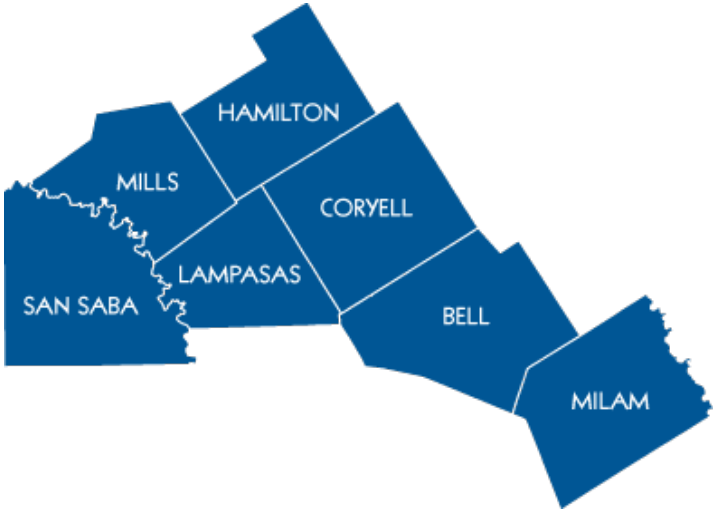
Ozone Conceptual Model for the Killeen-Temple-Fort Hood Area



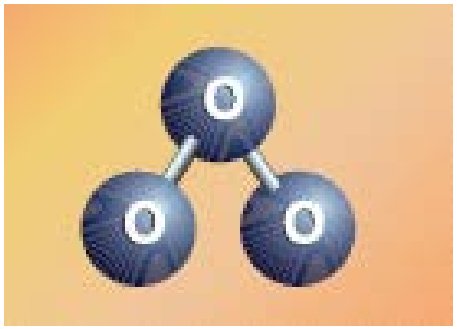
CTCOG Executive Committee Meeting

July 23, 2015

Sue Kemball-Cook, Jeremiah Johnson, John Grant, Lynsey Parker and Greg Yarwood

RAMBOLL ENVIRON

Ozone



"Good up high, bad nearby"

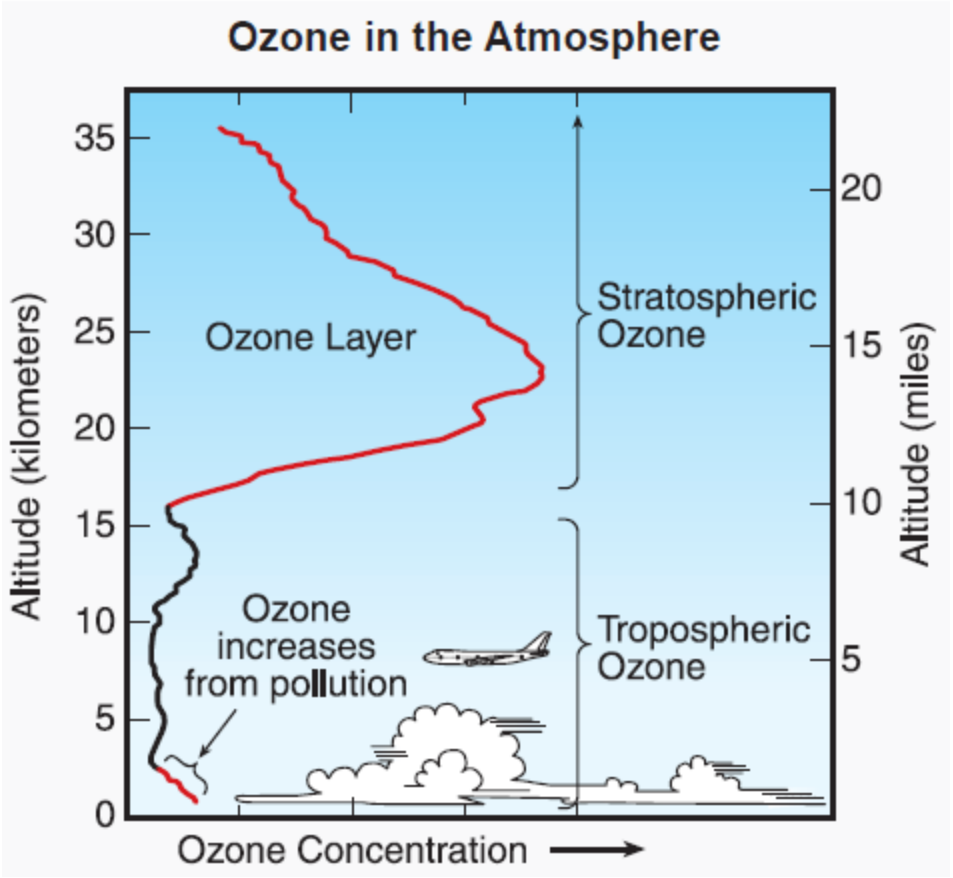
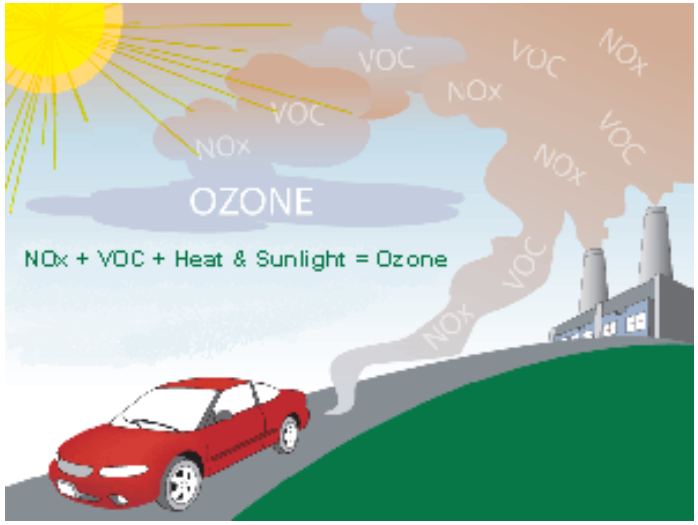


Figure: http://esrl.noaa.gov/csd/assessments/ozone/2006/chapters/Q1.pdf

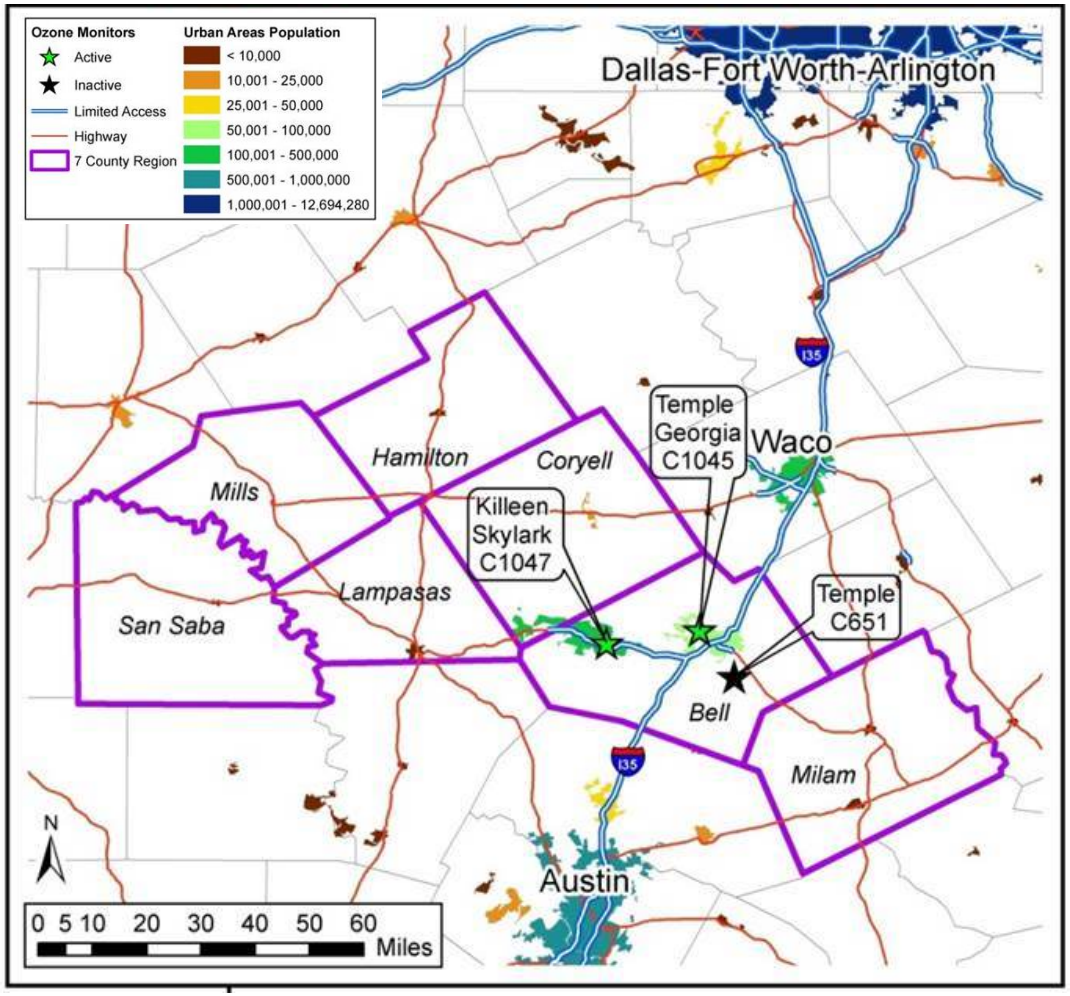
Ground Level Ozone and Air Quality



Figures:US EPA http://www.epa.gov/air/ozonepollution/basic.html

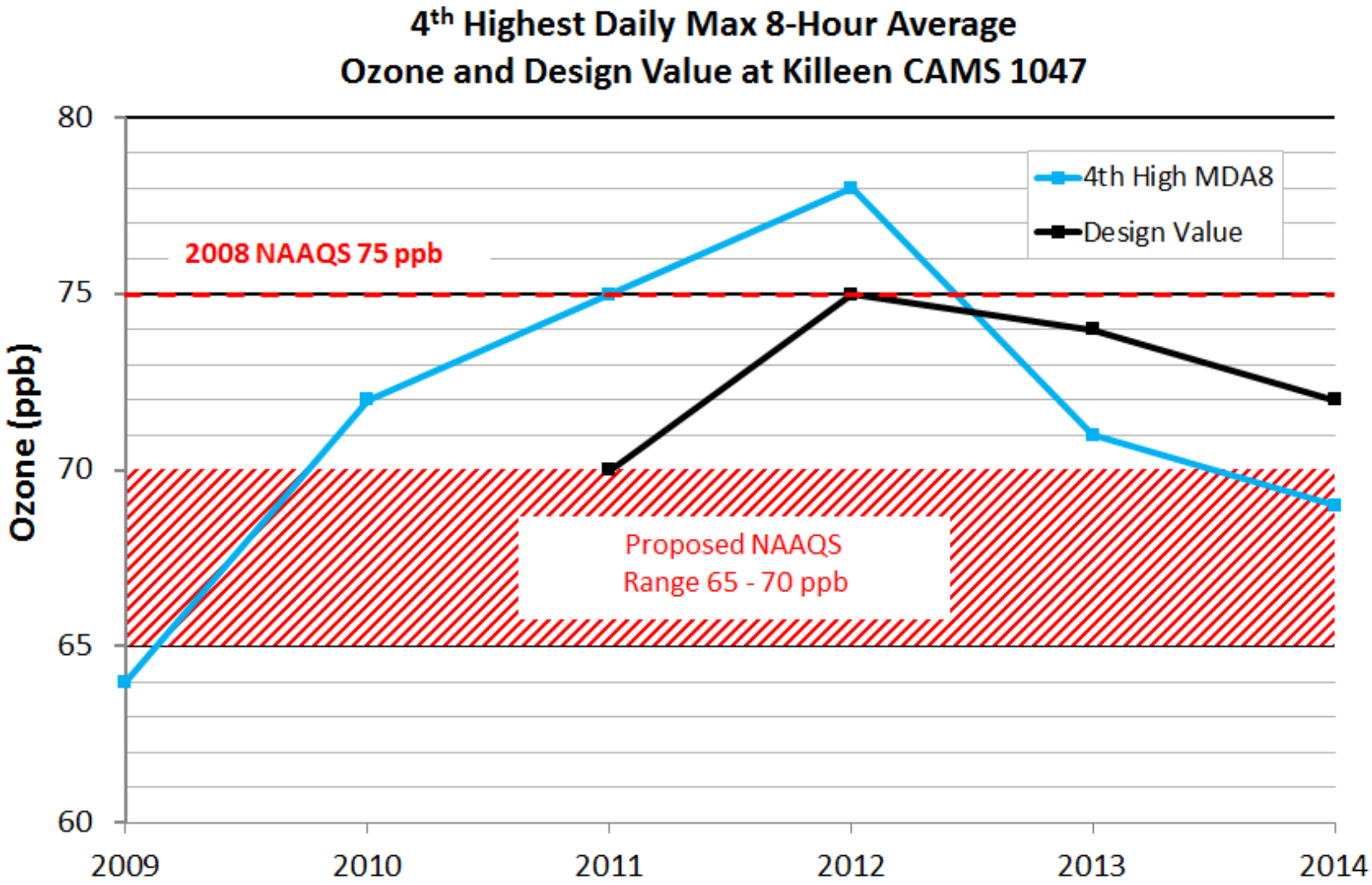
- Ozone is the main ingredient in smog
  - Affects human lung function (asthma, bronchitis)
  - Damages vegetation
- Clean Air Act primary standard for ozone (NAAQS)
  - Based on health impacts for sensitive groups
  - Economic penalties for non-attainment
- Forms from NOx and VOC in presence of sunlight, not emitted directly

Conceptual Model

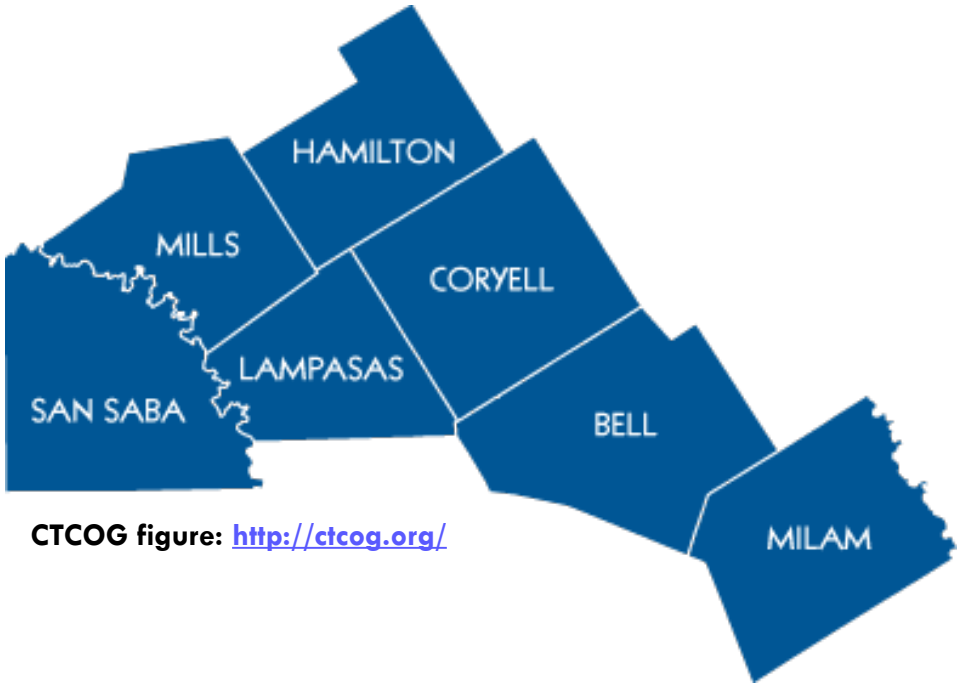


- What factors contribute to high ozone in the KTF area?
  - Emission inventory
  - Ozone and weather data and trends
  - Photochemical modeling

