

Upper Green River Basin Air Quality Citizens Advisory Task Force

Pinedale Library 21 March 2012

Pinedale Anticline Spatial Air Quality Assessment Updated Preliminary Findings and Provisional Results

DEPARTMENT OF ATMOSPHERIC SCIENCE

FIELD, SOLTIS, MONTAGUE



Tracy McCarty Middle School 05

Question

Question #1
Does natural gas development create ground level ozone?

Question #2
Can ground level ozone be detected in the Powder River Basin's gas development?

Hypothesis

Natural gas development creates ground level ozone. The fumes and chemicals get released and the mixture of hydrogen and oxygen with the methane in natural gas creates ground ozone. The normal amount of ozone in the atmosphere should be less than 90 parts per billion, but the Powder River Basin contains 120 parts per billion, a very high, unhealthy level of ground ozone because of all the natural gas development in the area.

Materials

Conclusion

The hypothesis that gas development is creating ground level ozone was supported. The Powder River Basin has 120 parts per billion of ground level ozone which is a very high level. It has more ozone than the levels of Powder, even though Powder has a lot of houses and traffic going through it everyday. Various places were tested such as Daniel, Powder, Boulder, and the Antelope. The more ozone appeared the closer the test sites were to the drilling locations. The least amount of ground level ozone was found in Daniel, and Daniel had seven parts per billion. The sites were tested at different times, therefore the humidity may have affected the results. To avoid this problem, a humidity test was taken at each site, and the amount of humidity was worked into the ground ozone calculation. High humidity makes the Schwanstein paper more sensitive to ground level ozone therefore a higher number is found.

The results came out very interesting, they indicated that since the gas development industry began in our area, there is a major increase of air pollution. Ground level ozone is a problem, significant in many, therefore is a harmful pollutant. The gas industry has made it clear that they are not affecting the air, but this project proves the opposite. The Powder Antelope is air is highly polluted with ground level ozone. This project does not definitively prove that it is from the gas development, but it is a strong

Abstract

Question
Does natural gas development create ground level ozone? Can ground level ozone be detected in the Powder River Basin's gas development?

Hypothesis
Natural Gas development creates ground level ozone. The fumes get released and the mixture of hydrogen and oxygen with the methane in natural gas creates ground ozone. The normal amount of ozone in the atmosphere should be less than 90 parts per billion, but the Powder River Basin contains 120 parts per billion, a very high, unhealthy level of ground ozone because of all the natural gas development in the area.

Testing
The hypothesis was tested using Schwanstein paper. The paper is a paper used to measure the amount of ground level ozone in the air. It changes color because of a chemical reaction from the ground ozone in the air. The paper was made with 100 milliliters of water, five grams of corn starch, one gram of potassium iodide, mixed together, and heated to create a black mixture. The mixture was painted onto filter paper and dried. It would take a humidity test because the humidity affects how sensitive is ozone the paper reads. The darker the paper, the more ozone pollution there is in the air.

Results
The hypothesis was supported by the results of the data that was collected. The results indicated that since gas development, there is a major increase of air pollution. The Powder River Basin has 120 parts per billion of ground level ozone, which is extremely high. The ground level ozone increased the further away from the gas development.

What was learned?
Many things were learned while testing the project. The results proved that the gas development is affecting the air and the environment. Ground level ozone is a major pollutant and it has many effects. Ozone is a gas that affects human health and human plants. Ozone is linked to increased hospital admissions and premature death. People with asthma, respiratory conditions, and farm production are most at risk from ground level ozone.

Expanded Project
This project was a very fun experience to test. An extension to the project could be tested in different areas with gas development. Whether gas development creates ozone levels, and the same results appeared, the project would be useful further.

Data

GROUND-LEVEL OZONE TESTING
This is the color scale that shows the ozone levels.

This is the color scale used to graph the results.

Schwainstein Color Scale

0-1	Lightest color
2-3	Lighter blue
4-5	Blue
6-7	Dark blue
8-9	Black

Ground Level Ozone

Location	Ground Level Ozone (ppb)
Daniel	7
Powder	120
Boulder	120
Antelope	120

Humidity Number

Location	Humidity Number
Daniel	10
Powder	10
Boulder	10
Antelope	10

Procedures

Schwainstein Paper Procedure

1. Place 100 milliliters of water in a 250-milliliter beaker.
2. Add 5 grams of cornstarch.
3. Heat on hot plate and stir mixture until it thickens.
4. Remove the beaker from the heat.
5. Add 1 gram of potassium iodide and stir well.
6. Let the solution Cool.
7. Lay a piece of filter paper on a glass plate at least 7.5 inches in diameter.
8. Carefully brush the starch onto the filter paper.
9. Turn the filter paper over and repeat the procedure.
10. Place paper on a microscope- safe plate and microscope on high for 30-60 seconds.
11. Cut filter paper into 1-inch wide strips.
12. Place them in a zipper- lock plastic bag or glass jar out of direct sunlight.

Humidity Testing Procedure

1. Use the sling psychrometer.
2. To take a reading, dip the cloth covered with distilled water.
3. Wait for the instrument around at the testing area.

Bibliography

Primary Sources

Dardick, Terry. Phone interview. Powder, Wyoming. 26 Oct. 2005.
Johnson, Jeff. Meeting. Powder, Wyoming. 1 Nov. 2005.
Johnson, Tom. Personal interview. Powder Middle School. 17 Nov. 2005.
McCarty, Beth. Personal interview. Powder, Wyoming. 28 Oct. 2005.
Walker, Perry. Phone interview. Powder, Wyoming. 4 Oct. 2005.

Secondary Sources

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"Ozone Fact Sheet." Environmental Health Center. 16 Nov. 1999. pdf. 11 Nov. 2005 <www.ohc.org/ohc/factsheet.html>.
"Ozone Health." A Toxicon. "U.S. Environmental Protection Agency." 2 Nov. 2005. graph. 11 Nov. 2005 <www.epa.gov/groundozone/faq/>.
"Frequently Asked Questions." Chapter 2 Page 2005. Ministry of the Environment. 10 Nov. 2005 <www.epa.gov/groundozone/>.
"Ozone." The Green Eye People. Netherlands. 14 Nov. 2005 <www.ozonebureau.com/>.
Web site, Carol. "Ground Level Ozone Testing." The Union Center of Atmospheric Research, October 2nd. 7 Nov. 2005 <www.unioncenter.com/ohc/Paragrade/faq.html>.

UW studies



A wide, shallow river with white water rapids under a clear blue sky. The water is turbulent and white with foam. In the background, there are low mountains or hills. The overall scene is bright and clear.

UPPER GREEN RIVER OZONE INVESTIGATION (O3i)

O3i

- **2008-09**

- *Mobile Air Quality Monitoring Lab is Mobile
(Five Locations)*

- *Capabilities: O₃, NO-NO₂-NO_x, CH₄, NMHC*

- **2009-10**

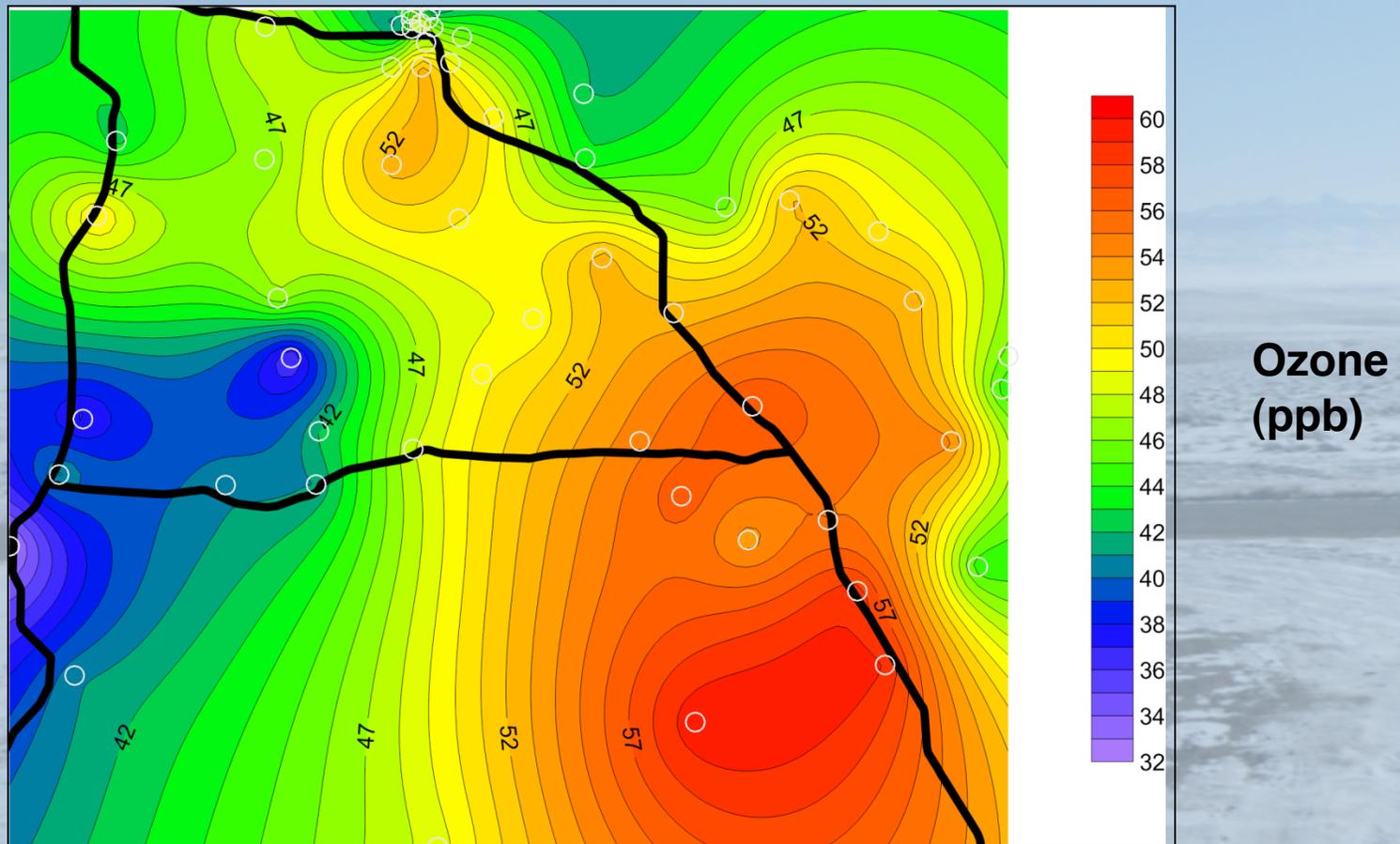
- *Mobile Air Quality Monitoring Lab is Stationary
(Olson Ranch)*

- *Capabilities: Added CO and O₃ Primary Standard*

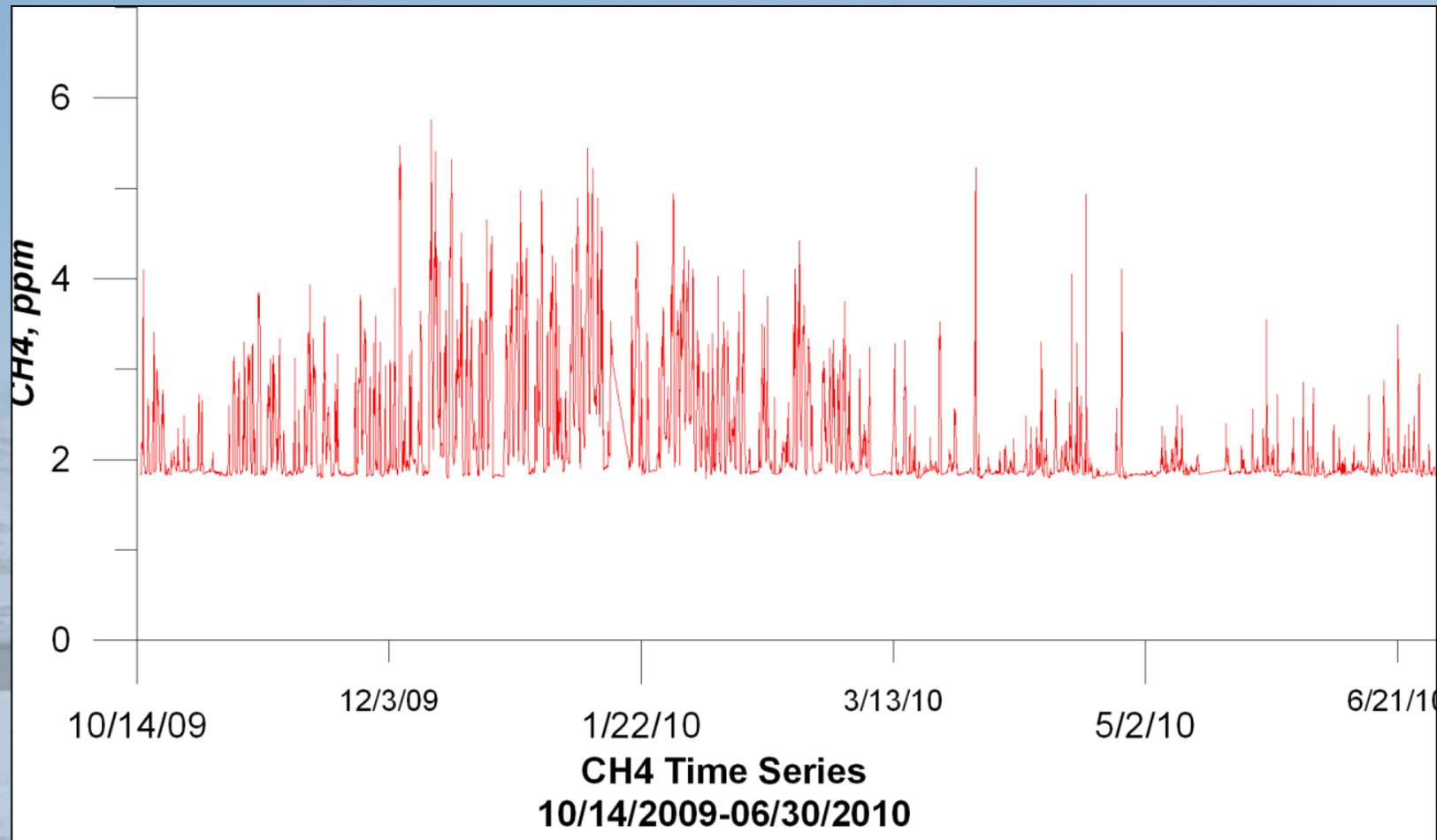
- **Traffic Survey**

Upper Green River Ozone Investigation (O3i)

