

Please Note: Suggested citation of this presentation is:

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Acknowledgements

- Ramboll Environ
 - Air Quality Modeling from 1970 to 2020
- Sonoma Technology, Inc.
 - Air Quality Modeling for 2011
- Charlie Blanchard (Envair)
 - SEARCH Data Analysis from 1996 to 2014

What is Background Ozone?

- US Background (USB)
 - Ozone concentrations in the absence of any anthropogenic emissions in US
- Contributors to US background ozone:
 - Natural emissions of VOC and NO_x (wildfires, soil, lightening)
 - Stratospheric Intrusions
 - Intercontinental Transport
 - Emissions from Canada and Mexico

Why is Background Ozone Important?

- The ozone standard in the U.S. was revised to 70 ppb, 8-hr average in 2015
- Strong evidence that the background ozone in the U.S. has been increasing over the years, although trend seems to be levelling off
 - Many rural areas in the western U.S. (especially at high elevation) exceed 65 ppb ozone
 - Impact from rising Asian emissions as well as from Mexico
- Understanding background ozone can help in developing plans for meeting new ozone standards

Two EPRI Studies

1970-2020 Modeling of Background Ozone

- Determine how changes in emissions affect USB over the long-term
- Use a global model (GEOS-Chem) for 2x2.5 degrees and a regional model (CAMx with CB05) for 36-km grid
- Simulations run for 1970, 1980, 1990, 2000, **2005** and 2020
- Emissions from U.S. EPA's National Emissions Inventory, CSAPR2005, EDGAR, RCP 8.5 Scenario
- Meteorology and wildfire emissions kept constant at 2005 level
- USB estimated conducting zero-out simulation with CAMx

Detailed Contribution Analysis for Ozone

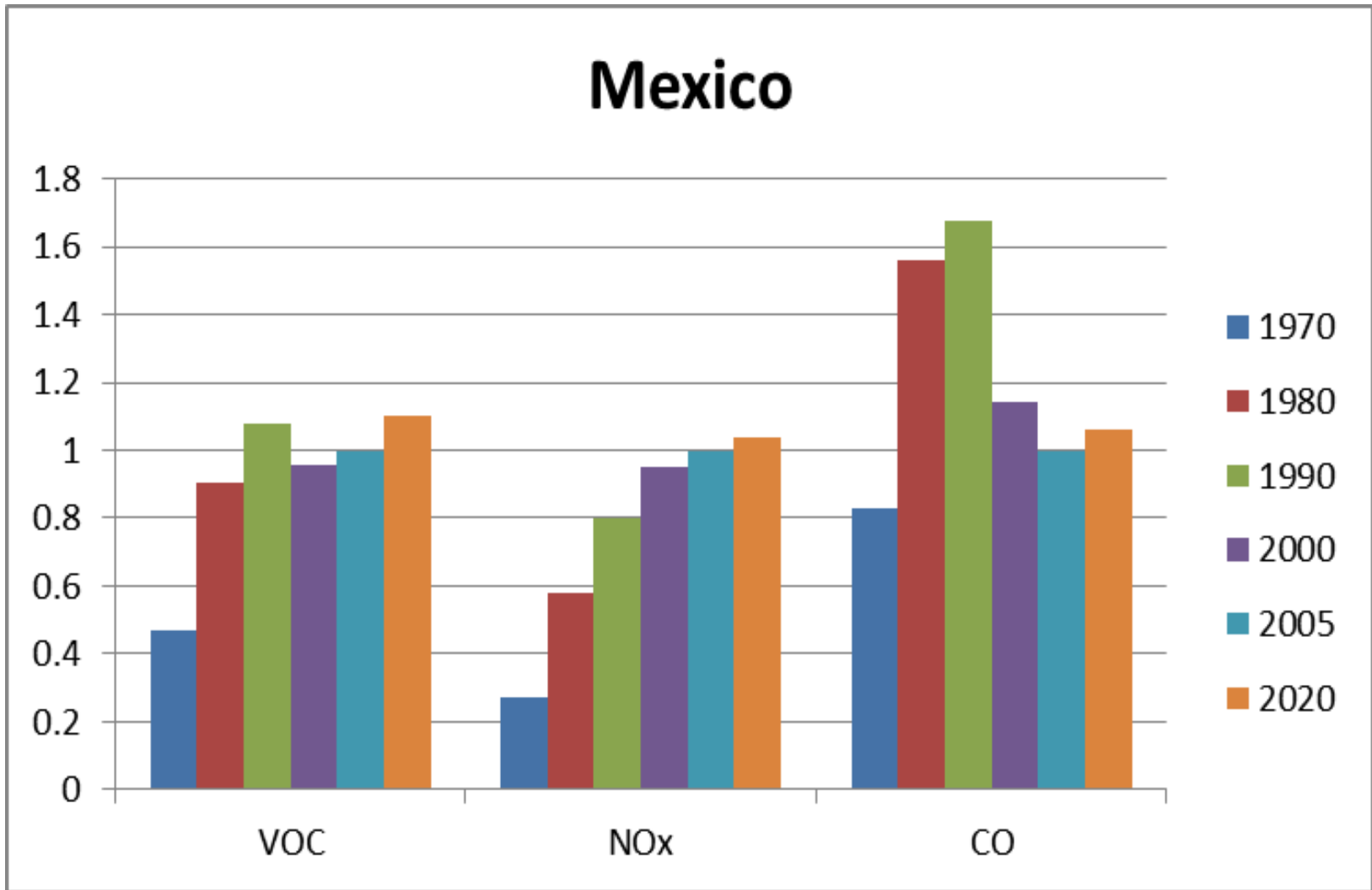
- Estimate “controllable” ozone at specific locations (Denver, Phoenix, Atlanta, Detroit)
- Use a regional model (CAMx with CB05) for EPA's 2011 modeling platform driven by boundary conditions from GEOS-Chem
- CAMx was run for a 12-km grid over the U.S.
- Estimate contribution of different regions/sources to ozone using Ozone Source Apportionment Technology (OSAT)
 - Include contribution from background ozone

Caveats

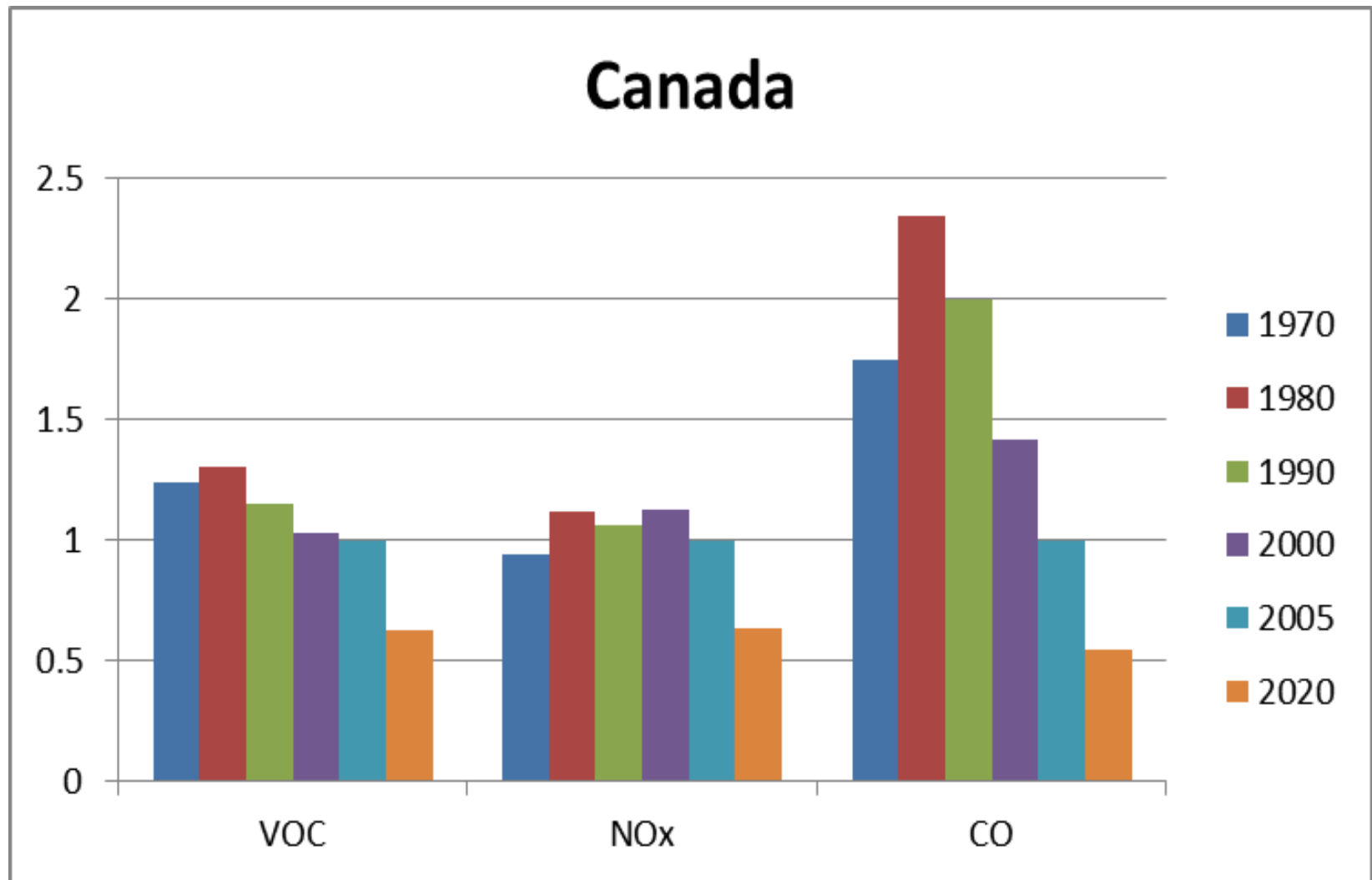
- Modeling studies have the usual caveats
 - All models are wrong, but some are useful
 - Useful tools for gaining insights
 - Main tools for air quality management

- We conducted model performance evaluation for baseline years for both modeling studies
 - Meet generally accepted criteria
 - Not presented here due to time constraints

