DFW Conceptual Model Summary for the 1997 8-Hour Ozone Standard

Clean Air Steering Committee August 27, 2010

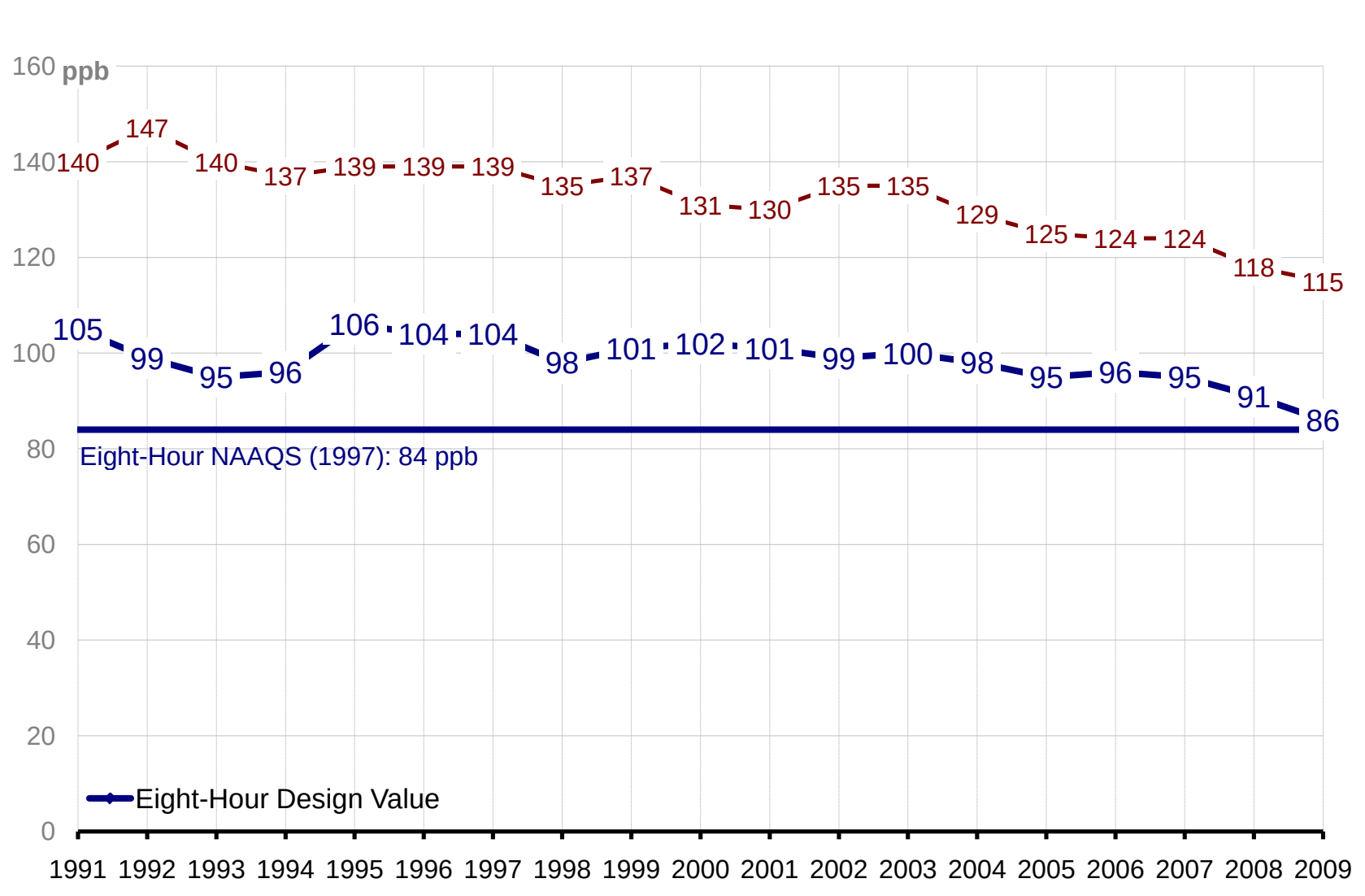
The Purpose of a Conceptual Model

- The conceptual model describes and explains the dynamics of ozone formation in a particular area.
- Furthermore, conceptual models are required by the U.S. Environmental Protection Agency (U.S. EPA) to accompany photochemical modeling performed for State Implementation Plans (SIP) (U.S. EPA, 2007).
- This conceptual model is for the 1997, 8-hour ozone standard which is 0.08 ppm. When referring to "high ozone" in this presentation this implies 8-hour ozone $\geq$ 85 ppb.
- The conceptual model will most likely change when the new ozone standard is announced.

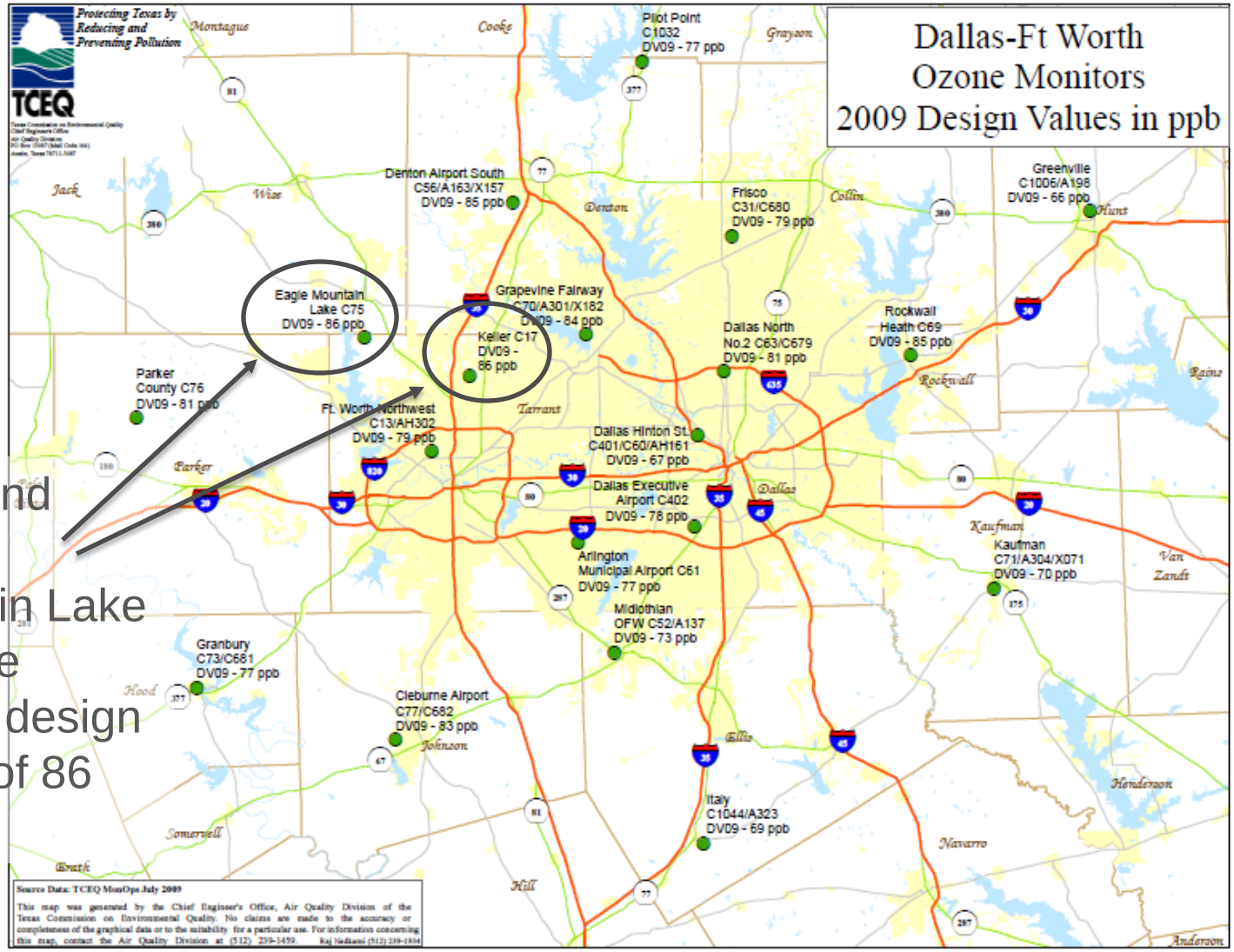
Topics

- Current ozone levels
- Conceptual model results
  - Trends of ozone, VOC and NOx
  - Typical high ozone wind patterns
  - Background ozone
  - Limitation ratios
  - Barnett Shale
    - Related Meteorology
    - PMF Source Identification
- Comparison of modeling episode to conceptual model results
  - Wind patterns
  - temperatures

