

# NASA Applied Remote Sensing Training (ARSET) Program Overview

Pawan Gupta, and Melanie Follette-Cook

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



# NASA's Applied Remote Sensing Training Program (ARSET)

<http://arset.gsfc.nasa.gov/>

- Empowering the global community through remote sensing training
- Part of NASA's Applied Sciences Capacity Building Program
- Goal: increase the use of Earth Science in decision-making through training for:
  - policy makers
  - environmental managers
  - other professionals in the public and private sector
- Trainings offered focusing on applications in:



Disasters  
9 Trainings



Eco  
12 Trainings



Health & Air Quality  
52 Trainings



Water Resources  
20 Trainings



# ARSET Training Levels

## **Advanced Training, Level 2**

- Online and in-person
- Requires Level 1 training or equivalent knowledge
- More in-depth or focused topics

## **Beginning Training, Level 1**

- Online and in-person
- Requires Level 0 training or equivalent knowledge
- Specific applications

## **Fundamentals Training, Level 0**

- Online only
- Assumes no prior knowledge of remote sensing



# ARSET Training Impacts: Health & Air Quality (2008-2017)

Total ARSET Participants (2009-2017): 13,042

Health & Air  
Quality  
Participants  
2,978



17 online trainings



75 countries

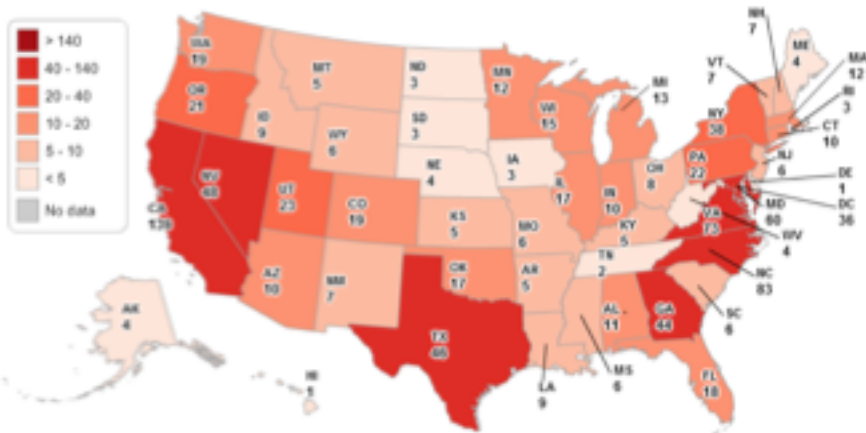


38 in-person trainings



836 organizations

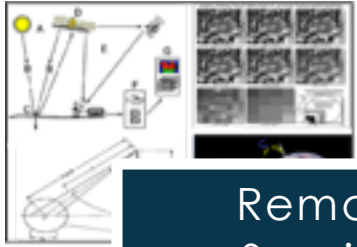
US Health & Air Quality Participants



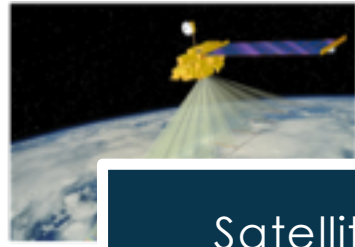
Global Health & Air Quality Participants



# ARSET Air Quality Trainings



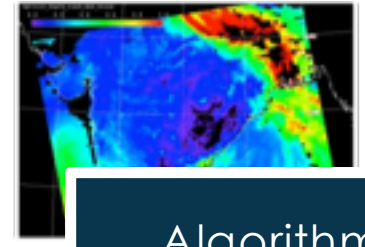
Remote Sensing



Satellites



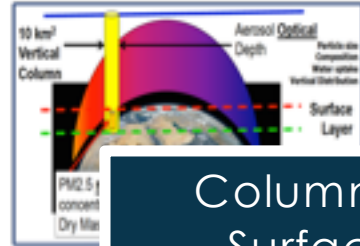
Imagery



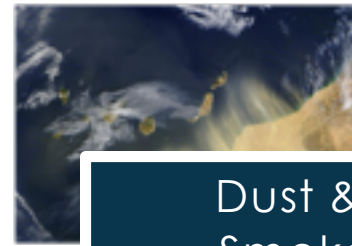
Algorithms



Data & Tools



Column to Surface



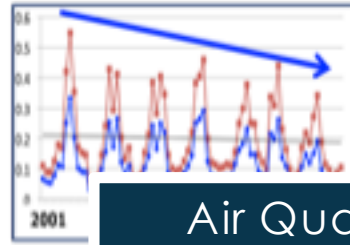
Dust & Smoke



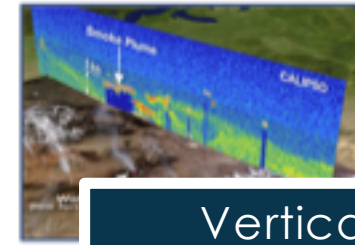
Plume Transport



Satellite & Model Comparison



Air Quality Trends



Vertical Profiles



# Learn More About ARSET

<http://arset.gsfc.nasa.gov/>

The screenshot displays the NASA ARSET website. At the top, the NASA logo and 'ARSET Applied Remote Sensing Training' are visible. Navigation links include 'Home', 'About', and 'Trainings'. A search bar and a Twitter icon are also present. The main content area features a large image of a satellite view of a coastal area with a greenish tint, overlaid with a dark menu listing categories: 'Fundamentals', 'Disasters', 'Health & Air Quality', 'Land', and 'Water Resources'. A prominent announcement for 'Introduction to Remote Sensing of Harmful Algal Blooms' is shown, including dates (Tuesdays, Sep 5-26, 2017) and times (11:00-12:00 or 21:00-22:00 EDT), with a 'Register Now' button. A sidebar on the right contains a list of links: 'ARSET', 'Online Trainings', 'In-Person Trainings', 'Sign up for the Listserv' (highlighted with a red arrow), 'Tools Covered', 'Suggest a Training', 'Personnel', and 'Resources'. Below this is a section for 'Upcoming Training' with the heading 'Water' and the sub-heading 'Satellite Observations of Water Quality for'.



# Training Outline

- **Day 1**

- Introduction
- Remote Sensing
- Image Access & Interpretation
- Data Formats
- Aerosol Observations
- Near Real Time
- Trace Gases
- Fire and Smoke

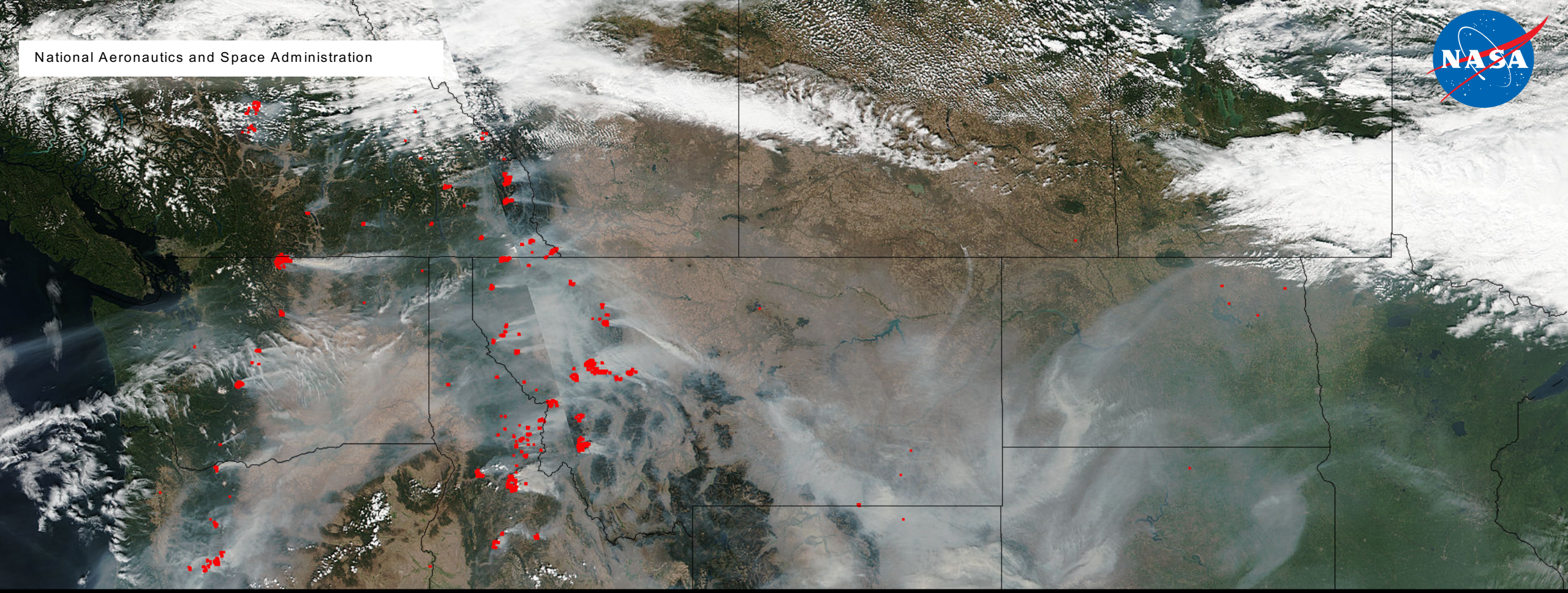
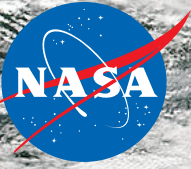
- **Day 2**

- Aerosol Products
- Aerosol Data Validation
- Reading and Mapping Aerosol data
- PM<sub>2.5</sub> Estimations
- PM<sub>2.5</sub> Data Sets
- PM<sub>2.5</sub> Applications
- CALIPSO & CATS
- Geostationary

- **Day 3**

- USFS
- Air Quality Forecast
- Reanalysis Data Sets
- Future Missions
- Case Study Analysis





# Overview of Satellite Capabilities for Air Quality Monitoring

Pawan Gupta, and Melanie Follette-Cook

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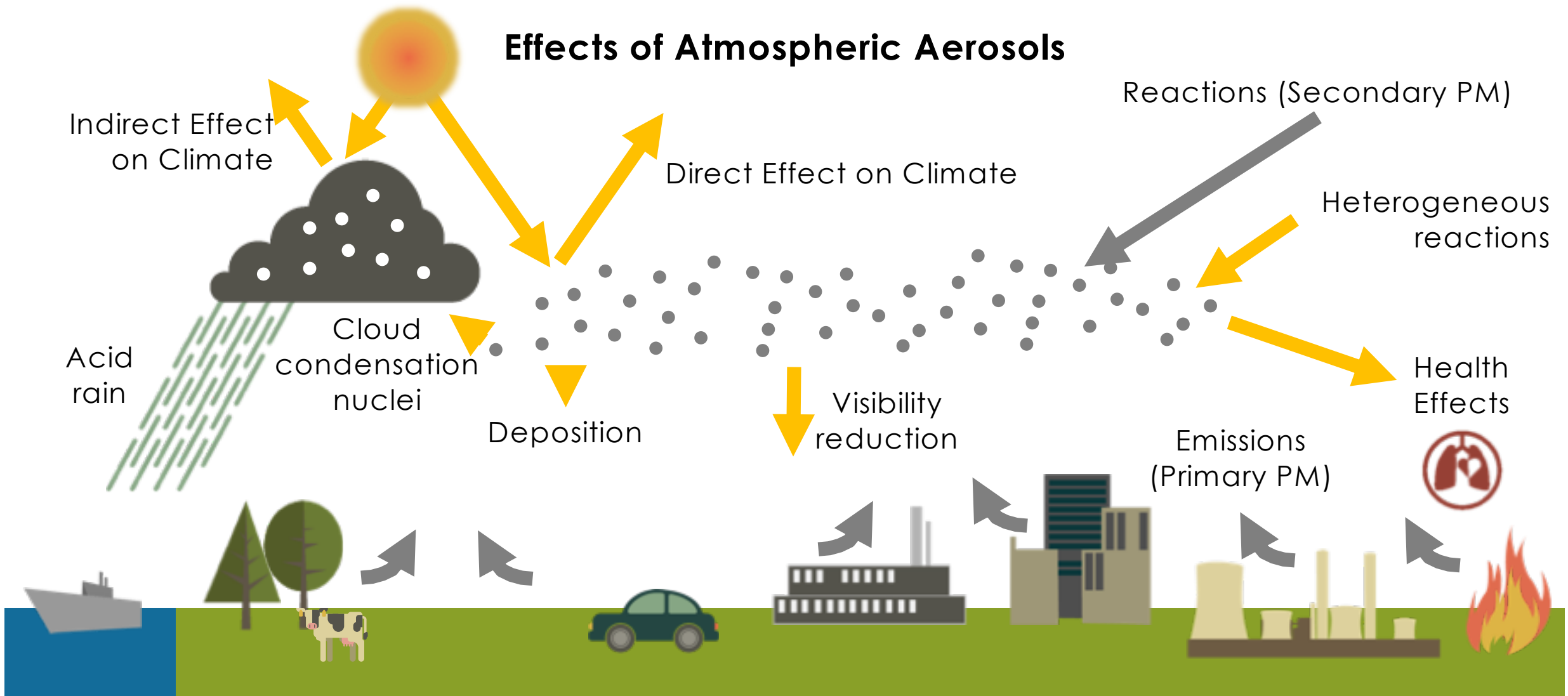
# Learning Objectives

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

- Describe existing satellite capabilities for global air quality monitoring
- Identify various air quality monitoring applications

