Preliminary Results of Ozone Modeling for the Dallas-Fort Worth (DFW) Area

Air Modeling and Data Analysis Section
Air Quality Division

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DFW State Implementation Plan (SIP) Technical Information Meeting
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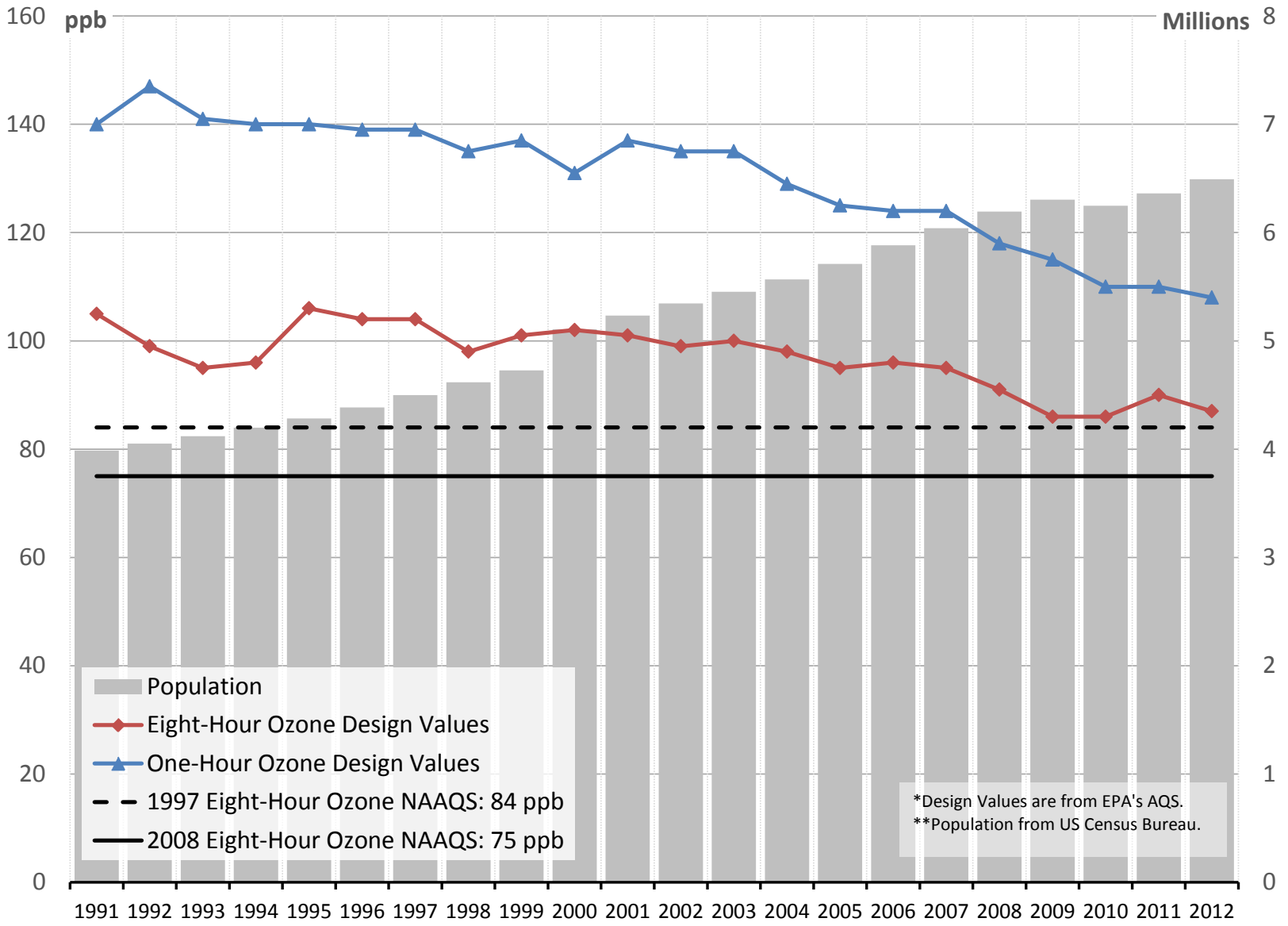
DFW Area Trends in Regulatory Ozone Design Values and Human Population from 1991-2012



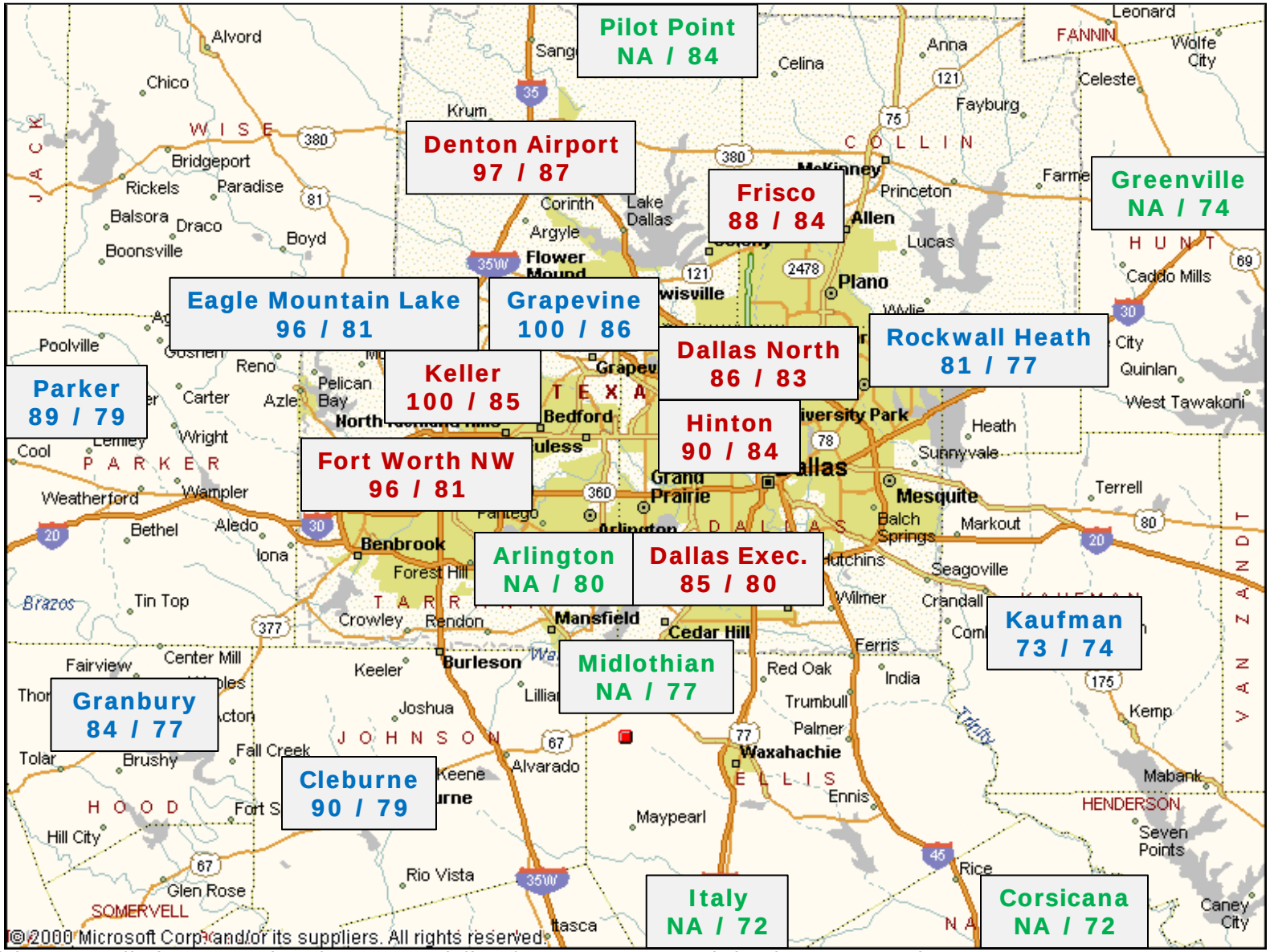
Eight-Hour Ozone Regulatory Design Value Changes by Monitor - 2003 / October 2013

Color Coding:

- **Monitors in red were operational prior to 2000**
- **Monitors in blue began operation in 2000**
- **Monitors in green began operation after 2000**

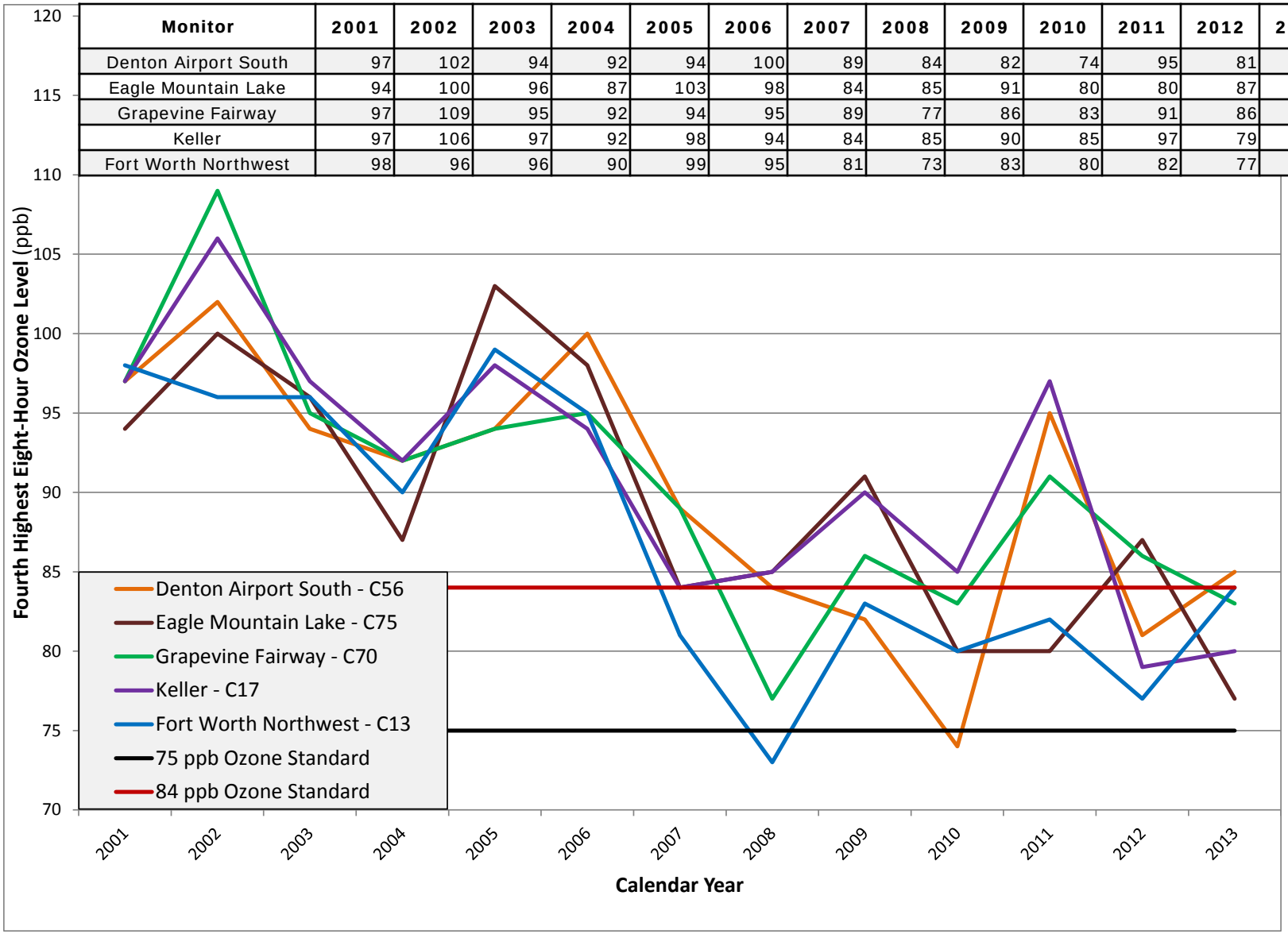
Note:

- **2013 values were updated on October 31 and are subject to change.**



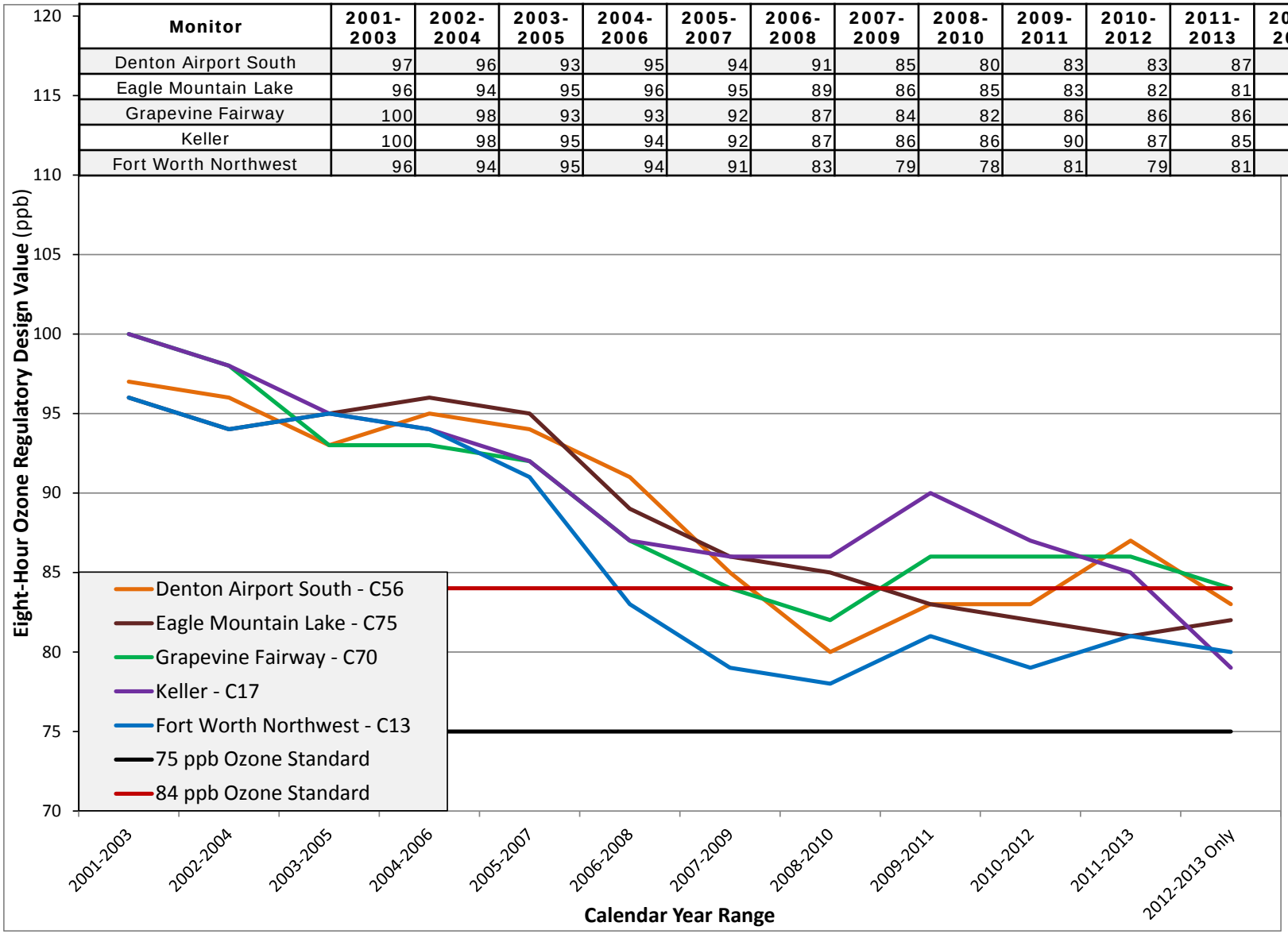
Fourth Highest Eight-Hour Ozone Levels at Five Northwest DFW Monitors from 2001-2013

Monitor	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denton Airport South	97	102	94	92	94	100	89	84	82	74	95	81	85
Eagle Mountain Lake	94	100	96	87	103	98	84	85	91	80	80	87	77
Grapevine Fairway	97	109	95	92	94	95	89	77	86	83	91	86	83
Keller	97	106	97	92	98	94	84	85	90	85	97	79	80
Fort Worth Northwest	98	96	96	90	99	95	81	73	83	80	82	77	84



Eight-Hour Ozone Regulatory Design Values at Five Northwest DFW Monitors from 2003-2013

Monitor	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2013
Denton Airport South	97	96	93	95	94	91	85	80	83	83	87	83
Eagle Mountain Lake	96	94	95	96	95	89	86	85	83	82	81	82
Grapevine Fairway	100	98	93	93	92	87	84	82	86	86	86	84
Keller	100	98	95	94	92	87	86	86	90	87	85	79
Fort Worth Northwest	96	94	95	94	91	83	79	78	81	79	81	80



Necessity of Photochemical Modeling to Demonstrate Attainment of the Ozone Standard

- Monitoring data cannot be used to predict the future. Attainment of the 75 parts per billion (ppb) ozone standard for a moderate nonattainment area like DFW will be determined by the average of the fourth highest ozone readings per year from 2016-2018 for each regulatory monitor, which will result from:
  - background ozone levels and the meteorological conditions that will occur; plus
  - the magnitude, spatial distribution, and temporal distribution of nitrogen oxides (NO_X) and volatile organic compounds (VOC) emissions.

- Photochemical modeling is a highly-advanced, but also imperfect, tool used to predict future ozone levels based on the projected level of precursor emissions. Basic steps:

1. **Episode:** Select a representative historical ozone episode, with preference given to longer synoptic cycles with transition from low to high and back to low ozone days.
2. **Base Case:** Develop modeling inputs for this episode that include meteorological fields, biogenic emissions, anthropogenic emissions, boundary conditions, initial conditions, etc.
3. **Performance:** Evaluate performance of the episode by comparing with historically monitored data.
4. **Baseline Case:** Run the base case meteorology and biogenic emissions with daily average inputs. For example, the base case has specific electrical utility emission measurements by hour; the baseline has a monthly/seasonal representative average instead.
5. **Future Case:** Develop daily average anthropogenic emission inputs for the future year accounting for known Federal, state, and local rules.
6. **Attainment Test:** Obtain future design values by applying the future/baseline modeled ozone ratios to monitored design values.

