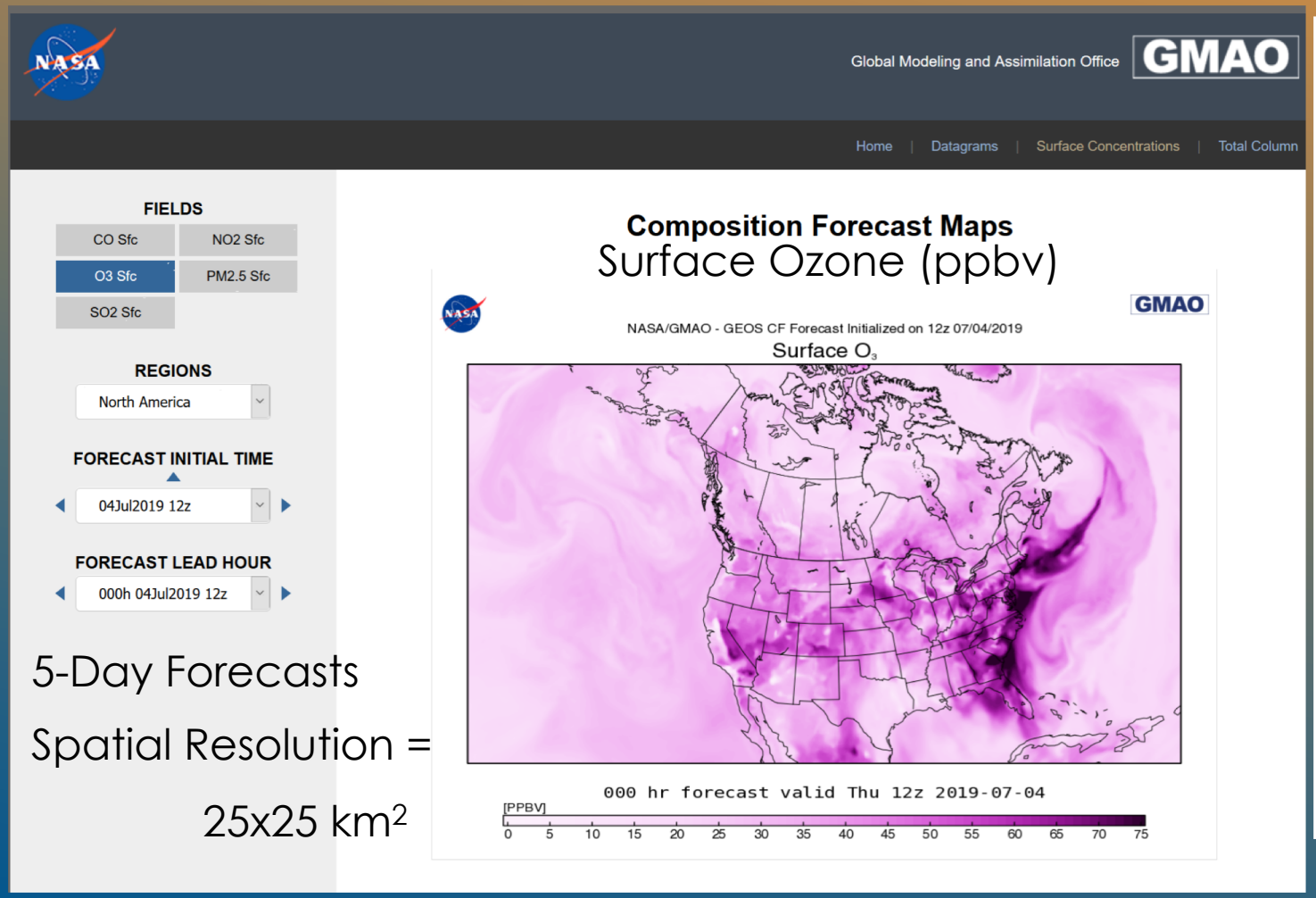
ENABLING GLOBAL CITIES TO BENEFIT FROM AIR POLLUTION FORECASTING AND RISK COMMUNICATION

Kevin R. Cromar (NYU), Bryan N. Duncan (NASA), Christoph A. Keller (NASA GMAO), K. Emma Knowland (NASA GMAO), + many others on the NASA GEOS-CF Team

