GeoXO ACX Science Team Meeting
May 7-9, 2024 -- Day 3, Session I: Stakeholder Needs

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Outline of this presentation

1. Exceptional Events

2. Background and baseline compounds

3. VOC/NOx ratios

4. Aerosols and particulate matter

5. Meteorology

6. Data access

NOx = Oxides of nitrogen
VOC = Volatile Organic Compounds
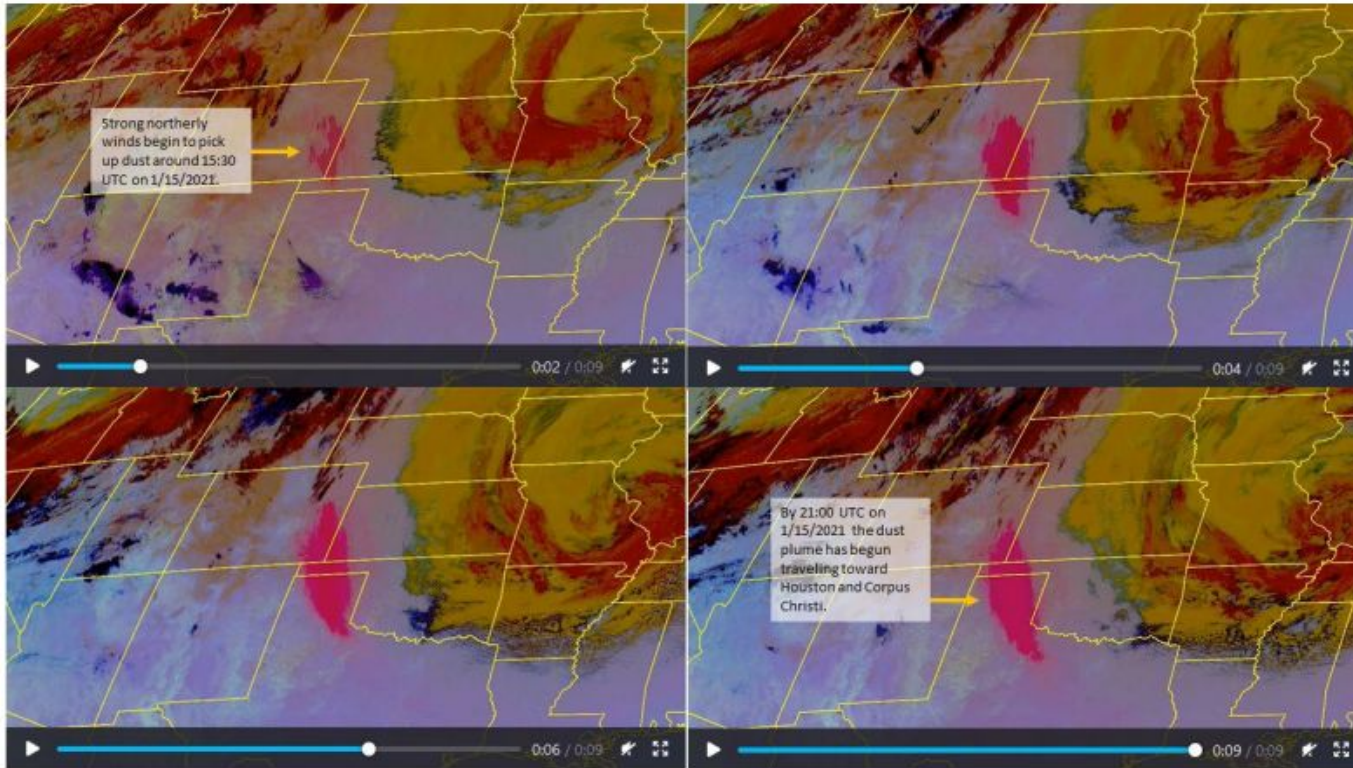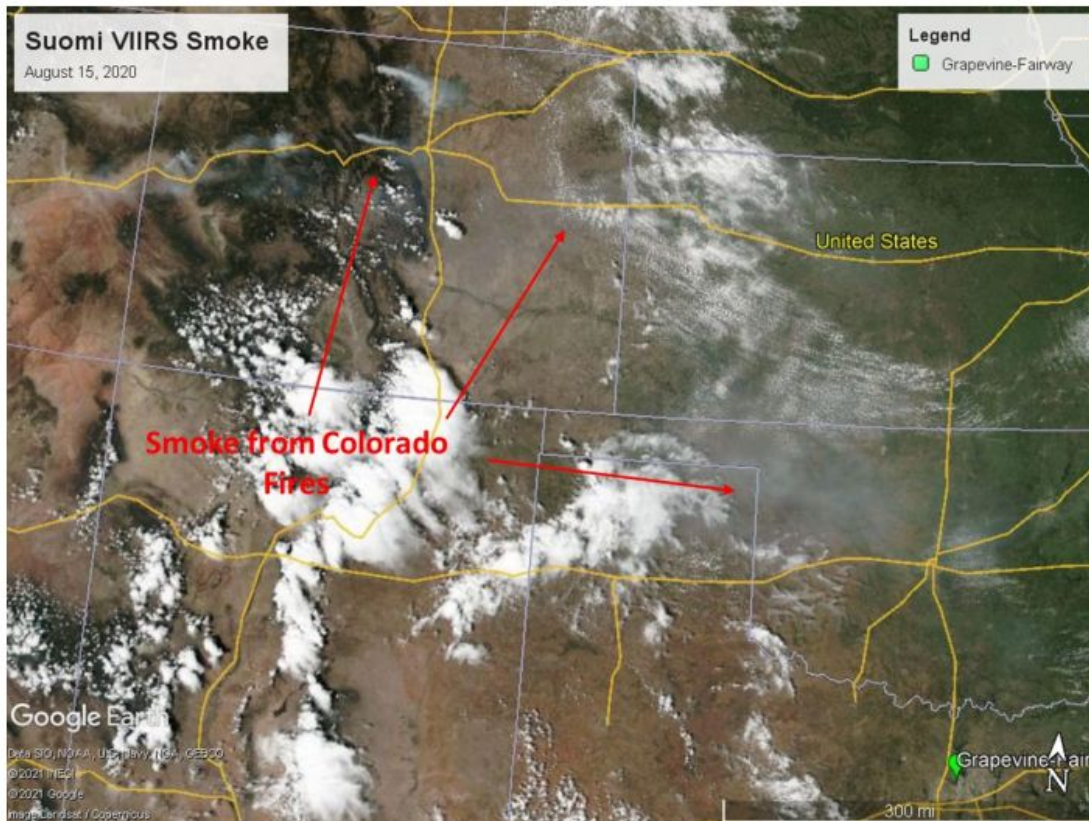
1. Exceptional Events

