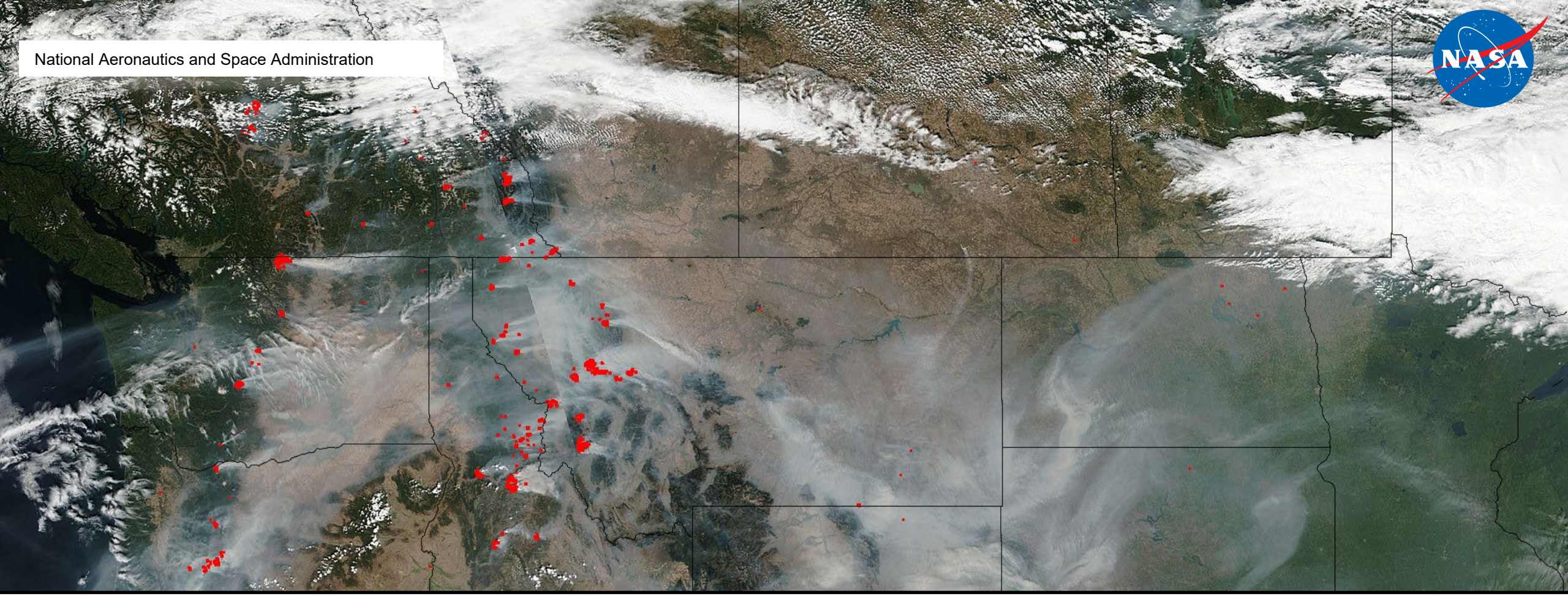
National Aeronautics and Space Administration



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

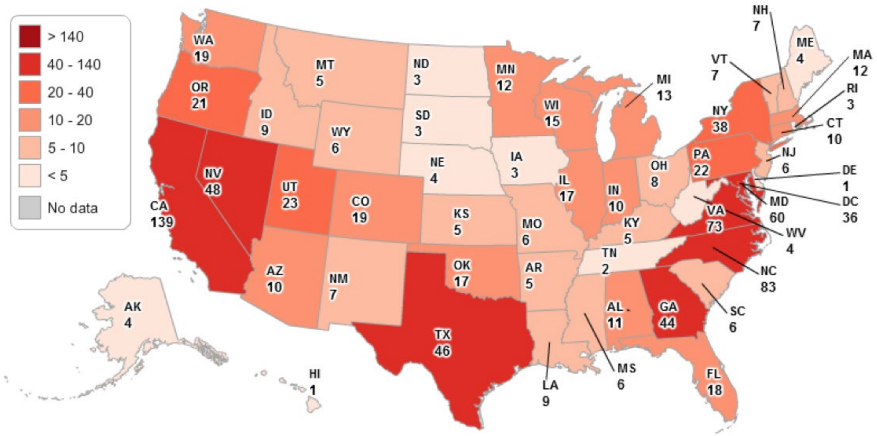
17 online trainings

75 countries

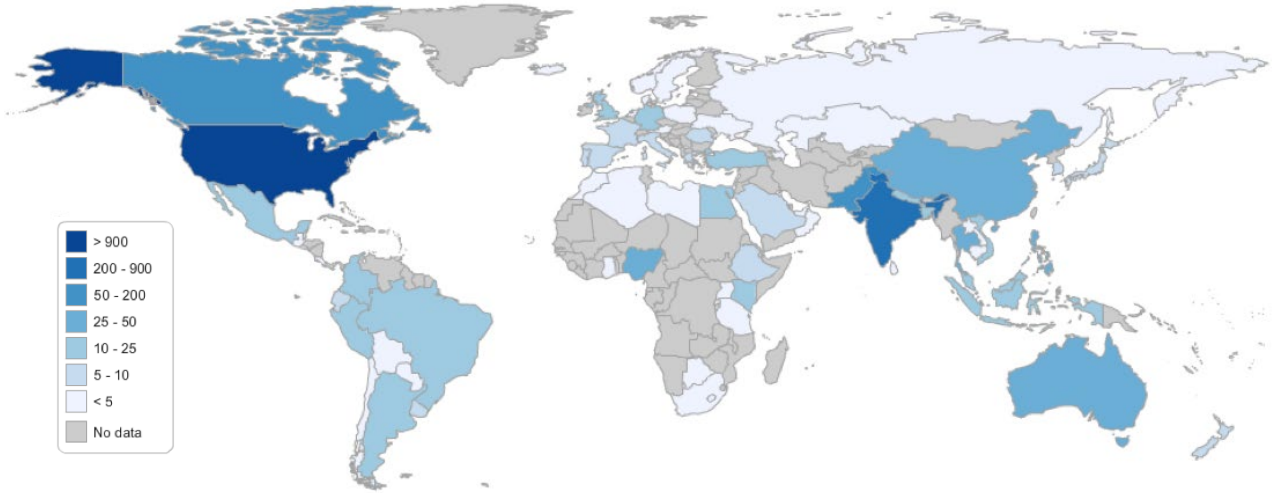
38 in-person trainings

836 organizations

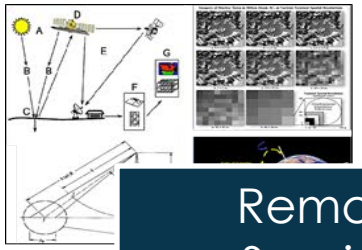
US Health & Air Quality Participants



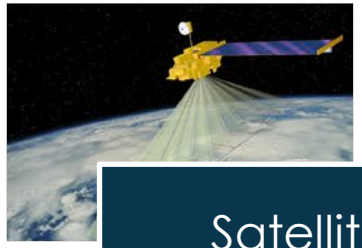
Global Health & Air Quality Participants



ARSET Air Quality Trainings

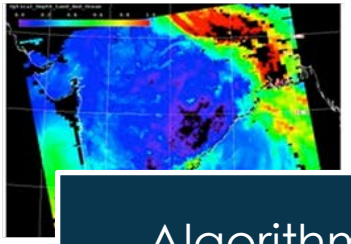


Remote Sensing

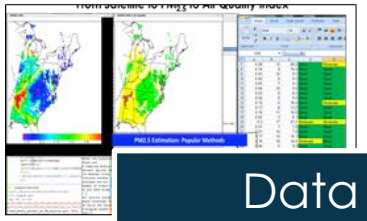


Satellites

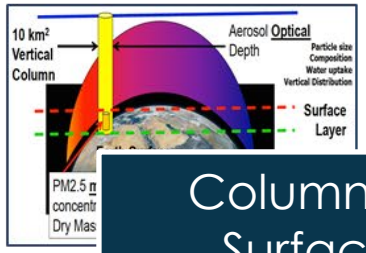
Imagery



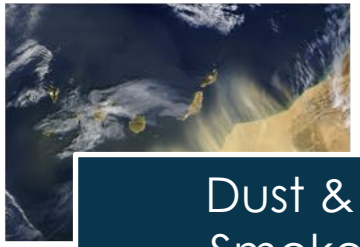
Algorithms



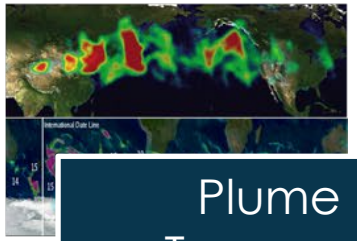
Data & Tools



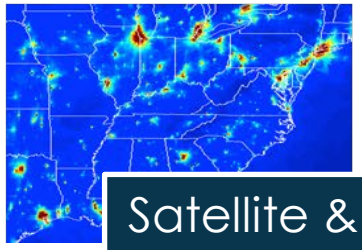
Column to Surface



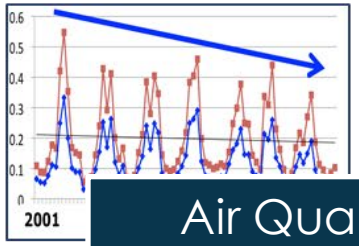
Dust & Smoke



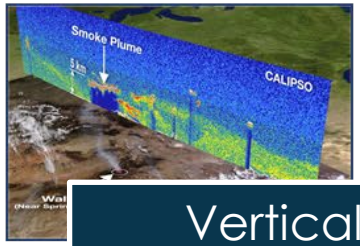
Plume Transport



Satellite & Model Comparison



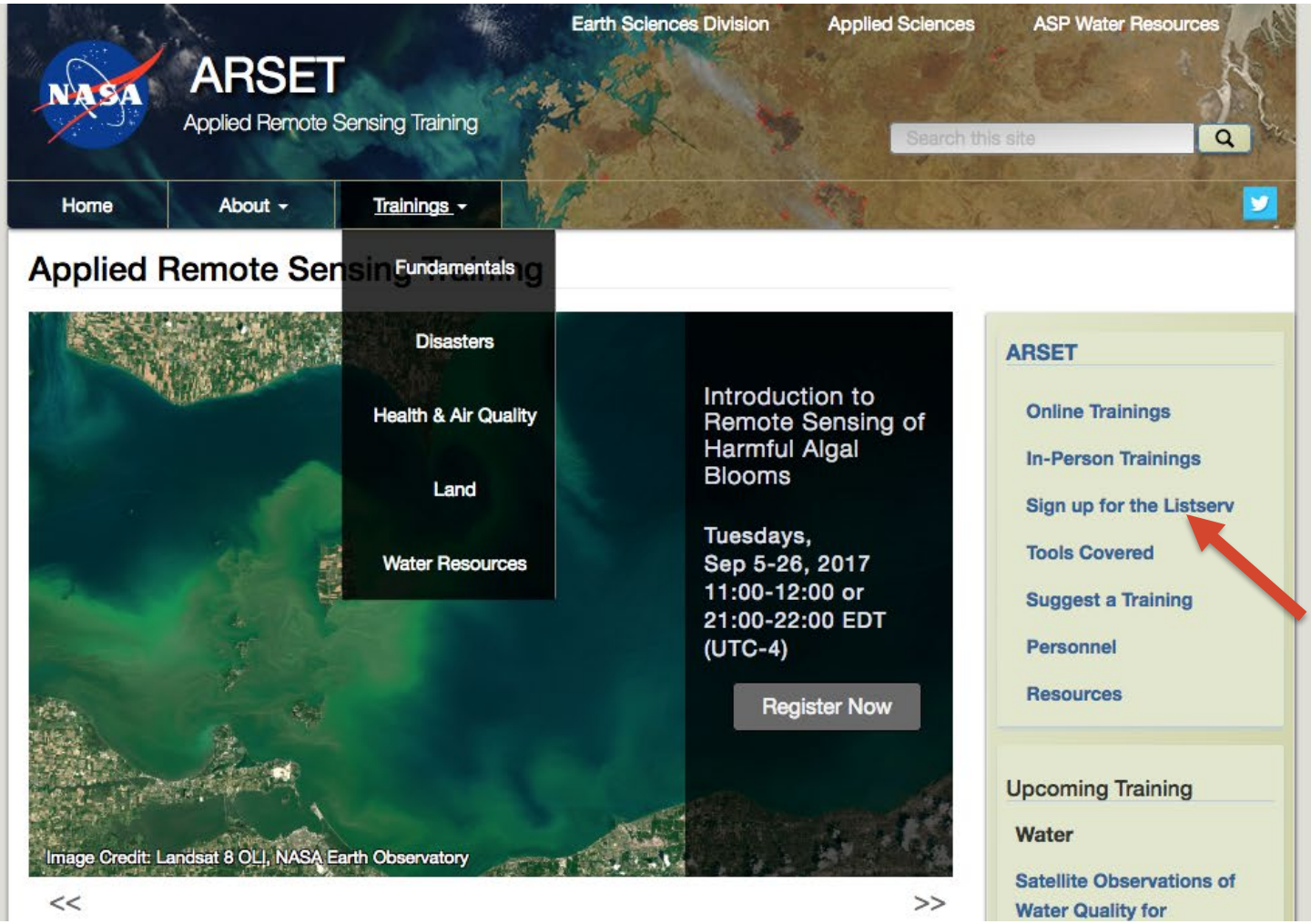
Air Quality Trends



Vertical Profiles

Learn More About ARSET

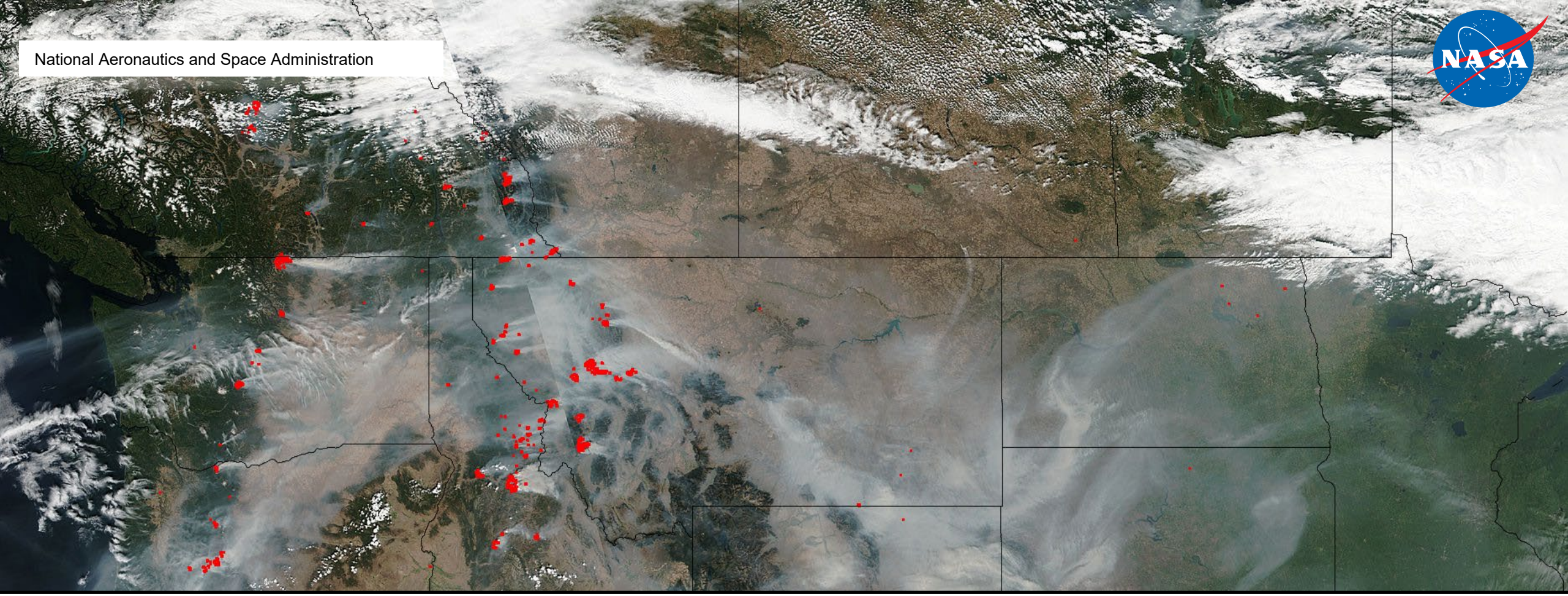
http://arset.gsfc.nasa.gov/



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
  - $PM_{2.5}$ Estimations
  - $PM_{2.5}$ Data Sets
  - $PM_{2.5}$ Applications
  - CALIPSO & CATS
  - Geostationary
- **Day 3**
  - USFS
  - Air Quality Forecast
  - Reanalysis Data Sets
  - Future Missions
  - Case Study Analysis

