

## Review on egosphere-2024-697:

“Simulation of the heat mitigation potential of unsealing measures in cities by parameterizing grass grid pavers for urban microclimate modelling with ENVI-met (V5)”

Eingrüber *et al.*

Submitted to GMD

2024-08-14

I think that the proposed parameterization of GPPs is a useful tool, as it allows to better map the influence of surface characteristics on urban heat. However, the paper could be better written and structured. I have added a lot of general and technical comments as I think there are some major limitations that come with this manuscript, such as citation errors, imprecise writing and redundancy, drawing conclusions from missing analysis results, and more. Therefore, I would rate the manuscript with a major revision.

### General Comments

- The overall impression of the work is particularly affected by imprecise writing und missing structures. There are many redundancies and the manuscript would be greatly improved by adding paragraphs and clearer/more precise writing. This needs to be done throughout the manuscript, not just the technical comments.
- Please ensure that all programs and concepts (such as UTCI) have a reference and all measurement advices are described properly with model, company, ...
- Use abbreviations for air temperature ( $T_a$ ) and surface temperature ( $T_s$ ).
- I could only find t-test results for  $T_s$ , not  $T_a$ ! Why? I think this is a major shortcoming, as you mention in the Abstract that you found a statistically significant difference for  $T_a$ , but never checked for it? Anyway, did you check for autocorrelation? Isn't it an assumption of the t-test that the data points of the samples must be independent? A three-day diurnal cycle must have some autocorrelation.
- Surface and air temperature are important measures for evaluating GPPs. However, I don't understand why the focus is on surface temperatures rather than thermal indices, as I think “heat mitigation potential”, as stated in the title, is better assessed by thermal indices. In

addition, Figure 16 shows the difference in UTCI at 3 m between S1 and S2, but is UTCI at 1 m not better for assessing human outdoor heat stress? And what is about the difference between S1 and S3? Later, I will ask if it is possible to combine some figures (see Point 2 in **Tables and Figures**). I wonder if such a figure would be possible for UTCI?

- When evaluating heat mitigation potential, how exactly did you analyze UTCI and PET changes (compare also to my comment on Line 340)? When and how often did the UTCI classes changed from very strong heat stress to strong heat stress? Pixel-wise or on spatial average? For individual hours or on temporal average? I think it is important to provide detailed information on this.
- Only pixels where sealed surfaces have been replaced by GPPs are compared (Lines 244-245). This is fine to investigate the effect of GPPs alone, but shouldn't there also be a comparison of all pixels to see the overall effect of GPPs on the outdoor thermal comfort of a whole neighborhood at pedestrian level? The surroundings are otherwise neglected, right? I would suggest to analyses  $T_a$ ,  $T_s$ , and all other indices with the same approach. Therefore, I think it is better to compare all pixel (exclude buildings).
- A lot of self-citation of conference abstracts, which do not seem to hold necessary information. Although I think it is ok to cite conference abstracts when no other information is available, citing this many conference abstracts without relation is not appropriate.

## Specific Comments

### 1. Introduction

- Re-structure the introduction with paragraphs (e.g., in lines 37, 54, 88 ...) and give each paragraph a subject such as general characteristics of urban areas and the impact of climate change, the need for adaptation measures, introduction of GPP and the research done about it, and the contribution of your paper to this field. These would improve the readability.
- As this study focuses on heat adaptation, please focus more on the effect of GPPs on heat. It is relevant to mention the effect of GPPs on urban hydrology, as you do in lines 59-64. However, I think this is sufficient to do it shorter to focus on urban heat. E.g. remove lines 93-95.

### 2. Methods

- It could be useful to have a figure with the study area and land cover classes, locations of the weather station, and Netatmo network, indicating the main roads and backyards, etc... and using this figure to describe the characteristics of the study rather than citing conference abstracts which does not always hold the information.

- Same as for the introduction: Please re-structure in different paragraphs such as “Model domain”, “Forcing and evaluation data (measurements)” and “Model setup”.
- After reading this chapter, I don’t think that I could reproduce the ENVI-met setup. I also did not find much information in the cited abstracts and papers (only in Eingrüber 2023b). Or add information like: “More information on the study area and the model step up can be found in ...”. But ensure that this information is present in the cited paper.
- Section 2.2: Please restructure. It does not get quickly apparent what is explained when. Lines 130-151 give an overview of the entire parametrization process, but also information about values used in DBManager. It seems a bit mixed up. In section 2.2.2 you write about field measurements of LAD (Lines 202-208). However, section 2.2.1 is about field measurements. I think this could be structured more clearly, also to remove redundancy.

