Influence and Policy Implications of International Emissions in the Northern Wasatch Front Ozone Nonattainment Area

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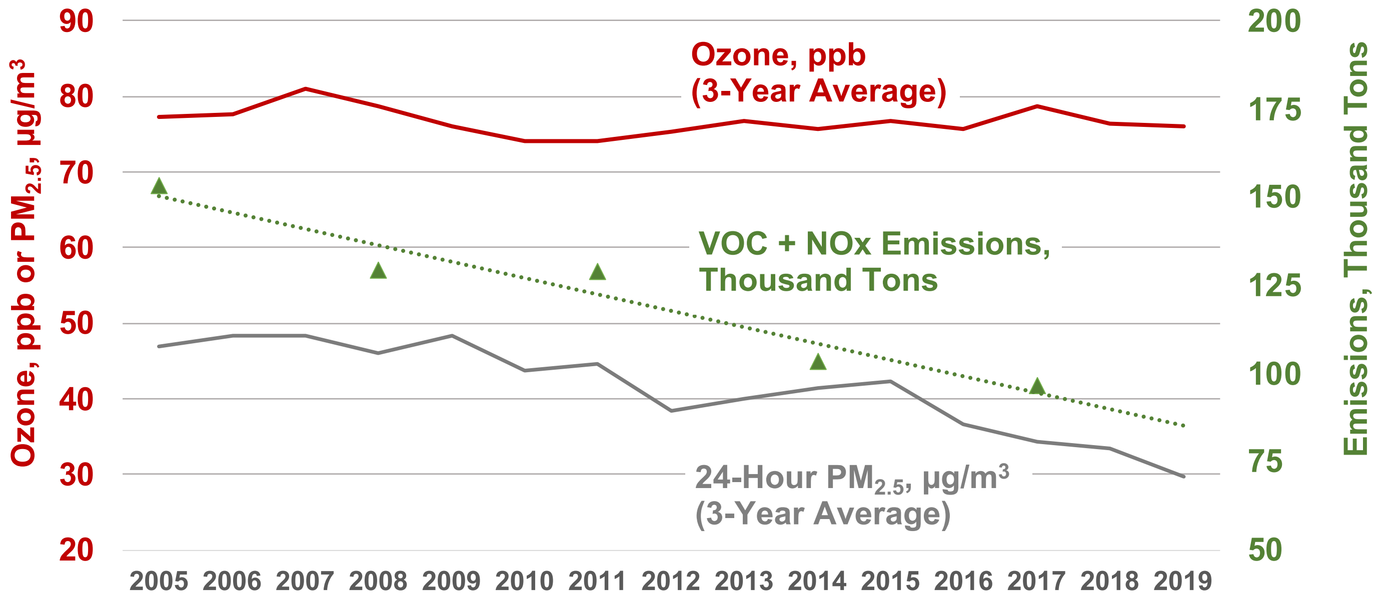
National Ambient Air Quality Standard (NAAQS) for Ozone in the Northern Wasatch Front

- 2015 Ozone NAAQS – Attainment based on “design value” (DV):
  - 3-year average of the annual 4th highest maximum daily average 8-hour ozone concentrations
- Northern Wasatch Front (NWF) designated “nonattainment”:
  - “Marginal” classification
  - Attainment date August 3, 2021.
  - All of Davis and Salt Lake and portions of Weber and Tooele Counties
- This discussion describes:
  - The difficulty for the NWF to attain the 2015 ozone NAAQS
  - An option using §179B of the Clean Air Act (CAA)

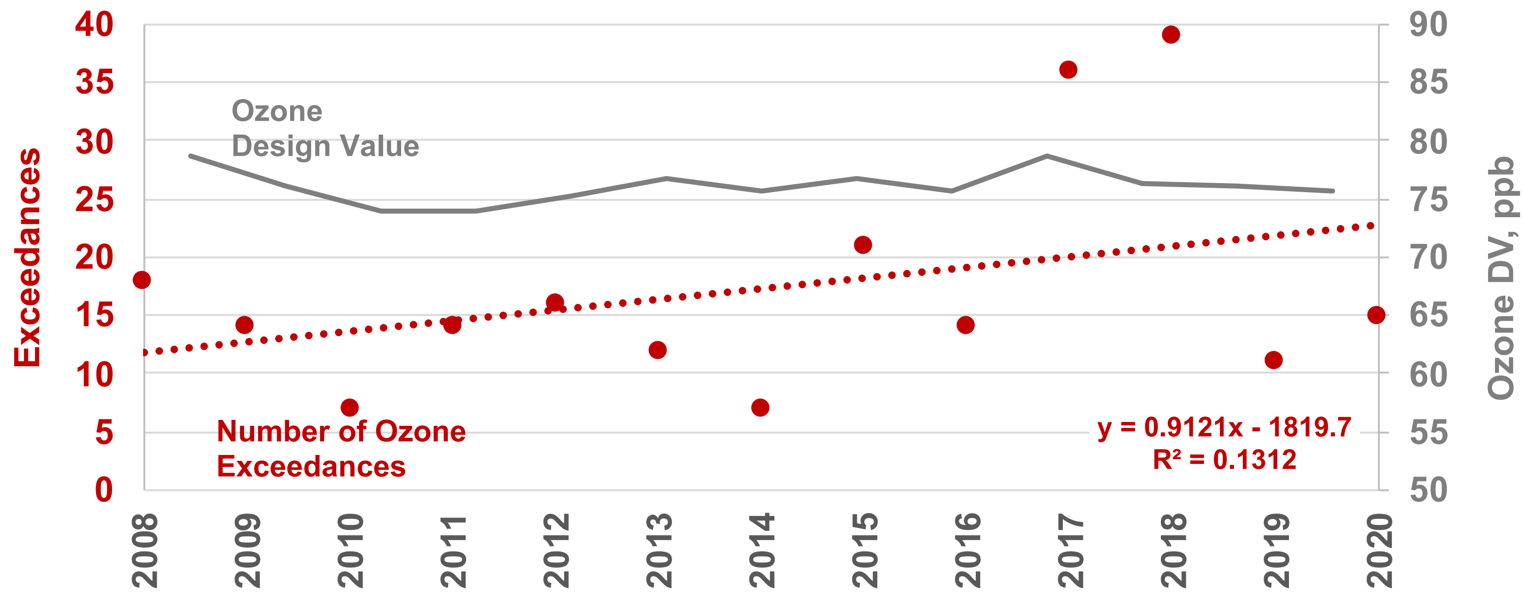
Trends: NWF Ozone and $PM_{2.5}$ with VOC + NOx Emissions



