A., R.V. Martin, B.L. Boys, and A. van Donkelaar. 2017. Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO<sub>2</sub>) Grids from GOME, SCIAMACHY and GOME-2. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <https://doi.org/10.7927/H4JW8BTT>. Accessed DAY MONTH YEAR.

ENW (EndNote & RefWorks)†  
RIS (Others)



# OMI Monthly Mean Surface NO<sub>2</sub> Data

[https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L4/OMI\\_Surface\\_NO2/Monthly/](https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L4/OMI_Surface_NO2/Monthly/)

- Download monthly mean surface estimates of NO<sub>2</sub> from OMI data (2005-2016)
- File formats are “.h5” so some software (e.g., Python, Matlab) may be necessary to read the files
- Within 5 years or so, hopefully one continuous NO<sub>2</sub> record (1996-present) will become available



The screenshot shows the NASA AVDC website interface. At the top, it says "GODDARD SPACE FLIGHT CENTER" and "You are not logged in. Login Sign up". Below this is a banner for "Aura validation data center" with a satellite image. A navigation menu includes "OVERVIEW", "DATA", "TOOLS", "DOCUMENTATION", "LINKS", and "EVENTS". The main content area is titled "OVERVIEW / HOME" and displays a directory listing of files. The listing has columns for "Name", "Last modified", and "Size".

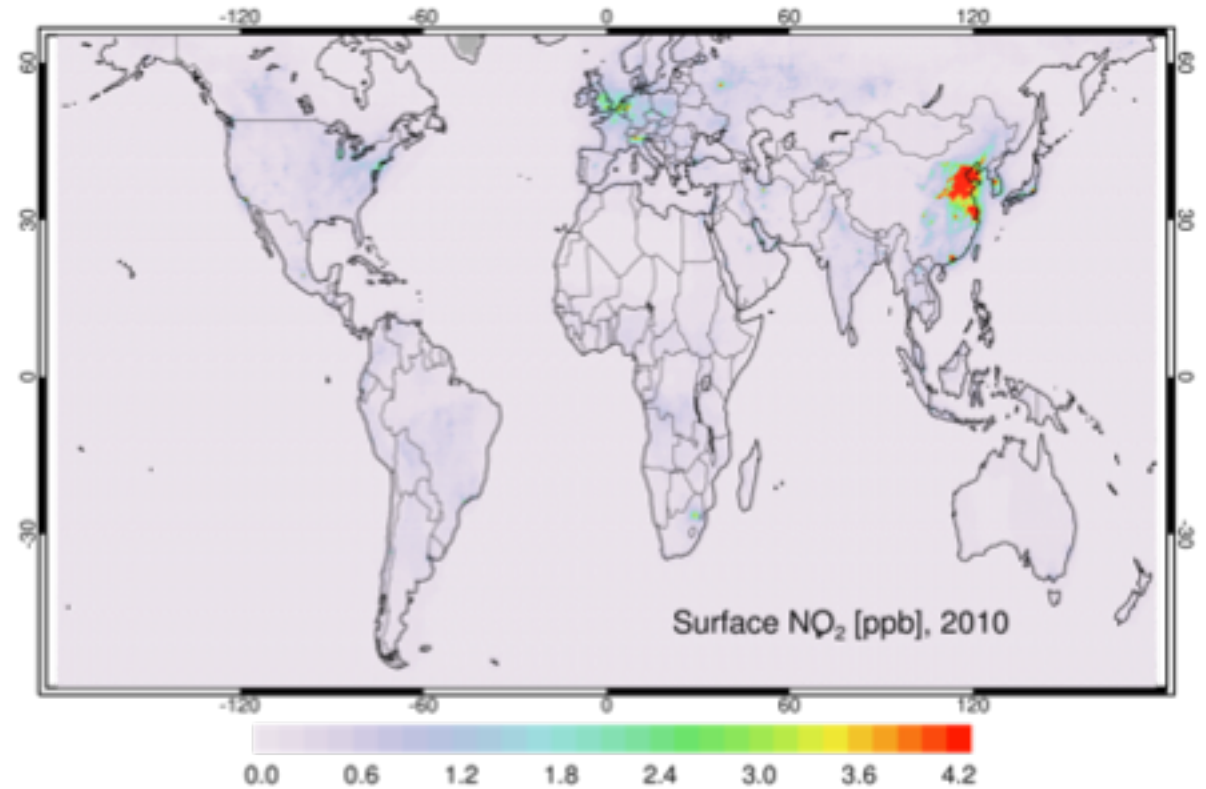
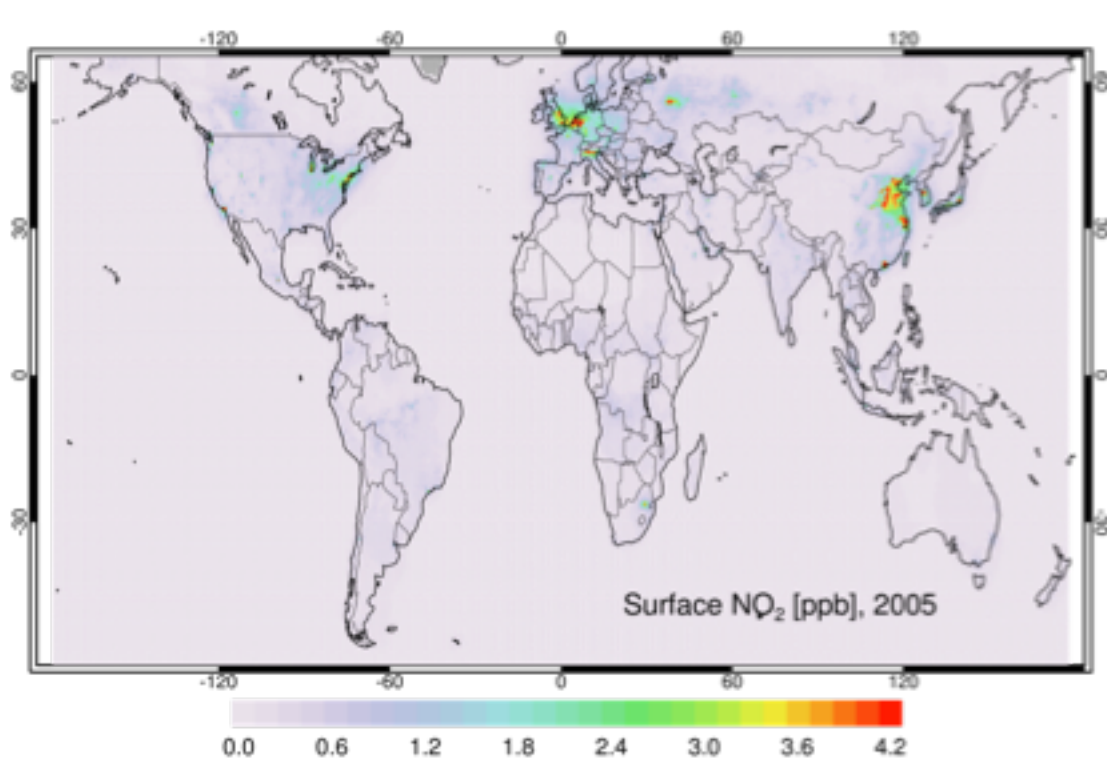
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Parent Directory	-	-
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# OMI Annual Mean Surface NO<sub>2</sub>