National Aeronautics and Space Administration



Overview of Satellite Capabilities for Air Quality Monitoring

Pawan Gupta, and Melanie Follette-Cook

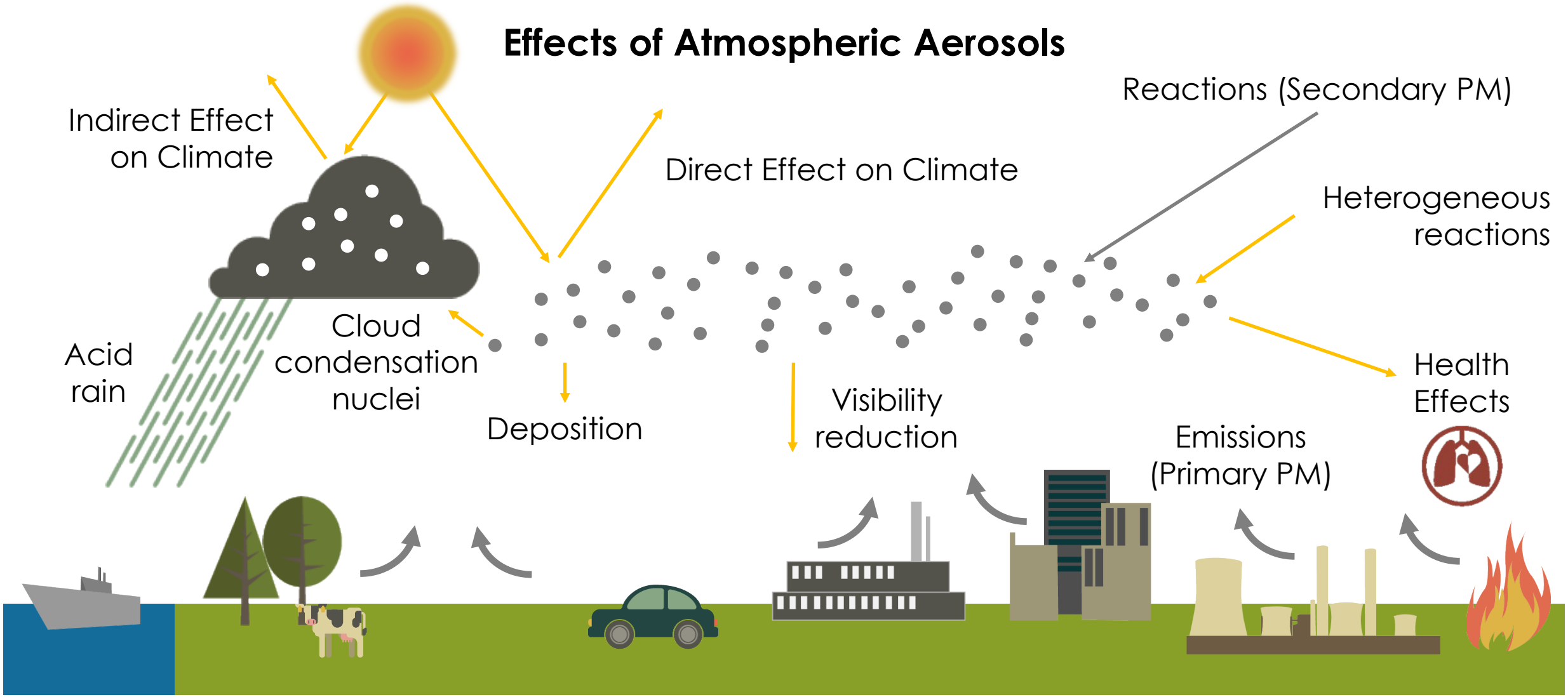
Satellite Remote Sensing of Dust, Fires, Smoke, and Air Quality, July 10-12, 2018

Learning Objectives

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

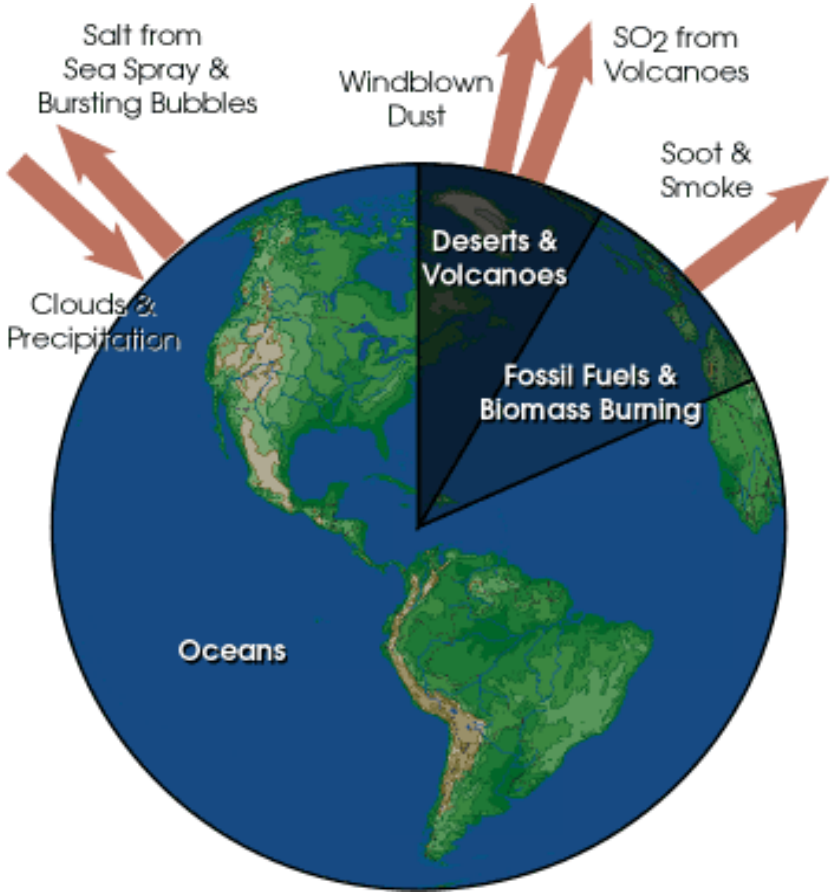
- Describe existing satellite capabilities for global air quality monitoring
- Identify various air quality monitoring applications

Motivation: Tiny, but Potent

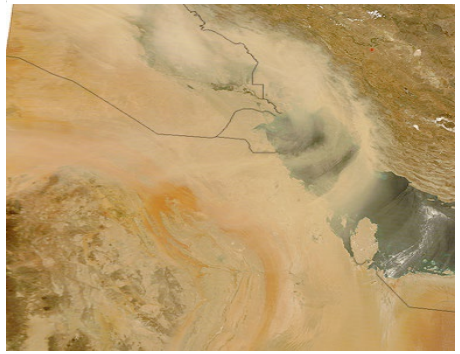


Pollution Sources

Atmospheric aerosols are highly variable in space and time



Dust

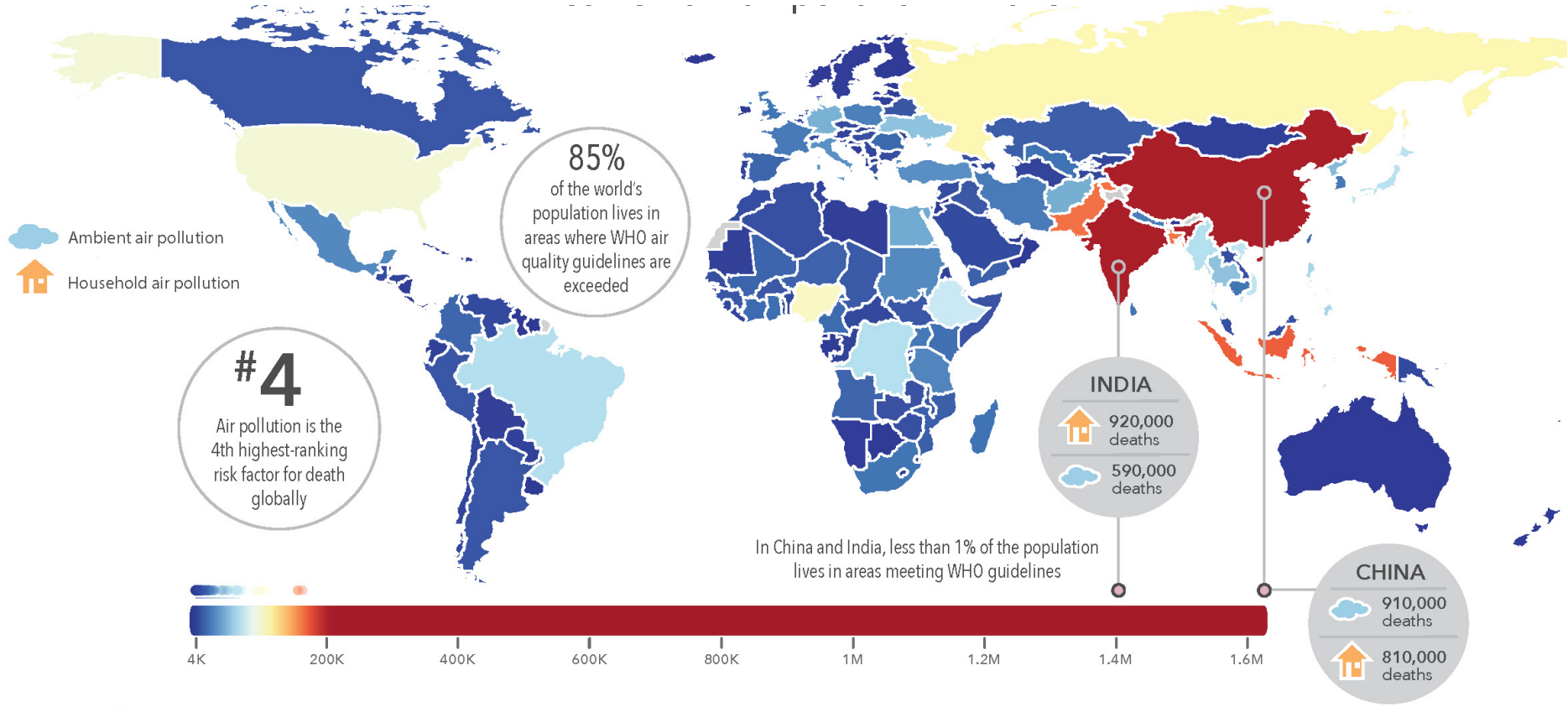


Volcanoes

Fossil Fuels & Biomass Burning

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://thelancet.com/gbd/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

