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Interactive comment on "Simulating Synthetic Tropical Cyclone Tracks for Statistically Reliable Wind and Pressure Estimations" *by* Kees Nederhoff et al.

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Rebuttal letter manuscript "Simulating Synthetic Tropical Cyclone Tracks for Statistically Reliable Wind and Pressure Estimations"

Dear editor, dear reviewers,

On the July 31, 2020, we have submitted the following manuscript to the Journal of Natural Hazards and Earth System Sciences titled: "Simulating Synthetic Tropical Cyclone Tracks for Statistically Reliable Wind and Pressure Estimations" (MS No.: nhess-2020-250). On the October 7, 2020, we were informed that the open discussion was

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Discussion paper

completed. In total, we received comments by two reviewers which provided a very positive feedback on the work done and valid suggestions. We would like to acknowledge their time and efforts, which have led to an improvement in the quality of our manuscript. Below you find a point-by-point reply to all specific questions and suggestions. Attached you also find the revised manuscript with the changes made to address the review comments tracked.

Kind regards, Kees Nederhoff — Anonymous Referee #1

General Comments:

1. An important limitation that I see in the applicability of this approach for studies on climate changes, is that it does not consider explicitly variables like SST in the cyclogenesis. Hopefully, this limitation will be overcome in future releases

We agree with the reviewer that climate change studies are of vital importance to our research field. TCWiSE does indeed not consider SST in the cyclogenesis but it can be used to study the effects of climate change using data from for instance IPCC studies on changes in the intensity and/or frequency distributions (Page 9 Lines 5-10; later in this rebuttal will be referred to as P9 L5-10).

Specific comments

1. p2, l8: how reliable are very old data? Can we assume that the frequency of TC 100 years ago was similar to that of today? The tool at the moment assumes stationarity, with historical data being assumed to describe the current climate. As stated in the reply to the general comment above, it possible to take into account a heuristic implementation of a factor on both the frequency and intensity. In order to address the first question we have added a statement on the increasing quality of historical data to the introduction (P2 L10-13).

2. p2, l18: the term "heading" should be defined We have added the definition of heading (P2 L22).

3. p4, l8: it could be useful to add, in the future, 1st order estimations of the ocean variables as well. TCWiSE only computes TC tracks and winds. We have at the moment no immediate plan to include, within TCWiSE, the effects of these winds on other variables, such as water level and surface currents. TCWiSE does however support the creation of output file in a format that can be used directly in open source models (currently only Delft3D4 and Delft3D-FM are supported including flow and wave). In addition, TCWiSE does take the ocean variable SST into account to determine track termination.

4. p4, l16: "number of points needed per KDE" does not read well. You mean, the kernel size? Adjusted as suggested (P4 L22-23).

5. p4, l17: "The user can also define bulk ... climate changes." But to do so I should assume a dependency between TC frequency and climate variables such as SST, or build a further statistical model to infer it. I believe this would be better done inside TCWiSE, please consider it as a future development. TCWiSE is a purely data-driven approach, with no ability to simulate the TC generation physical processes. This means that this information needs to be input from other sources. At the same time, this can also be seen as a flexible aspect of the tool, since no assumptions are being made on the TC generation process.

6. p4, l25: .. poisson distribution ... this is not very clear. how do you define the poisson dist? monthy or seasonally?" Annually and monthly. The Poisson distribution is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time or space if these events occur with a known constant mean rate. In TCWiSE, a Poisson distribution is being used for the number of events per year, with the distribution of events during a year being estimated based on a KDE of historical data (see also P4 L30-32 and P5 L1-4 and last paragraph of Section 2.3).

7. p5, l6: .. sea surface temperature (SST) .. I guess SST is somehow estimated by

TCWiSE? How? SST is an input variable. In the presented application, the SST data are extracted from the 1-degree resolution, worldwide monthly average SST map from the International Research Institute of Columbia University (2017) (see also P7 L14).

8. p5, l12: "last track". How does the algorithm decides that it has to generate nothing else? At the end of its time horizon The number of tracks to be generated is also an input variable, more precisely it is determined by multiplying the average number of tracks per year (based on data) with the number of years we want to generate tracks for. We have added additional information to the MS (Section 2.2 item 8).

9. p5, l16: "create wind swaths", in fig 1 it is said that is done by means of POT GPD. would you clarify how? Wind swaths are created based on either non-parametric and/or parametric estimates of the spatially-varying (extreme) wind fields. Non-parametric estimates are determined using the empirical distribution of the collected historical peak (POT) data, the parametric estimates are determined by fitting a GPD distribution to the historical peak (POT) data (see also P5 L24-29).

10. p5, l16: The difference between wind swaths and maximum wind is not very clear. Wind swaths are spatial maps of the maximum (computed) wind speeds per TCs. Hence, they are the same thing. The difference with spatially-varying wind field maps is that these maps have a timestamp. For example, for a 7-day long synthetic TC, we will have 7x8=168 (assuming hourly data) wind speed maps. If we take the maximum of all those maps, we will get the wind swath or maximum wind speed map of that TC. If we do a similar approach to all the synthetic TCs we can start associating probabilities to each wind swath since we have saved this information per grid cell. A more sophisticated approach would be to fit a GPD to the data (i.e. maximum wind speed per TC per grid cell). See also Section 2.2 item 8 where we explain this in the MS.

11. p7, l4: "temporal variability of genesis locations or other input parameters are included in the tool" but you mentioned earlier that a Poisson dist is used to model the

seasonal dependency (how?) We understand the question and agree that the reasoning was not clear in the previous version of the MS. We have changed our explanation in the current version of MS (see P7 L16-20).

