Aircraft Measurements in the Uintah Basin, February 2012

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Uintah Basin Campaign Overview

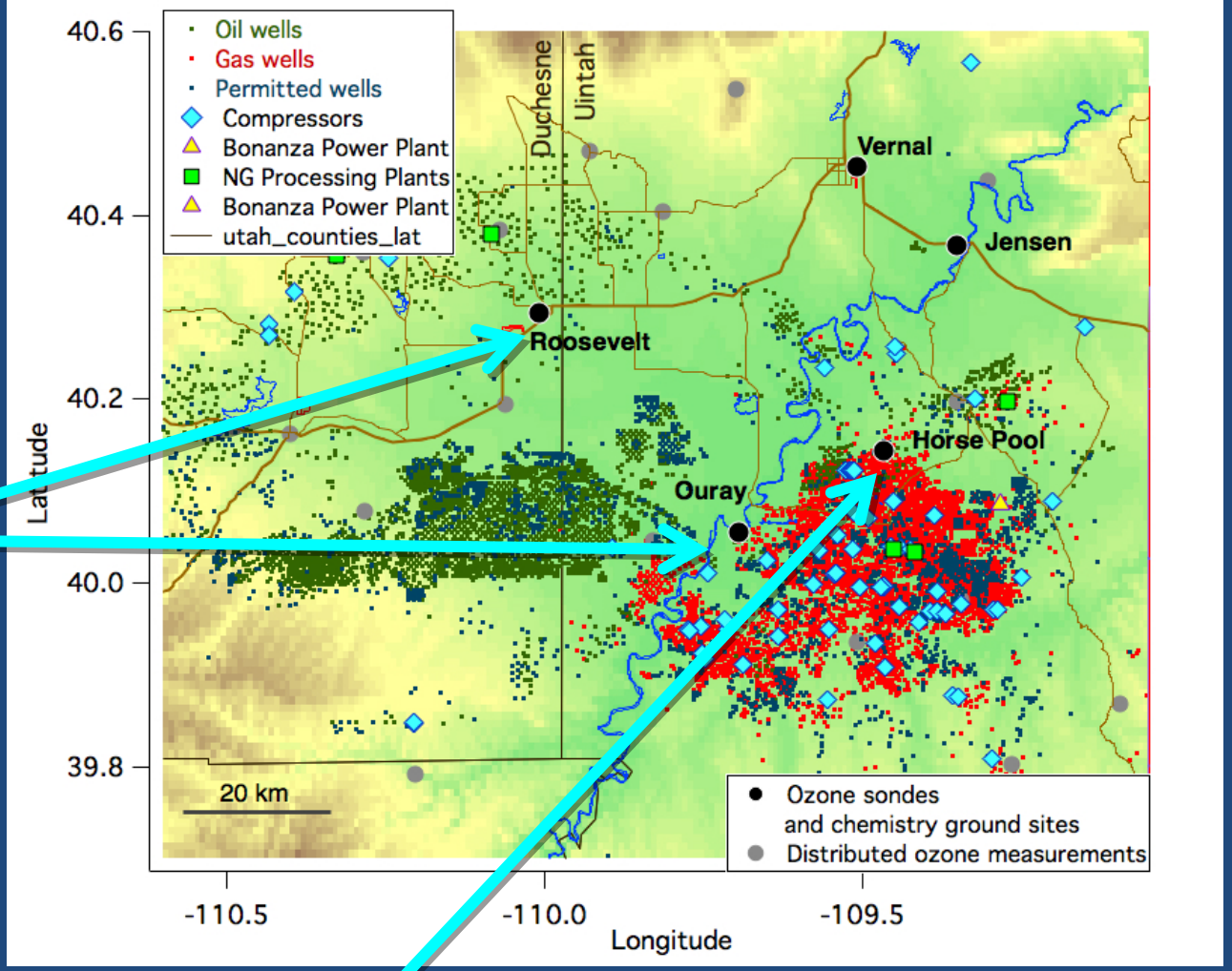
- Uintah County had the highest ozone levels in the nation in 2011
- Large producer of oil and natural gas
- Multi-agency/university field campaign
- Ozone precursor levels (VOCs) – mechanisms lead to high O_3 events in winter
  - Difficult to quantify and not well-known
- Methane is used as a tracer for natural gas leakage
  - raw gas usually contains 70-90% methane
  - instruments capable of high-frequency, accurate methane measurements
  - Emissions of CH_4 can be used to determine VOC emissions
- Please visit Gabrielle Petron's poster this afternoon

Mobile Lab: VOCs, ozone, CH_4, CO_2, CO

Light aircraft:

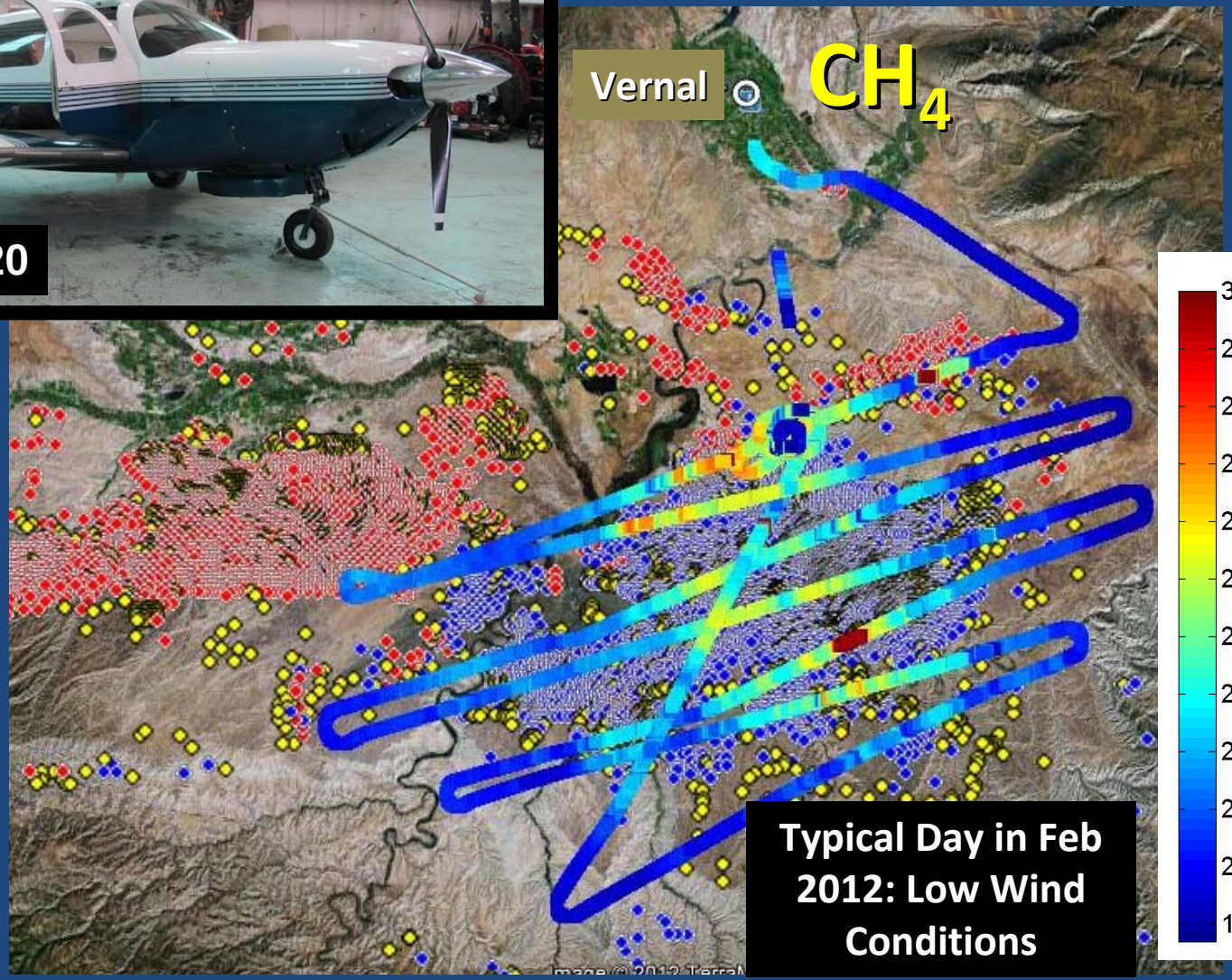
- ozone (2B)
- CH_4, CO_2 (Picarro)
- NO_2 (LGR)
- Flasks with VOCs
- Temp, RH