Ozone Design Values for the DFW Area

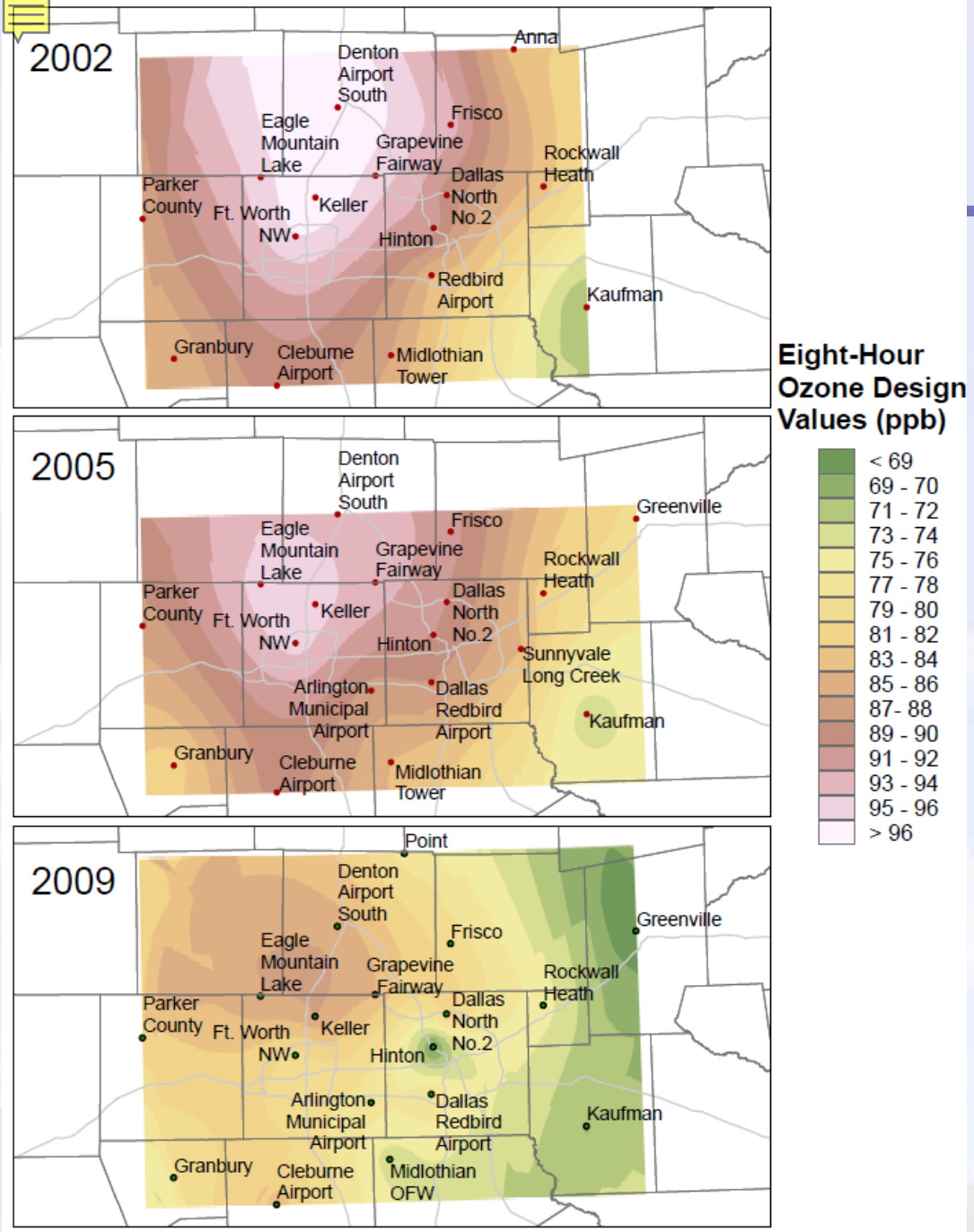


Design Value Setting Monitors for 2009



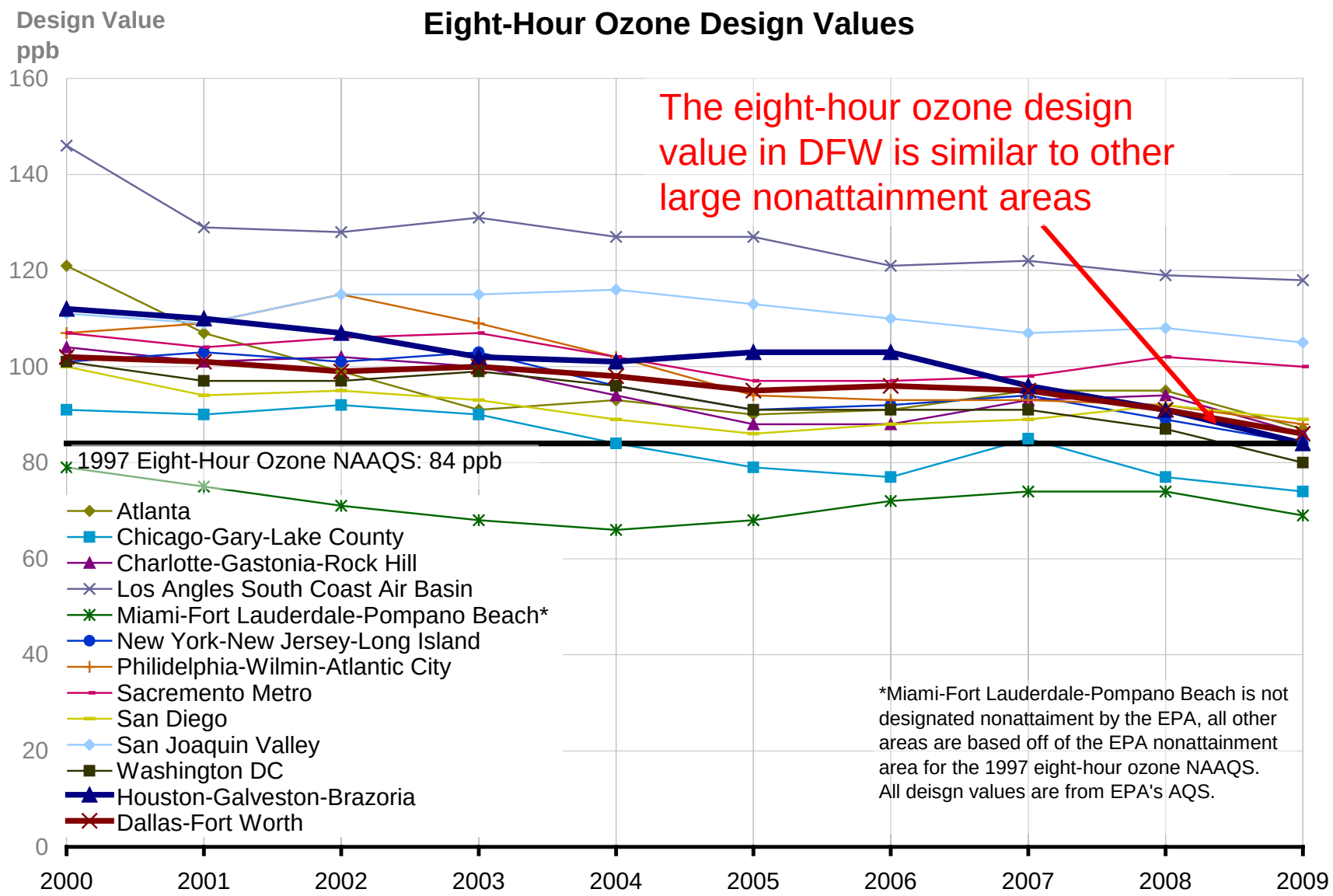
Keller and Eagle Mountain Lake have the highest design values of 86 ppb

Design Values Monitors



- Ozone has decreased throughout the DFW area
- Ozone peaks to in the northwest part of the DFW area, with the highest 2009 design values at Keller and Eagle Mountain Lake
- Even though ozone has decreased, the location of the peak ozone has remained the same

