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Dolwick, P. Mid-Atlantic States Section Annual Workshop, “Ozone: Challenges, Trends, Strategies, and New Developments.”New Brunswick, NJ, October 12th, 2017.

USEPA Update: Characterizing Background Ozone

Ozone: Challenges, Trends, Strategies, and New Developments

Mid-Atlantic AWMA: 10/12/17

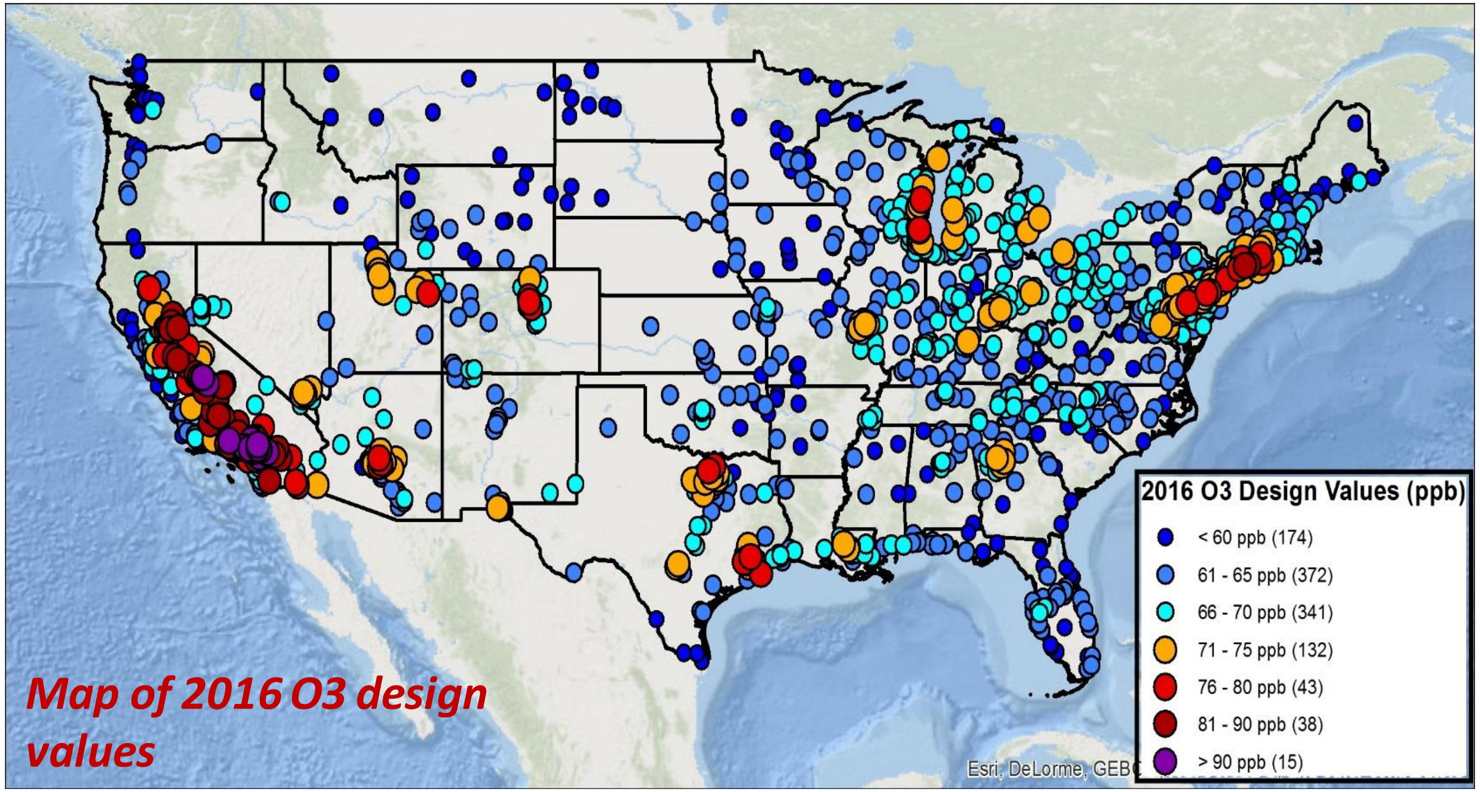
Pat Dolwick and Barron Henderson

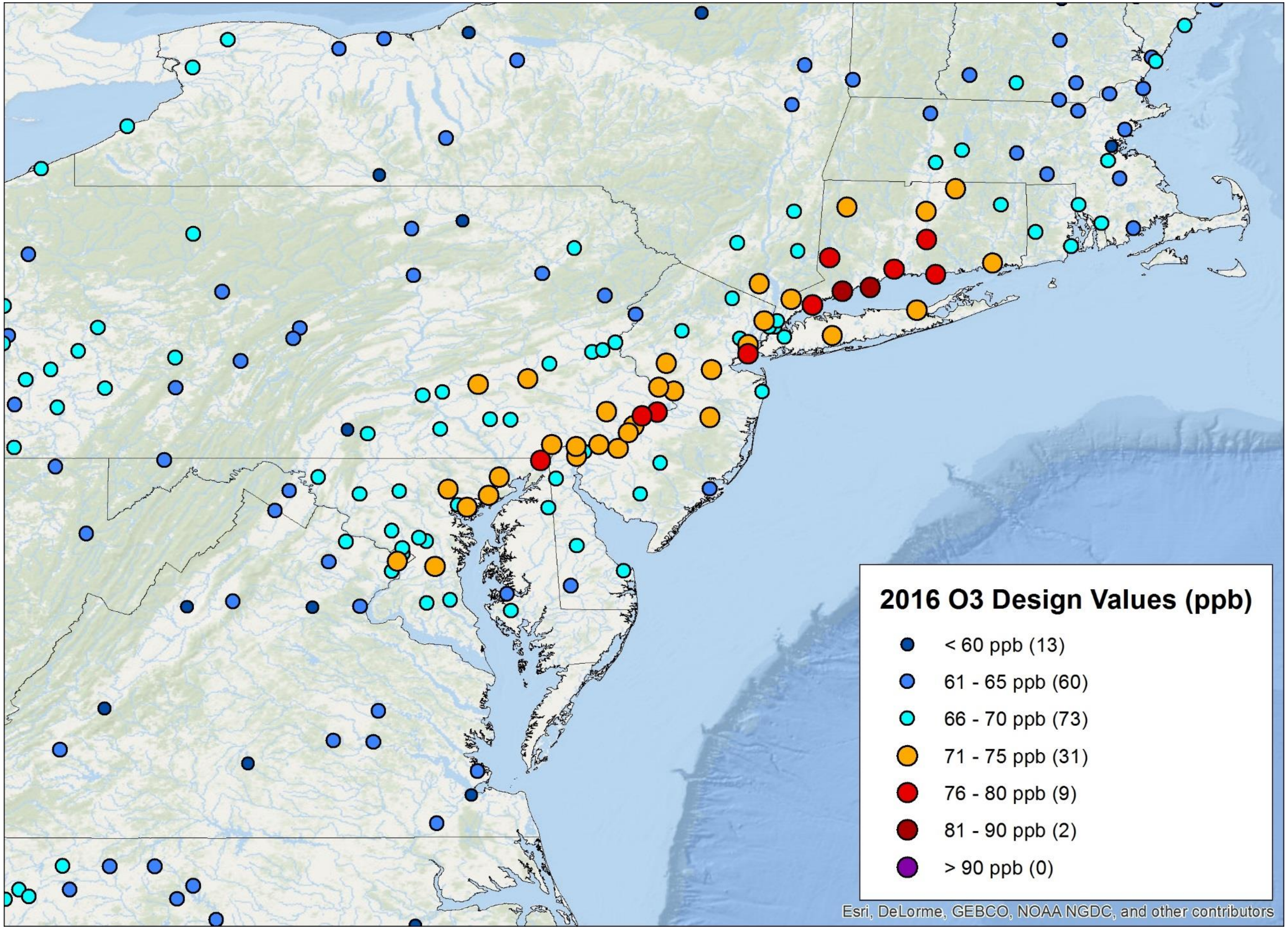
Why is O3 a problem?

- Breathing ozone (O3) can trigger a variety of health problems, including:
  - chest pain,
  - coughing,
  - throat irritation, and
  - airway inflammation

- O3 can also reduce lung function and harm lung tissue. Can worsen bronchitis, emphysema, and asthma, leading to increased medical care.

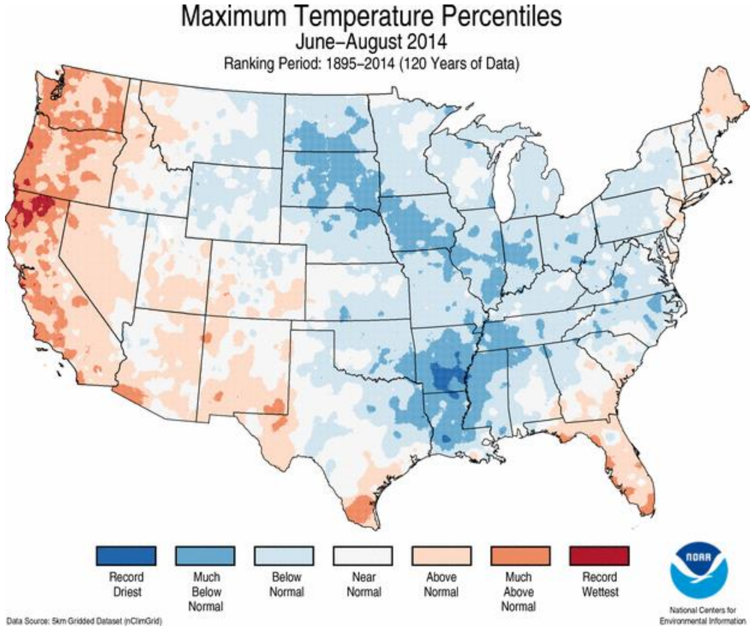
- In October 2015, EPA updated O3 NAAQS setting = 70 ppb
  - Numerous areas exceed NAAQS
  - Benefits of attainment ~ $3–6 billion/year

