

Emission and Air Quality Trends Review



Michigan

March 2012

Summary



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

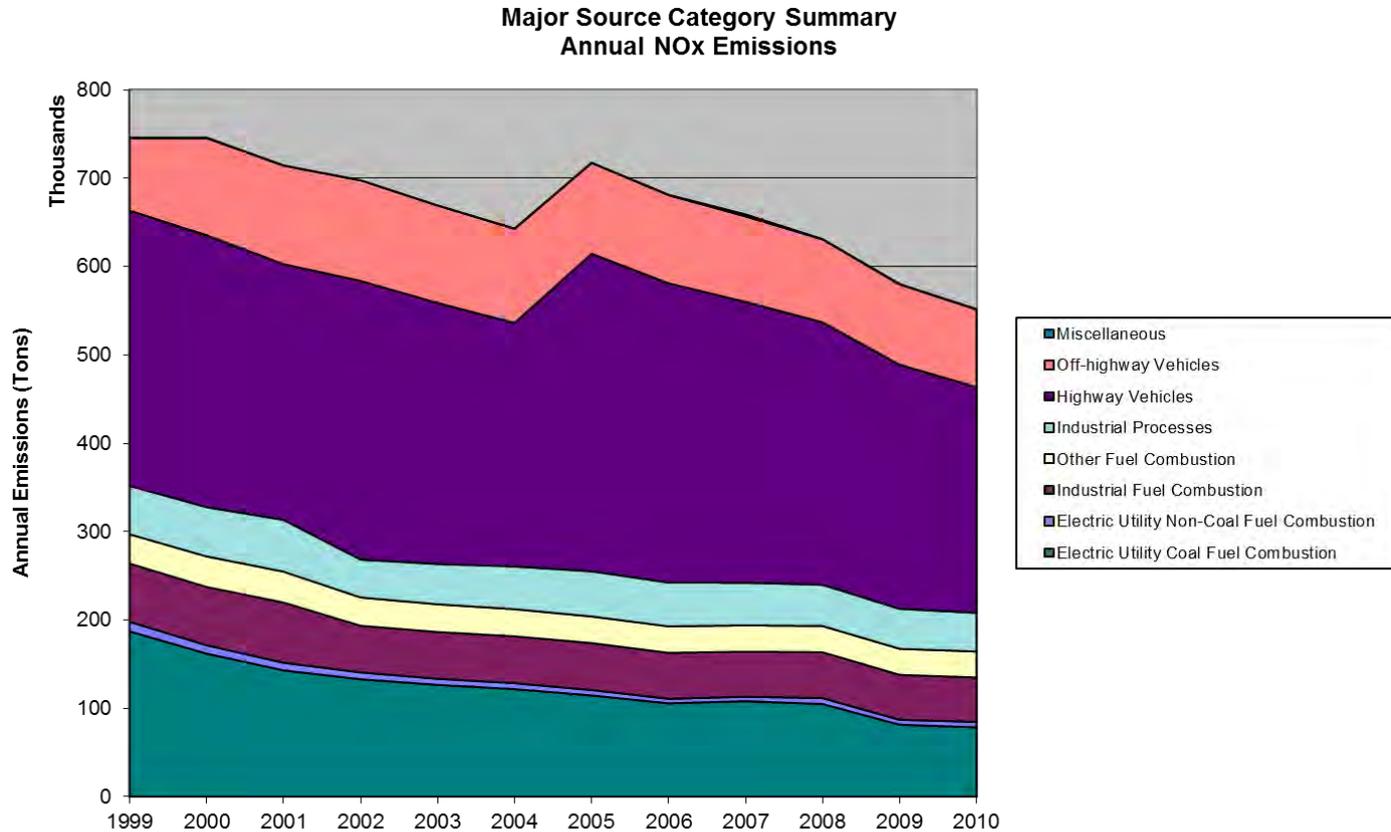
Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across Michigan
- NO_x and SO₂ from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NO_x Budget Trading Program and CAIR control implementation
- 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

Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across Michigan
- NO_x and SO₂ from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NO_x Budget Trading Program and CAIR control implementation
- All pollutants (except NH₃) from the Highway and Off-highway Vehicles categories show decrease over time as a result of various mobile source fuel and fleet rulemakings, including the Tier 2/Gasoline Sulfur rule and Heavy Duty Engine/Vehicle and Highway Diesel Fuel rules

Michigan Emission Trends (NO_x)

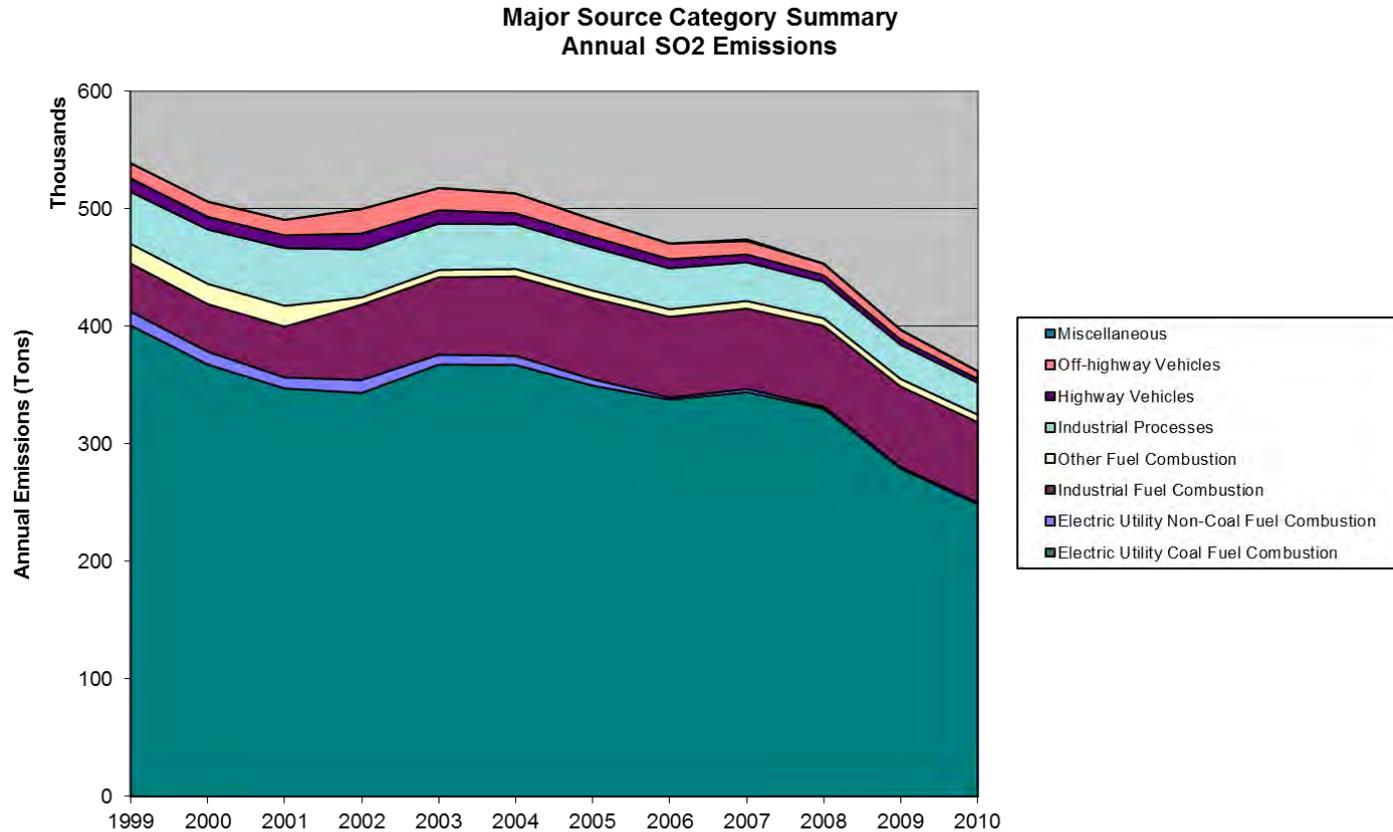


Michigan Emission Change (NO_x)

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	-25,262	-44,192	-54,272	-60,648	-65,476	-72,625	-81,525	-79,103	-82,392	-105,734	-108,821
Electric Utility Non-Coal Fuel Combustion	0	-1,302	-2,156	-3,023	-3,898	-4,055	-4,640	-5,688	-5,782	-4,070	-5,253	-4,606
Industrial Fuel Combustion	0	81	2,266	-13,045	-12,858	-12,759	-12,647	-13,776	-14,727	-13,825	-14,904	-15,444
Other Fuel Combustion	0	1,482	1,901	-1,102	-1,743	-2,383	-3,024	-3,164	-3,305	-3,446	-3,587	-3,728
Industrial Processes	0	911	3,648	-12,051	-9,287	-6,523	-3,759	-5,237	-6,715	-8,193	-9,672	-11,150
Highway Vehicles	0	-3,856	-22,181	3,797	-16,128	-36,053	47,801	27,015	6,230	-14,555	-35,340	-56,126
Off-highway Vehicles	0	27,879	29,484	31,772	28,100	24,428	20,729	17,719	14,710	11,700	8,690	5,680
Miscellaneous	0	67	-316	-478	-346	-213	-398	-95	1,726	-216	16	16
Total	0	0	-31,546	-48,403	-76,808	-103,035	-28,562	-64,750	-86,967	-114,998	-165,784	-194,178

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%	-24%	-29%	-32%	-35%	-39%	-44%	-42%	-44%	-56%	-58%
Electric Utility Non-Coal Fuel Combustion	0%	-12%	-20%	-28%	-36%	-38%	-43%	-53%	-54%	-38%	-49%	-43%
Industrial Fuel Combustion	0%	0%	3%	-20%	-20%	-19%	-19%	-21%	-22%	-21%	-23%	-23%
Other Fuel Combustion	0%	4%	6%	-3%	-5%	-7%	-9%	-10%	-10%	-10%	-11%	-11%
Industrial Processes	0%	2%	7%	-22%	-17%	-12%	-7%	-10%	-12%	-15%	-18%	-20%
Highway Vehicles	0%	-1%	-7%	1%	-5%	-12%	15%	9%	2%	-5%	-11%	-18%
Off-highway Vehicles	0%	34%	36%	39%	34%	30%	25%	22%	18%	14%	11%	7%
Miscellaneous	0%	14%	-64%	-97%	-70%	-43%	-80%	-19%	349%	-44%	3%	3%
Total	0%	0%	-4%	-6%	-10%	-14%	-4%	-9%	-12%	-15%	-22%	-26%

Michigan Emission Trends (SO₂)



Michigan Emission Change (SO₂)

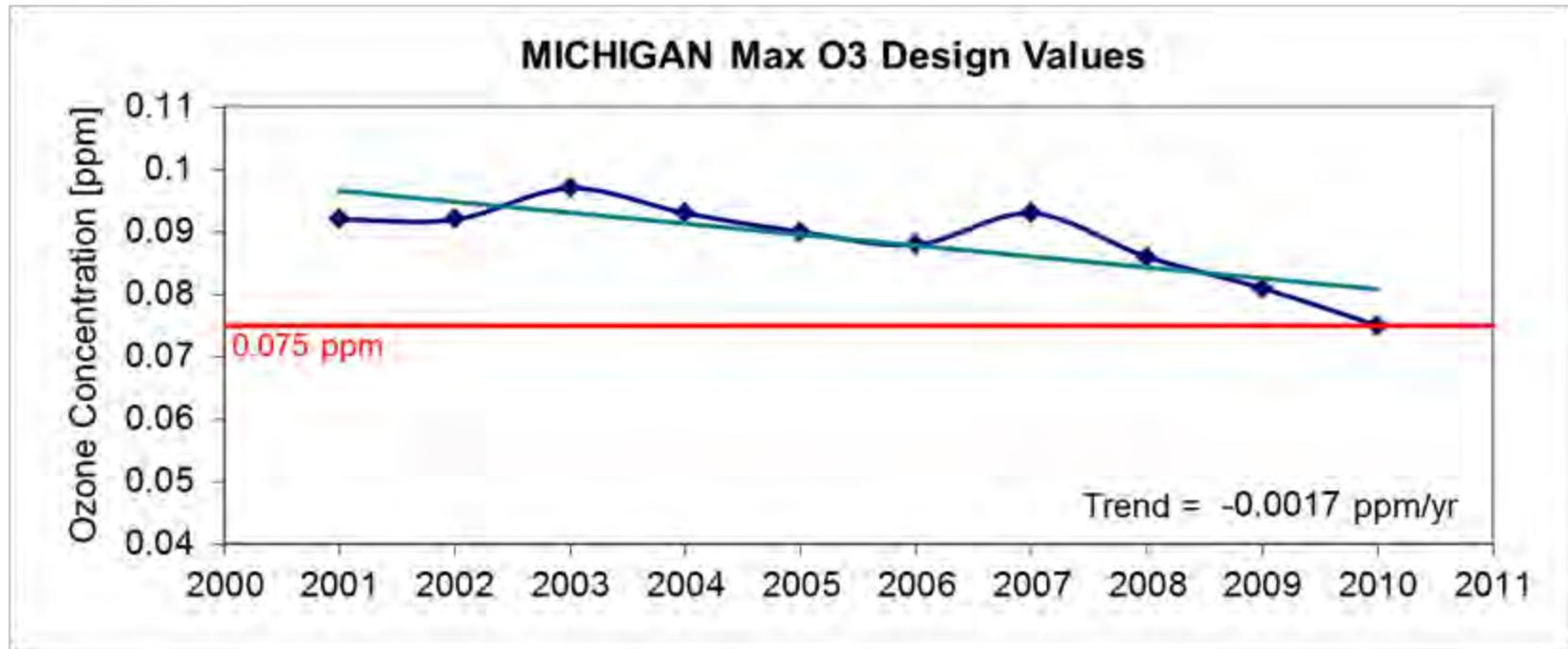
Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0	-33,297	-53,590	-57,518	-33,327	-33,605	-51,287	-63,107	-56,802	-70,826	-121,874	-152,077
Electric Utility Non-Coal Fuel Combustion	0	-699	-2,437	-589	-3,283	-4,018	-6,172	-9,993	-8,949	-10,123	-10,365	-10,377
Industrial Fuel Combustion	0	-495	2,399	23,160	24,915	26,670	28,058	27,769	27,479	28,025	27,677	27,527
Other Fuel Combustion	0	463	874	-10,664	-10,557	-10,450	-10,343	-10,344	-10,344	-10,345	-10,346	-10,347
Industrial Processes	0	2,149	5,014	-3,245	-4,628	-6,011	-7,395	-9,319	-11,243	-13,168	-15,092	-17,017
Highway Vehicles	0	-782	-633	1,996	-105	-2,206	-2,545	-3,700	-4,855	-6,010	-7,166	-8,321
Off-highway Vehicles	0	-27	271	7,974	5,942	3,909	1,941	292	-1,357	-3,006	-4,655	-6,305
Miscellaneous	0	18	-87	-127	-64	-1	-91	72	1,296	2	122	122
Total	0	-32,668	-48,188	-39,013	-21,108	-25,712	-47,833	-68,329	-64,776	-85,452	-141,700	-176,794

Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0%	-8%	-13%	-14%	-8%	-8%	-13%	-16%	-14%	-18%	-30%	-38%
Electric Utility Non-Coal Fuel Combustion	0%	-6%	-21%	-5%	-28%	-34%	-53%	-85%	-76%	-86%	-88%	-89%
Industrial Fuel Combustion	0%	-1%	6%	57%	61%	65%	69%	68%	67%	69%	68%	67%
Other Fuel Combustion	0%	3%	5%	-64%	-63%	-62%	-62%	-62%	-62%	-62%	-62%	-62%
Industrial Processes	0%	5%	11%	-7%	-10%	-14%	-17%	-21%	-25%	-30%	-34%	-39%
Highway Vehicles	0%	-7%	-6%	17%	-1%	-19%	-22%	-32%	-42%	-52%	-62%	-72%
Off-highway Vehicles	0%	0%	2%	62%	46%	30%	15%	2%	-11%	-23%	-36%	-49%
Miscellaneous	0%	14%	-66%	-96%	-49%	-1%	-69%	55%	985%	2%	92%	92%
Total	0%	-6%	-9%	-7%	-4%	-5%	-9%	-13%	-12%	-16%	-26%	-33%

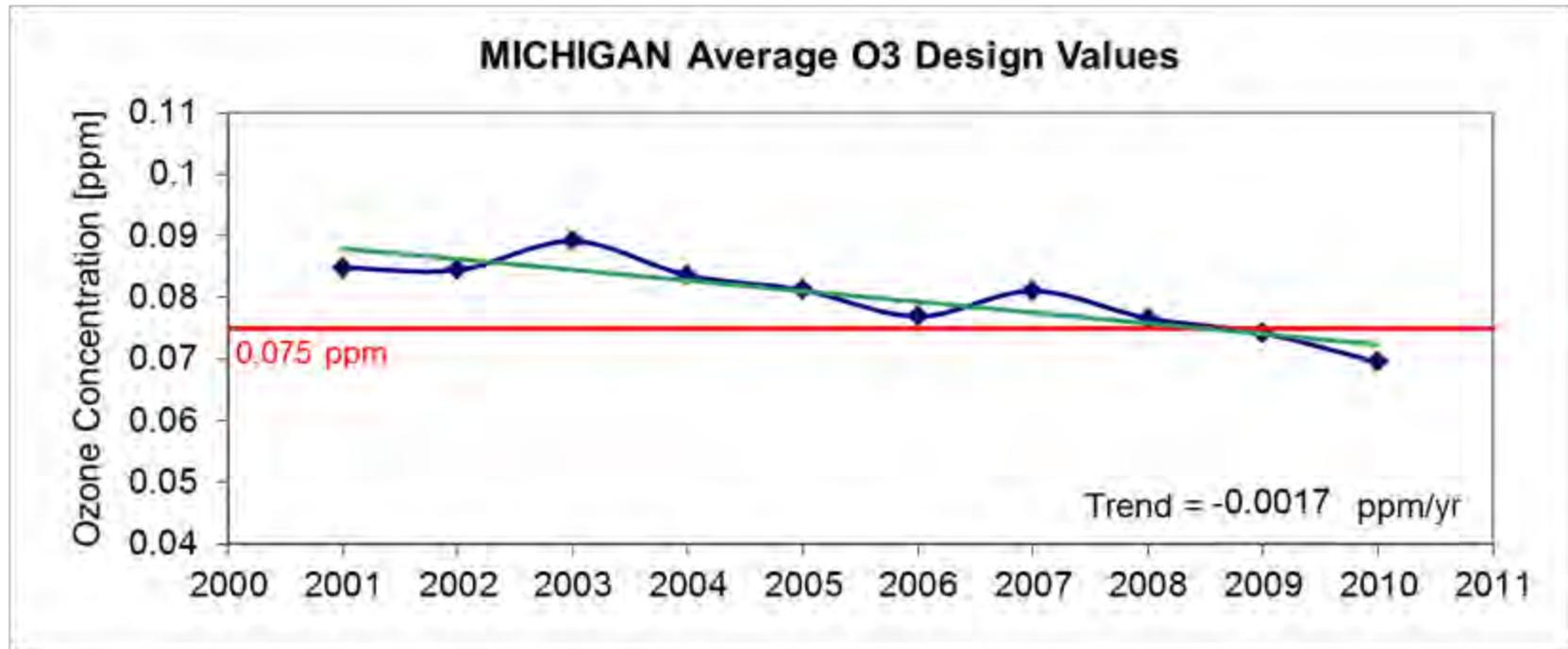
Air Quality Trends Summary

- Average O_3 and $PM_{2.5}$ design values have decreased since 1999 in Michigan
- O_3 and $PM_{2.5}$ design values have decreased since 1999 in all current O_3 and $PM_{2.5}$ non-attainment areas in Michigan