Ozone Trends at Killeen



KTF Area Emission Inventory Review



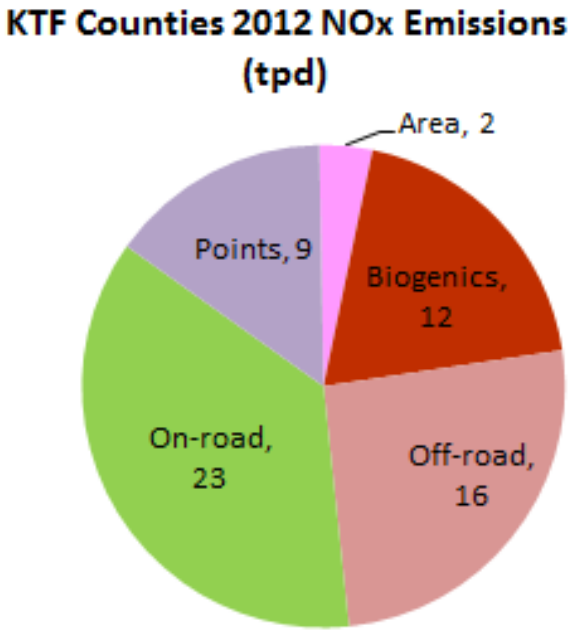
CTCOG figure: http://ctcog.org/

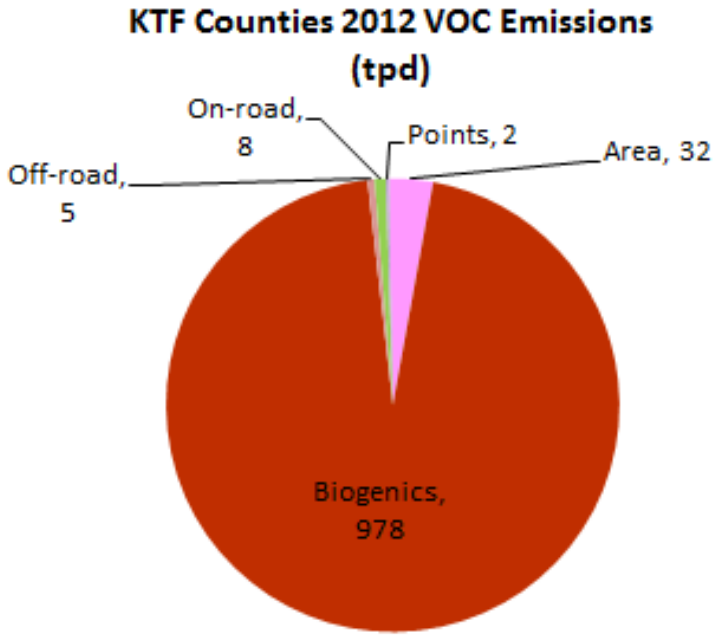
- TCEQ develops inventory for the State of Texas
- NNAs review the TCEQ EI for their area
- Identify emissions sources that are:
  - Uncertain,
  - Over- or under-estimated
  - Could be improved with local data

Emission Inventory

- List of sources of air emissions of ozone precursors
  - Point Sources
    - Emissions sources that meet TCEQ thresholds for reporting
    - Usually emitted from a stack
    - Power plants, chemical plants, compressor stations, etc.
  - Non-Point Emissions Sources
    - On-road mobile (cars, trucks, buses, motorcycles)
    - Off-road mobile (locomotives, drill rigs, construction, ag equipment)
    - Area sources (dry cleaners, degreasing operations, wells)
    - Biogenics (trees, crops, microbes in soil, fertilizer application)

Summary of KTF Area 2012 Emission Inventory



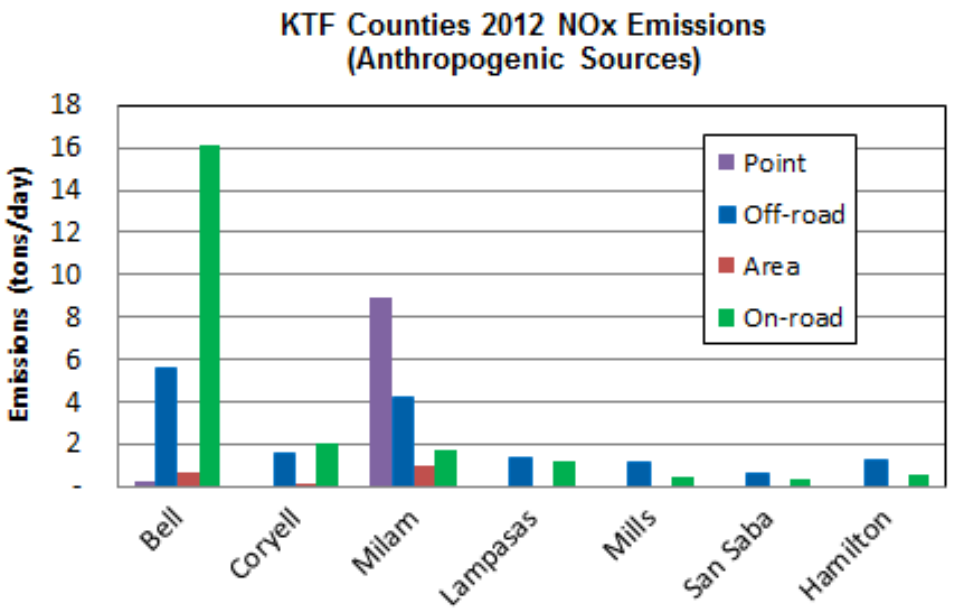


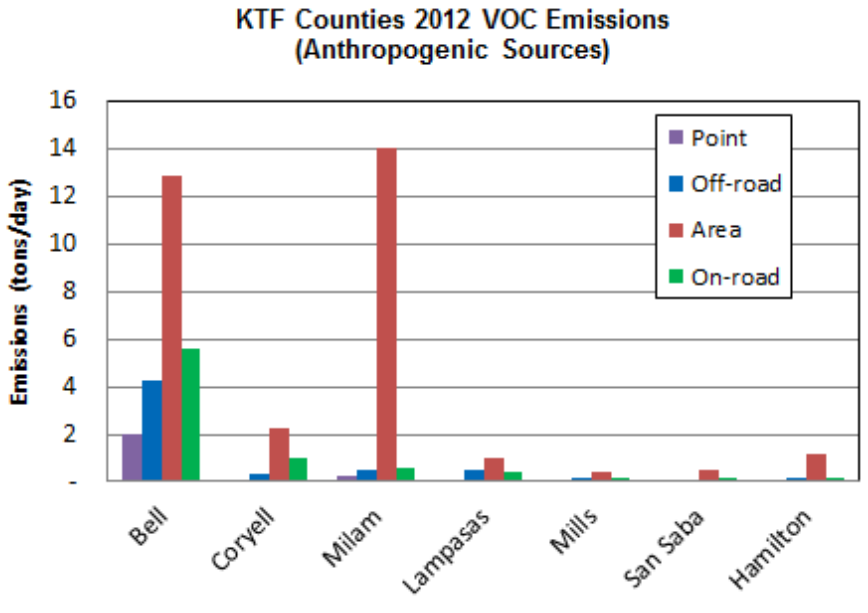
Total NOx Emissions: 62 tpd

Total VOC Emissions: 1,026 tpd

- Mobile sources are more than 50% of NOx inventory
  - Substantial biogenic NOx emissions contribution – agriculture?
- VOC inventory dominated by biogenics (natural sources)
  - Abundant biogenics mean there is typically sufficient VOC to form ozone
- **Ozone formation limited by the amount of available NOx**

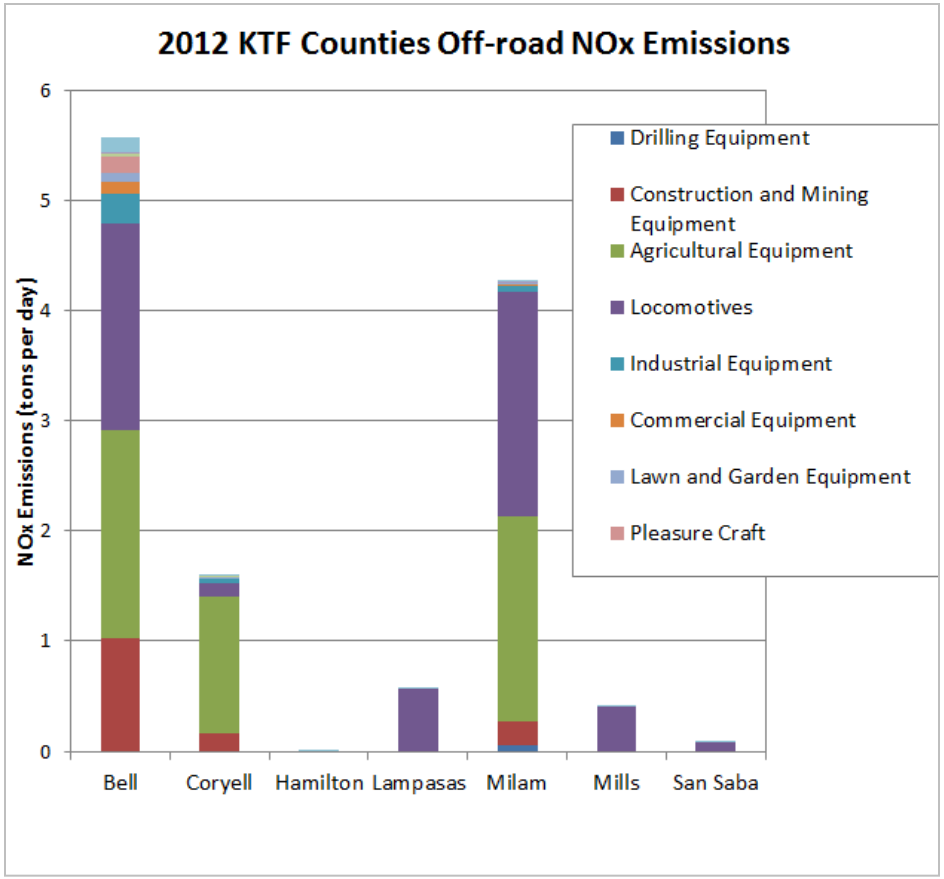
Anthropogenic Emissions by County





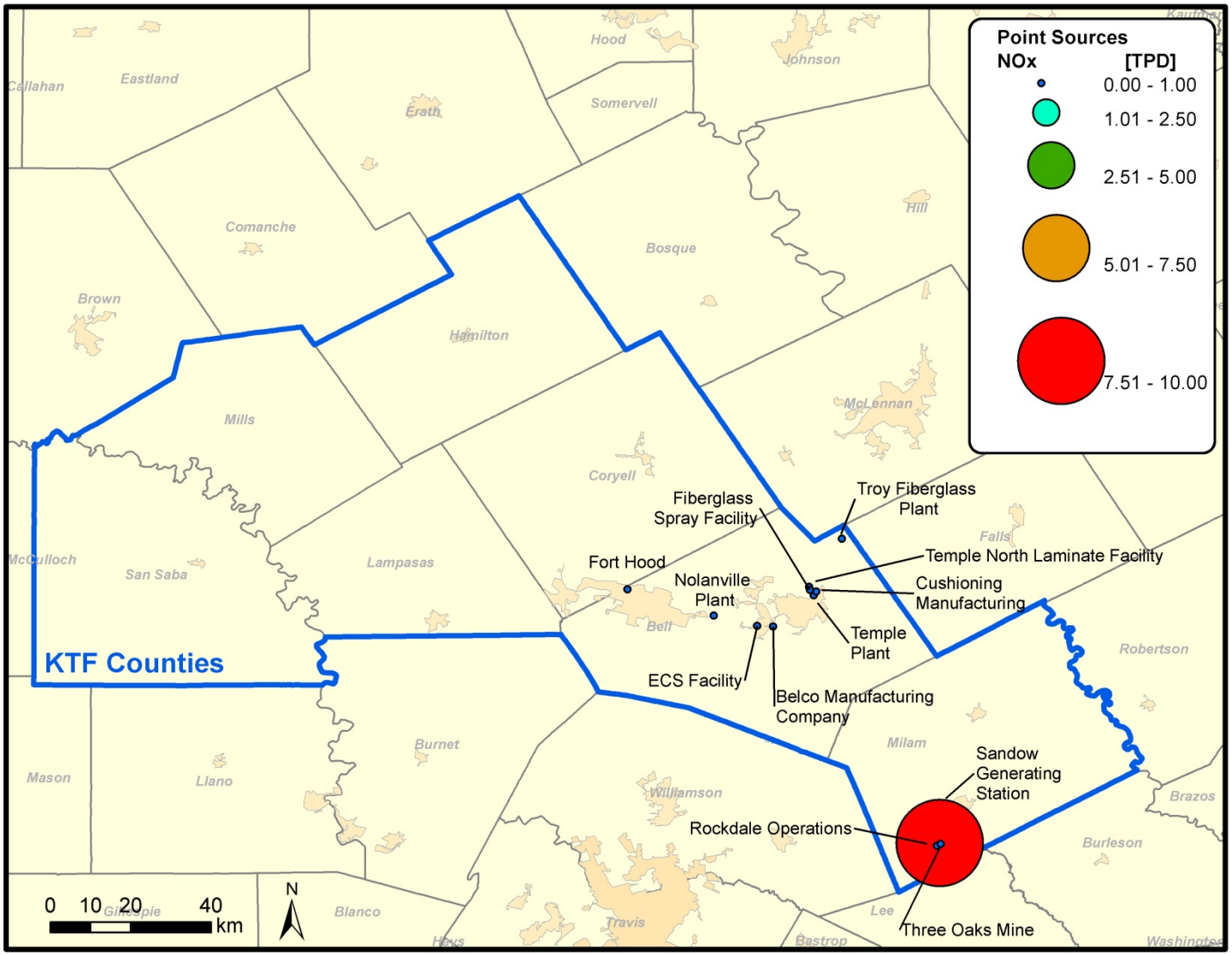
- 78% of NOx emissions from Bell and Milam Counties
- Nearly all of Milam Point source NOx emissions are from Sandow Power Plant
- Bell County NOx mainly due to on-road mobile (I-35)
- Milam area source VOC emissions mainly due to oil and gas
- Bell County off-road due to locomotives, ag, construction and mining

