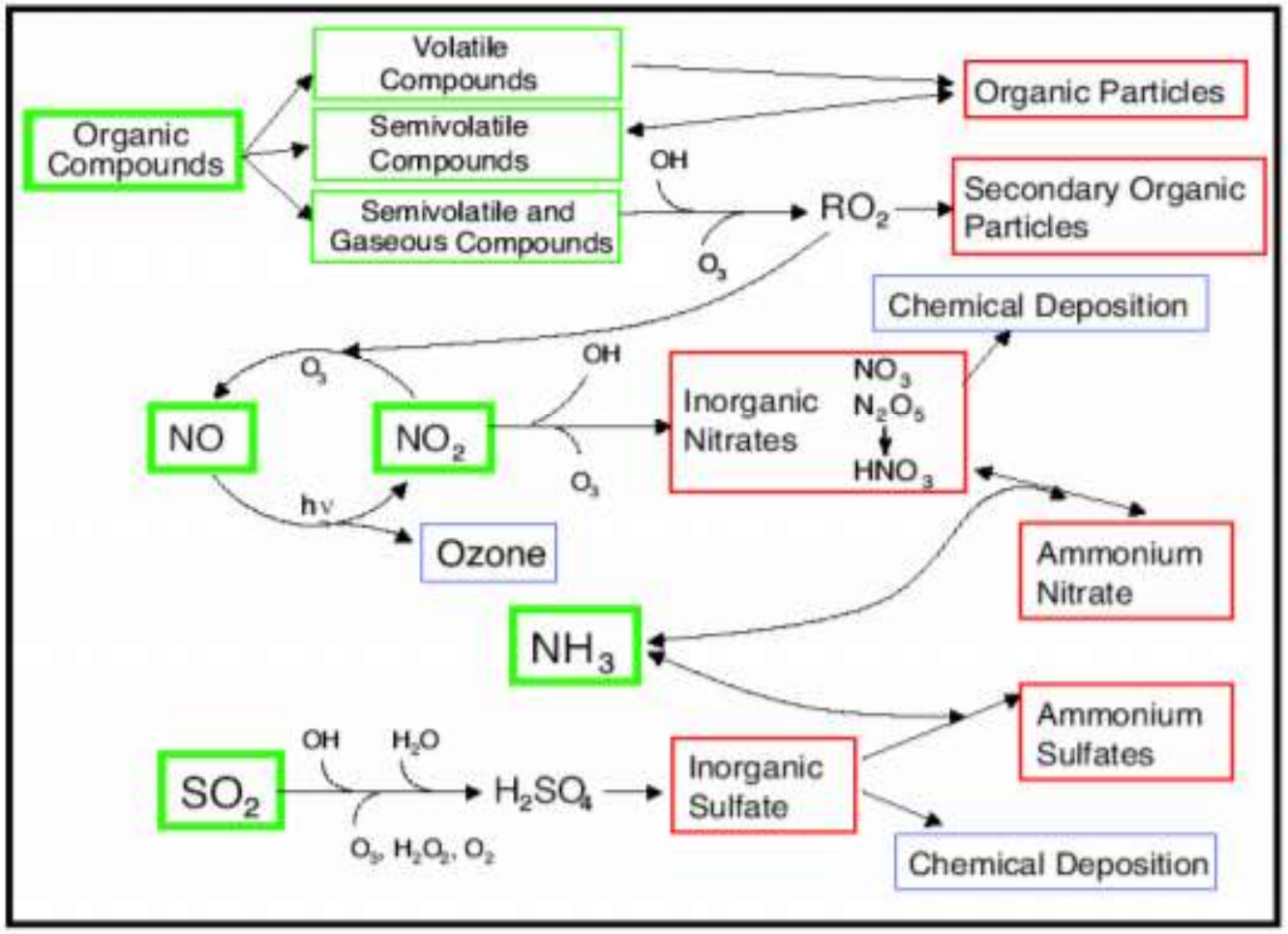
Introduction

- Ozone – Secondary pollutant is formed by a series of photochemical reactions under favorable meteorological conditions involving precursors, viz., oxides of nitrogen (NOx) and volatile organic compounds (VOC).
- Exposure to high levels of ozone induces a variety of human health problems including respiratory problems, cough, nasal discharge, headache, dizziness, sore throat, asthma, allergy problems and susceptibility to lung cancer.
- The federally mandated National Ambient Air Quality Standards (NAAQS) for ozone are as follows (EPA, 2008) –
  - 8-hour averaged values (three year average of the fourth highest levels) not to exceed 0.070 ppm

Introduction



Source: "Evaluating the Contribution of $PM_{2.5}$ Precursor Gases and Re-entrained Road Emissions to Mobile Source $PM_{2.5}$ Particulate Matter Emissions"

Study area

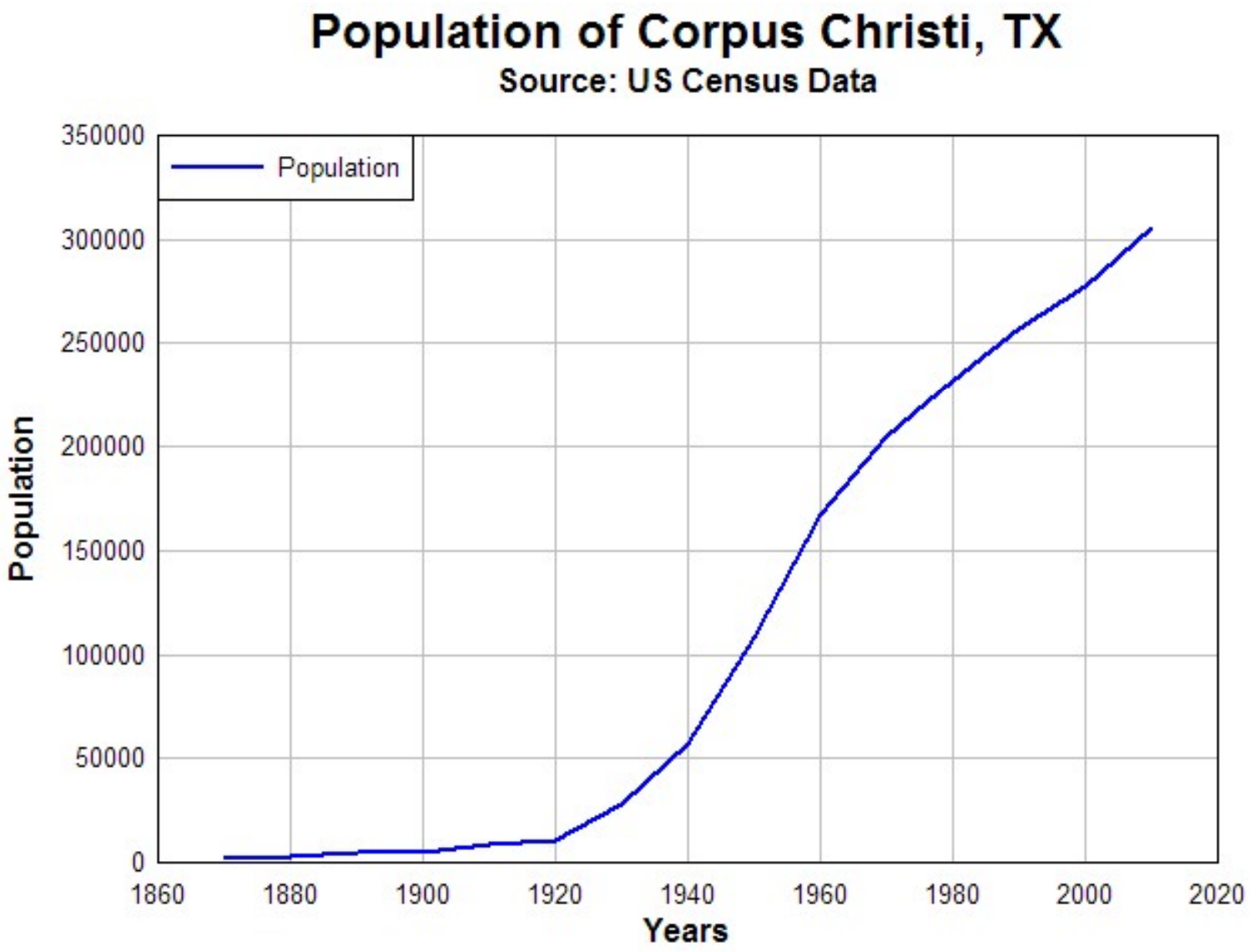
Corpus Christi metropolitan statistical area

