RELATION BETWEEN AMBIENT AIR QUALITY & LOCAL EMISSIONS AT COUNTY LEVEL

GROUND LEVEL OZONE & $PM_{2.5}$

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This is a combined Presentation of Two Papers

1. Relation between $PM_{2.5}$ in Ambient Air and Local Emissions at County Level

2. Relation between Ground Level Ozone and Local Emissions at County Level

NATIONAL AIR QUALITY STATUS

OZONE 80 ppb	NAAQS 2008 STANDARDS	$PM_{2.5}$ 15 mcg/m^3
2008	YEAR OF ASSESSMENT	2012
836	COUNTIES MONITORED	314
46 225	NON ATTAINMENT AREAS COUNTIES	9 20
611	COUNTIES IN ATTAINMENT	294
2,312	COUNTIES NOT MONITORED	2,795

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INFLUENCE OF LOCAL EMISSIONS

EMISSIONS	OZONE	$PM_{2.5}$
DIRECTLY EMITTED	NO	PARTLY
CO	✓	
NH_3		✓
NO_X	✓	✓
SO_2	✓	✓
VOC	✓	
PM_{10}		✓
$PM_{2.5}$		✓
Temperature	✓	✓

IN THEORY

AIR QUALITY = *f* EMISSIONS

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- **ANY QUANTITATIVE RELATION BETWEEN AIR QUALITY AND LOCAL EMISSIONS HAVE NOT BEEN SO FAR POSSIBLE INSPITE OF VOLUMINOUS DATA BOTH ON AIR QUALITY (AQS) AND EMISSIONS (NEI)**

- **MAIN REASON BEING LACK OF DATA COMPATIBILITY ON TEMPORAL AND SPATIAL SCALE**

- **THIS POSITON HAS CHANGED FOR BETTER WITH THE AVAILABILITY OF EMISSIONS DATA FROM ALL SOURCES IN MONTHLY INTERVALS AT COUNTY LEVEL FOR ALL POLLUTANTS FOR THE YEAR 2011**

- **THIS PRESENTATION GIVES EMPIRICAL RELATIONS DERIVED BETWEEN MONTHLY MAXIMUM O_3 OR $PM_{2.5}$ CONCETRATIONS IN AMBIENT AIR WITH ALL THE INDEPENDENT VARIABLES AT THE COUNTY LEVEL**

MULTIPLE REGRESSION ANALYSES

- **TRIAL AND ERROR REGRESSION ANALYSIS ARE CARRIED OUT TO RELATE REPORTED MONTHLY MAXIMUM CONCENTRATIONS OF DEPENDENT VARIABLE [OZONE] or [PM2.5] WITH MONTHLY EMISSIONS OF ALL INDEPENDENT EFFECTIVE VARIABLES AT COUNTY LEVEL**

- **BEST FIT CONDITIONS ARE PRESENTED**

- **SIMILAR FIT IS FOUND TO HOLD GOOD FOR A CONTIGUOUS AREA ACROSS STATES OR FOR A GROUP OF COUNTIES IN A STATE**

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DERIVED EMPIRICAL RELATION

[MONTHLY MAX AQ VALUE] = a x A + b x B + c x C… where, A, B, C,….. are independent variables & a, b, c are numerical constants.

Numerical values of the constants vary for counties as well as for a group of counties

This is expected, as one can visualize, that no two counties or areas are identical in any respect like covered area, emissions level, spread of sources, relative positioning of air quality monitors or the emission sources etc.

DERIVED EQUATIONS

For Ozone

$$O_3 = a * CO + b * HONO + c * NO + d * NO_2 + e * VOC + f * T$$

For $PM_{2.5}$

$$CPM_{2.5} = a*PM_{10} + b*PM_{2.5} + c*T + d*NO_X + e*SO_2 + f*NH_3 + g*VOC + h*CO$$

Where

O_3 is monthly maximum ozone concentration in air, ppm

$CPM_{2.5}$ is monthly maximum concentration of PM2.5 in ambient air, microgram per cubic meter

CO is monthly carbon monoxide emissions, tons

HONO is monthly emissions of nitrous acid, tons

NO is monthly emissions of nitric oxide, tons

NO_2 is monthly emissions of nitrogen dioxide, tons

NOX is sum of HONO, NO, NO_2, tons

VOC is monthly emissions of volatile organic compounds, tons

SO_2 is monthly emissions of sulfur dioxide, tons

NH_3 is monthly emissions of ammonia, tons

PM_{10} is monthly emissions of below 10 micron particulates, tons

$PM_{2.5}$ is monthly emissions of below 2.5 micron particulates, tons

T is monthly maximum temperature, ^0C

a' to 'h' are numerical constants

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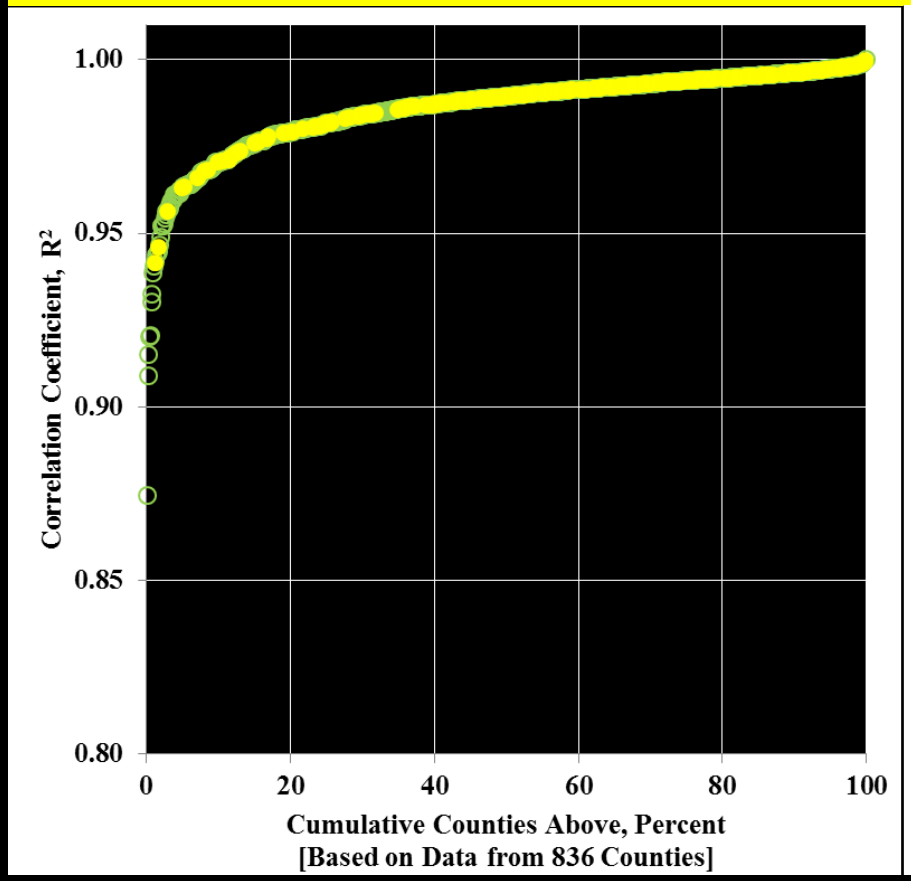
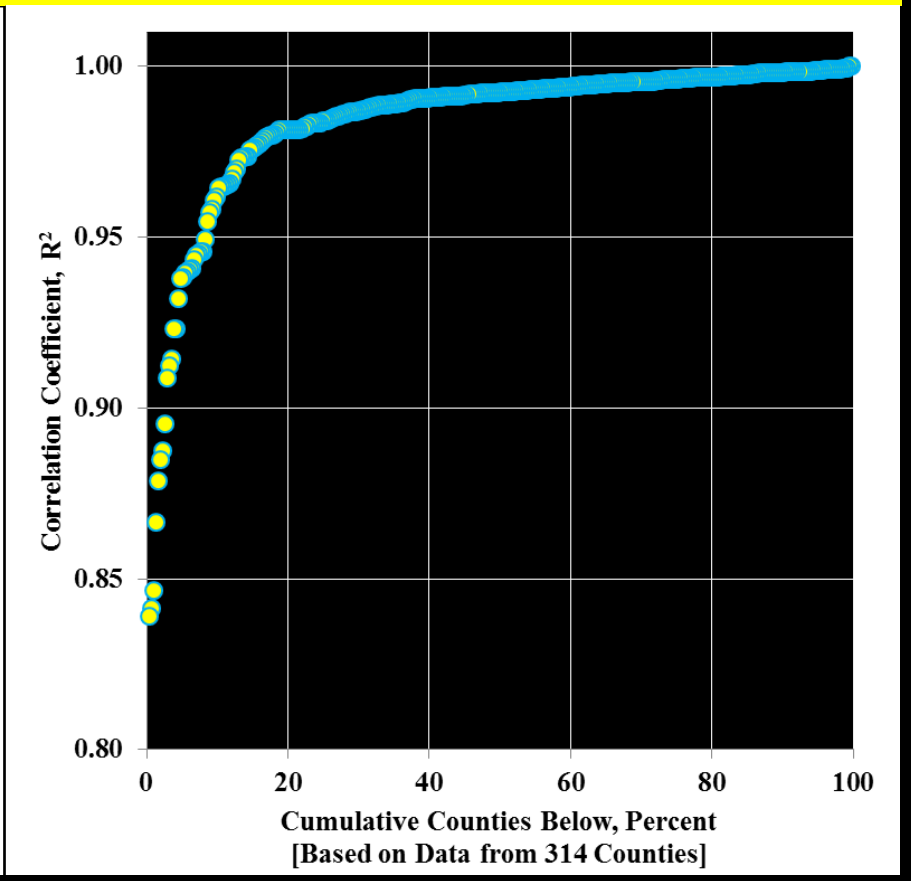
CORRELATION CONFIDENCE

