

## Reviewer 1

- Equation (1): please mention what is  $\gamma(\cdot)$ ?

**Reply:**  $\gamma(\cdot)$  represents the upper tail of the incomplete gamma function, which was specified in the text.

**Modification:** p.4, l.99-100

- Equation (3): shouldn't it be  $\phi_0^*$ ? (is the subscript 0 missing?)

**Reply:** Indeed, the subscript was missing, which we corrected in equation 3.

**Modification:** p.4, equation 4

- I suggest that the authors report their results regarding the 100-year return levels and the tail dependence coefficient in the main paper.

**Reply:** Thank you for this suggestion. We added the following sentence to our model evaluation: 'The suitability of the SEP and E-GPD distributions to model local T and P distributions also extends to the tails as 100-year return levels estimated from the observed and simulated series compare well for both variables.'

**Modification:** p.8, 182-184

## Reviewer 2

I thank the authors for considering my comments. They addressed my comments well and I find the paper improved. Therefore I recommend to publish the manuscript after some final technical revisions that can be applied based on my few last comments below.

Comments

1) L30 I suggest re-shaping the sentence slightly. That is, including the words "local" and "regional" (or "aggregated over a region"). The local impact depends on frequency and duration. The aggregated regional impacts depend, in addition, also on the extent. Reply: We integrated the terms local and regional by writing: 'While frequency of occurrence is an important factor determining local and regional impacts, the severity of impacts related to compound events likely also depends on their spatial extent, i.e. how large the affected region is, and their time scale, i.e. whether they just last weeks or extend over a longer period of time.'

Here there was misunderstanding. I would delete "and regional" or something along this line. "Regional" already implies a spatial aggregation, which is something that comes with the spatial extent later on in the sentence.

**Reply:** We removed both 'local and regional' because we agree that frequency and occurrence are generally important determinants of impact independent of whether the event is local or regional. The new sentence reads as follows: 'While frequency of occurrence is an important factor determining impacts, the severity of impacts related to compound events likely also depends on their spatial extent, i.e. how large the affected region is, and their time scale, i.e. whether they just last weeks or extend over a longer period of time.'

**Modification:** p.2, l.30-34

2) L45. This statement is interesting. We have recently worked on the topic and shown that it is very difficult to study seasonal precipitation extreme extents without large ensemble simulations (discussed at the end of the “Present-day spatial scale extremes” section): Bevacqua, E., Shepherd, T.G., Watson, P.A.G., Sparrow, S., Wallom, D., and Mitchell, D. (2020). “Larger spatial footprint of wintertime total precipitation extremes in a warmer climate”. Submitted. Preprint’s DOI: 10.1002/essoar.10505310.1  
Reply: We agree that using large ensemble simulations would be an alternative to using stochastic models. We therefore slightly adjusted the sentence to: ‘This challenge can for example be tackled...’. In the discussion section, we add that: ‘If physical consistency is a requirement for a specific application, stochastic approaches may be combined with physical approaches as e.g. in the weather generator AWE-GEN-2 by Peleg et al (2017) or one may rely on large climate ensemble simulation approaches (Deser et al. 2020; Bevaqua et al, 2020).

The sentence "If physical consistency is a requirement" unnecessarily weakens your study. I suggest something along the lines of the text I drafted below. Note that the second sentence goes in the direction of the next comment I had provided in my original review document. The text is related to the fact that the weather generator, being based on observations, may have limit in simulating events that strongly differ from the observed events. "We note that stochastic approaches may be combined with physical approaches as e.g. in the weather generator AWE-GEN-2 by Peleg et al (2017). In addition, large climate ensemble simulation approaches can allow for gaining information on yet unseen events that may be particularly different in nature from the observed events and therefore may not be simulated by an observation-driven weather generator (Deser et al. 2020; Bevacqua et al, 2020)."

**Reply:** *Thank you for these rephrasing suggestions, which we partly adopted: ‘We note that stochastic approaches may be combined with physical approaches as e.g. in the weather generator AWE-GEN-2 by (Peleg et al. 2017) or one may rely on large climate ensemble simulation approaches (Deser et al. 2020 and Bevacqua et al. 2021).’ Because also observation-driven weather generators such as the one presented in this study can generate yet unseen events, we did not adopt the second sentence proposed.*

**Modification:** p.15, l. 246-248

Bevaqua is spelled wrongly. It is Bevacqua et al. has a new citation: Bevacqua, E., Shepherd, T.G., Watson, P.A.G., Sparrow, S., Wallom, D., and Mitchell, D. (2021). “Larger spatial footprint of wintertime total precipitation extremes in a warmer climate”. Geophysical Research Letters, DOI: 10.1029/2020GL091990

**Reply:** *We adjusted the reference accordingly.*

**Modification:** p.18: l. 334-336

3) On the change you applied to describe the copula-based criterion to select compound events: Note that "bigger" is likely incorrect, as the difference between the size of the two spaces depends on the thresholds used to define the two spaces.

**Reply:** *We replaced ‘bigger’ by ‘different’. However, if the same percentile is chosen to define both spaces, bigger should be correct.*

**Modification:** p.7, l. 161

4) L168, “...at any given time scale. Then, for each grid cell, we determine the median spatial extent of those events it is affected by. ” “at any given time scale” should be also in the second sentence to make clear you are not mixing results from different time scales through the median.

**Reply:** *Thank you for this suggestion. We included time scale in the second sentence as well: ‘Then, for*

*each grid cell, we determine the median spatial extent of those events it is affected by at each time scale.'*

**Modification:** p.7, l.169

5) Please, revise L171 and the caption of figure 10 carefully. I understand what you do, but it was not straightforward to get the point right. For example, "across simulation" may sometime (also in the caption of figure 10) be misunderstood as a correlation between values of the different 100 runs.

About the text: L170 Text: "To explain the role of the individual variables T and P in compound event occurrence, we compute Kendall's correlation between the median bivariate distribution (empirical copula) and the median standardized indices STI and SPI over all simulation runs at different time scales. This correlation analysis is performed for nine hydro-climatic regions in the United States (Bukovsky; Bukovsky, 2011) to quantify the regional spread in the role of STI and SPI for compound event development, i.e., correlation is computed between median bivariate distributions and median STI or SPI at different grid cells within a region."

I suggest revising the text making sure that all the following steps are clear to the reader. For a given time scale of interest:

- Divide in regions
- At each location in the region, compute the median values based on the time series.
- Compute the correlation across the medians at the different locations in the region
- Present the region-based correlations in box plots to show the spread of the relationship

Regarding the results of the correlation itself, some guidance on the interpretation would certainly help the reader and is welcome.

**Reply:** *We agree that the phrasing in the caption was indeed not ideal. We rephrased to: 'Correlation of median bivariate distribution (empirical copula) per grid cell with median (a) STI and (b) SPI per grid cell. Correlations were computed using all simulation runs for nine hydro-climatic (Bukovsky) regions (spread of boxplot) per time scale (color) and level of extremeness (hue).'* This version covers the four aspects highlighted above.

**Modification:** p.14, caption Figure 10

L229, I would remove "occurrence" as your correlation between median values does not account for occurrence, rather it provides indirect information on the occurrence.

**Reply:** *We removed the word 'occurrence'.*

**Modification:** p.14, l.229