Aircraft Measurements in the Uintah Basin of Utah in Winter 2013 During a High Ozone Event

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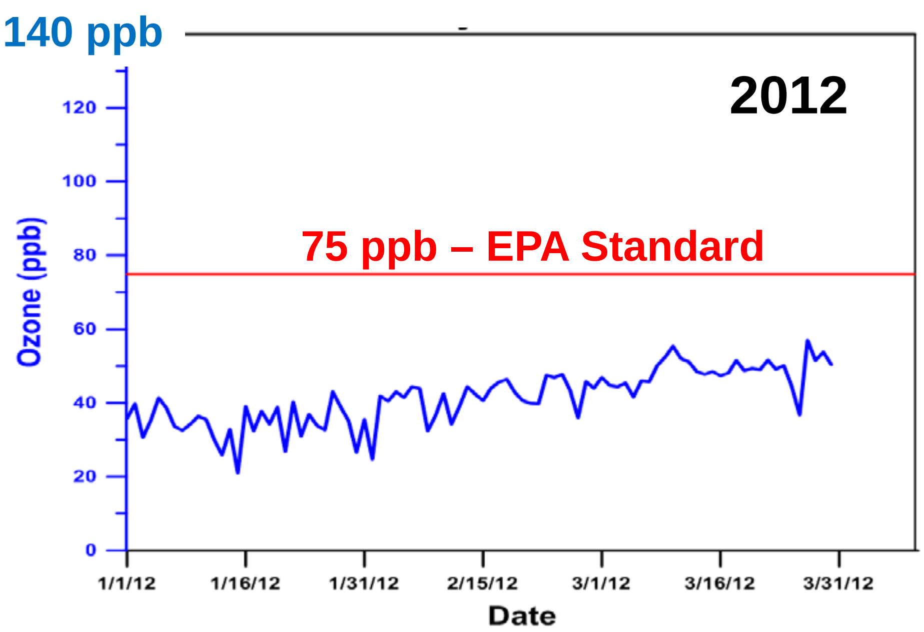
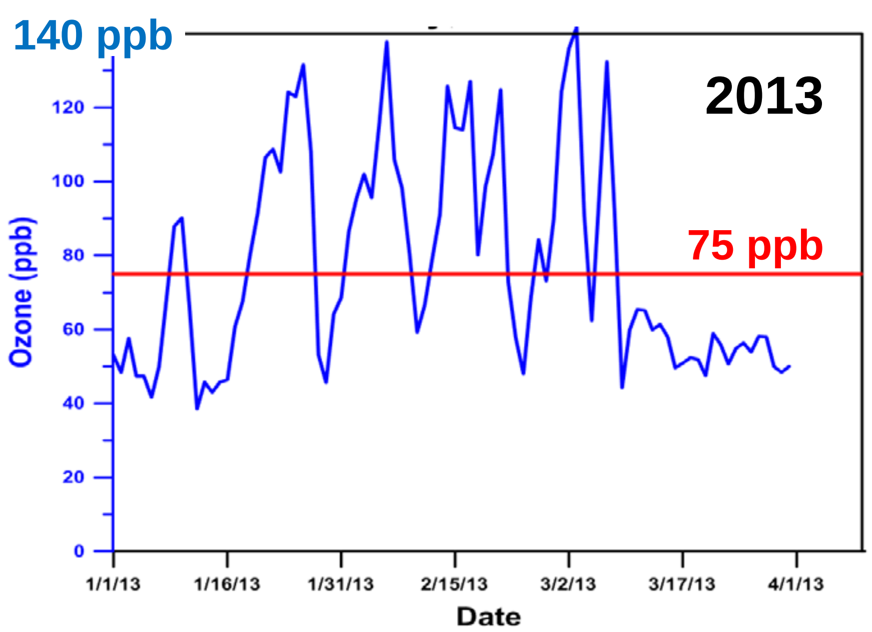
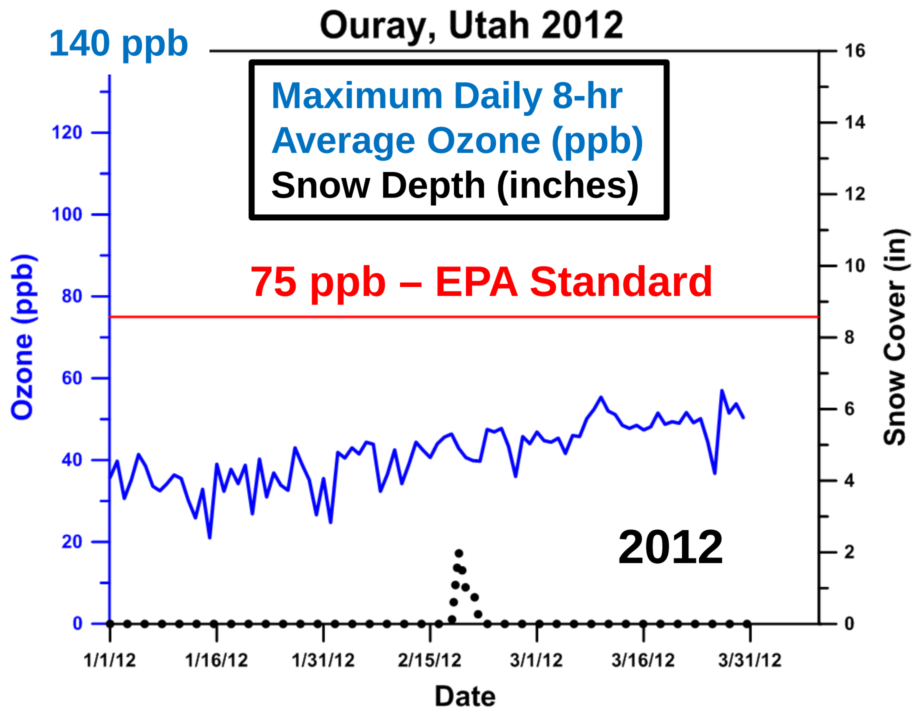
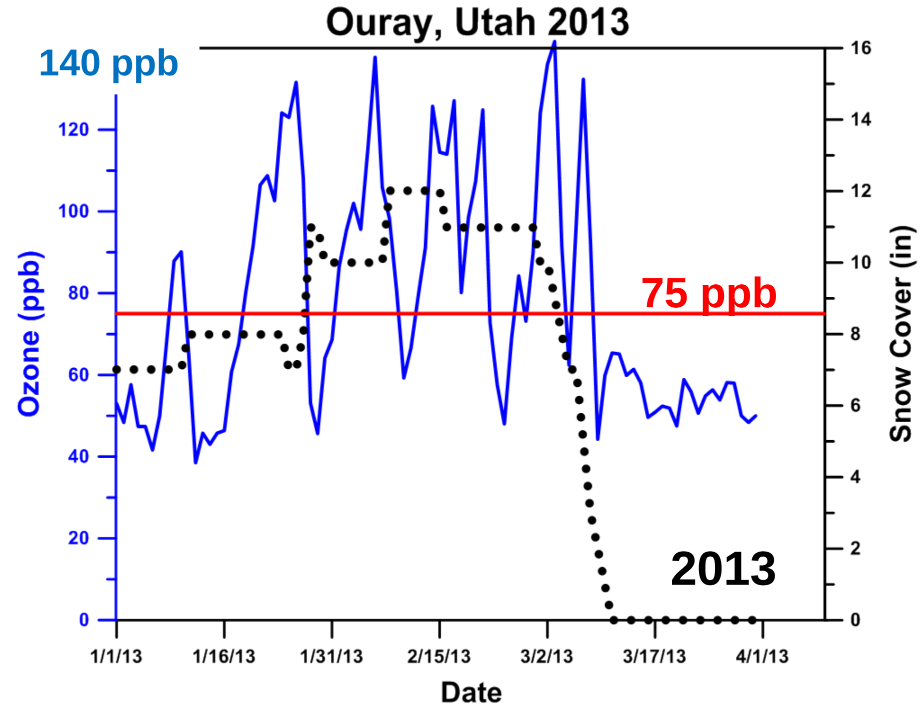
Maximum daily average 8-hour surface ozone in the Uintah Basin, Utah January – March 2012 and 2013





