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Distributions of types of urban fabrics around the world: Beyond narratives of global regularities and local specificities

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ABSTRACT

The physical forms of cities emerge from the interplay of diverse processes shaped by various factors, including political, cultural, economic, and geographic influences. As such, this physical aspect, the urban fabric is deeply heterogeneous at multiple levels, from the intra-urban to the global scales. Although peering into these two scales provided the field of urban morphology great insights, the combination of both scales has, to the best of the authors knowledge, never been investigated, mainly because of lack of data. Yet, this combination of such scales could enable the understanding of global and local processes of homogenization or specification of the urban fabric and the way they embed themselves in nowadays urbanization. The recent evolutions in data quality, coverage, comprehensiveness and consistency makes such cross-scaled investigations now possible. Previous work proposed a universal typology of intra-urban patterns relying on a global classification of intra-urban morphology. Based on these results, this study aims to localize the distinct intra-urban patterns across the globe to characterize their geographical distributions. By categorizing these geographical distributions into six main modes, ranging from the most local to the most global, we assess for each type of intra-urban patterns their global spread. This allows to quantify the *status quo* on the homogeneity or heterogeneity of the global urban fabric. We find that although close to half of the global urban fabric is composed of very widely spread patterns, a non-neglectable number of patterns exist only in very specific regions of the globe. We thus show empirically that in its current *status quo*, the global urban fabric leans toward a global homogeneity, yet at the same time, local heterogeneities are persistent on a worldwide scale. This informs us about the dissemination of urban planning practices and paradigms and enables us to critically ponder on their driving forces.

1. Introduction

The ways cities are shaped internally directly influences a wide range of urban phenomena. Intra-urban forms have been shown to impact, among others: urban heat islands (Aslam & Rana, 2022; Diem et al., 2023; Lemoine-Rodríguez et al., 2022a, 2022b; Stewart & Oke, 2012), air pollution (Hong et al., 2024; Schindler & Caruso, 2014; Zeng et al., 2024), noise pollution (Margaritis & Kang, 2016; Salomons & Berghauser Pont, 2012; Staab et al., 2022, 2023), traffic and transport (Hounsell & McDonald, 2001; Rode et al., 2017; Ulvi et al., 2024), walkability (Droin et al., 2023, 2024; Pafka & Dovey, 2017), and social segregation (Musterd et al., 2017; Salazar Miranda, 2020, 2020, Tammaru et al., 2021), among other issues.

As such, the study of urban forms for the purpose of informing better urban planning practices and paradigms towards more sustainable cities (United Nations, 2015) benefits from being led at an intra-urban scale (Wentz et al., 2018). Yet the validity of the intra-urban insights gained from empirical studies at a single place need sometimes to be nuanced

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for different geographical contexts, as exemplified in (Lemoine-Rodríguez et al., 2022a). To understand the impacts of intra-urban forms in relation to their geographical context and to better inform decision makers about which intra-urban form is advisable and in which geographical context, it is therefore relevant to investigate their global locations.

Yet, beyond studying where in the world do we find specific intra-urban forms, we further argue for the systematic study of the characteristics of their global distributions for the insights it might bring on the way we shape cities.

Let us picture for a moment having in our hands a big bag of Lego bricks. Legos, for those readers who don't know them, are construction toys that come in the form of bricks and can be easily spatially assembled to compose larger structures. These bricks are generally characterizable by their colors and their dimensions. As such, similar bricks are common. Now let us imaginarily shake this big bag of Lego bricks, mix it and finally let its content spread on a table. If we did a good job at shaking it, we expect all types of bricks to spread randomly, almost homogenously and uniformly distributed. Surely a few clumps of bricks of the same type would form, but overall, we do not expect any specific spatial patterns of significant grouping of these brick types. Now, let us change in our mind these allegoric Lego bricks to a more prosaic set of bricks: pieces of cities. Cities are a colorful assemblage of diverse constitutive parts, all having their specific type of morphology and composing all together the urban fabric. Just like Lego bricks, pieces of urban fabric can be categorized by some physical characteristics (such as their composition and their internal spatial arrangements, i.e. what we called so far the intra-urban forms). Yet, changing our allegoric table for a map of the world, do we expect all categories of pieces of urban fabric to be spread uniformly just like our metaphorical Lego bricks? Certainly not. And this begs for questions. What are the characteristics of the distributions of the different intra-urban forms? Do they differ in the range of their spreads? What is a more likely distribution: a local clumping or a global spread? Do they differ in their locations or do their distributions overlap? What would this teach us?

In this thought experiment the distributions of Lego bricks and types of pieces of urban fabric differ because the urban fabric is not the result of a random process. The distinct morphologies observed in urban fabrics are testimonies of the ways we build our cities, of how they evolved and in which conditions (Batty & Marshall, 2009, 2012, Conzen, 1960; M. R. G. Conzen & Conzen, 2004; Debray et al., 2023; Kostof, 1991, 1992, Moudon, 1997; Portugali & Stolk, 2016). The urban fabric is a physical human artefact (M. P. Conzen, 1980; Kostof, 1991), and this artefact is far from being a homogenous piece of work. At an intra-urban scale, the topological, historical, economic, functional or cultural contexts differentiate themselves spatially (M. R. G. Conzen, 1960; M. R. G. Conzen & Conzen, 2004; Griffiths et al., 2010; Moudon, 1997; Whitehand, 1972). From the overlay of these differentiated contexts emerge gradual or abrupt dissimilarities in designs or forms within the urban fabric (Batty & Marshall, 2012; M. R. G. Conzen, 1960; Debray et al., 2023; Kostof, 1991, 1992; Portugali & Stolk, 2016). These different types of intra-urban forms are the expression of the succession of social values through history. And more explicitly, especially since the end of the 19th century, these different intra-urban forms are the expression of specific urban planning practices and paradigms (Cozzolino, 2018; Friedmann, 2005; Kostof, 1991, 1992).

For these reasons, we argue that the systematic analyzes of the distribution of specific intra-urban forms help us to better understand the geographical disseminations of these practices and paradigms, and therefore, help us probe empirically into the factors driving these disseminations.

Literature from the fields of urban morphology, history of architecture and urban planning taught us to expect distinct geographical distributions of the types of the urban fabric. The vernacular or the vehicular characters of architectural traditions have been extensively studied. Reviews and discourses on the topic can be found in (Bertyák, 2021; Cataldi et al., 2002; Kostof, 1991, 1992; Panerai et al., 1999). Many works extrapolated specificities of the urban fabric of particular regions of the world based on limited observations, as in (Ehlers, 1993; Gaubatz, 1998; Griffin & Ford, 1980; Krapf-Askari, & (with Internet Archive), 1969; Lichtenberger, 1972; Lilley, 2001).

More recent studies followed a more comprehensive empirical approach and identified in which cities different types of urban fabric can be found, e.g. (Boeing, 2019, 2022; W. Chen et al., 2024; Debray et al., 2021; Lemoine-Rodríguez et al., 2020; Taubenböck et al., 2020; Tian et al., 2022; Zhou et al., 2022; Zhu et al., 2022). While the prime research objectives of these studies was not to study quantitatively the geographical spread of these patterns, the results they communicate allow inferences about the geographical distributions of the urban spatial patterns they mapped.

For example, Boeing (2019) analyzed the street networks of 100 large cities retrieved from Open Street Map (OSM). The "griddedness" of these networks was then assessed based on measures of the bearings of the streets. The study identified that cities in North America present a more gridded pattern while other regions of the world are characterized by a medium to low range of griddedness. In (Zhou et al., 2022), also using street networks from OSM for 8910 urban areas, a range of different geometrical and contextual metrics were estimated and cities were clustered in an unsupervised way based on these metrics. Zhou et al. (2022) identified seven types of spatial patterns. The pattern coined "Regular" was found primarily in Central United States, Argentina, Brazil and North-East China. "Long-street" were found mostly in two regions only: Northern India and China. "Large-size" was found to be corresponding to metropolis spread across the globe. "Irregular" was found to be widely spread across Eastern United States, Europe including United Kingdom, Western and Northern Africa and Egypt, Southeast Asia, India and Japan. "Varied-terrain" was found mostly in hilly or mountainous parts of North America, South America and Europe. "High-circuity" cities were found in Canada, India and China. Finally, the pattern labelled "High-altitude" was found to be located in the relatively highlands of Western United States, Mexico, Western South America, Eastern and Southern Africa, Turkey, Iran and North and South central China. Taubenböck et al. (2020) found seven structural city types across the globe. They analyzed the compositions and configurations of the urban morphology of 110 cities based on Local Climate Zones classification and used unsupervised clustering. 1) Cities of medium size with low structural variability, being mostly medium compact and low-rise were found mostly among Asian and African cities. 2) Cities of large size with medium structural variability, being medium compact and low-rise and was found to mainly describe Asian and American cities. 3) Cities of medium size with high structural variability, being mostly medium compact, and mid-rise was found to be predominant in Europe. 4) Small cities of high structural variability, being mostly low compact and lowrise were found mainly in Eastern Africa and Eastern Asia. 5) Small-sized cities of medium structural variability, being mostly of low density and low-rise were found predominantly in central Africa. 6) Medium-sized cities of high structural variability, being mostly medium compact and low-rise were found predominantly in Northeast Africa and Southern central Asia. 7) Very large cities of low structural variability, being mostly of medium density and mid-rise built-up height were found to be spread across the globe. In (W. Chen et al., 2024) OSM street networks were retrieved across 144 cities as the basis for a deep-learning supervised classification approach proposing six different classes of street patterns at three different scales (patches of 500m by 500m, of 1 km by 1 km and of 2 km by 2 km). At a scale of 1 km by 1 km the authors found that "gridiron" patterns are predominant in locations in central and west Northern America; "chaotic" patterns are found to be predominant in Central and South America, Central Africa and Easter Europe; "tributary" patterns are found to be predominant in central Europe and East Asia; "organic" patterns are found to be spread across the globe; "linear" patterns are rarely found to be predominant (once in East Europe and once in East Asia); and "radial" pattern is only found to be predominant once in Northern America.