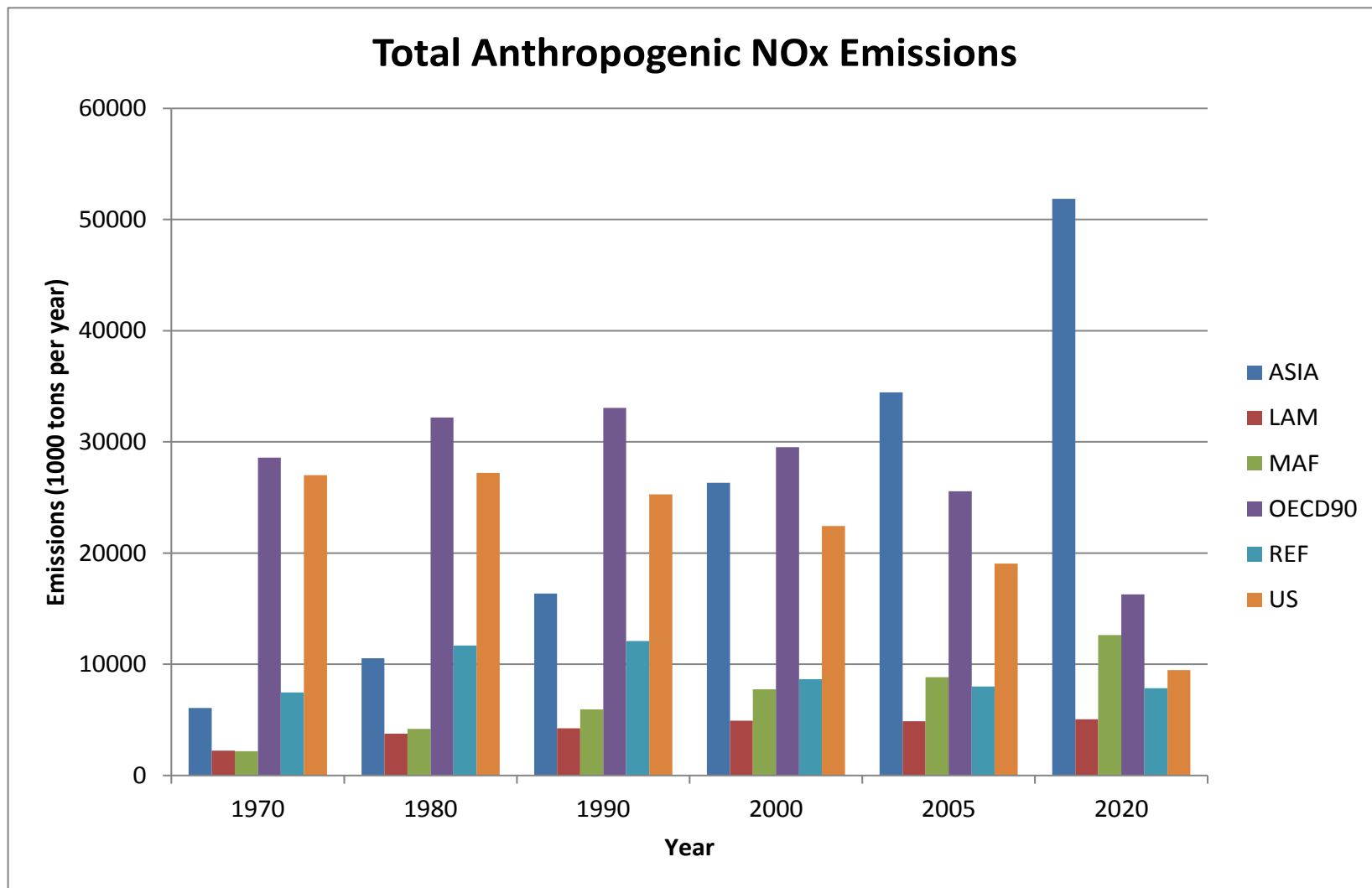
Emissions Trends in Mexico



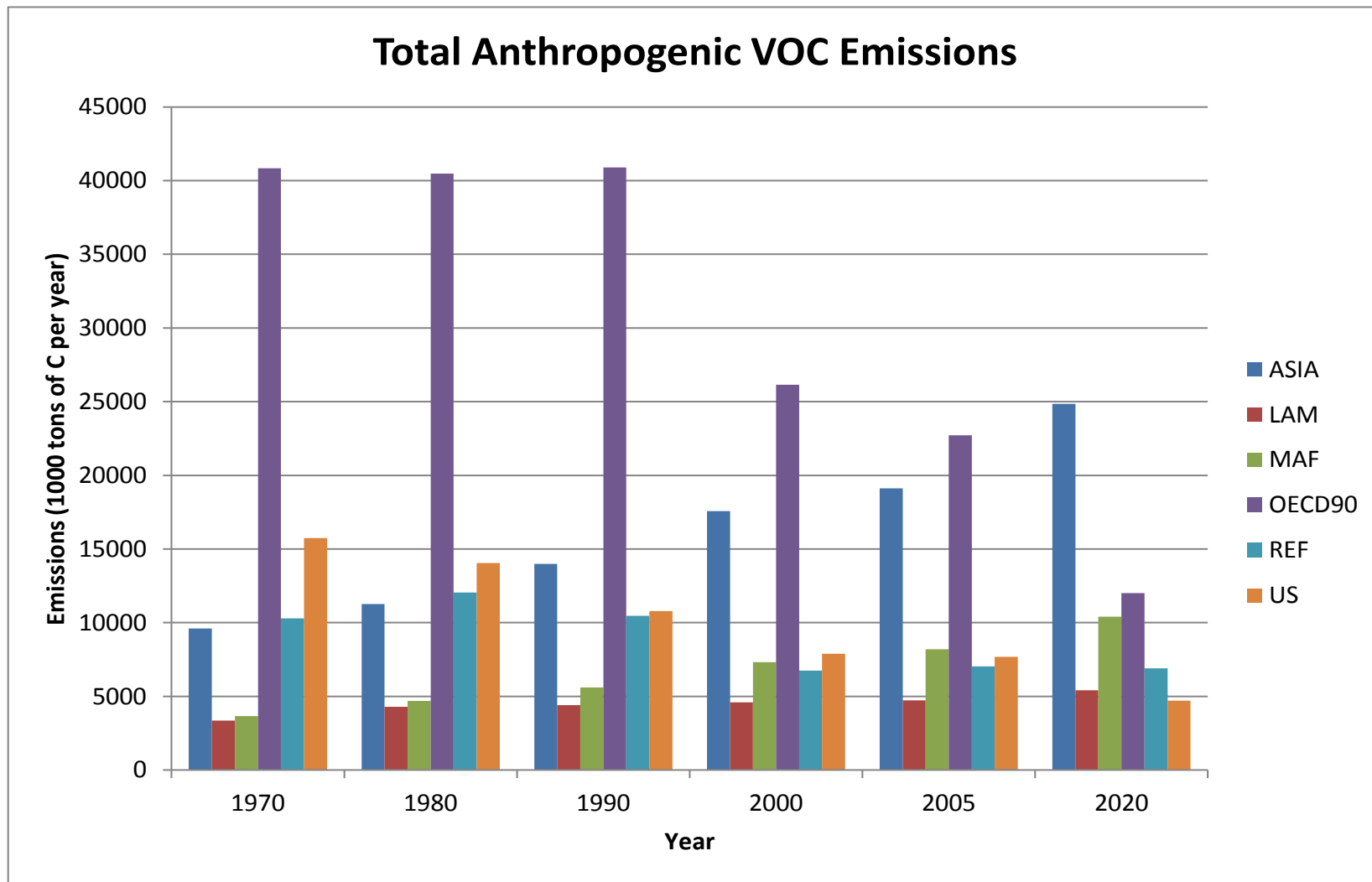
Emissions Trends in Canada



Global NOx Emissions Trends

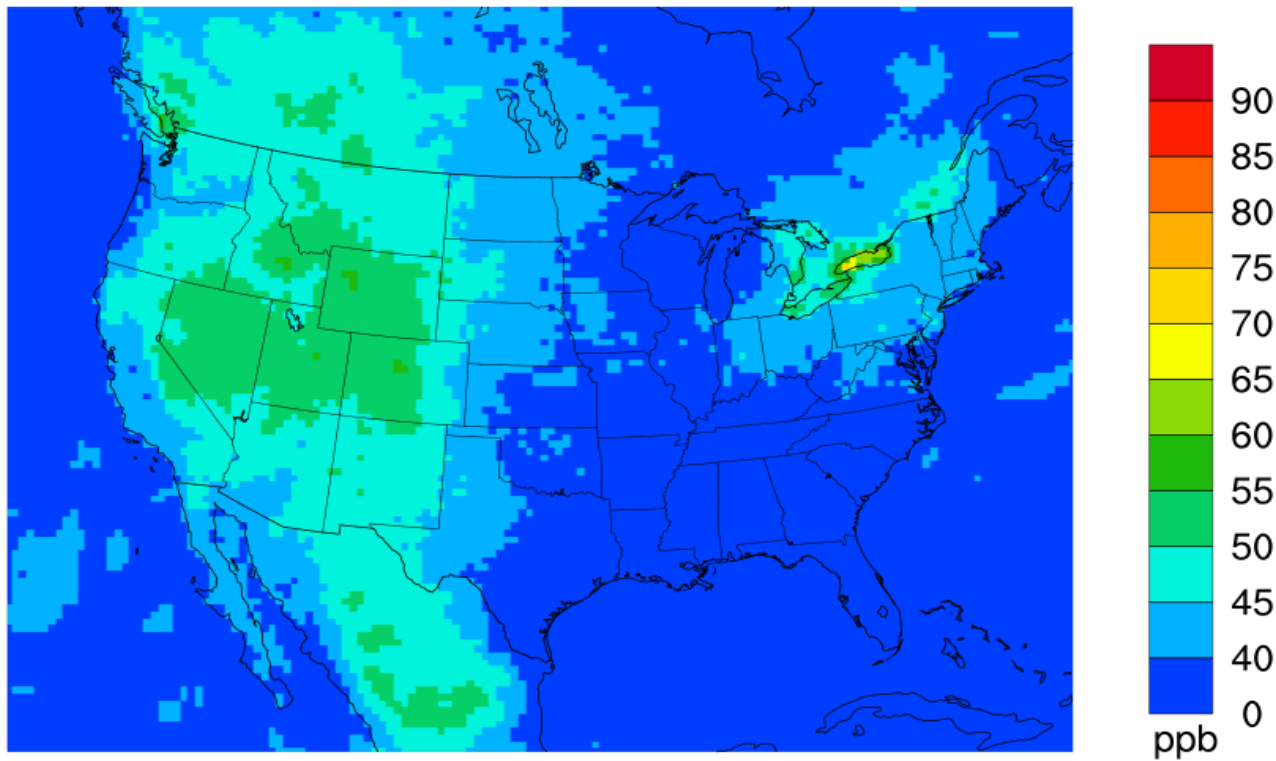


Global VOC Emissions Trends



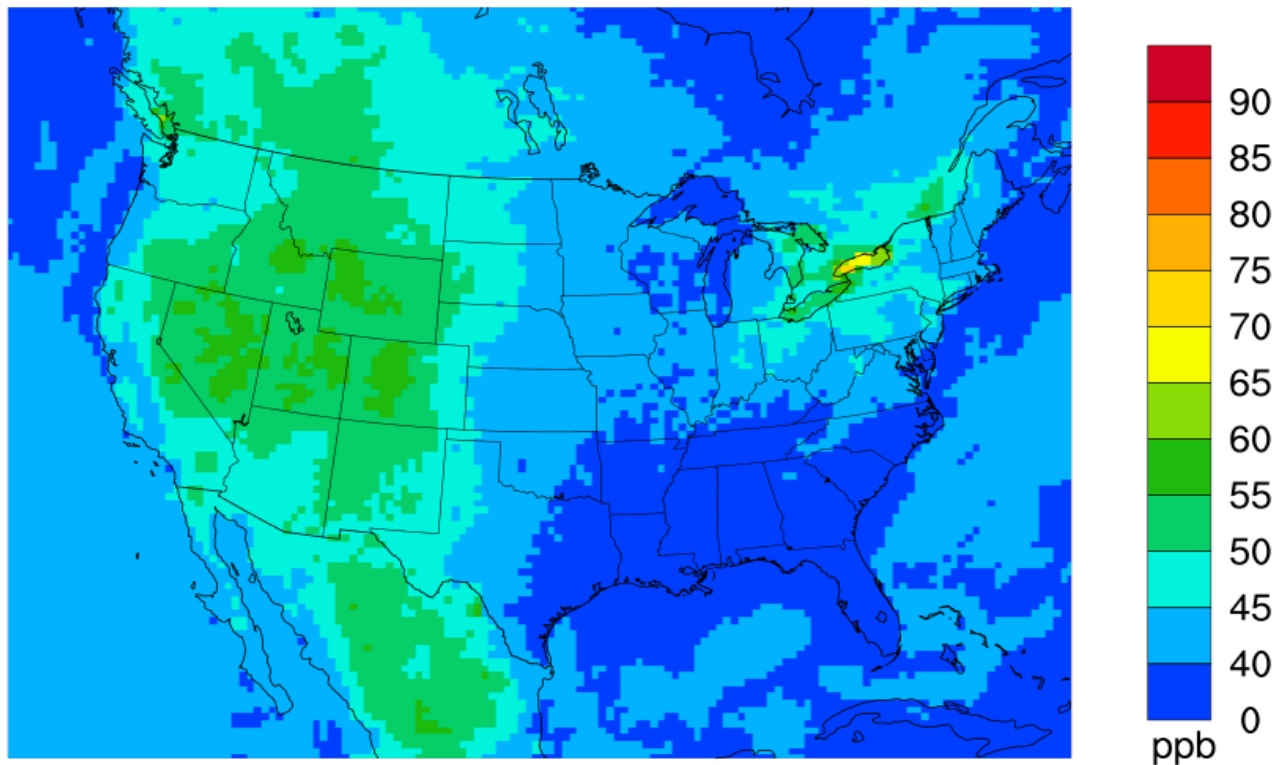
US Background 4th Highest 8-hour Ozone Predictions for 1970

