Flowchart of Resources and Data Products for Health and Air Quality Applications with an Emphasis on Satellite Data

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This resource is for users interested in using satellite data but are new to the data products and their capabilities. The flowchart that will guide users from a general question or need to a specific resource. For brevity this flowchart focuses on the United States, but this resource will be extended to provide data products for global applications. The possible end points include tutorials on the NASA Health and Air Quality Applied Sciences Team (HAQAST) website, Applied Remote Sensing Training (ARSET) tutorials, recommended publications, and websites with more information.

**Audience:** Novice users  
**Platform:** Interactive website with clickable boxes  
**End Points:** HAQAST tutorials, ARSET tutorials, websites, suggested readings, and publications  
**Goal:** Guide users from a general question to a specific resource  
**Starting Question Examples:** How can I get started looking at the variation of formaldehyde concentrations in my state? There is a smoke plume out west, where can I go to see it in real time? How can I see the change in aerosol optical depth over a couple of hours? Where can I go to see locations of active fires?
How to use this Flowchart

1. At the start, you will begin at the darkest shade of blue
2. Follow the best pathway related to your determined interest(s)
3. Based on your choice **click on the bubbles** to advance to the next slide in the series
4. As you advance through the flowchart, the colors will shift to a lighter blue, then green, then red to indicate an **ending point**
5. Once you reach a red bubble, click on it to go to your final slide
6. The end points were selected using the HAQAST website, the ARSET website and the Environmental Protection Agency (EPA) website
7. Links for all end point resources are provided on the last slide and will direct you to an external page
First, determine the location of interest:
Choose between the Continental United States (CONUS) and Hawaii or Alaska.

If interested in CONUS, determine what spatial scale you are interested in.

Depending on your choices, click on the pathway you are interested in to go to the next slide.
Large scale (state or larger) → Historical Data → Averaging over time → Map → Time series (line plot) → Go to page 7
Do you know how to use Python, Google Earth Engine, McIDAS, or IDL for satellite data? Or would you like to learn?

Yes

Download/work with satellite-based data

Go to page 8

No

Giovanni
What pollutant?

- Particulate Matter
  - Fine (PM2.5)
    - Go to page 9
  - Coarse (PM10)
    - Go to page 10
- Ozone
  - Go to page 11
- NO2
  - Go to page 12
- SO2
  - Go to page 13
- CO
  - Go to page 14
- Other
  - Go to "Satellite Data Download" Flowchart on page 50
Fine Particulate Matter (PM2.5)

Annual averages of pollutant concentration

Data within the years 1998-2021?

Yes


No

Monthly averages of pollutant concentration

Data within the years 1998-2021?

Yes

Wash U (1998-2021) dataset

No

Other

Go to “Satellite Data Download” Flowchart
Coarse Particulate Matter (PM10)

Annual averages of pollutant concentration

Data within the years 1988-2015?

Yes

CACES dataset (1988-2015)

No

Go to “Satellite Data Download” Flowchart

Other
Ozone

Annual averages of pollutant concentration

Data within the years 1979-2016?

Yes

CACES (1979-2015), or SEDAC (2000-2016) dataset

No

Go to “Satellite Data Download” Flowchart

Other
NO2

Annual averages of pollutant concentration

Data within the years 1979-2019?

Yes


No

Go to “Satellite Data Download” Flowchart

Other
Annual averages of pollutant concentration

Data within the years 1979-2015?

Yes

CACES dataset (1979-2015)

No

Other

Go to “Satellite Data Download” Flowchart
Annual averages of pollutant concentration

Data within the years 1990-2015?

Yes

CACES dataset (1990-2015)

No

Go to “Satellite Data Download” Flowchart
Large scale (state or larger)

Historical Data

Single day maps or plots

Map of smoke, dust, or fire locations

Aerosol Watch and Worldview

Pollutant concentrations or properties of particulate matter at a single time point in the day

Go to page 16

Map of AQI Values

Air Now Interactive Map

Fluctuations throughout the day of pollutant or smoke/dust plume

Go to page 27
Pollutant concentrations or properties of particulate matter at a single time point in the day

Data for analysis needed

Imagery only

Raw data

Do you know how to use Python, Google Earth Engine, McIDAS, or IDL for satellite data? Or would you like to learn?

Yes

Go to page 17

No

Pollutant concentrations or vertical structure of clouds and aerosols?

