Overview and Updates from the "Haze Tiger Team"

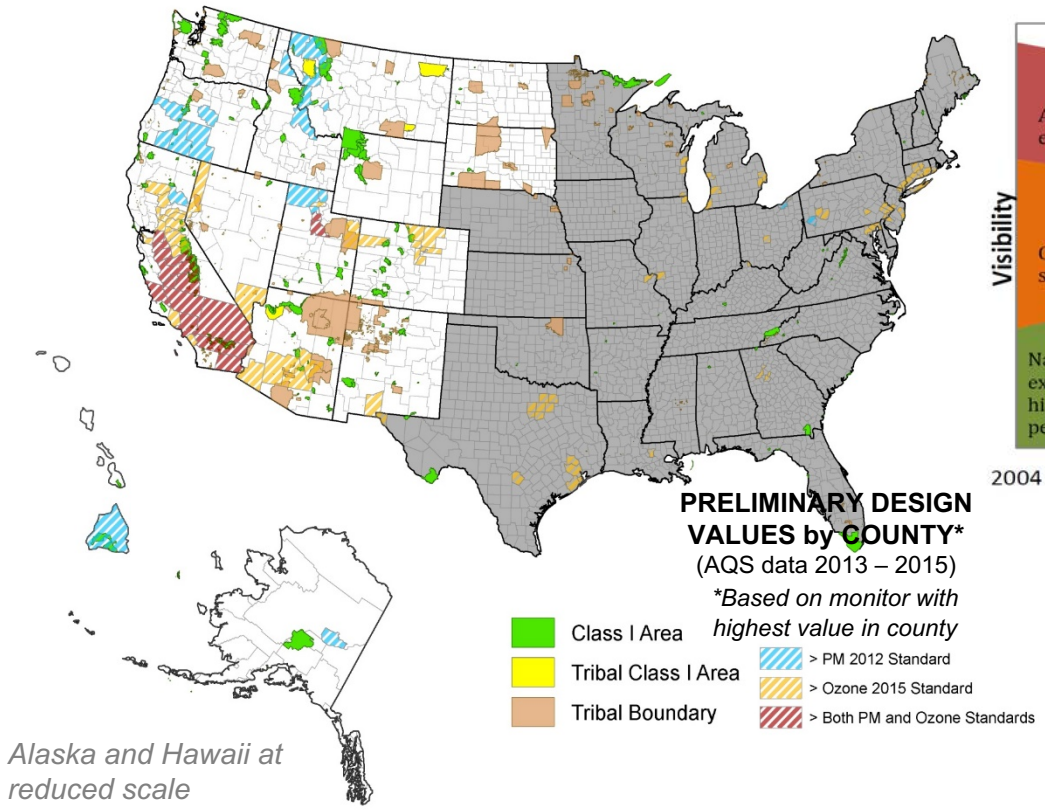
Photo credit: Pat Brewer (NPS), c/o Tom Moore (WESTAR and WRAP)

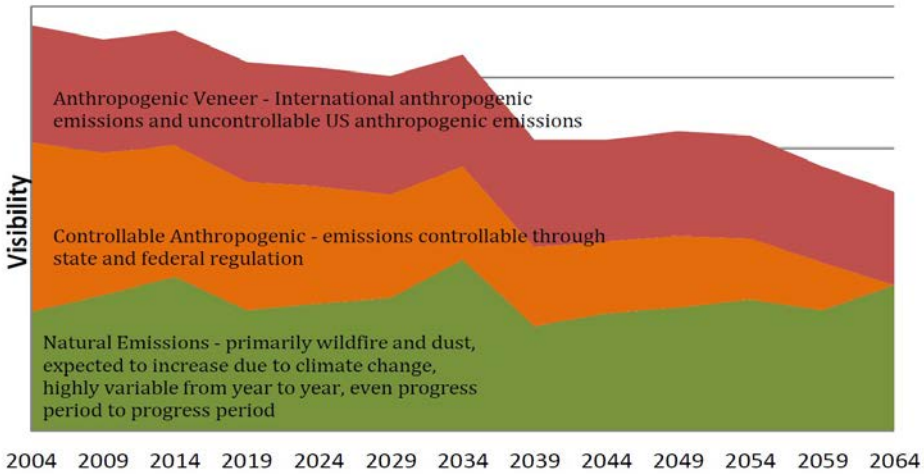
Arlene M. Fiore

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute
Columbia University
in the City of New York

NASA HAQAST5
Arizona State University, Phoenix, AZ
January 3, 2019

The regional haze rule requires “natural” visibility by 2064 in 156 Class I (national parks & wilderness) areas





Figures c/o Tom Moore (WRAP AQ Manager, WESTAR)

- Planning under the regional haze rule occurs in 10-year periods
- Next set of State Implementation Plans due in July, 2021
- Major issue for WUS (15 states, >75% of U.S. Class I areas)
- EUS perspectives to be featured in talks by Paul Miller (NESCAUM) and Michael Geigert (CT DEEP)

The source attribution challenge: Need daily breakdown of PM to identify most anthropogenically impaired days

	Source	Controllability	Trend	Variability
Anthropogenic	US Anthropogenic	Some emissions are controllable	Downward as sources are controlled	Relatively stable
		Some emissions will remain after all reasonable controls implemented	Could rise because of population increases	Relatively stable
	International Anthropogenic	Not controllable by state or federal regulations	Likely increasing due to increased development worldwide and rising population	Relatively stable
Natural	Fire, Dust, Sea Salt	Natural, not controllable	Increases due to climate change	Highly variable
	Volcanic	Natural, not controllable	Unpredictable	Highly variable
	Other Natural Sources	Not controllable	Potentially affected by climate change, e.g., changes in temperature	Relatively stable

Table Note: Shaded areas represent emissions that states cannot control.

