EARTH SCIENCE
APPLIED SCIENCES

EARTH SCIENCE APPLICATIONS WEEK 2022

Day 1: Health & Air Quality Applications

August 9, 2022

EARTH SCIENCE APPLICATIONS WEEK 2022

WELCOME!

DAY 1 – AUGUST 9th: HEALTH & AIR QUALITY

<u>Event Attendance Guidelines</u>

1. Please stay muted with cameras off
2. Post questions for speakers in the chat & they will be answered there

HEALTH & AIR QUALITY INTRODUCTION

John Haynes
Program Manager
Health & Air Quality Program

Health and Air Quality

Major Partners include International (e.g., GEO, WHO, UNICEF, PAHO), Federal (e.g., CDC, EPA, NIH, NOAA), State (e.g., South Dakota, California, Texas), and Private sectors (AER, Inc, Moore Foundation).

- NASA's Health & Air Quality Applications Area supports the use of Earth observations in air quality management and public health, particularly regarding **infectious disease and environmental health** issues.
- The area promotes uses of Earth observing data and models regarding **implementation of air quality standards, policy, and regulations** for economic and human welfare.
- The area addresses issues of **toxic and pathogenic exposure and health-related hazards** and their effects for risk characterization and mitigation.
- The Health & Air Quality Applications Area also addresses **effects of climate change on public health and air quality** to support managers and policy makers in their planning and preparations.

[ANIMALS]

[HUMANS]

ONE HEALTH

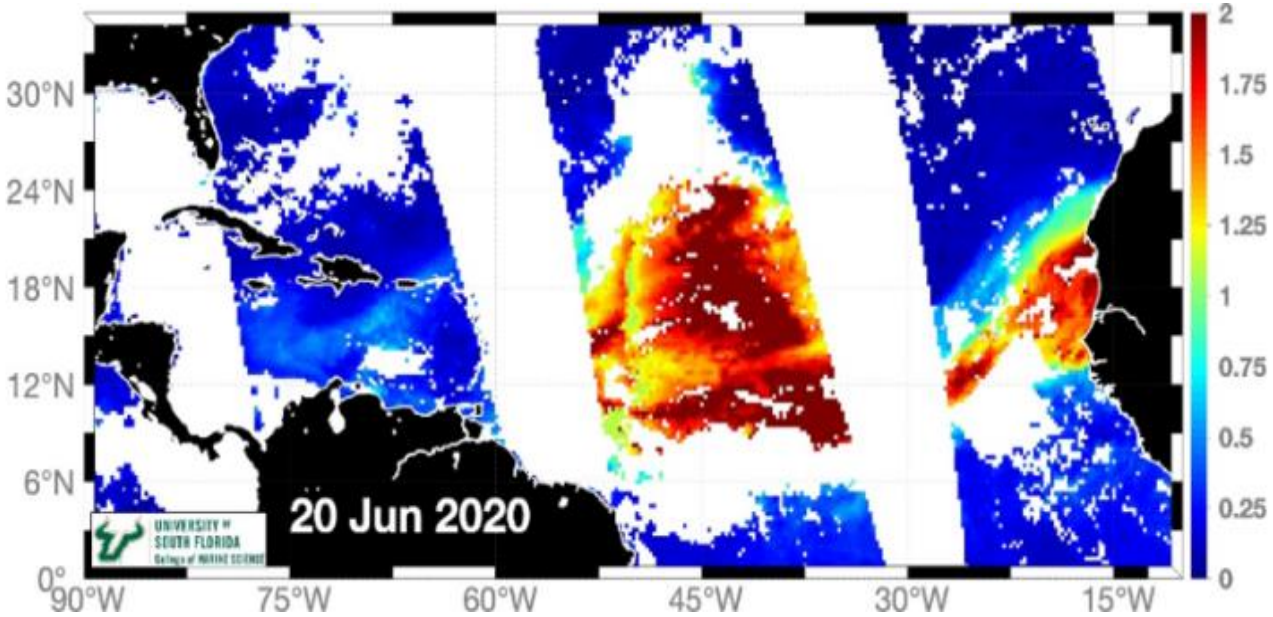
[ENVIRONMENT]

Human health is connected to the health of animals and our shared environment.

EARTH SCIENCE
APPLIED SCIENCES

Learn more at:
go.nasa.gov/3s1Mq2b

Credits: NASA/Pablo Méndez-Lázaro



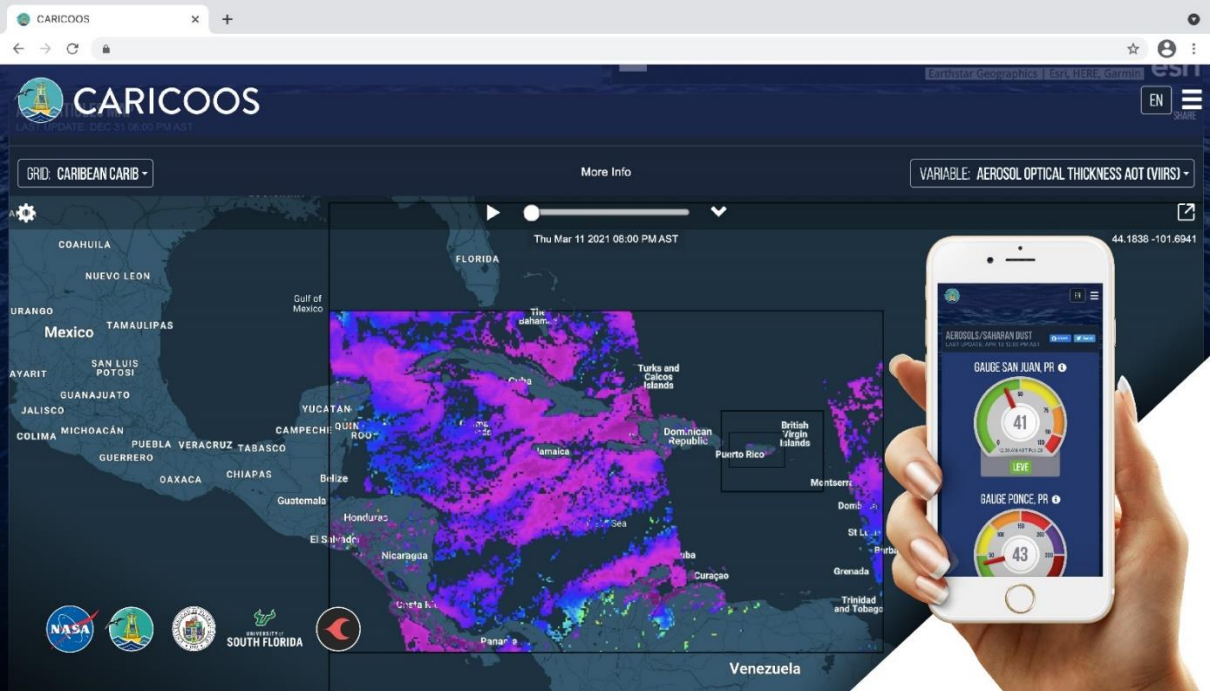
Forecasting Poor Air Quality Events in the Caribbean

Saharan dust storms crossing the Caribbean adversely impact air quality and human health. Robust applied research and community partnerships were developed in Puerto Rico to build an operational air quality forecasting tool that informs policy decisions, educates the public on health risks related to dust storms, and safeguards population health.

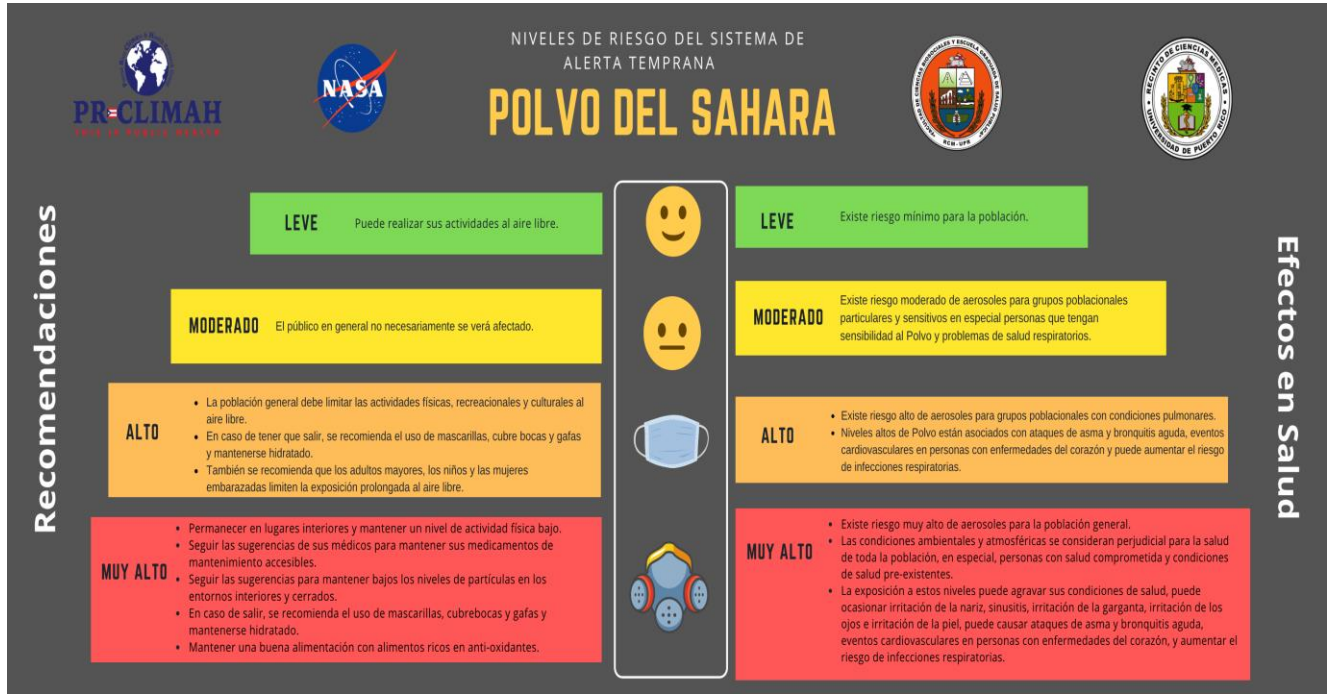
NASA Web Feature: https://www.nasa.gov/feature/nasa-helps-puerto-rico-prepare-for-saharan-dust-impacts

Aerosol Monitoring Support Tool

Caribbean Coastal & Ocean Observing System (CARICOOS)



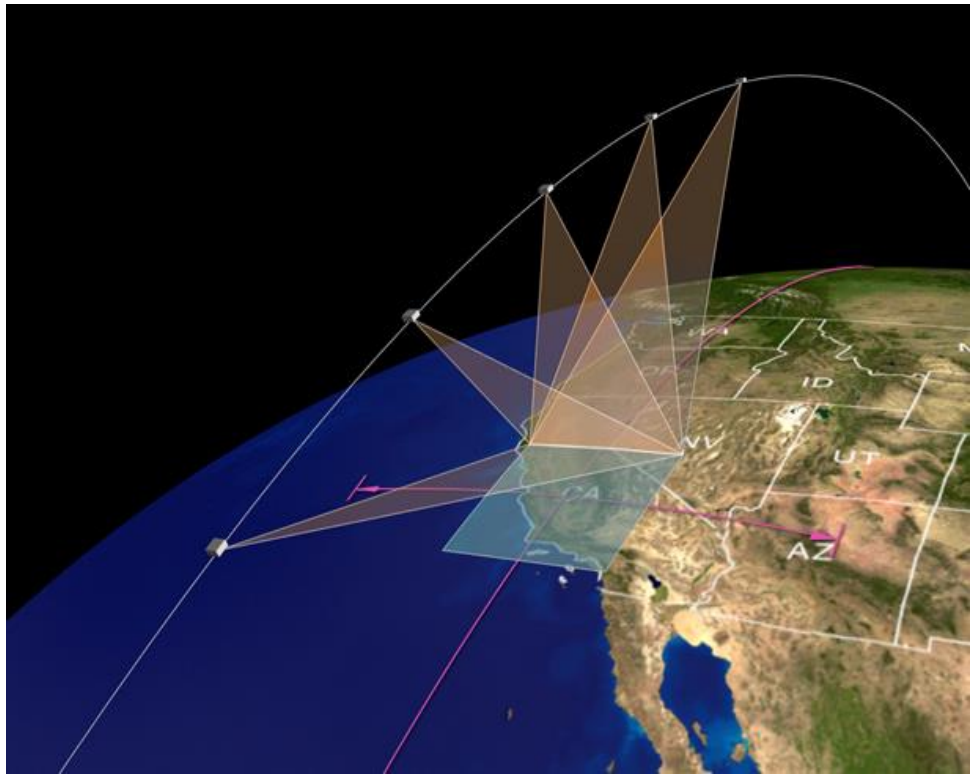
PR Department of Health's Office of Public Health Preparedness & Response



Caribbean Coastal & Ocean Observing System
CARICOOS: https://aerosoles.caricoos.org/

Earth Venture Instrument-3:
Multi-Angle Imager for Aerosols (MAIA)

- ***MAIA represents the first time NASA has partnered with epidemiologists and health organizations on a satellite mission to study human health and improve lives.***
- **Objective**: Assess linkages between different airborne particulate matter (PM) types and adverse birth outcomes, cardiovascular and respiratory disease, and premature deaths.
- **Instrument:** Multi-angle spectropolarimetric imaging instrument for operation in a sun-synchronous Earth orbit to measure the particle types, sizes, concentrations, and geolocation of atmospheric aerosols.
- Launch expected NET 2024.



https://maia.jpl.nasa.gov/

Thank You.

For further questions, please contact:
jhaynes@nasa.gov

HEALTH &
AIR QUALITY

Spatiotemporal variation in risk of *Shigella* infection in childhood

A global risk mapping and prediction model using individual participant data

Ben Zaitchik, Hamada Badr – Johns Hopkins University
Josh Colston, Margaret Kosek – University of Virginia

EARTH SCIENCE
APPLICATIONS WEEK 2022

Context

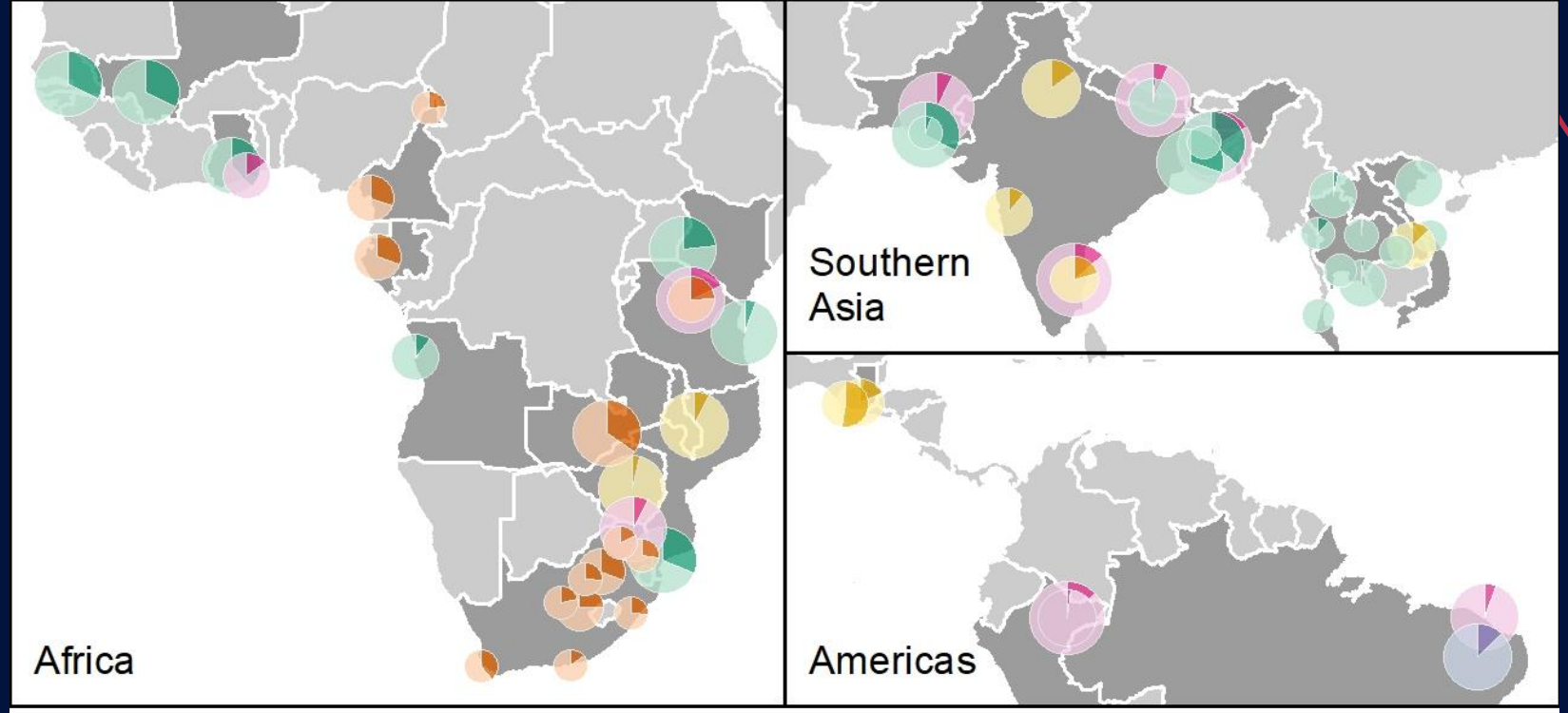
Shigella Infects 160 million people per year, primarily in LMIC

It causes ~64,000 of the 573,000 annual diarrheal disease deaths in children aged < 5 years

Context

Vaccines are being developed and will require targeting to areas of high risk.

But pathogen-specific studies of enteric infections are, traditionally, not readily available.