OZONE



For all points the value is >0.90 except 1

PM2.5



For 300 points value is >0.90; Others>0.88

ATTAINMENT & NON-ATTAINMENT POINTS ARE DISTINGUISHED BY COLOR

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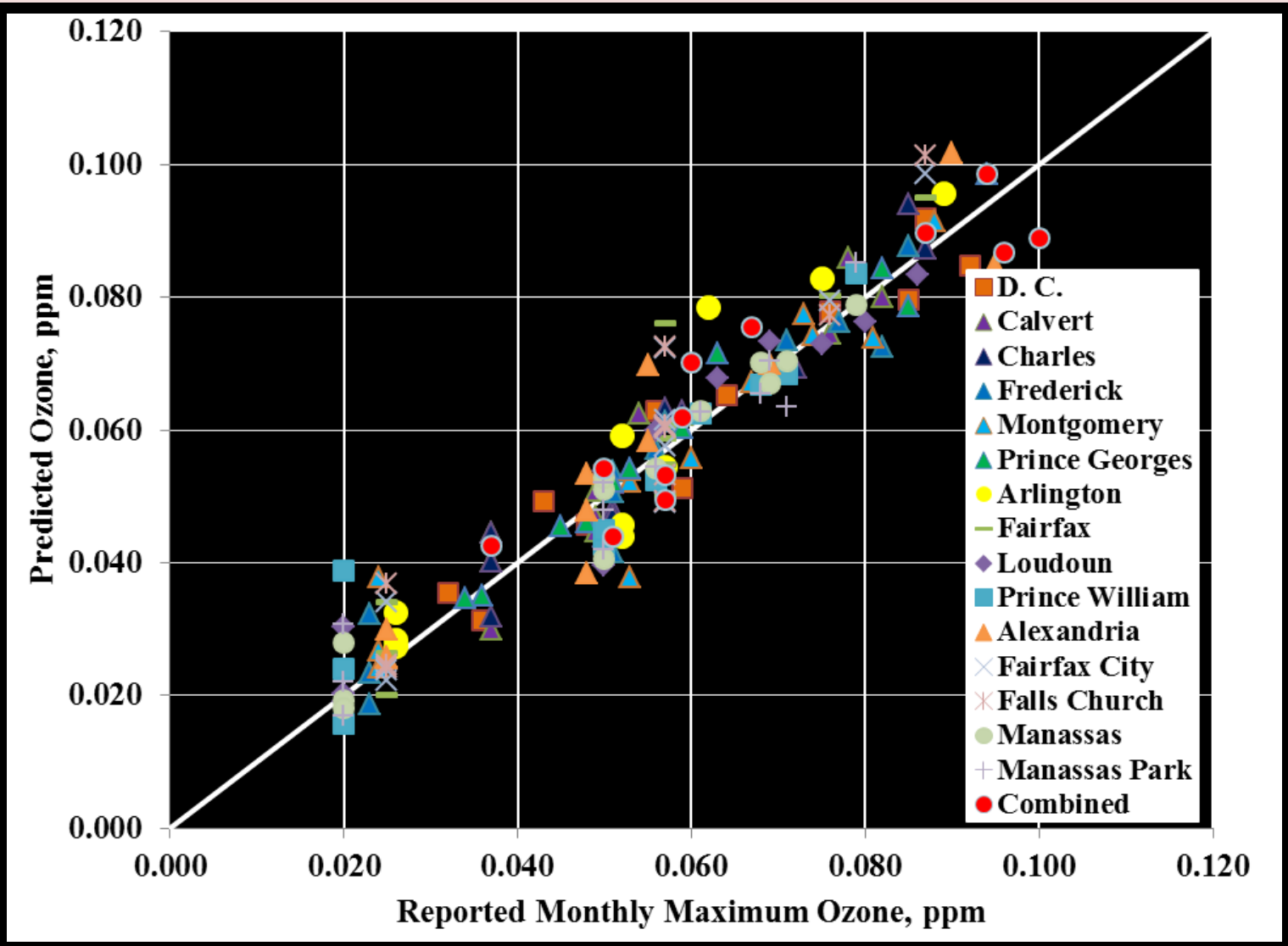
DETAILS SPECIFIC TO OZONE

