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Emission and Air Quality Trends Review

Oklahoma

March 2012

Summary

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Project Objective

- To develop and present publicly available information on trends in emissions and ambient air quality over the past ten years in easy to understand visual and tabular formats

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Emission Trends Summary

- All pollutants with the exception of VOC, CO and PM have decreased since 1999 in aggregate across Oklahoma
  - Increases due to forestry and industrial categories
- Onroad emission step increase seen between 2004 and 2005 is the result of EPA's method change and MOVES model integration for estimating onroad mobile source emissions

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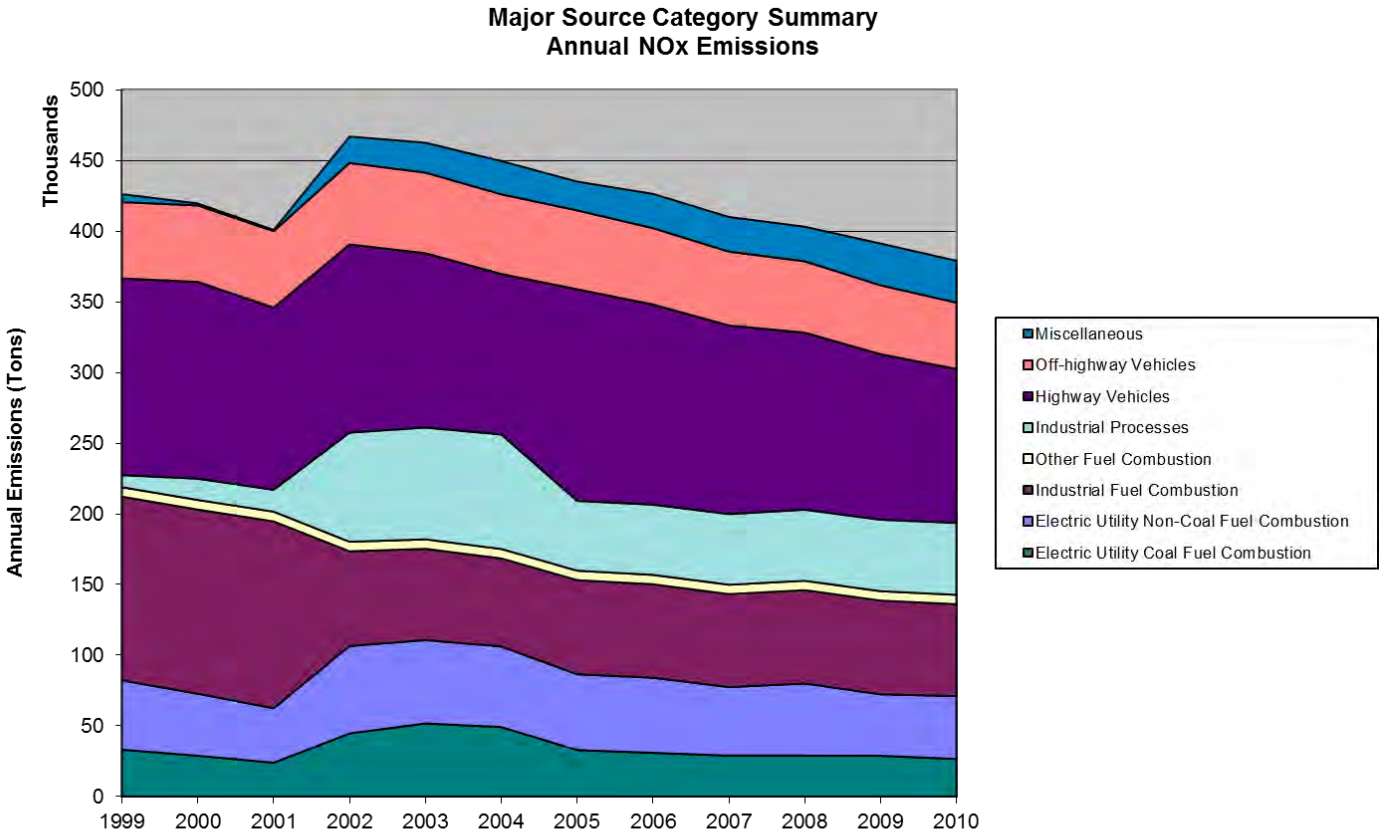
Oklahoma Emission Trends (NOx)



Oklahoma Emission Change (NOx)

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	-4,230	-9,168	11,525	18,612	16,043	-229	-2,171	-4,163	-4,147	-4,310	-6,534
Electric Utility Non-Coal Fuel Combustion	0	-5,200	-10,542	12,791	9,868	7,976	4,556	4,049	-608	1,943	-5,536	-4,588
Industrial Fuel Combustion	0	298	2,214	-62,974	-65,376	-67,722	-63,365	-63,860	-64,155	-63,925	-63,658	-64,959
Other Fuel Combustion	0	99	187	58	32	6	-20	-33	-45	-58	-70	-83
Industrial Processes	0	6,532	6,957	68,643	70,539	72,436	40,837	41,139	41,442	41,744	42,046	42,348
Highway Vehicles	0	101	-10,277	-5,967	-15,783	-25,599	10,601	2,434	-5,733	-13,899	-22,066	-30,233
Off-highway Vehicles	0	66	118	3,609	3,001	2,393	1,786	20	-1,747	-3,513	-5,279	-7,045
Miscellaneous	0	-4,267	-4,792	13,082	15,471	17,860	14,702	18,636	18,856	18,806	23,952	23,952
Total	**0**	**-6,602**	**-25,304**	**40,768**	**36,366**	**23,394**	**8,868**	**215**	**-16,152**	**-23,048**	**-34,922**	**-47,142**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	-13%	-28%	35%	56%	48%	-1%	-7%	-13%	-13%	-13%	-20%
Electric Utility Non-Coal Fuel Combustion	0%	-11%	-21%	26%	20%	16%	9%	8%	-1%	4%	-11%	-9%
Industrial Fuel Combustion	0%	0%	2%	-48%	-50%	-52%	-49%	-49%	-49%	-49%	-49%	-50%
Other Fuel Combustion	0%	1%	3%	1%	0%	0%	0%	0%	-1%	-1%	-1%	-1%
Industrial Processes	0%	76%	81%	801%	824%	846%	477%	480%	484%	487%	491%	494%
Highway Vehicles	0%	0%	-7%	-4%	-11%	-18%	8%	2%	-4%	-10%	-16%	-22%
Off-highway Vehicles	0%	0%	0%	7%	6%	4%	3%	0%	-3%	-7%	-10%	-13%
Miscellaneous	0%	-76%	-86%	233%	276%	319%	262%	333%	336%	336%	427%	427%
Total	**0%**	**-2%**	**-6%**	**10%**	**9%**	**5%**	**2%**	**0%**	**-4%**	**-5%**	**-8%**	**-11%**

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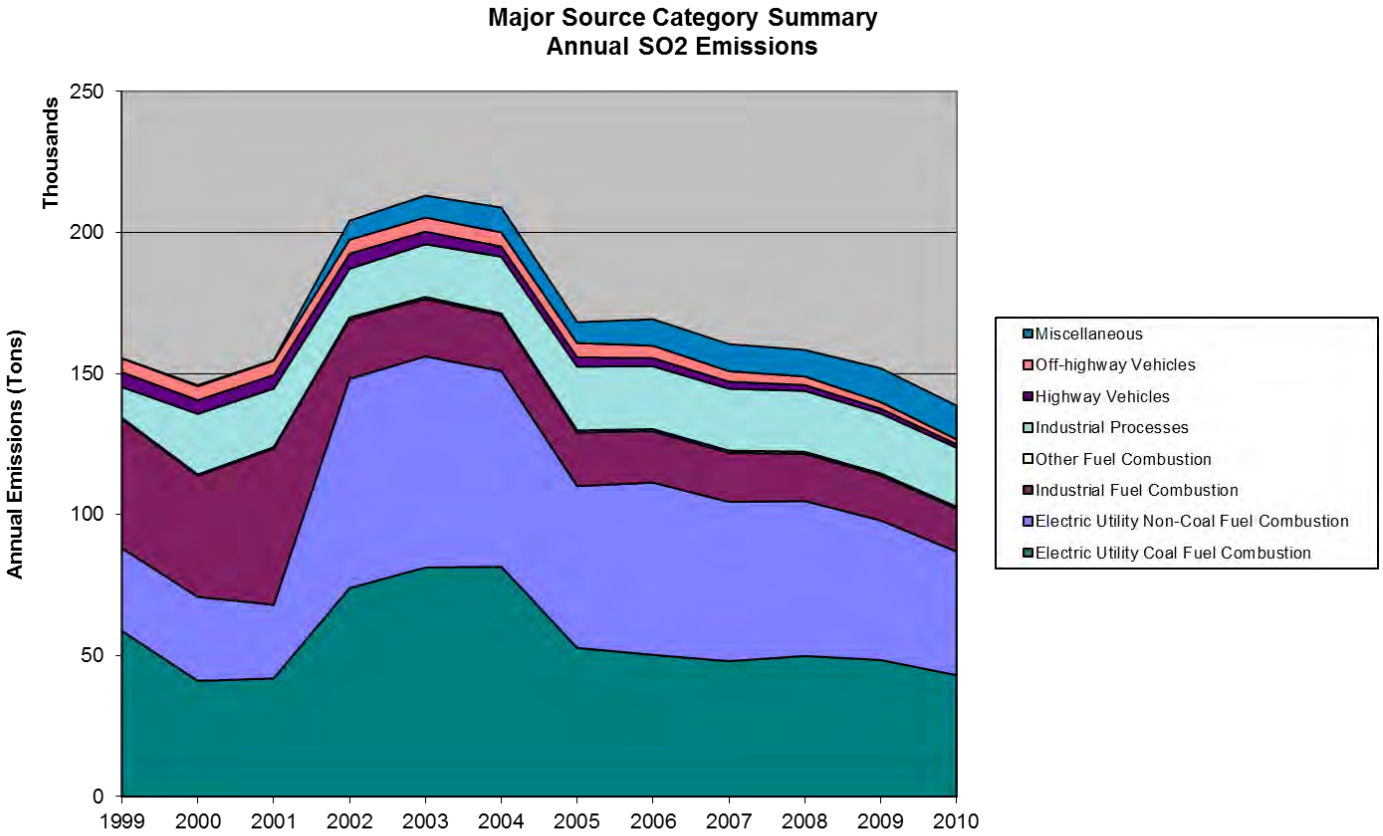
Oklahoma Emission Trends (SO_2)



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Oklahoma Emission Change (SO2)

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	-17,731	-16,833	15,175	22,471	22,778	-6,013	-8,494	-10,739	-8,871	-10,309	-15,699
Electric Utility Non-Coal Fuel Combustion	0	485	-3,230	44,863	45,522	40,030	28,045	31,754	27,147	25,613	20,163	14,506
Industrial Fuel Combustion	0	-2,840	9,651	-24,737	-25,419	-26,100	-26,782	-27,544	-28,305	-29,066	-29,828	-30,590
Other Fuel Combustion	0	12	22	298	295	291	288	287	286	285	285	284
Industrial Processes	0	10,571	9,853	6,334	7,787	9,240	11,707	11,366	11,025	10,684	10,344	10,003
Highway Vehicles	0	-442	-473	86	-795	-1,677	-1,942	-2,357	-2,773	-3,189	-3,605	-4,020
Off-highway Vehicles	0	92	196	79	104	130	155	-513	-1,180	-1,848	-2,516	-3,183
Miscellaneous	0	296	152	6,641	7,678	8,714	7,309	9,304	9,518	9,299	11,903	11,903
Total	**0**	**-9,559**	**-663**	**48,740**	**57,642**	**53,406**	**12,767**	**13,804**	**4,979**	**2,908**	**-3,563**	**-16,797**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	-30%	-29%	26%	38%	39%	-10%	-14%	-18%	-15%	-18%	-27%
Electric Utility Non-Coal Fuel Combustion	0%	2%	-11%	153%	155%	136%	96%	108%	93%	87%	69%	49%
Industrial Fuel Combustion	0%	-6%	21%	-54%	-56%	-57%	-59%	-60%	-62%	-64%	-65%	-67%
Other Fuel Combustion	0%	2%	5%	63%	63%	62%	61%	61%	61%	61%	61%	60%
Industrial Processes	0%	97%	90%	58%	71%	85%	107%	104%	101%	98%	95%	92%
Highway Vehicles	0%	-8%	-9%	2%	-15%	-32%	-37%	-45%	-53%	-61%	-69%	-76%
Off-highway Vehicles	0%	2%	4%	2%	2%	3%	3%	-10%	-24%	-38%	-51%	-65%
Miscellaneous	0%	425%	218%	9544%	11034%	12524%	10504%	13372%	13679%	13364%	17107%	17107%
Total	**0%**	**-6%**	**0%**	**31%**	**37%**	**34%**	**8%**	**9%**	**3%**	**2%**	**-2%**	**-11%**

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Air Quality Trends Summary

- Average O_3 design values have decreased since 1999 in Oklahoma; average annual and 24-hr $PM_{2.5}$ design values have decreased since 2000 (incomplete data in 1999)

- There are no O_3 and $PM_{2.5}$ non-attainment areas in Oklahoma

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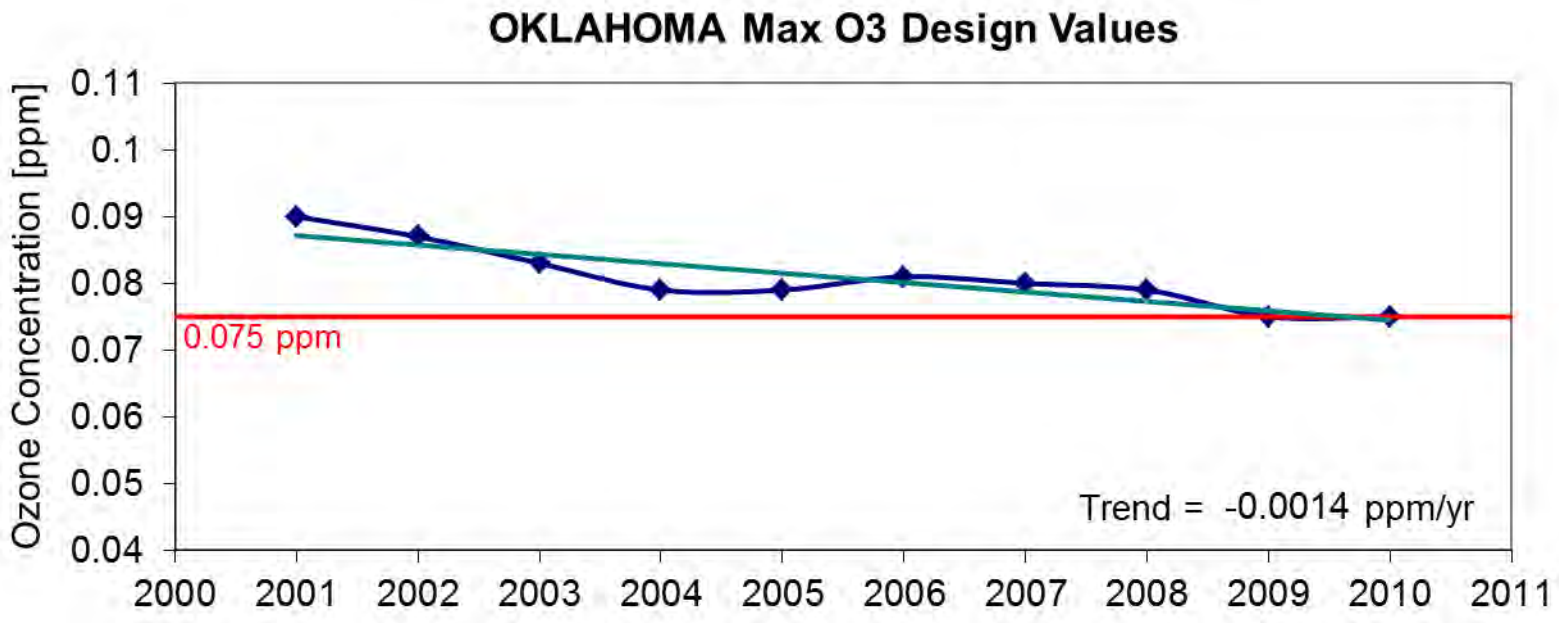
Max O_3 DVs and Trend



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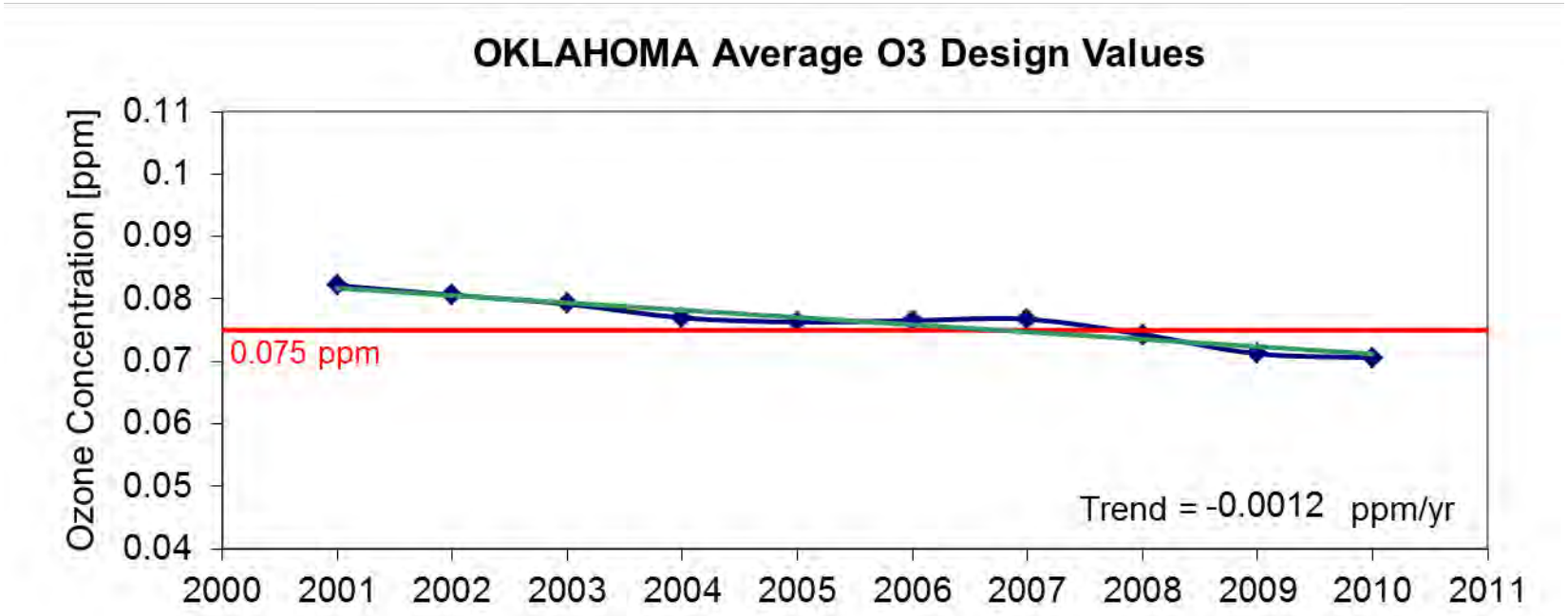
Average O_3 DVs and Trend