Off-Road NOx Emissions Sources by County



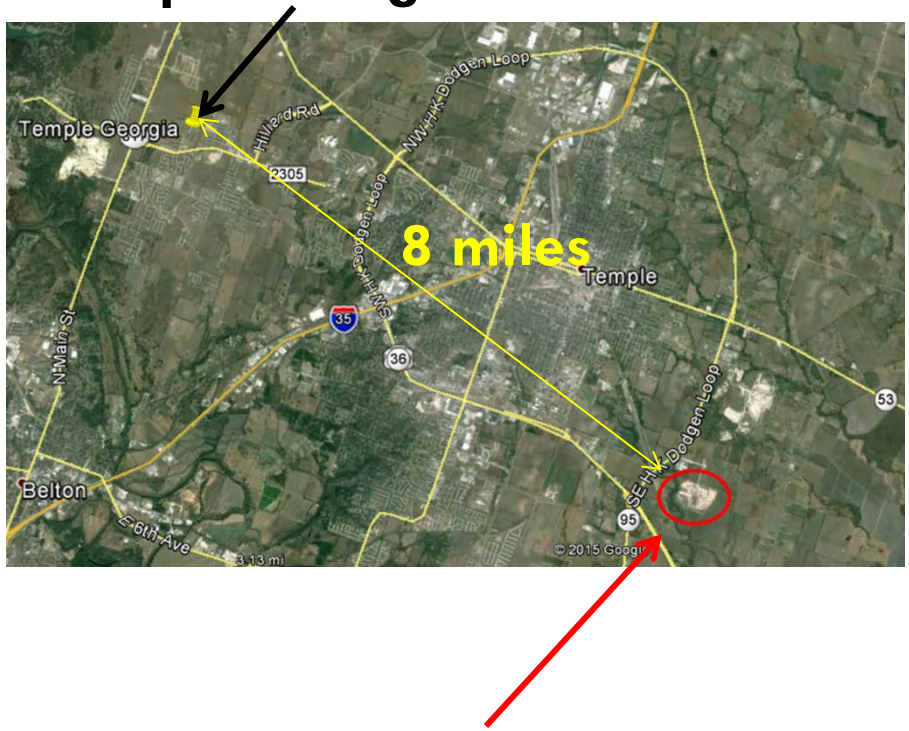
- Largest off-road categories are locomotives, ag, construction and mining

2012 KTF Area NOx Point Sources



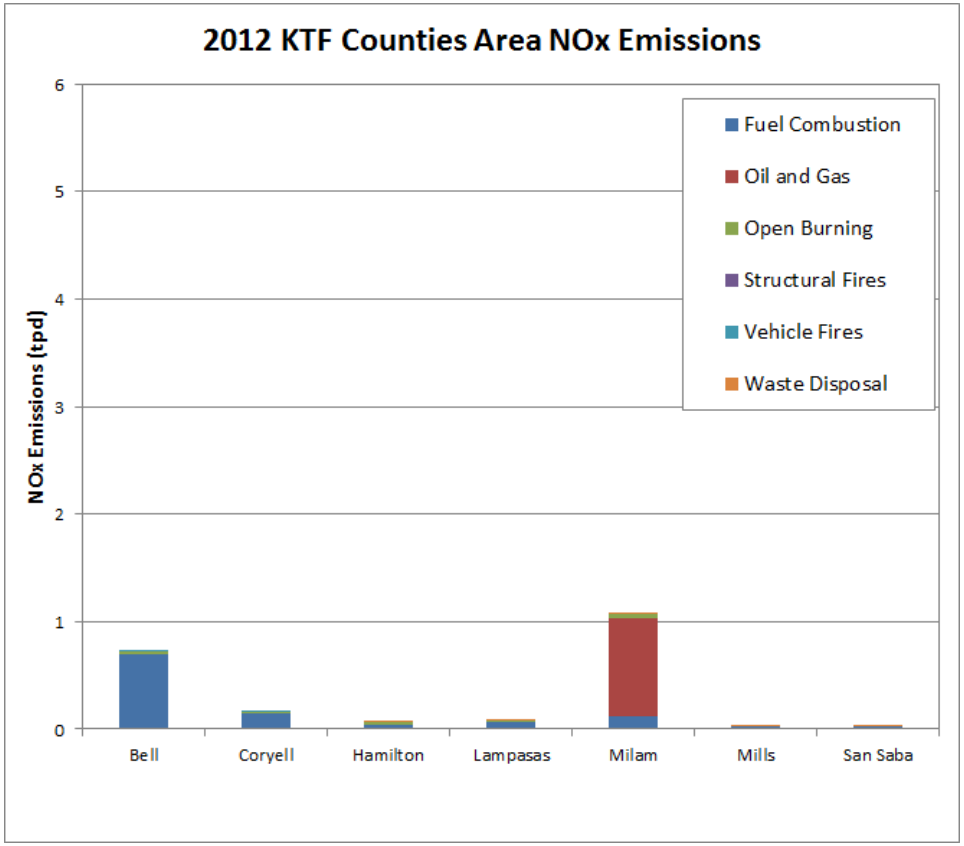
Panda Temple Power Plant not shown

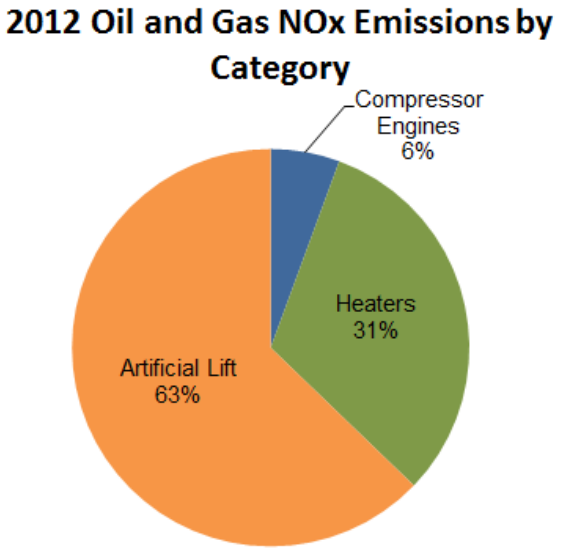
Panda Temple Power Plant



- Built in two phases, both operational by end of 2015
- 4 combined cycle natural gas-fired combustion turbines
- DLN + SCR NOx emission controls
- Baseload/peaking units
  - Likely to be operating on high ozone days
- New source of NOx near monitor and not in TCEQ 2012 emission inventory

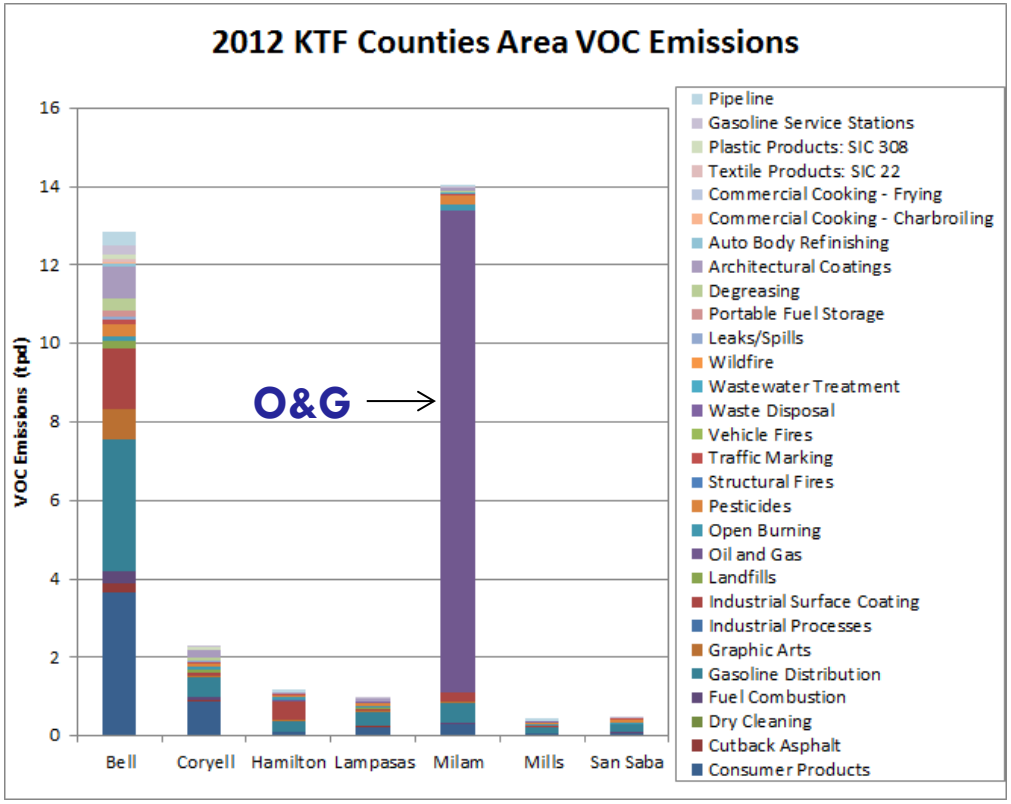
Area Source NOx Emissions by County

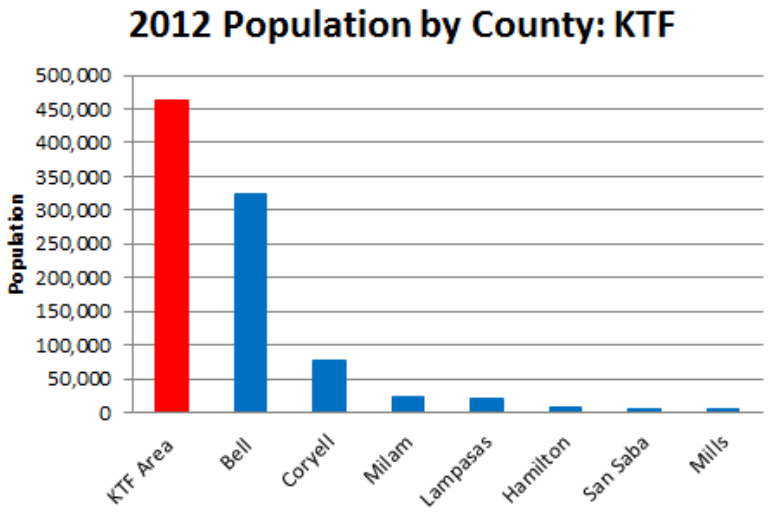


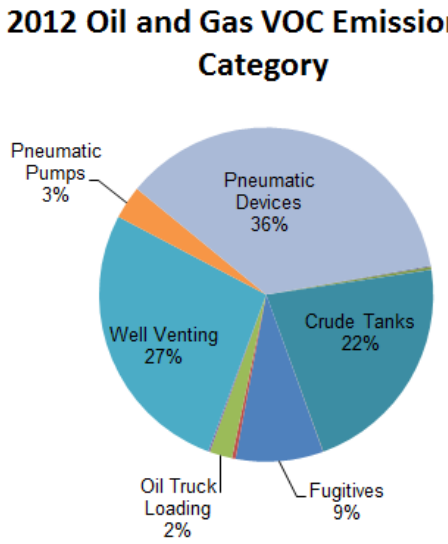


- Oil and gas NOx from artificial lift engines, heaters and gas compressor engines

Area Source VOC Emissions by County







- Non-O&G area VOC emissions from a variety of sources

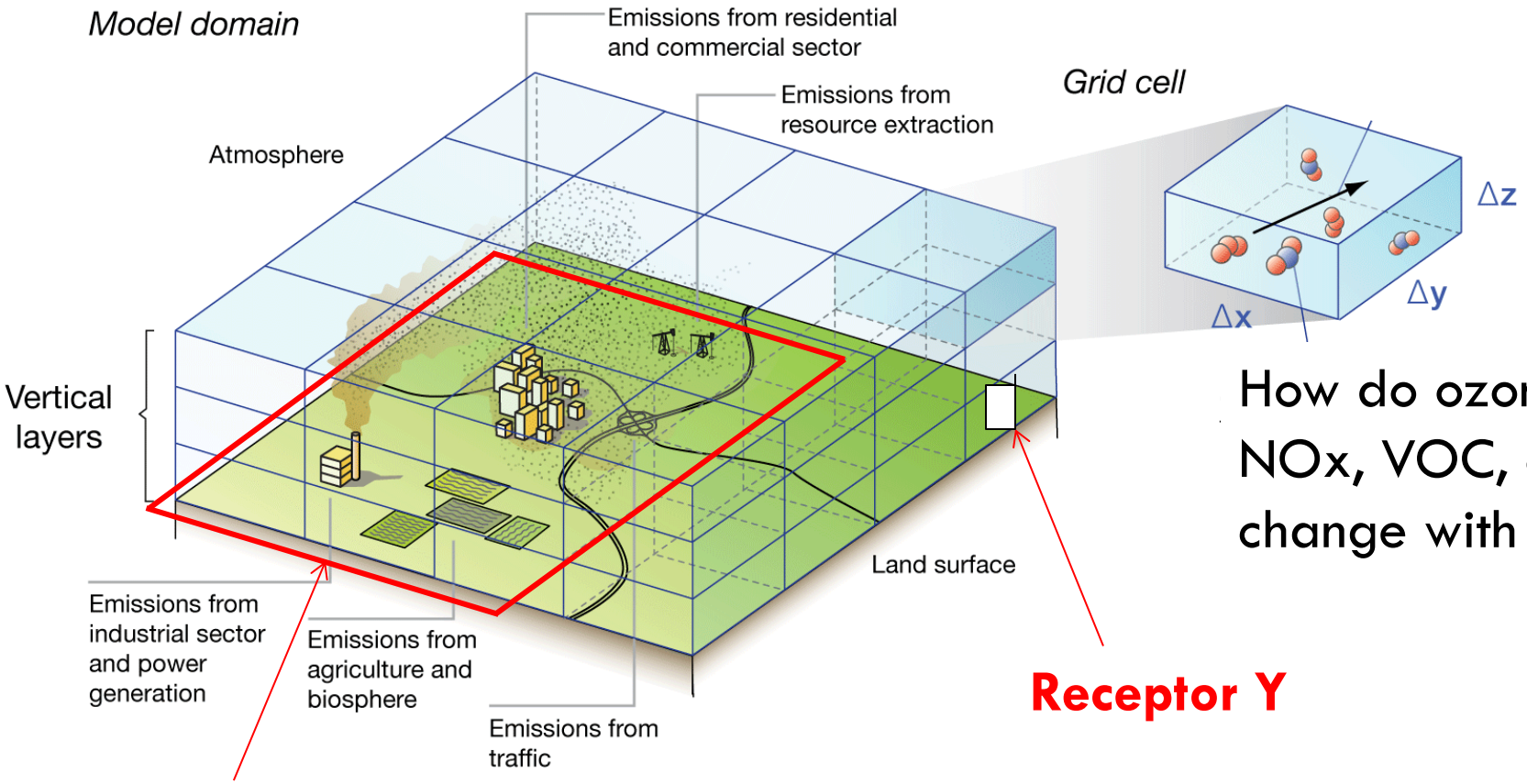
Weather Conditions Associated with High Ozone at the Killeen Monitor

- Strong sunlight (April-October, clear/partly sunny skies)
- High temperatures (T > 82°F)
- Light winds (< 12 mph)
- Winds coming from north-southwesterly direction
  - Transport of polluted, continental air
  - Low ozone days have strong, southerly winds that bring clean maritime air from Gulf of Mexico
- High pressure system, stationary front, or cold front passage