4th Highest Daily Max 8-hour Ozone
CAMx 1970 US Background Case



US Background 4th Highest 8-hour Ozone Predictions for 1990

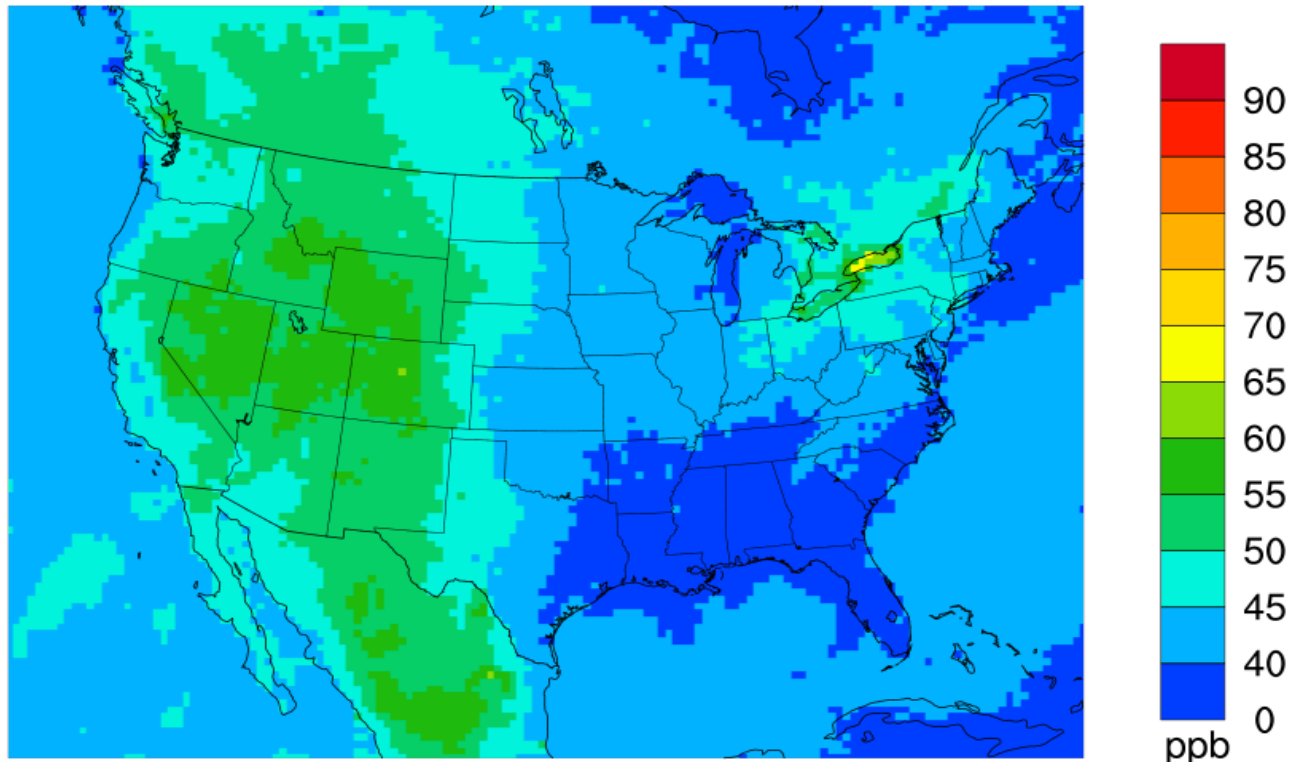
4th Highest Daily Max 8-hour Ozone
CAMx 1990 US Background Case



Min(146,1) = 34.67, Max(116,72) = 71.39

US Background 4th Highest 8-hour Ozone Predictions for 2005

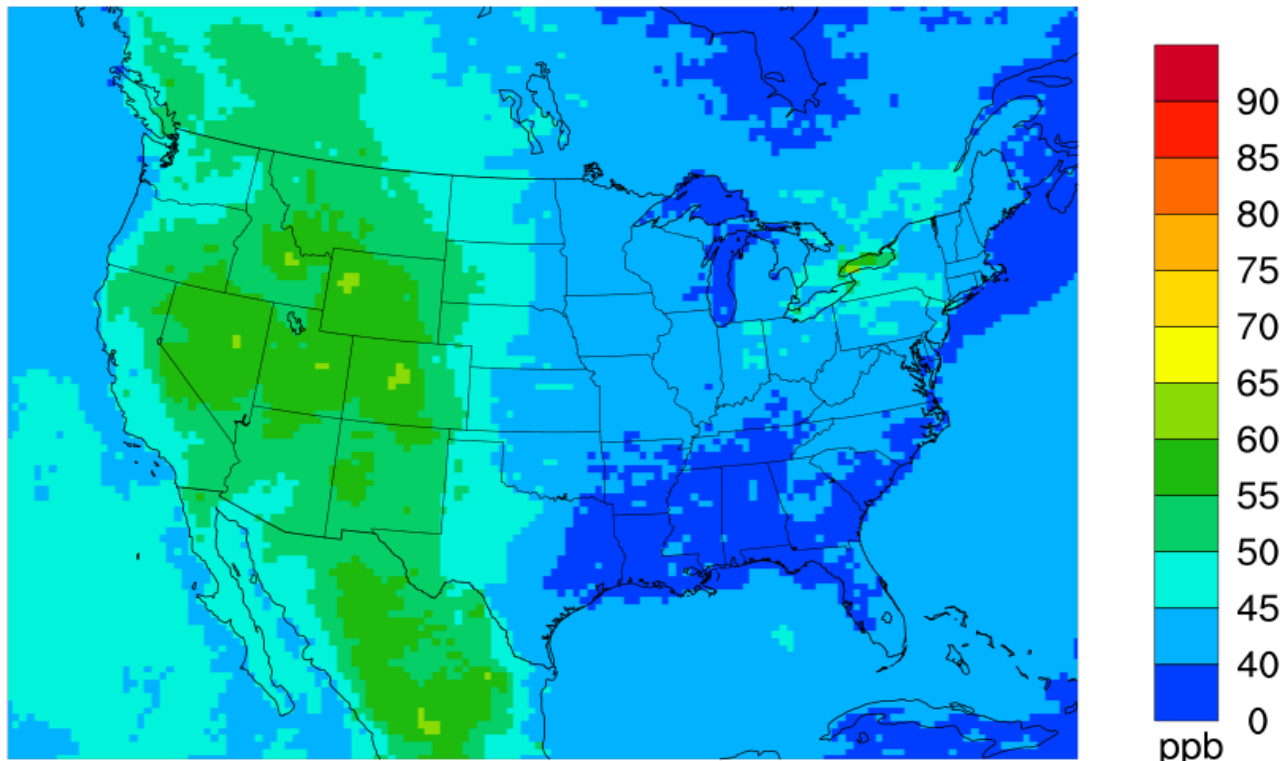
4th Highest Daily Max 8-hour Ozone
CAMx 2005 US Background Case



Min(146,1) = 35.82, Max(116,72) = 69.50

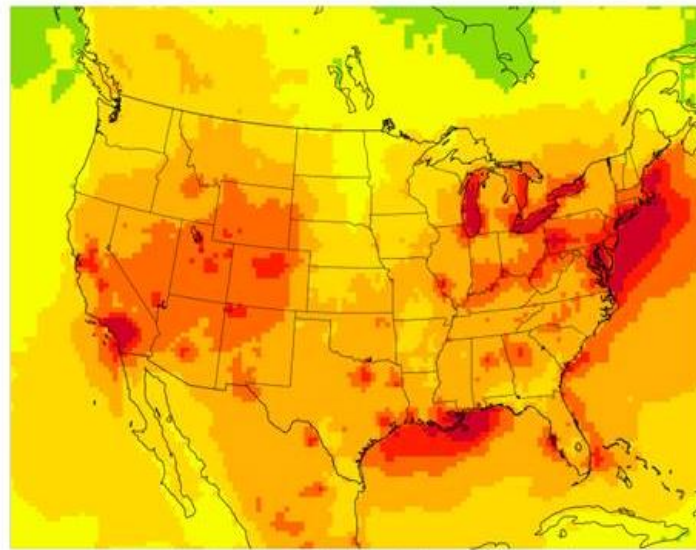
US Background 4th Highest 8-hour Ozone Predictions for 2020

4th Highest Daily Max 8-hour Ozone CAMx 2020 US Background Case

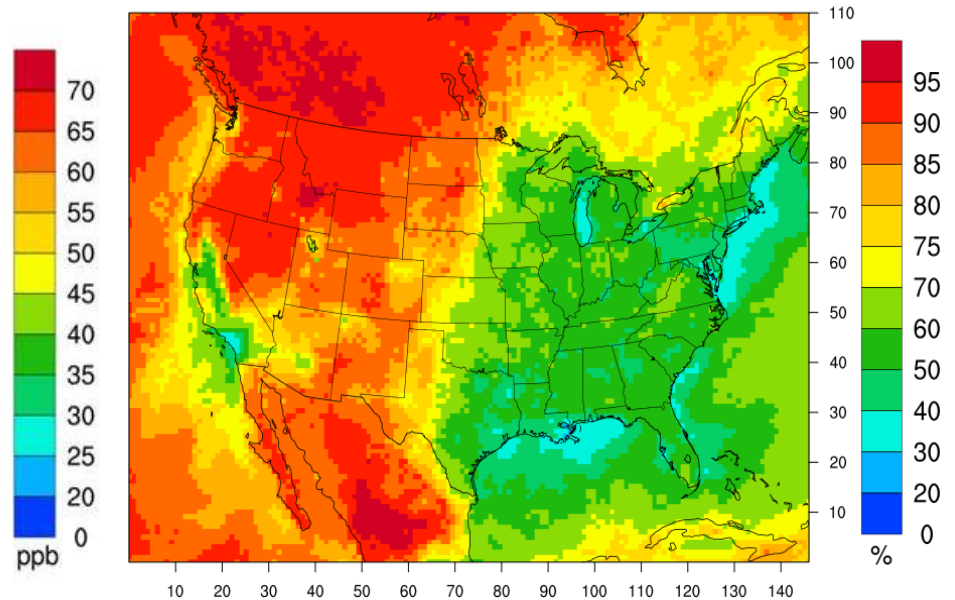


Min(146,83) = 36.36, Max(115,72) = 63.79

Average of the top 10 days of MDA8 O₃ in 2020 (left) and the corresponding USB contribution (% , right).

