



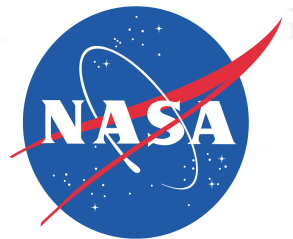
How Satellites See Air Pollution from Space

Tracey Holloway

Professor, Nelson Institute for Environmental Studies &
Atmospheric and Oceanic Sciences

University of Wisconsin—Madison

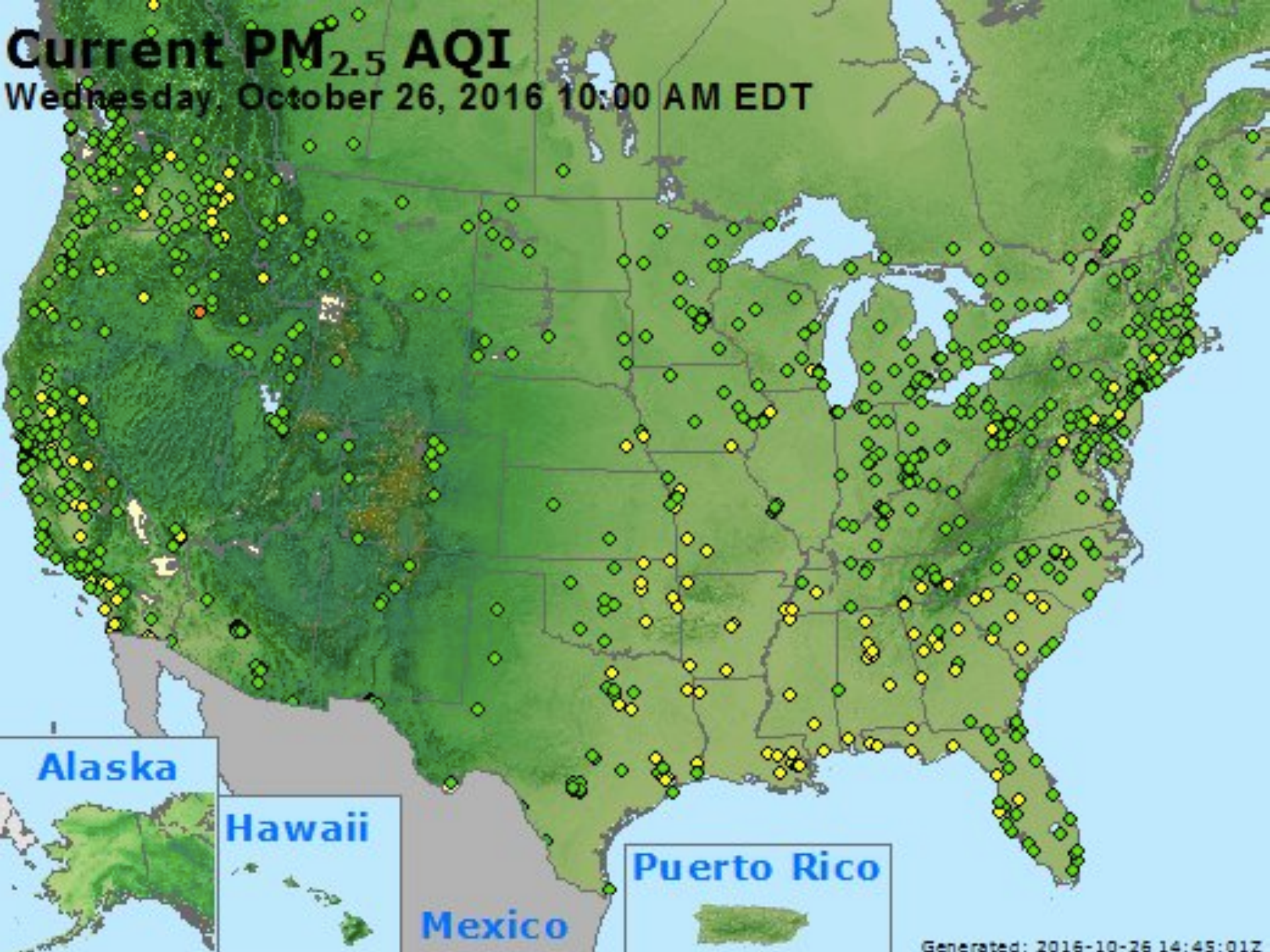
Leader, NASA Health & Air Quality Applied Sciences Team





Current PM_{2.5} AQI

Wednesday, October 26, 2016 10:00 AM EDT



Alaska

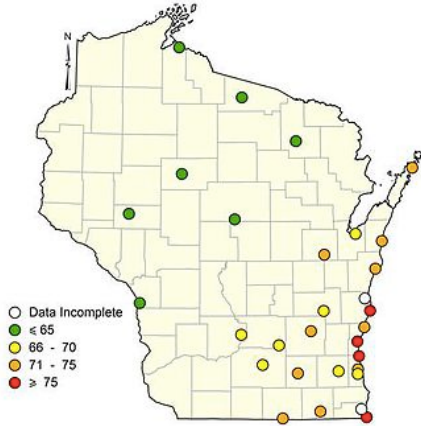
Hawaii

Mexico

Puerto Rico

Generated: 2016-10-26 14:45:01Z

Potential Monitoring Site Purposes



1. To Determine Compliance with National Ambient Air Quality Standards (NAAQS)
2. To Develop Regional Pollution Trends in Urban and Rural Areas
3. To Evaluate the Effects of Population, Land Use and Transportation on Air Quality
4. To Evaluate Air Dispersion Models
5. To Provide Air Quality Information to the Public

Problems with the status quo

Monitor data is only available in monitor locations (mostly urban areas)

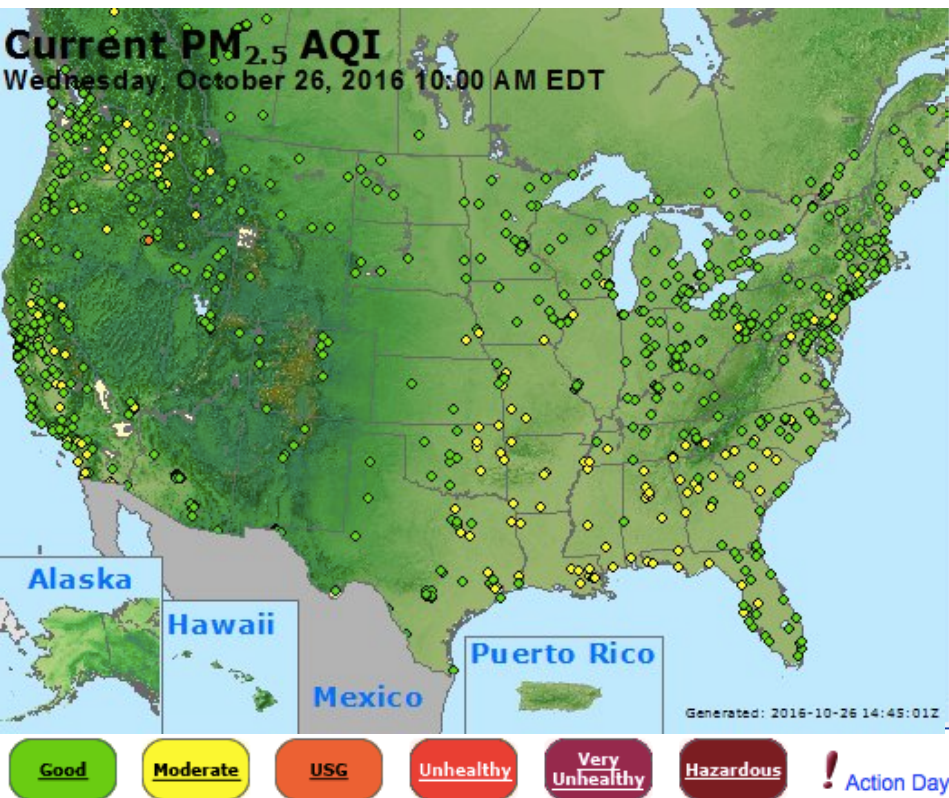
Lack of information about air quality away from monitors

