Preparation of Oil and Gas Emissions Inventories for Use in Photochemical Grid Modeling

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Outline

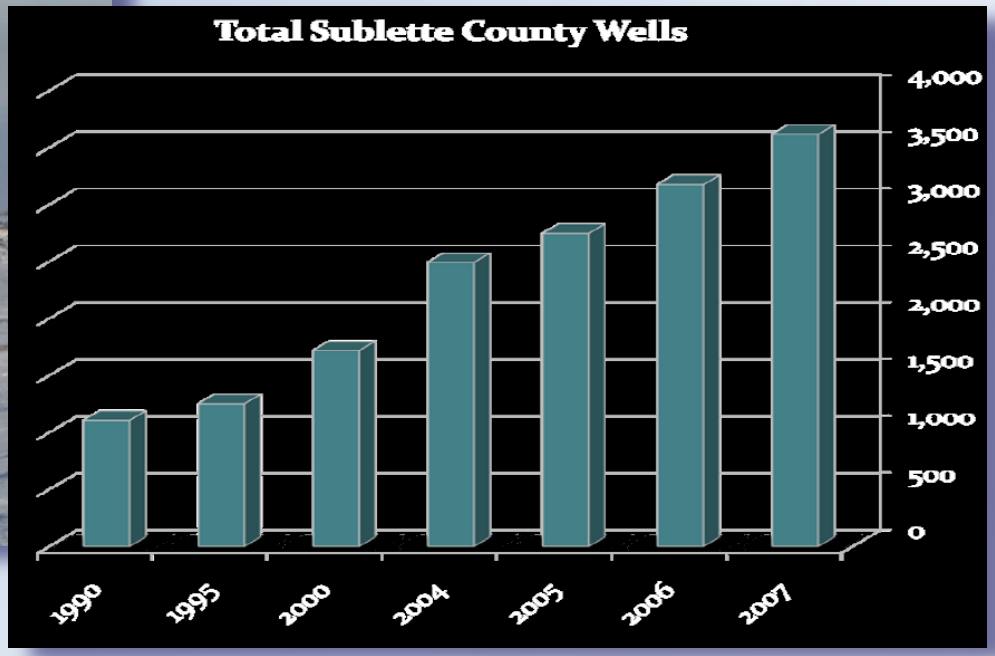
- Project background
- Emissions processing
- Emissions modeling
- Summary of results
- Questions and discussion

Background (1 of 3)

- In recent years, elevated 8-hour ozone concentrations have been observed during “winter” months (February and March) in the Upper Green River Basin (UGRB) in southwest Wyoming
- The Wyoming Department of Environmental Quality (WDEQ) has been proactive in its attempt to understand these occurrences
- WDEQ has performed field studies each winter from 2007 to 2011 to research ozone formation and meteorology
- Just recently, these counties became in non-attainment of the 2008 8-hr ozone NAAQS

Background (2 of 3)