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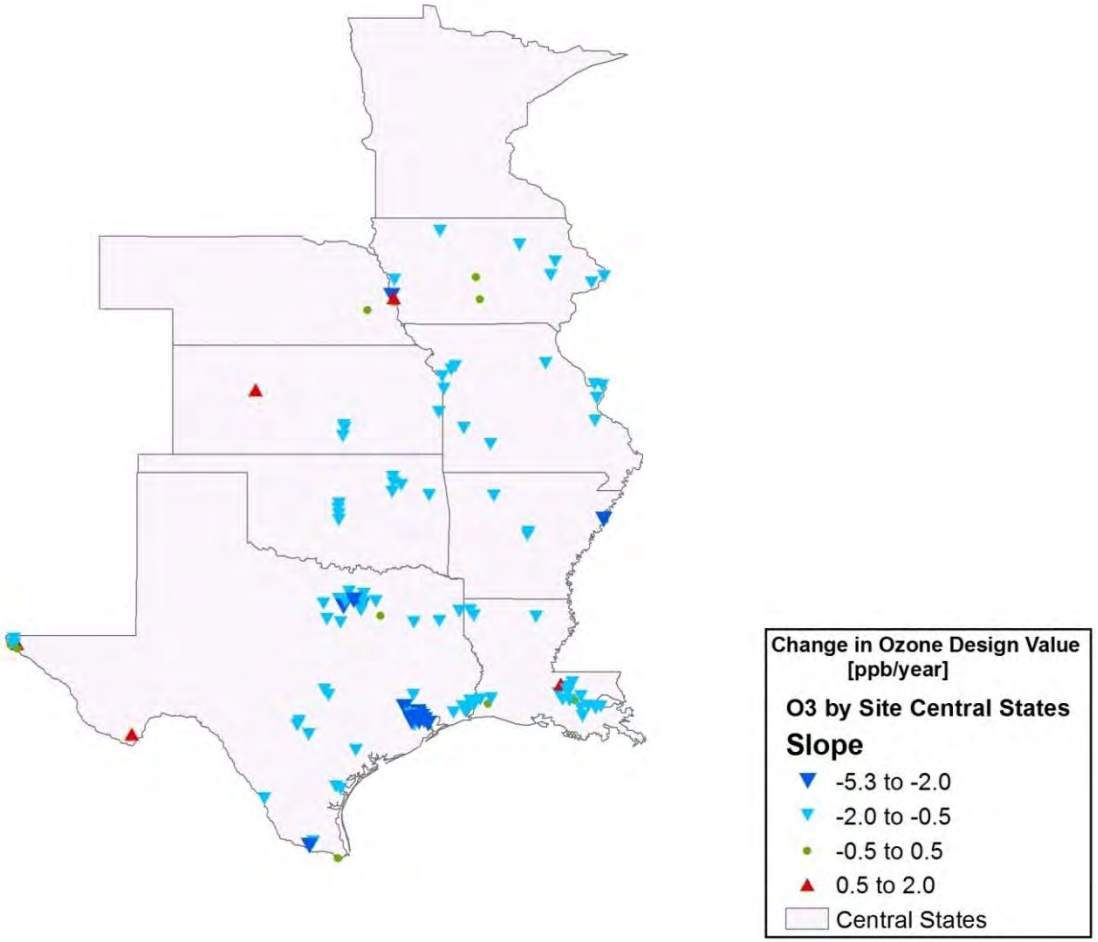
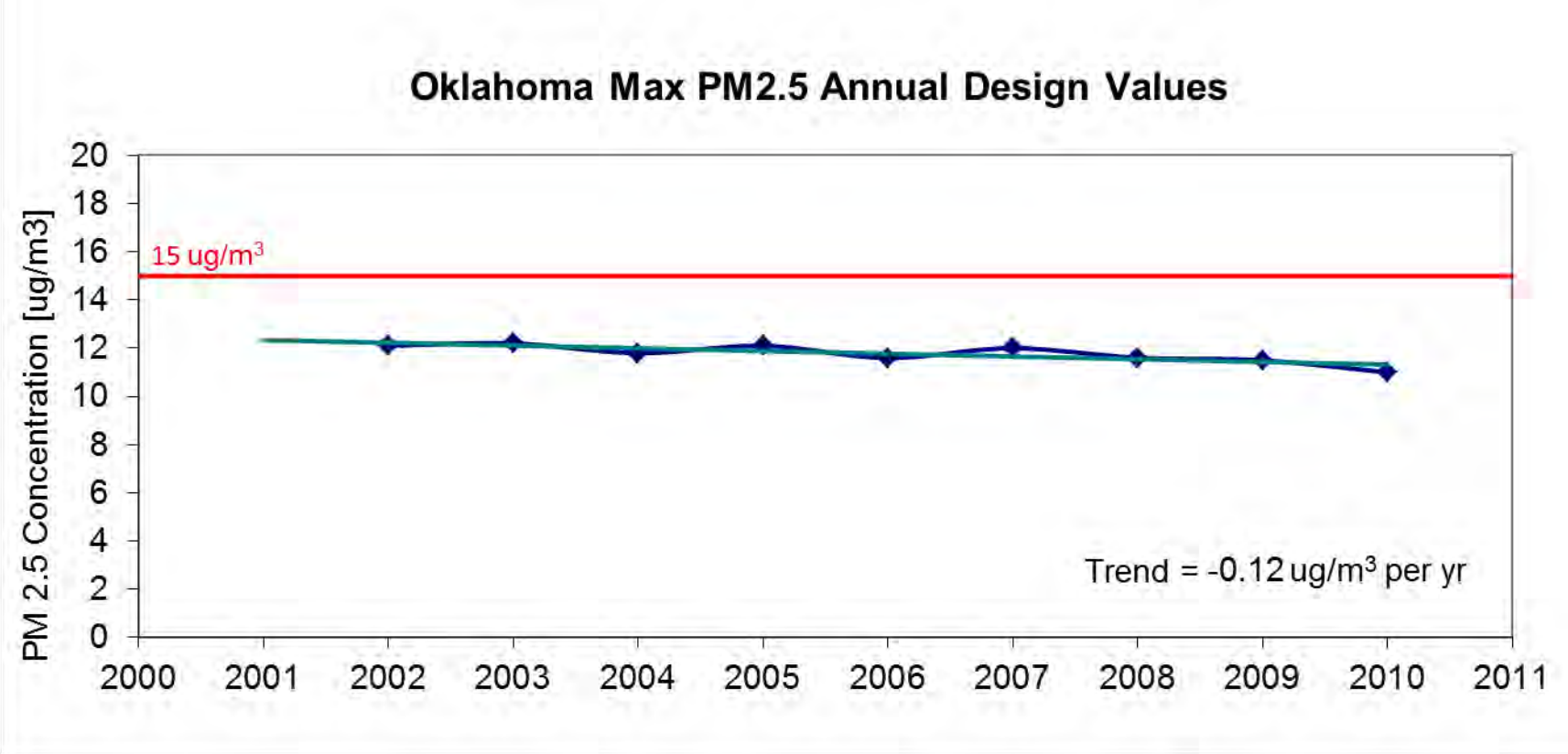
O_3 Trend Slopes at Monitoring Sites

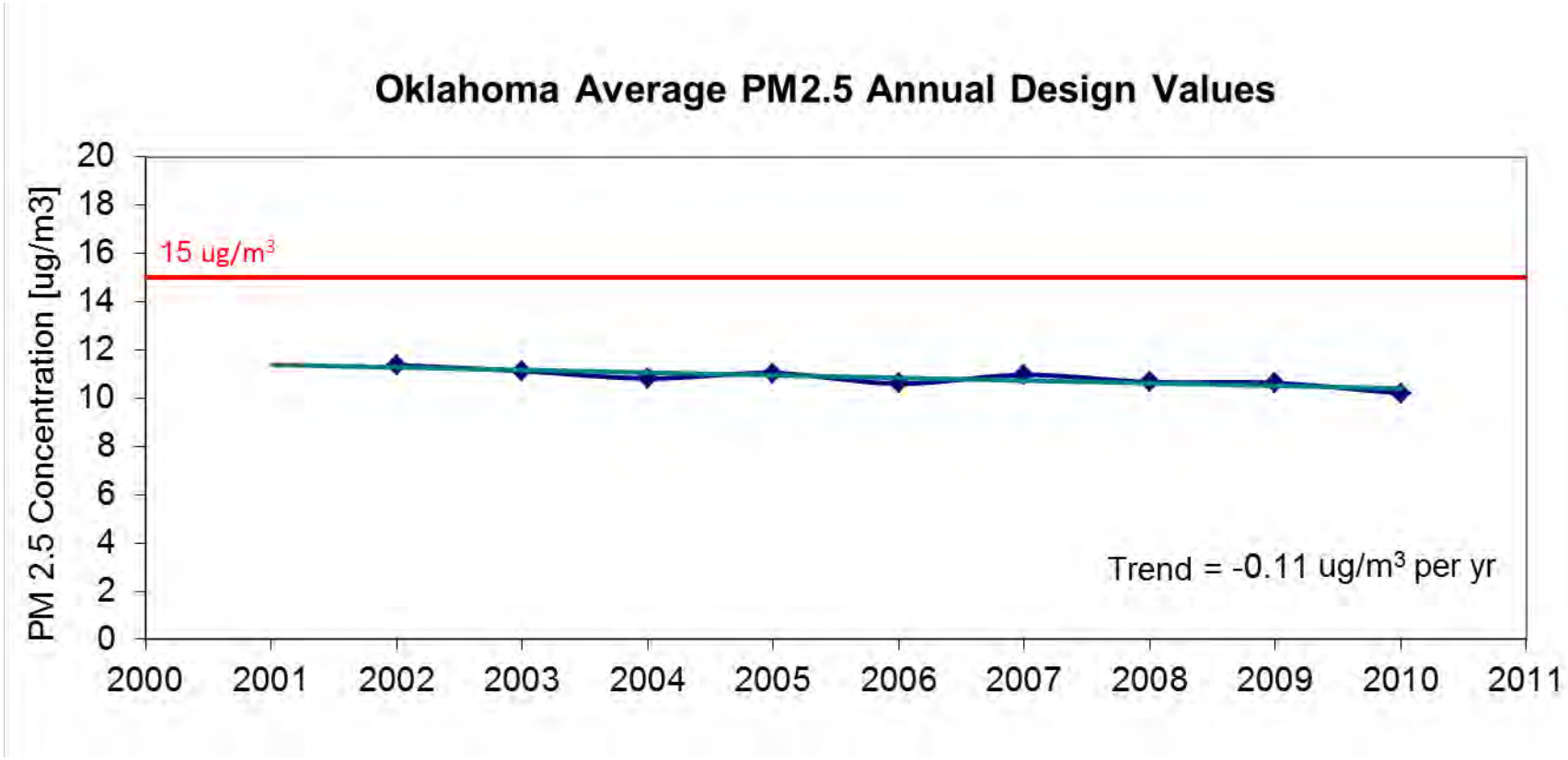


Max $PM_{2.5}$ Annual DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

Average $PM_{2.5}$ Annual DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

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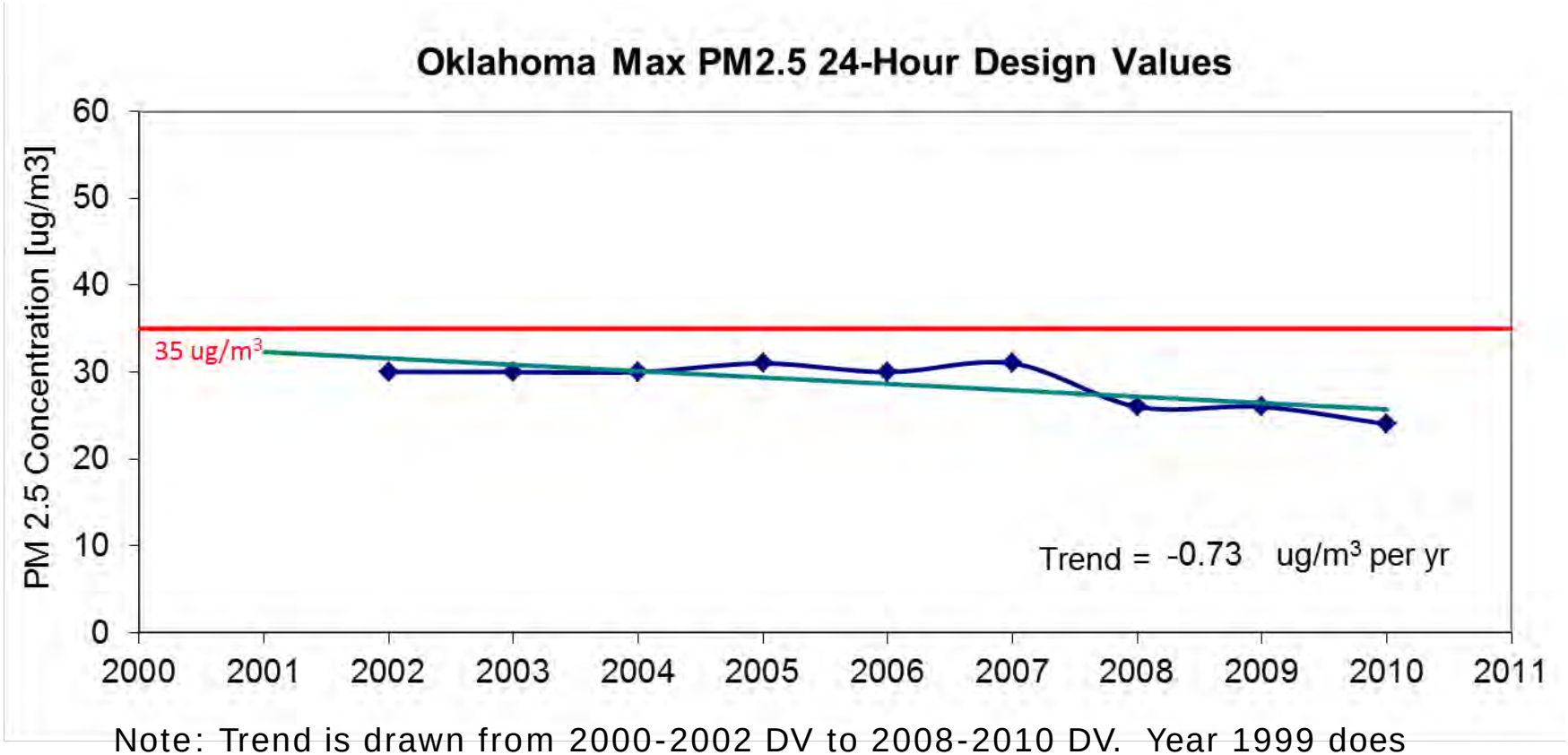
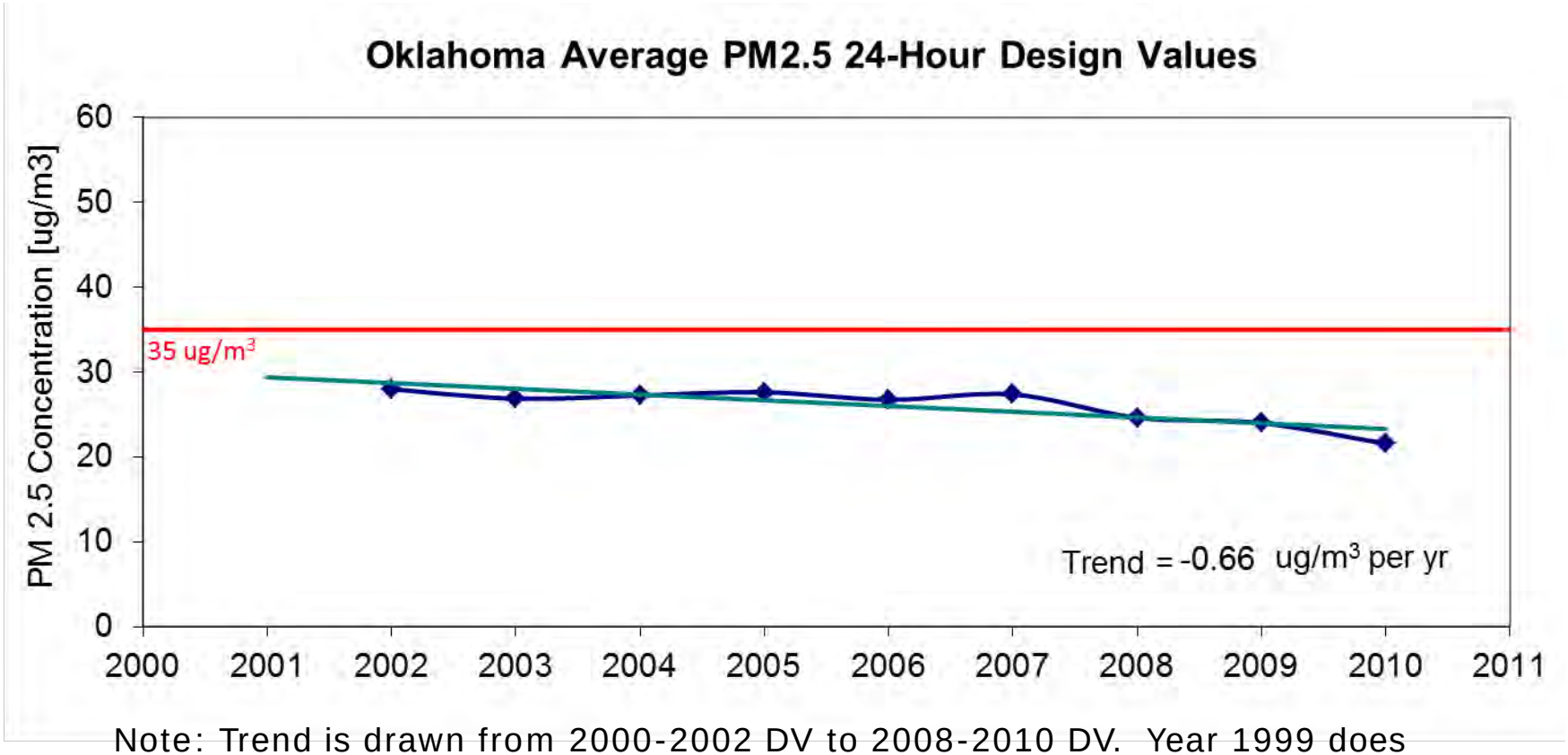
Max $PM_{2.5}$ 24-Hour DVs and Trend



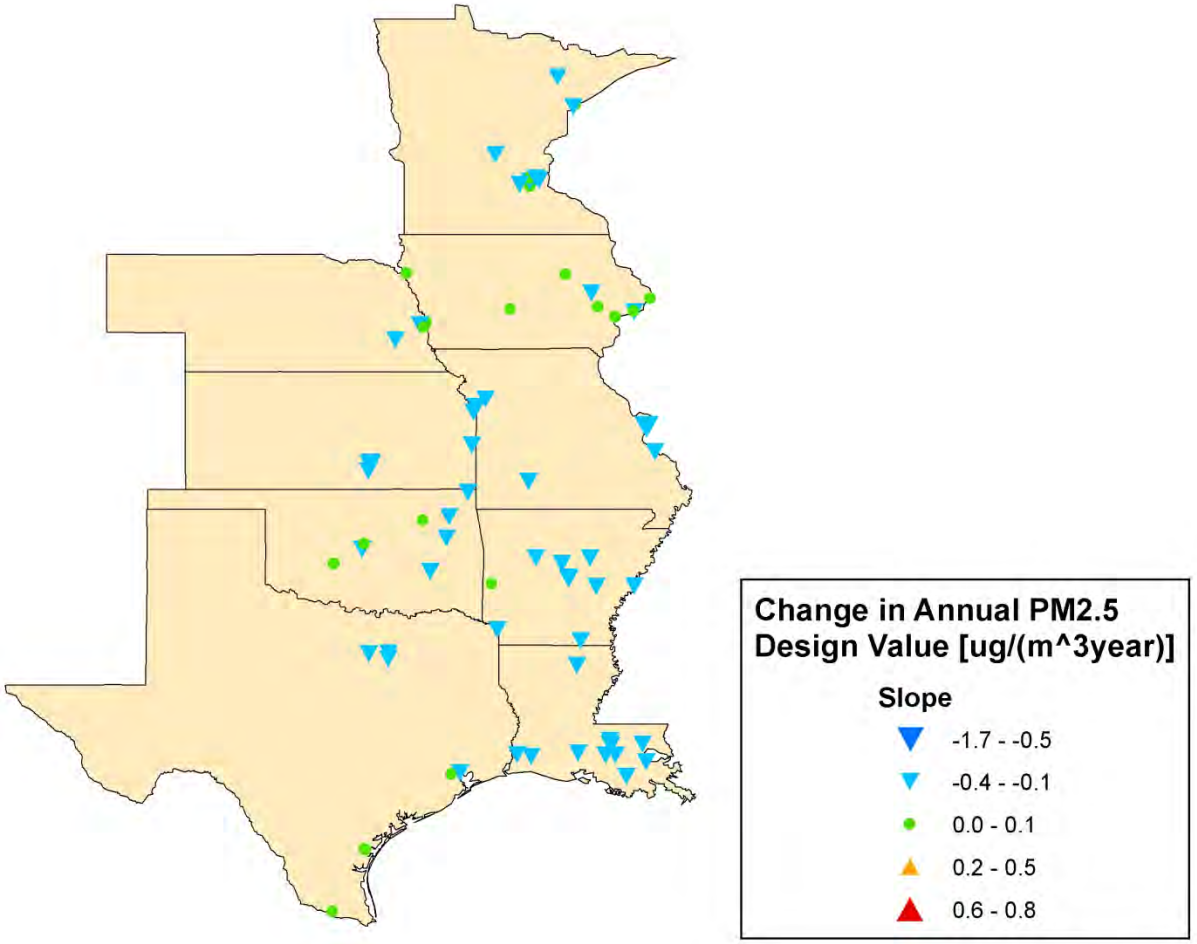
Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