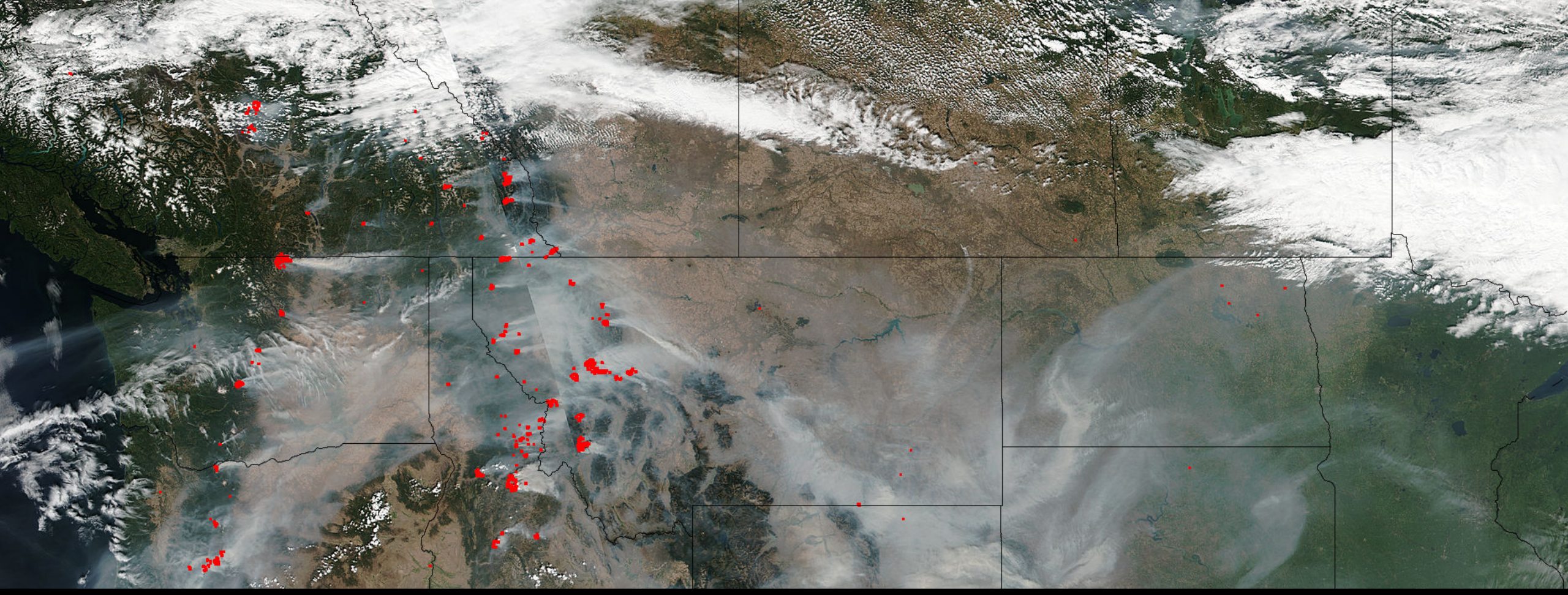
[https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L4/OMI\\_Surface\\_NO2/Monthly/](https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L4/OMI_Surface_NO2/Monthly/)



Lok Lamsal (NASA)







Giovanni -  
The Bridge Between Data and Science:  
an Online Visualization and Analysis Tool



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



# Time Averaged Maps: Step 1

- Go to the Giovanni website: <http://giovanni.gsfc.nasa.gov/giovanni/>

The screenshot shows the GIOVANNI website interface. At the top, there is a navigation bar with 'EARTHDATA' and several menu items: 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. Below this is the 'GIOVANNI' logo and the tagline 'The Bridge Between Data and Science v 4.24'. There are links for 'Release Notes', 'Browser Compatibility', 'Known Issues', and 'Earthdata Login'. A yellow banner indicates 'Time series area statistics temporarily unavailable ... [1 of 1 messages] Read More'.

The main content area is divided into several sections:

- Select Plot:** A dropdown menu is set to 'Maps: Time Averaged Map'. Other options include 'Comparisons', 'Vertical', 'Time Series', and 'Miscellaneous'.
- Select Date Range (UTC):** Fields for 'YYYY-MM-DD' and 'HH:mm' are present, with a 'Valid Range: 1948-01-01 to 2018-02-26' displayed below.
- Select Region (Bounding Box or Shape):** A text input field for the region, with a note 'Format: West, South, East, North'.
- Select Variables:** A list of variables is shown, categorized into 'Disciplines' and 'Measurements'. The 'Disciplines' section includes: Aerosols (185), Atmospheric Chemistry (89), Atmospheric Dynamics (414), Cryosphere (13), Hydrology (1093), Ocean Biology (20), Oceanography (19), and Water and Energy Cycle (1165). The 'Measurements' section includes: Aerosol Index (3), Aerosol Optical Depth (85), Air Pressure Anomaly (1), Air Pressure (53), Air Temperature Anomaly (2), Air Temperature (96), Albedo (24), Altitude (8), Angstrom Exponent (18), Atmospheric Moisture (118), Black Carbon (5), Buoyancy (2), CH4 (16), CO (30), CO2 (2), Canopy Water Storage (6), Chlorophyll (4), Cloud Fraction (37), Cloud Properties (75), Component Aerosol Optical Depth (7), Diffusivity (1), Dust (23), Emissivity (5), Energy (13), and Erythral UV (4).

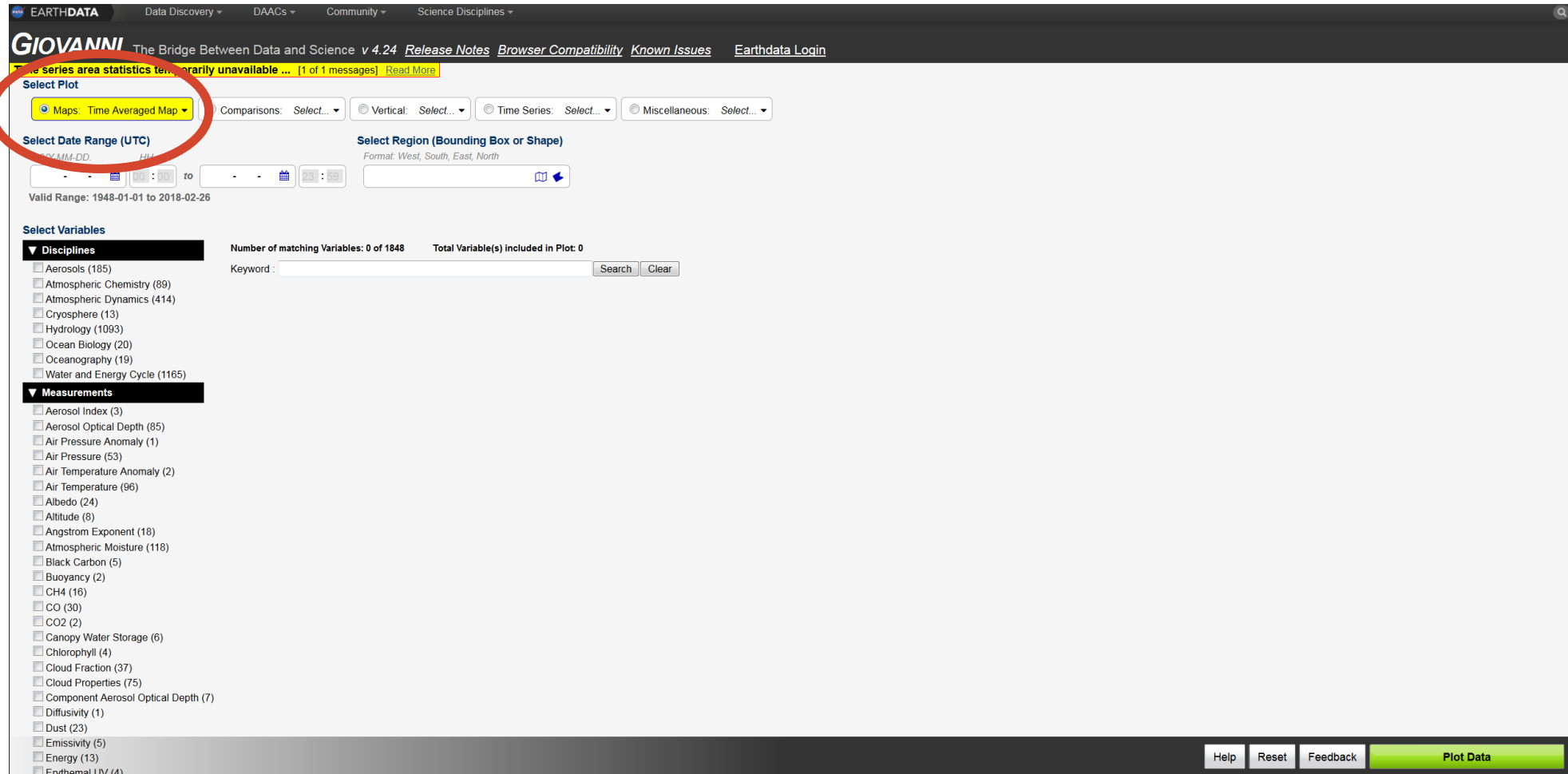
At the bottom right, there are buttons for 'Help', 'Reset', 'Feedback', and a prominent green 'Plot Data' button.





