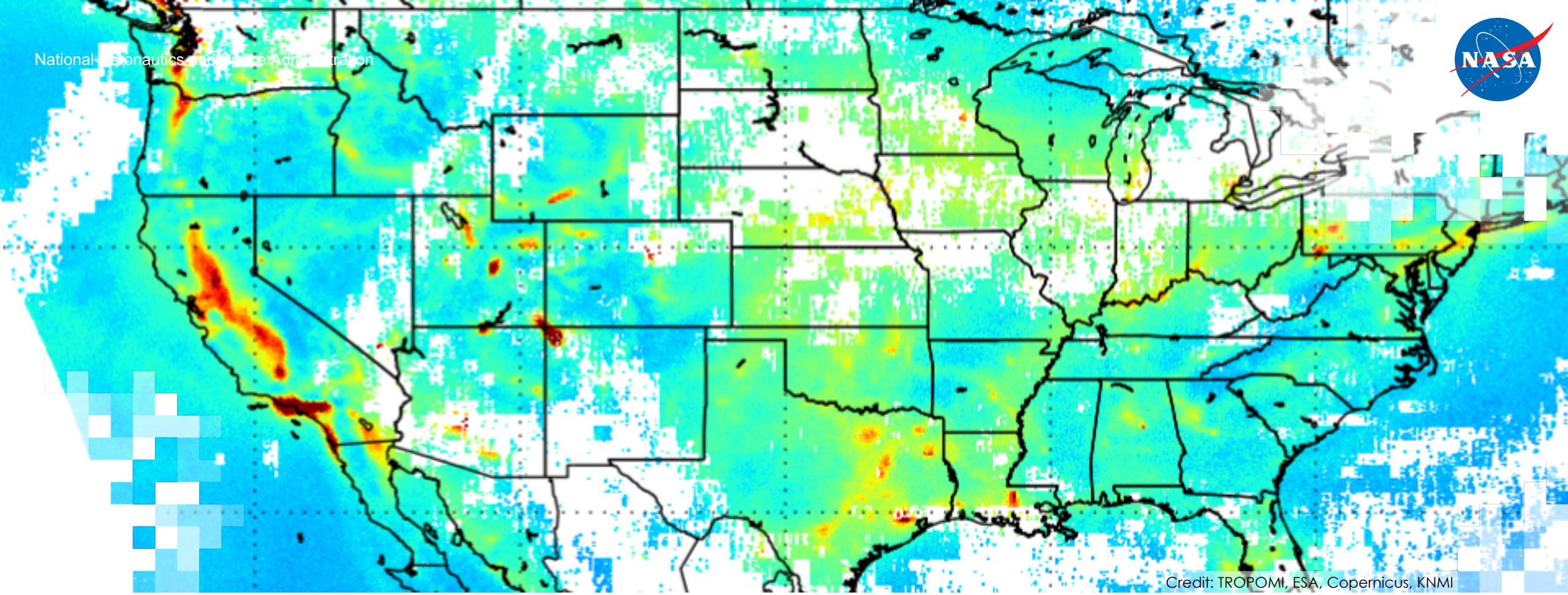


EPA AirNow Data and Satellite-Based $PM_{2.5}$ Data Sets

Melanie Follette-Cook and Pawan Gupta

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

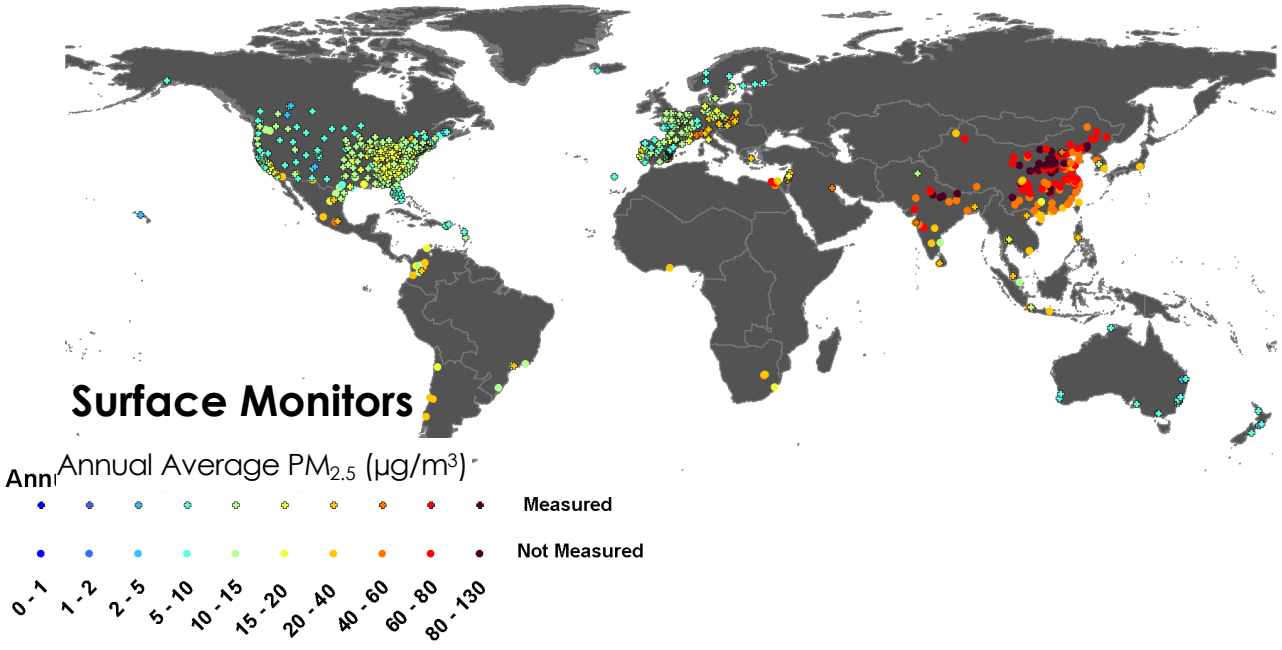
Learning Objectives

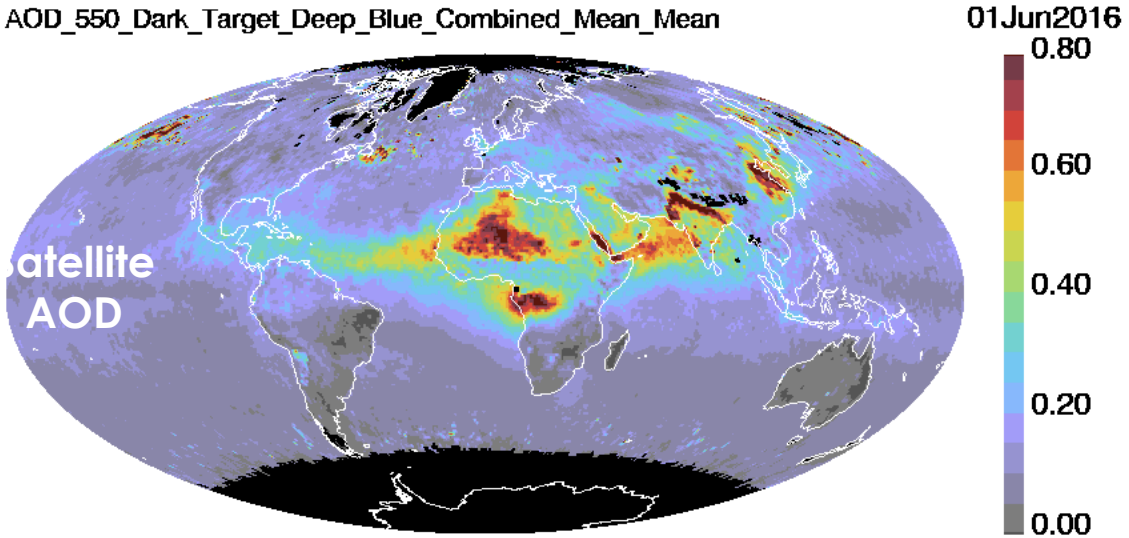
By the end of this presentation, you will be able to:

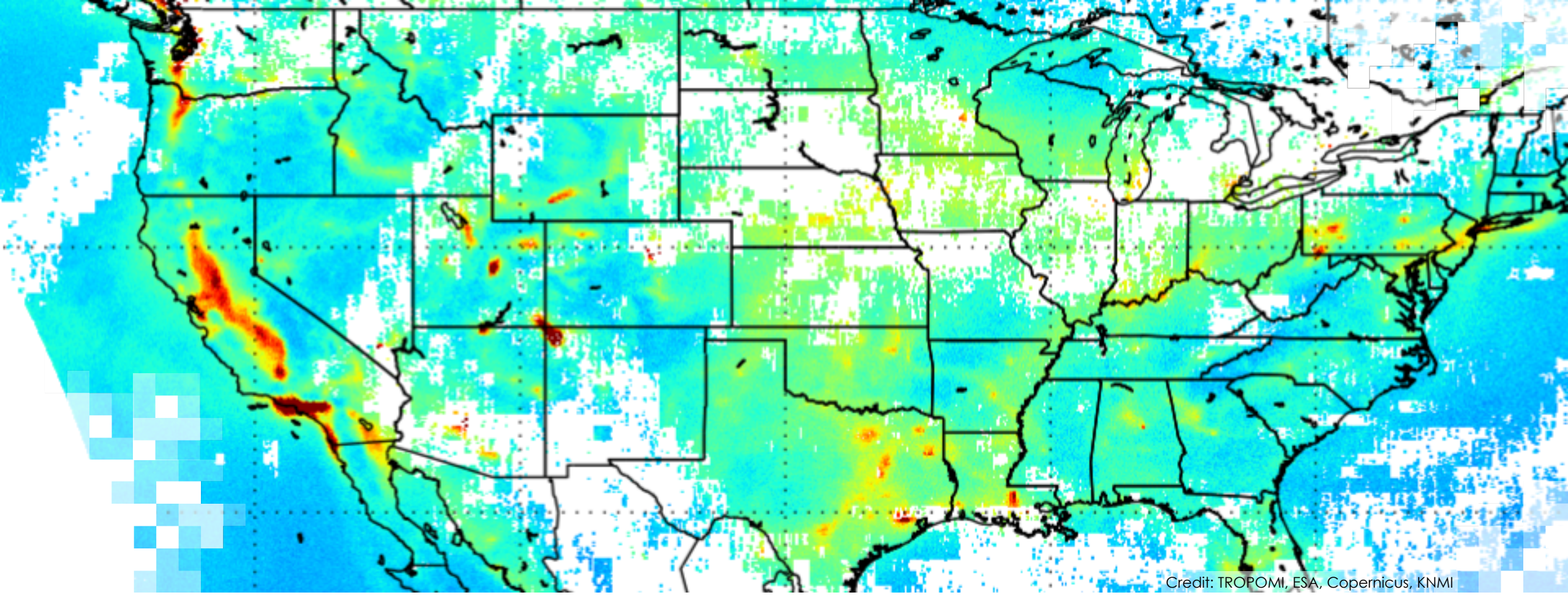
- use online tools to access EPA air quality data
- give examples of applications for surface $PM_{2.5}$ estimates
- recognize the DIMAQ model used to calculate $PM_{2.5}$ estimates
- use online tools to access and view World Health Organization (WHO) surface $PM_{2.5}$ estimates

