

Interactive comment on “A Lagrangian Advection scheme with Shape Matrix (LASM) for solving advection problems” by L. Dong et al.

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Dear Referee #1

Thanks a lot for your kindly comments! We will follow your advice to improve the manuscript. The following is our response to your two questions:

1. The numerical results indicate that the proposed LASM scheme is first order accurate (Fig. 8). The authors stated on page 4847 line 14 that the dominated error is from trajectory calculation. However, the trajectory equation (3) is solved by a 4th order Runge-Kutta method which is sufficiently accurate for many cases. Therefore, it seems that the error from trajectory calculation should not dominate the total numerical error. The first order accuracy of LASM should be further discussed. Response:

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There may be two factors that cause LASM to be first order accurate. Firstly, due to the Pole problems in the lat-lon coordinate system and lat-lon mesh, we have used a polar stereographic plane on the two Poles. The parcels will be projected onto that plane when their latitudes are within a distance (say R_{pole}) from a Pole (currently R_{pole} is 18°). The velocity is also transformed onto that plane, so the movement of parcels will eventually be affected by this projection more or less. Secondly, LASM used discrete velocity field on the lat-lon mesh, so the velocity on the parcel centroid location is calculated by using bilinear interpolation, while some other schemes evaluate the velocity by using analytical expression. It is noteworthy that if the trajectory of parcels is calculated exactly, LASM will give exact solution in this test case. We have conducted an experiment that only spatial resolution is reduced, the time step size is the same, and the errors are not reduced significantly. We also plan to conduct two extra experiments based on the above thoughts to see the changes on convergence rate. One is to reduce R_{pole} to 3° , the other is to use analytical velocity.

2. In Fig. 11, three diagnostics are reported in order to assess the capacity of LASM in preserving the pre-existing nonlinear correlation among tracers. It is observed that lu is non-zero. In fact, it is a very small number and far less lr . Further note that for many first order schemes such as the first order CSLAM and the first order upwind scheme, lu is zero. The authors could give an explanation why this is not the case for LASM. Response: The correlation preservation diagnostics of LASM are evaluated on the lat-lon mesh, so they contain the remapping errors (the weighted remapping will disturb the correlation more or less). As pointed out in the manuscript, when evaluated on the parcels, lu is exactly zero as expected.

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