Average $PM_{2.5}$ 24-Hour DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

Annual $PM_{2.5}$ Trend Slopes at Monitoring Sites



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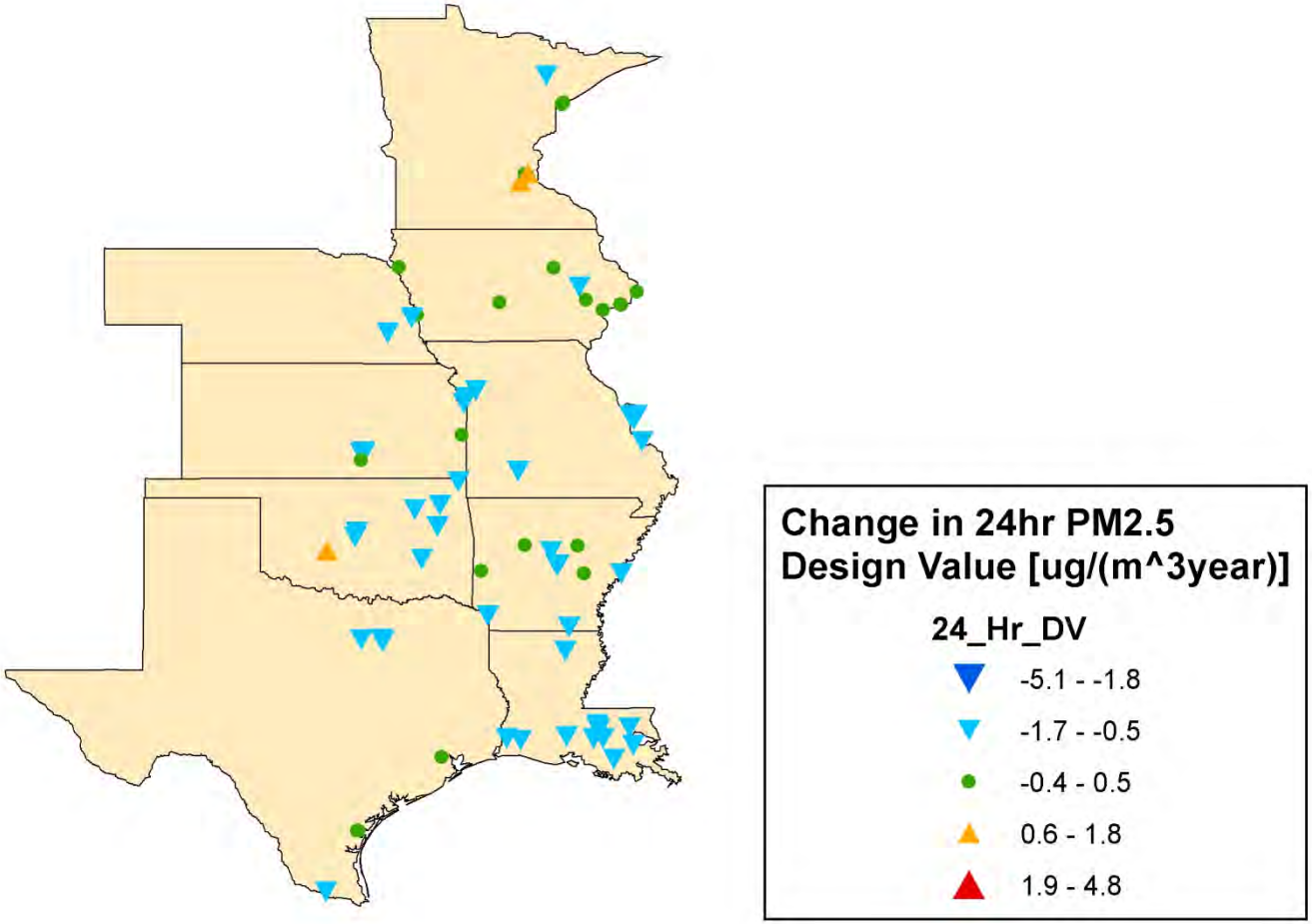
24-Hour $PM_{2.5}$ Trend Slopes at Monitoring Sites



Background

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Project Objective

- To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. over the past ten years in easy to understand visual and tabular formats

- Include additional qualitative assessment of meteorological influences on these trends as available for temperature and rainfall anomalies

Emission Trends

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Emission Trends

- Study Team collected and processed U.S. EPA emission inventories for years within the study period of interest (1999-2010)

- By pollutant and source category
  - electric generation fuel combustion
  - industrial fuel combustion
  - other fuel combustion
  - industrial processes
  - on-road vehicles
  - non-road engines and vehicles
  - miscellaneous

Emissions Data Summary

- Data Obtained from EPA National Emission Inventory (NEI) and Trends Websites
  - EPA's Trends reports and emission comparisons include interpolations of all categories between key years (1999, 2002, 2005, 2008, 2012 projection)
  - Pollutants: VOC, NOx, CO, SO_2, PM_{10}, $PM_{2.5}$ and NH_3
- Project Improvement
  - The Study Team augmented above data with year specific CEM emissions (2002 through 2010), MOVES onroad emissions (2005 through 2010), and wildfire emissions data (2005 through 2009)

Oklahoma Emission Trends (VOC)

	Annual Emissions (Tons)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	340	271	262	426	472	476	226	204	188	183	167	139
Electric Utility Non-Coal Fuel Combustion	680	816	766	1,024	937	847	483	479	454	454	428	420
Industrial Fuel Combustion	10,930	11,111	11,033	16,929	16,816	16,702	16,949	16,937	16,926	16,915	16,905	16,892
Other Fuel Combustion	7,420	7,926	7,925	7,678	6,988	6,299	5,609	5,479	5,348	5,218	5,087	4,957
Industrial Processes	148,426	135,096	139,436	186,692	190,112	193,532	248,301	248,780	249,260	249,740	250,219	250,699
Highway Vehicles	95,342	92,325	86,300	86,131	80,849	75,568	61,578	58,247	54,917	51,586	48,255	44,925
Off-highway Vehicles	31,521	31,236	30,860	39,566	38,701	37,837	36,972	35,476	33,980	32,483	30,987	29,491
Miscellaneous	11,329	2,962	1,810	25,128	46,154	67,180	38,611	95,833	106,067	91,890	164,945	164,945
Total	**305,988**	**281,742**	**278,392**	**363,573**	**381,030**	**398,440**	**408,729**	**461,435**	**467,139**	**448,469**	**516,993**	**512,467**

	Annual Emissions (Percent of Total)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Electric Utility Non-Coal Fuel Combustion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Industrial Fuel Combustion	4%	4%	4%	5%	4%	4%	4%	4%	4%	4%	3%	3%
Other Fuel Combustion	2%	3%	3%	2%	2%	2%	1%	1%	1%	1%	1%	1%
Industrial Processes	49%	48%	50%	51%	50%	49%	61%	54%	53%	56%	48%	49%
Highway Vehicles	31%	33%	31%	24%	21%	19%	15%	13%	12%	12%	9%	9%
Off-highway Vehicles	10%	11%	11%	11%	10%	9%	9%	8%	7%	7%	6%	6%
Miscellaneous	4%	1%	1%	7%	12%	17%	9%	21%	23%	20%	32%	32%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

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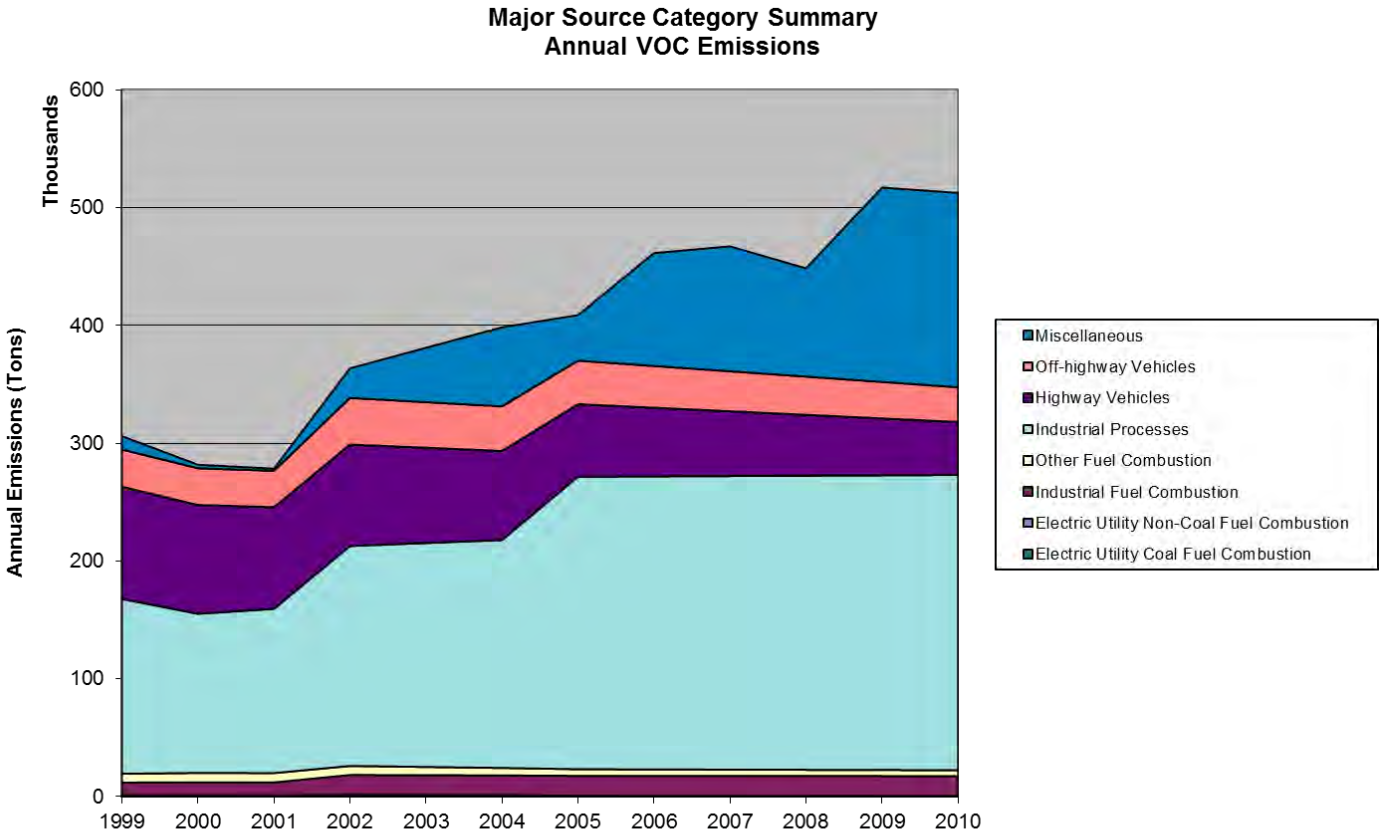
Oklahoma Emission Trends (VOC)



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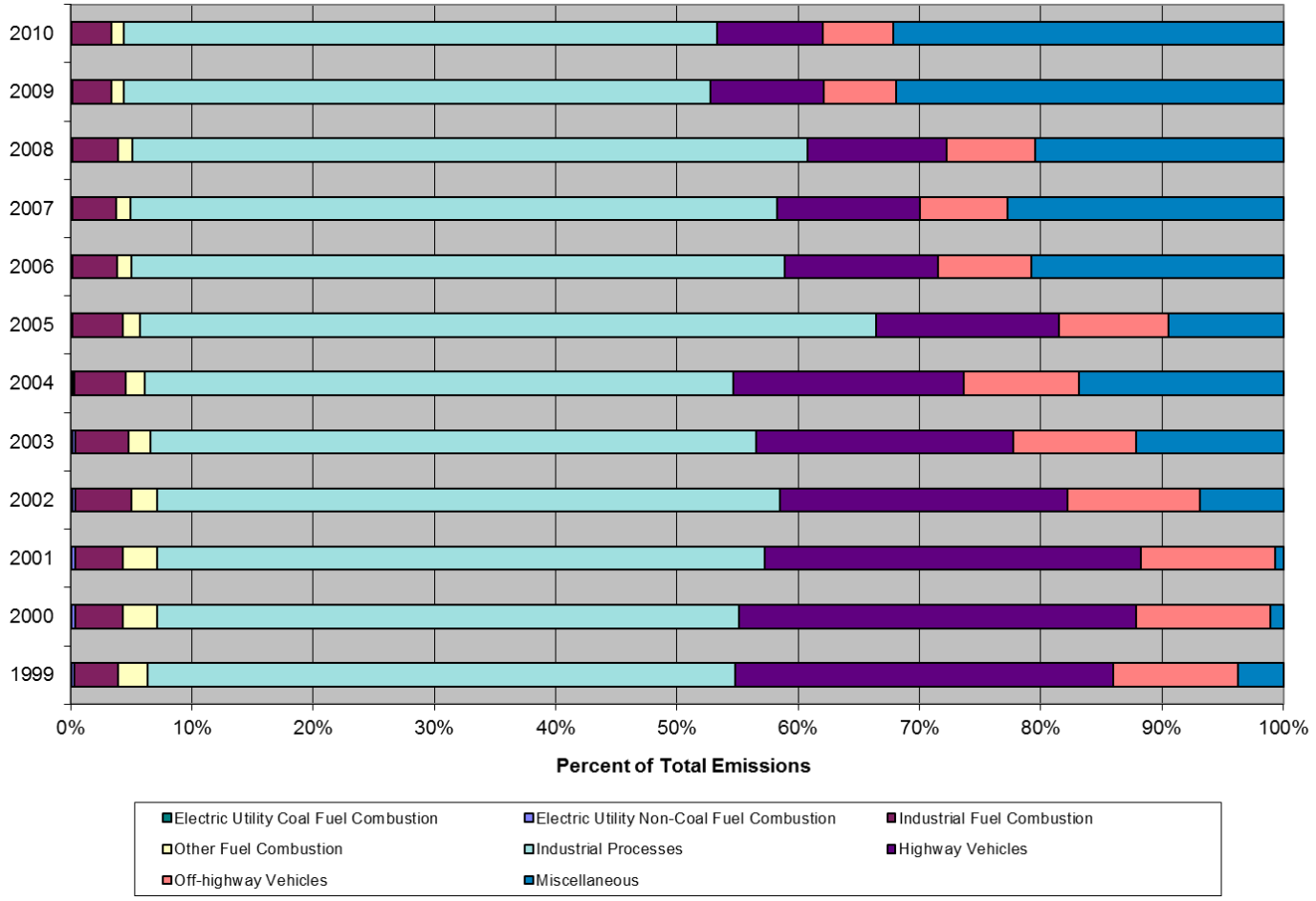
Oklahoma Emission Composition (VOC)



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Oklahoma Emission Trends (NOx)

	Annual Emissions (Tons)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	33,172	28,942	24,004	44,697	51,784	49,215	32,942	31,001	29,009	29,025	28,862	26,638
Electric Utility Non-Coal Fuel Combustion	49,064	43,863	38,521	61,855	58,932	57,040	53,620	53,113	48,456	51,007	43,528	44,476
Industrial Fuel Combustion	129,982	130,280	132,195	67,008	64,606	62,260	66,616	66,121	65,827	66,057	66,323	65,023
Other Fuel Combustion	6,685	6,784	6,872	6,743	6,717	6,691	6,665	6,653	6,640	6,627	6,615	6,602
Industrial Processes	8,565	15,097	15,522	77,208	79,105	81,001	49,403	49,705	50,007	50,309	50,611	50,913
Highway Vehicles	139,118	139,219	128,842	133,152	123,336	113,519	149,720	141,553	133,386	125,219	117,052	108,885
Off-highway Vehicles	54,016	54,082	54,134	57,625	57,017	56,410	55,802	54,036	52,270	50,503	48,737	46,971
Miscellaneous	5,604	1,337	812	18,686	21,075	23,465	20,306	24,241	24,460	24,410	29,556	29,556
Total	**426,207**	**419,604**	**400,902**	**466,975**	**462,573**	**449,601**	**435,074**	**426,422**	**410,054**	**403,158**	**391,285**	**379,065**

	Annual Emissions (Percent of Total)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	8%	7%	6%	10%	11%	11%	8%	7%	7%	7%	7%	7%
Electric Utility Non-Coal Fuel Combustion	12%	10%	10%	13%	13%	13%	12%	12%	12%	13%	11%	12%
Industrial Fuel Combustion	30%	31%	33%	14%	14%	14%	15%	16%	16%	16%	17%	17%
Other Fuel Combustion	2%	2%	2%	1%	1%	1%	2%	2%	2%	2%	2%	2%
Industrial Processes	2%	4%	4%	17%	17%	18%	11%	12%	12%	12%	13%	13%
Highway Vehicles	33%	33%	32%	29%	27%	25%	34%	33%	33%	31%	30%	29%
Off-highway Vehicles	13%	13%	14%	12%	12%	13%	13%	13%	13%	13%	12%	12%
Miscellaneous	1%	0%	0%	4%	5%	5%	5%	6%	6%	6%	8%	8%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

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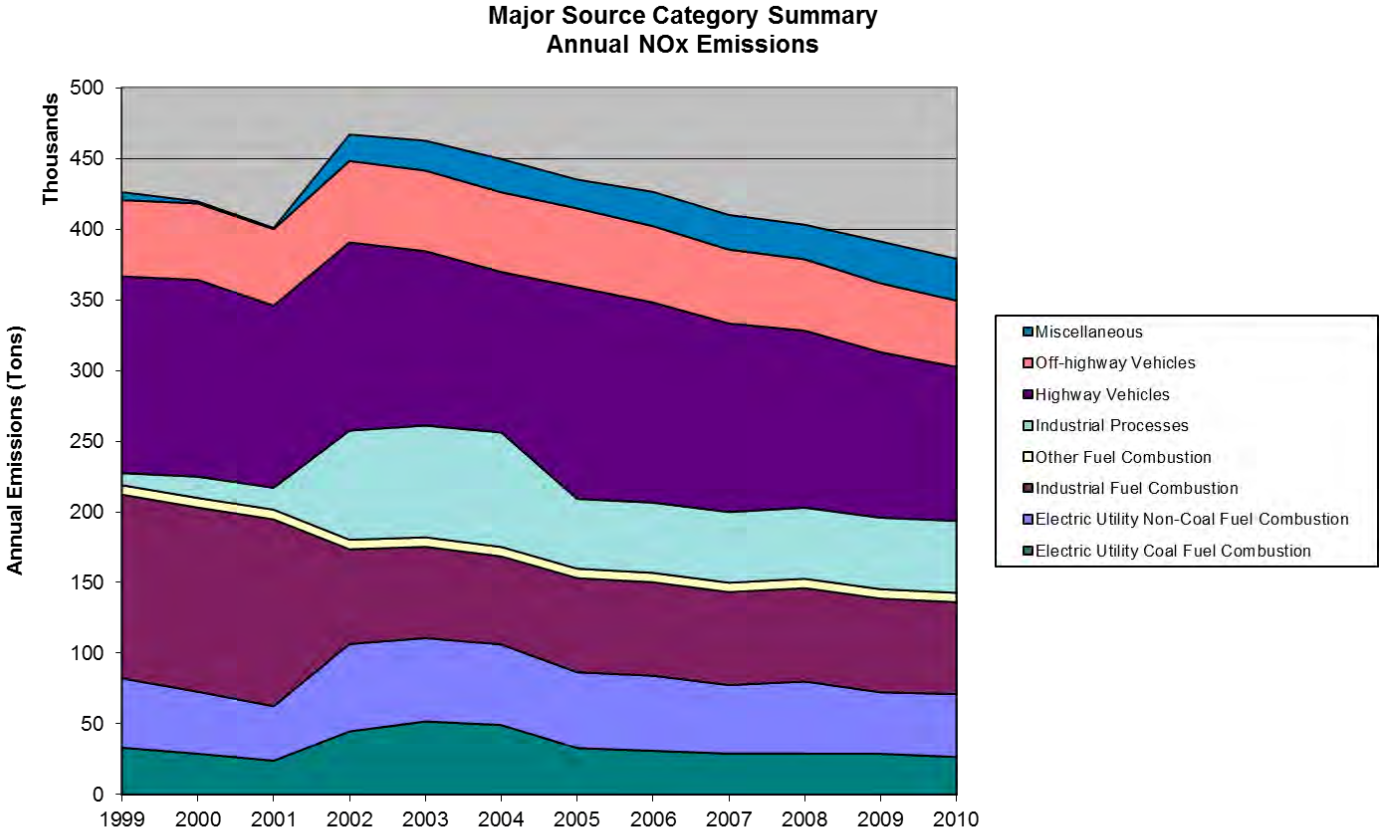
Oklahoma Emission Trends (NOx)



