Quantifying Regional Background Ozone for the Houston-Galveston-Brazoria (HGB) Nonattainment Area

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Introduction

- **Measured background ozone trend on US west coast is upward; linked to increasing Asian emissions** (Jacob et al. 1999; Jaffe et al. 1999, 2003; Cooper et al. 2010, 2012; Parrish et al. 2009; Reidmiller 2009; Brown-Steiner and Hess 2011; Lin et al. 2012; Zhang et al. 2008, 2011; Widger et al. 2013; Pfister et al. 2013)

- **Questions:**
  - **What is the regional background ozone trend in HGB?**
  - **What factors affect background ozone in the eastern half of Texas?**

Outline

- **Two methods for estimating background ozone in HGB, Principal Component Analysis and upwind-downwind:** Berlin, S., A. Langford, M. Estes, M. Dong, and D. Parrish (2013)
- **Seasonal variations in background ozone**
- **Transport effects upon background ozone**
- **Trends in regional background ozone**

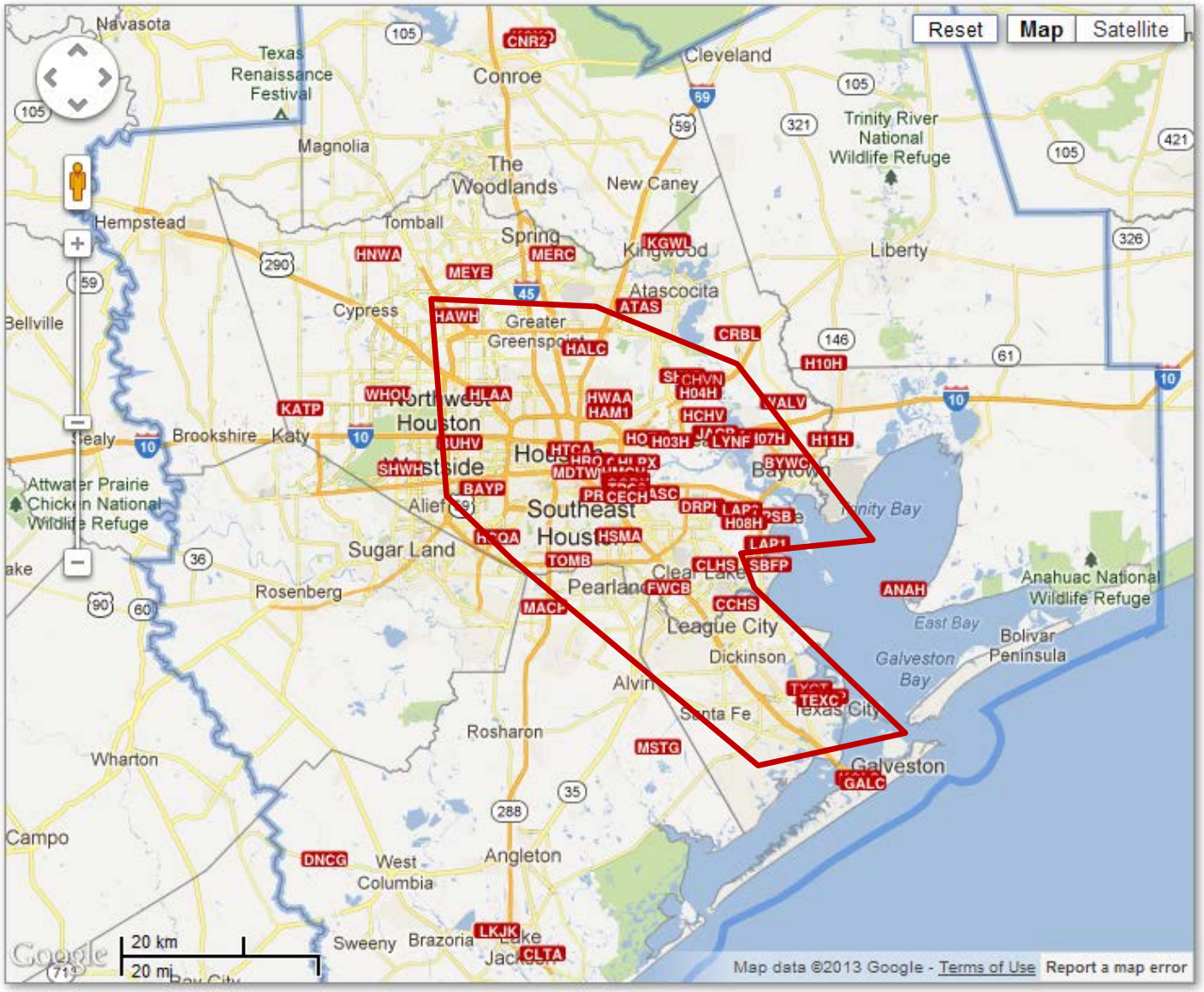
Definition of regional background ozone

- For these analyses, regional background ozone is the ozone transported into the area such that local emissions have little influence upon the ozone concentrations.
- Generally not equivalent to “natural background” or “policy-relevant background.”

Method details: Background ozone estimation at upwind sites

- Select sites in the HGB area that are capable of measuring background ozone, given the proper conditions. These sites are not located near large emission sources.
- Calculate maximum daily average 8-hour (MDA8) ozone concentration for each site.
- Select the lowest MDA8 ozone concentration from the subset of background sites.
- Ozone season defined as April 1 – Oct 31.
- Number of sites selected varied from 6 to 19, greatly increasing after 2002.

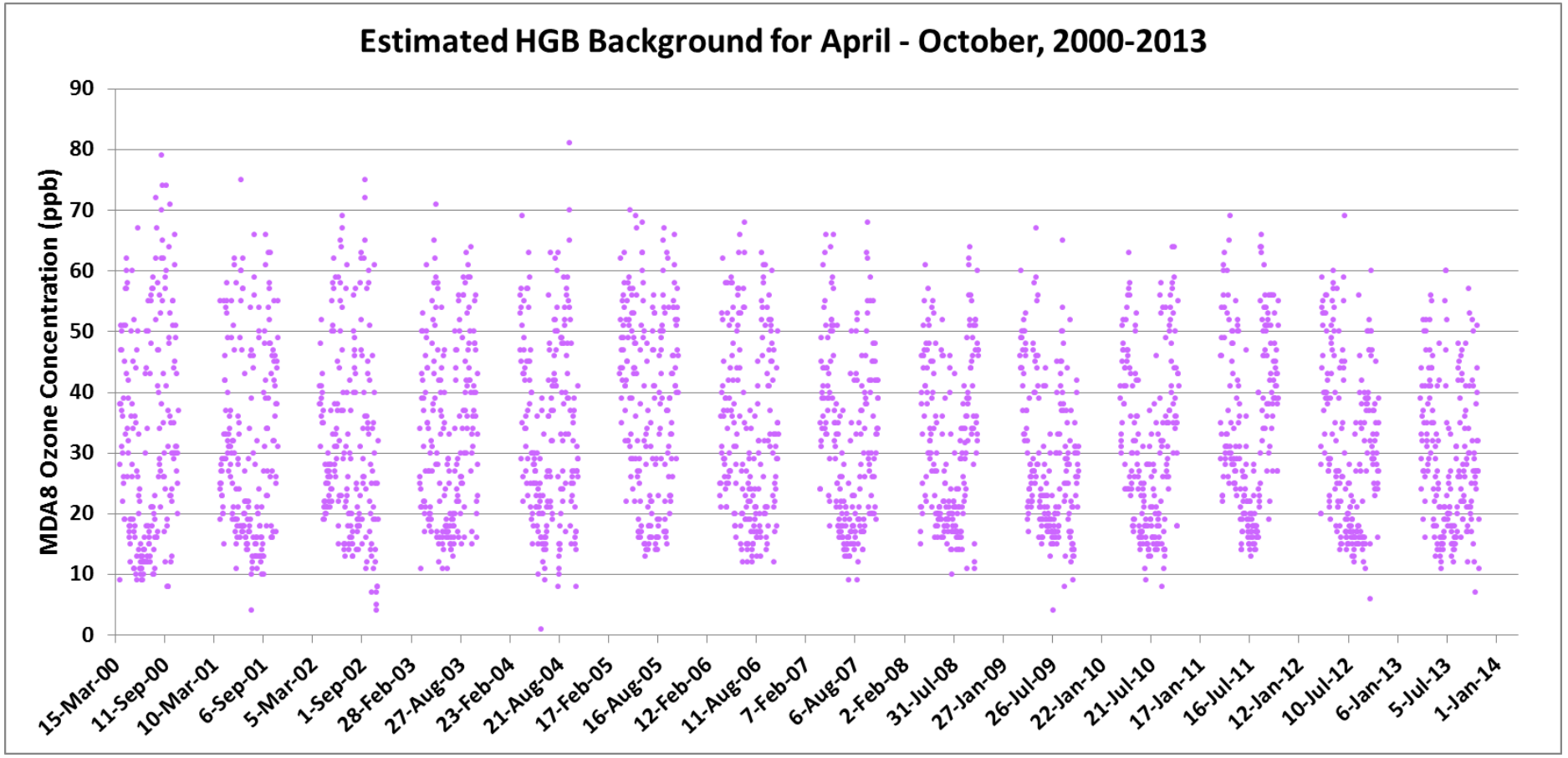
Sites outside the red boundary are able to measure background ozone reliably; sites inside often do not, due to influence from local sources.



Method details: Some limitations

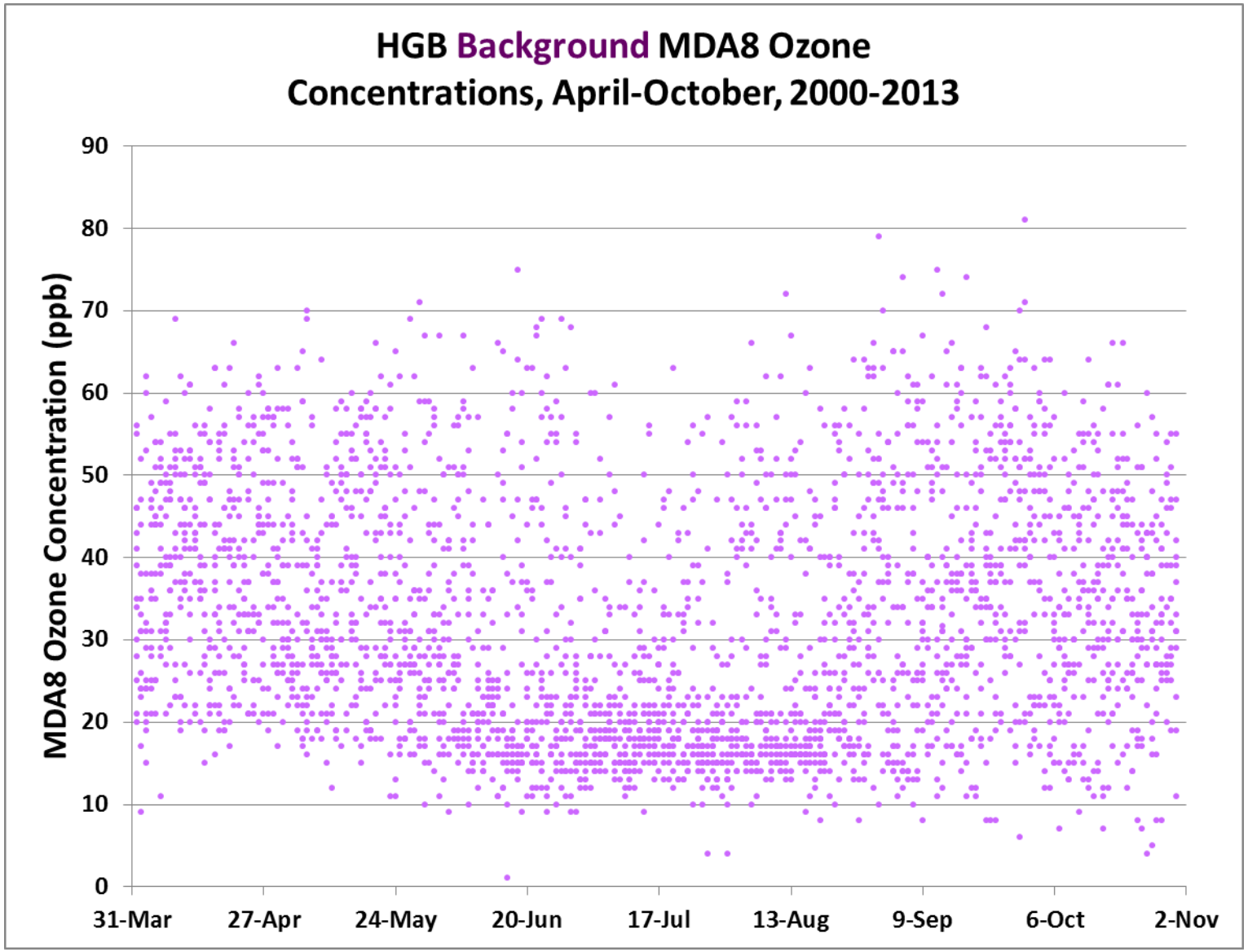
- The HGB area is fairly extensive geographically, and background can vary among monitor locations. This method only identifies the lowest background value.
  - Days when the sea breeze did not push completely through the area are especially prone to differing background levels in north vs. south HGB.
  - Some outlier observations were manually removed.