Preliminary 2018 DFW Future Design Values for 10 and 30 ppm Sulfur Gasoline Scenarios

DFW Area Monitor and CAMS Code	2018 Future Design Values (ppb)		
	Current 30 ppm Sulfur Gasoline	Proposed 10 ppm Sulfur Gasoline	10 ppm Sulfur Gasoline Reduction
Denton Airport South - C56	77.09	76.29	0.80
Eagle Mountain Lake - C75	76.38	75.64	0.74
Grapevine Fairway - C70	76.12	75.38	0.74
Keller - C17	75.31	74.55	0.76
Fort Worth Northwest - C13	74.07	73.37	0.70
Frisco - C31	73.33	72.59	0.74
Dallas North #2 - C63	71.82	71.18	0.64
Parker County - C76	71.75	71.12	0.63
Dallas Executive Airport - C402	71.41	70.82	0.59
Cleburne Airport - C77	70.91	70.36	0.55
Arlington Municipal Airport - C61	69.92	69.32	0.60
Dallas Hinton Street - C401	68.85	68.24	0.61
Granbury - C73	68.56	68.06	0.50
Midlothian Tower - C94	68.09	67.60	0.49
Pilot Point - C1032	66.91	66.22	0.69
Rockwall Heath - C69	65.82	65.33	0.49
Greenville - C1006	63.40	62.98	0.42
Midlothian OFW - C52	63.38	62.93	0.45
Kaufman - C71	63.10	62.71	0.39

Tier 3 and 10 ppm Gasoline Sulfur Standards for Light-Duty On-Road Vehicles

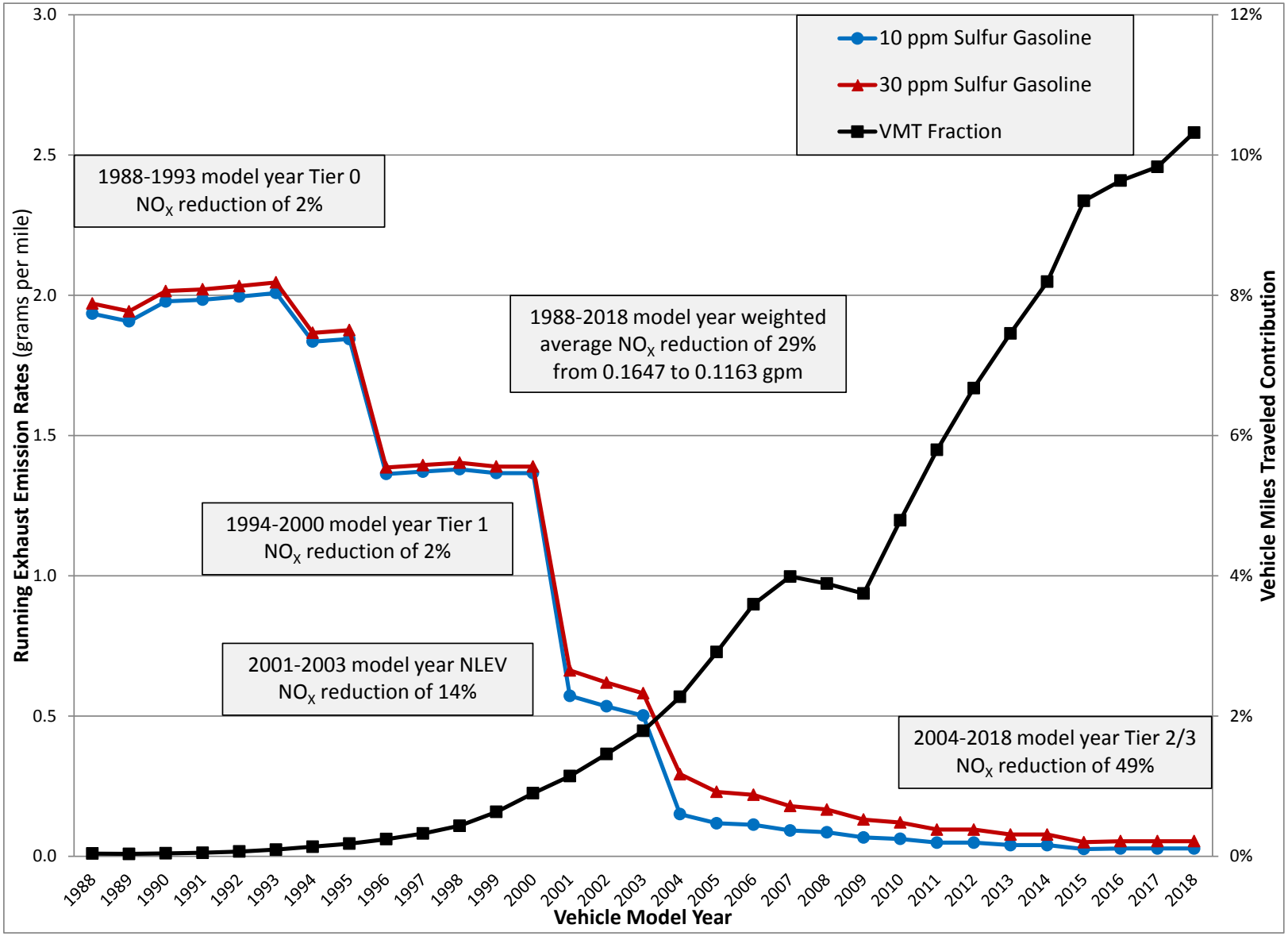
- Current proposal by EPA (http://www.epa.gov/otaq/tier3.htm) is to require:
  - more stringent Tier 3 standards for light-duty vehicles phasing in between the 2017-2025 model years; and
  - 10 parts per million (ppm) gasoline sulfur instead of the current 30 ppm level.

- Overall on-road fleet benefits accrue from both:
  - introduction of tighter standards with the 2017 model year; and
  - lower sulfur levels increasing catalytic converter effectiveness, which reduces emissions from in-use vehicles.

- Excerpt from page 12 of EPA's Tier 3 air quality modeling technical support document (http://www.epa.gov/otaq/documents/tier3/454r13006.pdf):
  - **"The maximum projected decrease in an eight-hour ozone design value in 2017 is 1.09 ppb in Tarrant County, Texas…"**

- Estimating Tier 3 on-road emission benefits for the 2018 attainment year:
  - the current MOVES2010b model does not include Tier 3 benefits;
  - MOVES2013 will include them and is scheduled for release after Tier 3 rule finalization;
  - TCEQ obtained the MOVEST3NPRM database available from EPA as part of the Tier 3 proposed rulemaking;
  - TCEQ ran 2018 gasoline scenarios for the current 30 ppm and the proposed 10 ppm levels; and
  - TCEQ applied ratios of the results by vehicle type, pollutant, and emission process (e.g., running exhaust versus start exhaust) to the 2018 on-road inventories based on 30 ppm.

Gasoline Passenger Car Running Exhaust NO_X Emission Rates in 2018 for 10 and 30 ppm Sulfur Gasoline



Source: 2018 Dallas County default runs of MOVES2010b by model year with the T3NPRM database. Refer to *Updates to MOVES for the Tier 3 NPRM Analysis*, U.S. EPA Office of Transportation and Air Quality, March 2013.

Estimated 10 ppm Sulfur Gasoline Reductions to 2018 Summer Weekday On-Road Emissions

Geographic Area	2018 Summer Weekday On-Road Emissions (tpd) Use of Current 30 ppm Sulfur Gasoline for In-Use Fleet						
	NO	NO_2	HONO	NO_X	VOC	CO	SO_2
Ten-County DFW	95.80	16.51	0.91	113.21	63.61	670.82	1.04
Eight-County HGB	87.01	15.50	0.83	103.34	57.88	656.24	1.55
236 Attainment Counties	344.32	58.84	3.25	406.41	181.18	1,925.78	3.03
Texas Total (254 Counties)	527.13	90.85	4.98	622.96	302.66	3,252.84	5.62
Non-Texas U.S. (2,856 Counties)	7,173.34	1,194.80	67.49	8,435.63	4,159.52	46,377.90	65.53
Southern Canada (10 Provinces)	406.42	66.50	3.81	476.73	483.56	8,201.72	18.31
Northern Mexico (562 Municipios)	91.77	15.73	0.87	108.37	196.27	833.96	2.90
Grand Total	8,198.65	1,367.89	77.15	9,643.69	5,142.02	58,666.41	92.36

Geographic Area	2018 Summer Weekday On-Road Emission Reductions (tpd) Use of Proposed 10 ppm Sulfur Gasoline for In-Use Fleet						
	NO	NO_2	HONO	NO_X	VOC	CO	SO_2
Ten-County DFW	8.46	1.43	0.08	**9.98**	2.39	13.25	0.54
Eight-County HGB	7.79	1.35	0.07	**9.21**	2.25	12.66	0.87
236 Attainment Counties	22.89	3.86	0.22	**26.97**	5.52	27.74	1.41
Texas Total (254 Counties)	39.14	6.65	0.37	**46.16**	10.16	53.65	2.83
Non-Texas U.S. (2,856 Counties)	588.39	104.59	5.59	**698.57**	126.58	873.91	34.96
Southern Canada (10 Provinces)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Mexico (562 Municipios)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	627.54	111.24	5.96	**744.73**	136.74	927.56	37.79

EPA's Estimated Ozone Reduction Benefits in 2017 from Tier 3/10 ppm Sulfur Rule Proposal

Metropolitan Area	Texas County	2017 Future Design Value		Ozone Reduction
		Without Tier 3	With Tier 3	
Austin	Travis	67.77	67.06	0.71
Beaumont-Port Arthur	Jefferson	75.14	74.86	0.28
	Orange	68.09	67.80	0.29
Dallas-Fort Worth	**Collin**	**75.35**	**74.46**	**0.89**
	Dallas	**76.92**	**76.02**	**0.90**
	Denton	**75.80**	**74.73**	**1.07**
	Ellis	**67.53**	**66.67**	**0.86**
	Hood	**65.82**	**64.80**	**1.02**
	Hunt	**66.40**	**65.94**	**0.46**
	Johnson	**68.73**	**67.85**	**0.88**
	Kaufman	**63.93**	**63.48**	**0.45**
	Parker	**69.66**	**68.65**	**1.01**
	Rockwall	**67.66**	**67.12**	**0.54**
	Tarrant	**77.34**	**76.25**	**1.09**
El Paso	El Paso	68.37	67.95	0.42
Houston-Galveston-Brazoria	Brazoria	83.33	82.80	0.53
	Galveston	75.38	75.12	0.26
	Harris	90.22	89.68	0.54
	Montgomery	73.00	72.41	0.59
Northeast Texas	Gregg	74.18	73.88	0.30
	Harrison	66.93	66.51	0.42
	Smith	69.81	69.44	0.37
San Antonio	Bexar	72.36	71.76	0.60

Source: *U.S. EPA Air Quality Modeling Technical Support Document: Proposed Tier 3 Emission Standards, Appendix B*

Comparing DFW Area Ozone Modeling from EPA for 2017 and TCEQ for 2018

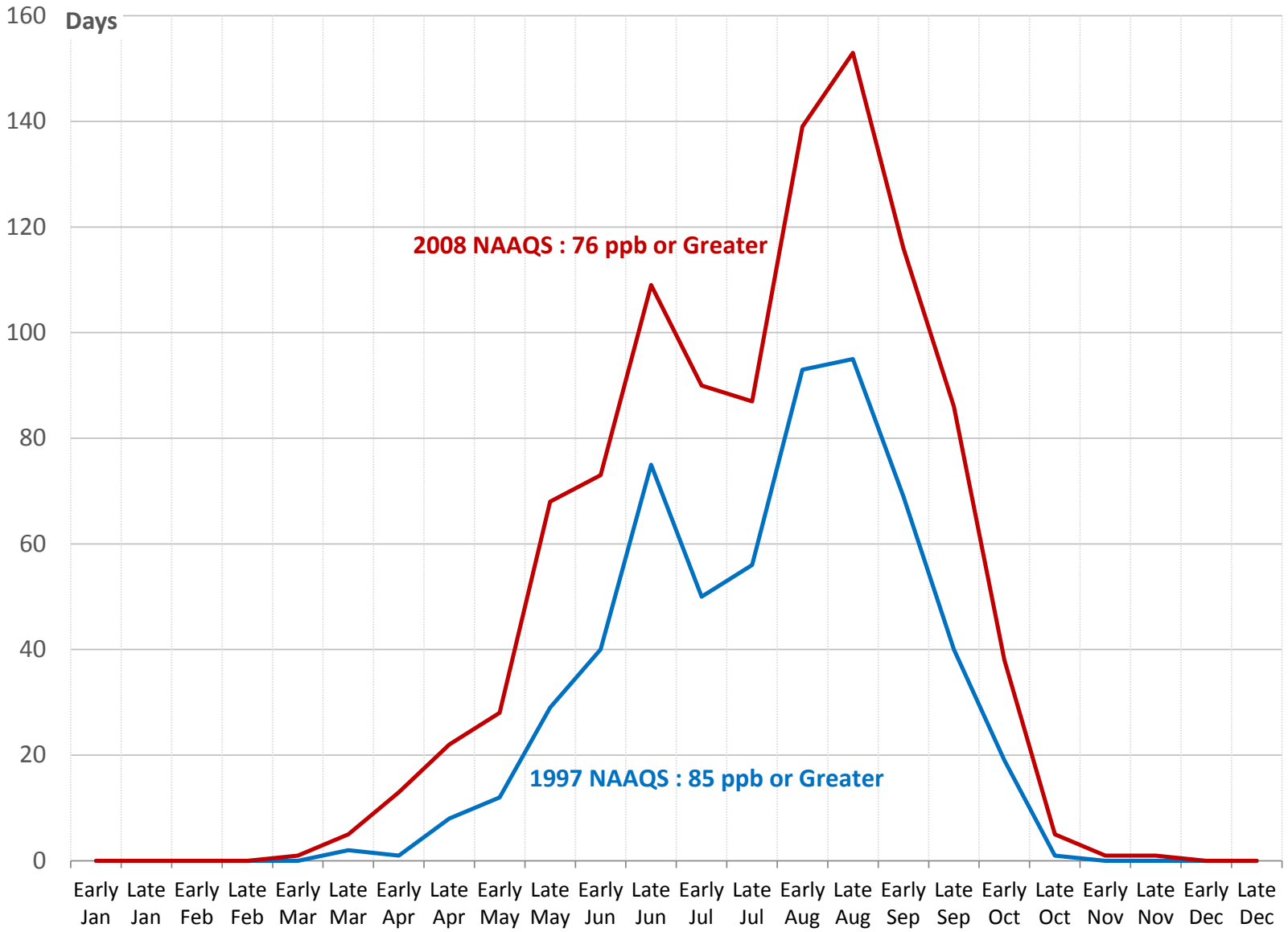
EPA Modeling – 2005 Base Case, 2017 Future Year, 12 km Resolution

Scenario Description	2017 Future Year Ozone Design Values (ppb)	
	Minimum – Kaufman	Maximum - Tarrant
With 30 ppm Sulfur Gasoline	63.93	77.34
With 10 ppm Sulfur Gasoline	63.48	76.25
Net Ozone Reduction	0.45	1.09

TCEQ Modeling – 2006 Base Case, 2018 Future Year, 4 km Resolution

Scenario Description	2018 Future Year Ozone Design Values (ppb)	
	Minimum – Kaufman	Maximum – Denton Airport
With 30 ppm Sulfur Gasoline	63.10	77.09
With 10 ppm Sulfur Gasoline	62.71	76.29
Net Ozone Reduction	0.39	0.80

Days at DFW Regulatory Monitors per Month from 1991-2012 with Ozone Levels Above 75/84 ppb



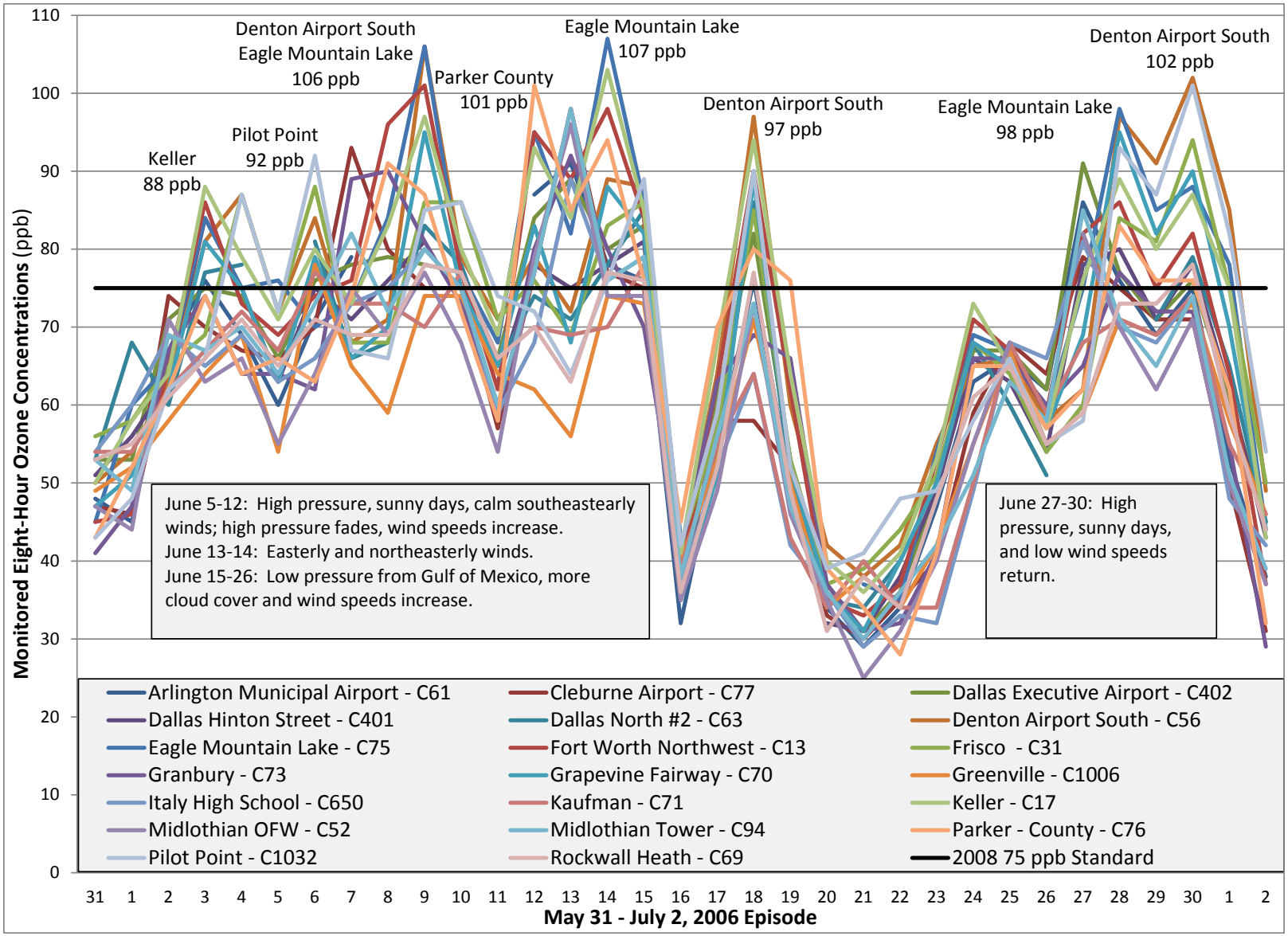
DFW Area Ozone Episodes Modeled Since 1991 for Attainment Demonstration SIPs