In the UGRB, oil and gas production sources dominate the emissions inventory



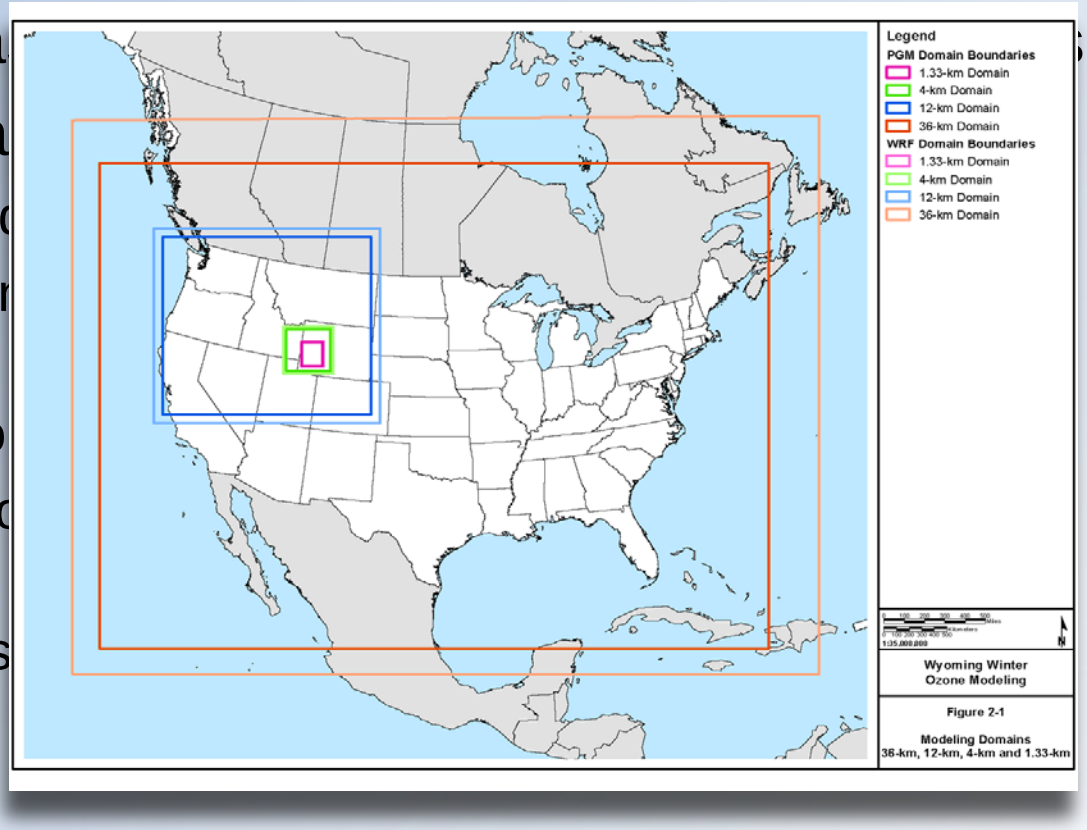
From WDEQ presentation

Background (3 of 3)

- To support air quality management in the region, it was determined that photochemical grid modeling will be conducted using two models to determine which model best replicates winter ozone formation
  - Community Multiscale Air Quality model (CMAQ)
  - Comprehensive Air Quality Model with extensions (CAMx)
- The ideal model should replicate both ozone formation processes and previously observed wintertime ozone episodes
  - This project focused on February to March, 2008, because of the number of ozone episodes, monitored values of peak ozone, and available monitoring and emissions data
- The goal is to set a platform for WDEQ to use for future air quality analysis

Emissions Processing (1 of 7)

- Model-ready emissions were generated for four modeling grids: 36, 12, 4, and 1.33 km
- Special attention wa
- The best data availa
  - WDEQ's 2008 oil an
  - The U.S. Environmer Emissions Inventory
  - WDEQ's statewide o
  - Model of Emissions version 2.1
  - EPA's 2008 fire emis

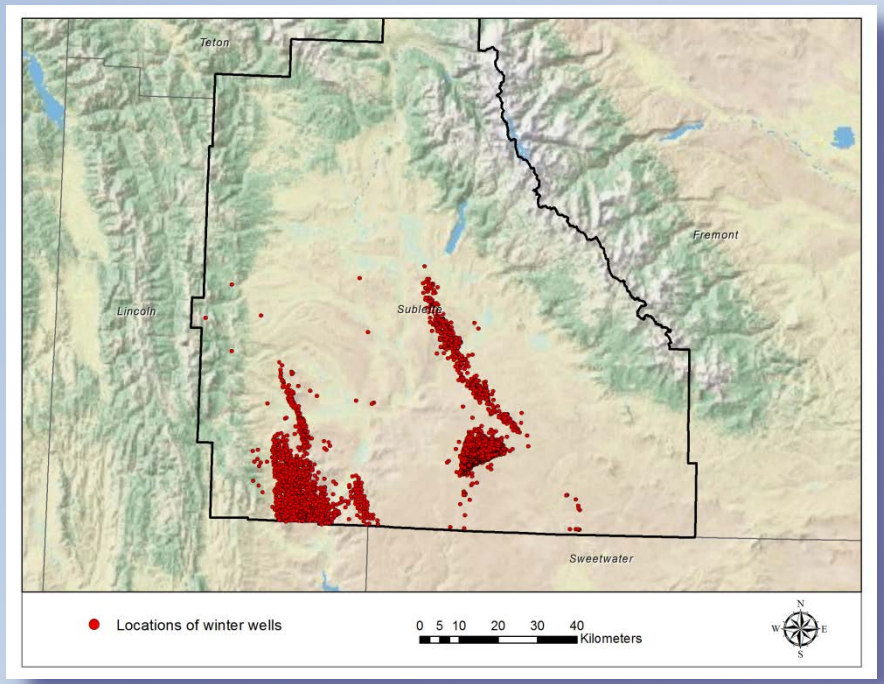


Emissions Processing (2 of 7)