Ozone Design Value Comparison for Different Non Attainment Areas

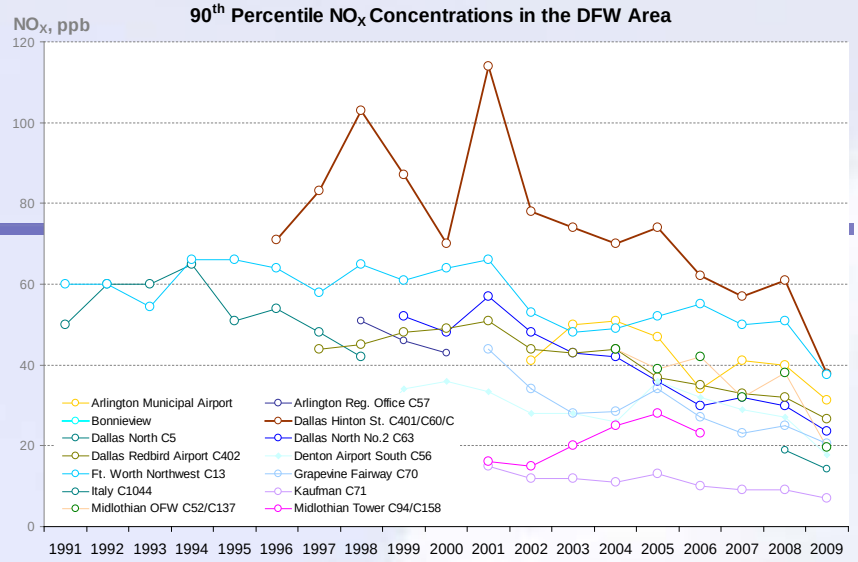


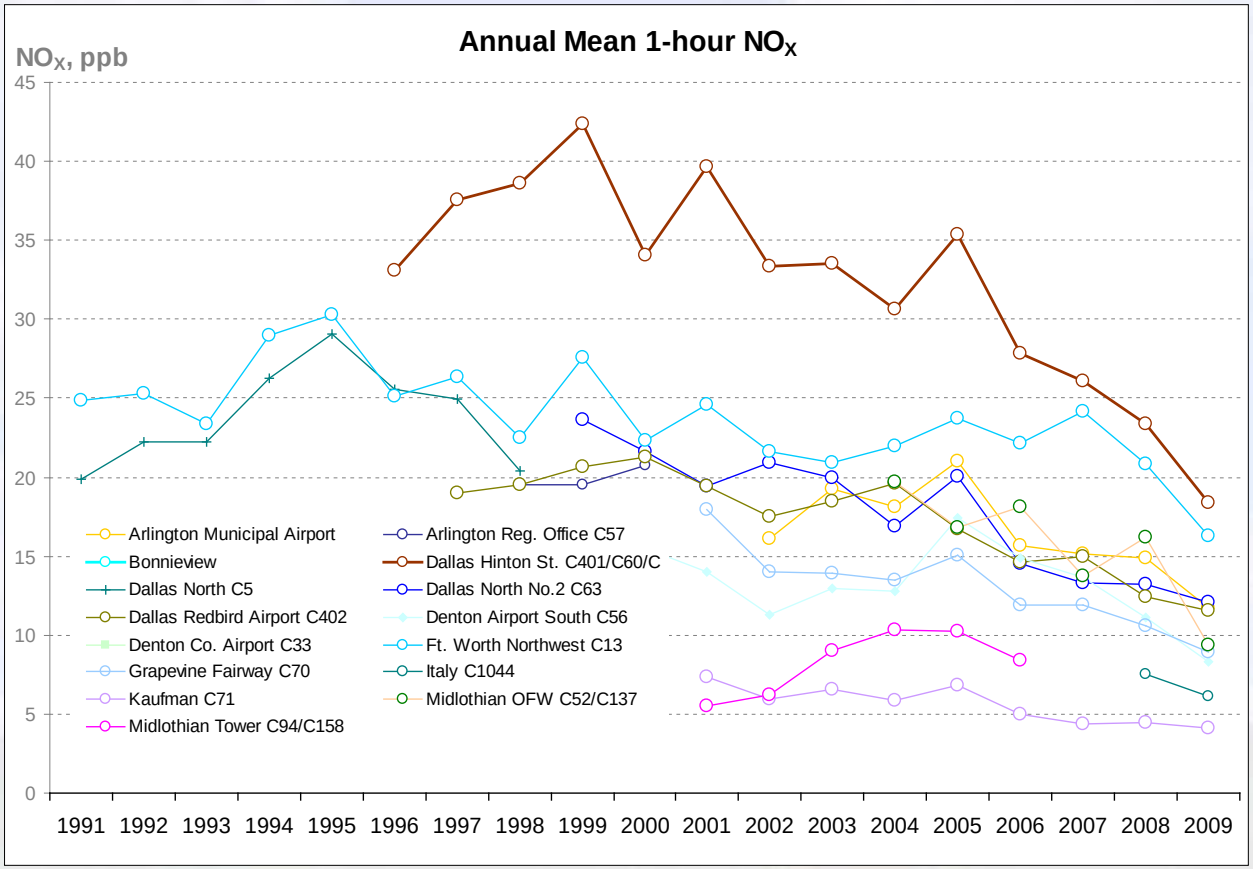
NOx Trends

Both the annual mean and the 90th percentiles are trending downward.

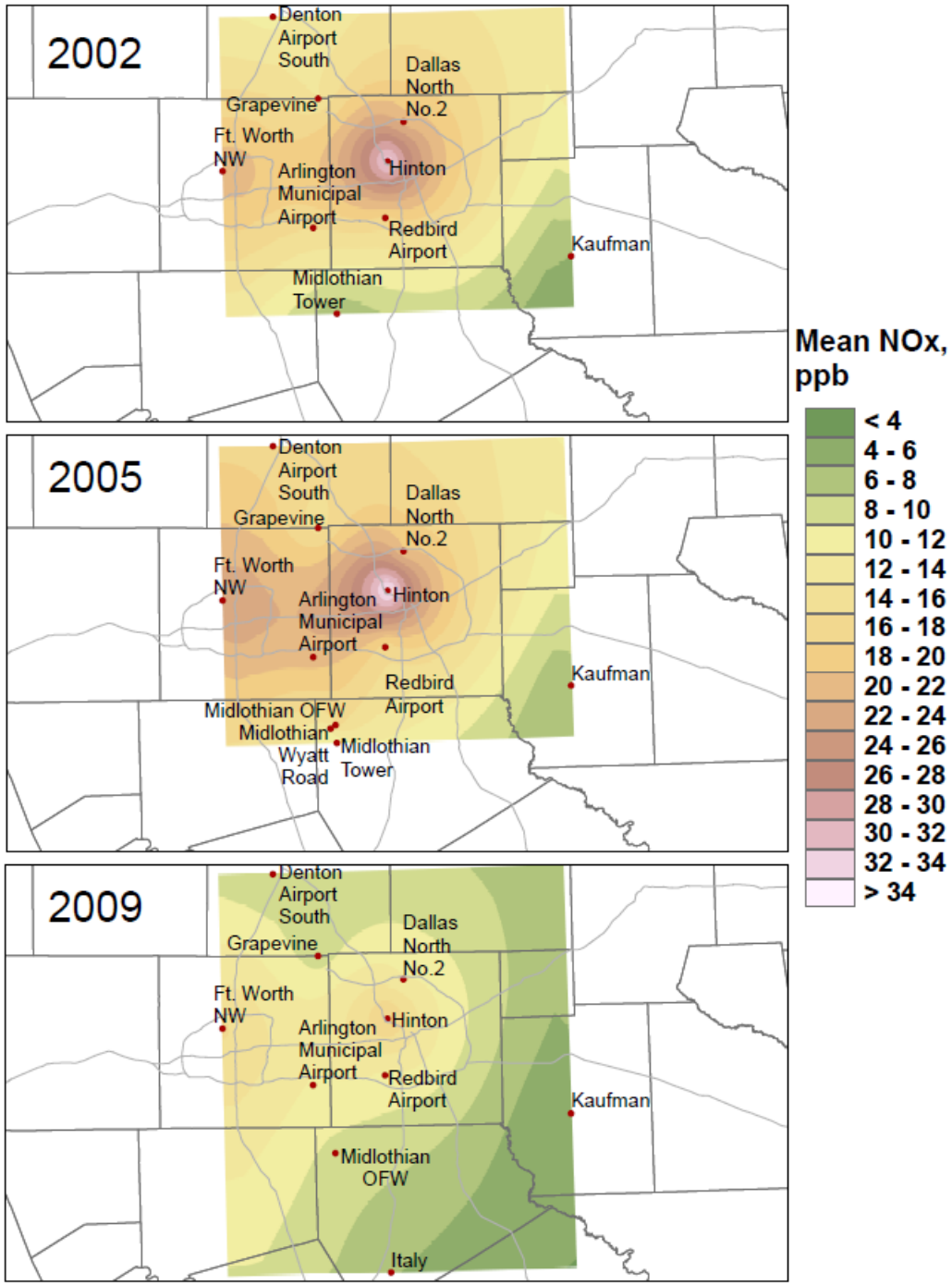
The Hinton monitor has seen the largest decrease.

