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Reply on RC1

Chloe Brimicombe et al.

Author comment on "Characteristics of Heatwaves in Africa: Morocco 2000 and South Africa 2015/16" by Chloe Brimicombe et al., Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2021-242-AC1>, 2021

The work here presented has the potential for being a relevant and useful study. The subject under discussion is of extreme importance considering the current climate change context, the natural and socio-economic impacts linked to heatwaves, the demographic projections for Africa and, finally, the lack of analysis conducted for this continent, where the living conditions of most of the population are poor and climate change is far from being a priority for the policymakers. I believe the authors share this perception and have in mind the relevance that studies of this kind have.

We thank the reviewer, our research does indeed work to address the under discussion of extreme heat and climate change.

However, the manuscript calls for major revisions and needs to be improved in many aspects. First, regarding the quality of writing, in many sections the text is confused, disconnected and with grammatical and syntax errors. The reader often struggles to understand the rationale and the ideas that authors pretend to share. Therefore, I strongly recommend a thorough review of the English writing throughout all the paper.

Thank you for this valuable feedback. We will thoroughly review and revise the manuscript.

Some of the methods and metrics adopted by the authors must be clarified. For instance, the UTCI index lacks a mathematical definition and a more detailed interpretation of its values.

We will clarify the methods section. The UTCI is a robust index and has been previously used for African Nations please refer to citations in this paper: *Guigma, et al. 2020*

In addition, We will include the mathematical definition of the UTCI which is:

Where T_a = air temperature, T_r = mean radiant temperature, V_a = wind speed P_a = water vapour pressure.

I also have some doubts regarding some of the methodologies that were adopted by authors to achieve the objectives that were proposed. In addition, some results are not consistent with the interpretation and discussion conducted throughout the manuscript text.

We have clarified our methods to ensure that the way in which they achieve the objectives is clear to the reader. We have also reviewed our results and find them to be consistent with our interpretation. We will address further comments on results below.

I found even some results "unexpected" and very strange, calling for an urgent review. As a consequence of this, most of the conclusions made by the authors find a weak support in the results presented. We have clarified the result section to discuss why the results are not unexpected and to make clear how our conclusions are supported by the evidence.

The manuscript needs major reviews. I ask the authors to kindly consider the following comments and suggestions:

We will change this to Morocco Heatwave.

Line 23: What is "Morocco heat"?

Line 26-27: Please clarify this sentence... I'm not sure what authors are trying to say here.

We will change this to "Further it can be seen that in some African Nations heatwaves are reported but this needs improvement in order to capture impacts across the continent."

Line 32-33: These deaths occurred mostly during two particular mega-heatwaves events in Europe. Authors should detail the particularities of these two episodes (duration, severity of the induced heat-stress levels) and explain why they were responsible for such high mortality rates and other impacts in many natural and socio-economic sectors... This would reinforce the importance of analyze in detail specific historical events such as the ones studied in this work.

We have a recent paper published showing that these mega-heatwaves were not just in Europe *Brimicombe, et al., 2021*. which will now make reference to. It shows that there were high heat stress levels during both the 2003 and 2010 August Heatwaves in parts of the African continent and that the impacts of heatwaves are under-reported.

Lines 36 – 45: This paragraph is very important to show the relevance of this study. It represents a substantial contribution to the understanding of natural hazards and their consequences. The authors should detail how the poor living conditions of most of the African population are crucial to explain the high levels of heat-related mortality and how the fragile economies struggle to recover from heatwaves and

We agree with the reviewer entirely and will add this to the manuscript as suggest. We will also include a nod to how building material can increase the indoor temperature. However, as noted in this paragraph there is sparse recorded evidence for heatwave impacts across Africa and therefore a lack of evidence recorded of economic struggles.

other climate extremes – showing once again the relevance of this type of studies, particularly for the African continent.

Line 75: Authors should provide a mathematical definition for the UTCI index. They should also provide a thorough interpretation of what this index really means. What are the variables involved and what are the implications for humans when extreme high/low values of this index are recorded?

We have included the mathematical definition of the UTCI which is:

Where T_a = air temperature, T_r = mean radiant temperature, V_a = wind speed P_a = water vapour pressure.

