Responses to the Referee#2 Comments and Suggestions

Journal: Ocean Sciences (OS)
Manuscript number: egusphere-2025-606
Manuscript title: Modelling river-sea continuum: the case of the Danube Delta

The original Reviewer's comments and suggestions are shown in regular typeface, while our responses are shown in italics. The line and figures numbers we use refer to the revised document.

R2.1 The paper introduces a rather unique SHYFEM configuration that is integrating the Danube delta and the RSLS lagoon system into a coastal model for the western Black Sea. This unified approach to modelling the land-estuary-sea continuum is demanding in terms of model numeric and physics. The authors have carried out a thorough study and achieved good and relevant results that were used to estimate the water transport and hydrographic conditions in the Danube delta system.

The following includes some general comments, followed by a more detailed review of the paper.

Response: We thank the referee for the in-depth and useful review. We appreciate the comments and we will improve the manuscript in accordance with all suggestions. In particular, we will restructure the manuscript to better clarify the scope and content of this study.

R2.2 The authors carried out a thorough research study, but could have done more to analyse the data in a more comprehensive way targeting well-defined research questions. I am missing a consistent storyline leading through the paper. This is the case for both the entire paper and individual chapters. As it is, the authors have basically written a general study of the Danube river and Razelm Sinoie Lagoon System (RSLS), which provides a lot of information, but is not embedding it into a consistent story-line. The manuscript is actually two papers in one, each with its own research question. The first paper is (1.) demonstrating that the river-sea continuum can be modelled successfully using unstructured grid models and (2.) the second paper is studying the impact of openings of the RSLS towards the Black Sea and its impact on local circulation pattern and hydrographic conditions. I would suggest the authors to define one or two research questions and then to develop a story line addressing this questions. With this, they could streamline the whole paper and make it more concise.

In the first paper (1.), I would expect to find an analysis of the impact of coastal high-resolution configurations on river plume modelling: comparison with and without the Danube river model and RSLS lagoon model. The paper could demonstrate the effect of improved river-plume-modelling on the freshwater distribution, pollutant distribution, etc., with impact on the local hydrographic conditions. To be true, this has been done, but the analysis could have been further expanded and could have been presented with a view to answer the research question rather than to present model results. The analysis could also include a comparison of modelled river data with either observations or hydrological model results (E-hype, SWAT, etc.). I think E-hype climatology is freely available.

The subject of the second paper idea (2.) mentioned above, the study of the effects of openings in the RSLS towards the Black Sea on the hydrographic conditions is only shortly covered in the paper. The analysis of impacts could be extended. The model results could be analyzed in the light of the objectives of the openings, which are not very clear to me. Here, too, I would prefer if the model results could be used to answer the research question rather than being presented.

Response: We thank the referee for the comment, which has helped us to clarify the scope and content of our paper. In the "Introduction" section we will specify that "this paper focuses on the investigation of the hydrodynamic processes, water exchange and connectivity among the different interconnected water compartements (river branches, channels, lagoons, coastal sea) forming the Danube Delta river-sea continuum. To archive this goal, we implemented the SHYFEM (System of HydrodYnamic Finite Element Modules; Umgiesser et al., 2022) model to the entire Danube Delta, covering about 500 km of the river network, the Razelm Sinoie Lagoon System and part of the prodelta coastal sea (Fig. 1). The model results are used to quantify water discharge distribution among the river branches, to evaluate the effects of multiple river plumes on the coastal dynamics, and to investigate the water exchange and the renewal capacity of the Razelm Sinoie Lagoon System. Moreover, the numerical tool is used to assess the potential impacts of different hypothetical lagoon-sea reconnection solutions (what-if scenarios) on the processes regulating the exchanges between the river, lagoon, and sea."

The analysis of the numerical model results will be improved to investigate the processes regulating the exchanges among the different water compartments.

We thank the reviewer for the suggestion of using hydrological model results for validating the SHYFEM model. Unfortunately, none of the available model datasets (EFAS, E-Hype, HERA) provides the water division in the river network of the Danube Delta, and, therefore, cannot be used in the model validation.

R2.3 The quality of the writing varies. I would strongly recommend to improve the orthography and grammar. Sometimes the construction of the sentences is not correct. Furthermore, the style is often rather direct, and focused on presenting facts. This is often done in loosely connected paragraphs, which could be better integrated.

Response: The manuscript's orthography and grammar will be improved.

R2.4 The different measures of water transport and mixing: ROFI, WFT, WRT could be introduced in a combined and more consistent way in the method section. Currently there is only WRT defined, in the part of thepaper that is dealing with the SHYFEM model (Line 77-87). WFT is later on defined when using it. A clear definition for ROFI has not been provided. It would be good to define these quantities and how they are used in a consistent way. It is for example not clear until later, that the ratio of WFT and WRT is used. This should be done in a separate part of the method section, not in the model description.

Response: We will include in the "Method" section the following paragraph describing the different measures of water transport and mixing (WFT, WRT, mixing capacity): "To investigate how the difference forcing and processes influence the water mixing and renewal in the semiclosed Razelm Sinoie Lagoon System, the numerical model has been used to estimate two transport time scales: the water flushing time (WFT) and the water renewal time (WRT) (Umgiesser et al., 2014). The basin-wide WFT is defined as the theoretical time necessary to replace the complete volume of the water body with new water and assuming a hypothetical fully mixed basin and is computed diving the basin volume by

the volumetric water flux flowing out of the system. WRT is computed by simulating the transport and diffusion of a Eulerian conservative tracer released uniformly throughout the entire lagoon system with a concentration corresponding to 1, while a concentration of zero was imposed on the seaward and freshwater boundaries. The local WRT is considered as the time required for each cell of the RSLS to replace the mass of the conservative tracer, originally released, with new water. The ratio between the basin wide WFT and WRT can be interpreted as an index of the mixing behaviour of the basin. The reader may refer to Cucco et al. (2009) and Umgiesser et al. (2022) for a more comprehensive description of the transport time scales."

Since these variables are directly estimated from model results, we will place this paragraph at the end of the "The modelling system" section.

ROFI is not a variable. This name, which is an acronym for Region Of Freshwater Influence, is commonly used in literature to define a coastal area influenced by the river plume. The definition for ROFI will be provided at the beginning of section 3.3.

R2.5 Chapter 0. Abstract. In its current form, the abstract outlines the scope of the study. It could provide more motivation as to why this study has been carried out. The key findings should be listed as well. It is good to think of the abstract as a mini-IMRAD scheme, including all the parts of the paper.