The Midlothian monitor is the only monitor that did not see a decrease but does not have complete data.





Mean NO_X in the DFW Area

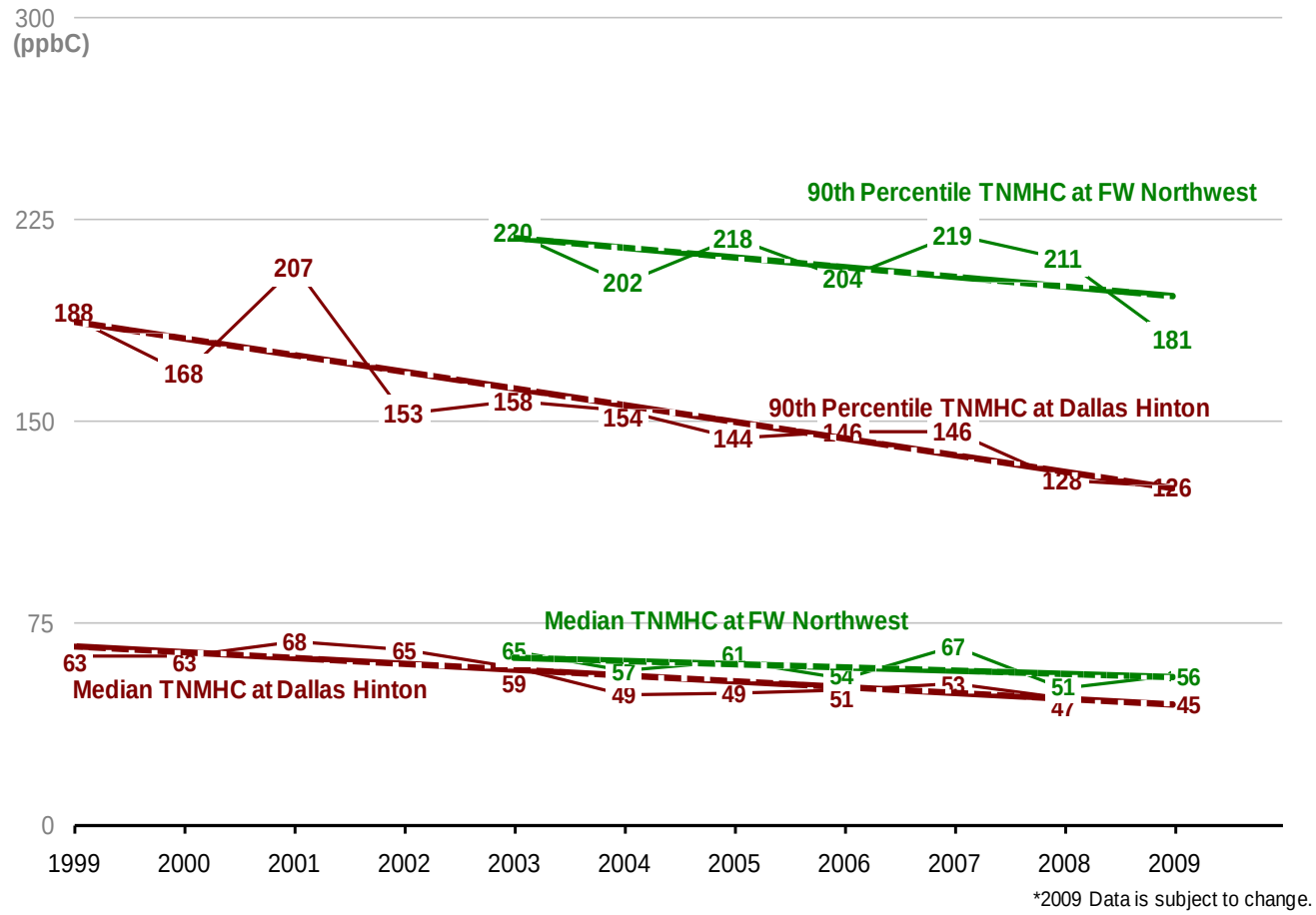


Overall NO_X in the DFW area has decreased by 65 percent from 1991 to 2009

The largest NO_X concentrations occur in the more urban areas, in the center of Dallas and Tarrant Counties

Although NO_X has decreased over time, the areas where NO_X concentrations are the largest remain the same

VOC Trends in DFW

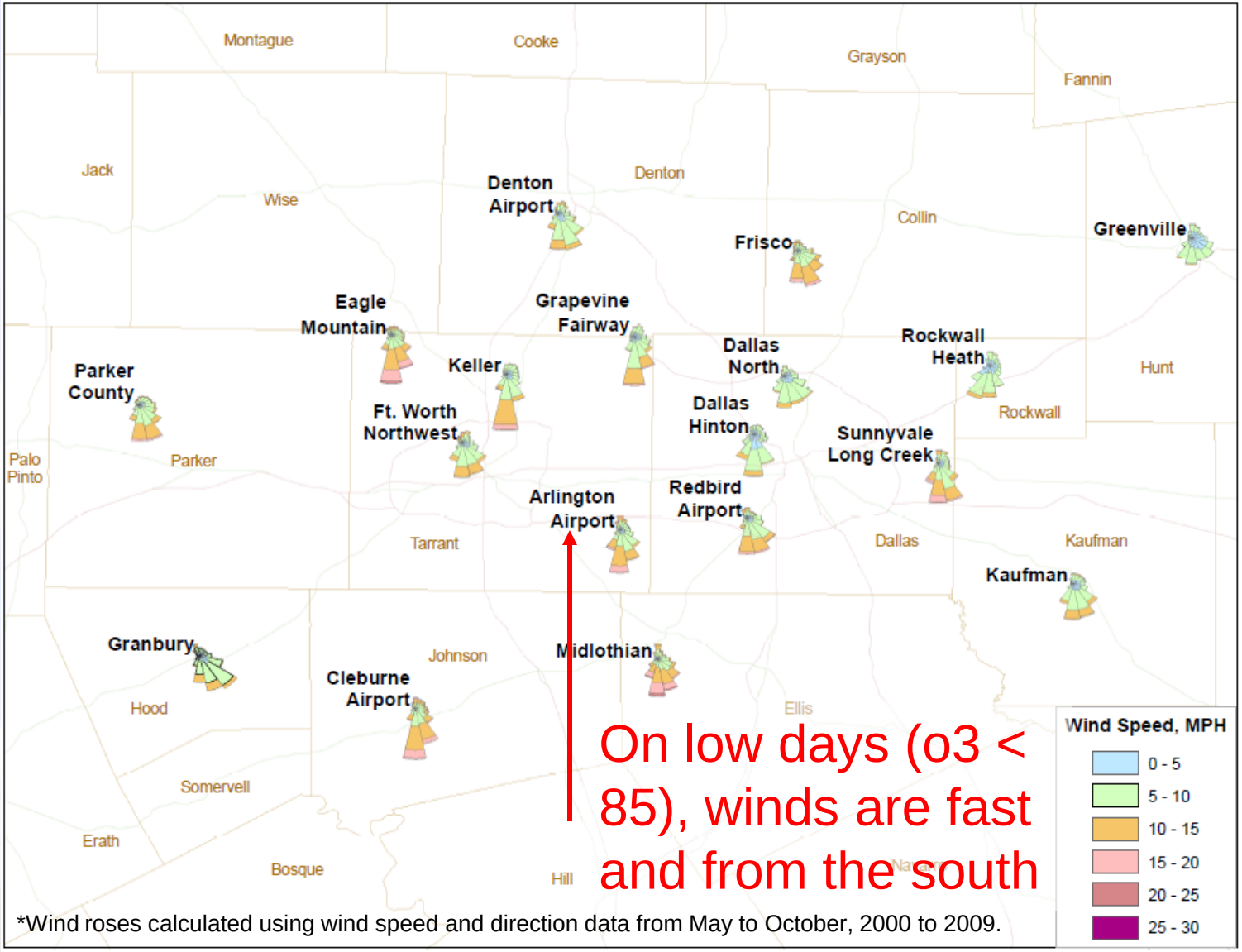


*2009 Data is subject to change.