Number of Samples

- <100
- 100 - 499
- 500 - 999
- 1,000 - 4,999
- ≥5,000

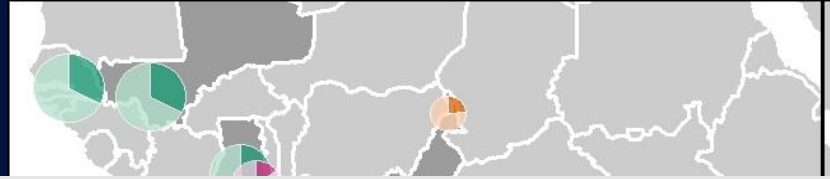
Study Design

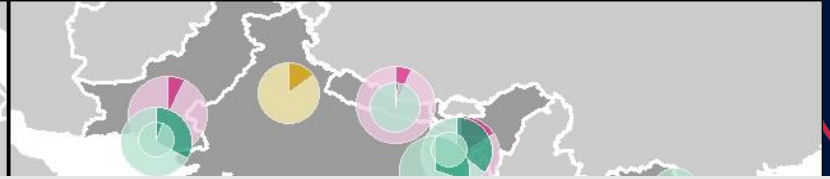
- Community-based Case-Control
- Community-based Cohort/Surveillance
- Health Facility-based Case-Control
- Health Facility-based Surveillance
- Intervention Trial

Countries Represented

***Shigella* positivity**

Negative Positive





Title Page

Title: Spatiotemporal variation in risk of *Shigella* infection in childhood: a global risk mapping and prediction model using individual participant data

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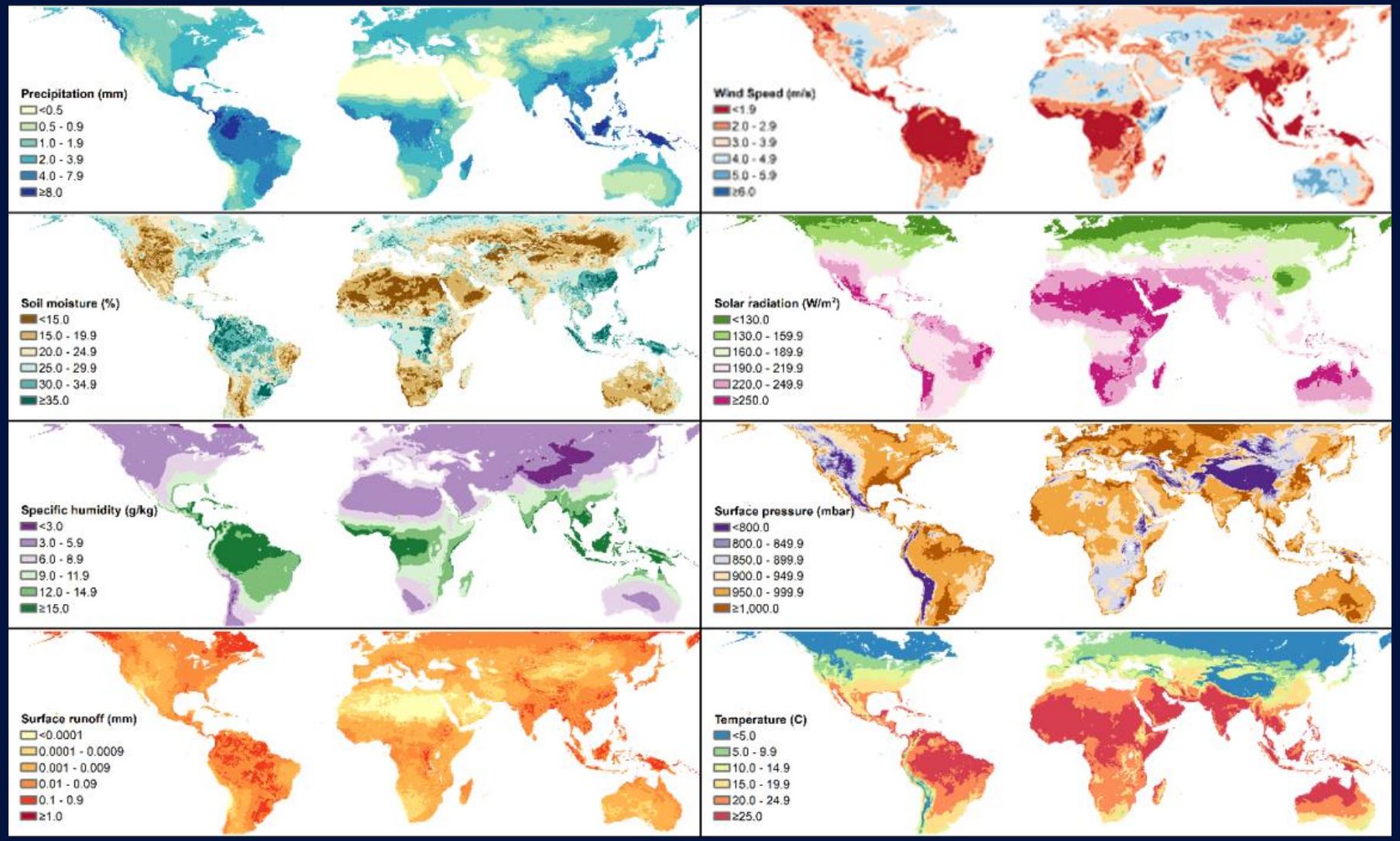
Countries Represented