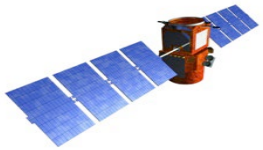
www.aqicn.org

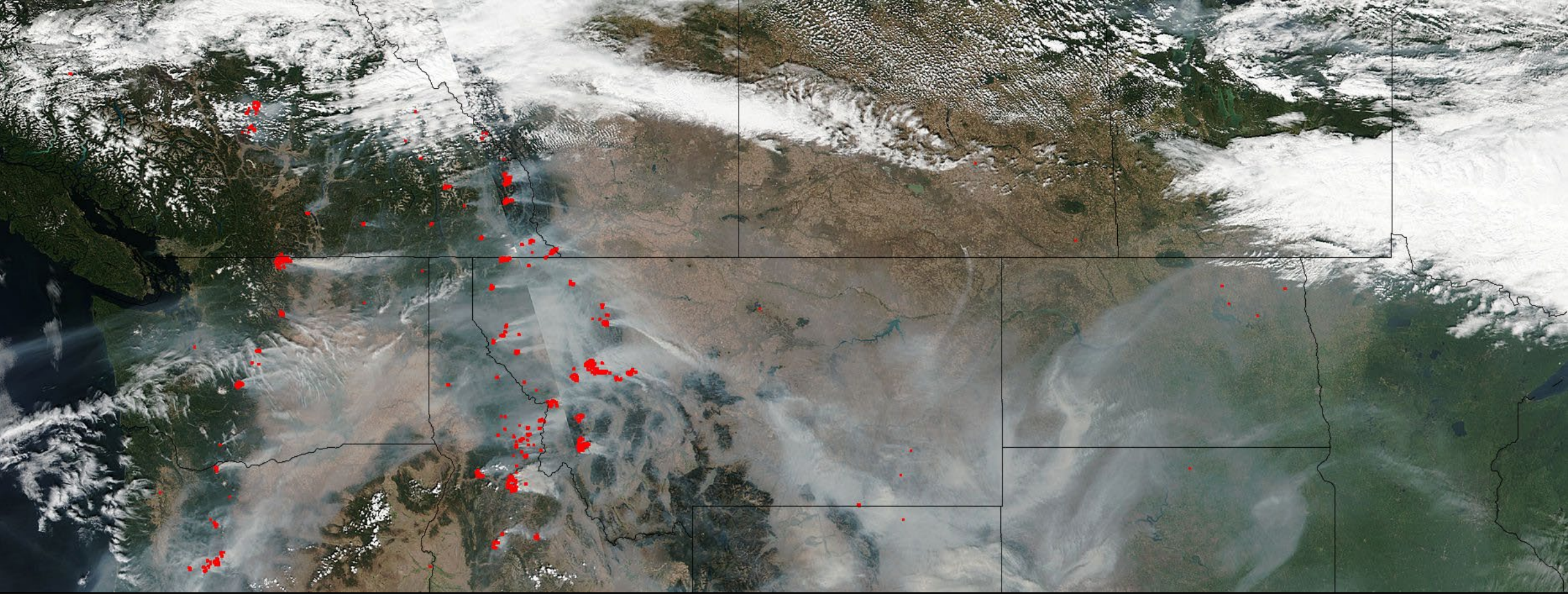
Air Pollution Monitoring

Ground Measurements

Air & Space Observations

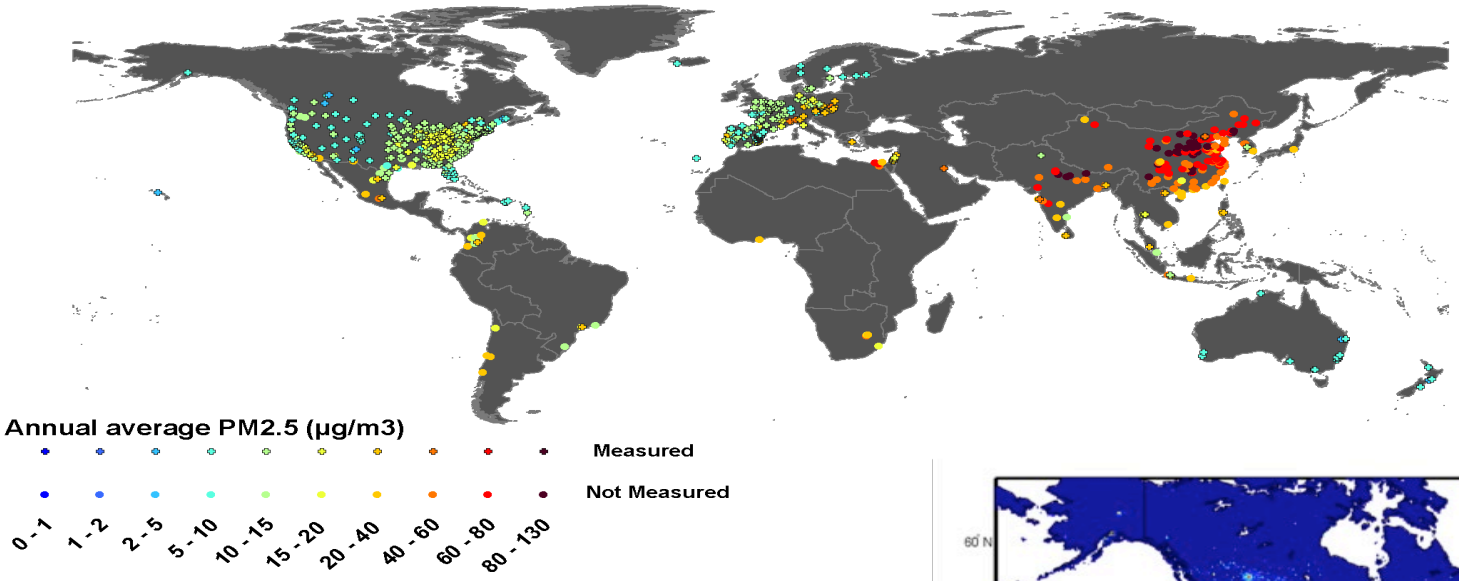
Models





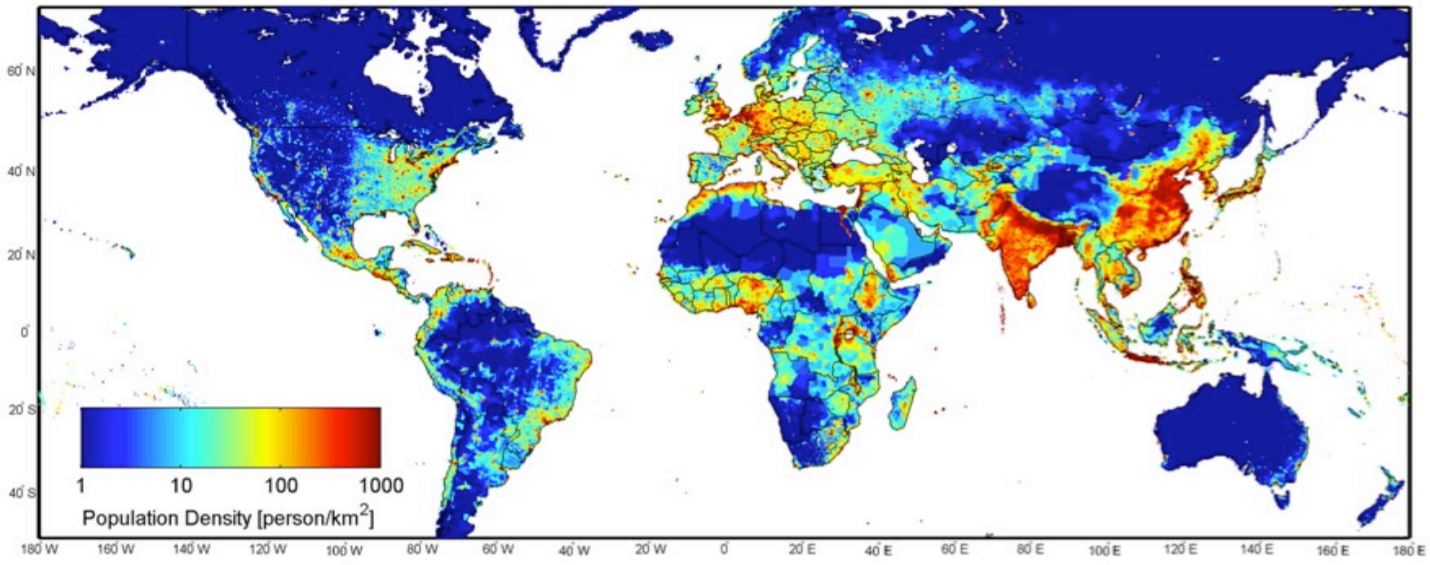
Why use satellite data?

Global Status of $PM_{2.5}$ Monitoring



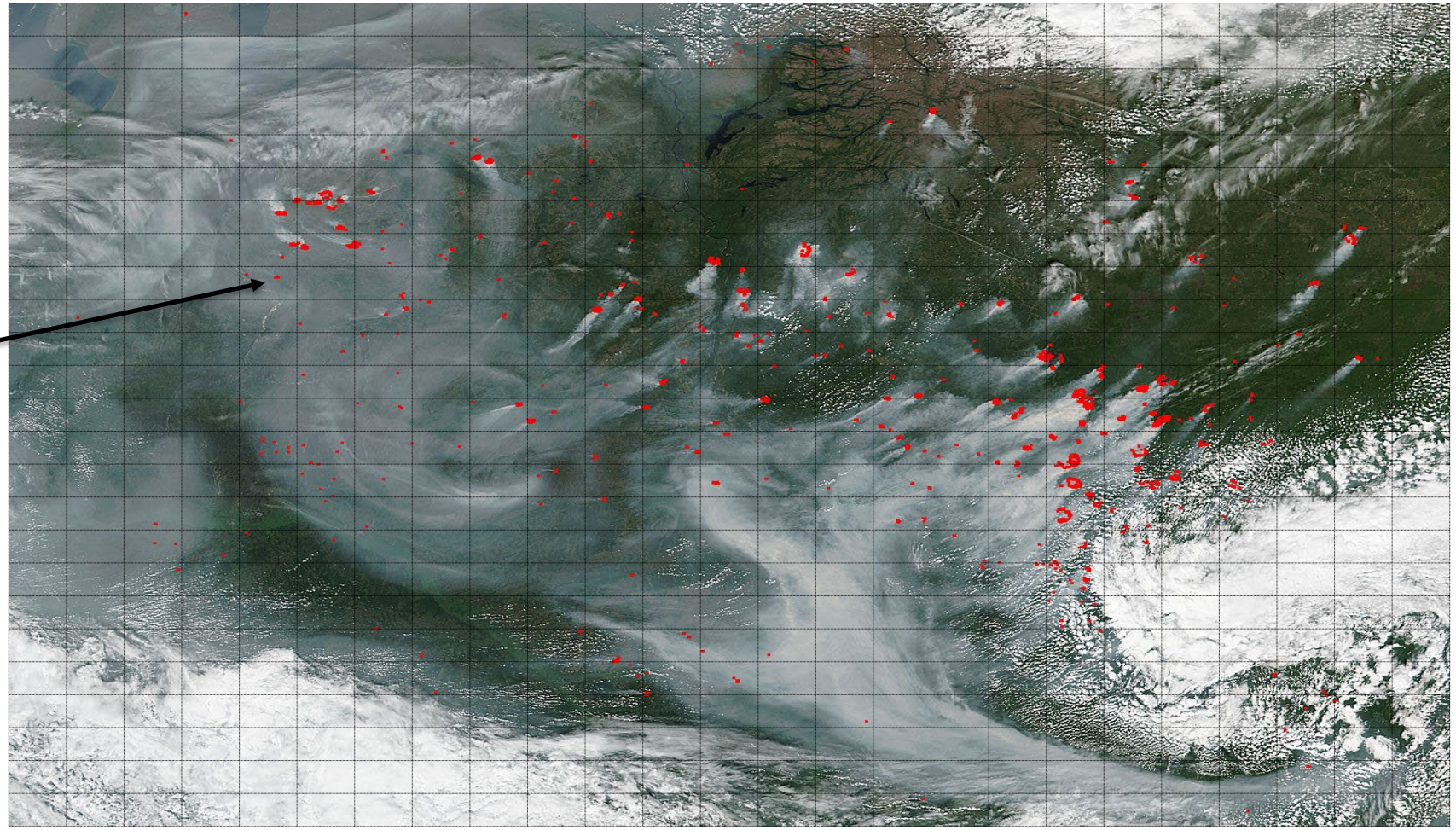
Ground Sensor Network

Population Density



“A Picture is Worth a Thousand Words”

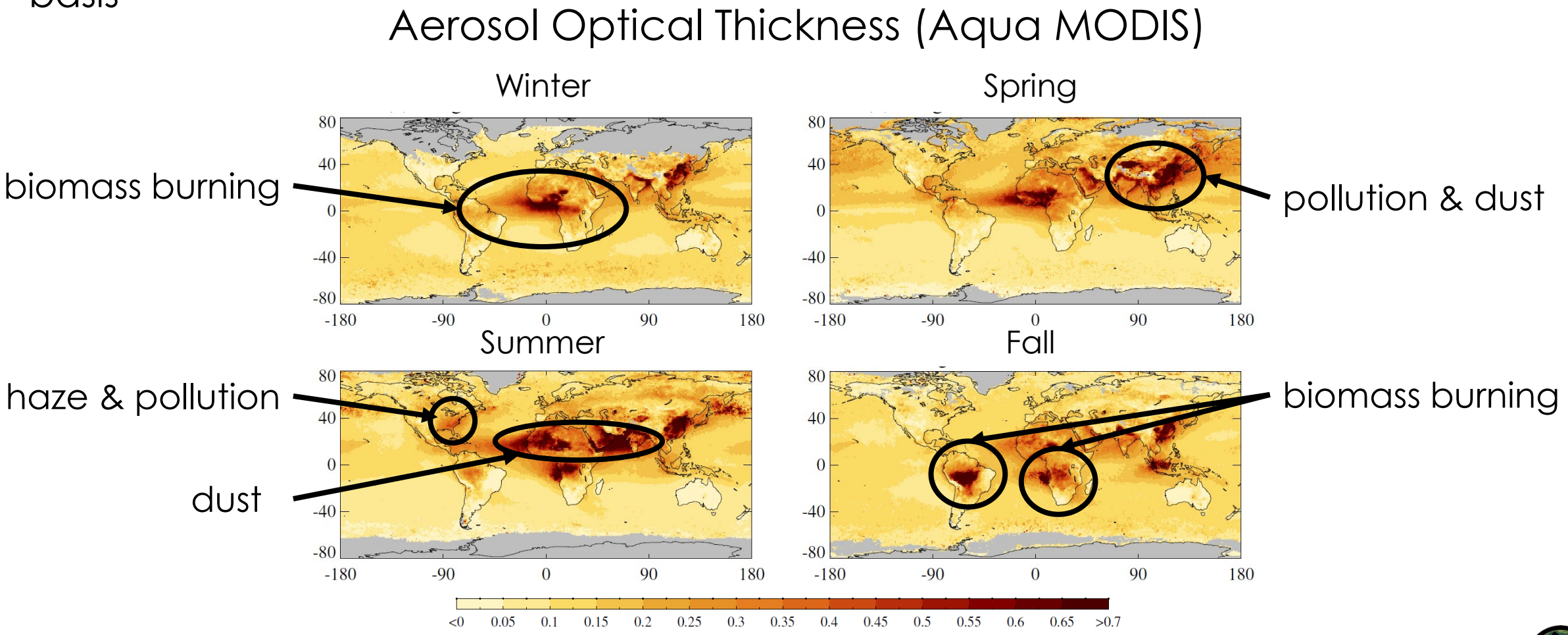
A satellite picture is worth ~~a~~ **millions of data points**



A geo-physical number

Aerosols from Satellites

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



Nitrogen Dioxide (NO_2)