Precursor Emissions Decrease of 37% Lowered the $PM_{2.5}$ but Ozone Remained Constant

Ozone and $PM_{2.5}$ are DVs. $PM_{2.5}$ DVs are 3-year averages of 98th percentile 24-hour average $PM_{2.5}$ concentrations from each year. Emissions plotted are annual emission inventories for counties represented in the Wasatch Front ozone nonattainment areas, obtained from https://deq.utah.gov/air-quality/statewide-emissions-inventories.

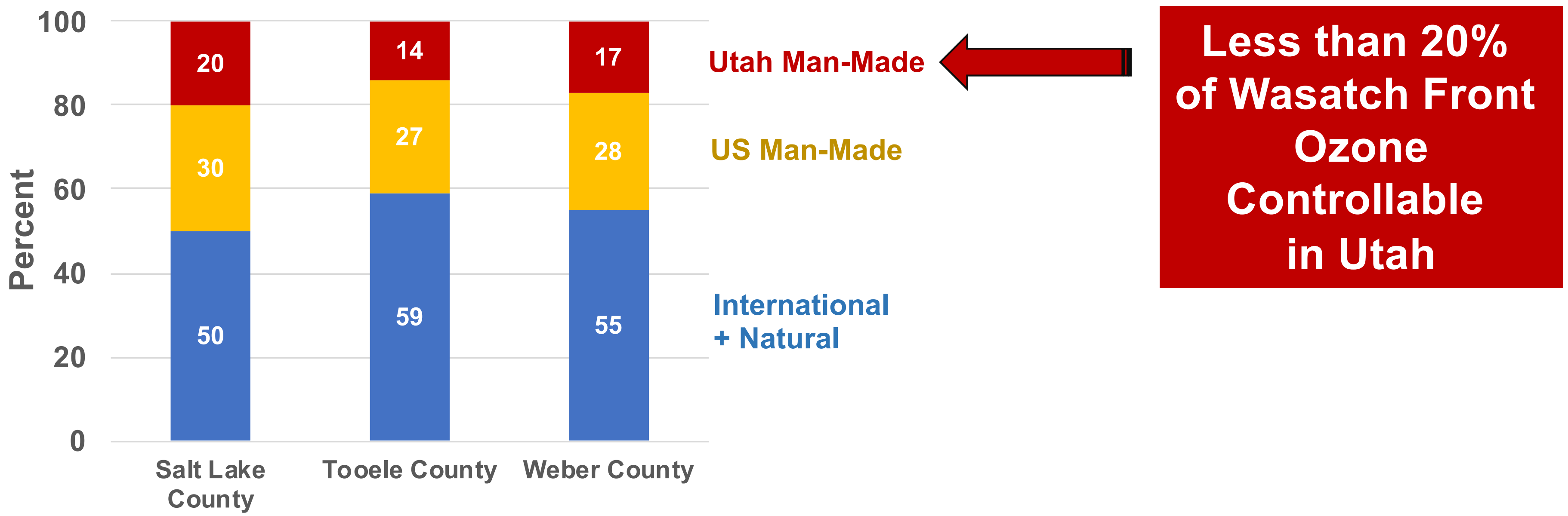
Annual Ozone Exceedances and Design Value, Salt Lake City Core-Based Statistical Area (CBSA)



While the Ozone DV Remained Constant, Annual Ozone Exceedances Have Not Decreased

Number of Exceedances per Year obtained from EPA outdoor air quality data website at https://www.epa.gov/outdoor-air-quality-data/air-data-ozone-exceedances.

Sources of Ozone in NWF



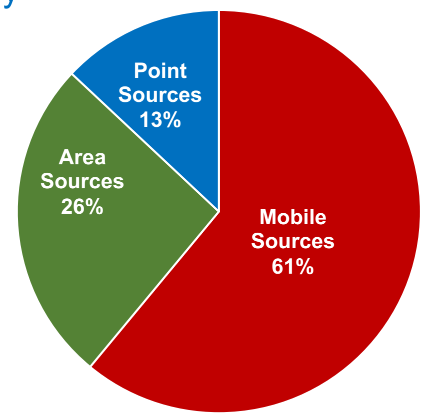
Source: EPA 2015 background ozone white paper (EPA website at https://www.epa.gov/ground-level-ozone-pollution/background-ozone-workshop-and-information - accessed on 1/21/2021)

Sources of Utah Man-Made Emissions in the Northern Wasatch Front

Point:
- Electric generation
- Petroleum refining
- Other large industry

Most Utah Man-Made Emissions From Difficult-to-Control Area Sources And Federally Regulated Mobile Sources

Area:
- Restaurants
- Auto body
- Painting
- Dry cleaners
- Gas stations
- Commercial
- Small industry
- Residential heating, cooking, hot water, wood-burning, etc.



