Bryan Duncan

Kevin Cromar

Ana Prados

Noussair Lazrak

Kellen Namusisi

Integrating NASA Resources into the Standard Operating Procedures of Stakeholders

PI: Bryan N. Duncan (NASA)
Co-Is: Ana I. Prados (UMBC), Kevin R. Cromar (NYU)
Contributors: Kellen Nyamurungi Namusisi (NYU), Noussair Lazrak (NYU)

HAQAST DC Showcase
Washington, DC, January 28, 2025

Project Methodology

Step 1: Engaging a diverse set of stakeholders to gauge their individual needs and to identify common needs.

Step 2: Identify ways to "scale up" engagement to reach many stakeholders.

GeoHealth

Review Article | Open Access

Augmenting the Standard Operating Procedures of Health and Air Quality Stakeholders With NASA Resources

Bryan N. Duncan, Carl A. Malings, K. Emma Knowland, Daniel C. Anderson, Ana I. Prados, Christoph A. Keller, Kevin R. Cromar, Steven Pawson, Holli Ensz,

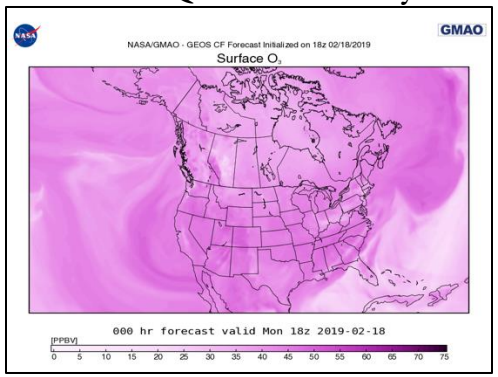
First published: 09 September 2021 | https://doi.org/10.1029/2021GH000451

Abstract

The combination of air quality (AQ) data from satellites and low-cost sensor systems, along with output from AQ models, have the potential to augment high-quality, regulatory-grade data in countries with in situ monitoring networks and provide much needed AQ information in countries without them, including Low and Moderate Income Countries (LMICs). We demonstrate the potential of free and publicly available USA National Aeronautics and Space Administration (NASA) resources, which include capacity building activities, satellite data, and global AQ forecasts, to provide cost-effective, and reliable AQ information to health and AQ professionals around the world. We provide illustrative case studies that highlight how global AQ forecasts along with satellite data may be used to characterize AQ on urban to regional scales, including to quantify pollution concentrations, identify pollution sources, and track the long-range transport of pollution. We also provide recommendations to data product developers to facilitate and broaden usage of NASA resources by health and AQ stakeholders.

