# Response to Reviewer 2 comments about the article "*A Bayesian Statistical Method to Estimate the Climatology of Extreme Temperature under Multiple Scenarios: the ANKIALE Package*"

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October 23, 2025

**Note** In this document, the text in regular format corresponds to the reviewers questions. The answers from authors are given in the grey blocks.

## 1 Reviewer 2 (Anonymous)

### 1.1 General comments

This manuscript by Robin et al. (2025) presents a significant methodological advance for the attribution of extreme temperature events, introducing a Bayesian framework and an open-source tool that enables the simultaneous treatment of multiple climate scenarios. The authors' approach addresses a key gap in the literature by ensuring consistency across scenarios and by rigorously propagating uncertainties from both models and observations. The manuscript is technically ambitious and, in my view, represents an important contribution toward making attribution studies more stringent and transparent. In particular, the explicit handling of the full range of uncertainties, rather than relying on single-scenario or point estimates, sets a new standard for rigor in this field. I commend the authors for this achievement, and I believe their work will be highly valuable for the climate science and risk assessment communities.

We thank the reviewer for her/his summary and for the appreciation of our work. We hope that the answers to the various questions below will be satisfactory.

### 1.2 Specific comments

#### 1.2.1 Code testing

Since GMD encourages reproducibility, I attempted to install and test the method myself. I appreciate the effort the authors have made to explain function calls and to provide well-structured code repositories with installation instructions. However, I was unable to install the prerequisite package SDFC, and did not pursue troubleshooting further. I recommend that the authors test the installation process in a clean environment, without assuming prior package installations (such as a default conda setup) or advanced Python knowledge on the part of users, to ensure accessibility for a broader audience.

We are sorry that you were unable to test our tools, and that you were particularly blocked by the installation of SDFC. This is indeed quite tricky because this package is partially written in C++ and needs to be compiled. The SDFC documentation specifies how the installation should be done, even if it is not necessarily obvious.
Hence, we now do hope that the installation will be easier and smoother.

### 1.2.2 Statistical nomenclature

The manuscript introduces $X$ as covariates from L104 onward, which is standard in statistical modelling. However, in line 118, the definition of the parameter vector $\theta$ includes these covariates alongside the scalar GEV parameters $(\mu_0, \mu_1, \ldots, \xi)$. This may cause confusion for readers familiar with statistical notation, as covariates are typically considered as observed or input variables, while parameters are the quantities to be estimated (often scalars).

I understand that in your Bayesian framework, the covariates themselves are uncertain and inferred from the data (due to model differences) and thus are treated as random variables. However, it would be helpful to add a clarifying sentence or two to explicitly distinguish between:

**Parameters** (e.g., the GEV parameters $\mu_0$, $\mu_1$, $\sigma_0$, $\sigma_1$, $\xi_0$, which are scalars to be estimated, and

**Uncertain covariates** (e.g., $X^{R,0}$, $X^{R,N}$, $X^{R,A}$), which, although treated as part of the parameter vector in the Bayesian synthesis, conceptually represent covariate trajectories or functions rather than fixed parameters. (Uncertain covariates may not be the best description, maybe you find a better one).

A brief clarification in the text would help readers understand why covariates appear in the parameter vector and how their uncertainty is handled in your framework.

There are numerous parameters, covariates, and coefficients defined throughout the manuscript, often annotated with various sub- and superscripts. If possible, I recommend retaining only those notations that are essential for understanding the material, and ensuring that their use is consistent throughout the text. For example, in L189, the $m$ in $\nu_m$ appears as a subscript, but it likely should be a superscript. Inconsistent or unclear notation makes it difficult for the reader to follow the argument, as it is not always apparent whether a symbol refers to a new concept or simply a different aspect of an existing one. Careful attention to notation and a streamlined set of symbols would greatly improve the manuscript's readability.

Indeed, a delicate point that is unusual in this type of article is that the covariate itself is random, and therefore part of the vector $\theta$. Section 3 has been completely reworked to simplify and clarify the presentation of the method.

