Carbon Sequestration and Urban Heat Island Mitigation by Urban Forests

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Introduction and Motivation

Parks and forests in cities serve as recreational spaces and heat sinks to reduce urban heat islands.

Urban forest are the primary nature-based carbon sequestration in cities.

High resolution remote sensing imagery can delineate individual trees and identify tree species.

In this work we demonstrate:

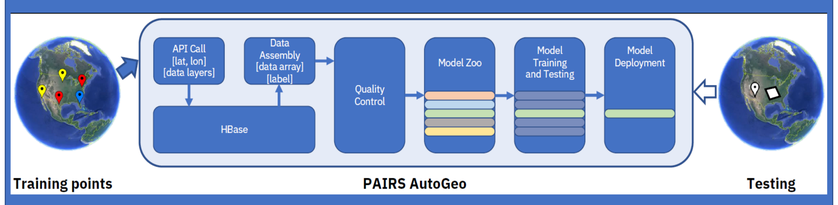
- The direct impact of individual trees on local temperature.
- The correlation between tree density and urban heat island.
- Validation of tree delineation from noisy label data (see poster **Rule-Based, Noisy Labels for Overhead Imagery Segmentation, see poster by** Albrecht et al., May 26, 6.11pm)

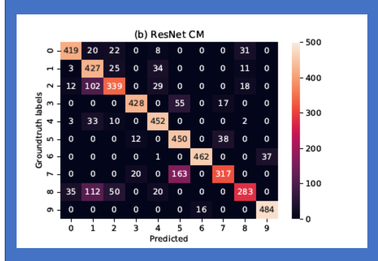
Tree Species Identification

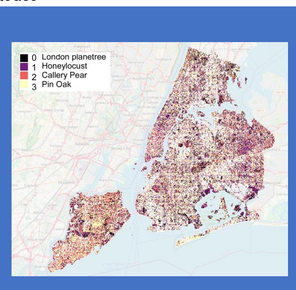
New York City (NYC) urban tree census counts ~600k trees on public domain (out of 3 million trees) and manually label their species and dimensions.

Tree species	Number of trees
London planetree	55903
honeylocust	43974
Callery pear	42384
pin oak	30575
Japanese zelkova	20271
littleleaf linden	17840
cherry	15782
ginkgo	15053

Automatic land cover classification using satellite data and geolocated tree species input: https://www.nycgovparks.org/trees/treescount



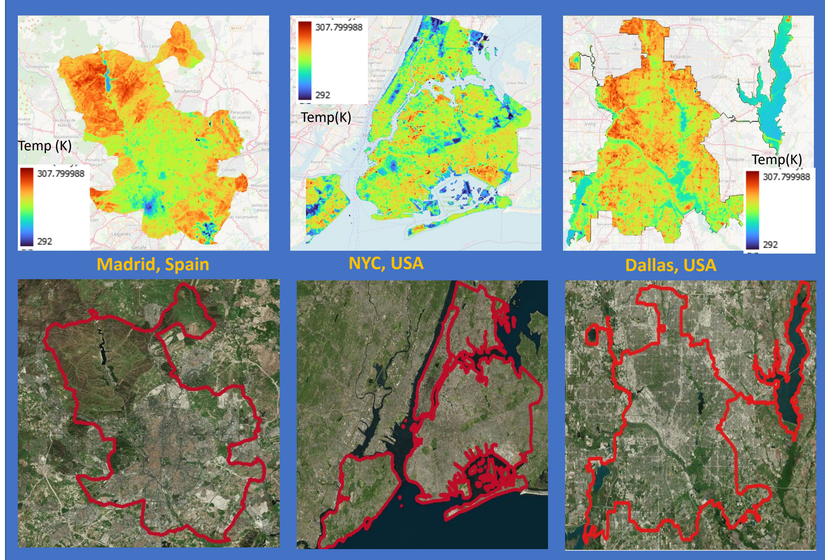




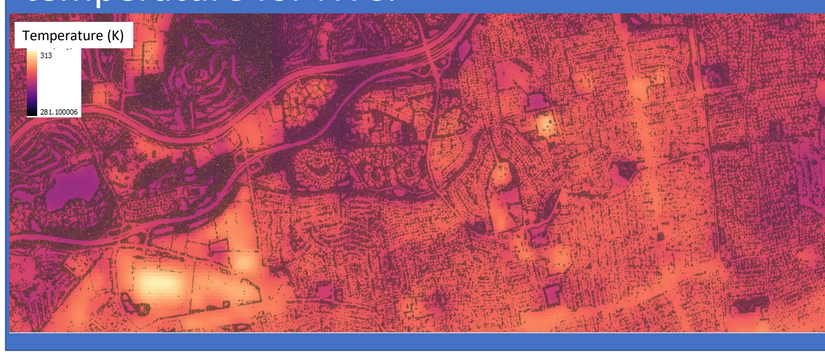
AutoGeoLabel: Automated Label Generation for Geospatial Machine Learning , https://arxiv.org/abs/2202.00067

Urban Heat Islands

Landsat 8 thermal band (Band 11) is used to assess surface temperature variation across an urban area with parks and forest having the lowest temperature and dense buildings having the highest temperature.