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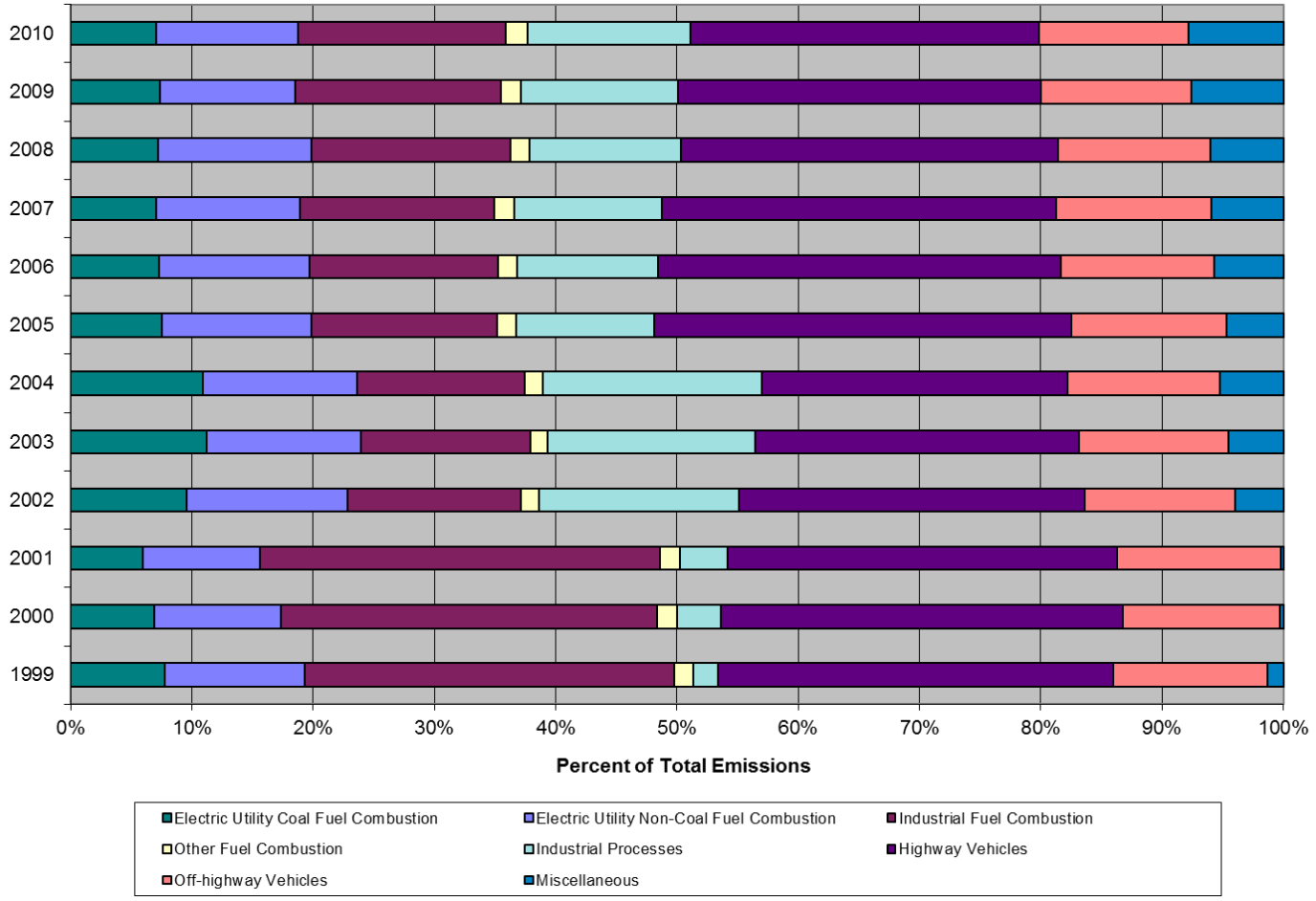
Oklahoma Emission Composition (NOx)



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Oklahoma Emission Trends (SO_2)

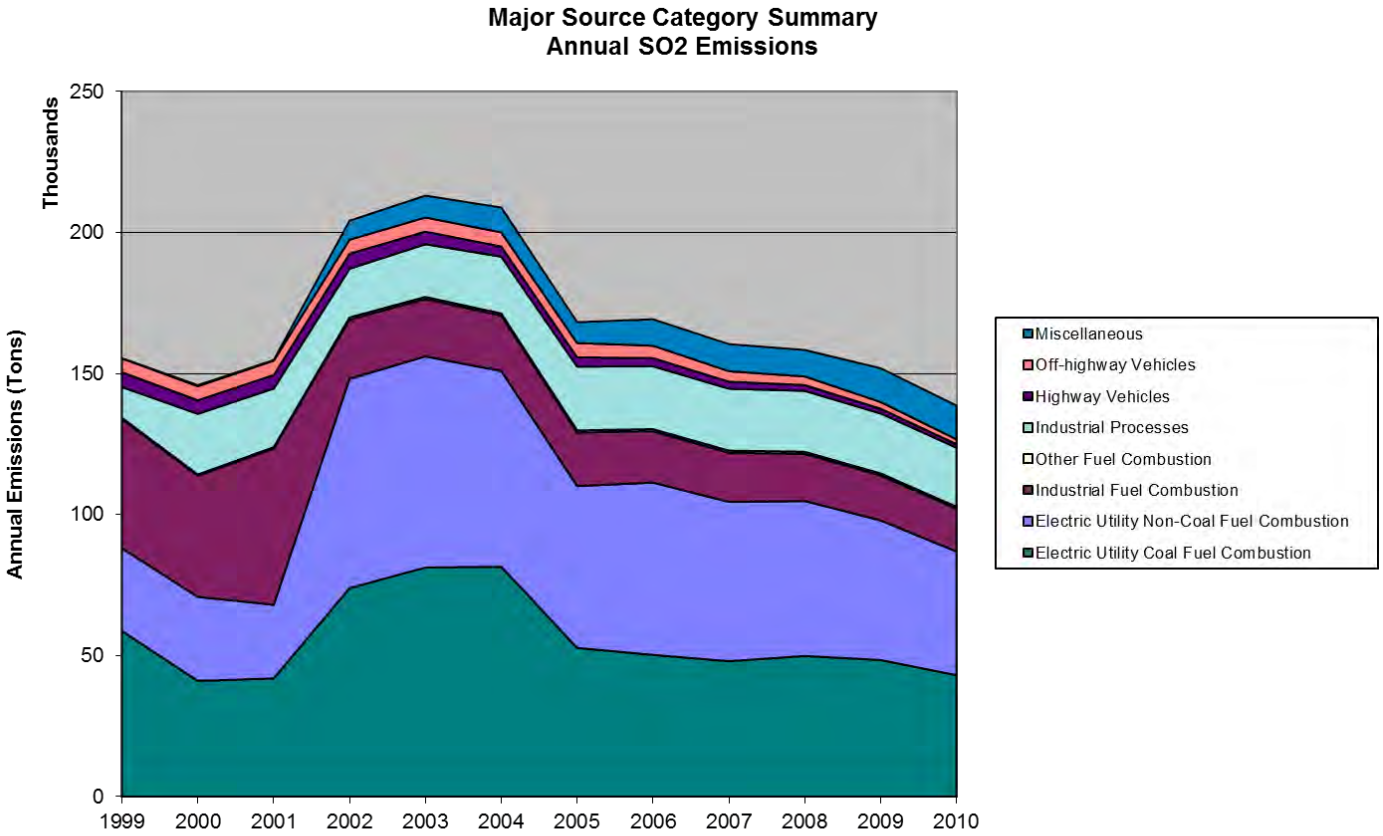
	Annual Emissions (Tons)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	58,739	41,009	41,907	73,915	81,210	81,517	52,726	50,246	48,000	49,869	48,430	43,040
Electric Utility Non-Coal Fuel Combustion	29,327	29,811	26,096	74,190	74,849	69,356	57,372	61,081	56,474	54,940	49,490	43,833
Industrial Fuel Combustion	45,749	42,909	55,399	21,012	20,330	19,649	18,967	18,205	17,444	16,683	15,921	15,159
Other Fuel Combustion	469	481	491	767	764	760	757	756	755	755	754	753
Industrial Processes	10,907	21,478	20,760	17,241	18,694	20,147	22,614	22,273	21,932	21,591	21,251	20,910
Highway Vehicles	5,257	4,815	4,784	5,344	4,462	3,581	3,316	2,900	2,484	2,068	1,653	1,237
Off-highway Vehicles	4,904	4,995	5,100	4,983	5,008	5,033	5,058	4,391	3,723	3,055	2,388	1,720
Miscellaneous	70	365	221	6,711	7,747	8,784	7,378	9,374	9,587	9,368	11,973	11,973
Total	**155,422**	**145,863**	**154,758**	**204,162**	**213,064**	**208,827**	**168,189**	**169,226**	**160,400**	**158,330**	**151,859**	**138,625**

	Annual Emissions (Percent of Total)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	38%	28%	27%	36%	38%	39%	31%	30%	30%	31%	32%	31%
Electric Utility Non-Coal Fuel Combustion	19%	20%	17%	36%	35%	33%	34%	36%	35%	35%	33%	32%
Industrial Fuel Combustion	29%	29%	36%	10%	10%	9%	11%	11%	11%	11%	10%	11%
Other Fuel Combustion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Industrial Processes	7%	15%	13%	8%	9%	10%	13%	13%	14%	14%	14%	15%
Highway Vehicles	3%	3%	3%	3%	2%	2%	2%	2%	2%	1%	1%	1%
Off-highway Vehicles	3%	3%	3%	2%	2%	2%	3%	3%	2%	2%	2%	1%
Miscellaneous	0%	0%	0%	3%	4%	4%	4%	6%	6%	6%	8%	9%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

ALPINE GEOPHYSICS

ENVIRON

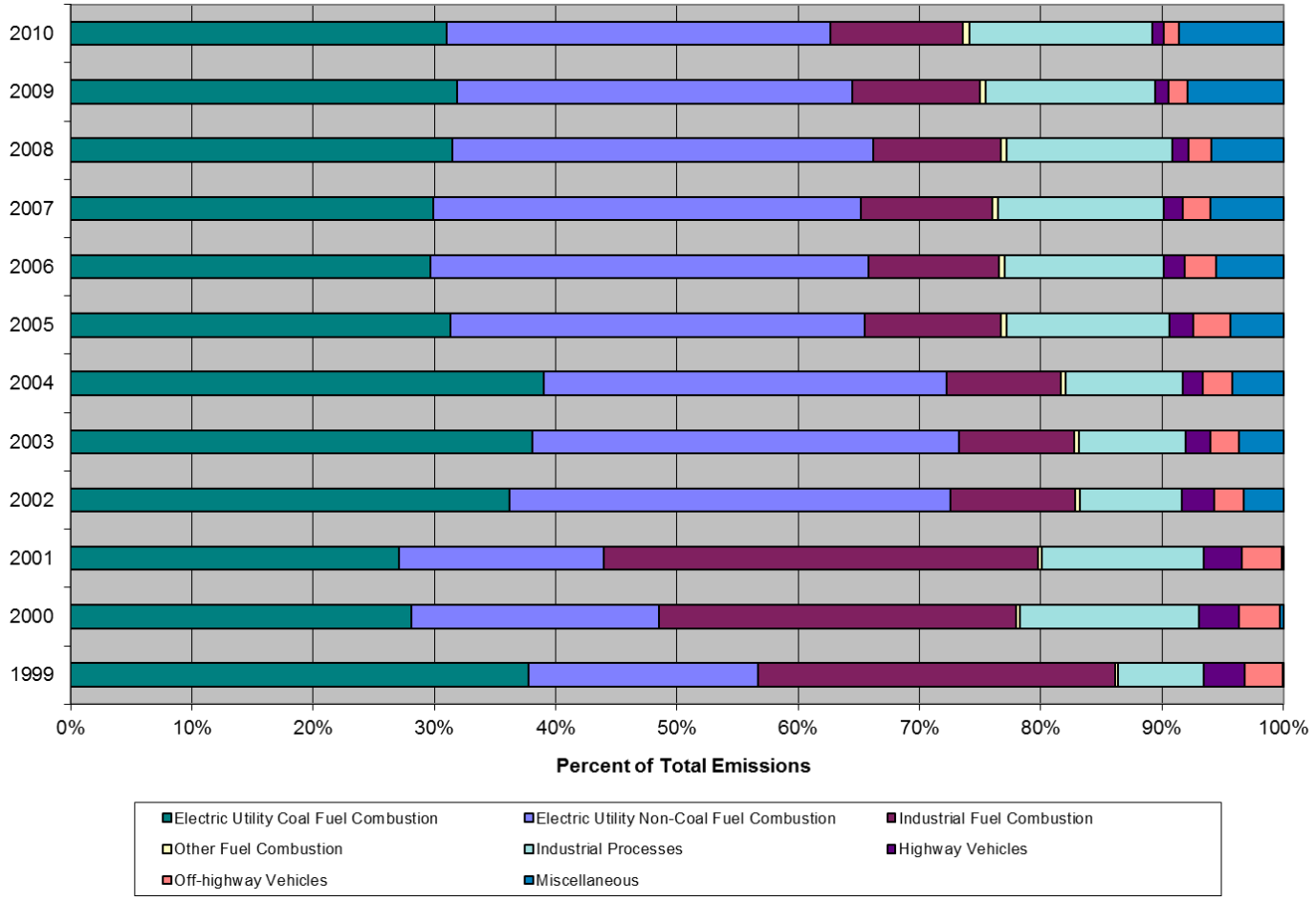
Oklahoma Emission Trends (SO_2)



ALPINE GEOPHYSICS

ENVIRON

Oklahoma Emission Composition (SO_2)



ALPINE GEOPHYSICS

ENVIRON

Oklahoma Emission Trends ($PM_{2.5}$)

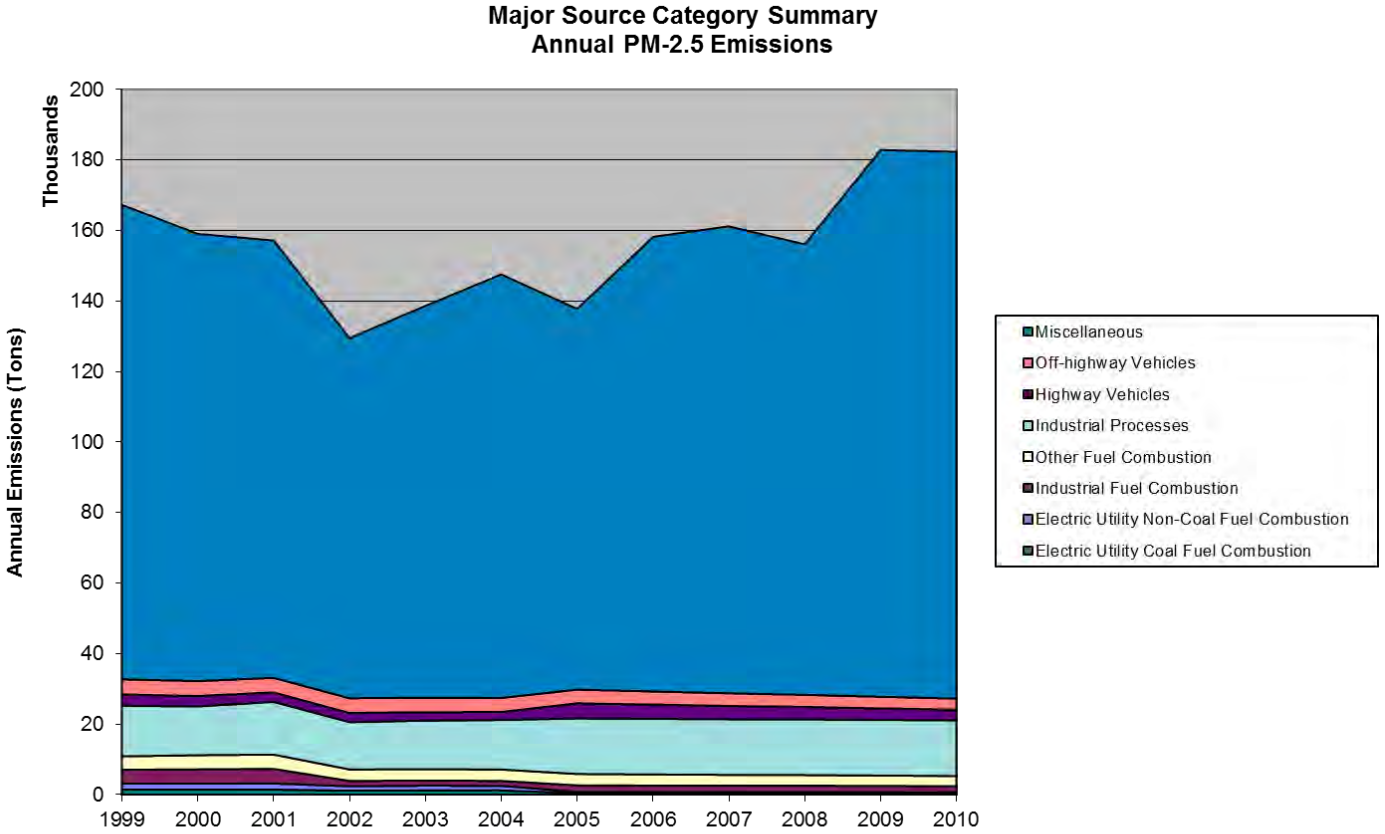
	Annual Emissions (Tons)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	1,407	1,436	1,434	1,100	1,203	1,184	435	393	349	340	309	253
Electric Utility Non-Coal Fuel Combustion	1,703	1,685	1,717	1,277	1,342	1,304	363	344	348	381	327	332
Industrial Fuel Combustion	3,944	4,053	4,158	1,505	1,457	1,409	1,837	1,836	1,834	1,833	1,831	1,830
Other Fuel Combustion	3,806	4,014	4,044	3,265	3,250	3,235	3,221	3,150	3,079	3,009	2,938	2,867
Industrial Processes	14,335	13,829	14,960	13,416	13,732	14,048	15,754	15,762	15,771	15,779	15,788	15,796
Highway Vehicles	3,177	2,955	2,685	2,592	2,424	2,256	4,291	4,033	3,776	3,518	3,261	3,003
Off-highway Vehicles	4,339	4,232	4,123	4,195	4,094	3,993	3,893	3,747	3,602	3,457	3,311	3,166
Miscellaneous	134,562	126,821	124,029	102,104	111,100	120,097	107,956	128,919	132,411	127,743	155,050	155,050
Total	**167,273**	**159,026**	**157,150**	**129,454**	**138,603**	**147,525**	**137,749**	**158,185**	**161,169**	**156,059**	**182,816**	**182,297**

	Annual Emissions (Percent of Total)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Electric Utility Non-Coal Fuel Combustion	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Industrial Fuel Combustion	2%	3%	3%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Other Fuel Combustion	2%	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%
Industrial Processes	9%	9%	10%	10%	10%	10%	11%	10%	10%	10%	9%	9%
Highway Vehicles	2%	2%	2%	2%	2%	2%	3%	3%	2%	2%	2%	2%
Off-highway Vehicles	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%
Miscellaneous	80%	80%	79%	79%	80%	81%	78%	81%	82%	82%	85%	85%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

ALPINE GEOPHYSICS

ENVIRON

Oklahoma Emission Trends ($PM_{2.5}$)