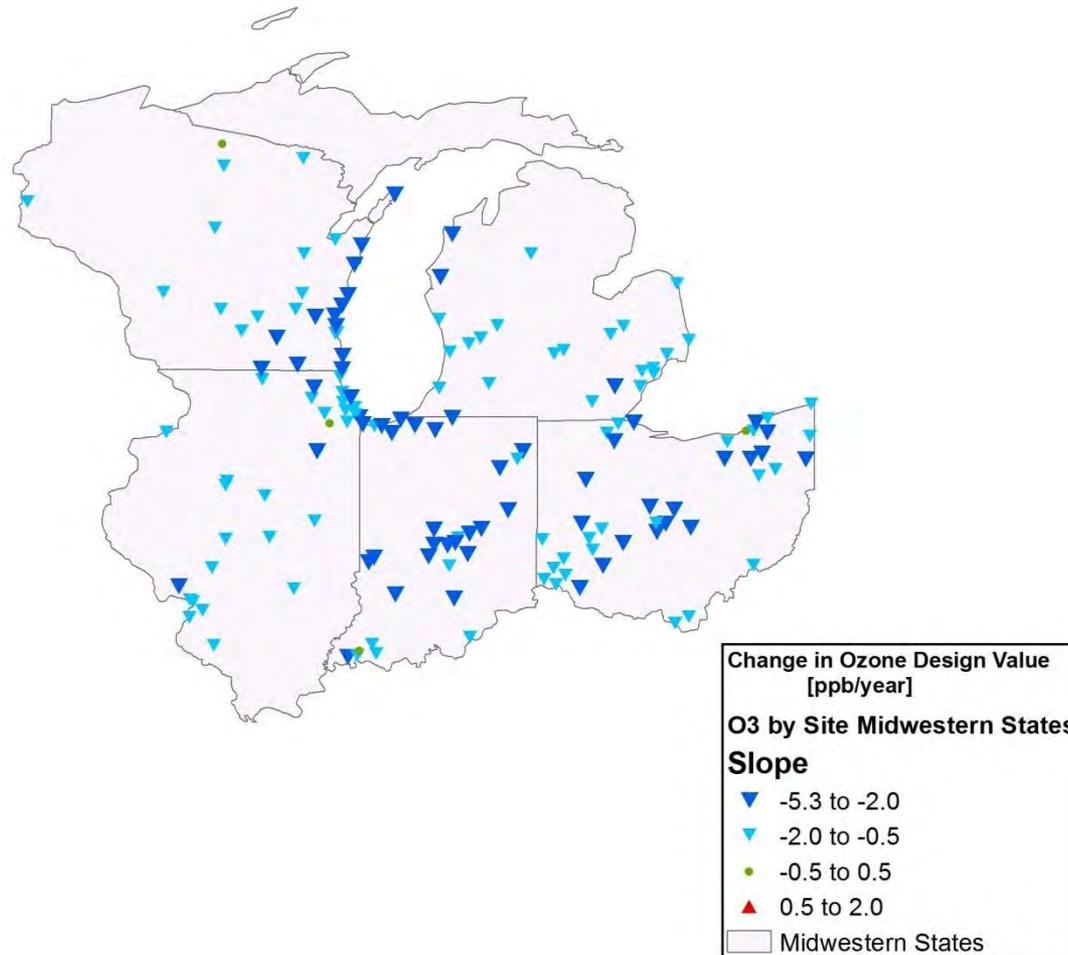
Max O₃ DVs and Trend



Average O₃ DVs and Trend

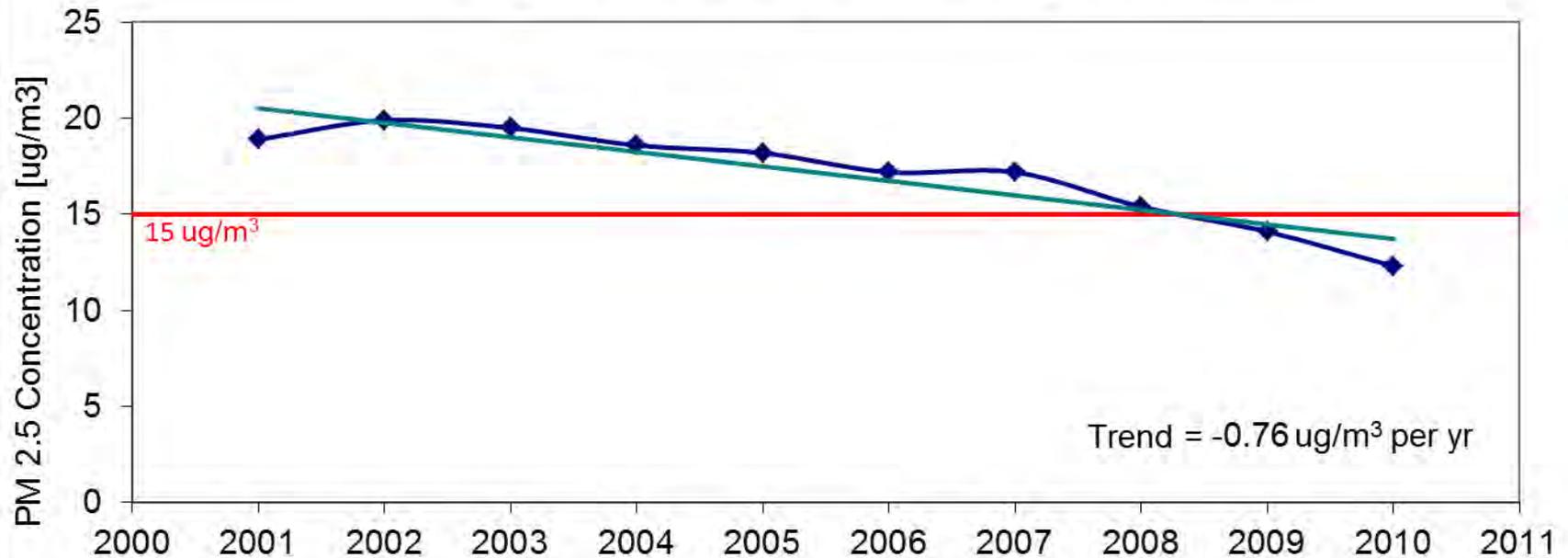


O₃ Trend Slopes at Monitoring Sites



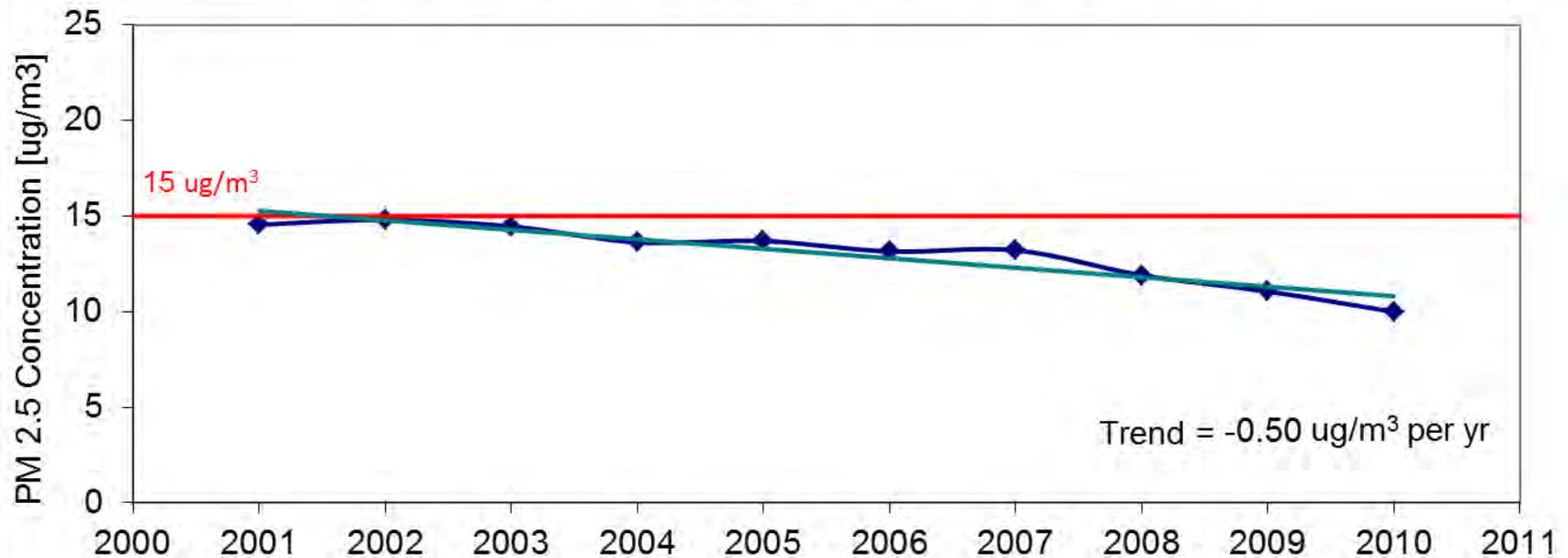
Max PM_{2.5} Annual DVs and Trend

Michigan Max PM_{2.5} Annual Design Values

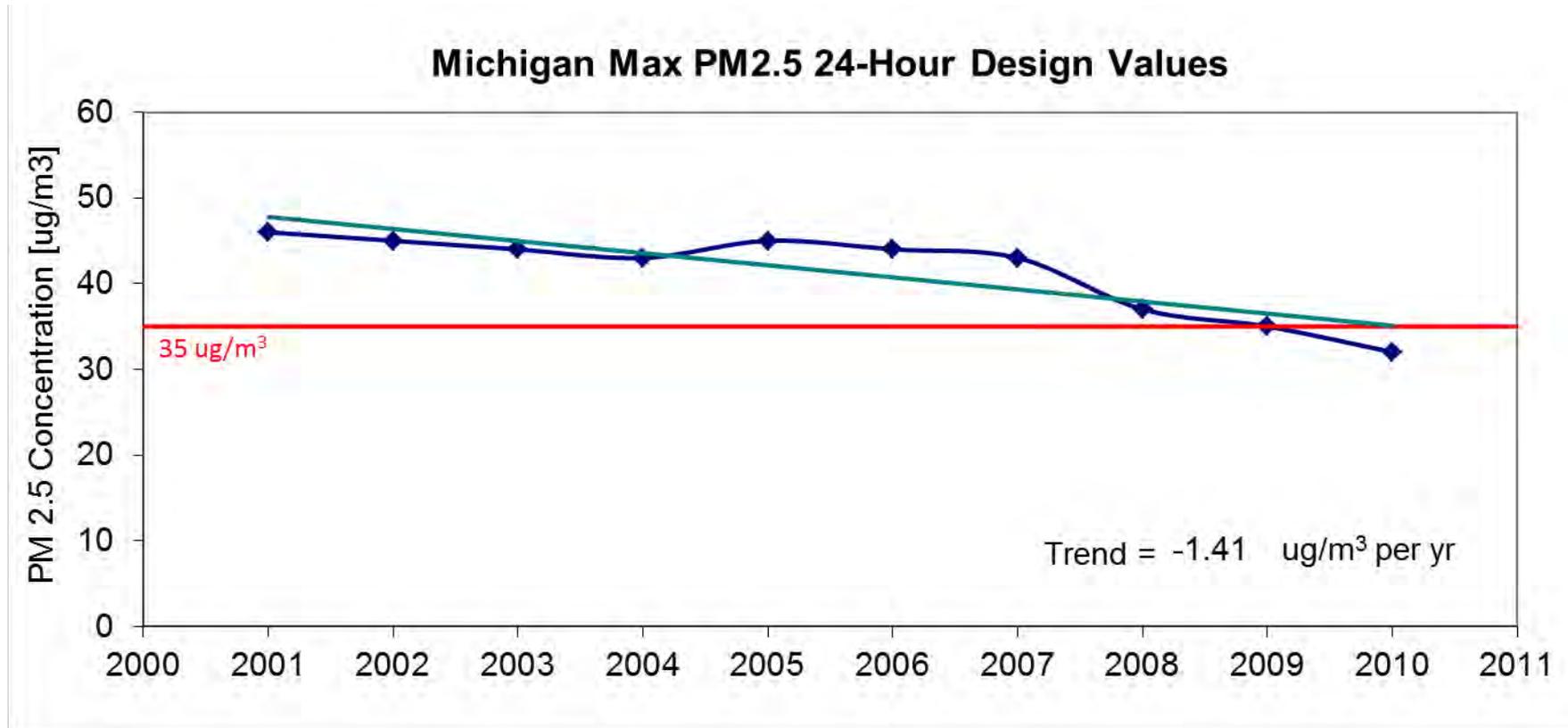


Average PM_{2.5} Annual DVs and Trend

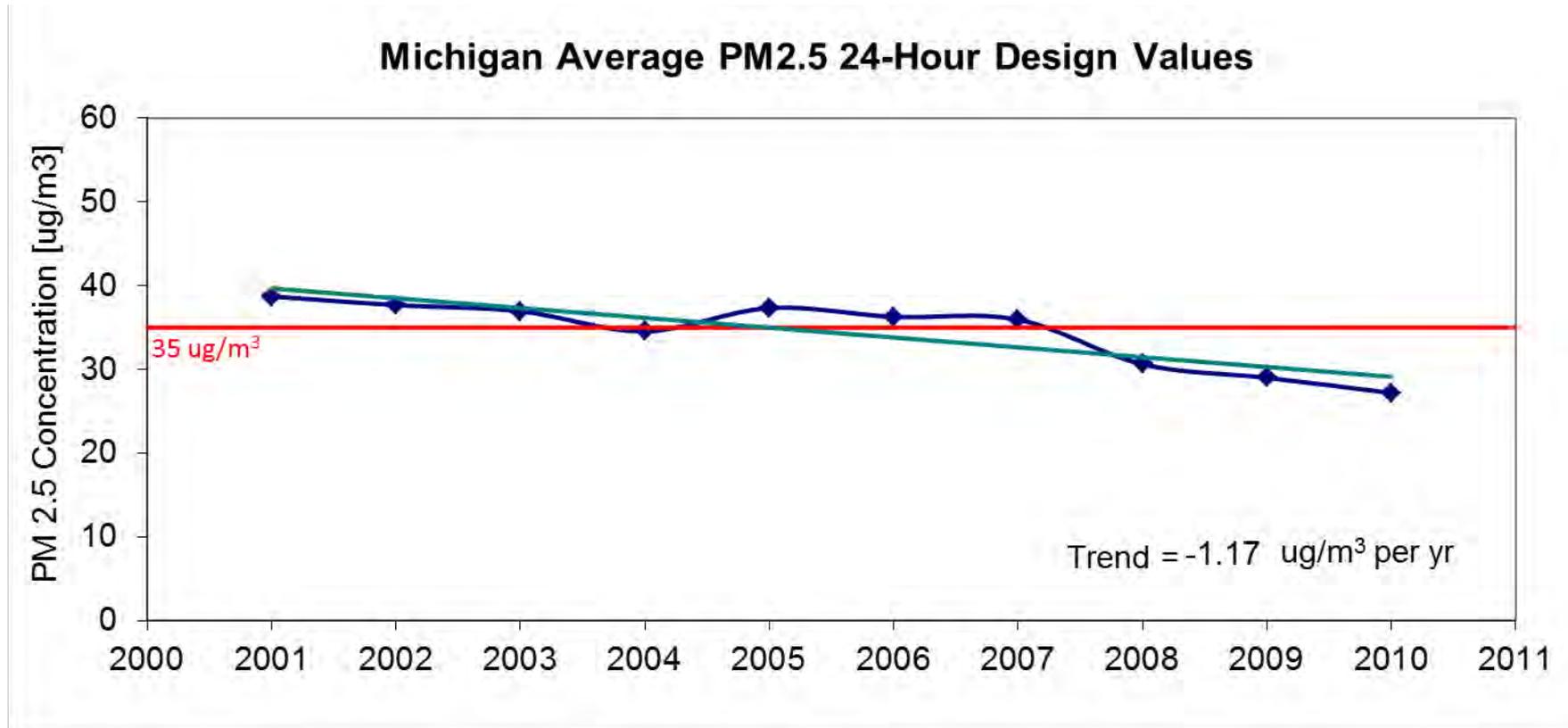
Michigan Average PM_{2.5} Annual Design Values



