Updates from the "Haze Tiger Team"

A source attribution challenge under the Regional Haze Rule:

Need breakdown of haze components on "most anthropogenically impaired days"

Arlene M. Fiore
Lamont-Doherty Earth Observatory
Columbia University | Earth Institute
Columbia University in the City of New York

NASA HAQAST6
Pasadena, CA
July 11, 2019

HAQAST Regional 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

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, Henze, 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 products (Columbia U academic commons), with links from NASA Air Quality page**

→ **Meetings & teleconferences/ webinars as opportunities arise**

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

Thanks to Daegan Miller (U WI) who is supporting communications

HAQAST "Haze TT" Stakeholder Partners

Stakeholder partners: ***Maine*** [Tom Downs], ***Connecticut*** [Michael Geigert], ***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; Shannon Koplitz];

Other agencies are welcome to join (WI, NV, CO, NPS, NJ).

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 PI Duncan

National/International Haze Sources Information on NASA AQ Website

https://airquality.gsfc.nasa.gov

Aura EOS Project OZONE HOLE WATCH

Air Quality
Observations from Space

Search this site

Home Pollutants Impacts News Resources Managers

NASA's Fleet of Earth Observing Satellites: Monitoring Our Planet's Health

NASA has a fleet of Earth-observing satellites whose instruments observe our planet's oceans, biosphere, and atmosphere. Several of these satellites have instruments that observe air pollutants around the world. The data collected are being used by air quality managers and researchers studying the impact of air pollution on human health and agriculture.

Air Pollutants Observed from Space

Nitrogen Dioxide (NO_2): NO_2 is unhealthy to breathe and is primarily generated during fossil fuel combustion, so thermal power plants and automobiles are the dominant sources.

Ozone (O_3) & Precursors: At Earth's surface, O_3 is unhealthy to breathe and also negatively impacts plants, reducing crop yields.

Particulate Matter (PM) & Precursors: PM are tiny particles (e.g., smoke and dust) that cause numerous health issues when breathed in.

Impacts of Air Pollution: How Satellite Data Can Help

Human Health: Exposure to outdoor air pollution is responsible for an estimated 4 million premature deaths annually with about another 3-4 million resulting from exposure to indoor air pollution; that is, air pollution is responsible for about 1 in 9 deaths worldwide (*WHO, 2018*; *Cohen et al., 2017*).

Agriculture: The economic impact of crop yield loss due to pollution is significant all over the world. Air pollution causes global crop yield losses for wheat, corn, and soybeans that are estimated to range from $11-18 billion annually, with the greatest economic loss estimated to occur in the United States ($3.1 billion).

Before and After: World Nitrogen Dioxide Levels, 2005-2016

NASA Food Security Initiative

The NASA Goddard Space Flight Center's Food Security Initiative promotes the use of Earth observations and Earth science data, models, and knowledge provide essential information and tools to support global food security. (Photo by Ishay Botbol from Pexels)

NASA AQ Forecast

The NASA Global Modeling and Assimilation Office (GMAO) develops and maintains the GEOS system of models, which has a suite of capabilities including simulating weather, climate,

https://airquality.gsfc.nasa.gov/hazevisibility-planning

Aura EOS Project OZONE HOLE WATCH

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Haze/Visibility Planning

Supporting the Use of Satellite Data in Regional Haze Planning

This HAQAST Tiger Team proposes to work with stakeholders to address three applications of satellite data of direct relevance to regional haze State Implementation Plans (SIPs). The team will develop technical guidance documents that describe their approaches to using satellite data for regional haze applications. We anticipate that the guidance developed under this project will also be relevant to health agencies seeking to assess health burdens due to natural events (e.g., dust, wildfires) associated with severe health effects. In addition, they'll aid air quality managers in the use of satellite data in the Regional Haze SIP process, provide tangible examples of the value of satellite data for addressing air quality and related health applications, to aid stakeholders who wish to conduct their own analyses, and lower the barrier for new health and air quality stakeholder agencies to apply satellite data.

Other related projects:

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

Efficacy of Environmental Regulations to Improve Air Quality in the U.S.

Deliverables

To be populated within the next f

Will populate with TT deliverables.

HAQAST Lead: Dr. Arlene Fiore (amfiore@ldeo.columbia.edu)

HAQAST Participants: Dr. Bryan Duncan, Dr. Daven Henze, Dr. Patrick Kinney, Dr. Talat Odman, Dr. Ted Russell, Dr. Daniel Tong, Dr. Jason West, Dr. Mark Zondlo

Stakeholder Partners: Mid-Atlantic Regional Air management Association, Northeast States for Coordinated Air Use Management, Texas Commission on Environmental Quality, US EPA, Connecticut Department of Energy and Environmental Protection, Maine Department of Environmental Protection.

Last updated: Jun. 24, 2019
NASA Official: Bryan Duncan
Webmaster: Susannah Pearce & Roosevelt Purification

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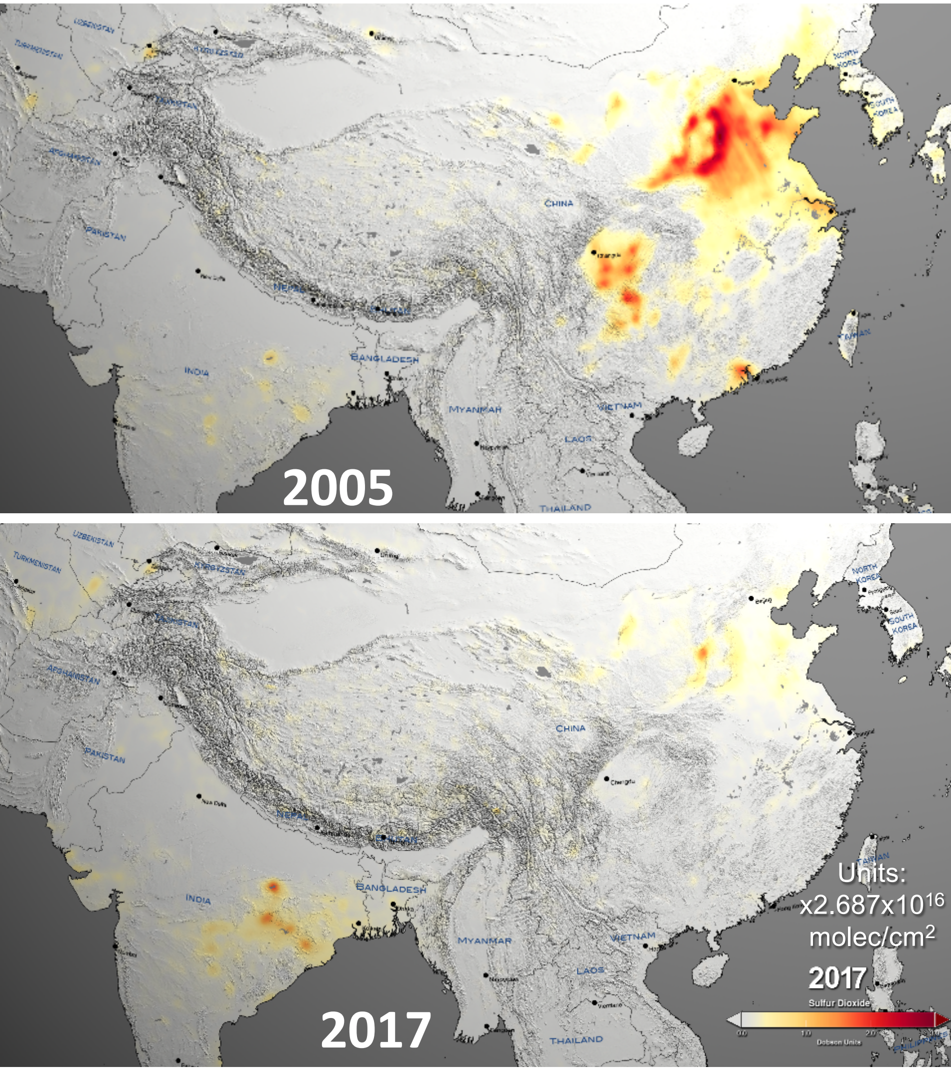
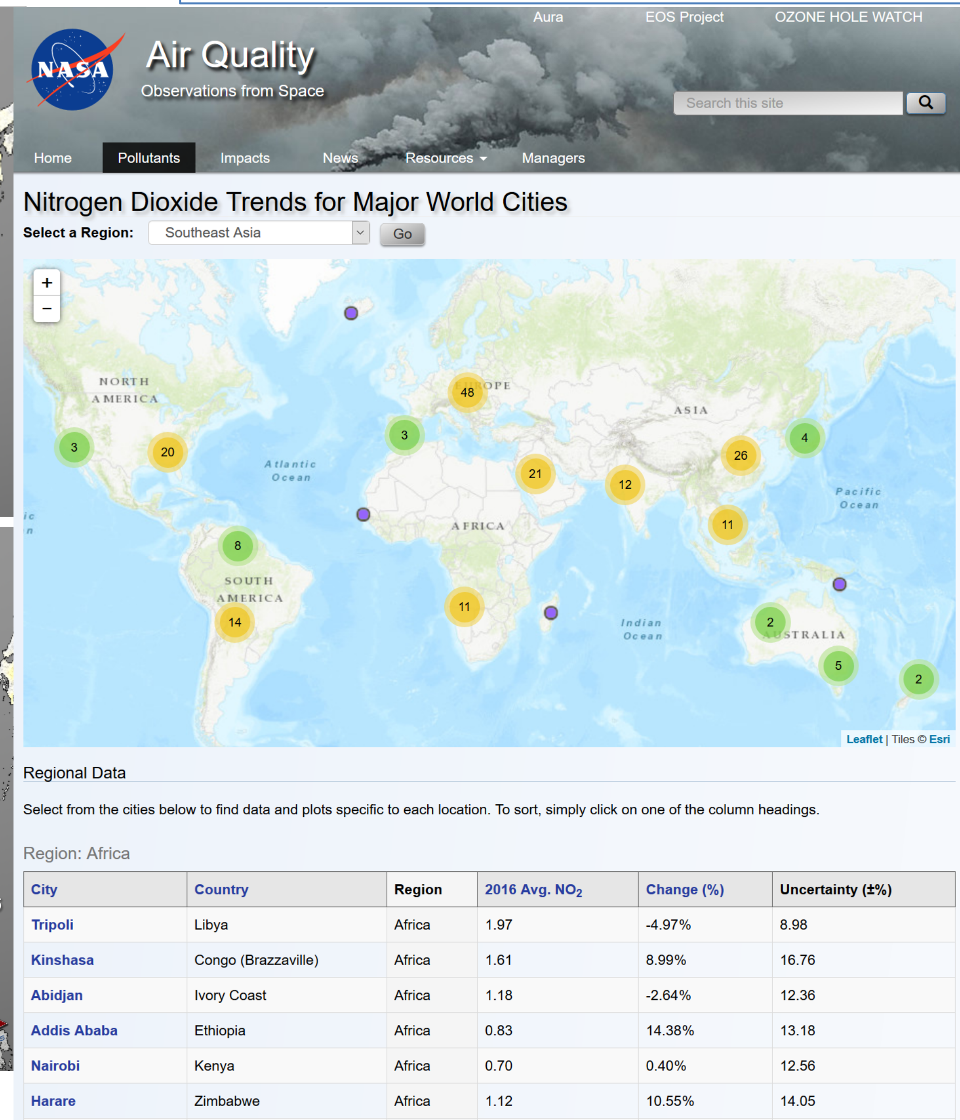
Also: See factsheet "Clean Air From Space" online or take paper copy home with you.