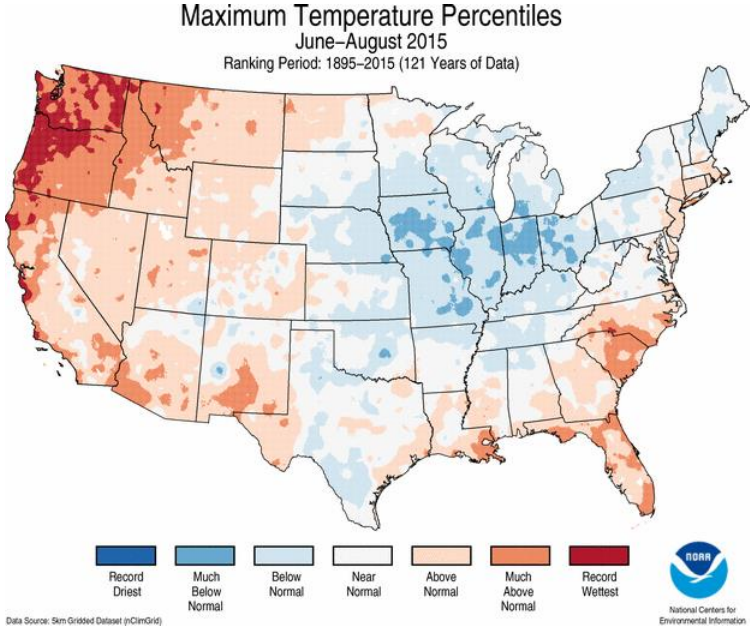




Highest O3 DV by State (R1, R2, R3)

State Name	County Name	AQS Site ID	Valid 2014-2016 Design Value (ppm)[1,2]
Connecticut	Fairfield	090019003	**0.085**
Pennsylvania	Bucks	420170012	**0.077**
Maryland	Cecil	240150003	**0.076**
New York	Richmond	360850067	**0.076**
New Jersey	Camden	340070002	**0.075**
Delaware	New Castle	100031010	**0.074**
Virginia	Arlington	510130020	**0.072**
Delaware	New Castle	100032004	**0.071**
District Of Columbia	District of Columbia	110010043	0.070
Massachusetts	Hampden	250130008	0.070
Rhode Island	Kent	440030002	0.070
West Virginia	Ohio	540690010	0.068
Maine	York	230312002	0.067
New Hampshire	Coos	330074001	0.067
Vermont	Chittenden	500070007	0.061


Maximum Temperature Percentiles
June–August 2014
Ranking Period: 1895–2014 (120 Years of Data)
Record Driest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Wettest
Data Source: 5km Gridded Dataset (nClimGrid)
National Centers for Environmental Information


Maximum Temperature Percentiles
June–August 2015
Ranking Period: 1895–2015 (121 Years of Data)
Record Driest
Much Below Normal
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Above Normal
Much Above Normal
Record Wettest
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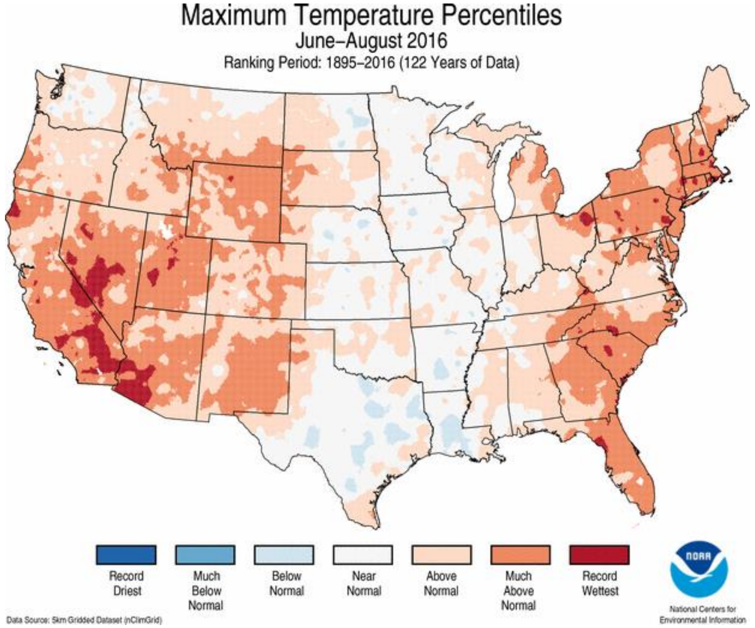
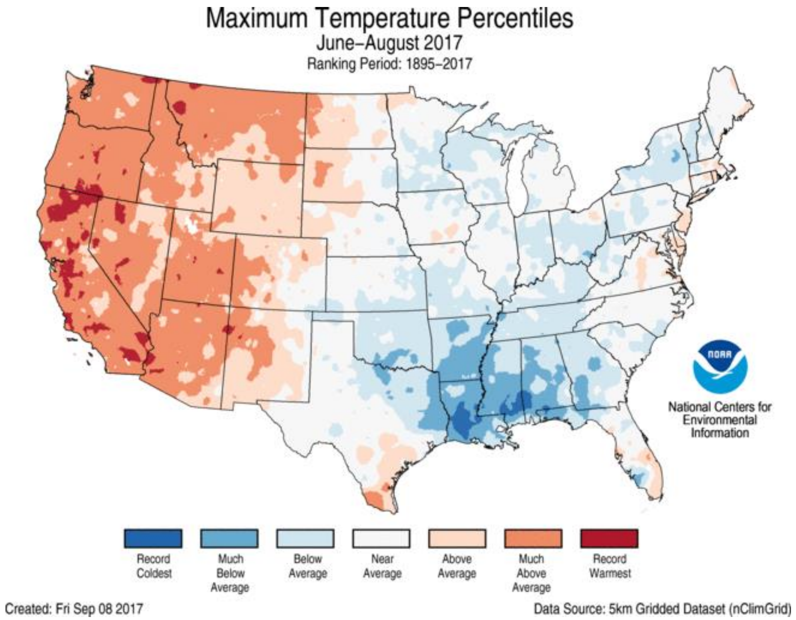
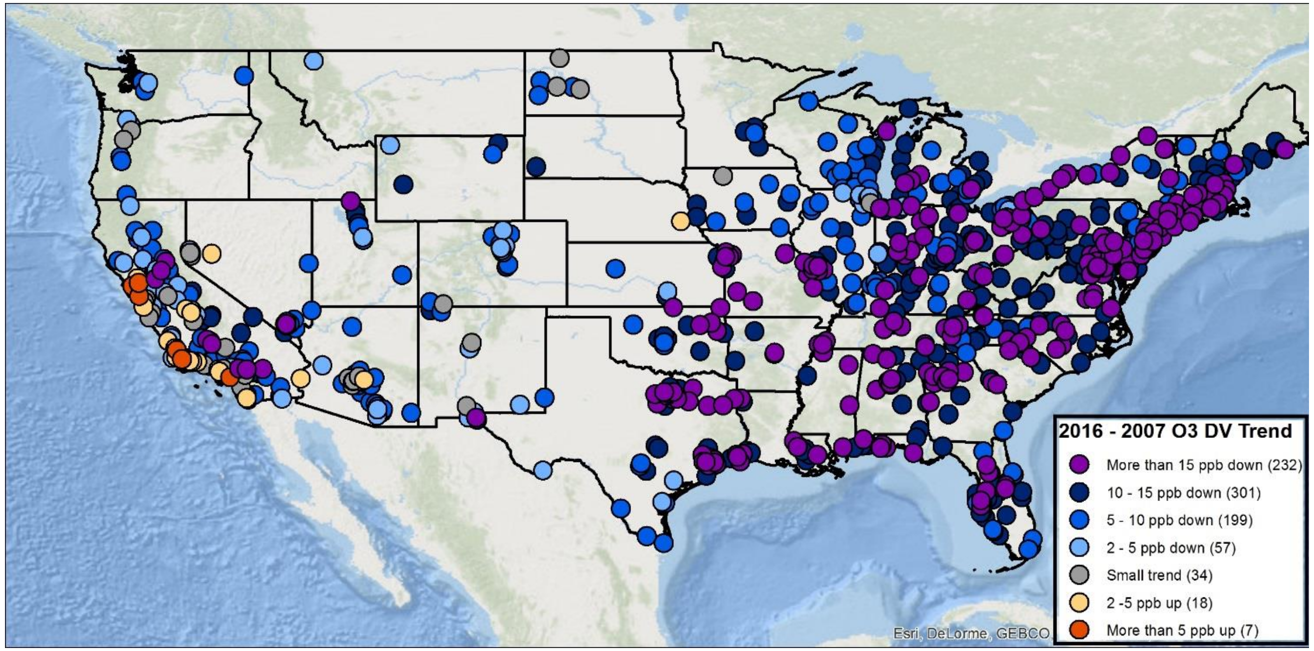
National Centers for Environmental Information


Maximum Temperature Percentiles
June–August 2016
Ranking Period: 1895–2016 (122 Years of Data)
Record Driest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Wettest
Data Source: 5km Gridded Dataset (nClimGrid)
National Centers for Environmental Information


Maximum Temperature Percentiles
June–August 2017
Ranking Period: 1895–2017
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Fri Sep 08 2017
Data Source: 5km Gridded Dataset (nClimGrid)

What are latest trends in ozone?



