Atmospheric Chemistry and Physics Discussions

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Reply on RC2

Volker Matthias et al.

Author comment on "The role of emission reductions and the meteorological situation for air quality improvements during the COVID-19 lockdown period in central Europe" by Volker Matthias et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-372-AC2, 2021

Point by point responses to the comments of Referee 1

We thank the referee for the valuable and very constructive comments that helped improving the manuscript considerably. All comments are repeated in this point-by-point answer of the authors. Reviewer comments are written in *Italics* while author's responses are given in **Bold**.

Comments Referee 1

Review of "The role of emission reductions and the meteorological situation for air quality improvements during the COVID-19 lockdown period in Central Europe" by Matthias et al.

This manuscript provides a comprehensive, methodological analysis of the individual and combined effects of COVID-related emission changes and meteorological variability on air quality over Central Europe during the core period of the COVID-19 lockdown in 2020. The study design is thoughtful and sound. The results provide a valuable contribution to the rapidly-growing set of studies investigating this topic, especially by highlighting the complex interactions between meteorology and emissions for key pollutants and cautioning against attributing observed concentration changes directly to changes in emissions without performing an in-depth analysis of potential confounding factors.

The manuscript is generally well written and organized.

The introduction section could potentially be shortened by either eliminating or reducing the summary of results from previous studies.

It was shortened

My only major comment is to consider adding analysis for modelled PM2.5 species to provide additional context on how changes in total PM2.5 are driven by how different processes (emission changes vs. meteorology) affect individual PM2.5 components (e.g. primary vs. secondary, inorganic vs. organic).

We added results for ammonium, nitrate, and sulphate in the appendix and we briefly discuss this in the context of interactions between these inorganic aerosol components when precursor emissions (here NOx emissions) are strongly reduced. We refrained from discussing results for EC and OC in order to not further extend the paper that is already quite long.

Specific comments:

Page 1, line 22: remove comma after "both"

done

Page 2, line 46: suggest moving "also" after "weather conditions"

done

Page 2, line 48: To my knowledge, Goldberg et al. (2020) is a notable exception to this statement and might be cited here: Goldberg, D. L., Anenberg, S. C., Griffin, D., McLinden, C. A., Lu, Z., & Streets, D. G. (2020). Disentangling the impact of the COVID-19 lockdowns on urban NO2 from natural variability. Geophysical Research Letters, 47, e2020GL089269. https://doi.org/10.1029/2020GL089269

The statement does not imply that there are no studies about the interaction of the meteorological situation and the lockdown emission reduction, but that they care rare. We included the publication by Goldberg et al. later in the introduction when we describe previous studies.

Page 2, lines 49 – 54: This section seems to summarize results obtained later in the paper without explicitly saying so, but without providing any separate reference, either. I suggest either providing a reference or removing it from this portion of the manuscript.

We shortened this paragraph and included a statement about meteorological influences on photochemistry in the remaining text.

Page 4, line 126: were the COVID-19 lockdown effects considered in the IFS-CAMS fields used as boundary conditions? If not, does this introduce an additional level of uncertainty into the analysis, especially as it relates to the role of meteorology and longer-range air mass transport?

IFS-CAMS fields do not consider lockdown effects. We added a sentence about this on page 4. Consequently, effects of lockdown measures outside Europe, e.g. in North America and Africa, on intercontinental transport are not considered in our simulations. However, the simulations consider emissions changes in entire Europe, while the evaluation is performed for Central Europe only. This setup already consider medium range transport inside Europe and reduces effects of intercontinental pollutant transport. In addition, intercontinental transport will not play a major role during the major lockdown period because the Großwetterlage with a blocking high pressure system in Central Europe did not favour this. In conclusion, we believe that the uncertainties caused by neglecting lockdown measures outside Europe are much lower compared to the inherent model uncertainties, which are now given in section 4.3 (former section 6.1).

Page 5, lines 145-146: suggest moving "best" from the end of the sentence to before "reproduces"

done

Page 5, line 169: can you please provide a reference for the NMVOC split profiles used inthis analysis?

