

## ***Interactive comment on “The 1-way on-line coupled atmospheric chemistry model system MECO(n) – Part 1: The limited-area atmospheric chemistry model COSMO/MESSy” by A. Kerkweg and P. Jöckel***

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First of all, we like to thank referee #2 for clearly stating that she/he approves of the MESSy concept and the model developments published in this article and that she/he only questions whether it should be published in this journal.

The latter concern is detailed by the reviewer in the second and third paragraph of her/his review. She/he mainly makes the point that the paper includes too many technical details and should not be published in its present form, as the larger part of the

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scientific community would not gain anything out of it.

In our opinion the GMD white paper

([http://www.geoscientific-model-development.net/gmd\\_journal\\_white\\_paper.pdf](http://www.geoscientific-model-development.net/gmd_journal_white_paper.pdf))

clearly dispels these concerns. GMD was, among other reasons, particularly established to provide model developers a forum to publish their developments and methodologies in a citable, peer-reviewed journal. Such (necessarily detailed) model documentations are a prerequisite to guarantee the reproducibility of scientific findings gained by complex numeric simulations. Moreover, they document the enormous efforts that are required in nowadays, increasingly complex model developments. Moreover, different model communities are often facing similar challenges rendering an exchange of knowledge by means of a peer-reviewed journal desirable. One example is stated by the referee her-/himself: The issue of the different orders of array ranks in two different (legacy) basemodels poses a specific challenge, if two such models are to share major parts of their extensions. One might come up with several different solutions to tackle this problem - and we provide one of these: the rank-identifiers introduced into our infrastructure. This solution minimises the number of required modifications in the legacy codes and is clearly of potential interest to larger community.

Furthermore, we want to underline here, that our activity is based on codes, which are used and supported by large communities: ECHAM, COSMO-CLM and MESSy (the latter also supported by a continuously growing community). Therefore, the article is naturally primarily of interest to readers already working with at least one of these codes. Nevertheless, to provide valuable information for a broader community, we first describe the tackled problems and their solutions in a way as general as possible, and only then provide specific examples for users familiar with the above mentioned model codes, in particular COSMO or MESSy. As this second part comprises a relatively large part of the paper the impression may prevail, that it is only of interest for those model communities.

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Another concern of the referee is that we are often forced to refer to other documentations about MESSy. Since this is apparently unavoidable, in particular for constantly growing, flexible (i.e., here modular) community models, such as the presented one, it has been well recognised by the Executive Editors of GMD, resulting in the possibility to collect well related model documentation papers into a virtual special issue (see white paper). This further enhances the usefulness of specific model documentations in GMD.

Nevertheless, if the Editor or the Executive Editors share the view of the referee, we are willing to further revise the manuscript accordingly.

At the end of the third paragraph the reviewer states: *“Two other papers regarding MECO are currently under discussion in GMDD, although I have not read them. In my opinion much of what is written here should be referenced as part of the code description and supplement in the other papers.”* Apparently, we have not yet been successful in motivating the separation into three companion publications about MECO(n). We will clarify this:

- This first publication documents the implementation of the MESSy infrastructure (plus a few diagnostic submodels to test mainly the TRACER infrastructure) into the COSMO model. This includes also the modifications and further developments of the MESSy infrastructure itself, which are required for this undertaking. The resulting model is a regional model of the atmosphere, enabled for (now standardised) further extensions into a regional atmospheric chemistry model. The functionality of the TRACER infrastructure, in particular, is proven. This is already a valuable major step on its own and a prerequisite for atmospheric chemistry applications.
- The second part is about a completely different issue, however, requires the COSMO/MESSy model of the first part: Here, we describe how the regional model COSMO/MESSy is on-line nested into the global ECHAM/MESSy, why

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it is desirable to develop such a system, and what it is going to be applied for.

- The third part, finally, provides a meteorological evaluation of the nested system, described technically in part 2. This evaluation, focusing on distinct meteorological events on synoptic scale, and on the question if and how they can be reproduced by MECO(n), is a prerequisite for further applications with chemistry, like chemical weather (air pollution) forecasts, measurement campaign analysis etc.

We spent a lot of time and efforts to be able to provide this separation as a compromise between size and complexity of the manuscripts and the requirement that each article more or less should stand on its own. We believe that a merger of the three documents in any way will be much more confusing and completely wear away the fundamental differences between the development of COSMO/MESSy and its nesting into ECHAM/MESSy.

