

We would like to thank the reviewer and the editor for the time of reading this manuscript and giving suggestions and inputs. Here is our response. The comments of reviewer and editor are in black ink, and our response follows in bold and blue ink. When applicable, the changes made in the manuscript are inserted in italic.

Response to Referee #1:

The article entitled "Track-dependency of tropical cyclone risk in South Korea" by Nam et al. addresses the issue of including cyclone tracks as the bridging factor between exposure and actual impacts of tropical cyclones. The article introduces the main problematic in the first section explaining the distinction between "active" hazards (e.g., rainfall and wind surges) and "potential" hazards (tropical cyclone intensity). Then, an extensive presentation of the datasets, tools and methods that the authors used is followed by a discussion of the results after applying a tree decision method that the authors propose for evaluating cyclones hazard. The method introduced in this paper seems to provide meaningful results when applied to the Korean peninsula and I would recommend the article to be published in NHESS.

My only major concern goes on the presentation and organization of the manuscript. In several parts, I found that the text is repetitive on the arguments and methods and thus less attractive to the reader. Furthermore, my opinion is that the results section is too long and difficult to follow. It should be divided to subsections in order to ease the reader with better articulation of the main findings. Finally, although understandable language could be improved.

Reply) Thank you for your comments. We have revised the entire manuscript to clearly suggest the importance of track in TC risk analysis. We divided the result section into two subsections: 3.1 TC hazards and risk of different track types & 3.2 Importance of track in TC risk analysis following the reviewer's suggestion. To improve English expression, we also got the English grammar correction service before the submission.

I would also recommend to the authors to include a discussion on the potential application of their method to different regions. It seems that the number of track clusters is detrimental for the complexity of the decision tree. Is the applicability of their method jeopardized if e.g. a broader region with complex geographical and exposure issues is taken into consideration?

Reply) Thank you for excellent idea! Although we are afraid that this is out of scope of our study, we indeed agree to the reviewer's suggestion. Hence, we just made some discussion on possible difference in importance of track in TC risk between countries as follows.

"On the other hand, the importance of track may differ by country because topography among the three factors suggested is not identical. If a country has major

mountainous area like South Korea, track information may become more important, and vice versa. The dependence of track in TC risk over Southeastern United States, for example, in which there is little mountainous area, may be less important than that of South Korea. As a future study, we would compare role of track in TC risk between countries having different topographic conditions.”

Response to the Editor:

This paper shows that for tropical cyclones affecting South Korea, track is the main factor responsible for damages, being more important in a decision tree analysis than other factors such maximum wind speed or minimum atmospheric pressure level. However, the manuscript needs to be extensively revised for being published. English (though understandable) needs to be improved, many sentences to be rephrased, several paragraph, in particular of the “Results” section to be better focused, figure captions to be more explicative, many typos to be corrected. Further the “Summary and conclusions” section does not deliver the main outcomes of the paper in a clear, direct and concise way. May be better to split it in two sections: ”Discussion” and “Conclusions”

Reply) Thank you for this comment. We have revised the entire manuscript to clearly suggest the importance of track in TC risk analysis. We made summary and conclusions section much more simplified to better deliver our main idea instead of splitting it into two sections. To improve English expression, we also got the English grammar correction service before the submission.

Moreover, it should be discussed whether this strong sensitivity of the risk on the tracks is a general characteristic of tropical cyclones or a peculiarity of the South Korea territory, depending on its characteristics in terms of morphology, land use and exposure. Tropical cyclones in the Gulf of Mexico hitting the southern United States would exhibit a similar dependence on their track position?

Reply) As we replied to the reviewer #1’s comment, this is an excellent idea to discuss whether the strong sensitivity of TC risk on track may vary by regions. While we cannot explicitly suggest if the southern US would exhibit a similar dependence on tracks or not, but it is likely different from South Korea case. This is because there is little mountainous area in southern US than South Korea. We made some discussion on possible difference in importance of track in TC risk between countries as follows.

“On the other hand, the importance of track may differ by country because topography among the three factors suggested is not identical. If a country has major mountainous area like South Korea, track information may become more important, and vice versa. The dependence of track in TC risk over Southeastern United States, for example, in which there is little mountainous area, may be less important than that of South Korea. As a future study, we would compare role of track in TC risk between countries having different topographic conditions.”

