Changes not directly related to the referees comments:

1. We changed the scenario names to make them more self-explanatory:

Old scenario name	New scenario name
ref	*ref*
slr55t0	*slr55*
slr55t55	*slr55tf55a*
slr55t55e	*slr55tf55b*
slr110t0	*slr110*
slr110t55	*slr110tf55a*
slr110t110	*slr110tf110a*
slr110t55e	*slr110tf55b*
slr110t110e	*slr110tf110b*

5   The letters 'a' and 'b' correspond to scenarios A and B described in the paper. 'tf' stands for tidal flats.

2. We added the following sentence in the method chapter:

    "Further details about the method of the applied tidal analysis can be found in Lang (2003) and BAW (2017)."

10

3. The manuscript was sent to a language editing service upon the advice of referee#1. The revised manuscript now includes many linguistic adjustments suggested by the language editing service.

15

Response to referee#1

Referee comment:
20   In the presented study, the authors applied a hydronumerical model of the Elbe Estuary in order to investigate future regional changes in tidal range in response to a combination of SLR and morphological changes in intertidal areas. For this purpose, two scenarios of SLR and different scenarios for the growth of intertidal flats were used. As shown by the authors projections, future tidal range in the Elbe Estuary will strongly depend on where and by which
25   amount the intertidal flats will grow. As also highlighted, the observed evolution of tidal range is governed by changes in geometrical features of the estuary (convergence length, hydraulic depth, and relative intertidal area).

Generally, the manuscript is written in a comprehensible manner and the results are well-visualized. My main issue with the manuscript is that the impact of the study should be high-
30   lighted in more detail. What is the main motivation of the study? Why exactly are the results relevant/impactful? This aspect is only very briefly addressed in the current version of the manuscript. A detailed list of my comments is listed below:

Response:

Dear Referee,

thank you very much for taking the time to review our manuscript. We appreciate the effort you put into reading our preprint and providing constructive comments. Your feedback and suggestions are very valuable to us to improve the quality of our manuscript and our research. We are taking your comments seriously and will address each one of them comprehensively in our revised manuscript. We will especially try to emphasize the motivation and impact of our study and results. In the following we will address each of your comment with a response and our action. If you have any additional insights or suggestions that you believe would further improve our research, please do not hesitate to share them with us. We look forward to sharing our revised manuscript with you soon.

Greetings from Hamburg

Referee comment:

1. There are a couple of issues with the language of the manuscript, e.g., the use (or lack thereof) of definite/indefinite articles, wrong prepositions, wrong punctuation etc. In order to improve the quality of the language, please give the manuscript to a native speaker or send it to a language editing service.

Response: Thank you for your feedback regarding the language of our manuscript. We sent the manuscript to a language editing service and included all linguistic corrections into the manuscript before resubmitting.

Action: The manuscript was sent to a language editing service and linguistically revised.

Referee comment:

2. *LL13-15: "The results show an increase of tidal range in the Elbe estuary due to SLR and further reveal, that tidal flat growth can have no effect, decrease or increase the tidal range relative to sole SLR."*

   The way this is written, this almost sounds like a non-result. Please describe in more detail in the abstract, which of your investigated scenarios leads to which results.

Response: Thank you for your comment, possibly the last part of the sentence addresses your concern. The full sentence in the abstract was the following:
LL13-15 (old version): "The results show an increase of tidal range in the Elbe estuary due to SLR and further reveal, that tidal flat growth can have no effect, decrease or increase the tidal range relative to sole SLR, depending on the location and amount of tidal flat elevation."
As it seems to be written in a confusing way and less specific, we rewrote it.

Action: We changed the sentence to:
LL13-16 (new version): "The analysis results show increasing tidal range in the Elbe estuary solely due to SLR. They also reveal strongly varying changes with different tidal flat growth scenarios: while tidal flat elevation up to the mouth of the estuary can cause tidal range to

2

75 *decrease, tidal flat elevation in the entire estuary can lead to an increase in tidal range relative to SLR alone."*

Referee comment:

3. *LL30-32: "However, facing the future acceleration of SLR, is difficult to quantify the amount to which tidal flat growth can keep pace with sea level rise, and it remains questionable, whether present hydromorphodynamic equilibrium will be maintained in the future."*

Please give a reference for the future acceleration of SLR.

Action: We added the following reference:
85 *LL31 (new version): "However, in view of the future acceleration of SLR (Fox-Kemper et al., 2021),[...]."*

Referee comment:

4. *LL48-49: "The Elbe estuary is the part of the Elbe river extending from the weir in Geesthacht to the North Sea (Figure 5)."*

90

Normally, the figure that is referenced first in your manuscript should be Figure 1. In my opinion, a map of the study area also makes sense as Figure 1.

Response: Thank you for this comment, Figure 1 shows the two model domains and therefore includes the Elbe estuary. We don't want to add another map of the Estuary, as we want to
95 keep the manuscript as short as possible. To refer to Figure 1 first, we changed the previous sentence.