Response: We thank the referee for the suggestion. The new abstract will read: "Understanding water transport and circulation in coastal seas and transitional environments is among the key topics of oceanographic and climate research, as well as recognizing the role of the land-sea interface. The Danube Delta represents a natural laboratory for river-sea hydrodynamic modelling due to its complex morphology composed by several river branches, channels and lagoons. Moreover, this coastal environment is subjected to several natural and anthropogenic stressors and a numerical model could provide the scientific basis to assess the impact of human activities. In this work, the SHYFEM finite element hydrodynamic model was applied to the whole river-sea continuum of the Danube Delta region to describe the transport and mixing processes in the different interconnected water bodies forming the delta. The model was run for the period 2015-2019 and allowed to characterize: 1) the water discharge distribution among the river branches, 2) the general hydrodynamic characteristics of the coastal region of freshwater influence, 3) the transport time scale of the Razelm Sinoie Lagoon System, and 4) the processes driving the river-lagoon-sea interconnections. Lastly, the Danube Delta modelling tool was used to evaluate the potential effects of hydrological reconnection (restoration) measures in the Razelm Sinoie Lagoon System designed to improve connectivity and water renewal."

R2.6 Line 3: The sentence should end after "morphology". Then a new sentence should start.

Response: We will modify the sentence as "The Danube Delta represents a natural laboratory for river-sea hydrodynamic modelling due to its complex morphology. Moreover, this coastal environment is subjected to several natural and anthropogenic stressors."

R2.7 Line 5: "The model was run for several years ..." How many? "Several year" is a bit vague.

Response: We will modify the sentence as "The model was run for the period 2015-2019 to ..."

R2.8 Line 19: Think of a better begin of the sentence than "Modelling these coastal transitional water systems". Are these not "estuaries and coastal seas".

Response: We will modify the sentence as "Modelling estuaries and deltas is challenging ..."

R2.9 Line 31: I would say "... Danube delta, covering ..." Please refer to Figure 1.

Response: We will modify the sentence as "... to the entire Danube Delta, covering about 500 km of the river network, the Razelm Sinoie Lagoon System and part of the prodelta coastal sea (Fig. 1)".

R2.10 Line 32 "The manuscript ...", maybe better: "The paper". You can also use the active voice and write "We focus ...'.

Response: We will modify the sentence as "The paper focuses ..."

R2.11 Note: This part of the introduction gives an overview of the scope of the paper. The different points could be used to identify the research question. The advantage of a good research question is that it describes the problem and the motivation for solving the problem.

Response: We will modify this part of the introduction to clarify the scope of the paper. See the response to comment R2.2.

R2.12 Line 36: When we talk about what-if scenarios here, then they must at least described in general terms. It must also be explained what a what-if scenario is. It is not a commonly used term.

Response: We will modify the sentence to clarify that the numerical tool is used to assess the potential impacts of different hypothetical lagoon-sea reconnection solutions (what-if scenarios) on the processes regulating exchanges between the river, lagoon, and sea.

R2.13 Line 44: Please rewrite the sentence starting with "The Romanian part ..." Line 46: "extends on about", use "extends for about" Line 51: "were finalized ... " not "ended up" Line 51: "As a result, more fresh water is discharged into the lagoon system"

Response: We will correct the mentioned sentences following the reviewer's suggestions.

R2.14 Line 54: Please mark Portit or use another way to show it on the map. It is not good to say: "near reconnection option A", before these have been introduced. The same is true for "reconnection option C" in Line 58.

Response: Following the reviewer's suggestion, we indicate the two former inlets in Fig. 1 (included in this document as Fig. 1).

R2.15 Line 55: It's not intuitive that a coastal defense structure could enhance coastal erosion. This sentence could be reformulated or explained in more detail.

Response: The mentioned sentence will be removed since it is not relevant to the purpose of this study.

R2.16 Line 62: The sentence starting with "Anyway" should be rewritten, like: As part of the master plan for the protection of the Romanian Littoral against erosion, a major hydraulic engineering project is currently implemented, to ensure a permanent water exchange through the Periboina Inlet. This is an example. The structure of many sentences in the document could be improved.

Response: We will correct the sentence in accordance with the suggestion.

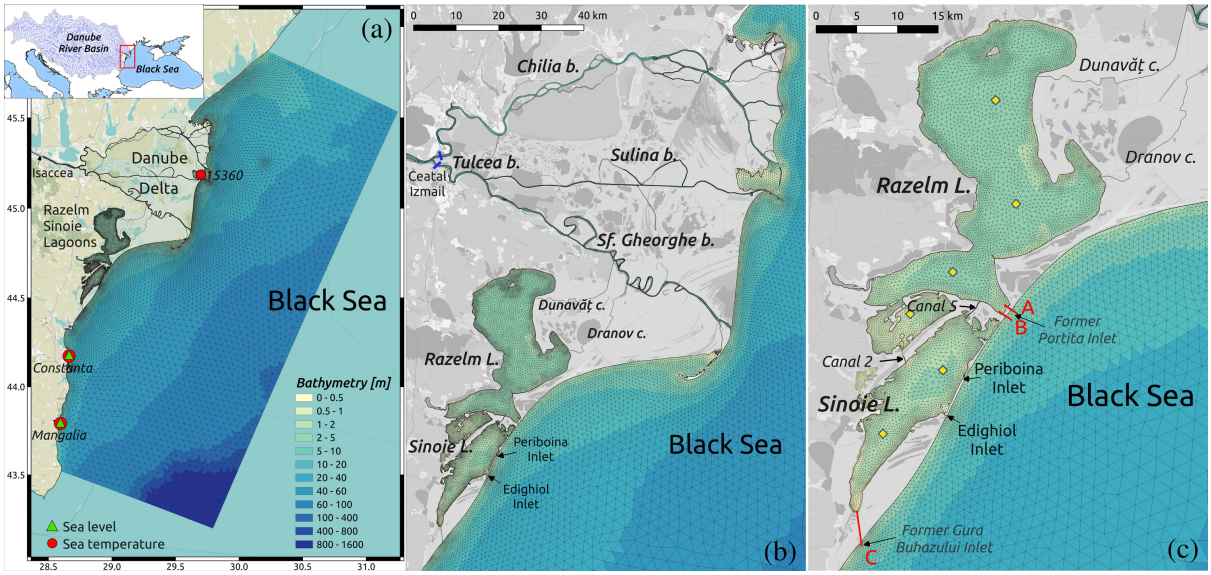

Figure 1: (a) Unstructured numerical grid and bathymetry of the hydrodynamic model of the Danube Delta and Black Sea shelf with the red dots and the green triangles marking the sea temperature and sea level monitoring stations, respectively; (b) zoom of the grid over the Danube Delta with the blue bars near Ceatal Izmail indicating the river discharge monitoring stations; (c) zoom of the grid over the Razelm Sinoie Lagoon Systems with the red bars illustrating the considered reconnection solutions and the yellow diamonds marking the satellite SST control points. Background: ©OpenStreetMap contributors 2024; distributed under the Open Data Commons Open Database License (ODbL) v1.0.

R2.17 Line 65: What does "lower part" mean? Please re-write: "... average water discharge of [so much], with values ranging from ..."

