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Revised version of: “A hazard model of subfreezing temperatures in the United Kingdom using vine copulas”
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General comment
I found the paper improved, and I appreciate the effort of the author in addressing the issues about the uncertainty. There are a couple of steps in the procedure employed for computing the uncertainties which are not fully clear to me. These steps might be potentially important. In principle, these steps might substantially affect/increase the computed model uncertainty. After these are addressed, I would suggest considering the paper for publication.

In the following, I will refer to the pages and lines of the pdf file including the corrections (in blue and red). My revision should be read, again, as a constructive advice.

Comments related to uncertainty quantification
P1 l8-9 “The model suggests that the extreme winter 1962/63 has a return period of approximately once every 89 years, with 95% confidence intervals between 81 to 120 years. However, the relative short record length together with the unclear effects of anthropogenic forcing on the local climate add considerable uncertainty to this estimate.”
Given the “However”, I am not sure that it is fully clear, here, that the uncertainty (95% CI) is due to the shortness of the data. In principle, the purpose of the uncertainty quantification is to account for the model uncertainty due to the shortness of the data. I see that you write in the following sentence “add considerably uncertainties”, which might be related to acknowledging that the employed procedure to compute the model uncertainty does not account for all of the uncertainties due to the short data length. But this sentence might be improved.

P11 l13 “Both together result in a virtual reduction in the dimensions of the pdf.” As I wrote in my first comment: “The author says that he is using many independent copula: if this is a reasonable choice then it corresponds to somehow virtually reduce the dimension of the pdf.” I would like to observe that I employed the “somehow virtually reduce” expression in the response, however, I have never seen this used in the literature.

P12 l 1. Section 3.1.2. You might consider changing the title of the section, referring to the uncertainties. In fact, this section explains the procedure to compute the uncertainties.

P12 l2 “The RVM is used to simulate 10K years of winter-seasons in the UK. For each year, the simulated AFI values at each grid cell depend on the other cells based on the fitted RVM.”
To guide the reader, I would explain why the model is used to simulate a so long sample. To reduce the uncertainties associated with the simulation (as explained in my previous comment, see the end of this document).

P12 l6 “Following Bevacqua et al. (2017), the model uncertainty is assessed using a parametric bootstrap approach...”
[Definition for the following discussion: Let’s define procedure1 and procedure2 the two procedures you present on page 13.]
Procedure1. While Bevacqua et al. consider the uncertainties of the marginal pdfs during the procedure, it is not clear to me whether these are accounted for here. **Thus, I am wondering if procedure2 is used to compute the uncertainty associated with the RVM only, or the uncertainty of the full model, i.e. of the joint pdf.** Specifically, going through the first 2 steps of procedure1, it is not clear to me whether you (a) simulate the real data (real, i.e. you transform the uniform variables simulated from the vine using the inverse marginal pdfs) and fit again both the marginals and the RVM to these “real” data, or (b) you simulate only the uniform variables and fit the RVM to them only.

If the procedure is (b), then this is different from the cited Bevacqua et al., and then I think that it should be stated (note that also procedure2 is an addition with respect to Bevacqua et al., but this is not clear). Other differences that would need to be highlighted:

- P12 l7 “...data from the selected RVM.” in Bevacqua this is “...data from the selected joint pdf”.
- Similarly at p13 l1. “In the selected RVM” in Bevacqua this is “...in the selected joint pdf”.
- Similarly at p13 l4. “A new RVM is fitted…” in Bevacqua this is “...a new joint pdf is fitted (via vines)...”.

Also, if you do not account for the uncertainty of the marginals (i.e. if you follow (b)), then I recommend to not talk about “model uncertainty (e.g., in line 6), but of RVM uncertainty only. However, the following comment is relevant.

The obtained uncertainty associated with the “model” seems very small (as you also argue later (p19 l30)). You might agree with me that this might be unexpected, given the small sample size. Thus, I am wondering if they are the uncertainty associated with the RVM only, or the uncertainty of the full model, i.e. of the joint pdf.
Specifically, I am wondering about: (1) how the model uncertainty would actually be affected by the uncertainty of the marginals (if you do not account for this already, i.e. if you follow (b)); (2) how the model uncertainty increases when the RVM structure is not fixed in procedure1 (step2).
Is there any reason for not considering these two uncertainties? (Again, maybe you already accounted for the marginal uncertainty (1)).
I can see that accounting for all of these uncertainties might be cumbersome strictly following procedure1. To my understanding, an easier alternative to procedure1 (to account for all the model uncertainty, i.e. to also account for (1) the marginal uncertainties and (2) the RVM structure uncertainties), you might consider the following: Applying procedure2*, but simulating 51 years of data (instead of 10k years). This alternative procedure should, in fact, give <u>similar</u> results to applying procedure1 (where also (1) the marginal uncertainties and (2) the RVM structure uncertainties are considered). In this case, it is clear that you would obtain larger**

uncertainties than obtained via the employed procedures (as you would procedeed as done for procedure2 but employing a much shorter sample).

***Clearly, the “real” data should be simulated, i.e. one should simulate the uniform variables from the vine, and then transform them into “real” variables employing the inverse marginal CDFs.

