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Natural Hazards and Earth System Sciences
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Discussions

Interactive comment on "Updating knowledge of cyclonic wave hazard for Tahiti and Moorea Islands (French Polynesia) through a probabilistic approach" *by* S. Lecacheux et al.

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Comment 1:

The probabilistic approach to the cyclone modelling is fundamentally flawed, and this compromises the results and conclusions of the study. The problem occurs due to the bootstrap resampling and the re-modelling of cyclones along existing tracks, but restricted to +/-0–1° latitude offset. This effectively reproduces the cyclones with the largest impact on the islands multiple times, along similar track corridor. The method used is highly reliant on the fact that a single intense cyclone (Veena?) passed within

+/-0–1° of the islands (as in RHS of Fig 7). The bootstrap technique then generates a corridor of Veena storms impacting the northern face of the islands. Had this cyclone been more than 1° away then calculated extreme wave climate would have been much different. Likewise, had this cyclone taken a different angle past the islands then the calculated spatial exposure of the coastline might have looked significantly different. This is discussed by the authors on p. 740. It is impossible to accurately calculate a frequency–magnitude relationship for extreme cyclone waves using the presented method. Accordingly, the authors recognize that the absolute values of the extreme wave heights are compromised, suggesting instead that the results be used to "nuance" the previously calculated 100-year ARI Hs = 12 m (Des Garets 2005). "Nuance" might have been achieved by simply simulating a design cyclone travelling past the islands on several justifiable pathways. The probabilistic cyclone modelling is overly complex and misleading and not justified for the "nuance" purpose to which it is applied, and should be omitted. The paper requires revision along these lines before publication in NHESS.

Answer to comment 1:

We agree with the referee on his comments. As it is explained in the paper (section 3.3 and discussion), the values of SWH100 calculated in this study should be considered only as approximations because of large uncertainties embedded in the proposed methodology. However we think our method and results are still interesting. Indeed, our main goal is not to nuance the previously calculated 100-year ARI SWH=12m (Des Garets, 2005). It is more general as highlights the title: "updating knowledge of cyclonic wave hazard. . .". In the paper, we are interested in characteristics of both frequent and rare cyclones. That is why we consider the 10-year return period and not only the 100-year RP. Nevertheless, we acknowledge more clarity is needed in the paper to avoid confusion. In that light, we believe our probabilistic approach based on bootstrap resampling is justifiable:

-As mentioned in section 3.1, the restriction to [-1° +1°] latitude and longitude offsets has been motivated by two main reasons: i) the possibility that a historical cyclone passing west of the island (for example) could very well have passed east of the island (the width Moorea-Tahiti is about 90km, a little bit less than 1°) ; ii) 1° is of the order of magnitude of differences one can notice between the position provided by two databases for a same cyclone. We can mention a third reason which is we did not extend more than 1° because we wanted to keep the native spatial distribution of cyclone over French Polynesia.

-As a result, cyclone Veena which passed very close to East Tahiti can be bootstrapped and generate synthetic cyclones passing right through the island. Our hypothesis is that such trajectories might have happened instead of the historical ones and could happen in the future. So if we had just considered historical cyclones, we would have missed important and very impacting cyclonic tracks, and we would have underestimated the risk (see discussion).

-We agree that the obtained values of SWH100 are very uncertain because as it can be seen in Fig 7, tracks associated with 10-100-year return periods and affecting the northern, eastern and southern sides of the islands, are essentially "bootstrapped Veenas". That implies the estimated parameters of the GPD are very influenced by those "synthetic Veenas" and we may reasonably question the results validity, as highlighted by the referee. This point is dealt with in the discussion but we agree it could be more developed. In particular, we could insist on the Veena's influence on results and talk about reference values or maximum values (based on the historical dataset) rather than 100-year ARI SWH. Our set of cyclones consists indeed of 132 years of data. Therefore, the values of SWH100 calculated on each site are very close to the maximum obtained. Should we have more synthetic cyclones (based on the same generation method), those values would not change much. By giving only approximations for SWH10 and SWH100 (Fig 6), we believe these values are representative of what cyclonic wave hazards (rare and more frequent) are on the two islands.

-In Fig 7, we see that tracks associated to 0-10-year RPs are very different whatever

the side of the islands. This suggests that the problem identified for 10-100-year RPs (multiple similar bootstrapped cyclones) does not apply here. We thus believe the derived values for 10-year ARI SWH are valid. Indeed, the historical dataset alone consists of 33 years of data, indicating it is adequate to estimate 10-year ARI SWH. The proposed bootstrap resampling allows enriching the dataset and a better estimation of those values.

-The bootstrap resampling also enables us to identify clearly which types of trajectory influence much the sides of the island for the two types of cyclonic wave hazard (rare and more frequent; see section 4.2). This would not be possible by considering only the historical cyclones.

