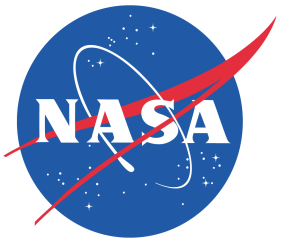


Update on the NASA Air Quality Applied Sciences Team

Tracey Holloway

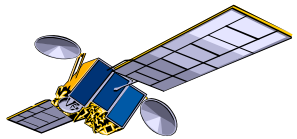
Assoc. Professor, University of Wisconsin—Madison

Deputy Leader, NASA Air Quality Applied Sciences Team

April 6, 2013

NASA Air Quality Applied Sciences Team

Earth Science Serving Air Quality Management Needs



satellites

suborbital platforms

models

AQAST

Pollution monitoring
Exposure assessment
AQ forecasting
Source attribution
Quantifying emissions
Natural & foreign influences
AQ processes
Climate-AQ interactions

Why is AQAST Unique?

All AQAST projects connect Earth Science and air quality management:

- Pursue science to support air quality management
- Collaborate with partners in air quality management
- Expand relationships through meetings, online tools, newsletters

AQAST has flexibility in how it allocates its resources

- Members can adjust work plans to meet evolving air quality needs
- Multi-member "Tiger Teams" compete for funding to address strategic problems requiring coordinated activity
- AQAST is self-organizing and can respond quickly to demands

AQAST supports two types of projects:

- Investigator Projects – core funding to individual members
- Tiger Team Projects – collaborations between AQAST members with supplementary funding to address urgent air quality management needs

Quick, collaborative, flexible, responsive to the needs of the AQ community

NASA

AQAST

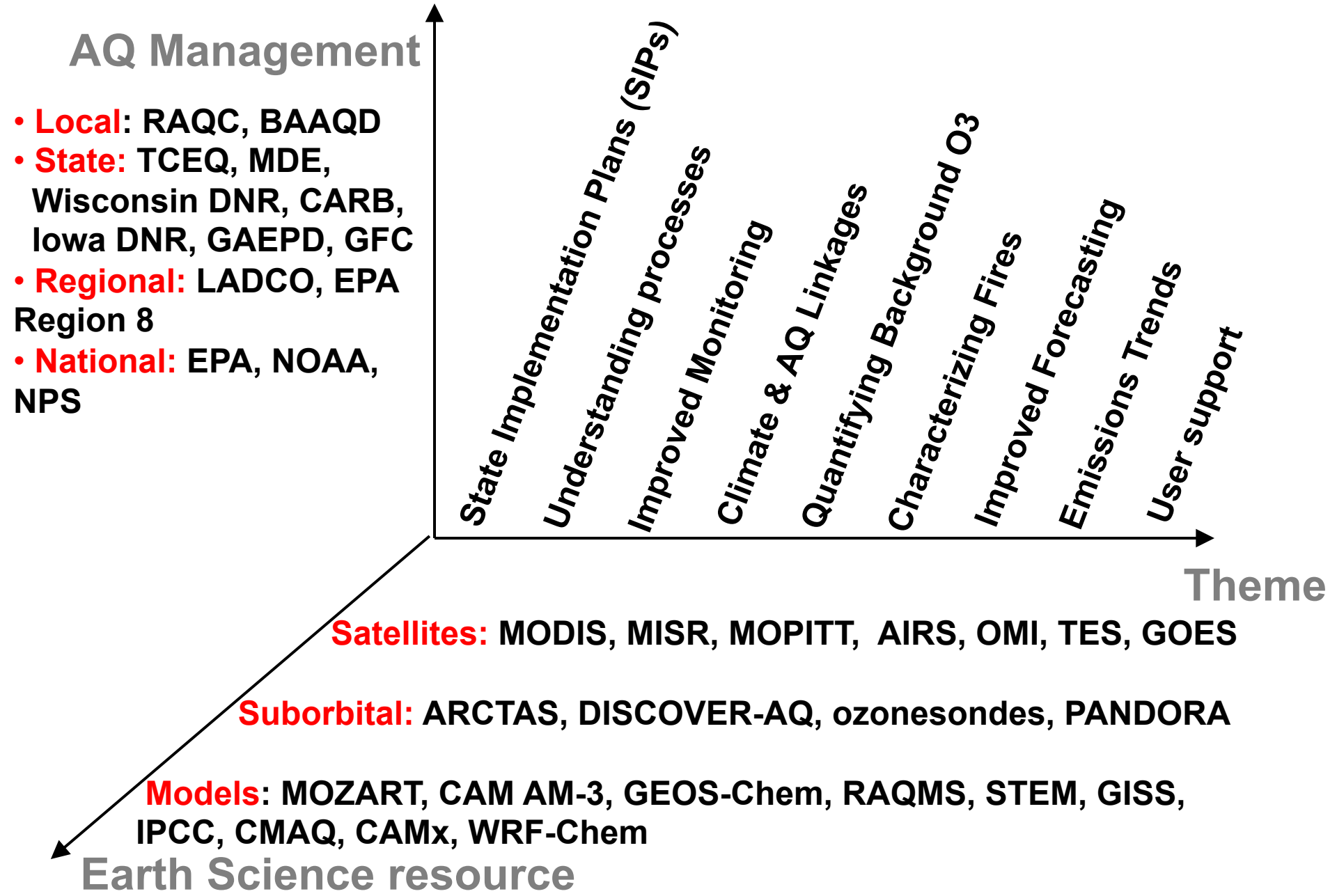
NASA Air Quality Applied Sciences Team

www.aqast.org

AQAST members

- **Daniel Jacob (leader),** Loretta Mickley (Harvard)
- **Tracey Holloway (deputy leader),** Steve Ackerman (U. Wisconsin); Bart Sponseller (Wisconsin DNR)
- **Greg Carmichael** (U. Iowa)
- **Dan Cohan** (Rice U.)
- **Russ Dickerson** (U. Maryland)
- **Bryan Duncan**, Yasuko Yoshida, Melanie Follette-Cook (NASA/GSFC); Jennifer Olson (NASA/LaRC)
- **David Edwards** (NCAR)
- **Arlene Fiore** (Columbia Univ.); Meiyun Lin (Princeton)
- **Jack Fishman,** Ben de Foy (Saint Louis U.)
- **Daven Henze**, Jana Milford (U. Colorado)
- **Edward Hyer,** Jeff Reid, Doug Westphal, Kim Richardson (NRL)
- **Pius Lee,** Tianfeng Chai (NOAA/NESDIS)
- **Yang Liu**, Matthew Strickland (Emory U.), Bin Yu (UC Berkeley)
- **Richard McNider**, Arastoo Biazar (U. Alabama – Huntsville)
- **Brad Pierce** (NOAA/NESDIS)
- **Ted Russell,** Yongtao Hu, Talat Odman (Georgia Tech); Lorraine Remer (NASA/GSFC)
- **David Streets** (Argonne)
- **Jim Szykman** (EPA/ORD/NERL)
- **Anne Thompson**, William Ryan, Suellen Haupt (Penn State U.)

Scope of current AQAST projects



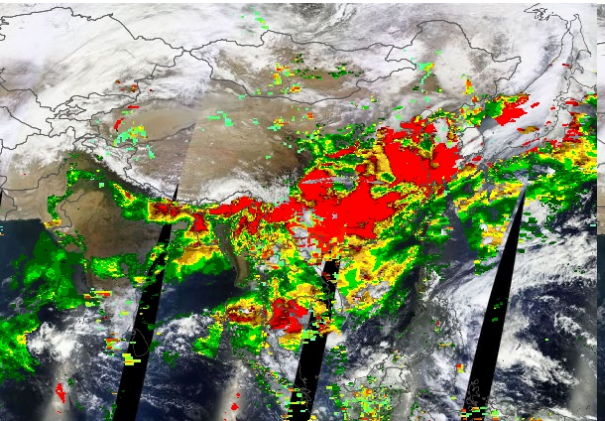
2013 Tiger Team Process

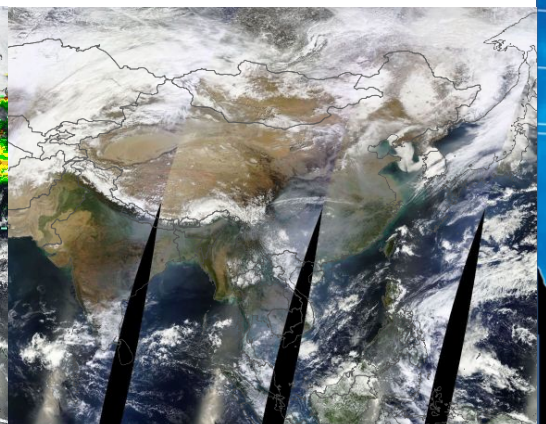
1. **Merit.** Is the work proposed sound, creative, interesting, important?
2. **Responsiveness.** Does it address a pressing AQ management need?
3. **Uniqueness.** Does it use Earth Science assets that go beyond standard AQ tools?
4. **Team.** Will team members effectively work together?