Goddard
Space Flight Center

AIR POLLUTION FORECASTS

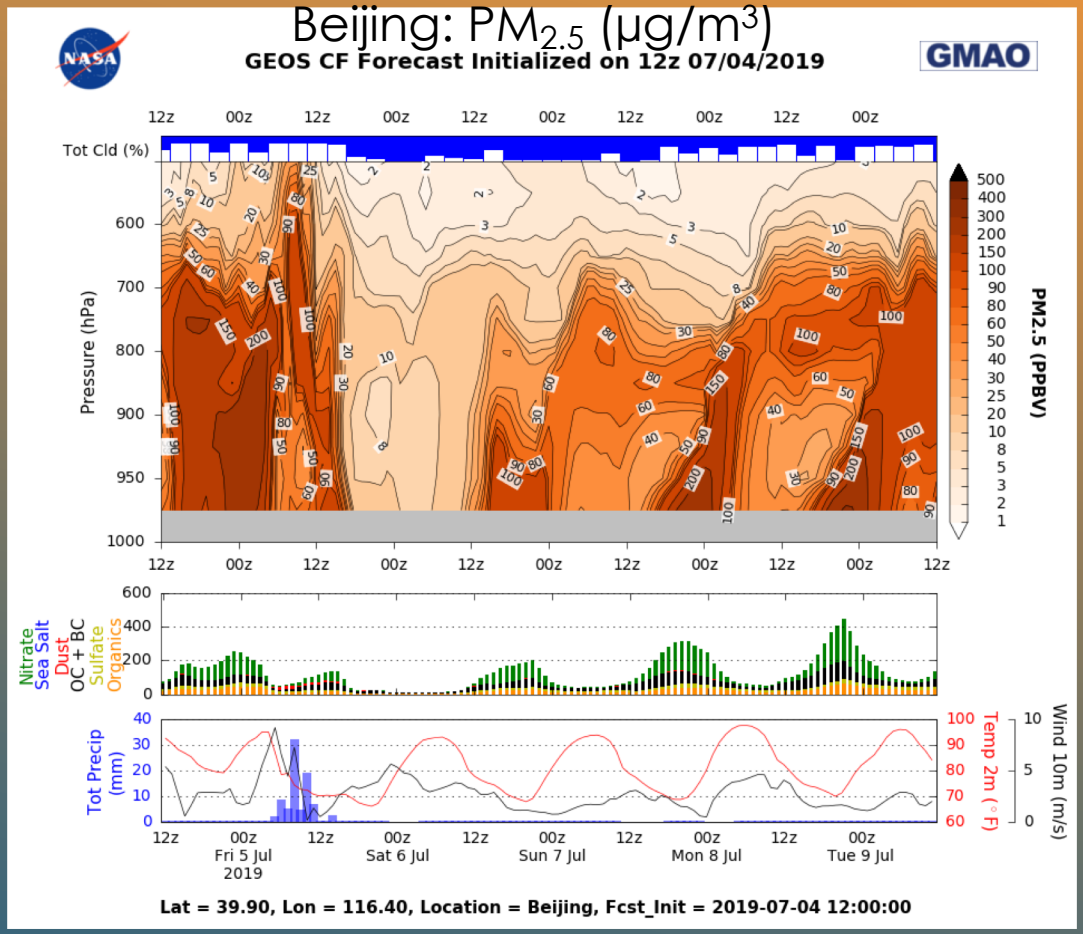
https://fluid.nccs.nasa.gov/cf/



5-Day Forecasts

Spatial Resolution =

25x25 km^2



AIR POLLUTION FORECASTS

Emma Knowland's presentation:

Air Pollution Forecasts using the NASA GEOS Model: A Unified Tool from Local to Global Scales

AIR POLLUTION FORECASTS

GOALS

NASA Applications: Societal Benefit

- Use NASA resources to create free & publicly-available AQ forecasts that have global coverage and high spatial resolution (25x25 km^2).

NASA Research & Development

- Use NASA computer models and satellite data assimilation techniques to enhance research and applications.

