Reviewer #2

In this manuscript, the authors present a comprehensive assessment of sea-level literature along European coasts. They use literature and data from the literature to summarize the state of the art. This is, of course, a huge effort, that should be very helpful to both scientists, planners and decision makers. However, in its current form, the manuscript is, in my opinion, not ready for publication. The use of acronyms is rather wild, the structure at times unclear and heterogenous among subsections and some important literature is missing. It seems to me that authors have worked individually on sections, but not enough effort has been undertaken to bring the different sections together. Therefore, I recommend major revisions. I'll further clarify these points below. Please also note that I could only read this massive manuscript once, so the authors should really make sure that everything is in shape for resubmission.

We warmly thank the reviewer for this review and for the time spent reading our manuscript and providing constructive feedback. We accounted for the comments and address them below.

General comments

- Acronyms are a mess (to be honest). The number of acronyms is huge and not homogeneous throughout the manuscript (way too many to specify them here). I feel that the readability would be way better if the authors would decide on a few really important acronyms that are then properly introduced and used consistently used throughout the manuscript.
  Acronyms were introduced in the abstract if used several times there (SLR, RSLR, GMSLR, ESL, GIA). They were then re-introduced in the main text at their 1st occurrence. We chose not to use acronyms in titles/ subtitles. The number of acronyms has been reduced (from 52 to 33). The list of acronyms and their expansion is now provided in Annex 1.

- The subsections in chapter 6 are very heterogeneous, both in terms of structure and content. For instance, some sections summarize VLM under past sea-level changes, while others use a full subsection (differently positioned among chapters). All chapters present the same type of figure, which is useful, but the figures are only discussed for the MedSea and the concepts presented are not really introduced. I also could not find references to these figures in some chapters. I would suggest introducing basic concepts, such as the use of the hybrid sea level reconstruction (Dangendorf et al., 2019), at the very beginning and report the associated numbers (also in reference to the figures) homogeneously for each section; also, in context to numbers presented in other literature. The same applies to the use of VLM information, which seems to follow Oelsmann et al. (2024; https://www.nature.com/articles/s41561-023-01357-2; not yet referenced)?
  Subsections in chapter 6 are dedicated to European regional seas. As main processes and topics to be discussed can differ across European regional seas, we do not necessarily aimed at having the same structure / content in each subsection, rather emphasizing key processes per European sea. However, we thank the reviewer for their comment and aimed at better homogenizing the structure of each subsection.

  Sections 6.1 to 6.5 are now organized more similarly with 1. General context, 2. Past sea level changes, 3. 21st century projections. The section on the Mediterranean Sea is an exception, as we kept the sub-sections on Medicanes and Meteotsumanis, as these are more Mediterranean Sea specific, and both the past, present and future conditions are discussed.

In addition, we now introduce the European regional seas discussed in Section 6 in the introduction of the section, with a figure (Figure 14 in the revised version) showing their geographical coverage. Basic concepts used in section 6 (such as the use of the hybrid sea level reconstruction by Dangendorf et al., 2019 and VLM by Oelsmann et al., 2024 –not yet published at the time of the 1st submission of this manuscript-) are also provided at the beginning of the section. Table 3 has be moved at the beginning of Section 6.
Figures 15-19 (formerly Figures 14-18) are now referenced in the different subsections of Section 6, and figures on VLM and 50-yr return levels of the recent past are provided in each subsection.

- Somewhat related to points 1 and 2, the authors make use of extreme value statistics very heterogeneously throughout the manuscript. While the abstract and parts of the text frequency mention "historical centennial events", all figures in section 6 use water levels corresponding to a 50-yr return period. I would suggest homogenizing that. I would also suggest to properly introduce jargon, e.g., amplification factors, very clearly. It would also not hurt to explain the meaning of the amplification factors in the caption of Figure 12 in support of readability again.
  Amplification factors were defined at the beginning of section 5.3.1.
  "Projections of future changes in ESLs due to SLR are often reported as factors by which the probability of a certain ESL will increase (called amplification factors; Buchanan et al., 2016; Fox-Kemper et al., 2021; Frederikse, Landerer, et al., 2020; Hermans et al., 2023; Jevrejeva et al., 2023; Lambert et al., 2020; Oppenheimer et al., 2019; Rasmussen et al., 2018; Tebaldi et al., 2021; Wahl et al., 2017) or as the height by which coastal defenses need to be raised to restore the historical flood probability (called allowances; Hunter, 2012; Hunter et al., 2013; Slangen et al., 2017; Woodworth et al., 2021)."