Adoption Date	Ozone Episode(s) Modeled	Ozone Standard
September 21, 1994	June 18, 1987 August 25 – 26, 1988 July 31 – August 1, 1991	One-Hour 120 ppb
February 24, 1999	June 18 – 22, 1995 July 1 – 4, 1996	One-Hour 120 ppb
April 19, 2000	June 18 – 22, 1995 July 1 – 4, 1996	One-Hour 120 ppb
May 27, 2007	August 13 – 22, 1999	Eight-Hour 84 ppb
December 7, 2011	May 31 – July 2, 2006	Eight-Hour 84 ppb
May/June of 2015	May 31 – July 2, 2006 August 13 – September 15, 2006	Eight-Hour 75 ppb

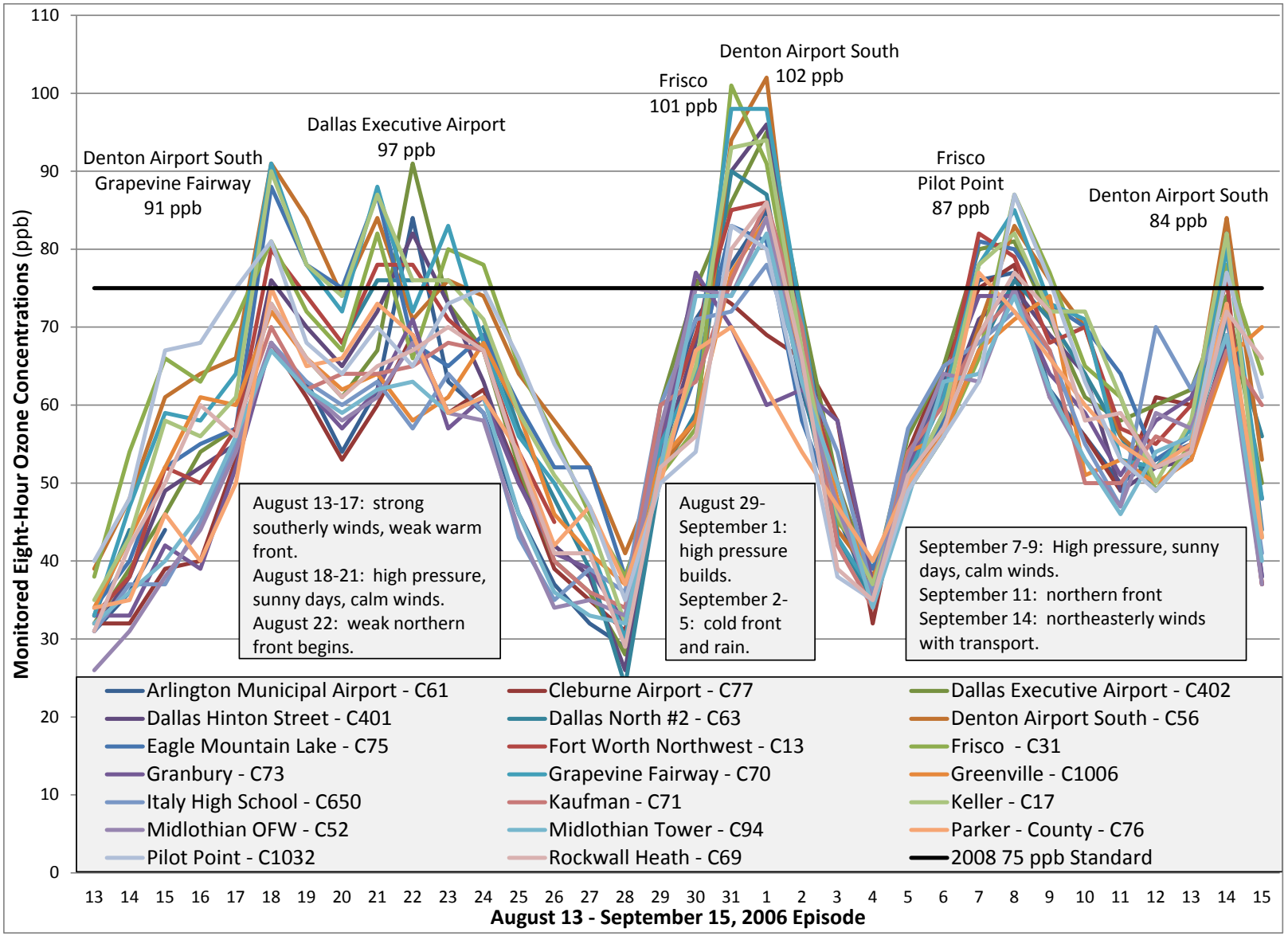
Days at Regulatory Monitors per Month in DFW from 2006-2012 with Ozone Levels Above 75 ppb

Month	2006	2007	2008	2009	2010	2011	2012
January / February	0	0	0	0	0	0	0
March	1	0	0	0	0	0	2
April	2	3	1	1	0	2	0
May	3	1	3	5	4	0	4
June	18	2	6	8	3	4	9
July	9	3	5	7	0	6	5
August	8	11	7	8	9	15	11
September	5	5	8	5	2	11	1
October	4	2	0	0	0	2	0
November / December	0	0	0	0	0	0	0
Annual	50	27	30	34	18	40	32
June Only	18	2	6	8	3	4	9
August/September	13	16	15	13	11	26	12
Jun/Aug/Sep Total	31	18	21	21	14	30	21

DFW Maximum Monitored Eight-Hour Ozone
May 31 – July 2, 2006 Episode

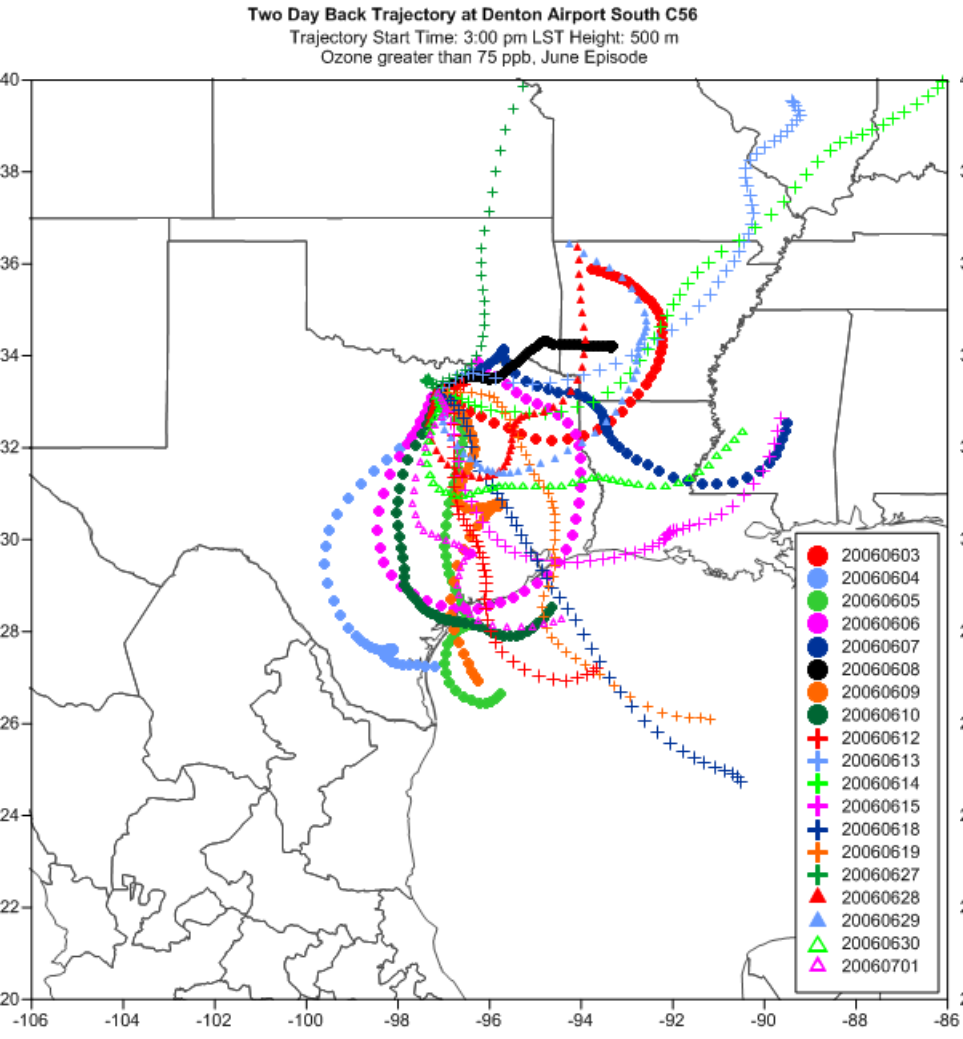


DFW Maximum Monitored Eight-Hour Ozone
August 13 – September 15, 2006 Episode

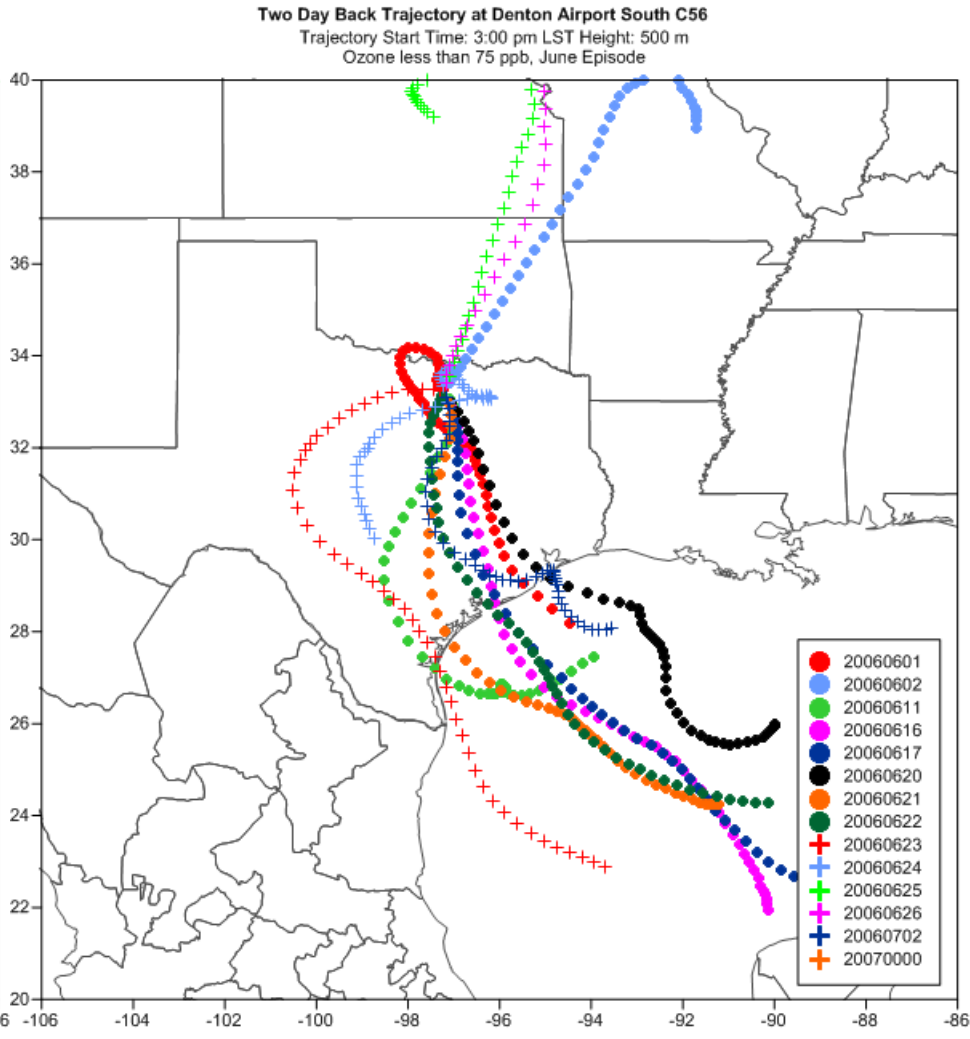


48-Hour Back Trajectories from Denton Airport South Monitor: May 31 – July 2, 2006 Episode

Episode Days Greater than 75 ppb

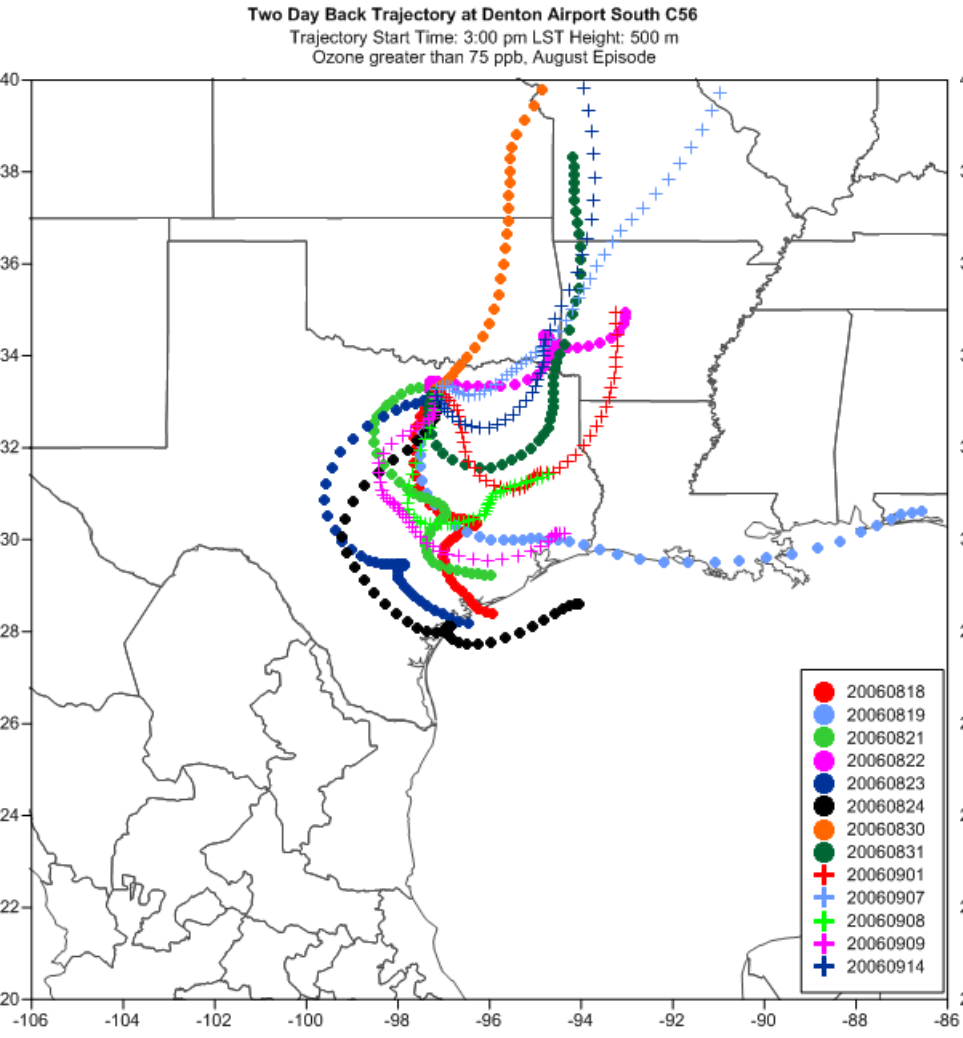


Episode Days Less than 75 ppb

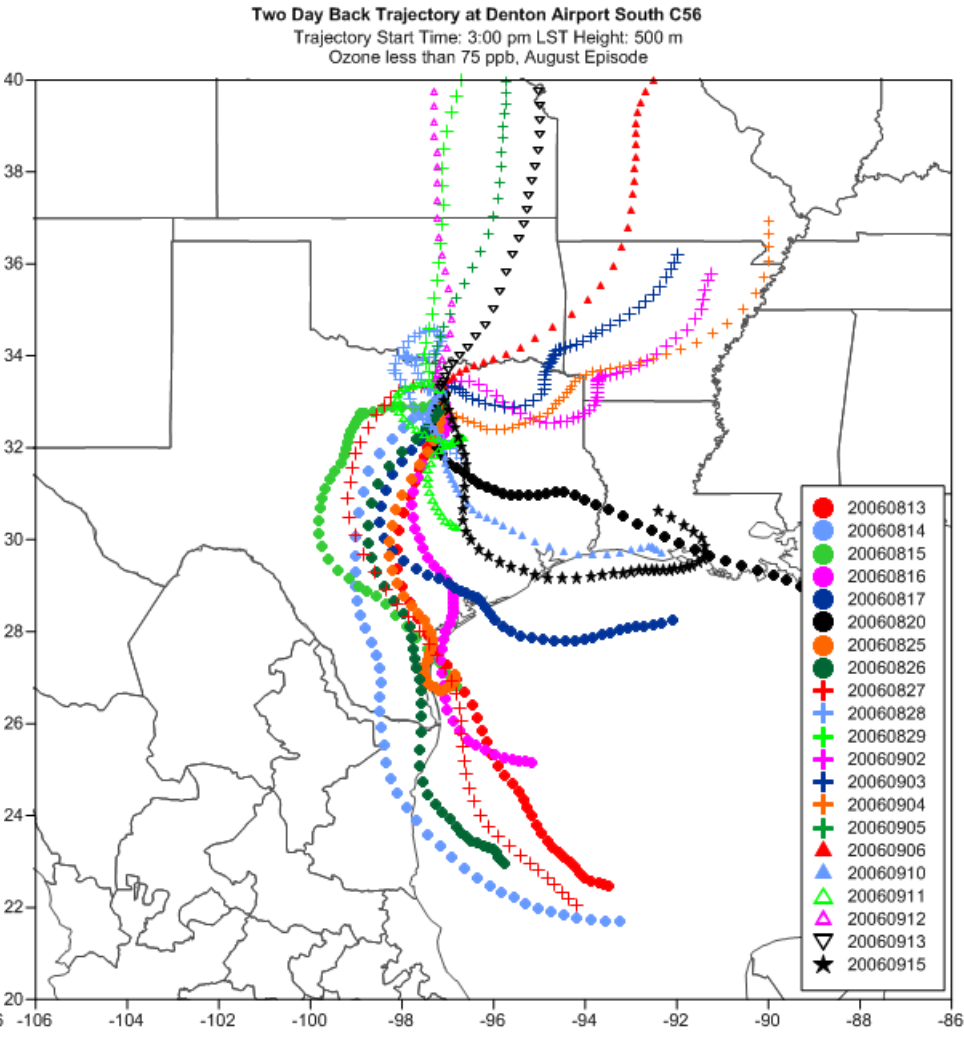


48-Hour Back Trajectories from Denton Airport South Monitor: August 13 – September 15, 2006 Episode

