We would like to thank the two reviewers and the editor for constructive feedback during this second round of reviews.

In the following, we provide a point-by-point Author Response (AR) to any of the Reviewer Comments (RC). When presenting suggestions for how the manuscript text could be revised, the text is presented in *italics*.

Round 2, answer to Reviewer 1

RC1.1: (RC/AR1:) I am not hundred percent satisfied with the treatment of uncertainties, which are more an "out of the box" estimate than a rigorous approach. I suggest moving the section 4.5 in the method section because it is very strange to have it just before the conclusion. The authors do not explain how they aggregate the uncertainties from single glacier values to Swiss-wide values (L503-505). I am not asking more work from the authors side, but it would be good to acknowledge that uncertainty estimates could still be improved.

AR1.1: Thanks for the suggestion. We agree and have moved the uncertainty section accordingly. We also include two equations that describe how the uncertainties have been aggregated at the regional scale. The new text reads as follows:

We compute the mass balance uncertainty at the Swiss-wide scale $\sigma_{B_{\mathrm{CH}}}$ *as:*

$$\sigma_{B_{\mathrm{CH}}} = \sqrt{\sum_i \left(\sigma^2_{b_i} \cdot \frac{A_i}{A_{\mathrm{tot}}} \right)}, \tag{1}$$

where σ_{b_i} *is the mass balance uncertainty for the i-th glacier, with its area* A_i*, and* A_{tot} *the total glacier area in Switzerland. Subsequently, we combine the uncertainties in Swiss-wide mass balance (see Eq. (1)) and the uncertainties in glacier area as follows to obtain an estimate of the uncertainty in computed ice volume change* σ_{dV}*:*

$$\sigma_{dV} = dV \cdot \sqrt{\left(\frac{\sigma_A}{A_{\mathrm{tot}}} \right)^2 + \left(\frac{\sigma_{B_{\mathrm{CH}}}}{B_{\mathrm{CH}}} \right)^2}. \tag{2}$$

where σ_A *is the estimated uncertainty in glacier area,* A_{tot} *the overall glacier area, and* B_{CH} *the average mass balance of all Swiss glaciers.*

As suggested by the reviewer, we have now also inserted a short statement that the uncertainty estimates could be further improved and are not conclusive.

This approach provides a first-order uncertainty estimate. However, there remains potential for conducting more rigorous uncertainty assessments.

RC1.2: (RC/AR3:) thanks for the clarification of the calibration procedure, it is formulated in a much clearer way.

AR1.2: Thanks.

RC1.3: (RC/AC14:) thanks for the clarification about the "ensemble" approach. How is the ensemble dispersion used? Does it go into the uncertainty estimate at some point?

AR1.3: Thanks. Indeed, the dispersion deriving from the input geodetic estimate is accounted for when computing the uncertainty ($\sigma_{geodetic}$, see Eq. 8). We have now added a statement to refer the reader to the corresponding section.

The ensemble spread is used to derive the uncertainty of our mass balance estimates (see Sect. 4.5).

RC1.4: RC/AR18: I insist that a diverging colorscale is not appropriate to show the data you are showing. I understand that you want to highlight regional patterns, but the colorscale you use introduces some artificial contrasts (Crameri et al., 2020).

AR1.4: Thanks for suggestion. We have changed the colorscale to sequential colorscales (Fig. 1).