HGB Ozone Season Background

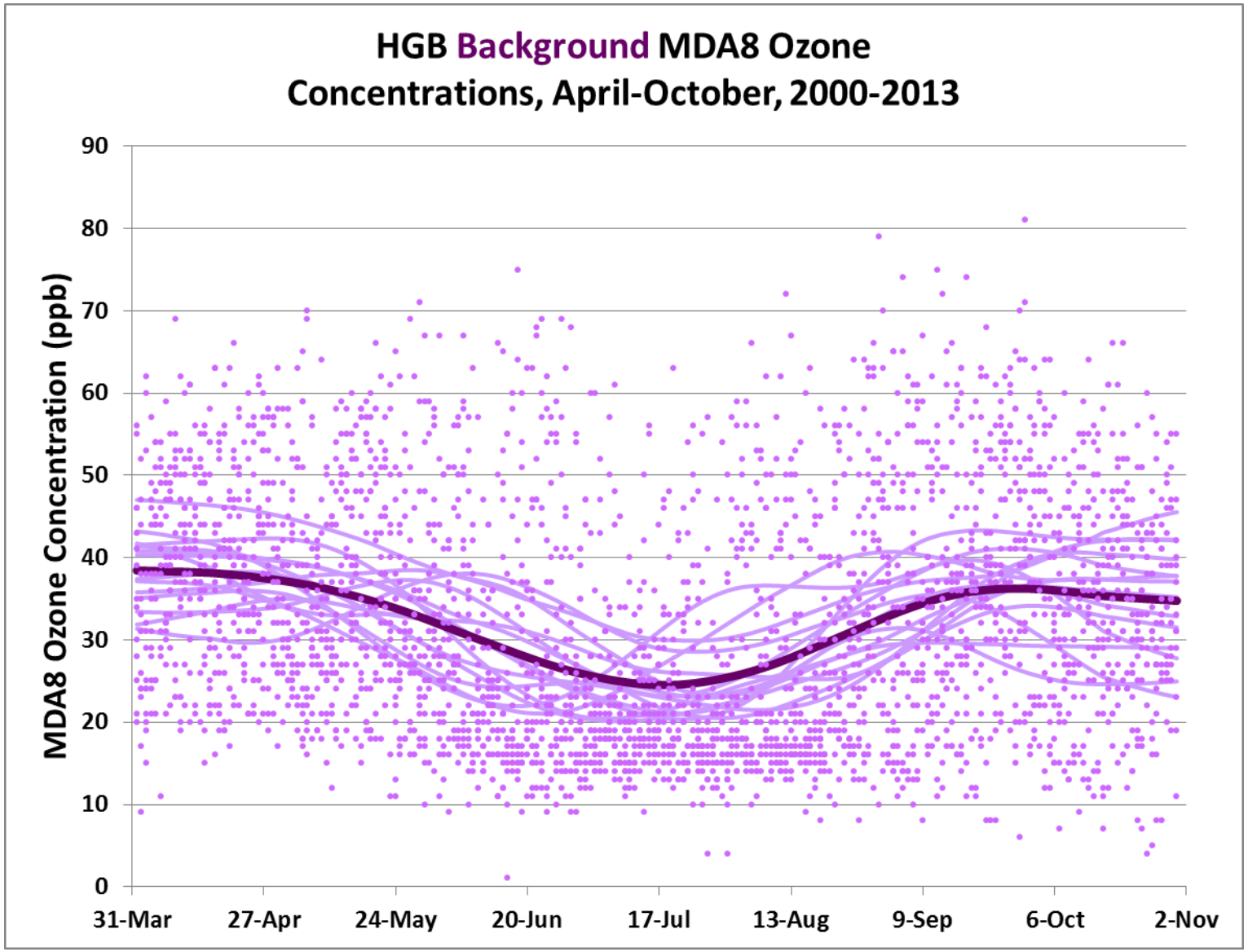


Median background ozone: 30 ppbv
Mean: 32.3 ppbv
95th percentile: 58 ppbv
Clearly, there are systematic variations in background ozone during the ozone season.

