MPD1: *Urban climate and form*

Understanding heat exposure through morphological descriptors of intra-urban heterogeneity

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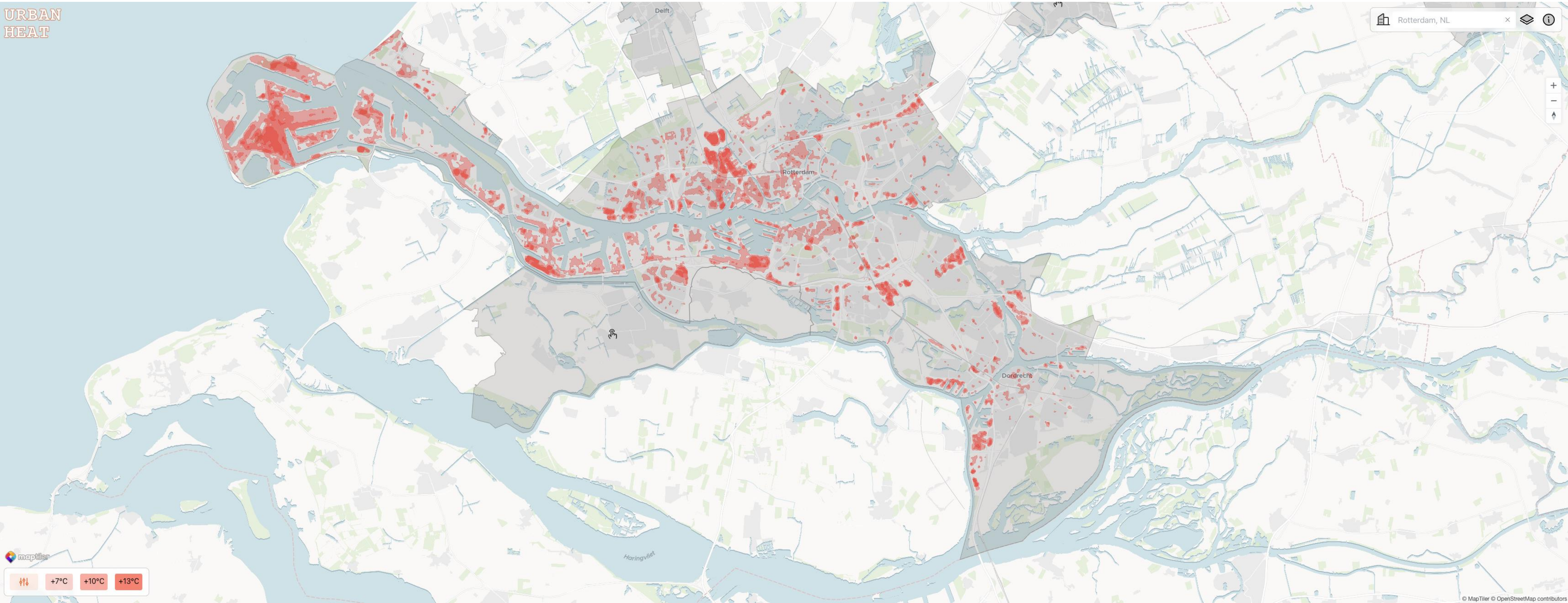
why?