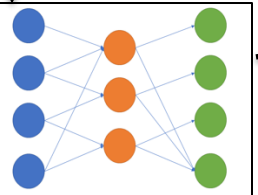
Project Methodology

NASA AQ Forecast System



Forecasts via NASA Fluid & WRI Resource Watch

Machine Learning



Tailored Forecasts via API

AQ Observations

© 2012 Daniele Costantini / Wikimedia Commons

Stakeholder Decision Making

AQ Forecasts & Alerts

from https://www.airnow.gov

Mitigation Planning

Photo by Patrick Hendry on Unsplash

Data

Low-Cost Sensors

Photo from Clarity Movement https://www.clarity.io/

Data

Satellite Data

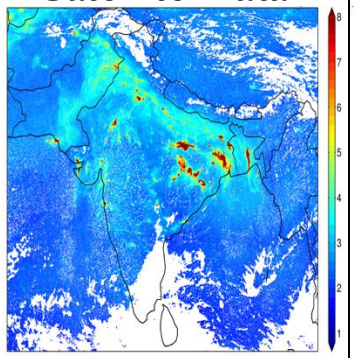
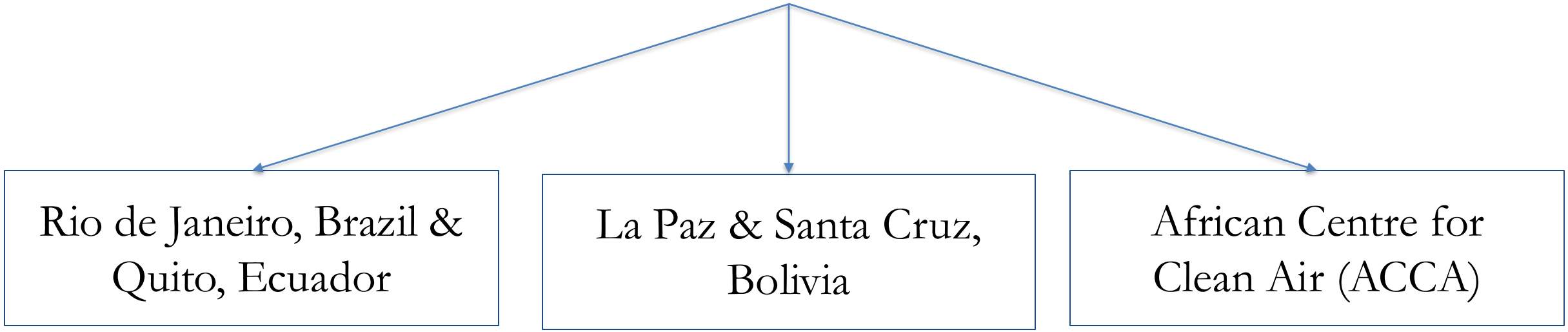


Image courtesy Lok Lamsal (NASA)

HAQI/ AQI Verification

HAQI/AQI

Step 1: Working with Select Stakeholders



Benefits of Working with International Stakeholders

The HAQAST program focuses on enabling US public and private stakeholders. However, building relationships with international stakeholders benefits NASA and US interests in numerous ways, including:

- Providing NASA and local datasets (i.e., data sharing) to US interests abroad [e.g., US embassies (State Dept.), military (USAPHC), private companies].

- Reducing pollution in other countries positively impacts the health of US citizens living abroad.

- Cost-savings to NASA:
  - Access to their datasets that may be used for validation and interpretation of NASA satellite data, especially in "data deserts" (e.g., tropics and subtropics).
  - NASA validation instrument deployment and/or maintenance.

Rio de Janeiro & Quito

(ARL 1-6)

Stakeholder needs: demonstrating specific health outcomes related to AQ data; monitor siting.

Primary contacts: Kevin Cromar & Ana Prados

Felipe Mandarino
Instituto Pereira Passos in Rio de Janeiro

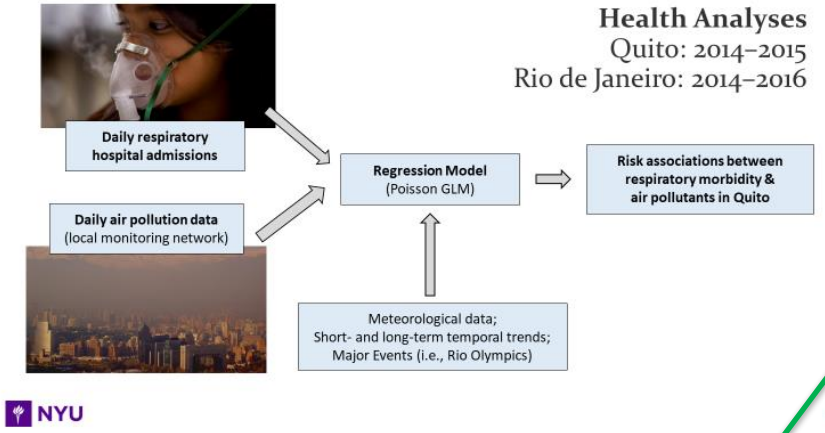
Valeria Diaz
Secretaría de Ambiente in Quito

