

Credit: TROPOMI, ESA, Copernicus, KNMI



EPA AirNow Data and Satellite-Based PM_{2.5} Data Sets

Melanie Follette-Cook and Pawan Gupta

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

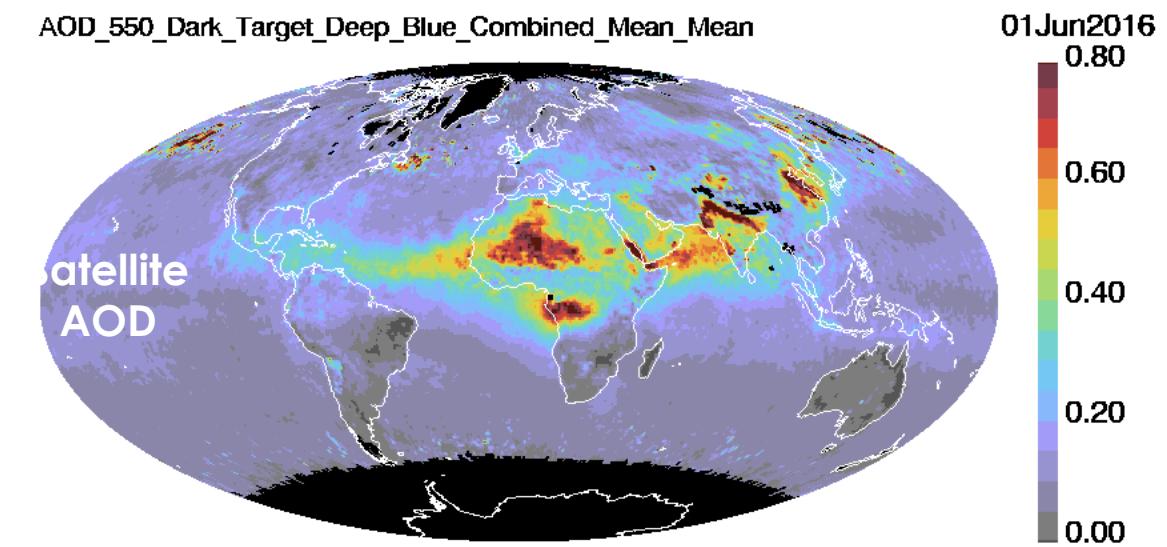
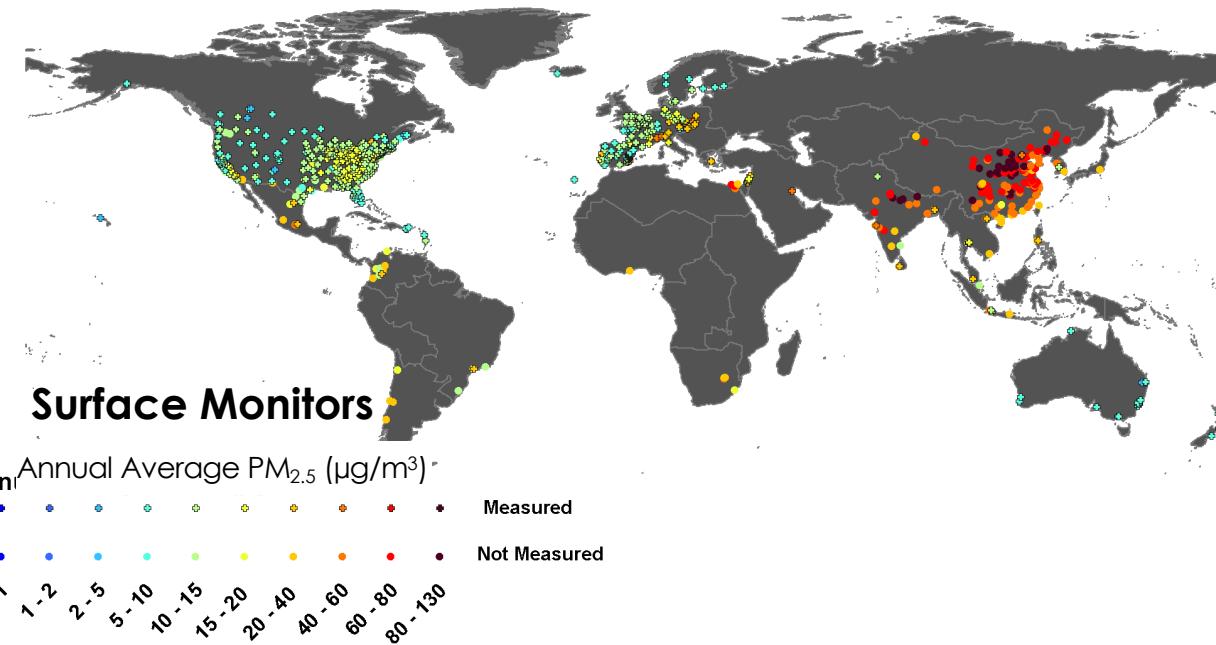
Learning Objectives

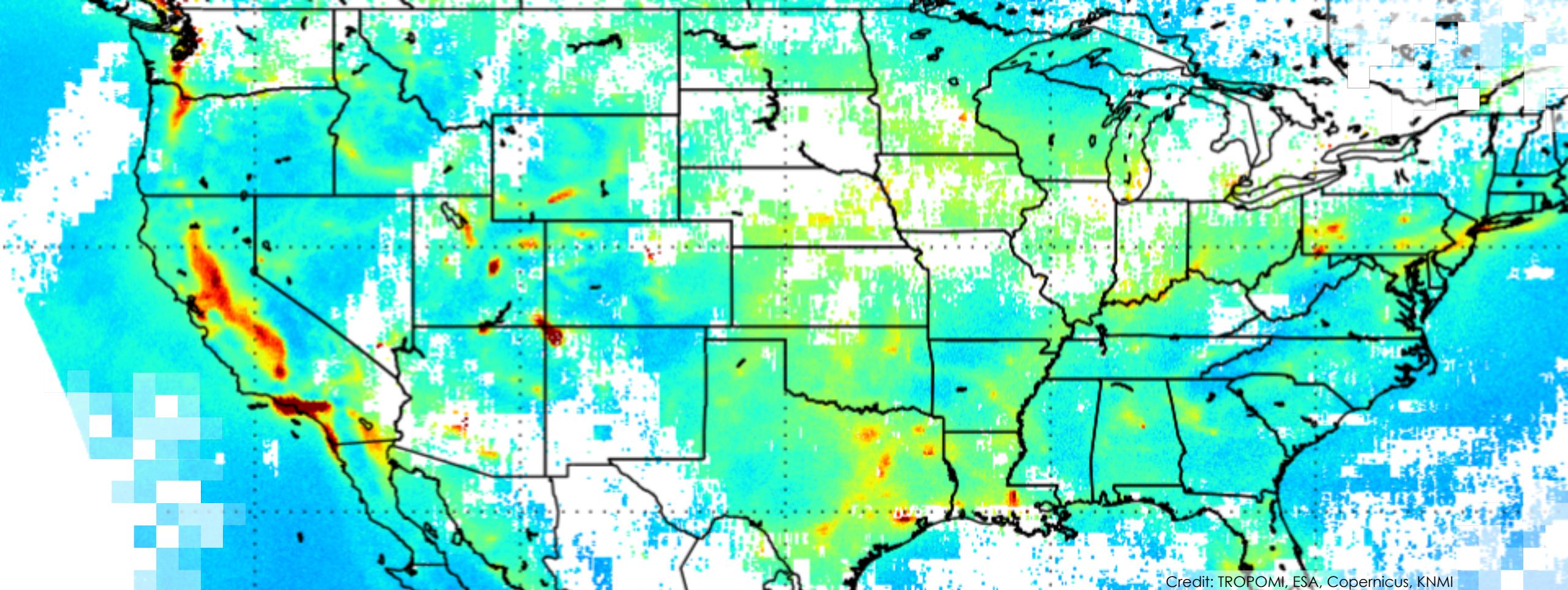
By the end of this presentation, you will be able to:

- 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





EPA AQS and AirNow Data

EPA Air Quality Data

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

The screenshot shows the EPA Air Quality Data homepage. At the top, there's a navigation bar with links for Environmental Topics, Laws & Regulations, About EPA, and a search bar. Below the header, a main title reads "Air Data: Air Quality Data Collected at Outdoor Monitors Across the US". To the right of the title are social media sharing icons and a "CONTACT US" link.

The page features several interactive components:

- Visualize Trends:** A multi-year tile plot showing long-term changes in air quality. A red box highlights a callout for "Detailed info and FAQ".
- Download Data:** Options for Pre-generated Data Files, Download Daily Data, and Download Raw Data (API). A red box highlights this section.
- Monitor Locations:** An interactive map of the United States showing monitor locations.
- View interactive map:** A large red box highlights this section.
- Summary Reports:** Links to Air Quality Index Report, Air Quality Statistics Report, Monitor Values Report, Monitor Values Report - Hazardous Air Pollutants, and Air Quality Index Daily Values Report.
- Data Viz:** Options for Tile Plot - Multiyear, Tile Plot - Single Year, AQI Plot, Concentration Plot, Ozone Exceedances Plot, and Concentration Map.
- Technical Reports:** Links to PM2.5 Continuous Monitor Comparability Assessments, PM10 Continuous Monitor Comparability Assessments, and Single Point Precision and Bias Report.
- Plot data:** A red box highlights this section.

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

Download data

Generate reports

Detailed info and FAQ

View interactive map

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

PM2.5

2. Year

2018

3. Geographic Area

Select a State ...

-- or --

Huntsville, AL

-- or --

Select a County ...

4. Monitor Site

All Sites
010890014

Get Data

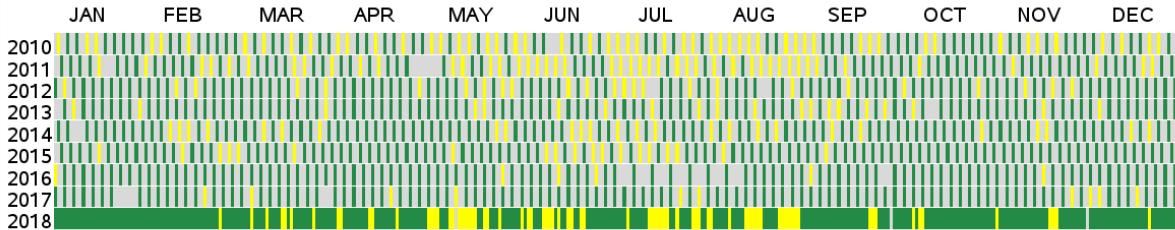
- Download pre-generated data files
- Download daily data
 - By state, city, or county
 - Creates a csv file to save
- Download raw data (through an API)
 - For NRT AQ data, use AirNow API

