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Comment on acp-2021-584

Anonymous Referee #2

Referee comment on "Reducing the tropospheric ozone bias in global models: the potential of processes modulated by weather" by Tamara Emmerichs et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-584-RC2>, 2021

In this manuscript, the authors run a series of sensitivity studies using the atmospheric chemistry model EMAC to test model sensitivity of ozone and NO₂ to weather-controlled processes. Specifically, they test water complexes, dry deposition, drought stress, soil emissions, and lightning. They find that the combination of all modifications leads to a reduction in EMAC global ozone burden by 20%, bringing the model into alignment with other model estimates and closer to observations. The water complex modification appears to be the most consequential change for ozone concentrations. The authors compare their model output to observations from the TOAR database and satellite NO₂ products. The authors find that their modifications lead to an underestimate of NO₂.

This manuscript is interesting and has potential to be a good contribution to the literature. However, the organization of the manuscript is confusing, and many details need to be fleshed out before it can be published.

Organization-wise, there is a lot of text scattered throughout the results that would be appropriate in the introduction and methods sections. As an example, section 4 details the author's reasoning for including the water complex, which is information that should be introduced at the beginning of the paper to give readers context for why this is included. Similarly for section 4.1, the kinetics are described but this should be placed in a methods section. This occurs throughout all sections 4-8 and makes the paper convoluted to read, as the organization is so different from what one expects when reading a scientific paper. I don't know where to find the information I need to properly understand what is being done, and I suggest the authors reorganize to a more traditional format.

More context is also needed in the introduction for understanding why some parameters are the ones examined. I think the reasoning for the water complex and dry deposition is there, but it would benefit from also including the introductory information that is presented in sections 4 and above. The reasoning behind the HONO and lightning NO_x sensitivities should be more fleshed out and the connection made clearer. Right now, the

connection to weather-driven processes is missing, especially for soil HONO.

The methods also need more fleshing out. Some methods are presented in sections 4.1, 5.1, etc., but methods for the HONO sensitivity need to be explained more, especially Table A1, which currently is uninterpretable for a reader unfamiliar with Oswald's work.

Further, a justification for the day and nighttime analyses instead of a seasonal analysis should be provided. Weather-driven processes typically have strong seasonality, so I would think that would be a priority for the authors. I suggest that the authors include a seasonal analysis if possible.

Minor comments:

Line 253. "The contribution of the RO₂/NO reaction to the change of the Ox production is with 7% much smaller than the 70% contribution by the HO₂/NO reaction." This sentence is confusing and I am having trouble interpreting it. Please reword.

Line 291. "Since the newly implemented cuticular uptake..." This is not a complete sentence. Consider adding this phrase to the previous sentence. Other fragments occur throughout, including lines 296 and 306.

Line 363. Can the authors provide more of an explanation for the HONO/NO_x ratio? What does this ratio tell us?

Figures and Tables:

Table 4. Why is the comparison done to the third IPCC report rather than a more recent one? Do more recent reports not contain this information?

Table A1. As mentioned previously, this table does not mean anything to people who have

not studied Oswald's work.

Figures 7 & 9. Consider making these into difference plots, rather than having readers look for differences between two panels. The authors could even consider adding a third panel that shows the difference.