Balloon: ozone, T , RH

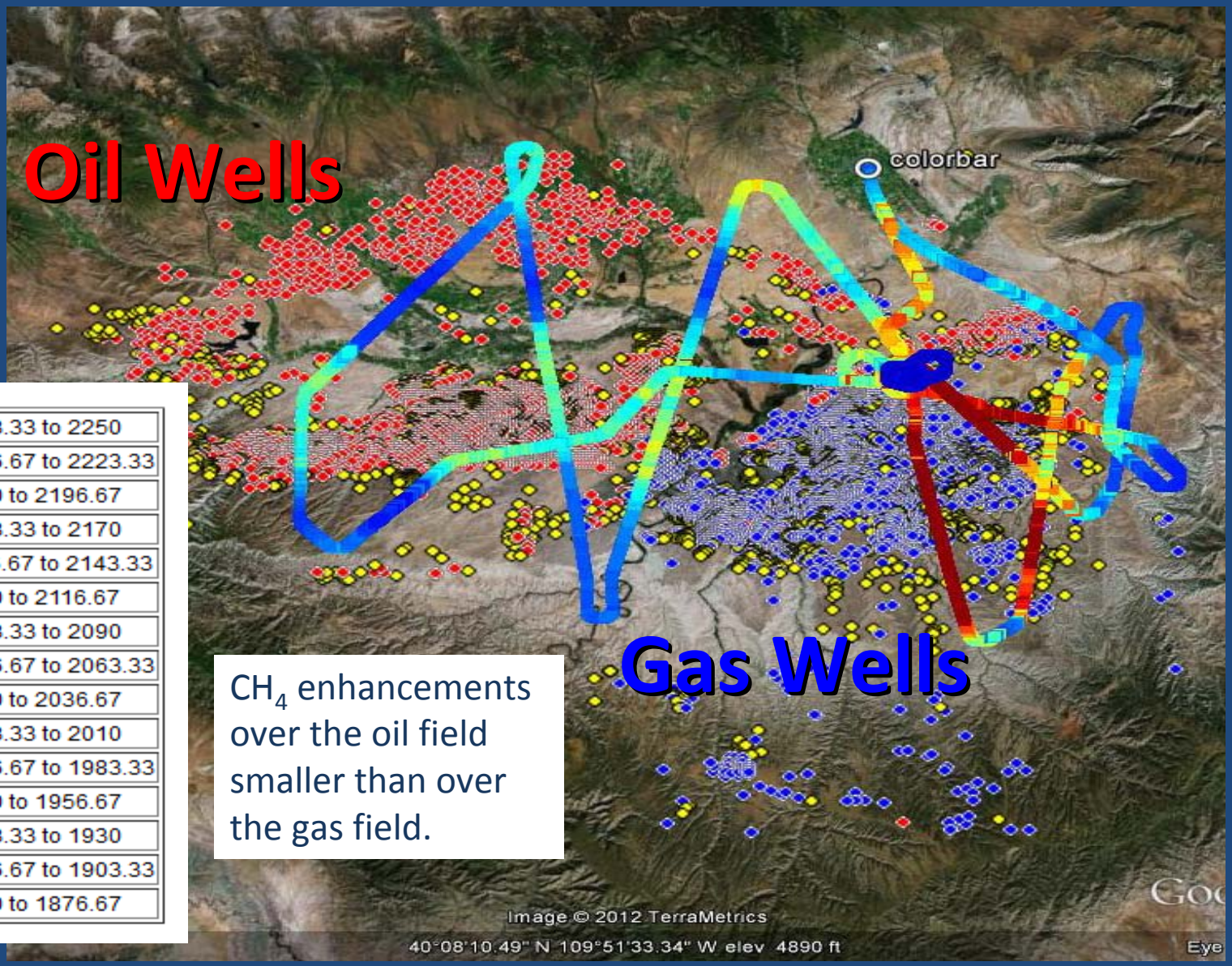


Ground site: Lidar wind profiler, VOCs, NOx, ozone, methane (CH_4), Met.

