

Credit: TROPOMI, ESA, Copernicus, KNMI



# EPA AirNow Data and Satellite-Based PM<sub>2.5</sub> Data Sets

Melanie Follette-Cook and Pawan Gupta

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

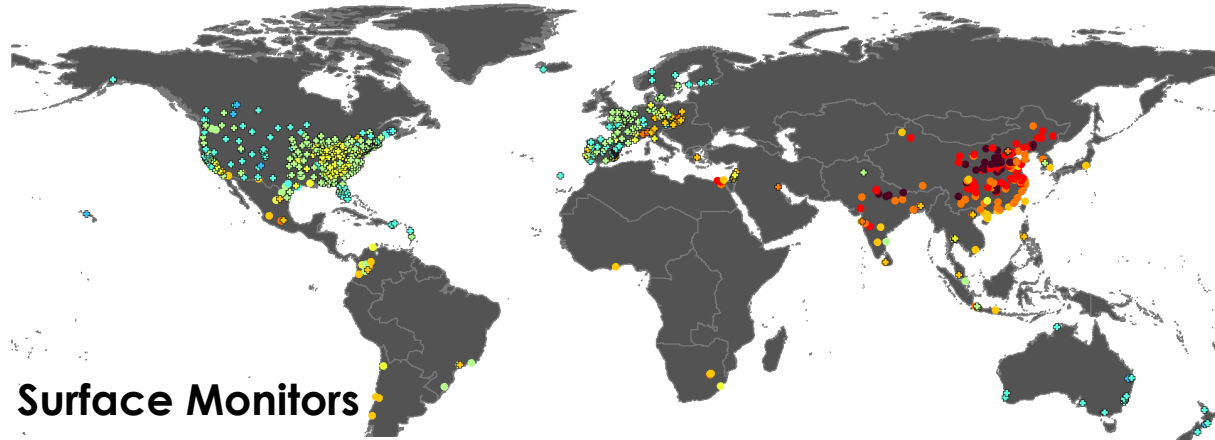
# Learning Objectives

By the end of this presentation, you will be able to:

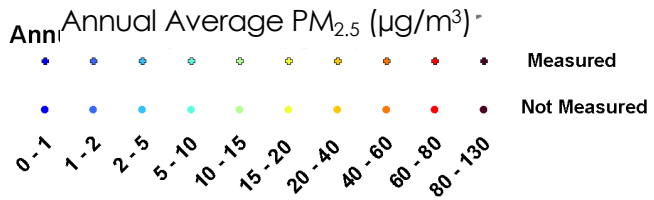
- use online tools to access EPA air quality data
- give examples of applications for surface  $PM_{2.5}$  estimates
- recognize the DIMAQ model used to calculate  $PM_{2.5}$  estimates
- use online tools to access and view World Health Organization (WHO) surface  $PM_{2.5}$  estimates

# Satellites Provide a “God’s Eye” View of the Earth

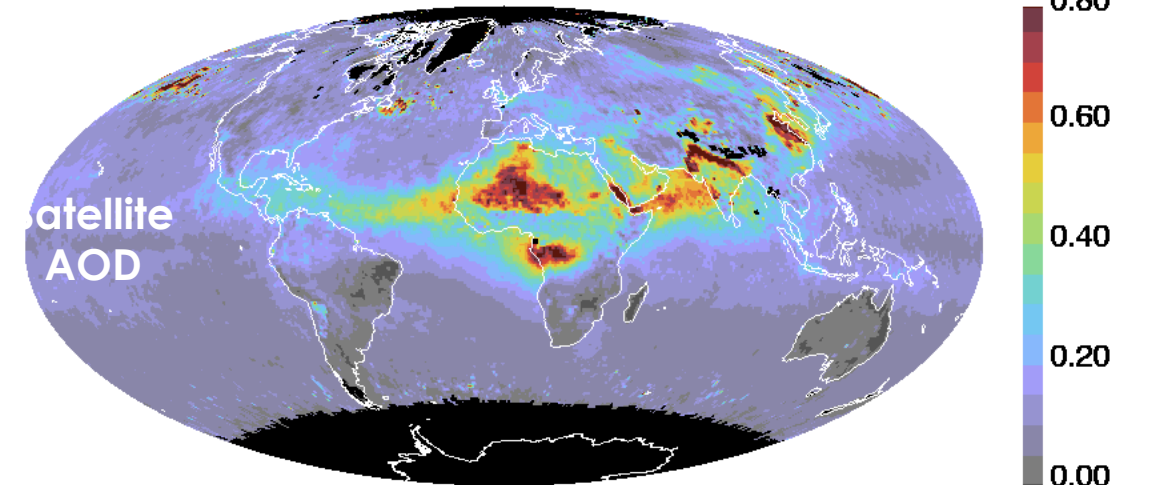
Spatial coverage is the primary advantage of satellite data

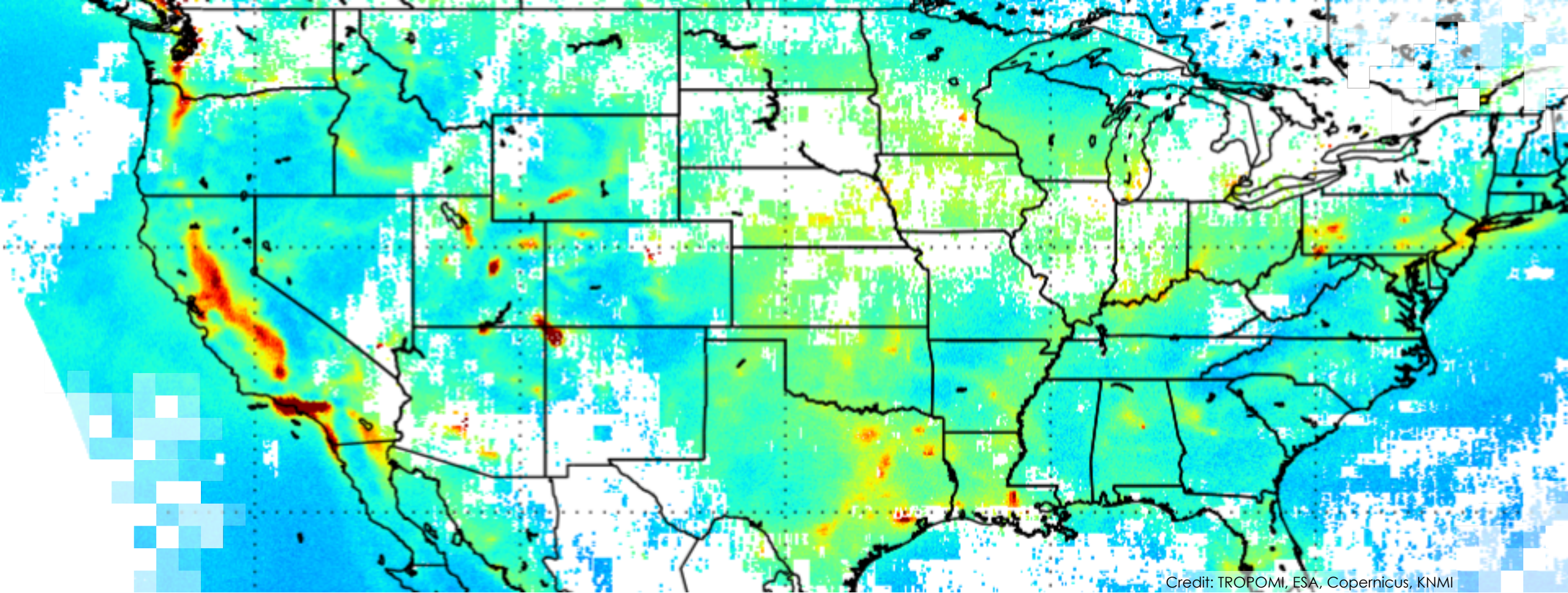


## Surface Monitors



AOD\_550\_Dark\_Target\_Deep\_Blue\_Combined\_Mean\_Mean

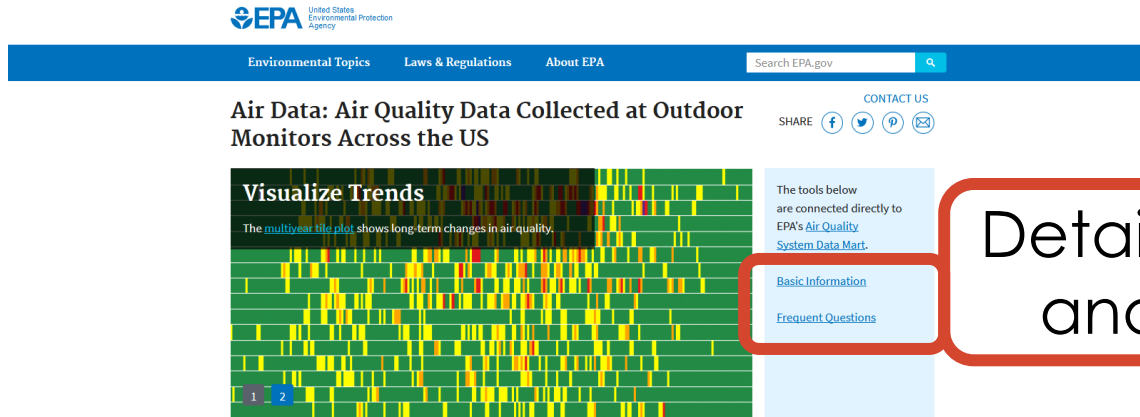




EPA AQS and AirNow Data

# EPA Air Quality Data

<https://www.epa.gov/outdoor-air-quality-data>



Detailed info and FAQ

Access to outdoor air quality data from the US, Puerto Rico, and the US Virgin Islands

Download data

### Download Data

- [Pre-generated Data Files](#)
- [Download Daily Data](#)
- [Download Raw Data \(API\)](#)

### Monitor Locations



View interactive map

Generate reports

### Summary Reports

- [Air Quality Index Report](#)
- [Air Quality Statistics Report](#)
- [Monitor Values Report](#)
- [Monitor Values Report - Hazardous Air Pollutants](#)
- [Air Quality Index Daily Values Report](#)

### Data Viz

- [Tile Plot - Multiyear](#)
- [Tile Plot - Single Year](#)
- [AQI Plot](#)
- [Concentration Plot](#)
- [Ozone Exceedances Plot](#)
- [Concentration Map](#)

### Technical Reports

- [PM2.5 Continuous Monitor Comparability Assessments](#)
- [PM10 Continuous Monitor Comparability Assessments](#)
- [Single Point Precision and Bias Report](#)

Plot data

# Download Data

## Download Daily Data

This tool queries daily air quality summary statistics for the criteria pollutants by monitor. You can get data for specific monitors or all monitors in a city, county, or state.

1. Pollutant

2. Year

3. Geographic Area

-- or --

-- or --

4. Monitor Site

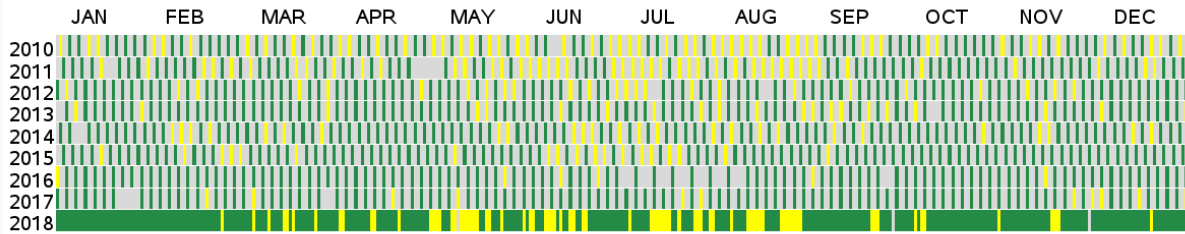
Get Data

- Download pre-generated data files
- Download daily data
  - By state, city, or county
  - Creates a csv file to save
- Download raw data (through an API)
  - For NRT AQ data, use AirNow API

# Data Visualization

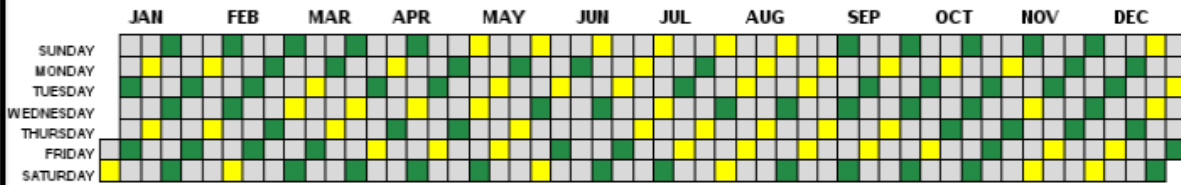
## Multiyear Tile Plot

PM2.5 Daily AQI Values, 2010 to 2018  
Huntsville, AL



## Single Year Tile Plot

PM2.5 Daily AQI Values in 2010  
Huntsville, AL

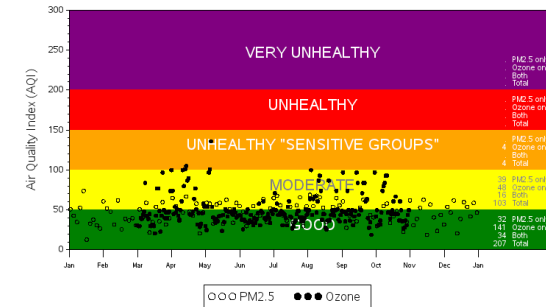


### AQI Category

- Good ( $\leq 12.0$   $\mu\text{g}/\text{m}^3$ )
- Moderate (12.1-35.4  $\mu\text{g}/\text{m}^3$ )
- Unhealthy for Sensitive Groups (35.5-55.4  $\mu\text{g}/\text{m}^3$ )
- Unhealthy (55.5-150.4  $\mu\text{g}/\text{m}^3$ )
- Very Unhealthy (150.5-250.4  $\mu\text{g}/\text{m}^3$ )
- Hazardous ( $\geq 250.5$   $\mu\text{g}/\text{m}^3$ )