### 3. Results

- Please add a table with all t-test results.
- Are there somewhere results for PET? Maybe add them to the Appendix.

### 4. Discussion

- The discussion is comprehensive. However, it is not always clear whether  $T_a$  or  $T_s$  is being discussed. As with the other sections, please restructure and add paragraphs to make it clearer (e.g., day-night, scenarios, shaded-unshaded, model limitations, ...).

## Technical Comments

### 1. Introduction

- Line 19: Period is missing.
- Line 64: Studies or study? Only one Citation.
- Line 90: physics-based / numerical
- Line 91: “Therefore, a...” not “are”?
- Line 93-95: I thought the focus is on heat, not on precipitation and flooding?
- Line 97: “using **data from a densely-distributed**”
- Line 104: “*air and surface temperatures*”
- Line 110: Add citation for LCZ.
- Line 115: 1 m
- Line 116: Add citation for ENVI-met model.

- Line 116: You cite a conference abstract (Eingrüber et al., 2022b) without any information on how the 3D data of your model domain was obtained.
- Line 119: Campbell? Please provide more information on the measurements, its instruments etc. Or provide a citation where everything can be found.
- Lines 120-123: What are the results of the validation (Eingrüber et al., 2022b)? A conference paper is cited without any results. I think this sentence/citation is not necessary, as in the next sentence a Journal article is cited and information about the accuracy is provided.
- Lines 120-124: Model evaluation of what? Air temperature?
- Line 122: I think in Eingrüber et al., 2023b the NSE is given with 0.91?
- Line 125: °C
- Line 126: I did not find any information about this Gumbel distributions in the conference abstract of Eingrüber et al. 2023a. Is this of relevance for the ENVI-met modelling? Or only for the 20-year heat extreme? I don't understand why this citation is added as there is no relation?
- Line 140: add units
- Line 146: roughness length =  $Z_0$  in line 148?
- Line 156: ... *"(39 % substrate to 61 % concrete) and is used"* ?

## 2. Methods

- Line 174: Sometimes you have a space between Number and %, sometimes not.
- Line 175: New paragraph
- Line 176: Model, Company?
- Line 179: *"... on a day with clear-sky..."*
- Lines 184-192: New paragraph and maybe re-arrange entire section with soil characteristics after hydraulic conductivity at line 175.
- Line 188: *"As description of the extent to which the surface deviates from a completely flat surface by elevations..."* Which surface? The GPP surface?
- Line 190/191: How is the profile meter defined? Does the orientation of the profile meter play a role? Or is it simply an approximation?
- Line 196: "parameters" instead of "parameterizations" (Compare Line 194)
- Line 201: Why emissivity of 0.9? References?
- Line 212:
- Lines 226.228: *"While GPPs were set for all side streets, the lane widths of the main traffic axes Volksgartenstraße (double-avenue in the middle of the street) and Vorgebirgsstraße were measured to determine the number of sealed grid cells in the model domain."*
- Line 244: References for Python and Leonardo DataStudio.
- Line 246: Reference for R.

- Lines 252-254: I don't think you have to describe how you created all results such as how you calculated the difference of mean temperature.
- Line 253: "*The hourly layers ~~per-day~~ were averaged using the raster calculator for individual days and the entire simulation period.*" What does "hourly layers per day" mean?
- Lines 254-266: Rephrase.
- Lines 257-258: References for PET, UTCI, and BIO-met.
- Line 259-261: Not necessary.