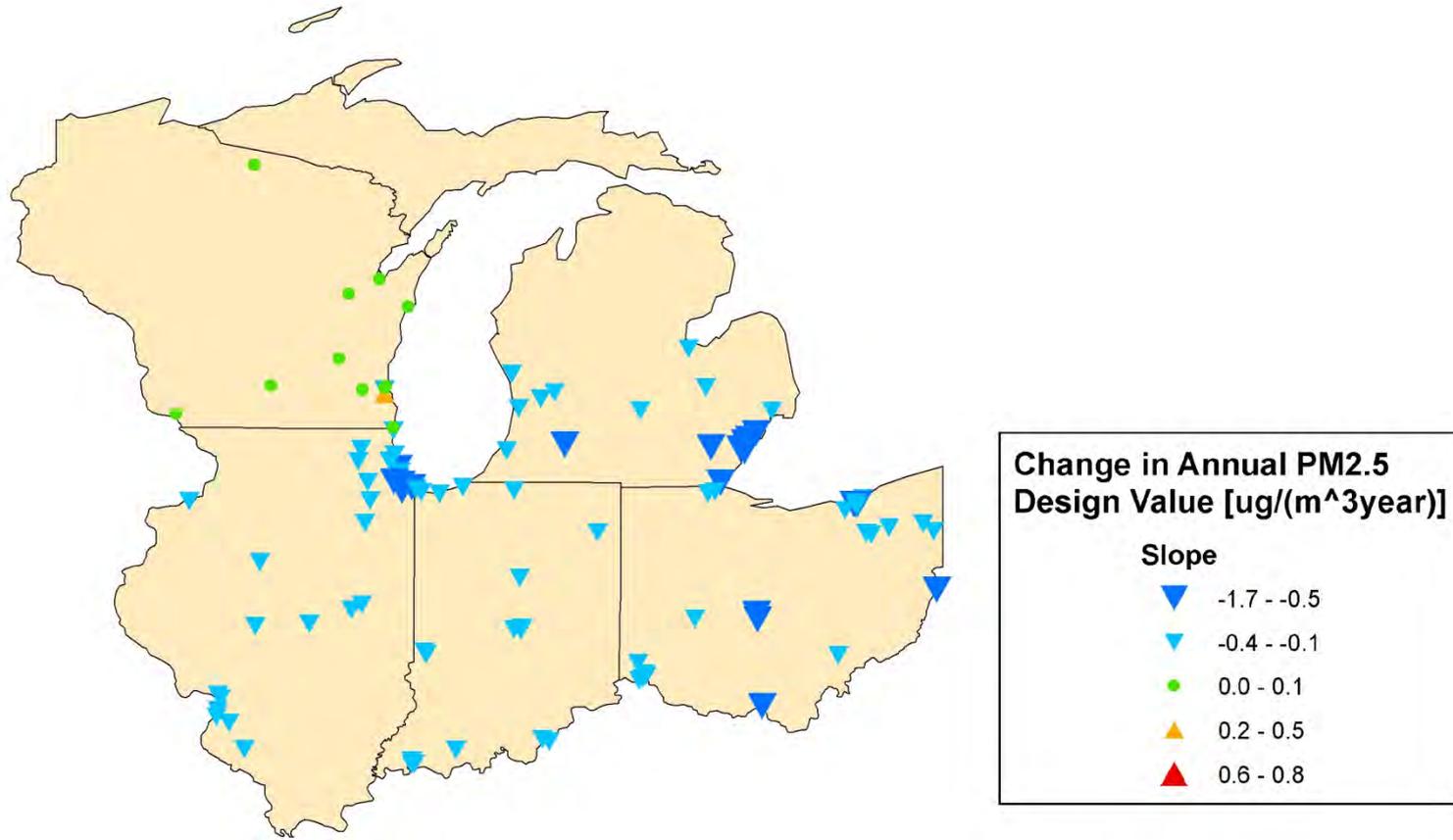
Max PM_{2.5} 24-Hour DVs and Trend



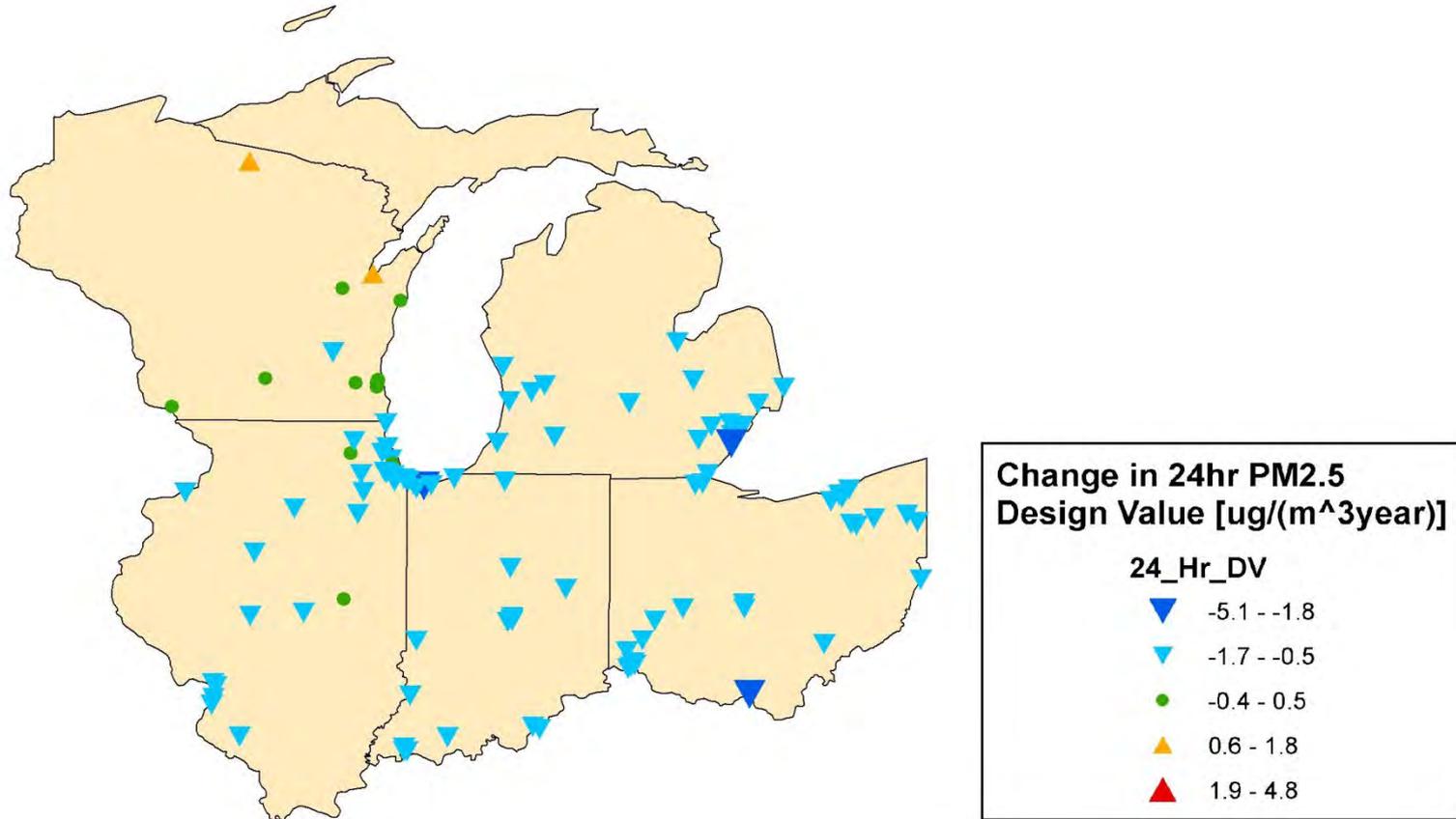
Average PM_{2.5} 24-Hour DVs and Trend



Annual PM_{2.5} Trend Slopes at Monitoring Sites



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



Background



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



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, NO_x, CO, SO₂, PM₁₀, PM_{2.5} and NH₃
- 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)

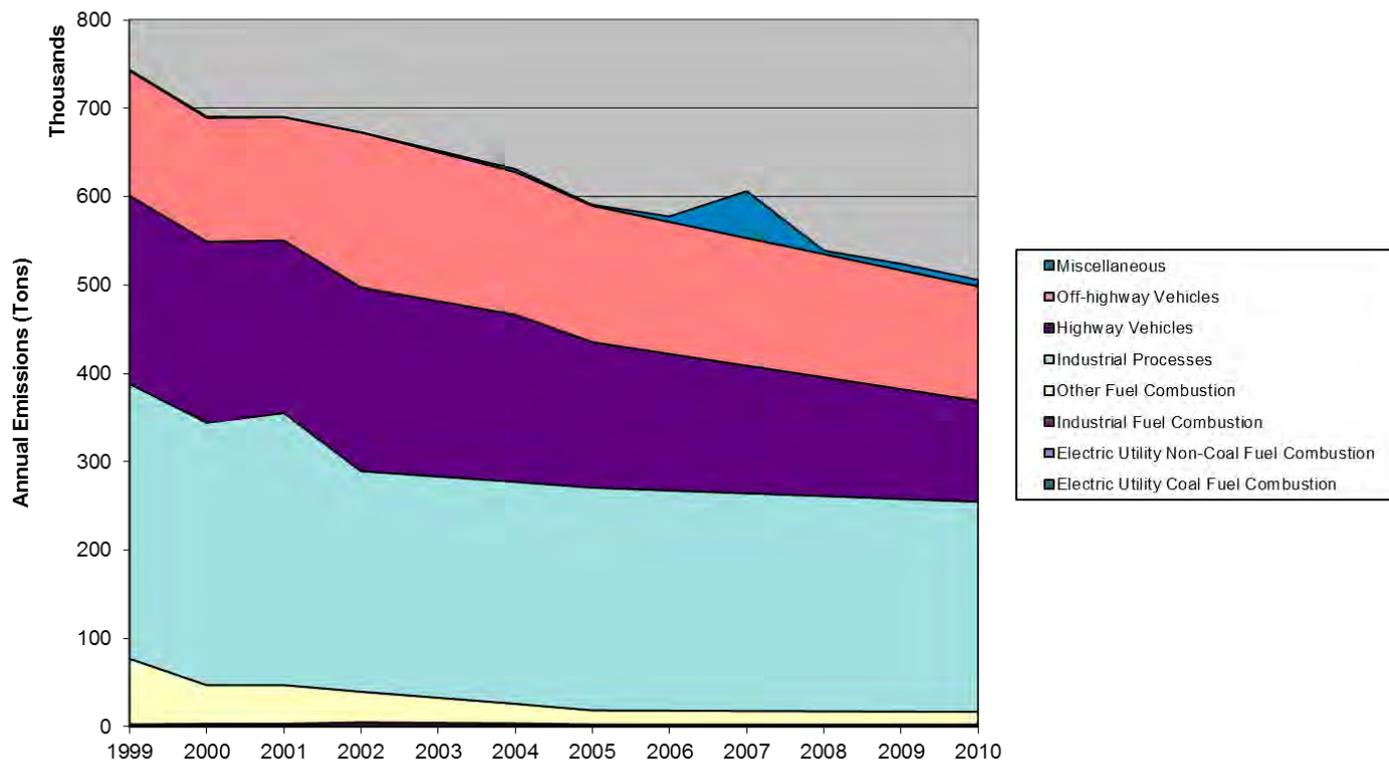
Michigan Emission Trends (VOC)

Annual Emissions (Tons)												
Source Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	389	387	404	987	1,039	1,105	648	639	656	668	622	632
Electric Utility Non-Coal Fuel Combustion	458	1,060	1,041	479	427	409	336	317	317	379	341	354
Industrial Fuel Combustion	1,890	1,932	1,951	3,695	3,029	2,362	1,695	1,674	1,656	1,647	1,628	1,610
Other Fuel Combustion	74,290	43,761	43,814	34,510	28,311	22,111	15,912	15,578	15,244	14,911	14,577	14,243
Industrial Processes	311,141	297,163	308,033	249,736	250,529	251,322	252,114	249,275	246,435	243,595	240,755	237,915
Highway Vehicles	212,941	204,955	195,180	207,711	198,445	189,179	164,701	154,604	144,506	134,409	124,311	114,214
Off-highway Vehicles	141,686	140,147	139,541	175,745	168,600	161,455	154,314	149,374	144,433	139,492	134,551	129,610
Miscellaneous	969	1,319	480	199	1,754	3,309	1,132	6,164	53,005	3,850	7,273	7,273
Total	743,763	690,725	690,443	673,062	652,135	631,254	590,853	577,624	606,251	538,950	524,058	505,852

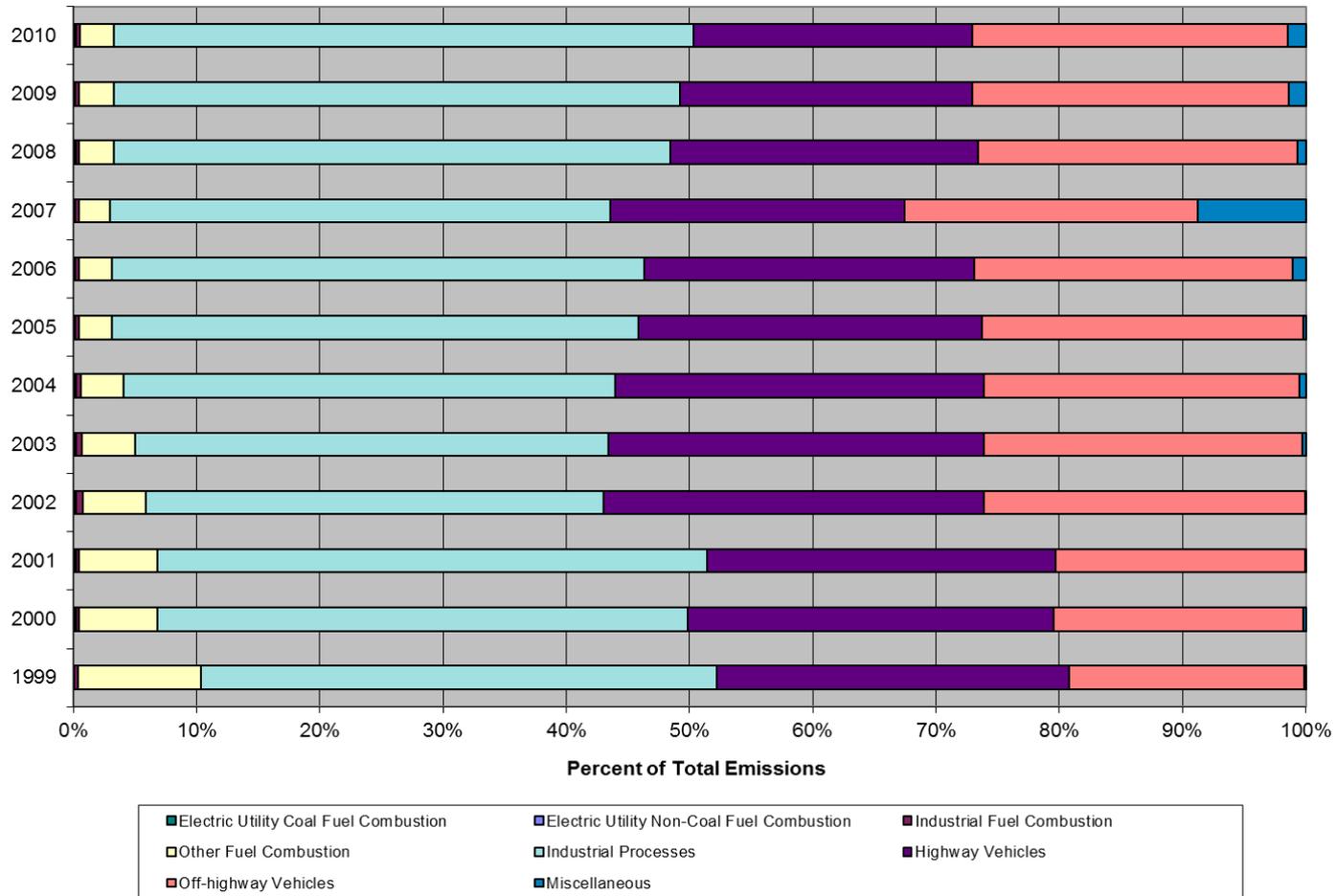
Annual Emissions (Percent of Total)												
Source Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Electric Utility Non-Coal Fuel Combustion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Industrial Fuel Combustion	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Other Fuel Combustion	10%	6%	6%	5%	4%	4%	3%	3%	3%	3%	3%	3%
Industrial Processes	42%	43%	45%	37%	38%	40%	43%	43%	41%	45%	46%	47%
Highway Vehicles	29%	30%	28%	31%	30%	30%	28%	27%	24%	25%	24%	23%
Off-highway Vehicles	19%	20%	20%	26%	26%	26%	26%	26%	24%	26%	26%	26%
Miscellaneous	0%	0%	0%	0%	0%	1%	0%	1%	9%	1%	1%	1%
Total	100%											

Michigan Emission Trends (VOC)

Major Source Category Summary
Annual VOC Emissions



Michigan Emission Composition (VOC)



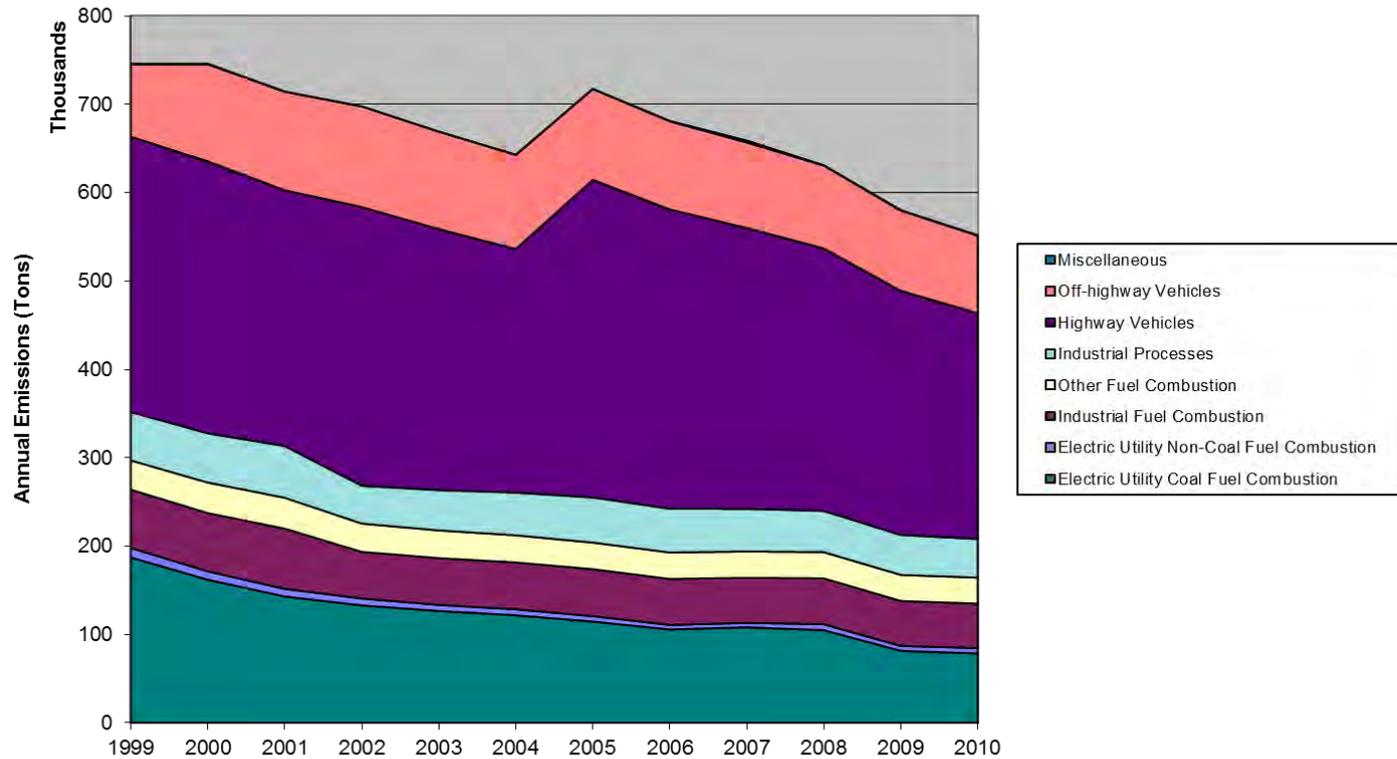
Michigan Emission Trends (NO_x)

Source Category	Annual Emissions (Tons)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	187,215	161,953	143,023	132,943	126,567	121,739	114,590	105,690	108,112	104,823	81,481	78,394
Electric Utility Non-Coal Fuel Combustion	10,805	9,503	8,649	7,782	6,907	6,750	6,165	5,117	5,023	6,735	5,553	6,199
Industrial Fuel Combustion	65,830	65,911	68,096	52,785	52,971	53,070	53,183	52,053	51,102	52,004	50,925	50,386
Other Fuel Combustion	33,093	34,575	34,994	31,991	31,350	30,710	30,069	29,929	29,788	29,647	29,506	29,365
Industrial Processes	54,871	55,782	58,519	42,820	45,584	48,348	51,112	49,634	48,156	46,678	45,199	43,721
Highway Vehicles	311,621	307,764	289,440	315,418	295,492	275,567	359,421	338,636	317,851	297,065	276,280	255,495
Off-highway Vehicles	82,166	110,045	111,650	113,937	110,266	106,594	102,895	99,885	96,875	93,866	90,856	87,846
Miscellaneous	494	561	179	16	149	281	97	400	2,221	278	510	510
Total	746,094	746,094	714,548	697,691	669,286	643,059	717,532	681,344	659,127	631,096	580,310	551,917