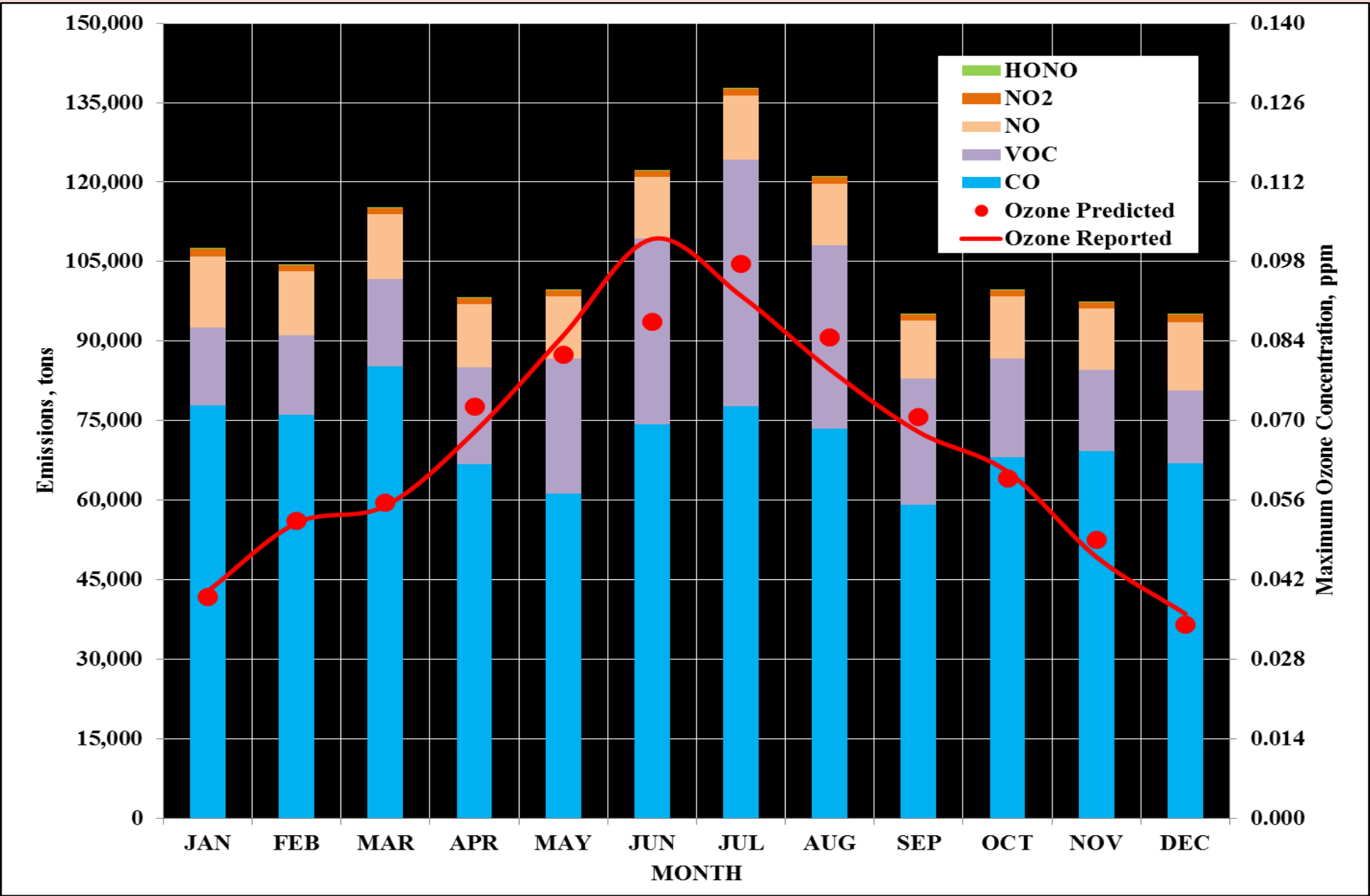
METROPOLITAN D. C. AREA

COUNTIES & COMBINED



METROPOLITAN D. C. AREA

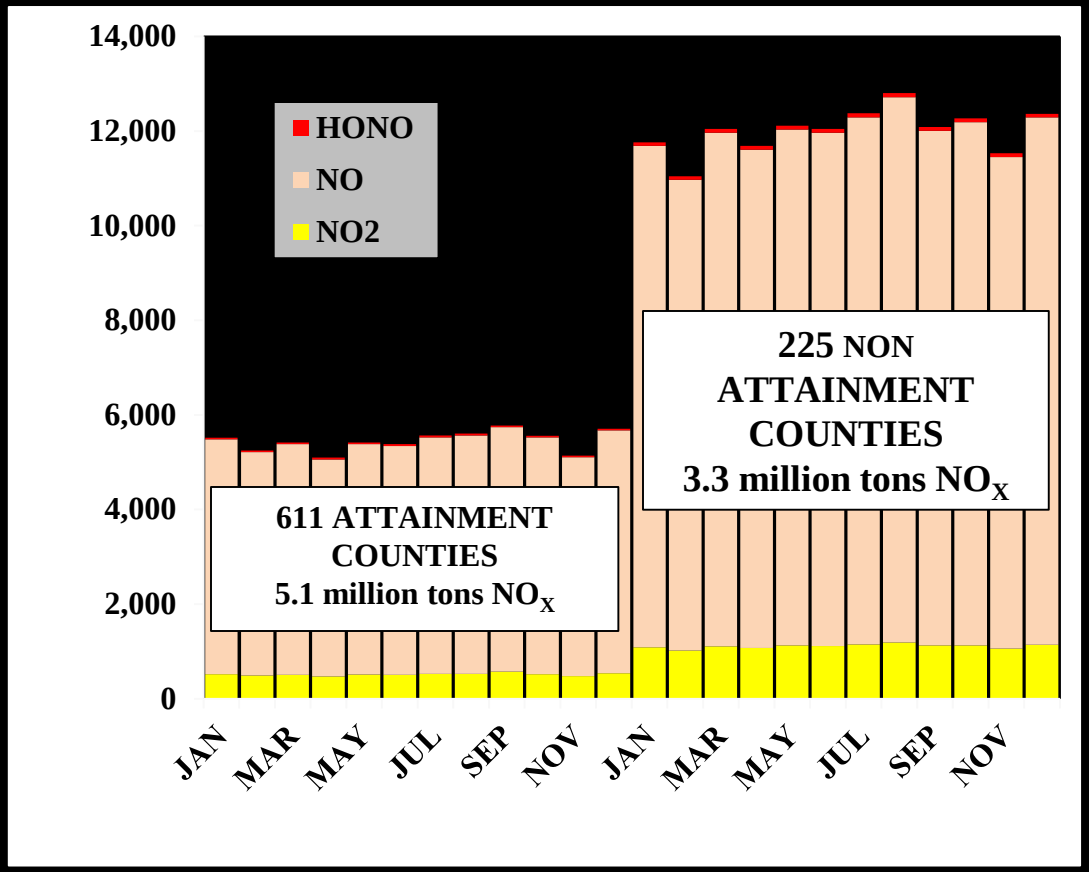
EMISSIONS & OZONE



DETAILS SPECIFIC TO OZONE

- USE OF NO_X COMPONENTS INDIVIDUALLY GAVE A BETTER FIT OF DATA THAN COMPOSITE VALUES OF NO_X
- RANGE OF NO_X EMISSIONS FOR OZONE ATTAIMENT AND FOR NON-ATTAINMENT OVERLAP CONSIDERABLY

AS THE RANGE OF NO_X OVERLAPED, TO DELINEATE NON-ATTAINMENT AREAS FROM ATTAINMEN AREAS CONSIDERATION IS GIVEN TO THE EFFECT OF RATIOS OF NO_X COMPONENTS TO CLASSIFY AREAS OF OZONE ATTAINMENT FROM THAT OF NON-ATTAINMENT AREAS