- Three and half counties (Nueces, San Patricio, Aransas Pass and part of Kleberg)
- Eighth most populous city in Texas
- Humid subtropical climate
- Fifth largest port in the U.S. and deepest inshore port on the Gulf of Mexico
- Consortium of petrochemical refineries along the ship channel
- United States military: the Corpus Christi Army Depot and Naval Air Station
- International airport and county airports (3)

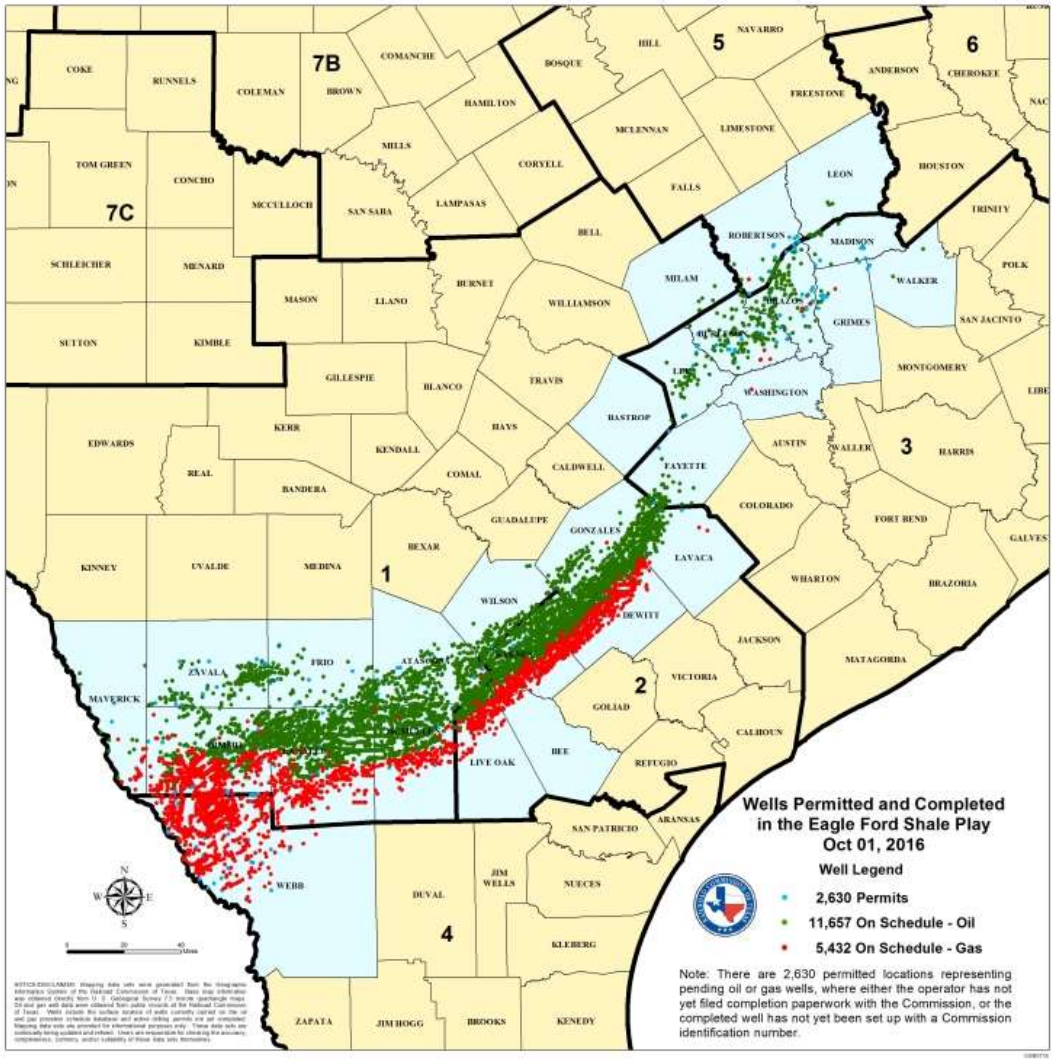
Study area


Dallas
El Paso
Texas
Austin
Houston
San Antonio
Corpus Christi
Brownsville

Background and Justification



Background and Justification



Objectives

- Exploratory and statistical analysis of ozone concentrations and prevailing meteorological conditions measured at compliance and research grade monitoring stations.
- Identification and characterization of ozone episodes.
- Meteorological characterization of the identified ozone episodes.
- Temporal trend analysis of $PM_{2.5}$ and identification and characterization of $PM_{2.5}$ episodes.
- Source apportionment of $PM_{2.5}$ filter mass concentrations.
- Statistical analysis of ozone and $PM_{2.5}$ episodes and identification of common regional sources contributing to long range transport.

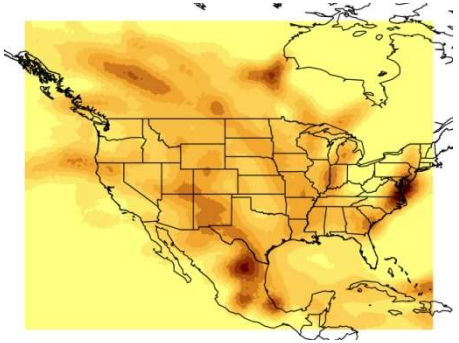
Methodology

- Trajectory and Cluster analysis
  - National Oceanic and Atmospheric Administration (NOAA) - Hybrid Single Particle Lagrangian Integrated Trajectory model – HYSPLIT (Draxler and Hess, 1997)
  - Three day backward trajectories; start height – 500m; global reanalysis data.
  - Cluster analysis using euclidean distance.