Photochemical Modeling

- Ozone model (photochemical grid model) is a computer simulation of the atmosphere
- Use the model to understand the area's ozone problem and suggest methods to reduce ozone
- Determine how much of the ozone at a given location can be attributed to:
  - Local emissions
  - Transport from other parts of Texas, other States, and from outside North America
- Determine how much of an area's ozone can be reduced by NOx vs. VOC emissions reductions

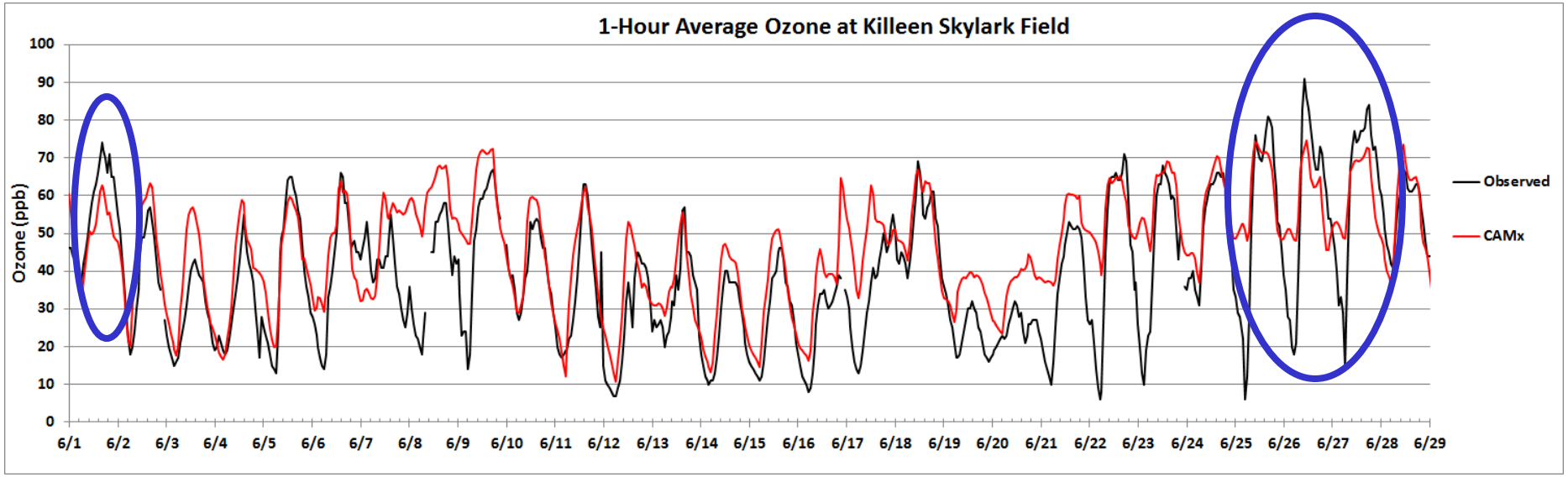
Ozone Model

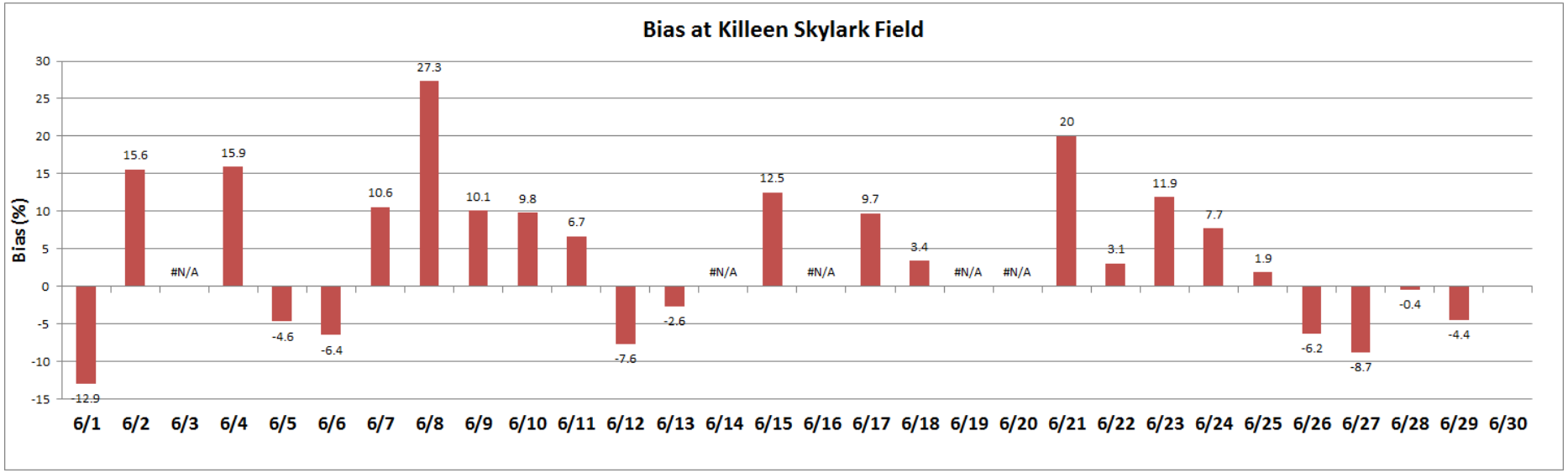


How do ozone, NOx, VOC, etc. change with time?

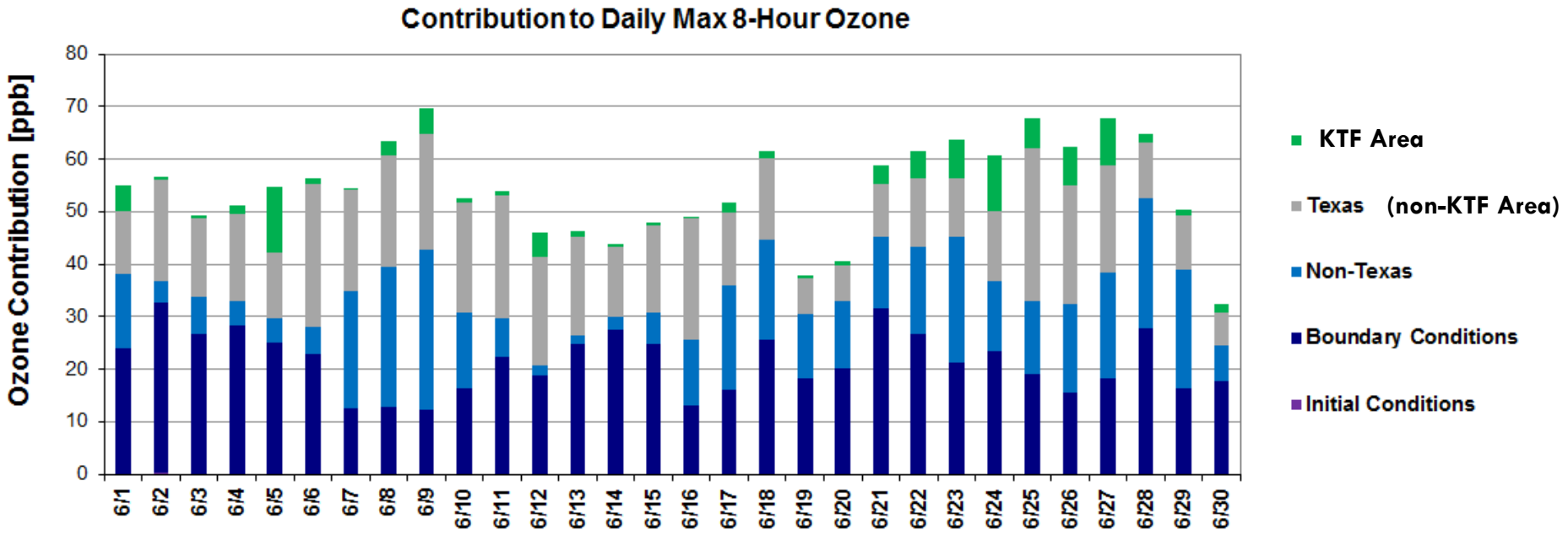
AWMA Environmental Manager magazine July 2012 issue on AQMEII
Douw Steyn, Peter Builtjes , Martijn Schaap and Greg Yarwood

2012 Model Performance at Killeen



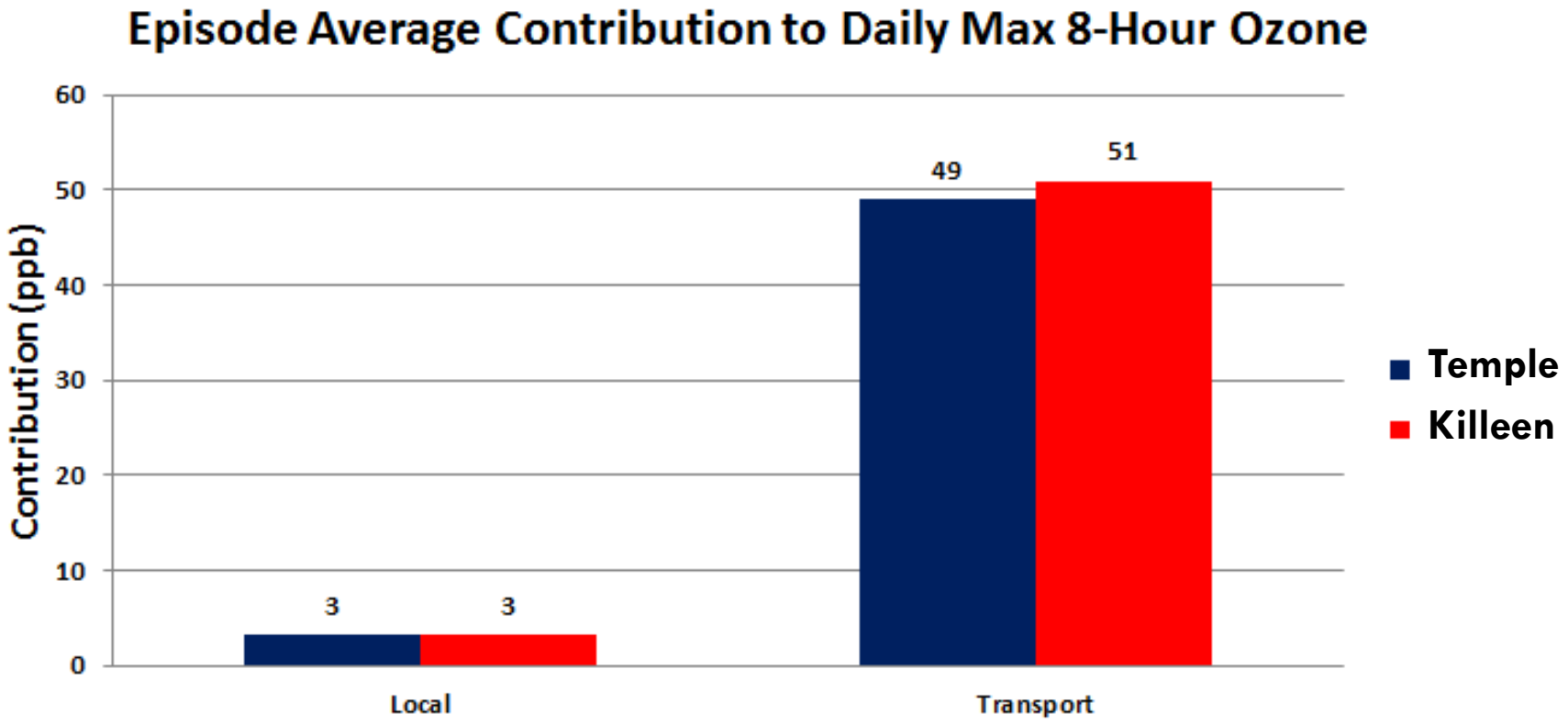


June 2012 Ozone Source Apportionment for Killeen Monitor



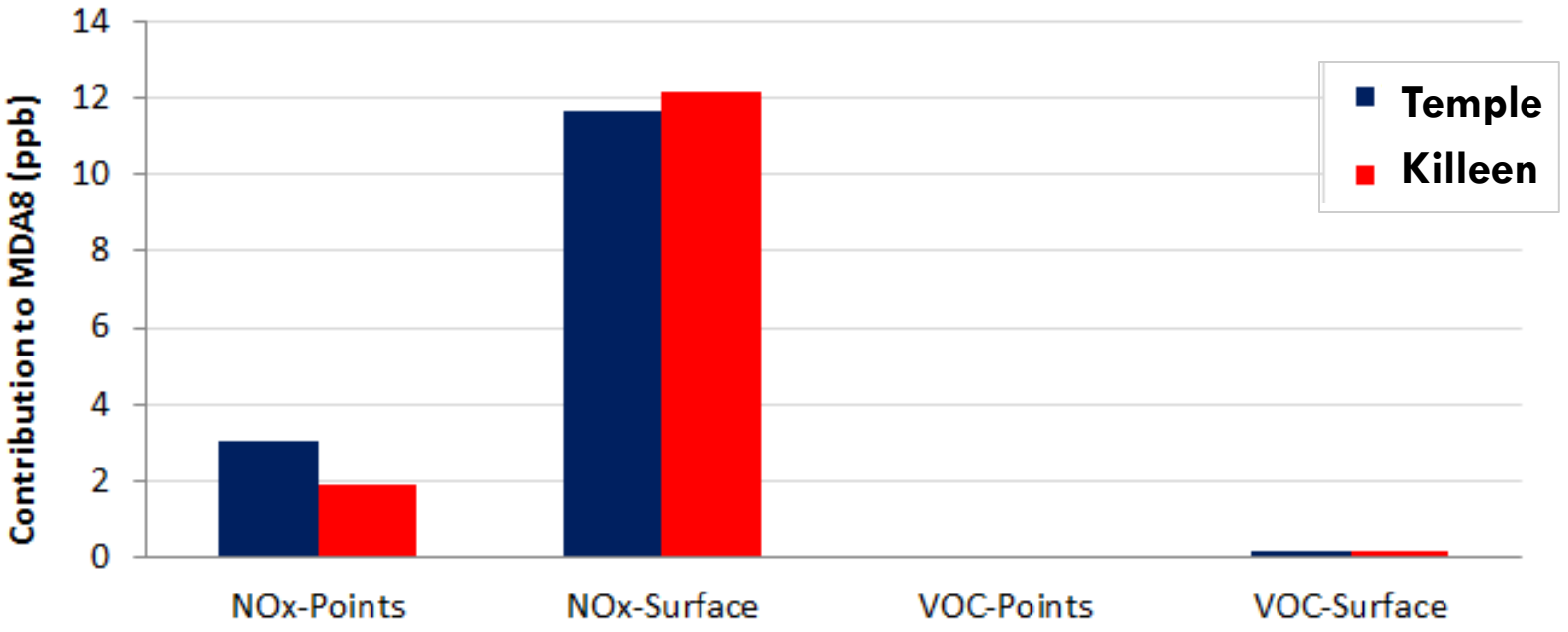
- Transported ozone dominates local contribution
- Local contribution from KTF is affected by uncertainties in KTF emission inventory, but modeling results indicate it can exceed 10 ppb
  - Local emissions controls can potentially reduce ozone at Killeen but cannot eliminate the ozone problem