Trends in 2007 -> 2016 O3 DV at AQS sites w/ complete data record

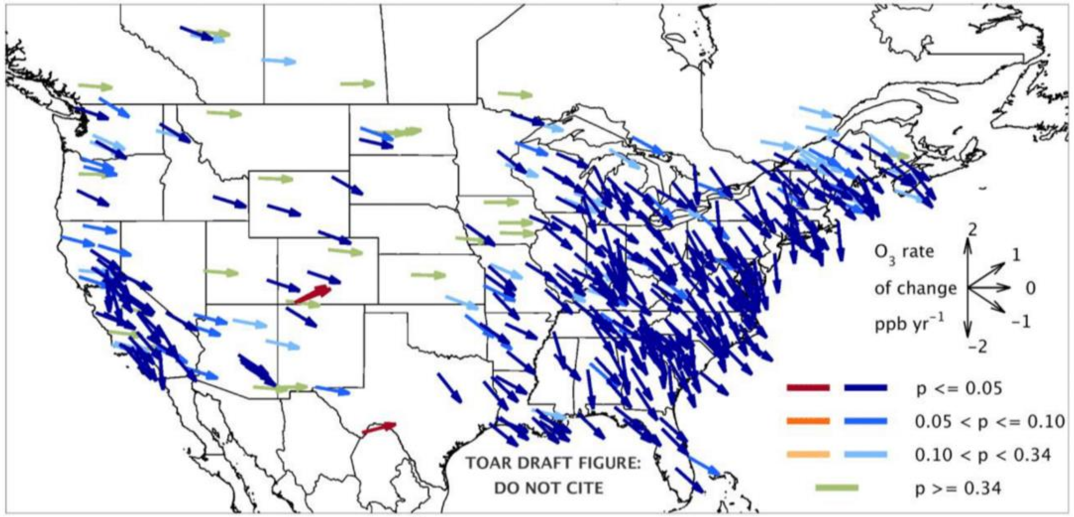


Figure S-XX. Trends of the annual 4th highest MDA8 ozone values (based on April-September observations) at all available rural ozone monitoring sites in the USA and Canada, for the period 2000-2014. Vector colors indicate the p-values on the linear trend for each site: blues indicate negative trends, oranges indicate positive trends and green indicates weak or no trend; lower p-values have greater color saturation. Figure provided by the Tropospheric Ozone Assessment Report [Schultz et al., 2017].

Trends in 2000 -> 2014 4th high MDA8 O3 at rural sites

- The last decade has seen significant improvements in O3 air quality over most of the U.S.
  - However, some parts of the country have seen flatter trends or even higher O3 levels (mostly WUS)
- States/stakeholders concern w.r.t. nonattainment due to sources outside their control.
- Can we identify culprits to remaining O3 issues?

Fundamental questions

- Which sources contribute to O3 across the U.S. and how do those contributions vary from location to location?
- What is the contribution of “background” O3 to ozone levels in the U.S.?

AMERICA

Smog In Western U.S. Starts Out As Pollution In Asia, Researchers Say

March 3, 2017 · 10:21 AM ET

BILL CHAPPELL

NPR (3/2017)

Nitrogen oxide pollution in India and China is offsetting U.S. gains in cutting emissions, researchers say. This photo from October shows road traffic, along with smoke and smog, in front of the landmark India Gate in New Delhi.

Manish Swarup/AP

Fort McMurray fires cause air pollution spike on other side of continent

Smoke from Alberta fire was so massive the plumes created their own environmental system

By Margo McDiarmid, CBC News Posted: Sep 26, 2017 5:00 AM ET | Last Updated: Sep 26, 2017 5:13 AM ET

CBC News (9/2017)

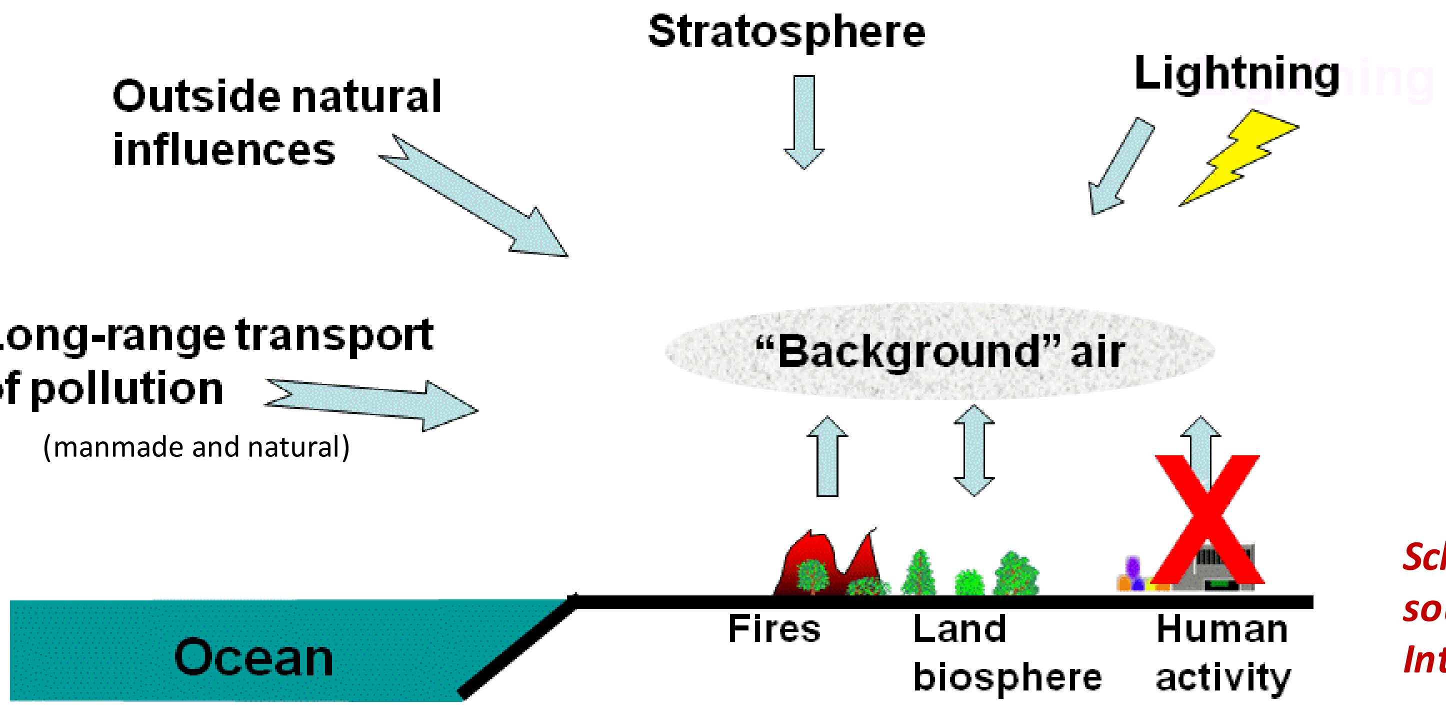
When Good Ozone Goes Bad

Weather patterns, trans-Pacific pollution cause spring ozone spikes in the southwest US

WEDNESDAY, JANUARY 25, 2017

CIRES News (1/2017)

What is "Background" Ozone?



Schematic of background O3 sources from the most recent Integrated Science Assessment

Definitions

"Ozone concentrations that are produced by sources other than _____"

- "all people" - Natural Background
- "all people in the U.S., Canada and Mexico" - North American Background
- "all people in the U.S." - U.S. Background
- "all people in a state" – State-specific background

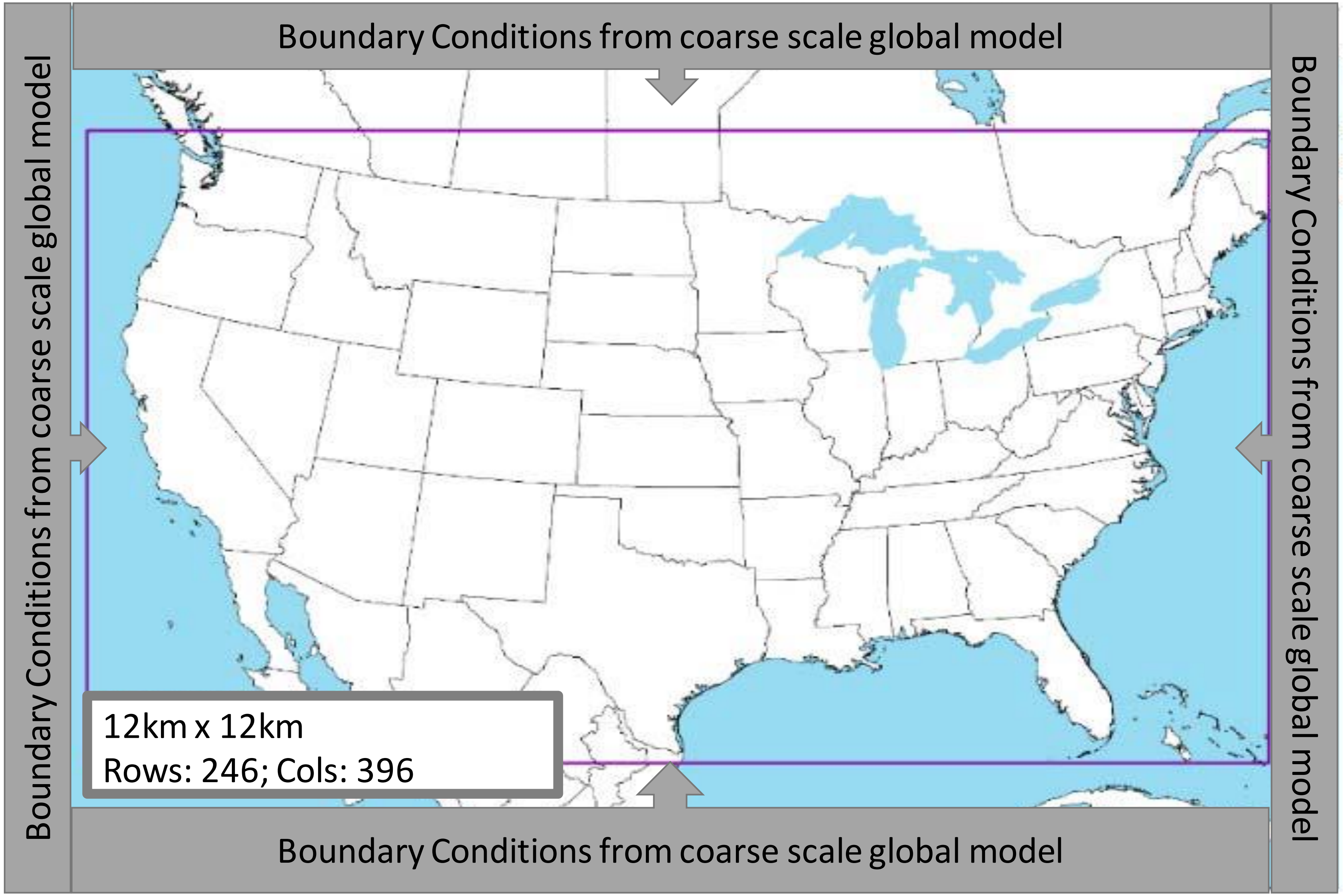
Background ozone is not directly measurable. Estimates require use of photochemical modeling tools.

