

# Successful Applications of Satellite Data Products in Air Quality Monitoring and Public Health Research and Decision Support

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# Outline

- My group and our research
- Past experiences with introducing RS data to partners
- Thoughts on select AOS enabled applications

# Research Overview



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Satellite Remote Sensing



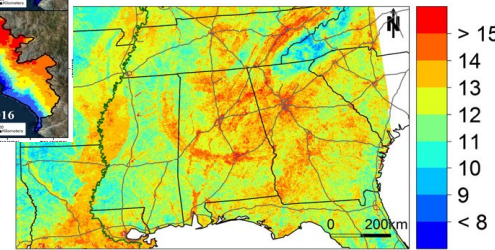
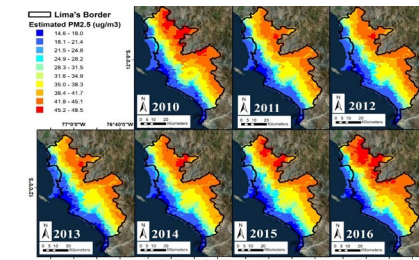
Hybrid ground  
truthing

Bias  
correction

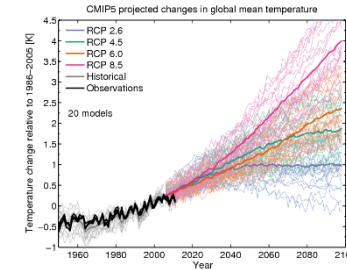
Low-cost  
Sensors



Exposure Models

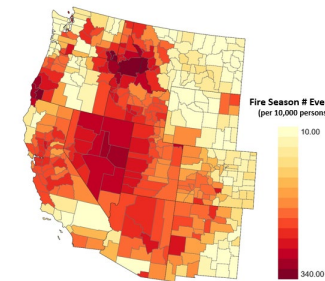
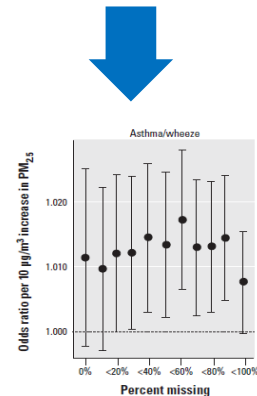


Climate Model  
Simulations



Data Products

EJ and climate justice



EJ and climate justice

Health Effects Research

Health Impact Assessment

# Experiences working with non-NASA partners



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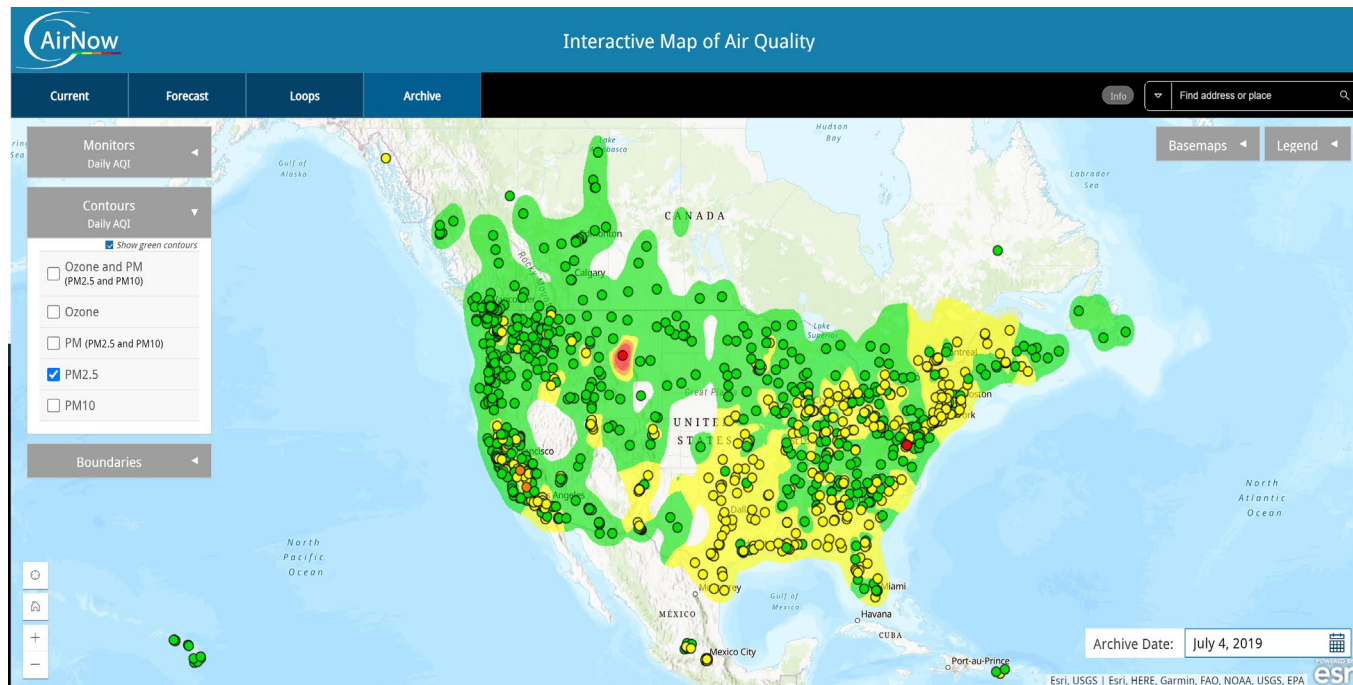


