Ozone Modeling Platform Development

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Presentation Topics

- Introduction to modeling platforms
- Episode selection process
- Modeling domains
- Current status of modeling input development and software testing
- Next steps

What is a modeling platform?

- The TCEQ uses photochemical modeling to estimate ozone concentrations for certain regulatory applications.
- A modeling platform is the foundation of all modeling applications, consisting of the various components that are used together to estimate ozone concentrations.
- The Environmental Protection Agency's Modeling Guidance (EPA Modeling Guidance)[1] provides a blueprint for the development of modeling platforms.

[1] *"Modeling Guidance for Demonstrating Air Quality Goals for Ozone, PM2.5, and Regional Haze*", available at https://www.epa.gov/sites/production/files/2020-10/documents/o3-pm-rh-modeling_guidance-2018.pdf

What are the components of a modeling platform?

Episode

A **time period in the recent past** with observed high ozone concentrations. The calendar year the episode is from is referred to as the **base year**.

Domains

The **geographical bounds** of the area to be modeled.

Inputs

Modeling inputs including **meteorology**, **emissions inventories**, and **initial and boundary conditions**.

Testing

Testing of **modeling software** to select appropriate versions, run options, determine run times, and estimate storage needs.

MPE

Model performance evaluation (MPE) to compare modeled ozone concentration to monitored observations for the episode.

Documentation

Details of the development of the modeling platform are documented in a **Technical Support Document (TSD)**.

Why is the TCEQ developing a new modeling platform?

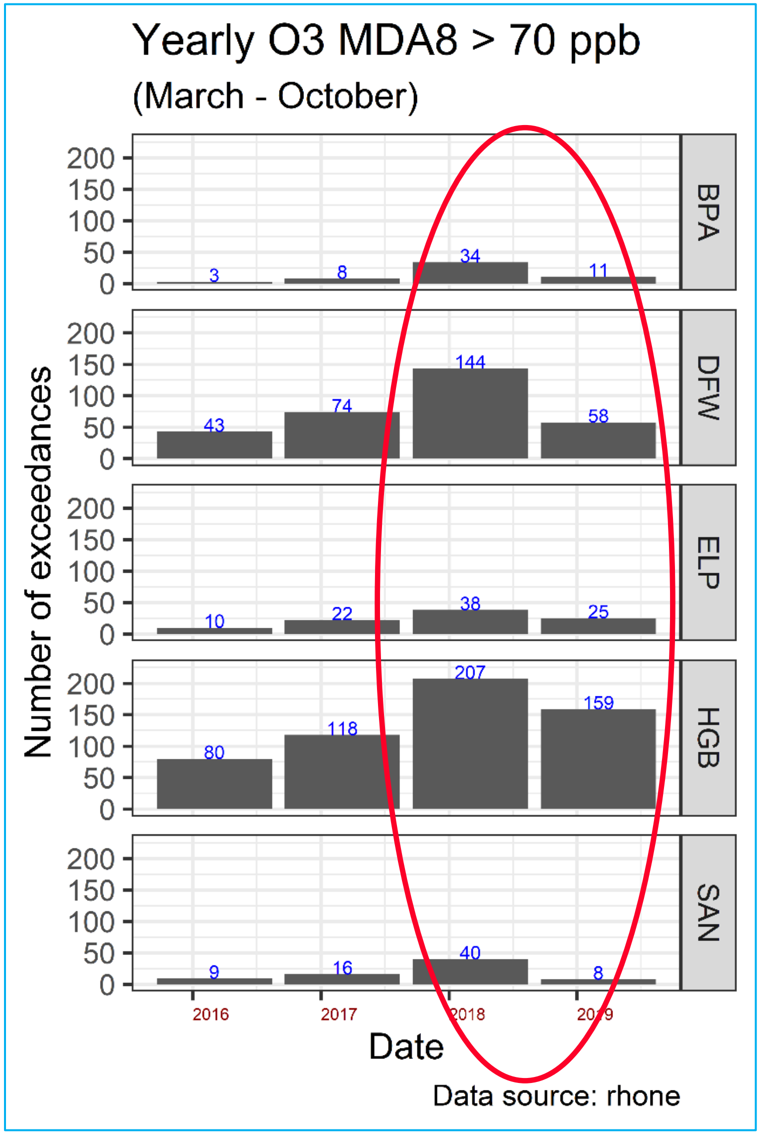
- Potential future applications of the ozone modeling platform include:
  - Modeling for attainment demonstration (AD) State Implementation Plan (SIP) revisions for ozone nonattainment areas with moderate and higher classifications, and
  - Scenario analyses to help with policy decisions.
- The last TCEQ ozone modeling platform used a 2012 base year, which is over 10 years prior to potential AD SIP revision future years.
- The most recent EPA platform is 2016, which is not an appropriate year to model ozone in Texas.

Episode

Episode Selection Criteria

- EPA Modeling Guidance recommends choosing a time period that:
  - Has a sufficient number of exceedance days;
  - Follows historically observed temporal patterns;
  - Includes a variety of meteorological conditions that frequently correspond to high ozone;
  - Has at least five days in the episode for each regulatory monitor in each nonattainment area with a monitored maximum daily average eight-hour (MDA8) value greater than or equal to 60 ppb; and
  - Is in the recent past, preferably close to a National Emissions Inventory (NEI) year.
- Timelines, resources, and data availability must also be considered.