Action: We changed the previous sentence to:
LL48-50 (new version): One of the main estuaries in the German Bight is the Elbe estuary (Figure 1), which contains the port of Hamburg and is therefore an important shipping route.
100 *The Elbe estuary is the part of the Elbe river that extends from the weir in Geesthacht to the North Sea (Figure 5)."*

Referee comment:

5. *LL56-57: "Nowadays the Elbe estuary is an amplified estuary, where the tidal amplitude increases in upstream direction and reaches its maximum close to the port of Hamburg."*
105

Is "amplified estuary" a commonly used term? At least I haven't stumbled upon this before. What you describe sounds like a "hypersynchronous estuary" to me (see Nichols and Biggs, 1985).

Response: Thank you for your input. The term "amplified estuary" is used e.g. by Savenije
110 (2012) and by van Rijn (2011). To me the term "amplified estuary" is more self-explanatory and comprehensible. I therefore would prefer to use it instead of "hypersynchronous estuary".

Action: We would like to keep using the term "amplified estuary".

Referee comment:

6. *LL60-61: "The future of the Elbe estuary depends not only on anthropogenic measures implemented on site, but also in particular on sea level rise and its implications."*

Previously, you have already used the abbreviation SLR for sea level rise. Please use the abbreviation after defining it.

Action: We changed sea level rise to SLR in the entire manuscript.

Referee comment:

7. *LL64-66: "Understanding the future evolution of tidal dynamics due to sea level rise in heavily utilised estuaries such as the Elbe estuary is important for the development of adaptation measures, e.g. in navigation, port infrastructure and water management."*

As far as I understand, this is the main motivation of your study. Accordingly, you should dedicate more than one sentence to this. Please explain in more detail, what impacts might be expected in estuaries in response to SLR. And what processes might be triggered by an amplification of tidal range (e.g., see Winterwerp and Zhang, 2013)? And please also describe in more detail, what this will mean for the future management of the estuary. It might also be useful to briefly address the recent deepening of the Elbe in order to showcase the perspective of different stakeholders on the estuary and how they might be impacted by further developments in the future.

Response: Thank you for the feedback. There are other sentences about the importance of tidal range in estuaries, which is part of the motivation of the study (e.g. LL90-95 old version). However, we agree, that the motivation of the study should be discussed in more detail. We therefore added a paragraph about the relevance of an amplification of tidal range and other possible *SLR* responses, which will give an idea of how many different stakeholders could be affected.

Action: We added the part LL62-79 (new version) about possible future SLR induced changes (especially in tidal range) in estuaries and their relevance. We slightly changed previous paragraph LL91-95 (old version) to LL107-112 (new version).

Referee comment:

8. *LL136-137: "Sea level rise is added at the open boundary of the German Bight Model."*

Why haven't you added the sea level rise at the boundary of the Dutch continental shelf model? Isn't the boundary of your German Bight model in areas, where tidal constituents will already be significantly impacted by SLR? Please discuss the effect of your assumption/simplification.

Response: Thank you for your comment. As we add *SLR* at the open boundary of the German Bight model, *SLR* induced changes at the model boundary are neglected in our study. Previous research by Jordan et al. (2021) shows large-scale changes of the M2 amplitude in the North Sea due to *SLR*. Referring the results of Jordan et al. (2021) to our model boundary, we

neglect changes of the M2 amplitude in the range of less than ±2 cm. Ideally *SLR* could be added at the boundary of the shelf model to consider changes in tidal dynamics in the continental shelf seaward of the German Bight Model boundary. However, this approach is not suitable in our case, since the resolution of the *DCSMv6FM* is insufficient for estimating *SLR*

160   induced changes (Rasquin et al., 2020). In our opinion, further research is needed regarding the required resolution of a hydrodynamic numerical model when simulating the effect of *SLR* in the North Sea. Such a study would require several models with increasingly higher resolution, to determine a resolution condition after which *SLR* induced changes remain approximately the same. Furthermore, the aim of our study is to understand effects of *SLR* and tidal

165   flat elevation on tidal dynamics in the Elbe estuary. Our results might show an incomplete picture of future changes due to *SLR*, as we neglect large scale changes arising in the North Sea. However, this deficiency can also be an advantage as helps to understand the distinct regional changes and therefore improve a system understanding.

170   **Action:** We included the following sentences in lines *LL160-163 (new version)* to explain why we added SLR at the German Bight model boundary:

"SLR is added at the open boundary of the German Bight Model, therefore SLR-induced changes in tidal dynamics seaward of the German Bight are neglected. Ideally, SLR would be added at the boundary of the shelf model to consider changes in tidal dynamics in the conti-

175   *nental shelf seaward of the German Bight Model boundary. However, this approach is not suitable in our case, since the resolution of the DCSMv6FM is insufficient for estimating SLR induced changes (Rasquin et al., 2020)."*

Action: We also added the following sentences (LL574-578 new version) in the discussion to

180   discuss the effect of our simplification:

"In our study, SLR-induced changes in tidal dynamics seaward of the German Bight model are neglected. Previous research by Jordan et al. (2021) shows large-scale changes in M2 amplitude in the North Sea due to SLR. Relating the results of Jordan et al. (2021) to our model boundary, we neglect changes of the M2 amplitude that are less than ±2 cm. We as-

185   *sume that this has no bearing on the key results of our study, which aims to improve system understanding of the changes in the Elbe estuary induced by SLR and tidal flat growth."*

9. *Figure 1.*

190

Please use a different colourbar for the left panel. When showing the European Continental Shelf with water depths of several thousand meters, it doesn't make sense to limit your colourbar to 37.5 m. Furthermore, when using different panels, they should be labelled by using (a), (b), (c), etc. This also applies to most of your other figures.

