

Review of “Concurrent modes of climate variability linked to spatially compounding wind and precipitation extremes in the Northern Hemisphere”

Overall impression of article

I think it is an important study on compounding extreme events, especially when linking this to potential impact (e.g. through the population metric used in this study). I also value the link to global drivers and teleconnections, as this can benefit short term predictions but also long term projections. Generally, I think this paper needs a bit more restructuring, notably the result and discussion sections. Furthermore, it needs another careful read through because it was difficult at times to understand the sentences. Below I mention more details in some major and some minor suggestions.

Major points of discussion

1. The motivation for this study is not so clear to me. Why look at compound wind&precip?
2. Similarly, the motivation for these exact modes of variability is a bit lacking in introduction. You do mention the Indian ocean as a potential influence in discussion. What about other modes? Why not include those?
3. Why do you choose to average the daily wind and precipitation values instead of taking the maximum wind speed and the sum of total precipitation of the day? Especially when it comes to wind, I’m worried that averaging is not the best choice to catch wind-extreme events.
4. Why are you considering seasonal mean indices? Why not look at weekly/monthly data? I think there is an issue with the different timelags here, since ENSO is clearly a yearly oscillation, but the NAO can also be defined on weekly/monthly timescales. I think this has to be motivated from a physical point of view.
5. Which threshold do you end up choosing? It is a bit unclear, you take 95th in ERA5 and 98th in CESM? How do these two compare to each other (I believe you compare 95th in both era and CESM in the supplementary)? Did you do sensitivity experiments to determine these two thresholds are the same?
6. I think the result & discussion sections should be re-structured: you already discuss the findings with respect to other literature in the results, I believe this should be moved to the discussion. In the results only mention your own findings. This will also make your paper easier to read.

Minor suggestions

Abstract

1. I miss the motivation for these specific SST-modes of variability in the abstract.
2. In the abstract I had to read the following sentence a few times before I understood: “we identify dependencies enabling extreme spatially compounding events with many regions experiencing CWP extremes in the same winter” L9/10.
3. “mitigation of spatially compounding CWP extremes.” L15 how could these CWP extremes be mitigated ?

Introduction

4. L24: “co-occurring compound wind and precipitation (CWP) extremes” co-occurring and compound is that not the same?
5. Introduction: are there any examples of spatially compounding CWP events that lead to extreme damages? You mention the flooding as an example. But it is not entirely

clear to me why CWP should specifically be investigated over other multi-hazard events (hot-dry, no wind-cold, etc.)

6. L46: “cyclones are particularly exposed to CWP extremes” are cyclones not considered a CWP extreme? How is a CWP defined actually?
7. Why do you focus on wintertime CWP only? Aren’t summer storms especially damaging (due to trees being in full leaves).
8. L156 how do you calculate significance?

Methods

9. Metric 1: if you average the count per grid point do you still need the latitude weight?
10. Metric 2: why 80th percentile?
11. Why do you only look at positive cases, e.g. when a mode has a positive effect? L151
12. Have you tried any kind of regression analysis? Maybe this also can take away the effect of ‘neutral’ states not really being neutral, as mentioned L139-140
13. Why not take significance level of 0.05? L 180: *significance level $\alpha = 0.10$*

Results

14. Your maps would be easier to interpret if you mask out the non-land areas.
15. What’s the difference between the following two statements in section 3.2 L250 and L259: “*Model simulations (CESM) show that not only individual variability modes can have effects on regional wintertime frequencies of CWP extremes, but also combinations of modes.*” vs “*Model simulations (CESM) show that concurrent anomalies in variability modes amplify the effects of individual modes in many regions.*” I think this section needs more attention. There are so many details in the figure, and the text is not complimenting this enough. It is very difficult to understand the main results at the moment, also because you weave discussion in here.
16. L118-119: “*in general agreement with existing literature,*”; either mention the literature or do not mention this. Generally, I think this should be part of the discussion not the results.
17. L315-325 suits better in discussion?
18. L328-331 this is motivation, should maybe go to introduction.
19. L333: “*Figure 5a shows Spearman correlations of regionally averaged CWP extreme frequencies (Metric 1) between all pairs of regions*” You regionally average CWP extreme frequencies, but I’m thinking this could be slightly problematic. The regions are quite large, whereas these CWP extremes can be very local. What happens when you sum the CWP counts instead? Also, why not perform a spatial-dependency analysis on the original CWP data on high frequency, e.g. monthly?
20. L374-376: “*In particular, variability modes in isolation do not lead to significant effects on the population exposure compared to neutral conditions, indicating the importance of considering combinations of modes to distil the effects of modes of variability on the population affected.*” Where do you draw this conclusion from? To me it is unclear how this is related to fig 6a (which you reference the sentence before).
21. Fig 7b: but NAO is an index of SLP, so in this sense when you compare NAO- to NAO neutral you will of course find a difference in SLP. Here you go into discussion how a NAO- can physically lead to more CWP extremes *as discussed in other literature*. This should not be a result in my opinion, unless you have actually show a physical mechanism in your results (e.g. convection anomalies, wind anomalies, latent heating anomalies,...). I think this last section of the results is mostly repetition from the

previous sections and can be taken out. Instead focus on interpreting these physical mechanisms in a discussion section.

Discussion

22. It is important to mention you use a climate model in the first sentence already
23. Some sentences are unclear, e.g. L 428: “*Simulations show that extreme spatially compounding events with many regions under CWP extremes in the same winter are enabled by positive dependencies between CWP extremes across different regions*”
24. L339: “*Our model evaluation against ERA5 reanalysis data indicates that the simulated anomalies in CWP extremes associated with modes of variability are well suited for the purpose of our analysis (Figs. S2-S5)*”. In my opinion there’s some differences between the ERA5 and CESM figures; notably, ERA5 seems more pronounced. There are also regions where ERA5 does not agree with CESM: e.g. S2 shows that parts of North America have a negative ratio in ERA5 under NAO+ whereas this is positive in CESM, or S3 shows parts of North Africa have differences for ENSO+. I think it is important to highlight this, because that means that for some regions we can not make strong statements.
25. Why didn’t you include IOD if you mention this has influence on CWP extremes? To me this comes back to the general motivation for this study; the choice for these exact modes need to be motivated clearly.