- WESTAR/WRAP: Effects of mobile, international, and uncontrollable emissions; evaluation of "rules-on-the-books" & consideration of potential additional Reasonable Progress controls
- EPRI & WEST sponsoring 2016-based international haze study

c/o Tom Moore (WRAP AQ Manager, WESTAR)

Perspectives from TCEQ

- Plan to conduct modeling for Regional Haze in-house
- Modeling Emissions Inventory
  - Texas-specific updates: refined estimates of in-state sources where possible
  - 2016/2028 EPA/States collaborative modeling platform for rest of U.S.
  - 2016/2028 BC from GEOS-Chem: either in-house or existing work if available
- For 2021 SIP deadline, most of the technical work will need to be completed in 2019 to allow for the administrative processes
- Areas where HAQAST team assistance would be helpful:
  - International transport of IMPROVE species, both anthropogenic and natural
  - International source identification and characterization of trends from satellite data, particularly close to or upwind from the BIBE1 site (perhaps plume tracking)
  - Characterization of dust impacts for comparison to modeling results
  - Characterization of fire impacts for comparison to modeling results
  - Data that can help inform estimates of natural conditions

Stephanie Shirley & Stephen Davis (TCEQ)

HAQAST "Haze" TT 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 Tonnesen]; **Other agencies are welcome to join throughout the project (WI, NV, CO, NPS).**

We anticipate outreach to health stakeholder communities in cases where guidance developed under this project is relevant for assessing health burdens (such as due to natural events including wildfires, dust)

HAQAST "Haze" TT: Team website, completed listening sessions with stakeholder partners

https://atmoschem.ldeo.columbia.edu/haqast-tt-haze/

HAQAST TT: Supporting the use of satellite data in regional haze planning

- Y2 TT proposal
- Team contact list (on Google Drive)
- Stakeholder needs spreadsheet (on Google Drive)
- Team member assignments list
- References for use of satellite data to constrain emissions over China, compiled by Fei Liu

NOTES FROM HAQAST TT CALLS:

- Regl Haze TT 8/28/18 call notes (WESTAR listening session)
- Regl Haze TT 9/24/18 call notes (LADCO listening session)
- Regl Haze TT 9/24/18 call notes (ME DEP listening session)
- Regl Haze TT 10/1/18 call notes (TCEQ listening session)
- Regl Haze TT 10/15/18 call notes (HAQAST team members only)
- Regl Haze TT 10/24/18 call notes (CT DEEP listening session)
- Regl Haze TT 10/29/18 call notes (All team meeting)
- Regl Haze TT 11/26/18 call notes (All team meeting)

WESTAR/WRAP	
	Can we separate balance of source mixes by region? Mixes, east and west, are very different.
	International/intercontinental transport--very desirable.
	Evaluation of models as they inform boundary conditions.
	NH3 sources and aerosol formation in West
	Separating planned fire from wildfire
	trend in and sensitivy of global models' and remote sensing plaforms' responses to changes in SO2 and NOx emissions in the West (not the East).
	trend or daily variation magnitude information about remote rural dust emissions
	Effects of oil and gas sources (fracking sites)--often distant from monitors--can sats see them?
	feasibility of using remote sensing products to evaluate concentration fields from the regional-scale and global-scale chemical transport model
	Anything to link up sats with bottom-up inventories
	Sort analyses into high priority "support for RH planning for the July 2021 SIP due date" and lower priority eastern issues
	Possible suggestion: 2000 and onward, build some kind of matrix to explain how spatial and chemical and temporal resolution is changing over past 20 years. Would be an enormous help to have description of retrievals for each criteria pollutant over the past 20 years.

HAQAST "Haze" TT: live team website [illegible] pleted listening sessions with stakeh[illegible]rs

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KEY

International transport = yellow

NH3=green

Fire = red

Future/innovative concerns=grey

Dust = tan

Accuracy of emissions inventory=blue

SIP preparation = br[illegible]

Model evaluation = purple

Interregional/inter-state transport=hot pink

Satellite/Data explainers=lavendar

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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 (see Zhen Qu talk, PI Daven Henze)

(3) Characterize spatial and temporal variability in ammonia emission inventories (see Rui Wang talk, PI Mark Zondlo)

HAQAST Haze TT Goals:

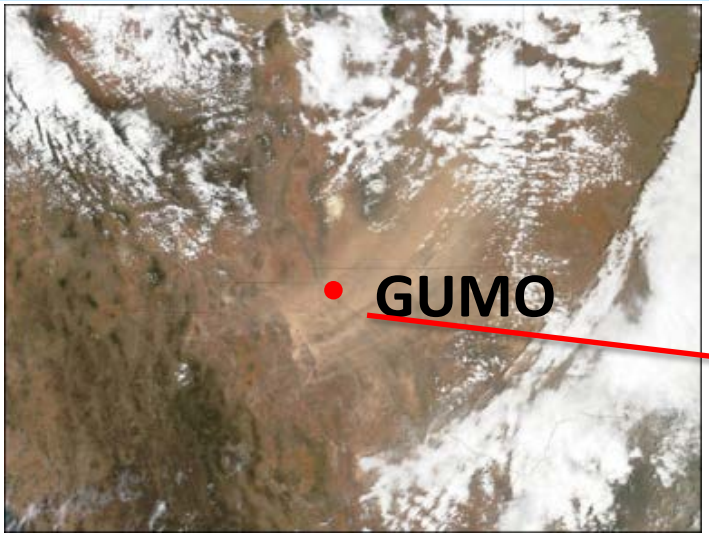
→ Assist in the attribution of observed visibility-impairing PM to natural and anthropogenic sources

