Nat. Hazards Earth Syst. Sci. Discuss., referee comment RC2
https://doi.org/10.5194/nhess-2022-192-RC2, 2022

Comment on nhess-2022-192
Anonymous Referee #2

Referee comment on "Heat waves monitoring over West African cities: uncertainties, characterization and recent trends" by Cedric Gacial Ngoungue Langue et al., Nat. Hazards
Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-192-RC2, 2022
Review – Heat waves monitoring over West African cities : uncertainties, characterization and recent trends by Ngoungue Langue et al.

This manuscript discusses the uncertainties related to the use of reanalysis datasets for the monitoring and recent evolution of heat wave indices over West Africa, with a focus on several urban areas.

Three types of uncertainties are addressed, that stemming from the dataset itself, the choice of the threshold for heat wave definition, and the type of indicator (minimum or maximum temperature, including or not the influence of other meteorological variables such as surface winds or humidity).

The results presented are consistent with several past works on the topic, adding recent years and in some aspects providing different diagnostics than the analyses previously published (e.g. Cecchirini et al. (2017), Moron et al. (2015), Barbier et al. (2018) - to cite only a few focused on West Africa). However, the manuscript in its present form has a number of shortcomings and fails to present results in a clear and concise way. I found some parts of the manuscript difficult to follow, and the number of figures (including all those in the supplemental) leave me with the impression that extracting key conclusions from the numerous statistics computed was a challenging, but uncompleted, task for the authors. Also missing from the manuscript, with respect to the title of the submission, is a clear description of what the authors are aiming for in using reanalysis data for city or district-level monitoring. The conclusions in terms of reanalysis uncertainties clearly point major caveats to such an approach, which then weakens the key messages of the paper.
Thank you to the reviewer for these pertinent comments. We have taken into consideration many of the recommendations proposed by the reviewer, and added

some analyses. Some points such as the interpolation method applied in the study, the classification of cities into different climate regions and the use of reanalysis data instead of local station data have been clarified in the manuscript. We are confident that all these changes to the paper will improve its quality.

That said, I am confident that the authors can revise their submission, taking into account major comments listed below, and turn this manuscript into a valuable contribution.

Major comments

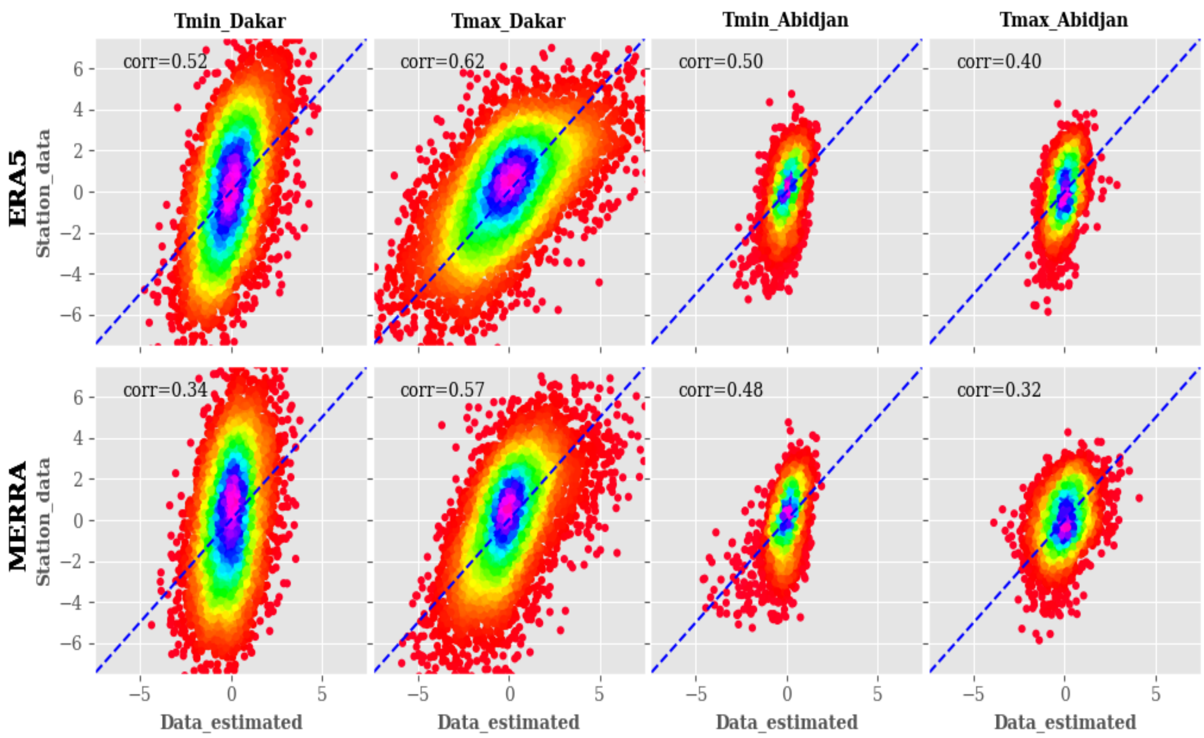
The manuscript dwells quite some time on the description of differences between the MERRA and ERA5 reanalyses, evidencing large uncertainties between both. Then, ERA5 is kept as "truth" for the rest of the paper (from section 3.3). Differences between heat indices over West Africa computed from reanalyses and other sources of data and related uncertainties have been discussed in a number of past publications (Barbier et al. 2018, Batté et al. 2018, Engdaw et al. 2022...). Why is ERA5 thought to be better a reference than MERRA, and why is reanalysis kept as a suitable source of data for the rest of the analysis?