What is the difference?

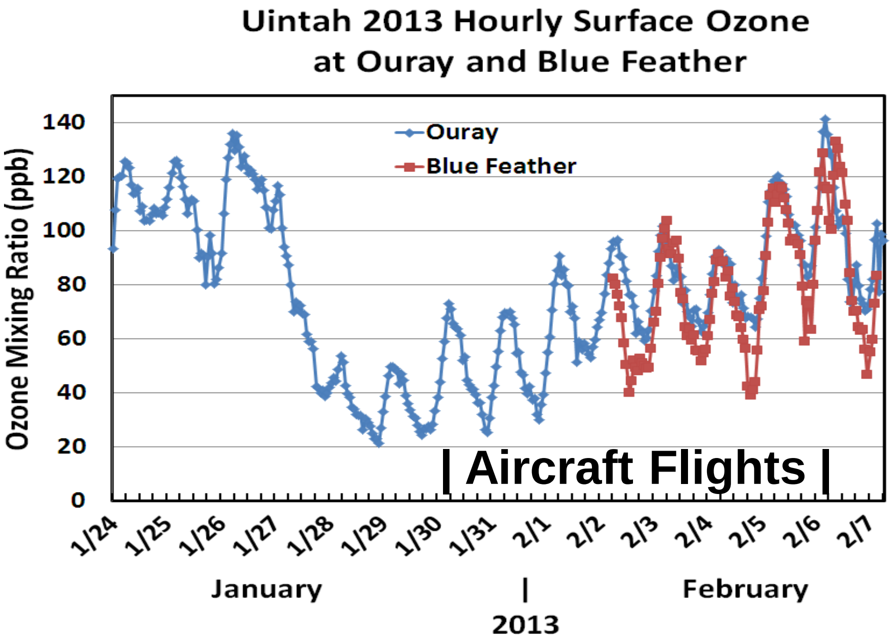


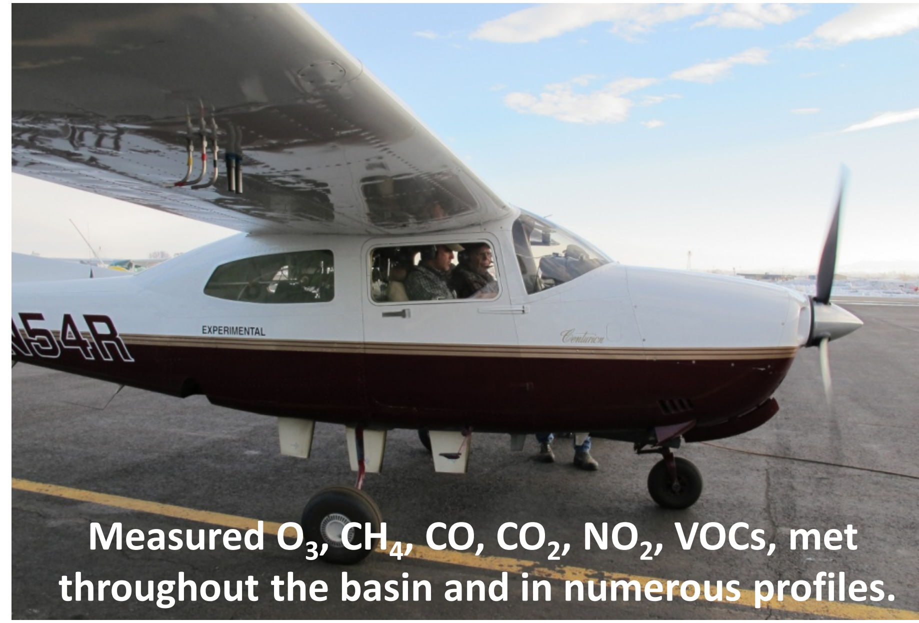


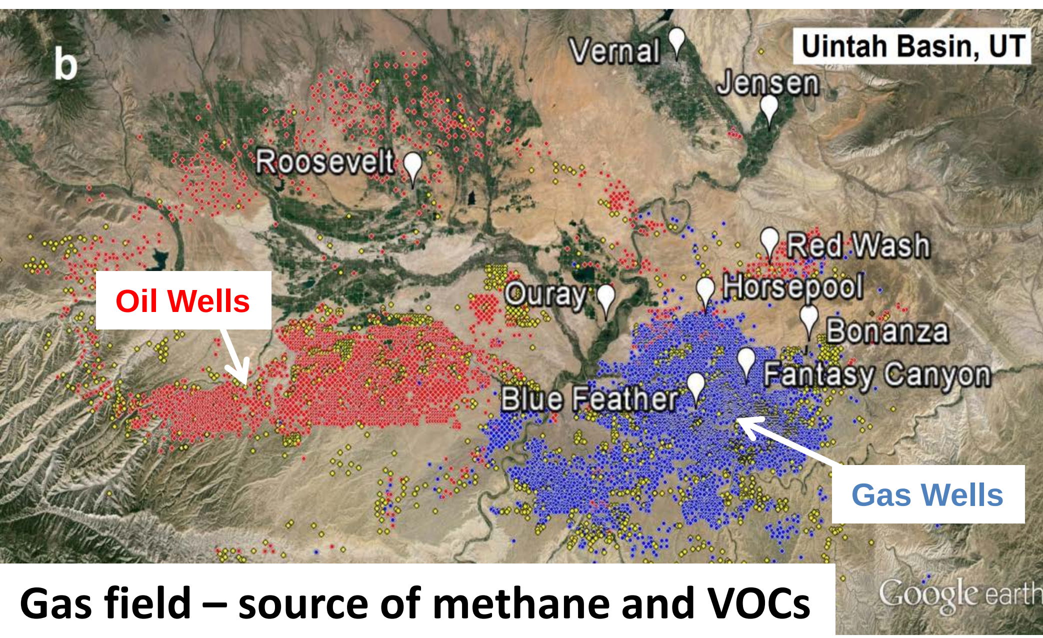
What is the role of snow cover?