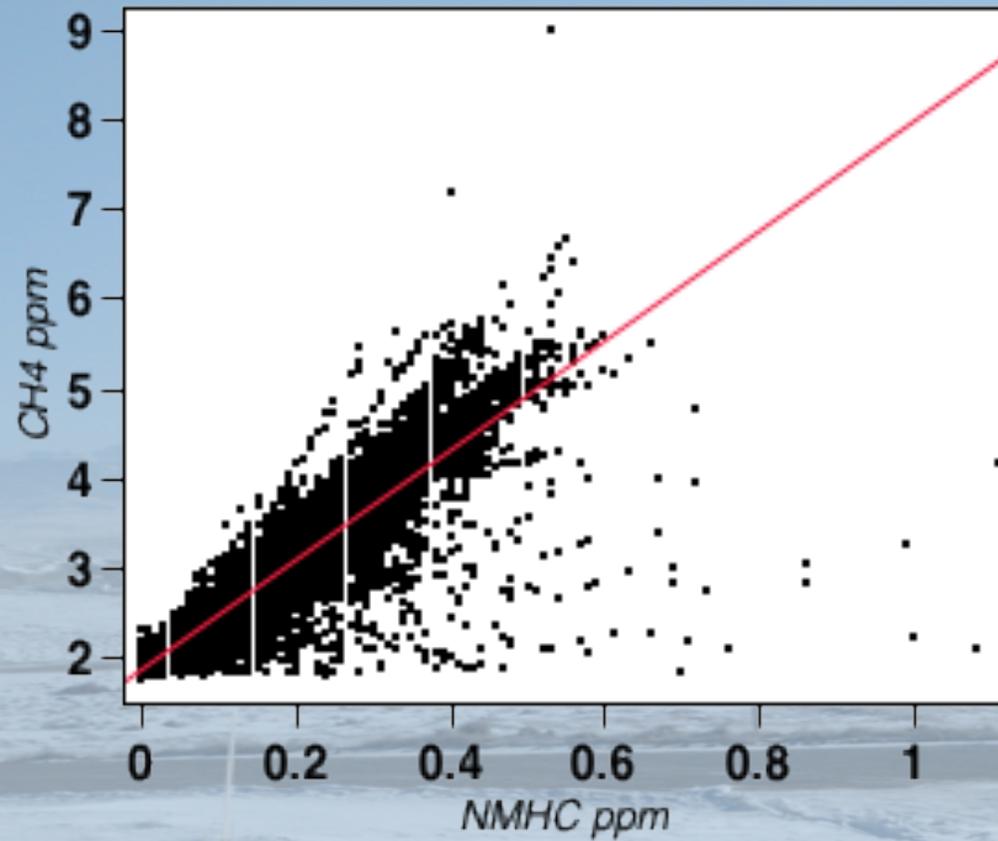
- *Spatial Ozone Survey 22 Feb 2009*



Methane at Olson Ranch



Methane and NMHC



$CH_4 \text{ ppm} = 1.8608231 + 6.0973174 \times NMHC \text{ ppm}$; Intercept = 1.86.

An aerial photograph of a coastal region, likely the Pinedale area. The foreground shows a large, shallow body of water with a sandy beach. In the middle ground, there are some structures and a road. The background features a range of mountains under a clear blue sky.

PINEDALE ANTICLINE SPATIAL AIR QUALITY ASSESSMENT

PASQUA 2011

Improved Study Design & Expanded Capabilities



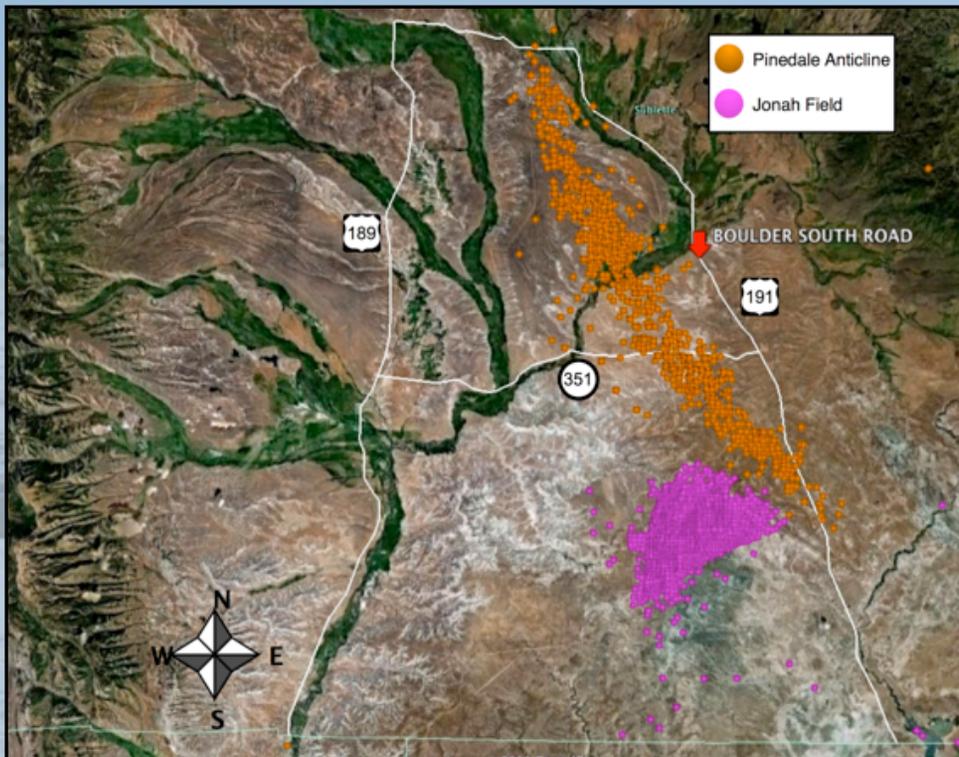
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BOULDER SOUTH ROAD

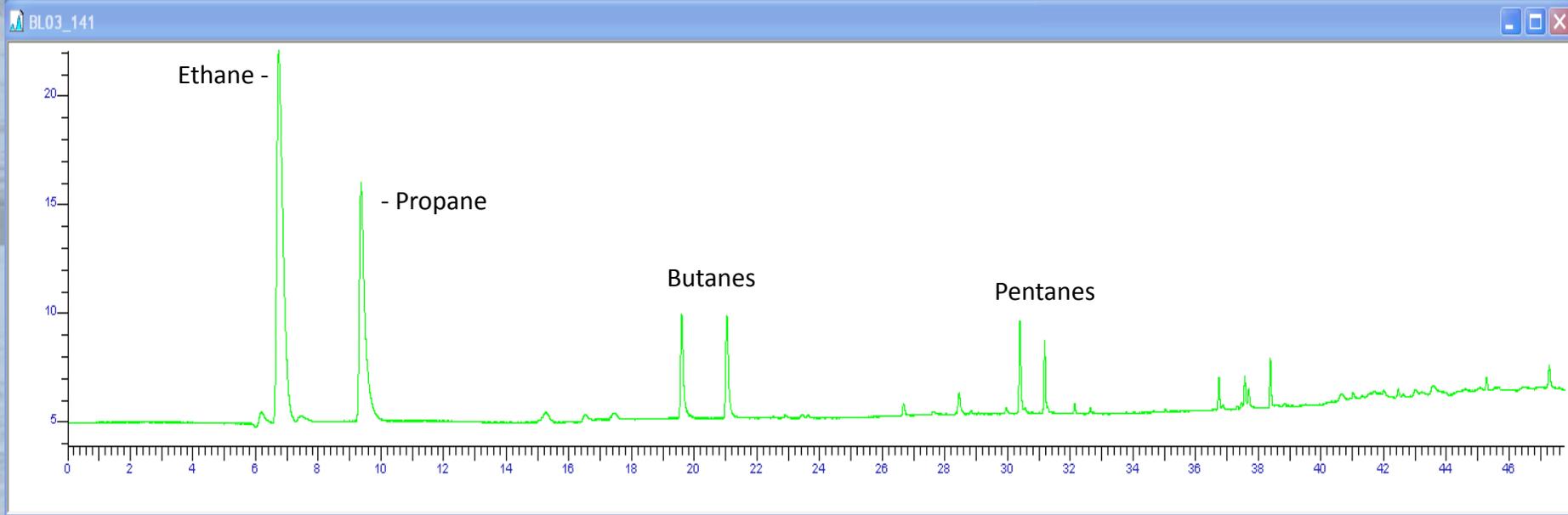
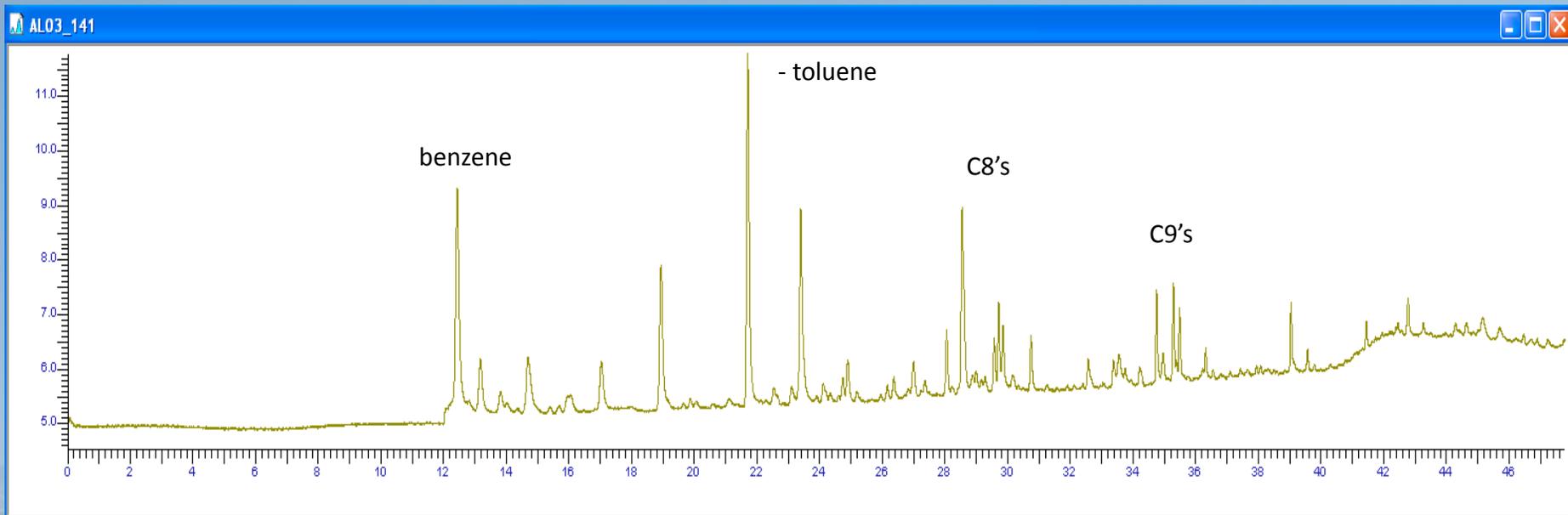
7019 ft

N42.6840° W109.7083°

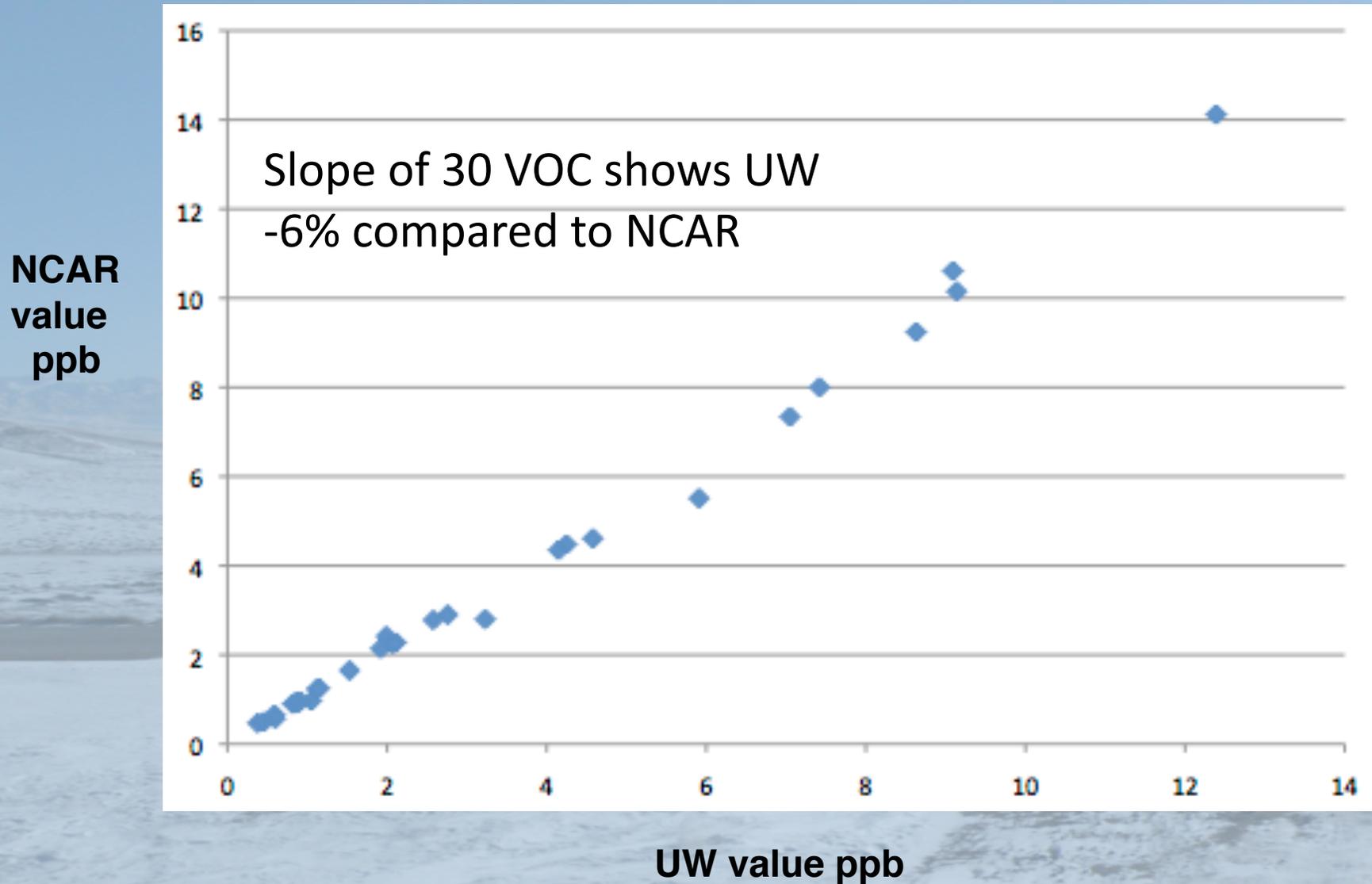
O₃
NO - NO₂ - NO_x
CO
CH₄ & NMHC
VOC
MET