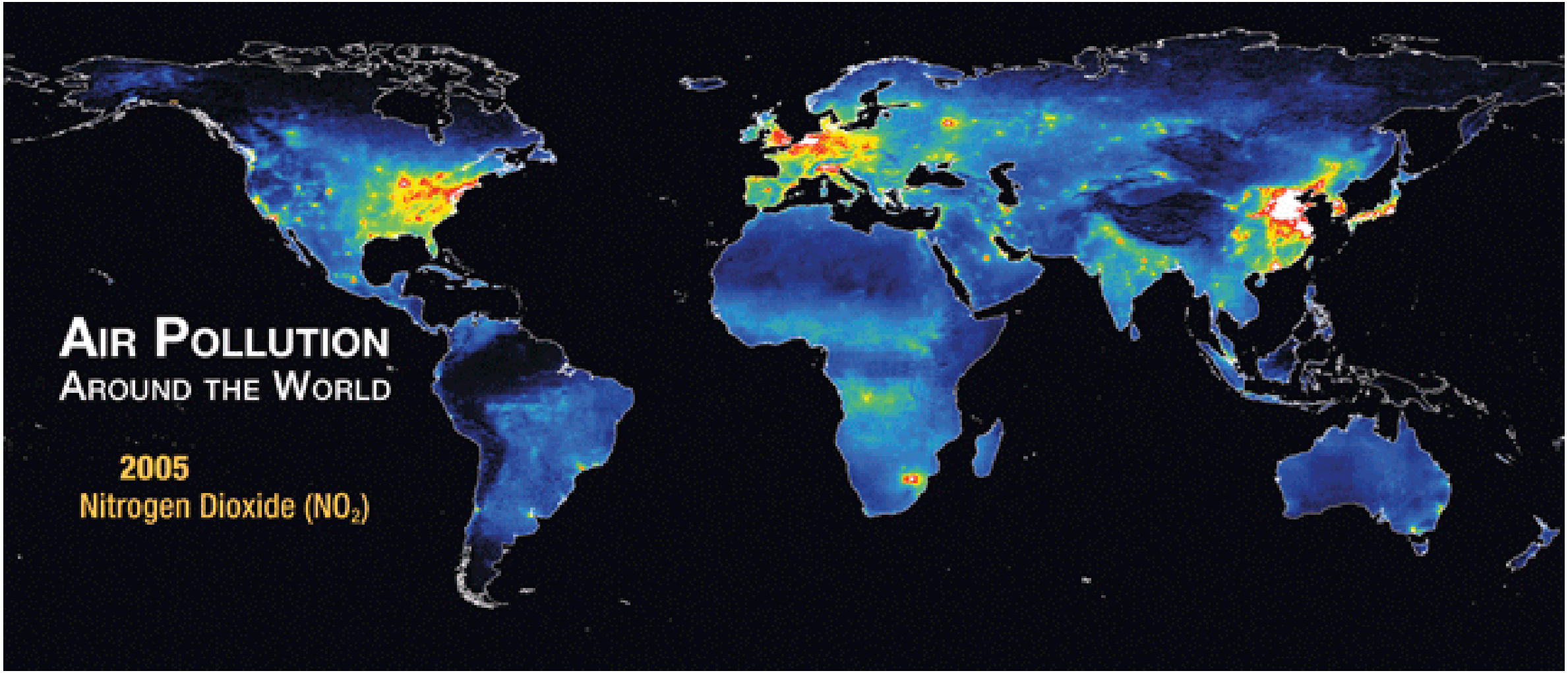


Image Source: https://aura.gsfc.nasa.gov/images/NASA_NO2_Global_FRONT.gif

Sulphur Dioxide (SO_2) – OMI - 2017

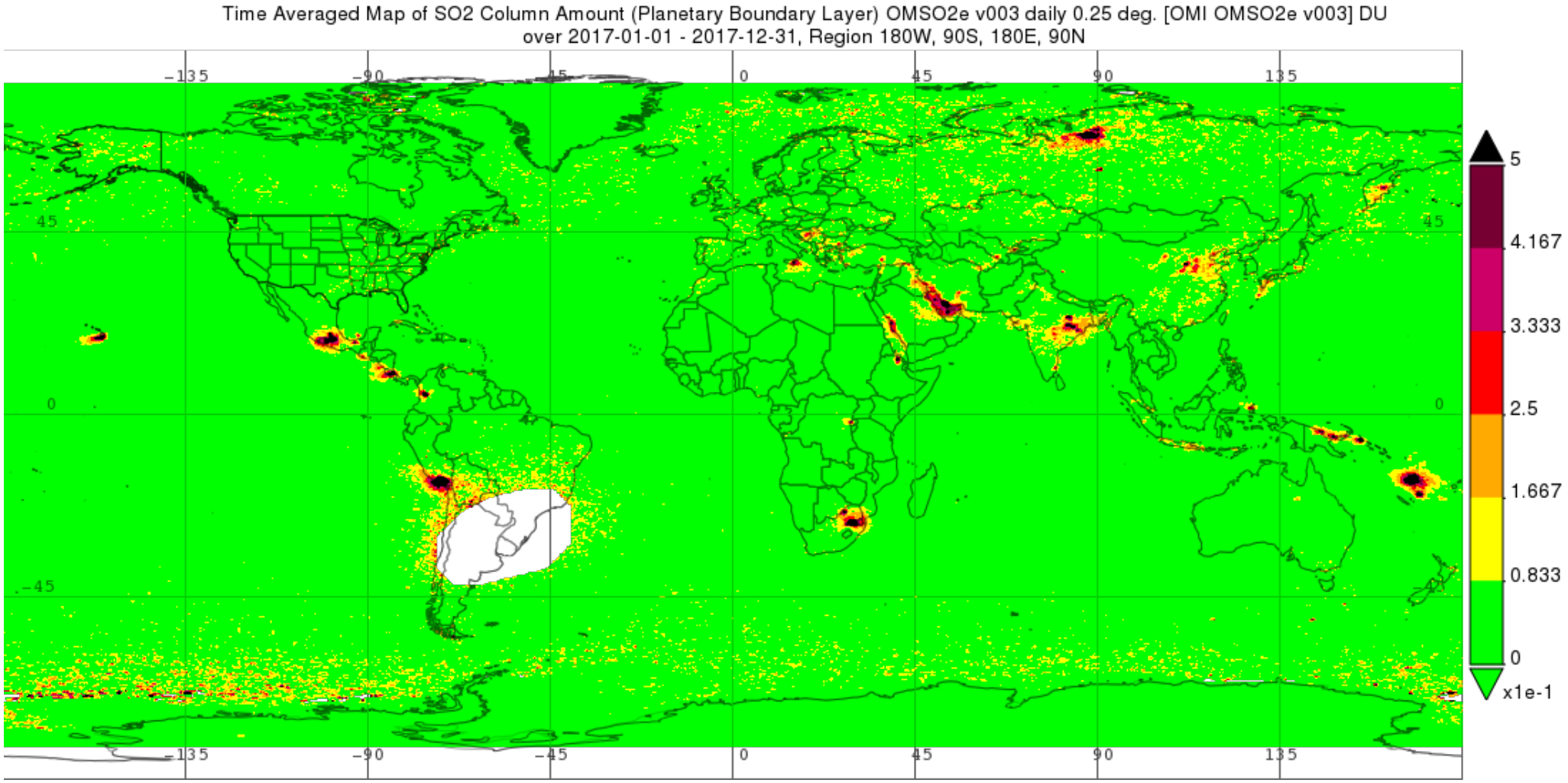
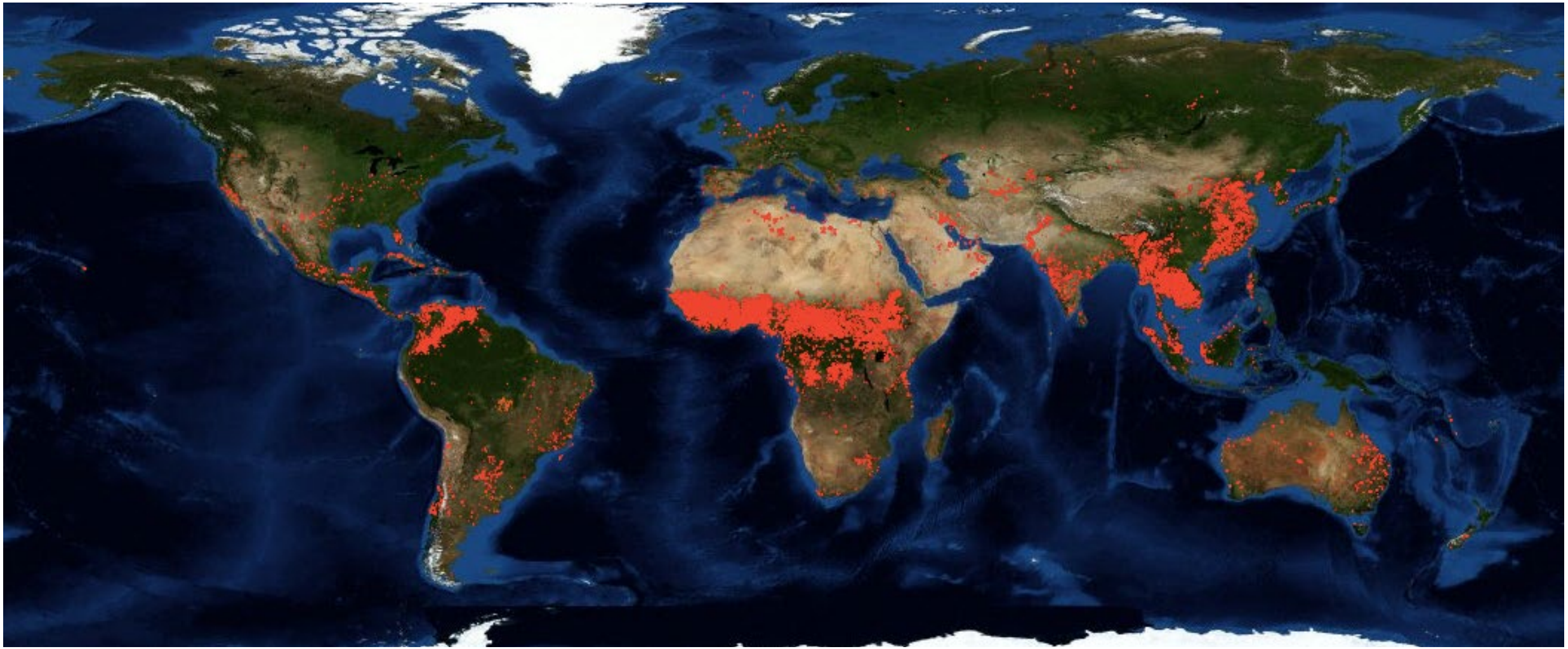


Image Credit: https://giovanni.gsfc.nasa.gov/

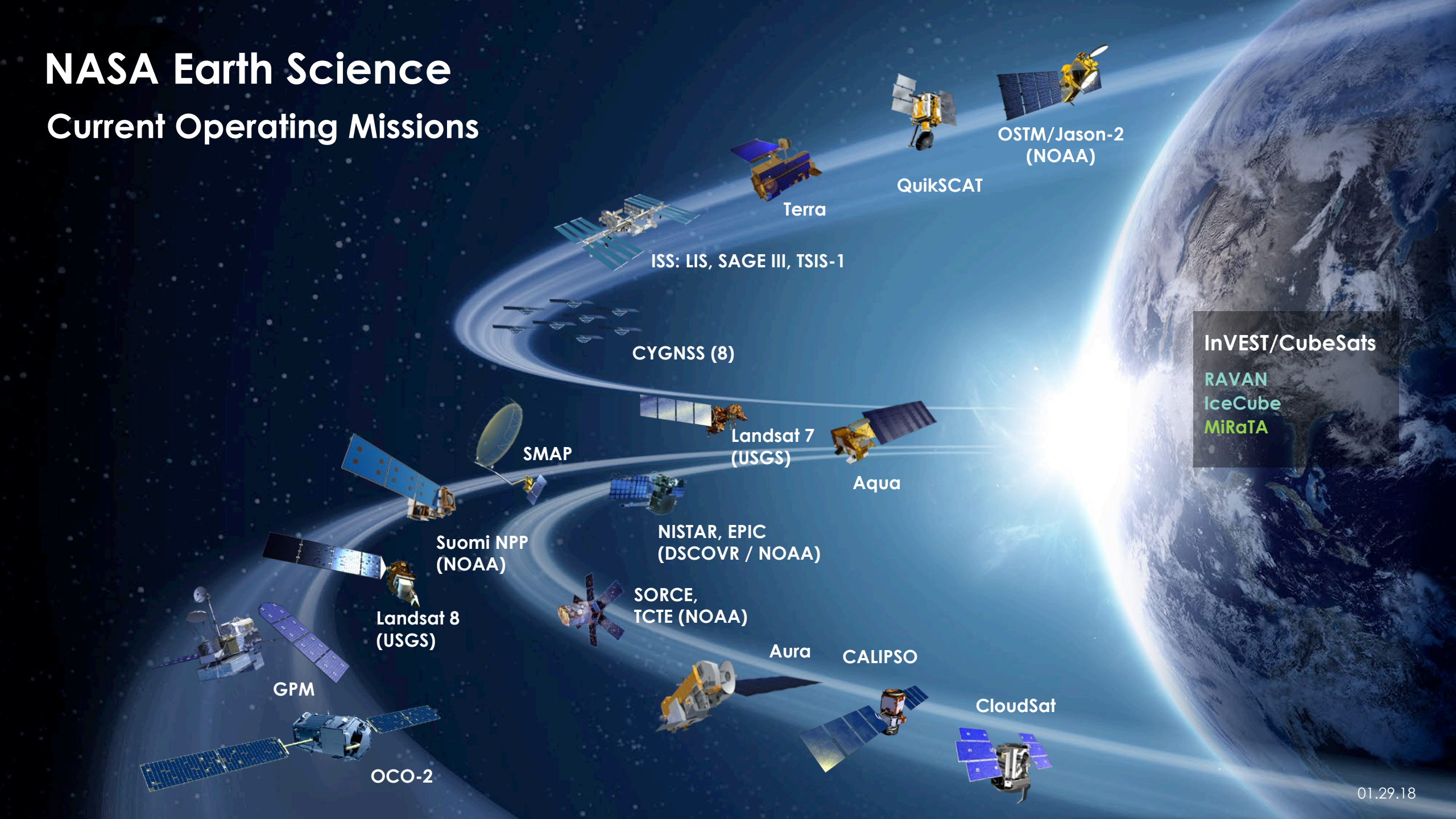
Active Fire Mapping – February 13, 2018



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

NASA Earth Science

Current Operating Missions



01.29.18

NASA Earth Science

Missions: Present Through 2023

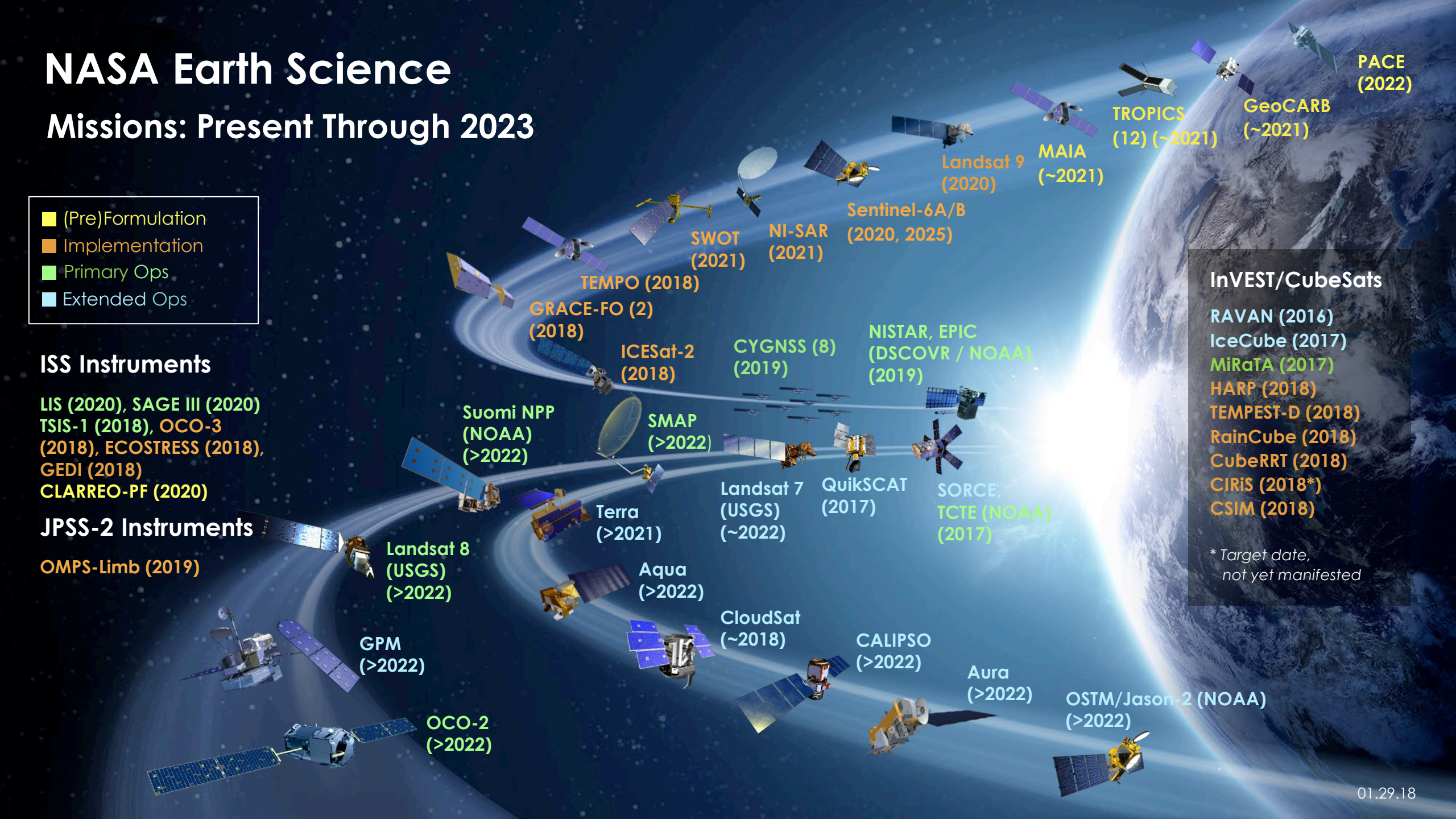
- (Pre)Formulation
- Implementation
- Primary Ops
- Extended Ops

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)