Concentrations

Vertical Structure

Worldview

Calipso

Go to page 22
Which pollutant

- SO2
  - Go to page 18
- NO2
  - Go to page 19
- Ozone
  - Go to page 20
- Particulate matter
  - Go to page 21
- Other
  - Worldview
SO2

Is the highest spatial resolution available required?

Yes

Before April 30th 2018?

Yes

Worldview

No

Worldview

No

Download data from TROPOMI (S5-P)
Is the highest spatial resolution available required?

- Yes
  - Data within the years 2000-2016?
    - Yes
      - Download SEDAC Dataset
    - No
      - Worldview

- No
  - Before April 30th 2018?
    - Yes
      - Worldview
    - No
      - Download data from TROPOMI (S5-P)
Particulate Matter

Concentrations or properties of the vertical structure of clouds and aerosols?

Concentrations

Data within the years 2000-2016?

Yes

No

Fine particulate matter (PM2.5)?

Yes

No

Worldview

No

Calipso

Yes

Download data from TROPOMI (S5-P)
Which pollutant

- SO2: Go to page 23
- NO2: Go to page 24
- Ozone: Go to page 25
- Particulate matter: Go to page 26
- Other: NASA Earth Data Search
SO2

Before April 30th 2018?

Yes:
Download data from OMI (Aura)

No:
Download data from TROPOMI (S5-P)
Data within the years 2000-2016?

Yes → Download SEDAC dataset

No → Before April 30th 2018?

Yes → Download data from OMI (Aura)

No → Download data from TROPOMI (S5-P)
Ground level ozone?

Yes

Data within the years 2000-2016?

Yes

Download SEDAC Dataset

No

Model

Total column ozone

Before April 30th 2018?

Yes

Download data from OMI (Aura)

No

Download data from TROPOMI (S5-P)
Particulate Matter

Concentrations or properties of the vertical structure of clouds and aerosols?

Concentrations

Vertical Structure

Data within the years 2000-2016?

Yes

No

Fine particulate matter (PM2.5)?

Yes

No

Before March 1st 2012?

Yes

No

Worldview

Calipso

Download data from MODIS (Terra or Aqua)

Download data from VIIRS (Suomi-NPP) or MODIS (Terra or Aqua) (AOD as a proxy)
Fluctuations throughout the day of pollutant or smoke/dust plume

Map Imagery

AOD, a smoke plume, and/or a dust plume?

Yes → Aerosol Watch

No → Time series of pollutant (line plot)

Data for Excel or Python → Model

EPA Data Download
Large scale (state or larger)

Near Real Time Data

Smoke/fire/dust

Smoke plume
- HMS and Aerosol Watch

Fire location
- FIRMS

Dust plume
- Aerosol Watch

Criteria Air Pollutants
- Ozone, particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, lead

Go to page 29
Criteria air pollutants

- AQI value
  - Air Now Interactive Map and BreezoMeter
- Pollutant concentration
  - Worldview
Rural

Historical Data

Single day maps or plots

Smoke/dust/fire locations

Aerosol Watch and Worldview

Pollutant concentrations or properties of particulate matter at a single time point in the day

Go to page 16

Map of AQI Values

Air Now Interactive Map

Fluctuations throughout the day of pollutant or smoke/dust plume

Go to page 33
Fluctuations throughout the day of pollutant or smoke/dust plume

Map Imagery

AOD, a smoke plume, and/or a dust plume?

Yes -> Aerosol Watch

No -> Time Series (Line Plot)

Model
Urban Real Time Data

Smoke/fire/dust

- Smoke plume
  - HMS and Aerosol Watch

- Fire location
  - FIRMS

- Dust plume
  - Aerosol Watch

Criteria Air Pollutants

Go to page 29
Urban

Historical Data

Averaging Over Time

Map

Time series (line plot)

Higher spatial coverage (more assumptions and/or estimations)

Data from a single point (true concentrations at ground level)

Ground monitor data for excel or Python

EPA Data Download

Go to page 7
Hawaii or Alaska

Historical Data
- Averaging over time
  - Go to page 39

Real Time Data
- Single day maps or plots
  - Go to page 40
- Map of current values or conditions
  - Go to page 49
Averaging Over Time

Map

Time Series (Line Plot)

Urban Area?