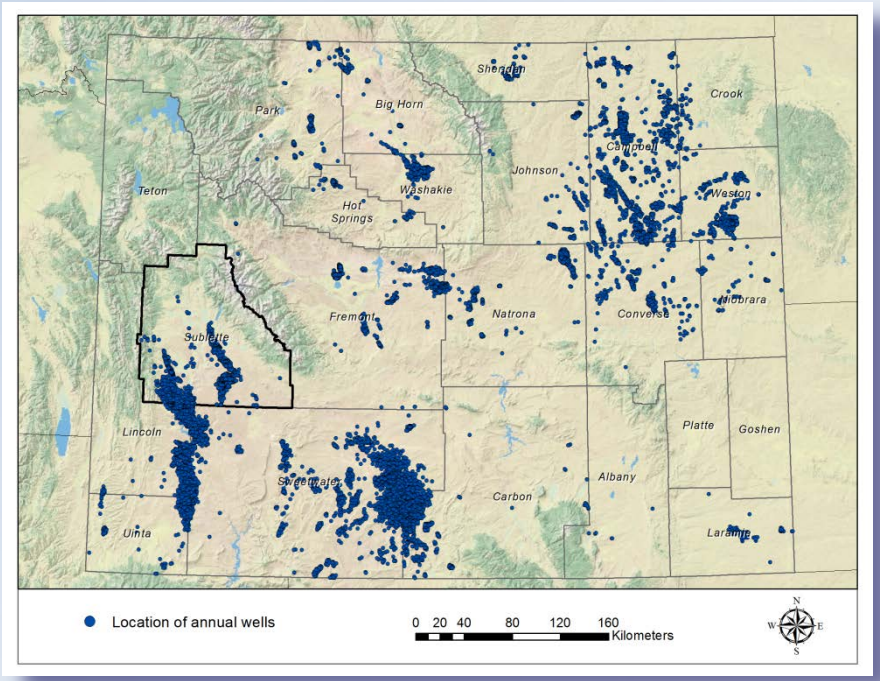
Oil and Gas Sources in Wyoming

WDEQ has two different oil and gas emissions inventories for 2008

Winter emissions inventory for the UGRB



Annual statewide minor source inventory



Emissions Processing (3 of 7)

Summary of All Oil and Gas Sources

Geographic Area	Oil and Gas Emissions Source
Sublette County, Wyoming	WDEQ detailed winter 2008 oil and gas emissions inventory
Other Wyoming counties	WDEQ 2008 annual statewide minor source inventory
WRAP states	WRAP 2008 oil and gas emissions inventory
Non-WRAP states	2008 NEI, version 2

Emissions Processing (4 of 7)