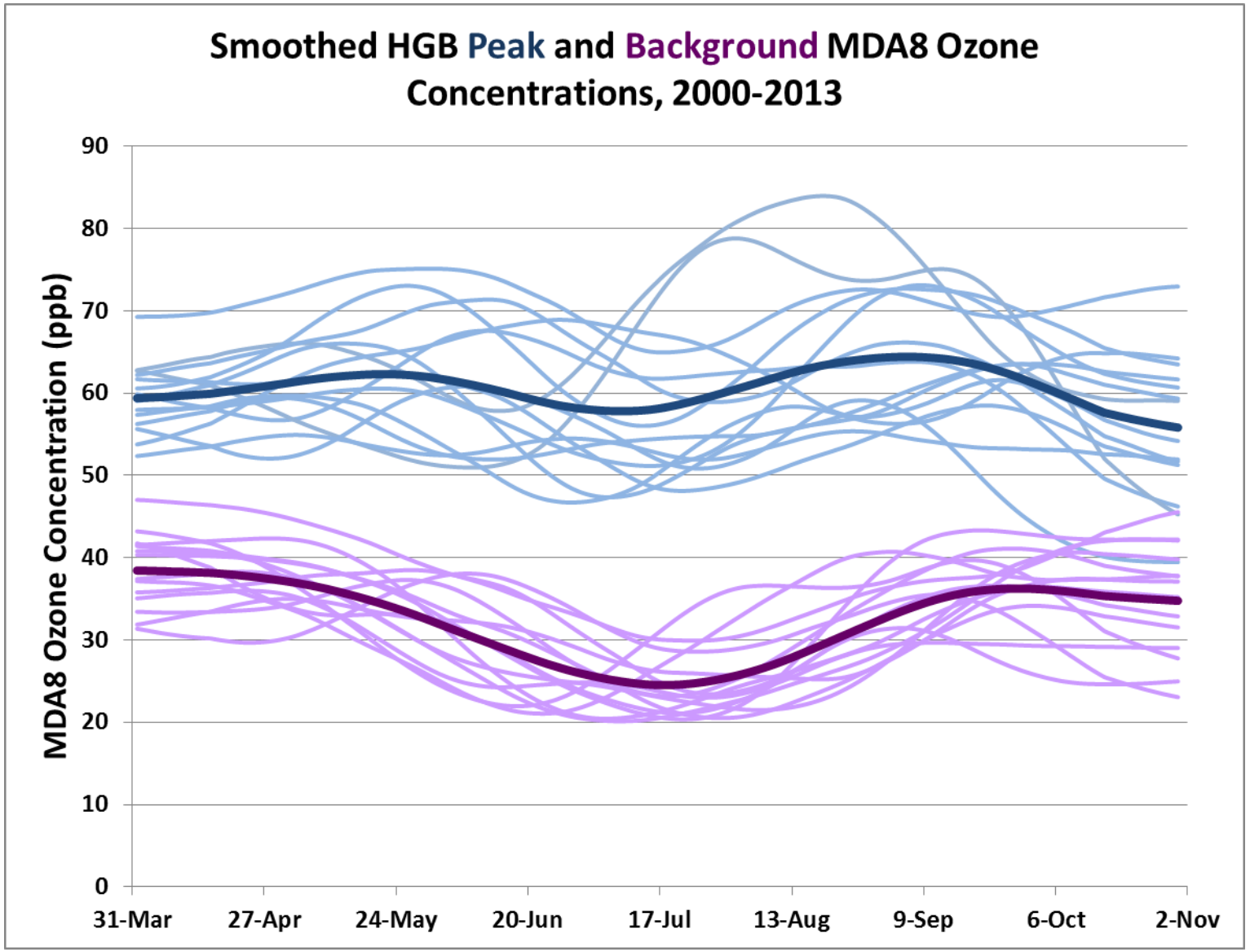
HGB Ozone Season Background



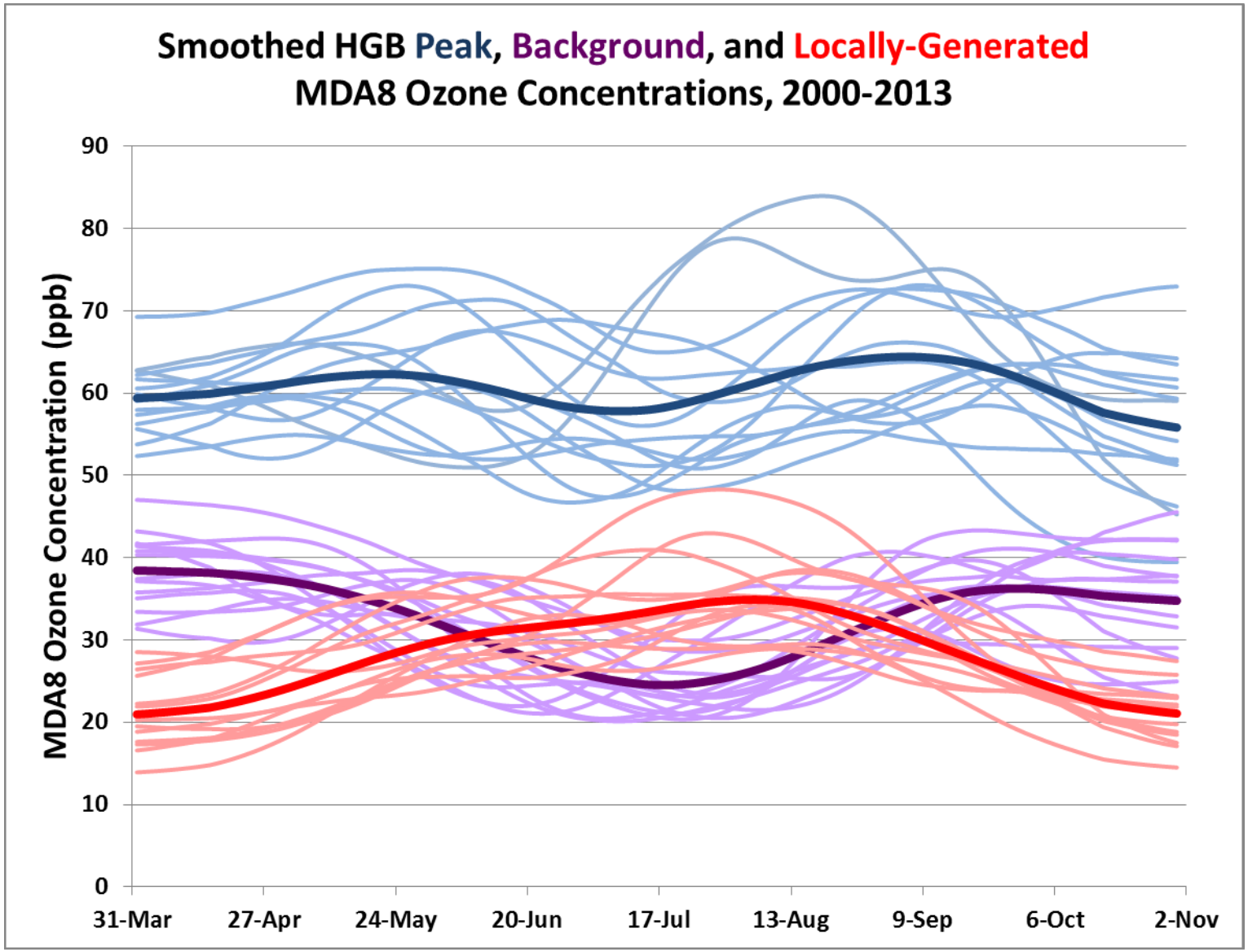
HGB Ozone Season Background

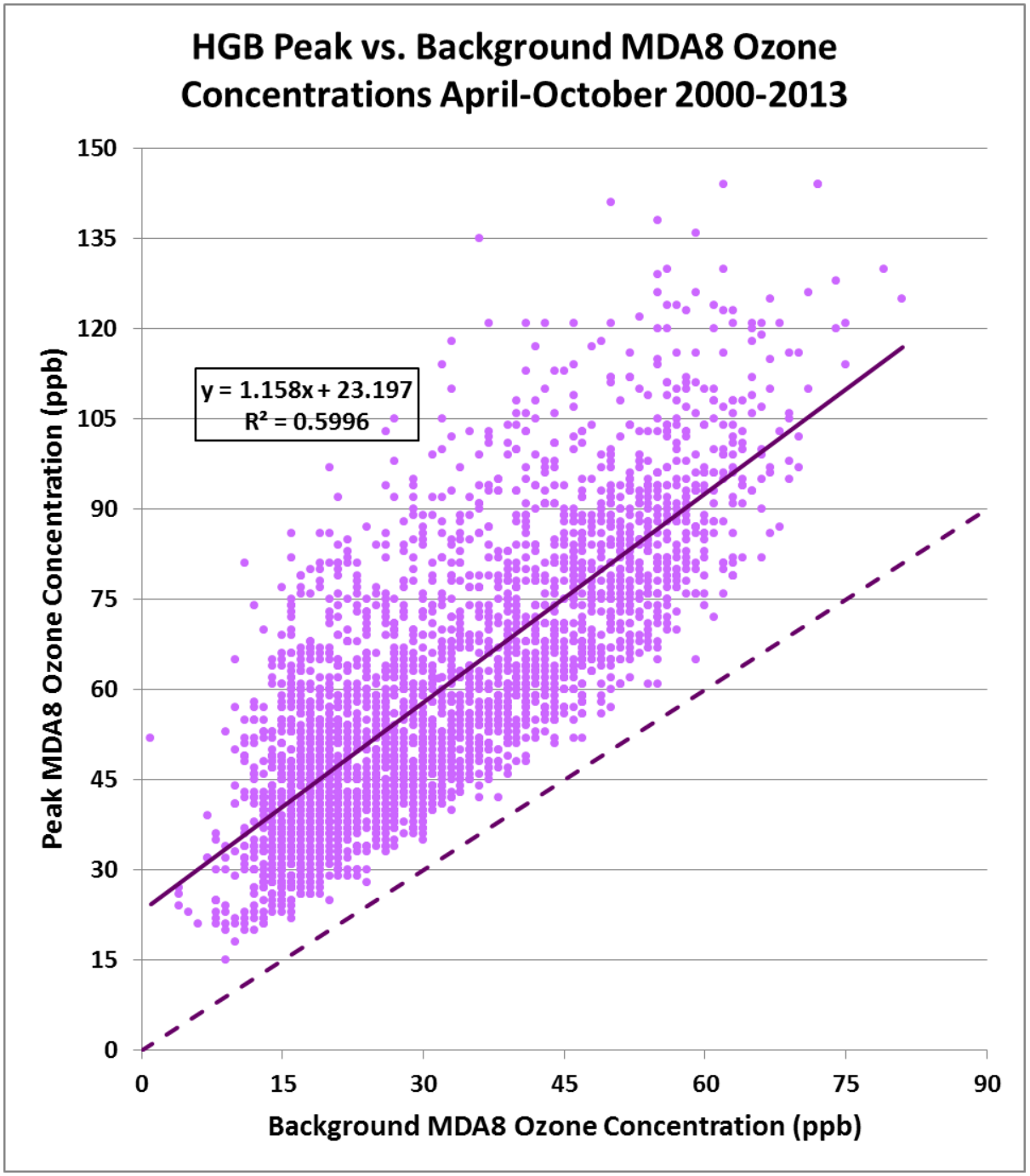


HGB Ozone Season Background

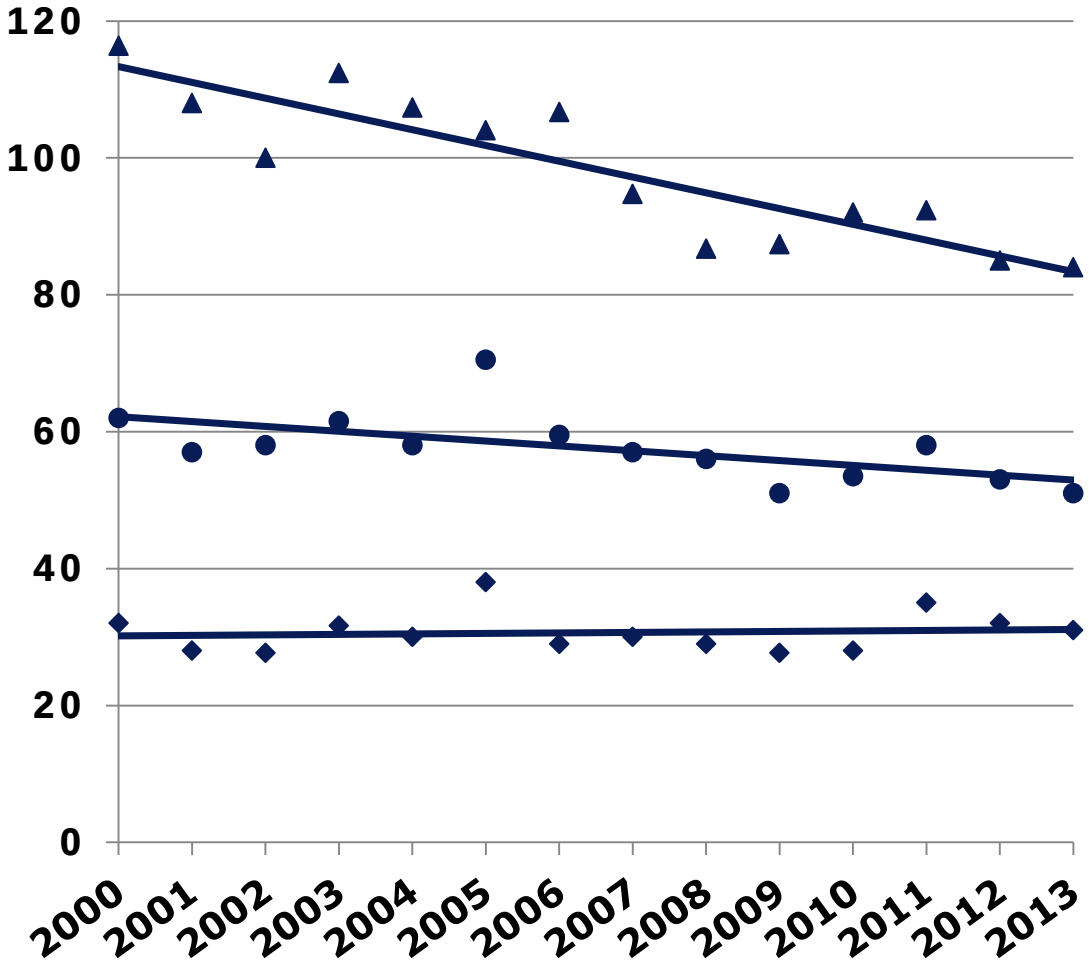


HGB Ozone Season Background



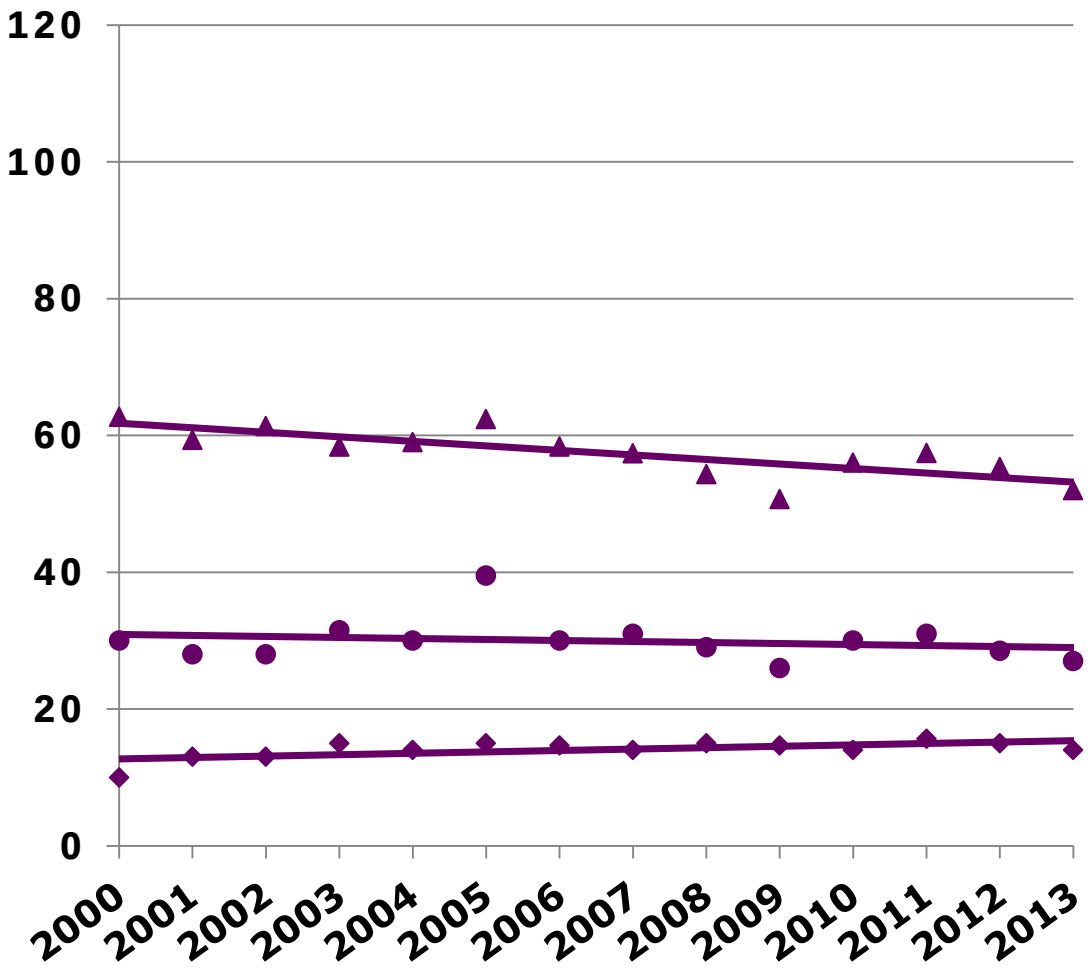

HGB Peak vs. Background MDA8 Ozone Concentrations April-October 2000-2013
y = 1.158x + 23.197
R² = 0.5996
Peak MDA8 Ozone Concentration (ppb)
Background MDA8 Ozone Concentration (ppb)
0
15
30
45
60
75
90
105
120
135
150

HGB Peak MDA8 Ozone Trends
April-October 2000-2013



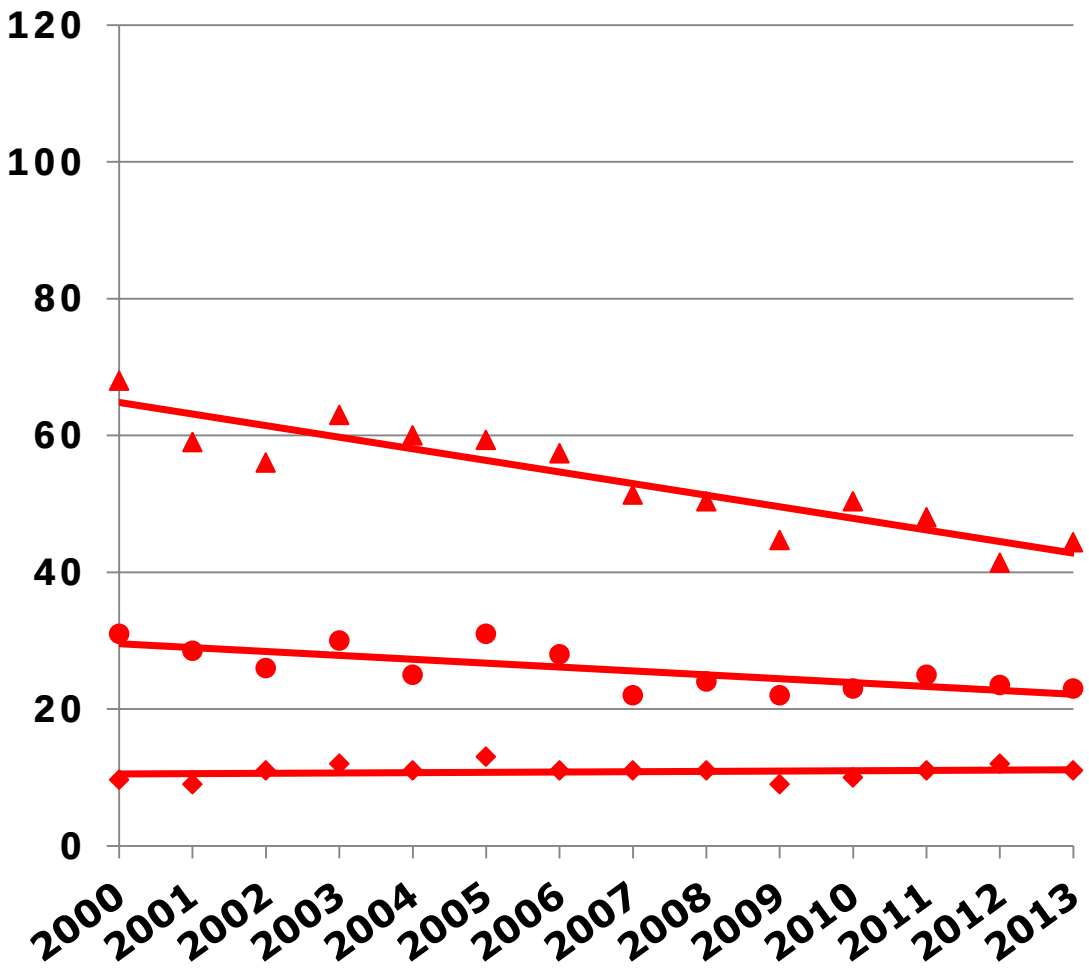
	Slope	R^2	p
▲ P95	-2.306	0.79	<.0001
● Median	-0.712	0.346	0.0269
◆ P05	0.0744	0.011	0.723