The data was provided by Jeroen Kuenen from TNO in a personal communication. There is currently no reference for the data available, which is why we cited it as "personal communication" and added an acknowledgement to Jeroen Kuenen.

Page 6, line 187: add comma after "time series data"

done

Page 6, lines 195 – 196: What was the rationale for not assuming any changes in shipping emissions between 2016 and 2020?

This is based on data for the Baltic Sea published by HELCOM and the Finnish Transport and Communications Agency (
see
https://portal.helcom.fi/meetings/MARITIME%2020-2020-787/Documents/Presentation%204_Ship%20emissions%20in%20the%20Baltic%20Sea%20area%202006%20-%202019.pdf) that shows a stable or even decreasing shipping

emissions in the Baltic Sea when only IMO registered ships (i.e. bigger ships) are considered. We conclude from this that also in the North Sea shipping emissions will most likely not show significant changes between 2016 and 2020.

In order to keep the description of the basic emission construction for 2020 concise, we do not explain this further in subsection 3.1

Page 7, lines 224 – 228: You may want to state upfront that this approach cannot distinguish between passenger cars and trucks which likely had very different activity changes resulting from the lockdown. This limitation is discussed in Section 6.2 but in my opinion should be mentioned here.

We added that vehicle types cannot be distinguished.

Page 7, line 237: most readers likely aren't familiar with the term RoRo for certain types of ferries, please define or spell out.

We now explain this in the text, Roll-on/Roll-off

Page 11, lines 286: suggest changing "… exceptional weather, what is assumed" to

"exceptional weather that is assumed"

done

Page 11, line 301: change "supplemented" to "supplemental"

removed

Page 12, line 327: remove comma after "meteorological fields"

done

Page 13, line 372: suggest moving "also" from before "advected pollutants" to after "meteorological conditions"

done

Page 13, line 373: add comma before "time series"

done

Page 14, line 386: add comma before "time series"

done

Page 20, lines 487 – 497 and Figure 12: recommend adding analysis and discussion for key PM2.5 species (sulfate, nitrate, ammonium, EC, OC) – see major comment above.

We analysed the main PM components sulphate, nitrate, and ammonium which contribute more than 2/3 of the total modelled PM2.5. We added a paragraph about the results in section 5.1 below the paragraph about PM2.5 concentrations. Figures that show the temporal development of the changes in sulphate, nitrate, and ammonium are given in the appendix. We refrained from extending the discussion for more details and other PM2.5 components, because the manuscript is already very long. In addition, model results about BC and OC are less reliable than those about secondary inorganics, as previous model intercomparison studies have shown. This is because BC, and also NMVOC emissions are still quite uncertain. In addition, SOA formation is usually underestimated in CMAQ model results.

Page 22, line 511: suggest replacing "observed" with "simulated" to avoid confusion

done

Page 23, line 531: remove comma after "both"

done

Page 23, line 539: remove comma before "only"

done

Page 26, lines 604 – 605: Differences between observations and model simulations likely also are caused by other errors in the modeling system (uncertainties in simulated meteorological fields, chemistry, deposition, base emission inventory, etc.), not only uncertainties in representing the lockdown effects. Suggest reconsidering this statement.

We added two sentences about typical model uncertainties.

Page 30, line 652: change "(Bauwens et al., 2020)" to "Bauwens et al., (2020)"

done

Page 30, line 661: remove comma after "selected"

done

Page 30, line 670: remove comma after "constellation"

done

Page 31, line 692: remove comma after "conditions"

done

Page 31, line 718: PM2.5 is both primary and secondary. My suggestion of adding analysis for PM2.5 components would potentially shed light on which portions of the PM2.5 changes are more sensitive to emissions changes vs. meteorology.

This is a very interesting investigation, but we think that it is not possible to do this in detail in this paper. Inorganic PM is now briefly discussed in section 5.1 and a number of figures was added in the appendix. A further discussion as the reviewer suggests would extend the entire paper which is already quite long. We consider to discuss changes in PM components in separate study based on the same model runs.

Page 33, line 769: remove comma before "only"

done

Please also note the supplement to this comment:
https://acp.copernicus.org/preprints/acp-2021-372/acp-2021-372-AC2-supplement.pdf