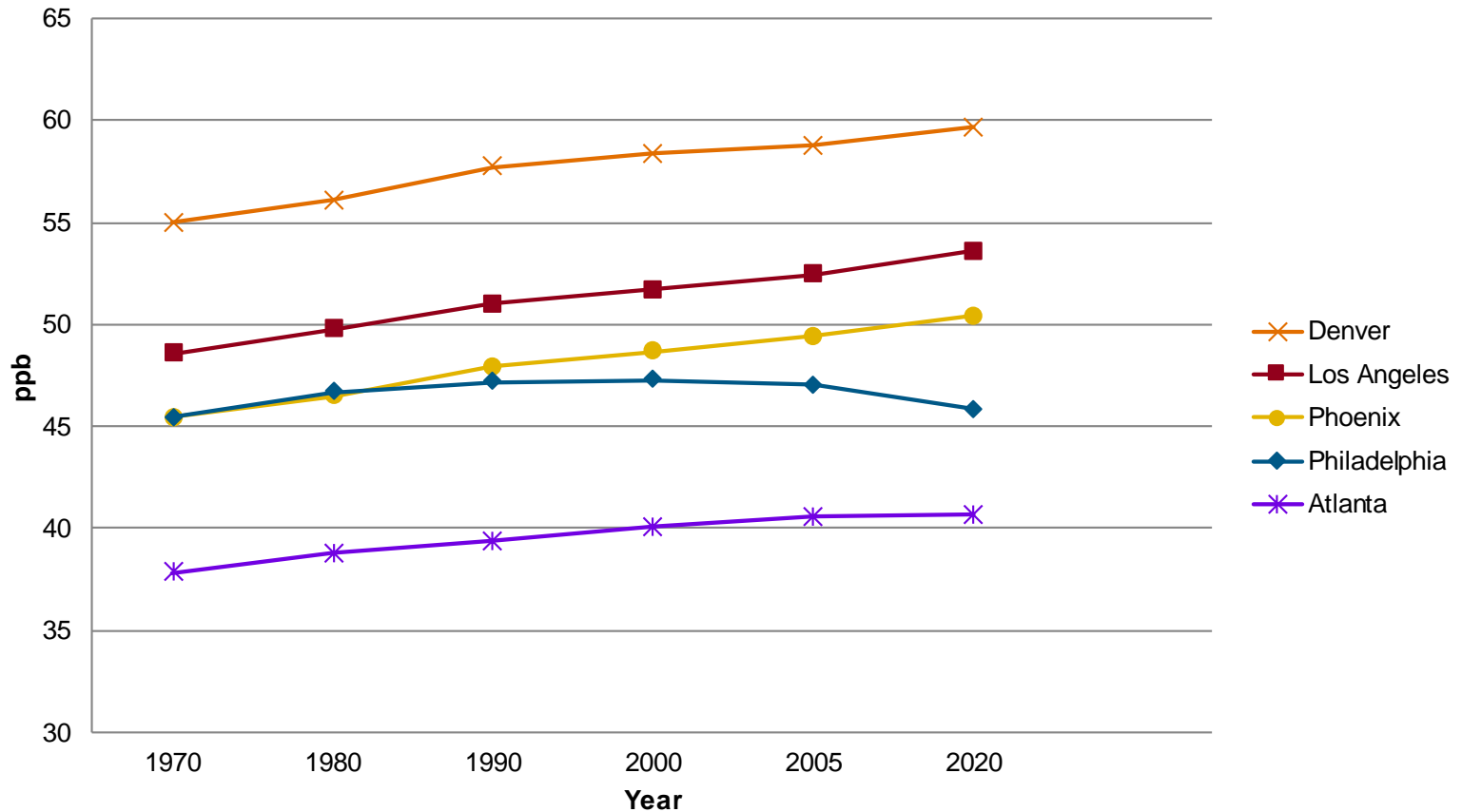


Min(105,101) = 40.22, Max(23,45) = 96.14

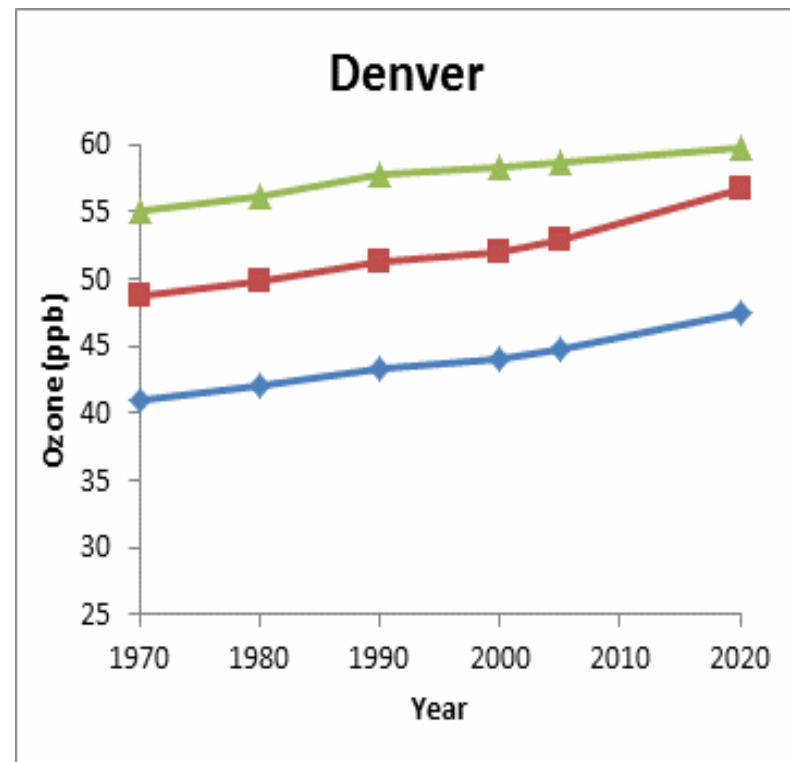
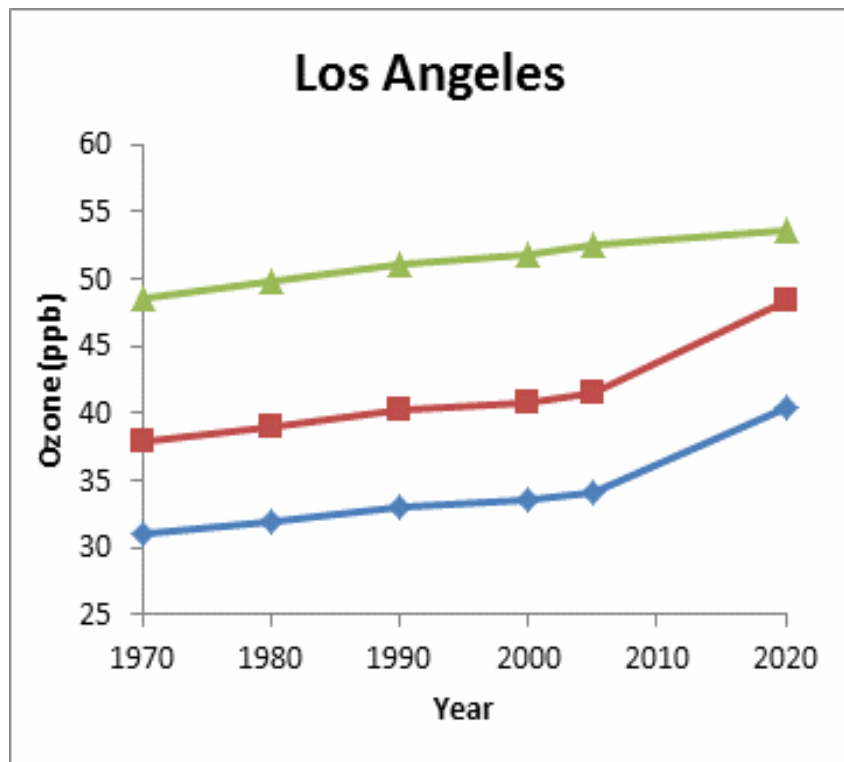


Predicted Change in USB (Fourth Highest Maximum 8-hr Daily) Ozone for Selected Cities

US-background H4MDA8 ozone concentration at 5 major US cities

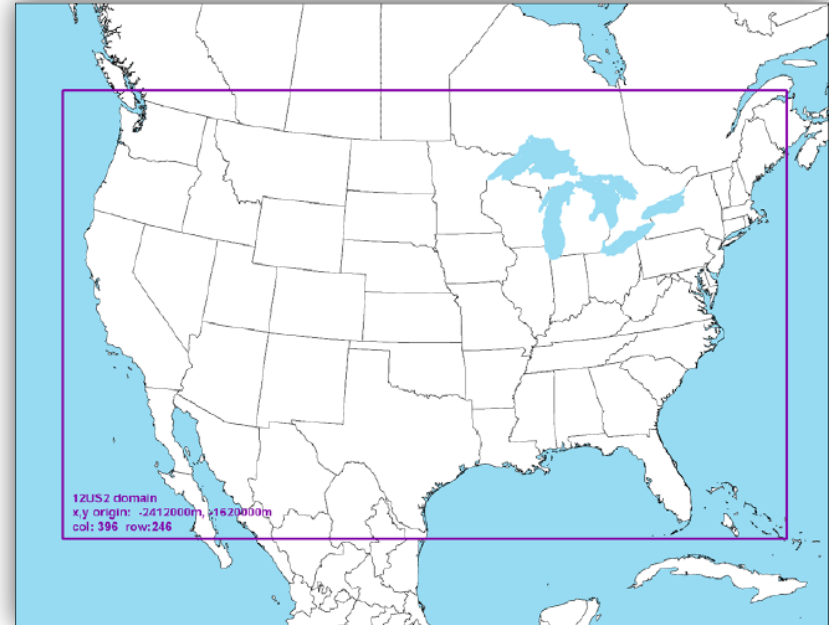


USB changes on top 30 MDA8 days (red square) and average summer days (blue diamond) compared to the changes in H4MDA8 USB (green triangle)



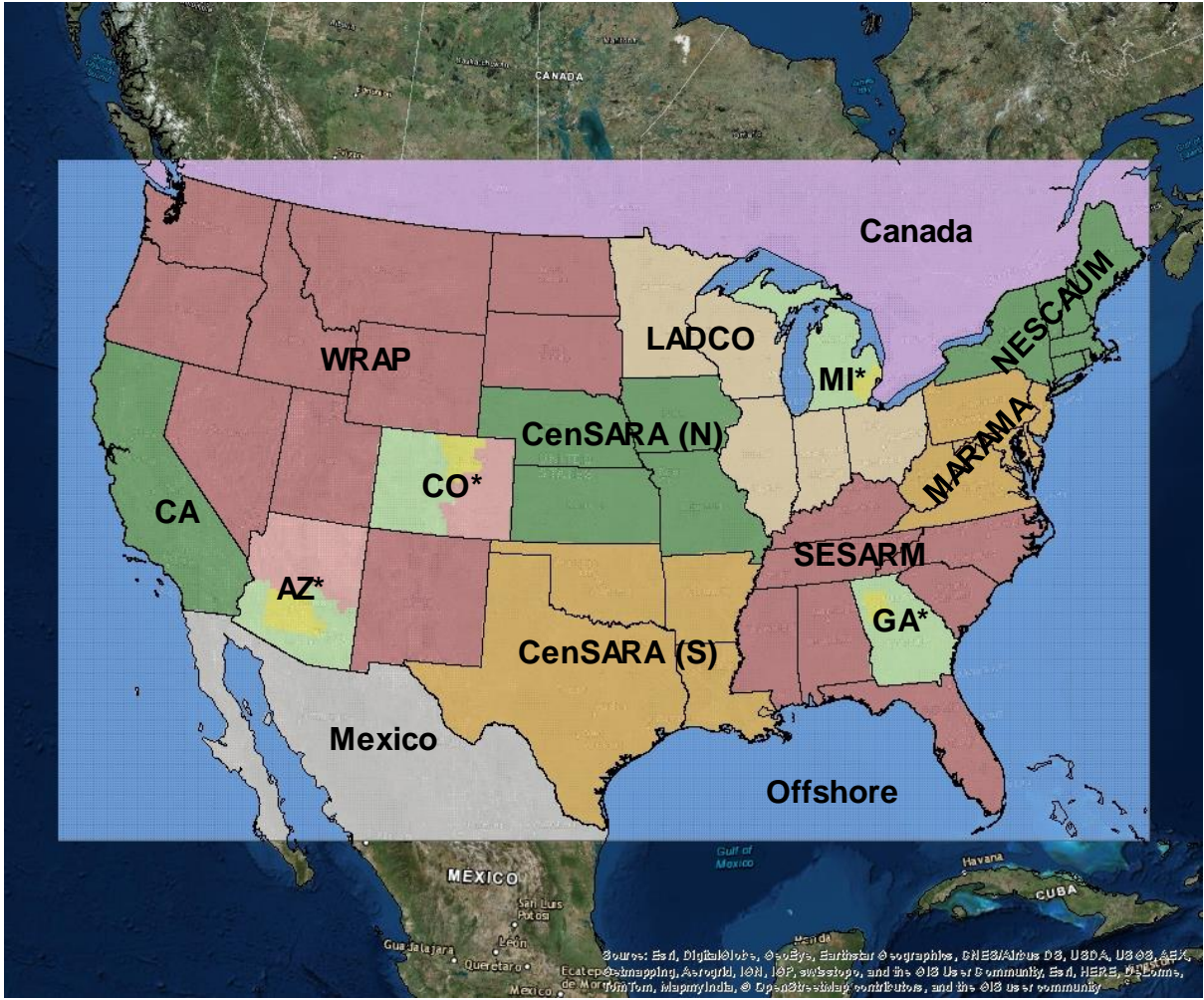
Contribution Analysis for Ozone

- 2011 ozone season (April to September) simulation with CAMx version 6.3
- Domain, inputs, and configurations based on EPA's 2011 modeling platform
 - WRF version 3.4
 - GEOS-Chem boundary conditions
 - Carbon Bond 6r2
- Ozone Source Apportionment Technology (OSAT) Version 3