Ozone Impact of KTF Emissions vs. Transport

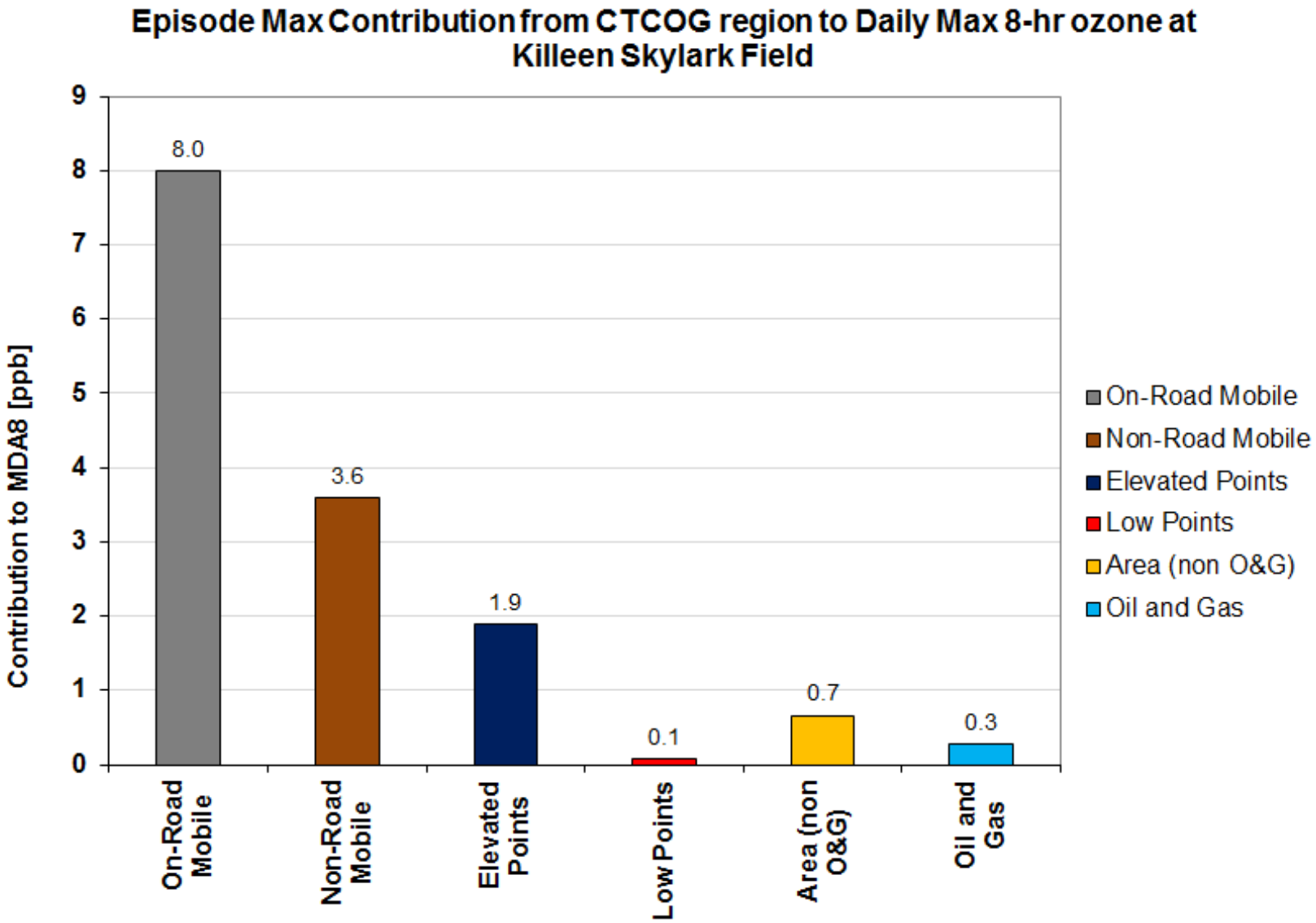


- Contribution of transport is far larger than local contribution from KTF emissions during June 2012

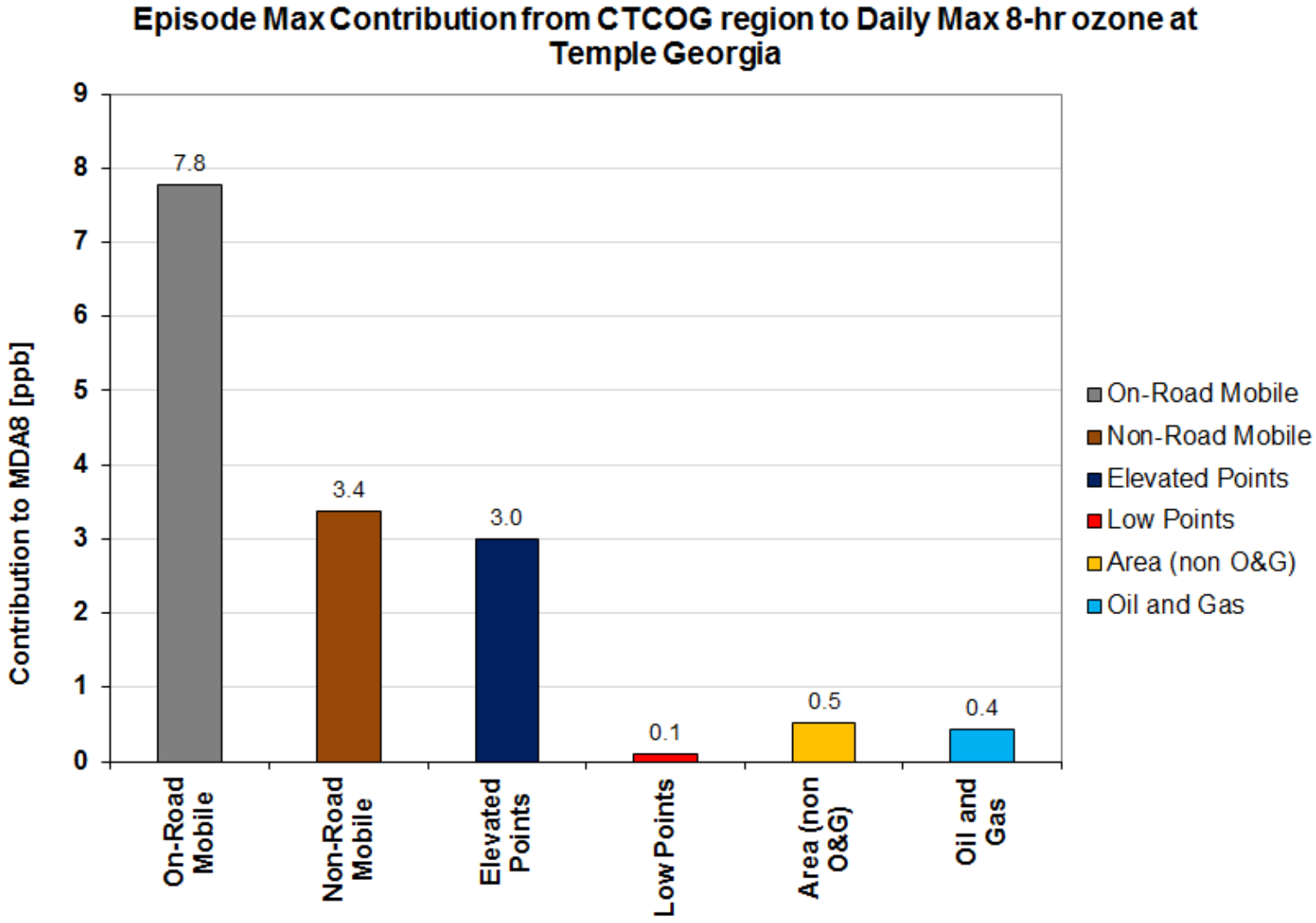
Maximum Contribution of KTF Area Emissions to Ozone at Killeen and Temple



- Ozone formation in KTF area is NOx-limited
  - Consistent with emission inventory VOC/NOx ratio
- **Local emissions controls should focus on NOx reductions**



- Consistent with emission inventory



- Results similar to Killeen monitor, but higher contribution from elevated points
  - Larger influence of Sandow power plant

Summary

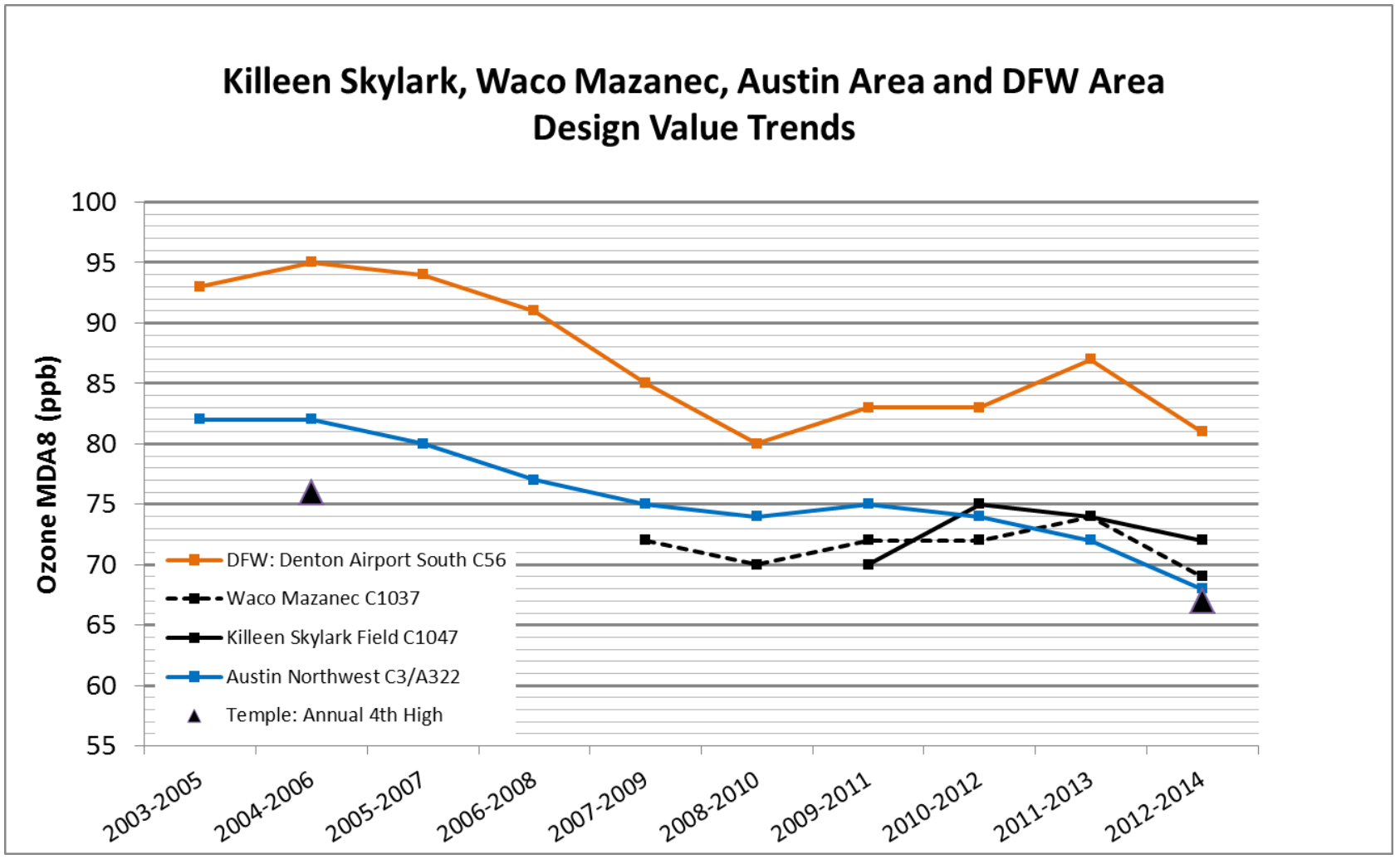
- Ambient monitoring data and ozone modeling show the importance of transport in determining ozone levels at the Killeen monitor
  - Local emissions make a far smaller but non-zero contribution to Killeen ozone
  - Magnitude of local ozone contribution affected by uncertainty in emission inventory
- Biogenic VOC emissions are sufficiently high that ozone formation is generally NOx-limited
  - Potential ozone impact of KTF emissions determined by NOx emissions
- Local emissions control strategies aimed at reducing local contributions to KTF area ozone should focus on reducing NOx emissions

Recommendations for FY16-17 Technical Work

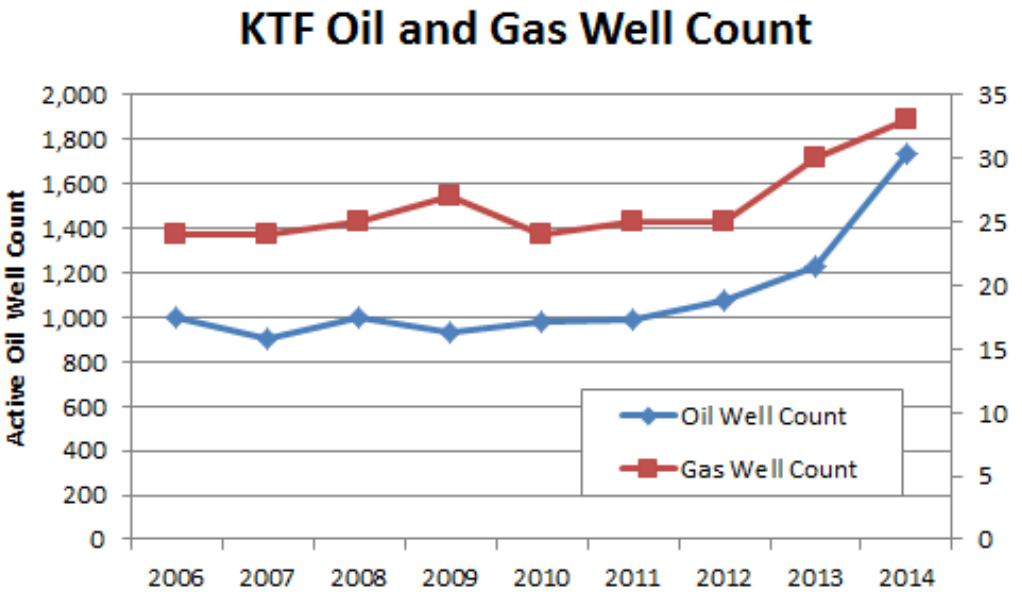
- Analyze and rank potential local NOx emission control strategies
- Refine TCEQ 2012 emission inventory for KTF area
- Photochemical modeling
  - Diagnose and improve 2012 TCEQ ozone model performance on high ozone days at Killeen
  - Evaluate emissions and potential ozone impacts of Panda Temple Power Plant
  - Evaluate ozone impacts of emission control strategies
- Analyze 2016-2017 high ozone days at Killeen and Temple Georgia