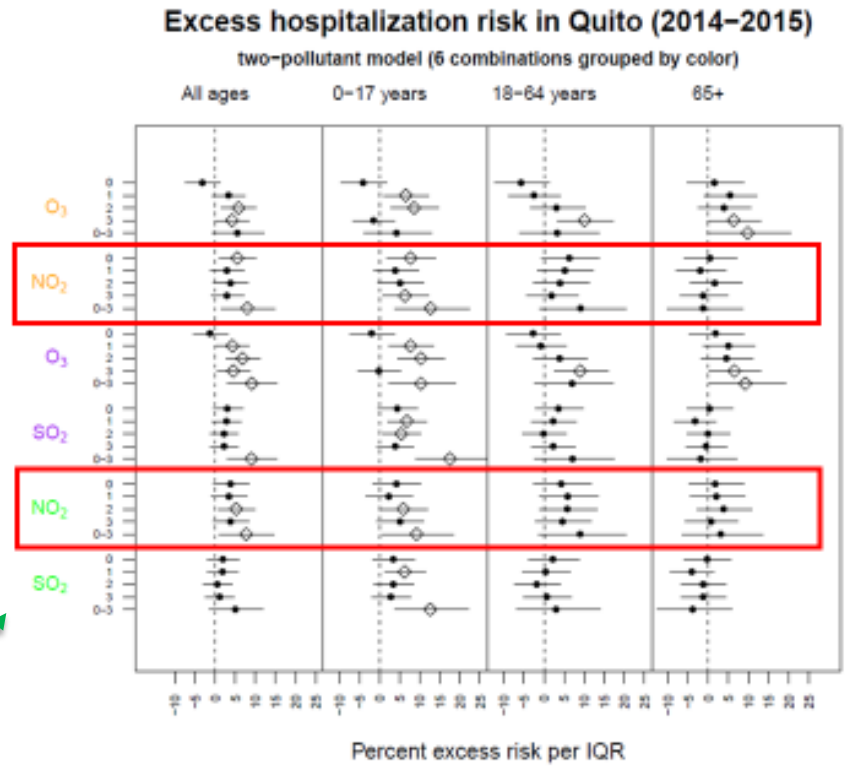
Upper management of the health and AQ agencies of both cities requested that we first show how air pollution affects health outcomes, using their AQ monitor data.

Takeaways from Health Analyses

- NO_2 is the strongest indicator of respiratory morbidity in both Latin American cities
- Studies increase equity of global epidemiological literature
- Directly benefits study populations by providing detailed risk information to local environmental managers
- Provide baseline information to inform future studies involving satellite-model data applications for broader collaborative project

Great! Satellites observe NO_2 well.





Results indicate that their AQ data are of good quality.

NO_2 associations persisted in two-pollutant models

Bolivia

(ARL 1-3)

Stakeholder needs: smoke monitoring & alerts

Primary contact: Ana Prados

Collaborators

Marcos Andrade
University Mayor de San Andrés in La Paz

Karen Crespo - Universidad Mayor de San Simon in Santa Cruz

Courtesy of NASA GSFC Pandora project.

Facilitating U.S.-Bolivian collaboration on AQ issues. A NASA Pandora instrument (NO_2, O_3, HCHO) is being installed by Andrade at the U.S. Consulate – Santa Cruz.

Universidad Mayor de San Andres AQ Blog

Using satellite data and model output to monitor transboundary transport of pollution from agricultural fires.

Suomi NPP VIIRS
October 5, 2024

Awareness Webinars (NASA & NOAA)

Seminario Nivel II: Monitoreo Satelital de la Calidad del Aire en Bolivia

Fecha: 7 de junio, 10 AM (hora local Bolivia)

Duración: 1 hora (incluye periodo de preguntas/respuestas)

Enlace de Inscripción

Objetivos del Aprendizaje

- Conocer los instrumentos satelitales y tipos de datos disponibles para el monitoreo de las particulas
- Conocer herramientas donde encontrar imagenes de la calidad del aire
- Descargar conjuntos de datos para la detección de las partículas

Próximos Seminarios

- Nivel II (gases traza): Septiembre/octubre 2023
- Nivel III: Noviembre 2023

Profesores: Dra. Ana Prados (UMBC/NASA) y Dra. Mariel Friberg (UMD/NASA)

Seminario en español. Se recomienda previamente haber asistido al seminario de Nivel I o escuchar la grabacion del mismo