Response: We will modify the sentence as "The Danube River before the delta has an average water discharge of 6500 m^3 s^{-1}, with values ranging".

R2.18 Line 77-88: I would suggest to move this paragraph to a different part of the method section and to enhance it. I don't think it makes sense here in the SHYFEM related part of the document. The WRT parameter should be introduced after the model. The other variables ROFI, WFT should be introduced as well. The motivation for using these variables to study water transport through the lagoon system should be clear from the beginning.

Response: As mentioned in the response to comment R2.2, the description of WFT and WRT will been enhanced. Such a description will be placed at the end of the The modelling system.

R2.19 Line 86: Does WRT really measure the time until the concentration fall to zero or is the time until they fall below a small value enough? I could imagine that it takes a long time until absolute zero is reached.

Response: We will modify the sentence as "The local WRT is considered as the time required for each cell of the RSLS to replace the mass of the conservative tracer, originally released, with new water."

R2.20 Line 86: I assume the water parcels are grid cells inside the investigated water body, i.e. the lagoon.

Response: See the response to comment R2.22.

R2.21 Figure 1a: The sea level and sea temperature stations could be marked a bit more clearly

Response: We will increase the size of the markers.

R2.22 Line 99-129: I would suggest to restructure this part of the document and to combine the information on model configuration: bathymetry data, boundary data, initial conditions, forcing data (atmosphere, river), etc. into one part. The first paragraph of 2.2 Numerical experiments is actually presenting the model configuration. It should be included here. The second paragraph of 2.2 Numerical experiments is actually belonging to the model settings that should be part of the SHYFEM related part of the method section. The information on the numerical experiments: (a.) the model validation and water transport assessment and (b.) for the what-if scenarios should be presented in a separate section. Here you could provide more background information on the choosen simulations.

Response: Following the reviewer's suggestion, we will restrucure the Numerical experiments by including:

- *in section 2.1 the description of the SHYFEM model, the numerical grid, the bathymetric dataset, the model setting and the methods for computing WFT, WRT and mixing capacity;*
- *in section 2.2 the description of the simulations duration, the forcing and boundary data, the initial conditions, and the what-if scenarios. In this last part, we will provide more background information on the choosen reconnection solutions.*

R2.23 Line 101-105: Please add the resolution of the input data. I assume that you used gridded data products. Who provided the data for the Razelm Sinoie Lagoon and the river branches?

Response: We will integrate the description of the bathymetric datasets as: "The model bathymetry is obtained by a bilinear interpolation on the numerical grid of the following available datasets (all referred to the Marea Neagra Sulina vertical datum):

- *the 2022 European Marine Observation and Data Network dataset (EMODnet Bathymetry Consortium, 2022) for the shelf sea on a regular grid of 1/16*1/16 arc minutes, ca. 115 metre grid;*
- *the 2024 dataset for the Razelm Sinoie Lagoon System acquired on (mostly West-East-oriented) transects spaced 450 m apart on average and covering the whole system. The distance between two points within each transect is ∼1 m.*
- *three separate multibeam datasets (provided at a ∼1 m resolution) for the main river branches: the 2023 dataset for Chilia; the 2019 dataset for Sulina; the 2016-2017 dataset for Sf. Gheorghe. Available sparse data was used for some secondary branches and small channels.*

"

R2.24 Line 123-129: Could you provide a bit more information on why these what-if scenarios were chosen? Are these realistic scenarios?

Response: We will integrate the description of the what-if scenarios as "Additional numerical experiments were conducted to investigate the potential effects on the lagoons' water renewal and salinisation of different reconnection solutions designed in collaboration with local stakeholders to enhance the river-lagoon-sea exchange. The dredging of

a new inlet is under consideration by local communities and authorities, as part of the activities developed under the framework of the Horizon Europe Project DANUBE4all (https://www.danube4allproject.eu/). The three what-if scenarios considered in this study consisted of opening a 1.5 m depth and 70 m wide channel to connect the either the Razelm Lagoon (solutions A and B in Fig. 1c) or the Sinoie Lagoon (solution C in Fig. 1c) with the Black Sea. These reconnection solutions are located in the vicinity of previous inlets, now either closed by humans (Portiţa) or now clogged (Gura Buhazului inlet, active till the beginning of the 1990s). The period, parametrization, forcing and boundary conditions considered in these what-if numerical experiments are the same as those adopted in the reference run (hereinafter called REF)."

R2.25 Line 130-151: In my opinion, it would be better to move the list of validation data sets to the validation chapter. The model validation chapter could be a separate part of the paper, because it is not so much presenting new results, but is demonstrating the quality and usefulness of the model.

Response: Following the reviewer's suggestion, we will move the description of the validation datasets to the "Model validation" section. This paper presents the first comprehensive modelling study of the Danube Delta, and we believe the validation must be presented in the "Results" section.

R2.26 Line 132-135: Please refer to figure 2 here. The validation could also include a comparison with hydrological model results: (E-Hype, SWAT). I think the E-Hype climatology is freely available. Annual mean discharges could be calculated and compared with hydrological model results.

Response: We thank the reviewer for the suggestion of using hydrological model results for validating the SHYFEM model. Unfortunately, none of the available model datasets (EFAS, E-Hype, HERA) provides the water division in the river network of the delta, and, therefore, cannot be used in the model validation.

R2.27 Line 136-137: Here you say that hourly values were available. Then why did you perform the model validation using daily averaged data sets? You say that the model can represent the sea level fluctuations (anomaly) associated with intense meteorological events (Line 168). But these have much shorter time scales. I assume that at least hourly data would be needed. We use 10 minutes data for sea level warnings.

Response: I understand that using daily averaged sea levels may seem unconventional; however, this approach is justified because tidal effects in the study area are negligible. As a result, sea level variations are primarily driven by open sea conditions and atmospheric disturbances with typical time scales of 1 to 10 days. Additionally, the model is forced at the Black Sea and Danube River boundaries using daily datasets. Given these assumptions and to limit the model's output volume, results are saved at a daily frequency. Finally, the analysis of sub-daily dynamics is beyond the scope of this study.

R2.28 Line 141-151: I'm a bit puzzled that you did not use CMEMS satellite SST product for Black Sea. Is the quality of the CMEMS product not good enough? Why did you use the level 2 product and not the gridded data set?

Response: The capacity of the model in reproducing the sea temperature in the coastal waters of the Black Sea was assessed through the comparison of in-situ timeseries (Constanta, Mangalia, 15360). Satellite SST data were only used to validate the model in the Razelm Sinoie Lagoon System. We used the level 2 product (kindly provided by colleagues from the University of Stirling) because they were specifically processed for a very shallow environment.

R2.29 Line 153-183: The chapter jumps right away into model validation statistical methods and results. It would be good if you could provide a bit more background information and motivate the validation exercise and the specific choice of parameters and methods.

Response: The "Model validation" section will be reworked to include background information, methods, validation data and validation results.

