

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2021-304

Anonymous Referee #2

Referee comment on "Measurement report: Observation-based formaldehyde production rates and their relation to OH reactivity around the Arabian Peninsula" by Dirk Dienhart et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-304-RC2>, 2021

The manuscript titled "Measurement report: Observation-based formaldehyde production rates and their relation to OH reactivity around the Arabian Peninsula" reported the shipborne observations of HCHO, OH, and OH reactivity from the Air Quality and Climate Change around in the Arabian Basin (AQABA) campaign in summer 2017. The authors calculated the effective yield of HCHO with total HCHO loss rates, OH and OH reactivity, by assuming a photochemical steady-state of HCHO and analyzed factors (e.g., NO_x, VOC speciation, OH reactivity) that potentially impact the effective yield of HCHO. The measurements in the unique environment and the simultaneous measurements of HCHO, OH and OH reactivity will add value to the community but the analysis is not clear and needs major modifications. I'll recommend publication of this manuscript after the authors address my comments below.

Page 1 Line 28: Biogenic is the natural emission from living organisms such as plants and does not include biomass burning. Most HCHO from biogenic sources is secondary produced.

Page 3 eqn 3 and eqn 4: If you did not use eqn3 to calculate $p(\text{HCHO})$, please state it clearly especially when you provide the detailed information about each term. when you used $L(\text{HCHO})$ in eqn 4 to calculate $P(\text{HCHO})$, would the steady-state assumption hold at zero OH ? It is not clear that the intercept can represent additional HCHO sources to VOC oxidation by OH and major question 1 can be addressed. The intercept looks like to be the dry deposition term actually. Please also provide more information about the uncertainties in the dry deposition term.

Page 3 line 18: Do you mean photochemical steady-state instead of photo-stationary state? I think photo-stationary state can mean recombination of the photolysis products to form HCHO. Please replace all "photo-stationary state" terms by "photochemical steady-state" throughout the manuscript. The lifetime of HCHO is 2.5 hrs or more in the study.

What is the HCHO lifetime at sunset and sunrise? Are they short enough to assume to be in steady-state?

Page 4 eqn 5: Please define $P_0(\text{HCHO})$

Page 8 line 17: No stickler et al. (2007) in the reference section

Page 9 line 15-18: Is direct emission of HCHO very small compared to unsaturated hydrocarbons in the fresh pollution plume? Please specify the region and time when the fresh pollution plume occurred. The HCHO and ROH in AG leg seem to be high.

Page 8 line 18-20: Specify which region and time had rainout and which region and time had primary emission.

Page 9 line 20- page 10 line 1-2: The intercept may not represent additional HCHO sources because the steady-state assumption does not work at very long lifetime. The intercept can be equal to the dry deposition term.

Page 10 line 9: How do primary emissions and transport affect the alpha derived here?

Page 11 line 12-17 Can primary emission of HCHO also play a role in the highest calculated $p\text{HCHO}$ on 30/07/2017 from figure 2?

Page 12 line 20: which are these three regions mentioned? Please be specific.

Page 12: As mentioned before, the intercept likely cannot be interpreted as $P_{\text{add}}(\text{HCHO})$ because of the long lifetime at $\text{OH}=0$. Do the intercepts correlate with dry deposition?

Page 13 line 13-23. "individual trace gases ($\text{R}(\text{OH})_x$) from alkanes ($\text{R}(\text{OH})$ alkanes), alkenes ($\text{R}(\text{OH})$ alkenes), OVOCs without HCHO" is confusing. Does x represent individual group (e.g., alkanes) instead of individual trace gas? I would expect less VOC species and higher measured $\text{R}(\text{OH})_x$ to total $\text{R}(\text{OH})$ ratio in cleaner or lower ROH environments. No information about the VOCs measurement methods is provided in Section 2. A table of the measured VOC species is needed to understand $\text{R}(\text{OH})_x/\text{R}(\text{OH})$.

Figure 5: Do you assume the unmeasured VOC groups are proportional to the measured R(OH)alkene, R(OH)alkanes, R(OH)OVOCs, and R(OH)(aromatics)? What about using the ratio $R(OH)_x / ROH$ in the x axis ? This sounds the way to go if you want to evaluate the impact of the different VOC groups on HCHO yield alpha.

Page 15 line 19-page 16 line 1-2: I think the statement "the role of NO_x in HCHO production is ambiguous" does not sound correct based on Wolfe et al. (2016) and Valin et al., (2016). Do you mean HCHO yield instead? The following explanation is also not clear. It is more evident that NO influencing the amount of OH radical can impact the production of HCHO. Explain how NO influencing the amount of OH radical can impact the yield of HCHO.

Page 17 line 10-11: again "photochemical steady-state" instead of "photo-stationary state".

Page 17 Line 11-12: Could you provide potential reasons why the yield of HCHO depends largely on the presence of absolute VOCs levels? This does not have a clear physical meaning to me.