Based on these previous findings, we formulated the following hypotheses: First, most urban spatial patterns are not found uniformly across the globe. And second, different spatial patterns present very different types of geographical spreads. While some are very localized, others present incontiguous regions. Some of these patterns are present in incontiguous regions existing in relative proximity to each other while others exist in regions that are far from each other, and some are so scattered that they can be considered as spanning the entire globe.

Beyond these findings, and to the best of our knowledge, the geographical distribution of intra-urban forms has not been investigated in a quantitative way. Yet, we identify that with the rise of data on the intra-urban morphology and the methodological frames for the analysis of global geographical distributions already existing (notably in the field of biogeography, e.g. (Brown et al., 1996; James et al., 2024)), this type of studies is increasingly enabled.

Over the last decades, with the rise of geo-data quality, quantity and spatial coverage, the field of urban morphology developed the capacity to empirically investigate the morphology of the urban fabric at an intra-urban scale, notably through the development of quantitative data-driven approaches (Bertyák, 2021; Fleischmann, Romice, & Porta, 2021). A number of these approaches focused on finding typologies of the intra-urban fabric based on its morphological characteristics, e.g.: (Berghauser Pont et al., 2017; Bobkova et al., 2019; Debray et al., 2025; Dibble et al., 2017; Dovey, 2020; Fleischmann & Arribas-Bel, 2022; Fleischmann, Feliciotti, et al., 2021; Pont & Olsson, 2018; Taubenböck et al., 2018). Notably, Fleischmann, Feliciotti, et al. (2021) proposed an unsupervised hierarchical clustering approach using geospatial vector data to find (intra-)"urban tissue types" in the cities of Amsterdam and Prague and found 20 such types. This concept was further developed in (Arribas-Bel & Fleischmann, 2022; Fleischmann & Arribas-Bel, 2022) for the identification of "spatial signatures" of the intra-urban fabric for the entirety of Great Britain and found 16 of them. On the same conceptual basis, Debray et al. (2025) developed an unsupervised deep-learning clustering approach using a global landcover classification across more than 1500 major cities around the world. With this dataset of vast completeness and global scale, they found 138 types of "intra-urban patterns" that are representing a large majority of the world's global diversity of urban fabric.

The latter study offers the possibility to peer into the geographical distribution of types of intra-urban fabric at a global scale. With this, we reformulate the questions asked above and operationalize them in terms of the geographical distribution of "intra-urban pattern" types (I-UPTs). We therefore pose the following research questions:

1) What is the specific geographical distribution of each I-UPT?
2) For each of these specific geographical distributions, do they correspond rather to a local or a global distribution?
3) Considering all I-UPTs combined, are there overall more global or more local I-UPTs?

To answer these questions, we employ the clustering results found in (Debray et al., 2025) for more than 315,000 patches of landcover classification data covering more than 1500 cities across the globe. With it, we estimate the geographical distribution of the density of each of the 138 I-UPTs that have previously been identified. This density estimation is then analyzed to determine for each of the I-UPT if they are rather locally or globally geographically distributed. This allows us to quantify and reach a conclusion on the current *status quo* of the global homogeneity of the urban fabric becomes possible.

2. Data

2.1. Morphological urban areas

As a spatial unit concept, we use the Morphological Urban Areas (MUAs) introduced in (Taubenböck, Weigand, et al., 2019). A MUA is the surface of an urban area delineated in a data-driven way, computed based on the decreasing gradient of built-up areas from the urban core to its rural hinterland. This dataset is a collection of MUAs of all major cities with more than 300,000 inhabitants across all continents according to a global census (Tatem, 2017). The MUAs delineation is therefore independent from the typical administrative boundaries of single cities. This allows the MUAs to not only represent one single major city per spatial unit but to also capture the smaller cities in their contiguous neighborhood. In this respect, the MUAs therefore enable the use of a spatially consistent frame for spatial unit while also capturing a wider diversity of city types and scales. For our study, we use a curated set of 1523 MUAs across the globe, as this spatial unit concept was the one used in the identification of the 138 I-UPTs in (Debray et al., 2025).

2.2. Intra-urban pattern type classification

As typology for the different patterns of the intra-urban fabric, we use the data-driven classification of intra-urban pattern types (I-UPTs) proposed in (Debray et al., 2025) as a reference. In this study, the authors used a global urban landcover product, namely the Local Climate Zone (LCZ) classification (Stewart & Oke, 2012) at a resolution of 100m*100m (Zhu et al., 2021) as a proxy for the morphology of the urban fabric. Although conceptualized for the analysis of the urban climate, the LCZ has been proven numerous times to be a valuable dataset for the analysis of urban morphology, as it is a neutral description of the physical configuration of the urban landscape (Bechtel et al., 2015; Debray et al., 2021; Demuzere et al., 2021; Taubenböck et al., 2020; Zhu et al., 2022).

In (Debray et al., 2025), the LCZ data is spatially subset using the MUAs dataset. Subsequently, it is subdivided in square patches of 3.2 km*3.2 km (i.e. 32*32 LCZ pixels). The dimension of these patches was chosen to reflect a scale where the aggregated LCZ landcover showcases relevant spatial patterns and at the same time would fit the technical aspects of their methodology. After this, an unsupervised deep-learning clustering approach is applied, namely, the combined *Semantic Clustering by Adopting Nearest neighbors* with *Robust learning for Unsupervised Clustering* (SCAN + RUC) framework (T. Chen et al., 2020; Park et al., 2021; Van Gansbeke et al., 2020). The clustering formulated yielded 138 types of intra-urban patterns on this global dataset. This typology was further proved to exergue types that are significantly different in terms of composition and configuration of their landscapes based on quantitative spatial metrics. From these results, we recovered cluster identifier of each of the patches (i.e. which of the 138 I-UPTs they belong to), the semantic description of the I-UPT, as well as the MUA from which the patch was originally extracted from.

3. Methodology

The field of geographical ecology has long been studying the geographical *range* of specific species, i.e. the zones or regions where these specific species are observed or expected to be observed (Brown et al., 1996; Posadas et al., 2006). This field is accustomed to study the characteristics of these ranges: their size (Allen & White, 2003; Smyčka et al., 2023), abundances of species within (McGeoch & Gaston, 2002; Shipley & Saupe, 2025) contiguities in the occupancy (Xu et al., 2023), or the global patterns they form, from the most endemic to the most cosmopolitan (James et al., 2024; Storch et al., 2012).

The overarching goal of our methodology is to evaluate if the geographical distributions of I-UPTs are distributed more globally or locally. To do so, we draw on the concepts formulated by this methodological frame and adapt them to our study. We devise the following methodological approach summarized in Fig. 1: *First*, we produce global density maps of the presence of each individual I-UPT (see Fig. 1 a), b), c)); *second*, we identify the regions with a significant presence of each I-UPT (see Fig. 1 d)); *third*, we characterize on quantitative bases the