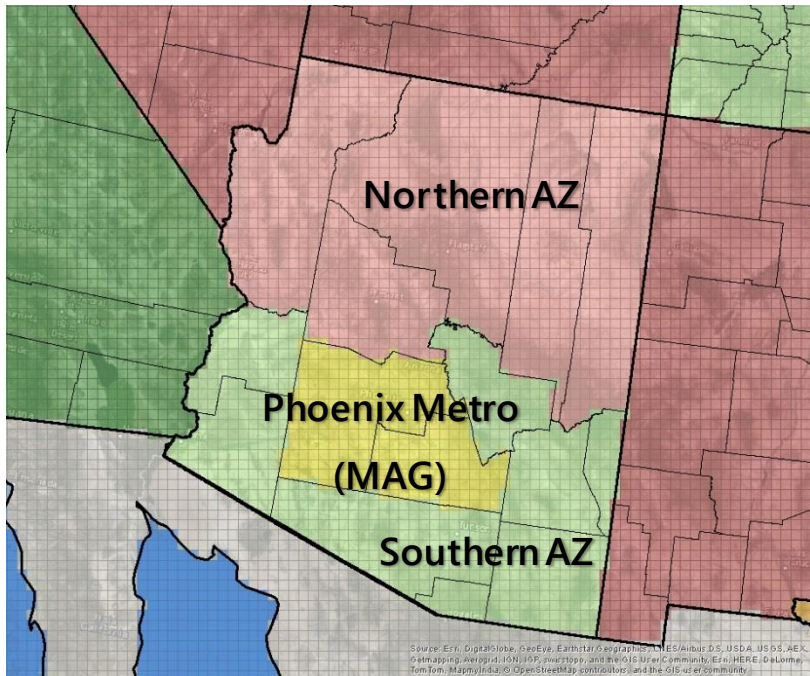
12 km CONUS modeling domain.

OSAT Source Group Regions (1)

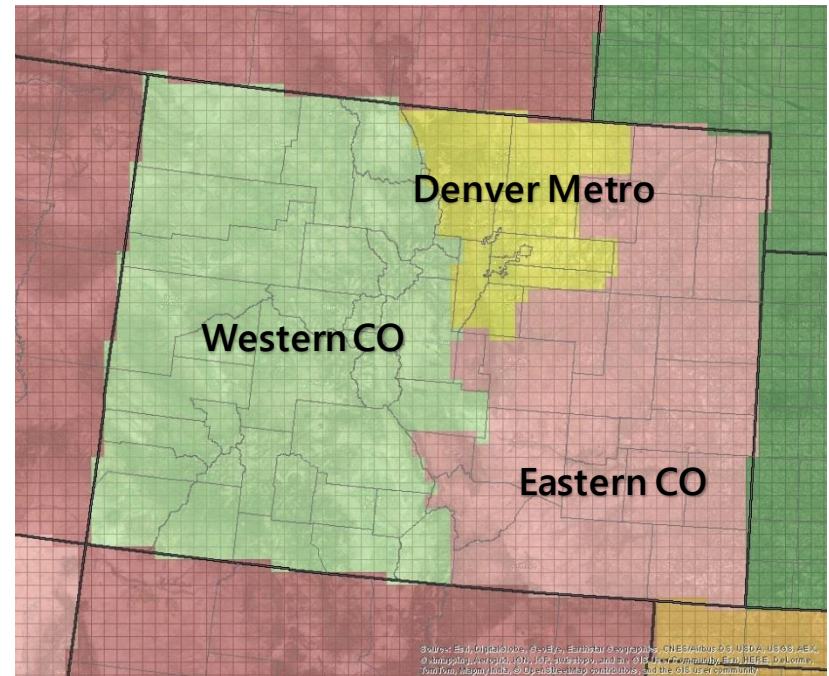


*Arizona, Colorado, Georgia, and Michigan contain multiple source regions.

OSAT Source Group Regions (2)

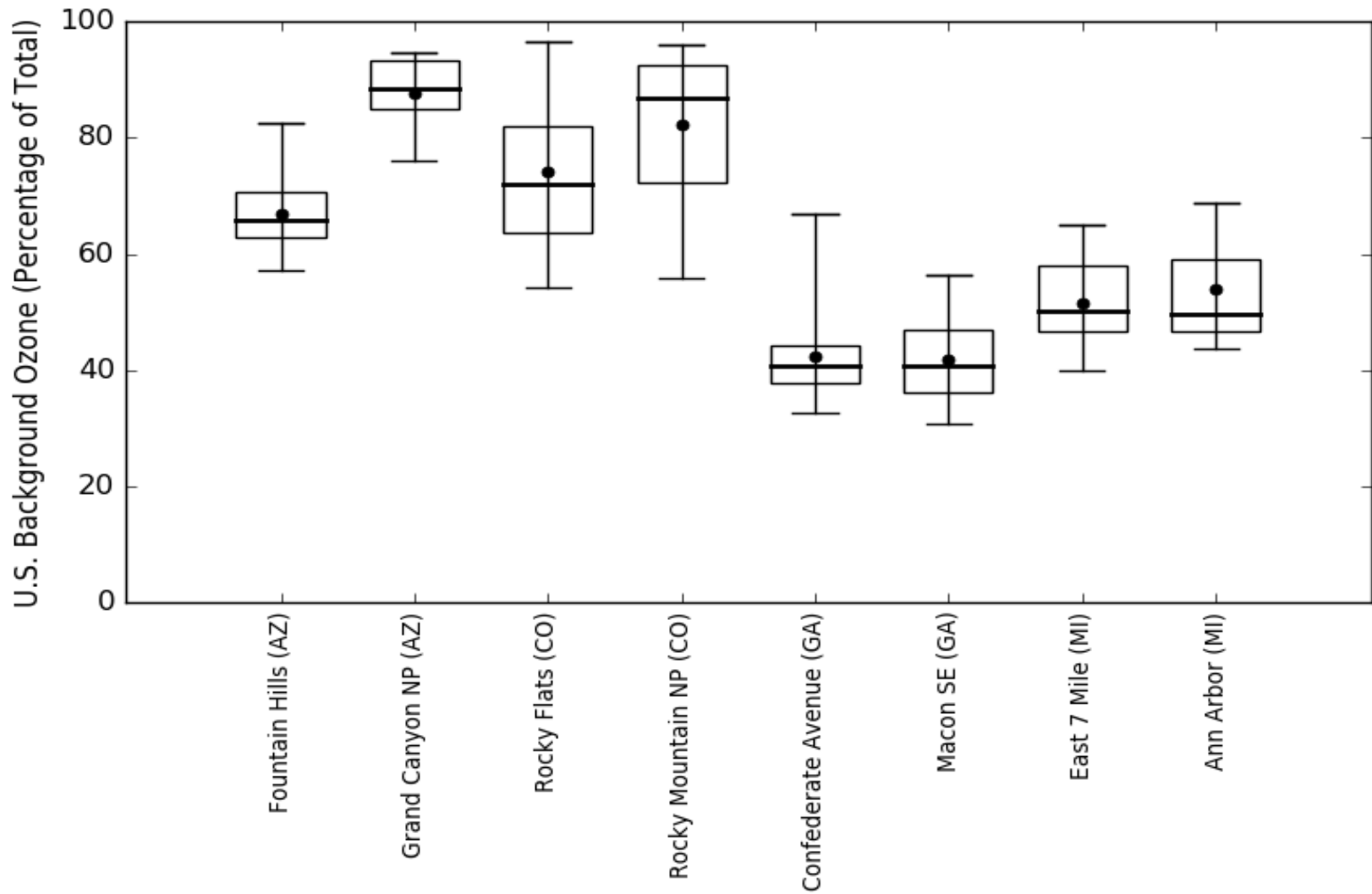


Phoenix Metro Area: Counties within the Maricopa Association of Governments (MAG).

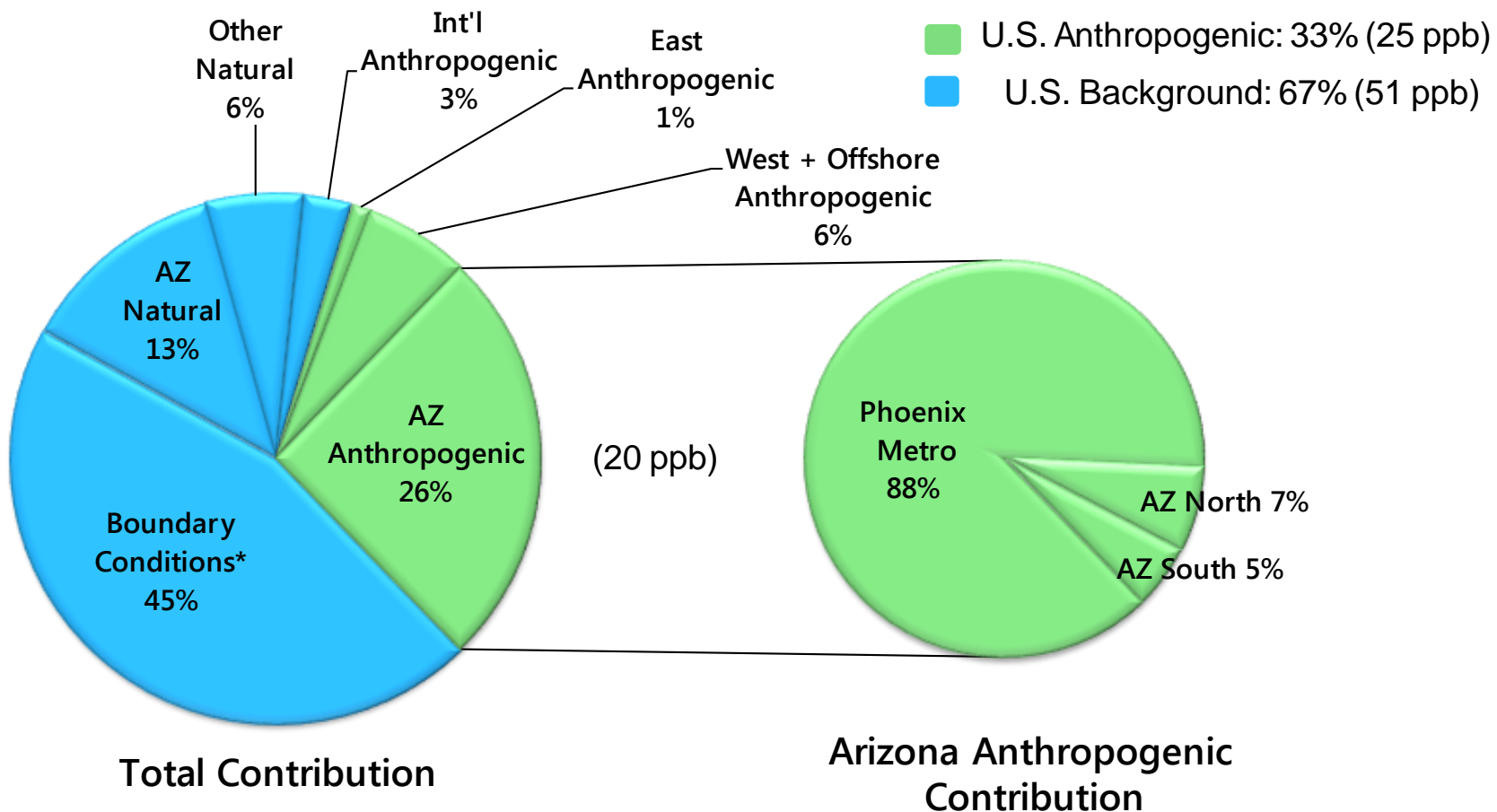


Denver Metro Area: Counties in the Denver Metro area and Northern Front Range region.

