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Interactive comment on "The on-line coupled atmospheric chemistry model system MECO(n) – Part 5: Expanding the Multi-Model-Driver (MMD v2.0) for 2-way data exchange including data interpolation via GRID (v1.0)" *by* Astrid Kerkweg et al.

Anonymous Referee #2

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This manuscript is part 5 of the documentation of the MECO(n) online coupled atmospheric chemistry system. It presents an update of the Multi-Model-DriverMMD from v1.0 to v2.0, which introduces the option of 2-way (as opposed to 1-way) coupling, and describes a new submodel GRID v1.0 for grid translations between the coupled model systems.

Online coupling of different model systems running on different grids, with different

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input and output requirements, different time steps, etc. and running as separate executables is a challenging task. The authors have done a marvelous job in accomplishing such a coupling between a global and a regional model and even between different instances of the regional model. The work is obviously not yet complete, and thus this publication should be seen as another update or extension. The manuscript is composed of a main part and comprehensive user manuals of MMD and GRID as supplements. The supplements provide all the details that are important for users. While I did not have time to look at them in detail, they seem to be well organized and comprehensive with detailed information on data structures and routines and the overall logic. The main body of the manuscript is a high-level description of MMD and GRID and, in addition, presents a few example applications of the coupled system. To me this looks like an appropriate approach for a GMD publication.

General/major points: ——————— An important general question for a journal like GMD seems to me at what stage an update of a model deserves to be published. In my view only major updates that add significant new functionality should be published, and such updates should be in a mature stage. While the first criterion is clearly fulfilled by the present manuscript (a 2-way coupling is certainly a major update), the second point is much less clear, as detailed especially in point 1 of my main concerns below.

Although the manuscript is reasonably well structured and written and the topic is relevant and suitable for GMD, I have some major reservations: 1. The 2-way coupling is still in a pre-mature stage because a) dynamical 2-way coupling (of meteorology) seems not yet possible between EMAC and COSMO and even between instances of COSMO only seems to work reasonably well over flat terrain (an example is presented over the ocean). The main reason for this seems to be inconsistencies in the vertical grid transformations, especially because different methods are used for the partent-to-child (int2lm) and the child-to-parent (GRID v1.0) transformations. b) as just mentioned, the COSMO pre-processor tool int2lm is still used for the parent-to-child transformations, which seems redundant since GRID should provide all functionally required for

this, and using GRID for both up- and down-scaling would provide much more consistency. It remains unclear why this issue has not been resolved. c) The GRID submodel seems to be still in a fairly rudimentary stage. E.g. only "conservative remapping" is implemented (see P7, L6), whereas the description of the GRID submodel in Section 3 also mentions "interpolation" as a final goal (see P9, L15). Also vertical grid transformations seem to be implemented only in a pre-mature way (see next point).

2. Some parts of the manuscript are lacking clarity and detail. I am particularly missing details regarding the grid transformations and the separation into horizontal and vertical transfor-mations. In particular, COSMO is a non-hydrostatic model running on a geometrically fixed grid, whereas EMAC is hydrostatic and formulated on a hybrid pressure grid. Although I understand the motivation of the authors to keep the descriptions generic, the transformation between these fundamentally different vertical representations is essential and should be much better described. Furthermore, COSMO variables are represented on a staggered (Aralawa-C type) grid, which requires different transformations for variables like temperature or concentrations defined on grid cell centers, and variables like wind or tendencies defined on grid cell interfaces. Neither the main body of the manuscript nor the documentation makes any reference to the issue of staggered variables. The manuscript talks about a "geo-hybrid-grid" without explaining this structure and later about the "basegrid". GRID seems to expect a hybrid pressure grid (see line 14 on page 10), but how COSMO variables are transformed to hybrid pressure levels is never explained. Furthermore, if GRID only supports hybrid-pressure levels, it will be little suited for transformations between two instances of COSMO, as these are both operating on geometric grids. I am also missing information on details of the coupling, especially with respect to the fre-quency of the coupling: Are fields exchanged at every model time step? Are the parent and child models forced to use the same time steps? Is the frequency of coupling the same for the upward and the downward directions? Such information my be added in Section 2.2. 3. The authors emphasize the need for developing computationally efficient interfaces and submodels (e.g. line 19 on page 9), but no information is provided that would

allow the reader to judge the efficiency of the coupling that is ultimately achived. What is the computational overhead introduced by the coupling in terms of additional memory usage and computation time? Maybe this has been addressed in previous publications, but if so, this should be referenced. Otherwise, I would strongly encourage the authors to benchmark the model system (e.g. for one of the simulation examples in Sect. 4) with detailed timings of the individual model components and additional diagnostics, as this is a fundamental first step towards identifying bottlenecks and improving efficiency. The manuscript may be acceptable after addressing my main concerns 2 and 3 (plus the minor points below), or it may be postponed until a more mature version of coupling is available (i.e. main concern 1 is also addressed).

Minor points: ———— - Introduction: The reasons for the external coupling mentioned on P2/L20-30 are not entirely clear. Why is it good to "prevent the patches approach"? What are the "limitations of the Fortran95 namespace"? On the other hand, an advantage not mentioned is that this external coupling allows testing the influence of the coupling of different (individual) variables, which would likely be more difficult with internal coupling. The introduction should also emphasize the disadvantages and challenges of the external coupling, e.g. the challenge of transforming between different vertical grids.

