Concurrent modes of climate variability linked to spatially compounding wind and precipitation extremes in the Northern Hemisphere *(François et al.)*

Overview:

This paper focuses on compound wind and precipitation (CWP) extremes, aiming to identify the drivers behind the occurrence of these events in the Northern Hemisphere. Climate model simulations from the Community Earth System Model are used with reanalysis data (ERA5) providing a "sense check". A few key climate variable modes are considered (ENSO, AMV, NAO & PNA). The individual effects of these events are found to follow existing literature, e.g. NAO+ increasing CWP extremes in Northern Europe. Concurrent phases of variability modes are considered with specific regional effects discussed. The NAO- & ENSO+ combination increased the likelihood of CWP extremes in eight regions. This motivated exploring spatially compounding extremes, where a positive trend between the number of anomalous variability modes and the number of regions was identified. Physical mechanisms for the statistical relationships were then discussed. This paper concludes ENSO is the most influential mode of variability for CWP extremes in the Northern Hemisphere.

Compound events are an area of current interest and this manuscript will appeal to the community. It is suitable for this NHESS special issue and I therefore recommend it's publication subject to the changes outlined below. I would therefore appreciate the author's response on the comments below.

General comments:

As this study covers a large region and many combinations of variability modes, the presentation of results is important. The paper has a wide scope which at times means detail on specific regions is lacking. Choosing two or three regions or one teleconnection index to focus on gives this study more impact.

While the standard of written English is fine, the language used makes this paper difficult to read at times. There are some very long sentences which could be split up or multiple sentences which may be more readable as a bullet pointed list. Redrafting Section 3 will make the paper more readable and therefore accessible to the wider scientific community.

Figures are meant to help convey information simply, Figures 3, 4 & 5 are complex. The authors should only include combinations of variability modes discussed in the text with the full figures available in the supplementary material.

The choices of percentile thresholds are arbitrary. The results of this study would hold more weight if a sensitivity analysis on these had been conducted. e.g. 98th percentile of daily precipitation seems low as this data is zero inflated.

Daily precipitation is not always proportional to any resulting impact – the authors should acknowledge the complexity of the precipitation-flood relationship. For more on this see Bloomfield et al. (2023) [https://doi.org/10.1016/j.wace.2023.100550].

While compound wind-precipitation events cause large impacts, they are rare (e.g. Fig. 2 from Jones et al. (2024) [https://doi.org/10.1002/wea.4573]). Considering these extremes in isolation gives the complete picture of a compound hazard. You have cited Manning et al. (2024) to highlight extratropical cyclones as drivers of CWP events, but Manning et al. (2024) notes CWP events can be driven by precipitation extremes.

Concurrent modes of climate variability linked to spatially compounding wind and precipitation extremes in the Northern Hemisphere *(François et al.)*

Specific comments:

L2: Change "agricultural crops" to "crops"

L6: Remove NAO & PNA abbreviations, they are not used in rest of abstract.

L13: Remove "For example" here, the reader knows you're giving them an example.

L17-22: Split into two sentences and rejig. Define compound events first, then highlight their importance from this IPCC report.

L51: Useful to describe what the deviation from mean NAO conditions is, how does it affect frequency & intensity of events?

L74: Specify which months the winter season covers.

L75: Change "effective" to "influential"

L84: Make the rationale behind the choice of these regions clearer. These shapes cut across country boundaries, making this study less applicable to the insurance industry.

L96: Why did you chose to begin with 1959? ERA5 covers from 1940 so matching the same period as CESM makes sense.

L96: "Singh et al. (2021)" reference doesn't make sense here? As far as I can tell, Singh et al. (2021) doesn't use ERA5?

L110: The 95th percentile of daily data considers 1114 days in this period (1959-2019) to be extreme. Yet the 98th percentile over 1950-2019 only considers 511 extreme days. Surely a higher threshold of ERA5 data is required for these periods to be comparable?

L115: Include rationale for weighting by cosine of latitude.

L151: Change "That is, in this study, we do not…" to "This study does not".

L154: Remove ", in principle,"

L162: The 280 year return period seems to be an arbitrary choice. Sensitivity analysis on this threshold would be of interest.

L176: Mismatched bracket after "subsection 2.2.3".

L180: A 10% significance level seems high, 5% (or even 1%) level is much more standard practice.

L185: How many times is "several times"? State this in the text.

L199-200: Change 100.000 to 100,000

L224: A significant body of literature exists linking extreme windstorms to strong winds (favourable conditions for CWP events). Here I would at least cite:

- Mailier et al. (2006) https://doi.org/10.1175/MWR3160.1
- Priestley et al. (2024): https://doi.org/10.5194/nhess-23-3845-2023

L312: I'd make this sentence clearer, "generally covers most of the time" is very ambiguous.

Concurrent modes of climate variability linked to spatially compounding wind and precipitation extremes in the Northern Hemisphere *(François et al.)*

L391: Change “Europa” to “Europe”.

L430: Is this not driven by atmospheric circulation patterns?

L480: Change “found” to “estimated”

L484: A natural next step would be repeating this study for the southern hemisphere.