Dear reviewers and editor,

First, we would like to thank you for the possibility to revise the paper HESS-2020-377 and for your consideration of its publication in Hydrology and Earth System Sciences. We greatly appreciate the careful reading of the paper and the constructive and precise comments that significantly helped to improve major portions of the manuscript. Main comments are raised from the historical damage analysis part, thus, we did major changes for it, especially in the Discussion part. We were keen to integrate all comments highlighted by the reviewers, evidenced by our comments on the reviewers' main points below. We maintained the order of comments as provided by the editor to facilitate reviewers finding their own comments.

Reviewer 1:

Thank you for the opportunity to review this manuscript. This study investigates the compound effects of storm surge and rainfall on coastal floods in China using gauged data from 11 tide gauges. It found that typhoon and sea level rise can potentially increases the frequency of compound coastal floods. In addition, the study attempted to explain the causes of compound events by investigating meteorological forcing. Finally the study concluded that there is a need to incorporate effect of compound floods in risk analysis and infrastructure design. This topic, the method used and the findings are not new. However, it does provide some insights into compound flood risk in China.

Response: Thanks for the comment. This is indeed the first time such a comprehensive study of compound flooding is carried out for coastal China; in addition to findings highlighted by the reviewer we also feel the results regarding the variation across seasons and regions are interesting and relevant.

I have a few comments and suggestions below for the authors to consider. 1. The authors stated that "To compare impacts caused by compound and noncompound events, we employ a typhoon database developed by Yap et al. (2015), which includes historical typhoon records from 1951 to 2012, ……The database contains information of 853 typhoons in total, with records of direct 115 normalized economic loss (in US$), death toll, and number of people affected". This implies that the authors defined compound coastal flood events as a subset of flood events occurred during typhoon events for impact analysis. Is this categorization correct? Did the authors imply that in China Typhoon is the only cause for compound coastal flood events? Are there any compound flood events occurred outside typhoon events? How the impact of the compound events outside the typhoon events are evaluated or are they included?

Response: Thanks for the comment. We agree with the reviewer that compound events outside the Typhoon season may be excluded, but also stress that in China, typhoon is the main cause for compound coastal flood events. As shown in the replotted Fig. 8a, all compound events (high storm surge and high precipitation at 98% thresholds) for Hong Kong were linked to typhoon records. If we assume 97% is the threshold, there were some compound events outside typhoon events. Not all those events lead to significant damages or the damages were not recorded. In this case, we would like to show the difference caused by compound and non-compound events, assuming that flooding was the main contributor to the damages or at least had a similar relative contribution to the damages.

Historical damage records are sparse and often unavailable to us; in addition it is of course tricky to match the damages to compound flood events. The reasons can be summarized into the following categories: 1) limited time series: most datasets we found have records after 1985. However, the observations are mainly between 1975 and 1997. It makes the damage record incompatible with observations. 2) incomplete information: most of them are annual flood damage records, with only one record for each year without information of occurrence time. It is not enough information to match the damages with compound events we extract from observations. 3) poor quality: global flood damage datasets (EMDAT for example) are too coarse to be useful for our purposes. Other datasets are raw damage reports without quality control. Thus, this dataset developed by Yap et al. (2015) is the most feasible for us to use at the moment.

The reviewer's comment has prompted us to reframe the way the damage dataset is considered, which includes changing some of the statements/conclusions we draw from it, and also moving it from the results section into a new discussion section, where we touch on some specific cases and the shortcomings outlined here (and in the next comment) are also addressed; we use this to highlight the necessity for better damage information to be made available and stress that our analysis is only a first step and could be used as a baseline in future research.
→See Section 5 Discussion Line 305-335 in the clean version.

2. The damages of compound flood events were assessed using the damages from the typhoon events. However, the damages of typhoon events are not only results of compound flood events embedded in these typhoon events, but also included damages from other effects of these typhoon events. How the impacts of other factors that are not related to compound flood events are isolated or are they included as part of the analysis?

Response: The reviewer raised a very good point, which is also pointed out by the third reviewer. We agree with the reviewer that typhoon damage records may also include effects like gale, storm surge, precipitation, etc. Unfortunately, there is no straightforward way to disentangle the fraction that each hazard contributed to the damage. Thus, we decided to still include parts of the damage analysis, but instead of showing it in the results we moved it to the discussion and explain the underlying uncertainties/issues.
→See Section 5 Discussion.