## AQI Plot

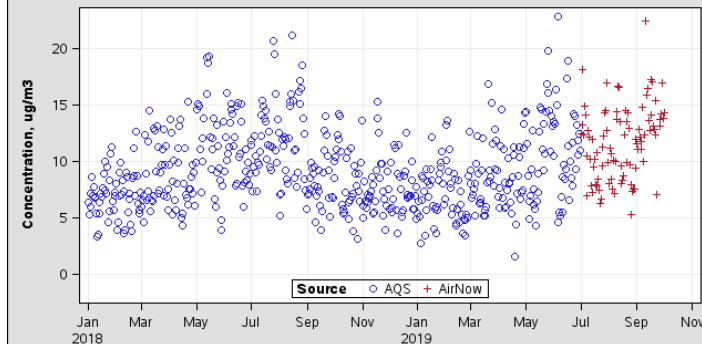
Daily PM2.5 and Ozone AQI Values in 2010  
Huntsville, AL



## Concentration Plot

Daily Mean PM2.5 Concentrations from 01/01/18 to 12/31/19

Parameter: Acceptable PM2.5 AQI & Speciation Mass (Applicable standard is 35  $\mu\text{g}/\text{m}^3$ )  
 CBSA: Huntsville, AL  
 County: Madison  
 State: Alabama  
 AQS Site ID: 010890014, poc 3  
 Local Site Name: HUNTSVILLE OLD AIRPORT



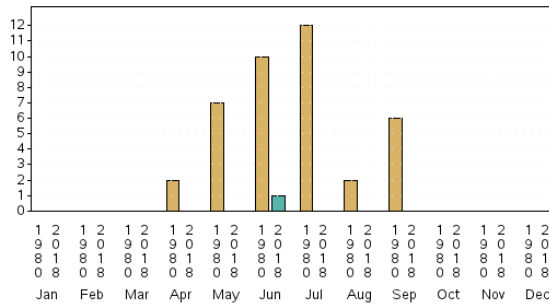
Source: U.S. EPA AirData <<https://www.epa.gov/air-data>>  
 Generated: October 2, 2019

# Data Visualization

## Ozone Exceedances Plots

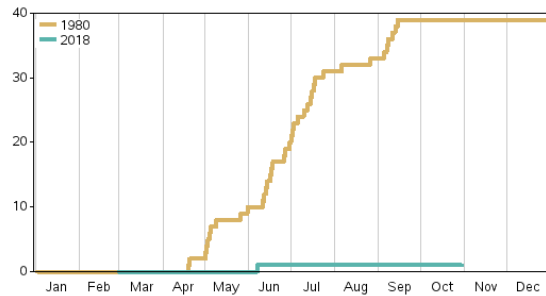
Number of Days 8-hr Ozone Daily Max > 0.070 ppm

1980 vs. 2018  
in Huntsville, AL



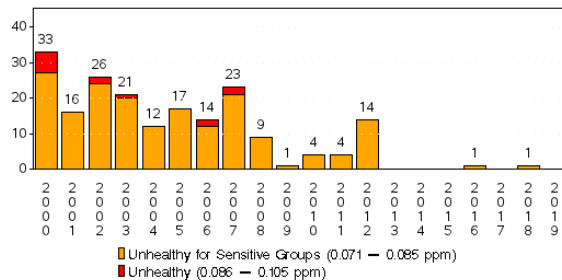
Cumulative Number of Days 8-hr Ozone Daily Max > 0.070 ppm

1980 vs. 2018  
in Huntsville, AL



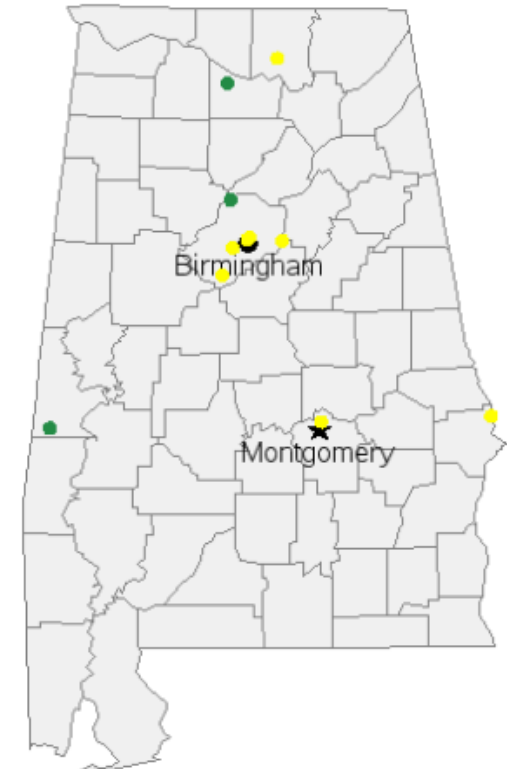
Number of Days 8-hr Ozone Daily Max > 0.070 ppm

2000-2019  
in Huntsville, AL



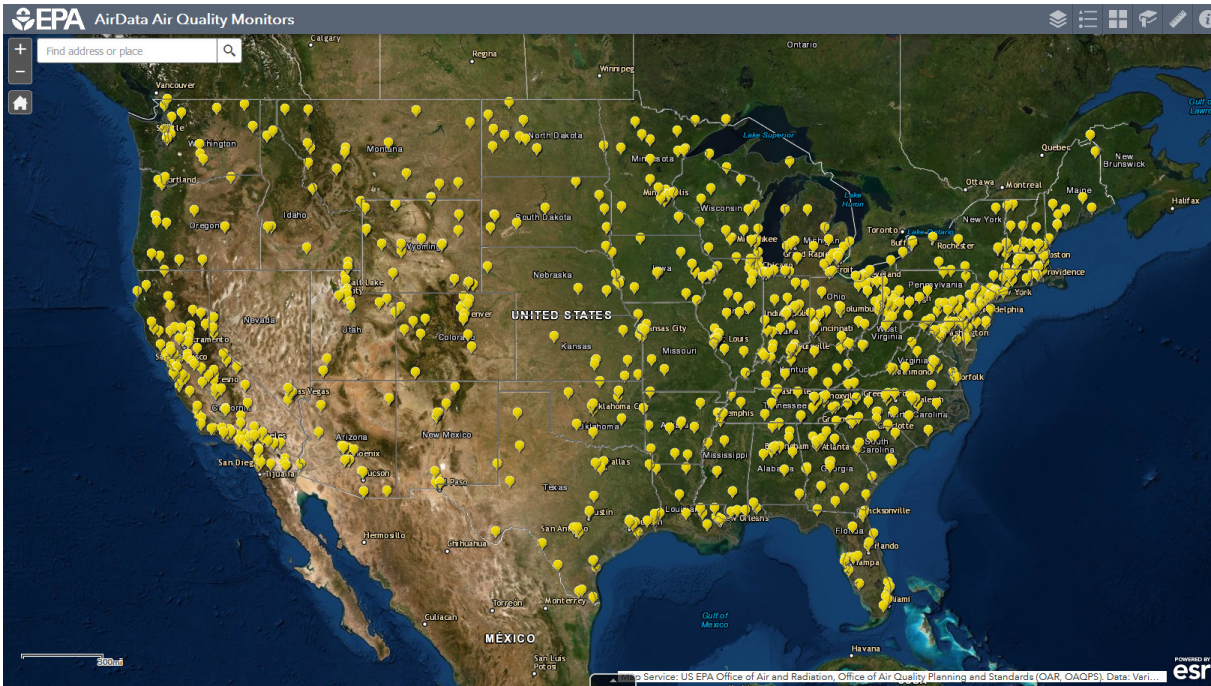
## Concentration Maps

PM2.5 AQI Values by site on 10/01/2019

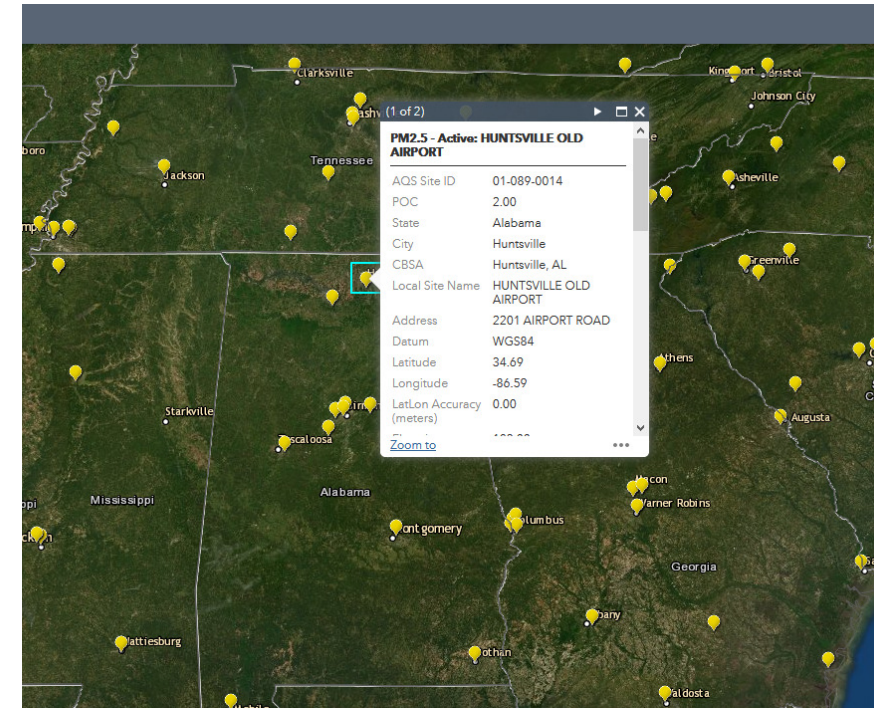


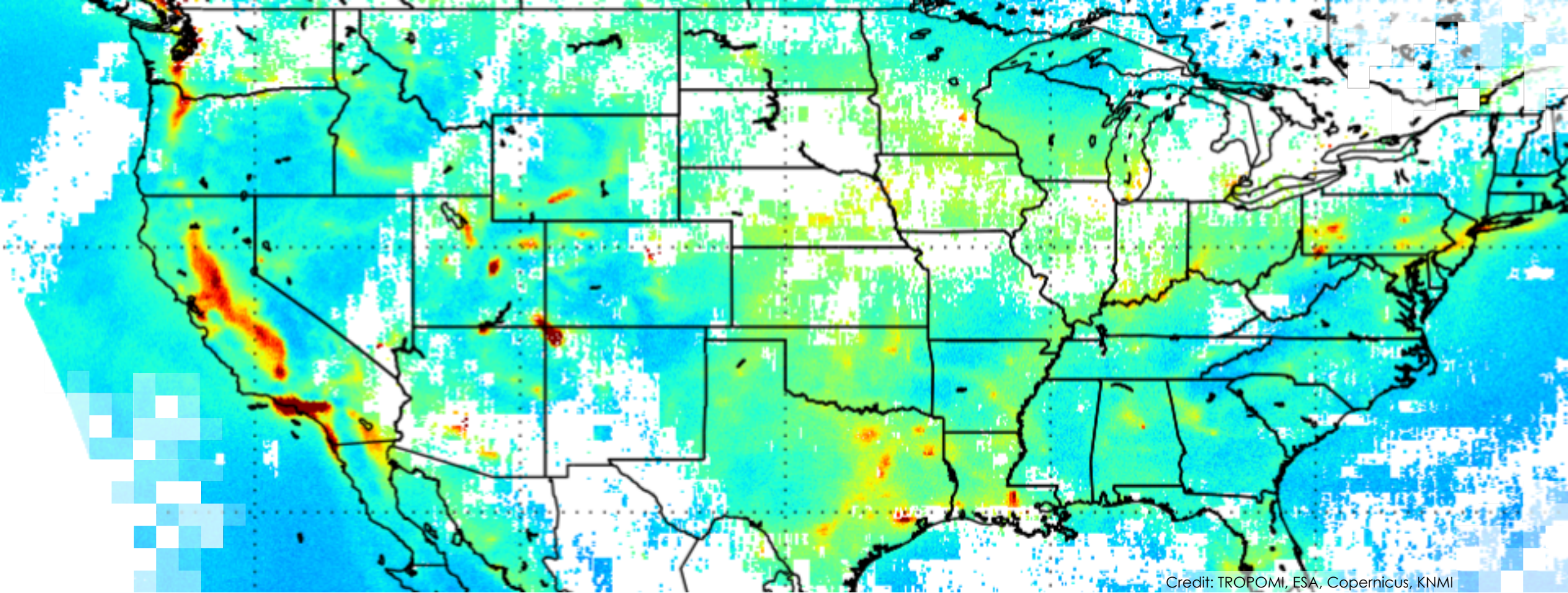


# Interactive Maps



- View locations of air quality monitors
  - Get monitor information
  - Download data
  - Display nonattainment, Tribal, and Federal Class I areas