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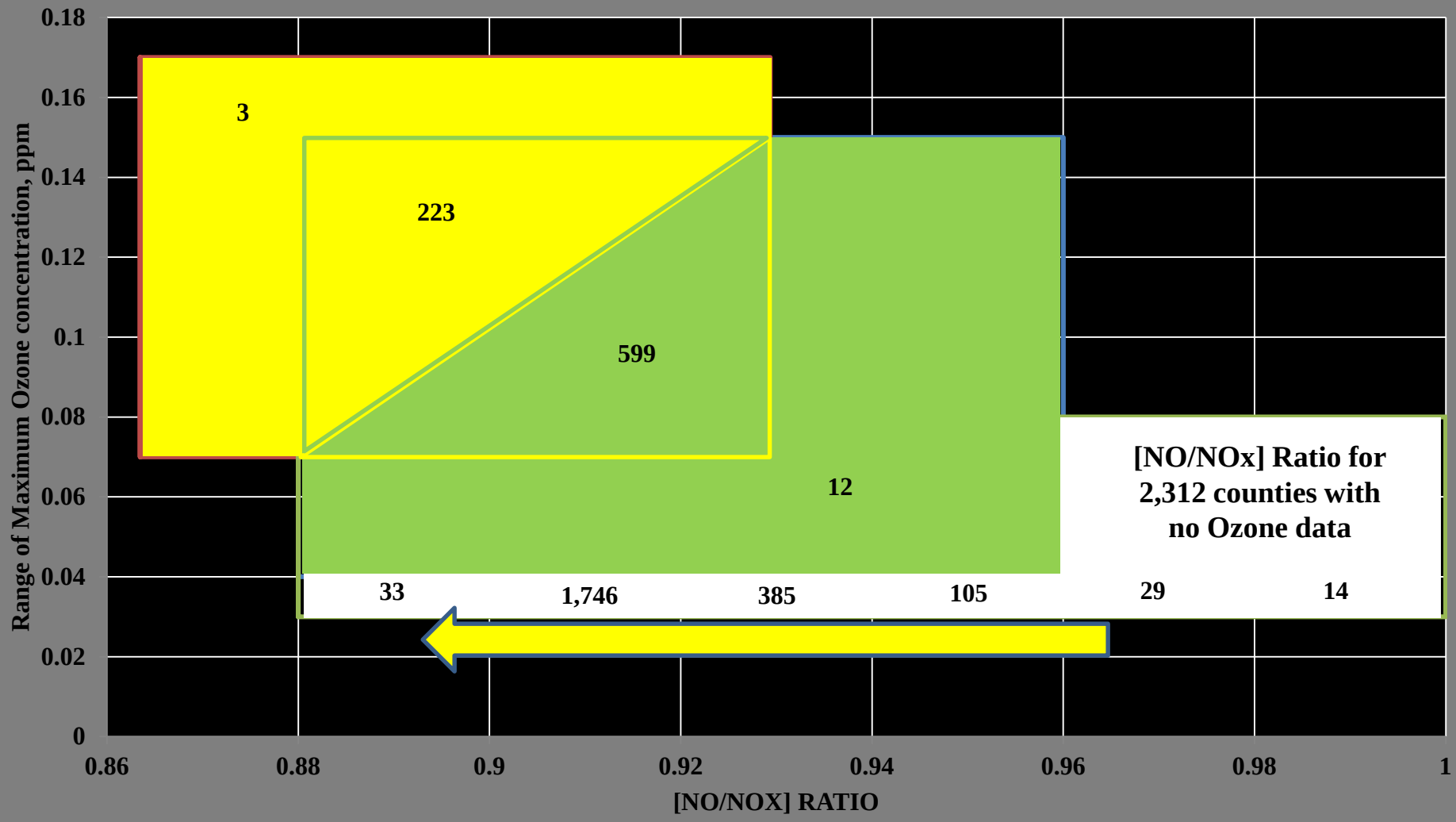
SIGNIFICANCE OF [NO/NO_X] RATIO



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NON-ATTAINMENT AREAS TEND TOWARDS LOWER [NO/NO_X] RATIOS

EMISSION SOURCE EFFECT ON [NO/NO_X] RATIO

Source (NO_X %)	Counties	NO_X %	[NO/NO_X] Ratio						
			0.85	0.87	0.9	0.92	0.93	0.95	1
On Road (38%)	Non-Attainment	10							
	Attainment	14							
	No Ozone Data	14							
Non Road (12%)	Non-Attainment	3							
	Attainment	4							
	No Ozone Data	5							
Non Point (17%)	Non-Attainment	3							
	Attainment	5							
	No Ozone Data	9							
Point EGU (14%)	Non-Attainment	2							
	Attainment	5							
	No Ozone Data	7							
Point Non EGU (12%)	Non-Attainment	2							
	Attainment	4							
	No Ozone Data	6							
Biogenic (9%)	Non-Attainment	0.5							
	Attainment	2							
	No Ozone Data	7							

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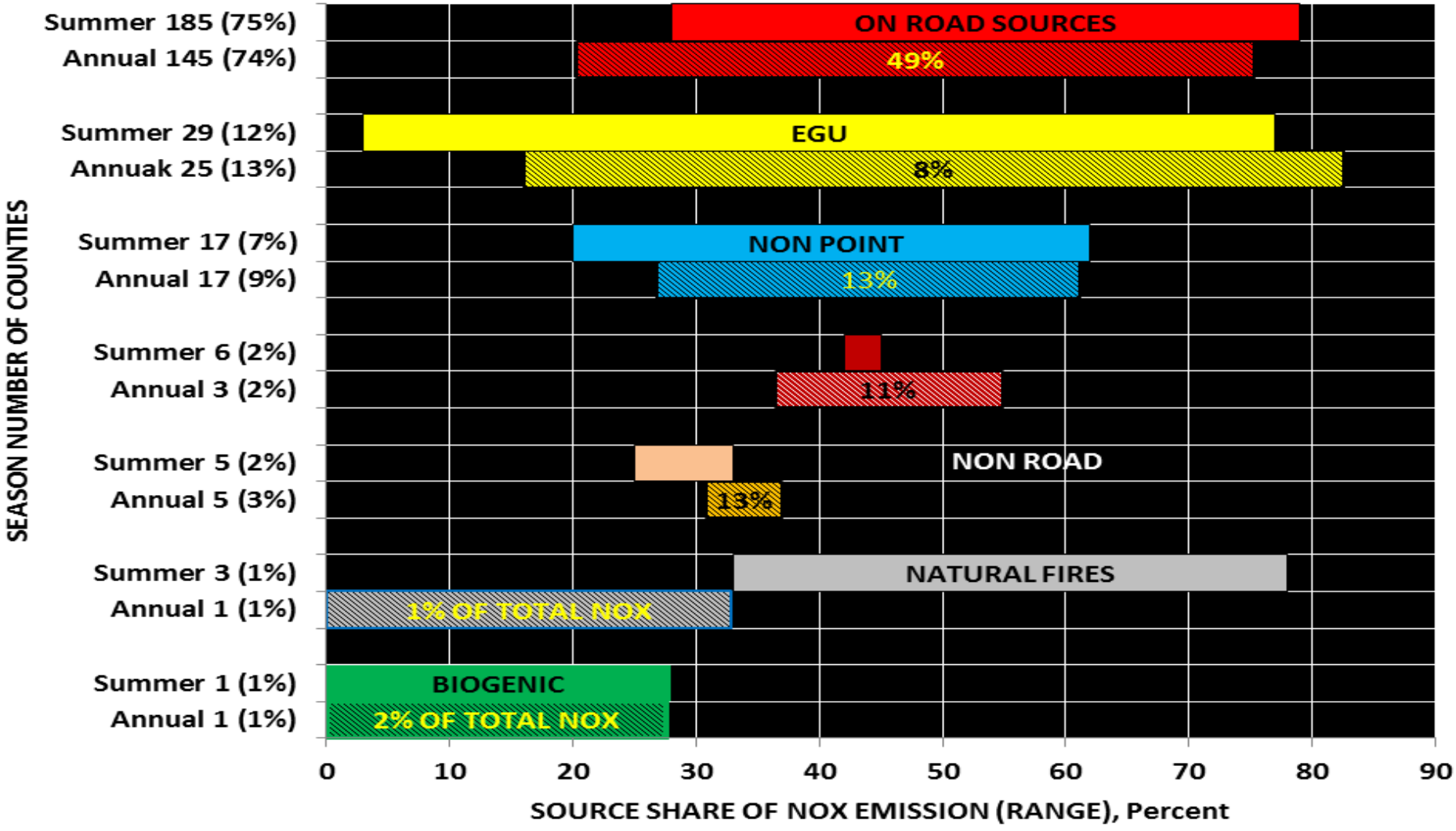
LOWER RATIOS ARE PREDOMINENTLY FROM ONROAD SOURCES

SEASON & SOURCE SHARE OF NO_X EMISSIONS



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MOBILE FOLLOWED BY POWER PLANTS ARE LEADING SOURCES

SOURCE SHARE OF NO_X EMISSIONS

Source	COUNTIES	On Road	EGU	Non Point	Non EGU	Bio	Non Road
		2011 Source Maximum NO_X Emissions, tons					
On Road	**1,725**	**4,635,304**	372,607	1,209,678	734,605	418,833	1,227,864
EGU	**201**	327,962	**1,472,566**	203,503	151,263	59,837	93,358
Non Point	**433**	297,631	33,257	**839,268**	192,746	173,367	158,245
Non EGU	**239**	248,512	71,194	186,379	**667,681**	73,552	83,476
Biogenic & Fire	**383**	106,577	5,593	94,603	23,348	**246,842**	90,795
Non Road	**135**	50,716	3,474	37,964	14,812	45,260	**98,112**
All Sources	**3,116**	**5,666,702**	**1,958,692**	**2,571,395**	**1,784,455**	**1,017,691**	**1,751,852**