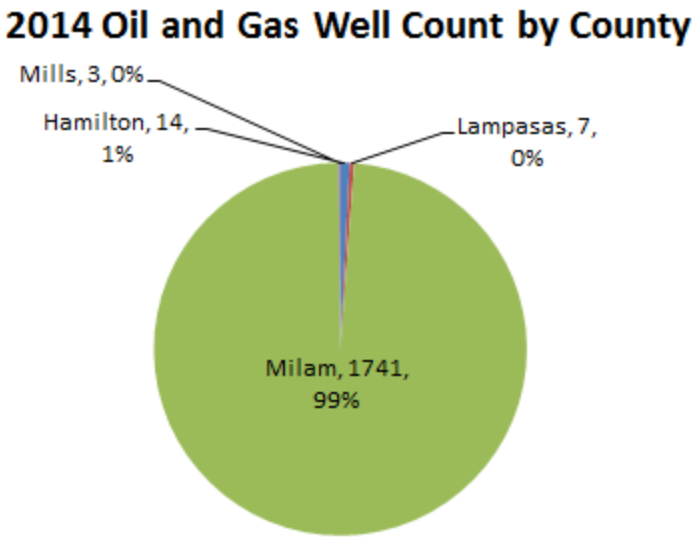
END

Regional Design Value Trends



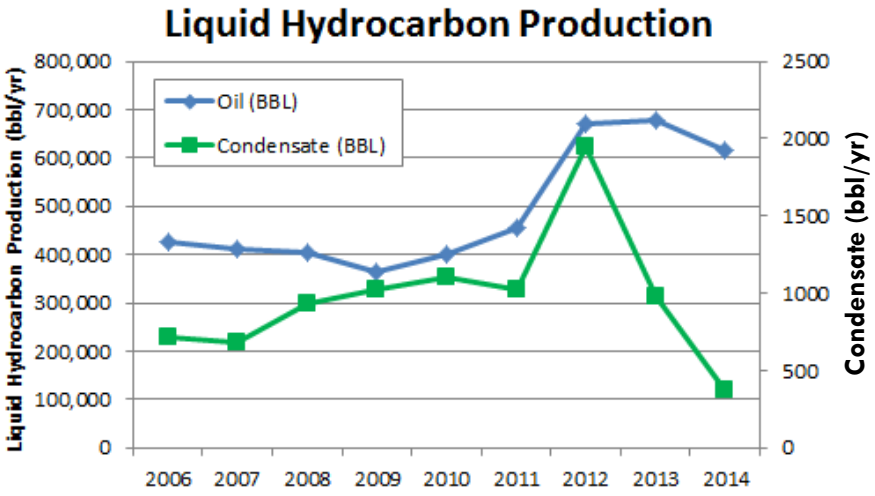
Oil and Gas Well Count Trends

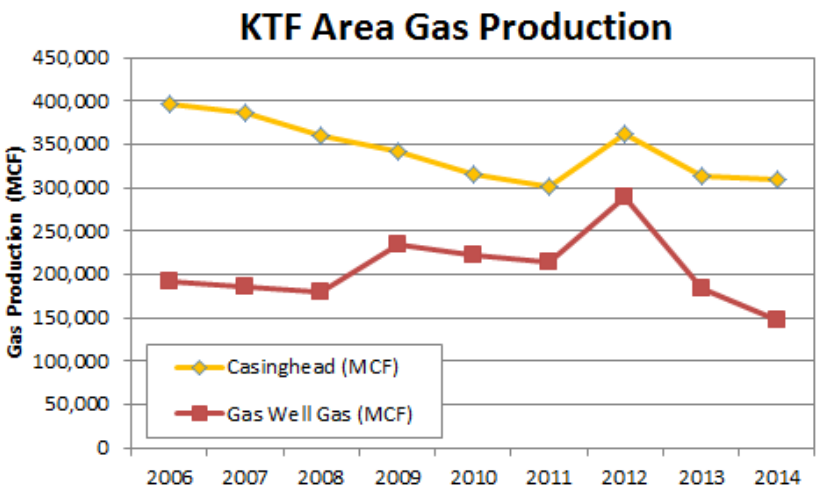


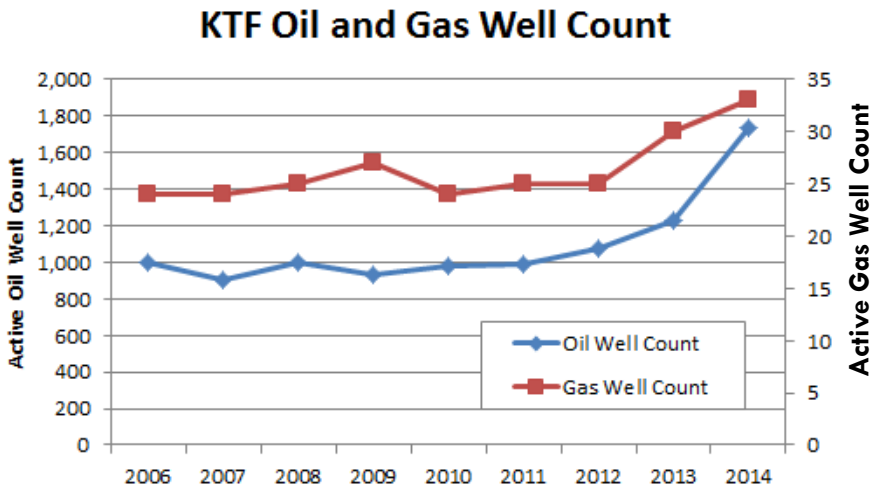


- Most of the oil and gas wells in the 7-county area are located in Milam County
- Sharp increase in well counts since 2012
- Oil wells far outnumber gas wells

KTF Area Production Trends

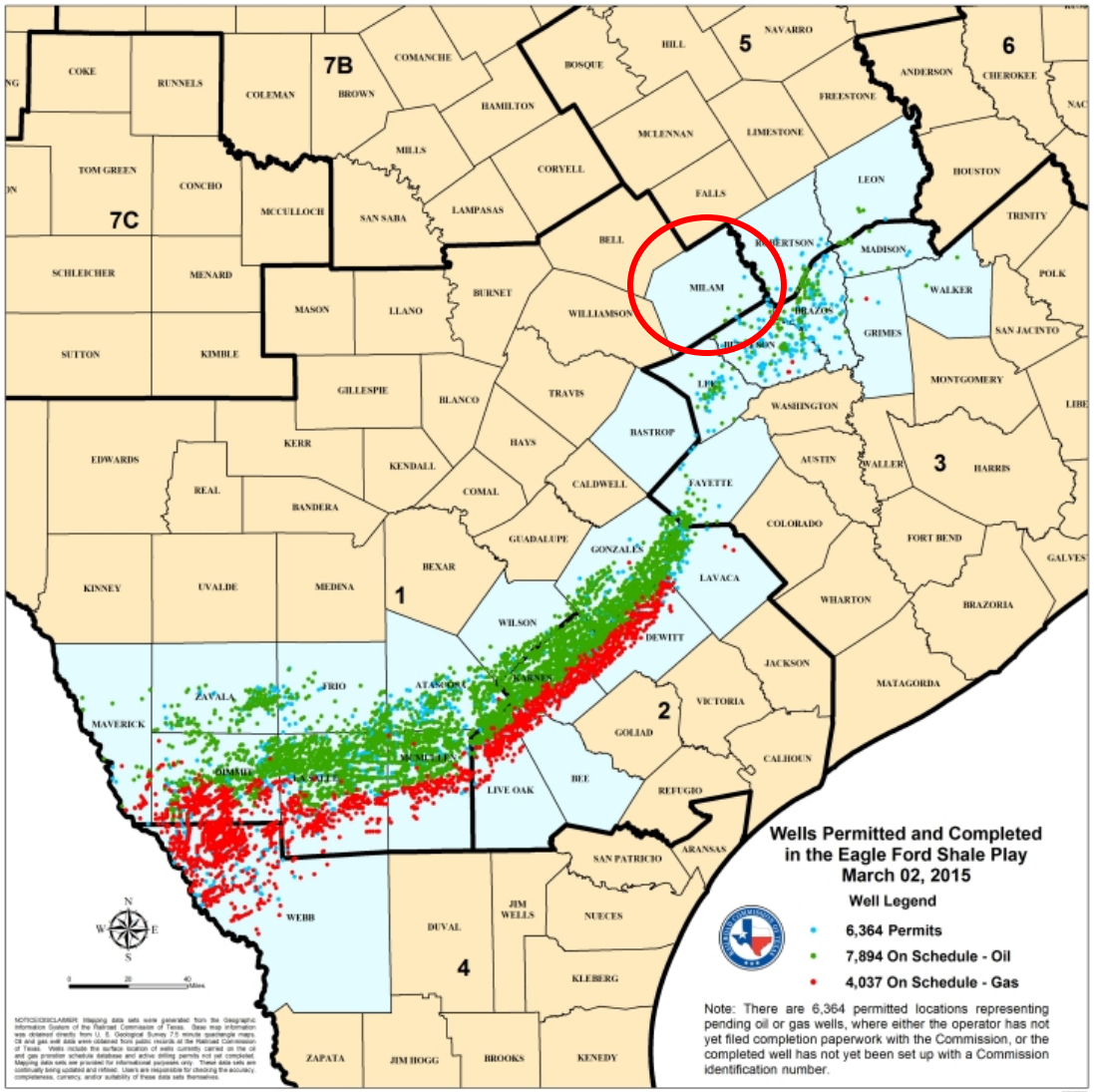






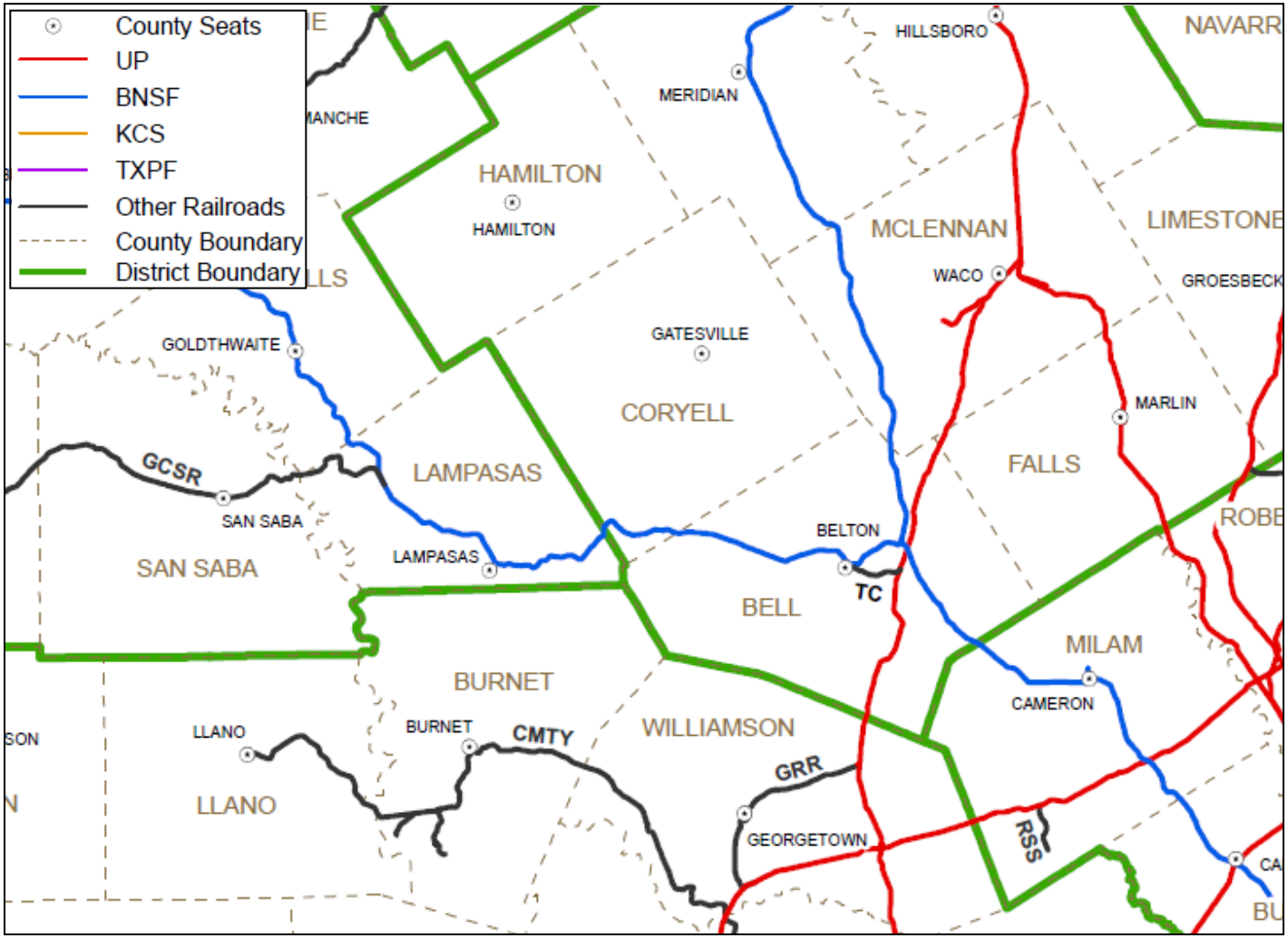
- Sharp increase in oil production in 2012
- Production trends seem inconsistent with well counts (e.g. 2012 and 2014)
  - 2014 Railroad Commission production data may be incomplete

The Eagle Ford Shale



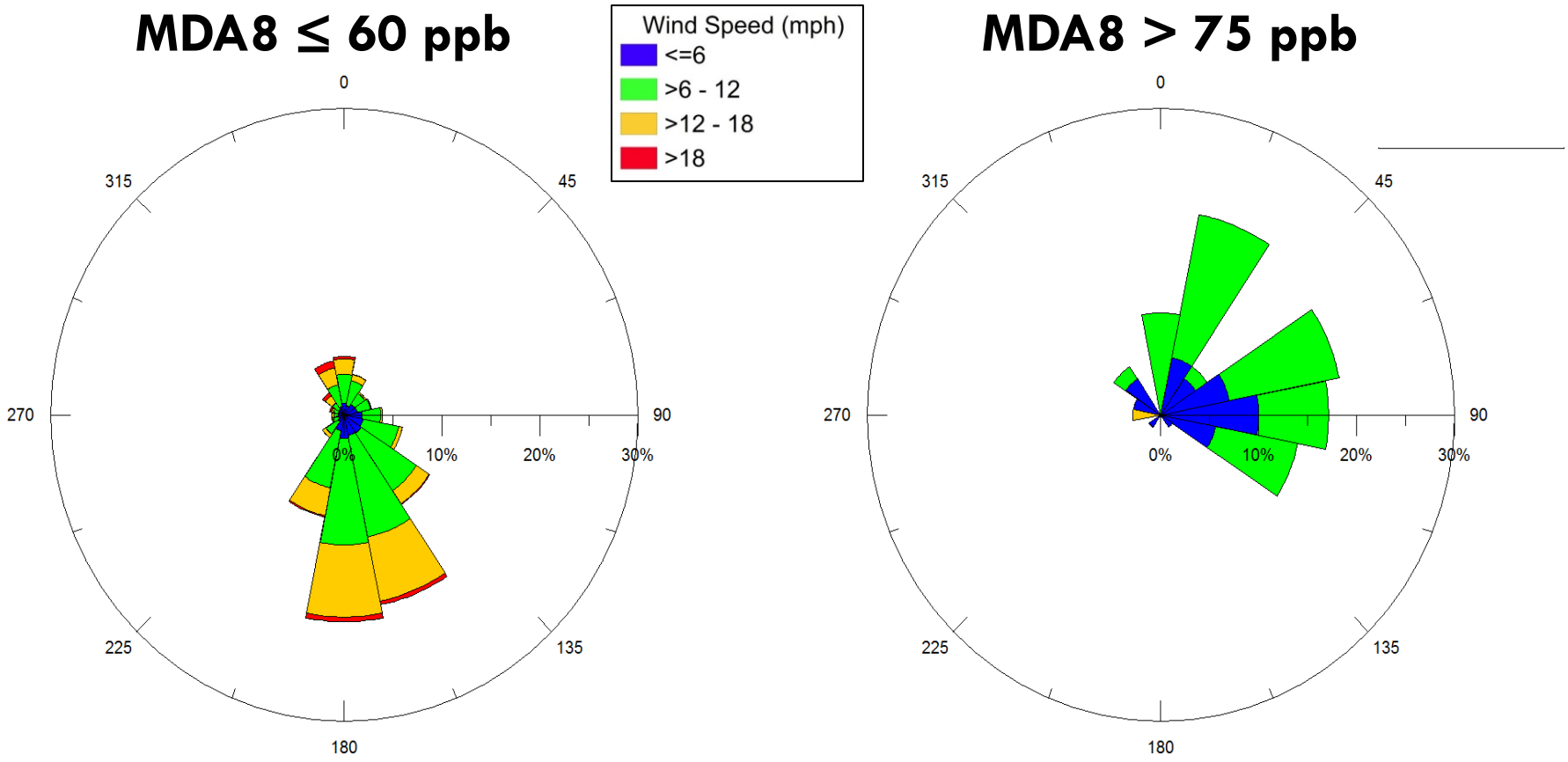
- The Eagle Ford Shale extends into Milam County
- Milam Eagle Ford well count is very small as of March, 2015

