

NASA Health and Air Quality Applied Sciences Team (HAQAST)

Armistead (Ted) Russell, Talat Odman and Yongtao Hu

Georgia Institute of Technology

And the whole NASA HAQAST Team



haqast.org



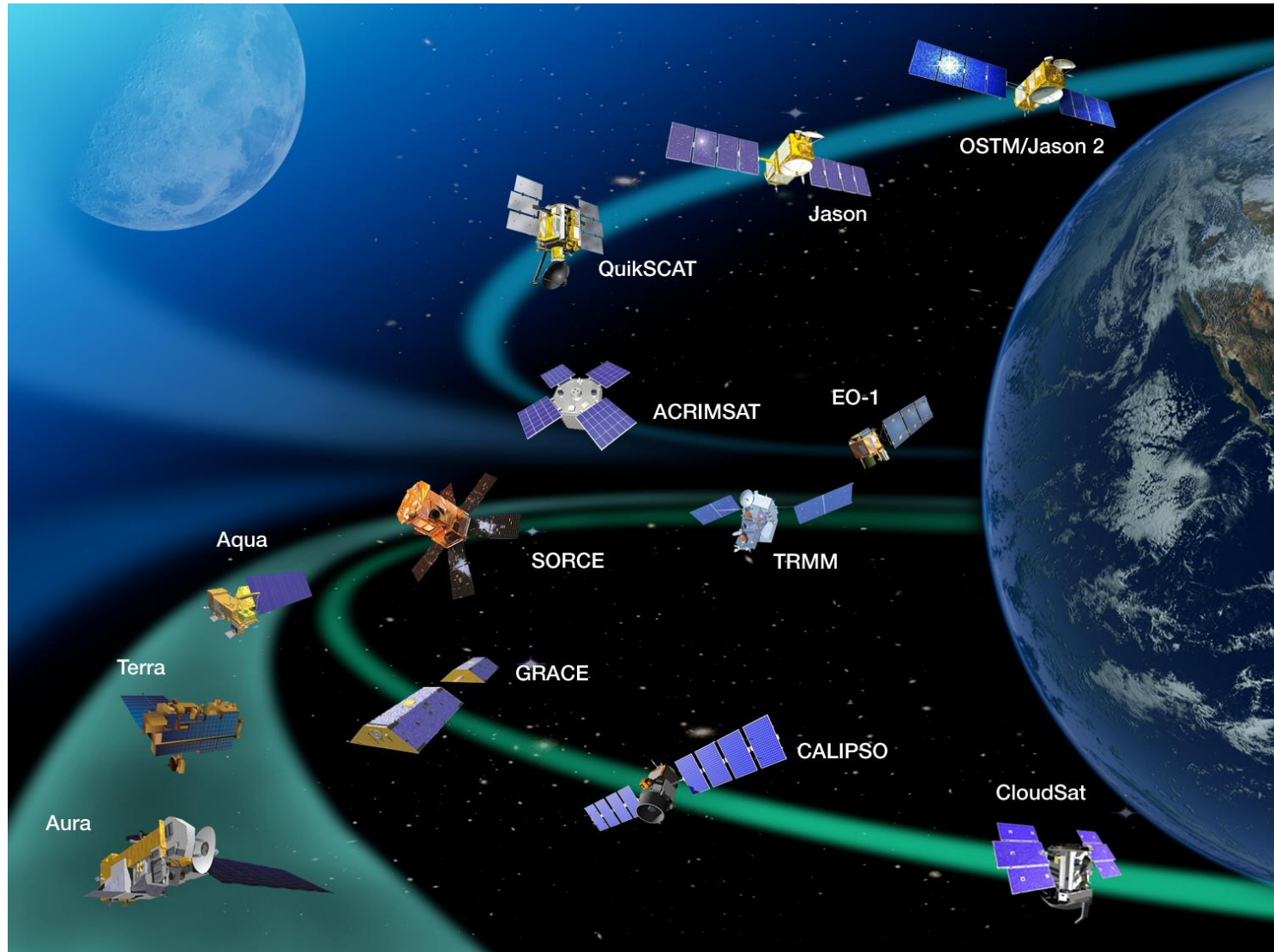
2016-2019



What is HAQAST?

- A group of 13 teams, competitively selected, that are focused on conducting applied, high impact and fundamental research using NASA (and other) earth science data and tools to solve real world problems related to air pollution, air quality management and related health issues.
 - Evolved from successful AQAST effort

Lots of information available from space...

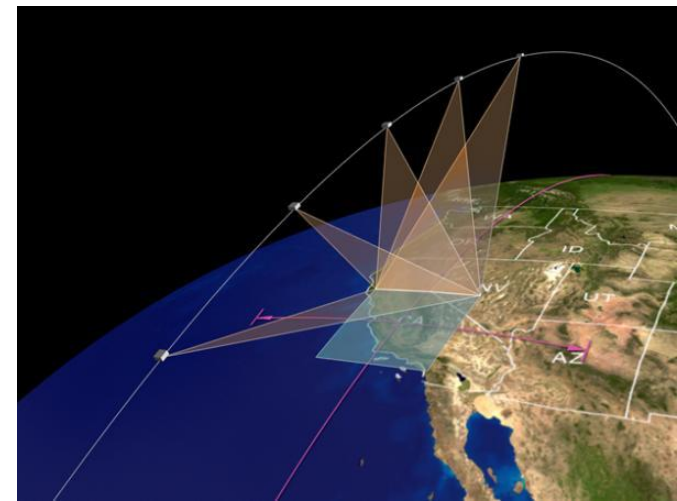
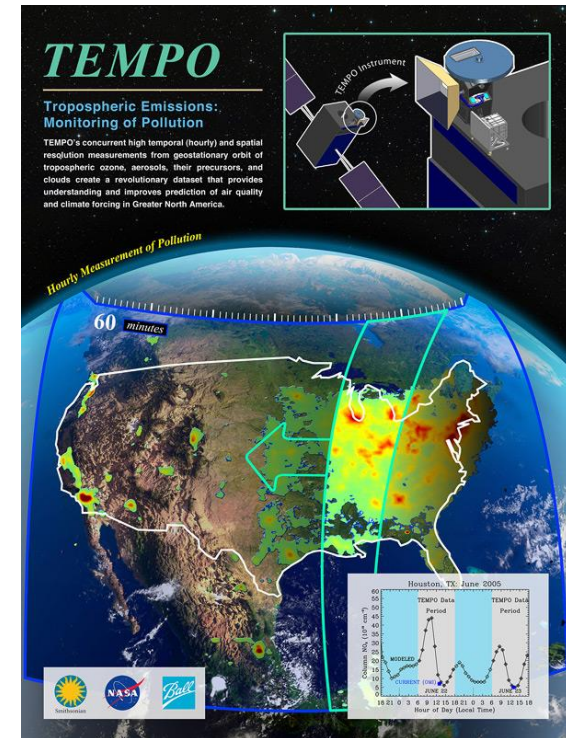