SPECIFIC POWER PLANTS IDENTIFIED

Sl No	FIPS	State	County	Plants, No	NO_X, tons
1	08001	Colorado	Adams	3	9,052
2	13015	Georgia	Bartow	2	15,130
3	18029	Indiana	Dearborn	1	5,095
4	18089		Lake	5	7,495
5	24003	Maryland	Anne Arundel	2	6,493
6	24017		Charles	1	1,256
7	29071	Missouri	Franklin	1	9,890
8	34009	New Jersey	Cape May	2	594
9	34033		Salem	4	851
10	36013	New York	Chautauqua	2	1,861
11	37071	North Carolina	Gaston	2	5,507
12	39025	Ohio	Clermont	2	15,982
13	39085		Lake	1	8,450
14	39093		Lorain	2	4,679
15	42005	Pennsylvania	Armstrong	3	23,891
16	42007		Beaver	3	14,874
17	42095		Northampton	5	3,588
18	42125		Washington	2	1,864
19	47001	Tennessee	Anderson	1	912
20	48157	Texas	Fort Bend	2	5,468
21	51510	Virginia	Alexandria City	1	558
22	55059	Wisconsin	Kenosha	2	2,496
23	56037	Wyoming	Sweetwater	2	27,073

NO_X EMISSIONS FROM
51
POWER PLANTS IN
23
COUNTIES IN
15
STATES

LIKELY TO MATTER MORE RELATIVELY

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CONCLUSIONS SPECIF TO OZONE

- **IT IS POSSIBLE TO RELATE AMBIENT OZONE CONCENTRATIONS TO LOCAL EMISSIONS OF NO_X COMPONENTS, CO, VOC AND MAXIMUM TEMPERATURE**
- **BESIDES TOTAL NO_X, RATIO OF [NO/NO_X] APPEAR TO MATTER IN SEPARATING ATTAINMENT FROM NON-ATTAINMENT AREAS**
- **MOBLE SOURCES FOLLOWED BY EGU ARE LEADING AMONG SOURCES THAT IMPACT OZONE CONCENTRATION**
- **IT MAY ALSO BE POSSIBLE TO DELINEATE POWER PLANTS THAT MAY MATTER MORE THAN OTHERS IN THE CONTEXT OF OZONE IN AMBIENT AIR**
- **EMPIRICAL RELATION DERIVED CAN BE OF USE IN DRAFTING STATE IMPLEMENTATION PLANS (SIP).**

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DETAILS SPECIFIC TO PARTICULATES

ANANLYSES SPECIFIC TO PARTICULATES

20 Non-Attainment Counties in 2012 for 2008 NAAQS $PM_{2.5}$ Standards					
States	**S1. California**				**S2. Ohio**
Area	**A1**	**A2**	**A3**	**A4**	**A5**
	San Joaquin Valley	**South coast Air Basin**	**Imperial**	**Plumas**	**Cleveland**
Counties	1. Fresno	9. Los Angeles	13. Imperial	14. Plumas	15. Cuyahoga
	2. Kern	10. Orange			16. Lorain
	3. Kings	11. Riverside			
	4. Madera	12. San Bernardino			
	5. Merced				
	6. San Joaquin				
	7. Stanislaus				
	8. Tulare				
States	**S3. Pennsylvania**			**S4. Idaho**	
Area	**A6**	**A7**	**A8**	**A9**	
	Allegheny	**Delaware**	**Lebanon**	**West Silver Valley**	
Counties	17. Allegheny	18. Delaware	19. Lebanon	20. Shoshone	

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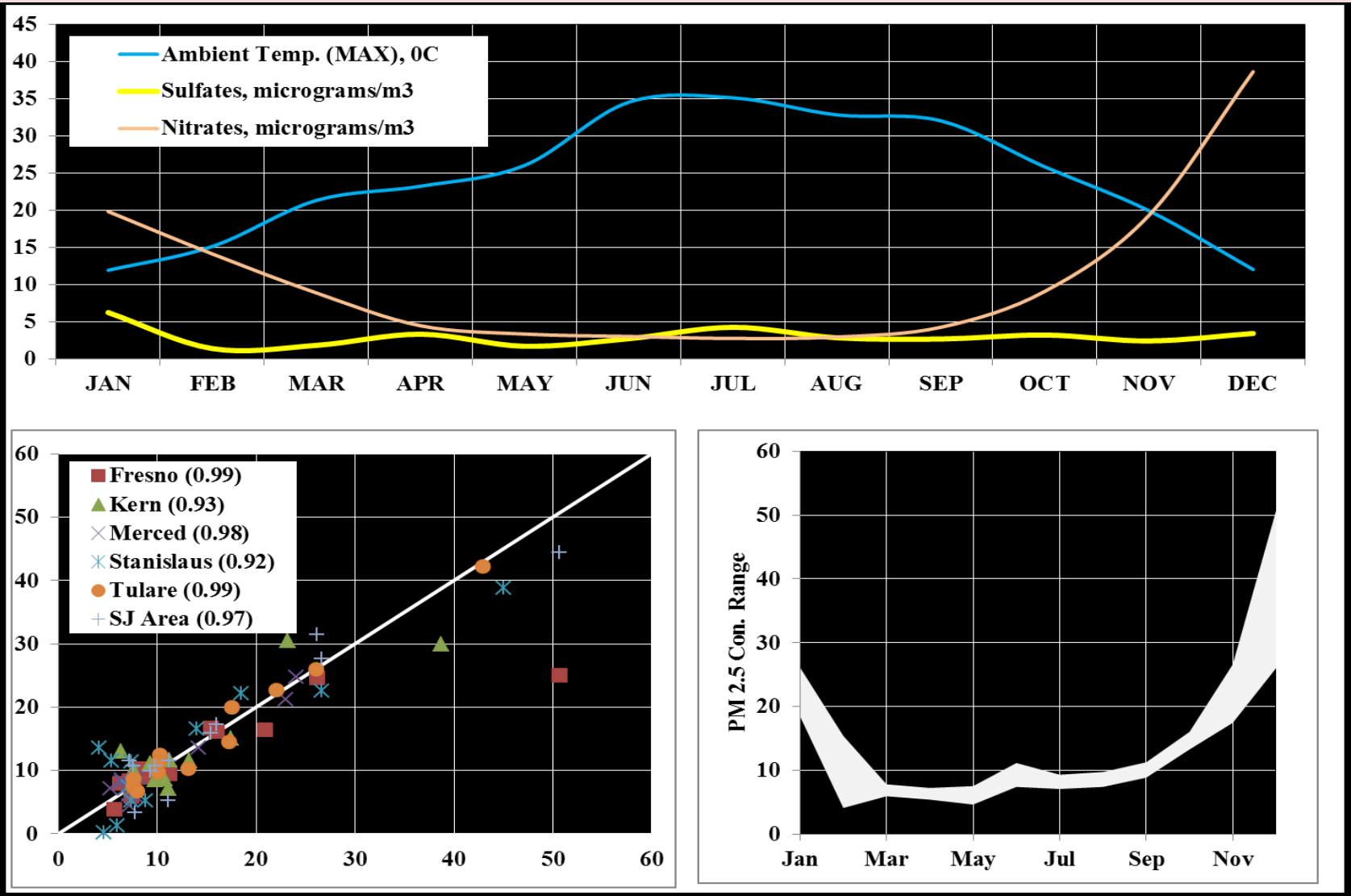
ANANLYSES SPECIFIC TO PARTICULATES COMPOSITION