Data Visualization

Multiyear Tile Plot

PM2.5 Daily AQI Values, 2010 to 2018

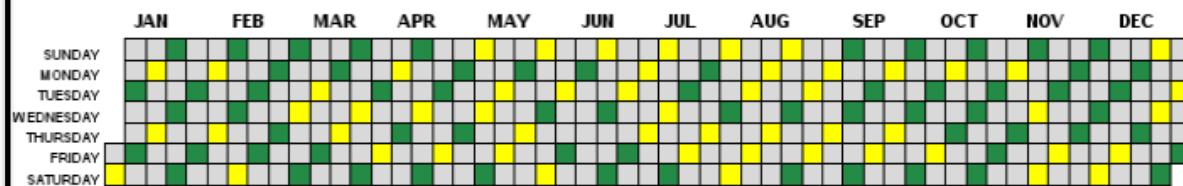
Huntsville, AL



Single Year Tile Plot

PM2.5 Daily AQI Values in 2010

Huntsville, AL

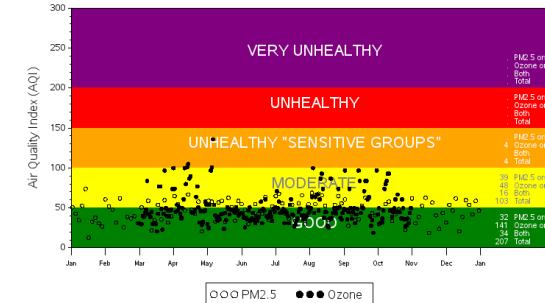


AQI Category

- Good (<=12.0 ug/m³)
- Moderate (12.1-35.4 ug/m³)
- Unhealthy for Sensitive Groups (35.5-55.4 ug/m³)
- Unhealthy (55.5-150.4 ug/m³)
- Very Unhealthy (150.5-250.4 ug/m³)
- Hazardous (>=250.5 ug/m³)

AQI Plot

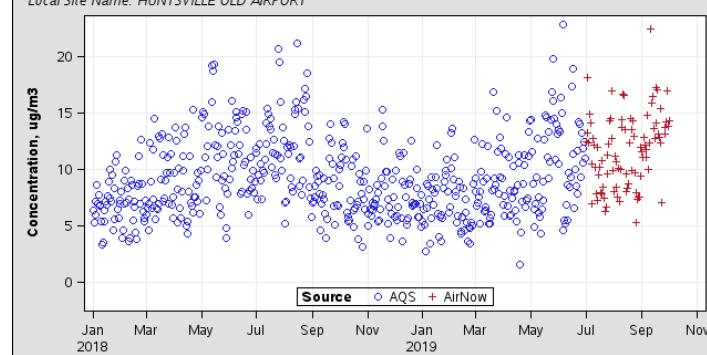
Daily PM2.5 and Ozone AQI Values in 2010
Huntsville, AL



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 ug/m³)
CBSA: Huntsville, AL
County: Madison
State: Alabama
AQS Site ID: 010890014, poc 3
Local Site Name: HUNTSVILLE OLD AIRPORT

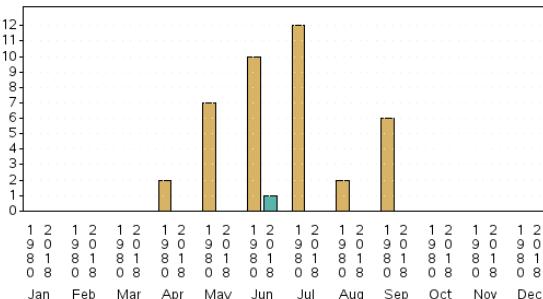


Data Visualization



Ozone Exceedances Plots

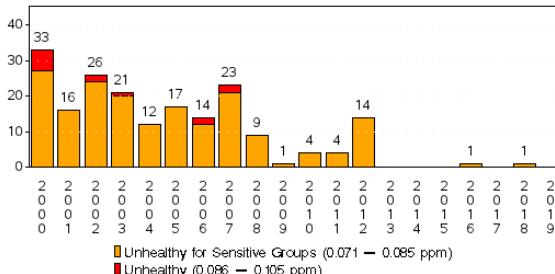
Number of Days 8-hr Ozone Daily Max > 0.070 ppm
1980 vs. 2018
in Huntsville, AL



Cumulative Number of Days 8-hr Ozone Daily Max > 0.070 ppm
1980 vs. 2018
in Huntsville, AL

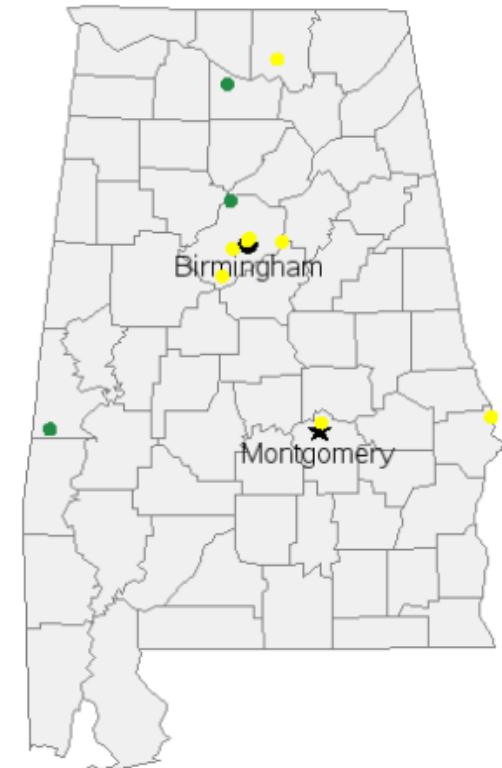


Number of Days 8-hr Ozone Daily Max > 0.070 ppm
2000-2019
in Huntsville, AL



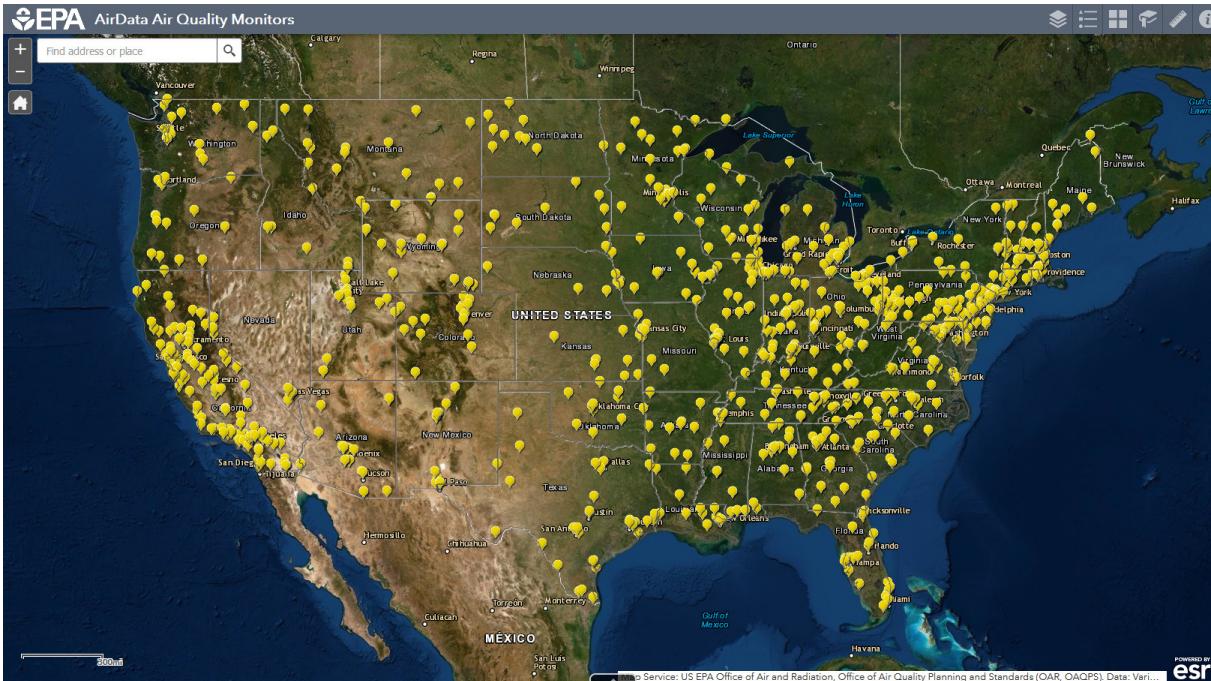
Concentration Maps

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

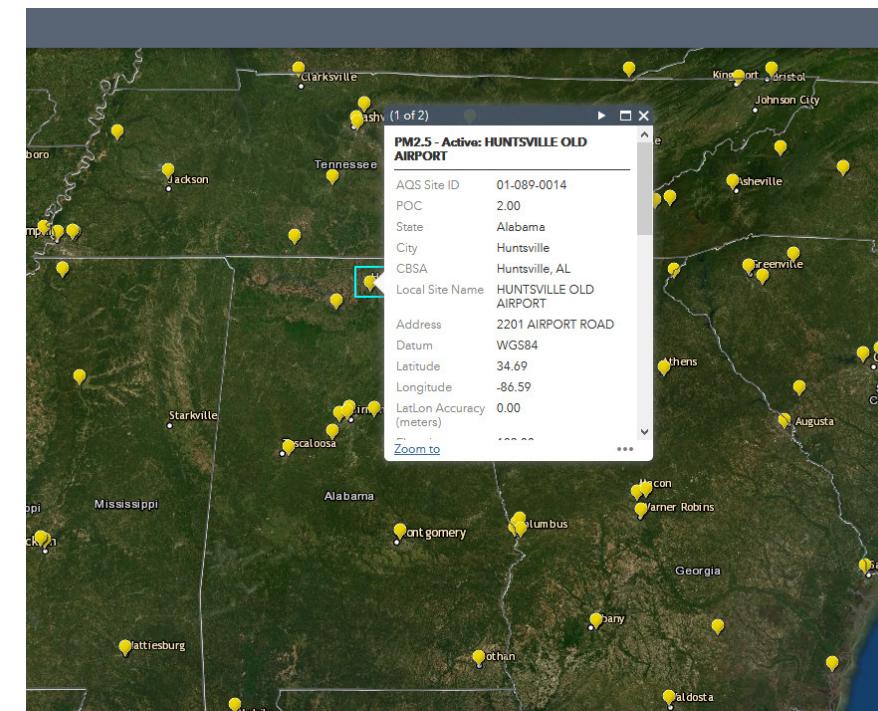


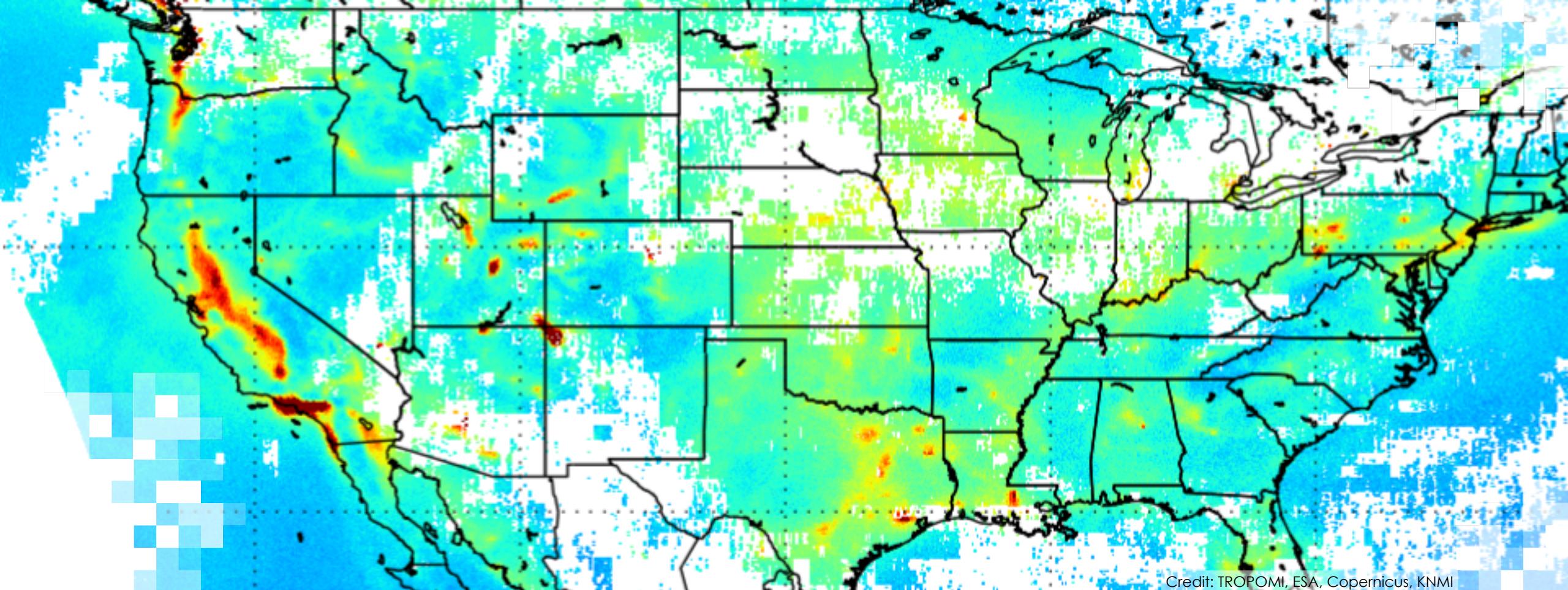
- Good
- Moderate
- Unhealthy for Sensitive Groups
- Unhealthy
- Very Unhealthy
- Hazardous