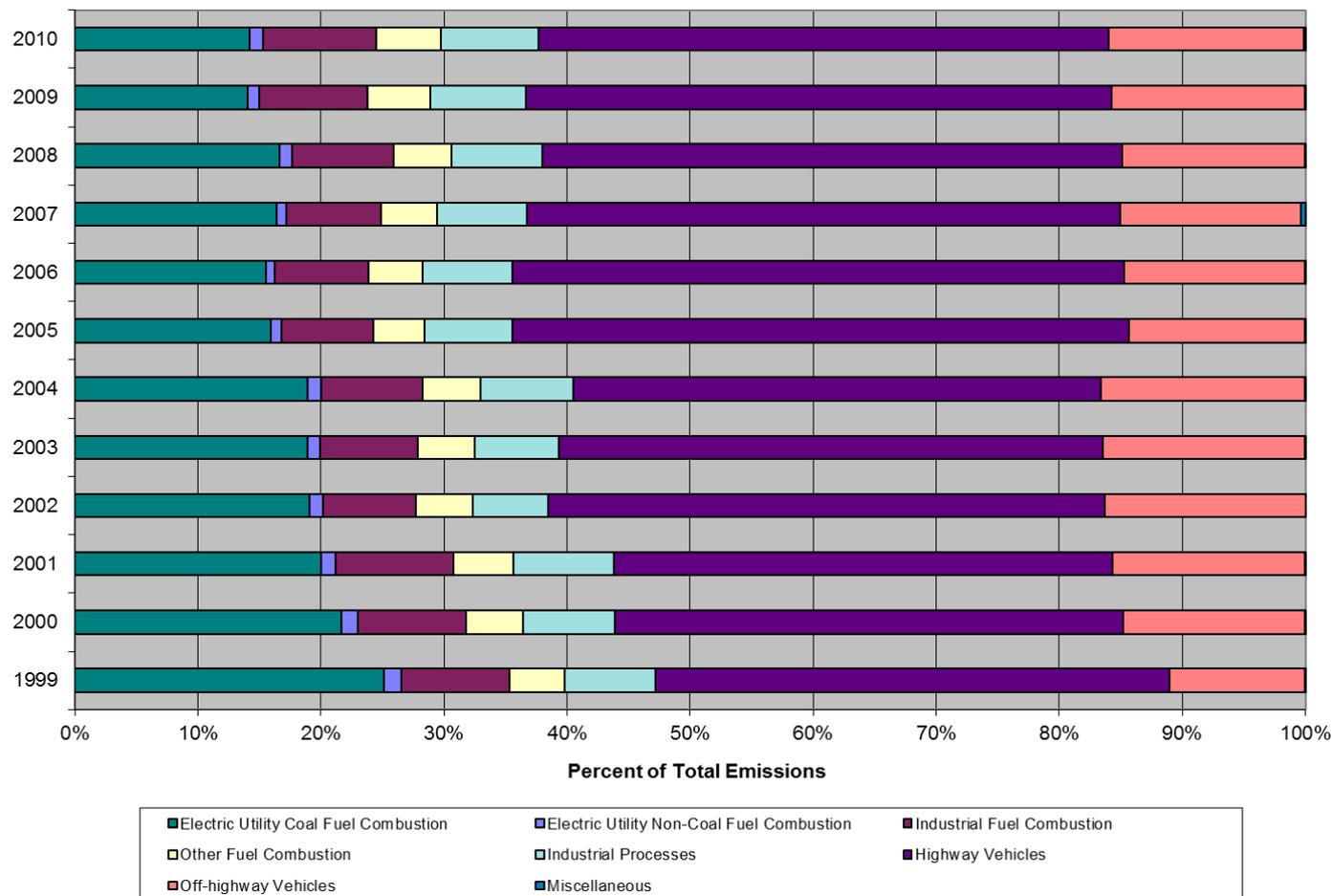
Source Category	Annual Emissions (Percent of Total)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	25%	22%	20%	19%	19%	19%	16%	16%	16%	17%	14%	14%
Electric Utility Non-Coal Fuel Combustion	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Industrial Fuel Combustion	9%	9%	10%	8%	8%	8%	7%	8%	8%	8%	9%	9%
Other Fuel Combustion	4%	5%	5%	5%	5%	5%	4%	4%	5%	5%	5%	5%
Industrial Processes	7%	7%	8%	6%	7%	8%	7%	7%	7%	7%	8%	8%
Highway Vehicles	42%	41%	41%	45%	44%	43%	50%	50%	48%	47%	48%	46%
Off-highway Vehicles	11%	15%	16%	16%	16%	17%	14%	15%	15%	15%	16%	16%
Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Michigan Emission Trends (NO_x)

Major Source Category Summary
Annual NO_x Emissions



Michigan Emission Composition (NO_x)

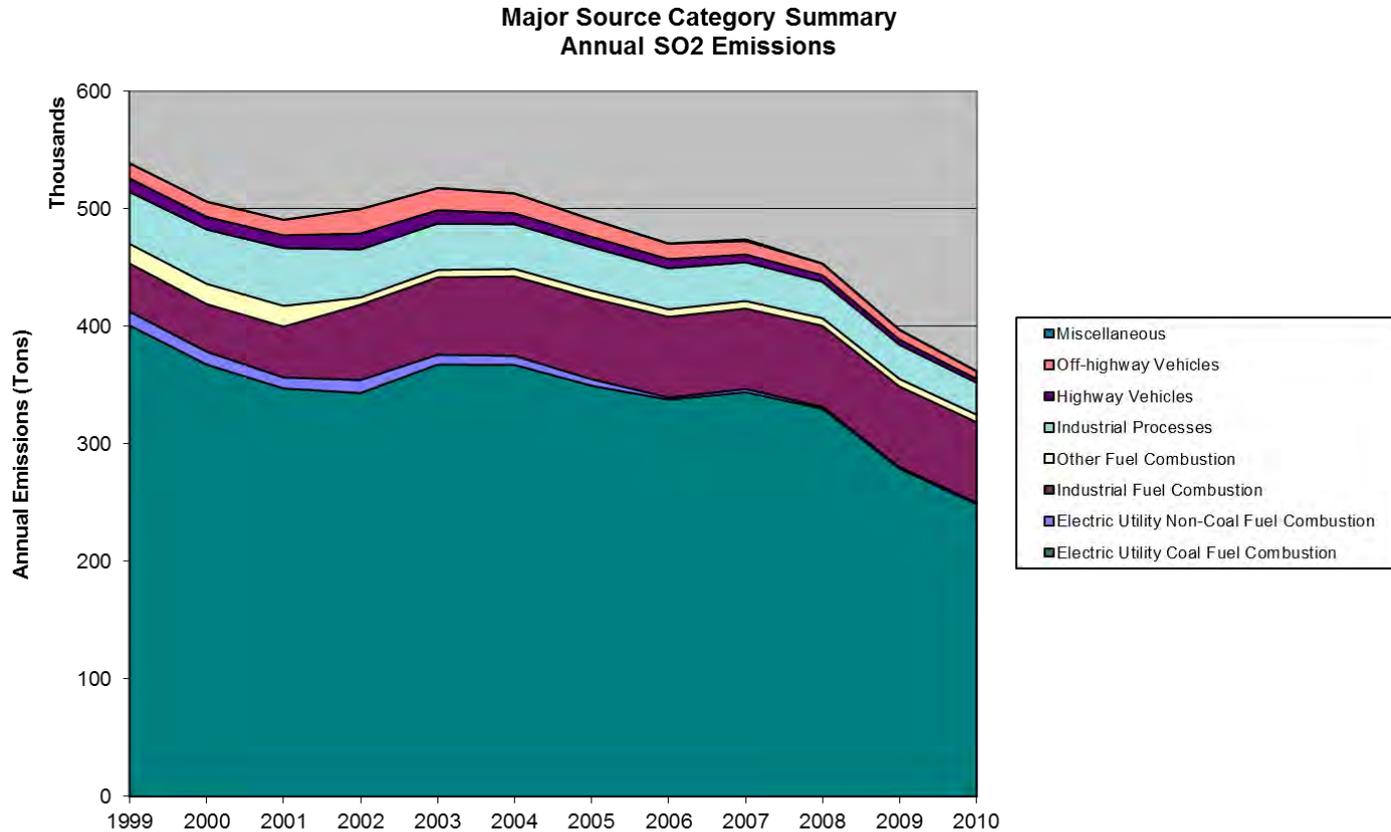


Michigan Emission Trends (SO₂)

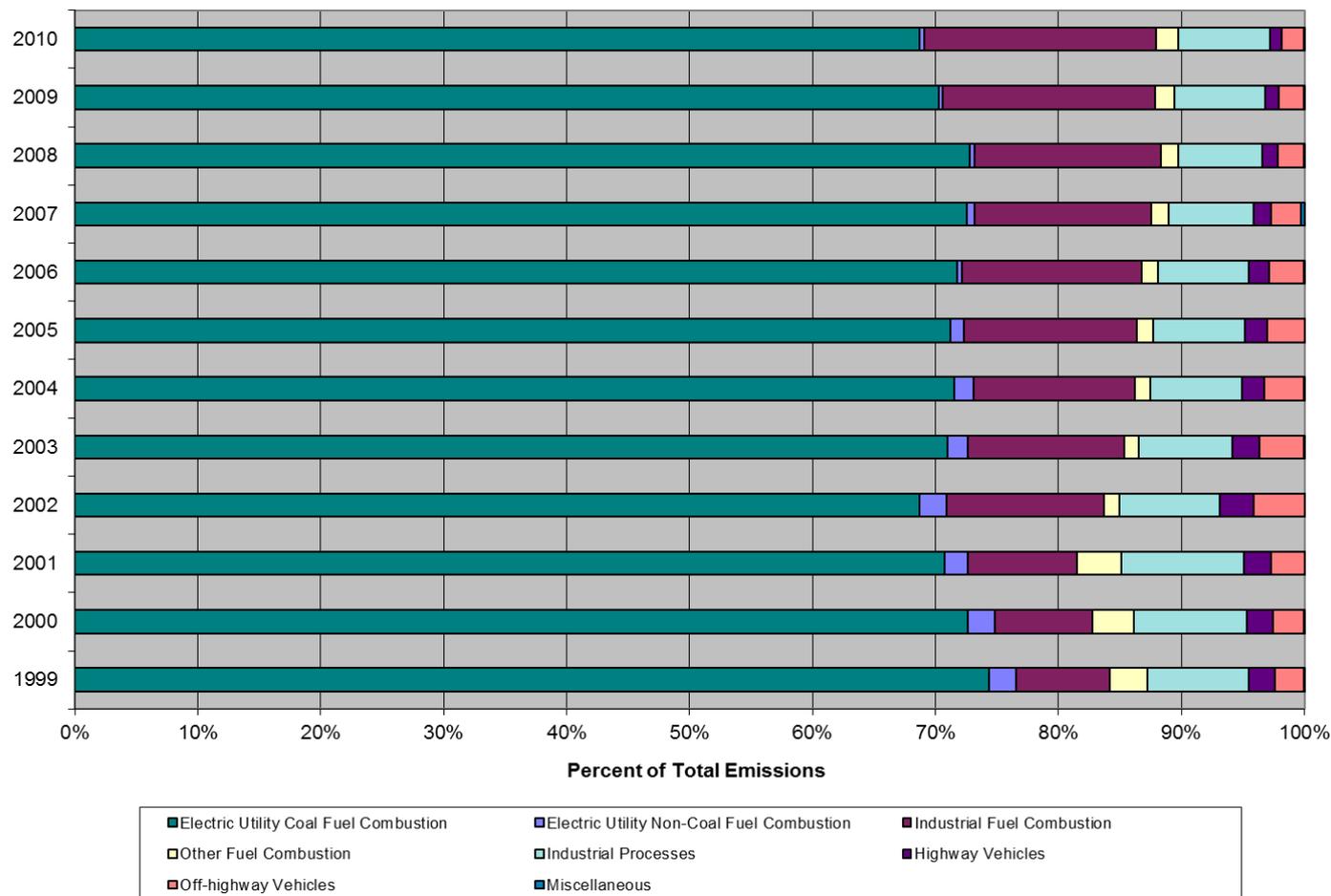
Source Category	Annual Emissions (Tons)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	400,868	367,572	347,278	343,350	367,541	367,263	349,581	337,761	344,066	330,042	278,994	248,791
Electric Utility Non-Coal Fuel Combustion	11,725	11,026	9,288	11,136	8,442	7,707	5,553	1,732	2,776	1,602	1,360	1,348
Industrial Fuel Combustion	40,878	40,383	43,277	64,037	65,792	67,547	68,936	68,646	68,356	68,902	68,554	68,405
Other Fuel Combustion	16,775	17,238	17,649	6,111	6,218	6,325	6,432	6,431	6,430	6,429	6,429	6,428
Industrial Processes	44,146	46,296	49,160	40,901	39,518	38,135	36,752	34,827	32,903	30,978	29,054	27,130
Highway Vehicles	11,511	10,729	10,877	13,507	11,406	9,305	8,966	7,811	6,655	5,500	4,345	3,190
Off-highway Vehicles	12,859	12,832	13,130	20,833	18,800	16,768	14,800	13,151	11,501	9,852	8,203	6,554
Miscellaneous	132	150	45	5	68	131	41	204	1,428	134	253	253
Total	538,892	506,224	490,704	499,879	517,784	513,181	491,059	470,563	474,116	453,441	397,192	362,098

Source Category	Annual Emissions (Percent of Total)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	74%	73%	71%	69%	71%	72%	71%	72%	73%	73%	70%	69%
Electric Utility Non-Coal Fuel Combustion	2%	2%	2%	2%	2%	2%	1%	0%	1%	0%	0%	0%
Industrial Fuel Combustion	8%	8%	9%	13%	13%	13%	14%	15%	14%	15%	17%	19%
Other Fuel Combustion	3%	3%	4%	1%	1%	1%	1%	1%	1%	1%	2%	2%
Industrial Processes	8%	9%	10%	8%	8%	7%	7%	7%	7%	7%	7%	7%
Highway Vehicles	2%	2%	2%	3%	2%	2%	2%	2%	1%	1%	1%	1%
Off-highway Vehicles	2%	3%	3%	4%	4%	3%	3%	3%	2%	2%	2%	2%
Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Michigan Emission Trends (SO₂)



Michigan Emission Composition (SO₂)



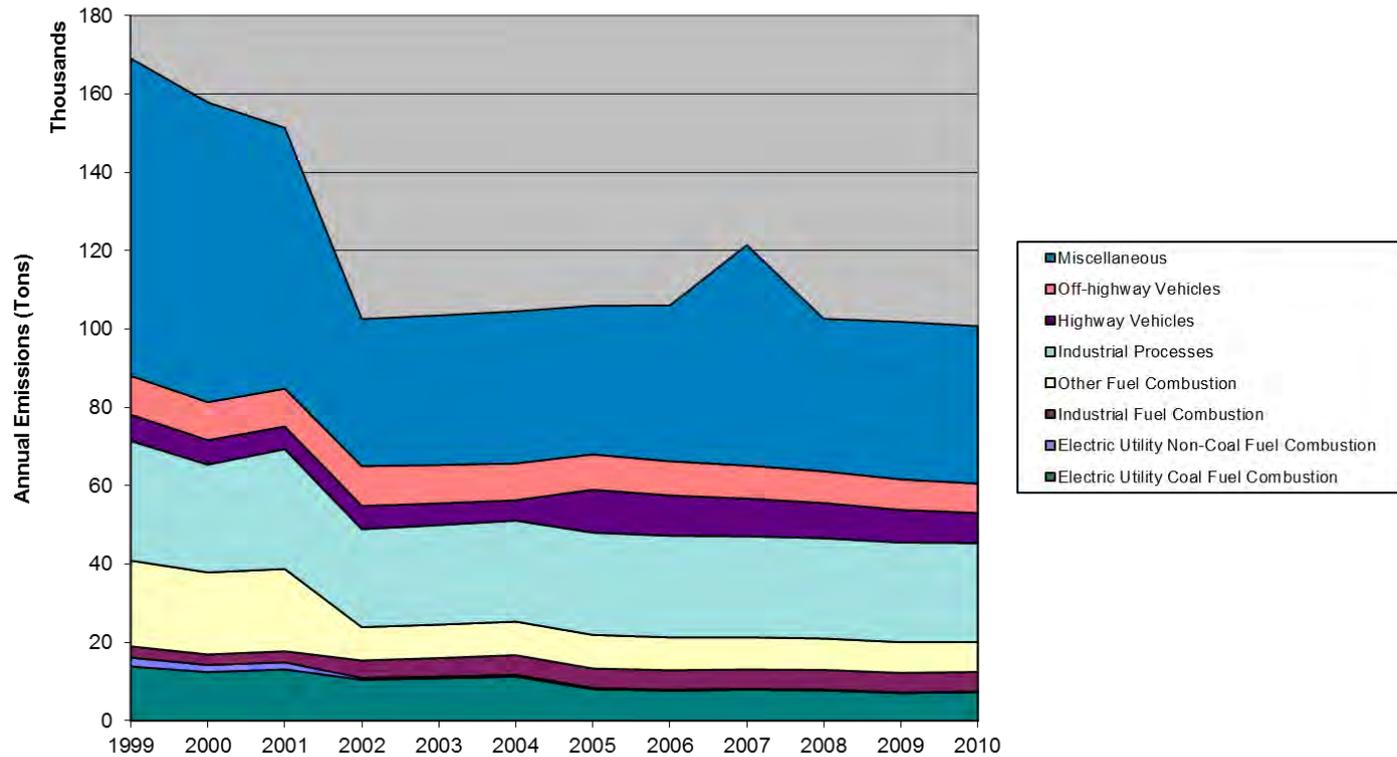
Michigan Emission Trends (PM_{2.5})

Source Category	Annual Emissions (Tons)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	13,854	12,418	13,121	10,463	10,832	11,266	8,053	7,687	7,902	7,747	7,045	7,257
Electric Utility Non-Coal Fuel Combustion	2,271	1,828	1,801	484	457	490	322	252	262	233	213	236
Industrial Fuel Combustion	2,869	2,687	2,820	4,445	4,721	4,994	4,967	4,955	4,944	4,992	4,979	4,969
Other Fuel Combustion	21,892	20,951	21,019	8,509	8,540	8,571	8,588	8,400	8,212	8,024	7,836	7,648
Industrial Processes	30,544	27,506	30,581	25,030	25,409	25,787	26,108	25,941	25,774	25,607	25,440	25,274
Highway Vehicles	6,725	6,224	5,771	5,894	5,538	5,182	10,940	10,285	9,630	8,976	8,321	7,666
Off-highway Vehicles	9,919	9,728	9,658	10,171	9,788	9,406	9,032	8,723	8,415	8,106	7,798	7,490
Miscellaneous	80,988	76,500	66,584	37,550	38,179	38,808	37,932	39,758	56,283	38,921	40,194	40,194
Total	169,062	157,843	151,355	102,547	103,464	104,505	105,941	106,001	121,423	102,606	101,826	100,734

Source Category	Annual Emissions (Percent of Total)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	8%	8%	9%	10%	10%	11%	8%	7%	7%	8%	7%	7%
Electric Utility Non-Coal Fuel Combustion	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Industrial Fuel Combustion	2%	2%	2%	4%	5%	5%	5%	5%	4%	5%	5%	5%
Other Fuel Combustion	13%	13%	14%	8%	8%	8%	8%	8%	7%	8%	8%	8%
Industrial Processes	18%	17%	20%	24%	25%	25%	25%	24%	21%	25%	25%	25%
Highway Vehicles	4%	4%	4%	6%	5%	5%	10%	10%	8%	9%	8%	8%
Off-highway Vehicles	6%	6%	6%	10%	9%	9%	9%	8%	7%	8%	8%	7%
Miscellaneous	48%	48%	44%	37%	37%	37%	36%	38%	46%	38%	39%	40%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Michigan Emission Trends (PM_{2.5})