- **DETAILED ANALYSES OF PARTICULATE BEHAVIOR CARRIED OUT WITH RESPECT TO AMBIENT CONCENTRATION & THEIR COMPOSITION BASED ON SPECIATION DATA REPORTED IN AQS FOR ALL THE 20 NON ATTAINMENT COUNTIES AS WELL AS FOR STATES AS A WHOLE**

- **BASED ON THE COMPUTED SULFATES & NITRATES CONCENTRATION CORRESPONDING TO THE MAXIMUM CONCETRATION RANGE RENDER STATES TO BE CLASSIFIED INTO TWO GROUPS OF SULFATES RICH OR NITRATES RICH PARTICULATE EMISSION**

CONCENTRATION & COMPOSITION VARIATION SAN JOAQUIN VALLEY – CALIFORNIA



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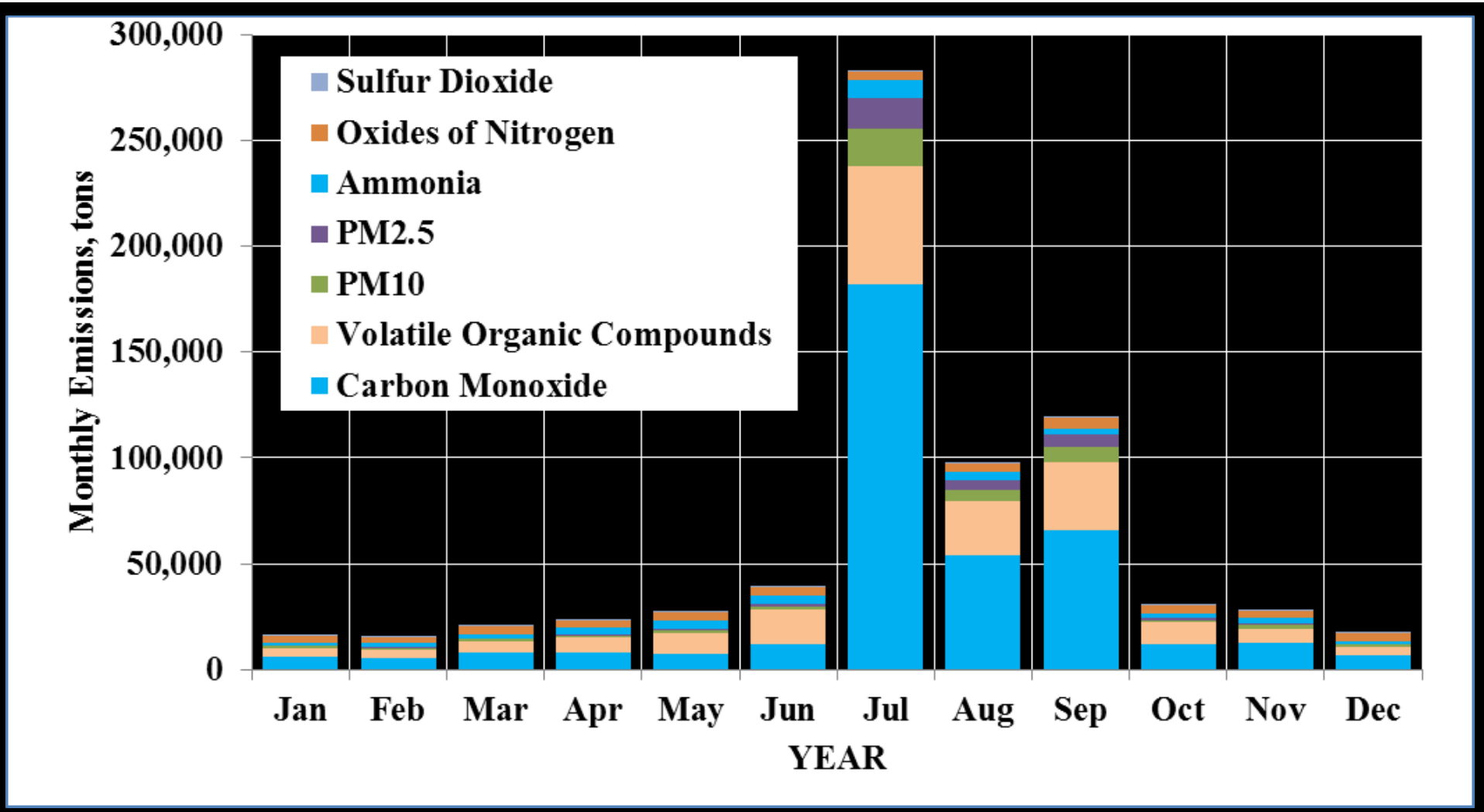
MONTHLY EMISSION OF VARIABLES
SAN JOAQUIN VALLEY CALIFORNIA



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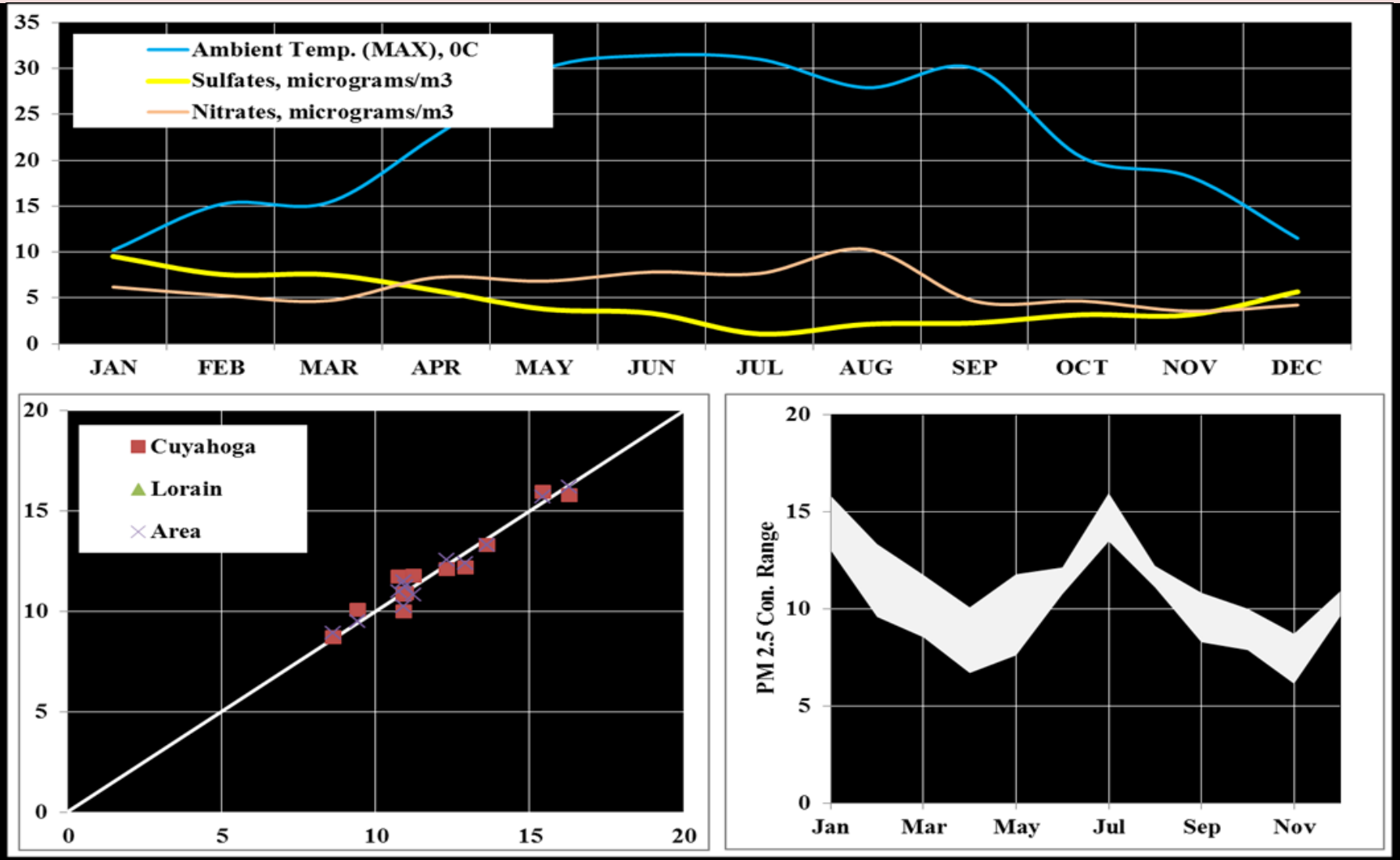
CONCENTRATION & COMPOSITION VARIATION SAN CLEVELAND - OHIO