National/International Haze Sources Examples: Changes in Precursors over Time

OMI Sulfur Dioxide (SO_2)



OMI Nitrogen Dioxide (NO_2)



City	Country	Region	2016 Avg. NO_2	Change (%)	Uncertainty (±%)
Tripoli	Libya	Africa	1.97	-4.97%	8.98
Kinshasa	Congo (Brazzaville)	Africa	1.61	8.99%	16.76
Abidjan	Ivory Coast	Africa	1.18	-2.64%	12.36
Addis Ababa	Ethiopia	Africa	0.83	14.38%	13.18
Nairobi	Kenya	Africa	0.70	0.40%	12.56
Harare	Zimbabwe	Africa	1.12	10.55%	14.05

https://airquality.gsfc.nasa.gov

HAQAST PI Duncan

National/International Haze Sources Examples: Changes in Precursors over Time

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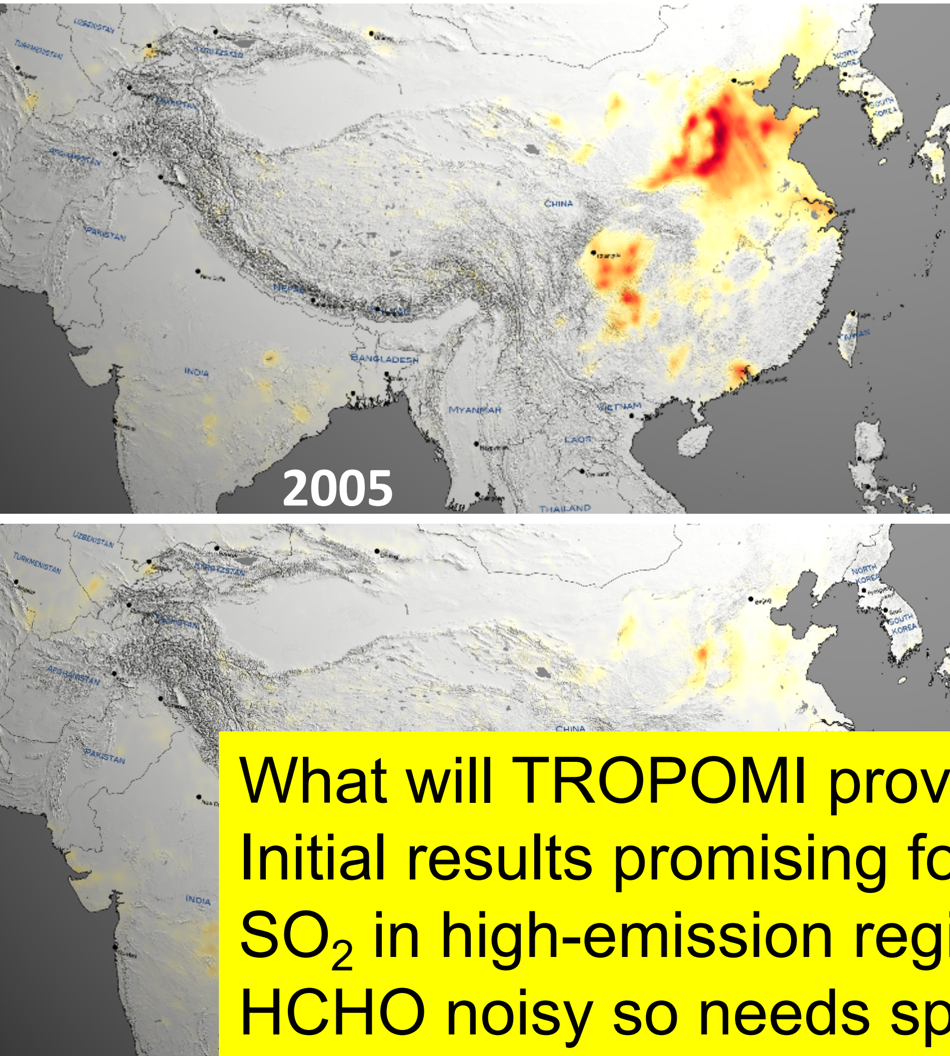

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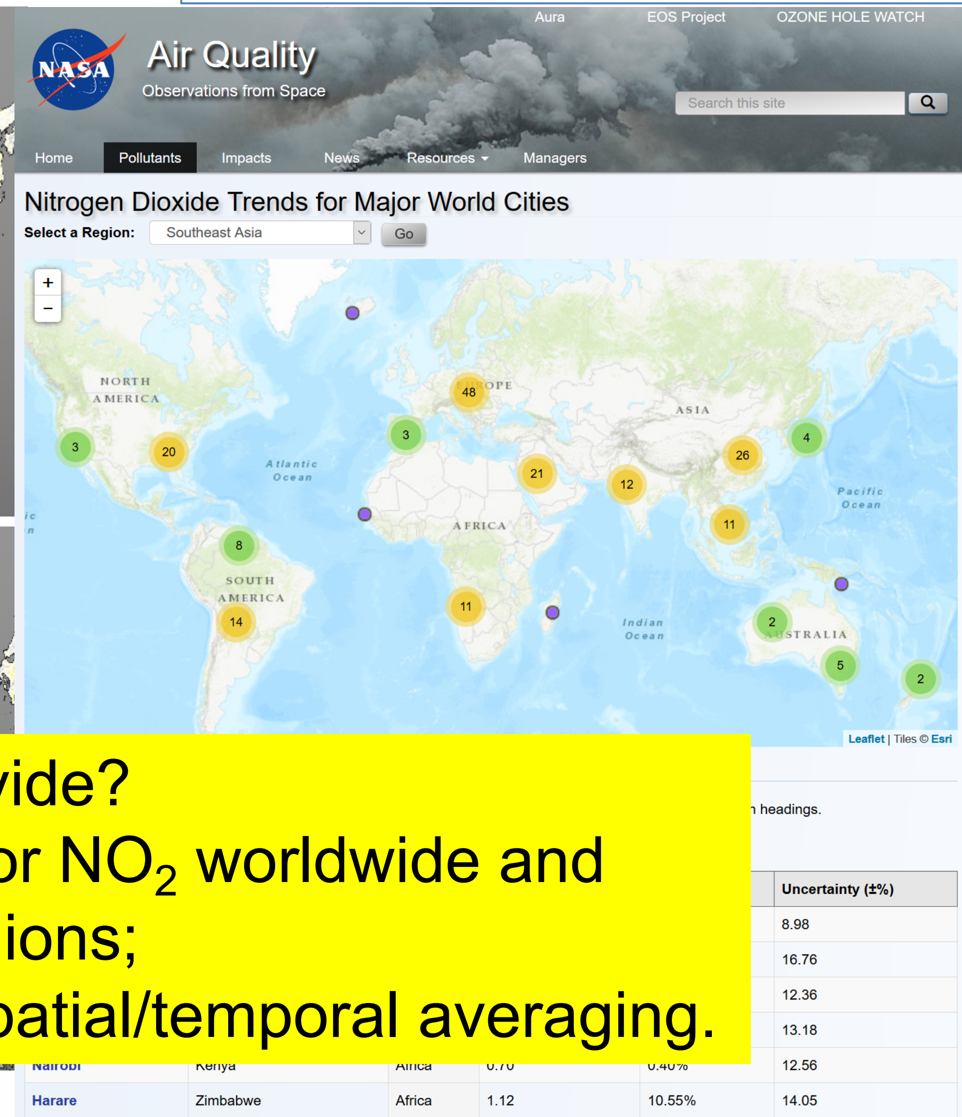


What will TROPOMI provide?

Initial results promising for NO_2 worldwide and SO_2 in high-emission regions;

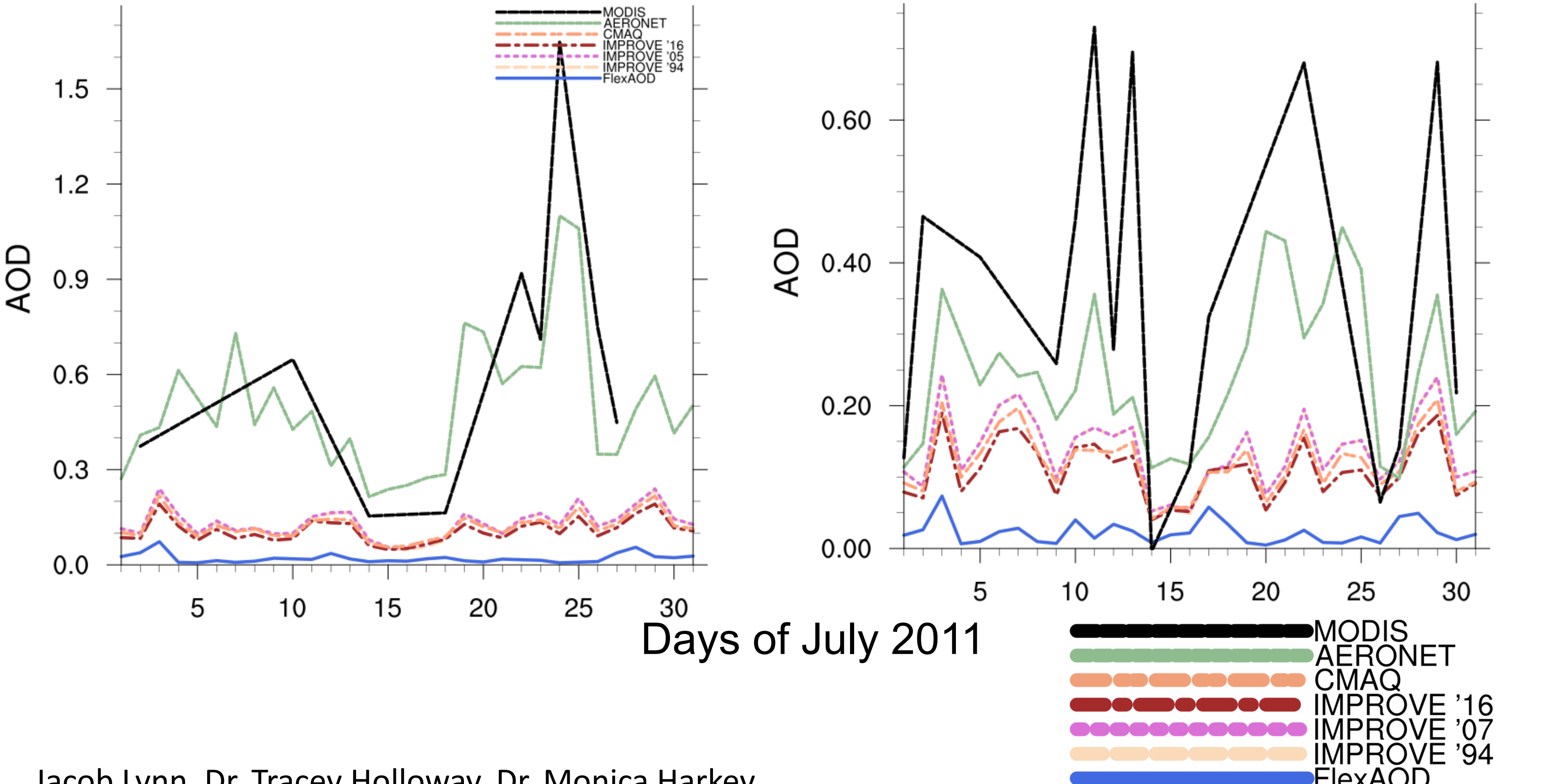
HCHO noisy so needs spatial/temporal averaging.