Interactive Maps



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



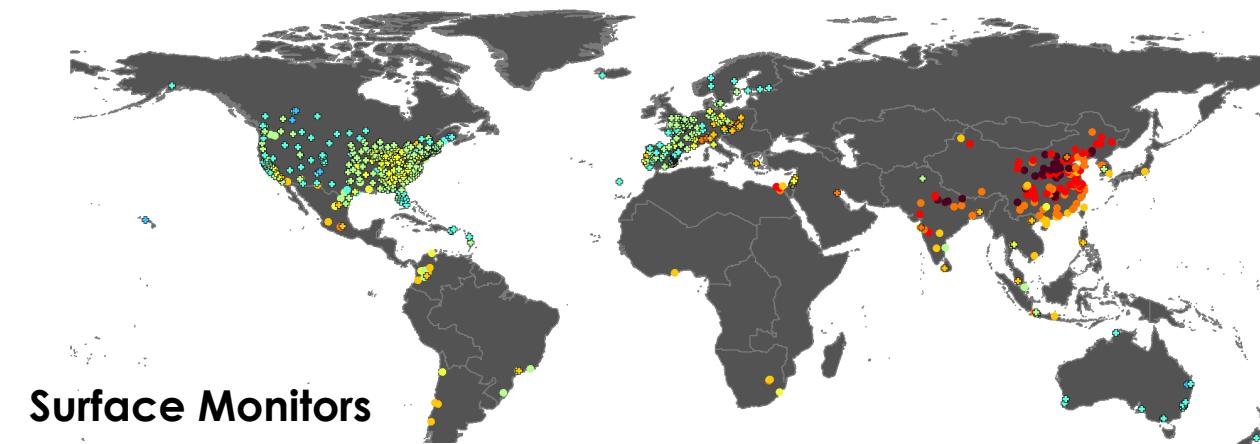


Credit: TROPOMI, ESA, Copernicus, KNMI

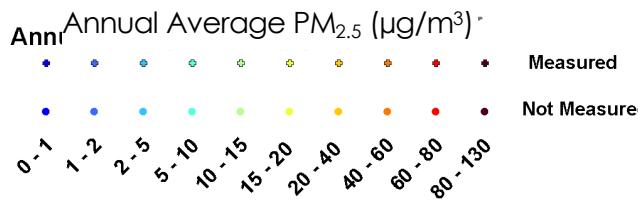
Examples of Applications Using Surface PM_{2.5} Estimates

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

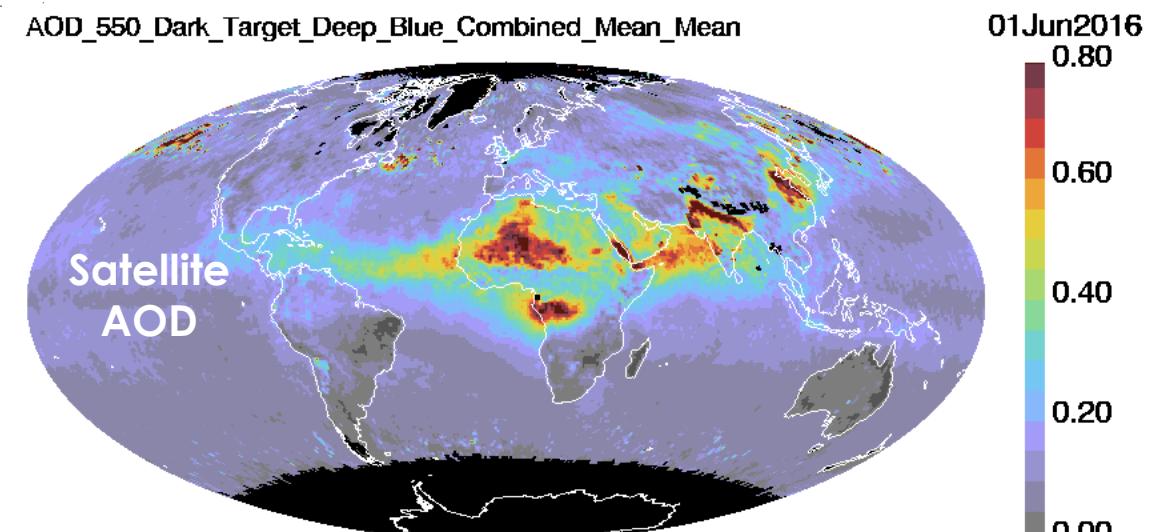
Spatial coverage is the primary advantage of satellite data



Surface Monitors



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

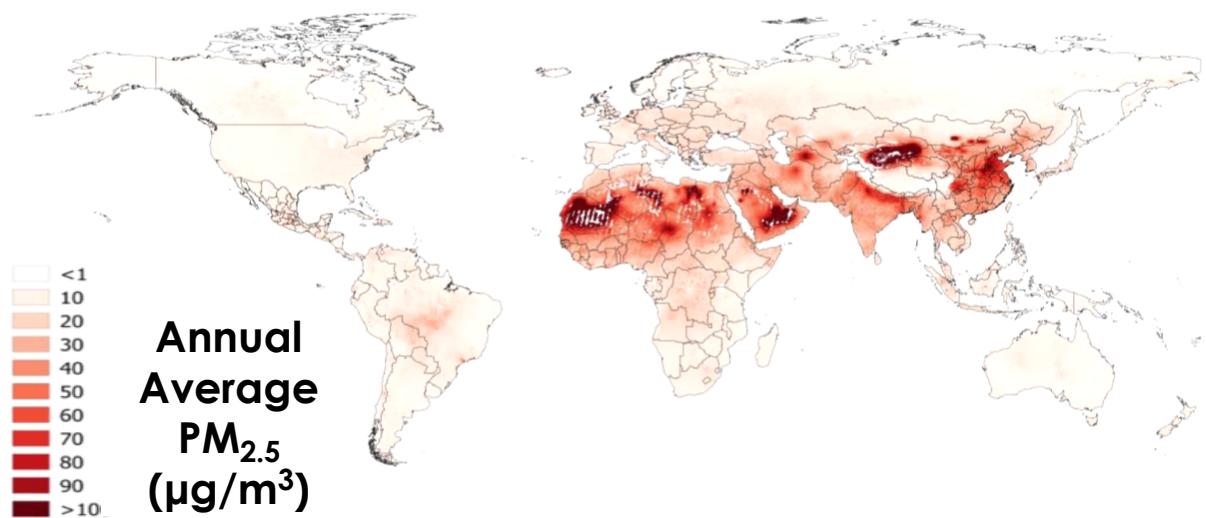


Health Studies of Exposure

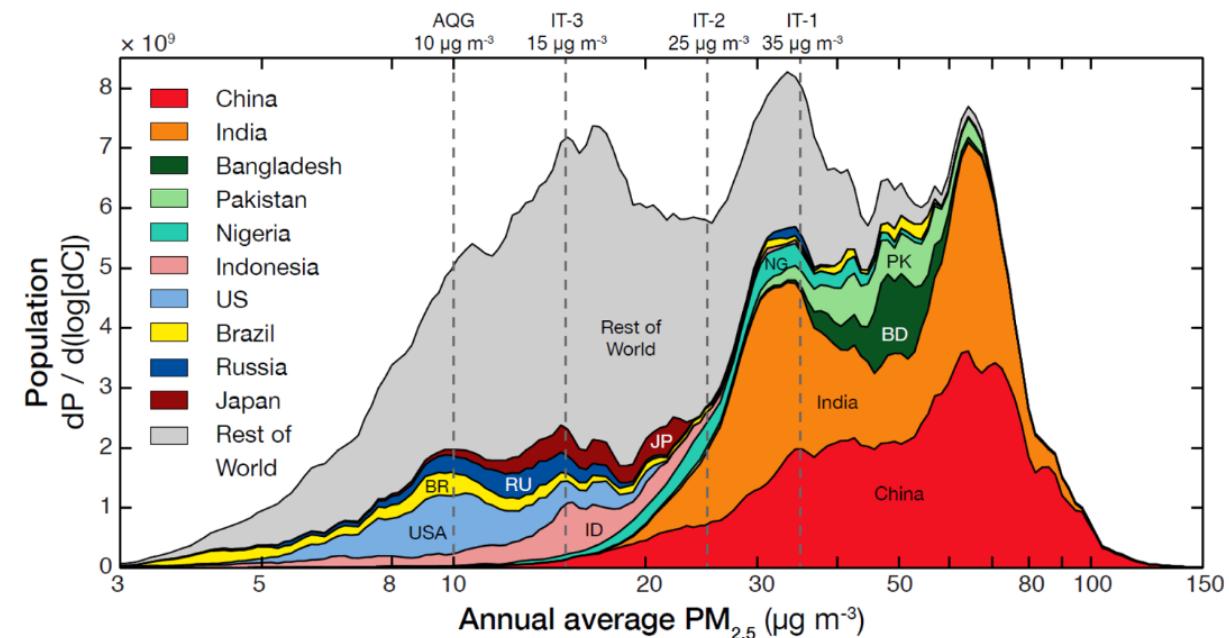


Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013

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

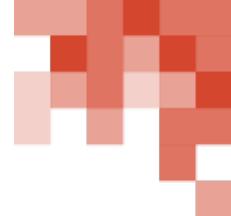


WHO Interim Targets



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 ($PM_{2.5}$))