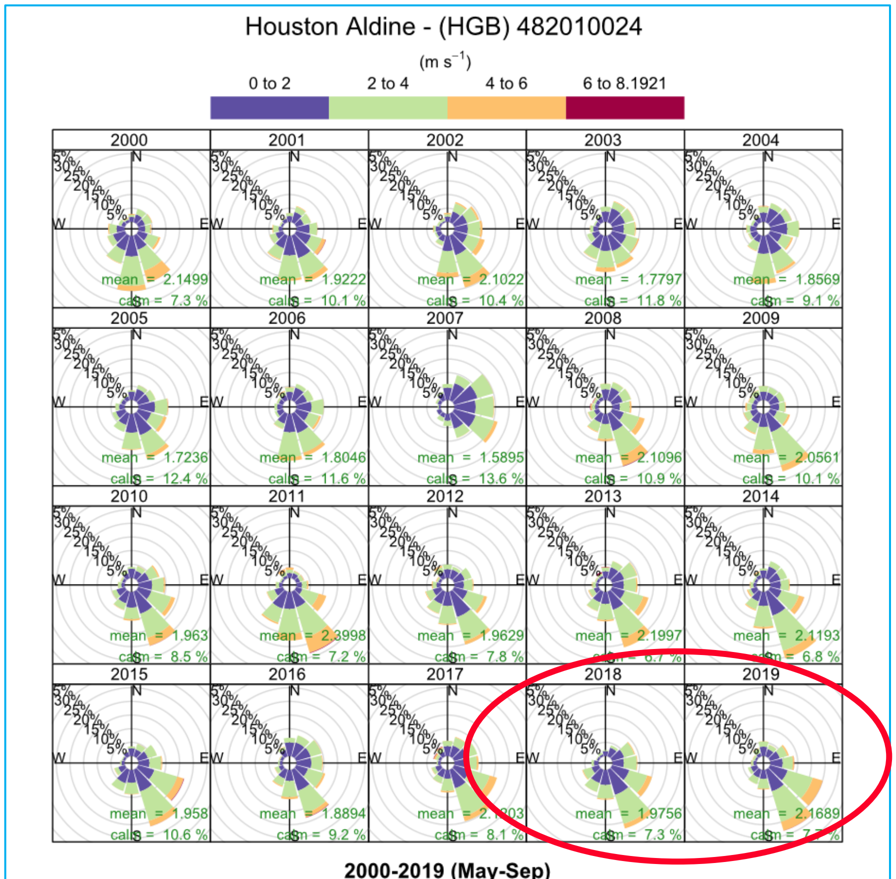
Which recent years have the most exceedance days?

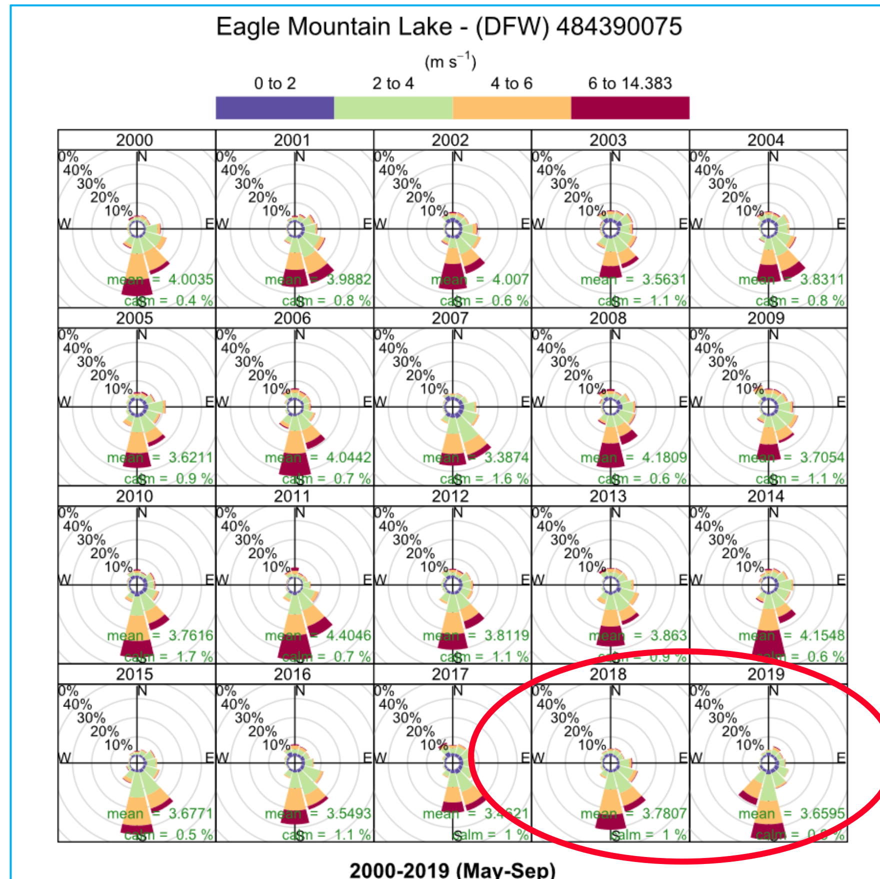


Conclusion: **2018 has the greatest number of exceedance days during the March to October ozone season, followed by 2019.**

Was Texas meteorology typical in 2018 and 2019?

Analyses focused on meteorological variables such as temperature, wind direction, stagnation, relative humidity, and precipitation to compare 2018 and 2019 to historical trends and averages.





