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Interactive comment on “The implementation of a MiXed Layer model (MXL, v1.0) for the dynamics of the atmospheric boundary layer in the Modular Earth Submodel System (MESSy)” by R. H. H. Janssen and A. Pozzer

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Reply to anonymous referee 2

The authors present a new MESSy submodel for a more detailed calculation of boundary layer dynamics and chemistry. The authors show that MXL embedded into a (currently 2-box) column model named VERTICO is a useful tool for analysing measurement campaign data. In the future the model should also be used to develop better parametrisations of BL processes for the global 3D model EMAC. The paper is well

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written and contains a lot of detailed information about the model MXL. Therefore I recommend the article for publication after minor revisions as listed below.

We thank referee 2 for his/her constructive review. Below, we will address the individual comments. The comments are printed in italics and our replies in normal font.

Comments to the content of the paper: The information, that MXL is really only the submodel and that in addition a column model named "VERTICO" was developed is given very late in the article. It would be good to mention this also in the introduction.

We will change the introduction accordingly also to the comments of referee 1 (p. 7198 line 16): 'Here we describe the implementation of a MiXed Layer model for the dynamics of the atmospheric boundary layer (ABL) and a generic 1D basemodel called VERTICO (VERTical COlumn) in the Modular Earth Submodel System (MESSy, Jöckel et al. 2010). The implementation of the latter is necessary because of the structure of the MESSy framework: in this framework, a basemodel determines the basic configuration of the coupled model, which can be a box, 1D or 3D model, and the individual processes are represented by basemodel independent process submodels that are coupled to the basemodel through an interface layer (Jöckel et al., 2010).'

Section 2.1: I think it to be very confusing that the subscript "s" in Eq. 1 stands for "surface", while in Eq. 3 it is used for "subsidence". It would be better to used different subscripts to avoid this confusion.

Good point, to avoid confusion we will replace w_s with w_l (for large-scale vertical velocity) in the revised MS.

Eq. 11: Please give a short explanation why the approximately equal sign is valid.

The approximately equal sign is valid because the 1st term between brackets is much larger than the 2nd and 3rd: Θ (order 10^2) times a turbulent fluctuation (indicated by the primes (')) is much larger than q (order 10^{-3}) times a turbulent fluctuation, and the multiplication of 3 small numbers (w' , Θ' and q') gives a smaller number compared to

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multiplying only two of them) (see also Stull 1988).

Sect. 2.4: (A) From my perspective it looks like using a sledge hammer to crack a nut to use TNUDGE for a model located at one point. (B) Do you want to use TNUDGE in the BL or the FT box?

A) We agree with the referee and as first instance a simpler method could be implemented. Nevertheless, we believe that using the relative tools in MESSy would make the overall model more consistent and coherent, in line with the usage of other MESSy submodels. B) We intended to use it for the BL box, since generally observations of tracer concentrations are only present for the BL.

page 7211, line 16: Please explain, why you used 173. The middle of the year would be 182.5, so I could understand 183, but why 173?

In the calculation of the solar declination angle, day 173 is the day of the summer solstice (see Stull 1988, eq. 7.3.16). In the revised MS, we will add this information.

Sect. 3, line 4: What do you mean? Does VERTICO include its own time integration, as it has to define its number of vertical boxes or does it use the generic MESSy submodel TIMER? If not, why? You are taking advantage of the rest of the MESSy infrastructure, why not using TIMER?

TIMER is used for the time stepping and general time management of the model. Nevertheless, the chemical/physical tendencies are integrated in the base model, analogously to what done in the 3D model ECHAM5/MESSY. We will rewrite this paragraph and a part of the introduction as it was also unclear to referee 1 what the use of VERTICO exactly is.

p. 7219, line 1-8: 'For the implementation of MXL, a generic 1D basemodel is created in MESSy, called VERTICO. VERTICO contains calls to modules for time and tracer management, the time loop which integrates the model equations and in VERTICO tracer concentrations are updated each timestep, combining the tracer tendencies from

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each active submodel. It is de facto a 3D basemodel in which the horizontal resolution has been reduced to a single grid box, to facilitate the submodel coupling within the MESSy framework. This also facilitates the possible development of a column model that includes more vertical levels in both boundary layer and free troposphere.'