https://airquality.gsfc.nasa.gov

Assessing different approaches to convert CMAQ model mass distributions to AOD for evaluation with satellite data

Rural: Baseline Surface Radiation Network
Wallops, VA

Urban: Goddard Space Flight Center
Greenbelt, MD



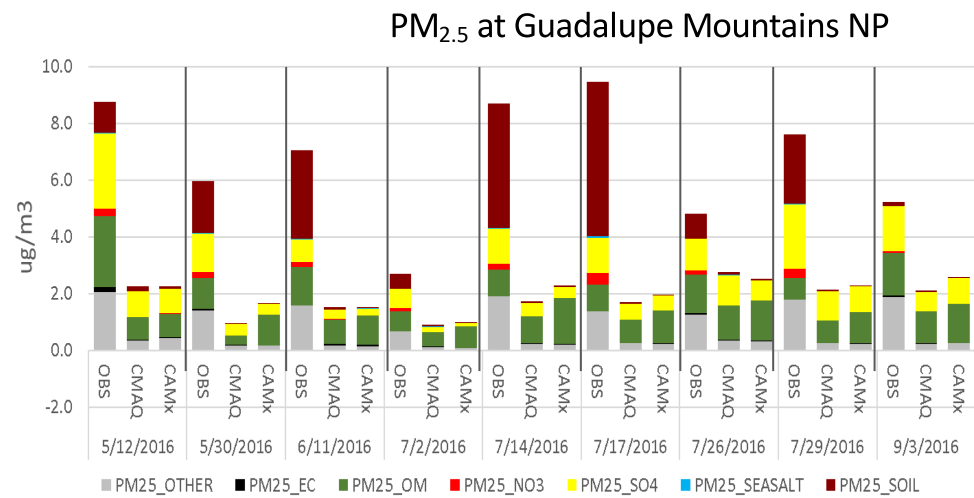
Jacob Lynn, Dr. Tracey Holloway, Dr. Monica Harkey

Georgia Institute of Technology

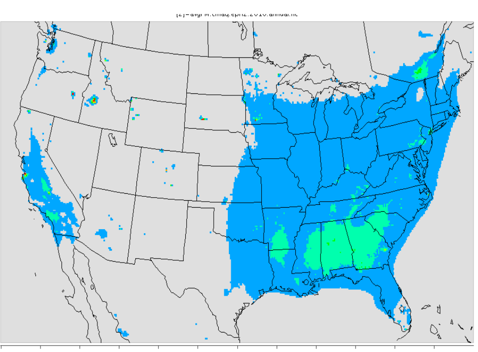
2016 Simulations Regional Haze Simulations

- Over the 12-km CONUS domain
- EPA 2016 beta emissions
- WRF (v3.9.1.1) meteorology
- CMAQ (v5.2.1) and CAMx (v6.50)
- Large difference in organic matter

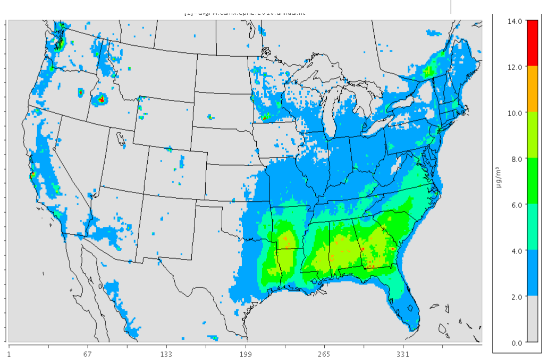
- Evaluation at IMPROVE sites
- Lacking transport from Mexico



CMAQ



CAMx



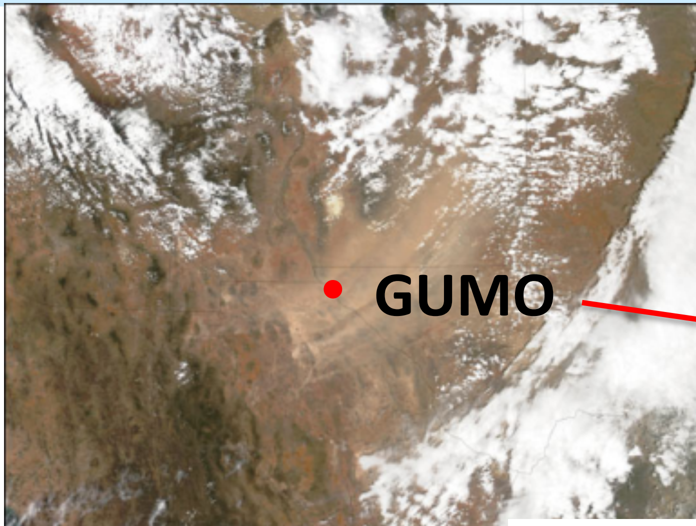
Annual average organic $PM_{2.5}$

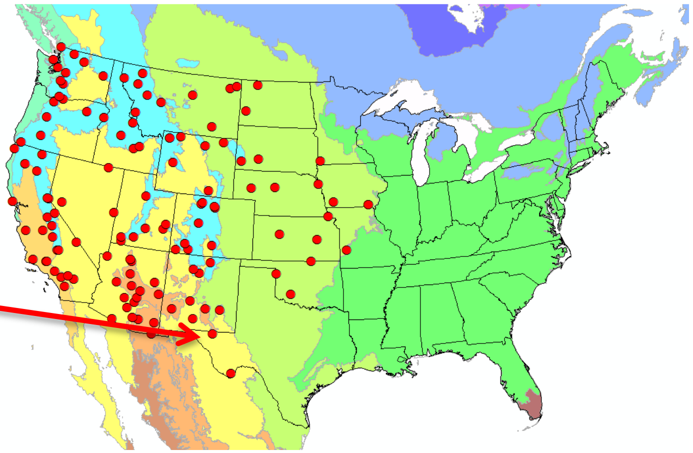
Simulations underway with

- GEOS-Chem boundary conditions
- Source apportionment

Dust Storms and Regional Haze

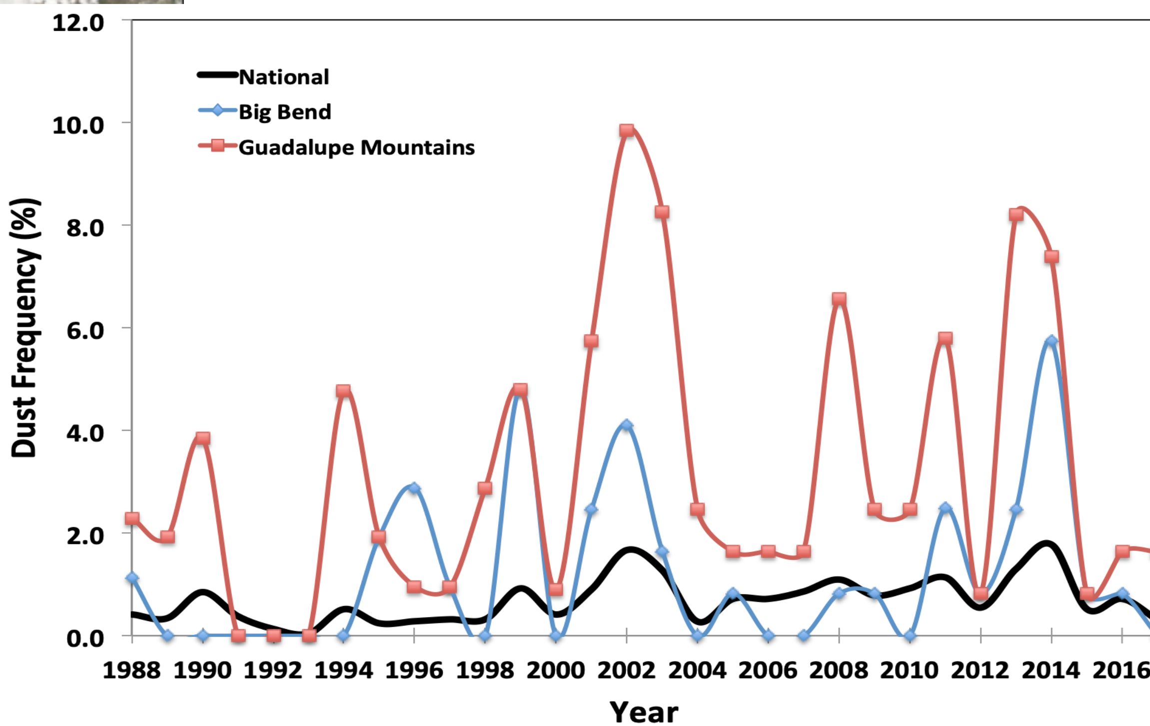
MODIS Dust





IMPROVE Network

Dust storm events were detected from two IMPROVE sites using satellite-trained detection algorithm.



HAQAST PI Fiore

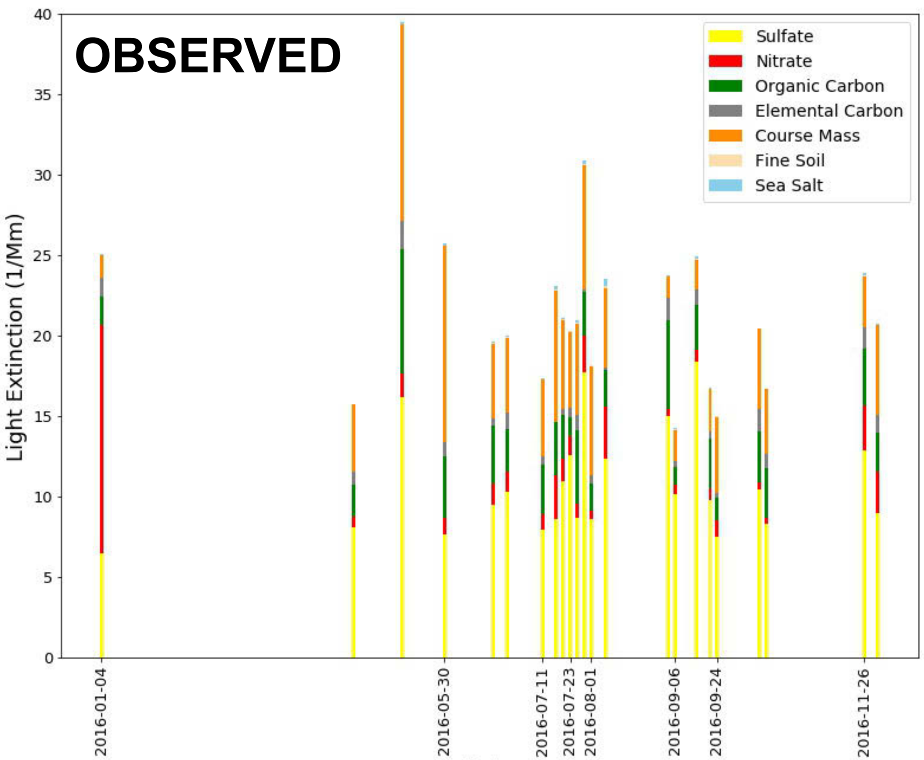
Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