- **Produces strong temperature inversions giving a shallow, confined layer (~200 m).**
- **High reflection of the snow nearly doubles the UV radiation available for photochemistry.**
- **Much less deposition (loss) to the ground.**
- **Chemistry on snow surfaces?**

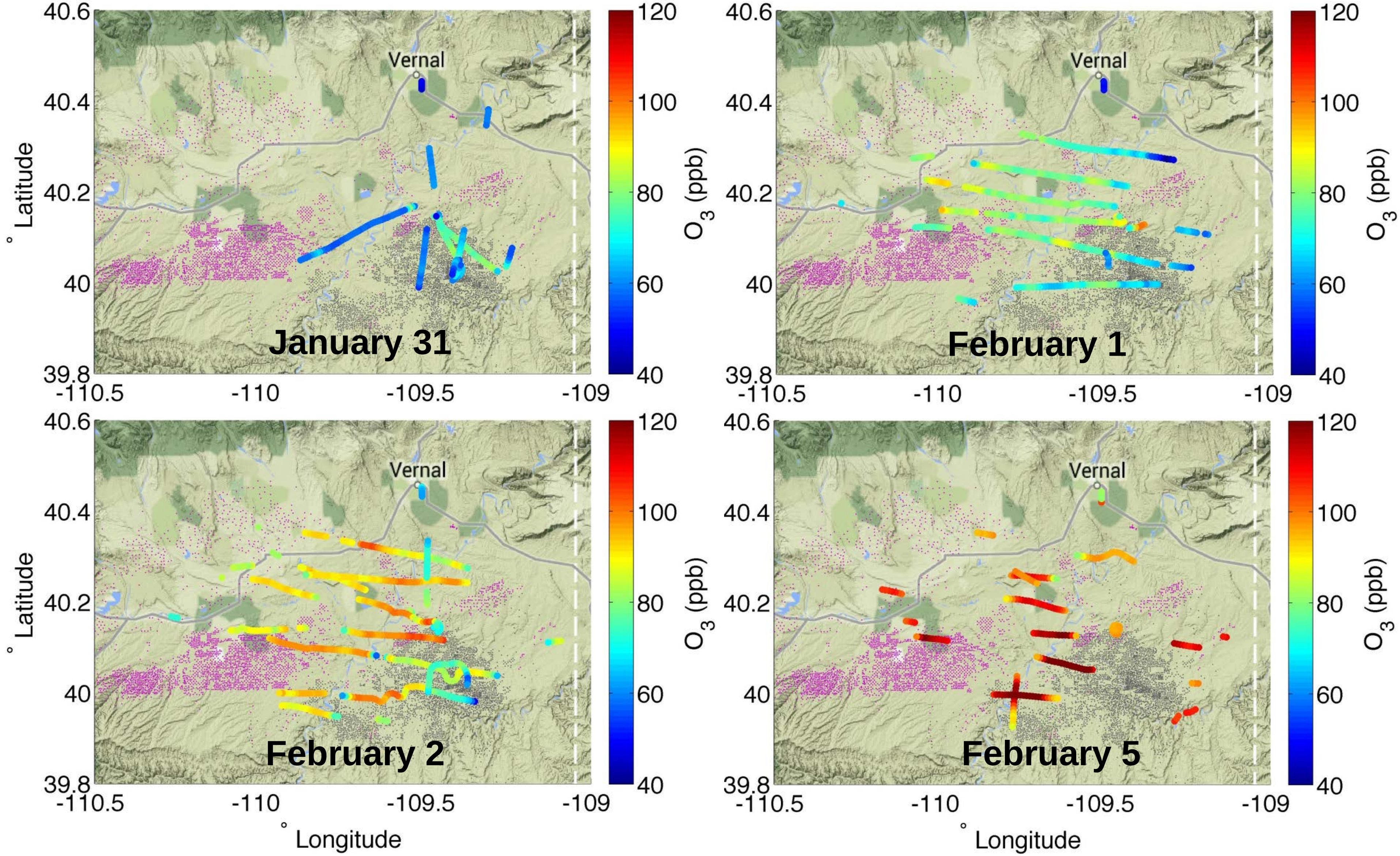
What is Unique About the Uintah Basin of Utah?







What did we see?



Ozone across the basin on Jan. 31, Feb. 1, 2, and 5

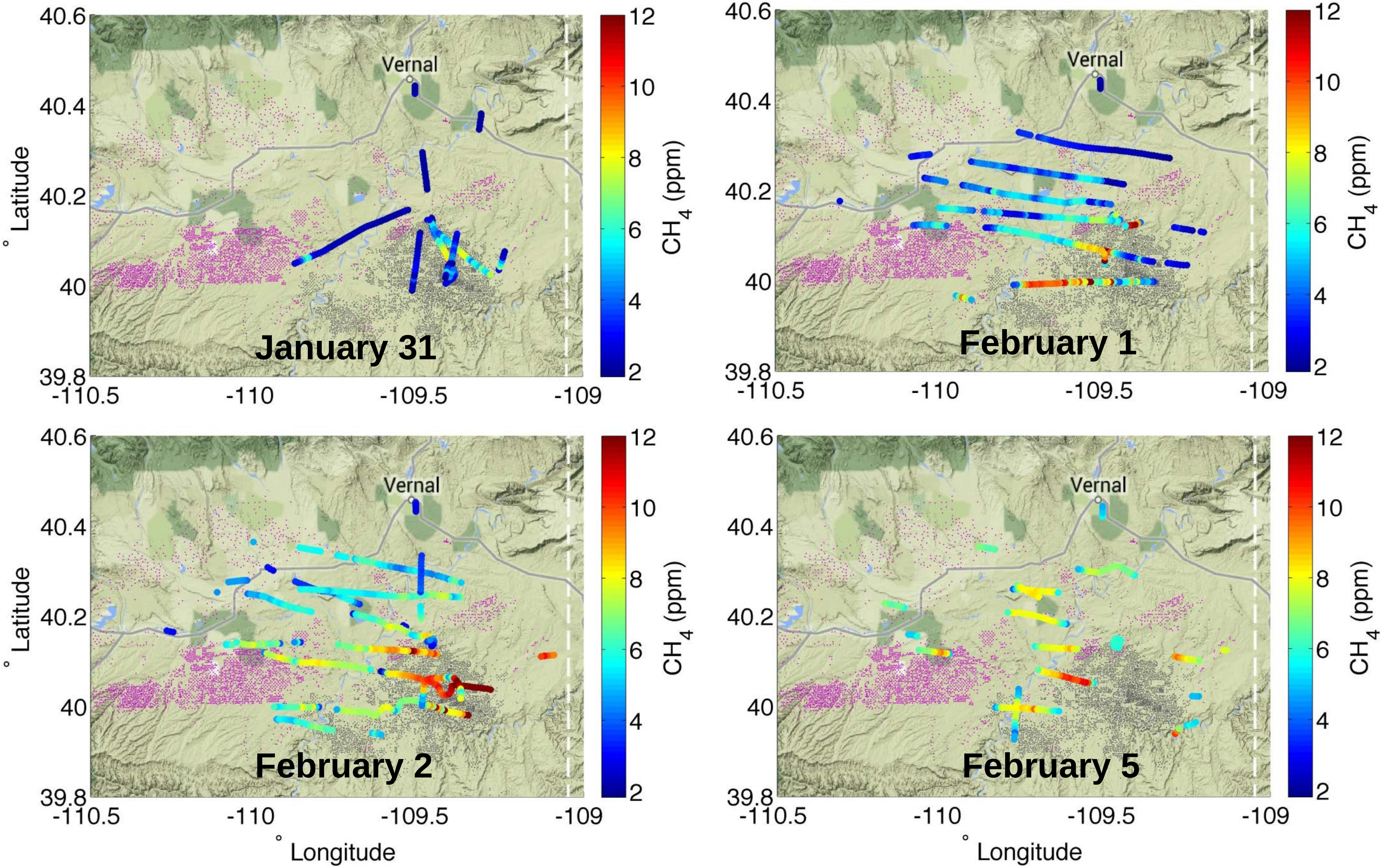
(Measurements in the boundary layer < 200 meters above ground level)