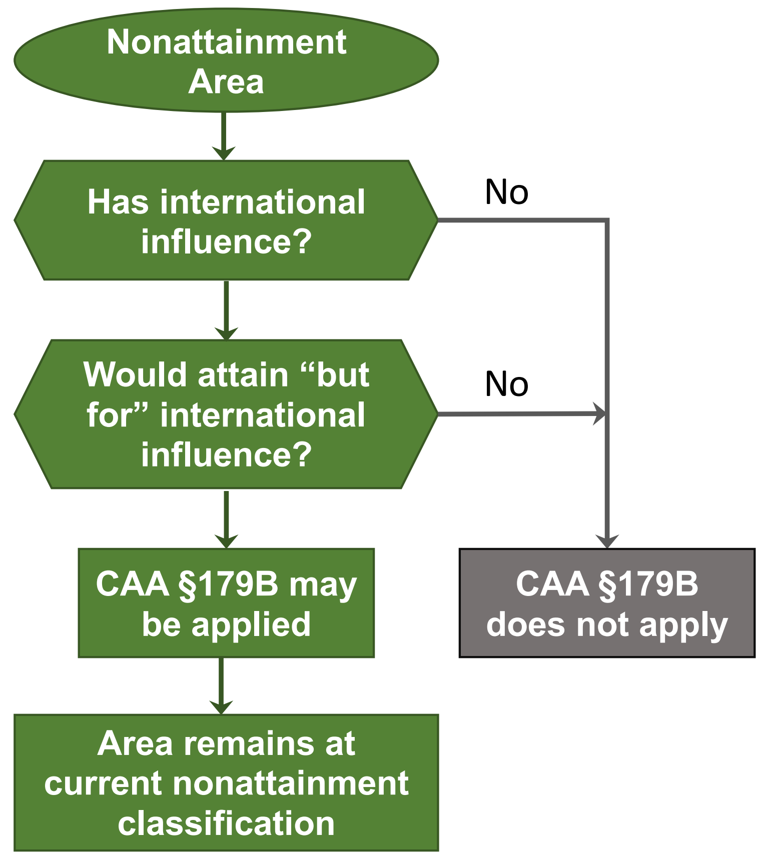
Mobile:
- On-road cars and trucks
- Off-road trains, construction, lawn/garden, airport, etc.

Source of pie chart: DAQ-2020-007464 "Marginal Ozone Inventory", Northern Wasatch Front, UT; June 2020; Table 3, Nonattainment area ozone season day emissions in tons per day