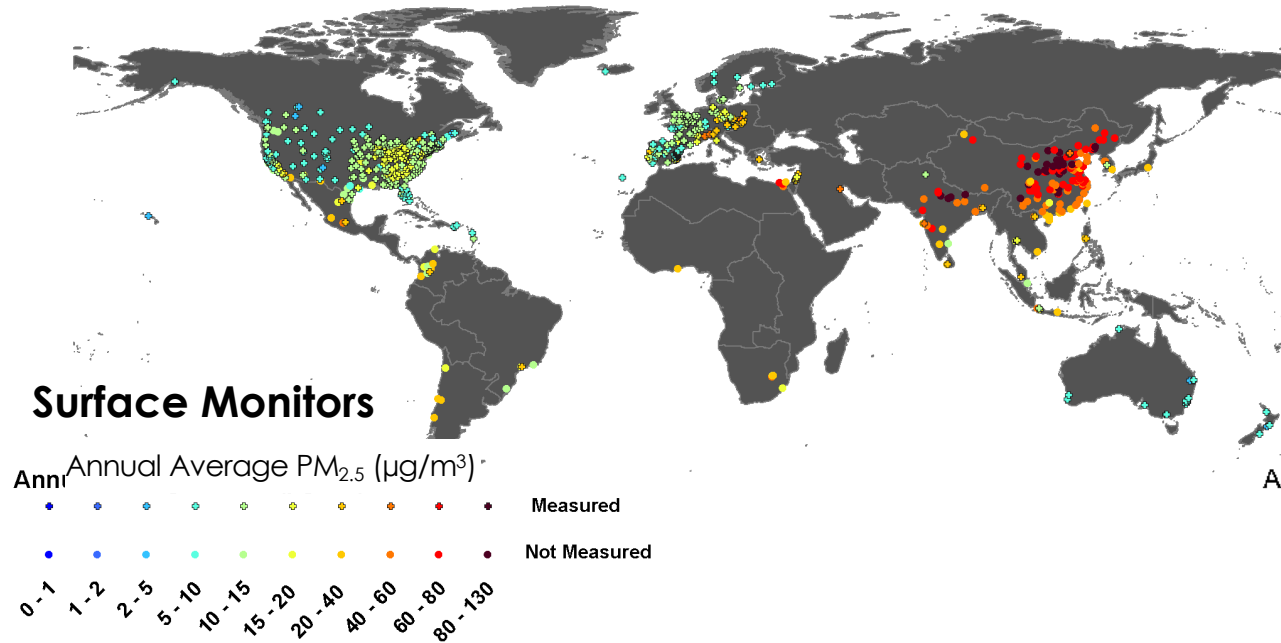




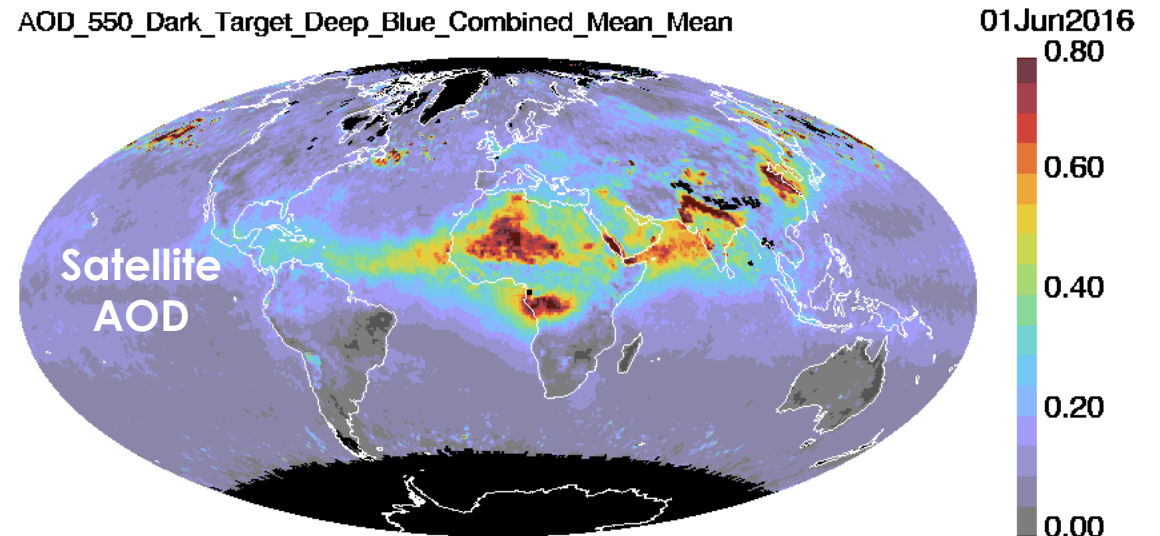
## Examples of Applications Using Surface $PM_{2.5}$ Estimates

# Satellites Provide a “God’s Eye” View of the Earth

Spatial coverage is the primary advantage of satellite data



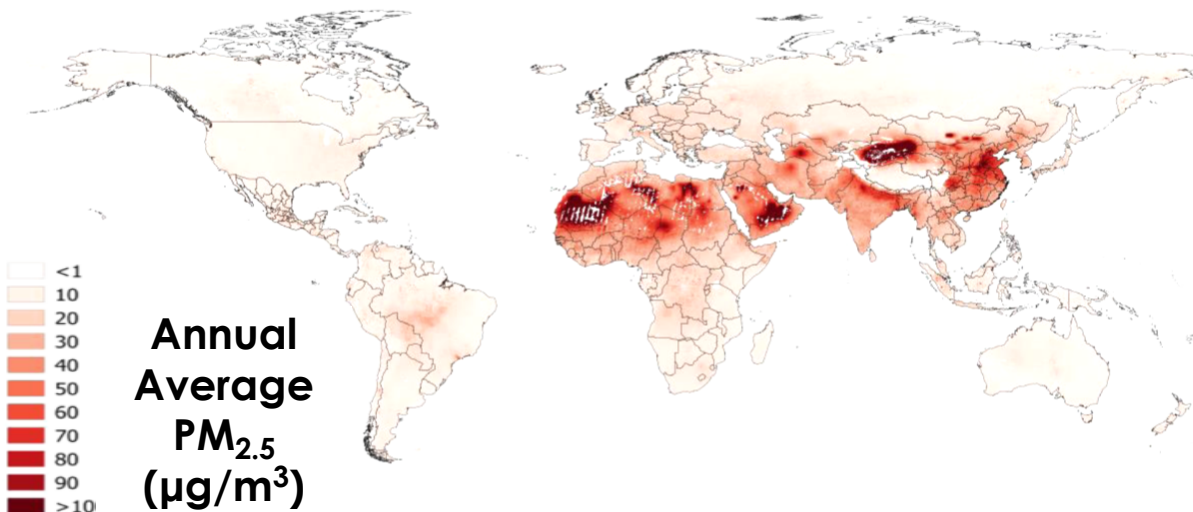
The spatial coverage afforded by satellite data offers increased statistical power that strengthens inference of the relation between pollutants and health outcomes



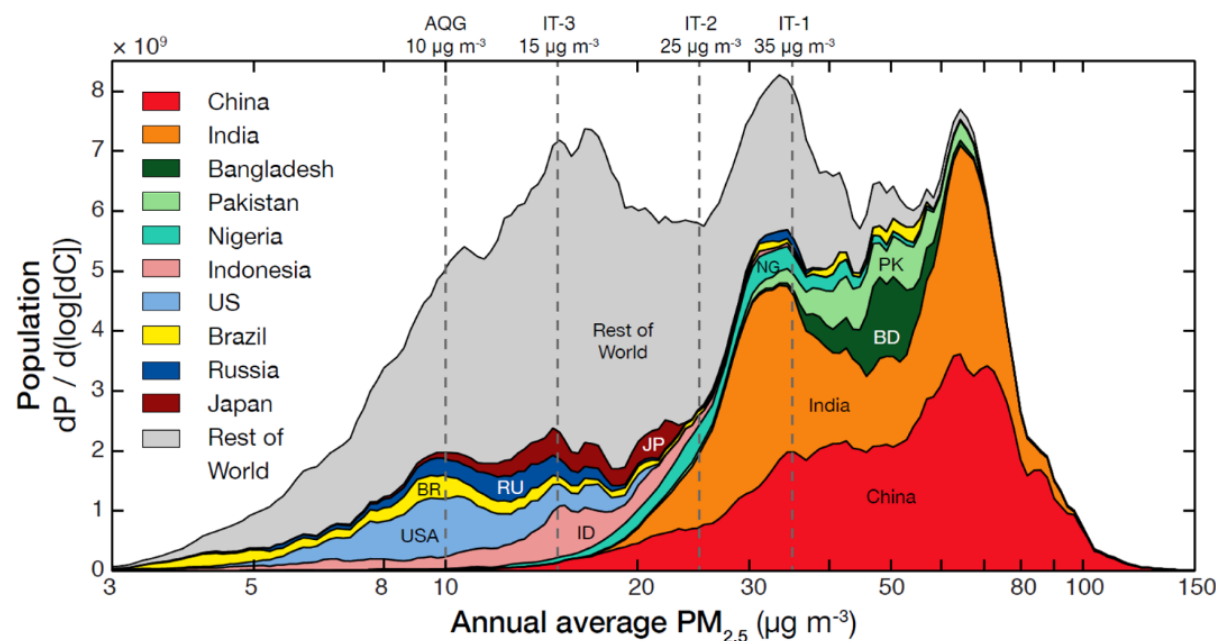
# Health Studies of Exposure

## Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013

Michael Brauer<sup>†</sup>, Greg Freedman<sup>†</sup>, Joseph Frostad<sup>†</sup>, Aaron van Donkelaar<sup>§</sup>, Randall V. Martin<sup>§</sup>, Frank Dentener<sup>¶</sup>, Rita van Dingenen<sup>¶</sup>, Kara Estep<sup>†</sup>, Heresh Amini<sup>†</sup>, Joshua S. Apte<sup>#</sup>, Kalpana Balakrishnan<sup>∇</sup>, Lars Barregard<sup>¶</sup>, David Broday<sup>◊</sup>, Valery Feigin<sup>◆</sup>, Santu Ghosh<sup>∇</sup>, Philip K. Hopke<sup>¶</sup>, Luke D. Knibbs<sup>▲</sup>, Yoshihiro Kokubo<sup>⊙</sup>, Yang Liu<sup>★</sup>, Stefan Ma<sup>⊙</sup>, Lidia Morawska<sup>¶</sup>, José Luis Texcalac Sangrador<sup>⊙</sup>, Gavin Shaddick<sup>†</sup>, H. Ross Anderson<sup>◁</sup>, Theo Vos<sup>†</sup>, Mohammad H. Forouzanfar<sup>†</sup>, Richard T. Burnett<sup>⊗</sup>, and Aaron Cohen<sup>‡</sup>



## WHO Interim Targets



Brauer, M., et al., Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013, Environ. Sci. & Tech., 50 (1), 79-88, doi: 10.1021/acs.est.5b03709, 2016.