Para mas informacion únase al ***grupo de WhatsApp***

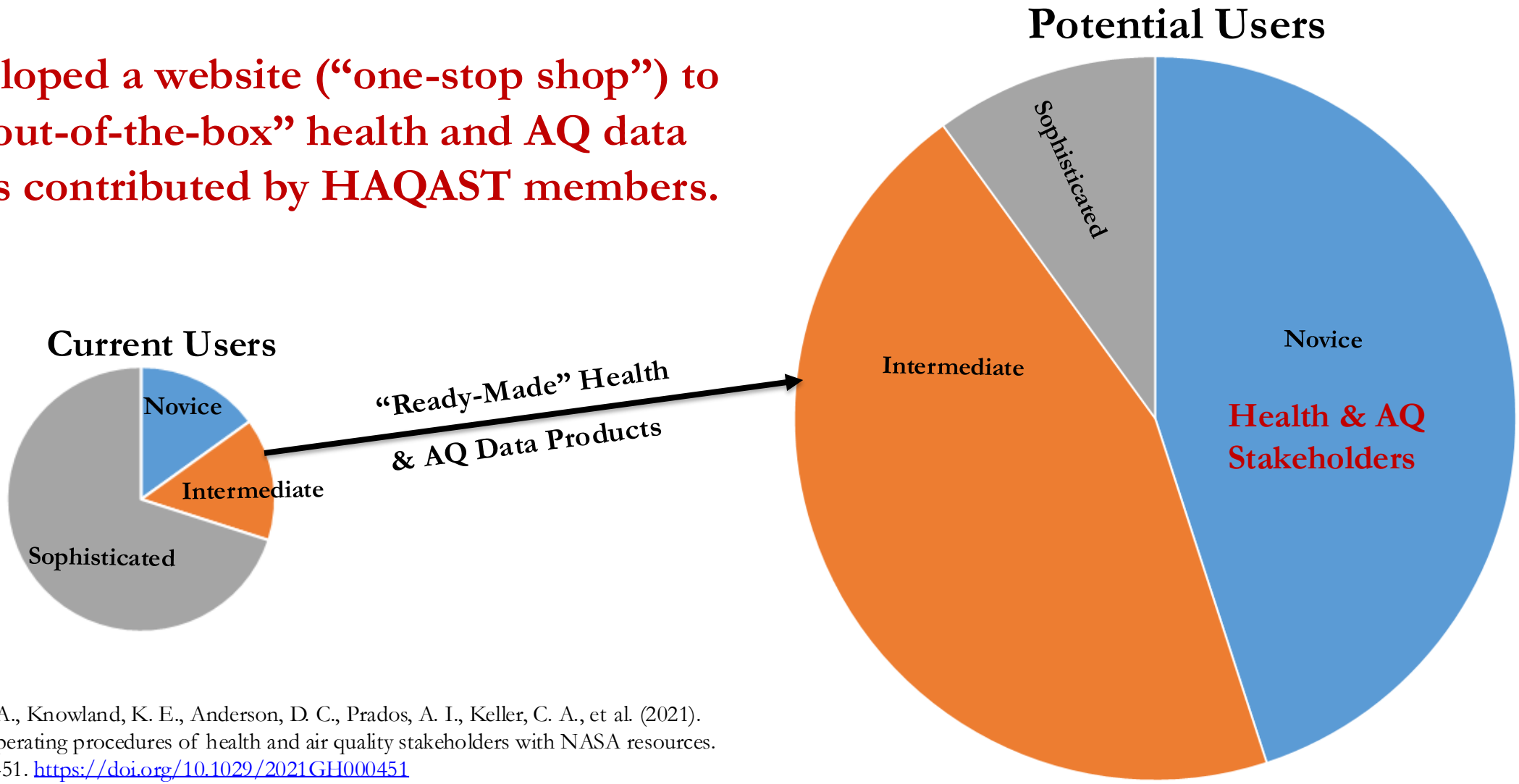
NASA
UMBC
CISTEL
Centro de Investigaciones y de Servicios en Teledetección
UMSS
PER ASPERA - AD ASTRA
fan
fundación amigos de la naturaleza

Step 2: Scaling up Engagement to all Stakeholders

Cromar's Tiger Team:

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

We developed a website ("one-stop shop") to house "out-of-the-box" health and AQ data products contributed by HAQAST members.