The difference between the tracks of the (west and east) cyclone clusters is about 250km. Is this difference sufficiently large to be predictable for an individual cyclone in advance? How many days before reaching South Korea? Authors mention that uncertainty in track of future

projections should, therefore, be accounted for. Is this distance among clusters larger or smaller than uncertainty of projections? In there any indication of such a change for South Korea?

Reply) The 250-km distance is not long considering that average errors of track forecasting in the western North Pacific are about 200 and 400 km for 24 and 48 hours, respectively (Roy and Kovordanyi 2012). Hence, this high sensitivity of damage on track shown in Fig. 3 suggests that the current skill of TC track forecasting may not be enough to exactly estimate TC risk distribution over South Korea in advance of 1 day and over. We added the related explanation in the revised manuscript as follows.

“Although the average zonal distance between the mean tracks of east-types (i.e. east-short and east-long) and west-types (i.e. west-short and west-long) was only about 250 km, hazards (both potential and active) and damages caused by the TCs are significantly different depending on the four TC track patterns at the 99% confidence level based on the Kruskal-Wallis test (Fig. 3). This highlights the importance of track in TC risk assessment because the 250 km distance is not long considering that the average errors of track forecasting in the western North Pacific are about 200 and 400 km for 24 and 48 hours, respectively (Roy and Kovordanyi 2012). Meanwhile, the high sensitivity of damage on the track shown in Fig. 3 suggests that the current skill of TC track forecasting may not be enough to exactly estimate TC risk distribution over South Korea in advance of 1 day and over.”

In addition, we deleted the sentence on future uncertainty in the abstract because we did not explicitly look into that in the present study. Instead, we just discussed on it in the conclusion and discussion section as follows.

“Our results also suggest that it is necessary to consider possible large uncertainty in future TC risk projection because of high sensitivity of TC risk on track, as well as the lack of reliability of future projection of TC tracks (Knutson et al. 2010, Walsh et al. 2015).”

The supplement material contains three tables and a figure to support the description of the decision tree. However, the methodology for construction and validation of the decision tree is not described. I suggest to add a very short text describing it in the main body of the manuscript (in section “Material and methods”) and use the supplement for providing more information.

Reply) We have included the description on cross-validation method in the revised manuscript, and have provided the associated supplementary table (See the last paragraph of section 2.2.1 Data mining methods)

Here is a list of minor comments (which is no way meant to be exhaustive)

Reply) Thank you for the editor's helpful comments. We are sorry for not giving line-by-line responses, however, we have extensively revised manuscript including figure captions following the comments. We marked the changes associated with important reviewer comments with sky blue ink in the revised manuscript.

Page 7
line 2 "navigable"?

Reply) Navigable circle is a terminology used in meteorology. For readers who are unfamiliar with the term, we added explanation on it in the revised manuscript as follows.

"This can be attributed to the concepts of dangerous and navigable semicircles. In the case of west-type tracks, South Korea falls within a dangerous semicircle (right-hand side of the direction of TC movement), in which the TC translation speed and rotational wind field are additive, and hence strong wind speed is observed therein. In contrast, in the case of east-type tracks, the country is located under a navigable semicircle (left-hand side of the direction of TC movement), in which the TC translation is counter-directional to the rotational wind. Therefore, weaker wind speeds are found there than that in the dangerous semicircle."

Line 30 "Xie and Beni index, and Dunn index" should be briefly described

Reply) We briefly described them in the revised manuscript as follows.

"The partition coefficient measures how much overlapping the fuzzy clusters have, and inversely proportional to the average overlap between the clusters. Both of the partition and separation indices are computed by compactness and separation of the clusters. However, the partition index represents separation as the sum of the distances between the clusters while the separation index does as the minimum of them. The Dunn index is calculated by the ratio of the shortest and the longest distances of the two objectives within a same cluster. The larger partition coefficient and smaller partition index, separation index, and Dunn index create better clustering (for a more detailed explanation and formula of validity measures for the optimum cluster number, refer to Appendix B of Kim et al. 2011)."

Section CONCLUSION

In the text I cannot find a precise definition of Active hazard (it should be provided). Anyway, my understanding is that they are hazard that actually produce some losses, victims, accidents emergency. In such case the sentence at line 5-6 page 9 is trivial as it follows for the definition of active hazard .Pease explain better or deleted it.

Reply) We now define the different modes of hazard more explicitly at the first part of result section in the revised manuscript as follows.