# UN Sustainable Development Goals (SDGs)

## Transforming Our World: The 2030 Agenda for Sustainable Development

### Goal 3 – Good Health and Well Being

- Target 3.9; Indicator 3.9.1
- Mortality rate attributed to household and ambient air pollution (annual mean levels of air pollution ( $PM_{2.5}$ ))

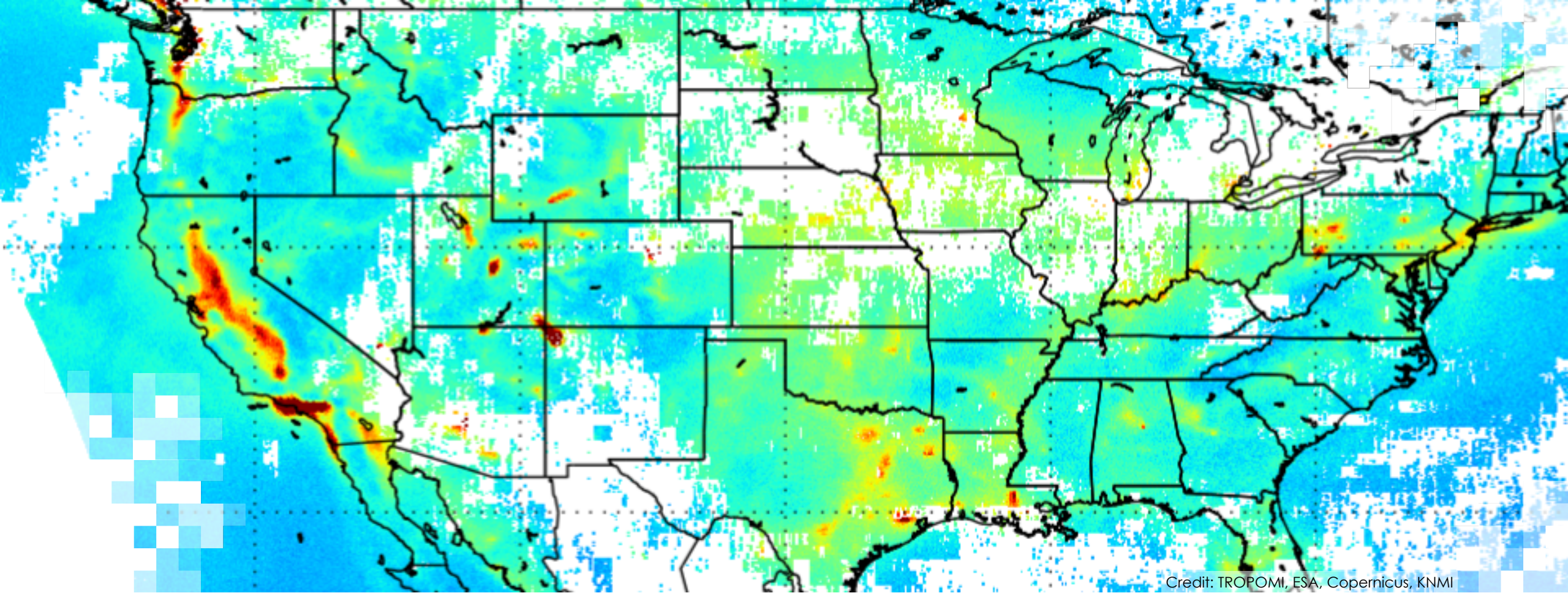
### Goal 11 – Sustainable Cities and Communities

- Target 11.6; Indicator 11.6.2
- Annual mean levels of fine particulate matter (e.g.  $PM_{2.5}$  and  $PM_{10}$ ) in cities (population weighted)

## SUSTAINABLE DEVELOPMENT GOALS



Text adapted from "[Transforming our world: the 2030 Agenda for Sustainable Development](#)"

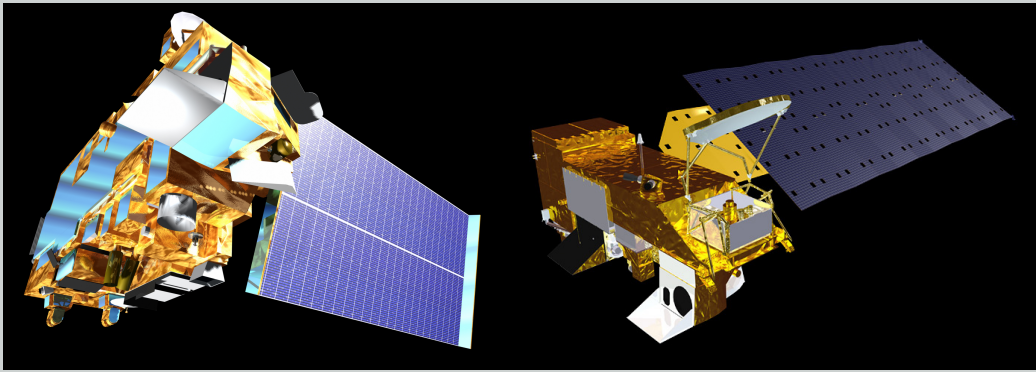
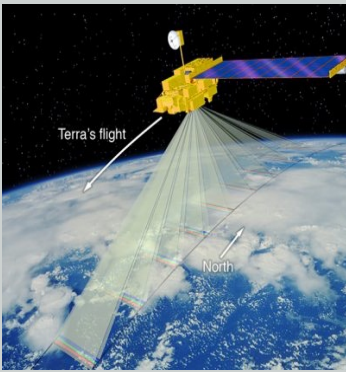
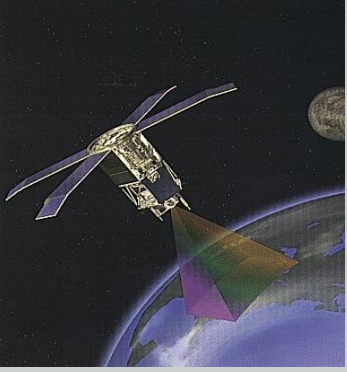


Credit: TROPOMI, ESA, Copernicus, KNMI

Satellite-Based Estimates of Surface  $PM_{2.5}$  –  
NASA SEDAC – Van Donkelaar et al. (2016)

# Satellite-Based Estimates: AOD from Satellites

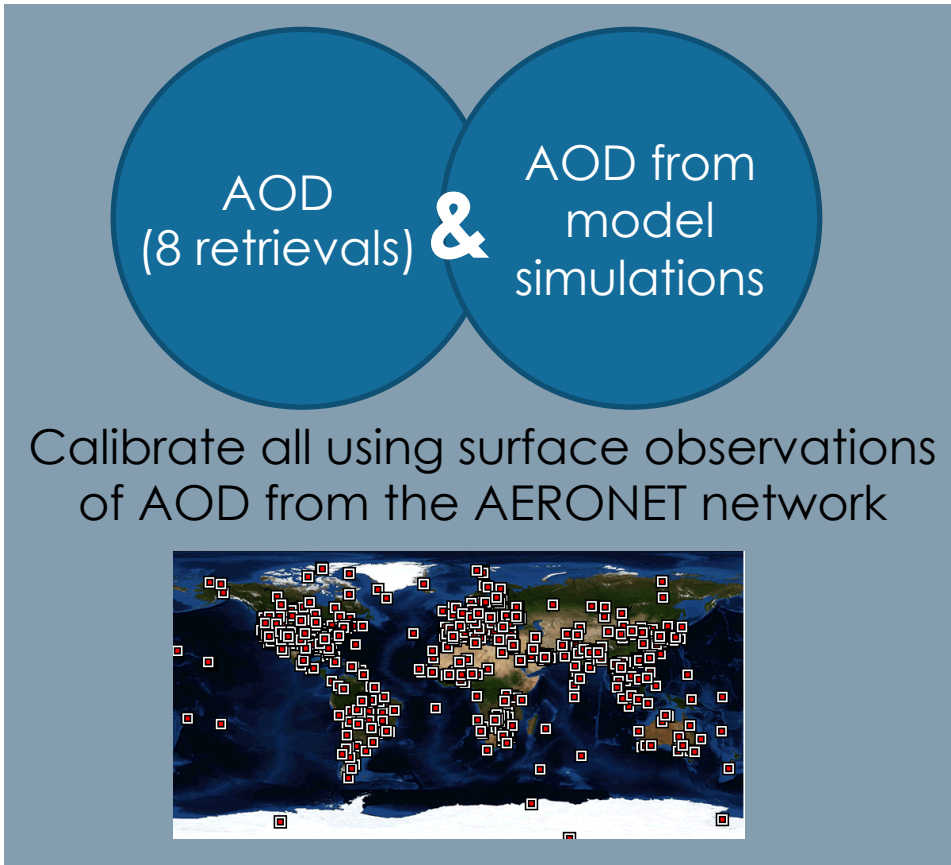
Eight retrievals of AOD from four different instruments

Instrument	MODIS: Terra/Aqua			MISR	SeaWiFS
					
Retrieval Algorithm	Deep Blue	Dark Target	MAIAC	MISR	Deep Blue
Horizontal Resolution	10 km	10 km	1 km	17.6 km	13.5 km

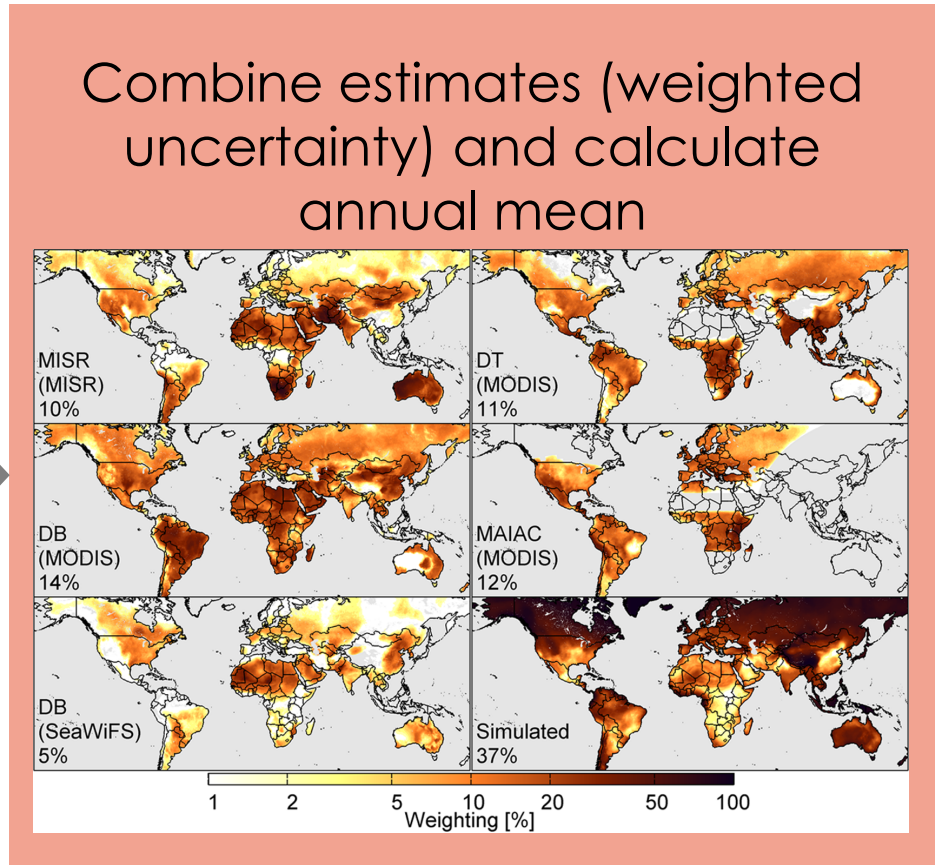
Van Donkelaar et al., 2016, doi:10.1021/acs.est.5b05833. The Van Donkelaar product is available at: <http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012>

# Satellite-Based Estimates

AOD  $\Rightarrow$  PM<sub>2.5</sub>



Calculate PM<sub>2.5</sub> from AOD using model AOD-to-PM<sub>2.5</sub> relationship



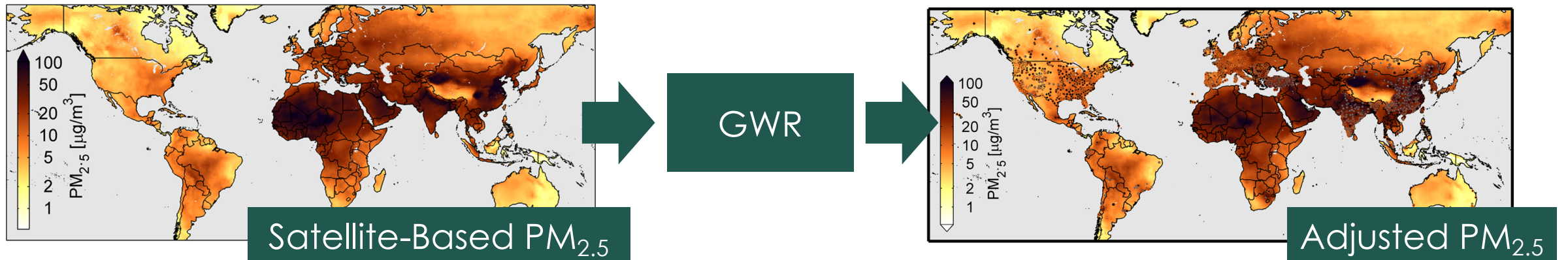
The Van Donkelaar product is available at: <http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012>. Image (right) Van Donkelaar et al., 2016, Figure 2 (Only MODIS-Terra shown)



# Satellite-Based Estimates

## Geographic Weighted Regression (GWR)

GWR corrects the satellite estimate using the relationship between  $PM_{2.5}$  from ground monitors and variables such as model aerosol composition, elevation data, and land use indicators

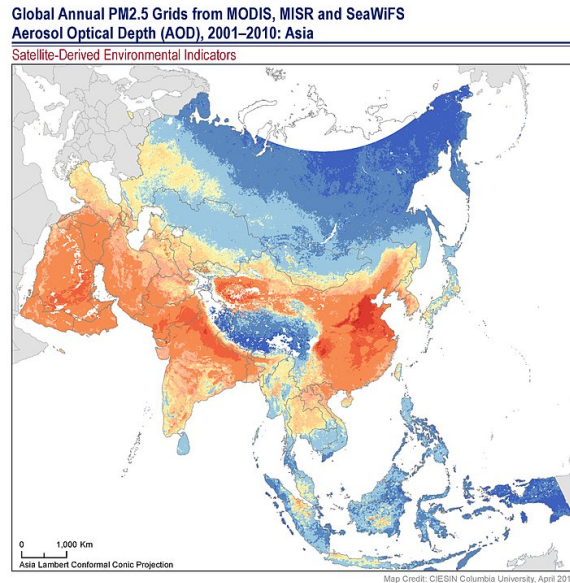


The Van Donkelaar product is available at: <http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012>. Left Image: Van Donkelaar et al., 2016, Figure 3. Right Image: Van Donkelaar et al., 2016, Figure 5

# Annual Mean Surface PM<sub>2.5</sub>

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

- Download data (GeoTIFF files) and pre-made images of surface PM<sub>2.5</sub> inferred from satellite observations



The Global Annual PM<sub>2.5</sub> Grids from MODIS, MISR and SeaWiFS Aerosol Optical Depth (AOD) data sets represent a series of three-year running mean grids (1998-2012) of fine particulate matter (solid particles and liquid droplets) that were derived from a combination of MODIS (Moderate Resolution Imaging Spectroradiometer), MISR (Multi-angle Imaging SpectroRadiometer) and SeaWiFS (Sea-Viewing Wide Field-of-View Sensor) AOD satellite retrievals. A global decadal (2001-2010) mean PM<sub>2.5</sub> concentration grid was also produced and is mapped here. Together the grids provide a continuous surface of concentrations in micrograms per cubic meter of particulate matter 2.5 micrometers or smaller (PM<sub>2.5</sub>) for health and environmental research. The raster grid cell size is approximately 10 km at the equator, and the extent is from 70 degrees north to 55 degrees south latitude.