purple dots – oil wells ***black dots – gas wells***

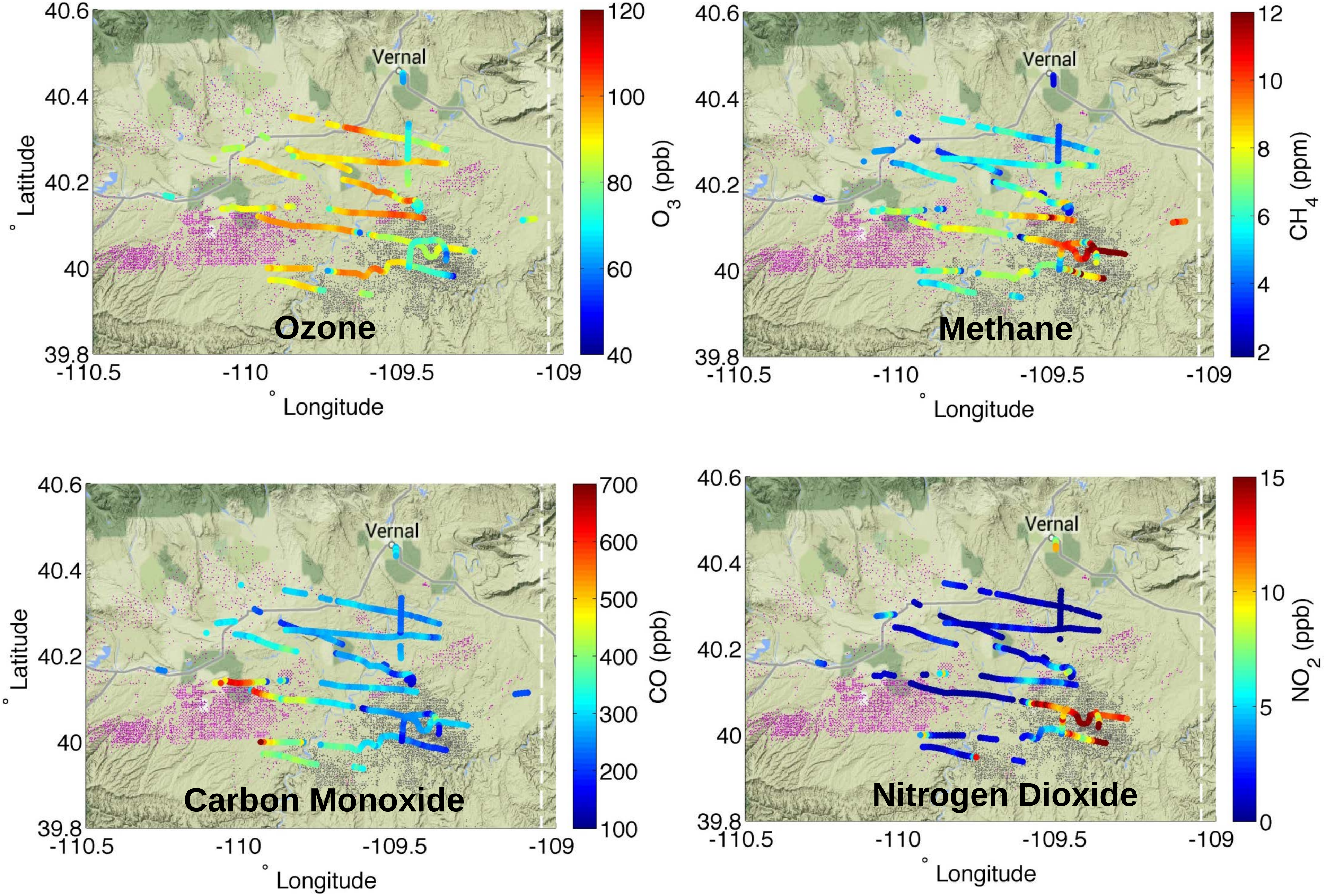
Methane across the basin on Jan. 31, Feb. 1, 2, and 5

(Measurements in the boundary layer < 200 meters above ground level)