Major Source Category Summary
Annual PM-2.5 Emissions



Midwestern States Emissions Summary

Annual Emissions (Tons) -- 2010

State	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Illinois	525,635	671,004	2,237,567	362,822	765,310	155,829	116,927
Indiana	347,045	492,798	1,687,132	562,301	689,032	153,360	103,464
Michigan	505,852	551,917	2,345,643	362,098	460,859	100,734	62,553
Ohio	501,485	616,633	2,477,343	699,262	540,259	141,480	121,403
Wisconsin	342,760	297,585	1,407,290	177,957	322,259	78,632	118,971
Total	2,222,777	2,629,937	10,154,975	2,164,440	2,777,719	630,036	523,318

Emission Changes

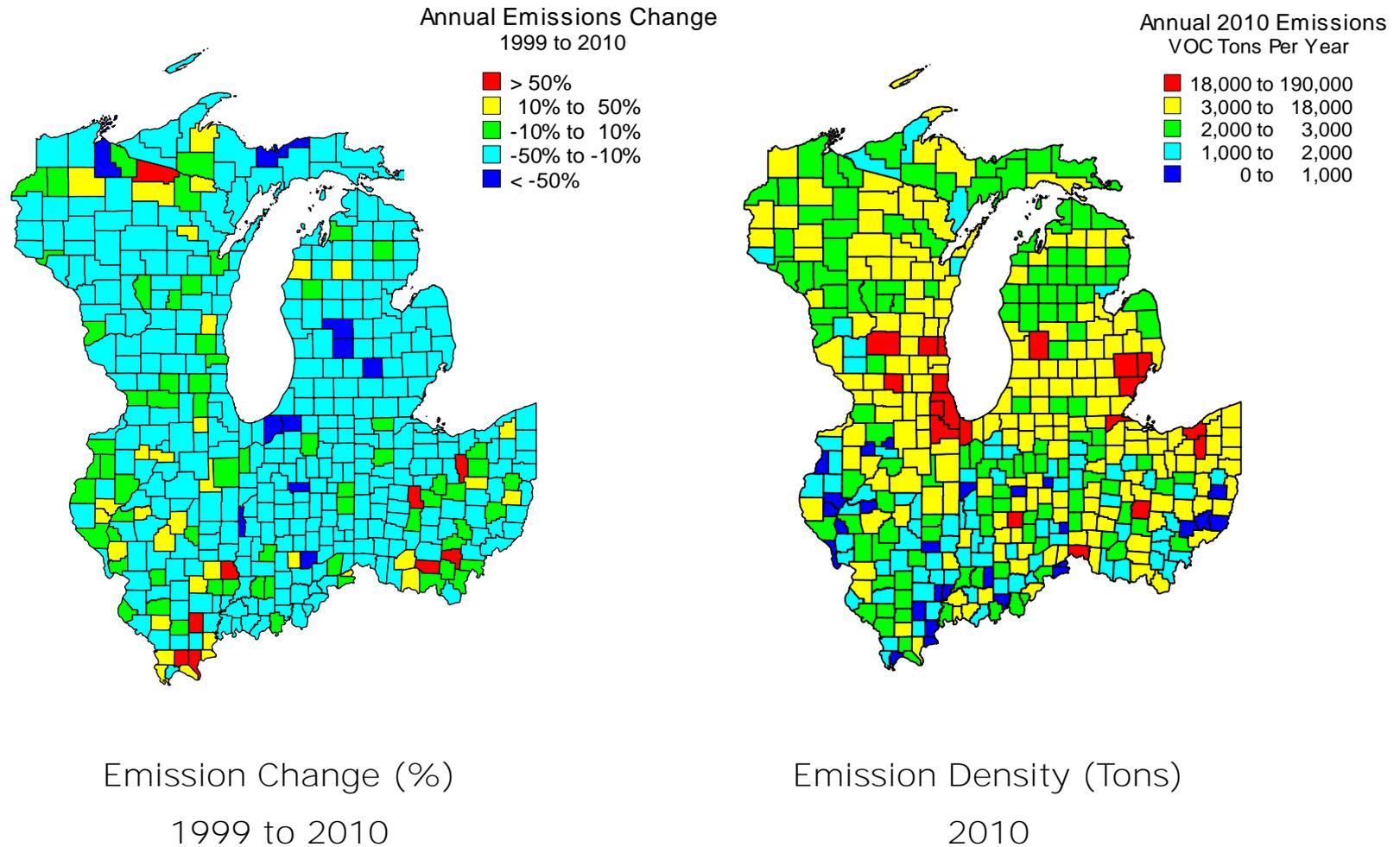
- The following slides represent the percentage-based emissions change from 1999 to 2010 for each pollutant as well as a comparison map of 2010 annual emissions
- Negative values indicate decrease in emissions, positive values indicate an increase

Michigan 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	-2	15	598	650	716	259	250	267	279	233	243
Electric Utility Non-Coal Fuel Combustion	0	602	583	21	-31	-49	-122	-141	-141	-79	-117	-104
Industrial Fuel Combustion	0	42	61	1,805	1,139	472	-195	-216	-234	-243	-262	-280
Other Fuel Combustion	0	-30,529	-30,476	-39,780	-45,979	-52,179	-58,378	-58,712	-59,046	-59,379	-59,713	-60,047
Industrial Processes	0	-13,978	-3,108	-61,405	-60,612	-59,819	-59,027	-61,867	-64,706	-67,546	-70,386	-73,226
Highway Vehicles	0	-7,986	-17,761	-5,230	-14,496	-23,761	-48,240	-58,337	-68,435	-78,532	-88,629	-98,727
Off-highway Vehicles	0	-1,539	-2,145	34,059	26,915	19,770	12,629	7,688	2,747	-2,194	-7,135	-12,075
Miscellaneous	0	351	-489	-769	786	2,341	163	5,196	52,036	2,881	6,304	6,304
Total	0	-53,038	-53,320	-70,701	-91,629	-112,509	-152,910	-166,139	-137,513	-204,813	-219,706	-237,911

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%	0%	4%	154%	167%	184%	67%	64%	69%	72%	60%	63%
Electric Utility Non-Coal Fuel Combustion	0%	132%	127%	5%	-7%	-11%	-27%	-31%	-31%	-17%	-26%	-23%
Industrial Fuel Combustion	0%	2%	3%	95%	60%	25%	-10%	-11%	-12%	-13%	-14%	-15%
Other Fuel Combustion	0%	-41%	-41%	-54%	-62%	-70%	-79%	-79%	-79%	-80%	-80%	-81%
Industrial Processes	0%	-4%	-1%	-20%	-19%	-19%	-19%	-20%	-21%	-22%	-23%	-24%
Highway Vehicles	0%	-4%	-8%	-2%	-7%	-11%	-23%	-27%	-32%	-37%	-42%	-46%
Off-highway Vehicles	0%	-1%	-2%	24%	19%	14%	9%	5%	2%	-2%	-5%	-9%
Miscellaneous	0%	36%	-50%	-79%	81%	242%	17%	536%	5371%	297%	651%	651%
Total	0%	-7%	-7%	-10%	-12%	-15%	-21%	-22%	-18%	-28%	-30%	-32%

Annual Emission Summary (VOC)

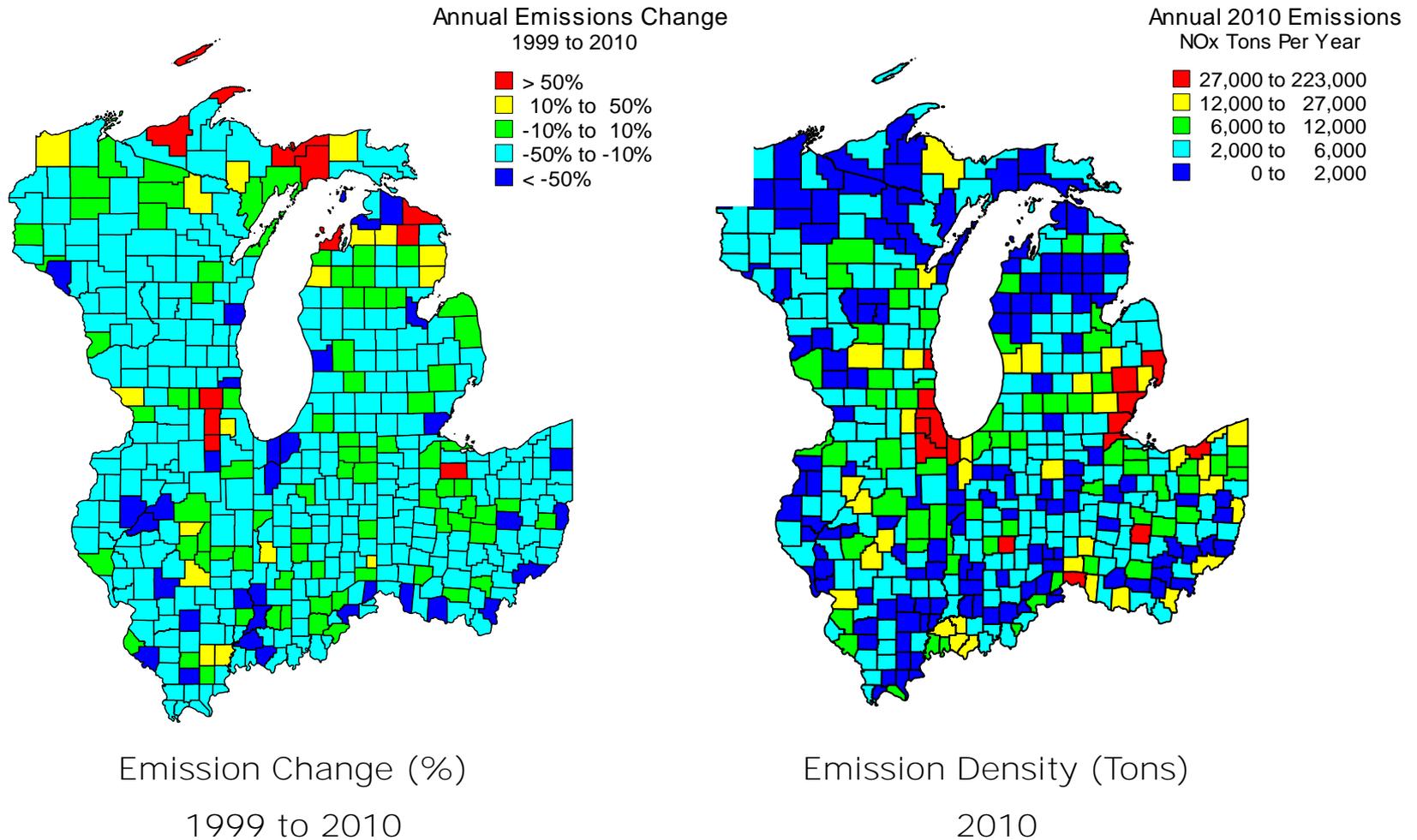


Michigan Emission Change (NO_x)

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	-25,262	-44,192	-54,272	-60,648	-65,476	-72,625	-81,525	-79,103	-82,392	-105,734	-108,821
Electric Utility Non-Coal Fuel Combustion	0	-1,302	-2,156	-3,023	-3,898	-4,055	-4,640	-5,688	-5,782	-4,070	-5,253	-4,606
Industrial Fuel Combustion	0	81	2,266	-13,045	-12,858	-12,759	-12,647	-13,776	-14,727	-13,825	-14,904	-15,444
Other Fuel Combustion	0	1,482	1,901	-1,102	-1,743	-2,383	-3,024	-3,164	-3,305	-3,446	-3,587	-3,728
Industrial Processes	0	911	3,648	-12,051	-9,287	-6,523	-3,759	-5,237	-6,715	-8,193	-9,672	-11,150
Highway Vehicles	0	-3,856	-22,181	3,797	-16,128	-36,053	47,801	27,015	6,230	-14,555	-35,340	-56,126
Off-highway Vehicles	0	27,879	29,484	31,772	28,100	24,428	20,729	17,719	14,710	11,700	8,690	5,680
Miscellaneous	0	67	-316	-478	-346	-213	-398	-95	1,726	-216	16	16
Total	0	0	-31,546	-48,403	-76,808	-103,035	-28,562	-64,750	-86,967	-114,998	-165,784	-194,178

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%	-24%	-29%	-32%	-35%	-39%	-44%	-42%	-44%	-56%	-58%
Electric Utility Non-Coal Fuel Combustion	0%	-12%	-20%	-28%	-36%	-38%	-43%	-53%	-54%	-38%	-49%	-43%
Industrial Fuel Combustion	0%	0%	3%	-20%	-20%	-19%	-19%	-21%	-22%	-21%	-23%	-23%
Other Fuel Combustion	0%	4%	6%	-3%	-5%	-7%	-9%	-10%	-10%	-10%	-11%	-11%
Industrial Processes	0%	2%	7%	-22%	-17%	-12%	-7%	-10%	-12%	-15%	-18%	-20%
Highway Vehicles	0%	-1%	-7%	1%	-5%	-12%	15%	9%	2%	-5%	-11%	-18%
Off-highway Vehicles	0%	34%	36%	39%	34%	30%	25%	22%	18%	14%	11%	7%
Miscellaneous	0%	14%	-64%	-97%	-70%	-43%	-80%	-19%	349%	-44%	3%	3%
Total	0%	0%	-4%	-6%	-10%	-14%	-4%	-9%	-12%	-15%	-22%	-26%

Annual Emission Summary (NO_x)

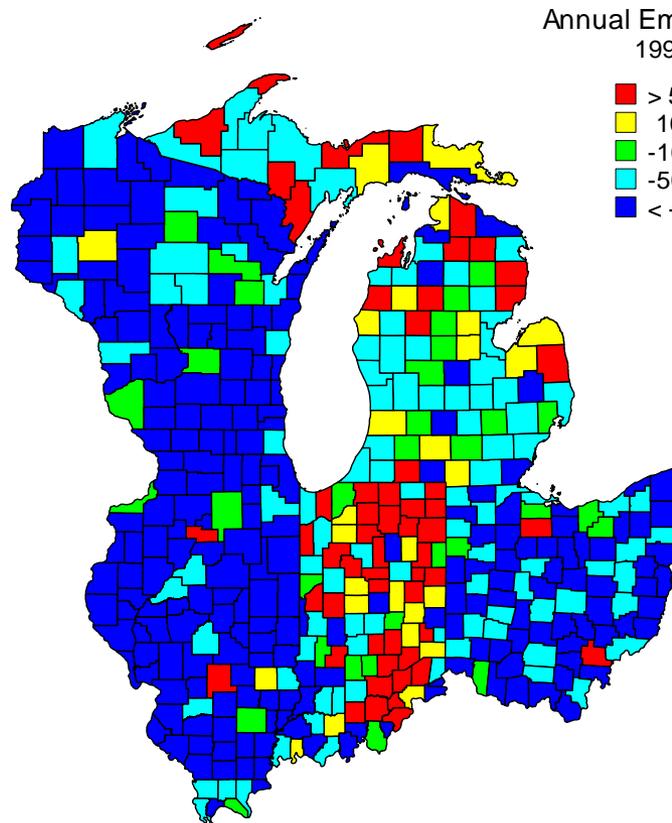


Michigan Emission Change (SO₂)

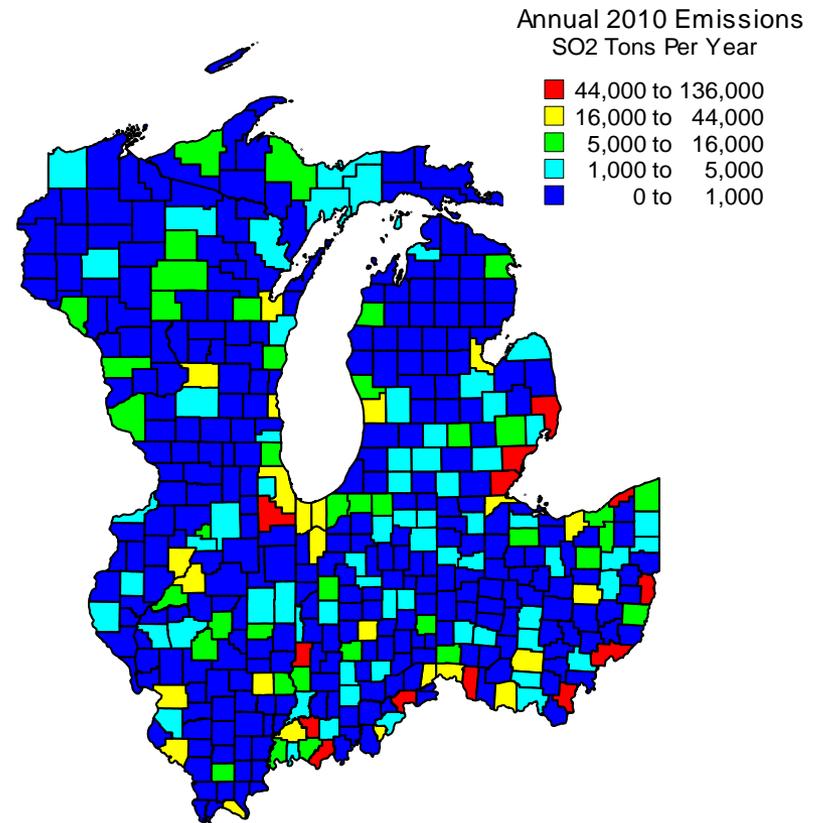
Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0	-33,297	-53,590	-57,518	-33,327	-33,605	-51,287	-63,107	-56,802	-70,826	-121,874	-152,077
Electric Utility Non-Coal Fuel Combustion	0	-699	-2,437	-589	-3,283	-4,018	-6,172	-9,993	-8,949	-10,123	-10,365	-10,377
Industrial Fuel Combustion	0	-495	2,399	23,160	24,915	26,670	28,058	27,769	27,479	28,025	27,677	27,527
Other Fuel Combustion	0	463	874	-10,664	-10,557	-10,450	-10,343	-10,344	-10,344	-10,345	-10,346	-10,347
Industrial Processes	0	2,149	5,014	-3,245	-4,628	-6,011	-7,395	-9,319	-11,243	-13,168	-15,092	-17,017
Highway Vehicles	0	-782	-633	1,996	-105	-2,206	-2,545	-3,700	-4,855	-6,010	-7,166	-8,321
Off-highway Vehicles	0	-27	271	7,974	5,942	3,909	1,941	292	-1,357	-3,006	-4,655	-6,305
Miscellaneous	0	18	-87	-127	-64	-1	-91	72	1,296	2	122	122
Total	0	-32,668	-48,188	-39,013	-21,108	-25,712	-47,833	-68,329	-64,776	-85,452	-141,700	-176,794

Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0%	-8%	-13%	-14%	-8%	-8%	-13%	-16%	-14%	-18%	-30%	-38%
Electric Utility Non-Coal Fuel Combustion	0%	-6%	-21%	-5%	-28%	-34%	-53%	-85%	-76%	-86%	-88%	-89%
Industrial Fuel Combustion	0%	-1%	6%	57%	61%	65%	69%	68%	67%	69%	68%	67%
Other Fuel Combustion	0%	3%	5%	-64%	-63%	-62%	-62%	-62%	-62%	-62%	-62%	-62%
Industrial Processes	0%	5%	11%	-7%	-10%	-14%	-17%	-21%	-25%	-30%	-34%	-39%
Highway Vehicles	0%	-7%	-6%	17%	-1%	-19%	-22%	-32%	-42%	-52%	-62%	-72%
Off-highway Vehicles	0%	0%	2%	62%	46%	30%	15%	2%	-11%	-23%	-36%	-49%
Miscellaneous	0%	14%	-66%	-96%	-49%	-1%	-69%	55%	985%	2%	92%	92%
Total	0%	-6%	-9%	-7%	-4%	-5%	-9%	-13%	-12%	-16%	-26%	-33%

