Hunsoo Song, Gaia Cervini, Jinha Jung

Lyles School of Civil Engineering, hunsoo@purdue.edu, gcervini@purdue.edu, Jinha@purdue.edu

Unraveling the relationship between 3D urban landscape and urban heat island effect using deep learning

ABSTRACT

Effective landscape design can mitigate the intensity of urban heat islands (UHIs), thereby improving the sustainability and livability of cities. However, designing such landscapes is challenging due to the complex interplay of various factors that affect UHI intensity, including climate, geography, anthropogenic heat, and surface materials. To address this challenge, we developed a deep learning model that can estimate land surface temperature based on local 3D urban landscapes by utilizing large-scale 3D urban land cover maps. Our deep learning model has achieved an estimation accuracy of approximately 1 Kelvin mean absolute error over the metropolitan area of Dallas, TX. Using the trained model and simulated 3D urban landscapes, we investigated the impact of various factors, such as building height, tree height, water bodies, vegetation, and impervious surfaces, on UHI intensity. Our approach to unraveling the relationship between 3D urban landscapes and UHIs would offer insights into developing heat-resilient cities.

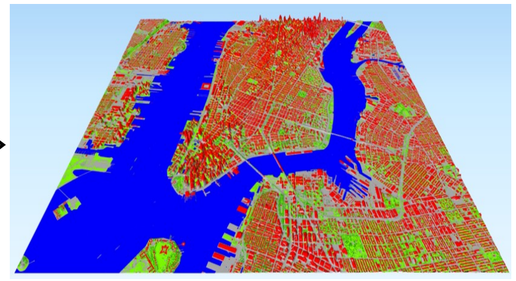
Deep Model Training

Deep Model (**X**: **3D urban landscape**, climate, geography, …) = **Y**: **Land Surface Temperature (°C)**

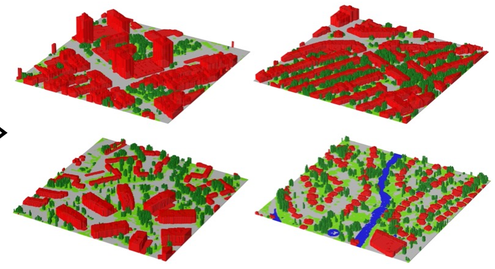
≅ **Y**: **Urban Heat Intensity**

X

Airborne LiDAR and Optical Data



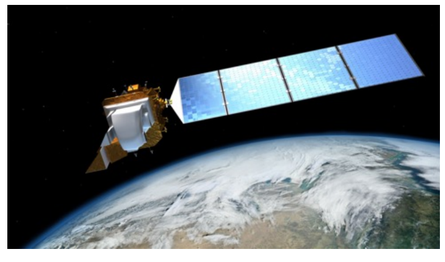
3D Land Cover Map



3D Landscape

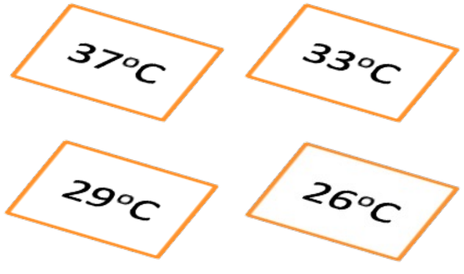
Deep Model

Y



Satellite Data (Landsat)

Land Surface Temperature (LST)



3D Landscape's LST

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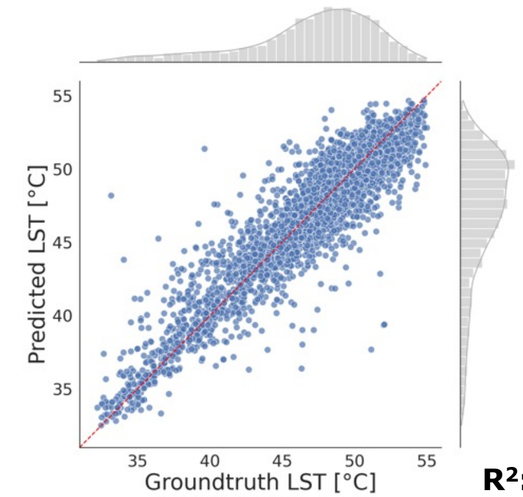
GDSL @ Purdue

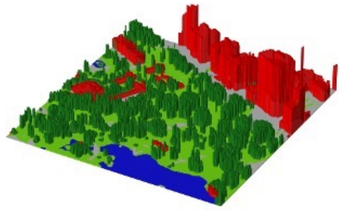
The Deep Model's Performance

Test area: Dallas, TX
LST acquisition date: August 18, 2020



R^2: 0.87
Mean absolute error: 1.12

Hey deep model, is it heat-resilient?



New Design

Deep Model

?

Estimated Urban Heat Intensity

Hey deep model, could you design a heat-resilient landscape?