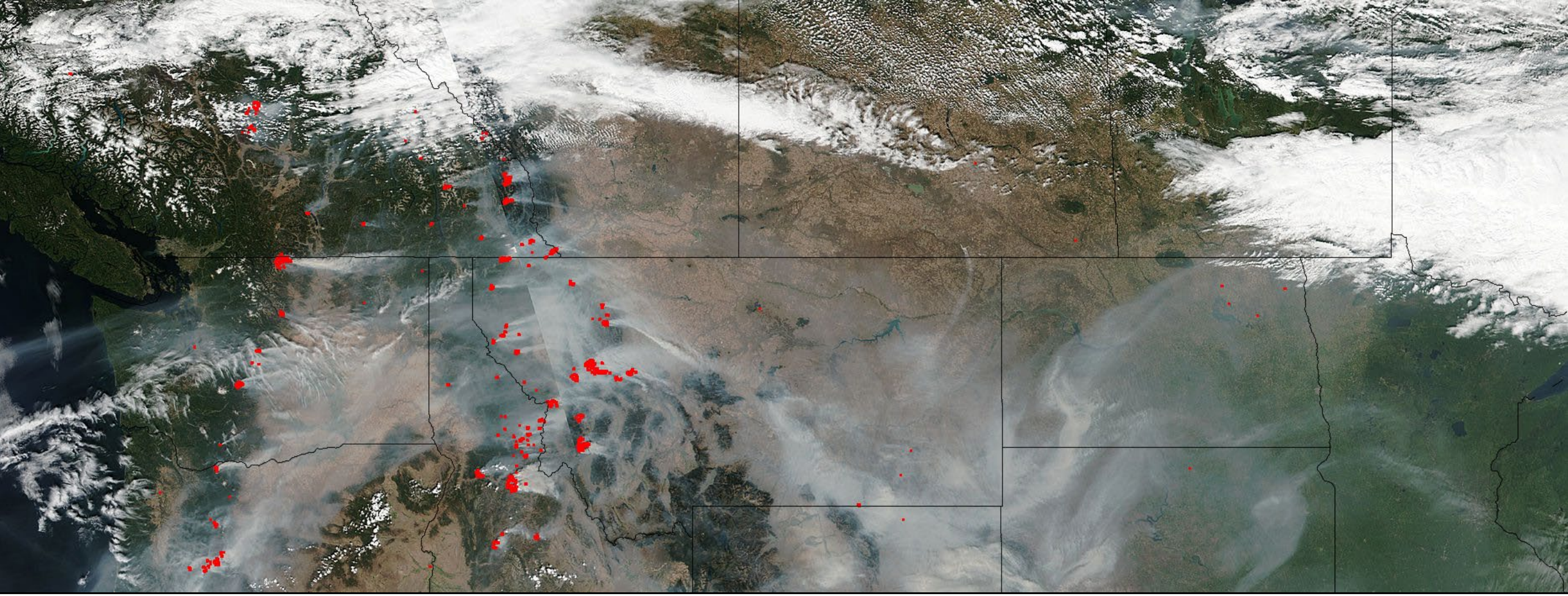


InVEST/CubeSats

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

** Target date, not yet manifested*

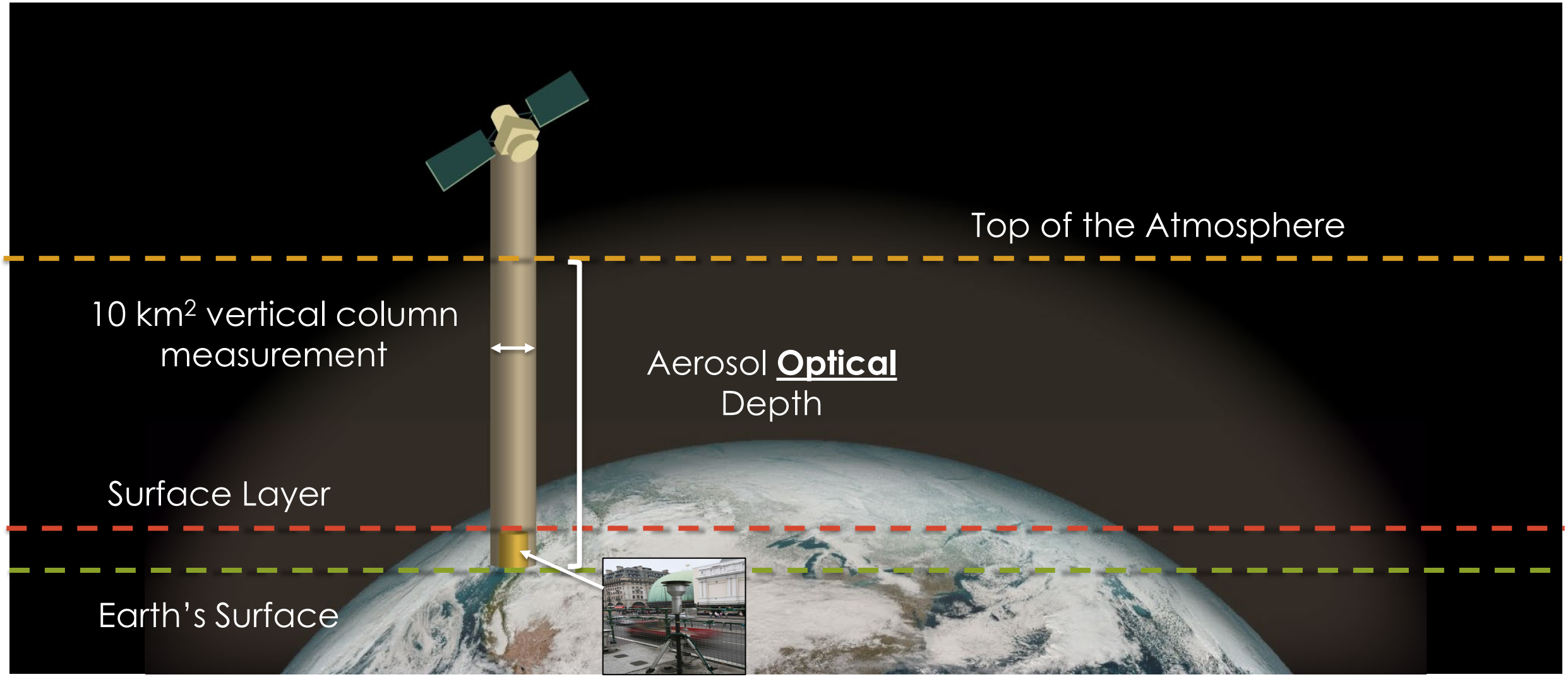
01.29.18



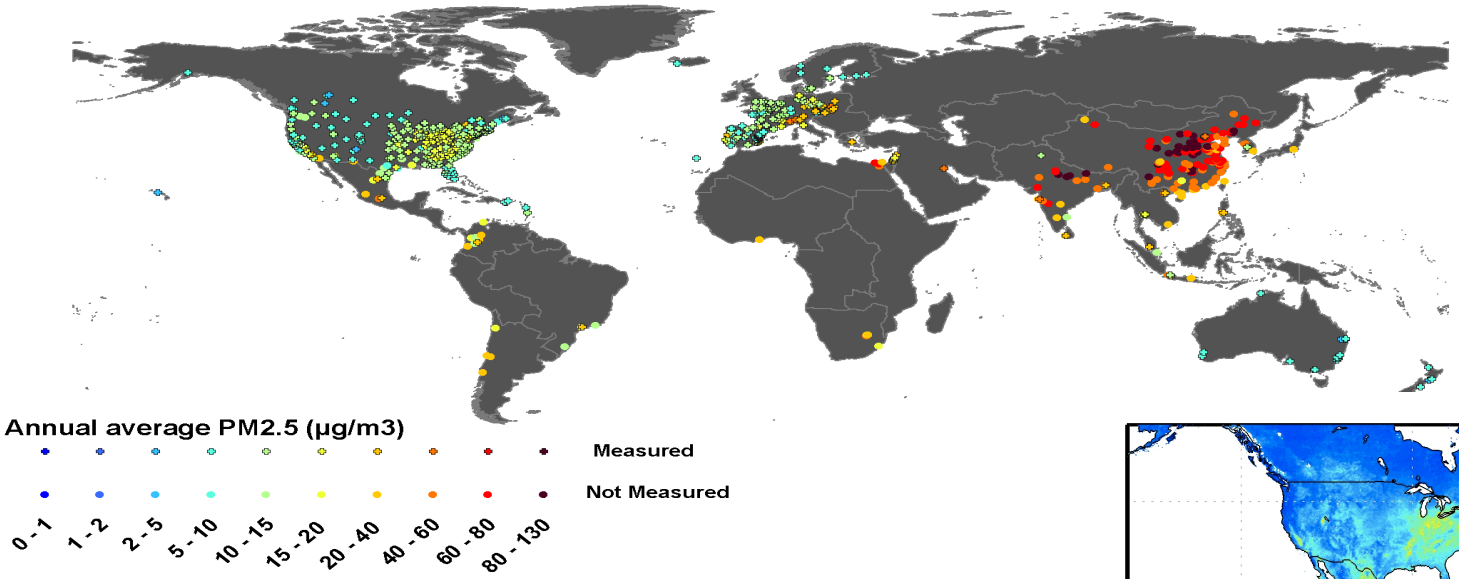
Air Quality Applications

Satellite vs. Ground Observation

Satellite vs. Ground Observation

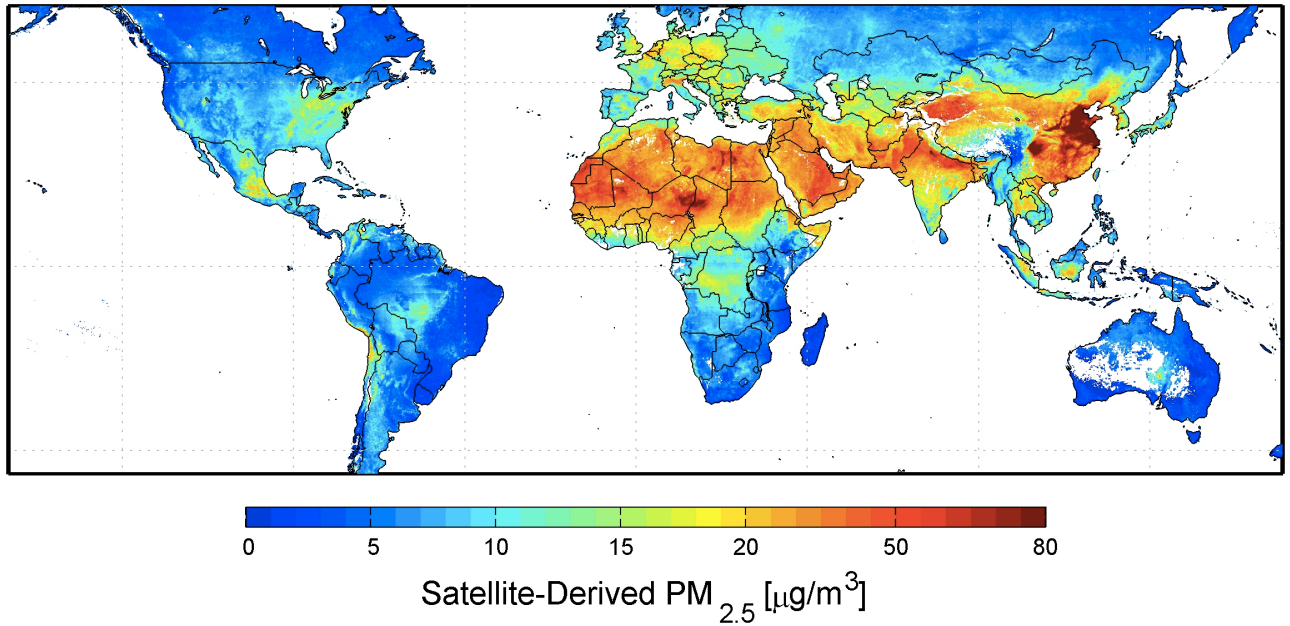


Global Status of $PM_{2.5}$ Monitoring



Ground Sensor Network

Satellite Estimated $PM_{2.5}$

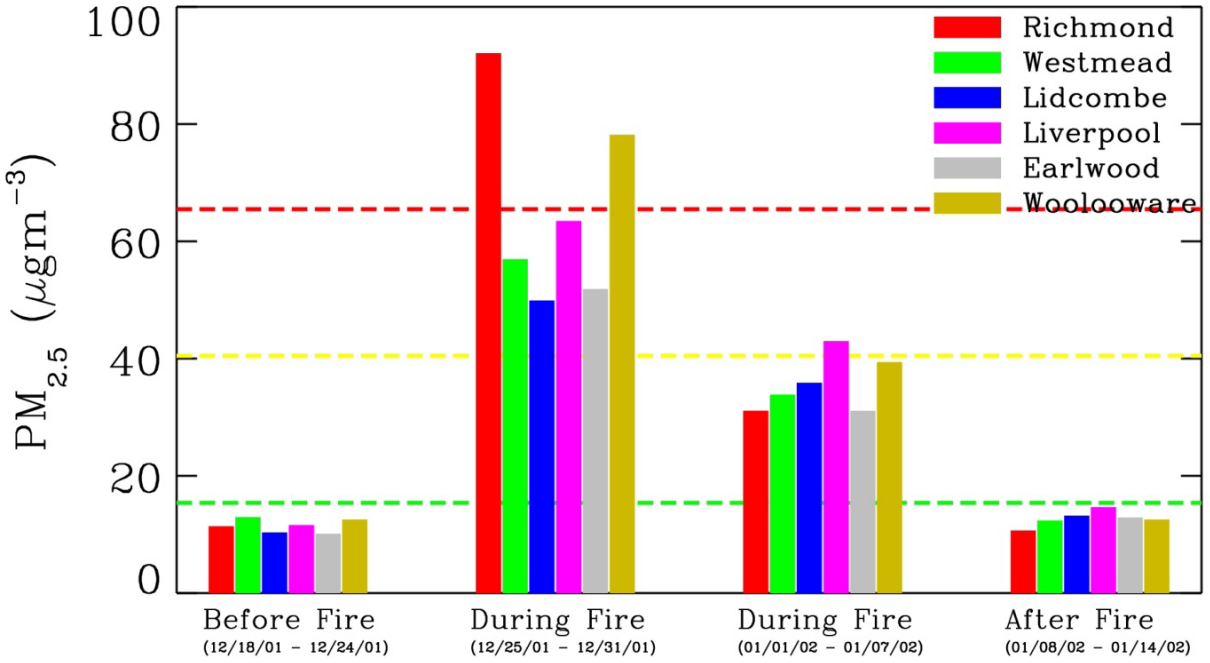


Credit: van Donkelaar et al., 2010

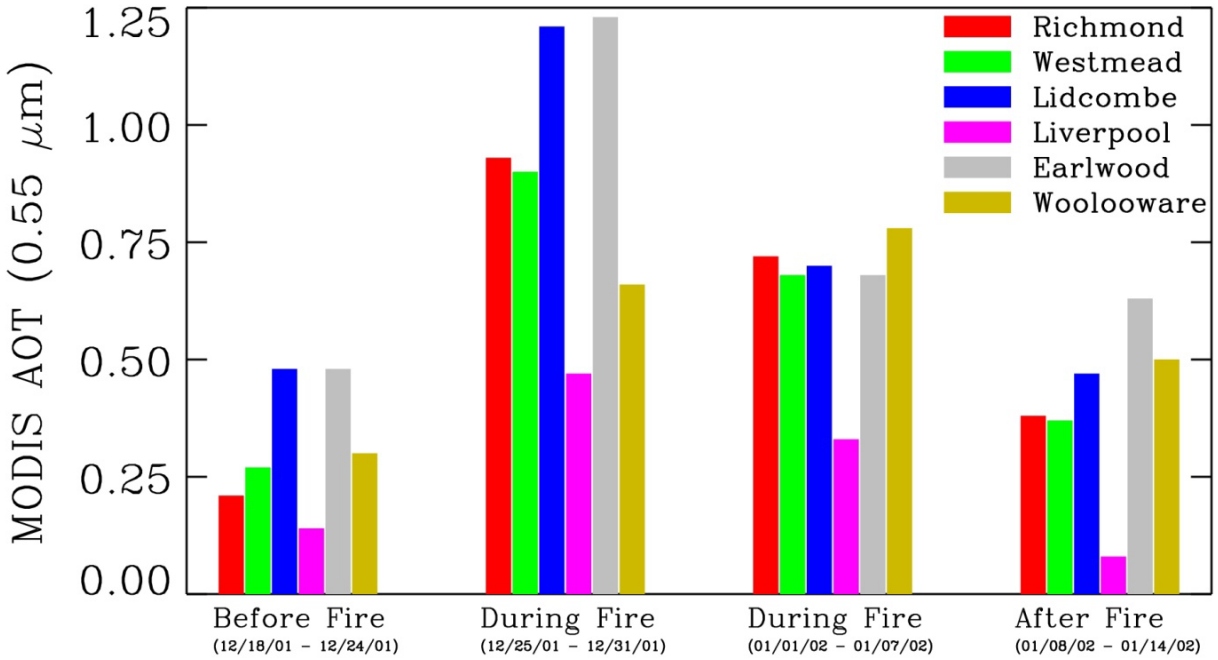
Application of Satellite Observations

Bushfires in Sydney, Australia

Surface $PM_{2.5}$