R2.30 Line 154-157: Please split this sentence. It is much too long. Line 155: I assume it is "Pearson correlation" rather than "Pearson cross-correlation" Line 156: "slope of the linear regression best-fit line". I would suggest to write the "best fit calculated by linear regression". Line 160: "The model well represents ... ", change to "The model represents ..... well." Line 162-163: I would suggest avoiding this type of reduced writing using brackets. You can form sentences like: While it is underestimating here, it is overestimating there.

Response: We will revise the manuscript in accordance with the reviewer's suggestions.

R2.31 Line 158-165: This is a less comprehensive validation study of the quality of hydrological predictions than I would have expected from a paper focusing on river-to-sea continuum modelling. Only 2 stations close to the Danube source point have been chosen. There is a straight river section running from the source point to the Danube river branching point at Ceatal Izmail where the model is validated. I can only assume that errors accumulate further down the river network. The validation exercise could be extended with a comparison of modelled discharge values using SHYFEM and modelled discharge values using hydrological model (E-Hype, SWAT,...). Maybe a literature study would also provide runoff data that could be used for comparison.

Response: We acknowledge the reviewer's concerns; however, the area of interest is poorly monitored. Limited spatial and temporal coverage of existing monitoring networks, along with restricted (freely) available data, are critical issues in the Danube Delta. To address this, we reached out to various authorities and research centers to gather data on bathymetry, river discharge, water level, temperature, and salinity for use in the development and validation of our model. We used all available datasets, and while we agree that validation could be further enhanced, we believe the results demonstrate the robustness of our model. We hope this modelling effort will encourage more effective data sharing among institutions and contribute to advancing research in this ecologically significant transitional environment.

R2.32 Line 162: Are the situations with underestimation at Chilia coinciding with situations of overestimation at Tulcea?

Response: Yes, we will mention it in the manuscript.

R2.33 Figure2: Fit2 (a): Is this the river runoff time series at Isaccea? Could this location be marked in Fig 1. What do the different colors of the symbols in Fig2 (b) and (c) represent? There are periods of systematic undeprediction (Constanta: July-September 2027). Could these be linked to meteorological conditions?

Response: Isaccea is indicated with name and arrow in Fig. 1a. The figure's caption will be improved by adding the following sentence "The black diamonds, the red circles and the red lines in panels b and c represent the scatter data, the 5 to 99th percentiles and the line of best fit, respectively."

The underestimation and overestimation during flood events in the two branches is likely attributable to the model's inability to correctly reproduce the river overflow into the sur-

rounding floodplains. We expect that meteorological conditions do not significantly affect the river flow in the upper delta.

R2.34 Line 168: As mentioned before, I doubt that the model quality with regards to predicting storm events can be validated using daily mean sea level data. It is not possible to do a peak error validation. At least hourly data (which is available, Line 136) should be used.

Response: See the response to comment R2.29.

R2.35 Line 169: It is mentioned here that storm events up to 10 days lead time can be predicted well. This would require a forecast validation (assessing the quality of the forecast according to lead time), which has not been presented. The validation exercise uses daily hindcast data sets.

Response: The numerical model is run in hindcast mode and no forecasts are presented in this study. We will correct the sentence to clarify that, in the study area, the sea level variations are primarily driven by open sea conditions and atmospheric disturbances with typical time scales of 1 to 10 days.

R2.36 Line 170-171: Could the validation results be presented in a table, maybe table 1.

Response: Following the reviewer's suggestion, the results of the statistical analysis of river discharge, sea level and sea temperature will be reported in a table (included in this document as Table 1).

Table 1: Statistical analysis of simulated river discharge, sea level, sea temperature and sea surface temperature.

Variable	**Station**	**N data**	**RMSE**	**BIAS**	**CC**	**SLOPE**
River discharge	Chilia	120	158	-46	1.00	0.90
(m^3 s^{-1}	Tulcea	120	158	43	1.00	1.10
Sea level	Constanta	624	6.5	-	0.66	0.70
(cm)	Mangalia	722	7.8	-	0.55	0.62
Sea Temperature	15360	972	1.7	0.2	0.98	1.08
(°C)	Constanta	966	1.6	-0.4	0.97	0.98
	Mangalia	908	1.5	-0.2	0.97	0.96
SST (°C)	Razelm Sinoie	135	1.0	0.3	0.97	0.99

R2.37 Line 172: You mention that sea level prediction errors originate from the reanalysis product that you use at the boundaries. You could validate the CMEMS reanalysis product at the two stations Mangalia andConstanta to demonstrate this. The CMEMS Black Sea MYP QUID unfortunately does not use tide-gauge data for validation.

Response: To better explore this dependence, we reported in Fig. 2 both the timeseries of the sea level simulated by our SHYFEM application and by the Black Sea Physics Reanalysis (hereinafter BLKSEA).

The figure clearly shows the strong dependency of the SHYFEM results on the imposed boundary conditions. However, the statistical analysis reported in Table 2 demonstrates that SHYFEM is performing slightly better than BLKSEA. This is due to the higher resolution of the SHYFEM model application at the coast, which allows to represent coastal dynamics better.

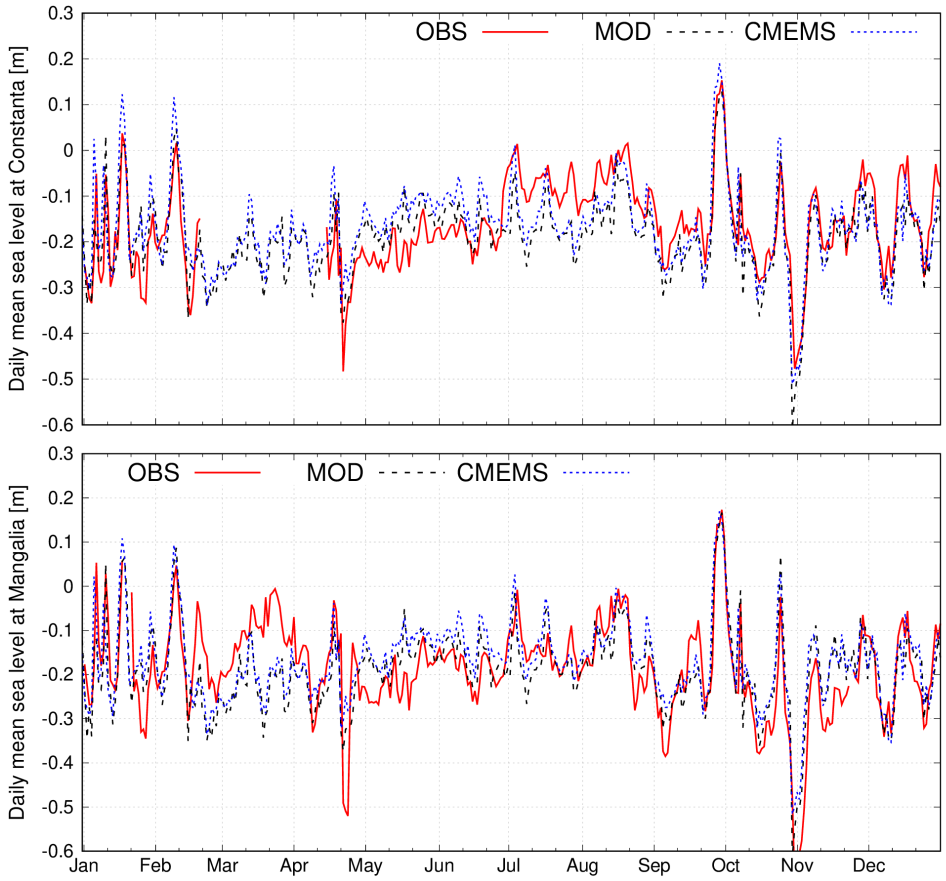

Figure 2: Observed (red line) and simulated (black dashed line) sea levels at Constanta (top panel) and Mangalia (bottom panel) for year 2017.

