This paper reviews impacts and consequences of sea-level rise (SLR) in Europe. This is not an easy task given the heterogeneity of the literature on this topic, so the authors should be congratulated for their effort.

Thank you

To do so, the authors have adopted a focus on the physical processes causing flooding erosion and salinization, rather than e.g. a focus on different types of coastal areas in Europe. The advantage is that it gives a useful reminder of the physical mechanism, the drawback is that it takes always some time before each section start addressing issues specific to Europe.

Besides this focus on impacts, some information is provided on consequences, e.g. on erosion based on previous publications, but overall the information on consequences is limited. To me this is not a surprise given the heterogeneity of information available on the consequences of SLR in Europe and the uncertainties, but may be it would be useful that the authors clearly say that we are lacking aggregated observations of consequences and – if they agree with me – the information on projections based on modelling are often difficult to assess and compare due to model assumptions and limitations.

We have tried to sharpen the purpose of the paper in the second paragraph and included this comment.

The terminology used in the paper is clear overall, except sometimes when it comes to the terminology on hazards and adverse events (see ref below to the UNISDR and IPCC terminology). This should be clarified.

We aim to streamline the terminology by using the concept of source, pathway and receptor which we introduce in a separate paragraph and consequently use throught the remaining text.

The main problem of the paper, from my perspective is a lack of clarity on its objectives : who is the target audience? What will they learn in this article? This is not quite clear in the current version and could be precised at the end of the introduction and reflected in the conclusion.

This paper aims to describe the different impacts of sea-level rise in Europe following from the physical evidence expressed by Melet et al. (2024) and is intended for local and

governmental stakeholders planning for raising awareness and consider adaptation measures in their region. We have put this upfront in the paper.

Below are specific comments

Specific comments (moderate)

1. Introduction

The introduction is interesting, but it would benefit from a bit of reorganisation and update. For example, the statements on exposure increase rely on relatively old references published in 2003. Meanwhile, as recognized by the authors line 65, setback zones have been setup, and this may have curbed trends in exposure, at least in some contexts. Furthermore, it would be good to remind that Europe has a long history of coastal protection compared to many other regions in the world already at this stage of the manuscript. Finally it is not clear whether the whole introduction is focused on present days, or both present days and the future. In the first case, it would be good to cover the topic of attribution of coastal impacts to sea-level rise. In the second case it would be good to separate clearly what applies to today, and what is projected to 2050, 2100 or beyond. For example migrations patterns could be different today and in 2100 when sea-level rise becomes a major driver of coastal migration.

One way to clarify this could be to reorganize the introduction in a way that explains more clearly what is known with "high confidence" (e.g., flood risk will increase) from what is uncertain (e.g. the precise magnitude of flood or erosion impacts) or almost unknown (e.g., future migration responses to SLR). Another option would be to remind the target audience of the paper, their potential challenges and how this paper is going to help them. There may be other options.

Added a sentence arguing that coastal migration is more in the future and hard to quantify.

Added a sentence on the high confidence

2. Summary of previous assessments

The review makes sense overall, and it is good to remind where coastal impacts can be found in AR6, but it is unclear to me how useful it is for a review focused on Europe: in practice, the authors could well say in the introduction that there has been previous assessments on climate change in Europe (IPCC), on specific coastal hazards (Eurosion…), on some relevant regions (Medecc), but that the Knowledge Hub is the first attempt to do what it does. So in summary I am not sure such a long summary is needed, may be a few sentences in the introduction would be sufficient.

Besides, there are several points that could require some precisions (see below, minor comments)

We believe that the strength of the section is not only that it points out where the information is in the AR6 reports but that it ditails the information which is specific for Europe. To clarify this, we changed the title of the section to express this rather than incorporating the information in the introduction, which would then get too long.

3. Source, Pathways, Receptors and consequences framework

The Source, Pathways, Receptors and Consequences framework section is very short. I wonder if it could be included in the introduction as this is framing the rest of the manuscript.

We agree this section is short, however we deliberately keep this section short, because it is simply introducing the concept, which is then explored in depth in the sections below. We have added an additional sentence, on the advice of the other reviewer to gives some examples of where it has been used previously.

4. Coastal flooding and compounding flood events

This section has a focus on physical processes causing flooding. It is good to have a section on compound flooding, but it may be not clear to readers how increased precipitations due to climate change (higher atmospheric moisture due to increased temperatures) have been considered in the references cited.

This is a really good point, thank you. We have added the following sentence to stress this:

'However, in regard to compound flooding, climate change also impacts precipitation (as average temperatures increase, more evaporation occurs, which, in turn, increases overall precipitation) and therefore river flow.'

In the sentences below, we do reference some papers regarding changes in precipitation.

The discussion on pathways highlights the need to maintain defenses in order to maintain security levels, which is good. However, it does not mention the risk of coastal defenses being raised at the costs of coastal biodiversity losses (see e.g. Bednar-Friedl et al., 2022 p 1843).

