

March 6, 2013

## TECHNICAL MEMORANDUM No. 4e

To: Tom Moore, Western Governors' Association (WGA) (WRAP)

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Subject: Source of Oil and Gas Emissions for the WestJumpAQMS 2008 Photochemical Modeling

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### INTRODUCTION

ENVIRON International Corporation (ENVIRON), Alpine Geophysics, LLC (Alpine) and the University of North Carolina (UNC) at Chapel Hill Institute for Environment are performing the West-wide Jump Start Air Quality Modeling Study (WestJump AQMS) managed by the Western Governors' Association (WGA) Air Quality Program. WestJumpAQMS is setting up the CAMx photochemical grid model for the 2008 calendar year (plus spin up days for the end of December 2007) on a 36 km CONUS, 12 km WESTUS and several 4 km Inter-Mountain West domains. The WestJumpAQMS Team are currently compiling emissions to be used for the 2008 base case modeling, with the 2008 National Emissions Inventory (NEI) being a major data source, and are preparing 13 Technical Memorandums discussing the sources of the 2008 emissions by major source sector:

1. Point Sources including Electrical Generating Units (EGUs) and Non-EGUs;
2. Area plus Non-Road Mobile Sources;
3. On-Road Mobile Sources that will be based on MOVES;
4. Oil and Gas Sources;
5. Fires Emissions including wildfire, prescribed burns and agricultural burning;
6. Fugitive Dust Sources;
7. Off-Shore Shipping Sources;
8. Ammonia Emissions;
9. Biogenic Emissions;
10. Eastern USA Emissions (superseded);

- 11. Mexico/Canada;
- 12. Sea Salt and Lightning Emissions; and
- 13. Emissions Modeling Parameters including spatial surrogates, temporal adjustment parameters and chemical (VOC and PM) speciation profiles.

This Technical Memorandum discusses the approach to be used for developing 2008 emissions for the oil and gas (O&G) exploration and production source sector that are not covered by the current update of the WRAP Phase III and Permian Basin oil and gas emissions inventories to 2008. Note that downstream oil and gas emissions (e.g., refining) will be addressed under the point and area source categories. Also note that although WRAP Phase III is developing emissions inventories for the Williston and Great Plains Basins in Montana/Dakotas, at the time of the WestJumpAQMS emissions modeling they were not available so oil and gas emissions for the Montana/Dakotas are based on the 2008 NEIv2.0 and are discussed in this Memorandum.

The O&G Emissions Technical Memoranda series number 4 are sub-divided into 5 separate documents of which this is the last one. The 5 documents are shown below in Table 1. Because of the variation in activities and key data sources among the various states and regions in the WRAP Phase III analysis, it was determined that 5 separate memoranda would be generated to describe the development of the oil and gas projected 2008 emissions. This Technical Memorandum Number 4e discusses the oil and gas emissions not covered by the WRAP Phase III and Permian Basins.

**Table 1. WestJumpAQMS O&G emissions technical memoranda.**

Technical Memorandum	
4a: 2008 O&G Emissions for Colorado Basins (Denver-Julesburg, Piceance, and North San Juan)	
4b: 2008 O&G Emissions for the South San Juan (NM) and Uinta (UT) Basins	
4c: 2008 O&G Emissions for Wyoming Basins (Greater Green River, Powder River and Wind River)	
4d: 2008 O&G Emissions for the Permian Basin (NM and TX)	
4e: 2008 O&G Emissions for Other Areas	✓

## OIL AND GAS EMISSIONS INPUTS AND QUALITY ASSURANCE

There are five sources of O&G emissions that will be developed for the WestJumpAQMS 2008 base case modeling:

- The WRAP-IPAMS Phase III 2006 oil and gas (O&G) emissions that were projected to 2008 for the Basins covered and available as of the end of 2012:
  - South San Juan, North San Juan, Uinta, Piceance, Denver-Julesburg, Southwestern Wyoming, Wing River and Powder River Basins;
- A 2008 O&G emissions inventory was developed for the Permian Basin covering southeast New Mexico and northwest Texas;

- O&G emissions for the other locations not covered by the WRAP Phase III or Permian Basins are based on the 2008 NEI;
- Off-shore oil and gas production emissions; and
- O&G emissions for Canada and Mexico, which will be based on those countries’ national emission inventories.

**O&G Emissions outside of WRAP Phase III and Permian Basin Areas**

Oil and gas emissions for areas not covered by the WRAP Phase III and Permian Basin updates will be based on Version 2.0 of the 2008 National Emissions Inventory (NEIv2.0<sup>1</sup>). The WRAP Phase III O&G emissions covered Basins in New Mexico, Utah, Colorado, Montana and North Dakota. However, the WRAP Phase III emissions for Basins in Montana and North Dakota were not ready at the time the WestJumpAQMS emissions modeling, so O&G emissions for Montana/Dakotas were based on the 2008 NEIv2.0. There are also some smaller Basins in New Mexico, Utah, Colorado and Wyoming not covered by the WRAP Phase III basins. These include the Paradox Basin in southeastern Utah/southwestern Colorado, the Big Horn Basin in north-central Wyoming and areas in southeastern Colorado/northeastern New Mexico, for which O&G emissions will also be based on the 2008 NEIv2.0. In developing the 2008 NEI, EPA acquired O&G emissions for basins not covered by Phase III in the Inter-Mountain West from the WRAP Phase II inventory, emissions for Texas and Oklahoma from the two states’ air agencies, and used California’s submission directly. These represent the best O&G emissions data available for these states at this time. More details on the development of these O&G emissions can be found in the NEIv2.0 documentation and documentation provided by the states (e.g., Texas, Oklahoma and California).

To develop the Non-Phase III oil and gas inventory, the NEIv2.0 inventory was parsed for oil and gas related emissions. Emission related to the selected oil and gas development Source Classification Code (SCC) numbers were removed from the NEI. A list of the selected SCC numbers used to identify oil and gas exploration and production sources is contained in Table 2.