No

Higher spatial coverage (more assumptions and/or estimations)

Yes

No

Data from a single point (true concentrations at ground level)

Do you know how to use Python, Google Earth Engine, McIDAS, or IDL for satellite data? Or would you like to learn?

Yes

Download/work with satellite-based data

No

Giovanni

Data for excel or Python

EPA Data Download

Go to “Satellite Data Download” Flowchart
Single day maps or plots

- Smoke/dust/fire locations
- Worldview
- Map of AQI Values
- Air Now Interactive Map

Pollutant concentrations or properties of particulate matter at a single time point in the day

Go to page 41

Fluctuations throughout the day of pollutant or smoke/dust plume

Go to page 48
Pollutant concentrations or properties of particulate matter at a single time point in the day

Imagery only or raw data for analysis needed

Imagery only

Raw data

Do you know how to use Python, Google Earth Engine, McIDAS, or IDL for satellite data? Or would you like to learn?

Yes

Go to page 42

No

Go to page 45

Pollutant concentrations or vertical structure of clouds and aerosols?

Concentrations

Worldview

Vertical Structure

Calipso
Which pollutant

- Particulate matter
  - Pollutant concentrations or vertical structure of clouds and aerosols?
    - Concentrations
      - Worldview (AOD as a proxy)
    - Vertical Structure
      - Calipso
  - Go to page 43

- NO2 or SO2
  - Go to page 43

- Ozone
  - Go to page 44

- Other
  - Worldview
Is the highest spatial resolution available required?

- No
- Yes

NO2 or SO2

- No
- Yes

Before April 30th 2018?

- Yes
- No

Worldview

- Yes
- No

Download data from TROPOMI (S5-P)

Worldview
Ozone

Total column ozone?

Yes

Is the highest spatial resolution available required?

Yes

Before April 30th 2018?

Yes

Worldview

No

Model

No

Worldview

Download data from TROPOMI (S5-P)
Which pollutant

- NO2 or SO2
  - Go to page 46

- Ozone
  - Go to page 47

- Particulate matter
  - Go to page 52

- Other
  - NASA Earth Data Search
NO2 or SO2

Before April 30th 2018?

Yes -> Download data from OMI (Aura)

No -> Download data from TROPOMI (S5-P)
Ozone

Total column ozone?

Yes

Before April 30th 2018?

Yes

Download data from OMI (Aura)

No

Model

Download data from TROPOMI (S5-P)

No
Fluctuations throughout the day of pollutant or smoke/dust plume

Map Imagery

Time Series (Line Plot)

Urban Area?

No

Model

Yes

EPA Data Download
Map of current values or conditions

- Smoke/dust/fire locations
  - Smoke or dust plumes: Worldview
  - Fire locations: FIRMS
- Criteria Air Pollutants
  - AQI value: Air Now Interactive Map and BreezoMeter
  - Pollutant concentration: Worldview
Do you have a specific pollutant in mind?

Yes

Which Pollutant?

Ozone (O3), Formaldehyde (CH2O), NO2, or SO2

Go to page 51

CO

Download data from AIRS (Aqua)

No

Look at NO2 from OMI and TROPOMI

Particulate Matter

Go to page 52

Other

NASA Earthdata Search
Looking for data before April 30th, 2018?

Total column ozone (O3), ground ozone sensitivity, formaldehyde (CH2O), NO2, or SO2

Ground ozone sensitivity

Looking for data before April 30th, 2018?

Yes

Download HCHO and NO2 data from OMI (Aura)

No

Download HCHO and NO2 data from TROPOMI (S5-P)

Total column ozone (O3), formaldehyde (CH2O), NO2, or SO2

Looking for data before April 30th, 2018?

Yes

Download data from OMI (Aura)

No

Download data from TROPOMI (S5-P)
Particulate Matter

Vertical Structure of Aerosol Cloud Layer or Aerosol Optical Depth as a proxy for particulate matter?

Vertical Structure

CALIPSO

Aerosol Optical Depth

Looking for data before March 1st 2012?

Yes

Download data from MODIS (Terra or Aqua)

No

Download data from VIIRS (Suomi-NPP) or MODIS (Terra or Aqua) (AOD as a proxy)
Giovanni has the capabilities to create a variety of maps and plots to display satellite imagery without coding skills. Some examples available include a time averaged map, animations, or a time series plot. Additionally, the user can select the time frame and the region of the globe.