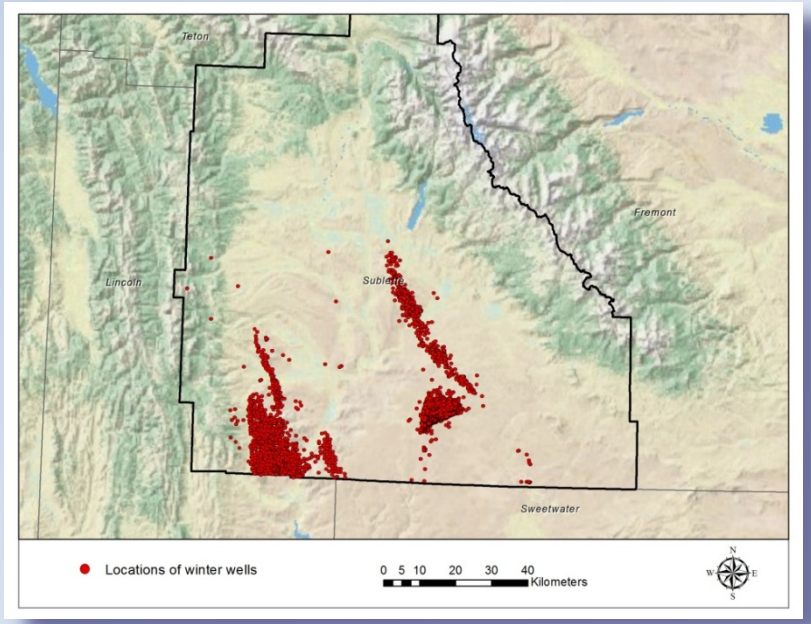
Detailed 2008 Winter Emissions for UGRB

- WDEQ surveyed oil and gas operators in Sublette County
- Operators provided emissions and control information for the following emissions sources:
  - Drill rig engines
  - Process heaters
  - Tanks and pressurized vessels
  - Glycol dehydration units
  - Pneumatic pumps
  - Fugitives
  - Truck loading
  - Well head and workover engines
  - Venting and blowdown events
  - Well completions (including flares)
  - Compressor stations

Emissions Processing (5 of 7)

WDEQ provided a complete list of oil and gas wells with the following information:

- Well latitude and longitude
- Well type
- Oil and gas production levels
- Temporal information for intermittent sources (e.g., start and end time for drilling and venting/blowdown events)
- Well-specific emissions by source type
- Stack information for individual sources



Emissions data were provided for 20 pollutants, including NO_x and speciated VOCs

Emissions Processing (6 of 7)

Speciated VOC Emissions

- Operators were required to submit gas and liquid analysis as part of the New Source Review permit application from WDEQ
- Field-wide average gas analyses were used to determine speciated hydrocarbon emissions from a variety of sources
  - Venting/blowdowns
  - Fugitives
  - Pneumatic pumps
  - Dehydration units

Emissions Processing (7 of 7)

Sublette Co. Winter 2008 Oil and Gas Emissions (tons)

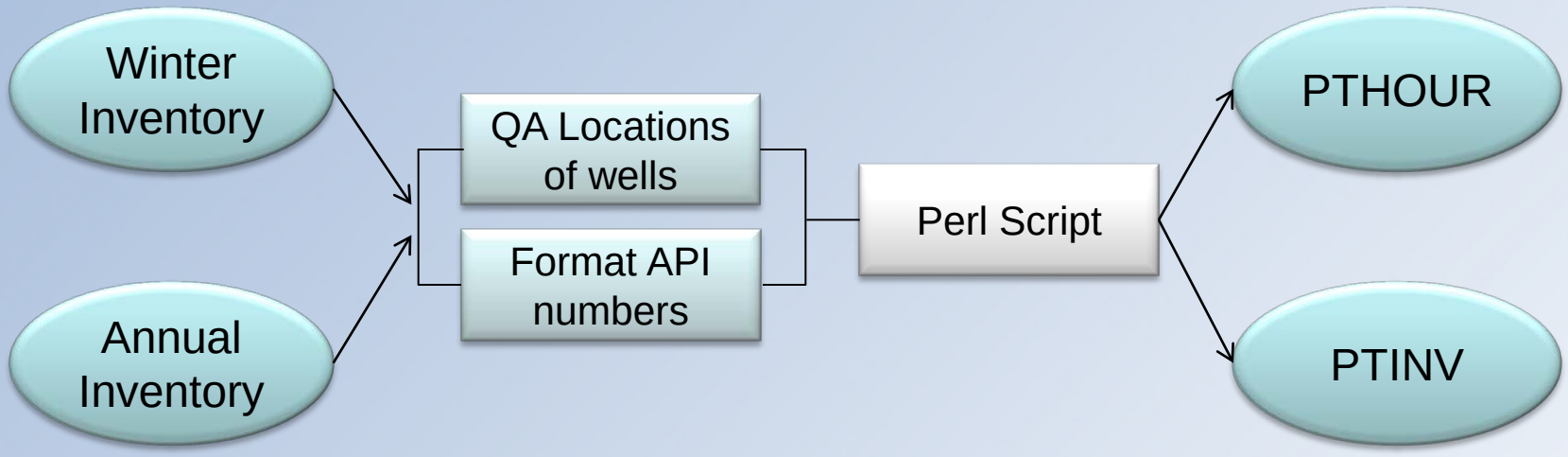
Source Category	NO_X	CO	HONO	Formaldehyde	PM	SO_2	Total VOC	Speciated VOC
Drill rigs	578.2	315.9	17.3	0.3	12.1	7.8	17.4	
Process heaters	86.8	57.2	2.6	0.0			3.2	
Tanks and pressurized vessels	80.2	18.6	2.4				754.4	✓
Glycol dehydration units	136.2	48.2	4.1				689.0	✓
Pneumatic pumps	14.3	3.5	0.4				565.6	✓
Fugitives							394.9	✓
Truck loading							143.4	✓
Compressor engines	236.8	188.8	7.1	24.1	1.5	0.1	143.2	
Workover engines	36.4	33.9	1.1		1.5	0.5	3.3	
Well vent and blowdown events							30.9	✓
Well completions	1.4	0.3	0.0				5.5	✓
Total	**1,170.3**	**666.4**	**35.0**	**24.4**	**15.1**	**8.4**	**2,679.1**	