Satellites Provide a "God's Eye" View of the Earth

Spatial coverage is the primary advantage of satellite data



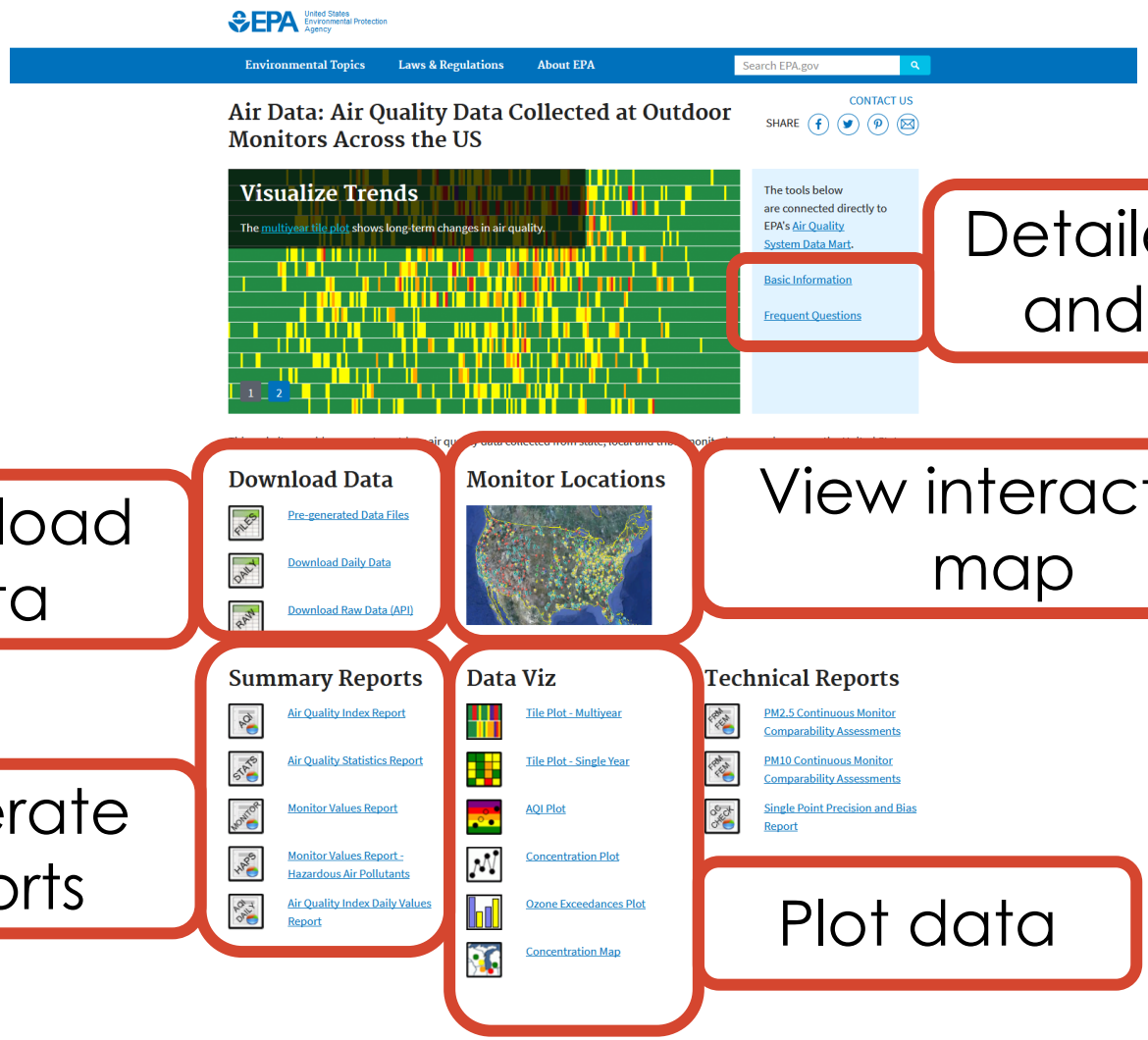




EPA AQS and AirNow Data

EPA Air Quality Data

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



Detailed info and FAQ

Download data

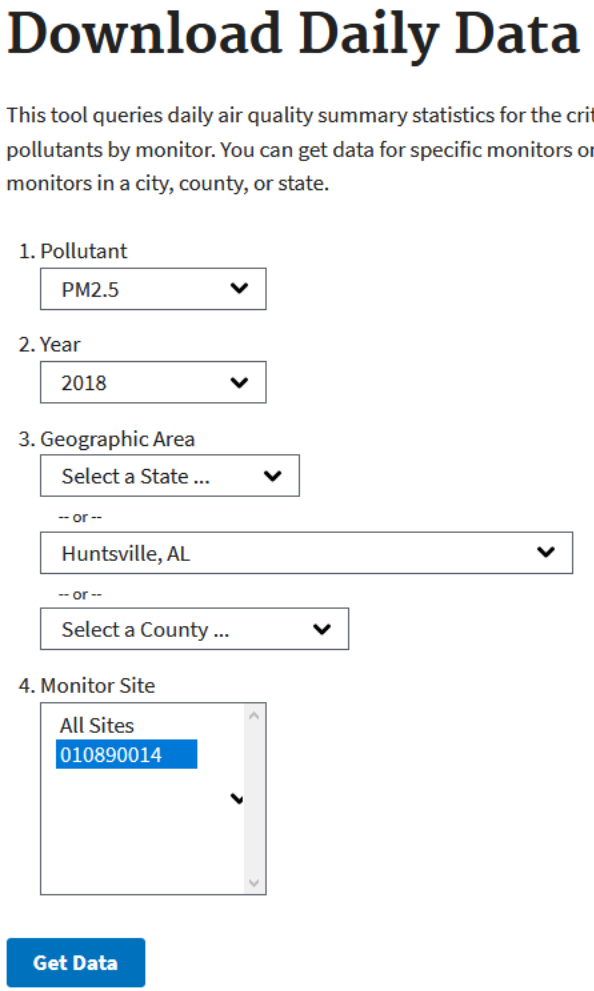
View interactive map

Generate reports

Plot data

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

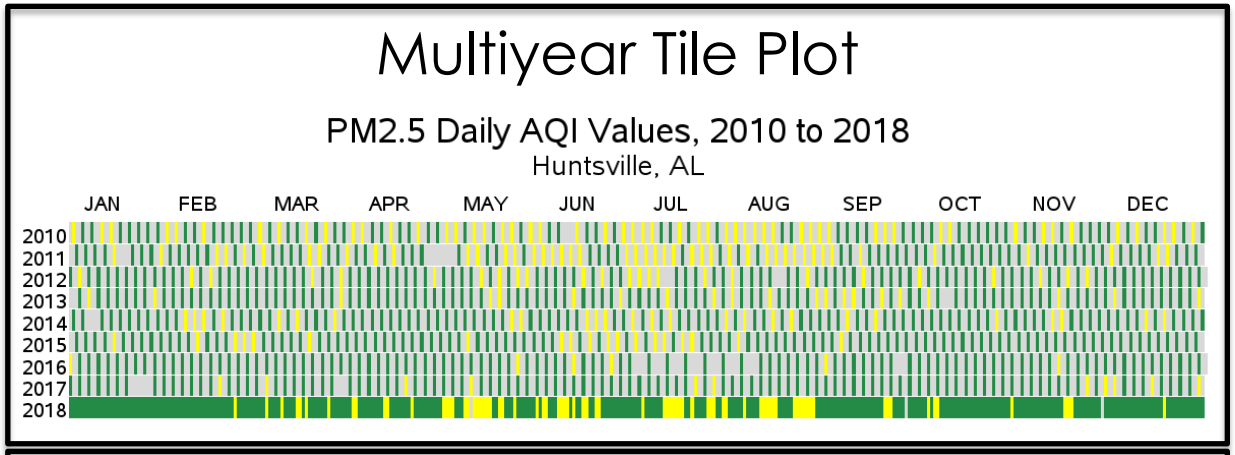
Download Data



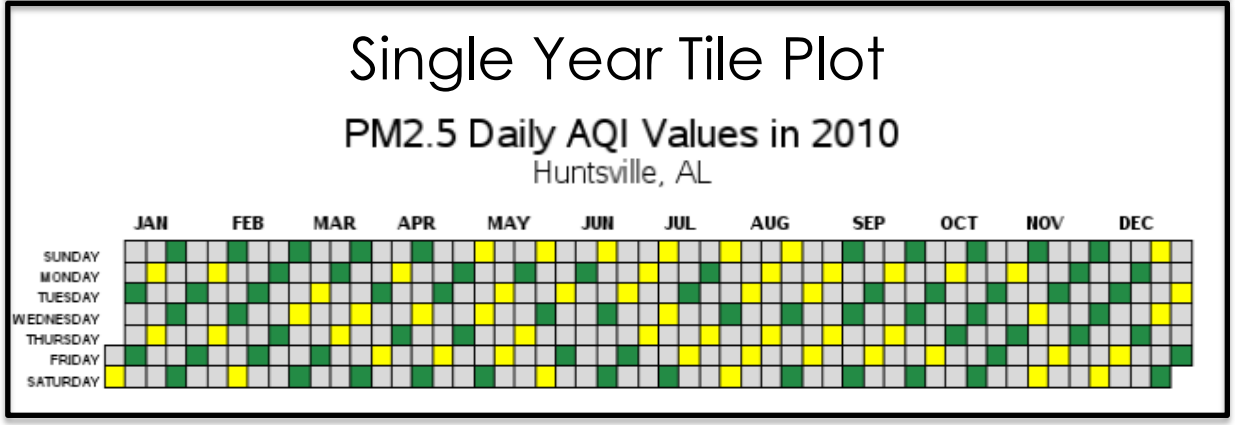
- Download pre-generated data files
- Download daily data
  - By state, city, or county
  - Creates a csv file to save
- Download raw data (through an API)
  - For NRT AQ data, use AirNow API