Estimated U.S. Background Ozone (from OSAT)



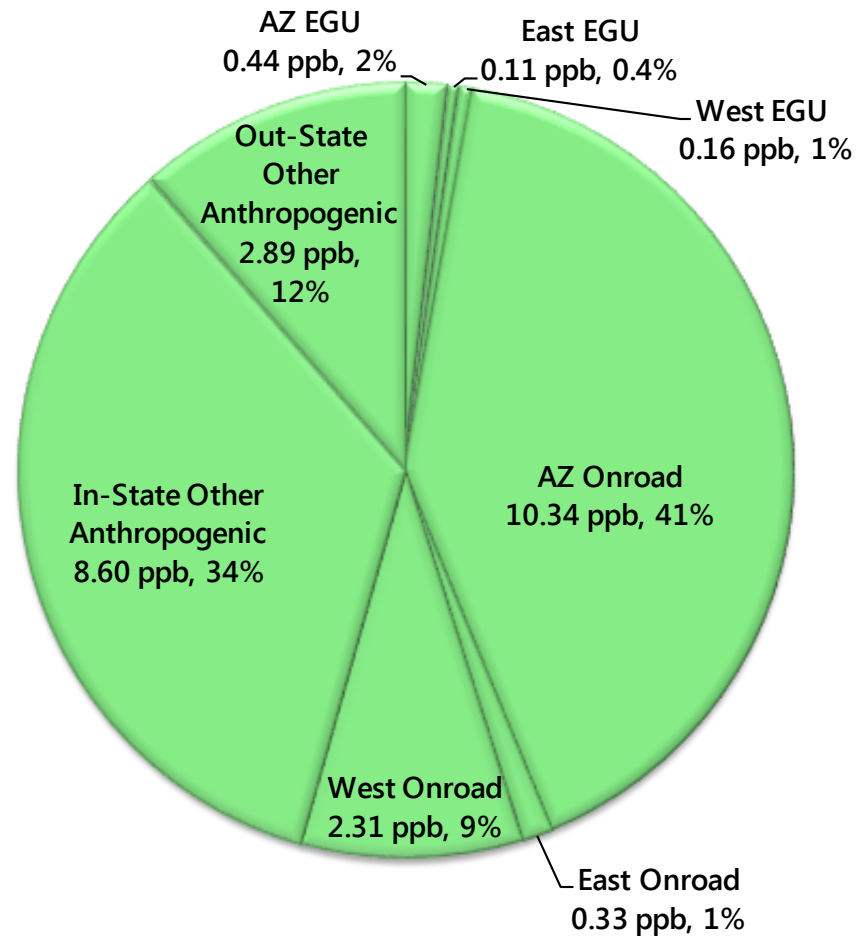
Ozone Source Contributions: Phoenix



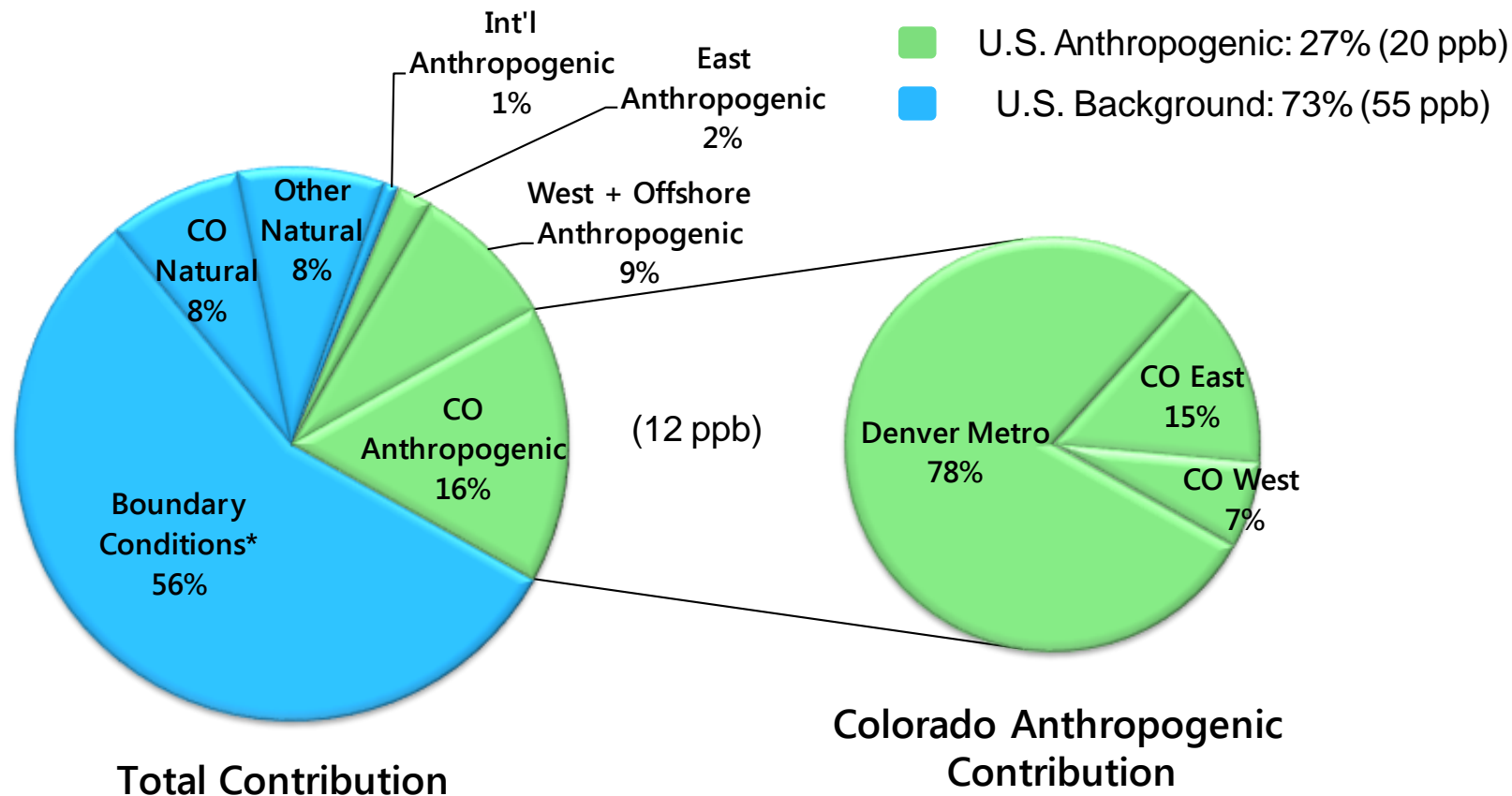
Modeled ozone contributions at the Fountain Hills monitor when monitored ozone was greater than 70 ppb (20 days; monitoring avg. was 76 ppb).