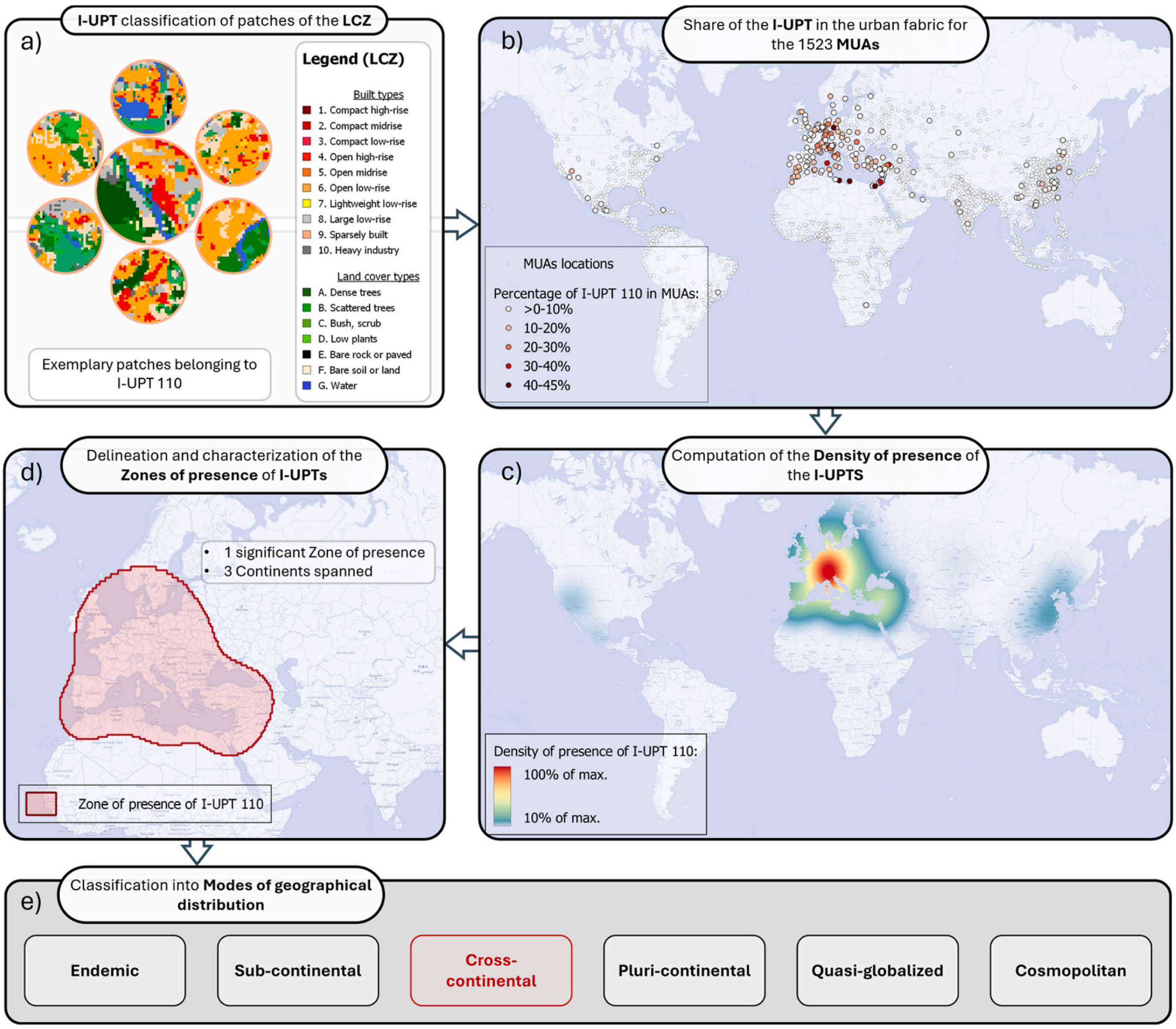

Fig. 1. Workflow of the five successive methodological steps: a) Retrieving information on the I-UPTs; b) Computation of the share of the I-UPTs in the MUAs; c) Computation of the KDE of the share of the I-UPTs; d) Extraction of the significant zones of presence of the I-UPTs and computation of their characteristics; e) Classification of the geographical distribution of the I-UPTs into six distinct modes.

regions with a significant presence of each I-UPT (see Fig. 1 d)); *fourth* and last, we use this quantitative information to classify the spatial mode of global geographical distribution of the I-UPTs (see Fig. 1 e)). Based on the results, we then discuss the *status quo* of the global homogeneity of intra-urban morphology across the globe.

3.1. *Estimation of the density of presence of the I-UPTs*

For each MUA, the cluster identifier of each of its patches is retrieved. With this, the specific share of each I-UPT is computed at the MUA level. This information is aggregated for every individual MUA and attached to its geographic location using its centroid based on the WGS 84 geographic system.

Then, for estimating the density of presence of the I-UPTs, we follow approaches based on Kernel Density Estimators (KDE) (Parzen, 1962; Rosenblatt, 1956). This was first applied for geographical analysis by Worton (1989, 1995) who, with it, evaluated the core and home ranges of species. This was later adopted for multiple applications related to geographical analysis of observed phenomena with proband results and accuracies, as in, e.g. (Arcila-Calderón et al., 2025; Bartoszek et al., 2021; di Sciara et al., 2025; Downs et al., 2011).

For each individual I-UPT, we apply a KDE on the MUA centroids as location input and the spatial share of the I-UPT as a weight. We use a gaussian kernel, using the haversine distance (Gade, 2010) to conserve distances in the geographical projection. We do so with the Python implementation in the Scikit-learn library (Pedregosa et al., 2011). Furthermore, we fix the bandwidth of the KDE at 0.08 after doing a grid search method present in the same library. We output the KDE result on a global raster map with a resolution of 0.5° with typical spanning from -90° to 90° in the south-north axis and -180°–180° in the west-east axis. We then apply an exponential transformation of the log-likelihood values estimated by the KDE to extract the standard likelihood. With this, we obtain global density maps for each I-UPT based on their relative presence in the 1523 urban areas included in our study.

3.2. *Extraction of zones of presence of the I-UPTs*

With the 138 density maps of the relative presence of the specific I-UPTs across the world, we define their respective zones of significant presence. Following the approach described in (Worton, 1989, 1995), we define these regions using a specific threshold level relative to the density distribution. In the context of biogeographical definition of the home range and the close range of animal species (Worton, 1989, 1995), uses thresholds levels of 5 % and 50 % of the distribution maximum. This biogeographical rational does not translate well in our field. Therefore, we propose to define the significant presence of an I-UPT as the regions in the world where we find that the values in the density map of the relative presence are of a similar order of magnitude as the maximum value in the corresponding density map. In other words, we filter the density map to only keep values greater than a threshold, defined for each I-UPT as:

$$\tau_{I-UPT_i} = \frac{\max\left(density\ map_{I-UPT_i}\right)}{10} \quad (1)$$

After this filtering step, we keep the geographical regions defined by the zones of the density map greater than the threshold. These geographical regions are defined for each I-UPT as their zones of significant presence. By design, these zones of presence do not reflect the fact that all cities falling in these zones do actually have significant amounts of the I-UPT considered: the zones of presence only account for the contiguous areas of significantly higher cumulative density of the I-UPT and are only to be interpreted as such.

To further evaluate the robustness of our results, we perform the same analysis for thresholds of 1 %, 5 %, 15 %, and all increments of 5 % until 50 %. In Fig. 3 and Appendix A, we display the results of this additional analysis to highlight the statistical magnitudes of the presence of the I-UPT, while drawing the focus on the prime results obtained for a threshold of 10 %.

3.3. Geographical characterization based on the zones of presence of the I-UPTs

For each of the I-UPT's geographical distribution, we compute the number of significant zones and the significant continental span. For each I-UPT geographical distribution, we consider a zone to be still significant if its surface area is not less than 10 times smaller than the next bigger zone that is already considered significant. The significant continental span is computed as the number of continents that are overlapping with the significant zones of presence for at least 5 % of the combined surface area of all significant zones of presence of the I-UPT.

3.4. Modes of geographical distributions of the I-UPTs

For a semantic description of the geographic distribution, we classify the geographical distribution based on key characteristics of their global spread. Drawing on the field of biogeography (James et al., 2024; Storch et al., 2012) and on the different global spread identified in the literature of urban morphology (Boeing, 2019, 2022; W. Chen et al., 2024; Debray et al., 2021; Lemoine-Rodríguez et al., 2020; Taubenböck et al., 2020; Tian et al., 2022; Zhou et al., 2022; Zhu et al., 2022), we identify six classes that we hereafter refer to as *modes* of geographical distributions of the I-UPTs. We define the following six modes from the most local to the most global spread:

- Endemic: This corresponds to I-UPTs that are only being found with a significant share in a single region confined within a single continent. It is the most local mode of geographical distribution. This distribution reflects the fact that the I-UPT is observed within a singular geographical or socio-cultural context and was not adopted in other parts of the world.
- Sub-continental: This corresponds to I-UPTs that are confined to a single continent but appear in multiple regions within this continent. This distribution reflects the fact that the I-UPT is observed in non-contiguous regions that are nonetheless within the same continent, and therefore within relative proximity, indicating potentially shared socio-cultural context while still being geographically separated.
- Cross-continental: This describes I-UPTs that are present in only one region and this region spreads over continental borders. This distribution reflects the fact that the I-UPT is observed within a singular region that expand potentially into different geographical or socio-cultural contexts, or on the contrary, indicating that this cross-continental region shares to some extent a socio-cultural or geographical context. The fact that the I-UPT is not observed anywhere else can be indicative of a specificity of the region or of the I-UPT itself.
- Pluri-continental: This mode of geographical distribution corresponds to I-UPTs having multiple zones of presence, being located at different continents but not being significantly widespread across more than three continents. On the one hand, this distribution reflects the fact that the I-UPT is observed frequently across the globe, indicating a potential specificity of the I-UPT in term of its adequacy to multiple contexts or a phenomenon of mimicry across regions. On the other hand, the fact that the I-UPT is not more widespread can be indicative of the socio-cultural or geographical connection between the I-UPT and the specific regions it is observed in.
- Quasi-globalized: This describes I-UPTs being present in most of the inhabited continents while not being significantly present on a few. This distribution reflects the fact that the I-UPT is observed very frequently across the globe and is all the more indicative of the ability of this I-UPT to be adopted or employed across the globe. Yet, the fact that there is a few continents on which the I-UPT is not present can be indicative of a negative socio-cultural or geographical connection between the I-UPT and these continents.
- Cosmopolitan: This corresponds to I-UPTs that can be found with significant shares on at least five continents. It is the most global mode of geographical distribution. This distribution reflects the fact that the I-UPT is observed almost everywhere across the globe in the same proportion. This can be indicative of a clear non-specificity in term of connection to any socio-cultural or geographical context.

