

Geosci. Model Dev. Discuss., author comment AC4
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Reply on EC1

Vera Fofanova et al.

Author comment on "Plume spreading test case for coastal ocean models" by Vera Fofanova et al., Geosci. Model Dev. Discuss.,
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Dear Reviewer 2,

Suggested reference to Xia et al. 2007 "Modeling of the Cape Fear River estuary plume" does not analyze performance of different tracer advection schemes or limiters with respect to numerical mixing. The individual and coupled effects of the astronomical tides, river discharge, and atmospheric winds were considered to investigate the Cape Fear River Estuary dynamics. On page 699 (right side) the paper provides a brief description of the used EFDC model. Only here the advection scheme is mentioned : 'The model includes the anti-diffusion upwind advection scheme that is more suitable for the plume study than the upwind scheme or the central difference scheme (Berdeal et al. 2002). '

It looks like a misunderstanding, because we do not consider different mixing schemes, indeed physical eddy diffusivity is set to 0, eddy viscosity is calculated based on k-eps style turbulence closure or set to background value. We consider the numerical mixing level attributed to the different tracer advection schemes and limiters. This is clearly written through the paper.

As we have mentioned in our first reply, we propose the test case and diagnostic metrics by which the numerical mixing in ocean models can be quantified. Spurious numerical mixing in circulation models can destroy stratification and frontal features, and significantly alter the plume dynamics. While considering the effect of physical forcings on the plume dynamics is certainly relevant, it is out of the scope of the present article. The community needs benchmark test cases (see attached Lemarié et al., 2019 summary) that are reproducible, can be compared against analytical solutions and offer the analysis of "isolated" effects (not blurred by the interplay of many different processes as in complex realistic scenarios) and the direct connection to specific numerical choices in the model core. The suggested idealized plume scenario with a unique set of parameters is reproduced differently by different, but commonly used, advection schemes+limiters. And this is not surprising because the plume dynamics in some zones can be characterized by nonlinear flow regimes with sharp frontal boundaries. Simplicity or non-simplicity of idealized experiments depend on the accuracy level you chose as acceptable.

We have read all the papers suggested by the Reviewer. However, their scopes are beyond that of our study. Please, find below a brief report on the suggested articles:

- Niu, Q., Xia, M. (2021) "The behavior and wind-driven dispersions of two dynamically

distinctive limnetic river plumes in a semi-enclosed basin," *Estuarine, Coastal and Shelf Sciences.*(In press)

We did not find an article which exactly matches the title, perhaps the Reviewer meant 'The behaviors of two limnetic river plumes discharging into the semi-enclosed western basin of Lake Erie during ice-free seasons' .

The article is about wind-driven dynamics of the Detroit and Maumee River sediment plumes in the semi-enclosed western basin of Lake Erie on several temporal scales. In our case study the wind- driven dynamics has not been considered.

- Niu, Q., Xia, M., Ludsin, S.A., Chu, P.Y., Mason, D.M., Rutherford, E.S. (2018). "High turbidity events in Western Lake Erie during ice-free cycles: Contributions of river-loaded vs. resuspended sediments," *Limnology and Oceanography*,00, 1-18.

The article investigates the contributions of river loading (Detroit and Maumee Rivers) versus resuspension to high-turbidity events in Western Lake Erie during ice-free conditions in 2002–2012 using a wave-current forced sediment model (FVCOM based). The major result is that suspended sediment dynamics and high turbidity events in the area were dominated by wind and waves in the offshore regions, and were driven by river loadings near the mouths.

We agree that it is a very important regional study, however, it has focus on sediment dynamics and is hardly relevant to our idealised plume scenario and its major aim.

- Jiang, L., & Xia, M. (2016). "Dynamics of the Chesapeake Bay outflow plume: Realistic plume simulations and its seasonal, interannual variability," *Journal of Geophysical Research: Oceans*, 121, 1424-1445.

The article identifies five types of real-time plume behavior regulated by wind and river discharge. Also it contains some sensitivity experiments related to the grid cell sizes considering fine and coarse grids. The article gives very valuable insights about Chesapeake Bay outflow plume behaviour. However, these five types are defined based on presenting physical conditions (preliminary by wind conditions) and there is no established connection to the numerical scheme performance. Therefore, the topic and analysis of the paper are beyond the topic and aims of our manuscript.

- "The ideal response of a Gulf of Mexico estuary plume to wind forcing: Its connection with salt flux and a Lagrangian view," *Journal of Geophysical Research*, 116, C08035.

The questions posted by the article are:

- 1) How does wind forcing affect bay water as it encounters the Gulf?
- 2) How do plume distribution, fluxes, and particle transport change with changing wind conditions?

The questions are important to understand the regional dynamics. However, as they deal with physical forcings, the topic is beyond the current study.

5. Xia, M., Xie, L., Pietrafesa, L.J. (2010). "Winds and the orientation of a coastal plane estuary plume," *Geophysical Research Letters*,37, L19601.

The suggested article deals with the Cape Fear River Estuary. and its river plume behavior (type) under different wind forcing and river discharge conditions. Results showed that wind direction, wind speed, and to a lesser extent river discharge contribute to plume

transitions from one type to another among six defined major types. This topic is interesting, but not relevant for our study.

6. Xia, M., Xie, L., Pietrafesa, L.J. (2007). "Modeling of the Cape Fear River estuary plume," *Estuaries and Coasts*, 30(4), 698-709.

Please, see the comment above.

Please also note the supplement to this comment:

<https://gmd.copernicus.org/preprints/gmd-2020-438/gmd-2020-438-AC4-supplement.pdf>