195   **Response:** You are right. We gladly implemented your suggestion.

Action: We added panel labels and replaced the figure of the DCSMv6FM Model with a figure with better colourbar.

Referee comment:

10. *Figure 2.*

Why are only three days shown here? Why isn't a whole spring-neap cycle shown? Is the performance of the model better/worse during different phases of the spring-neap cycle? Even though you mention that the validation of the model is presented in another paper, it also wouldn't hurt to briefly describe the model quality here in terms of selected parameters (e.g., what is the mean RMSE across all tide gauges in the model domain).

Response: We decided to show only three days, because the differences in the shape of the curves would not be clearly visible otherwise. However, as you mentioned, it could be of interest to see an entire spring-neap-cycle and possible variations in the performance. Therefore, we added two figures of an entire spring-neap cycle in the appendix. We also added information about the mean RMSE, BIAS and a skill-score after Willmott et al. (1985) of 39 tide gauges in the model domain.

Actions:
Figures of an entire spring-neap cycle are added to the appendix.

We added the following sentence:
LL174-176 (new version):"A similar display for an entire spring–neap cycle can be found in the appendix. It shows that there are no distinctive differences in performance during the different phases of the illustrated spring–neap cycle."

We added the following sentence:
LL169-171 (new version):"A comparison of water levels between model results and observations at 39 gauges in the model domain for this period reveals a mean RMSE of 16.4 cm, a mean bias of 7.3 cm and a mean skill score after Willmott et al. (1985) of 0.993."

Referee comment:

11. *Figure 3.*

Apparently, the dashed-lines indicate certain cross-sections along the estuary that are shown in Figure 5. This should be explained. For readers not being too familiar with the Elbe Estuary, it could also help to use labels that highlight the location of the different sections along the river (e.g., "outer section", "mouth section", etc.).

Response: I am not sure, if I understand your comment correctly. I think such labels are already displayed in most of the figures. However, they are not yet displayed in Figure 3, as the subdivision into sections is explained afterwards in 2.3.1: "*[...]. Furthermore, the estuary is roughly divided into five sections, which are displayed in Figure 5 and named (from west to east): outer section, mouth section, lower section, Hamburg section and upper section.*" In accordance to your comment we added such labels in Figure 3 too.

Action: Labels for the subsections are added in Figure 3.

Referee comment:

Response: Thank you for your comment. We have chosen not to visualise and describe the scenarios of *SLR* 55 cm in detail, as that would have strongly expanded the length of the manuscript. However, we wanted to determine, if the changes due to *SLR* are in principle similar for a different *SLR* scenario. Therefore, we show a comparison of the change of max. *TR* relative to reference condition for the two *SLR* scenarios in Table 2. The focus of this study lies on the interrelation between *SLR*, changes in estuarine geometry and changes in tidal dynamics. As we write in the discussion: *"[…]TR shows qualitatively similar changes in the scenarios with SLR of 55 cm, those are assumingly induced by similar alterations in estuarine geometry as for a SLR of 110 cm."* We are planning to further examine the different changes due to varying *SLR* scenarios in future studies. To address your comment, we added some more sentences regarding the scenarios with a *SLR* of 55 cm in the results part.

Action: We edited the following parts in the results chapter:

LL355-358 (new version):"We focus on the results of the scenarios with 110 cm SLR to gain a better system understanding. The results of the scenarios with SLR of 55 cm are not shown here in detail, but are included to determine whether the changes due to SLR are in principle similar for a different SLR scenario."

LL371-377 (new version):"Table 2 lists the changes in maximum TR relative to the reference condition (maximum TR = 3.87 m) for all simulated scenarios with SLR 110 cm as well as SLR 55 cm. Maximum TR increases by 6.5 cm for an SLR of 55 cm and by 12.5 cm for an SLR of 110 cm, which is about 11–12 % of the respective SLR. Both SLR scenarios with 100 % tidal flat elevation in Scenario A (slr55tf55a and slr110tf110a) show an increase in maximum TR that is less than with SLR alone. In both SLR scenarios with 100 % tidal flat elevation in Scenario B (slr55tf55b and slr110tf110b) the increase in maximum TR is greater than in the scenarios without tidal flat elevation."

Action: We added the following sentences in the discussion chapter*:*

LL583-587(new version):"We selected the SLR scenario of 110 cm with corresponding hypothetical tidal flat elevation scenarios which we analysed in detail. For scenarios with 55 cm SLR we found qualitatively similar changes in maximum TR and therefore assume similar alterations in estuarine geometry. However, to ensure that our results are in principle

applicable to other scenarios than an SLR of 110 cm, it would be necessary to simulate a
280 *range of several SLR scenarios with their corresponding tidal flat growth scenarios and ana-*
lyse the changes in tidal dynamics and estuarine geometry for each of them."