Railroads



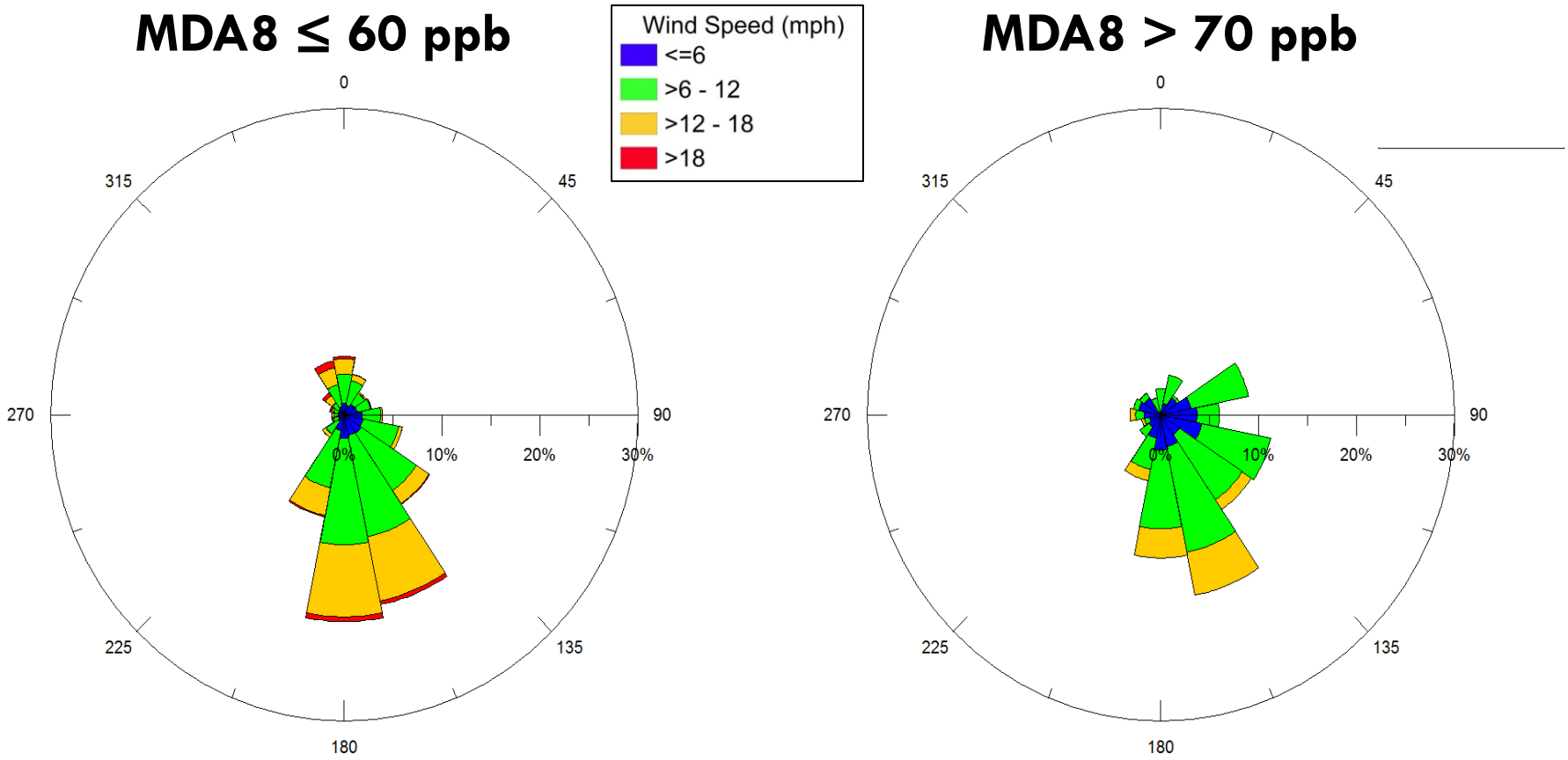
- Emissions distribution consistent with rail line locations

Killeen Monitor Wind Roses



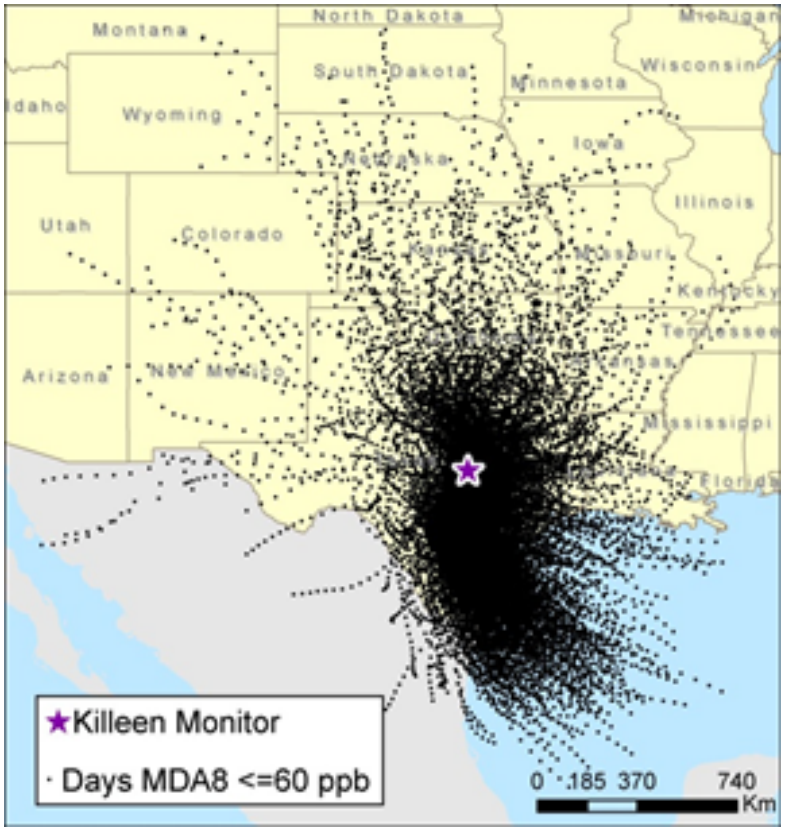
- On MDA8 ≤ 60 ppb days, stronger, southeasterly winds
- On MDA8 > 75 ppb days, lighter northeasterly through southeasterly winds

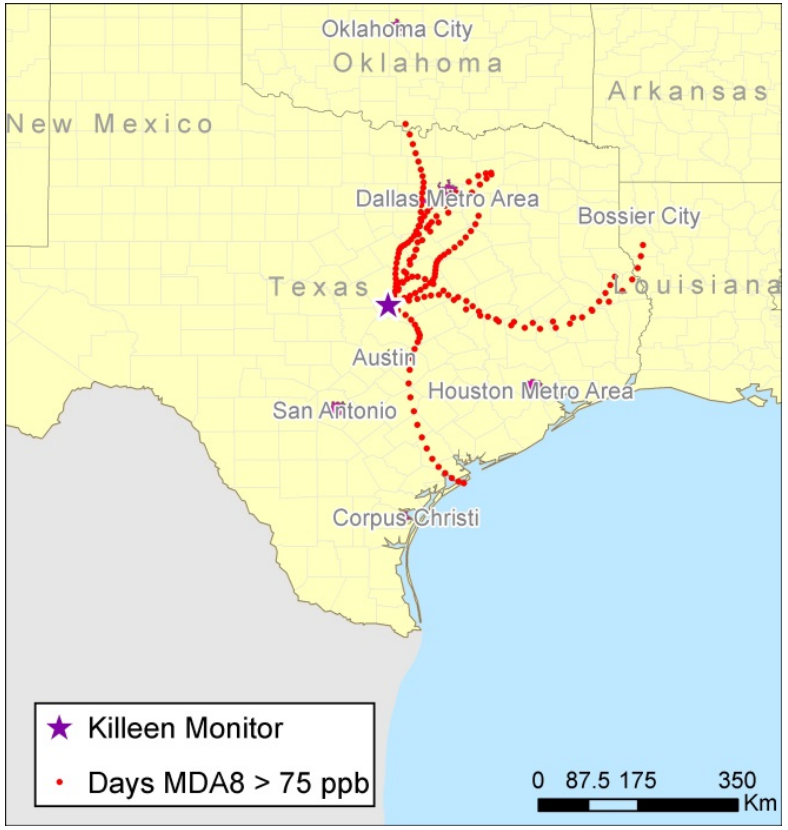
Killeen Monitor Wind Roses



- On MDA8 ≤ 60 ppb days, stronger, southeasterly winds
- On MDA8 > 70 ppb days, lighter northeasterly through southwesterly winds

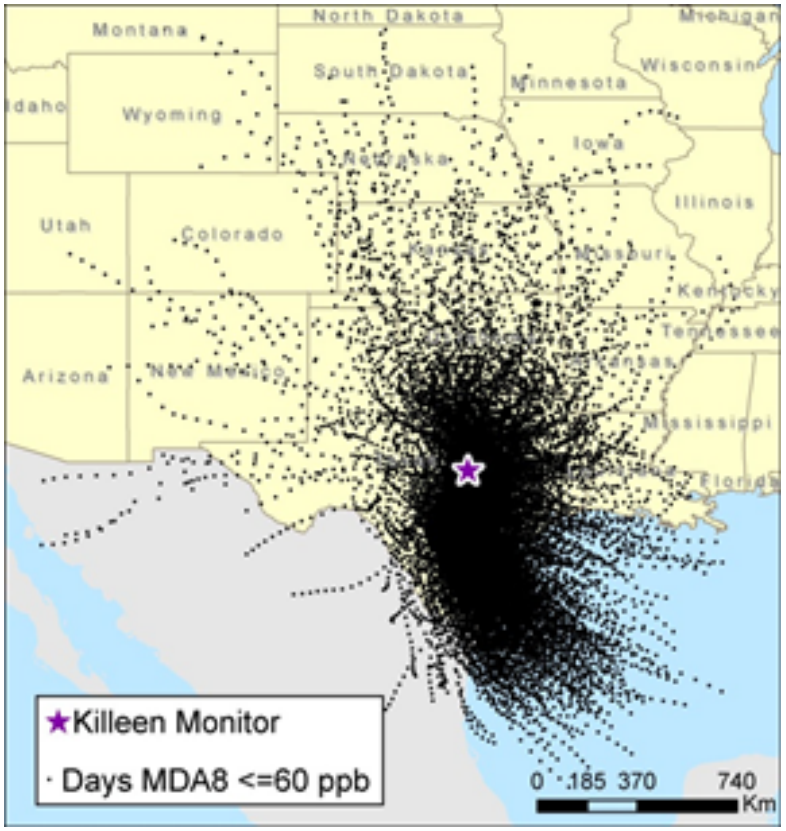
HYSPLIT Model 24-Hour Back Trajectories

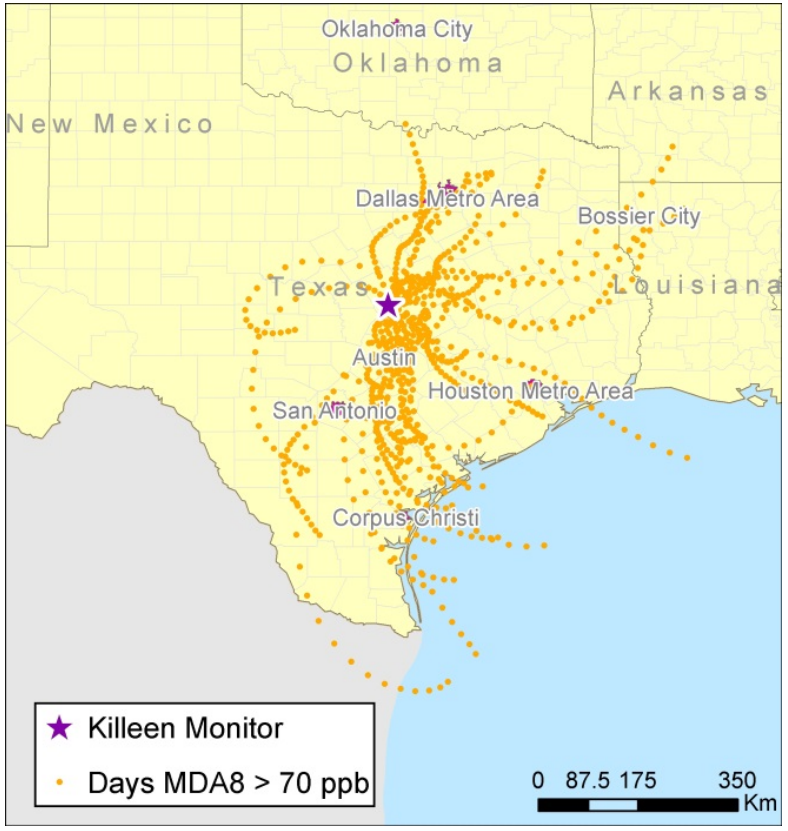




- When MDA8 ≤ 60 ppb, back trajectories are longer (higher wind speed) and most frequently extend southward
- When MDA8 >75 ppb back trajectories are shorter (lower wind speed) and most frequently extend northeastward