U.S. Anthropogenic Ozone Contributions: Phoenix

When Monitored 8-hr Ozone > 70 ppb at Fountain Hills Monitor



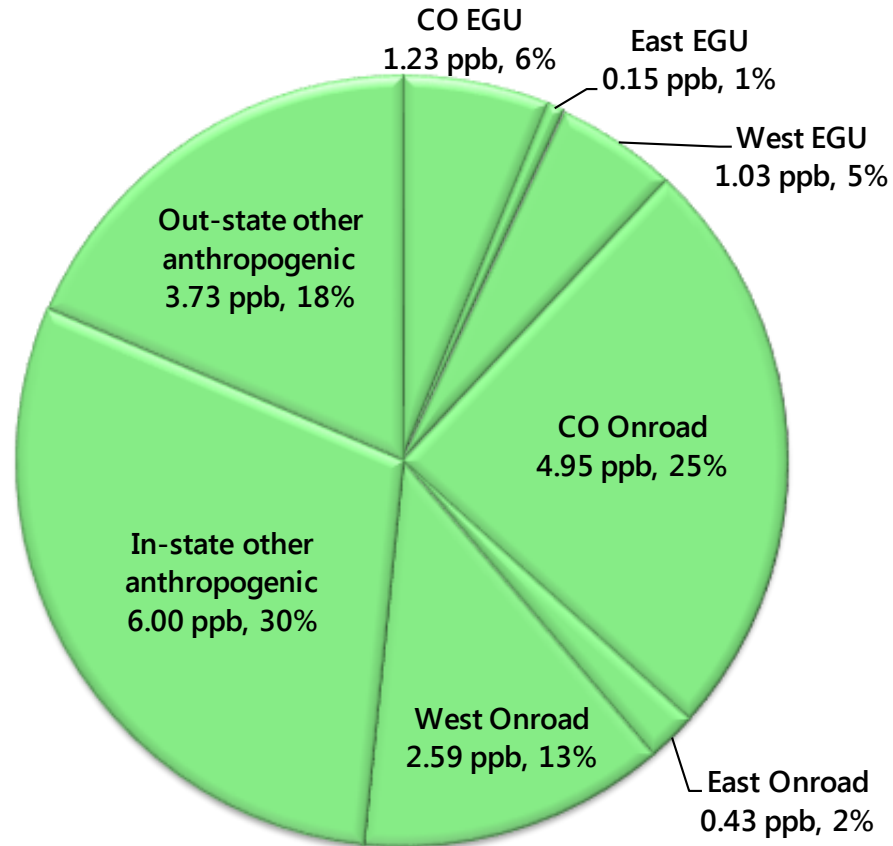
Ozone Source Contributions: Denver



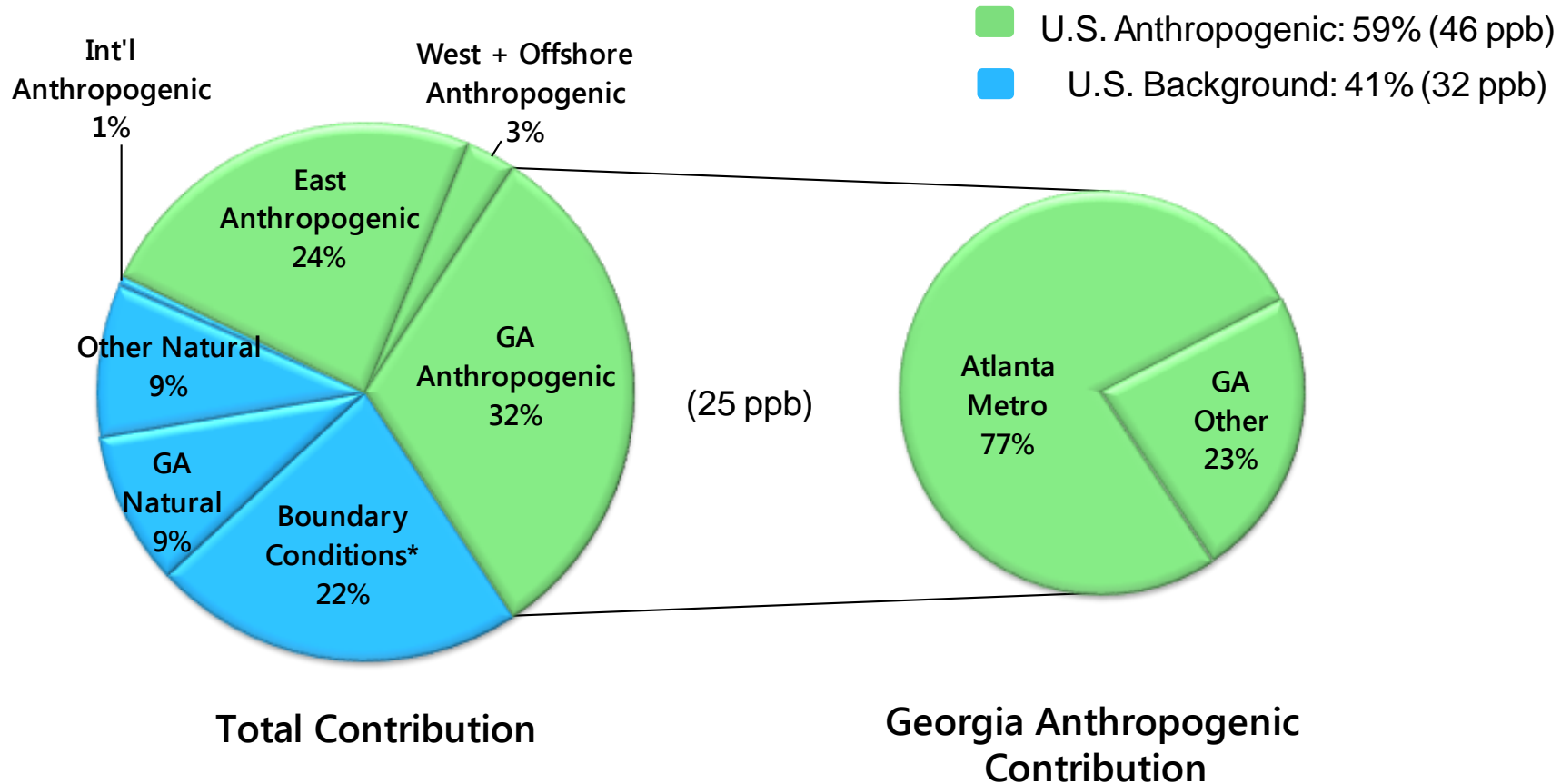
Modeled ozone contributions at the Rocky Flats monitor when monitored ozone was greater than 70 ppb (30 days; average was 75 ppb)

U.S. Anthropogenic Ozone Contributions: Denver

When Monitored 8-hr Ozone > 70 ppb at Rocky Flats Monitor



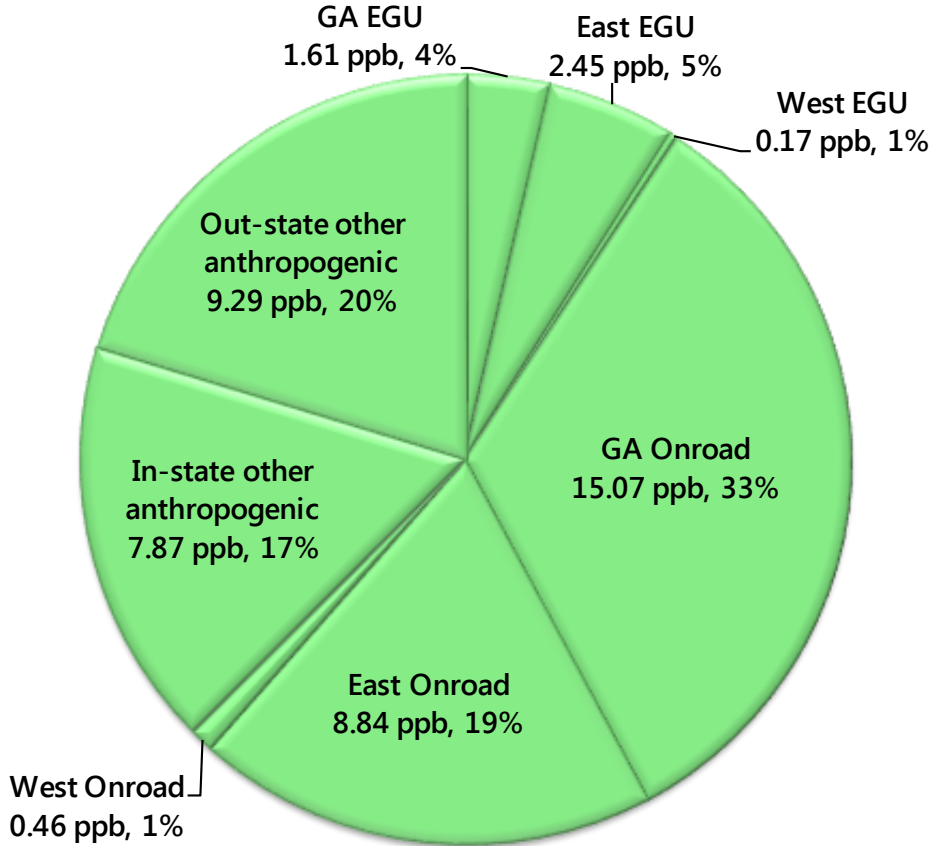
Ozone Source Contributions: Atlanta



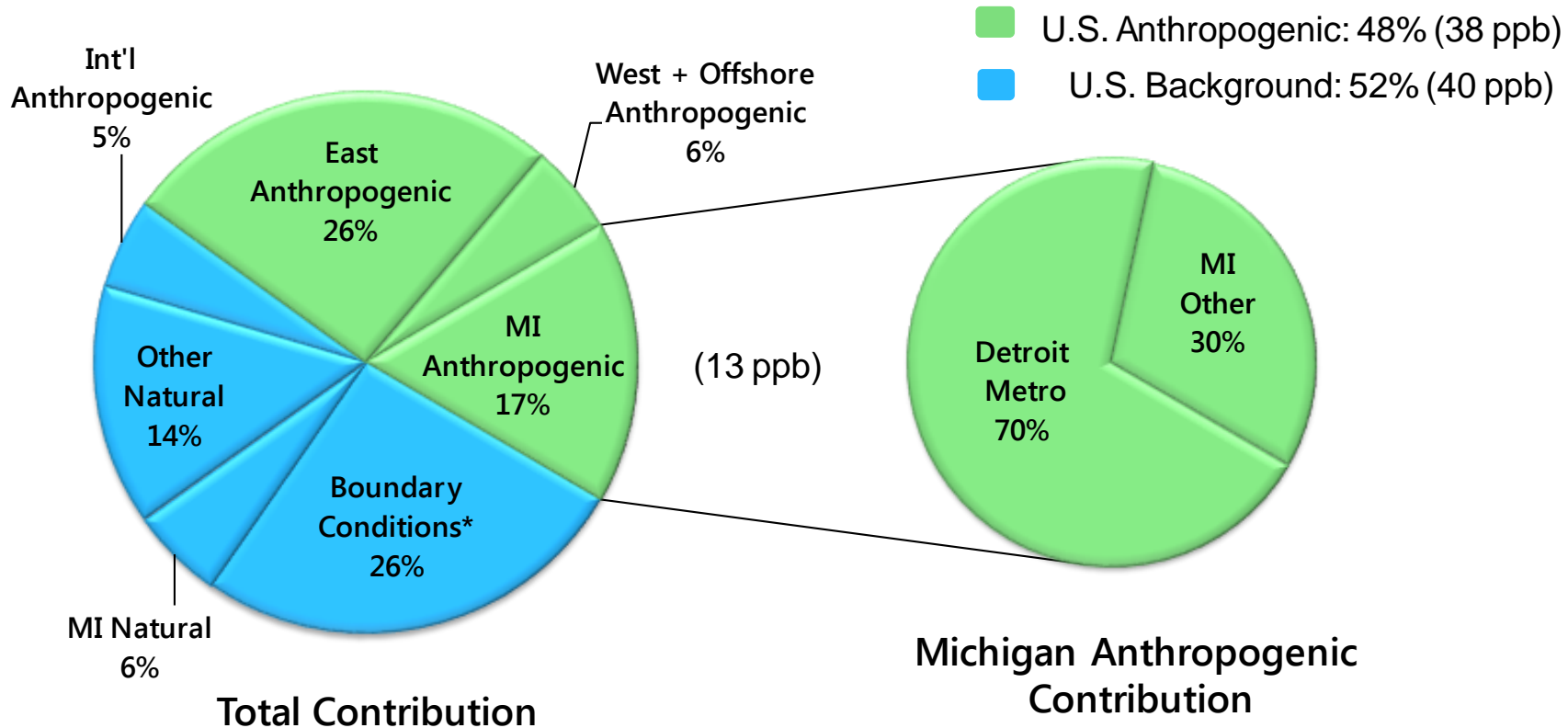
Modeled ozone contributions at the **Confederate monitor** when monitored ozone was greater than 70 ppb (25 days; monitoring avg. was 78 ppb).

U.S. Anthropogenic Ozone Contributions: Atlanta

When Monitored 8-hr Ozone > 70 ppb at Confederate Monitor



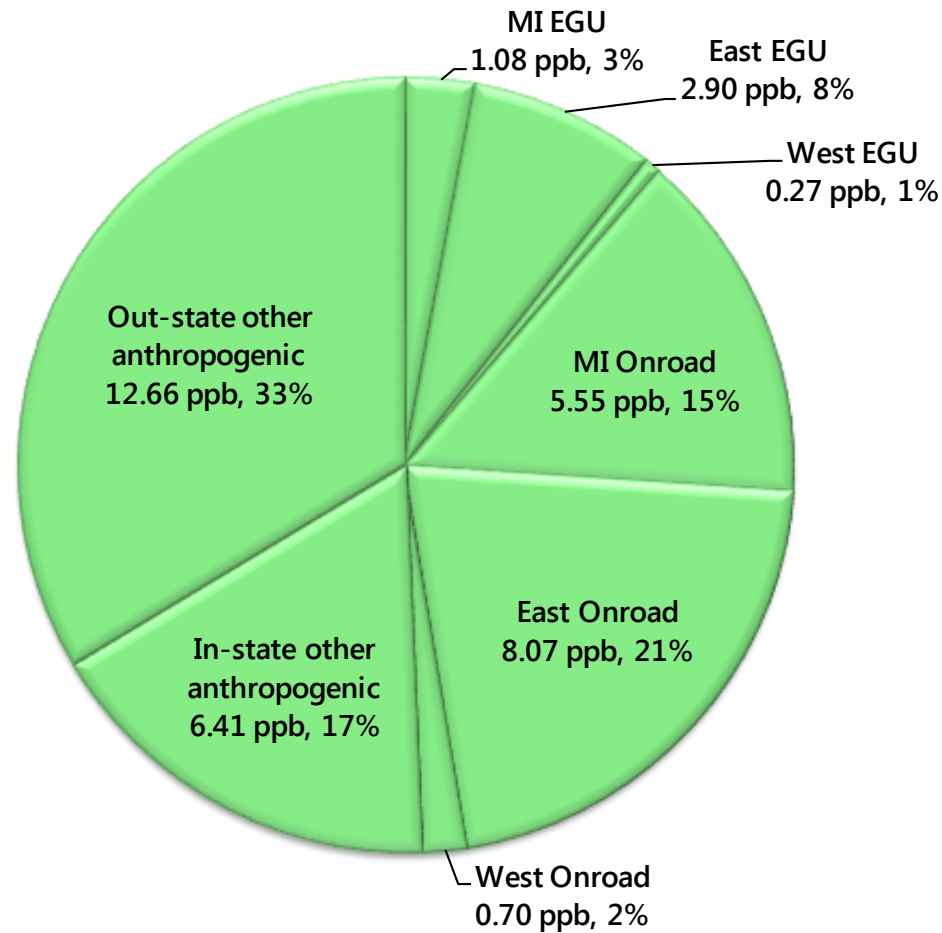
Ozone Source Contributions: Detroit



Modeled ozone contributions at the East 7 Mile monitor when monitored ozone was greater than 70 ppb (16 days; average was 78 ppb).