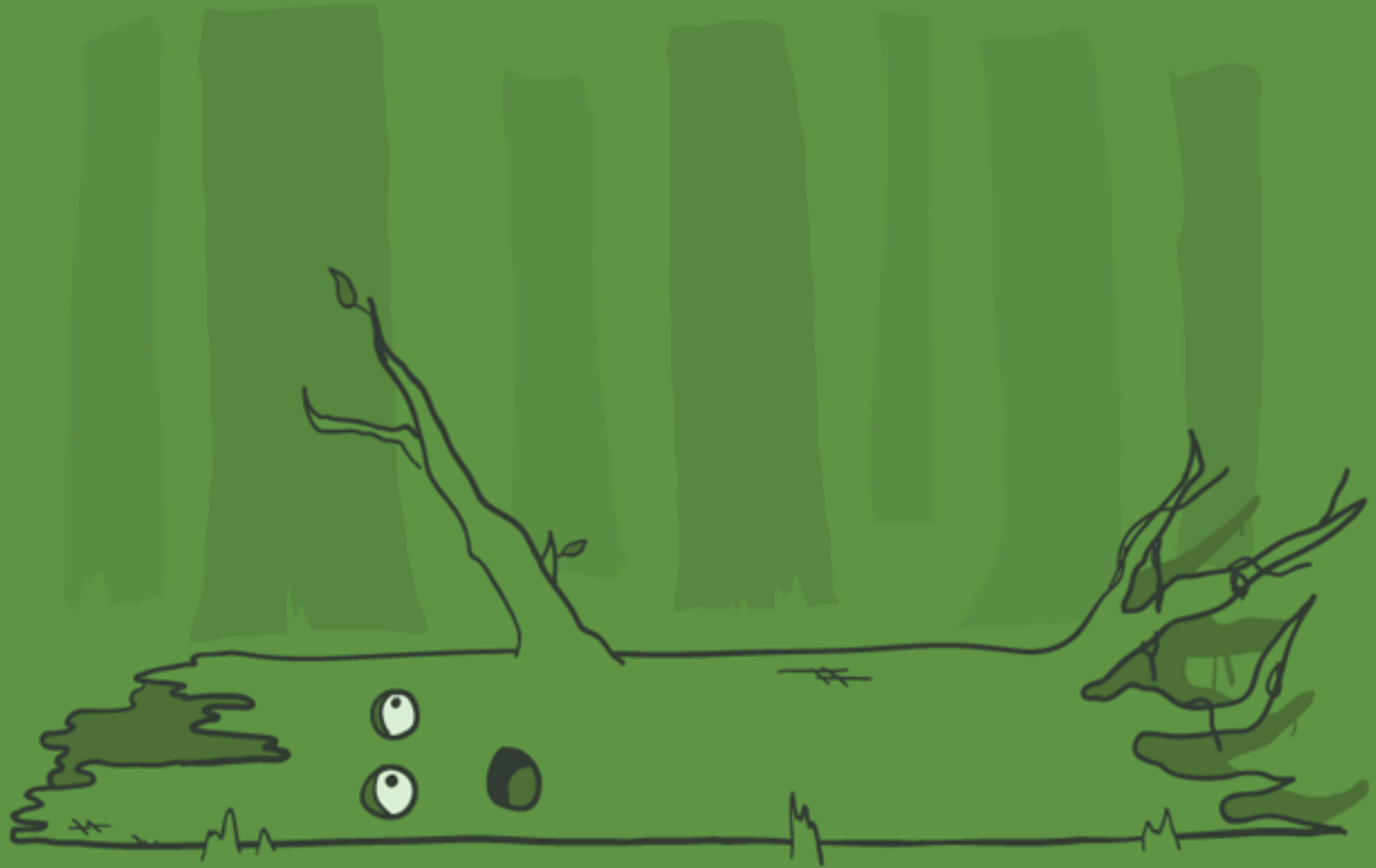
Lack of information about emission sources away from monitors

Lack of information about model performance away from monitors

Monitors are \$\$ to install and maintain

Monitors cannot be moved easily

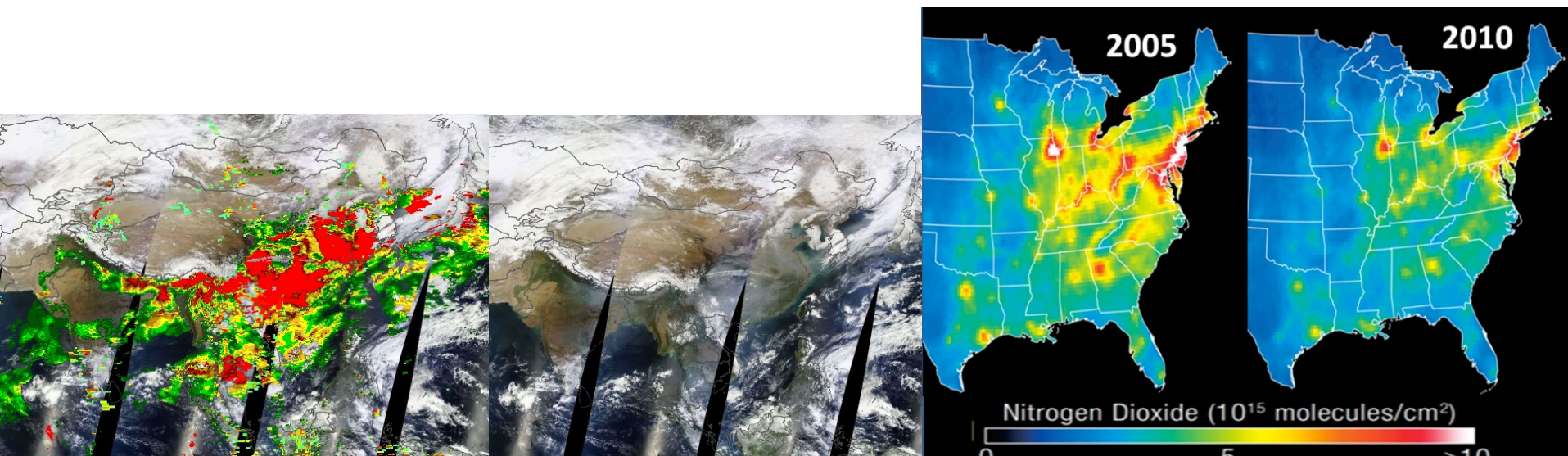




HELLO? CAN ANYBODY HEAR ME?

