Review of the paper Modelling river-sea continuum: the case of the Danube Delta, by Christian Ferrarin, Debora Bellafiore , Alejandro Paladio Hernandez, Irina Dinu and Adrian Stanica.

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.

General points:

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.

Comments: Below, I list some ideas for the two paper ideas mentioned above. Of course, this is all hypothetical and intended only for providing some ideas.

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.

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.

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 the

paper 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.

In the following, I go through the paper from start to end and provide some more detailed comments. I will always provide the line number for reference.

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.

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

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

Chapter 1. Introduction

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

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

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

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.

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.

Chapter 1.1 The Danube Delta

Line 44: Please rewrite the sentence starting with "The Romanian part …"

Line 46: "extends on about", use "extends for about"

Line 50: correct: "connect Razelm lagoon with the …"

Line 51: "were finalized … " not "ended up"

Line 51: "As a result, more fresh water is discharged into the lagoon system"

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

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.

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.

Line 65: What does “lower part” mean? Please re-write: “… average water discharge of [so much], with values ranging from …”

Chapter 2. Methods

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.

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.

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

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

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.

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?

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

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.

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.

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.

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?

Chapter 3. Results

Chapter 3.1 Model Validation

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.

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.

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.

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

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?

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.

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.

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

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 and

Constanta to demonstrate this. The CMEMS Black Sea MYP QUID unfortunately does not use tide-gauge data for validation.

Line 178: “varies strongly” rather than “strongly varies”

Line 178: Could you write which year

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?

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

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.

Chapter 3.2 Water division in the river network of the delta:

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.

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

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.

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.

Chapter 3.3 Spatial and temporal variability of coastal dynamic

Line 206: “river plumes”

Line 209: Could you briefly introduce the variable ROFI.

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

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

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.

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

Line 226: “seasonal analysis”

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.

Line 233: “multiple mouth”. I would use another term.

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.

Chapter 3.4 River-Lagoon-sea connectivity

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.

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

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.

Chapter 3.5 Assessment of lagoon-sea reconnection solutions

Line 268: “connections remain open”

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.

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

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.

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.

Line 278: “enhanced inflow into the lagoon” and “reduced outflow out of the lagoon”

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

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

Chapter 4. Discussion

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 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.

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.

Line 305: Please rewrite " .. flows into the Black sea via different mouths, having different dimension and discharge"

Line 309: "A deeper analysis … " This sentence sounds more like conclusions than discussions.

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.

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?

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

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

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.

Figure 12:

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.

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

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

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

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.

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

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)

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

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

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.

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.