TITLE - The Role of Rivers in Ocean Forecasting

RECOMMENDATION: Major revisions

This paper aims at providing a review of the river release representation in ocean modeling, spannnig from global to coastal scales.
It offers a valuable contribution to ocean modeling developers and practitioners, as it assesses current advancements and offers recommendations for the next generation modeling of the global coastal ocean to more accurately account for riverine inputs.

I encourage the authors to make additional efforts to deliver a comprehensive and detailed overview of the current state of the field, ensuring it serves as a valuable reference for the community.

As it stands, the manuscript is lacking in several key topics. It would greatly benefit from incorporating a broader range of relevant studies and addressing open issues that deserve reporting and discussion.

Major comments:

Title: I suggest to modify the title to clarify the the paper aims at providing a review of the state of art of river release representation within OOFS

Line 52-53: The "point source input" here mentioned is not a rigorous definition. More precise, the river release entering as surface point sources affects the vertical velocity surface boundary condition of the free surface equation (i.e. the vertically integrated continuity equation, not the continuity equation itself) and the surface boudary conditions for the diffusive heat and salt fluxes (Beron Vera 1999)

Line 70: "to account for baroclinic flow", I'd suggest to replace with "to account for baroclinic and barotropic flows"

Line 75: Figure 1 caption. Which EBM does the caption refer to? Please include a reference to the model

Line 97-98: please detail more the relevant result found out by Bao et al 2022 by comparing 2way versus linked approach.

Line 98-99: this sentence is too concise. Moreover the seamless river-sea continuum modeling deserves a specific additional section, e.g. Section 2.4

Add discussion and references on the topics below:

- **-The Influence of Seasonal and Non-Seasonal River Release on Stratification and Sea Level Variability:** It is important to discuss how variations in river release can impact both stratification and sea level changes. Relevant studies include in addition to the already mentioned Chandanpurker et al 2022:
    - Zhang, Y. J., Ye, F., Stanev, E. V., & Grashorn, S. (2016). Seamless cross-scale modeling with SCHISM. *Ocean Modelling*, *102*, 64-81.

- Giffard, P., Llovel, W., Jouanno, J., Morvan, G., & Decharme, B. (2019). Contribution of the Amazon River discharge to regional sea level in the tropical Atlantic ocean. *Water*, *11*, 2348. https://doi.org/10.3390/w11112348
- Piecuch, C. G., Bittermann, K., Kemp, A. C., Ponte, R. M., Little, C. M., Engelhart, S. E., & Lentz, S. J. (2018). River-discharge effects on United States Atlantic and Gulf coast sea-level changes. *Proceedings of the National Academy of Sciences*, *115*(30), 7729-7734.
- Piecuch, C. G., & Wadehra, R. (2020). Dynamic sea level variability due to seasonal river discharge: A preliminary global ocean model study. *Geophysical Research Letters*, *47*(4), e2020GL086984.
- Verri, G., Pinardi, N., Oddo, P., Ciliberti, S. A., & Coppini, G. (2018). River runoff influences on the Central Mediterranean overturning circulation. Climate dynamics, 50(5-6), 1675-1703

- **Unstructured Modeling of the River-Sea Continuum:** This approach offers various advantages, including alleviating the challenges associated with prescribing river salinity because it can be set equal to zero at the head of an estuary solved by an unstructured grid. A dedicated section discussing this topic is warranted. Key references for this discussion include, in addition to the already mentioned Zhang et al 2016: Le Bars et al 2016, Maicu et al (2021), Bellafiore et al (2021), Vallaeys et al. (2018), Vallaeys et al. (2021), and Verri et al. (2023), Bonamano et al (2024), among many others.