# Time Averaged Maps: Step 2

- Under **Select Plot**, go to **Maps** and select **Time Averaged Map**



The screenshot shows the GIOVANNI web interface. At the top, there is a navigation bar with 'EARTHDATA', 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. Below this is the GIOVANNI logo and the tagline 'The Bridge Between Data and Science v 4.24'. A message banner indicates that 'Time series area statistics temporarily unavailable'. The 'Select Plot' section is highlighted with a red circle, and the 'Maps: Time Averaged Map' option is selected. Other options include 'Comparisons', 'Vertical', 'Time Series', and 'Miscellaneous'. Below this are sections for 'Select Date Range (UTC)', 'Select Region (Bounding Box or Shape)', and 'Select Variables'. The 'Select Variables' section is expanded to show 'Disciplines' and 'Measurements' with various checkboxes and counts. At the bottom right, there are buttons for 'Help', 'Reset', 'Feedback', and 'Plot Data'.



# Time Averaged Maps: Step 2

- Under **Measurement**, select **NO<sub>2</sub>** and **SO<sub>2</sub>**

The screenshot shows the GIOVANNI web interface. At the top, there are navigation menus for 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. Below this is the 'GIOVANNI' logo and the tagline 'The Bridge Between Data and Science v 4.24'. There are links for 'Release Notes', 'Browser Compatibility', 'Known Issues', and 'Earthdata Login'. A message banner indicates 'Time series area statistics temporarily unavailable ... [1 of 1 messages] Read More'. The main content area is titled 'Select Plot' and has several radio buttons for 'Maps: Time Averaged Map', 'Comparisons', 'Vertical', 'Time Series', and 'Miscellaneous'. Below this is the 'Select Date Range (UTC)' section with input fields for start and end dates and times, and a 'Valid Range: 1948-01-01 to 2018-02-26' note. To the right is the 'Select Region (Bounding Box or Shape)' section with a text input field and a 'Format: West, South, East, North' note. The 'Select Variables' section is the focus, showing a list of variables under two categories: 'Disciplines' and 'Measurements'. The 'Measurements' category is expanded, and a red circle highlights the 'Measurements' header. A red arrow points downwards with the text 'Scroll down' next to it. The list of variables includes 'Aerosol Index (3)', 'Aerosol Optical Depth (85)', 'Air Pressure (53)', 'Air Temperature Anomaly (2)', 'Air Temperature (96)', 'Albedo (24)', 'Altitude (8)', 'Angstrom Exponent (18)', 'Atmospheric Moisture (118)', 'Black Carbon (5)', 'Buoyancy (2)', 'CH4 (16)', 'CO (30)', 'CO2 (2)', 'Canopy Water Storage (6)', 'Chlorophyll (4)', 'Cloud Fraction (37)', 'Cloud Properties (75)', 'Component Aerosol Optical Depth (7)', 'Diffusivity (1)', 'Dust (23)', 'Emissivity (5)', 'Energy (13)', and 'Erythral UV (4)'. At the bottom right, there are buttons for 'Help', 'Reset', 'Feedback', and 'Plot Data'.



# Time Averaged Maps: Step 2

- Under **Measurement**, select **NO<sub>2</sub>** and **SO<sub>2</sub>**

The screenshot shows a list of various atmospheric and oceanic measurements. Two red circles are drawn around the 'NO2 (2)' and 'SO2 (4)' entries, indicating they should be selected. The 'NO2 (2)' entry has a checked checkbox, while the 'SO2 (4)' entry has an unchecked checkbox. At the bottom of the interface, there are buttons for 'Help', 'Reset', 'Feedback', and a prominent green 'Plot Data' button.

Measurement	Count	Selected
Diffusivity	1	<input type="checkbox"/>
Dust	23	<input type="checkbox"/>
Emissivity	5	<input type="checkbox"/>
Energy	13	<input type="checkbox"/>
Erythral UV	4	<input type="checkbox"/>
Evaporation Anomaly	1	<input type="checkbox"/>
Evaporation	44	<input type="checkbox"/>
Evapotranspiration Anomaly	1	<input type="checkbox"/>
Evapotranspiration	48	<input type="checkbox"/>
Flooding	3	<input type="checkbox"/>
Geopotential	12	<input type="checkbox"/>
Heat Flux Anomaly	2	<input type="checkbox"/>
Heat Flux	106	<input type="checkbox"/>
Height, Level	13	<input type="checkbox"/>
Incident Radiation Anomaly	2	<input type="checkbox"/>
Incident Radiation	76	<input type="checkbox"/>
Iron	2	<input type="checkbox"/>
Latent Heat Flux	5	<input type="checkbox"/>
Latent Heat	1	<input type="checkbox"/>
Mixed Layer Depth	2	<input type="checkbox"/>
NO <sub>2</sub>	2	<input checked="" type="checkbox"/>
Nitrate	2	<input type="checkbox"/>
OLR	19	<input type="checkbox"/>
Organic Carbon	5	<input type="checkbox"/>
Particulate Matter	40	<input type="checkbox"/>
Phytoplankton	11	<input type="checkbox"/>
Precipitation Anomaly	3	<input type="checkbox"/>
Precipitation	124	<input type="checkbox"/>
Quality Info	1	<input type="checkbox"/>
Reflectivity	6	<input type="checkbox"/>
Runoff Anomaly	1	<input type="checkbox"/>
Runoff	71	<input type="checkbox"/>
SO <sub>2</sub>	4	<input checked="" type="checkbox"/>
SO <sub>4</sub>	4	<input type="checkbox"/>
Scattering Angle	4	<input type="checkbox"/>
Sea Salt	5	<input type="checkbox"/>
Sea Surface Temperature	6	<input type="checkbox"/>
Sensible Heat Flux	6	<input type="checkbox"/>
Sensible Heat	1	<input type="checkbox"/>
Snow/ice Anomaly	2	<input type="checkbox"/>
Snow/ice	39	<input type="checkbox"/>
Soil Moisture Anomaly	6	<input type="checkbox"/>
Soil Moisture	228	<input type="checkbox"/>
Soil Temperature Anomaly	1	<input type="checkbox"/>
Soil Temperature	107	<input type="checkbox"/>
Statistics	24	<input type="checkbox"/>
Streamflow	1	<input type="checkbox"/>
Surface Runoff	1	<input type="checkbox"/>





# Time Averaged Maps: Step 3

- Select one of the following two variables:
  - NO<sub>2</sub> Tropospheric Column (30% Cloud Screened) (OMNO2d\_v003)
  - SO<sub>2</sub> Column Amount (Planetary Boundary Layer) OMSO2e\_v003 (OMSO2e\_v003)

**Number of matching Variables: 6 of 1947    Total Variable(s) included in Plot: 2**

Variable	Units	Source	Temp.Res.	Spat.Res.	Begin Date	End Date
<input type="checkbox"/> NO <sub>2</sub> Total Column (30% Cloud Screened) (OMNO2d_v003)	1/cm <sup>2</sup>	OMI	Daily	0.25 °	2004-10-01	2018-06-24
<input checked="" type="checkbox"/> NO <sub>2</sub> Tropospheric Column (30% Cloud Screened) (OMNO2d_v003)	1/cm <sup>2</sup>	OMI	Daily	0.25 °	2004-10-01	2018-06-24
<input checked="" type="checkbox"/> SO <sub>2</sub> Column Amount (Planetary Boundary Layer) OMSO2e_v003 (OMSO2e_v003)	DU	OMI	Daily	0.25 °	2004-10-01	2018-06-24
<input type="checkbox"/> SO <sub>2</sub> Column Mass Density (ENSEMBLE) (M2TMNXAER_v5.12.4)	kg m <sup>-2</sup>	MERRA-2 Model	Monthly	0.5 x 0.625 °	1980-01-01	2018-05-31
<input type="checkbox"/> SO <sub>2</sub> Surface Mass Concentration (ENSEMBLE) (M2TMNXAER_v5.12.4)	kg m <sup>-3</sup>	MERRA-2 Model	Monthly	0.5 x 0.625 °	1980-01-01	2018-05-31
<input type="checkbox"/> SO <sub>2</sub> Column Mass Density (ENSEMBLE), time average (M2T1NXAER_v5.12.4)	kg m <sup>-2</sup>	MERRA-2 Model	Hourly	0.5 x 0.625 °	1980-01-01	2018-05-31



# Time Averaged Maps: Step 4

- Set the date range as **July 1, 2005** to **July 31, 2005**

The screenshot shows the GIOVANNI web interface with the following elements:

- Select Plot:** Radio buttons for 'Maps: Time Averaged Map' (selected), 'Comparisons: Select...', 'Vertical: Select...', 'Time Series: Select...', and 'Miscellaneous: Select...'.
- Select Date Range (UTC):** A date range selector showing '2005-07-01' to '2005-07-31' with a time of '23:59'. This area is circled in red. Below it, the text 'Valid Range: 2004-10-01 to 2018-06-24' is visible.
- Select Region (Bounding Box or Shape):** A text input field for region coordinates.
- Select Variables:** A sidebar on the left with 'Disciplines' and 'Measurements' sections. The 'Measurements' section includes various atmospheric and oceanographic variables.
- Number of matching Variables: 6 of 1947** and **Total Variable(s) included in Plot: 1**.
- Keyword:** A search bar with 'Search' and 'Clear' buttons.
- Table of Variables:** A table listing variables with columns for Variable, Units, Source, Temp.Res., Spat.Res., Begin Date, and End Date. The selected variable is 'NO2 Tropospheric Column (30% Cloud Screened) (OMNO2d v003)'.
- Buttons:** 'Help', 'Reset', 'Feedback', and a prominent green 'Plot Data' button.