  Return periods of 50-yr were kept in section 6 for practical reasons and to cover another return period since 100-yr return levels of the historical periods are also discussed in other sections. 50-yr return levels are used throughout section 6.

- The concept of relative and absolute sea level changes is not properly used in terms of the hybrid sea level reconstruction presented in section 6. The reconstruction contains Gravitation, Rotational and Deformational effects related to present day barystatic mass changes. Thus, even after the removal of GIA, it still contains solid earth components. These can make an important contribution to relative sea level, particularly in the Nordic Seas (as mentioned for the Baltic Sea). Therefore, I would suggest using the term: Relative sea level after the removal of GIA.
  Thanks, done in the captions of Fig 15-19 and also specified in the introduction of Section 6.

- The role of the NAO is in my opinion overstated in this manuscript. First, it is the dominant atmospheric mode only during winter. Second, many publications have shown that it only explains a fraction of the variability (e.g., Jevrejeva et al., 2006: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0870.2005.00090.x), which is either due to the presence of other important teleconnection patterns (e.g. Chafik et al., 2017: https://www.mdpi.com/2077-1312/5/3/43) or more complex oceanic processes that are communication through ocean circulation and therefore integrated over time.

- There are some important references missing for some of the subsections that are provided in the specific comments below.
  We address them in the comments below.

Specific Comments:
Line 75: To be consistent with the concepts in Gregory et al. (2020), I would suggest introducing the term sterodynamic at this point, which is also used in later parts of the manuscript.
Done. We added the sentence: *"When combined together, the global mean steric SL change and ocean dynamic SL changes are called sterodynamic SL change (Gregory et al., 2019)."*

Line 98: I am not sure what the text in the parenthesis is referring to
This was referring to a companion paper (same special issue), that was only submitted at this stage. The paper is now referred to Jimenez et al., 2023.

Jiménez, J. A., Bonaduce, A., Depuydt, M., Galluccio, G., Van Den Hirk, B., Meier, H. E. M., Pinardi, N., Pomarico, L. G., Vazquez Riveiros, N., and Winter, G.: Sea Level Rise in Europe: Knowledge gaps identified through a participatory approach, https://doi.org/10.5194/sp-2023-34, 2023.

Line 103: I would suggest: "These contrasting atmospheric and oceanic environments lead to…"
Agreed, thanks.

Line 105: I guess you mean SL changes; SLR changes mean acceleration
This has been reformulated:
"Here, the state of knowledge of observed and 21st century projected changes in mean and extreme SL is documented for European basins as part of the Knowledge Hub on Sea Level Rise Assessment Report".

Section 2.1.: Although summarizing the last IPCC report, I think it is important to give proper references to the original sources in the text. Just as an example, the statement in line 127 should cite Kopp et al. (2016, https://www.pnas.org/doi/full/10.1073/pnas.1517056113)
While we are sympathetic to the reviewer's comment we believe that is it neither practical nor desirable to include comprehensive line-of-sight from the IPCC summary presented here to the underlying supporting literature. For our purposes, the IPCC assessments are taken as a "point-of-departure" for the European-focused report we present here, building on those findings. We have included the following additional sentence in the opening paragraph of section 2.1 to make our stance clear in this regard:
"The IPCC reports synthesize a huge body of literature, and we refer the reader to the above assessment reports and references therein for further discussion on the topics summarized in this section."

