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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: an implementation of the dry removal processes DRY DEPosition and SEDImentation in the Modular Earth Submodel System (MESSy)" *by* A. Kerkweg et al.

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We thank the three referees for their support on publishing this Technical Note and their helpful comments. In the following we go into the details of the individual comments:

1.) Comment of referee #1:
Many thanks for "very much appreciating such a detailed model description." We see your concerns about double documentation, however, in fact the submodel contents are not doubled between ONLEM/OFFLEM/TNUDGE and DRYDEP on the one side and EMDEP on the other side: The processing of offline emissions

such as in OFFLEM is not implemented in EMDEP (Ganzeveld et al., 2006). Vice versa, the core routines of DRYDEP and parts of ONLEM are indeed based on an early version of EMDEP, but EMDEP currently contains more parameterisations as ONLEM and DRYDEP.

This seems in fact confusing, it is, however, due to profound reasons tightly connected to the overall MESSy structure. As described by Jöckel at al. (2005), the MESSy standard allows the implementation of different concurrent realisations (or parameterisations) of the same process as different submodels for various reasons. This offers several advantages (see Jöckel et al., 2005). In the present case, EMDEP on the one hand, constitutes a “development” submodel containing the most recent parameterisations and hypotheses with respect to surface / air exchange of trace gases and aerosols. Accordingly, it is continuously subject to change and the coding is necessarily not always done with high diligence. The application of this submodel is highly recommended for model simulations which focus primarily on the surface / air exchange of trace gases and aerosols. ONLEM and DRYDEP, on the other hand, contain only well established (i.e., “state-of-the-art”), evaluated and – with the present Technical Note – fully documented algorithms for calculating online emissions and the dry deposition of trace gases and aerosols. The application of ONLEM and DRYDEP is highly recommended for production simulations, which do not primarily focus on the processes of surface / air exchange, which however, nevertheless require those processes to be taken into account. In ONLEM and DRYDEP much more effort went into a robust, well tested, and transparent coding, and their future development will be much more conservative than the further development of EMDEP (so to say, ONLEM and DRYDEP will always be one step behind EMDEP).

Finally, ONLEM and DRYDEP on the one side, and EMDEP on the other side do nicely complement each other from another perspective: All (pretended) improvements or experimental setups of EMDEP can first safely be tested against the results obtained with ONLEM and DRYDEP as a conservative reference. This possibility within an elsewhere identical numerical framework is an advantage that must not be undervalued.

For the above reasons, we are not in favour of combining the articles: ONLEM describes emission processes and is (in a process oriented way) published together with OFFLEM and TNUDGE (Kerkweg et al., 2006). DRYDEP simulates a different process, namely dry deposition, and is w.r.t. its effect on trace gases and especially aerosols conceptually more related to SEDImentation. Last but not least, the article of Ganzeveld et al., (2006) will be largely revised.

Specific comments: We apply all suggested technical corrections. In the following we go into detail about your comments or questions:

- p. 6861, l. 14: Since aerosol modes are described as lognormal distributions, the centre of mass of a mode is associated with the mass mean radius and not with the mass median radius. In a distribution of particles with constant density larger particles deposit faster than smaller particles. Thus it is more appropriate to use the mass mean radius for the dry deposition of the mass instead of the median radius. We add this explanation in the article.
- p. 6874, l. 18: This is a misunderstanding: The phrase "prescribed fields" is always used to indicate that these fields (here LAI and roughness length) are external input fields provided with the submodel. Thus the roughness lengths are not part of the base model and therefore do not have to be restricted/changed there. The point is that the input field for the roughness length is provided as monthly means in 0.5° x 0.5° resolution. During the model initialisation phase this high resolution information is rediscretised (Jöckel, 2006) for the usually coarser model resolution. The resulting average within a model grid box is potentially too large for the bare soil and snow fraction of the box. Consequently the assumption of a constant surface roughness of 0.005 m for *slsn* yields more realistic results. For over-

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grown surfaces the opposite is the case. In a model grid box with a high fraction of bare soil and snow, the average value for the roughness length is potentially too small for the vegetation covered fraction. As the roughness length of vegetation is normally larger than 0.02 m a minimum of 0.02 m is appropriate. We change the text for the revised version accordingly.

- p. 6882, l. 17: λ_p and λ_{air} are basically the same, but the units in the formulae are different and in SEDI λ_{air} must be calculated for all model layers, whereas λ_p is only defined in the lowest layer. We add this explanation.

2.) Comment of referee #2:
We take over the corrections proposed in item 1-3.
Regarding 4): Yes, Δp in Eq. (20) is indeed the thickness of the box in pressure units. Since the algorithm is formulated in height coordinates, but is usually applied for vertical pressure coordinates tendencies and fluxes need to be converted consistently. In Eqs. (20)-(21) the negative tracer mixing ratio tendency of the upper box is converted into a positive mixing ratio tendency for the box below by multiplication with the factor $\frac{\Delta p(i-1)}{g}$ (in units of kg/m^3).

3.) Comment of referee #3:

- Surface types: Maybe the sentence was not as clear as it should be, we rephrase it. What we meant is that the calculation for the species O_3, HNO_3, NO, NO_2 and SO_2 is based on Ganzeveld et al. (1995,1998). For the other trace gases we use the approach of Wesely (1989) i.e., the deposition velocity of the trace gas is scaled to those of sulphur dioxide and ozone.
- Effective Henry's Law coefficients: They are defined for water of near-neutral pH. This information was indeed missing. We add it in the text and in Table 1.
- The required soil pH maps are imported from external input fields. They are

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in netCDF-format and are provided with the submodel code. We add this information in Appendix A2.1.

We agree with all technical corrections with two exceptions:

– page 6854, line 24: We do not agree with the limitation to size-distributions, as also mass distributions are calculated, but we rephrase the sentence according to your suggestion.

– page 6860, Eq. 7: Indeed the formula is wrong, however the suggested correction is also wrong. Since the velocity over water is calculated here, the fraction f_{land} is meaningless due to Eq. (5). We correct the formula for the revised version.

References

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