https://urbandesignlab.in/what-is-an-urban-heat-island/

RESEARCH CONTEXT: URBAN FORM AND CLIMATE

Understanding heat exposure through urban form



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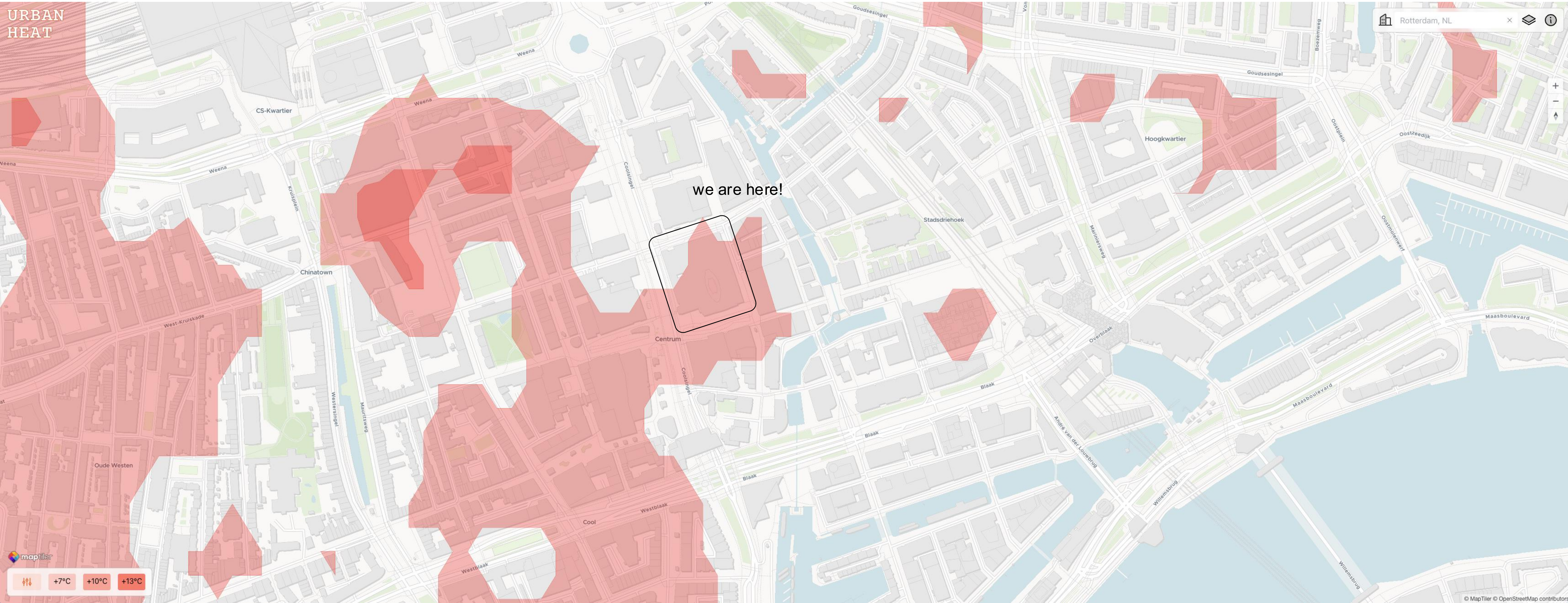


