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Top-down identification of mixed vs. residential use in urban areas:

Evaluation of remotely sensed nighttime lights for a case study in Cuenca City, Ecuador

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Introduction - Context

- Issues of urban development are increasingly being addressed at the **global scale**
- It becomes more and more evident that **spatial data** is playing a **crucial role** for consistent cross-regional analyses and unbiased evaluation of locally implemented actions
- **Remote sensing** data in particular provide a rich and globally **consistent** source for analyses at multiple levels
- At global scale different aspects have to be considered than for local-level spatial analyses, including consistency, scalability, retraceability

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Country Disaster Risk Profiles Project

- The World Bank's CDRP initiative is currently implemented at **continental scale** for Central America with the clear aim of further extension to other regions
  - Global applicability and **easy transferability** are considered crucial for the model setup
- The overall objective of CDRP is set at disaster risk and loss estimation, with one of the key elements being a spatially disaggregated property stock exposure model
  - Spatial linking of tabular property stock information, compiled at the level of **inventory regions** (such as PAGER-STR)

  → **Spatial identification** of those inventory regions required

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Inventory region identification

- CDRP inventory regions refer to a primary **urban-rural** distinction and within that classification an additional separation of **residential** and **non-residential** occupancy
  - Urban-rural classification is done in built-up-adjusted manner (*not topic of this presented study*)
- Focus of this study:
  Top-down identification of non-residential as opposed to residential areas within urban agglomerations
  - Remotely sensed **nighttime lights** (ISA Impervious Surface Area) data from the DMSP-OLS sensor are used as proxy to identify **areas of peak human activity**, often associated with a high likelihood of **commercial** and/or **industrial** presence
  - Case study: Cuenca City, Ecuador

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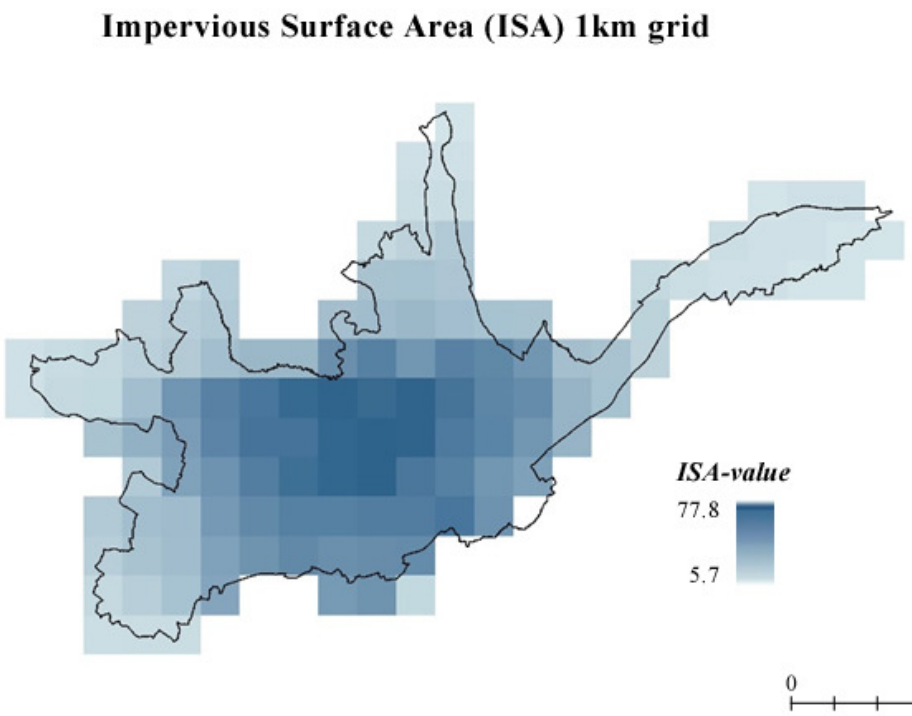
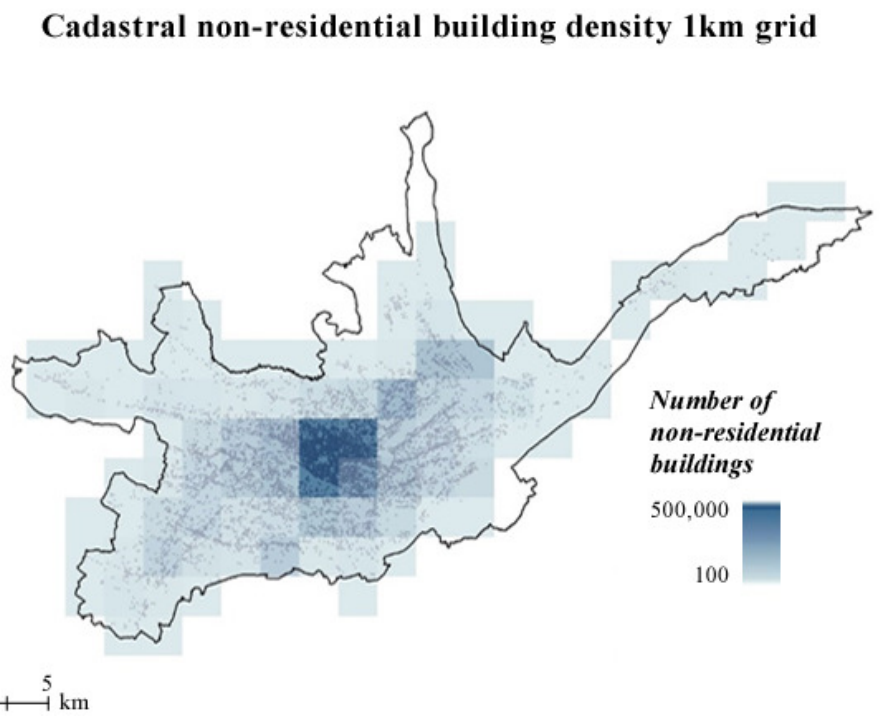
Top-down vs. ground reference data