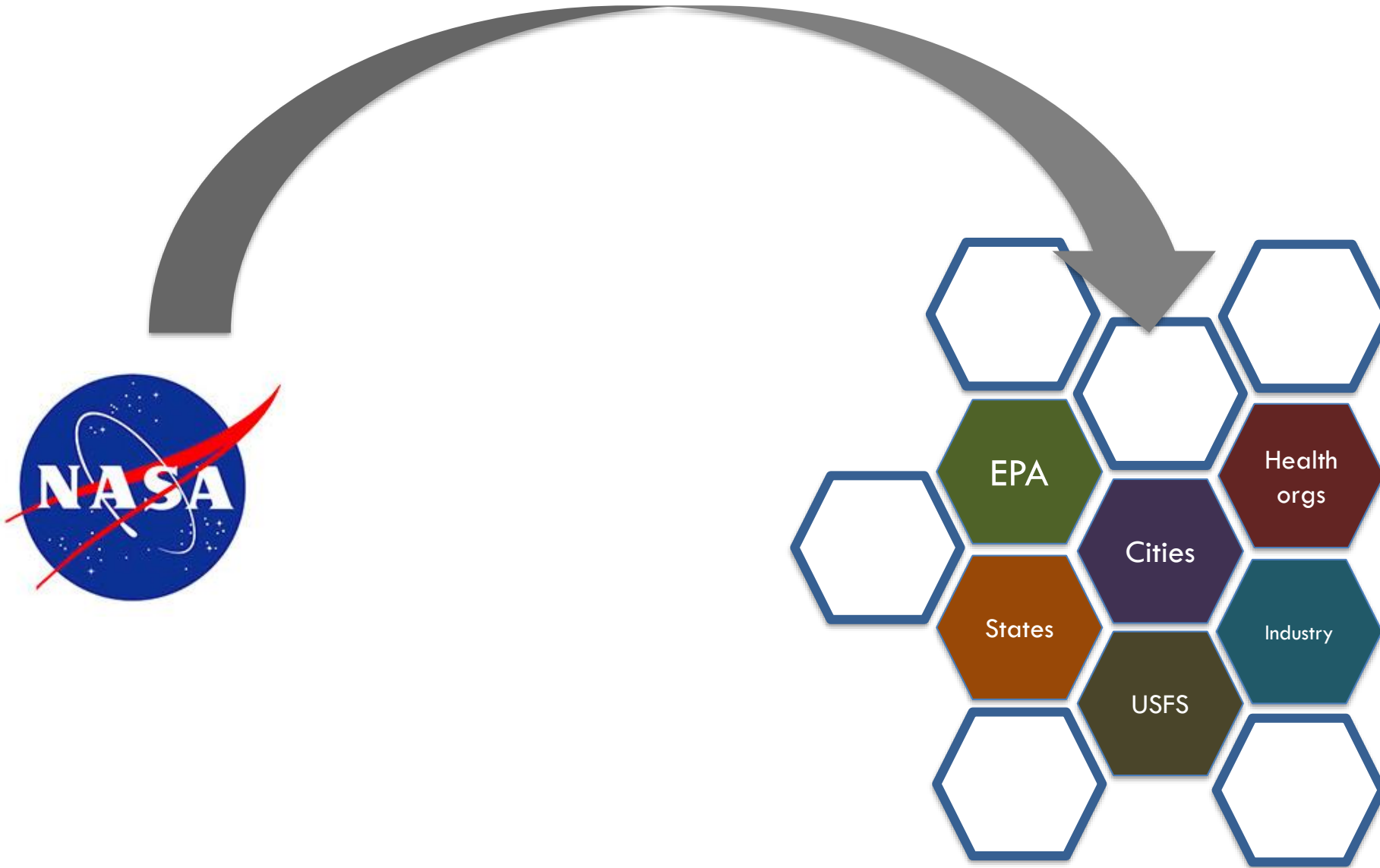
Even more globally...

