



LAND-USE MONITORING IN CITIES

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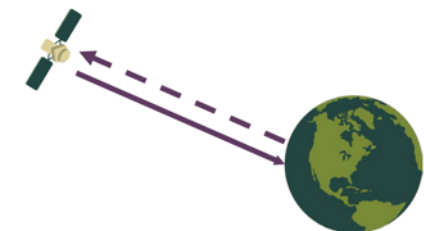
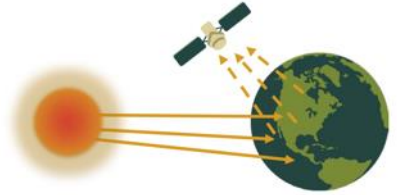
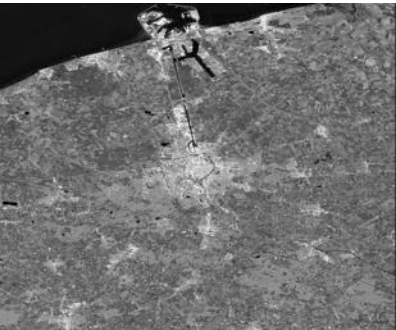

Context and objectives

- **Context**
 - Land and built-up area major **environmental** and **economic** factors
- **Aim**
 - Monitoring in **near real-time land-use** in OECD functional urban areas (FUA = city + commuting zone)
- **How?**
 - By using public **Sentinel satellite imagery** data and **Deep Learning models** trained on the **Copernicus urban atlas**
- **Applications**
 - **Urban expansion**: speed, density, shape
 - **Land conversion** (deforestation, afforestation, agricultural expansion)
 - **Land artificialisation**, loss of natural areas
- **Indicator characteristics**
 - Near real-time, yearly indicators
 - **Coverage**: OECD FUAs
 - 10 m spatial resolution



Project description

Sentinel satellite constellation

	Sentinel 1	Sentinel 2
Type	Synthetic Aperture Radar (SAR) Active Sensors 	Multi-spectral Passive Sensors 
Resolution	10 m	10 - 30 m
Time revisit	12 days with 1 satellite	5 days with 2 satellites
Example		

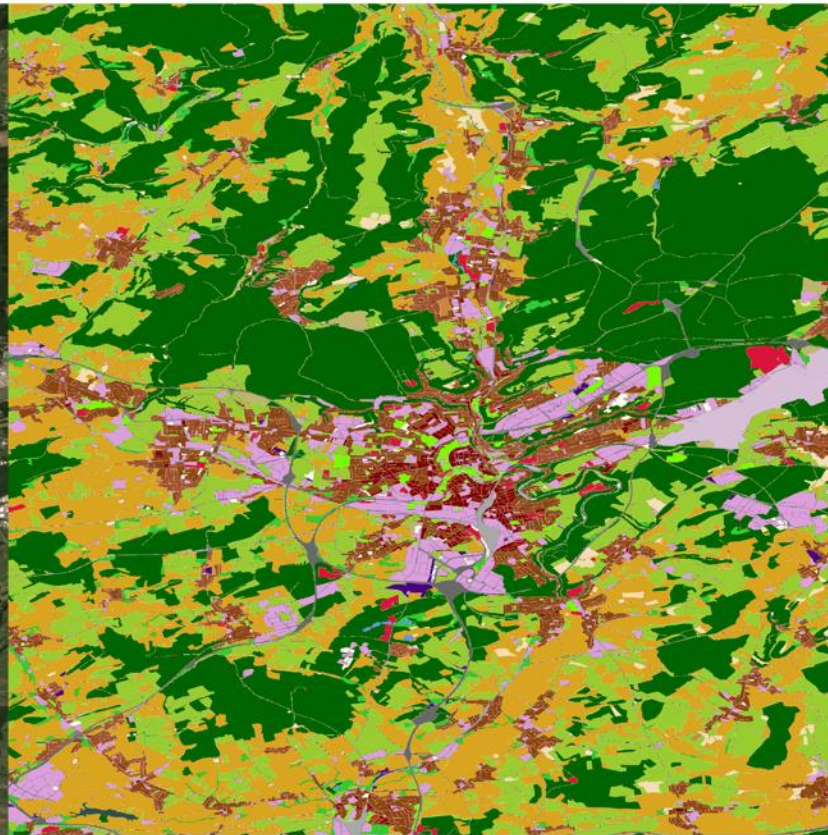
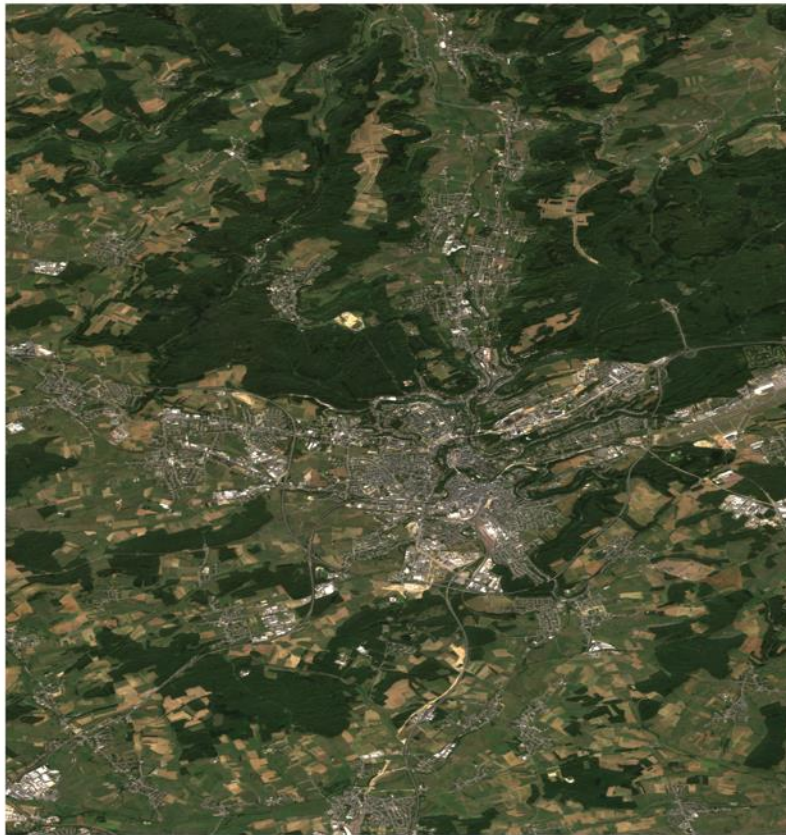


