Reply to reviewers' comments

We thank the two reviewers for their thorough reading of the manuscript and their valuable remarks that helped us to improve the manuscript. In the following, the original reviewer comments are given in italic and all line numbers and figure numbers refer to the original submitted version that was reviewed if not mentioned otherwise.

Reply to review of reviewer 1

The study gives an overview of past analyses of compound events in Europe, and proposes an empirical approach not relying on copulas to build a new climatology of compound discharge/surge peaks of NW European rivers. It concludes that westward facing coasts show more than random CEs, while eastward facing coasts are not shown to demonstrate an expected nr of events. For most areas Cyclonic Westerlies are held responsible. Large basins show fewer CEs.

The method is robust – as demonstrated by using different datasets and system parameters – and yields results that are physically understandable: the westerlies, certainly when their directional wind fields constrain the fetch over which surges can develop, generate both a surge and anomalous rainfall, which for smaller catchments comes to joint water level peaks. This expected physical interpretation is both a demonstration of skill of the method, but also a bit disappointing because it is not really a surprising result.

We thank reviewer 1 for the positive evaluation of our manuscript.

Other studies have elaborated on the physical backgrounds of CEs in westerly storm track climates, and extended it further by also including explicit considerations of time lag (Kew et al 2013) and hydrological/meteorological memory (Khanal et al, 2019).

We added the following sentence to line 318:

Khanal et al. (2019) and Kew et al. (2013) likewise reported that the most extreme events in the Rhine delta are connected to westerly winds.

It is not really clear how the findings in this paper will contribute to practical applications, such as enhanced predictability, statistical underpinning of infrastructure design and others. This is not a requirement for a study like this to be published, but some extension of the implications of these findings for the better understanding or development of societal applications would be welcome.

We believe that it is at this stage too early to speculate about possible societal applications. As discussed in lines 341-349, more scientific work is needed to gather a better understanding on what makes CW that cause CFE different from those that do not. Our work should therefore rather be seen as a pointer in a direction for further investigation.

* *Other definitions of compound events than the SREX report are provided by Leonard et al (2014) and (already cited) Zscheischler et al (2018).*

We added the following text to line 28:

A more general definition was proposed by Leonard et al. (2014), who defined it as "an extreme impact that depends on multiple statistically dependent variables or events."

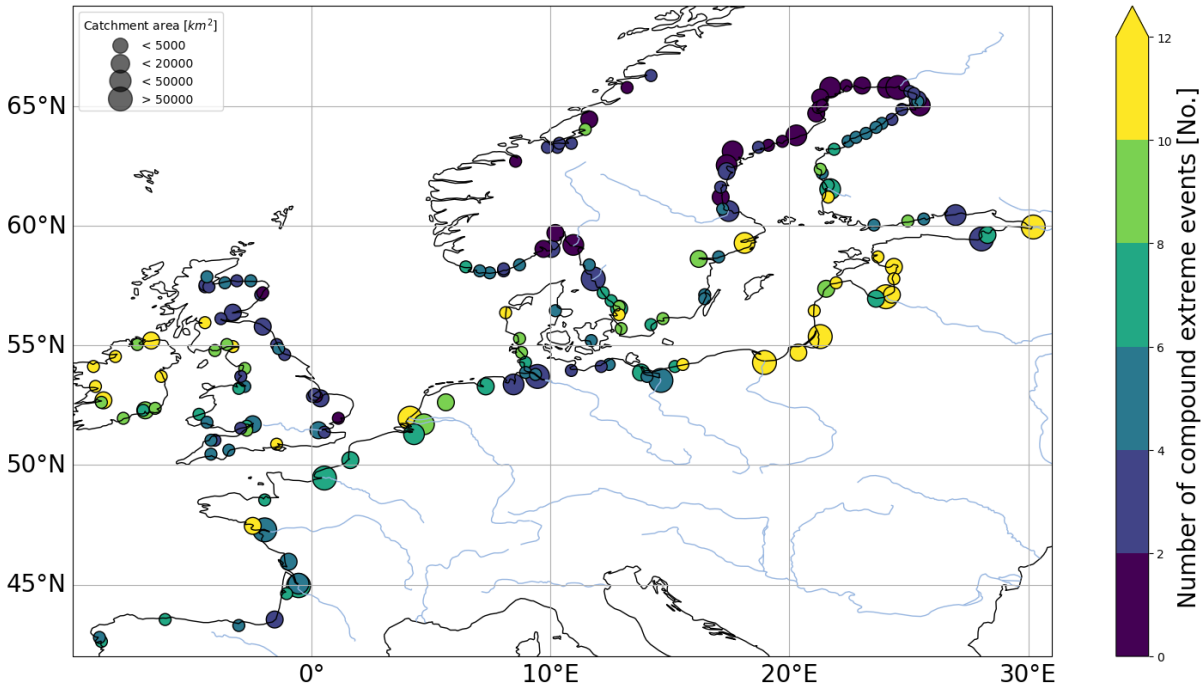
* *Relevance to consider compound events in risk assessment are also clearly exposed by de Ruiter et al (2020)*