ENVIRONMENTAL  
COMMUNITY ACTION, INC



# Integration of RS data into EPA AirNow

(<https://www.airnow.gov/>)



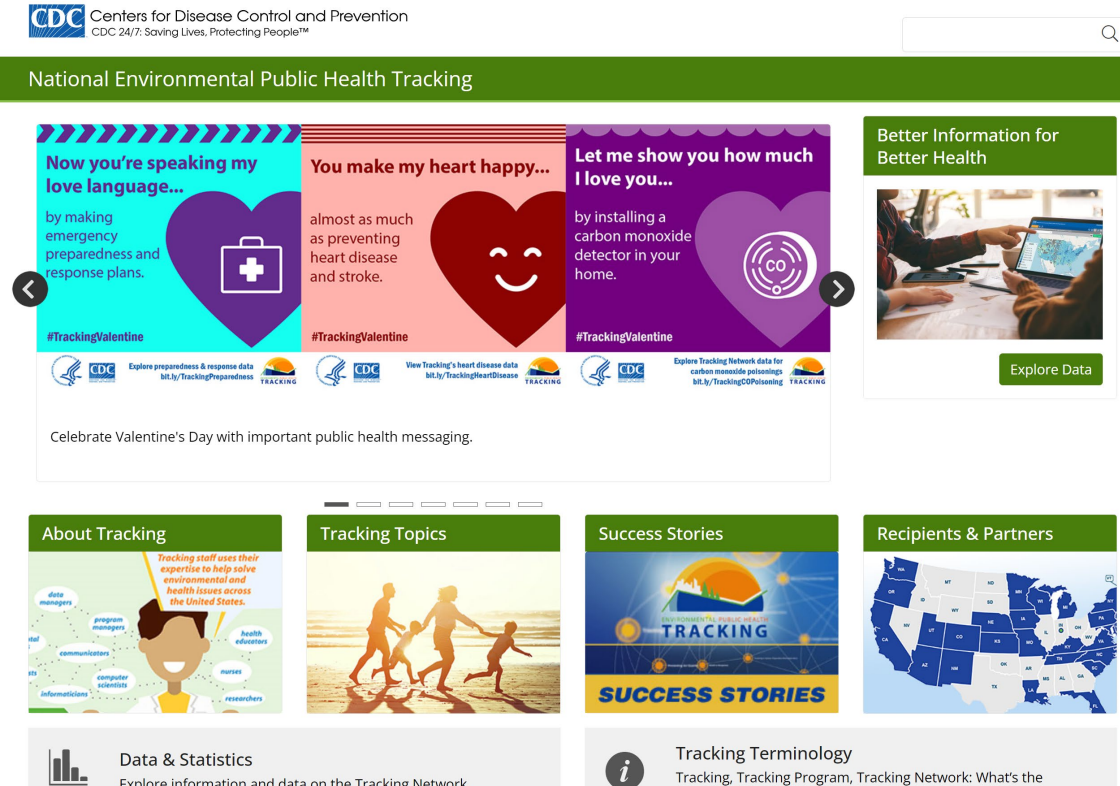
- Started in 1997 with ground based EPA air quality monitors (PM2.5, PM10, O3)
- Contours generated by inverse distance weighting. The maps are interpolated to a resolution of ~ 5km for most of the continental US.
- NowCast calculation uses past 12 hours of PM/O3 measurements for relating hourly data to the AQI
- Many more datasets and tools