AIR POLLUTION FORECASTS

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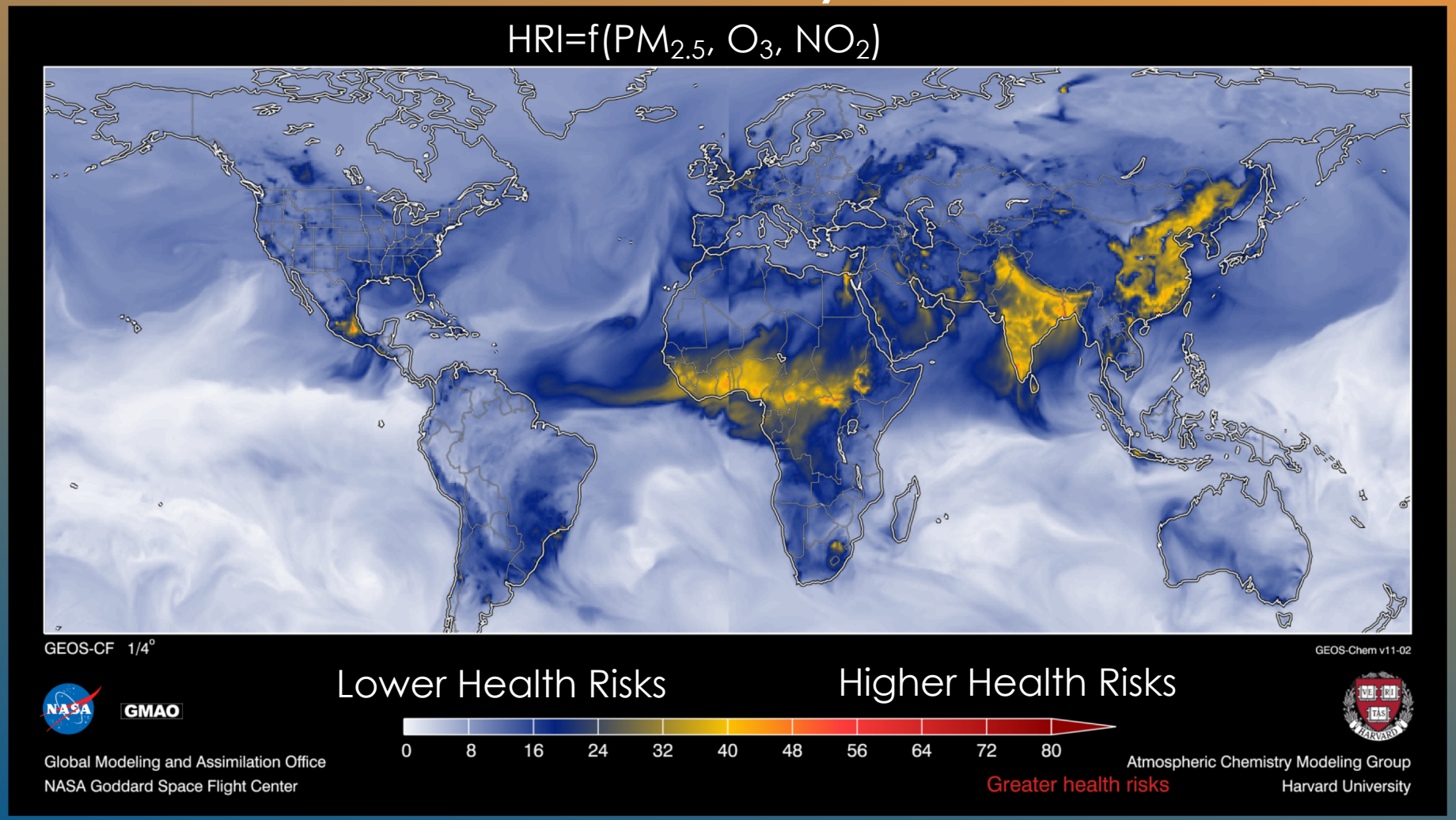
AIR POLLUTION FORECASTS

POTENTIAL APPLICATIONS

Health Risk Index: January 1st, 2017

Health Risk Index developed by Kevin Cromar (NYU)



Health Risk Index

24-h avg $PM_{2.5}$ & NO_2

daily max 8-h O_3

AIR POLLUTION FORECASTS

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Health Risk Index: July 1st, 2017