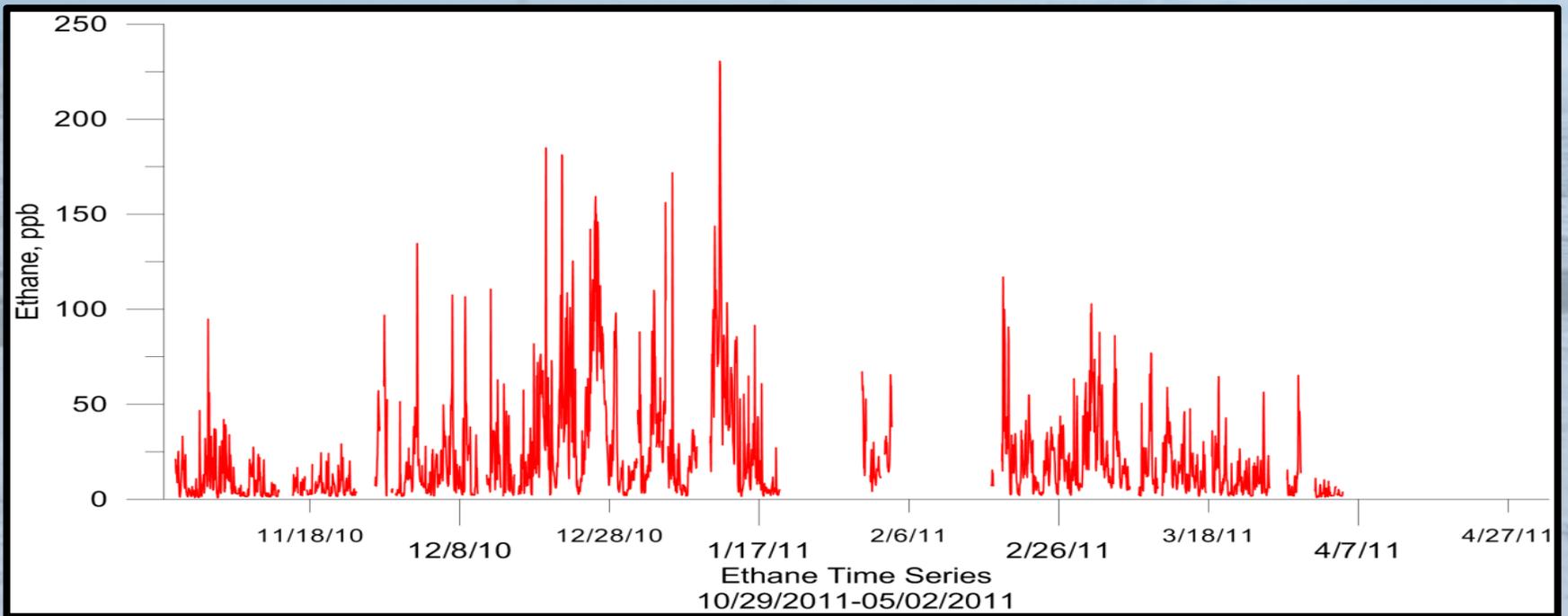
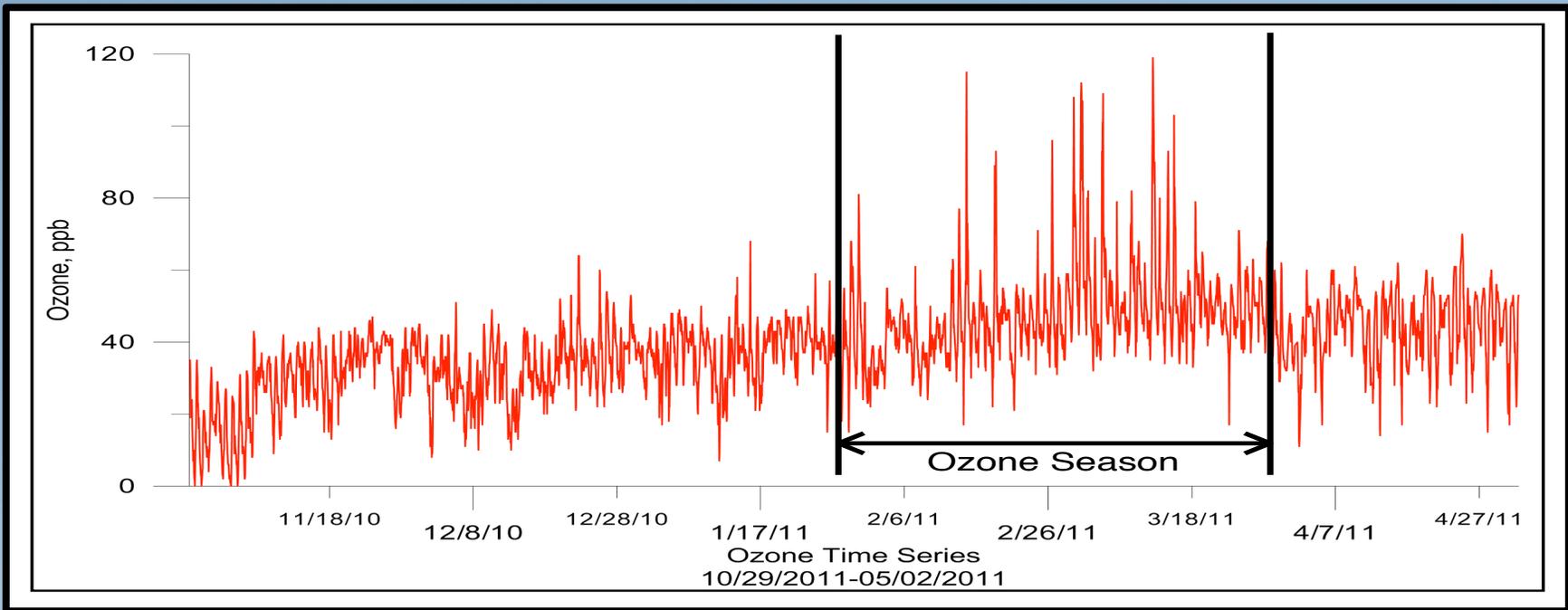


Chromatograms 5/1/2011 12:00



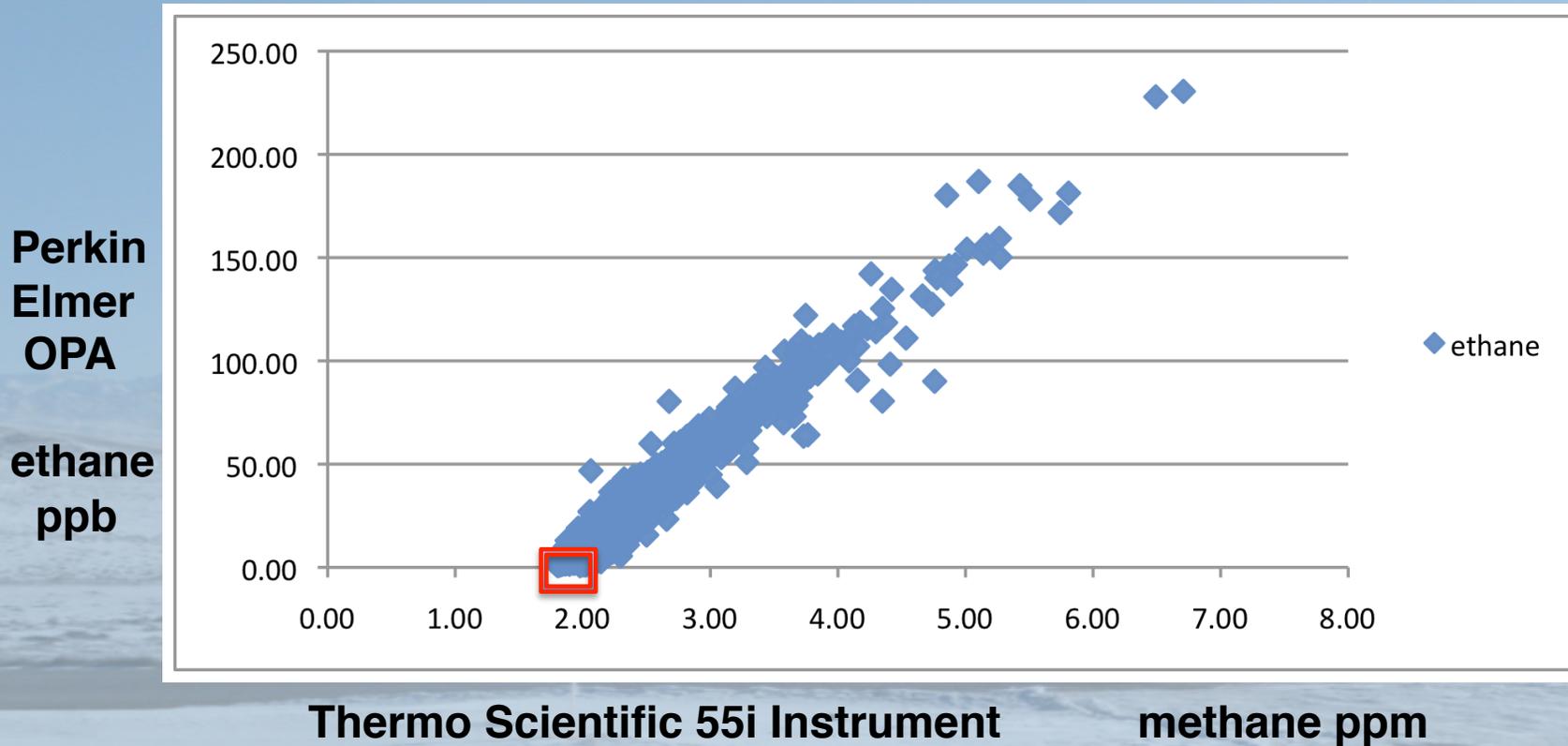
Audit by NCAR 2011





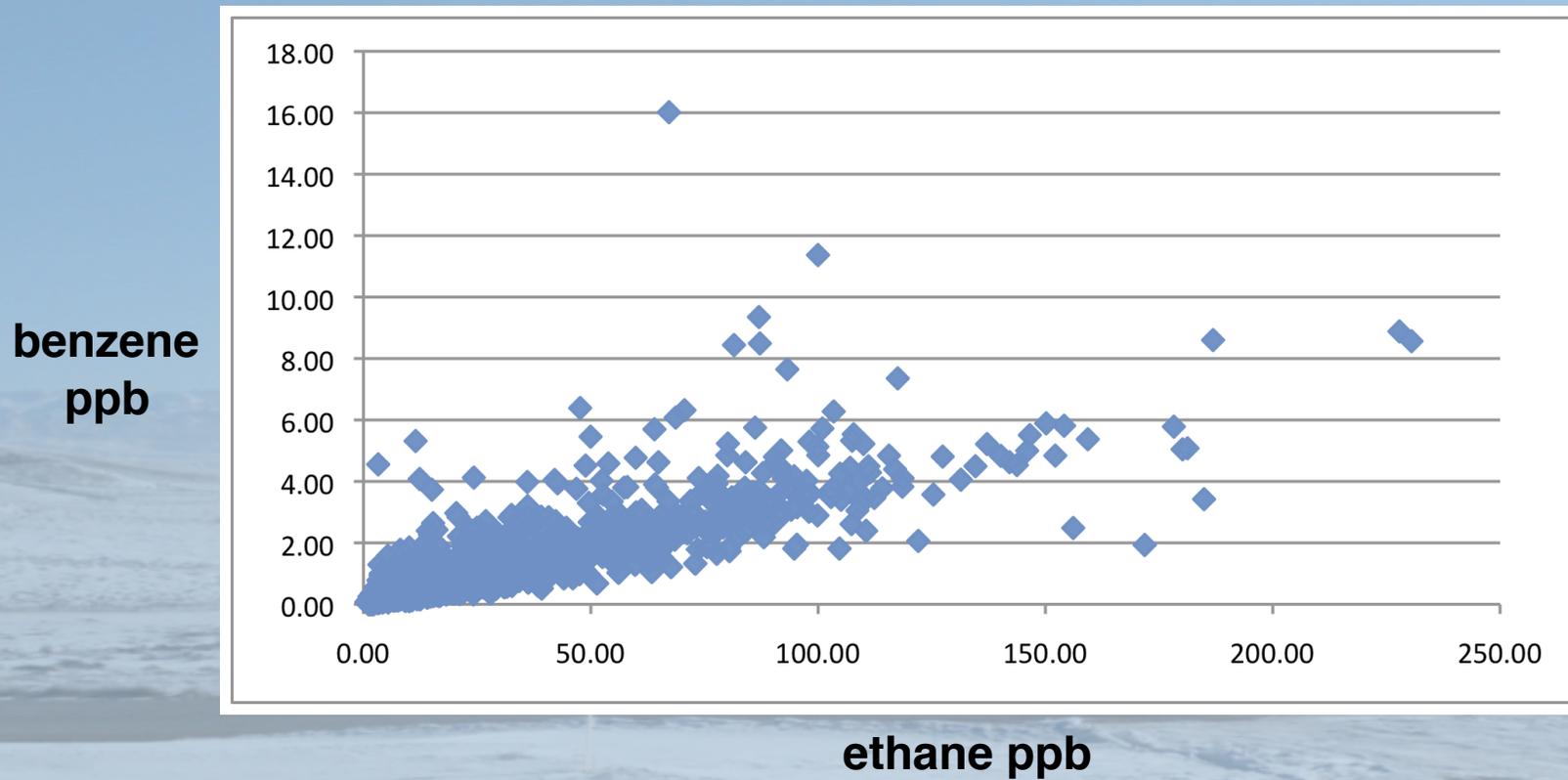
Methane vs. Ethane

Nov 2010 to Apr 2011



Benzene vs. Ethane

Nov 2010 to Apr 2011



PAPA Wet Gas vs. Ambient air

% contribution based on ppb

PAPA		UW
51.6	Ethane	51.0
22.7	Propane	18.9
7.0	i-Butane	5.2
6.1	n-Butane	5.4
0.4	Cyclopentane	0.2
3.4	i-Pentane	2.6
1.6	n-Pentane	1.8
	2-methylpentane	0.7
	3-methylpentane	0.4
1.1	n-Hexane	1.0
0.4	Benzene	2.0
1.0	Cyclohexane	1.1
2.6	Heptanes	1.0
0.1	i-octane	0.3
0.3	Methylcyclohexane	
0.7	Toluene	4.1
0.6	n-octane	0.9
0.0	Ethylbenzene	0.4
0.4	Xylenes	2.8