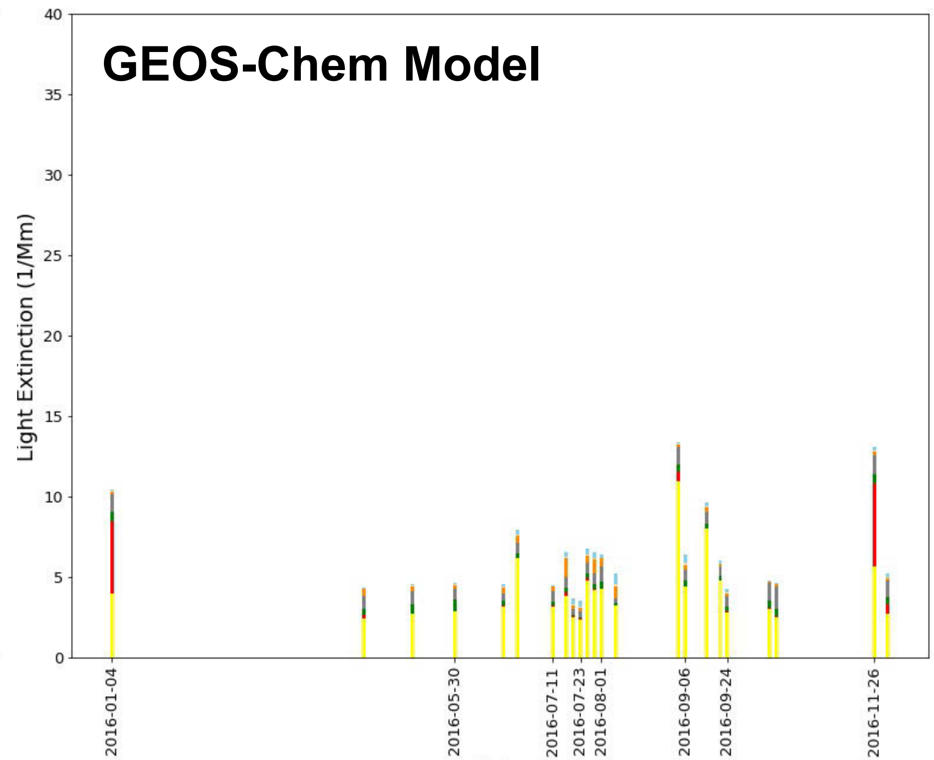
Evaluating modeled visibility by component on top 20% anthropogenically impaired days (at IMPROVE sites)

GUADALUPE MOUNTAIN (GUMO) TX, 2016

GEOS-Chem (v12.0.2; 2°x2.5°; ECLIPSEv5a w/ NEI11 over USA)

model sampled at site, only on most impaired days determined from obs. (c/o Brett Gantt, EPA)





→ MODEL TOO LOW; ESPECIALLY FOR COARSE MASS & ORGANIC CARBON

Laurel Quinones & Erik Helstrom (LDEO/Columbia); Simulations c/o Alex Karambelas, LDEO

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Evaluating modeled visibility by component on top 20% anthropogenically impaired days (at IMPROVE sites)

SAN GABRIEL MOUNTAINS (SAGA1) CA, 2016

GEOS-Chem (v12.0.2; 2°x2.5°; ECLIPSEv5a w/ NEI11 over USA)
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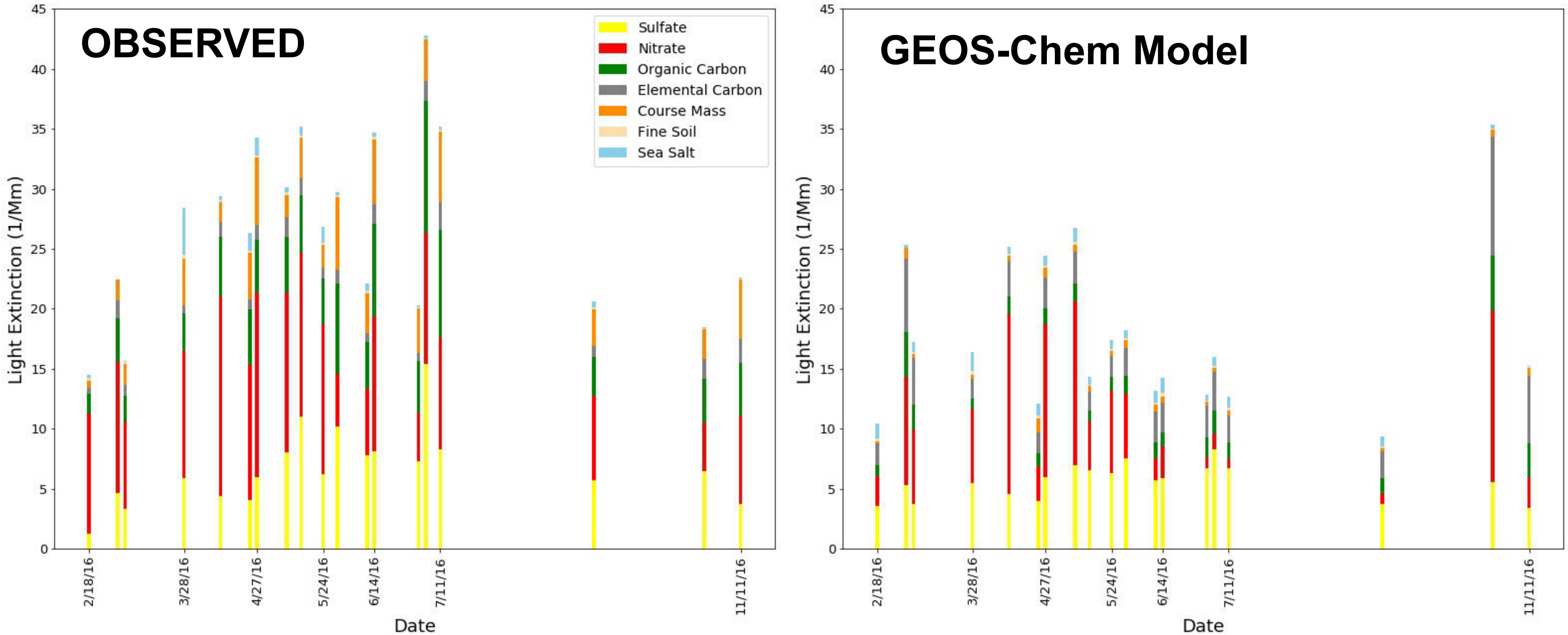


→MODEL CLOSER TO OBS HERE; ESPECIALLY FOR SULFATE & NITRATE

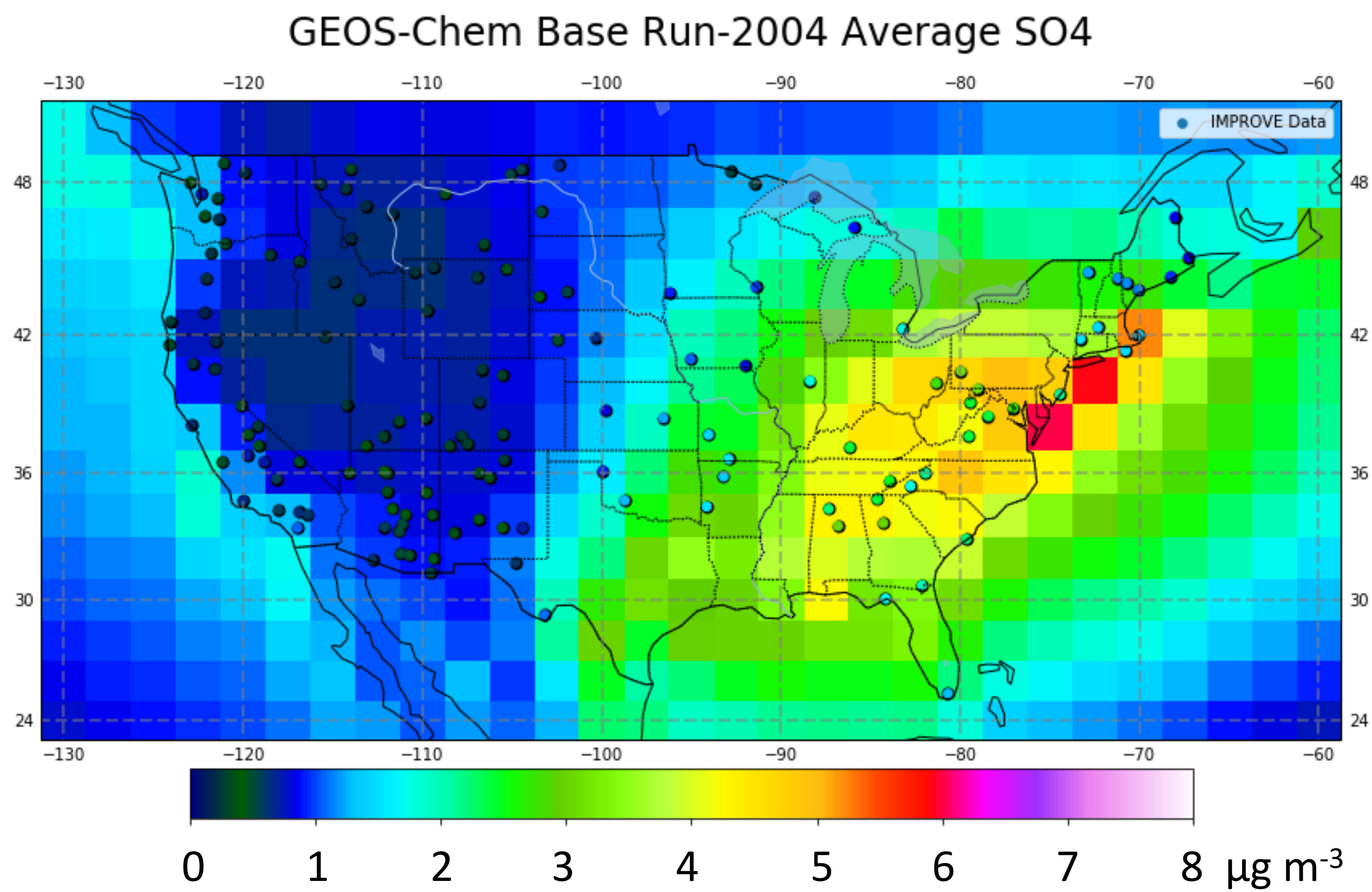
We can generate these plots, all days, haziest days, at any IMPROVE site, 2004-2012* & 2016

*GEOS-Chem v 9.02, MERRA meteorology [see Guo et al.,ACP, 2018 for details]

Laurel Quinones & Erik Helstrom (LDEO/Columbia); Simulations c/o Alex Karambelas, LDEO

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Model captures downward trend in ANNUAL MEAN SULFATE observed at IMPROVE sites (filled circles)