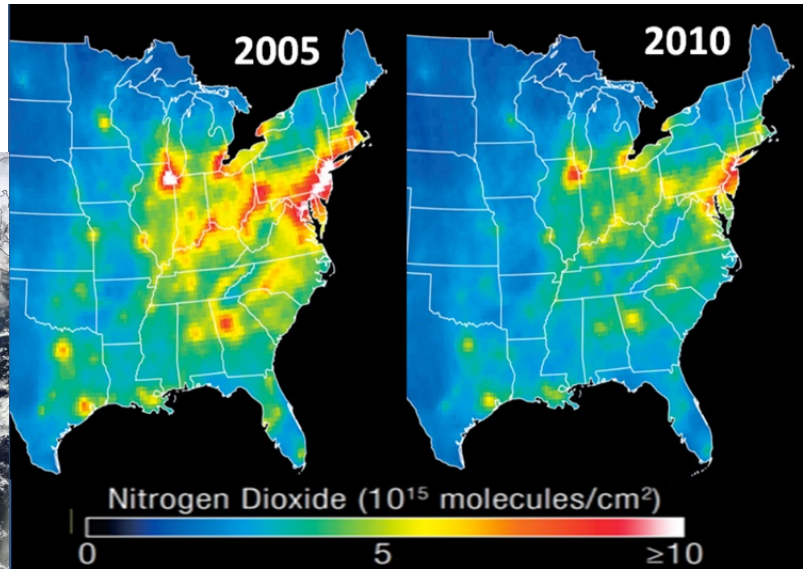
The Opportunities

- Continuous global coverage:

  NO_2, SO_2, 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.
- Compelling images for public awareness

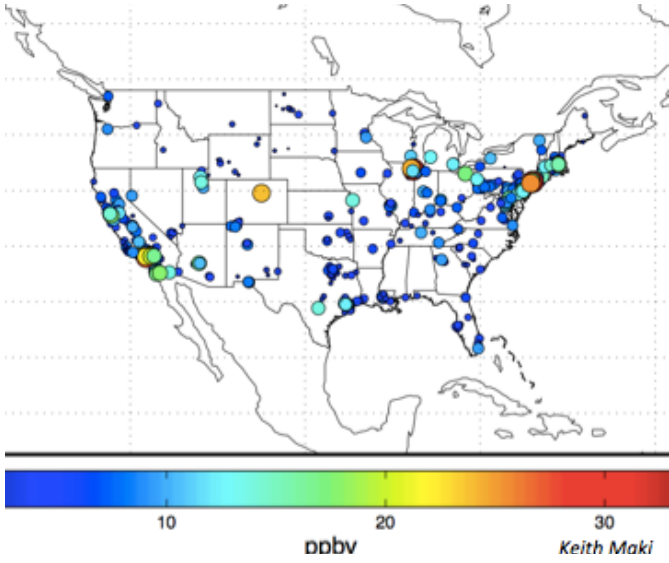


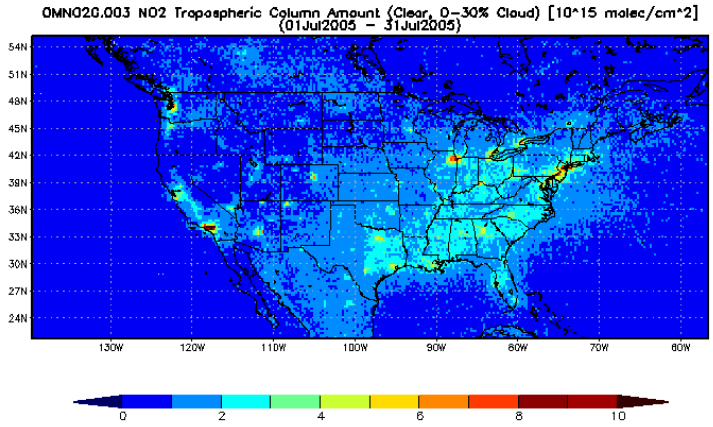




The Challenges…

- No legal/policy framework
- Column vs. ground-level
- Limited suite of products comparable to criteria pollutants (NO_2 and AOD ~ PM most equivalent)
- Satellite data are available < 1 x per day (e.g. 1:45 local time for Aura, not on cloudy days)





Potential Monitoring Site Purposes

	A Role for Remote Sensing?
1. To Determine Compliance with National Ambient Air Quality Standards (NAAQS)	**Support Analysis**
2. To Develop Regional Pollution Trends in Urban and Rural Areas	**Yes!**
3. To Evaluate the Effects of Population, Land Use and Transportation on Air Quality	**Yes!**
4. To Evaluate Air Dispersion Models	**Yes!**
5. To Provide Air Quality Information to the Public	**Yes!**

Adapted from a slide of
Bart Sponseller, WI DNR

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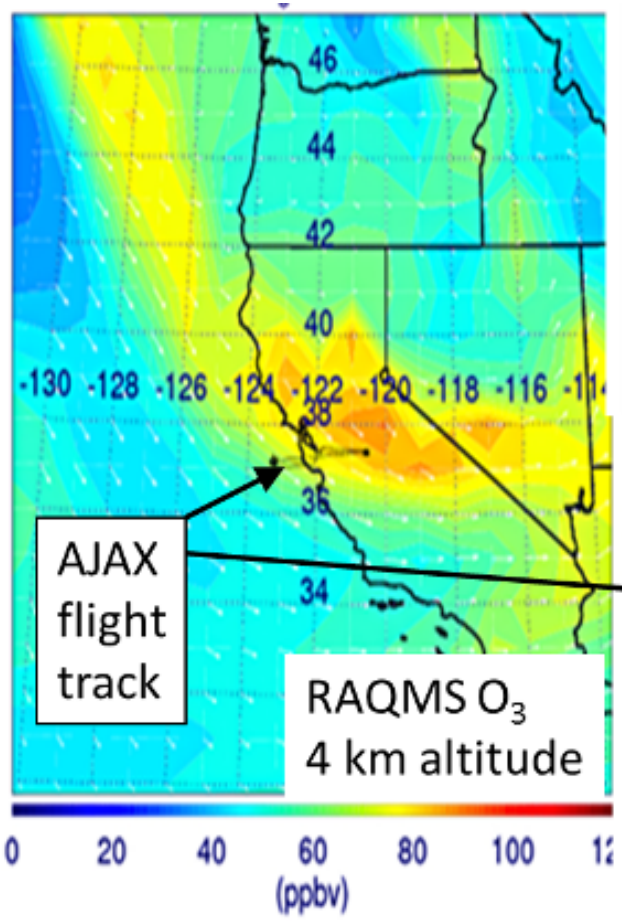
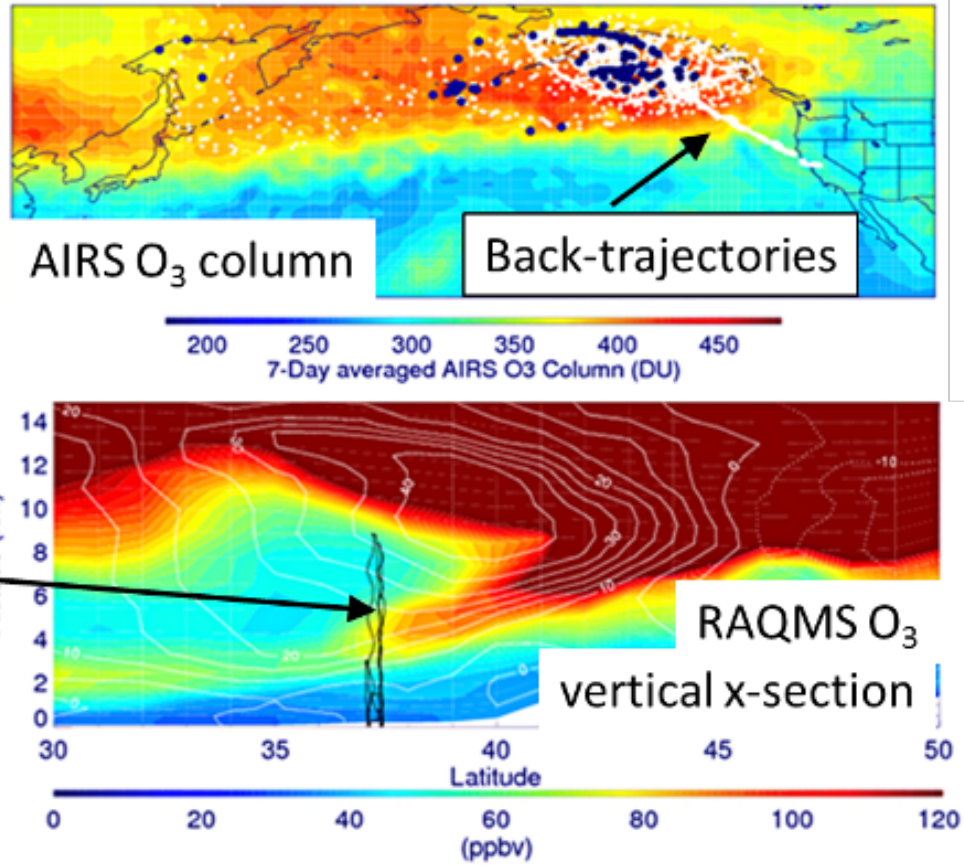
Bart Sponseller, WI DNR

AQAST Highlight: Wyoming Exceptional Event Demonstration

Wyoming DEQ/AQD used AQAST resources to issue an exceptional event demonstration package for an ozone exceedance at Thunder Basin, June 6, 2012





R.B. Pierce et al.