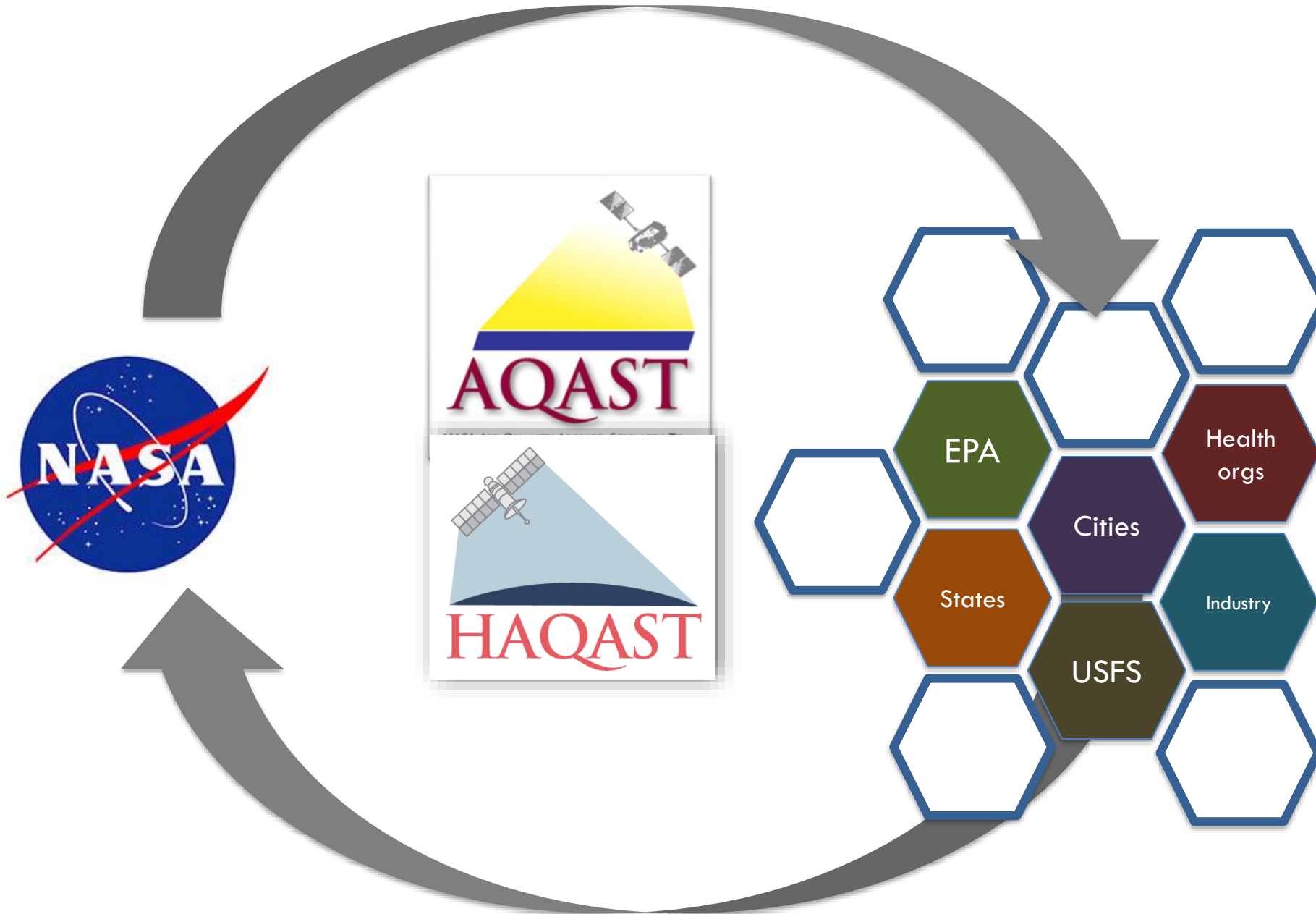


More coming

- TEMPO: Tropospheric Emissions: Monitoring of Pollution
 - Geostationary, multiple pollutants
 - 2020-2021(?)
- MAIA: Multi-Angle Imager for Aerosols
 - Provide information on PM speciation
 - 2021(?)







NASA Health and Air Quality Applied Sciences Team (HAQAST)

- Tracey Holloway (Team Lead, UW-Madison)
- Bryan Duncan (NASA GSFC)
- Arlene Fiore (Columbia University)
- Minghui Diao (San Jose State University)
- Daven Henze (University of Colorado, Boulder)
- Jeremy Hess (University of Washington, Seattle)
- Yang Liu (Emory University)
- Jessica Neu (NASA Jet Propulsion Laboratory)
- Susan O'Neill (USDA Forest Service)
- Ted Russell (Georgia Tech)
- Daniel Tong (George Mason University)
- Jason West (UNC-Chapel Hill)
- Mark Zondlo (Princeton University)



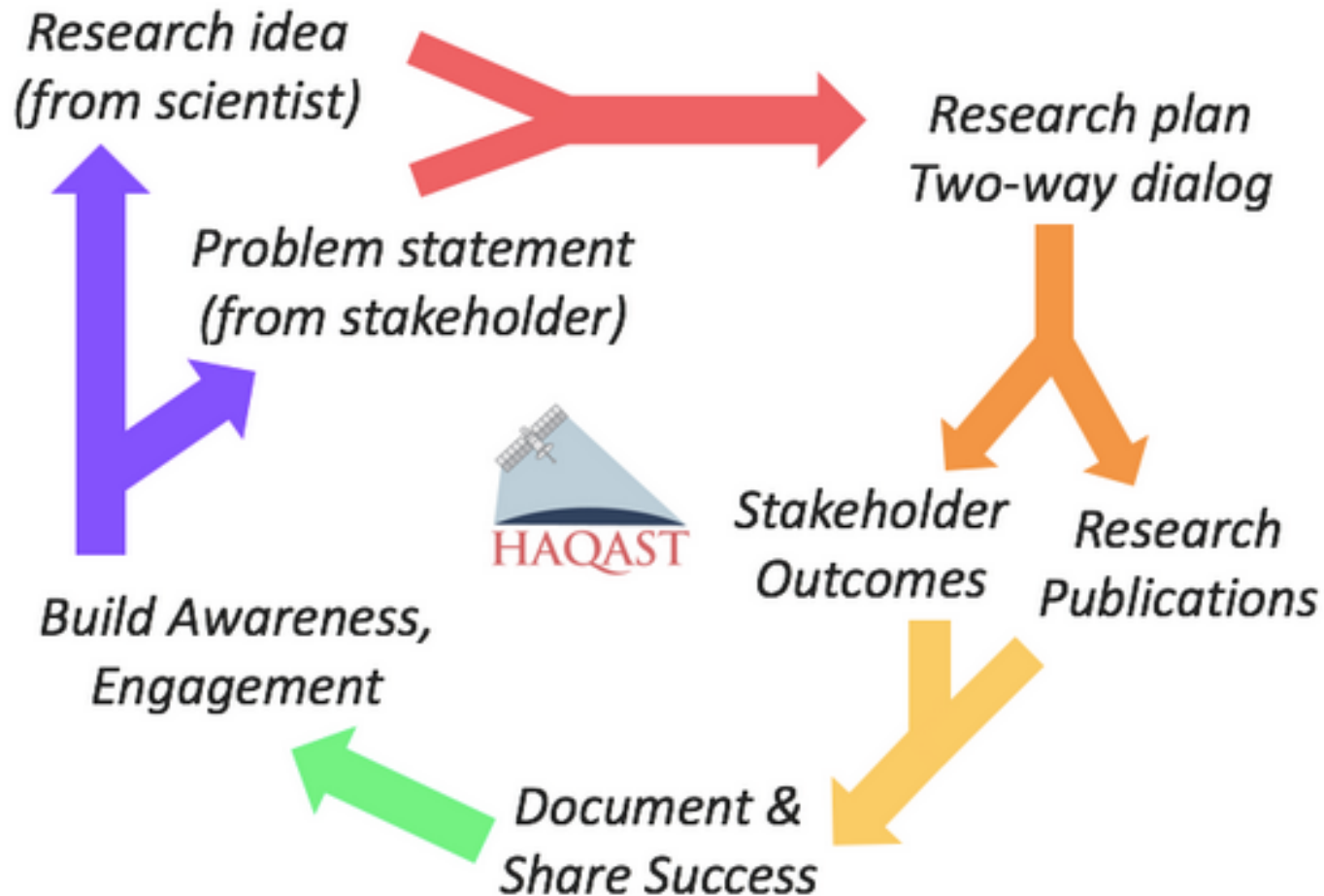
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HAQAST Approach

- Each institution has its base project and receives extra support for being involved in one or more Tiger Teams
 - Base projects address an applied research question over the period of the project using NASA and other Earth Science data and projects
 - Georgia Tech is advancing our prescribed fire pollution impact prediction system: Hi-ResX
 - Tiger teams are short-term, high-impact collaborative efforts
 - Rapid, multifaceted solutions to pressing health and air quality issues.
- Meetings between stakeholders and project teams to identify issues and communicate findings
 - Phoenix (January) then RTP(?)

HAQAST Approach



Example Projects

Observing AQ over the Gulf Of Mexico

- HAQAST members Bryan N. Duncan and Anne M. Thompson partnering with to evaluate the current capabilities of satellite data for air quality monitoring and emissions validation over the Gulf of Mexico.
- This project is a feasibility study to identify NASA resources for BOEM to aid in monitoring the impact of offshore pollution on inland communities.
- Two main project parts:
 - 1) Evaluation of NASA datasets for monitoring offshore air pollutants.
 - 2) Field campaign coordinated to measure surface to validate the satellite data.