In addition to the results section: The UTCI is a thermal index which makes use of the meteorological parameters of 2m temperature, water vapour pressure, 10m wind speed and mean radiant temperature and a body model (Di Napoli *et al* 2021). It has been compared to many other thermal indices such as apparent temperature and heat index and captures well an average body response to the thermal environment (Zare *et al* 2018, Jendritzky *et al* 2012, Blazejczyk *et al* 2012). It has further been shown to be able to forecast heatwaves internationally (Pappenberger *et al* 2015) and accurately indicate extreme heat for Africa (Guigma *et al* 2020).

Line 93-97: Check the syntax of this sentence.

Thank you we have checked the syntax

Line 98: I'm not sure what authors mean by "notably area"; check the syntax. Also, try to use a more robust and objective reason (severity, magnitude of the events, spatial extend.....) to justify the decision of choosing these two events in particular... I'm not convinced. Also, "Reported Impacts"? Which ones?

Line 118-119: Poor English writing.

We will simplify the sentence structure.

Academic Literature and reports show that 39 heatwaves have been reported since 1980 in Africa.

Line 122: Showing the coordinates of these regions only makes sense if the authors reference a figure....

We have asked a range of colleagues and they find the longitude and latitude references useful to understand where in Africa each region is.

Line 125-126: I'm confused. This is not clear. Rewrite this sentence please.

We will change this to: "Characteristics of heatwaves (n=26) are reported more than their impacts (n=9)."

- The caption of the figure is very poor. We will describe each figure in more detail.

Authors should provide more information about the variables and the figures that are presented: What are the panels showing? Anomalies? "Temp" is surface temperature?

- The location of South Africa (Morocco) We agree and will add a box highlighting within the African continent should be highlighted.

- I don't like the layout (horizontal) of the figure... It's not easy for the reader to follow the figure and the text at the same time. Try to order the panels in a vertical way. We agree but this was necessary because of the format of NHESS peer-review system.

- Try to save some space by removing the colorbars and the legends of the x-axis/y-scale on each figure. Our colleagues have found it useful to have a axis that are repeated throughout the several panels.

- The bottom panel with the UTCI time series is supposed to be Figure 1d, isn't it? Also, are these area averaged UTCI values for South Africa (Morocco in Figure 2)? This is not mentioned... Please clarify. We will clarify this in the figure description please see as above.

Line 157: I'm not sure about the need to show the Z850 anomalies considering that you are already showing the 500-hpa geopotential anomaly.

It has previously been shown that the Saharan Heat Low is best captured by between 700 and 900hpa values, a higher height than 500hpa (Lavaysse et al 2016). We have clarified this in the text.

Line 160 – 161: Is this true for Temp? Over South Africa, the anomalies are close to zero! I have doubts about the quality of these results. If the temperature values are within the expected values, we can't consider this as a Heatwave. For instance, Pretoria region has even negatives anomalies of Temp (once again, what is Temp??)... In table 1 authors say the following: "*Heatwave Concurrent with a drought and an ENSO event. Temperatures reached 42.7 °C in Pretoria and 38.9 °C in Johannesburg on 6 th January.*" Something here is not right. I know that the heatwave definition used by authors is based on the UTCI values, but, isn't it strange to have a Heatwave event with lower temperatures than the expected values? Once again, how are the UTCI values obtained? This needs a careful and urgent review!!

The figure is showing over the part of South Africa where the heatwave is present anomalies in temperature (Temp) are up to 2C hotter than the climate. We will clarify this in the text.

The UTCI is not the same as temperature, please refer to the methods section. It is a model of a body response to the thermal environment. It assess how temperature, mean radiant temperature, water vapour pressure and wind speed effect an average body and indicates heat stress (Di Napoli, et al., 2018,2019,2021).

In the figure the parts of South Africa experiencing a heatwave are on the southern coast including over cape town. The anomalies are present at up to 2C hotter in Temperature for both Pretoria and Johannesburg.

ERA5 data as a reanalysis dataset will not give the same values as recorded observed temperature and we will also clarify this in the methods section. ERA5 however has been found to accurately identify heatwaves despite not having values that match the maximum temperature recorded (Di Napoli, et al 2018, Brimicombe et al 2021,Hersbach et al 2020).

Line 165: It should be Z850... Once again, the authors are not extracting any relevant information from the Z850 anomaly field.