### 1.2.3 Grammar and spelling mistakes

While reviewing the manuscript, I noticed a considerable number of grammar and spelling mistakes throughout the text. Many of these issues could likely have been avoided with more thorough proof-reading or by using automated spelling and grammar checking tools. This has also led to a certain fatigue during the review of this manuscript, so please be prepared for additional comments in a second review round. I understand from my own experience that such errors can easily slip through, my own manuscripts have certainly not been immune to this. Nevertheless, I would encourage the authors to carefully revise the manuscript for language quality, as this will significantly improve readability and the overall impression of the work.

We apologise for this inconvenience and will be much more careful with the next iteration of the manuscript.

## 1.3 Technical corrections

**Line 16** Please correct “which consists in establishing” -> “which consist in establishing”.

Done.

**Line 19** The phrase “has made a specialty of producing attribution studies within a short time (delay of the order of a week) following the occurrence of an event” is awkward. Consider revising to: “has specialized in producing attribution studies within a short time (typically within a week) following the occurrence of an event.”

Done.

**Line 24** Do you mean "the statistical distribution"?

Obviously, we have reformulated.

**Line 29** "compbining"

Corrected.

**Line 30** "within a Bayesian framwork"?

Done.

**Lines 34-37** Which are the two inconsistencies? Could you please expand on this part a bit more. Assuming that everyone has the RR20 paper in mind is probably a bit of a stretch. In which sense can inconsistencies arise across scenarios? May it be that parameters that should be estimated the same way independently of the scenario (shape parameter in the counterfactual for example) are not the same?

In the revised article, we now discuss these inconsistencies further.

**Line 38** THE probability ratio.

Done.

**Line 49** An an...

Done.

**Fig1** referring to the UNSD (2020) M49 norm -> Not quite sure why this is important here.

Indeed, it is of little importance from a climate perspective. The idea here is simply to point out that the division of the domain is not arbitrary, but follows a standard (potentially recognised by all) that does not depend on us.

**Line 57** I believe "Section 4" should not be abbreviated in the beginning of a sentence.

It is true. Corrected.

**Line 57** Is it not rather "where estimates are derived independently for different scenarios"? (can 'scenarios' be estimated?)

Corrected.

**Line 60** Which 'specific definition'?

We have reformulated.

**Line 67** refer -> referred

Done.

**Line 85** 1850 – 2014

Done.

**Line 94** "as well as the future projections of the four SSP scenarios described above".

Done.

**Line 101** As $T_t$ is a set of maxima?

This is the random variable derived from annual maxima, we have reformulated.

**Line 105** "The covariate $X_t^{R,F}$ is the sum of.."

Done.

**Line 107** Please add $X_t^{G,F}$ also to Eq. 1, as it's not a different model (right?), otherwise it's not quite clear what you mean.

Added in the new methodology section.

**Line 108** Indirectly or independently?

Indirectly. The dependence between the global and regional covariates is taken into account.

**Line 111** "so we are.." -> this sounds too colloquially.

We have reformulated.

**Line 113** the choice [...], is entirely

Done.

**Lines 115-116** In Robin.. => Please rephrase this sentence.

We have reformulated.

**Line 124** "in the case" -> "for the case"?

Done.

**Line 126** I believe does not fit an estimation, rather use infer?

Done.

**Line 128** Please (already here!) provide some more context on what you mean with a "multi-model synthesis. Is it a random vector estimated across various models?

Yes, it is. We have reformulated.

**Line 134** There is no $\theta^m$ in Eq. (2)

We have reformulated.

**Line 138** "Let us start" -> too colloquial, covariateS

Done.

**Line 139** ".. are derived using GAMs" (as $X_t^{R,F}$ and $X_t^{G,F}$ are fits of a GAM model to data, I don't think one should refer to the fits as models).

The entire Section 3 has been rewritten.

**Line 143** twice Energy Balance Model. Can you please provide more context what this refers to, as all GCMs are in some sense energy balance models.