Referee comment:

13. *Figure 8.*
285

I first had to take a closer look at Figure 5 to understand why there are so few markers in
the "Hamburg section". In my opinion, it would help to explain that the whole city of
Hamburg is considered as one control volume (thus being relatively large in comparison
to neighbouring control volumes).

290 **Response:** For more clarity we added a sentence to explain the large control volume contain-
ing the two branches of the Elbe estuary in the region of Hamburg.

Action: the following sentence is added in section 2.3.1:
*LL227-229 (new version): "As the Elbe estuary splits into two branches, which reunite close
to the port of Hamburg and enclose the island of Wilhelmsburg, this region is contained in*
295 *one relatively large control volume compared to the other control volumes."*

Referee comment:

14. *L367: "To access the rate at which cross-sectional-flow-area of an estuary decreases in*
upstream direction, the geometric parameter convergence length (L_a) is calculated by fit-
ting an exponential function (Eq. (2)) to the data sets (see 2.3.3)."
300

Do you really mean "to access" or should it be "to assess"?

Response: Thank you for the note. We mean "to assess" not "to access". We corrected the
term in L367 (old version) as well as in L99 (old version). We also sent the manuscript to a
language editing service and implemented their corrections.

305 **Action:** We replaced "access" by "assess" in L367 (old version) and L99 (old version) ac-
cordingly.

Referee comment:

15. *Table 3.*

310 I don't quite understand, why you compare scenario "slr110t0" to your reference scenario
and all other scenarios to "slr110t0"? Why not comparing all scenarios to the reference
scenario? Otherwise one might ask, why you don't show all the possible scenario combi-
nations (e.g., "slr110t110e" to "slr110t55e", etc.)? Due to the presented changes in A_0 and
L_a, it should still be possible to see that the differences between certain scenarios are neg-
315 ligible (e.g., "slr110t110e" to "slr110t0").

Response: Thank you for your comment. Initially we decided not to show all comparisons of
all possible combinations of scenarios to keep the manuscript short and clear. In the discus-
sion part (4.4) we try to answer the following three questions:

1. Why does sole SLR without topographic changes causes tidal range to increase in the Elbe
320 estuary?
2. Why does SLR with tidal flat elevation in the mouth of the estuary causes no changes or a
decrease in tidal range compared to sole SLR?
3. Why does SLR with tidal flat elevation in the entire estuary increases tidal range compared
to sole SLR?
325 As these are the main questions we want to answer, we choose the combinations accordingly
in the analysis of the differences in convergence length. However, after thinking about your
and the other referee's comment, we decided to additionally show the combination of all sce-
narios to reference condition.

Action:

330 -We changed the sentence (LL401-402 new version) before Table 4 (previous Table 3) in the
following way:
*"The results of the weighted multiple non-linear least square regression for all scenarios
compared to the reference condition and to slr110 are displayed in Table ."*
-We extended Table 3 by adding the combination of all scenarios to reference condition.
335 **-**We made changes in the paragraph after Table 4 (LL408-418 new version) and included the
additional scenarios.

Referee comment:

16. *Figures 9 & 10.*

340   It is not described, what the different lines represent. I presume it is the mean of all con-
trol volumes in a section, right?

Response: Thank you for your comment. Yes, the markers represent the value of each control
volume, while the lines represent the mean values of the sections.

345 **Action:** We changed the description of figure 9 and 10 in the following way:

*Figure 9: Relative change in mean hydraulic depth (ht a) and hc b)) in each control volume
(**markers**) and each section (**lines**) relative to reference condition for scenarios slr110 (dark
blue rhombuses), slr110tf110a (light blue squares), slr110tf110b (green triangles). (The re-
sults of scenarios slr110tf55a and slr110tf55b are not shown in the figure for better readabil-
350 ity.)*

Referee comment:

17. *Figures 11 & 12.*

       You use different types of lines and colours in these figures, which are not explained. In
355   Figure 12, it also isn't mentioned, what S_{INT}' and MW' stand for.

Response: You are right, and we therefore added a better Figure description; however, S_{INT}
and MW have already been defined in section 2.3.

Action: We changed the figure description in the following way:
Figure 11: Schematic of SLR in an estuary cross-sections (a) with large (1) and small (2)

SINT and schematic plan view of an estuary (b). The black lines in the cross-sections show the MW for a reference scenario (dark blue) and two SLR scenarios (light blue and light green).

Figure 12: Schematic of SLR in estuary cross-sections and the resulting changes in the inter-tidal area (SINT) for different topographic gradients between high water (HW) and low water (LW). The left side of the figure shows a low gradient; the right side shows a higher gradient. The black lines correspond to MW for the reference condition (dark blue) and SLR (light blue). All parameters with an apostrophe belong to the scenario with SLR. The dashed grey lines show HW and LW for both scenarios; the coloured dotted lines show SHW and SLW.