**Table 2. SCC Numbers Selected as Oil and Gas Related Emissions.**

SCC Number	Definition
2310000000	Oil and Gas Production: SIC 13; All Processes; Total: All Processes
2310000220	Oil and Gas Production: SIC 13; Drill rigs
2310000330	Oil and Gas Production: SIC 13; Artificial lift
2310010000	Oil and Gas Production: SIC 13; Crude Petroleum; Total: All Processes
2310010100	Oil and Gas Production: SIC 13; Crude Petroleum; Oil well heaters
2310010200	Oil and Gas Production: SIC 13; Crude Petroleum; Oil well tanks - flashing & standing/working/breathing
2310011020	Oil and Gas Exploration and Production; On-Shore Oil Production; Storage Tanks: Crude Oil
2310011100	Oil and Gas Exploration and Production; On-Shore Oil Production; Heater Treater
2310011201	Oil and Gas Exploration and Production; On-Shore Oil Production; Tank Truck/Railcar Loading: Crude Oil

<sup>1</sup> <http://www.epa.gov/ttnchie1/net/2008inventory.html>

2310011450	Oil and Gas Exploration and Production; On-Shore Oil Production; Wellhead
2310011501	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Connectors
2310011502	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Flanges
2310011503	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Open Ended Lines
2310011504	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Pumps
2310011505	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Valves
2310011506	Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Other
2310020000	Oil and Gas Production: SIC 13; Natural Gas; Total: All Processes
2310020600	Oil and Gas Production: SIC 13; Natural Gas; Compressor engines
2310021010	Oil and Gas Exploration and Production; On-Shore Gas Production; Storage Tanks: Condensate
2310021030	Oil and Gas Exploration and Production; On-Shore Gas Production; Tank Truck/Railcar Loading: Condensate
2310021100	Oil and Gas Production: SIC 13; Natural Gas; Gas well heaters
2310021101	Oil and Gas Exploration; On-Shore Gas Production; Natl Gas Fired 2Cycle Lean Burn Compressor Engines < 50 HP
2310021102	Oil and Gas Exploration; On-Shore Gas Production; Natl Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
2310021203	Oil and Gas Exploration; On-Shore Gas Production; Natl Gas Fired 4Cycle Lean Burn Compressor Engines 500+ HP
2310021300	Oil and Gas Production: SIC 13; Natural Gas; Gas well pneumatic devices
2310021301	Oil and Gas Exploration; On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines <50 HP
2310021302	Oil and Gas Exploration; On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
2310021400	Oil and Gas Production: SIC 13; Natural Gas; Gas well dehydrators
2310021402	Oil and Gas Exploration; On-Shore Gas Production; Nat Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP w/NSCR
2310021403	Oil and Gas Exploration ;On-Shore Gas Production; Nat Gas Fired 4Cycle Rich Burn Compressor Engines 500+ HP w/NSCR
2310021501	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Connectors
2310021502	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Flanges
2310021503	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Open Ended Lines
2310021504	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Pumps
2310021505	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Valves
2310021506	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Other
2310021509	Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: All Processes
2310021600	Oil and Gas Production: SIC 13; Natural Gas; Gas well venting
2310030000	Oil and Gas Production: SIC 13; Natural Gas Liquids; Total: All Processes
2310111700	Oil and Gas Exploration and Production; On-Shore Oil Exploration; Oil Well Completion: All Processes
2310111702	Oil and Gas Exploration and Production; On-Shore Oil Exploration; Oil Well Completion: Venting

After the O&G emissions for the SCC numbers listed in Table 2 were extracted from the 2008 NEIv2.0, O&G emissions for states and counties accounted for in the WRAP Phase III and Permian Basin updates as of the end of 2012 were removed. The remaining emissions were processed as the Non-Phase III Oil and Gas datasets. Table 3 displays the counties covered by the WRAP Phase III Basins with 2008 oil and gas emissions; oil and gas emissions within these counties were removed from the 2008 NEI emissions inventory. Note that although the WRAP Phase III O&G emissions are identified by state and county codes, for O&G emissions on tribal lands the 2008 NEI uses tribal codes and not county codes. Thus, in the initial elimination of the O&G emissions from the 2008 NEI for locations covered by the WRAP Phase III Basins (except Montana and North Dakota whose Phase III emissions were not generated at the time of this analysis), O&G emissions located in the Southern Ute Indian Tribe (SUIT) areas in southwestern Colorado were not eliminated from the 2008 NEI. Consequently, in the first WestJumpAQMS 2008 base case emissions inventory (2008 BaseA), the SUIT O&G emissions were double counted. This error was fixed in the second WestJumpAQMS 2008 base case scenario (2008 BaseB) and in this Memorandum.

**Table 3. Counties covered by the WRAP Phase III 2008 O&G emission updates where O&G emissions were removed from the 2008 NEIv2.**

Basin	County	State	Basin	County	State
North San Juan	Archuleta	Colorado	South San Juan	McKinley	New Mexico
North San Juan	La Plata	Colorado	South San Juan	Rio Arriba	New Mexico
North San Juan	San Juan	Colorado	South San Juan	San Juan	New Mexico
North San Juan	Hinsdale	Colorado	South San Juan	Sandoval	New Mexico
North San Juan	Mineral	Colorado			
			DJ	Adams	Colorado
Uinta	Carbon	Utah	DJ	Arapahoe	Colorado
Uinta	Duchesne	Utah	DJ	Boulder	Colorado
Uinta	Emery	Utah	DJ	Broomfield	Colorado
Uinta	Grand	Utah	DJ	Crowley	Colorado
Uinta	Uintah	Utah	DJ	Denver	Colorado
Uinta	Wasatch	Utah	DJ	Douglas	Colorado
			DJ	Elbert	Colorado
Wind River Basin	Fremont	Wyoming	DJ	El Paso	Colorado
			DJ	Fremont	Colorado
Powder River Basin	Big Horn	Montana	DJ	Jefferson	Colorado
Powder River Basin	Powder River	Montana	DJ	Kit Cars	Colorado
Powder River Basin	Campbell	Wyoming	DJ	Larimer	Colorado
Powder River Basin	Converse	Wyoming	DJ	Lincoln	Colorado
Powder River Basin	Crook	Wyoming	DJ	Logan	Colorado
Powder River Basin	Johnson	Wyoming	DJ	Morgan	Colorado
Powder River Basin	Natrona	Wyoming	DJ	Phillips	Colorado
Powder River Basin	Niobrara	Wyoming	DJ	Pueblo	Colorado
Powder River Basin	Sheridan	Wyoming	DJ	Sedgwick	Colorado
Powder River Basin	Weston	Wyoming	DJ	Teller	Colorado
			DJ	Washington	Colorado
Southwest Wyoming	Carbon	Wyoming	DJ	Weld	Colorado
Southwest Wyoming	Daggett	Utah	DJ	Yuma	Colorado
Southwest Wyoming	Summit	Utah	DJ	Laramie	Wyoming
Southwest Wyoming	Albany	Wyoming	DJ	Platte	Wyoming
Southwest Wyoming	Lincoln	Wyoming	DJ	Goshen	Wyoming
Southwest Wyoming	Sublette	Wyoming	DJ	Sioux	Nebraska
Southwest Wyoming	Sweetwater	Wyoming	DJ	Dawes	Nebraska
Southwest Wyoming	Uinta	Wyoming	DJ	Box Butte	Nebraska
			DJ	Sheridan	Nebraska
Piceance	Delta	Colorado	DJ	Scotts Bluff	Nebraska
Piceance	Garfield	Colorado	DJ	Banner	Nebraska
Piceance	Gunnison	Colorado	DJ	Kimball	Nebraska
Piceance	Mesa	Colorado	DJ	Morrill	Nebraska
Piceance	Moffat	Colorado	DJ	Cheyenne	Nebraska
Piceance	Rio Blanco	Colorado	DJ	Garden	Nebraska
Piceance	Routt	Colorado	DJ	Deuel	Nebraska
Piceance	Pitkin	Colorado	DJ	Custer	South Dakota
Piceance	Eagle	Colorado	DJ	Fall River	South Dakota
Piceance	Lake	Colorado	DJ	Shannon	South Dakota
Piceance	Chaffee	Colorado			