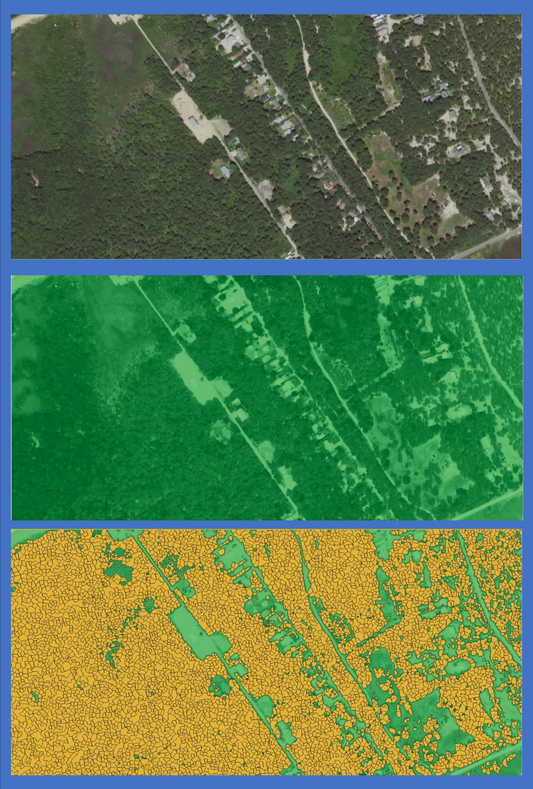


Overlay of the delineated trees and surface temperature for NYC.



Tree Delineation from Remote Sensing Imagery

Image processing and segmentation on orthorectified imagery to delineate individual trees using Random Forest and Support Vector Machine classification



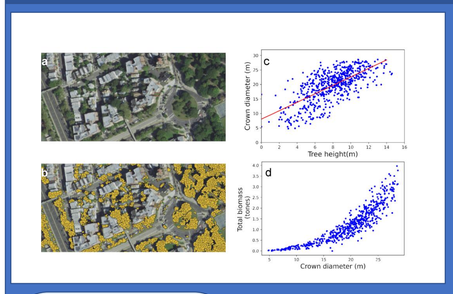
Orthorectified Imagery

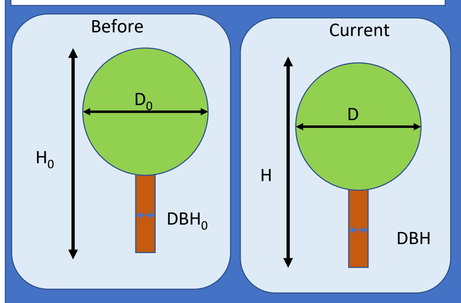
Hyperspectral Analytics

Land cover classification and tree segmentation

Tree species specific allometric equations are built for each species to extract above and below ground biomass.

Carbon Storage and Sequestration in Trees





Above ground biomass (AGB)

$$AGB = F\ x\ \varrho\ x\ V\ x\ H = F\ x\ \varrho\ x\ \left(\frac{\pi D^2}{4}\right)\ x\ H$$

Below ground biomass(BGB)

BGB= f AGB
where F is an AI estimated form factor that is tree species specific

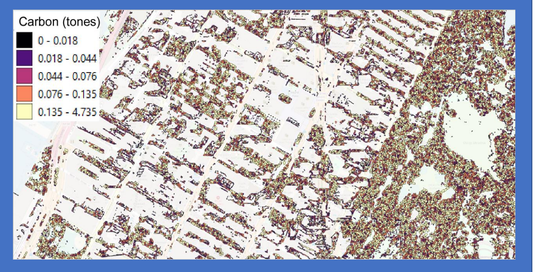
Total biomass (TB_{iomass})
TB_{iomass}=BGB+AGB

Carbon stored in trees/bushes/grass:
f1 TB_{iomass} ;where f1 is an AI estimated vegetation and weather/climate specific factor; changing geographically

Carbon sequestration (CS)
Time dependent change in TB_{iomass} volume

$CS=(TB_{iomass})_{Current}-(TB_{iomass})_{Before}$

Carbon sequestration is defined as increase in biomass across a time interval, converted to carbon.



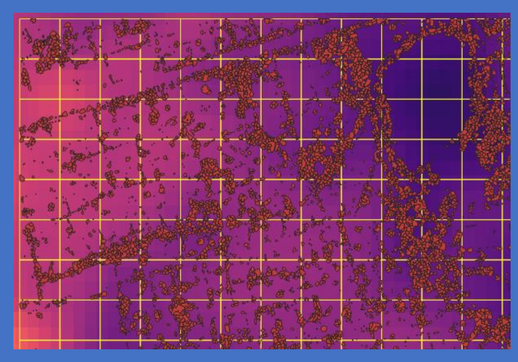
Sum up carbon from all 300,000 trees:
52,000 tones of Carbon for Manhattan, NYC

Ground truth: carbon sequestered estimated for Manhattan NYC using manual inspection is 43,500 tones of Carbon

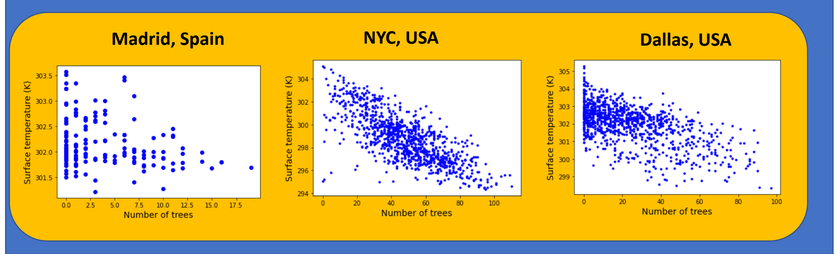
Quantification of Carbon Sequestration in Urban Forests, https://arxiv.org/abs/2106.00182

Impact of Tree Density on Urban Heat Islands

The yellow grid overlay on tree map density and surface temperature defines the bounding boxes to count trees within a cell and to calculate the mean temperature.



Local tree distribution impacts the local surface temperature, but land cover plays also an important role.



Conclusion

Urban tree density and tree planting patterns can minimize urban heat islands in cities.