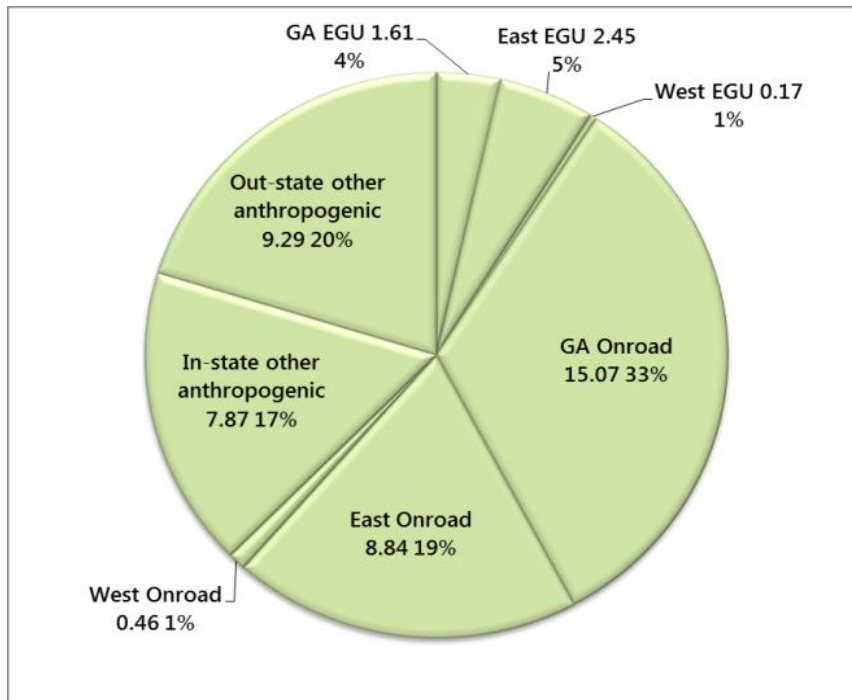
U.S. Anthropogenic Ozone Contributions: Detroit

When Monitored 8-hr Ozone > 70 ppb at East 7 Mile Monitor

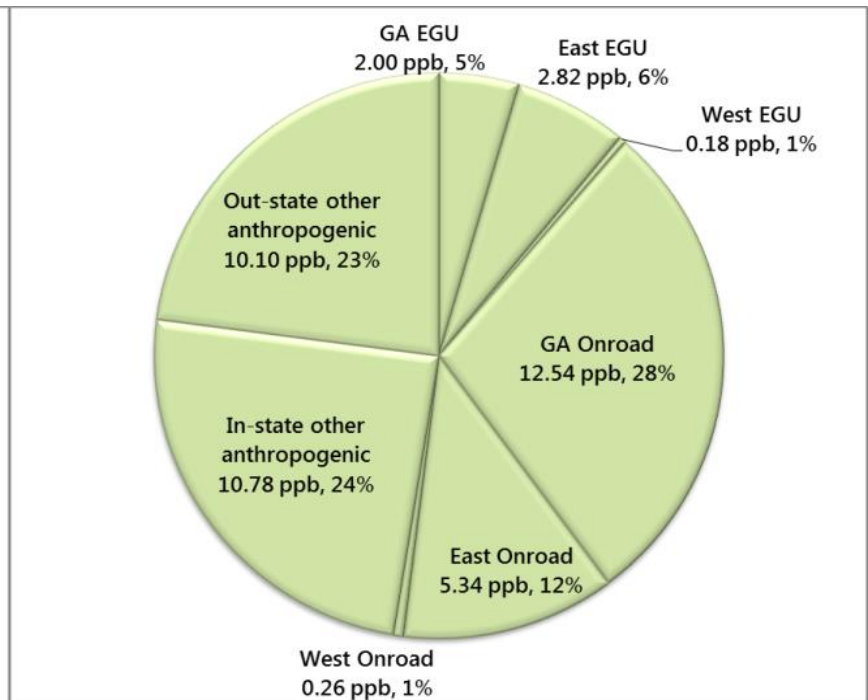


Effect of Reducing Onroad NOx Emissions by 50% at Atlanta, GA

Base Case (45.77 ppb)



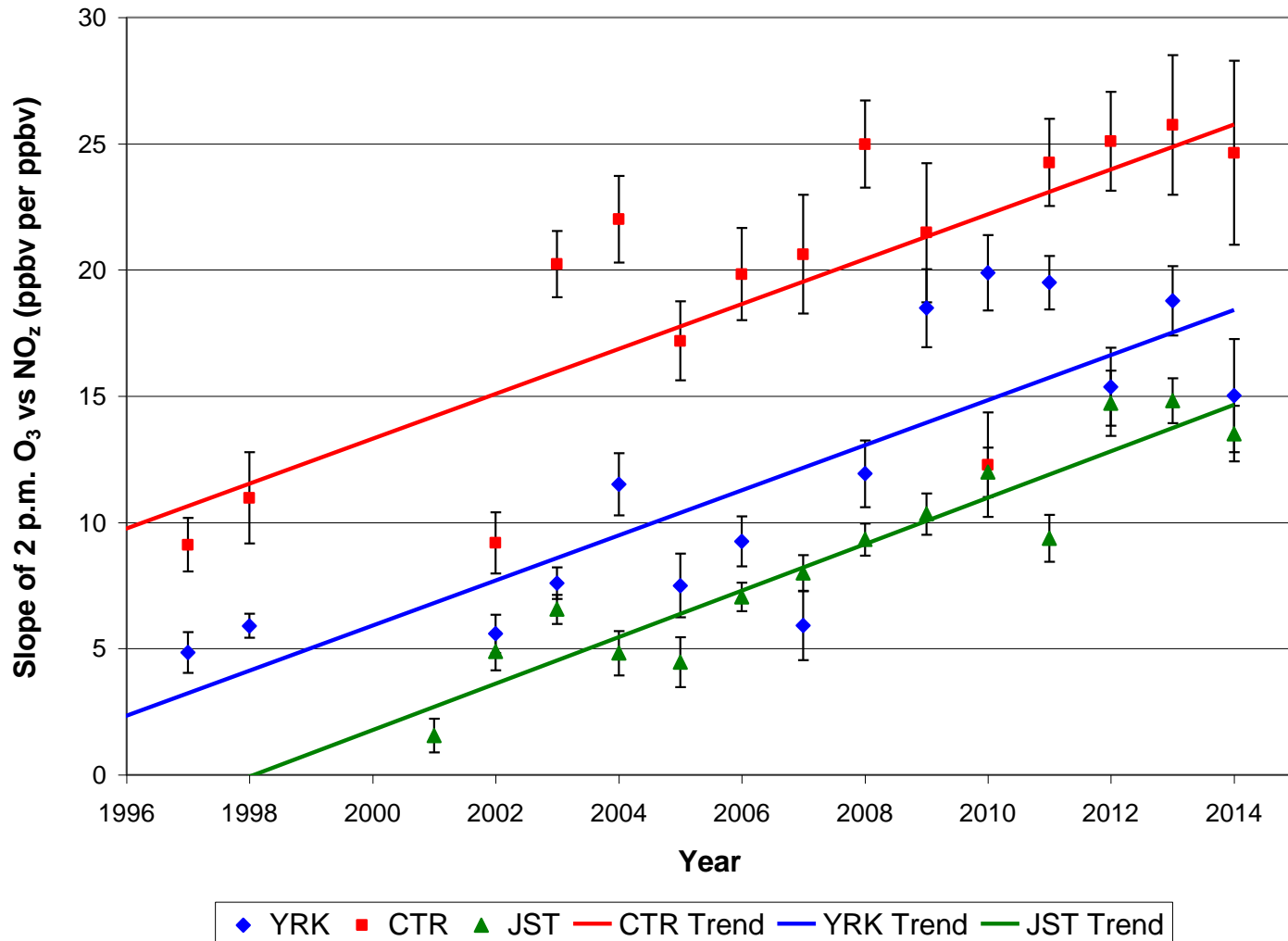
NOx Sensitivity (44.03 ppb)



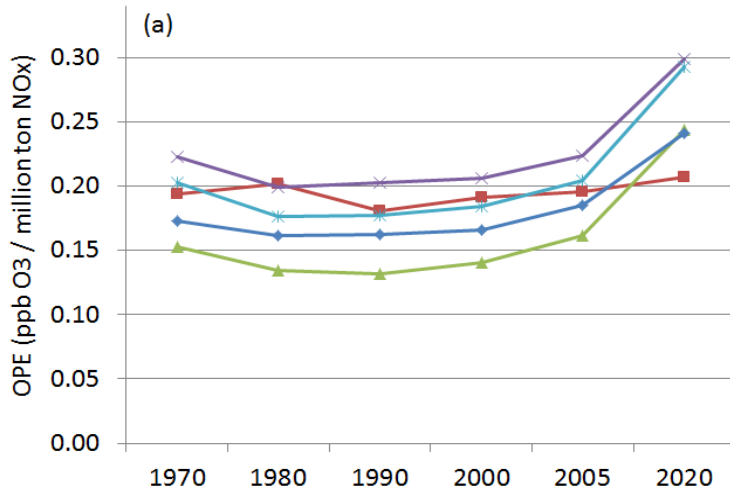
Ozone Production Efficiency (OPE)

- Conceptually, OPE is the number of molecules of O_3 formed per molecule of NO_x consumed
- Related to the number of NO- NO_2 cycles – each cycle generates one O_3 until NO_2 is oxidized to HNO_3 (termination reaction) or to other species
 - Some species – such as PAN – regenerate NO_2
- Empirically, afternoon O_3/NO_z has been used to estimate OPE

OPE at SEARCH Sites (Yorkville, Centerville, Jefferson Street)



Trends in OPE using Modeling from 1970 to 2020

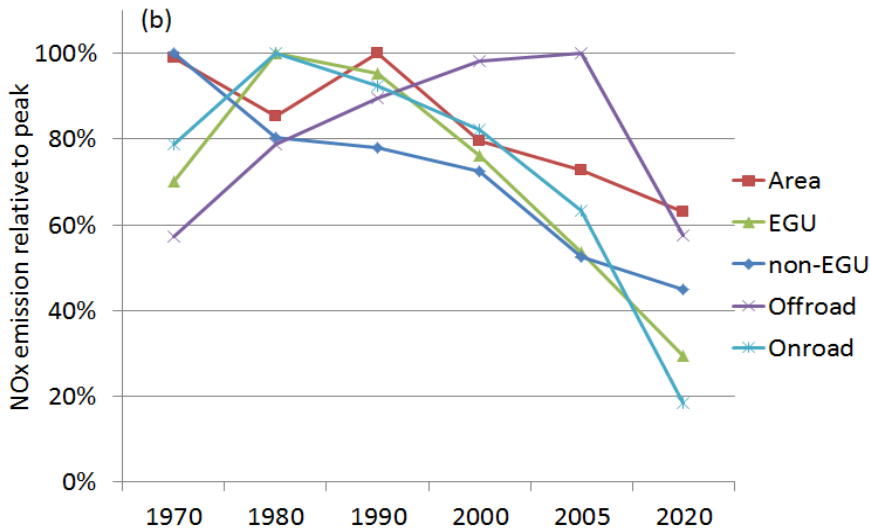


- OPE is calculated here as ratio of ozone to NOx emissions

- OPE was at its lowest in 1980 or 1990

- OPE for EGU's lower than other categories except in 2020

- Biggest change in OPE corresponds to the biggest change in NOx emissions from 2005-2020



Summary

- Rising emissions from Asia and Mexico have contributed to the increasing trend in USB ozone concentrations
 - A steady increase estimated from 1970 to 2020 in the western U.S.
 - Flattening of USB in the eastern U.S. after 2000
- In the Mountainous West region USB can be higher than 90% of total ozone on high ozone days
- Contributions of U.S. anthropogenic emissions to ozone at four locations ranged from ~25% to ~60% on high ozone days
- U.S. anthropogenic ozone contributions were virtually unchanged in response to the 50% NO_x reductions from onroad emissions
 - Decrease in contributions from the onroad sector was offset by increased contributions from other anthropogenic and non-anthropogenic source sectors
- Both observations and modeling results suggest OPE has been increasing as NO_x emissions have gone down since 1990



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