Thanks to the reviewer for this remark.
The choice of ERA5 as reference for this analysis is based on previous work. For instance, Olauson, 2018 and Ramon et al., 2019 found that ERA5 provides a good representation of various near surface meteorological variables including near surface humidity and wind speed in comparison to others reanalyses including MERRA. However in order to clarify this point, we added in the manuscript some analyses on heatwaves evolution with MERRA reanalysis. Reanalyses are more representative of the spatial variability of the city than a local station.

Did you find similar caveats in the MERRA dataset than those highlighted by Engdaw et al. 2022?
Engdaw et al. 2022 found that MERRA in comparison to the other datasets (NCEP, ERA5, GSOD..), overestimates the evolution of heatwaves indices during the 2000s. In our analyses, we did not find this specific overestimation of heatwave characteristics with MERRA. However some discrepancies are noticed between MERRA and ERA5.

You (very briefly) mention station data in Supplemental Fig S8, but did you perform some assessment of ERA5 versus MERRA with respect to station data corresponding to your cities of interest? How adequate is ERA5 to represent heatwaves in these cities? All of this is left to the reader to guess or infer, which is a bit confusing given the title of the manuscript.

Thanks to the reviewer for this remark.
We conducted some analyses on ERA5 versus MERRA with respect to station data with the nearest grid to the station with a land sea mask greater or equal to 0.5. We found that ERA5 shows slightly better correlation to the station data than MERRA (see the [FigS3b] below).



I'm a bit puzzled by the mention of station data and the separation of the region of interest in climatic regions, and the use of gridded reanalysis data in the study. It wasn't fully clear to me upon reading the manuscript whether the approach used was completely validated. In the supplement, there is a figure (S8) which appears to tackle this question, but it is only very briefly mentioned in the manuscript. The authors furthermore say they find high levels of correlation, but I would argue this is only the case for Tmax over Dakar out of the four results shown.

We clarified this point in the response of the comment related to section 2.3.1

The classification of cities should be described in more detail, and justified. Indeed the classes found are used to compute composites of characteristics in section 3.4, but this approach will be valid only if there is indeed some level of consistency between the cities. Given the spatial distribution of cities of interest, some will likely be characterized by neighboring grid points from the reanalysis, whereas others are much more distant. I'm missing a clear justification of why this approach is valid.

We clarified this point in the manuscript.

We changed:

"The choice of these regions has been validated by conducting some analyses over the cities belonging to each region (not shown). The repartition of the different climatic regions is given as follows :

– Continental zone (CONT hereafter) including the cities of Bamako, Ouagadougou and Niamey [Fig1];

– Coastal atlantic zone (AT hereafter) including the cities of Dakar, Nouakchott, Monrovia and Conakry [Fig1];

– Coastal Guinean zone (GU hereafter) including the cities of Yamoussoukro, Abidjan, Lomé, Abuja, Lagos, Accra, Cotonou and Douala [Fig1]."

To:

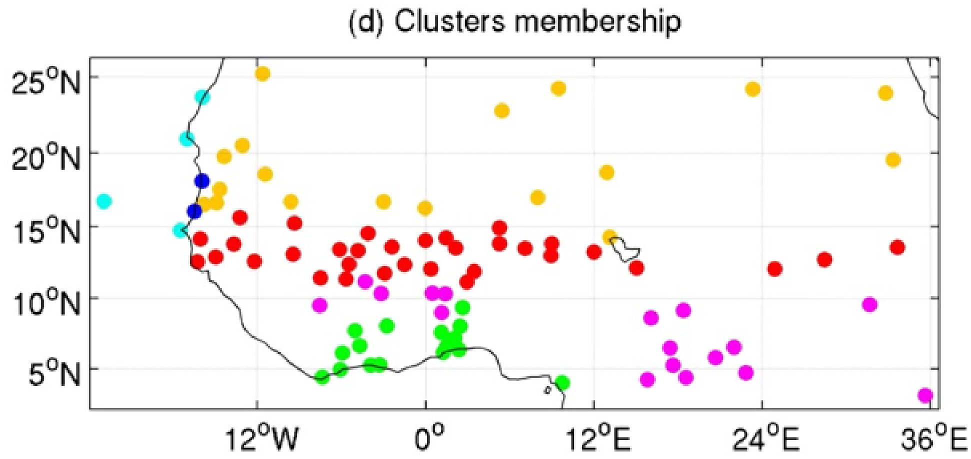
" The choice of these regions is coherent with Moron et al. (2016) who used a hierarchical clustering approach to define some blocs of cities over West Africa. The fifteen cities investigated here have been classified in three regions as follows:

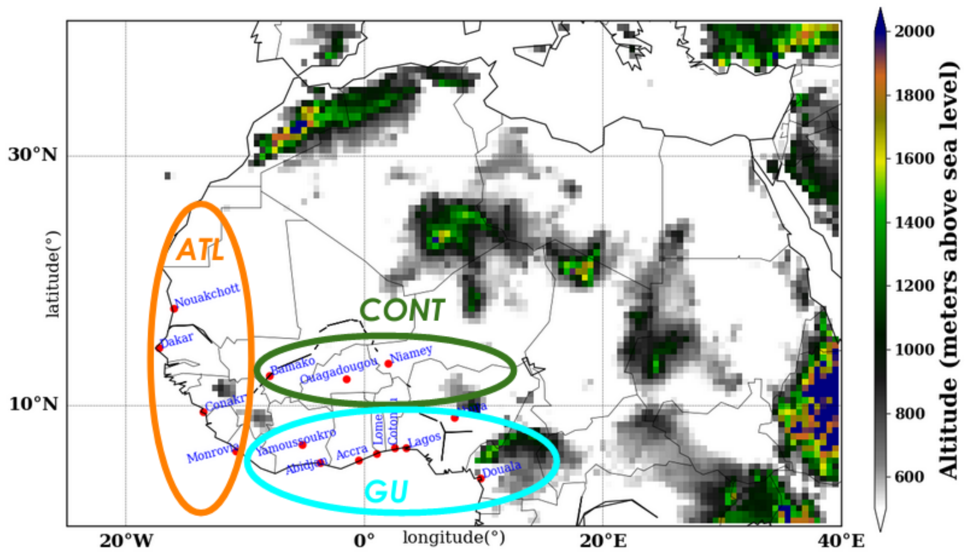
– Continental zone (CONT hereafter) including the cities of Bamako, Ouagadougou and Niamey [Fig1];

– Coastal atlantic zone (ATL hereafter) including the cities of Dakar, Nouakchott, Monrovia and Conakry [Fig1];

– Coastal Guinean zone (GU hereafter) including the cities of Yamoussoukro, Abidjan, Lomé, Abuja, Lagos, Accra,
Cotonou and Douala [Fig1].

The CONT and GU regions are very similar to the clusters found by Moron et al. (2016) (see figure below under the title 'Clusters membership'). The ATL region is a specific case because all the cities belonging to the region are not present in the clusters defined by Moron et al. (2016). Therefore, we have investigated the spatial variability of heatwave characteristics for each city in the ATL region. As result, we found coherent evolution between the cities (see [FigS1] in supplement material for maximum values of T2m using the 90th percentile as threshold); and we put them together to form the ATL bloc."





A final point more related to editing is the numbering and order of figures. The figures (including supplemental figures) should be numbered according to the order of appearance in the text. If not, the reader has to go back and forth between figures and this makes the paper tedious to read.

We reorganized the numbering and order of the figures as they appear in the manuscript.

Specific comments

Abstract

What is the main goal of the manuscript? Already from reading the (quite long) abstract, it appears that the scientific questions are not very specific.
We rearranged the abstract as suggested in the comment.

We changed :
"Heat waves can be one of the most dangerous climatic hazards affecting the planet; having dramatic impacts on the health of humans and natural ecosystems as well as on anthropogenic activities, infrastructures and economy. Based on climatic conditions in West Africa, the urban centers of the region appear to be vulnerable to heat waves. In this study, we assess the potential uncertainties encountered in the process of heat waves monitoring and analyse their recent trend in West Africa cities. This is investigated using two state-of-the-art reanalysis products namely ERA5 and MERRA for the period 1993-2020. Three types of uncertainties are discussed. The first type of uncertainty is related to the reanalyses themselves, with MERRA showing a cold bias with respect to ERA5 over the Sahel and Guinean regions except over some countries (Guinea Bissau, Sierra Leone,Liberia). Furthermore, large discrepancies are found in the representation of extreme values in the reanalyses over the southern Sahel and the Guinea coast. The second type of uncertainty is related to the sensitivity of heat waves frequency to the threshold values used to monitor them. Heat waves detected using the lowest threshold value are very persistent and last for several days; while the duration of heat waves related to high threshold values is shorter. The choice of indicators and the methodology used to define heat waves constitutes the third type of uncertainty. Three sorts of heat waves have been analysed, namely those occurring during daytime, nighttime and both daytime and nighttime concomitantly. Four indicators have been used to analyse heat waves based on 2-m temperature, humidity, 10-m wind or a combination of these. Nighttime and daytime heat waves are in the same range of occurrence while concomitant day- and nighttime events are extremely rare

because they are more restrictive. The climatological state of heat wave occurrence shows large differences between the indicators. We found that humidity plays an important role in nighttime events; concomitant events associated with wet-bulb temperature are more frequent and located over the north of Sahel. Most of the events detected in the regions (75%) have a duration around 3-6 days. The most dangerous events with a duration of at least 10 days contributed up to 12% of the total number of events.For all indicators, the interannual variability of heat waves in the west Africa region evidences 4 years with a significantly higher frequency of events (1998, 2010, 2016 and 2019) possibly due to higher sea surface temperatures in the Equatorial Atlantic corresponding to El Nino events. All indicators also highlight that the cities in the Gulf of Guinea region experienced more heat waves than those lying along the Atlantic coastline and those located in continental Sahel during the last decade. The heat wave events occurring in the Guinean region show short duration and weak intensity, while in the coastal and continental regions, events are persistent with strong intensity. We find a significant increase in the frequency, duration and intensity of heat waves in cities during the last decade (2012-2020) compared to the previous two decades. This is thought to be a consequence of climate change acting on extreme events."