Figure B-21: Satellite Imagery of the Initiation of Particulate Matter Transport into Texas

A. This is an example from a Texas PM$_{10}$ Exceptional Events demonstration.

B. These images from the GOES-16 Dust RGB product show dust (pink) transported into Texas at roughly 2-hour intervals on January 15, 2021.

C. The dust plume (pink) originates in eastern CO (top left) and is transported by swift winds south and east to western KS and OK and the TX panhandle (top right).

D. The dust plume (pink) enlarges (bottom left) and extends farther into TX (bottom right).

EE = Exceptional Events
PM10 = Particulate matter less than 10 microns diameter

1. Exceptional Events

Figure 3: True Color Imagery from VIIRS Instrument on August 15, 2020

A. This is an example from a Texas PM_{10} Exceptional Events demonstration.

B. This VIIRS true color image of the central Great Plains region of the US from NASA Worldview shows smoke and haze from fires in CO on August 15, 2020, as well as clouds.

Critical Need for Exceptional Events: how to show <u>subsidence to the surface layer</u> monitoring network.

VIIRS = Visible Infrared Imaging Radiometer Suite

2. Background and baseline compounds

Since most of our work involves evaluating anomalies, we would benefit from multi-month and multi-year "typical" aggregates to compare with anomalous days.

A. Background ozone, $PM_{2.5}$, others?
   i. We are interested in non-anthropogenic background.
   ii. **Critical need:** surface layer would be ideal.
   iii. Flexibility to define time period (season, quarter, years) and geographic region.
   iv. Flexibility to choose a statistic: average, median, 95th percentile?

B. Baselines for aerosols, HCHO, NO_2, really any ACX compound
   v. Similar to background: surface layer, flexibility, statistic.

3. VOC/NOx ratios

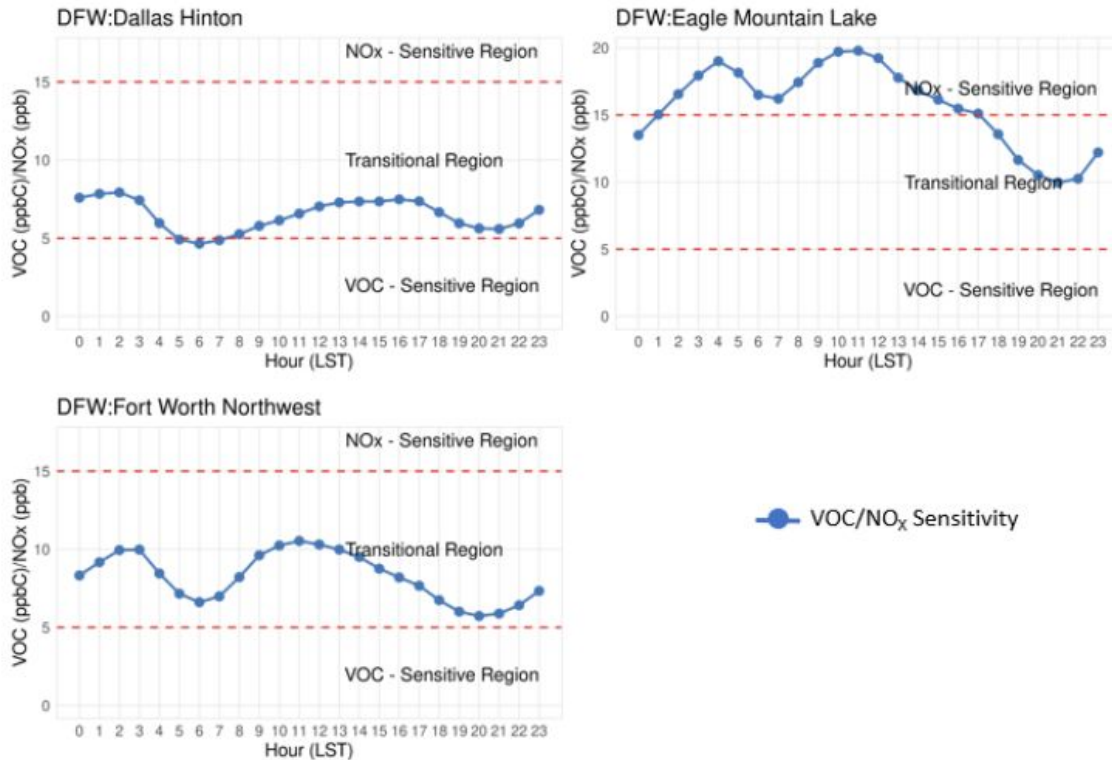DFW Severe Area Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone NAAQS

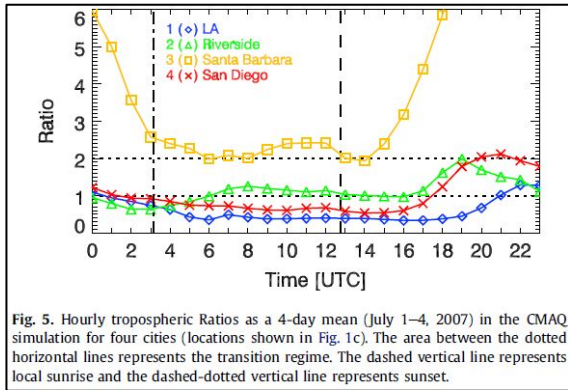Figure 4-2: Median Hourly VOC-to-NOx Ratios During Ozone Season in the DFW Nonattainment Area