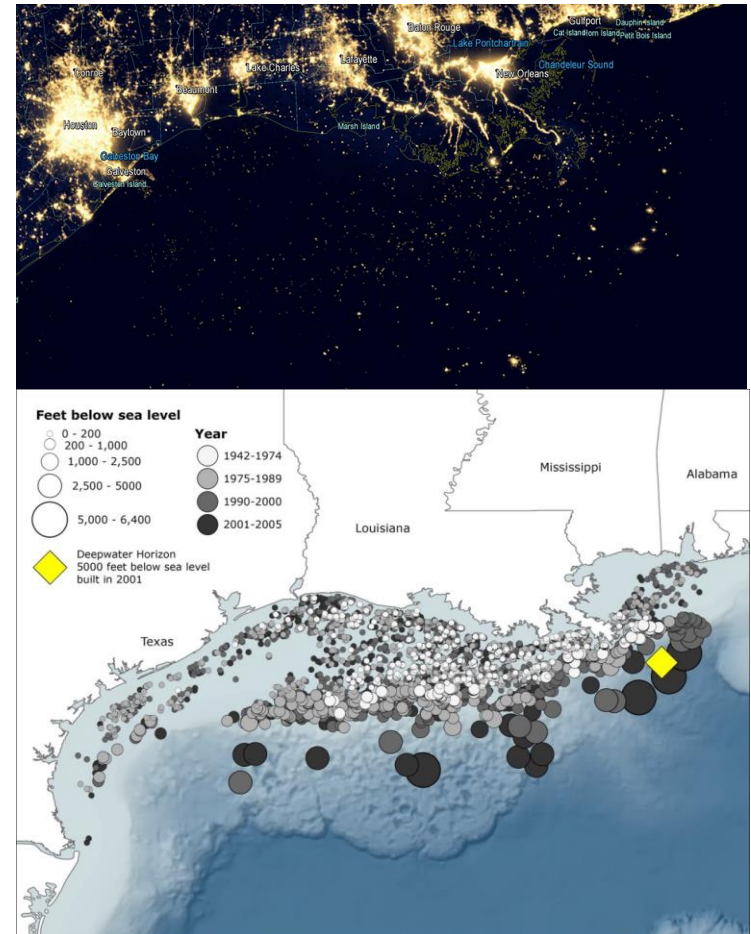


Figure. Suomi VIIRS “Lights at Night” data clearly show the locations of oil rigs and platforms

Connecting NASA Data and Tools With Health and Air Quality Stakeholders

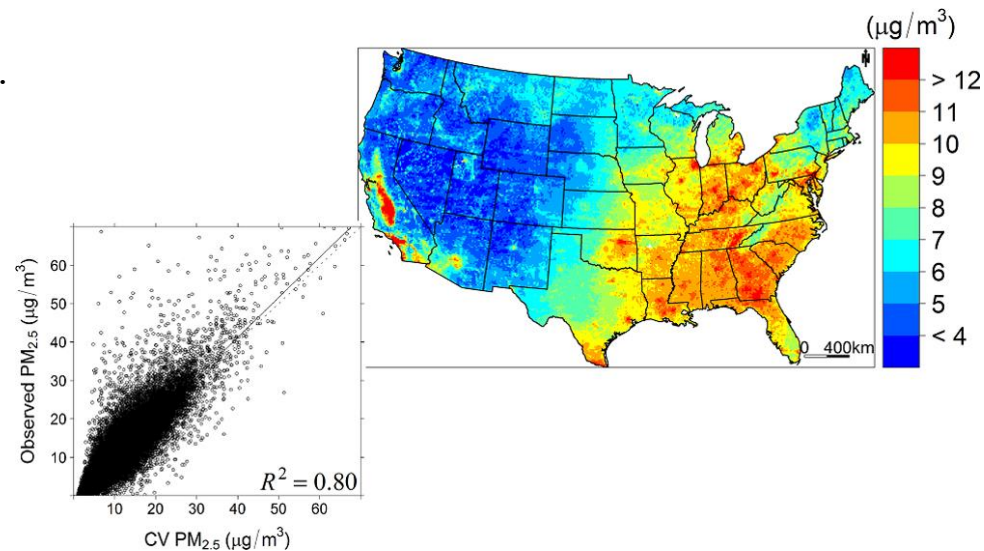
WWW.HAQAST.ORG

TWITTER.COM/NASA_HAQAST

A Machine-Learning Approach to Map Air Pollution in the US

- PM_{2.5} a key driver of global disease burden: WHO estimated 3 million deaths in 2014 due to it.
- Research indicates biggest health benefits in reducing PM_{2.5} pollution may lie in the **low concentration** regions such as North America.
- Newly developed machine-learning technique takes advantage of NASA satellite data to provide accurate PM_{2.5} exposure information
- NASA's MODIS AOD, GEOS-Chem simulations and NLDAS-2 meteorological fields were used
- Effort led by Prof. Yang Liu at Emory University, Rollins School of Public Health
- For more information, contact Yang Liu (yang.liu@emory.edu)

- **The figure shows model-estimated annual mean PM_{2.5} patterns in the US in 2011.**



Connecting NASA Data and Tools With Health and Air Quality Stakeholders

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Informing international climate pollutant reduction strategies with NASA satellite data & models

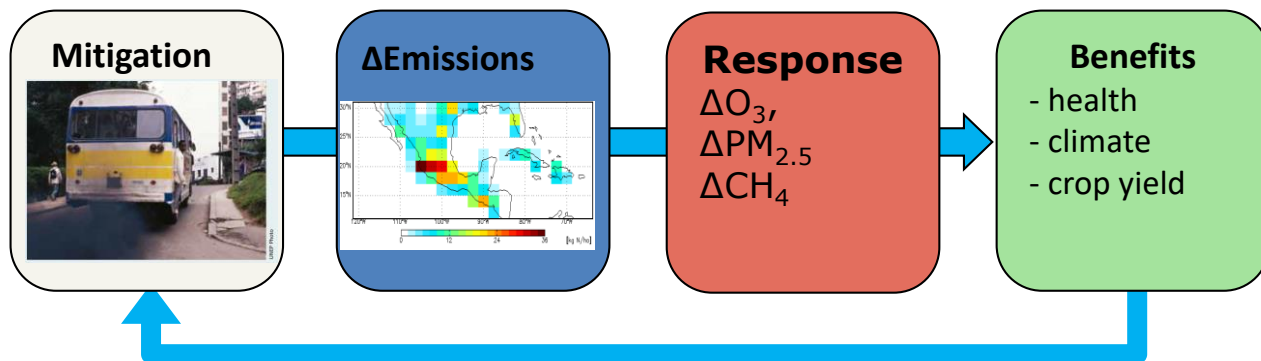
- NASA **H**ealth and **A**ir **Q**uality **A**ppplied **S**ciences **T**eam (HAQAST)
- Climate and Clean Air Coalition (CCAC) uses LEAP-IBC to aid member states in developing strategies for reducing emissions of short-lived climate pollutants (SLCP's, e.g., CH₄, aerosols, O₃) and estimating the associated air-quality and climate co-benefits.
- Research and NASA earth observation expertise: Daven K. Henze (University of Colorado Boulder), Susan Anenberg (George Washington University), Patrick Kinney (Boston University), in collaboration with Randall Martin and Aaron van Donkelaar at Dalhousie University.
- CCAC partners: Amanda Curry-Brown (US EPA), Johan Kuylenstierna (Stockholm Environment Institute), Helen Molin Valdes (CCAC Secretariat), Julie Cerqueira (US State Department).
- This project developed the LEAP-IBC tool, used in >12 countries world-wide for SLCP planning.
- LEAP-IBC incorporates constraints from NASA remote sensing of aerosols (MODIS, MISR, CALIPSO), greenhouse gases (TES O₃), and model calculations (GEOS-Chem adjoint).