Thank you we have corrected this typo

Line 166 – 167: Not sure about what the authors mean to say here. Please clarify

We will re-write this to clarify:

Considering the drop in temperature and UTCI anomalies it can be inferred that this low pressure has a cooling influence on the region.

Line 190: Slight cool anomalies? According to the results, there are regions reaching values between -5°C and -10°C.

Thank you this is a typo we have clarified that anomalies are between -5C and -10C

Line 196 – 198: Not sure about this... Morocco is still under the influence of high anomalies of Temp (reaching levels very close to 5°C). Authors need to Check the data because the results are not consistent with what is discussed in the text.

We will add a box to the figure to aid the comparison of the written text and figure. The results are consistent with what is discussed in the text.

Line 198 – 200: Please rewrite this sentence.

We will restructure this sentence 'the z850 and z500 negative geopotential anomalies to the east of Morocco indicate a low pressure system which could be in part having a cooling influence on the region.'

Lines 200 – 201: Please rewrite this sentence. Not sure about what authors are trying to say here.

We will restructure the sentence.

'The peak of the UTCI and temperature are similar during the Morocco 2000 and South Africa 2015/16 Heatwave, with anomalies of up 2°C respectively.'

Lines 232 – 234: Authors should include some possible explanations for this, for instance, the topography, the influence of more local meteorological processes, the influence of the Sahara Desert, different land covers....

Yes we agree and have expanded this section to include information about the desert winds that influence the temperature regime of Morocco (Filahi, *et al* 2016) As well as discussing the position of the Saharan Heat Low which also influences the air flows for Northern Africa (Lavaysse *et al* 2016).

Lines 234 – 236: Which pressure pattern? Authors were able to link heatwaves in South Africa and Morocco with geopotential anomalies. Here, in the discussion, they should detail what are the synoptic processes that are behind this link.

Thank you we have clarified that this is a high pressure system.

Lines 236 – 239: Authors should rewrite this sentence please.

We will rewrite this as follows: Heatwaves drivers are closely linked to the climatology and synoptic systems in a region for both of the heatwaves examples

Line 240: This would be the ideal paragraph to authors mention some of the limitations of this study.

We agree and have clarified this paragraph's aim:

Further work should consider more fully the meteorology of the heatwave this study has more of a focus on extreme heat impacts, such as heat stress.

Lines 259 – 260: Authors should rewrite this sentence please.

We will rewrite the following as African heatwaves have a lack of observations,

under-reporting fuels a lack of evidence and a patchy research field, intrinsic factors that has a growing mandate to be addressed globally

Lines 267 – 276. Authors should rewrite all the Conclusion paragraph. There are a lot of syntax and grammatical errors. The text is confused and disconnected. I'm not sure if authors were successful in covering the ideal

bullets for the Conclusion section (Why is this study relevant? What were the key findings and what can we learn from them? Is this a novel approach for Africa? How

could these results be used to predict future events? Should policymakers and authorities start to look at these climatic extreme with more attention? Basically, why this work should be publish and shared.

We agree here's how we would approach your questions in the conclusion.

Why is this study relevant?

This study is relevant because it highlights extreme heat risk for a continent where this research is sparse and where the impacts to heatwaves are ever increasing.

What were the key findings and what can we learn from them?

The key finding is that reporting although patchy for the continent is not captured in international databases, even in retrospect. And that heatwave characteristics although a rise in temperature and heat stress are diverse when taking into account the local climate and geography of a region. This means that specialist information should be provided to nations weather services to suite.

Is this a novel approach for Africa?

This will be the first peer-reviewed systematic list of heatwaves including recorded physical characteristics and impacts for the continent. This is also the first time that the Universal Thermal Climate Index has been used at a continental scale to assess heat stress during a heatwave in Africa.

How could these results be used to predict future events?

These results can be used to improve nations understanding of the characteristics and impacts of heatwaves, in the short term. In addition, the methods can be adapted and applied to climate projections to look into future risk.

Should policymakers and authorities start to look at these climatic extreme with more attention?

The main finding is that policy-makers and authorities should put in place adaptations to address extreme heat as a growing risk for their countries. And our results demonstrate heat is not just a future risk but a real risk with devastating impacts now.