Positive Matrix Factorization (PMF) UW 2011 Data

A two factor solution:

1. Wet gas fugitive short chain VOC
2. Aromatic and long chain VOC*

*in March 2011 factor 2 tracks ozone rise during episode conditions

Ozone Production Potential based on OH reactivity and UW Ambient Air concentrations

% contribution based on ppb March 2011

Number of Compounds	Group	Carbon Number	% Contribution
<u>n=1</u>	Methane	C1	7.9
<u>n=8</u>	Alkenes	C2 to C5	8.7
<u>n=11</u>	NG Short Chain Alkanes	C2 to C6	25.8
<u>n=8</u>	Aromatics	C6 to C9	43.4
<u>n=4</u>	Long Chain Alkanes	C7 to C10	13.8

LOCATION, LOCATION LOCATION (vs. Canisters)

Ozone Production Potential Biggest Targets

% contribution based on ppb March 2011

Compound(s)	% Contribution
Toluene	~10
Xylene isomers	~15
Trimethylbenzene isomers	~15
Total	40

Biggest Target (B)TEX-TMB

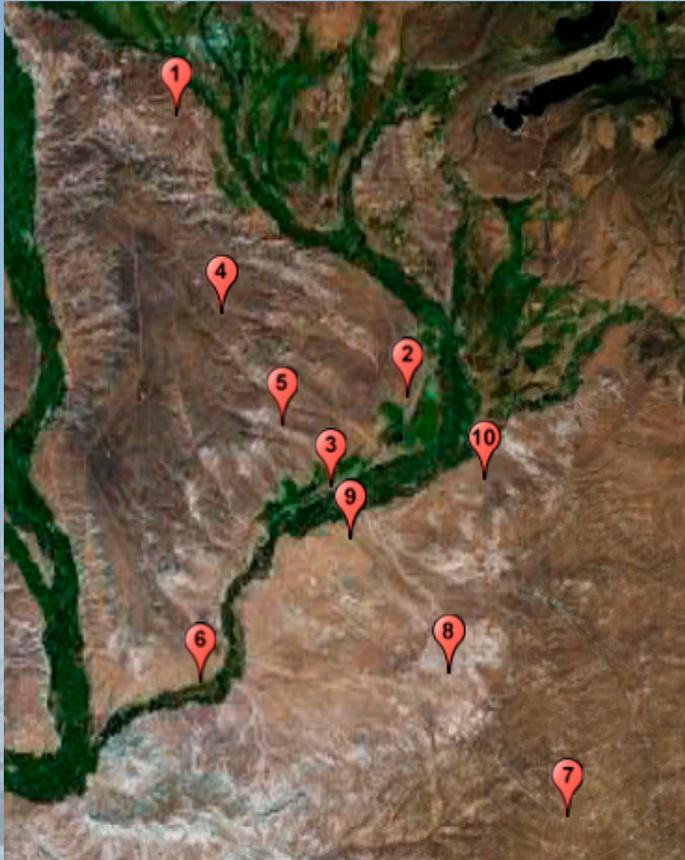
Do we know the relative importance of contributing emission sources for these compounds?

90+ % of JPDA Condensate consists of C7 and above compounds

PASQUA 2012



12 CANISTER SURVEYS 2012



12 Canister Surveys

One a week

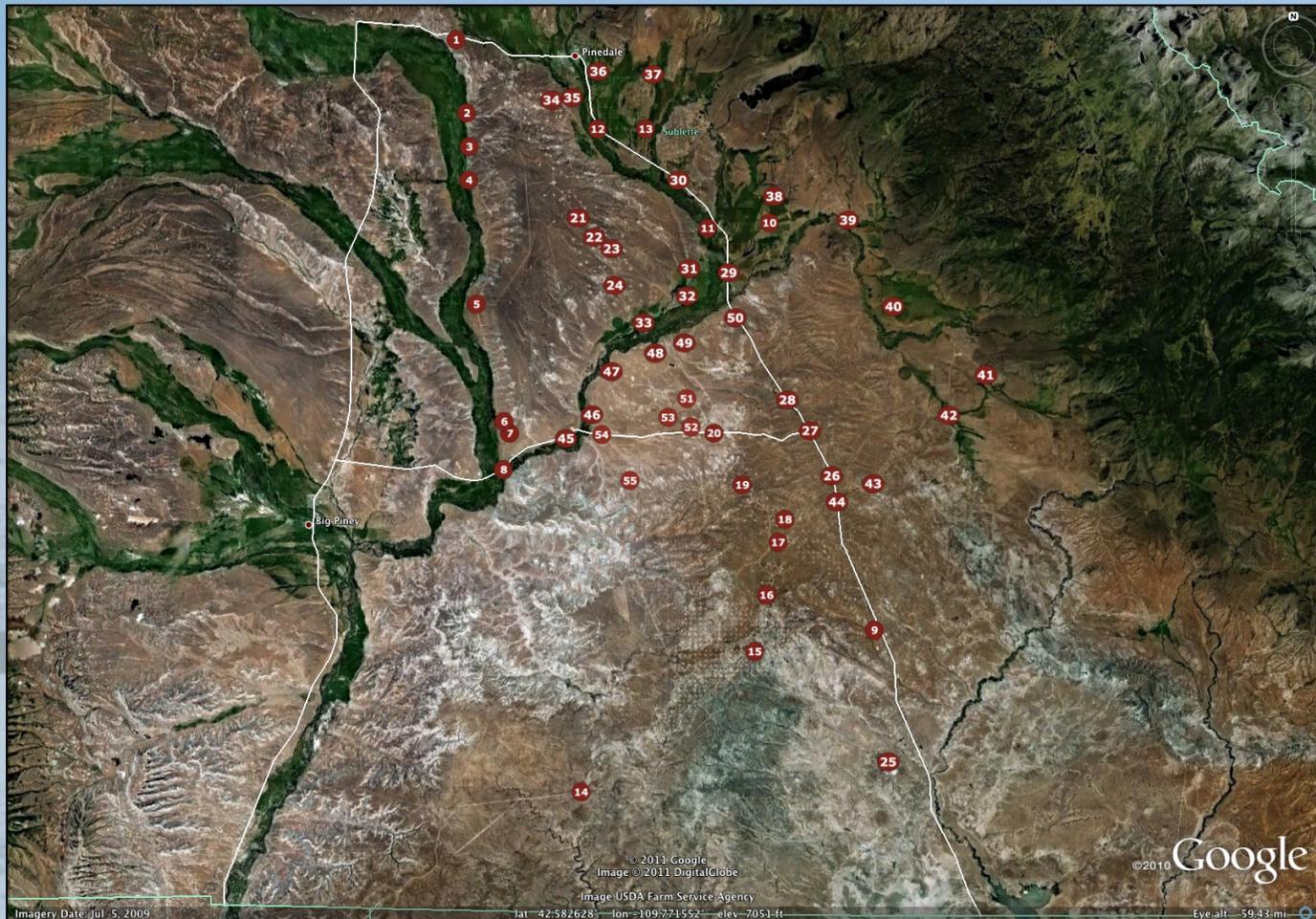
January to March 2012

The background of the slide is a light blue, semi-transparent image of a coastal landscape. It shows waves breaking on a sandy beach in the foreground, with a range of mountains or hills in the distance under a clear sky. The overall tone is calm and natural.

SPATIAL SURVEYS BTEX AND NO_x

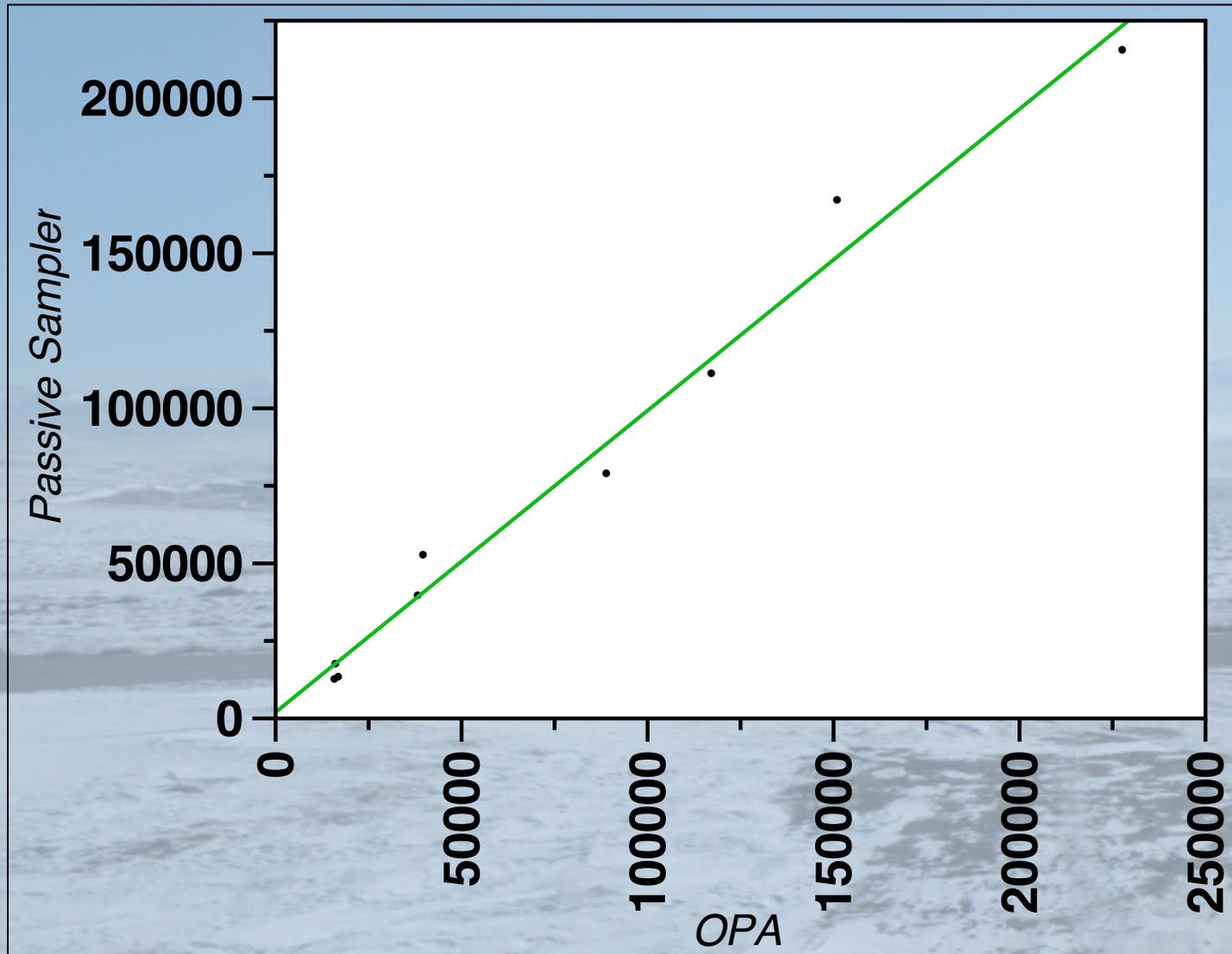
**(March 2011)
November 2011
February 2012**