Episode Days Greater than 75 ppb



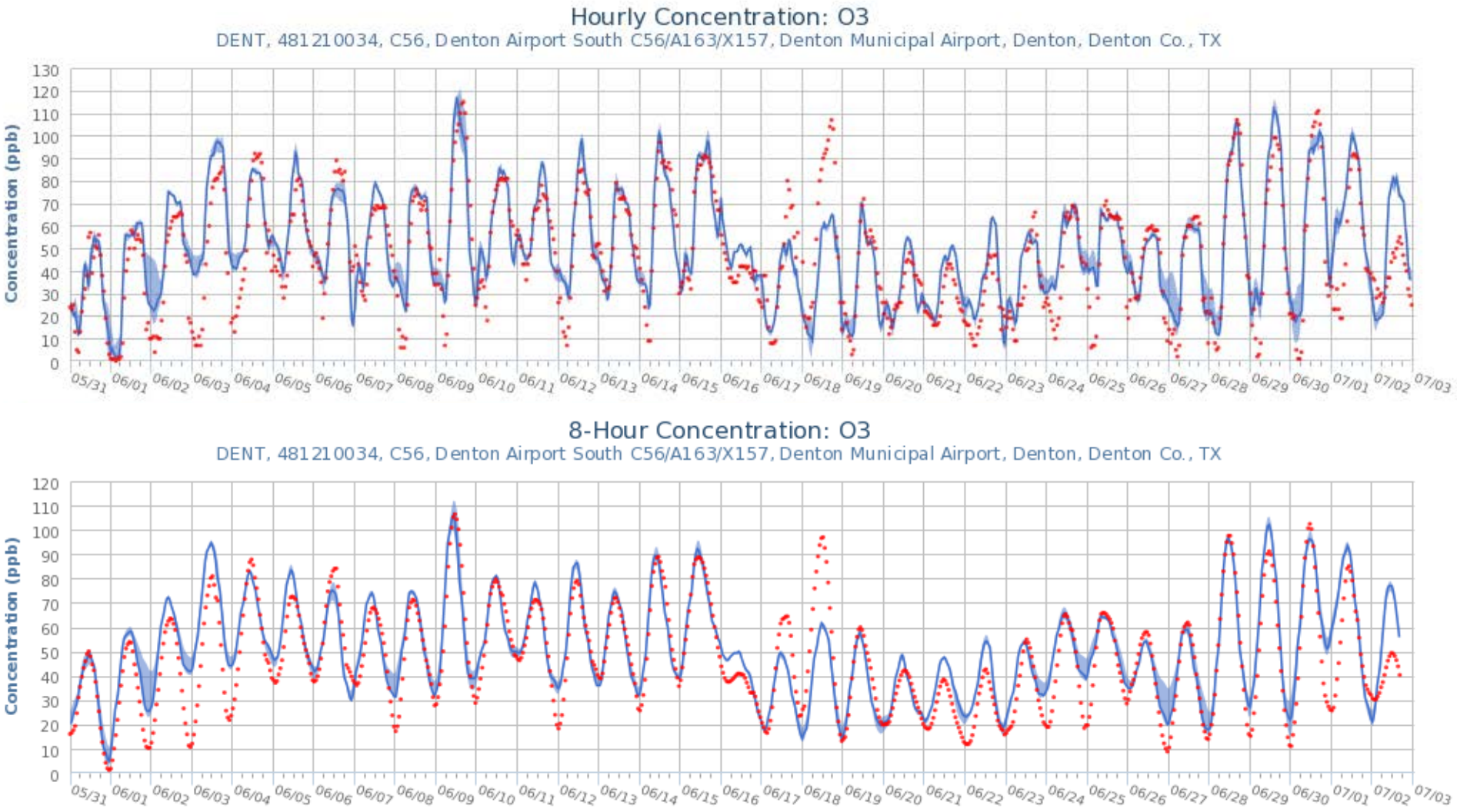
Episode Days Less than 75 ppb



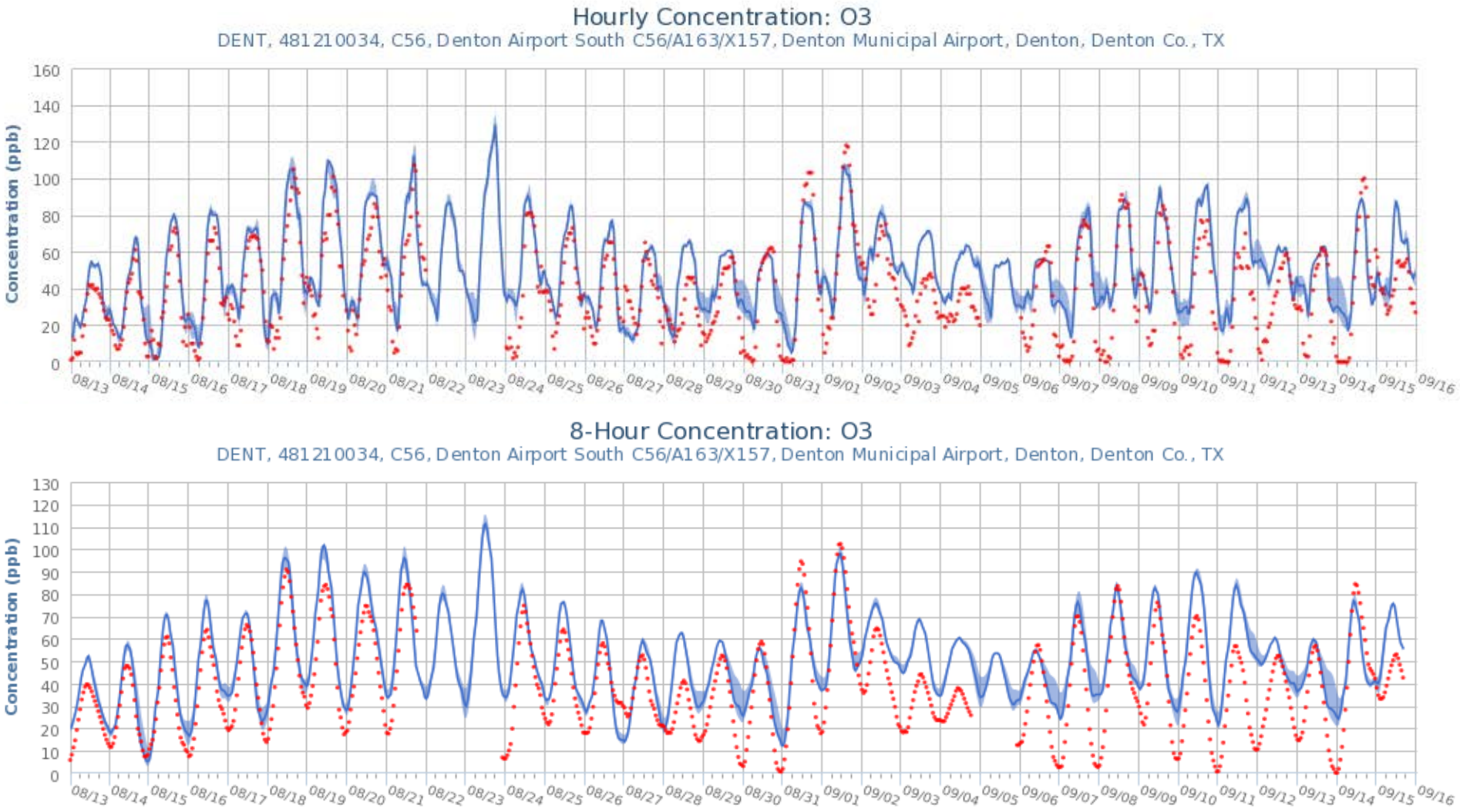
DFW Area Monitor Specific Ozone Data for 67 Days from 2006 Combined Episodes

Monitoring Site Name and CAMS Code	Max Eight-Hour Ozone (ppb)	Days Above 70 ppb	Days Above 75 ppb	Days Above 85 ppb
Denton Airport South - C56	106	29	22	11
Eagle Mountain Lake - C75	107	27	22	9
Keller - C17	103	33	25	11
Grapevine Fairway - C70	98	26	19	9
Fort Worth Northwest - C13	101	27	21	9
Parker - County - C76	101	19	12	4
Frisco - C31	101	25	20	9
Cleburne Airport - C77	98	18	8	2
Dallas Executive Airport - C402	95	28	18	5
Dallas North #2 - C63	90	19	14	3
Arlington Municipal Airport - C61	91	18	14	3
Granbury - C73	92	16	8	3
Dallas Hinton Street - C401	96	22	13	2
Rockwall Heath - C69	86	16	9	1
Greenville - C1006	84	13	3	0
Kaufman - C71	86	11	5	1
Pilot Point - C1032	101	23	17	9
Midlothian Tower - C94	98	17	8	1
Midlothian OFW - C52	96	14	5	1
Italy High School - C650	89	14	6	1

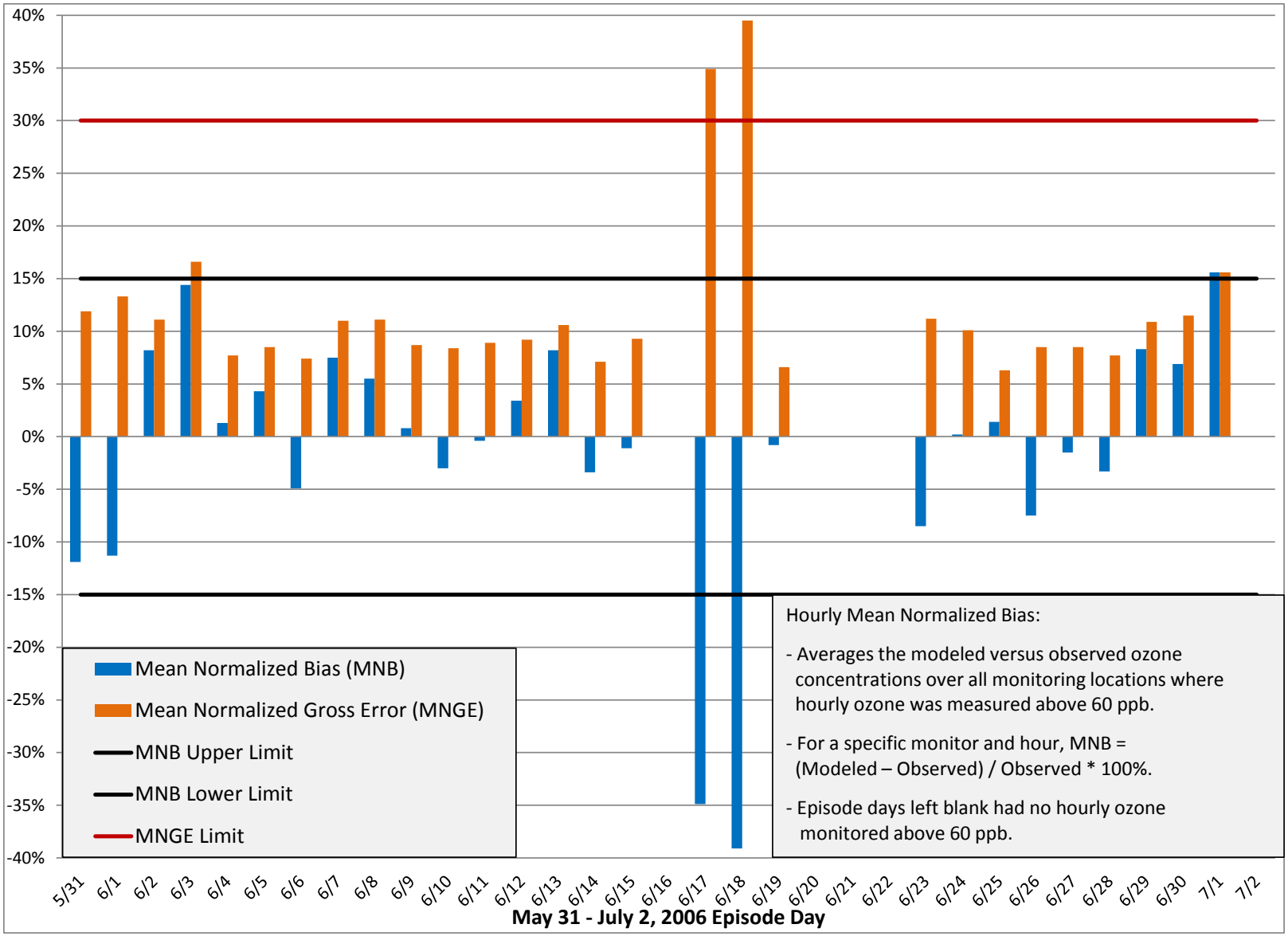
Denton Airport South Ozone Monitor Performance
May 31 – July 2, 2006 Episode



Denton Airport South Ozone Monitor Performance
August 13 – September 15, 2006 Episode



2006 Base Case Hourly Performance Across All Monitors for Episode Days Above 60 ppb – May 31-July 2



Source: EPA *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, April 2007, Section 18.4.1, Ozone Operational Evaluation, Pages 198-202.

2006 Base Case Hourly Performance Across All Monitors for Episode Days Above 60 ppb – August 13-September 15

Source: EPA *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, April 2007, Section 18.4.1, Ozone Operational Evaluation, Pages 198-202.

Comparing Ozone Modeling for Previous DFW Attainment SIP to Current Work

- Base case episodes:
  - Continue to use June 2006 episode (May 31 – July 2) with improvements.
  - Add an August/September 2006 episode (August 13 – September 15) with latest inputs.
- Modeling domain:
  - Previous SIP domain covered two-thirds of eastern U.S. with a fine grid over the DFW area.
  - Newer domain covers most of North America with a large fine grid over eastern Texas.
- Meteorological model:
  - Previous SIP relied on the Fifth Generation Mesoscale Model (MM5, http://www.mmm.ucar.edu/mm5/).
  - Newer work is being done with the Weather and Research Forecasting (WRF, http://www.wrf-model.org/index.php) model.
- Photochemical model:
  - Previous SIP relied on the Comprehensive Air Quality Model with Extensions (CAM_X, http://camx.com/) version 5.20.1.
  - CAM_X version 6.00 was released on May 6, 2013, and either it or future updates will be used.
- Speciation mechanism:
  - Previous SIP relied on the Carbon Bond 05 (CB-05) speciation mechanism that typically underestimated ozone levels.
  - Current work is being done with improved Carbon Bond 6 (CB6) mechanism.
- Emissions inventory:
  - Latest available inputs for on-road, non-road, off-road, oil and gas, area, point, etc.
  - For biogenics, now using Model of Emissions of Gases and Aerosols from Nature model (MEGAN, http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm) model instead of the Global Biosphere and Interactions System (GLOBEIS, http://www.globeis.com/) model.