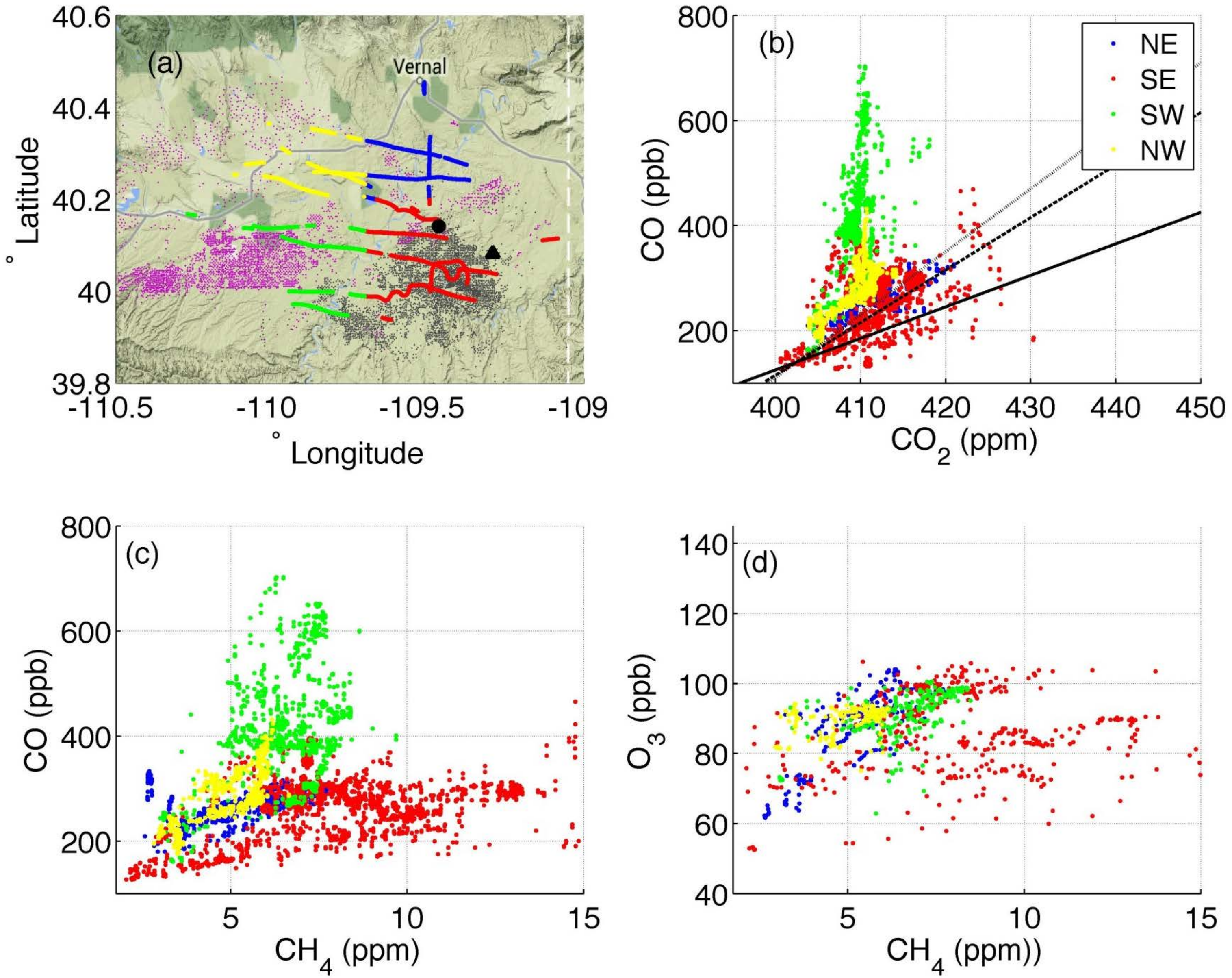
purple dots – oil wells ***grey dots – gas wells***



O_3, CH_4, CO, and NO_2 below 1650 masl on Feb. 2

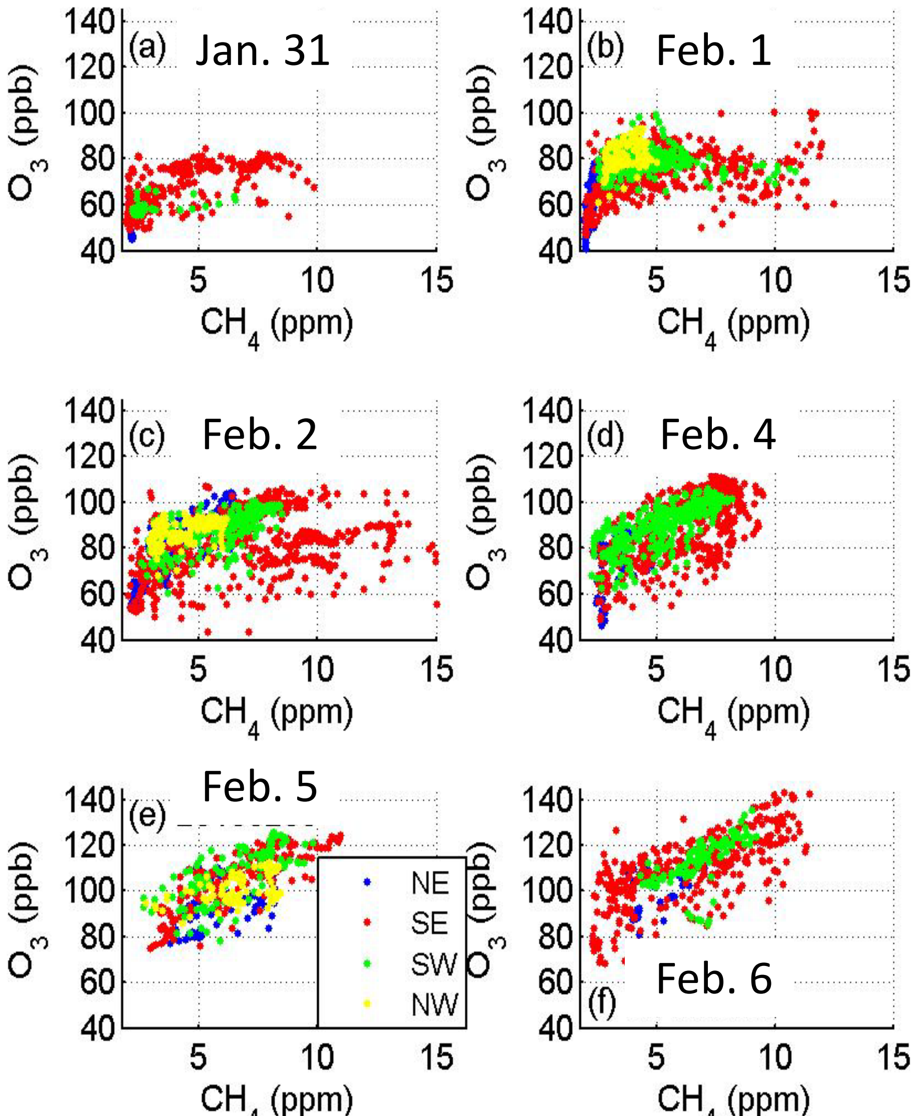


Correlations during the February 2, 2013 flight. Flight track below the inversion (1650 masl) colored by quadrant

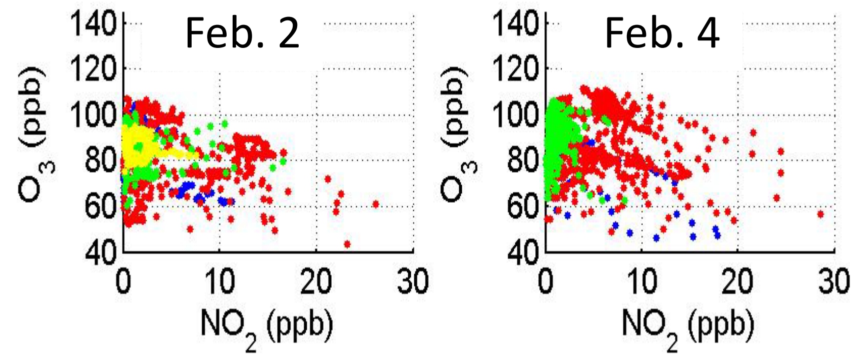


Correlation of O_3 with CH_4 and O_3 and NO_2 and CO below 1650 masl (under the inversion) in four quadrants across the Basin