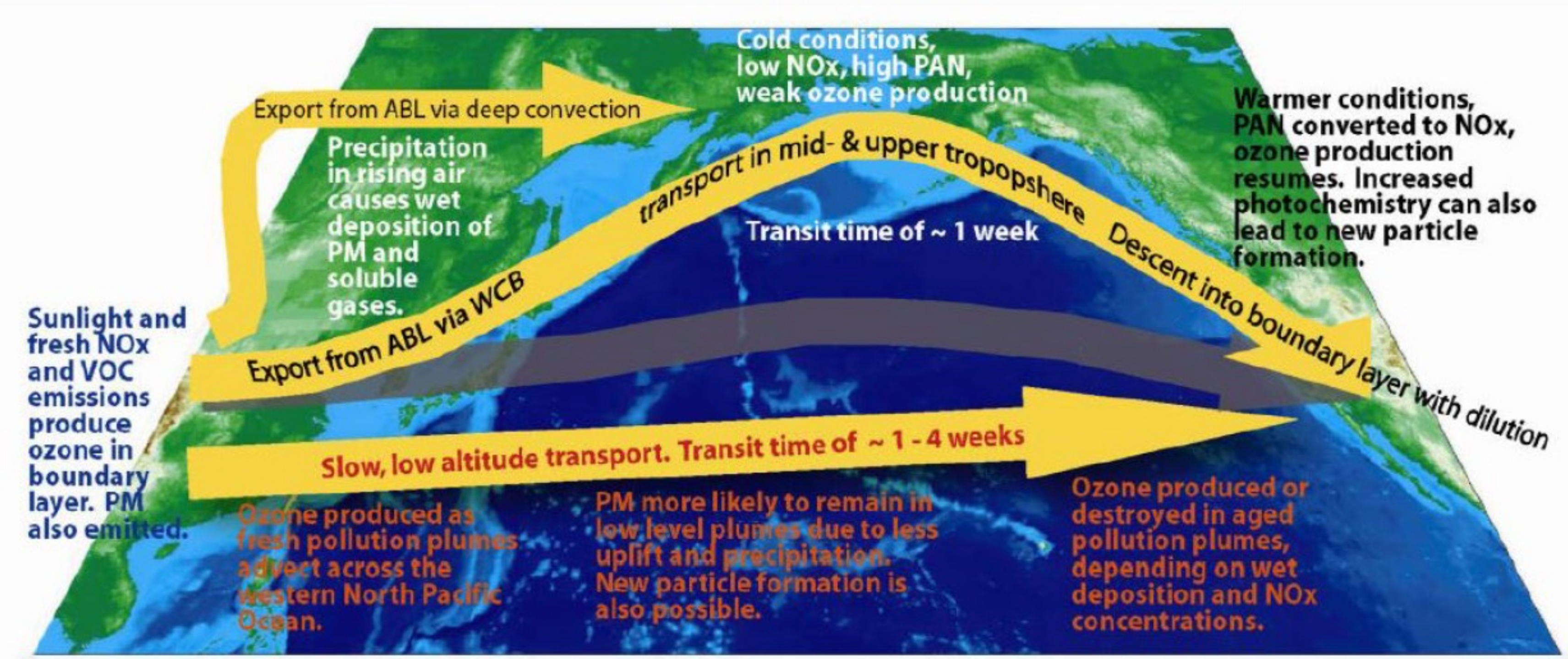
CAA §179B

- CAA §179B
  - For nonattainment areas that would meet a NAAQS “but for” the influence of international emissions
  - State submits technical demonstration
  - EPA approves
- If applied to the NWF at Marginal
  - Remains nonattainment at Marginal
  - No “bump up” to “Moderate”
- The rest of the discussion focuses on international emissions
  - Global transport to intermountain west
  - Modeling study to quantify the influence on the NWF

CAA §179B Offers Viable Option for NWF



Conceptual Model of Trans-Pacific Ozone Transport*



Blue text on left applies to continental boundary layer processes, **red text** applies to low level transport, and **black/white** text applies to high altitude transport.

*Source: "Hemispheric Transport of Air Pollution 2010: Part A: Ozone and Particulate Matter Air Pollution Studes, No. 17": http://htapold.kaskada.tk/publications/2010_report/2010_Final_Report/HTAP%202010%20Part%20A%20110407.pdf

Photochemical Modeling

- Simulate global international anthropogenic emission (IAE) contributions to NWF ozone
  - Follow EPA guidance for §179B demonstrations
  - Adhere to EPA modeling guidelines for State Implementation Plans (SIPs)
  - Apply EPA's 2016 national modeling platform (MP) for CMAQ & CAMx photochemical models
- CMAQ "sensitivity" run: remove IAE contributions and assess resulting ozone in NWF
- CAMx "source apportionment" (SA) run: track IAE contributions to ozone in NWF
- Different approaches establish a range of plausible IAE impacts as weight of evidence

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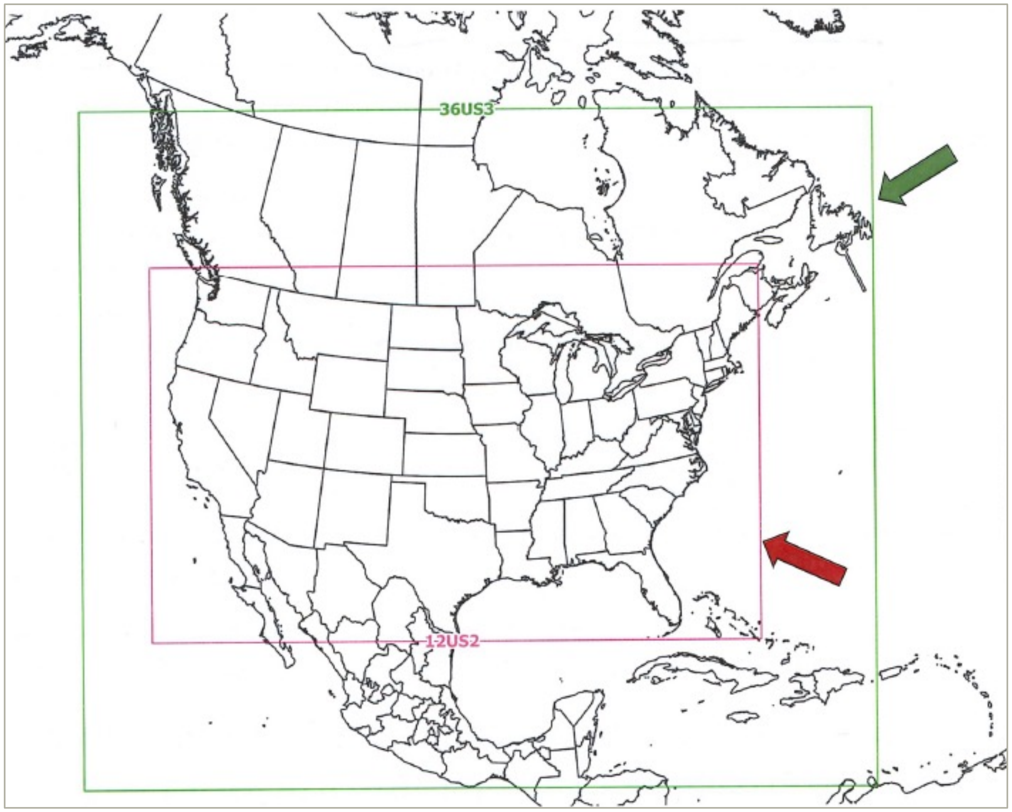
EPA 2016 Modeling Platform

- Nested modeling grids:
  - North America (NA) 36 km resolution
  - Continental US (CONUS) 12 km resolution
- 2016 "BASE" scenario:
  - Global anthropogenic emissions
  - North America: US, Canada, Mexico
  - Natural: biogenic, fires, lightning NOx, oceanic
- "Zero Rest of World" (ZROW) scenario:
  - Remove all non-US anthropogenic emissions
- Global modeling provides NA boundary conditions for BASE and ZROW