Annual Emission Summary (SO₂)



Emission Change (%)
1999 to 2010



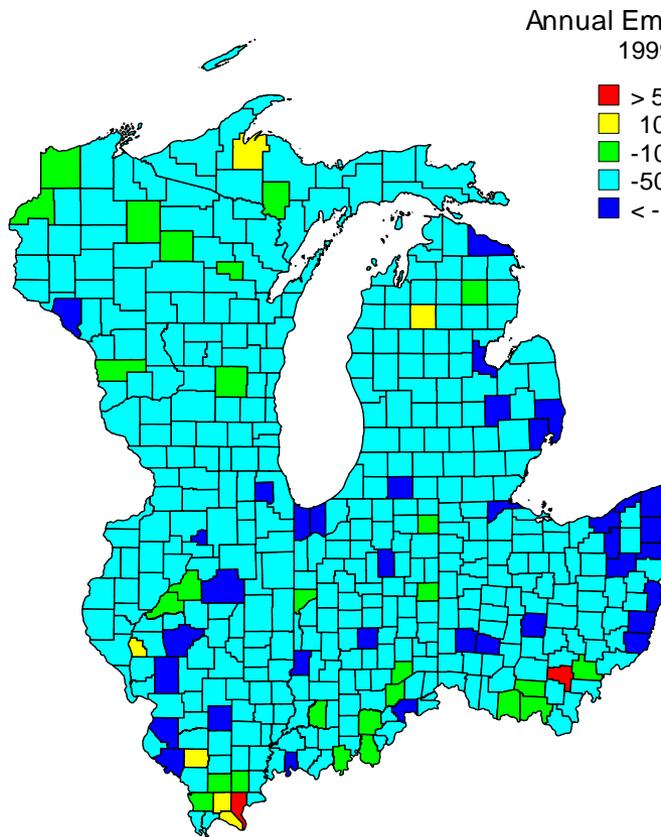
Emission Density (Tons)
2010

Michigan Emission Change (PM_{2.5})

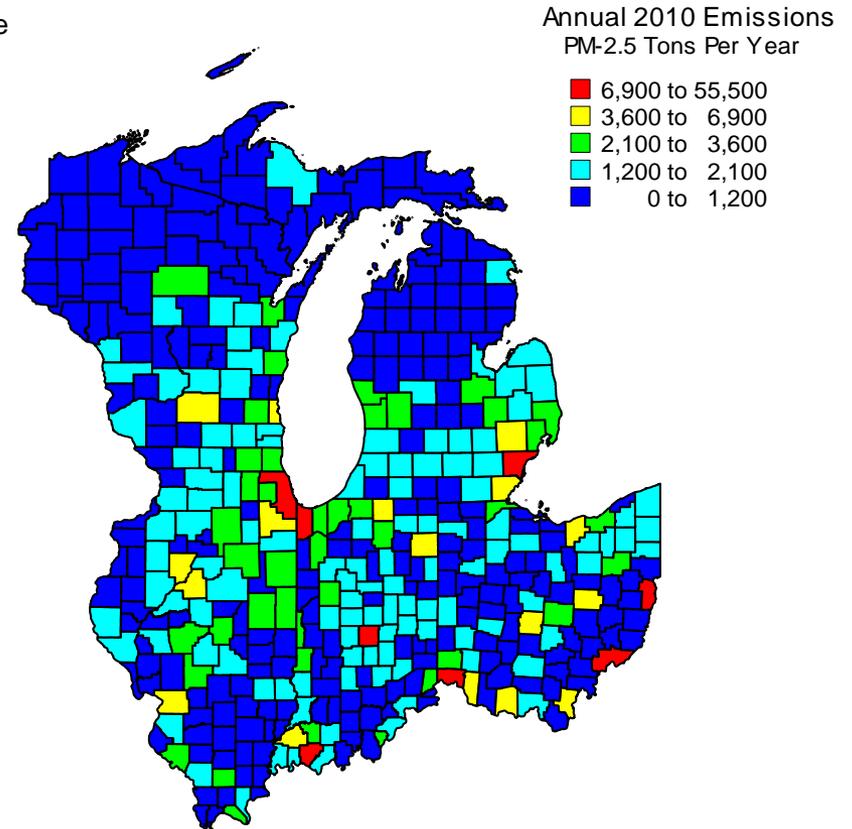
Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0	-1,436	-733	-3,391	-3,022	-2,588	-5,801	-6,167	-5,952	-6,107	-6,809	-6,597
Electric Utility Non-Coal Fuel Combustion	0	-444	-470	-1,787	-1,815	-1,781	-1,949	-2,020	-2,009	-2,038	-2,058	-2,035
Industrial Fuel Combustion	0	-182	-49	1,576	1,852	2,125	2,098	2,086	2,075	2,123	2,110	2,100
Other Fuel Combustion	0	-941	-873	-13,383	-13,352	-13,321	-13,304	-13,492	-13,680	-13,868	-14,056	-14,244
Industrial Processes	0	-3,037	37	-5,513	-5,135	-4,756	-4,436	-4,603	-4,770	-4,936	-5,103	-5,270
Highway Vehicles	0	-500	-954	-831	-1,187	-1,543	4,215	3,561	2,906	2,251	1,596	942
Off-highway Vehicles	0	-191	-261	251	-131	-513	-888	-1,196	-1,505	-1,813	-2,121	-2,430
Miscellaneous	0	-4,488	-14,404	-43,438	-42,809	-42,180	-43,056	-41,230	-24,705	-42,067	-40,794	-40,794
Total	0	-11,219	-17,707	-66,515	-65,598	-64,557	-63,121	-63,061	-47,639	-66,456	-67,235	-68,328

Source Category	Annual Emissions Change (from 1999)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electric Utility Coal Fuel Combustion	0%	-10%	-5%	-24%	-22%	-19%	-42%	-45%	-43%	-44%	-49%	-48%
Electric Utility Non-Coal Fuel Combustion	0%	-20%	-21%	-79%	-80%	-78%	-86%	-89%	-88%	-90%	-91%	-90%
Industrial Fuel Combustion	0%	-6%	-2%	55%	65%	74%	73%	73%	72%	74%	74%	73%
Other Fuel Combustion	0%	-4%	-4%	-61%	-61%	-61%	-61%	-62%	-62%	-63%	-64%	-65%
Industrial Processes	0%	-10%	0%	-18%	-17%	-16%	-15%	-15%	-16%	-16%	-17%	-17%
Highway Vehicles	0%	-7%	-14%	-12%	-18%	-23%	63%	53%	43%	33%	24%	14%
Off-highway Vehicles	0%	-2%	-3%	3%	-1%	-5%	-9%	-12%	-15%	-18%	-21%	-24%
Miscellaneous	0%	-6%	-18%	-54%	-53%	-52%	-53%	-51%	-31%	-52%	-50%	-50%
Total	0%	-7%	-10%	-39%	-39%	-38%	-37%	-37%	-28%	-39%	-40%	-40%

Annual Emission Summary (PM_{2.5})



Emission Change (%)
1999 to 2010



Emission Density (Tons)
2010

Midwestern States Emissions Change Summary

Annual Emissions Change (Tons) -- 1999 to 2010

State	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Illinois	-188,778	-286,815	-1,704,633	-665,187	-158,731	-102,337	-19,416
Indiana	-177,145	-333,719	-1,418,318	-517,941	16,430	-85,862	-868
Michigan	-237,911	-194,178	-1,733,455	-176,794	-86,871	-68,328	-7,957
Ohio	-167,241	-457,279	-1,947,203	-842,762	-113,147	-100,390	35,781
Wisconsin	-79,551	-140,150	-1,042,028	-159,117	-50,071	-35,004	11,186
Total	-850,626	-1,412,140	-7,845,637	-2,361,802	-392,389	-391,922	18,727

Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across Michigan
- NO_x and SO₂ from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NO_x Budget Trading Program and CAIR control implementation
- 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}

AQ Trends Scope

- Compute, summarize and display ozone and PM_{2.5} design value trends in the Midwestern states for the period 1999 – 2010
- Create a spreadsheet database of O₃ 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/m³
- PM_{2.5} 24-Hour
 - Annual 98th percentile of daily averages averaged over three consecutive years
 - Current standard = 35 ug/m³

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

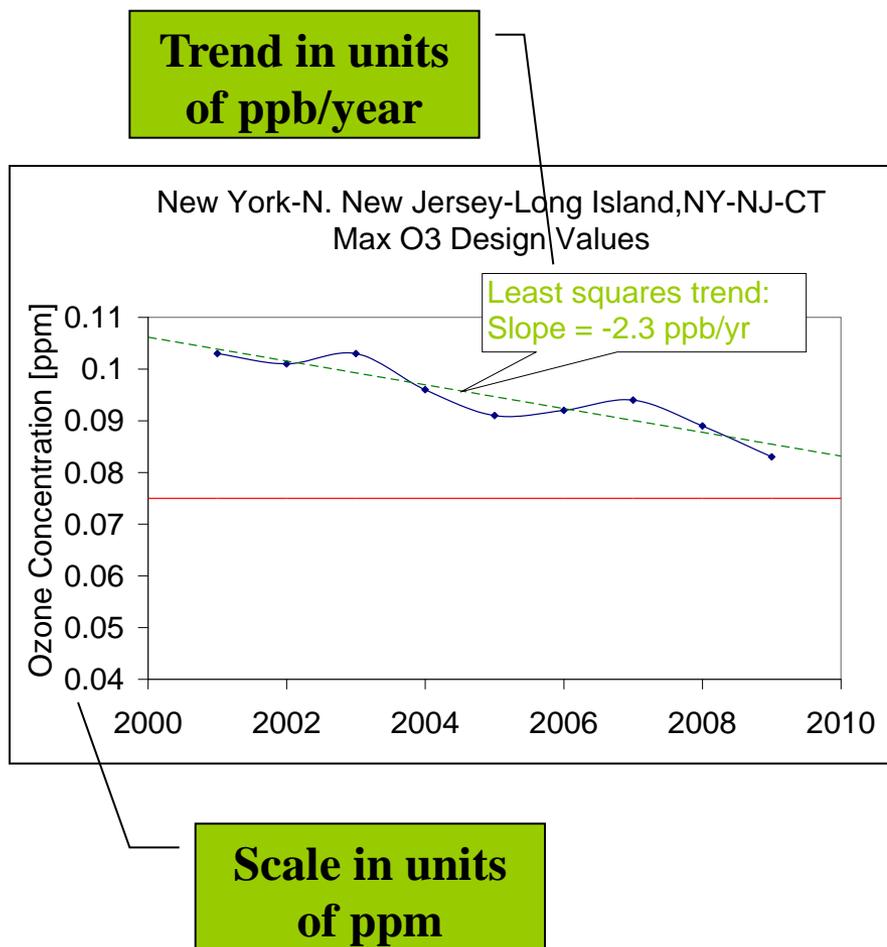
Data Handling Procedures

- O₃ 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

Data Handling Procedures

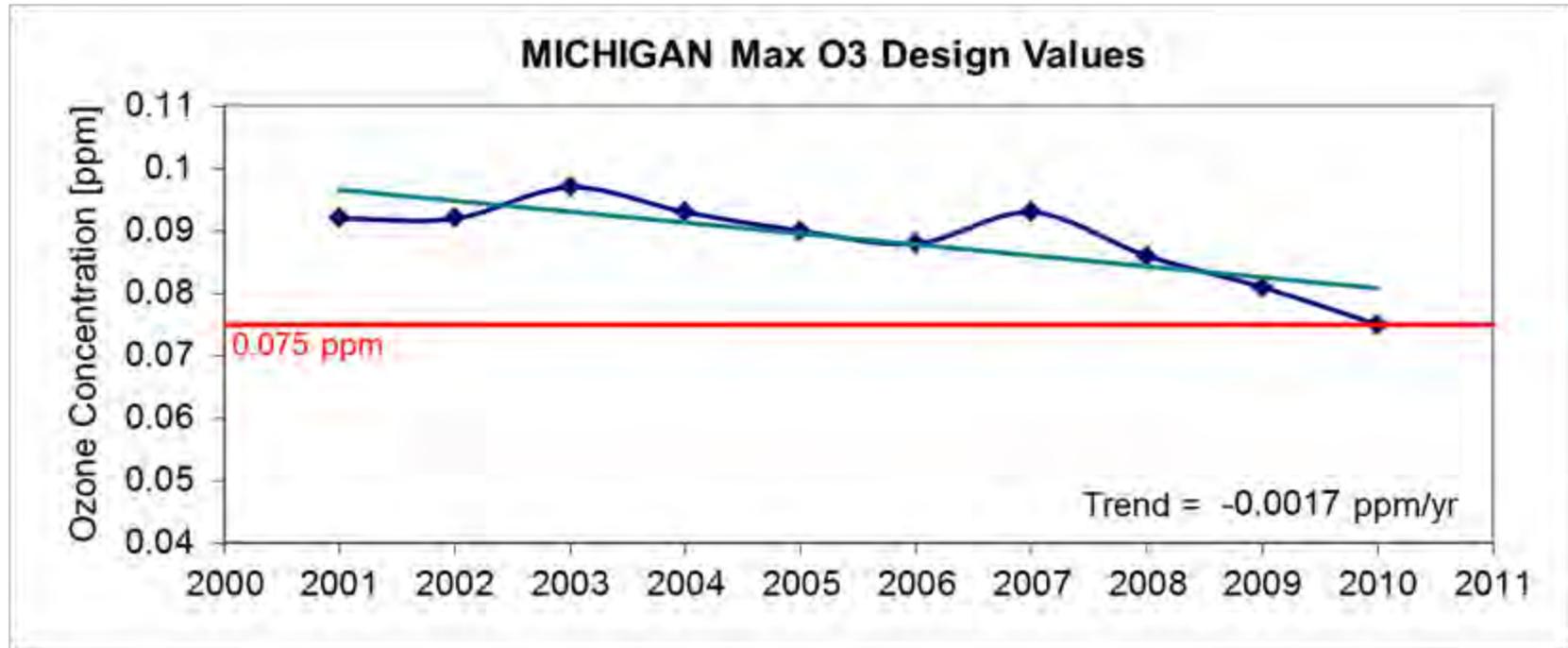
- Annual $PM_{2.5}$ DV and 24-hr $PM_{2.5}$ DV for each overlapping three-year period starting with 1999-2001 and ending with 2008-2010
 - DV calculations based on EPA data handling conventions
 - Data extracted from monitors that have a non-regulatory monitoring type are omitted
 - Selection of trend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

Trend Calculation

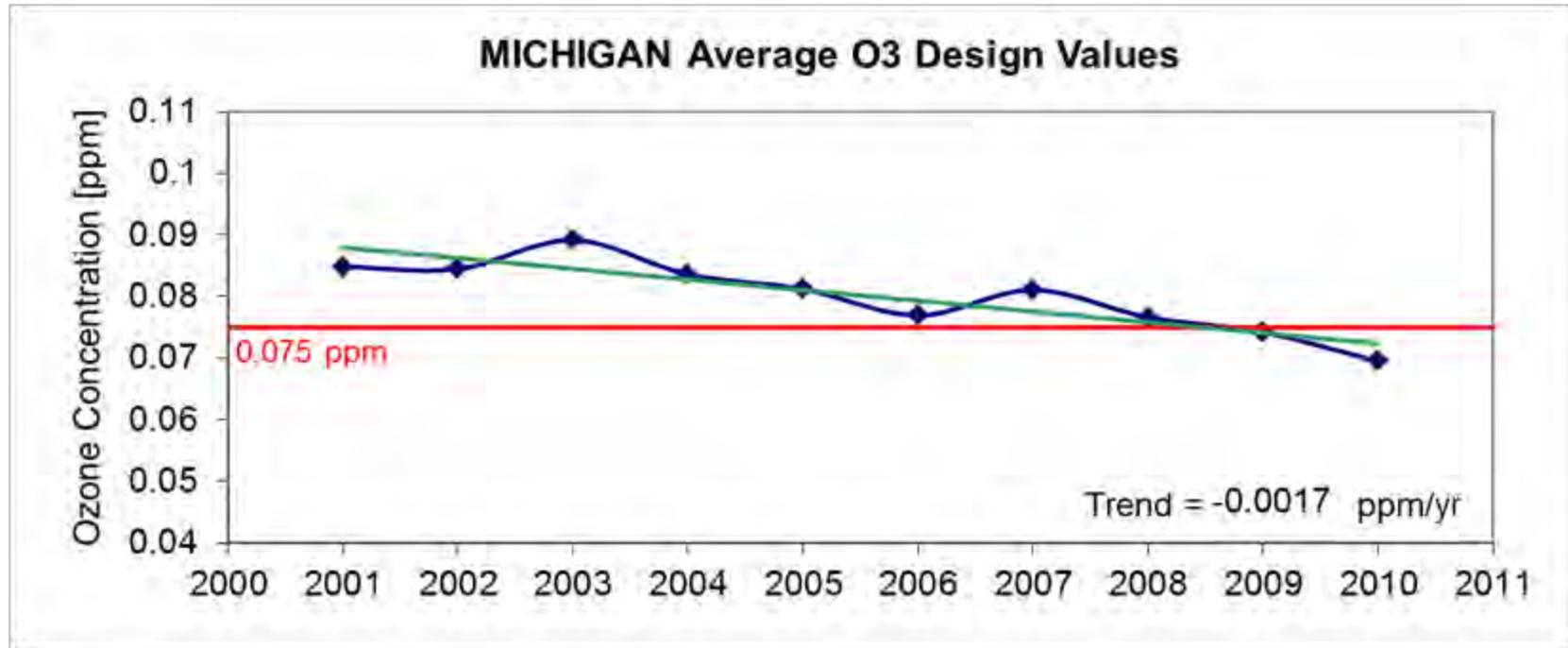


- Trends based on linear least squares fit to rolling three year design values (DVs)
- Negative trend indicates improving air quality
- DVs based on each 3-year period: 1999-2001, 2000-2002, ... 2008-2010
- Notes
 - On plots, DVs are for three year period ending in year shown (i.e., 2007-2009 DV plotted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

Max O₃ DVs and Trend



Average O₃ DVs and Trend



Ozone Trends by Site in Michigan

Monitoring Sites	County	Trend [ppm/yr]
2600500034420101	Allegan, MI	-0.0015
2601900034420101	Benzie, MI	-0.0021
2602100144420101	Berrien, MI	-0.0018
2603700014420102	Clinton, MI	-0.0019
2604900214420101	Genesee, MI	-0.0019
2604920014420101	Genesee, MI	-0.0020
2606300074420101	Huron, MI	-0.0018
2606500124420102	Ingham, MI	-0.0016
2607700084420101	Kalamazoo, MI	-0.0015
2608100204420101	Kent, MI	-0.0011
2608100224420101	Kent, MI	-0.0015

