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Geoscientific
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Discussions

Interactive comment on "A new method to diagnose the contribution of anthropogenic activities to temperature: temperature tagging" *by* V. Grewe

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The reviewer raised a couple of interesting questions and I am thankful for this, since it enhances the readability of the paper. Please find detailed answers below. The reverer's commetns are highlighted in bold.

1) I think that there is need for more description of how the method would fit to a larger scale complex model. The reader will need the parts of the manuscript before Sect. 4 to be better connected to Sect. 4 itself, in order to understand the potential applications of the technique on more specific problems. For example, it is not clear how an approach applied here to an equilibrium .big picture. con-

text would be applied to a regional medium-range weather prediction context, such as the Russian heatwave case. I think the author should use this example (Russian heatwave) to explain further how such a problem would be approached practically using the tagging method.

A detailed description of how to implement this technique into a complex model is out of the scope of this paper, but hopefully of a follow-up paper. Nevertheless, I think it is important to understand that this technique can be, in principle, transferred to a 3D model right away. To support this, I included a flow chart. In black a very short version of an ordinary atmosphere model is given and in red the extensions for the tagging scheme. If we include two tracers 1) temperature with natural background and 2) anthropogenic temperature, then the second tracer gives a 3D temperature field of the contribution of anthropogenic emissions to the total temperature. Of course, the process is much more complex, since also surface models and ocean models have temperature fields, which have to be taken into account. Note also that the box model used here is not a steady-stade model.

Here the text, which is included in Sec. 4. after the first paragraph:

Fig. 10 gives an simplified overview on an arbitrary 3D climate model (black) and necessary extensions for the tagging scheme (red). First, quantities are defined and intitialised. Without loss of generality temperature is regarded here as a tracer, i.e. an advected quantity. For the tagging scheme additional tracers have to be defined and intialised accordingly. For the Russian heat wave example, this would imply two tracers, one which experinences all natural effects and one with anthropogenic greenhouse gase effects. The sum of both fields equals the temperature field. These fields are then advected by the models's advection scheme. During the physics and radiation calculation all temperature tendencies have to be extracted and tagging tendencies calculated from these tendiencies, which is basically the heart of the tagging scheme and refers to Sec. 2.3 in this paper and to Grewe (2013). Finally the temperature field and the tagged fields have to be integrated, i.e. the next time step value is calculated based on the tendencies. This leads to two 3D fields for every timestep, which gives the contribution (in K) from natural and anthropogenic effects to temperature.

2) Furthermore, it would be interesting to discuss in Sect. 4 how other radiative forcing agents such as aerosols, which do not only absorb radiation and have a mixture of properties, could be treated using the tagging technique in a complex model.

Here I like to refer to Grewe (2013), where a consistent tagging technique for arbitrary quantities and processes are defined.

3) I would like to see some more referencing or at least support for the choice of certain values for parameters that have been used. Table 2 includes a variety of such values and it would be good to document where they come from.

Table 2 now includs a detailed referencing, except for some well-known physical constants. The specific heat capacities are derived from Hilsenrath et al., 1955 for air (1004 J/kg/K), Osborn et al., 1939 for liquid water (4180 J/kg/K) and Bowers and Hanks, 1962 for soils (630 to 1045 J/kg/K). A mean specific heat capacity for the surface is calculated as 2/3 4180 J/kg/K + 1/3 715 J/kg/K = 3025 J/kg/K. Other parameters, such as albedo, are taken from Andrews (2010) and others (see revised version) or are reasonable estimates.

Specific comments:

Page 3190, Line 5-6: Please explain how and why a 30-year response was achieved.

The response of the atmosphere-shallow water system is roughly 30-40 years according to e.g. Hasselmann 1993. Of course a single time scale is not representing the atmopshere ocean correctly, but it is a reasonable assumption for this simple climate box model. A reference is included in the revised version.

Hasselmann, K., Sausen, R., Maier-Reimer, E., and Voss, R.: 1993, On the Cold

Start Problem in Transient Simulations with Coupled Atmosphere-Ocean Models, Clim. Dynam. 9, 53-61.

Page 3190, Line 16-17: Please explain how these values were chosen (reference?).