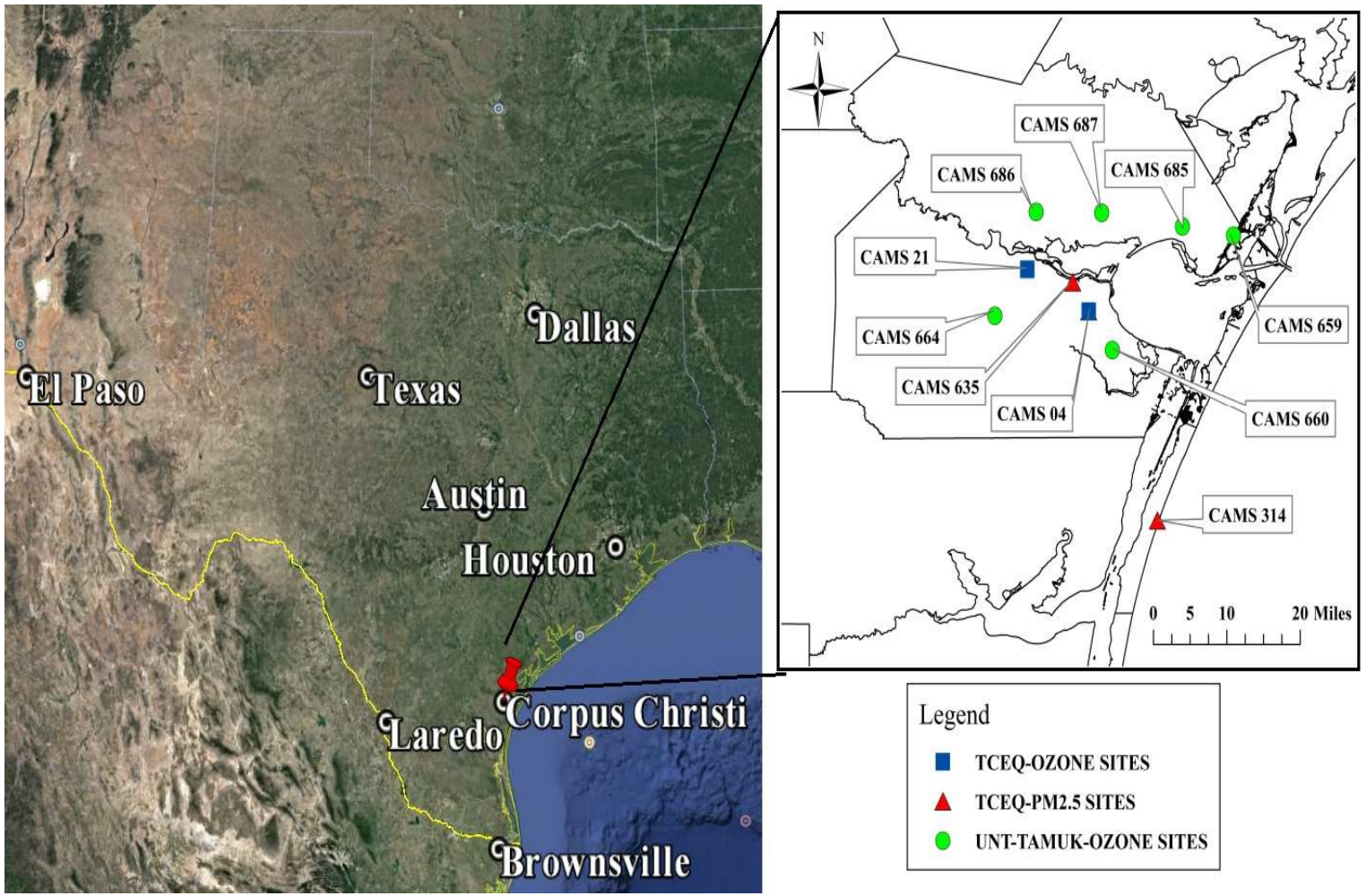
Potential Source Contribution Function (PSCF) analysis: PSCF*ij* is the conditional probability that an air parcel that passed through the *ij*th cell has a high concentration upon arrival at the monitoring site.

$$PSCF_{ij} = \frac{m_{ij}}{n_{ij}}$$

where m_{ij} is the number of trajectories passing through the cell that are associated with a "high concentration" of $PM_{2.5}$ from that source observed at the receptor site, and n_{ij} is the total number of trajectories end points arriving at the cell.