Based on the significant continental span and the significant number of zones of each I-UPT, we classify their geographical distribution in the six modes described above. For the purpose of this classification, we propose the decision tree illustrated below in Fig. 2. Although the categories are, to some extent, defined arbitrarily, they help putting a conceptual frame for an assessment of where on a global-local spectrum the geographical distribution of the I-UPTs are.

3.5. Analysis of the relative importance of the modes of geographical distribution

With the classification of each I-UPT into one of the six modes of geographical distribution, we summarize this information first by counting how many I-UPTs belong to each mode and second by counting how many patches belong to each mode. The first result allows to assess the overall typological distribution among the modes. The second result allows to analyze the *status quo* of the predominance of the different modes in terms of the proportion they account for within the global urban fabric.

4. Results

4.1. Distributions of regions of presence of the I-UPTs

Across the 138 I-UPTs, we identified that some I-UPTs were localized in a single region, within one single continent or sitting partially across multiple continents (i.e. presenting 'Endemic' or 'Cross-continental' modes of distributions). We found I-UPTs present in multiple incontiguous regions in close proximity to each other, within the confines of a single continent (i.e. presenting 'Sub-continental' distributions). Other I-UPTs were identified to be present in multiple incontiguous regions in relative distance to each other, across multiple continents (i.e. presenting 'Pluri-continental' distributions). And last, other I-UPTs were observed in multiple incontiguous regions across almost all continents or across all continents (i.e. presenting 'Quasi-globalized' or

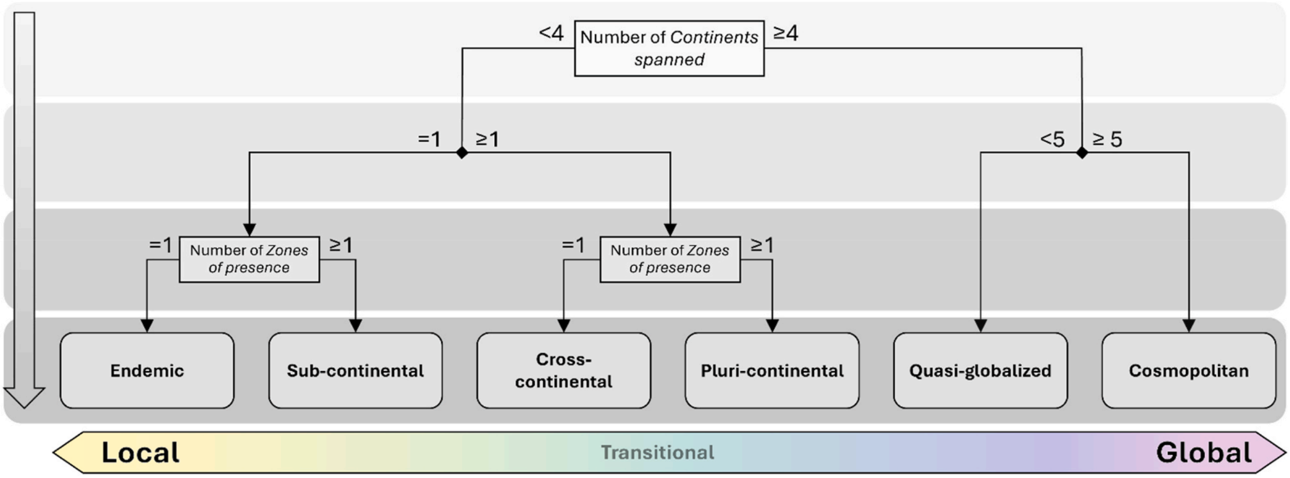

Fig. 2. Decision tree for the classification of geographical distributions into the six modes identified.

'Cosmopolitan' distributions). Therefore, despite using different data and methods, we identified the same types of geographical distributions as those showcased in previous studies (Boeing, 2019, 2022; W. Chen et al., 2024; Debray et al., 2021; Lemoine-Rodríguez et al., 2020; Taubenböck et al., 2020; Tian et al., 2022; Zhou et al., 2022; Zhu et al., 2022). A complete visual summary of each of the 138 I-UPTs can be found in Appendix A. A summary of the geographic distribution of each I-UPT can be found below in Table 1.

With this, our results show that the geographical distribution of I-UPTs varies greatly - from endemic to cosmopolitan urban patterns. We exemplify the six different modes of geographical distributions with twelve distinct I-UPTs (see Fig. 3).

As examples for *Endemic distributions*, I-UPT n° 28 (described as "*Small residential settlements at the edge of large industrial areas*" in (Debray et al., 2025)) was found with a significant share only in a region covering the east of China as well as South and North Koreas. I-UPT n° 59 ("*Low density homogeneous settlements with integrated commercial area surrounded by meadows*") as another example, was found to be endemic to mostly U.K.

I-UPT n° 38 ("*Mixed residential areas with industrial areas or commercial and business parks at the edge of farmlands on the shores of rivers or canals*") was found with a significant share in three different zones, one covering eastern continental Asia and Taiwan, one spanning over central India until east Myanmar and one in the near-east. These three zones all being within Asia, making it an I-UPT with an Asian Sub-continental mode of geographical distribution. I-UPT n° 129 ("*Lowly built residential areas of mixed density bordering strips and areas of industrial, commercial or business parks*") is present in five different zones: western North America, eastern North America, south of Brazil, the Mozambique coast and a zone covering southernmost India to Sri Lanka. Yet out of the four continents, only the zones in North America contribute to a significant presence in that continent due to their relative sizes – as per our definitions presented in section III.5. Therefore, I-UPT n° 129 is significantly present in North America only with multiple distinct zones of presence within it and thus is considered as having a North American Sub-continental mode of geographical distribution.

The I-UPT n° 110 ("*Dense midrise residential areas surrounded by less dense midrise and lowly built areas bordered by commercial or business parks*") was found to have a significant share in only one zone that extends from northern occidental Europe to northern Africa and until Iraq in the East, effectively spanning significantly three continents and therefore being classified as an African-Asian-European Cross-continental I-UPT. I-UPT n°115 ("*Industrial areas with midrise residential compounds*") was found to cover a larger single zone extending from eastern Asia to the Baltic region along a corridor mostly going through North-West China, central Russia and western Russia. Therefore, the geographical distribution of I-UPT n° 115 was classified as Asian-European Cross-continental.

I-UPT n° 10 ("*Fragmented agricultural lands or plains in arid context and at the edge of settlements*") was found to be present with significant share in eight distinct regions, four of which being located within Africa, one covering most India and Pakistan and three sitting at continental border regions: one in the region of the Horn of Africa and the Arabic Peninsula, one ranging from Egypt to central Iran and one spanning from Algeria to Spain. Of the three continents where I-UPT n° 10 was found, only Africa and Asia were found to be significant. Therefore, I-UPT n°10 was classified as an African-Asian Pluri-continental I-UPT. I-UPT n° 93 ("*Low density residential neighborhood on canals or riversides with commercial parks*") was found to be significantly present in two distinct zones: one covering largely western Europe and the other one covering the eastern region of North America between lake Michigan to the Newfoundland Island of Canada. This I-UPT was classified as a European-North American Pluri-continental one.

I-UPT n° 39 ("*Lowly built residential areas with industrial areas or commercial and business parks at the edge of farmlands on the shores of rivers or canals*") was found in 11 different zones, spanning with significant shares over 4 continents: Africa, Asia, Northern America and Southern America and being still hosted yet in an unsignificant manner in Europe and Oceania making it a Quasi-globalized I-UPT. I-UPT n° 68 ("*Low density residential developments at the edge of farmlands*") was found to be significantly present in 6 zones being hosted significantly in Africa, Asia, Europe and North America but not significantly in Oceania and South America characterizing it as a Quasi-globalized I-UPT.

I-UPT n° 55 ("*Agricultural lands with residential and industrial encroachments*") was found to be disseminated with significant shares in 8 zones located in Africa, Asia, Europe, North America and South America and therefore was classified as having a Cosmopolitan mode of geographical distribution. I-UPT n° 80 ("*Lowly built mixed settlements of commercial and residential with a decreasing gradient of density from center to the edges shared with meadows or large agricultural parcels*") was found with significant shares in 16 regions and on 5 continents: Africa, Asia, North America, Oceania and South America. It was also found in Europe, although not with a non-significant share. With this, I-UPT n° 80 was found to be a Cosmopolitan I-UPT.