HGB Background MDA8 Ozone Trends
April-October 2000-2013



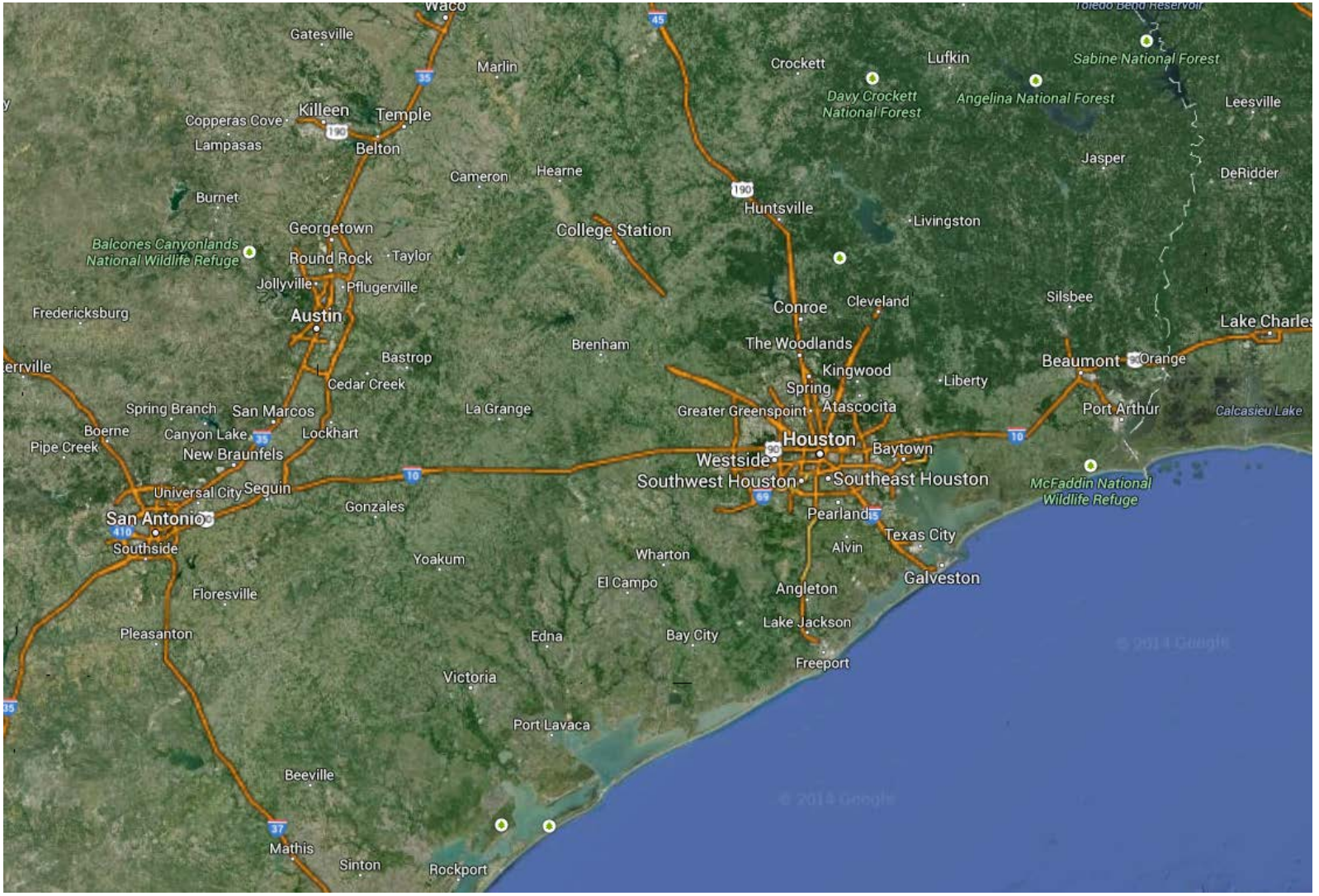
	Slope	R^2	p
▲ P95	-0.663	0.603	0.0011
● Median	-0.148	0.038	0.5025
◆ P05	0.205	0.376	0.0196

HGB Locally-Generated MDA8 Ozone Trends
April-October 2000-2013



	Slope	R^2	p
▲ P95	-1.170	0.827	<0.0001
● Median	-0.569	0.533	0.0030
◆ P05	0.045	0.028	0.5657

Galveston, Texas



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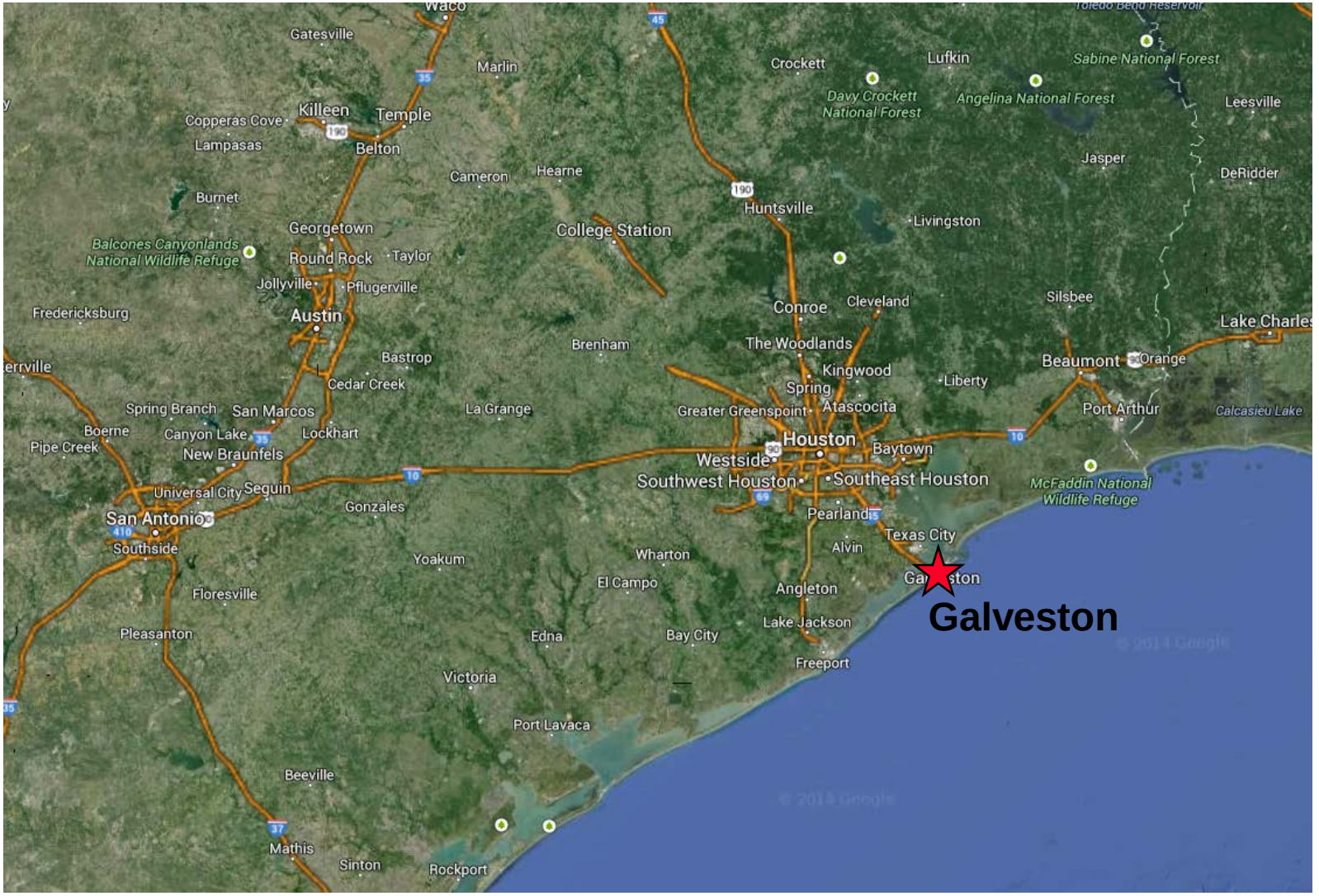
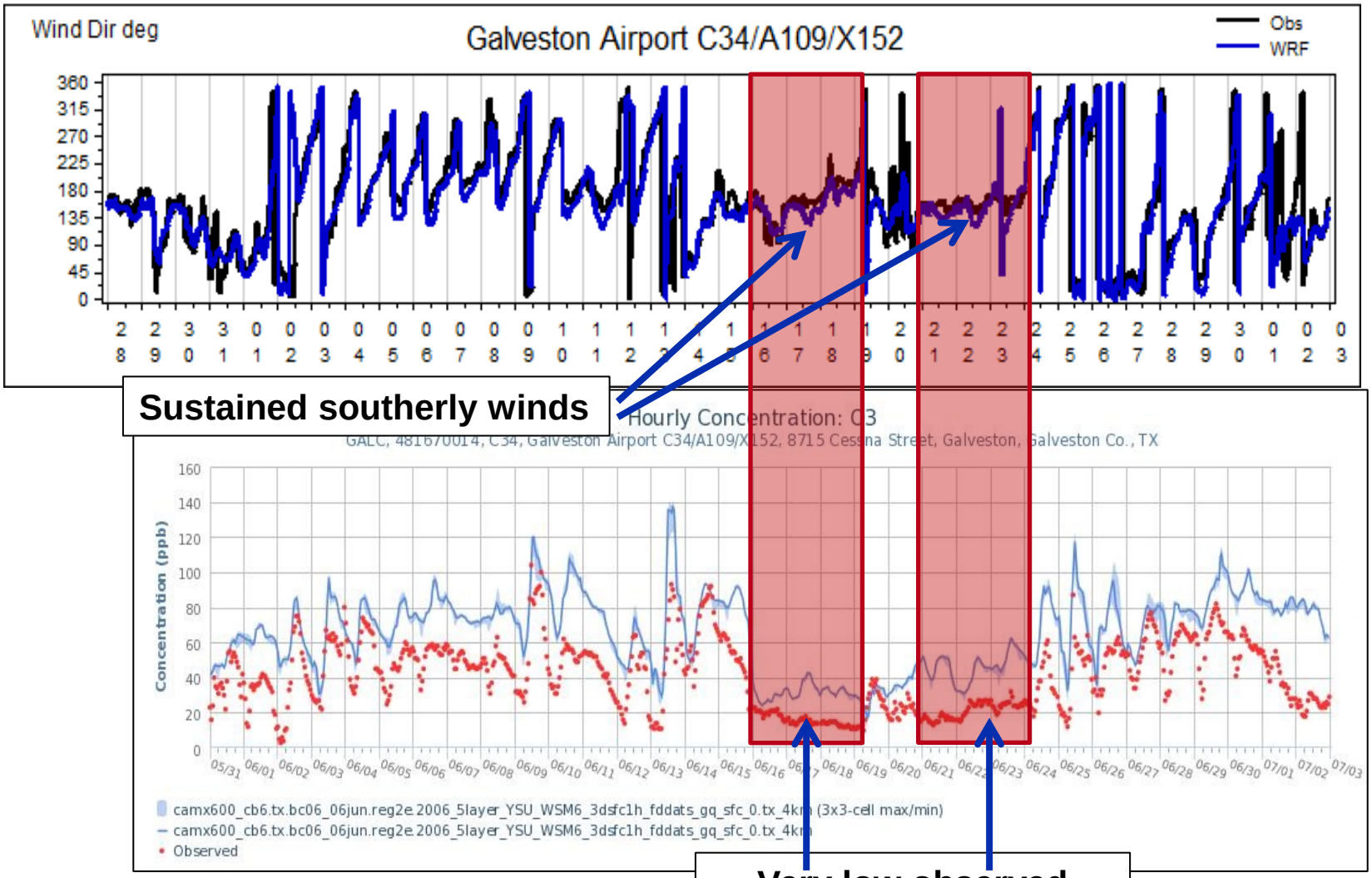