RESEARCH CONTEXT: URBAN FORM AND CLIMATE

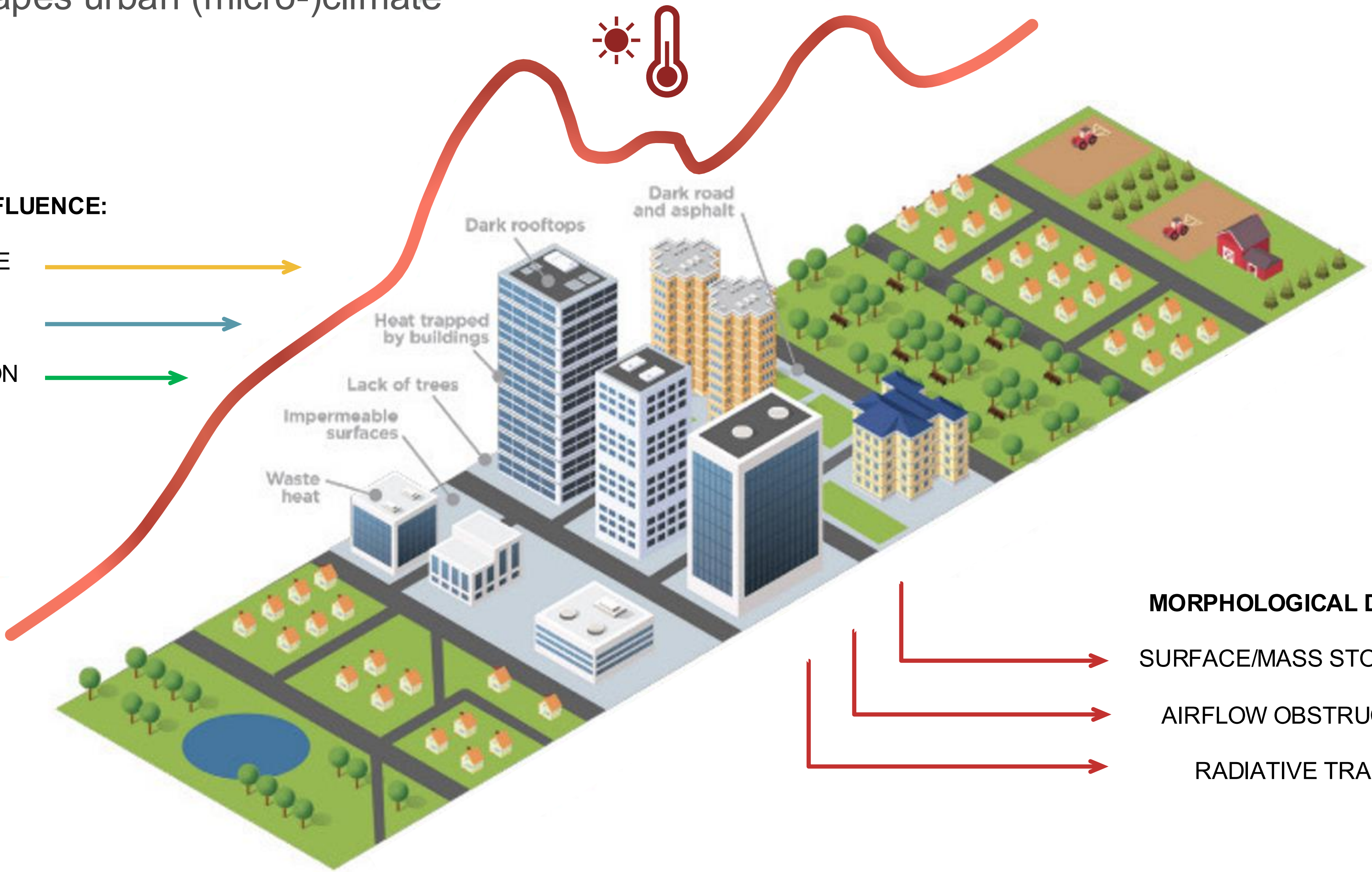
Urban form shapes urban (micro-)climate