- *One crucial problem is that the advection code is not positive definite. The authors are to be commended for clearly identifying problems with their code, but they have not identified what type of problems the code can be used for. They state: “...” and suggest there will be improvements in the future. Figure 5 shows conservation properties over the domain. For advection domain-wide conservation issues appear to exist. However, what are the valid scientific applications of this code at present? Have the authors encountered problems of this type? Is the code ready for chemistry?*

The referee kindly acknowledges that this “paper describes a great deal of work”, and - from our point of view - the second part describes an even greater amount of work. In such complex developments, progress can naturally be achieved only step by step. The first three major milestones towards a two-way, online

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nested, global/regional atmospheric chemistry model are now accomplished and documented as described above.

One prerequisite for the next step, namely the inclusion of the submodels relevant for atmospheric chemistry applications with COSMO/MESSy, is the correct functionality of the TRACER infrastructure which handles the data and meta-information of chemical constituents, e.g., whether or not a specific tracer should be advected or not. This functionality has been tested in the presented tracer tests. These tests have been limited by a problem, not with our, but with the advection algorithm of the COSMO legacy code. This problem is known by a broader community and the COSMO community is currently working on a solution - independent and in parallel to our developments. We do not want to provide our own solution for it, but rather make use of the community wide solution. With the current issue in the advection algorithm, the model is not yet ready for atmospheric chemistry applications. Nevertheless, despite these limitations, we were able to positively evaluate the functionality of our TRACER infrastructure.

We will clarify this in the revised manuscript.

- *In the tracer tests the impact of lateral, lower and upper boundary conditions on the tracer's mass is not clear to me. Does one expect the tracer mass to be conserved within the domain under inflow and outflow conditions using a perfect transport scheme?*

The mass within the regional model domain is not expected to be conserved. With a perfect transport scheme, however, the mass budget of passive tracers (i.e., without sources or sinks in the regional domain) is expected to be closed, implying that the tracer mass within the domain plus inflow minus outflow in/out of the domain is conserved. The latter (inflow and outflow) are determined, at least implicitly, by the boundary conditions. This mass balance might be slightly

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violated by non-physical processes (present mainly for numerical reasons), such as Rayleigh damping at the top of the domain.

Due to the current limitations described above, this can at the moment not entirely be verified and needs further diagnostic tools, e.g., the budgeting of all individual process tendencies of a specific tracer. Such a tool is currently under development in the MESSy framework and will be applied also to the COMSO/MESSy model as soon as it becomes available.

As stated above, we will clarify the intention we had with the tracer tests in the revised manuscript.

- *Page 1332, line 22-23. It is not clear the extent to which the internal sources and sinks for a homogeneous tracer is important? What are the maximum and minimum values of  $H$  within the domain?*

Apparently, this is a misunderstanding, because we did not fully explain what we meant with “homogeneous”. Indeed, the tracer is not only homogeneous (i.e., initialised with a constant mixing ratio everywhere in the domain), but also passive, meaning it has no internal sources or sinks. In an ideal model, none of the transport processes must cause the tracer mixing ratio to deviate from its initial value at any time and any place within the domain (i.e., minimum and maximum value in the entire domain are equal). For a regional model, this monotonicity test also requires the same constant mixing ratio being prescribed at all domain boundaries. We will state this more clearly in the revised text.

- *I am not sure Figure 7, 10 or 11 really give much new information. These figures look nice, but do not really give us any information about how good the tracer advection is.*

Advection is not the only tracer transport process taken into account. The figures show results for advection, vertical diffusion and convection. We agree, however,

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that Fig. 7 gives no additional information and will remove it from the revised version. Figs. 10 and 11, however, are valuable, since they illustrate the discussion about convection and, more specifically, on how comparable convective transport of tracers between the global and the two regional model instances is.

- *Figures 8 and 9 show qualitatively COSMO/MESSy looks reasonable, but is it possible to come up with more quantitative measures? What is the tracer maximum in the COSMO/MESSy domain versus that in ECHAM5/MESSy. Is there a change in the vertical distribution of tracer?*

We will include some numbers for the COSMO/MESSy domains and the ECHAM/MESSy domain in the revised manuscript.

The last question is unfortunately unclear to us. In case “the difference of the tracer distribution between the model instances” is meant, the answer is provided by the analysis of the transport of radon.

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