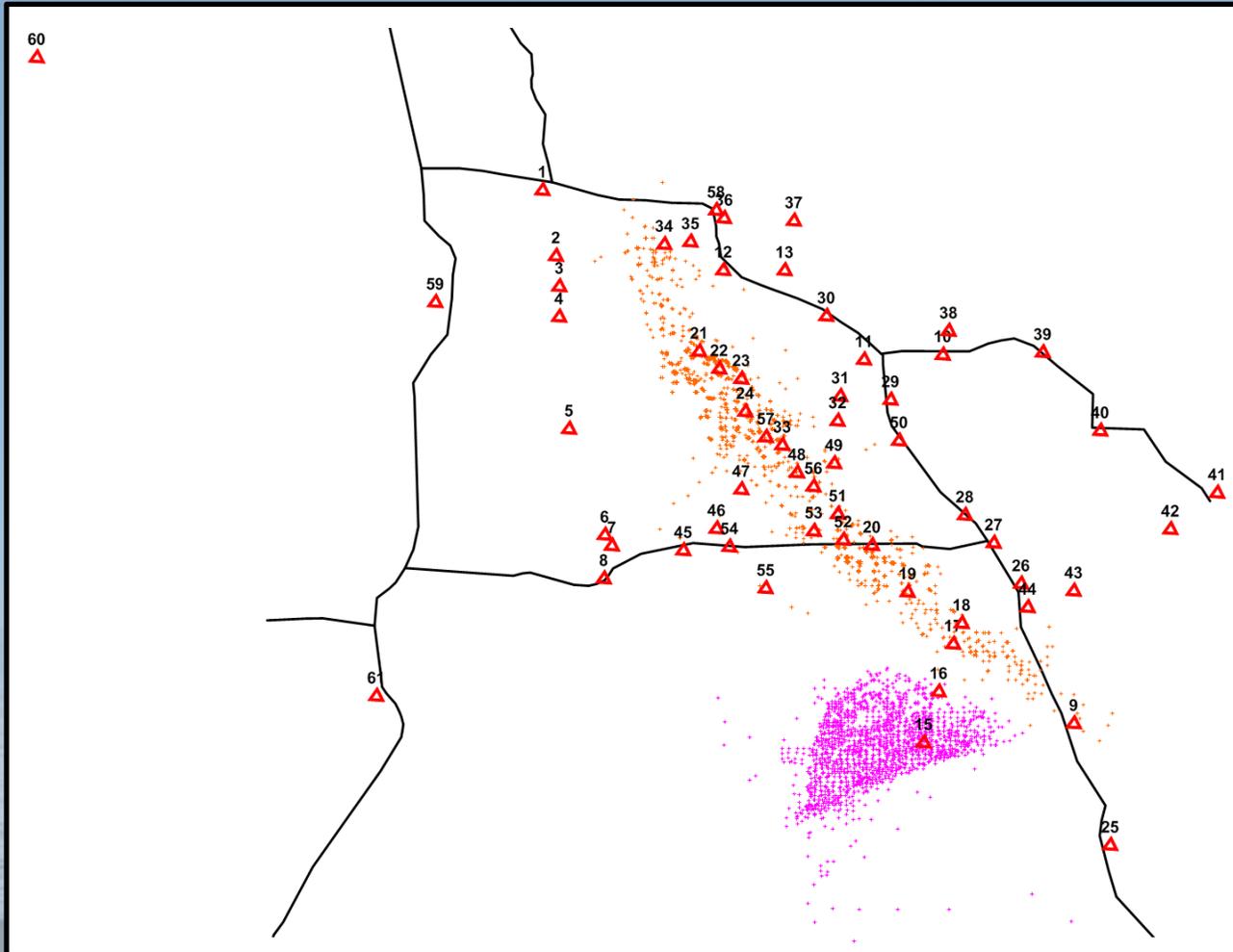
LOCATIONS: BTEX & NO_x SURVEYS



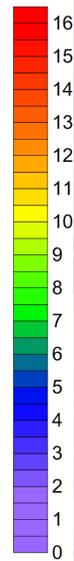
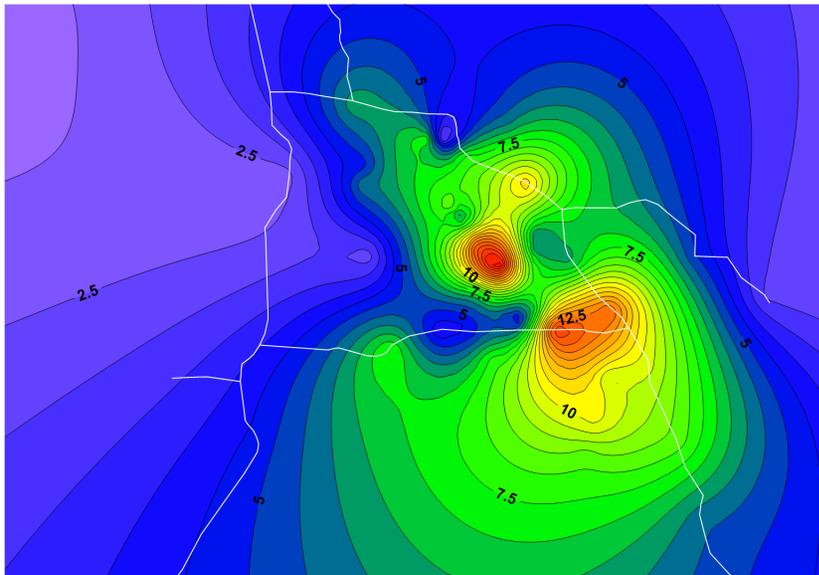
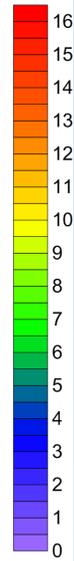
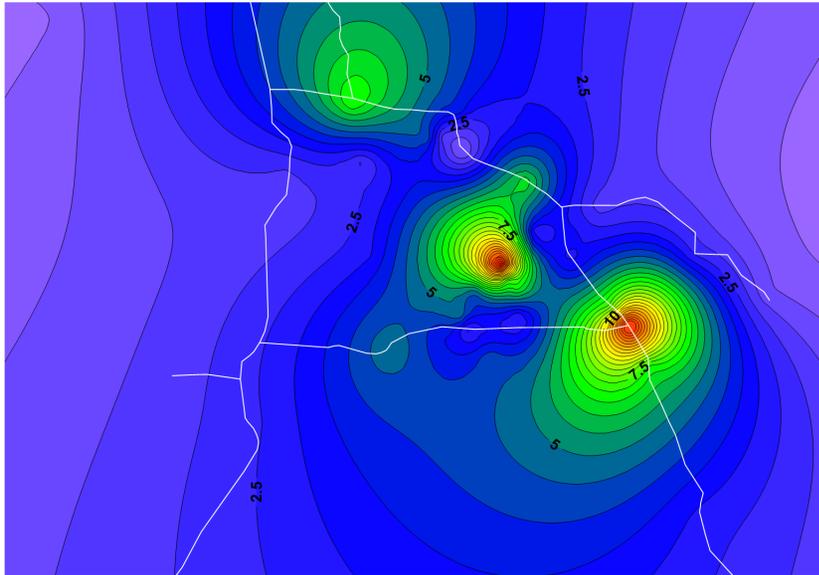
11 CO-LOCATED SITES 2011

RAW BENZENE RESPONSE





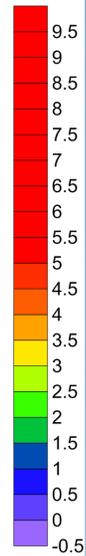
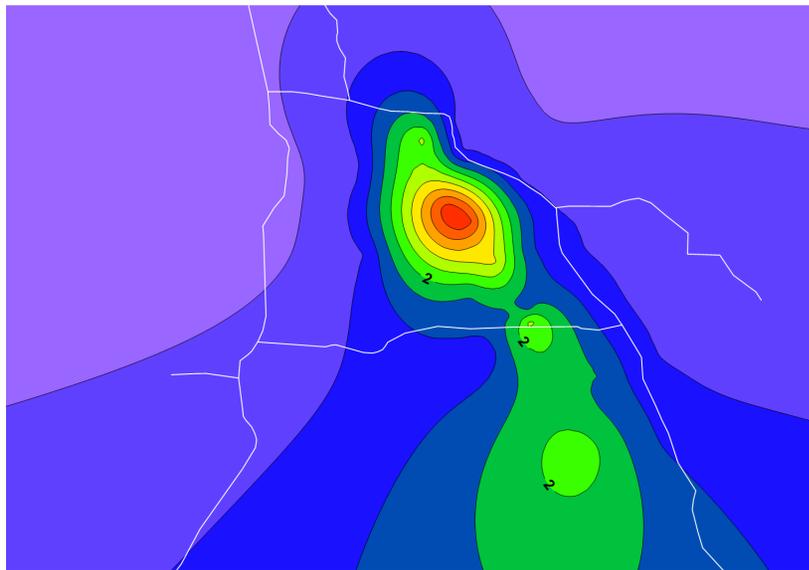
2011-12 PASQUA BTEX-NO_x Sites



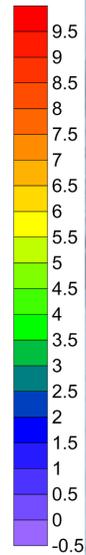
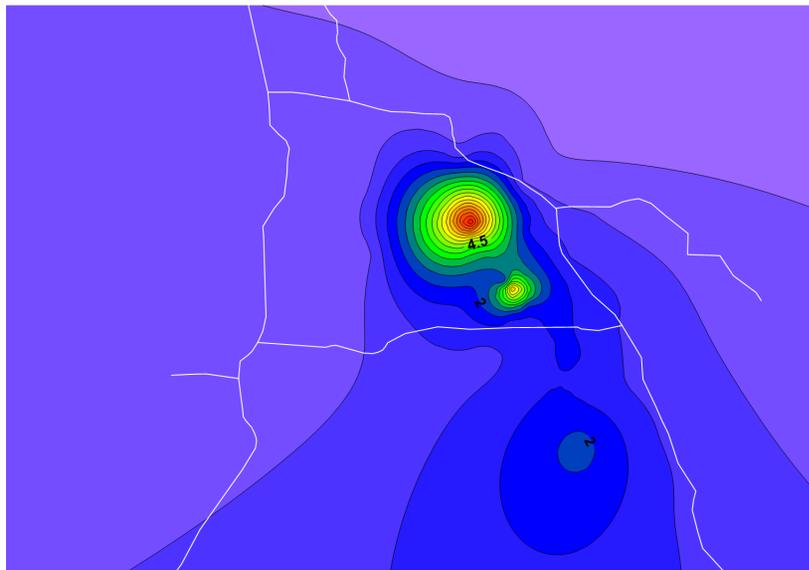
**November 2011
NO_x ppb**

**February 2012
NO_x ppb**

**Traffic and
Compressor Stations**

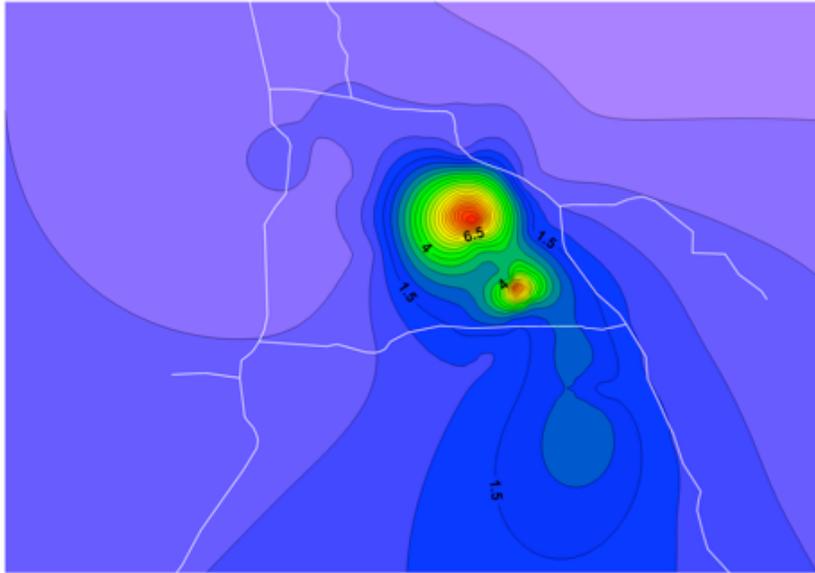


**November 2011
benzene ppb**

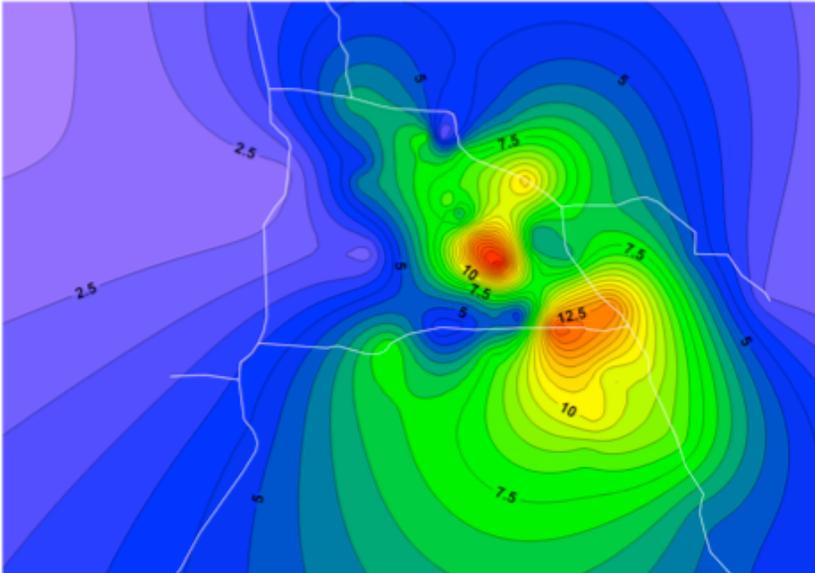
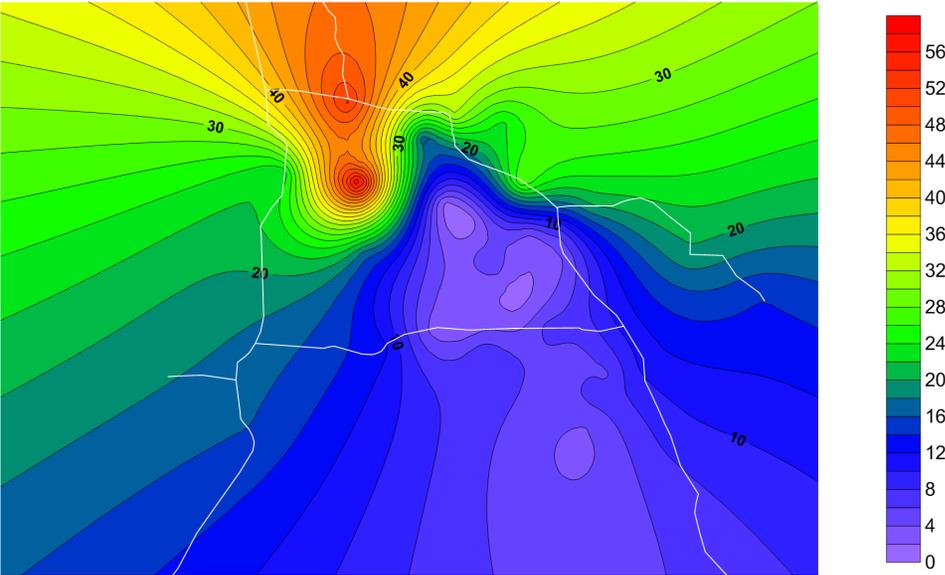


**February 2012
benzene ppb**

**Production and
Handling**



February 2012 NO_x : Toluene



Ozone production zone

UW ATSC Results:

On-going:

Seinfeld and Carter (2012) published

Field et al (2012) in preparation

Rappenglueck and Field (2012) in preparation

And...