# Time Averaged Maps: Step 5

- Select your region either by typing in coordinates, or by clicking **Show Map** and drawing a box (about 10 x 10 degrees) around your area of interest
- If you pick too large of an area or time period, it will take a long time for your image to be created
- Click on **Plot Data** (green button) in lower right-hand corner

The screenshot shows the GIOVANNI web interface. The 'Select Region (Bounding Box or Shape)' section is active, with a bounding box of -128.6719,31.0547,-117.4219,52.8516. A map window is open, showing a bounding box over the United States with coordinates 47°13'N, 16°52'W. The 'Plot Data' button is highlighted in green in the bottom right corner.

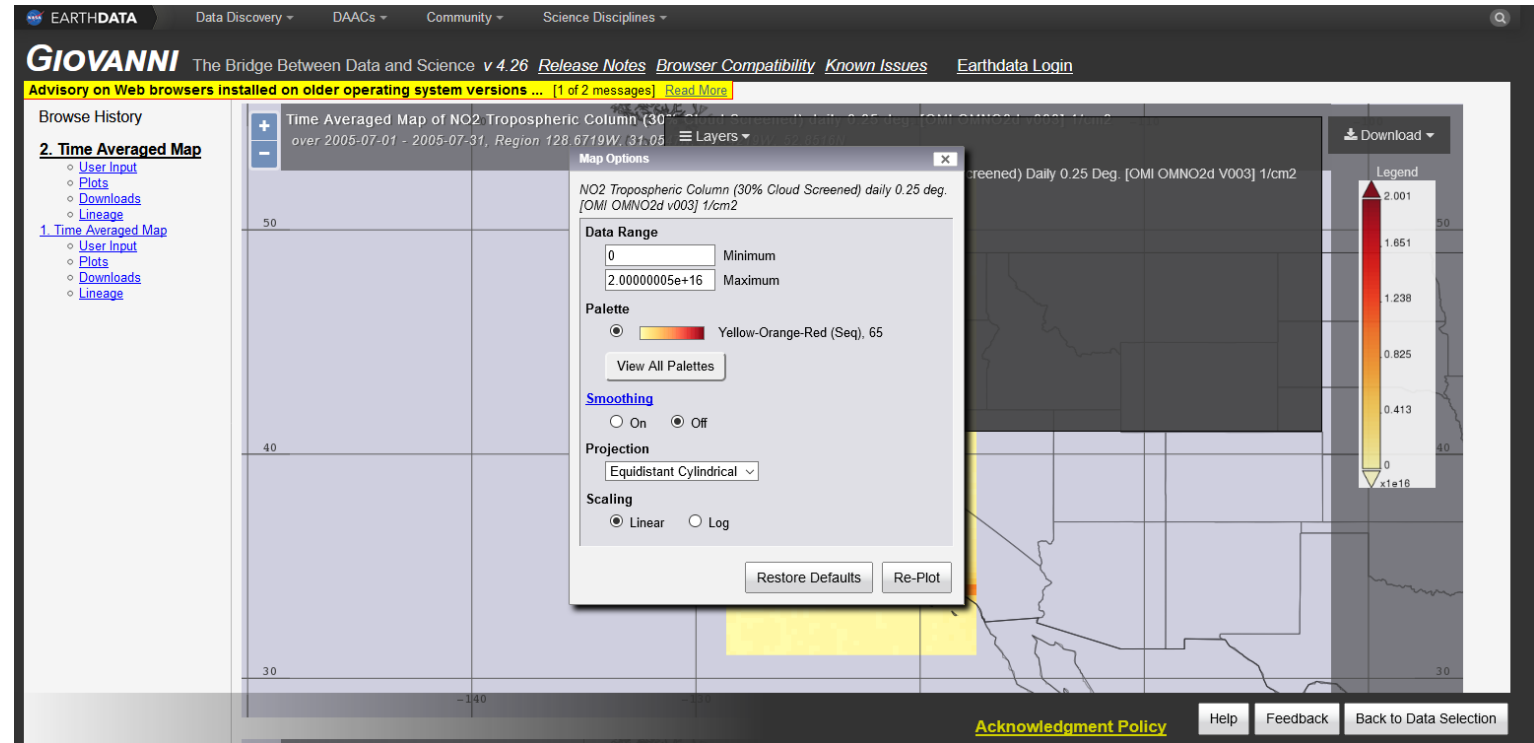
	Units	Source	Temp.Res.	Spat.Res.	Begin Date	End Date
	1/cm2	OMI	Daily	0.25 °	2004-10-01	2018-06-24
	1/cm2	OMI	Daily	0.25 °	2004-10-01	2018-06-24
	DU	OMI	Daily	0.25 °	2004-10-01	2018-06-24
	kg m-2	MERRA-2 Model	Monthly	0.5 x 0.625 °	1980-01-01	2018-05-31
	kg m-3	MERRA-2 Model	Monthly	0.5 x 0.625 °	1980-01-01	2018-05-31
	kg m-2	MERRA-2 Model	Hourly	0.5 x 0.625 °	1980-01-01	2018-05-31





