

Dear Dr. Ceppi,

We have completed the minor revisions requested by the reviewers for our manuscript titled **ClimaMeter: Contextualising Extreme Weather in a Changing Climate**. We have addressed all of Reviewer #1's comments as follows:

**1. Text Corrections:**

- Corrected various typographical errors and improved phrasing as noted.

**2. Clarifications and Additions:**

- Clarified data usage (Line 86).
- Removed the sentence about excluding multi-day events (Lines 134-135).
- Corrected all instances of "ClimaMeter" (Line 164).
- Clarified the computation of metrics by introducing Q and Q\_a (Line 191).
- Updated figure presentations and descriptions, especially Figure 2a (Lines 210, 220).
- Repositioned the "statistics of events" section for better flow (Line 219).
- Revised discussions on natural variability and climate change contributions (Lines 228-229, 231).
- Added limitations and potential future work considerations (Lines 499, 507).
- Addressed the 33% reduction approach and potential biases (Lines 520-521).
- Expanded on ClimaMeter's capabilities and role in attribution (Lines 534, 539-541).

We have ensured that all suggestions have been incorporated and that the manuscript is now more precise and clearer. Detailed answers are provided below.

Thank you for considering our revised manuscript.

Best regards,

**Davide Faranda**

On behalf of the ClimaMeter team

## Report #1

The authors have clearly taken my comments on board and made substantial revisions, and the focus of the paper – and the aim of the ClimaMeter methodology – is clearer as a result. I have a few additional comments below, mainly relating to the new text.

51. Replace ‘at the basis of’ with ‘which forms the basis of’

**corrected**

59. ‘a visual overview’

**corrected**

67. ‘and Storm Poly’

**corrected**

86. Suggest ‘Operationally we use data from MSWX’ to make the distinction clearer

**suggestion accepted**

99. Typo – ‘Finally, while’

**corrected**

134-5. It’s not clear whether analogues within a window of events that last for more than one day are also excluded. Why are one-day events treated differently?

**We have removed this sentence. This is a feature that we are still implementing and that was not applied to the case studies shown in this paper. The exclusion protocol will be applied to all events, including those lasting longer than one day, in further studies and versions of ClimaMeter.**

164. Punctuation: ClimaMeter (please also do a case-sensitive search to check for other instances of this)

**We have corrected all the instances ClimaMeter with the right spelling**

191. I think the definition of Q is still a little unclear. Is Q the mean of the EDs or does each analogue have 15 Q values, one for each analogue? Suggest ‘If ... Q\_obs (the mean ED from the actual event to the analogues) is below the 75<sup>th</sup> percentile...’, and replacing Q with Q\_obs where necessary.

**We thank the reviewer for this suggestion. Indeed, the previous formulation was confusing. We have now introduced two quantities. We leave Q as the analogue quality and name Q<sub>a</sub> the full distribution of Euclidean distances of the best analogues of the event. Introducing Q<sub>a</sub> makes the computation of the metric more understandable.**

210. Remove ‘creating the corresponding difference maps’ – I don’t think maps of the bootstraps are produced, only the standard deviations are used to identify significant differences.

**corrected**

213. Typo: ‘is highlighted’

**corrected**

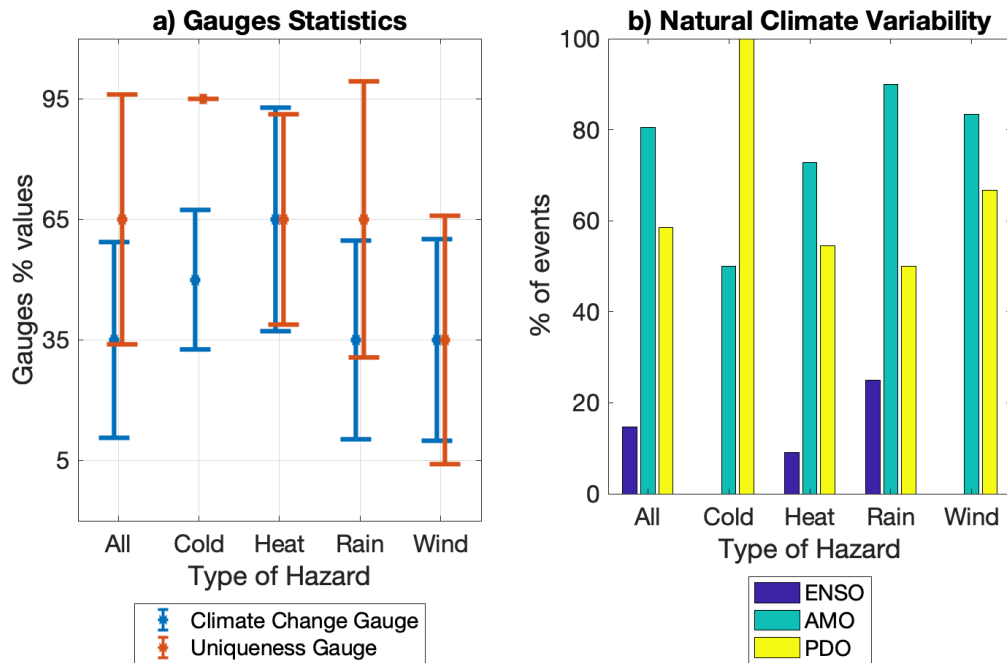
219. I think the addition of the ‘statistics of events’ here breaks up the flow of the description of the methodology, which would otherwise move smoothly from description of the analysis to the communication protocol. Suggest moving this to just before the conclusions, where it would fit better.