Ozone Control Big Picture

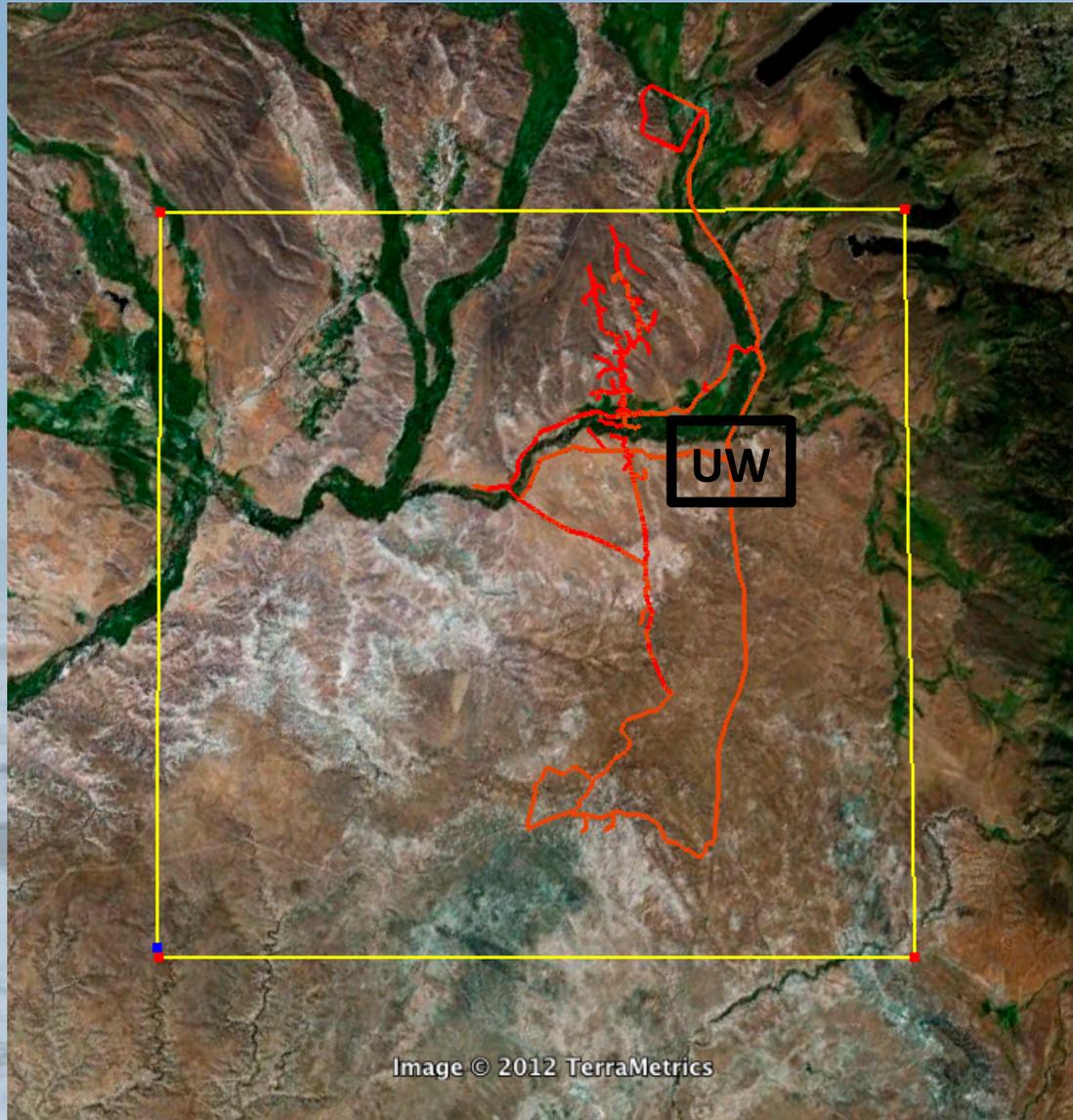
EI Validation First Steps

Key work

OZONE Control

1. NO_x starvation (Derwent pc)
 - engines in major sources
 - reduce traffic in key areas
2. Reduce reactive VOC (Field pc)
 - targeted at (B)TEX-TMB
 - production & handling

EI Validation and Refinement



Selected VOC Emission Rates: WDEQ Emission Inventory Estimate vs. UW Ambient Box Calculation March 2011 ($r^2 = 0.97$)

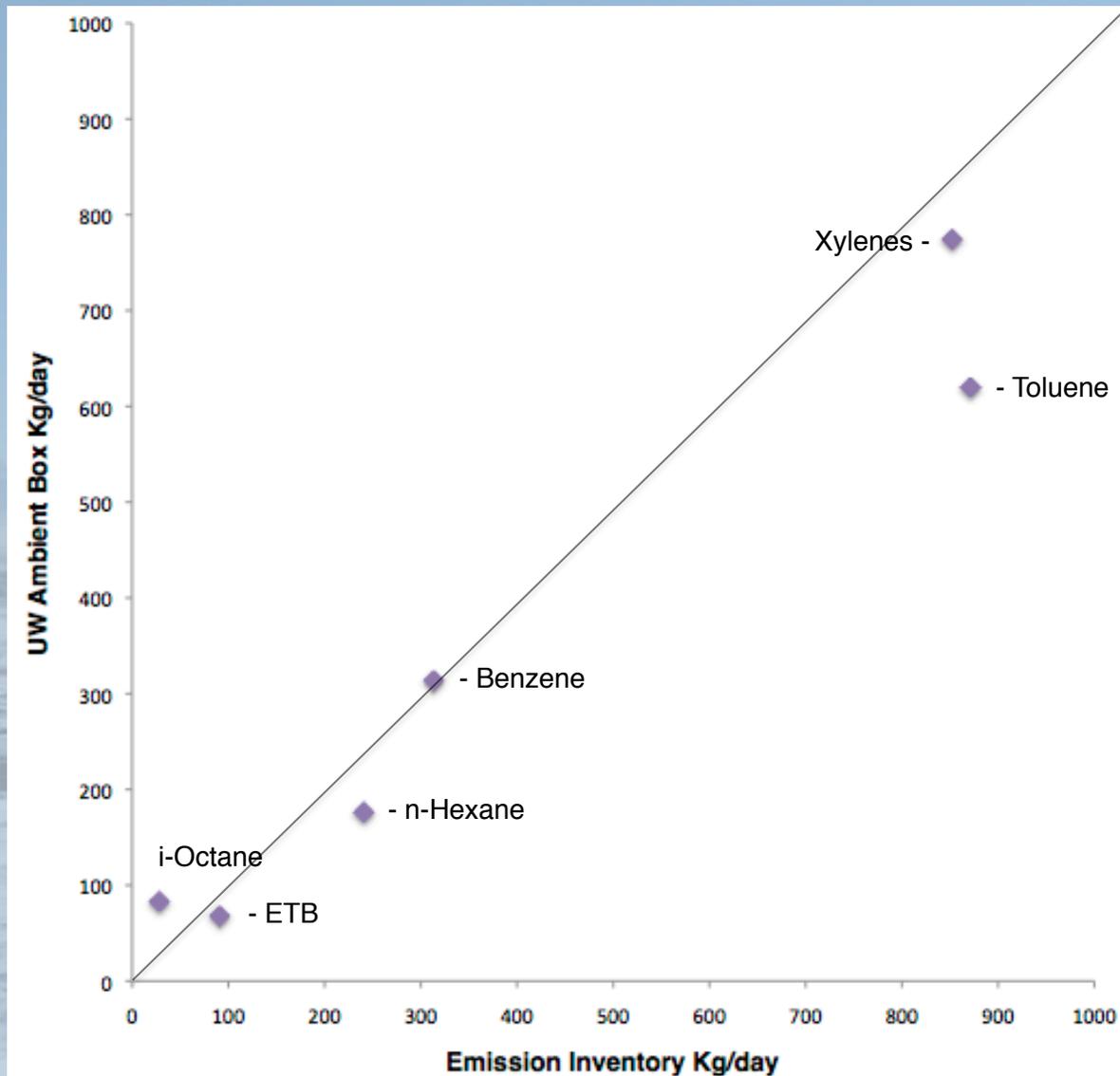
Case 1: Slope 1.2
simple base case

Case 1: Slope <0.3
box is unrealistic
Reasons.....

Case 1: Slope >0.3
EI is unrealistic
Reasons.....

Lucky?

Guessing game! vs.
systematic science



Selected Emission Rates:

WDEQ Emission Inventory Estimate vs. UW Ambient Box Calculation March 2011

	WDEQ EI Kg/day	UW Ambient Box Kg/day
VOC	12,549	10,784
CO	3,606	5,000
NMHC		16,399
NO _x	9,151	1,165
CH ₄		26,500

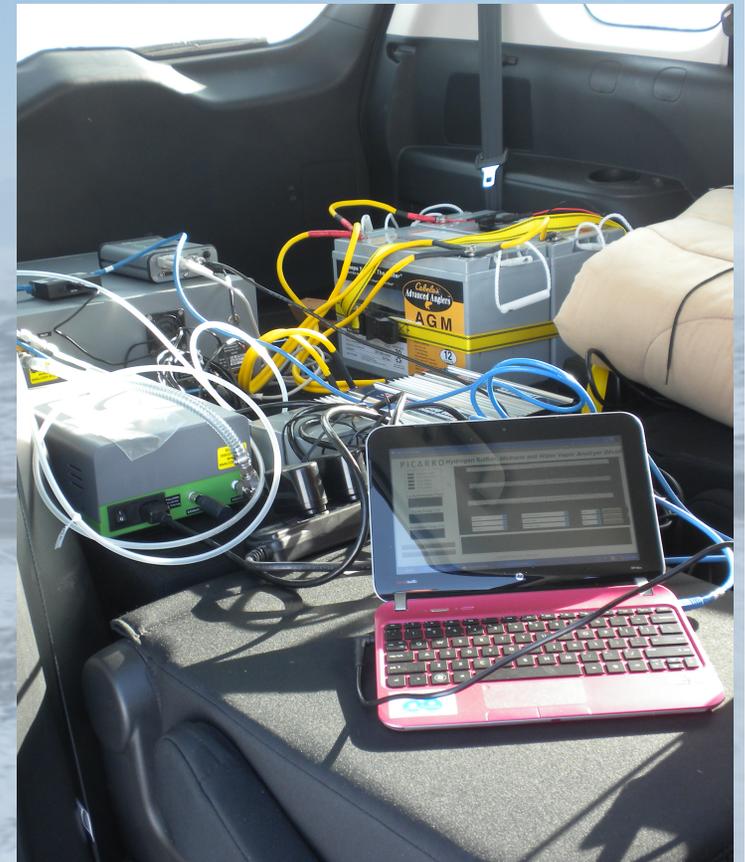
A Paradigm Shift for Air Quality



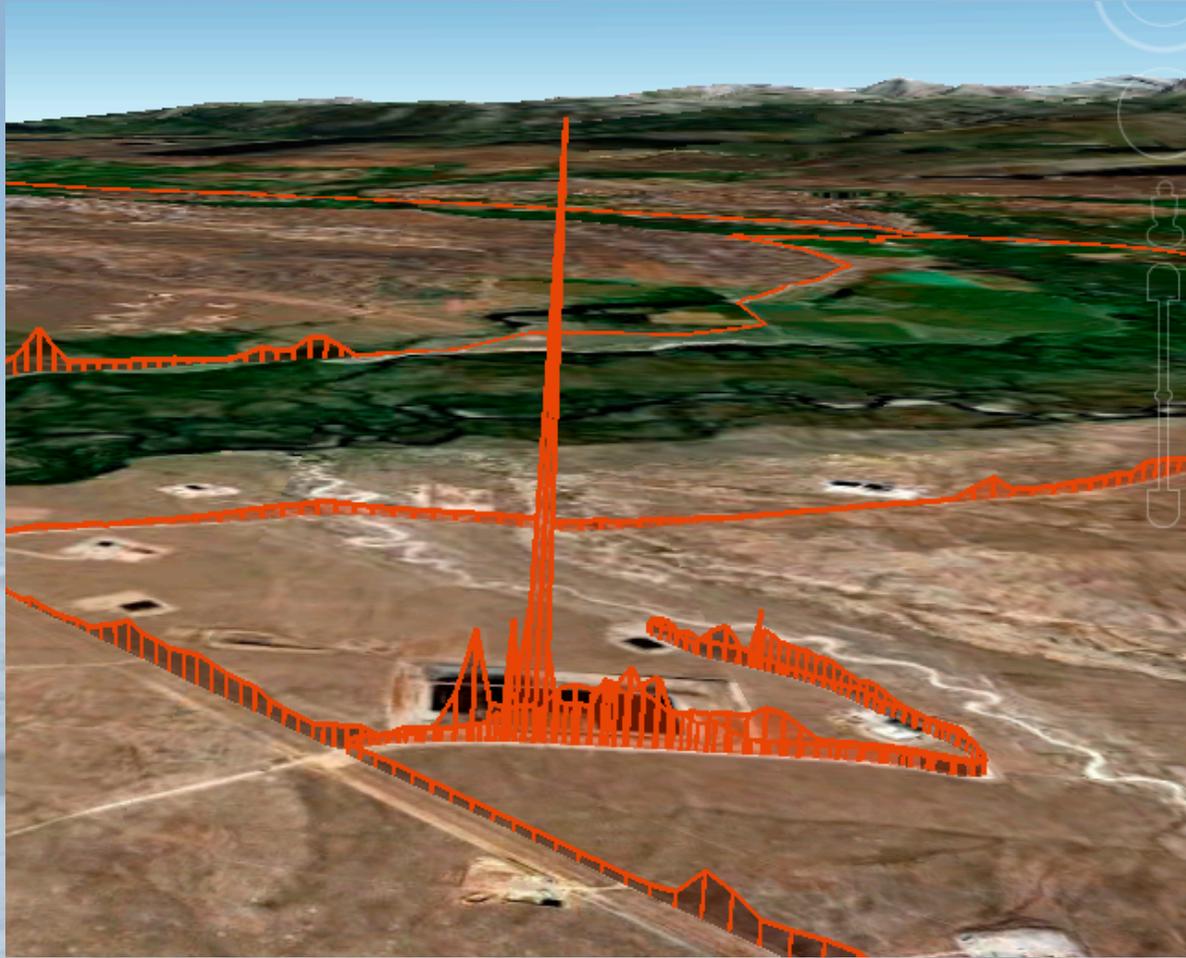
Real-time Highest Quality Mobile Monitoring