AQAST Member: B. Pierce

AQAST
NASA Air Quality Applied Sciences Team

Tiger Team activity: Key factors contributing to differences in model estimates for O_3 "background"

Problem: Poorly quantified errors in background distributions complicate NAAQS-setting and interpreting SIP attainment simulations

To date, EPA N. American Background estimates provided by one model.

Approach:

1) Compare GFDL AM3 and GEOS-Chem NAB (Mar-Aug 2006)

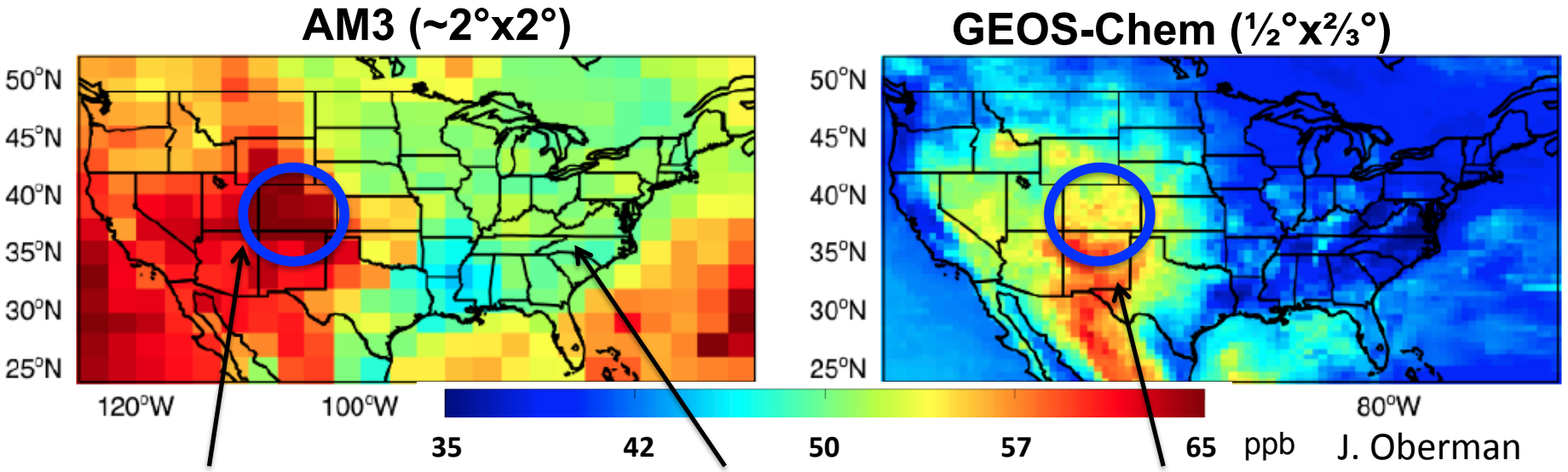
2) Process-oriented analysis of factors contributing to model differences

YEAR 2006	GEOS-Chem	GFDL AM3
Resolution	½°x⅔° (and 2°x2.5°)	~2°x2°
Meteorology	Offline (GEOS-5)	Coupled, nudged to NCEP U and V
Strat. O_3 & STE	Parameterized (Linoz)	Full strat. chem & dynamics
Isoprene nitrate chemistry	18% yield recycling	IO_x recycling (obs al, 2007)
Lightning NO_x	tied to mo clouds, sc climat; high	ective clouds
Emissions	NEI 2005 + 2006 fires (emitted at surface)	ACCMIP historical + RCP4.5 (2005, 2010); vert. dist. climatological fires

ALL DIFFERENT!

Estimates of North American background in 2 models
(simulations with N. American anth. emissions set to zero)

Fourth-highest North American background MDA8 O_3
in model surface layer between Mar 1 and Aug 31, 2006



Higher background:
More exchange with surface?
Larger stratospheric influence?

High AM3 bias in EUS; caution on N. Amer. Background here!

Excessive lightning NO_x in summer

→ Models robustly agree N. American background is higher at altitude in WUS
→ Multi-model enables error estimates, in context of observational constraints

AQAST Members: A. Fiore & D. Jacob

AQAST Year 3 Tiger Team Proposal
Performance period: 10/1/2013-9/30/2014

Quantifying Source Contributions to O_3 and $PM_{2.5}$ Pollution Episodes Across the Eastern U.S.

Lead PI: Tracey Holloway (Univ. of Wisconsin) and Arlene Fiore (Columbia/LDEO)
Other AQAST participants: Greg Carmichael (Univ. of IA), Daniel Cohan (Rice Univ.), Bryan Duncan (NASA), Daven Henze (CU-Boulder), Daniel Jacob (Harvard), Russ Dickerson (Univ. of MD), Gabriele Pfister (NCAR)
AQ management contacts: Bart Sponseller [Wisconsin DNR]; Angela Dickens [Wisconsin DNR/LADCO]; Tad Aburn [Maryland Dept. Env.]; Mark Estes [Texas/TCEQ]; other states representatives to serve on Advisory Council; Terry Keating, Kirk Baker [US EPA]

Problem to be solved: Designing effective State Implementation Plans (SIPs) requires knowledge of the relative contributions from emissions within a state, transported from other states, imported across U.S. borders, and natural sources. As the ozone (O_3) and fine particulate matter ($PM_{2.5}$) NAAQS thresholds are lowered, it becomes increasingly important to estimate accurately source contributions so that a state can determine the emphasis to place on controlling local emissions, a multi-state approach or determining if exemptions are required due to sources other than U.S. anthropogenic emissions. In the Eastern U.S., these information needs are particularly acute, given challenges to the Clean Air Interstate Rule (CAIR) and the Cross-State Air Pollution Rule (CSAPR), which will be reviewed by the Supreme Court.

AQ responsiveness: We address a request noted in multiple NASA AQAST meetings[1]: the need for

Potential Monitoring Site Purposes

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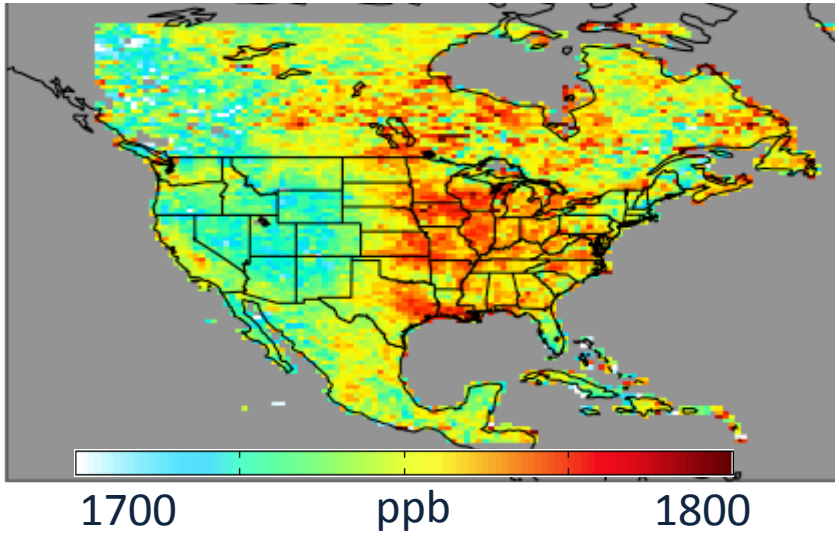
3. To Evaluate the Effects of Population, Land Use and Transportation on Air Quality	**Yes!**
4. To Evaluate Air Dispersion Models	Yes!
5. To Provide Air Quality Information to the Public	Yes!