LEAP-IBC: rapid emission and scenario assessment toolkit

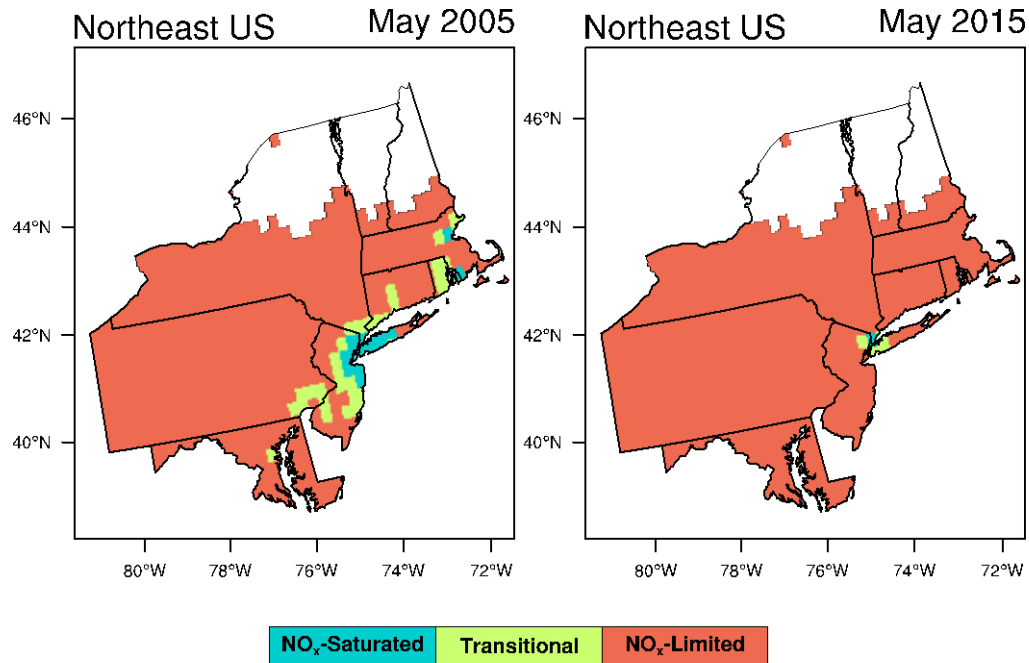
<http://www.ccacoalition.org/en/climate-tags/leap-ibc>



www.unep.org/ccac



OMI satellite data show Northeast U.S. NO_x emission reductions should lower ground-level ozone



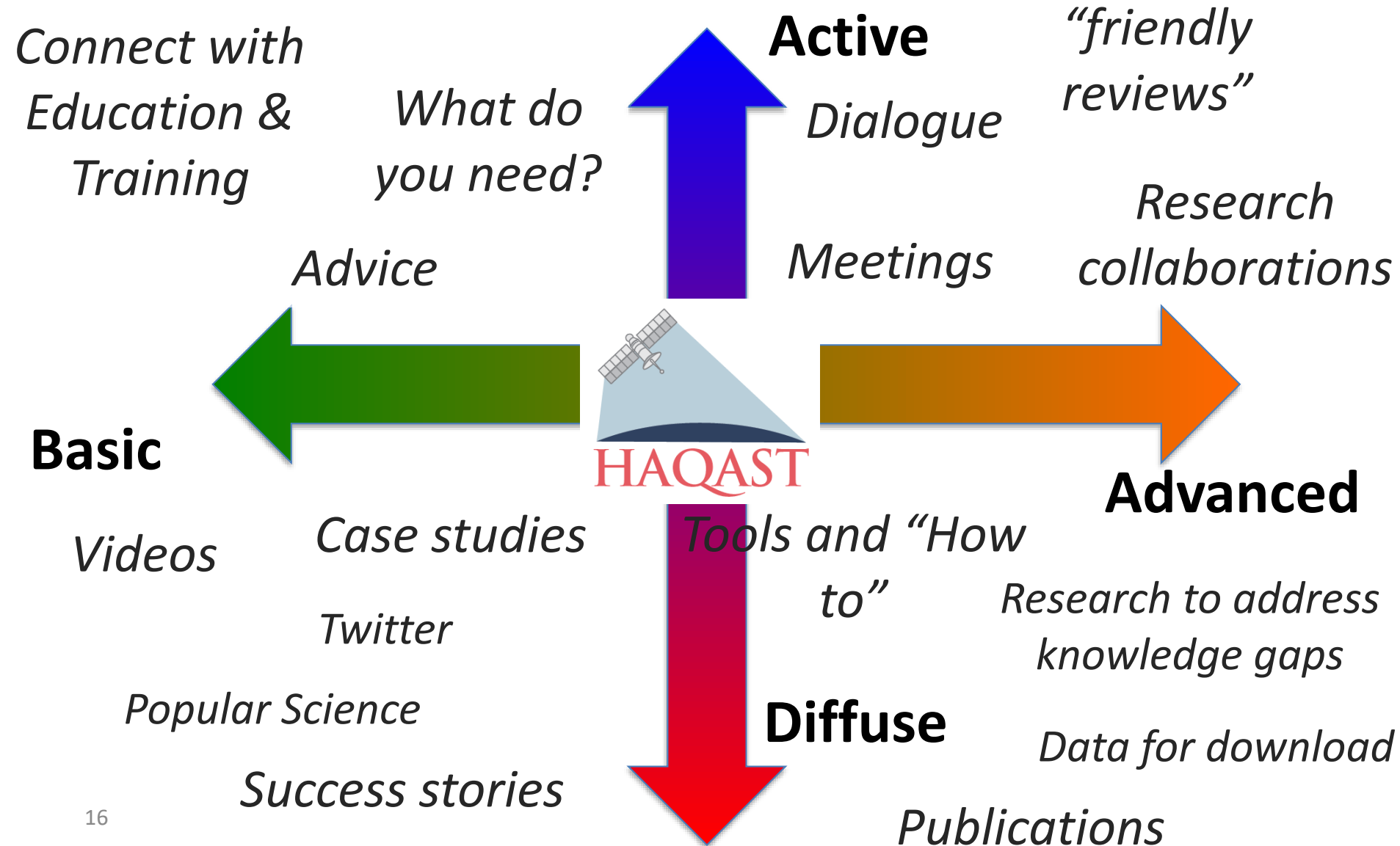
From 2005 to 2015 during May, areas showing sensitivity of ozone formation to changes in:

- NO_x emissions (NO_x-limited) increased;**
- VOC emissions (NO_x-saturated) decreased;**

→ confirms expectations of declining NO_x emissions on known chemistry for ozone formation

- Arlene Fiore & Xiaomeng Jin (LDEO/Columbia) provided maps of the sensitivity of ozone formation to emissions of nitrogen oxides vs. volatile organic compounds derived from OMI satellite data for use by the Connecticut state air agency in their state implementation planning process.
- Demonstrates success of past air pollution controls, and anticipated continued improvements to air quality from continued NO_x emission controls

HAQAST Scope of Work





2017 Tiger Teams from HAQAST

- **Tiger teams** are short-term, high-impact collaborative efforts between HAQAST members and public stakeholders to identify and solve an immediate problem using NASA data and products. Each Tiger Team draws on the expertise of multiple HAQAST PIs to find the best, multifaceted solutions to pressing health and air quality issues.
 - Demonstration of the Efficacy of Environmental Regulations in the Eastern U.S. for Health and Air Quality
 - Supporting the use of satellite data in State Implementation Plans (SIPs)
 - High Resolution Particulate Matter Data for Improved Satellite-Based Assessments of Community Health
 - Improved NEI NO_x emissions using OMI Tropospheric NO₂ retrievals



Example output from a 2017 Tiger Team

- Supporting the use of satellite data in State Implementation Plans (SIPs)
 - Guidance documents
 - [Using satellite observed formaldehyde \(HCHO\) and nitrogen dioxide \(NO₂\) as an indicator of ozone sensitivity in a SIP:](#)
 - [A Brief Tutorial on Using the Ozone Monitoring Instrument \(OMI\) Nitrogen Dioxide \(NO₂\) Data Product for SIP Preparation:](#)
 - [Guide to Using Satellite Images in Support of Exceptional Event Demonstrations:](#)
 - Comparison of CMAQ Simulation to Satellite Observations: NO₂ Column versus OMI NO₂
 - A primer on ammonia satellite products
 - How-to use the NASA Giovanni portal to create time series plots of satellite NO₂



Example: Technical Guidance Docs Completed under a 2017-2018 TT

A Brief Tutorial on Using the Ozone Monitoring Instrument (OMI) Nitrogen Dioxide (NO_2) Data Product for SIPS Preparation

<https://doi.org/10.7916/D80K3S3W>



And archived at Columbia U Academic Commons Repository



<https://doi.org/10.7916/D84B4HT6>

Guide to Using Satellite Images in Support of Exceptional Event Demonstrations

Lead Author: Bryan N. Duncan (NASA)
Contributing Authors: Michael Geigert (CT DEEP)



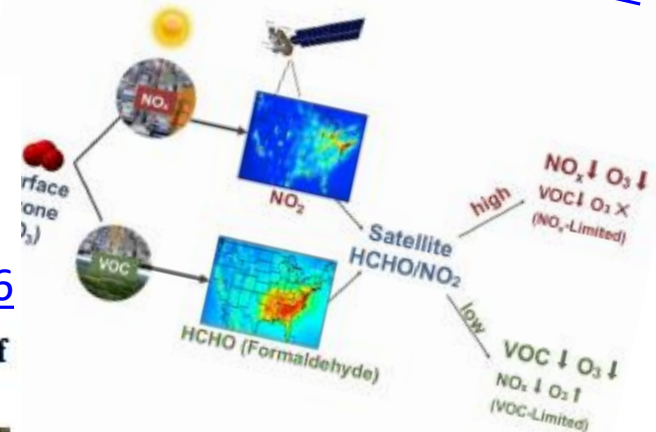
Michael Geigert

CTDEEP

March 2018

Using satellite observed formaldehyde (HCHO) and nitrogen dioxide (NO_2) as an indicator of ozone sensitivity in a SIP

<https://doi.org/10.7916/D8M34C7V>



Xiaomeng Jin and Arlene Fiore (LDEQ/Columbia)
Michael Geigert (CT DEEP)
Publication Date: June 12, 2018

Example: Technical Guidance Docs Completed under a 2017-2018 TT



<https://doi.org/10.7916/D84B4HT6>

Guide to Using Satellite Images in Support of Exceptional Event Demonstrations



Michael Geigert

CTDEEP

March 2018

<https://academiccommons.columbia.edu/doi/10.7916/D84B4HT6>

NASA's air quality from space website "Managers" tab

(Example from a 2017-2018 TT)



AQ Managers

Publicly available NASA satellite data can help with State Implementation Plans (SIPs)

Background: NASA's Earth science program maintains a large fleet of earth-observing satellites, all of which offer free data products. A number of these can be used to illustrate NO_x emissions trends and their relevance to ozone attainment, as well as for weight-of-evidence under the EPA's Exceptional Events Rule. A collaborative team of NASA-funded scientists and public stakeholders has recently developed a suite of easy-to-follow technical guidance documents to support state and local air quality agencies that want to bring the power of NASA's satellites to bear on the documentation of exceptional events. This work is a product of the NASA [Health and Air Quality Applied Sciences Team \(HAQAST\)](#) Year 1 (2017-2018) Tiger Team "Supporting the Use of Satellite Data in State Implementation Plans (SIPs)"

What, specifically, can NASA help me with? Our team has developed three guidance documents:

Thanks to Bryan Duncan and his team for hosting these!



