Employing Terrestrial LiDAR to detail Tree Canopy Structure and Shade for the Cooling Effect Analysis

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Abstract

Urban warming has become a serious problem along with global warming and the rapid urbanization. One important phenomina is the increasing urban heat island (UHI) effect, which has caused serious negative impacts on energy consumption, environmental pollution and human well-being. Trees lower surface and air temperatures by providing shade and through evapotranspiration, and therefore, are a useful strategy to effectively mitigate the UHI effect. Cooling effects of different trees is different due to the different tree crown size, density and optical properties of their leaves. Selecting the best species to plant is important for the mitigation of the urban thermal environment and for saving energy as well as sustainability. In this research, we selected four woodlands with different vegetation structure. Three woodlands were dominated by common species (*Cinnamomum camphora*, *Metasequoia*

glyptostroboides, *Magnolia grandiflora*) frequently planted in Nanjing city, China, and one is a mix-woodland with several different species. The HOBO meteorological stations were used to measure the microclimate environment. Terrestrial LiDAR was employed to detail the vegetation canopy structure and capture the three-dimensional point cloud of leaves as well as the shade at each station. The statistical analysis has been used to capture the cooling effect characteristics of different woodland and their related impact factors. The findings of this research revealed that the vegetation could influence the microclimate underneath the tree canopy and their impacts differed among species. The statistical analysis also showed that the woodlands have an obvious temperature reduction in the daytime (5:00 h-19:30 h) but weak during the night (19:30 h- 5:00 h).The temperature reduction of different species was (in decreasing order) *Metasequoia glyptostroboides*, *Cinnamomum camphora*, *Magnolia grandiflora* and then the mixed broad-leaved woodland. Compared with LAI (Leaf area index) and SVF (Sky view factor) with the L_V_{3DPC} and shade respectively, L_V_{3DPC} and shade can more accurately reflect the impact that vegetation canopy have on the cooling effect. The correlation analysis between L_V_{3DPC} and shade, microclimate and cooling effect proved that shading by trees is of prime importance in mitigating the thermal environment. The high significance of L_V_{3DPC} and shade indicate that the tree canopy is a major component that is able to contribute to microclimatic environments- particularly the cooling effect under the tree canopy. The research presents an innovative technique for analyzing tree canopy shade by using ground-based LiDAR data to analyze the cooling effect of trees. The results can be

used as a guide for selecting the best species for urban greenspace planning and designing to mitigate the urban thermal environment and enhance energy savings in urban environments.

Key words： Urban thermal environment; Cooling effect; Terrestrial laser scanner; vegetation canopy; three-dimensional point cloud (3DPC); Tree shade; Urban greenspace; Urban planning