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Interactive comment on "The backward Îto method for the Lagrangian simulation of transport processes with large space variations of the diffusivity" *by* D. Spivakovskaya et al.

Anonymous Referee #1

The paper introduces the backward Ito method for simulating the transport of Lagrangian particles to the oceanographic community. The backward Ito method was developed by LaBolle et al. (2000) for groundwater-flow in situations where the diffusivity changes rapidly or discontinuously. The present paper argues convincingly that in situations where the diffusivity changes rapidly, such as at the base of the mixed layer, the backward Ito scheme is superior to other schemes and if the rapid changes in the diffusivity are approximated by a jump then only the backward Ito scheme produces the correct answer.

The paper is clearly written. It serves almost as a tutorial on how to code up random

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walk models to simulate diffusion in a Lagrangian particle tracking code and as such it is a useful contribution. There is not much new in the paper in terms of oceanographic result since most if not all the results on the mean residence time of particles presented in the paper have already been published elsewhere. The paper confirms that the backward scheme works in the presence of discontinuous diffusivity, but this had already been demonstrated adequately in the LaBolle et al. paper. I'm not an expert in stochastic differential equations, but the connection between the choice of numerical scheme – Ito (Euler), backward Ito (backward Euler) and Stratonovich (Heun) – and the implied differences in the choice of boundary condition that applies to the advection-diffusion equation being solved appears to be a novel contribution beyond what is in the paper by LaBolle et al. (2000). This is not highlighted in the abstract or conclusions, so I'm not sure if this is in fact the case. My impression however, is that the main value of this paper is to introduce to the oceanographic community the numerical issues associated with discontinuous diffusivity and illustrate that the problems can be avoided by using the backward Ito scheme.

One issue that was not addressed in the paper but that I think should have been is the following: Given that the diffusivity in the ocean is not truly discontinuous all schemes should in principle converge to the same correct answer provided the time-step size dt is chosen small enough for the particles to sample the region of rapidly changing diffusivity. Some advice on the choice of dt and the convergence rate of the different schemes as a function of the length scale d over which the diffusivity changes rapidly should have been included in the paper.

Some minor points: 1) page 625 line 5: the citation to Spivakovskaya et al. 2005 is not in the list of references

2) Second line of equation 19: there is a factor of dt missing inside the square root sign

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