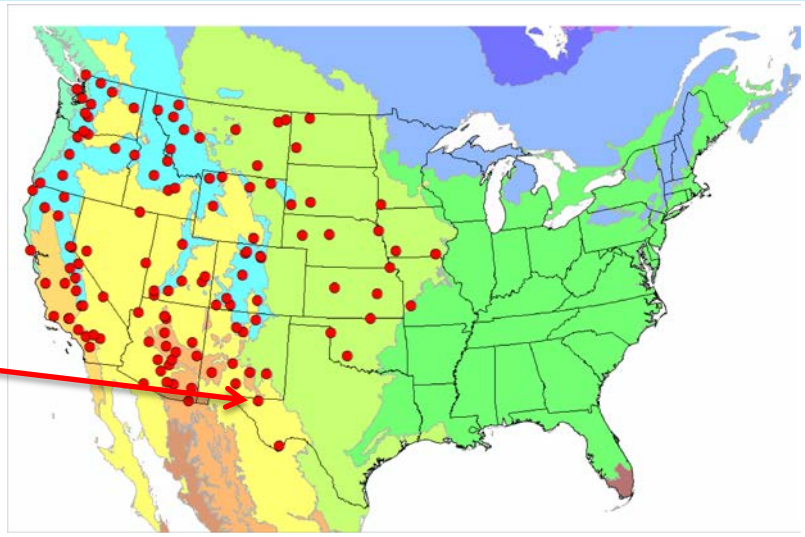
→ Provide tangible, user-friendly examples of using satellite data for haze applications

Satellite-aided Dust Storm Detection

(Source: Tong et al., 2017)

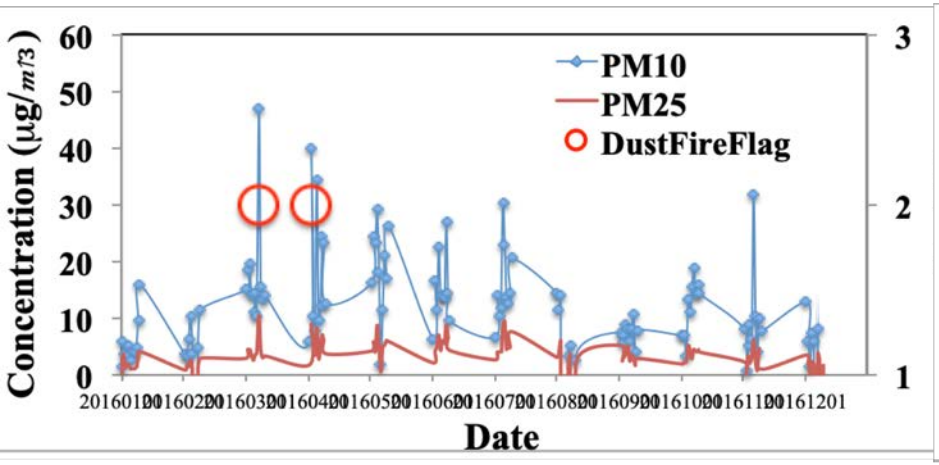
MODIS Dust

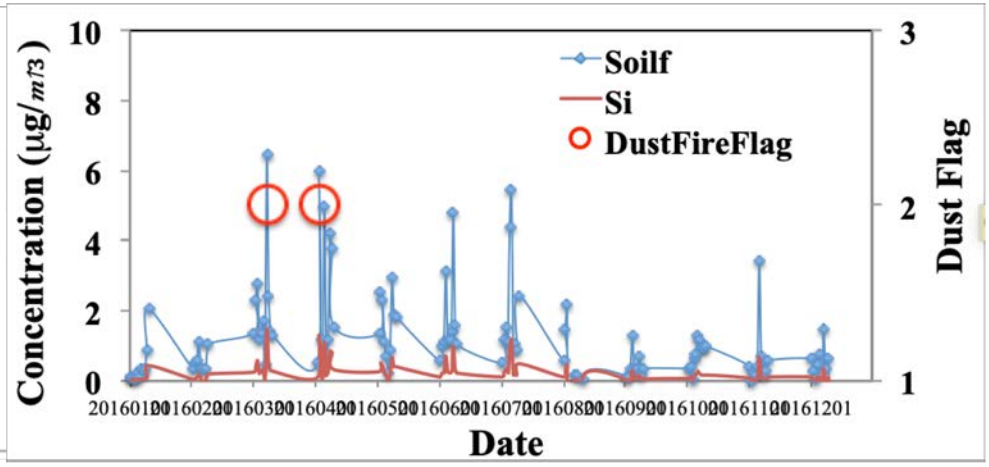




IMPROVE Network

Guadalupe Mountains National Park (GUMO1)