Line 132: Recent literature suggests that the acceleration started in the 1960s/1970s and was initiated by steric expansion, while mass input from the ice-sheets came into play over the past few decades.
This section summarizes IPCC SROCC and AR6 main findings, focusing here on the acceleration of GMSLR over the past few decades. We added the sentence *"SLR has accelerated since the late 1960s."*.
In section 4.2 - Sea Level Budget, we discuss further recent literature on acceleration of GMSLR, with the following sentence:
"Recent studies show that GMSLR started to accelerate in the 1960s/1970s, initiated by an acceleration of thermosteric SLR due to an intensification and a basin-scale equatorward shift

of Southern Hemispheric westerlies and induced increased ocean heat uptake (Dangendorf et al., 2019). Since the 1990s, accelerated ice mass loss, mostly from the Greenland icesheet, has also contributed to the GMSLR acceleration (Dangendorf et al., 2019, Frederikse et al. 2020b)".

Line 135-139: I am not sure what this statement means for Europe. Tropical cyclones primarily affect the other Western Atlantic region.
True. We removed this sentence.

Line 175: GIA is more than only VLM, geoid contributions are significant particularly in northern Europe
True. We have changed the sentence to also include gravity and rotational changes:
"A key driver of these spatial variations is GIA: the ongoing GRD response to past ice mass changes"

Line 223: Forecasted (i.e., initialized from observations) or projected sea levels?
The web tool "Se havnivå i kart" allows to visualize both present-day, forecasted sea levels (provided by the Norwegian Meteorological Institute-MetNO) and projected sea levels.
An example is provided here by clicking on the Tromsø tide gauge:

https://www.kartverket.no/en/at-sea/se-havniva/result?id=1082341

Information in the "Tides and Water Level" tab is related to observations, predicted tides and forecasted water levels, while information in the "Sea Level" tab is related to sea level projections.

Line 262: What are low-frequency global mean sea level records? What is low frequency, what is global mean?
The sentence :
"Low frequency global mean SL records at tide gauges at monthly and yearly frequencies are obtained by national providers and compiled and distributed by the GLOSS Permanent Service for Mean Sea Level (www.psmsl.org) (Holgate et al., 2013)." has been reformulated to:
"Monthly and annual mean SL records from tide gauges are obtained by national providers worldwide and compiled and distributed by the GLOSS Permanent Service for Mean Sea Level (www.psmsl.org) (Holgate et al., 2013)."

Figure 3: Might make sense to add the longest period covered by those tide gauge records.
Figure 2 already shows the length of PSMSL tide gauge records. Doing it for GESLA in Fig 3b would provide a very similar figure.

Figure 4: I suggest to add uncertainty bands to these plots.
Done. Fig 4 caption has been updated accordingly.

Line 301: sea level dynamics are highly….
Corrected.

Figure 5: What's the meaning of the two periods; why only since 2001?

Two 10-yr periods were selected to highlight the changing decadal trend of global mean sea level.

Line 322: Cloud and rain patterns lead to changes in thermal expansion?

Refers to the following sentence of the submitted manuscript: *"On interannual time scales the global mean SL record shows significant variations which are mostly generated by El Nino Southern Oscillation events during which the cloud pattern and the rain pattern are changed leading to changes in thermal expansion and land water storage respectively (e.g., Cazenave et al., 2014; Hamlington et al., 2020)."*

During El Nino events, the global hydrological cycle and atmospheric circulation are altered, with modifications of cloud cover and rain patterns. During El Nino, more precipitation occurs over the ocean (mostly in the tropics), resulting in a tendency for land water deficit. As a result, global land water storage is reduced during El Nino, and GMSL is temporarily increased.
It has been suggested that steric and barystatic effects both have sizeable, or even comparable, contributions to the GMSL budget during ENSO (Piecuch and Quinn, 2016; Hamlington et al., 2020), with a temporarily increased steric contribution to GMSL during the warm phase of ENSO and accumulated heat in ocean (mostly upper tropical Pacific Ocean).