72% of Total NO_X

86% of Total VOC

Emissions Modeling (1 of 3)

Convert Emissions to SMOKE-Ready Format

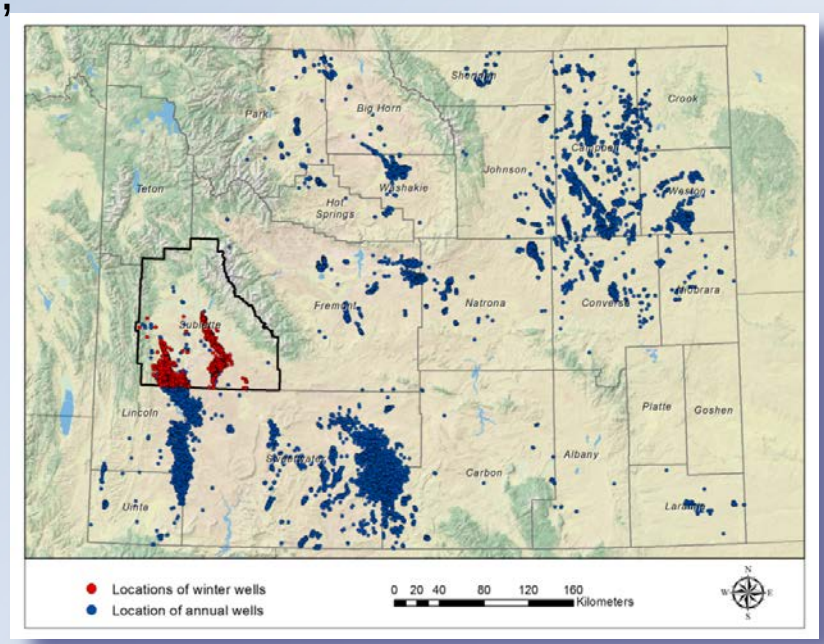


Generating PTHOUR and PTINV files preserved the temporal and spatial variability of the raw emissions data

Emissions Modeling (2 of 3)

Convert Emissions to SMOKE-Ready Format

- Using the PTINV and PTHOUR files, SMOKE was able to reconcile the two oil and gas emissions inventories
- Each well was treated as a discrete point source with multiple emissions-producing parameters, including stack information
- Since the oil and gas point sources have stack information, LAYPOINT was ran producing plume rise information for each well
- QA was performed on the oil and gas source locations and emissions



Emissions Modeling (3 of 3)