Data Visualization

Multiyear Tile Plot



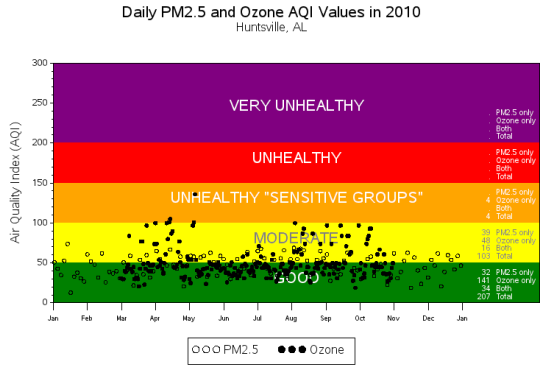
Single Year Tile Plot



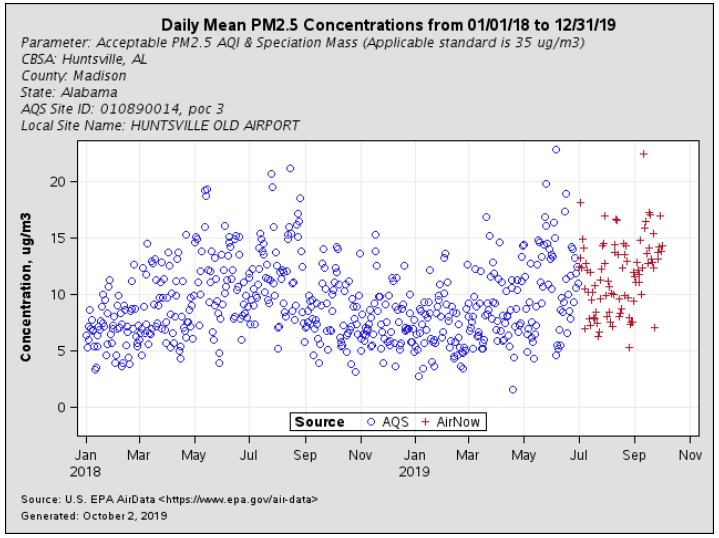
AQI Category

- 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

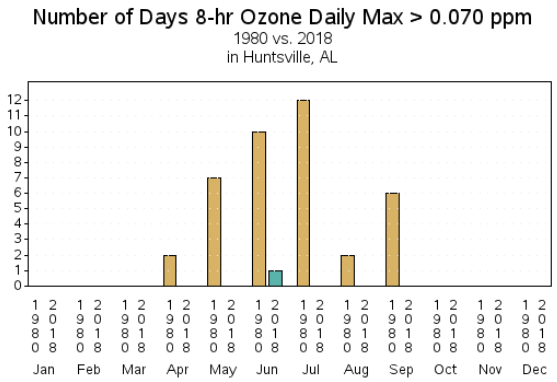


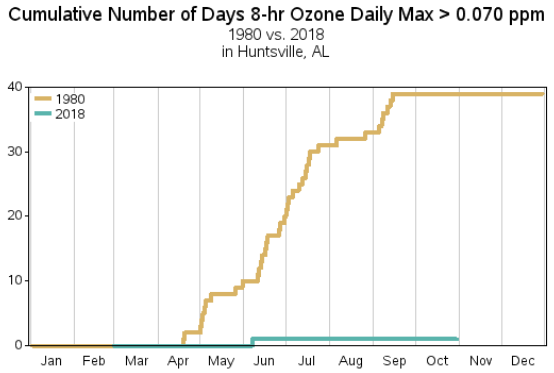
Concentration Plot

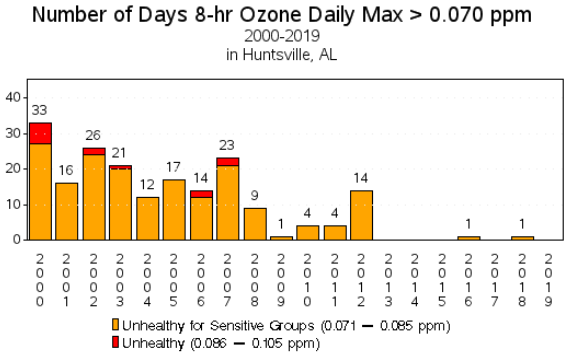


Data Visualization

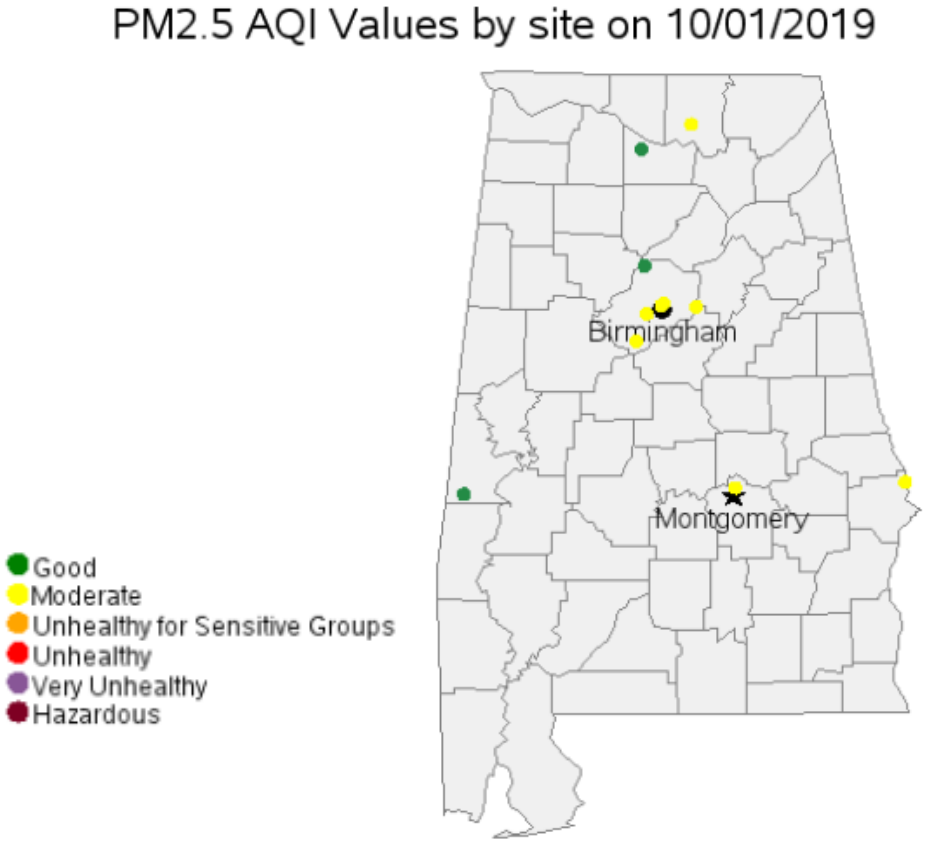
Ozone Exceedances Plots



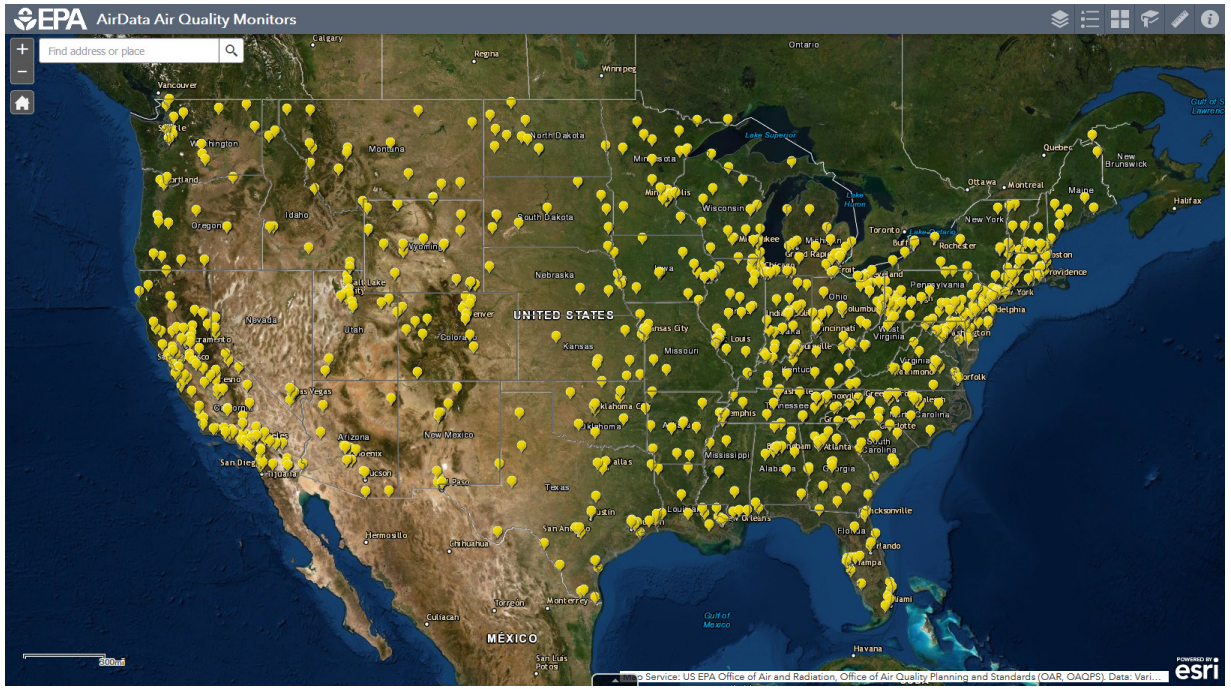




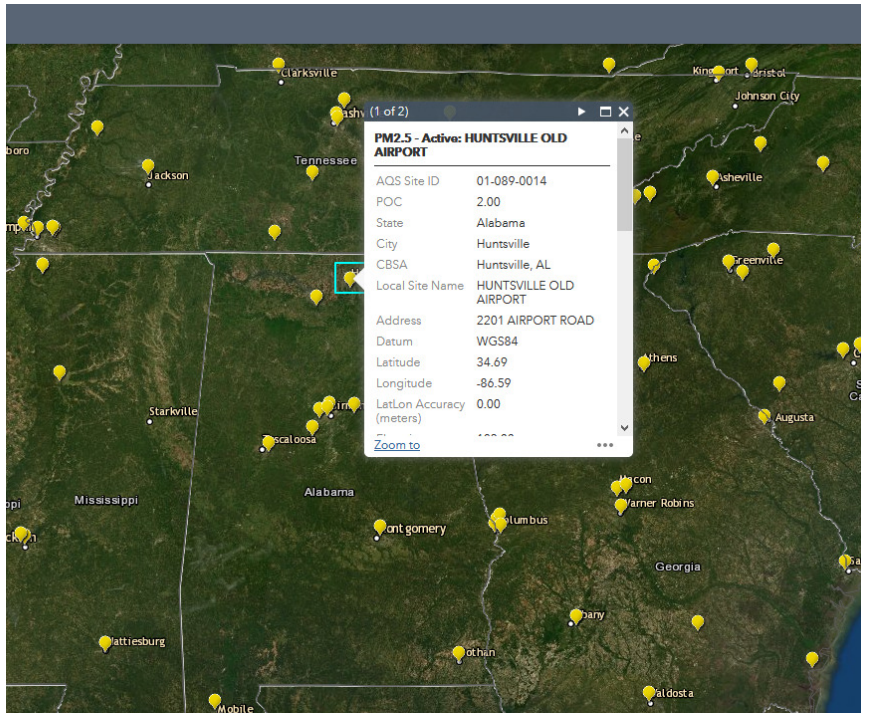
Concentration Maps

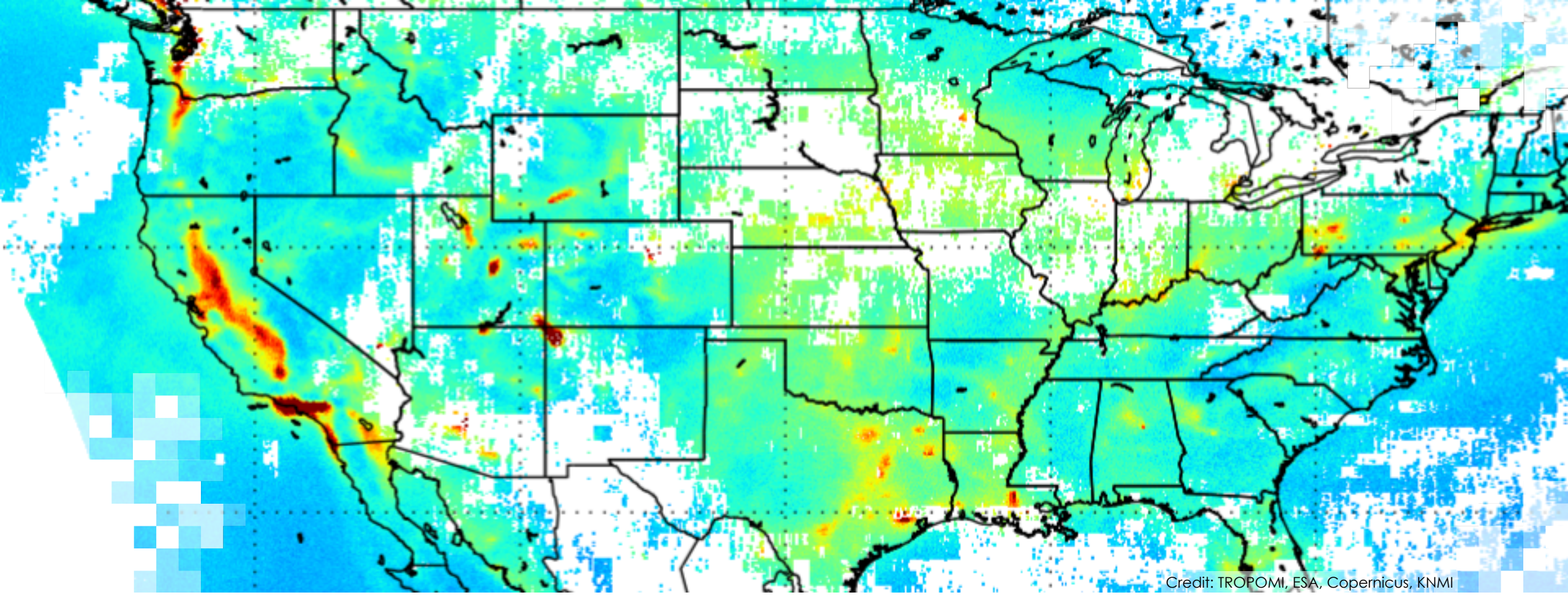


Interactive Maps



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

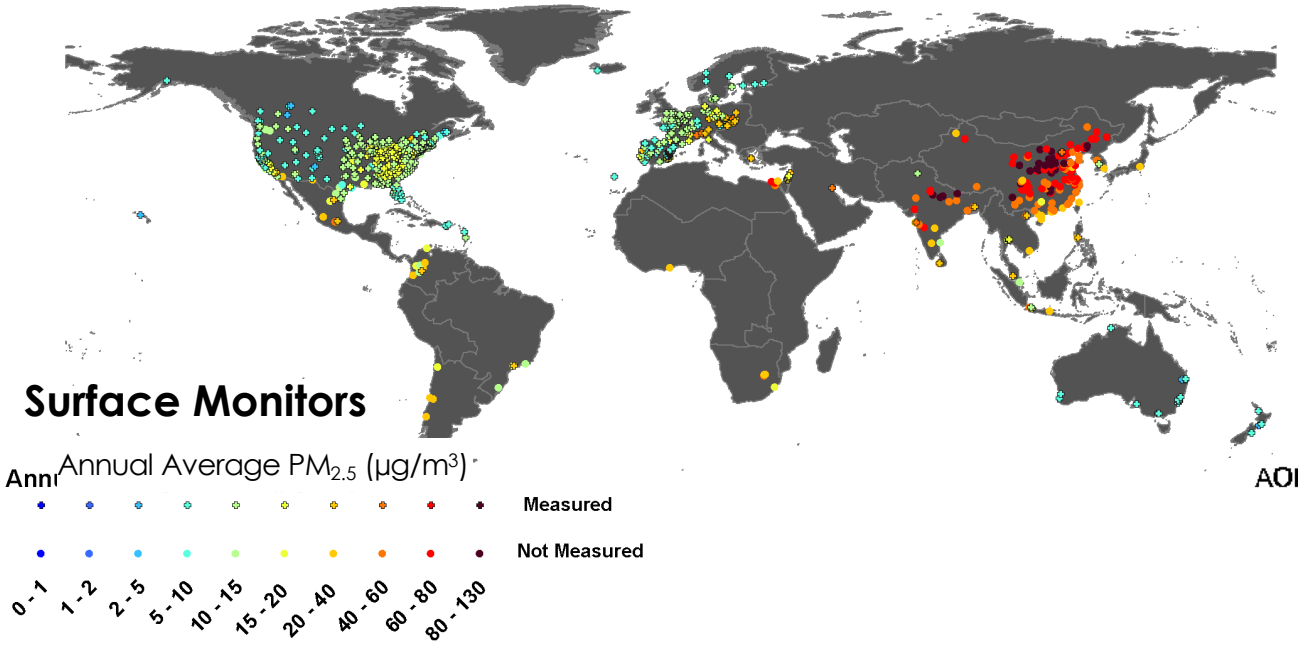




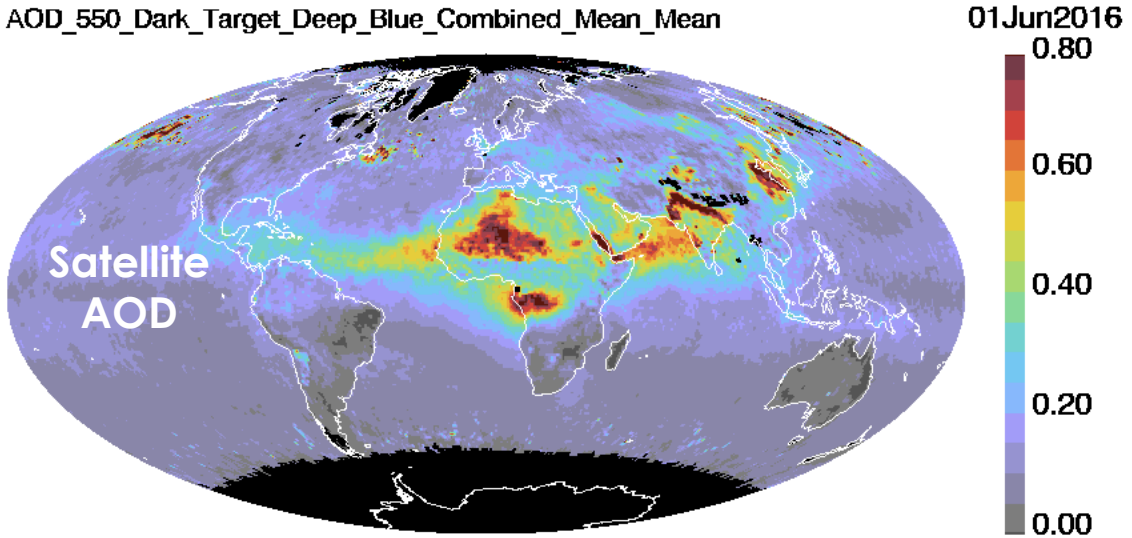
Examples of Applications Using Surface $PM_{2.5}$ Estimates

Satellites Provide a "God's Eye" View of the Earth

Spatial coverage is the primary advantage of satellite data



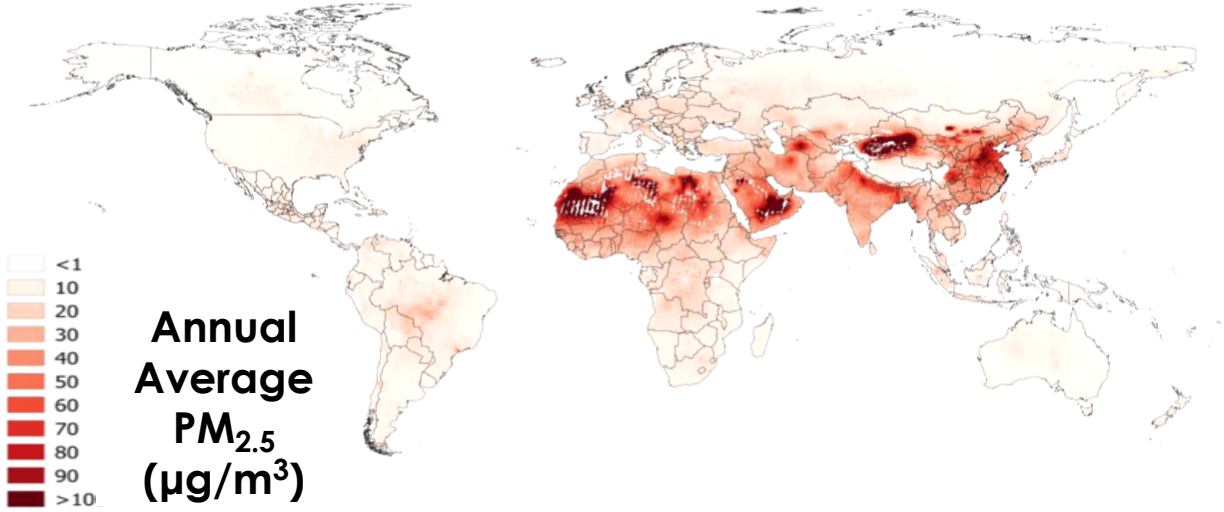
The spatial coverage afforded by satellite data offers increased statistical power that strengthens inference of the relation between pollutants and health outcomes



