

## Evidence of Emissions from Oil and Gas Drilling Operations in Northeastern Colorado

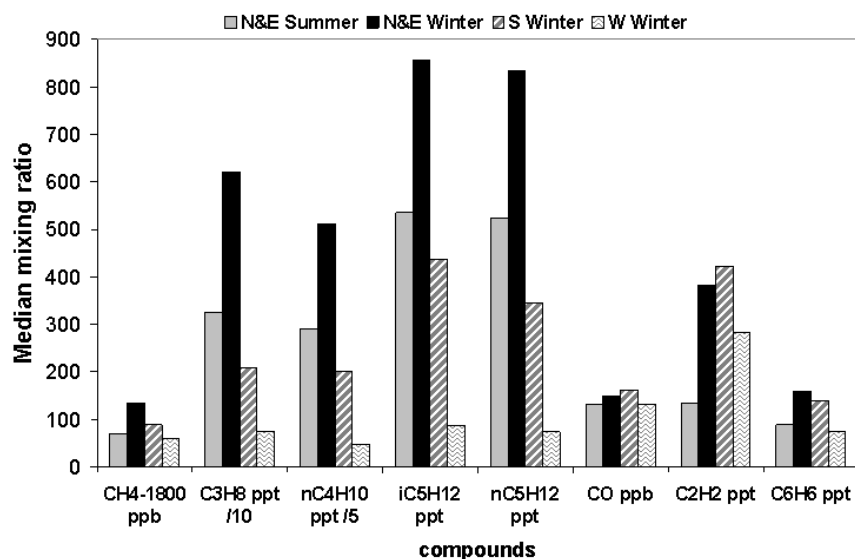
G. Petron<sup>1</sup>, G. Frost<sup>1</sup>, S. Montzka<sup>2</sup>, B. Miller<sup>1</sup>, A. Hirsch<sup>3</sup>, A. Karion<sup>1</sup>, C. Sweeney<sup>1</sup>, J. Kofler<sup>1</sup>, A. Andrews<sup>2</sup>, E.J. Dlugokencky<sup>2</sup>, M. Trainer<sup>2</sup>, D. Welsh<sup>2</sup>, D. Wolfe<sup>2</sup> and P. Tans<sup>2</sup>

<sup>1</sup>Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; 303-497-4890, E-mail: Gabrielle.Petron@noaa.gov

<sup>2</sup>NOAA Earth System Research Laboratory, Boulder, CO 80305

<sup>3</sup>National Renewable Energy Laboratory, Golden, CO 80401

Since 2007, air samples collected regularly at NOAA tall towers and from aircraft across the U.S. have been analyzed for over sixty different species, including greenhouse gases ( $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ,  $\text{SF}_6$ ), CO, several hydrocarbons (propane, n-butane, pentanes, benzene, acetylene), and ozone-depleting substances. The Boulder Atmospheric Observatory (BAO) is a 300-m tall tower located 35 km north of the Denver metropolitan area in the northern Colorado Front Range. The BAO sits on the southwestern edge of the Denver-Julesburg fossil fuel Basin, home to over 15,000 oil and gas wells. Using *in situ* meteorological data, we analyze the air composition of the BAO samples for three different wind sectors: the North and East sector (with strong contributions from oil and gas production operations and cattle feedlots), the South sector (dominated by the Denver urban area), and the West sector (containing the foothills of the Rocky Mountains and a few oil and gas wells). Air samples from the BAO North and East sector exhibit enhanced levels of alkanes that are strongly correlated with each other. To put these BAO samples in a regional context, we drove a mobile laboratory around BAO during the summer of 2008. A continuous methane analyzer was used to detect regional enhancements in methane and local plumes from point sources (including a natural gas processing plant, feedlots, and waste water treatment plant). Targeted air samples within and outside of plumes were collected and later analyzed in the NOAA lab. We will present results from the analysis of the BAO and Mobile Lab data and use the atmospheric data together with a bottom-up estimate of propane emissions from oil and gas production operations in Weld County to derive source estimates for methane, n-butane, i-pentane, n-pentane and benzene.



**Figure 1.** Summertime and wintertime median mixing ratios of several species measured in air samples from the 300-meter level at the BAO tower for three wind sectors: North and East (N&E) where the density of gas drilling operations is highest, south (S) with Denver 35 km away, and west (W) with mostly clean air. The time span of the data is from August 2007 to April 2010. Summer includes data from June to August and winter includes data from November to April. Due to the small number of data points, we do not show summer values for the S and W wind sectors. Data outside of the 11am-3pm local time window were not used. Notice the different scales used for methane, propane and n-butane.