Uintah Basin, Feb 7, 2012: NOAA Airborne Measurements



NOAA Global Monitoring Division
Aircraft Measurements of CH_4, February 4 , 2012

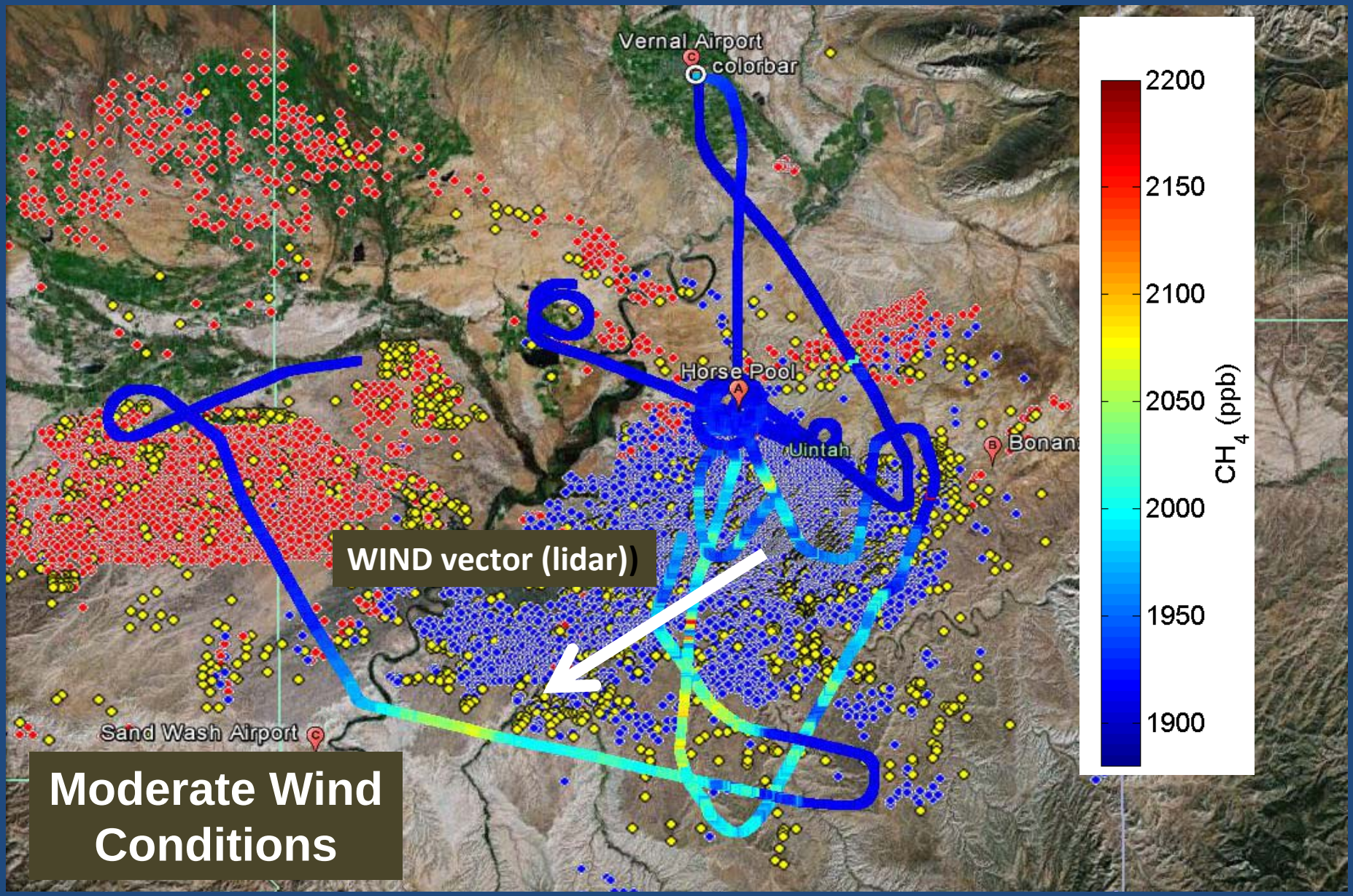


CH_4 (ppb)

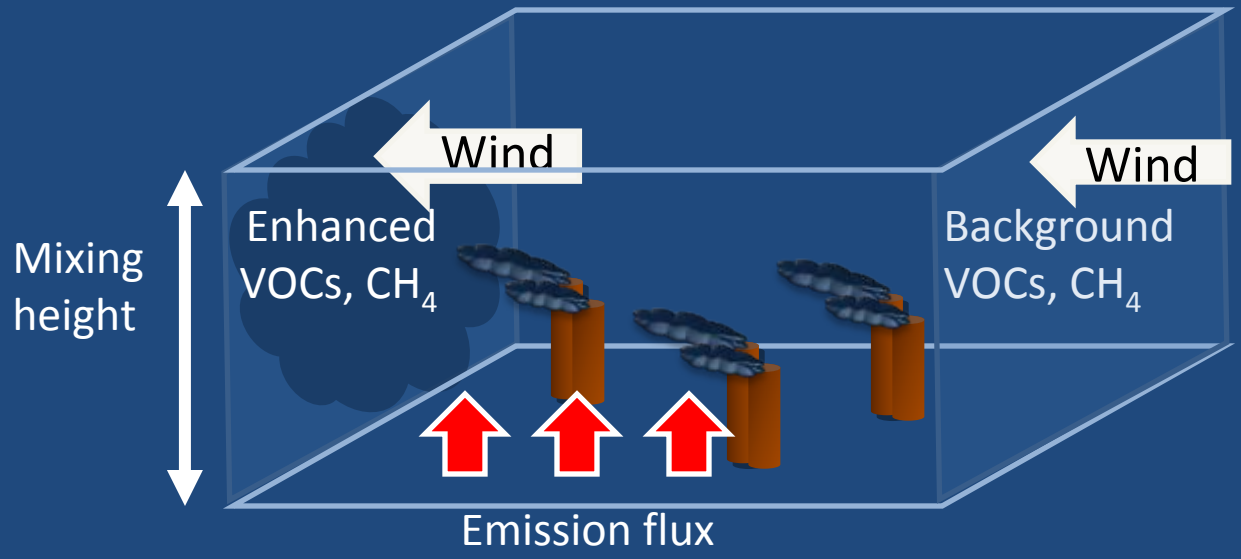
2223.33 to 2250
2196.67 to 2223.33
2170 to 2196.67
2143.33 to 2170
2116.67 to 2143.33
2090 to 2116.67
2063.33 to 2090
2036.67 to 2063.33
2010 to 2036.67
1983.33 to 2010
1956.67 to 1983.33
1930 to 1956.67
1903.33 to 1930
1876.67 to 1903.33
1850 to 1876.67

CH_4 enhancements over the oil field smaller than over the gas field.

