

***Interactive comment on* “Contribution from the ten major emission sectors in Europe and Denmark to the health-cost externalities of air pollution using the EVA model system – an integrated modelling approach” by J. Brandt et al.**

Anonymous Referee #2

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GENERAL COMMENTS

The paper of Brandt et al. is dealing with the integrated model system EVA which is used to assess the health-related externalities of air pollution from specific emission source categories based on the SNAP code terminology. Main objective of the work is the identification of those source categories that contribute most to health related external costs. One aim is to support policy-making with respect to emission control. The study is focused on Europe and Denmark. The chemistry and physics within EVA is handled by the evaluated complex nonlinear chemistry transport model DEHM

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(Danish Eulerian Hemispheric Model) ranging from hemispheric scale with a horizontal grid resolution of 150 km to regional scale for Denmark with a grid resolution of 16.67 km. Europe is treated within an intermediate nest using a grid resolution of 50 km. Therefore the modeling system is able to handle long-range transport on hemispheric as well as regional scale. The modeling system due to its coarse horizontal resolution however is not sufficient for the urban scale and street canyons. Central for the model is the tagging method which allows for a better numerical treatment of the contributions of a specific emission source or category to the overall air pollution (δ contribution). Brandt et al. try to minimize numerical noise (Gibbs phenomenon) by using the tagging method instead of the more simple subtraction method. Brandt et al. state that the δ if using the subtraction method is in the same order as the numerical noise and therefore less accurate than the tagging method. However the tagging method needs more computer resources with respect to storage and time.

The concentrations as calculated by DEHM are used as input for the computation of different health impacts of air pollution using exposure-response functions and health cost estimations.

The paper is well written, the model description is detailed and sufficient. The chemistry transport model DEHM takes into account the nonlinearities in the modeling system in particular within the nonlinear chemical reaction scheme. Its limitations are in the quite coarse horizontal resolution which does not allow for the detailed treatment of air pollution on the urban scale and within street canyons where high concentrations of NO₂ and PM_{2.5} are measured. As in most complex modeling systems uncertainties in the large amount of parameters and input data used will lead to uncertainties in the model results. It is difficult to estimate the range of uncertainties in complex modeling systems as EVA but one should have in his mind that the numbers given in the paper, in particular on costs and health impact or air pollution may change considerably due to these uncertainties if increasing scientific knowledge leads to changes/updates in these parameters, e.g. on the toxicity of air pollutants, in particular for atmospheric

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aerosols (composition, size, form).

I have some general recommendations with respect to the tagging methods, which is termed as central for the paper and the uncertainties related to parameterization and horizontal grid resolution.

I recommend illustrating the improvements achieved by the tagging method with concrete numerical examples to give the reader an insight into the orders of magnitudes for the δ in both methods and the numerical noise (which also might depend on the numerical method used to solve the dynamic equations).

Further I recommend discussing the consequences of uncertainties in the parameters used in the EVA system on the numbers given for health impact, mortality and external costs. To my opinion it should be clarified that these numbers are not completely on safe ground in the sense that we really know how many people suffer in Europe from air pollution and what the costs are. Each number is based on model calculation and the underlying empirical assumptions with a lot of uncertainties. There is no direct evaluation of the model output possible; it might be even never possible for the whole of Europe or Denmark. This is not to criticize the study, my opinion is that the study illustrates on a good scientific basis as Brandt et al. stated, the capability of the EVA system to give useful input for the planning of regulation policies. But one should be careful to take the numbers as they are without taking a very critical look on the uncertainties/limitations in the EVA system (parameters, emissions, horizontal resolution) and the empirical relations for the calculation of health effects (exposure-response functions) as well as economic valuation. With respect to the DEHM it should be noticed that horizontal resolution is known to have in particular strong impact on high concentrations of NO₂ and to a lesser extent on PM_{2.5} in source dominated regions. Both are primary emissions leading to high concentrations e.g. in street canyons. These peak concentrations cannot be simulated with a coarse horizontal resolution of 16.67 km.

Nevertheless, with these limitations in mind, to my opinion the study by Brandt et al.