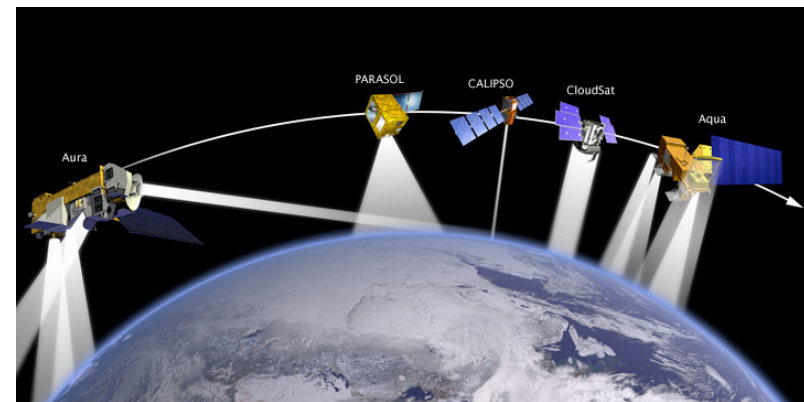
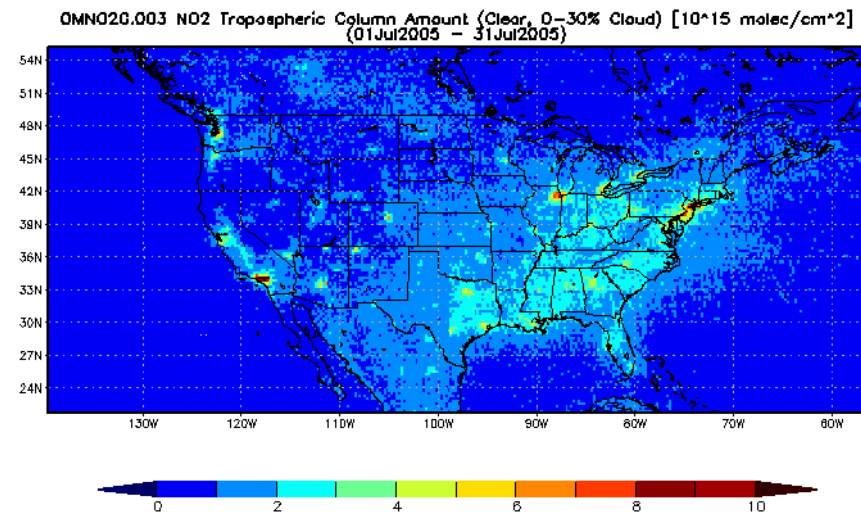
Satellite Data – the Upsides

- Continuous global coverage:
NO₂, SO₂, AOD ~ PM, CO, HCHO ~ VOCs, etc.
- “See” pollutants where no monitors exist
- Inform day-to-day and multi-year trends
- Products on wildfires, climate, land cover, etc.
- 2016 TROPOMI; 2016 GOES-R; 2018-19 TEMPO



Satellite Data – the Downsides

- No legal/policy framework
- Column vs. ground-level
- Limited suite of products comparable to criteria pollutants (NO_2 and AOD $\sim$ PM most equivalent)
- Satellite data are available < 1 x per day (e.g. $\sim 1:00$ local time for Aura, not on cloudy days)



Potential Monitoring Site Purposes

A Role for Remote Sensing?

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No

Yes

Yes

Yes

Yes

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1. To Determine Compliance with National Ambient Air Quality Standards (NAAQS)

No

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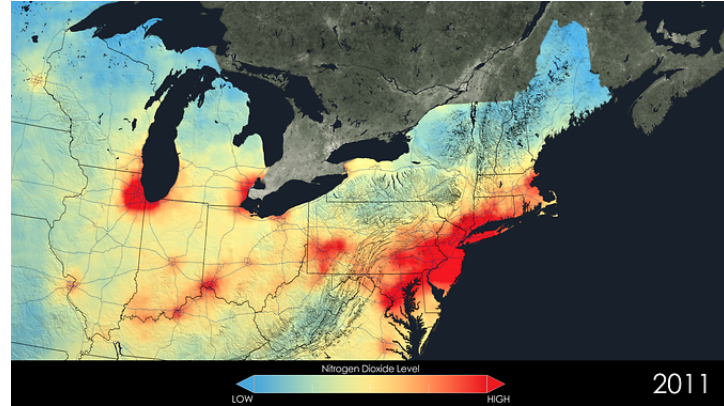
Yes