Table 2: Statistical analysis (in terms of centered RMSE, BIAS and R) of simulated sea temperature at the monitoring stations.

Station	**RMSE (cm)**		**CC**	
	SHYFEM	BLKSEA	SHYFEM	BLKSEA
Constanta	6.5	7.6	0.66	0.58
Mangalia	7.8	8.3	0.55	0.51

It is not our intention, unless specifically requested by the reviewer, to present in our manuscript a validation (either as timeseries in the figure or as statistical metrics in the text) of the Black Sea Physics Reanalysis.

R2.38 Line 178: "varies strongly" rather than "strongly varies.

Response: We will correct the sentence.

R2.39 Line 178: Could you write which year

Response: We will modify the sentence as "... that sea surface temperature in RSLS varies strongly over time with values ranging..."

R2.40 Line 178-183: Why did you use daily mean values for satellite SST validation? Aren't midnight values usually used to reduce the errors related to the impact of diurnal warming on the skin-to-bulk temperature conversion?

Response: Yes, they are midnight values. We will better describe the SST dataset in the "Model validation" section.

R2.41 Line 178-183: could you present the validation results in a figure, maybe even a spatial distribution of model errors.

Response: Due to the limited number of available values at each control point, we prefer to apply the statistical analysis to a dataset containing all samples. Moreover, spatially SST in the lagoons has a small spatial variability with difference among stations lower than 1.5 °C.

R2.42 After Line 183: The model validation chapter provides a lot of data, but only little analysis. Could you write a paragraph evaluating the model performance and in the light of your model application, i.e. the adequate representation of the river-to-sea continuum for detailed model studies of the Danube delta. I think this is needed.

Response: The following paragraph will be added at the end of the "Model validation" section: "Concluding, the validation analysis demonstrates that the SHYFEM model application correctly reproduces hydrodynamics in the different water compartments of the delta. The variable model resolution is of fundamental importance for reproducing the complex morphology of the Danube Delta realizing a seamless transition between different spatial scales, from river branches to the coastal sea. The validation of the model could be further improved with the availability of new observations in the future, particularly river discharge and salinity data. We hope this modelling effort will promote more effective data monitoring and support ongoing research in this ecologically significant transitional environment."

R2.43 Line 185: First 3 sentences: I think you should rewrite these sentences to make them more clear. I think you want to say that you can only use the model system to estimate the water discharge distribution among the "main" river branches.

Response: We will reformulate these sentences as "The Danube Delta River network comprises a highly complex system of hundreds of natural and artificial channels, streams, and lakes, whose morphological complexity exceeds the resolution capabilities of the numerical model. Consequently, the model was configured to represent only the most hydraulically significant watercourses, enabling the estimation of water discharge distribution among the principal river branches."

R2.44 Line 188: "estimate the relative load". I think you mean "relative runoff". The term load refers to substances carried with the river, liked pollutants.

Response: We will correct the mentioned sentences following the reviewer's suggestion.

R2.45 Figure 5 and text: Can you provide a number for the total runoff in the considered period 2015-2019. Then readers can calculate the absolute values of river runoff from the percentages presented in the figure.

Response: We will provide the value of the average the Danube River discharge imposed at the open boundary of Isaccea (6500 $m^3\ s^{-1}$)

R2.46 Line 194-203: Would it be possible to compare your river runoff data with literature values or values from hydrological models, to get a feeling for the quality of the prediction. This could be done in the validation section.

Response: See the response to comment R2.28.

R2.47 Line 209: Could you briefly introduce the variable ROFI.

Response: See the response to comment R2.6.

R2.48 Line 215: and following: Why do you use the unit g/L and not the more widespread unit psu?

Response: The numerical model is computing salinity as g/L. It can be converted to Practical Salinity Units (PSU) by understanding that 1 PSU is approximately equal to 1 gram of salt per kilogram of solution.

R2.49 Line 218: Is this the 15 th of Jun 2019?

Response: We will correct the text.

R2.50 Line 222: The currents in figure 6 are not very easy to see. Do you know what drives these coastal currents? Are they influenced by steeric effects? In other words, does the amount of discharged freshwater and its distribution affect the coastal currents.

Response: We increased the arrows' line width. Moreover, following Reviewer#1's suggestion, we added to Fig. 6 (here Fig. 3) the plots of salinity along transect N-S.