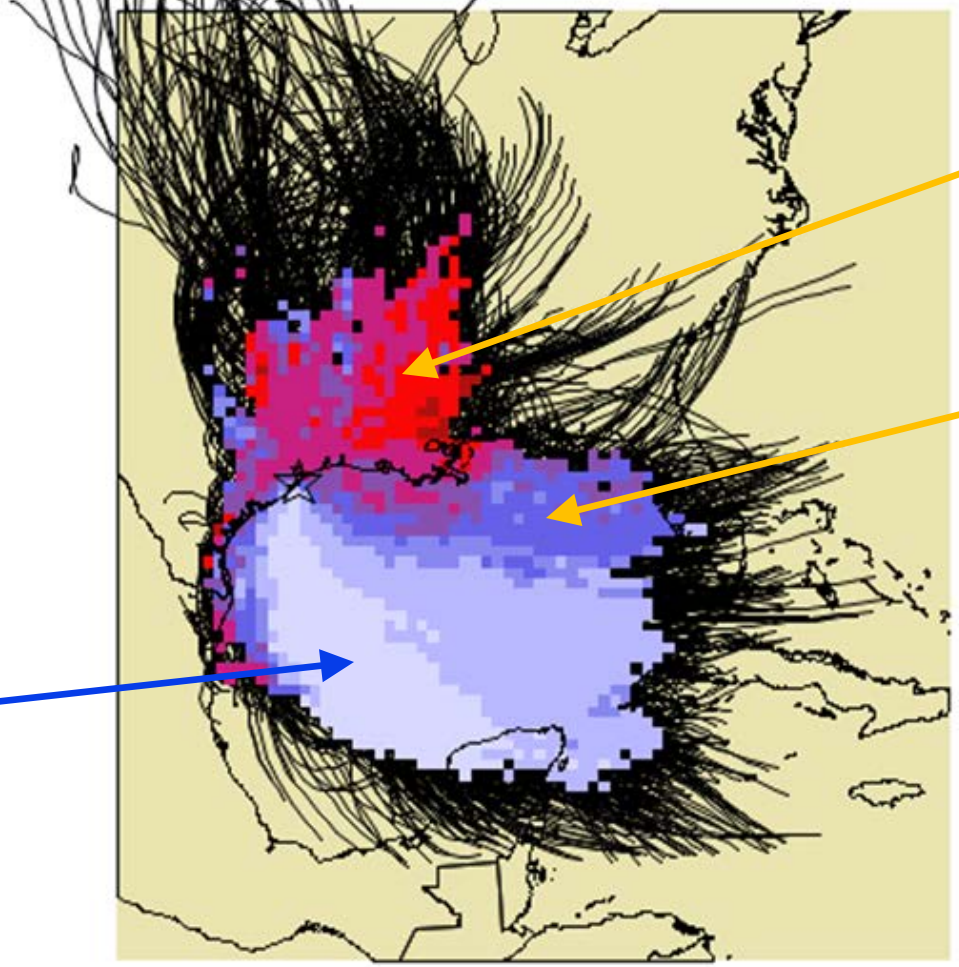
Observed and Modeled Galveston Ozone



All Trajectories Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 30 Values per Grid Cell



Highest concentrations linked to continental flow

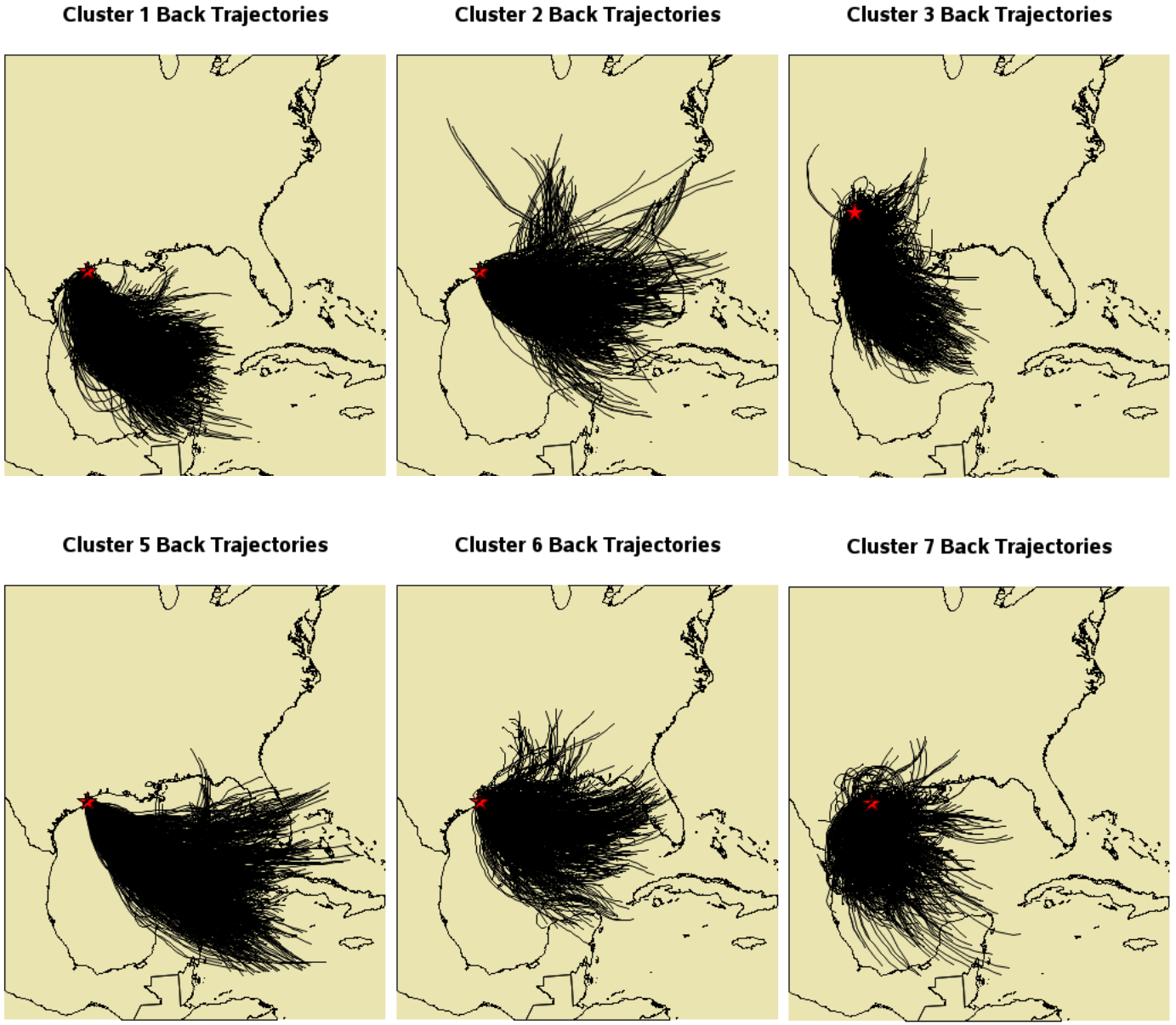
Intermediate concentrations linked to coastal flow

Lowest concentrations linked to Gulf of Mexico flow

Ozone (PPB)

<15 15-20 20-25 25-30 30-35 35-40 40-50 50-60 60-70 >70

Seven clusters of 3-D Galveston back trajectories produced by SAS FASCLUS procedure.



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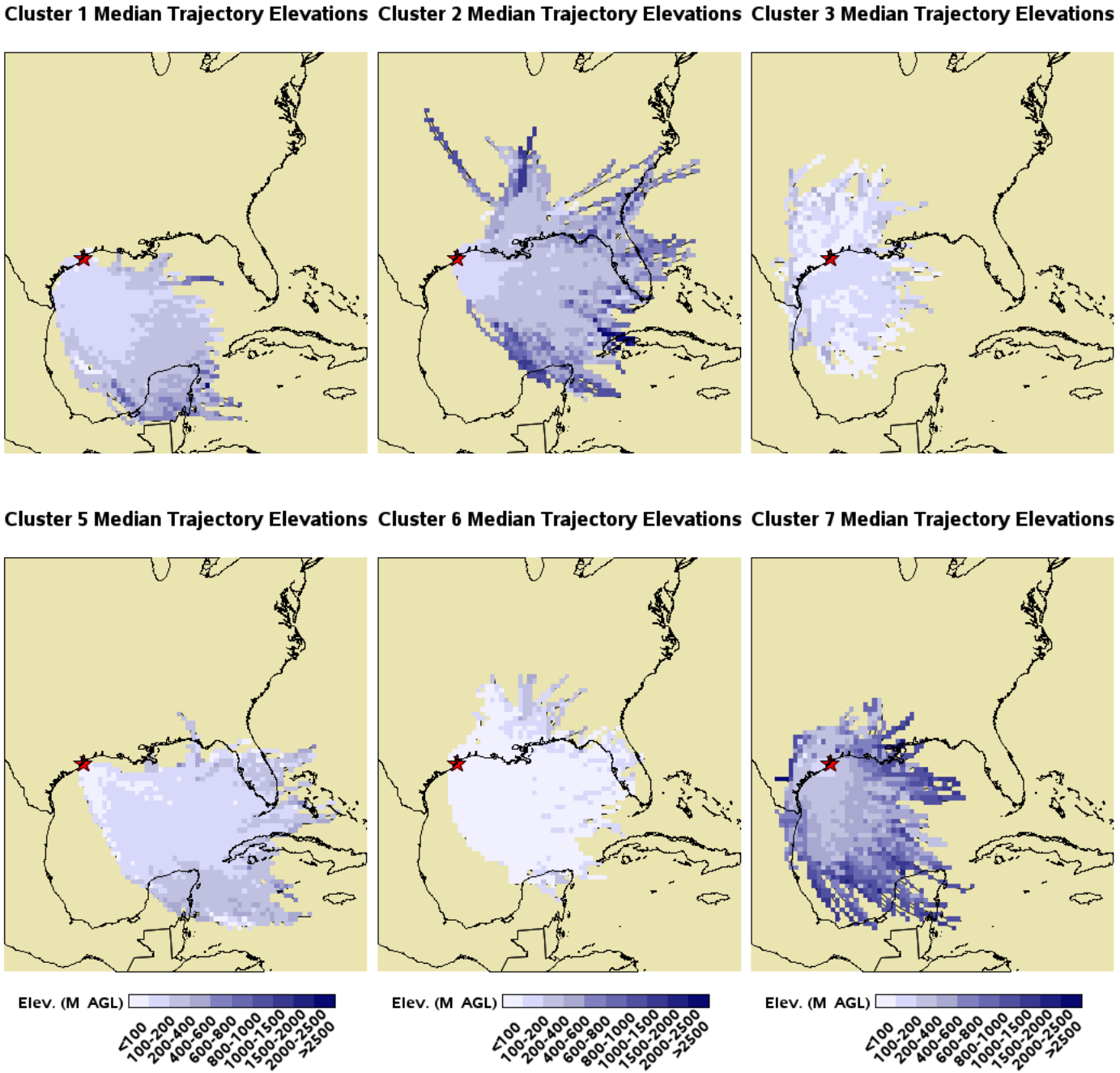
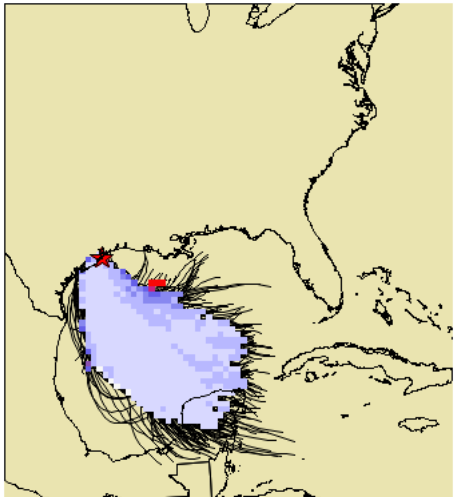
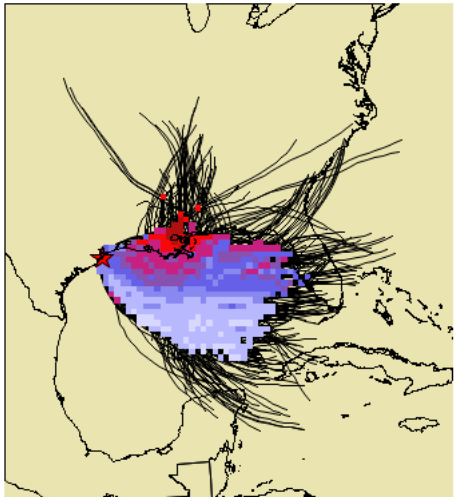


Seven clusters of 3-D Galveston back trajectories produced by SAS FASCLUS procedure.