4.2. Modes of geographical distribution per I-UPT and their relative importance

Overall, we found that out of the 138 I-UPTs that define that global intra-urban fabric and according to our classification scheme, 17 I-UPTs

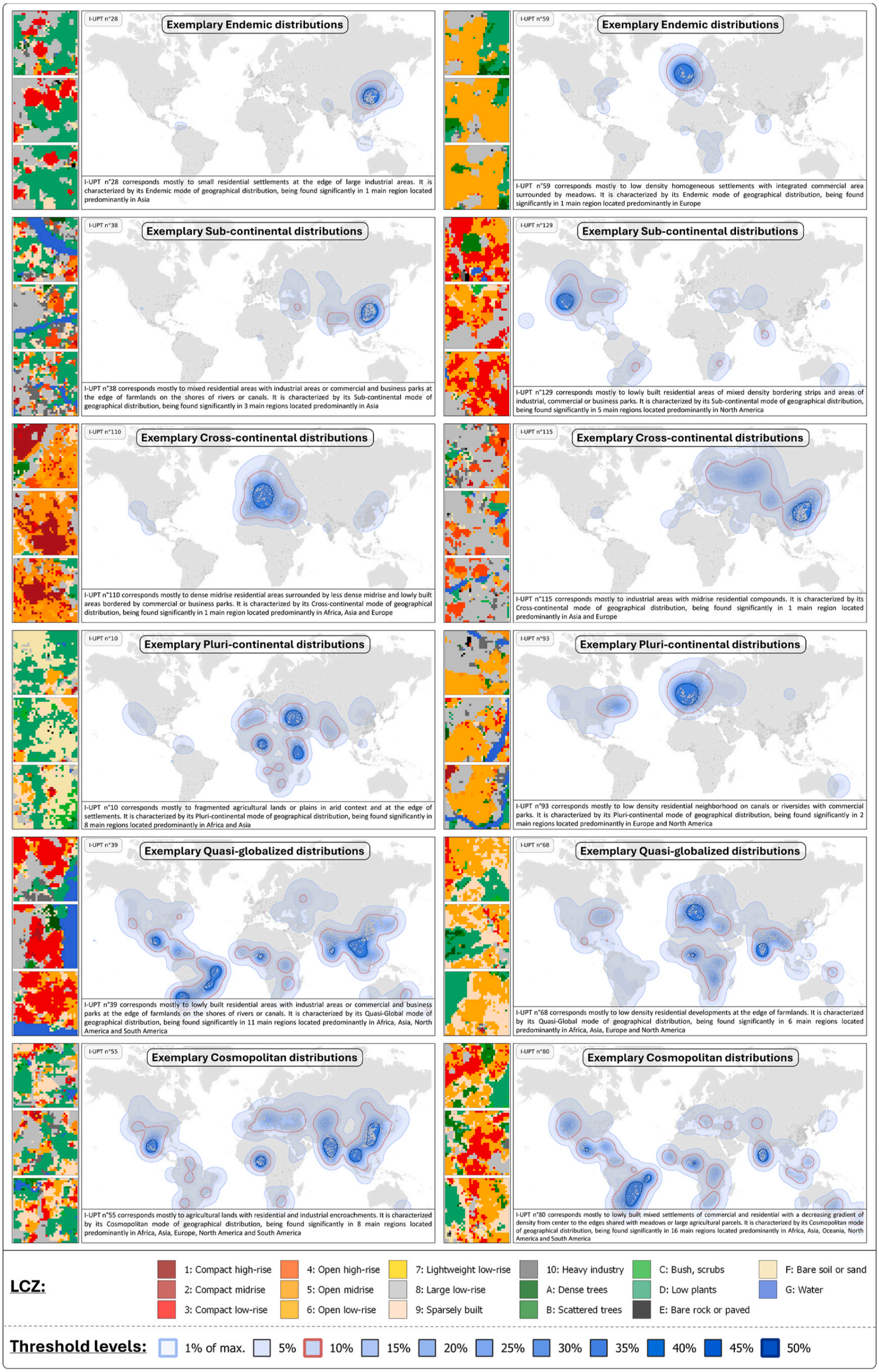

Fig. 3. Twelve I-UPTs exemplified by and their zones of presence illustrating the six modes of geographical distributions.

Table 1
List of the characteristics of the geographical distributions as well as the number of patches of each I-UPT.

I-UPT n°	Number of zones of presence	Number of continents spanned	Mode of geographical distribution	Number of patches	I-UPT n°	Number of zones of presence	Number of continents spanned	Mode of geographical distribution	Number of patches
1	5	3	*Pluri-continental*	3747	**70**	1	1	*Endemic*	1092
2	8	4	*Quasi-globalized*	1638	**71**	1	1	*Endemic*	2214
3	3	2	*Pluri-continental*	2596	**72**	4	3	*Pluri-continental*	2338
4	7	4	*Quasi-globalized*	1671	**73**	9	4	*Quasi-globalized*	1143
5	9	4	*Quasi-globalized*	1762	**74**	1	1	*Endemic*	2526
6	10	4	*Quasi-globalized*	2624	**75**	9	4	*Quasi-globalized*	4368
7	7	4	*Quasi-globalized*	2988	**76**	7	3	*Pluri-continental*	1371
8	7	4	*Quasi-globalized*	1180	**77**	6	2	*Pluri-continental*	4577
9	10	4	*Quasi-globalized*	2621	**78**	2	2	*Pluri-continental*	5689
10	8	2	*Pluri-continental*	2556	**79**	1	1	*Endemic*	2618
11	1	1	*Endemic*	2522	**80**	16	5	*Cosmopolitan*	1133
12	3	2	*Pluri-continental*	2283	**81**	1	1	*Endemic*	963
13	4	3	*Pluri-continental*	2172	**82**	2	1	*Sub-continental*	3107
14	6	3	*Pluri-continental*	1196	**83**	1	2	*Cross-continental*	1285
15	3	2	*Pluri-continental*	1043	**84**	6	3	*Pluri-continental*	2860
16	8	2	*Pluri-continental*	2624	**85**	5	3	*Pluri-continental*	3237
17	4	3	*Pluri-continental*	2832	**86**	1	1	*Endemic*	1225
18	6	4	*Quasi-globalized*	1365	**87**	4	4	*Quasi-globalized*	1092
19	4	3	*Pluri-continental*	269	**88**	9	4	*Quasi-globalized*	1755
20	5	3	*Pluri-continental*	3214	**89**	10	5	*Cosmopolitan*	2832
21	8	4	*Quasi-globalized*	2272	**90**	5	2	*Pluri-continental*	5272
22	9	2	*Pluri-continental*	2080	**91**	10	3	*Pluri-continental*	877
23	4	4	*Quasi-globalized*	889	**92**	2	1	*Sub-continental*	2840
24	3	3	*Pluri-continental*	3342	**93**	2	2	*Pluri-continental*	3218
25	1	2	*Cross-continental*	1995	**94**	5	2	*Pluri-continental*	2032
26	1	2	*Cross-continental*	2775	**95**	1	1	*Endemic*	2573
27	2	2	*Pluri-continental*	2889	**96**	6	3	*Pluri-continental*	4121
28	1	1	*Endemic*	2319	**97**	2	2	*Pluri-continental*	3054
29	3	3	*Pluri-continental*	2960	**98**	2	2	*Pluri-continental*	2876
30	3	2	*Pluri-continental*	2556	**99**	8	4	*Quasi-globalized*	2606
31	1	1	*Endemic*	2345	**100**	10	4	*Quasi-globalized*	2864
32	7	3	*Pluri-continental*	3391	**101**	5	3	*Pluri-continental*	3602
33	6	3	*Pluri-continental*	2673	**102**	8	3	*Pluri-continental*	2029
34	9	4	*Quasi-globalized*	1298	**103**	1	1	*Endemic*	2197
35	6	4	*Quasi-globalized*	2050	**104**	1	1	*Endemic*	1818
36	1	1	*Endemic*	2358	**105**	1	3	*Cross-continental*	1953
37	2	2	*Pluri-continental*	3255	**106**	6	2	*Pluri-continental*	2361
38	3	1	*Sub-continental*	2501	**107**	5	4	*Quasi-globalized*	2024
39	11	4	*Quasi-globalized*	733	**108**	6	3	*Pluri-continental*	2727
40	2	2	*Pluri-continental*	2307	**109**	1	3	*Cross-continental*	2280
41	1	2	*Cross-continental*	2825	**110**	1	3	*Cross-continental*	2513
42	2	2	*Pluri-continental*	2561	**111**	2	3	*Pluri-continental*	2834
43	5	4	*Quasi-globalized*	2663	**112**	1	2	*Cross-continental*	3864
44	1	3	*Cross-continental*	1373	**113**	8	3	*Pluri-continental*	2069
45	7	4	*Quasi-globalized*	1809	**114**	4	1	*Sub-continental*	2263
46	1	2	*Cross-continental*	3399	**115**	1	2	*Cross-continental*	2148
47	6	3	*Pluri-continental*	1958	**116**	1	2	*Cross-continental*	3598
48	8	3	*Pluri-continental*	4010	**117**	7	3	*Pluri-continental*	2047
49	2	2	*Pluri-continental*	460	**118**	6	3	*Pluri-continental*	779
50	4	3	*Pluri-continental*	1408	**119**	2	1	*Sub-continental*	3449
51	1	2	*Cross-continental*	3466	**120**	1	1	*Endemic*	1456
52	2	3	*Pluri-continental*	1759	**121**	6	4	*Quasi-globalized*	2579
53	5	5	*Cosmopolitan*	2048	**122**	12	4	*Quasi-globalized*	1741
54	4	4	*Quasi-globalized*	3883	**123**	4	2	*Pluri-continental*	2554
55	8	5	*Cosmopolitan*	1950	**124**	2	3	*Pluri-continental*	1493
56	4	4	*Quasi-globalized*	782	**125**	8	4	*Quasi-globalized*	2257
57	6	3	*Pluri-continental*	3092	**126**	3	3	*Pluri-continental*	1580
58	1	1	*Endemic*	1451	**127**	8	4	*Quasi-globalized*	2664
59	1	1	*Endemic*	2343	**128**	9	5	*Cosmopolitan*	1345
60	9	4	*Quasi-globalized*	1872	**129**	5	1	*Sub-continental*	92
61	2	2	*Pluri-continental*	2826	**130**	3	2	*Pluri-continental*	2375
62	2	2	*Pluri-continental*	2837	**131**	1	1	*Endemic*	1664
63	4	3	*Pluri-continental*	2476	**132**	9	4	*Quasi-globalized*	1819
64	2	3	*Pluri-continental*	4130	**133**	3	2	*Pluri-continental*	2213
65	4	2	*Pluri-continental*	749	**134**	6	3	*Pluri-continental*	3305
66	5	3	*Pluri-continental*	907	**135**	3	2	*Pluri-continental*	1647
67	7	3	*Pluri-continental*	649	**136**	6	3	*Pluri-continental*	1418
68	6	4	*Quasi-globalized*	3363	**137**	8	3	*Pluri-continental*	1276
69	2	2	*Pluri-continental*	2500	**138**	8	4	*Quasi-globalized*	1092

