CENSUS of Cities: LCZ Classification of Cities (Level 0) – Workflow and Initial Results from Various Cities

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Bechtel, Benjamin¹, Foley, Micheál², Mills, Gerald², Ching, Jason³, See, Linda⁴, Alexander, Paul⁵, O’Connor, Martin², Albuquerque, Taciana⁶, Andrade, Maria de Fatima, Brovelli, Maria⁸, Das, Debashish⁹, Fonte, Cidalia Costa¹⁰, Petit, Gwendall¹¹, Hanif, Uzma¹², Jimenez, Jose¹³, Lackner, Stefan¹⁴, Liu, Weibo¹⁵, Perera, Narein¹⁶, Rosni, Nur Aulia¹⁷, Theeuwes, Nathalie¹⁸, Gál, Tamás¹⁹

¹ University of Hamburg, Germany;  *benjamin.bechtel@uni-hamburg.de  ² University College Dublin, Ireland, ³ University of North Carolina, USA, ⁴ IIASA, Austria, ⁵ National University of Ireland Maynooth, Ireland, ⁶ Federal University of Minas Gerais, Brazil, ⁷ University of Sao Paulo, Brazil, ⁸ Politecnico de Milano, Italy, ⁹ Jadavpur University, India, ¹⁰ University of Coimbra, Portugal, ¹¹ Institute for Research on Urban Sciences and Techniques, France, ¹² Government College University Lahore, Pakistan, ¹³ National University of Colombia, Colombia, ¹⁴ University of Vienna, Austria, ¹⁵ University of Kansas, USA, ¹⁶ University of Moratuwa, Sri Lanka, ¹⁷ International Islamic University Malaysia, Malaysia, ¹⁸ Wageningen University, The Netherlands, ¹⁹ University of Szeged, Hungary
WUDAPT

• **Knowledge about** the footprint and **internal structure of urban areas** is relevant for various applications

• The World Urban Database and Portal Tool: international collaborative project for the **acquisition, storage and dissemination of climate relevant data** on the physical geographies of cities worldwide

• result will be a physical census of cities

• describe the **form** (surface cover, the construction materials and geometry) and **function** (metabolism, i.e. exchange of energy, water and materials) of cities **in different levels of detail**
Level 2
- Detailed description of urban landscape parameters at a scale suited to boundary-layer models
- Use of all available databases (e.g. building footprints)

Level 1
- More precise parameter values for each LCZ
- Focus on aspects of form (e.g. building heights, street width) and functions (e.g. building use).
- Sampling of LCZ using GeoWiki

Level 0
- Local Climate Zones (LCZ) along with parameter ranges
- Categorise city neighbourhoods into LCZ types
- Local experts provide training areas
- GoogleEarth, Landsat8 and Saga

Fig. 1. WUDAPT’s data hierarchy
The landscape universe

Local Climate Zones (Stewart & Oke 2012)

- regions of uniform surface cover, structure, material, and human activity that span hundreds of meters to several kilometers in horizontal scale
- Each LCZ has a characteristic screen-height temperature regime
- Generic, no cultural bias
- Large number of geometric, thermal, radiative, metabolic, and surface cover properties
Are LCZs suitable for mapping?

- Developed for measurement site description of UHI studies
- but also useful discretization of the landscape with respect to its surface layer climate
- Can an LCZ be assigned to any urban structure? (complete)
- And can only one LCZ be assigned to a given structure? (disjoint)

Bechtel et al. 2015

- no overlaps or holes, outliers excluded from the standard set
- scheme considers a priori knowledge about the frequency certain structures
- possibility to define subclasses (= mixtures between the standard classes)
- some areas fuzzy in terms of LCZ
- LCZ provide a disjoint and largely complementary discretisation
- well balanced between accuracy and universality
A simple mapping methodology

Requirements for LCZ mapping

• simple workflow in the form of a protocol
• enabling local operators with different backgrounds to derive a LCZ map
• Universal
• as objective as possible
• computationally efficient
• fiscally inexpensive (based on free and widely available data and software)

LCZ mapping schemes evaluated

• manual sampling of grid cells using Geo-Wiki (Mills 2013)
• digitisation of homogenous LCZs
• GIS-based approach using building data (Lelovics et al. 2014)
• object based image analysis (Gamba et al. 2012; Weng 2014)
• supervised pixel-based classification (Bechtel 2011; Bechtel and Daneke 2012).
workflow

Raster processing
- Load LS data
  GDAL: Import Raster
- Crop to ROI
  Clip Grid with Polygon
- Resample
  1. grid system Resampling
- Resample further grid systems Resampling