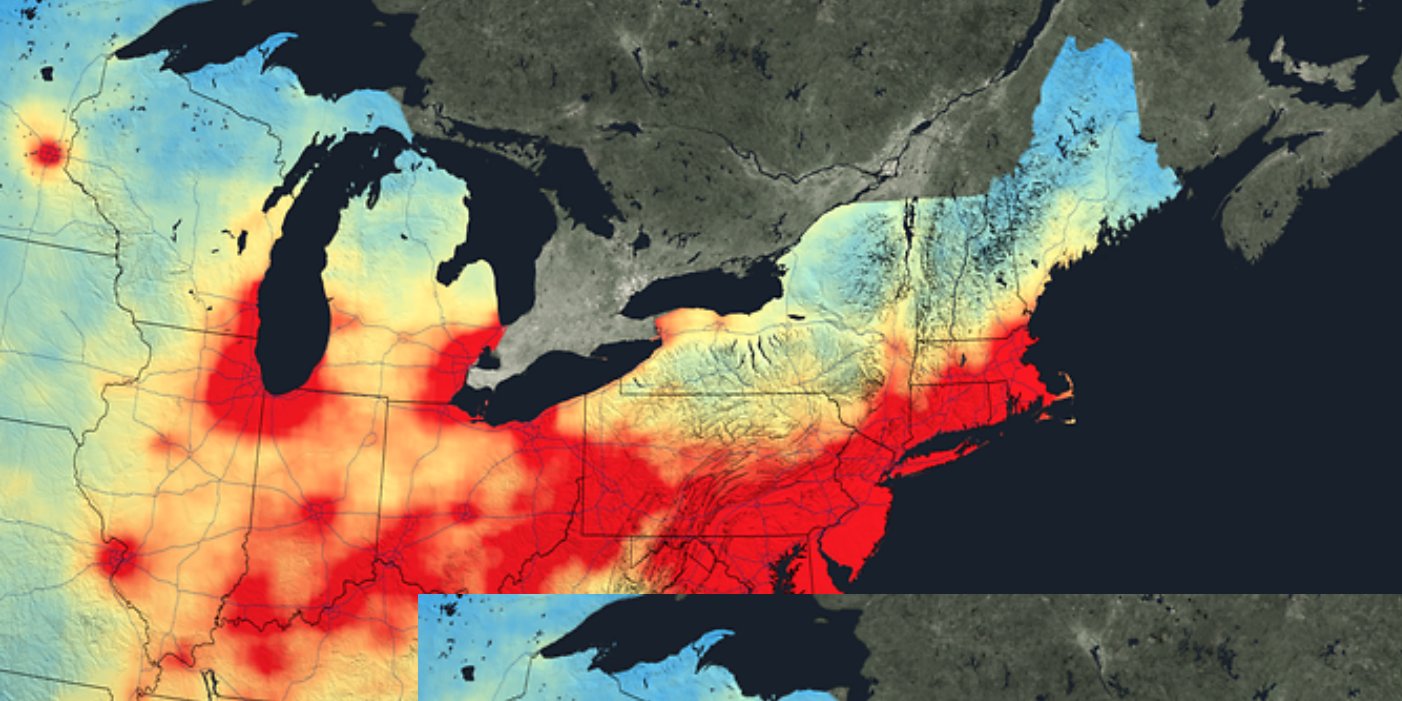
4. To Evaluate Air Dispersion Models

Yes

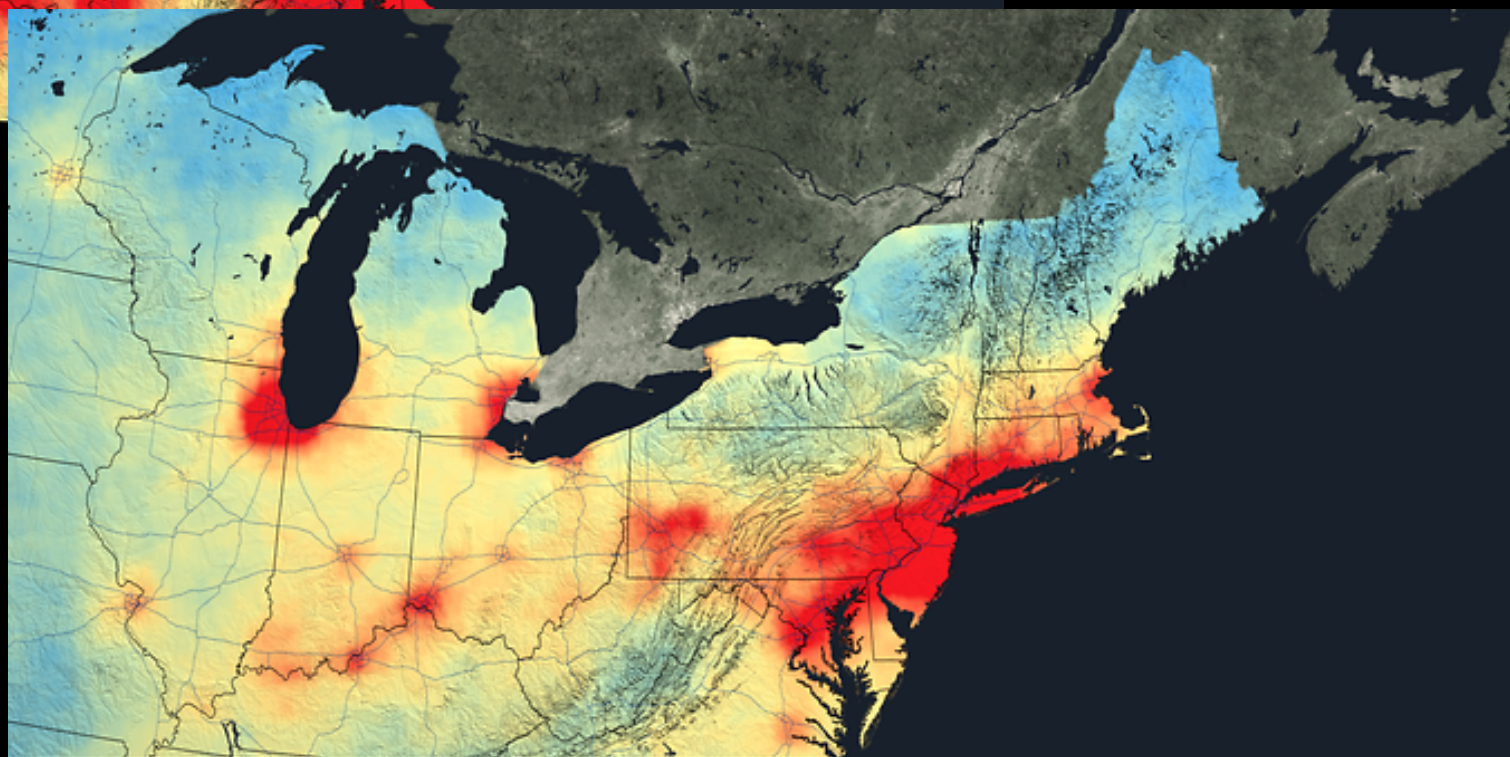
5. To Provide Air Quality Information to the Public