can be considered ‘Endemic’, 6 have a ‘Sub-Continental’ distribution, 13 span in a ‘Cross-Continental’ mode, 65 are distributed in a ‘Pluri-Continental’ way, 32 are ‘Quasi-Global’ and 5 are ‘Cosmopolitan’.

When weighted by the number of patches classified in each of the I-UPTs, this ranking of relative importance remains relatively stable. Overall, we find that ‘Endemic’ I-UPTs count on average 2417 patches and account for 13.0 % of the global fabric; ‘Sub-continental’ I-UPTs count on average 2292 patches and account for 4.3 % of the global fabric; ‘Cross-continental’ I-UPTs count on average 2852 patches and account for 11.7 % of the global fabric; ‘Pluri-continental’ I-UPTs count on average 2307 patches and account for 47.4 % of the global fabric; ‘Quasi-Global’ I-UPTs count on average 1929 patches and account for 19.5 % of the global fabric; ‘Cosmopolitan’ I-UPTs count on average 2593 patches and account for 4.1 % of the global fabric.

Thus, first, we find that the ‘Pluri-continental’ mode represents the main trend of geographical distribution of I-UPTs. This corresponds to I-UPTs that are found in a handful of distinct regions of the world. Second come I-UPTs that are ‘Quasi-global’, i.e. that populated a large swath of the continents. This second mode relates to close to 2.5 times less of the global urban fabric than ‘Pluri-continental’ I-UPTs. Third and fourth are found of the ‘Endemic’ and ‘Cross-regional’ I-UPTs that are both present with significant share only in single regions of the world with ‘Endemic’ I-UPTs being circumscribed to only a continent and ‘Cross-continental’ I-UPTs sitting at cross-continental borders. They represent respectively close to 3.5 and 4 times less of the global urban fabric as ‘Pluri-continental’ I-UPTs. Last come ‘Sub-continental’ and ‘Cosmopolitan’ I-UPTs that each are representative of less than 11 times of the global urban fabric than ‘Pluri-continental’ I-UPTs.

We observe a specific statistical distribution reflecting a strong prominence of patterns that are spread to multiple regions of the globe yet not being found at full global scale. And, in a second order, we observe patterns specific to very localized single regions. On the contrary, we observe that patterns that can be found consistently across the entire globe are relatively few and represent only a small share of the global urban fabric. The same can be said of patterns that are spreading in multiple regions of a same continent.

In summary, our empirical results reveal that the global urban fabric, down to its intra-urban scaled patterns, has multiple preferential modes of geographical distribution that are not as polarized on the local-global continuum as previously thought.

5. Discussion

5.1. Status quo on the global regularities vs. local specificities of the urban fabric

Globalization is often seen as a factor of global homogenization (Ritzer, 2007) and some of its aspects lead to the question of whether this is reflected in the morphology of the urban fabric (Friedmann, 2005, 2012). In this scope, studies on urban structures and spatial patterns focus mostly on either showcasing local specificities of the urban fabric, e.g. (Adams, 2005; Frankhauser, 2004; Gaubatz, 1998; Griffin & Ford, 1980; Lichtenberger, 1972) or putting forth regularities at a global scale, e.g. (Debray et al., 2021; Lemoine-Rodríguez et al., 2020; Taubenböck et al., 2020). In this study, however, we go beyond this local vs. global dichotomous conceptualization to characterize the full gradient of existing geographical distributions and introduce six modes of geographical distribution. We show that, rather than fitting in these two extremes (global or local) a vast majority of intra-urban patterns exert in-between geographical distributions, neither fully global nor fully local.

We showed that across all types of intra-urban patterns composing the global urban fabric, their most prominent mode of geographical distribution is a ‘Pluri-continental’ distribution. This mode of geographical distribution stands almost at the middle of the local-global continuum we conceptualized. Second come ‘Quasi-global’ patterns that are slightly more global but not yet fully globally widespread. In third position, with almost the same relative importance in the global urban fabric, we found ‘Endemic’ and ‘Cross-continental’ patterns. While ‘Cross-continental’ patterns are sitting in the middle of the local-global continuum, ‘Endemic’ patterns are the most local patterns of our scheme. The last two modes of geographical distribution account for the ‘Sub-continental’ patterns (rather local) and ‘Cosmopolitan’ patterns (the most global mode in our scheme).

We interpret this distribution of the global urban fabric across the different geographical modes in two ways: First it can be said that far from fitting simple narratives of complete regional specificity or of full homogeneity of the global urban fabric, the *status quo* lies between these two extremes. Second, all I-UPTs do not share, by far, a single mode of geographical distribution, which we interpret as a sign that the global urban fabric is in itself a patchwork resulting from the complex overlapping of rather global and rather local patterns alike. In other words and coming back to our introductory thought experiment: We found that the 138 identified types of Lego bricks spread in differentiated modes across the globe. Therefore, we have to understand each city as a mosaic composed of bricks of potentially different origins: some only locally found, some other found more globally.

Given the important nuances just described, it must still be recognized that the majority of I-UPTs appear to have a wider spread than that of a simple regional containment. This means that on a local-global spectrum, the cursor is pushed by more patterns and a greater proportion of the global urban fabric in the direction of a widespread, global-leaning distribution. This distribution is *per se* neither good nor bad, yet it indicates that certain urban patterns are re-occurring across vastly diverse contexts. This raises questions on the suitability of these widespread urban patterns to all the context they are found in and on the implications it has for cities.

At a global scale, institutions monitoring urban planning policies increasingly call for empirical research to feed into and support initiatives for bettering cities on multiple social and environmental challenges such as climate resilience, air quality, mobility, accessibility, well-being and social justice. Among these calls, the most globally prominent is probably the United Nations Sustainable Development Goal 11: “Make cities and human settlements inclusive, safe, resilient and sustainable” (DESA, 2025; United Nations, 2015). With these calls, the incentives for researcher is getting stronger to derive quantitative indicators to monitor specific urban phenomena (e.g.: urban heat islands, urban pollution, transportation, walkability, well-being, segregation) related to these crucial aspects of cities. Answering this call, empirical studies have assessed different characteristics of urban form such as compactness, land use patterns, built height, or street networks topologies which are expected to have influence on some of these urban phenomena (Bibri et al., 2020).

Yet this approach assumes that these characteristics of urban forms are shaping the urban phenomena in constant ways or that they are at least good enough predictors of the phenomena. Against this, literature shows that the effect on urban phenomena depends greatly on the local context in which the urban form is embedded. Lemoine-Rodríguez et al. (2022a) showed that the local background climate of cities modifies the impact of urban forms on the intra-urban climate. Mouratidis (2018, 2019) found that the sociodemographic context strongly conditions the relation between subjective well-being of residents and urban form. Samad et al. (2023) found that the topological context affects the way given urban forms influence air quality and urban climate.