There is also a tutorial for Giovanni on the HAQAST website.
The websites of these datasets offer publications that have utilized the datasets. It is recommended to explore these websites for more information.
Wash U (1998-2021) dataset →

The website of this dataset offers publications that have utilized the dataset. It is recommended to explore the website for more information.
The CACES website offers publications that have utilized this dataset. It is recommended to explore this website for more information.
The websites of these datasets offer publications that have utilized the datasets. It is recommended to explore these websites for more information.
The websites of these datasets offer publications that have utilized the datasets. It is recommended to explore these websites for more information.
CACES (1979-2015) dataset

The website of this dataset offers publications that have utilized the dataset. It is recommended to explore this website for more information.
The website of this dataset offers publications that have utilized the dataset. It is recommended to explore this website for more information.
Aerosol Watch

Aerosol Watch is a web-based platform where the user can map satellite imagery and the smoke or dust mask for the day of interest.

NASA Worldview

NASA Worldview is a web-based platform that can show satellite detections of fires for any day the user chooses. Additionally, there is a tutorial for Worldview on the HAQAST website.

Worldview Tutorial
Aerosol Watch is a web-based platform where the user can map satellite imagery and the smoke or dust mask for the day of interest. The user can view satellite data from the GOES-16 and GOES-17 geostationary satellites. A geostationary satellite takes multiple measurements per day of the same area, so it can track changes throughout one day. Both GOES-16 and GOES-17 provide true color imagery (useful for trying to see a smoke or dust plume) and AOD (aerosol optical depth).
The Air Now Interactive Map shows AQI values for ozone and particulate matter using data from monitors in North America.
The Air Now Interactive Map shows AQI values for ozone and particulate matter using data from monitors in North America.

BreezoMeter shows the overall AQI across the world using ground-based measurements from monitors and satellite data from all 6 of the criteria air pollutants.
NASA Worldview is an interactive web-based platform that displays satellite-based data products related to air quality and health. NASA Worldview displays satellite-based data products providing the pollutant concentration. In this platform, the user can plot aerosol optical depth (AOD) as a proxy for particulate matter. Additionally, there is a tutorial for Worldview on the HAQAST website.
The Calipso website offers profile observation images from the year 2013-present. For information about Calipso, downloading the data, and visualizing the data see sources below

CALIPSO Data User's Guide

CALIPSO Data
Download data from TROPOMI (S5-P)

TROPOMI offers higher resolution SO2, NO2, and ozone data than what is available on NASA Worldview or the OMI satellite. Data from the TROPOMI instrument is available at NASA Earthdata Search. Additionally, there is an Applied Remote Sensing Training (ARSET) tutorial available for using TROPOMI data.

NASA Earth Data Search ➔

ARSET Tutorial ➔
Download HCHO and NO2 data from TROPOMI (S5-P)

TROPOMI offers higher resolution SO2 data than what is available on NASA Worldview. A tutorial for ozone sensitivity using HCHO and NO2 is available through the Holloway Group website. Additionally, see related publications below.

Mapping TROPOMI Tutorial ➔

Publication: Inferring Changes in Summertime Surface Ozone–NOx–VOC Chemistry over U.S. Urban Areas from Two Decades of Satellite and Ground-Based Observations ➔

Publication: Investigating Changes in Ozone Formation Chemistry during Summertime Pollution Events over the Northeastern United States ➔
Download HCHO and NO2 data from OMI (Aura)

If it is, then they will be guided to downloading data from OMI. Additionally, there are Applied Remote Sensing Training (ARSET) tutorials available for using OMI data.

ARSET: Data Analysis Tools for High Resolution Air Quality Satellite Datasets

ARSET: Satellite Remote Sensing of Air Quality
Download data from OMI (Aura)

There are Applied Remote Sensing Training (ARSET) tutorials available for using OMI data below

ARSET: Data Analysis Tools for High Resolution Air Quality Satellite Datasets

ARSET: Satellite Remote Sensing of Air Quality
Download data from OMI (Aura)

OMI has data from 2004-present but has a coarser spatial resolution compared to TROPOMI. Data from the OMI instrument is available at NASA Earthdata Search. If the user has yet to work with OMI data, it is recommended to complete the ARSET tutorial. For more information about the capabilities of OMI, view the publications below.