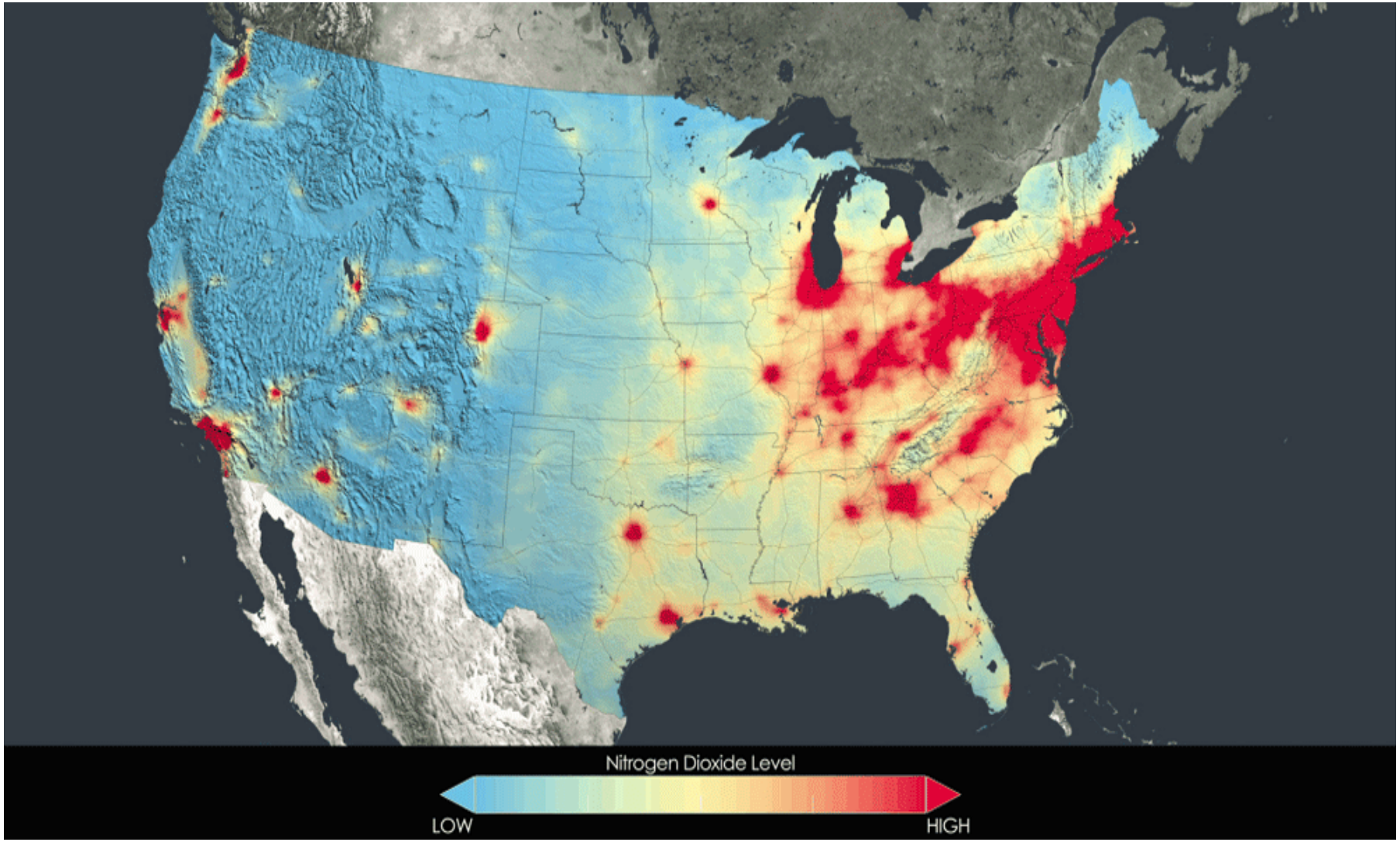


AOD from Satellites



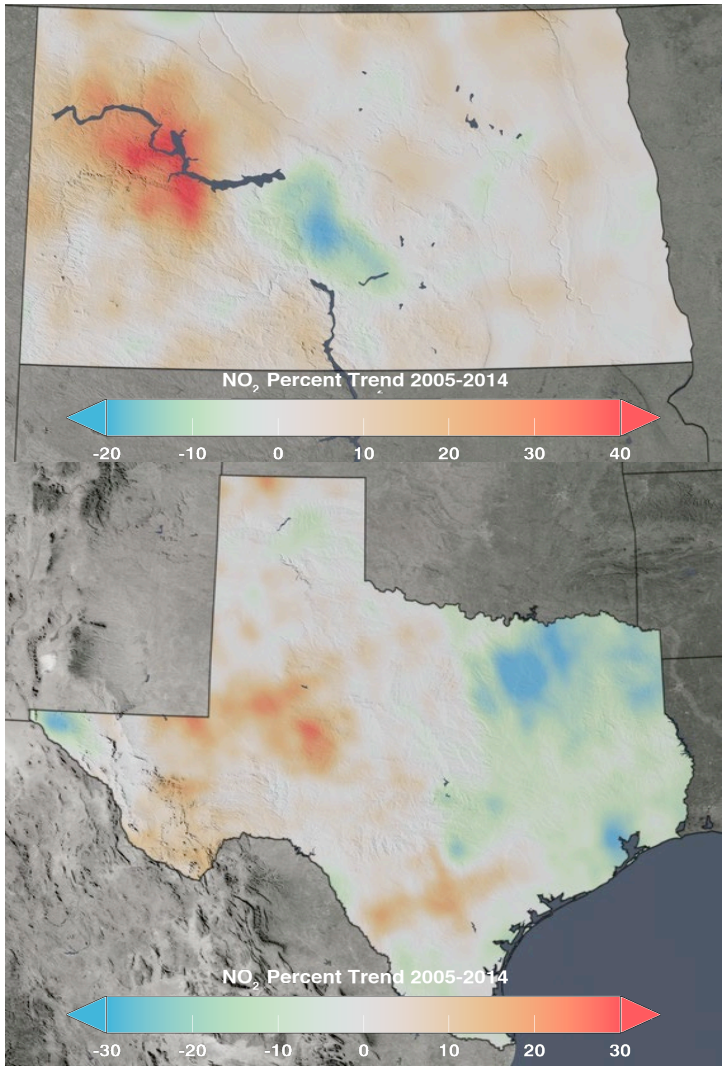
Credit: Gupta and Christopher, 2007

NO_2 Trends Over the United States



OMI Detects NO_2 Increases from ONG Activities

2005 - 2014

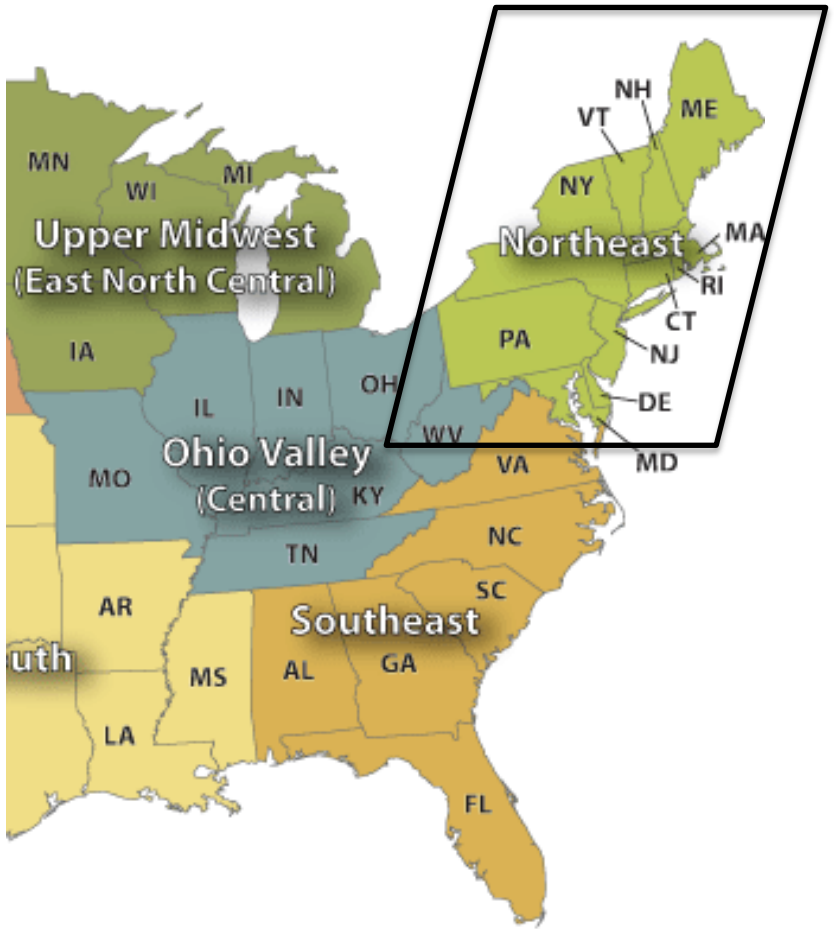


North Dakota

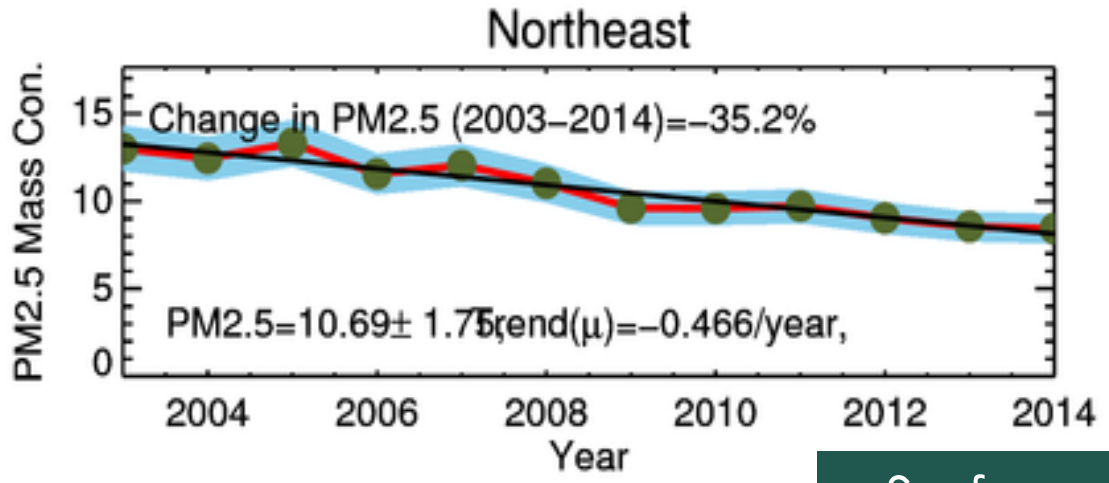
Suomi NPP VIIRS Lights at Night

Texas

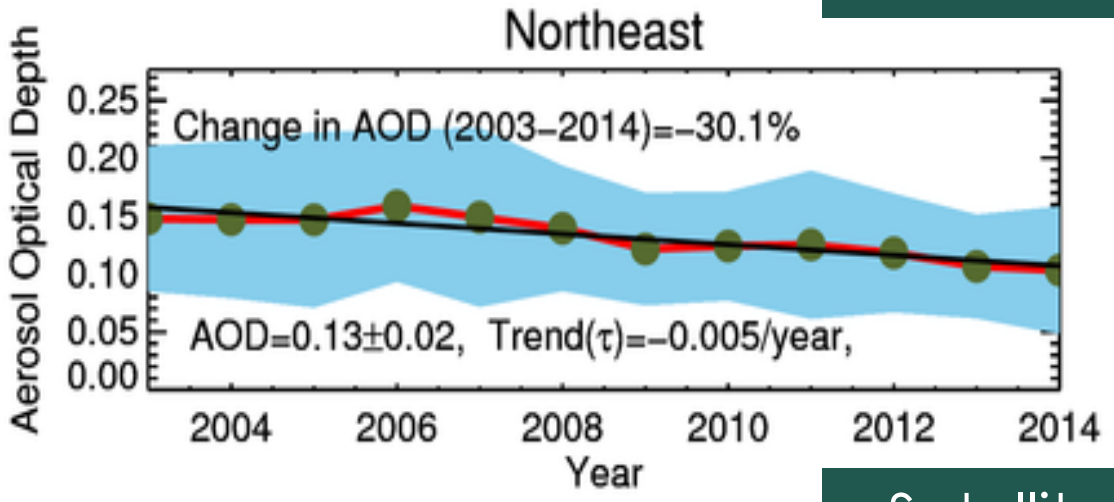
Measurements: Surface vs. Satellite



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



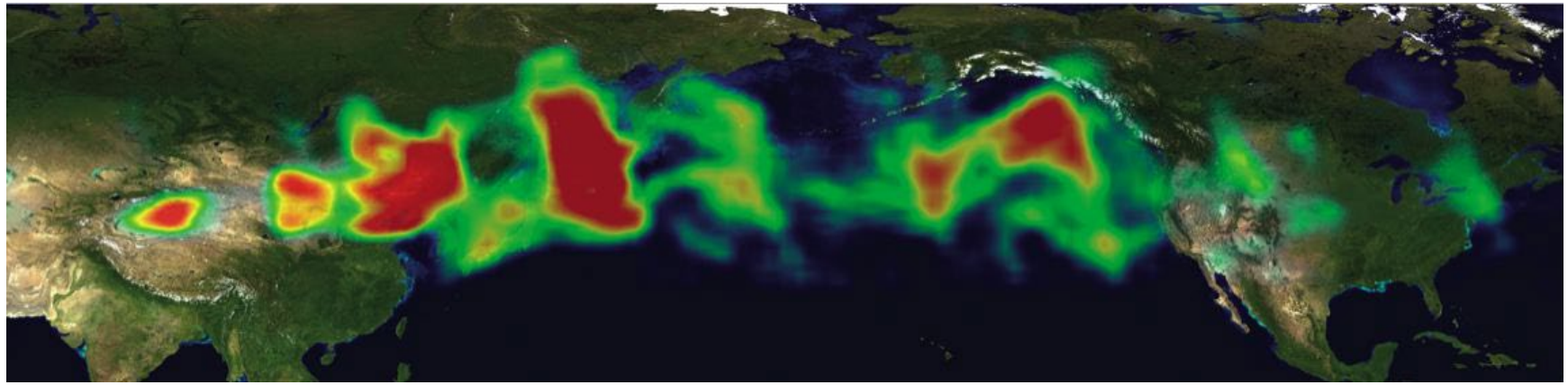
Surface



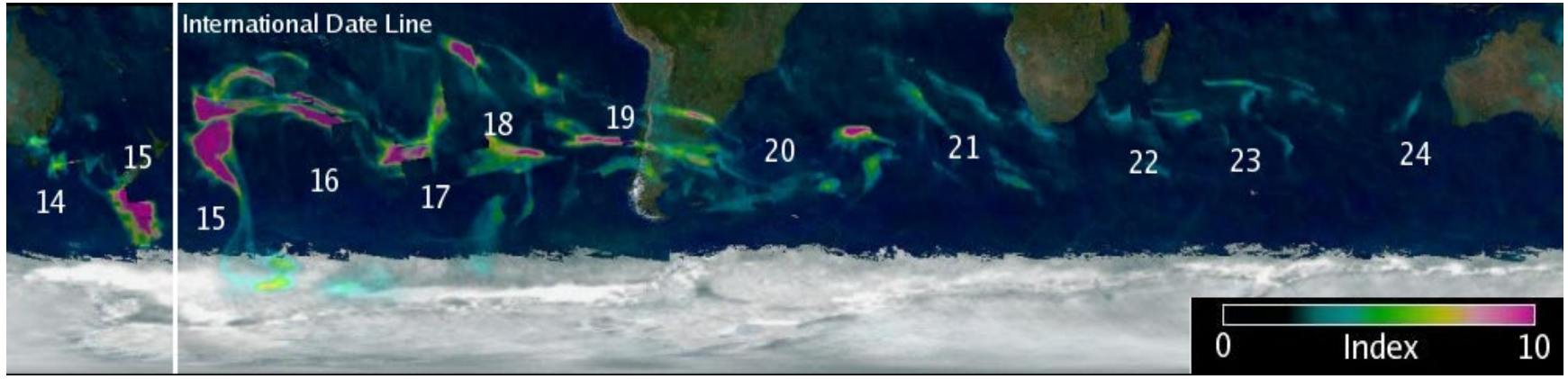
Satellite

Long Range Transport

Dust from Mongolian Deserts Reaches the U.S.



