Comment on acp-2021-604
Anonymous Referee #1

Referee comment on "COVID-19 lockdown NO\textsubscript{x} emission reductions can explain most of the coincident increase in global atmospheric methane" by David Stevenson et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-604-RC1, 2021

Stevenson et al. explained the extraordinarily high methane growth rate in 2020 with anomalously low methane sink (less OH) in response to reduced anthropogenic NO\textsubscript{x} emissions due to COVID-19 lockdown. They referred to previous modeling results to quantify the sensitivity (CH\textsubscript{4} mixing to NO\textsubscript{x} emissions) and argued that the observed additional methane growth can be almost fully explained by reduced NO\textsubscript{x} emissions. While their hypothesis is an interesting and potentially important one, it still lacks concrete and convincing proof of the hypothesis as usually found in a research paper.

Specific comments are as follows.

First, the authors did not assess the impact of other species whose emissions may also have reduced together with NO\textsubscript{x} during COVID-19, for example, CO and NMVOC. Reduced emissions of these species have an opposite effect to that of NO\textsubscript{x}, that is, to increase OH and reduce CH\textsubscript{4} lifetime. According to Fig 3 of Lamboll et al. (2021), emissions of CO and NMVOC were also substantially reduced though with slightly smaller fractions compared to NO\textsubscript{x}. Fry et al. (2012) showed with their model that the net effect on OH is close to 0 with compensating effects from a combined 20% reduction of NO\textsubscript{x}, CO, and NMVOC. So, the author's argument can be much stronger if they can estimate the net chemical effect of the COVID-19 emission perturbation.

Second, the calculation of the authors relies on the sensitivity of CH\textsubscript{4} mixing to NO\textsubscript{x} emissions, taken from previous studies. Most of the studies cited are from the 2000s. The "baseline" emissions of NO\textsubscript{x} as well as other chemicals may have changed a lot from the early 2000s to 2020. I wonder if the sensitivity of global OH and CH\textsubscript{4} to NO\textsubscript{x} emissions will also change, and if so change by how much, with the "baseline" emissions. This chemical system is known to be nonlinear.

Third, independent observation evidence on reduced global OH, if there is, can be really powerful. The 5 ppb additional increase in methane mixing ratio translates roughly to a 3% decrease in global OH concentration if they were attributed entirely to reduced NO\textsubscript{x} emissions. This magnitude of decrease in global OH can have detectable signals on burden or distribution on many species besides CH\textsubscript{4}, such as CH\textsubscript{3}CCl\textsubscript{3}. If these analyses are consistent with the author's hypothesis of NO\textsubscript{x} chemical feedback, it can really increase the confidence, though it may be a lot of work.