Ocean Sci. Discuss., 4, S318–S320, 2007
www.ocean-sci-discuss.net/4/S318/2007/

Ocean Science
Discussions

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.

D. Spivakovskaya et al.

Received and published: 11 November 2007

We are grateful to the referee for the comments. Here is a detailed answer.

- Referee comment: **"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. . . "**

  We believe that the manuscripts does contain new results. In particular, the fact that in the sinking-diffusion model the Ito random walk model leads to one residence time and the backward Ito scheme leads to another one is a completely new result, that has never been published. The analytical solution of this problem has been obtained by Deleersnijder et al. (2006b). The authors approached to the problem using the Eulerian formulation; however, the question whether it was possible to construct the corresponding Lagrangian model was still open. In the present paper it is shown that a possible method to handle the problem of the residence time in the presence of the discontinuity of the diffusivity term is the backward Ito model.

- Referee comment: **‘...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).”**

  We did not mean that the choice of the numerical scheme is completely determined by the formulation of the SDE. At least for the equations with the smooth coefficients each of the proposed method (Euler, backward Euler and Heun) can be applied; however, the corresponding transformation of the advection term is required (see, for instance, Kloeden and Platen (1999). We just wanted to emphasize that each formulation of the SDE is consistent with one the numerical schemes.

- Referee comment: **“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.”**

  To introduce the particle methods associated with discontinuous diffusivity to the oceanographic community was really one of the main goals of the paper. As we noticed earlier, the random walk model that is able to handle the discontinuity in diffusion coefficient was not known in the oceanographic literature before (see, for instance, Ross (2006)).

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Interactive Comment

- Referee comment: **"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. . . "**

  The diffusivity in the ocean is not really discontinuous. However, there are some regions where the rapid but continuous change in the turbulence statistics that occurs may be represented by a discontinuity. In this case the traditional random walk methods will not give the right answer. When the diffusion term is continuous function, all random walk methods considered in the paper should lead to the same solution. However, this is not always guaranteed. One of the examples is mentioned by LaBolle in his comment of this paper.

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

  Done.

- **Second line of equation 19: there is a factor of dt missing inside the square root sign.**

  Done

References. Ross, O.N. (2006), Particles in motion: How turbulence affects plankton sedimentation from an oceanic mixed layer, Geophysical Research Letters, 33, L10609, doi: 10.1029/2006GL026352.

Interactive comment on Ocean Sci. Discuss., 4, 623, 2007.