- Footnote "2" on MPI-ESM seems little relevant in the context of this manuscript and could easily be deleted in my view.

- P3, L8: Sentence "This article documents the development of the . . .". No, this article is only part of a documentation.

- The following lines are presented in italics, which I found confusing until I realized that this is a citation. It would be clearer to present the references at the beginning and then the quoted text, e.g. "As described in Jöckel et al. (2015), Baumgaertner et al. (2016) and the Messy homepage (..), the Modular Earth System Model (MESSY) is "a sofware providing . . .".

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- P4, L3: Delete the bracket "(Messyfied ECHAM ...)", this was already explained earlier.

- P4, L14: "update of MMD" -> "update of MMD presented here"

- At the end of the introduction section I was wondering whether GRID is now used for both directions replacing INT2LM entirely or not. It should already be explained here that the present implementation of GRID is only used for the child-to-parent transformation.

- P6, L15: What does "imprints its time settings" mean? Start and end of the simulation, time step, or something else? Does "imprint" mean that the child model has to use the same time step as the parent?

- P6, footnote 9: It would be better to include this information in the main text rather than as a footnote. Is it really necessary to distinguish between INT2LM and INT2COSMO in this manuscript?

- P7, L9-16: What is the difference between Option "0" and Option "1a"? On line 16, shouldn't it be Option "0" rather than "(a)", since (a) was introduced as an option available only for prognostic variables?

- P8, L17: The weight functions should remain the same during the simulation, at least the horizontal weights. Are the functions nevertheless transformed at each time step, i.e. the same transformation is repeated over and over again?

- P8, L28: The statement "for all required grid transformations" is not correct, since int2lm is used for partent-to-child transformations.

- P8, L29: I didn't understand this sentence. "Ideally" points at an ideal state not yet reached and should therefore be followed by "would be implemented" rather than "is implemented".

- P9, L1: What exactly do you mean by "as one central part of the model infrastructure"?

- P9, L5-8: I don't agree with the definition of regular and irregular grids. A "lambert conformal" grid as often used e.g. in WRF is also a regular orthogonal grid. A grid is usually regular in one projection but irregular (non-orthogonal) in another projection. Here it sounds like any non-lat-lon grid would be irregular (same issue in Section 3.1).

- Equally important as the horizontal grid transformation (and actually more challenging) is the vertical transformation. This needs more attention in section 3.

- P10, L11: What is a "geo-hybrid grid" structure?

- P10, L13: Why is a grid "defined by geographical longitude and latitude and vertically be hybrid pressure coefficients"? Is this a design choice for the GRID submodel? Does that imply that for a COSMO-COSMO nesting the COSMO grids (which may share the same projection) have to be first converted to geographical coordinates and then back to rotated ones? It would seem much more logical to me that GRID would translate everything to the same projection (e.g. the one used in the parent model), irrespective of whether it is a geographical coordinate system or not. How is the COSMO vertical grid transformed to hybrid pressures?

- Section 3.1.1 GRID_TRAFO: Grid transformations have been implemented in standard libraries like gdal (http://www.gdal.org/) and proj.4 (http://proj4.org), which also support rotated grids as used in COSMO. Why did you not choose to link to such a library that could provide a great level of flexibility? The SCRIP software seems to offer comparatively little flexibiliy. In my view one should strictly distinguish between coordinate translations (as can be accomplished by such libraries) and the final mapping between grids, which can be done by linear, cubic, or spline interpolation of any other (possibly conservative) mapping, and may be implemented as separate routines in GRID. Please make clear from the beginning that NREGRID is only implemented in GRID for vertical transformation, while SCRIP is used for all horizontal transformations, not only at the end of Section 3.1.3 (and more explicitly in the conclusions). Otherwise the reader - like myself - is confused about the role of NREGRID.

- P11, L1: Why is NREGRID recursive? Is this information relevant here? It sounds strange to me to have a recursive algorithm for grid translations.

- P12, L16: "For 2-way applications" -> "For 2-way coupling applications"

- P12, L21-26: A missing important point why size matters in atmospheric chemistry is that this chemistry is highly non-linear.

- P13, L7: dry deposition velocities do not only depend on soil type but also on turbulence, which could be another difference between the models.

- P15, L8: Is really only the pressure perturbation exchanged, i.e. the deviation from a reference pressure profile?

Typos and grammar: ———————— - P4, L30; "software as" -> "software such as"

- P5, L5: "reasonable" seems not the right word here.

- P7, L6: "At the time being" -> "For the time being"

- P7, L17: "For both option" -> "For both options"

- P12, L4: "handy" is not a good word in a scientific publication

- P12, L6: "tools, can" -> "tools can"

- P12, L31-32: Change to "If COSMO/Messy were 2-way coupled into EMAC and EMAC were using the NO emissions .."

- P13, L2: "what is mostly" -> "which is mostly"

- P13, L5: "pervious" -> "previous"

- P13, L6: I would say "slightly but systematically" rather than "systematically"

- P14, L4: "good" -> "well"

- P23, Fig. 5: "been mask" -> "been masked"

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