to :

" Heat waves can be one of the most dangerous climatic hazards affecting the planet; having dramatic impacts on the health of humans and natural ecosystems as well as on anthropogenic activities, infrastructures and economy. Based on climatic conditions in West Africa, the urban centers of the region appear to be vulnerable to heat waves. The goals of this work is firstly to assess the potential uncertainties encountered in heatwaves detection; and secondly analyse their recent trend in West Africa cities during the period 1993-2020. This is done using two state-of-the-art reanalysis products namely ERA5, MERRA and two local station datasets in Dakar-Senegal and Abidjan in Ivory Coast. An estimation of station data from reanalyses is proceed using an interpolation technique : the nearest neighbor to the station with a land sea mask >=0.5 . Three types of uncertainties are discussed: the first type of uncertainty is related to the reanalyses themselves, the second is related to the sensitivity of heat waves frequency to the threshold values used to monitor them; and the last one is linked to the choice of indicators and the methodology used to define heat waves. Three sorts of heat waves have been analysed, namely those occurring during daytime, nighttime and both daytime and nighttime concomitantly. Four indicators have been used to analyse heat waves based on 2-m temperature, humidity, 10-m wind or a combination of these. We found that humidity plays an important role in nighttime events; concomitant events associated with wet-bulb temperature are more frequent and located over the north of Sahel. For all indicators, we identified 4 years with a significantly higher frequency of events (1998, 2010, 2016 and 2019) possibly due to higher sea surface temperatures in the Equatorial Atlantic corresponding to El Nino events. A significant increase in the frequency, duration and intensity of heat waves in the cities has been observed during the last decade(2012-2020); this is thought to be a consequence of climate change acting on extreme events. "

Introduction

The first two sentences are already a bit confusing to someone not familiar with the reference period chosen in IPCC reports to assess temperature evolution with climate change. The first sentence refers to temperature changes since the industrial revolution whereas the second also states a change of 1.5°C, not yet reached, which must be with respect to the IPCC baseline 1850-1900 reference period. This is not central to the manuscript but I would suggest rephrasing.

We rephrased the sentences accordingly.

We change:

"Since the industrial revolution, the Earth is experiencing a global warming around 1.5°C related to human activity ((Hartmann et al., 2013); Intergovernmental Panel on Climate Change-IPCC-report 2021). The last report of IPCC shows that this warming will exceed 1.5°C under different Shared Socio-economic Pathways (SSP) in 2100 if the rate of greenhouse gas emissions is not reduced."

To:

"Since the industrial revolution, the Earth is experiencing a global warming related to human activity ((Hartmann et al., 2013); Intergovernmental Panel on Climate Change-IPCC-report 2021). The last report of IPCC shows that this warming will exceed 1.5°C with respect to the IPCC baseline 1850-1900 under different Shared Socio-economic Pathways (SSP) in 2100 if the rate of greenhouse gas emissions is not reduced."

l. 65: Either explain more how this result is important (if relevant for your work) or shorten the paragraph.

We added some explanations on this point in the manuscript.

We changed:

"Another important result of this work, is the radiative effect of water vapor on minimum temperatures during the heat wave period."

To:

"Another important result of this work is the radiative effect of water vapor on minimum temperatures during the heat wave period. This can lead to extreme heat conditions during the night and cause death to eldery. "

Region of interest, data and methods

l. 110: "The choice of these regions has been validated by conducting some analyses over the cities belonging to each region (not shown)."

This is a shame, since it clearly is a key aspect in your use of this regional scale in the analyses that follow, and links to the title of the manuscript (see one of my major comments above).

This point has been clarified in response to the major comments.

l. 124: The authors restrict their analysis to 1993-2020. Both MERRA and ERA5 data are available before 1993, and statistics would likely be more robust by including more years. Is there a specific reason for this?

We agree with the reviewer that MERRA and ERA5 data are available before 1993, and also that the statistics will be more robust with more years. The idea at the beginning of this study was to do a comparative analysis with the seasonal forecast models (hindcasts) that are commonly available since 1993. In this study, we do not focus on the climatic evolution of heat waves but on heat wave processes. Therefore, a period of 28 years is already sufficient for the analyses.

Section 2.3.1: As stated earlier, I think this section leaves a lot of crucial points of the study partially hidden to the reader, which weakens the conclusions.

We explained in more detail the approach used for the estimation of atmospheric variables at the local scale in this study, which we completed as well in the paper.

