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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Identifying and Quantifying Source Contributions of Air Quality Contaminants during Unconventional Shale Gas Extraction" *by* Nur H. Orak et al.

Anonymous Referee #2

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The manuscript examines concentrations of a range or pollutants (e.g. CH4, CO2, O3, VOCs, NO, NO2) using a monitoring laboratory near a well-pad to examine emissions pathways using PMF during horizontal drilling through production phases. The study reports 2 factors related to the on-site operations: a "natural gas" factor and an "engine emission" factor. It is an interesting study, but it would benefit greatly from additional discussion of the results and what they mean for the relative importance of the emission pathways for the various pollutants observed. Given the importance of methane, this would be an especially important place to dive in further. For example, over 3 pages are spent describing well-established details of the PMF method and application, but only 1.5 pages are spent on the source profile results themselves (including 1 figure).

This is not to say that the length of a discussion is indicative of quality, but it is provided here as an example of where the interpretation of results are relatively thin compared with the discussion of methods and the reporting of data. As another example, the manuscript closes with "Understanding the air quality impacts of operational phases is important since it has potential to help inform future decision-making and constrain cumulative impact assessments" and it would seem like the authors have data here to say something more quantitative about the different operational phases and their relative contributions, but the discussion and analysis does not sufficiently touch on this (and would need to account the wind issues identified below).

Overall, the paper has the potential to make useful contributions to the field, but should be carefully reviewed by the authors to expand on the discussion of their results where possible. A range of other comments are provided below.

Abstract:

- "The objective of this study is to investigate the effect of unconventional natural gas development activities on local air quality as observed at an active Marcellus Shale well pad" it would seem the objective is better stated as investigating the "emissions at the well pad", not the effect on local air quality, which is still interesting, but different. Please consider revising.

- "Moreover, model results suggest that the major contributions to the regional transport/photochemistry factor occurred during horizontal drilling and drillout stages." This is just a relative shift where there are less emissions at the site so the background factor appears more pronounced. As it reads, one could think it was contributions to photochemistry or nearby photochemistry–worth clarifying.

Fig 1: where is the monitoring lab on this map?

Lines 259-262 discuss a lot of basic details about the figure that would be better in the caption, with the results and discussion section focused on substantive observations.

Fig 3 caption seems to end abruptly. Also, adding dates in the caption for each phase would be extremely helpful.

An opportunity is missed to comment on the production volumes of the well and how that relates to the observed "natural gas" factor emissions. There could also be more discussion of this factor. Efforts like this to quantify emissions would be useful, or at least to discuss quantitatively the role of each factor in the observed emissions (2 of the factors)–this only exists in fig 5.

Fig 5 could be much more clear. I suggest incorporating color.

It is unclear how the wind direction is driving the PMF results and the observed average concentrations of pollutants at the site (Figs 3-4). The authors state that “With wind direction at this location most frequently from the southwest (Figure 2), this position optimized the occurrences of the laboratory being downwind of the well pad.” But the wind is still only coming from that direction $\sim$23% of the time and there is no clear understanding of how that changes over the course of the study. Some effort needs to be taken to demonstrate that this is not biasing the concentrations or PMF results, perhaps by conducting the PMF analysis with the wind isolated to that direction, or quadrant. Otherwise the wind direction could be a driver of relative differences in the PMF factors.

- For example, it could play a role in observations like this “The skewness of the data for this phase indicates that the data may not be normally distributed.” (line 268)

The SI states there is a lot more VOC data, anything interesting in there? Are there indeed significant aromatics in the Marcellus natural gas emissions as the data would suggest or is this just from the engine exhaust factor? Fig 5 shows it all on the natural gas factor, but the text talks about toluene with the engine factor. This is unclear and needs to be cleared up.

- Can the VOC data be used to further substantiate the observed PMF factors (beyond

what is done so far, which is useful)? This is a hint of this that appears at line 317. This seems like a big data set, but most of it is just left to the list in the SI without any data.

- “Propane and isobutane had the second and third highest average concentrations, respectively, for each phase of development.” (line 286), might be useful to clarify and show a figure in the SI for this since the sentence is not fully clear.

Supplement:

Generally, this needs to be cleaned up with more. Some of the figures are hard to read and the final section on uncertainty estimation is very challenging to follow given its structure.

Figure S4-5 could be quite useful, even in the main text if the format showed the periods of the different activities with sufficient image clarity.

Figure S6 needs a better caption to explain what is being shown.

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