2018 Tiger Teams from HAQAST

- **Satellite-Evaluated and Satellite-Informed O₃ Distributions for Estimating U.S. Background O₃ ***
 - BAAQMD, the South Coast Air Quality Management District, the California Air Resources Board, CT DEEP, New Hampshire Air Resources Division, New York State Department of Air Quality, the Texas Commission on Environmental Quality, WESTAR & WRAP, US EPA, and OAQPS
- **Supporting the Use of Satellite Data in Regional Haze Planning ***
 - U.S. EPA OAQPS, MARAMA, NESCAUM, TCEQ, ME DEP, and CT DEEP
- **Using Satellite Remote Sensing to Derive Global Climate and Air Pollution Indicators**
 - Partnership with the Lancet Commission on Pollution and Health, University College London/Lancet Countdown, and the Health Effects Institute/State of Global Air
- **Air Quality and Health Burden of 2017 California Wildfires***
 - Partnership with BAAQMD, NOAA, the USFS Fire & Aviation Management Program, EPA, Sonoma Technology Inc., the National Park Service, Princeton University, the University of Washington, and the University of California, Davis

***Georgia Tech involved**



HAQAST “Haze” Participants

HAQASTers: Arlene Fiore (LDEO/Columbia), Bryan Duncan (NASA GSFC), Daven Henze (University of Colorado – Boulder), Tracey Holloway (University of Wisconsin—Madison), Talat Odman and Ted Russell (Georgia Institute of Technology), Daniel Tong (George Mason University), Jason West (UNC), Mark Zondlo (Princeton University)

Stakeholder partners: *Maine* [Tom Downs], *Connecticut* [Michael Geigert, Kate Knight], *Texas Commission on Environmental Quality (TCEQ)* [Stephanie Shirley]; *Western States Air Resources Council (WESTAR) and Western Regional Air Partnership (WRAP)* [Tom Moore]; *Lake Michigan Air Directors Consortium (LADCO)* [Zac Adelman]; *Mid-Atlantic Regional Air Management Association (MARAMA)* [Julie McDill], *Northeast States for Coordinated Air Use Management (NESCAUM)* [Paul Miller]; *U.S. EPA* [Brett Gantt, Barron Henderson, Gail Tonneson]; **Other agencies are welcome to join throughout the project.**

How can satellite data be included in regional haze planning?

- (1) Weight-of-evidence for haze transport from specific sources (e.g., dust, fires, international, agricultural) to supplement analysis of IMPROVE data and models
- (2) Constraints on emission changes in upwind countries to underpin assessments of temporal trends in international transport
- (3) Evidence for spatial and temporal variability in agricultural ammonia emission inventories

→ Assist in the attribution of observed visibility-impairing $\text{PM}_{2.5}$ to natural and anthropogenic sources



HAQAST Haze Deliverables

1. **Initial Phone meetings** between HAQAST participants and stakeholder partners
 - First chance to hear emerging questions & priorities for specific case studies and trend analyses
 - Help team prioritize efforts that are of broad interest
2. **Technical guidance documents**
 - At least 2 case studies (wildfire, and/or international transport events) with detailed instructions for how to obtain and visualize satellite products alongside IMPROVE and/or model data used in regional haze planning (Odman, Russell, Fiore)
 - Contribution of wind-blown dust emissions to local air quality (Tong)
 - Regridding satellite AOD for model evaluation (Holloway)
3. **Summary reports**
 - trends in international emissions inferred from space (Duncan, Henze, Zondlo, Fiore, West)
 - Temporal (seasonal) and spatial (by animal type) patterns of ammonia over the EUS(Zondlo)



HAQAST Haze Deliverables

4. Monthly team-wide phone calls

- Communication across team throughout the project helps promote efficient progress along a direction of most use for planning
- HAQAST PIs can address (some) emerging questions as they arise.
- Summary notes from phone meetings & draft docs will be available on team **website** (e.g., see 2017-2018 TT site <https://blog.ldeo.columbia.edu/atmoschem/haqast-tt-satellite-sips/>)

5. Web documentation housed @ airquality.gsfc.nasa.gov “Managers” Tab (Duncan)

6. Disseminate case studies

- One page memos
- Permanent archival of tech. guid. Docs (Columbia U academic commons)
- Meetings including AGU, HAQAST5
- Regional group phone meetings if opportunities arise



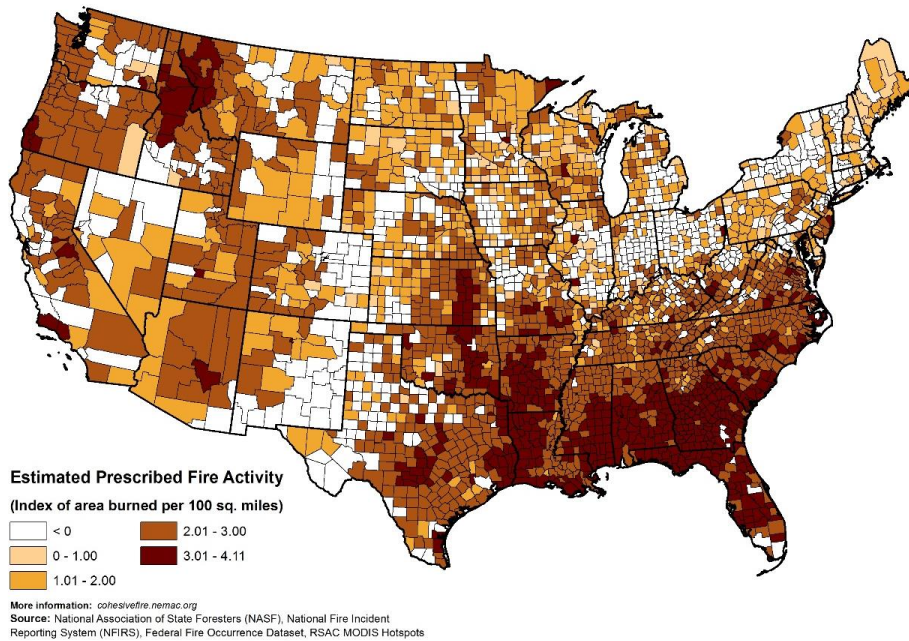
**HIRES-X: SCIENTIFIC AND GEOGRAPHIC EXTENSION OF
AN OPERATIONAL HIGH RESOLUTION, PROGNOSTIC AIR
QUALITY SYSTEM PROVIDING SMOKE IMPACTS
FORECASTS FOR HEALTH PROTECTION, ECOSYSTEM
MANAGEMENT AND ECONOMIC DEVELOPMENT USING
EARTH OBSERVATIONS**



Approach

- Extend current, operational, forecasting system (HIRES-X) to provide air quality impacts of prescribed fires
 - Georgia Tech has been providing air quality model-based air quality ozone forecasts since the 1996 Olympics
 - Major extensions
 - Domain increased to US, Added PM2.5
 - Source impact forecasts
 - Mobile source, power plants
 - Prescribed fires in Georgia
- Adding capability to forecast fire impacts in additional southeastern states
 - Improving fire prediction system
 - Using inexpensive sensors to provide additional information

Prescribed fire in the Southeast



According to 2014 NEI, prescribed burning is the largest source of $PM_{2.5}$ (24%) in Southeastern USA.