Adapted from a slide of
Bart Sponseller, WI DNR

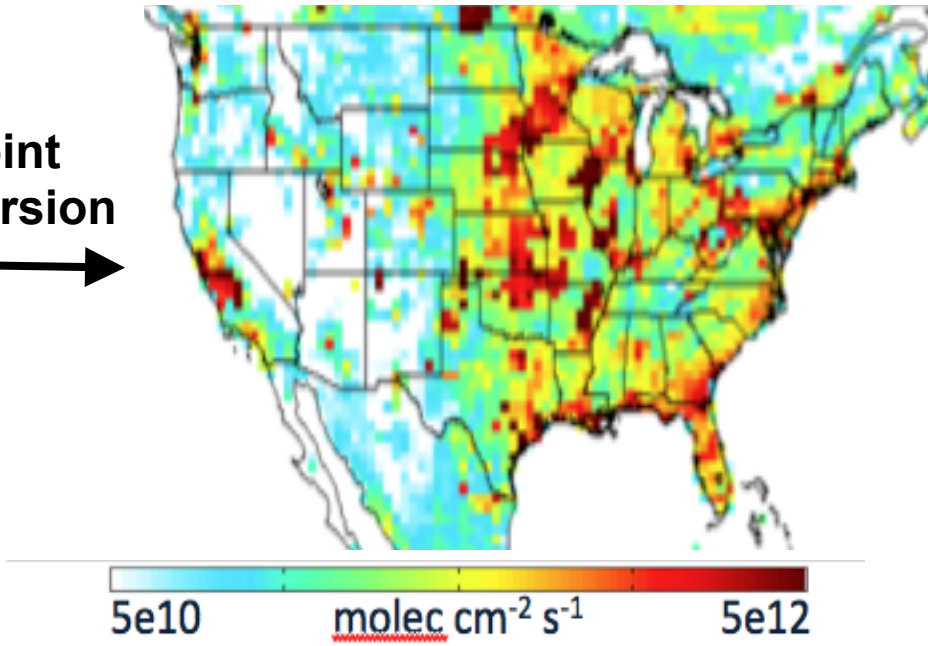
Using satellite observations of methane to constrain US methane emissions

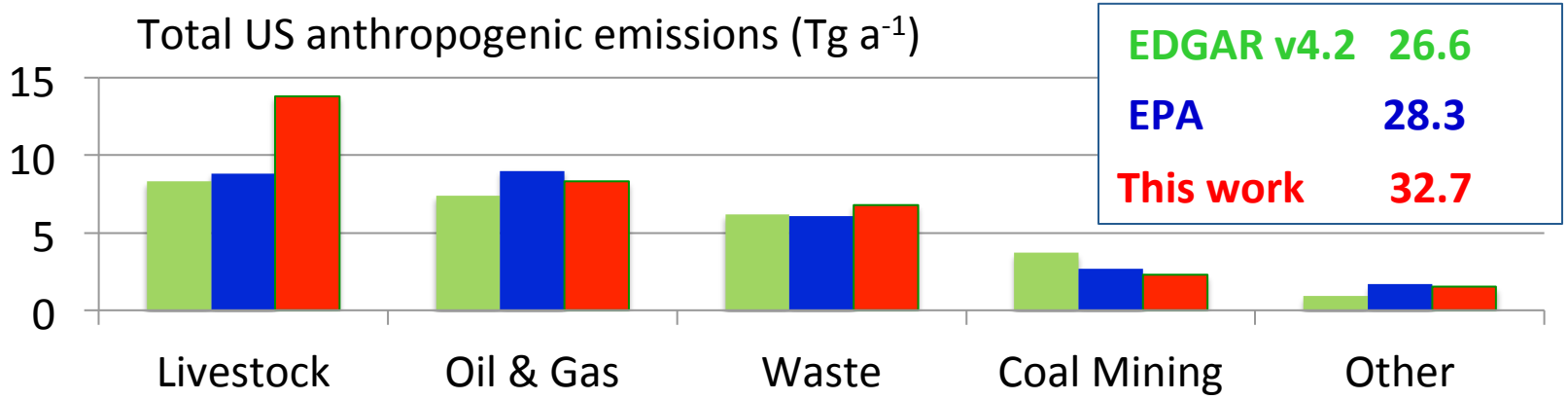
SCIAMACHY methane (Jul-Aug 2004)



adjoint inversion →

methane emissions





***AQAST Member: D. Jacob**; Wecht et al. [in prep]*

Potential Monitoring Site Purposes

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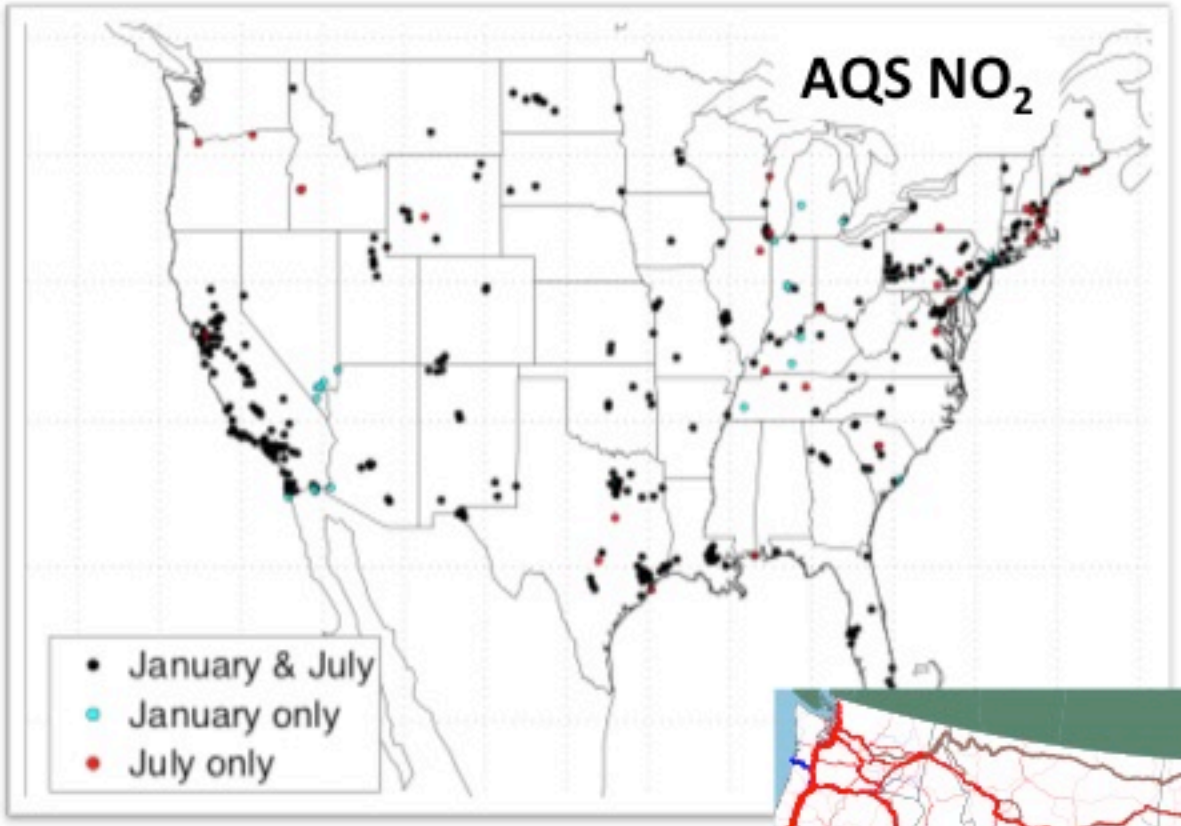
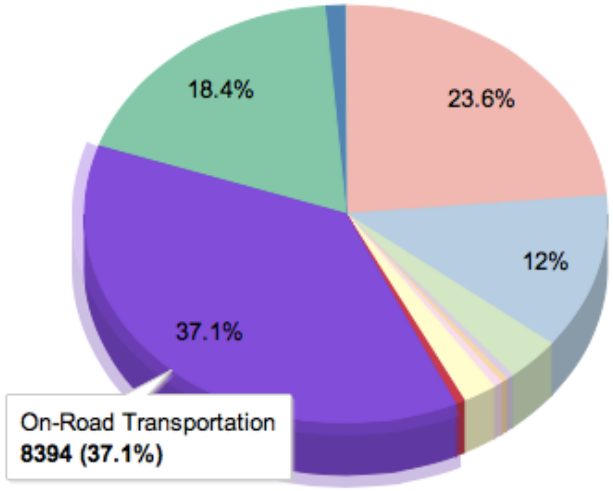


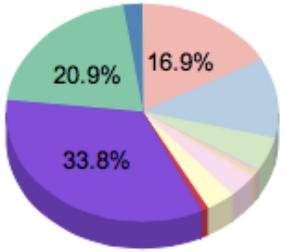
Surface Monitors concentrated in urban areas