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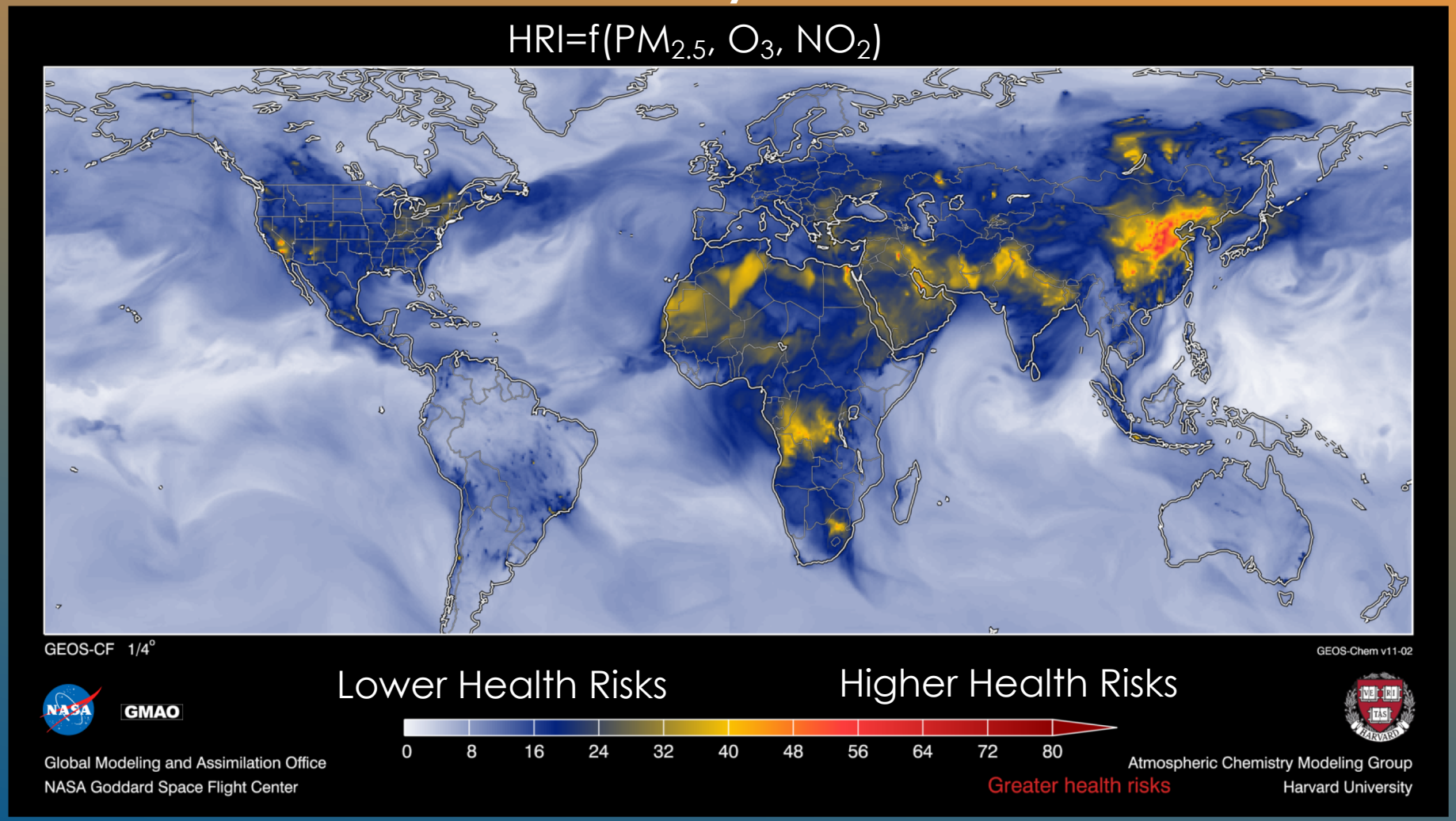