Sect. 3: If I understand correctly, you are describing the processes in the ABL in the required detail. But where is the description of the applied equations and assumptions for the FT box?

Good point, we will add the following description of the FT box:

p. 7219, line 12 The FT is represented as a well-mixed box in which only chemistry and aerosol partitioning takes place. We have fixed the top of the FT to 10 km, so changes in the BL height only slightly influence the volume of the FT box. FT values of temperature, moisture and pressure that are needed for the calculations of FT reaction rates are taken at the inversion.

Sect. 3.1, first paragraph: You forgot to mention the diagnostic submodels. List process and diagnostic submodels or use the terminology of “regular” submodels, which is used in other MESSy publications for process and diagnostic submodels all together.

We will use the terms process and diagnostic submodels instead of process submodels in the revised MS, since these are more descriptive terms than regular.

Table 1 (and text): You write that you (want to) use TNUDGE, OFFEMIS and ONEMIS. All these submodels depend on data input via the generic submodel IMPORT or you have to provide your data otherwise. As IMPORT is not named in Table 1, I assume that you provide the data otherwise. But you do not provide the information on how you are doing this and what you are prescribing, where you take the emission fluxes and mixing ratios from? On the other hand its looks quite an effort to use IMPORT for a single point.

We indeed use IMPORT to read time series of data e.g. from an emission database,

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but forgot to mention this in the MS. We will add this to the text and include IMPORT in Table 1.

Table 1 and text: To my knowledge RAD and SURFACE are very ECHAM specific. How realistic is it to use it for MXL?

According to the MESSy standards, submodels should contain processes representations and should therefore be rather generic. Nevertheless, even if RAD and SURFACE are ECHAM5 specific, with their implementation we will have access to possible further implementations of such submodels, therefore allowing us to use a larger range of parameterizations.

Typos and technical corrections: page 7201, line 23: “in into” ! “into” page 7205, line 6: “for the both” ! “for both” page 7205, line 9: “account” ! “accounts” page 7211, line 3: “taken at” ! “to be” page 7211, line 10: “universal time” ! “universal time coordinate” page 7212, line 4: “taken equal to” ! “assumed to be” or “set to 1” page 7219, line 4: “is a de facto” ! “is de facto a” page 7220, line 25: “in the ” ! “in” page 7222, line 7: “in into” ! “into” page 7222, line 11: “it possible” ! “it is possible”

Typos will be corrected

Table A1 / A2: why are these tables labeled as Appendix tables?

Because they will be in the appendix

Table 1: PTRAC is no process submodel, use regular instead of process or write process and diagnostic.

We will use diagnostic submodel for PTRAC

Table A1, caption: “as as” ! “as”

will be corrected

Table A1, caption: “have zero initial concentration and zero surface emissions”! “are

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zero and have no surface emissions”

We will replace this sentence by: 'have an initial concentration of zero and no surface emissions'

caption Fig. 6: “evolution of gas phase chemistry” is very unclear. I had to look at the picture a longer time, to see that each plot is for a different chemical species. Please elaborate the content of the figure in more detail.

We will change the caption into: 'Observed and modeled mixed-layer mixing ratios of a) O₃, b) NO₂, c) NO, d) isoprene, e) HNO₃, f) OH, g) H₂O₂ and h) HO₂ and i) NO₂ photolysis rate for the DOMINO case, comparing ...'

a list of abbreviation in the appendix would be a great help for the reader.

We will include a list of abbreviations with the revised MS

References

Stull, R. B. 1988. An Introduction to Boundary Layer Meteorology, 666 pp. Dordrecht, Boston, London: Kluwer Academic Publishers.

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