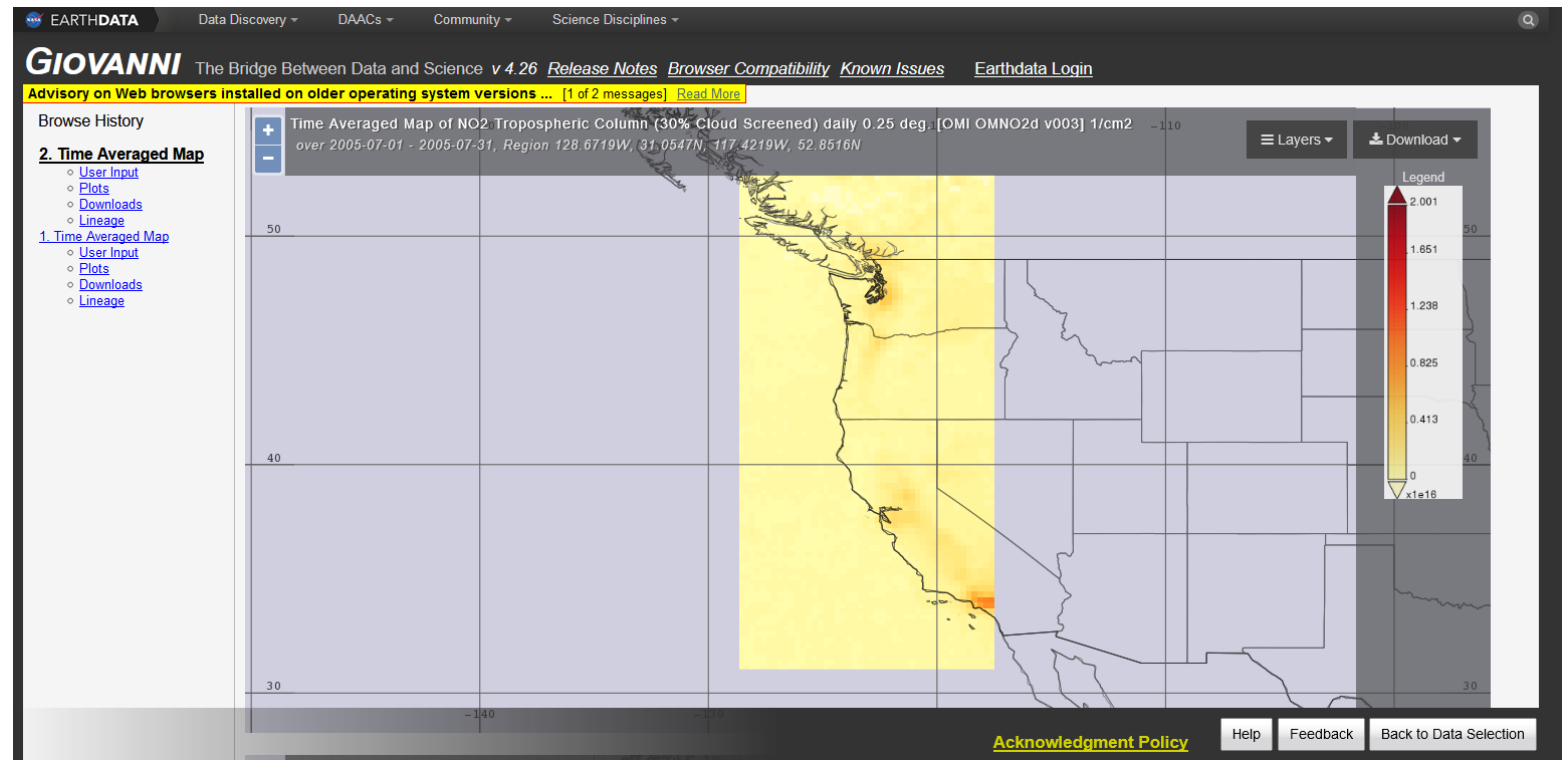
# Time Averaged Maps: Step 6

- Scroll down to view the various maps. You can change the color scale, max, and min under the **Layers >> Options** button on the top right of each map. You can download each image (either as .png or a GeoTIFF) under the Download button



# Time Averaged Maps: Step 6

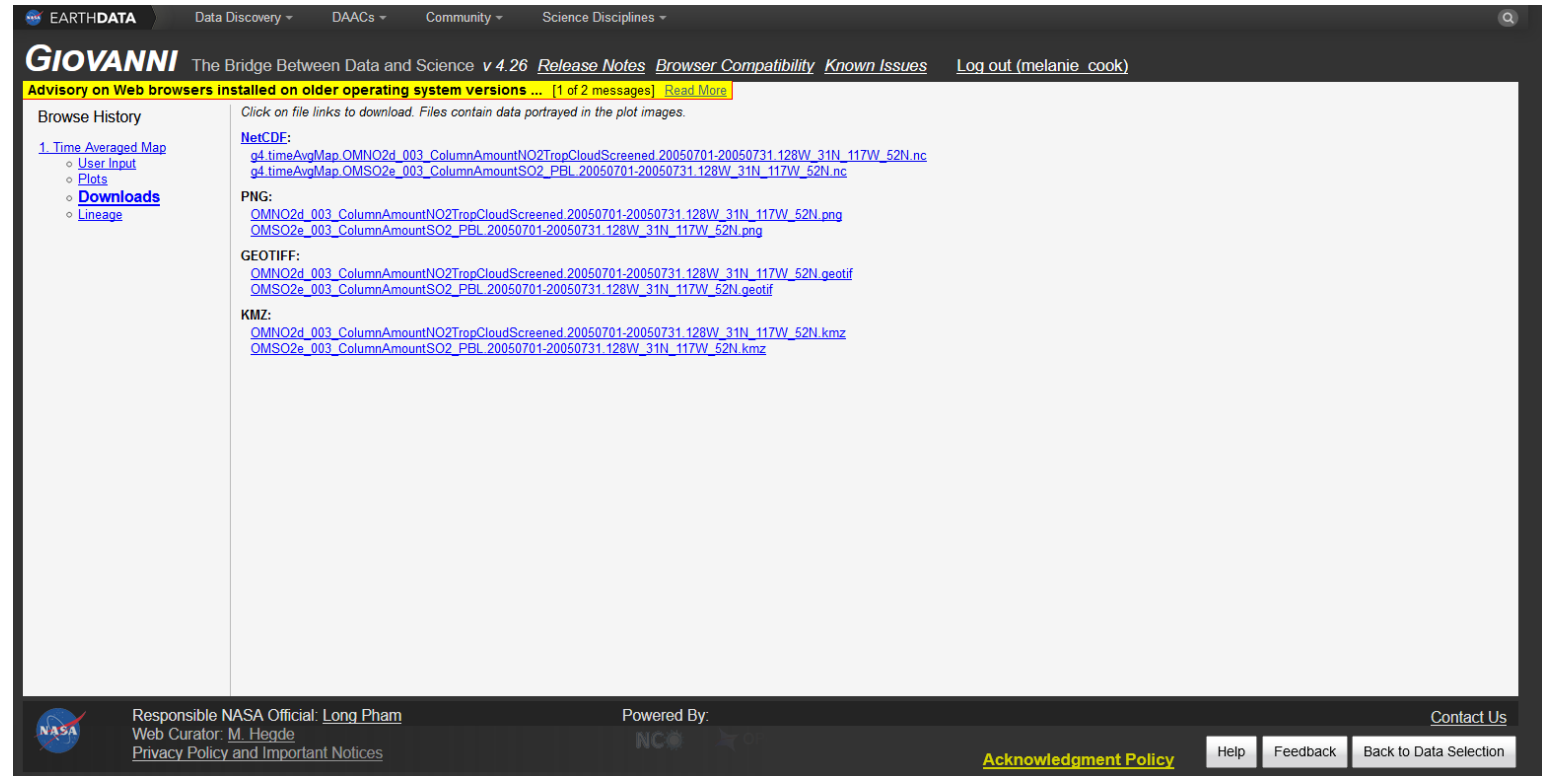
- Scroll down to view the various maps. You can change the color scale, max, and min under the **Layers >> Options** button on the top right of each map. You can download each image (either as .png or a GeoTIFF) under the Download button





# Time Averaged Maps: Step 7

- In the panel on the left, under **Time Averaged Map**, click the **Downloads** link
- Here you can download the maps in .png or GeoTIFF format, or the data in NetCDF format



The screenshot displays the GIOVANNI web interface. At the top, there is a navigation bar with 'EARTHDATA', 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. The main header includes the 'GIOVANNI' logo and the tagline 'The Bridge Between Data and Science v 4.26', along with links for 'Release Notes', 'Browser Compatibility', 'Known Issues', and a 'Log out (melanie\_cook)' button. A yellow advisory banner at the top of the main content area reads: 'Advisory on Web browsers installed on older operating system versions ... [1 of 2 messages] Read More'. Below this, a note states: 'Click on file links to download. Files contain data portrayed in the plot images.' The main content area is divided into sections for different data formats: 'NetCDF:', 'PNG:', 'GEOTIFF:', and 'KMZ:'. Each section contains two blue hyperlinks for downloading files. On the left side, a 'Browse History' panel is visible, showing a list of items: '1. Time Averaged Map', 'User Input', 'Plots', 'Downloads', and 'Lineage'. The 'Downloads' item is highlighted. At the bottom of the page, there is a footer with the NASA logo, 'Responsible NASA Official: Long Pham', 'Web Curator: M. Hegde', and 'Privacy Policy and Important Notices'. To the right, it says 'Powered By: NC' and includes a 'Contact Us' link. Further right are buttons for 'Acknowledgment Policy', 'Help', 'Feedback', and 'Back to Data Selection'.