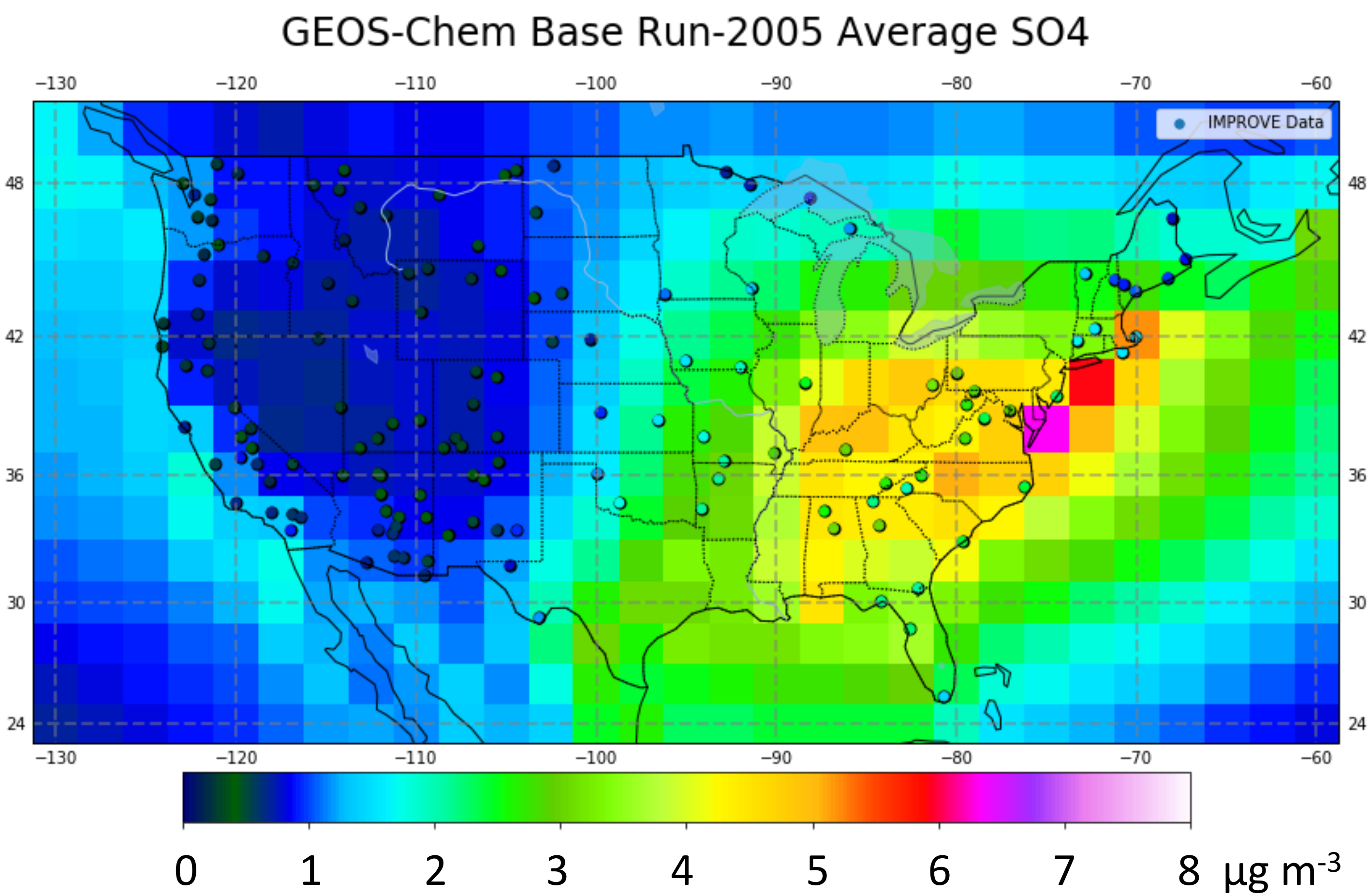


→ MODEL SULFATE HIGHER THAN OBSERVED

We have these plots for $PM_{2.5}$, individual components (GCv9.02)

Erik Helstom LDEO; Simulations from Guo et al., ACP 2018

Model captures downward trend in ANNUAL MEAN SULFATE observed at IMPROVE sites (filled circles)



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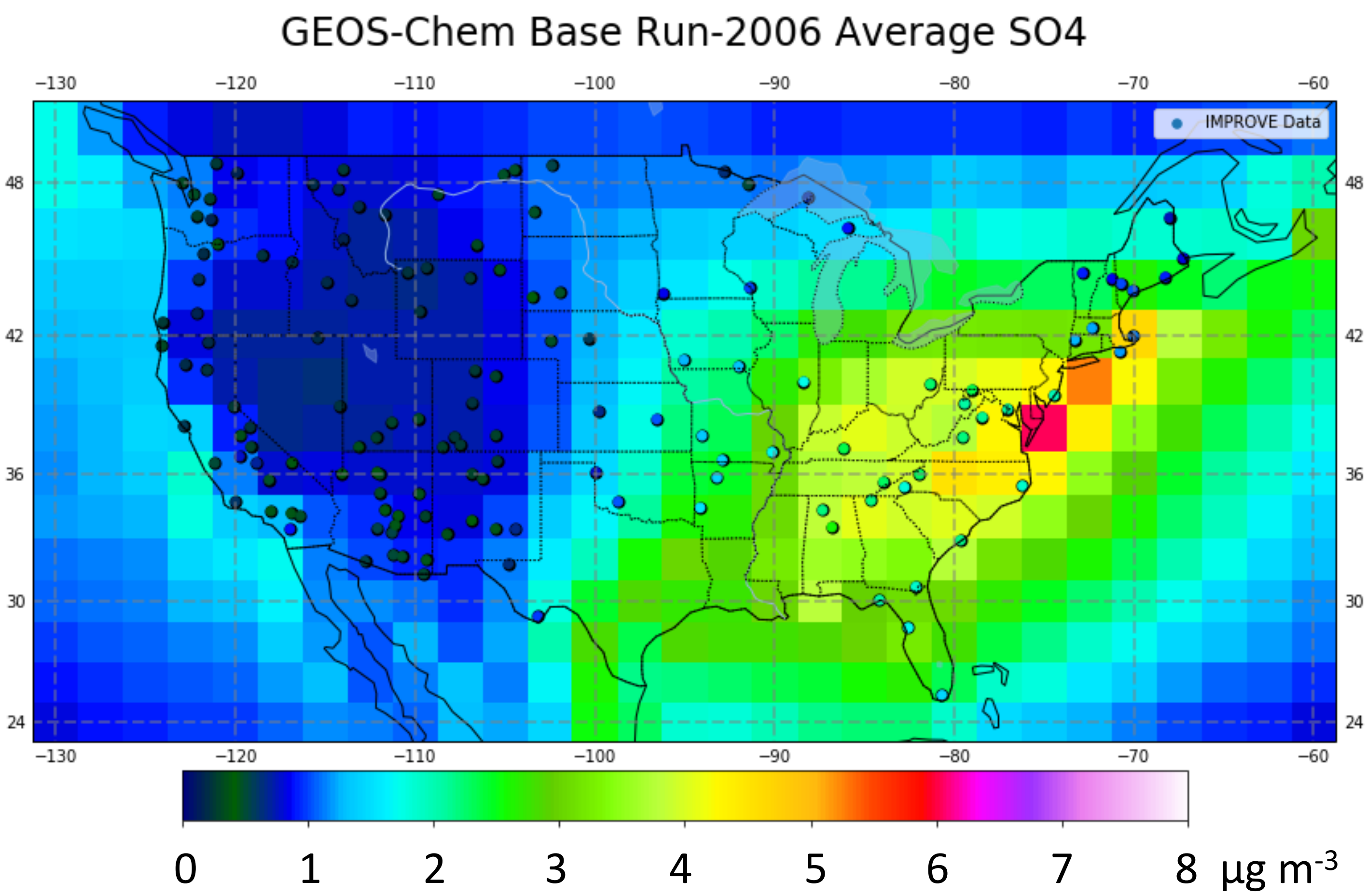

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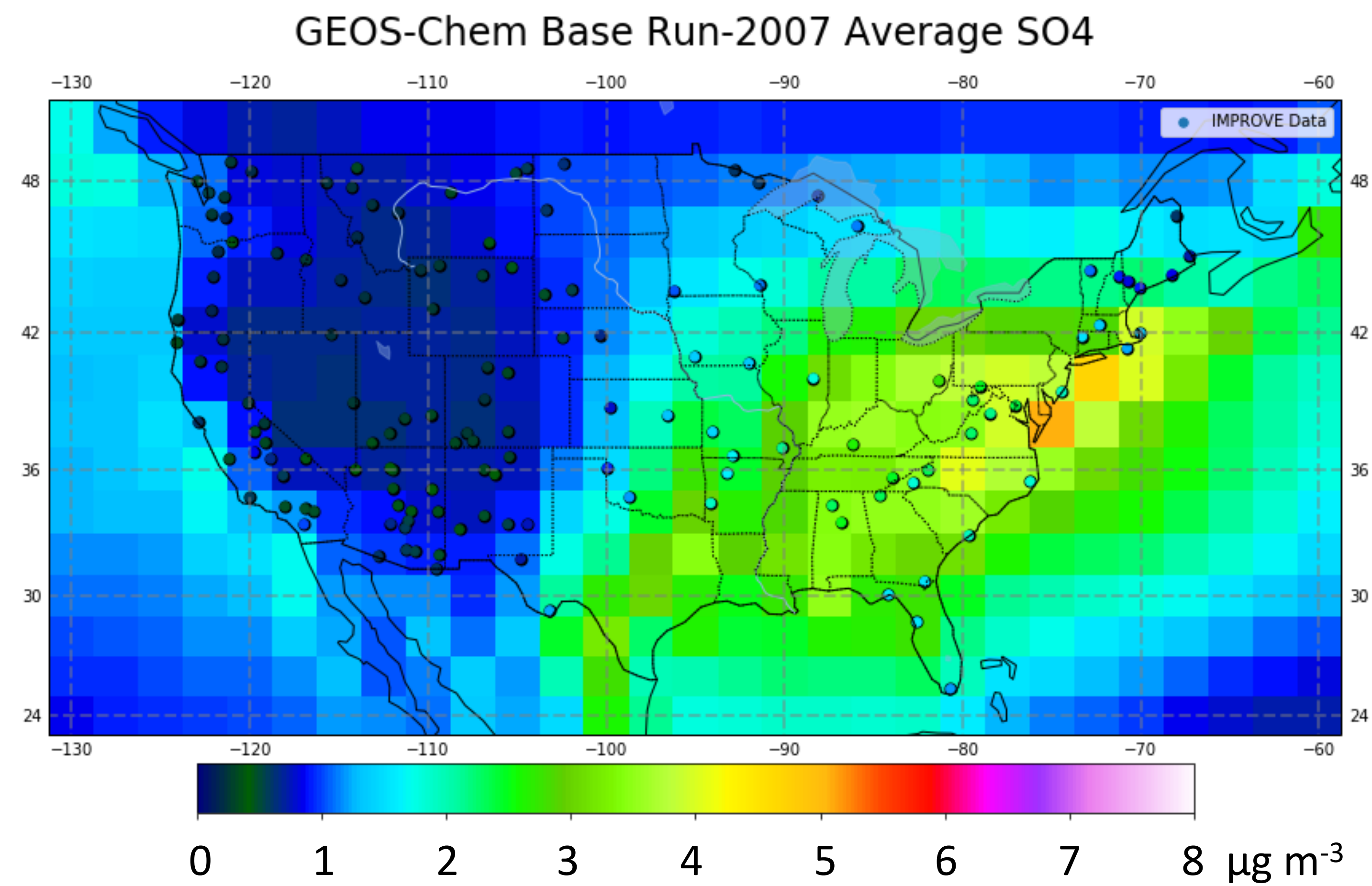