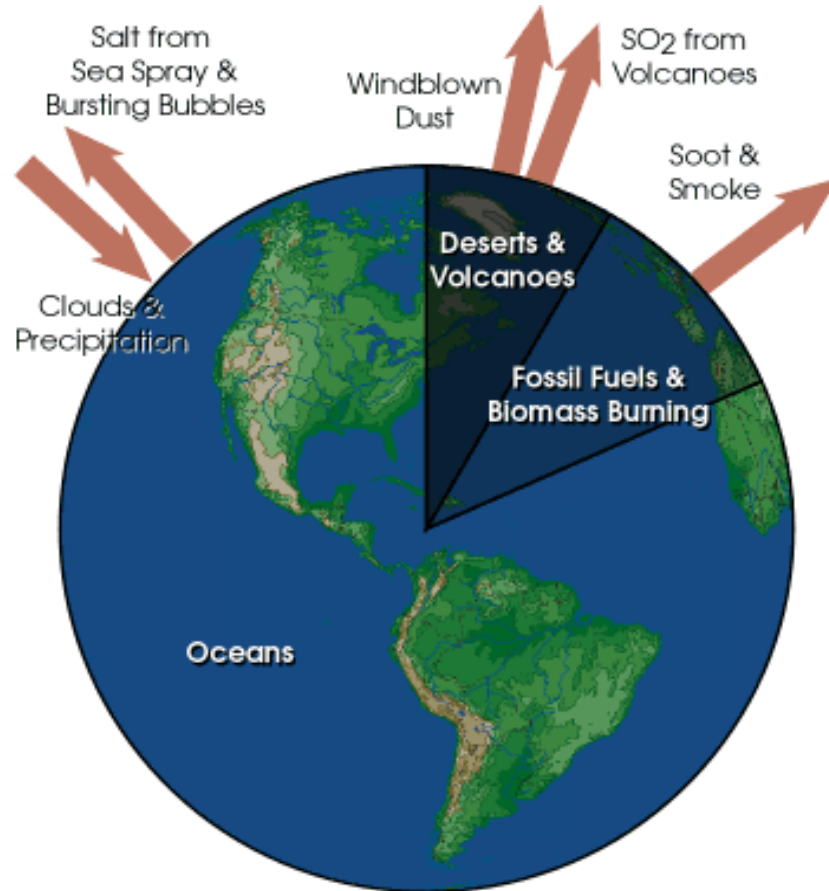


# Motivation: Tiny, but Potent

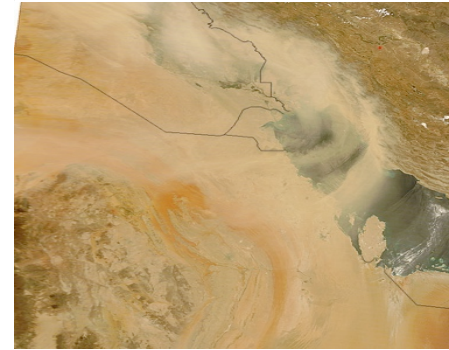


# Pollution Sources

Atmospheric aerosols are highly variable in space and time



Dust



Fossil Fuels & Biomass Burning



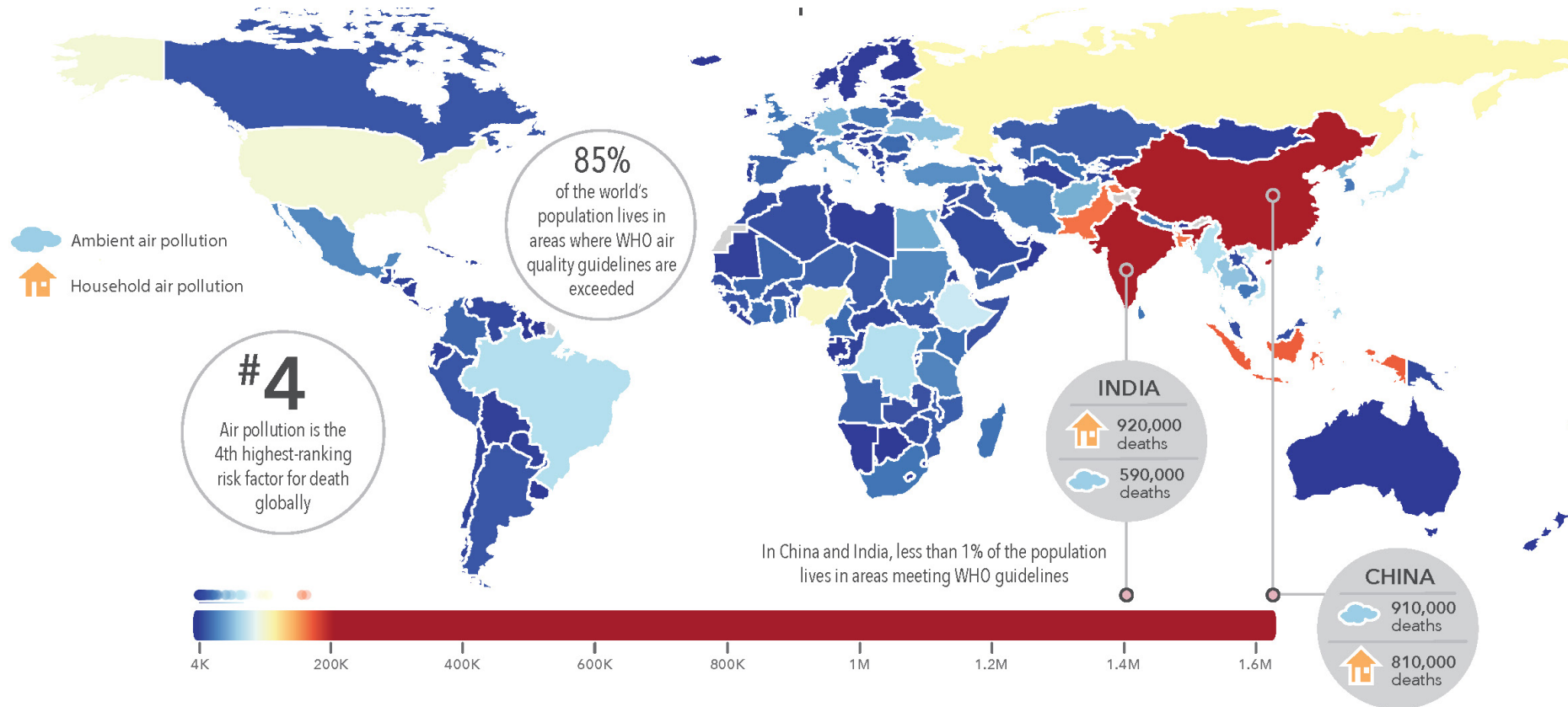
Volcanoes



Soot & Smoke



# Global Burden of Air Pollution



- Air pollution was responsible for 5.5 million deaths in 2013
- Satellite data can help quantify the impact on human health

Image Credit: <http://theancient.com/gba/2013>



# UN Sustainable Development Goals (SDGs)

Transforming Our World: The 2030 Agenda for Sustainable Development



- A plan of action for people, planet, and prosperity
- All countries and all stakeholders, acting in collaborative partnership, will implement this plan
- 17 SDGs and 169 targets under this agenda
- Balance the three dimensions of sustainable development:
  - economic, social, and **environmental**

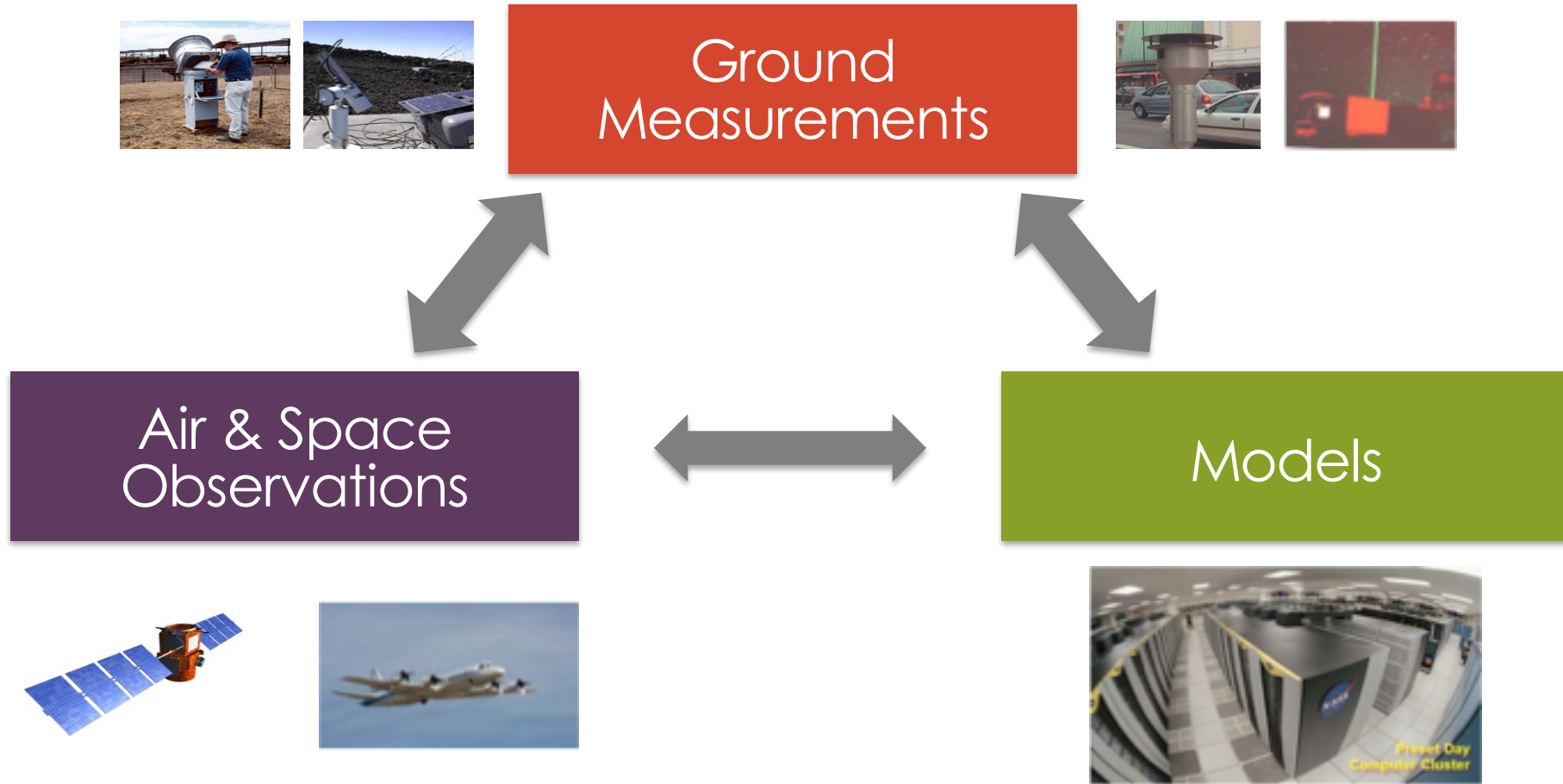
Text adapted from "Transforming our world: the 2030 Agenda for Sustainable Development"

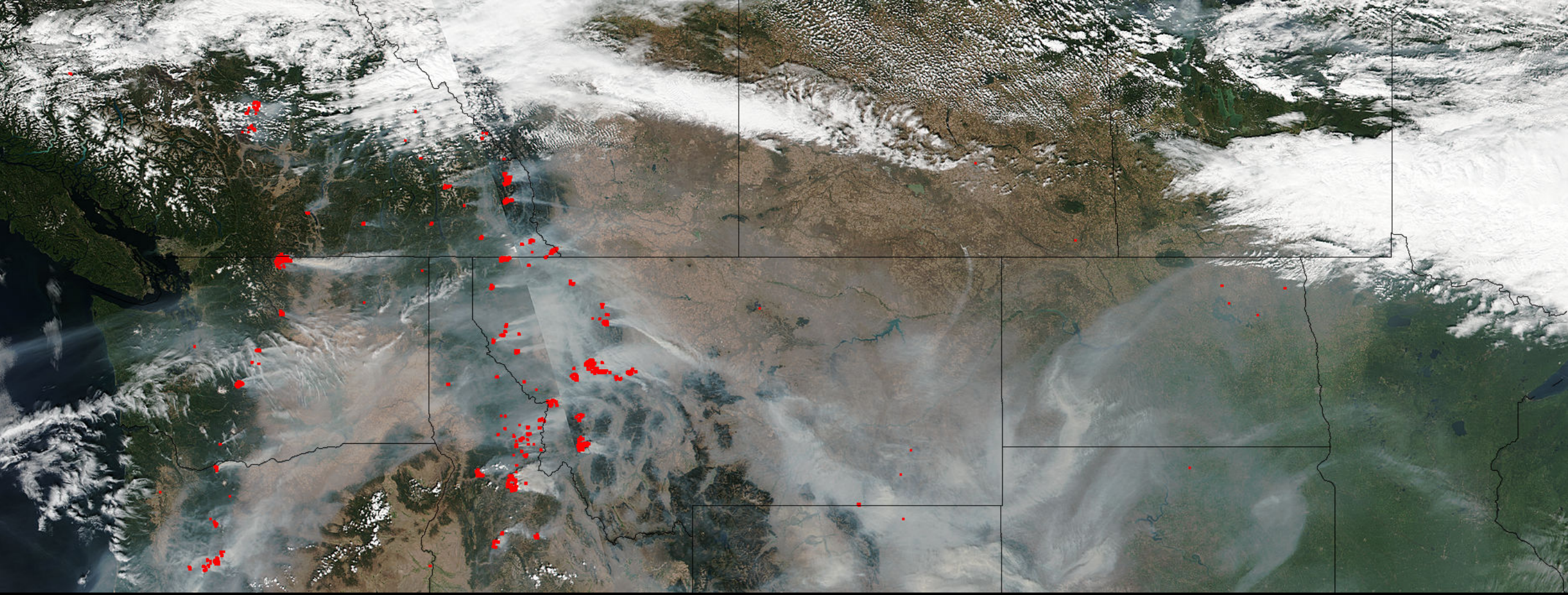


# Traditional Air Quality Monitoring



# Air Pollution Monitoring

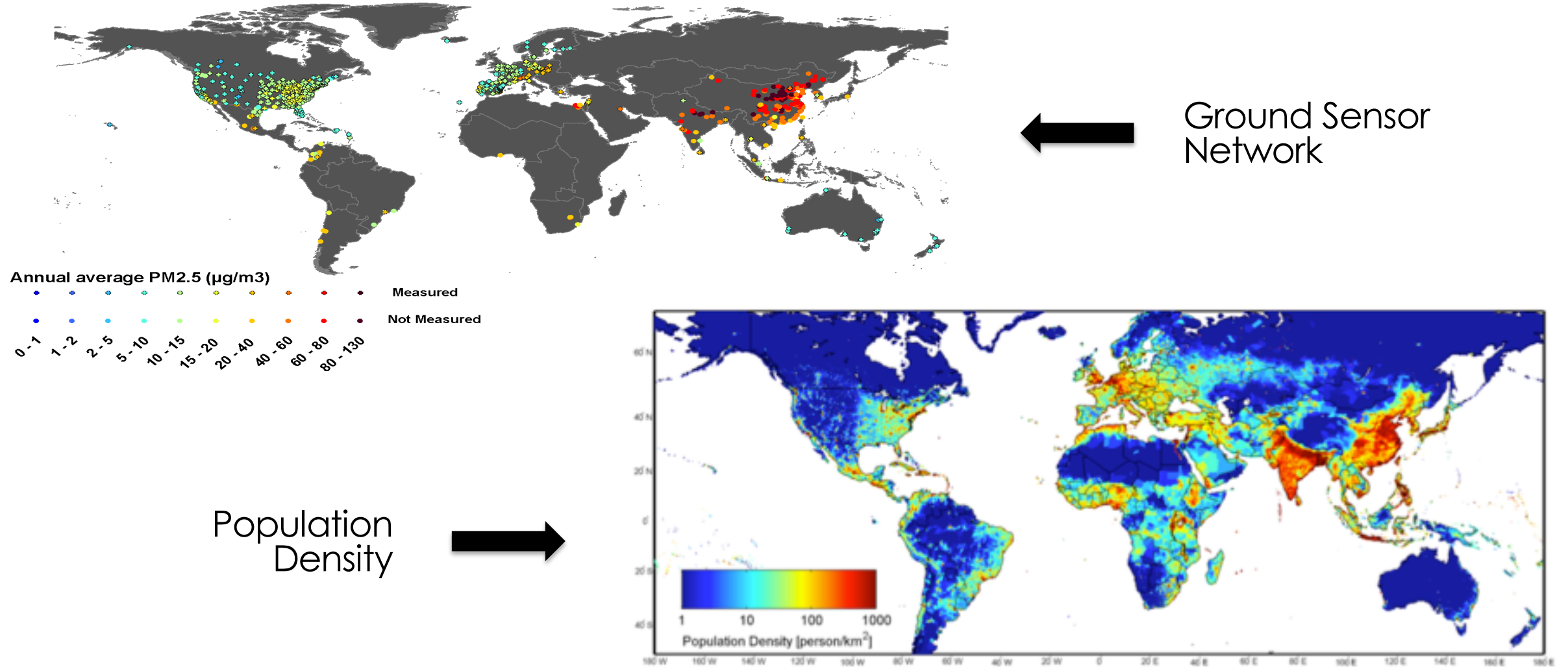




Why use satellite data?