Table 4a displays the 2008 O&G area source emissions in the U.S. not located within the counties covered by the WRAP Phase III and Permian Basins. Table 4b lists the percent contributions of non-WRAP/Permian area source O&G emissions to the total by state. Texas is the largest non-WRAP/Permian Basins O&G emissions state and contributes 75% of the NO<sub>x</sub> and 81% of the VOC emissions. Oklahoma is the next largest area source O&G contributor with 23% of the NO<sub>x</sub> and 17% of the VOC; together Texas and Oklahoma contribute 97% or more of the NO<sub>x</sub>, VOC, CO and PM<sub>2.5</sub> area source O&G emissions not included in the WRAP/Permian Basins. However, for non-WRAP/Permian Basins area source O&G SO<sub>2</sub> emissions, Texas and Oklahoma only contribute 37% of the total with Wyoming (45%) and Arkansas (18%) also having large SO<sub>2</sub> emission contributions.

Table 5b displays the emissions data by state for point source O&G emissions not located in the WRAP/Permian Basins with Table 5b giving the percent contribution by state. There are many more states that report point source O&G emissions than area source O&G emissions in the NEIv2.0. This is because for most states the individual area source O&G emission sources have emission rates that are below the emission thresholds that trigger permit and reporting requirements. So the area source O&G emissions exist for these states, they just aren't reported so are unavailable in the NEIv2.0. The individual point source O&G sources (e.g., compressors and sulfur recovery units) tend to have higher emission rates so many of them have to undergo permit and reporting requirements. These results emphasize the need for studies to provide detailed documentation and reporting of all O&G emissions sources, like the WRAP Phase III study for the inter-mountain west states. For non-WRAP/Permian Basins point source O&G emissions, Texas (17% and 26%) and Louisiana (29% and 20%) have the highest NO<sub>x</sub> and VOC contributions.

Table 6 compares the total non-WRAP/Permian Basins area and point source O&G emissions. Even with the lack of reporting of area source O&G sources for most non-WRAP/Permian Basin states in the NEIv2.0, with the exception of one pollutant the area source O&G emissions contribute more than the point source O&G emissions (73% to 99%) for the non-WRAP/Permian Basin total O&G emissions in the 2008 NEIv2.0. The exception is for SO<sub>2</sub> O&G emissions where the area source O&G only accounts for 5% of the total SO<sub>2</sub> emissions for the non-WRAP/Permian Basins O&G emissions. Presumably this is due to the presence of centralized large sulfur recovery unit point sources that remove the sulfur from sour gas. Of the point source O&G SO<sub>2</sub> emissions in the non-WRAP/Permian Basins, Alabama has the highest O&G SO<sub>2</sub> emissions (49%) followed by Texas (19%) and Missouri (16%) (see Table 5b).

**Table 4a. 2008 NEI v2.0 Area Source Oil and Gas Emissions (tons per year) for Areas of Whole States and County Portions of States Not Included in the WRAP Phase III and Permian Basin Updates.**

Area NEIv2.0	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	PMC
State	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
Arizona	0	0	12	0	0	0	0
Arkansas	4,478	6,183	1,250	380	781	0	781
California	446	2,221	15,149	0	7	7	0
Georgia	0	0	2	0	0	0	0
Louisiana	0	0	1,627	0	0	0	0
Michigan	0	0	10,505	0	0	0	0
Oklahoma	56,772	68,744	190,548	10	2,611	397	2,214
Texas	95,893	226,818	922,209	759	3,424	3,371	53
Wyoming	177	516	1,530	947	0	0	0
<b>Total</b>	<b>157,766</b>	<b>304,483</b>	<b>1,142,831</b>	<b>2,096</b>	<b>6,823</b>	<b>3,775</b>	<b>3,047</b>

**Table 4b. Percent Contribution of 2008 NEI v2.0 Area Source Oil and Gas Emissions (tons per year) for Areas of Whole States and County Portions of States Not Included in the WRAP Phase III and Permian Basin Updates.**

Area NEIv2.0	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	PMC
State	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Arizona	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Arkansas	2.8%	2.0%	0.1%	18.1%	11.4%	0.0%	25.6%
California	0.3%	0.7%	1.3%	0.0%	0.1%	0.2%	0.0%
Georgia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Louisiana	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Michigan	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%
Oklahoma	36.0%	22.6%	16.7%	0.5%	38.3%	10.5%	72.7%
Texas	60.8%	74.5%	80.7%	36.2%	50.2%	89.3%	1.7%
Wyoming	0.1%	0.2%	0.1%	45.2%	0.0%	0.0%	0.0%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>



**Table 5a. 2008 NEI v2.0 Point Source Oil and Gas Emissions (tons per year) for Areas of Whole States and County Portions of States Not Included in the WRAP Phase III and Permian Basin Updates.**