Back to the 2012 Future Case with the June 2006 Episode – Updating Last DFW SIP

DFW Area Monitor and CAMS Code	2012 Future Design Value (ppb)		2012 Regulatory Design Value (ppb)
	CAMx 5.2 – CB05 MM5 – GLOBEIS	CAMx 6.0 – CB6 WRF - MEGAN	
Denton Airport South - C56	77	84	83
Eagle Mountain Lake - C75	78	82	82
Grapevine Fairway - C70	76	82	86
Keller - C17	76	81	87
Fort Worth Northwest - C13	75	80	79
Frisco - C31	74	79	83
Dallas North #2 - C63	71	77	81
Parker County - C76	72	78	78
Dallas Executive Airport - C402	70	77	81
Cleburne Airport - C77	70	76	79
Arlington Municipal Airport - C61	70	75	83
Dallas Hinton Street - C401	67	74	82
Granbury - C73	69	74	77
Midlothian Tower - C94	66	73	Monitor Not Operational
Pilot Point - C1032	67	73	82
Rockwall Heath - C69	63	70	77
Greenville - C1006	60	67	72
Midlothian OFW - C52	62	68	76
Kaufman - C71	60	67	70

Preliminary 2018 DFW Future Ozone Design Values – Comparing CB05/CB6 Mechanisms

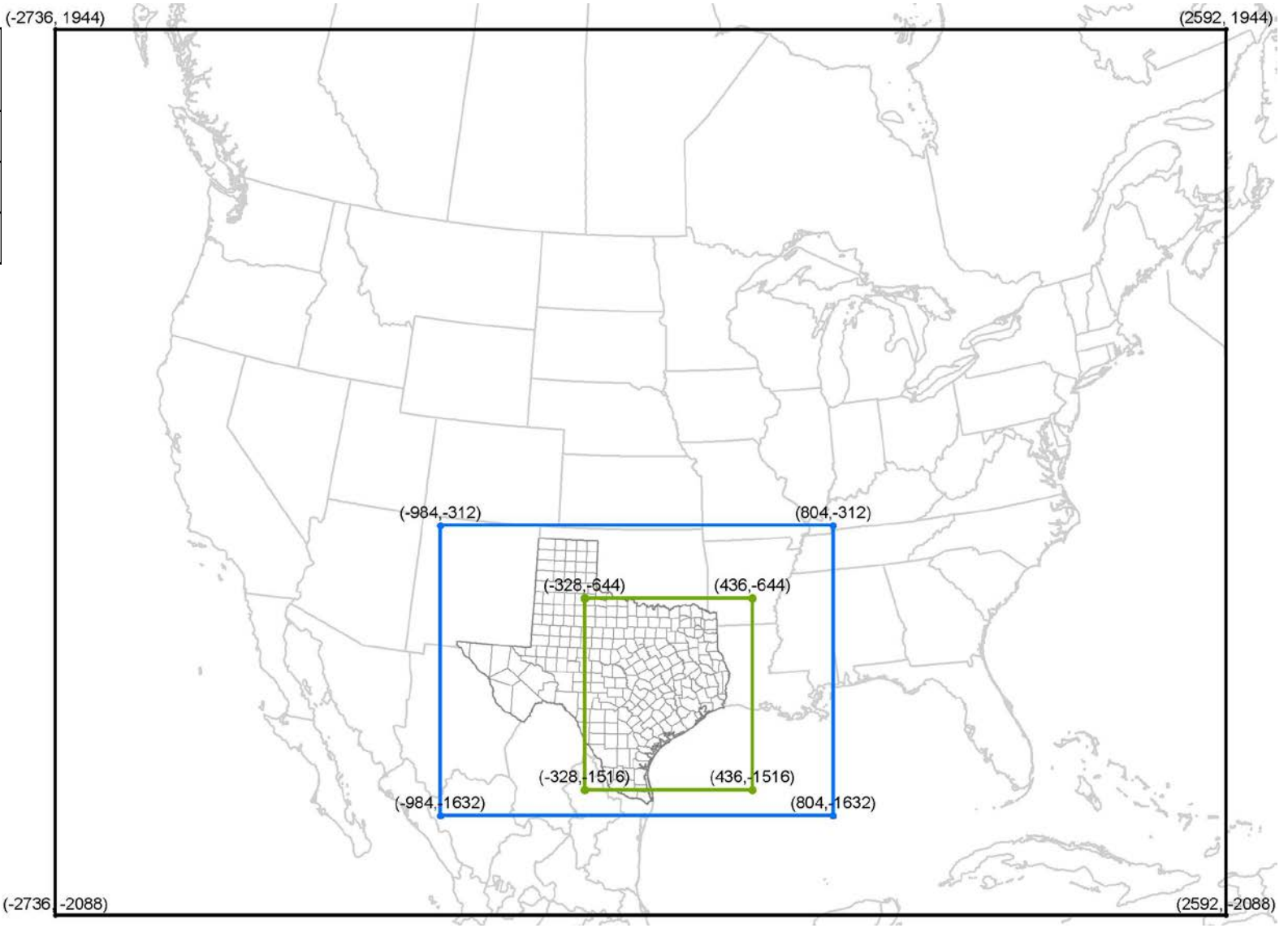
DFW Area Monitor and CAMS Code	2018 Future Design Values for Both Episodes (ppb)		
	CB05 Mechanism	CB6 Mechanism	Net Increase
Denton Airport South - C56	75.69	77.09	1.40
Eagle Mountain Lake - C75	74.91	76.38	1.47
Grapevine Fairway - C70	74.53	76.12	1.59
Keller - C17	74.01	75.31	1.30
Fort Worth Northwest - C13	72.81	74.07	1.26
Frisco - C31	71.79	73.33	1.54
Dallas North #2 - C63	70.29	71.82	1.53
Parker County - C76	70.92	71.75	0.83
Dallas Executive Airport - C402	70.54	71.41	0.87
Cleburne Airport - C77	69.40	70.91	1.51
Arlington Municipal Airport - C61	68.96	69.92	0.96
Dallas Hinton Street - C401	67.38	68.85	1.47
Granbury - C73	67.74	68.56	0.82
Midlothian Tower - C94	66.90	68.09	1.19
Pilot Point - C1032	65.73	66.91	1.18
Rockwall Heath - C69	64.84	65.82	0.98
Greenville - C1006	63.42	63.40	-0.02
Midlothian OFW - C52	62.25	63.38	1.13
Kaufman - C71	63.46	63.10	-0.36

Preliminary 2018 DFW Future Ozone Design Values – June versus August/September

DFW Area Monitor and CAMS Code	2018 Future Design Values (ppb)		
	June Episode	August/September Episode	Both Episodes
Denton Airport South - C56	77.67	76.58	77.09
Eagle Mountain Lake - C75	76.40	76.36	76.38
Grapevine Fairway - C70	76.33	75.89	76.12
Keller - C17	75.37	75.26	75.31
Fort Worth Northwest - C13	74.61	73.50	74.07
Frisco - C31	73.69	73.01	73.33
Dallas North #2 - C63	72.07	71.54	71.82
Parker County - C76	72.16	71.74	71.75
Dallas Executive Airport - C402	72.29	70.49	71.41
Cleburne Airport - C77	70.78	71.31	70.91
Arlington Municipal Airport - C61	70.47	69.30	69.92
Dallas Hinton Street - C401	69.34	68.34	68.85
Granbury - C73	68.92	68.32	68.56
Midlothian Tower - C94	68.71	67.34	68.09
Pilot Point - C1032	67.28	66.61	66.91
Rockwall Heath - C69	66.70	65.04	65.82
Greenville - C1006	64.03	62.79	63.40
Midlothian OFW - C52	64.02	62.62	63.38
Kaufman - C71	63.77	62.49	63.10

North American Regional Planning Organizations (RPO) Domains for Texas Air Quality Modeling Efforts

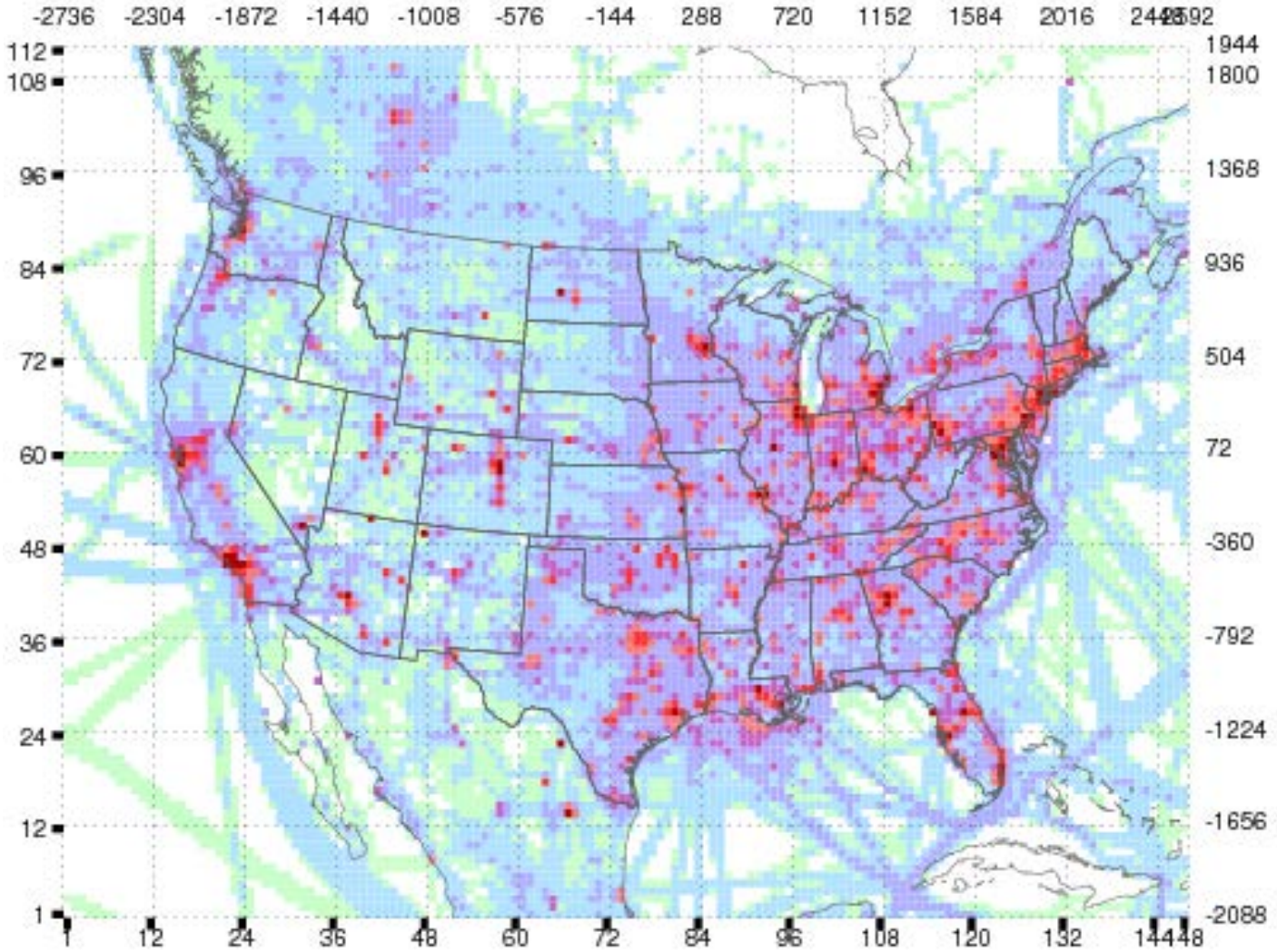
Domain Name	Grid Cells
tx_4km	16,576
tx_12km	6,580
rpo_36km	41,638

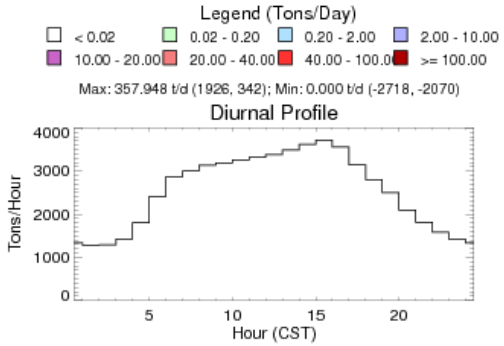


2006 Summer Weekday NO_x Emission Estimates for North American 36 km Domain – June 14 Episode Day

Emissions Plotted

Country	Tons/Day
Canada	4742.66
Mexico	1165.40
United States	48791.95
Area SUBTOTAL:	54700.01
MAP TOTAL:	61453.95

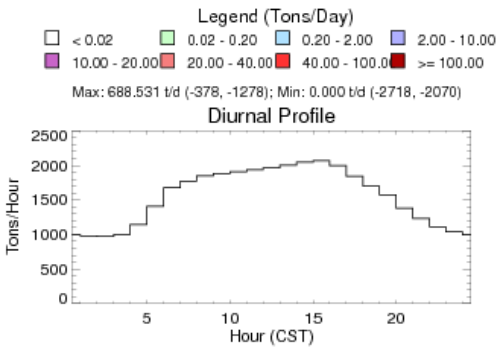


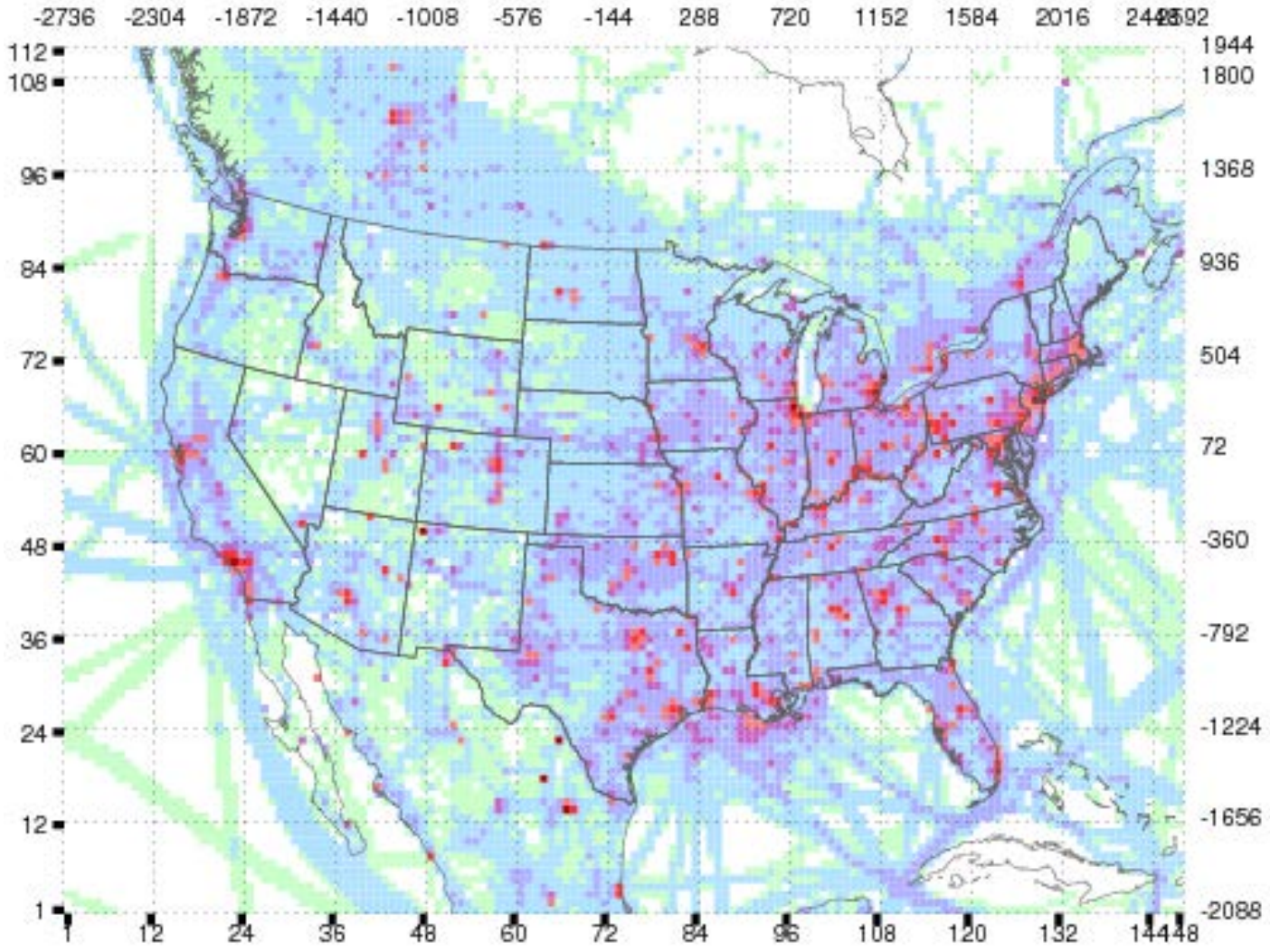


2018 Summer Weekday NO_x Emission Estimates for North American 36 km Domain – June 14 Episode Day

Emissions Plotted

Country	Tons/Day
Canada	3610.56
Mexico	1457.81
United States	27685.85
Area SUBTOTAL:	32754.22
MAP TOTAL:	37496.47

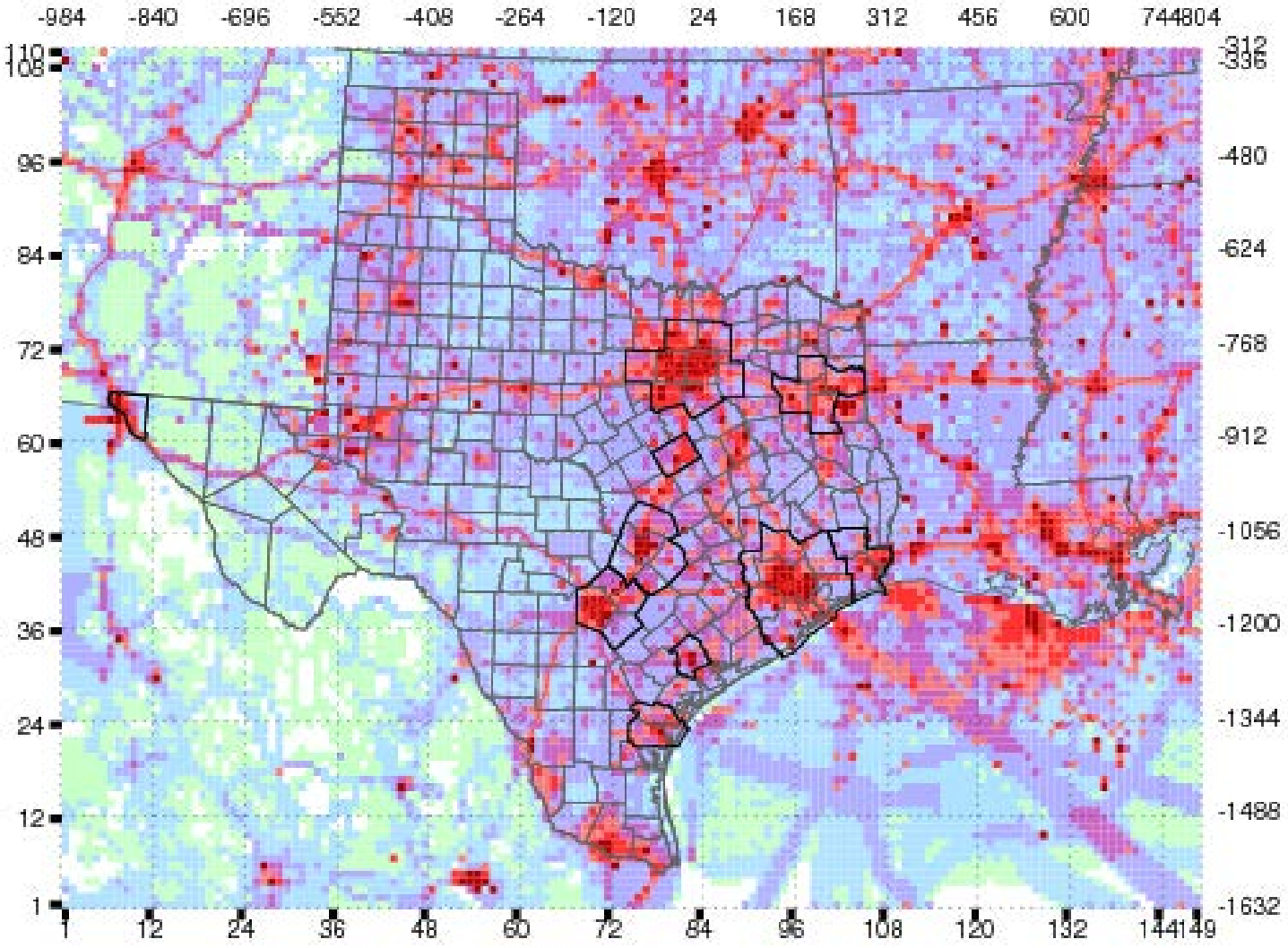


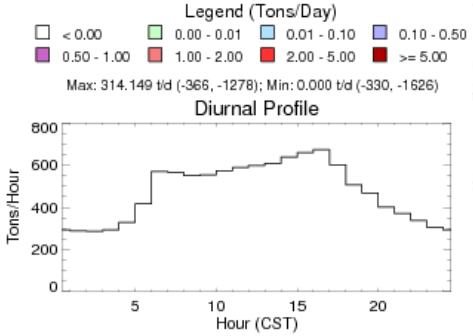


2006 Summer Weekday Anthropogenic NO_X Emissions Texas 12 km Domain – June 14 Episode Day

Emissions Plotted

Area	Tons/Day
Arkansas	700.49
Kansas	31.25
Kentucky	21.14
Louisiana	1325.18
Mississippi	702.52
Missouri	132.39
New Mexico	372.63
Oklahoma	1279.60
Tennessee	278.00
Texas	4537.53
Mexico	821.55
Gulf of Mexico	1143.21
Area SUBTOTAL:	11345.49
MAP TOTAL:	11493.98