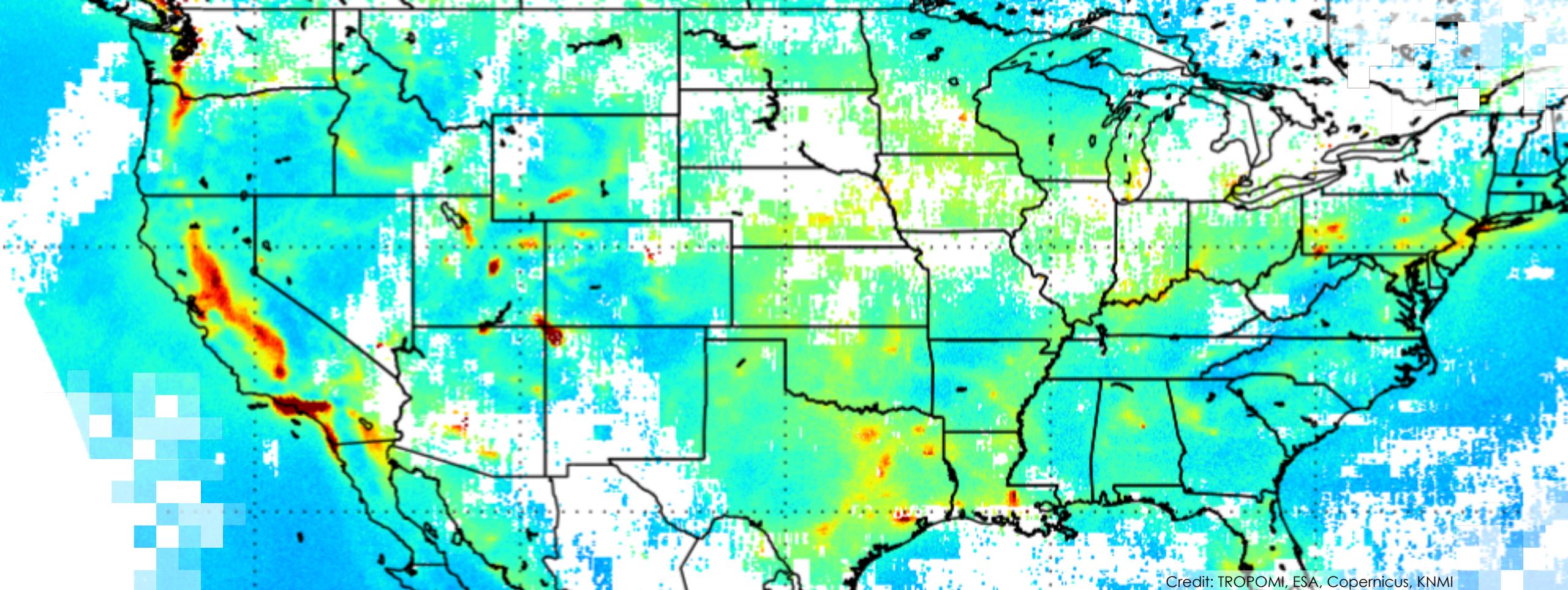
Goal 11 – Sustainable Cities and Communities

- 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



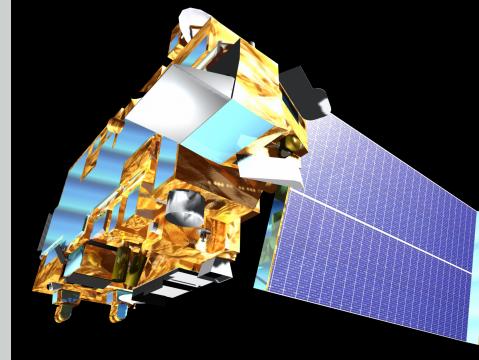
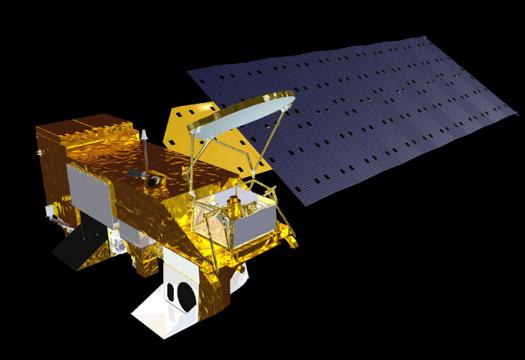
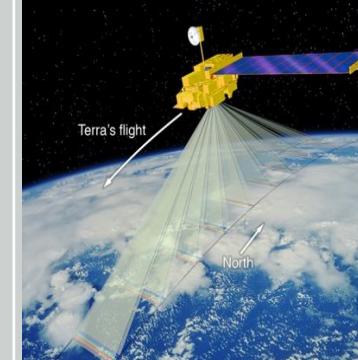
Text adapted from "[Transforming our world: the 2030 Agenda for Sustainable Development](#)"



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

Satellite-Based Estimates: AOD from Satellites

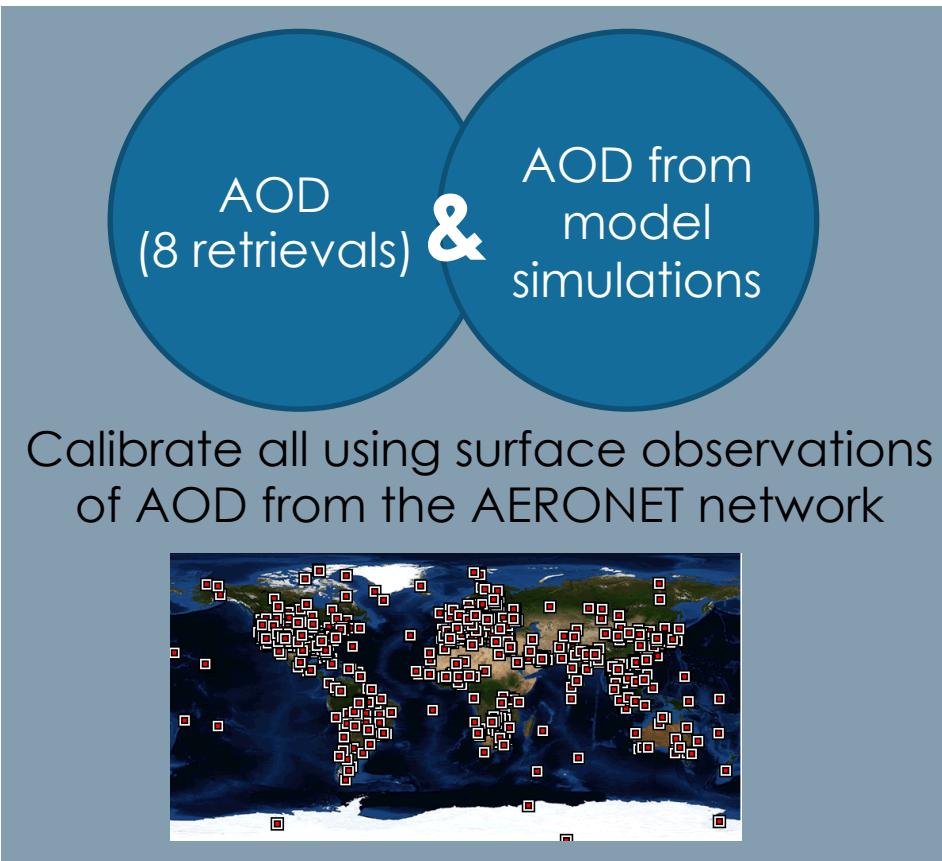
Eight retrievals of AOD from four different instruments

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_{2.5}

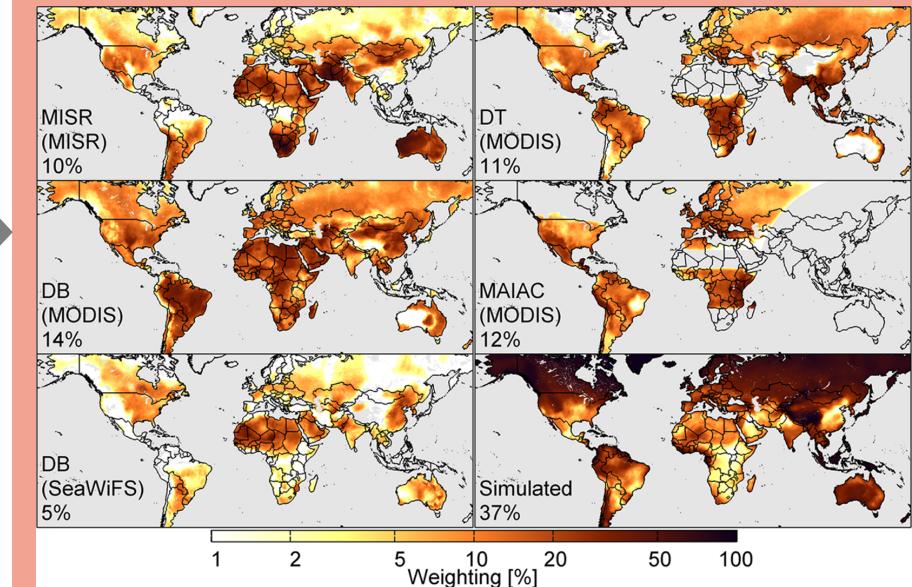


Calibrate all using surface observations of AOD from the AERONET network



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

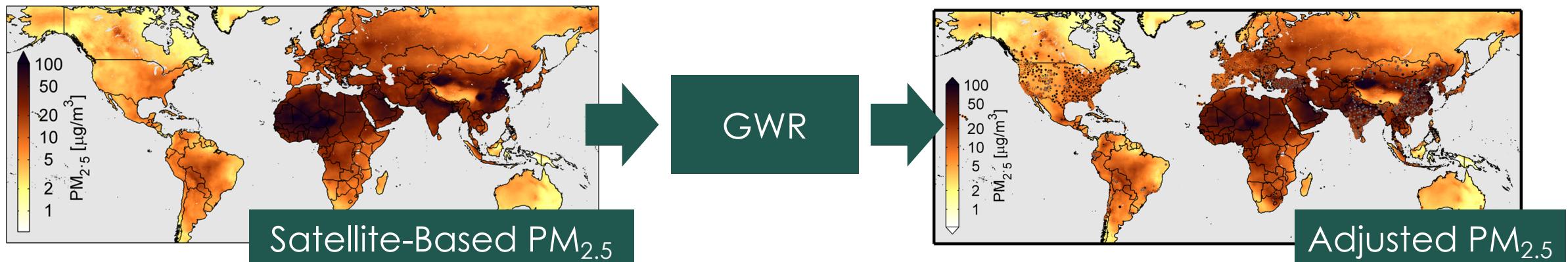
Combine estimates (weighted uncertainty) and calculate annual mean



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

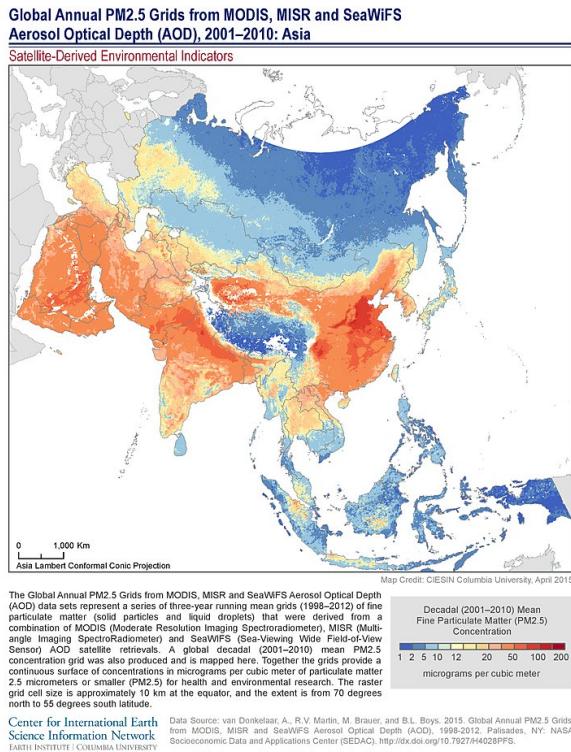


The Van Donkelaar product is available at: <http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012>. Left Image: Van Donkelaar et al., 2016, Figure 3. Right Image: Van Donkelaar et al., 2016, Figure 5

Annual Mean Surface PM_{2.5}

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

- Download data (GeoTIFF files) and pre-made images of surface PM_{2.5} inferred from satellite observations



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

DATA MAPS THEMES RESOURCES SOCIAL MEDIA ABOUT HELP

In the Sp... DATA COLLECTION FEATURED DATA USES Map Gall... DATA CITATIONS CITATIONS DATABASE

India Winter Cropped Area, 2016

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

More...