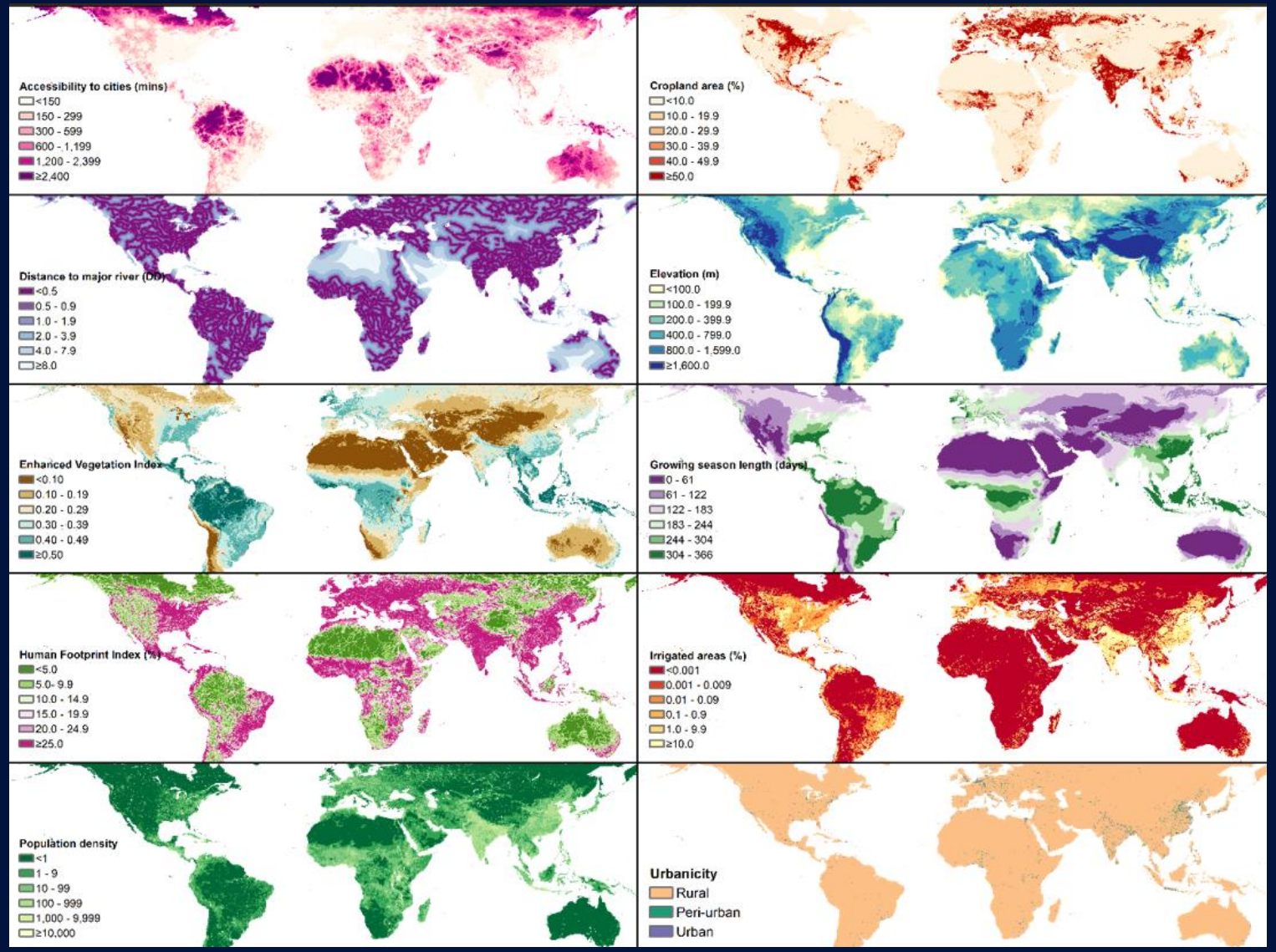
***Shigella* positivity**

Negative Positive

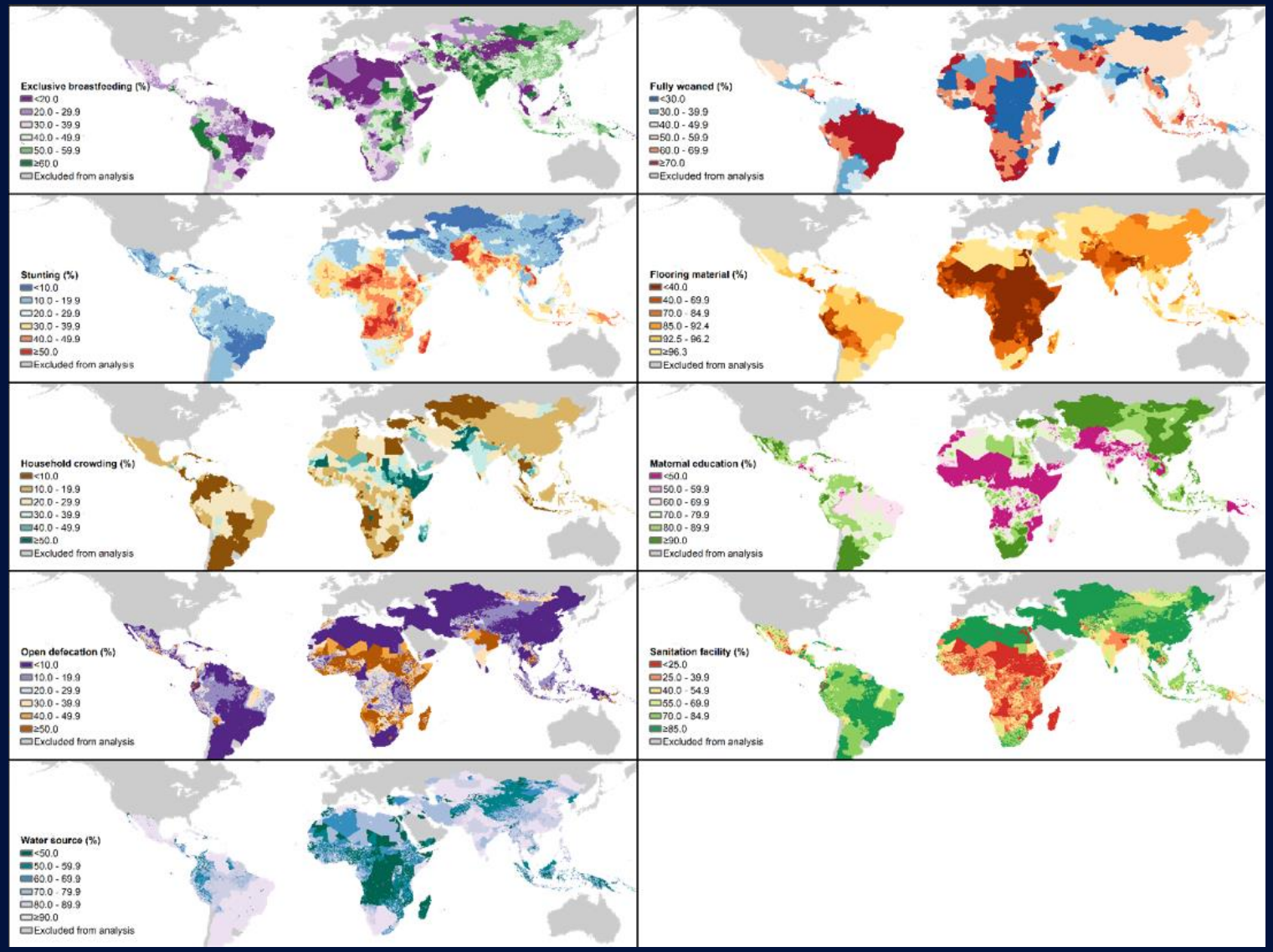
Earth Observation: hydrometeorology



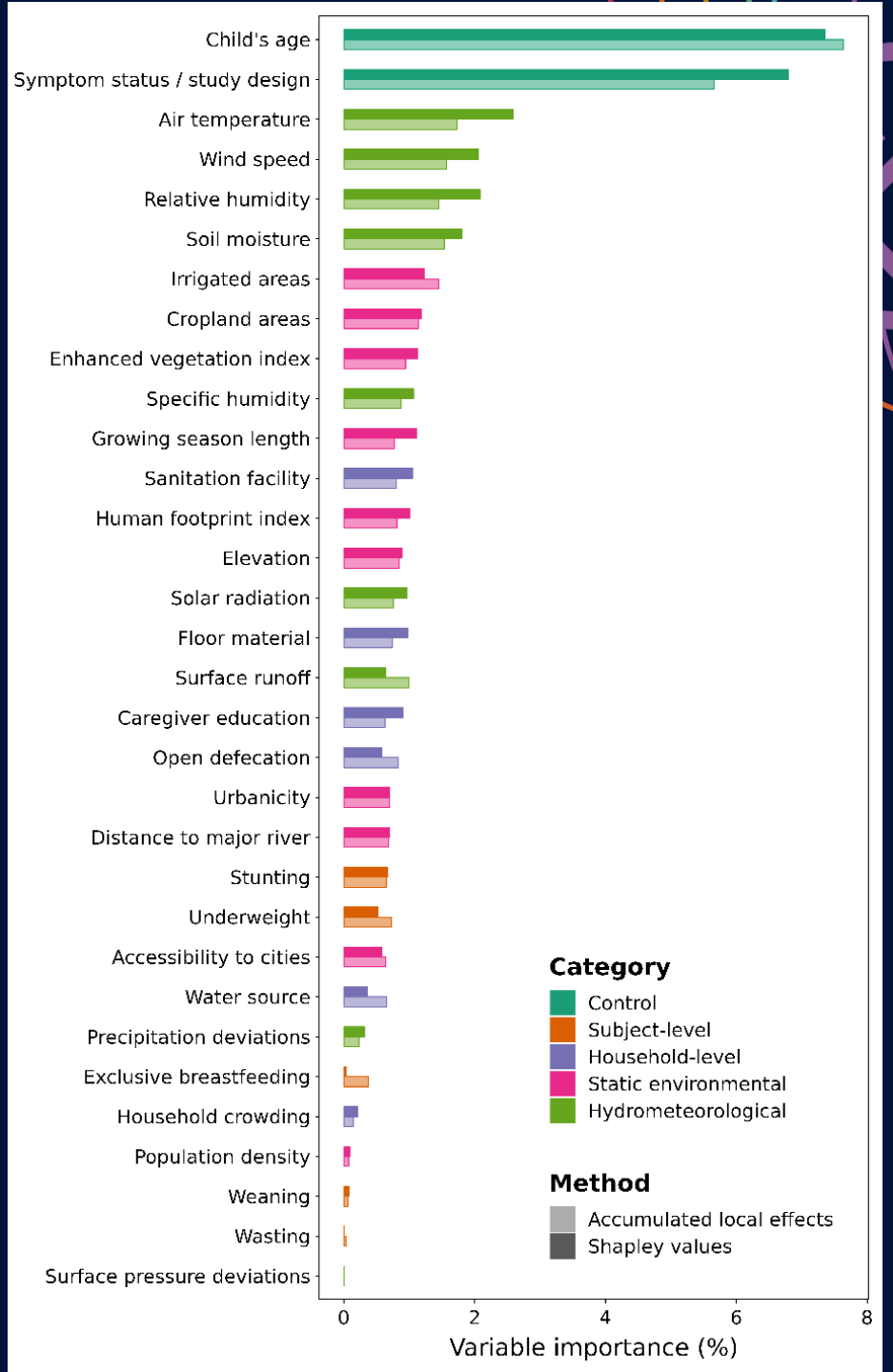
Landscape and human systems



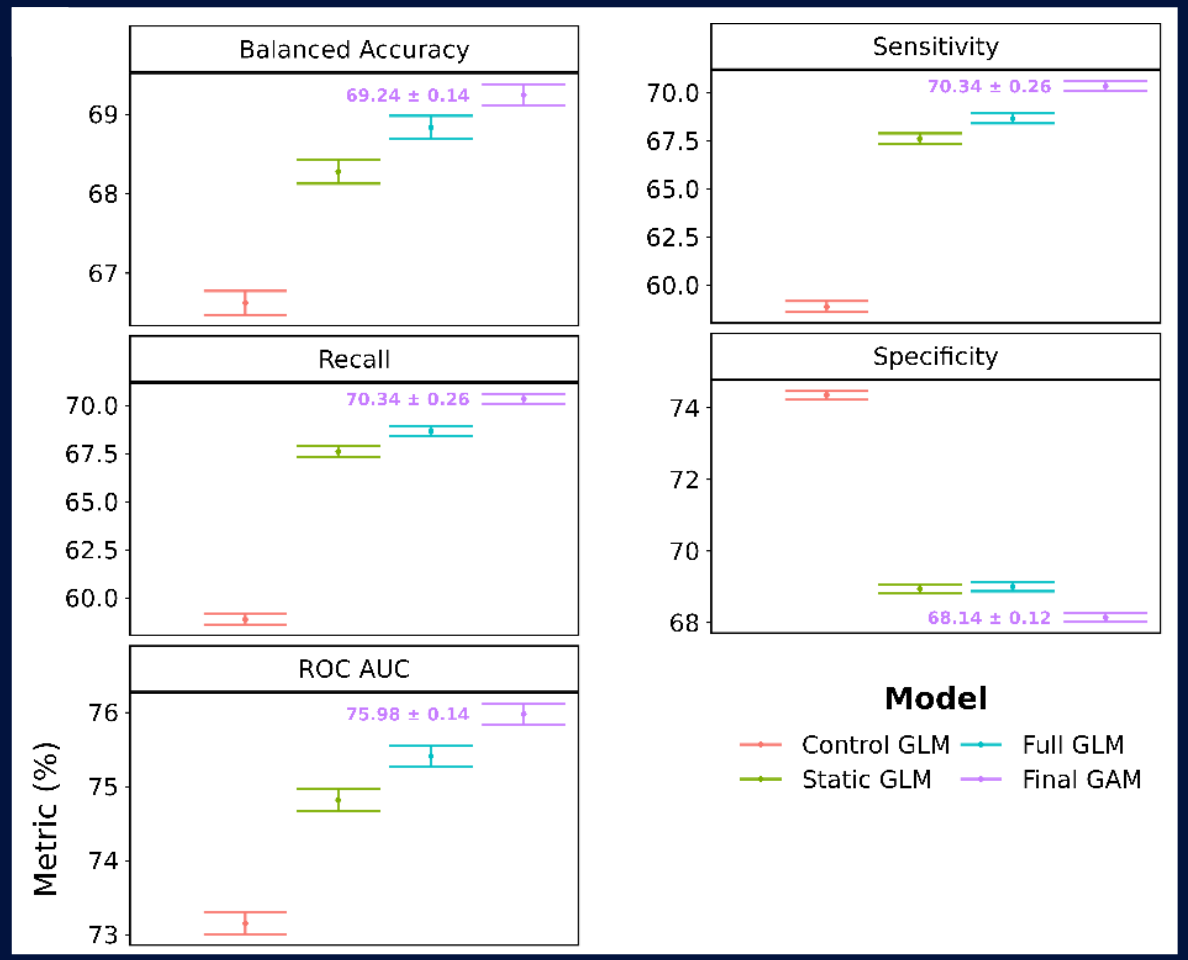
Household factors

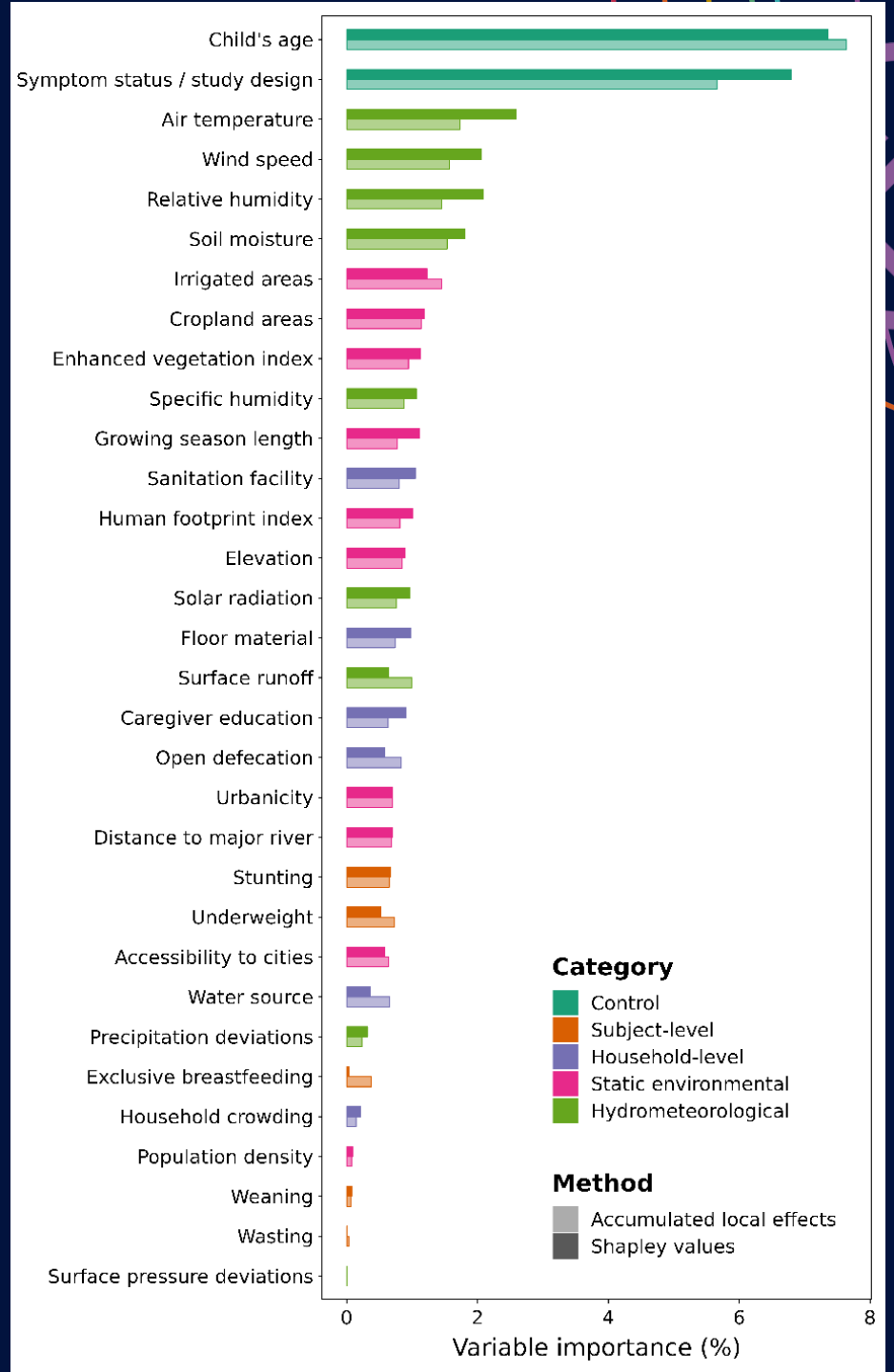


Predictive modeling

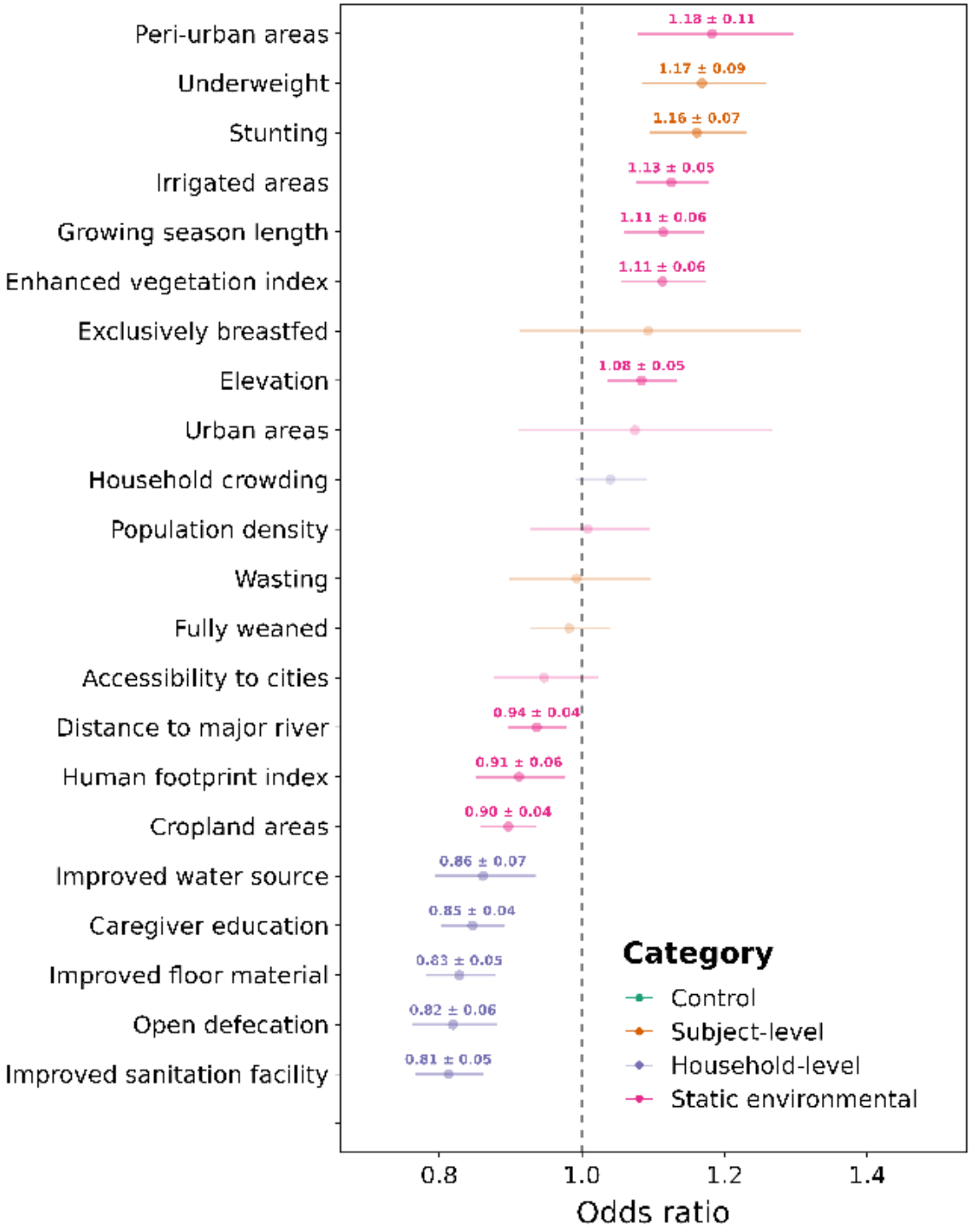


Predictive modeling





Variable Influence



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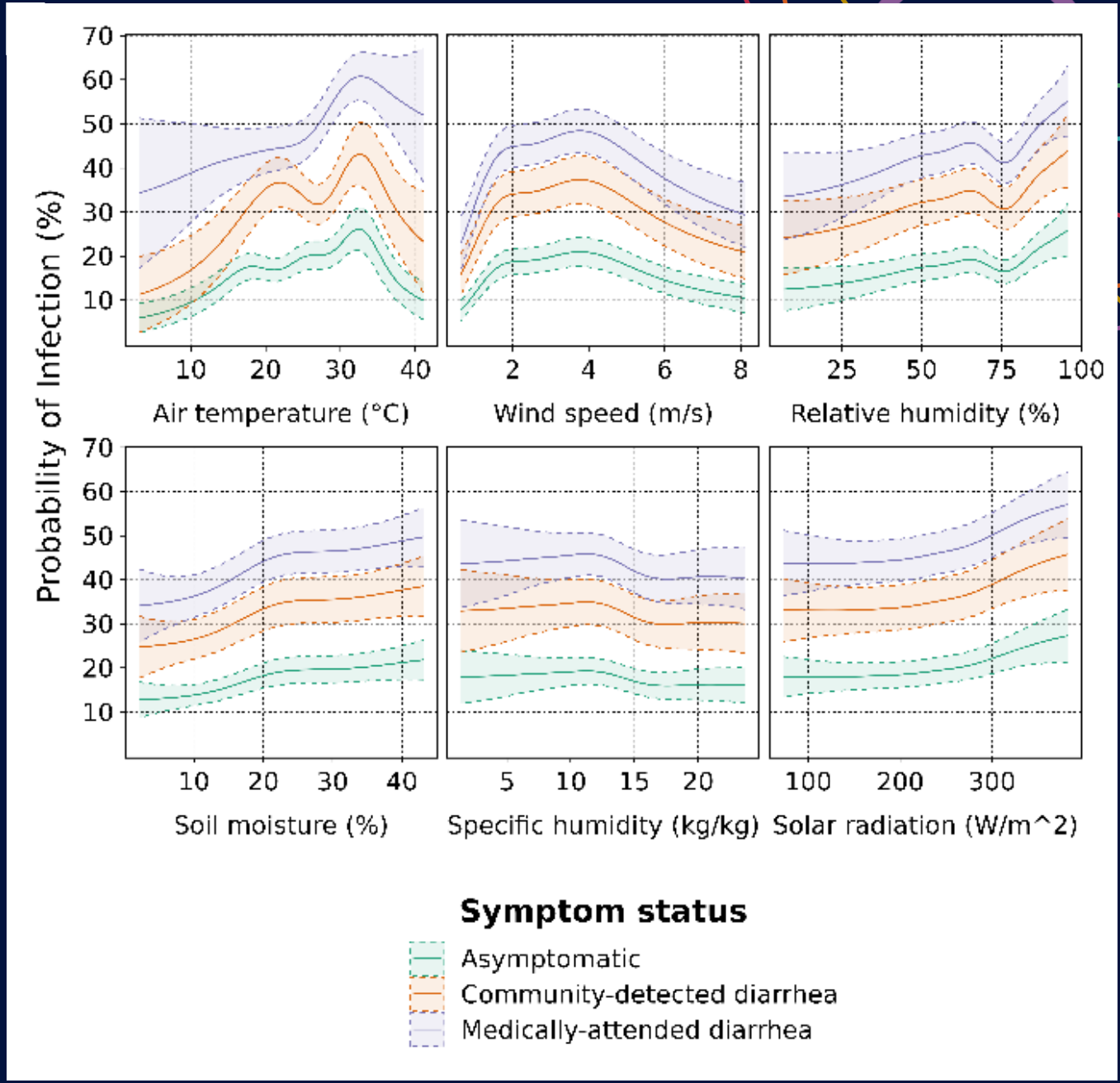
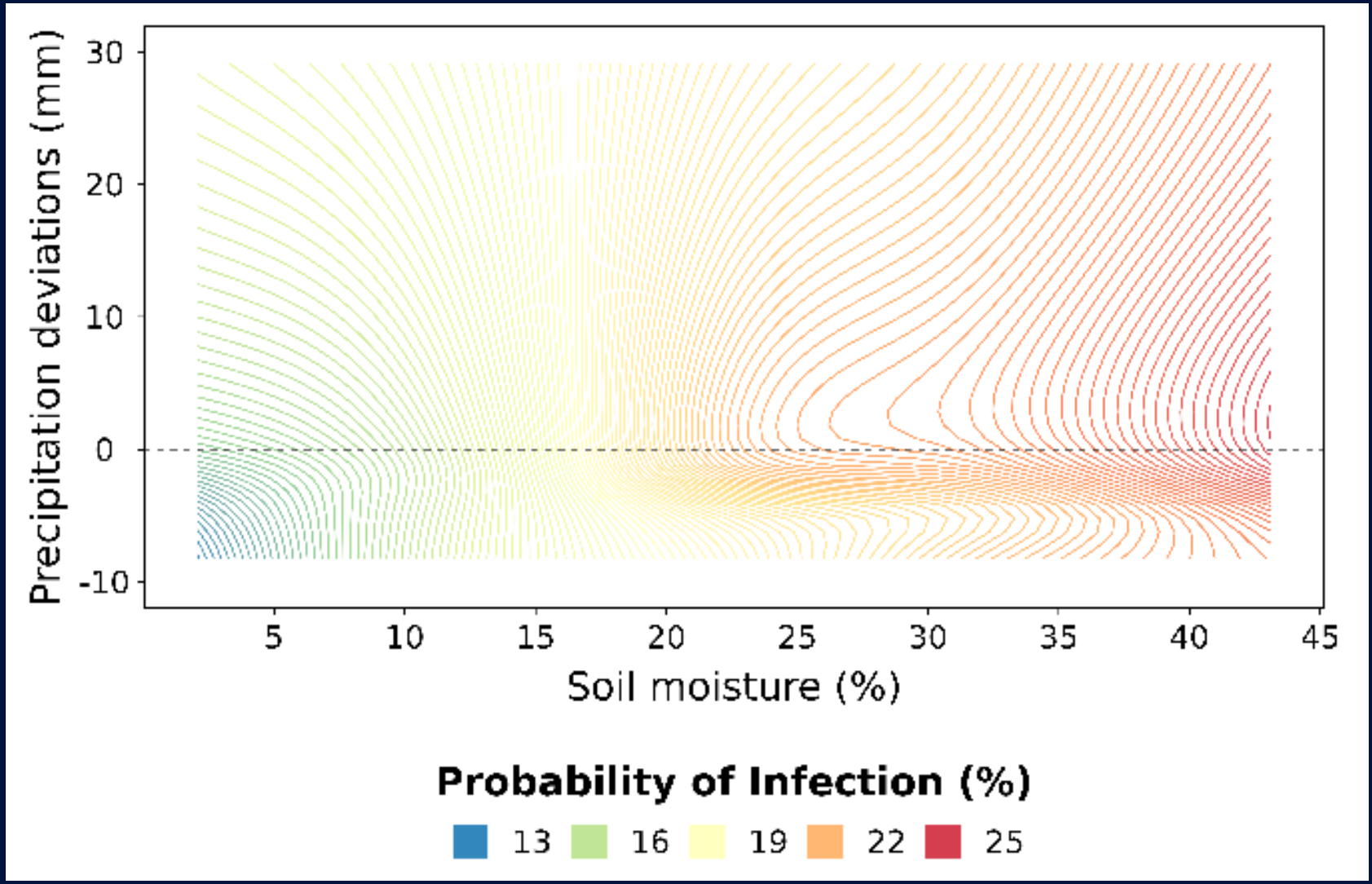
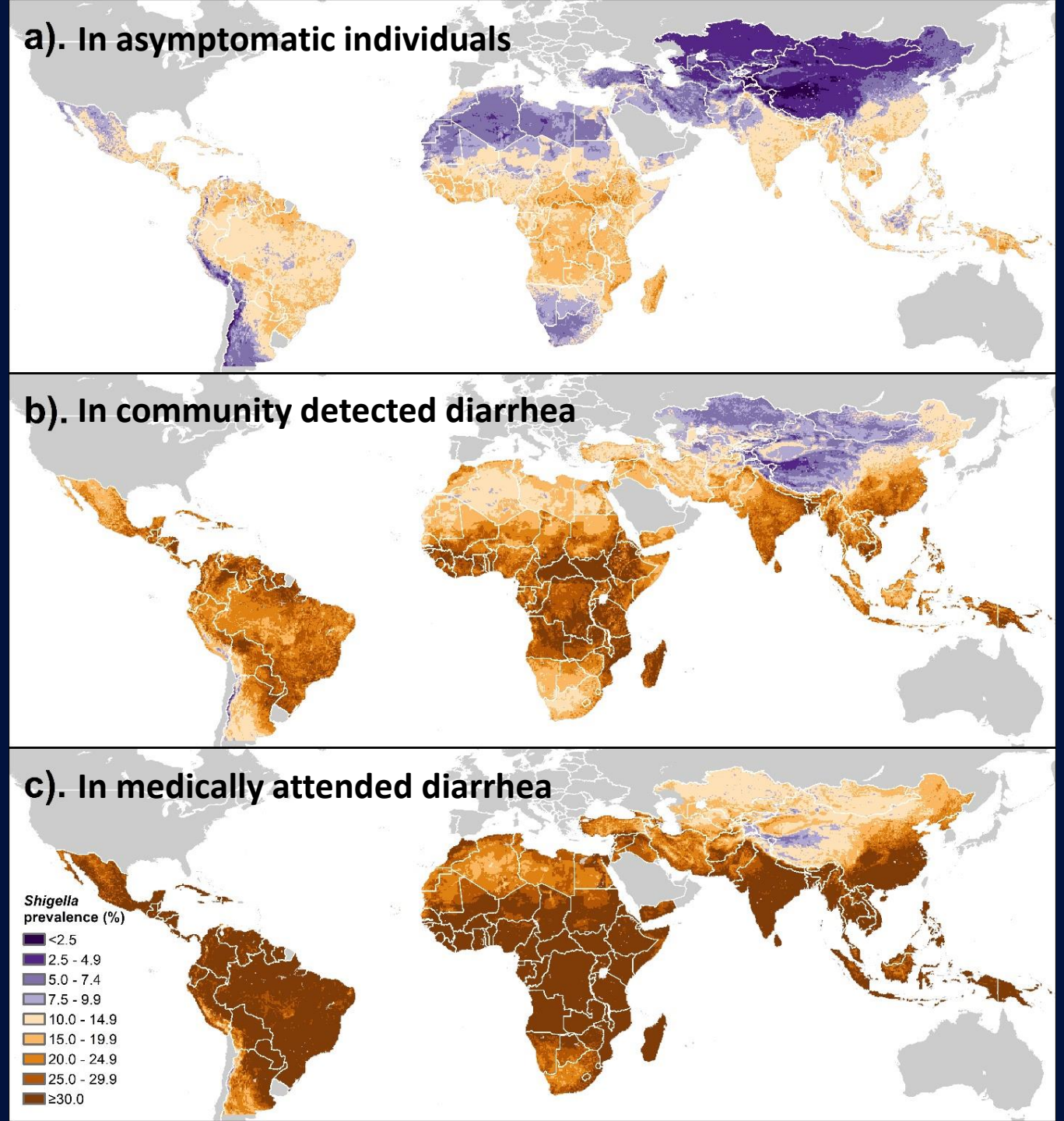


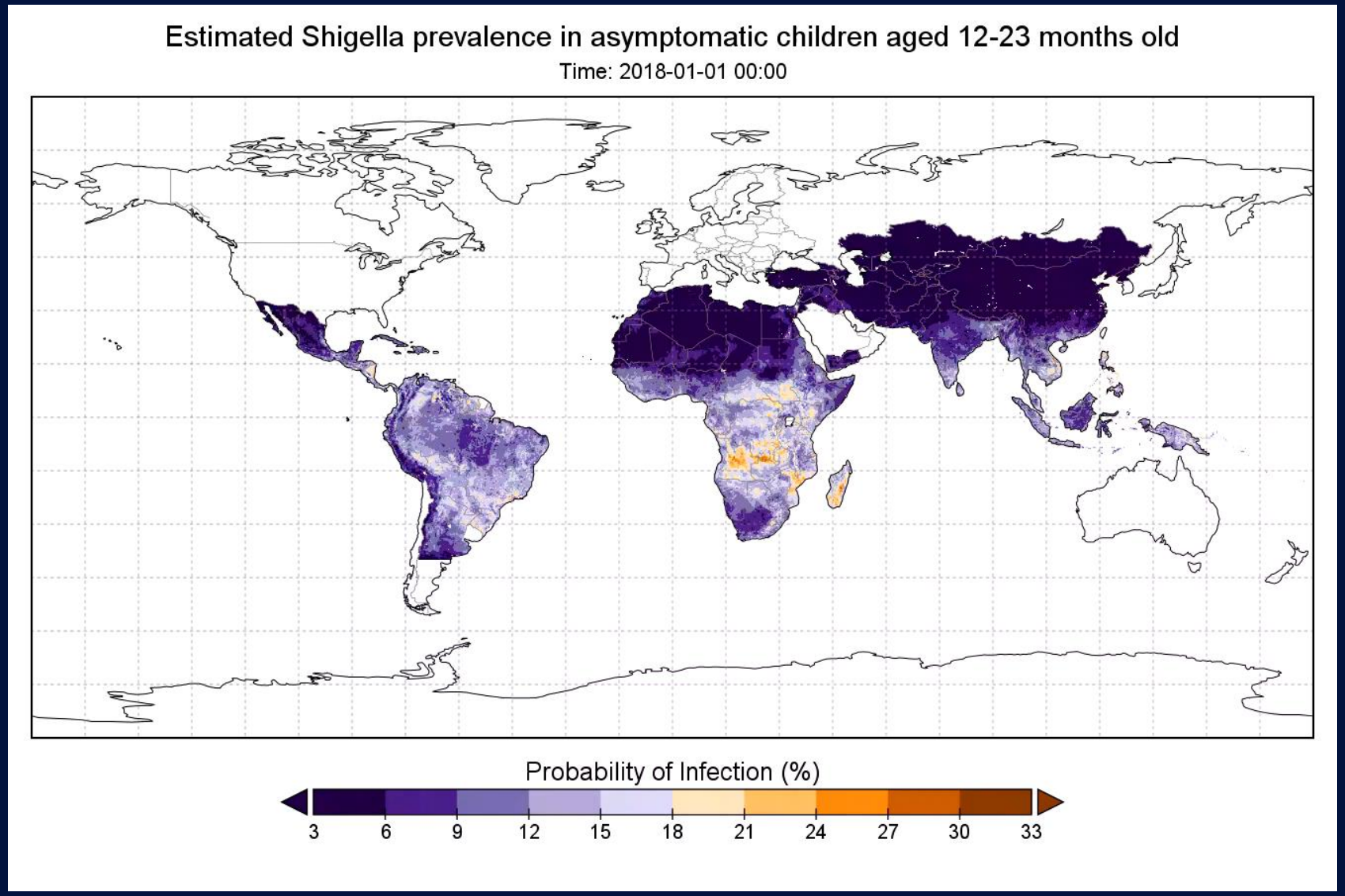
Variable Influence



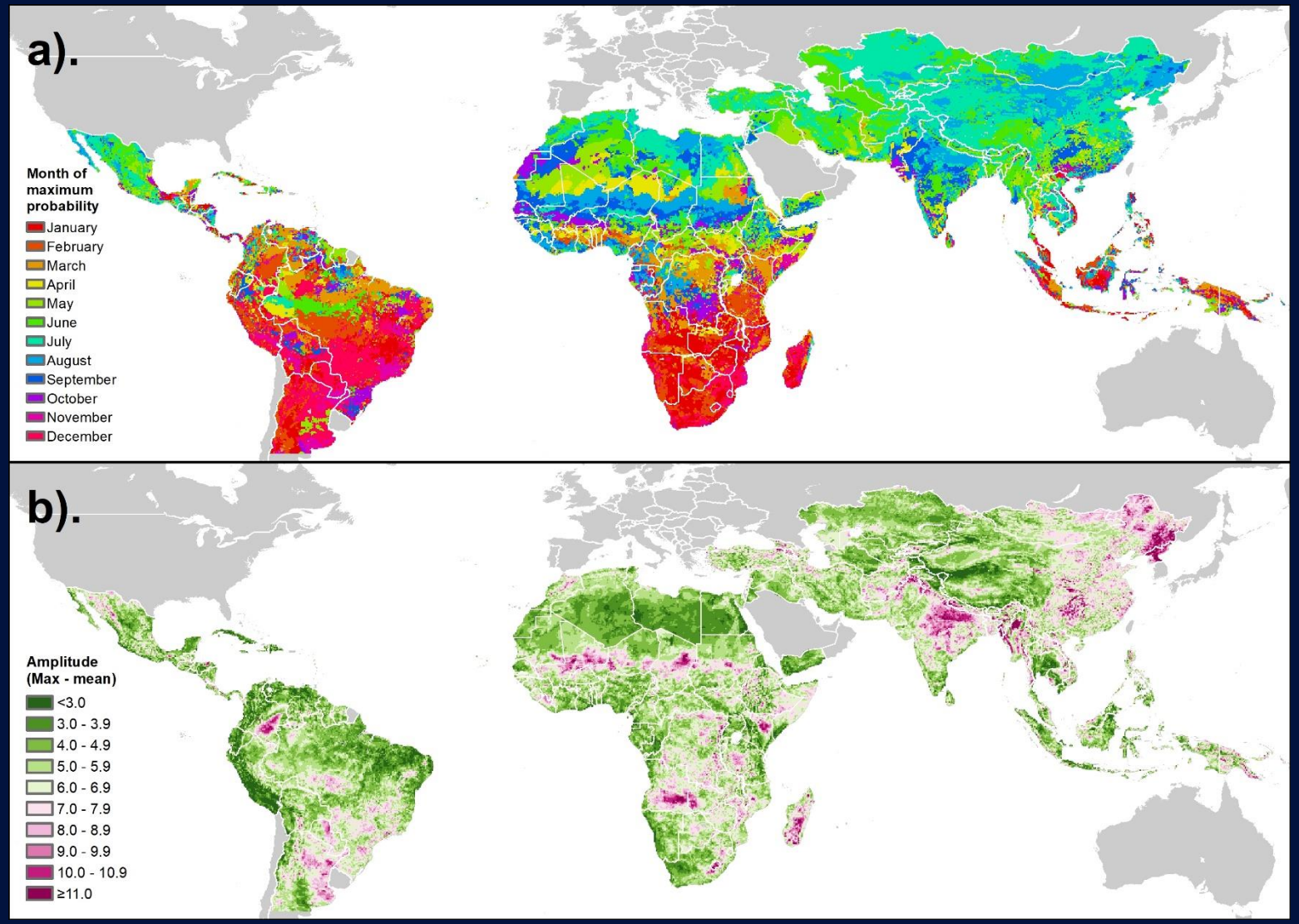
Prevalence


a). In asymptomatic individuals
b). In community detected diarrhea
c). In medically attended diarrhea
Shigella prevalence (%)
<2.5
2.5 - 4.9
5.0 - 7.4
7.5 - 9.9
10.0 - 14.9
15.0 - 19.9
20.0 - 24.9
25.0 - 29.9
≥30.0