Operational forecasting of prescribed fire impacts for dynamic management

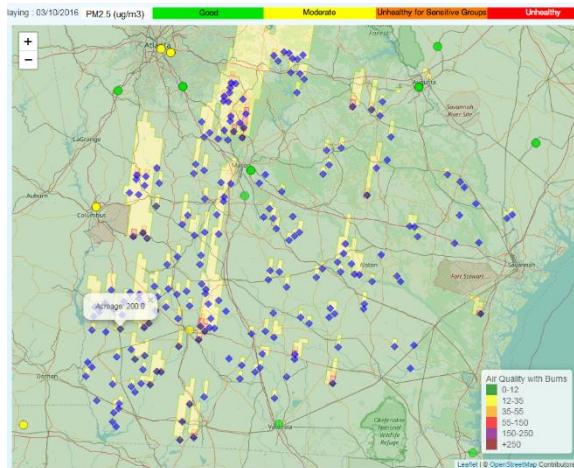
- Daily forecasts of prescribed-fire related air quality impacts to state agencies for prescribed burn and air quality management

<https://forecast.ce.gatech.edu>

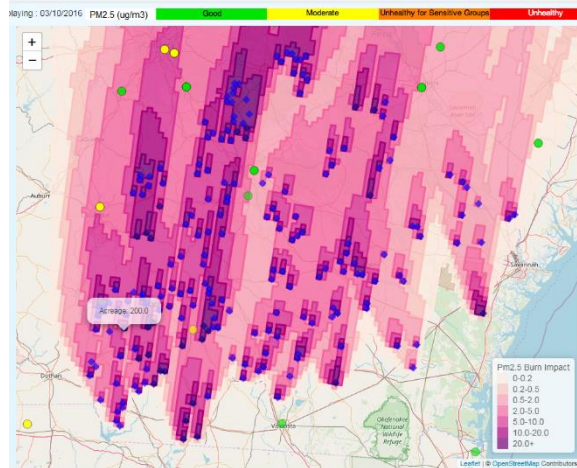
- Prescribed-fire related exposures to CDC and its partners for public health tracking and source-specific epidemiological assessments

<https://ephtracking.cdc.gov>

PM_{2.5} Forecast



Burn Impact Forecast

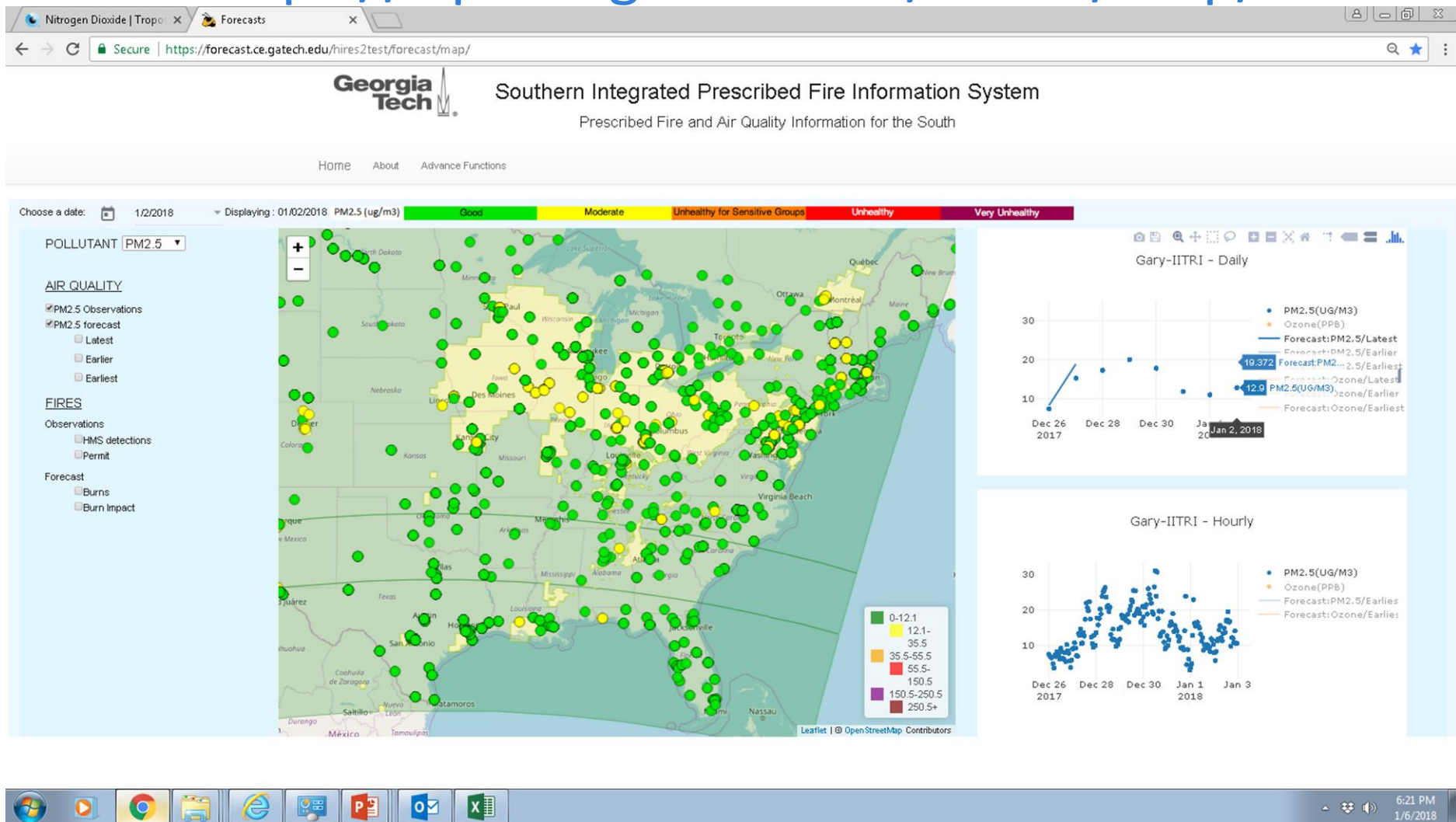


Public Health Tracking Network



Web Portal:

<https://sipc.ce.gatech.edu/SIPFIS/map/>



HiRES-X Summary

- Prescribed fire impacts forecasting expanded
 - Extending to other states
 - Using satellite fire products in states with no prescribed fire data
- Combining information from satellites, air quality models, inexpensive sensors, routine monitors and burn permits
 - Inexpensive sensor packages deployed at schools in southern Georgia
 - Limited other monitoring in region
 - No one system capturing all the burns and burned acreage correctly
 - Working on approaches to more fully integrate available information
- Disseminating prescribed fire information for fire, air quality and health management
 - Web portal: <https://sipc.ce.gatech.edu/SIPFIS/map/>



HAQAST Summary

- Satellite data can be an incredibly powerful, expanding resource for air quality planning and analysis
 - Mainly need to know what exists, how to use it
- HAQAST researchers taking on projects to facilitate using earth science products and data for use in air quality planning and health
 - Individual institution projects
 - Tiger Teams
 - Resources to stakeholders (e.g., getting started guides)
 - Haqast.org (check it out!)
- Get involved!
 - Work with team(s) involved in research of interest
 - Come to meetings (Phoenix, RTP; travel funding available)

Thanks for your interest
ted.russell@Gatech.edu



2016-2019

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