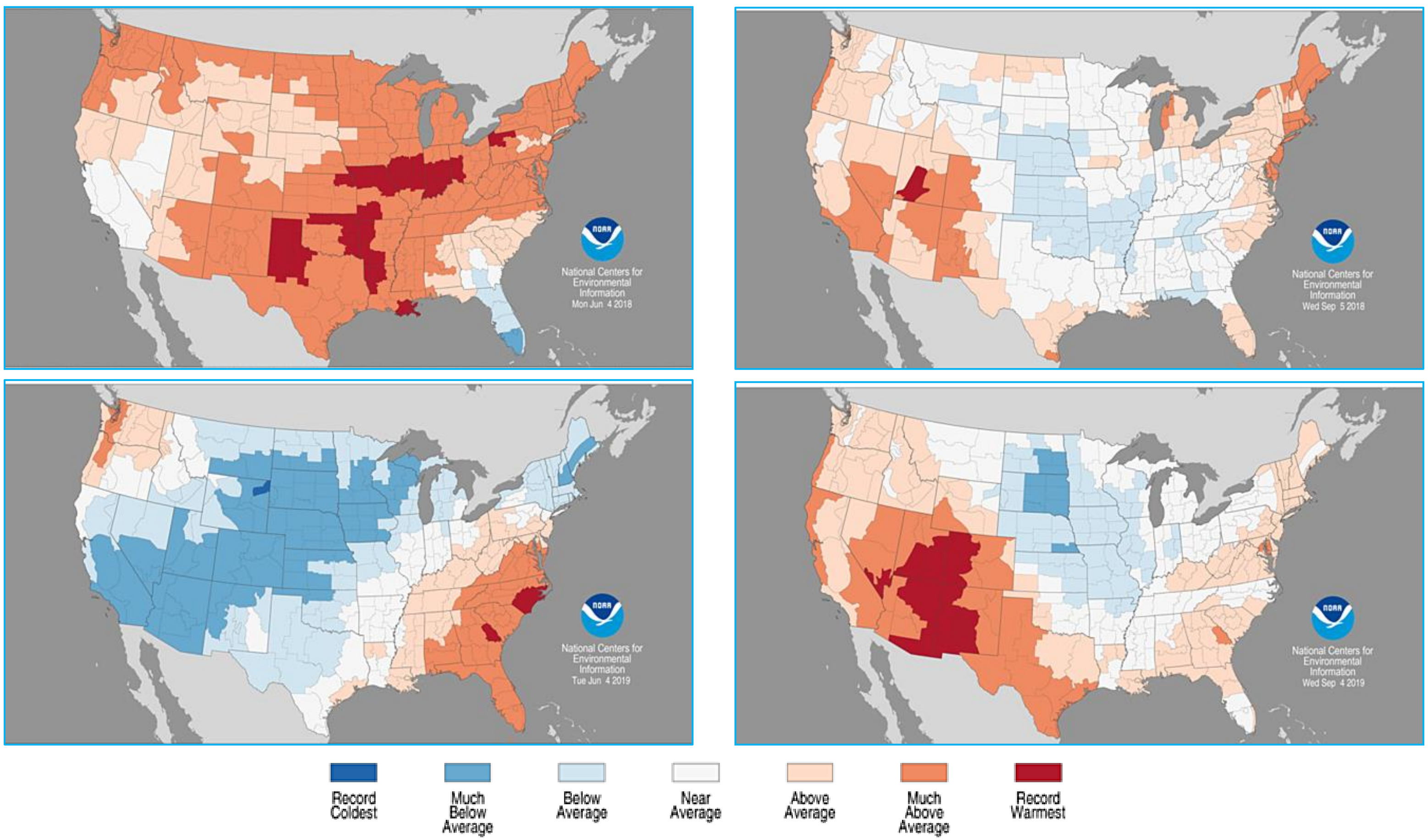
Was Texas meteorology typical in 2018 and 2019? (cont.)