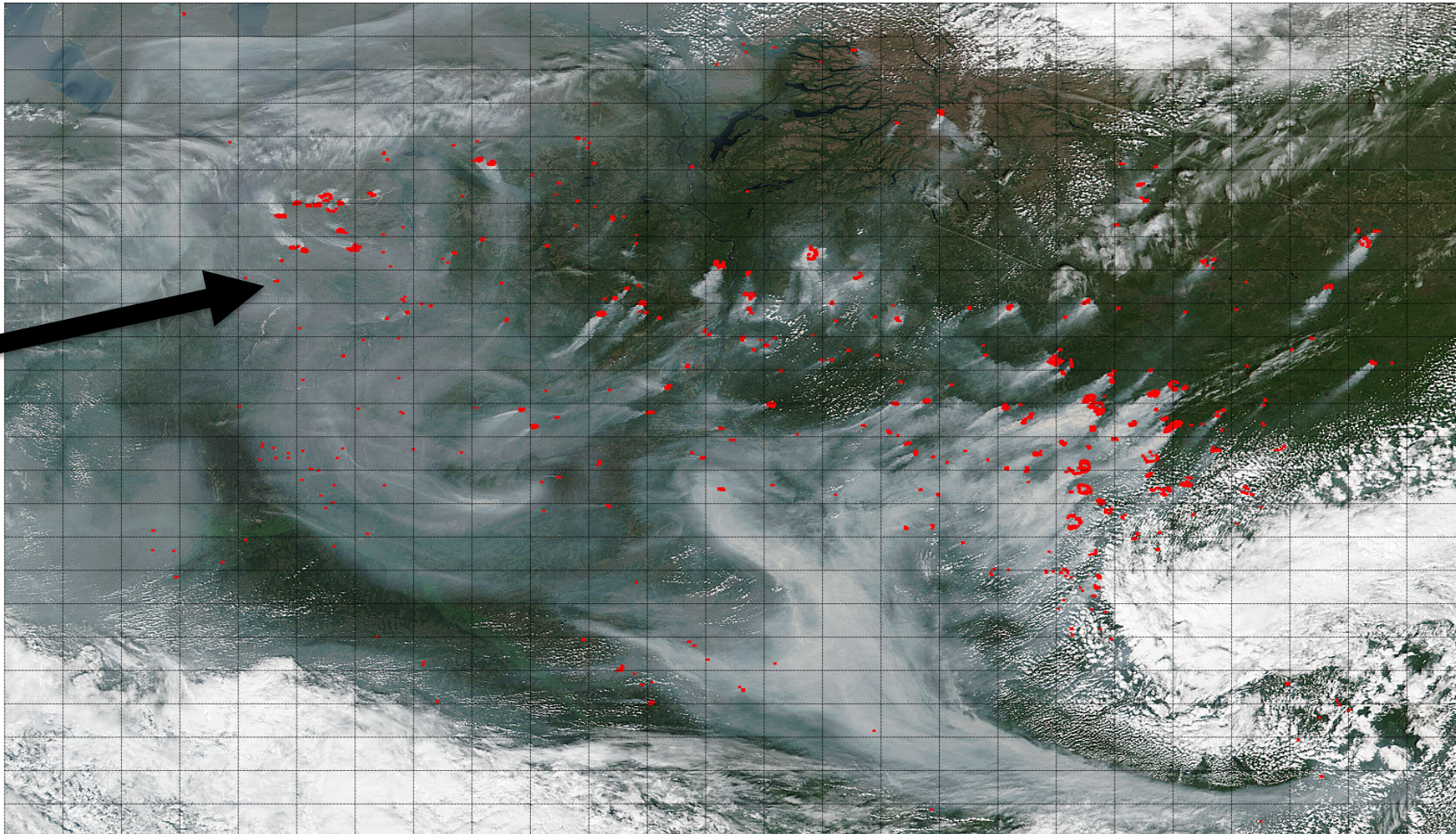
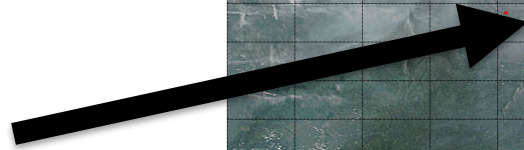
# Global Status of PM<sub>2.5</sub> Monitoring



# “A Picture is Worth a Thousand Words”

A satellite picture is worth ~~a~~ **millions of data points**

A geo-physical number



# Aerosols from Satellites

- Several satellites provide state-of-the-art aerosol measurements globally, on a daily basis

## Aerosol Optical Thickness (Aqua MODIS)

Winter

Spring

Summer

Fall

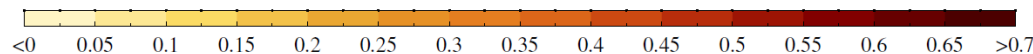
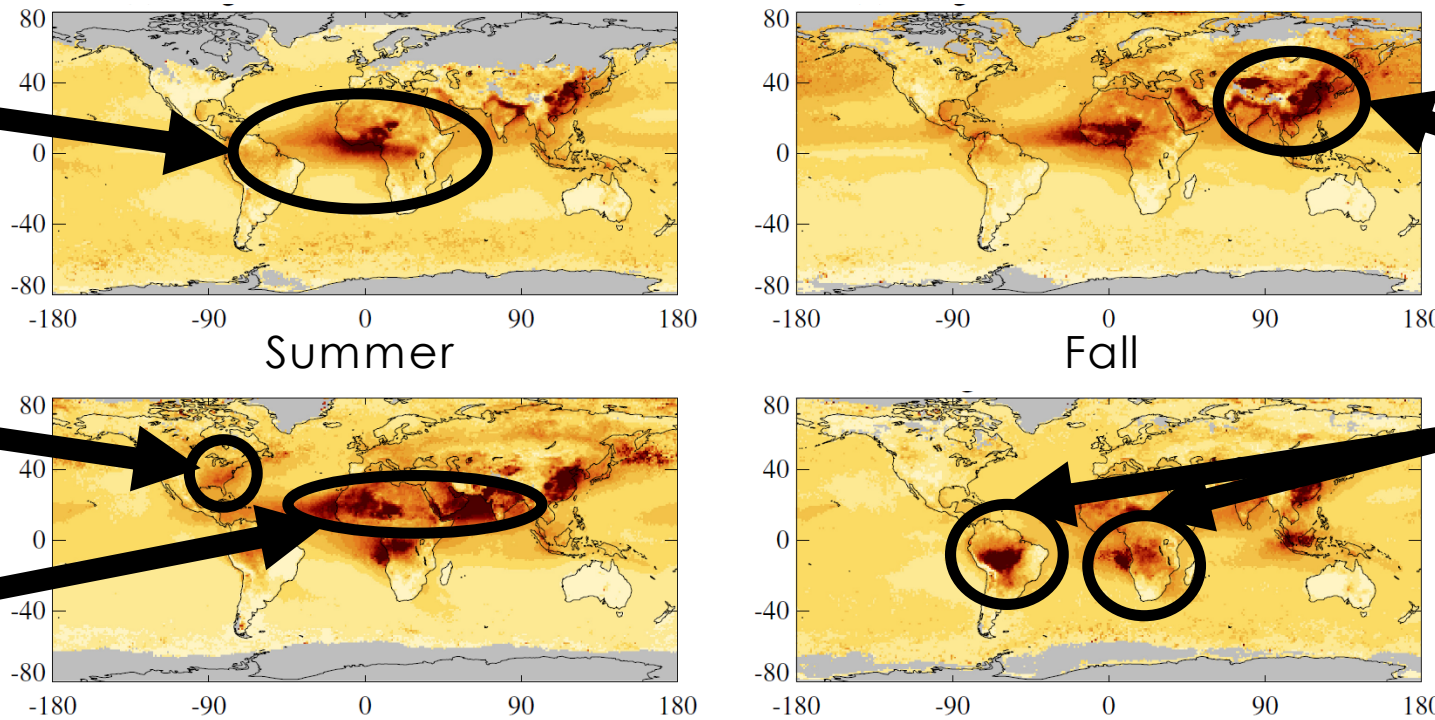
biomass burning

pollution & dust

haze & pollution

biomass burning

dust



# Nitrogen Dioxide (NO<sub>2</sub>)

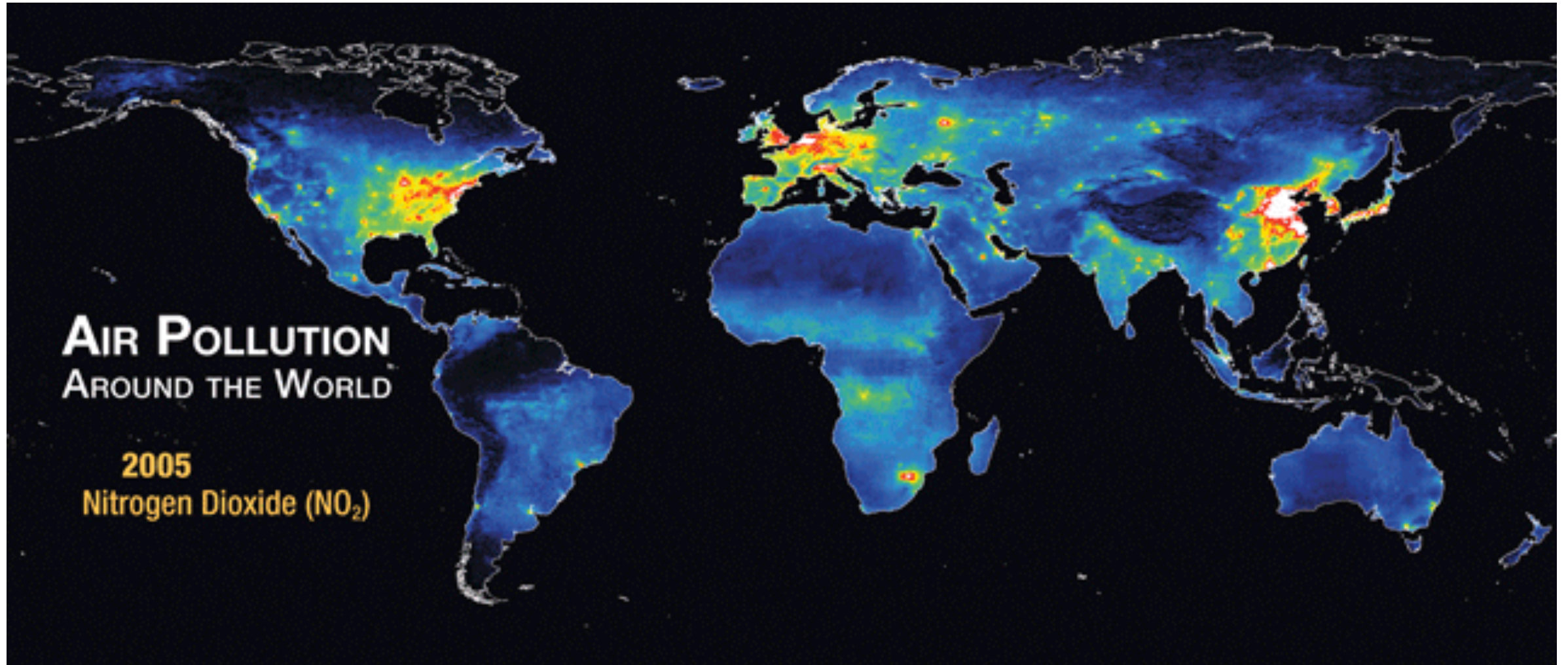


Image Source: [https://aura.gsfc.nasa.gov/images/NASA\\_NO2\\_Global\\_FRONT.gif](https://aura.gsfc.nasa.gov/images/NASA_NO2_Global_FRONT.gif)



# Sulphur Dioxide (SO<sub>2</sub>) – OMI - 2017

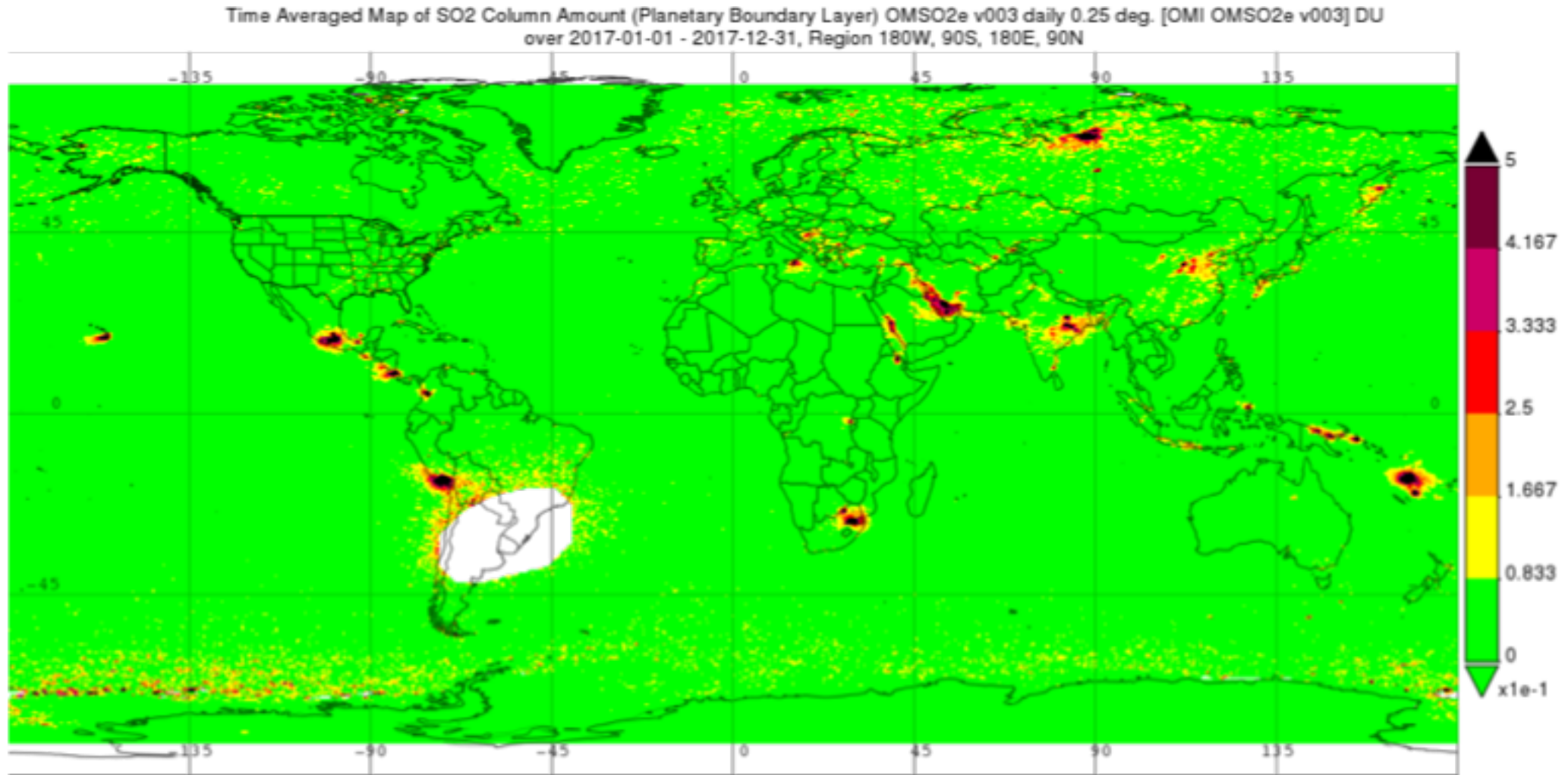
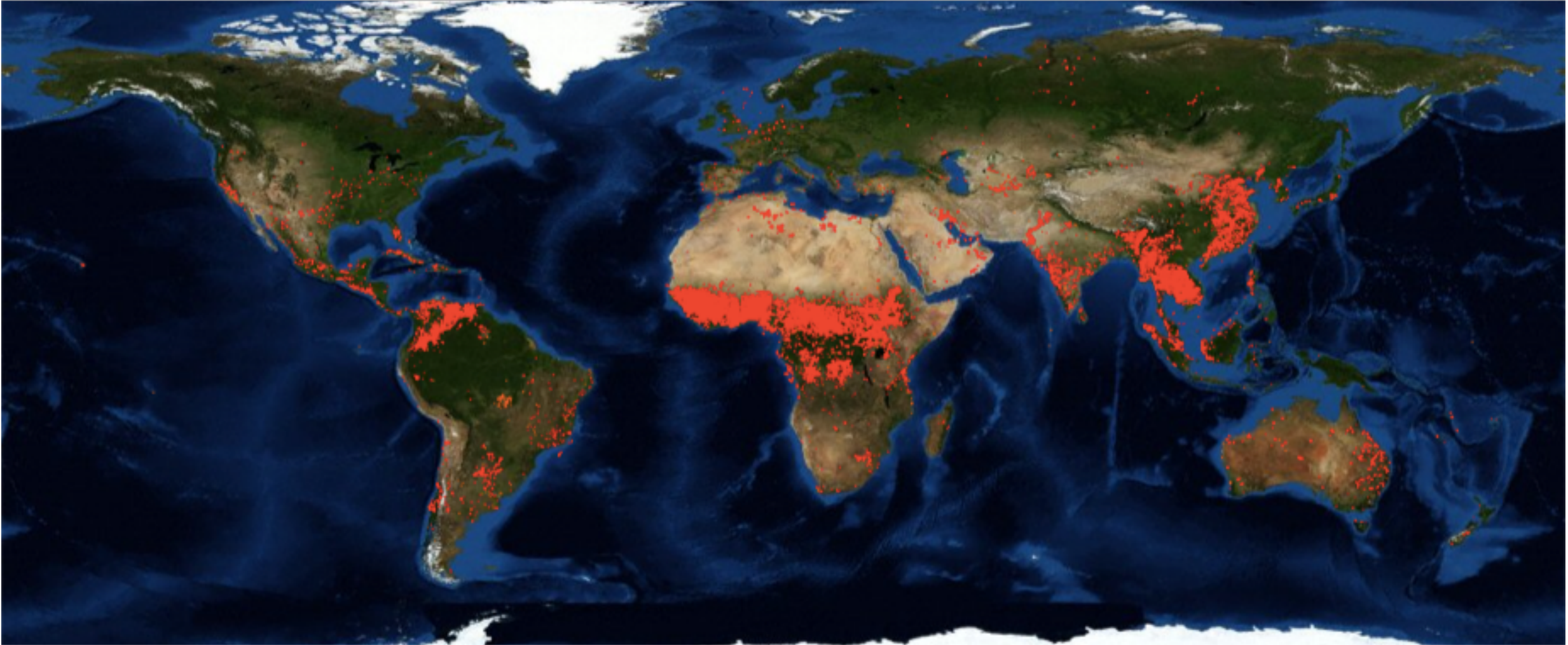