3. It is well known that the threshold selection will have an impact on the dependence analysis, as the authors showed with their results from the sensitivity analysis. Are there any insights derived from this sensitivity analysis that can be used for future analysis, apart from the fact that the results are sensitive to the threshold values used?

Response: Thanks for the suggestion. We tried to draw such conclusions in the beginning, but realized it is difficult to draw generalizable insights from this sensitivity analysis. It is very localized and highly dependent on the underlying data. There are other methods to represent bivariate extremes (e.g. Salvadori, et al. (2016), A multivariate copula-based framework for dealing with

hazard scenarios and failure probabilities. Water Resources Research, 52(5), pp.3701-3721.), which we didn't employ here as it would go beyond the scope of our study.
→See Section 4.1 Line 183-186 in the clean version.

4. For seasonal analysis "four periods are considered: typhoon season (July-October), summer (July-August), autumn (September-November), and whole year". Again, this is more related to typhoon events than the defined compound events.

Response: In this study, we select these three seasons to show seasonal variation. Our hypothesis is that there will be seasonal variation in compound flood frequency, with some coastal regions experiencing a greater dependency in summer or in typhoon seasons. We first sample all compound events, then select compound events which happened in these three seasons, to calculate their dependence. It helps to understand in which season the likelihood of compound events to occur is relatively higher.

5. Overall, there seems to be a varying definition of "compound flood events" used in the different analysis throughout the paper (e.g. sometimes mixed with typhoon events). This is not only confusing and can be sometimes mis-leading, e.g. for damage analysis commented above.

Response: Sorry for the confusion, in the revised version make it clearer why events are selected the way they are for the different analysis steps. Typhoons are the leading cause for compound flooding events and hence we pay particular attention to these. The point regarding the damage analysis is addressed in our responses above (and also in our comments for reviewer #3).

In addition, although various types of analysis were conducted (all of which have been used in previous studies), the manuscript lacks a central theme tying everything together– in other words, why the different types of analysis were selected (apart from the fact that they have been used in similar studies previously) and how they collectively contribute to the understanding of the specific problem under investigation?

Response: Thanks for the suggestion.
The reason for selecting different types of compound events depends on the purpose of analysis as well as sample sizes. The core definition could be seen in Fig. 2 in the manuscript. The reason for selecting Case1 and Case2 could been seen in Wahl et al. (2015) and also in Line 120-130. Case1 and Case2 could be separated into three zones (see Hendry et al. 2019 and Zheng et al., 2013).
In the revised version, we changed the title to "Assessing the characteristics and drivers of compound flood events from storm surge and precipitation in coastal China". The manuscript has three objectives: 1) identify and collate compound events from storm surge and precipitation, and analyse their dependence; 2) examine how the strength of dependence between storm surge and precipitation are influenced by seasons and threshold selection; 3) identify the driving weather patterns of compound/non-compound events. We believe that addressing these 3 objectives in concert reflects our overarching goal related to the (new) title, and the conclusion section will be reworked accordingly. As outlined above, we add a new discussion section where we make the transition from focusing on the dependence, it's variability across seasons and regions, and the

driving weather patterns to the impacts caused by compound events (based on historical damage records).

→*See Section 1 Line 88-91 in the clean version.*

Hendry, A., Haigh, I., Nicholls, R., Winter, H. and Neal, R., 2019, April. Assessing the characteristics and likelihood of compound flooding events around the UK. Hydrol. Earth Syst. Sci., 23, 3117–3139.

Wahl, T., Jain, S., Bender, J., Meyers, S.D. and Luther, M.E., 2015. Increasing risk of compound flooding from storm surge and rainfall for major US cities. Nature Climate Change, 5(12), p.1093.

Zheng, F., Westra, S., Sisson, & S., A. 2013. Quantifying the dependence between extreme rainfall and storm surge in the coastal zone. Journal of Hydrology. 505. pp.172-187

6. Finally a minor point: The authors pointed out that there is a need to assess "the relationship to climate indices". This has been done to some extent. The authors may be interested in the following paper on this topic: Wenyan Wu and Michael Leonard 2019 Impact of ENSO on dependence between extreme rainfall and storm surge Environ. Res. Lett. 14 124043.I hope my comments are helpful for the authors to improve their manuscript.

