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Work title: Do cities exist in all shapes and sizes? An EO based investigation

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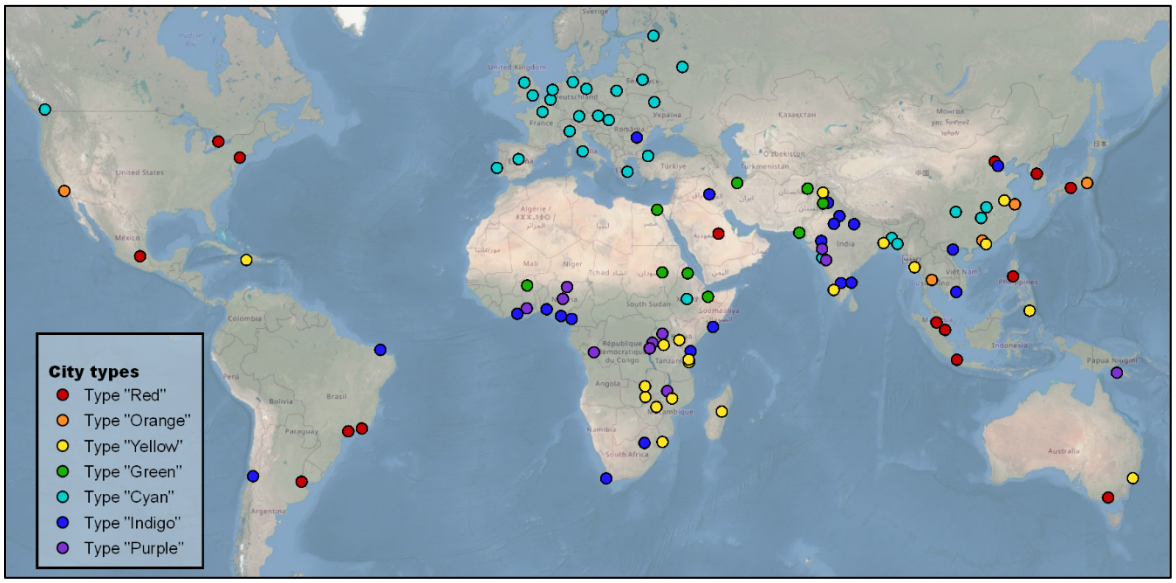
Project Image:



Short project summary:

In this work, unsupervised clustering on Earth Observation (EO) data was applied to investigate cities' morphology across the globe. Based on 110 cities, we found seven city types of similar morphologic patterns whose geographical distribution underpins the influence of urbanistic culture on the built landscape.

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Keywords:

Urban morphology, Local Climate Zones, Remote sensing, City models, Comparative urban research

1. Introduction:

The built-up environment of a city is the theatre of the life of its citizens. Studies proof that its morphological configuration makes a decisive contribution to whether the city offers quality of life or not. Therefore, if we want to make cities more livable, we first have to understand the urban space. A key aspect to understanding urban spaces is to comprehend their regularities, the shared morphological characteristics of cities across the globe, and – at the same time – their dissimilarities.

Literature concerning models of urban space has been prolific, and we notice both, a focus on drawing universal models (Park et al., 1925) and a dedication to attach a singular model to a specific cultural area (Ehlers, 1993; Gaubatz, 1998; Griffin & Ford, 1980; Hahn, 2014; Lichtenberger, 1972).

In accordance with the studies of Debray et al. (2021) and Taubenböck et al. (2020) we investigated here the relevance of both approaches: Are cities globally following a universal model, or do they feature differences in their morphology? And should morphological differences exist, are they based on cultural settings?

2. Methods:

We selected 110 cities across the globe. All have more than 300,000 inhabitants, and they are located on all continents. The cumulated population of selected cities per continent is proportional to the continents' population share relative to the global population.

For each of the selected cities, we produced a morphological description of their built landscape. For this purpose, we derived a landcover classification based on the Local Climate Zone (LCZ) scheme (Stewart & Oke, 2012). Although the LCZ scheme is primarily intended to study urban climate, it is based on a rich morphological description of the built- and non-built landscape through 17 thematic classes. These are mostly characterized by the nominal height and density of the element considered. The landcover classification was achieved through the use of a recurrent residual artificial network (Re-ResNet) trained on the LCZ42 dataset (Zhu et al., 2019) and was applied on multi-seasonal Sentinel-2 satellite data. The obtained LCZ classification is of 100 meters of resolution and accounts for an overall accuracy of 86.7%. For more details we refer to (Qiu et al., 2019). Last, to operate our comparison between cities in a spatially consistent manner, we rely on the Morphological Urban Area as our spatial unit for this study (Taubenböck et al., 2019). With this, we represented each city as a vector of 18 dimensions, where 17 of these

are accounting for the share of the 17 LCZ classes in each city, and one is accounting for the area of the particular city.

Using this 18-dimensional feature space, we investigated if distinguishable types of cities existed. The Gap Statistic algorithm (Tibshirani et al., 2001) was applied after a prior analysis of how many clusters our sample of cities presented in this feature space. Then we used the k-means method (Hartigan & Wong, 1979) to administer an unsupervised clustering on our cities, based on the amount of clusters found.

3. Results:

The results showed that within our sample of 110 cities, and based on the morphological description we used, seven different types of cities can be exposed. This indicates that universal models of cities are seemingly inappropriate to understand urban structures across the globe. Rather, the morphological differences identified allow to define seven distinct urban types.

Second, we observe that the geographical distribution of the seven city types follows to certain extent the pattern of cultural zones. We mainly identify three modes of geographical distribution: First, some types cover the entirety of a cultural zone, but also appear in other cultural zones. The “Cyan” type covering Europe is such an example (project image). Second, some types are exclusive to a specific cultural zone but are not the only types in this cultural zone as for the “Green” type. Third, some types collaborate together to cover a cultural zone into distinctive sub-regions while still being present in other parts of the world like the “Yellow”, “Indigo” and “Purple” types sharing Sub-Saharan Africa.

4. Conclusions:

While a stereotypical portrayal of cities based on their geographical locations and cultural zones tempts us to duly acknowledge their physical diversity across the globe, it also denies us of a more complex and nuanced truth. Remote sensing allows to capture these complex structures in a highly accurate and global manner and to document and understand the built landscape on an unprecedented empirical basis. Specific regions of the world witnessed specific ways of development in cities, in the sense that they have been the playgrounds of specific doctrines of spatial planning. City types that appear in multiple corners of the world vastly testify of vehicular doctrines of planning. Whereas, city types that are represented almost only in one region, point toward specific vernacular processes of urban growth, tied to a local culture.

Therefore, conversing about city types in relation to a “culture” – here denoting a static context, homogeneous in a given region – seems inadequate. Rather, we advocate to relate city types to urbanistic culture, i.e. the consideration of the strata through history of the cities attitudes towards urban growth and its two main drives: slow accretion of bottom-up processes and project-based top-down spatial planning.

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