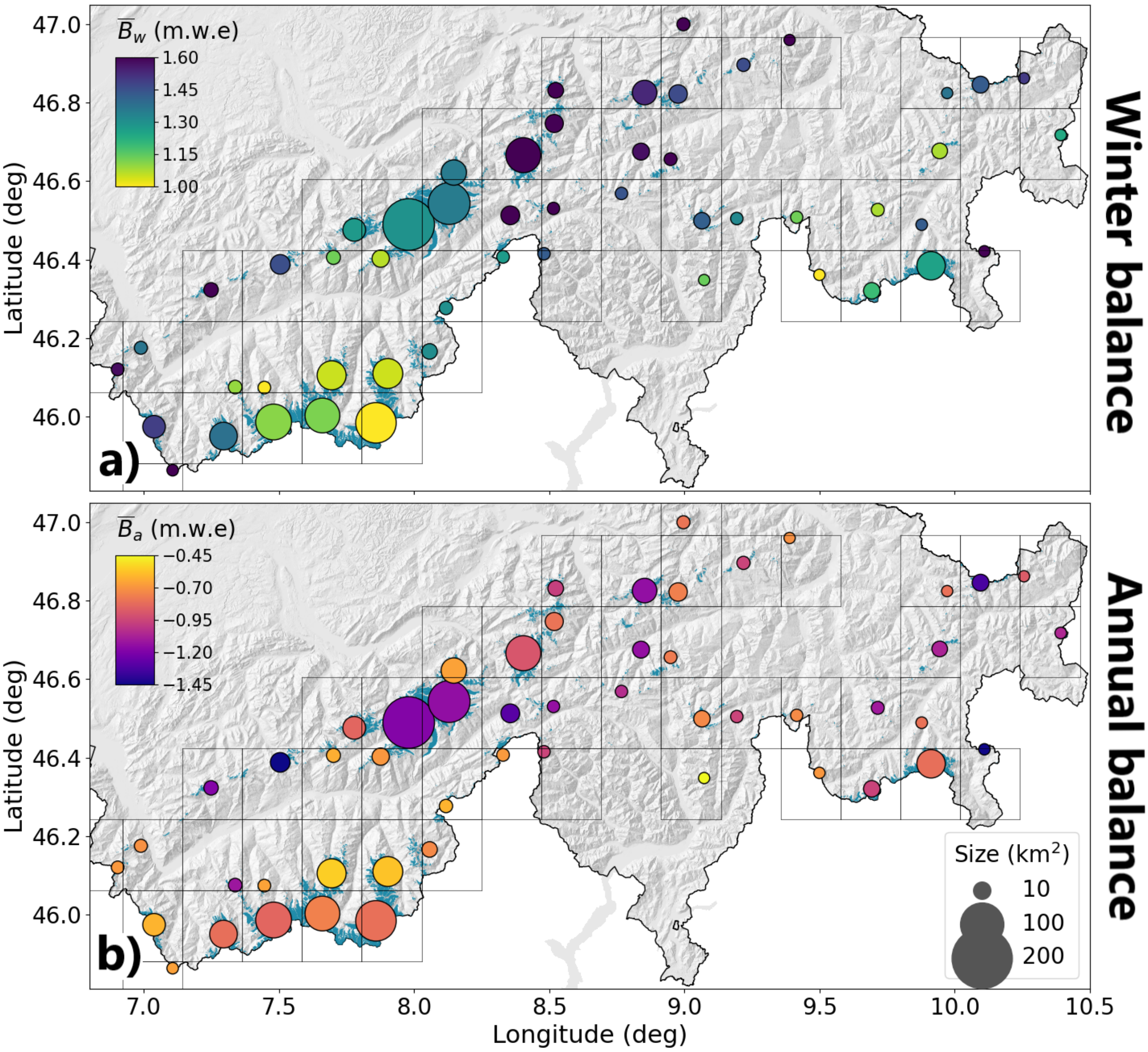

Figure 1: Average seasonal mass balance for the Swiss Alps over 2010-2024. (a) Average winter balance (30 April), and (b) average annual balance (30 Sept). Glacier-wide values are aggregated over a 20x20km grid with area-weighted averaging, whereby the size of the circles shows the glacierized area within each grid cell.

RC1.5: Fig. 3 – why are there two grey boxes at the top with cprec twice and the melt parameters are separated?

AR1.5: As we used two melt models (each with their own parameters), there are two boxes. The parameter c_{prec} is shown twice to highlight that the melt models are coupled with the same accumulation model. We have now clarified this by adding a hint on top that each box referring to the respective melt model.