Image Credit: <https://giovanni.gsfc.nasa.gov/>



# Active Fire Mapping – February 13, 2018

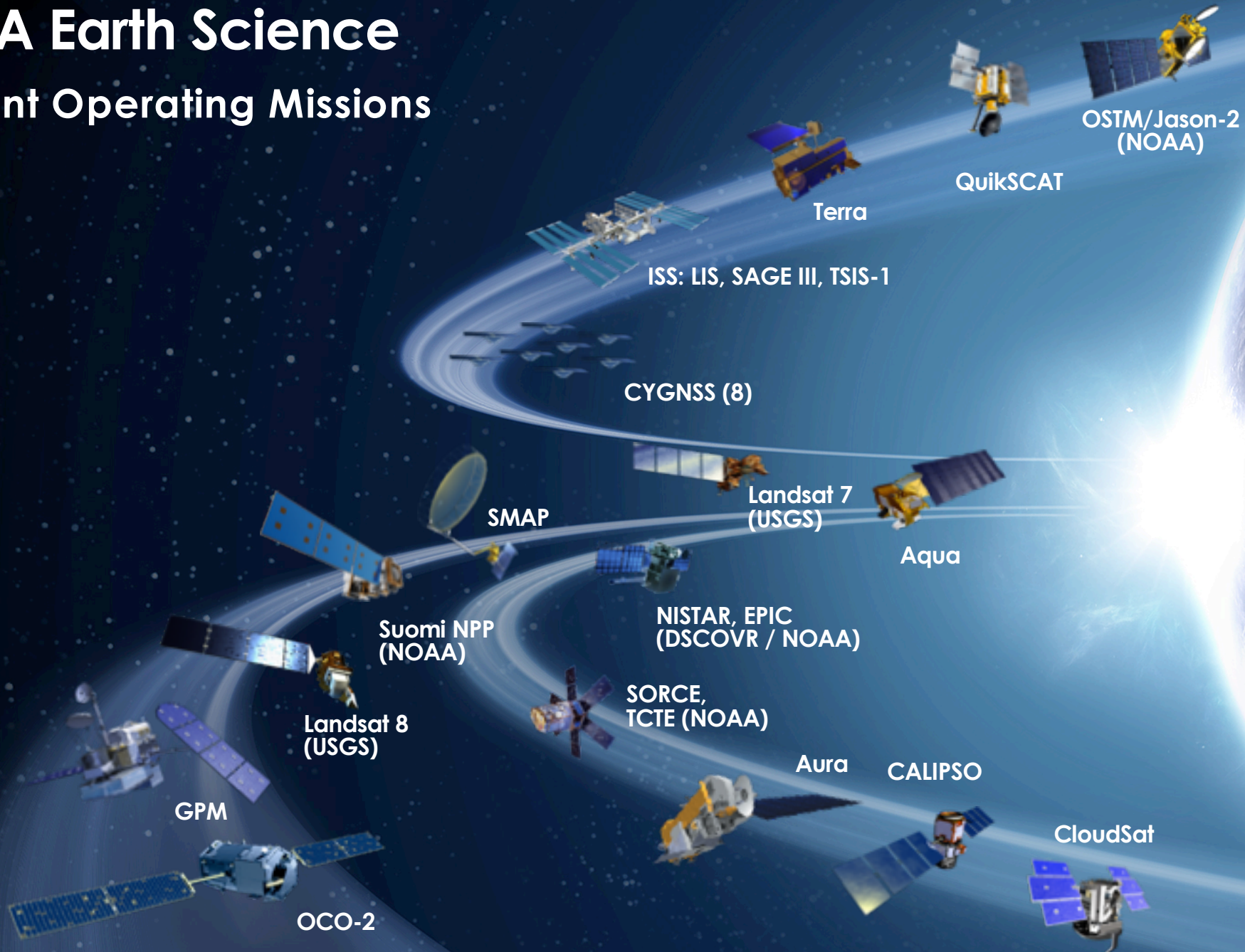


<https://firms.modaps.eosdis.nasa.gov/>



# NASA Earth Science

## Current Operating Missions



InVEST/CubeSats  
RAVAN  
IceCube  
MiRaTA

# NASA Earth Science

## Missions: Present Through 2023

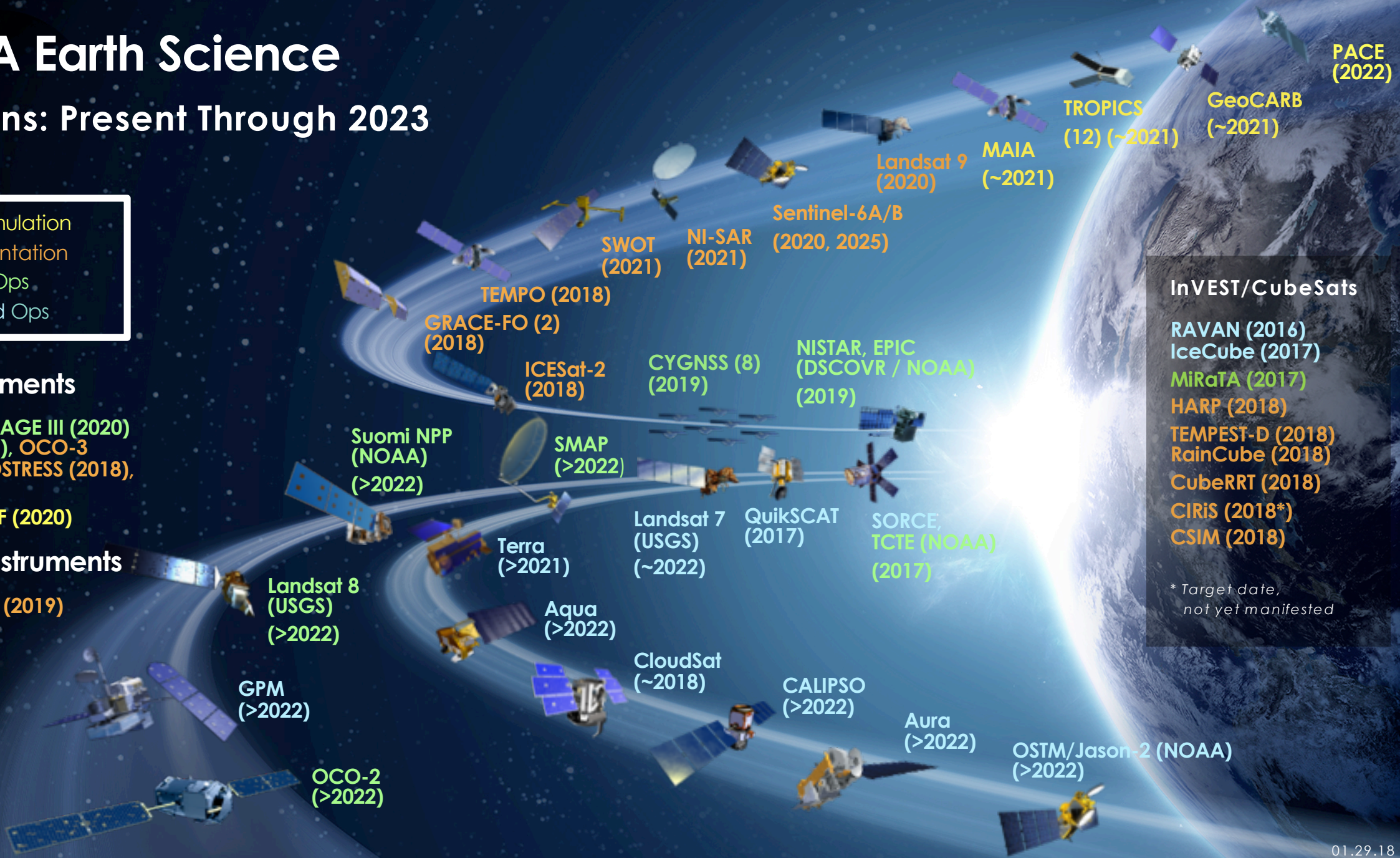
- (Pre)Formulation
- Implementation
- Primary Ops
- Extended Ops

### ISS Instruments

LIS (2020), SAGE III (2020)  
TSIS-1 (2018), OCO-3 (2018), ECOSTRESS (2018),  
GEDI (2018)  
CLARREO-PF (2020)

### JPSS-2 Instruments

OMPS-Limb (2019)

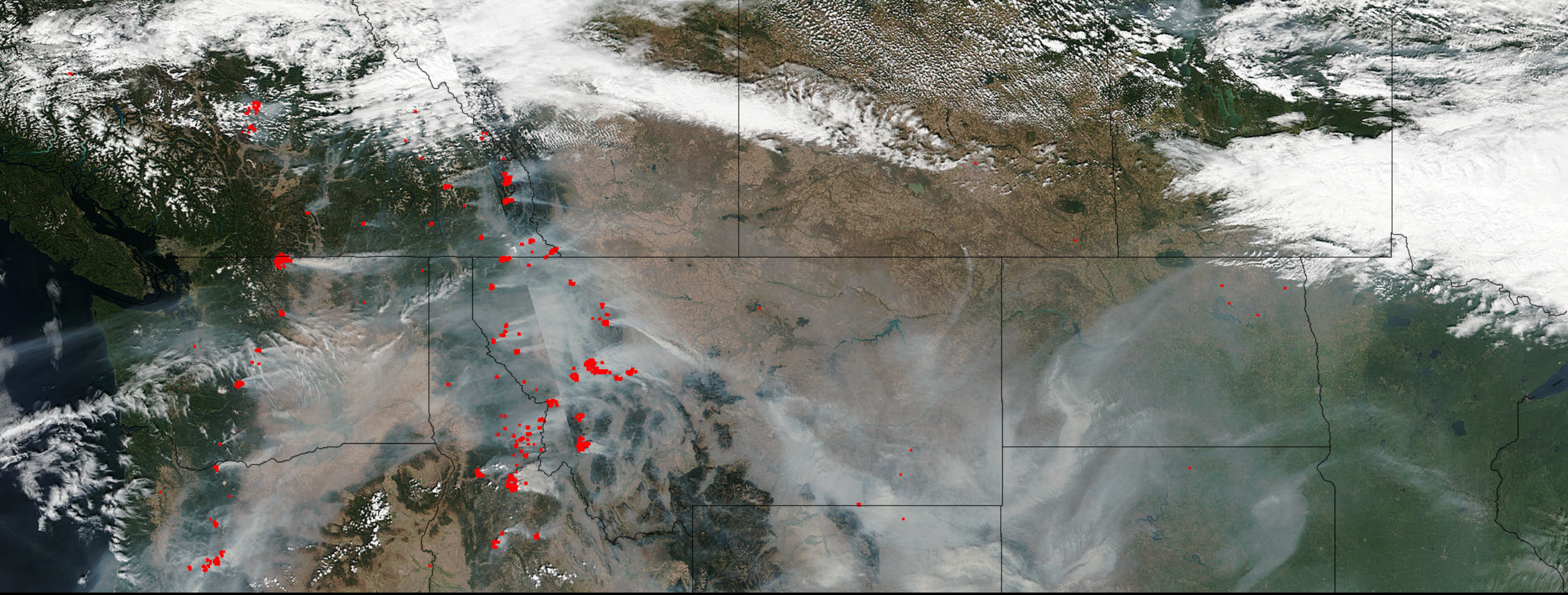


### InVEST/CubeSats

- RAVAN (2016)
- IceCube (2017)
- MiRaTA (2017)
- HARP (2018)
- TEMPEST-D (2018)
- RainCube (2018)
- CubeRRR (2018)
- CIRiS (2018\*)
- CSIM (2018)