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AIR POLLUTION FORECASTS

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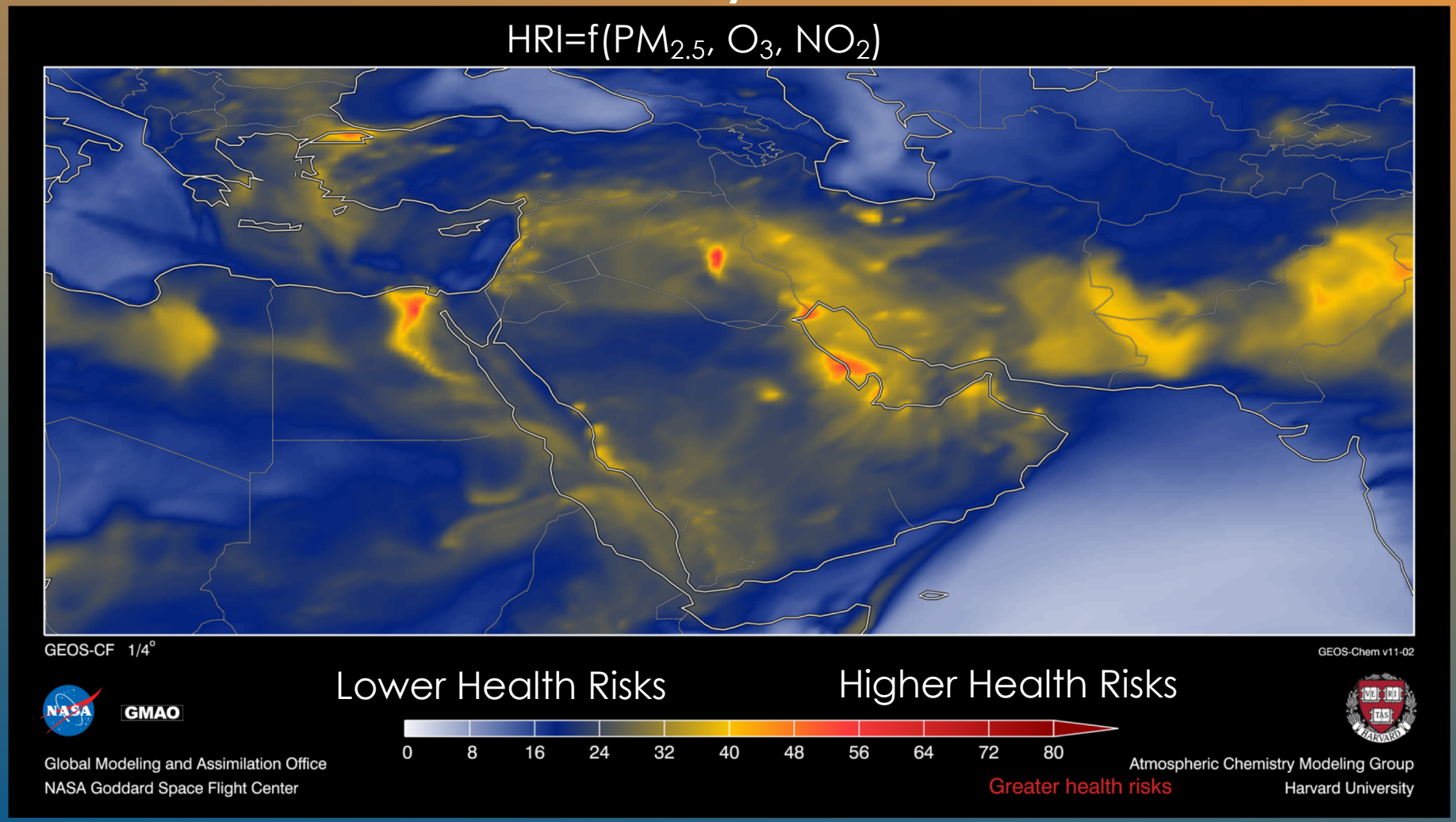

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AIR POLLUTION FORECASTS

POTENTIAL USERS

City Partners

- Rio de Janeiro
- Jakarta
- Others?

Other Partners

IBM, APHC, UNICEF, etc.

Provide Input to NASA for Model Improvement

- Pollutant Emissions
- Surface AQ Data
- Local Expertise

AQ Forecasts

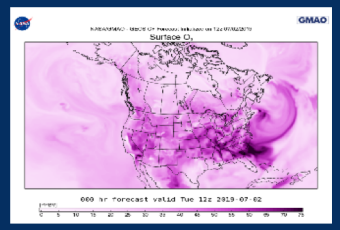
- Distribute Forecasts
- Handle Messaging

Timeline

2016

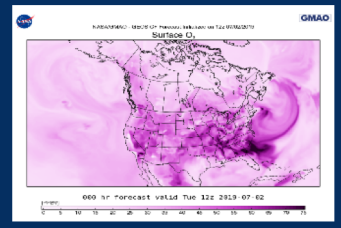
UNICEF asked, "When will the NASA global AQ forecasts be ready?"