Divisional Maximum Temperature Ranks from 1895-2019

May | August

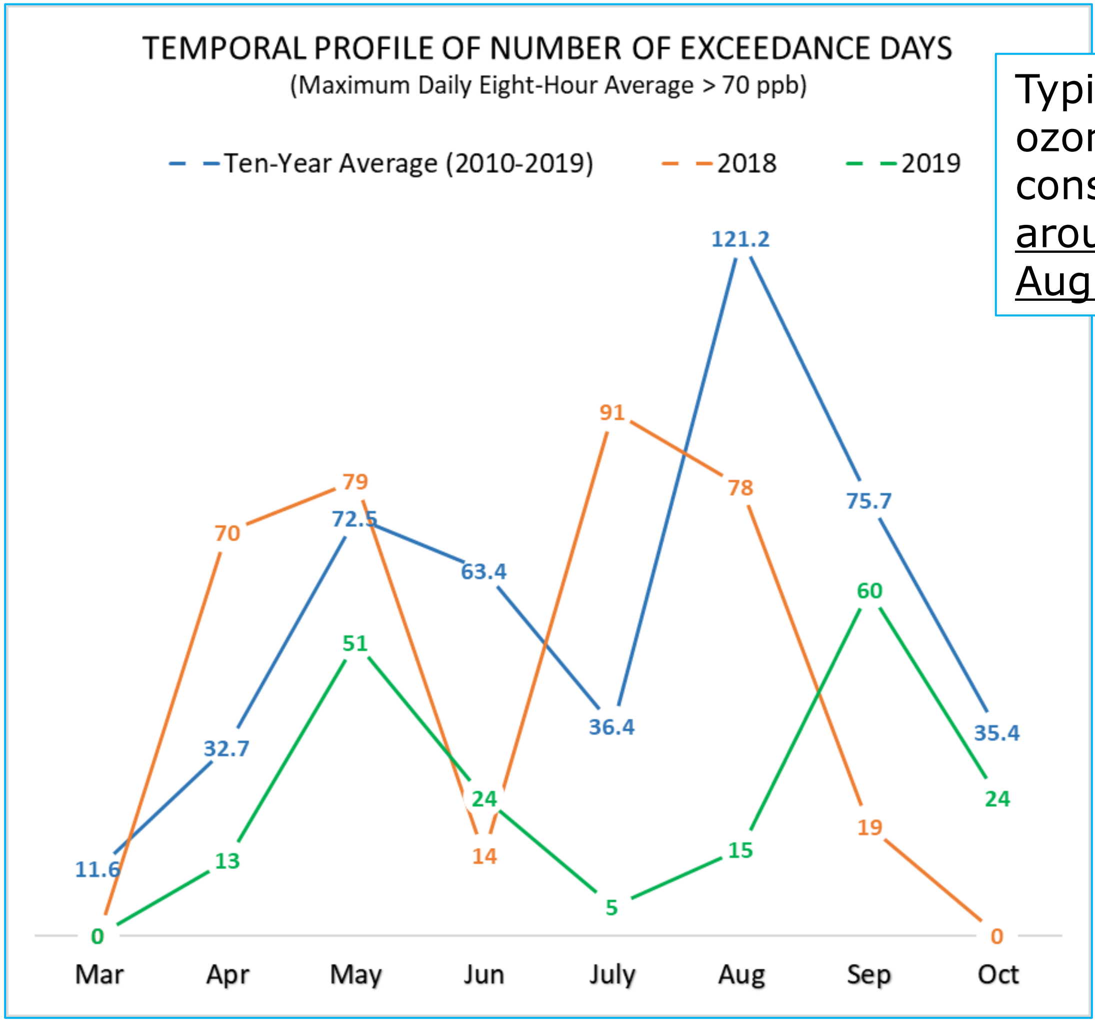
2018

2019



Conclusion: **Meteorology in 2018 and 2019 are both reasonable for ozone modeling.**

Did 2018 and 2019 have typical temporal profiles in exceedance days?



Typical temporal pattern during the ozone season months in DFW and HGB consists of a bi-modal peak centered around May/June and August/September with a low in July.

Conclusion: **July 2018 is unusual with more exceedance days than seen in the past ten years. June and September of 2018 are unusual with very low exceedances.**

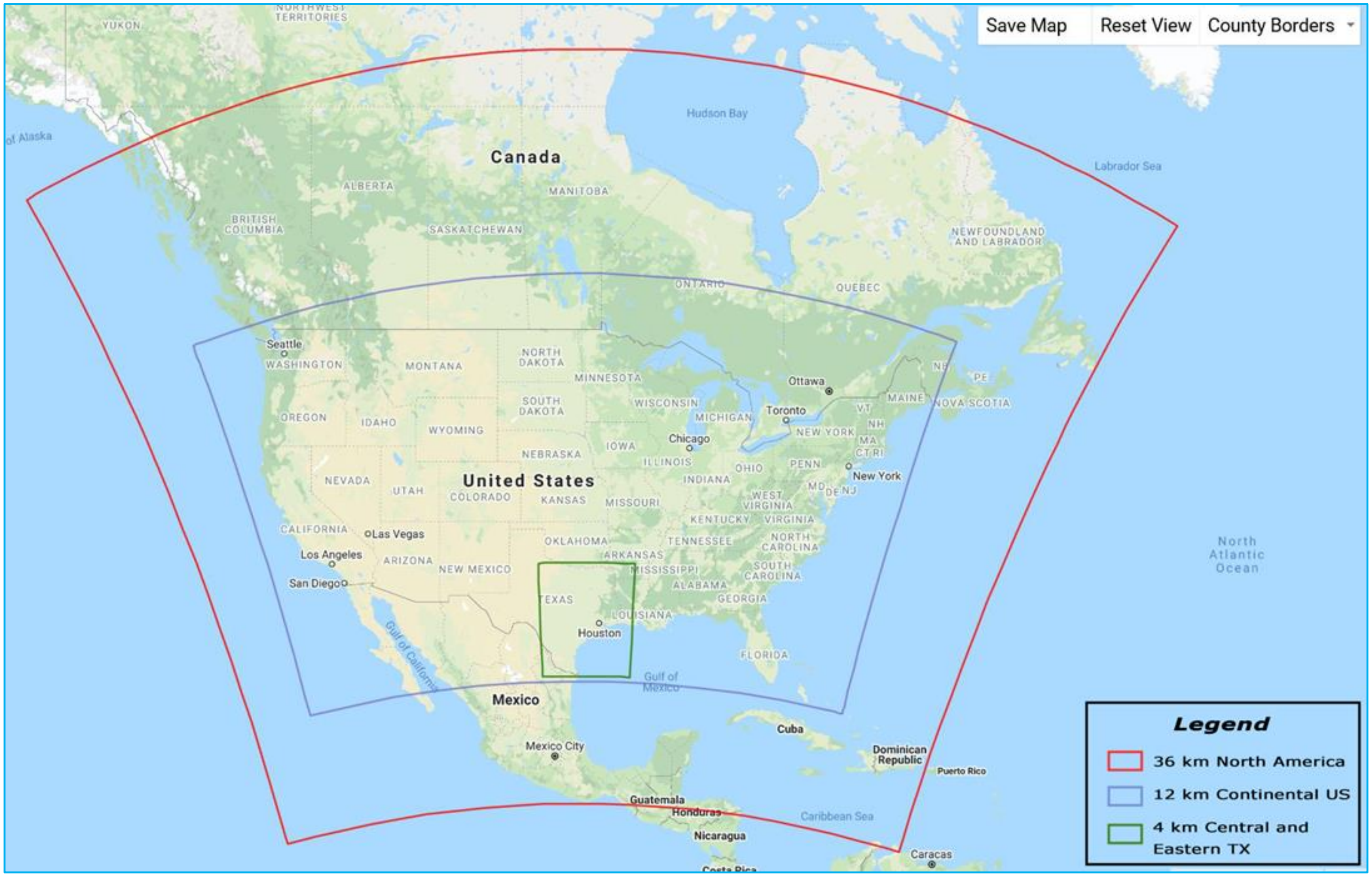
Selected Episode: April through October 2019

- ✓ The April through October 2019 seven-month episode has sufficient exceedance days for both the 2015 and 2008 eight-hour ozone NAAQS (223 and 82 days, respectively).
- ✓ Exceedances in HGB and DFW nonattainment areas follow the expected temporal pattern.
- ✓ 2019 meteorology is representative of typical ozone forming conditions.
- ✓ All but one monitor in DFW have at least five days with a monitored MDA8 value greater than 60 ppb.
- ✓ 2019 is the latest year with complete data, and the modeling platform will remain representative in terms of emissions and fleet characteristics for longer.