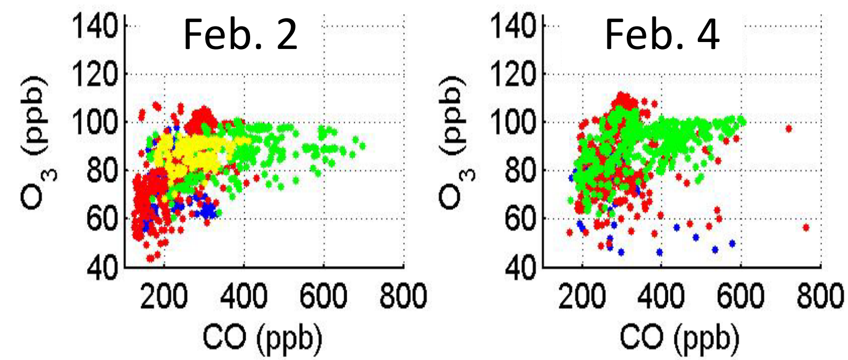
O_3 vs. CH_4 on 6 days



O_3 vs. NO_2

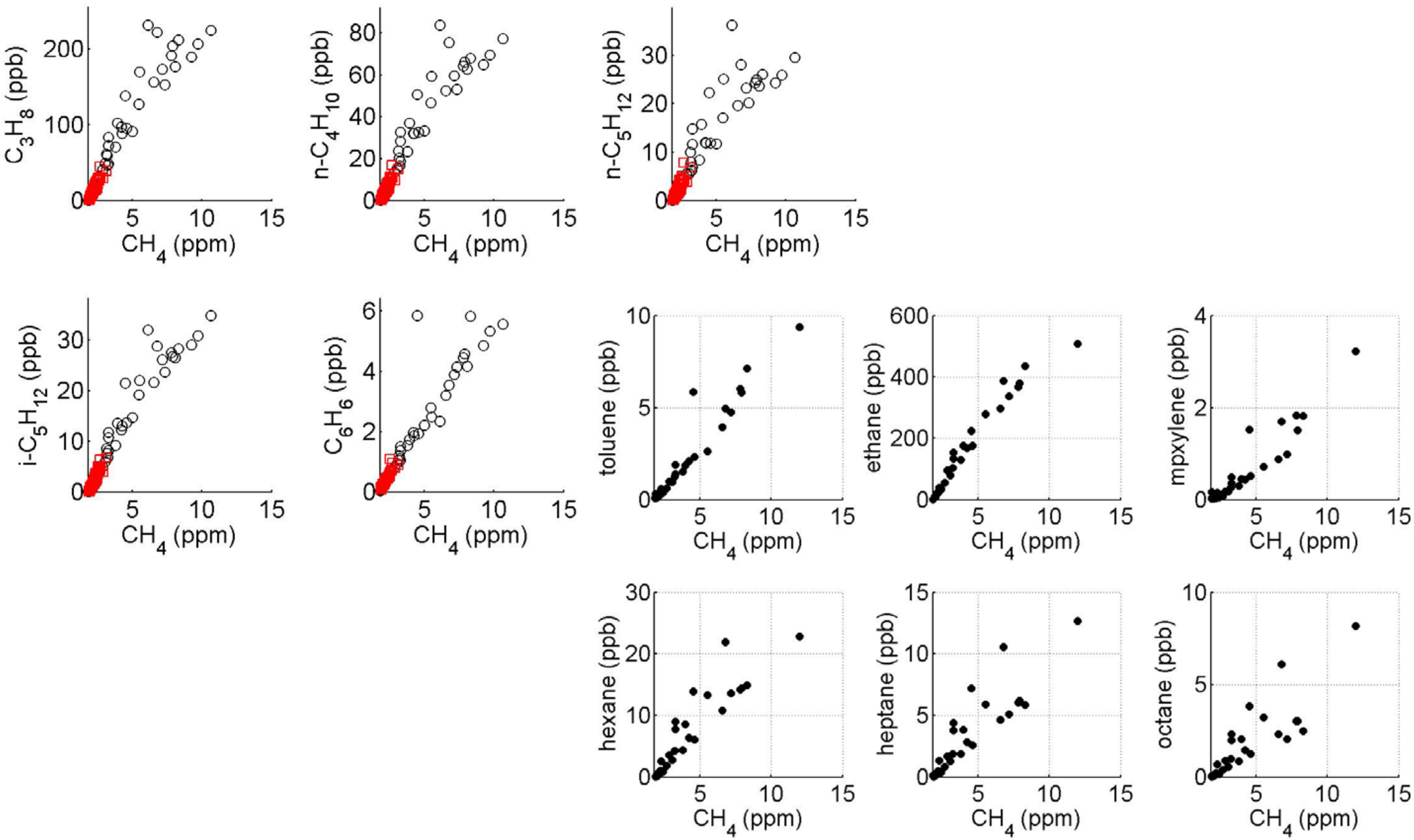


O_3 vs. CO

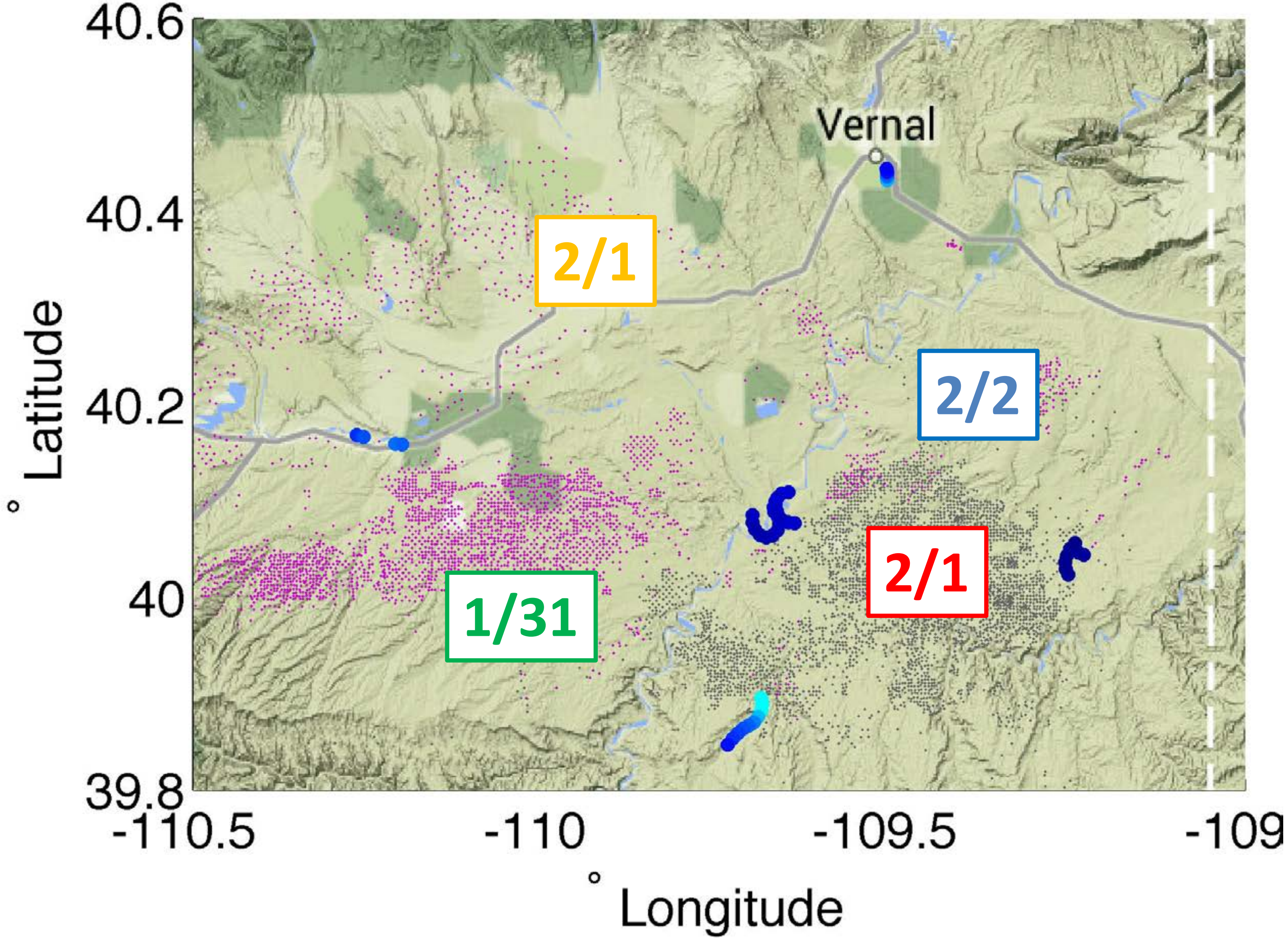