Decadal (2001-2010) Mean Fine Particulate Matter (PM<sub>2.5</sub>) Concentration

1 2 5 10 12 20 50 100 200  
micrograms per cubic meter

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

Data Source: van Donkelaar, A., R.V. Martin, M. Brauer, and B.L. Boys. 2015. Global Annual PM<sub>2.5</sub> Grids from MODIS, MISR and SeaWiFS Aerosol Optical Depth (AOD), 1998-2012. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC), <http://dx.doi.org/10.7927/H4K289PF6>.  
© 2015. The Trustees of Columbia University in the City of New York.

NASA 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

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In the Spotlight  
Map Galleries

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

# Annual Mean Surface PM<sub>2.5</sub>

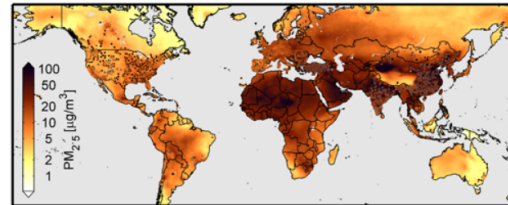
[http://fizz.phys.dal.ca/~atmos/martin/?page\\_id=140](http://fizz.phys.dal.ca/~atmos/martin/?page_id=140)

## Atmospheric Composition Analysis Group

Research | Publications & Presentations | GEOS-Chem | Satellites | Datasets | SPARTAN | Group Info

### Surface PM<sub>2.5</sub>

Global Estimates (V4.GL.02):



We estimate ground-level fine particulate matter (PM<sub>2.5</sub>) by combining Aerosol Optical Depth (AOD) retrievals from the NASA MODIS, MISR, and SeaWiFS instruments with the GEOS-Chem chemical transport model, and subsequently calibrated to global ground-based observations of PM<sub>2.5</sub> using Geographically Weighted Regression (GWR) as detailed in the below reference.

#### References:

van Donkelaar, A., R.V. Martin, M.Brauer, N. C. Hsu, R. A. Kahn, R. C. Levy, A. Lyapustin, A. M. Sayer, and D. M Winker, **Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors**, *Environ. Sci. Technol*, doi: 10.1021/acs.est.5b05833, 2016. [\[Link\]](#)

Estimates prior to 2008 incorporate temporal information from:

Boys, B.L., Martin, R.V., van Donkelaar, A., MacDonell, R., Hsu, N.C., Cooper, M.J., Yantosca,R.M., Lu, Z., Streets,D.G., Zhang,Q., Wang,S., **Fifteen-year global time series of satellite-derived fine particulate matter**, *Environ. Sci. Technol*, 10.1021/es502113p, 2014. [\[Link\]](#)

van Donkelaar, A., R. V. Martin, M. Brauer and B. L. Boys, **Global fine particulate matter concentrations from satellite for long-term exposure assessment**, *Environmental Health Perspectives*, 123, 135-143, DOI:10.1289/ehp.1408646, 2015. [\[Link\]](#)

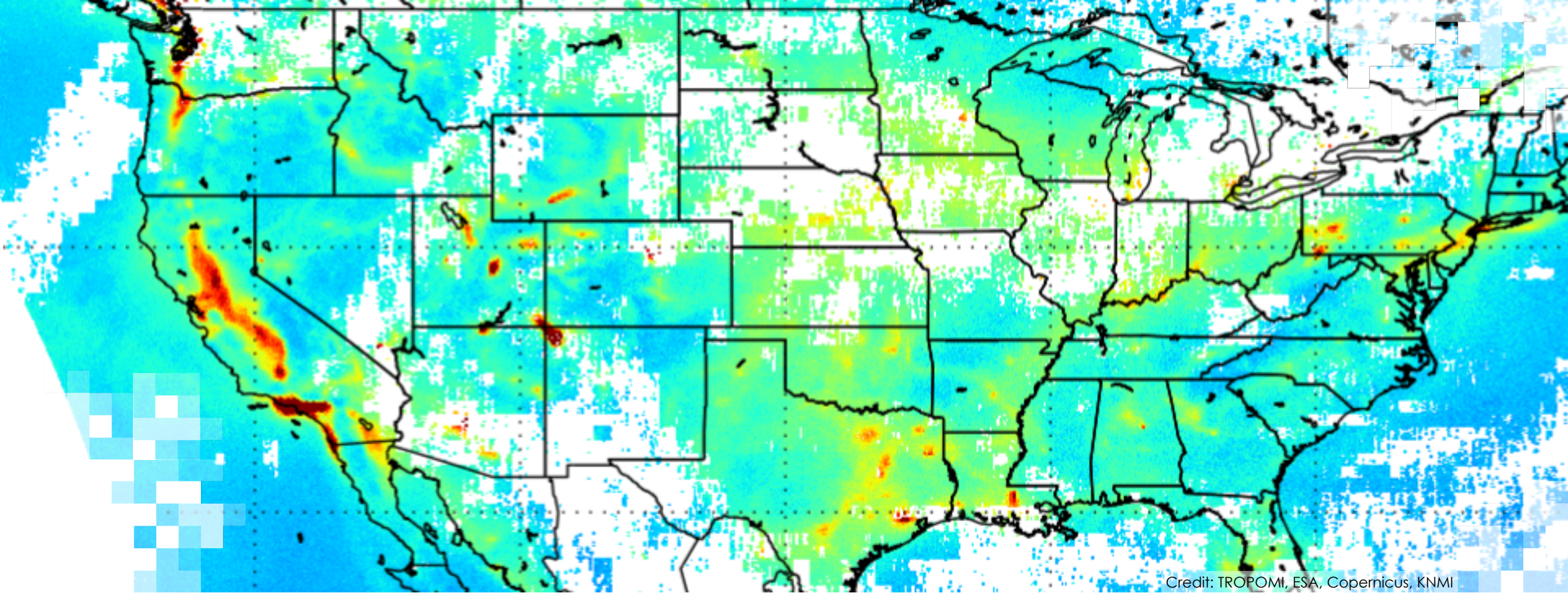
#### Scientific Datasets:

Global resolved datasets are provided in ArcGIS-compatible NetCDF [.nc] or zipped ASCII [.asc.zip] file. Note that the unzipped ASCII files can be cumbersome. Gridded files use the WGS84 projection. Corresponding files for Google Earth are also provided [.kmz]. Country means are also provided in a comma separated ascii (.csv) format. Dust and Sea-Salt Removed PM<sub>2.5</sub> estimates apply simulated compositional information to our full-composition values, following van Donkelaar et al., EHP, 2015. Other extractions can often be produced upon request. Please contact Aaron van Donkelaar (Aaron.van.Donkelaar@dal.ca) for further information.

# Satellite-Based Estimates

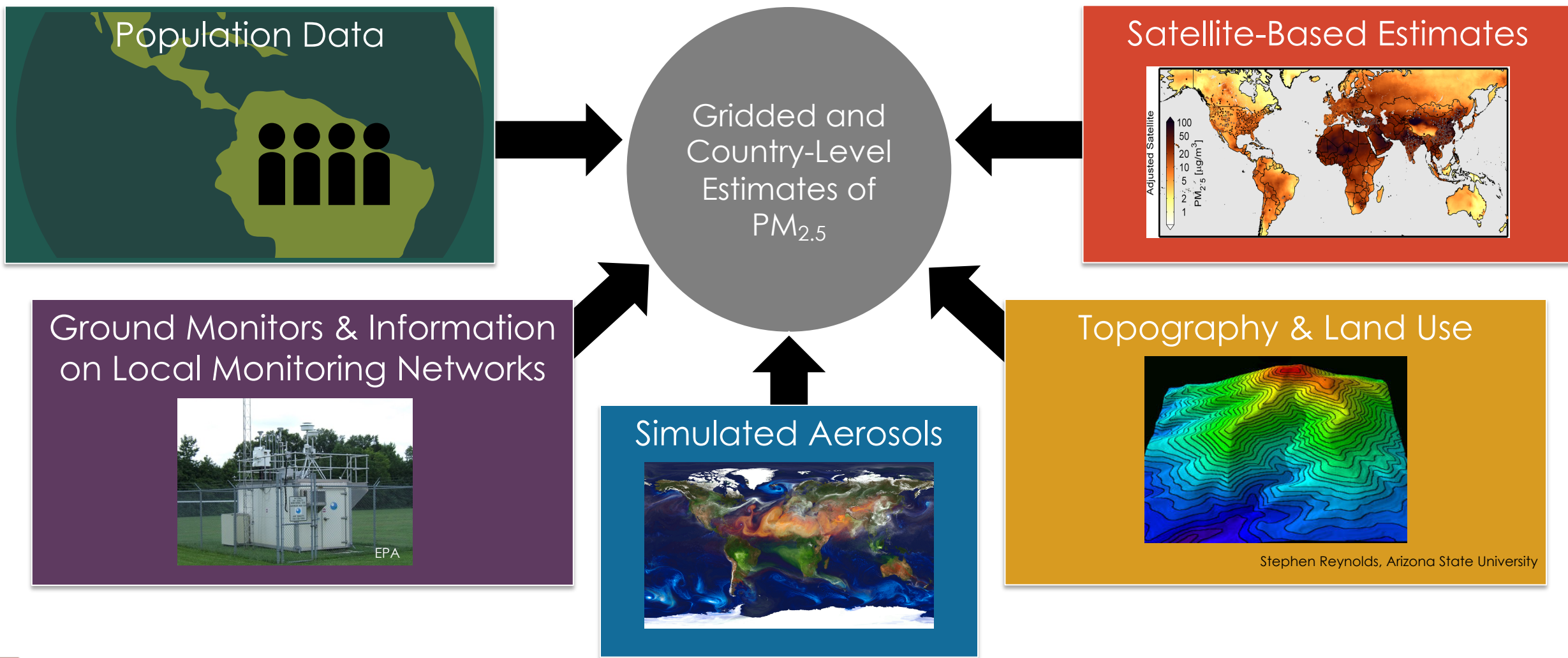
## Limitations

- The van Donkelaar estimate provides annual mean estimates of  $PM_{2.5}$
- However, this and other estimates do not provide an analysis of uncertainties
- The WHO and the University of Bath have led the development of the Data Integration Model for Air Quality (DIMAQ)
  - This model estimates  $PM_{2.5}$  along with associated measures of uncertainty



