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Geoscientific Model Development Discussions

Interactive comment on "Local Fractions – a method for the calculation of local source contributions to air pollution, illustrated by examples using the EMEP MSC-W model (rv4_33)" *by* Peter Wind et al.

Anonymous Referee #1

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The manuscript of Wind et al. (gmd-2019-296) presents a new method for source apportionment called local fractions. The authors present the general idea of the method and show some results of it, implemented in the EMEP model. Further, a discussion about potential future applications is presented.

General comments:

The local fractions are a very interesting method, which is complementing to other methods for source apportionment. The general idea of the method is described well and the manuscript clearly fits into the scope of GMD. Before publication, however, I think major revisions are necessary. As the method is completely new the authors should characterise the method in more detail and answer questions like ''What window sizes are needed for which scientific questions?' Further, the authors need to discuss the pros and cons of their method compared to other methods in more detail and add details of the implementation of the method and the model set-up. In addition, the authors seem to overstate their method in some parts. More details are given in the specific comments below.

Specific comments:

- First of all the authors claim that their method is inexpensive wrt. the computational costs. Considering Table 1 I agree that the costs are low for small window sizes (e.g. 11x11 or 21x21), but with larger sizes the costs get remarkably large. Of course a simulation with 161x161 would replace 161x161 perturbation simulations (if I understand the method correctly), but for source apportionment studies one would usually not be interested in the contribution from 161x161 gridboxes to each other. Instead, one would be more interested in contributions from different regions/and/or emission sectors, right? For linear species this could be achieved by "just" adding additional tracers for different regions/emission sectors which should end up in far less additional costs compared to the large overhead for a 161x161 window. To better judge the the advantages of the method the authors should make clear how large the windows (x,y and z direction) for different purposes need to be. For the downscaling example given in Sect. 4.2 or the example in Sect. 4.3 small windows might be enough, but for the source apportionment I guess that very large windows are necessary. At least from the information of Figs 5,6,7 and 8 I have the feeling that 9 levels and a window of 80x80 are

necessary (at minimum) to account for all sources (e.g. a completeness of $\approx$ 1). Further, pollutants with different lifetimes should need different window sizes (for a completeness of 1, see Fig.4). I think is is very important that the authors characterise the method in more detail and critically discuss the advantages and disadvantages of their method compared to other methods for different scientific questions.

- In the description of the method the authors explain how they deal with emissions, advection, diffusion, deposition and chemistry, but it remains unclear how to deal with convection. On the coarse grid applied in the example convection needs to be parametrized I guess (providing convective mass fluxes). Therefore, please describe how you deal with convection in the LF framework.

- The presentation of the examples is rather vague and many details are missing. Clearly, the main goal of the authors is the description of the method in general (e.g., the mathematical concept), which is fine. However, the results depends heavily on the implementation of the method in one specific model and the authors give no details about the implementation procedure in EMEP MSC-W. The authors claim that *'The updates of the Local Fractions can be added on top of an existing model in separate routines.'* (p14l7ff) I am not familiar with the EMEP model, but when inspecting the provided code it seems to me that several modules (including the advection module) needed to be touched to implement the method. Therefore, I would strongly recommend that the authors add more details about the technical implementation in the model (maybe as Supplement). In this context I ask the authors to please provide examples of CTMs/CCMs where the flux at each grid box is an available quantity. To my opinion, the flux might not be an easily available quantity in many models (depending heavily on the applied advection scheme).

- The authors are not providing any details of the model set-up. Of course the

manuscript is not intended as model evaluation etc., but some basic details of the set-up would help to understand the presented results and it would help other users of EMEP to reproduce the results.

- The method assumes linearity for chemical processes, which is acknowledged by the authors. However, the authors state in the abstract that the method is valid for all primary pollutants, even tough some of them have non-linear chemistry (e.g. NOx, NO3). This should be clarified in the abstract. Further, the authors discuss in Sect. 4.4 that they aim to include chemical processes. The consideration of the full chemistry, however, would lead to a highly more complex implementation (and more costly wrt to the computational resources). In this case 'traditional' tagging approaches (e.g. Li et al., 2012, Emmons et al., 2012, Kwok et al., 2015, Valverde et al., 2016, Grewe et al., 2017, Butler et al. 2018 (and references therein)) might be superior compared to the LF approach. Could the authors please comment on this?

- On p14l11ff & p15l3 the authors mention the large memory footprint of the method. Information about the relative increase of the memory demand caused by the LFs would be interesting. How much more nodes are needed if the method is applied?

- The definition of 's' is unclear in the manuscript. On p3l7 's' is defined as the source term (i.e. emission sector). On p6l25 's' is defined as pollutant. In all example there is no differentiation between emission sectors an I assume that the number of emission sectors is 1 in all examples? Information like this should be part of the model description Section.

- Please reconsider the usage of the term 'contribution'. Especially in the introduction (p2l11ff) 'contributions' and 'impacts' are mixed. With the 'direct' method only impacts can be calculated and only for linear species 'impact' equals 'contribution' (see e.g., Thunis et al., 2019).

Technical corrections:

- The colour bars in Figure 4 are not very helpful. They are showing many orders of magnitude, which make it hard to judge the difference between direct and LF. Maybe additional difference plots could be provided additionally.
- Please check the references. For example Emmons et al., 2012 is listed in the bibliography but the reference seems to be missing in the manuscript. Further, I do not see how a reference to a manuscript in preparation is useful in any way (Denby et al.)
- p2l20f: Why using present perfect here? I would say the tagging method is unpractical in these cases.
- Caption figure 2: Please clarify what total emissions averaged over on month are. Are you showing total emissions of the month or an monthly average flux of molecules?

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