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

More...

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

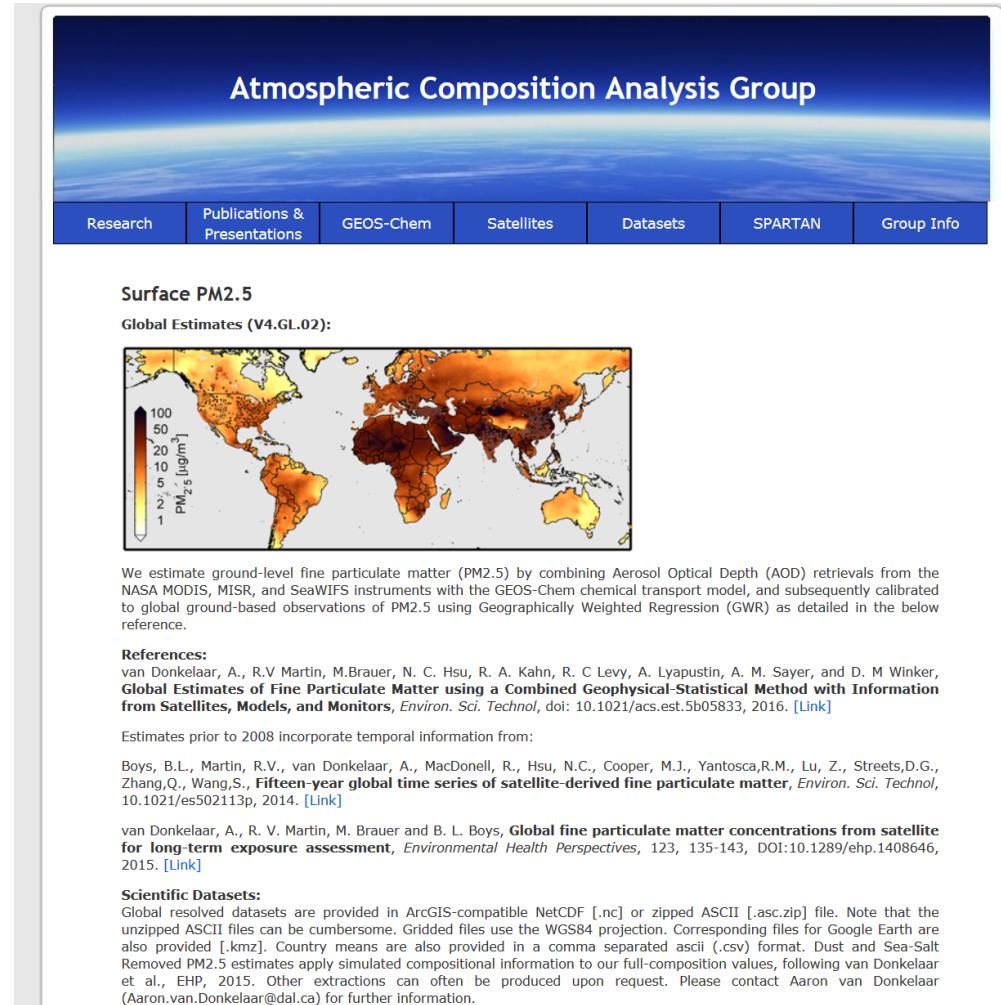
Gridded Population of the World (GPW), v4

India Data Collection

Population Dynamics

Annual Mean Surface PM_{2.5}

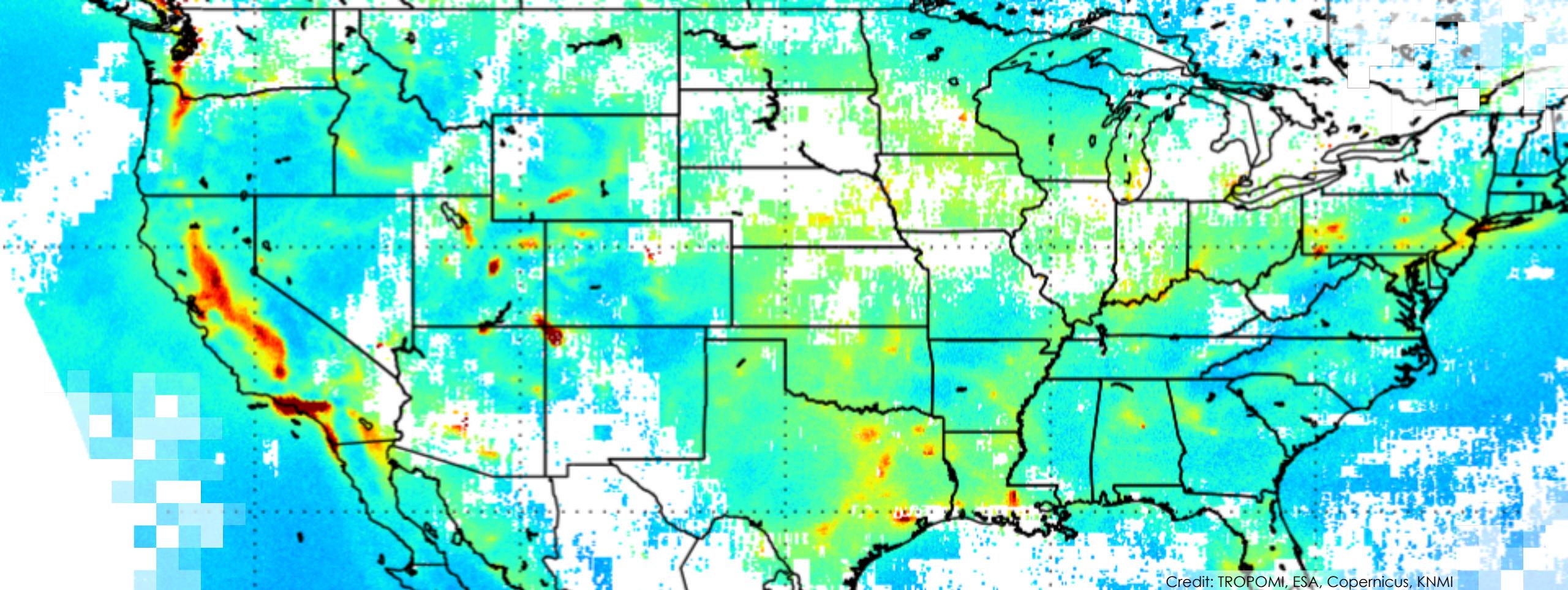
http://fizz.phys.dal.ca/~atmos/martin/?page_id=140



Satellite-Based Estimates

Limitations

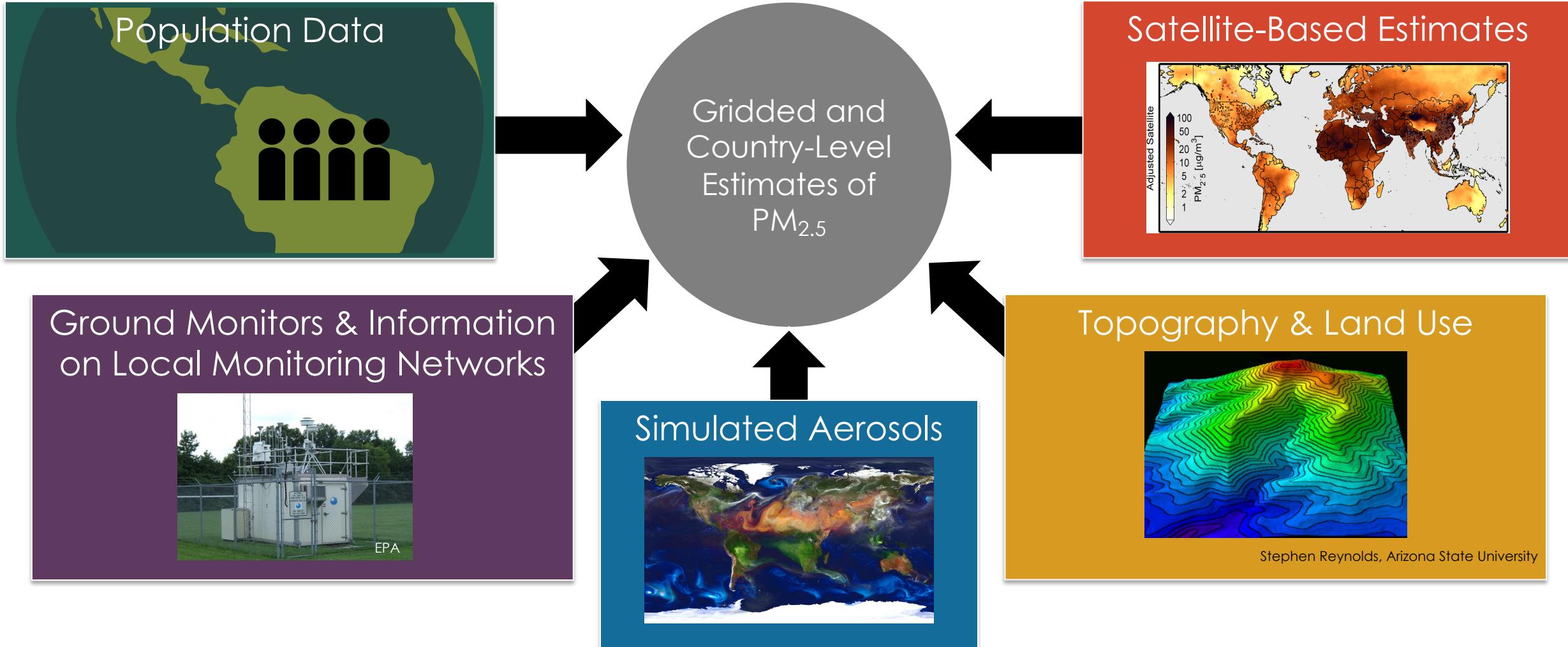
- The van Donkelaar estimate provides annual mean estimates of PM_{2.5}
- However, this and other estimates do not provide an analysis of uncertainties
- The WHO and the University of Bath have led the development of the Data Integration Model for Air Quality (DIMAQ)
 - This model estimates PM_{2.5}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



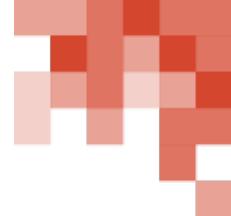
Credit: TROPOMI, ESA, Copernicus, KNMI

Data Integration Model for Air Quality (DIMAQ)

Data Integration Model for Air Quality (DIMAQ)



Data Integration Model for Air Quality (DIMAQ)