# AirNow: where satellite data fit in

- Initial attempt - AirNow Satellite Data Processor
  - ROSES project funded by NASA Applied Sciences Division, 2009 – 2014, built a system run at the AIRNow Data Management Center (DMC) to convert MODIS AOD to PM2.5 using fixed scaling factors over a grid.
  - Challenge: daily satellite PM2.5 based on polar orbiters not frequent enough.
- Second attempt - AirNow-Tech
  - Password-protected web portal, access mainly limited to federal, state, tribal, and local air quality organizations. MODIS & GOES true-color imagery and MODIS AOD as external layers.
- **Next round: Integrating hourly PM2.5 estimates based on GOES-16 AOD (HAQAST Tiger Team project in 2022 led by Pawan Gupta at GSFC)**



# Integration of RS data into CDC's Environmental Public Health Tracking (<https://ephtracking.cdc.gov/>)



The screenshot shows the CDC National Environmental Public Health Tracking website. At the top left is the CDC logo with the text "Centers for Disease Control and Prevention" and "CDC 24/7: Saving Lives. Protecting People™". Below this is a green navigation bar with the text "National Environmental Public Health Tracking". The main content area features a carousel of three Valentine's Day-themed cards. The first card is blue and says "Now you're speaking my love language..." with a heart icon containing a first aid kit. The second card is red and says "You make my heart happy..." with a smiling heart icon. The third card is purple and says "Let me show you how much I love you..." with a heart icon containing a CO detector symbol. To the right of the carousel is a box titled "Better Information for Better Health" with a photo of people looking at a laptop and an "Explore Data" button. Below the carousel are four menu items: "About Tracking", "Tracking Topics", "Success Stories", and "Recipients & Partners". At the bottom are two boxes: "Data & Statistics" and "Tracking Terminology".

- Started as a CDC program in 2002. The first national effort to provide the US with standardized health, environmental, and hazard data as part of regular surveillance activities
- Mission: provide information from a nationwide network of integrated health and environmental data that drives actions to improve community health
- Collected, integrated, and analyzed non-infectious disease and environmental data from a nationwide network of partners. Launched the online data portal in 2009

# Initial attempt – satellite-driven PM<sub>2.5</sub> concentrations



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**National Environmental Public Health Tracking**

Air Quality  
Tracking Air Quality  
Monitor + Modeled Air Data  
Health Impacts of Fine Particles in Air  
Related Links  
Air Quality Indicators  
Outdoor Air Communication Tools  
Search Air Quality Data

**Tracking Links** | Environments | Health Effects | Population Health | Info by Location

**Quick Links**  
Air and Health  
Air Monitoring in the US  
Air Contaminants  
Air Toxics **NEW**  
Remote Sensing data **NEW**

**Atmospheric Remote Sensing: Modeled PM<sub>2.5</sub>**

Atmospheric remote sensing can be used to measure levels of some air pollutants. Remote sensing data come from satellites. These data can be used in combination with other data to help us better understand when and where air pollution is happening. This is important because air pollution can cause health problems. Knowing more about when and where air pollution is happening can help public health officials and others do more to protect our health. Read more about the health problems related to air pollution [here](#).