Domains

Lateral Boundaries and Resolution

- 36 km domain covers all of Mexico and almost all of Canada
- 12 km domain covers continental United States (CONUS)
- 4 km domain in central and eastern Texas covers the full TX gulf coast



Vertical Boundaries and Resolution

- Photochemical modeling is three-dimensional and grid-based
- Vertical domain height is around 20 km, with variable grid resolution

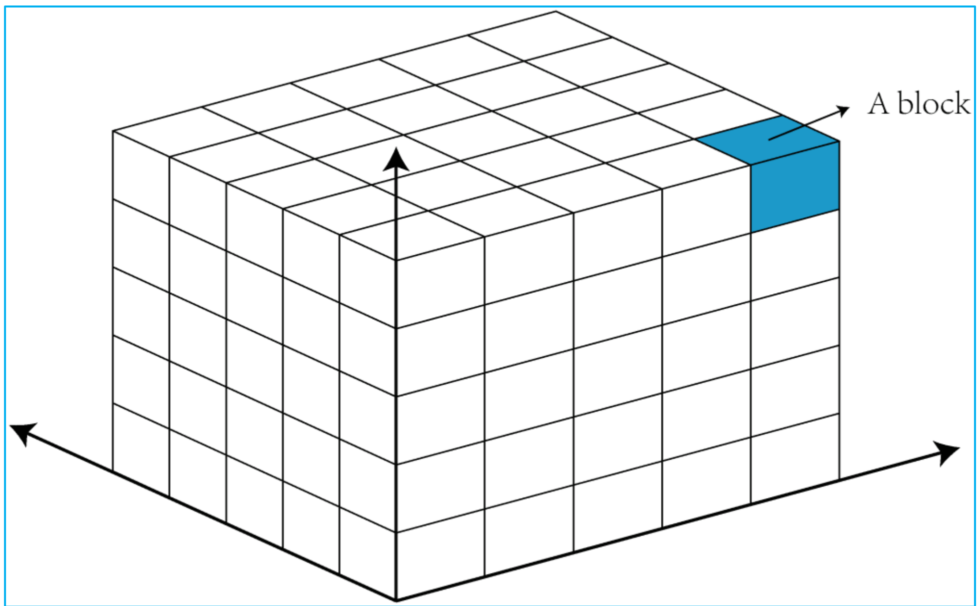
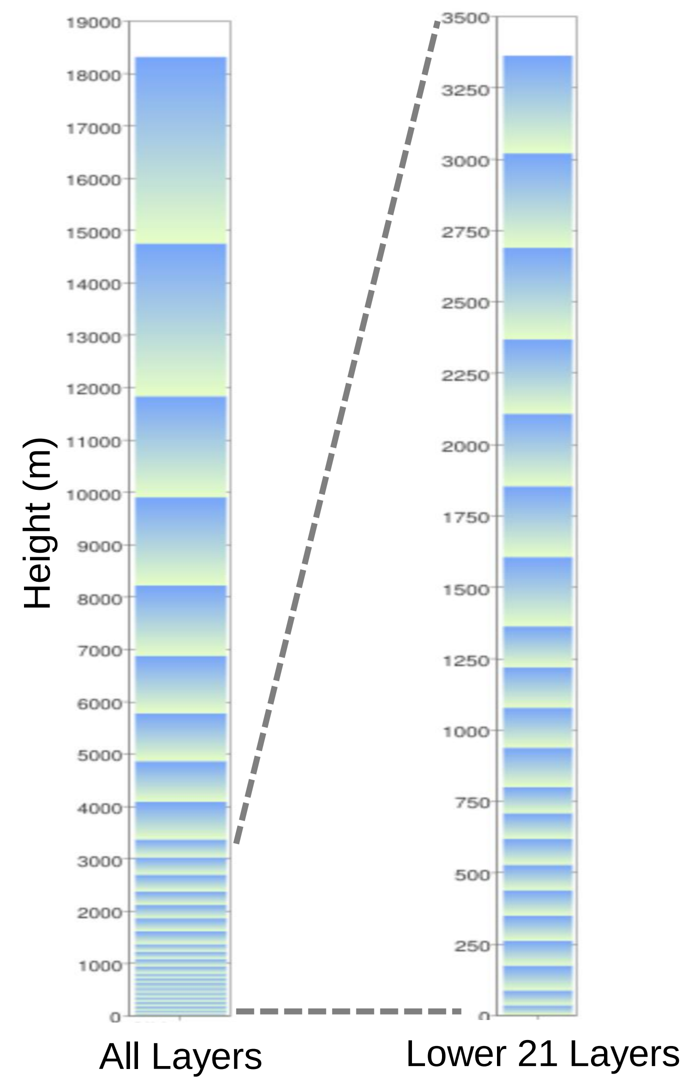