Consideration. To my understanding, showing the Monte Carlo uncertainty (procedure2) in the paper helps to see that the RVM uncertainty (procedure1) is almost the same as the Monte Carlo uncertainty, and therefore you can conclude that the RVM uncertainty is negligible. I see the reasoning, and in principle I like it; however, see the previous discussion about the RVM uncertainty which might become larger if computed differently. Otherwise, personally, I have difficulties in seeing a reason for describing and employing procedure2. **Thus, the reader should be helped to understand the differences between the two uncertainty procedures, e.g. explaining why they are both computed.**

P17 l24-25
According to me, a comparison between purely Monte Carlo uncertainties (obtained simulating an as long as possible sample size) and uncertainties of the “empirical curve” is not conceptually meaningful. As stated in the previous comment revision (see the end of this file), the purely Monte Carlo uncertainties (obtained simulating an as long as possible sample size) is meaningful only to quantify the uncertainty driven by the limited length of the simulation (from a given a pdf that might be assumed to be non-biased).

Instead, it makes sense to me to compare the uncertainty computed using procedure1 with the uncertainties of the “empirical curve”. (As stated in the previous pages, I see a sense in comparing uncertainties form procedure1 and procedure2 for stating that the RVM uncertainties are negligible. However, I discussed potential issues of procedure2 above).

P17 l26. “The accuracy can be improved by increasing the number of simulated years, but at a computational cost”. I am not comfortable with the message that might be taken from this sentence. The purely Monte Carlo uncertainty can be reduced by simulating long samples, but it should be clear that this is not related with the uncertainty of the model (in a general case).

Other comments
P3 l25 “(1)”
Please, write “equation (1)” or “eq. (1)”.

Eq (1):
Write AFI_Year maybe?
Should the AFI_Year be defined as =0 if there are no days with negative temperatures? It is currently not exactly defined in this case, while you refer to f(x) for x=0 in equation 3.

Figure 2. Not necessary, but you might consider plotting the -NAOI rather than the NAOI (or -mAFI) to highlight the correlation between the time series.

P5 l8 “exceed”? P(X<=x)

P6 l15 “in order to geographically smooth the GEV..”
You might explain the reason for wishing to have smoothed parameters.

Fig 3 correct “:,”

P7 l4 I would write: “The largest observed AFI...”

Table1 caption. “Cell id”?

P9 l1 Please, use “The probability density function (pdf) of X, ...”. Also later you talk about “densities”. Later, I suggest using pdf.

P9 l6 “copula density” instead of “copula function”?

P10 l10 “eq 2 and 10” should be eq 2 and 3.

P10 l14. Is this only an intuition? Anyway, you might rephrase.

P10 l15 Please, define what a tree is, as it would help the reader. You might “use” the 4-dim example to explain what a tree and a first tree are. You might consider using the term “tree” or “level” only in the full text, as you refer to the same thing with these two different words, and this might confuse the non-expert reader (e.g., p10 l23-24).

P11 l6 “largest contribution at the second level”. Add something like “after the independent copula”.

P17 l15 average AFI, please: add (mAFI)

P17 l20 “However, the non-stationary fits were statistically similar to the stationary ones, with β1 parameters not significantly different from zero.”
You might write: “Despite the significant anticorrelation found between the average AFI (mAFI) and the NAOI, the non-stationary fits were statistically similar to the stationary ones, with β1 parameters not significantly different from zero.”
Then the next sentence (“This is probably related to the quite noisy character of the phenomenon and the relatively short historical record used in this study, which makes it difficult to discern the statistical differences in the extreme temperatures between positive and negative NAO winters”) could be rephrased, maybe explicitly referring to the noise as a function of the spatial scale (in fact, the noise is not visible when looking at the average AFI (mAFI), as the correlation between mAFI and NAOI is about -0.6).

P19 l10 (a) and (c) are pretty similar: you might unify them. Furthermore, as previously discussed, the the full multivariate pdf (marginals and copula) has uncertainties, and not only the copula (RVM) (as it looks from c).

P20 l13
In these cases (fig8b), is the RVM structure always the same as the RVM structure used in the full study so far? Are there independent copulas in the RVMs used for the sensitivity study? Please, very briefly specify these details.

Here I paste a comment I gave in the previous revision. This might be useful, given the comment I have written in this review.
“The 10,000 years time series should be long enough to neglect uncertainties associated with the Monte Carlo simulations (which is the method used for extracting the return period associated with the fitted parametric pdf) (Serinaldi et al. (2015) and Bevacqua et al. (2017)). [One should ensure if the sample is “long enough” via repeating the (10,000 years) simulations several times and checking if the there are differences in the estimated return period (if there are no differences, the 10,000 years sample is long enough)]. Performing a long enough simulations allows one to get a convergence to the true return period that one would get analytically from the fitted pdf (given the complexity of the problem it is impracticable to get an analytical derivation of the RP). Performing a long simulation does not solve the issue about the model uncertainties (uncertainties existing about the pdf), which is there because the pdf is calibrated on a finite - very short - sample. I suggest to discuss this in a way to make difference between these different type of uncertainties. “

Best regards.