## Data Integration Model for Air Quality (DIMAQ)

# Data Integration Model for Air Quality (DIMAQ)



# Data Integration Model for Air Quality (DIMAQ)

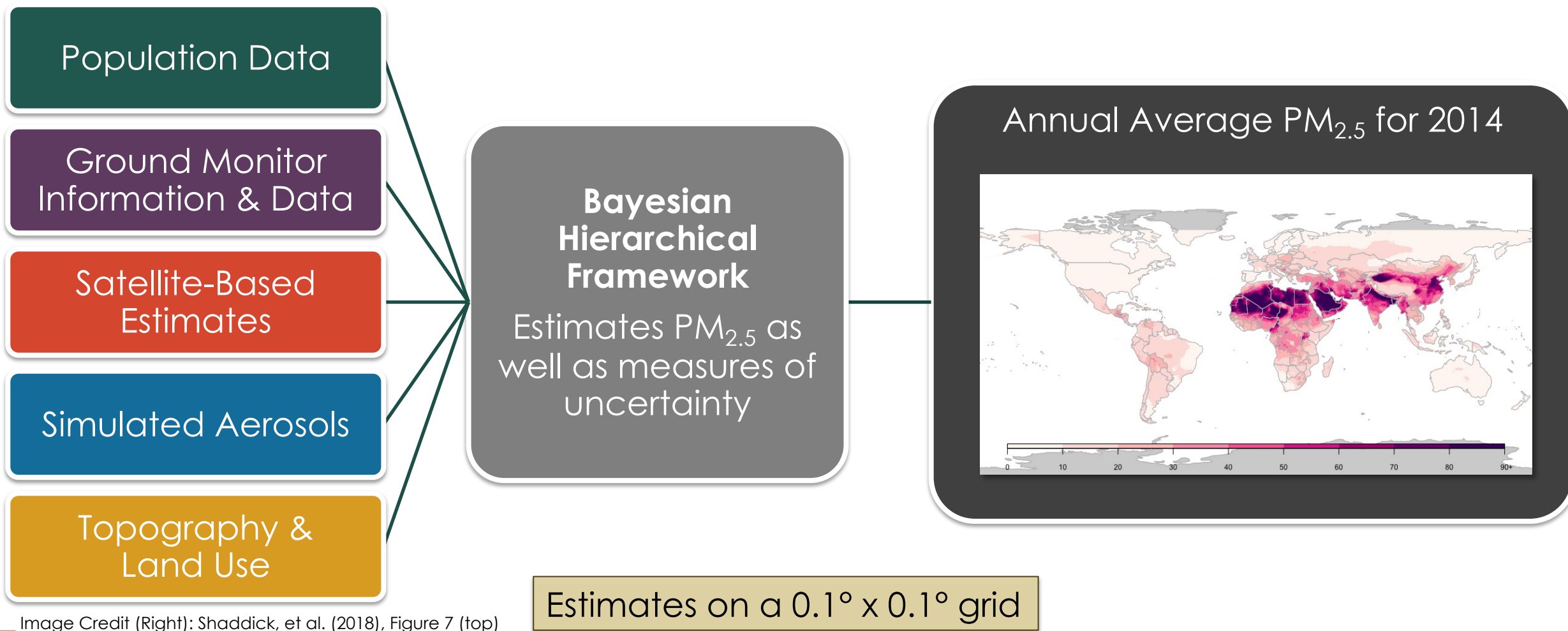
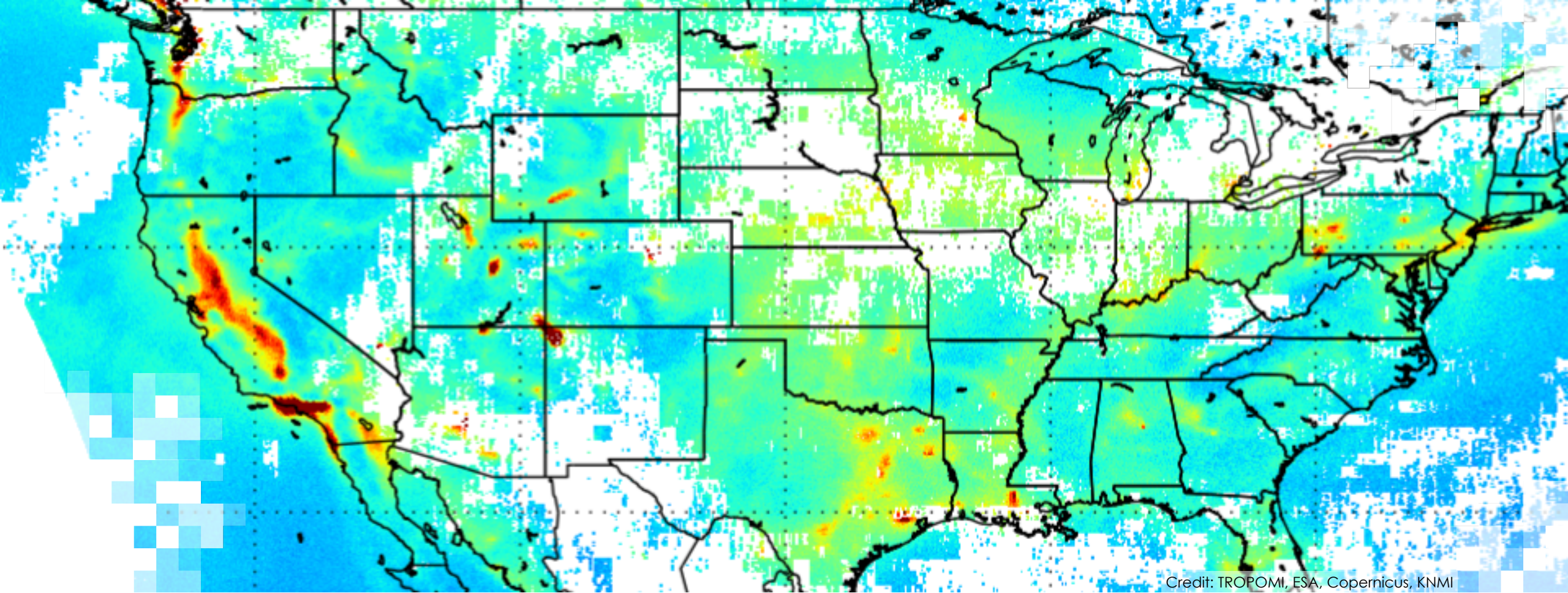


Image Credit (Right): Shaddick, et al. (2018), Figure 7 (top)



Available World Health  
Organization (WHO) Tools



# Where to Find and View the Data

## WHO Website – Country Level

### Global Health Observatory (GHO) data

#### Global Health Observatory data

Data repository

Reports

Country statistics

Map gallery

Standards

### Exposure to ambient air pollution

The mean ambient air pollution of particulate matter with an aerodynamic diameter of 2.5  $\mu\text{m}$  or less (PM2.5) in country urban areas ranges from less than 10 to over 100  $\mu\text{g}/\text{m}^3$ . In urban areas, the mean concentration of particulate matter with an aerodynamic diameter of 2.5  $\mu\text{m}$  or less (PM2.5) ranges from less than 10 to over 100  $\mu\text{g}/\text{m}^3$ , and from less than 10 to over 200  $\mu\text{g}/\text{m}^3$  for particulate matter with an aerodynamic diameter of 10  $\mu\text{m}$  or less (PM10)

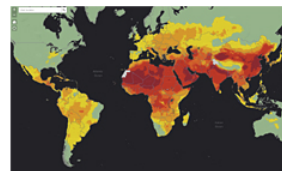


#### Situation at country level

[View interactive map/graph](#)

[View data](#)

[Read more](#)



#### Situation at grid level

[View interactive map](#)

[View data, metadata and detailed methods of estimation](#)



#### Situation at city level

[View full size map \(PM10\)](#)

[View full size map \(PM2.5\)](#)

[View data](#) | [Read more](#)

[Share](#) [Email](#) [Facebook](#) [Twitter](#) [Google+](#) [+](#)

#### More PHE data products

[Maps](#)

[Reports](#)

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[Links](#)

- [http://www.who.int/gho/phe/outdoor\\_air\\_pollution/exposure/en/](http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/)

Follow this link to download 2014 country level data:

- Formats: csv, Excel, html, XML, etc.
- Can also filter by country and download

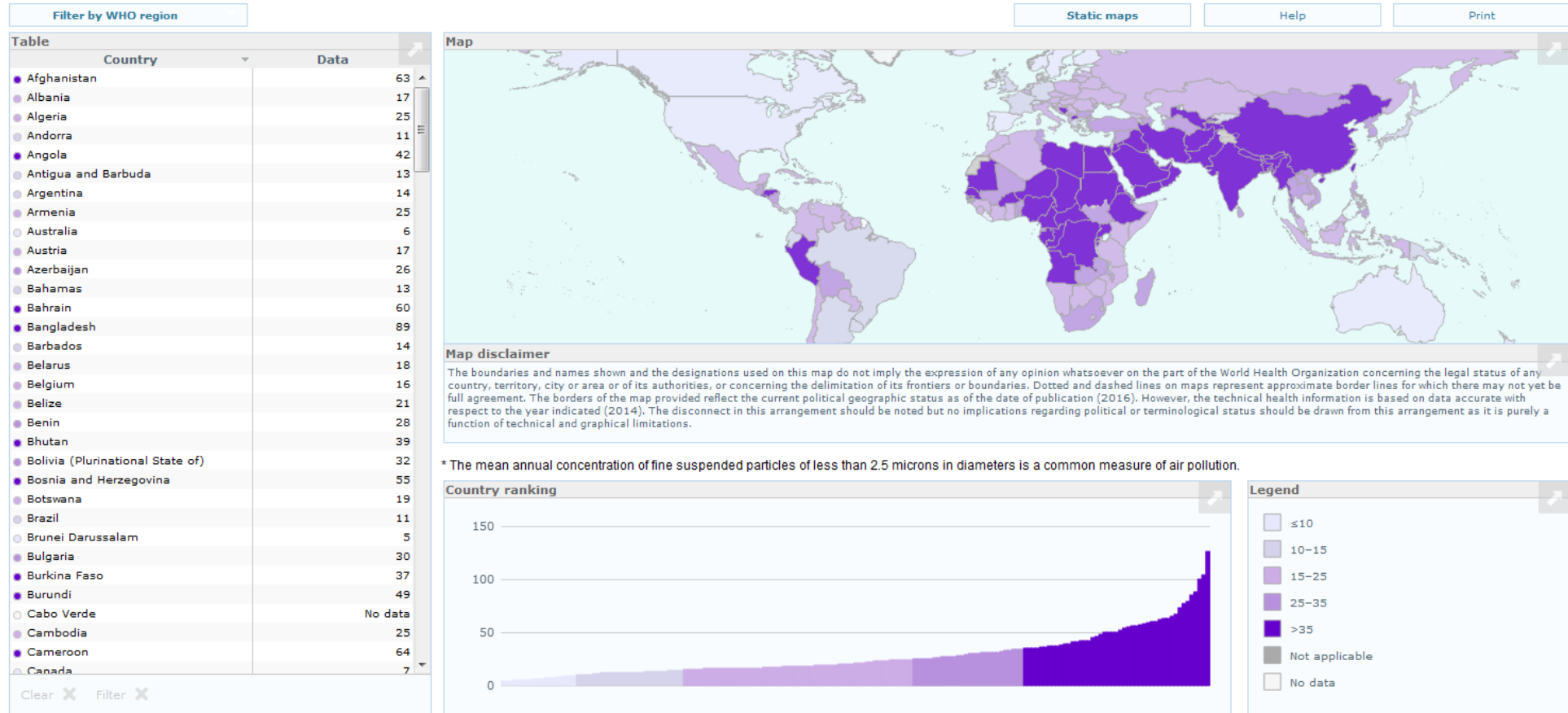
Global Health Observatory (GHO) data > Ambient air pollution

# PM<sub>2.5</sub> at Country Level

[http://gamapservers.who.int/gho/interactive\\_charts/phe/oap\\_exposure/atlas.html](http://gamapservers.who.int/gho/interactive_charts/phe/oap_exposure/atlas.html)



Public Health and Environment (PHE): ambient air pollution  
Annual mean concentrations of fine particulate matter (PM<sub>2.5</sub>) in urban areas (µg/m<sup>3</sup>), 2014\*



© WHO 2016. All Rights Reserved.

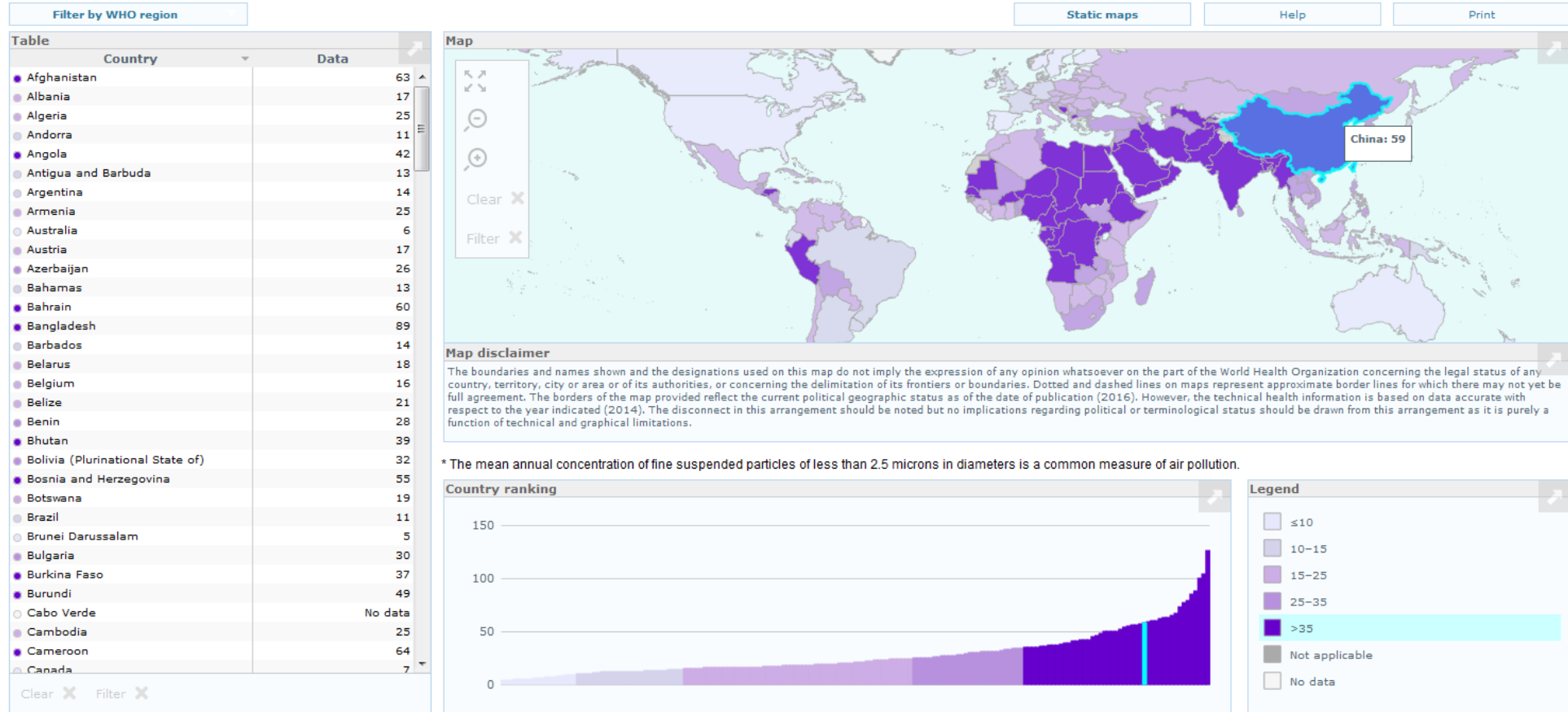


# PM<sub>2.5</sub> at Country Level

[http://gamapservers.who.int/gho/interactive\\_charts/phe/oap\\_exposure/atlas.html](http://gamapservers.who.int/gho/interactive_charts/phe/oap_exposure/atlas.html)