CLIMATOLOGICAL INFLUENCE:

RADIATIVE EXCHANGE

CONVECTIVE FLOW

EVAPOTRANSPIRATION



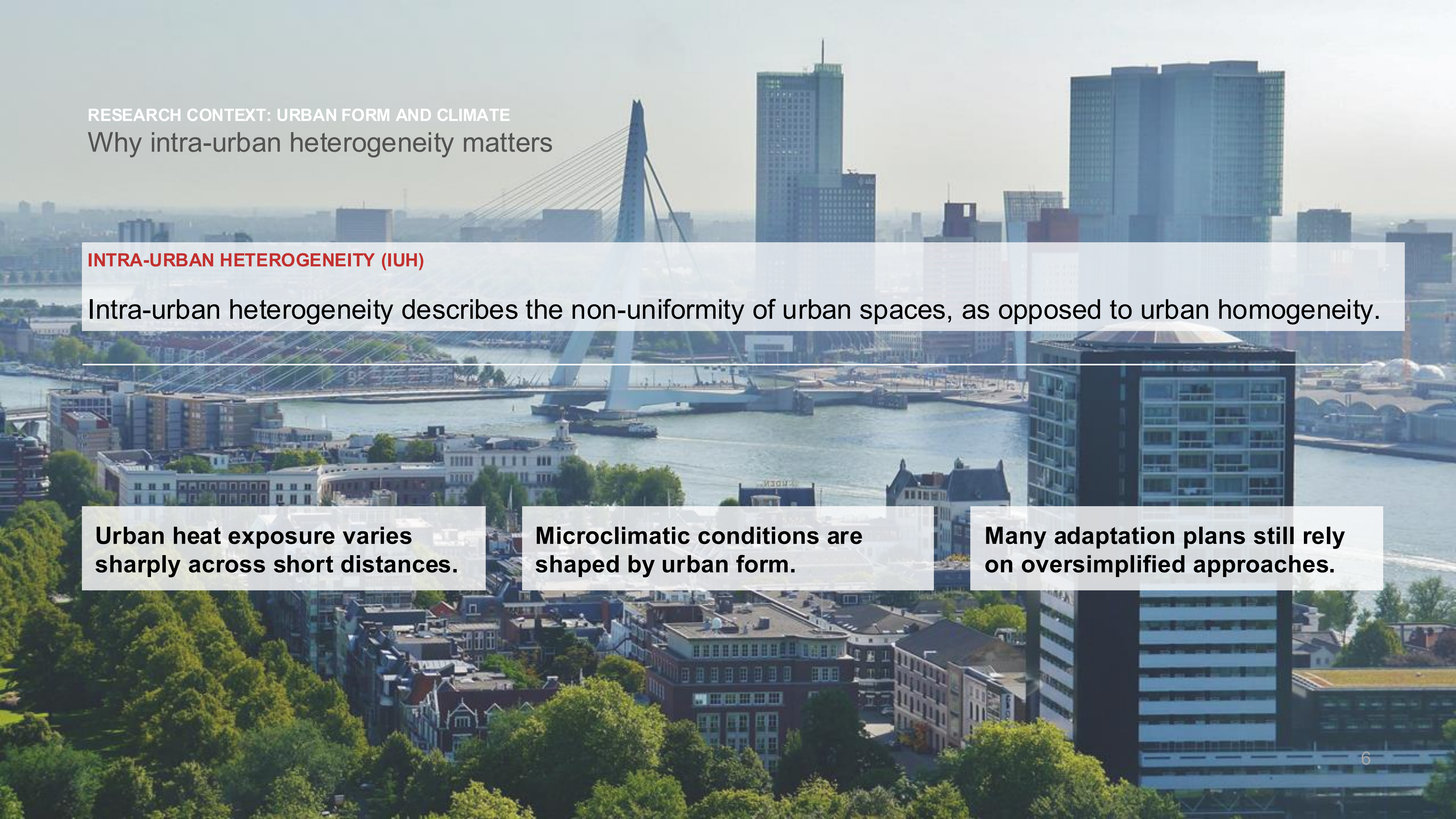
MORPHOLOGICAL DRIVE:

SURFACE/MASS STORAGE

AIRFLOW OBSTRUCTION

RADIATIVE TRAPPING

https://www.moodyscre.com/insights/cre-news/why-is-it-hotter-in-cities-unpacking-the-urban-heat-island-effect/



RESEARCH CONTEXT: URBAN FORM AND CLIMATE

Why intra-urban heterogeneity matters

INTRA-URBAN HETEROGENEITY (IUH)

Intra-urban heterogeneity describes the non-uniformity of urban spaces, as opposed to urban homogeneity.

Urban heat exposure varies sharply across short distances.

Microclimatic conditions are shaped by urban form.

Many adaptation plans still rely on oversimplified approaches.

Problem statement

DESCRIPTORS

Descriptors are often used without clear consistency.

HOMOGENEITY VS. HETEROGENEITY

Homogeneity is often assumed within spatial units.

SPATIAL VARIATION

Only few studies assess if descriptors actually capture real spatial variation.

how?

Review process and evaluation strategy

1.

Identify and categorise morphological descriptors used in urban climate studies

Systematic literature review

screened about 200+ studies

2.

Evaluate how descriptors capture intra-urban heterogeneity.

Developed parameter matrix

scale, data type, formula, IUH detection, etc.

3.

Assess relationship with heat exposure and thermal variability.