- **Machine Learning Approaches to Estimate Riverine Release.** Key references to consider include studies that highlight successful machine learning applications in hydrology and oceanography. Regarding the salinity at river mouths some references are provided below:
  - Fang, Y., wei Chen, X., Cheng, N.-S., 2017. Estuary salinity prediction using a coupled GA-SVM model: A case study of the Min River Estuary, China. Water Sci. Technol.: Water Supply 17, 52–60.
  - Qiu, C., Wan, Y., 2013. Time series modeling and prediction of salinity in the Caloosahatchee River Estuary. Water Resour. Res. 49 (9), 5804–5816. http: //dx.doi.org/10.1002/wrcr.20415, arXiv:https://agupubs.onlinelibrary.wiley.com/ doi/pdf/10.1002/wrcr.20415, URL: https://agupubs.onlinelibrary.wiley.com/doi/ abs/10.1002/wrcr.20415.
  - Guillou, N., Chapalain, G., Petton, S., 2023. Predicting sea surface salinity in a tidal estuary with machine learning. Oceanologia 65 (2), 318–332. http://dx.doi.org/10. 1016/j.oceano.2022.07.007, URL: https://www.sciencedirect.com/science/article/ pii/S0078323422000835.
  - Qi, S., He, M., Bai, Z., Ding, Z., Sandhu, P., Zhou, Y., Namadi, P., Tom, B., Hoang, R., Anderson, J., 2022b. Multi-location emulation of a process-based salinity model using machine learning. Water 14 (13), http://dx.doi.org/10.3390/w14132030, URL: https://www.mdpi.com/2073-4441/14/13/2030
  - Saccotelli, L., Verri, G., De Lorenzis, A., Cherubini, C., Caccioppoli, R., Coppini, G., Maglietta, R., 2024. Enhancing estuary salinity prediction: a

Machine Learning and Deep Learning based approach. *Applied Computing and Geosciences*

- Maglietta, R., Verri, G., Saccotelli, L., De Lorenzis, A., Cherubini, C. Caccioppoli, R., Dimauro, G., Pinardi, N., Coppini, G. (2024) Advancing Estuarine Box Modeling: a Novel Hybrid Machine Learning and Physics-Based Approach. Environmental Modelling and Software

Regarding the water level along estuaries:

- Sampurno, J., Vallaeys, V., Ardianto, R., and Hanert, E.: Integrated hydrodynamic and machine learning models for compound flooding prediction in a data-scarce estuarine delta, Nonlin. Processes Geophys., 29, 301–315, https://doi.org/10.5194/npg-29-301-2022, 2022.

- **Estimation of River Temperature and Its Minor Role:** The estimation of river temperature should be acknowledged in the context of riverine release even if it is not the primary factor influencing oceanographic processes

Minor comments:

Line 10: I'd mention also the subsurface water discharge

Line 40: The first time the acronym OOFS is mentioned, it should be spelled out in full.

Line 48-49: the prescribed salinity values at river mouths are tipically based on costant annual/monthy values which are the result of sensitivity tests and/or in situ campaigns *(Verri, G., Pinardi, N., Oddo, P., Ciliberti, S. A., & Coppini, G., 2018. River runoff influences on the Central Mediterranean overturning circulation. Climate dynamics, 50(5-6), 1675-1703)*

Line 75: Figure 1 caption. Which EBM does the caption refer to? Please include a reference to the model

Line 111-112: I believe here you should refer to Verri et al 2018 rather than Verri et al 2021. Sensitivity tests by Verri et al 2018 demonstrate that a more realistic estimates of riverine inputs would produce a more accurate representation of coastal (plume) to basin wide circulation and dynamics (dense water formation, overturing circulation cells, water exchange at the straits …)

Line 192: "However, strong land-sea differences in microwave emissivity make satellite observations unreliable within some 70 km of the coast" I belive the water turbidity is the main limit to be mentioned here

Line 194-195: The satellite retrieved salinity close to the river mouth is a crucial chalenge and more recent studies should be mentioned and briefly discussed *e.g. Medina et al 2020; Sakai et al 2021, Chen et al 2017*

Section 3.1.2: a missing reference in the list is the recent database of climatological runoff for the Adriatic rivers provided by *Aragão, L., Mentaschi, L., Pinardi, N., Verri, G., Senatore, A., & Di Sabatino, S. (2024). The freshwater discharge into the Adriatic Sea revisited. Frontiers in Climate*

Section 3.3 all theOOFS should be references through links to their web pages /pubblications