The sentence has been reformulated to:
"On interannual time scales, the global mean SL record shows significant variations which are mostly generated by El Nino Southern Oscillation events and its influence on the ocean heat content and global hydrological cycle. During El Nino events, the global mean SL is temporarily increased due to both an increase in ocean mass and in ocean thermal expansion (e.g., Cazenave et al., 2014; Piecuch and Quinn, 2016; Hamlington et al., 2020). Indeed, during El Nino events, more precipitation occurs over the ocean (mostly in the tropics), resulting in a temporary increase in the barystatic component of global mean SL. In addition, the ocean heat content temporarily increases during El Nino, with a dominance of the Tropical Pacific Ocean, leading to sizeable increases in global mean steric SL."

Piecuch, C. G. and Quinn, K. J.: El Niño, La Niña, and the global sea level budget, Ocean Sci., 12, 1165–1177, https://doi.org/10.5194/os-12-1165-2016, 2016.

Line 330: What is an "effective temporal resolution", and why is it 34 days? Isn't every along-track point tracked every 10 days?

Although gridded altimetric products are provided as daily means over a 1/4° grid from a combination of satellite missions (amongst which the Topex/Poseidon, Jason1-3 and Sentinel-6 with a 10-d revisit time), the dynamical content of these maps does not have full 1⁄4° spatial and 1 d temporal resolutions due to the filtering properties of the optimal interpolation. The effective resolution corresponds to the spatiotemporal scales of the features that can be properly resolved in the maps. This is fully explained in Ballarotta et al., (2019) as cited in the text.
The text has been reformulated to:
"To analyze sea level changes at regional scales, gridded altimetric product can be used. Although such products are provided as daily maps on a 1/4°x 1/4° grid, the dynamical content of these maps does not have full 1/4∘ spatial and 1-d temporal resolutions due to the filtering properties of the optimal interpolation. The effective resolution corresponds to the spatiotemporal scales of the features that can be properly resolved in the maps. The temporal effective temporal resolution has been estimated to around 34 days (spatially varying), and the

effective spatial resolution has been estimated to range from 100 to 200 km in the north-eastern Atlantic, and from 90 to 160 km in the Mediterranean and Black Seas (Ballarotta et al., 2019).”

Line 349: estimates
Thanks, done.

Line 384: InSAR can image the spatial pattern of VLM…
Done.

Line 413: I think this statement refers to extreme sea levels rather than storm surges. Jänicke et al (2021) assessed changes in the mean tidal range, so those do not correspond to any changes in storm surge. An additional reference here is Dangendorf et al., 2013: https://link.springer.com/article/10.1007/s10236-013-0614-4
Thank you. We have substituted the reference as suggested.

Line 467: What ranges do these numbers refer to?
We modified the sentence to:

“Fox-Kemper et al. (2021) assess the Antarctic contribution to global mean SLR in 2300 (without MICI) to range between –0.14m and +0.78m (17-83 percentile) for a low emission scenario (SSP1-2.6, and to range between –0.28m and +3.13 m for a very high emission scenario (SSP5-8.5).”

Line 513: I am not sure whether that statement is correct. This is period dependent and does not hold for each individual contributions, right? Maybe state: Since the late 1960s, the sum of individual contributions have led to a persistent acceleration.
The sentence *“Since the late 1960s, all contributions to SLR accelerated (Dangendorf et al., 2019)”* has been reformulated to:
“Recent studies show that GMSLR started to accelerate in the 1960s/1970s, initiated by an acceleration of thermosteric SLR due to an intensification and a basin-scale equatorward shift of Southern Hemispheric westerlies and induced increased ocean heat uptake (Dangendorf et al., 2019). Since the 1990s, accelerated ice mass loss, mostly from the Greenland icesheet, has also contributed to the GLMSLR acceleration (Dangendorf et al., 2019, Frederikse et al. 2020b)”.

Line 548: To be fair, I would add that uncertainty exists in this region with respect to VLM estimates. For instance, the reported numbers in Frederikse et al. (2016) for a slightly different period are smaller than in Dangendorf et al. (2021).
This has been added, thank you.