Image: © 2019 Peng, Wang. https://doi.org/10.1371/journal.pone.0212881.g001



Modeling Software and Inputs

Photochemical Model

- Comprehensive Air Quality Model with Extensions (CAMx), version 7.1
- Tasks completed:
  - CAMx v7.1 compiled and ready to go
  - O3MAP program and Tropospheric Ultraviolet and Visible (TUV) processed to be compatible with CAMx v7.1 and CB6r5
- Several test runs for CAMx v7.1:
  - V7.0 vs. v7.1 using CB6r4
  - Binary vs. NetCDF EI inputs
  - CB6r4 vs. CB6r5 with CAMx v7.1

Meteorological Inputs

- Weather Research and Forecasting (WRF), version 4.1.5
- 2019 WRF configuration:
  - Hybrid vertical coordinate system
  - Noah Land Surface Model (LSM)
  - Yonsei University (YSU) Planetary Boundary Layer (PBL)
  - Kain-Fritsch (KF) Cumulus
- Other configurations tested:
  - Pleim-Xu LSM, YSU PBL, with Multi-Scale KF Cumulus
  - Observational nudging with radar profiler data

Emissions Inputs

Emissions inventories being developed for 2019 base year, and 2023 and 2026 future years.

Selected data sets and models by emissions sector:

Model Sector	Datasets/Models
EGU Points	2019 Air Markey Program Data (AMPD)
TX Non-EGU Points	2019 State of Texas Air Reporting System (STARS)
Non-TX Non-EGU Points	EPA 2016v1 Modeling Platform
International Eis	2019 Community Emission Data System (CEDS); SMOKEv4.7_CEDS
TX Non-Point Oil & Gas	2019 Railroad Commission on Texas (RRC)
Non-TX Non-Point Oil & Gas	EPA 2017 Modeling Platform
Offshore/Gulf of Mexico	2017 Bureau of Ocean Energy Management (BOEM)
On-Road Mobile	MOVES3
Non-Road Mobile	TexN2.2 (TX); MOVES3 (non-TX)
TX Area	2017 Air Emissions Reporting Requirements (AERR)
Non-TX Area	EPA 2017 Modeling Platform
Shipping	2019 Automatic Identification System (AIS); MARINER v1
Biogenics	Biogenic Emission Landuse Database (BELD5); BEISv3.7 and SMOKEv4.8
Fires	2019 MODIS and VIIRS; FINNv2.2

Initial/Boundary Conditions Inputs

- Model used: GEOS-Chem v12.7.1
- Set up for 2019 Initial/Boundary Conditions (IC/BC):
  - Meteorology: Modern-Era Retrospective analysis for Research and Application, Version 2 (MERRA-2)
  - Grid resolution: 2-degree by 2.5-degree grid
  - Chemistry scheme: tropospheric chemistry (trochem) with simplified secondary organic aerosols
- Anticipated future year IC/BC (2023 and 2026):
  - Emissions interpolated based on a moderate emissions from Representative Concentration Pathways (RCP4.5)
  - Regional scaling factors used for North America and China

Baseline vs. Base Case

- EPA guidance no longer recommends using a baseline emissions inventory for future year design value (DV_F) calculations.
- Comparison of previous baseline and base case model runs found only minor differences in DV_F.

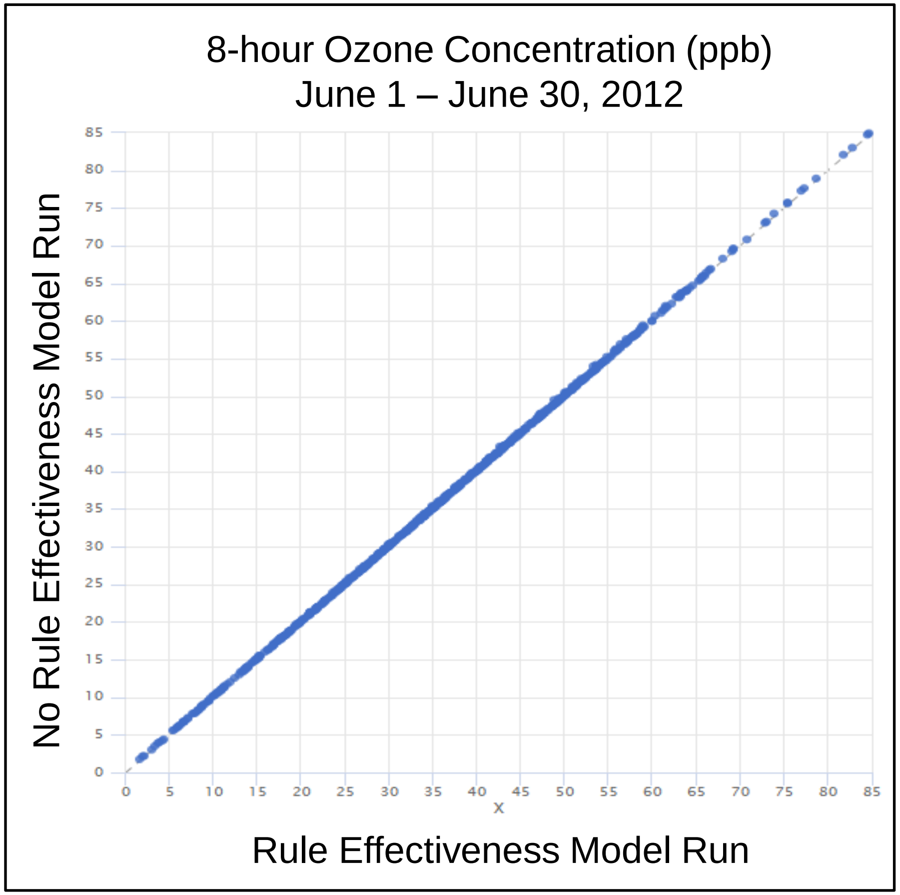
Nonattainment Area	Avg. DV_F Difference	Max DV_F Difference	Min DV_F Difference
DFW	0.450 (0.372)	1 (0.958)	0 (0.092)
HGB	0.225 (0.245)	1 (1.007)	0 (0.005)
SAN	0.546 (0.558)	2 (1.076)	0 (0.152)

Rounded (Unrounded) in parts per billion

Baseline will not be developed for the 2019 platform.