Seasonality



Seasonality



Conclusions

- *Shigella* infection rates exhibit substantial climate sensitivity
- EO-informed risk mapping and variability analysis can inform interventions
- These results are relevant to upcoming vaccination trials and campaigns, and are being shared with relevant decision-makers

Thank you

zaitchik@jhu.edu

Overview of NASA HAQAST

The NASA Health and Air Quality Applied Sciences Team (HAQAST)

3rd Generation; 2021-2025

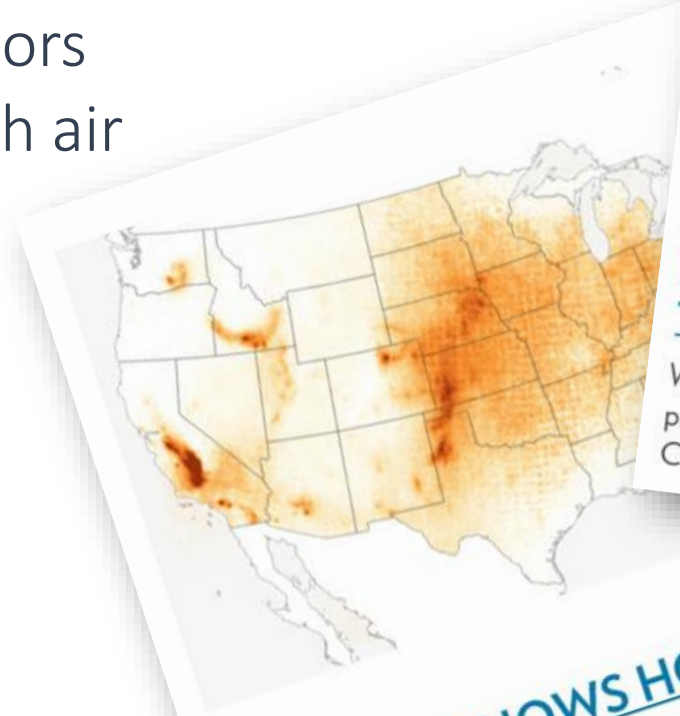
Jenny Bratburd, University of Wisconsin—Madison

What is “hay-kast”?

- Health and Air Quality Applied Sciences Team
- NASA-funded Applied Sciences Team
- 4 year initiative through 2025
- 14 Members and 70+ co-investigators
- Mission: Connect NASA science with air quality and health applications
- ~ $12+ Million Total Cost
- Three types of work:
  - Member projects
  - Tiger team projects (collaborative)
  - Outreach, engagement, rapid response

NASA WORLDVIEW VIDEO TUTORIAL NOW AVAILABLE

Watch HAQAST’s NASA Worldview video tutorial, produced by the NASA HAQAST Communications Team



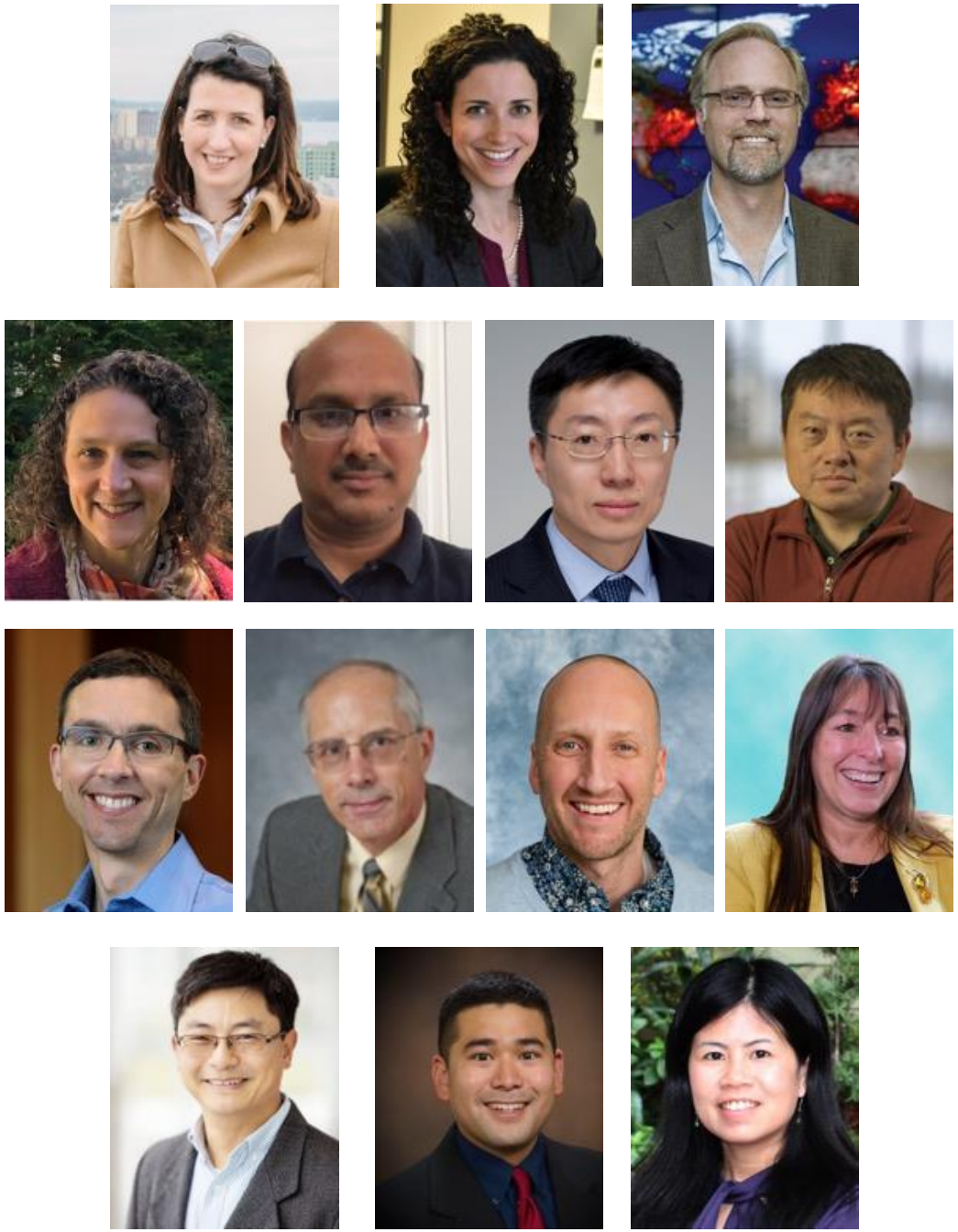
O SHOWS HOW
BREATHES
hm of NH3

HAQAST1:
2011-2016

HAQAST2: *2016-2020*
HAQAST3: *2021-2025*

The team structure fundamentally changes outcomes.

- Increased visibility of work and resources to end-users
- Culture to support and promote collaborations and synergies
- Growth of two-way dialogue
- Increased collaborations to meet stakeholder needs
- Rapid spin-up of high-value activities



14 NASA Health and Air Quality Applied Sciences Team Members (HAQAST)

Tracey Holloway (Team Lead, UW-Madison)
Susan Anenberg (George Washington University)
Bryan Duncan (NASA GSFC)
Arlene Fiore (Columbia University)
Pawan Gupta (Universities Space Research Association)
Yang Liu (Emory University)
Jingqiu Mao (University of Alaska, Fairbanks)
Randall Martin (Washington University)
Ted Russell (Georgia Tech)
Jeffrey Pierce (Colorado State University)
Amber Soja (National Institute of Aerospace)
Daniel Tong (George Mason University)
Christopher Uejio (Florida State University)
Qian Xiao (University of Texas Health Science Center at Houston)

haqast.org

HAQAST Ambassadors

NASA HAQAST continues to advance applied research and partnerships, with over 70 investigators, 100s of meeting attendees, and over 1000 email subscribers.

New “Ambassadors” program engages a high-level stakeholders committed to advancing NASA data for societal benefit, and willing to serve as liaisons to their communities.

“NASA satellite data and training has allowed for collaboration and partnerships that … build a community of practice using satellite data for EJ applications

We are currently part of a HAQAST project that will … look at health effects of … air quality and extreme heat in the context of climate policy initiatives in the state.”

The Greening Diplomacy Initiative (GDI) … aims to leverage and integrate satellite data in Department products to provide accurate forecasting capabilities for our personnel overseas.”

“NASA’s MODIS imagery is fundamental in both the analysis and forecasts processes [for wildfires across Alaska].”

13 HAQAST Ambassadors so far represent 4 states/regions (CT, GA, NY, Western states), 3 federal agencies (EPA, Dept. of State, National Park Service); 4 non-profits (American Cancer Society, Health Effects Institute, Earth Stewards); 2 private companies (Breezometer & IQAir)

Smoke replaces ice at Lake Winnipeg.

True color image Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite, from the NASA Earth Observatory, May 2021 over Winnipeg, Canada.
Source: https://Earthobservatory.nasa.gov/images/148340/smoke-replaces-ice-at-lake-winnipeg.

The Four Things to Know about Satellite Data for Air Quality Management

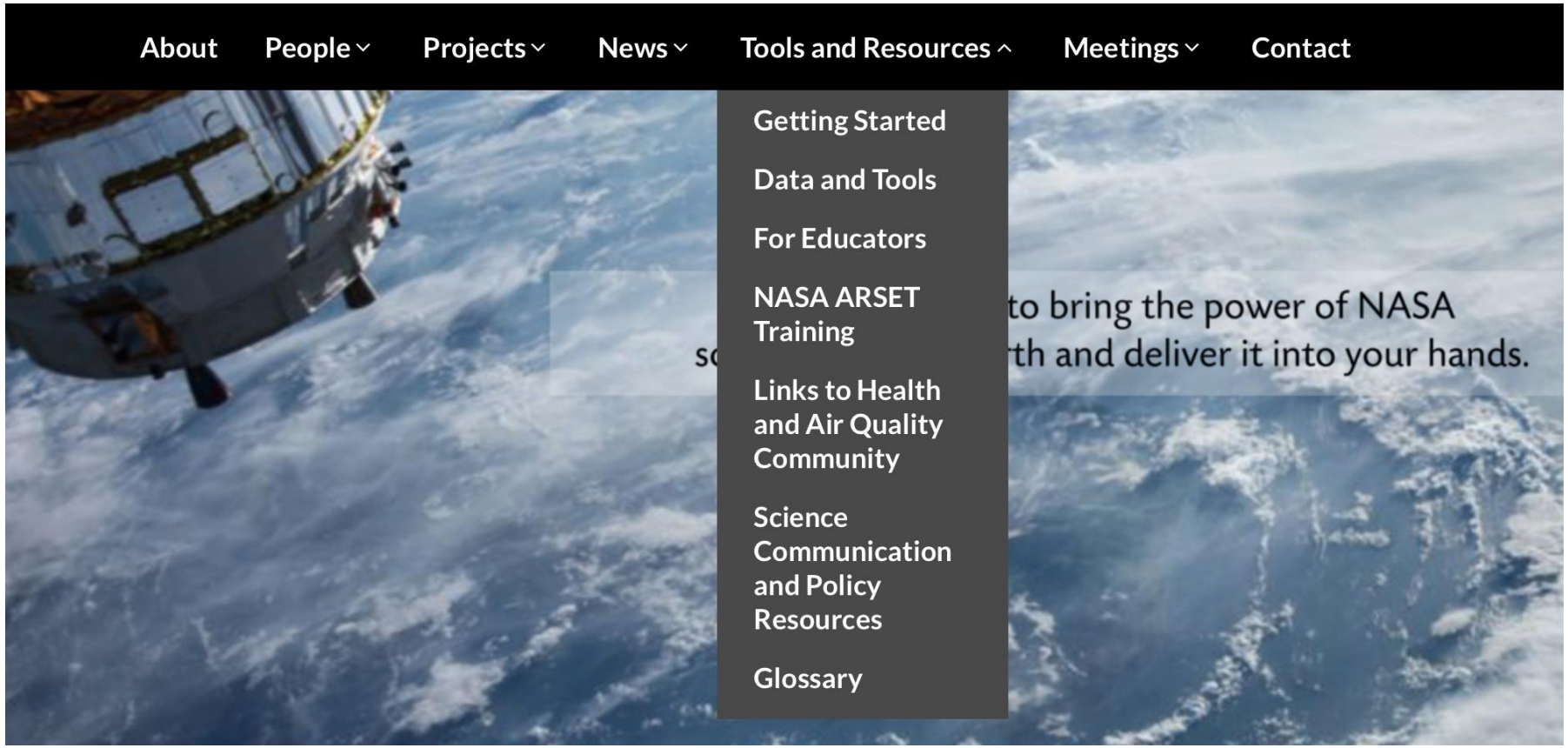
by Tracey Holloway and Jennifer Bratburd

Getting Started Is Easy

HAQAST

NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders



ehp Environmental Health Perspectives

Vol. 127, No. 7 | Commentary

Making Open Science Work for Science and Society

Kevin C. Elliott and David B. Resnik

Published: 29 July 2019 | CID: 075002

The open science movement encompasses a number of initiatives [including to] **promote successful communication between experts and decision makers** so they can make effective use of scientific information (Holloway et al. 2018; Royal Society 2012).

Government agencies have also been involved in innovative efforts to help decision makers make more effective use of data and influence research projects to make them as socially relevant as possible…. **NASA has supported a Health and Air Quality Applied Sciences Team (HAQAST), which helps stakeholders make use of NASA data** to answer stakeholders' environmental health questions (Holloway et al. 2018).

HAQAST Supports Two Types of Projects: Individual & Tiger Team

NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders

2021 Tiger Teams

Satellite data for environmental justice (SD4EJ)

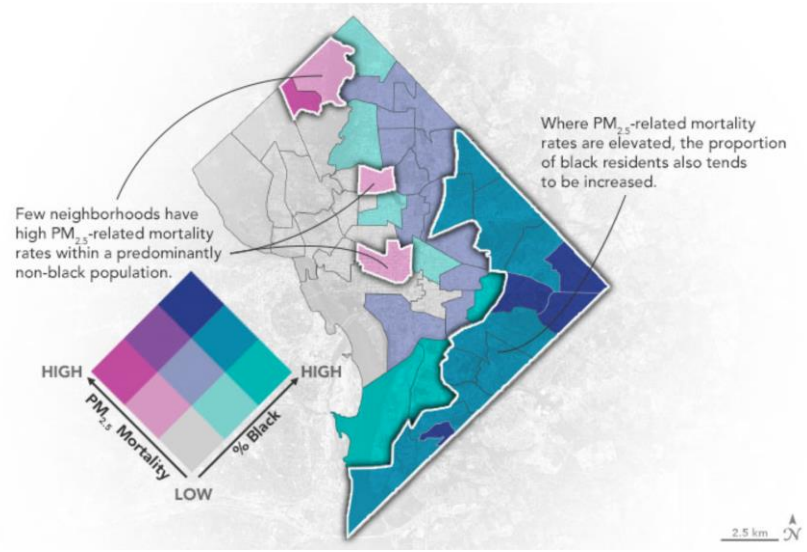
Enabling Stakeholder Access and Utilization of Data Products for Health and AQ Applications (First Steps)

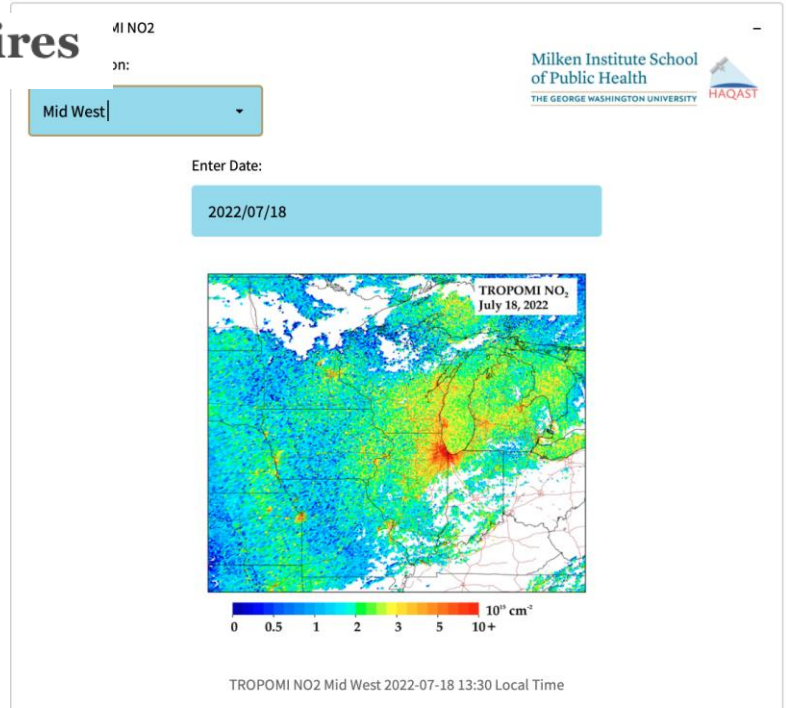
Communicating the uncertainties of satellite-based NOx emissions for urban planning

Enabling USEPA to ingest high-frequency satellite air quality data into the AirNow system

Fused earth observations to quantify health impacts from agricultural fires

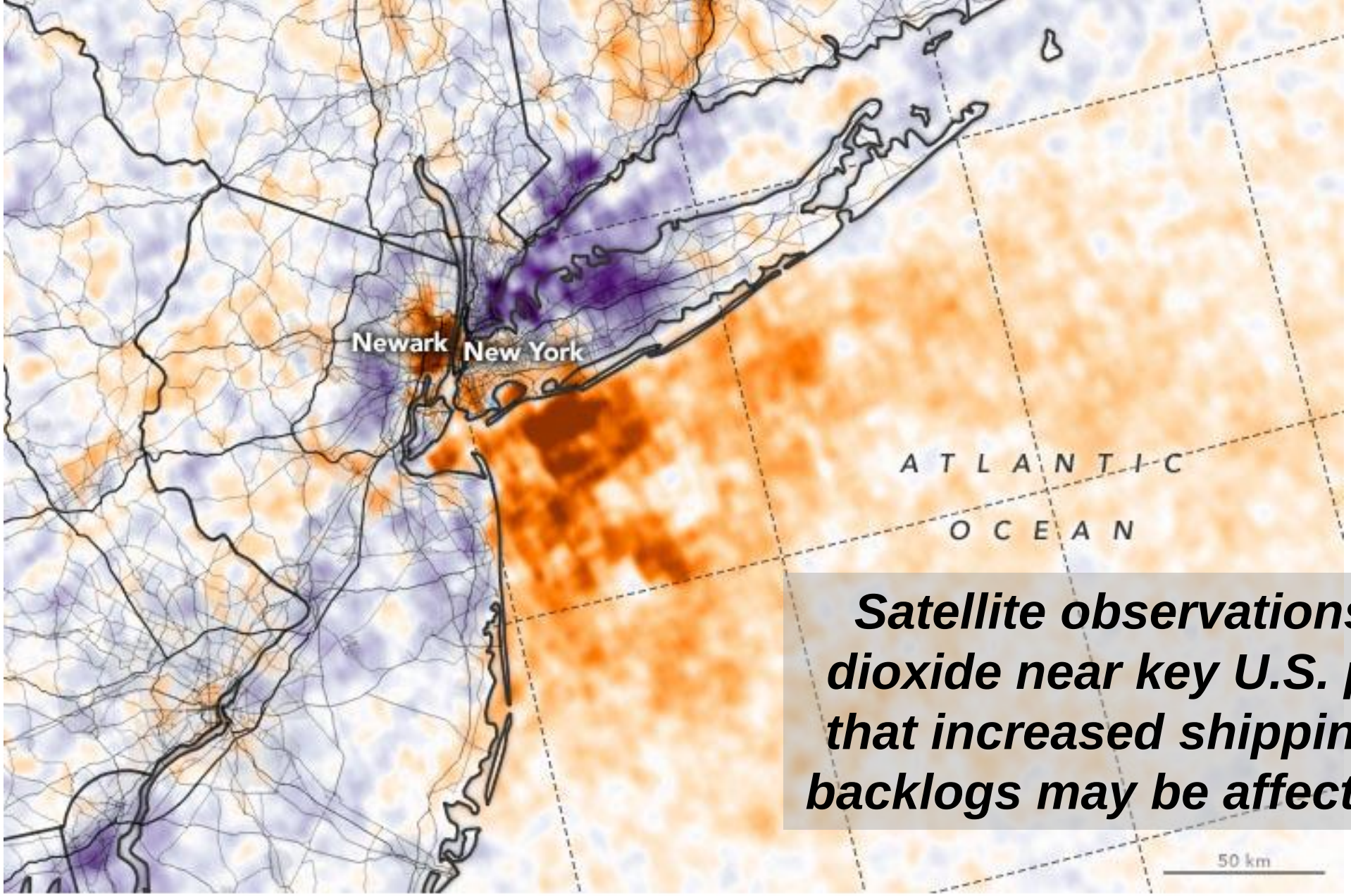
Example outputs: (left) high-resolution analysis of pollution for EJ applications; (right) new website for easy analysis of TROPOMI over the U.S.