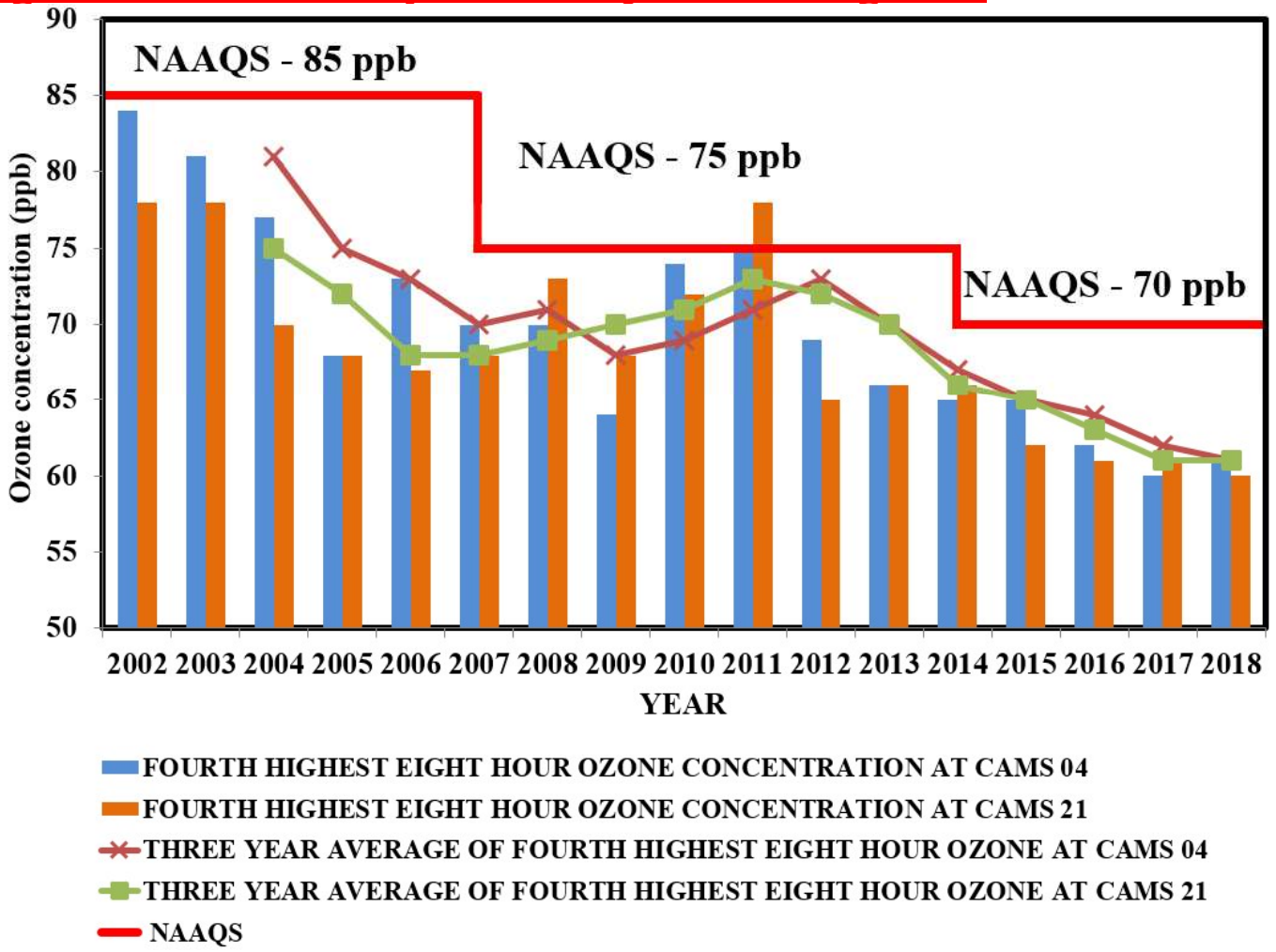


Ambient Monitoring



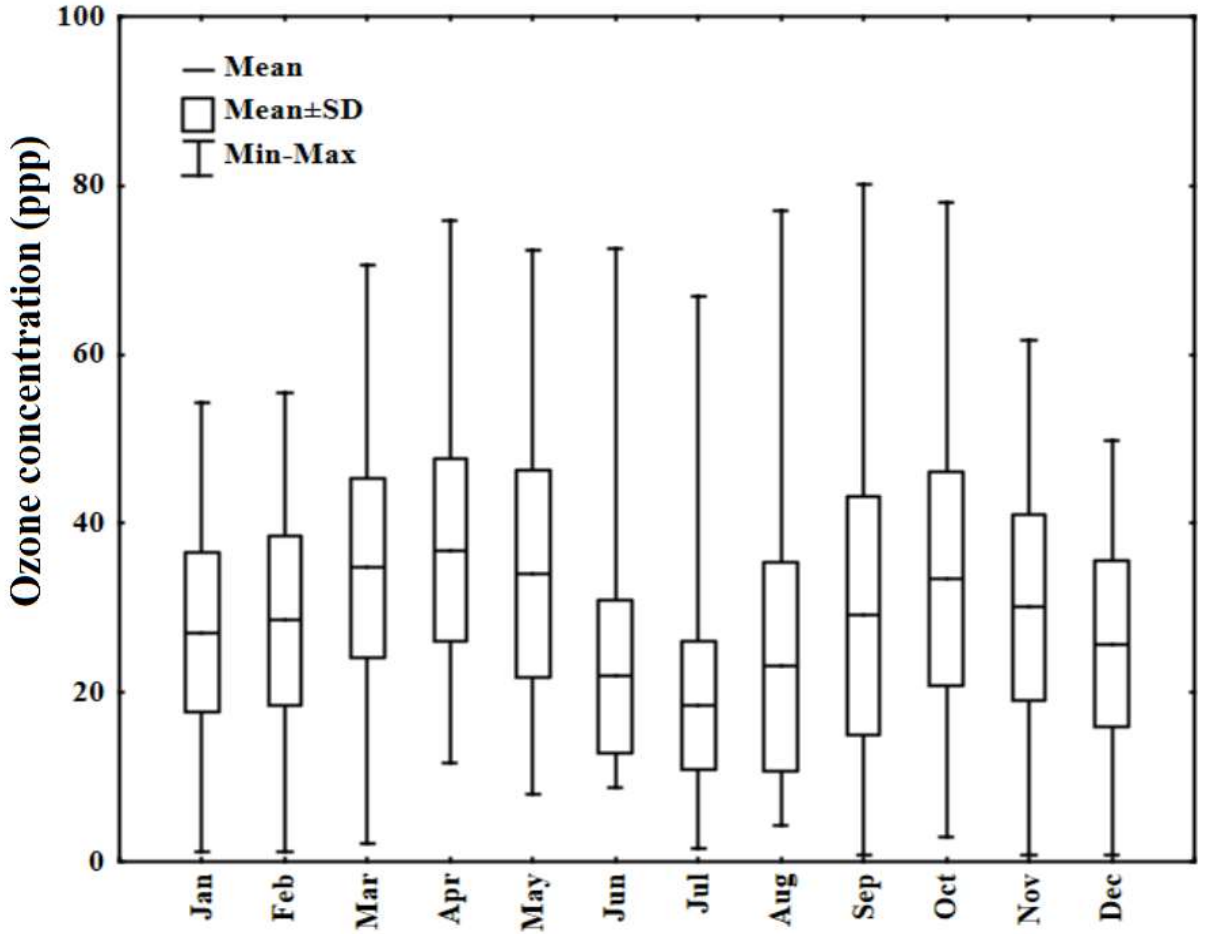
Results and Discussion

Design value trend analysis – TCEQ monitoring sites



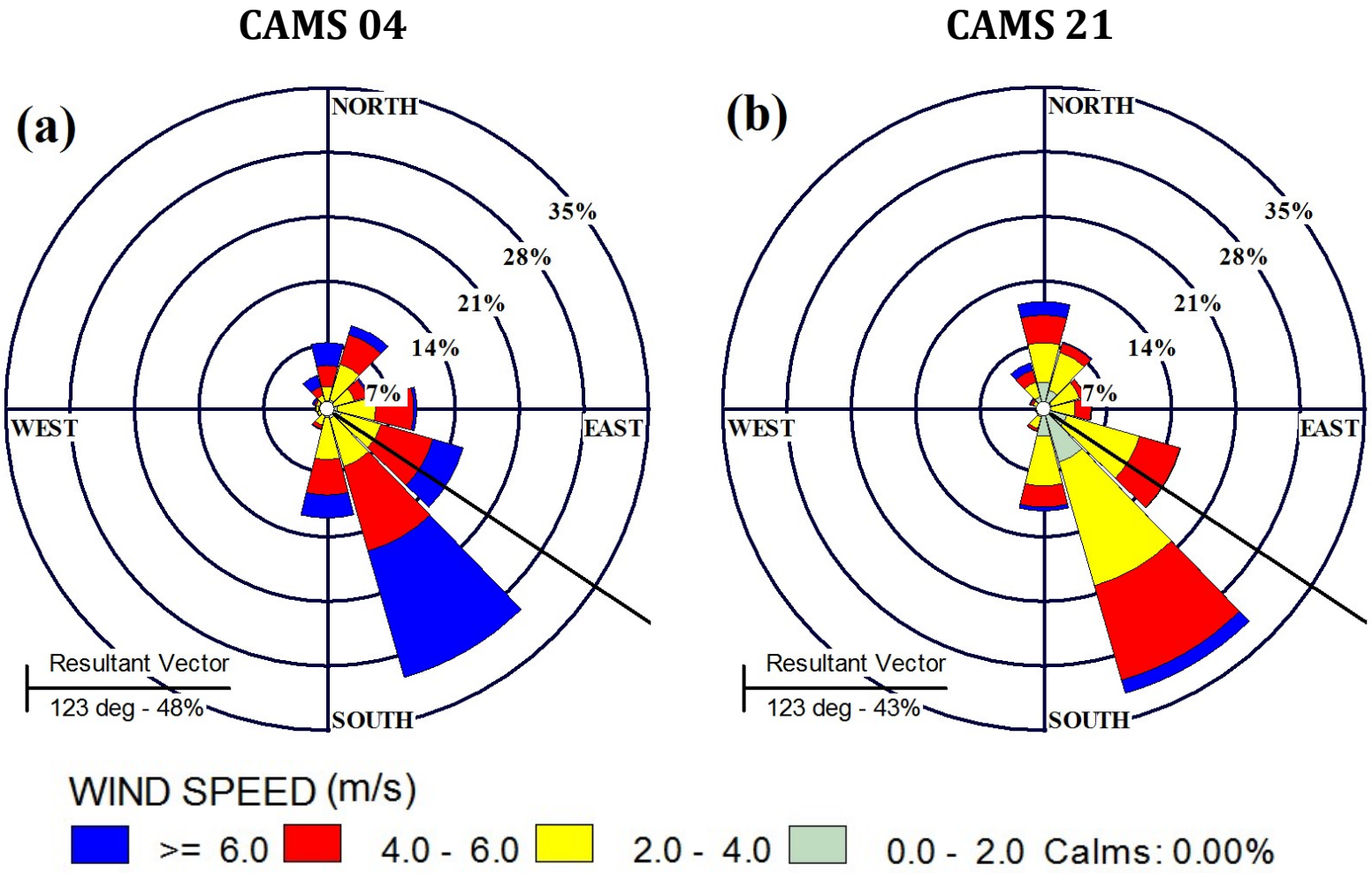
Results and Discussion

Seasonal trend - Eight hour ozone concentration



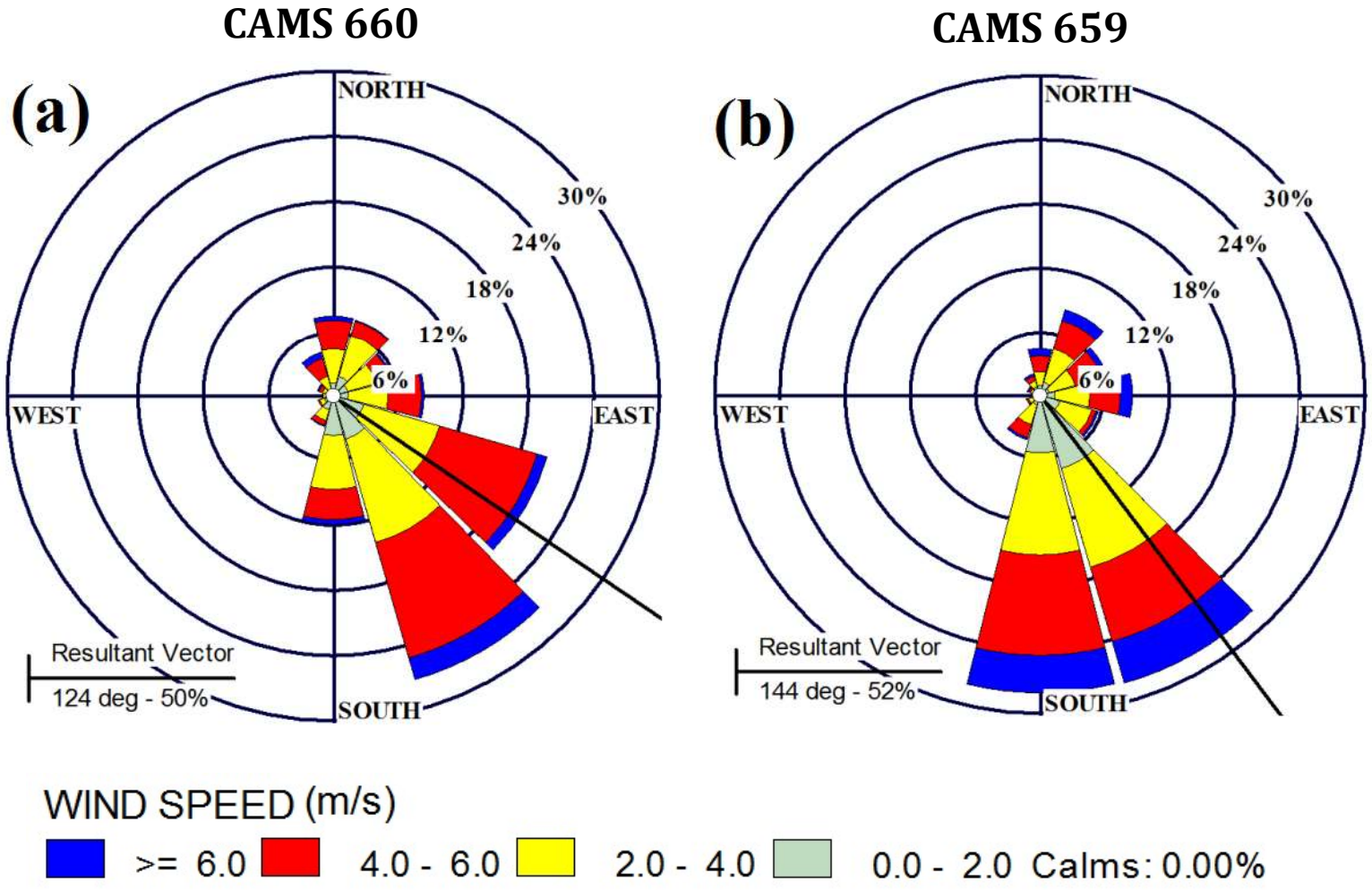
Results and Discussion

Overall meteorological conditions (2010 – 2014)



Results and Discussion

Overall meteorological conditions (2010 – 2014)