Health Studies of Exposure

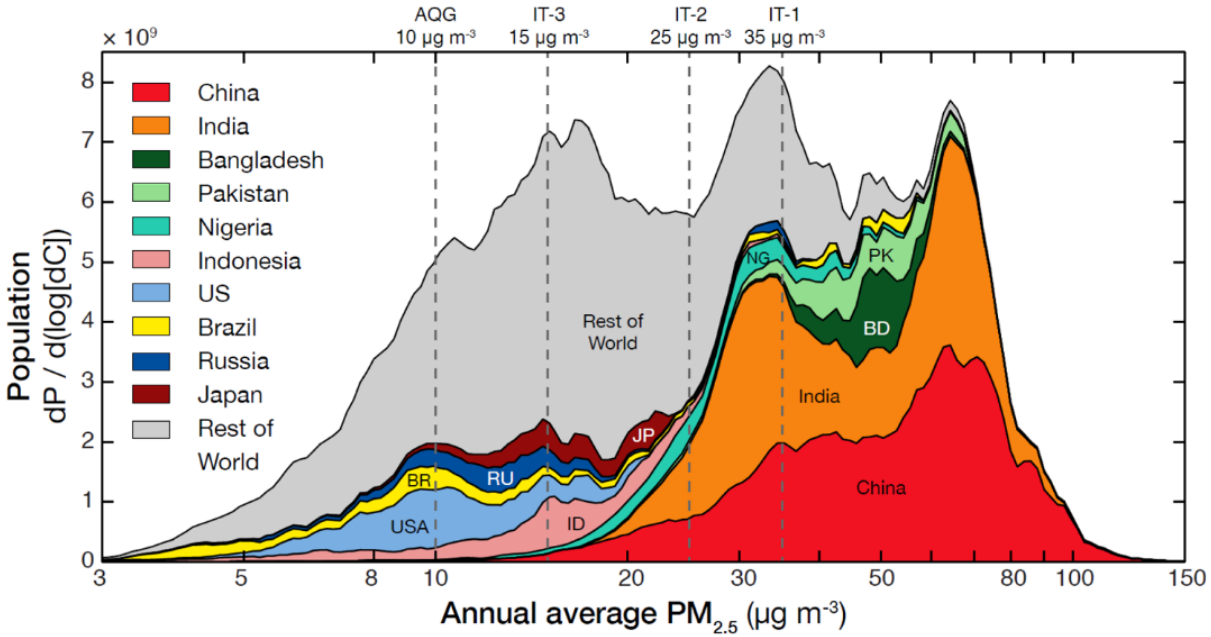
Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013

Michael Brauer[*†], 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[h], 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[r], H. Ross Anderson[⌿], Theo Vos[‡], Mohammad H. Forouzanfar[‡], Richard T. Burnett[⧖], and Aaron Cohen[∂]



Annual Average $PM_{2.5}$ (µg/m³)

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

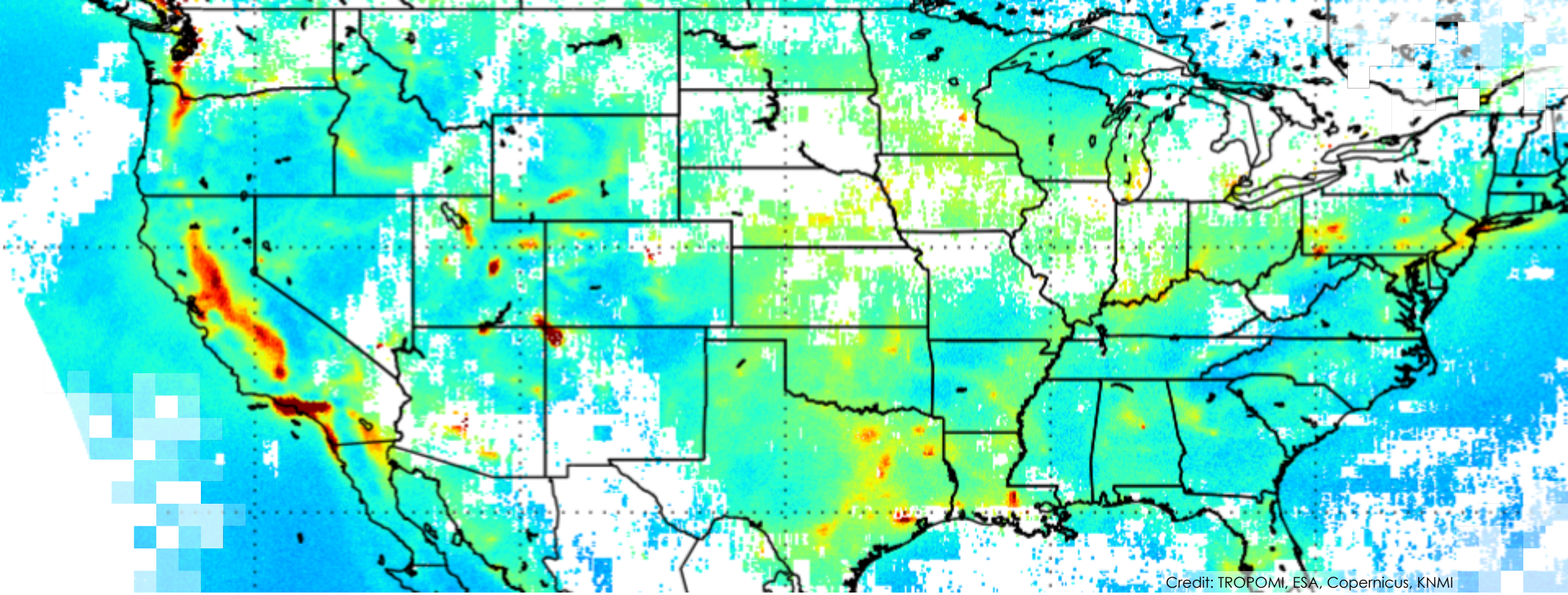
Goal 3 – Good Health and Well Being

- 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)

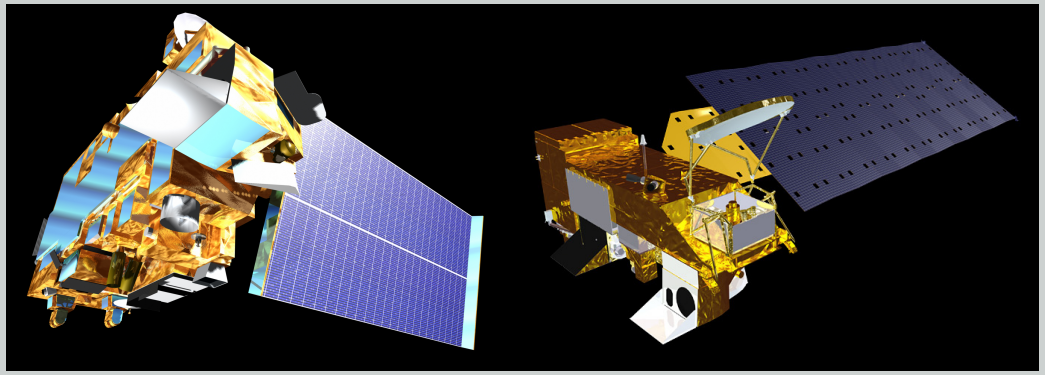
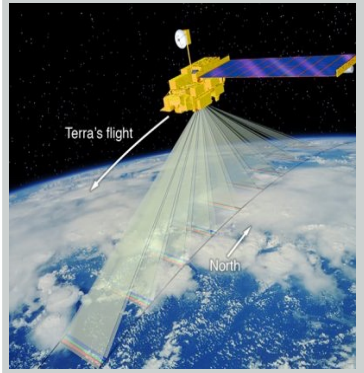
Text adapted from "Transforming our world: the 2030 Agenda for Sustainable Development"



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

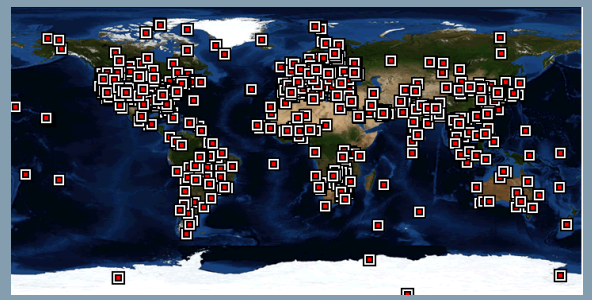
Van Donkelaar et al., 2016, doi:10.1021/acs.est.5b05833. The Van Donkelaar product is available at: http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012

Satellite-Based Estimates

AOD ⇨ $PM_{2.5}$

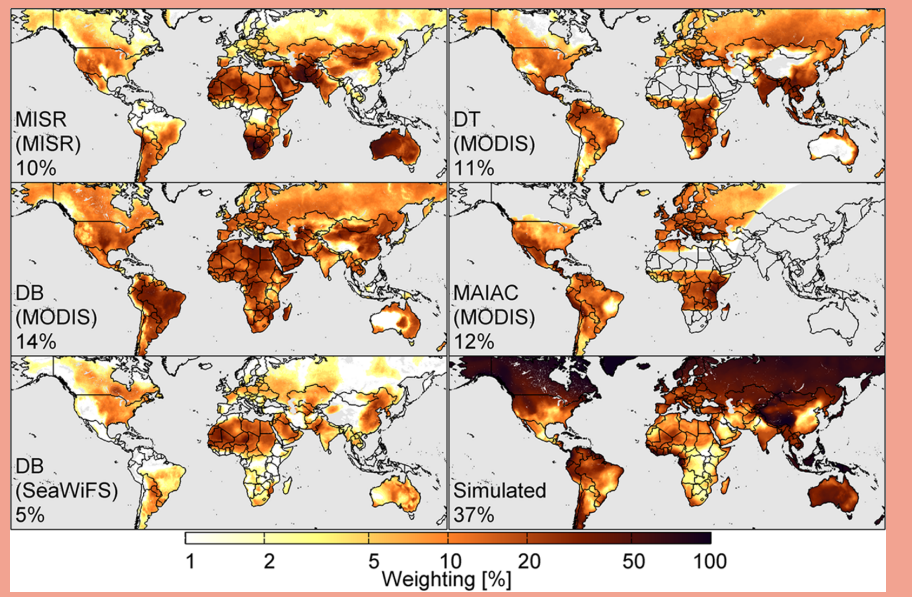
AOD (8 retrievals) & AOD from model simulations

Calibrate all using surface observations of AOD from the AERONET network



Calculate $PM_{2.5}$ from AOD using model AOD-to-$PM_{2.5}$ relationship

Combine estimates (weighted uncertainty) and calculate annual mean

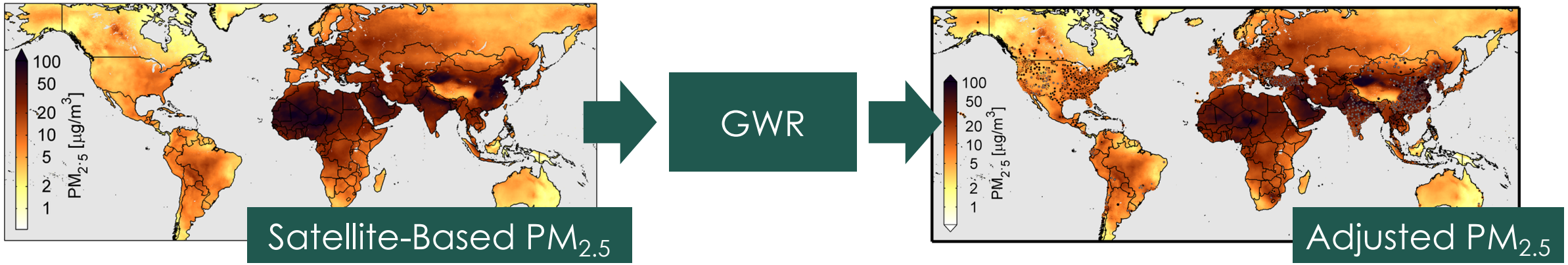


The Van Donkelaar product is available at: http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012. Image (right) Van Donkelaar et al., 2016, Figure 2 (Only MODIS-Terra shown)