Rapid Response Projects

- Responding to the need of smoke forecasts in Alaska: A data fusion approach with advanced deep learning algorithms
- Collaborating with the New Mexico Department of Health to Respond to Wildfires and Extreme Heat
- Distribution and pollution: Investigating the influence of warehouse-related transportation activities on NO2 and PM2.5 using satellites, models, and monitors
- And more!



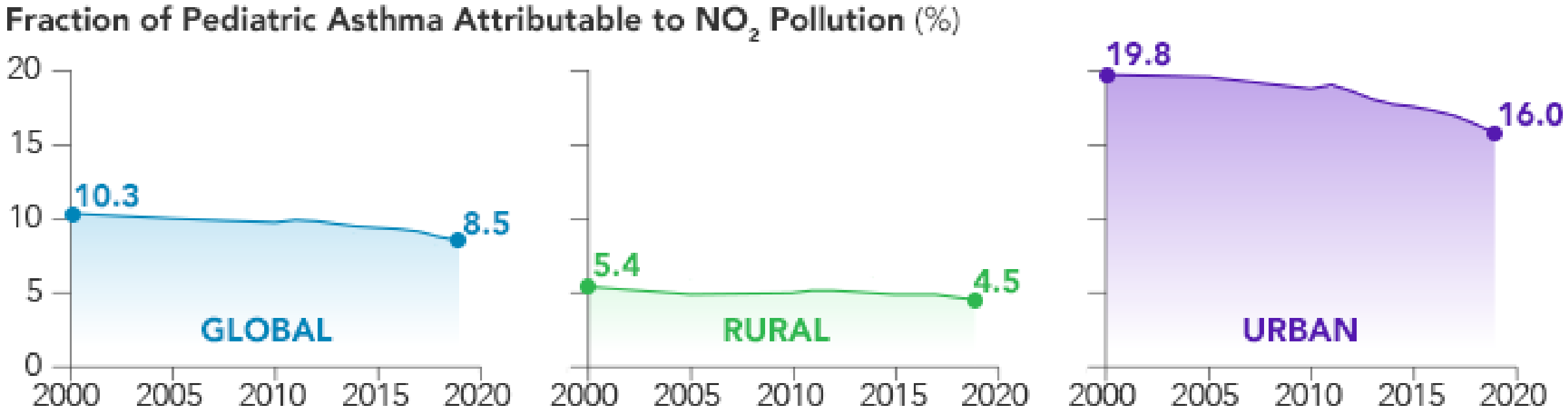
Satellite observations of nitrogen dioxide near key U.S. ports suggest that increased shipping activity and backlogs may be affecting air quality.

Change in Mean Tropospheric NO_2 Column Density, 2018-19 vs 2021 ($\mu mol/m^2$)

≤-40 0 ≥40

https://earthobservatory.nasa.gov/images/149004/scientific-questions-arrive-in-ports

A new satellite-derived global dataset links concentrations of nitrogen dioxide with cases of pediatric asthma in urban areas around the world.



Anenberg, S.C., *et al.* (2022)

Air quality experts incorporate more satellite data and customized models from NASA to better track ozone pollution around the Great Lakes.

https://earthobservatory.nasa.gov/images/150135/clearer-view-of-great-lakes-air-quality

HAQAST Wisconsin

- October 20th & 21st, 2022
- Public, hybrid meeting
- Dialogue with stakeholders & scientists

NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders

ARSET Health & Air Quality Trainings Overview

Pawan Gupta (USRA/MSFC)
(pawan.gupta@nasa.gov)

https://appliedsciences.nasa.gov/join-mission/training

EARTH SCIENCE
APPLICATIONS WEEK 2022

NASA Applied Remote Sensing Training (ARSET)

https://appliedsciences.nasa.gov/arset

- ***ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.***
- Our trainings are:
  - Online and in-person
  - Open to everyone
  - Live, instructor-led, or self-guided
  - Provided at no cost, with materials and recordings available from our website
  - Often multi-lingual
  - **Tailored to those with a range of experience in remote sensing, from introductory to advanced**

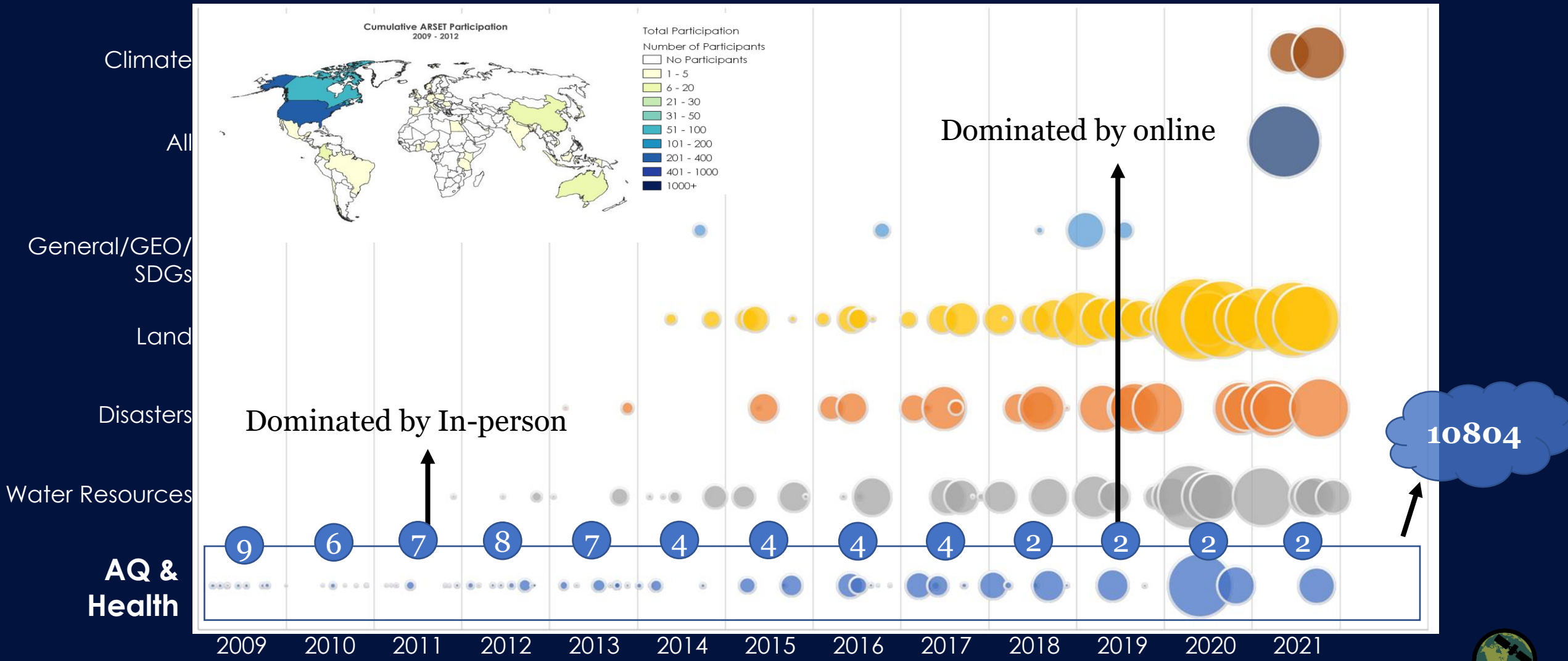
ARSET offers trainings for:

- Disasters
- Health & Air Quality
- Land Management
- Water Resources
- Climate

ARSET now offers climate trainings,

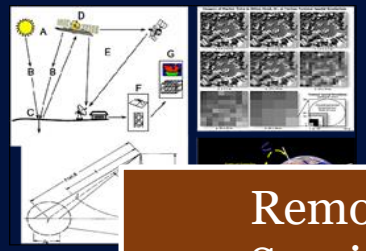
ARSET Trainings 2009 - 2021

162 trainings | 86,000+ participants | 179 countries | 14,000+ organizations



* Size of circles corresponds to number of participants

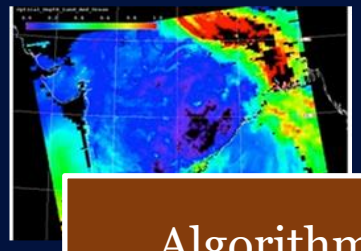
ARSET Air Quality Trainings



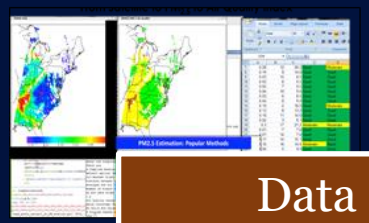
Remote Sensing

Satellites

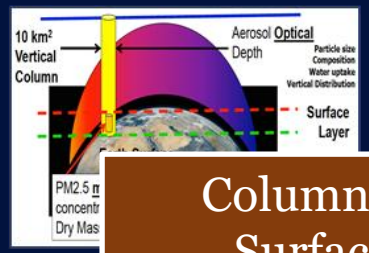
Imagery



Algorithms



Data & Tools

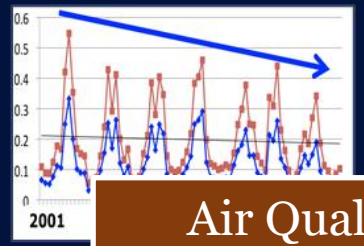


Column to Surface

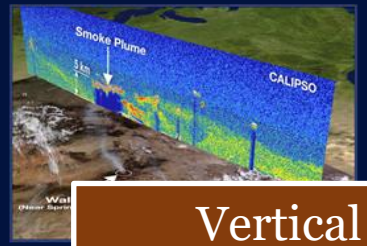
Dust & Smoke

Plume Transport

Air Quality Forecasting



Air Quality Trends



Vertical Profiles

Time Sensitive Topics and Response

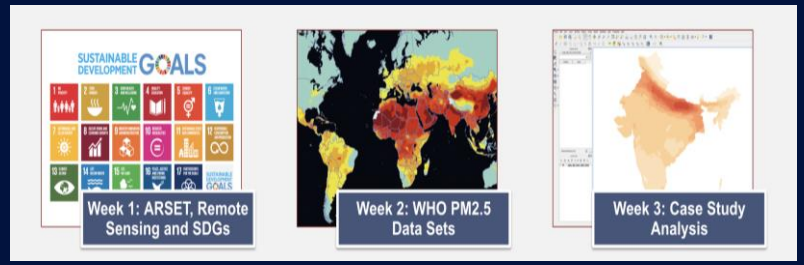
2017 Sustainable Development Goals

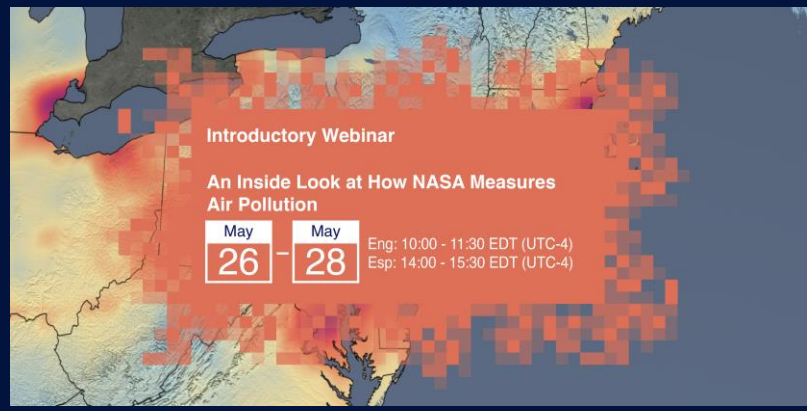
2020 COVID, Lockdown, & Pollution

2020

2021 Wildfires and Smoke

2023 Environmental Justice





Recent Training Example

Three-parts, advanced training
(Python Jupyter Notebook)

Advanced Webinar

Tools for Analyzing NASA Air Quality Model Output

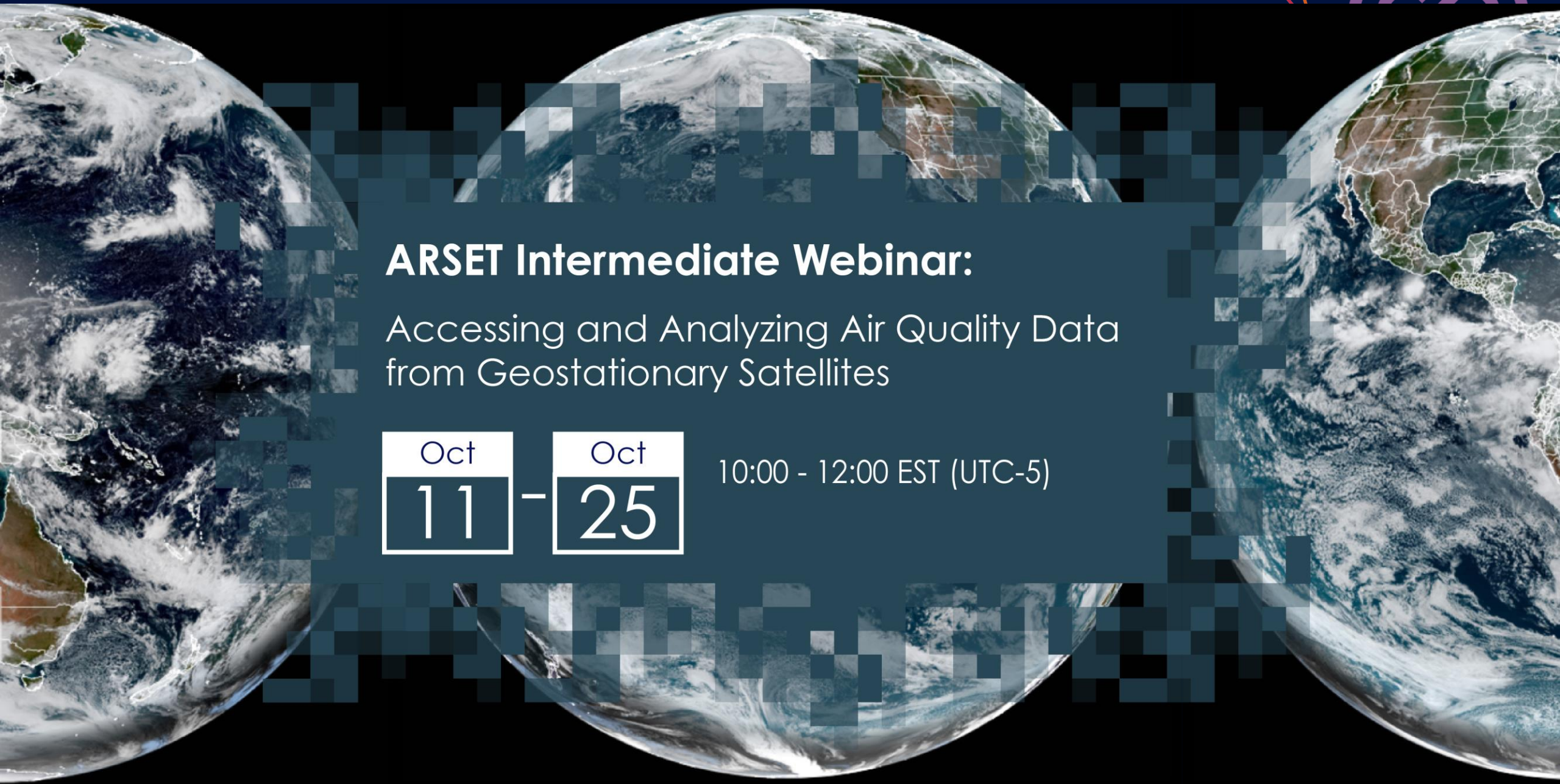
Feb 22 – Mar 01

10:00 - 12:00 EST (UTC-5)

- **632** Participants
- **350** Organizations
- **91** Countries
- **33** US States

- GEOS FP and GEOS-CF forecasts, and MERRA-2 Reanalysis
- GES DISC tools for visualization and analysis
- Hands-On Exercise: Intercomparison with Satellite Observations
- Hands-On Exercise: Validation with Surface Observations
- Case Study Analysis: Instructor-led exercise to combine data and apply tools to assess forecast and analysis performance

Upcoming … Partnering with NOAA & GEMS Team



Some Fun !!

Mission Highlight:

Tropospheric Emissions Monitoring of Pollution (TEMPO) Overview

Dr. Aaron Naeger

EARTH SCIENCE
APPLICATIONS WEEK 2022

Tropospheric Emissions: Monitoring of POllution (TEMPO) Mission

Selected in November 2012 as NASA's first Earth Venture Instrument

PI: Kelly Chance, SAO: STM, ground systems, science data processing center

Instrument Development: Ball Aerospace

Instrument Project Management: NASA LaRC, PM: Kevin Daugherty

Deputy Program Applications Lead: Aaron Naeger

Other Institutions: UAH, NASA SPoRT, NASA GSFC, NOAA, EPA, NCAR, Harvard, UC Berkeley, St. Louis U, U Nebraska, RT Solutions, Carr Astronautics, etc.