The 90th percentile VOC concentrations decreased 33 percent from 1999 to 2009 at Hinton and 18 percent from 2003 to 2009 at Fort Worth Northwest

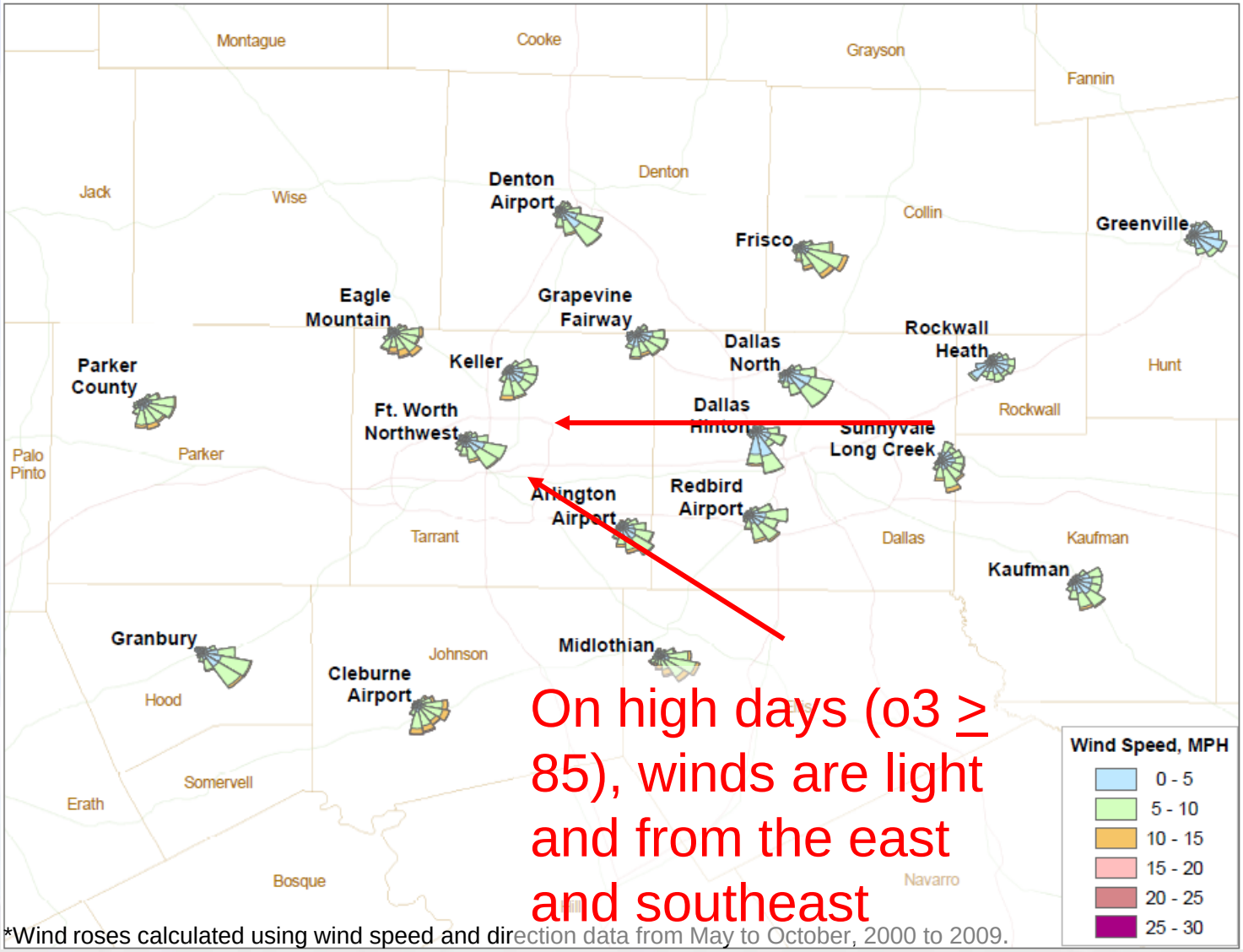
Median VOC decreased 29 percent from 1999 to 2009 at Hinton and 15 percent from 2003 to 2009 at Fort Worth Northwest

Surface Wind Speed and Direction on Low Eight-Hour Ozone Days



*Wind roses calculated using wind speed and direction data from May to October, 2000 to 2009.

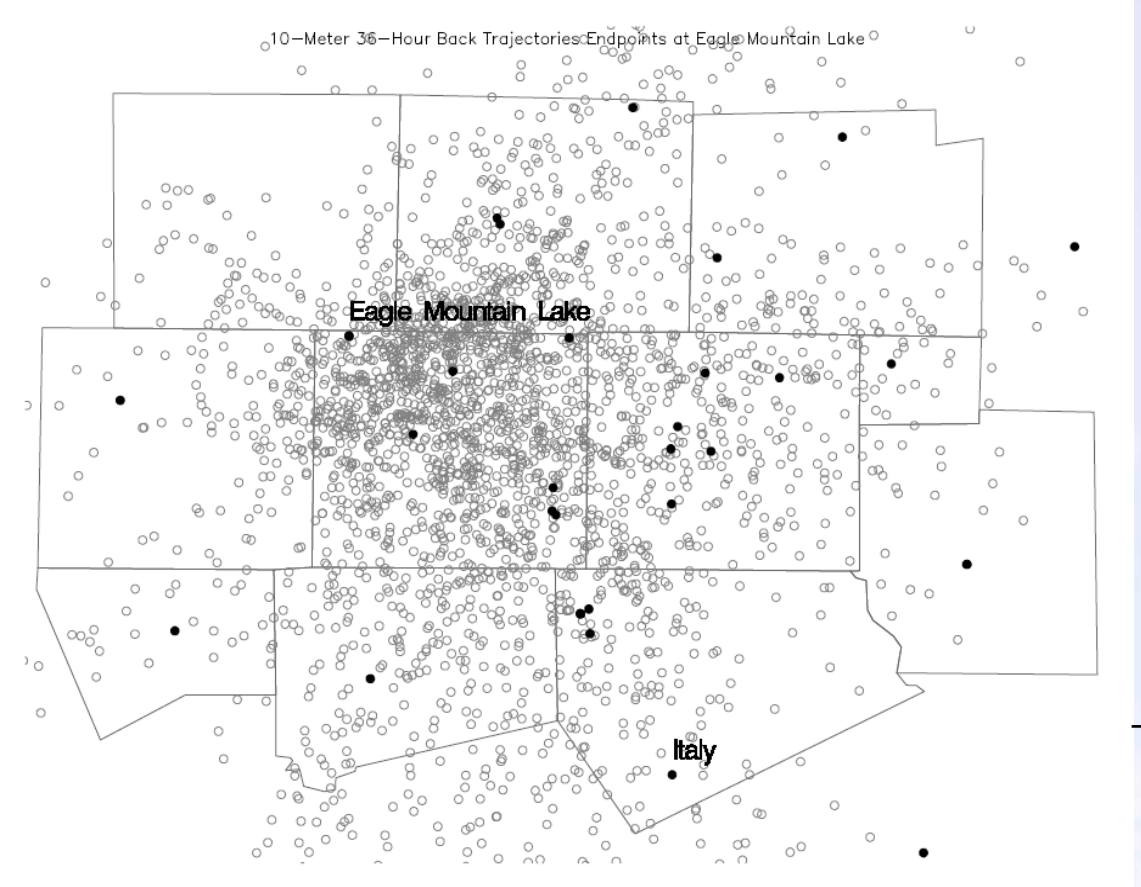
Surface Wind Speed and Direction on High Eight-Hour Ozone Days



On high days (o3 ≥ 85), winds are light and from the east and southeast

*Wind roses calculated using wind speed and direction data from May to October, 2000 to 2009.

