

## **Diurnal variation of amplified canopy urban heat island in Beijing megacity during heat wave periods: Roles of mountain-valley circulation and urban morphology**

### **Review**

This study focuses on the canopy urban heat island (CUHI) for the city of Beijing, based on surface weather station observations. It seeks to understand the effects of intensification of the UHI phenomenon during heat waves, and the role of local breeze circulations (mountain and valley) and of urban parameters on the temporal and spatial variability of the intensification.

It is an interesting scientific subject that looks at the urban climate of cities in complex environments, and that fits in well with the target scientific journal. It is addressed through an experimental approach, made possible by a fairly dense surface observation network in the city and surrounding area.

Nevertheless, the central scientific questions of the study are not, in my opinion, presented and structured clearly enough. The article would be clearer and more interesting if these questions were clearly stated and accompanied by a well-structured step-by-step analysis. As it is, the article investigates many different issues (CUHI, the effect of heatwaves, the effect of breeze circulation, the effects of urban parameters, cross-effects, the comparison of statistical approaches, etc.), and it is sometimes difficult to see the coherence of the whole. And in the end, the main findings don't stand out clearly enough. Also, the data used and the methodologies chosen (as well as the Figures) could be explained more precisely.

In my opinion, this work needs to be reworked in depth and some methodological issues need to be revisited. I do not recommend publication of this article.

### **Major comments**

First, the methodologies are not clearly explained, so the reader often lacks elements of understanding:

- For example, there is no clear understanding of the available network, i.e. the location of stations according to urban typologies, the different land use characteristics in and around the city. This should be presented in the section on methods and data.
- The geographical context is presented, but there is a lack of a more complete description of mountain and valley breeze situations (based in particular on the existing literature, which is apparently fairly extensive): the mechanisms involved, the factors of variability in terms of intensity and daily cycle, the influence of HW conditions, etc.
- The method used to calculate CUHI is unclear to me. Is it based on all days of the year vs heatwave days, or on summer days vs heatwave days?

Also, some methodological choices are highly questionable.

1/ the time period 2016-2020 is far too short to be considered as a climatology; a time series of around thirty years is needed to extract HW detection thresholds

2/ some of the stations are located in urban environments, so the maximum daily temperature can potentially be influenced

3/ Again, if some of the stations are located in urban environments, they should not be considered when calculating the synoptic wind (the urban environment disturbs the surface wind measurement). The synoptic wind should be calculated on the basis of rural stations only.  
> If the objective here is to identify HWs on a regional/local scale, I suggest applying detection only to non-urban stations (to avoid any urban influence), and selecting stations for which very long time series are available.

Generally all the captions need to be improved, especially the legends which are not detailed enough, so that it can be difficult to understand what is presented.

It seems to me that it is difficult to conclude from these figures about the influence of mountain or valley breezes on the CUHII knowing that the phenomenon of CUHI has a marked diurnal cycle. On the other hand, the effect of the wind on the UHI may be delayed over time: if there was wind during the day, there is less heat accumulation and then possibly less UHI at night. Same for urban parameters: it's very interesting to see how the different urban parameters rank in terms of their influence on CUHII. However, I wonder about the relevance of comparing this for the "mountain breeze" and "valley breeze" cases. The CUHI phenomenon is different during the day and at night, and is not related to the same physical processes, so it seems difficult to draw relevant conclusions from these comparisons.

### Minor comments

P3, L69

"... more than 1,400 km<sup>2</sup> ..."

P3, L71

"The altitudes of those mountains exceede 2,000 meters."

P3, L71

"The northeastern partregion comprises ..."

P3, L73

Please clarify what you mean by "weak weather system"

P3, L73-75

It would be interesting to summarise here the main findings of these various studies on breezes and local atmospheric circulations

P4, L82-83

*Land cover modulates the energy exchange, water, and carbon cycle between different regions of the Earth, and accurate land cover data is the basic parameter of climate research.*

I should remove the second part of the sentence.

P5, L85

*The annual China Land Cover Dataset (CLCD) is a dynamic data set accounting for land use in China released by Professor Yang and Professor Huang of Wuhan University. Yang & Huang (2021). They made the land cover datasets with a spatial resolution of 30 m based on 335,709 Landsat images on Google Earth Engine.*

P5, L88

Define the acronym LCZ (local climate zone) which is use here in the text for the first time, and include the ref to Stewart and (2012).

P5, L90

*"... within the research buffer areas of the target stations"*

This information should be introduced later in the text once the stations have been presented.

P5, L94-95

Replace "encompasses" (not really appropriate) and clarify what you mean by "related elements"

P5, L110

*"... otherwise, it was considered as a non heat wave (NHW) ~~an NHW~~ day."*

Are NHW days defined for the whole year or just for the summer period?

P5, L111-112

*"... by selecting reference stations for ground temperature observations and urban stations"*

Please clarify this sentence, do you mean "... by selecting urban reference stations for retrieving near-surface air temperature observations"?