Compliance with air pollution standards usually is measured through the use of EPA's Air Quality System monitors. These monitors are on the ground and are placed around the country, mainly in large cities. Data from these monitoring stations are considered the "gold standard" for determining outdoor air pollution. However, this information is limited because the monitoring stations are usually near big cities and may take air samples only every three days or during periods when air pollution is very high. Read more about air monitoring [here](#). Using remote sensing data from satellites can help fill in the gaps that exist from air monitors on the ground.

Although atmospheric remote sensing data can help estimate air pollution levels, these data have limitations especially if used on their own. Satellite data are not always available. For example, it is nearly impossible to collect satellite data on a cloudy day. Clouds can interfere with the satellite's ability to collect data which can cause a gap in the information that comes from them. This is one reason why atmospheric remote sensing data should be used in addition to monitoring and modeled air data.

The National Aeronautics and Space Administration (NASA) provides atmospheric sensing data from their satellites for this project. Scientists from CDC, NASA, and Emory University are working together to determine how these data can be used with other air pollution monitoring data to measure fine particulate matter in outdoor air. Fine particulate matter is also called PM<sub>2.5</sub>. Read more about PM<sub>2.5</sub> [here](#).

The Tracking Network is now providing estimates of annual average PM<sub>2.5</sub> concentrations using remote sensing data. Currently, data are available only for Alabama, Georgia, and parts of South Carolina, Tennessee, North Carolina, Florida, and Virginia.

**Tracking Hot Topics**  
Download the Extreme Heat: Prevent Heat-Related Illness Widget  
Tips for Preventing Heat-Related Illness  
Stay Healthy and Safe in Hot Weather PSA  
Recognizing, Preventing, and Treating Heat-Related Illness Online Training  
View our Tracking Success Stories to learn how Tracking is making a difference across the U.S.

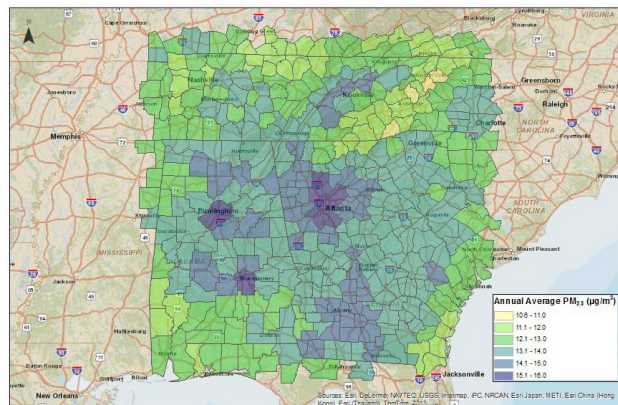
**Resources**  
Communication Tools  
Training  
Join our List-serv  
Document Library  
Quick Reports  
Technical Notes

**Contact Us:**  
Centers for Disease Control and Prevention  
1600 Clifton Rd  
Atlanta, GA 30333  
800-CDC-INFO (800-232-4636)  
TTY: (888) 232-6348  
New Hours of Operation  
8am-8pm ET/Monday-Friday

- A ROSES 2008 project funded by NASA Applied Sciences Division led by Emory
- Developed advanced spatial statistical models driven by MODIS AOD to estimate daily PM<sub>2.5</sub> concentrations in the Southeastern US
- Gridded and county level data delivered to CDC who built a information webpage and provided data download links.
- Challenge: model had limited spatial coverage, product continuity couldn't be sustained after the project ended.
- EPA provided fused observation+CMAQ data with full national coverage (3 yr lag)

