Anonymous Referee #2

Thanks for your detailed review and your comments. They have been very useful for us to improve the paper. Please, find below the answers to your questions and the amendments that will be introduced in the revised version of our manuscript, one by one:

This paper presents a methodology to evaluate the exposure to extreme temperatures using the Local Climate Zones framework, which allows a direct comparison between different cities of the world. The proposed methodology is applied and demonstrated for the case of Barcelona. Overall, the manuscript is well written and of interest for the NHESS audience, and the methodology seems to be scientifically sound. However, some portions of the methods and discussion are not very clear and should be improved.

Thank you very much for your positive comments and suggestions. We will try to improve our paper following them.

1- Line 18: "proposal" could be replaced by methodology or framework?

We have replaced proposal by methodology. We have also replaced the term framework by classification. All changes we have made to the original text appear in *italics.*

"This paper presents a *methodology* to evaluate the urban and peri-urban effect on extreme temperatures exposure in Barcelona (Spain), using the Local Climate Zone (LCZ) *classification* as a base statement, that allows…"

2- Line 23, 255 and Figure 7: It is not clear what is the purpose of including the maximum temperature for this manuscript. It is barely discussed.

The maximum temperature gives us an idea of the potential worst conditions that are important to know for risk management, as well as the HUMIDEX index, that it is mainly used by mass media to explain to the population the different warm sensation that they perceive in function of the humidity. However, following your comment, we have added a paragraph in section 3.1.

"The maximum temperature provides an estimate of the worst conditions that can be expected. It is important for risk management and avoiding heat stroke, which usually occurs during the hours of the day when the temperature reaches its highest value. The dew point temperature (Tdew) was used as a starting point …"

3- Lines 31 and 421 "about 3-4◦C compared" should be "about +3-4ºC compared"?

Thank you, it is not clear. We have modified the sentence as follows:

"temperatures for the 90th percentile (about 3-4ºC *above the* average conditions) leads."

4- Line 186-198 and 423-429: It is claimed that the WUDAPT map suffers from a lack of characterization of different types of urban areas compared to the LCLU method. This might be true, but the results and discussion presented here are not very clear on why the additional types of urban areas in LCLU are an improvement. Potentially, one may add more but unrealistic types.

Thank you for your observation that has been useful for us to detect some misunderstandings. We have modified a sentence and added a new one in Line 190 and modified the paragraph 423-425.

Line 190. "the same type of coverage occupies just 37.3%. *It is a consequence of the difference in the LCZ characterization processes that both methods follow. Although 17 LCZs are distinguished in the two methods, WUDAPT uses the spectral radiance provided by satellite images and applies a supervised classification based on a random forest generalization method based on training areas (Bechtel et al. 2015). On the contrary, the method LCLU proposed here analyses the intrinsic variables that characterizes each category of LCZ and consequently it has major integrity and quality. It is to say, it has a better resolution.* In both methods…."

Lines 423-425. "This paper also provides comparison of two *methodologies to cartography the Local Climate Zones (LCZ): WUDAPT and LCLU. The international standard method WUDAPT (is exclusively based on satellite earth observation data (Ching et al., 2018). The LCLU (Land Cover Land Use) departs from land use maps, urban atlas, LIDAR measurements and orthophotos."*

5- Line 273: What is CI?

CI is Confidence Interval. We have replaced the acronym by confidence interval.

"… significant when the lower bound of the *confidence interval* is greater than 1".

6- Lines 273-280: It is not evident to me what is the advantage of using a new index HEI instead of using RR at 0.2 steps? Why introduce HEI? The explanation of HEI should be improved.

There are three reasons:

- The first one tries to avoid any confusion with the use of the term "risk" (RR, relative risk). The word risk usually means the convolution of hazard and vulnerability, although, depending on the disciplines, vulnerability may appear separate from exposure and even from response capacity (see latest UNDRR classification, 2020). The curve RR published by Achebak et al. (2018) refers to the impact of the temperature to a people sample and would be part of the risk equation. For this reason, we prefer to use the term "heat exposure" as it is applied in other papers referred to health (Vicedo-Cabrera et al., 2014; Lowe et al., 2015; Achebak et al., 2019).

- Secondly, we are working with an approximation, since the objective is to transfer to each LCZ a range of temperatures under certain conditions, being impossible to associate them with a specific temperature.
- The third one is that the HEI categories can be applied to any city independently of its range of temperature

In order to clarify it we have added the following sentence:

Line 280. " …risk of mortality associated with high temperatures. *The use of seven HEI categories has the advantage that it can be applied to any city by adjusting them to the temperature values of that city and to the RR curve considered."*

In the introduction (line 94) of the manuscript with corrections we have added some references of heat exposure referred to health:

"…be applied to estimate the level of heat exposure *(Vicedo-Cabrera et al., 2014; Lowe et al., 2015; Achebak et al., 2019)* to …"

7- Lines 316-322: This description of the LCZ-T model is rather obscure. Given the relevance of this model in the present manuscript, I would suggest improving the clarity of this description. What are "anisotropy levels" in this context? Built what curves for the LCZs? How did you define the scenario for the percentiles (what percentiles)? Etc.