12. p7, l9: "Genesis location in ocean surface temperatures less than a user-definable value .." this sentence is not well formulated We have rephrased the sentence following the reviewer's comment (see P7 L12).

13. p7, l23: "The KDE that is sampled are constructed for each grid point based on input data within a specific search range." this sencence does not read well We have rephrased the sentence following the reviewer's comment (see P7 L29).

14. p8, l25: "... not completely similar to the historical ..." maybe this could also depend on the way the termination in historical data is defined? Do all the agencies define the TC termination in the same way? For historical data, termination is defined as the last point of the TC track. TCWiSE can be run purely on historical termination which will result in almost an identical synthetic termination probability compared to historical. However, in TCWiSE it is also possible to add environmental factors to impose TC termination (e.g. wind speed or SST). This is the main source of deviations between synthetic and historical termination.

15. p8, l30 & p9, l3: see my previous comment for p4, l17 See our reaction to specific comment #5 above.

16. p9, l11: wind swaths: it is still a bit unclear what the wind swaths are and how you do generate them - on what variable is the GPD fitted? See our reaction to specific comment #10 above.

17. p11, l30: "MAE": you mean, the MAE between historical and TCWiSE cdf? Please clarify We have added the definitions of MAE and nMAE (see P11 L29-33).

18. p11, paragraph 3.3.1: I would suggest adding formulas with the error indicators used See our reaction to specific comment #17 above.

19. p12, l15: "the genesis patterns ..." this sentence does not read well figure 4: "is the maximum wind speed per TC and not the same as the wind field and/or wind swaths" again, the difference should be explained We have rephrased the sentence about genesis patterns (see P12 L14-15). Moreover, we have added an explanation of the difference between the intensity of the TC eye and wind swaths.

20. p15, l9: "for example" looks out of context Removed. (see P15 L9).

21. p15, l9: the TCWiSE bias of c vs historical looks generally slightly negative. Is it only in this case? Based on our experience on the use of TCWiSE in the Western Pacific Ocean and North + South Indian Ocean, there are no clear biases in terms of the forward speed that are always either positive or negative. The only tendency we noticed is an overestimation of wind speeds at land stations. This is arguably due to the lack of roughnes effects, with the synthetic tracks being largely above water conditions.

22. figure 7: the scale looks in radiants rather than in deg Thank you for noticing this. We have changed this figure in the current version of the MS.

23. figure 8: the bias in TCWiSE max wind looks slightly positive. Is it a systematic tendency or is it random? See our reaction to specific comment #21 above.

24. p19, track termination. To what extend may these differences depend on the uncertainty of historical data on track termination. Differences in track termination between historical and synthetic tracks are compounded over the duration of the simulation. This means that uncertainty in TC track also is partly responsible for the error in the track termination (see P19 L2-14)

25. p20, l7: estimates *of* TC winds We have changed this in the manuscripts, thanks for noticing.

26. p21, l2: How many TC were used for the estimation of the extremes on the historical? How do you ensure the extremes on the historical are compatible with the ones on the synthetic tracks? We have used a total 10 000 years of synthetic TCs in the ex-

treme value analysis. In particular, per grid cell, we have saved maximum wind speeds per TC. Subsequently, using a peak over threshold (POT) method selected a limited number of peaks to fit the Generalised Pareto Distribution (GPD). The historical data are used to create the synthetic tracks which ensure that both are compatible (see P21 L1-3).

27. p21, l5-9: the authors should mention here that the large differences are due to the differences between the historical, used to fit the model, and the observations. They should also mention, earlier, that the historical data are model data, and not observations We have changed the wording slightly in order to emphasize this point (see P22 L2-5).

28. p24, l10: "this makes TCWiSE also more sensitive to input errors compared ...", unclear why this should be: the algorithm used by other authors may as well be sensitive to input errors The reviewer is correct. The point that we are trying to put across is that because TCWiSE is relatively user-friendly, compared to pre-generated global synthetic TC databases, there are more steps involved and therefore room for more user errors.

29. p25, l2: ".. using datasets derived by global climate models .." you mean, CMIPX? How? These models are quite unable to represent properly the TCs. That's a reason why statistical tools like this can come in handy Although TCWiSE can accurately generate high-resolution wind fields it depends on other sources for the definition/determination of the TC genesis, propagation, intensity, and frequency distributions. What we are here stating is that one can use data from Global Climate Model (GCM), such as are being generated by NCAR and GFDL, to infer changes in TC patterns (as done by Knutson et al., 2010) and use these as input. We agree that GCM models often lack resolution and that statistical tools could also be used (e.g. in conjunction with GCM model) to more accurately project changes in the TC distributions. All this together would lead to the generation of more accurate extreme wind field projections by TCWiSE.

30. p25, l20-22: this sentence is a bit unclear and full of repetitions We have changed the wording of this sentence (see P25 L22-24).

31. p25, l25: " It does seem however that synthetic TC tracks have a less clear southwest-"from what do you see this? We have revised and deleted this sentence.

32. p25, l27: subtitute Jetstream with "climate dynamics" We have changed this in the manuscripts, thanks for noticing.

33. p25, l30: "These differences can be attributed to the fact that TC termination can get triggered by ..." this sentence does not read well We have changed the wording of this sentence (see P26 L1).

34. If the tool is open source, I believe it would be useful to provide a link to a code repository After acceptance for publication, we will make the source code publicly available.

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