between the two, possibly indicating that past historical thresholds had little impact on the perception brought about by the current year's maximum temperatures. This aligns with the previously mentioned abnormal climate change case in Cfb climate types.

In conclusion, we also confirmed that heat perception could predict climate change in a region to some extent. This study provides significant contributions to understanding residents' heat perception and paves the way for applying these insights to climate adaptability planning.

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Keywords: climate change, human perception, climate adaptation, emotion, natural language processing

HOW DO MULTI-DIMENSIONAL FACTORS OF GREEN ROOFS AFFECT URBAN HEAT ISLAND?

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Rapid urbanization and high-density development have encroached on the natural landscape, exacerbating the urban island heat (UHI) effects – higher temperatures in built areas than in non-urban areas, which can adversely affect the health and comfort of city dwellers and increase energy use and carbon emissions (Dong et al., 2020). Green roofs, which convert concrete rooftops to vegetation-covered roofs, are found to be effective in mitigating UHI effects.

Many existing studies have examined multi-dimensional factors of green roofs (e.g., green roof area and the Normalized Difference Vegetation Index (NDVI) as two-dimensional (2D) factors and building height as a three-dimensional (3D) factor) to better understand their relationship with UHI effects, thus helping to develop appropriate policies related to urban green roofs (Hu et al., 2020). However, few have considered the 3D structure of roof vegetation into 3D factors and examined its effects. In fact, Bai et al. (2019) recently proposed an efficient and scalable method to calculate the 3D green index of green space by retrieving vegetation heights from high-resolution remote sensing images, providing a realistic representation of the 3D landscape of green space. In this regard, there are new opportunities to investigate how the 3D green volume (3DGV) of green roofs can affect UHI effects. On the other hand, while comprehensive climate models, such as the Weather Research and Forecasting Model, are adopted in prior studies, their complexity and data requirements limit their use by most urban planners. Some researchers also employed linear regression to evaluate the effects of green roofs, but their impacts can vary over their full range and have a threshold (Lin et al., 2021). Moreover, such biases caused by non-linearity can be solved by implementing machine learning (ML) models, such as XGBoost. Yet, such non-linear effects of green roofs using ML methods are relatively under-addressed.

To address these gaps, this study, using the central districts of Shanghai as a case study, aims to assess the multi-dimensional features of green roofs (2D and 3D) and their non-linear relationship with UHI effects, utilizing remote sensing images and ML methods. First, the land surface temperature (LST) for each green roof was extracted from Landsat 8 to represent the urban heat environment. Following the methods from Bai et al. (2019), the 3DGV of each green roof measured from GF-1 images, along with the total area of diverse vegetation types (e.g., lawn and brush and tree) were integrated to reflect 3D vegetation structure. Additionally, the underlying influential spatial factors, such as NDVI, building height, and spatial features of nearby green space, were further controlled and analyzed. Finally, besides OLS model, several non-parametric ML methods (e.g., random forest and XGBoost) were adopted to assess the non-linear effects of green roofs on LST.

The preliminary results indicated that ML models outperform OLS model in explaining the relationship between green roofs and UHI effects, highlighting the necessity of considering the non-linear effects of green roofs. It would enrich and enhance our understanding of the effective range of various factors of green roofs affecting UHI effects. More importantly, we anticipate that this research would provide insights for urban planners and policymakers on how to spatially configure the vegetation structure of green roofs and arrange green roofs to improve the urban thermal environment.

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Keywords: Green roofs, Urban heat island, Non-linear relationship, Machine learning