### 3. Results

- Line 264: "*surface temperatures from -2.00 K up to -8.26 K...*"
- Line 268: Is this now the comparison of all grid cells or only the grid cells with GPPs? (compare with line 244).
- Lines 264-...: Please always define if it is air or surface temperature ( $T_a$  &  $T_s$ ), not only "temperature".
- Line 277: "*...(19th July 2022), the surface temperature was...*" not sure about, but do you mean  $T_a$ ?
- Line 284: Move to discussion.
- Line 288: "*~~unshaded, tree-free areas on the third day.~~*"
- Line 295: "*S2 and S3 ~~also~~ show a smaller IQR of 9.27 °C and 9.47 °C, respectively.*"
- Line 297: Maybe add a table with the statistical results (t-, and p-value) to the Appendix.
- Section 3.1: Please use paragraphs for  $T_s$  and  $T_a$ .
- Line 303: "*(4.09 K more for S3)*". More?
- Line 304: "*~~While significant differences were found between the different scenarios both during day and night, Since p-values are lower during the day than at night time and thus, cooling effects are stronger and more significant during the day.~~*"
- Line 315: Again, all grid cells? Or only the GPP grid cells as written in the figure caption?
- Line 320: 72 values or timesteps?
- Line 330: New paragraph or even section? In general, why summarize results? Isn't this a part for conclusion?
- Line 330-335: "*~~The Sensible heat flux and the soil heat fluxes are reduced~~ **decreased** due to ~~the~~ GGP implementation, while ~~the~~ sensible heat flux, relative humidity and soil water content ~~are~~ decreased due to ~~the~~ unsealing, ~~the~~ increased LAD and ~~the~~ different material properties of the GGPs.*"
- Line 335-337: Rephrase.

- Line 339: Does thermal comfort improve in the entire study area (Fig. 16?). It is a bit difficult to distinguish between the different classes in Figure 16. For me, it appears that a lot of pixels have a value between -0.31 K and 0.33 K, which does not seem to be the entire study area.
- Line 340: When and how often did the UTCI classes changed from very strong heat stress to strong heat stress? Pixel-wise or on spatial average? For individual hours or on temporal average?
- Lines 343-353: Move to Conclusion?

#### 4. Discussion

- Lines 360-364: Surface or air temperature? Not clear, as first it is written “At the surface level”, but then it is compared to  $T_a$ .
- Line 383: Again, which differences are higher during the day? I think its  $T_s$ , right?
- Line 387: “*The surface temperatures ~~above~~ of the grass areas*”
- Lines 384-388: For my understanding: In your study the sensible heat flux was reduced by 130  $\text{Wm}^{-2}$ , which means from 140  $\text{Wm}^{-2}$  to 10  $\text{Wm}^{-2}$ , and in TAKEBAYASHI & MORIYAMA (2009) it was reduced from 250  $\text{Wm}^{-2}$  by 100  $\text{Wm}^{-2}$  to 150  $\text{Wm}^{-2}$ . Is this correct? But isn't there a big difference between 10  $\text{Wm}^{-2}$  and 130  $\text{Wm}^{-2}$ ? Is there an overview of all fluxes?
- Lines 299-401: If I understood correctly, you wrote about  $T_s$  in the adjacent sentences. Here you mention thermal indices, which are less affected by  $T_s$  but rather by  $T_a$ . So, I don't get the context. Or is this already part of the following sentences, where you start writing about  $T_a$ ?
- Line 404-405: Rephrase: “*At nighttime, cooling effects of GGPs on surface temperature are much lower, but significantly higher differences in air temperature occur in both S2 and S3 than during daytime.*”
- Line 409:  $T_a$  increase in percentage? I think this is rather uncommon. It does not seem that you use the Kelvin scale? To my understanding, everything else will give arbitrary results, as Celsius has no “absolute zero” point in 0°C. So, its maybe better to avoid using percentage for temperatures changes.

#### Tables and Figures

- Table 1: “*Thermal conductivity [W/(mk)]*”
- Figures 9, 11, and 12: Merge to one figure with subplots a, b, and c? Would make understanding easier. Then you would need only one legend with S1, S2, and S3. In addition, a boxplot of all  $T_a$  and  $T_s$  differences would be nice to see, not averaged by timestep, just 72x400x400 values to get an impression of the entire “cooling” distribution.
- Same for figures 13 and 15.
- Can this merged figure also be done for UTCI?

- Why is figure 10 so small compared to figure 14? You could also merge them. Could you add confidence intervals? As you only show the spatial mean.
- Figure 8 caption: "*The color scales correspond to those in Figure 6 and Figure 7.*" Is it possible to add these color scales to the figure 8? Makes it easier to analyze.
- Figures 6-8: I wonder about the edges of almost all plots. Also, in comparison to Figure 5. It somehow looks like the model domains have different edges between S1 and S2/S3 (Figure 5)? Does this lead to the high differences at the edges from Figure 6?
- Figure 16: What about the mean?