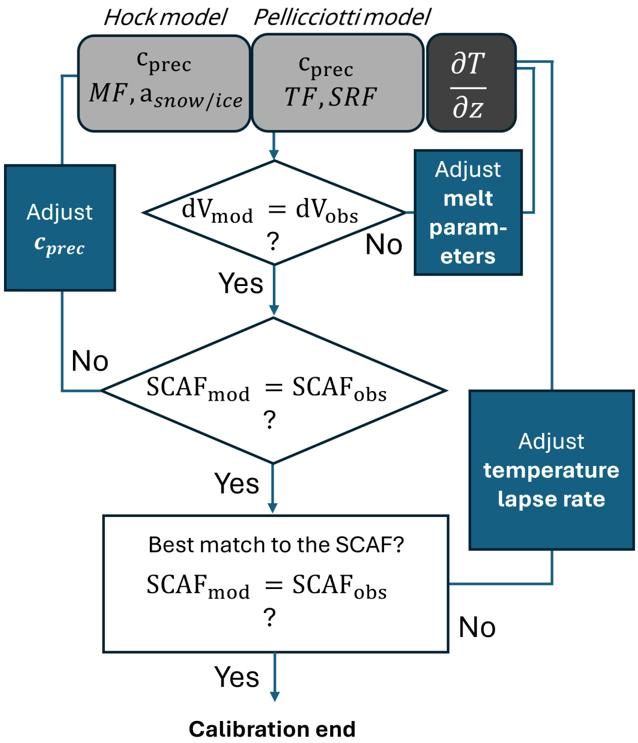

Figure 2: Three-step model calibration scheme. In the first step, the melt parameters (MF, $a_{snow/ice}$, TF, and SRF) are adjusted to match the observed ice volume change. In the second step, the precipitation correction factor (c_{prec}) is adjusted to optimise the reproduction of the observed SCAF over the melt seasons. In the third step, the temperature lapse rate is adjusted to further minimise differences between modelled and observed SCAF.

RC1.6: Fig. 10b – what is represented by the black line? I can't ell if it is a regression line or a 1:1 line (which would be meaningless given that variables with different units are compared)?

AR1.6: The black line indeed represented the 1:1 line. However, we note that this was not necessary for the interpretation of the figure and thus have removed it to avoid confusion. The revised figure is pasted below.