PointNEIv2.0	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	PMC
State	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
Alabama	1,768	567	875	18,183	46	45	2
Arizona	0	0	11	0	0	0	0
Arkansas	146	178	56	325	3	3	0
California	350	967	1,690	814	767	766	1
Colorado	45	103	616	9	1	1	0
Florida	99	120	140	13	19	18	1
Georgia	0	30	0	0	0	0	0
Illinois	274	906	320	397	7	6	0
Indiana	8	2	4	81	3	3	0
Iowa	0	0	1	0	0	0	0
Kansas	97	113	623	13	6	6	0
Kentucky	80	415	273	28	7	7	0
Louisiana	1,459	3,268	4,237	273	296	292	4
Michigan	128	543	596	6	23	23	0
Missouri	85	89	1,876	5,914	6	6	0
Montana	28	16	224	131	2	2	0
Nebraska	104	173	44	0	11	11	0
Nevada	0	0	8	0	0	0	0
New Jersey	1	1	1	18	0	0	0
New Mexico	39	114	31	1	2	2	0
New York	1	3	11	0	0	0	0
North Dakota	120	164	27	1,620	19	19	0
Ohio	13	3	69	0	1	1	0
Oklahoma	413	342	1,738	616	25	24	1
Pennsylvania	1	1	347	0	0	0	0
Texas	3,083	1,878	5,480	7,222	128	124	4
Utah	21	59	34	1	3	3	0
Virginia	0	0	10	0	7	7	0
W. Virginia	16	3	959	0	0	0	0
Wisconsin	2	0	3	0	0	0	0
Wyoming	12	49	283	1,594	0	0	0
Tribal Data	187	1,051	135	5	22	19	3
<b>Total</b>	<b>8,580</b>	<b>11,158</b>	<b>20,722</b>	<b>37,264</b>	<b>1,404</b>	<b>1,388</b>	<b>16</b>

**Table 5b. Percent of 2008 NEI v2.0 Point Source Oil and Gas Emissions for Areas of Whole States and County Portions of States Not Included in the WRAP Phase III and Permian Basin Updates.**

PointNEIv2.0	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	PMC
State	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Alabama	20.6%	5.1%	4.2%	48.8%	3.3%	3.2%	12.5%
Arizona	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Arkansas	1.7%	1.6%	0.3%	0.9%	0.2%	0.2%	0.0%
California	4.1%	8.7%	8.2%	2.2%	54.6%	55.2%	6.3%
Colorado	0.5%	0.9%	3.0%	0.0%	0.1%	0.1%	0.0%
Florida	1.2%	1.1%	0.7%	0.0%	1.4%	1.3%	6.3%
Georgia	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Illinois	3.2%	8.1%	1.5%	1.1%	0.5%	0.4%	0.0%
Indiana	0.1%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%
Iowa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Kansas	1.1%	1.0%	3.0%	0.0%	0.4%	0.4%	0.0%
Kentucky	0.9%	3.7%	1.3%	0.1%	0.5%	0.5%	0.0%
Louisiana	17.0%	29.3%	20.4%	0.7%	21.1%	21.0%	25.0%
Michigan	1.5%	4.9%	2.9%	0.0%	1.6%	1.7%	0.0%
Missouri	1.0%	0.8%	9.1%	15.9%	0.4%	0.4%	0.0%
Montana	0.3%	0.1%	1.1%	0.4%	0.1%	0.1%	0.0%
Nebraska	1.2%	1.6%	0.2%	0.0%	0.8%	0.8%	0.0%
Nevada	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
New Jersey	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
New Mexico	0.5%	1.0%	0.1%	0.0%	0.1%	0.1%	0.0%
New York	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
North Dakota	1.4%	1.5%	0.1%	4.3%	1.4%	1.4%	0.0%
Ohio	0.2%	0.0%	0.3%	0.0%	0.1%	0.1%	0.0%
Oklahoma	4.8%	3.1%	8.4%	1.7%	1.8%	1.7%	6.3%
Pennsylvania	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%
Texas	35.9%	16.8%	26.4%	19.4%	9.1%	8.9%	25.0%
Utah	0.2%	0.5%	0.2%	0.0%	0.2%	0.2%	0.0%
Virginia	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%	0.0%
W. Virginia	0.2%	0.0%	4.6%	0.0%	0.0%	0.0%	0.0%
Wisconsin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wyoming	0.1%	0.4%	1.4%	4.3%	0.0%	0.0%	0.0%
Tribal Data	2.2%	9.4%	0.7%	0.0%	1.6%	1.4%	18.8%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

**Table 6. 2008 NEI v2.0 Area and Point Source and Total Oil and Gas Emissions for Areas of whole States and county portions of States Not Included in the WRAP Phase III and Permian Basin Updates.**

NEIv2.0	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	PMC
Area	157,766	304,483	1,142,831	2,096	6,823	3,775	3,047
Point	<b>8,580</b>	<b>11,158</b>	<b>20,722</b>	<b>37,264</b>	<b>1,404</b>	<b>1,388</b>	<b>16</b>
Total	166,346	315,641	1,163,553	39,360	8,227	5,163	3,063
% Area	94.8%	96.5%	98.2%	5.3%	82.9%	73.1%	99.5%
% Point	5.2%	3.5%	1.8%	94.7%	17.1%	26.9%	0.5%

Table 7 displays a summary the total U.S. O&G exploration and production emissions broken down by the WRAP Phase III Basin, the NM and TX portions of the Permian Basin and by state for the Non-WRAP/Permian Basin data, with the smaller emitted states grouped together in a “Remainder” category (see Tables 3 and 4 for details on these states). Approximately 45% of the O&G emissions in the U.S. come from the WRAP Phase III and Permian Basins with the remainder of the country contributing approximately 55%. Texas is by far the largest emitting O&G state with 53% of the NO<sub>x</sub> and 63% of the VOC (including the Permian Basin). The O&G NO<sub>x</sub>, VOC and CO emissions are spread across the various Basins, although Basins with primarily coal bed methane development tend to have relatively lower VOC emissions (e.g., PRB). However, the O&G SO<sub>2</sub> emissions are much spottier. For example the four states with the highest O&G SO<sub>2</sub> emissions contribute 65% of the total U.S. O&G SO<sub>2</sub> emissions and are Alabama (28%), New Mexico (21%), Texas (18%) and Missouri (9%).