Vector processing
- Digitize training data
- Load KML
  OGR: Import Vector Data
- Merge Layers
- Project
  Coordinate transformation (shapes)
- Supervised classification
  Random Forest (ViGra)

Evaluate

Export 2 KML
Export Grid to KML

Post class filtering
Majority Filter
Khartoum
## Testcases

<table>
<thead>
<tr>
<th>City</th>
<th>Köppen Climate Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombo, Kolkata, Medellin, Vitoria</td>
<td>Tropical/megathermal climates</td>
</tr>
<tr>
<td>Khartoum</td>
<td>Dry (arid and semiarid) climates</td>
</tr>
<tr>
<td>Budapest, Coimbra, Dublin, Guangzhuo, Houston, Milan, Nantes, Sao Paolo, Vancouver, Wageningen</td>
<td>Temperate/mesothermal climates</td>
</tr>
<tr>
<td>Beijing, Chicago</td>
<td>Continental/microthermal climates</td>
</tr>
</tbody>
</table>
Lessons learned

- Applicable in different parts of the world (climates and cultures)
- Good framework to compare settlement structures
- Spectral separability difficult in arid areas
- Subclasses needed (some built-up areas are close to natural classes in climate response)
Outlook

**LS1**
[Bands 7-4-2]

**SAR**
[GLCM\textsubscript{contr} \(A\textsubscript{vv} - A\textsubscript{vh}\)]
[RF, LS1]

**LCZ**
[RF, all]
Achievements of level 0

LCZ

**DEFINITION**

*Form:* Attached or closely spaced buildings 1–9 stories tall. Buildings separated by narrow streets and inner courtyards. Buildings uniform in height. Sky view from street level significantly reduced. Heavy construction materials (stone, concrete, brick, tile); thick roofs and walls. Land cover mostly paved or hard-packed. Few or no trees. Moderate space heating/cooling demand. Moderate to heavy traffic flow.

*Function:* Residential (multi-unit housing; multistorey tenements); commercial (office buildings, hotels, retail shops); industrial (warehouses, factories). *Location:* Core (old city, old town; inner city, central business district); periphery (high-density sprawl). *Correspondence:* LCZ2 (Oke 2001); A1, A2, A4, D2 (Elfferich 1990/91).

**ILLUSTRATION**

*High angle*

*Low level*

**PROPERTIES**

- **Sky view factor**
  - 0.3 – 0.6
- **Canyon aspect ratio**
  - 0.75 – 2
- **Mean building height**
  - 10 – 25 m
- **Terrain roughness class**
  - 2 – 8
- **Building surface fraction**
  - 0 – 100%
- **Impervious surface fraction**
  - 0 – 100%
- **Impervious surface fraction**
  - < 20 %
- **Surface albedo**
  - 0.10 – 0.40
- **Anthropogenic heat flux**
  - < 75 W m⁻²
Height min
The Proportions of Compact, Open-set, and Extensive land cover present
**LCZ COMPACT MID-RISE**

**Definition**

*Form:* Attached or closely spaced buildings 3–9 stories tall. Buildings separated by narrow streets and inner courtyards. Buildings uniform in height. Sky view from street level significantly reduced. Heavy construction materials (stone, concrete, brick, tile); thick roofs and walls. Land cover mostly paved or hard-packed. Few or no trees. Moderate space heating/cooling demand. Moderate to heavy traffic flow.

*Function:* Residential (multi-unit housing; multistorey tenements); commercial (office buildings, hotels, retail shops); industrial (warehouses, factories). *Location:* Core (old city, old town; inner city, central business district); periphery (high-density sprawl). *Correspondence:* UCZ2 (Oke 2004); A1, A2, A4, Dc2 (Ellenbogen 1990/91).

**Illustration**

*High angle*

*Low level*

**Properties**

- **Sky view factor:** 0.3 – 0.6
- **Canyon aspect ratio:** 0.75 – 2
- **Mean building height:** 10 – 25 m
- **Terrain roughness class:** 6 – 7
- **Building surface fraction:** 40 – 70 %
- **Impervious surface fraction:** 30 – 50 %
- **Pervious surface fraction:** <20 %
- **Surface admittance:** 1,500 – 2,200 J m⁻² K⁻¹
- **Surface albedo:** 0.10 – 0.20
- **Anthropogenic heat flux:** < 75 W m⁻²

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Stewart & Oke 2012
Get involved

Classify your city

Manuals at wudapt.org

Attend workshop tomorrow
22nd July, at 4pm
Cassiopea room