Results and Discussion

Shapiro-Wilks test - Daily maximum eight hour ozone concentrations

Spearman's correlation coefficient (2010 – 2014)

Variables	CAMS 04	CAMS 21	CAMS 660	CAMS 664	CAMS 659	CAMS 685	CAMS 686	CAMS 687
CAMS 04	1.00							
CAMS 21	0.97	1.00						
CAMS 660	0.97	0.96	1.00					
CAMS 664	0.91	0.94	0.91	1.00				
CAMS 659	0.96	0.94	0.96	0.89	1.00			
CAMS 685	0.94	0.94	0.94	0.88	0.96	1.00		
CAMS 686	0.95	0.97	0.93	0.91	0.94	0.95	1.00	
CAMS 687	0.87	0.88	0.85	0.81	0.86	0.85	0.87	1.00

Results and Discussion

Spearman's correlation coefficient

JUNE

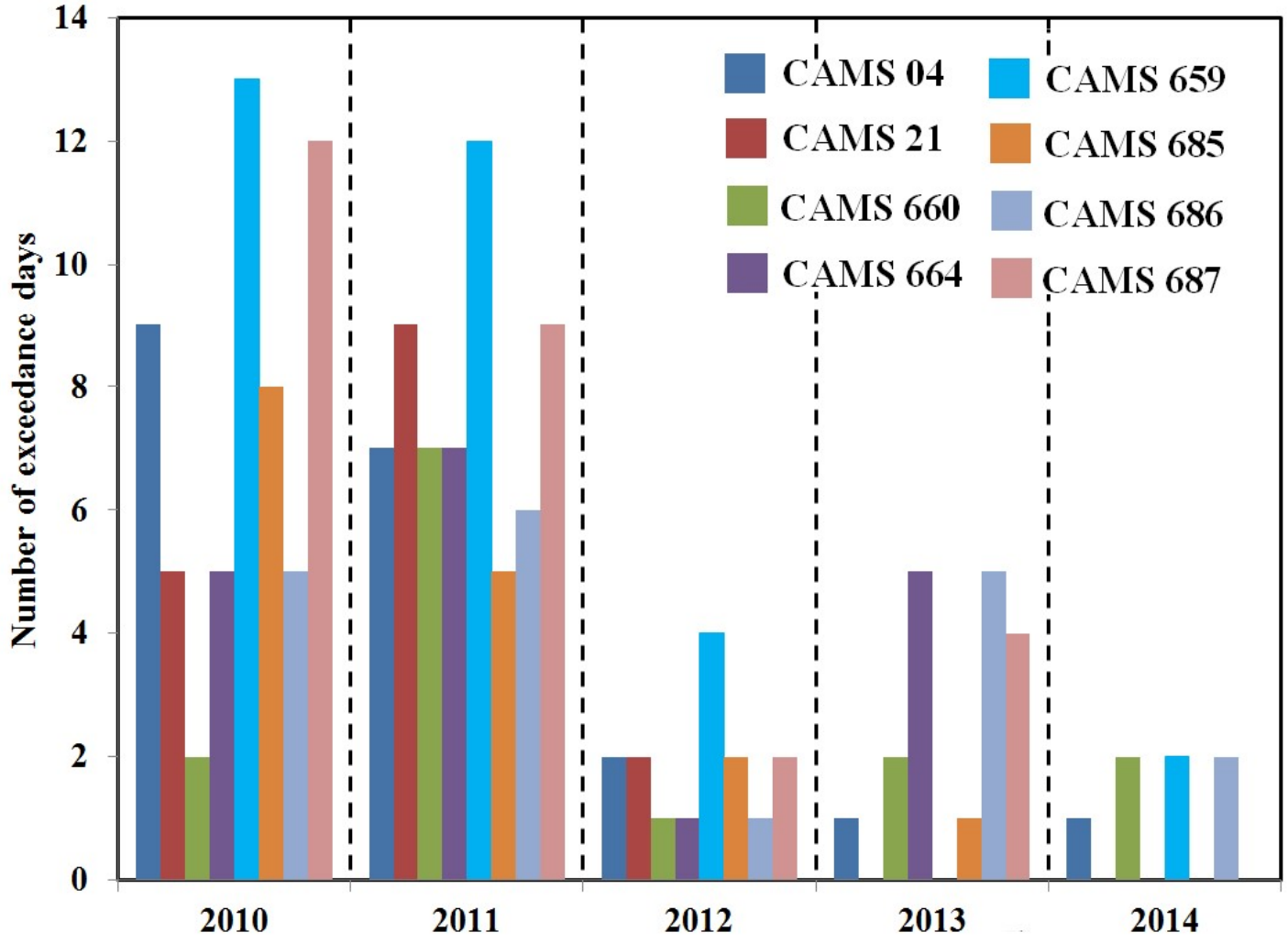
Variables	CAMS 04	CAMS 21	CAMS 660	CAMS 664	CAMS 659	CAMS 685	CAMS 686	CAMS 687
CAMS 04	1.00							
CAMS 21	0.95	1.00						
CAMS 660	0.73	0.73	1.00					
CAMS 664	0.89	0.90	0.63	1.00				
CAMS 659	0.90	0.85	**0.58**	0.82	1.00			
CAMS 685	0.92	0.91	0.75	0.78	0.91	1.00		
CAMS 686	0.85	0.87	**0.58**	0.77	0.77	0.84	1.00	
CAMS 687	0.88	0.85	**0.55**	0.86	0.89	0.84	0.74	1.00