We use VOC/NOx ratios in our SIPs (left) to:
  i. assess chemical conditions,
  ii. evaluate emissions reduction strategies, and
  iii. validate emissions inventories.

B. Our in-house work is limited to sites with co-located VOC+NOx instruments: 7 sites in Houston, 3 in Dallas-Fort Worth.

C. Satellites expand this capability dramatically with HCHO & NO_2 retrievals as proxies for VOC, NOx.

D. After methods, details worked out in professional journals, technical reports, we apply approach in SIPs.

Proof-of-concept ⟹ validation ⟹ application.

HCHO = formaldehyde
SIP = State Implementation Plan

3. VOC/NOx ratios

Fig. 5. Hourly tropospheric Ratios as a 4-day mean (July 1–4, 2007) in the CMAQ simulation for four cities (locations shown in Fig. 1c). The area between the dotted horizontal lines represents the transition regime. The dashed vertical line represents local sunrise and the dashed-dotted vertical line represents sunset.

A. This figure (top) is from **Duncan** et al. (2010) which demonstrated a "proof of concept" of HCHO/NO$_2$ using OMI.

B. Others (not shown) extended this concept to other regions and other instruments.

C. **Goldberg** *et al*. (2022) assessed regions in TX using TROPOMI (bottom).
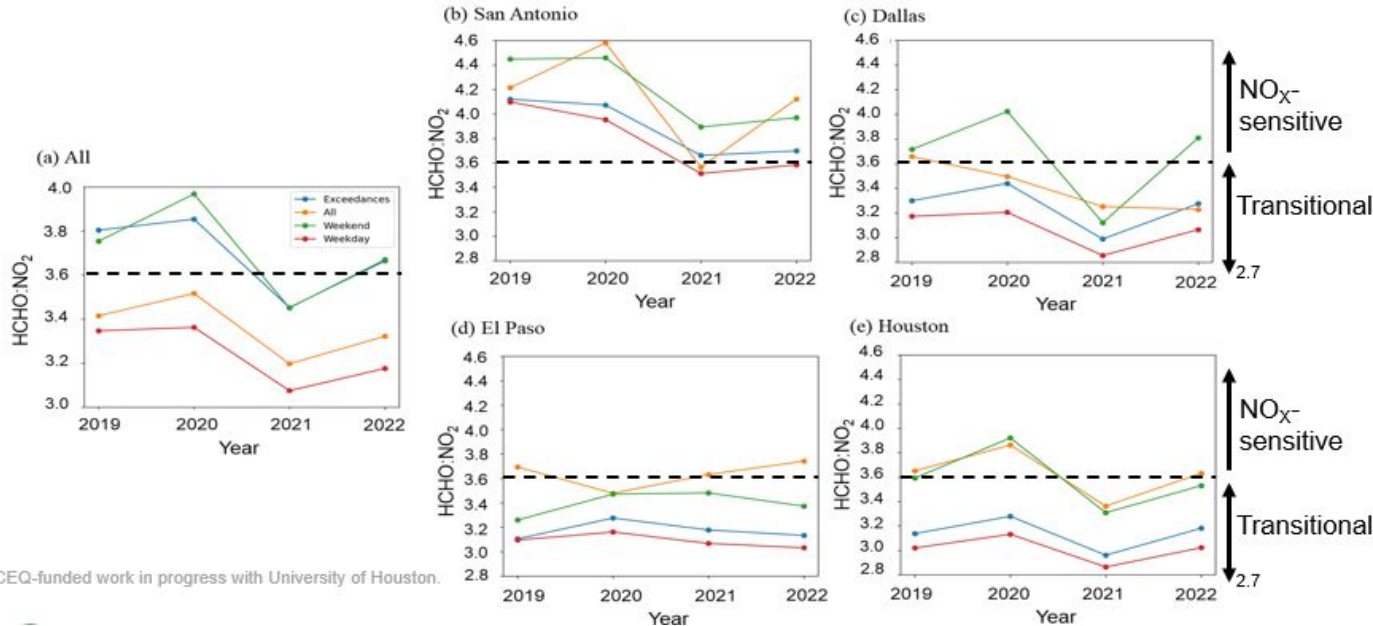

Model Derived FNR: Variability By Area And Time

Goldberg, D. L., et al., 2022.

FNR = Formaldehyde-NO$_2$ Ratio
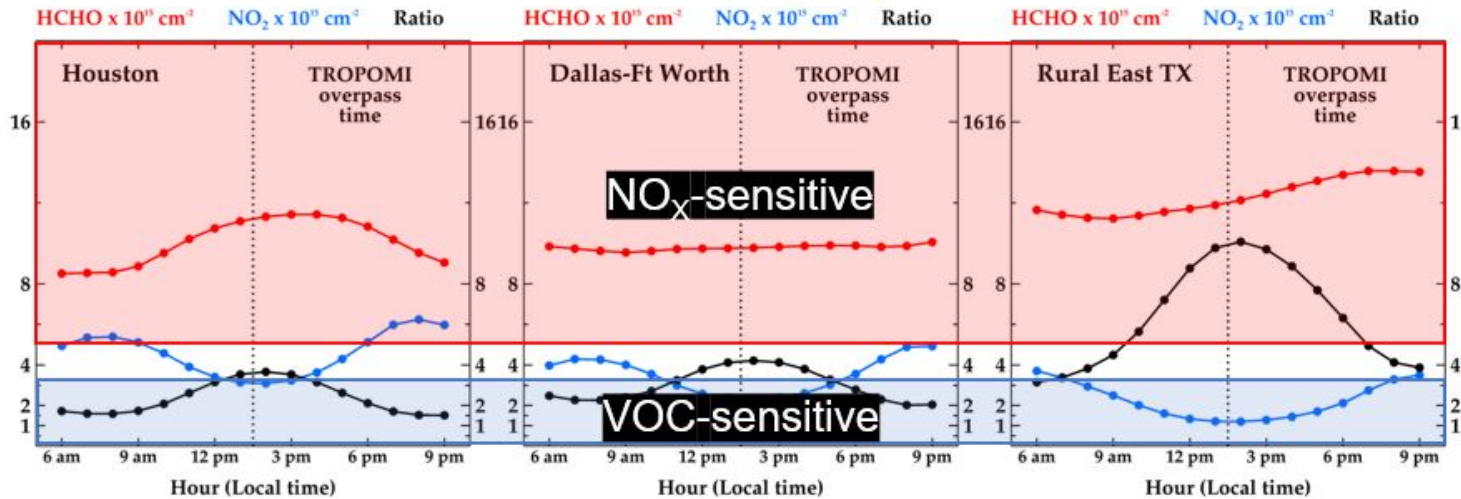
3. VOC/NOx ratios

Satellite (TROPOMI) Derived FNR: 2019-2022

TCEQ-funded work in progress with University of Houston.

A. TCEQ contracted with **Wang** to develop this further with TROPOMI, to compare with TX surface monitors.

B. Final report is due June 2024.

    i. Satellite Derived Ozone-NOx-VOC Sensitivity in Texas Urban Areas, Task 3 Report for PGA No. 582-23-43887-030

    ii. Surface Derived Ozone-NOx-VOC Sensitivity in Texas Urban Areas, Task 4 Report for PGA No. 582-23-43887-030

New instruments (TEMPO, GeoXO) provide hourly retrievals, which let us see diurnal evolution even where we don't have surface monitors. This is huge!