Remotely Sensed Annual Average PM<sub>2.5</sub> Estimates, 2007

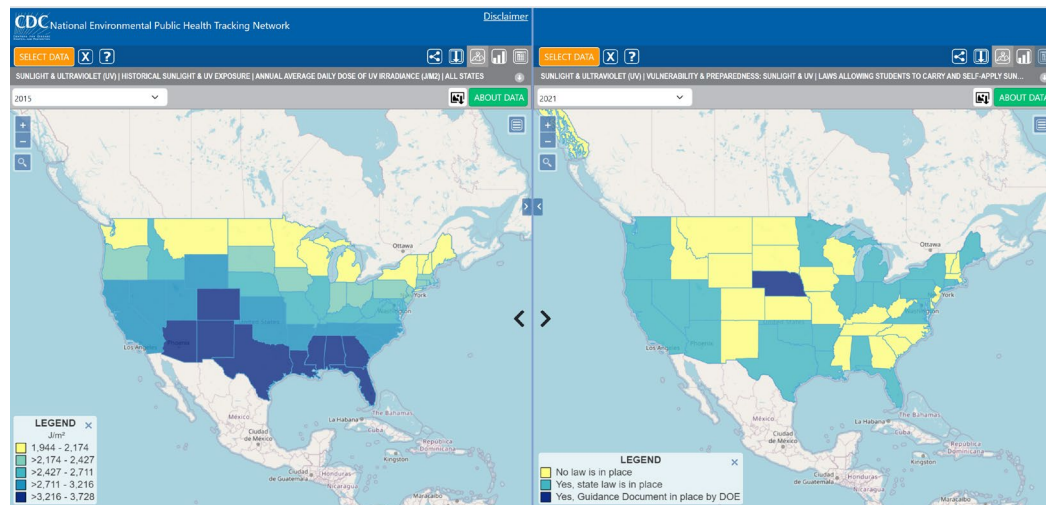
Remote Sensing data are available for the Southeastern United States only.