**Table 7a. Summary of oil and gas exploration and production emissions (tons per day) by the WRAP Phase III Basins, the Permian Basin (separately for TX and NM) and using 2008 NEI for areas not covered by the WRAP Phase III and Permian Basins.**

	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>
State	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
<u>2008 NEIv2 States O&amp;G</u>					
Texas	98,976	228,696	927,689	7,981	3,552
Oklahoma	57,185	69,086	192,286	626	2,636
California	796	3,188	16,839	814	774
Michigan	128	543	11,101	6	23
Louisiana	1,459	3,268	5,864	273	296
Missouri	85	89	1,876	5,914	6
Wyoming	189	565	1,813	2,541	0
Arkansas	4,624	6,361	1,306	705	784
W. Virginia	16	3	959	0	0
Alabama	1,768	567	875	18,183	46
Kansas	97	113	623	13	6
Colorado	45	103	616	9	1
Remainder	978	3,058	1,707	2,295	103
<u>WRAP Phase III and Permian Basins</u>					
Southwest WY	16,024	23,824	87,374	6,030	679
Powder River	15,445	20,980	14,787	596	682
Wind River	2,062	1,335	10,993	1,276	31
North San Juan	6,456	5,917	2,187	30	72
Piceance	11,520	20,113	45,714	519	1,812
Denver-Julesburg	14,367	22,165	100,622	115	717
South San Juan	23,602	42,233	54,469	273	557
Uinta	11,569	15,508	97,302	431	716
Permian (TX)	15,467	61,594	387,611	3,729	1,502
Permian (NM)	12,427	24,649	128,074	13,569	552
<b>Total</b>	<b>295,285</b>	<b>553,958</b>	<b>2,092,687</b>	<b>65,928</b>	<b>15,547</b>

**Table 7b. Percent Contribution of oil and gas exploration and production emissions(tons per year) by the WRAP Phase III Basins, the Permian Basin (separately for TX and NM) and States using 2008 NEI for areas not covered by the WRAP Phase III and Permian Basins.**

All	CO	NO <sub>x</sub>	VOC	SO <sub>2</sub>	PM <sub>10</sub>
State	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
<u>2008 NETv2 States O&amp;G</u>					
Texas	33.5%	41.3%	44.3%	12.1%	22.8%
Oklahoma	19.4%	12.5%	9.2%	0.9%	17.0%
California	0.3%	0.6%	0.8%	1.2%	5.0%
Michigan	0.0%	0.1%	0.5%	0.0%	0.1%
Louisiana	0.5%	0.6%	0.3%	0.4%	1.9%
Missouri	0.0%	0.0%	0.1%	9.0%	0.0%
Wyoming	0.1%	0.1%	0.1%	3.9%	0.0%
Arkansas	1.6%	1.1%	0.1%	1.1%	5.0%
W. Virginia	0.0%	0.0%	0.0%	0.0%	0.0%
Alabama	0.6%	0.1%	0.0%	27.6%	0.3%
Kansas	0.0%	0.0%	0.0%	0.0%	0.0%
Colorado	0.0%	0.0%	0.0%	0.0%	0.0%
Remainder	0.3%	0.6%	0.1%	3.5%	0.7%
<u>WRAP Phase III and Permian Basins</u>					
Southwest WY	5.4%	4.3%	4.2%	9.1%	4.4%
Powder River	5.2%	3.8%	0.7%	0.9%	4.4%
Wind River	0.7%	0.2%	0.5%	1.9%	0.2%
North San Juan	2.2%	1.1%	0.1%	0.0%	0.5%
Piceance	3.9%	3.6%	2.2%	0.8%	11.7%
Denver-Julesburg	4.9%	4.0%	4.8%	0.2%	4.6%
South San Juan	8.0%	7.6%	2.6%	0.4%	3.6%
Uinta	3.9%	2.8%	4.6%	0.7%	4.6%
Permian (TX)	5.2%	11.1%	18.5%	5.7%	9.7%
Permian (NM)	4.2%	4.4%	6.1%	20.6%	3.6%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
Non-WRAP (NEI)	56.3%	57.0%	55.6%	59.7%	52.9%
WRAP Phase III	43.7%	43.0%	44.4%	40.3%	47.1%

## Emissions Processing

The non-WRAP/Permian Basin O&G emissions were processed by the Sparse Matrix Operator Kernel Emissions (SMOKE<sup>2</sup>) emissions modeling system. The area source O&G emissions are processed using the spatial surrogate 680 – “Oil and Gas Wells” spatially assign the emissions to the modeling grids.

Speciation profiles for the CB6 chemical mechanism were based on SPECIATE 4.3 database. Unlike the WRAP Phase III Basin emissions, basin specific speciation has not been developed, and speciation assignments will be based on profiles developed for the NEIv2.0 inventory.

Standard temporal profiles assigned by SCC code were used to temporally allocate the O&G emissions.

## Quality Assurance

Quality assurance (QA) was performed following the emissions quality assurance protocol developed during WRAP (Adelman, 2004<sup>3</sup>). These procedures include systematic procedures for:

- Modeling QA – accuracy assurance and problem identification.
- System QA – software and data tracking.
- Documentation – tracking QA issues, recording the QA process and report writing.

An emissions QA checklist is developed that delineates each step of the QA process and allows a systematic approach to the QA process to assure critical steps are not overlooked. The completed QA checklists and templates include:

- Model configuration settings.
- Inventory file log.
- Ancillary input file log.
- Model execution log.

A series of QA products are produced that are compared to other studies and the expected outcomes:

- Spatial plots of emissions by source category.
- Annual time series plots of emissions for subregions.
- Diurnal time series plots.
- Daily vertical profile plots.

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<sup>2</sup> <http://www.smoke-model.org/index.cfm>

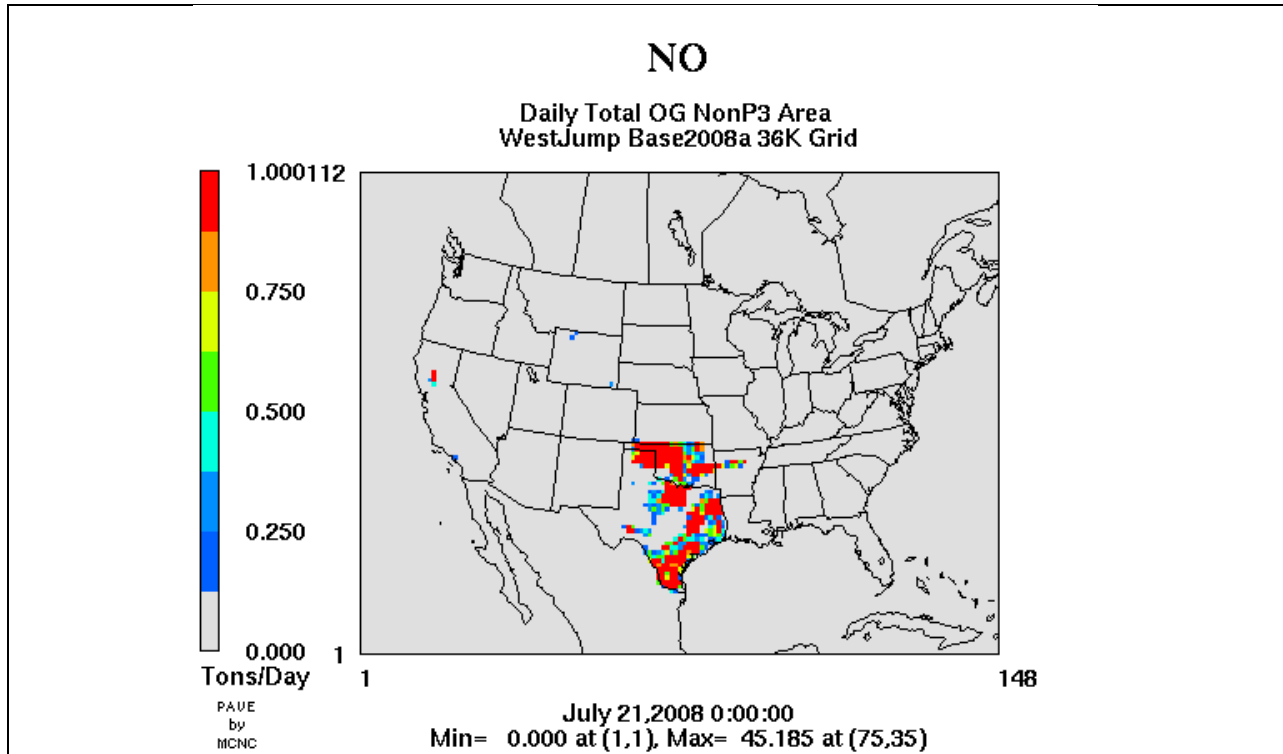
<sup>3</sup> [http://www.epa.gov/ttnchie1/conference/ei13/gaqc/adelman\\_pres.pdf](http://www.epa.gov/ttnchie1/conference/ei13/gaqc/adelman_pres.pdf)