Yes





2005



Nitrogen Dioxide Level



2011

<https://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/#.Vhf03njimlw>



U.S. » NASA data shows nationwide air improvement -- but still more needed

Live TV

U.S. Edition +

NASA data shows nationwide air improvement -- but still more needed

By Dugald McConnell, CNN

Updated 9:39 PM ET, Fri June 27, 2014



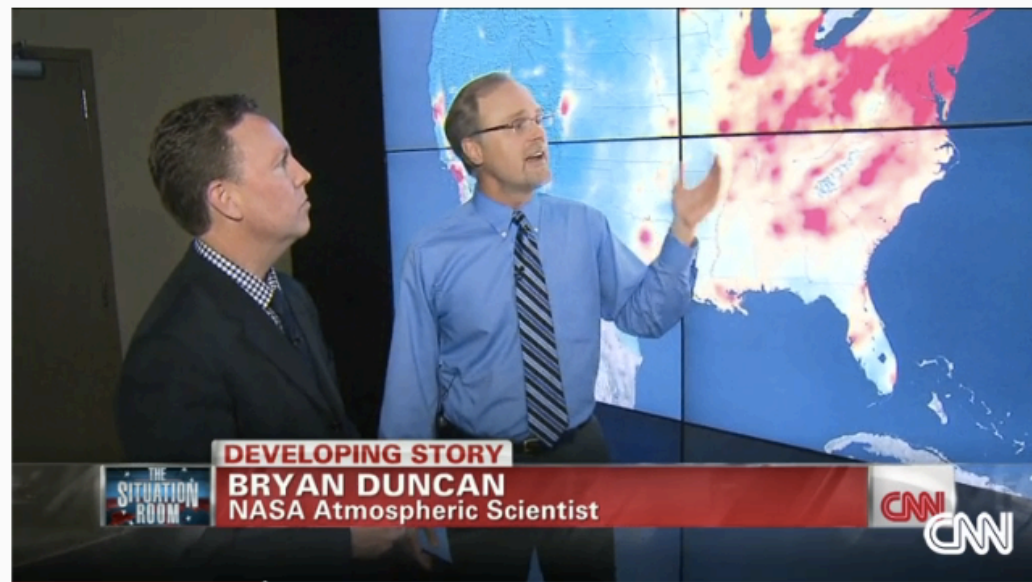
Top stories



Gold-medal winner mugged in Rio



Bank employees publicly spanked



DEVELOPING STORY

BRYAN DUNCAN

NASA Atmospheric Scientist



Source: CNN



Nitrogen Dioxide Level

LOW

HIGH

2005

2011



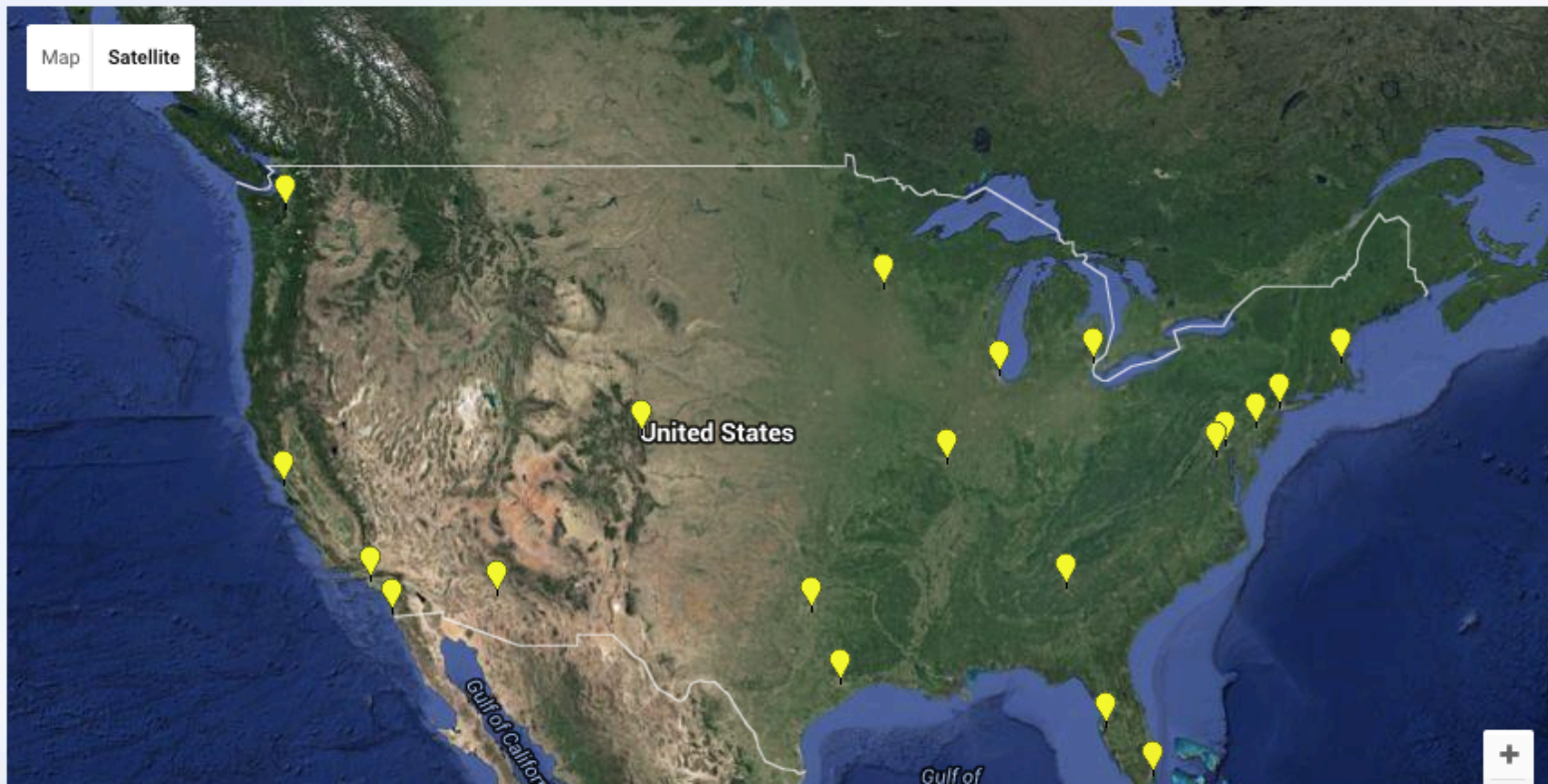
Air Quality

Observations from Space

[AURA](#)[EOS Project](#)[OZONE HOLE WATCH](#)[Home](#)[Data ▾](#)[News](#)[Maps ▾](#)[Publications](#)[Resources](#)

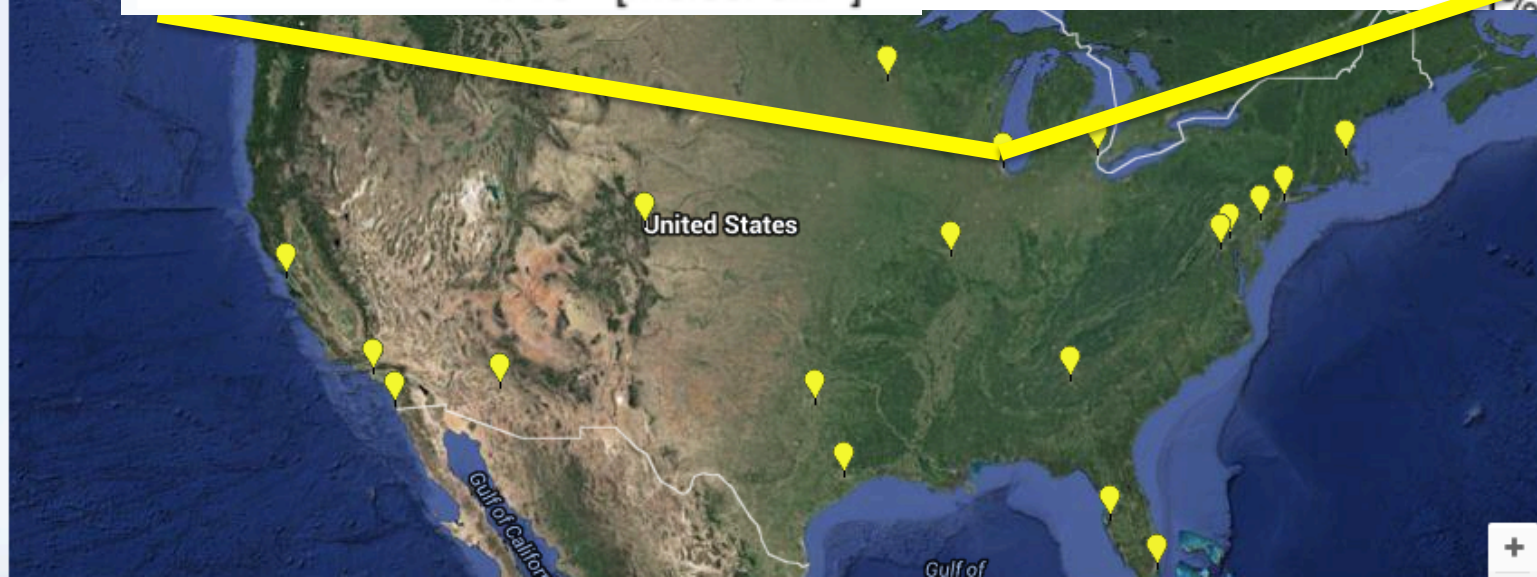
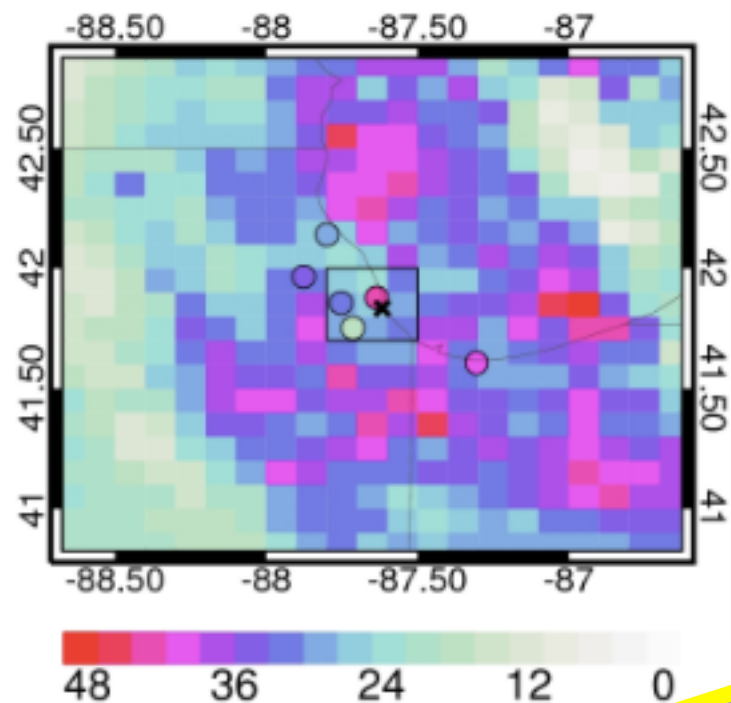
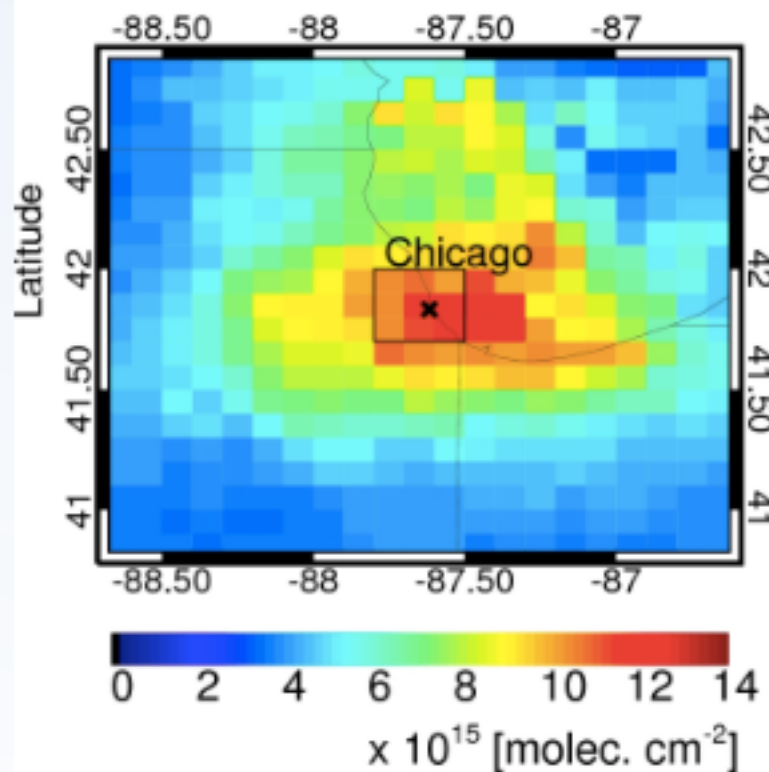
Air Quality for the Top 20 US Cities

Zoom in and click on a city below to find analyses and information. There are a number of ready-made plots of OMI NO₂ data for each city.