We changed :

"Climate models used for weather studies are generally run at global scale, therefore information at local scale is missing in many regions; this is a critical issue. To overcome this problem, downscaling methods can be used. In this work, we studied phenomena at the scale of the city while our products have much coarser spatial resolution. In this context, we need a downscaling approach to attribute variables of interest from global to local scale. Another problem we faced is that most of the cities are located along the coast and influenced by the ocean flow (see [Fig1]). The evaluation of the spatial variability of the correlation between the local scale variable (station) and reanalyses (ERA5), showed high correlation values over the continent [FigS8]. To estimate the proportion of land on a grid point, we used the land sea mask whose values range from 0 to 1. A land sea mask (lsm) of 0 means no land (a point located in the ocean), and a lsm of 1 means that the model cell is fully covered by land. Hence, to estimate the temperature over the city using reanalyses, we use the nearest grid point of reanalyses to the station which satisfies a lsm equal or greater than 0.5 (see [Table3] for lsm values of all the cities considered in this study)."

To:

" Reanalysis dataset used for weather studies are generally run at global scale, therefore information at local scale is missing in many regions; this is a critical issue in regions where there is a lack of observation stations as is the case of African cities. To overcome this problem, sometimes downscaling methods can be used. In this work, we study phenomena at the scale of the cities and reanalyses (ERA5 and MERRA) have too coarse a spatial resolution. The scales of the reanalyses are more representative of the spatial variability of a heat wave occuring in a city than an isolated local stations. Nevertheless, a certain validation must be conducted of testing stations, especially to find the best interpolation technique to estimate local temperature from the reanalyse. This is especially important over the coastal regions. Indeed, most of the cities used in this study are located along the coast and influenced by the ocean air masses (see [Fig1]). The evaluation of the spatial variability of the correlation between the local scale variable (station) and reanalyses (ERA5) for T2m for example, showed high correlation values over the continent [FigS2] (Dakar, Abidjan). This suggests that the station data are well correlated with ERA5 grid points which are located on the continent; so there is a need to know whether a ERA5 grid point is over the continent or not before applying an interpolation technique. To estimate the proportion of land on a grid point, we used the land sea mask (lsm) whose values range from 0 to 1. The land sea mask is a measure of the land occupation on a grid point. A lsm of 0 means no land (a grid point located in the ocean), and a lsm of 1 means that the model cell is fully covered by land. Therefore, to estimate the climate variables over the cities from reanalyses, we use the nearest grid point of reanalyses to the station which satisfies a lsm equal or greater than 0.5 (see [Table1] for lsm values of all the cities considered in this study). This approach was chosen after evaluating different methods such as (see [FigS3a] for more details) :

– a bilinear interpolation using the four nearest grid points of reanalyses around the station [FigS3a (a,d)];

– a linear gradient approach which considers that the gradient of temperature is constant between two grid points based on a linear interpolation with a condition on the lsm value (>0.5) [FigS3a (c,f)];

– the selection of the nearest grid point of reanalyses from the station with different values of lsm (>=0.5, 0.75 and 1; we only show for lsm>=0.5) [FigS3a (b,e)] "

- a dynamical downscaling approach taking into account the effect of winds (not shown).

l. 157: Did you compare the nearest neighbor strategy with lsm > 0.5 to the station data? Of course station data will be representative of temperature at a very local scale, but on the other hand, resolution of the reanalyses is quite coarse when compared to cities.
Thanks to the reviewer for this question.
The nearest neighbor strategy with lsm > 0.5 has been compared to the station data through a correlation analysis (see [Fig S3.a] in the supplement material). We took it into account in the previous comment.

Section 2.3.3 and heat wave duration computation

I was confused by the equation l. 200 and the explanation.
In lines 196-199 you explain that heat wave duration is computed as the mean over the number of heat waves of the total number of hot days in heat waves (I agree with this definition). But then when describing the equation terms, it appears you count all of the hot days whether belonging to a heat wave or not. If d is the number of hot days, then shouldn't δj in the sum be an indicator of the day belonging to a heat wave rather than the corresponding temperature exceeding the 90th percentile (this condition is already fulfilled for a hot day...)?

Thanks to the reviewer for this comment. When computing the duration of heatwaves, we take into account just the hot days belonging to heatwaves. Yes we agree with the reviewer that the kronecker δj here is an indicator of day belonging to a heatwave not the temperature exceedance from the 90th percentile. 'd ' is the number of hot days in heatwaves. We clarified this point in the manuscript.

We changed :

"N represents the total number of heatwaves per grid point and 'd' the number of hot days."

To :

"N represents the total number of heatwaves per grid point and 'd' the number of hot days in the heatwave events. The kronecker δj is used here because we pooled heatwaves separated by 1 day together to form single events. For example, two heatwaves with respective duration of 4 and 3 days separated by 1 day below the threshold will be counted as 1 event with a duration of 7 days. "

Later in the manuscript, it wasn't clear to me why mean duration could be lower than 3 days (for instance in Fig. 7), since your criteria to define a heat wave is for having at least 3 consecutive days above the given threshold. I may have missed something here, but in any case, this needs clarification in the methods section.

Thanks to the reviewer for this remark.

We clarified this point in the manuscript, and we agree with the reviewer. As the min duration of heat waves is supposed to be 3 days, this implies that the mean duration will be greater or equal to 3 days (see [Fig S17] in the supplement material).

Section 2.3.4

You define POD but then refer to "hit rate" when discussing the results and in Fig. S1. More generally, in your definitions of the statistical metrics, you use the terms "forecast system" and "observations". Implicitly, later in your discussion of results, ERA5 is often the "observation" and MERRA2 the "forecast system", but I would argue that these terms are quite misleading and suggest you rather use terms like "evaluated dataset" and "reference".