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Identifying 'non-residential/mixed'

- Working on a **1 km grid level** (frequently used for global models) the spatial identification and distinction of unique inventory regions is often **not unambiguously** possible at the grid cell level → **mixed pixel issue**
  - Large urban residential areas and certain dedicated industrial zones are still often built in rather compact manner and can thus indeed cover entire grid cells
  - **Commercial areas**, however, are commonly **intertwined with residences** forming wider **areas of mixed use**
- Top-down identification of urban non-residential areas
  - Reasonable to assume a **certain share of residential occupancy throughout** and consider grid cells that also include a non-residential share as **areas of mixed use**

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Iterative binary ISA classification

- Cadaster shows a 75-25 distribution ratio of residential vs. mixed areas (taken as reference for top-down identification)

ID	ISA Distribution				Building Distribution	
	Min	Threshold	Max	Percentile	Residential Use	Mixed Use
1	5.7	15	77.8	13%	32.00%	68.00%
2	5.7	25	77.8	27%	52.00%	48.00%
3	5.7	35	77.8	41%	70.00%	30.00%
4	**5.7**	**42**	**77.8**	**50%**	**74.00%**	**26.00%**
5	5.7	51	77.8	63%	96.00%	4.00%

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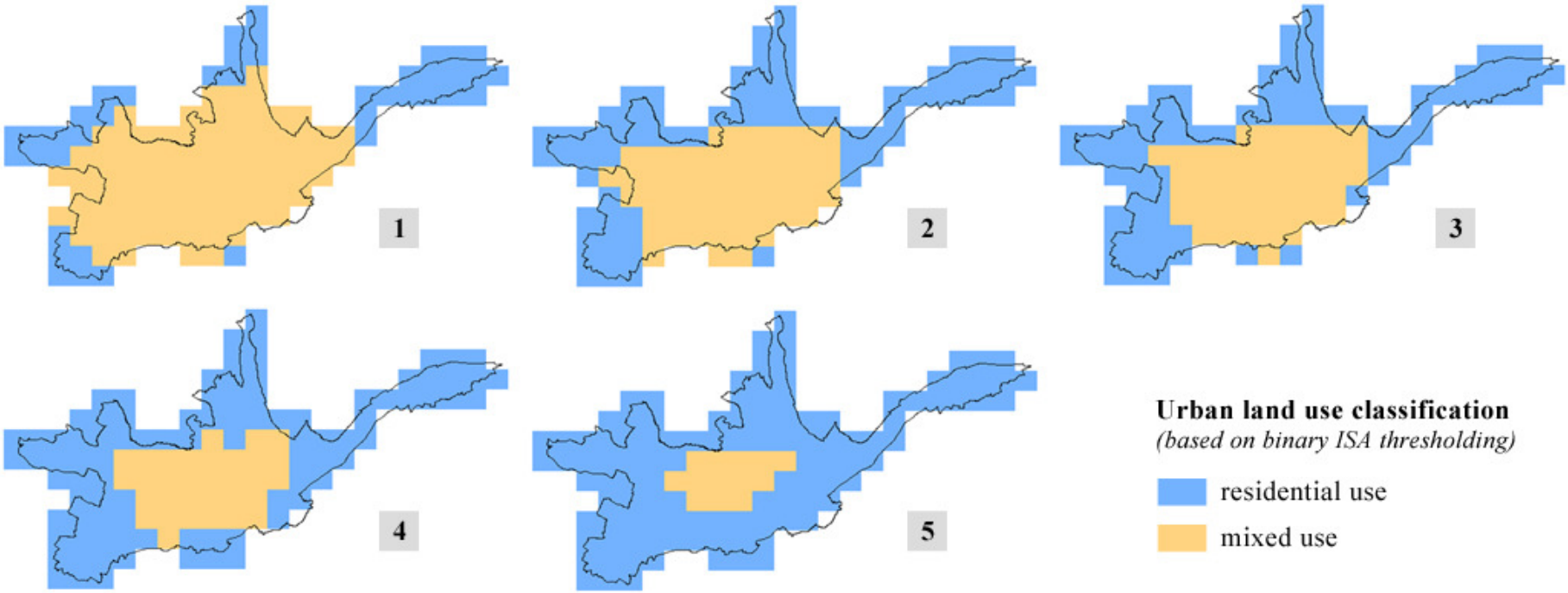
Iterative binary ISA classification

- ID 4 shows best match of top-down and ground reference



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Discussion

- Top-down identification of **median ISA value** as cutoff point confirms the prior non-evaluated assumption implemented in the Central American CDRP model
  - Without ground reference data (as available for this presented test case study), the use of the median value seemed most appropriate as it introduces the **least possible subjectivity** and merely separates a certain data set in high and low according to its histogram without additionally induced statistical skew.
- Cadastral data furthermore enables evaluation of the **degree of spatial overlap** as a measure of model output accuracy
  - 82.8% of the total non-residential building stock of Cuenca City (3.6 of 4.3 million km²) is captured within the selected top-down-derived binary mixed use mask

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Outlook to future work

- CDRP has been implemented for all of Central America → **further test studies** can be carried out to increase the sample size of the model evaluation and test the approach in different regional settings
  - While in Central America no big deviations are expected with regard to the model applicability, it will be interesting to see testing results when extending to the **Caribbean** and across
- DMSP-OLS-based ISA data seems to work well as input data source for the residential-mixed identification model → still **significant further accuracy improvements** are expected when referring to more recent **VIIRS data** (Visible Infrared Imaging Radiometer Suite)
  - Higher spatial and radiometric resolution

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Thanks for your interest!

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