Freight activity in rural America

Freight and Air Quality

- Transportation is the largest source of NO_x emissions.
- Freight accounts for **33%** of transportation NO_x (20% of all NO_x)
- *Bickford et al., in prep; Bickford et al., 2013*





2000 & 2012 U.S. NOx Emissions

On-Road Transportation
Off-Road Transportation
Electricity
Industrial

NO_2 from On-Road Diesel

New:
WIFE

Existing:
LADCO

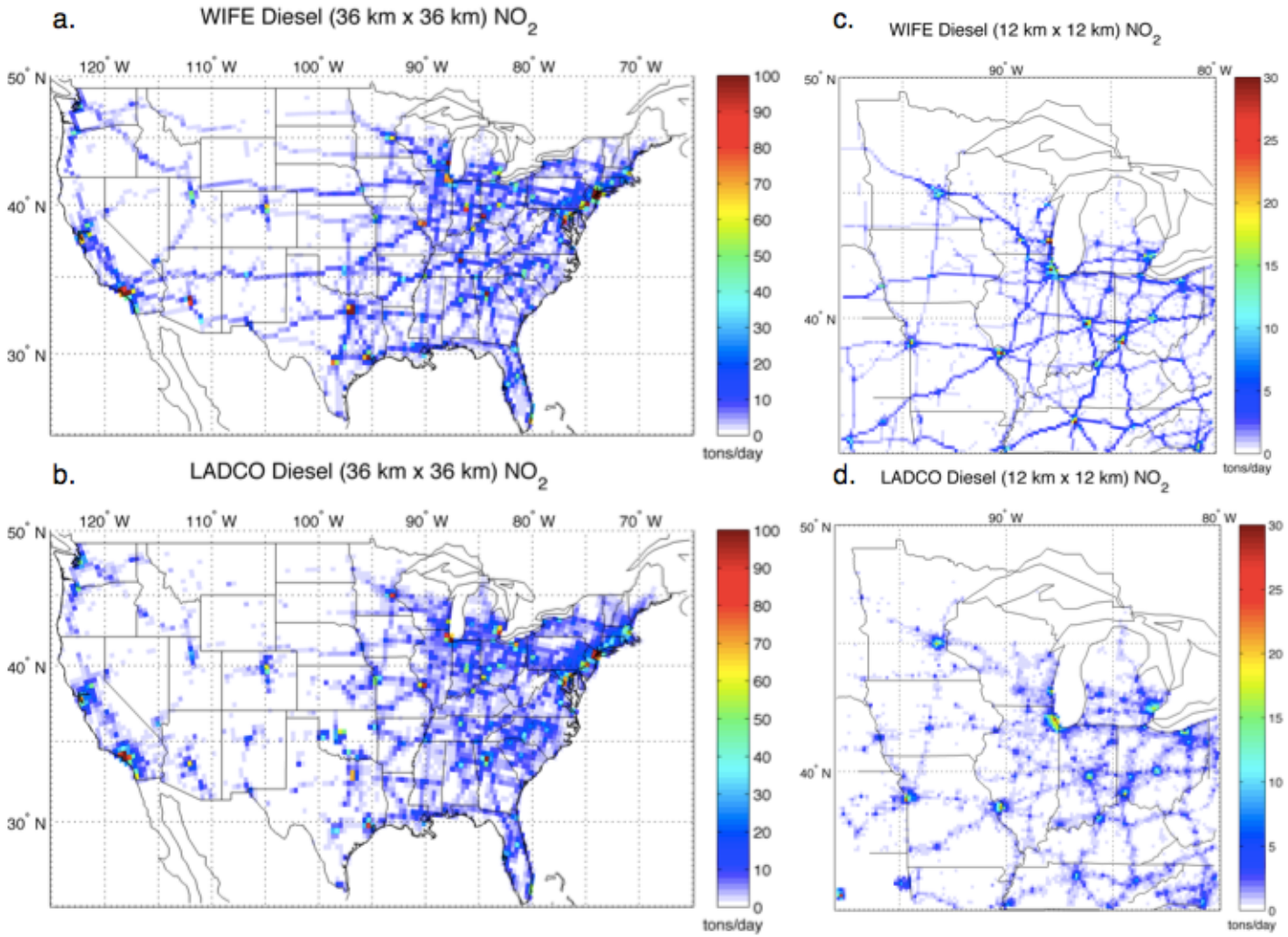
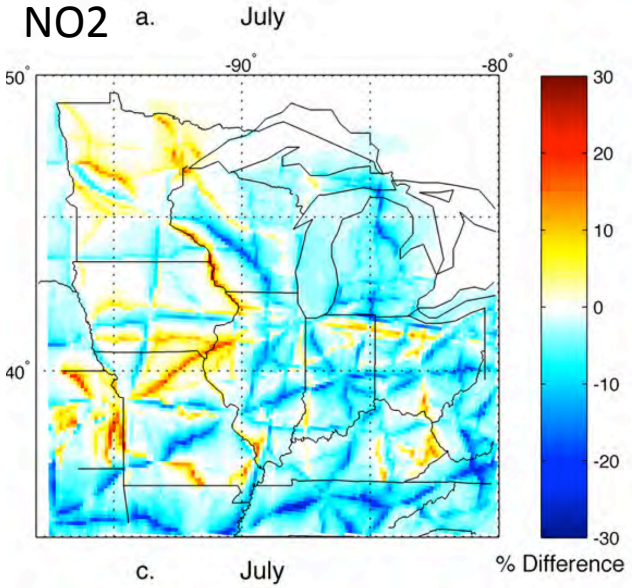
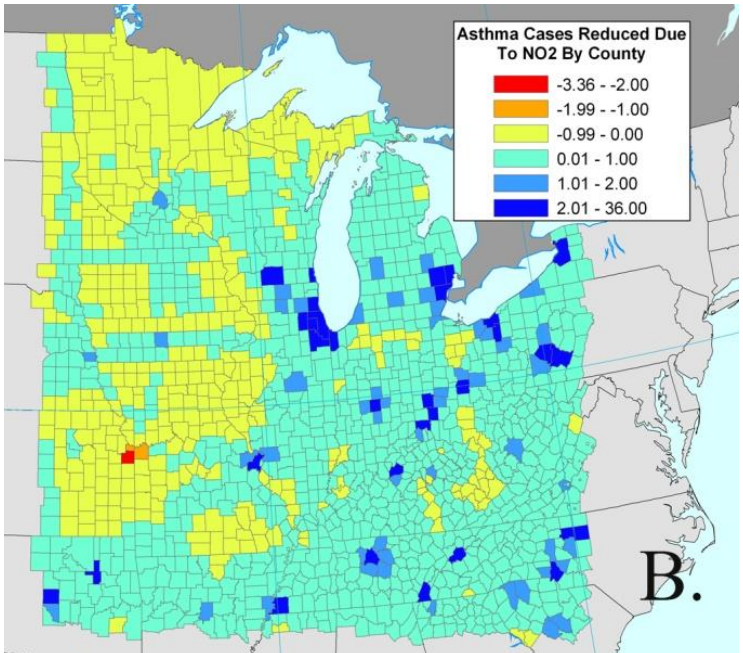
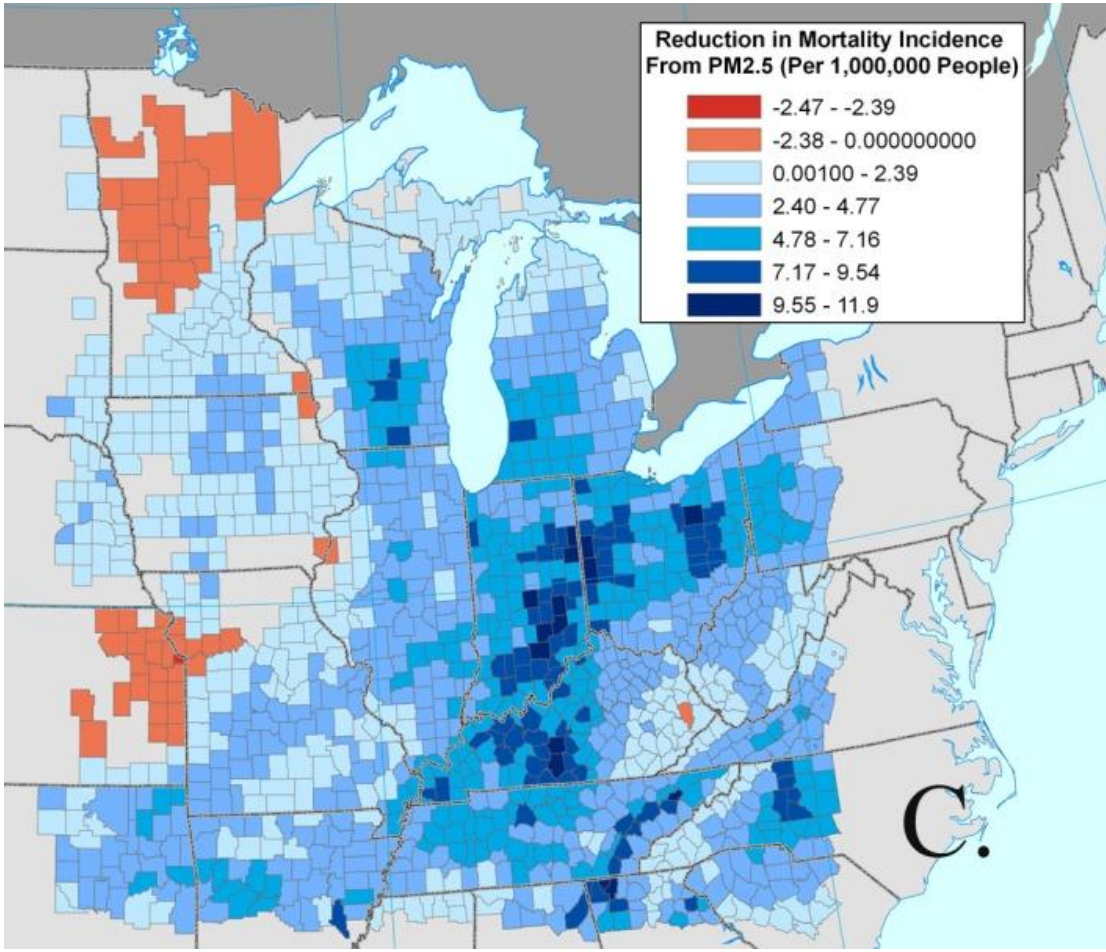