Thanks to the reviewer for this suggestion, we correct this point accordingly.

We changed :

"The POD, also known as the "hit", is a measure of the fraction of events detected by a forecast system knowing that the events happen in the observations at the same time."

To :

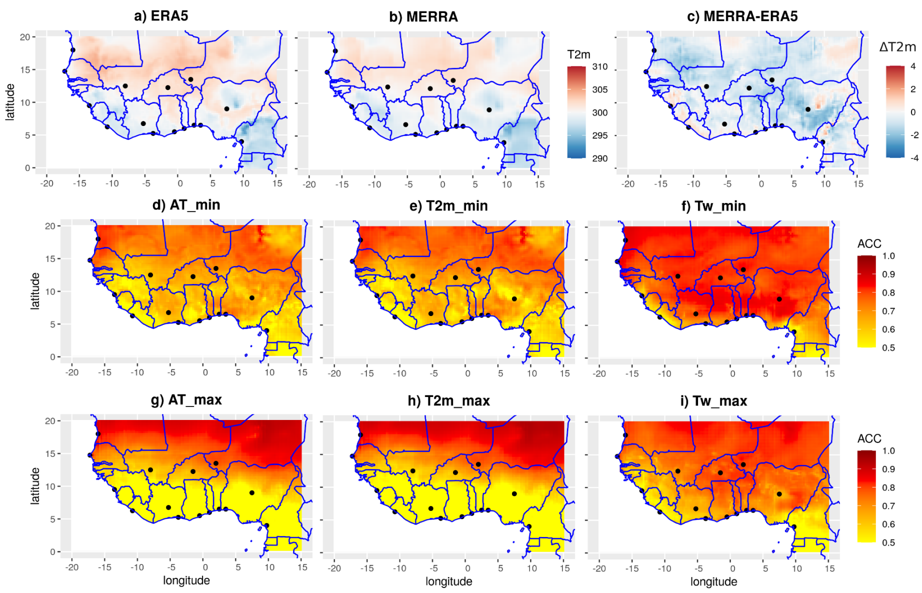
"The Hits rate, also known as the "hit", is a measure of the fraction of events detected in an evaluated dataset knowing that the events happen in the reference at the same time. Some previous work such as (Olauson, 2018; Ramon et al., 2019) found that ERA5 provides a good representation of various near surface meteorological variables including near surface humidity and wind speed in comparison to others reanalyses including MERRA. Therefore for the computation of the hit, we choose ERA5 as the reference and MERRA the evaluated dataset"

Results

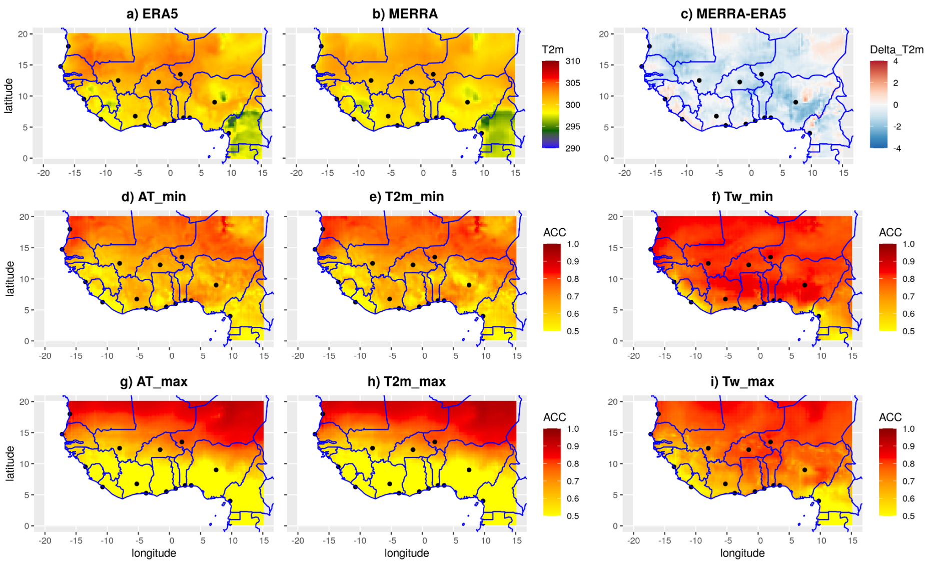
Fig. 3: The blue/red color scale for figures a) and b) isn't the best choice.

Thanks to the reviewer for this remark. We changed the color in Fig 3 a) and b) accordingly.

We changed :



To:



l. 263: It would be worth specifying either here on in section 2.3.4 for what event the scores are computed (hot days).

Thanks to the reviewer for this remark. We added this information to the manuscript.

We changed:

" The hit rate and GSS have been computed using T2m "

" The coherence of reanalyses at regional scale has been evaluated using statistical metrics such as the probability of detection (POD), anomaly of correlation (ACC) and the Gilbert skill score (GSS)"

To:

" The hits rate and GSS have been computed in terms of hot days using T2m"

"The coherence of reanalyses at regional scale has been evaluated using statistical metrics such as the hits rate, anomaly of correlation (ACC) and the Gilbert skill score (GSS). The hits rate and GSS are used to evaluate hot days in the reanalyses."

l. 281: "changes of heat waves occurrence": What do you call occurrence? The total number of events over the period of study?