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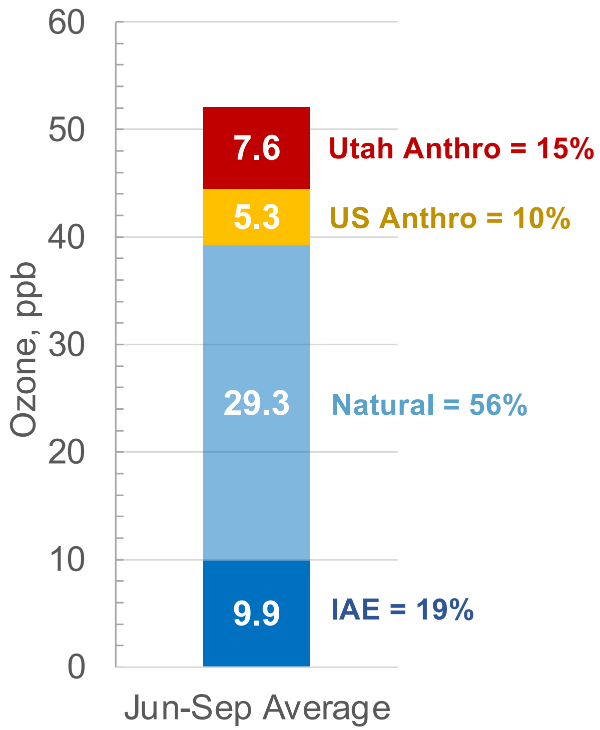
Modeled Sensitivity vs. Source Apportionment

- CMAQ sensitivity run (BASE – ZROW):
  - "How does ozone ***change*** when IAE contributions are removed?"
- CAMx SA run on BASE scenario:
  - "What is the ***ozone contribution*** from IAE in the BASE environment?"
  - Sources tracked with SA:
    - IAE: Global (Boundary Conditions) + Canada + Mexico
    - Anthropogenic: Utah and rest of US
    - Natural: Utah, rest of US, international
- These questions are equivalent for linear problems, but differ for non-linear problems like ozone

Modeled Average Ozone Contributions at Bountiful Viewmont Monitor Site: Summer 2016



Utah anthropogenic contributions average 15%

IAE contributions average ~10 ppb or 19%

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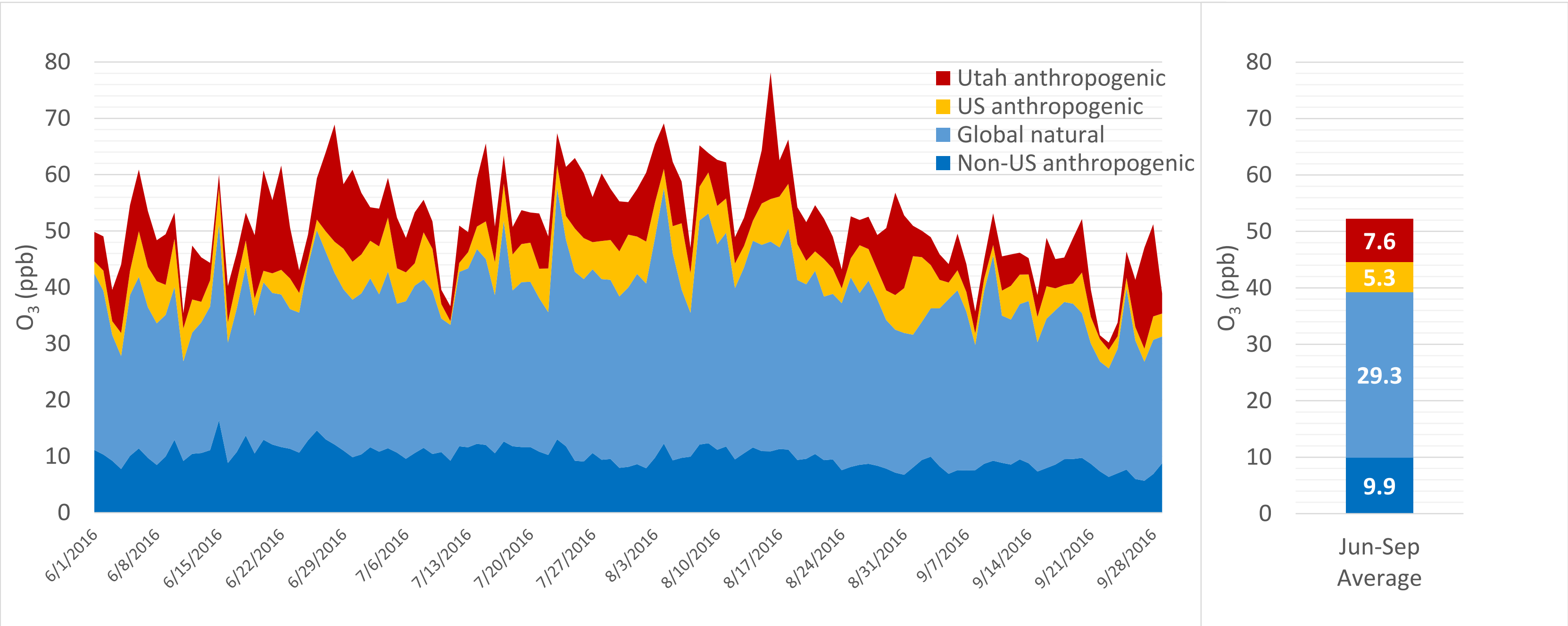
Modeled Daily Ozone Contributions at Bountiful Viewmont Monitor Site: Summer 2016



Time series of MDA8 ozone SA results over June-September 2016 (left), and summer-average contributions (right). The IAE contribution is shown at the bottom in dark blue, and all colored contributions sum to the total ozone at the top of each graph.