# Time Averaged Maps: Step 8

- Click the **Back to Data Selection** button in the lower right and keep all parameters the same, except change the range to **July 1, 2017** to **July 31, 2017** and plot the map again
- Now you have two maps of NO<sub>2</sub> and SO<sub>2</sub> for two time periods to compare



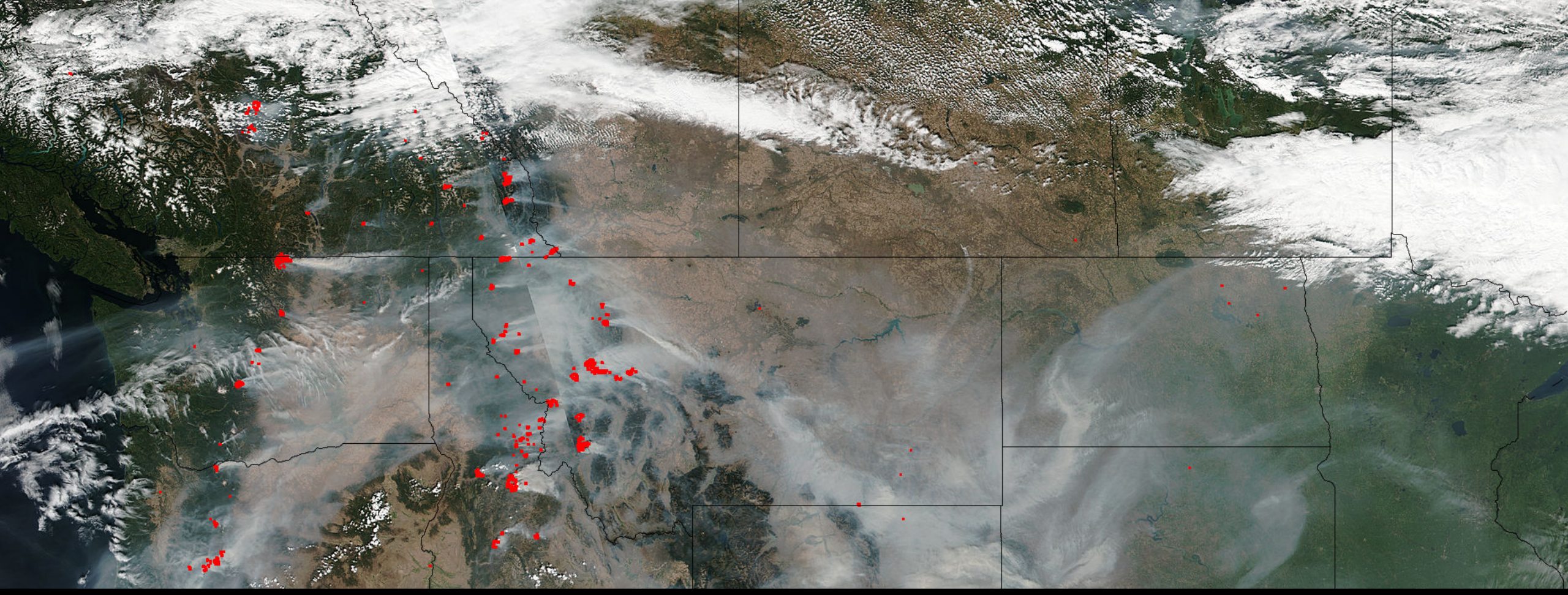


# Time Averaged Maps – Questions

- What are two differences in the NO<sub>2</sub> and SO<sub>2</sub> maps generated for the two time periods?
- Did you observe any increasing or decreasing trends in NO<sub>2</sub> or SO<sub>2</sub> over your area of interest?







Earthdata: Download Level 2 and 3 Data



# Step 1: Add NASA GESDISC to your Applications

- Login to Earthdata (<https://urs.earthdata.nasa.gov>)
- Click on **Applications**, then **Authorized Apps**
- If NASA GESDISC DATA ARCHIVE isn't in your Approved Applications then click on **Approve More Applications**
- Look for NASA GESDISC DATA ARCHIVE in the list or search
- Add NASA GESDISC DATA ARCHIVE to your applications

You should see NASA GESDISC DATA ARCHIVE in list of approved applications

**EARTHDATA LOGIN** My Profile Sign Out

Bryan Duncan

Profile Home Edit Profile Change Password Applications My Groups

### Approved Applications

Applications that use your Earthdata Login profile for authentication.

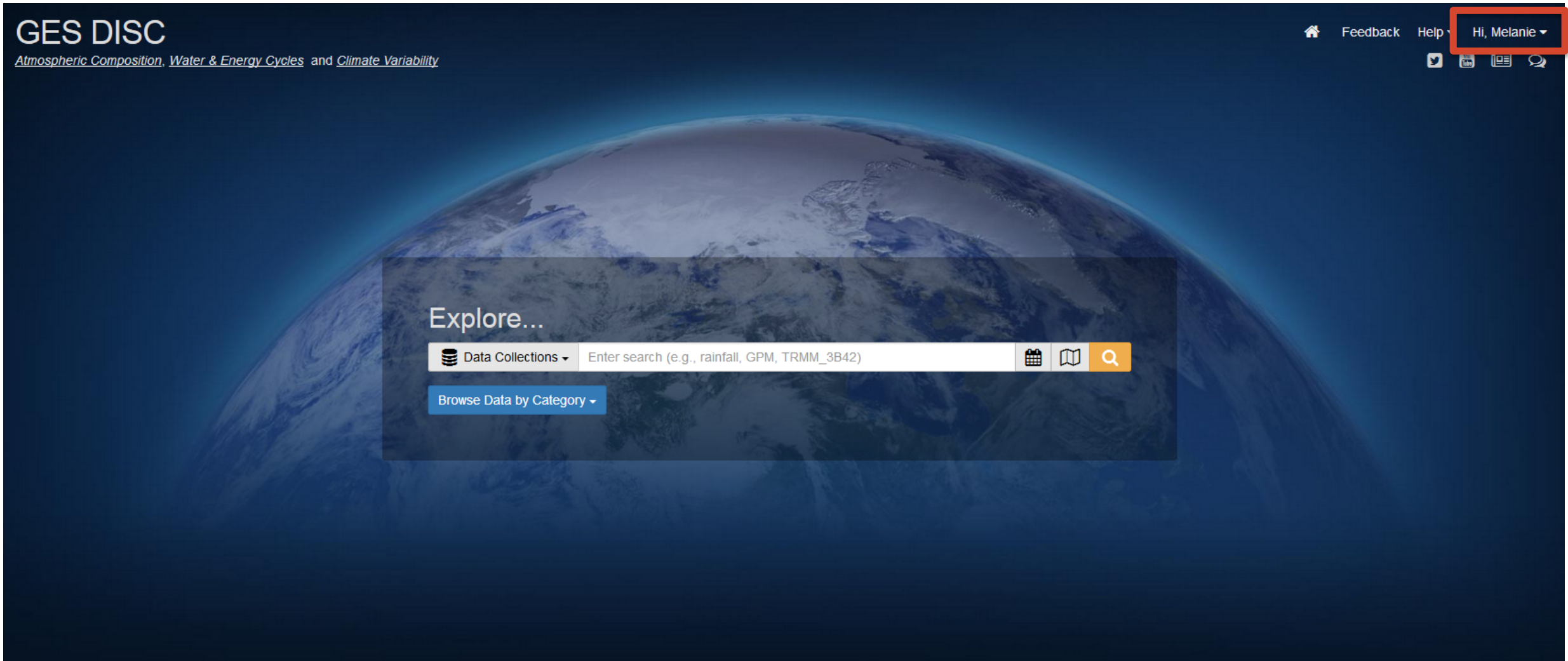
Earthdata Feedback Module	?
Earthdata Code Collaborative	?
Earthdata Website	?
SEDAC Website	✎ +
Metadata Management Tool	?
<b>NASA GESDISC DATA ARCHIVE</b>	✎ +
GESDISC	✎ +

**APPROVE MORE APPLICATIONS**





# Step 2: Login at <https://disc.gsfc.nasa.gov/>



The screenshot shows the NASA GES DISC website. The header includes the text "GES DISC" and "Atmospheric Composition, Water & Energy Cycles and Climate Variability". In the top right corner, there is a navigation menu with "Feedback" and "Help", and a user profile dropdown menu that says "Hi, Melanie" and is highlighted with a red box. Below the header is a large image of Earth from space. In the center, there is a search interface with the text "Explore..." and a search bar containing "Data Collections" and "Enter search (e.g., rainfall, GPM, TRMM\_3B42)". There are also icons for a calendar, a book, and a search icon. Below the search bar is a button that says "Browse Data by Category".



# Step 3: Enter Search Keywords (e.g. OMNO2 or OMSO2)

The screenshot shows the GES DISC website interface. At the top left, the text "GES DISC" is displayed in white, with the subtitle "Atmospheric Composition, Water & Energy Cycles and Climate Variability" below it. In the top right corner, there are navigation links for "Feedback", "Help", and "Hi, Melanie", along with social media icons for Twitter, YouTube, and LinkedIn. The main content area features a dark blue background with a satellite view of Earth. A central "Explore..." panel is overlaid, containing a "Data Collections" dropdown menu, a search input field with the placeholder text "Enter search (e.g., rainfall, GPM, TRMM\_3B42)", and a "Browse Data by Category" button. The search input field is highlighted with a red rectangular border. To the right of the search field are icons for a calendar, a book, and a magnifying glass.