[Map](#)[Satellite](#)

OMI tropospheric NO₂ VCD

2005-2013 reduction

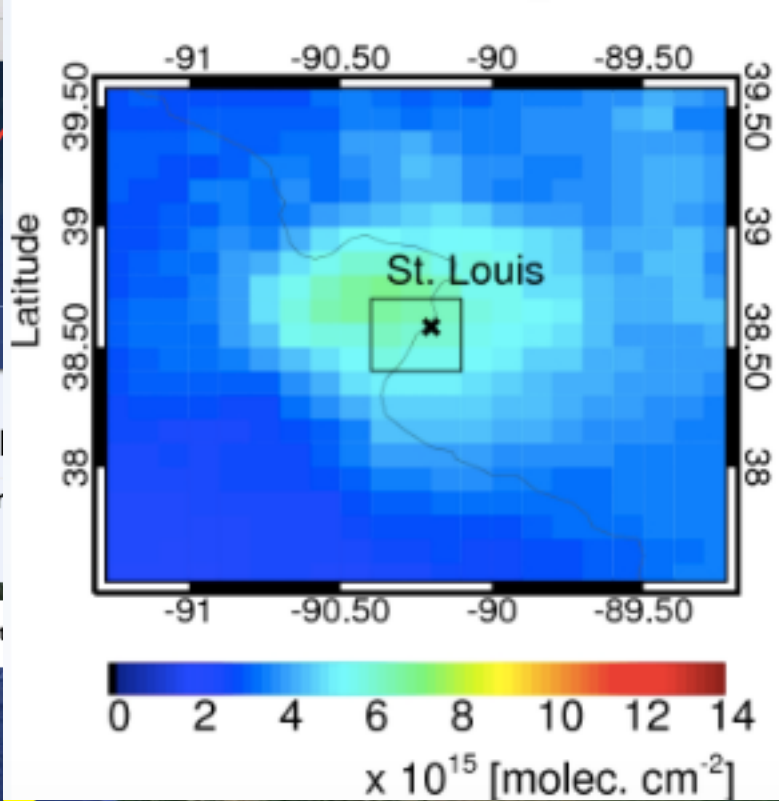




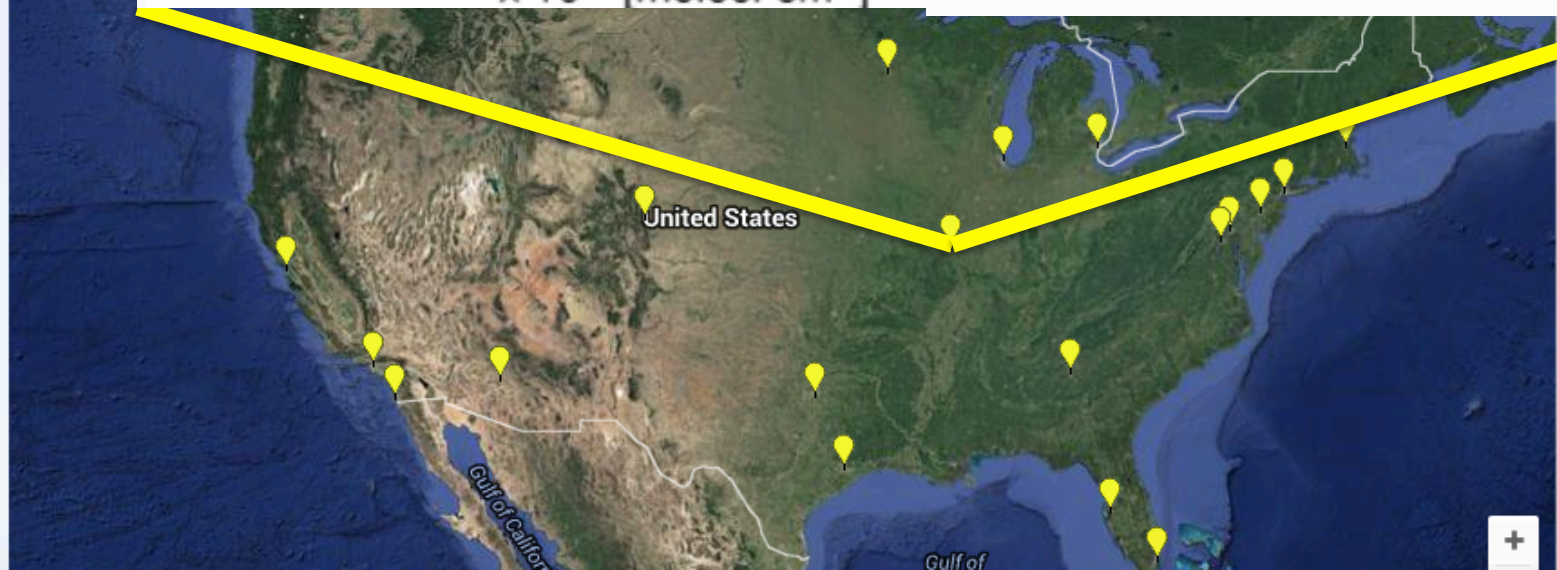
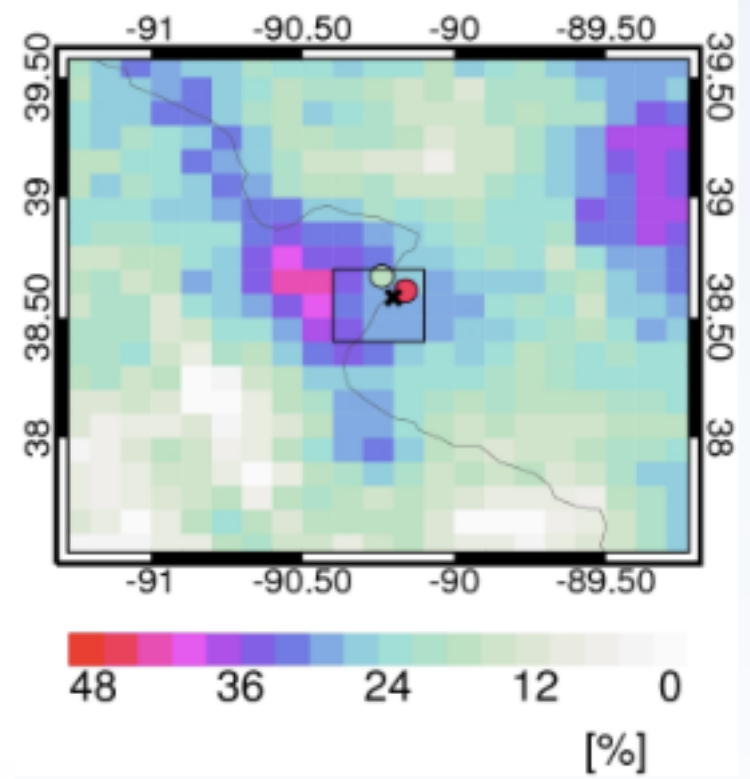
Air Qual
Zoom in ar
city.