Critical need: Can $HCHO/NO_2$ ratio (FNR) be pre-computed so user does not have to download HCHO and NO_2 and build it? We still need to consider how sensitivity thresholds differ across regions and how they correlate with thresholds for more familiar VOC/NOx ratio.

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FNR = Formaldehyde-NO_2 Ratio

4. Aerosols and particulate matter

Worldview: MODIS Aerosol Optical Depth (column)
Dark Target (Terra)   MAIAC (Aqua & Terra)
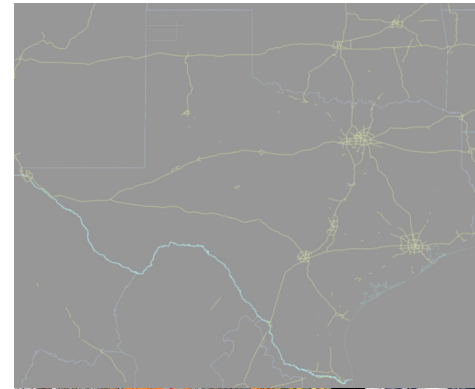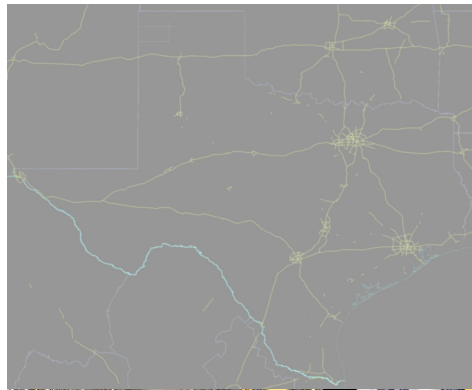
A. Here is a situation we observe regularly. June 30, 2022 was a high ozone day in DFW but not elsewhere in TX. Why?

B. Dark Target (top left) showed scattered light AOD in north TX but not DFW.

C. MAIAC (top right) is an improvement, resolves higher density AOD over DFW but still struggles with cloud interference.

Critical Need: What level of AOD can we effectively ignore? Currently filtering out <0.15 but would need a robust reference

MAIAC = Multi-Angle Implementation with Atmospheric Correction

5. Meteorology

A. Cloud placement

B. Surface winds, <u>especially vertical</u>

C. Mixed layer height

Critical Need: PBL and its evolution throughout the day.

Hourly data is very useful here.

6. Data access

A. In-house. It is unlikely we would do much more than look at images, not much accessing data.

B. Server storage space. Quantity of data is already enormous.

C. Data archives. Our work is almost exclusively retrospective, not NRT, so we need an archive.

D. Access methods. Panoply, HDFLook, R, Python.

References

Duncan, et al. 2010. Application of OMI observations to a space-based indicator of NOx and VOC controls on surface ozone formation, Atmos. Environ.

Jin, et al. 2020. Inferring Changes in Summertime Surface Ozone-NOx-VOC Chemistry over U.S. Urban Areas from Two Decades of Satellite and Ground-Based Observations. Environ. Sci. &Tech.

Goldberg, et al. 2022. Evaluating NOx emissions and their effect on O3 production in Texas using TROPOMI NO2 and HCHO. Atmos. Chem. Phys.

Exceptional Event Demonstration for Particulate Matter of 10 Microns or Less in Aerodynamic Diameter (PM10) for January 16, 2021; June 21, 2021; and December 6, 2021 (texas.gov)

Houston-Galveston-Brazoria Severe Area Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone NAAQS

Dallas-Fort Worth Severe Area Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone NAAQS

True Color Satellite Imagery for DFW Exceptional Event Demonstration (archive-it.org)

Thank you!

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Many thanks to contributors to this presentation:

University of Houston: Yuxuan Wang, Yunsoo Choi, Masoud Ghahremanloo, Sagun Kayastha
TCEQ: Doug Boyer, Erik Gribbin, Chola Regmi, Sushil Gautam
Et alia: All those co-authors who I didn't name but I borrowed their work.