The lw absorption is roughly 0.8 (Andrews, 2010). Here I parameterised the lw absorption with two constraints:

- base case represents roughly a_l=0.8 (here a_l=0.77)
- CO_2 increase leads to an increase in the absorption, which gets saturated

Page 3196, Line 3-4: Would it not be more reasonable to set the CO2 concentrations to 360 ppmv for the spin up period as well?

This is probably a misunderstanding. The background CO_2 concentration is set to 360 ppm during the spin-up and then additional 360 ppm are included in the system. Text rephrased.

Page 3196, Line 7-8: Please provide reference to support that this is a widely used definition.

I added 5 references from text books many more can be added. Note that some authors calculate the difference of the surface temperature with and without atmosphere and some take only the difference due to longwave absorption into account, which basically leads to the same result, since the sw absorption is small. The basic difference between this approach and the tagging approach is that the first concentrates on the effect of a perturbation whereas tagging calculates the contribution of a process. In economy, the correspondig terms are marginal costs and unit costs.

E.g. Andrews, 2010;
Roger Graham Barry,Richard John Chorley,"Atmosphere, Weather and Climate", 8th

edition, outledge, New York, USA, 2003. (p. 61)
Mark Z. Jacobsen, Atmospheric Pollution: History, Science and Regulation, Cambridge University Press, UK, 2002 (p. 318).
Ramanathan, Trace-gas greenhouse effect and global warming: Underlying principles and outstanding issues, Ambio 27, 187-197, 1998.
Smil, V., The Earth's Biosphere: Evolution, Dynamics, and Change, MIT-Press, USA, 2003 (p. 107)

Page 3197, Line 23-27: Is the much larger effect of non-CO2 forcers consistent with our current understanding? Please comment and provide supportive references.

Yes totally consistent. The natural greenhouse effect is due to H_2O (60%), CO_2 (25%), and others, ... e.g Smil (2003), see above. This should not be confused the with additional anthropogenic greenhouse warming. Here CO_2 dominates.

Page 3200, Lines 2-4: Please explain this further.

In the companion paper Grewe (2013) "A generalized tagging method", the difference in the perturbation of the system and of the tagged species is analysed for a simple differential equation ($\dot{x} = P - x^{\alpha}$). It shows a complex interaction of the tagged species and a dependency on the value α, the degree of non-linearity. This dependency is similar to the difference between the lifetime of a system and the lifetime of a perturbation. In the example, the difference is a factor of α, since the perturbation acts also non-linearily on the background values of x. A prominent example is the difference in the lifetime of methane (8-9 years) and the lifetime of a perturbation (12 years). I think a detailed discussion of the differences between the lifetimes is deviating from the scope of the paper.

Fig. 9: What is TnG in this plot? And why is TnC dropping? Please double-check colours used for labeling the different contributions.

Figure revised.

Interactive comment on Geosci. Model Dev. Discuss., 5, 3183, 2012.

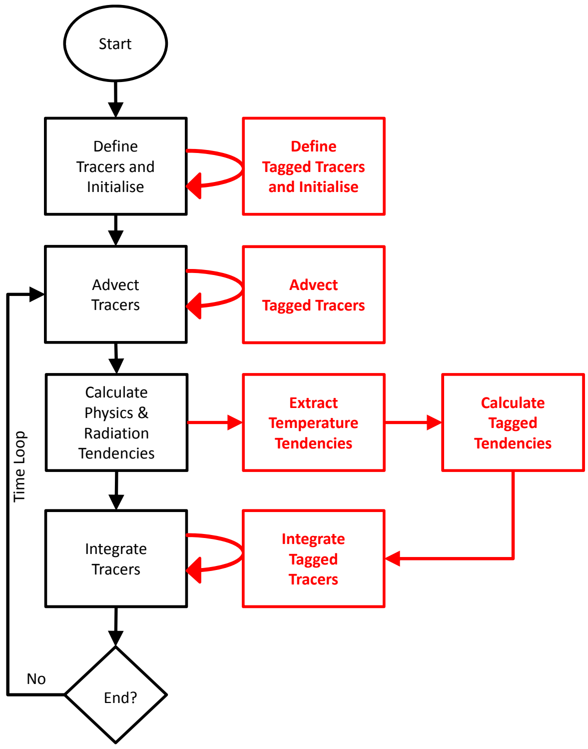

Fig. 1. Flowchart of a GCM and necessary extentions for a tagging scheme (red).