JULY

Variables	CAMS 04	CAMS 21	CAMS 660	CAMS 664	CAMS 659	CAMS 685	CAMS 686	CAMS 687
CAMS 04	1.00							
CAMS 21	0.80	1.00						
CAMS 660	0.84	0.68	1.00					
CAMS 664	0.64	0.74	0.69	1.00				
CAMS 659	0.79	0.62	0.68	**0.51**	1.00			
CAMS 685	0.78	0.68	0.68	**0.41**	0.78	1.00		
CAMS 686	0.78	0.83	0.68	0.64	0.72	0.80	1.00	
CAMS 687	0.60	0.67	**0.51**	**0.55**	0.65	0.72	0.84	1.00

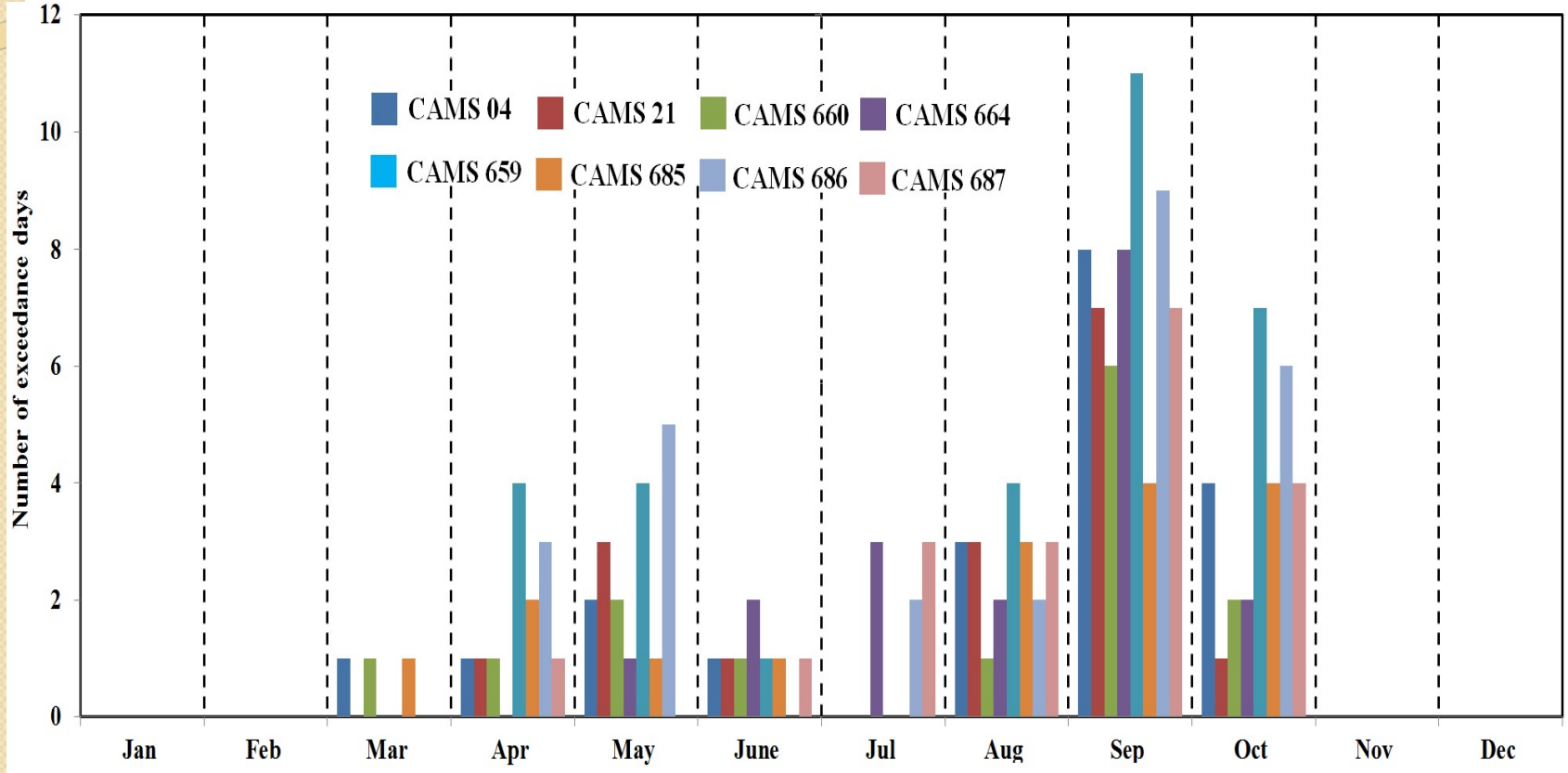
Results and Discussion

Annual trend of ozone exceedance days



Results and Discussion

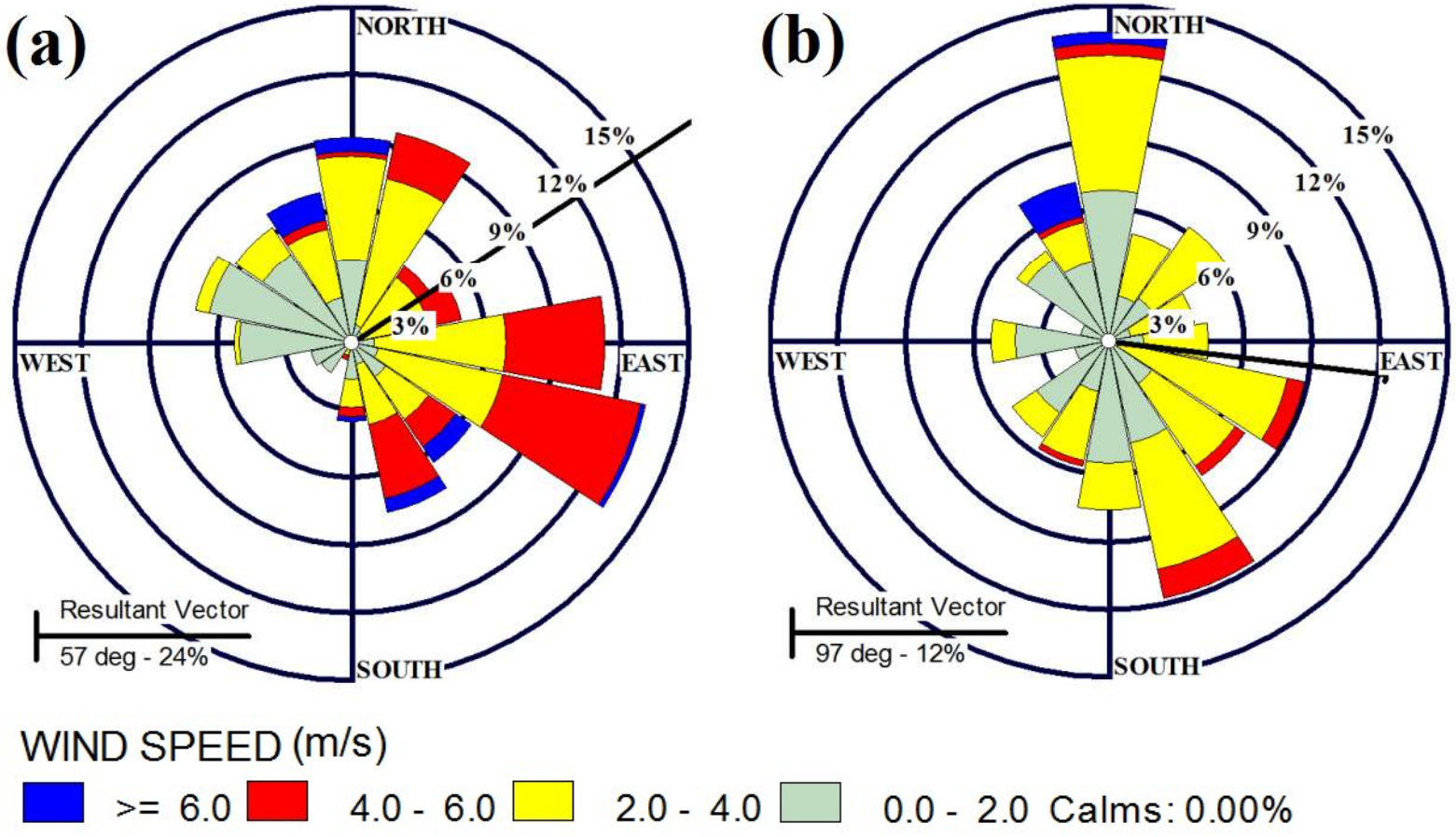
Seasonal trend of ozone exceedance days



Results and Discussion

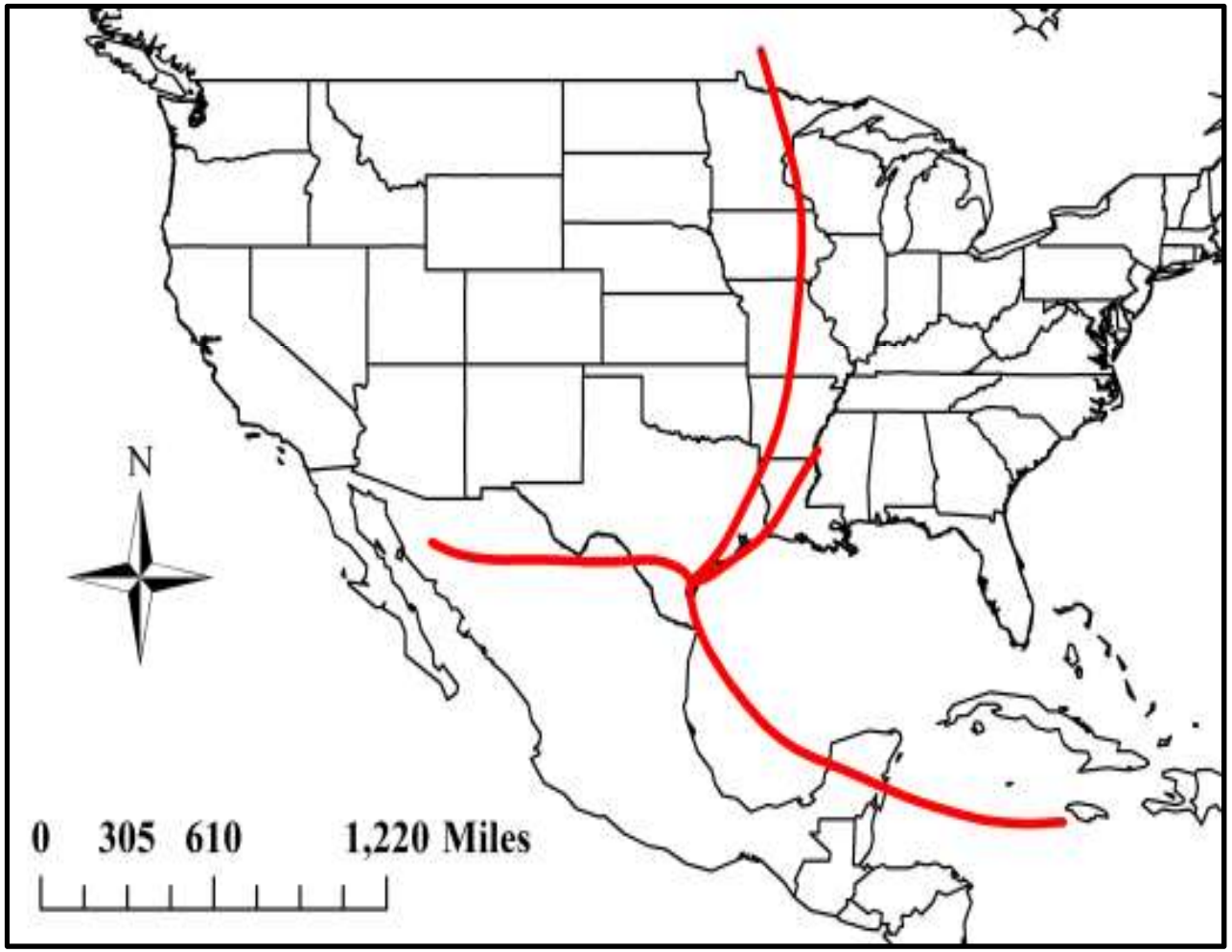
Meteorological conditions during high ozone days

