Review SERGHEI v2.1: a Lagrangian Model for Passive Particle Transport using a 2D Shallow water Model (SERGHEI-LTP)

By Vallés et al.

The authors present a Lagrangian model for passive particles coupled to a 2D shallow water model (SERGHEI). In particular, the paper analyzes the accuracy of three different schemes: online 4th order RK, online 1st order Euler and offline 4th order RK. For this the authors consider four test cases: a steady vortex, a flow resulting of damn break that collides with some buildings, a channel with cavities, and realistic runoff flow after two precipitation events. For some of the test cases, the particles move only due to advection and for others by both advection and subgrid diffusion (due to unresolved turbulence). The main conclusions are that 1) the model performs well and 2) the Euler scheme gives the best tradeoff between accuracy and computational efficiency.

Overall, I find that the work interesting and the model seems to indeed perform well. However, I find the discussion many times superficial, inaccurate, and confusing. I hope that the comments below will help the authors improve their manuscript.

As a disclaimer, I want to mention that I was already preparing this review when I was notified that the other reviewer had upload their comments. I have still finished my review without looking into the other reviewer's comments to avoid bias. However, I have read the comments after finishing to avoid possible repetition or contribute further to the already ongoing discussion. Still, it seems that we have quite different concerns.

Major comments

1- Lines 37-38. The Lagrangian approach does not, in general, offer detailed insights into processes like deposition, fragmentation, and degradation. This is only the case if such processes are implemented. The main difference between the Lagrangian and the Eulerian approach is that the Lagrangian approach provides insight into the pathways linking the origin to the destination of individual particles.

2- The discussion about research on Lagrangian transport in coastal environments (l. 43-48) seems inappropriate. I think that there are certainly differences in the numerical approach and maybe the physics of the problem (typical velocities or time scales?) but drying and flooding occurs over vast extents in some coastal systems. The authors can see for example the work by Cucco et al. [1] or recent work by Fajardo-Urbina et al. [2,3] for passive particles transported by depth-averaged flows over regions that flood and dry twice a day! Furthermore, they used offline methods, so lack of flooding and drying is not the reason for using them. I think that one of the main differences is that in these coastal studies the flow of interest changes with a typical time scale that is much longer than the time step needed to advance the particles. Notice that it is common to use temporal interpolation besides using RK4 [4].

3- Lines 63-64. The sentence "In this context, two-dimensional models ... " needs to specify the application. This is not the case in general.

4- Lines 100-106.The discussion about the vertical position of the particles is inconsistent. First, the equation of $z_p$in (5) is not correct. The particle position has a vertical velocity equal to the velocity of the free surface. In fact, the authors later say that $z_p = h + z_b$, so $\frac{dz_p}{dt} = \frac{dh}{dt}$. Even then, this is still inconsistent with the rest of the problem, because the particles are carried by a depth averaged flow, which is different than the flow at the free surface. In fact, the depth averaged flow is a mathematical construction so that particles transported by it have no vertical position.

5- Line 119. Turbulence is not a quantity so it cannot be proportional to velocity.

6- Figure 1. I find figure 1 very confusing. I really don't understand why/how the particle would follow the green path. It looks also quite different than in Figure 3c. Furthermore, the vector on the cell to the left of the obstacle does not seem right because it would transport particles into the obstacle.

7- Section 4.1. The authors do not give sufficient information to reproduce the results. Particularly, the shape of the vortex, the location of release, the velocity of the vortex. The fact that the authors only considered an offline method updated every five hydrodynamic time steps seems restrictive. What if the there is a better tradeoff when updating every 3 time steps? In addition, I find figure 6 close to useless. In the caption, it is mentioned that the error is normalized by the Euler error, but it is actually normalized by the RK4 error. By doing this, all the information about how the RK4 error depends on Δx is lost. I would suggest plotting lines in a log-log plot without normalizing. Are the errors scaling as they are supposed to?

8- Section 4.2. The authors say that this is a well-known test case, but they do not test much or compared against any other results.

9- Section 4.3. Again, there is no benchmark. I agree that it is a good sign that the results remain symmetric, but this is not a proof that the code is doing everything fine. It is just a proof that there are no asymmetric errors. Furthermore, it is clear in both 4.2 and 4.3 that the diffusive terms are doing something, but it is not shown that what they are doing is correct.

10- Section 4.4. I find this section interesting as a nice application, but there is some unbalance between the number of figures and the analysis. I find it also strange that for this section the scheme used is not mentioned.

11- Finally, the authors do not really justify their conclusion that the Euler scheme gives the best tradeoff between accuracy and computational efficiency. A more careful explanation of what they mean and how they reach their conclusion is necessary. At the moment, it remains somewhat subjective in the sense that the error does not seem much larger than for RK4, but it is more efficient, so I can leave with the error.

Minor comments

1- Use scientific notation for the number of particles.
2- Line 81: “The equations flow” -> “The flow equations”
3- The authors use sometimes **u** and sometimes **v** to denote the velocity. I suggest being consistent.
4- Line 175. Define $\boldsymbol{A} = (A_x, A_y)$ and $\boldsymbol{q} = \left(q_x, q_y\right)$.
5- Use italics (math) x and y throughout the paper when referring to coordinates.
6- Line 334-335. This sentence can join the previous paragraph. Also, specify what is meant with overhead of 2.39 and 1.10. I guess that you mean “Increase ratio” as in Table 1.

[1] Cucco, A., Umgiesser, G., Ferrarin, C., Perilli, A., Canu, D. M., & Solidoro, C. (2009). Eulerian and lagrangian transport time scales of a tidal active coastal basin. Ecological Modelling, 220(7), 913-922.

[2] Fajardo-Urbina, J. M., Arts, G., Gräwe, U., Clercx, H. J., Gerkema, T., & Duran-Matute, M. (2023). Atmospherically Driven Seasonal and Interannual Variability in the Lagrangian Transport Time Scales of a Multiple-Inlet Coastal System. Journal of Geophysical Research: Oceans, 128(6), e2022JC019522.

[3] Fajardo-Urbina, J. M., Liu, Y., Georgievska, S., Gräwe, U., Clercx, H. J., Gerkema, T., & Duran-Matute, M. (2024). Efficient deep learning surrogate method for predicting the transport of particle patches in coastal environments. Marine Pollution Bulletin, 209, 117251.

[4] Van Sebille, E., Griffies, S. M., Abernathey, R., Adams, T. P., Berloff, P., Biastoch, A., ... & Zika, J. D. (2018). Lagrangian ocean analysis: Fundamentals and practices. *Ocean modelling*, *121*, 49-75.