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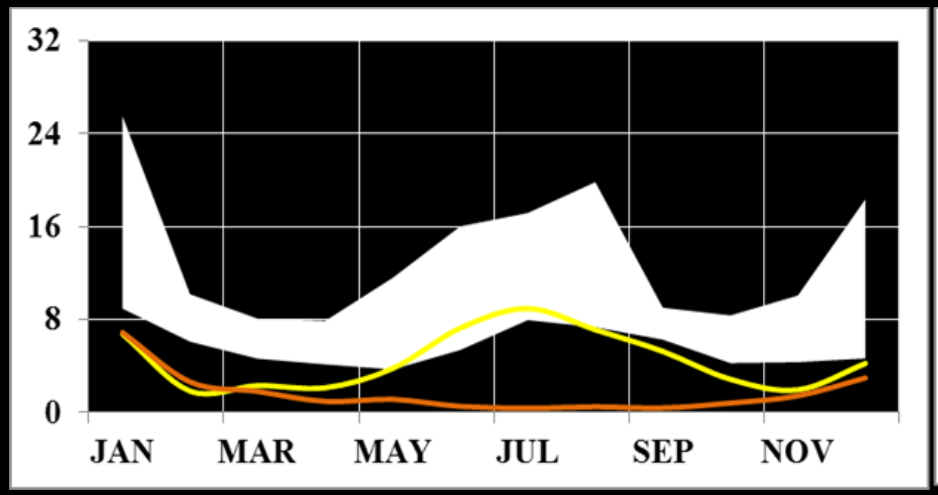
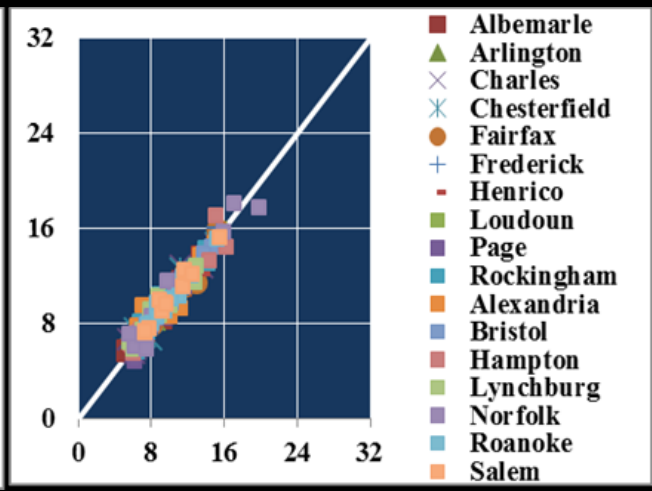
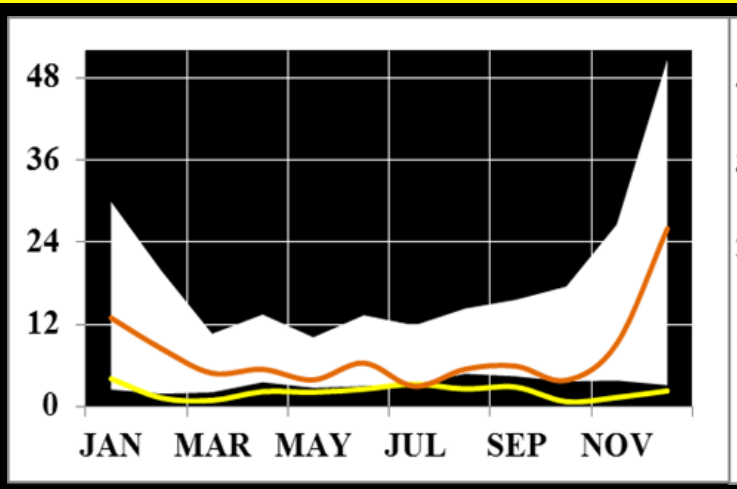
STATE WISE ANALYSES

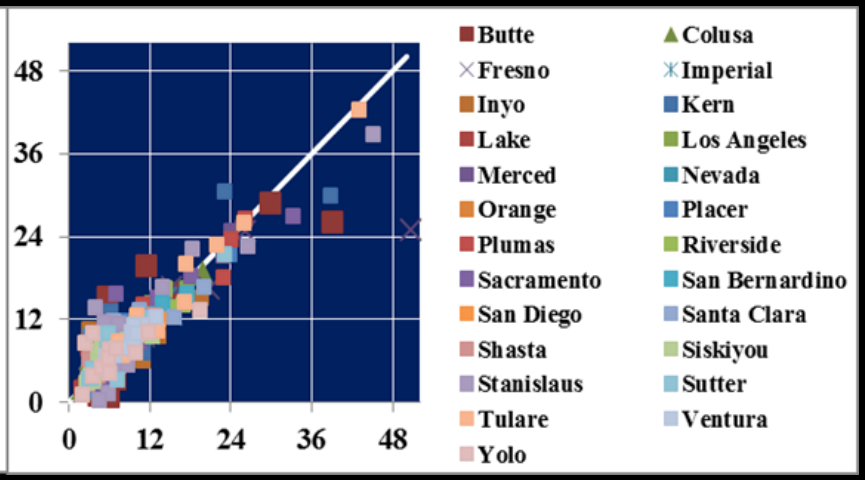
TYPICALLY SULFATES PREDOMINANT PARTICULATES - VIRGINIA





TYPICALLY NITRATES PREDOMINANT PARTICULATES - CALIFORNIA





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STATES CLASSIFICATION BASED ON PARTICULATE CHARECTERISTICS

SULFATES RICH		NITRATE RICH			
1	Alabama	1	Arkansas	16	Nevada
2	Connecticut	2	Arizona	17	New Jersey
3	Rhode Island	3	California	18	North Dakota
4	Delaware	4	Colorado	19	Ohio
5	Georgia	5	Indiana	20	Oregon
6	Louisiana	6	Iowa	21	Utah
7	Massachusetts	7	Kentucky	22	Washington
8	New Hampshire	8	Kansas	23	Wisconsin
9	North Carolina	9	Maryland	24	Wyoming
10	South Carolina	10	Michigan	25	Vermont
11	Pennsylvania	11	Minnesota	Non attainment counties are located in highlighted states	
12	Tennessee	12	Mississipi		
13	Texas	13	Missouri		
14	Virginia	14	Montana		
15	West Virginia	15	Nebrska		

CONCLUSIONS SPECIFIC TO PARTICULATES

- **IT IS POSSIBLE TO RELATE PARTICULATE CONCENTRATION IN AIR TO LOCAL EMISSIONS OF PM_{10}, $PM_{2.5}$, NO_X, SO_2, NH_3, VOC, CO & MAXIMUM TEMPERATURE**