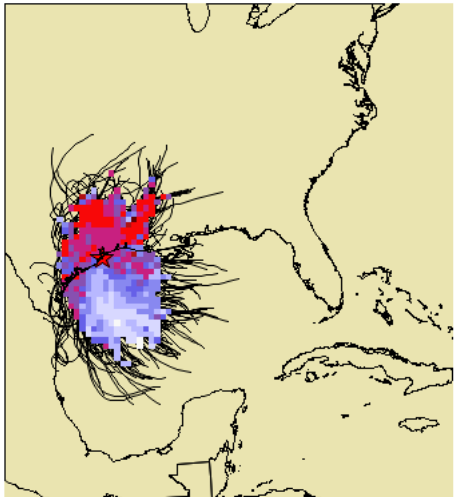
Cluster 1 Median Terminal Ozone Concentrations
Min 15 Values per Cell



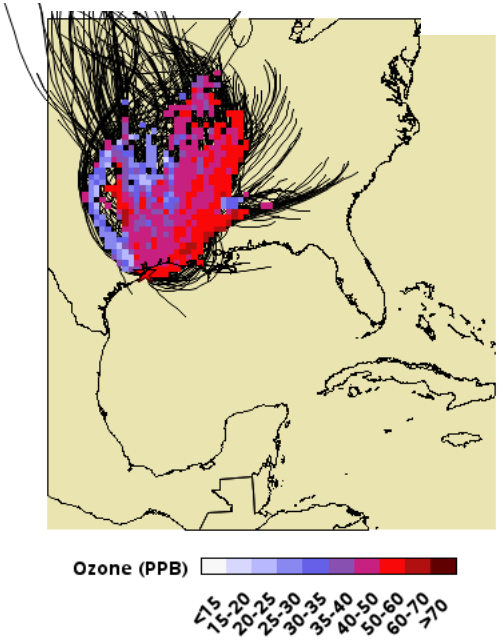
Cluster 2 Median Terminal Ozone Concentrations
Min 15 Values per Cell



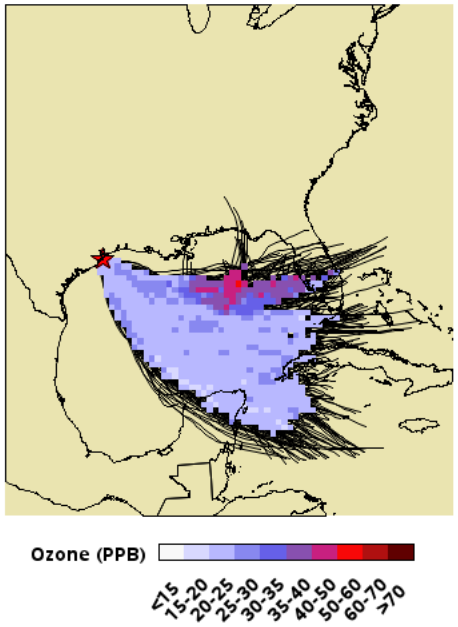
Cluster 3 Median Terminal Ozone Concentrations
Min 15 Values per Cell



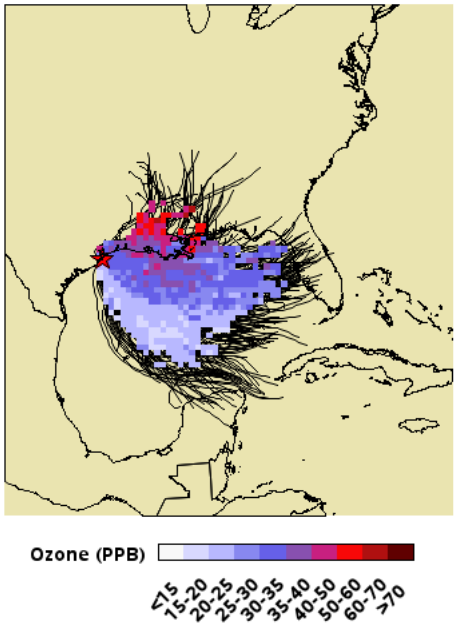
Cluster 4 Median Terminal Ozone Concentrations
Min 15 Values per Cell



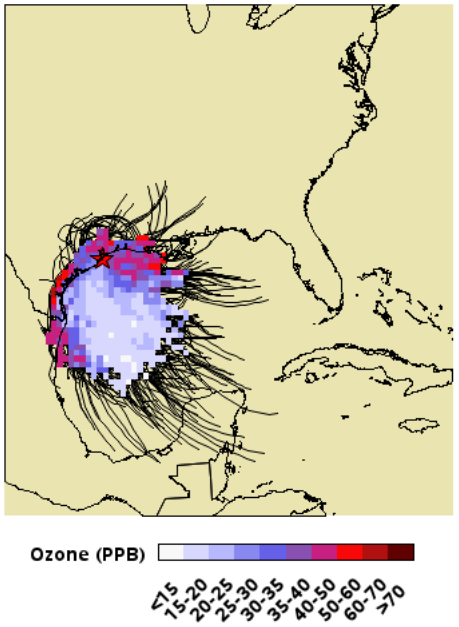
Cluster 5 Median Terminal Ozone Concentrations
Min 15 Values per Cell



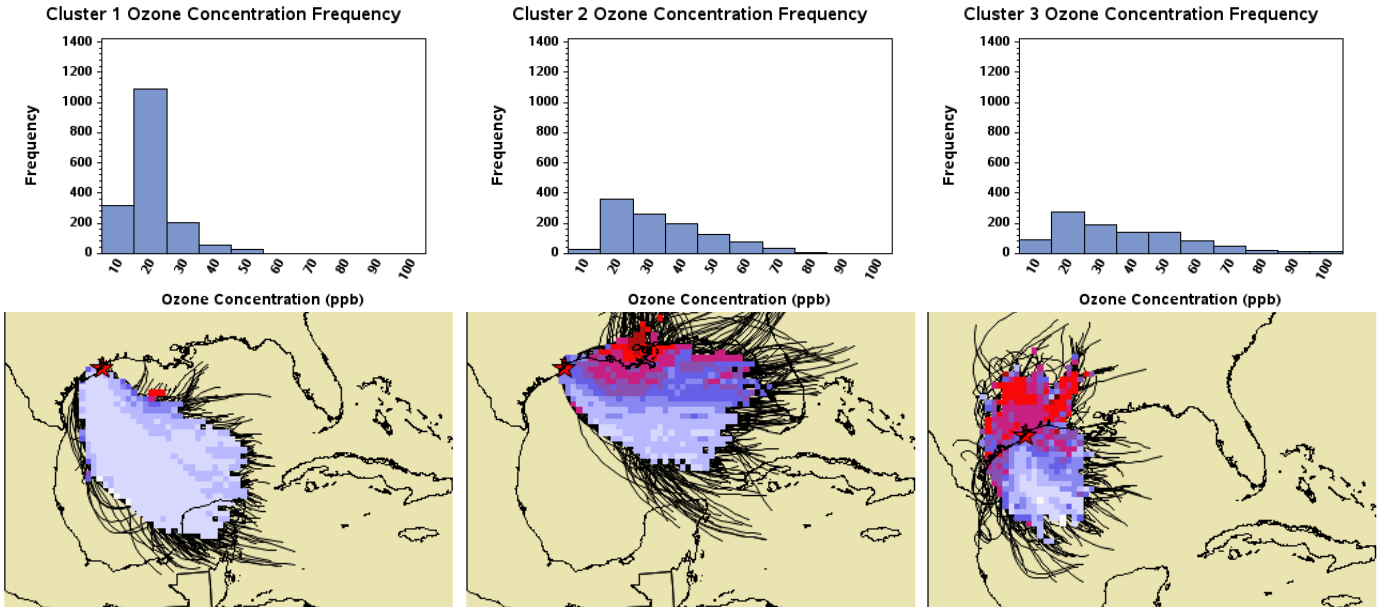
Cluster 6 Median Terminal Ozone Concentrations
Min 15 Values per Cell



Cluster 7 Median Terminal Ozone Concentrations
Min 15 Values per Cell

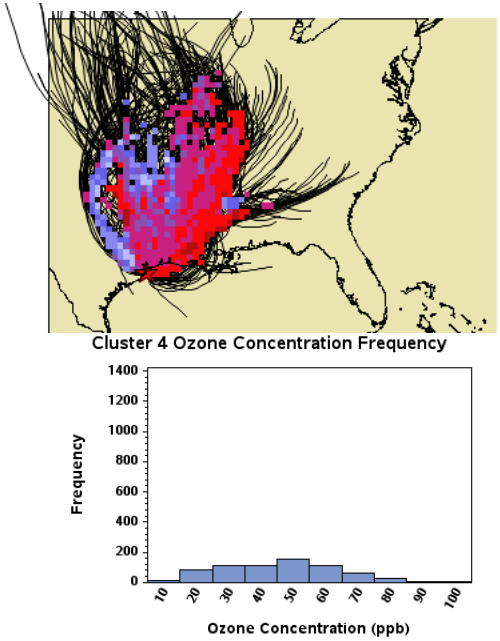


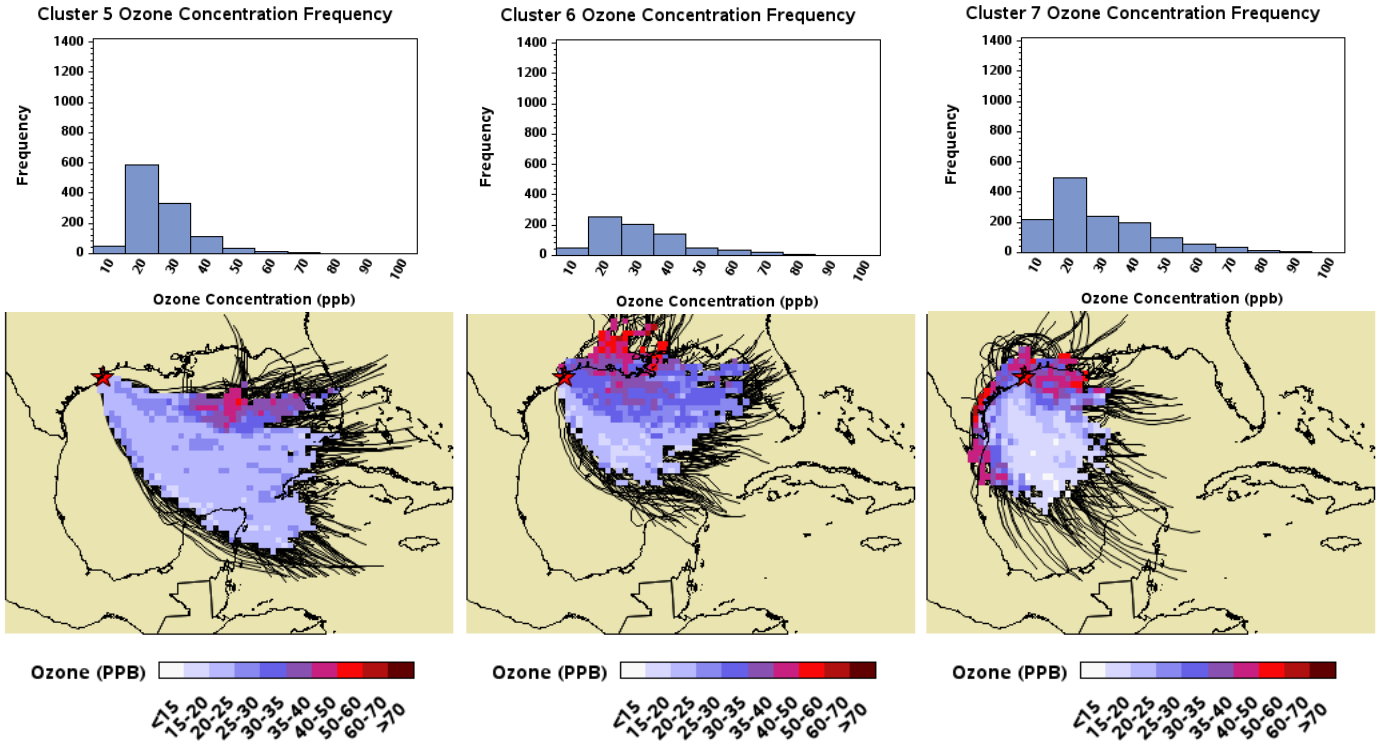
Median observed ozone concentrations at Galveston associated with clusters.



