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Discussions

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Interactive comment on "Modelling dependence and coincidence of storm surges and high tide: Methodology and simplified case study in Le Havre (France)" *by* Amine Ben Daoued et al.

Anonymous Referee #1

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The authors present a new method for quantifying the exceedance probability of extreme sealevels and compare it with two existing methods. One of these method is to directly sample extreme sealevels, while the other two methods indirectly construct the extreme sealevel distribution by applying a convolution between the astronomic high tide and either the skew surge or the maximum storm surge within a 12h window around high tide.

I fully agree with the authors that characterizing extreme sealevel distribution is of utmost importance to estimate coastal flood hazard and in this regard I find the idea conveyed by the title a relevant scientific and technical question. However, after read-

ing the manuscript, the reader is left with more questions and suggestions on how to study the dependence and coincidence of storm surges and the tide than answers. Therefore, I would not recommend publishing the manuscript in this current state unless some extensive extra work and analysis are performed. I also found the text hard to follow and I would suggest that the authors restructure their manuscript and carefully review the text for grammar and spelling mistakes.

General comments:

Too many details are sometimes given in points that are not further elaborated upon in the manuscript and on the opposite some critical information on the methods is missing. For example, the authors start the manuscript by discussing about nuclear power plant but this is not discussed further in the text other than they should not change the reference method. This seems to discredit the whole idea behind the need to compare and discuss different methods.

In the introduction, the authors discuss at length different types of other hazards happening in coastal areas (pluvial, fluvial floods) but this is not further looked into in the paper. If I understood correctly, the present study is on extreme sea levels and therefore extensively discussing about pluvial and fluvial floods seems out of the scope in my opinion. Similarly, it was not clear to me why the authors present in Table 1 the rainfall datasets if this is not used in this study.

There may be a general point to make that including statistical dependence is important to include when estimating (coastal) hazard but I am not sure why the authors put so much emphasis on this point if they don't themselves assess this statistical dependence in their selected case study. Throughout the paper, it is assumed that the tide and storm surge are independent but the authors never report on the validity of their assumption by reporting this statistical dependence. A good example of locations where this assumption might or might not be correct is given in Sterl, A., van den Brink, H., de Vries, H., Haarsma, R., and van Meijgaard, E.: An ensemble study of extreme

storm surge related water levels in the North Sea in a changing climate, Ocean Sci., 5, 369–378, https://doi.org/10.5194/os-5-369-2009, 2009.

At multiple points in the paper, the authors successively mention that dependence is not important but also that it could be important. These two statements, without further results or analysis, seem contradictory. For example page 3 – line 108-109: "Unlike to what is done very often in the literature, the question of dependency is not essential at all to combine phenomena in the present work. Indeed, as mentioned in the introductory section, tidal signals and SSs are independent." and later page 8 –line 283-284 "It has also been suggested that the questions of coincidence and dependency are essential for a combined tide and SS hazard analysis. "

The authors state that the maximum storm surge (MSS) can happen randomly somewhere within the tidal cycle. Again as showed in Sterl et al. (2009), I would argue that this is not the case and that the timing of the maximum storm surge is often closely related to physical properties of the coastal system. If this temporal dependence is present, I believe that the suggested method is likely to overestimate extreme sea levels

Table 2 and Figure 4 are not in line while I believe they should report the same values. When reading Table 2 for the 1000 year return period, one reads that MSS > ESL > SSS while when looking at Figure 4 the order is SSS > MSS > ESL. Based on my previous comment, I would suspect that the legend is Figure 4 was incorrectly labelled and that the highest curve shows the method based on the convolution with MSS.

In the discussion, the authors reflect on ways in which the possible dependence between the tide and storm surge and the timing between the latter could be included. The research presented here would greatly improve by actually doing these suggestions.

This paper would highly benefit from having more figures and analysis to make their point clear. For example, it would be interesting to see the studied time-series of Le

Havre, examples of extreme events, an analysis of the dependence between the tide and the skew surge and/or and/or the MSS and/or the ESL events.

The authors did not discuss nor report the effect of potential trends and jumps in the sea water level time series. They can greatly affect and invalidate the fit of the pdf and are often present in such time series.

Specific comments

The abstract would benefit from being more explicit: describe the three methods used and highlight some of the main differences (with numbers) and implications from these methods.

The extensive use of brackets makes the text at times hard to follow.

At the beginning of the results section, the authors present the R packages they used. In my opinion, this should belong to the Methods section.

Page 1 – line 11: "Tide and extreme SSs are considered as independent". Is this an assumption you made for this research or based on your results? If this is an assumption, then it seems contradictory to want to study the dependence but already assume that it is independent.

Page 1 – line 18: "It has also been suggested that the questions of coincidence and dependency are essential for a combined tide and SS hazard analysis." I would think that this is the question this paper is trying to answer.

Page 2 – line 53: "that the probability of failure (The probability of exceeding an extreme event)": Written in this way, it implies that the probability of failure is the equal to the exceedance probability and this is incorrect.

Page 2 – line 65: "SSS": At this point in the text, this acronym has not been defined yet.

Page 2 – line 71: "Salvadori and De Mechele". Please correct this typo for "Salvadori

and De Michele"

Page 3 – line 111:" On the other hand, it is commonly known today that the tidal signals can be predicted". Did the authors want to put the emphasis on the accuracy of the tidal predictions? Because the use of "today" implies that this is recent while this is actually known for some decades.

Page 4 – line 124: I think there is a mistake in equation 2 because fz(z) appears on both side of the equation. If I understood correctly, it should only be on the left-hand side of the equation

Page 4 – line 38-39: "Indeed, a SSS occurring with a high tide is more likely to induce a high sea level than an instantaneous SS occurring with any other tide." This statement is not clear to me. Can the authors elaborate to make their point?

Page 5 – line 150: "This feature makes the MSS a variable particularly useful for carrying out a PFHA exploring the entire tidal signal, not only the high tide ". If my understanding of the method is correct, each MSS value per tidal cycle is paired with the high tide value within this tidal cycle. If the MSS does not occur randomly within the tidal period, I believe this might highly overestimate your extreme sea levels which may not be useful for PFHA.

Page 5 – line 157: "As it can also be noticed for this reference procedure, the variable of interest would be the maximum sea level between 2 high-tide values. " Why do the authors mention "between 2 high-tide values"? Did you sample using a peaks over threshold method with some independence window criteria or using GEV?

Page 6 – line 187: please mention the final threshold selected, the resulting number of peaks used to fit the distribution in each case and add in supplementary the supplementary graphs.

Page 6 – line 193: "storm surge RLs": shouldn't this be water level return levels?

Page 6 – line 197: "with the delta method". Please briefly explain what is the delta

method and add appropriate references. I believe this is important since the authors go on to compare the width of the confidence interval.

Page 6 – line 218: " However, it should be noticed that extreme levels such as the MSSs may be only very weakly dependent." Can the authors elaborate on this sentence? I don't see why this would or would not be the case.

Page 7 – line 222: "This assumption is the most critical one since sea levels are highly non-stationary (due to the tide). " Shouldn't "tide" be replace with "storm surge" here?