



*Supplement of*

## **Oil and gas impacts on air quality in federal lands in the Bakken region: an overview of the Bakken Air Quality Study and first results**

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## Supplementary Material

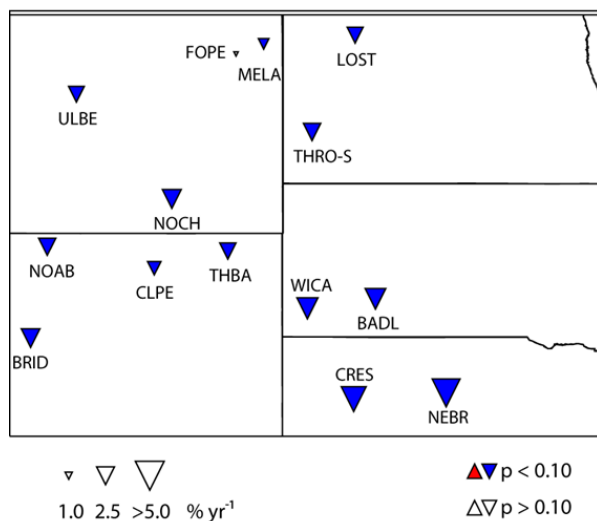
Figure S1 shows annual trends of sulfate, nitrate, soil and EC from 2000 to 2014 for IMPROVE sites near the Bakken and in the surrounding regions. As can be seen in the figure, trends for EC and nitrate for the three sites north of THRO-s are not consistent with regional decreasing trends in these species.

A box plot of mean daily values of IMPROVE EC concentration at THRO-S is presented in Figure S2 for all available data since 2000. IMPROVE data represent one in three day sampling. All of the EC data from THRO-S from the two study periods suggest that concentrations were typical relative to previous years.

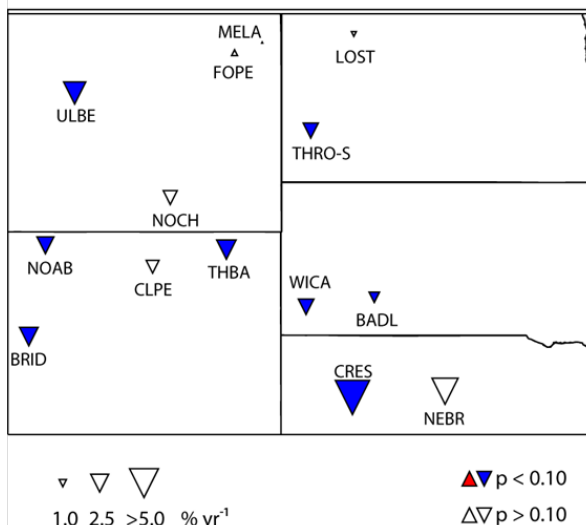
Figure S3 presents results from the second study period utilizing a photochemical clock, based on VOC measurements at THRO-N. These data are meant to show the extent of photochemical processing of the airmasses that reach the measurement site. The colors of the points on the plot represent SO<sub>2</sub> concentrations. The highest observed concentrations of SO<sub>2</sub> correspond to airmasses with fresh emissions.

In Figure S4 trends are shown for the ratio of concentrations between the given site and THRO-S for sulfate, nitrate, EC and soil. As for Figure S1, upward pointing arrows designate increasing trends, while downward pointing arrows represent decreasing trends; filled symbols are significant at a level of  $p < 0.10$ . The trends in Figure S4 thus represent trends in these species relative to trends at THRO-S. The purpose of utilizing a ratio rather than absolute concentrations is to better identify changing emissions in the basin while accounting for regional trends, which may be driving the observed concentrations at THRO-S.