References

Fox-Kemper, B., Hewitt, H. T., Xiao, C., Aðalgeirsdóttir, G., Drijfhout, S. S., Edwards, T. L., Golledge, N. R., Hemer, M., Kopp, R. E., Krinner, G., Mix, A., Notz, D., Nowicki, S., Nurhati, I. S., Ruiz, L., Sallée, J.-B., Slangen, A., and Yu, Y.: Ocean, Cryosphere and Sea Level Change., In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 6, S.1211-1362, doi:10.1017/9781009157896.011., 2021.

HTG: Empfehlungen des Arbeitsausschusses "Ufereinfassungen" Häfen und Wasserstraßen EAU 2020: (inkl. E-Book als PDF), 12. Auflage, Ernst Wilhelm & Sohn, Berlin, 700 pp., 2020.

Jordan, C., Visscher, J., and Schlurmann, T.: Projected Responses of Tidal Dynamics in the North Sea to Sea-Level Rise and Morphological Changes in the Wadden Sea, Front. Mar. Sci., 8, 40171, doi:10.3389/fmars.2021.685758, 2021.

Khojasteh, D., Glamore, W., Heimhuber, V., and Felder, S.: Sea level rise impacts on estuarine dynamics: A review, The Science of the total environment, 780, 146470, doi:10.1016/j.scitotenv.2021.146470, 2021.

Savenije, H. H. G.: Salinity and Tides in Alluvial Estuaries: Second Completely Revised Edition, 2.6th ed., 2012.

van Rijn, L. C.: Principles of fluid flow and surface waves in rivers, estuaries, seas, and oceans, Edition 2011, Aqua Publications, Amsterdam, 2011.

Willmott, C. J., Ackleson, S. G., Davis, R. E., Feddema, J. J., Klink, K. M., Legates, D. R., O'Donnell, J., and Rowe, C. M.: Statistics for the evaluation and comparison of models, J. Geophys. Res., 90, 8995, doi:10.1029/JC090iC05p08995, 1985.

Winterwerp, J. C. and Wang, Z. B.: Man-induced regime shifts in small estuaries—I: theory, Ocean Dynamics, 63, 1279–1292, doi:10.1007/s10236-013-0662-9, 2013.

Response to referee#2

405   **Referee comment:**
Dear authors,

First of all, congratulations on the manuscript and research. It was a very interesting read, and it is for sure a very welcome contribution to the estuarine and climate research. The authors use a comprehensive hydrodynamic model to evaluate how different tidal flat increase pat-
410   terns would impact changes in the tidal range under different SLR scenarios. The research suggests that different patterns of increase on both spatial distribution and vertical increase lead to very distinct patterns in tidal range along the estuary.

I consider it a very solid research design, with very interesting results. However, the manu-
script needs a bit more work on the textual side and the discussion area to have a proper im-
415   pact and be acceptable for further publication.

Please, find below my suggestions. I hope it helps the authors improve an already interesting and promising manuscript.

Response:
Dear Referee,
420

thank you very much for your kind and encouraging words. We appreciate the time and effort you put into reading our preprint and providing constructive comments. Your feedback and suggestions are very valuable to us for improving the quality of our manuscript and our re-
search. We will comprehensively incorporate all of your feedback in our revised manuscript.
425   In the following we address each of your comment with a response and/or our action. If you have any additional insights or suggestions that you believe would further improve our re-
search, please do not hesitate to share them with us. We look forward to sharing our revised manuscript with you soon.

430   Greetings from Hamburg

Referee comment:
Line 20-21: Add citation(s) to support the sentence. Also, might be worth adding some exam-
ples of how SLR would affect tidal dynamics (you can just use the e.g. format and add short examples).

435   **Action:** We added examples and citations in the following way:
*LL20-22(new version):"Future global mean sea level rise (SLR) as it is projected for this cen-
tury (Fox-Kemper et al., 2021), will not only raise water levels in the German Bight, but will also affect, for example, tidal dynamics (e.g. tidal amplitude and tidal asymmetry) in several ways (Jordan et al., 2021; Wachler et al., 2020)."*

440   **Referee comment:**
Line 23-25: Add citation.

Action: We added the following citation:
LL24-25 (new version):"The Wadden Sea is a geologically and ecologically unique region, which is structured into several tidal basins with barrier islands, tidal channels and intertidal
445   *areas (Kloepper et al., 2017)."*

Referee comment:
Line 30: "…SLR, it is…"

Action: We changed the sentence as suggested.

Referee comment:
450 Line 35: "..other factors (e.g. vertical…)"

Action: We changed the sentence as suggested.

Referee comment:
Line 39: Remove "In any case", as it makes what is said before is redundant. Also, add a space before.

455 **Action:** We changed the sentence as suggested.

Referee comment:
Line 78-79: Remove the parenthesis from the citation.

Action: We changed the sentence as suggested.

Referee comment:
460 Line 79: "Rasquin et al. (2020) found that insufficient bathymetric resolution may lead to overestimation of the tidal amplitude increase in the German Bight."

Action: We changed the sentence as suggested.

Referee comment:
Line 90 – 100: There are two aims written down. Choose one and properly narrow the prob-
465 lem definition towards it. Consequently, change or adapt throughout the text (e.g. first line of the conclusion).
Lines 98-104: These lines are kind of doubled in the methods. Remove bits that do not add to the problem setting that is the main focus of the introduction.