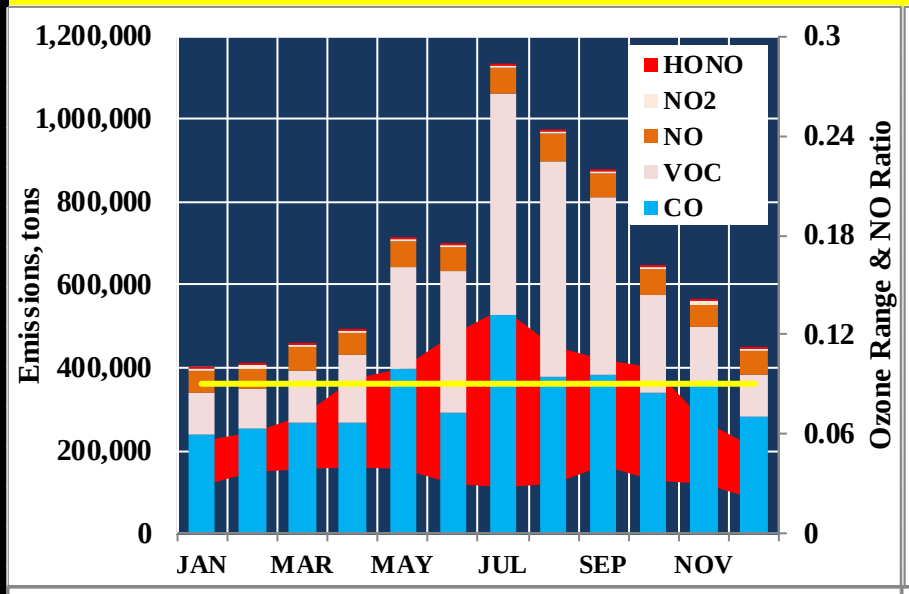
- **ANNUAL PATTERN OF CONCENTRATION & ITS COMPOSTION VARIES WITH LOCALITIES WITH TWO DISTINCT PATTERNS:**

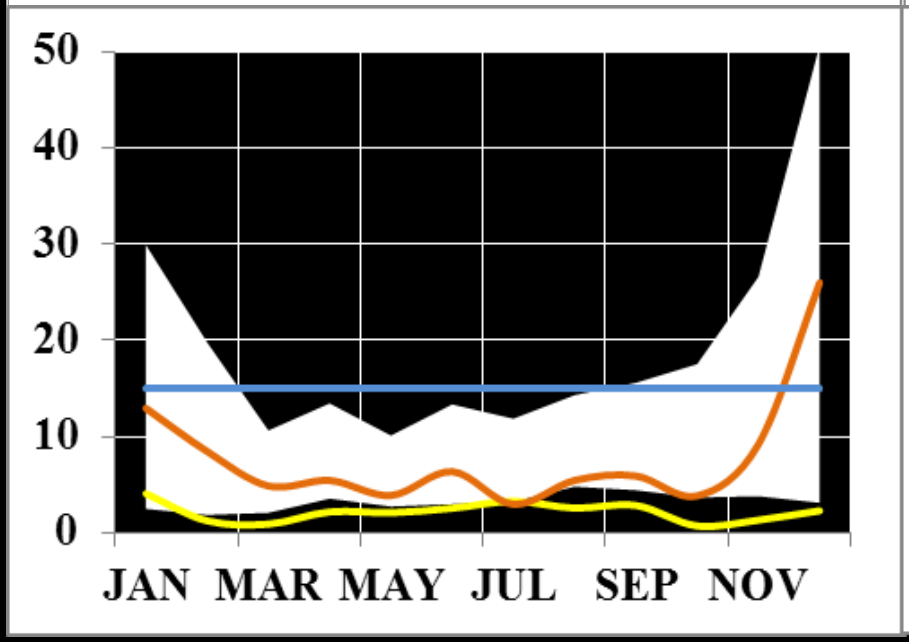
  - **ONE WITH PEAK CONCENTRATION IN SUMMER MONTHS TYPICALLY RICH IN SULFATES [15 STATES]**

  - **OTHER PEAK CONCENTRATIONS IN WINTER MONTHS TYPICALLY RICH IN NITRATES [25 STATES]**

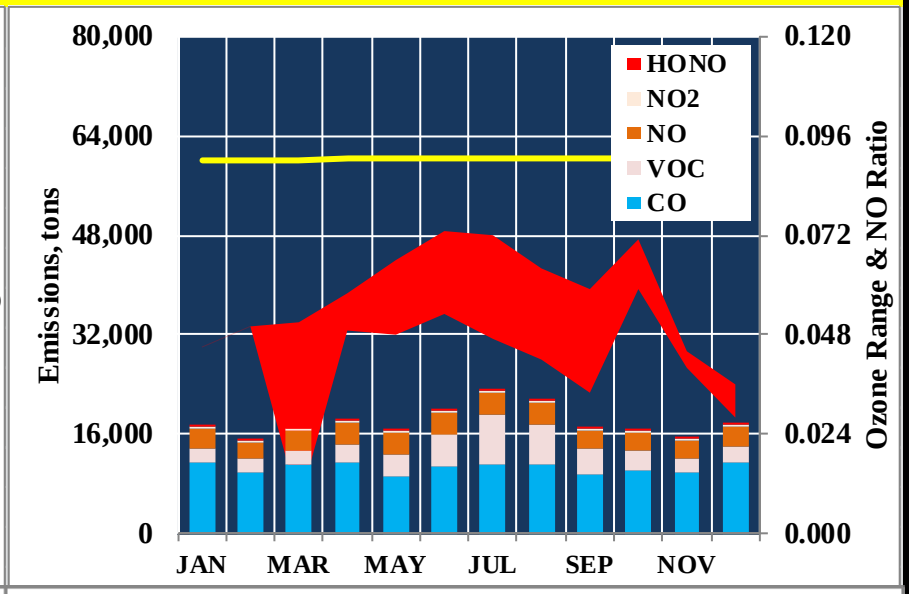
INDIVIDUAL STATES

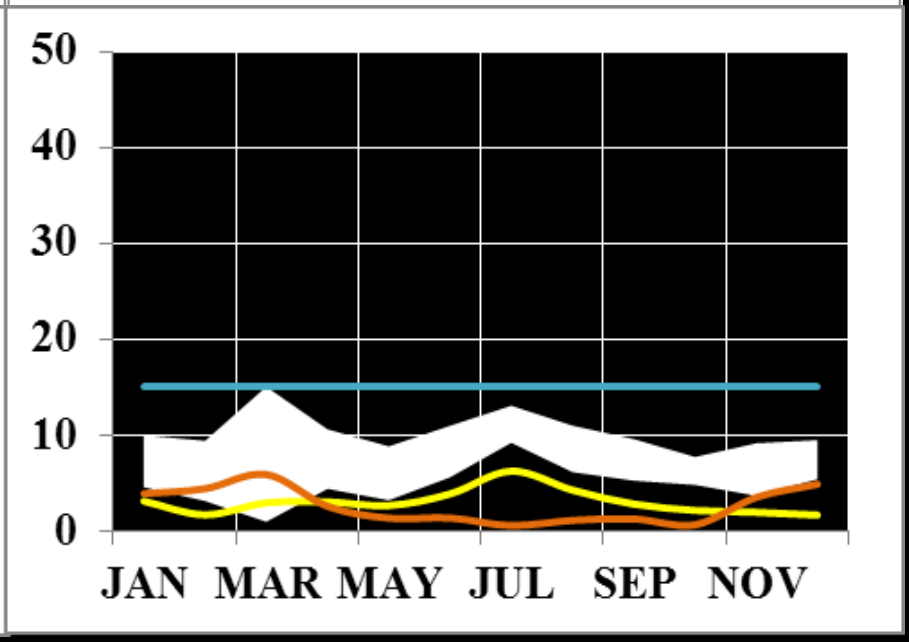
CALIFORNIA





NEBRASKA





Acknowledgements:

- Thank You All for Listening;
- EPA/EIC2017 Organizers for the Opportunity;
- MARAMA/VADEQ for Financing;
- Thomas R. Ballou, Director, Air Data Analysis & Virginia DEQ

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