Figure 2.1.1 *2007 January diesel NO_2 emissions inventory comparison (in tons/day) between the WIFE freight + non-freight on-road diesel inventory and LADCO's on-road diesel inventory, for the continental U.S. gridded to 36 x 36 km², and the upper Midwest gridded to 12 x 12 km².*

New Inventory to Test Scenarios:
e.g. AQ & Health Impacts of More Rail, Less Trucking

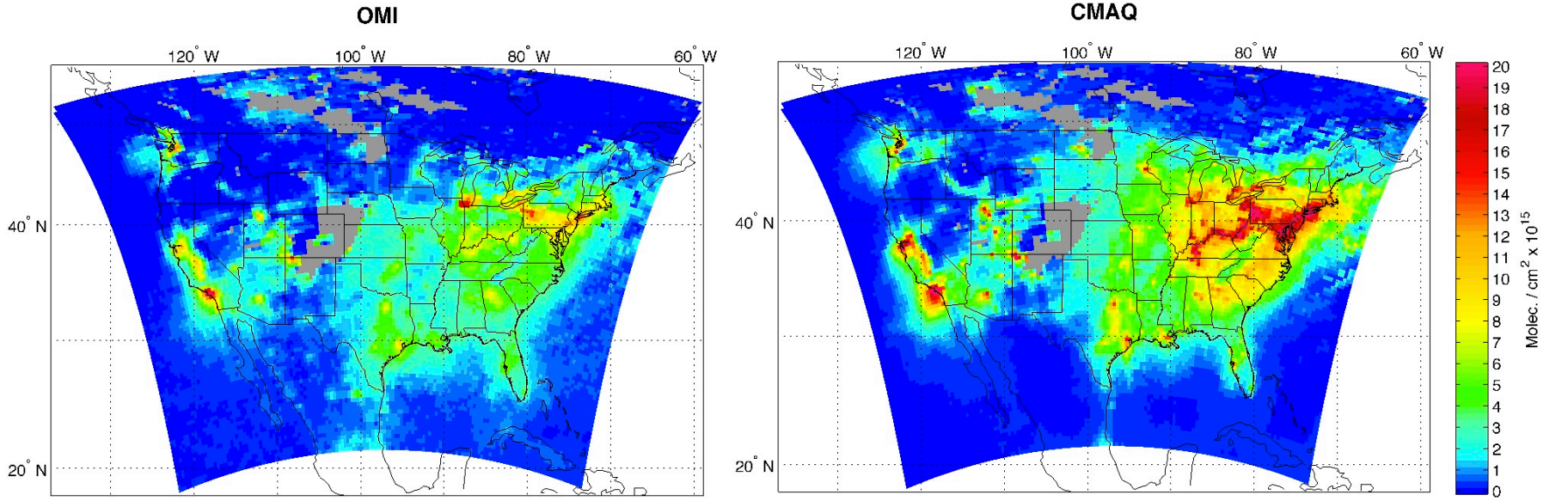




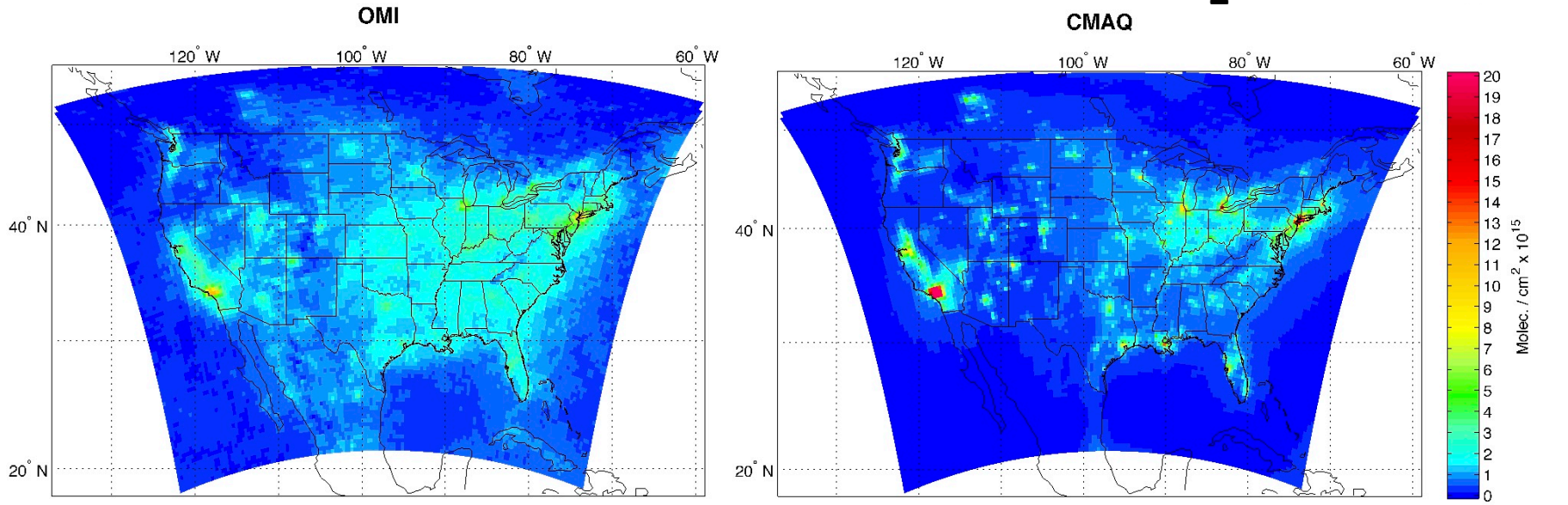


Bickford et al., in press, ES&T
Greene, M.S. Thesis, 2012

January Monthly Mean Total Column NO_2



July Monthly Mean Total Column NO_2



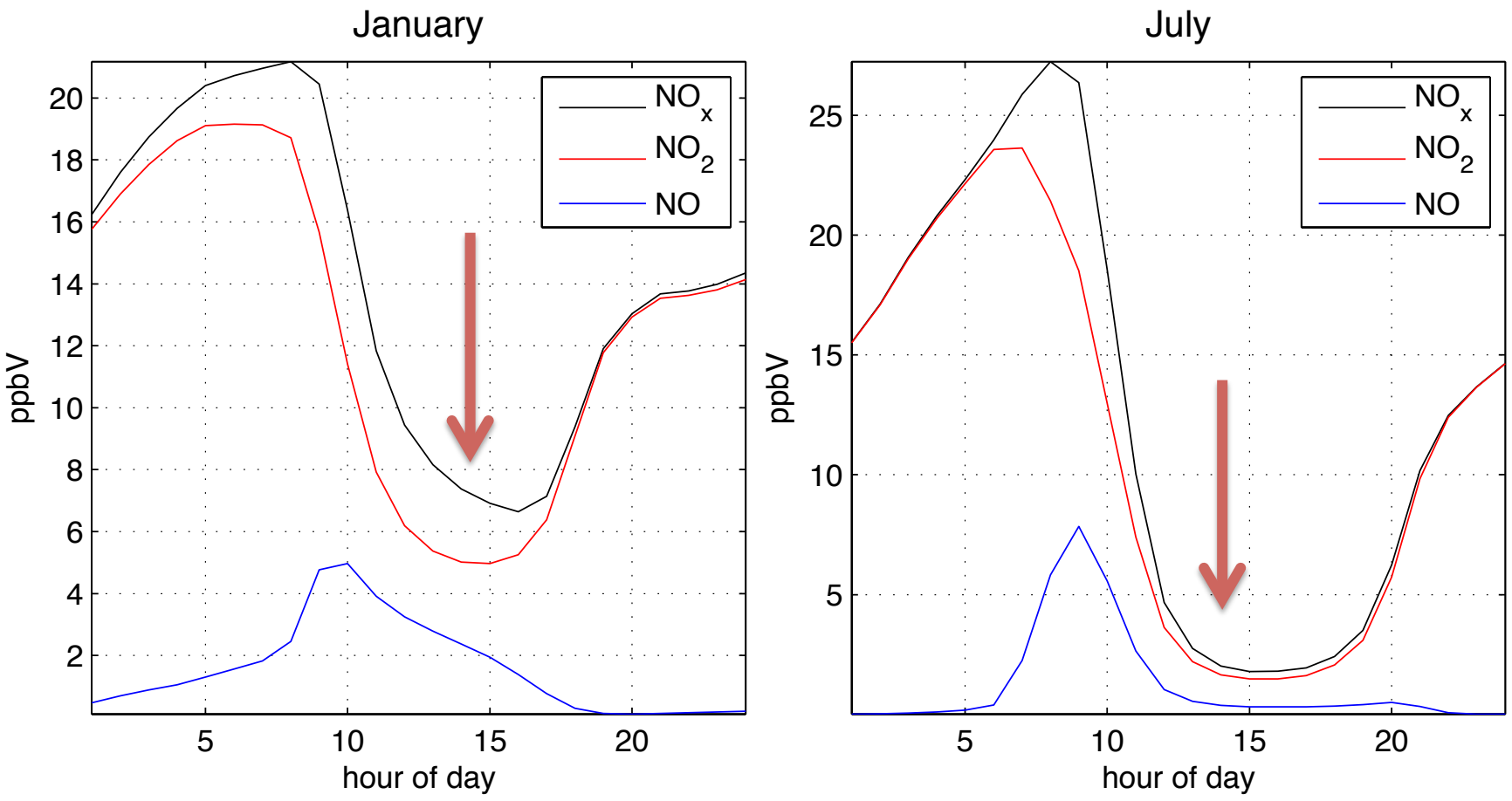
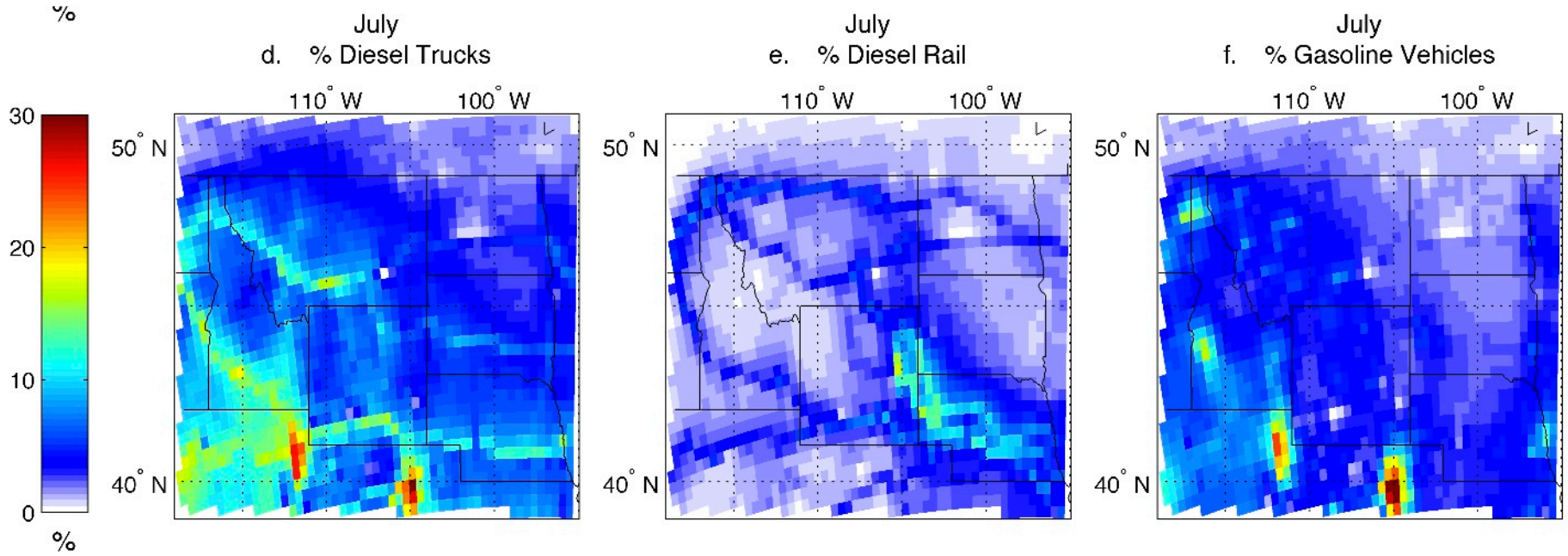


Figure 1.2.1 *CMAQ modeled monthly mean diurnal concentration pattern for NO, NO_2 and NO_x over Madison, WI in January and July 2007. Concentrations of NO peak early in the day before dropping off at night when NO is converted to NO_2. Concentrations of NO_2 track closely with concentrations of NO_x.*

CMAQ Model Scenario		CONUS 36 km x 36 km				MIDWEST 12 km x 12 km			
		LADCO Diesel		WIFE Diesel		LADCO Diesel		WIFE Diesel	
	Metric	January	July	January	July	January	July	January	July
AQS surface NO_2	mean-r	0.39	0.37	0.39	0.36	0.34	0.29	0.37	0.28
	NMB (%)	-35.5	-0.3	-14.5	25.9	-21.6	-4.1	-3.3	15.9
	NME (%)	49.5	49.6	45.8	62.4	45.5	56.6	47.4	67.0
	n	266	271	266	271	100	103	100	103