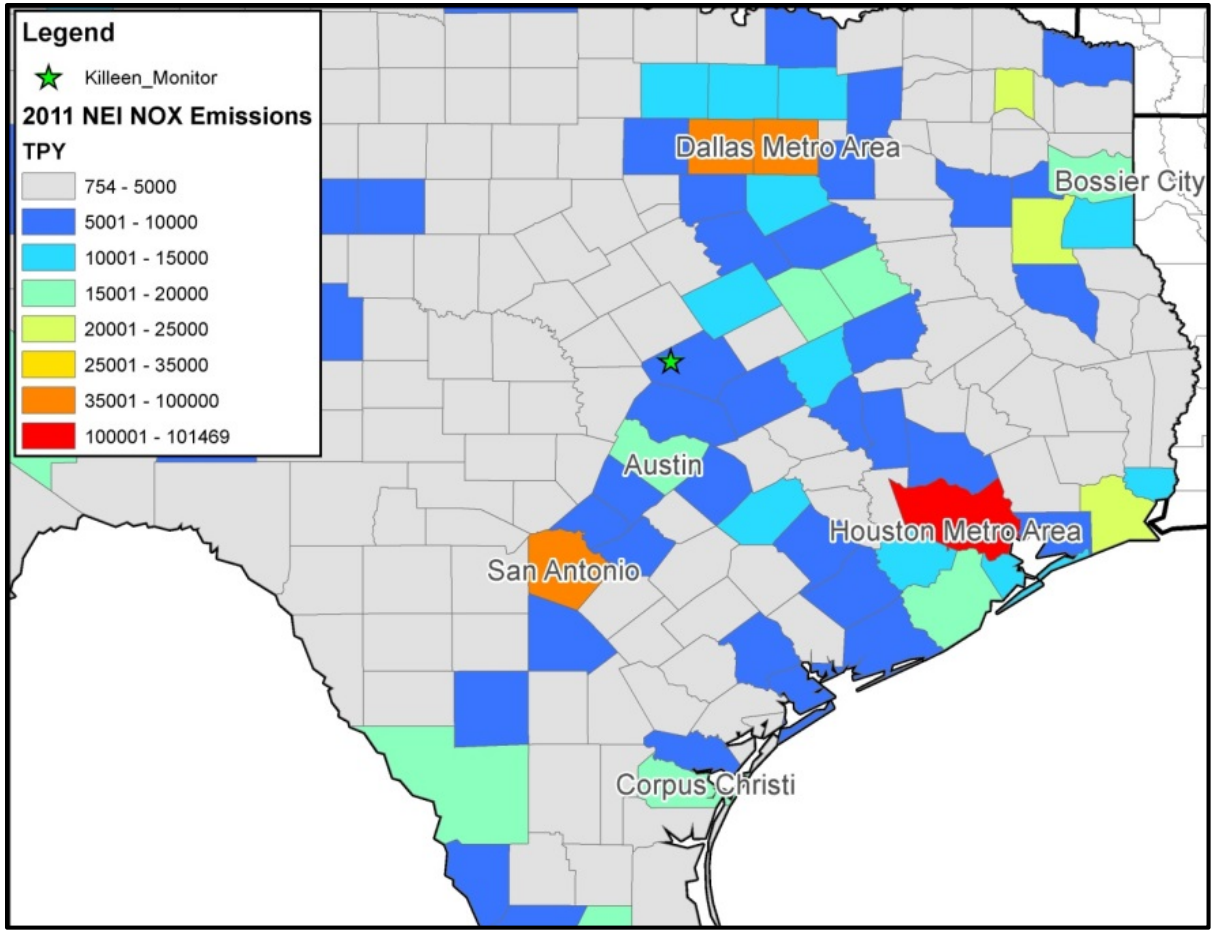
HYSPLIT Model 24-Hour Back Trajectories





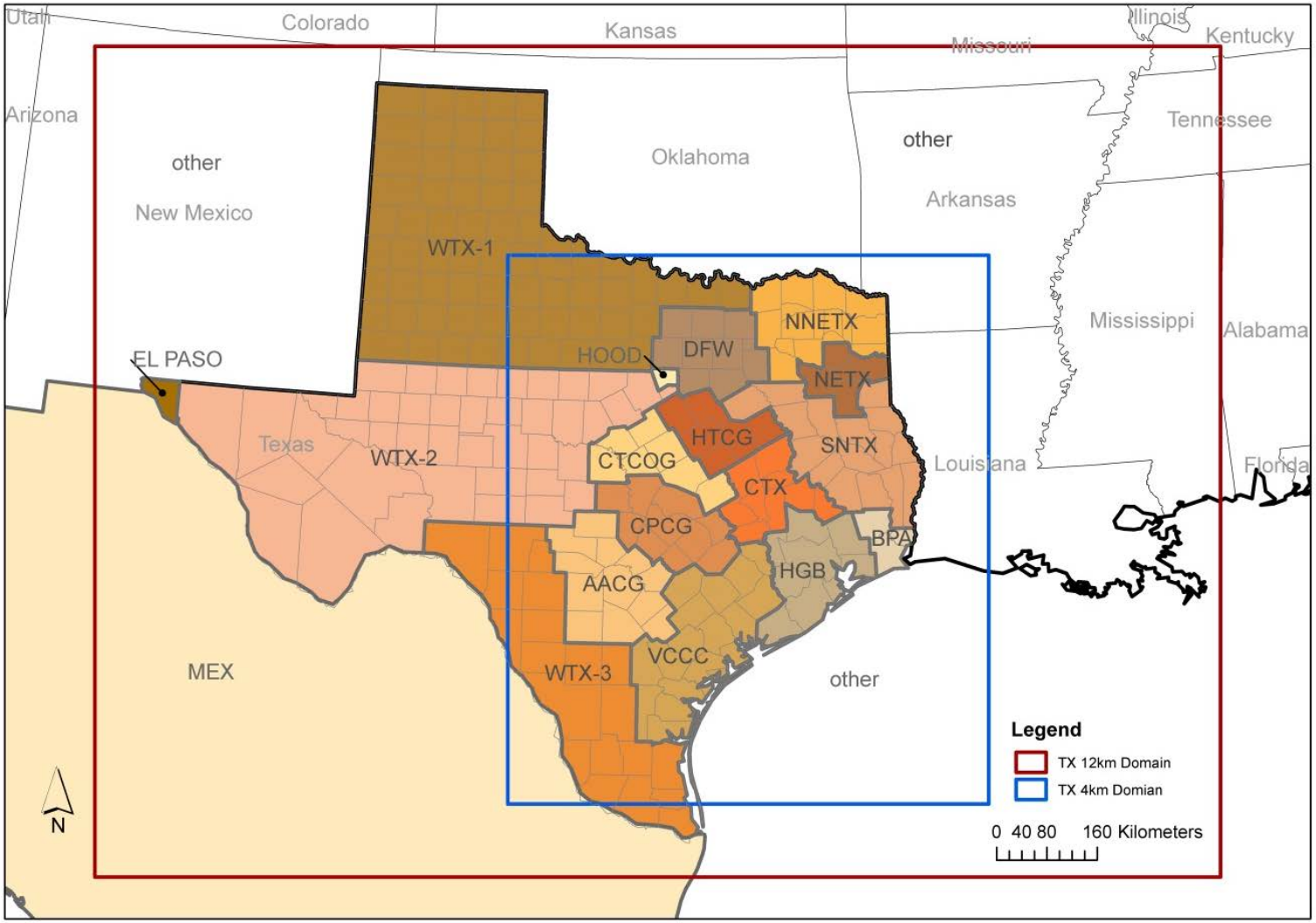
- When MDA8 ≤ 60 ppb, back trajectories are longer (higher wind speed) and most frequently extend southward
- When MDA8 >70 ppb back trajectories are shorter (lower wind speed) and most frequently extend northeast through southwest

Regional NOx Emissions

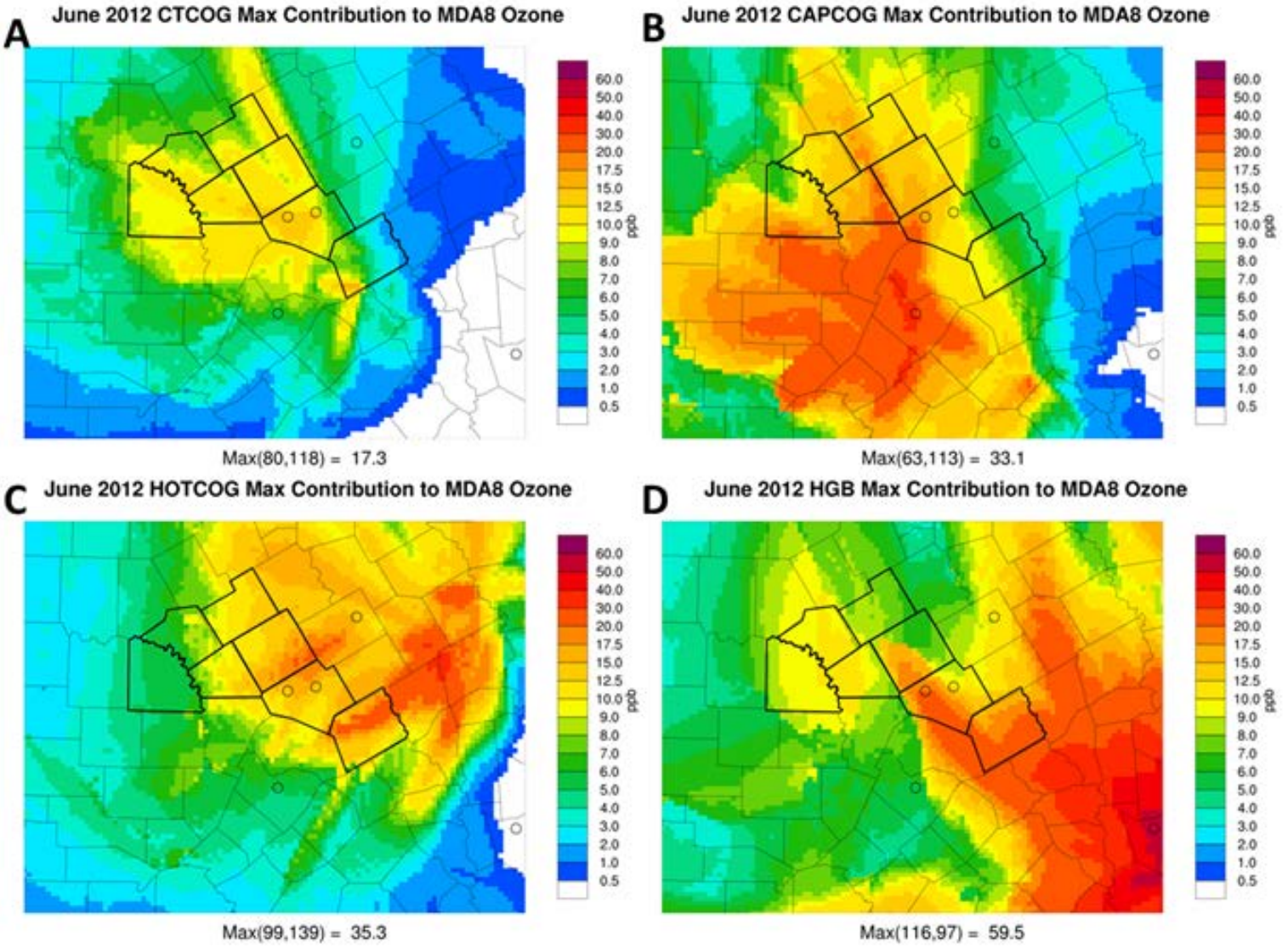


- Texas areas with higher NOx emissions to the North through southwest

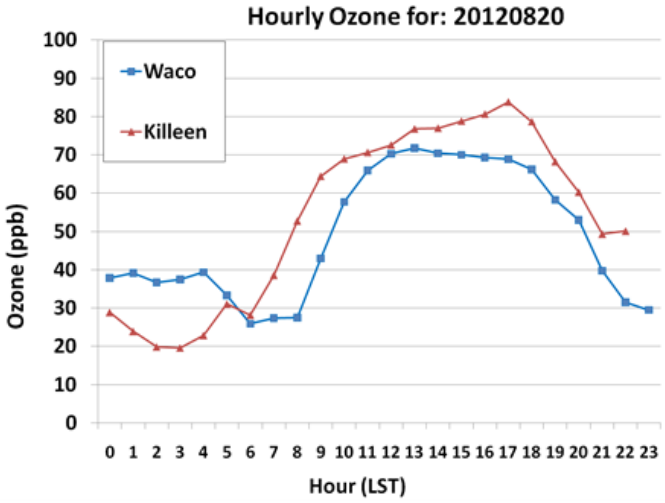
CAMx Source Apportionment Map

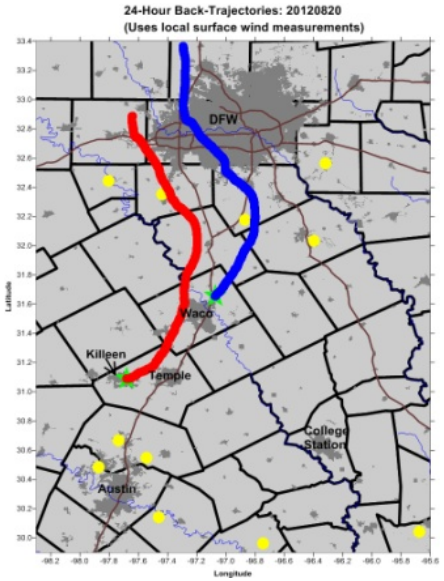


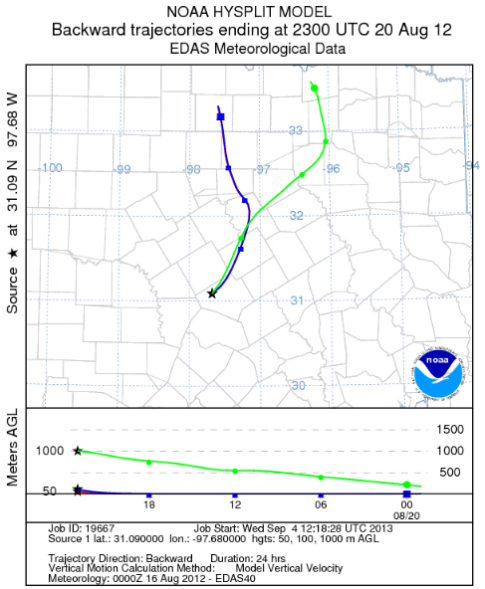
Ozone Contributions from Surrounding Regions

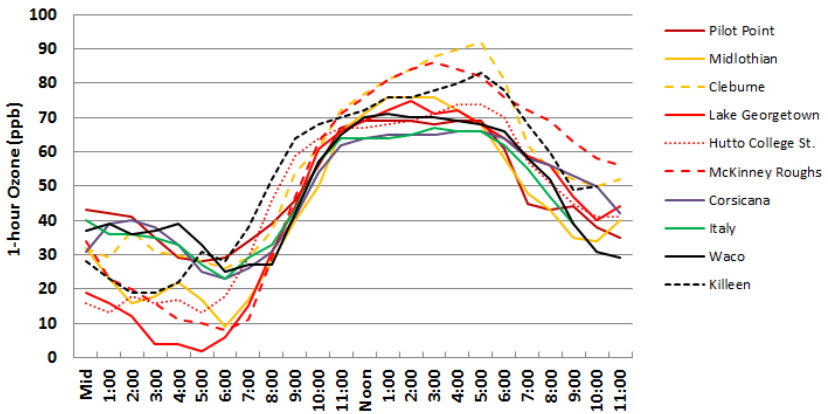


High Ozone Day Analysis









- Ozone at local and regional monitors
- Winds, origin of air mass
- Relative importance of transport and local emissions