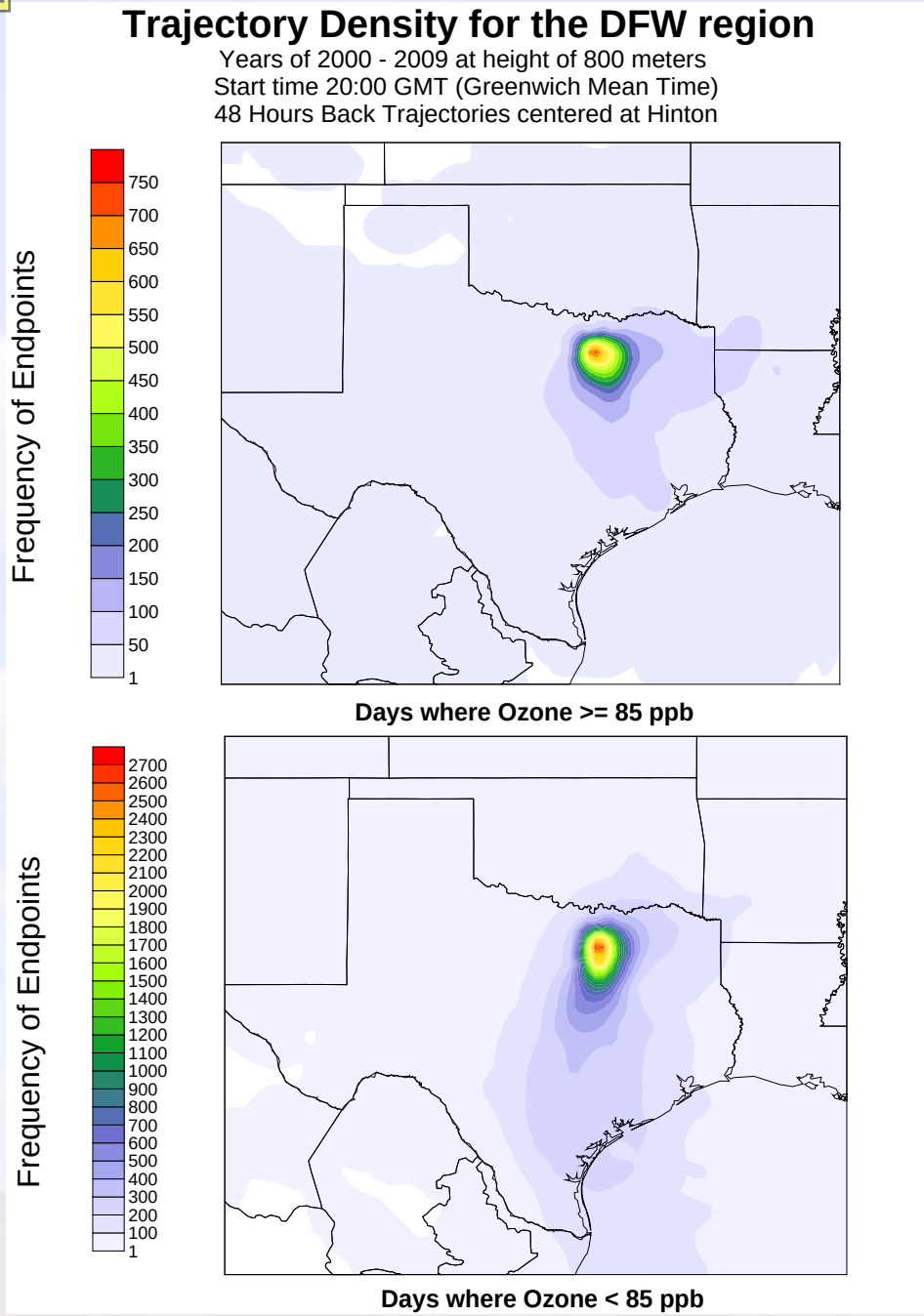
Back Trajectories on Ozone Days



- 10-meter back trajectories 10-hour back.
- Days with 8-hour ozone ≥ 85 ppb for 2000-2009.

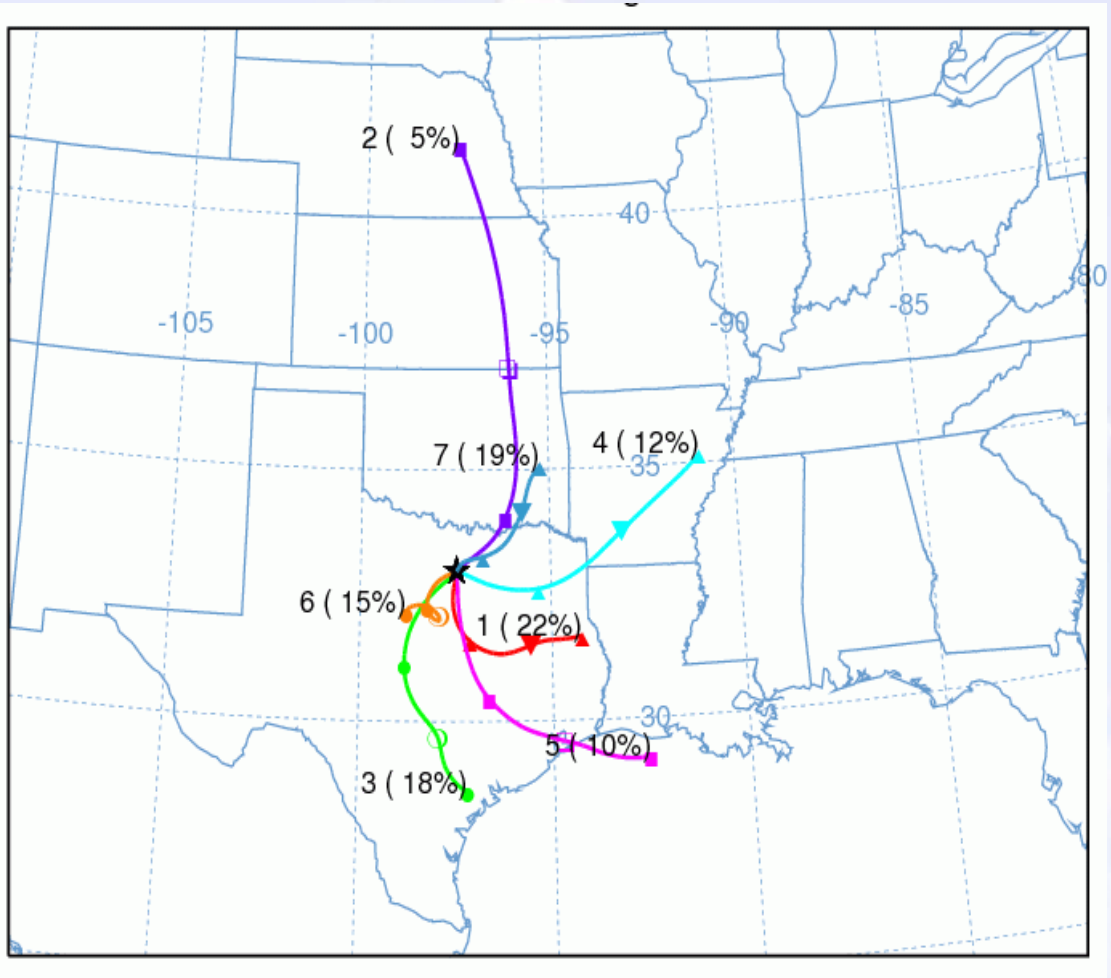
Rank	County	Frequency of Endpoints	Percentage of Total Endpoints
		#	%
1	Tarrant	519	32
2	Dallas	243	15
3	Denton	137	8
4	Collin	67	4
5	Parker	50	3
6	Wise	28	2
7	Other	595	36
	Total	1,639	100

Upper Level Winds



- Similar to the surface winds, on high ozone days, upper level trajectories are typically from the east and southeast and slow.
- On low ozone days, trajectories tend to be from the south to the south-southwest and fast

Barnett Shale High Ozone Trajectories



- Although emissions from Barnett Shale are observed at the VOC monitors, very few high ozone days have winds from the west, the direction of Barnett Shale.
- Ongoing studies show no relationship between VOC concentrations and high ozone days in the DFW area.
- Using 10-years of data, there is a similar chance of having high or low VOC concentrations on any particular day.
- Only one out of 19 days in 2009 with an ozone concentration greater than 75 ppb had winds from the west.