Create SMOKE-Ready Speciation Profiles

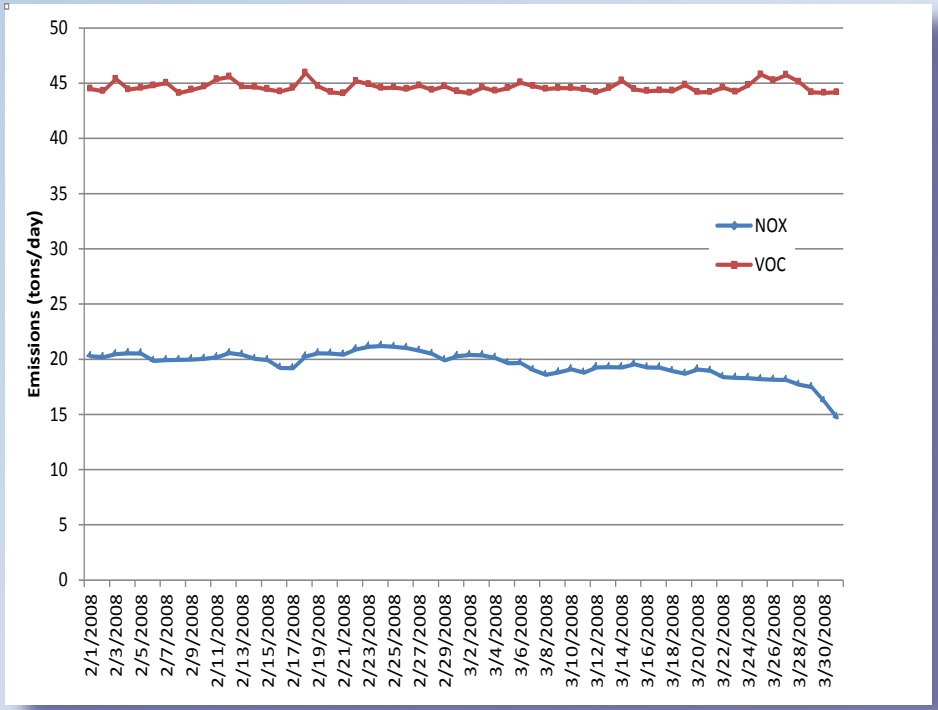
- To capture the distribution of species in the speciated VOC emissions data, since air quality models cannot treat them explicitly
- To translate VOC emissions into reactivity groups needed by air quality models, we used the Carbon Bond V mechanism
- Conversion was done using a spreadsheet tool derived and modified from work by Dr. William Carter (http://www.engr.ucr.edu/~carter/emitdb/)

Inventory Hydrocarbon Species	Moles of CB05 species per mole of inventory species					
	Paraffins	Toluene	Xylene	Methane	Ethane	Unreactive
methane	-	-	-	1.00	-	-
ethane	-	-	-	-	1.00	-
propane	1.50	-	-	-	-	1.50
2-methylpropane; isobutane	4.00	-	-	-	-	-
n-butane	4.00	-	-	-	-	-
isomers of pentane	5.00	-	-	-	-	-
n-pentane	5.00	-	-	-	-	-
isomers of hexane	5.83	-	-	-	-	0.17
benzene	1.00	-	-	-	-	5.00
toluene	-	1.00	-	-	-	-
ethylbenzene	1.00	1.00	-	-	-	-
m-xylene and p-xylene	-	-	1.00	-	-	-
isomers of heptane	6.81	-	-	-	-	0.19
isomers of octane (c8 paraffin)	7.75	-	-	-	-	0.25
isomers of nonane (c9 paraffin)	8.88	-	-	-	-	0.13
2,2,4-trimethylpentane	7.00	-	-	-	-	1.00
isomers of decane (c10 paraffin)	9.88	-	-	-	-	0.13

Summary of Results (1 of 2)

Sublette County oil and gas emissions

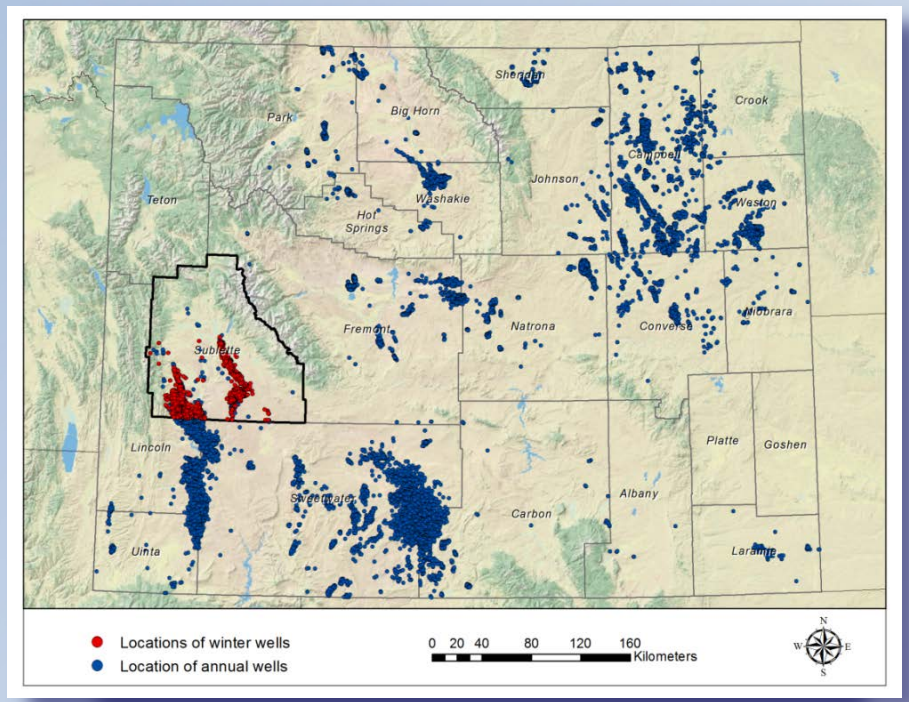
- NO_x and VOC emissions levels vary little day to day
- VOC emissions from episodic gas releases are small compared to other VOC emissions
- Total emissions (tons) account for
  - 72% of the total NO_x emissions
  - 86% of the total VOC emissions