The Copernicus Urban Atlas

Urban Atlas 2018 for Luxembourg

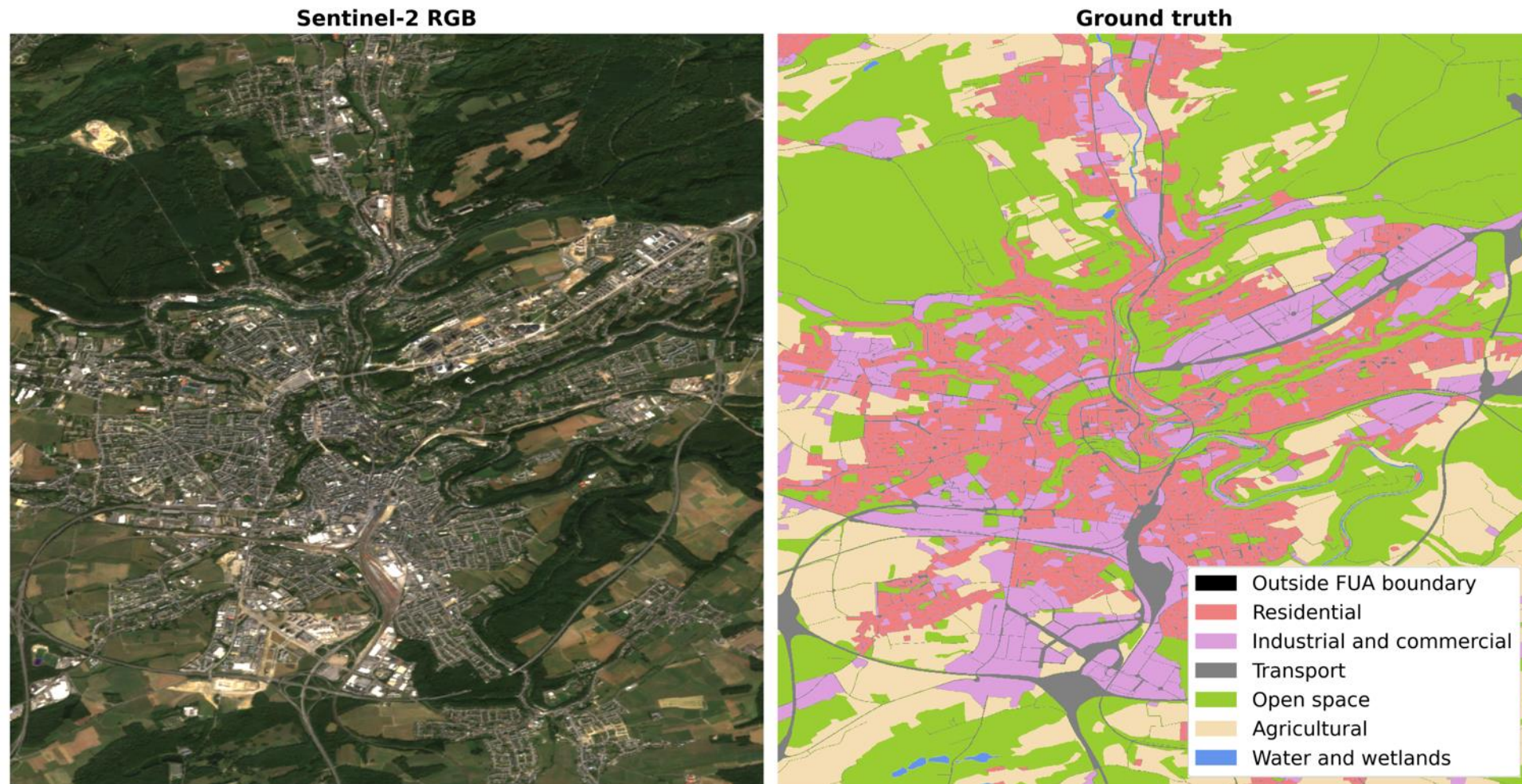
Sentinel-2 RGB

Urban Atlas 2018



- Outside FUA boundary
- Continuous urban fabric (S.L. : > 80%)
- Discontinuous dense urban fabric (S.L. : 50% - 80%)
- Discontinuous medium density urban fabric (S.L. : 30% - 50%)
- Discontinuous low density urban fabric (S.L. : 10% - 30%)
- Discontinuous very low density urban fabric (S.L. : < 10%)
- Isolated structures
- Industrial, commercial, public, military and private units
- Fast transit roads and associated land
- Other roads and associated land
- Railways and associated land
- Port areas
- Airports
- Mineral extraction and dump sites
- Construction sites
- Land without current use
- Green urban areas
- Sports and leisure facilities
- Arable land (annual crops)
- Permanent crops (vineyards, fruit trees, olive groves)
- Pastures
- Complex and mixed cultivation patterns
- Orchards at the fringe of urban classes
- Forests
- Herbaceous vegetation associations (natural grassland, moors...)
- Open spaces with little or no vegetation (beaches, dunes, bare rocks, glaciers)
- Wetlands
- Water