**As suggested, we have moved this section before the conclusions.**

220. This explanation is not very clear. Suggest ‘Figure 2a presents the median value of the gauge values over all 41 events studied by ClimaMeter to date; Figure 2b shows the proportion of events found to be influenced by each of the modes of natural climate variability considered’.

Actually, I don’t think this is a very clear way of displaying this information: both subfigures are bar plots, but one represents the median gauge value (and should therefore only be able to take values between 5 and 95%) while the other represents the proportion of events affected. Using a bar chart for the proportions, which can take any value between 0 and 100 and where the shaded area is meaningful, is fine. However, Figure 2a is potentially misleading: a better approach would be to use histograms showing the distribution of the gauge values. A more compact alternative would be to plot a bar from 5-95% for each column, then to shade the appropriate segment according to the number of occurrences; in which case, to avoid confusion over the meaning of the two plots, it might be better to show Figure 2a using horizontal bars, rather than vertical.

**We agree with the reviewer’s comment and we now present (ex Figure 2a and now Figure 9) as an error-bar plot. The new figure shows error-bars reporting the median values (circles) and the standard deviation (whiskers) of ClimaMeter’s climate change and uniqueness gauges. We have consequently updated the description of the figure in the text.**



228-9. This isn't strictly accurate: Figure 2a doesn't show the full distribution, so it's not clear whether most studies have only 50% contribution from climate change, or whether half have 5% contribution and the other half 95%. Furthermore, the ClimaMeter method doesn't actually evaluate the contribution from ACC directly, it only excludes the influence of other modes of variability: it would therefore be better to say something along the lines of 'the median percentage value suggests that differences between the analogues in the current and past periods can often be at least partially explained by modes of natural variability, rather than by climate change alone'.

**Thanks for this important comment. We have changed this sentence and the discussion of Fig. 2 along the lines suggested by the reviewer.**

231. It's worth mentioning that the finding that the climate change signal is most visible in heat extremes is in line with the IPCC's findings – see Figure SPM.3 (<https://www.ipcc.ch/report/ar6/wg1/figures/summary-for-policymakers/figure-spm-3>)

**Thank you for the suggestion, this has been updated as suggested.**

236. I don't see how this demonstrates the capabilities of ClimaMeter, although it's useful to have an overview of the results of past analyses – suggest removing the first part of the sentence and moving this paragraph to the end of the section.

**We have modified the sentence accordingly**

375. 'the content is consistent with...'

**corrected**

413. Suggest 'than usual for the time of year' for clarity

**corrected**

420. 'weather situations' seems like an odd phrase here – maybe 'large-scale pressure events' or something similar?

**corrected**

423. Typo: 'the pressure over Brittany has become higher, while it has become lower over Italy'.

**corrected**

440. The conclusions here need to be updated.

**updated**

485. Add reference to Figure A4

**added**

488. Given the uniqueness of the event, is it accurate to talk about 'storms similar to Poly'? What are the events that are identified as analogues?

**The identified patterns consist of low pressure systems with weaker anomalies or displaced spatially; this has been added to the text.**

492. Typo: Fig 8)

**corrected**

496-8. Typos: 'when comparing the gauge plots. Indeed, we find evidence that for the MSWX analogues the event is unique'

**corrected**

499. Could the selection of different analogues be due to choosing too small a domain size? Would it be better to consider a larger domain in order to find more consistent analogues? It

would also be useful to know if differences in analogues are more common for certain types of weather events – this could be cited as potential future work if there’s not enough information to judge at the moment.

**These limitations are now clearly stated, see our answer to the reviewer comment for LL 539-541 indicated by (\*)**

504. Typo: ‘and the C3s...’

**corrected**

507. You should recap in the conclusions that, as mentioned in lines 99-100, there are limits to where analogues can be used effectively; this would also be a good place to acknowledge that the results may be sensitive to the choice of dataset and domain used.