	R	0.60	0.65	0.64	0.67	0.54	0.56	0.54	0.54
OMI trop. column NO_2	mean-r	0.37	0.16	0.37	0.17	0.44	0.22	0.45	0.22
	NMB (%)	8.2	-41.3	30.6	-37.2	26.5	-41.4	44.1	-38.5
	NME (%)	74.3	62.7	84.2	62.7	73.4	61.0	82.1	60.3
	n	15,967	16,576	15,967	16,576	19,190	19,564	19,190	19,564
	R	0.88	0.72	0.89	0.68	0.85	0.75	0.85	0.75
OMI trop. column NO_2 at AQS gridcells	mean-r	0.53	0.25	0.53	0.25	0.34	0.20	0.35	0.22
	NMB (%)	11.6	4.2	37.0	29.5	14.2	1.8	30.1	9.4
	NME (%)	52.2	62.6	65.0	79.4	56.4	68.1	64.3	70.4
	n	265	271	265	271	99	103	99	103
	R	0.87	0.82	0.88	0.82	0.81	0.87	0.81	0.85
OMI trop. column NO_2 in rural areas	mean-r	0.65	0.16	0.35	0.16	0.45	0.24	0.46	0.24
	NMB (%)	6.7	-45.5	29.0	-43.2	41.9	-47.1	62.0	-44.9
	NME (%)	87.1	65.0	96.6	63.9	96.2	62.5	107.2	61.7
	n	14,596	15,233	14,596	15,233	13,467	14,080	13,467	14,080
	R	0.73	0.67	0.75	0.69	0.64	0.69	0.64	0.69


%
30
20
10
0
%
July
d. % Diesel Trucks
110° W
100° W
50° N
40° N
July
e. % Diesel Rail
110° W
100° W
50° N
40° N
July
f. % Gasoline Vehicles
110° W
100° W
50° N
40° N


6036
6036
SOO LINE

Take Home Points

- Satellite data are well suited for emissions inventory evaluation
- How does the new trucking inventory perform away from cities? (Work in progress...)
- OMI has pros and cons for evaluating NO_2 emissions – morning overpass (GOME) would capture maximum values
- The importance of lightening emissions is evident in satellite evaluation