Rule Effectiveness (RE)

- Under RE, non-Electric Generating Unit (EGU) emissions are increased to reflect inefficiencies of new regulatory programs.
- There are no new regulations currently being phased in.
- RE is no longer used by others in the modeling community.
- Test shows that RE has no impact on model performance.



RE will not be used in developing non-EGU emissions for the 2019 modeling platform.

Summary and Next Steps

Conclusion

Summary

- April through October 2019 is the episode for the new modeling platform.
- Software versions, datasets, and models have been selected.
- Meteorology performance testing is complete and WRF configuration is selected.

Next Steps:

- TCEQ is working to finish the base and future year emissions inventories.
- Base and future year emissions inventories will be made available to the public in the fall of 2021.

Questions?

air modeling data analysis

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Why is 2016 not appropriate for ozone modeling in Texas?

- There weren't sufficient exceedance days.

Number of exceedance days (counted at each regulatory monitor)

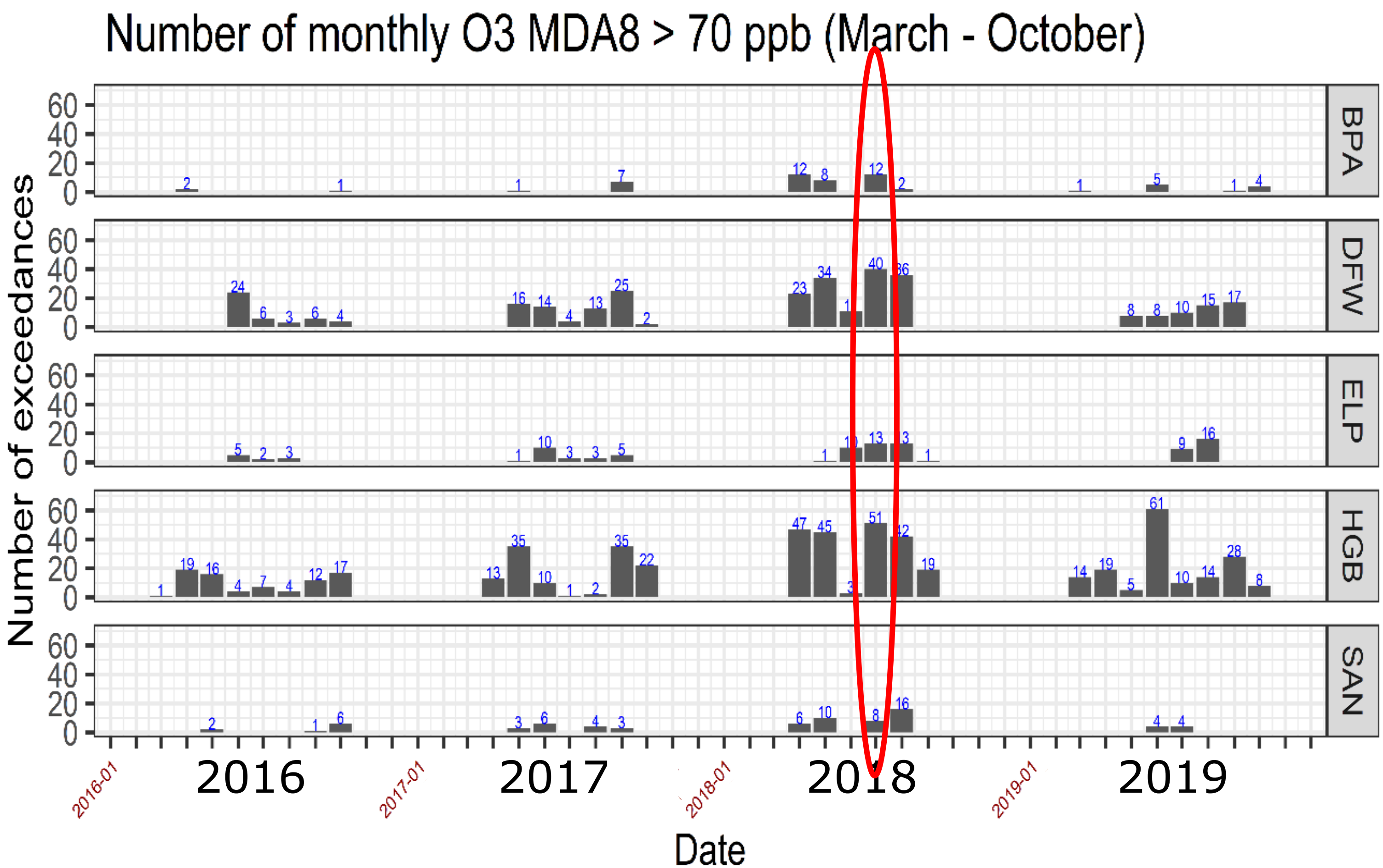
Area	2015 Eight-Hour Ozone NAAQS in the 2012 Episode (May - September)	2015 Eight-Hour Ozone NAAQS in the 2016 Episode (April - October)	2008 Eight-Hour Ozone NAAQS in the 2012 Episode (May - September)	2008 Eight-Hour Ozone NAAQS in the 2016 Episode (April - October)
Dallas-Forth Worth (DFW)		43	145	21
Houston-Galveston-Brazoria (HGB)		44	88	19
San Antonio (SAN)	26	7		
El Paso (ELP)		10		
Beaumont-Port Arthur (BPA)		3		

- Numerous monitors in many areas did not have the number of days required for the modeled attainment test.