The global-leaning distribution of a majority of urban patterns makes the plurality of contexts a given urban pattern can be found in especially salient. With this the question can be asked how a given pattern interplays with the different contexts it is found in, and if ultimately all combinations of patterns and contexts are suitable. Therefore, while we support calls for better monitoring the characteristics of urban fabrics globally, we also argue that there is an urgent need to integrate knowledge about how these characteristics are effectively impacting urban phenomena in different contexts. In other words, the translation of global findings into the specific local context remains to be explored. This calls for the involvement of both academics and urban planning policy makers. On the one hand, beyond the monitoring of characteristics of urban fabrics, there is a need for extensive documentation of the local context in which these characteristics are measured. With this, research should be performed to comprehensively understand how local context and urban forms interact to shape urban phenomena. On the other hand, the evaluation of planning policies and practices should systematically integrate indicators of the context-suitability of the specific urban forms fostered by these policies and practices.

While the question of the context-suitability is made very salient in the case of global-leaning urban patterns, this question is not restricted to those patterns only. The fact that a given pattern is only found locally does not necessarily mean that it is suitable for the context it is found in. Therefore, a comprehensive inquiry should not consider these patterns as exempt of a potential non-suitability to their context.

On a broader scale, this also leads to the question of whether we observe any difference of context suitability between global-leaning or local leaning patterns. While any presupposition at this stage would be too uncertain, such results would inform greatly whether local based urban planning or best-practices based global urban planning should be encouraged.

5.2. Hypothesis on global-scale co-evolutions of intra-urban patterns

Our results suggest that current urbanization is characterized by a large share of intra-urban patterns being spread at an almost global scale, creating a certain degree of sameness at a global level. Several factors could explain the geographical distribution or spread of any intra-urban patterns, including geography, climate, resource availability, socio-economic and cultural conditions and historical paths. Although analyzing in detail how the geographical distribution of each I-UPT emerges is beyond the scope of this study, our findings contribute to the broader discussion of these global-leaning distributions.

In the literature, the global distribution of similar urban patterns is often argued from two different conceptual approaches that we formulate here as hypotheses that share a common posit. This is the posit we defined in section I) Introduction, that the different types of urban fabric (here proxied by the I-UPTs) are representative of specific urban planning practices and paradigms (M. R. G. Conzen, 1960; M. R. G. Conzen & Conzen, 2004; Cozzolino, 2018; Friedmann, 2005; Kostof, 1991, 1992; Taubenböck, Gerten, et al., 2019). Beyond this shared assumption, the two hypotheses rely on diametrically different views on the evolution of cities.

The first hypothesis, that we coin the "*independent co-evolution*" hypothesis, proposes that some intra-urban patterns appear in multiple regions of the globe without the need for communications between them. This parallel co-evolution thus supports the idea of the existence of common laws driving the development of cities given a certain context as shown by empirical observations of global regularities as in, e.g.: (Bettencourt et al., 2007; Bettencourt & Lobo, 2016; Rybski et al., 2019; Uhl et al., 2020). This hypothesis deals with the "*spontaneous*" processes in cities and their evolution with respect to their context.

While it is plausible that universal laws partially explain a global re-occurrence of intra-urban patterns, in today's highly connected world the existence of exchanges in urban planning practices seems hard to refute (Friedmann, 2005; Othengrafen & Reimer, 2013; Ritzer, 2007). Focusing on these exchanges, we therefore frame a second hypothesis: "*influenced co-evolution*".

This second hypothesis posits that the re-occurrence of intra-urban patterns across regions reflects the dissemination of urban planning cultures and their associated practices, policies and designs (Friedmann, 2005, 2012; Knieling & Othengrafen, 2015; Othengrafen & Reimer, 2013), leading to a relative homogenization. Such dissemination may occur through mutual expositions where different planning cultures adopt observed policies, practices or designs deemed successful and adaptable to their own context. Beyond these symmetrical disseminations, asymmetrical influences also exist, particularly in contexts of asymmetrical power dynamics such as colonization, post-colonization or cultural hegemony (Guerrieri, 2018; Hassa, 2016; Kostof, 1991, 1992; Laurie & Philo, 2020; Salomon, 2019; Silva, 2015). This hypothesis deals with the "*geopolitical*" processes influencing the development of cities.

While testing these hypothesis falls out of the scope of this study, some of our findings on the geographical distributions of patterns merit to be discussed through this prism. We observed that the I-UPTs from the three most local modes of geographical distribution occur mostly in the Northern hemisphere (see Fig. 4 left panel). Conversely, the most global patterns cover almost uniformly the urbanized extent of the globe (see Fig. 4 right panel). These two findings highlight a certain vernacularity (local-leaning) of patterns of the Northern hemisphere relative to a larger background of more vehicular (global-leaning) patterns in both hemispheres. Many hypothetical causal chains can be drafted to explain this contrast in distribution.

Stepping on these findings, we propose the following hypothetical causal chain tied to colonization which explicitly exemplifies how a "*influenced co-evolution*" could emerge from a specific historical process of influence. During colonization, urbanization in colonies was generally conducted by practitioners tied to the central colonizing powers (Guerrieri, 2018; Hassa, 2016; Kostof, 1991, 1992; Salomon, 2019; Silva, 2015). Even after colonial times, western trained urban planners were routinely commissioned to design new cities or new extensions of cities in non-western countries (Hassa, 2016; Kostof, 1991, 1992; Laurie & Philo, 2020; Silva, 2015). With this, the practice of urban planning was influenced by the practices of the western world at a global scale by colonization, post-colonization influence, and later by dependency to already established practices (Buttner et al., 2025; Coelho et al., 2025; Ferretti, 2021; Ghosh et al., 2021; Laurie & Philo, 2020). This would potentially translate into specific urban patterns with a global-leaning geographical spread, covering countries where they originated from and countries where they were disseminated. Furthermore, this colonial and post-colonial influence was effective during the most prominent urbanization phases of non-western countries (Taubenböck et al., 2025). This potentially exacerbated the influence this process had in shaping large fractions of the current global urban fabric, which in turn could have contributed to the preponderance of global-leaning patterns. On the contrary, the presence of more vernacular patterns being specific to the Northern hemisphere potentially reflects vernacular patterns specific to the western world that were not exported as part of this colonial and post-colonial vehicular influence. This might have been accompanied by destruction or complete restructuration of prior vernacular urban patterns existing in the Southern hemisphere as part of armed conflicts or *tabula rasa* practices (Kostof, 1991).

This exemplified line of interpretation of our results is to be taken as hypothetical and is to be further questioned empirically. We acknowledge that other causal chains might contribute to explain better the specific geographical distribution of the intra-urban patterns. The purpose of this example here is to make explicit how geopolitical influence can shape the global distribution of urban patterns through an "*influenced co-evolution*". We therefore clearly state that these observations do not constitute any empirical proof. Yet, we raise them here to encourage future empirical investigations of this topic that has been lacking until now. For such an empirical investigation, a precise spatio-temporal analysis of the emergence of each pattern crossed with socio-economic and historic contextual factors is needed.

Furthermore, it is to be noted here that, while these two hypotheses might seem to support opposite stances, we do not claim them to be unconciliable. We acknowledge that certain intra-urban patterns might appear in different regions because of a willing, incentivized or forced importation, some other patterns might emerge from underlying processes in specific geographical or cultural contexts. With this, we

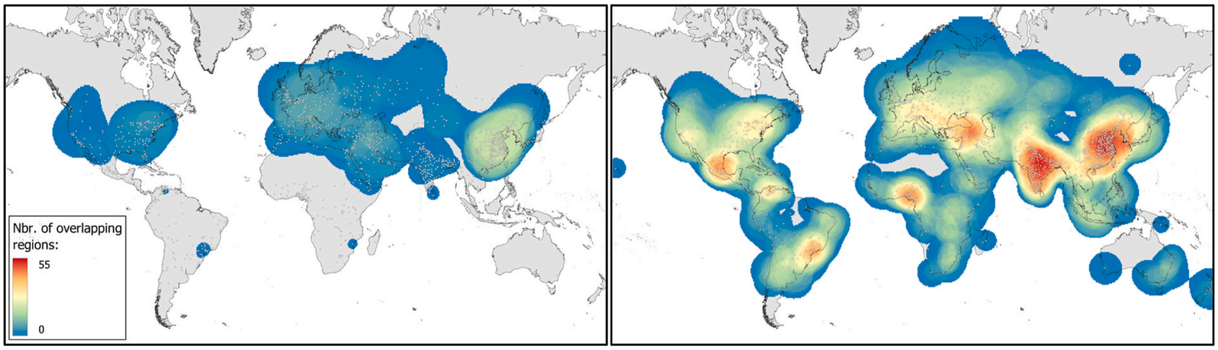

Fig. 4. On the left: overlapping of all the regions of presence of I-UPTs of Endemic, Sub-continental, Cross-continental modes. On the right: overlapping of all the regions of presence of the I-UPTs of Pluri-continental, Quasi-global, Cosmopolitan modes. The color scales of both maps are the same. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

therefore encourage future works to look at empirical results on regularities in urban morphology from the vantage point of both "*independent co-evolution*" and "*influenced co-evolution*" hypotheses.