Line 589 following: Treu et al. (2024; https://essd.copernicus.org/articles/16/1121/2024/) produced the first full sea level reconstruction based on a combination of different reconstruction and modelling approaches.
Treu et al (2024) uses hydrodynamic model outputs to account for extreme sea levels. We therefore believe that this approach lies in the former group discussed in the paragraph above. The source data for high-frequency changes is Muis et al (2020), already cited in there.

Section 5.2.: I feel that MISI and MICI might be explained more thoroughly in terms of the associated physics.
We have added a short explanation on these mechanisms in section 5.2

Section 5.3.2.: The literature summary is rather recent. I would suggest incorporating early attempts such as Woth (2005): https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2005GL023762 , Woth et al. (2005): https://link.springer.com/article/10.1007/s10236-005-0024-3; WASA (1998): https://www.webofscience.com/wos/woscc/full-record/WOS:000073809200001?SID=USW2EC0FB7RmlUpG8iI3Cn6Fxd3jY; Sterl et al. (2009): https://os.copernicus.org/articles/5/369/2009/

L780 (in section 5.3.2) has been modified to include early attempts. *"In the southern North Sea, Jevrejeva et al., (2023) showed an increase of +50 cm in extreme storm surges and waves under a low-probability high-impact scenario (Figure 13), in line with early attempts to account for dynamic changes in storm surges (Woth 2005; Woth et al., 2005)."* The Woth et al. (2005) reference has also been added in Sect., 6.2. WASA (1998) and Sterl et al., 2009 were discarded as no significant changes in storm surges (and waves) were found for the past period for WASA (1998) and 21st century projections for Sterl et al., (2009).

Line 782: Here and throughout the manuscript, SLR is handled as the only driving factor behind changes in tides and corresponding extremes. However, recent literature (including the cited Jänicke paper) suggests significant contributions by density changes. Thus, it should be noted that the reported numbers in projections are lacking those mechanisms.
The sentence has been modified, as the mentioned studies have considered the spatial variations of MSL and not just SLR:
"For example, tidal ranges may change by several tens of centimeters in Europe depending on the spatial variability of SLR, considered SL drivers and the inclusion of flooding of low-lying topography (Haigh et al., 2020; Idier et al., 2017; Pickering et al., 2017)."
The reference Jänicke et al., 2021 has also been added L789 reporting changes in tides over the historical period.
Note that another sentence addresses changes in tides in section 6.2.2:
"Changes in water depth and other non-astronomical factors, such as changes in stratification and large construction measures, affect tides along the North Sea coast (e.g., Jänicke et al., 2021; A. Jensen, 1984; J. Jensen and Mudersbach, 2007; Mudersbach et al., 2013; P. Woodworth et al., 2017), including in estuaries (e.g., Amin, 1983; Keller, 1901; Jiang et al., 2020) and harbors (e.g., Doodsen, 1924; Marmer, 1935; Schureman, 1934; Vellinga et al., 2014). However, a comprehensive and generalized analysis is still missing."

Line 830: Where are these numbers coming from? From the trend assessment tool? Why not plot them for those periods? Also, the reference PSMSL is not in the list
This sentence has been deleted.

Line 834: Is this true? Isn't GIA, or VLM in general, the dominant driver of regional sea level trends in the region?
This sentence discussed the driver of the spatial heterogeneity of RSLR over this region, not - contributions to basin-mean RSLR (cf Fig 9.26 IPCC AR6). GRD effects are mentioned in the sentence.

Line 885: What's the historical centennial climate extreme event?
This is defined in Section 5.3.1. A reference to that section was added to clarify.

Section 6.2.2.: An important reference here is Wahl et al. (2013): https://www.sciencedirect.com/science/article/abs/pii/S0012825213000937 that has not been included yet. I am also missing all the Woodworth (e.g., https://academic.oup.com/gji/article/213/1/222/4757068 and some more earlier assessments) and Hogarth (e.g., https://www.sciencedirect.com/science/article/pii/S0079661120300720) UK sea level assessments that the authors should be very familiar with.