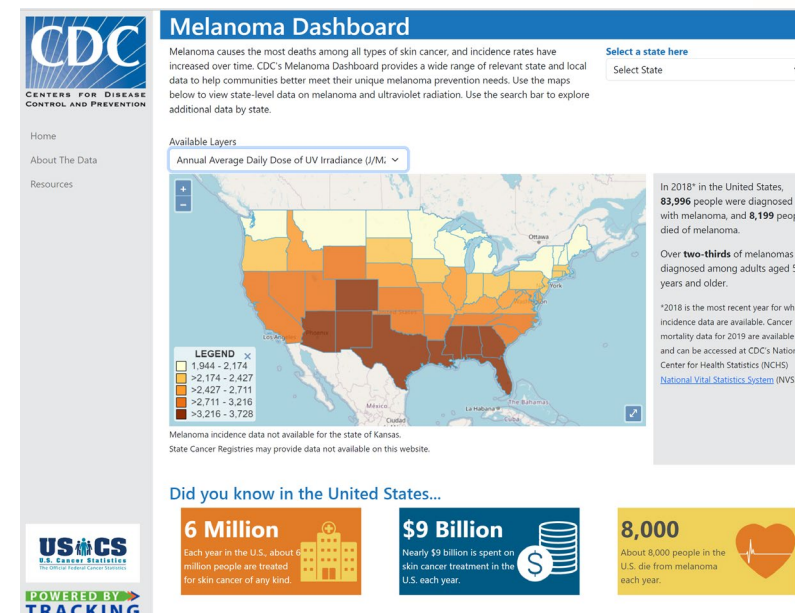




# Second attempt – surface UV radiation



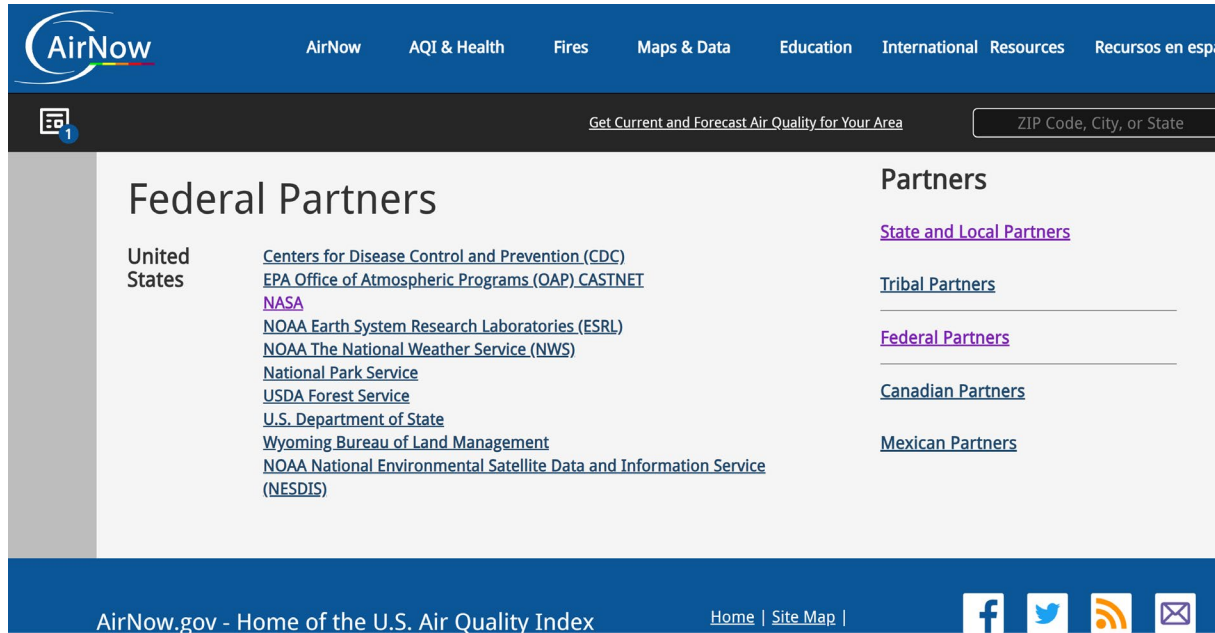
Data Explorer (content area of sunlight & UV): UV indicators between 2005 – 2015 co-developed by Emory, U Iowa, and CDC Tracking with NASA Applied Sciences Division funding (ROSES 2013)



Melanoma dashboard: created through a partnership between the CDC's Division of Cancer Prevention and Control. Secondary use of UV data in Data Explorer y CDC Tracking.

**Next round: funded by NASA Applied Science Division as part of Emory's HAQAST core projects, extend UV data to cover 1995 – 2020, Hawaii and Alaska to better support Data Explorer and Dashboard.**