*\* Target date, not yet manifested*



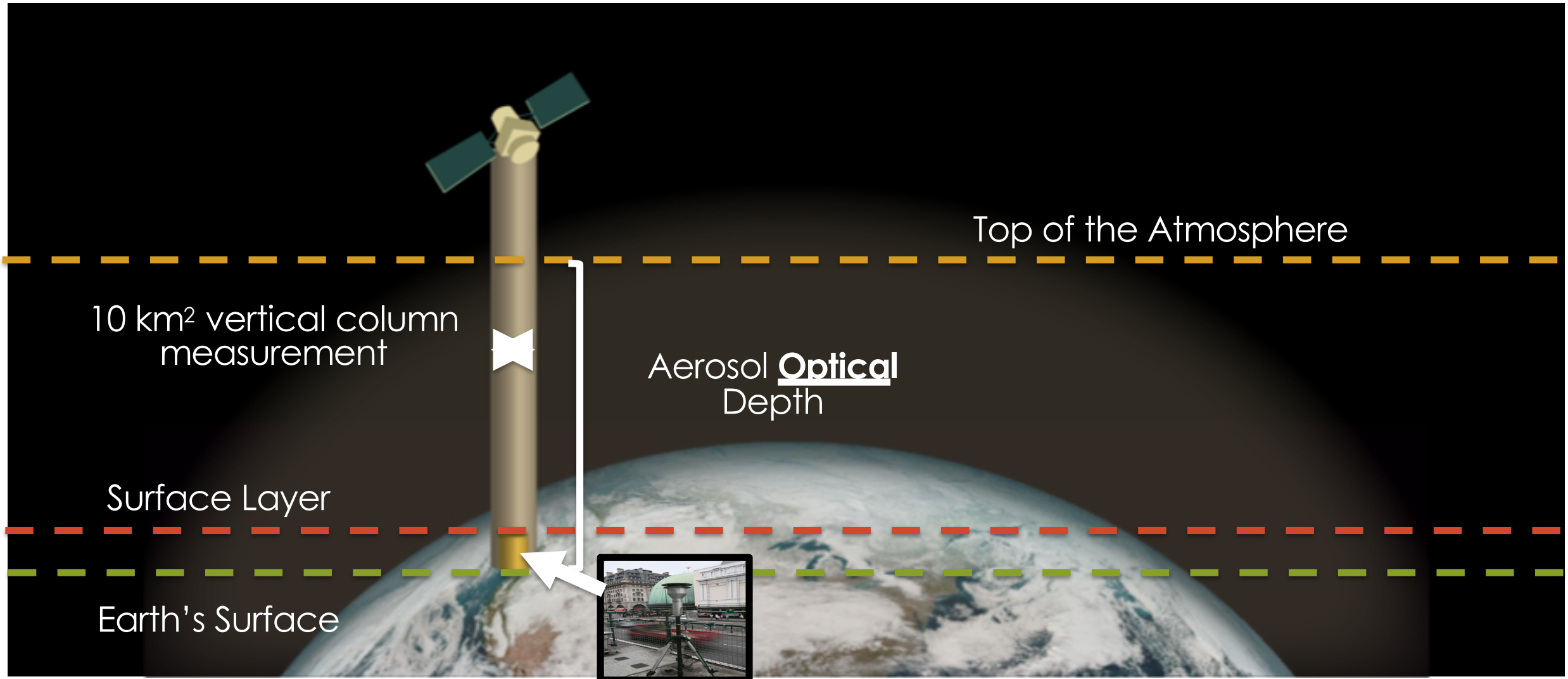


# Air Quality Applications

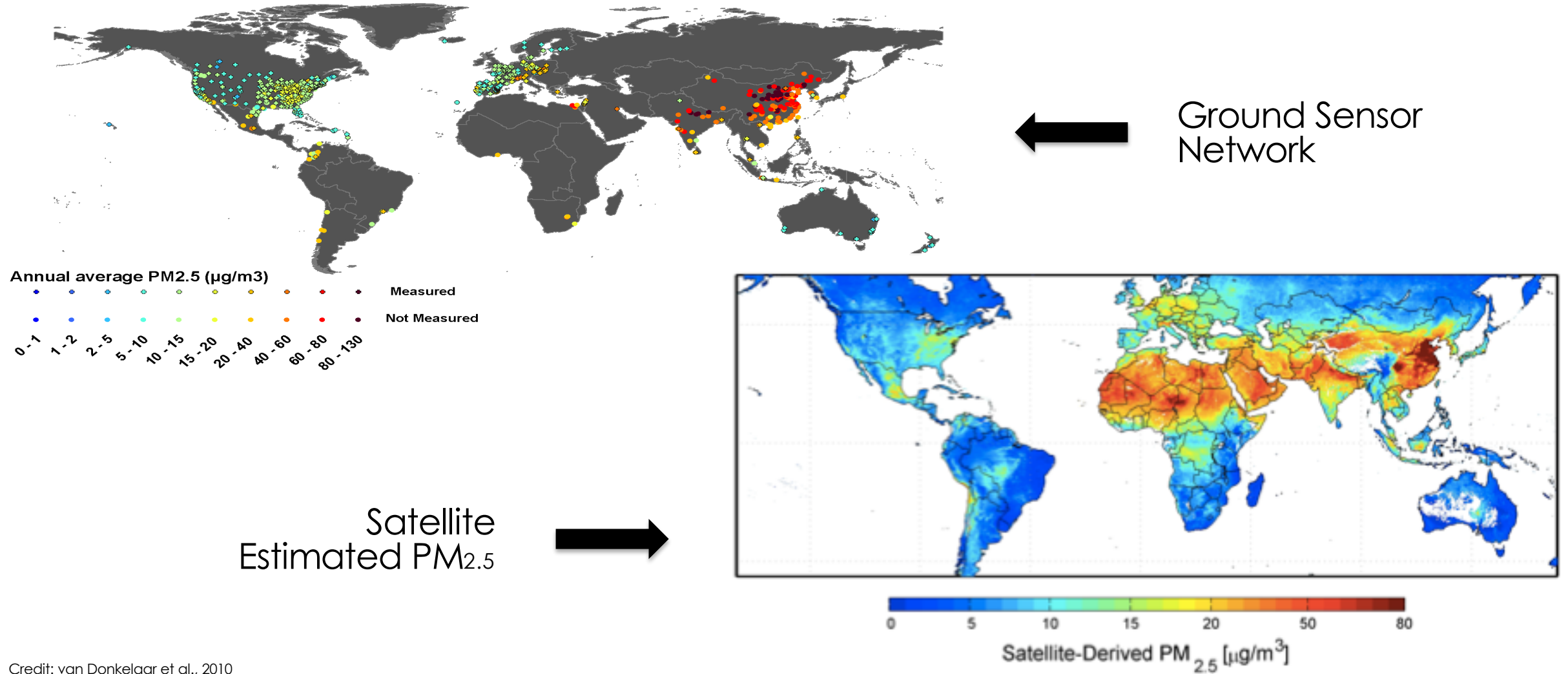
# Satellite vs. Ground Observation



# Satellite vs. Ground Observation



# Global Status of PM<sub>2.5</sub> Monitoring



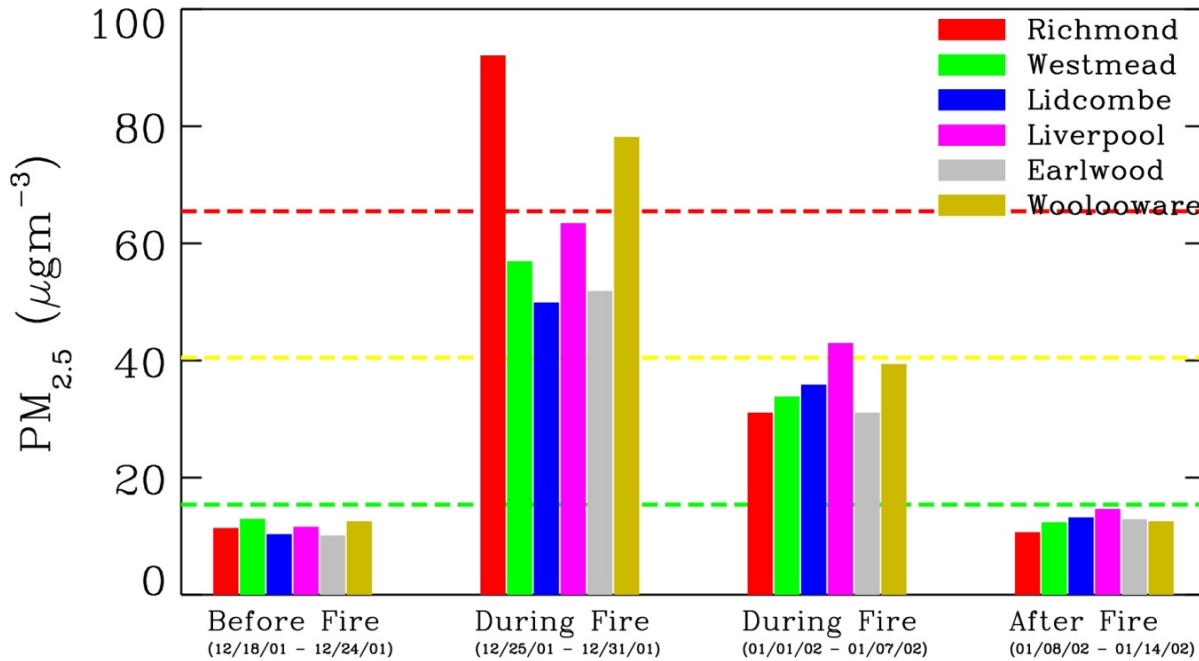
Credit: van Donkelaar et al., 2010



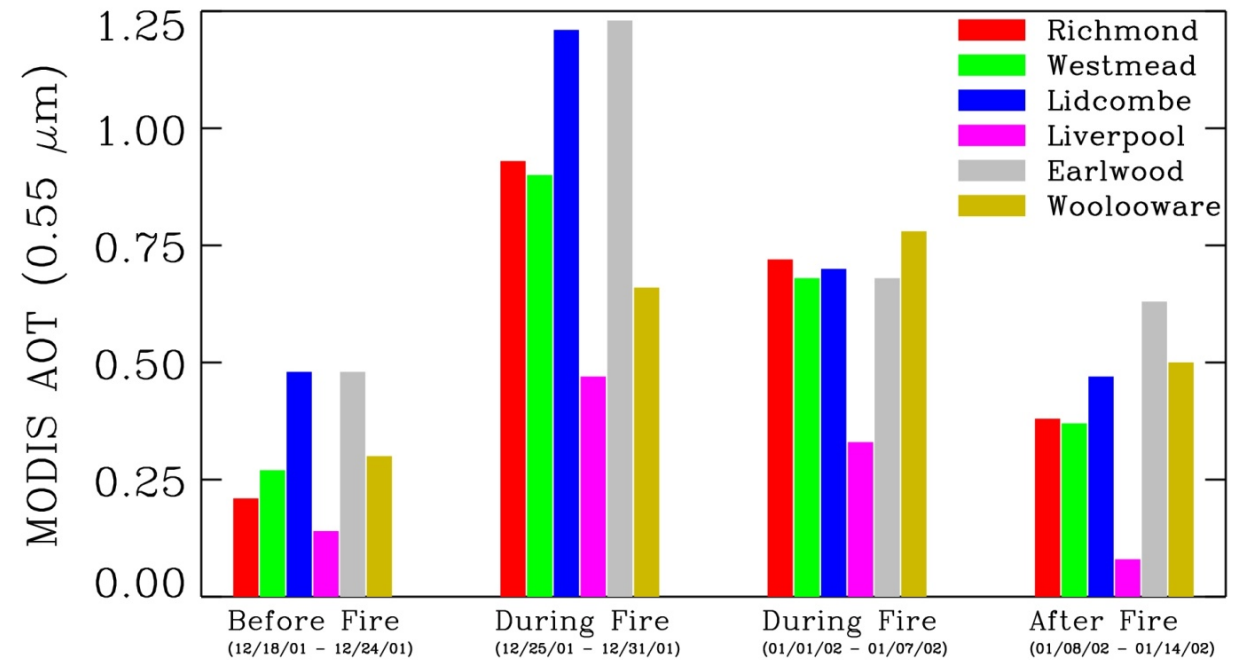
# Application of Satellite Observations

## Bushfires in Sydney, Australia

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



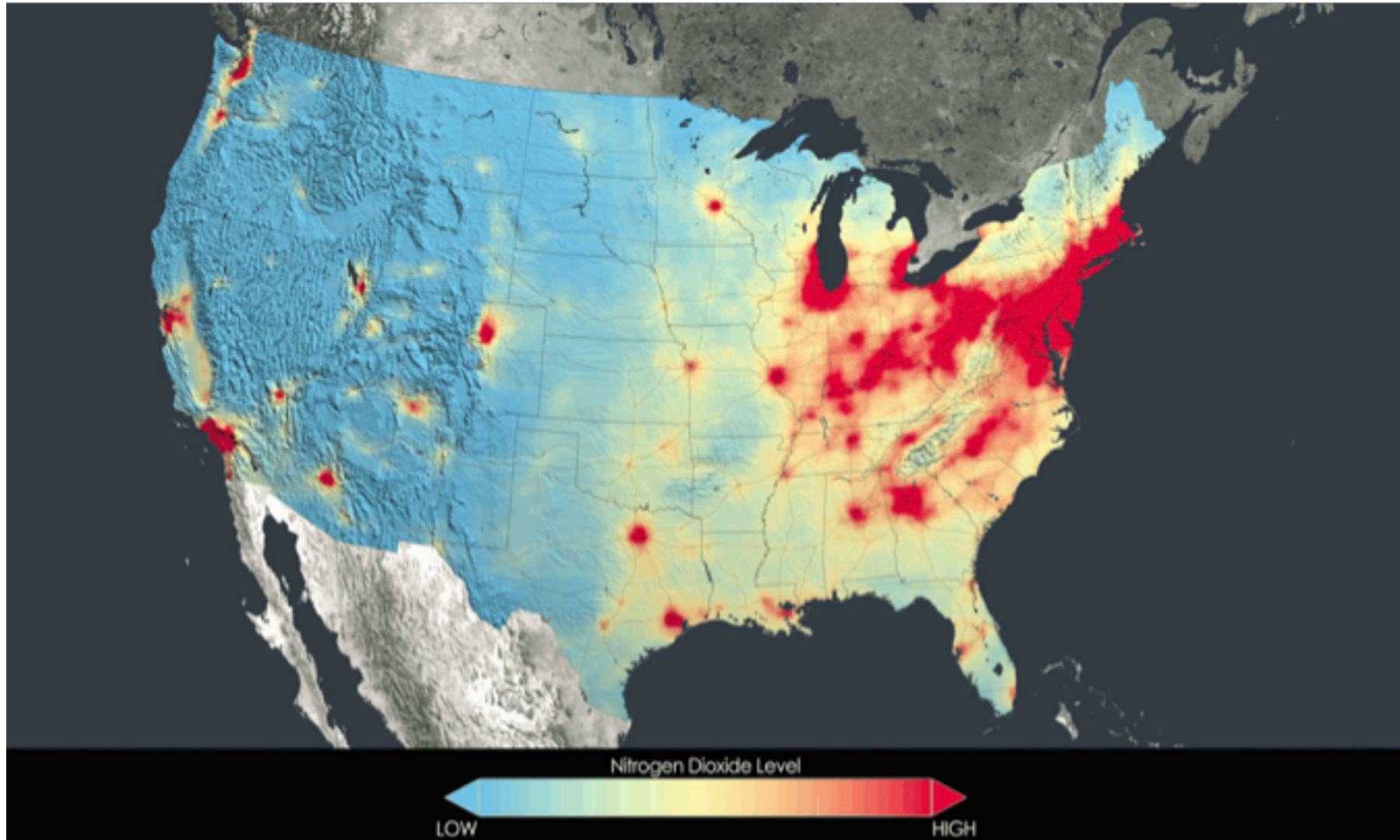
### AOD from Satellites



Credit: Gupta and Christopher, 2007

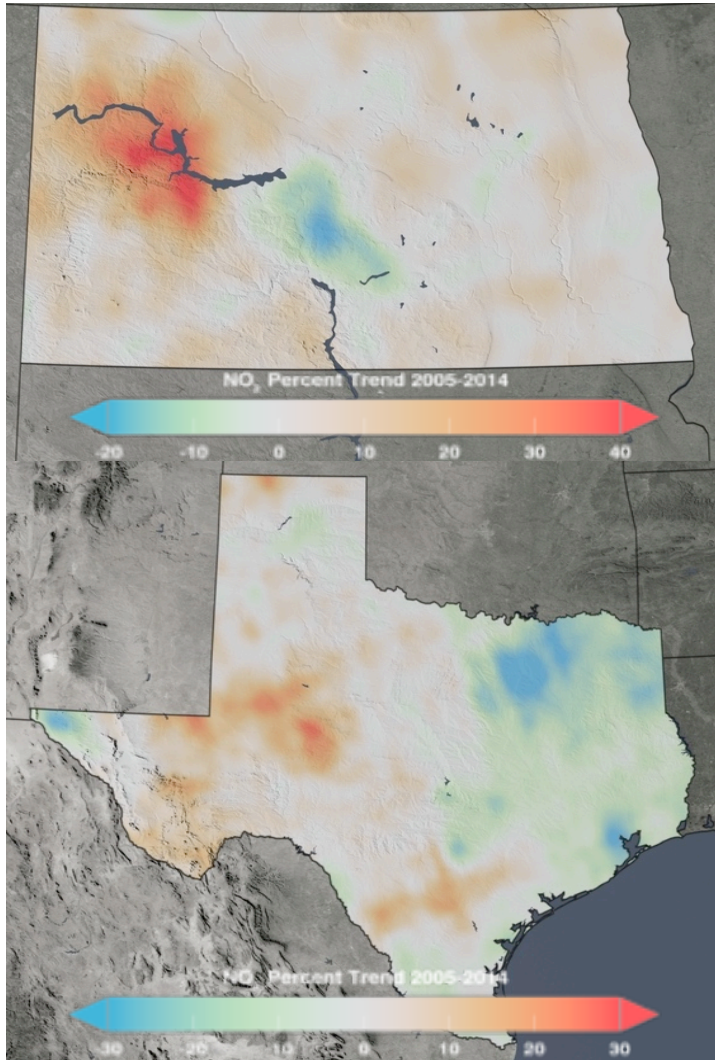


