Geosci. Model Dev. Discuss., 3, C269–C273, 2010
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Geoscientific Model Development Discussions

GMDD

3, C269–C273, 2010

Interactive Comment

Interactive comment on "On the attribution of contributions of atmospheric trace gases to emissions in atmospheric model applications" *by* V. Grewe et al.

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Reply to Anonymous Reviewer # 2

We like to thank the reviewer for the constructive comments, which improved the mansucript.

Note that we have indicated changes in bold in the revised mansucript.

Balance between equations and explanations:
We agree that there is a large number of equations, which might distract the reader. However, they are included deliberately to give the reader the chance to exactly follow

the calculations. We take the comment serious and revise/add a couple of explanations (see below for further details). Further, we have included an overview table with the used variables.

Figure 1:
Both reviewer suggest to split the figure into 2 or more parts, which makes sense. We now introduce the Figures (see enclosed Figure)
1a General settings
1b Linear case and perfect agreement
1c Nonlinear case and good agreement
1d Nonlinear case and obvious problems
1e Details on calculation of contributions
1f Details on the two error definitions

1a to 1d are now included in the introduction to motivate the whole story.

Figure 1d is also briefly discussed in Sect. 3.1

The reviewer's sentence "The basic point is obviously that a tangent is not always well constraint by two points" shows that we obviously failed to motivate the problem correctly. Because this is only a part of the story and only a minor one, since it can be resolved. This refers to error ϵ_α. The more problematic issue is that the contributions calculated with the sensitivity method are not adding up to 100%, which is only the case, when the tangent goes also through the origin. This discussion is added with an extended Figure 1. The introduction and abstract is revised to clarify this point.

Error Section:
The first part in Section 5 describes the relative error of the sensitivity method, when applied to calculate contributions from individual sectors to the concentration of Z and $\tilde{Z}$, i.e. for the two chemical systems. The first, partly linear system is without the tilde, the totally non-linear system is denoted with the tilde. The relative error in the sensitivity method is calculated according to Eq. (72) and (73). How the PDF is calculated is

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explained just below Eq. (72) and (73).

So we are a little bit puzzled what kind of information is lacking. Probably, it is hard to follow the text with the numerous symbols, which we tried to motivate at various places. To overcome this problem, we included a table, with most of the symbols explained.

Steady-State Solutions: We totally agree with the reviewer that in nature chemistry is not in steady-state. The concentration on the steady-state solutions has a couple of reasons: First, the solutions can be calculates easily analytically, which is - of course - only a practical reason. Secondly, we consider quasi steady-state climate-chemistry simulations, which are to some extend comparable to steady-state assumptions in a box model approach, as stated on page 830 line 20-24; The annual mean values behave like a boxmodel in steady state.

Explanation for R11-R12: We have extended the explanations: For the Z-production reaction (R11) we consider a molecule X_i, i.e. a molecule X, which has been emitted by source i and a molecule Y_j, i.e. a molecule Y, which has been emitted by source j. The product is one molecule Z, but since both emission categories i and j are involved equally important the resulting species are $\frac{1}{2}Z_i$ and $\frac{1}{2}Z_j$. In the case that a molecule X_i reacts with Y_i, we obtain a molecule Z_i. For the Z-loss reactions (R12-R13) this consideration is in analogy: When molecules X and Z react, where X and Z are assigned to emission category i and j, i.e. X_i and Z_j, then both categories are equally important for the destruction of 1 Z molecule and the change $-1Z$ arises from $-\frac{1}{2}Z_i - \frac{1}{2}Z_j$. Starting from 1 molecule Z_j, this results in $-\frac{1}{2}Z_i + \frac{1}{2}Z_j$ on the left side of reaction (R12).

Section 3.3:

"Section 3.3. should more clearly distinguish in its introduction what the sensitivity method can and cannot provide, when emission impacts are assessed." Since reviewer # 1 also asked for clearer statements on this, we have rephrased the introduction and conclusion. We also have included a löast line at the end of Sec. 3.3.

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Since both reviewer misunderstood the wording "chemical reactor", we changed it into "chemical system".

Interactive comment on Geosci. Model Dev. Discuss., 3, 819, 2010.

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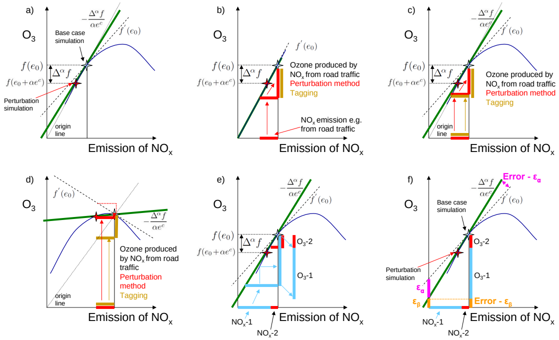

Fig. 1. Illustration of the sensitivity method (pair of simulation) to derive contributions from emission categories and intercomparison with the tagging method. The ozone concentration in arbitrary units is shown as a function of the emission of NO_x. Two simulations (base case and a simulation in which the emissions e_c is changed by a factor α) are indicated with stars. The derivative is added as a tangent for the base case (dashed line). The line through the base case simulation and the origin (origin line) is dotted. The green line shows the estimated derivative, based on the two simulations. a) General settings and calculation of the derivative. b) Assumption of linearity in ozone chemistry for illusrtation purpose. An arbitrary NO_x emission (horizontal red line) is considered. The vertical red and brown lines indicate the ozone contributions caused by this NO_x source (sensitivity method in red and tagging in brown) giving identical results. c) As b) but for the assumption of a non-linear ozone chemistry, however in a situation, which is close to the linear case. The green and dotted lines are used to calculate the contributions based on the sensitivity and tagging method, respectively. d) As c), but for a situation, which is far from the linear regime. e) Calculation of the ozone contributions; Two emission categories are considered (NO_x-1: light blue, NO_x-2: red) and the ozone contributions O_3-1 and O_3-2 indicated with vertical lines. f) Error analysis; The two errors ϵ_α (magenta) and ϵ_β (orange), which describe uncertainties associated with the determination of the tangent and the total estimate of all contributions (intersection of y-axis and tangent) (see Sect. 6).

Fig. 1.