Duncan, B. N., Malings, C. A., Knowland, K. E., Anderson, D. C., Prados, A. I., Keller, C. A., et al. (2021). Augmenting the standard operating procedures of health and air quality stakeholders with NASA resources. *GeoHealth*, 5, e2021GH000451. https://doi.org/10.1029/2021GH000451

NASA GES DISC: https://disc.gsfc.nasa.gov/ & search for "HAQAST"

EARTHDATA Find a DAAC

GES DISC Mission Guides Enter search (e.g., rainfall, GPM, TRMM_3B42)

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Feedback Cloud Migration Help Login My Dashboard

Back to mission guides

HAQAST

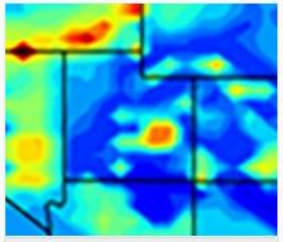
- Introduction
- Related Projects
- Resources
- Data Collections
- Data Collections outside GES DISC
- References

Introduction

HAQAST is part of a decade-long effort by NASA's Applied Science Program to re-envision how applied science teams work. The effort began with the Air Quality Applied Science Team (AQAST), which ran from 2011 – 2016. Recognizing that health was an integral component of applied air quality research, NASA formed the first HAQAST team, which ran from 2016 – 2020. Due to the success of both AQAST and HAQAST, NASA expanded the newest version of HAQAST (2021 – 2025) to fourteen members composed of air quality and public health scientists, led by Dr. Tracey Holloway at the University of Wisconsin-Madison. Though HAQAST is headquartered at UW-Madison, its members are spread across the U.S., in government offices and public universities.

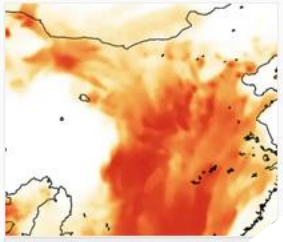
Our interests are both focused – we use NASA satellite data to help solve real-world public health and air quality problems – and diverse: we work on issues from wildfire smoke to diesel emissions. We collaborate with public stakeholders, who help guide our research. We also pursue short-term, high-impact projects with teams – you can find out more about those here. The HAQAST team provides many additional ways to keep informed about their work, including a newsletter, Twitter, publ

Related Projects



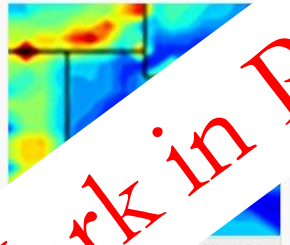
HAQAST: Bias Corrected Global Hourly Surface Total...

This dataset offers MERRA-2 bias-corrected global hourly mean PM2.5 mass concentration for 2000 to 2024 based on Machine Learning model. The model was trained based on MERRA-2...



HAQAST: Global and Regional Daily Air Quality Forecasts

This dataset offers the GEOS-CF forecasts of surface O3, NO2 PM2.5 everywhere in the world, plus localized, bias-corrected model forecasts based on model-observation...

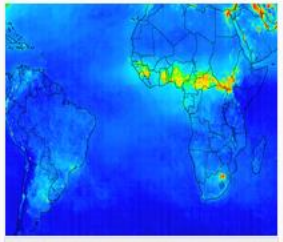


Daily PM2.5

offers hourly and daily 2.5 mass concentration for to 2021 based on Machine rning model. The models were rained for the Continental United States...

HAQAST: Global Surface NO2 Concentrations Incorporatin...

The dataset is based on a land-use regression model which estimates the annual surface NO2 concentrations.

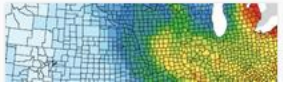


HAQAST: Level 3 Tropospheric Vertical Colum...

This dataset offers a detailed look at the monthly, seasonal, and annual averages of tropospheric Nitrogen dioxide (NO2) vertical column density

HAQAST: SEDAC - Country Trends in Major Air Pollutants

To provide a framework of public-health-focused air quality indicators that quantifies country trends in exposure to major air pollutants.