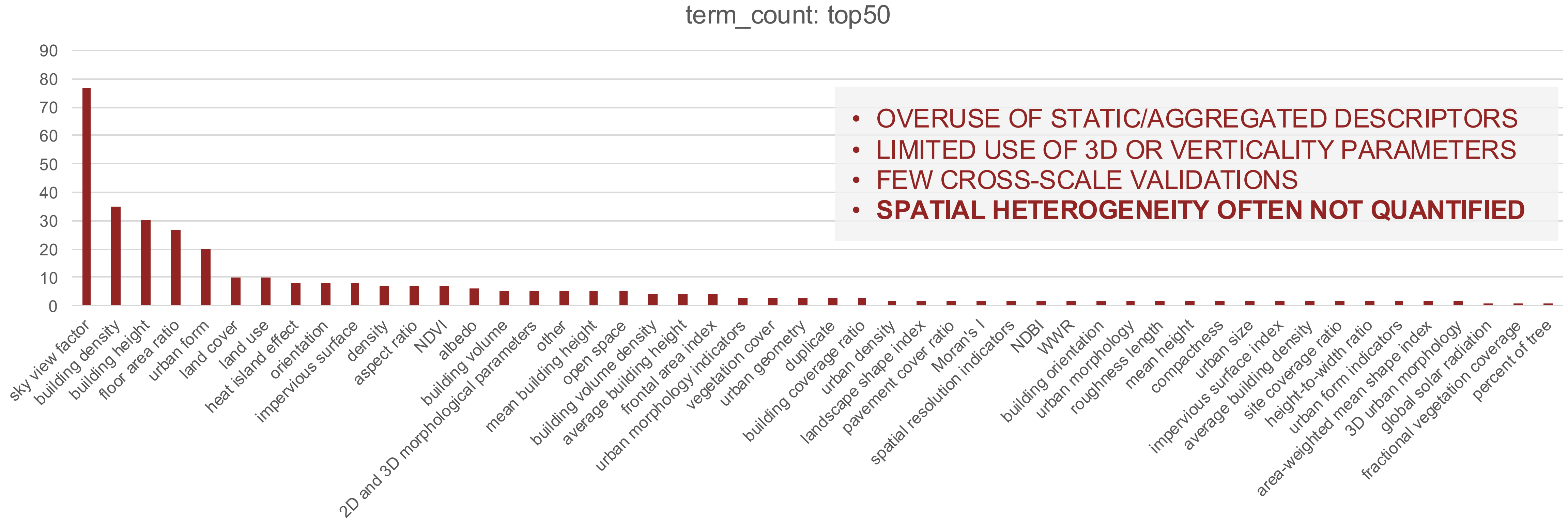
Evaluated descriptors

by: spatial resolution, correlation with thermal metrics, sensitivity across case studies

results

RESULTS: COMMON GAPS IN THE LITERATURE

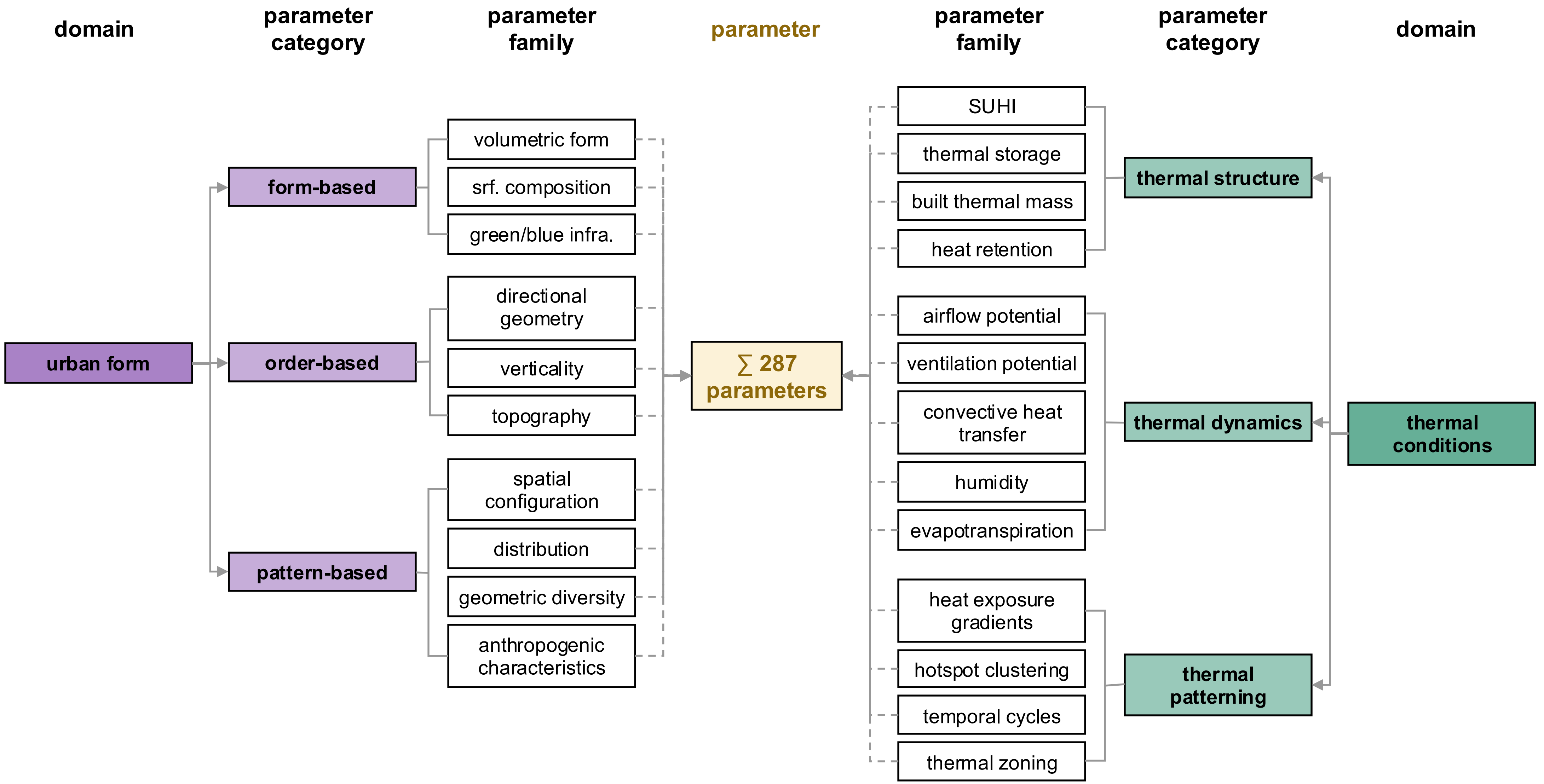
What's missing in current practice?