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

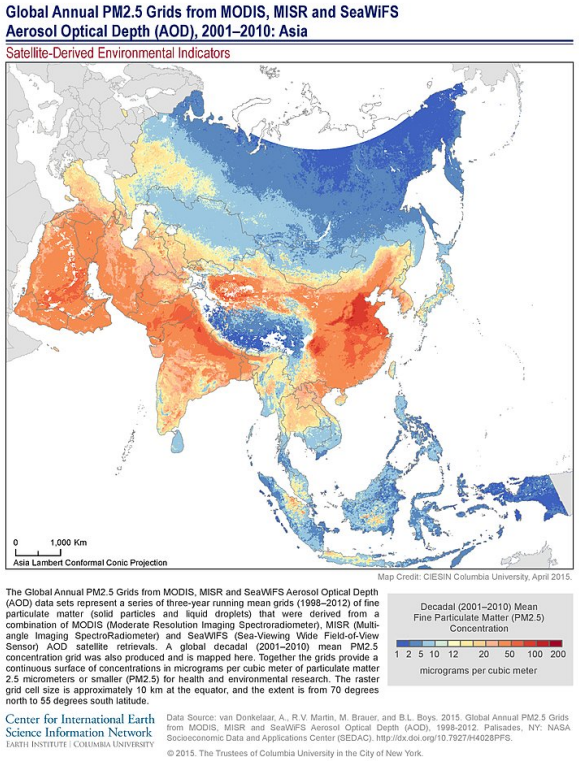


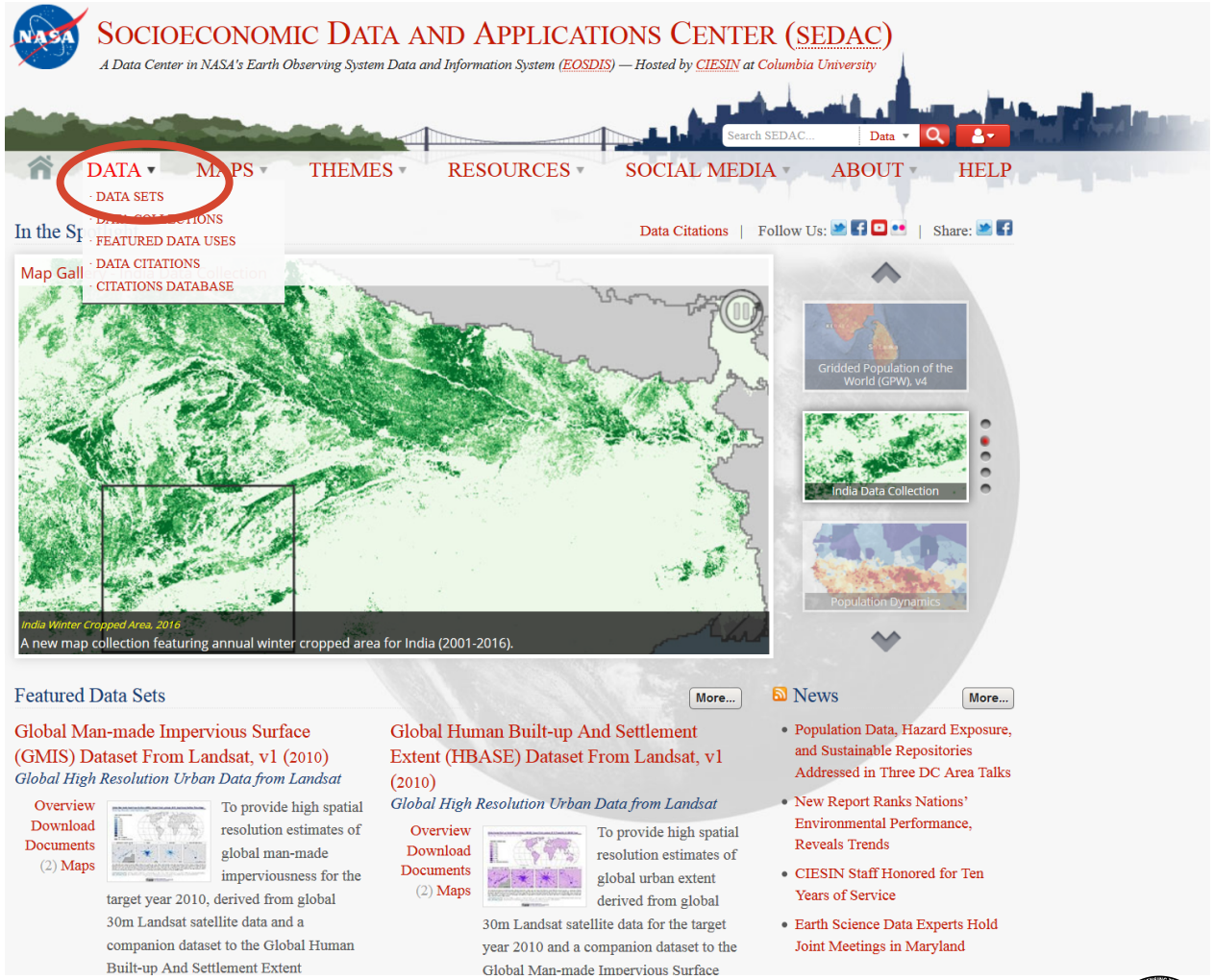
The Van Donkelaar product is available at: http://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-avg-pm2-5-modis-misr-seawifs-aod-1998-2012. Left Image: Van Donkelaar et al., 2016, Figure 3. Right Image: Van Donkelaar et al., 2016, Figure 5

Annual Mean Surface $PM_{2.5}$

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

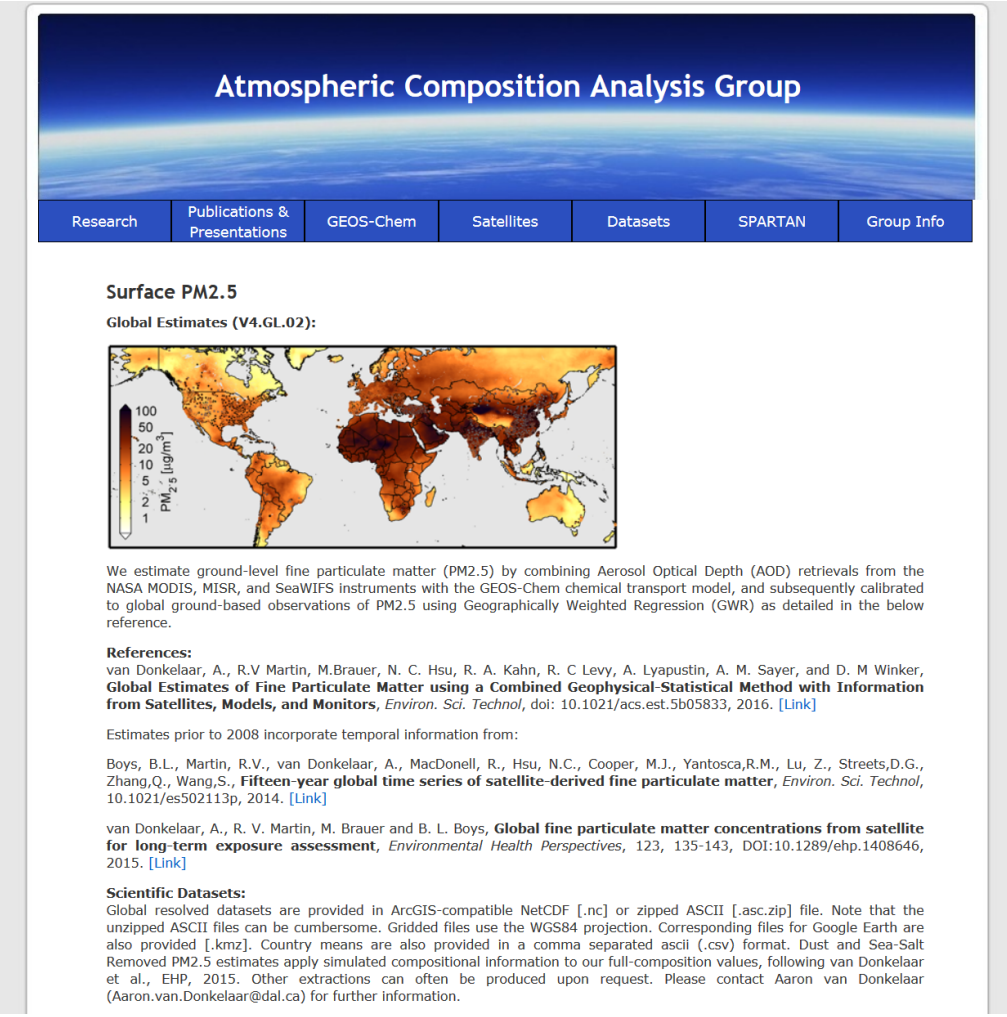
- Download data (GeoTIFF files) and pre-made images of surface $PM_{2.5}$ inferred from satellite observations





Annual Mean Surface $PM_{2.5}$

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 PM2.5

Global Estimates (V4.GL.02):

We estimate ground-level fine particulate matter (PM2.5) 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 PM2.5 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]

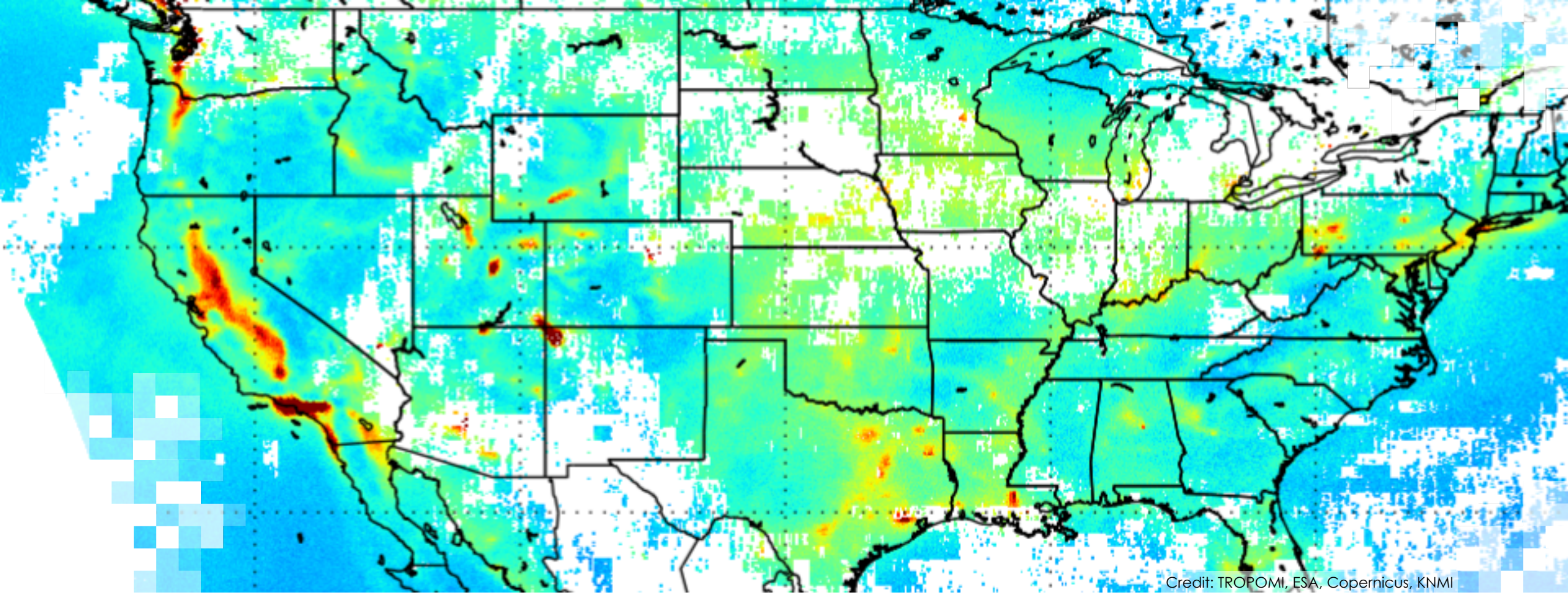
Scientific Datasets:

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 PM2.5 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



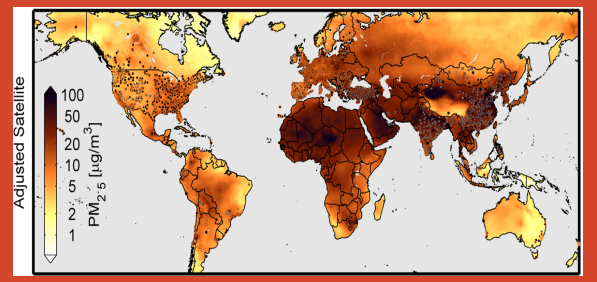
Data Integration Model for Air Quality (DIMAQ)

Data Integration Model for Air Quality (DIMAQ)

Population Data

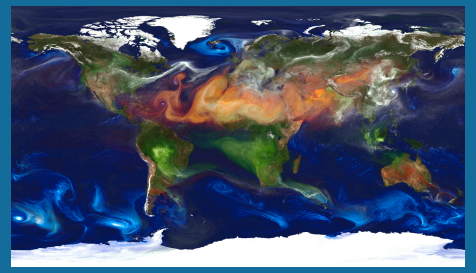
Gridded and Country-Level Estimates of $PM_{2.5}$

Satellite-Based Estimates

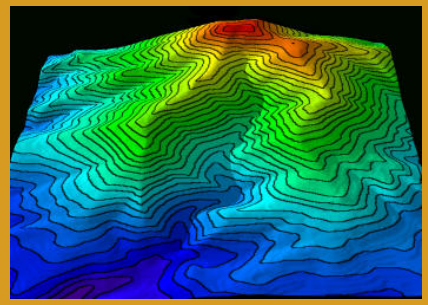


Ground Monitors & Information on Local Monitoring Networks

Simulated Aerosols



Topography & Land Use



Stephen Reynolds, Arizona State University

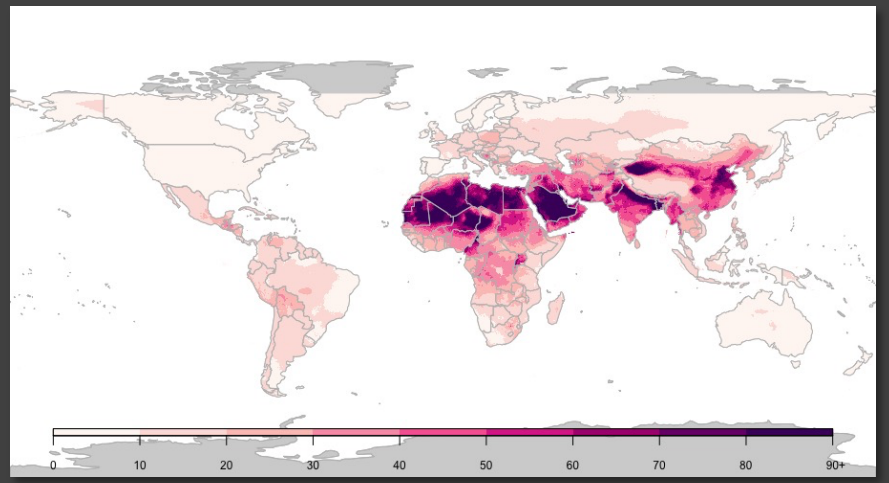
Data Integration Model for Air Quality (DIMAQ)

- Population Data
- Ground Monitor Information & Data
- Satellite-Based Estimates
- Simulated Aerosols
- Topography & Land Use