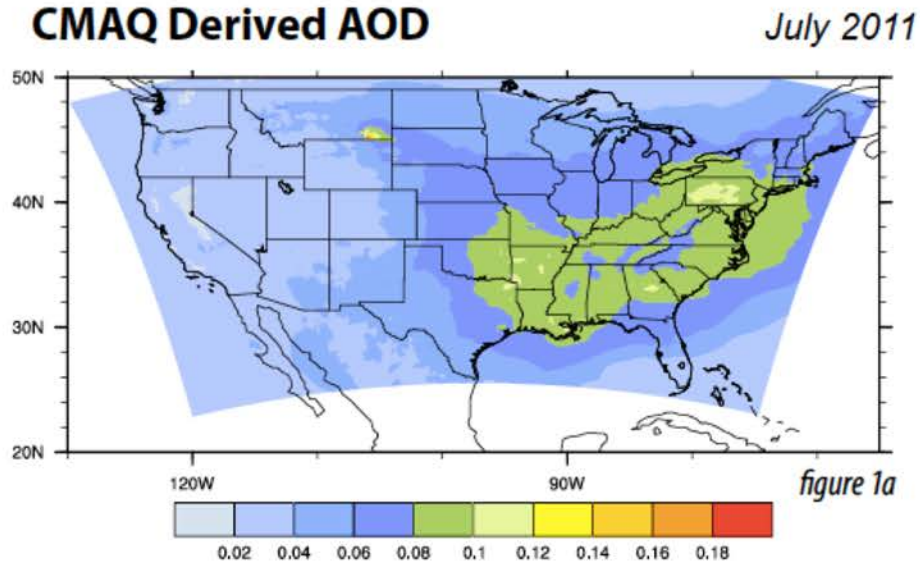


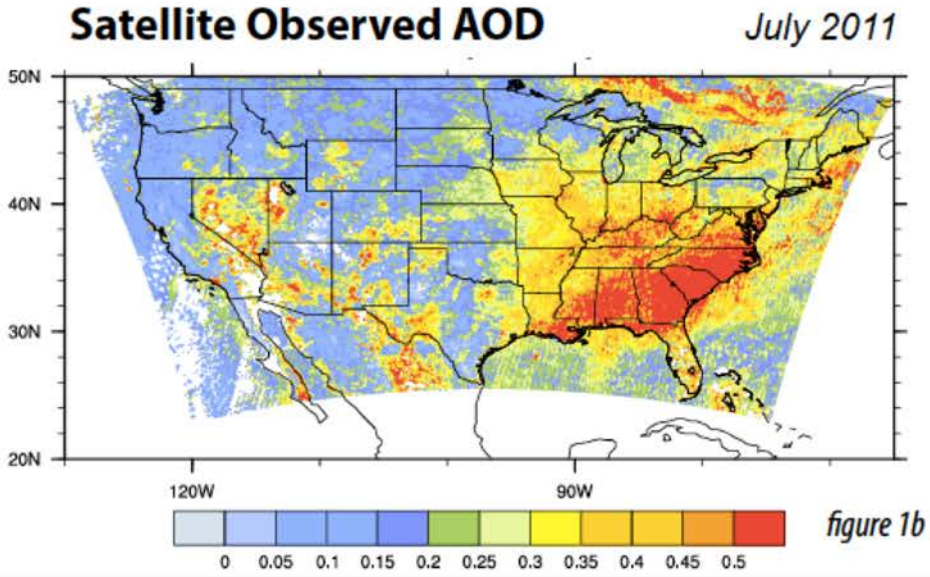


Satellite-trained dust detection for haze analysis

HAQAST PI Tracey Holloway

Evaluating CMAQ vs. Satellite AOD





Left: CMAQ-derived AOD at 550 nm for July 2011 from mass-extinction method;
Right: MODIS/Terra AOD at 550 nm for July 2011 using Dark Target retrieval

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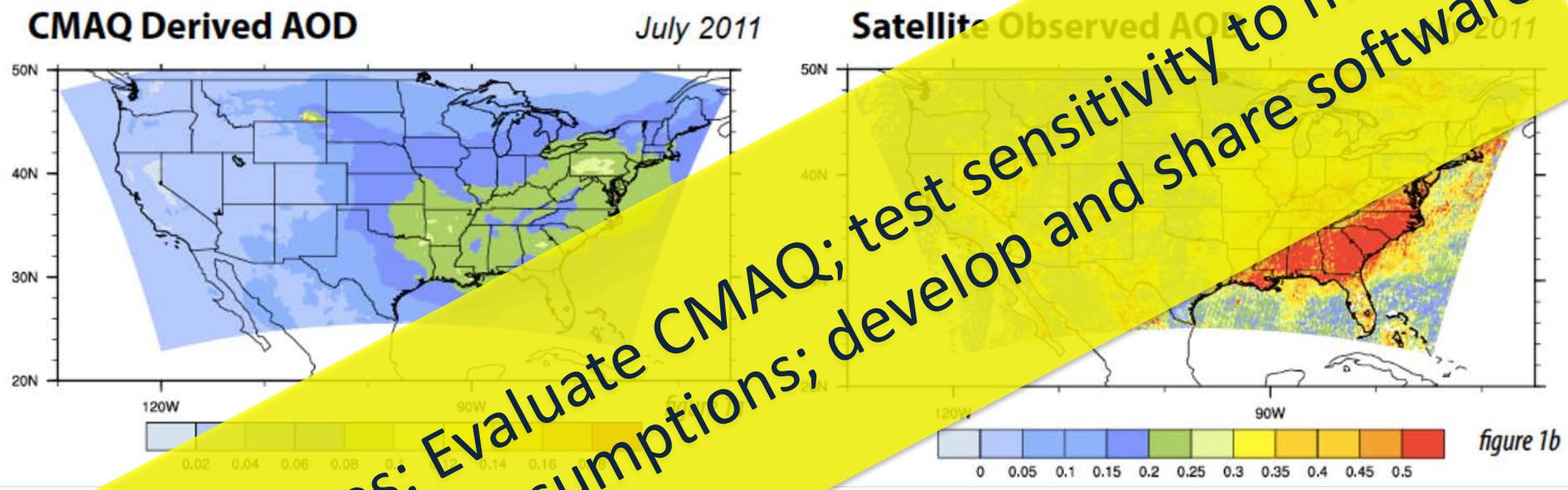
UNIVERSITY OF WISCONSIN-MADISON