The emissions QA officer is required to generate, review and distribute the QA products to the modeling team and buy off on the results prior to execution of the air quality model.

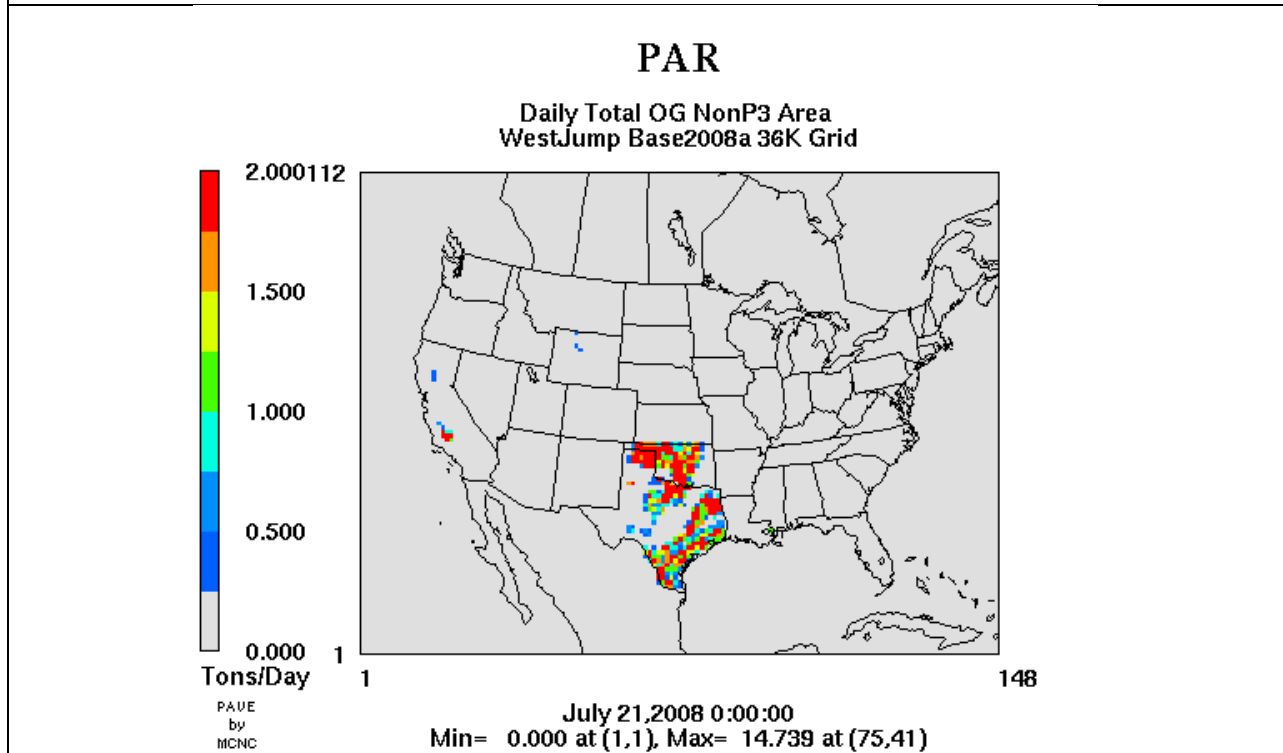
### **Spatial Distribution of Emissions**

Figures 1 and 2 display example QA plots for the non-WRAP/Permian Basins O&G area and point source emissions processing, respectively. These figures display the spatial distribution of O&G area and point source nitric oxide (NO) that typically represents ~90% of the NO<sub>x</sub> emissions, CB05 paraffin (PAR) species that is the largest VOC species and SO<sub>2</sub> emissions. Consistent with Table 4, Texas and Oklahoma have by far the most O&G area source NO<sub>x</sub> and VOC emissions for this category, even without including the Permian Basin portion of Texas. There are also O&G area source O&G NO<sub>x</sub> and VOC emissions visible in Louisiana, Arkansas and California as well as in the southeast and northeast corners of Wyoming that are not covered by the Southwest Wyoming, Wind River and Powder River Basin Basins that were inventoried in the WRAP Phase III study. As noted previously, many states do not have any area source O&G emissions reported in the 2008 NEI because their emission rates are below the reporting threshold (e.g., Montana/Dakotas). Non-WRAP/Permian Basins area source O&G SO<sub>2</sub> emissions are visible in Texas, Arkansas and Wyoming; the Wyoming So<sub>2</sub> emissions are located in the Big Horn Basin not covered by WRAP Phase III.

The spatial distribution of the non-WRAP/Permian Basins point source O&G NO, VOC and SO<sub>2</sub> emissions (Figure 2) are seen in more states than the area source O&G emissions because they have emissions sources (e.g., compressors, gas plants, etc.) with rates that are above emissions threshold reporting requirements. Thus we see point source O&G emissions in states like North Dakota where there were no area source O&G emissions.