- OVERUSE OF STATIC/AGGREGATED DESCRIPTORS
- LIMITED USE OF 3D OR VERTICALITY PARAMETERS
- FEW CROSS-SCALE VALIDATIONS
- **SPATIAL HETEROGENEITY OFTEN NOT QUANTIFIED**

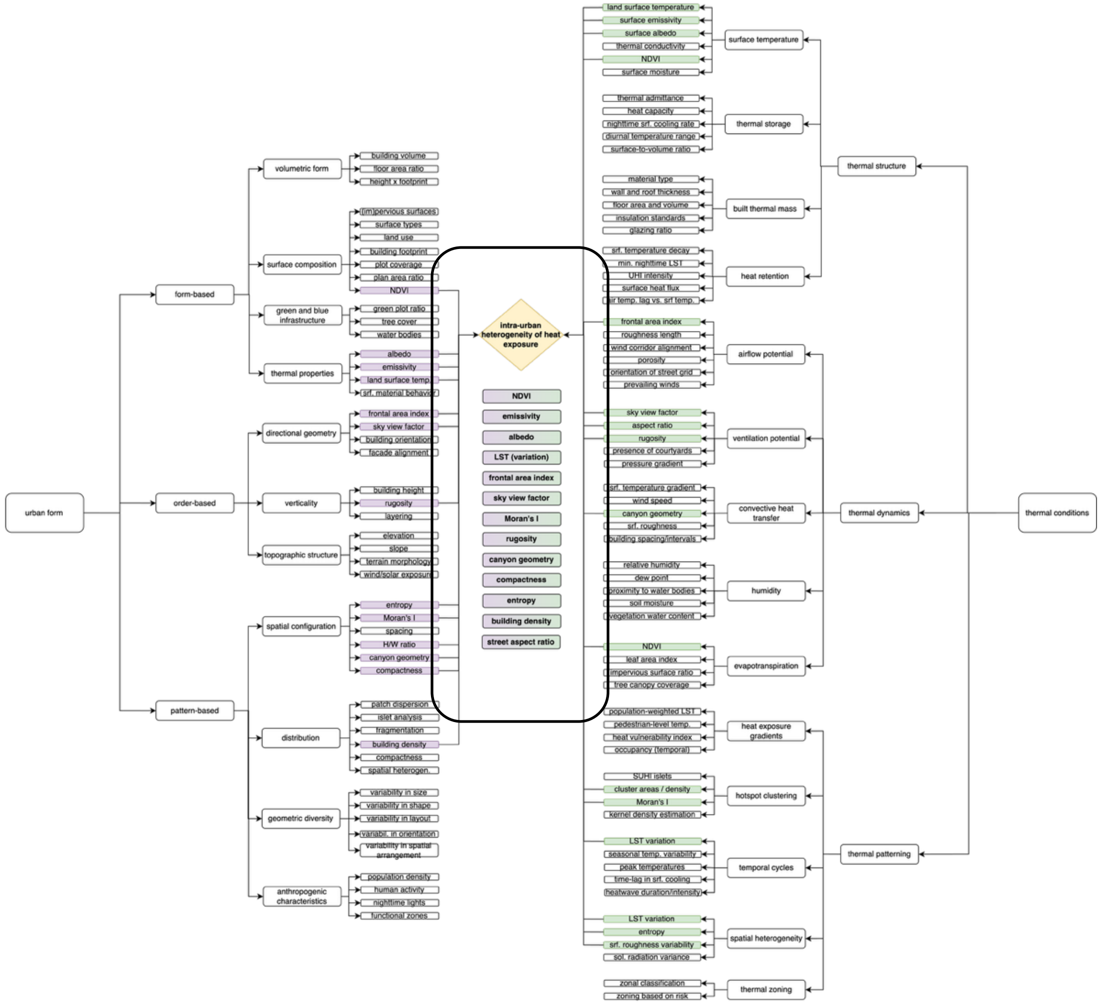
RESULTS: IUH TYPOLOGY

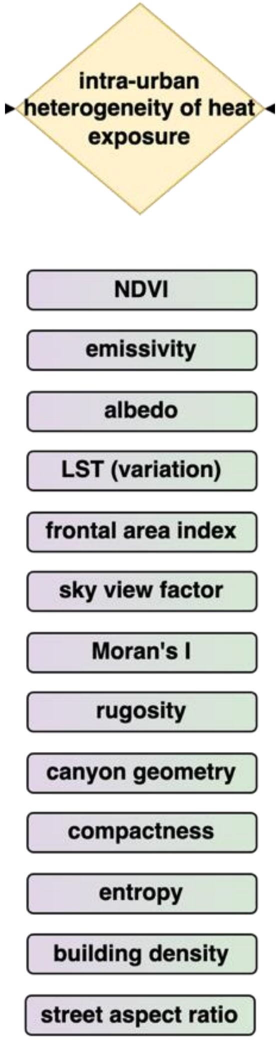
Parameter categories and families:



RESULTS: TYPOLOGY TAXONOMY OF INTRA-URBAN HETEROGENEITY FOR CAPTURING HEAT EXPOSURE

Which descriptors capture IUH and thermal variation best?





RESULTS: TYPOLOGY TAXONOMY OF INTRA-URBAN HETEROGENEITY FOR CAPTURING HEAT EXPOSURE

Which descriptors capture IUH and thermal variation best?

NDVI	vegetation cover: contrast in NDVI directly reveals spatial variability in surface temperature and exposure
emissivity	a surface's ability to radiate heat: explains localised heat retention and variability
albedo	surface reflectivity: distinguishes thermal behaviour at a granular scale
LST (variation)	direct thermal heterogeneity: high variability in LST signals a diverse thermal environment; locates heat stress zones or cool pockets
frontal area index	extent of built surfaces exposed to wind: high FAI blocks wind and traps heat
sky view factor	sky visibility: low SVF = heat trapping, limited radiative cooling
Moran's I	spatial autocorrelation: reveals clustering/dispersion of hot/cool areas; quantifies spatial heterogeneity of urban heat
rugosity	vertical surface complexity: variation in building heights or 3D forms; high rugosity = low wind flow, higher heat accumulation
canyon geometry	affects shading, radiation trapping, ventilation
compactness	more enclosed areas have less airflow, greater shading, and higher heat accumulation
entropy	uniformity or disorder in the spatial arrangement. high entropy can indicate mixed microclimates and can reflect structural heterogeneity influencing thermal patterns
building density	intensity of development: heat trapping, blocked airflow, reduced cooling potential
street aspect ratio	height/width: influence on solar access and radiative exchange in street canyons. heat trapping, reduced cooling, street-level temperature variations

what's next?

Implications for urban climate models

DESCRIPTOR SETS

Need for descriptor sets that are multi-scalar and form-sensitive.

INTEGRATION

Suggest integration of vertical and spatial patterning metrics into existing classification systems.

CASE STUDIES

Opportunity for hybrid methods: morphology + climate sensitivity

CONCLUSION AND OUTLOOK

Toward better climate-based urban classification

KEY TAKEAWAYS

- Urban form must be more precisely described to assess heat exposure.
- The descriptor matrix / taxonomy offers a path toward tailored classification methods.
- Next steps: Applying the framework to case studies and refining method selection strategies.

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Evaluating morphological methods for climate-based classification of urban heat: a systematic review

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thank you!