ALPINE GEOPHYSICS

ENVIRON

Central States Emissions Summary

	Annual Emissions (Tons) -- 2010						
State	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Arkansas	382,050	233,202	1,652,404	114,909	345,454	134,072	143,080
Iowa	172,612	256,763	754,323	189,563	504,847	91,615	263,459
Kansas	240,967	306,111	1,583,292	99,008	772,261	194,465	175,371
Louisiana	826,763	551,507	3,329,015	260,089	478,587	269,796	105,718
Minnesota	339,921	383,642	1,624,338	88,106	796,905	151,181	172,898
Missouri	369,650	417,045	1,747,307	354,115	1,010,829	172,426	122,394
Nebraska	85,802	206,145	432,551	80,201	460,901	69,982	174,968
Oklahoma	512,467	379,065	1,807,827	138,625	788,303	182,297	125,252
Texas	1,493,547	1,652,339	5,738,864	773,611	2,560,407	503,337	404,372
Total	**4,423,780**	**4,385,819**	**18,669,920**	**2,098,227**	**7,718,496**	**1,769,169**	**1,687,512**

ALPINE GEOPHYSICS

ENVIRON

Emission Changes

- The following slides represent the percentage-based emissions change from 1999 to 2010 for each pollutant as well as a comparison map of 2010 annual emissions

- Negative values indicate decrease in emissions, positive values indicate an increase

Oklahoma Emission Change (VOC)

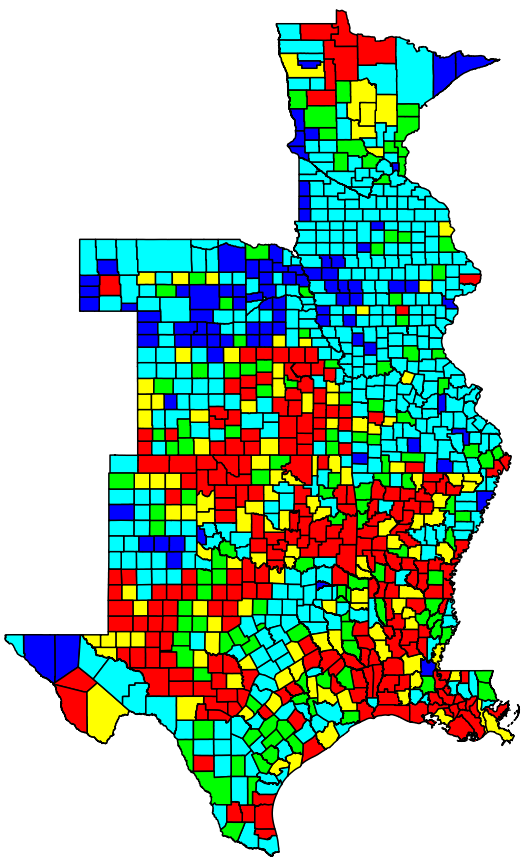
	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	-70	-79	86	132	136	-114	-136	-152	-158	-173	-201
Electric Utility Non-Coal Fuel Combustion	0	136	86	344	258	167	-197	-201	-226	-226	-252	-260
Industrial Fuel Combustion	0	181	103	5,999	5,885	5,772	6,019	6,007	5,996	5,985	5,974	5,962
Other Fuel Combustion	0	506	505	258	-432	-1,121	-1,811	-1,941	-2,072	-2,202	-2,333	-2,463
Industrial Processes	0	-13,331	-8,990	38,266	41,686	45,106	99,874	100,354	100,834	101,313	101,793	102,272
Highway Vehicles	0	-3,017	-9,042	-9,211	-14,492	-19,774	-33,764	-37,095	-40,425	-43,756	-47,086	-50,417
Off-highway Vehicles	0	-285	-660	8,045	7,181	6,316	5,451	3,955	2,459	963	-534	-2,030
Miscellaneous	0	-8,367	-9,519	13,799	34,825	55,851	27,282	84,504	94,737	80,561	153,616	153,616
Total	**0**	**-24,246**	**-27,596**	**57,585**	**75,042**	**92,452**	**102,741**	**155,446**	**161,151**	**142,480**	**211,005**	**206,479**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	-20%	-23%	25%	39%	40%	-34%	-40%	-45%	-46%	-51%	-59%
Electric Utility Non-Coal Fuel Combustion	0%	20%	13%	51%	38%	25%	-29%	-30%	-33%	-33%	-37%	-38%
Industrial Fuel Combustion	0%	2%	1%	55%	54%	53%	55%	55%	55%	55%	55%	55%
Other Fuel Combustion	0%	7%	7%	3%	-6%	-15%	-24%	-26%	-28%	-30%	-31%	-33%
Industrial Processes	0%	-9%	-6%	26%	28%	30%	67%	68%	68%	68%	69%	69%
Highway Vehicles	0%	-3%	-9%	-10%	-15%	-21%	-35%	-39%	-42%	-46%	-49%	-53%
Off-highway Vehicles	0%	-1%	-2%	26%	23%	20%	17%	13%	8%	3%	-2%	-6%
Miscellaneous	0%	-74%	-84%	122%	307%	493%	241%	746%	836%	711%	1356%	1356%
Total	**0%**	**-8%**	**-9%**	**19%**	**25%**	**30%**	**34%**	**51%**	**53%**	**47%**	**69%**	**67%**

ALPINE GEOPHYSICS

ENVIRON

Annual Emission Summary (VOC)

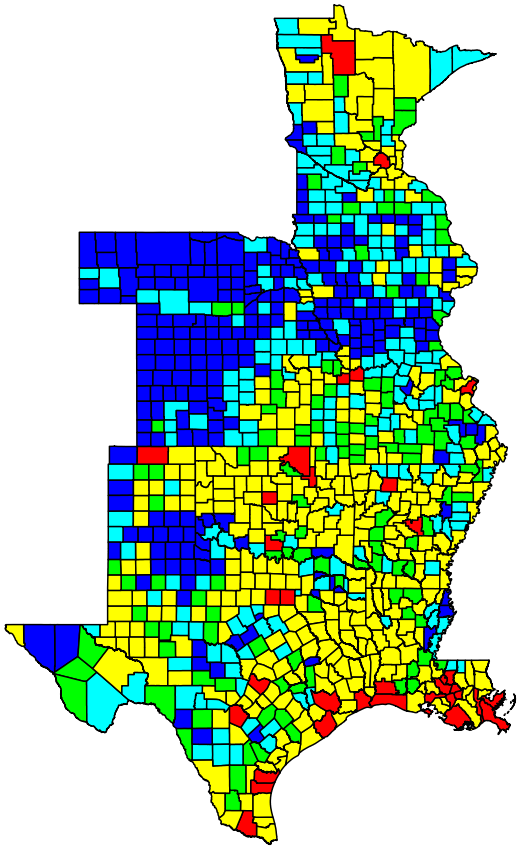


Annual Emissions Chang
1999 to 2010

- > 50%
- 10% to 50%
- -10% to 10%
- -50% to -10%
- < -50%

Emission Change (%)

1999 to 2010



Annual 2010 Emissions
VOC Tons Per Year

- 18,000 to 190,000
- 3,000 to 18,000
- 2,000 to 3,000
- 1,000 to 2,000
- 0 to 1,000

Emission Density (Tons)

2010

Oklahoma Emission Change (NOx)

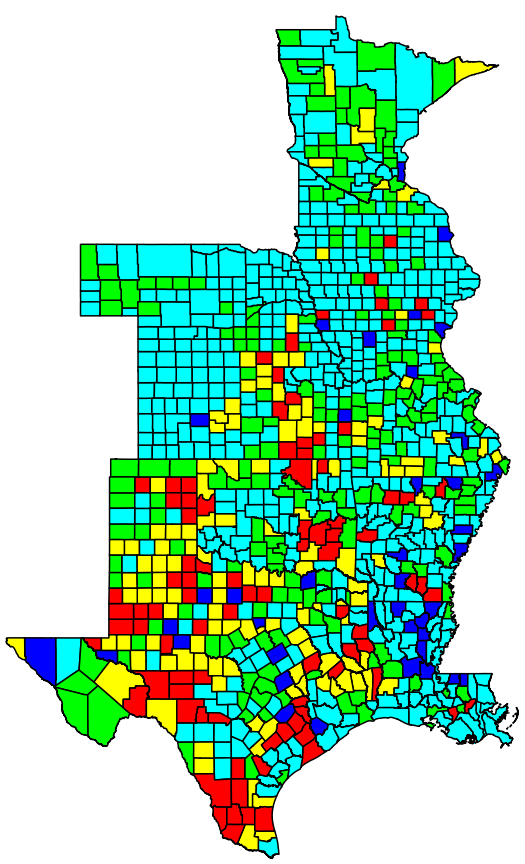
	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	-4,230	-9,168	11,525	18,612	16,043	-229	-2,171	-4,163	-4,147	-4,310	-6,534
Electric Utility Non-Coal Fuel Combustion	0	-5,200	-10,542	12,791	9,868	7,976	4,556	4,049	-608	1,943	-5,536	-4,588
Industrial Fuel Combustion	0	298	2,214	-62,974	-65,376	-67,722	-63,365	-63,860	-64,155	-63,925	-63,658	-64,959
Other Fuel Combustion	0	99	187	58	32	6	-20	-33	-45	-58	-70	-83
Industrial Processes	0	6,532	6,957	68,643	70,539	72,436	40,837	41,139	41,442	41,744	42,046	42,348
Highway Vehicles	0	101	-10,277	-5,967	-15,783	-25,599	10,601	2,434	-5,733	-13,899	-22,066	-30,233
Off-highway Vehicles	0	66	118	3,609	3,001	2,393	1,786	20	-1,747	-3,513	-5,279	-7,045
Miscellaneous	0	-4,267	-4,792	13,082	15,471	17,860	14,702	18,636	18,856	18,806	23,952	23,952
Total	**0**	**-6,602**	**-25,304**	**40,768**	**36,366**	**23,394**	**8,868**	**215**	**-16,152**	**-23,048**	**-34,922**	**-47,142**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	-13%	-28%	35%	56%	48%	-1%	-7%	-13%	-13%	-13%	-20%
Electric Utility Non-Coal Fuel Combustion	0%	-11%	-21%	26%	20%	16%	9%	8%	-1%	4%	-11%	-9%
Industrial Fuel Combustion	0%	0%	2%	-48%	-50%	-52%	-49%	-49%	-49%	-49%	-49%	-50%
Other Fuel Combustion	0%	1%	3%	1%	0%	0%	0%	0%	-1%	-1%	-1%	-1%
Industrial Processes	0%	76%	81%	801%	824%	846%	477%	480%	484%	487%	491%	494%
Highway Vehicles	0%	0%	-7%	-4%	-11%	-18%	8%	2%	-4%	-10%	-16%	-22%
Off-highway Vehicles	0%	0%	0%	7%	6%	4%	3%	0%	-3%	-7%	-10%	-13%
Miscellaneous	0%	-76%	-86%	233%	276%	319%	262%	333%	336%	336%	427%	427%
Total	**0%**	**-2%**	**-6%**	**10%**	**9%**	**5%**	**2%**	**0%**	**-4%**	**-5%**	**-8%**	**-11%**

ALPINE GEOPHYSICS

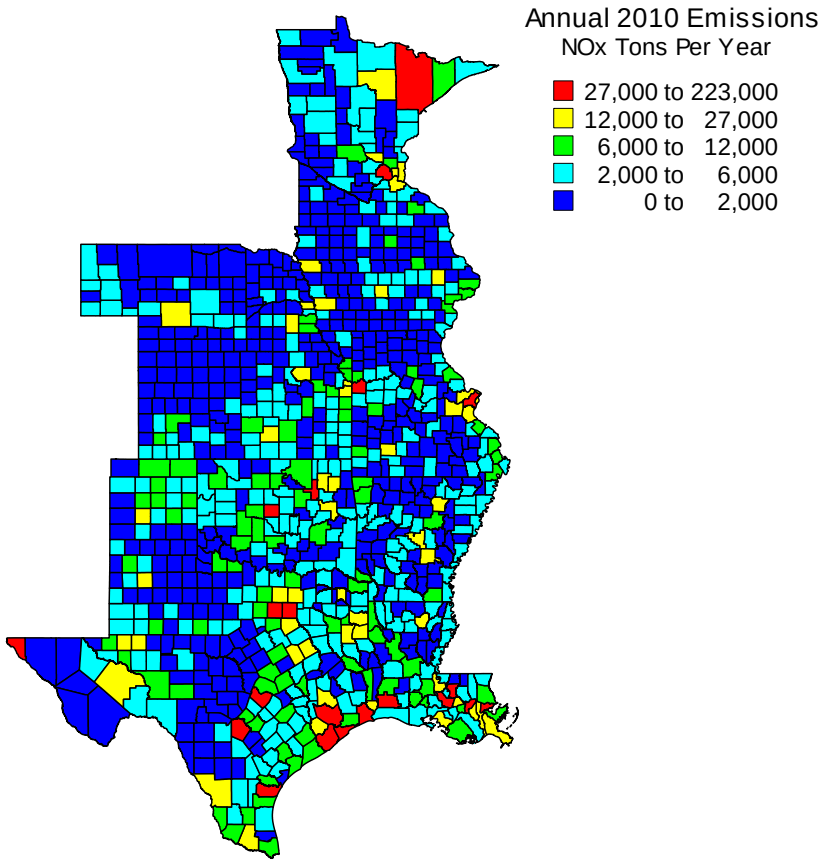
ENVIRON

Annual Emission Summary (NOx)



Emission Change (%)

1999 to 2010



Emission Density (Tons)

2010

Oklahoma Emission Change (SO2)

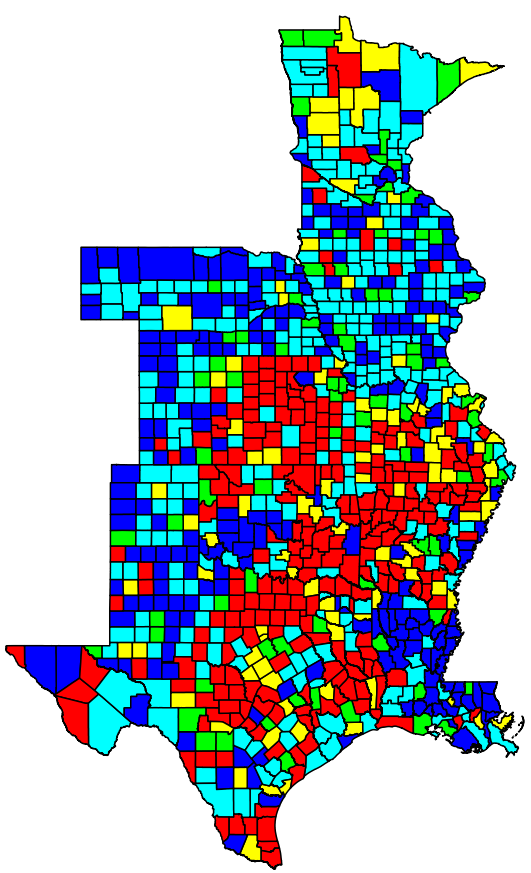
	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	-17,731	-16,833	15,175	22,471	22,778	-6,013	-8,494	-10,739	-8,871	-10,309	-15,699
Electric Utility Non-Coal Fuel Combustion	0	485	-3,230	44,863	45,522	40,030	28,045	31,754	27,147	25,613	20,163	14,506
Industrial Fuel Combustion	0	-2,840	9,651	-24,737	-25,419	-26,100	-26,782	-27,544	-28,305	-29,066	-29,828	-30,590
Other Fuel Combustion	0	12	22	298	295	291	288	287	286	285	285	284
Industrial Processes	0	10,571	9,853	6,334	7,787	9,240	11,707	11,366	11,025	10,684	10,344	10,003
Highway Vehicles	0	-442	-473	86	-795	-1,677	-1,942	-2,357	-2,773	-3,189	-3,605	-4,020
Off-highway Vehicles	0	92	196	79	104	130	155	-513	-1,180	-1,848	-2,516	-3,183
Miscellaneous	0	296	152	6,641	7,678	8,714	7,309	9,304	9,518	9,299	11,903	11,903
Total	**0**	**-9,559**	**-663**	**48,740**	**57,642**	**53,406**	**12,767**	**13,804**	**4,979**	**2,908**	**-3,563**	**-16,797**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	-30%	-29%	26%	38%	39%	-10%	-14%	-18%	-15%	-18%	-27%
Electric Utility Non-Coal Fuel Combustion	0%	2%	-11%	153%	155%	136%	96%	108%	93%	87%	69%	49%
Industrial Fuel Combustion	0%	-6%	21%	-54%	-56%	-57%	-59%	-60%	-62%	-64%	-65%	-67%
Other Fuel Combustion	0%	2%	5%	63%	63%	62%	61%	61%	61%	61%	61%	60%
Industrial Processes	0%	97%	90%	58%	71%	85%	107%	104%	101%	98%	95%	92%
Highway Vehicles	0%	-8%	-9%	2%	-15%	-32%	-37%	-45%	-53%	-61%	-69%	-76%
Off-highway Vehicles	0%	2%	4%	2%	2%	3%	3%	-10%	-24%	-38%	-51%	-65%
Miscellaneous	0%	425%	218%	9544%	11034%	12524%	10504%	13372%	13679%	13364%	17107%	17107%
Total	**0%**	**-6%**	**0%**	**31%**	**37%**	**34%**	**8%**	**9%**	**3%**	**2%**	**-2%**	**-11%**

ALPINE GEOPHYSICS

ENVIRON

Annual Emission Summary (SO2)

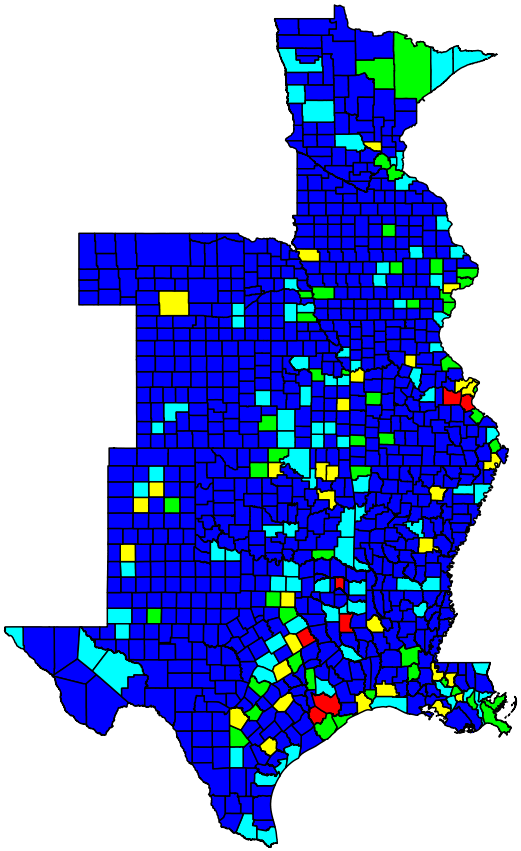


Annual Emissions Change
1999 to 2010

- > 50%
- 10% to 50%
- -10% to 10%
- -50% to -10%
- < -50%

Emission Change (%)

1999 to 2010



Annual 2010 Emissions
SO2 Tons Per Year

- 44,000 to 136,000
- 16,000 to 44,000
- 5,000 to 16,000
- 1,000 to 5,000
- 0 to 1,000

Emission Density (Tons)

2010

Oklahoma Emission Change ($PM_{2.5}$)