IAE contribution *does not vary significantly day to day*

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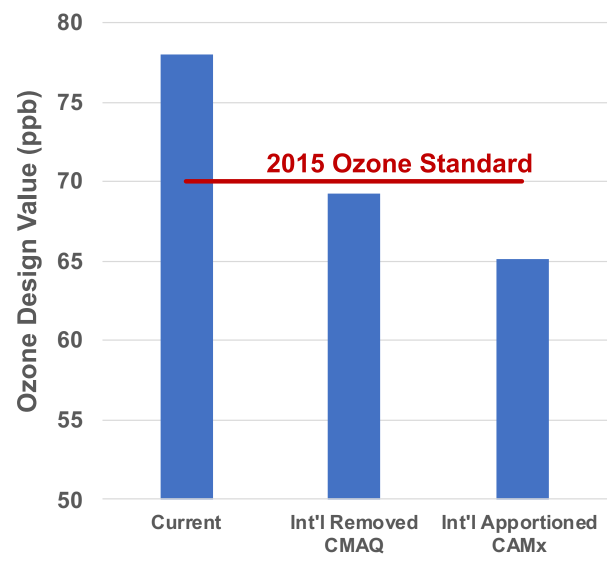
Summary and Conclusions

- It will be difficult for the NWF to attain the ozone NAAQS on schedule
- CAA §179B offers a viable path forward
- Scientific literature and EPA describe the conceptual model for trans-Pacific transport
  - Our analyses support the conceptual model
- CMAQ & CAMx show projected DV ≤ 70 ppb at all sites
  - Maximum projected DV is 68 ppb
  - SA indicates the IAE contribution:
    - Averages ~10 ppb over the summer season
    - Does not vary significantly day to day



"But for" international anthropogenic contribution, the NWF would meet the ozone standard

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End

Modeled Ozone vs. Measurements

- CMAQ & CAMx agreement is good & within benchmarks for acceptable performance
  - At levels typically achieved for SIP modeling
  - Consistent under prediction, performance degrades on days >60 ppb
- Systematic under prediction may be an issue
  - Analyses suggests global and US background ozone are well simulated
  - Simulated local ozone production may be too low

EPA's CMAQ Run			
MDA8 Ozone	**Correlation**	**Bias**	**Error**
All summer days	0.63	-7%	11%
Days > 60 ppb	0.34	-13%	14%
Benchmark*	>0.50	<±15%	<25%

Ramboll's CAMx Run			
MDA8 Ozone	**Correlation**	**Bias**	**Error**
All summer days	0.78	-6%	10%
Days > 60 ppb	0.42	-12%	13%
Benchmark*	>0.50	<±15%	<25%

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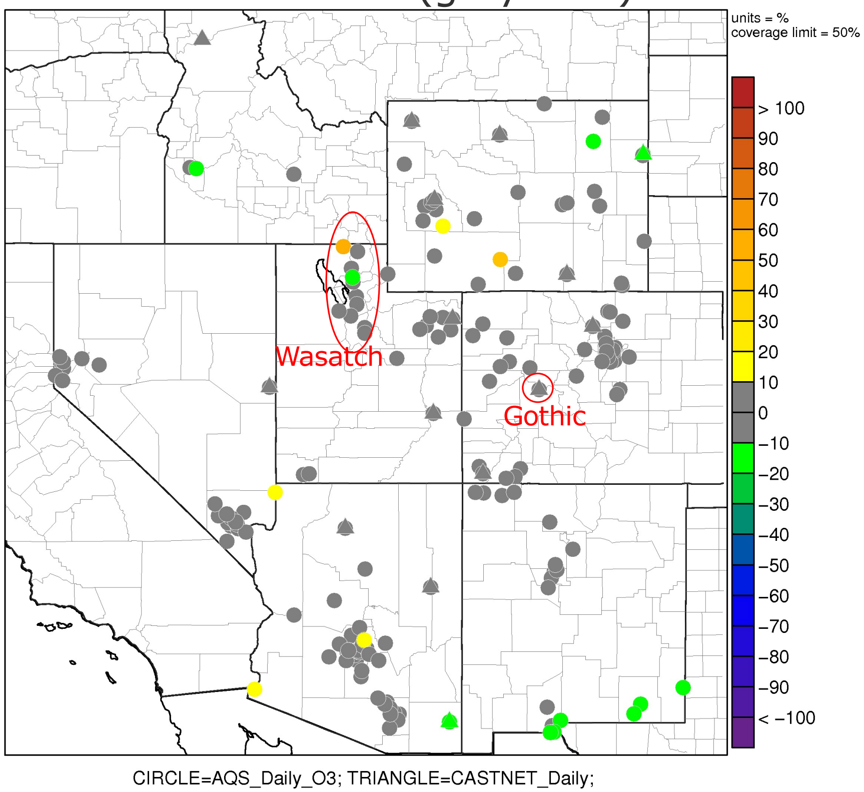
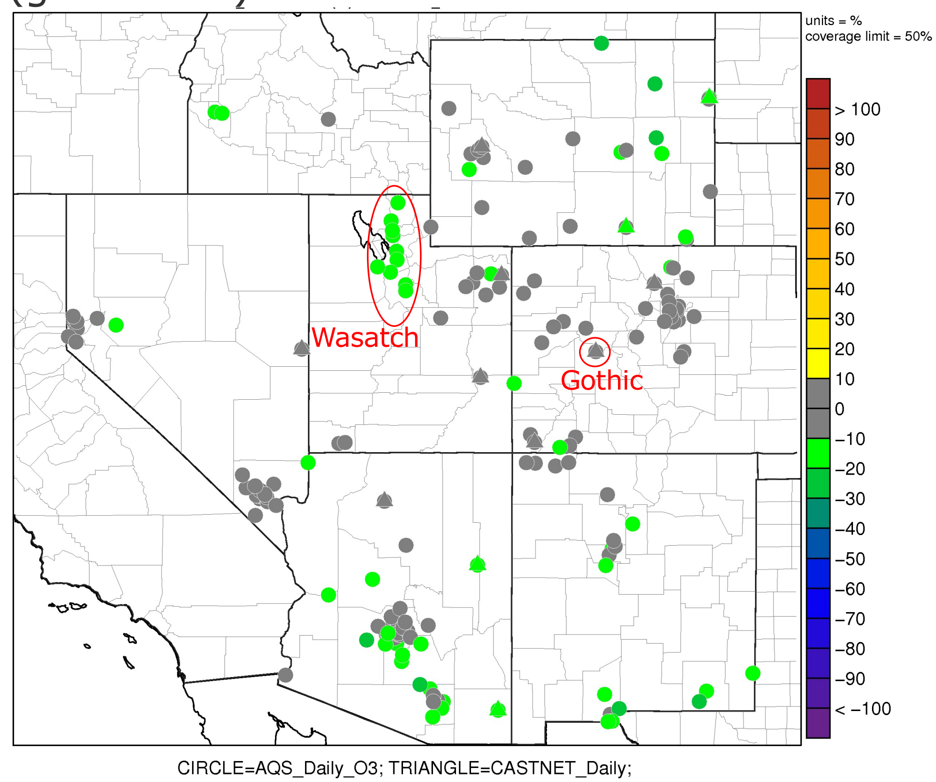
*Emery, C., Z. Liu, A.G. Russell, M.T. Odman, G. Yarwood, N. Kumar (2016): Recommendations on statistics and benchmarks to assess photochemical model performance, J. Air & Waste Management Association, http://dx.doi.org/10.1080/10962247.2016.1265027