# NO<sub>2</sub> Trends Over the United States

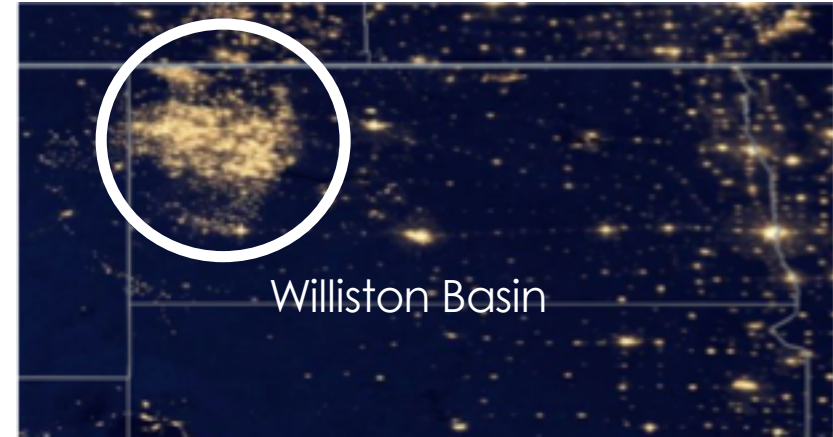


# OMI Detects NO<sub>2</sub> Increases from ONG Activities

2005 - 2014



North  
Dakota



Williston Basin

Suomi NPP VIIRS Lights at Night

Texas

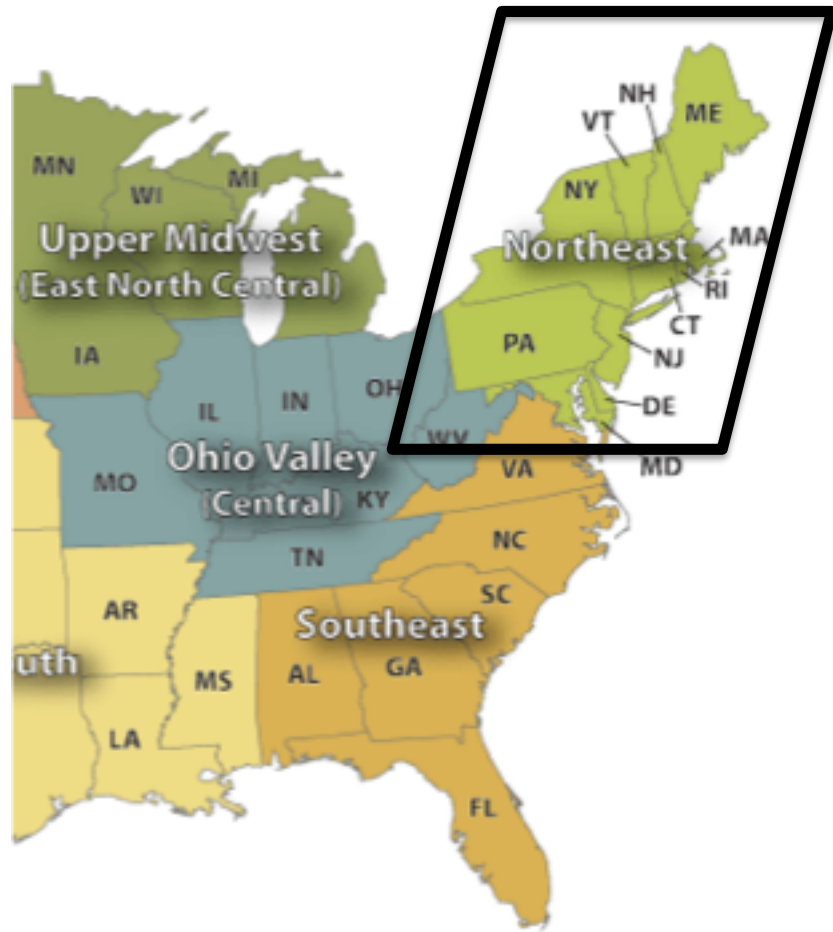


Permian Basin

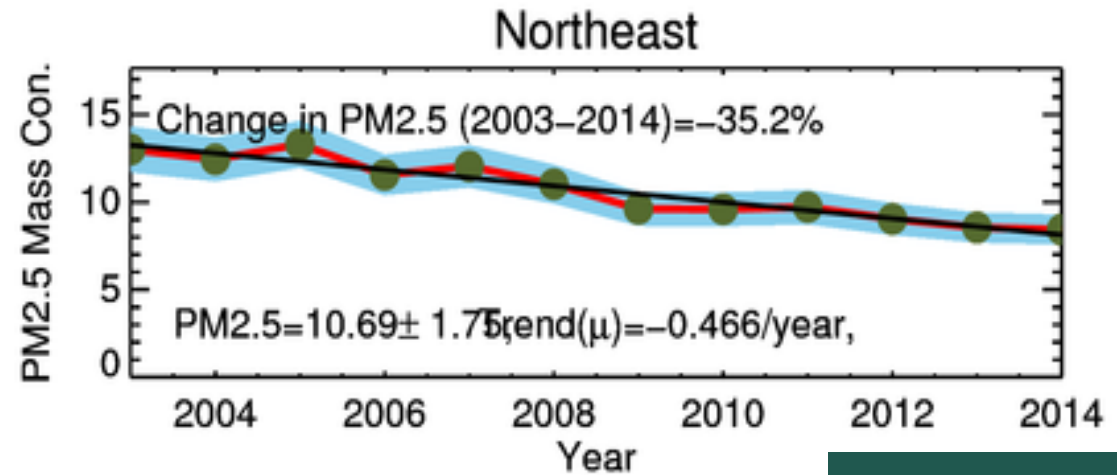
Eagle Ford



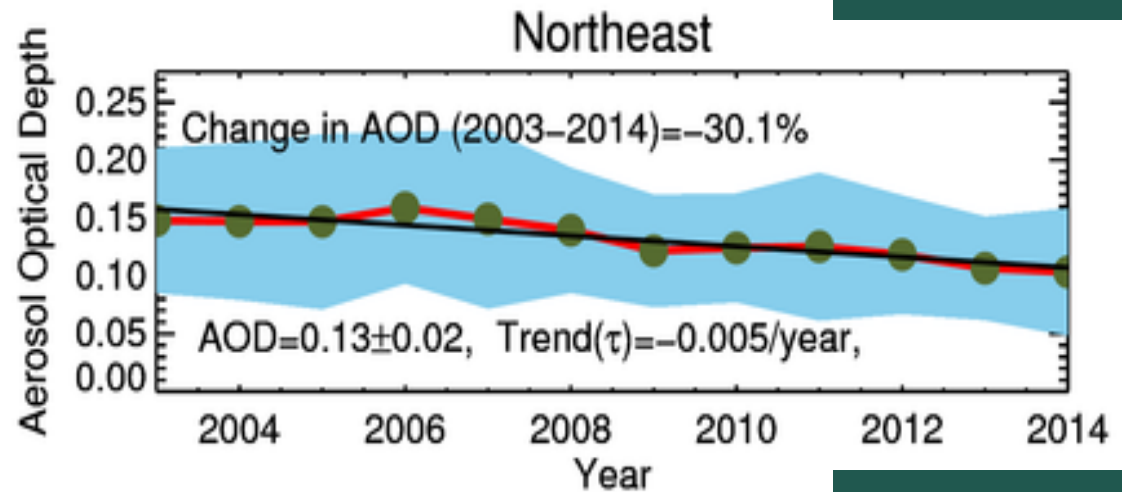
# Measurements: Surface vs. Satellite



Map Credit: U.S. Climate Regions, NOAA; Time Series Credit: Gupta



Surface



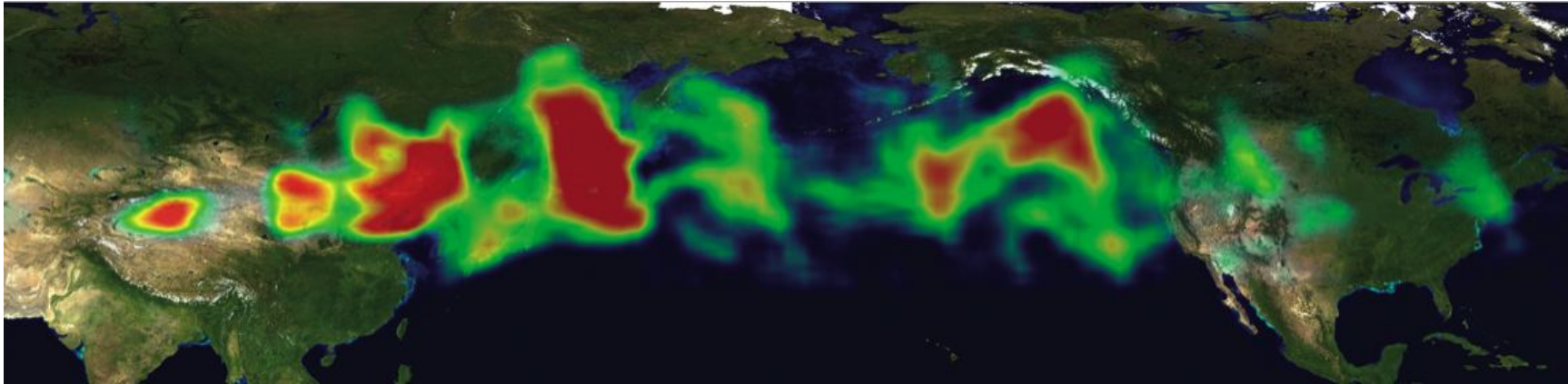
Satellite



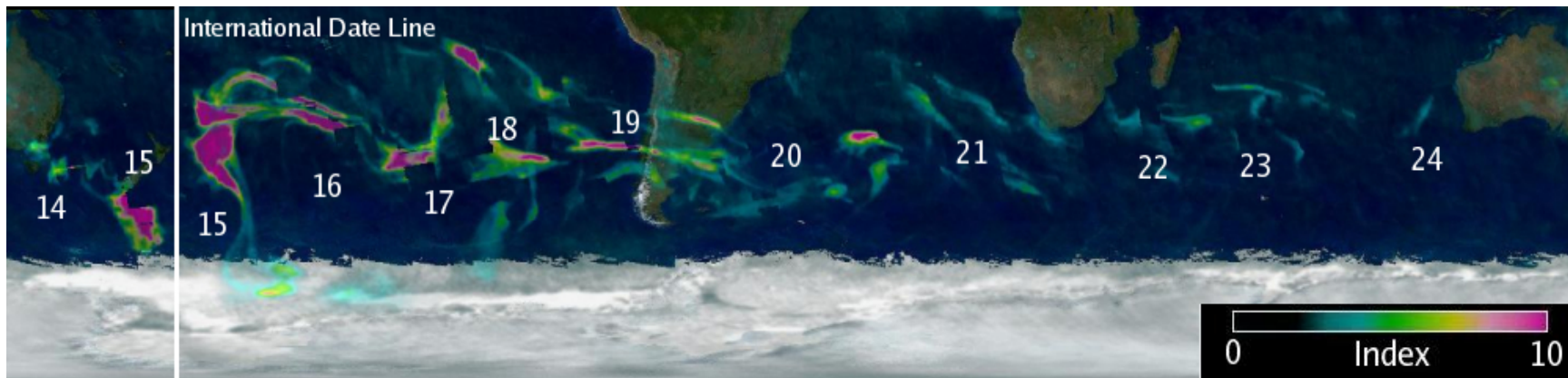


# Long Range Transport

Dust from Mongolian Deserts Reaches the U.S.