How do we use models to examine ozone formation?

Methods

- Zero-out
- Brute force sensitivities
- Adjoint
- Direct Decoupled Method
- Source Apportionment
  - Kinetic Collision Theory?
  - CMAQ ISAM
  - CAMx OSAT/APCA

- Modeling typically done at 12x12 km resolution with NEI-based emissions and WRF-based meteorology



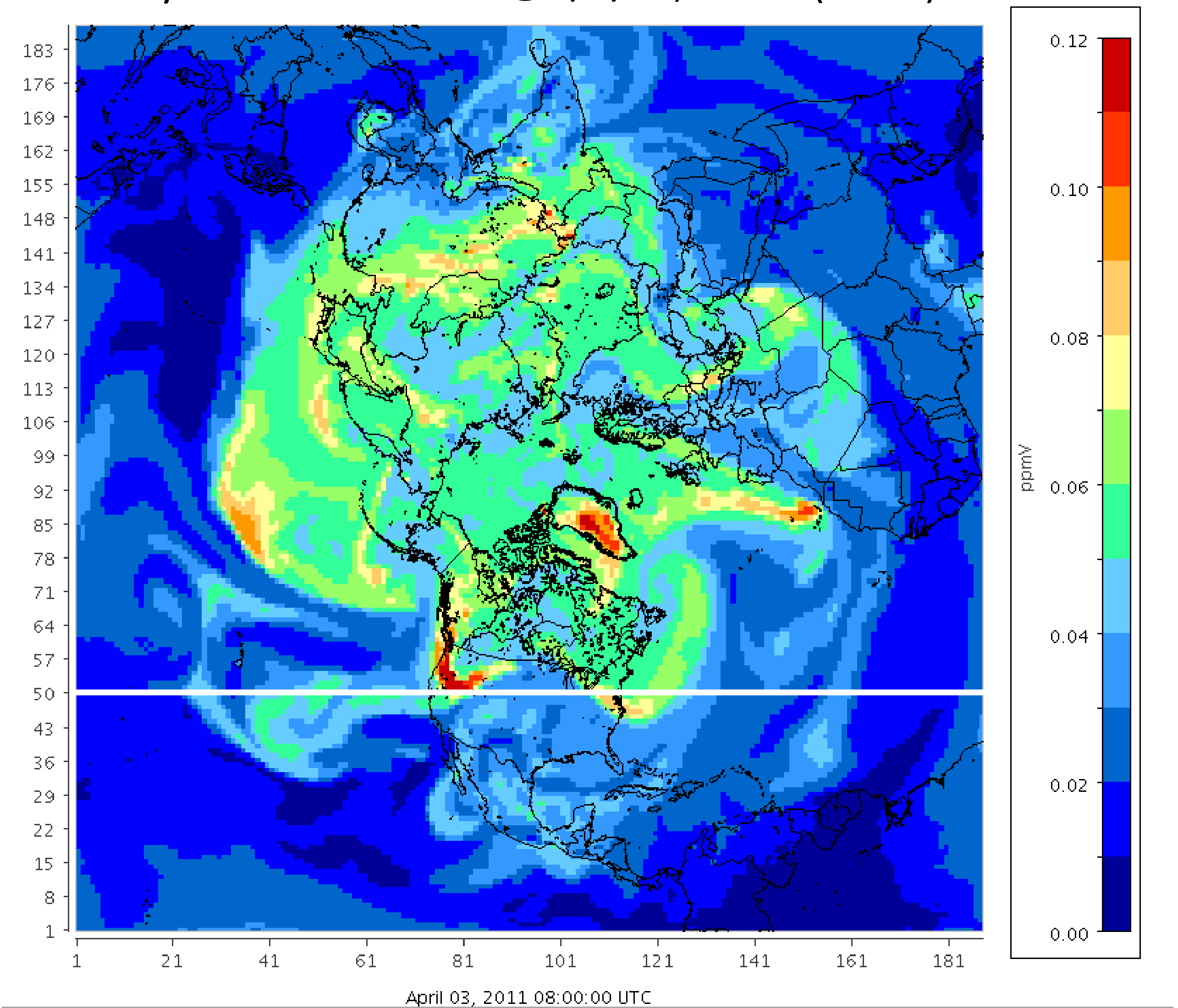
Many sources of background ozone are global

- Biogenics
- Soil NOx
- Wildfires
- Lightning*
- Stratosphere*
- Anthropogenic International Transport*
- O3 from methane*

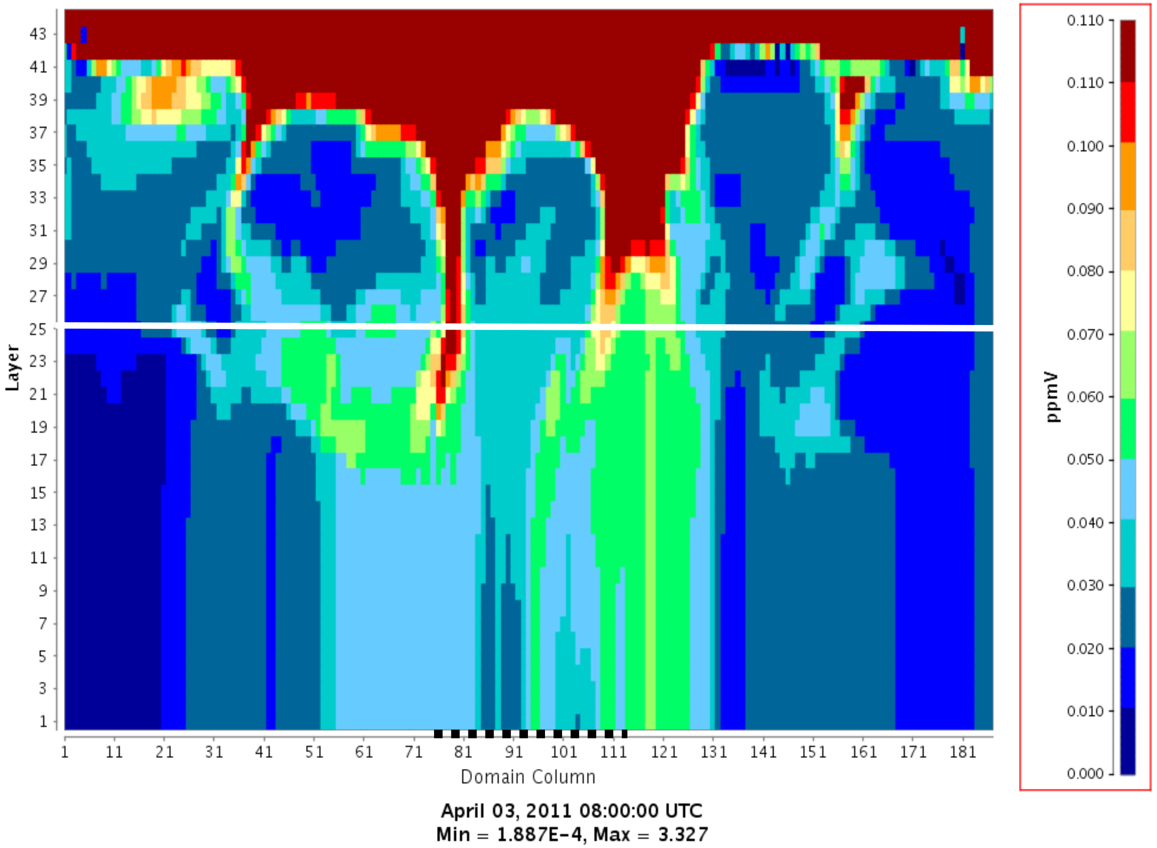
Almost exclusively from global/hemispheric model

Case study: Stratospheric intrusion in H-CMAQ

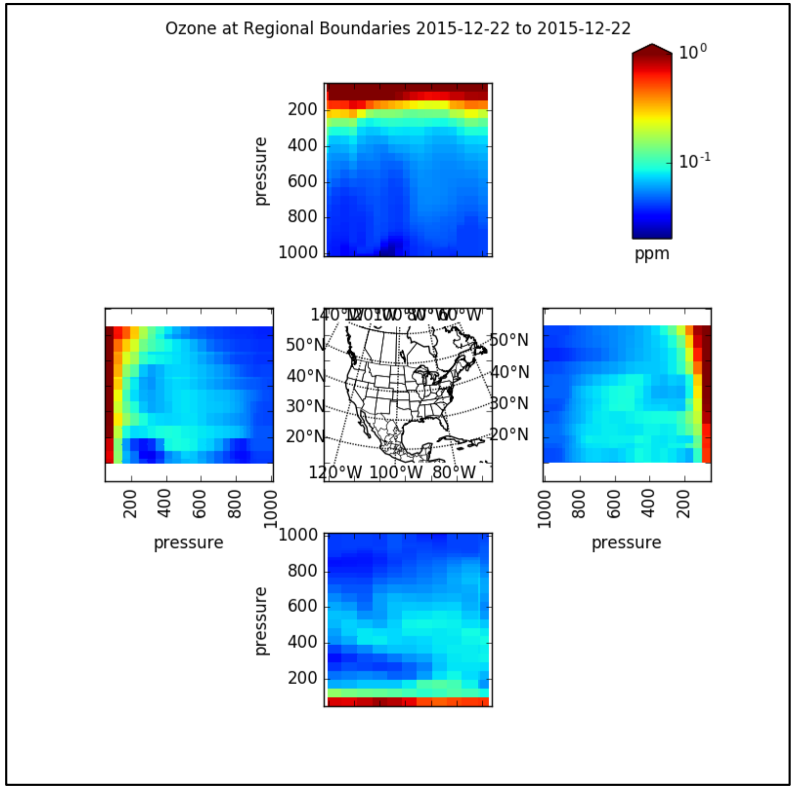
Layer 25 H-CMAQ O3 @4/3/11, 0800Z (~4km)



Row 50 H-CMAQ O3 @ 4/3/11, 0800Z

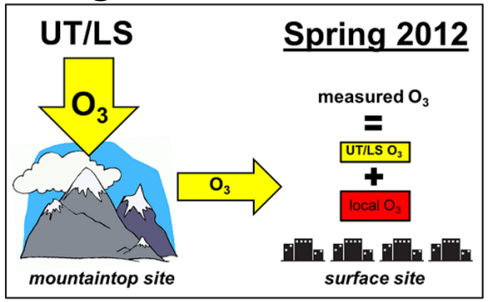


What approaches should be used to evaluate global models?