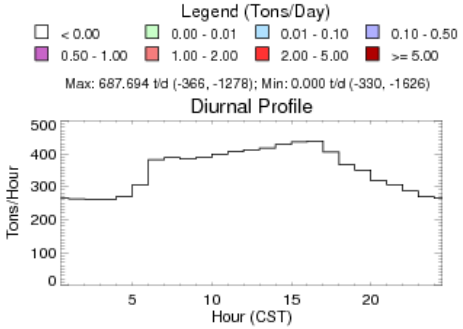


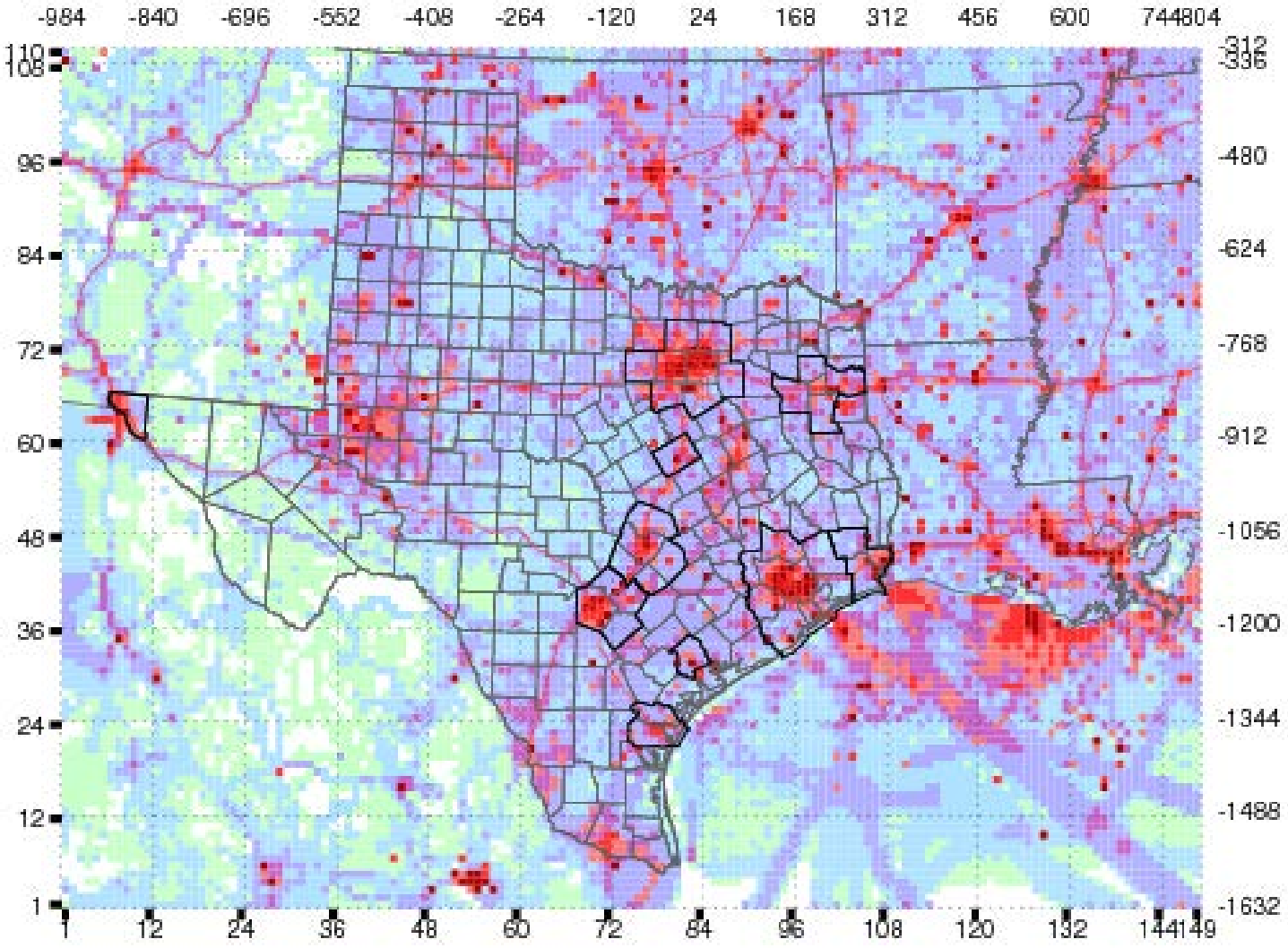


2018 Summer Weekday Anthropogenic NO_X Emissions Texas 12 km Domain – June 14 Episode Day

Emissions Plotted

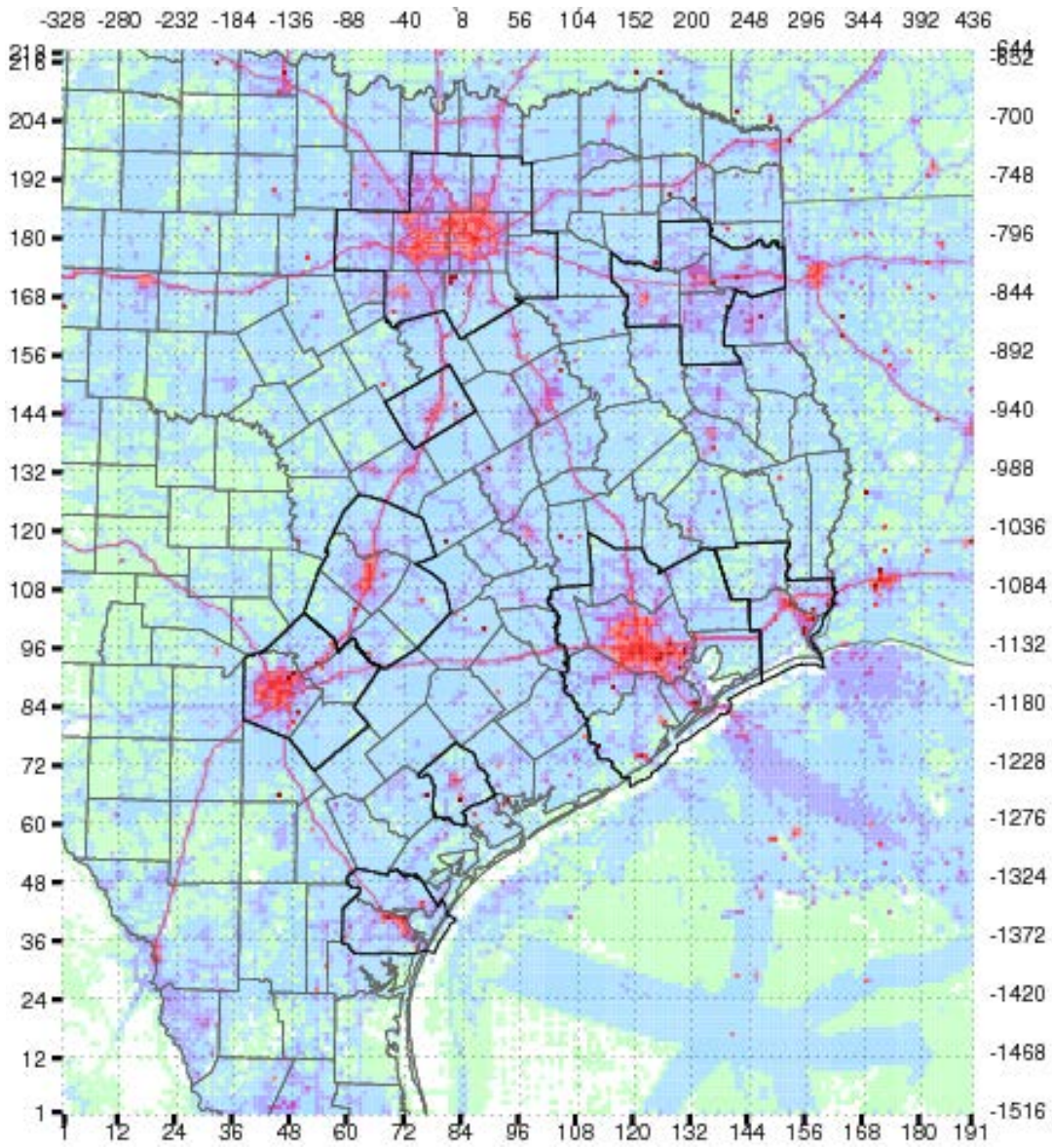
Area	Tons/Day
Arkansas	456.47
Kansas	23.73
Kentucky	15.56
Louisiana	968.80
Mississippi	401.95
Missouri	123.94
New Mexico	204.68
Oklahoma	876.72
Tennessee	157.70
Texas	2761.53
Mexico	1295.53
Gulf of Mexico	1022.40
Area SUBTOTAL:	8309.01
MAP TOTAL:	8407.66





2006 Summer Weekday Anthropogenic NO_X Emissions Texas 4 km Domain – June 14 Episode Day

Map Total = 4523.73 NO_X tpd

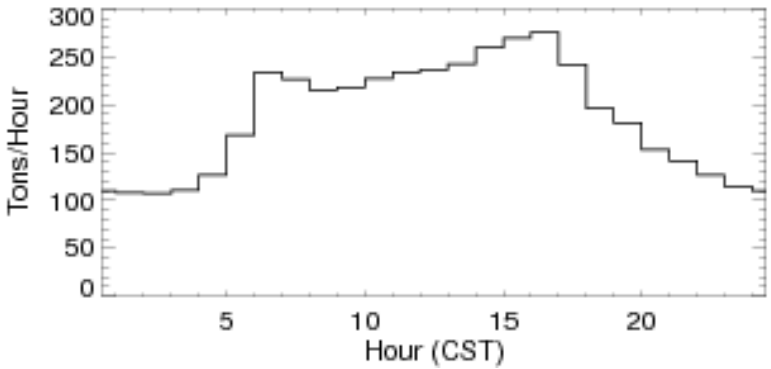


Legend (Tons/Day)

< 0.00	0.00 - 0.01	0.01 - 0.10	0.10 - 0.50
0.50 - 1.00	1.00 - 2.00	2.00 - 5.00	>= 5.00

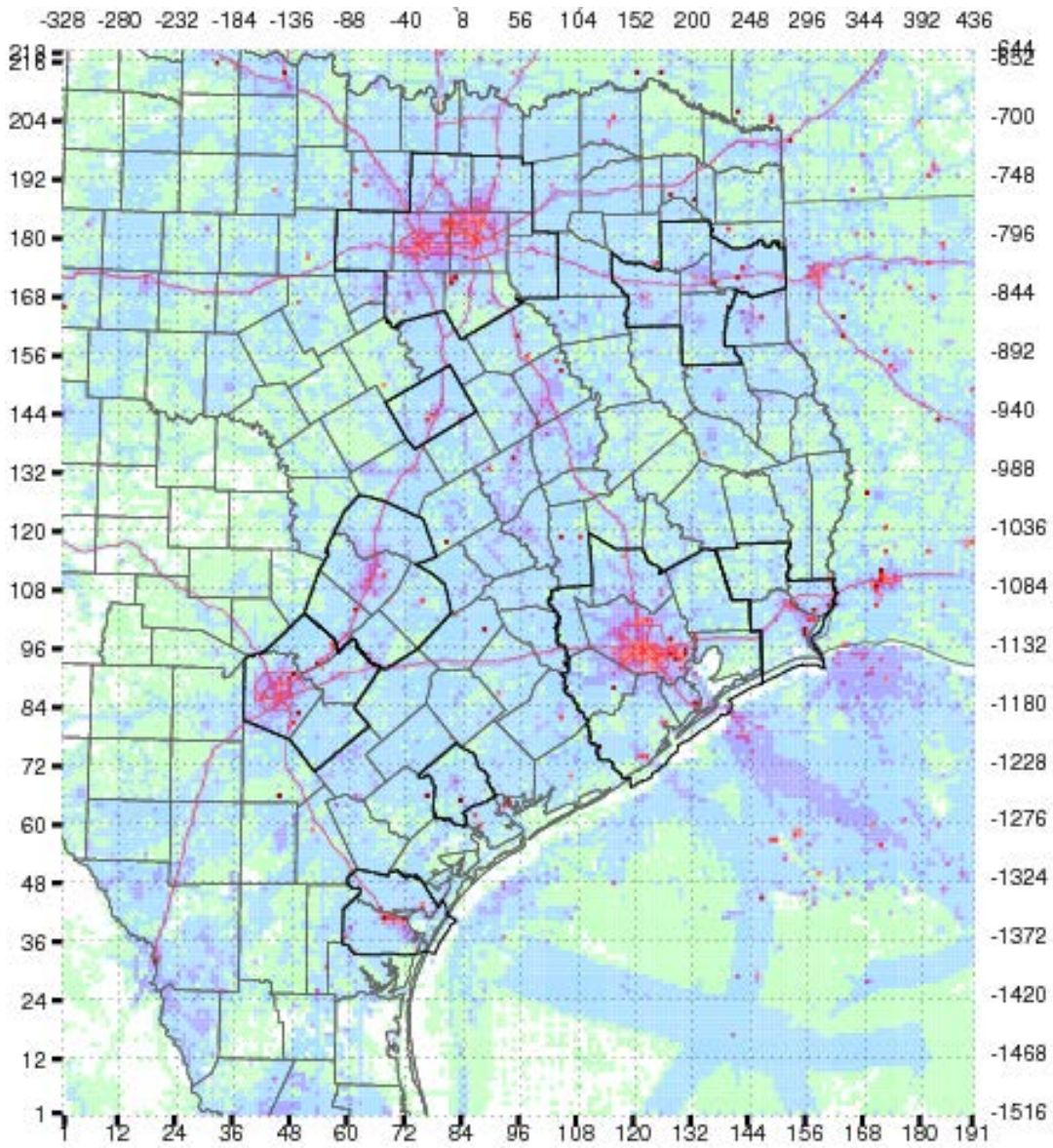
Max: 47.436 t/d (230, -854); Min: 0.000 t/d (-326, -1514)

Diurnal Profile



2018 Summer Weekday Anthropogenic NO_X Emissions Texas 4 km Domain – June 14 Episode Day

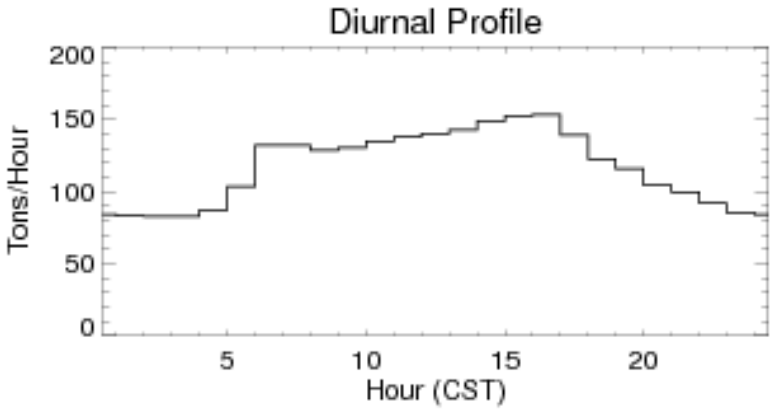
Map Total = 2814.11 NO_X tpd



Legend (Tons/Day)

< 0.00	0.00 - 0.01	0.01 - 0.10	0.10 - 0.50
0.50 - 1.00	1.00 - 2.00	2.00 - 5.00	>= 5.00

Max: 42.614 t/d (70, -950); Min: 0.000 t/d (-326, -1514)



