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Thermal behavior and its seasonal and diurnal variability of urban green infrastructure in a mid-latitude city - Berlin

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Land surface temperature (LST) is a key variable in characterizing the surface energy and water balance at the land surface-atmosphere interface. Vegetation reduces LST by providing shade and absorbing radiation energy via transpiration and photosynthesis. In urban environments, vegetation is generally spatio-temporally heterogeneous, with variations in vegetation type, species, vegetation density, vegetation height, leaf area, microclimate, water accessibility, and soil and water characteristics. A review of research on urban green spaces recommended that future research should incorporate functional, structural, and configurational parameters of urban vegetation in order to more fully assess the thermal effect of green spaces. This study aims to fill this research gap by considering satellite-derived LST (Landsat 8), biotope types, 3D vegetation data, and vegetation indices in a study of LST across diurnal and seasonal temporal scales in a mid-latitude city (Berlin). Biotope types are defined as topographical units characterized by similar physical conditions suitable for specific flora and fauna. We figured out how different biotope types affect LST and how LST of different biotope types varies across a mid-latitude city. Four cloud-free Landsat 8 scenes representing each season of 2018 were analyzed. A night Landsat 8 scene with comparable air temperatures was selected from July 2014 due to the unavailability of night Landsat images covering Berlin in 2018. The summer day and night scenes were used to assess the day/ night difference in LST. The Wang et al. mono-window algorithm was applied to derive LST from Landsat 8 Band 10. A biotope type map provided by the Berlin Environmental Atlas provided GIS data for biotope types in Berlin. Kruskall-Wallis tests and Dunn's post-hoc tests were applied to assess the significance of difference between LST of biotope classes and sub-classes within seasons and day-night. Overall, LST varied significantly between the majority of biotope classes and sub-classes. The relative coolness of each biotope class differed based on the season. The coolest biotope class in the summer scene was standing waters, closely followed by forests. In the spring, autumn, and winter scenes, the two coolest biotope classes were standing waters and flowing waters. Dwarf shrub heaths were the warmest biotope class in the winter and summer. In the spring scene, built-up areas were the warmest biotope class, while fields were the warmest biotope class for the autumn scene. The lowest day/night LST variation could be noted for the water biotope classes (standing waters and flowing waters), followed by forests. The highest day/night LST variation could be noted for dwarf shrub heaths, fields, and green spaces. Vegetation height was significantly negatively correlated with LST (p-value<0.001) for all day scenes, with the strongest correlation ($r = -0.66$) in summer and weakest correlation ($r = -0.24$) in winter. Vegetation height and LST were weakly negatively correlated in the night summer scene ($r = -0.06$, p-value<0.001). Our results contribute to an enhanced understanding of how biotope types influence LST in an urban environment, which will be vital to urban planning in light of climate change.