We added the citation to line 21:

The occurrence of extreme flood events either simultaneously or in close succession can lead to severe damage, which greatly exceeds the damage those events would cause separately (de Ruiter et al., 2020, Xue et al., 2022).

* *The color scale in Figure 1 is not very intuitively ranging between low to high values*

Changed colormap of Figure 1 to viridis:



* *Line 290: a Western Cyclone GWL can not last for weeks, I would say. As shown by Kew, series of low pressure systems may well affect compound events in large river basins like the Rhine, provided a time lag is allowed*

As shown in Table 4 on page 21 of the Großwetterlagen catalogue v.7 (https://www.pik-potsdam.de/en/output/publications/pikreports/.files/pr119.pdf), it is possible for CW to last for over 3 weeks.

We changed line 222 to:

These weather regimes can persist from a few days up to a few weeks in extreme cases.

We changed line 290 to:

We found that compound flood events can occur during short Großwetterlagen that only last 3 days, which is by definition the minimum duration, as well as Großwetterlagen that remain over two weeks.

List of added references:

Kew, S., Selten, F., Lenderink, G., and Hazeleger, W.: The simultaneous occurrence of surge and discharge extremes for the Rhine delta, Natural Hazards and Earth System Sciences, 13, 2017–2029, https://doi.org/10.5194/nhess-13-2017-2013, 2013.

Khanal, S., Lutz, A. F., Immerzeel, W. W., Vries, H. d., Wanders, N., and Hurk, B. v. d.: The impact of meteorological and hydrological memory on compound peak flows in the Rhine river basin, Atmosphere, 10, 171, https://doi.org/10.3390/atmos10040171, 2019

Leonard, M., Westra, S., Phatak, A., Lambert, M., van den Hurk, B., McInnes, K., Risbey, J., Schuster, S., Jakob, D., and Stafford-Smith, M.: A compound event framework for understanding extreme impacts, Wiley Interdisciplinary Reviews: Climate Change, 5, 113–128, https://doi.org/10.1002/wcc.252, 2014

Ruiter, Marleen C. de, Anaïs Couasnon, Marc J.C. van den Homberg, James E. Daniell, Joel C. Gill, and Philip J. Ward. 2020. "Why We Can No Longer Ignore Consecutive Disasters." Earth's Future. John Wiley and Sons Inc. https://doi.org/10.1029/2019EF001425.

Xu, H., Tian, Z., Sun, L., Ye, Q., Ragno, E., Bricker, J., Mao, G., Tan, J., Wang, J., Ke, Q., et al.: Compound flood impact of water level and rainfall during tropical cyclone periods in a coastal city: the case of Shanghai, Natural Hazards and Earth System Sciences, 22, 2347–2358, https://doi.org/10.5194/nhess-22-2347-2022, 2022