We clarified it in the manuscript.

We changed :

"To quantify the changes of heat waves occurrence with respect to the threshold value"

To:

" To quantify the changes of heat waves frequency with respect to the threshold value"

l. 308: "we use the 90th for heat wave analyses" → you mean the 90th percentile?

Thanks to the reviewer for this remark. We took it into account in the manuscript accordingly.

We changed:

l. 308: "we use the 90th for heat wave analyses"

To:

l. 308: "we use the 90th percentile for heat wave analyses"

l. 321: "Tw takes in account the effect of humidity on the temperature" → I would argue this is also the case for AT, which includes this influence through the term related to water vapor pressure.

We change

"Tw takes in account the effect of humidity on the temperature"

To :

"It appears that Tw is more sensitive to humidity than the other indicators (see formula of Tw). "

l. 332-334: These sentences introduce a new aspect of results, I would therefore recommend moving this to section 3.4. By the way, the numbering of Fig.12 should be Fig. 7.

At this stage of the manuscript, we want to provide a summary of the findings in this section. Therefore, we kept these sentences at the end of this section.

l. 336: "CONT, AT and GU see section "region of interest" for more details" → As a reader I was frustrated at this stage since the details in the section to which you refer doesn't provide these details (it is even stated "not shown").

We already took this remark into account previously (see response to the comment on the classification of cities)

l. 344: "The heat waves detected in the GU region have a short duration and a weak intensity [Fig 7]" → As mentioned earlier, I was surprised that duration is lower than 3 whereas by your definition heatwaves should last a minimum of three days to be

considered as such. Maybe the values are divided by the number of cities? This is a clear blind spot in your methodology. Please clarify this (also in the figure legend).
We clarified this point in the manuscript, and we agree with the reviewer. As the min duration of heat waves is supposed to be 3 days, this implies that the mean duration will be greater or equal to 3 days (see figure S17 in the supplement material).

l. 364-374: Splitting the (already short) period into yet shorter sub-periods calls for some comment on the robustness of the analysis, especially since other factors may influence the occurrence of heat waves (e.g. El Nino, decadal variability, ...)
Thanks to the reviewer for this comment. The idea behind the splitting of the study period was to quantify the evolution of heatwaves during the last 3 decades in a context of global warming.

Discussion

Regarding the differences between ERA5 and MERRA2, Engdaw et al. (2021) identify striking differences between MERRA and other reanalysis and observational datasets in the 2000s for heatwave indices. MERRA appears to be a clear outlier. Did you look into this and draw similar conclusions?
Engdaw et al. 2022 found that MERRA in comparison to the other datasets (NCEP, ERA5, GS0D..), overestimates the evolution of heatwaves indices during the 2000s. In our analyses, we didn't find this specific overestimation of heatwave characteristics with MERRA. However some discrepancies are noticed between MERRA and ERA5.

l. 412: The correspondence between heatwaves and El Nino events was suggested in Moron et al. 2016 which you could include in your introduction and at this stage of the discussion.
Thanks to the reviewer for this suggestion, we included it in the manuscript.

Typos and editing suggestions

l. 64: CRNM → CNRM
Modify as suggested

AT is used as an abbreviation both for apparent temperature and the Atlantic cities
Thanks to the reviewer for this remark.

We change:

"AT region"

To:

"ATL region"

l. 280: "see [Fig S3] Fig. S3 in the supplemental material"

Thanks to the reviewer, we took it into account.

We changed:

"see [Fig S3] Fig. S3 in the supplemental material"

To:

"see [Fig S3] in the supplemental material"

Please harmonize the notations used and specify carefully each notation: for example Ws is wind speed in the AT equation, this is never specified. What is Ta in the same equation?

Thanks to the reviewer for the remark. We clarified it in the manuscript.

We changed:

"Where T(°C), Td(°C), p(hPa) and q are respectively the ambient temperature, dew-point temperature, pressure and specific humidity"

To:

"Where T(°C), Td(°C), T0(K), p(hPa), Ws(m/s) and q are respectively the ambient temperature, dew-point temperature, reference temperature, pressure, wind speed and specific humidity."

Table 2, C2: typo peristent → persistent

Thanks to the reviewer, we took it into account in the manuscript.

Classes	Duration (days)	Degree of persistence
C1	3	normal
C2	4-6	persistent
C3	7-9	very persistent
C4	10-12	severe
C5	+13	very severe

Figure 6: Top row figure titles are missing

We corrected it in the manuscript.

