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Interactive comment on "Source apportionment and sensitivity analysis: two methodologies with two different purposes" *by* Alain Clappier et al.

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Congratulations to the authors for this well-written comparison of methods related to the evaluation of emission impacts! We think that an inclusion of similar discussions from the chemistry-climate community would even strengthen the paper. Four aspects may be especially of interest: 1. We believe that the tagging method presented in Section 4.1 is identical to tagging approaches used in global model. (e.g. Horowitz and Jacob, 1999; Lelieveld and Dentener, 2000; Meijer et al., 2000; Grewe, 2004; Gromov et al., 2010; Butler et al.,2011; Emmons et al., 2012; Grewe et al., 2012,2017) Is that correct? Can you comment on this?

R1: We agree. The tagging methods used in global model are similar to those used

to estimate contributions in the frame of climate-chemical studies at global scale. We added a paragraph at the end of section 4.1 and included the suggested references.

2. Are the results of your comparison deviating from earlier intercomparisons between the two methods (source apportionment and sensitivity analysis)? Here we refer to Grewe (2013) where the simple differential equation with x the concentration of a chemical species, is used to analyse the differences between the two approaches. Further, we refer to Grewe et al. (2010) where a more complex chemical system (3 species: pseudo NOy, pseudo VOC and pseudo O3 and 3 differential equations) is investigated. This system shows the characteristics similar to that of tropospheric ozone chemistry and is hence well suited as a test bed. This system was evaluated with respect to the differences between both methods. Grewe et al. (2010) and Grewe (2013) also nicely show that both methods are equal in a linear regime, which supports the author's statement.

R2: We agree and added a couple of lines (and references) referring to those works in the text.

3. We agree that depending on the purpose of the analysis one or the other method is appropriate, as discussed by the authors. However, we miss a clear statement that the combination of both methods give a much better basis for the interpretation of mitigation options.

R3: This is an important point, made by one of the Reviewers as well. We now inserted a few lines to address it in the text. Rather than a combination of the two approaches, we stressed the need to calculate sensitivities at different levels of emission reduction whenever non-linearity is important. New approaches like the path-integral method are in this respect very useful. We stressed this point again in the conclusions.

4. On top of the previous point, a more in depth discussion on the effectiveness and suitability of the discussed methods for the use in political and economic frameworks, which try to provide incentives for mitigation options might be helpful to understand the

implications of using those methods. For example, only the sensitivity method (or also called perturbation method) is suitable to evaluate the impact of a mitigation measure. However, while having said this, deducing from this statement that only the sensitivity measure should be used in any political and economic framework for incentivising measures, might be plainly false. We think that this is an important point which should be raised in the paper. Let's take exemplarily the response of the ozone chemistry on a decrease of NOx emissions (see Fig. 1). In a saturated chemical regime a decrease of NOx from e.g. road traffic (Fig. 1a) might not lead to any change in the ozone concentration (Fig. 1b). As NOx emission decrease, but not the ozone concentration, the net-ozone production (NO3P) per NOx-molecule (Fig. 1c) increases. Hence this mitigation measure leads to important change in the chemistry without affecting the ozone concentration. The chemistry might have left the saturation regime because of this first measure. If a second NOx emission reduction is implemented, this second measure reduces the ozone concentration, since the chemical regime is not anymore saturated and hence takes advantage of the first measure. An ozone reduction is only achieved because the first measure took place. Assessing the two measures by the sensitivity analysis makes the effectiveness prone to the order of implementation. This has been touched in the conclusion (line 802), but might be clarified. On the other hand tagging methods would be more suitable in assessing the effectiveness of mitigation measures, since they are largely (of course not totally) independent of the order of implementation. This is sketched in Fig 1d). The perturbation approach would not see a change of the road traffic impact, as the ozone concentration would not change. The contribution, however, as calculated with a tagging method would be lowered as less NOx molecules from road traffic are involved in the production of ozone. A first discussion of these effects were given in Grewe et al. (2012) and will further discussed in a paper which we will submit this summer to ACPD (Mertens et al. 2017). The Fig. 2 is taken from that paper and nicely illustrates the impact of the degree of saturation of a chemical regime on the assessment of mitigation options.

R4: Additionally to our response to point 3 above, we believe that calculating sensitivi-

ties and interactions at various level of emission reductions seems the only alternative when non-linearities are important. Source apportionment would provide the impact of reducing all emissions by 100% (and could be considered as an overall sensitivity) but this overall sensitivity might represent far away conditions from the limited reductions (e.g. 30 or 50%) considered by policymakers. Even if used in combination, the gap between the source apportionment and sensitivity approaches might still be too large to provide useful information to policymakers. As mentioned above, new approaches like the path-integral methodology represent a powerful approach (although on the expense of additional computer calculations). This point is now addressed in the text.

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