ARSET Tutorial → NASA Earth Data Search →

Publication: Ambient Formaldehyde over the United States from Ground-Based (AQS) and Satellite (OMI) Observations →

Publication: The benefits of lower ozone due to air pollution emission reductions (2002-2011) in the Eastern United States during extreme heat →
These datasets provide daily concentrations at the zip code and 1km spatial resolution. The SEDAC website offers publications that have utilized the dataset. It is recommended to explore this website for more information.
Using a Model

If the day of interest is not between the years 2000-2016, you are recommended to use a model. Publication related to ground level ozone and modeling:

Publication: An Ensemble Learning Approach for Estimating High Spatiotemporal Resolution of Ground-Level Ozone in the Contiguous United States
Using a Model

If you are not interested in AOD, a smoke plume, or a dust plume, you will be guided towards using a model. This is because there is not currently a satellite that monitors one area multiple times a day for anything other than AOD or true color imagery. To learn more about modeling, see resources below.

EPA Support Center for Regulatory Atmospheric Modeling (SCRAM) →

EPA Air Quality Modeling →

Publication: Daily, Seasonal, and Spatial Trends in PM2.5 Mass and Composition in Southeast Texas Special Issue of Aerosol Science and Technology on Findings from the Fine Particulate Matter Supersites Program →
**Aerosol Watch**

Aerosol Watch is a web-based platform where the user can map satellite imagery and the smoke or dust mask for the day of interest. It has aerosol optical depth (AOD) data products that can be used as a proxy for particulate matter.

**NASA Worldview**

NASA Worldview is a web-based platform that can show satellite detections of fires for any day the user chooses. It has aerosol optical depth (AOD) data products that can be used as a proxy for particulate matter. Additionally, there is a tutorial for Worldview on the HAQAST website.

**Worldview Tutorial**
Aerosol Watch is a web-based platform where the user can map satellite imagery and the smoke or dust mask for the day of interest. Aerosol Watch plots true color imagery from the GOES-16 and GOES-17 geostationary satellites as well as a smoke mask. Useful when identifying a smoke plume.

NOAA HMS

NOAA Hazard Mapping System (HMS) uses satellite data to show where there are smoke plumes and fire points.
NASA Earth Data Search

NASA Earth Data Search is a website where the user can filter through keywords and data formats to find certain data products and explore pollutants measured by satellite data.
Download satellite data from the MODIS sensor aboard the Terra and Aqua satellites. Additionally, there is an Applied Remote Sensing Training (ARSET) tutorial available for using MODIS data. For a publication using MODIS data, see below.

ARSET Tutorial →

Publication: Estimating PM2.5 in Southern California using satellite data: Factors that affect model performance →
Download data from VIIRS (Suomi-NPP) or MODIS (Terra or Aqua) (AOD as a proxy)

Download satellite data from the VIIRS sensor aboard the Suomi-NPP satellite or the MODIS sensor. Additionally, there is an ARSET tutorial available comparing MODIS and VIIRS data to help the user learn more about the two sensors and choose between the two. Both sensors measure aerosol optical depth (AOD) that can be used as a proxy for particulate matter.

ARSET Tutorial →

Publication: Long-term variation of aerosol optical properties associated with aerosol types over East Asia using AERONET and satellite (VIIRS, OMI) →
The EPA offers hourly data, daily data, and pre-generated data files for criteria air pollutants, speciation data, hazardous air pollutants and more. For more information and a related publication, see resources below.

**EPA Data Download Daily Data**

**EPA Data Download Pre-Generated Data Files**

**Publication: Diurnal Patterns in Global Fine Particulate Matter Concentration**
NASA FIRMS is an interactive website that uses data from the Landsat satellite, the VIIRS sensors (aboard the S-NPP and NOAA-20 satellites), and the MODIS sensors (aboard the Aqua and Terra satellites) to indicate the locations of fires and hotspots.
If you are interested in CO, you can download data from the AIRS sensor. For a tutorial on using satellite data and a related article, see below.

**ARSET Tutorial →**

**Article: NASA Monitors Carbon Monoxide From California Wildfires →**
Look at NO2 from OMI and TROPOMI

If you do not have a specific pollutant in mind, then look at NO2 data from the satellite instruments OMI and TROPOMI. These instruments measure various air pollutants such as NO2 which is a great place to start. Data from these instruments are available through NASA Earthdata Search. To get started, there is an Applied Remote Sensing Training Program (ARSET) tutorial.

ARSET Tutorial

NASA Earth Data Search