Work in Progress!

https://disc.gsfc.nasa.gov/ & search for "HAQAST"

NYU Marron Institute of Urban Management

NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

HAQAST: GEOS-CF Air Quality Forecasts Fact Sheet

Key Highlights	High-resolution (0.25°) global constituent prediction model Developed by NASA's Global Modeling and Assimilation Office (GMAO) Provides near real-time estimates and forecasts of atmospheric composition
Dataset Overview	GEOS-CF is a high-resolution global constituent prediction model developed by NASA's Global Modeling and Assimilation Office. It provides near real-time estimates and forecasts of atmospheric composition, offering both gridded data and localized, bias-corrected forecasts.

Use Cases

Wildfire impact assessment: Researchers used GEOS-CF to simulate $PM_{2.5}$ spread and ozone formation from the May-June 2019 Alberta wildfires, demonstrating its ability to provide real-time air quality forecasts during severe wildfire events.[1]

Air quality trends. A global study using GEOS-CF found that COVID-19 restrictions reduced NO_2 concentrations by an average of 18% worldwide from February 2020, with some cities experiencing up to 60% reductions, often beginning before official lockdowns.[2]

Health impact assessment. Researchers developed a global air quality index using GEOS-CF to assess respiratory health risks among children, providing a framework for cities to communicate pollution impacts and protect children's health, particularly in areas without ground monitoring.[3]

Limitations

- Overestimation of aerosols by 20%-50% due to known issues in GEOS-Chem v12.0.1. This bias may affect the accuracy of particulate matter predictions, particularly in regions with high aerosol concentrations.
- Skill scores for 5-day forecasts are comparable to 1-day hindcasts, indicating limited improvement in longer-term predictions. This suggests that the model's accuracy may not significantly increase for extended forecast periods beyond one day.

Suggested Applications

Air Quality Impact Assessment for Major Events
Use GEOS-CF to predict air quality changes during large-scale events like international sports competitions or festivals, helping organizers and local authorities plan mitigation strategies.

Long-Range Pollution Transport Studies
Use the global coverage to track the intercontinental transport of air pollutants, such as dust storms or wildfire smoke, and assess their impacts on distant regions.

Health Risk Forecasting
Integrate GEOS-CF predictions with population data to develop early warning systems for vulnerable groups (e.g., asthmatics, elderly) about upcoming poor air quality episodes.

How to Use

Step 1 Download the data
- Visit the NASA GMAO website and download NetCDF or Cloud-Optimized GeoTIFF files for gridded data or ask for CSV files for localized forecasts if needed.

Step 2 Data Preparation
- Use Python's xarray for NetCDF files or QGIS for geospatial visualization.
- Compare GEOS-CF predictions with ground-based measurements.

Step 3 Analysis
- Create time series plots and spatial maps to visualize pollutant trends and distributions.

Visual Data Breakdown

Parameter	Description
Spatial Resolution	0.25° (~25 km x 25 km)
Geographic Coverage	Global
Temporal Resolution	January 1, 2018 to present (Hourly)

Quick Tip When working with GEOS-CF data, consider using the localized bias-corrected forecasts for specific locations of interest. These forecasts incorporate model-observation data fusion to provide more accurate predictions for particular sites.

Technical Details
Author
Global Modeling and Assimilation Office (GMAO)
GEOS CF Data Access
Version: V1

Contact
Website
NASA GMAO
Email
geos-cf-users-owner@lists.nasa.gov

Quick links
NASA Health and Air Quality Applied Sciences Team (HAQAST)
NASA GES DISC | HAQAST
NASA Earthdata

[1] Saunders, Emily, et al. "GEOS-CF Model Assessment of $PM_{2.5}$ During Wildfires: Inferring the Impact of $PM_{2.5}$ Exposure on Adverse Respiratory & Cardiovascular Conditions." International Global Atmospheric Chemistry (IGAC) Science Conference. No. GSFC-E-DAA-TN61923, 2018. https://ntrs.nasa.gov/citations/20180007249

[2] Keller, Christoph A., et al. "Global impact of COVID-19 restrictions on the surface concentrations of nitrogen dioxide and ozone." Atmospheric Chemistry and Physics 21.5 (2021): 3555-3592. https://doi.org/10.5194/acp-21-3555-2021