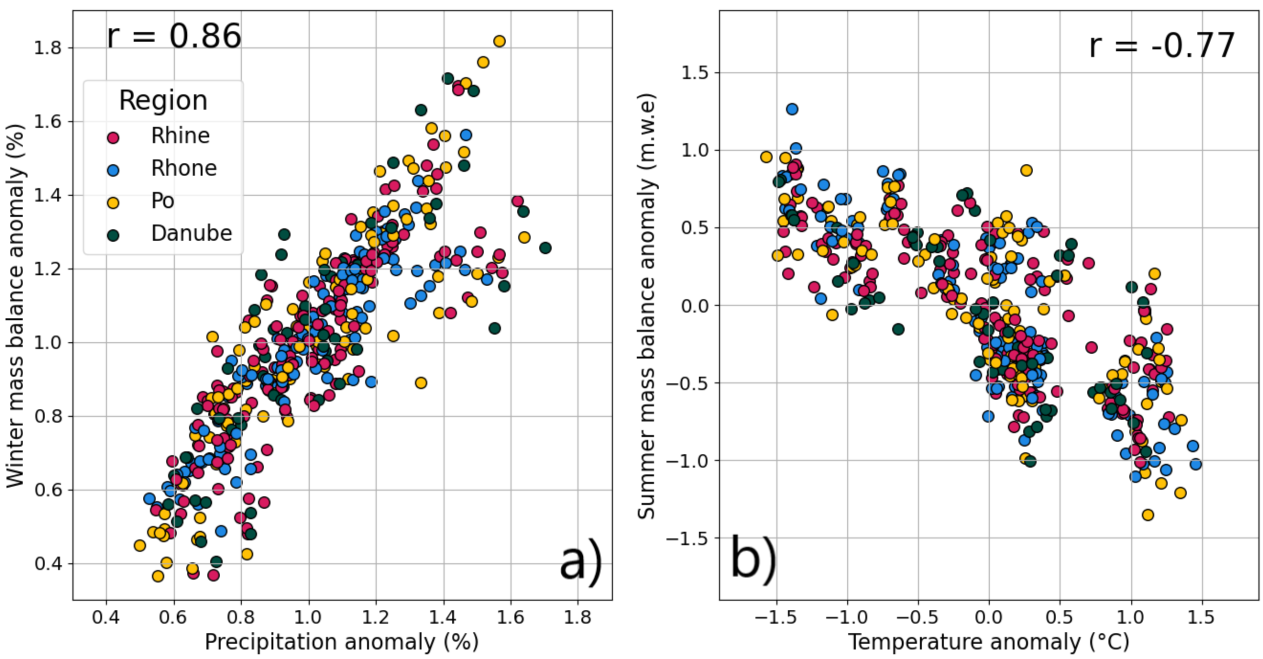

Figure 3: Correlation between mass balance anomalies and the anomalies in meteorological variables for all Swiss glaciers (aggregated on the 20 x 20 km grid). (a) Winter precipitation anomaly versus winter mass balance anomaly. b) Summer temperature anomaly versus summer mass balance. The colours distinguish the different hydrological basins where the glaciers are located.

Round 2, answer to Reviewer 2

RC2.1: Referring to Fig4: Could you add a plot the distribution of the glacier-specific mean biases and MADs for all the 10 glaciers in the supple, and discuss the outliers or regional pattern, if any?

AR2.1: Thanks for this suggestion. We agree that this could indeed be useful for interpreting the validation result. We thus added two figures to a newly generated Supplementary Material showing the deviation between modelled and observed seasonal mass balance for the ten glaciers individually, both for winter and annual mass balance (Figures 4 and 5, below).

However, extracting statistically robust insights into the spatial distribution of the glacier-specific biases or their relation with glacier characteristics is difficult both due to the limited sample size (only 10 glaciers) and their large heterogeneity. Thus, these ten glaciers would not allow a reliable analysis of the spatial distribution of glacier-specific biases, meaning that any such discussion would remain largely speculative. We therefore leave it to the reader to assess potential biases now clearly depicted in the Supplementary Material, for example in the context of local studies.

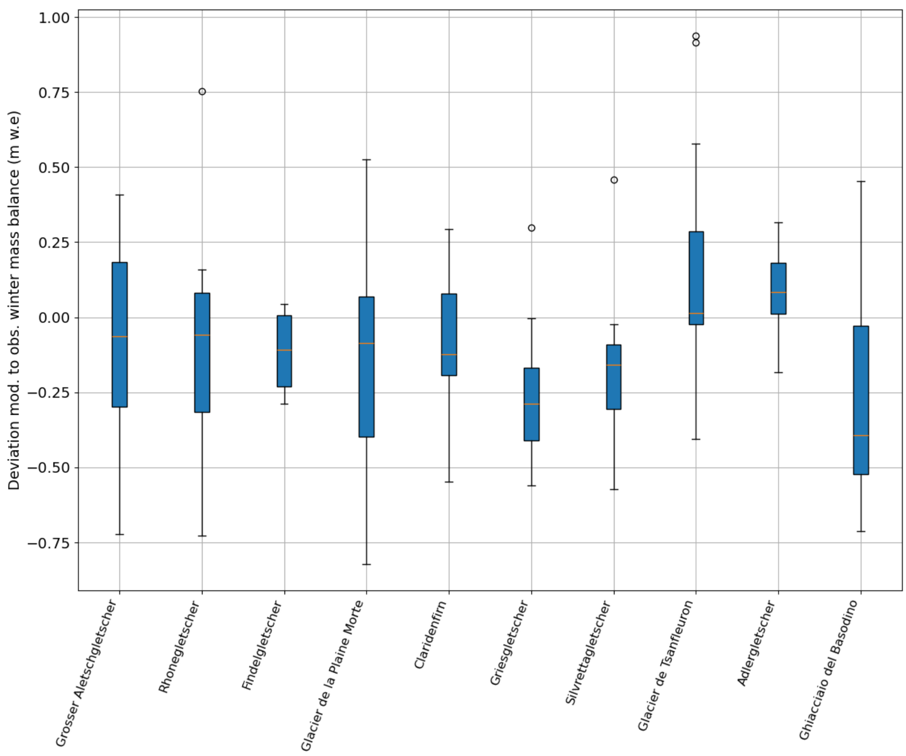

Figure 4: Deviation between modelled and observed glacier-wide winter mass balance for the 10 glaciers with detailed seasonal monitoring data over the period 2010-2024.