Class aggregation used in the analysis

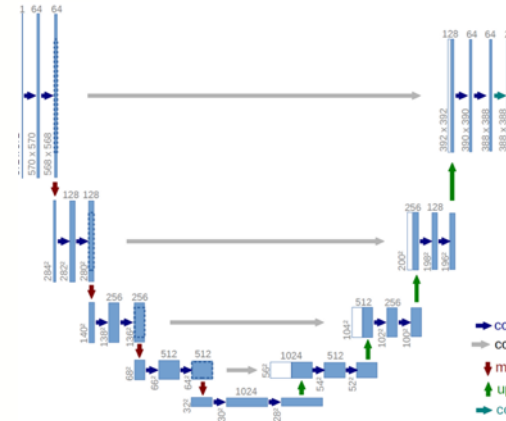
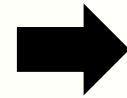




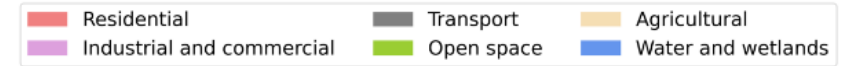
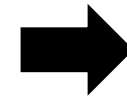
Pipeline overview



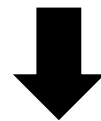
Sentinel-1 and 2
satellite image



U-Net Deep Learning Model



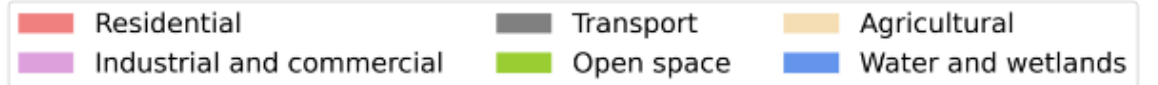
Land use predictions in cities



Training and testing with **Sentinel satellite images** and the
Copernicus Urban Atlas



Model predictions on Amsterdam



Amsterdam
Acc = 0.85, F1 macro = 0.76

Sentinel-2 RGB



Prediction

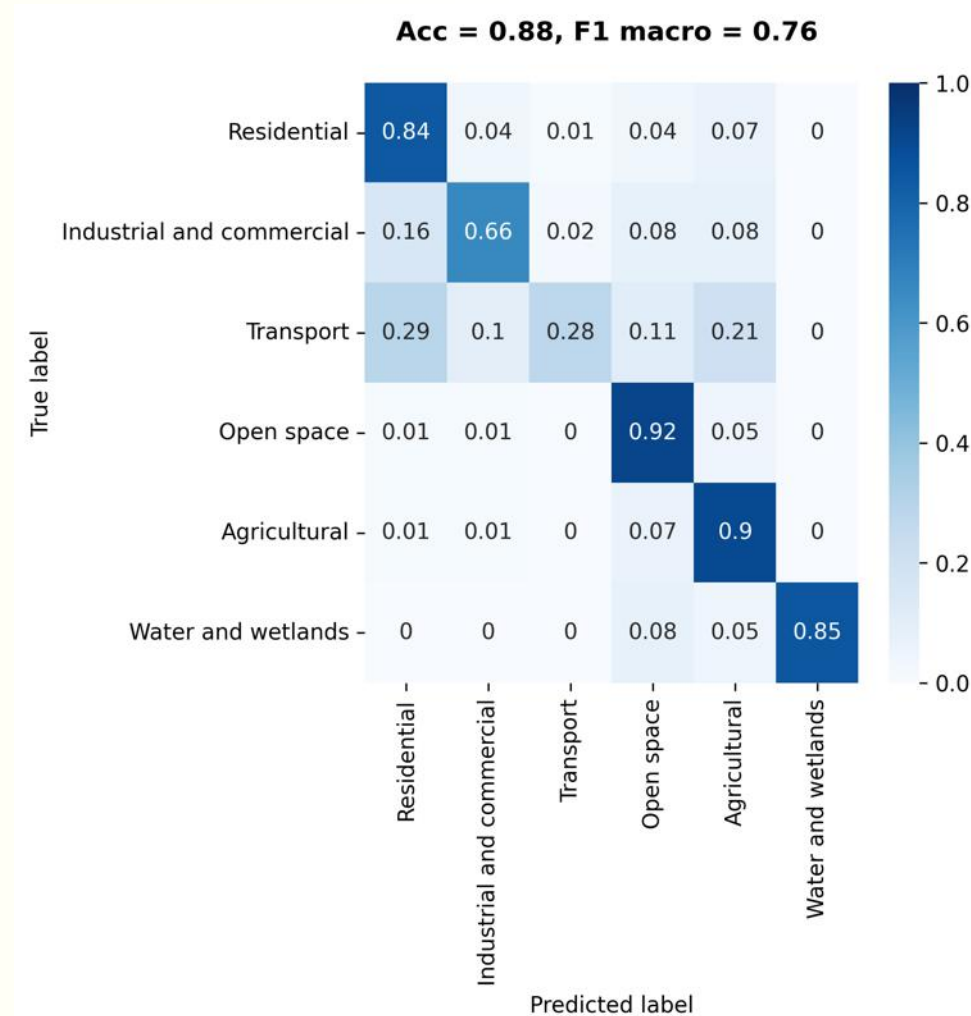


Ground truth





Overall performance very good, except for transportation networks



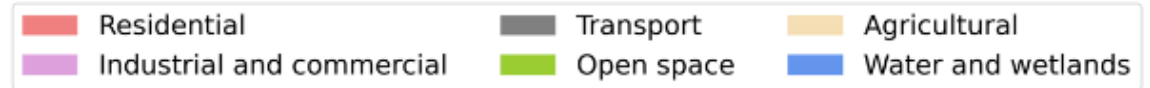
Accuracy	Results
1	Perfect
0.9-1	Excellent
0.7-0.9	Very Good
0.6-0.7	Good
0.4-0.6	Fair
0-0.4	Poor