Number of monitors without at least five days with MDA8 value ≥ 60 ppb

Area	2012 Episode (May - September)	2016 Episode (April - October)
DFW	0	4
HGB	0	2
SAN	0	0
ELP		1
BPA		3

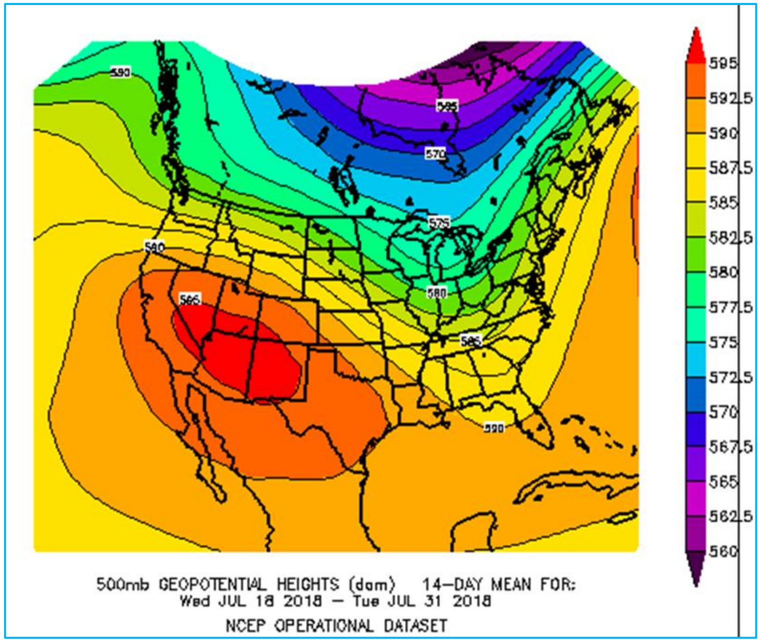
Did 2018 follow the expected temporal pattern in exceedances?

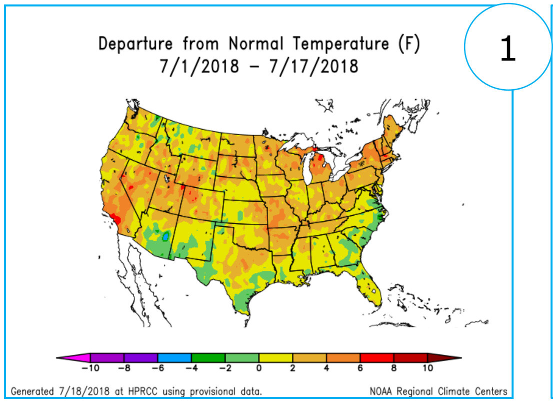


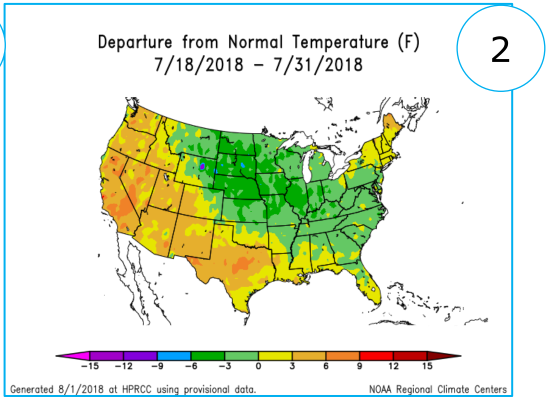
Observation: **July 2018 looks different than the other years with a higher number of exceedance days than usual.**

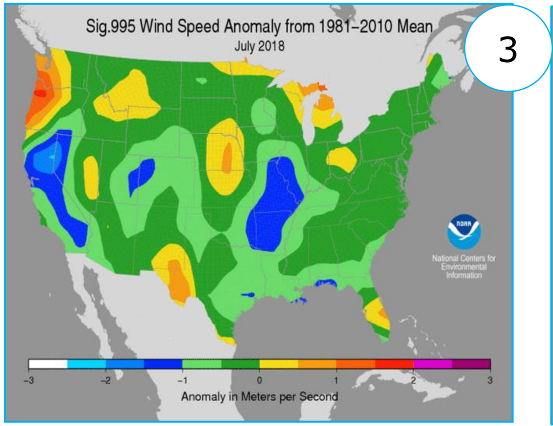
Do the July 2018 exceedances correlate to an unusual jet stream event?

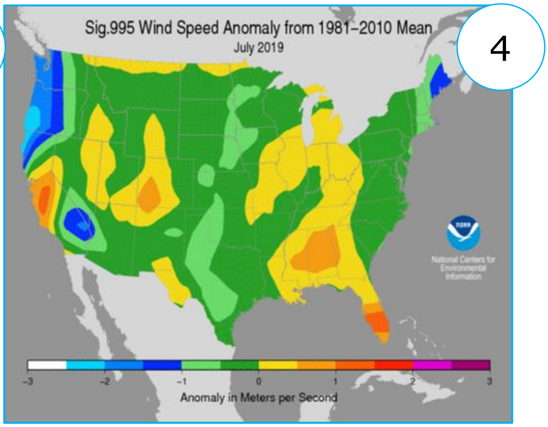
A jet stream event in July 2018 was identified as a potential factor in the unusual exceedances.











Conclusion: **Meteorological analysis could not definitively tie the unusual number of ozone exceedances in July 2018 to the jet stream event.**