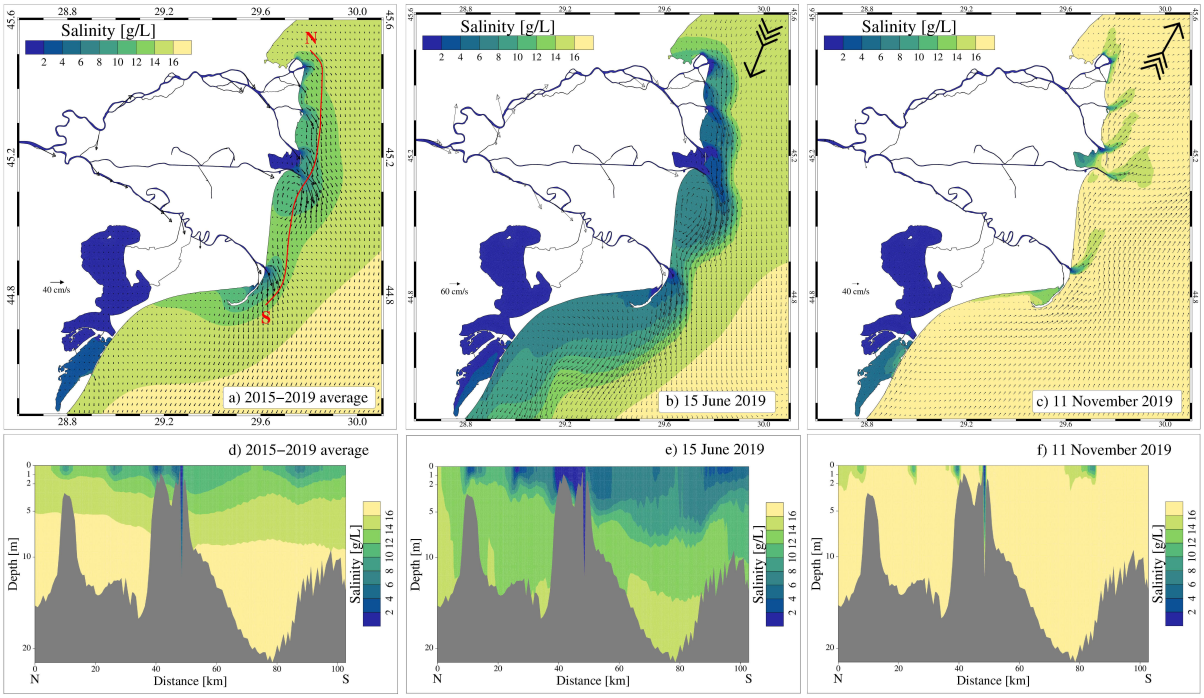

Figure 3: Surface salinity and current velocity maps, and N-S salinity transects: a) and d) average values over the 2015-2019 period; b) and e) instant values on 15 June 2019; c) and f) instant values on 11 November 2019. The arrows in the top right corner of panels b and c indicate the wind direction.

We will improve the description of the spatial and temporal variability of coastal dynamics.

R2.51 Line 222 and following: If you want to use standard unit for currents, then you should use m/s.

Response: We will correct the unit for currents to m s^{-1}.

R2.52 Line 226-236: What exactly is a seasonal standard deviation? Is it the standard deviation of the month of all years belonging to the season? Could you motivate, why you are

doing a seasonal analysis? You say that you are using a seasonal analysis to calculate the standard deviation, but that can not be the motivation for the analysis.

Response: To clarify the motivation and method of the season analysis, we will modify the mentioned sentence as "To analyse the temporal variability of the coastal dynamics, the model results were processed to computed the standard deviation (hereinafter STD) of the month of all years belonging to the four seasons (winter=DJF, spring=MAM, summer=JJA, fall=SON)."

R2.53 Line 233: "multiple mouth". I would use another term.

Response: We will modify the sentence as "The freshwater discharged by the different branches determine a similar coastal salinity pattern in winter (Fig. 7e) and fall (Fig. 7h)."

R2.54 Line 205-236: This is just an idea: To show the advantage of using SHYFEM for modelling the Danube delta and RSLS, a comparison of 2 simulations – one including and one excluding the Danube delta and RSLS domain could be presented. In the second type of simulations without Danube delta and RSLS domain, the freshwater discharge could be added to the coarse Black Sea grid. I think the simulation would show that the second type of simulations are less able to produce realistic river plumes and discharge patterns. This is the advantage of resolving the lagoons and estuaries using dynamical models.

Response: The additional simulation proposed by the reviewer would entail substantial effort and falls outside the scope of the present study. The Black Sea Physics Reanalysis (`https://doi.org/10.25423/CMCC/BLKSEA_MULTIYEAR_PHY_007_004`) serves as an example of a coarse-resolution model that is unable to realistically simulate river plumes and discharge patterns in front of the Danube Delta.

R2.55 Line 238-264: Can you provide a motivation for why you want to study River-Lagoon-Sea connectivity? The main purpose seems to be, to calculate the ratio of WFT and WRT. Later, however, only WRT is used for assessing the what-if scenarios.

Response: We agree with the reviewer that River-lagoon-sea connectivity was not an appropriate title for this section. We will change the title to Lagoons's water exchange and renewal.

R2.56 Line 238: What is a "choked water body". Can you please explain this term or use another one.

Response: According to (Kjerfve and Magill, 1989), coastal lagoons can conveniently be subdivided into choked, restricted, and leaky systems based on the degree of water exchange between lagoon and ocean. Since the classification of the RSLS is beyond the scope of the present study, we will remove the "chocked" term in the revised manuscript.

R2.57 Line 242-249: Could you rewrite this part and make the different contributions more clear? The following questions may help you. Of the 62 m3/s water discharge from the Dunavat and Dranov channel, are 42 m3/s discharged into the Black Sea? Should the sum of the inflow from the Black Sea (+16 m3/s), the outflow to the Black Sea (42 m3/s), the river/channel runoff (+62 m3/s) and the amount of water lost by evaporation (-20 m3/s) cancel out? When I add all the contributions, I get 16 m3/s, which is equal to the inflow from the Black Sea.

Response: We will rewrite this part to clarify the different contributions to the RSLS's water budget. The new text will read as "The RSLS has a water volume of about 1300 millions m^3 and receives 40 and 22 m^3 s^{-1} of freshwater from the Dunavăţ and Dranov

canals, respectively. This excess water entering the lagoons is primarily discharged into the Black Sea via the Edighiol and Periboina inlets, resulting in a average seaward flow of 58 m^3 s^{-1}. The average inflow of marine water into the RSLS amounts to 16 m^3 s^{-1}. Evaporation over the lagoon system overpasses precipitation resulting in a net loss of 20 m^3 s^{-1}. The lagoons receive a total water flux of 78 m^3 s^{-1} from the sea and the river. Therefore, the basin-wide water flushing time is 193 days."

R2.58 Line 266-272: Could you provide a few more words on the different proposals for reconnecting RSLS with the Black Sea? Could you motivate the choice of the proposals.

Response: A more detailed description of the different reconnecting solutions will be included in "Numerical experiments" section. See the response to comment R2.26.

R2.59 Line 266 and following: What is the time scale of the assessment? How long are the model simulations? Which years do they cover?

Response: The simulations for the what-if scenarios span the period 2014–2019 (year 2014 is considered the model spin-up time and not included in the analysis), consistent with the reference simulation. We will add a sentence to specify that the period, parametrization, forcing and boundary conditions considered in the what-if numerical experiments are the same adopted in the reference run.

R2.60 Table 2: It took me a minute to understand the table. I guess, I expected it also to cover the case of multiple openings: single opening, two openings together, three openings together. Maybe this could be explained somewhere.

Response: No multiple openings scenarios were simulated. The three what-if scenarios considered in this study consisted of opening one 1.5 m depth and 70 m wide channel to connect the either the Razelm Lagoon (solutions A and B in Fig. 1c) or the Sinoie Lagoon (solution C in Fig. 1c) with the Black Sea. The above sentence will be included in the manuscript to clarify the setting of the different scenarios.

R2.61 Line 277-297: It should be explained somewhere that changing the net-flow through the lagoon, changes also the sea level in the lagoon. This is visible in figure 13.

Response: This hydrodynamic feedback is reported in the discussion (lines 357-360): "Connecting the Razelm Lagoon with the Black Sea with solutions A and B do not only allow the inflow of marine waters but also changes the water level of the two basins (lines red and magenta in Fig. 13) decreasing the water exchange between the two lagoons and the outflow via the existing inlets (Table 2)."