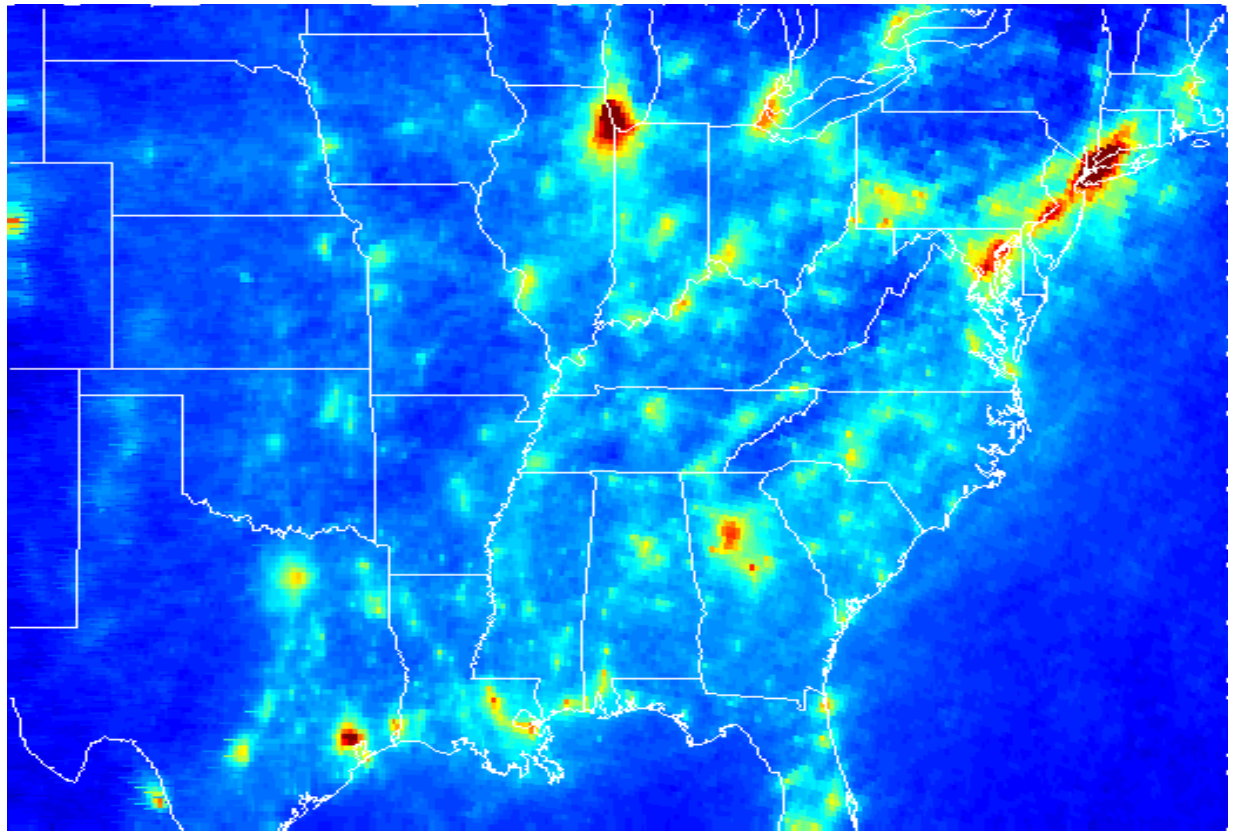
Smoke Travels Around the World in 11 Days

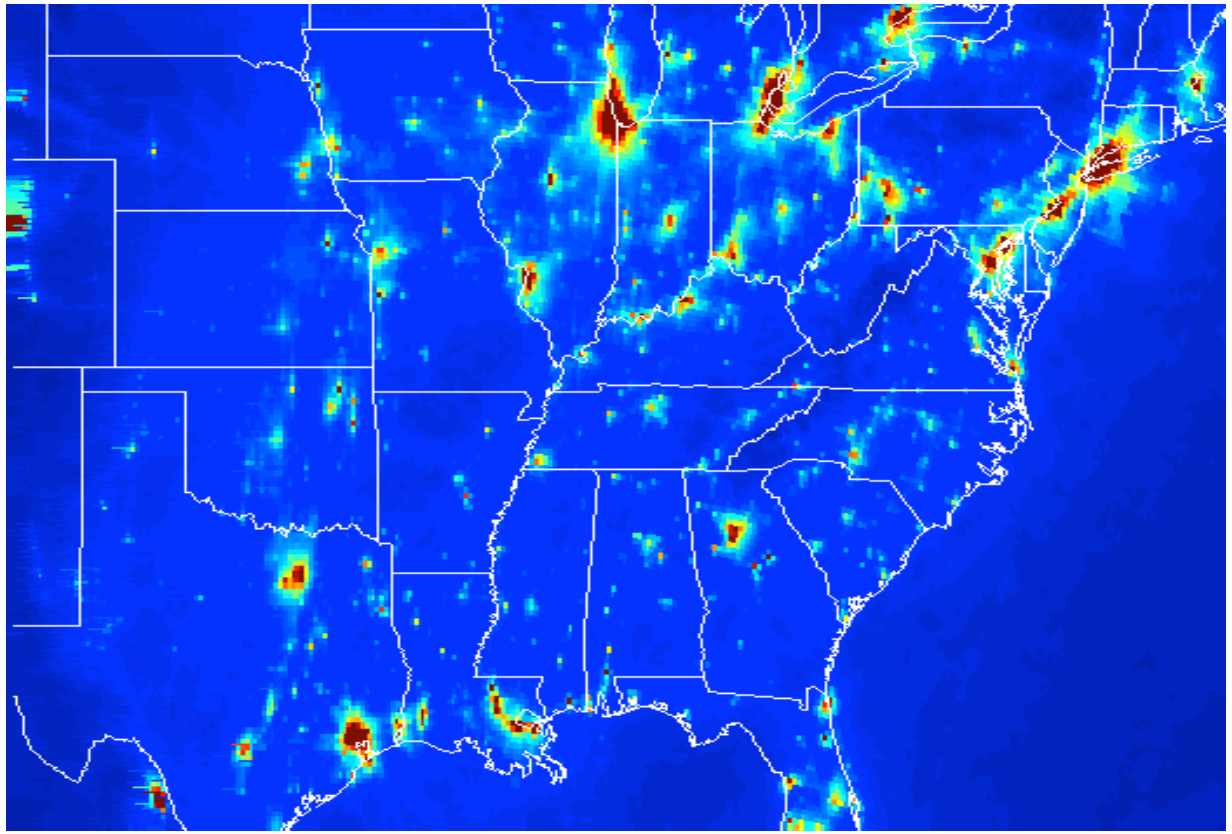


Model-Satellite Inter-Comparison

CMAQ Model NO2

OMI NO2





GOES-16 Loop: Fires and Smoke over Canada

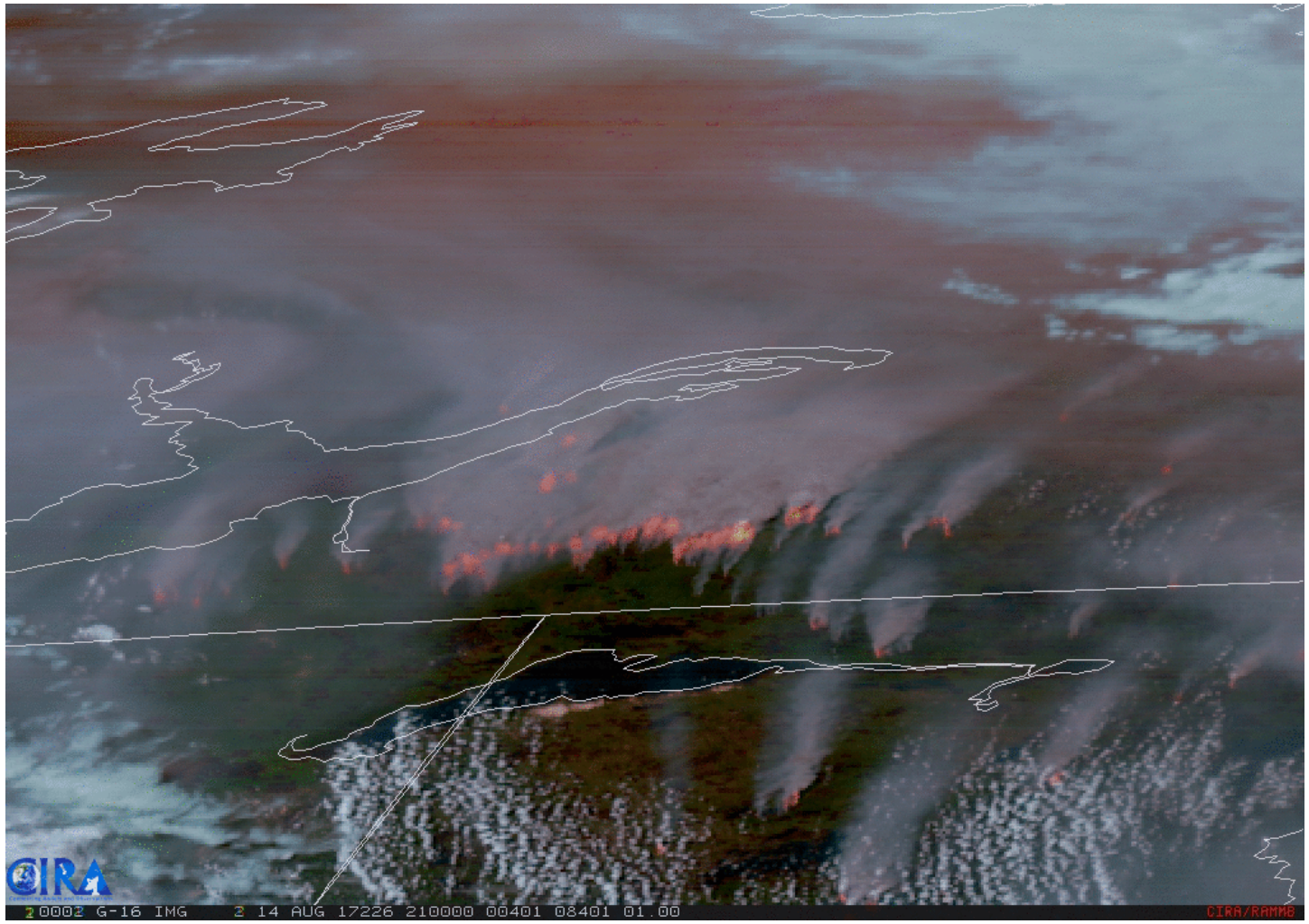
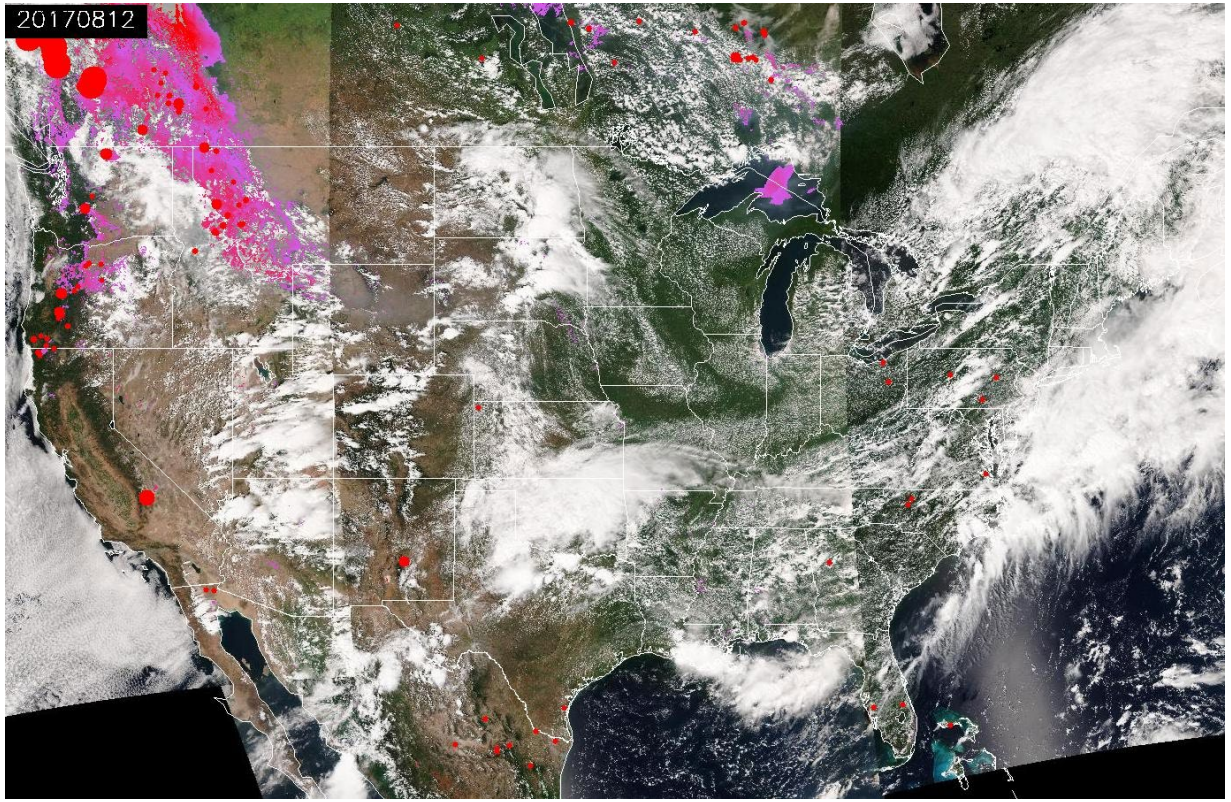


Image Credit: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/

Smoke and Surface Air Quality – August 12, 2017



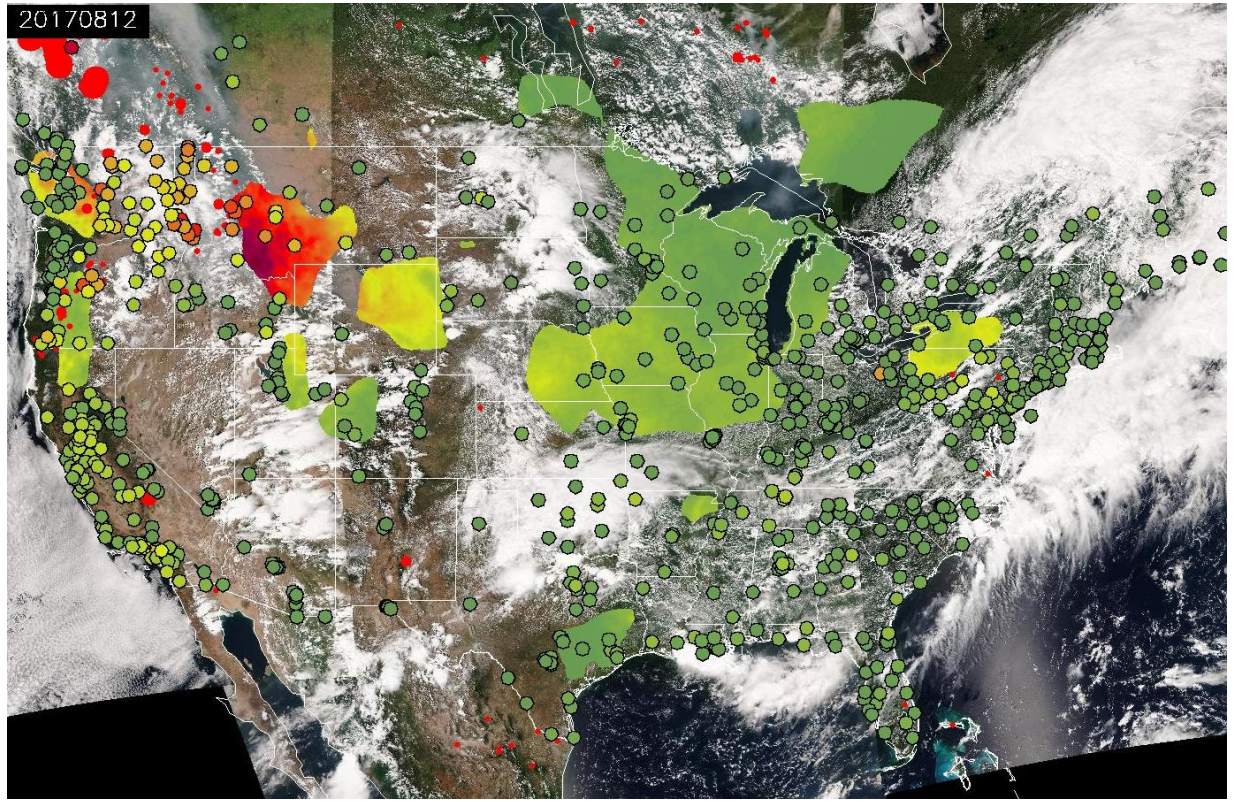


Image Credit:https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/index.php?plot_sel=3&goto_date=20170814