- Basic consistency checks
- Only "Baseline" monitors
- Ozone sondes and Profilers
- Routine aircraft measurements
- Satellite
  - Tropospheric Emission Spectrometer Ozone
  - Ozone Monitoring Instrument: Ozone, Nitrogen Dioxide
  - Measurements Of Pollution In The Troposphere: Carbon Monoxide

e.g, Mount Bachelor



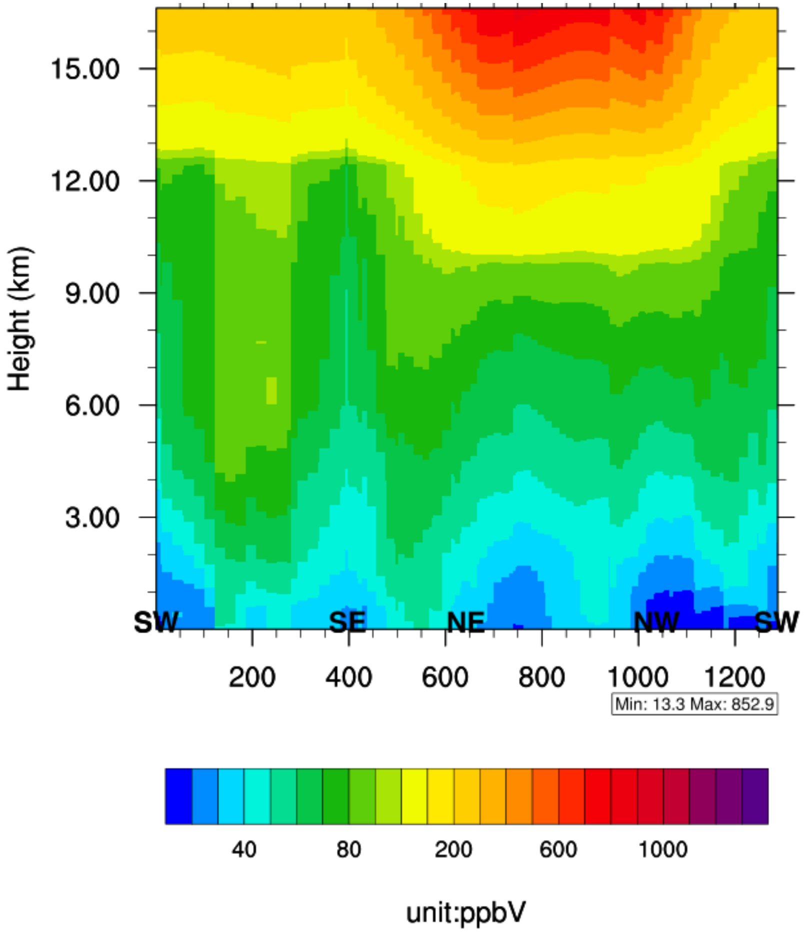
e.g, Trinidad Head, CA

e.g, IAGOS

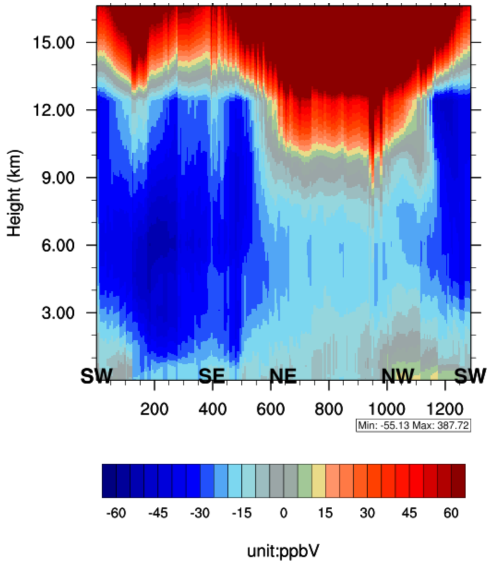
e.g, TES

Sample evaluation products (basic consistency checks)

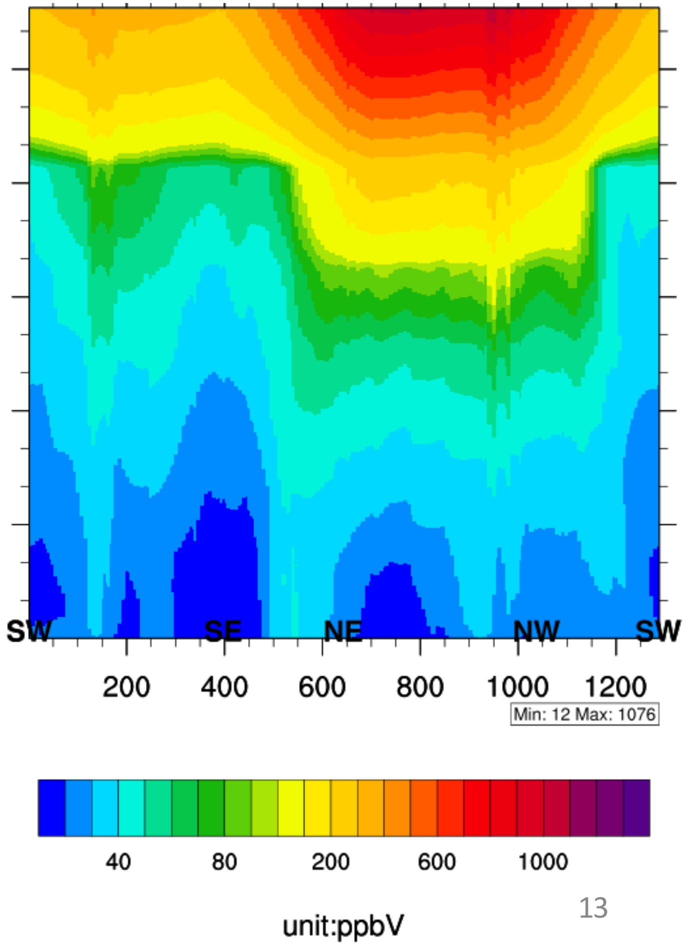
GEOS-CHEM (August Mean O3)



Difference plot

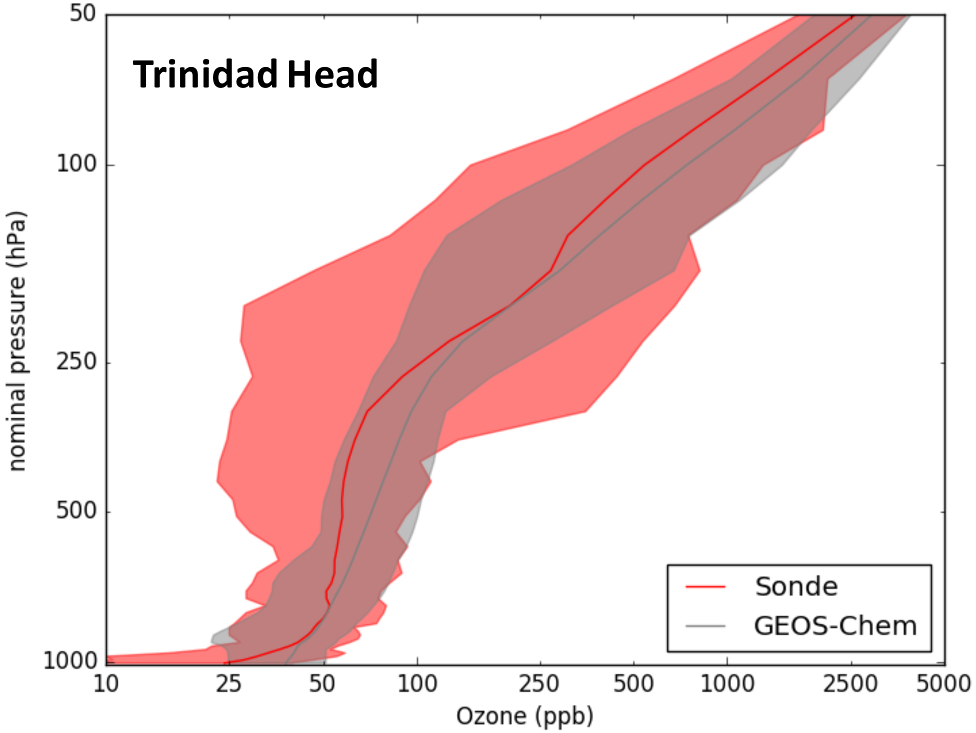


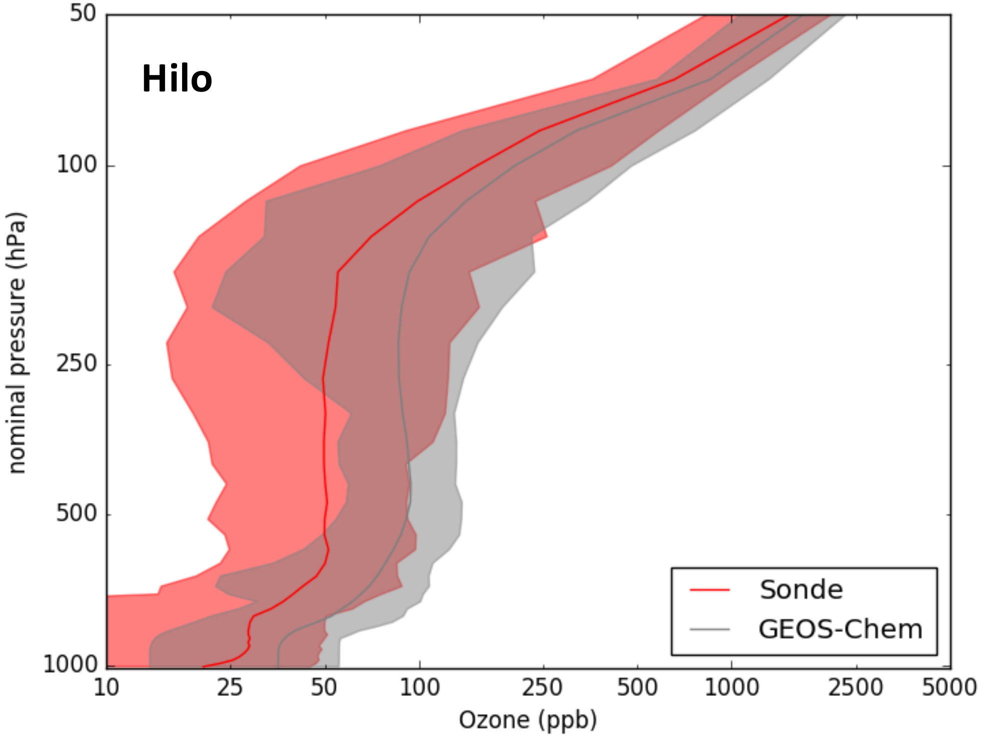
H-CMAQ (August Mean O3)



