Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2019-353-AC1, 2020

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Spatial and temporal analysis of extreme sea level and skew surge events around the coastline of New Zealand" *by* Scott A. Stephens et al.

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Received and published: 28 January 2020

Also see attachment

Anonymous Referee #1 Received and published: 23 December 2019 GENERAL COMMENTS In this paper, the authors analyse sea level and skew surge extremes (values greater than the 5-yr return level are considered extremes) from 30 tide gauges around the coast of New Zealand. The objective is to characterise the frequency and magnitude of these extreme events andalsoestimatethecontributionofeachsealevelcomponent(tide,surgeandMSLA) to the sea level extremes. Sea level rise is not taken into account in this study. In my opinion, the manuscript is very well written, well struc-

tured, clear and easy to understand. However, I have one main scientiïňĄc concern and a few smaller issues that are explained below. SPECIFIC COMMENTS I have one main concern regarding the extremes' methodology: The authors say they use a GPD+POT model to obtain the return levels, but they deïňĄne POT as the 5 largest events per year (line 99), which in my opinion is the r-largest method and not POT. The POT method should keep a constant threshold through time and in this case it varies each year. I think that extremes selected with the r-largest method should be ïňĄtted to a GEV instead to a GPD, so I am not sure if the return levels obtained here are correct. Response: We did use the POT method with a fixed height threshold for each site but had not accurately explained it in the text, which made it appear as if we used an r-largest method when in fact we used POT. We have amended the text as shown below, to accurately describe what we did. For further confirmation, in Table 1 below we have also included the number of maxima exceeding the (1.69 m) threshold at Auckland, wherein the number of exceedances of the threshold is seen to vary year to year.

lines 115-116: It is difïňĄcult to extract this information from table S7, maybe those TGs longer than 50 yr could be highlighted or the table could be order by the TGs length instead of the site number? Response: Rather than refer to Table S7, we have added a new supplementary Figure S1 (other supplementary figures sequentially renumbered) which demonstrates how the SSJPM and GPD models are similar for extreme sea levels $\geq$ 5-year return period but the SSJPM generally better matches the larger outlying maxima in the longer records. Table S7: It is not clear to me what the "model percentile" means in table S7. Are 2.5% and the 97.5% the conïňĄdence intervals? maybe the table could be simpliïňĄed using the GPD or SSJPM values +- the conïňĄdence intervals?. Response: We have added a description to the caption to make it clear that 50% = median of the fitted distribution, 2.5% = lower 95th percent confidence interval, 97.5% = upper 95th percent confidence interval. Simplifying the table using a $\pm$ confidence interval is not possible because the confidence limits are not symmetrical about the median. We have simplified the Table to remove the GPD results, following review comments from Franck Mazas. Why is it that this information does not appear in table S8 for the skew surge?. Response: the SSJPM method cannot be applied to skew-surge, which is a component of extreme sea level. But we have now included the 95% confidence intervals for the skew-surge in Table S8. Thanks. Another main concern I have is that the return level estimations should not exceed 4 times the length of the observations (Pugh & Woodworth, 2014), since the longest TG is 120 yr, the 1000 return level is not reliable for any location. Maybe the reliable return levels, at each location, could be highlighted. Also, if sea level rise is not included, maybe there is no point in obtaining such large return periods. Response: This is a good point and so we have provided some guidance to temper the use of the return level estimates. Using GPD the reliable return levels are about 4 times the record length, but this can be about 10 times the record length for joint-probability methods (see Haigh et al. 2010). Therefore, immediately preceding Table S7, we have added a paragraph to guide the use of Table S7, which says: "Table S7 presents extreme storm-tide return period height estimates out to 1000-year return period. Whereas direct GPD estimates are generally only reliable for return periods up to 4 times the record length (Haigh et al. 2010; Pugh & Woodworth, 2014)†, joint-probability (e.g., SSJPM) estimates can be statistically reliable to about 10 times the record length (Haigh et al. 2010). The record lengths are included in the table to guide the use of extreme storm-tide return period height estimates. For example, the 6-year record length at Whangaroa up to 50-year return period using the SSJPM." We note that return periods are surrogate for probability of occurrence, e.g., 1000-year return period is equivalent to 0.001 annual exceedance probability. Return periods (aka probabilities of occurrence) should not be confused with time periods over which sea-level rise might act. There are several papers showing that show (even quite small) sea-level rise will dramatically change the probability of exceedance of sea-levels reaching a fixed height relative to a land-based datum, but it is still relevant to provide low exceedance probability sea-level height estimates at present-day mean sea levelâĂŤquantifying how these exceedance rates could change (e.g., Hunter 2010, Sweet & Park 2014, Stephens et al. 2018) is an extra

step beyond the present research paper. lines 134-135: I am not sure if I understand: Some of the 155 SL extremes are not independent, so after keeping only those separated more than 3 days, it results in 85 independent events, is that right? (same for the Skew surges?). Also, which methodology (GPD or SSJM) is used for obtaining the return periods in table S2 and S3?. Response: We have rearranged the text to clarify, as below:

Response: The captions of Tables S2 and S3 now describe which method was used. Thanks. line 163: from ïňĄgure S2 I am not able to infer those values. For example, the ratio for station 18 should be aprox. 1.2m/2m, right?, but ïňĄgure S2c reads ratio equal to 1. Response: In plot c we had mistakenly plotted maximum skew-surge / MHWS-7. This has now been corrected. Thanks. lines 169-170: Are those equations used somewhere else? what info can we infer? maybe they are not needed? Response: The equations are not used elsewhere in the paper but might be of relevance to a user conducting local studies within NZ, so we prefer to leave them as is. ïňĄgures S3b and S4a shouldn't be identical? Response: Figure S3b and S4a (S4b and S5a in revised supplementary information) shouldn't be identical and are not identical. S3b shows high tide at Auckland and S4a shows mean storm-tide elevation throughout NZ. ïňĄgures 7a and S7a shouldn't be identical? Response: We deliberately reproduced Figure 7a within Figure S7a for comparison with Figure 7b, to enable the reader to make a quick visualisation of the impact of MSLA on the seasonal distribution of extremes, without having to flick back to the paper . lines 252-254: I am not able to extract this information from ïňĄgure 8a Response: The information can be inferred from Figure 8aâĂŤthere are no events (blue dots) falling within 4–10 days on the y-axis? Haigh et al. 2016 conveyed similar information using the same type of plot (Figure 6, Haigh et al. 2016). line 269: maybe this event could be highlighted in ïňĄgure 3a Response: We have altered the text as per below to point to the event in Figure 3a. We have also updated the numbers relative to those originally transferred from Stephens et al. (2014) to report skew-surge instead of storm-surge and have updated the value for MSLA (Stephens et al. 2014 used a wavelet filter rather than a 30-day running average).

TECHNICAL CORRECTIONS Figure 4: x-axis is MHWS or MHWS-7?. y-axis is extreme sea level? I think storm-tide is not deïňĄned in the paper. Response: We have re-labelled the axes. Storm-tide is now defined in the first paragraph of the Data and Methods section. line 219-220: September-December? Response: Correct, thanksâĂŤtext amended to September–December. line 221: April-July? Response: March–July are consecutive months that have higher monthly occurrences of ≥5-year ARI skew-surges than any other month line 228: April-July? Response: March–June is correct based on the peak of the mean annual cycle (not shown).

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-353/nhess-2019-353-AC1-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2019-353, 2019.