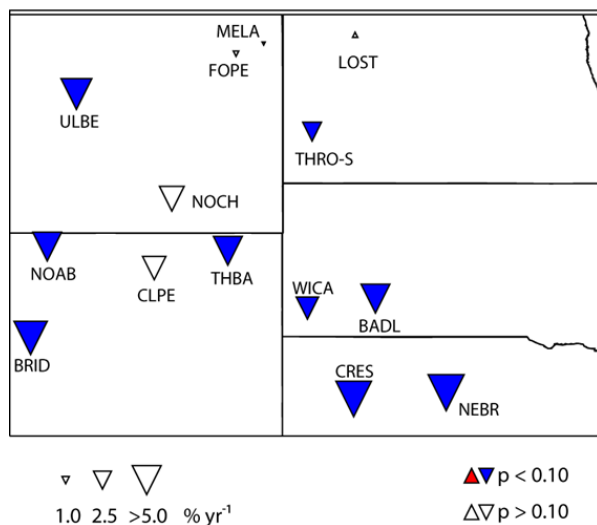
a. IMPROVE 2000-2014 Annual Sulfate



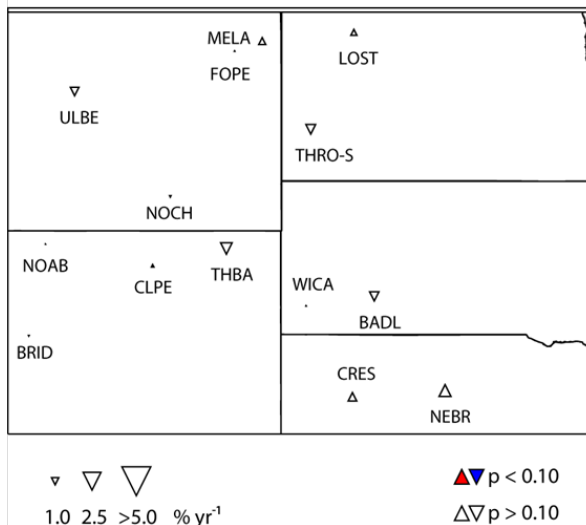
b. IMPROVE 2000-2014 Annual Nitrate



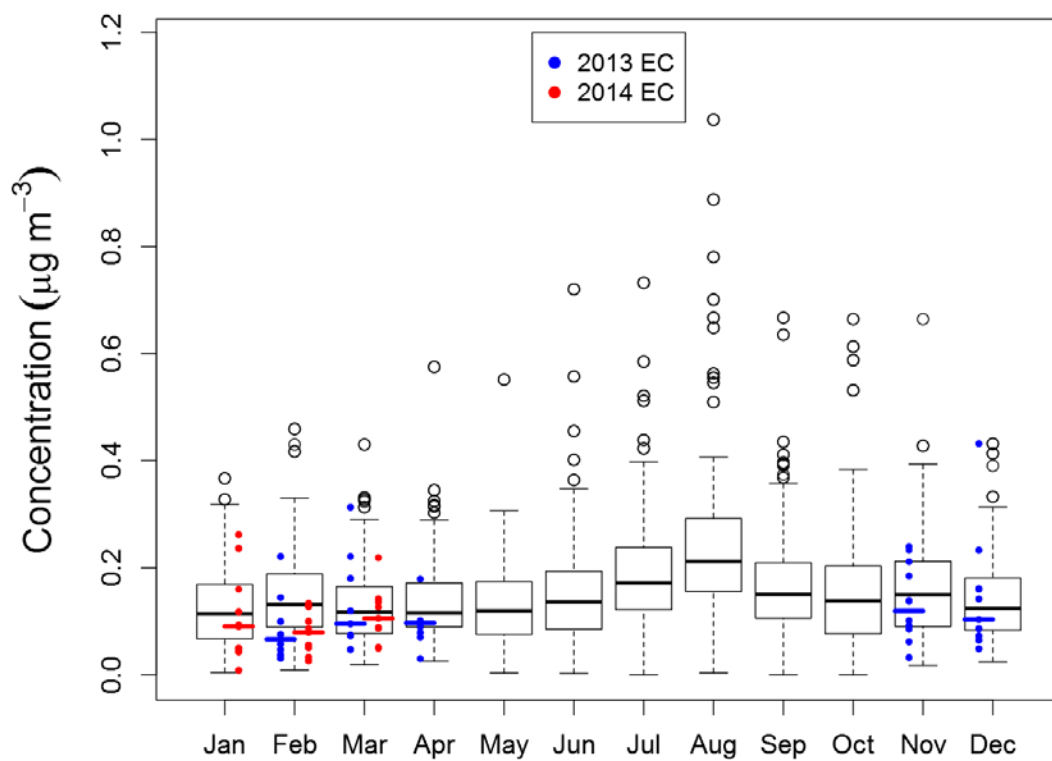
c. IMPROVE 2000-2014 Annual EC



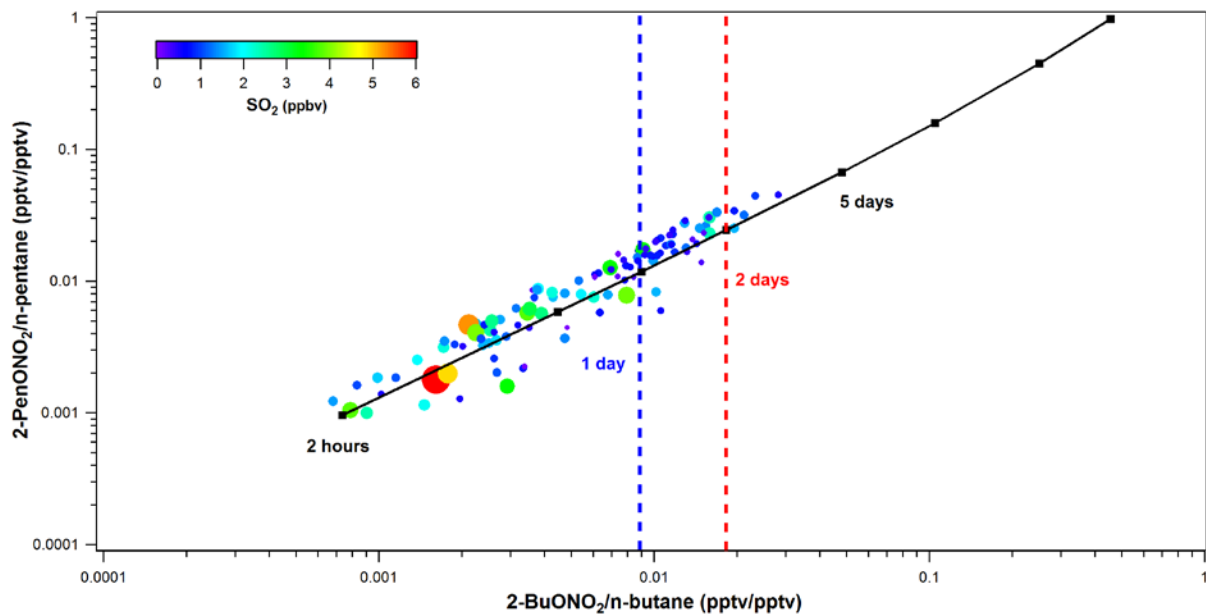
d. IMPROVE 2000-2014 Annual Soil



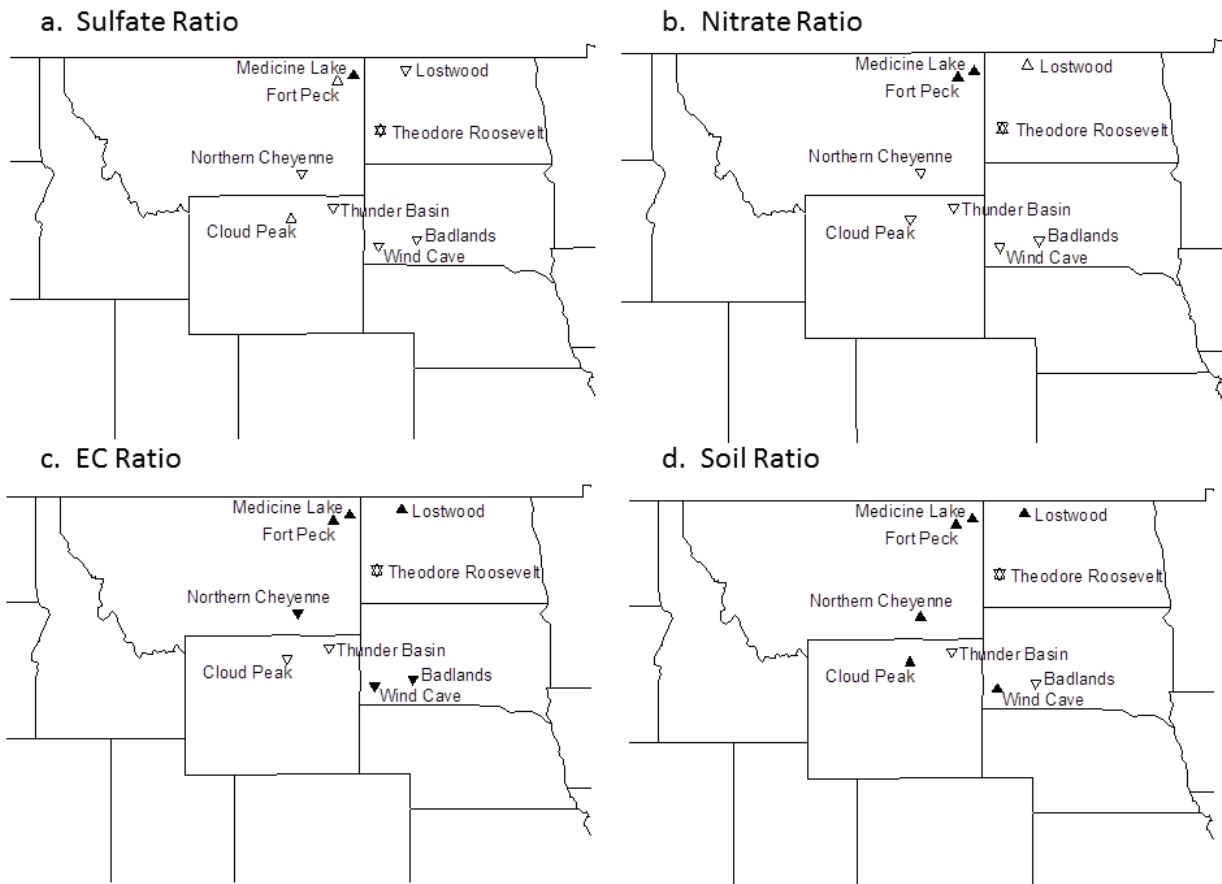
**Figure S1.** 2000-2014 annual trends from IMPROVE for particulate concentrations of (a) sulfate (b) nitrate, (c) EC and (d) soil. The direction of the arrow designates either a decreasing (down) or increasing (up) trend. Filled symbols are significant to the 90% confidence level ( $p < 0.10$ ). Unfilled triangles represent trends with  $p > 0.10$ . The size of the triangle designates the magnitude of the trend.



**Figure S2.** Box plot of daily mean concentrations of EC from IMPROVE at THRO-S, shown in black, for all data available from these sites dating back to 2000. Also shown are daily averaged data collected during the study periods in 2013 and 2014, with median concentrations shown as horizontal line segments.



**Figure S3.** A photochemical clock utilizing ratios of alkyl nitrates to n-alkanes. Modeled ratios are shown as the solid line, and measured data are given as points, colored by daily averaged  $\text{SO}_2$  concentrations.



**Figure S4.** Trends of ratios of concentrations of species measured from IMPROVE, relative to concentrations at THRO-S, for particulate (a) sulfate, (b) nitrate, (c) EC, and (d) soil concentrations. The direction of the arrow designates either a decreasing (down) or increasing (up) trend. Filled symbols represent significant trends ( $p < 0.10$ ). Unfilled triangles represent trends with  $p > 0.10$ .