Thank you for your observation. The use of the term "anisotropy" was not correct. We have modified the paragraph as follows:

"*First, for each climatic percentile (P50, P75, P90, P95 and P99) of daily mean temperature (although it could be also done for maximum temperature and HUMIDEX) we analysed the thermal response of the LCZ (LCZ-T) (Fig. 7). To do it we compared, pixel by pixel, the temperature maps with the LCZ maps and we built a boxplot for each LCZ (Fig. 9).*

In order to characterise each LCZ we tested its normality and test the differentiate behaviour of each probability density curves adjusted to each LCZ. The results of the normality tests (based on central limit theorem) and comparable variations on the relation between LCZ-T indicated that ANOVA may be used for testing whether the differences in LCZ mean temperatures outlined above are significant or not (Geletic et al., 2016). LCZ C, F and 6 do not follow a normal distribution (at 95%) although they tend to it. This is due to the high thermal variability in these categories. There were statistically significant differences in mean LSTs between most LCZs, but LCZs 4 and 5 were recognized as zones less distinguishable from other LCZs. Once we had the temperature distribution it was possible to map HEI.

Transposing the model on LCZ maps allowed us to map heat exposure distributions for Barcelona. This methodology has the advantage that they can be transferred to other cities because it relates each LCZ with a HEI value. It is only need having the LCZ map

and knowing some temperature values in the city to calibrate the model. In the case that there would not be a RR-T curve available, it could be applied the same HEI of this paper".

8- Line 374 Please re-phrase

Done. The following paragraph:

Lines 374-377: "Along this paper a methodology to characterize the distribution of daily mean temperature for the different LCZs in different scenarios has been proposed. This characterization has been done for the summer months and climate percentiles have been obtained for the period 1987-2016 and applied at 100 m resolution to the city of Barcelona."

Has been replaced by:

"*This paper presents* a methodology to characterize the distribution of daily mean *temperature in basis to the LCZs mapping in different temperature scenarios on summer (JJA). The* climate percentiles have been obtained for the period 1987-2016 and applied at 100 m resolution to the city of Barcelona."

9- Line 387 Replace "quite a few" (for example by "multiple") to avoid repetition and confusion.

Done. New sentence is:

"Currently, there are *multiple* studies characterizing…."

10- Line 393 "LCZ A and C that belong to the most prevalent categories" maybe specify the meaning of the LCZ A and C to avoid that the reader has to go and check the Supplementary Table. This applies to the remainder of the discussion

We have removed the supplementary table because it is the same displayed in the paper of Stewart and Oke (2012), and it is part of the general knowledge of LCZ. So, we have added the meaning of the main LCZ next to each relevant category, not only LCZ A and C. The new text is:

Figure 9 shows that LCZ 8 (large low-rise buildings), 1 (compact high-rise), E (asphalt) and 2 (compact mid-rise) (from highest to lowest), have usually the highest temperatures. These LCZ in general terms correspond to the categories with high admittance and high impervious (Stewart and Oke, 2012). In contrast, the lowest temperatures correspond to LCZ 9 (sparsely built), A (dense trees), C (bushes) and G (water), which are wooded areas and parks on the outskirts of the city.

11- Line 424 LCZ has been already introduced

The sentence “This paper also provides comparison of two methodologies to cartography the Local Climate Zones (LCZ)” has been deleted and it has been substituted by the following:

Line 424. “*This paper also provides comparison of two methodologies to cartography the LCZ: The WUDAPT and the LCLU based on land use maps.”*

12- Line 432 Why was “However” used here?

It was a mistake. We have replaced however by “In addition to this” and we have modified a little the sentence

Line 432. “*In addition to this, future work includes mapping the sensitivity* taking into account….”

13- Lines 438-441: As pointed above, the description of LCZ-T is rather obscure but it seems that it was derived from a relatively long high-resolution model simulation (UrbClim). Can the required temperature distribution be obtained from other sources? It will still likely require relative long and high-resolution datasets which might not be easily available. So, this advantage of LCZ-T might be limited to data availability. This should be made clearer.

Following your proposal, we have modified the description of LCZ-T. As you say, in some occasions it is not possible to have the outputs of high-resolution model simulations and this is the main reason of our relationship to transform LCZ in HEI maps. Figures 9 and 10 show how the methodology developed here could be applied in the hypothesis that the results obtained for Barcelona Metropolitan Area could be extrapolated to this other city. The information provided by the HEI maps could be useful to improve risk management in front high temperatures showing in which part of the city the same event could have the worst impacts.

14- The manuscript has a very large number of acronyms, and it is very difficult for the reader to keep track of all of them. I suggest a reduction where possible.

You are right, we have tried to reduce some acronyms along the manuscript, especially in the conclusions and the acronyms that appear few times.