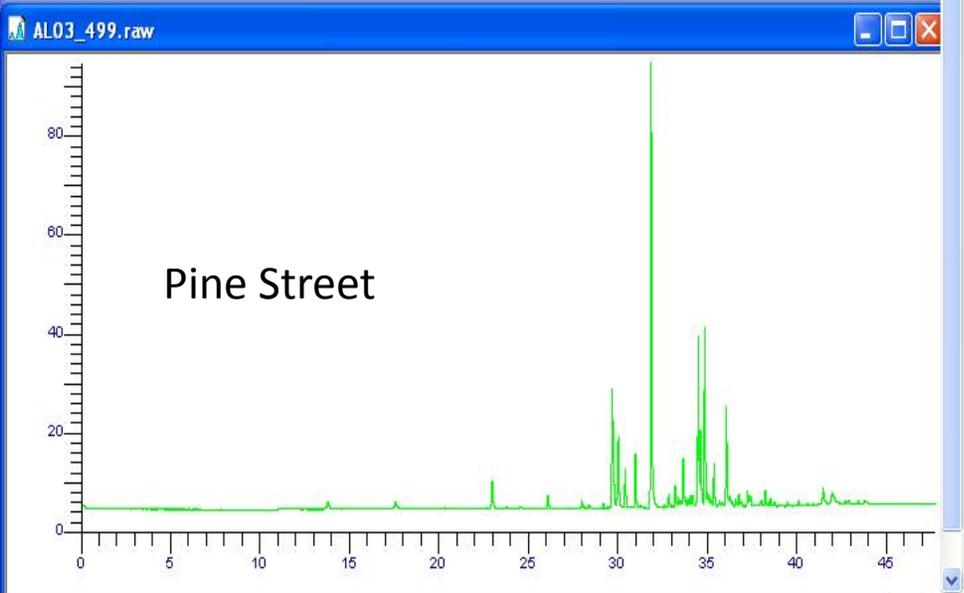
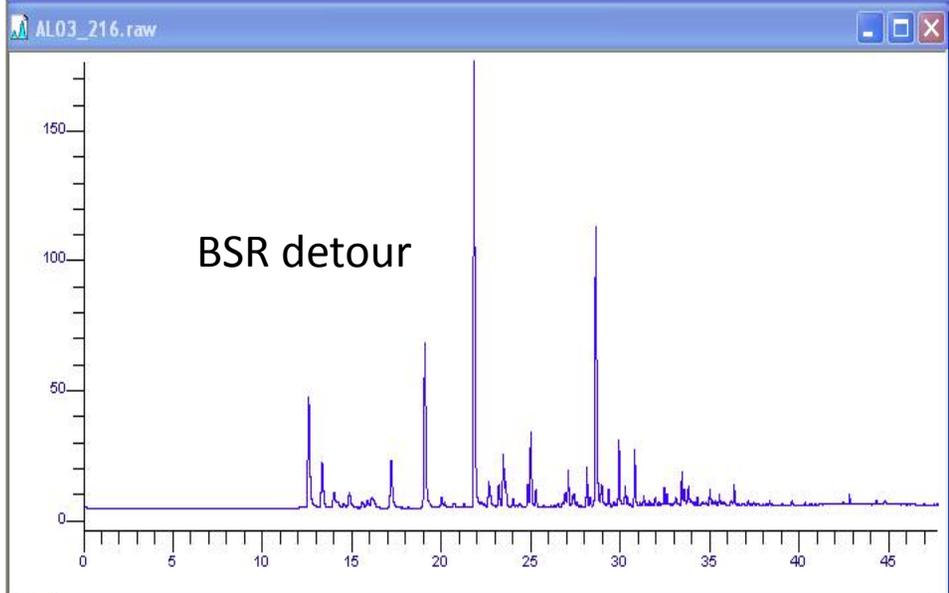
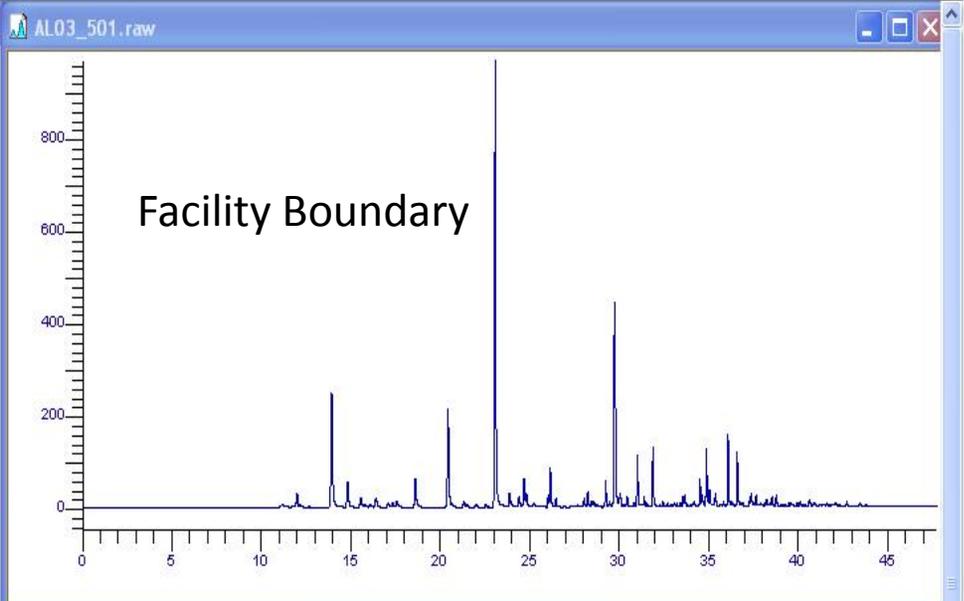
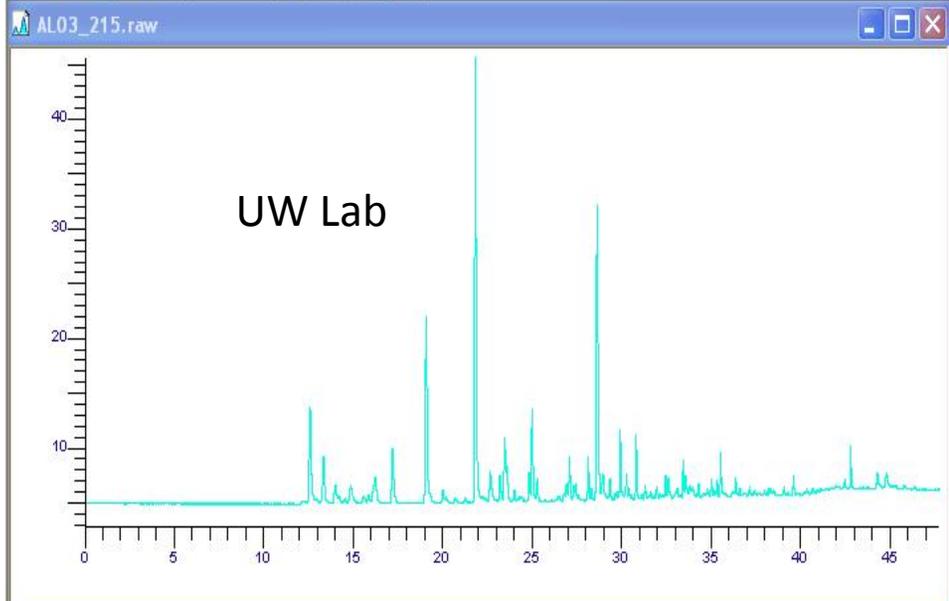
Picarro CH₄ & H₂S