Bayesian Hierarchical Framework

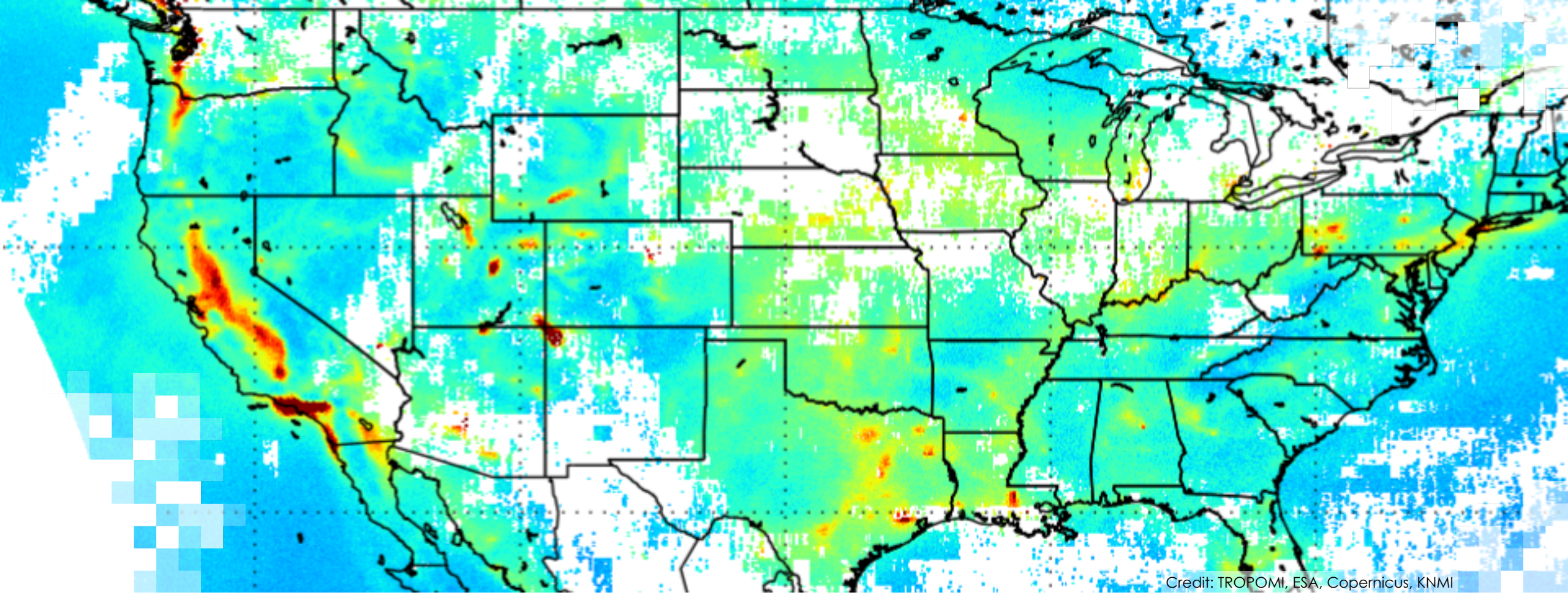
Estimates $PM_{2.5}$ as well as measures of uncertainty

Annual Average $PM_{2.5}$ for 2014



Estimates on a 0.1° x 0.1° grid

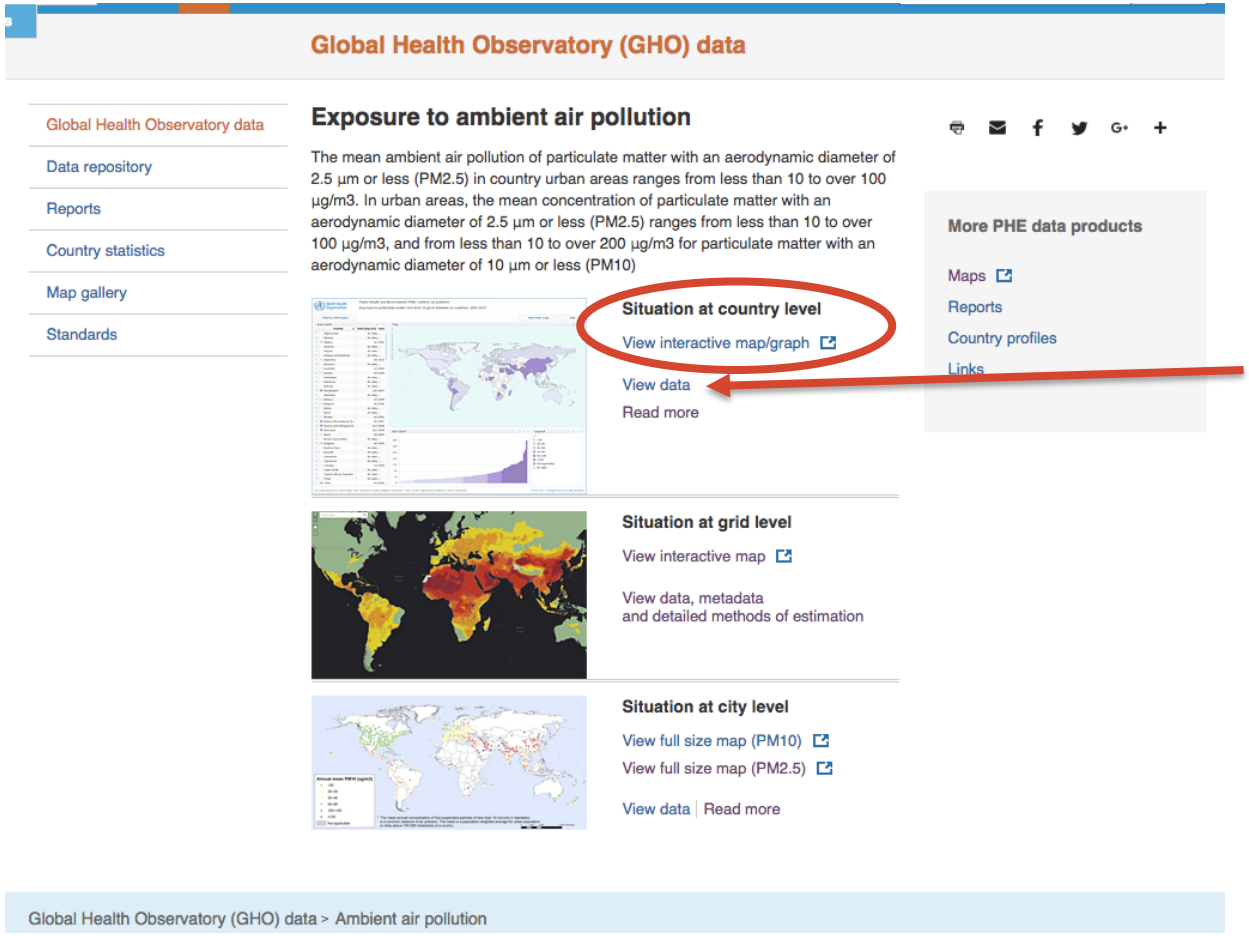
Image Credit (Right): Shaddick, et al. (2018), Figure 7 (top)



Available World Health Organization (WHO) Tools

Where to Find and View the Data

WHO Website – Country Level



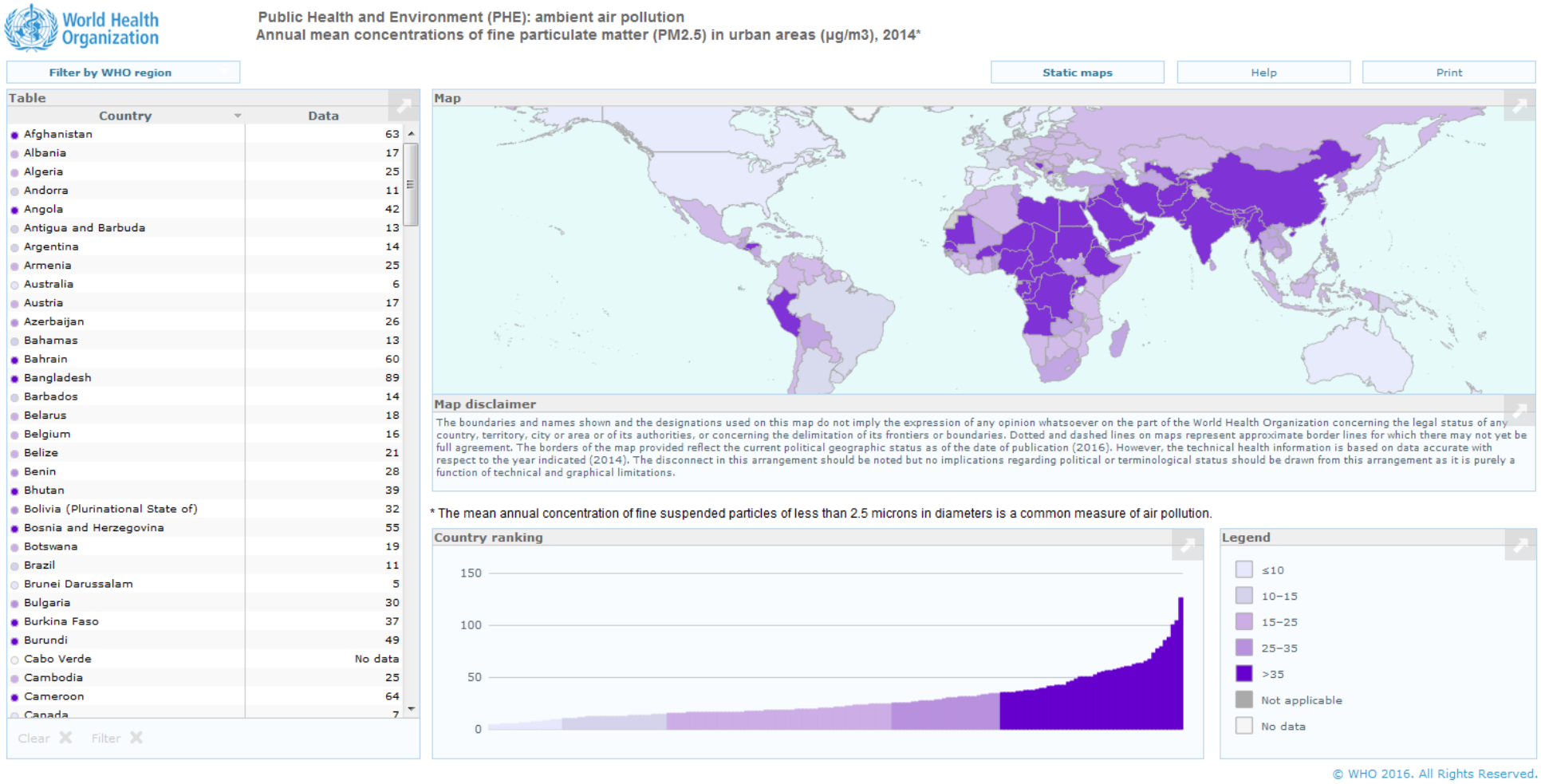
- http://www.who.int/gho/phe/outdoor_air_pollution/exposure/en/

Follow this link to download 2014 country level data:

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

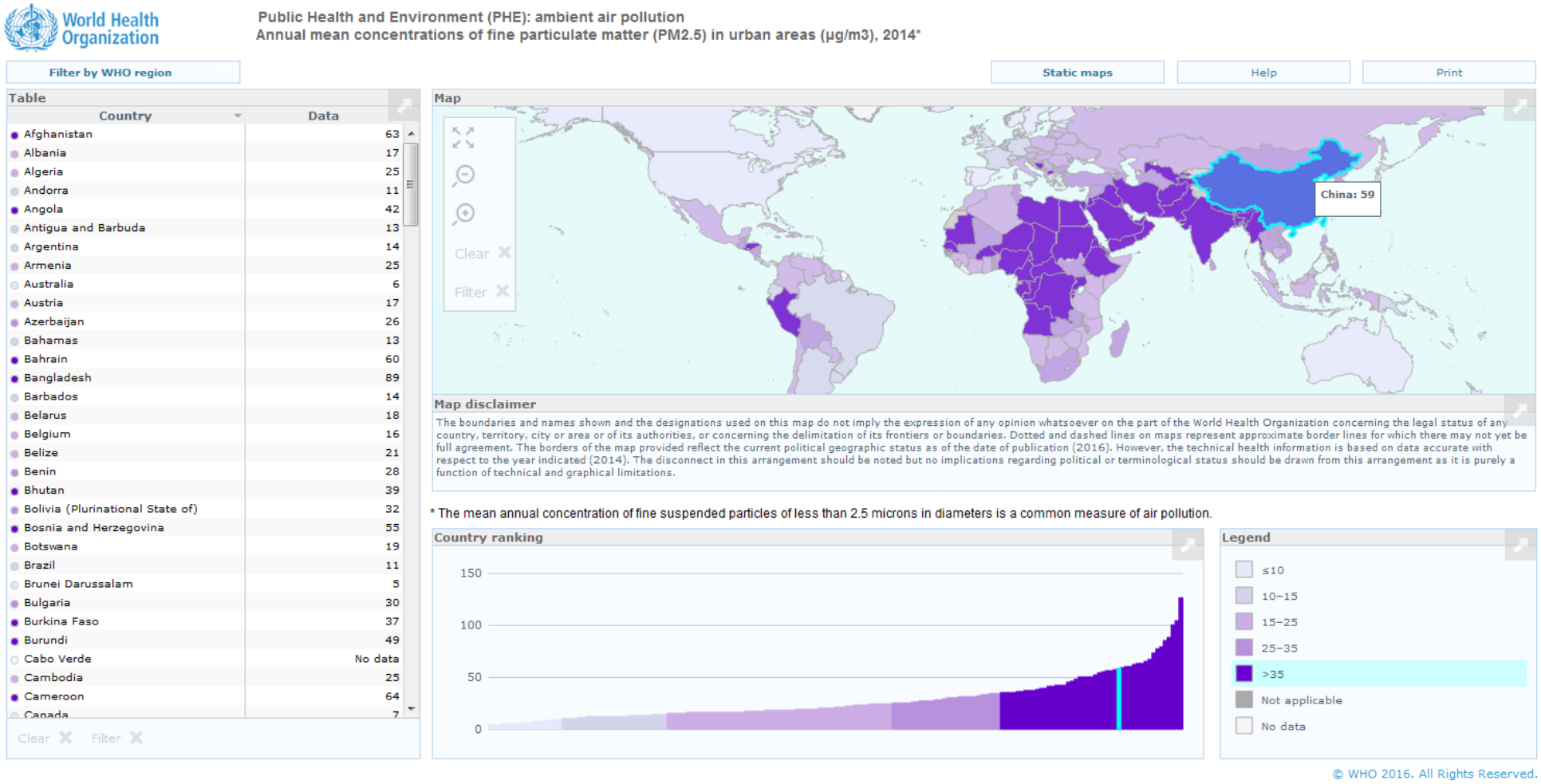
$PM_{2.5}$ at Country Level

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



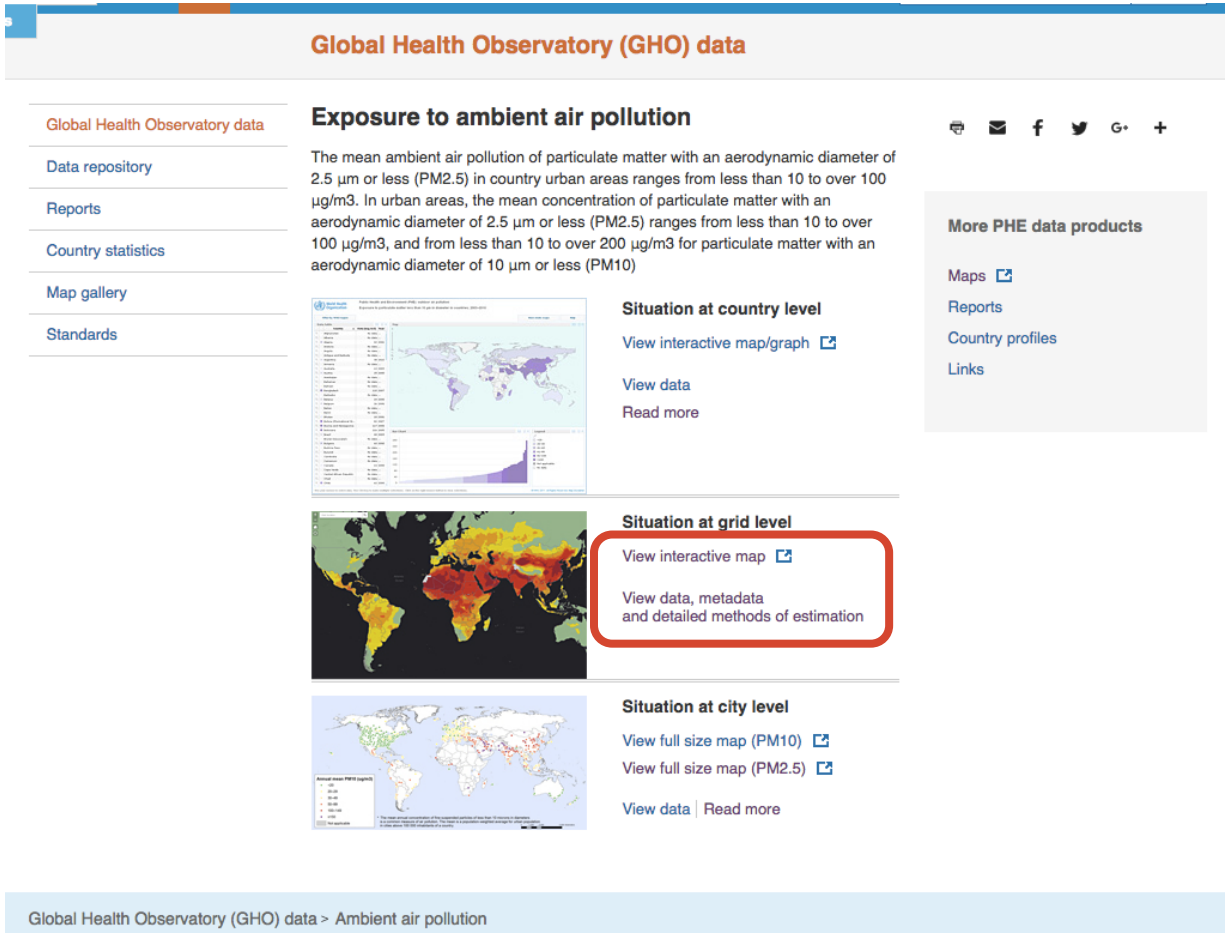
$PM_{2.5}$ at Country Level

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



Where to Find and View the Data

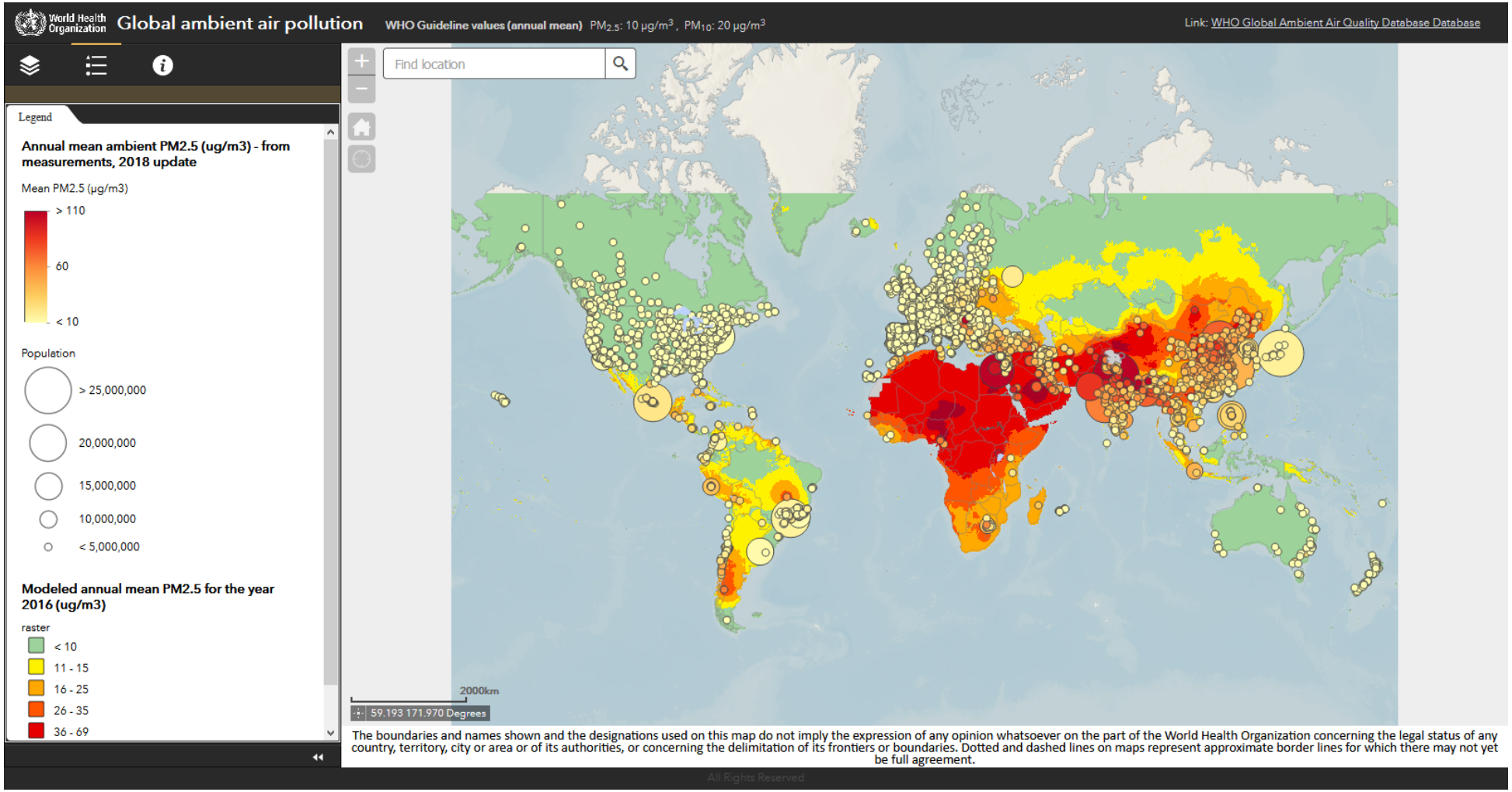
WHO Website – Grid Level



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

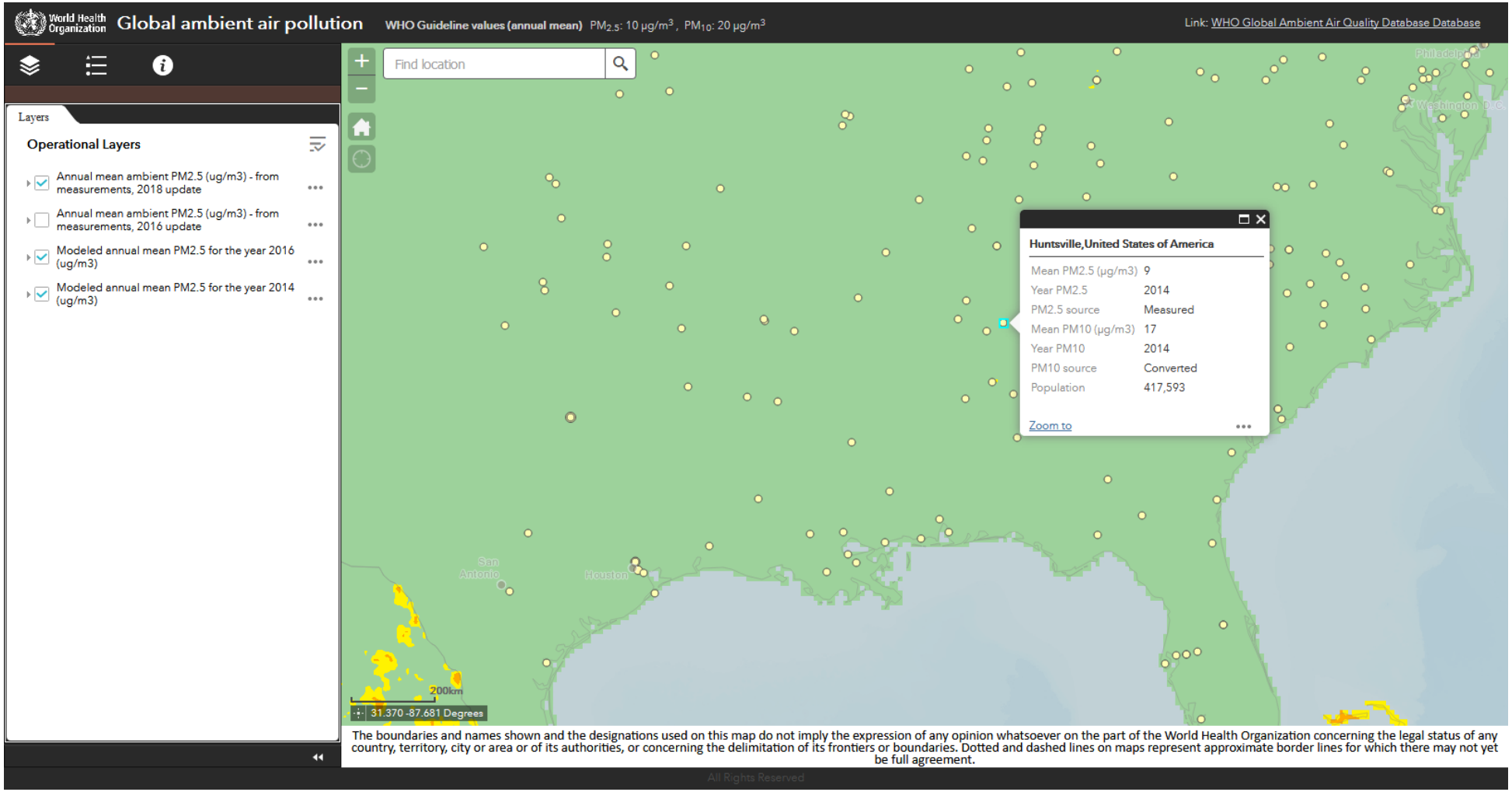
$PM_{2.5}$ at Grid Level

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



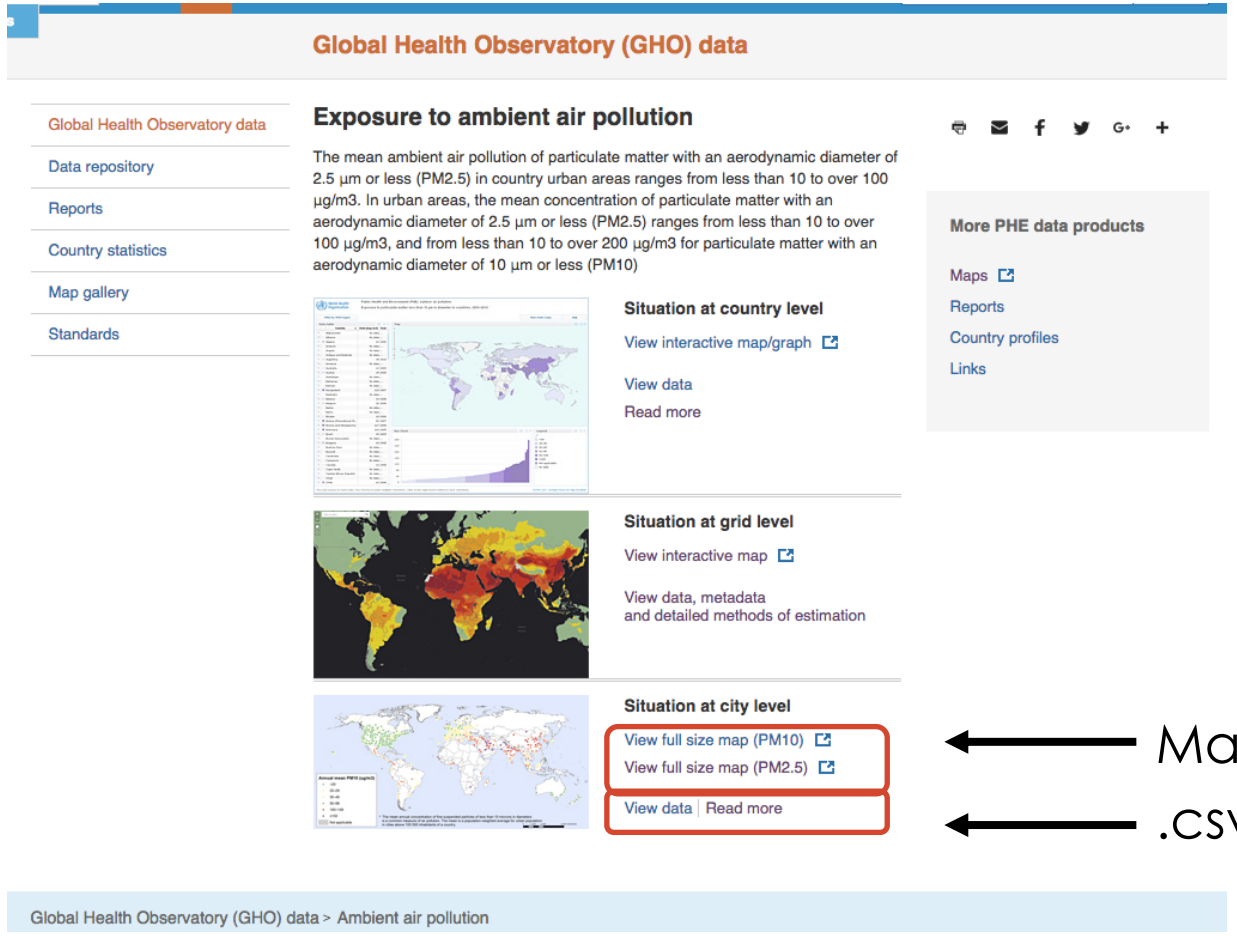
$PM_{2.5}$ at Grid Level