Thank you – this is a good point. We have added the following sentence citing that suggested paper:

'There is also concern that raising existing coastal defences, or building new ones, will come at the cost of further biodiversity losses (Bednar-Friedl et al., 2022).'

Another point which is missing is the projected change in terms of flooding modes: from overtopping to overflow, as shown in IPCC AR6 WGII CCP4 page 2245. This risk is important as areas currently exposed only to overtopping may not be prepared to future overflow and the associated risks to human life and larger economic damages. These aspects should at least be mentioned for completeness.

Again, this is a very good point and we have added the following sentence, and your suggested reference:

'With higher SLR coastal flooding will progressively change, due to changes in the pathway from overtopping to overflow, high-tide flooding and ultimately permanent flooding (Ali et al., 2022).'

5. Coastal erosion

It is good (and not a surprise given the list of authors!) that the section identifies the topic of erosion/flooding interactions. There is also a summary of observed and projected erosion, which can be useful. However, it should be precised that these figures assume no geological constraints (to be confirmed by the authors – see Thiéblemont et al 2019 for this caveat) and no protection or nourishment.

The reviewer is raising an important point, especially for the projected values (the baseline ones come from observations and are the result of different meteorological, geological and antropogenic factors). Therefore, we have added a small section discussing geological constraints, citing relavant papers including the one suggested by the reviewer.

This section is structured in a different way than the other ones on coastal flooding and salinization, which is not necessarily a problem, but raises the following questions: (1) why a section on monitoring for erosion and not flooding and salinizations? Why not an analysis on historical and future flooding and/or salinization?

It is true that this may seem not conistent but we believe that historic shoreline change trends are a key component for projecting the future shoreline positions. As such, understanding more about the (un)certainty in such historic trends is important when projecting into the future. This is different in case of flooding and salinization.

6. Saltwater intrusion

I am less qualified on this topic and may not cover all subsections adequately. In general the section recognizes well the importance of aquifer recharge and water usages in driving current salinization in aquifers, but since the topic of this paper is on sea-level rise, a specific discussion on the impacts of sea-level rise or the vulnerability of different types of European aquifers could be useful. The Jouzel report in 2015 (in French) could provide some useful examples:
https://www.ecologie.gouv.fr/sites/default/files/ONERC_Climat_France_XXI_Volume_5_VF_revisee_27fevrier2015.pdf

We provided more references in the saltwater intrusion section

Figure 12 seems good to me, but it is not well exploited in the text. Furthermore it would be useful to say clearly that the known case study are not exhaustive - e.g. salinization in the Loire estuary has been reported during the 2022 drought with concerns to drinking water supply, and is not reported here.

Added “not exhaustive” to the figure caption.

Section 6.2 is clear, but I do not understand the focus on river salinization – the statements on reduced recharge apply to aquifers as well, do not they?

Removed “surface” from the title.

In section 6.4, I am not sure that all messages apply to Europe (see detailed comments and the comment on sand mining in river beds).

The sentence referring to sand mining has been removed.

Finally may be one study to consider: https://doi.org/10.1029/2023EF003581

Reference added.

7. Ecosystems and estuaries

The good point in this section is the reminder that coastal protection is often implemented at the cost of coastal ecosystem losses, as already reminded by the IPCC WGII report. That said, this section does not fit very well in the structure of this manuscript: the title suggests it may either focus on a particular type of receptor (ecosystems), or a particular type of geomorphological features (estuaries). In both cases it is not clear why this receptor or type of environment is not addressed in the previous sections. Besides, if a focus on ecosystems could be useful if it could give insight on how healthy ecosystems can reduce the hazards above, but this is not addressed here. I suggest reconsidering this section.

We agree and decided to remove this section as it did not fit.

8. Conclusion

The conclusion could include a summary of gaps of knowledge / recommendations for future assessments.

We added that impact of coastal ecosystems is one of the major knowledge gaps at the moment.

Minor comments

- line 41: suggest: these threats "can be" reinforced by subsidence caused by human activities

Changed accordingly

- line 45: consider replacing "losses" by "risks"

Changed accordingly

- line 47: Vousdoukas et al 2018b focus on extreme water levels. Therefore the statement on trends on exposure can not come from this paper. Suggest to either refer here to papers assessing impacts for various SSPs or to delete "with the relative importance of trends in exposure (related to coastward migration, urbanization and rising asset values) diminishing over time", as the next sentence is about the same topic.

Sorry we referenced to the wrong paper. We also rephrased slightly to clarify

- line 49: The discussion on exposure in the introduction relies on papers published a long time ago (20 years). Meanwhile, setback zones have been defined in many countries to reduce exposure (e.g. Croatia, France...). This may have had an impact on exposure trends or not depending on the context. It would be good if the authors could either find a paper addressing this issue, or identify a gap of knowledge.

We have included this in the conclusion section at the end.

- line 98 and earlier: the SYR builds on all AR6 reports, not only SROCC as suggested.

Corrected

- line 116: please note this is expected annual damage, not annual damages. Furthermore these are projections based on flood models with coarse resolution and strong assumptions must be made on protection and exposure. Therefore these figures are indicative.

