

Interactive comment on “Compound flood potential from storm surge and heavy precipitation in coastal China” by Jiayi Fang et al.

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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 increase 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.

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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. 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. We agree that compound events outside the Typhoon season are excluded, but also stress that in China, typhoon is the main

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cause for compound coastal flood events. 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 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.

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. As there is no proper way to separate the damage into difference sources, 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.

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

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would go beyond the scope of our study.

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 firstly 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 top 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 we will make sure that the definitions are coherent and 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. In the revised version, we would like to change

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 analyses their dependence; 2) examine how the strength of dependence between storm surge and precipitation are influenced by seasons and threshold selection; 3) understand 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) and also discuss potential impacts of climate change (in particular sea level rise).

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 the sharing. It is useful to include it in the discussion, and it is possible to carry out this study in the further study.

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