RC2.2: Referring to Fig5: Could you plot of the mean bias and MAD, binned by observed mass balance values? The point is that to understand the model performance just relying on two scalar metrics may not be enough. For examples, what if your MAD and bias are changing systematically with things like mean mass balance, glacier size, location etc.? It is good to look for and flag such instances, than relying on only two numbers and visual inspection by the readers. To illustrate the above point, while you claim 'no systematic skew' in Fig5, probably only by a visual inspection, I calculate mean bias and MAD for the window shown in the plot above to get a mean bias of 0.27 m/y. Can it bias your results in the extreme years? Please provide the value of bias along with MAD in the text. If you analyse model performance as suggested here, and find any systematic pattern, then the implications needs to be considered.

AR2.2: We thank the reviewer for this detailed consideration of our results. We agree that the data points would allow a series of further statistical analyses but we also need to consider if these have a

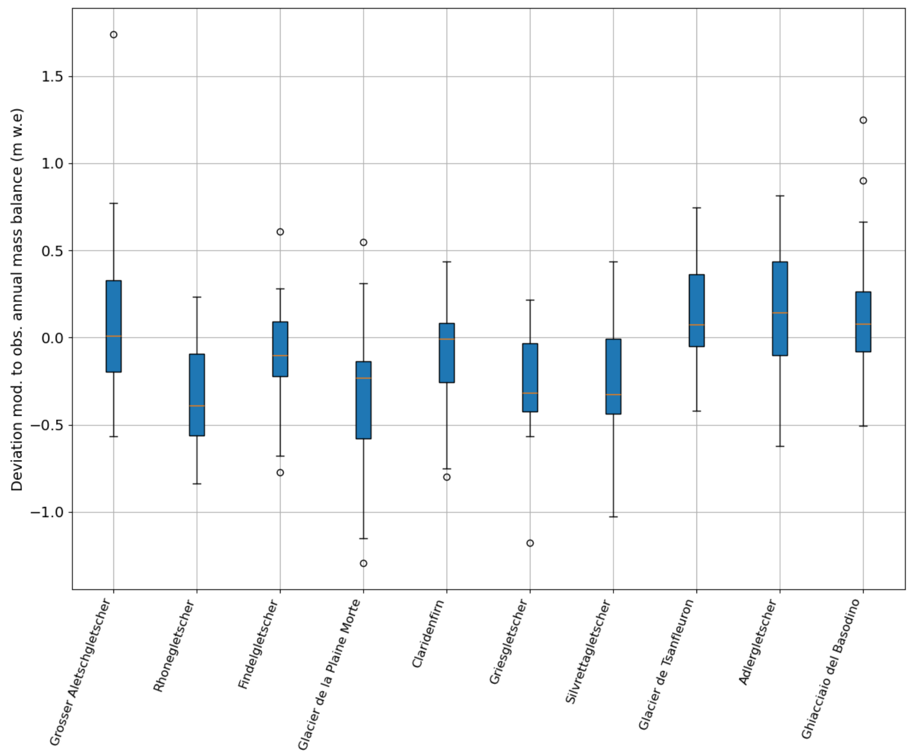

Figure 5: Deviation between modelled and observed glacier-wide annual mass balance for the 10 glaciers with detailed seasonal monitoring data over the period 2010-2024.

relevant potential to influence our results and conclusions. Fig. 5 clearly shows that the model results in general match the observations well in sub-periods throughout the year, and we have included a corresponding statistical metric in Figure 5 and in the text to underlie this statement.