2017



NASA GMAO GEOS-CF was launched in March.

2018

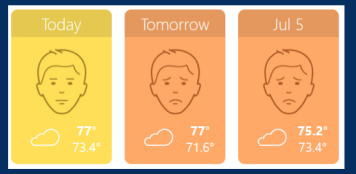


GEOS-CF global AQ forecasts went live in November.

Now

Stakeholder Engagement

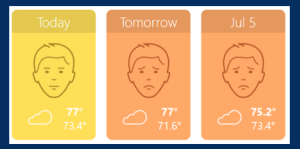
Stakeholder & End-User Requirements



Current Challenge
Forecast Interface: *One Size Does Not Fit All*

We require a sophisticated, flexible interface to meet the wide range of user needs

General Public
Needs: Easy Access & Simple Message
(e.g., local air quality agency needs daily pollution and Index values at the city level)

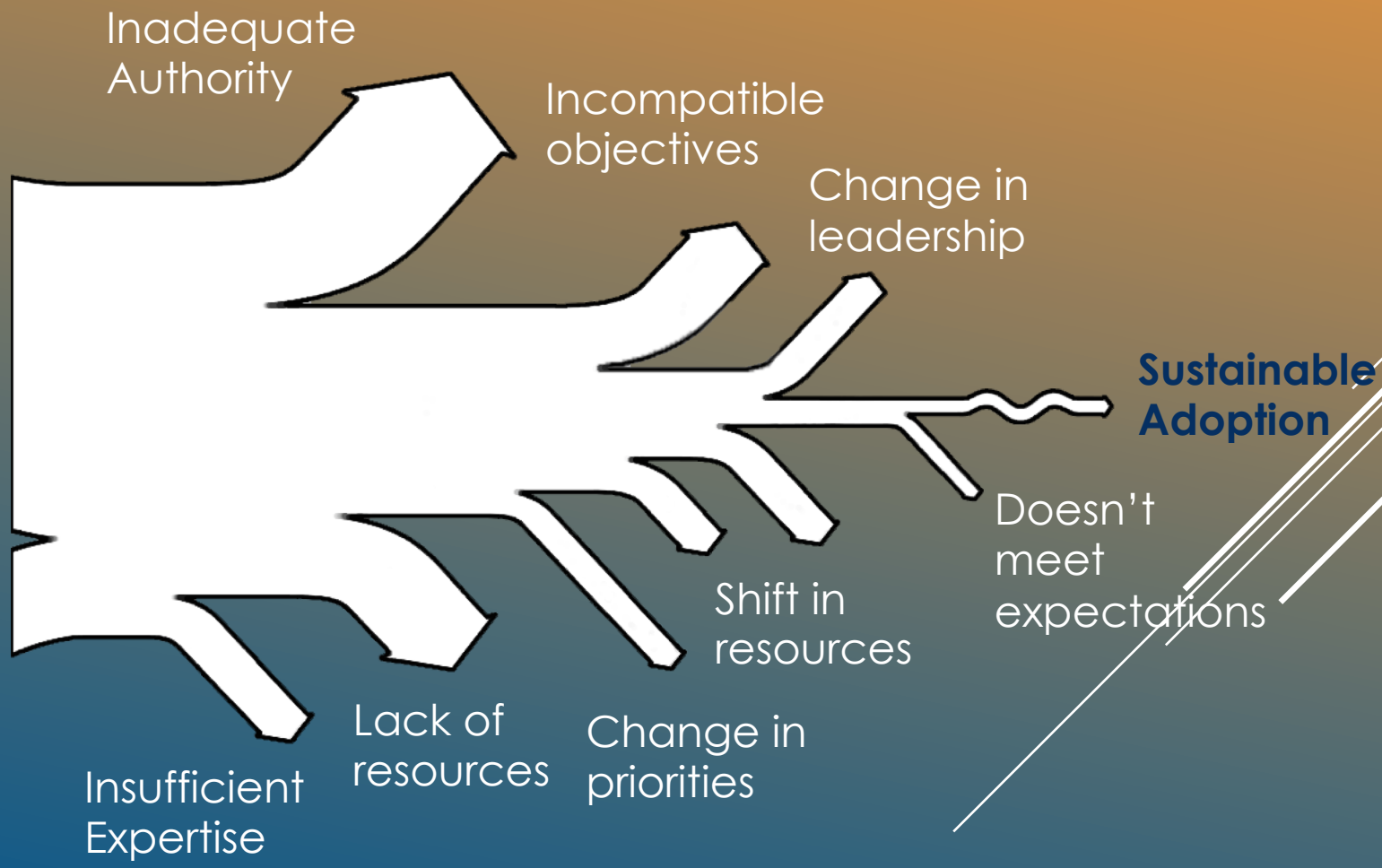


APHC
Needs: On-Demand Forecasts for Troops in Field
(e.g., troops deployed in the field can access forecasts without a cyber trail of their location)

BOEM
Needs: Extract 3-D Fields
(e.g., personnel to use forecasts to help interpret satellite data, including 3-D structure, & identify pollution events)

IBM:
Needs: High speed, high volume access
(e.g., study forecasts in conjunction with other datasets for decision-making, etc.)

Strategies for Sustainability
Acknowledge the Likelihood of Failure



Strategies for Sustainability
Active Recruitment of Cities as Stakeholders

National Aeronautics and Space Administration

Forecasting and Risk Communication
Air Pollution in Your City

Forecasted air pollution values for $PM_{2.5}$, NO_2, O_3, and SO_2 are available for your city up to 5 days in advance.

A health-based air quality index is also available to help with local risk communication.

These values can be specifically tailored to your city by sharing local air pollution and daily health data.

The Global Modeling and Assimilation Research Office (GMAO) at NASA can provide city-level estimates of outdoor air pollution for every city in the world, even for areas without existing air quality monitors. This information is publicly available and provided free of charge.

FORECASTING AIR POLLUTION IN YOUR CITY

Air pollution estimates are made using satellite data, information about global emissions, advanced weather forecasting, state-of-the art chemical modeling, and machine learning to tailor the results to individual cities. The most important aspect of this information is that it can provide predictions of air pollution values for the next five days. These forecasts can help residents in your city know beforehand when severe pollution episodes will occur; help individuals make plans regarding their outdoor activities; and provide information to improve local air quality management decisions.