2016 V1 CAMx Ozone Model Performance Evaluation
June-September Normalized Mean Bias (NMB)

NMB for all days: good agreement at most rural and urban sites (grey dots)



NMB for days > 60 ppb: urban low bias (green dots)



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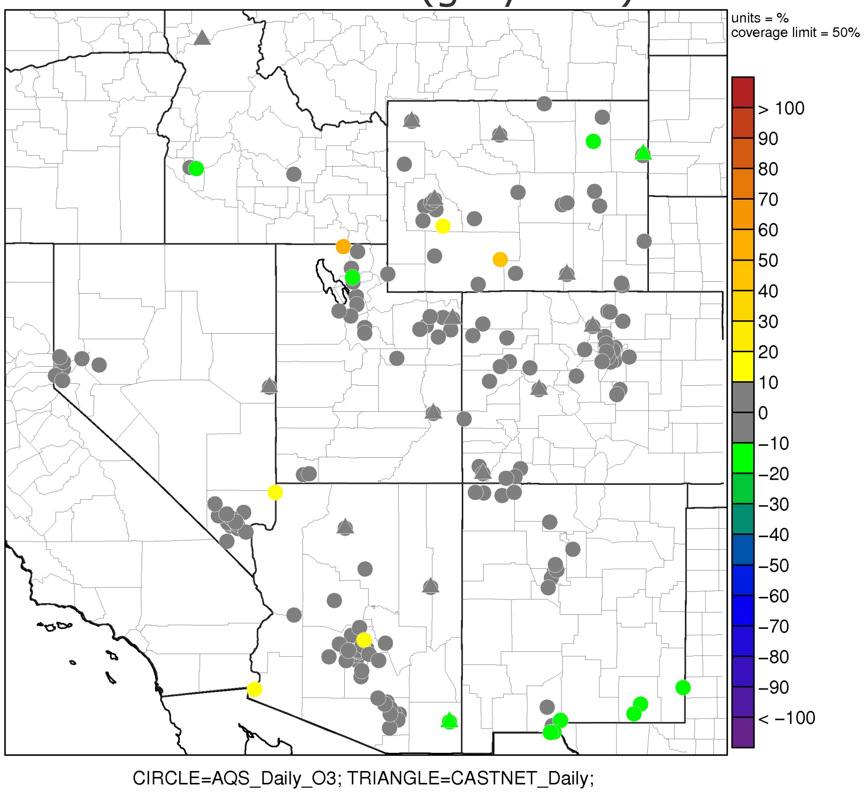
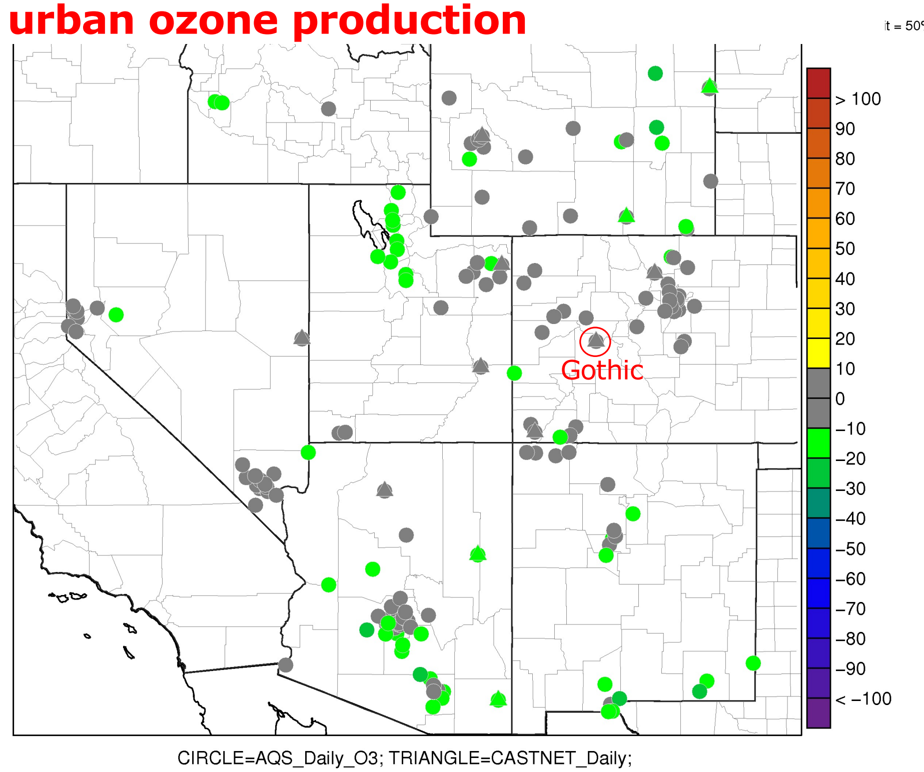