Population Data

Ground Monitor
Information & Data

Satellite-Based
Estimates

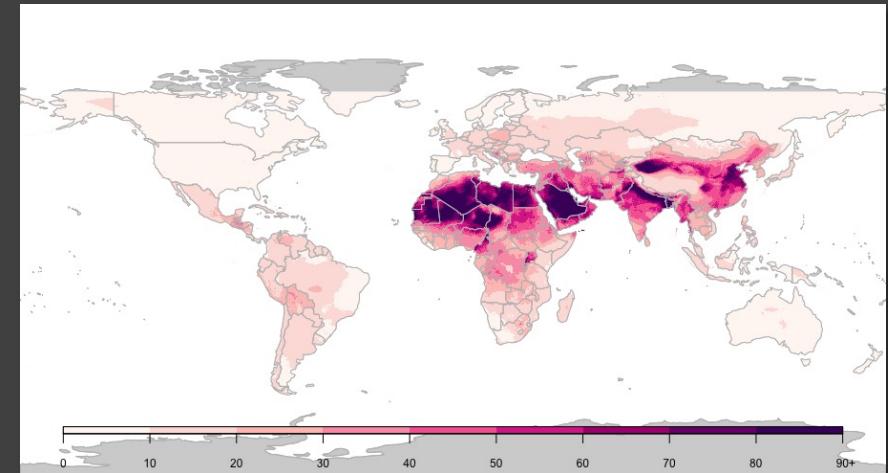
Simulated Aerosols

Topography &
Land Use

Bayesian Hierarchical Framework

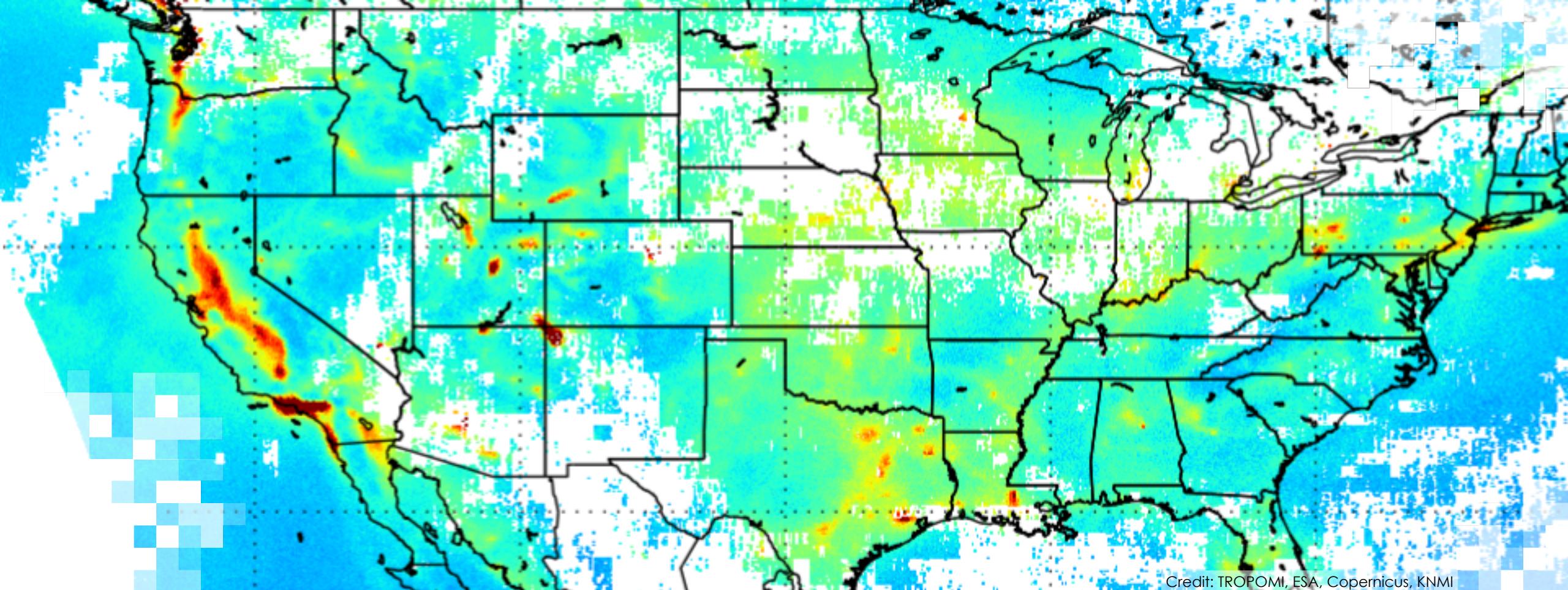
Estimates PM_{2.5} as
well as measures of
uncertainty

Annual Average PM_{2.5} for 2014



Estimates on a 0.1° x 0.1° grid

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

The screenshot shows the WHO GHO data page for ambient air pollution. The top navigation bar includes links for Global Health Observatory data, Data repository, Reports, Country statistics, Map gallery, and Standards. The main content area is titled "Exposure to ambient air pollution" and contains a detailed text about PM2.5 concentrations. Below the text are three maps: "Situation at country level" (a world map with color-coded countries), "Situation at grid level" (a world map with colored grid cells), and "Situation at city level" (a world map with individual city locations). Each map has associated links: "View interactive map/graph" (circled in red), "View data", and "Read more". A sidebar on the right lists "More PHE data products" such as Maps, Reports, Country profiles, and Links. The bottom of the page shows a breadcrumb trail: "Global Health Observatory (GHO) data > Ambient air pollution".

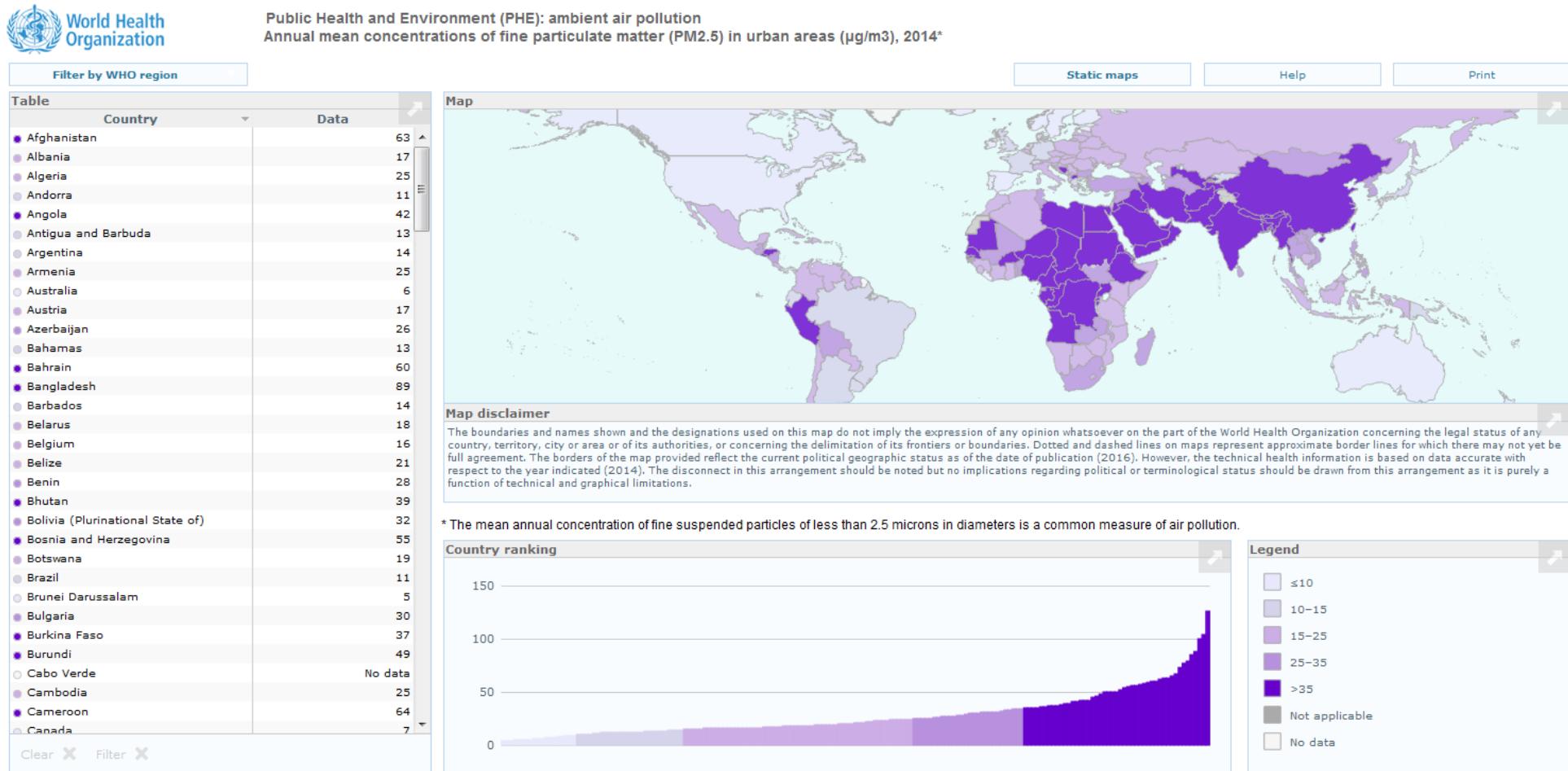
- http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/

Follow this link to download 2014 country level data:

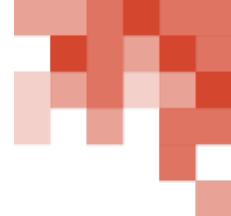
- Formats: csv, Excel, html, XML, etc.
- Can also filter by country and download

PM_{2.5} at Country Level

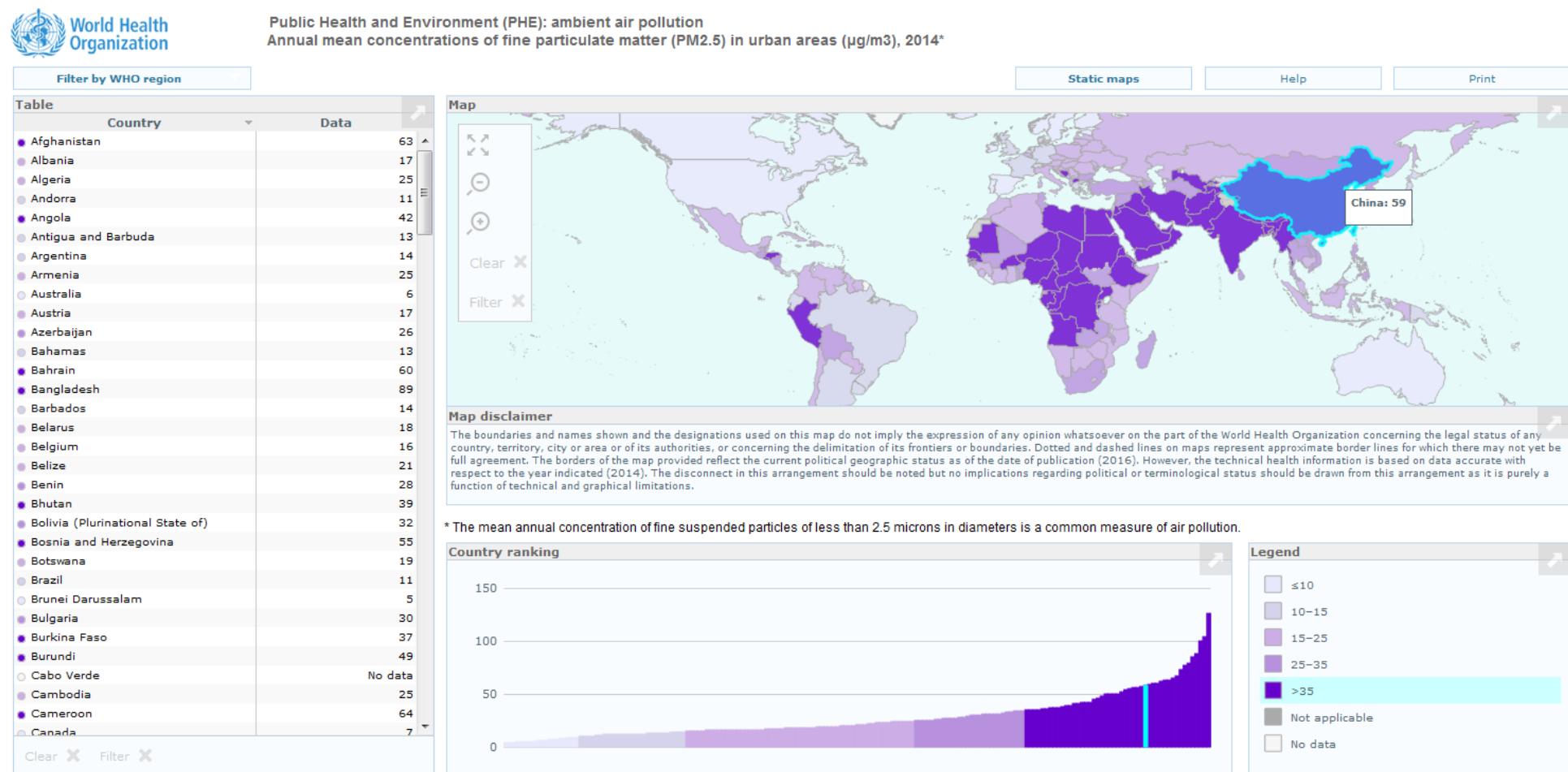
http://gamapserver.who.int/gho/interactive_charts/phe/oap_exposure/atlas.html