See HAQAST poster by Jacob Lynn, Tracey Holloway, Monica Harkey and Peidong Wang

HAQAST PI Tracey Holloway

Evaluating CMAQ vs. Satellite AOD



Objectives: Evaluate CMAQ; test sensitivity to model and retrieval assumptions; develop and share software

Left: CMAQ derived AOD at 550 nm for July 2011 from mass-extinction method;
Right: MODIS/Terra AOD at 550 nm for July 2011 using Dark Target retrieval

See HAQAST poster by Jacob Lynn, Tracey Holloway, Monica Harkey and Peidong Wang

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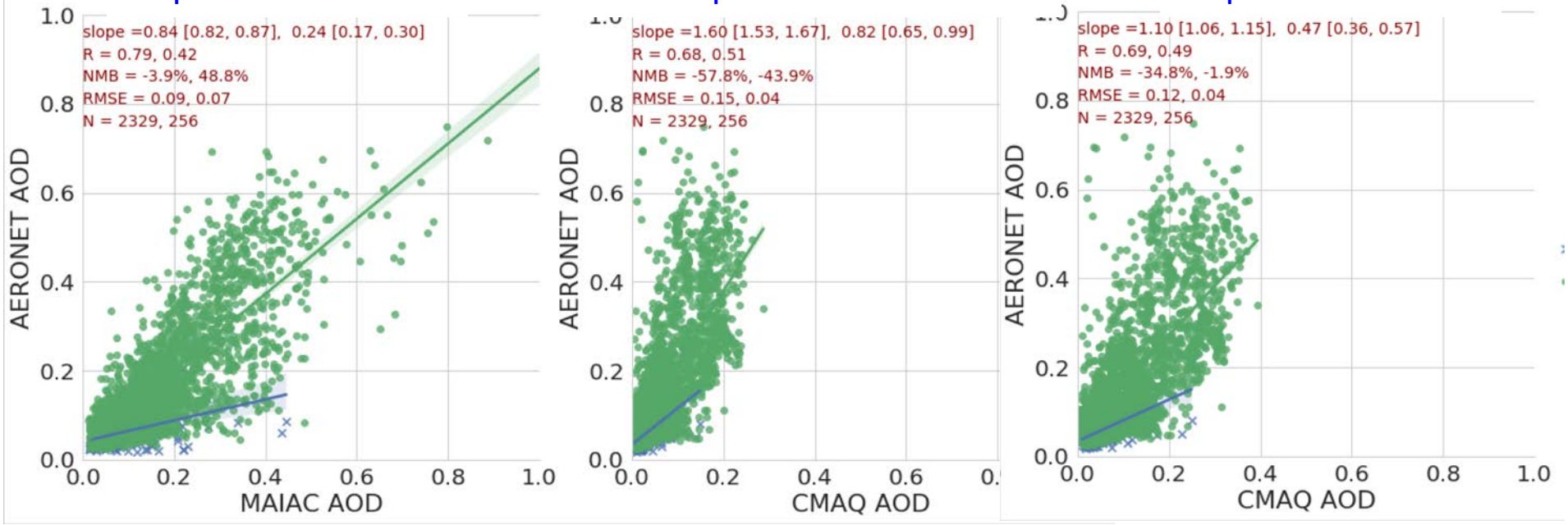
Evaluating model (& satellite) AOD at AERONET sites (NE US)