Public Health and Environment (PHE): ambient air pollution  
Annual mean concentrations of fine particulate matter (PM<sub>2.5</sub>) in urban areas (µg/m<sup>3</sup>), 2014\*



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# Where to Find and View the Data

## WHO Website – Grid Level

### Global Health Observatory (GHO) data

#### Global Health Observatory data

Data repository

Reports

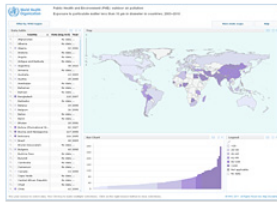
Country statistics

Map gallery

Standards

### Exposure to ambient air pollution

The mean ambient air pollution of particulate matter with an aerodynamic diameter of 2.5 µm or less (PM2.5) in country urban areas ranges from less than 10 to over 100 µg/m3. In urban areas, the mean concentration of particulate matter with an aerodynamic diameter of 2.5 µm or less (PM2.5) ranges from less than 10 to over 100 µg/m3, and from less than 10 to over 200 µg/m3 for particulate matter with an aerodynamic diameter of 10 µm or less (PM10)

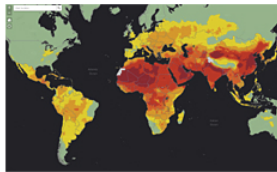


#### Situation at country level

[View interactive map/graph](#)

[View data](#)

[Read more](#)



#### Situation at grid level

[View interactive map](#)

[View data, metadata and detailed methods of estimation](#)



#### Situation at city level

[View full size map \(PM10\)](#)

[View full size map \(PM2.5\)](#)

[View data](#) | [Read more](#)

[Share](#) [Email](#) [Facebook](#) [Twitter](#) [Google+](#) [+](#)

#### More PHE data products

[Maps](#)

[Reports](#)

[Country profiles](#)

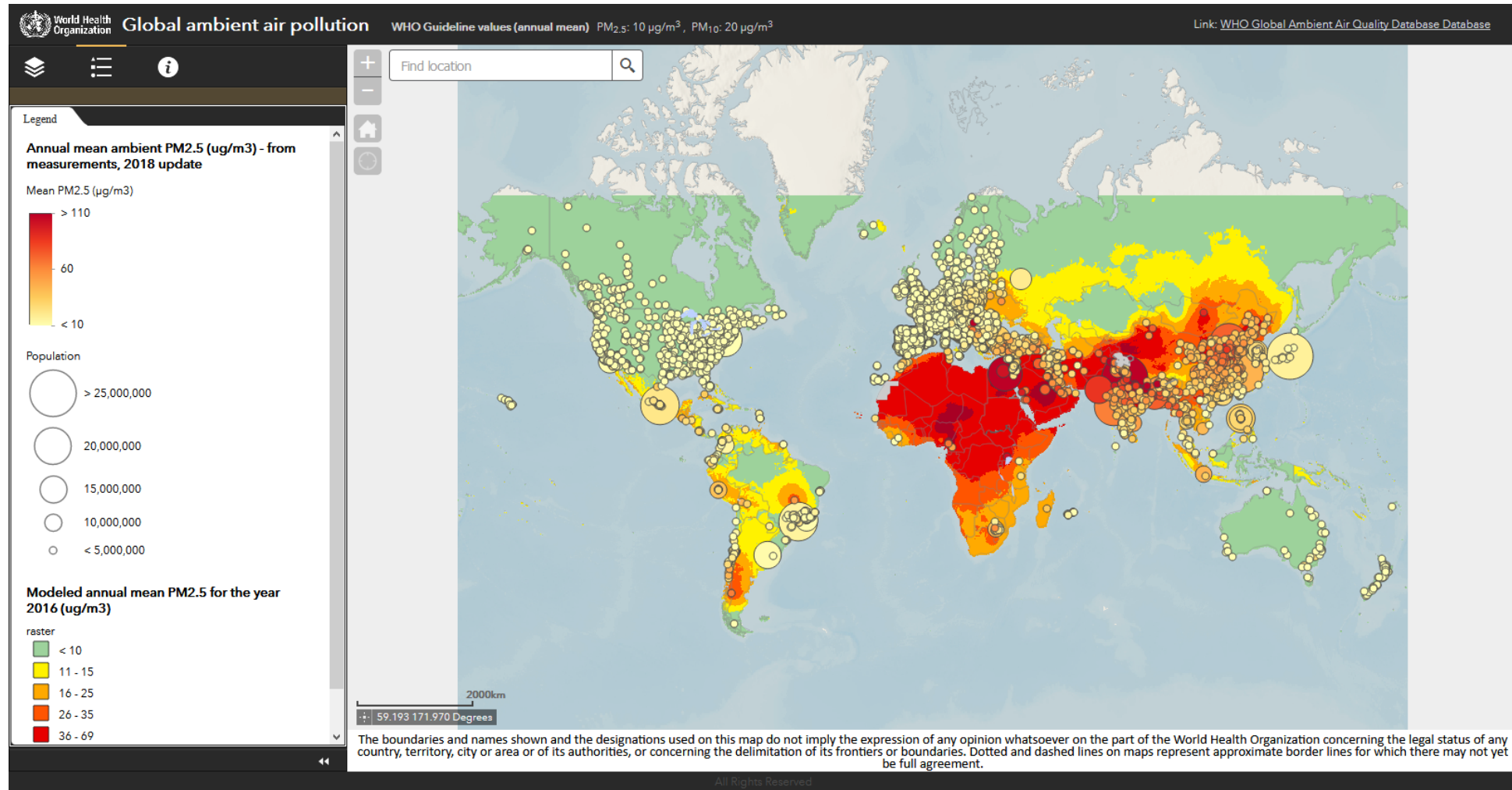
[Links](#)

- [http://www.who.int/gho/phe/outdoor\\_air\\_pollution/exposure/en/](http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/)

Global Health Observatory (GHO) data > Ambient air pollution

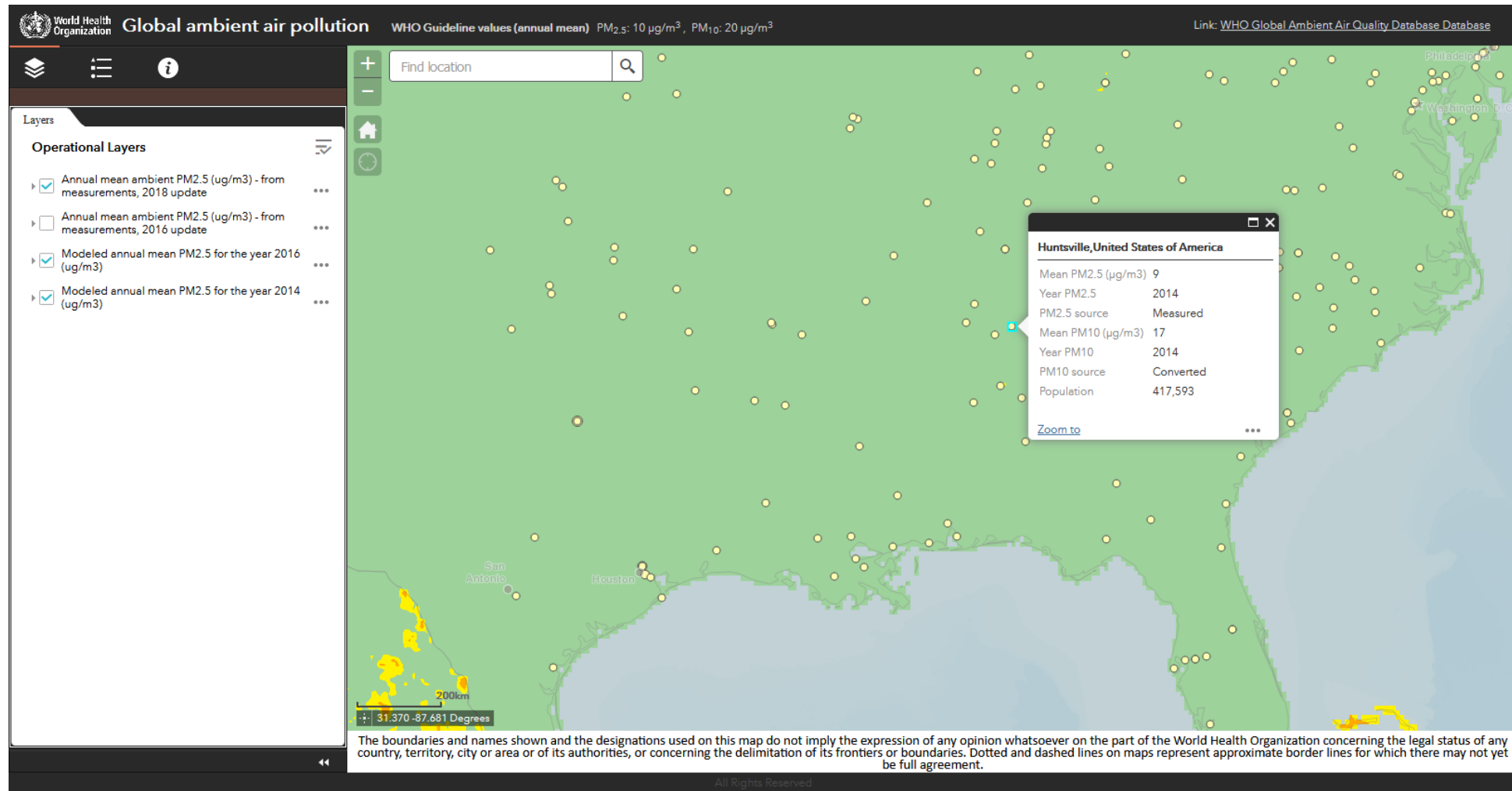
# PM<sub>2.5</sub> at Grid Level

<http://maps.who.int/airpollution/>



# PM<sub>2.5</sub> at Grid Level

<http://maps.who.int/airpollution/>



# Where to Find and View the Data

## WHO Website - City Level

### Global Health Observatory (GHO) data

Global Health Observatory data

Data repository

Reports

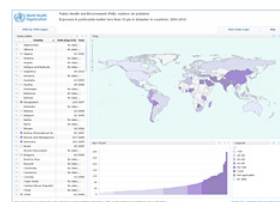
Country statistics

Map gallery

Standards

### Exposure to ambient air pollution

The mean ambient air pollution of particulate matter with an aerodynamic diameter of 2.5  $\mu\text{m}$  or less (PM<sub>2.5</sub>) in country urban areas ranges from less than 10 to over 100  $\mu\text{g}/\text{m}^3$ . In urban areas, the mean concentration of particulate matter with an aerodynamic diameter of 2.5  $\mu\text{m}$  or less (PM<sub>2.5</sub>) ranges from less than 10 to over 100  $\mu\text{g}/\text{m}^3$ , and from less than 10 to over 200  $\mu\text{g}/\text{m}^3$  for particulate matter with an aerodynamic diameter of 10  $\mu\text{m}$  or less (PM<sub>10</sub>)

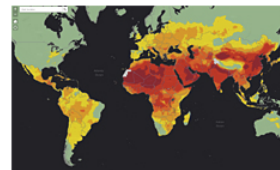


#### Situation at country level

[View interactive map/graph](#)

[View data](#)

[Read more](#)



#### Situation at grid level

[View interactive map](#)

[View data, metadata and detailed methods of estimation](#)



#### Situation at city level

[View full size map \(PM<sub>10</sub>\)](#)

[View full size map \(PM<sub>2.5</sub>\)](#)

[View data](#) | [Read more](#)

[Print](#) [Email](#) [Facebook](#) [Twitter](#) [Google+](#) [+](#)

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[Links](#)

[http://www.who.int/gho/phe/outdoor\\_air\\_pollution/exposure/en/](http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/)