[3] Gladson, Laura A., et al. "Communicating respiratory health risk among children using a global air quality index." Environment international 159 (2022): 107023. https://doi.org/10.1016/j.envint.2021.107023

Next Steps

Quito & Rio de Janeiro

- Duncan/Cromar secured additional $ via HQ to support health analysis for Rio de Janeiro.
- Cromar secured additional $ (1 y) for two pilot awards funded under NIHES Children's Environmental Health Research and Translation Center (CEHRT):
  - to understand regional approaches to risk communication, to further refine forecasting of NO_2, and to determine how to approach weighting multiple pollutants for risk communication purposes.
- NASA A.43 Earth Action: Health and Air Quality (HAQ) solicitation:

  "Improving public health in Latin America by integrating advanced air pollution forecasting and risk communication tools into local operations": *Cromar (PI) with Co-Is Prados and Duncan* **(submitted in August 2024)**
  - This project aims to significantly improve air quality management and risk communication in Rio de Janeiro and Quito by integrating advanced Earth observations that have been validated using local health data.
  - This project is designed as direct response to requests from project stakeholders in Latin America to assist in their ongoing efforts to improve forecasting and risk communication of outdoor air pollution in their cities.

Bolivia?

ACCA?

ACCA

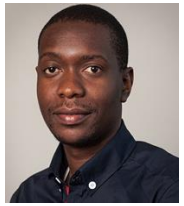
(ARL 1)

Stakeholder needs:
characterizing urban pollution; smoke monitoring & alerts

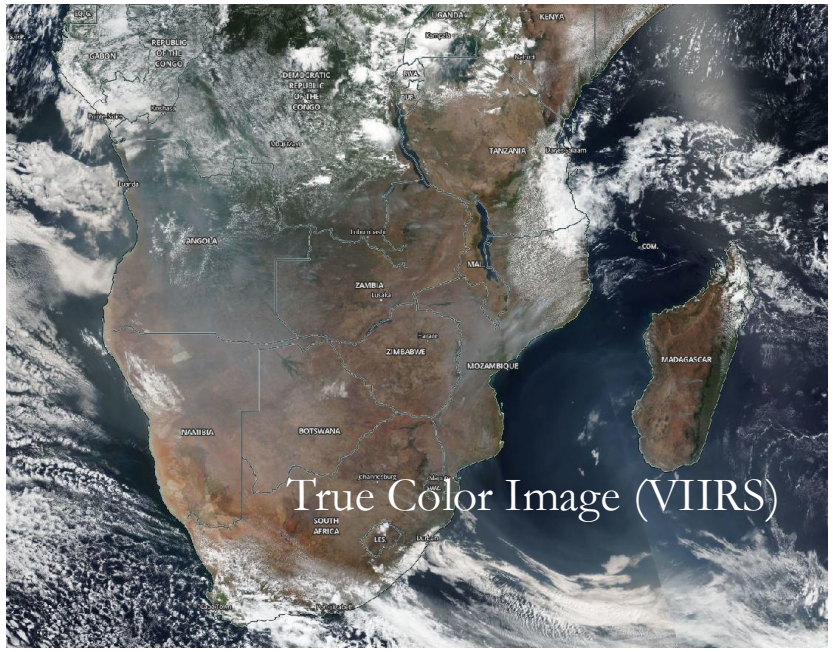
Primary contact: Kevin Cromar, Bryan Duncan

Collaborators

Kellen Namusisi – African Centre for Clean Air (ACCA)