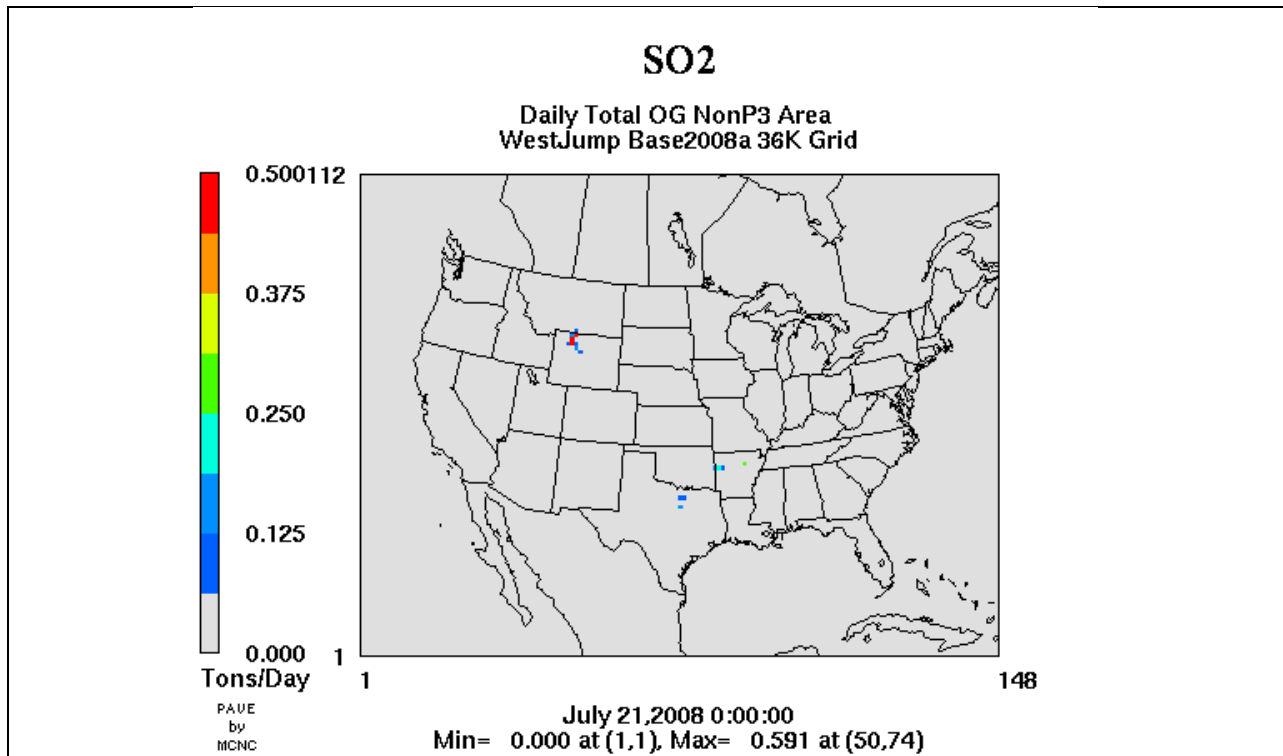


**Figure 1a. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development area source NO emissions that are not located in the WRAP Phase III or Permian Basins.**

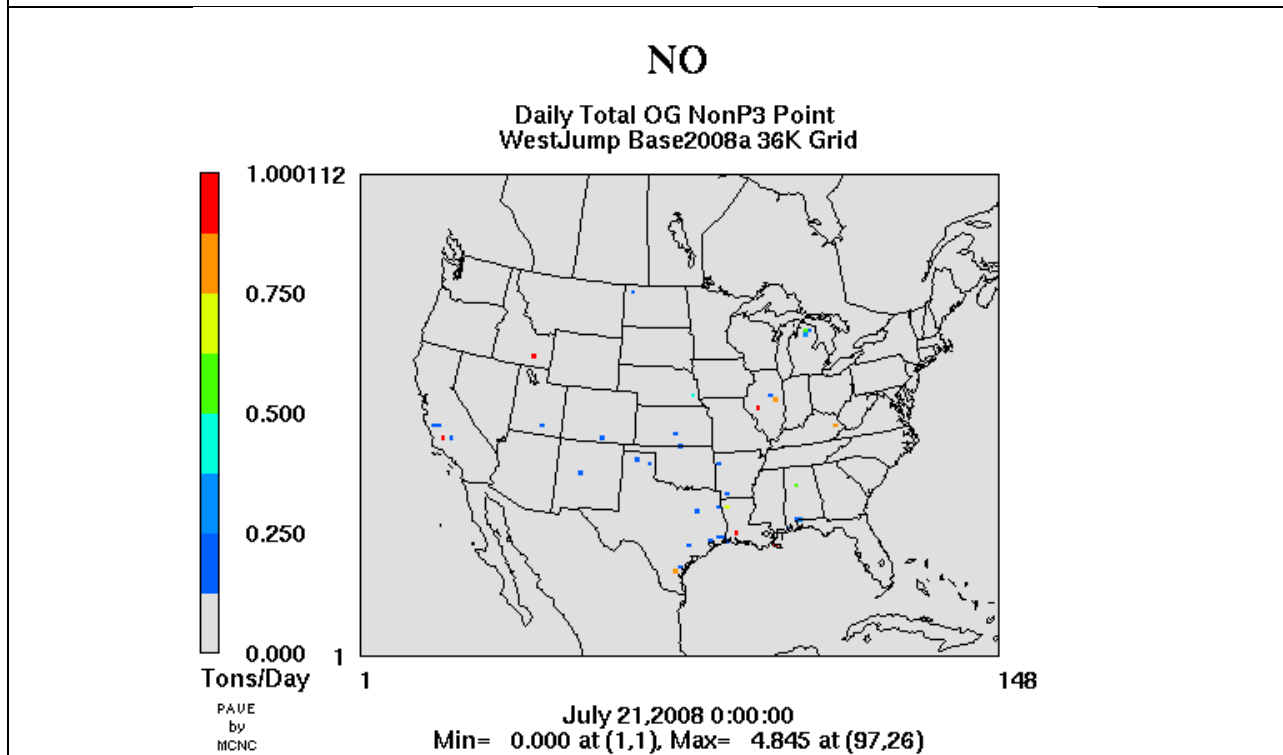


**Figure 1b. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development area source PAR emissions that are not located in the WRAP Phase III or Permian Basins.**

