Construction of the Eulerian atmospheric dispersion model SILAM based on the advection algorithm of M.Galperin

by
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GMD - Discussions, 2015
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1 General comments

The paper describes a modified version of the Galperin transport scheme and its implementation in Silam. The Galperin transport scheme is quite interesting and with the modifications described in the paper it seems that it may be sufficiently accurate and efficient for operational implementation. However, there are some issues that are not covered sufficiently well in the manuscript.

A main issue is the numerical accuracy. Probably it is rather difficult to perform an analytic von Neuman analysis with calculation of amplification factors etc. However, this can easily be (and should be) done numerically for different harmonic wave numbers using different time steps (and fft's back and forth). Such an analysis should include a comparison with a known scheme, i.e., a classical semi-Lagrangian scheme with cubic interpolation.

The scheme has some tendency to introduce anti-diffusion for certain shapes and a smoother is therefore introduced in a rather non rigorous way (equation 20). This smoothing seems important in order to obtain reasonable results. However, the nature of the smoother is rather unusual and a more detailed analysis of its performance is requested. In particular it must be clarified in a quantitative way why the value of ϵ is set to approximately 0.08. What is the exact value that is used in the different runs (hopefully the same value in all runs)?

As far as I can judge, the scheme has similarities to the CIP and CIP-CLSR schemes by Xiao and others - see below under Specific comments.

2 Specific comments

l. 146 Units are not just mol or kg but mol/kg and kg/kg since they represent mixing ratios.

l. 159 "The Eq. (1)" should be replaced by "Eq. (1)"

l. 173 "Eulerian dynamics of SILAM". It is proposed to change this to "Eulerian transport scheme of SILAM". Otherwise the reader may be confused to think that the scheme is used for the atmospheric dynamics (on-line coupling), which is not the case.

l. 186 "The Eq. (5)" should be replaced by "Eq. (5)"

l. 205 "in the Eq. (5)" should be replaced by "in Eq. (5)"

l. 253 In my opinion the review of similar schemes is not complete without a discussion of the CIP-CLSR scheme by Xiao (2002). In its essence this scheme is quite similar to the new scheme presented in the manuscript. In CIP, the total field is represented by the cell averages as well as the interphase values between cells. In this way the interphase values play the same role as the center of mass locations in the Galperin scheme. The reference is:

Xiao, F., T. Yabe, X. Peng, and H. Kobayashi, 2002: Conservative and oscillation-less atmospheric transport schemes based on rational functions. J. Geophys. Res., 107, 4609, doi:10.1029/2001JD001532.

See also related papers and an application of CIP-CLSR in the paper: Peng, Xiao, Ohfuchi and Fuchigami (2005): Conservative Semi-Lagrangian Transport on a Sphere and the Impact on Vapor Advection in an Atmospheric General Circulation Model. MWR.

Thus, a careful discussion of the essential difference between CIP / CIP-CLSR and the new scheme is requested.

l. 291 "In application to Galperin scheme" should be "For application to the Galperin scheme" or "For application in the Galperin scheme"

l. 320-334 Apparantly the Galperin scheme is somehow antidiffusive - although not for all shapes. The distortions seem to be a rather serious issue. The smoothing effectively introduced via the expression in eq. (20) seems, as also noted by the authors, to be a non-rigorous fix. It is, however, obvious that the numerical diffusion is enhanced when this "filter" is introduced. An analysis of this should be included in the "numerical von Neuman analysis" mentioned under General comments.

Sect. 6.2 . It is really good that all these tests have been run. I don't think, however, that the weaknesses of the scheme are commented/recognised in sufficient depth. You should discuss the rather widespread noise away from the advected entities. The most depressing result is probably the tendency for the scheme to unmix even when the smoother is on (Figure 11). A general discussion of the Figures 7 through 11 should be included, which directly compare the results with some of the schemes in L14.

l. 476 "Eq. (21)" should be "in Eq. (21)". However, I am a little confused since this equation relates to the vertical direction, while the tests described here are horizontal. I suspect that the equation number should be (20) and not (21). The correlated tracer runs are run both with and without the smoothing. It is unclear, however, if the smoother in (20) was applied to all other runs or if it has been included or not on an ad hoc basis. This must be clarified.

l. 506-514 It makes little sence to compare the performance of the Galperin scheme on one computer with that of other transport schemes, which are run on a different computer. One should instead compare directly with the performance of another transport scheme on the same computer. I suggest a simple (non-conserving) semi-Lagrangian scheme with bi-cubic interpolation. For a model like SILAM it is highly relevant to test the multi-tracer efficiency, as it was done for instance in Kaas et al. (2013), which you refer to. This should be done.

Figure 2 It is disturbing that the legends overlap the figures. Please, use one common legend, e.g., between the two upper and two lower panels. Also, in the caption "Legend includes ..." should be replaced with "The Legend includes ...".