SATELLITE:
Slope = 0.84 r = 0.79

CMAQ (IMPROVE algorithm)
Slope = 1.6 r = 0.68

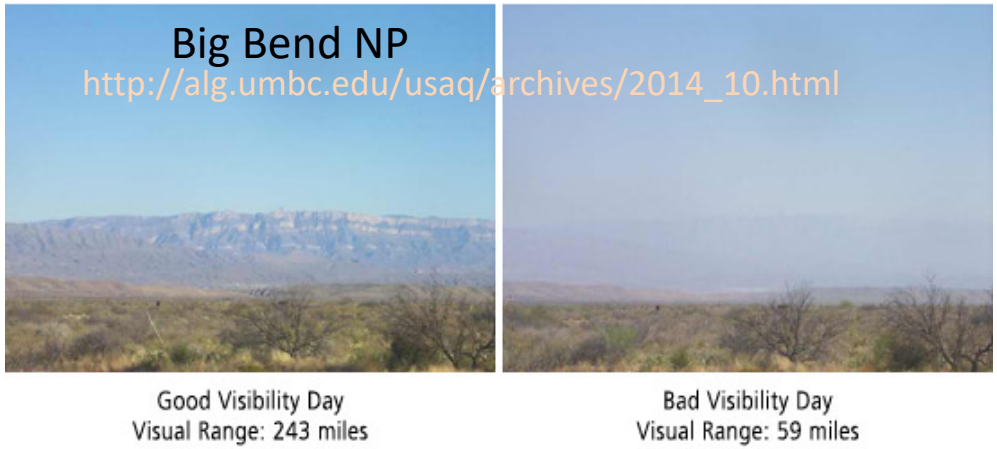
CMAQ (FlexAOD)
Slope = 1.1 r = 0.69

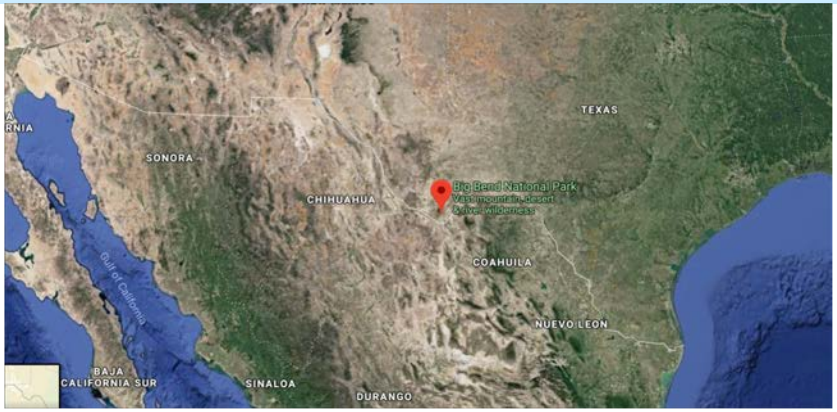


Differences in the two right-most panels arise from optical property assumptions
→Implications for regional haze planning?

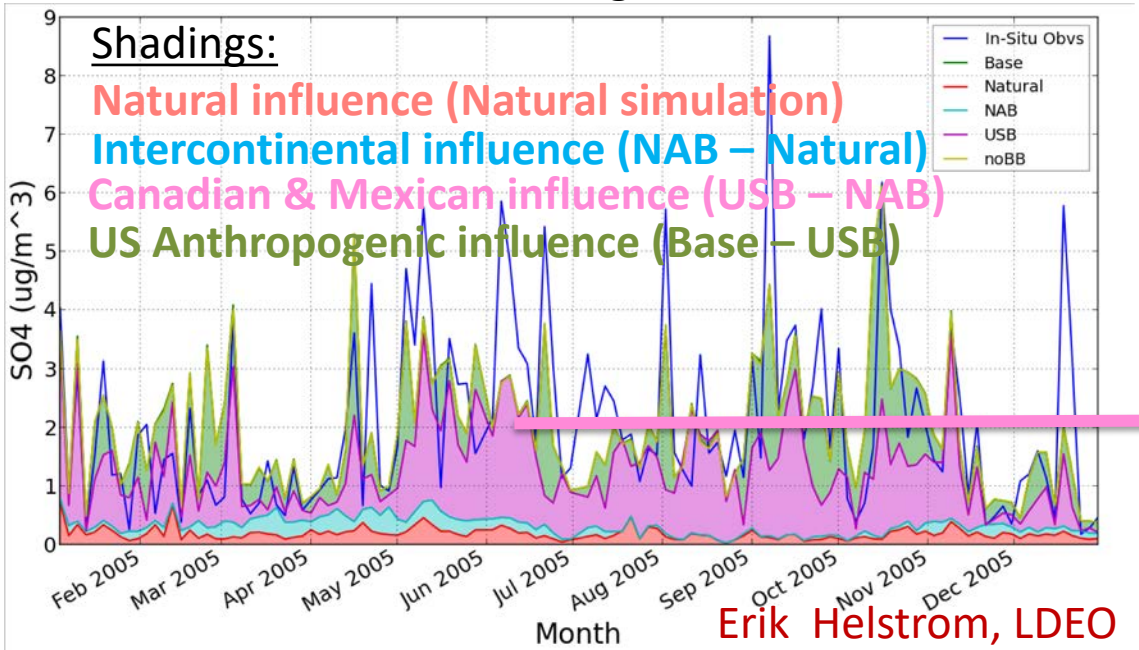
Xiaomeng Jin (Columbia U/LDEO)
see also Jin et al., ACP, 2019