Map Sat

OMI tropospheric NO₂ VCD



2005-2013 reduction





<http://tinyurl.com/obamaNO2>

Potential Monitoring Site Purposes

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Yes

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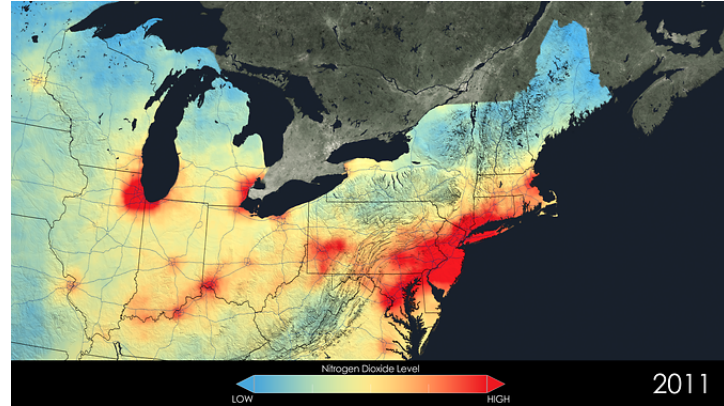
Yes

4. To Evaluate Air Dispersion Models

Yes

5. To Provide Air Quality Information to the Public

Yes



Satellite NO₂ & HCHO → ozone sensitivity

Story on Patrick Reddy
from Colorado, and his
use of satellite indicator
ratios

total volatile organic compounds (VOCs), but the OMI instrument does detect formaldehyde (HCHO). Past studies have shown how satellite HCHO can be used to estimate VOC abundance.⁴

Tales from the Front Range

Colorado is part of the U.S. Environmental Protection Agency (EPA) Region 8, where the Rocky Mountains and other topographic features affect the NO₂ distribution in a way that would be nearly impossible to assess from ground-based data alone. Using space-based data, air quality managers can see detailed NO₂ distributions by month, or in some cases by day, across all of Colorado and neighboring states. Figure 1a provides an overview of this region's topography, and Figure 1b shows an example of satellite-detected NO₂ distributed throughout canyon areas.

In 2009, there was debate as to whether the Front Range region operated as a nitrogen oxides (NO_x)-sensitive regime, suggesting that NO_x controls would be effective in controlling ozone (O₃) levels.

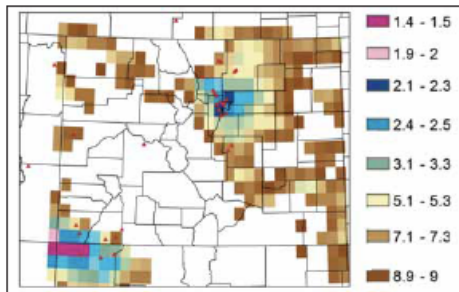


Figure 2. Ratio of tropospheric HCHO to tropospheric NO₂ over the Colorado Front Range area, derived from mean GOME2 satellite measurements for July 2007 and 2008. A ratio of above 1.0 may indicate a NO_x-sensitive ozone production regime. All ratios in this region show ratios are above 1.0. Gridded data from KNMI TEMIS (<http://www.temis.nl/airpollution/no2.html>).

Figure courtesy of Patrick Reddy, from presentation "2009 Ozone Season Review: Briefing to the Colorado Air Quality Control Commission," September 17, 2009 (Figure legend adjusted for clarity). Full presentation available at http://www.colorado.gov/airqualityrepository/index_file.aspx?file=O3+2009+AQCC+Presentation+Sept+Et+without+stres.ppt.



Above and Left:
Witman, Holloway and Reddy, EM 2014;
http://acmg.seas.harvard.edu/publications/aqast/articles/February_2014_EM.pdf

Potential Monitoring Site Purposes

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No

Yes

Yes

Yes

Yes



WORLDVIEW



+ Add Layers



All

Fire

BASE LAYERS

OVERLAYS

Fires and Thermal Anomalies (Day and Night)



Terra and Aqua/MODIS

Fires and Thermal Anomalies (Day and Night)



Terra/MODIS

Fires and Thermal Anomalies (Day and Night)