PM_{2.5} at Country Level



http://gamapserver.who.int/gho/interactive_charts/phe/oap_exposure/atlas.html



Where to Find and View the Data

WHO Website – Grid Level

Global Health Observatory (GHO) data

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 \(PM2.5\)](#)

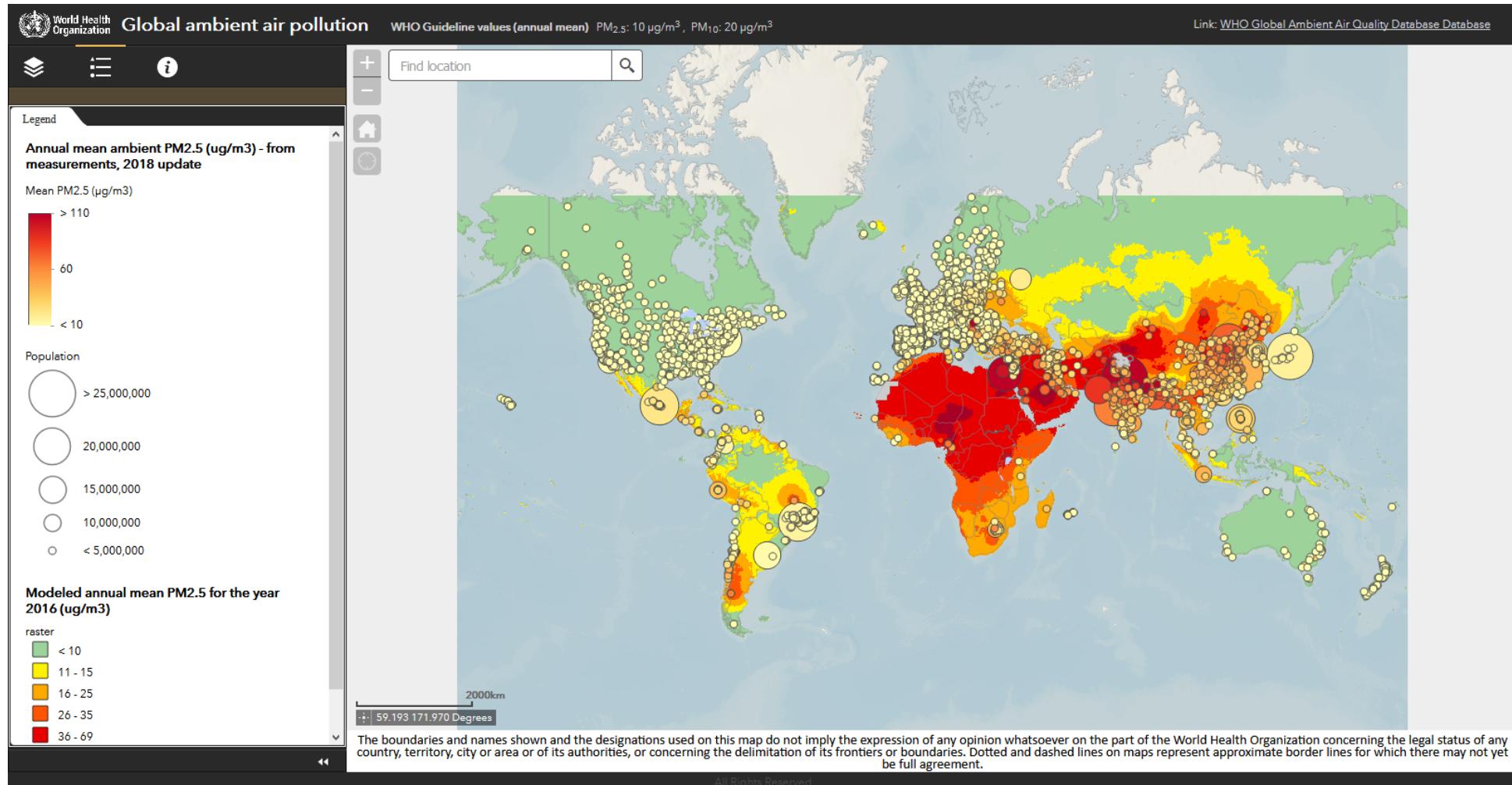
[View data](#) | [Read more](#)

Global Health Observatory (GHO) data > Ambient air pollution

- http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/

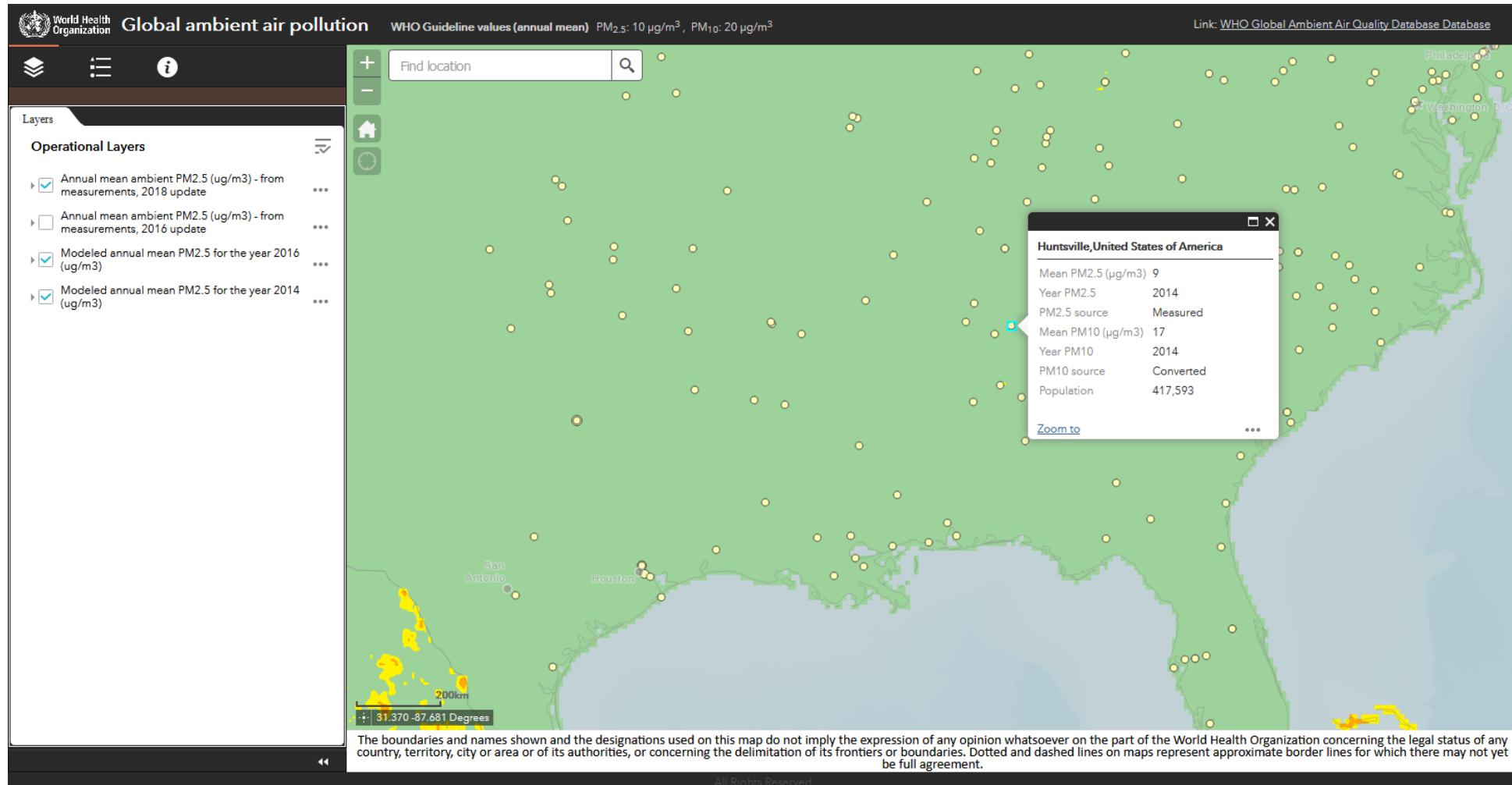
PM_{2.5} at Grid Level

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



PM_{2.5} at Grid Level

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



Where to Find and View the Data

WHO Website - City Level

Global Health Observatory (GHO) data

Exposure to ambient air pollution

The mean ambient air pollution of particulate matter with an aerodynamic diameter of 2.5 μm or less (PM_{2.5}) 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 μm or less (PM_{2.5}) 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 μm or less (PM₁₀)

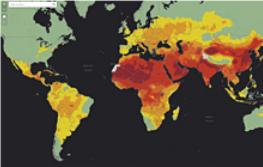


Situation at country level

[View interactive map/graph](#)

[View data](#)

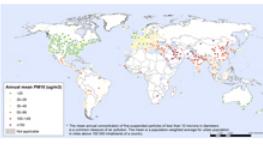
[Read more](#)



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 \(PM_{2.5}\)](#)

[View data | Read more](#)

Global Health Observatory (GHO) data > Ambient air pollution

http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/

← Maps of city level PM₁₀ and PM_{2.5}

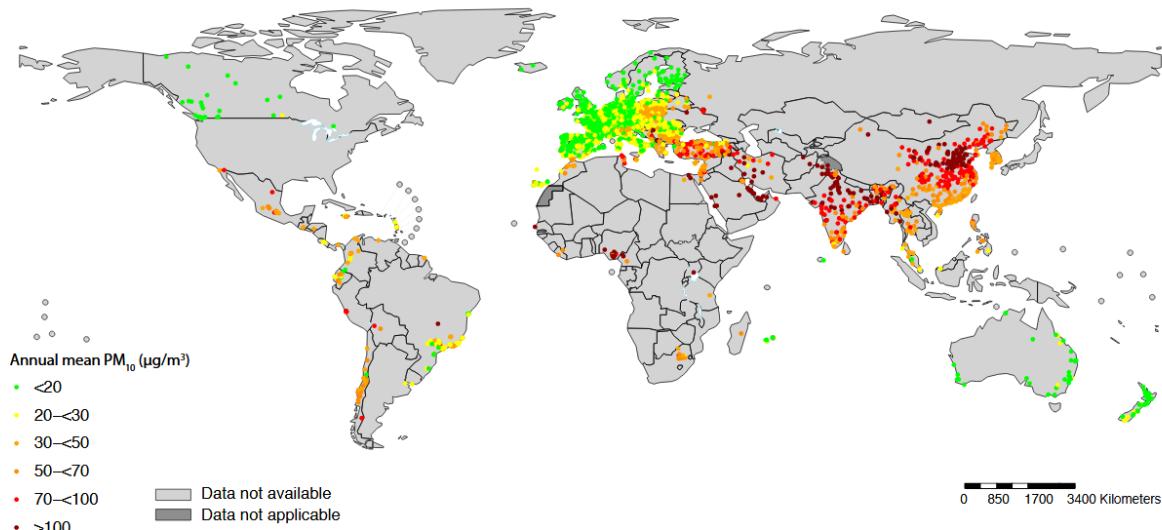
← .csv file with city level annual means