Identifying international transport of haze





GEOS-Chem sulfate at Big Bend NP in 2005

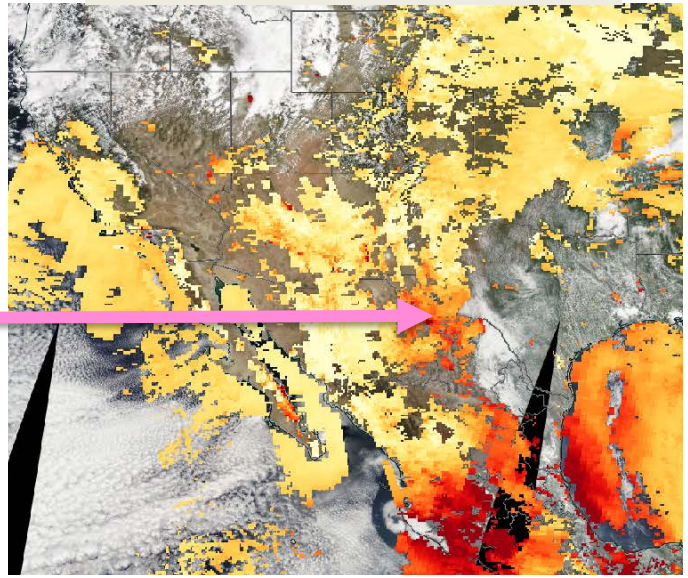


Erik Helstrom, LDEO

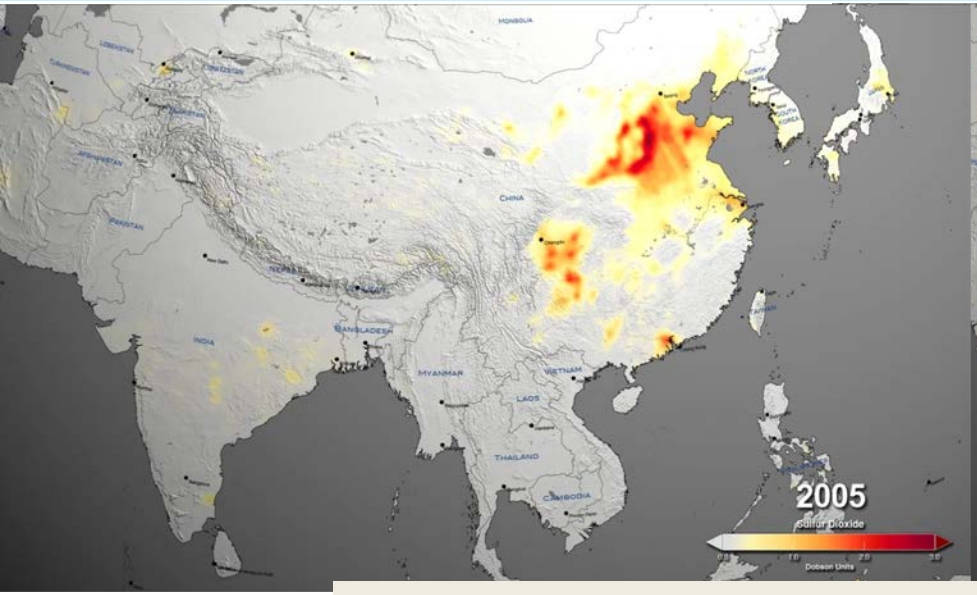
(sent 2004-2012 info to TCEQ, EPA collaborators)

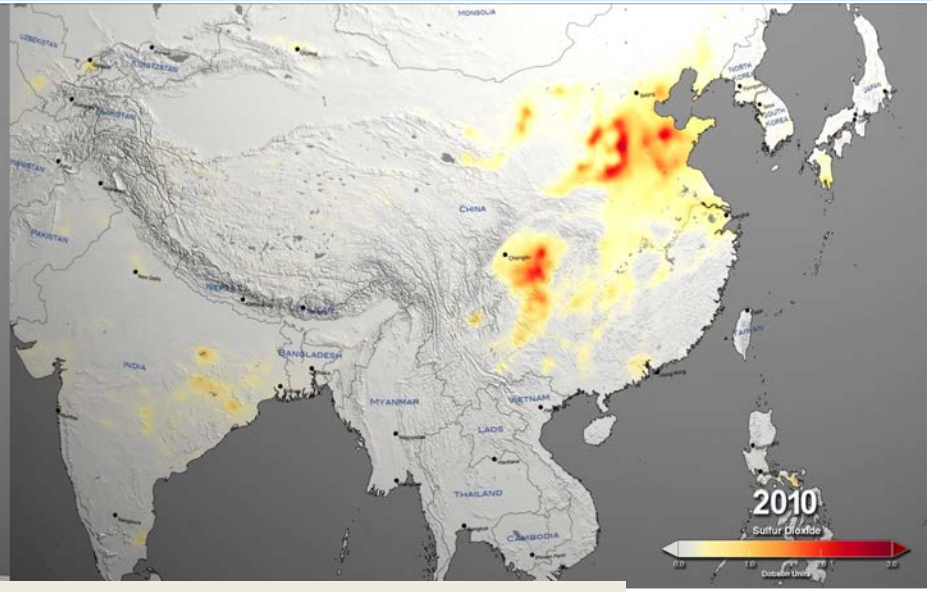
Can we detect events from space?
→ Work in progress!! (NO_2? SO_2?)