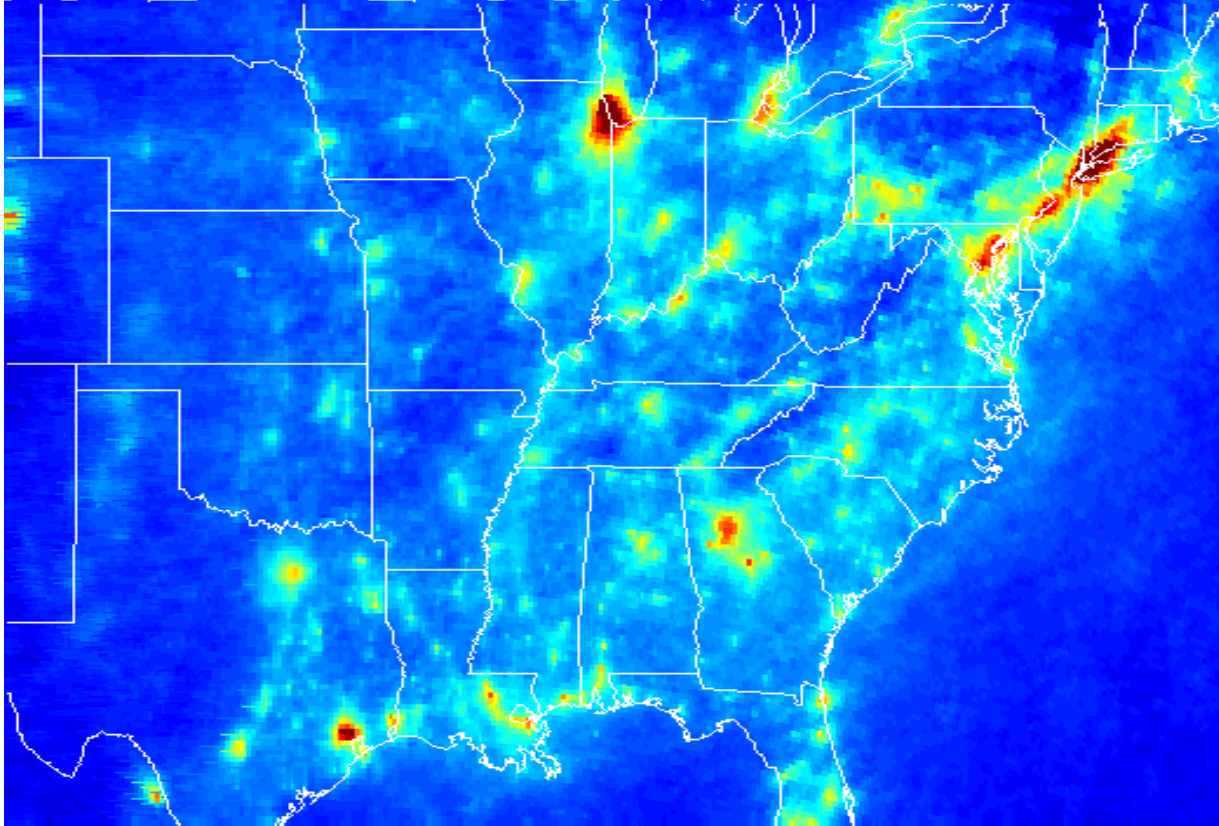


Smoke Travels Around the World in 11 Days

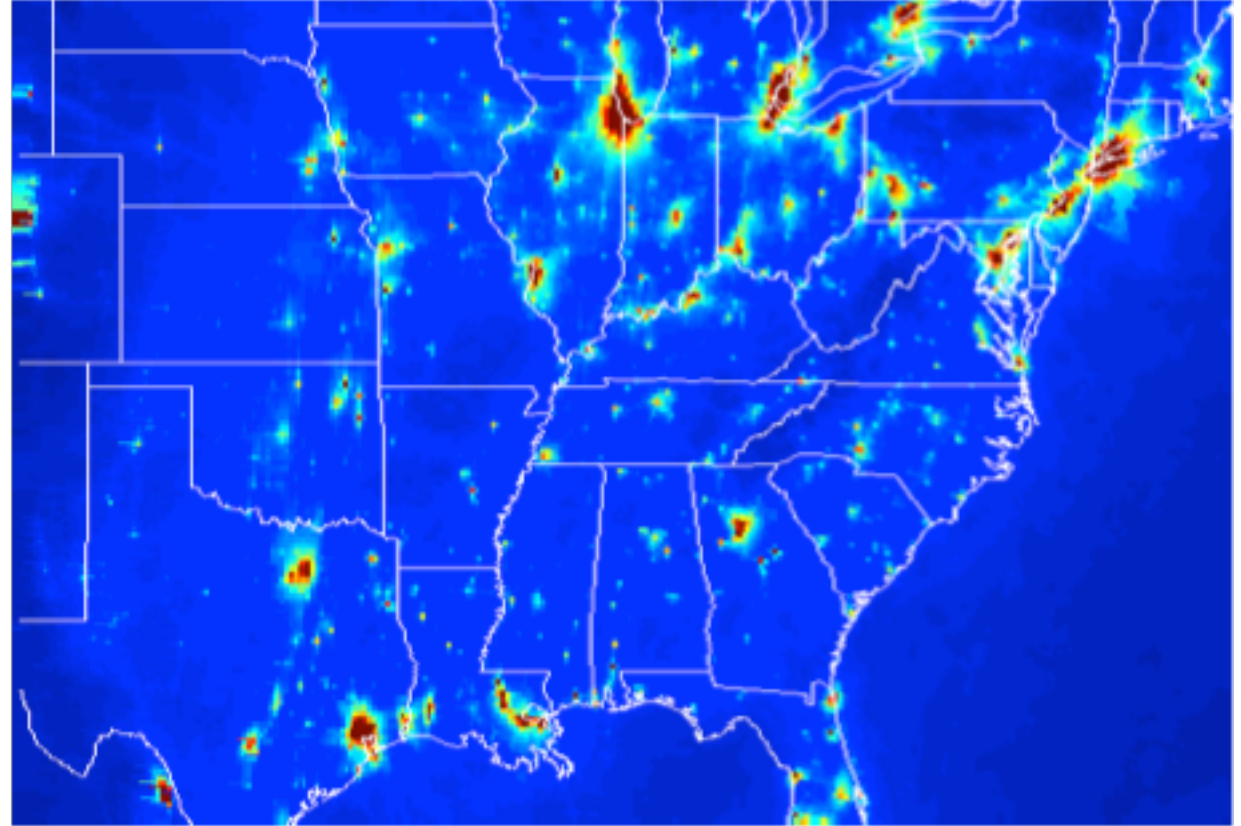


# Model-Satellite Inter-Comparison

CMAQ Model NO<sub>2</sub>



OMI NO<sub>2</sub>



# GOES-16 Loop: Fires and Smoke over Canada

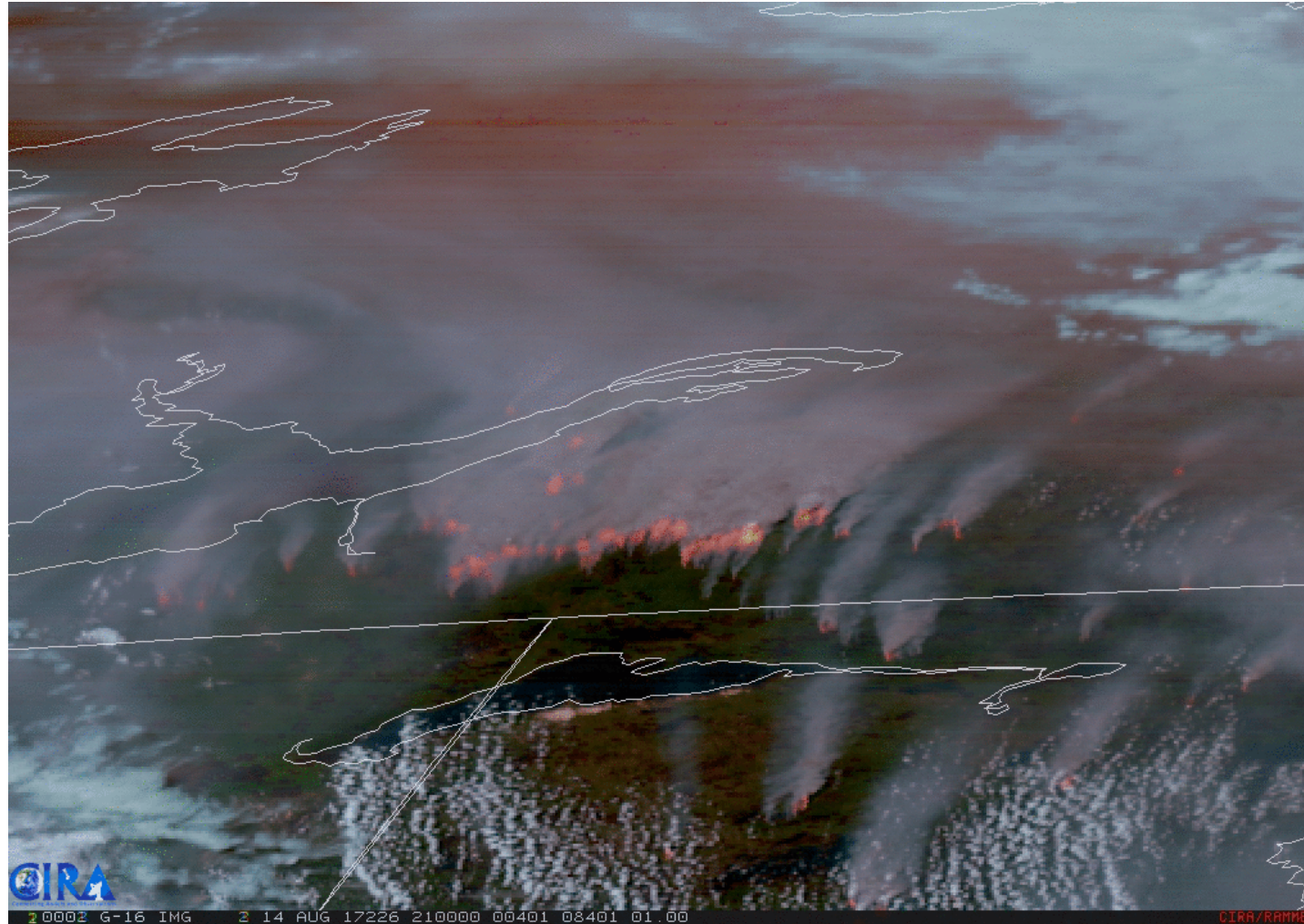


Image Credit: NOAA CoRP, STAR: [http://rammb.cira.colostate.edu/ramsdis/online/loop\\_of\\_the\\_day/](http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/)



# Smoke and Surface Air Quality – August 12, 2017

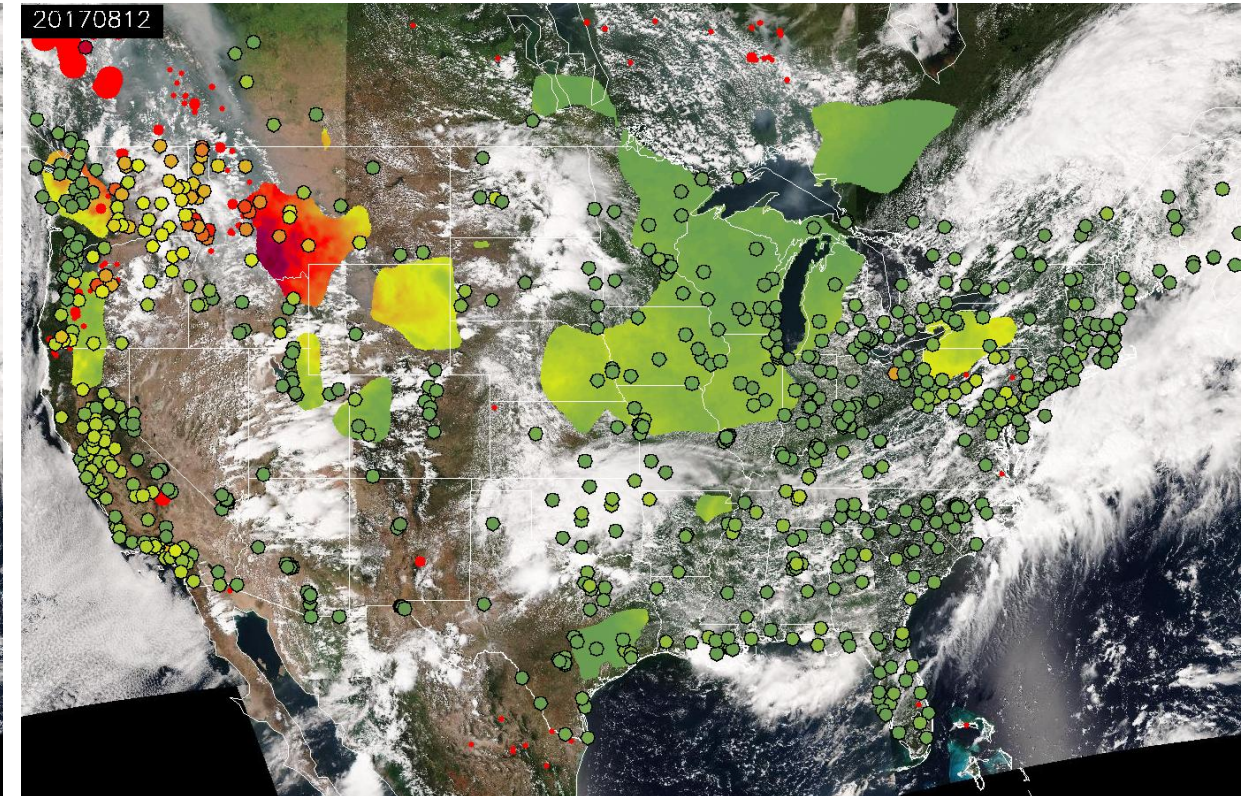
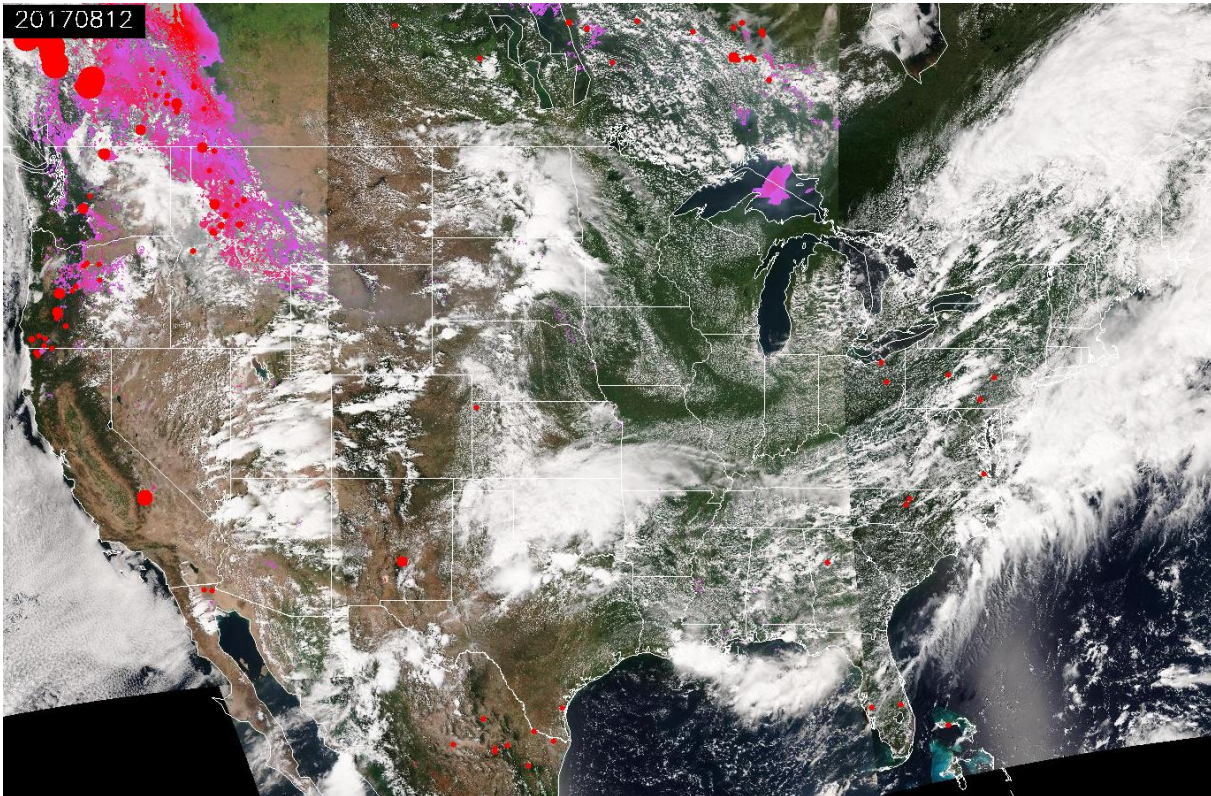


Image Credit: [https://www.star.nesais.noaa.gov/smcd/spb/aq/eidea/index.php?plot\\_sel=3&goto\\_date=20170814](https://www.star.nesais.noaa.gov/smcd/spb/aq/eidea/index.php?plot_sel=3&goto_date=20170814)