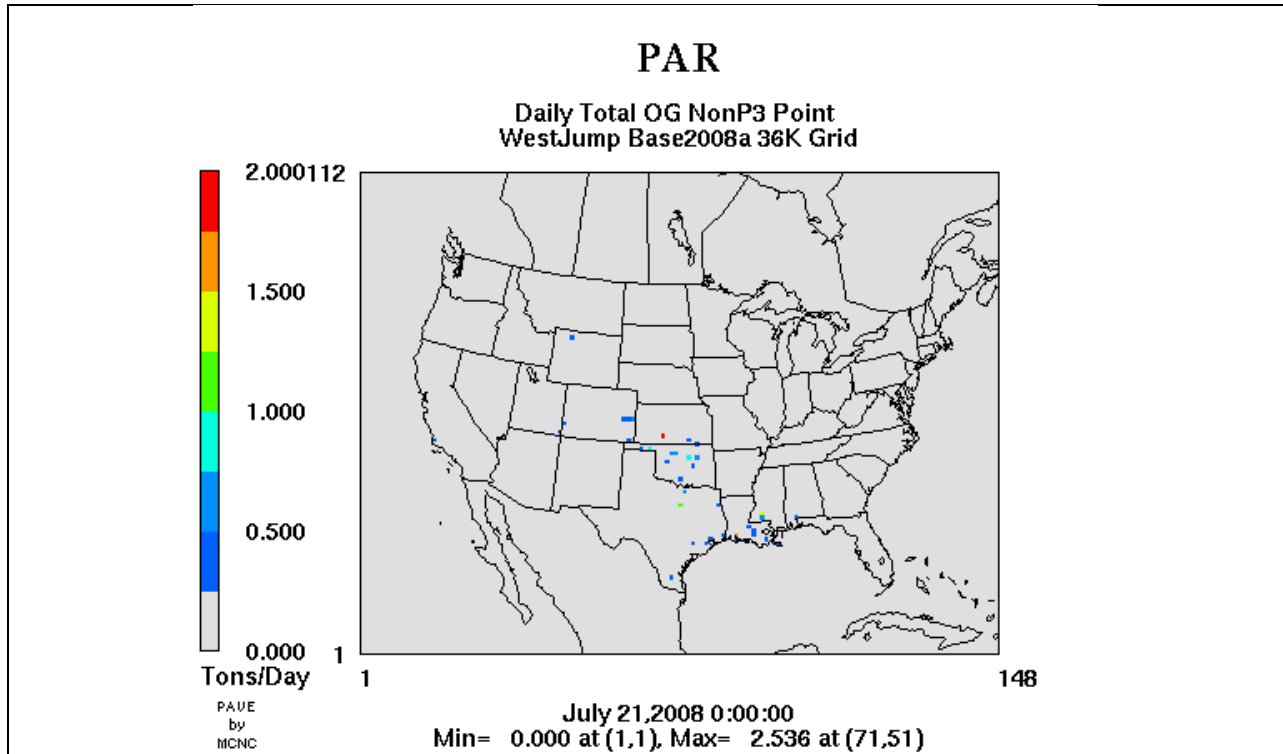




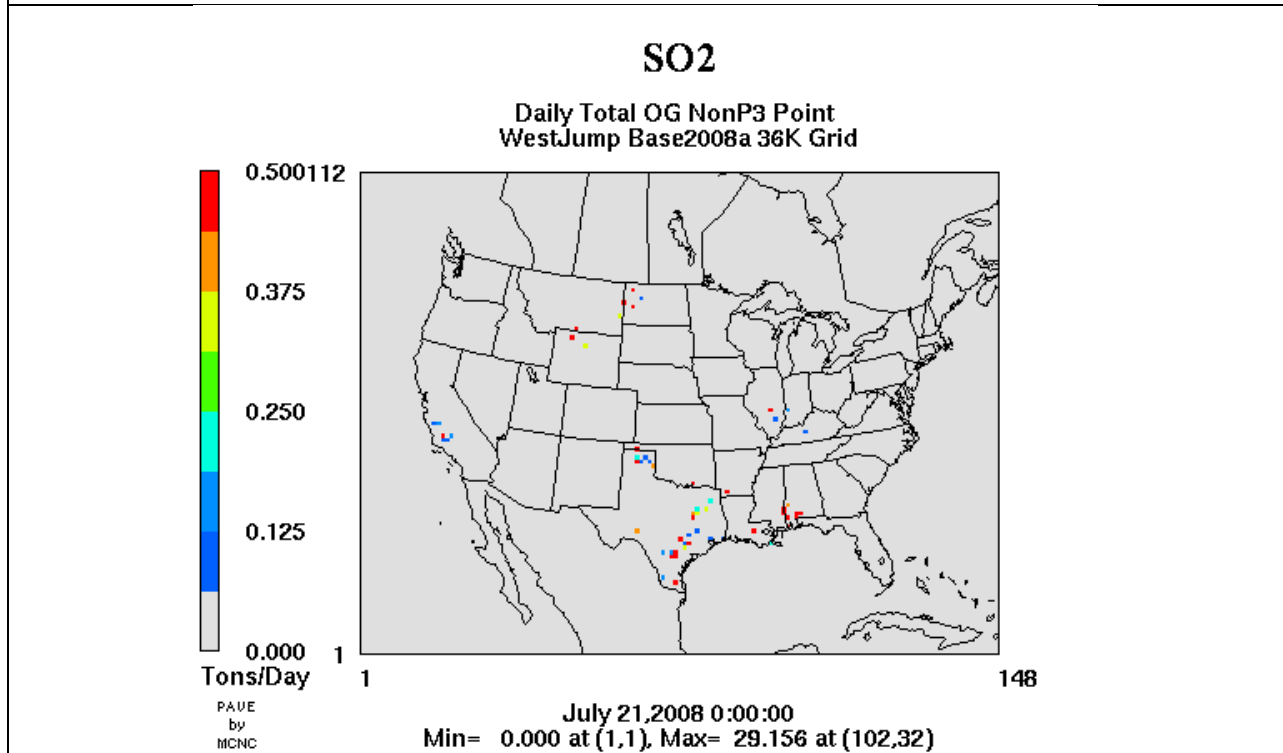
**Figure 1c. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development area source SO<sub>2</sub> emissions that are not located in the WRAP Phase III or Permian Basins.**



**Figure 2a. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development point source NO emissions that are not located in the WRAP Phase III or Permian.**



**Figure 2b. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development point source PAR emissions that are not located in the WRAP Phase III or Permian Basins.**



**Figure 2c. Spatial distribution of the 2008 NEIV2.0 oil and gas exploration and development point source SO<sub>2</sub> emissions that are not located in the WRAP Phase III or Permian.**