MODIS AOD June 6, 2005

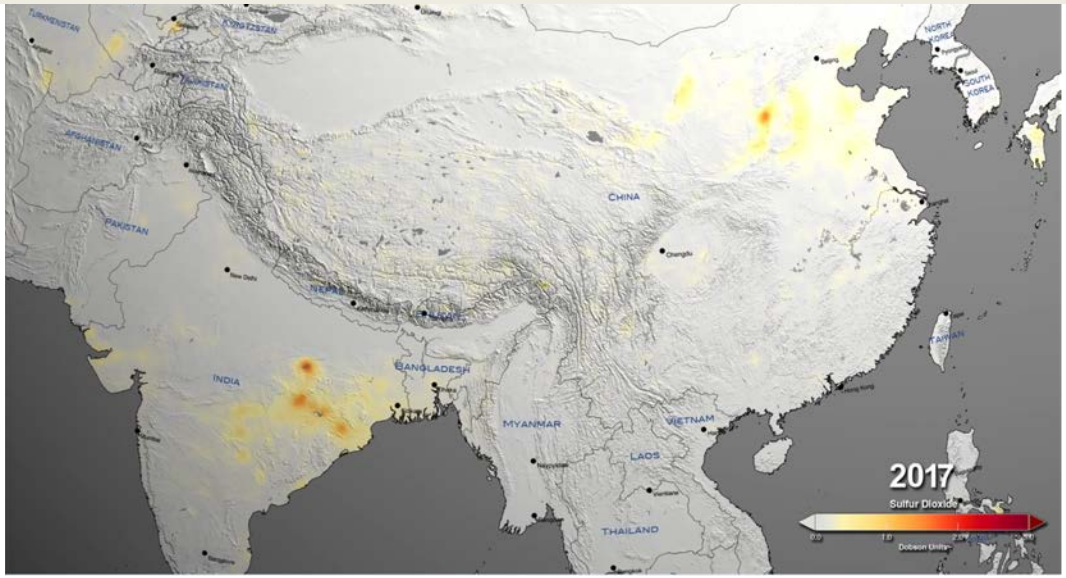


Using satellite (columns) to examine trends in International Emissions (SO_2 over Asia)





Available at https://airquality.gsfc.nasa.gov/particulate-matter



Available for other world regions (USA), cities, + NO_2.

Deliverables for HAQAST "Regional Haze" TT

1. **Initial Phone meetings** between HAQAST participants and stakeholder partners
   → **Heard emerging questions & priorities for analyses**
   → **Helped 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)**

Deliverables for HAQAST "Regional Haze" TT

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.**

→ **Phone meeting summaries & draft docs available on team website https://atmoschem.ldeo.columbia.edu/haqast-tt-haze/**

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 + regional phone meetings / webinars as opportunities arise**

7. (NEW) Share analysis products (powerpoint slides, excel files, software)

Thanks to Daegan Miller (U WI) who is supporting communications for this Tiger Team

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

(Example from a 2017-2018 TT)

Managers

Air Quality & Health Stakeholder Engagement

Thanks to Bryan Duncan and his team for hosting these!

State Implementation Plans

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

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:

Year 2.5 Progress Update, PI Fiore

Source attribution using satellite products and models to inform air quality planning and health accountability

- Assess uncertainties in deriving surface $PM_{2.5}$ from satellite AOD over NYS
  - Paper accepted (ACP), includes detailed evaluation (including with DISCOVER-AQ data) of different sources of uncertainty in deriving $PM_{2.5}$ from satellite AOD over the Northeast
- Connect trends in air pollution exposure to hospital records over NYS from last decade
  - Ongoing analysis of multiple $PM_{2.5}$ datasets (including from satellite); paper in preparation.
  - Deriving new exposure functions & consider uncertainty as represented by the spread in trends across multiple $PM_{2.5}$ products. Also considering O_3 and NO_2.
- Advance understanding of background ozone across the U.S.A.
  - Paper published on interannual variability in individual background sources from 2004 to 2012 (ACP)
  - Co-authored published review paper (Elementa)

- 14+ academic talks; 8+ stakeholder or public talks; hosted and obtained support for HAQAST3; team members visited CT DEEP in August 2017; 3+ teleconferences with NYS DEC and DOH stakeholder partners; Kinney authored "Interactions of Climate Change, Air Pollution & Health" (Current Environmental Health Reports).

Tiger Team (TT) Participation

- Leading TT on Satellite Data for Regional Haze Planning
  - Communication: listening sessions with 5 stakeholder partner agencies; monthly calls with 10+ stakeholder agencies, meeting notes, compiled stakeholder needs, prioritized action items (see team website)
  - Sent analysis of model attribution at SW IMPROVE sites to stakeholder partners at TCEQ and EPA.
- Contributing to TTs on Background Ozone & Global Health Indicators
- Led TT on Satellite Data in SIPS.
  - Communication: monthly calls with 9+ stakeholders, meeting notes, team web page, visit to CT DEEP, editing/archival of tech. guidance docs linked to NASA AQ from space site
  - Student Xiaomeng Jin wrote a technical guidance document on using $HCHO:NO_2$ as an indicator for ozone sensitivity to NO_x versus VOC & provided data to GA EPD and MAG in AZ.
  - Worked with D. Miller to develop 1-page memos.
- Co-I Pat Kinney Led Tiger Team on Hi-Resolution PM2.5 data for health applications
  - Communication: monthly team calls; web page; stakeholder calls; final webinar.
  - MAIAC-derived estimates of 1 km^2 $PM_{2.5}$ generated over NYC and southern California
  - Impacts assessed for cardiac and respiratory health outcomes
- TT Duncan/West: Demonstrating Efficacy of Environmental Regulations over the EUS
  - Trends in $HCHO:NO_2$ as indicator of changes in ozone sensitivity over the NE; provided data to MAG in AZ (8/18)
  - Student Xiaomeng Jin provided animation of HCHO, NO2, and $HCHO:NO_2$ for https://airquality.gsfc.nasa.gov/ozone.