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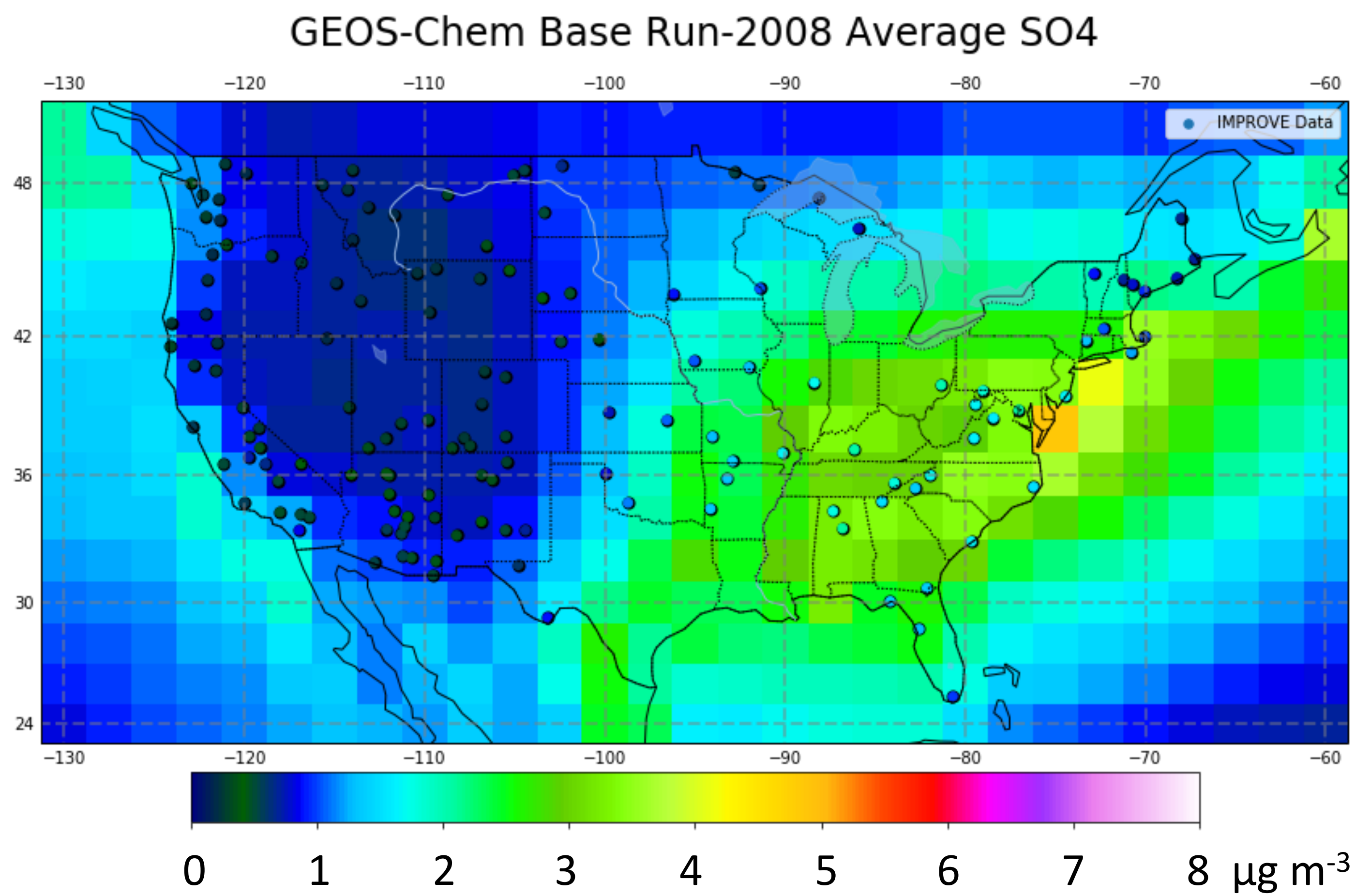

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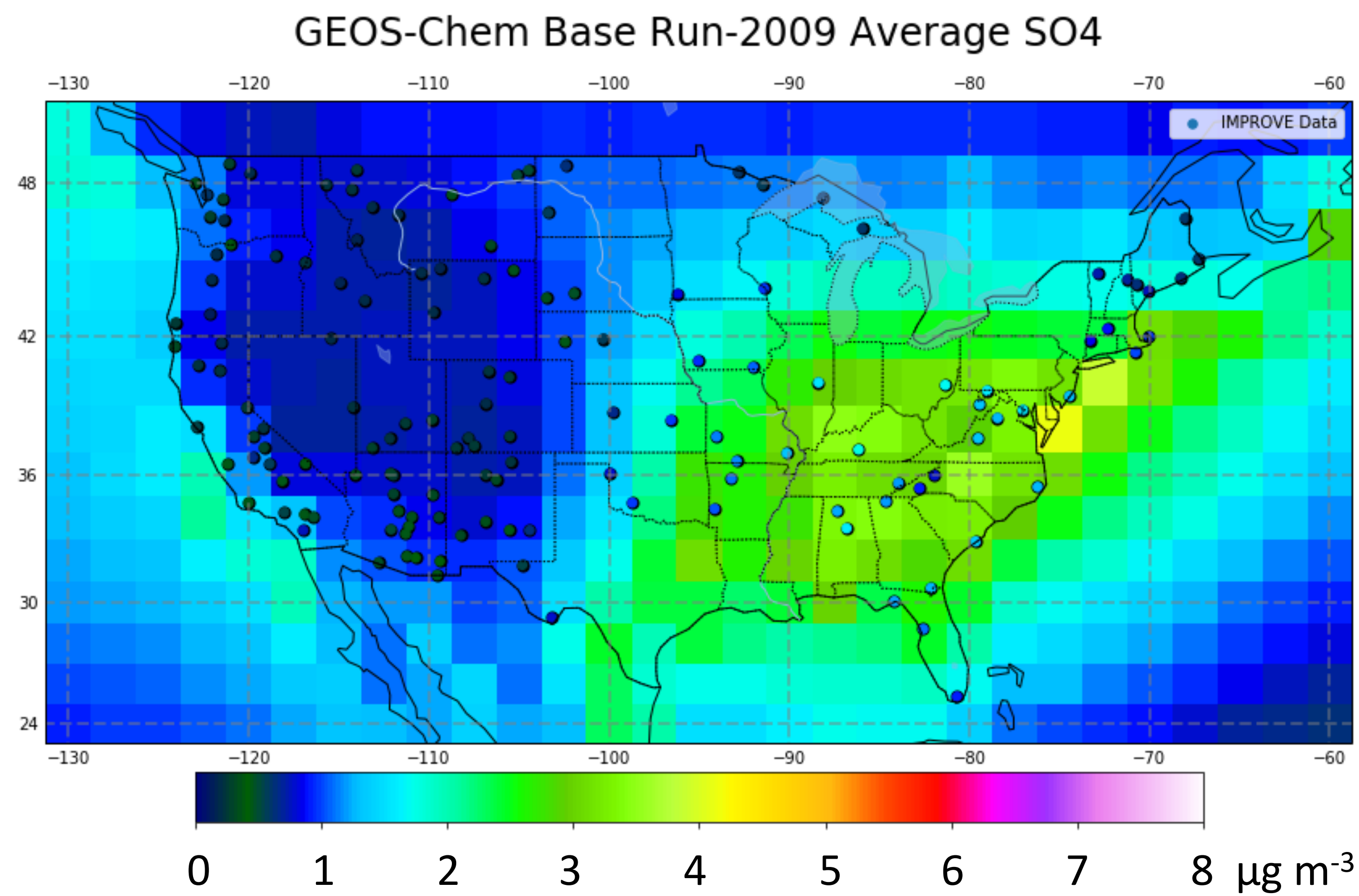

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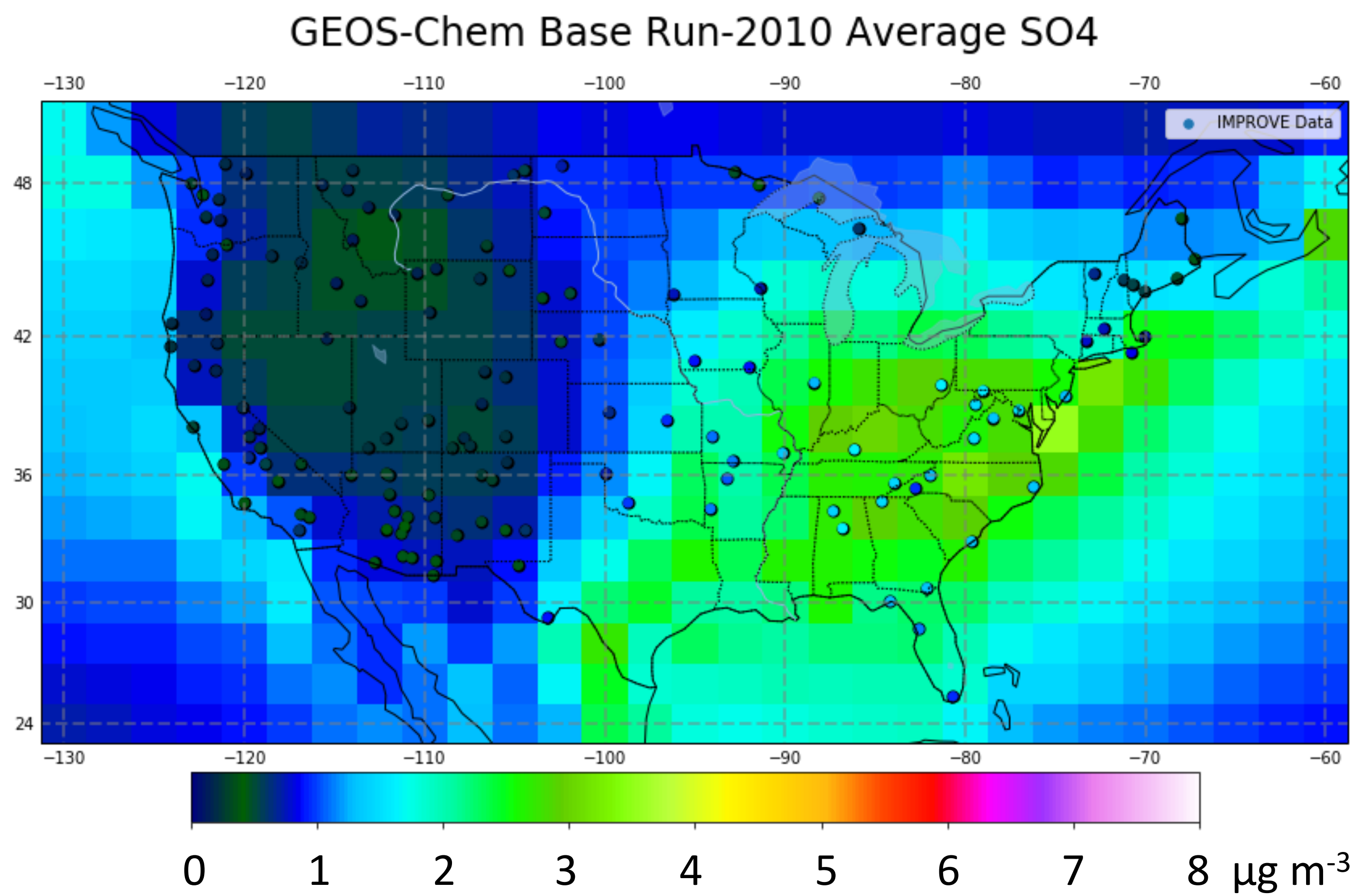

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Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