Correlation between CH_4 and several non-methane hydrocarbons obtained from flask samples

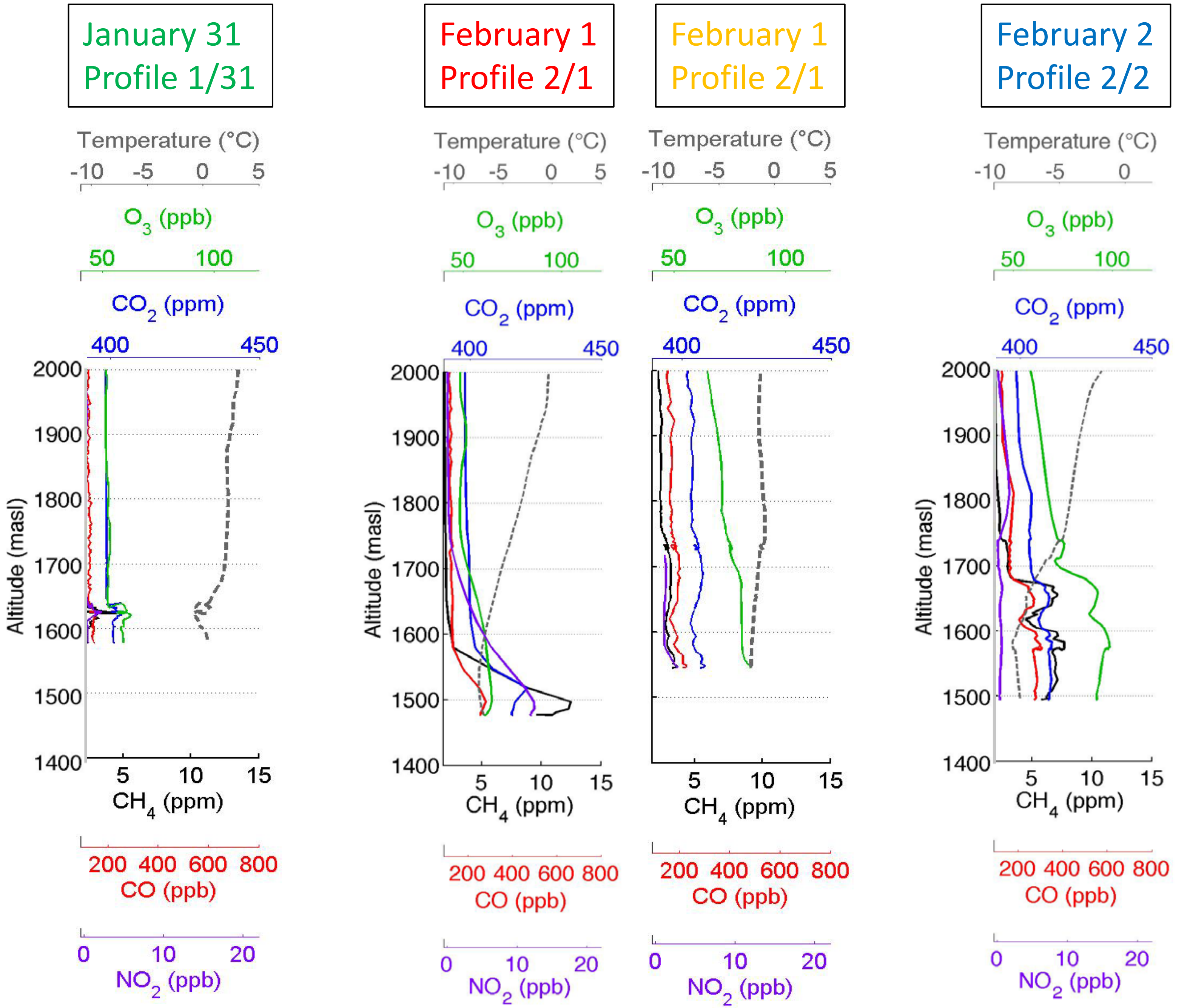
(red circles are 2012   black circles/dots are 2013)