Response: Thank you for your comments. As you pointed out, there are two research ques-
470 tion addressed in our study: To analyse the influence of SLR and tidal flat growth scenarios on tidal range in the Elbe estuary and to explain these changes with changes in estuarine ge-ometry. However, the general aim is to gain a better understanding of the possible effects of potential SLR and tidal flat growth scenarios in the Elbe estuary. We rewrote this part and re-duced the sentences which are addressing the methods.

475 **Action:** We rewrote the part LL102-116 (new version) to describe the aim in a clearer way and we removed lines, which are doubled in the methods.

Referee comment:
Line 120: Fix citation

Action: We modified the citation:
480 *LL132-133 (new version):"The variation of the surface drag coefficient with wind speed is parametrised according to Smith and Banke (1975)."*

Response: Yes, our model has fixed vertical layers.

485   **Action:** To clarify this fact, we changed the sentence in the following way: LL140-141 (new version):"*The model has vertically fixed layers with a resolution of 1 m up to a depth of 27.5 m and a resolution of 10 m below this depth.*"

490   **Response:** Thank you for your comment. I believe you are referring to the sentence: "*Salinity is set to a constant value of 33 PSU at the open boundary and 0.4 PSU at the upstream boundary of the Elbe estuary.*" We decided to uses these constant values for the salinity at the boundaries as a simplified assumption. We added two sources on which those assumptions are based on.

495   **Action:** We added two citations:
LL146-147 (new version):"*Salinity is set to a constant value of 33 psu at the open boundary (based on BSH (2016)) and 0.4 psu (based on Bergemann (2009)) at the upstream boundary of the Elbe estuary.*"

Response: Thank you for the remark, we improved the figures 1 and 5 for the revised manuscript.

505   **Action:** Figures 1 and 5 are created with thicker lines and fonts.

510   **Response:** Thank you for the remark. We got a similar comment on the validation from the other referee and therefore added information about the mean RMSE, BIAS and a skill-score after Willmott et al. (1985) for the water level of 39 tide gauges in the model domain. We additionally added residuals in Figure 2 and changed to colour and y-axis of the figure for better visibility. To address your recommendation on the quantification of validation for figure 3, 515   we also added a table with the RMSE for tidal range, low water, high water and tidal mean water for the gauges Cuxhaven, St. Pauli and the mean of the gauges in the Elbe estuary.

Actions:
- We added the following sentence regarding the quantification of Figure 2:
LL169-172 (new version):"*A comparison of water levels between model results and observa-* 520   *tions at 39 gauges in the model domain for this period reveals a mean RMSE of 16.4 cm, a mean bias of 7.3 cm and a mean skill score after Willmott et al. (1985) of 0.993.*"

- We added residuals in Figure 2.
- We added the following sentence regarding the quantification of Figure 3:
LL184-186 (new version):*"The RMSE for the mean TR, MW, tidal high water (HW) and tidal low water (LW) for the gauges Cuxhaven, St. Pauli and the mean of 15 gauges in the Elbe estuary is shown in Table 1."*
-we added Table 1 which shows the RMSE for the mean TR, MW, tidal high water (HW) and tidal low water (LW) for the gauges Cuxhaven, St. Pauli and the mean of 15 gauges in the Elbe estuary.

Referee comment:
Line 274: Remove "see"

Action: We changed the sentence as suggested.

Referee comment:
Line 275: Remove "as discussed by"

Action: We changed the sentence as suggested.

Referee comment:
Line 317: Not necessarily in this line, but I miss a study area subtopic. It does not need to be large, but it is focused on the Elbe and German Bight, so it would be interesting for readers that are not familiar with the area to get a bit of general overview (it does not need to be large, and you can take some parts from the introduction if needed).

Response: Thank you for the recommendation. We have a paragraph about the study area in the Introduction. Additionally, we added a few lines in section 2.3.1.

Action: We added the lines LL219-225 (new version) about the Elbe estuary in the beginning of section 2.3.1.
To avoid doubling, we deleted two sentences in the introduction.

Referee comment:
Line 320: "In Figure 7, tidal…"

Action: We added the comma.

Referee comment:
Line 322-323: Rephrase (or remove). The way it is written can be interpreted as the authors did not look into it in detail, whereas the authors mean that it is not being presented in detail, as you are focusing only on one scenario for better system understanding.

Action: We changed rephrased this part in the following way:
LL357-360 (new version):*"In this section we focus on the results of the scenarios with 110 cm SLR to gain a better system understanding. The results of the scenarios with SLR of 55 cm are not shown here in detail, but are included to determine whether the changes due to SLR are in principle similar for a different SLR scenario."*

Referee comment:
Line 350-354: I am not sure if I understood the message you tried to convey here. If it is to pave the way to further explain patterns found in TR in the following subtopic, it would be

important to be more specific (e.g. cite defined examples instead of loose definitions like "some scenarios", or "other scenarios"). I would encourage the authors to be specific here. Nonetheless, if that is the goal, one would expect that the next subtopic would continue from where you stopped here, trying to explain such patterns, which is not what happens.

565 **Response:** Thank you for your comment. We wrote these sentences as a transition between the subtopic of tidal range to the subtopic of estuarine geometry. As it seems to be confusing and unnecessary, we removed this part.