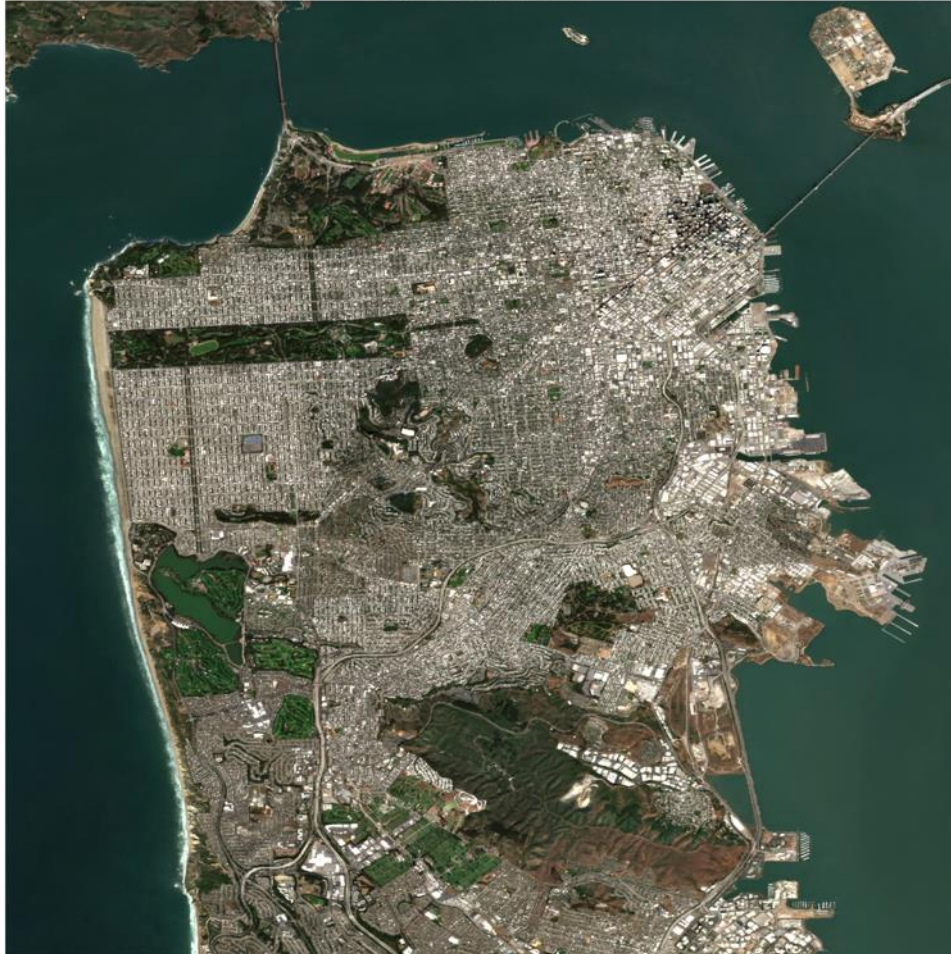
**Illustration: Predictions in
non-European FUA's**



Metropolitan area of San Francisco (2020)