Rephrased

- Line 125: in Mediterranean ports the problem is also that waves are projected to propagate within ports with shallow bathymetry (see page 2244 in IPCC AR6 CCP4)

Rephrased

Line 134: It is true that one of the four key risks of Chapter 13 is the impacts of heat to ecosystems and that the marine heatwaves are causing massive mortalities, especially in the Mediterranean, as reported in CCP4, so the statement is certainly valid for coastal aquatic ecosystems. Yet in practice for coastal ecosystems another risk that is mentioned several time in the report is a massive use of hard engineering protection in response to coastal hazards and SLR, and therefore reducing habitats of coastal ecosystems (see page 1843 in Chapter 13). Coastal squeeze, not necessarily related to SLR, is also a major threat. To contextualize, references to IPBES here would be useful to remind the 5 major causes of ecosystem losses, which all apply to coastal ecosystems.

Rephrased

Line 144: Hazard is a potential occurrence of an adverse event (see https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Annex-II.pdf) here the source describes the origin of the event (not the hazard)

Line 145: the “entity” could be named exposed element https://www.preventionweb.net/files/7817_UNISDRTerminologyEnglish.pdf

We have reworded so the Source is described as the origin of the event that cases flooding. Entity simply means the thing that is flooded. We have also replaced entity with exposed element. Thanks for your suggestions.

Line 168 – Fig 3 – the figures seems to assume overtopping only but there are other modes of flooding to consider (overflow, breaching)

We have rephrased the caption and mentioned the other two examples

Line 171 – “governing hazards” –confusion between adverse events and hazards (see above comment line 144)?

We have replaced governing hazard with event.

Line 209 – the fact that lower tidal range mean higher sensitivity to SLR is clear but why this precise threshold of 2m here?

Adjusted

Line 337 – some figures are available on www.eurosion.org (2004)

We imply in peer reviewed papers

Line 342 – reference needed.

We removed this sentence

Line 463 – the sentence is not clear to me (?)

We have rephrased the paragraph, and we are confident that it reads better now.

Line 498 – Figure 7 – on this figure it is not very clear what the pathway is.

With coastal erosion it is hard to clearly show the pathway in an illustration. However, it is the pathway by which water gets to the base of the cliff, and so is impaced by the state of the tide, width and slope of the beach. Also, if there is a big cliff fall, sediment can lie on the beach for many months, preventing further erosion, as illustrated in Figure 3.7.

Line 534 – “Earth Observation” may refer to satellite and in-situ monitoring – suggest to change to Earth observation from space or similar.

Done

Line 545 and around: important to mention that erosion in www.eurosion.org can be assigned to coastal cliffs retreating at about 20cm a year in average, well above the detection threshold of Luijendijk et al 2018 – therefore the two datasets can not be compared.

Here, we are not comparing the two studies on erosion rates. The comparison is only made on the occurrence of sandy beaches (in %); see lines 552 “Analysis on satellite-derived sandy beach detection reveals that about 35% of the European coastline is sandy, which agrees largely with the 40% Eurosion estimate (EUROSION, 2004).” We agree with the reviewer that comparing erosion rates would not be appropriate given the accuracy of SDS, coastal types included, and different time frame.

Line 554 – Figure 8 –this type of representation has the problem that points are superimposed, so it is very difficult to visualize anything. Furthermore the precision of the dataset is low (0.5m/yr) – in some areas e.g. upper Normandy – rates of 0.2m/year are causing trouble for land use planning and human security. One way to simplify the figure and give justice to the dataset would be to plot only hotspots, that is areas with large erosion rates (e.g. larger than 1m/year)

Thank you for the suggestion, we agree and we improved the figure such that is show the hotspots only.

Line 569 – I think this assumes no geological constraint – see Thieblemont et al 2019

We have added some lines on the geological constraints and control from 580-585 addressing this remark.

Line 574 – this is without protection and without consideration of geological constraints (unerodible layers beneath the beach) – TBC

We have added some lines on the geological constraints and control from 580-585 addressing this remark.

Line 632 – Figure 10 – suggest to add arrows to define precisely where is the source, the pathway and the receptor in this figure – note also that this assumes a porous, homogeneous and unconfined aquifer (e.g. not the case in many aquifers in southern france for example). Figure 11 shows some more complexity.

These figures are meant just as an illustration. We would prefer to leave it as it is.

Line 758 – The study is in Vietnam. In Europe river bed sand mining is quite strictly regulated by e.g. the water framework directive, isn't it? Is there any message applicable to Europe here?

The sentence has been removed.

Line 770 – Figure 10 and Figure 14 are quite similar – consider merging

Commented [CF1]: I do agree.

We agree and removed figure 3.14.

Line 776 – it would be good to cite work in Europe as it exists (see references in IPCC reports, e.g. Cooper et al., 2016…)

We added several references in the paragraph.

I hope this review is useful

Gonéri Le Cozannet, BRGM, 29/01/2024

Thanks Gonéri the answer is YES

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