Thanks for your suggestion, we have added the following two sentences and referenced these and other relevant papers:

"Observed trends vary by one to three tenths of a mm/yr between different parts of the North Sea region (Wahl et al., 2013). Several assessments of sea level trends around the British Isle' (e.g., Woodworth et al., 1999, 2009; Haigh et al 2009; Woodworth, 2017; Hogarth et al. 2020, 2021), include tide gauge sites in the North Sea, and again observed trends typically range between one to three tenths of a mm yr^{-1}, over the last century".

Hogarth, P., Pugh, D.T., Hughes, C.W, Williams, S.D.P.: Changes in mean sea level around Great Britain over the past 200 years, Progress in Oceanography, 192, 2021.

Hogarth, P., Hughes, C.W, Williams, S.D.P., Wilson, C: Improved and extended tide gauge records for the British Isles leading to more consistent estimates of sea level rise and acceleration since 1958, Progress in Oceanography, 184, 2020.

Haigh, I., Nicholls, R.J., Wells, N.: Mean sea level trends around the English Channel over the 20th century and their wider context, Continental Shelf Research, 29 (17), 2083-2098m 2009.

P.L. Woodworth, M.N. Tsimplis, R.A. Flather, I. Shennan: A review of the trends observed in British Isles mean sea level data measured by tide gauges. Geophysical Journal International, 136 (3), 651-670, 1999.

P.L. Woodworth, R.M. Teferle, R.M. Bingley, I. Shennan, S.D.P. Williams: Trends in UK mean sea level revisited. Geophysical Journal International, 176 (1) (2009), pp. 19-30

Philip L Woodworth, Sea level change in Great Britain between 1859 and the present, Geophysical Journal International, Volume 213, Issue 1, April 2018, Pages 222–236, https://doi.org/10.1093/gji/ggx538

Line 1015: Please quantify "large effect"

The order of magnitude was added : "*up to 30% of the total sterodynamic SLR simulated for the 21st century*"

Line 1070: I think there is a link missing?

The reference to NKG has been cut so a link is not needed anymore.

Line 1099: Isn't GIA the biggest factor in those areas?

We agree this is poorly formulated so have change to:

"Projections for the European Arctic indicate the region will experience a SL change somewhat below the global average rise (e.g. Simpson et al., 2017; Table 3). Apart from GIA, several components of projected SL changes are relevant for the European Arctic...."

Line 1171: Black Sea sea level
Done, thanks.

Line 1180: This information should go at the beginning of section 6 as it is used for the figures in all regions. I would also suggest to pick the results up in each section in the context of the corresponding literature. Furthermore, the approach requires a bit more introduction in general. Is it based on Oelsmann et al. (2024; https://www.nature.com/articles/s41561-023-01357-2)?
VLM linear trends shown in Figures 15-19 are indeed based on Oelsmann et al. 2024. At the time of submission of our manuscript, the study by Oelsmann et al. Was not yet published. As it is now, we introduce the study at the beginning of Section 6.

Line 1287: Again, shouldn't GIA be the dominant factor, leading to far lower than global projections? Shouldn't that factor first be emphasized given its importance?
We agree and rephrased the paragraph *"It is expected that SLR in the southern Baltic Sea approximately follows the projected GMSLR (or slightly less) due to the melting of ice sheets and glaciers and the expansion of the warming water (Hieronymus and Kalén, 2020; Meier, et al., 2022; Pellikka et al., 2020; Weisse et al., 2021). However, in the northern sub-basins of the Baltic Sea, GIA (Section 3.3) is the dominant driver (Ekman, 1996)."*

Section 6.5.2.: This section is lacking some literature: e.g., Gräwe et al. (2019): https://journals.ametsoc.org/view/journals/clim/32/11/jcli-d-18-0174.1.xml; Donner et al. (2012): https://npg.copernicus.org/articles/19/95/2012/; some of the Ekman studies (https://psmsl.org/products/author_archive/ekman_2003.pdf and references therein)
A discussion of all related articles is out-of-scope of this review as we rely on the most recent Baltic Earth assessment report by Weisse et al. (2021). Following the suggestions by the reviewer, we added the references Donner et al. (2012) and Gräwe et al. (2019).