Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2021-694

Anonymous Referee #2

Referee comment on "Measurement report: Photochemical production and loss rates of formaldehyde and ozone across Europe" by Clara M. Nussbaumer et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-694-RC2, 2021

The manuscript by Nussbaumer et al. provides the first HCHO budget calculations across Europe using *in situ* measurements as opposed to evaluating the HCHO budget using model simulations. Additionally, the authors show that HCHO production is dominated primarily by the oxidation of methane, methanol, acetaldehyde, and isoprene during three campaigns (CYPHEX, HOPE, and HUMPPA) representing a coastal, mountain, and forested site, respectively. The HCHO yield from isoprene and fraction of methyl peroxy radicals (CH_3O_2) forming HCHO were also shown as an alternative method for determining whether a location is NO_x or VOC-limited (or in some transition regime).

General comments: While the oxidation of methane, methanol, acetaldehyde, and isoprene are the dominant VOC precursors to HCHO production, care should be taken throughout the manuscript to never imply that only these four chemical species make up the entirety of the HCHO budget. HCHO is commonly used as a VOC tracer and comes from more than simply those four species as the authors showed with the pie chart in Figure 6. As an example, Line 75 is misleading since it states that "HCHO production can be accounted for by the oxidation of methane, methanol, acetaldehyde, and isoprene" which implies 100%. Rather, it should read "...predominantly accounted for..." or some other conditional phrasing.

The manuscript fits well within the scope of ACP and provides a good, detailed analysis of uncertainty. I recommend publication after attention to the previous general comment and the following specific comments/technical corrections.

Specific Comments:

- For the reader, explicitly define somewhere in the text what is meant by "atmospheric variability" (i.e., what factors control this uncertainty)

- Whenever mentioning the detection limit of an instrument (for instance, in Section 2.3.1), the integration time necessary to achieve that detection limit should be mentioned.

- Figure 1: There is space above (or below) the HCHO precursors to write the actual chemical name for each of the chemical formulas (i.e., acetone, MHP, etc.)

- Line 197: The determination of the acetaldehyde and formaldehyde photolysis frequencies are from a parameterization using IUPAC quantum yield data and measurements of $j(NO_2)$ and $j(O^1D)$. This parameterization should be explicitly shown in the SI for the reader.

- Figure 4: At least for the example shown, it is odd that points were selected when the HCHO mixing ratio was still increasing and were included in the fit. In this particular case, the slope would be underestimated and the deposition velocity would be biased. What motivated the decision to always select points between 21:00 - 01:30 UTC as opposed to looking at the underlying nighttime HCHO mixing ratio data over several hours?

- Lines 395-396: Please create pie charts for HOPE and HUMPPA (as done for CYPHEX) since this readily shows the contributions of the four dominant precursors as well as the other reactions included in your chemical mechanism. Could either place resulting figure in main text or SI.

Line 475: Explicitly state that specialized instrumentation is still required (particularly for OH and HO_2) for these alternative methods of determining the chemical regime.

Technical Corrections:

Throughout text: Formatting for d[HCHO]/dt is inconsistent (for example, line 260 and 275)

Line 404: Misspelling of acetaldehyde

Figure S7A: Please clarify whether the data is from CYPHEX or HUMPPA

Figures: Font size on axes should be increased since the axes are hard to read when printed