Methane February 7th 2012 Water Treatment Facility

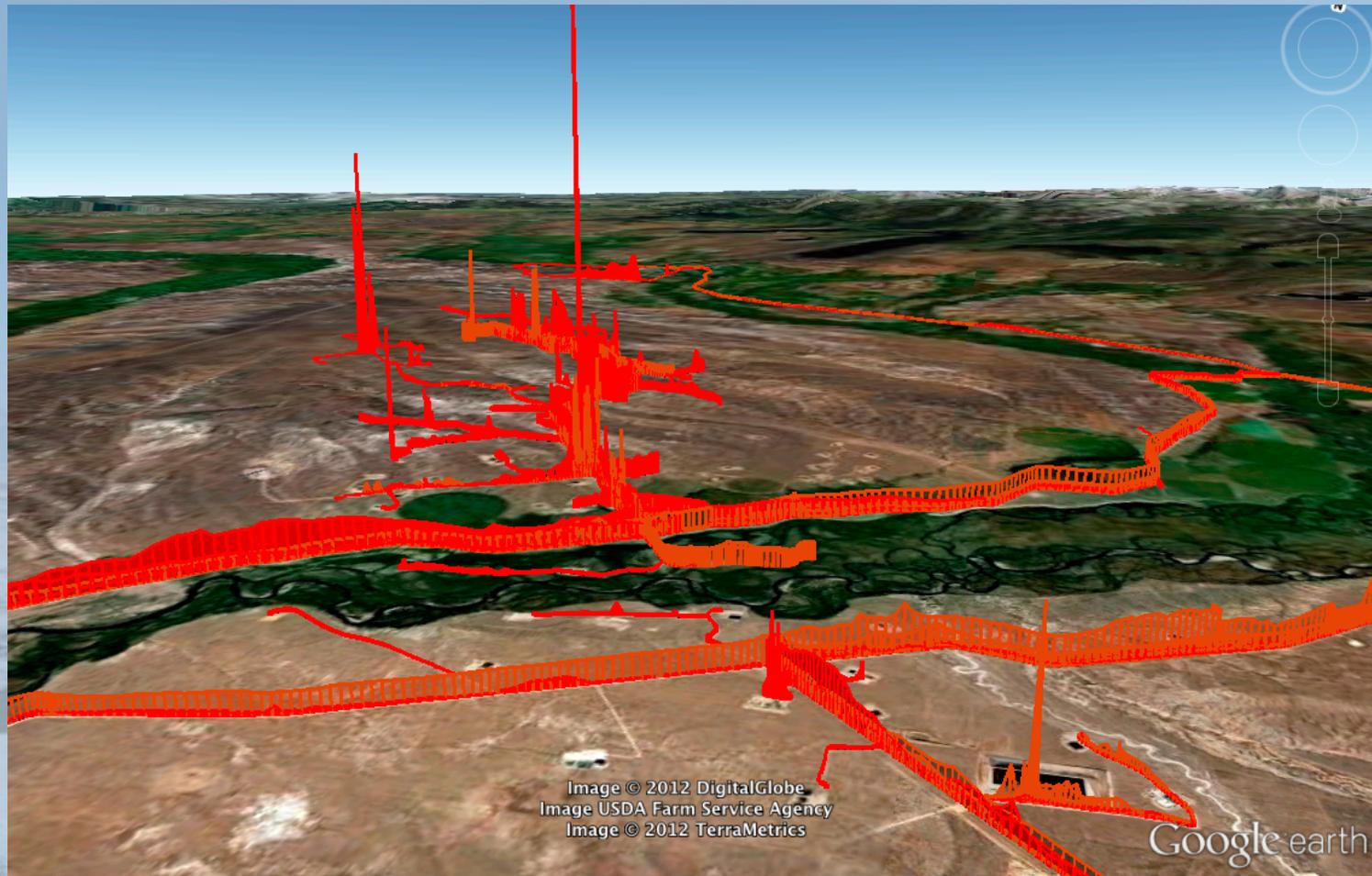






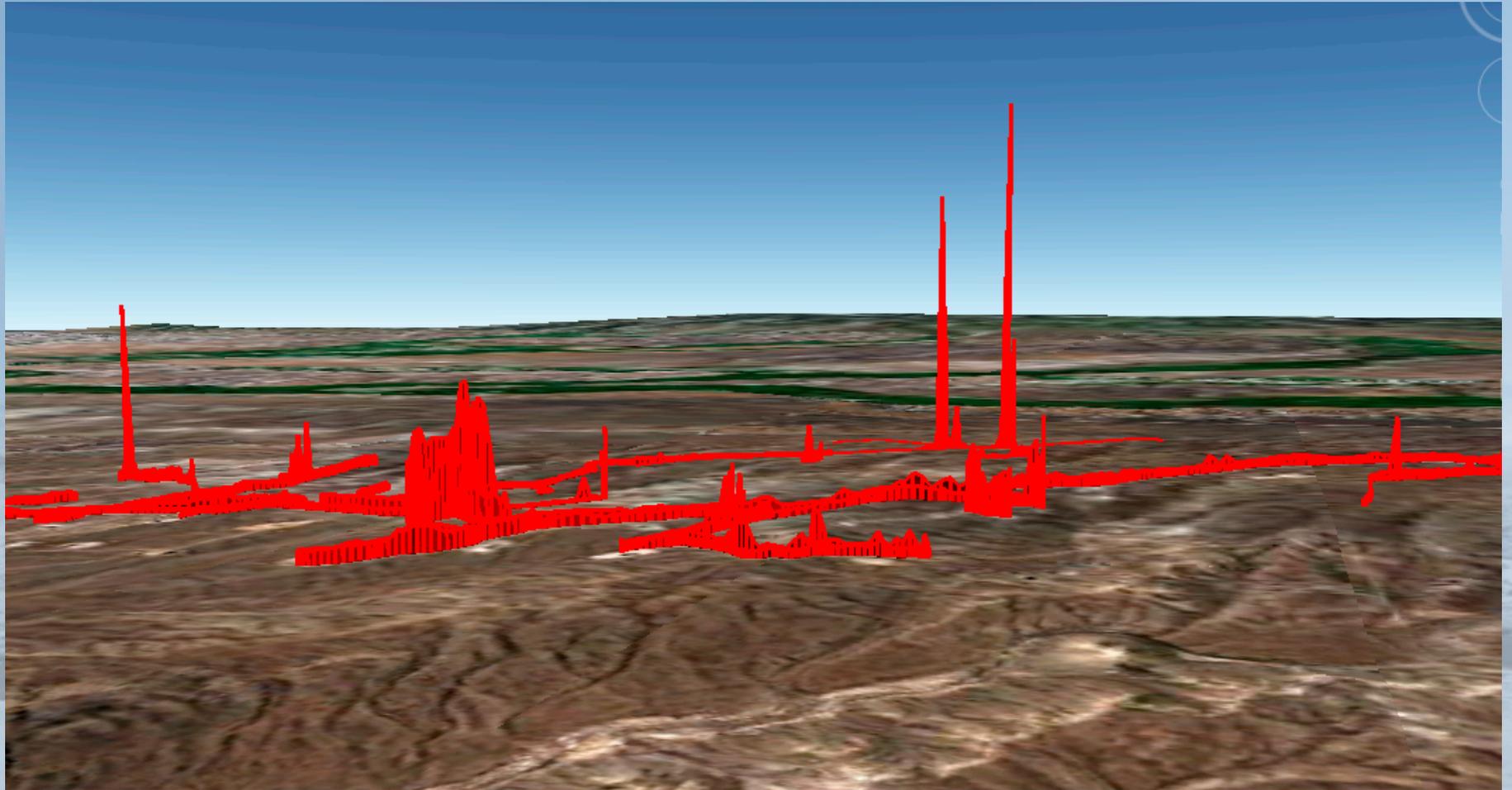
Combination Plot 3 hour runs

February 7th, 9th and 23rd; March 4th and 5th



Methane on the Mesa

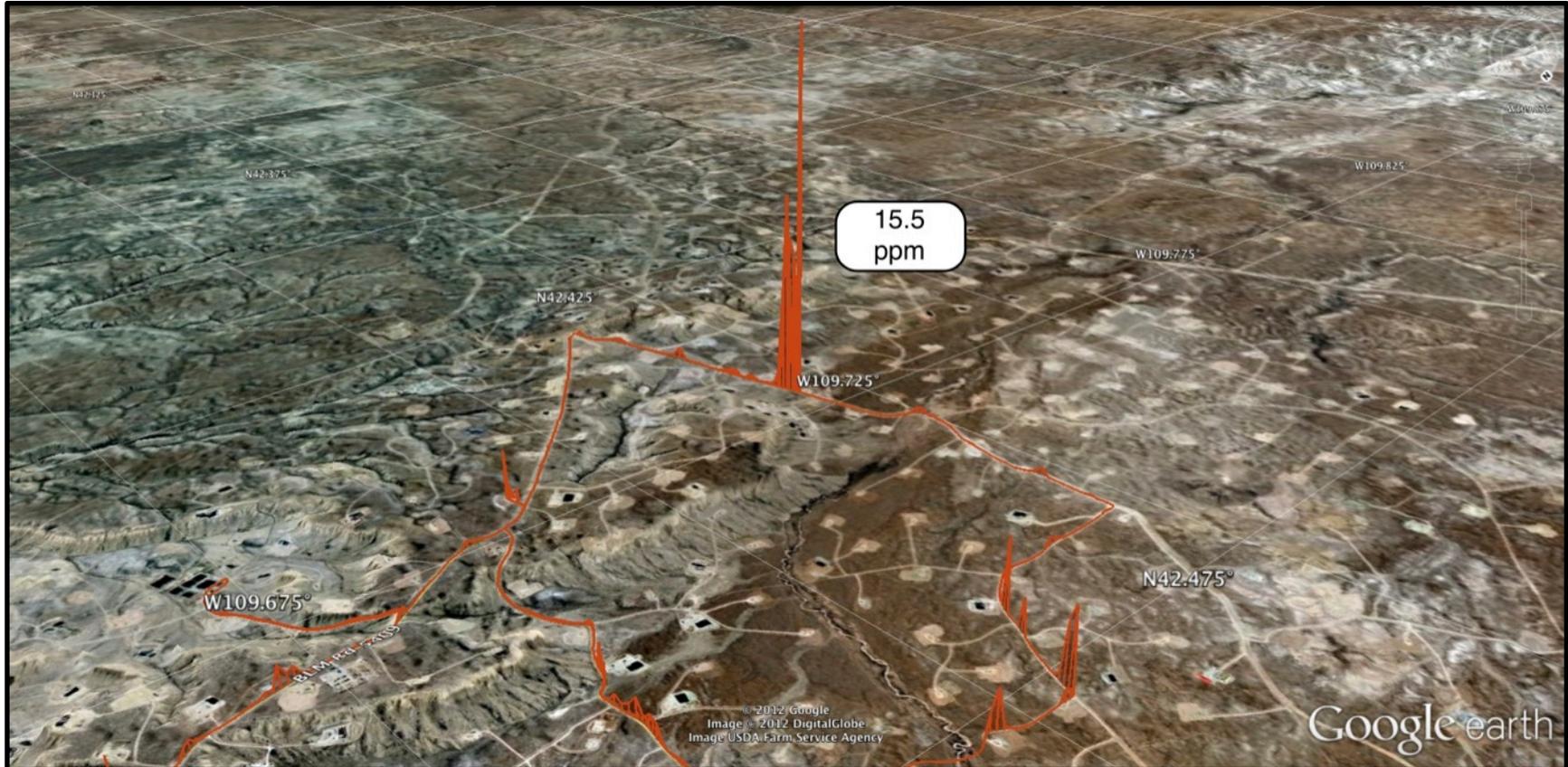
March 4th 2012





07 FEB 2012

Venting a Well



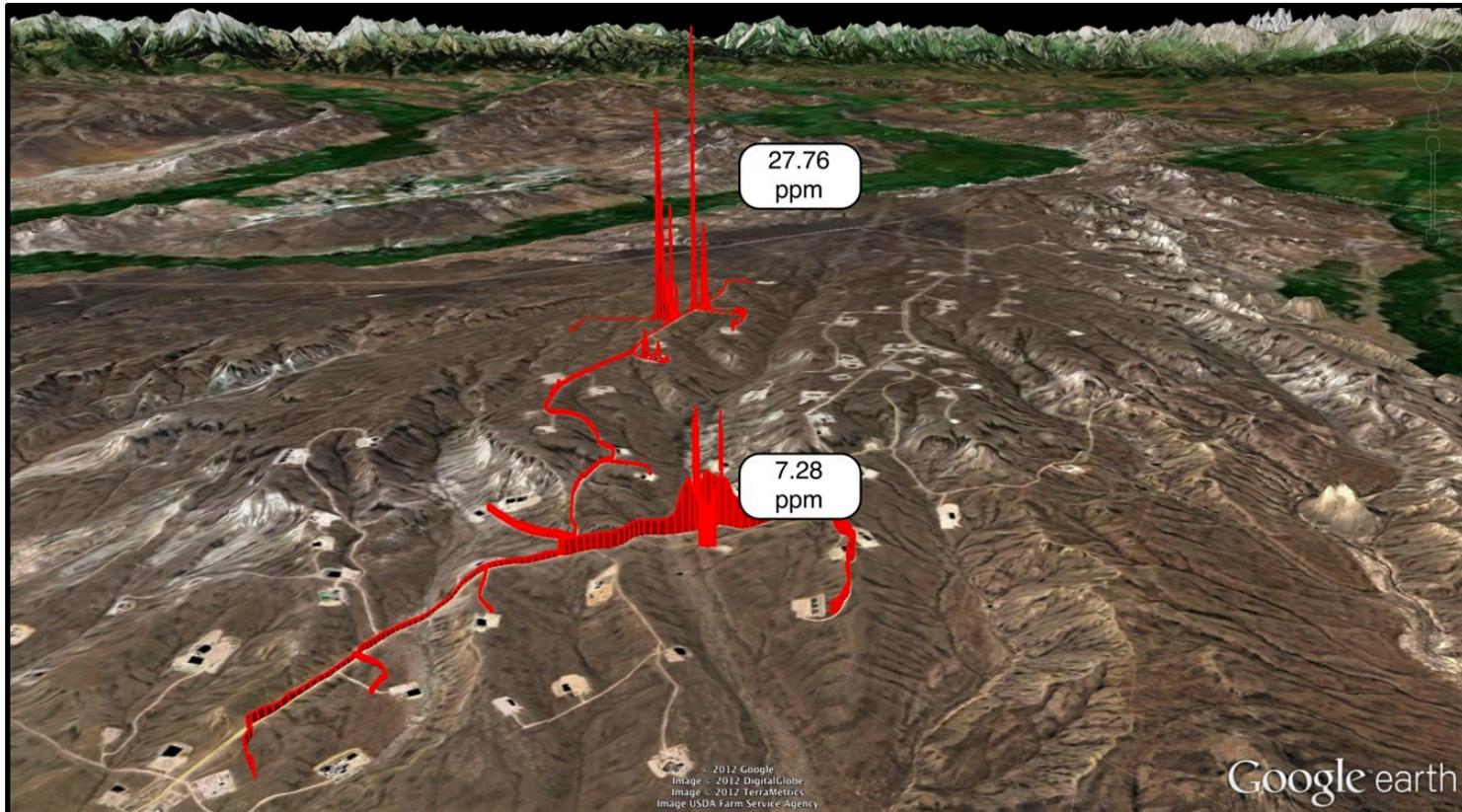
23 FEB 2012

Well Closed Due to Mishap

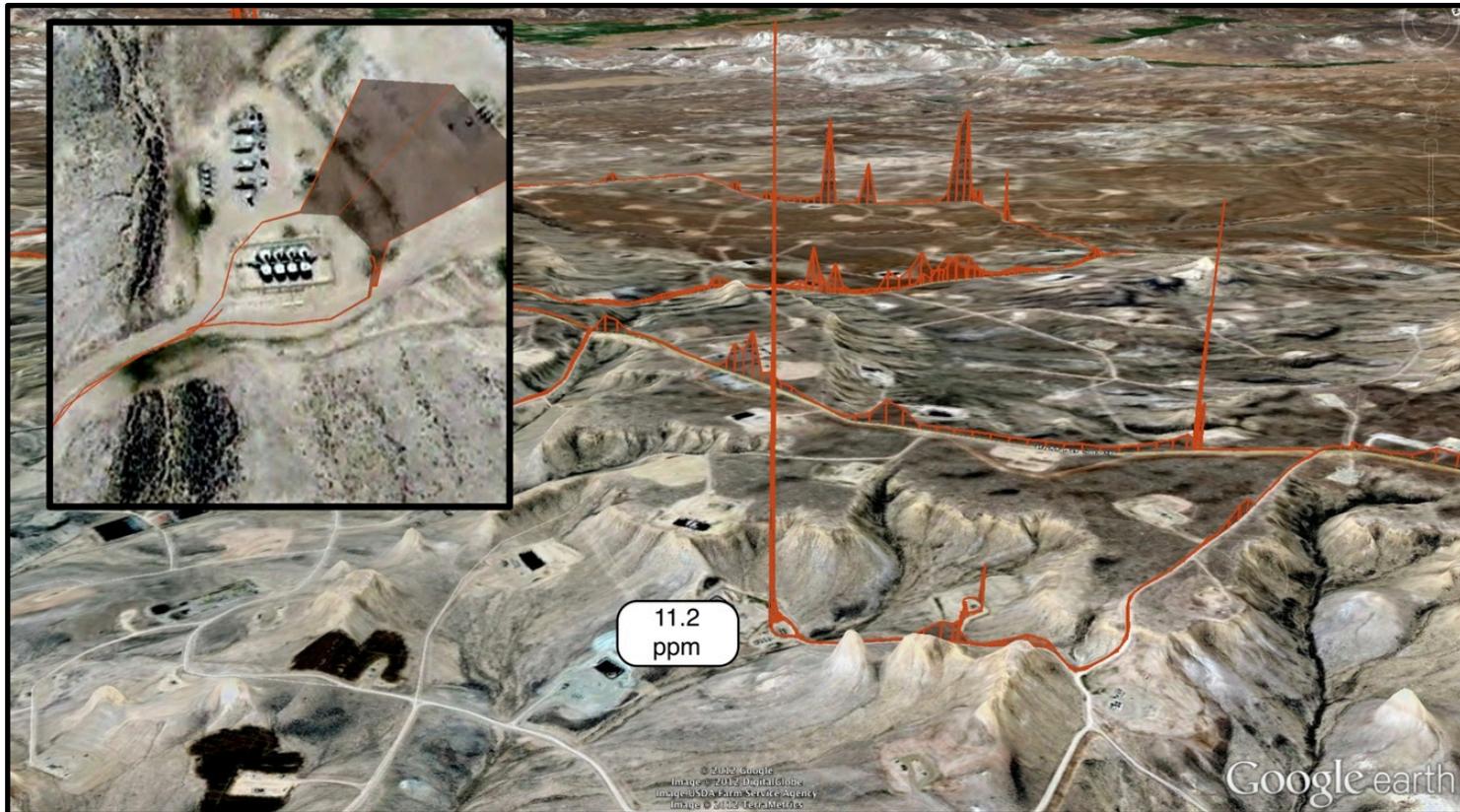


04 MAR 2012

Well drilling activity



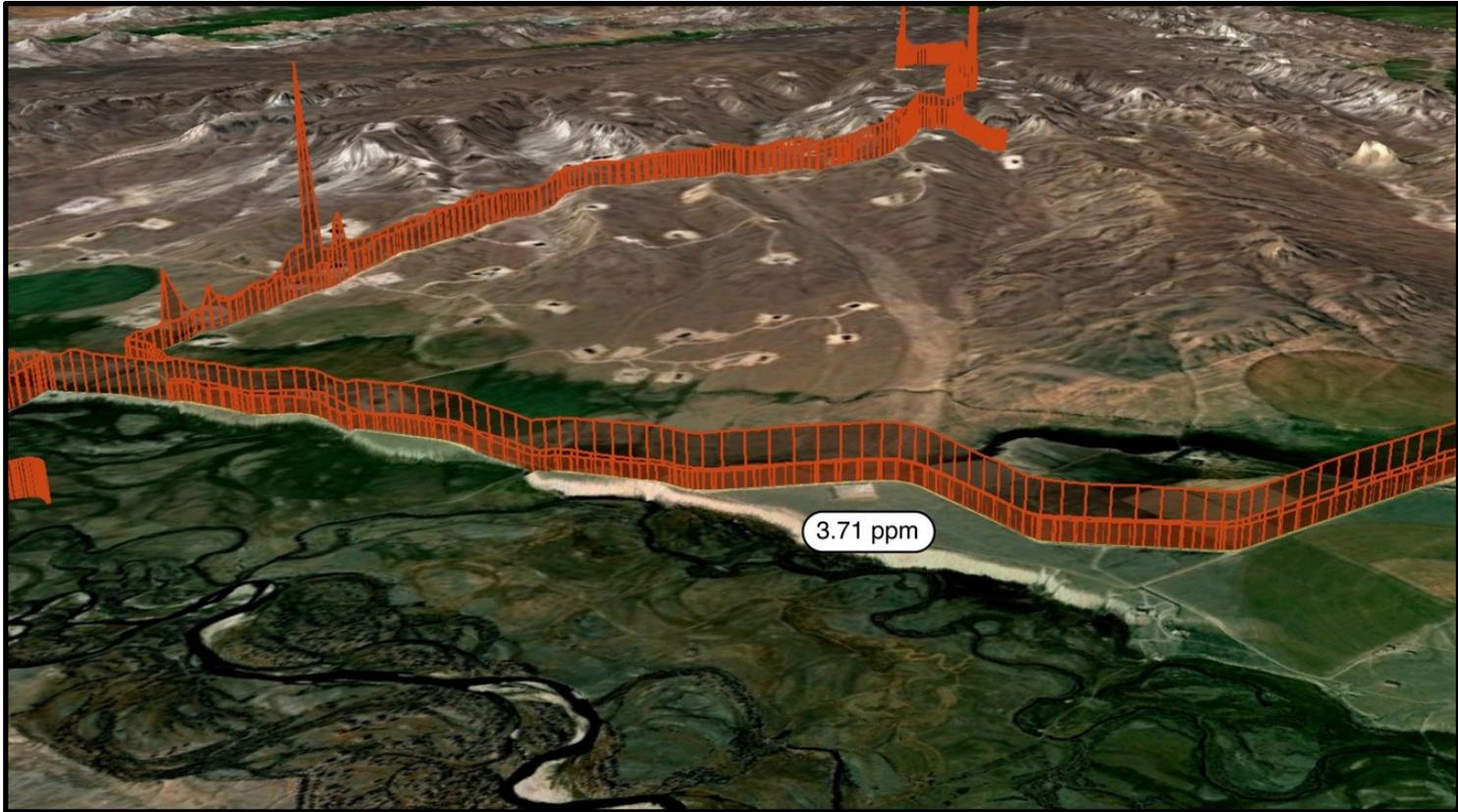
Drainage Flow from Previous Slide Drilling Activity



23 FEB 2012
Very Windy days
Isolated spikes easy to
identify sources



23 FEB 2012
Windy conditions show
peaks on background
baseline



07 FEB 2012
Same journey but very
different conditions
leading to accumulation

What new work is needed for Problem Resolution?

Photochemical Grid Model

**Emission Inventory Refinement and
Validation**

What can UW ATSC contribute?

Two Linked Projects:

“PAPA Mobile methane and NOx assessment”

“Targeted VOC canister source measurements”

Why? To identify opportunities with developers for emission reduction and to identify mitigation routes to eliminate the ozone problem without relying on the weather

Also because an emission inventory is a tool not reality! ..

Thank You & Questions?



RField1@uwyo.edu