VOC and NO_X Limitations

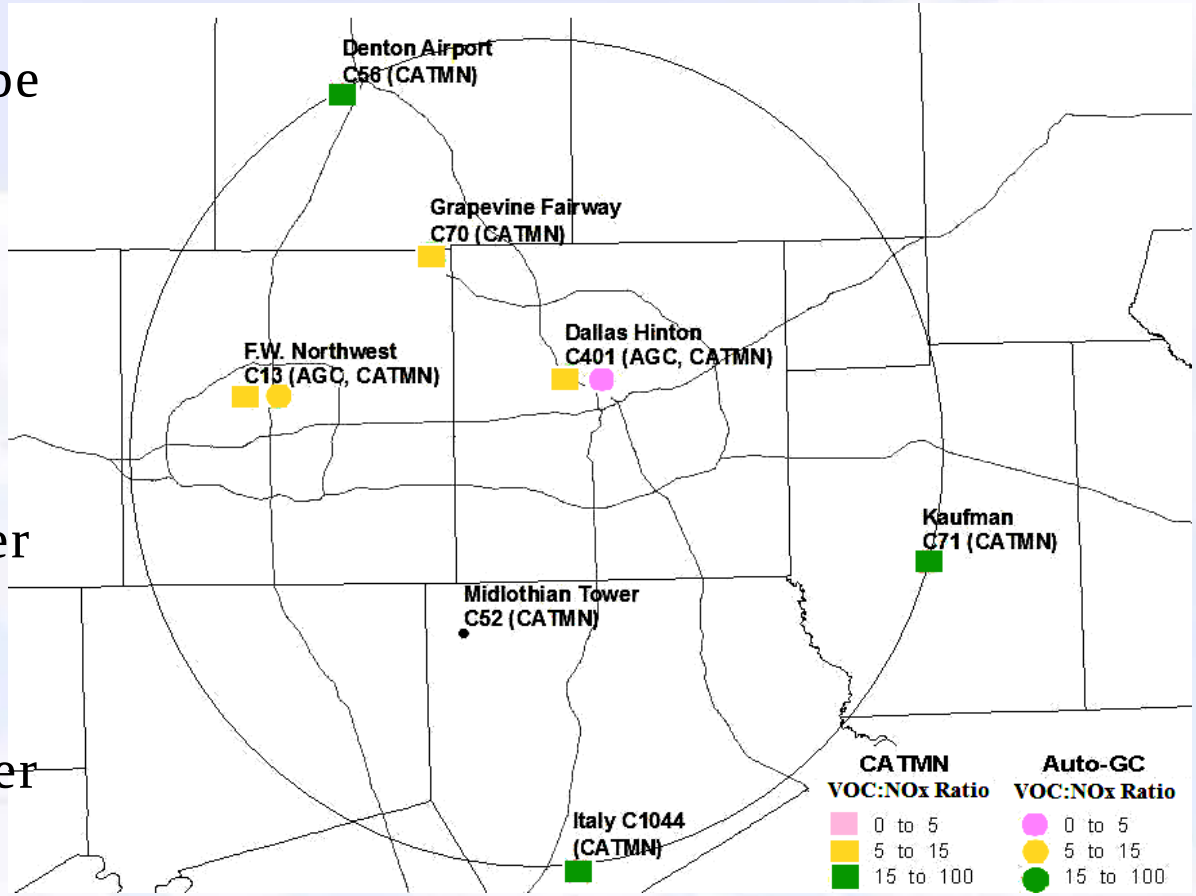
The more urban and high traffic areas in DFW tend to be VOC limited to transitional

The places further from the urban areas tend to be more NO_X limited

In NO_X limited regimes controlling NO_X helps to lower ozone

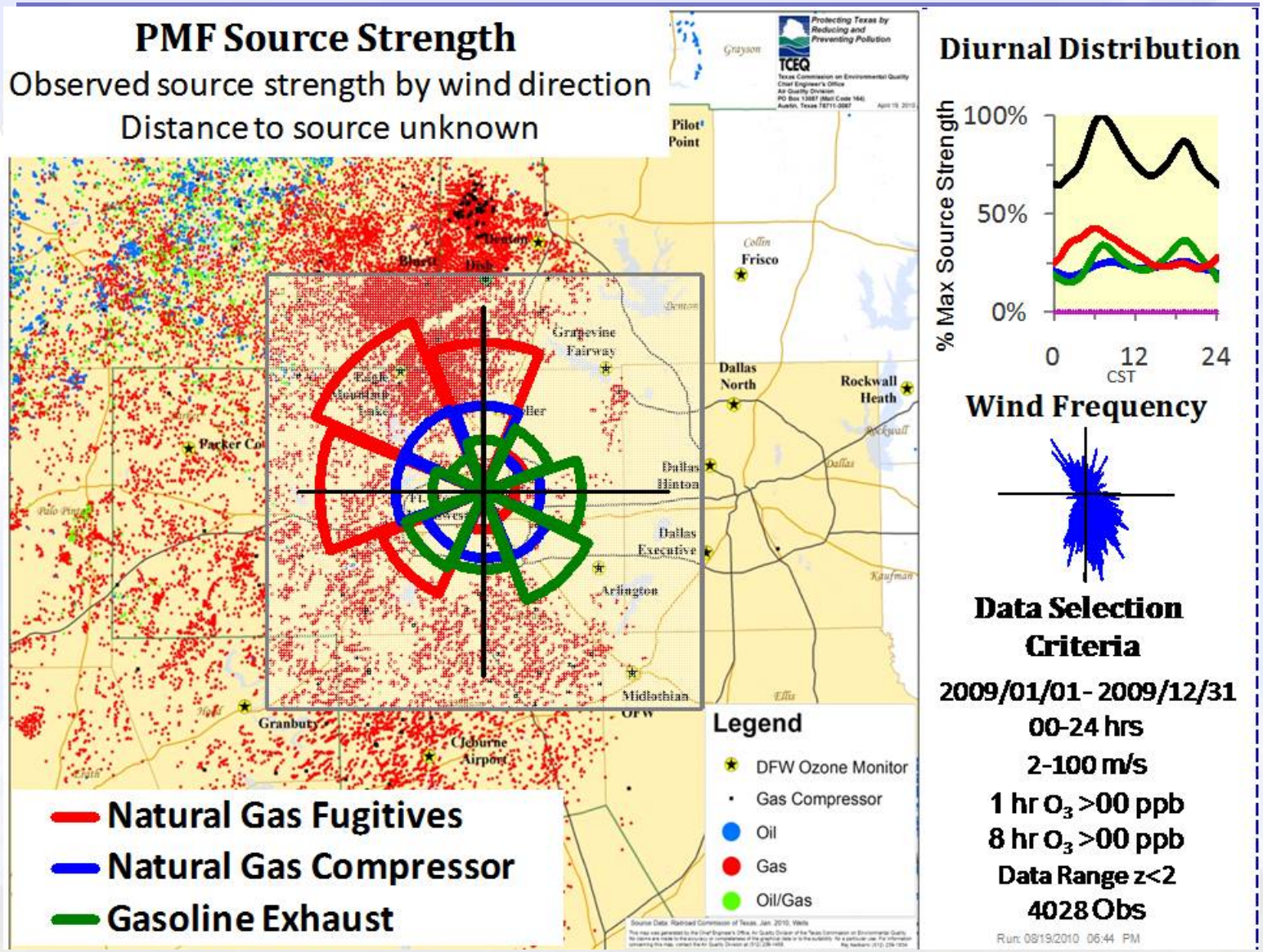
In VOC limited regimes controlling VOC helps to lower ozone

In transitional regimes controlling either VOC or NO_X will help lower ozone



*Pink dots represent VOC limited regimes, orange dots transitional, and green dots NO_X limited. Ratios were calculated using 2009 data.