PM_{2.5} at City Level

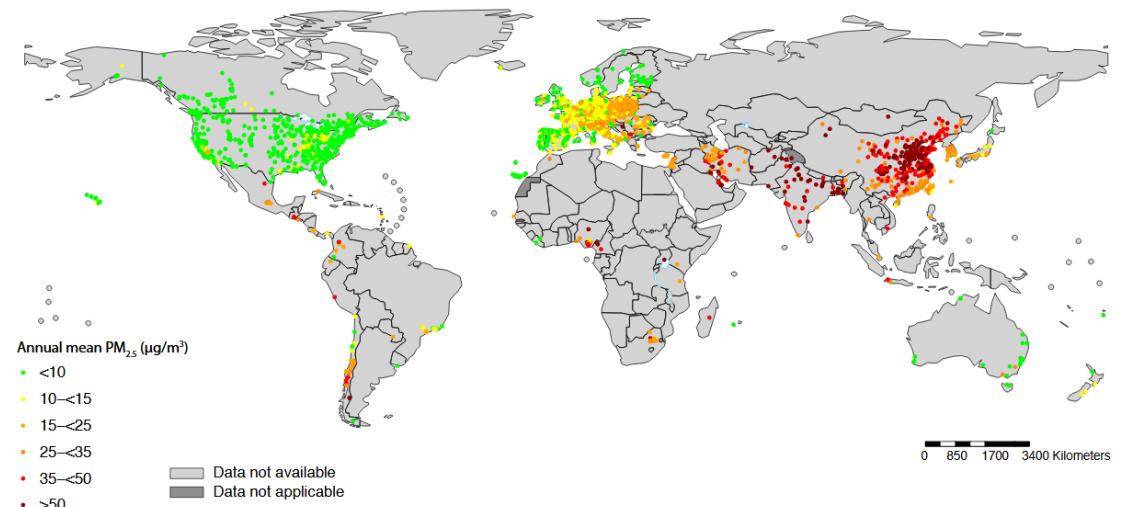


http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/

PM₁₀



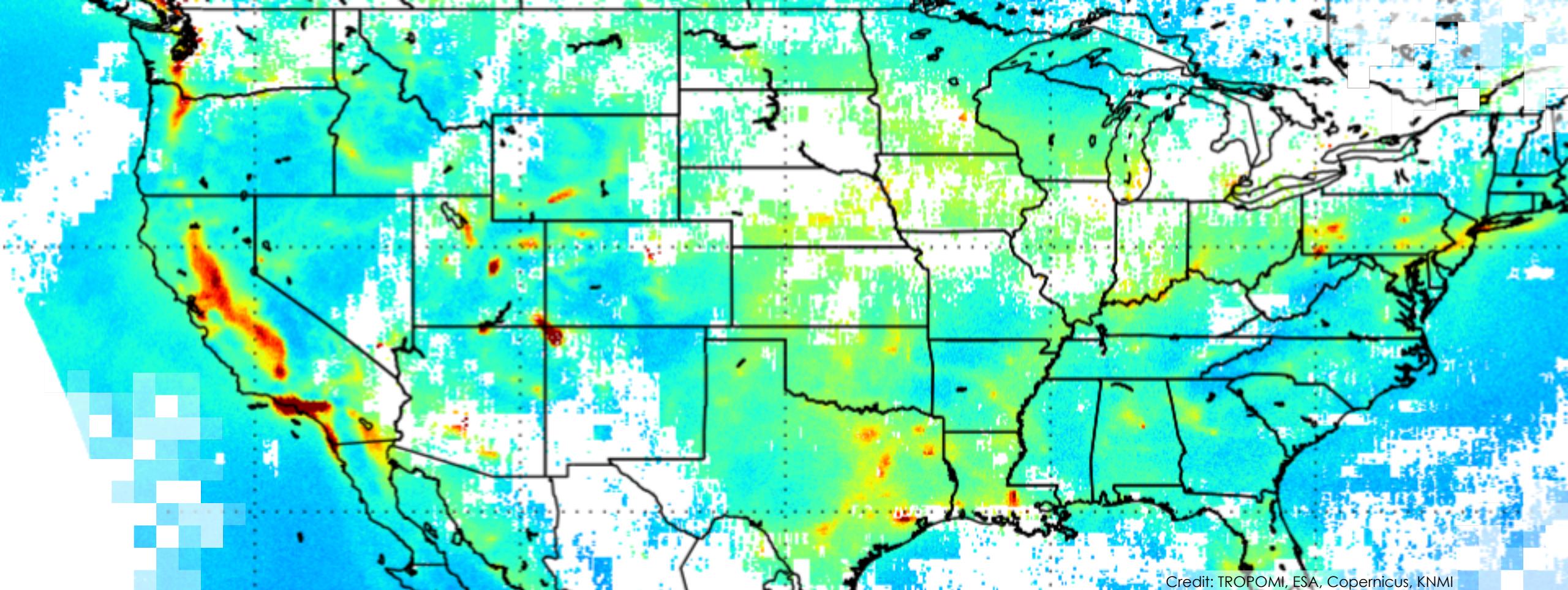
PM_{2.5}



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/
- There is also a readme.txt file



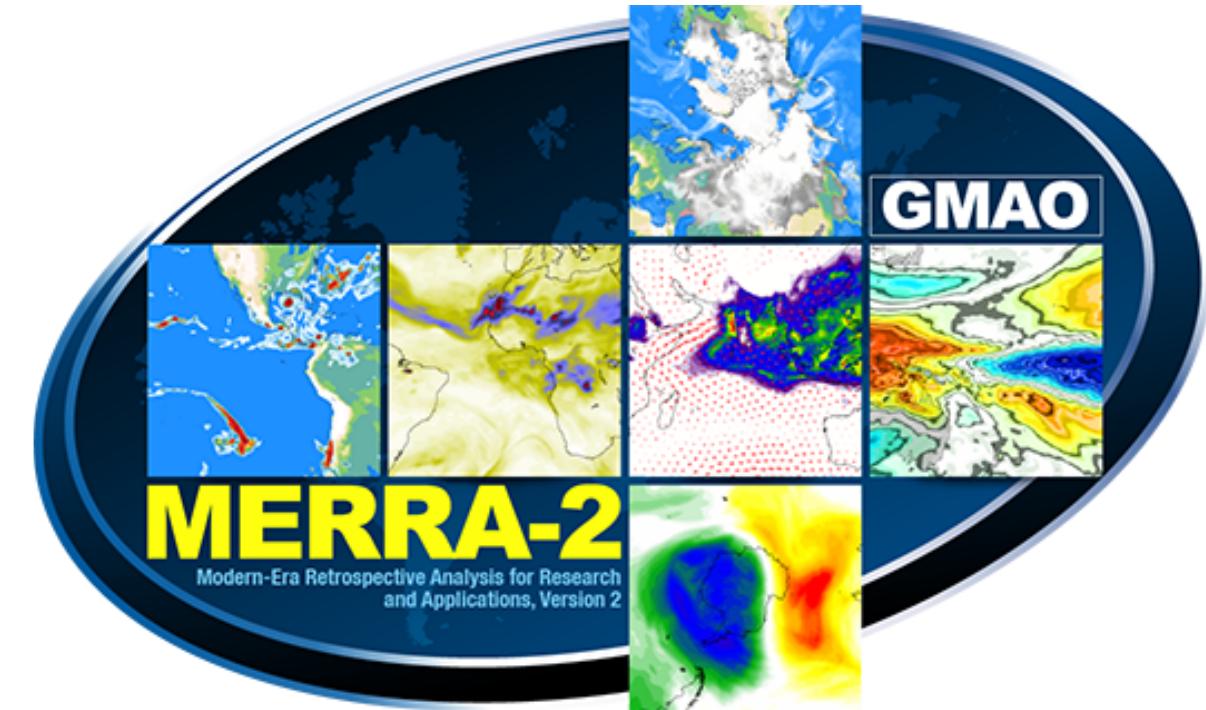
Credit: TROPOMI, ESA, Copernicus, KNMI

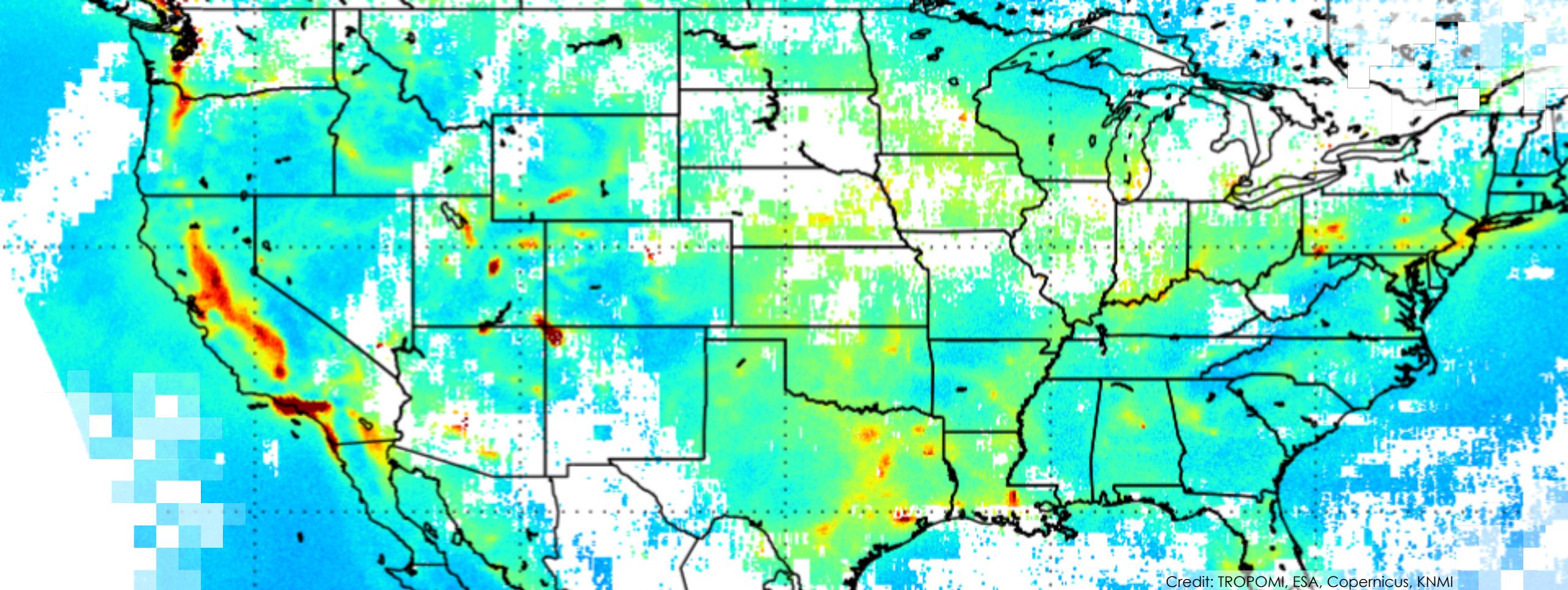
NASA GMAO MERRA-2 Model Output

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)





Credit: TROPOMI, ESA, Copernicus, KNMI

Questions