Aqua/MODIS

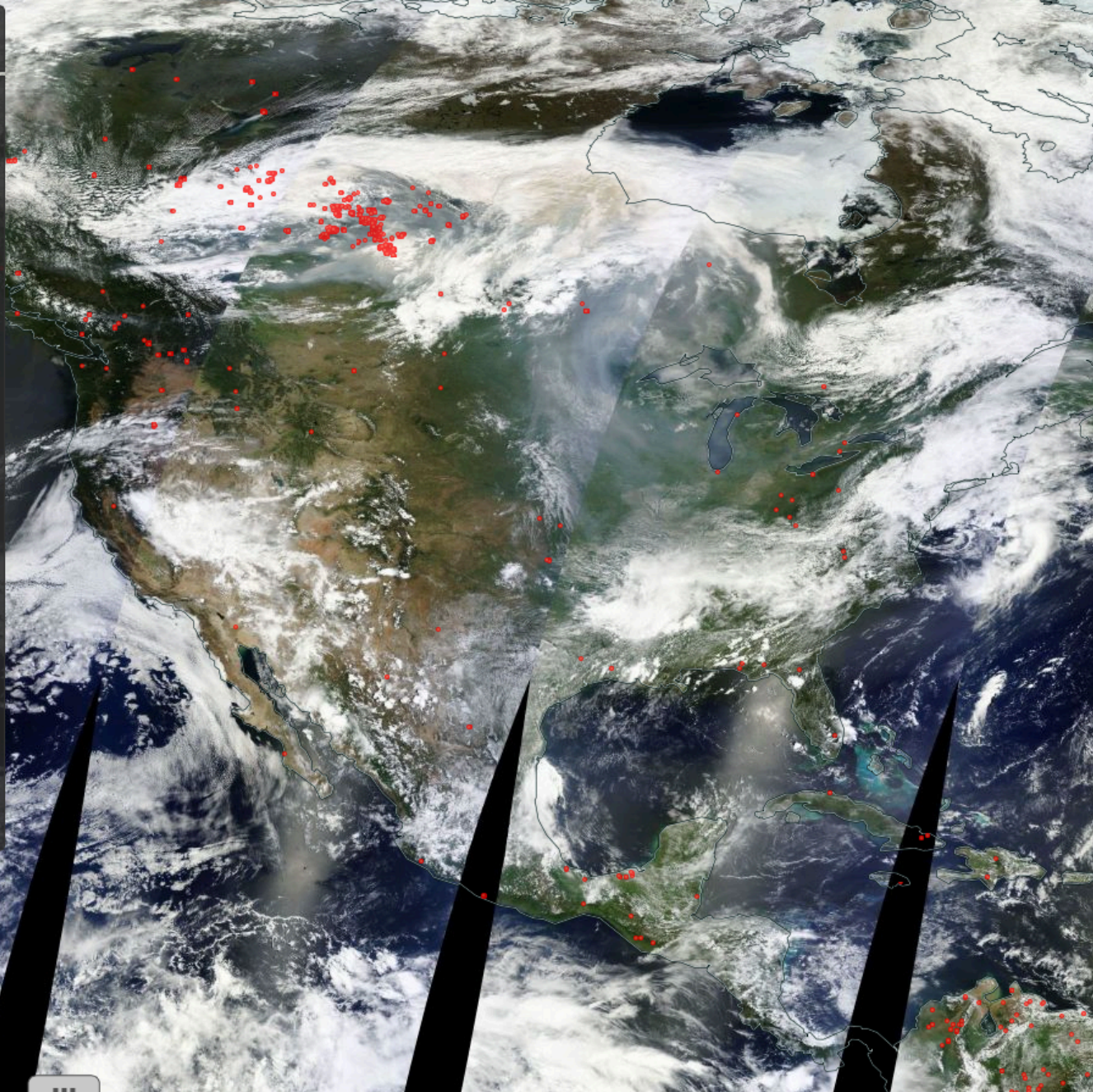
2015 JUL 04



JUL 2015

AUG 2015

SEP 2015



NASA

WORLDVIEW

+

Add Layers

All

AOD

BASE LAYERS

OVERLAYS

Aerosol Optical Depth

Terra / MODIS

Aerosol Optical Depth

Aqua / MODIS

MODIS Combined Value-Added Aerosol

Optical Depth

Terra and Aqua / MODIS

Absorbing Aerosol Optical Depth

Aura / OMI

Aerosol Optical Depth

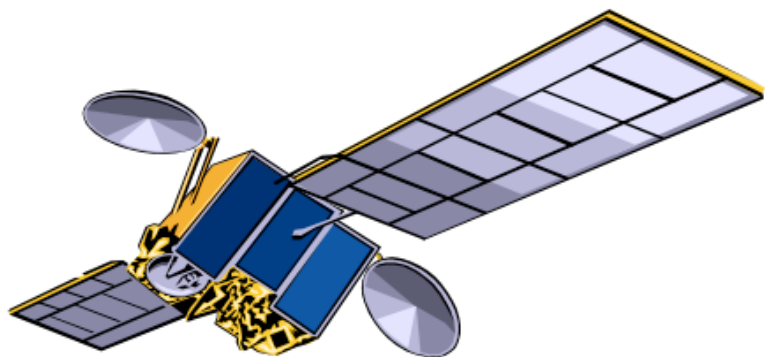
Aura / OMI

2015 JUL 04

JUL 2015

AUG 2015

SEP 2015



HAQAST Mission:

*Research and
outreach to connect
NASA science with
stakeholders in health
and air quality*

HAQAST History

Health & Air Quality Applied Sciences Team



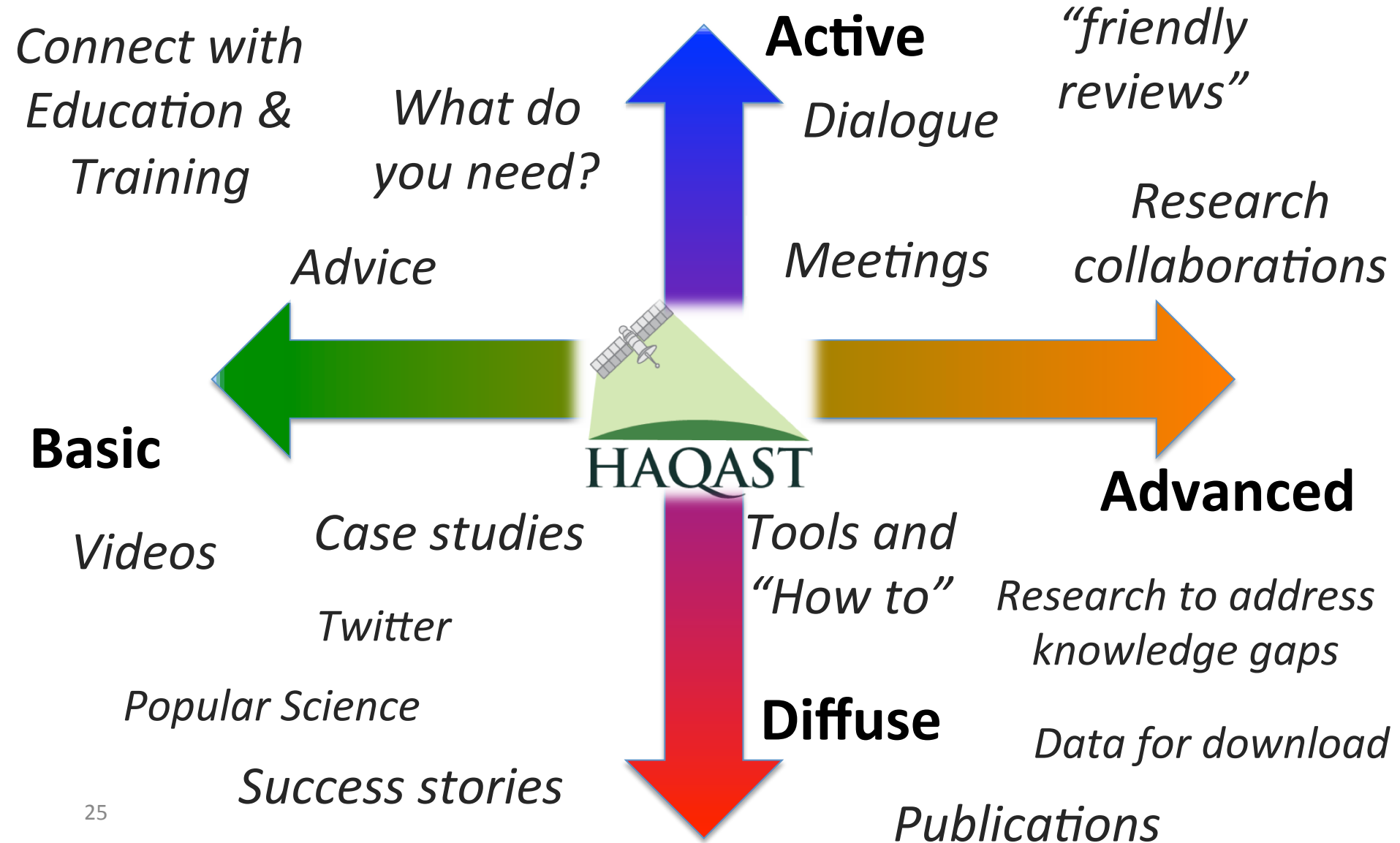
- Late 2009 – AQAST Solicitation
- March 2010 – AQAST applications due
- March 2011 – AQAST membership announced
- 2011-2016 – 5 year AQAST duration
- Late 2015 – H-AQAST Solicitation
- March 2016 – H-AQAST applications due
- July 22, 2016 – H-AQAST team announced
- 2016 – 2019 – 3 year HAQAST duration

HAQAST members



- **Tracey Holloway** (Team Lead, UW-Madison)
- **Bryan Duncan** (NASA GSFC)
- **Arlene Fiore** (Columbia University)
- **Frank Freedman** (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)

HAQAST Scope of Work





HOME



INTRO

GROWTH

NAAQS

WEATHER

VISIBILITY

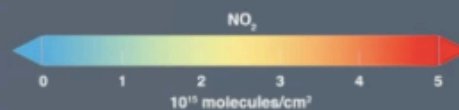
TOXICS

OUTLOOK

TODAY AMERICANS BREATHE CLEANER AIR AND FACE LOWER RISKS OF PREMATURE DEATH AND OTHER SERIOUS HEALTH EFFECTS.

2005 - 2014 NO₂ SATELLITE IMAGERY COURTESY OF NASA

1 MINUTE PRESIDENT OBAMA VIDEO



2006





*Check out: tinyurl.com/AQASTVideo
& tinyurl.com/AQASTVideoEnergy*

Thank you!

Contact: Tracey Holloway taholloway@wisc.edu

www.aqast.org & www.aqast-media.org



NASA Air Quality Applied Sciences Team

Earth Science Serving Air Quality Management Needs