Cluster 4 Median Terminal Ozone Concentrations

Min 15 Values per Cell





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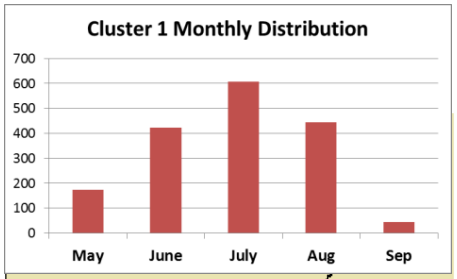
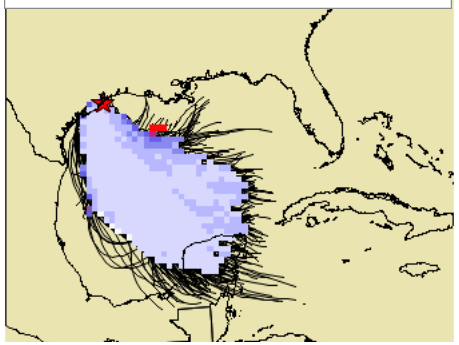
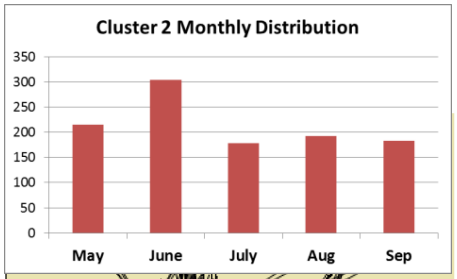
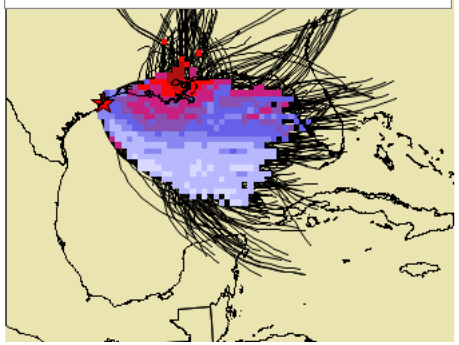
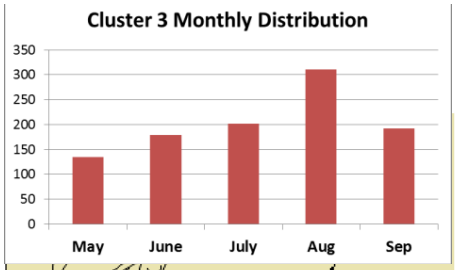
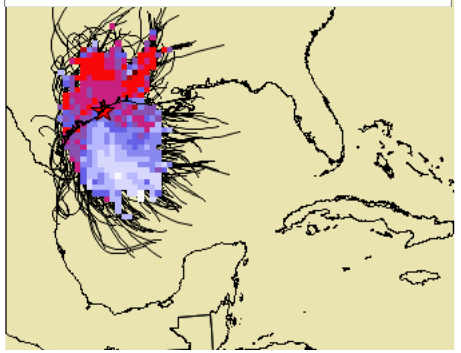






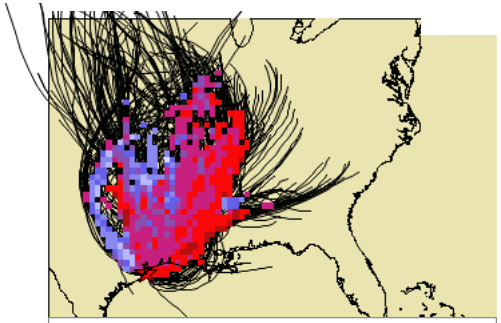


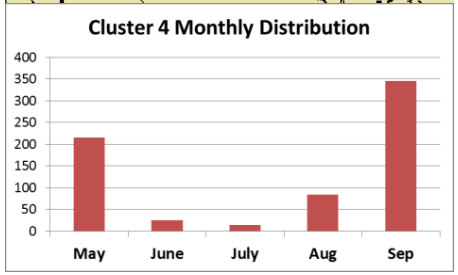


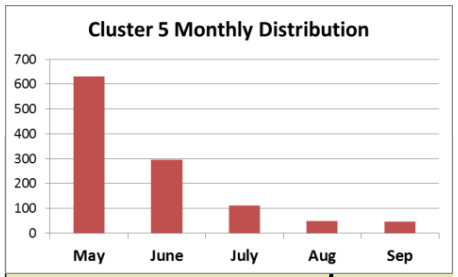


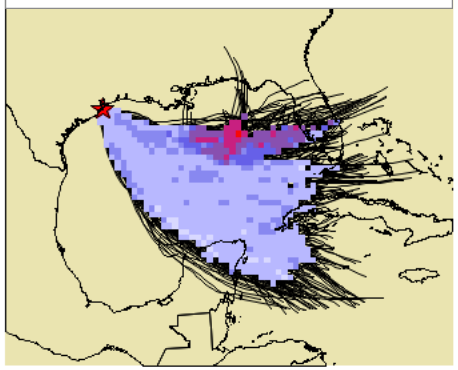
Cluster 4 Median Terminal Ozone Concentrations