NOAA Global Monitoring Division
Aircraft Measurements of CH_4, February 3 , 2012



Mass Conservation



$$\dot{m}_{CH_4} = \iint_{CS} \rho_{CH_4} V_n \, dA_{out} - \iint_{CS} \rho_{CH_4} V_n \, dA_{in}$$

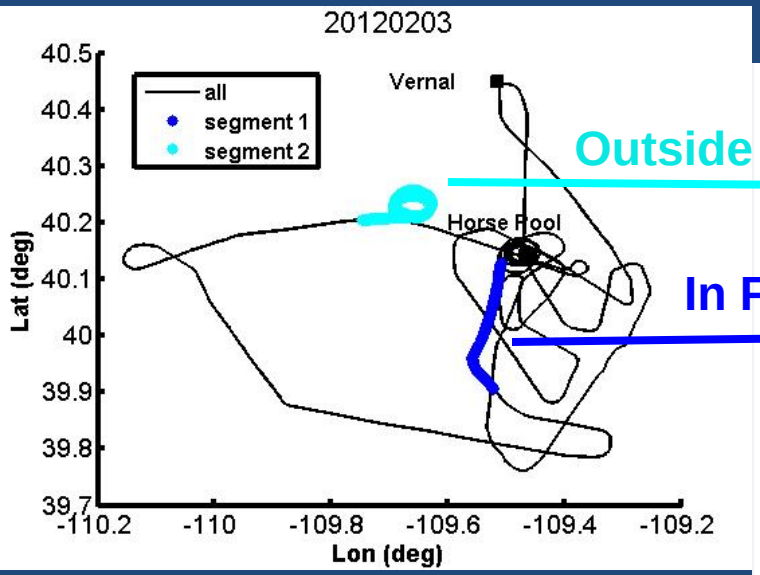
Rate of emission

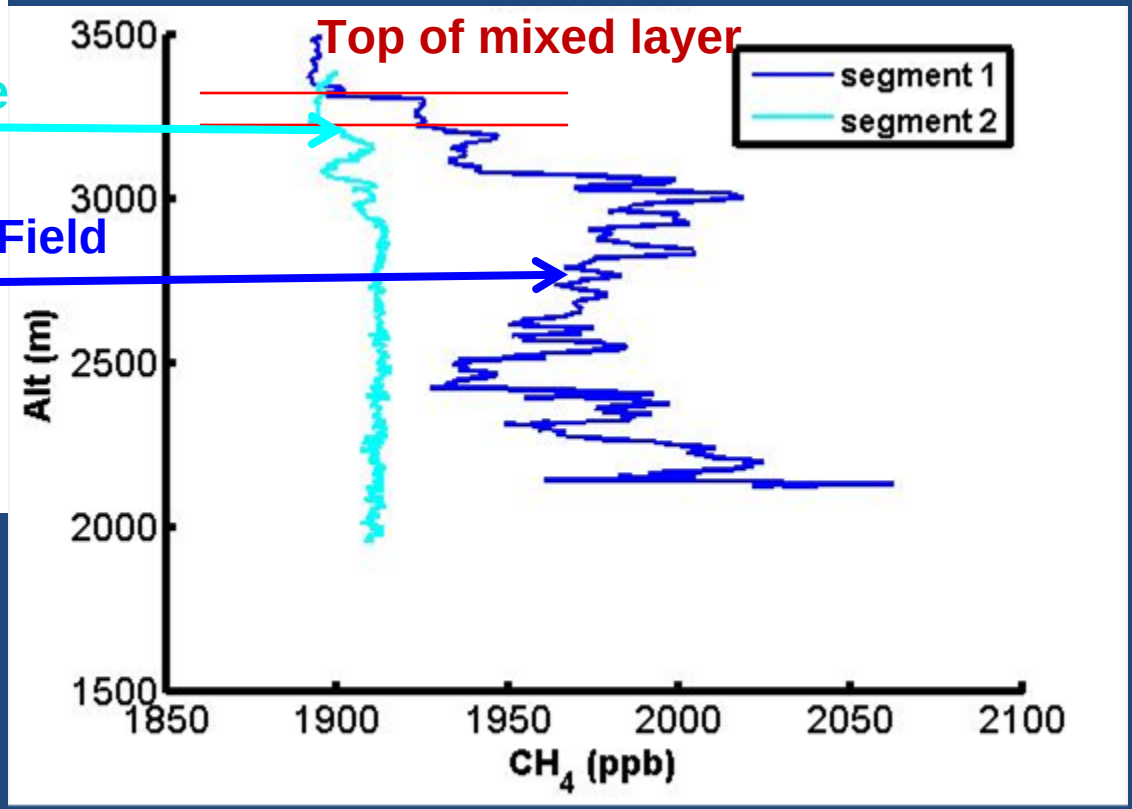
Rate of mass exiting volume

Rate of mass entering volume

Determining a CH_4 flux will let us calculate the VOC flux using measured emission ratios from flasks.