*“In this paper, we adopted the hazard mode concept (**potential** versus **active hazard**) from the risk management field (MacCollum 2006). For the hazard mode concept, active hazard refers to a situation when “a harmful incident involving the hazard has actually occurred”, whereas potential hazard refers to a situation where “the environment is currently affected but not yet activated at a given place and time”. By this definition, we refer to heavy rainfall and wind gust induced at the local area by the TC as active hazards, and we consider the TC system’s minimum central pressure, maximum wind speed, and size over South Korea as potential hazards. These two modes of TC hazard (potential and active) are utilised throughout this paper.”*

Page 1

Line 6, delete “of”

Line 7 Rephrase the sentence.

Line8 comma missing before “while”. Delete “mainly”

Line 10 I suggest “to predict damage.” or “to predict the occurrence of damage.”

Insert “ ≤ 250 km” among brackets

Line 12 I suggest to replace “the other hazards developing from a potential to an active hazard” with “an hazard developing from a potential to an active one” But may be I do not understand the sentence. Please rephrase.

Line 14-15 “physical geography experience, duration of influence, and relative position of dangerous semicircle side of the TC”, this phrasing looks strange to me

Line 16, add comma after “modeling”

“risk modeling” or “risk assessment”?

What is meant with “trivial”?

Line 16 authors, apparently, in the final sentence of the abstract consider “error” and “uncertainty” as equivalent terms. In general they are not. Please explain better.

End of section 1: a description the content of the paper is missing

Section 2 replace “Materials and method” with “Data and methods”

Page 3 line 1, definition of TC size is unclear

Line 4 following, consist,

Line 5: “standardized to the value of money in 2005 and taking inflation into account”
Should”and” be replace with “by”? otherwise it looks a duplication of the same concept

Line 6 avoid repeating “collected”

Line 8 was including

Line 10 bad phrasing, The damage was likely indeed caused by waves, which in turn were caused by the TC

Line 16 bad phrasing. I suggest replacing “if there exist any” with “the presence of”
Probably “if” should be replaced with “whether”

Line 14 what is the “damage period”?

Line 25 delete “of”

Line 26 delete “of provinces”

Line 29 what is the “influence duration”? delete “also”

Line 31 rephrase “the range of duration was limited by the summation”. Sentence is not clear

Page 4

Line 1 “defined and distinguished” better “identified”?

Line 4-5 “influential” means having great influence on someone or something. This criterion does not account in any way for the size of the impact of the cyclone

Line 14 “more comprehensive” than what?

Line 18 replace “from” with “in”. “their intensity was above TS” replace with “their wind speed
was above the TS threshold”

Line 29-31 The explanation of the grouping criteria and why four clusters have been used is not

clear to me. What is here a validity measure? The definition of the used indices is missing

Line 26 replace “not for the whole tracks from genesis to disappearance, but for” with
“considering only”

Line 26-28 long sentence

I stop here with comments on the English form

Page 5

Line 16-17 what is meant here with stability and consistency of results? How was this checked?

Section RESULTS

Page 6

line 1 distance between types? How is defined the distance between two types

Line 11 “TC-based hazard ranking” on which variable is based? How is the ranking

computed?

Line 15 ... apparently a self-contradicting statement

line 11-12 sentence: ranking based on which quantity?

In my view the second paragraph not well focused. It addresses some differences between hazards rankings among clusters, between this and previous studies, and among hazards ...all together . please explain better

I think that “damaged “ or “undamaged” can refer to the territorial units, to the population, to the exposed goods, but not to a ”case”. The expression “damaged case” sounds odd to me

Third paragraph long and not well focused

Line 29-30 repetition

Section CONCLUSION

Line 11 “When local active hazard information is missing, TC track acts to bridge the information gap between the TC system and local risk” is not clear to me

FIGURES

figure 2

first and third quantile values are 0.25 and 0.75? please be specific

The sentence “The plotted whiskers extend to the adjacent value, which is the most extreme data point that is not an outlier.” is not clear

The panel G “property losses” seems to be inconsistent with the caption (in it there are no boxes, no whiskers 9 and an odd number of horizontal bars)

It is not clear which and whether differences among TC characteristics with reference to track patterns are statistically significant

figure 3

what is plotted here? the mean, the value of the centroid of each cluster? Infulence (typo), labels

on panels are not used (should be deleted)

Improve the caption to explain the meaning of panels and annotations

Figure 4

The unit used “billion (10⁻⁴%)” is not clear

Figure 5

the meaning of abbreviations used is not explained in the caption. May be replace “damaged” and “undamaged” with “damage” and “no damage”? or specify in the caption what is damaged or “undamaged”