Action: We removed these sentences.

Action: We changed the sentence as suggested.

575 **Response:** This part is meant to be a short repeat of the methods for this section. A detailed description can be already found in the method section. We shortened this part in the result section.

Action: We shortened the paragraph in the following way:
LL399-402 (new version):"*The geometric parameter of convergence length (La) is calculated*
580 *by fitting an exponential function (Eq. (2)) to the data sets (see 2.3.3). To determine whether the convergence length significantly changes between two scenarios, a multiple regression is performed. The results of the weighted multiple nonlinear least-square regression for all scenarios compared to the reference condition and to slr110 are shown in Table 4.*"

Response: Thank you for your remark. You are right, there is no reason to mention two different alphas. We therefore changed the text and only used alpha=0.1.

590 **Action:** We changed the text and used alpha=0.1 consistently.

Response: Thank you for your recommendation. We added the standard deviation for each
595 value in Tables 5 and 6 (former 4 and 5).

Action: We added the standard deviation in Tables 5 and 6 (former 4 and 5):

Referee comment:

Figure 8: For readability, change the numbers on the y-axis.

Action: We changed the numbers from e.g. 8e+04 to 80000.

600   **Referee comment:**

Lines 385 – 420: When showing and discussing the data for Figures 8 and 9, the authors are focusing only on the mean values. While I understand and agree with this approach as a first, the authors should also discuss the spread of the data here, as looking only at the mean can be misleading. For example, the relative change in ht in the mouth section has a mean close to

605   zero for slr100t0, but the data has two main components, being higher closer to the mouth with a sharp decrease towards the lower section. The lower section, even though without a pattern, also shows a very large spread. The same holds for the relative intertidal area, where the spread is very visible, and should be quantified and presented here in the results (and it must be discussed in the discussion as well).

610   **Response:** Thank you for the feedback. We agree that the spread of data needs to be described in the results and discussed in the discussion. We therefore added sentences to describe and discuss the reasons for the data spread.

Action: We added/changed the following lines in the result section to address the data spread: LL436-437 (new version), L453 (new version) and LL454-455 (new version). We also

615   changed some sentences in the discussion chapter: LL490-493 (new version) and LL508-509 (new version).

Referee comment:

Lines 423-435: This might be more on style, but this chunk of text is just repeating what has been said. The subtitle suggests that you would discuss the limitation, but rather most of what

620   is written has been said elsewhere in the paper. So, I would rather discuss the limitations or just erase this part and go directly to the main discussion.

Response: Thank you for your recommendation, we removed the sentences which are repeating the methods and aim of the study. We slightly changed the structure by adding a subsection about the limitations at the end of the discussion chapter.

625   **Action:** We removed the sentences which are repeating the methods and aim of the study. We added a subsection (4.6.) at the end of the discussion chapter, where the limitations are discussed.

Referee comment:

Lines 437-445: Consider removing or considerably reducing this. It does not add anything

630   new and also does not help the reader follow your thoughts. In these lines, you just re-interact what you said in the results, without discussing anything on TR (which you only do later on page 22). One suggestion would be to remove the 4.1 and 4.2 subtopics, write one introduction sentence for the discussion instead and properly start from 4.3 onwards.

Response: Thank you for your suggestion. We revised the structure of the discussion chapter

635   accordingly.

Action: We deleted the subtopics "Objectives and Limitations" and "Changes in tidal range" in the discussion and added a short introduction paragraph instead. We added a subtopic "Limitations" at the end of the discussion chapter.

Action: We added a space.

Response: Yes, tidal flat elevation causes a decrease in cross-sectional-flow area in the regions of elevation. Therefore, an elevation of tidal flats in the mouth but not further upstream, can cause a weaker overall convergence of the estuary.

Action: We changed the sentence in the following way:

LL477-478:"Tidal flat elevation decreases A regionally and seems to significantly counteract SLR-induced changes in convergence in scenario slr110tf110a, but not in the other scenarios."

Response: Thank you for the comment, unfortunately I am not sure if I understand it correctly. We added two sentences to explain the statement in Line 471-473 (old version).

Action: We added the following sentences:
LL493-497 (new version):*"A decrease in hc due to SLR can be explained by an effect where the shallow areas next to the previous channels become part of the enlarged channels (Friedrichs et al., 1990): due to an elevated LW, some of the areas next to the channel that previously belonged to the intertidal zone can develop into subtidal areas and thus become part of the channel (Figure 12). Because of the relatively small water depth in this new part of the channel, the hydraulic depth averaged over the channel cross-section can decrease."*

Action: We removed the sentence.

675 **Response:** Thank you for the comment. In this sentence we are actually not referring to our results, but to general possible effects of SLR which we try to show in figure 12. We therefore decided not to change the sentence.