R2.62 Line 283-288: I think it would be easier to analyse difference plots (figure 9).

Response: Following Reviewer#1's suggestion, we created a figure (included in this document as Fig. 4) presenting the results of the reference simulation as absolute values and of the reconnection scenarios as differences with respect to the reference run. In the revised version of the manuscript, we will discuss the presented findings in details.

R2.63 Figure 9: Here in the figure you use the salinity unit psu, whereas in the text you are using g/L.

Response: The figure will be corrected to ensure that g/L is used consistently throughout the manuscript.

R2.64 Line 299: I'm not sure that I understand the structure of the paper. After analyzing the time scales of water transport in the Danube delta system and introducing the what-if scenarios for water transport, now you take one step back and discuss the hydrographic

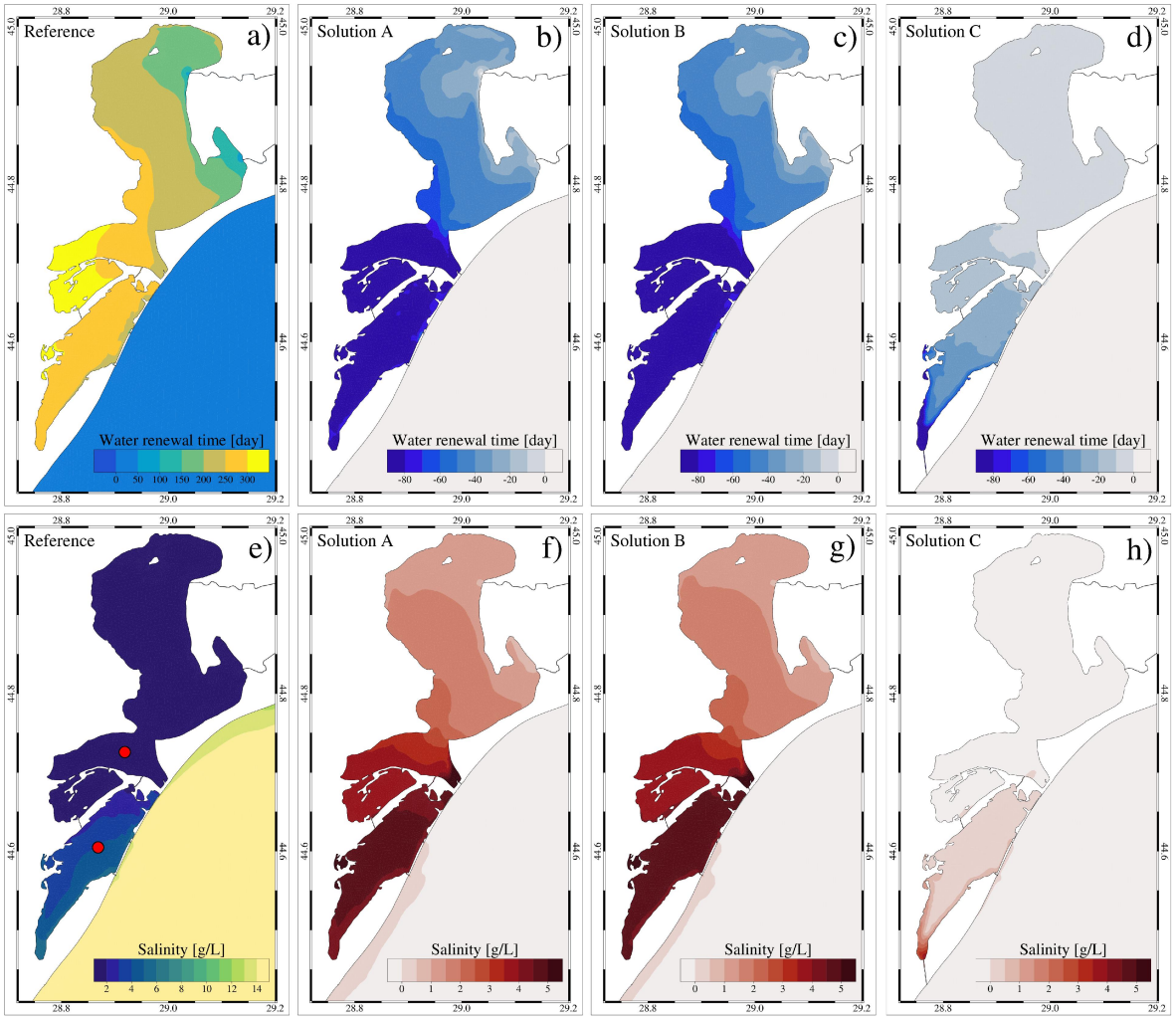

Figure 4: Average water renewal time and salinity over the Razelm Sinoie Lagoon System for the reference simulation (as absolute values) and the reconnection scenarios A, B and C (as difference with respect to the reference run). The red dots in panel *e* indicate the location of the two control points where the salinity timeseries were extracted (Fig. 10).

conditions predicted by your model. I would rather suggest move this part to the model study and validation exercise as it is related to the general dynamic in the area. You could focus on the what-if scenarios here.

You could also split the analysis into a Danube and the RSLS part. This way you could have one chapter dealing with the what-if scenarios.

This chapter presents many new results that properly analyzed could form even another paper. I would suggest to take a step back, to define a research question and to restructure the paper accordingly.

Response: All results will be presented in the "Results" section, while the interpretation of our findings within a broader context will be included in the "Discussion and Conclusions" section.

R2.65 Line 299: The first 2-3 sentences are very general. You could just say that you want to investigate the water exchange between the different parts of the Danube delta to study their impact on the local hydrographic conditions. I guess you want to discuss as part of the what-if scenario studies, but this is not clear her.

Response: The "Discussion" section will be restructured. See the response to comment R2.64.

R2.66 Figure 10: Could you please choose some different colors. I can not see the difference between A and B. Solution C is also rather difficult to see.

Response: Following the reviewer's suggestion, we changed the lines' colours in the mentioned figure (included in this document as Fig. 5).