# GOES-16 Loop: Dust Storm in Southern California

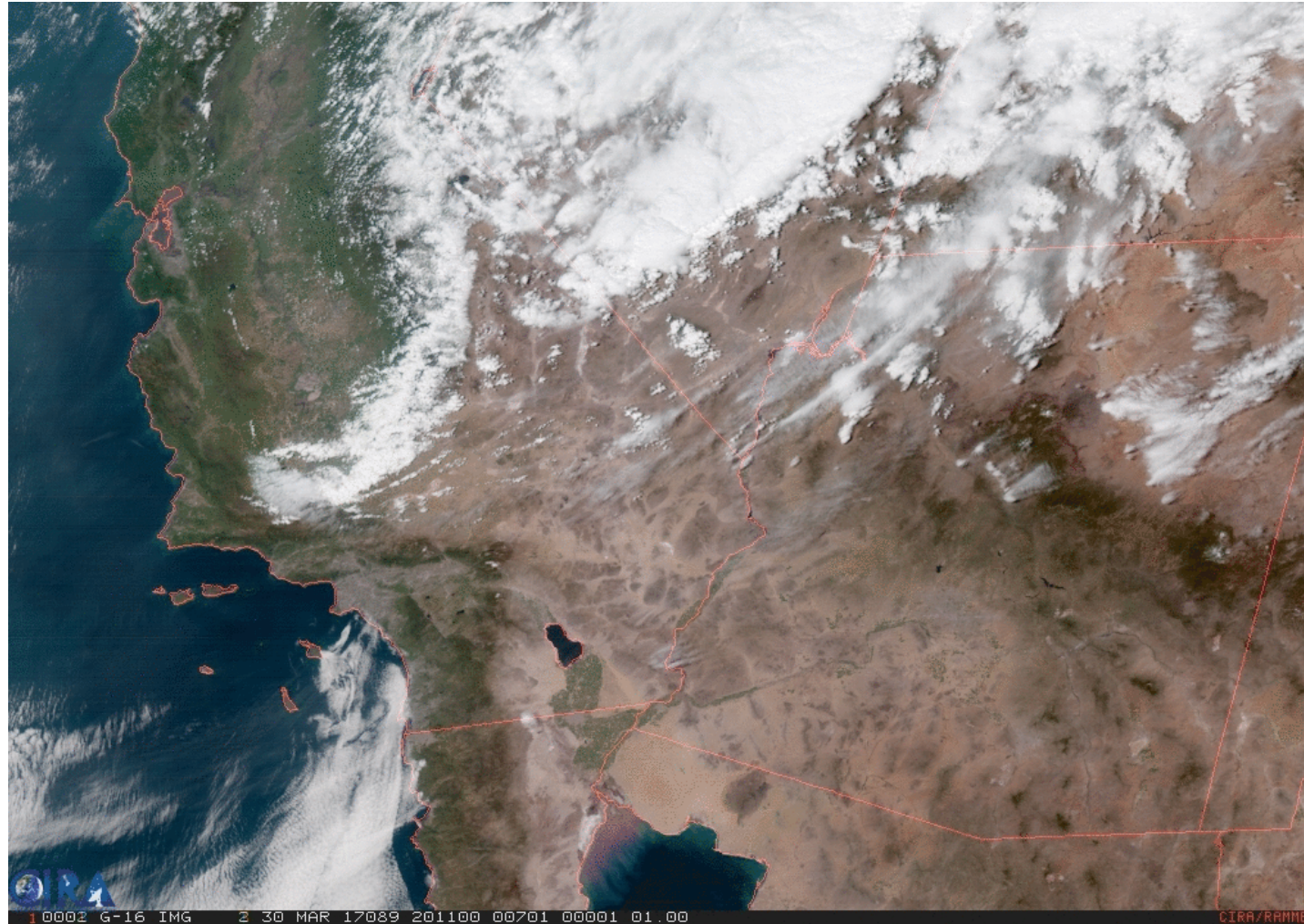
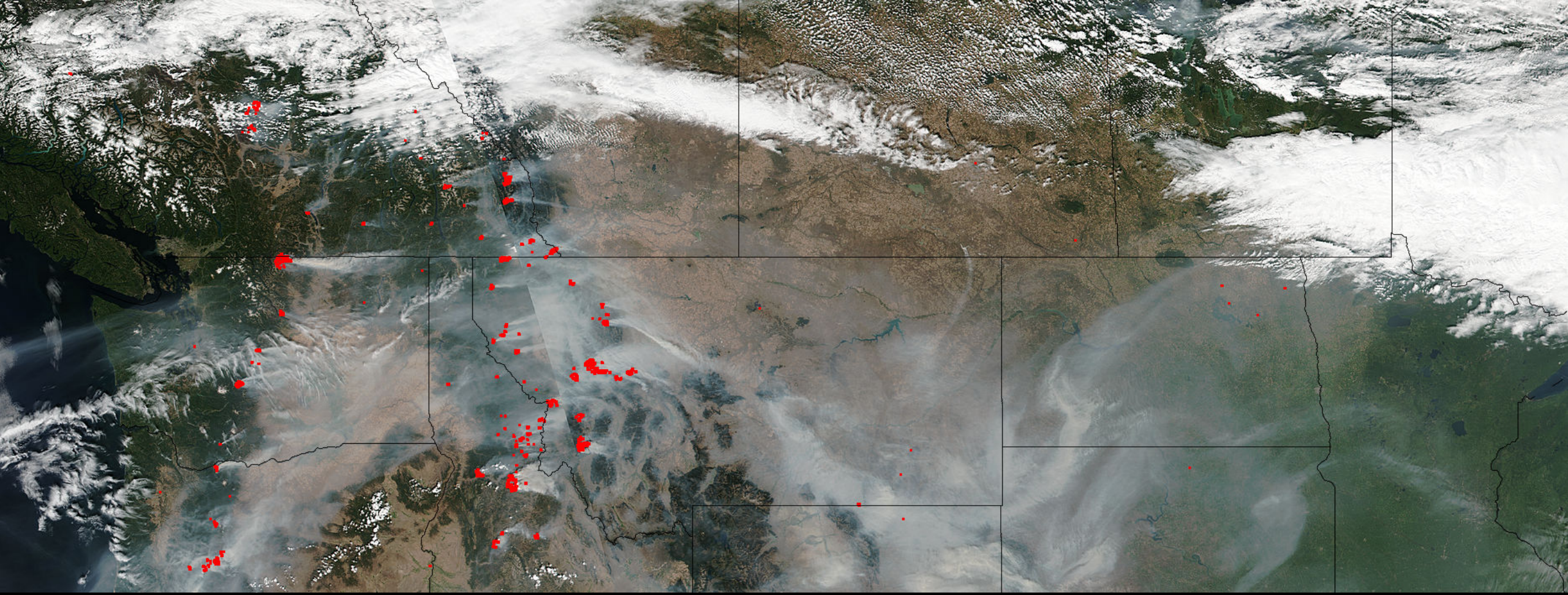


Image Credit: NOAA CoRP, STAR: [http://rammb.cira.colostate.edu/ramsdis/online/loop\\_of\\_the\\_day/](http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/)





## Upcoming Missions

# Global pollution monitoring constellation (2018-2020)

## Policy-relevant science and environmental services enabled by common observations

- Improved emissions, at common confidence levels, over industrialized Northern Hemisphere
- Improved air quality forecasts and assimilation systems
- Improved assessment, e.g., observations to support the United Nations Convention on Long Range

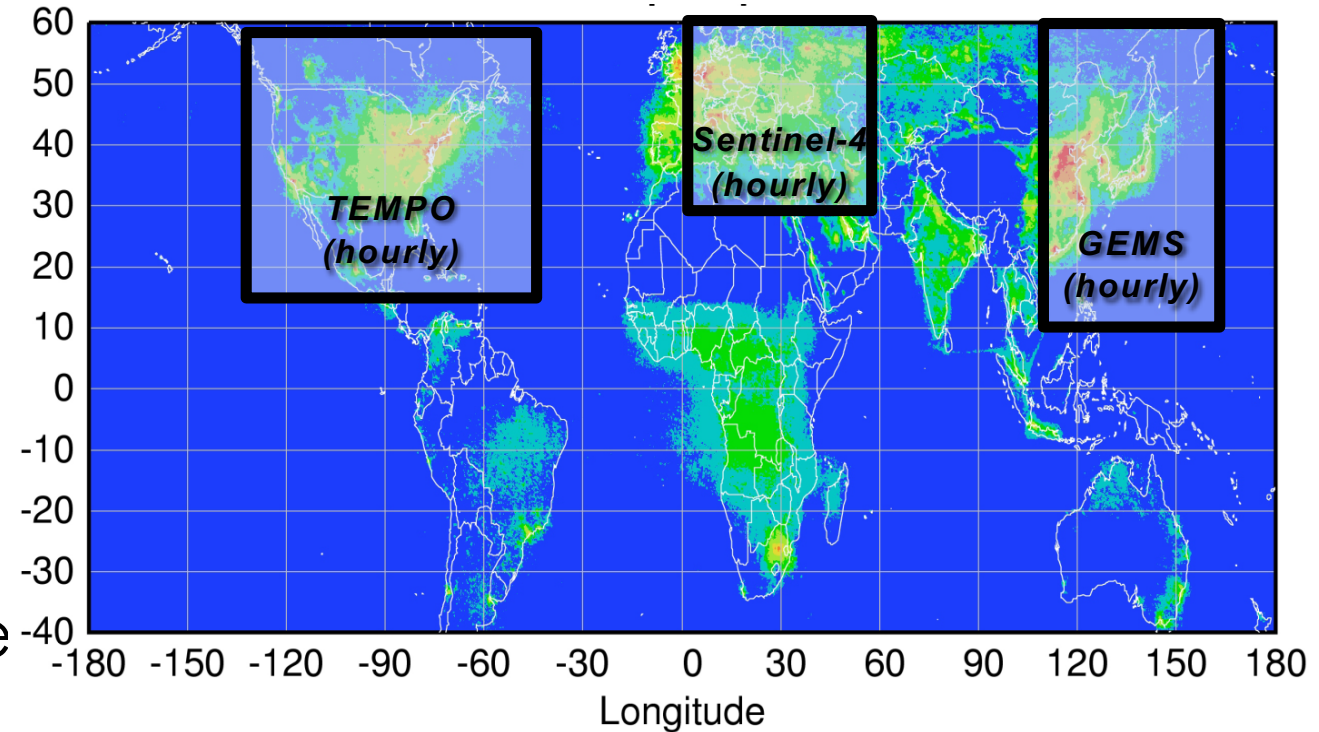
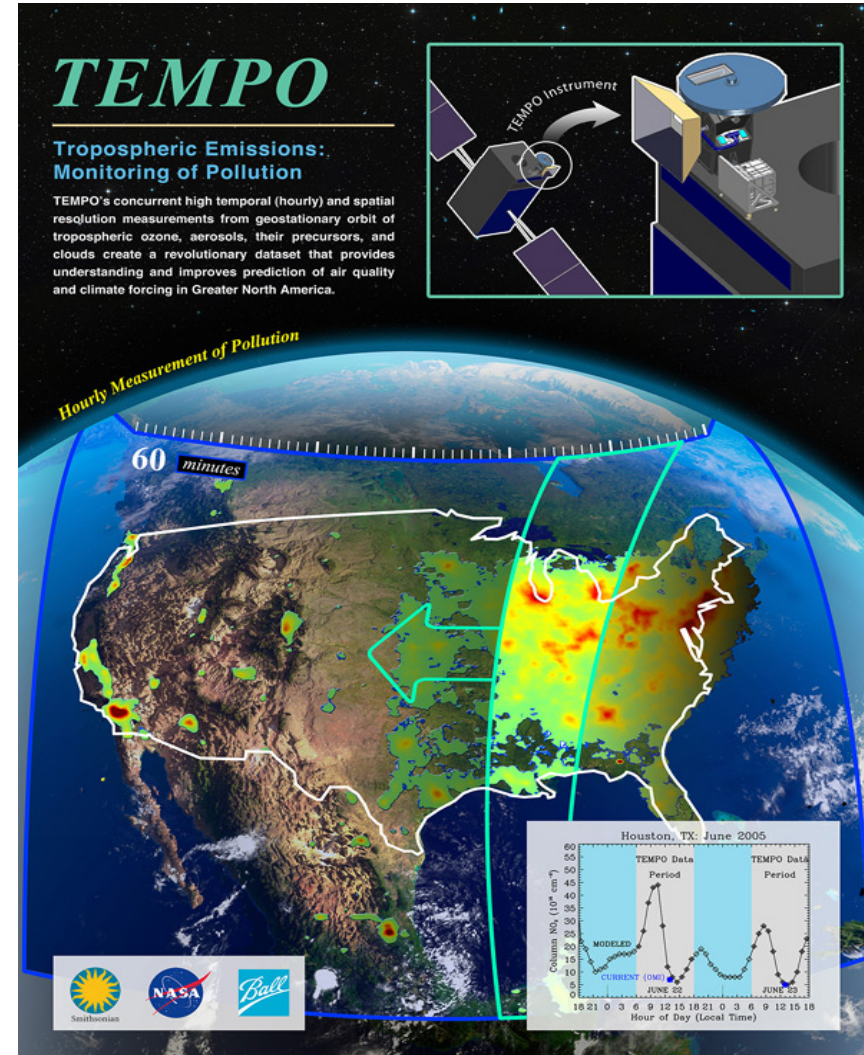


Image Credit: Courtesy Jhoon Kim, Andreas Richter



# TEMPO

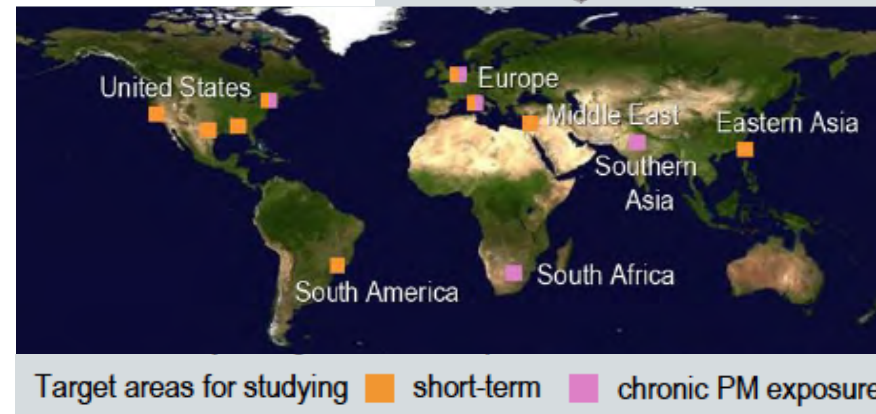
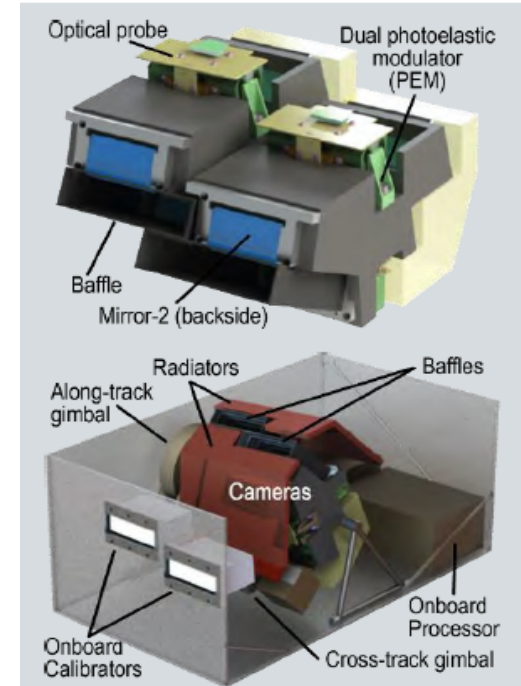
- Geostationary over North America
- High Temporal Resolution
  - 1 hr
- High Spatial Resolution
  - 2.2 x 4.7 km
- Spectral Range
  - 290-740nm
- Data Products:
  - O<sub>3</sub>, NO<sub>2</sub>, C<sub>2</sub>H<sub>2</sub>O<sub>2</sub>, aerosols, cloud parameters, & UVB radiation
- Expected Launch: 2021





# Multi-Angle Imager for Aerosols (MAIA)

- Mission Goal: Assess linkages between different airborne particulate matter types and adverse birth outcomes, cardiovascular and respiratory disease, and premature deaths
- Sun synchronous orbit
- Spatial Resolution: 230 m
- Large Swath Width: 600 km
- Expected Launch: 2021



# Can satellites help fill some of the data gaps?

What are the advantages of polar orbiting satellites compared to geostationary satellites and vice-versa?