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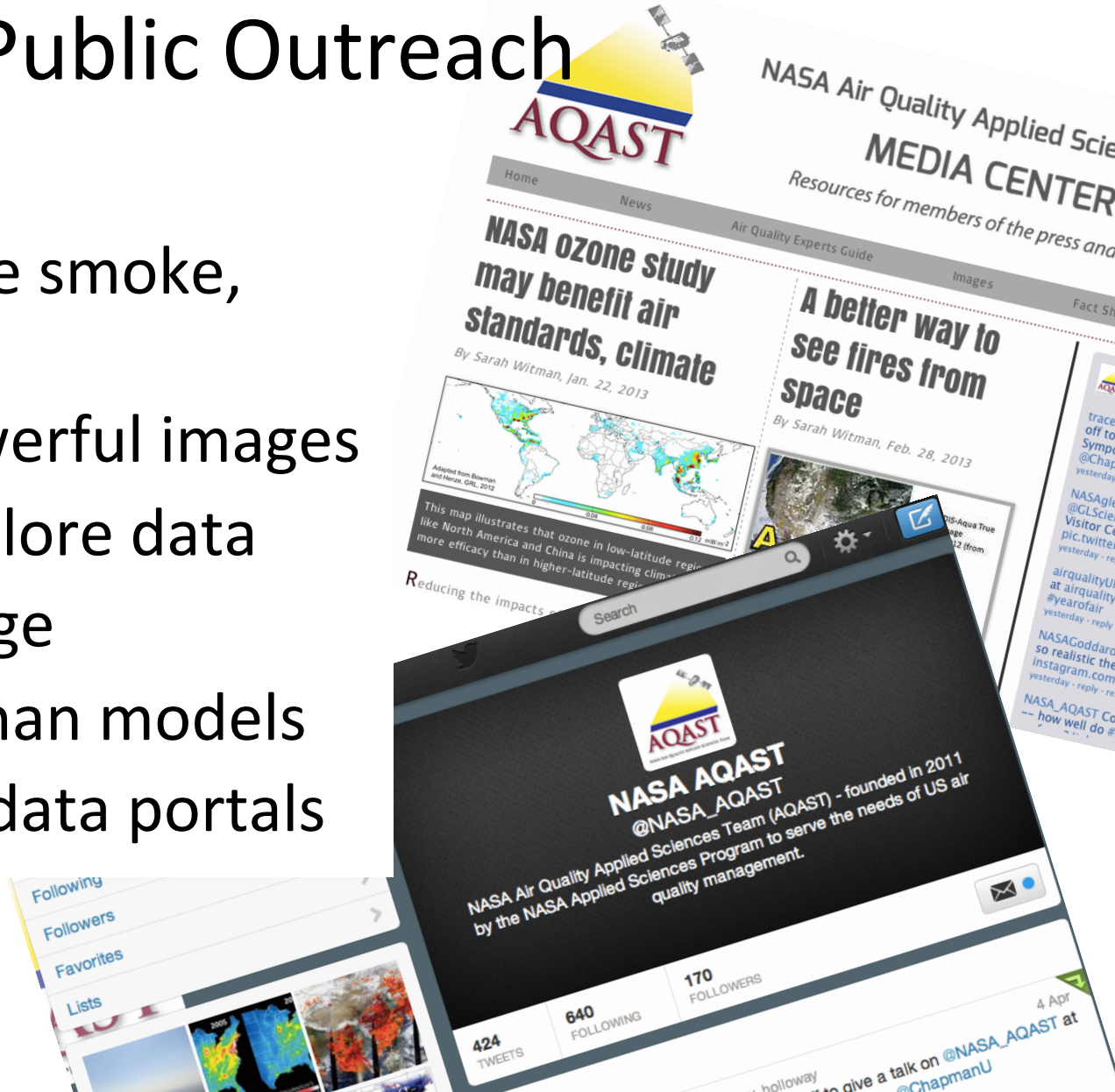
Adapted from a slide of
Bart Sponseller, WI DNR

Benefits of Satellite Data for Public Outreach

- NASA is cool!
- Intuitive to see smoke, haze
- Engaging, powerful images
- Public can explore data
- Global coverage
- More “real” than models
- User-friendly data portals



Case study: January ‘13 Beijing Smog

Case study: OMI NO_2 in BBC

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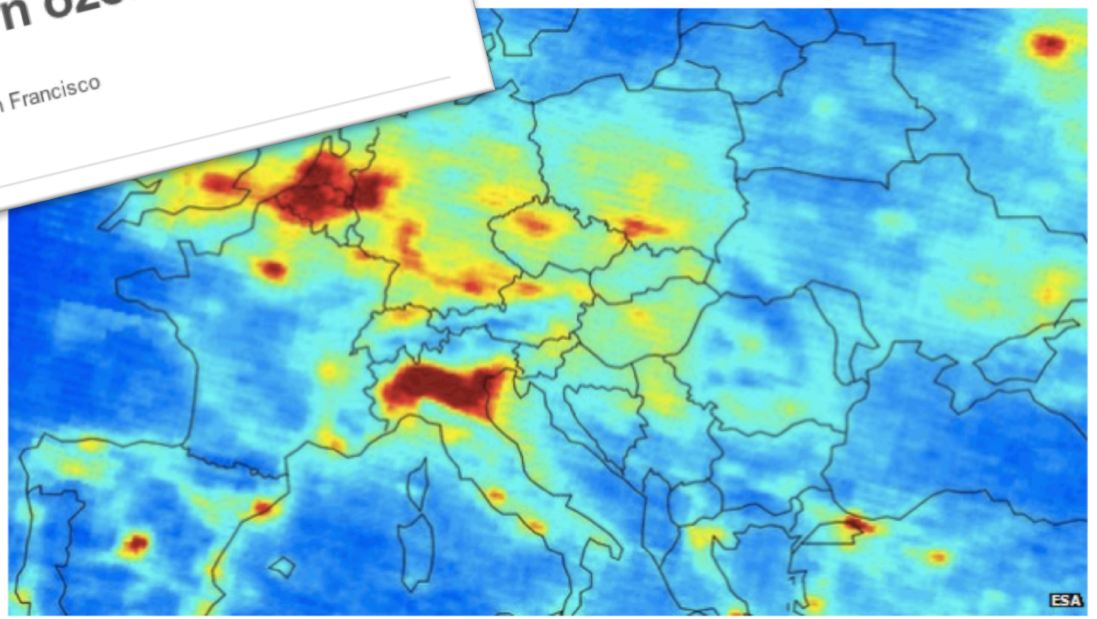
6 December 2012 Last updated at 10:57 ET

London's clue to stubborn ozone levels

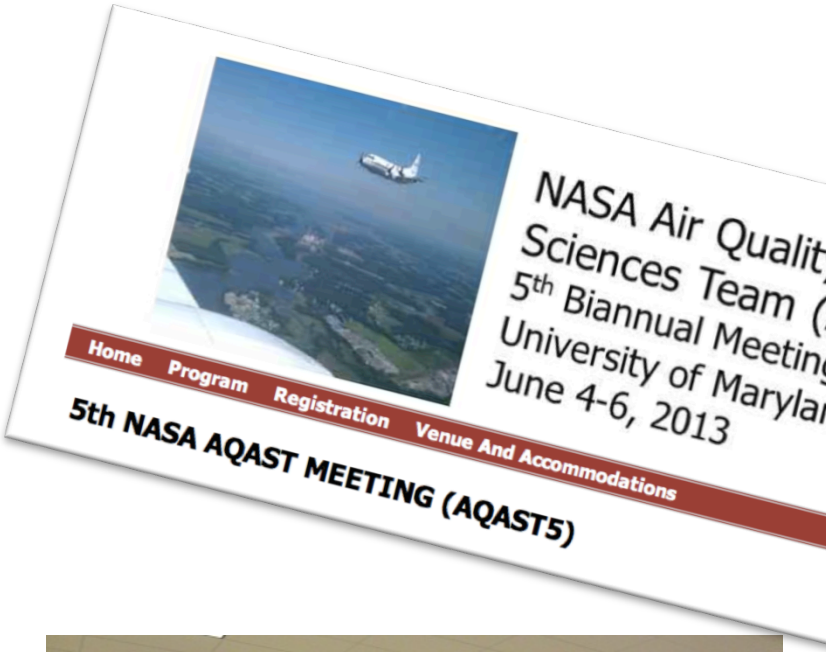
By Jonathan Amos
Science correspondent, BBC News, San Francisco



Nitrogen oxides are produced from many sources including power stations, motor vehicles, and industrial and domestic heating systems

The Path Forward…

- **Engage** air quality managers directly (responsive research, partnerships, twice yearly meetings)
- Use **stakeholder input** to inform future missions
- Develop **analysis methods** to support satellite use for air quality management
- Build **new tools and data** sets to meet user needs



Twitter @NASA_AQAST

Thank you!

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

AQAST

NASA Air Quality Applied Sciences Team

Earth Science Serving Air Quality Management Needs

NASA

2.5 Year Accomplishments

Quick, collaborative, flexible, responsive to the needs of the AQ community

AQAST
NASA Air Quality Applied Sciences Team

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