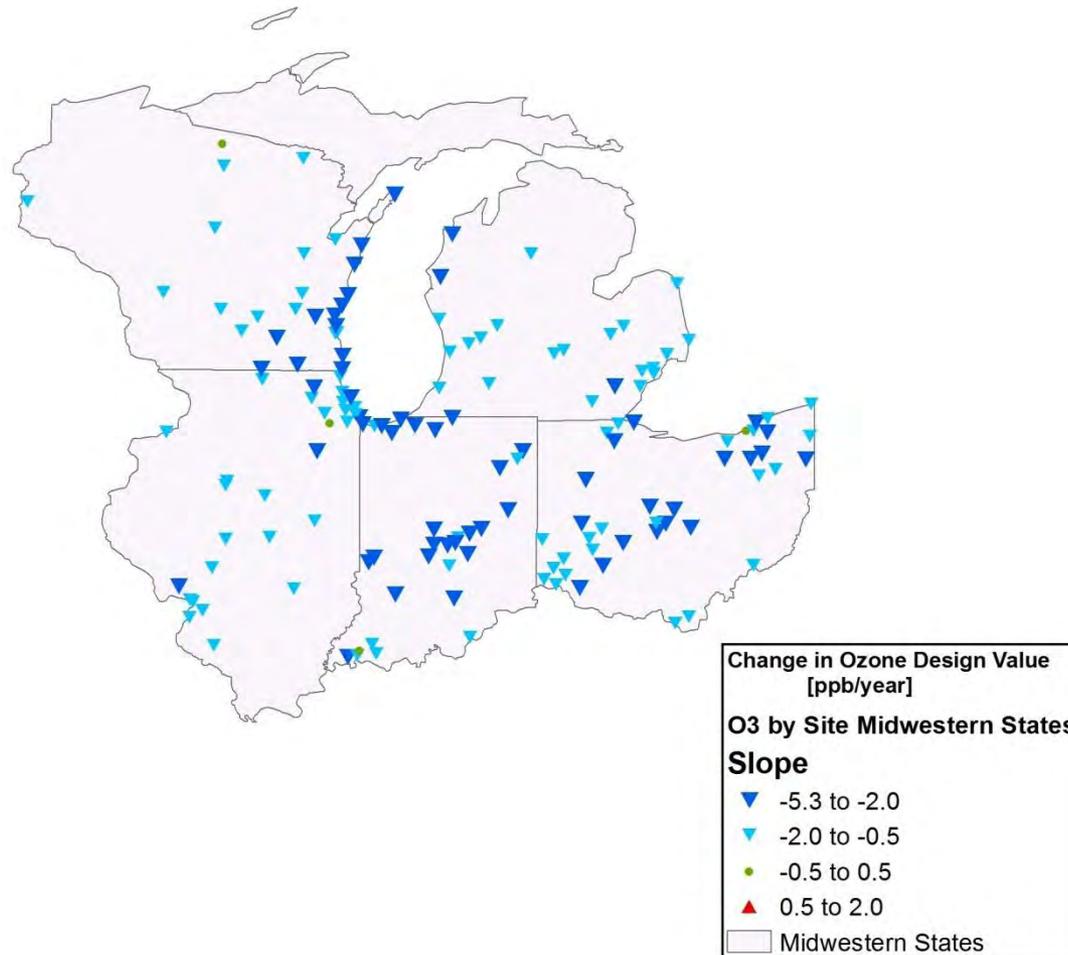
Note: Only monitoring sites meeting data completeness criteria listed

Ozone Trends by Site in Michigan

Monitoring Sites	County	Trend [ppm/yr]
2609100074420101	Lenawee, MI	-0.0016
2609900094420101	Macomb, MI	-0.0018
2609910034420101	Macomb, MI	-0.0017
2610500074420101	Mason, MI	-0.0023
2611300014420101	Missaukee, MI	-0.0017
2612100394420101	Muskegon, MI	-0.0019
2612500014420102	Oakland, MI	-0.0016
2613900054420101	Ottawa, MI	-0.0015
2614700054420101	St. Clair, MI	-0.0017
2616100084420101	Washtenaw, MI	-0.0028
2616300014420102	Wayne, MI	-0.0016
2616300194420102	Wayne, MI	-0.0012

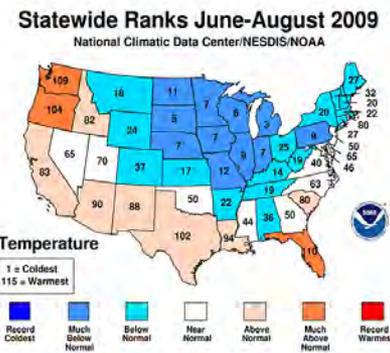
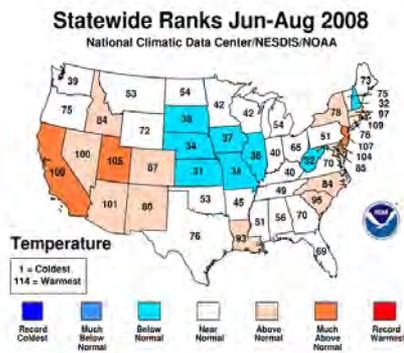
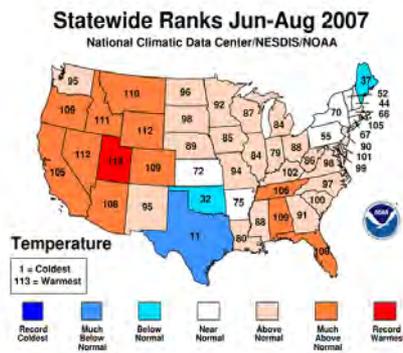
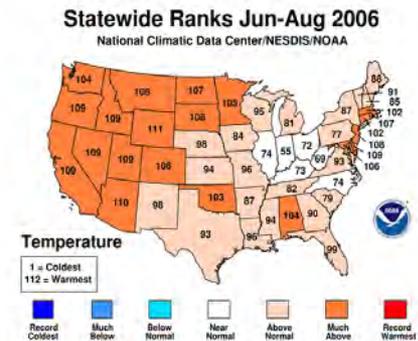
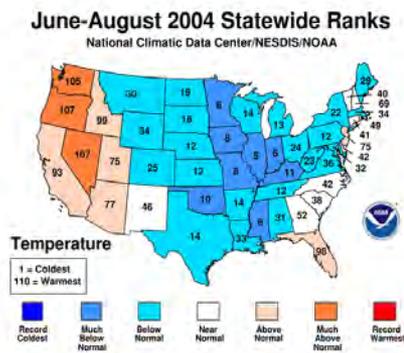
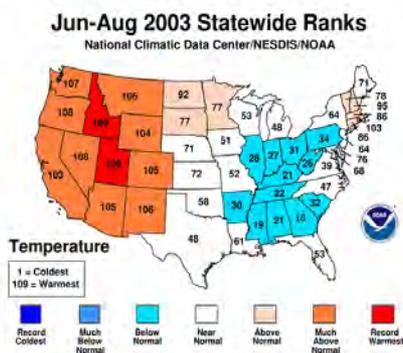
Note: Only monitoring sites meeting data completeness criteria listed

O₃ Trend Slopes at Monitoring Sites



Qualitative Meteorological Trends

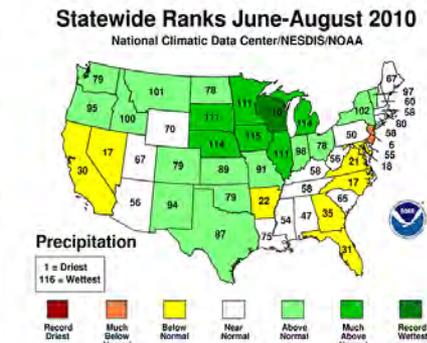
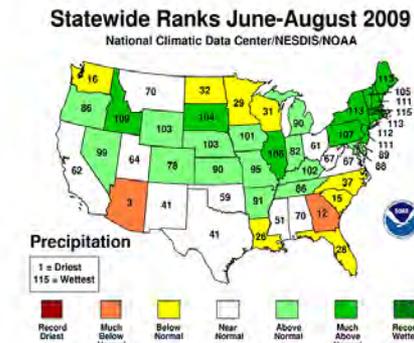
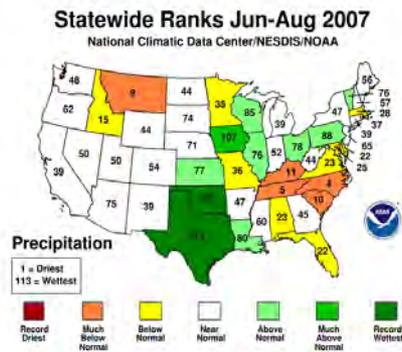
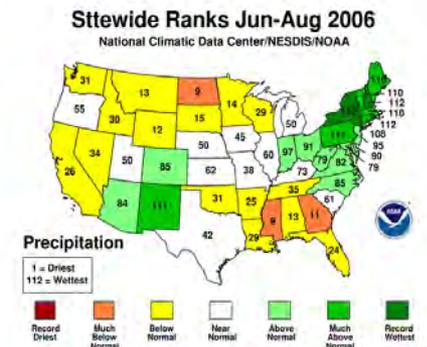
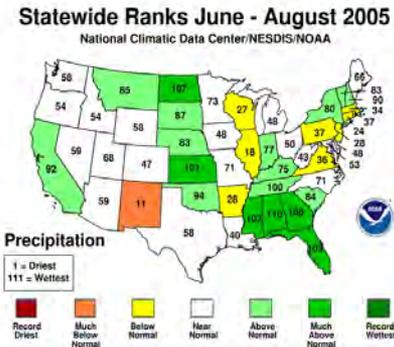
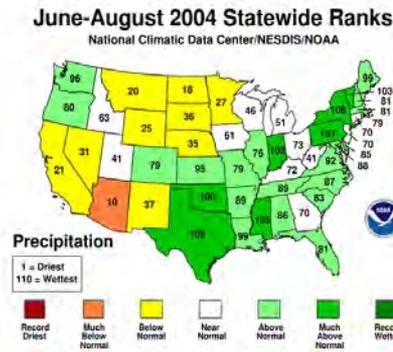
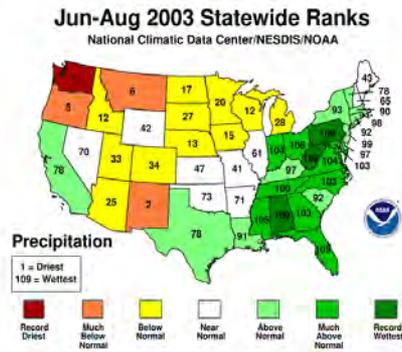
June-August Temperature 2003-2010



Blue colors represent the coldest years, red hottest
2005-2007 and 2010 most ozone conducive in Midwest
from temperature standpoint

Qualitative Meteorological Trends

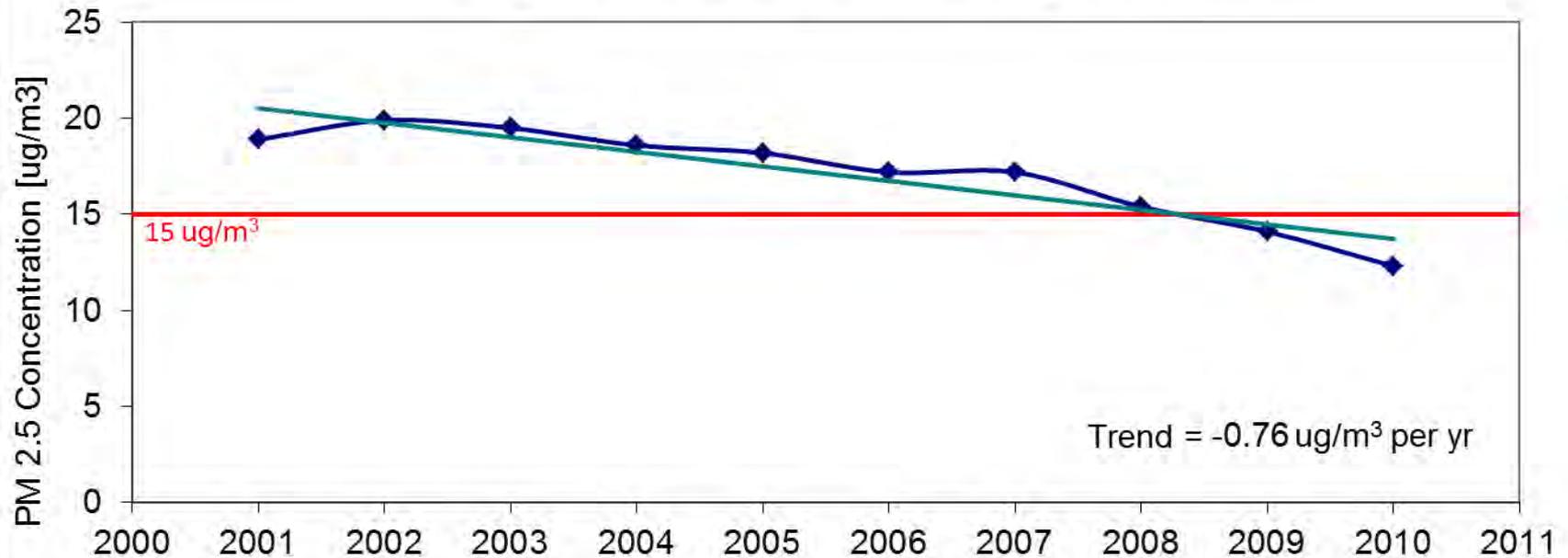
June-August Precipitation 2003-2010



Red colors represent the driest years, dark green wettest
2005, 2006, 2007 most ozone conducive in Midwest from precipitation standpoint