# Key factors to a successful integration

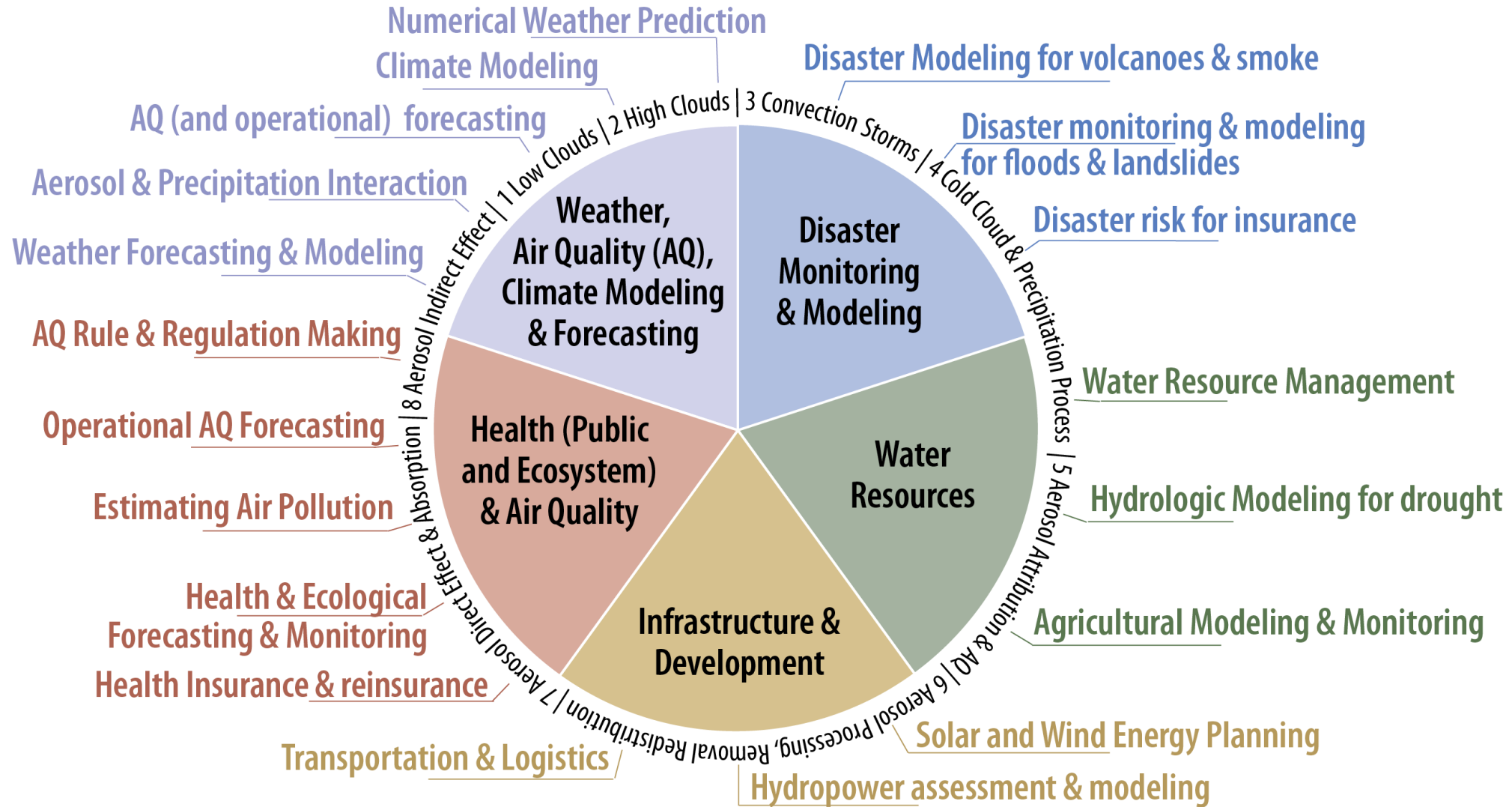


## Tracking's key federal partners

- Department of Health and Human Services (HHS)
- EPA
- NASA
- NOAA

- Highly sophisticated agency partners (e.g., PhD level staff)
- Satellite data has the potential to fulfill agency's need to provide environmental risk factor information with better spatial coverage
- Scope of work decided by agency investigators and endorsed by management
- NASA provided funding for R&D
- Agency commitment of technical support and sustained use
- Long standing partnership and trust between research institutions, agency, and NASA

# AOS Enabled Applications



# AQ Rule and Regulation Making

Decision Approach	End User	Most Relevant GV	Most Relevant Observables	new GV	similar to POR GV
Use aerosol and aerosol precursor emissions, including aerosol-type speciation; attribute and track plume transport ; determine spatio-temporal variations of PM, including PM type, for exceptional event exceptions and to monitor and set Rules and Regulations	EPA, state AQ agencies, international AQ agencies, legislatures (e.g., California A.B. 617)	Aerosol Type Aerosol Extinction AOD cloud Mask cloud and aerosol profiles	These stakeholders might not have the expertise to create the 2D surface particulate matter concentration	Near-surface vertical aerosol distribution AND speciated aerosol-type/PM products	Aerosol distribution

**My thought: satellite data have been used in exceptional event justification reports prepared by state AQ agencies so this is possible.**