CAMS 04 **CAMS 21**



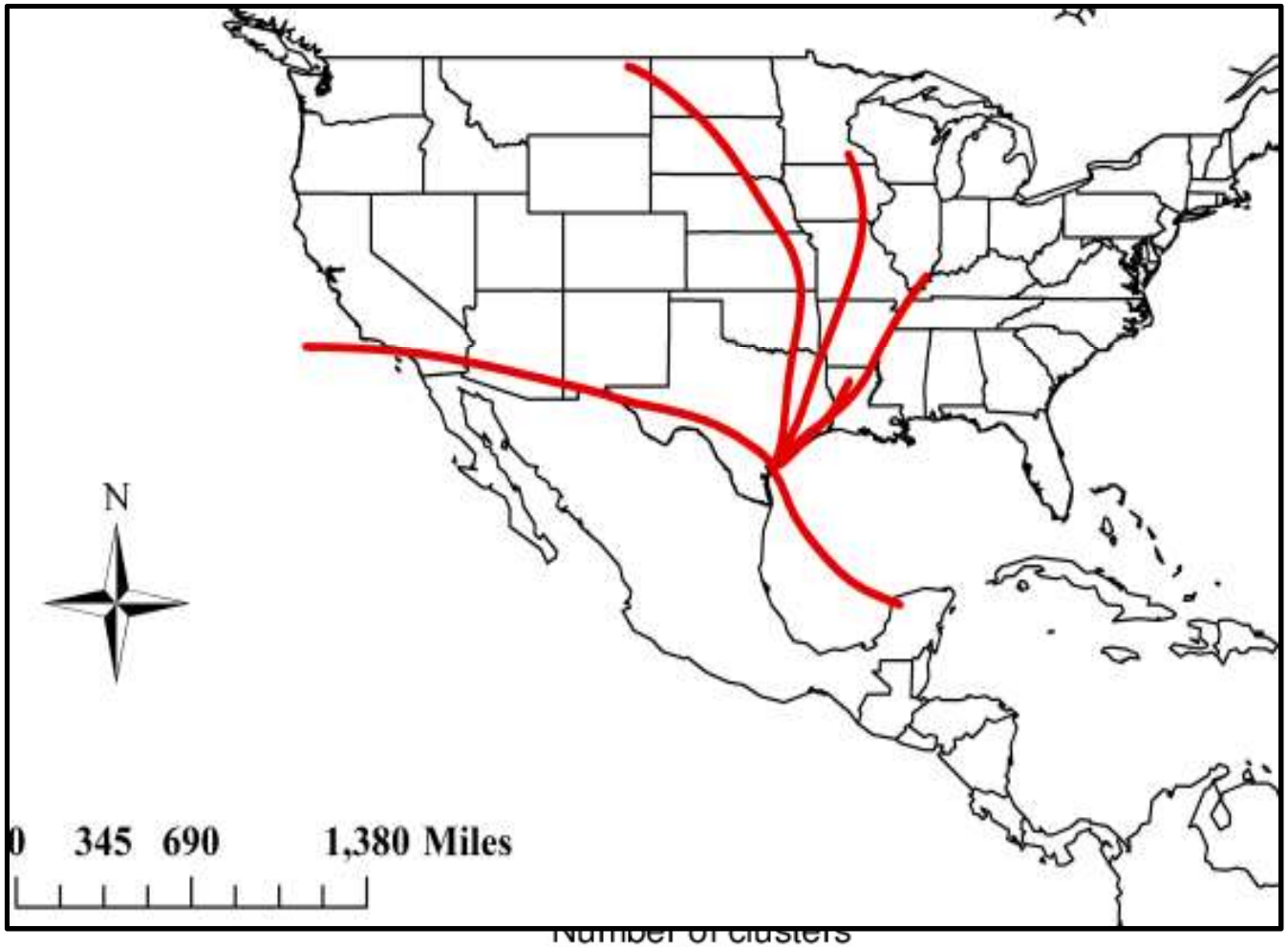
Results and Discussion

Cluster analysis of high ozone episodes – CAMS 21

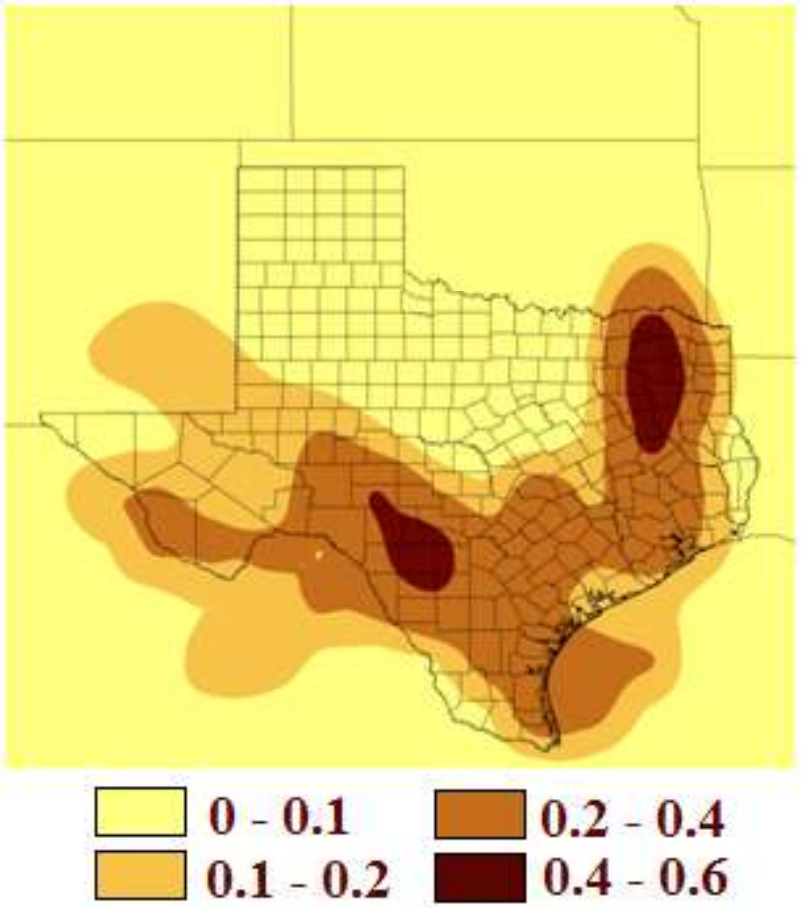


Results and Discussion

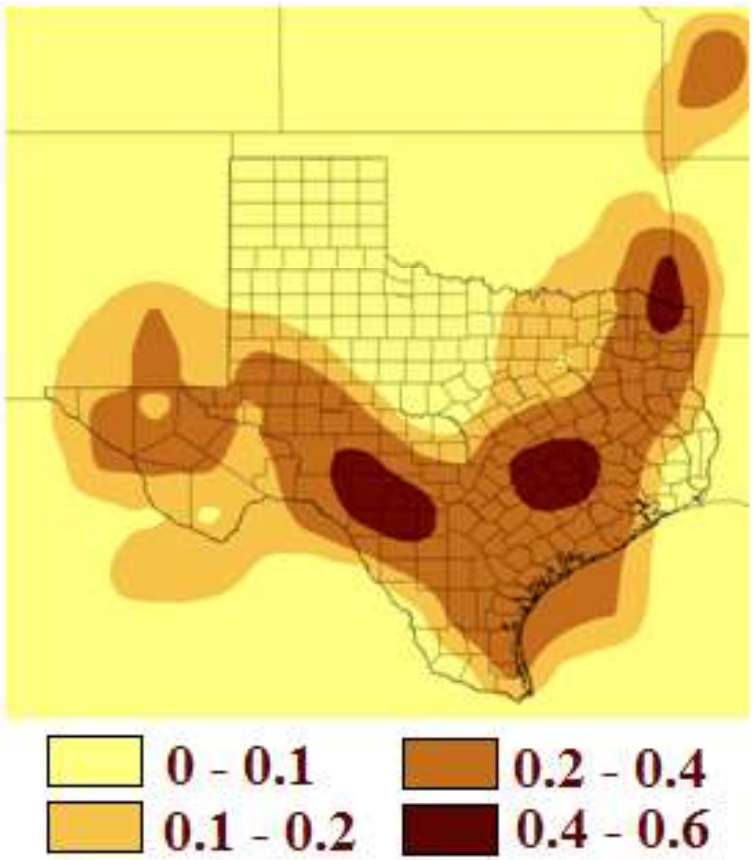
Cluster analysis of high ozone episodes – CAMS 659



Potential Source Contribution Function Analysis - TCEQ



Potential Source Contribution Function Analysis - TAMUK



SUMMARY FINDINGS

- The urban airshed is currently in attainment with ozone NAAQS.
- The mean hourly eight hour ozone concentrations exhibited a bi-modal distribution with peak measurements during spring months of March through May and fall months of September and October.
- Diurnal trends exhibited elevated concentrations from 8:00 AM to 10:00 and 2:00 PM to 6:00 PM.
- During 2010 through 2014 dominant southerly winds were noted along with significant contribution from north, northeast and easterly winds.
- Spearman's correlation coefficients indicated strong correlations during peak ozone months while during winter months of January, and February, summer months of June and July weak correlations were noted.

- Krustall-Wallis test conducted between eight hour ozone concentrations resulted in p-values below significance level concluding variability in source contribution.
- A decrease in annual trend of days exceeding daily maximum eight hour ozone concentrations above 70 ppb was noted.

SUMMARY FINDINGS

- Seasonal trend analysis of high ozone episodes demonstrated bi-modal distribution with peak concentrations from April, May and September, October.

- Cluster analysis indicated influence of long range transport from industrialized cities of Texas including Houston-Galveston, Dallas – Fort-Worth and surrounding states of Louisiana and Mississippi.