International collaboration: Mexico, Canada, Cuba, Korea, U.K., ESA, Spain

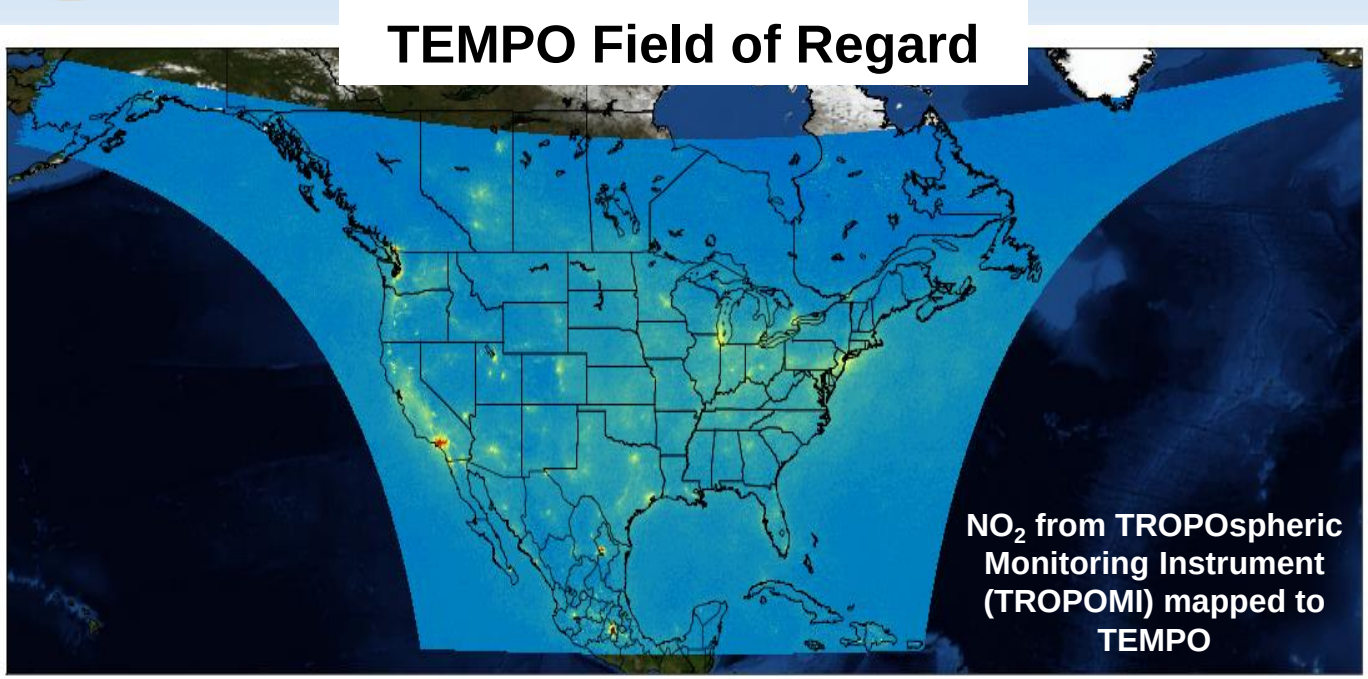
Host Satellite Provider: Maxar Technologies
Satellite Host: Intelsat (IS40e)
Launch: SpaceX

Numerous other organizations (50+) are actively engaged in the **TEMPO Early Adopters Program**

TEMPO being integrated with Intelsat 40e

Image Courtesy of Maxar Technologies

TEMPO Quick Facts



- TEMPO will measure North American air pollution every daylight hour at high spatial resolution from geostationary Earth orbit
- Grating spectrometer with 2 detectors measuring backscattered radiances from ~293-494 & 538-741 nm with resolution and sampling of ~0.6 and 0.2 nm
- TEMPO will be sensitive to key air pollutants, including **EPA criteria "policy-relevant" pollutants of NO_2, SO_2, and O_3**

- TEMPO's Field of Regard will cover the U.S., Canada, Mexico, Cuba, Puerto Rico, and The Bahamas
- TEMPO instrument integration with host satellite, Intelsat 40e, was recently completed in June
- Launch expected late February to early March 2023 to operating position at 91°W longitude
- Baseline mission duration: 20 months
- Member of a geostationary satellite constellation for observing global air quality

TEMPO Data & Operations

TEMPO Data Products

Level	Product	Key Outputs	Res km^2 *	Freq/Size
L0	**Digital counts**	Reconstructed digital counts	2.0 x 4.75	Daily/hourly
L1-b	**irradiance**	Calibrated & quality flags		daily
	radiance	Geolocated, calibrated, viewing	2.0 x 4.75	Hourly, granule
L2 ★	**Cloud**	Cloud fraction, cloud pressure	2.0 x 4.75	Hourly, granule
	O_3 (Ozone) profile	O3 profile, tropospheric & 0-2 km O3 column, errors	**8.0 x 4.75**	Hourly, granule
	Total O_3	Total O3, Aerosol Index, cloud fraction	2.0 x 4.75	Hourly, granule
★	**NO_2** (Nitrogen Dioxide)	SCD, strat./trop. VCD, errors	2.0 x 4.75	Hourly, granule
★	**HCHO** (Formaldehyde)	SCD, VCD, errors	2.0 x 4.75	Hourly, granule
	$C_2H_2O_2$ (Glyoxal)		2.0 x 4.75	Hourly, granule
	H_2O (Water Vapor)		2.0 x 4.75	Hourly, granule
	BrO (Bromine)		2.0 x 4.75	Hourly, granule
★	**SO_2** (Sulfur Dioxide)	SCD, VCD (PBL,TRL,TRM,TRU,STL)	2.0 x 4.75	Hourly, granule
★	**Aerosol**	AAI, UVAOD, UVSSA, AOCH, VISAOD	**8.0 x 4.75**	Hourly, granule
	TEMPO/GOES-R Synergistic	Radiance, aerosol, cloud & mask, fire/hotspot, lightning, snow/ice, etc.	2.0 x 4.75	Hourly, granule
L3	**Gridded L2**	Same as L2	2 x 2 (TBD)	Hourly, scan
L4	**UVB**	UV irradiance, erythemal irradiance, UVI	TBD	Hourly, scan

Black text: Baseline products; **Orange text**: Additional / proposed products

★ **Proposed Near real-time products (latency < 3 hours)**

** Center of Field of Regard

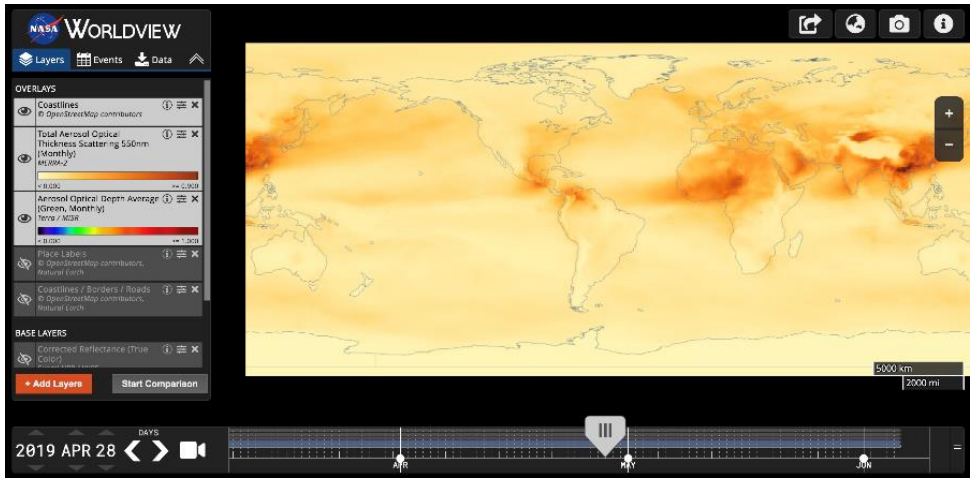
SCD: Slant Column Density
VCD: Vertical Column Density

AAI: Aerosol Absorption Index
UVAOD/VISAOD: UV/VIS Aerosol Optical Depth
UVSSA: UV Single Scatter Albedo
AOCH: Aerosol Optical Centroid Height

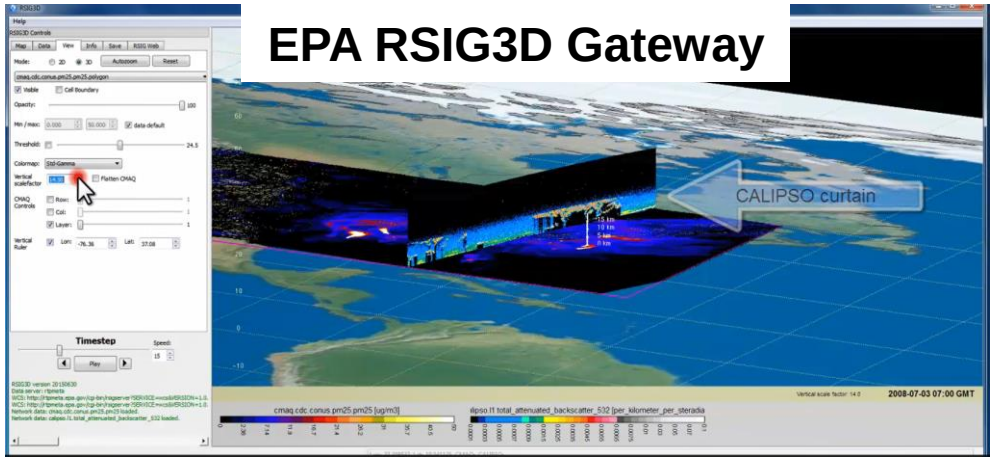
Operational Timeline & Data Distribution

- TEMPO commissioning phase: mid-June – mid Sept 2023
- Nominal operation: ~6 months after launch
- Plan to release L1b ~Jan 2024, **L2/3 in ~6 months to the public after commissioning phase (March 2024 for L2/3)**
- Data products will be **publicly available and free** via NASA Earthdata Search
- Latency of standard (Offline) products expected to be around 6 hours, except for ozone profile (~24-hour latency)
- **Latency of ~2-3 hours of proposed near real-time (NRT) products**

✓NASA WorldView



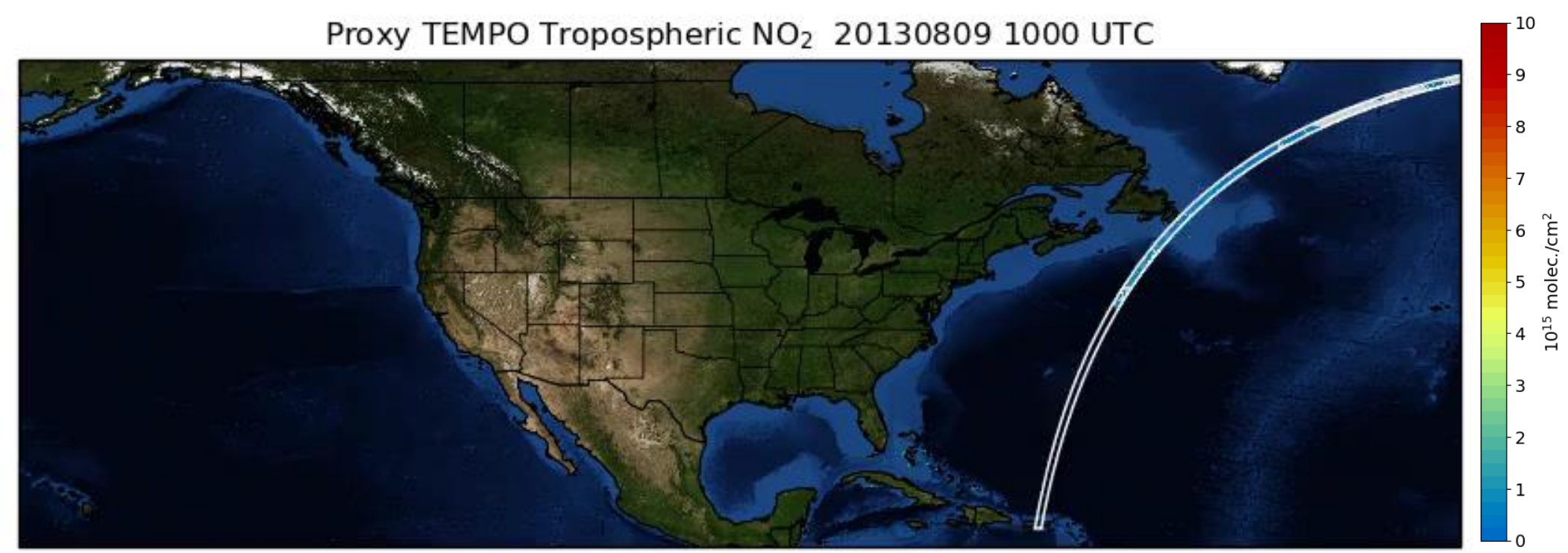
TEMPO imagery will be available in Worldview



TEMPO data can be served directly through the EPA RSIG.
https://www.epa.gov/hesc/remote-sensing-information-gateway

Adapted from slides at TEMPO STM 2020 & EAWNov2021 (Jeff Walter, Tim Larson)

TEMPO Scan Operations



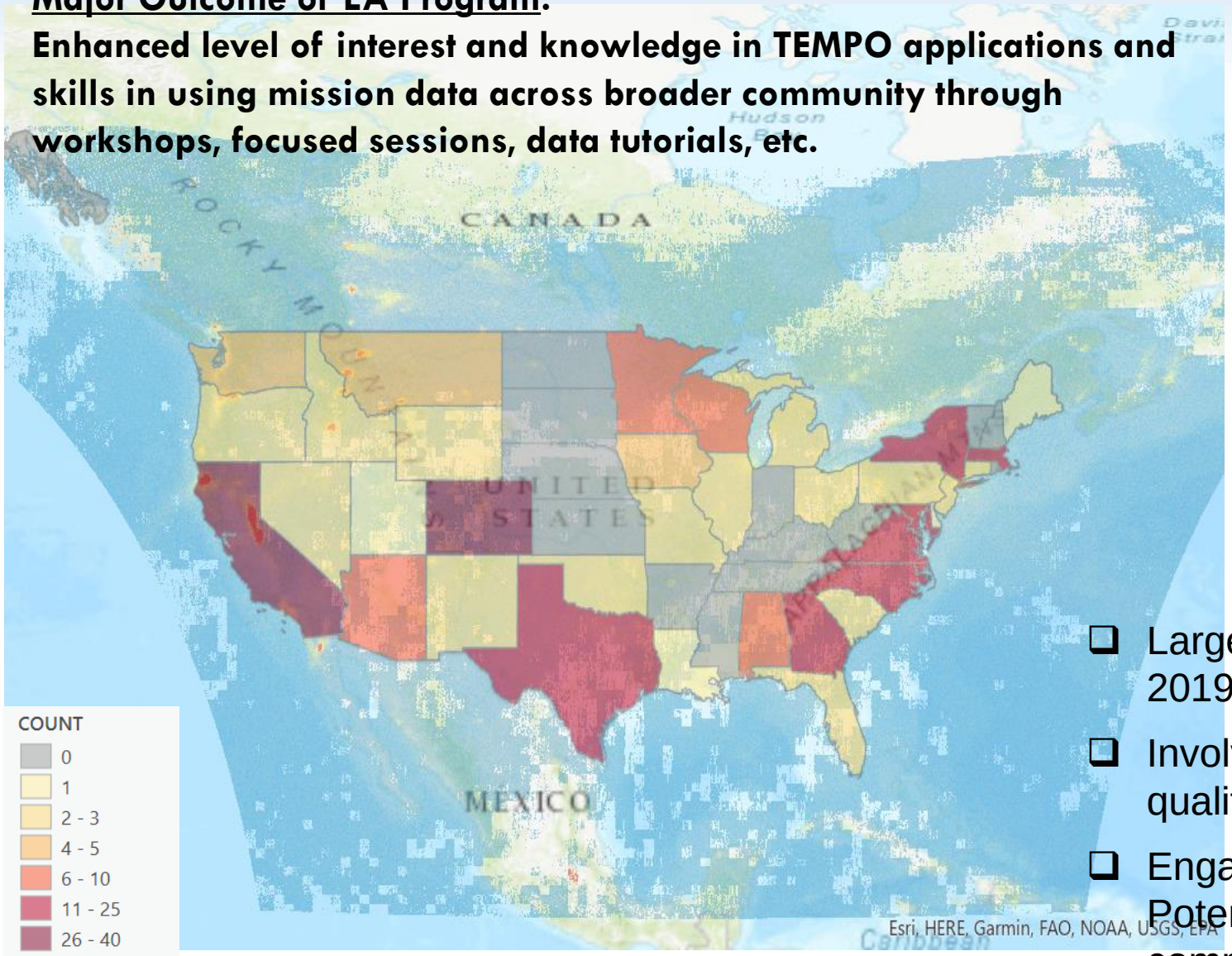
- TEMPO will perform standard East-West hourly daytime scans consisting of ~1226 mirror steps across the Field of Regard (FoR) over Greater North America
- Sub-hourly scans will also be performed:
  1) Optimized scans across the East and West during sunrise and sunset periods, respectively, when SZA is too high (> 80°) over portions of the FoR to complete a full hourly scan
  2) **Non-standard (special) operations for dedicated experiments (e.g., wildfires, volcanoes, dust storms) over a subset of steps / time intervals (e.g., <= 10 min)**

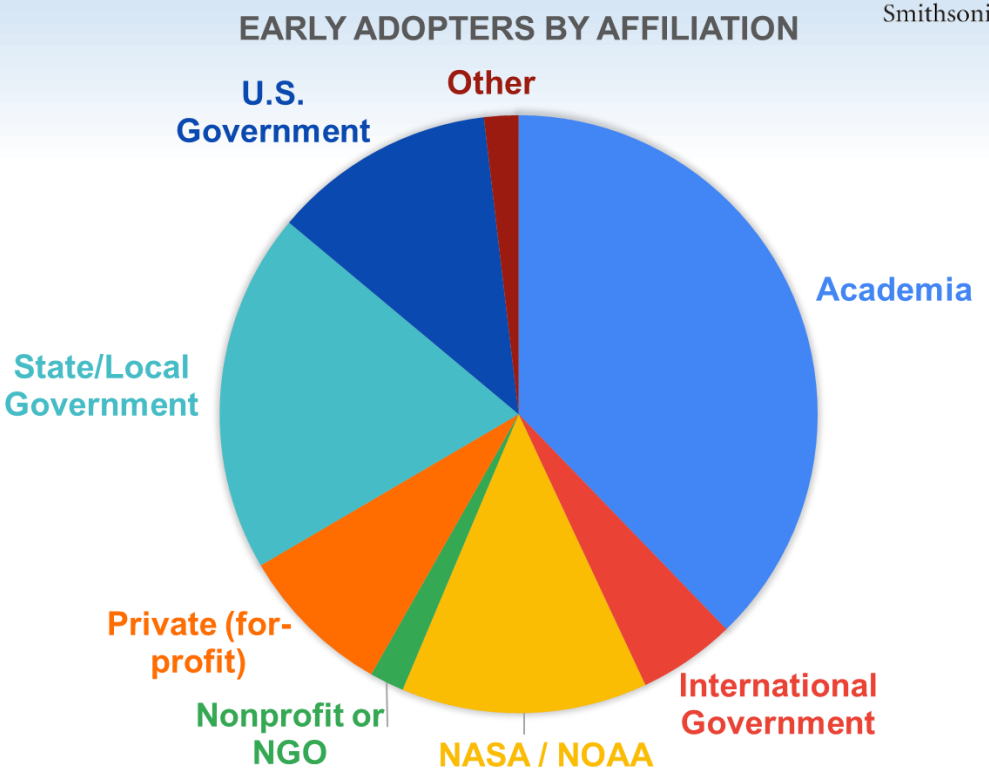
TEMPO Applications & Early Adopter Program

Early Adopters by Affiliation & Area

Major Outcome of EA Program:

Enhanced level of interest and knowledge in TEMPO applications and skills in using mission data across broader community through workshops, focused sessions, data tutorials, etc.