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is an interesting and valuable example for the application of a sophisticated complex chemistry transport model embedded into the EVA system. Brandt et al. have shown in a very impressive way how such a model system can be used as a valuable tool for policy planning and regulatory measures. A complex modeling system like EVA never can be perfect and is – due to its interdisciplinary complexity going from atmospheric dynamics and chemistry to exposure-response and costs of health impacts of air pollution - in a permanent process of further development with respect to increasing scientific knowledge in all the areas. Therefore a permanent update of all parts of the model is always necessary, but nevertheless the EVA system is a good basis for that. I am looking forward to the next steps in the future developments of EVA going perhaps to urban scale and street canyon modeling, improvement of parameters and exposure-response functions. In its current stage the EVA system is a good basis for further improvement and application of complex modeling system which might be useful to optimize air pollution reduction strategies in Europe. Therefore I recommend the paper for publication in ACP.

SPECIFIC COMMENTS

p. 5874, line 5, abstract; p. 5880, section 2.3; tagging method

The tagging method is termed as central and I agree with Brandt et al. that the tagging method might be a central and valuable development to get more sophisticated results for the δ -concentrations. Therefore I would appreciate if this could be illustrated by concrete numerical examples in section 2.3 to give a better insight into the numbers we are talking about if we discuss “numerical noise, Gibbs phenomenon”, δ -concentrations by subtraction method and δ -concentration by tagging-method. Numerical noise also might depend on the method used for the solution of the transport part in the DEHM. Different methods might show different numerical noise and therefore might influence the improvement which is achieved by using the tagging method instead the subtraction method. It might be helpful to have a discussion on this issue according to the following questions just to emphasize the importance of the tagging method:

What is the order of magnitude of numerical noise e.g. for a certain scenario for the different air pollutants calculated by the model? What is the value of the δ as calculated by the subtraction method in comparison with the δ as calculated with the tagging method? Is the difference of the two methods in the order of some per cent or is it up to 100% or even more? Does the difference between the methods depend on scenario or/and constituents which is considered? How is the numerical noise influenced by the numerical method selected to solve the transport equations in the DEHM-CTM?

p. 5874, line 15 “When quantifying emissions, more than ten major emission sectors are defined . . .” My recommendation: Just define the term “SNAP category” here, it is done later in the text, but the ten emission sectors are mentioned here for the first time and perhaps a hint to SNAP code terminology and table 2 might be helpful for the reader even in this early place in the introduction.

p.5878, section 2.2: The Danish Eulerian Hemispheric Model

What is the height of the upper boundary of the model (layer 20)?

How is ozone treated, in particular for the upper part of the model (upper troposphere)? Is the exchange between stratosphere and troposphere taken into account?

What is the thickness of the lowest layer?

Are natural NO-emissions included in the model?

It is not clear to me how the different classes of the particulate matter interact? Is coagulation, condensation, nucleation included? Is a modal or sectional approach used? Is the formation of secondary organic particles considered? Is there an interaction between clouds (cloud water, aqueous phase) and particles? How is the interaction of gases and particles treated?

p. 5879, section 2.3: The tagging method

as mentioned above: Did Brandt et al. perform a model run for the same case a) using

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the tagging method and b) using the subtraction method? What are the differences with respect to the constituents and the source category considered?

Different constituents might show different performance in the δ , also for the different source categories? Is the subtraction method, which is commonly used, completely insufficient in all cases? How is the δ influenced by different numerical solution methods of the transport equation?

The tagging method is one of the central issues in this paper as claimed by Brandt et al., I would appreciate if there will be one example which underline the improvement in calculating the δ by the use of the tagging method.

p.5882, section 2.5: Exposure-response functions and monetary values

Compounds included in the EVA system are: O₃, CO, SO₂, SO₂₋₄, NO₋₃, primary emitted PM_{2.5}.

Can Brandt et al. comment on NH₄- ? Is it part of DEHM or EVA? Is benzene or other hydrocarbons considered? What about PAH?

How is primary PM_{2.5} separated from secondary PM_{2.5} which might be formed by gaseous precursors during transport?

Maybe that I missed that somewhere, but what is WTP (p. 5885, line 21)

p. 5896, section 5: Discussion and overall conclusions:

As mentioned also by Brandt et al., there is a lot of uncertainties in parameters (e.g. exposure-response functions) or input data (as emissions) used in the DEHM as well as in the exposure-response functions and the numbers used for the calculation of the costs. I recommend discussing the uncertainties of the model outcome (e.g. number of deaths attributed to certain species and source categories with respect to changes in parameters, input data (emissions), horizontal resolution (which cannot account for the urban scale and street canyon concentrations) with the aim to make clear that the

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current application is a starting point for further improvements and development of the EVA system.

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