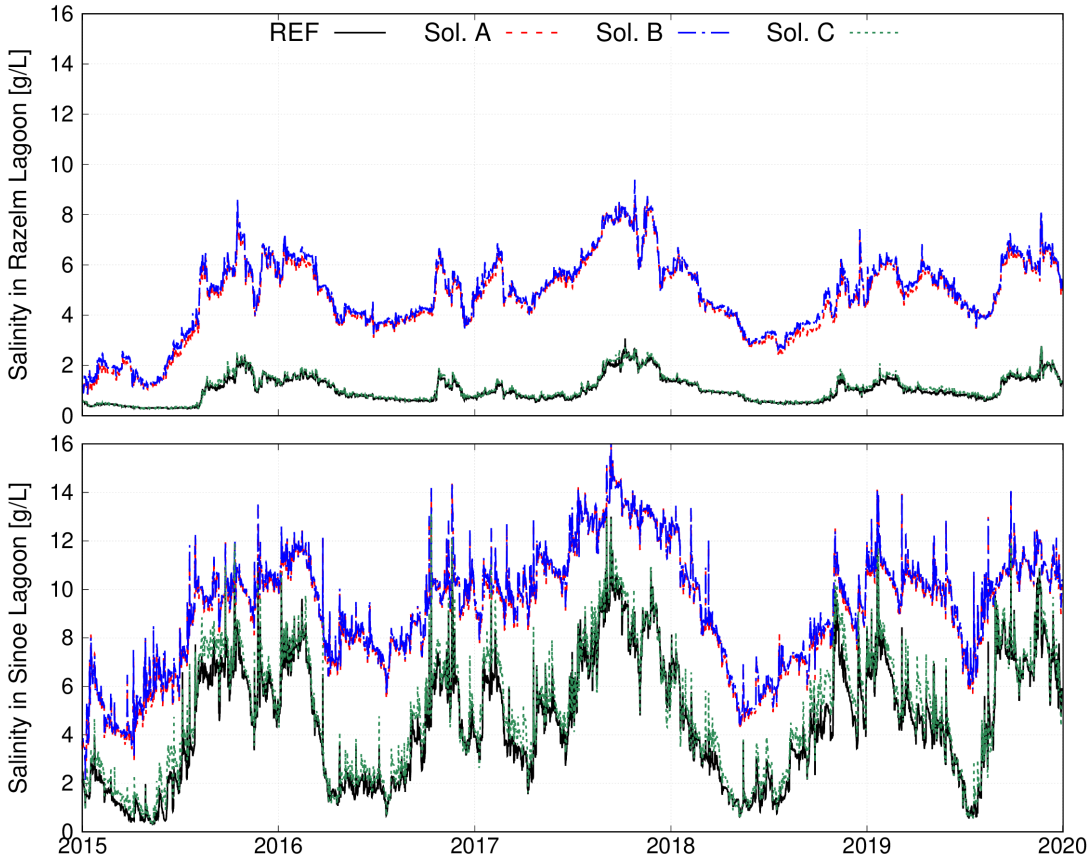

Figure 5: Timeseries of modelled salinity extracted in the control points in the Razelm (top panel) and Sinoie (bottom panel).

R2.67 Line 311: "Water bulges". I can only see the temperature distribution, not the sea level. Is this because of the limited transport capacity from the near-shore to the off-shore?

Response: We will use "patterns" instead of "water bulges".

R2.68 Line 313: I would suggest to avoid constructions like "warmer (colder)".

Response: We will remove them.

R2.69 Line 314: Upwelling is usually the result of water mass transport, not mixing.

Response: We will reformulate the sentence as "The vertical alongshore sea temperature transect presented in Figs. 6c and Figs. 6d indicate an upwelling-driven transport of marine waters from deeper layers to the coastal zone, enhancing mixing between open sea and riverine waters."

R2.70 Line 313-317 and figure 11: thanks for the nice plot, but I don't know exactly which point you want to make here. The upwelling event is likely wind driven and would

have happened with and without rivers. It is of course clear that the horizontal surface temperature distribution would look different without the implementation of the rivers. But I'm not sure that this is what you want to say, that running a model with an extended Danube estuary results in a better representation of the river plumes.

Response: Figure 11 illustrates distinctive coastal circulation patterns that emerge off the delta during southerly wind conditions. The interaction between wind-driven coastal upwelling and river outflow gives rise to small-scale nearshore features, situated between river mouths, which exhibit thermo-haline properties distinct from those of the surrounding waters. The model's variable resolution is crucial for capturing the seamless transition from river branches to the coastal sea, enabling the accurate reproduction of such complex coastal dynamics.

These results will be moved to the "Results" section.

R2.71 Line 318-329: further studies could investigate if the salt water intrusions happen gradually with time or if they are related to certain meteorological conditions and events.

Response: We will remove the section describing saltwater intrusion since it does not add significant advancements for this specific study area.

R2.72 Line 323-324: The locations of maximum salt water intrusion could be shown on the map.

Response: See the response to comment R2.73.

R2.73 Line 330: Here you present the part related to the what-if scenario. This could be combined with the assessment in chapter 3.4.

Response: Following the reviewer's suggestion, we will move the part related to the what-if scenario to section 3.5.

R2.74 Line 331: Can you rewrite the sentence starting with "Due to the input ...". Results should not be put in brackets. Time periods should be put to the end of the sentence.

Response: We will rewrite the sentence as "The freshwater inflow from the Dunavăţ and Dranov canals creates a persistent water level gradient from Razelm Lagoon to Sinoie Lagoon and the adjacent coastal sea (green line in Fig. 10)."

R2.75 Line 333: The flow is not necessarily barotropic because of a sea level gradient. You can still have a stratified flow. But your model results should show if at least a seasonal halo-or thermocline in the RSLS exist.

Response: We thank the reviewer for highlighting this point. We will clarify that due to the wind energy and relatively shallow water (the average depth is 1.8 m), the water masses are generally vertically well mixed.

R2.76 Line 338: I assume that meteorological conventions are used and the winds are from north-easterly directions.

Response: We will correct the sentence as "... by the dominant winds from north-easterly direction".

R2.77 Figure 13: The results in this figure could be analyzed for the different what-if scenarios. The differences in sea level could be related to the differences in water transport (table 2, chapter 3.5).

Response: We will move these results to section 3.5 and discuss them in relation to the water fluxes presented in Table 2.

R2.78 Line 349: There could be an easier formulation for the sentence starting with: "The inflow of marine waters."

Response: We will modify the sentence as "Marine waters flow into the lagoon when there is a positive water level gradient from the sea to the lagoon."

R2.79 Figure 14: It should be made clear that this figure is using results from the reference simulation.

Response: We will indicate in the figure's caption that the results are from the reference simulation.

R2.80 Line 348-363: The discussion here is rather qualitative. Only time series results from the reference simulation are presented. The different what-if scenarios are only discussed in general terms. I would suggest to extend the analysis and to present quantitative results for the different what-if scenarios. Otherwise, the analysis remains a bit unsatisfying. As mentioned before, this study could be combined with chapter 3.5.

Response: Following the reviewer's suggestion, we will improve the analysis and combine the part related to the what-if scenario with section 3.5.

R2.81 Chapter 5: Concluding remarks and perspectives. The concluding remarks focus on the comprehensive modelling tools that have been developed, but they leave the results of the modelling study out. As mentioned before, I would restructure the paper, defining a research question and a story line. The conclusions should summarize the key findings.

Response: We will restructure the manuscript following the reviewer's suggestions. All results will be presented in the "Results" section, while the interpretation of our findings within a broader context will be included in the "Discussion and Conclusions" section.

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