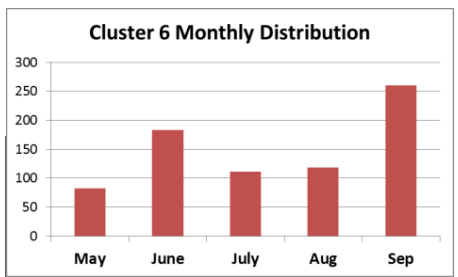
Min 15 Values per Cell

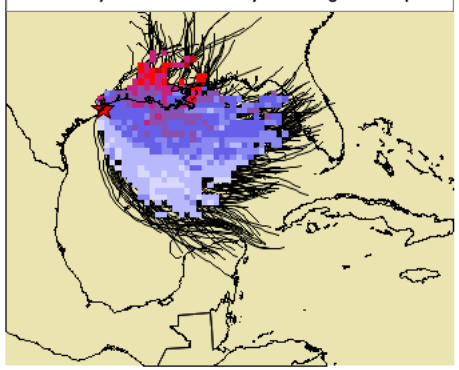


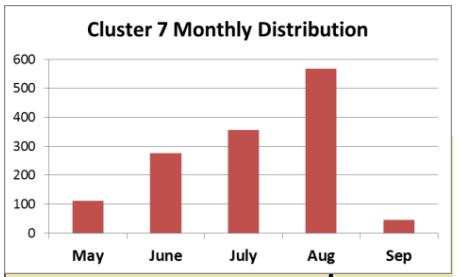


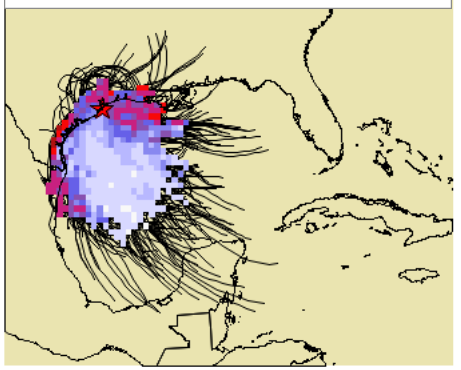


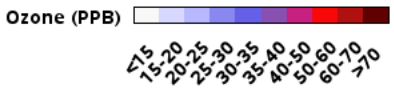


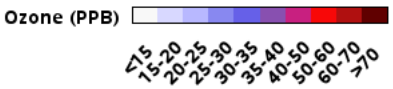


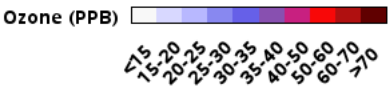




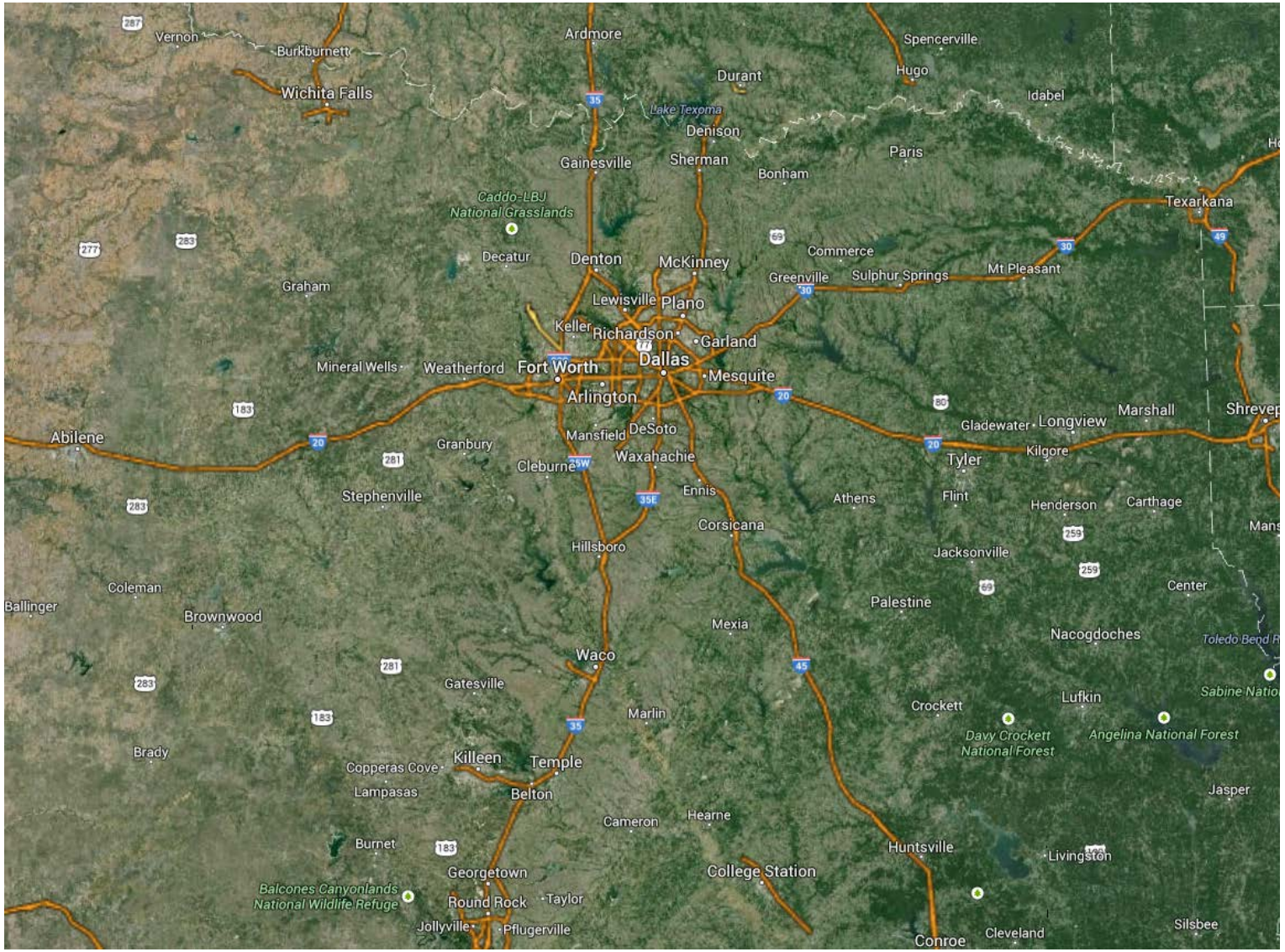




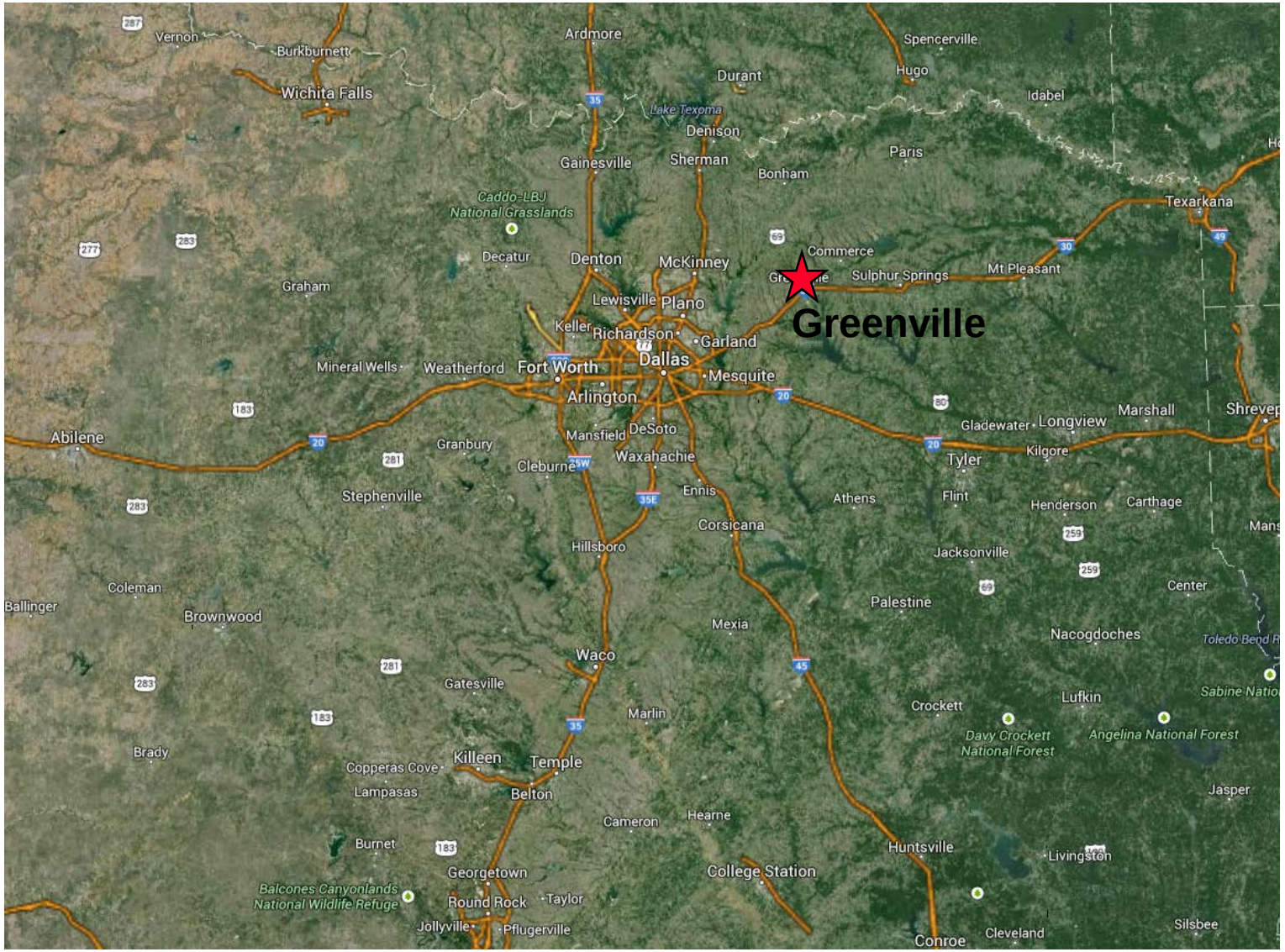




How about Dallas-Fort Worth?

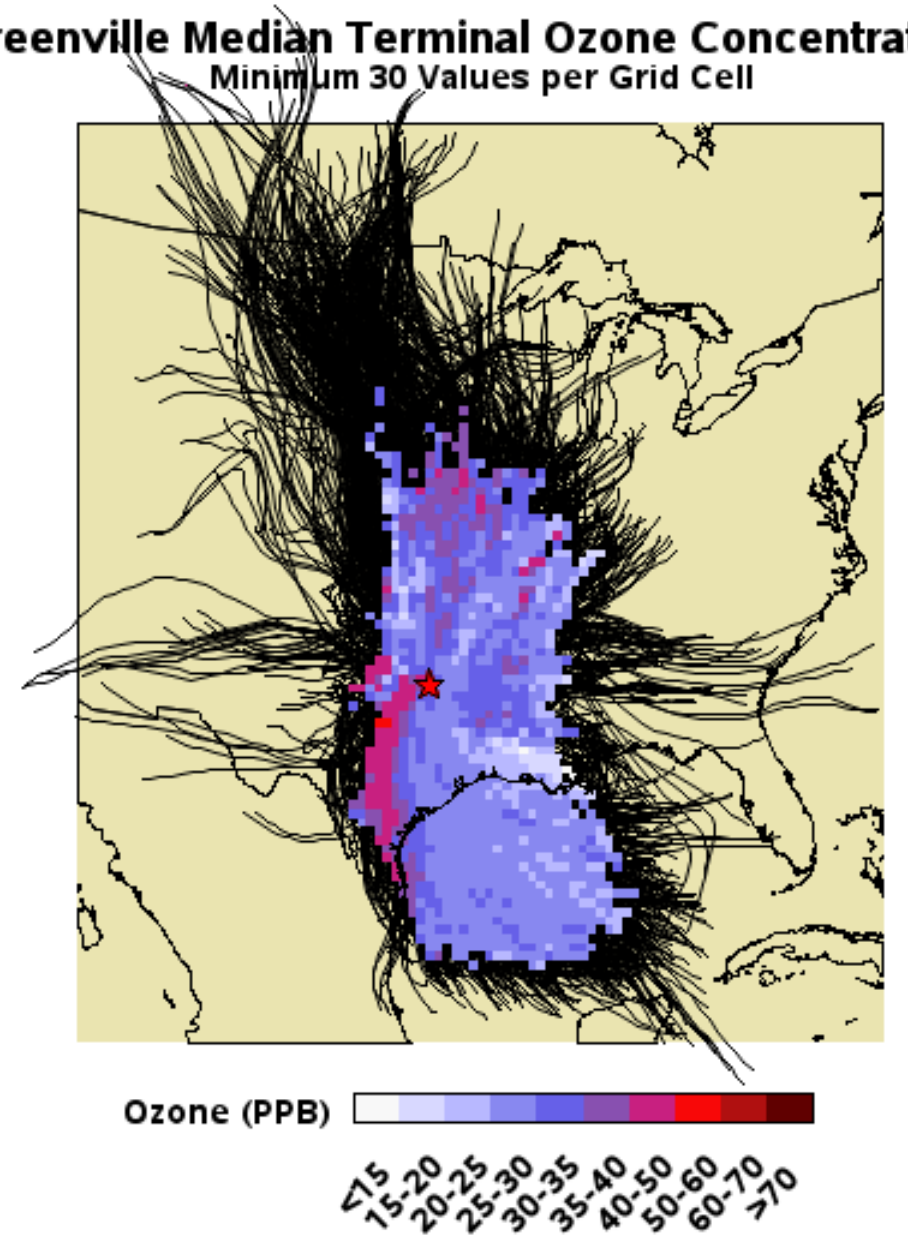


How about Dallas-Fort Worth?



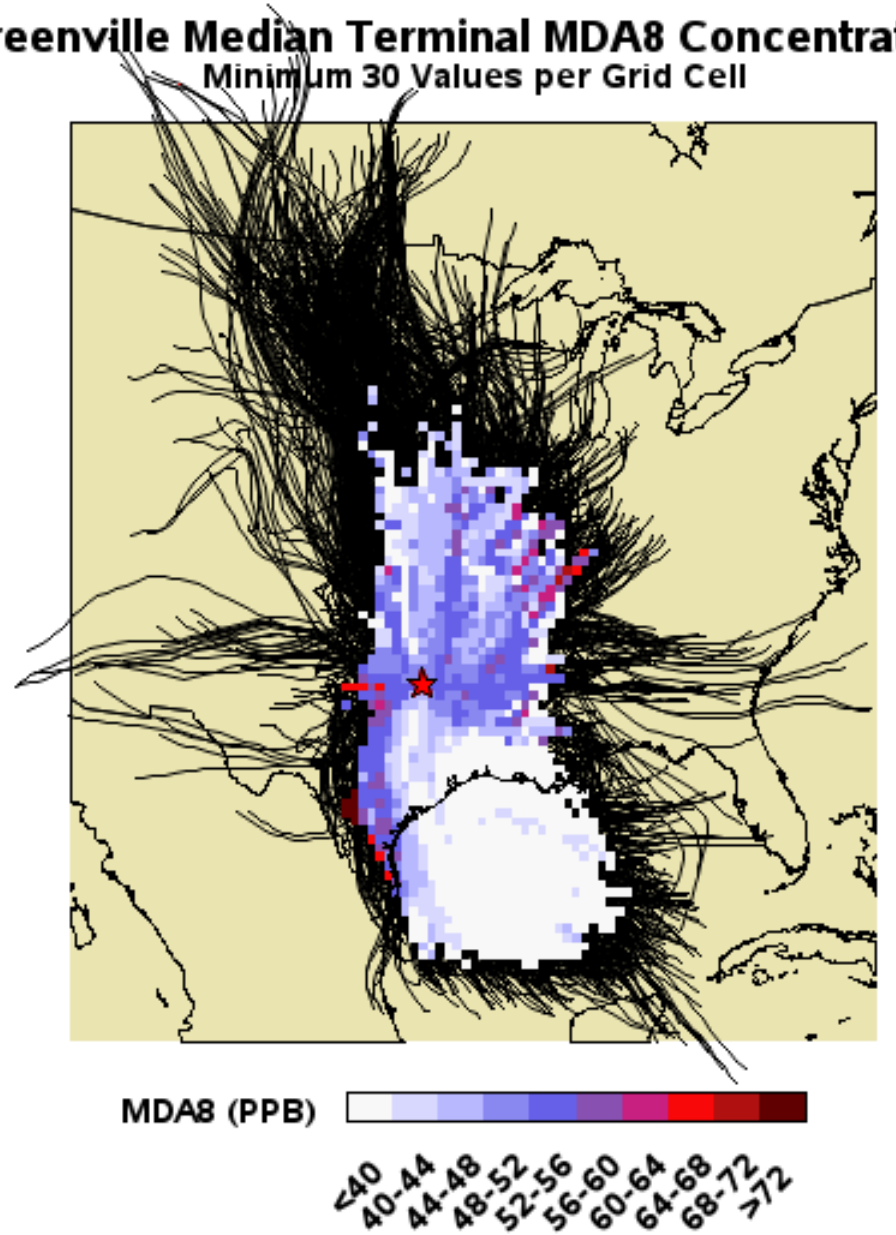
Greenville Median Terminal Ozone Concentrations

Minimum 30 Values per Grid Cell



Greenville Median Terminal MDA8 Concentrations

Minimum 30 Values per Grid Cell



Conclusions

- **Regional background ozone concentration trends are flat or decreasing in HGB**. The increase observed on the US west coast due to Asian emissions is not apparent in Houston.
- **In Houston, background ozone varies strongly with transport pattern**. In Houston, background ozone trends vary with transport direction, with flow from the Gulf of Mexico having zero trend, and flow from continental US having a downward trend (Berlin et al. 2013).
- Peak daily 8-hour ozone concentrations in Houston is positively correlated with regional background ozone.
- In Houston, background and local ozone vary with season; highest total ozone tends to occur when both peak.
- **Analyses imply that much of the seasonal ozone variation is contributed by large-scale spatial and temporal patterns.**

Future needs

- This analysis focuses upon *averages, not case studies or exceptional events*. Studies of days with high regional background ozone and/or high local ozone production would be useful.
- Quantifying sources of regional background ozone: within Texas, within US, outside US, natural and anthropogenic. Quantifying the effects of changes in precursor emissions. Quantifying the effects of different meteorological patterns.
- Improved modeling of regional background ozone, both over ocean and over land—in general, models are overpredicting background ozone.

Contact information

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- Jim.Smith@tceq.texas.gov
  - (512) 239-1941

Background Ozone References

- Berlin, S., A. Langford, M. Estes, M. Dong, and D. Parrish (2013), Magnitude, decadal changes and impact of regional background ozone transported into the greater Houston, Texas area, *Environ. Sci. Technol.*, 2013, *47* (24), pp 13985–13992, DOI**:** 10.1021/es4037644
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