# Step 4: Make a Product Selection

**GES DISC** Data Collections OMSO2  
*Atmospheric Composition, Water & Energy Cycles and Climate Variability*

Feedback Help Hi, Melanie

Data Collections Showing 1 - 3 of 3 datasets associated with OMSO2

**Refine By**

**Subject** Sort  
 Atmospheric Chemistry (3)

**Measurement** Sort  
 Sulfur Dioxide (3)

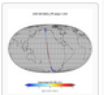
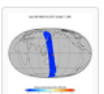
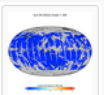
**Source** Sort  
 Aura OMI (3)

**Processing Level** Sort  
 2 (2)  
 3 (1)

**Project** Sort  
 ATDD (1)  
 Aura (2)

**Temporal Resolution** Sort  
 98 minutes (1)  
 98.8 minutes (1)  
 1 day (1)

**Spatial Resolution** Sort  
 13 km x 24 km (2)  
 0.25 ° x 0.25 ° (1)

Image	Dataset	Source	Temporal Resolution	Spatial Resolution	Process Level	Begin Date	End Date
 Hover	OMI/Aura Level 2 Sulphur Dioxide (SO2) Trace Gas Column Data 1-Orbit subset Swath along CloudSat track 1-Orbit Swath 13x24 km (OMSO2_CPR.003) - Atmospheric Chemistry <a href="#">Get Data</a>	Aura OMI	98.8 minutes	13 km x 24 km	2	2006-06-01	2018-01-17
 Hover	OMI/Aura Sulphur Dioxide (SO2) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2.003) - Atmospheric Chemistry <a href="#">Subset / Get Data</a>	Aura OMI	98 minutes	13 km x 24 km	2	2004-10-01	2018-01-17
 Hover	OMI/Aura Sulfur Dioxide (SO2) Total Column L3 1 day Best Pixel in 0.25 degree x 0.25 degree V3 (OMSO2e.003) - Atmospheric Chemistry <a href="#">Subset / Get Data</a>	Aura OMI	1 day	0.25 ° x 0.25 °	3	2004-10-01	2018-01-17





# Step 5: Choose Data Access (we will use Earthdata)

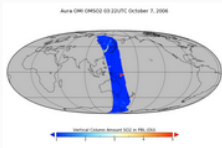
GES DISC Data Collections OMSO2

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Feedback Help Hi, Melanie

Go to Search Results

## OMSO2: OMI/Aura Sulphur Dioxide (SO2) Total Column 1-orbit L2 Swath 13x24 km V003



The Aura Ozone Monitoring Instrument (OMI) Sulphur Dioxide Product 'OMSO2' Version 3 is now available to the public from the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC). The OMSO2 product contains three values of SO2 Vertical column corresponding to three a-priori vertical profiles used in the retrieval algorithm. It also contains quality flags, geolocation and other ancillary information. The lead scientist for the OMSO2 product is Nickolay Kroktov. The shortname for this Level-2 OMI total column SO2 product is OMSO2.

The OMSO2 files are stored in the version 5 EOS Hierarchical Data Format (HDF-EOS5). Each file contains data from the day lit portion of an orbit (~53 minutes). There are approximately 14 orbits per day. The maximum file size for the OMSO2 data product is approximately 21 MB.

**Data Access**

- Online Archive
- EARTHDATA Search
- Simple Subset Wizard
- OPENDAP DATA

Product Summary Data Citation Documentation

**Shortname:** OMSO2  
**Longname:** OMI/Aura Sulphur Dioxide (SO2) Total Column 1-orbit L2 Swath 13x24 km V003  
**DOI:** 10.5067/Aura/OMI/DATA2022  
**Version:** 003  
**Format:** HDF5  
**Spatial Coverage:** -180.0,-90.0,180.0,90.0  
**Temporal Coverage:** 2004-10-01 to present  
**File Size:** 26 MB per file  
**Data Resolution**  
**Spatial:** 13 km x 24 km  
**Vertical:** 80 km  
**Temporal:** 98 minutes



# Step 6: Select Product

The screenshot displays the NASA Earthdata Search interface. At the top, the search bar contains the text 'OMSO2\_003'. Below the search bar, a map of the world is shown, with a white mouse cursor pointing to the Atlantic Ocean. To the left of the map, a sidebar lists various search filters: Features (Map Imagery, Near Real Time, Subsetting Services), Keywords, Platforms, Instruments, Organizations, Projects, and Processing levels. Below the map, a search results section is visible, showing '2 Matching Collections'. The first result is highlighted with a red border and contains the following information:

- OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC**
- 67736 Granules • 2004-10-01 ongoing • The Aura Ozone Monitoring Instrument (OMI) Sulfur Dioxide Product Version 3 is now available to the public from the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC). The OMSO2 product contains three values of SO<sub>2</sub> Vertical column corresponding to...
- MAP IMAGERY | OMSO2 v003 - NASA/GSFC/SED/ESD/GCDC/GESDISC

The second result is:

- OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 NRT**
- 114 Granules • 2004-07-15 ongoing • The Ozone Monitoring Instrument (OMI) was launched aboard the EOS-Aura satellite on July 15, 2004 (1:38 pm equator crossing time, ascending mode). OMI with its 2600 km viewing swath width provides almost daily global coverage. OMI is a contribution of the Netherlands Space Office...
- MAP IMAGERY | NRT | OMSO2 v003 - OMI SIP5



# Step 7: Select Time

To choose time, click on + or - to change the time resolution (e.g. Click - to change to year, and + to change to day)

Back to Collections

OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC

Showing 20 of 67736 matching granules    Sort by: Start Date, Newest first    Granule Search: Search Single or Multiple Granule IDs...    Search Time: 0.4s    Report a metadata problem

Granule ID	START	END
OMI-Aura_L2-OMSO2_2018m0118t0800-o71867_v003-2018m0118t142500.he5	2018-01-18 08:00:41	2018-01-18 09:39:35
OMI-Aura_L2-OMSO2_2018m0118t0621-o71866_v003-2018m0118t141452.he5	2018-01-18 06:21:48	2018-01-18 08:00:41
OMI-Aura_L2-OMSO2_2018m0118t0442-o71865_v003-2018m0118t123448.he5	2018-01-18 04:42:55	2018-01-18 06:21:48
OMI-Aura_L2-OMSO2_2018m0118t0304-o71864_v003-2018m0118t092759.he5	2018-01-18 03:04:01	2018-01-18 04:42:55
OMI-Aura_L2-OMSO2_2018m0118t0125-o71863_v003-2018m0118t073427.he5	2018-01-18 01:25:08	2018-01-18 03:04:01
OMI-Aura_L2-OMSO2_2018m0117t2346-o71862_v003-2018m0118t055001.he5	2018-01-17 23:46:15	2018-01-18 01:25:08
OMI-Aura_L2-OMSO2_2018m0117t2207-o71861_v003-2018m0118t041541.he5		
OMI-Aura_L2-OMSO2_2018m0117t2028-o71860_v003-2018m0118t041510.he5		
OMI-Aura_L2-OMSO2_2018m0117t1849-o71859_v003-2018m0118t021312.he5		
OMI-Aura_L2-OMSO2_2018m0117t1710-o71858_v003-2018m0117t231809.he5		
OMI-Aura_L2-OMSO2_2018m0117t1531-o71857_v003-2018m0117t211323.he5		
OMI-Aura_L2-OMSO2_2018m0117t1352-o71856_v003-2018m0117t200605.he5		

MONTH: + -

Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec    Jan 2018





# Step 8: Select Swath

Clicking on a swath will show you its location on the map

OMSO2\_003

Find a DAAC

Earthdata Login

2000 km  
1000 mi

Back to Collections

OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC

Showing 15 of 15 matching granules for the selected day. (Show All) Sort by: Start Date, Newest first Granule Search: Search Single or Multiple Granule IDs... Search Time: 0.2s Report a metadata problem

