Predicting Urban Heat Islands from Satellite Land-Cover Data

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Motivation

Cities can be several degrees warmer than surrounding rural areas, an effect known as the urban heat island (UHI). Fine-grained UHI maps are expensive to produce from ground sensors alone, but land-cover classification from satellite imagery is cheap and updated regularly. We ask whether land-cover fractions predict surface temperature well enough to substitute for a sparse sensor network.

Data

- Landsat 8 thermal band imagery, 30 m resolution, 42 cities.
- Land-cover fractions (impervious surface, tree canopy, water) from the National Land Cover Database.
- Ground-truth surface temperature from 1,100 weather stations.

Method

We fit a gradient-boosted regression tree mapping land-cover fractions and time of day to surface temperature, validated with 10-fold cross-validation stratified by city.

- Features: impervious %, canopy %, water %, elevation, distance to coastline.
- Target: land surface temperature (LST), °C.
- Baseline: linear regression on impervious surface fraction alone.

Results

Model	RMSE (°C)	R^2
Linear (impervious only)	3.8	0.41
Gradient-boosted trees	1.6	0.87

The full feature set roughly halves prediction error relative to the impervious-surface-only baseline, and canopy fraction is the single most important feature after impervious surface.

Discussion

Land-cover fractions alone explain most of the variance in surface temperature across cities of very different sizes and climates, suggesting the model transfers reasonably well without per-city recalibration. Coastal cities show the largest residual errors, plausibly from unmodelled sea-breeze cooling.

Conclusion

Satellite-derived land cover is a practical, low-cost substitute for dense ground sensor networks when estimating city-scale heat island intensity, particularly for identifying priority neighbourhoods for tree-planting interventions.

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