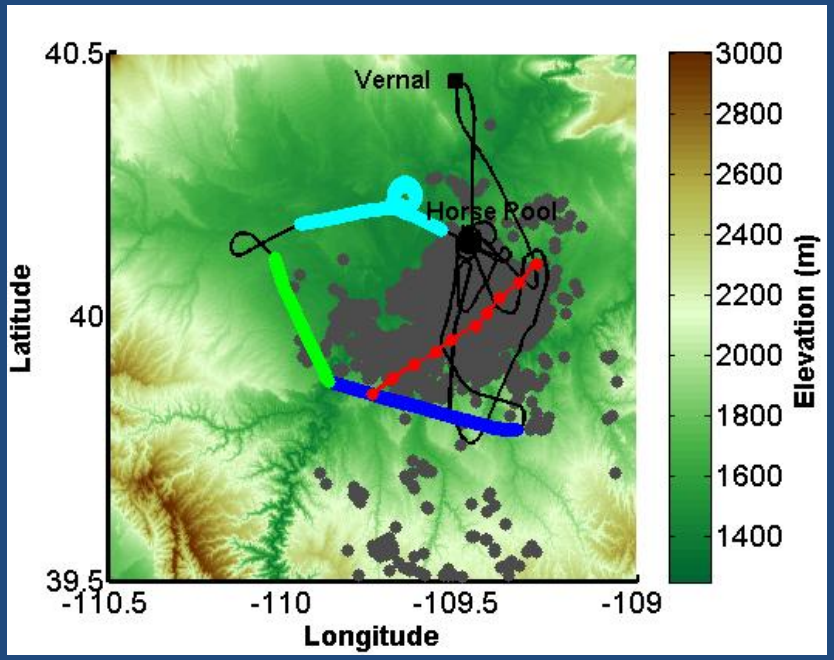
CH_4 Profiles Within and Outside of the Gas Field: Feb 3, 2012

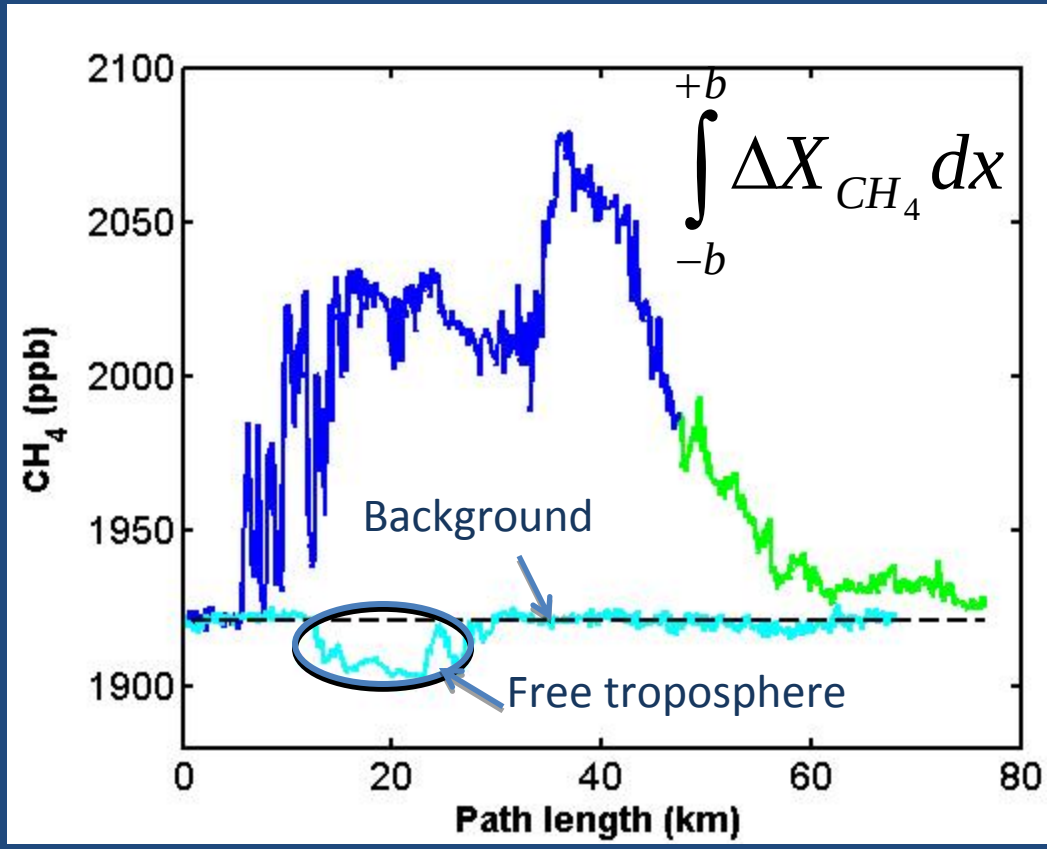




CH_4 is well mixed in the planetary boundary layer (PBL)

Downwind Plume Integration





Methane enhancement in plume downwind of field is integrated over the horizontal extent to calculate the CH_4 surface flux.