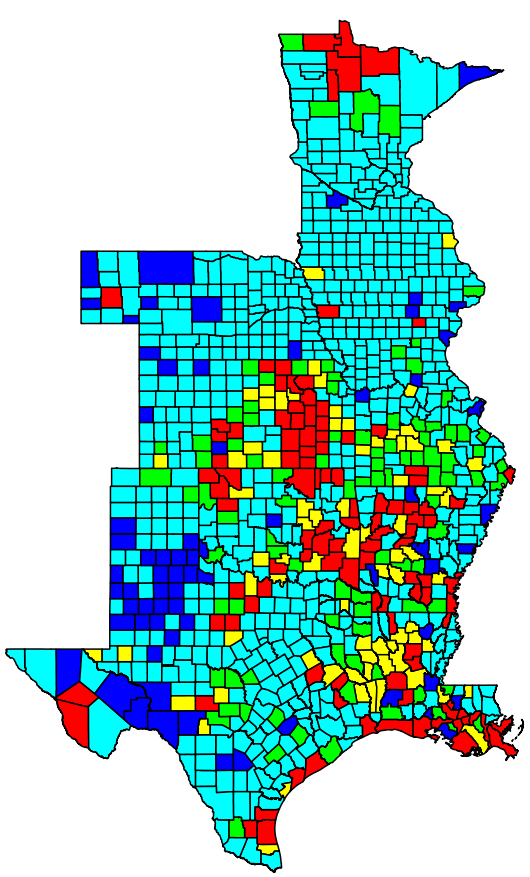
	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0	29	27	-308	-204	-223	-972	-1,015	-1,058	-1,068	-1,098	-1,154
Electric Utility Non-Coal Fuel Combustion	0	-17	14	-425	-361	-399	-1,339	-1,358	-1,355	-1,322	-1,375	-1,371
Industrial Fuel Combustion	0	109	214	-2,439	-2,487	-2,536	-2,107	-2,109	-2,110	-2,112	-2,113	-2,115
Other Fuel Combustion	0	208	238	-541	-556	-571	-585	-656	-727	-797	-868	-938
Industrial Processes	0	-506	625	-919	-603	-287	1,419	1,427	1,436	1,444	1,453	1,461
Highway Vehicles	0	-222	-492	-584	-752	-920	1,114	857	599	342	84	-174
Off-highway Vehicles	0	-108	-216	-144	-245	-346	-447	-592	-737	-883	-1,028	-1,173
Miscellaneous	0	-7,741	-10,533	-32,458	-23,461	-14,465	-26,606	-5,643	-2,151	-6,819	20,488	20,488
Total	**0**	**-8,247**	**-10,123**	**-37,818**	**-28,670**	**-19,747**	**-29,524**	**-9,088**	**-6,104**	**-11,214**	**15,543**	**15,024**

	Annual Emissions Change (from 1999)											
Source Category	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electric Utility Coal Fuel Combustion	0%	2%	2%	-22%	-15%	-16%	-69%	-72%	-75%	-76%	-78%	-82%
Electric Utility Non-Coal Fuel Combustion	0%	-1%	1%	-25%	-21%	-23%	-79%	-80%	-80%	-78%	-81%	-81%
Industrial Fuel Combustion	0%	3%	5%	-62%	-63%	-64%	-53%	-53%	-54%	-54%	-54%	-54%
Other Fuel Combustion	0%	5%	6%	-14%	-15%	-15%	-15%	-17%	-19%	-21%	-23%	-25%
Industrial Processes	0%	-4%	4%	-6%	-4%	-2%	10%	10%	10%	10%	10%	10%
Highway Vehicles	0%	-7%	-15%	-18%	-24%	-29%	35%	27%	19%	11%	3%	-5%
Off-highway Vehicles	0%	-2%	-5%	-3%	-6%	-8%	-10%	-14%	-17%	-20%	-24%	-27%
Miscellaneous	0%	-6%	-8%	-24%	-17%	-11%	-20%	-4%	-2%	-5%	15%	15%
Total	**0%**	**-5%**	**-6%**	**-23%**	**-17%**	**-12%**	**-18%**	**-5%**	**-4%**	**-7%**	**9%**	**9%**

ALPINE GEOPHYSICS

ENVIRON

Annual Emission Summary ($PM_{2.5}$)

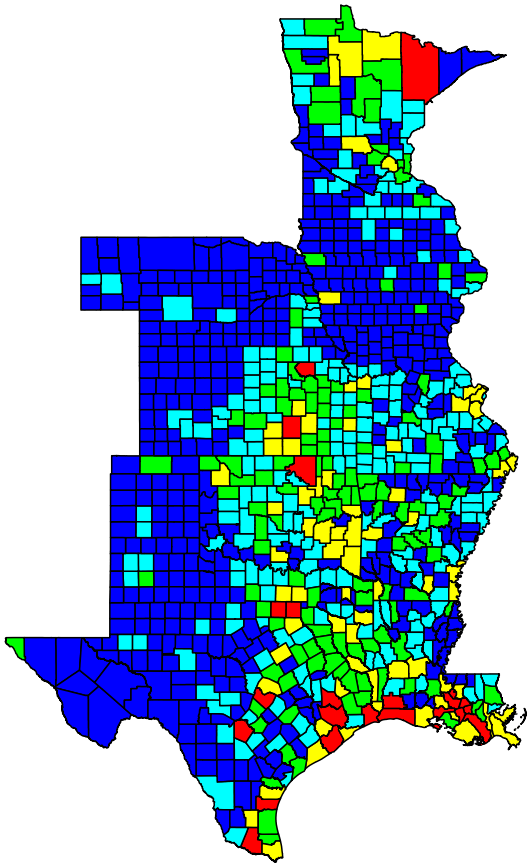


Annual Emissions Change
1999 to 2010

- > 50%
- 10% to 50%
- -10% to 10%
- -50% to -10%
- < -50%

Emission Change (%)

1999 to 2010



Annual 2010 Emissions
PM-2.5 Tons Per Year

- 6,900 to 55,500
- 3,600 to 6,900
- 2,100 to 3,600
- 1,200 to 2,100
- 0 to 1,200

Emission Density (Tons)

2010

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Central States Emissions Change Summary

	Annual Emissions Change (Tons) -- 1999 to 2010						
State	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Arkansas	147,785	-73,407	358,671	-47,909	-116,069	14,707	-5,224
Iowa	-68,598	-71,925	-503,067	-95,456	-57,951	-38,546	-34,589
Kansas	28,592	-65,187	354,407	-50,443	-11,544	21,404	-54,059
Louisiana	460,825	-267,458	1,440,016	-155,032	103,843	94,939	24,568
Minnesota	-76,821	-78,094	-871,065	-61,214	-73,483	-52,730	-21,365
Missouri	-112,691	-180,039	-772,807	-73,336	11,718	-41,776	-82,453
Nebraska	-54,023	-22,670	-330,750	-6,707	-94,480	-41,713	-69,408
Oklahoma	206,479	-47,142	186,662	-16,797	-14,263	15,024	-89,860
Texas	99,690	-213,382	-2,109,688	-279,149	-51,419	-85,724	-111,094
Total	**631,238**	**-1,019,304**	**-2,247,621**	**-786,042**	**-303,649**	**-114,414**	**-443,483**

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Emission Trends Summary

- All pollutants with the exception of VOC, CO and PM have decreased since 1999 in aggregate across Oklahoma
  - Increases due to forestry and industrial categories
- Onroad emission step increase seen between 2004 and 2005 is the result of EPA's method change and MOVES model integration for estimating onroad mobile source emissions

Air Quality Trends

Ozone & $PM_{2.5}$

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AQ Trends Scope

- Compute, summarize and display ozone and $PM_{2.5}$ design value trends in the Central states for the period 1999 – 2010

- Create a spreadsheet database of O_3 and $PM_{2.5}$ values at each monitoring site for additional analyses

Design Values

- Ozone
  - Annual 4th highest daily maximum 8-hour average averaged over three consecutive years
  - Current standard = 0.075 ppm
- $PM_{2.5}$ Annual
  - Annual arithmetic mean of quarterly means averaged over three consecutive years
  - Current standard = 15 ug/m^3
- $PM_{2.5}$ 24-Hour
  - Annual 98th percentile of daily averages averaged over three consecutive years
  - Current standard = 35 ug/m^3

State-Wide Design Value (DV) Trends

- Trends in state-wide maximum DV and average DV
  - Max DV: Maximum DVs over all valid trend monitoring sites in the state in each overlapping three year period
  - Average DV: Average of DVs over all valid trend monitoring sites in the state in each overlapping three year period
- Compute linear trend via least-squares regression

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Data Handling Procedures

- O_3 design value (DV) for each overlapping three-year period starting with 1999-2001 and ending with 2008-2010
  - DV calculated using annual 4th highest daily max 8-hr averages and percent of valid observations, based on EPA data handling conventions
  - Data associated with exceptional events that have received EPA concurrence are omitted
  - Selection of trend sites require valid DV in at least 8 out of 10 three-year periods between 1999 and 2010

ALPINE GEOPHYSICS

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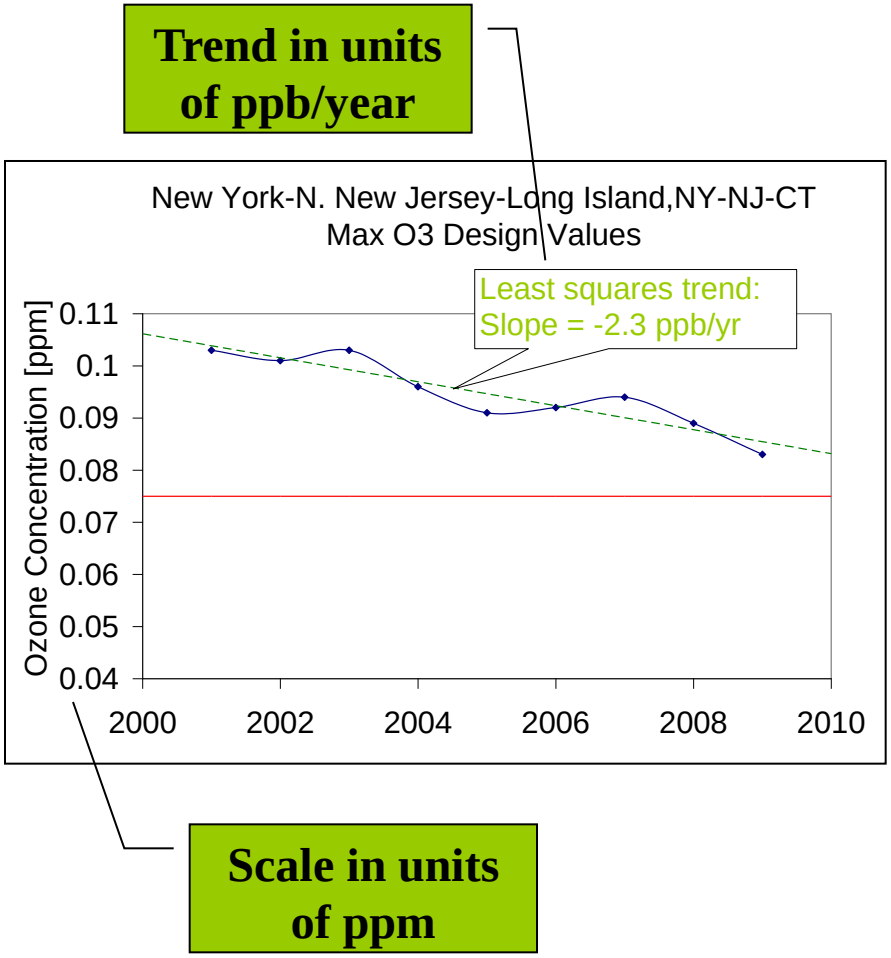
Data Handling Procedures

- Annual $PM_{2.5}$ DV and 24-hr $PM_{2.5}$ DV for each overlapping three-year period starting with 1999-2001 and ending with 2008-2010
  - DV calculations based on EPA data handling conventions
  - Data extracted from monitors that have a non-regulatory monitoring type are omitted
  - Selection of trend sites require valid DV in at least 8 out of at 10 three-year periods between 1999 and 2010

Trend Calculation

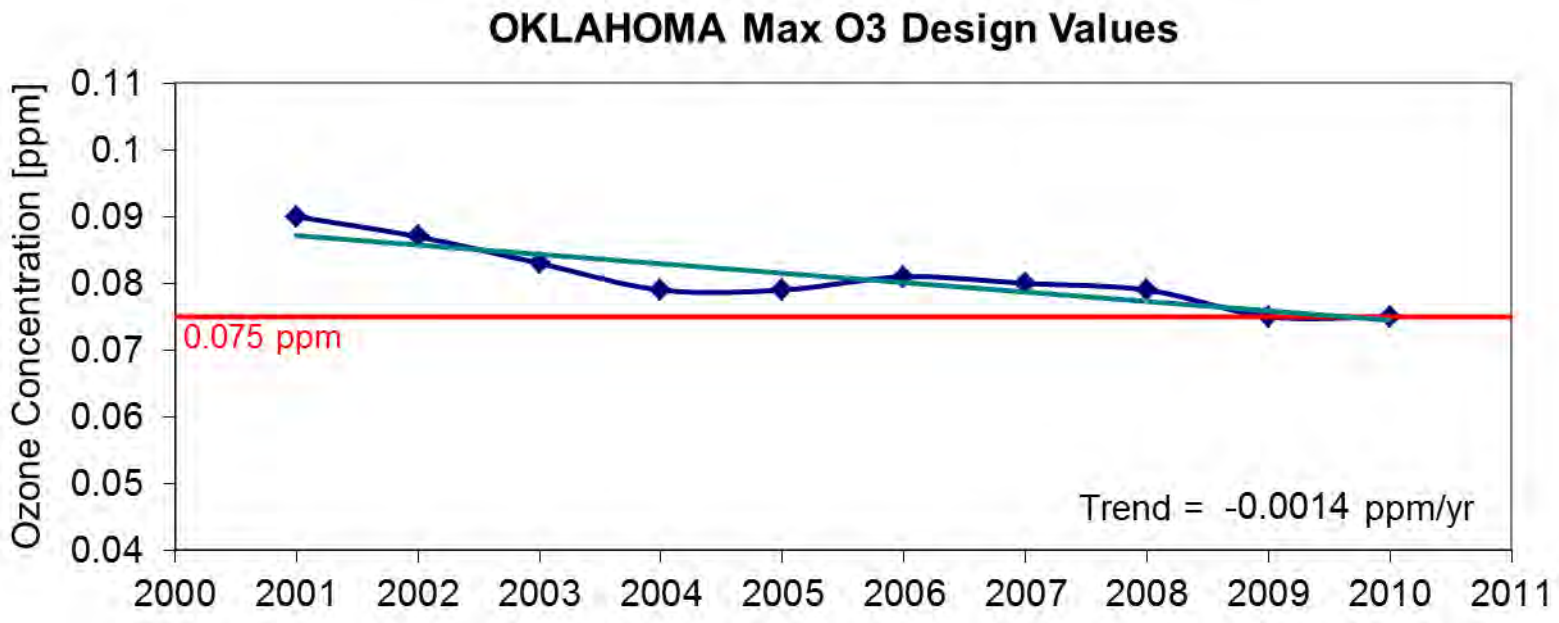


- Trends based on linear least squares fit to rolling three year design values (DVs)
- Negative trend indicates improving air quality
- DVs based on each 3-year period: 1999-2001, 2000-2002, … 2008-2010
- Notes
  - On plots, DVs are for three year period ending in year shown (i.e., 2007-2009 DV plotted as 2009 value)
  - Ozone trend values expressed as ppb/year (1,000 ppb = 1 ppm); DVs are plotted as ppm

ALPINE GEOPHYSICS

ENVIRON

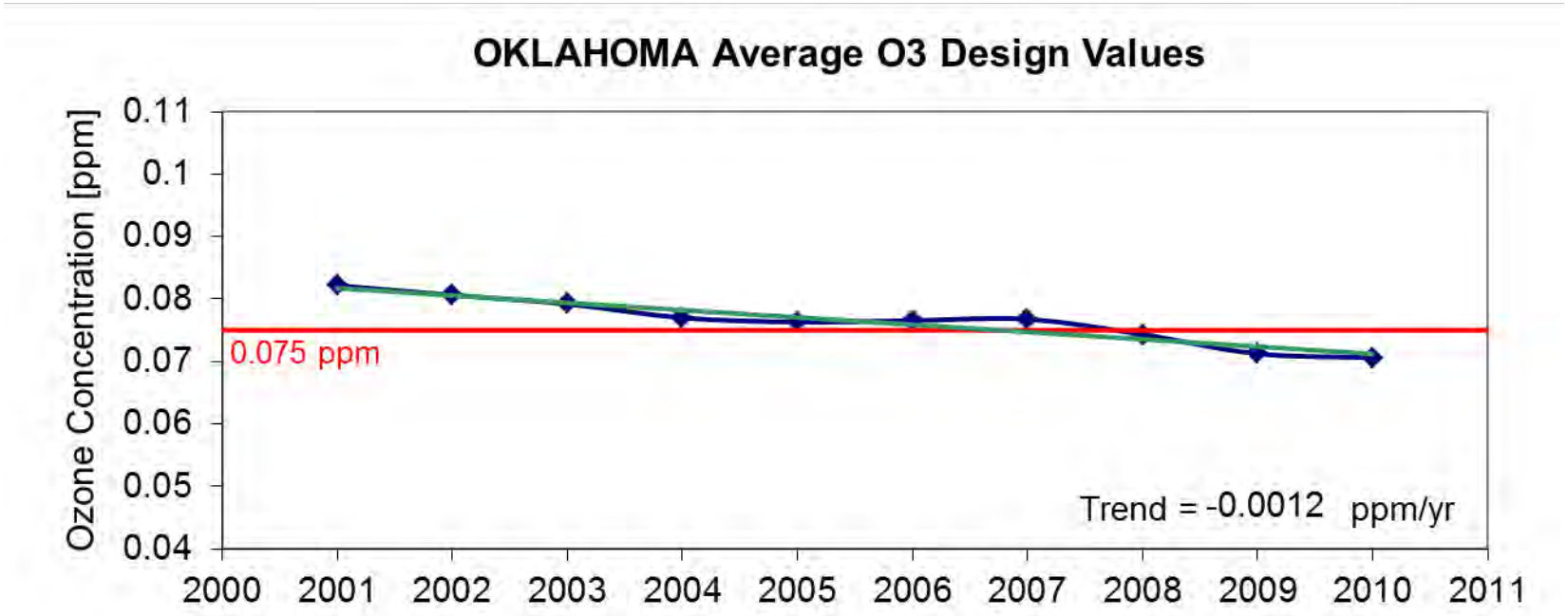
Max O_3 DVs and Trend



ALPINE GEOPHYSICS

ENVIRON

Average O_3 DVs and Trend



ALPINE GEOPHYSICS

ENVIRON

Ozone Trends by Site in Oklahoma

Monitoring Sites	County	Trend [ppm/yr]
4002190024420101	Cherokee, OK	-0.0012
4002700494420101	Cleveland, OK	-0.0009
4008710734420101	McClain, OK	-0.0014
4010900334420101	Oklahoma, OK	-0.0008
4010910374420101	Oklahoma, OK	-0.0006
4014301374420101	Tulsa, OK	-0.0015
4014301744420101	Tulsa, OK	-0.0017
4014301784420101	Tulsa, OK	-0.0013
4014311274420101	Tulsa, OK	-0.0012

Note: Only monitoring sites meeting data completeness criteria listed

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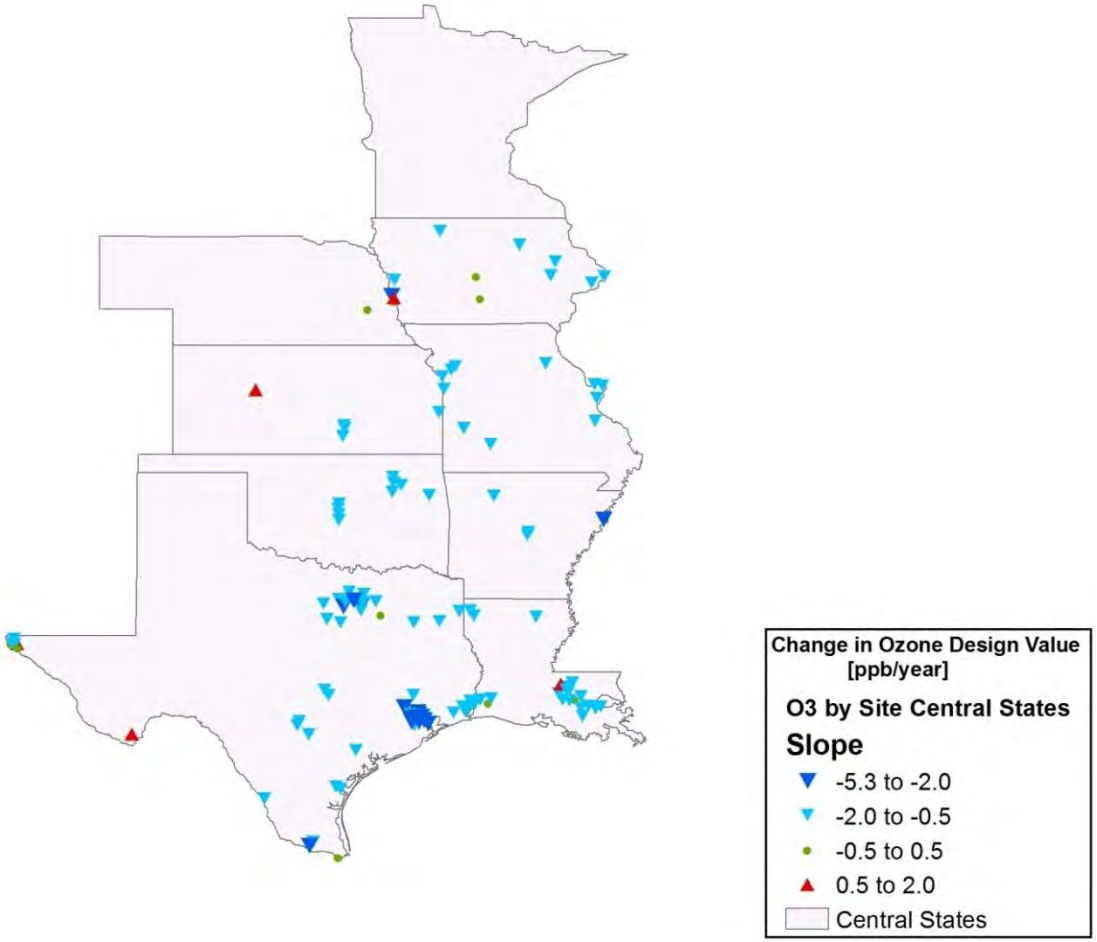
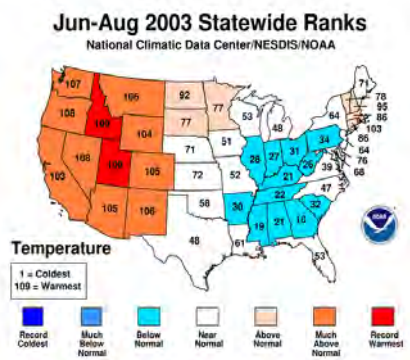
O_3 Trend Slopes at Monitoring Sites