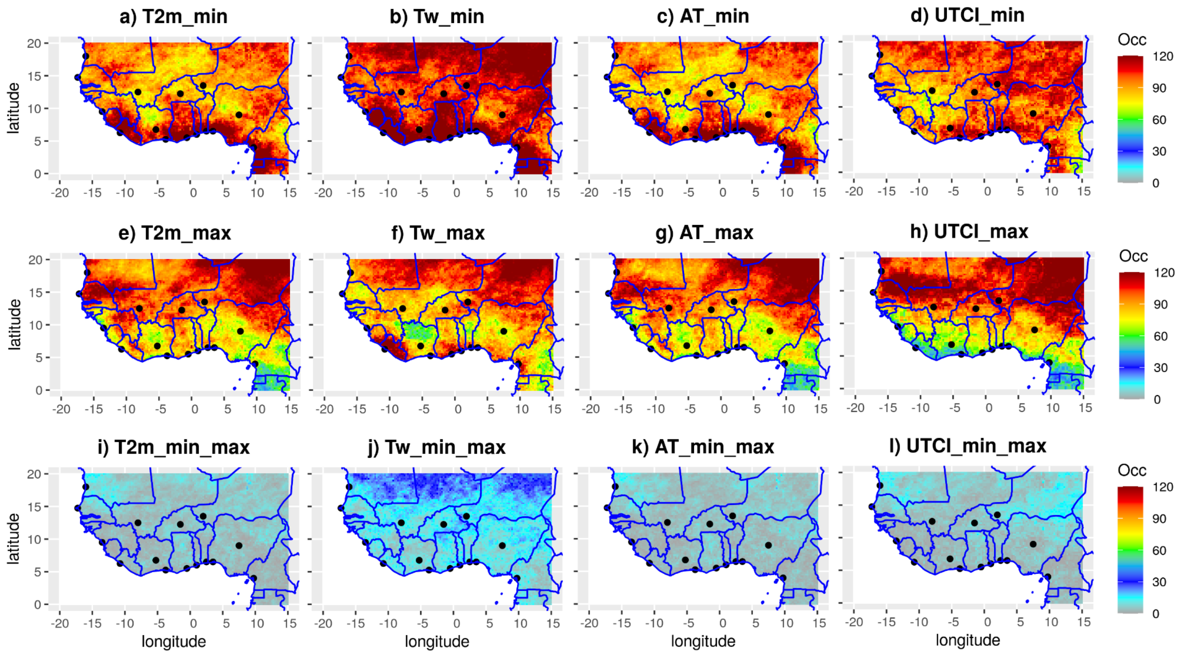
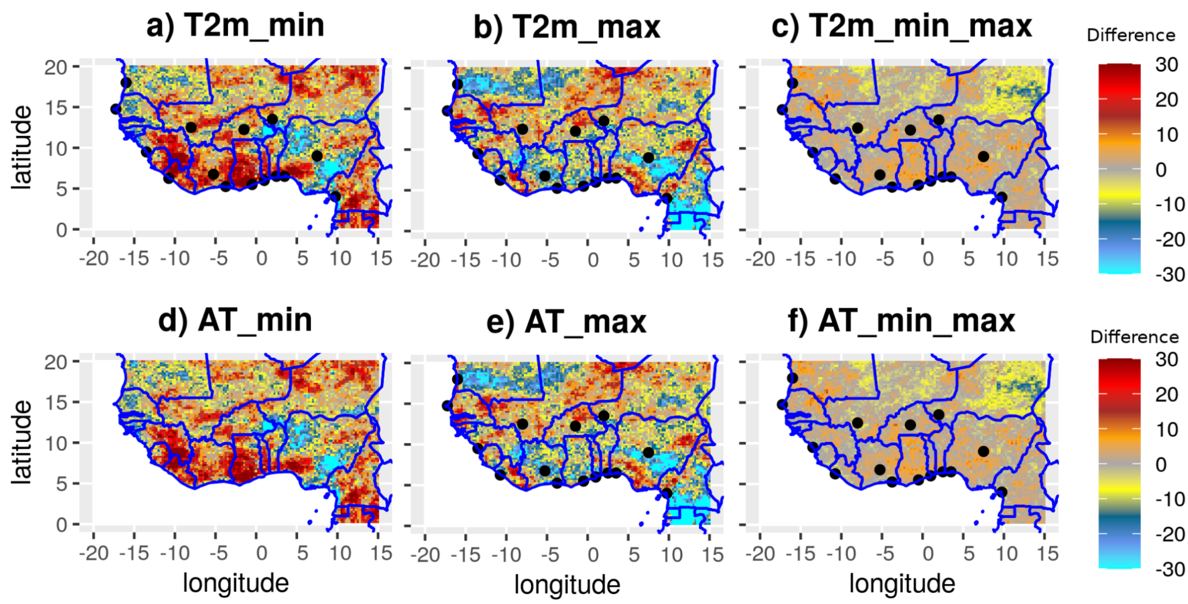


Figure S16: "incertitude" → you mean uncertainty?

We corrected it in the manuscript.



Overall the manuscript requires careful proofreading (watch out for missing parentheses and brackets).
Thanks to the reviewer for this reamark, we took it into account in the manuscript.

The figure captions should also be revised carefully, and include information on the datasets used (the reader shouldn't have to dig for this information in the text).
Thanks to the reviewer for this advice, we corrected the captions accordingly.

Suggested reference:
Moron, V. et al. (2016) Trends of mean temperatures and warm extremes in northern tropical Africa (1961–2014) from observed and PPCA-reconstructed time series. J. Geophys. Res. Atmos., 121, 5298–5319, doi:10.1002/2015JD024303.
Thanks to the reviewer for this suggestion, we added it to the manuscript.