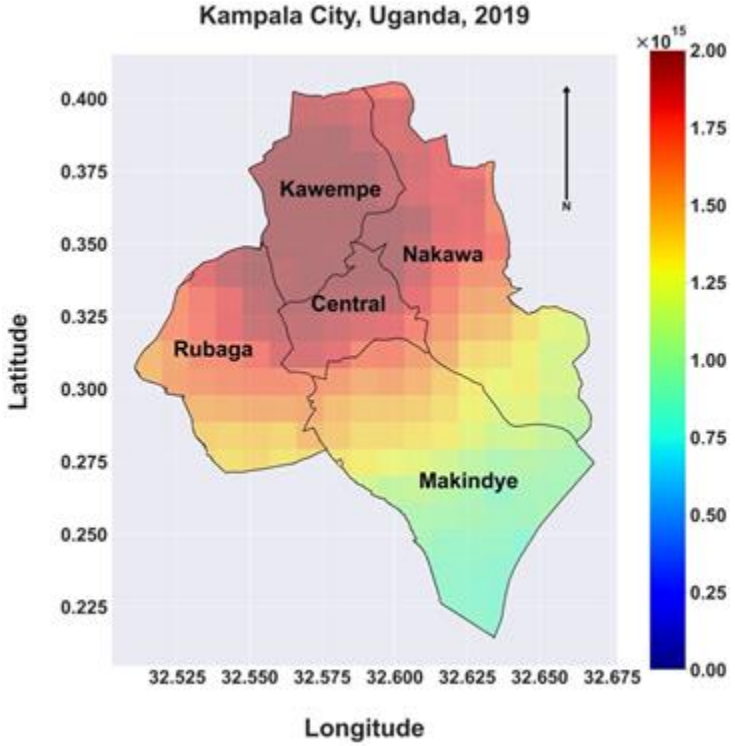


Gabriel Okello – African Centre for Clean Air (ACCA)



Urban Pollution

Nitrogen Dioxide (TROPOMI)

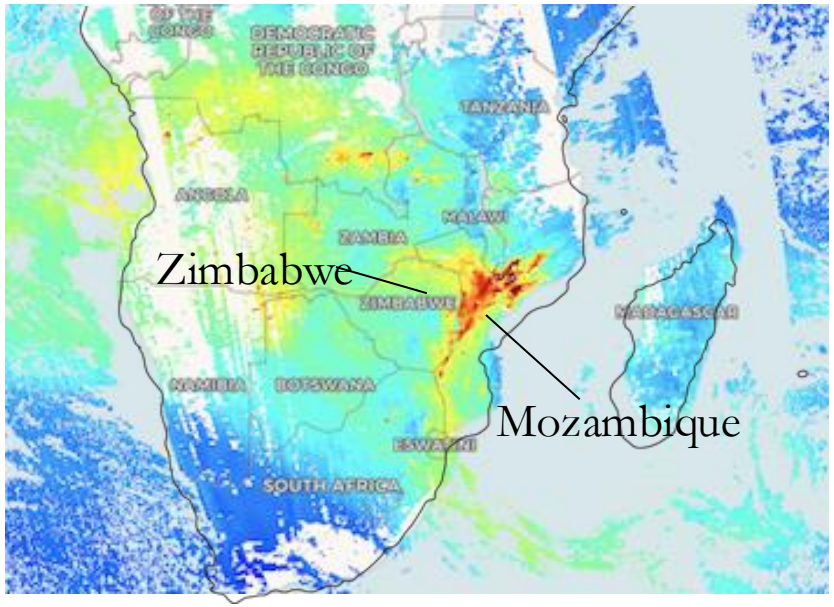


ACCA's Mission

"African Centre for Clean Air (ACCA) applies multi-disciplinary participatory approaches in collaboration with actors in policy, businesses, communities and academia to co-design evidence informed solutions to tackle air pollution to protect people, the environment and create more livable spaces that support improved public health and wellbeing."

Seasonal Agricultural Burning

Carbon Monoxide (TROPOMI)



Lessons Learned

- Building relationships with governmental stakeholders take time and funding.
  - > 1 funding cycle.
  - Local academics and NGOs facilitate these relationships.
- "Out-of-the-box" health and AQ data products are required for stakeholders who do not have the financial resources to invest in capacity building. They also benefit all stakeholders.
- Stakeholders are often interested in health analyses that show the connection between pollutants and specific health outcomes (e.g., to justify investment in AQ observations, site new monitors).

Opportunities

- Many stakeholders are smart and talented scientists, but they are largely resource-starved.

- NASA has the opportunity to enable all stakeholders by creating "out-of-the-box" health and AQ data products as well as by building capacity.