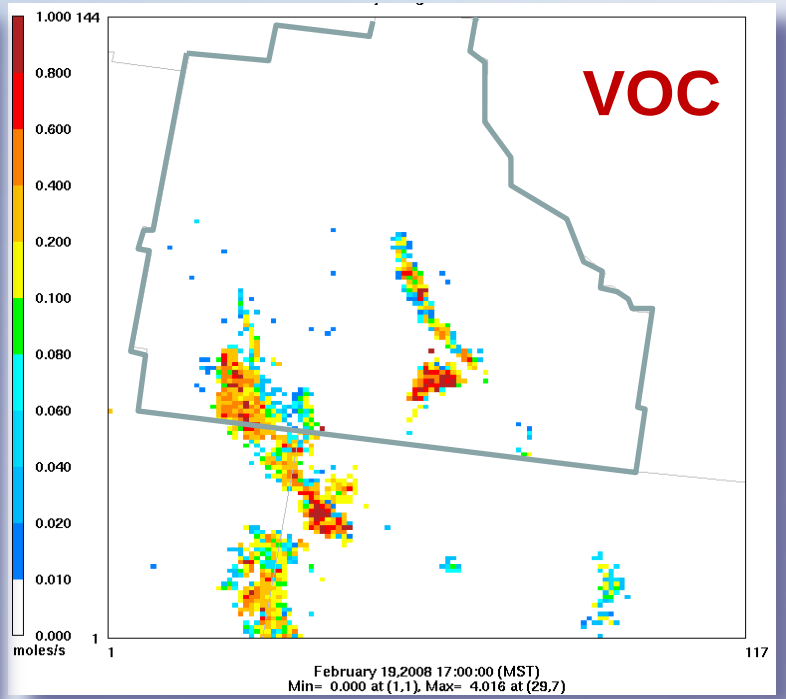


Source	CO	NO_x	VOC	NH_3	SO_2	PM_{10}	$PM_{2.5}$
Point	160.0	215.9	155.0	0.0	0.1	1.0	0.5
Nonpoint	57.0	4.1	40.5	**49.0**	1.0	**1,716.7**	**183.0**
On-road Mobile	**1,184.3**	184.0	7.9	2.4	4.0	9.8	8.4
Nonroad Mobile	660.5	46.2	237.9	0.1	1.0	9.6	9.0
Fire	13.0	0.0	3.1	0.2	0.2	1.5	1.3
Oil and Gas	664.5	**1,170.9**	**2,677.9**	0.0	8.3	15.0	14.9
Total	**2,739.3**	**1,621.2**	**3,122.4**	**51.7**	**14.5**	**1,753.6**	**217.1**

Summary of Results (2 of 2)

- Daily emissions plots show the spatial distribution of NO_x and VOC emissions from oil and gas sources in the UGRB
- The use of discrete point sources in modeling more accurately represents the locations of the emissions sources





Recap

- Historically, sources in the oil and gas production sector have typically been represented as nonpoint sources and VOC emissions have been chemically speciated using default speciation profiles from EPA's SPECIATE database or other sources
- This project uses detailed, well-specific information from WDEQ to treat oil and gas wells as discrete point sources, with emissions assigned to actual well locations
- In addition, speciated VOC emissions used are from field-specific analysis
- Finally, stack parameters assigned to each oil and gas source allow plume rise to be characterized more accurately

Next Steps

- Finalize QA of the emissions inventory
- Expect modeling to start next month

Questions and Discussion

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