**Challenge: Air quality rules & regulations can have significant social and economical impacts in a region, therefore their making often follows strict guidelines (e.g., how CMAQ can be run). For satellite data to be useful, they probably first need to be made an eligible source of evidence. This might mean dealing not only with partner’s technical staff, but also management or even legislature.**

# Operational Air Quality Forecasting

Decision Approach	End User	Most Relevant GV	Most Relevant Observables	new GV	similar to POR GV
Use AQ forecasts with ground-based data to issue AQ alerts and identify AQ events that will likely have an acute impact on human health: e.g., wildfires, dust. Use satellite data for model validation as well as improving simulation of aerosol processes.	Federal (NOAA, EPA) and state AQ agencies , public and private companies, nonprofits and environmental justice groups	Aerosol Extinction Profile Aerosol-Cloud Feature Mask (Profile) AOD Aerosol Number Concentration	Extinction profiles, multiangle radiance and polarization parameters	Vertical aerosol distribution AND Aerosol PM2.5 Concentration	AOD

**My thought: this sounds promising**

**Challenge: need to first demonstrate enhancement over benchmark or current approach with limited AOS data from polar and inclined orbit, then demonstrate the feasibility of data continuity, then partner need to commit to sustained use. All of these means funding for applied research**



# Estimating air pollution: exposure and impact on health outcomes

Decision Approach	End User	Most Relevant GV	Most Relevant Observables	new GV	similar to POR GV
Apply L4 vertical and horizontal surface PM data to determine spatio-temporal variations of exposure.	CDC, WHO, NIH, health researchers at universities/hospitals (e.g., GBD), nonprofits and environmental justice groups	Aerosol Extinction Profile, Aerosol-Cloud Feature Mask (Profile), Aerosol Optical Depth, Aerosol Number Concentration	Many of these stakeholders will likely not have the expertise to create the L4 product.	First global high-resolution (spatial and temporal) satellite-derived speciated PM datasets	Aerosol distribution

**My thought: global PM<sub>2.5</sub> mass and speciation datasets can be created with existing satellite data. Data quality depends on ground observations and can be improved with AOS observations.**

**Challenge: must demonstrate enhancement with limited AOS data from polar and inclined orbit. The impact of this application depends on if NASA can generate and host a L4 global speciated PM dataset in a user-friendly format.**

# Health insurance and reinsurance - pollution exposure risks

Decision Approach	End User	Most Relevant GV	Most Relevant Observables	new GV	similar to POR GV
Apply L4 horizontal and vertical surface PM data to determine spatio-temporal variations of exposure.	reinsurance industry (e.g., SwissRE), health insurance industry	2D surface particulate matter concentrations, Aerosol Extinction Profile, Aerosol-Cloud Feature Mask (Profile), Aerosol Optical Depth, Aerosol Number Concentration	These stakeholders will likely not have the expertise to create the L4 product from relevant observables.	First global high-resolution (spatial and temporal) satellite-derived speciated PM datasets	AOD

**My thought: interesting choice of stakeholders. Might be a good way to engage the private sector**

**Challenge: Probably need to link pollution with specific diseases in order to estimate the value of information. Having a willing and able partner is key.**



# Partner expertise needed to enable application

- **RS data analysis + CTM simulations**
  - Air Quality Rule and Regulation Making
  - Operational Air Quality Forecasting
  
- **RS data analysis + exposure/epi/eco/actuarial modeling**
  - Estimating Air Pollution
  - Health and Ecological Forecasting/Monitoring
  - Health Insurance and Reinsurance

# Factors to consider for success

- Value proposition (e.g., NASA vs. NOAA)
- Data continuity
  - NASA is R&D and there is no guarantee that the same data product or data access method will remain after the mission is concluded. Users are nervous about investing man power and infrastructure in something that will only last 3-5 years.
- Technical support
  - Need dedicated technical support to sustain data use and system function
- Trust building takes time and (NASA) money
- Promotion of policy change to encourage the integration of satellite data in agency mandates

# THANK YOU!

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<https://scholarblogs.emory.edu/remote-sensing-group>