Sample evaluation products (O3 sonde comparisons)

Cloud = 0,100%; Red = Observation; Grey = GEOS-Chem





- Consistent with benchmark evaluation published with each GC release
- Trinidad Head performance is better than Hilo
- More variance in observations than model

Continual efforts to improve global model simulations

- Satellite constraints on global emissions
- International emission trends (see right)
- Wildfire emissions
- Lightning NOx parameterization
- Halogen chemistry at the global scale
- Stratospheric/tropospheric exchange
- Vertical transport between the free troposphere and the boundary layer.
- Many, many other inputs/parameters

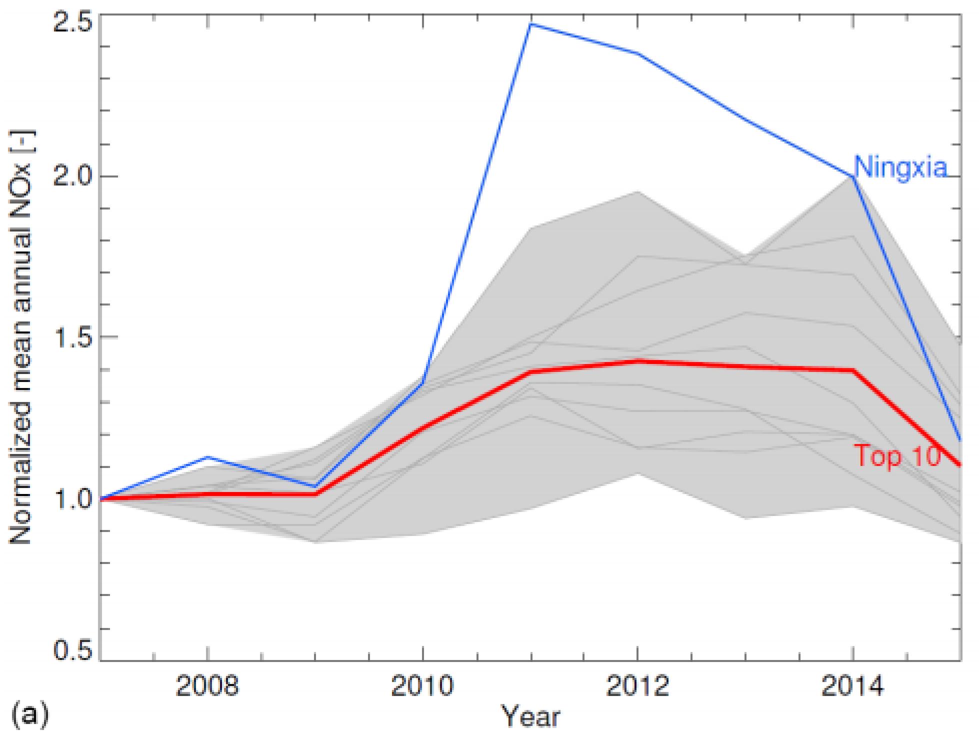
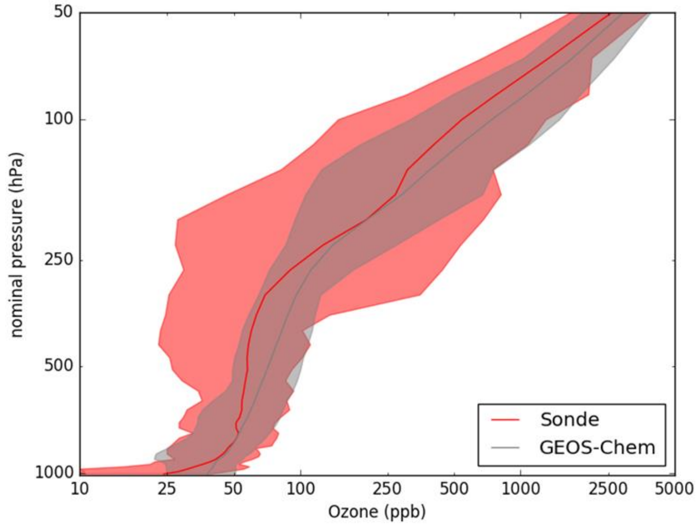


Figure 5a. The annual total NOx emission estimates for the last 9 years for the top 10 highest NOx -emitting provinces in East China. Emissions are derived with DECSO V4 using OMI observations. The thin grey lines show the individual time series of those provinces.

van der A, Atmos. Chem. Phys., 17, 1775–1789, 2017

State of the science w.r.t. global models

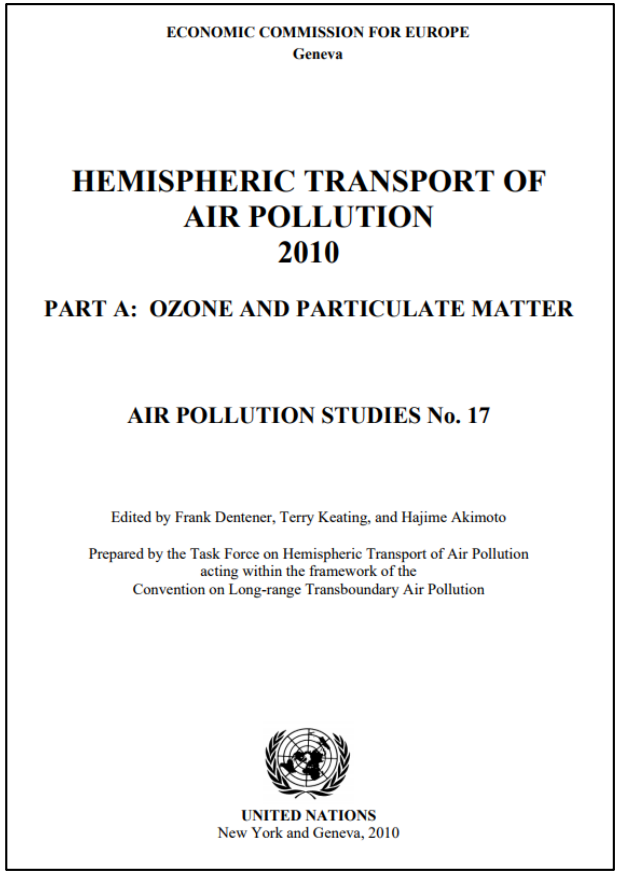
- Global science can provide key insights
  - How does international transport influence local concentrations?
  - How do global background source influence local concentrations?
- Global models provide key inputs
  - Hourly boundaries are a key input for regional models, but not a key output for global modelers.
  - We must use responsibly, which means first understanding and next evaluating.
- Boundary Condition Evaluation
  - Must be evaluated separately from surface measurements.
  - Satellites, sondes, and aircraft (need more of all of them)
- Global emissions are not constant
  - **Updating** and **projecting** is very important to this community
  - Evaluating international inventories is challenging
- Need partners
  - What global model/simulation are you using?
  - What features need evaluation and can we help?



On-going efforts to quantify international impacts?

- There are multiple, on-going community efforts designed to assess ozone attribution, especially domestic vs. imported.
  - Hemispheric Transport of Air Pollution, Phase 2 (HTAP)
  - Background Ozone Scientific Assessment (BOSA)
  - NASA Health and AQ Applied Science Team (H-AQAST)
  - Regional/State/Local/Stakeholder analyses

- EPA modelers are actively engaged in community efforts. Our methodologies generally align with community analyses (models, emissions, meteorology, etc.), although results can vary.
  - Plans to model recent years with multiple global models (GEOS-Chem, hemispheric CMAQ)
  - Plans to evaluate model performance and perform diagnostic tests to improve simulations
  - Plans to assess sensitivity of upstream international emissions on simulated U.S. ozone
  - Plans to assess multiple future years with multiple global models


