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Discussions

Interactive comment on "Quantifying the effect of sea level rise and flood defence – a point process perspective on coastal flood damage" *by* M. Boettle et al.

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This paper proposes a stochastic approach to quantify the impacts of SLR for coastal flooding damages. The approach is based on the well established point process approach. One strength of the approach is the fact that it provides approximate analytic forms for the expectation and variance of the objective functions (here: damages).

The article is solid, and I think it is relevant to NHESS. I only have minor comments and suggestions. Mostly, these are (1) to provide more explanations/intermediate steps in the analysis, in order to help the reader follow the different steps of the analysis; (2) to precise (numerically) the domain of applicability of the formula found.

Section 1: introduction (this comment also applies to the discussion)

It seems to me that strength of this work is to provide approximate analytic forms to compute the expected damages and their standard deviations. Others may try finding similar quantities using a Monte-Carlo approach, for example by using the Poisson distribution to compute the number of storms and then comparing the water level given by the GPD with the critical threshold of coastal defenses. I think that the reader would be interested to read the author's opinion on the drawbacks and advantages of this approach.

Next, to integrate uncertainties on future sea-level rise (due to climate change) in the analysis, skewed distributions will be needed. Therefore, the expectation and standard deviation will not be enough to describe the uncertainties, and other moments of the distribution of the value of damages could be needed. Do the authors have ideas on how to address this issue? This could be a topic for the discussion.

Section 2: methods:

General comment: this section is solid. Although the methods are known, I think that some more explanations would be helpful for the reader, especially because some key references are not easily accessible for anyone.

Page 6233 Formula (1) holds for $(1+\xi(x-u)/\sigma)^{-1/\xi} > 0$ (?)

Page 6234 - The reference Embrechts et al. (1997) being not accessible (at least to me), I think a few explanations' would be useful to help the reader understanding how formula (3) is obtained. I suggest to do this by showing how $P(X > u|X > \mu)$ relates to Λ.

- I suggest to discuss the possibility that tides are altered by sea-level rise, and, therefore, that the sea-level distribution is not just shifted upwards.

- Are there chances that because of sea-level rise, we are no longer in the asymptotic domain?

Page 6234:

- Line 20: equation: indicate that n is the year? In addition, another "n" is used for the computational approach for estimating the integrals in equations 8 and 9 – I suggest to identify them differently. Section 3:Sea level rise impacts: should it be 'coastal flooding impacts" ?

Page 6237, line 21: this sentence is confusing (which mean sea-level and which μ is this?). In this section and in other parts of the manuscript, I suggest to distinguish water levels reached during a storm and the long term sea level rise trend

Page 6239 line 5: 5/7: I would be interested to read from which previous hypothesis this results comes: in practice, two storms with same water level return periods but different wind/waves directions patterns can affect different sectors in the city and cause different damages depending on the topography (I don't think that the world "orography" is appropriate here).

Page 6239 line 16: this is completely right. At one point, it could be useful for the reader to mention all sources of uncertainties of interest in this type of approach, including, for example, uncertainties on the parameters of the GPD functions that apply to each specific site, or uncertainties on future sea-level rise.

Section 4: application

I have the following points:

- The sea-level scenarios are mean or median projections, but real projections also include uncertainties (see my second comment in the introduction). I was wondering if the asymptotic behavior still holds by 2050 for the A1B scenario, and/or, if the authors could advice by which value of sea-level rise one should avoid using a GDP-Poisson approach.

- Considering Fig. 3, it is not clear to me why the threshold 100cm was chosen in Copenhagen (?)

- The values (in Euros or DKK) provided in figures 4 and 6 seem high to me (I am not familiar with the specific site). While it is presented in previous work, could remind how they get these figures from the damage function and discuss them?

- The number of significant digits should be reconsidered (e.g., "xmax = 215.28 cm" should be rounded)

- Page 6241, line 14-15: I understand that the expected and std damages are calculated by a monte carlo approach and compared to the asymptotic equations (14 and 15). Is that the case ? Note also that the text includes Fig. and Figure – should be made consistent

Section 5: the effect of protection measures; Section 6: Comparison with GEV; and section 7 discussions, are interesting.

Page 6245, line 10: actually, the method enables to identify situations where the water level is higher than the coastal protections. However, often, coastal flooding occurs just because of waves overtopping. The related damages would come in addition and can be considered by none of these methods.

Typo: page 6244 line 27: "i.e." (little i) (same issue page 6245)

Annex B

Several points are not clear to me:

- in many places, I am not sure that the hypothesis of large ω / σ or μ would be valid under actual values for flooding protection in many places. Figure 7seems to confirm this. For those interested in using the formulas of this article, it would be useful to add more details regarding the domain of applicability of the formula (in numerical terms).

- The authors chose not to mention integrals boundaries, in order to simplify the notations. However, it could facilitate the understanding of the demonstrations (especially theorem 2), since there are changes of variables and swaps of limits / integrals signs involved. I suggest also to write the exact version of the uniform convergence theorem that is invoked at least once, since it is key in the demonstrations.

- Annex B2 explicitly presents the Taylor expansions that are used to obtain the approximate formula. Similarly, it seems to me that in annex B1, equation (B2) could incorporate the Taylor expansion of equation (3) for large sigma. In addition, adding details on how equation B3 is obtained would help the reader (not clear to me).

As a general note, the Annex B is not easy to follow for readers, who, like me, have not been doing this type of maths since 10 years. I suspect that many readers of NHESS interested in this article could face similar problems in this section, so I strongly encourage the authors to make this annex as clear as possible.

I hope these comments are useful.

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