← Maps of city level PM<sub>10</sub> and PM<sub>2.5</sub>

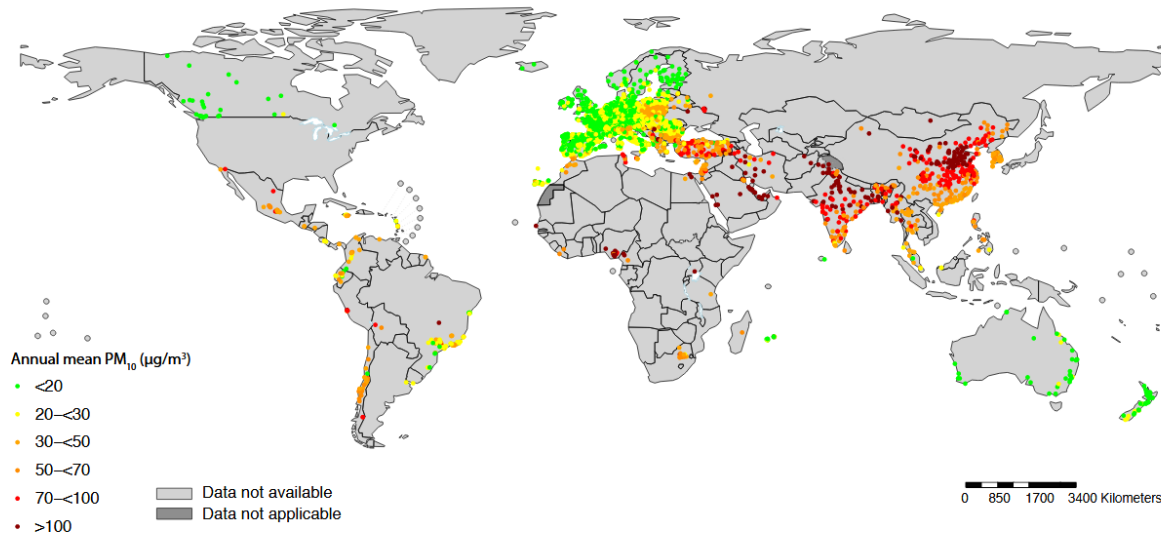
← .csv file with city level annual means

Global Health Observatory (GHO) data > Ambient air pollution

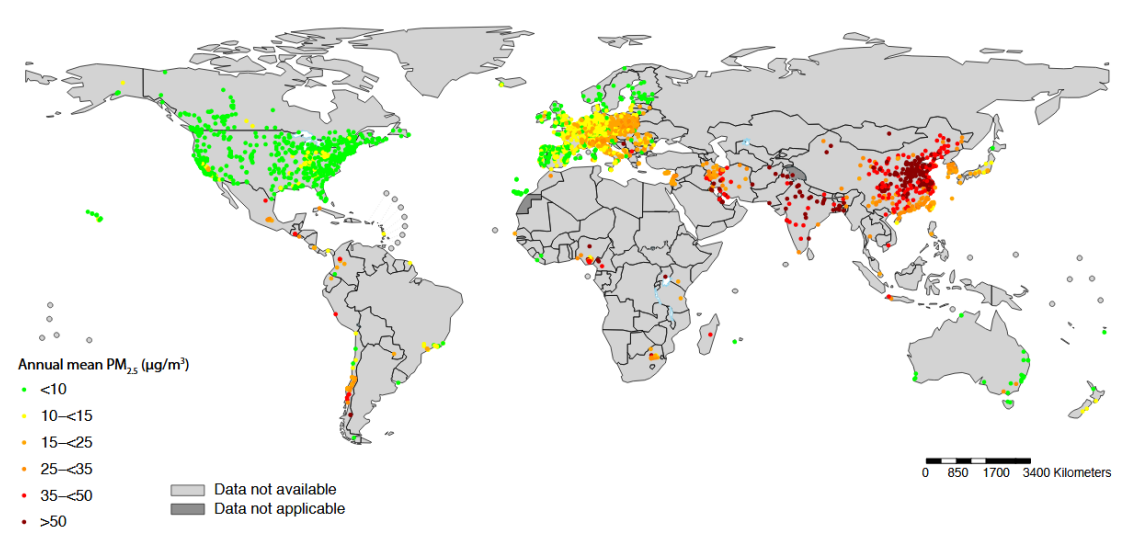
# PM<sub>2.5</sub> at City Level

[http://www.who.int/gho/phe/outdoor\\_air\\_pollution/exposure/en/](http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/)

PM<sub>10</sub>



PM<sub>2.5</sub>

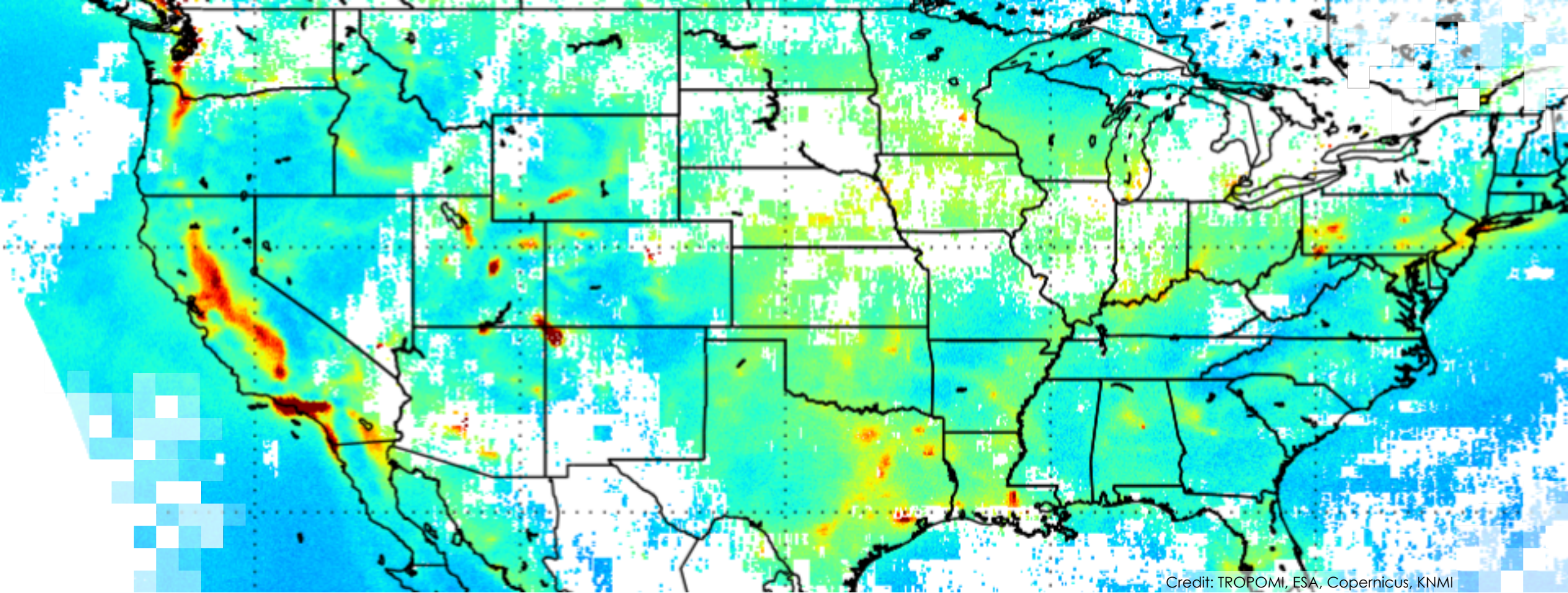




# Where to Find the Data

## NASA Aura Validation Data Center

- Dr. Pawan Gupta has subsetted the DIMAQ gridded data by country
- The individual country .csv files are available at:
  - [http://avdc.gsfc.nasa.gov/pub/tmp/WHO\\_PM25\\_2014\\_COUNTRY\\_DATA/](http://avdc.gsfc.nasa.gov/pub/tmp/WHO_PM25_2014_COUNTRY_DATA/)
- There is also a readme.txt file



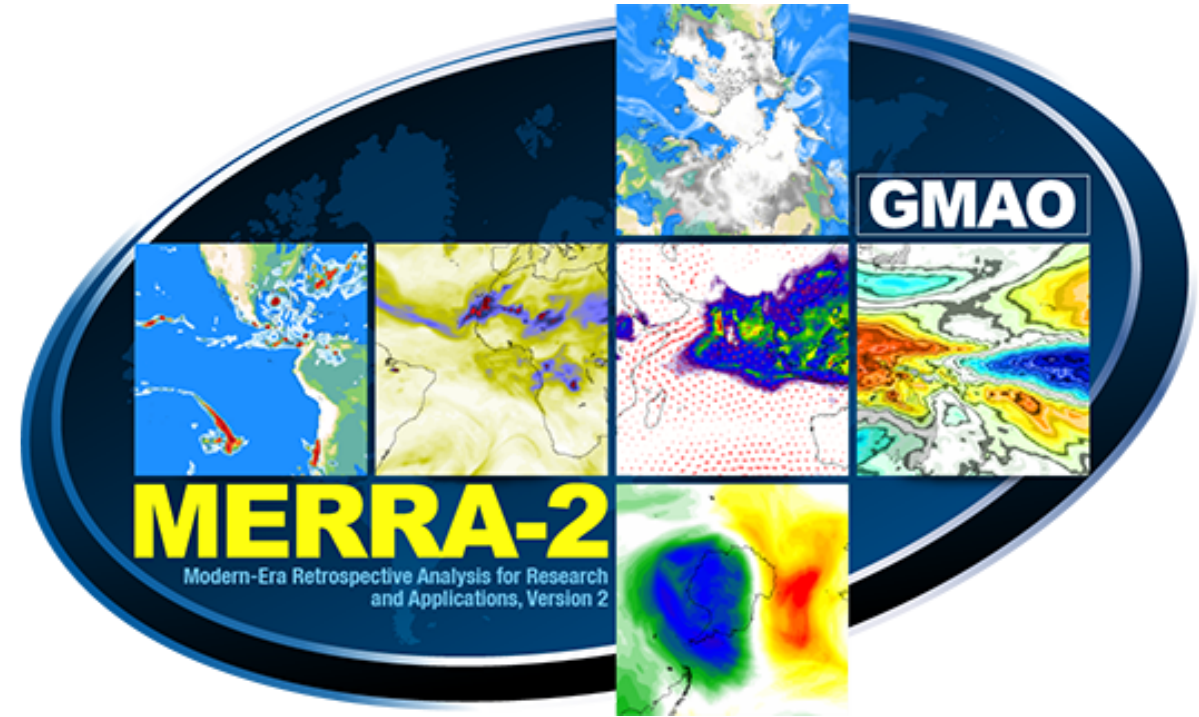
Credit: TROPOMI, ESA, Copernicus, KNMI

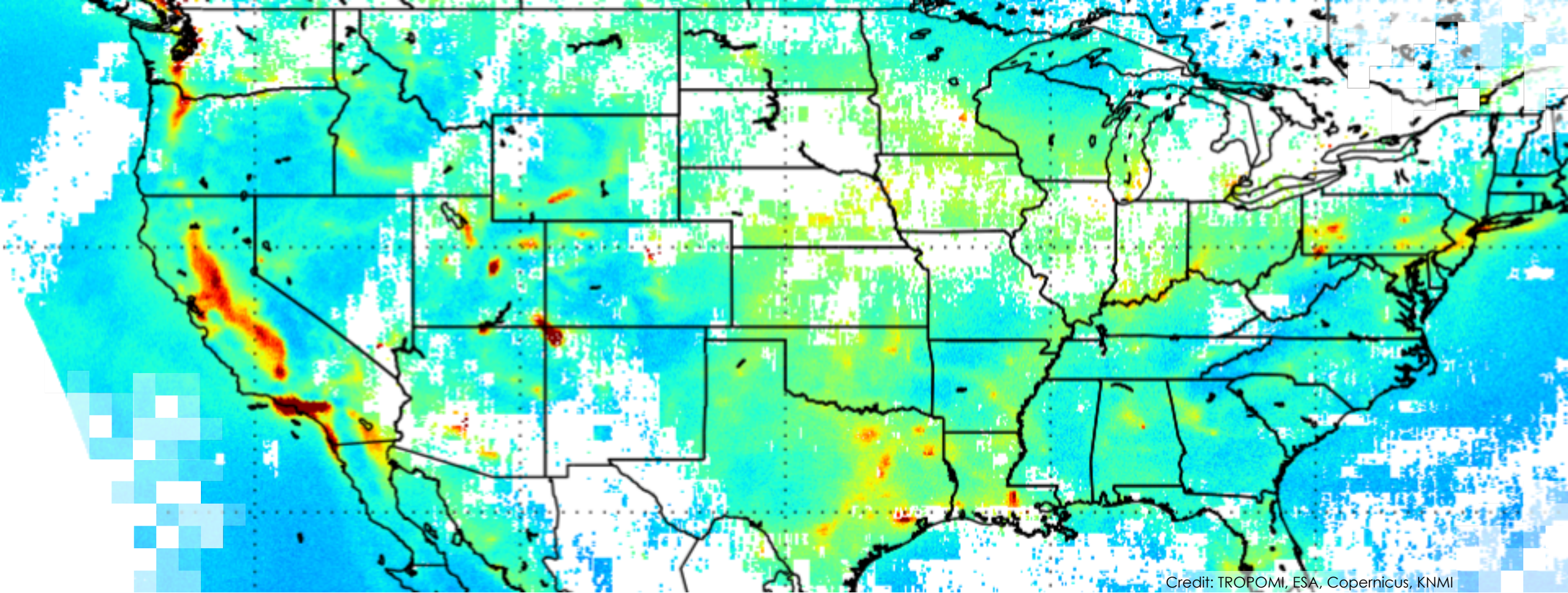
NASA GMAO MERRA-2 Model Output

# Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2)

<https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/>

- NASA's Global Model and Assimilation Office (GMAO) produces estimates of surface  $PM_{2.5}$  over the period of 1980 to the present day
- The model system assimilates meteorological data as well as some atmospheric constituents (e.g., ozone, AOD)





Questions