Granule ID	START	END
OMI-Aura_L2-OMSO2_2016m1024t1228-o65302_v003-2016m1024t222720.he5	2016-10-24 12:28:14	2016-10-24 14:07:06
OMI-Aura_L2-OMSO2_2016m1024t1049-o65301_v003-2016m1024t224733.he5	2016-10-24 10:49:21	2016-10-24 12:28:14
OMI-Aura_L2-OMSO2_2016m1024t0910-o65300_v003-2016m1024t174753.he5	2016-10-24 09:10:29	2016-10-24 10:49:21
OMI-Aura_L2-OMSO2_2016m1024t0731-o65299_v003-2016m1024t163627.he5	2016-10-24 07:31:36	2016-10-24 09:10:29
OMI-Aura_L2-OMSO2_2016m1024t0552-o65298_v003-2016m1024t163822.he5	2016-10-24 05:52:43	2016-10-24 07:31:36
OMI-Aura_L2-OMSO2_2016m1024t0413-o65297_v003-2016m1024t114026.he5	2016-10-24 04:13:51	2016-10-24 05:52:43

DAY

OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Oct 2016



# Step 9: Download a Single Granule by Clicking the Gear Icon

The screenshot shows the Earthdata search interface. At the top, there's a search bar with 'OMSO2\_003' and a 'Find a DAAC' dropdown. Below the search bar is a map of the Atlantic Ocean with green lines indicating the swath of the satellite. A tooltip shows two granule IDs: '2016-10-24 09:10:29' and '2016-10-24 10:49:21'. Below the map, there's a 'Back to Collections' button and a 'Download Data' button. The main content area shows a table of 15 granules for the selected day. The table has columns for granule ID, start time, and end time. A red box highlights the gear icon for the granule with ID 'OMI-Aura\_L2-OMSO2\_2016m1024t0910-o65300\_v003-2016m1024t174753.he5'. Below the table is a timeline for the day of October 2016, with a green bar indicating the swath of the satellite.

OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC

Showing 15 of 15 matching granules for the selected day. (Show All) Sort by: Start Date, Newest first Granule Search: Search Single or Multiple Granule IDs... Search Time: 0.2s Report a metadata problem

Granule ID	START	END
OMI-Aura_L2-OMSO2_2016m1024t1228-o65302_v003-2016m1024t222720.he5	2016-10-24 12:28:14	2016-10-24 14:07:06
OMI-Aura_L2-OMSO2_2016m1024t1049-o65301_v003-2016m1024t224733.he5	2016-10-24 10:49:21	2016-10-24 12:28:14
OMI-Aura_L2-OMSO2_2016m1024t0910-o65300_v003-2016m1024t174753.he5	2016-10-24 09:10:29	2016-10-24 10:49:21
OMI-Aura_L2-OMSO2_2016m1024t0731-o65299_v003-2016m1024t163627.he5	2016-10-24 07:31:36	2016-10-24 09:10:29
OMI-Aura_L2-OMSO2_2016m1024t0552-o65298_v003-2016m1024t163822.he5	2016-10-24 05:52:43	2016-10-24 07:31:36
OMI-Aura_L2-OMSO2_2016m1024t0413-o65297_v003-2016m1024t114026.he5	2016-10-24 04:13:51	2016-10-24 05:52:43

DAY: OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31  
Oct 2016



# Step 10: Choose “Direct Download” and Click “Submit”

**Data Access**  
Review and select service options for your data prior to download

**1** OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO<sub>2</sub>) at GES DISC

**Review & Select Service Options**

**Review**

1 Granule  
26.2 Megabytes

**Granule List**

Expand List

**Select Data Access Method**

**Direct Download**  
Download data as-is now from your browser or access script.

Submit





# Step 11: Click “View Download Links” to Download

**The following collections are available for immediate download**

Click the "View Download Links" button to view a page containing links to your data. You may bookmark this page for later access. A browser download manager plugin such as Firefox's [DownThemAll!](#) can assist you in managing a large number of download links.

- **OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC**

[View Download Links](#) [Download Data Links File](#) [Download Access Script](#)

**Additional Resources and Documentation**

- **OMI/Aura Sulphur Dioxide (SO<sub>2</sub>) Total Column 1-orbit L2 Swath 13x24 km V003 (OMSO2) at GES DISC**

[https://aura.gesdisc.eosdis.nasa.gov/opensdap/Aura\\_OMI\\_Level2/OMSO2\\_003/contents.html](https://aura.gesdisc.eosdis.nasa.gov/opensdap/Aura_OMI_Level2/OMSO2_003/contents.html)  
<https://disc.sci.gsfc.nasa.gov/SSW/#keywords=OMSO2>  
<https://aura.gsfc.nasa.gov/>  
[http://projects.knmi.nl/omi/research/news/newsWrap.php?language=only\\_enhttps://www.knmi.nl/omitimeFrame=latesthttps://www.knmi.nl/omichoise=page](http://projects.knmi.nl/omi/research/news/newsWrap.php?language=only_enhttps://www.knmi.nl/omitimeFrame=latesthttps://www.knmi.nl/omichoise=page)  
<https://so2.gsfc.nasa.gov/>

**Next Steps**

- [Back to Earthdata Search Results](#)
- [Start a New Earthdata Search Session](#)
- [View Your Download Status & History](#)



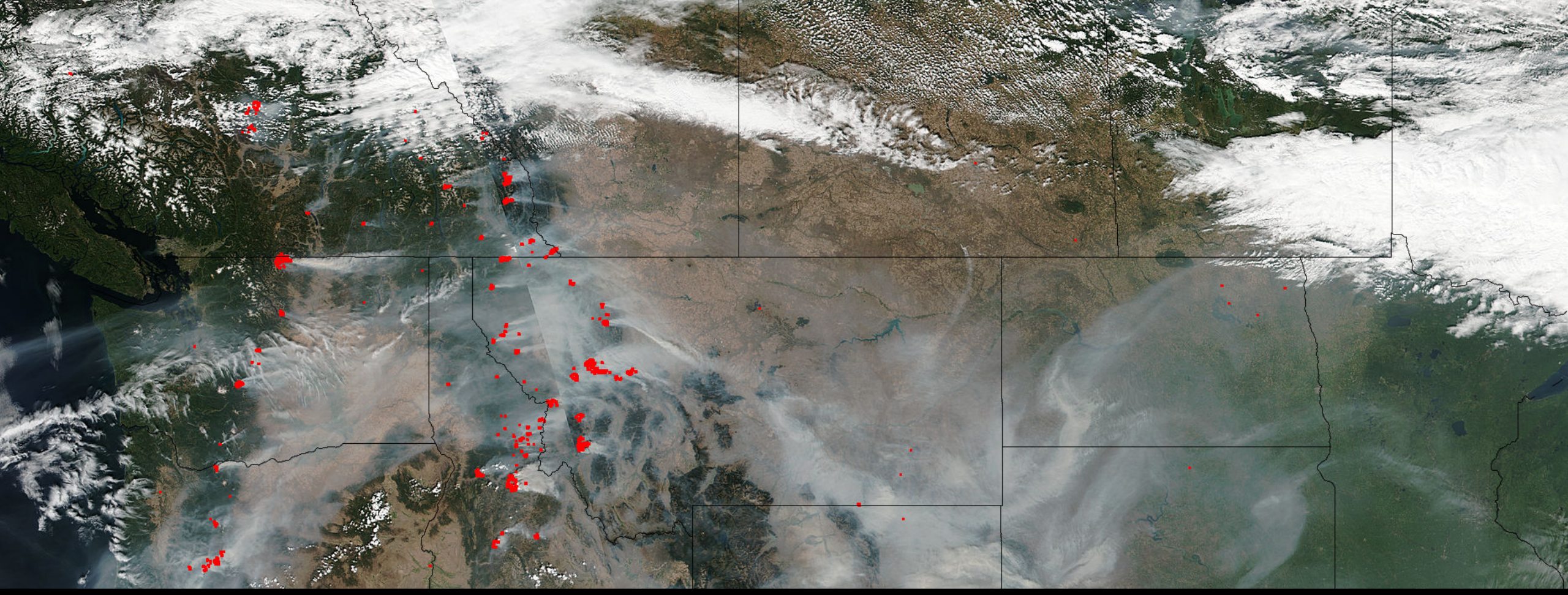
# Step 12: Download the Data

- [http://aura.gesdisc.eosdis.nasa.gov/data/Aura\\_OMI\\_Level2/OMSO2.003/2016/298/OMI-Aura\\_L2-OMSO2\\_2016m1024t0910-o65300\\_v003-2016m1024t174753.he7](http://aura.gesdisc.eosdis.nasa.gov/data/Aura_OMI_Level2/OMSO2.003/2016/298/OMI-Aura_L2-OMSO2_2016m1024t0910-o65300_v003-2016m1024t174753.he7)

Click on the provided link and save the data.







Questions