2018 Ten-County DFW Area Anthropogenic Emissions Summary by Source Category

Source Category Description	2018 Summer Weekday Emissions (tpd)				
	NO_X	VOC	CO	SO_2	$PM_{2.5}$
On-Road	113.21	55.61	670.82	1.04	3.06
Non-Road	39.87	32.77	577.15	0.11	3.98
Area	30.76	284.94	78.09	7.14	80.82
Airports	11.77	3.53	34.59	1.36	0.23
Locomotive - Line-Haul	12.78	0.55	3.26	0.07	0.32
Locomotive - Switchers	6.11	0.39	0.84	0.02	0.15
Oil and Gas - Production	12.20	43.54	14.39	0.01	0.33
Oil and Gas - Drill Rigs	5.83	0.01	0.42	0.83	0.12
Point - Electric Utilities	10.22	1.73	24.96	0.39	2.45
Point - Cement Kilns	17.60	0.80	12.18	26.54	1.80
Point - Other	24.95	44.26	29.02	6.07	5.32
Total	285.30	468.13	1,445.72	43.59	98.58

2018 Ten-County DFW Area Anthropogenic Emissions Distribution by Source Category

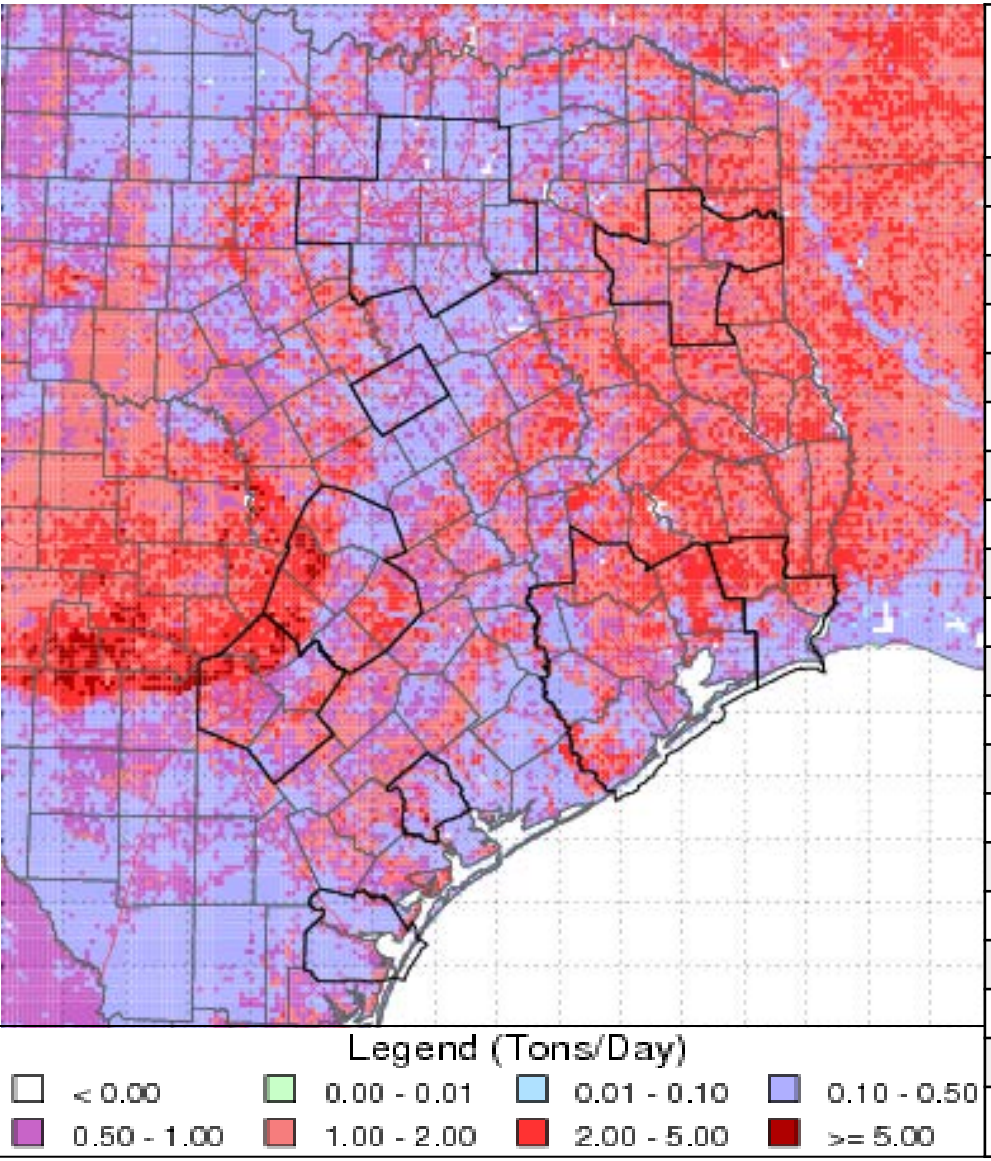
Source Category Description	2018 Summer Weekday Emissions Distribution				
	NO_X	VOC	CO	SO_2	$PM_{2.5}$
On-Road	39.68%	11.88%	46.40%	2.39%	3.11%
Non-Road	13.97%	7.00%	39.92%	0.26%	4.04%
Area	10.78%	60.87%	5.40%	16.39%	81.98%
Airports	4.12%	0.76%	2.39%	3.13%	0.23%
Locomotive - Line-Haul	4.48%	0.12%	0.23%	0.15%	0.33%
Locomotive - Switchers	2.14%	0.08%	0.06%	0.04%	0.16%
Oil and Gas - Production	4.27%	9.30%	1.00%	0.03%	0.33%
Oil and Gas - Drill Rigs	2.04%	0.00%	0.03%	1.90%	0.12%
Point - Electric Utilities	3.58%	0.37%	1.73%	0.88%	2.48%
Point - Cement Kilns	6.17%	0.17%	0.84%	60.88%	1.82%
Point - Other	8.75%	9.45%	2.01%	13.93%	5.40%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Speciation of Volatile Organic Compounds with the Carbon Bond 6 (CB6) Mechanism

Carbon Bond 6 (CB6) Species		Maximum Incremental Reactivity (MIR)		
Code	**Description**	Moles O_3/VOC	Relative to XYL	XYL Ton Ratio
XYL	Xylene and Other Polyalkyl Aromatics	20.50	100.0%	1.00
IOLE	Internal Olefin Carbon Bond (R-C=C-R)	16.00	78.0%	1.28
ISOP	**Isoprene**	**12.70**	**62.0%**	**1.61**
TERP	**Monoterpenes**	**9.91**	**48.3%**	**2.07**
OLE	Terminal Olefin Carbon Bond (R-C=C)	9.66	47.1%	2.12
ALDX	Propionaldehyde and Higher Aldehydes	8.35	40.7%	2.46
TOL	Toluene and Other Monoalkyl Aromatics	7.39	36.0%	2.78
ALD2	Acetaldehyde	5.80	28.3%	3.53
ETH	Ethene	4.95	24.1%	4.15
FORM	Formaldehyde	4.87	23.8%	4.20
KET	Ketone Carbon Bond (C=O)	4.86	23.7%	4.22
ETOH	Ethanol	1.53	7.5%	13.33
ETHY	Ethyne	1.39	6.8%	14.71
ACET	Acetone	0.56	2.8%	35.71
PRPA	**Propane**	**0.54**	**2.6%**	**38.46**
PAR	**Paraffin Carbon Bond (C-C)**	**0.51**	**2.5%**	**40.00**
BENZ	Benzene	0.49	2.4%	41.67
MEOH	Methanol	0.48	2.3%	43.48
ETHA	Ethane	0.14	0.7%	142.86

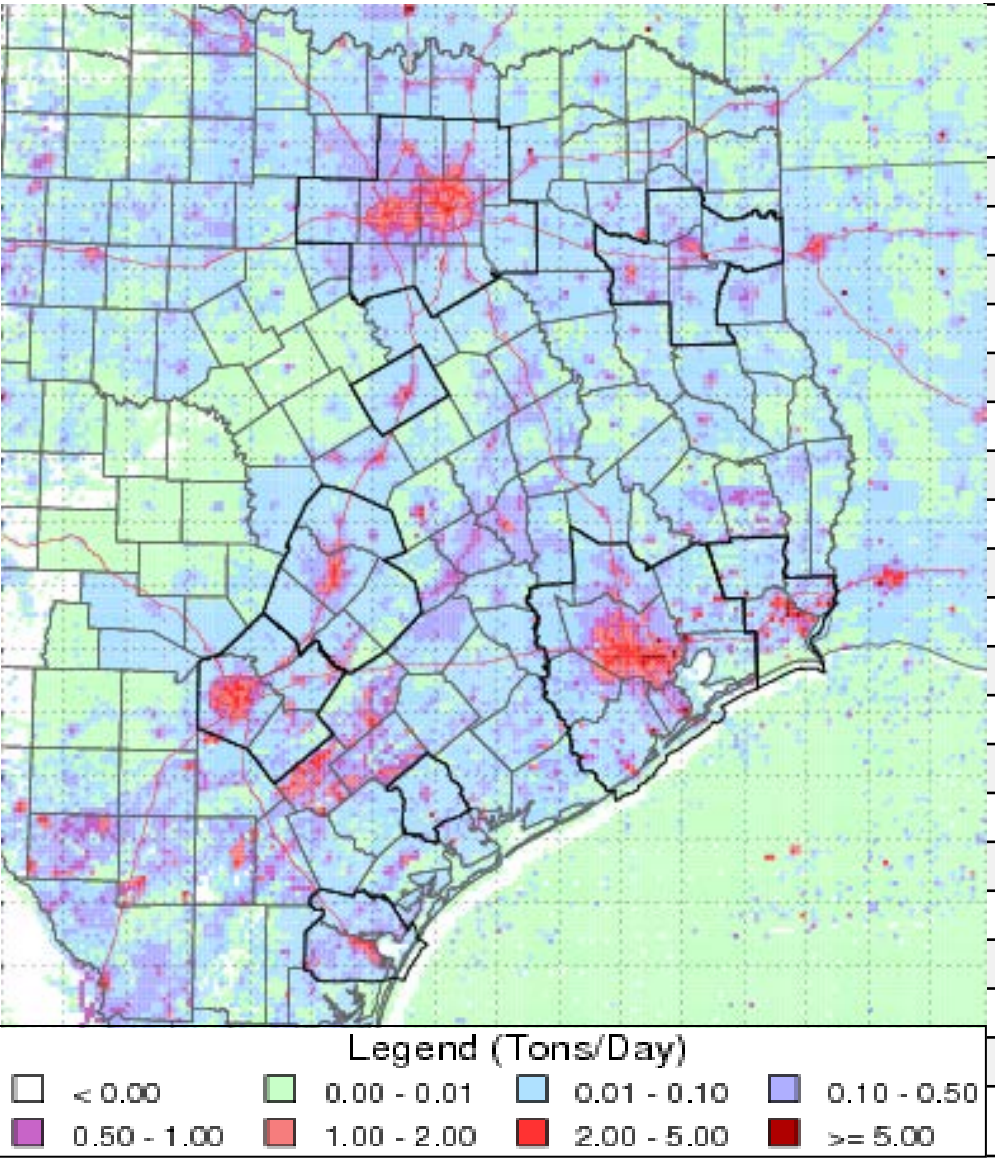
Source: *CAM_X User's Guide, Version 6.00*, Environ, May 2013, Table C-3, Page 290.

2018 Summer Weekday - June 14th Episode Day
Reactivity Summary of Biogenic VOC Emissions



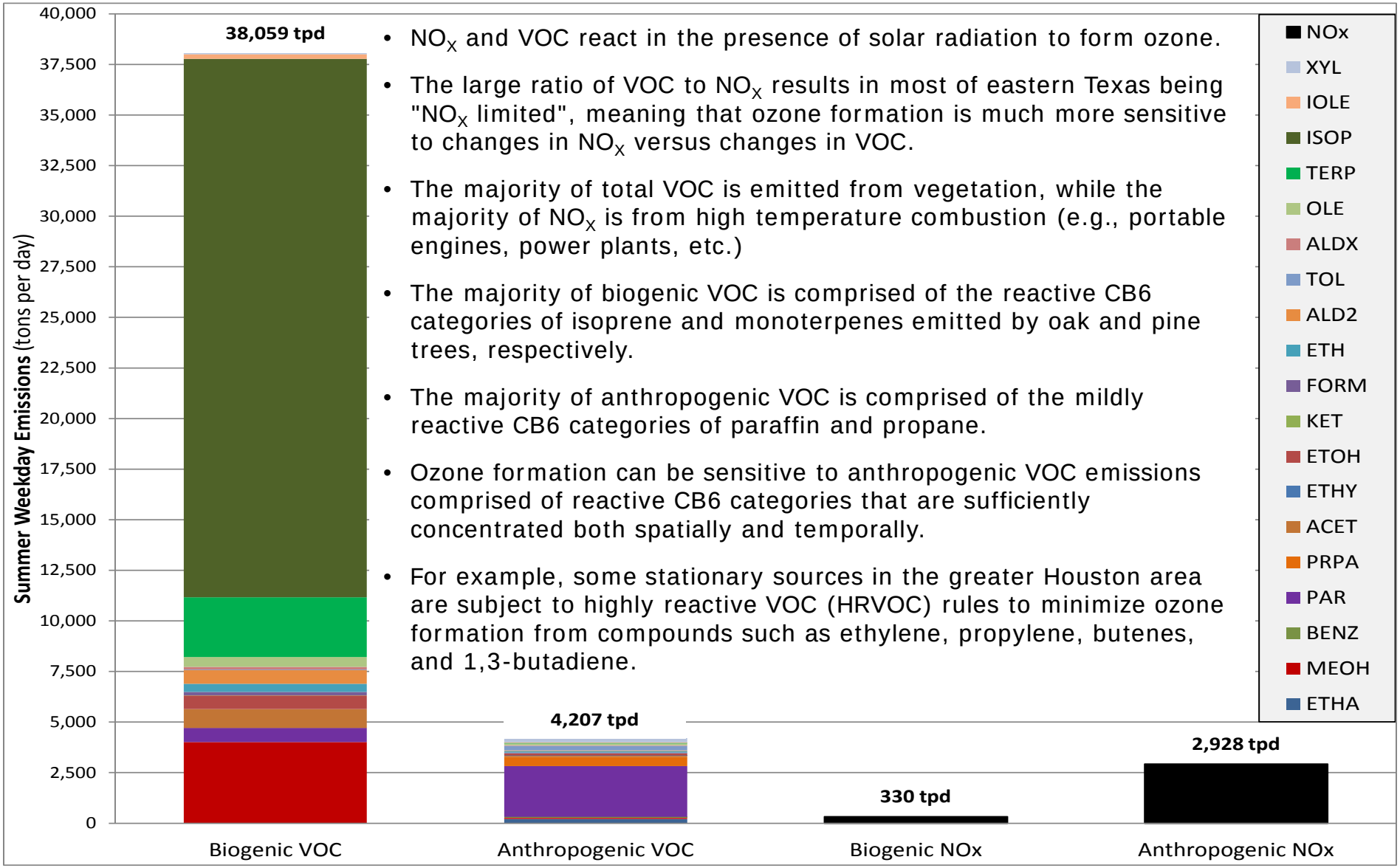
CB6 Code	Reactivity Index	Biogenic Emissions	
		Tons per Day	Distribution
XYL	100.0%	49	0.1%
IOLE	78.0%	231	0.6%
ISOP	**62.0%**	**26,607**	**69.9%**
TERP	**48.3%**	**2,954**	**7.8%**
OLE	47.1%	491	1.3%
ALDX	40.7%	131	0.3%
TOL	36.0%	27	0.1%
ALD2	28.3%	671	1.8%
ETH	24.1%	409	1.1%
FORM	23.8%	162	0.4%
KET	23.7%	10	0.0%
ETOH	7.5%	670	1.8%
ETHY	6.8%	0	0.0%
ACET	2.8%	932	2.4%
PRPA	2.6%	1	0.0%
PAR	2.5%	699	1.8%
BENZ	2.4%	0	0.0%
MEOH	2.3%	4,007	10.5%
ETHA	0.7%	7	0.0%
VOC Total		38,059	100.0%

2018 Summer Weekday - June 14th Episode Day
Reactivity Summary of Anthropogenic VOC Emissions



CB6 Code	Reactivity Index	Anthropogenic Emissions	
		Tons per Day	Distribution
XYL	100.0%	202	4.8%
IOLE	78.0%	31	0.7%
ISOP	62.0%	2	0.0%
TERP	48.3%	37	0.9%
OLE	47.1%	77	1.8%
ALDX	40.7%	27	0.7%
TOL	36.0%	231	5.5%
ALD2	28.3%	27	0.7%
ETH	24.1%	72	1.7%
FORM	23.8%	46	1.1%
KET	23.7%	9	0.2%
ETOH	7.5%	97	2.3%
ETHY	6.8%	12	0.3%
ACET	2.8%	69	1.6%
PRPA	**2.6%**	**442**	**10.5%**
PAR	**2.5%**	**2,508**	**59.6%**
BENZ	2.4%	56	1.3%
MEOH	2.3%	44	1.0%
ETHA	0.7%	217	5.2%
VOC Total		4,207	100.0%

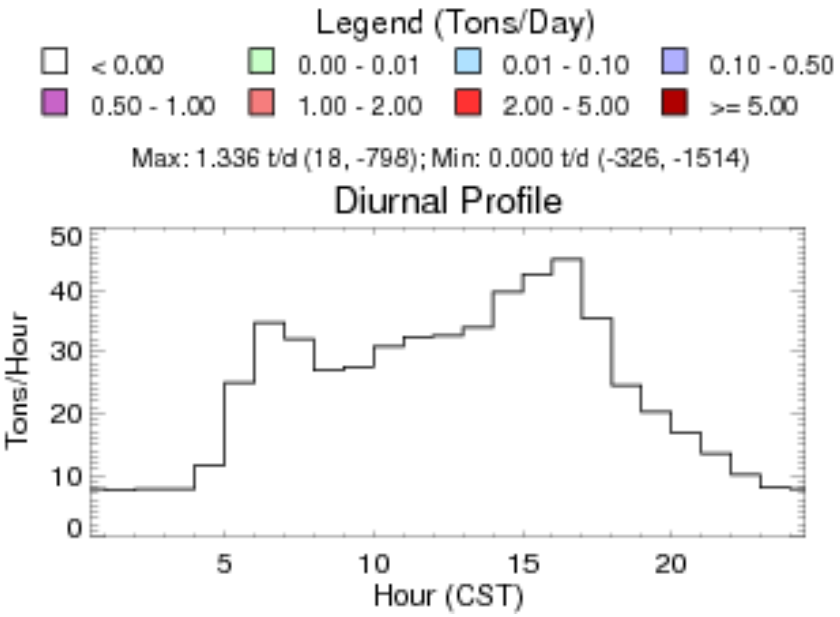
2018 Summer Weekday NO_X and VOC Emission Totals Texas 4 km Domain – June 14 Episode Day