PMF Pollution Rose

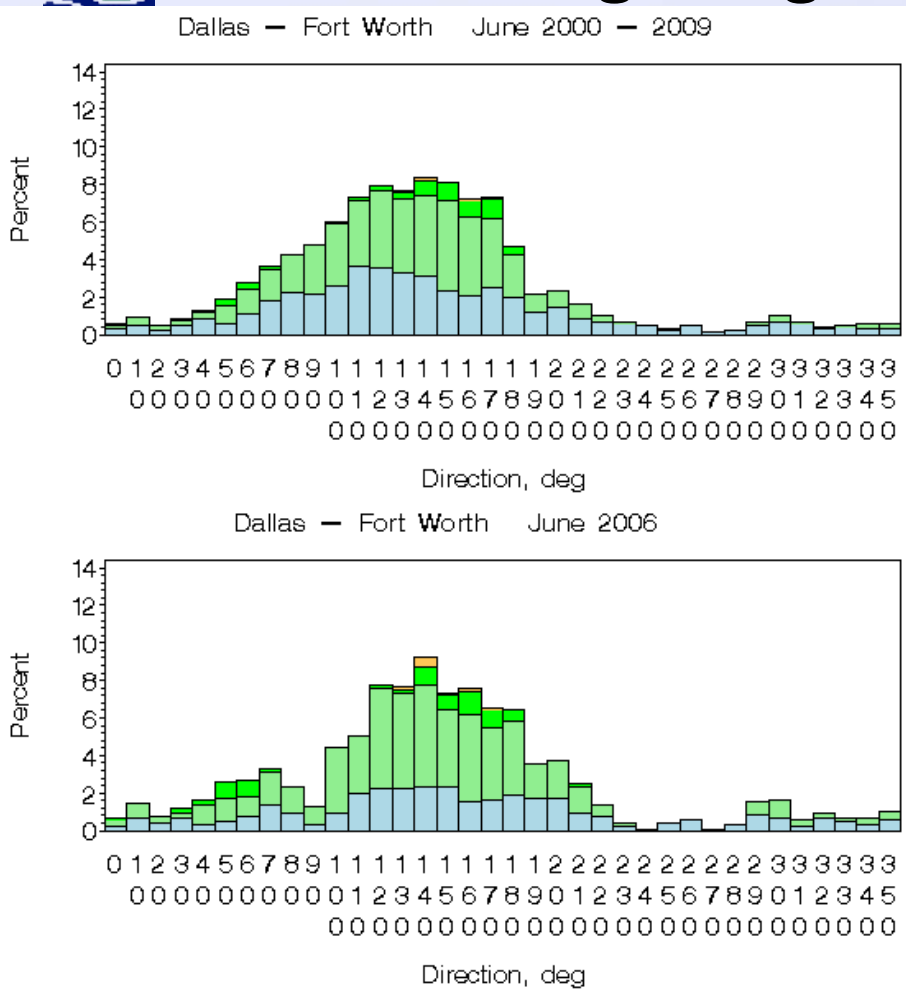


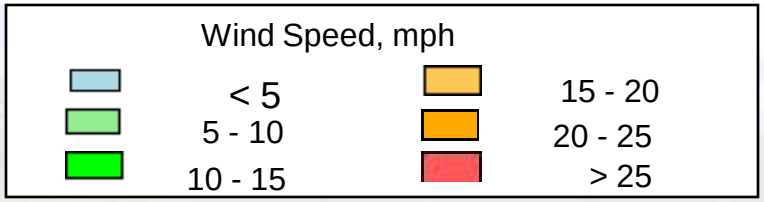
Background Ozone on High Eight-Hour Ozone Days

	Upwind 8-Hour Ozone	Downwind 8-Hour Ozone	Local Eight-Hour Ozone Contribution
Maximum	78	100	35
Minimum	55	85	10
Average	66	92	26

- Background ozone in the DFW area is direction dependent.
- On average, the DFW area contributes 26 ppb to ozone formation on high ozone days. The background concentration on these days is 66 ppb
- This analysis only used high eight-hour ozone days with no recirculation from 2006 through 2009.
- Winds on these days were typically out of the southeast.

Surface Wind Speed and Direction on High Eight-Hour Ozone Days





- Daytime winds between 0500 and 1900 local standard time.
- On high ozone days, winds in the Dallas – Fort Worth area are typically light and out of the Southeast.
- Winds on high ozone days in June of 2006 were similar to winds on high ozone days in the month of June in 2000 through 2009.

DFW June Temperature Comparison

Year	Days with max temp over 90 F at any monitor site
2000	13
2001	21
2002	22
2003	16
2004	16
2005	28
2006	**28**
2007	12
2008	30
2009	27
2000 – 2009 Average	21.3

- High ozone concentrations typically occur on days with maximum temperatures above 90.
- June 2006, used in the model episode had 28 days with maximum temperatures above 90 degrees, this is above the 2000-2009 average of 21.3 days.
- All exceedance days in 2006 occurred on days with maximum temperatures above 90 degrees.

June 9, 2006 High Ozone Event

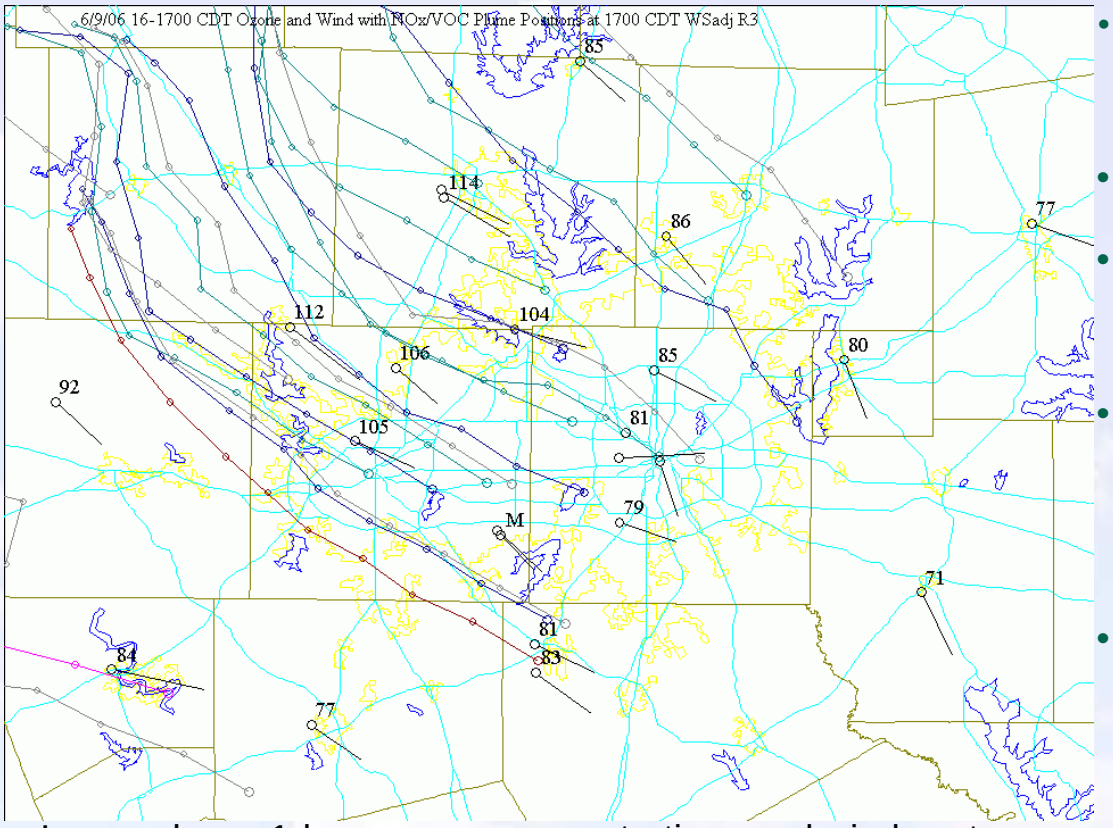


Image shows 1-hour ozone concentrations and wind vectors valid for the 1600-1700 CDT time frame. Source plume trajectories are overlaid to show where the air mass moved.

- June 9th was an example of a typical high ozone day in the DFW area.
- Winds were light out of the southeast.
- The maximum temperature at DFW airport was 98 degrees.
- Highest concentrations were measured on the north and northwest side of the area.
- 8-hour background concentrations were measured between 70 and 80 ppb at the Rockwall, Midlothian, Italy, and Kaufman monitors.
- The highest 8-hour concentrations, 106 ppb, were measured at the Denton and Eagle Mountain Lake monitors.

Summary

- Ozone, NOx and VOC trends are down.
- Ozone design setting monitor location has not changed - northwest FW area.
- Higher ozone concentrations are from the east through southeast directions.
- PMF source analysis identifies three sources, including an oil & gas activity source, which does not correlated well with high ozone days.
- Trajectory analysis show little or no correlation to high ozone day.
- Background ozone averages 66 ppb on high ozone days.

Summary Cont.

- Modeling episode meteorology fits the conceptual model findings.
- Lastly, a typical high ozone day is sunny, hot, light wind speeds with possible recirculation and from the east or southeast directions transport ozone to the northwest region of the DFW area.

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