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



Where to Find and View the Data

WHO Website - City Level



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

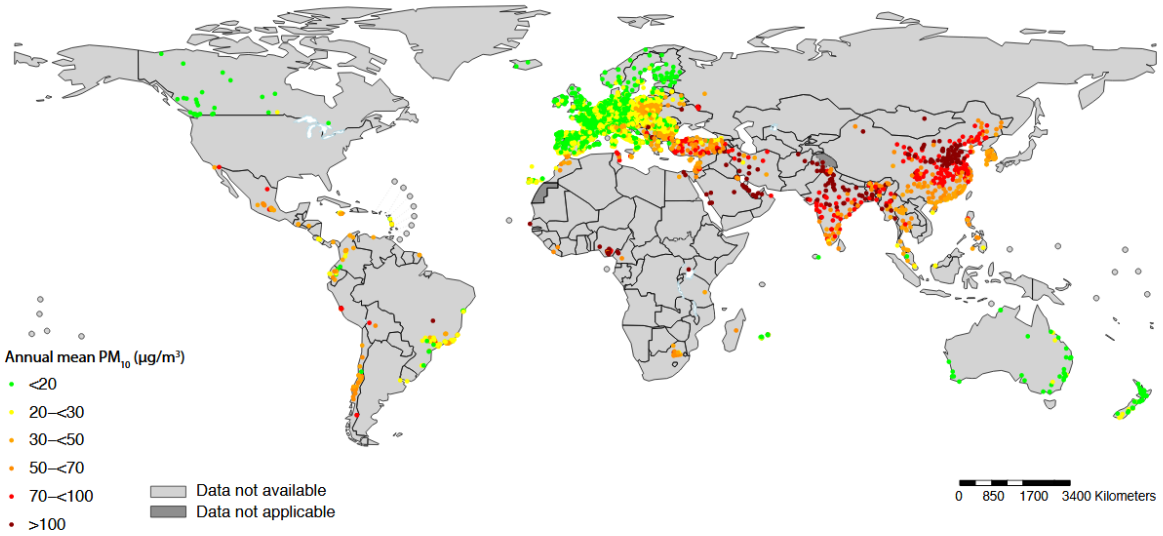
← Maps of city level PM_{10} and $PM_{2.5}$

← .csv file with city level annual means

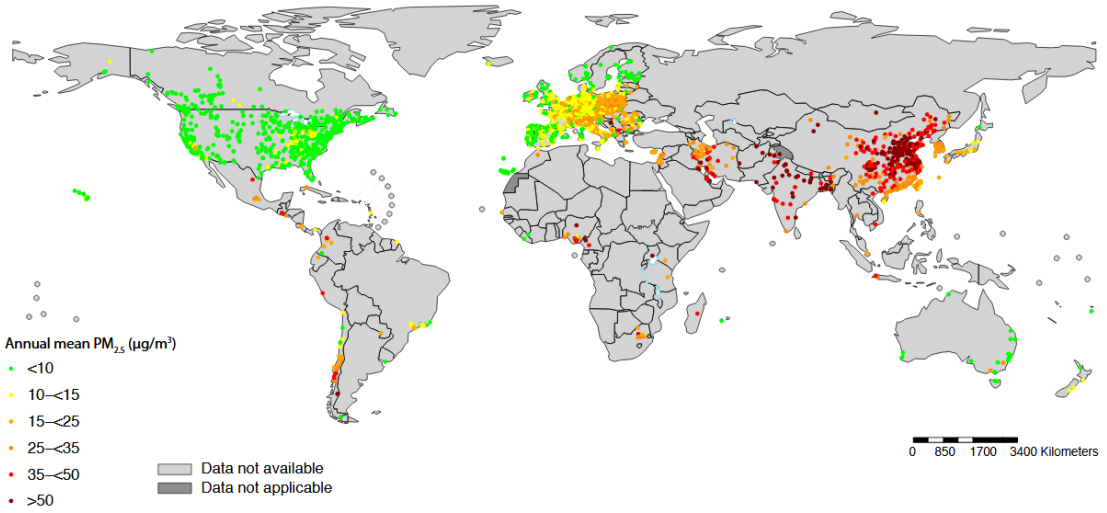
$PM_{2.5}$ at City Level

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

PM_{10}



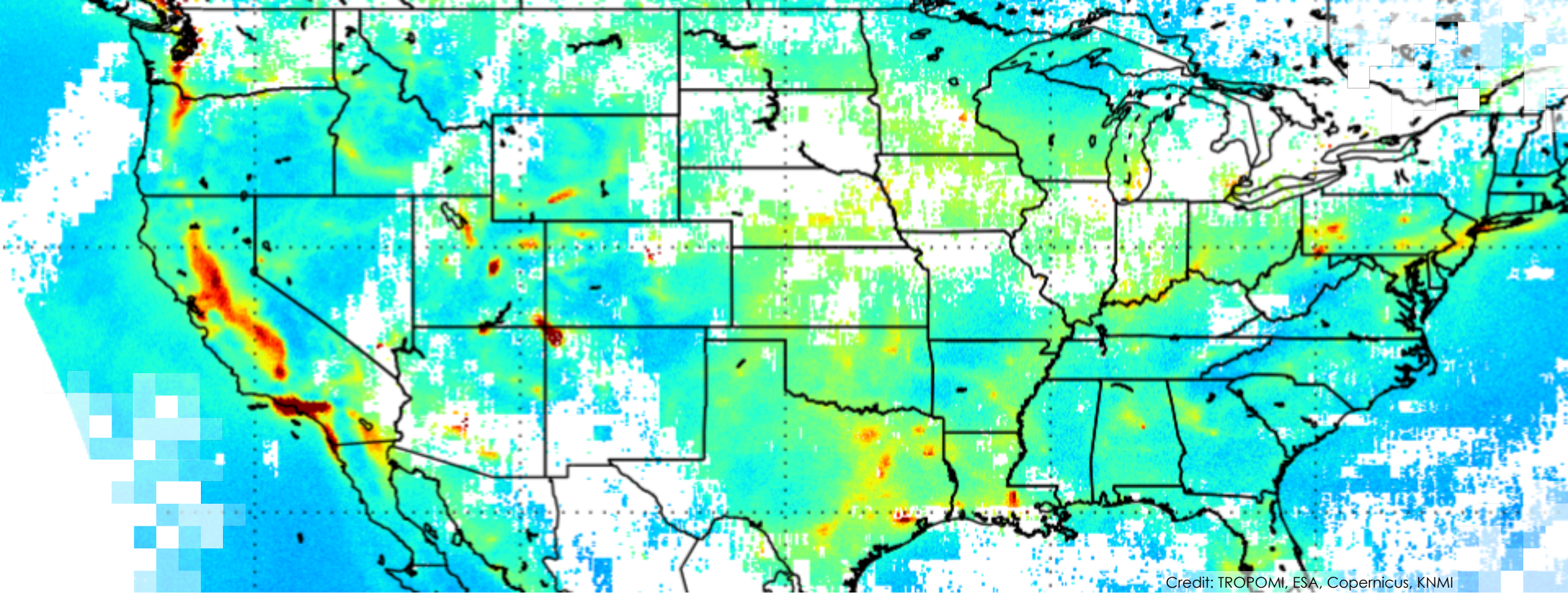
$PM_{2.5}$



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

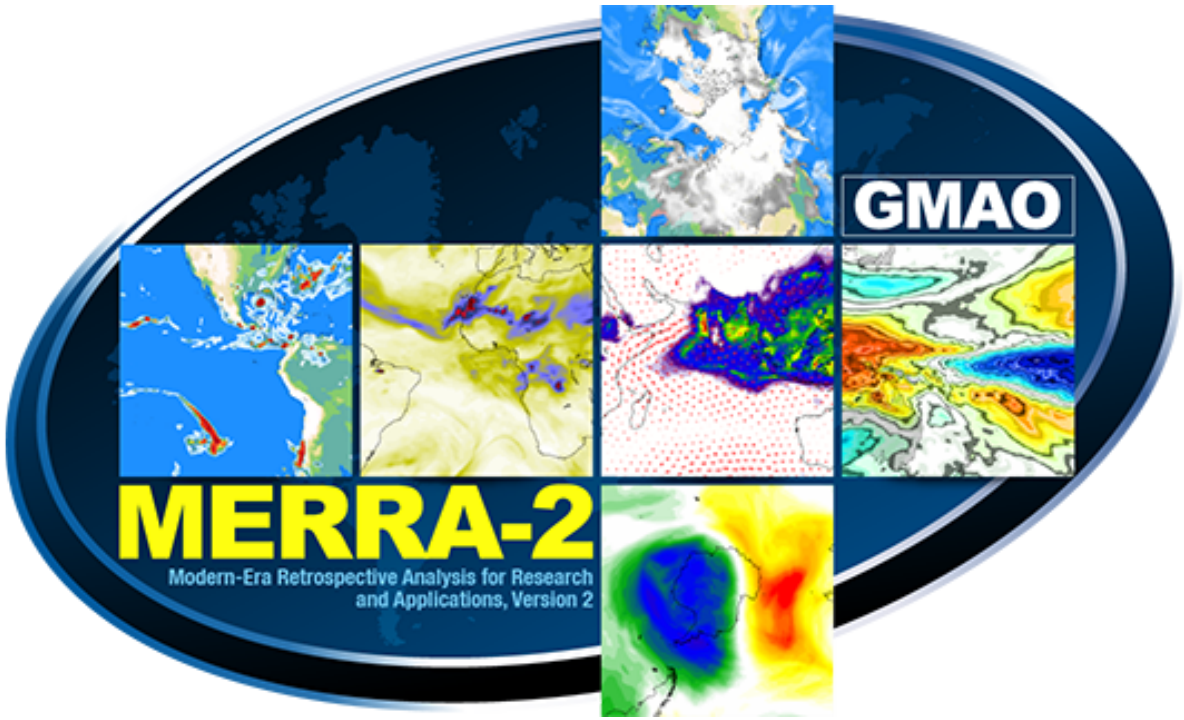


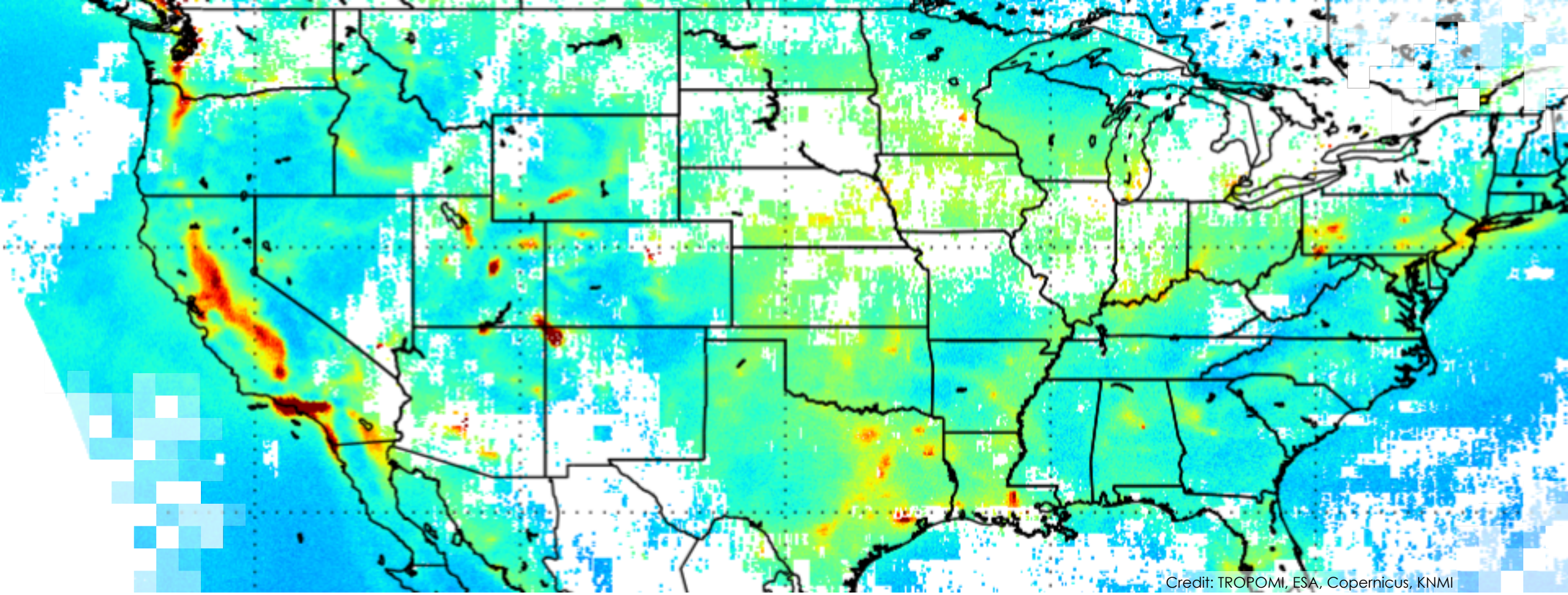
NASA GMAO MERRA-2 Model Output

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