ECONOMIC COMMISSION FOR EUROPE
Geneva

HEMISPHERIC TRANSPORT OF AIR POLLUTION 2010

PART A: OZONE AND PARTICULATE MATTER

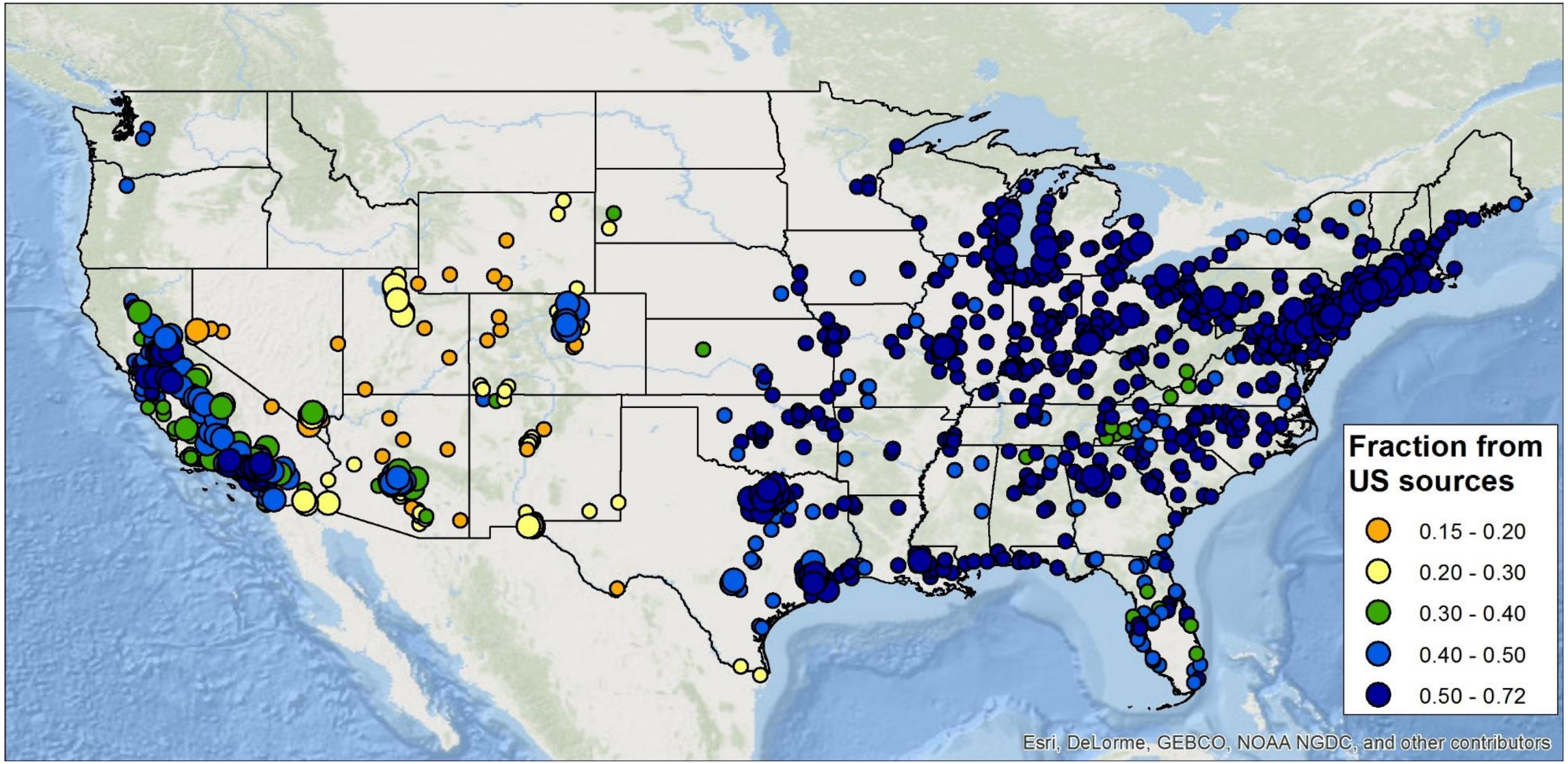
AIR POLLUTION STUDIES No. 17

Edited by Frank Dentener, Terry Keating, and Hajime Akimoto

Prepared by the Task Force on Hemispheric Transport of Air Pollution acting within the framework of the Convention on Long-range Transboundary Air Pollution

UNITED NATIONS
New York and Geneva, 2010

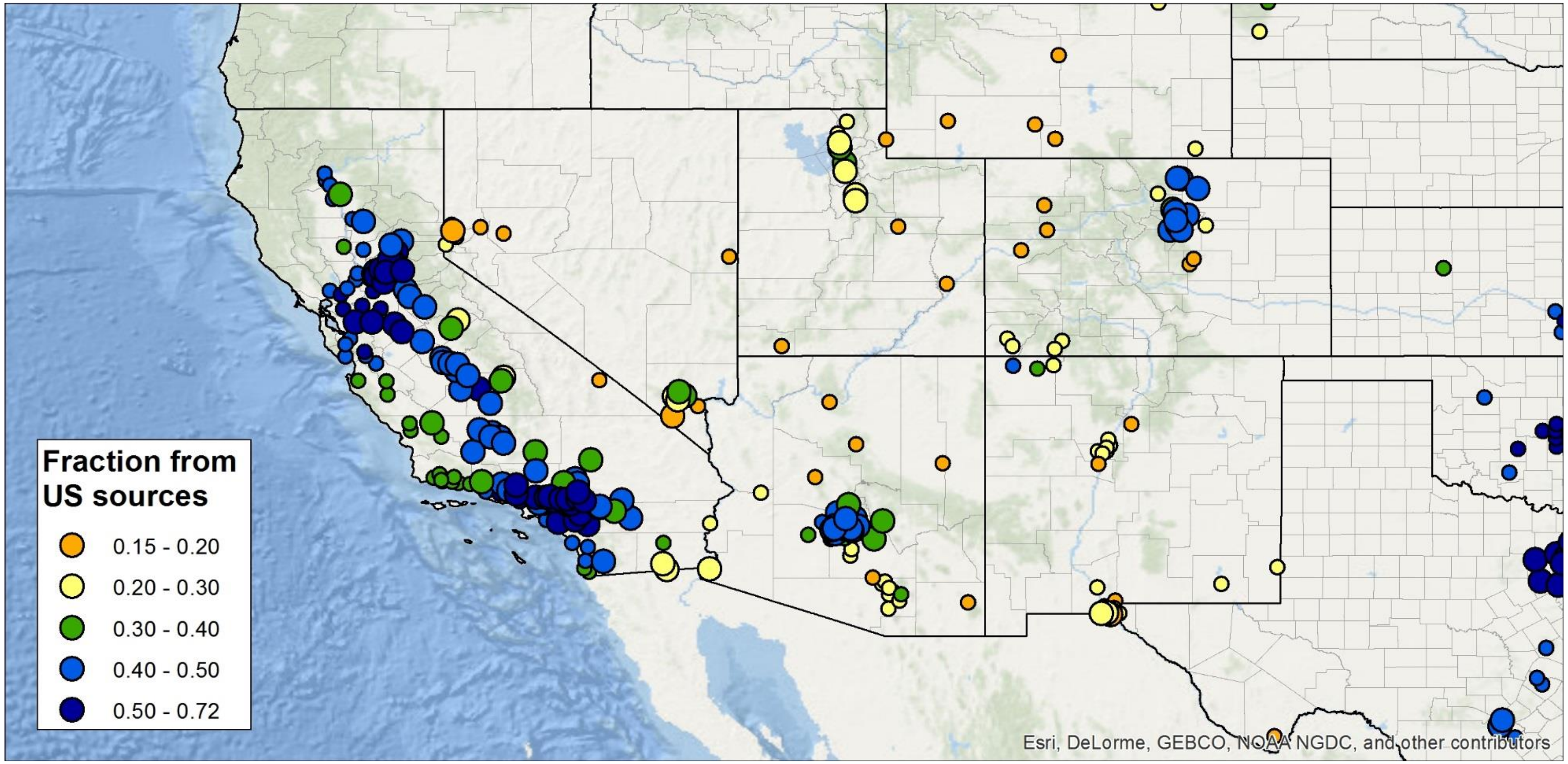
How much O3 is estimated to come from U.S. sources?



Map of estimated manmade U.S. contribution to ozone design values based on CAMx source apportionment modeling (2011). Larger circles represent sites with 2015 DVs > 70 ppb.

- Domestic manmade emissions are the dominant contributor to ozone design values at most locations in the EUS and parts of California.
- Note: the thresholds in the legend are not intended to reflect regulatory significance of USB in any particular area.

How much O3 is estimated to come from U.S. sources?



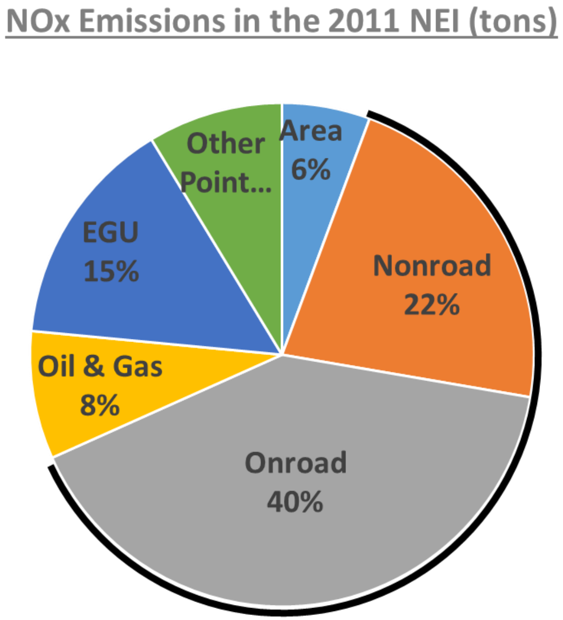
Map of estimated manmade U.S. contribution to ozone design values based on CAMx source apportionment modeling (2011). Larger circles represent sites with 2015 DVs > 70 ppb.

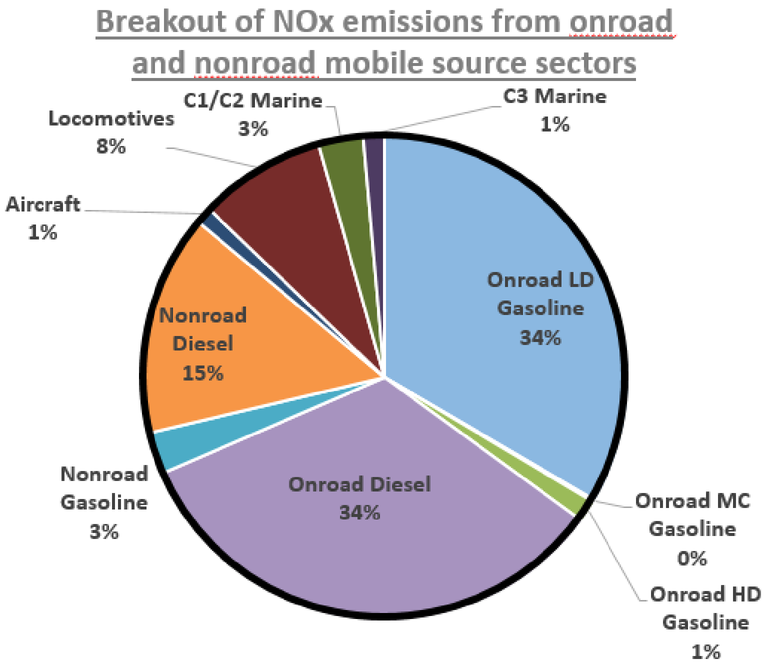
- This ***illustrative*** analysis suggests regional differences in the role of USB and NAAQS attainment.
- California: Urban areas have large impact from own-state sources, but higher elevation sites, and near-border sites can be more affected by background.
- Inter-mountain western U.S.: Urban areas can have large impact from own-state sources, but nearby sites can be strongly influenced by background as well. Some rural, high-elevation areas can be near / above the NAAQS w/ lesser U.S. contributions.

