Overview and Updates from the “Haze Tiger Team”

Arlene M. Fiore

Photo credit: Pat Brewer (NPS), c/o Tom Moore (WESTAR and WRAP)
The regional haze rule requires “natural” visibility by 2064 in 156 Class I (national parks & wilderness) areas

- 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

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

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)
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)
HAQAST "Haze" TT: live team website, completed listening sessions with stakeholder partners

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

Guadalupe Mountains National Park (GUMO1)

Satellite-trained dust detection for haze analysis
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

See HAQAST poster by Jacob Lynn, Tracey Holloway, Monica Harkey and Peidong Wang
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
Evaluating model (& satellite) AOD at AERONET sites (NE US)

HAQAST PI Fiore

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

**Big Bend NP**

**Shadings:**
- Natural influence (Natural simulation)
- Intercontinental influence (NAB – Natural)
- Canadian & Mexican influence (USB – NAB)
- US Anthropogenic influence (Base – USB)

**Can we detect events from space?**
→ Work in progress!! (NO₂? SO₂?)

**MODIS AOD June 6, 2005**

**GEOS-Chem sulfate at Big Bend NP in 2005**

- Good Visibility Day
  - Visual Range: 243 miles
- Bad Visibility Day
  - Visual Range: 59 miles

**Erik Helstrom, LDEO**
(sent 2004-2012 info to TCEQ, EPA collaborators)
Using satellite (columns) to examine trends in International Emissions (SO₂ over Asia)

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

Available for other world regions (USA), cities, + NO₂.
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
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 NOx 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:
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, NO$_2$, and HCHO:NO$_2$ for https://airquality.gsfc.nasa.gov/ozone.