-Finally, the proposed method (bootstrap+statistical analysis) allows dealing with extraction points around the islands (Fig 3) in a systematic and homogeneous way, leading to consistent variations of SWH10 and SWH100 along the coasts. This would not be possible by working with a single design cyclone as suggested by the referee.

In conclusion, we agree with the referee that, by giving approximations of SWH100, we want to nuance the previously calculated 100-year ARI SWH=12m (Des Garets, 2005). If that was our only goal, we would follow the referee's suggestion of simulating a design cyclone travelling past the islands on several justifiable pathways. However, our main objective is more general. We are interested in both rare and more frequent cyclonic wave hazards on those Pacific islands. We give approximations for the corresponding SWH but we also interpret and discuss types of impacting trajectories for each hazard frequency and each island side. This goal can be achieved with the proposed bootstrap method combined with a statistical analysis. We agree precisions and clarity are needed to better describe our goal and to insist on the limits of the method, especially for 100-year ARI values. In particular, we propose to talk about reference values or maximum values rather than 100-year ARI SWH to avoid confusion and misinterpretations of the results.

Comment 2:

The modelling approach and some of the manuscript text suggests that the authors ideas have been influenced by the 2011–12 Cook Islands study “Climate change impacts on coastal inundation at Oneroa village, Mangaia”, which employed a similar mixed cyclone/swell wave modelling approach. If this is the case then the authors should reference that study appropriately.

Answer to comment 2:

The authors did not know this study but it can be added in the references.

Comment 3:

The swell wave analysis is incomplete, and it is not clear why only southern swell waves have been included. Northern Hemisphere storms can generate significantly large swell also. For example the December 2008 northern hemisphere swell caused severe inundation in Kiribati, Marshall Islands, Micronesia (Federated States of), Papua New Guinea, Solomon Islands. In December 1969 two storms in the north Pacific 40–50°N generated swell of 4– 6 m height that travelled over 7000 km to the south and impacted Tahiti. For completeness, the swell wave analysis should also consider waves approaching from the northern hemisphere.

Answer to comment 3:

The results presented in the article are part of a more general study on cyclonic and seasonal wave hazard in French Polynesia. In this initial study, a complete analysis of seasonal waves was performed on several points around the islands (including trade-wind waves, southern swells and waves from Northern Hemisphere). It pointed out that for the different return periods, cyclonic waves were higher and longer than all types of seasonal waves except for the southern part of Tahiti, where southern swell were longer. Thus, as the scope of the article was voluntarily centered on cyclonic wave hazard, we decided to present the results of southern swells only. However, the

analysis of the other types of waves can be added in the article to provide a more complete view.

Comment 4:

10-years of wave hindcast data is insufficient to calculate a 100-year ARI Hs. This is not just due to statistical uncertainty in fitting the GPD model, but is caused by climate variability that has cycles longer than 10 years (e.g. the 10-year hindcast might be unusually benign or severe, e.g. the 1969 event). A usual extrapolation period is 3–5 times the record length (Coles 2001), leading to 50-year ARI. If more data are not available, then the authors should at least discuss this uncertainty and put it in context. Standard hindcast lengths are 30-40 years?

Answer to comment 4:

Global hindcasts such as ERA-40 provide long time periods of data (up to 40 years) but their temporal and spatial resolution are to coarse to properly reproduce extreme waves that are often underestimated. Furthermore, the resolution of global hindcasts or reanalysis does not enable to take into account the numerous small islands hampering the propagation of distant swells throughout French Polynesia. On the contrary, the IOWAGA hindcast is performed with a higher resolution model (from 0.5° to 0.05° around the Society Islands) and an island blocking scheme. The swell events are thus supposed to be far better reproduced than in other datasets. That’s why this dataset was chosen despite the short time series available (10 years of data available when the study was performed). However, we acknowledge that the choice of the dataset and the related limitations should have been discussed in the paper. Since then, the data of the IOWAGA hindcast have been completed and 17 years of data are now available for the 0.05° resolution grid. The analysis of seasonal waves could thus be updated with this data.

Conclusion and propositions:

In conclusion, the authors propose two solutions to satisfy the requirements of the referee:

1.Without changing the scope of the article, the text can be corrected following the suggestions made in the responses to the comments: clarify the goal of the study, insist on the limits of the method, and talk about reference values or maximum values rather than 100-year ARI SWH. The complete seasonal wave analysis performed with the updated IOWAGA hindcast can also be added.

2.If these suggestions are considered insufficient, the paper can be reoriented to present (1) an analysis of the impact of historical cyclones and a design cyclone with several justifiable pathways (2) the complete seasonal wave analysis performed with the updated IOWAGA hindcast. In this case, considering the work it would imply, another manuscript will be submitted later on.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 725, 2014.