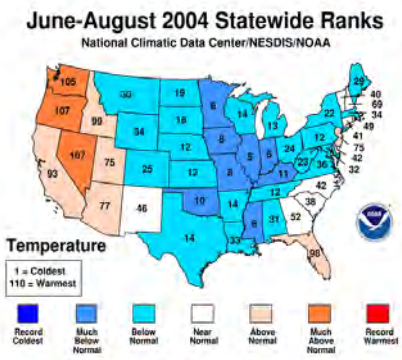


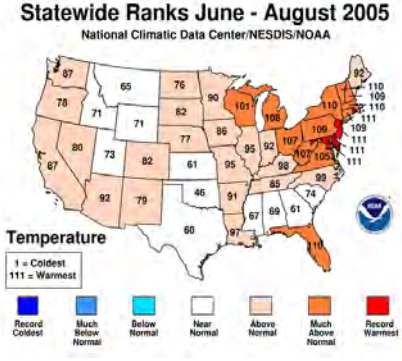
ALPINE GEOPHYSICS

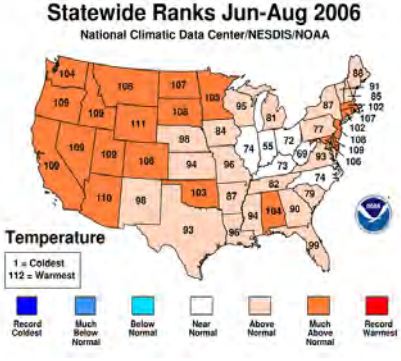
ENVIRON

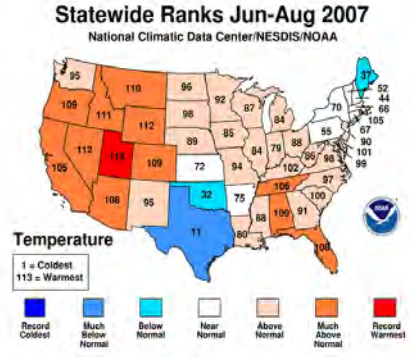
Qualitative Meteorological Trends
June-August Temperature 2003-2010

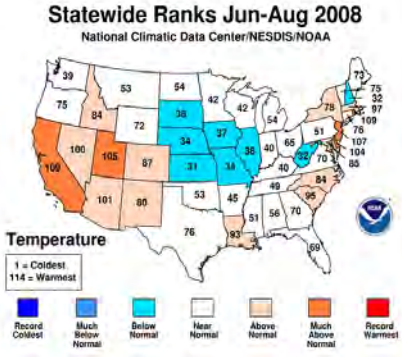


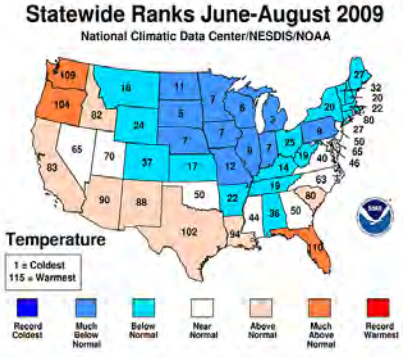


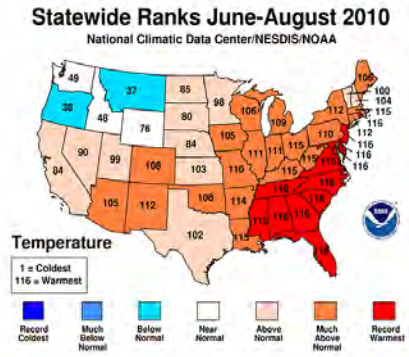












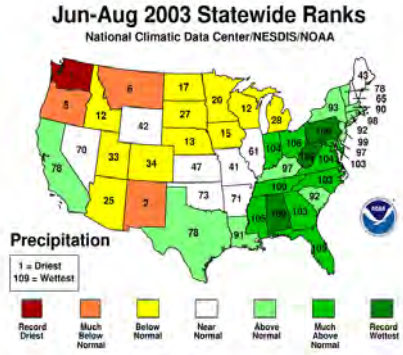
Blue colors represent the coldest years, red hottest

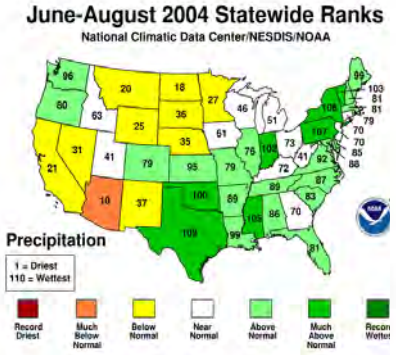
2005-2007 and 2010 most ozone conducive in Central U.S. from temperature standpoint

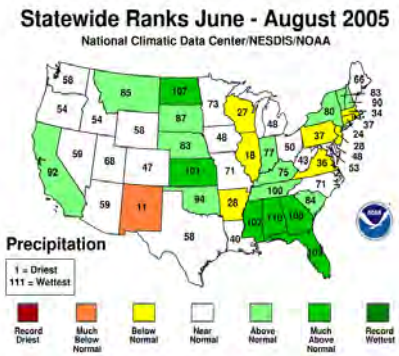
ALPINE GEOPHYSICS

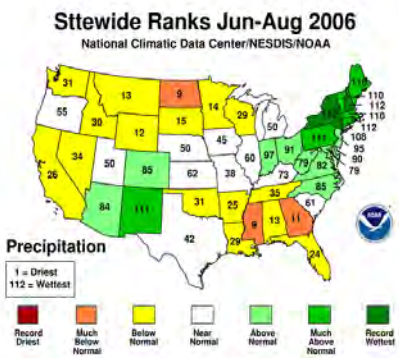
ENVIRON

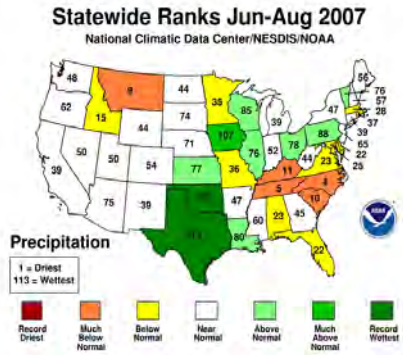
Qualitative Meteorological Trends
June-August Precipitation 2003-2010

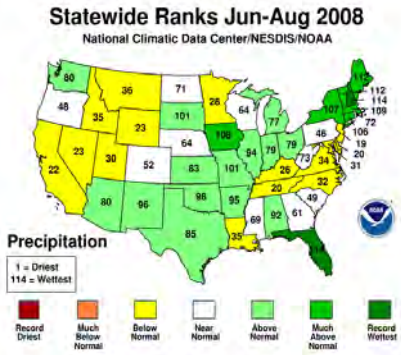


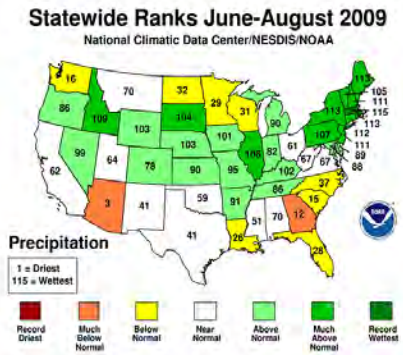


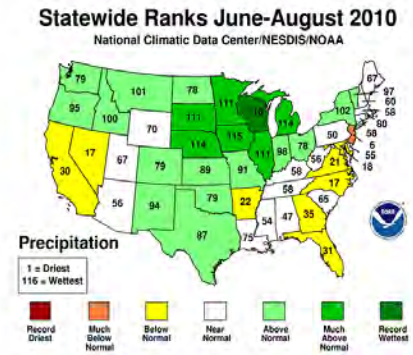








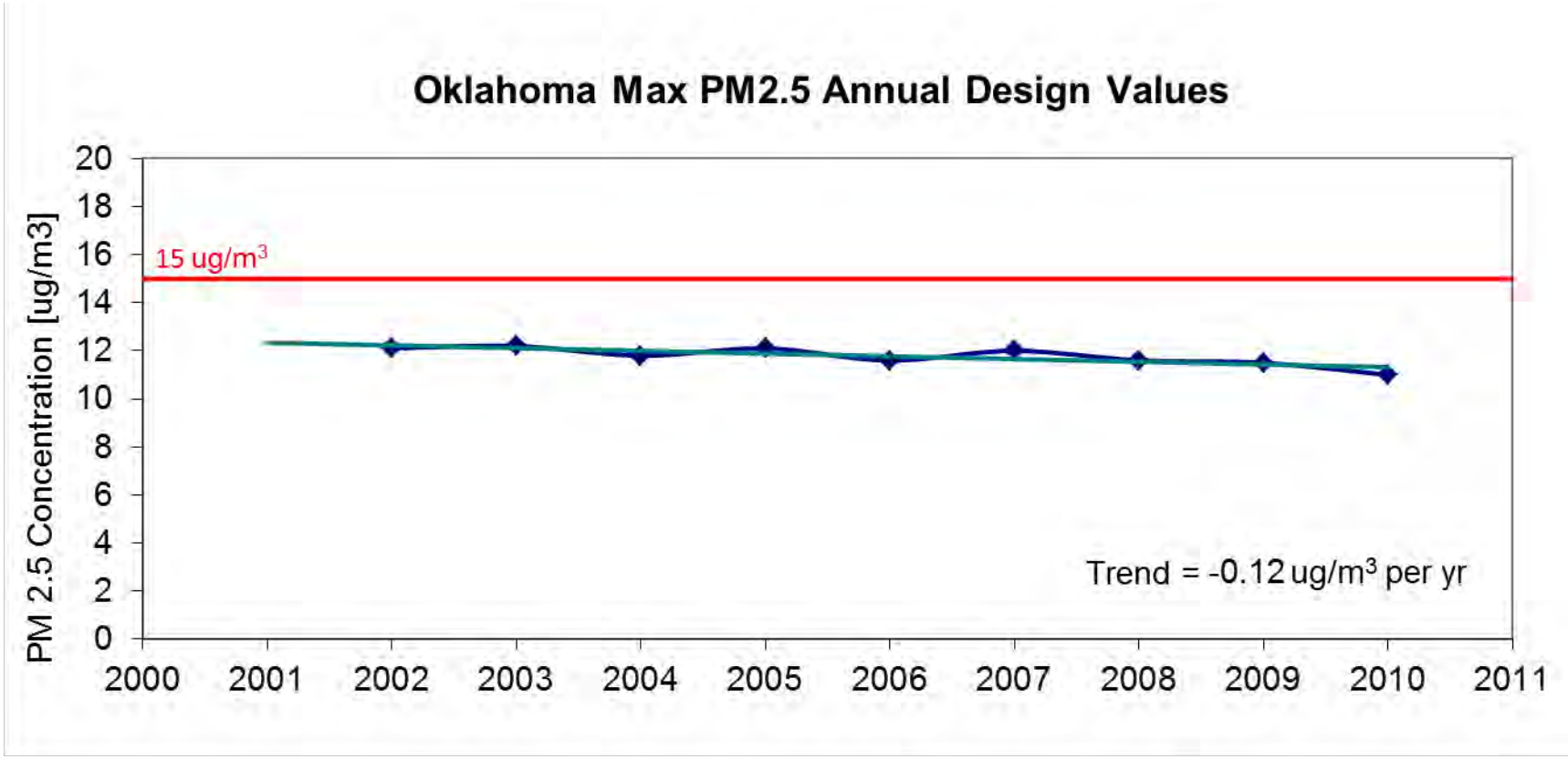




Red colors represent the driest years, dark green wettest

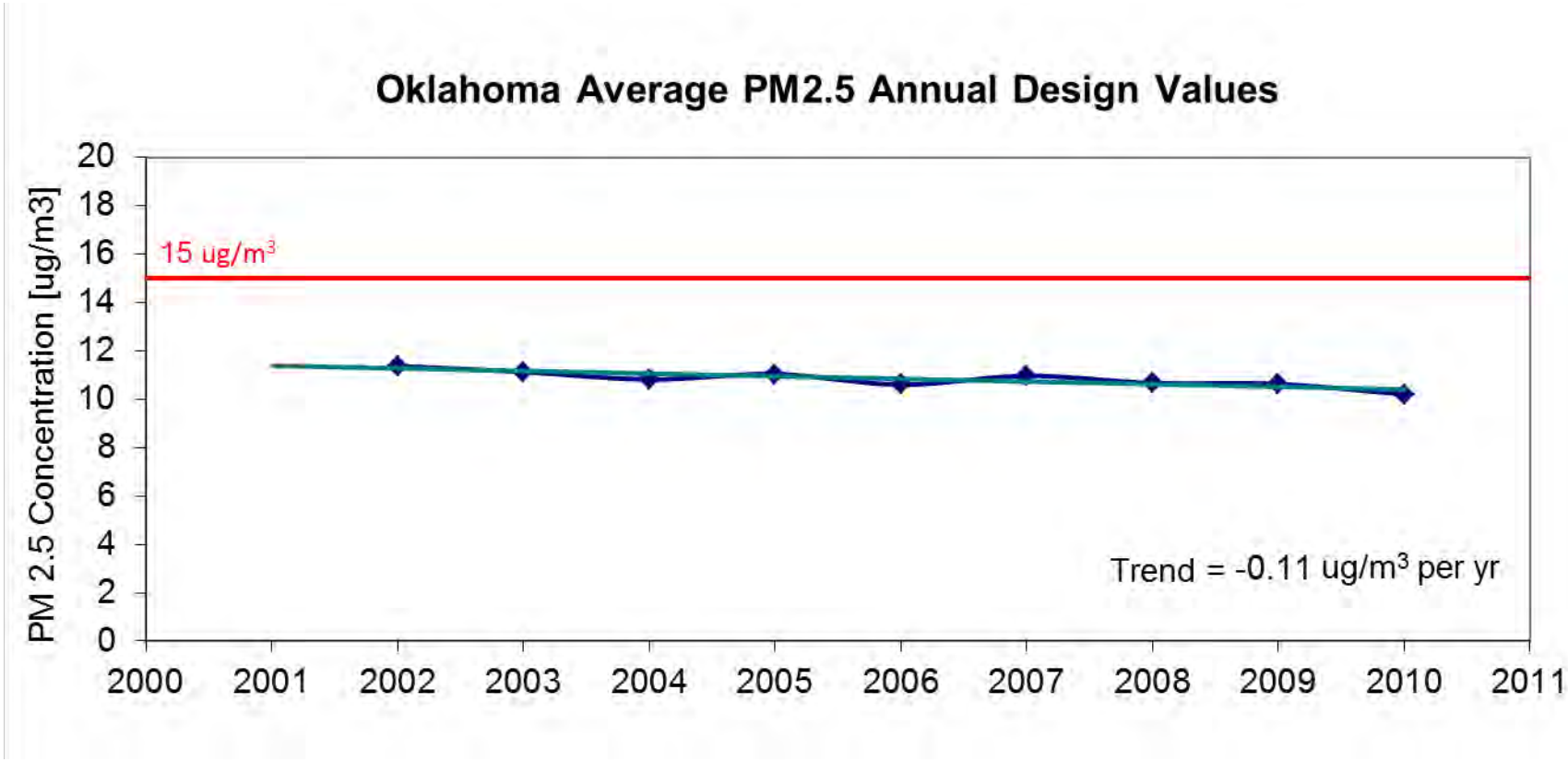
2004 and 2006 most ozone conducive in Central U.S. from precipitation standpoint

