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Interactive comment on "The hybrid Eulerian Lagrangian numerical scheme tested with Chemistry" *by* A. B. Hansen et al.

A. B. Hansen et al.

ayoebuus@gmail.com

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Anonymous Referee #2

Reviewer: Though the title indicates that this article is about a proposed numerical scheme, it actually focuses on some test results on comparison between the HEL scheme, developed and reported in the authors' unpublished paper (Kaas 2012), and two existing traditional advection schemes. The results would be impressive if shortened and added into the unpublished paper as a section. But as a standalone paper, this paper needs to be improved in the following aspects in my opinion:

Answer: The unpublished paper Kaas et al. (2012) has now been published (Kaas et al., 2013). A section describing the chemical scheme applied in the study will be added

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to the paper. The work in the submitted paper is, to our opinion, far too extensive to be added to the Kaas et al. (2013) paper, which was already a very extensive paper.

Reviewer: The title should be revised.

Answer: We think that the title describes the scope of the paper very well.

Reviewer: It is not clear if SL and ASL are the state-of-art. If not, the merit of applying HEL in air pollution modeling may be not sufficiently apparent. More background on these two schemes should be given in the introduction.

Answer: The background for the SL and ASL schemes have been described in Hansen et al. (2011), so therefore we do not find it appropriate to repeat this in this paper. The ASD was at its time of development a state-of-the-art scheme, as is SL, see Hansen et al. (2011) for the SL scheme and Frohn et al. (2002) for the ASD scheme, and references therein.

Reviewer: The comparison of the three schemes was made based on errors while the computational cost of each scheme is not addressed. To show HEL is superior to the other two schemes, it is also important to consider efficiency.

Answer: We agree that it is important to consider efficiency. As described in Kaas et al. (2013), HEL has been shown to be considerably faster than CSLAM-M. Also, for multi-tracer transport, some of the trajectory calculations can be re-used for all tracers, i.e., do not need to be calculated for each individual tracer. The test of computational cost was carried out in Kaas et al. (2013) and therefore, we have not included the test in this paper.

Reviewer: The authors performed 12 methods with different resolutions and CFL conditions for individual tests, and the results implied that the performance of tested schemes was related to resolutions or CFL conditions. I would suggest the authors to discuss the relation in detail, followed by a possible guide on how to choose resolutions for a given application.

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Answer: This paper builds on a similar test setup as in in Hansen et al. (2011). A full description of the resolutions used can be found here. However, we will include a discussion /guide on how to choose resolutions in this paper.

Reviewer: It would be more convincing if the authors can provide the values of error norms instead of ranking in Sec 4.2. There could be a possibility that high-ranked schemes may have insignificant advantage in terms of accuracy.

Answer: The values of selected error norms are given in detail throughout the paper. The ranking was performed to give an overview and inter-comparison of the performance of the schemes. We agree with the reviewer that high-ranked schemes may have insignificant advantages in terms of accuracy, however, the values of the error norms are also given in other tables, so the reader is able to conclude whether the advantages are significant or insignificant.

Reviewer: It would be more insightful if the authors can explain why HEL can outperform the other two schemes.

Answer: In short, HEL outperforms ASD and SL because only HEL fulfils all desirable properties. At the time of submission of this paper, the paper describing the HEL was not yet published, and therefore the timing of this paper was not optimal. However, the advantages of the HEL scheme with respect to advection are now published in Kaas et al. (2013). A short summary of this will be included in the paper.

References Frohn, L. M., J. H. Christensen and J. Brandt, 2002: "Development of a high resolution nested air pollution model – the numerical approach". Journal of Computational Physics. Vol. 179, pp. 68-94, 2002.

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Kaas, E., , B. Sørensen, P. H. Lauritzen, and A. B. Hansen (2013): A hybrid Eulerian–Lagrangian numerical scheme for solving prognostic equations in fluid dynamics.

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