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Interactive comment on "Global mass fixer algorithms for conservative tracer transport in the ECMWF model" *by* M. Diamantakis and J. Flemming

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Dear Dr Sørensen,

We would like to thank you for reviewing this paper and providing corrections and interesting comments for further discussion. This is our reply:

Comment 1

Yes, indeed we have considered re-distributing. We had a test version in which the amount of tracer the limiter was truncating was distributed in the vertical. This was reducing the magnitude of MFA corrections and had the additional benefit of a further

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reduction of the cold bias in climate runs. However, for NWP runs in higher resolution was giving slightly negative skill scores.

We have also considered distributing in a full 3D fashion as it is done in ILMC filter by Sørensen et al. This would have been ideal but there are some difficulties with respect to its implementation in IFS:

(a) IFS is parallelized in a way which is highly efficient and safe for code development but puts limits in what can be done. According to the opinion of our experts in this area, for a safe and bit-reproducible implementation of ILMC in IFS, the cost of SL advection would have to increase significantly.

(b) One additional subtle point is that IFS is not using density as a variable and tracers are represented by their specific mixing ratios. Therefore, redistributing interpolation over/under-shoots at different points means altering ratios inconsistently with their actual mass.

For these reasons we decided not to pursue further this idea.

Comment 2 (section 4.3)

We would prefer not to include further figures at this stage as we have assessed the mass fixers on a number of different situations and we believe that the given information is sufficient to expose the strengths and weaknesses of MFAs. Individual plots in Fig. 7 have features which stand out. For example, the strongly dissipative nature of linear interpolation, the non-physical mixing the unlimited cubic introduces as well as differences between individual MFAs and limiters are fairly visible (or example BC versus MG fixer).

Comment 3 (section 4.4)

We agree that this can be an issue for some mass fixers. However for the ones we consider here, this may only happen with PR fixer which can compute both positive and negative increments. Mass transfer from one plume to another implies that the

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MFA will decrease the mass of one plume and increase the mass of the other plume. For BC and ZE fixers equations (5)-(8) dictate that the sign of the correction is uniform and determined by the sign or global mass error (see delta M in eq. 5). This issue is discussed in the last paragraph of section 3.2. So when the total mass is overestimated then mass will be taken from all plumes but at different amounts which depend on the smoothness of the field in the region of the gridpoint which is corrected.

It is not so obvious what happens with MG fixer, however, if we make an additional assumption that the interpolation results are positive definite then after some algebraic manipulation we can show that same sign mass fixer increments are obtained as in BC and ZE fixers.

Technical corrections

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