Sentinel-2 RGB

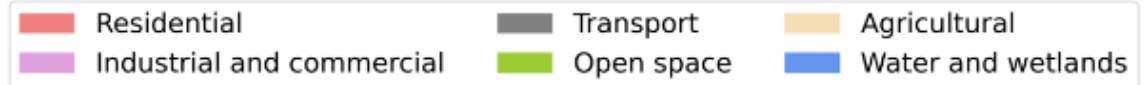


Prediction

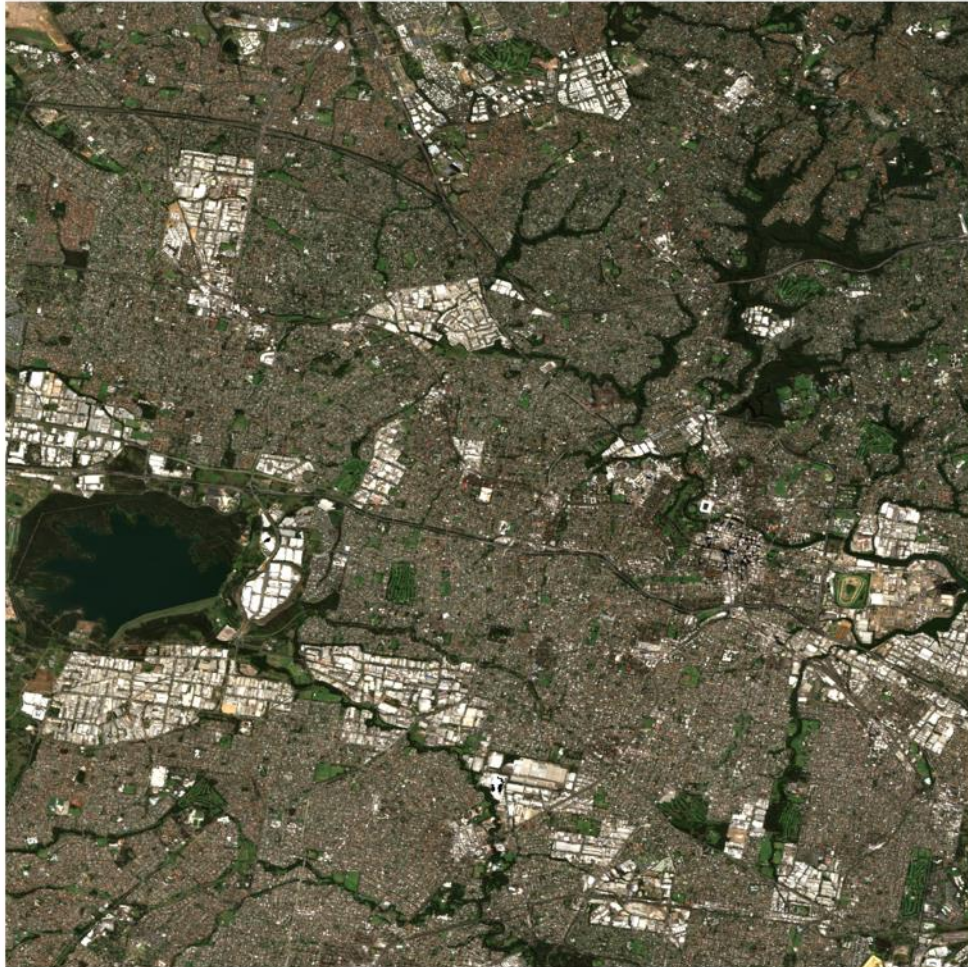




Metropolitan area of Sydney (2020)



Sentinel-2 RGB

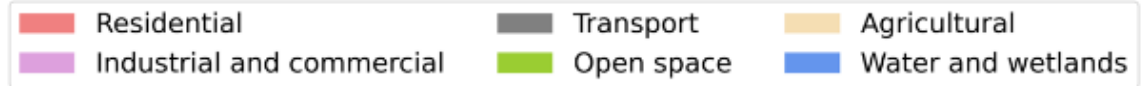


Prediction

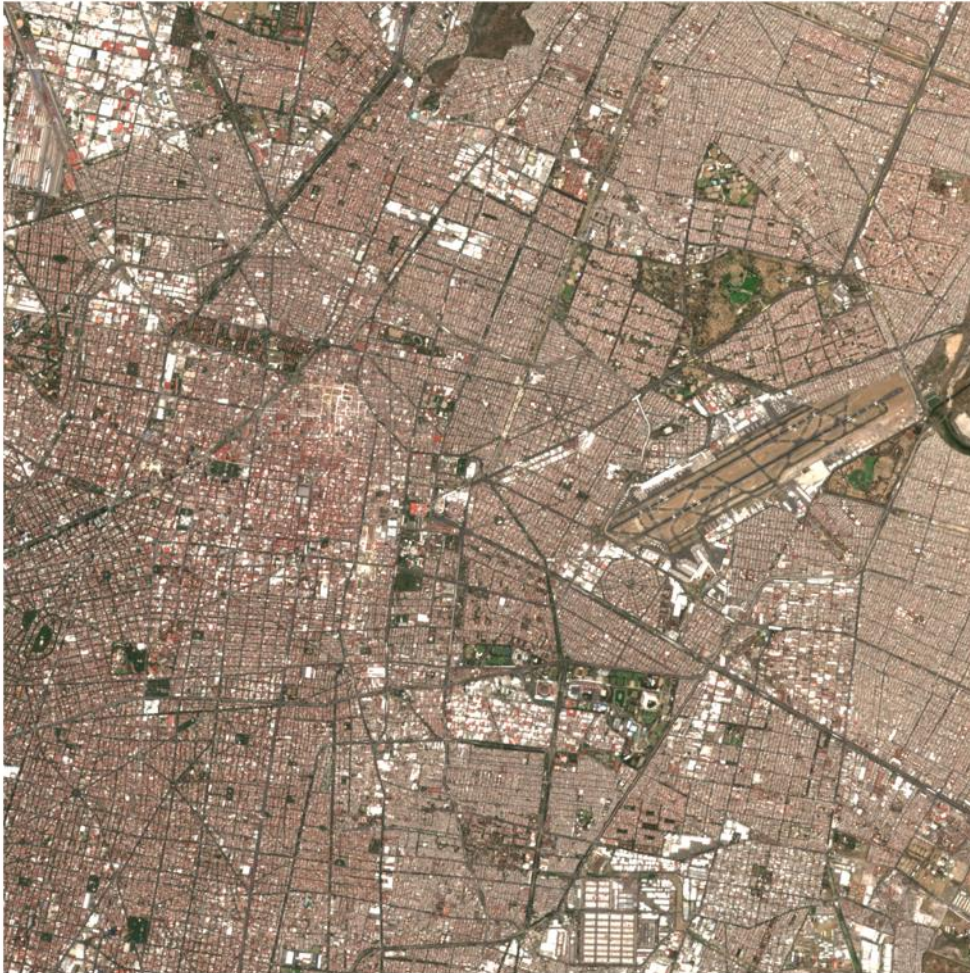




Metropolitan area of Mexico City (2020)