As suggested by the reviewer, we have now also evaluated the average MAD and bias for bins of equal observed mass balance (intervals of 0.5 m w.e) and have included the corresponding figures in the Supplementary material (Figures 6 and 7, below). The results indicate a slight trend towards larger MADs for periods with more negative mass balance (Fig. 6). This is directly explained by the magnitude of the analyzed changes: The potential for larger absolute deviations increases with the length of the period, or the intensity of mass change. This is a reason why we interpret the relative deviation in Figure 5. As suspected by the reviewer, periods with more negative mass balances are generally characterized by somewhat more negative modelled mass balance than observed, however without a consistent pattern (Fig. 7). With respect to the total mass balance over the investigated periods we consider these differences to be minor. They remain below 10% of the mass balance signal for all classes of equal observed balance. We thus do not see a need to further interpret these differences individually. Such an interpretation would also be poorly constrained and speculative as many individual factors can play a role (comparison across different glaciers, with different specific locations of the point observations, different lengths of the observation period, and more or less extreme years). Nevertheless, we now refer the reader to these new figures and evaluations in the Supplementary Material as follows:

By binning the individual data points of Figure 5 into classes of observed mass balance, it becomes clear that the model matches the observations well over the full range of the measurments (Supplementary Fig. 6 and 7). A locally increased bias, for example, in the bin with the most negative observed mass balance, may be related to specific conditions at the considered data points but is not sufficiently pronounced to be interpreted in a general sense.

RC2.3: More discussion on patterns seen in fig10, including a potentially low correlation between the anomalies of summer MB and T for the positive-mass-balance years

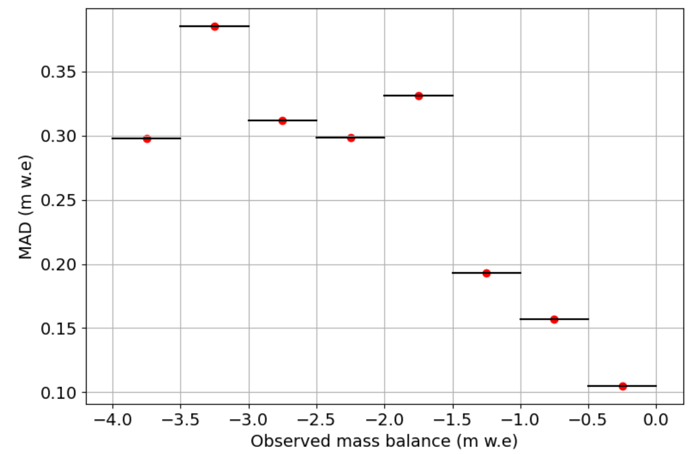

Figure 6: Average Mean Absolute Deviation (MAD) in sub-seasonal point mass balance over arbitrary time periods of between 7 and 90 days classified to classes of observed mass balance.

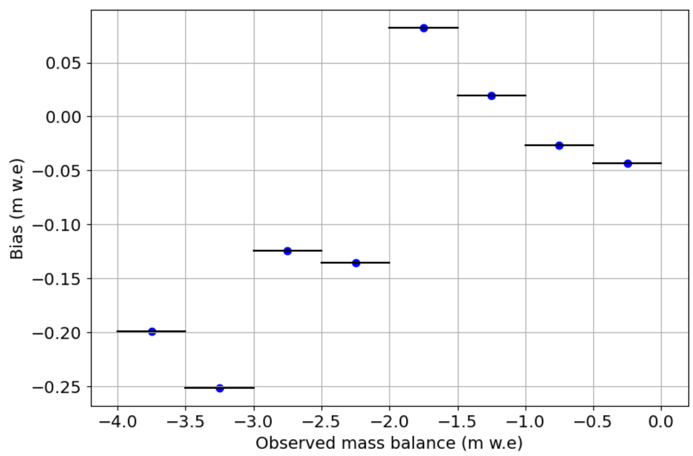

Figure 7: Average bias in sub-seasonal point mass balance over arbitrary time periods of between 7 and 90 days classified to classes of observed mass balance.

AR2.3: As suggested, we added more interpretation regarding the data shown in Figure 10 to the corresponding paragraph, especially regarding the limited temperature-correlation of positive mass balance years. As the figure shows the model output, we find it delicate, however, to strongly expand this as statements about the relations may become quickly speculative. Basically, the analysis simply presents what the calibrated model, including optimal constraints to various data types, comes up with.

An interesting aspect is the limited dependence of annual mass balance on the temperature anomaly in the case of mass gain (Fig. 10b). For example, annual mass balances of between 0 and +1 m w.e. can occur with the same air temperature offset. This can be attributed to the pivotal role of the precipitation regime in a given year that does not need to be correlated with the temperature anomaly.

References