Geosci. Model Dev. Discuss., 5, C1076–C1078, 2012
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Geoscientific
Model Development
Discussions

Interactive comment on "A generalized tagging method" *by* V. Grewe

Anonymous Referee #2

Received and published: 18 December 2012

A more generalized formulation for making attribution calculations with a numerical model for chemistry and climate is presented. It is a useful contribution, but needs to be made more accessible by recognizing the parallels with other methods and explaining some aspects of the mathematics. As far as I can see this approach looks at the parts of the continuity (tendency) equation that can be partitioned among different sourced tracers and then generates a tendency in other tracers based on the Jacobian and a decomposition of net P-L terms to deal with the non-linear (non-additive) nature of parsing the total tendency into its components.

Tagging is just one approach to following the consequences of a specific perturbation and then attributing down-link consequences (ozone depletion, climate change). The most straightforward way to do this is to perform both control and perturbation numerical calculations and then to difference them. These are described as sensitivity/perturbation experiments here. The obvious issue with perturbation calculations is

that they are effectively a linearization of the system about the current state, and do not apply as one drops all anthropogenic emissions or other sources and the system shifts to a very different state with different sensitivities. The manuscript derides sensitivity calculations (with the case of tropospheric ozone production) in that a NOx saturated regime is insensitive to added NOx. But that is true: Perturbations to NOx have little impact, but if one were to eliminate all the NOx and then add a perturbation, the NOx would generate much more ozone. This is a problem with any non-linear system, and it cannot be fixed with tagging or any other approach as all of them must make arbitrary decisions in framing the question. Thus, the example here has no "correct" answer.

Moreover, if I follow the derivations here correctly, then the ultimate equation (10) is really no different than the sensitivity runs. Effectively the tendency (F) is merely partitioned among the various tagged tracers using the Jacobian, which is only a linearization about the current state. The perturbation / sensitivity runs implicitly use this same linearization. The singularity issue is interesting, but seems to be just a zero-divided-by-zero issue?

The heating rate section has analogies with the UV radiative coupling of the N2O-O3 system (Prather, Science 1998) in which the coupling is across all levels. It becomes an (n-species x m-levels)-squared problem. While this worked in a 1-D diffusion model, I doubt that the tagging across all levels is practical in a 3-D model as the matrices described here would become unmanageable.

This approach needs a serious re-think. If published, the author should fix some of the following:

3312/15-3313/13 I think differences between this method and the perturbation method are not that great. The answers should be the same unless you make arbitrary decisions about the non-linearity.

3313/7-11 This is the problem with tagging. The simple perturbation calculation includes all of these automatically.

3313/22 ‘ansatz’ is not a common English word, try another.

3315/ From here on out it is not clear what quantities are vectors, matrices, scalars – can you help clear this up? Equation (10) for example – the multiplier of F(x) is a scalar? Also, the GRAD F notation appears in (10) without definition.

3321/12 Missing a word: “which allows to. . .”

3321/19 ‘ansatz’ again

Interactive comment on Geosci. Model Dev. Discuss., 5, 3311, 2012.