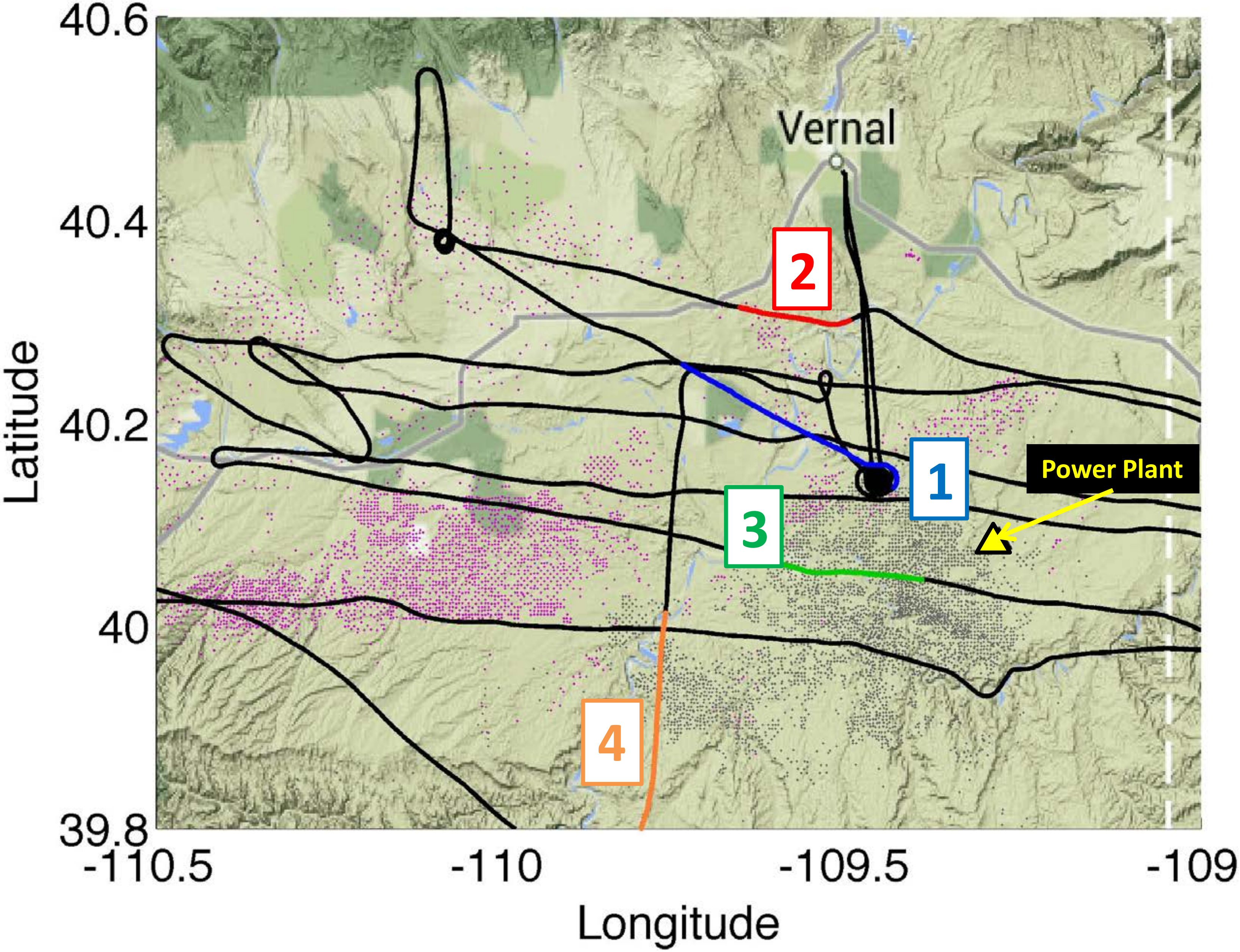
Location of aircraft profiles of O_3, CH_4, CO, CO_2, NO_2 and Temperature on January 31, February 1 & 2



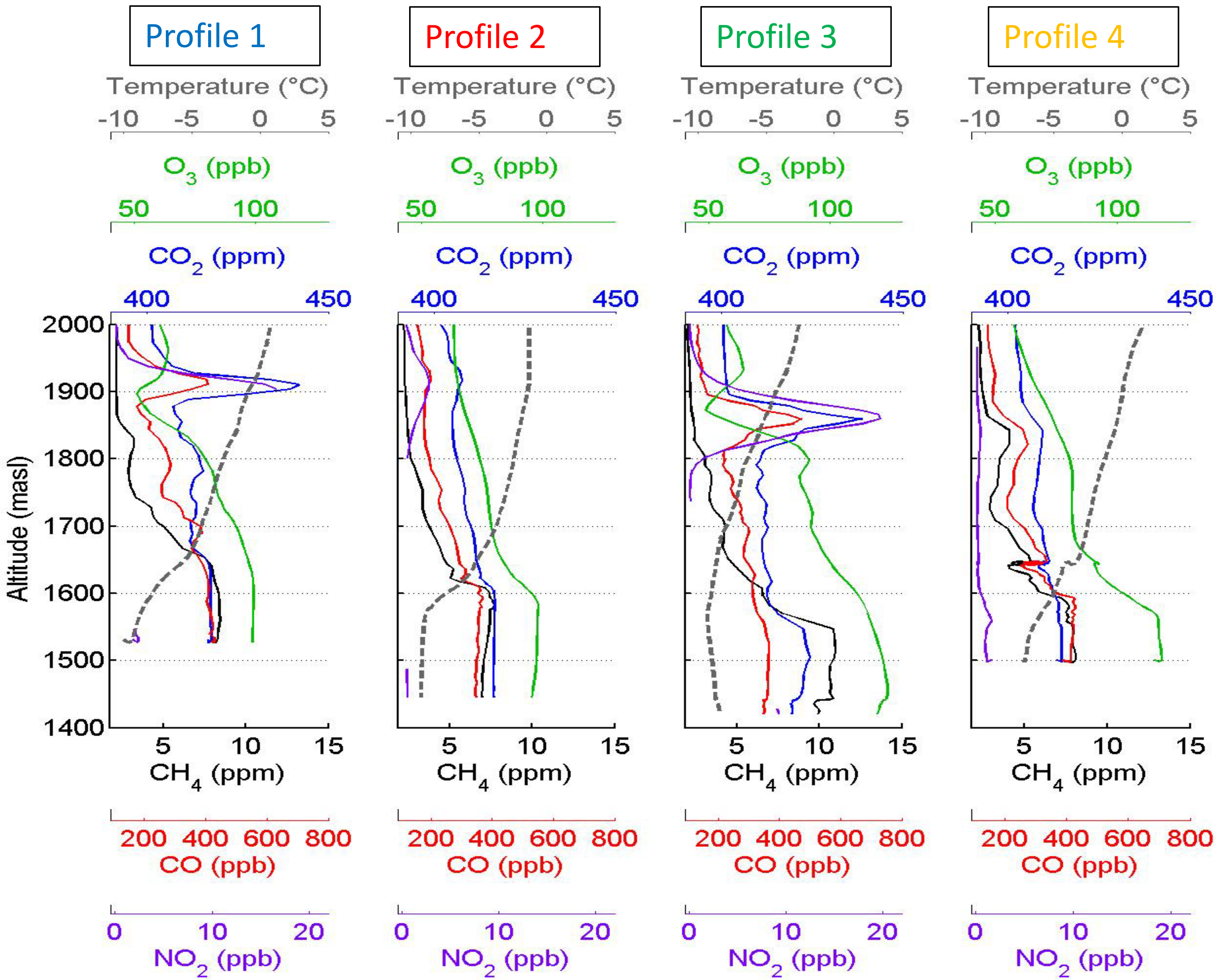
Aircraft profiles of O_3, CH_4, CO, CO_2, NO_2 and Temperature



Location of aircraft profiles of O_3, CH_4, CO, CO_2, NO_2 and Temperature on February 5



Aircraft profiles of O_3, CH_4, CO, CO_2, NO_2 and Temp. on Feb. 5



What we learned

- **Unparalleled data for understanding winter high-ozone events.**
- **In 2013 the necessary ingredients for strong ozone production were present in the Uintah Basin.**
  - **Snow covered ground (high albedo – enhanced UV)**
  - **Persistent temperature inversion**
  - **Abundant ozone precursors**
- **Ozone and ozone precursors built up to extraordinary levels during temperature inversion events.**
- **A strong relationship exists between methane (VOCs co-emitted) and ozone.**
- **The hot spot for precursor emissions is in the main gas field.**
- **But high ozone is seen across the basin—a sign of strong ozone formation throughout the basin.**