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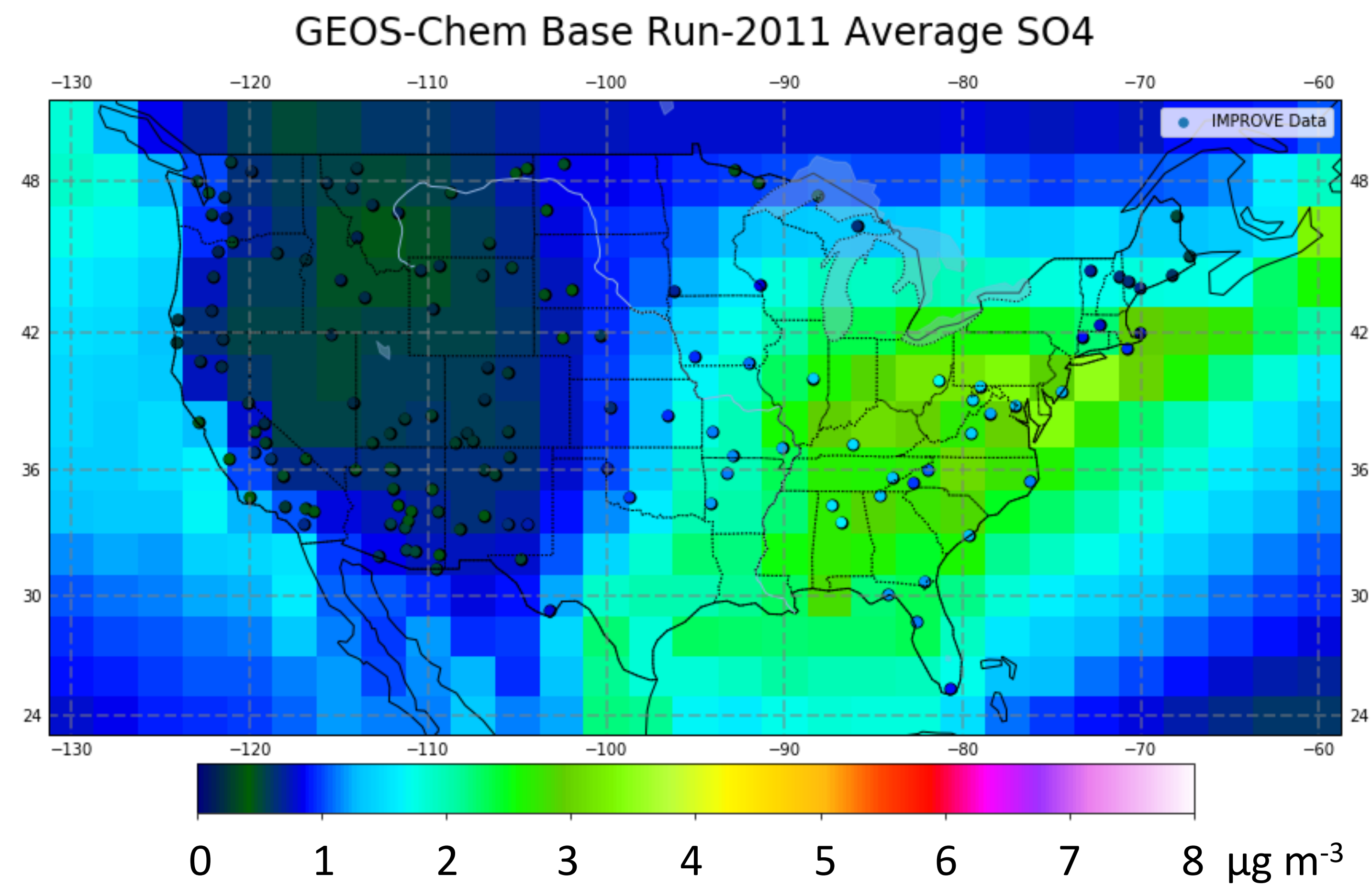

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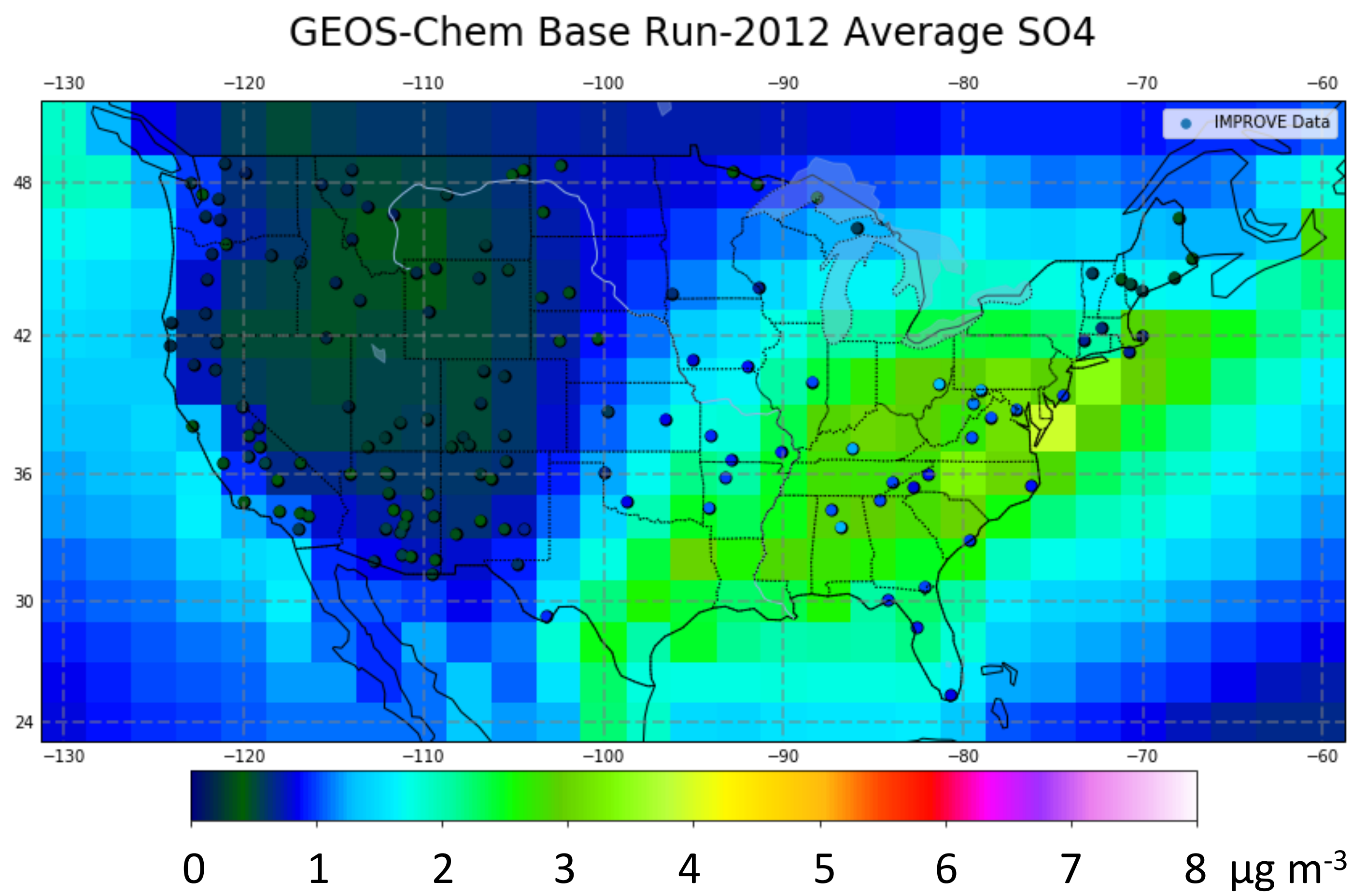
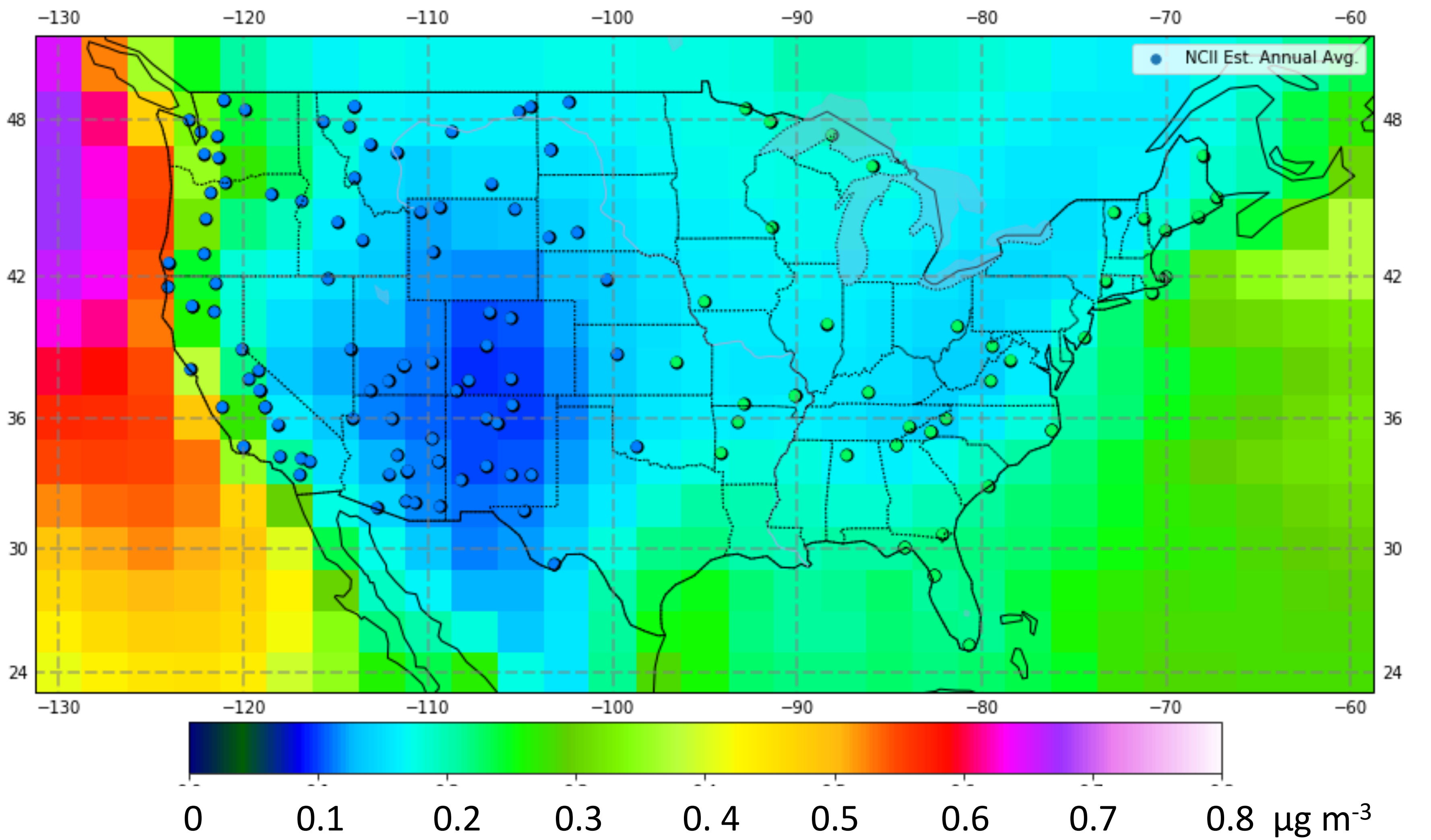


We have these plots for $PM_{2.5}$, individual components (GCv9.02)

