

# Strong Wintertime Ozone Events in the Upper Green River Basin, Wyoming

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## Observations:

Over the last years elevated ozone ( $O_3$ ) values have been observed repeatedly in the Upper Green River Basin (UGRB), Wyoming, during wintertime, when snow cover is present. Here we focus on high ozone days in late winter 2011 (1-hour average up to 166 ppbv). Intensive Observational Periods (IOPs) were performed which included comprehensive surface and boundary layer measurements. Low windspeeds in combination with low mixing layer heights (~50 m above ground level around noontime) are essential for accumulation of pollutants within the UGRB. Ozone profiles do not indicate any carry over. However, boundary layer air masses contain substantial amounts of reactive nitrogen ( $NO_x$ ) and non-methane hydrocarbons (NMHC) emitted through fossil fuel exploration activities of the Pinedale Anticline.

In particular, high HONO levels were observed (maximum hourly median on IOP days: 1,096 pptv). These HONO levels are likely favored by a combination of shallow boundary layer conditions and enhanced photolysis rates due to the high albedo of the snow surface.

## Topographic Setting of the Upper Green River Basin

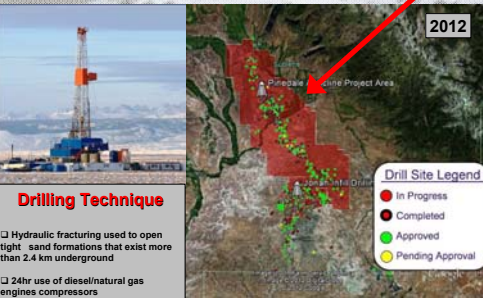
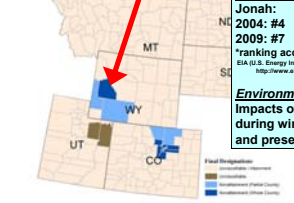


**April 2012:**  
 ~ 2008 Ground-level Ozone standards (8 hr Ozone > 75 ppbv) - Region 8 Final Designation:

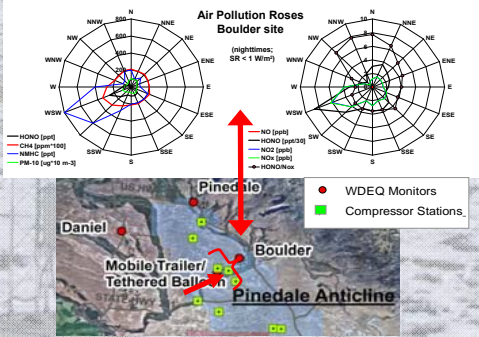
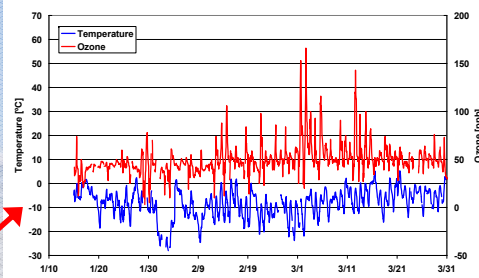
## Two important US Natural Gas Reserves Upper Green River Basin\*

Jonah: Pinedale Anticline:  
 2004: #4      2004: #6  
 2009: #7      2009: #3  
 \*ranking according to EIA (2009)

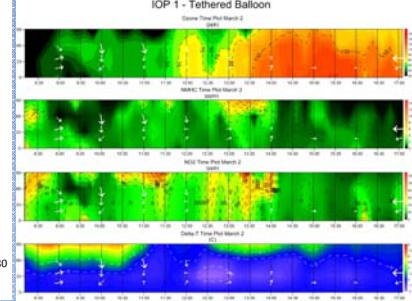
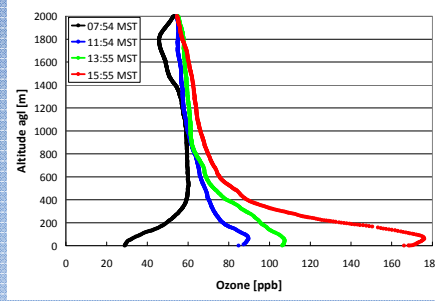
**Environmental Concerns:**  
 Impacts of hydraulic fracturing activities during wintertime with cold temperatures and presence of snow surface



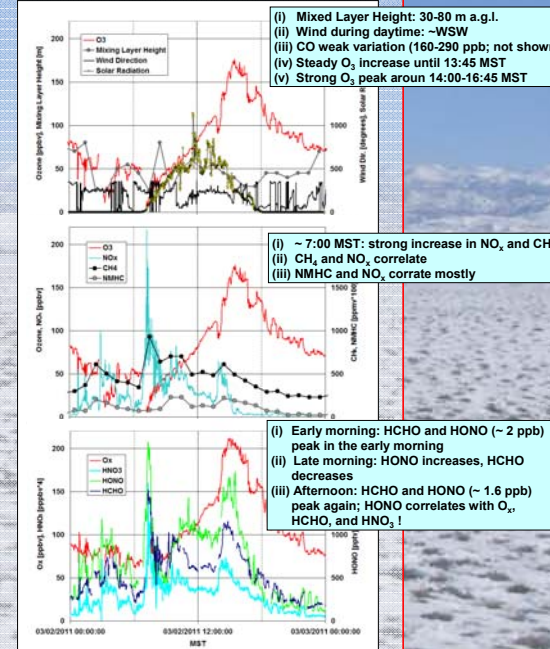
## General Observations at the Boulder/WY site in January-March 2011



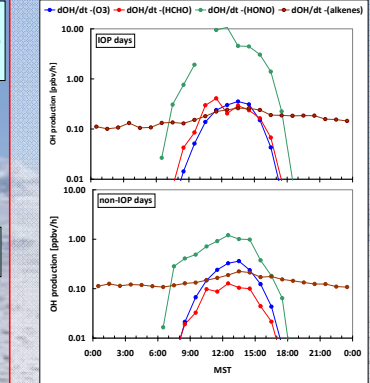
## Case Study: March 02, 2011; upper air measurements



## Case Study: March 02, 2011; surface measurements



## OH sources IOP vs non-IOP days



## Summary:

Observations in winter 2011 indicate that photochemical processes in the Upper Green River Basin occur within a very shallow boundary layer and is enhanced by the high albedo of the snow surface. OH production on IOP days is mainly due to HONO. On a 24-hr basis and at a height of 1.80 m above the surface HONO photolysis on IOP days can contribute ~83% to OH production on average, followed by alkene ozonolysis (~9%). Photolysis by ozone and HCHO photolysis contributes about 4% each to hydroxyl formation. HONO is most likely formed through (i) abundant  $HNO_2$  produced in atmospheric oxidation of  $NO_x$ , deposited onto the snow surface and undergoing photo-enhanced heterogeneous conversion to HONO.

Further information:  
 Rappenglück B. et al. (2014), *Atmos. Chem. Phys.*, 14, 4909-4934