P5, L113

*"... located outside of a 50km radius"*

Please add a space between "50" and "km" (and do the same everywhere in the rest of the text)

P5, L112-114

Based on which temperature distribution (day, night, average)? Why not base it on the land use map?

P5, L116

*"... than the average altitude of the 45 urban stations"*

How is the station's rural environment defined? From the land use map, I presume ?

As I understand it, this means that the other 45 stations (which are not classed as "rural") are all urban, and that they all meet the min distance to the city centre and land use conditions ?

P6, L119-121

You should explain more clearly what is a valley/mountain breeze.

P6, L125

*"... the daily average components of the wind U and V were obtained ..."*

Section 2.3.3 and Tab1

Not all morphological indicators are well described or easy to understand. The methodology lacks precision. For example: (1) what does "patch" mean? (2) on which zone are the indicators calculated, is this the case for all? (3) what is the size of the buffer? What are the final results ?

P7, L151-152

What means "The impact of urban spatial morphology on urbanization bias was evaluated" ?

P8, 164-175

The presentation and analysis of Fig 2 are extremely confusing. Personally, I don't understand what is presented here. Is it a difference between urban and rural areas, given that the aim is to study "urban warming excess" ?

P9, L180-189 and Fig. 3

- CHUII values are relatively low for a city like Beijing. We would expect higher intensities, particularly during heatwaves. How do you explain this? And could it have something to do with the methodology?
- I don't think that the variability is any greater during the day than at night. It also follows a plateau during the day (except in the transition phases).
- *"The diurnal variation of CUHII may be modulated by anthropogenic heat emissions, aerosols, atmospheric circulation, etc. (Zheng et al., 2018; Zheng et al., 2020; Yang et al., 2020)."* This sentence is off-topic, there is no link with the discussions of the diurnal cycles.
- Fig.3: I suggest plotting the daily CUHII cycles centred on the night-time hours (when intensities are at their highest).
- Explain in the text what means BJT
- The fact that urban heat islands are stronger during heatwaves is well known. It is based on the physical processes involved and has been observed in a large number of situations/cities.

P12, L194 and Fig. 4

- The times at which the  $\Delta$ CUHII is calculated are not specified (day, night, daily average). It would make much more sense to separate the hours of day and night, or even focus of nighttime (the phenomenon being nocturnal).
- Fig. 4: This figure presents both the spatial variability of  $\Delta$ CUHII and the interannual variability. This could be interesting if the analyzes were a little more in-depth. Here there are no very clear conclusions/messages about the influence of e.g. urban morphology or the variability of synoptic conditions.

P12, L205

*"In this section, this research analyzed the modulation of mountain-valley breeze on the synergies between HW and CUHI..." > "... the modulation of the synergies between HW and CUHI by the mountain-valley breeze" ??* This is what you mean ?

P15, L242-244

I don't understand on what basis this comment is made

Section 3.3

The city configuration with variability of building densities and heights is interesting.

P 16, Fig. 7c

According to the figure, D-value (for dense vs open) is stronger for "whole days" case than for both "mountain breeze" and "valley breeze" cases. However, the D-value for "whole days" should be intermediate to the other two cases, if it's calculated as an average over all the hours of the day, right?

P17, L287

What do you mean by "during 3D indicators" ? I don't understand this sentence.

P17, L287

The term "amplified CHUII" could be clearly explained once and then replaced by  $\Delta\text{CUHII}$  (everywhere in the text and figures).

P18, L289-291

You say "*Urban morphological indicators had weaker relationships with amplified CHUII during the mountain breeze period but showed stronger correlations with amplified CHUII during the valley breeze period.*"

According to Fig. 8, the effect of urban indicators on  $\Delta\text{CUHII}$  according to the breeze circulations is the opposite of what is written here: the effect is stronger during mountain breezes.

Fig. 9

We don't understand what is presented here, the names of the axes are not explicit and the legend is not detailed enough. I presume it is  $\Delta\text{CUHII}(\text{OBS})$  vs  $\Delta\text{CUHII}(\text{MODEL})$  ?

P18, 297-303

- Linear model: It's rather debatable to say here that the linear model is good (especially as you go on to say that it doesn't perform well...). The RMSE of  $0.14^\circ\text{C}$  is rather high given the average values. > you should adapt your comments
- SVR and RF: both models overestimate high values and underestimate low values, why ?

P20, L331

*"... the importance of SVF and BCR in the 2D3D and 3D2D indicators ..."*

Fig. 11

- Again we don't understand what is presented here, what is the partial dependence ? clarify what is presented both in the text and in the caption. >> Is it  $\Delta\text{CUHII}$  on y-axis ?
- The range of y-axis is different in the different plots, you should use the same.
- What do the small vertical lines on the x-axis represent?
- For (c) panel, do you think it is relevant to interpolate the data ? I would use symbols instead. Also you should add a color legend

P22, L370-372

On what basis do you say here that the synergistic effect observed at S1 and S2 is lower than that observed at S3 and S4 ? The differences are considered as significative for ex. between S2 and S4 ?