Sentinel-2 RGB



Prediction



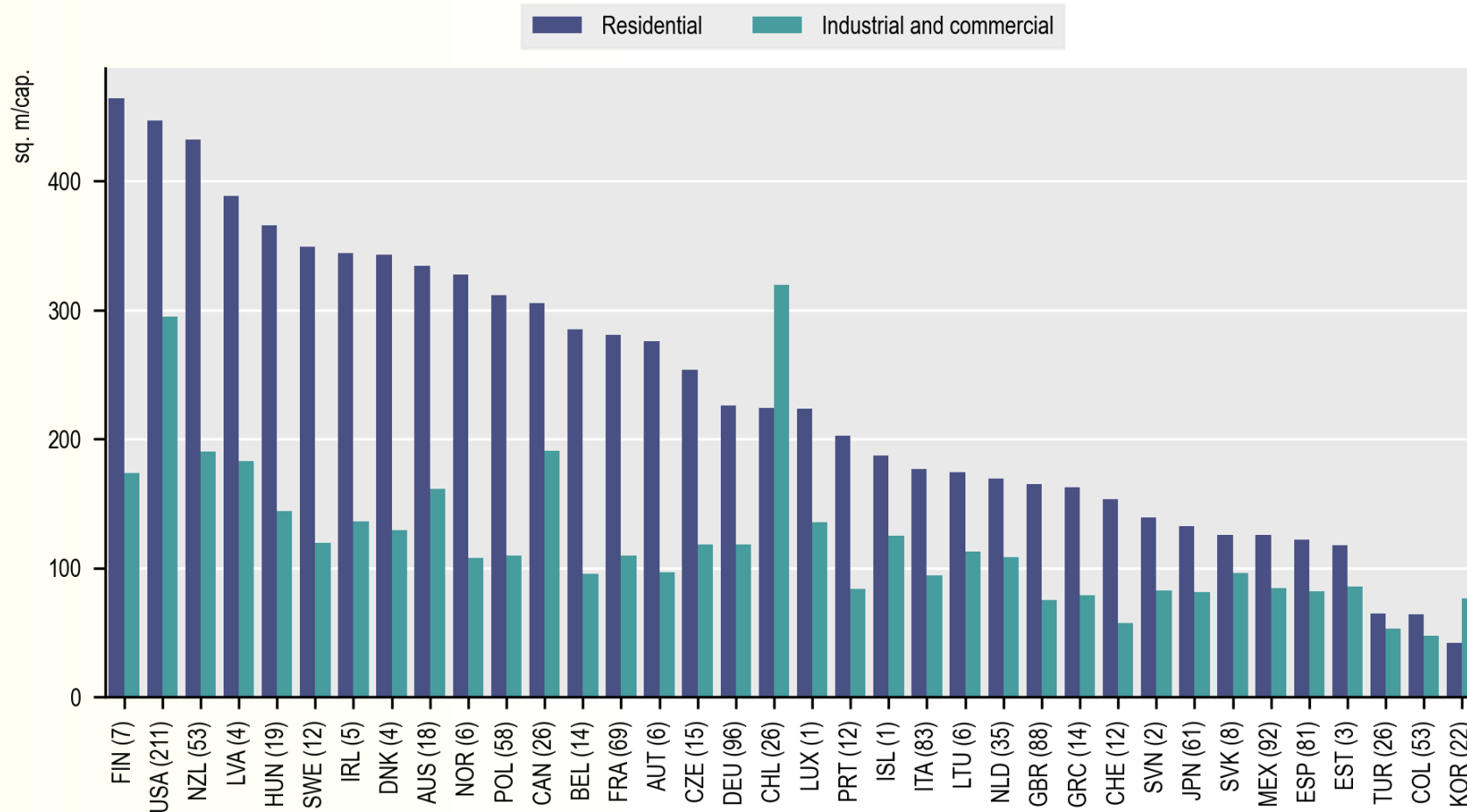


Analysis



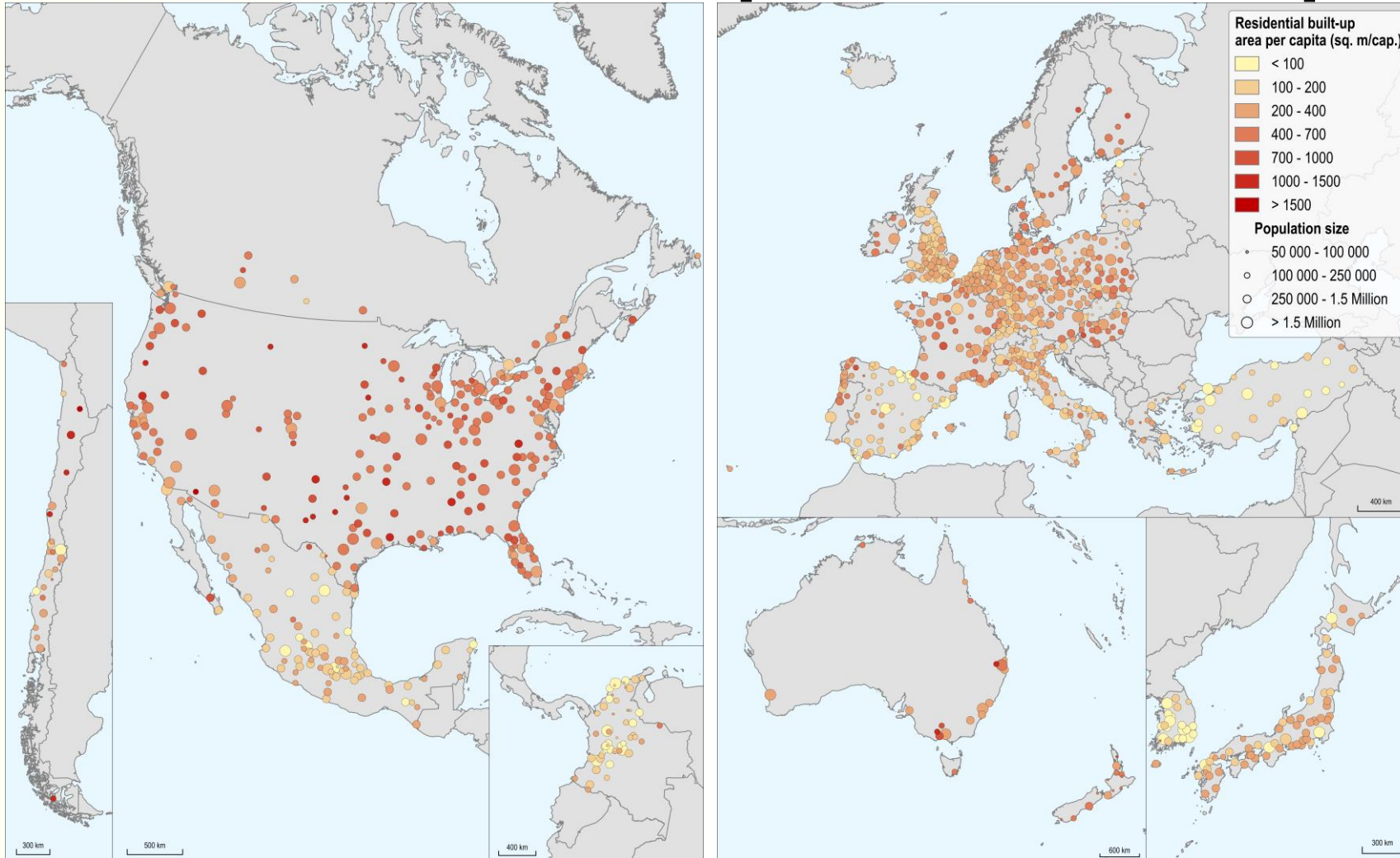
Built-up area per capita varies substantially across countries