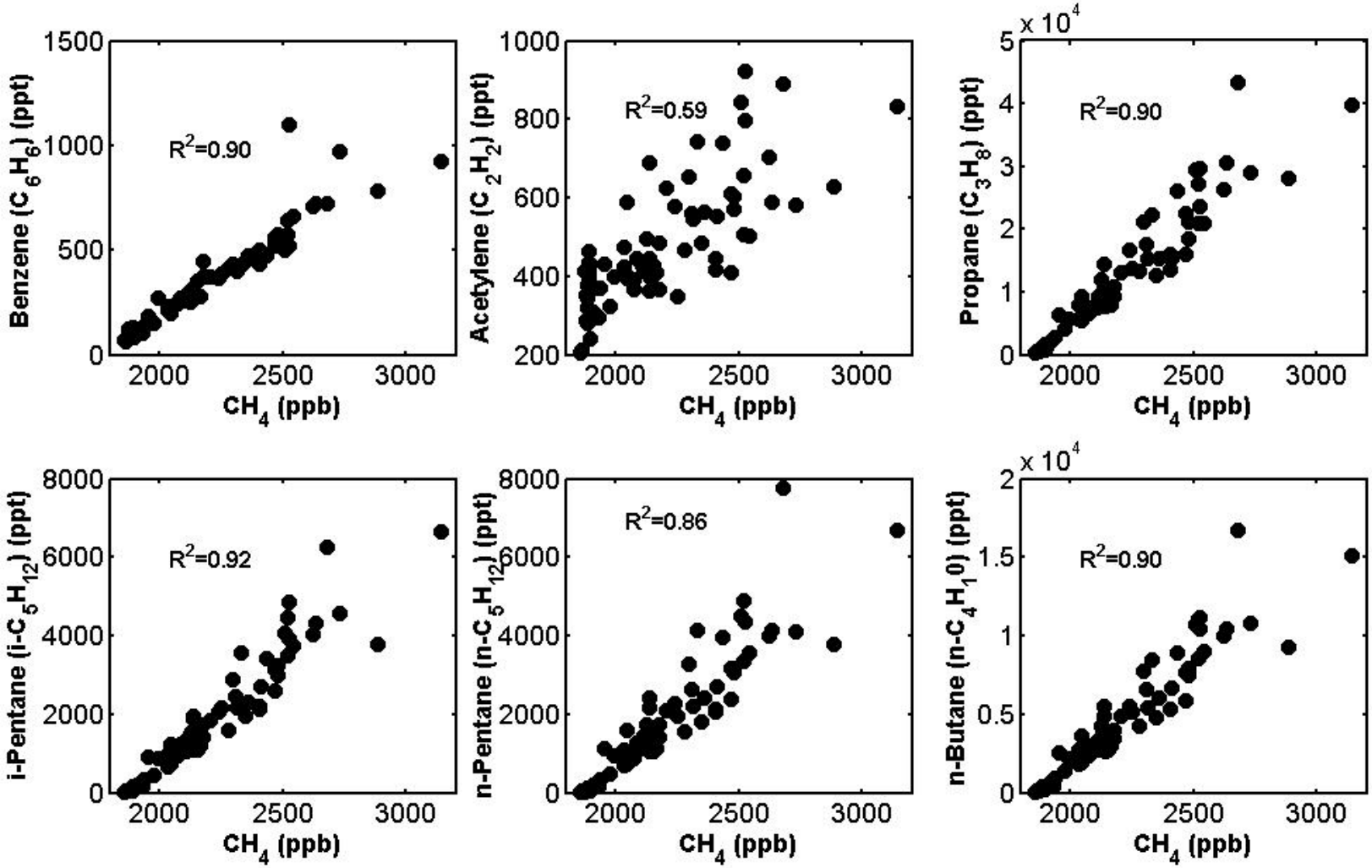
Flux calculation for February 3 2012

$$\dot{n}_{CH_4} = V \cos\alpha \int_{-b}^{+b} \Delta X_{CH_4} \left(\int_{h(x)}^{PBL} n_{air}\, dz \right) dx$$

Parameter	Symbol	Mean Value	Variability	% Uncertainty
Wind Speed	V	5.1 m/s	0.7 m/s	13%
Wind Direction		54.4°	11°	
Cosine of angle between wind direction and normal to heading	cos α	0.74 0.99	0.14 0.05	19%
Methane enhancement	ΔX_{CH4}	84 ppb	5.4 ppb	6.4%
Mixing layer depth	PBL-h(x)	1539 m	100 m	6%
Total Molar Flux (CH_4)	**$\dot{n}_{CH4}$**			**25%**

This is the uncertainty of a single day observation. Relatively low uncertainty on this observation due to consistent winds.