COMMUNICATION OF HEALTH RISKS

In addition to providing estimates of outdoor concentrations of multiple air pollutants ($PM_{2.5}$, NO_2, O_3 and SO_2) a health-based air quality index has also been created that can easily communicate the combined risks of multiple air pollutants on a day-to-day basis. These easy-to-understand values are particularly useful for individuals that are sensitive to outdoor air pollution such as people with asthma and other respiratory diseases.

TAILORING THE DATA TO YOUR CITY

Air pollution and risk communication index values can be further tailored to the specific conditions in your city if you provide additional local data to the NASA and NYU project team. Sharing data is not required to access the forecasted pollution values and health-based air quality index. However, it can help improve the usefulness of the forecasts for your city. Three examples are provided on the next page to illustrate how sharing data helped to improve the specificity of air pollution and risk communication information for individual cities.

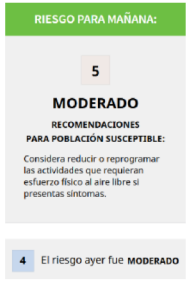
CONTACT

Please contact Bryan Duncan (bryan.n.duncan@nasa.gov) and Kevin Cromar (kevin.cromar@nyu.edu) to learn more about accessing forecasted air pollution and health-based air quality index values. They can also help you learn how this information can be specifically tailored to the local conditions in your city.

NYU Marron Institute of Urban Management

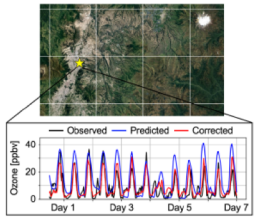
CASE STUDY #1:
Mexico City shares daily health data with project team to validate health-based air quality index values

The city government of Mexico City provided project team members with daily health statistics for emergency department visits and hospital admissions in order to validate a health-based air quality index. As a result of sharing these data, the project team was able to confirm that the index values are associated with respiratory health risks in both children and adults and could be effectively used as a risk communication tool. The health-based air quality index is now available to the public and continuing efforts by the Mexico City ministries of health and environment are being made to promote the use of their new air quality index.