Built-up area per capita and by land use, 2021





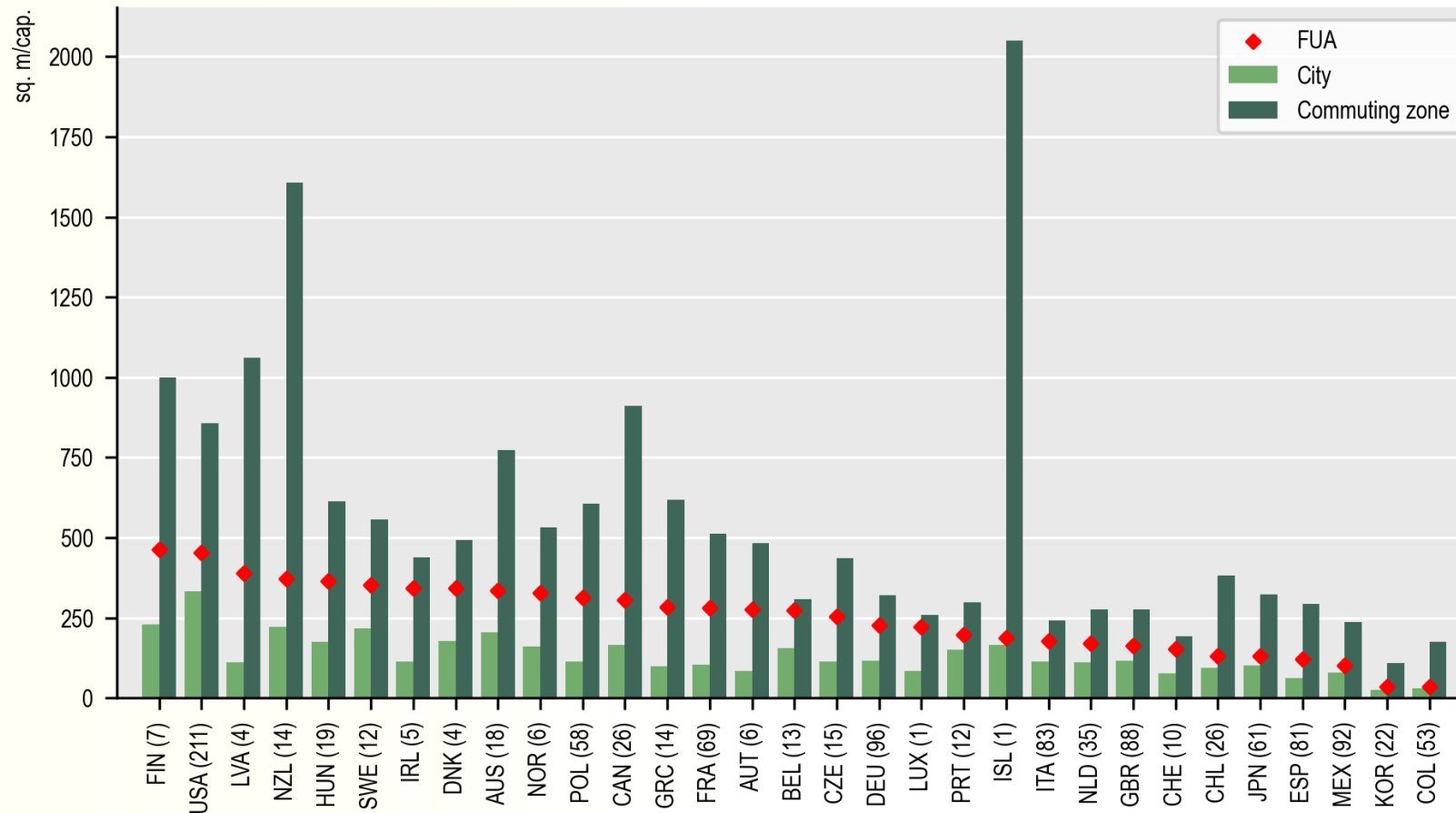
Cities in Southern Europe, Asia and Latin America have more compact urban shapes