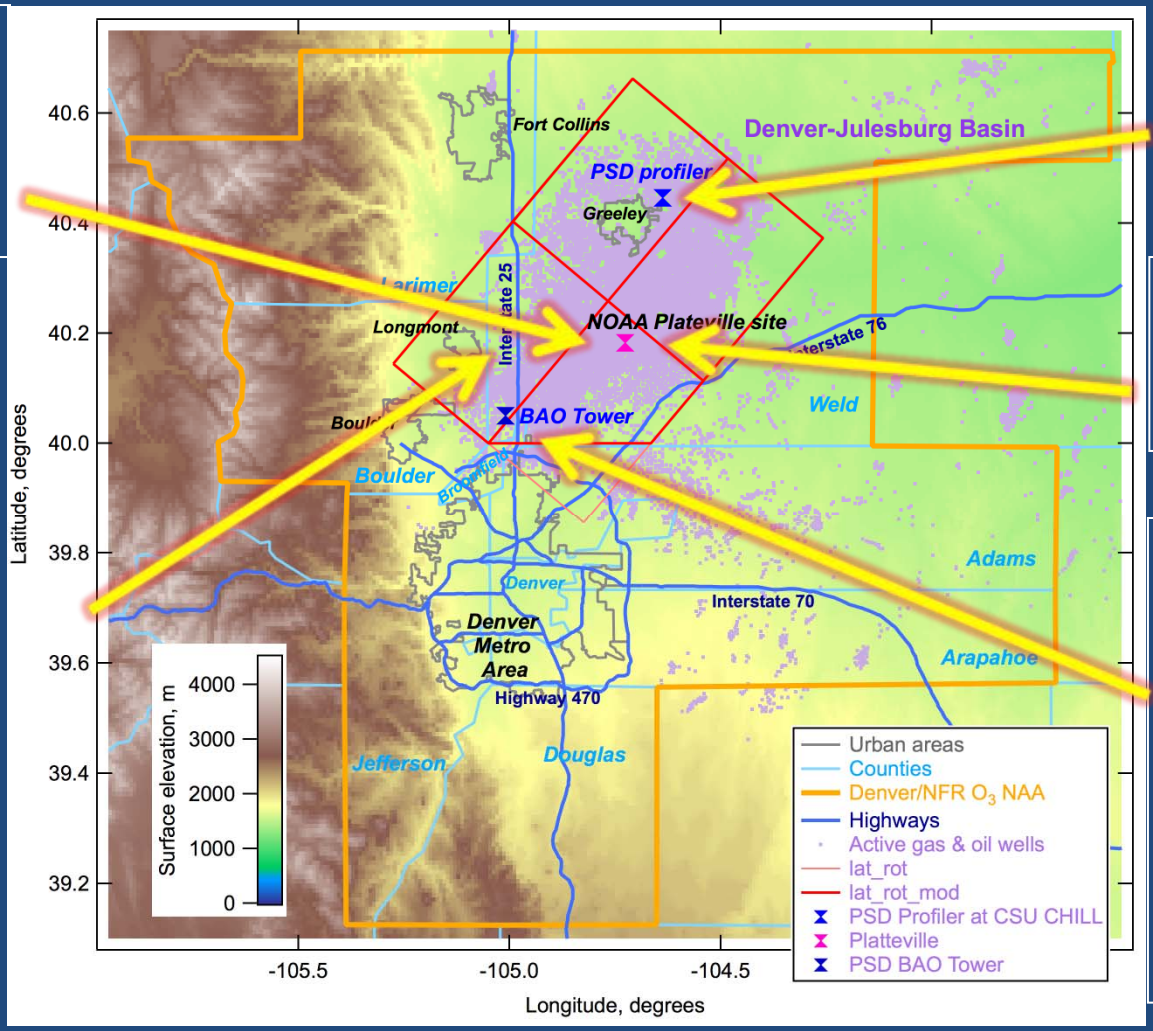
NOAA GMD Flask Data (Aircraft Only)
Hydrocarbons



Denver-Julesburg Basin Campaign
May 2012

High Resolution Doppler LIDAR
-BLD
-winds

Mobile Van
-winds
-CO_2
-CH_4
-CO
Multi-species flasks
CH_4 isotopes



915 MHz Profiler
-BLD
-winds

Tethered Balloon
-winds

Tall Tower measurements
-CO_2
-CH_4
-CO
-winds
Multi-species flasks

Summary

- Light aircraft measurements are a valuable tool for investigating emissions distributed over a large spatial area.
  - Map out extent and gradient of emissions
  - Can be used (with accurate MET data) to calculate emissions flux independent of bottom-up inventories
- As expected, flask measurements show high degree of correlation between various hydrocarbons and CH_4.
- The next step will be to calculate emissions for several VOCs measured in air samples collected by the aircraft.

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