Action: -

680 Line 523-525: I am not sure if I follow the rationale here. For example, slr110t55 and slr110t55e have different behaviours in terms of TR. The authors argue that the main reason for both is the increase in mean hydraulic depth (lines 515 and 525). For the first, it compensates for the increase in Sint, whereas for the second, it follows the decrease in Sint. Considering that for both an increase in mean hydraulic depth is seen (despite different behaviours on
685 TR), why would the main reason for the increase in TR in these scenarios be the change in mean hydraulic depth? Perhaps is a matter of wording (the use of "main reason" may mislead the reader). Also, the authors mention that no significant change in convergence is detected (line 523) but later state that convergence is increased in these scenarios (line 526).

Response: Thank you for your comment. In scenarios slr110t55 and slr110t110 tidal flats are
690 elevated only in the estuary mouth which causes mean hydraulic depth to increase in the mouth. Whereas in scenario slr110t55e and slr110t110e tidal flats are elevated in the mouth and lower section of the estuary, which causes mean hydraulic depth to increase in both of these sections. This means that in scenario slr110t55e and slr110t110e mean hydraulic depth increases in a much larger part of the estuary and therefore most likely has a much stronger
695 effect on *TR*. Additionally the changes in Sint might compensate the effects of changed mean hydraulic depth in the mouth in slr110t55 and slr110t110, but might increase them in the lower section in slr110t110e.
We cannot for sure say, which is the main reason for the different behaviours in TR but we assume that it is the increase in mean hydraulic depth in a much larger part of the estuary. The
700 reason for our assumption is, that the decrease of Sint in the lower section is notable in slr110t110e but very small in slr110t55e.
Regarding the changes in convergence we were referring to a change relative to slr110t0 in line 523 (old version), but to a change relative to reference condition in line 526 (old version). We now realise that we were not fully accurate and clear in those sentences. Also, we now
705 show and discuss additional combinations of scenarios in the results and discussion part, following a suggestion of the first referee. We revised the discussion part in the manuscript to make our statements and reasoning clearer.

Action: We revised the entire discussion part in the manuscript to make our statements and reasoning clearer.

710
Line 530: As a reader, I was expecting a deeper discussion relating to these different scenarios. For example, I was expecting a certain level of discussion with other authors (such as those you mentioned in lines 25-45), or other studies that pointed a bit on the topic (such as Stark et al., 2016-2017 in the Scheldt estuary). Also, it is cool to separate the discussion into
715 subtopics, but there must be a bit more discussion between the scenarios. For example, you could explore a bit more the difference between increasing flats only in the outer part vs. everywhere. The authors have such nice data, it would be interesting to add a deeper discussion here.

Response: Thank you for your comment. We agree and therefore added some sentences in the discussion regarding the comparison between the scenarios. Furthermore, we added the subsection "Comparison to other studies" in the discussion chapter where we compare our study with other authors.

Action: We added the subsection "Comparison to other studies" (4.5) in the discussion chapter where we compare our study with other authors. Also, we added some sentences regarding the comparison between our scenarios (LL554-555).

Referee comment:
Line 535-536: Consider removing, as it does not add much to the text (you reiterate it in the following lines).

Action: We removed the line.

Referee comment:
Line 549: Add a short paragraph after this line, where the authors add the conclusion of the study itself and wrap it up with the aim itself. Without it, the conclusion seems more of a summary.

Action: We added the following sentences:
LL606-609 (new version): *"The results of this study show that the future development of TR in the Elbe estuary depends not only on future SLR but also on the development of tidal flats. The results further show varying changes in estuarine geometry for the different scenarios, which can explain the differing changes in TR and improve understanding of the system in the context of SLR."*

References

Bergemann, M.: Salzgehalt am Wehr Geesthacht, personal communication, 2009.

BSH: Nordseezustand 2008-2011, Bundesamt für Seeschifffahrt und Hydrographie, Hamburg und Rostock, Berichte des BSH, 54, 2016.

Jordan, C., Visscher, J., and Schlurmann, T.: Projected Responses of Tidal Dynamics in the North Sea to Sea-Level Rise and Morphological Changes in the Wadden Sea, Front. Mar. Sci., 8, 40171, doi:10.3389/fmars.2021.685758, 2021.

Kloepper, S., Baptist, M. J., Bostelmann, A., Busch, J. A., Buschbaum, C., Gutow, L., Janssen, G., Jensen, K., Jørgensen, H. P., de Jong, F., Lüerßen, G., Schwarzer, K., Strempel, R., and Thieltges, D.: Wadden Sea Quality Status Report: https://qsr.waddensea-worldheritage.org/?_gl=1*1lhw65f*_ga*MTk4MTkxMDczLjE2OTcwMTU4Njc.*_ga_W7PEFV8FMW*MTY5NzAxNTg2Ni4xLjAuMTY5NzAxNTg2Ni4wLjAuMA., last access: 11 October 1023.

Wachler, B., Seiffert, R., Rasquin, C., and Kösters, F.: Tidal response to sea level rise and bathymetric changes in the German Wadden Sea, Ocean Dynamics, 70, 1033–1052, doi:10.1007/s10236-020-01383-3, 2020.

Willmott, C. J., Ackleson, S. G., Davis, R. E., Feddema, J. J., Klink, K. M., Legates, D. R., O'Donnell, J., and Rowe, C. M.: Statistics for the evaluation and comparison of models, J. Geophys. Res., 90, 8995, doi:10.1029/JC090iC05p08995, 1985.