GOES-16 Loop: Dust Storm in Southern California

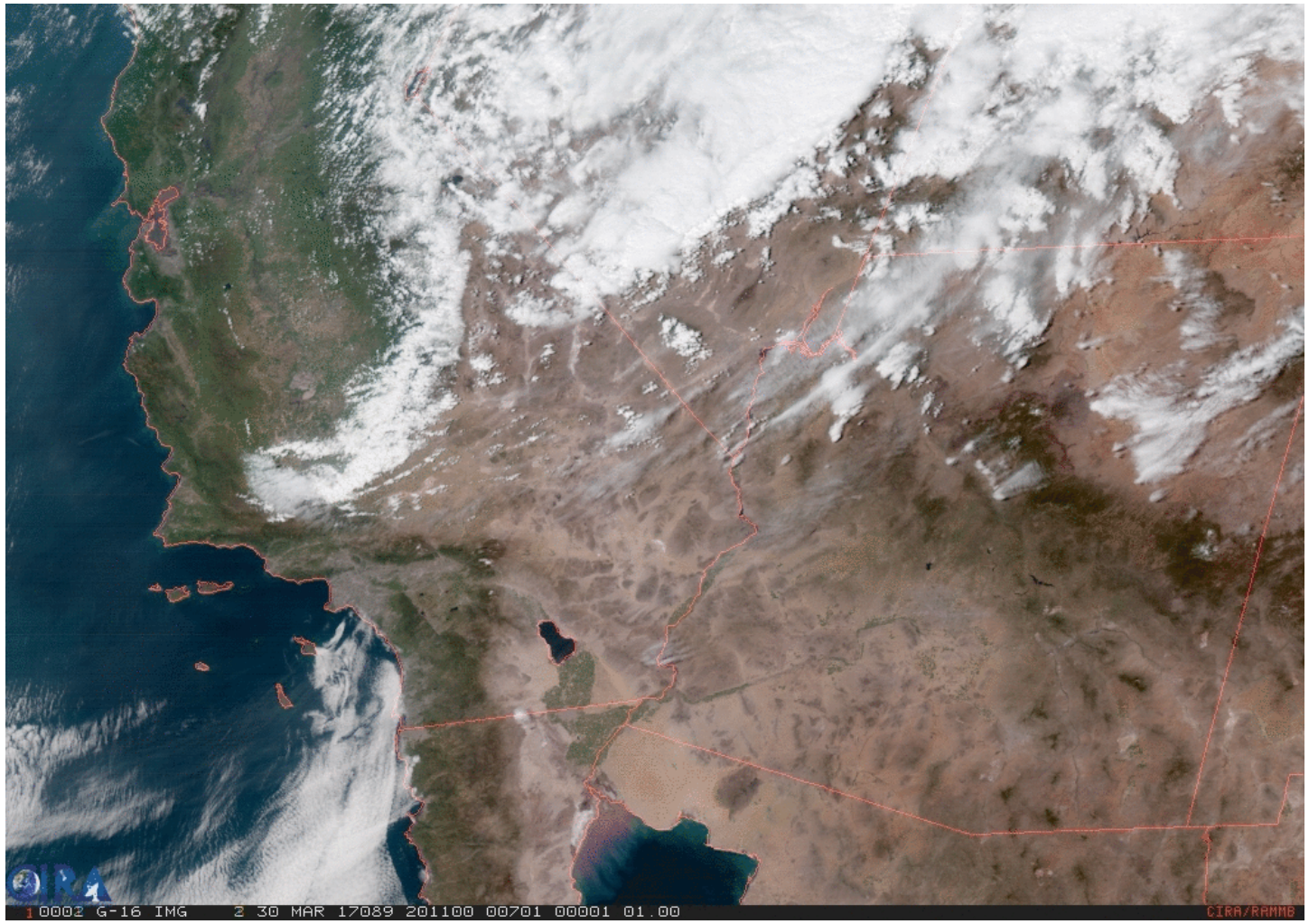
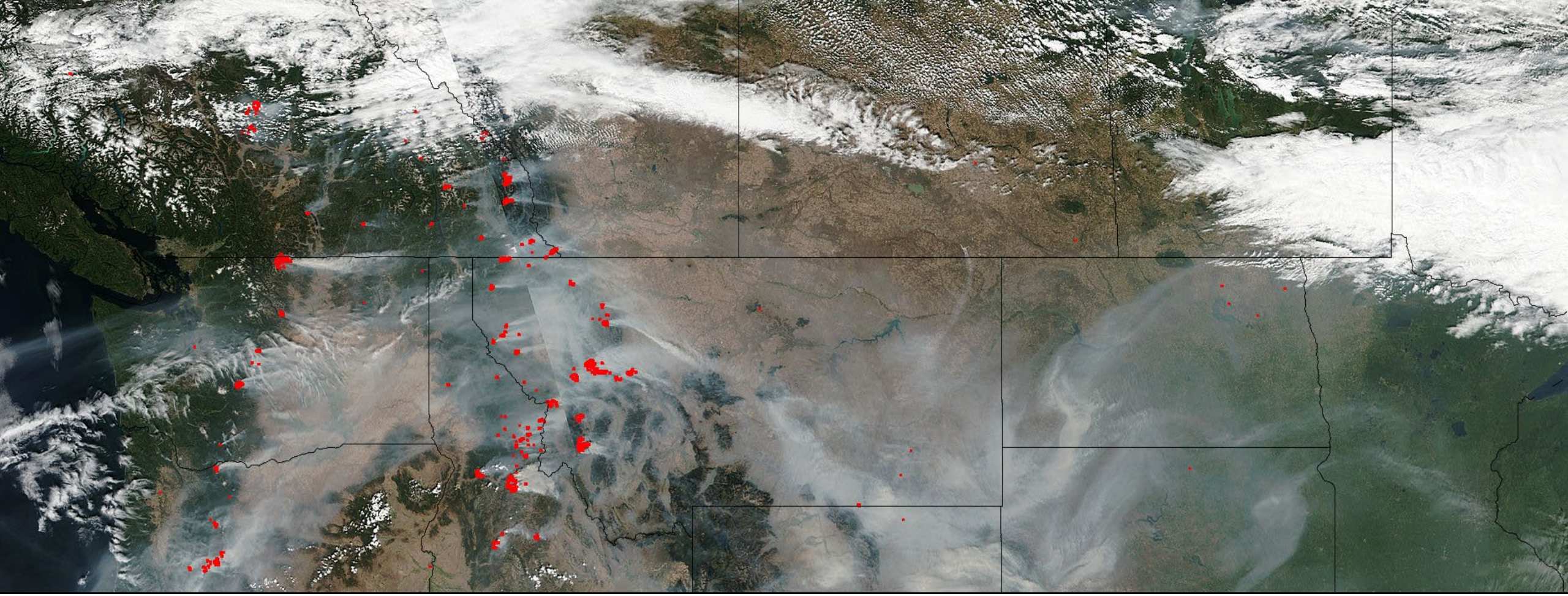


Image Credit: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/



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

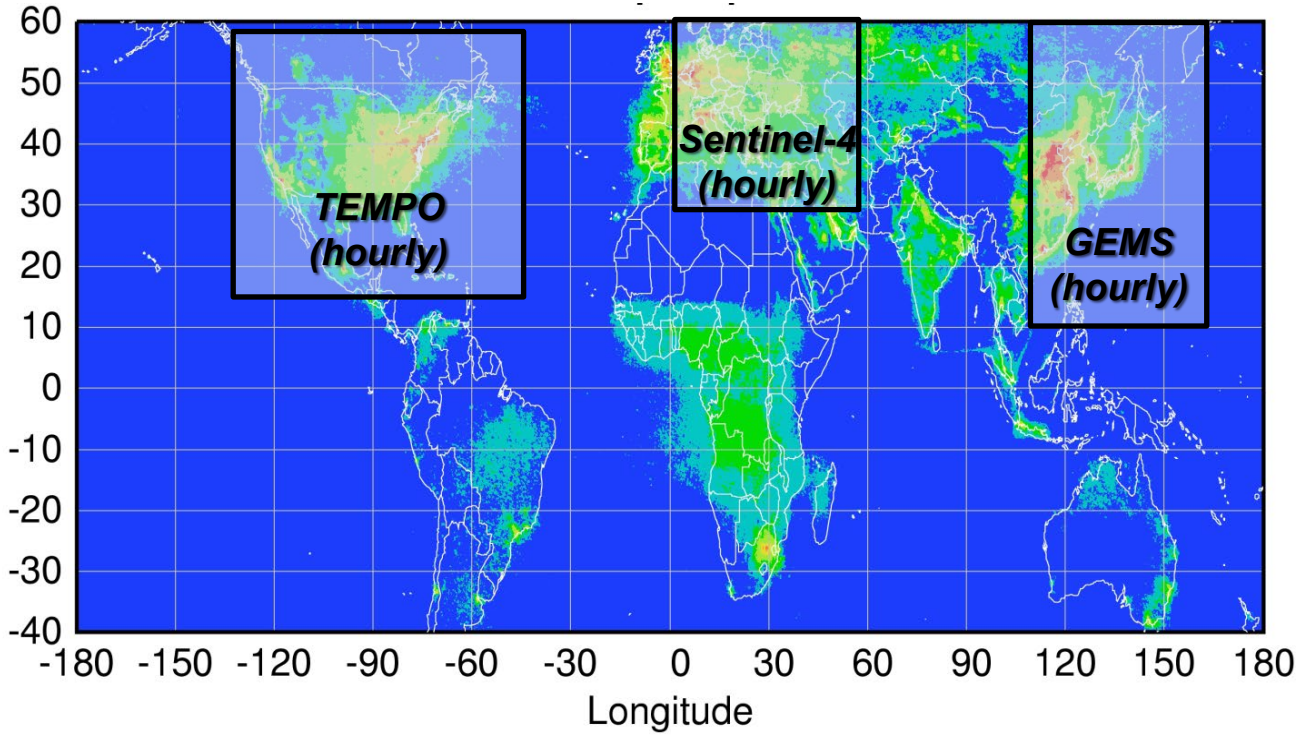
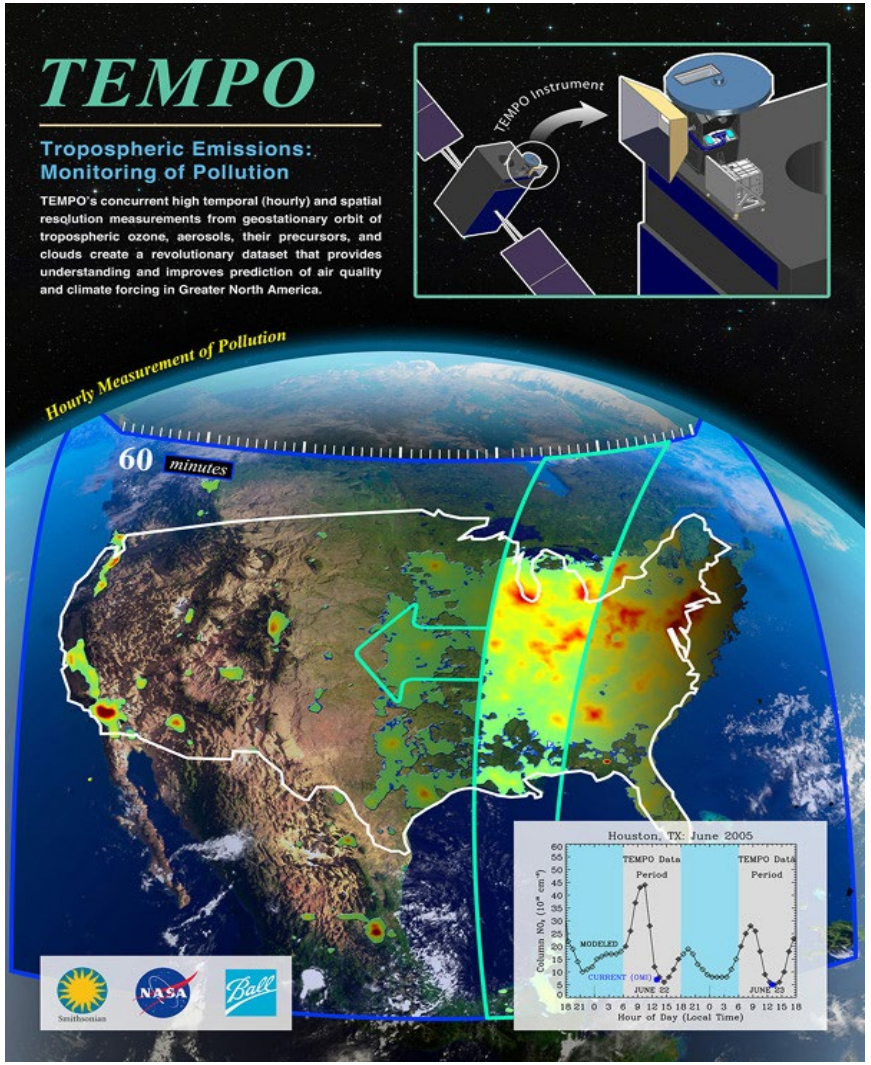


Image Credit: Courtesy Jhoon Kim, Andreas Richter

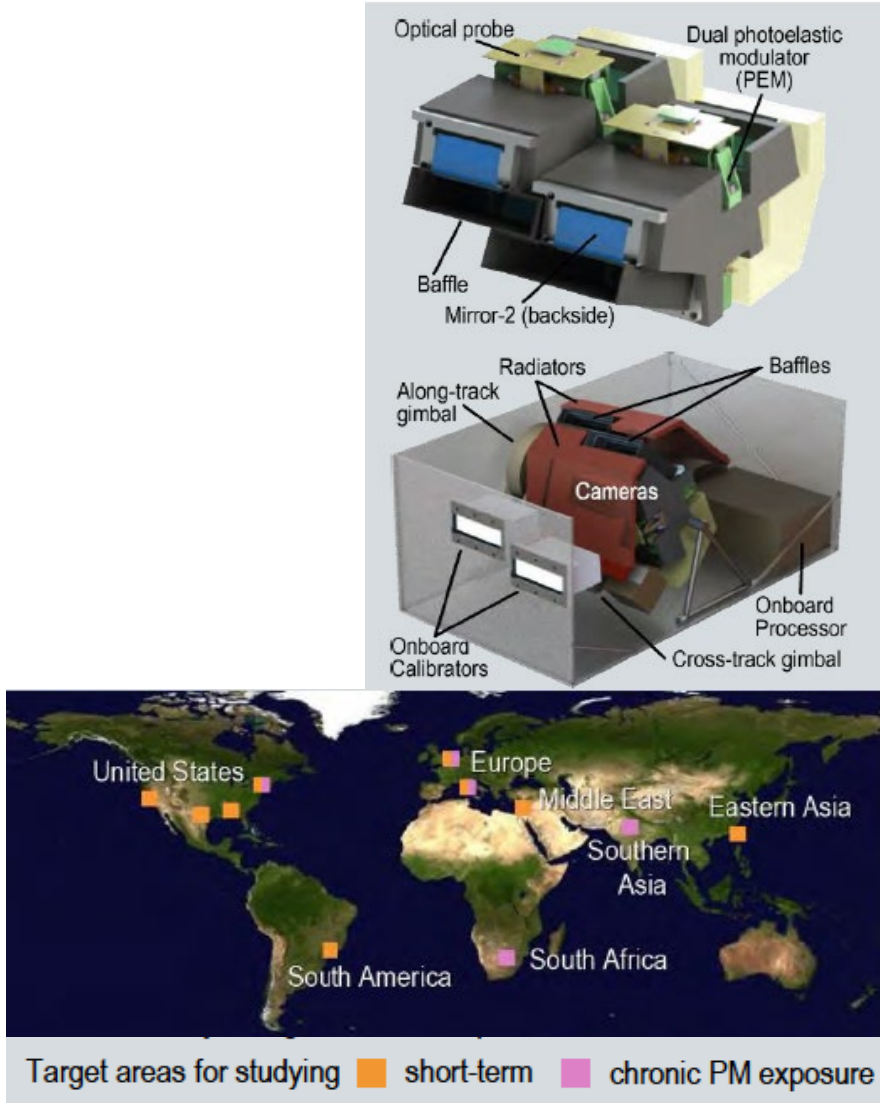
TEMPO

- 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_3, NO_2, $C_2H_2O_2$, 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?