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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A new diagnostic for tropospheric ozone production" *by* Peter M. Edwards and Mathew J. Evans

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Anonymous Referee #2

General Comments This paper presents a new method for diagnosing ozone production based on the processing of chemical bonds. The authors show that this new diagnostic changes our view of the relative importance of different hydrocarbon emissions, which is an improvement over previous methods using a simple total carbon-based approach. The authors also quantify the ozone-producing efficiency of the emitted bonds. The ability of this diagnostic to separate the difference between shifting the NO/NO2 ratio and its impact on ozone production vs. the increase in the fraction of RO2 reacting with NO is valuable. Overall, the discussion of the diagnostic and model sensitivities

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Discussion paper

is quite lengthy and could be shortened by spending less time on the discussion of methane, per the comment below. This paper should be published after addressing the comments below, in particular, how this diagnostic could be relevant to our understanding of the differences in ozone production across models without actually implementing the diagnostic in every single chemical transport model.

Specific Comments

1) The discussion of methane and isoprene is confusing due to the model implementation of methane as a fixed concentration. It might be better to focus the discussion on evaluating perturbations to isoprene emissions, and contrast that to methane, as opposed to the way it is presented now, with the caveat about model treatment of methane. Then the discussion of the dependence of methane 'emission' on OH would not be needed (i.e. Figure 7) which is difficult to follow.

Response: We accept the reviewers comment that the discussion of methane and isoprene could be confusing. However, the fundamental differences in both their chemistries and treatment in the majority of chemical transport models mean we strongly feel that they warrant individual treatment. We have significantly shortened and simplified the discussion of methane, and have simplified Fig. 7 (see response to referee #1 comment 6). As the 1st reviewer did not have an issue with the individual discussions of methane and isoprene we respectfully leave it to the editor to decide if our response to this comment is adequate.

2) This analysis would also be strengthened by presenting the types of information that global model comparisons of ozone production should include to take advantage of this type of diagnostic. For example, it seems that if all models presented their total methane, isoprene, CO, and NOx budgets, this diagnostic would help interpret the resulting impact on ozone production without actually implementing the diagnostic in each model. This might increase the scientific contribution of this paper.

Response: We have added the following paragraph to the conclusions section of the

paper.

Changes to manuscript: Another potentially important application is in model-model comparisons. Increases in our understanding of why different models calculate different O3 production and burdens has been slow [Stevenson et al., 2006; Wu et al., 2007; Young et al., 2013]. Although a complete tagging like that described here is unlikely to occur for all of the models involved in the comparison, a small number of additional diagnostics is likely to produce a significantly better understanding of the models. Diagnosing (1) the total bond flux (direct emissions plus the flux for those species kept constant), (2) the rate of production of RO2 and (3) the rate of production of O3, could help differentiate why certain models produce more or less O3 than others. The ratios between these fluxes would help identify what aspect of the emissions of chemistry differs between the models.

3) The paragraph starting on line 341 needs clarification. What do you mean by "the final 20% due to the increased OH competing for the available oxidisable bonds." Doesn't this just mean that with higher NOx, you get higher OH concentrations and thus you increase the concentration of RO2 as well and NO?

Response: This sentence has been reworded to avoid confusion.

Changes to manuscript: "the final 20% due to the increased OH concentration competing for the available oxidisable bonds and resulting in increased RO2 production."

Technical Corrections

4) Is discussing SO2 oxidation relevant to ozone in any way? If not, it is confusing and should be removed.

Response: Although SO2 oxidation has minimal direct impact on O3 production it is still a source of peroxy radicals that are central to this diagnostic approach (SO2 + OH + O2 $\rightarrow$ SO3 + HO2). We therefore would prefer to keep the sentence on SO2 for completeness and also to aid others in reproducing the diagnostic approach.

5) You say that over a long enough timescale, the global atmosphere can be considered to be in steady-state, and thus equation (1) applies. Please clarify the conditions where this diagnostic is useful/applicable. For example, could it be used for a daily analysis of ozone production.

Response See response to referee #1 comment 2.

6) Please be consistent with the use of CH3O2 or MO2.

Response: This has been addressed.

7) On line 438, the sentence that starts with “With the majority” is not a full sentence.

Response: This has been addressed.

8) On line 440, remove the comma after OH.

Response: This has been addressed.

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