What sources and regions contribute to U.S. ozone?

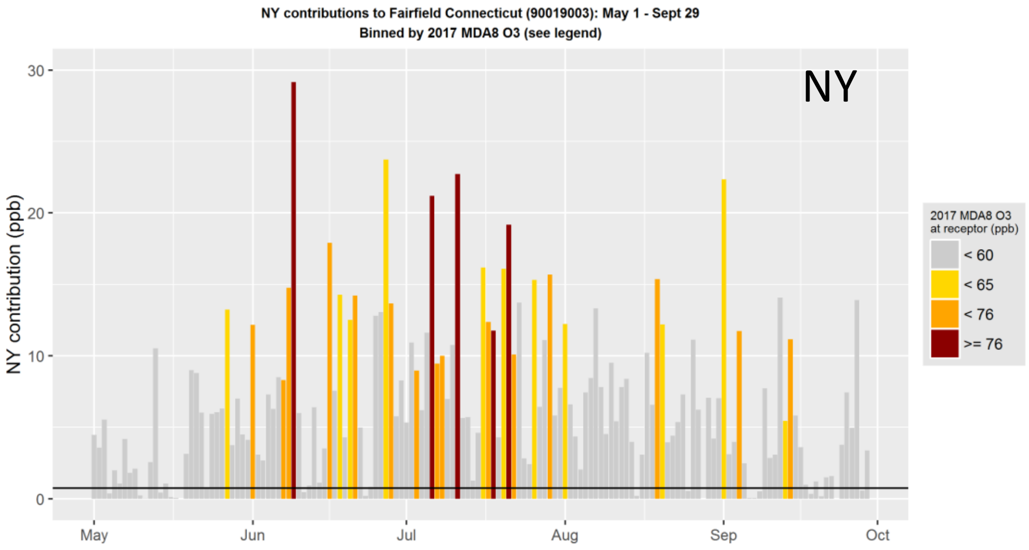
- Model attribution modeling can be configured to isolate source regions and/or source sectors

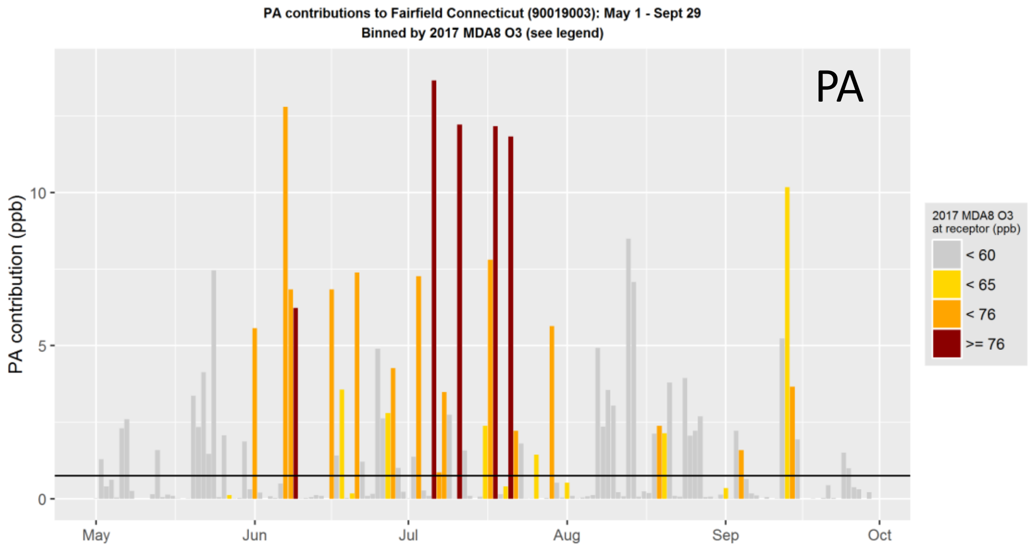
- Source attribution analyses have led to the following simplistic conceptual models of O3 in the U.S.
  - Eastern U.S.: Regional and local NOx & VOC emissions from EGUs and from mobile sources likely key sources
  - California (urban areas): In-state NOx & VOC emissions important with USB impacts in some areas
  - Rest of western U.S.: Local and regional NOx & VOC emissions important with USB impacts

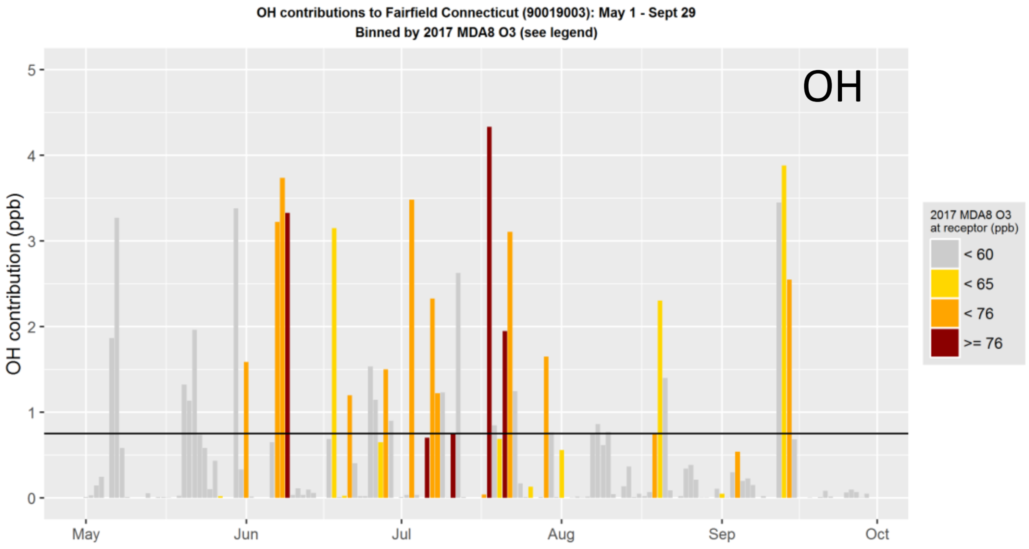


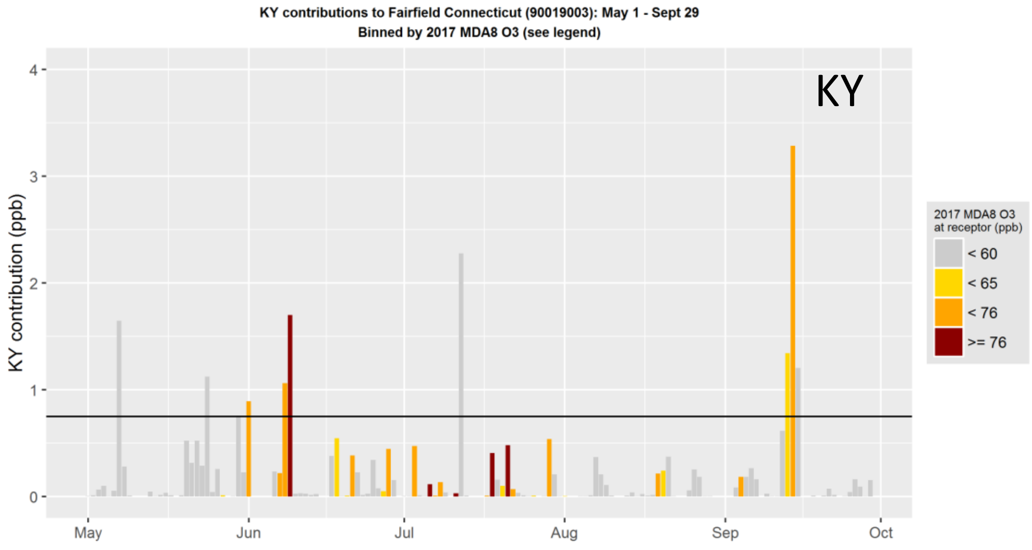


For example, what regions contribute to CT ozone?









CAMx source apportionment modeling for CSAPR Update (AQMG, 2016)

Clean Air Act Provisions for Dealing with Background O3

- Exceptional event exclusions (Clean Air Act section 319):
  - Air monitoring data that would otherwise indicate an exceedance of the O3 standards and lead to a nonattainment designation may be excluded from designation determinations, if the data are determined to be affected by exceptional events.
  - An exceptional event is one that affects air quality, is not reasonably controllable or preventable, and is either a natural event or one caused by human activity that is unlikely to recur at a particular location.
- Smaller NAA boundaries where little impact from nearby sources (CAA section 107(d))
- Rural transport areas (CAA section 182(h))
- International transport provisions (CAA section 179B)
  - In nonattainment areas appreciably affected by international transport, the CAA provides that under certain circumstances a State's attainment plan may be approved even if it does not demonstrate attainment.
  - To receive such an approval, the State would need to show that its plan would achieve attainment by the relevant date but for the influence of international emissions.

Summary

- As efforts are undertaken to implement the O3 NAAQS, questions regarding ozone contributions will continue to be asked at the local, regional, and national scales.
  - Questions regarding the quantitative role of background sources, in particular international sources, are expected to be relevant at international border areas and across areas in the western U.S.

- Modeling attribution simulations are being applied within the AQ community. These tools are in a continual state of improvement.

- EPA has been and will continue to partner with States and other interested parties on any/all issues involving O3 background.