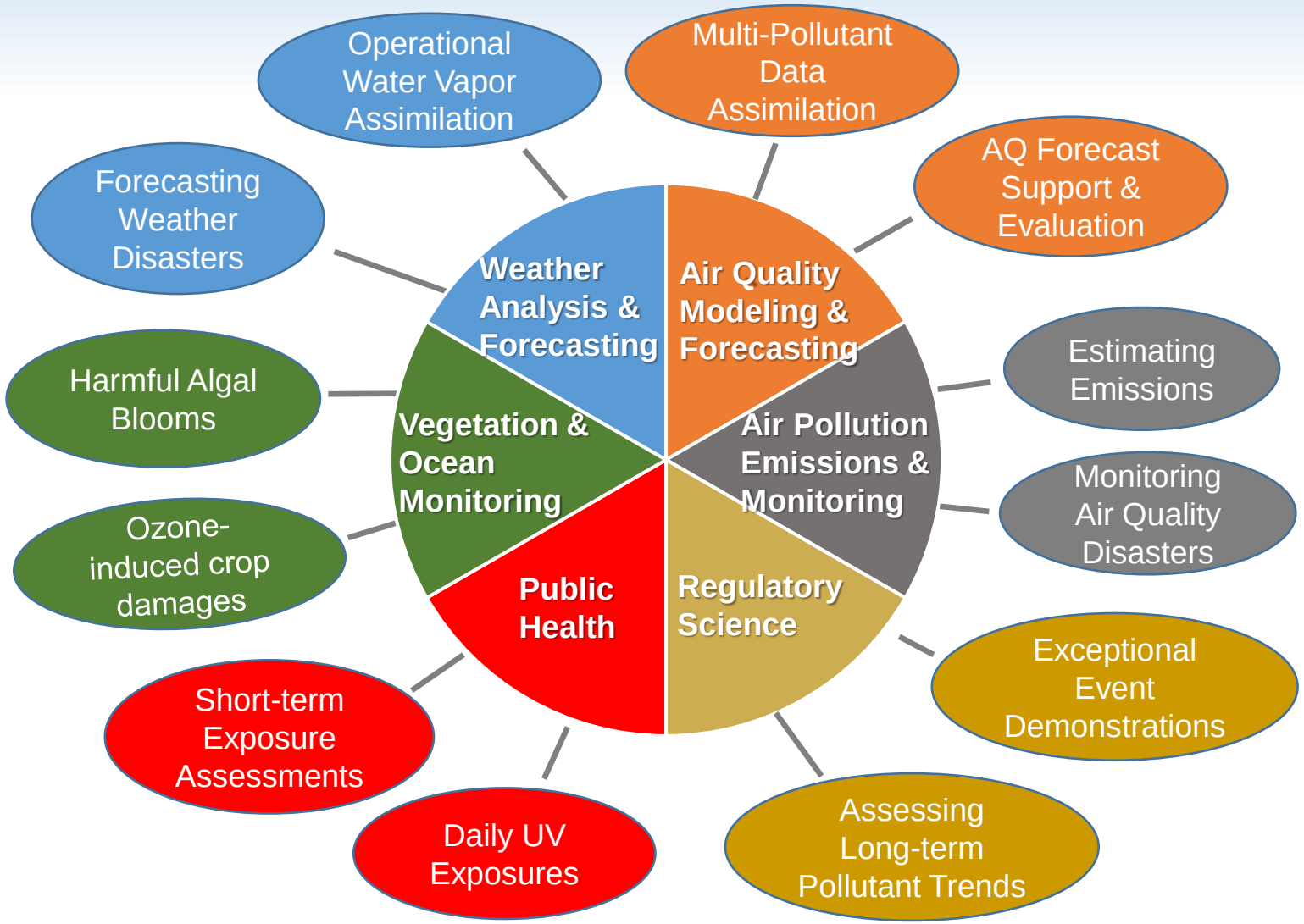




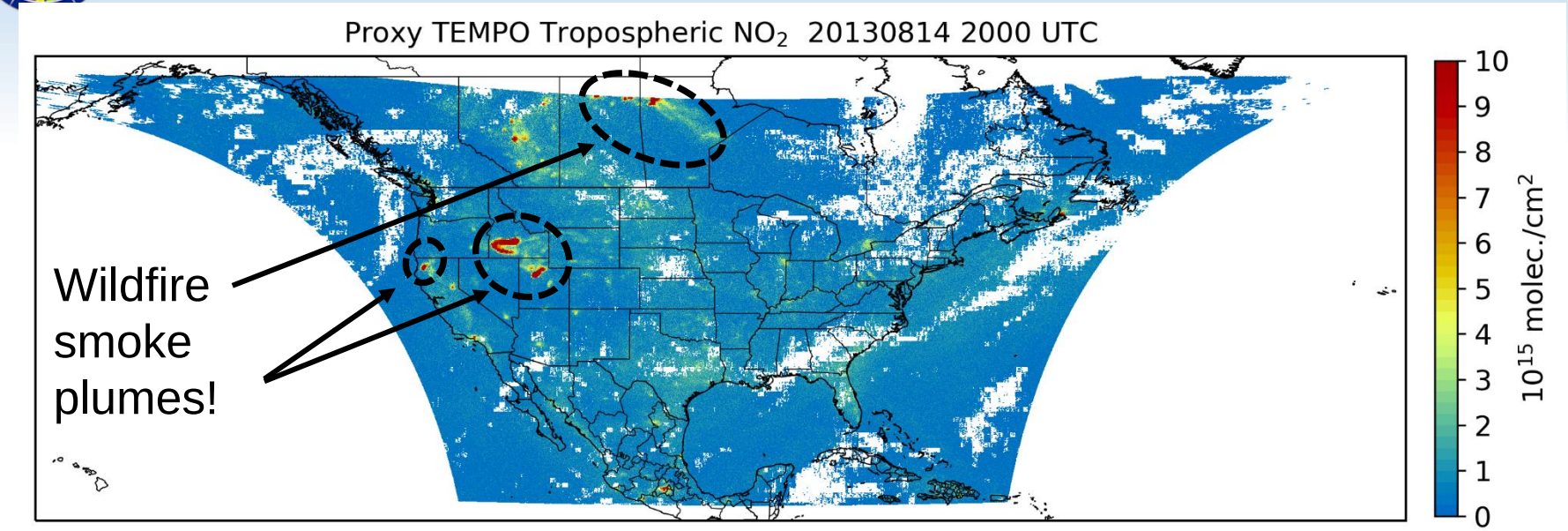
- Large expansion in Early Adopters Program since 2019 to 320+ members across TEMPO FoR
- Involvement from 50+ federal, state, and local air quality agencies, health organizations, and NGOs
- Engagement with Community of Practice and Potential (e.g., Environmental Justice & Health communities)

TEMPO Applications & Proxy Data

- TEMPO data will enable new and enhanced science studies spanning a diversity of application areas
- Early Adopters have played a key role in expanding TEMPO applications
- TEMPO proxy data created for Early Adopters with following goals:
  - Enable early understanding of TEMPO file structure and content
  - Facilitate development of best practices / methods of incorporating TEMPO data into science studies
  - Help prepare decision support systems for ingestion of real TEMPO data
  - **Inspire scientific experiments based on expected TEMPO information!**

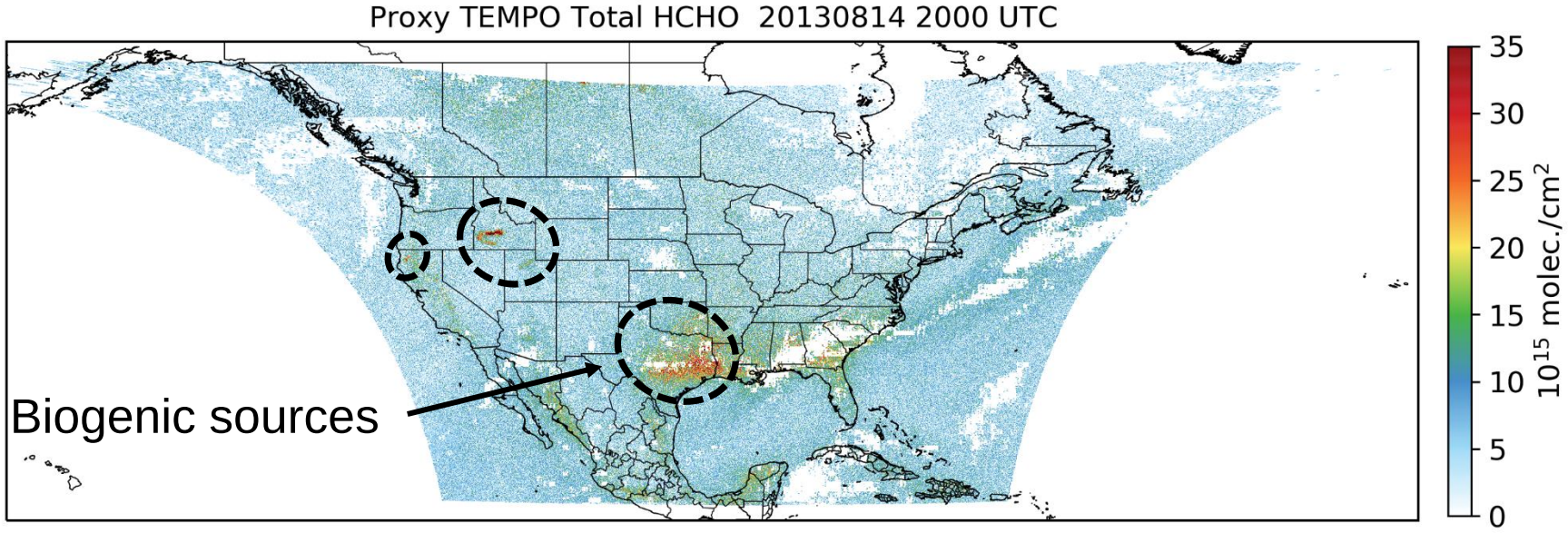


TEMPO Proxy NO_2 & HCHO



TEMPO proxy data developed from GEOS Nature Run model output from July 2013 – June 2014 along with realistic TEMPO information and retrieval effects

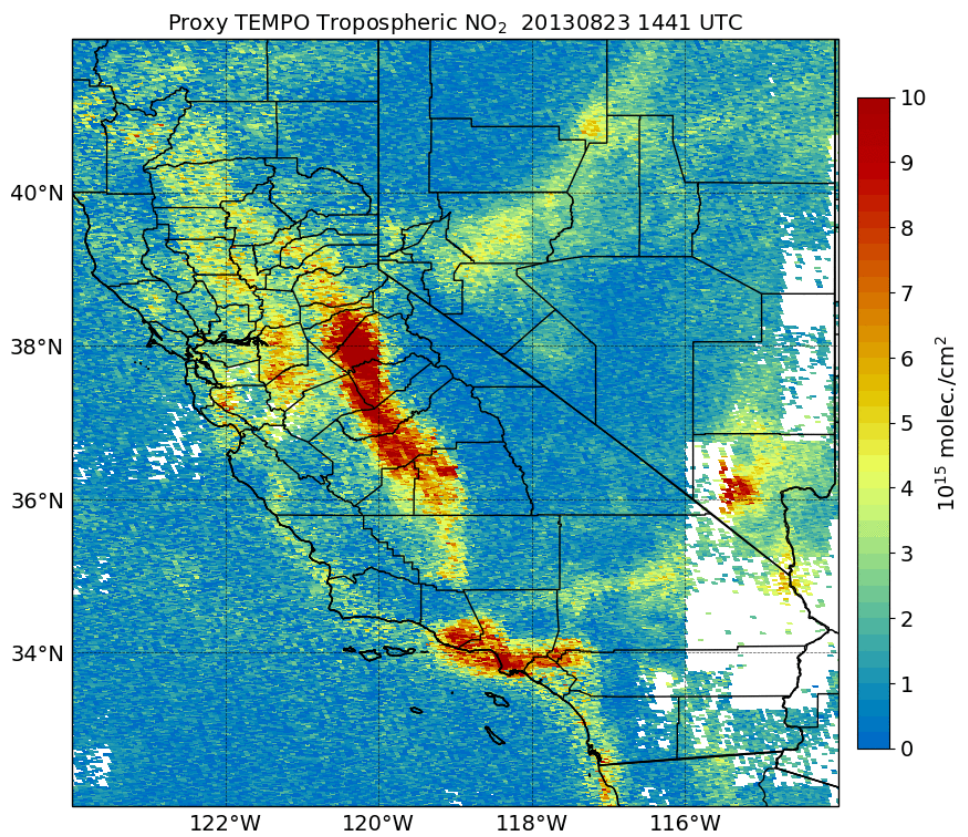
Maps produced from stitching together 10 different TEMPO granule data files across FoR and removing footprints with cloud fraction > 30%



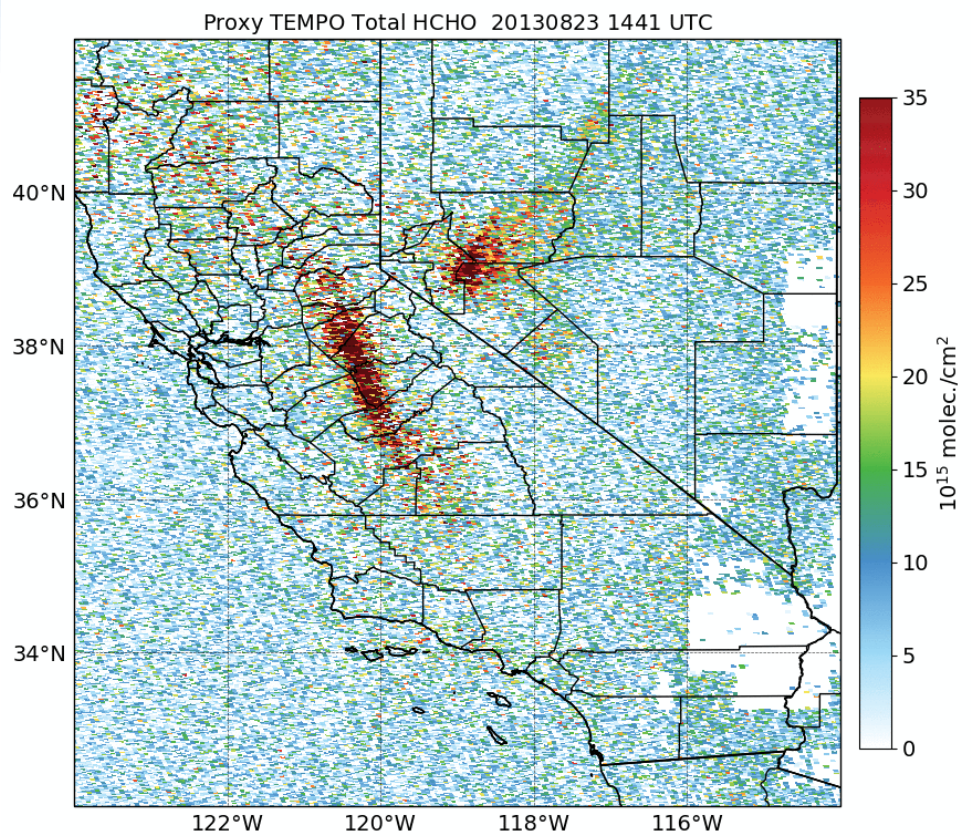
Hourly NO_2 & HCHO

Aug. 23, 2013

Tropospheric NO_2



Total HCHO

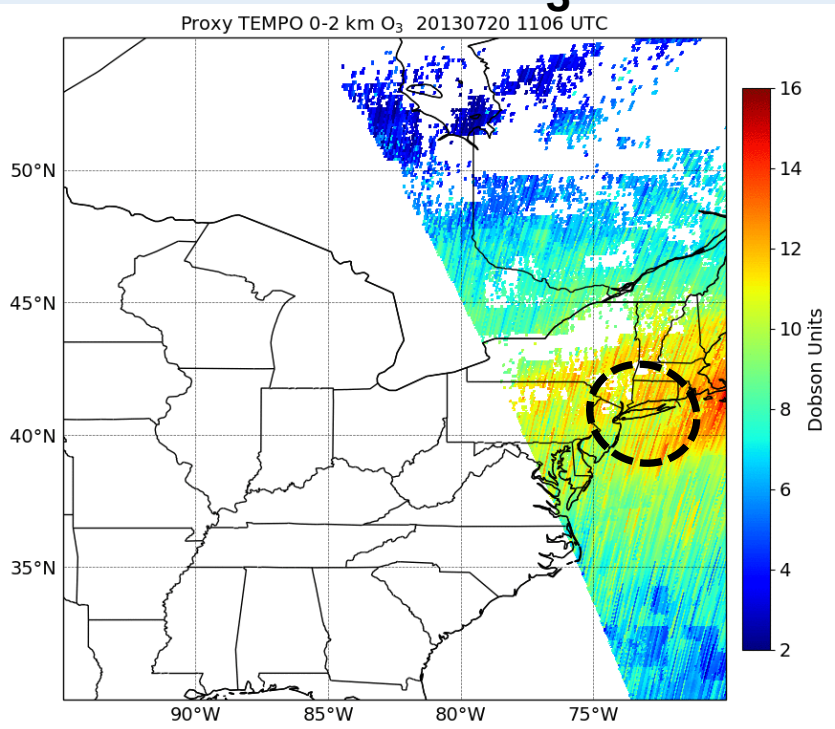


- TEMPO will be particularly suited for monitoring the rapidly varying NO_2 columns within wildfire smoke plumes as peak fire intensity generally occurs in the later afternoon
- TEMPO's ability to monitor other highly varying emission sources, such as urban areas and traffic corridors, will help better characterize emissions, pollutant transport, and source contributions

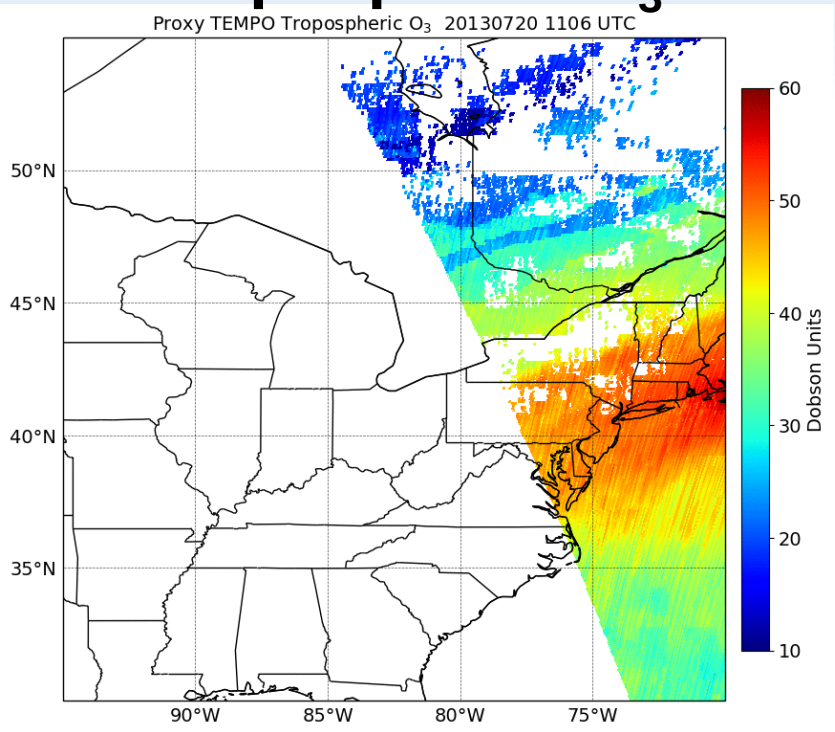
TEMPO Proxy O_3 Profile

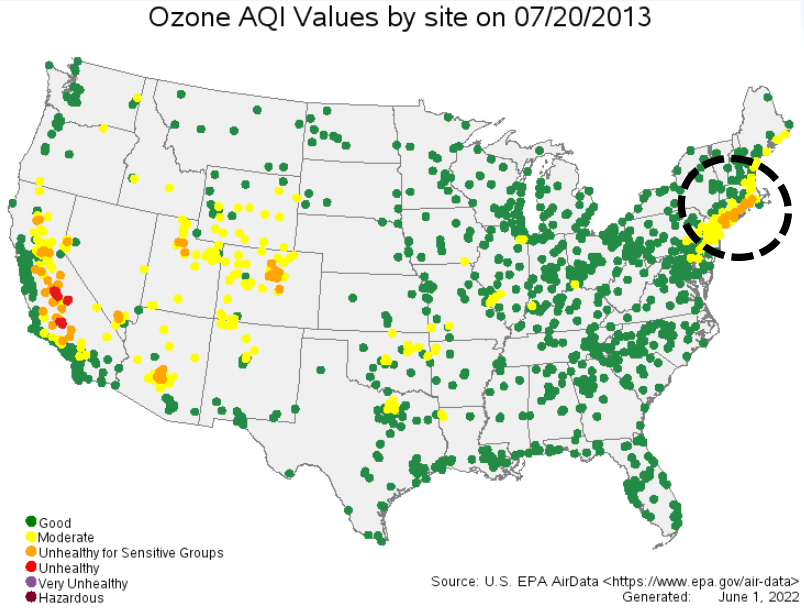
July 20, 2013

0-2 km O_3



Tropospheric O_3





- TEMPO will be able to track O_3 pollution in the tropospheric layer throughout the daytime
- Proxy O_3 profile product demonstrates the sensitivity of the TEMPO instrument to O_3 pollution in the lower troposphere
  - Provides early understanding of the information content expected from the operational product
- **TEMPO will provide new information on O_3 pollution within layer of air where people live**

TEMPO Special Experiments

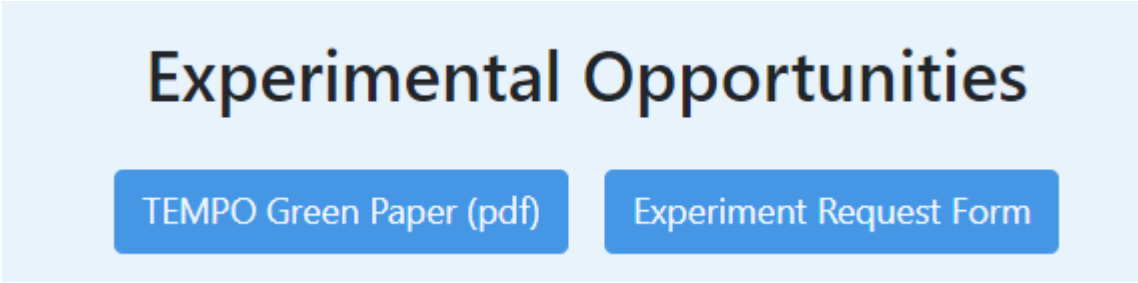
- Up to 25% of TEMPO's observing time will be devoted to special" operations with sub-hourly frequency (e.g, <= 10 min) over selected portion / slice of FoR (reduced E/W spatial coverage)
- **Air quality disasters** (*e.g., wildfires, dust storms, volcanoes, industrial accidents*) and **research studies** (*e.g, agriculture, lightning* NO_x) can be conducted using special scans
- Pre-loaded scan patterns can be easily initiated a few days prior to event, with possibility of a few hours prior to event
- Experiments can be done during commissioning phase period, expected June – Sept 2023

TEMPO special operations will further increase societal benefit of TEMPO data!