Max $PM_{2.5}$ Annual DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

Average $PM_{2.5}$ Annual DVs and Trend

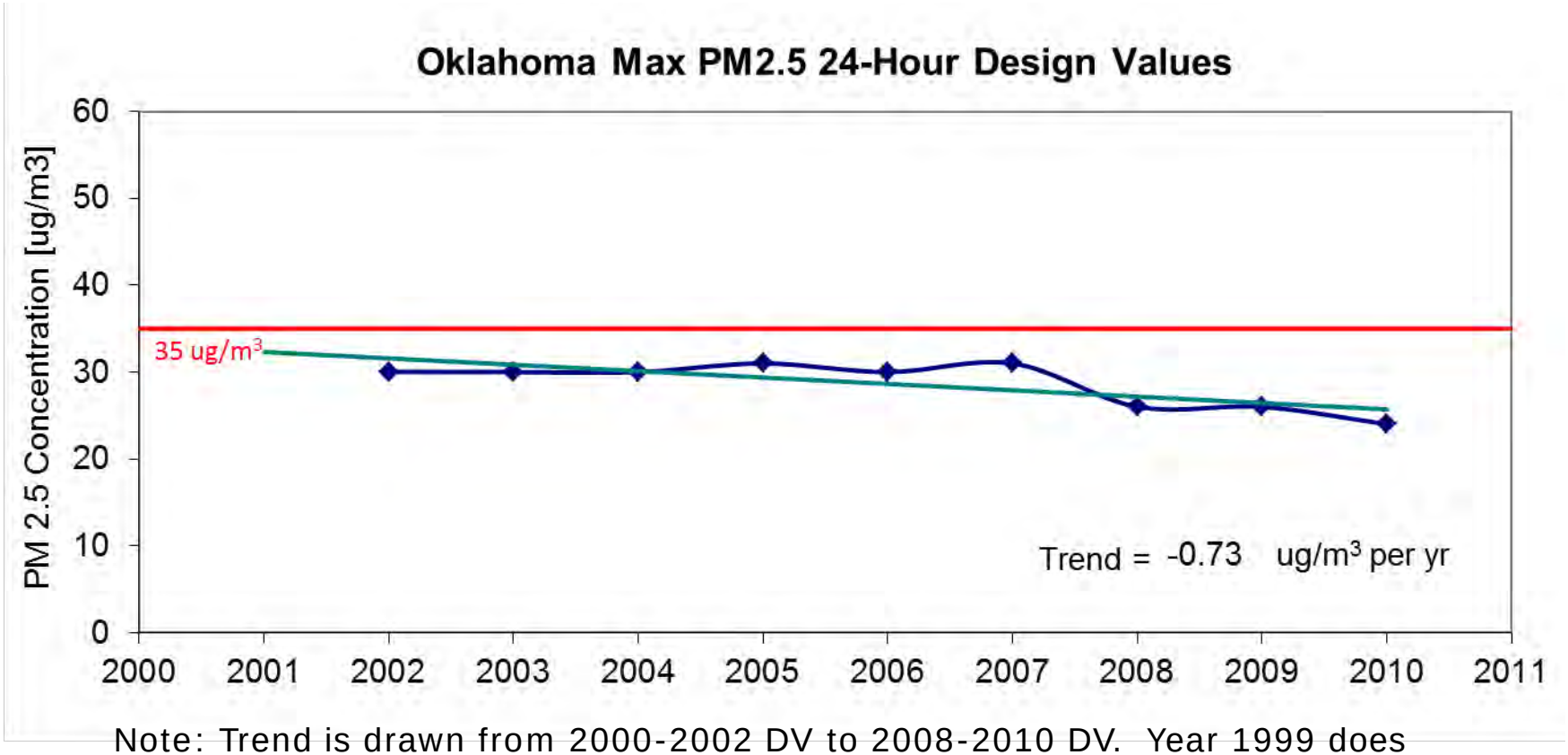


Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

ALPINE GEOPHYSICS

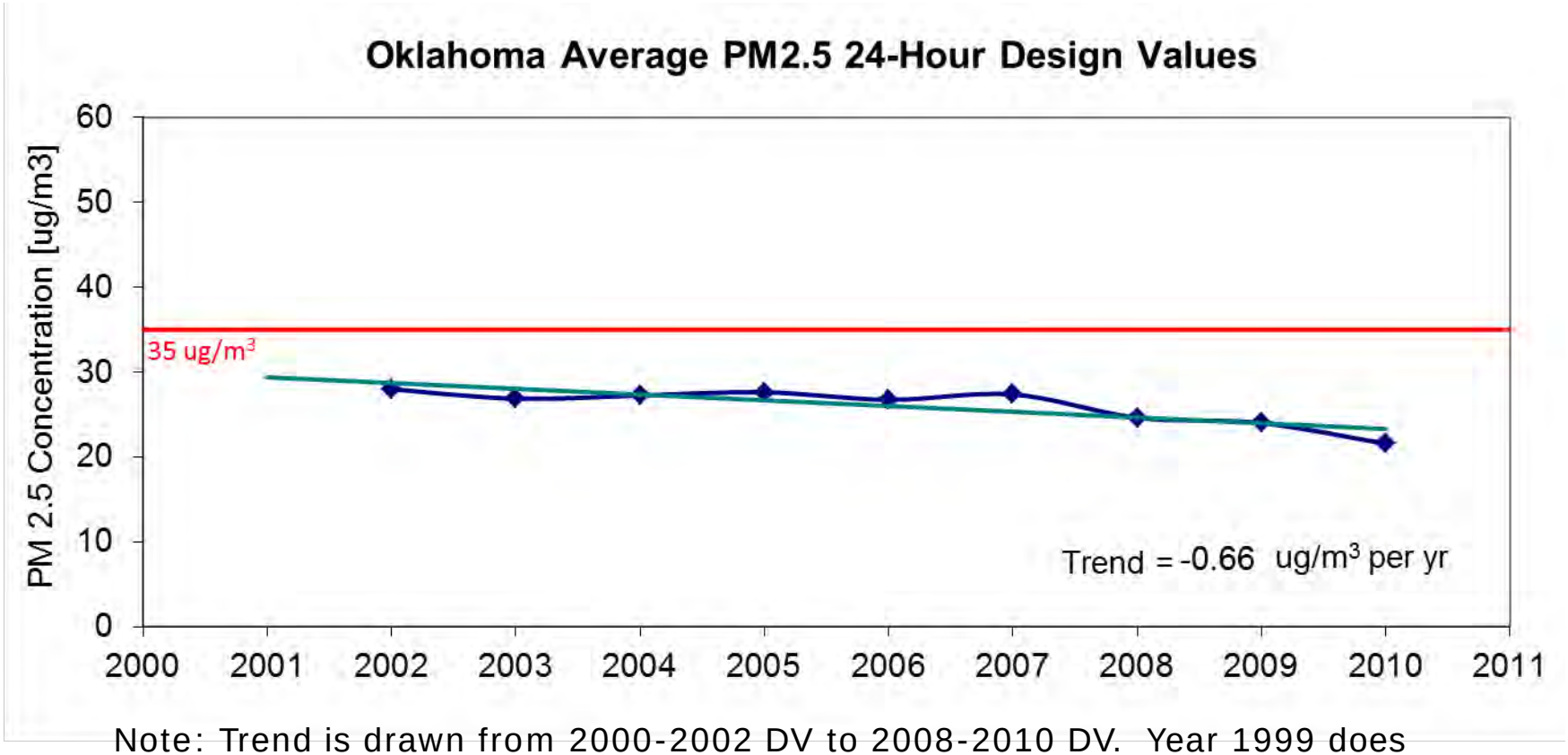
ENVIRON

Max $PM_{2.5}$ 24-Hour DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

Average $PM_{2.5}$ 24-Hour DVs and Trend



Note: Trend is drawn from 2000-2002 DV to 2008-2010 DV. Year 1999 does not meet data completeness requirement for this trend study.

ALPINE GEOPHYSICS

ENVIRON

$PM_{2.5}$ Trends by Site in Oklahoma

		Trend [ug/m³ per year]	
Monitoring Site	**County**	**Annual DV**	**24-Hr DV**
400159008	Caddo	-0.03	0.58
400970186	Mayes	-0.10	-1.00
401010169	Muskogee	-0.13	-0.62
401090035	Oklahoma	-0.10	-0.85
401091037	Oklahoma	-0.02	-0.77
401159004	Ottawa	-0.12	-0.75
401210415	Pittsburg	-0.10	-0.70
401431127	Tulsa	-0.09	-0.92

Note: Only monitoring sites meeting data completeness criteria listed

ALPINE GEOPHYSICS

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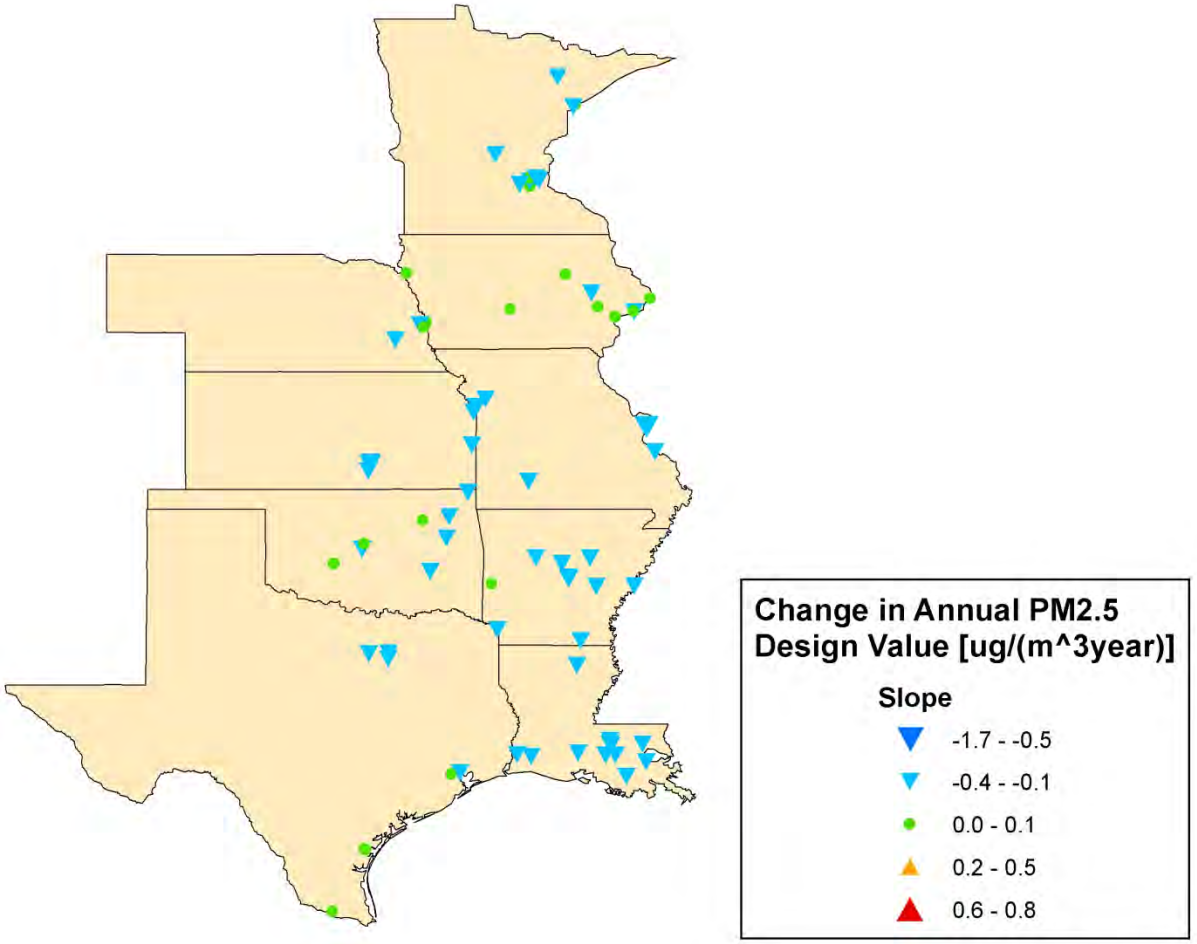
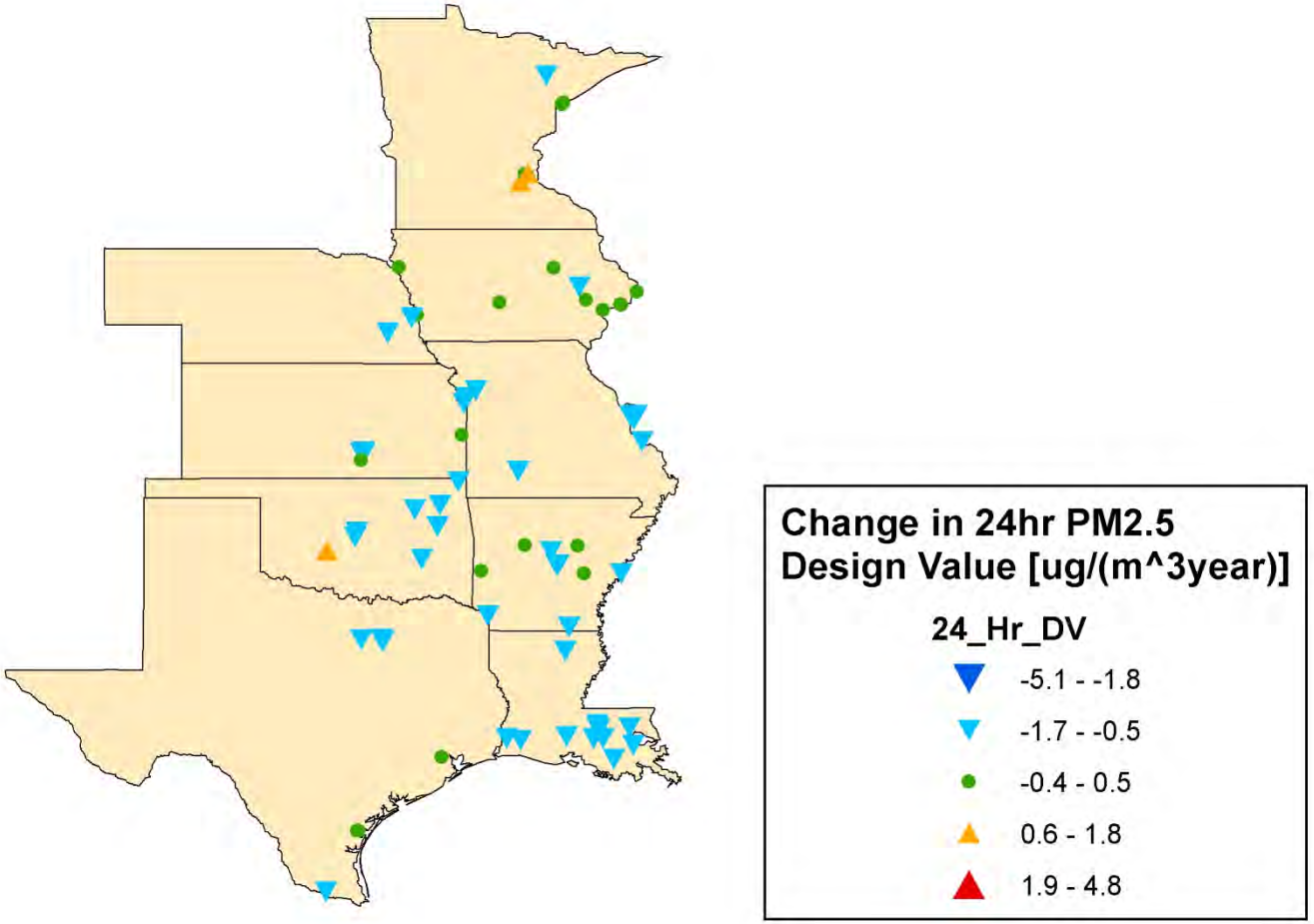
Annual $PM_{2.5}$ Trend Slopes at Monitoring Sites



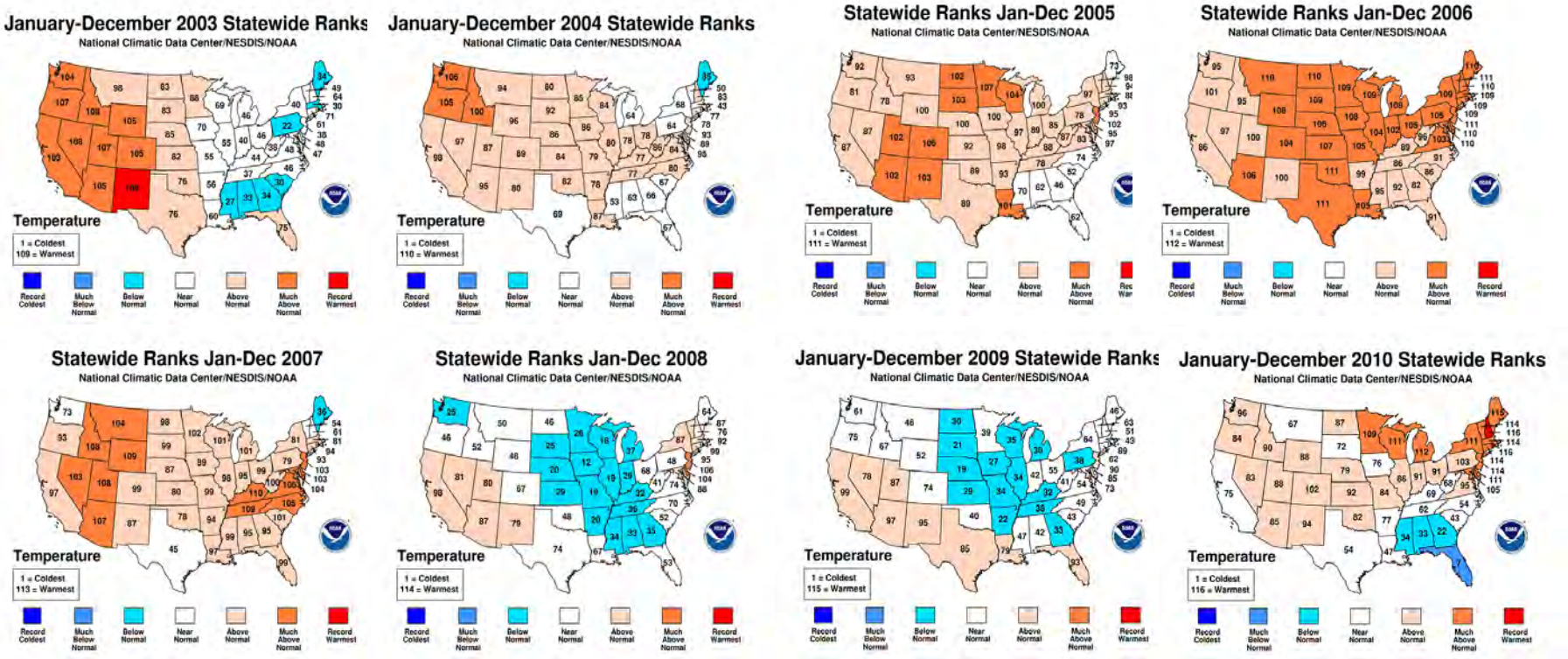
24-Hour $PM_{2.5}$ Trend Slopes at Monitoring Sites



ALPINE GEOPHYSICS

ENVIRON

Qualitative Meteorological Trends
Annual Temperature 2003-2010



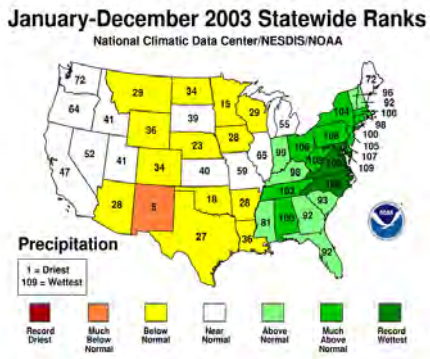
Blue colors represent the coldest years, red hottest

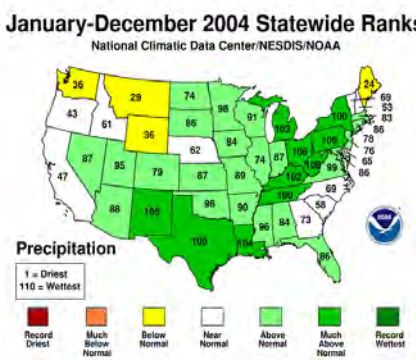
2003-2007 and 2010 most $PM_{2.5}$ conducive in Central U.S. from temperature standpoint

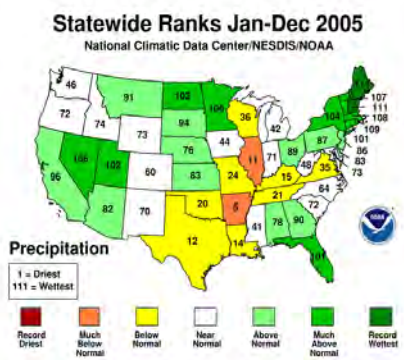
ALPINE GEOPHYSICS

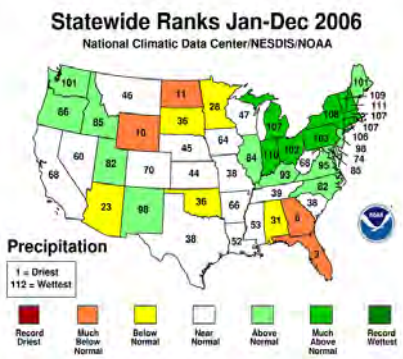
ENVIRON

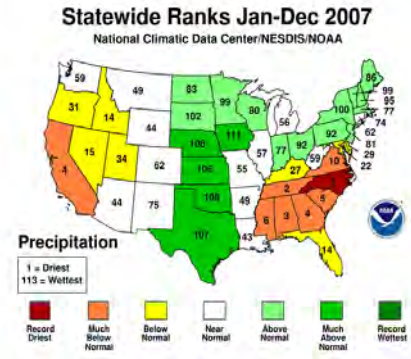
Qualitative Meteorological Trends
Annual Precipitation 2003-2010

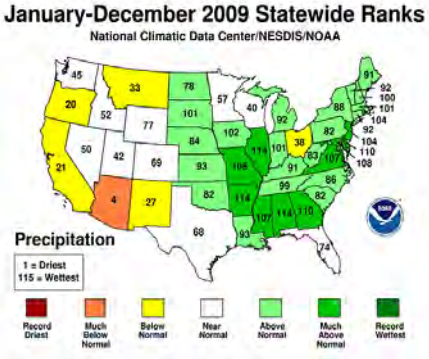


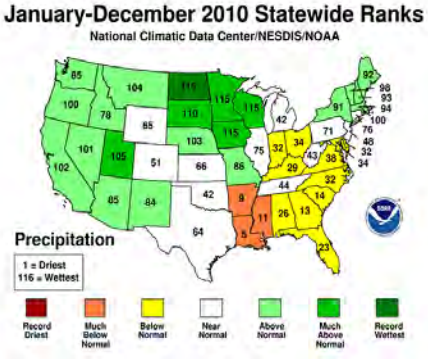












Red colors represent the driest years, dark green wettest

2003, 2005 and 2010 most $PM_{2.5}$ conducive in Central U.S. from precipitation standpoint

ALPINE GEOPHYSICS

ENVIRON

Air Quality Trends Summary

- Average O_3 design values have decreased since 1999 in Oklahoma; average annual and 24-hr $PM_{2.5}$ design values have decreased since 2000 (incomplete data in 1999)

- There are no O_3 and $PM_{2.5}$ non-attainment areas in Oklahoma