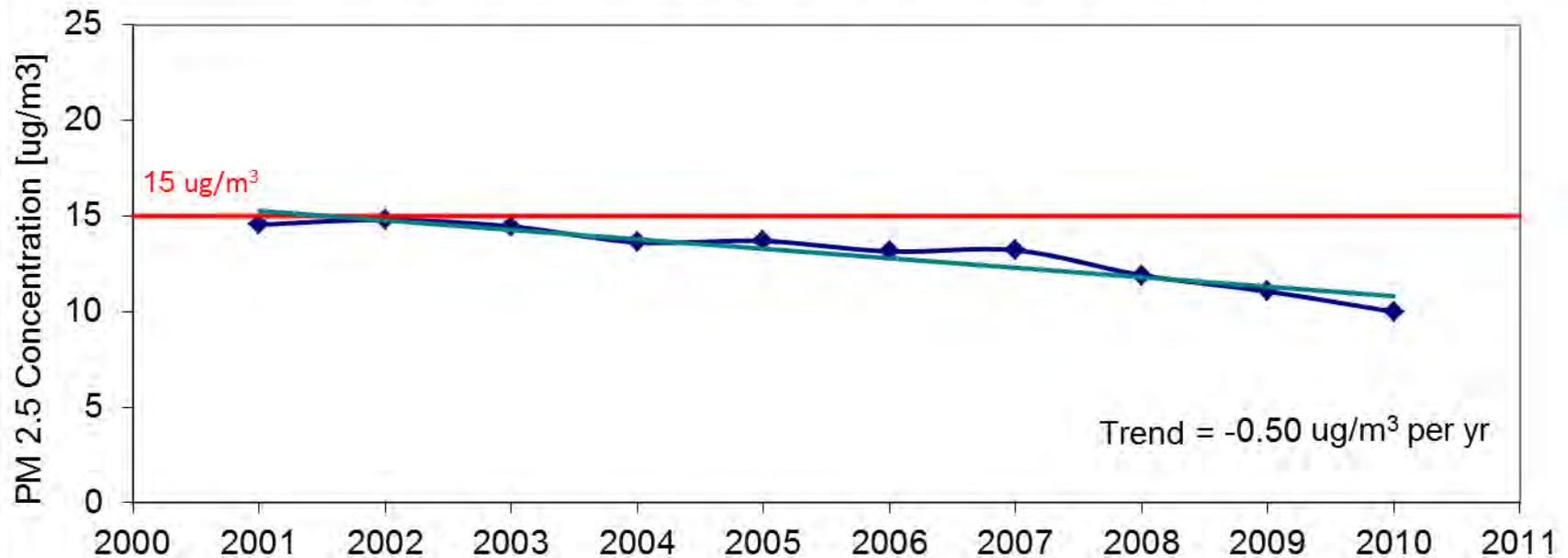
Max PM_{2.5} Annual DVs and Trend

Michigan Max PM_{2.5} Annual Design Values

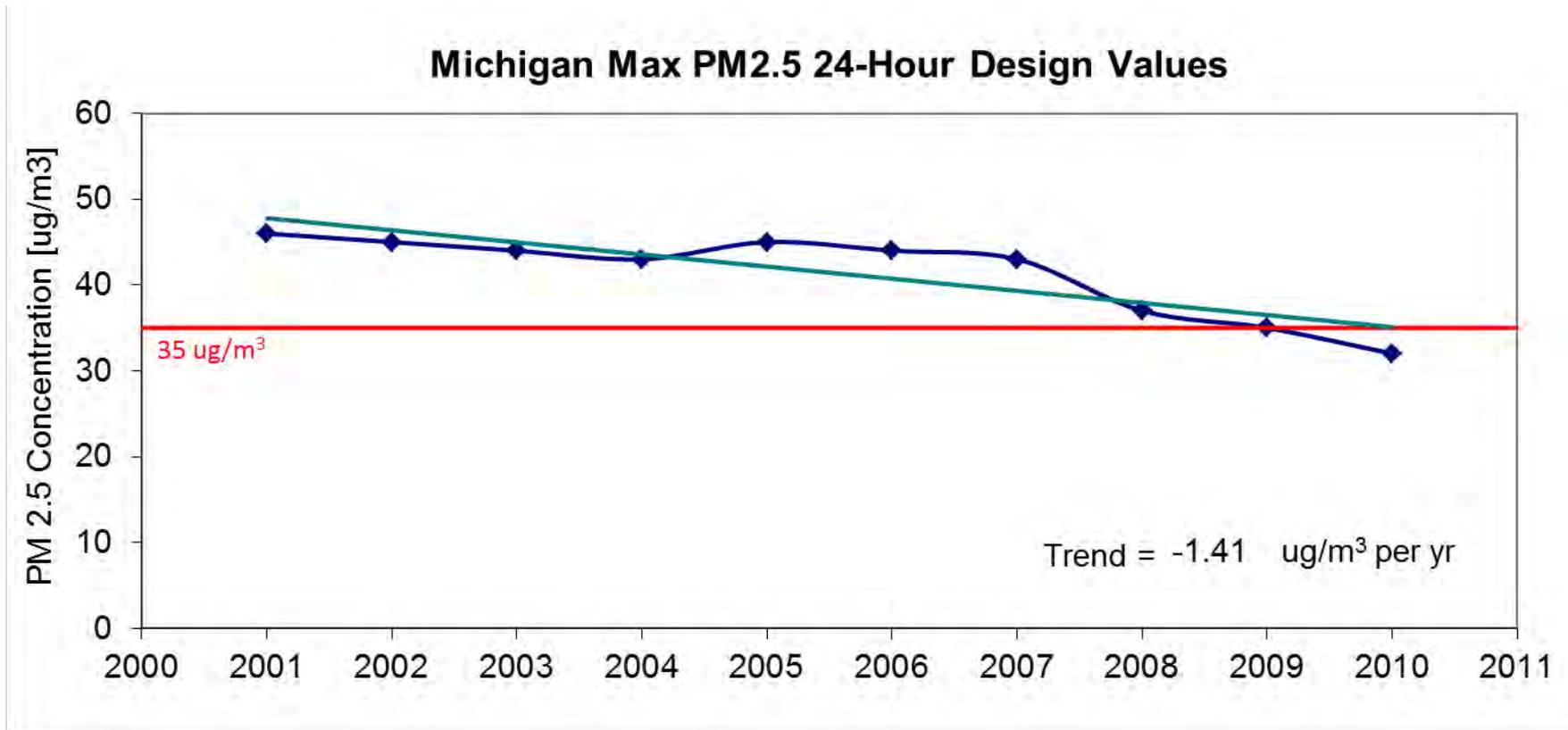


Average PM_{2.5} Annual DVs and Trend

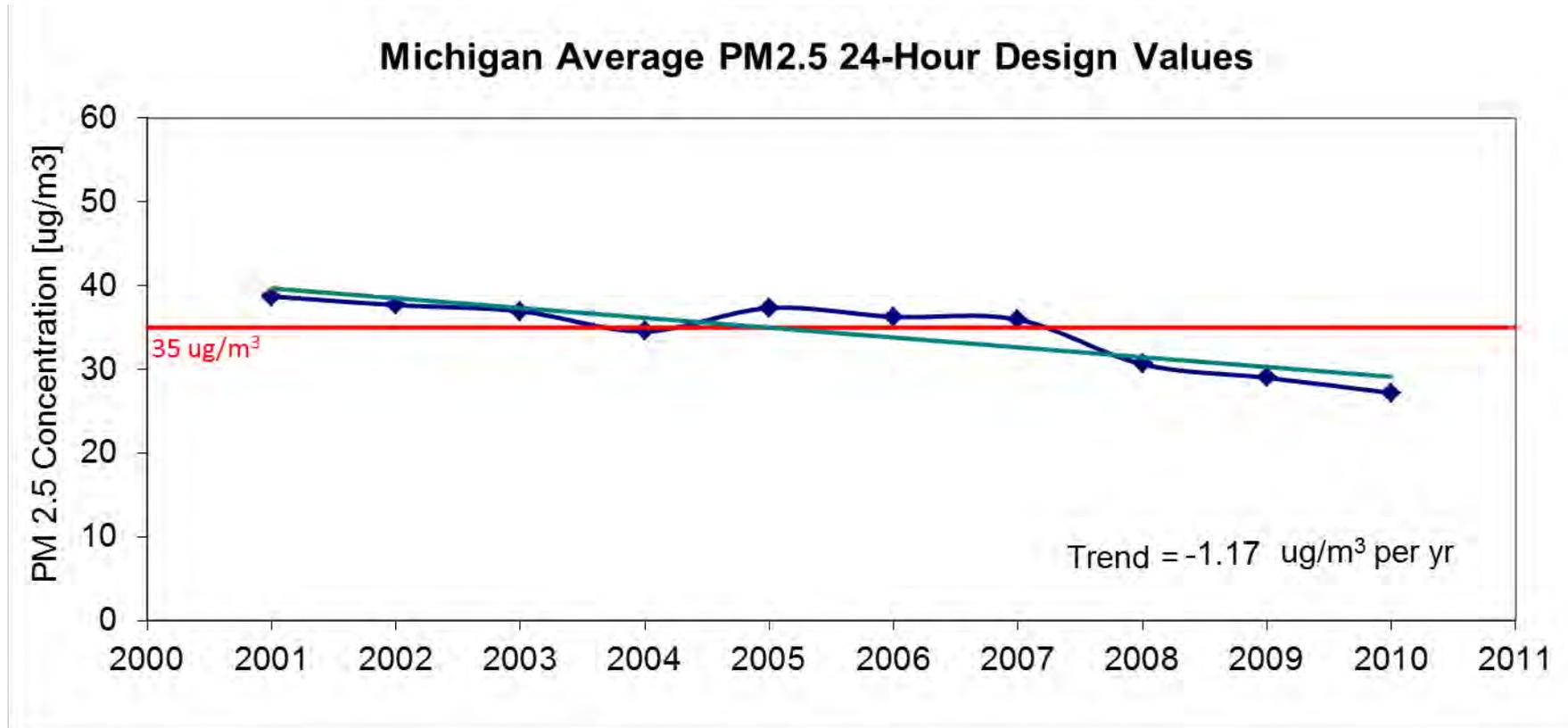
Michigan Average PM_{2.5} Annual Design Values



Max PM_{2.5} 24-Hour DVs and Trend



Average PM_{2.5} 24-Hour DVs and Trend



PM_{2.5} Trends by Site in Michigan

Monitoring Site	County	Trend [$\mu\text{g}/\text{m}^3$ per year]	
		Annual DV	24-Hr DV
260050003	Allegan	-0.33	-1.07
260170014	Bay	-0.38	-0.94
260210014	Berrien	-0.34	-0.75
260490021	Genesee	-0.39	-1.10
260650012	Ingham	-0.44	-1.18
260770008	Kalamazoo	-0.52	-1.27
260810020	Kent	-0.43	-1.19
260990009	Macomb	-0.38	-0.98
261150005	Monroe	-0.60	-1.72
261210040	Muskegon	-0.34	-0.99

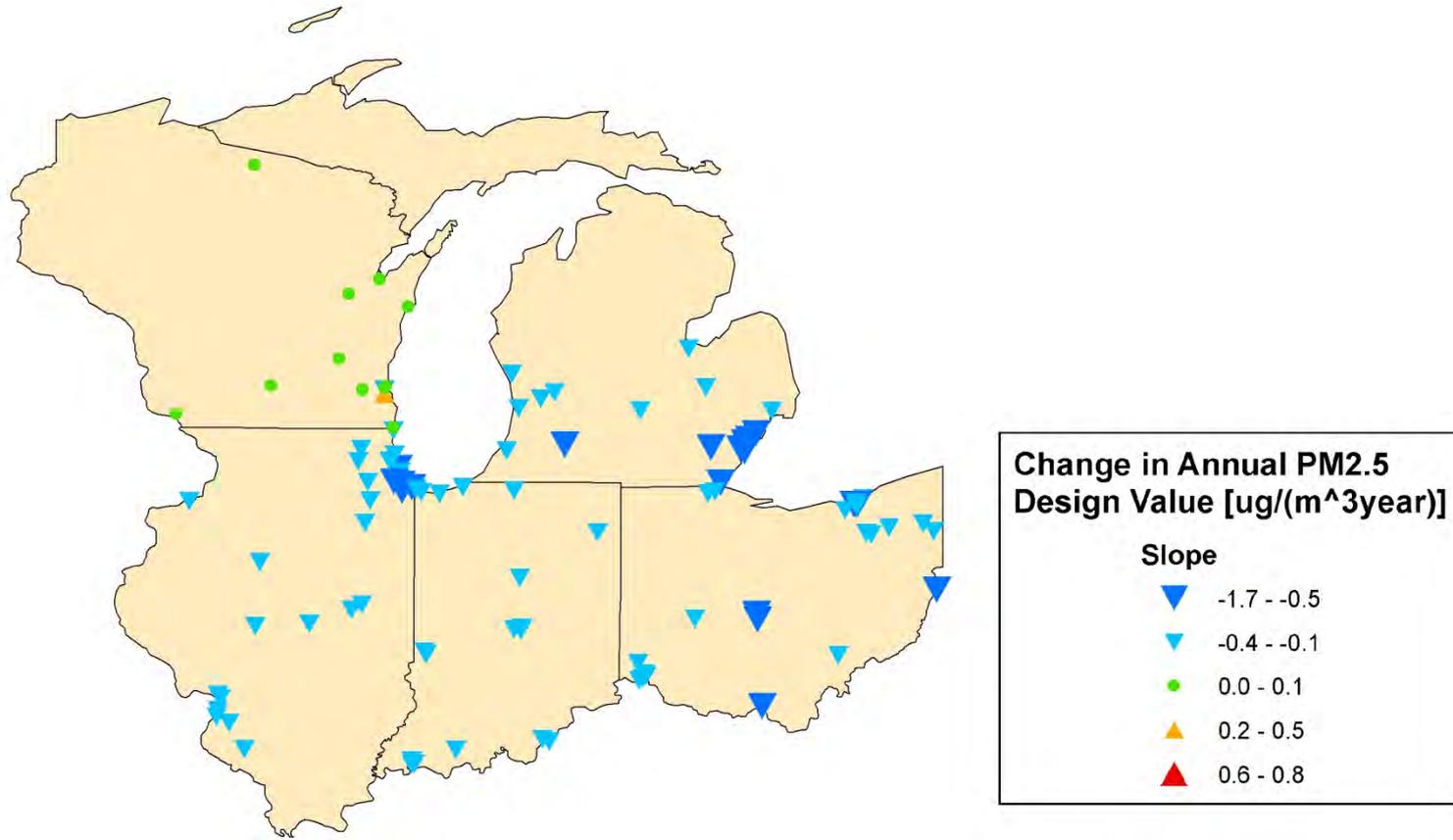
Note: Only monitoring sites meeting data completeness criteria listed

PM_{2.5} Trends by Site in Michigan

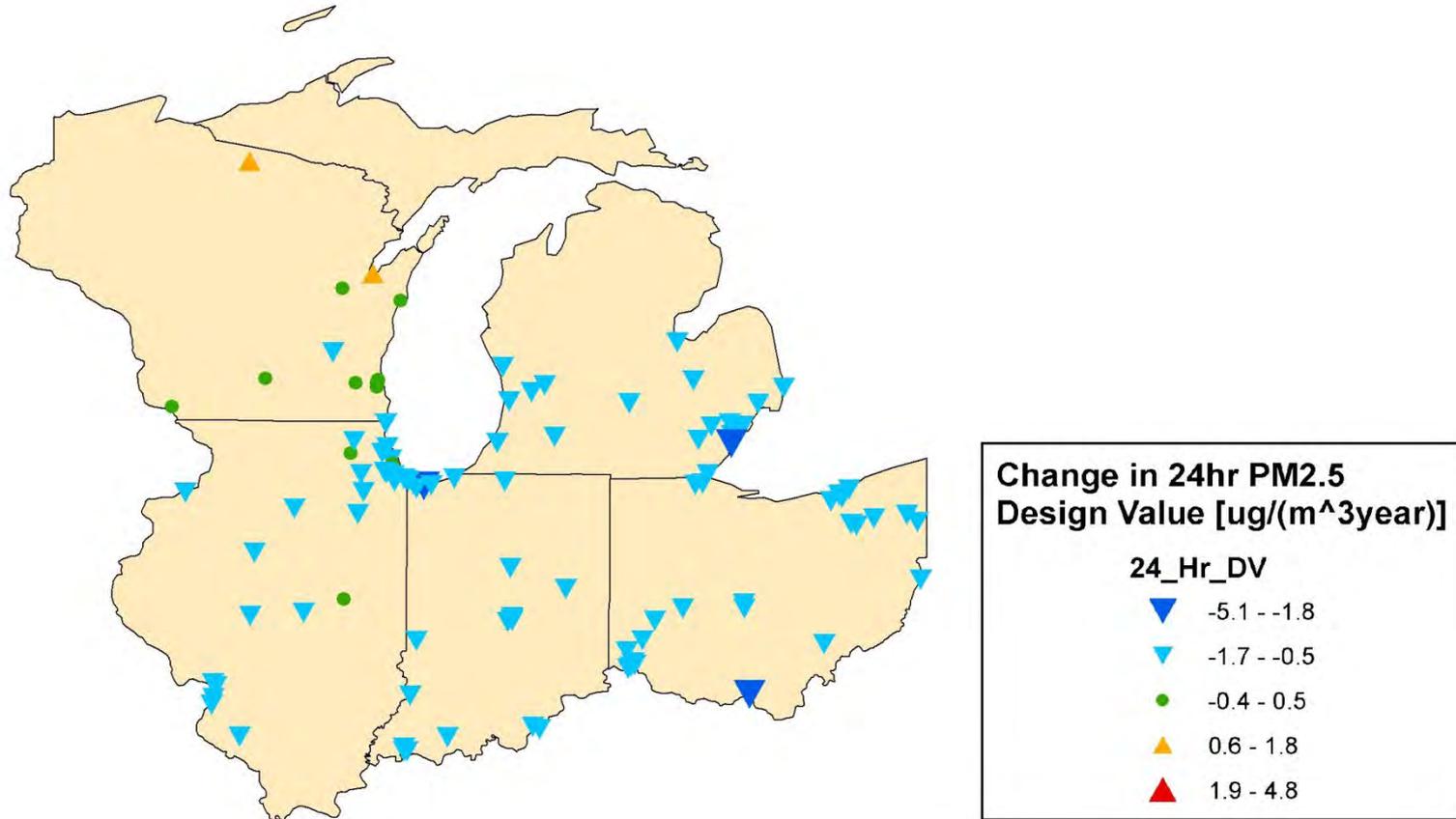
Monitoring Site	County	Trend [$\mu\text{g}/\text{m}^3$ per year]	
		Annual DV	24-Hr DV
261390005	Ottawa	-0.38	-1.11
261610008	Washtenaw	-0.62	-0.99
261630001	Wayne	-0.61	-1.42
261630015	Wayne	-0.70	-1.21
261630016	Wayne	-0.59	-1.35
261630019	Wayne	-0.62	-1.07
261630033	Wayne	-0.76	-1.29
261630036	Wayne	-0.80	-1.90
261250001	Oakland	N/A	-1.08
261470005	St. Clair	N/A	-0.75
261630025	Wayne	N/A	-1.30

Note: Only monitoring sites meeting data completeness criteria listed

Annual PM_{2.5} Trend Slopes at Monitoring Sites



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

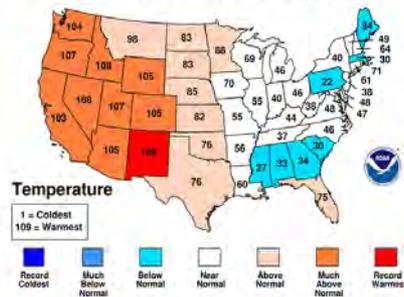


Qualitative Meteorological Trends

Annual Temperature 2003-2010

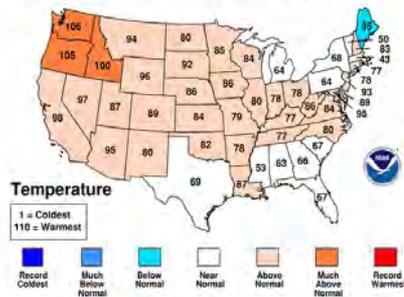
January-December 2003 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



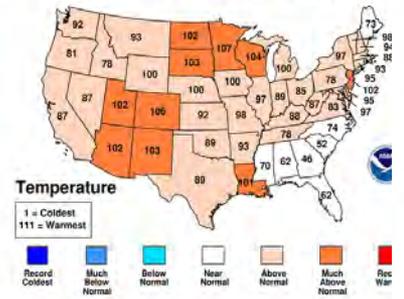
January-December 2004 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



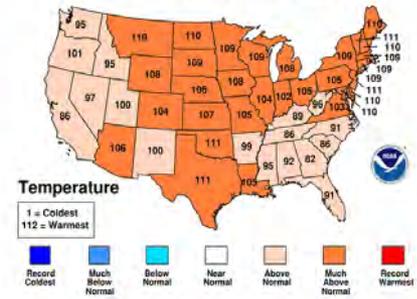
Statewide Ranks Jan-Dec 2005

National Climatic Data Center/NESDIS/NOAA



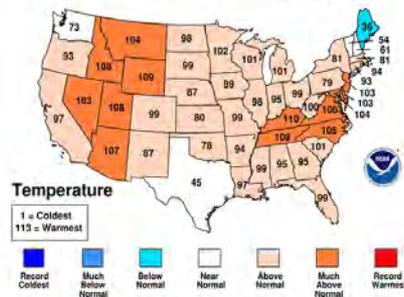
Statewide Ranks Jan-Dec 2006

National Climatic Data Center/NESDIS/NOAA



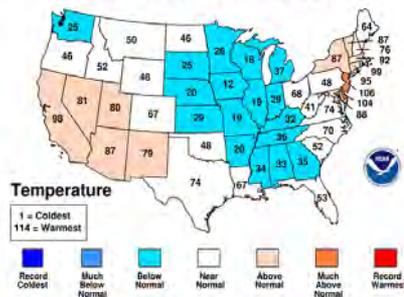
Statewide Ranks Jan-Dec 2007

National Climatic Data Center/NESDIS/NOAA



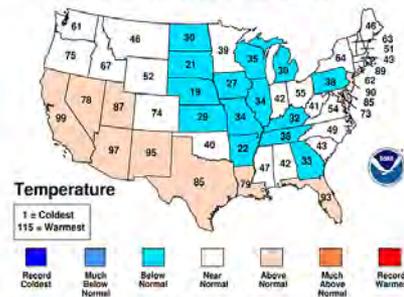
Statewide Ranks Jan-Dec 2008

National Climatic Data Center/NESDIS/NOAA



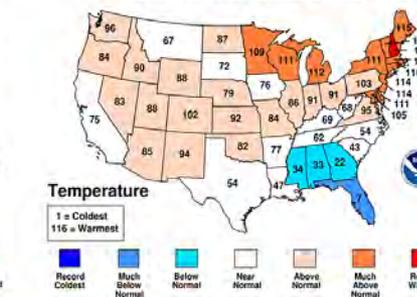
January-December 2009 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



January-December 2010 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



Blue colors represent the coldest years, red hottest

2004-2007 and 2010 most PM_{2.5} conducive in Midwest from temperature standpoint

Qualitative Meteorological Trends

Annual Precipitation 2003-2010

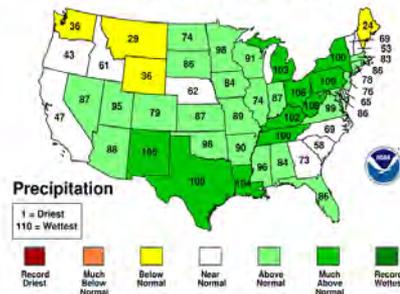
January-December 2003 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



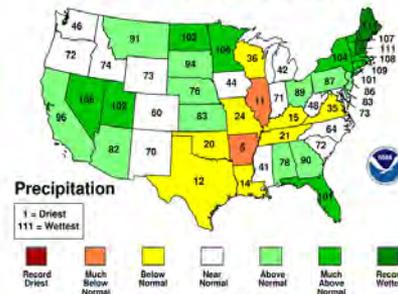
January-December 2004 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



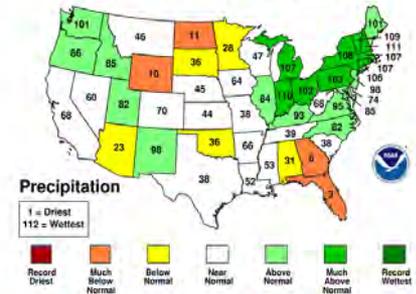
Statewide Ranks Jan-Dec 2005

National Climatic Data Center/NESDIS/NOAA



Statewide Ranks Jan-Dec 2006

National Climatic Data Center/NESDIS/NOAA



Statewide Ranks Jan-Dec 2007

National Climatic Data Center/NESDIS/NOAA



Statewide Ranks Jan-Dec 2008

National Climatic Data Center/NESDIS/NOAA



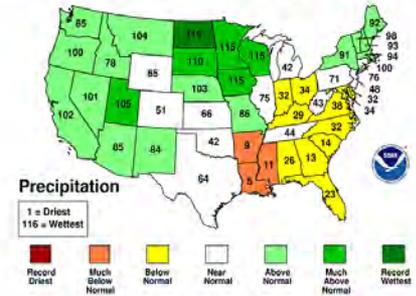
January-December 2009 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



January-December 2010 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



Red colors represent the driest years, dark green wettest
2003, 2005 and 2010 most $PM_{2.5}$ conducive in Midwest from precipitation standpoint

Air Quality Trends Summary

- Average O₃ and PM_{2.5} design values have decreased since 1999 in Michigan
- O₃ and PM_{2.5} design values have decreased since 1999 in all current O₃ and PM_{2.5} non-attainment areas in Michigan