Erik Helstom LDEO; Simulations from Guo et al., ACP 2018

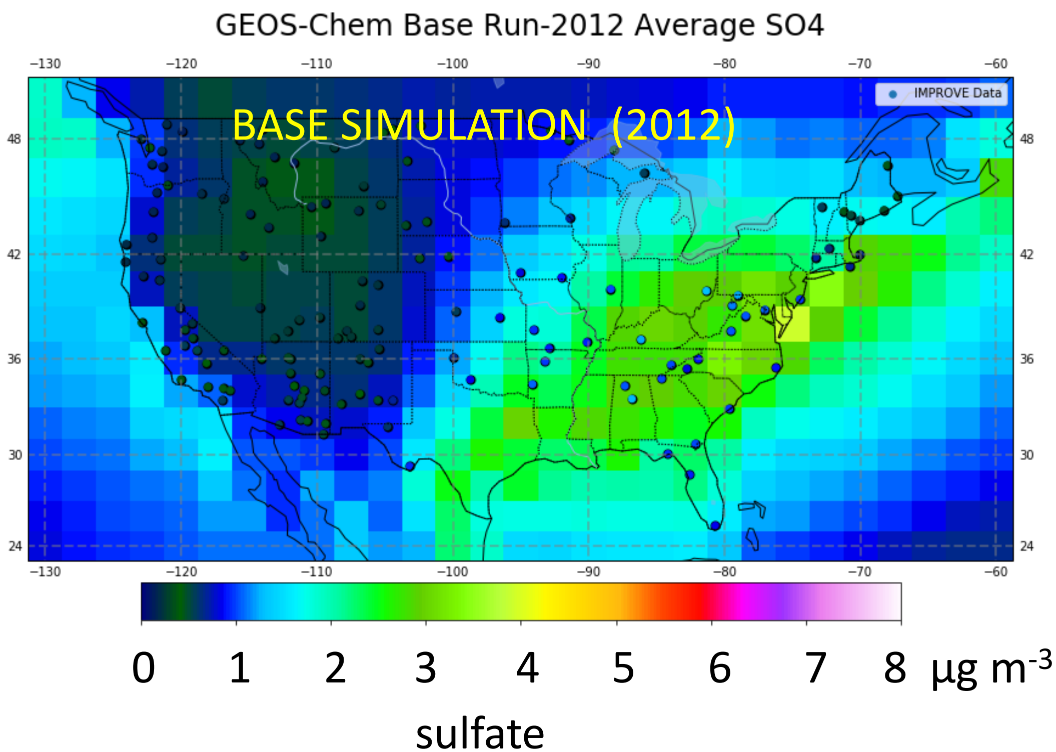
"NATURAL" SULFATE ANNUAL MEAN
Model vs NCII estimates: 2012 GEOS-Chem w/ all anthropogenic emissions turned off

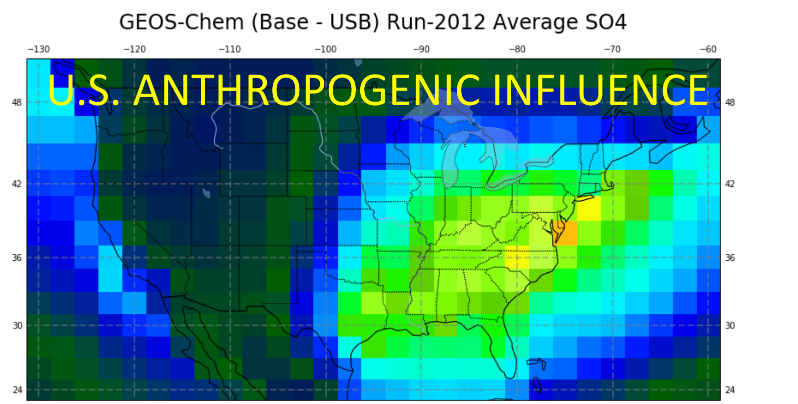


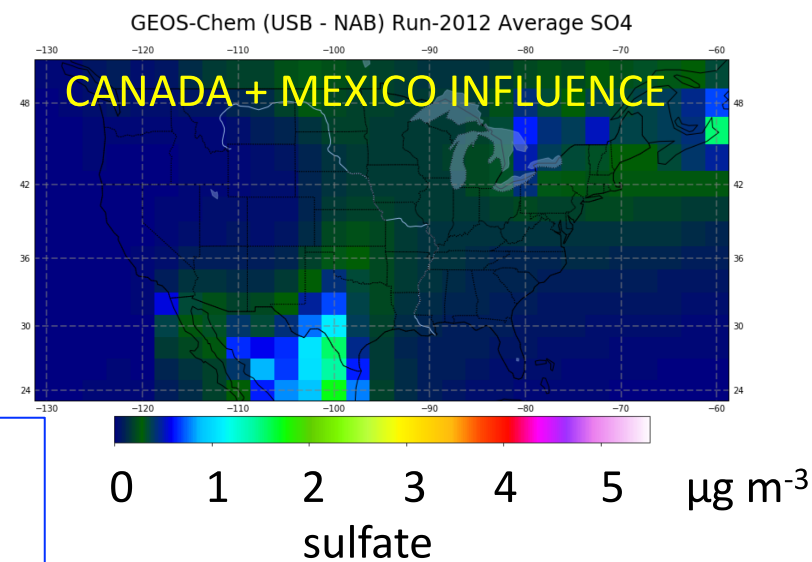
*We have these plots for $PM_{2.5}$ components 2004-2012 (GCv9.02)

Erik Helstom LDEO; Simulations from Guo et al., ACP 2018

Estimating U.S. Anthrop., Canada+Mexico influence on haze (SULFATE) with sensitivity simulations







→ Model indicates U.S. anthropogenic emissions are dominant sulfate influence except near Mexican border with TX in the model

*We have these plots for $PM_{2.5}$ components 2004-2012 (GCv9.02)

Erik Helstom LDEO; Simulations from Guo et al., ACP 2018

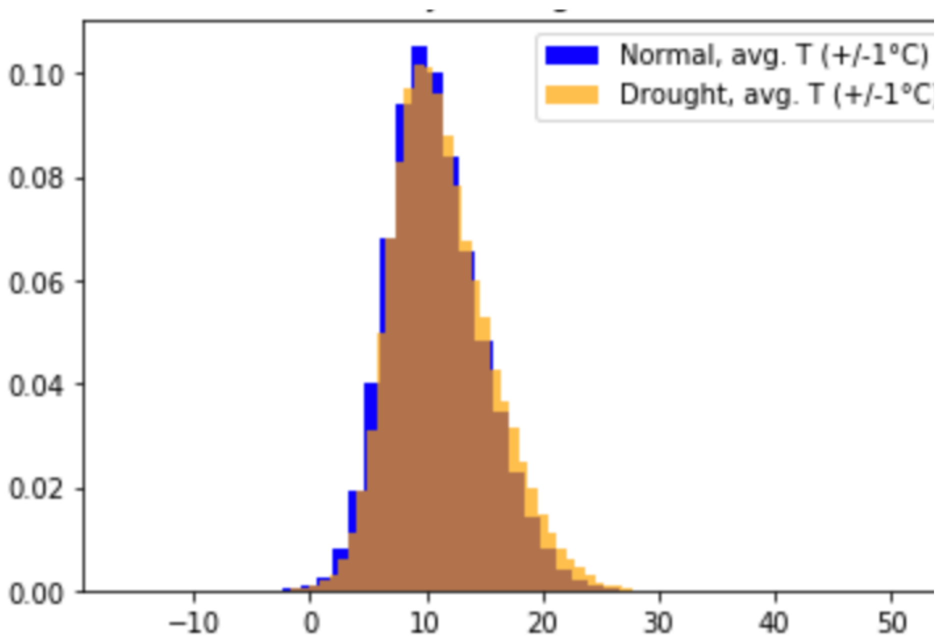
How might drought influence haze (and ozone) precursors?

OMI QA4ECV HCHO dataset (0.125° grid), June-August 2005-2014 over USA

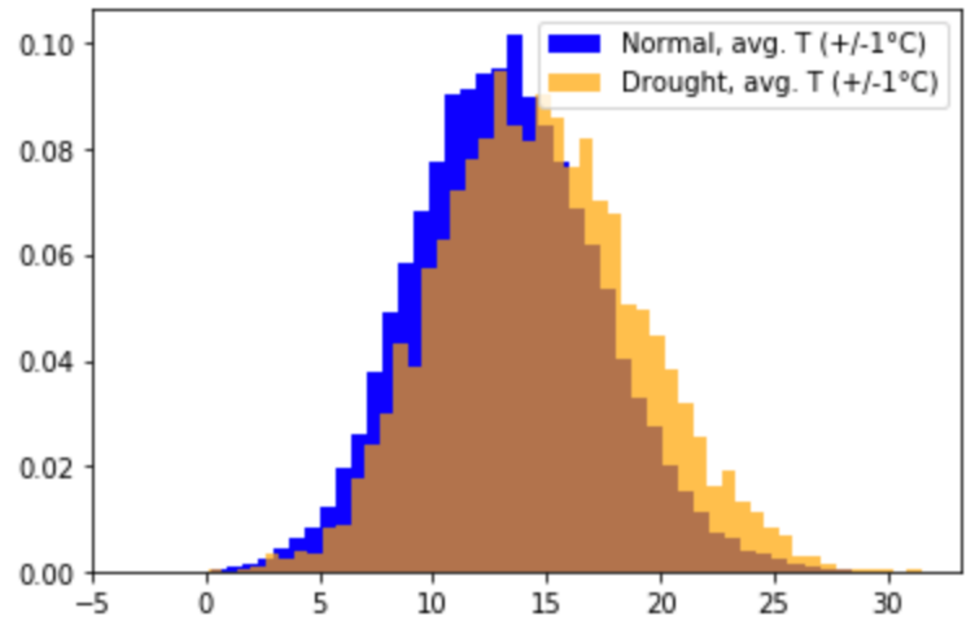
NORMAL vs. **DROUGHT**

(SPEI-based; following *Wang et al. 2017*; within ±1° temperature anomalies)

ALL U.S. GRID CELLS



U.S. GRID CELLS CLASSIFIED AS DECIDUOUS/BROADLEAF FORESTS



OMI HCHO Concentration (1×10^{15} molecules cm^{-2})

We are investigating OMI HCHO and NO_2 for different land cover types & regions

Jake Naimark, Columbia U undergraduate senior thesis; data processed by Xiaomeng Jin

Year 3 Progress Update, PI Fiore

HAQAST

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 published (ACP) on 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
  - Paper accepted (ERL) analyzing multiple $PM_{2.5}$ datasets applied for a health impact analysis from 2002-2012 over NYS.
  - Paper in preparation that derives new exposure functions for NYS & considers uncertainty by using multiple $PM_{2.5}$ products.
- 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)
- 4 academic talks; 3 stakeholder/public talks; 2 presentations to stakeholders on teleconferences

4 papers published; 1 paper accepted;
3 papers submitted; 1 in prep

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; ongoing discussions /planning analysis (see preliminary results in today's talk)
- TT Neu: Background Ozone
  - Evaluating simulations with Trinidad Head ozone sondes using Stauffer et al. 2016, 2017 self-organizing maps
  - Have 2016 AM3 and GC global simulations which can be re-run to provide regional model boundary conditions
- Led TT on Satellite Data in SIPS.
  - Finalizing editing/archival of tech. guidance docs & linking to NASA AQ from space site
  - Responding to data requests from stakeholders
- Co-I Pat Kinney led TT on Hi-Res PM2.5 data for health applications
  - Communication: monthly calls; web page; 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
  - Papers in review
- Participating in TT Anenberg: Global Health Indicators