<u>NMB for days > 60 ppb</u>: urban low bias (green dots) – **points to lack of local urban ozone production**



DV Scaling Approach

- Monitored DVs for each site in the Wasatch Front area
  - DV = 3-year average of annual 4th-high MDA8 ozone concentration
- Calculate site-specific “relative response factor” (RRF): apply as a scaling factor
  - RRF = average relative model change over high modeled ozone days (>60 ppb)
  - Allows use of year-specific modeling (2016) to apply to range of recent DV years
  - Model-scaled DVs ≤ 70.9 ppb indicate attaining monitors “but for” IAE

$$DV_{scaled} = DV_{monitored} \times \underbrace{\left(\frac{\bar{C}_{ZROW}}{\bar{C}_{Base}}\right)}_{\text{RRF}}$$

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SMAT DV Scaling Using EPA Beta CMAQ BASE and ZROW Output

Site	County	2013-2017 Average DV[1]*	Modeled RRF (ZROW/Base)	ZROW DV (≤70.9 Attains)
Northern Wasatch Front				
490110004 Bountiful	Davis	74	0.8869	66.0
490353006 Hawthorne	Salt Lake	76	0.8924	68.0
490353013 Herriman	Salt Lake	76	0.8686	66.0
490450004 Erda	Tooele	73	0.8592	62.7
490570002 Ogden	Weber	72	0.8811	63.4
490571003 Harrisville	Weber	72	0.8784	63.5
Southern Wasatch Front				
490490002 Provo	Utah	71	0.8881	63.6
490495010 Spanish Fork	Utah	72	0.8905	64.1

[1] SMAT-CE is delivered with DV data up through 2017; these results are directly from SMAT-CE.
* EPA modeling guidance recommends scaling the 3-year average DV: in this case, 2013-2015, 2014-2016, 2015-2017

Site	County	2015-2017 DV[1]	Modeled RRF (ZROW/Base)	ZROW DV (≤70.9 Attains)
Northern Wasatch Front				
490110004 Bountiful	Davis	75	0.8869	66.5
490353006 Hawthorne	Salt Lake	78	0.8924	69.6
490353013 Herriman	Salt Lake	76	0.8686	66.0
490450004 Erda	Tooele	73	0.8592	62.7
490570002 Ogden	Weber	73	0.8811	64.3
490571003 Harrisville	Weber	73	0.8784	64.1
Southern Wasatch Front				
490490002 Provo	Utah	72	0.8881	63.9
490495010 Spanish Fork	Utah	71	0.8905	63.2

[1] Using latest DV available in SMAT-CE; these results are directly from SMAT-CE.

Site	County	2016-2018 DV[1]	Modeled RRF (ZROW/Base)	ZROW DV (≤70.9 Attains)
Northern Wasatch Front				
490110004 Bountiful	Davis	78	0.8869	69.2
490353006 Hawthorne	Salt Lake	76	0.8924	67.8
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Southern Wasatch Front				
490490002 Provo	Utah	N/A	0.8881	N/A
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Site	County	2017-2019 DV[1]	Modeled RRF (ZROW/Base)	ZROW DV (≤70.9 Attains)
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490570002 Ogden	Weber	71	0.8811	62.6
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Southern Wasatch Front				
490490002 Provo	Utah	N/A	0.8881	N/A
490495010 Spanish Fork	Utah	70	0.8905	62.3

[1] Using latest EPA-official DV; these results apply RRF to 2017-2019 DV outside of SMAT-CE.

In every case ZROW results in DV<70 ppb, well within attainment

SMAT DV Scaling Using V1 CAMx OSAT Output

Site	County	2013-2017 Average DV[1]*	Modeled RRF	OSAT DV (≤70.9 Attains)
Northern Wasatch Front				
490110004 Bountiful	Davis	74	0.8346	62.1
490353006 Hawthorne	Salt Lake	76	0.8293	63.2
490353013 Herriman	Salt Lake	76	0.8224	62.5
490450004 Erda	Tooele	73	0.8375	61.1
490570002 Ogden	Weber	72	0.8297	59.7
490571003 Harrisville	Weber	72	0.8432	60.9
Southern Wasatch Front				
490490002 Provo	Utah	71	0.8326	59.6
490495010 Spanish Fork	Utah	72	0.8330	59.9

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[1] Using latest EPA-official DV; these results apply RRF to 2017-2019 DV outside of SMAT-CE.

In every case ZROW results in DV<<70 ppb, well within attainment