Commuting zones drive up the total built-up area per capita

Residential built-up area per capita in cities and their commuting zones, 2021





**Illustration: detecting
land-use changes**



Example on the city of Naas (FUA of Dublin)

2018





Example on the city of Naas (FUA of Dublin)

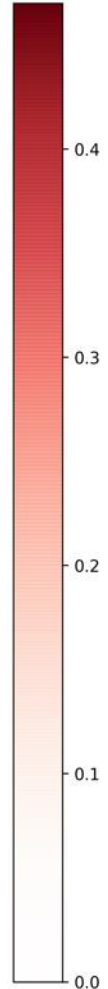
2021





Example on the city of Naas (FUA of Dublin)

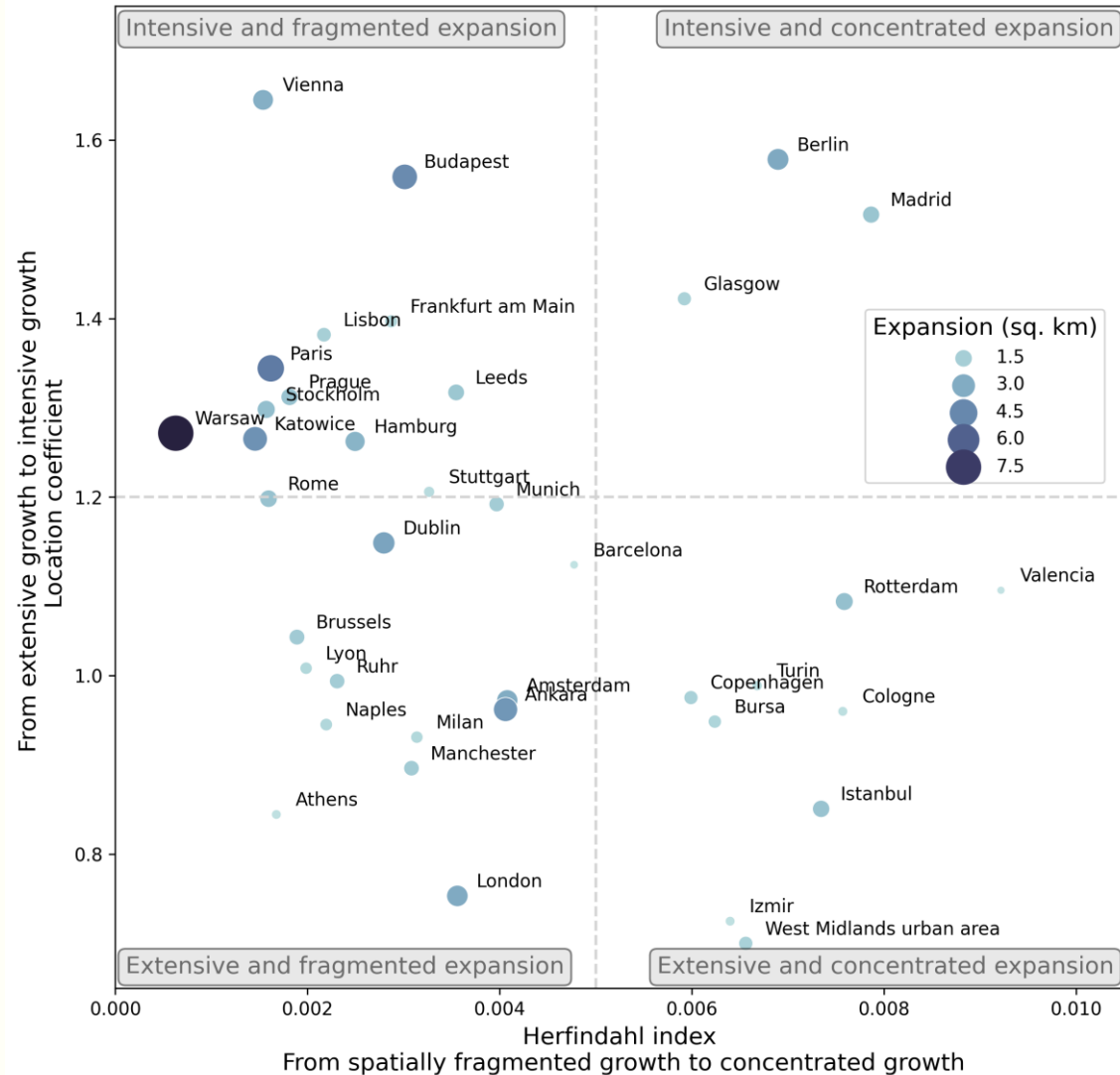
Residential expansion




Commercial & industrial expansion



Speed and shape of urban expansion





Conclusion

- **Model enabling to track land use in OECD cities:**
- Validation on European FUAs
- Qualitative validation on non-European FUAs and for change detection
- Working paper available here: <https://doi.org/10.1787/dc8e85d5-en>
- Interactive web app coming soon

Thank you!



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