**These limitations are now clearly stated, see our answer to the reviewer comment for LL 539-541 indicated by (\*)**

520-1. I don’t think this is necessarily a limitation of considering only the satellite era: this could also lead to overestimation of the effect of climate change since preindustrial times due to changes in the rate of local warming, but since the effect of climate change isn’t actually estimated in ClimaMeter reports, that’s not a major problem. I’d comment instead that the method risks underestimating the contribution of climate change by reducing the assumed influence of climate change by 33% each time a significant difference is detected in a mode of natural variability, when actually both factors may contribute to the observed change in intensity.

**Thank you for the suggestion, we have modified the text accordingly and now concerning the analysis period chosen, we highlight the issue with the brevity of the time series rather than specifying in which direction potential biases that this introduces would go. We have further added a comment on the approach of reducing the assumed influence of climate change by 33% each time a significant difference is detected in a mode of natural variability, noting that this indeed risks underestimating the true contribution of climate change.**

532. Given the comment in lines 527-529 about ClimaMeter’s role as an initial evaluation of the event, I think it’s important not to oversell the potential use of the method in its rapid-attribution form in the next line. Suggest changing to ‘Researchers can utilize ClimaMeter’s methodology to...’

**corrected**

534. What kind of events not addressed in the literature?

**We modified the sentence as follows:**

**“Researchers can utilize ClimaMeter’s methodology to delve into the relationship between climate change and specific extreme events, even those not typically addressed in statistical attribution studies, such as medicanes, explosive extratropical cyclones, tropical cyclones, Acqua Alta events in Venice and others.”**

538. Typo: ‘to investigate the role...’

**corrected**

539-541. Again, the role of other attribution services should be acknowledged: confidence in any attribution result is increased if different methods produce similar or consistent conclusions. Suggest ‘Policymakers can rely on ClimaMeter as an additional source of evidence as to how and to what extent specific extreme event categories in a given geographical area have changed over time thus enhancing the overall knowledge basis...’ (since the changes are not, strictly speaking, attributed to climate change by this method).

**(\*) Thank you for the comment, we agree with these considerations. We have rephrased the passage where we discuss the use of ClimaMeter by policy makers. We have additionally included the following paragraph in the conclusions:**

**“Related to this, we also reiterate that the spatial domain used for the analogues is chosen based on expert judgment from members of the ClimaMeter project, and therefore it carries an arbitrary component. The results of a ClimaMeter analysis are likely to provide different results if different domains are chosen, especially if larger or smaller-scale features become dominant due to a much larger or smaller domain. Furthermore, we stress that there are limits to the analogues approach. For example, conclusions about the impact of climate change are more robust in case studies where the analogue quality is high, and the long-term climate trends match the changes in the extreme event itself. Finally, ClimaMeter is designed to work for extreme events whose dynamics can be well represented through circulation analogues. Small-scale events where local processes are important – e.g. an isolated tornado or a hail storm – are currently outside the scope of ClimaMeter.”**

541-544. This would follow on well from the end of the previous paragraph highlighting the benefit of ClimaMeter (and, I think, currently its main function) as a rapid communication tool, so I’d move this up to the start of this paragraph, and perhaps highlight again the speed with which reports can be produced.

**As suggested, we have repeated the advantage of ClimaMeter in terms of rapidity for producing quick reports on extreme weather events in the conclusions**

561. (Perhaps more of an operational point) – it’s important to distinguish between low confidence due to uniqueness of the event and low confidence due to inconsistency with previous results: for example, a very unique heatwave we would still be confident that

climate change played a part, but under this framework the headline would be ‘low confidence’, which could be misleading.

**We have this point well in mind for our “operational” approaches. Yet we believe that a single confidence statement should be provided in the report for clarity of communication with the media and general public and that it is better to err on the side of caution rather than potentially overstating the confidence we have in our results.**

Figures A1-A6. The observed values of ENSO, AMO and PDO are still missing .

**Thanks again for this suggestion. However, as mentioned in the previous answer for revision 1, we will not add this information to the supplementary ClimaMeter figure or to this paper. In most cases, ClimaMeter covers weather extremes immediately after the event, so that monthly teleconnection indices are not usually available at the time of the analysis. Furthermore, the observed values of ENSO, AMO, and PDO are not used to compute any statistics for ClimaMeter or to write the text report - we only use the statistical difference (or lack thereof) of the two ENSO/AMO/PDO distributions.**

697. Bibliography entry for Guardian article is wrongly formatted.

**This reference no longer appears in the text.**

**Report #2**

Accept as it is