The entire Section 3 has been rewritten.

**Line 151** twice $\theta^R$

Done.

**Line 154** I.e. per time step, is it the average over four values?

Yes. However, we changed our approach between the two iterations. So, this has been modified.

**Line 156** I would strongly suggest to keep Fig S2 in the main text.

A new figure synthesising Figures 2, S2 and S3 has been created and is now included in the main text.

**Line 161** Draw the vectors -> Not rather 'estimate'?

Corrected.

**Line 166** derive the GEV parameters

Done.

**Line 167** with the $T_t^{SSP}$ series as target variable?

Yes, we have reformulated.

**Line 169** Why do we get different results? Different starting values for the MLE optimisation?

No, the optimization for each scenario gives a different estimation.

**Line 171** no "is"

Done.

**Line 184** Can you please outline briefly what this hypothesis means? Does it refer to the assumption that the various climate simulations could all be potential realisations of actual climate, aside from a bias term $\nu^m$?

The entire Section 3 has been rewritten.

**Line 203** Which model has been excluded?

This is the Norwegian Earth System Model `NCC / NorESM2-LM` (Seland et al., 2020).

**Line 238-239** Why not detrend the observations with a GAM before calculating the variance?

The whole problem lies in estimating this trend in the observations, especially if we want to take uncertainty into account.

**Line 254-270** This is a quite general description of Bayesian sampling techniques. I would suggest to drastically shorten it and put the extended version into the supplementary material.

The entire Section 3 has been rewritten.

**Line 311** Where do we see the thing about SSP370 in Fig S5?

As the differences were not clear, we completely revised our analysis in order to better highlight the potential contributions (See the new Sect. 3.4).

**Line 313** Missing full stop.

Done.

**Line 312** "does a good job" -> too colloquial

We have reformulated.

**Line 325** “allowing to reproduce” -> “allowing reproduction of the results presented in this paper.”

Done.

**Line 344** model data

Done.

**Line 344** This is quite a specific format for a NetCDF. Do I understand correctly that most NetCDFs will require reformatting before they could be used here?

Indeed, the input data uses a specific format for NetCDF, and the data must be converted to the correct format.

**Line 357** Figures S1 is only referenced now.

This has been corrected.

**Line 361** Make it clear that this is an example application.

Done.

**Line 372** The sentence “No form of spatial dependency is taken into account, so the existence of an event at one place does not imply anything at another.” could be clearer as: “No spatial dependency is considered, so the occurrence of an event at one location does not imply anything about another location.”

This is corrected.

**Line 375** Maybe add maps of parameter estimates, too see how much they different from grid point to grid point.

A figure containing the maps of $\mu_0$, $\mu_1$, $\sigma_0$, $\sigma_1$, $\xi_0$ and the 1961/1990 anomaly of TX3x has been added.

**Line 378** Change in intensity -> Does that refer to a change in intensity if the return period of the event is assumed the same under both factual and counterfactual conditions?

Yes, we have reformulated.

**Lines 391/391** I would replace the lower value by lower bound.

This could lead to confusion with the GEV distribution.

**Line 421** What is the end of the sentence supposed to mean?

We have reformulated.

**Line 450** Maybe not directly applicable in this scenario, but I believe the paper by Jewson et al. (2025) is very relevant for this community.

Thanks, the citation has been incorporated into the rewritten conclusion.

**Fig S1** What are BEST observations?

When we began this work, we used BEST to estimate the GMST. As BEST is known to have a warm bias, we then switched to GISTEMP. So it is an error that has crept into the text. This is now corrected.

# Bibliography


Jewson, S., T. Sweeting, and L. Jewson (Feb. 2025). "Reducing Reliability Bias in Assessments of Extreme Weather Risk Using Calibrating Priors". In: *Adv. Stat. Clim. Meteorol. Oceanogr.* 11.1, pp. 1–22. ISSN: 2364-3579. DOI: 10.5194/ascmo-11-1-2025.

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