Response: Thanks for sharing. This is included now in the discussion, and it would be interesting to carry out a similar analysis in the future. We have added related references in the discussion part.

→*See Section 5 Discussion Line295-300 in the clean version.*

Reviewer 2:

This manuscript focuses on compound flood potential from storm surge and heavy precipitation in coastal China, results of which may be a support for urban flood control and management. The idea, the data and the methods used are not new and innovative. The results are common and direct. Two main parts should be improved firstly for further reconsideration for potential publication in HESS.

1. Data are basis for analysis. Tide data collected are mainly from 1975 to 1997 which are not in accord with that of precipitation. Does the tide data in the last 23 years potentially changed under climate change affect the results? If it does, how to improve it?

Response: Thanks for the comment.

As mentioned in Line 106-108 in the original manuscript the time series of precipitation observations are usually longer and more complete than tide gauge observations (where data after 1997 is often not publicly available). We are using the longest possible overlapping periods for both datasets in this study.

Climate change may have an impact on the tides (through sea level rise), but over the timescales analyzed here it would be negligible (see for example recent review paper by Haigh et al., "The tides they are a-changing", https://doi.org/10.1029/2018RG000636) . We have considered the effect of sea level rise explicitly in our analysis (by removing it's influence through a year-by-year tidal analysis). We also found there is an increase of compound events when mean sea level rise is included (see Section 4.2).

2. It has been widely accepted that storm surge and heavy precipitation are the first main influence factors of urban flood or waterlogging disasters. Please do not just list the data and their difference, discussions and conclusions must go deeper, mechanism of the results and potential application in design of flood defenses should be clarified.

Response: Thanks for the suggestion. In the revised version, we added a discussion part to have a deeper discussion about impacts by compound events (in parts based on historical damage records) and threats by climate change drivers, and also touch on potential ramifications for the design of flood defenses.

→See Section 5 Discussion.

Reviewer 3:

This study investigates the compound events from storm surge and heavy precipitation using 11 tide gauges along the coast of China and discusses some potential driving for the occurrences of compound events. This study can provide an important supplement for the analysis of compound events in China owing to the most comprehensive records of storm surge used, even though the methods and results are not very innovative and surprise. There are some concerns that should be addressed for further consideration for potential publication in HESS. Firstly, in the section of "3.1 Selecting compound events", Figure 2 shows the scatter plot for daily maximum storm surge and daily maximum precipitation. You have hourly sea-level data of 11 tide gauge, do you mean to extract the daily maximum one-hour sea level data from these hourly data firstly? But for precipitation data, you only have daily precipitation data, how can you have daily maximum precipitation?

Response: Thanks for the comment. We are sorry for the confusion. Firstly, we apply a harmonic tidal analysis by using hourly sea level observations to extract the surge (or non-tidal residual) part. Then, we extract the daily maximum surge from hourly surge data. For daily precipitation data, it is the amount of accumulated daily precipitation. This is clarified in the revised version.

→See Section 2.

Secondly, in the section "4.2 Effects of sea-level rise on compound event frequencies", it is not very clear how to remove the sea level rise. Do you mean the daily sea level minuses the annual sea level?

Response: We removed the mean sea level influence by applying a year-by-year harmonic tidal analysis (see Line 100). In doing so we effectively remove the tidal influence but also the annual mean sea level from the hourly (and daily maxima) storm surge data which is ultimately used in the analysis. This is the same approach used in many previous studies and we will make it clearer in the revised version of the paper.

→See Section 2.

Thirdly, in the section of "4.5 Impacts caused by compound and non-compound flood events", how can you separate the damages induced by compound events based on typhoon related damages records? For instance, heavy wind due to typhoon events can also result in damages and losses. It is hard to separate the damages from different disasters.

Response: Thanks for the comment.

We agree with the reviewer that there is no straightforward way to disentangle the fraction that each hazard contributed to the damage. In this case, we would like to show the difference caused by compound and non-compound events, assuming that flooding was the main contributor to the damages or at least had a similar relative contribution to the damages. We realize that this is a big assumption to make and based on the reviewer's comment (and similar comments from the first reviewers) we moved this part into a new discussion section where the underlying issues are discussed when attempting to link compound and non-compound events to the damage database.

→*See Section 5 Discussion.*