Contribute to our Green Paper!

For additional information on the Green Paper and special experiments:

https://weather.msfc.nasa.gov/tempo/green_paper.html



Submit an experiment request for your idea(s) on new or enhanced TEMPO applications, especially those **desiring special observing time**!

You will become a co-author on the TEMPO Green Paper

Planning is being done now to best coordinate the special observing time

NASA Airathon Crowdsourcing Challenge

NASA@WORK

https://drivendata.co/blog/nasa-airathon-winners/

DRIVENDATA

Smithsonian

A. David Lander

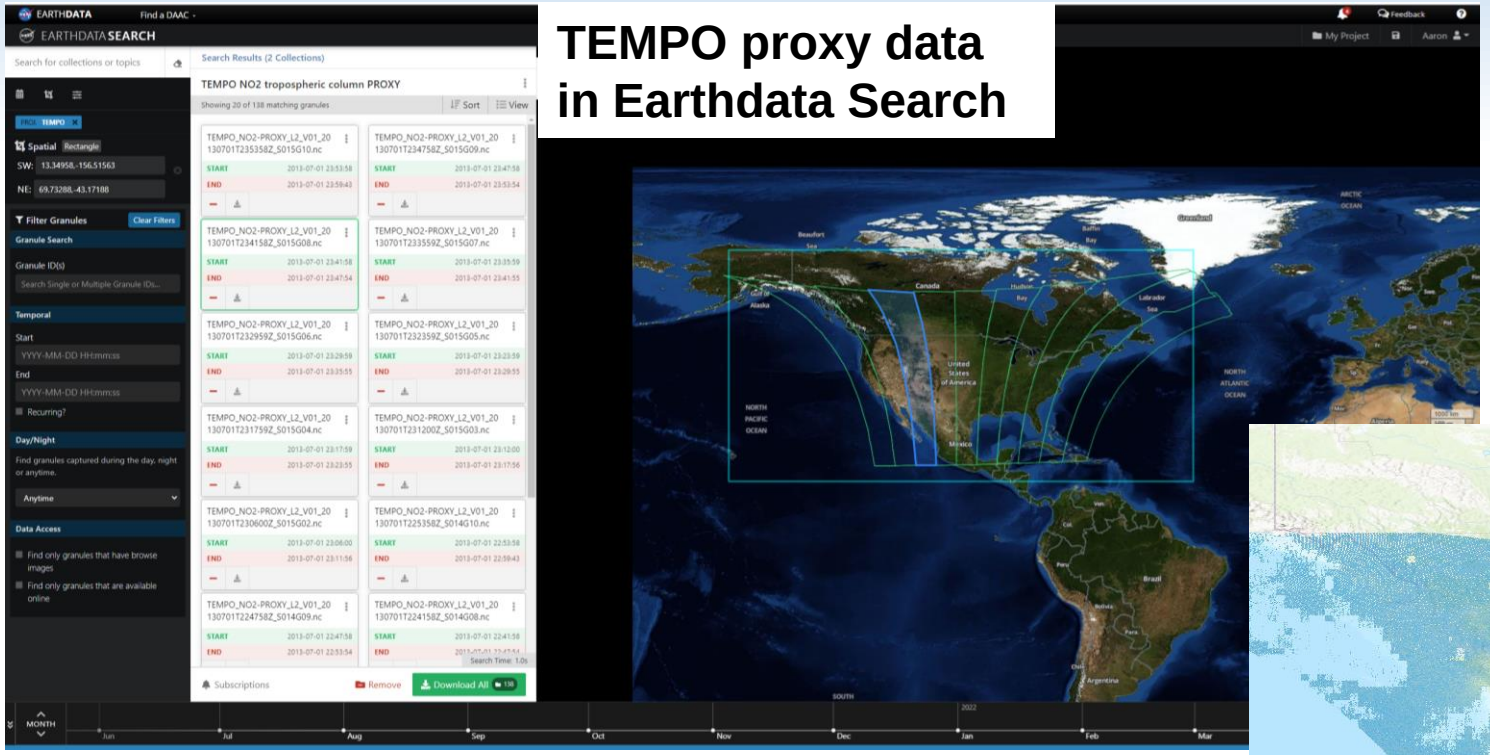
Vishwas Chepuri

Place	PM2.5 Track	NO2 Track
1st Place	Vishwas Chepuri	A. David Lander
2nd Place	Raphael Kiminya	Raphael Kiminya
3rd Place	Kudaibergen Abutalip	Sukanta Basu

- **Overarching Goal:** Develop unique algorithms using Earth science data, particularly satellite data, to retrieve accurate surface-level NO_2 and PM2.5 amounts, key TEMPO and MAIA products
- **Problem:** No current NASA satellite mission provides ready-to-use data products on criteria surface-level air pollutants with low enough latency to protect public health

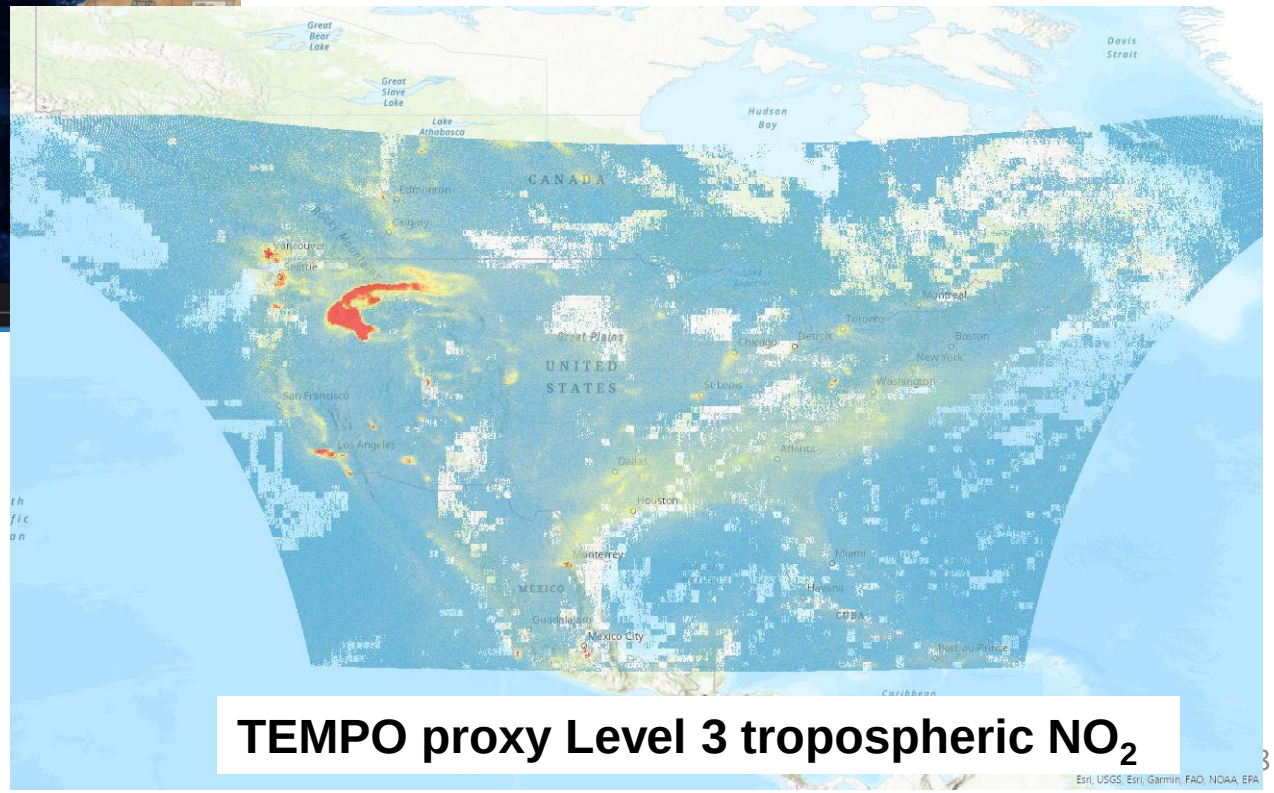
- **Tremendous engagement from community** with over 1,250 submissions and more than 1,000 participants from 123 countries and winners from four continents
- Challenge winners used tree-based ensemble machine learning models to accurately estimate daily surface-level NO_2 concentrations from OMI and/or TROPOMI data along with other auxiliary data
- Winning solutions and lessons learned from challenge will be used by the TEMPO team as we generate technical resources and air-quality products for the user community
- U.S. Department of State plans to apply methods from the winning models to provide air quality information to its employees and the general public at various embassy locations.

Preparing Data Services for TEMPO



TEMPO proxy data in Earthdata Search

- TEMPO proxy level 2 NO_2, HCHO, and O_3 products currently available in NASA Earthdata for TEMPO team (Early Adopters)

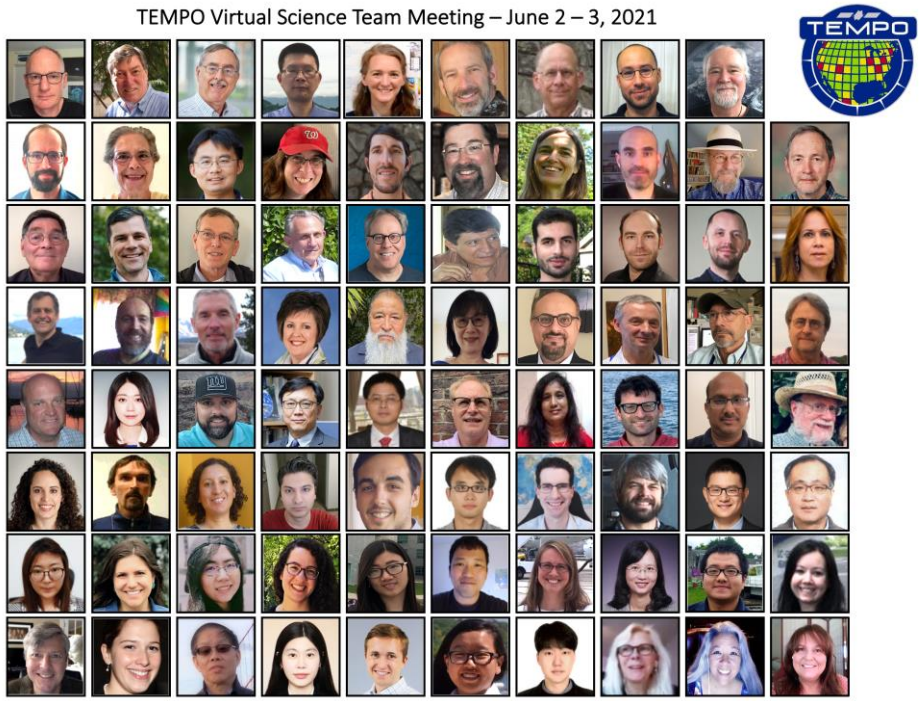


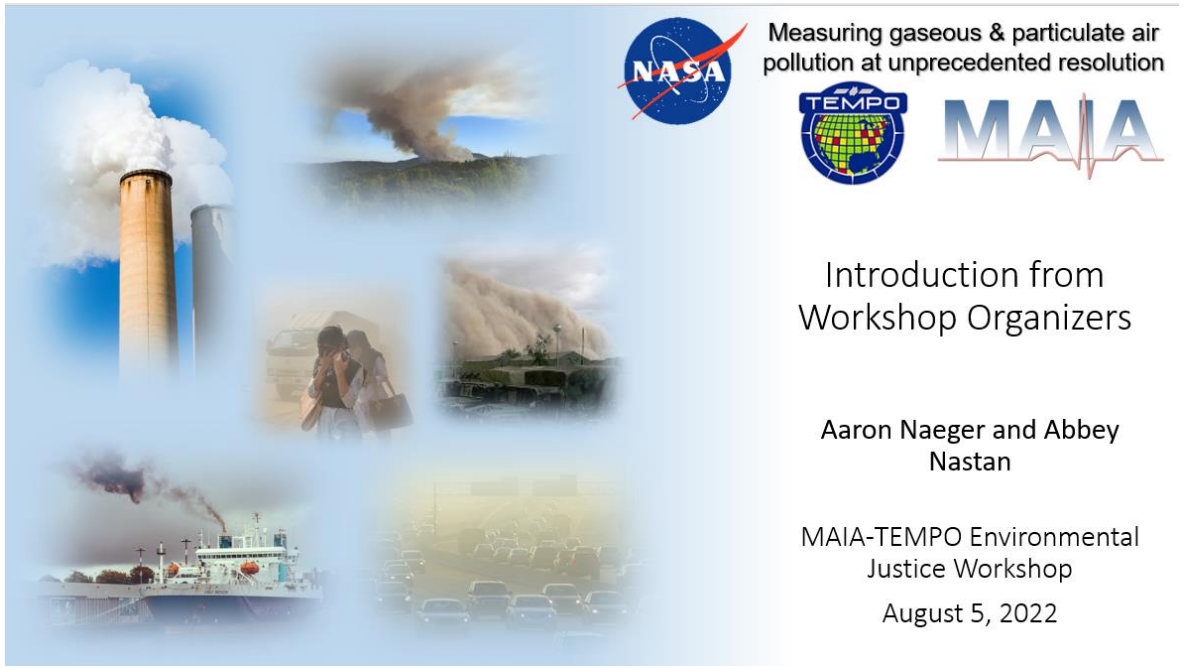
TEMPO proxy Level 3 tropospheric NO_2

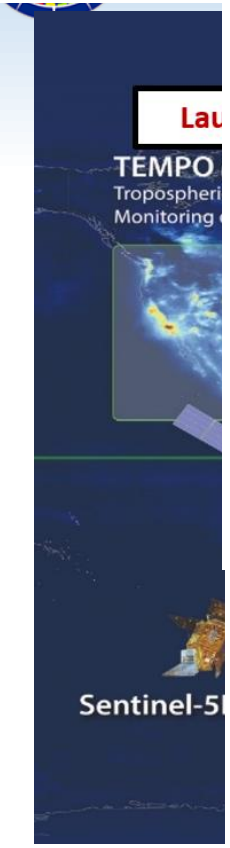
- Development of enhanced data services at NASA to expand breadth of TEMPO users and applications

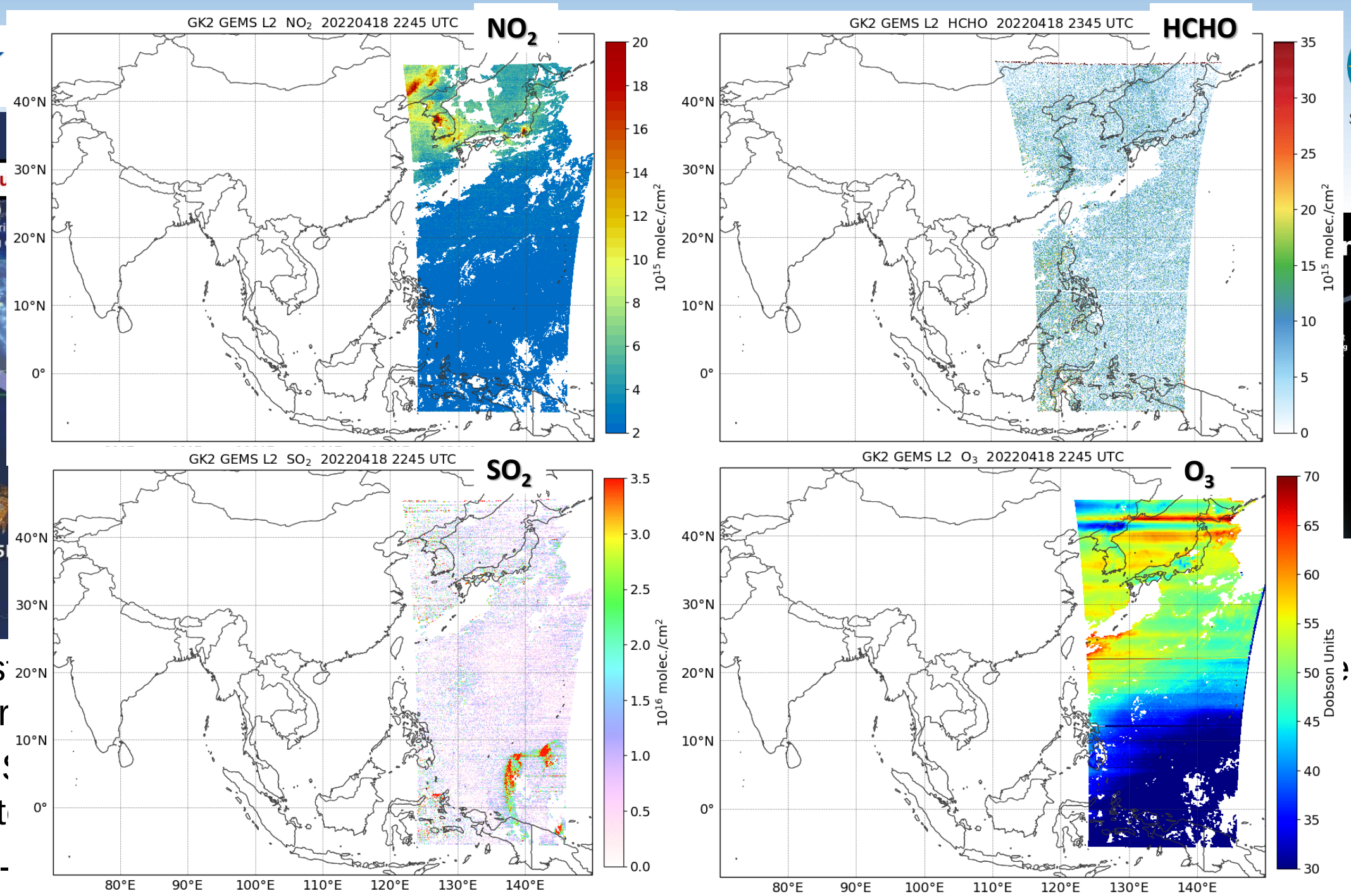
Recent Early Adopter Activities

- ❑ Data tutorial sessions highlighting TEMPO proxy data last Fall
- ❑ Joint meeting with TEMPO Science Team & HAQAST in June
- ❑ Technical meetings involving TEMPO with Air Quality agencies (e.g., National Tribal Air Association / EPA)
- ❑ MAIA-TEMPO Environmental Justice workshop last Friday!









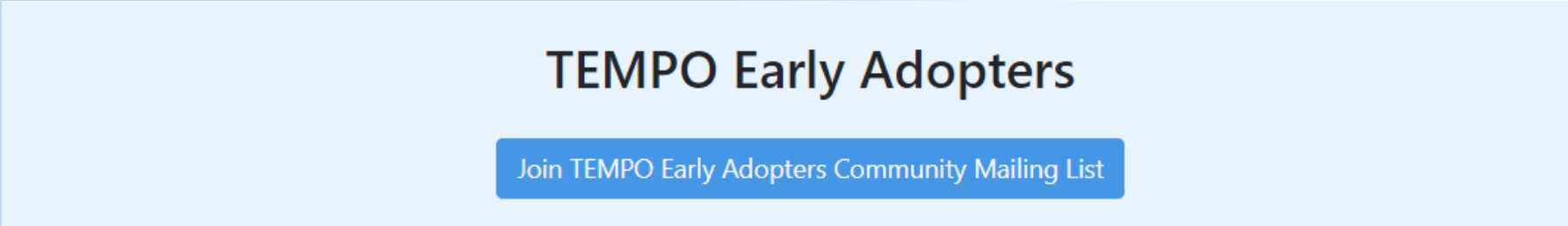
- Geos
  obser
- GEMS
  const
- GEO-

Thank You!

To join the TEMPO Early Adopters Community, go to:

https://weather.msfc.nasa.gov/tempo/

And click on the button link to sign up!



More information on TEMPO can be found on our Early Adopters site and on the TEMPO Mission website here:

http://tempo.si.edu/

aaron.naeger@nasa.gov

@NaegerAaron

Thank you

RETURN AT 3:00PM