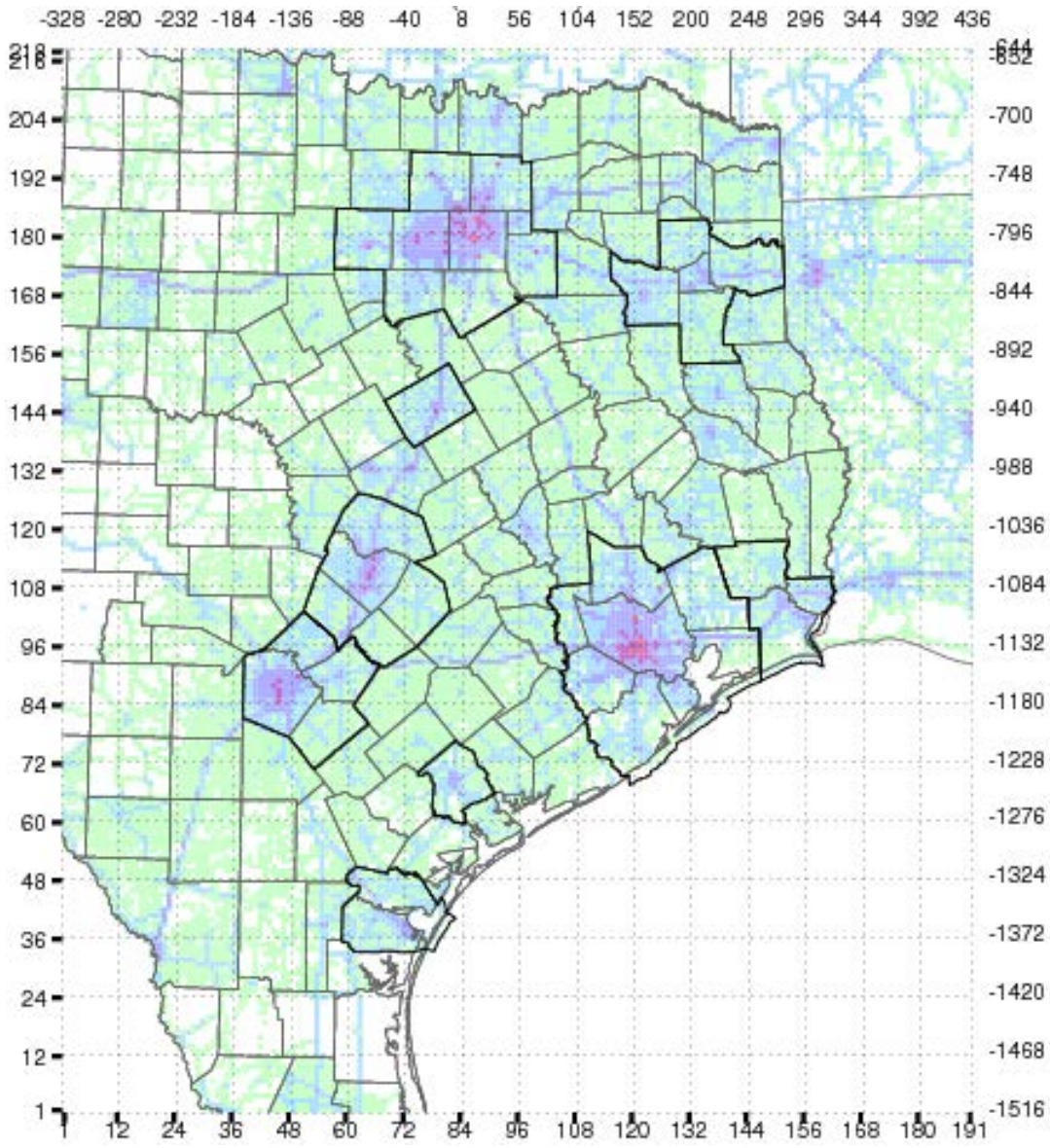


- NO_X and VOC react in the presence of solar radiation to form ozone.
- The large ratio of VOC to NO_X results in most of eastern Texas being "NO_X limited", meaning that ozone formation is much more sensitive to changes in NO_X versus changes in VOC.
- The majority of total VOC is emitted from vegetation, while the majority of NO_X is from high temperature combustion (e.g., portable engines, power plants, etc.)
- The majority of biogenic VOC is comprised of the reactive CB6 categories of isoprene and monoterpenes emitted by oak and pine trees, respectively.
- The majority of anthropogenic VOC is comprised of the mildly reactive CB6 categories of paraffin and propane.
- Ozone formation can be sensitive to anthropogenic VOC emissions comprised of reactive CB6 categories that are sufficiently concentrated both spatially and temporally.
- For example, some stationary sources in the greater Houston area are subject to highly reactive VOC (HRVOC) rules to minimize ozone formation from compounds such as ethylene, propylene, butenes, and 1,3-butadiene.

2018 Summer Weekday On-Road NO_X Texas 4 km Domain – June 14 Episode Day

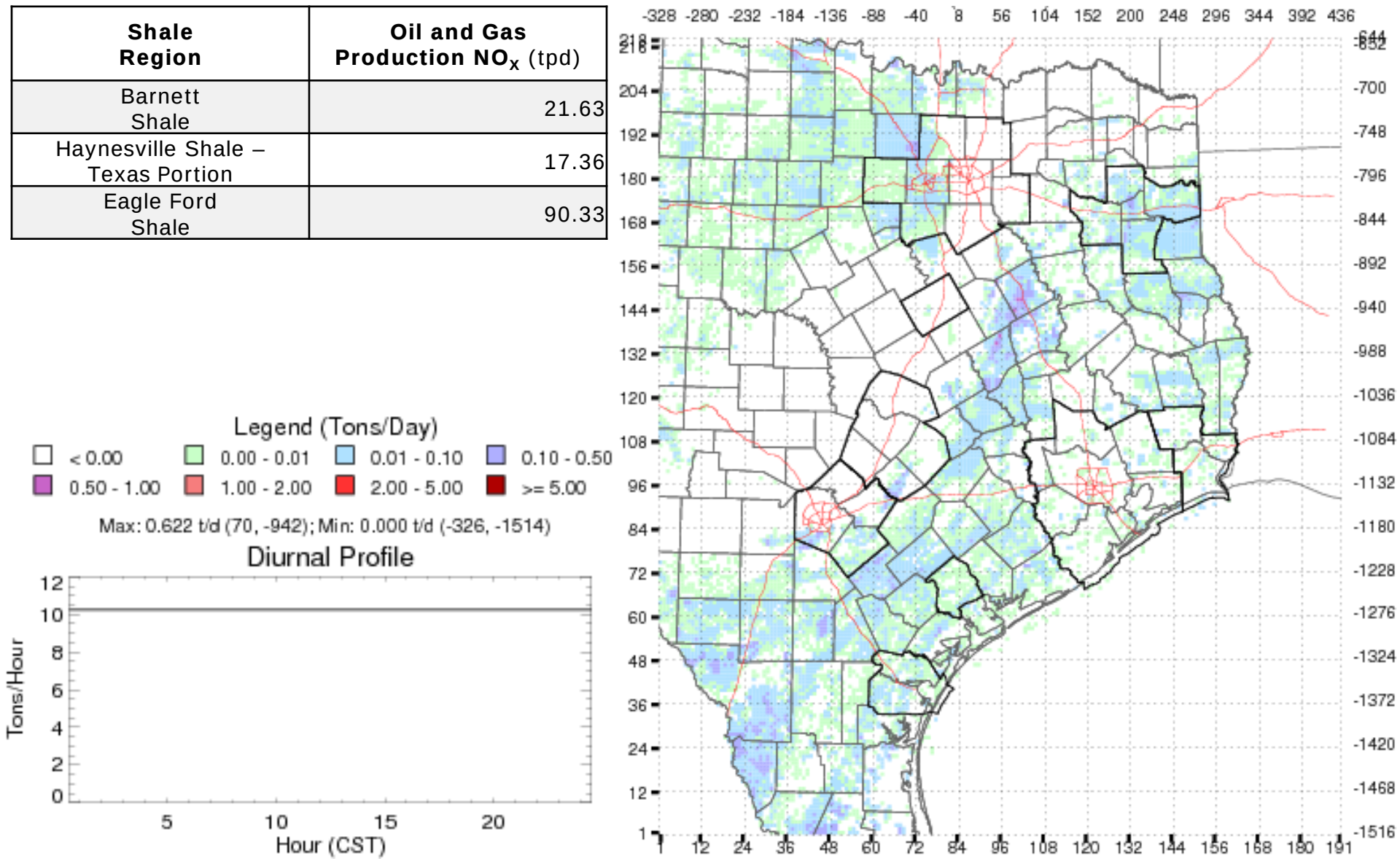
County	On-Road NO_X (tpd)
Collin	12.99
Dallas	40.26
Denton	10.03
Ellis	4.49
Johnson	3.65
Kaufman	4.26
Parker	5.12
Rockwall	2.28
Tarrant	27.44
Wise	2.68
Ten-County Total	113.21





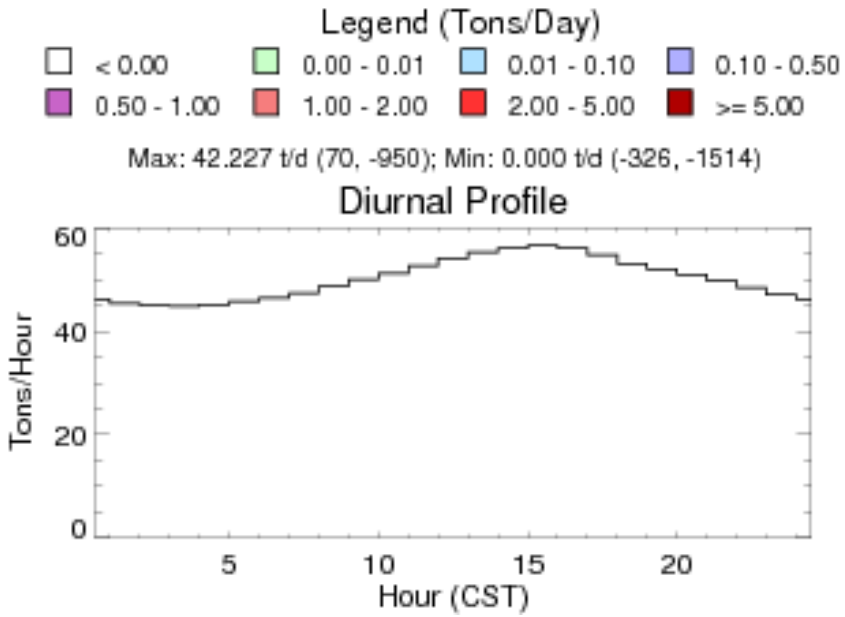
2018 Summer Weekday Oil and Gas Production NO_X Texas 4 km Domain – June 14 Episode Day

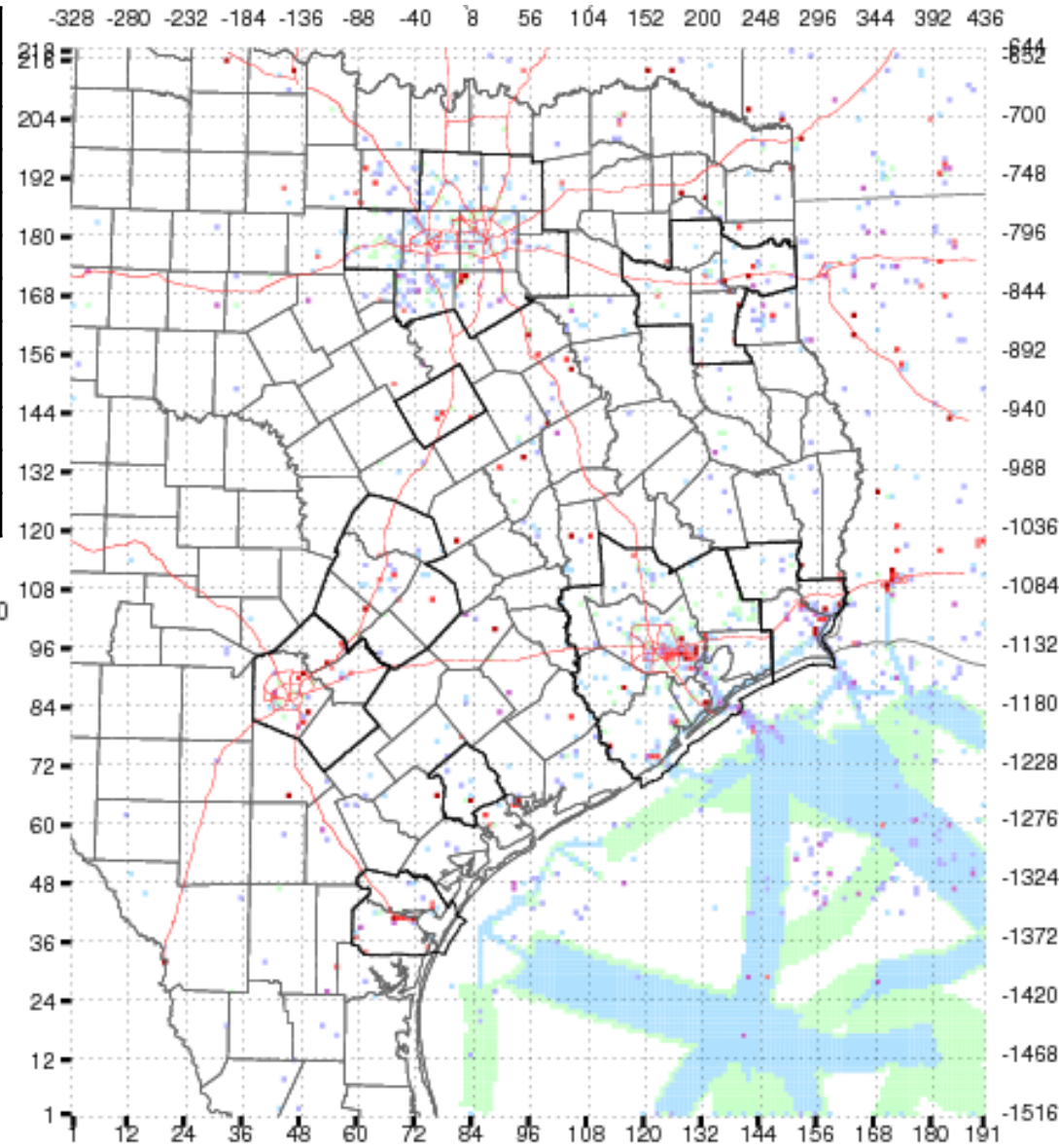
Shale Region	Oil and Gas Production NO_X (tpd)
Barnett Shale	21.63
Haynesville Shale – Texas Portion	17.36
Eagle Ford Shale	90.33



2018 Summer Weekday Elevated Point Source NO_x Texas 4 km Domain – June 14 Episode Day

County	Point Source NO_x (tpd)
Collin	0.63
Dallas	2.89
Denton	1.48
Ellis	21.70
Johnson	6.49
Kaufman	3.88
Parker	1.26
Rockwall	0.01
Tarrant	4.04
Wise	10.39
Ten-County Total	52.77





Current Ozone Modeling Plans and Known Future Changes

- Emission estimate updates:
  - 2018 (and maybe 2006) on-road emissions after MOVES2013 is released by EPA, which is scheduled to occur in 2014. Currently relying on emission estimates from MOVES2010a and MOVES2010b.
  - 2018 point source emission projections based on 2013 acid rain database (ARD) for electric generating utilities (EGUs) and 2012 State of Texas Air Reporting System (STARS) database for non-EGUs (NEGUs). Currently using 2012 ARD and 2011 STARS.
  - 2018 oil and gas emissions based on recently received 2012 production data from the Texas Railroad Commission. Currently projecting from 2011 production data.
  - If version 2 of the 2011 National Emissions Inventory (NEI) is released by EPA, update 2018 future projections for non-Texas areas. Version 1 of the 2011 NEI was recently released and is currently being used.

- Chemical mechanism:
  - Implement any CB6 improvements that result in improved base case performance.
  - Currently using the "revision 2" option for CB6 in CAMx to estimate ozone.
  - 2006 base case CAMx runs showed that both the initial version of CB6 and "revision 1" caused significant over estimation of ozone.
  - CB05 was an improvement over its predecessor (CBIV), but still had under estimation problems.

- Meteorological modeling:
  - Implement any WRF improvements that result in improved base case performance.
  - Currently using WRF 3.2 output.
  - The recently released WRF 3.5 has been run for the 2006 episodes and the output is currently undergoing quality assurance review.

Electronic File Availability for Ozone Modeling and Emissions Inventory Development

Description	Web Page Address / FTP Directory
TCEQ Ozone Modeling Files Web Page	http://www.tceq.texas.gov/airquality/airmod/rider8/rider8Modeling
TCEQ Ozone Modeling Files FTP Directory	ftp://amdaftp.tceq.texas.gov/pub/TX/
TCEQ On-Road Emission Inventory FTP Directory	ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/
EPA On-Road Motor Vehicle Emission Simulator (MOVES) Model Web Page	http://www.epa.gov/otaq/models/moves/
TCEQ Non-Road Emission Inventory FTP Directory	ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TEX/
Texas NONROAD (TexN) Model FTP Directory	ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TexN/
TCEQ Airport Emission Inventory FTP Directory	ftp://amdaftp.tceq.texas.gov/pub/Offroad_EI/Airports/
Texas Air Emissions Repository (TexAER) for Periodic Inventories (2005, 2008, 2011, etc.)	http://www5.tceq.state.tx.us/texaer/index.cfm
TCEQ Point Source Emissions Inventory Web Page	http://www.tceq.texas.gov/airquality/point-source-ei/psei.html
TCEQ Air Quality Research and Contract Projects Web Page	http://www.tceq.texas.gov/airquality/airmod/project/pj.html

Questions?

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air modeling data analysis