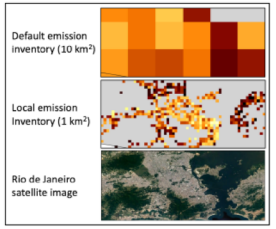
CASE STUDY #2:
Quito provides local air monitoring data to down-scale pollution estimates using machine learning

The city of Quito provided the project team with local air monitoring data from monitors within the city. Using these data, the project team was able to apply machine learning and artificial intelligence methods to down-scale the pollution estimates from city-level spatial resolution to neighborhood-level resolution. The figure shows the improved estimates at an air monitoring location in Quito.



CASE STUDY #3:
Rio shares emissions inventory data to improve local air quality forecasts

The city of Rio de Janeiro provided the project team with local emission inventory data from its transportation sector. Even though these data only represented a small percentage of the total pollution emissions in the city, the incorporation of these data into the model helped improve forecasted pollution levels. The Rio city government also shared local air quality monitoring data to help improve the forecasts (similar to the Quito example above).



Strategies for Sustainability
Sustainable Intermediary Partnerships

Strategies for Sustainability
Validation with Local Health Data

Air Pollution Monitoring for Health Research and Patient Care: An American Thoracic Society Workshop Report

"As air monitoring information is increasingly accessible for LMIC it is important that health studies in these locations are pursued rather than only relying on concentration response functions from wealthier countries to assess risks and health impacts. **The key challenge for health research in these locations moving forward may be the availability and accessibility of health data for use in these studies."**

(Cromar, Duncan, et al., 2019)

AIR POLLUTION FORECASTS

FUNDING SOURCES

NASA GMAO personnel (e.g., Keller, Knowland) gratefully acknowledge support by the NASA Modeling, Analysis & Prediction (MAP) Program

Duncan & Cromar gratefully acknowledge support by the NASA Applied Sciences Program (ASP) via the Health & AQ Applied Sciences Team (HAQAST)

Year 3 Progress Update, Bryan Duncan

A Satellite-Based Global Health Air Quality Index (HAQI): Development and Assessment

- Black bullets=milestones; red = accomplishments
- Dept. of Interior Bureau of Ocean Energy Management (BOEM; Holli Ensz POC)
  - NASA field campaign in May 2019 in support of NASA-BOEM project (Duncan PI) to scope the feasibility of using satellite data to monitor off-shore AQ.
- Work with NASA GMAO (*Christoph Keller, Emma Knowland*) to develop and evaluate global AQ forecast system (https://airquality.gsfc.nasa.gov/forecast) & to develop stakeholder relationships, including with *Kevin Cromar* (NYU)
  - Went "Live" on November 2, 2018!
  - Evaluation & subsequent model debugging ongoing, but lack AQ data in most world cities.
  - Developing relationships with several partner cities: Rio de Janeiro, Jakarta, Quito.
  - Working with stakeholders, including IBM, U.S. Army Public Health Center, to facilitate access to forecasts.
  - Writing global AQ forecast system description paper.
- Novel applications of satellite data
  - Working to infer CO_2 emissions from Co-emitted NO_2 estimated from satellite data (3 papers submitted)
  - Working with NASA GSFC's new Food Security Office to develop a theme on the impact of air pollution on crop yields. Completed website and factsheet: https://airquality.gsfc.nasa.gov/food-security
- 1 invited talk; 1 academic talk; 4 stakeholder or public talks

See Ryan Stauffer's Poster

Tiger Team Participation

- Duncan & West: Efficacy of Environmental Regulations on AQ & Health
  - Completed development of materials (https://airquality.gsfc.nasa.gov/us-air-quality-trends) for stakeholders to demonstrate that air quality regulations are working in the eastern U.S.
- Fiore: Supporting the use of satellite data in regional haze planning
  - Contributing trends in Asian & U.S. NO_2 and SO_2 (e.g., https://airquality.gsfc.nasa.gov/particulate-matter ; https://airquality.gsfc.nasa.gov/surface-level-ozone)
  - Exploring TROPOMI data of NO_2, SO_2, & HCHO
- Anenberg: Using Satellite Remote Sensing to Derive Global Climate and Air Pollution Indicators
  - Exploring TROPOMI data of NO_2, SO_2, & HCHO
  - Contributing surface concentrations in global NO_2

Paper copies of factsheets available here.

2 papers published
5 papers submitted