5.3. Technical and methodological considerations

With the results of this work, we hope to contribute to future empirical investigations on the multitudes of processes behind the different modes of geographical distributions of intra-urban patterns from the most endemic to the most cosmopolitan. Yet, we also acknowledge the limitations of the data and the methods of this study that need to be considered in the interpretation of our results.

In (Debray et al., 2025), introducing the I-UPTs, the authors acknowledged their typology to be potentially impacted by the uncertainties reported by the authors of the LCZ classification they use (Zhu et al., 2021) and by the MUAs delineations of cities (Taubenböck, Weigand, et al., 2019). With this, they concluded that some of the clustering results might be affected by these input data and eventually their own methods and, therefore, this typology is not to be considered as definitive. However, we are confident on our results, as the main results of the present study are consistent with some empirical evidence beyond the uncertainties of the data used. At the same time, we encourage future research to replicate the approach presented here with other data sources such as the global LCZ classification produced by Demuzere et al. (2021) or alternative classifications schemes of urban patterns, e.g. by Arribas-Bel and Fleischmann (2022).

As for the developed method to analyze the geographical distribution of the I-UPTs, we reflect on three main limitations: *First*, we acknowledge that using a KDE as the basis for the identification of regions of presence comes with a certain influence on our results, i.e. to the resolution and the bandwidth that we are working with. We accounted for this using a grid search method to adapt the bandwidth to the resolution at which we worked and to the global distribution of MUAs. Yet, the computation of the density at any given resolution might be slightly impacted by methodological challenges related to the Modifiable Areal Unit Problem (MAUP) as shown for several spatial analysis tasks (Openshaw, 1984; Wong, 2009). *Second*, we state here that we are aware of the shortcomings of the arbitrary definition of the threshold used to delineate the regions of presence based on the estimated density of I-UPTs. Without proper guidelines on the matter, the decision of having a threshold at 10 % of the maximum of the estimated density allowed to propose a threshold representing the different distributions of densities of the I-UPTs. Yet, as can be observed from the results of the computation at other threshold levels (see Appendix A), the results present some variabilities across threshold levels. We observed that the higher the threshold level was, the more regions of lesser significance are progressively filtered out. The aggregated results in terms of modes of geographical distributions led us to confirm that the main results of our study are valid across threshold levels (i.e. the predominance of Pluri-continental I-UPTs while there is uncontested importance of Quasi-globalized, and on the opposite of Endemic I-UPTs (see Appendix B)). Yet, we encourage the reader to take the specific geographical distributions results across multiple thresholds for each I-UPT into account. *Third* and last, we acknowledge that the six modes of geographical distribution and the way we categorized the I-UPTs along them, although being conceptually convenient for formulating a simple quantitative frame, while guided by the literature, are partially arbitrary. However, as to the best of our knowledge, there is no generally accepted way to differentiate modes of geographical distribution. Therefore, our categorization of the I-UPTs needs to be understood as a first attempt on the matter and might serve as a starting point towards the need of standardized schemes. Thus, we argue that our results need to be understood with this caveat and future studies re-utilizing our approach should be encouraged to define their own categories.

In the scope of our experimental set-up, the cumulated impact of these uncertainties and limitations are not quantifiable. Yet, the results provide a body of evidence strong enough that we see the effects of these uncertainties and limitations as fairly marginal for the overall assessment of the *status quo* of the regularity of geographical distributions of the different intra-urban morphological patterns.

5.4. Conceptual limitations

We further acknowledge that some relevant aspects of the intra-urban morphology were kept out of the conceptual frame of our approach and limit the scope of interpretation of our results.

First, we acknowledge that the I-UPTs are defined at an intermediate scale between, on one side, the scale of blocks and buildings traditionally addressed in the field of urban morphology (M. R. G. Conzen & Conzen, 2004) and on the other side, the more loosely defined scale of the neighborhood. In this sense, the results we drew in this study have to be understood at this intermediate scale rarely addressed in urban morphology literature. Future assessments are suggested to test the effects of analyzing the urban fabric considering other scales of analysis of the urban fabric.

Moreover, in this study we focused merely on the presence of the I-UPTs without considering where in the MUAs they are located (e.g. at the periphery or in the central core of urban areas), which plays an important role in terms of urban use and function. In other words, re-using the introductory metaphor, we only considered the "Lego bricks" of the urban fabric and not which of these brick types are usually located together in close vicinity. Debray et al. (2021), in their search of alternative approaches to constitute empirical typologies of cities as in (Taubenböck et al., 2020) showed that investigating the structural contexts of the intra-urban fabric brings further nuances in the typologies they produced. Here we believe that using the structural context of the I-UPTs will bring further insights in the investigation of their geographical distributions.

Further, although our present approach focused on the *status quo* of the homogeneity of the global urban fabric, the state of this homogeneity is dynamical as shown in (Lemoine-Rodríguez et al., 2020). Stepping forward, we believe that a systematic multi-temporal approach of the urban fabric, as identified in (Wentz et al., 2018), could benefit the understanding of the dynamics of the global distribution of urban fabric types. We believe in the case of the I-UPTs that such a diachronic approach will allow to measure nuanced dynamic processes of the global urbanization as well as better refining the understanding of types of intra-urban fabric by putting them into their historical frame.

6. Conclusion and outlook

Discourses on the *status quo* of the diversity and homogeneity of the urban fabric across the globe usually present two opposite polarized scenarios: 1) The urban fabric of each city is unique, or 2) The urban fabric of all cities are sharing regular traits. These discourses are relevant from multiple points of view (e.g., political, social, environmental). Yet, the empirical assessment of these scenarios was until recently facing challenges of lack of specific data pertaining to morphological patterns of the urban fabric at a global scale. With the recent constitution of such a dataset, we developed a straightforward approach to analyze the geographical distribution of 138 *intra*-urban pattern types at a global scale.

By analyzing the intra-urban pattern types identified in (Debray et al., 2025) and their associated geographical locations, we quantitatively estimate the regions where they are present. Knowing the locations of these regions helps to understand the geographical contexts in which these intra-urban patterns exist and can be used to analyze in a nuanced way the way they influence and are influenced by different urban phenomena. We envision this as enabling more precise policies that do not only consider the presupposed performances of certain urban forms but also the adequacy to the context in which they are to be enacted.

In turn, relating the regions where these patterns are located to the local socio-cultural context helps us identify specific intra-urban patterns as the enactment of specific urban planning paradigms or practices. For example, I-UPT n°59 "*Low density homogeneous settlements with integrated commercial area surrounded by meadows*" is being located almost exclusively in the U.K. This helps to identify the type as representing the enactment of a suburban planning practice dating from Victorian times (Kostof, 1991; Tizot, 2018) that would later form the basis for the English Garden city movement).

With the regions of presence identified for each type of intra-urban pattern, we characterize their geographical distribution that we summarize in six categories, presenting a continuum from local to global distributions. This characterization has the potential to evaluate the dissemination of particular urban planning paradigms and practices and further research the specific driving forces responsible for their dissemination.

Aggregating these measures for all the 138 types identified by Debray et al. (2025), we are able to probe the *status quo* of the diversity and homogeneity of the urban fabric across the globe down to the intra-urban scale. Quantifying the relative importance of each of these modes in the makeup of the global urban fabric, we found that Pluri-continental and Quasi-globalized I-UPTs (i.e. I-UPTs that are localized across few continents) are the most numerous and represent the largest share of the global urban fabric. We further found that patterns that can only be found in specific single regions account for a lower but still significant share of the global urban fabric, while, on the other hand, fully globalized patterns are scarce.

Stepping on these results, we reflected on the distinct spatial logics behind the different modes of geographical distribution and suggested hypotheses explicating processes that could have brought this *status quo*. While empirically investigating these hypotheses falls out of the frame of this study, we encourage future works to find adequate experimental setups aimed at empirically confirming or refuting these or other hypotheses on the matter. Furthermore, we encourage future research on the topic of the influence of urban form on urban phenomena to expand these analysis by including contextual considerations for better informing local policy makers and urban planners.

With this work, we put to use and experimented with recently developed datasets on intra-urban morphology at a global scale. We see this study as an effort to find local idiosyncrasies in the intra-urban fabric while, at the same time, to explicit global relationships across the intra-urban morphology of distant regions of the globe. With the results of this work, we hope to trigger theoretical reflections on the meanings of the global distribution of the human artifacts that cities and their fabrics are. At the same time, we hope to showcase the relevance of empirical investigations of the intra-urban fabric in relation to local context at a global scale and motivate further such investigations.

CRediT authorship contribution statement

Henri Debray: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Richard Lemoine-Rodríguez:** Writing – review & editing, Supervision. **Michael Wurm:** Writing – review & editing, Supervision. **Xiaoxiang Zhu:** Writing – review & editing, Supervision, Funding acquisition. **Hannes Taubenböck:** Writing – review & editing, Visualization, Supervision, Funding acquisition, Conceptualization.

Funding sources

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Henri Debray reports financial support was provided by European Research Council. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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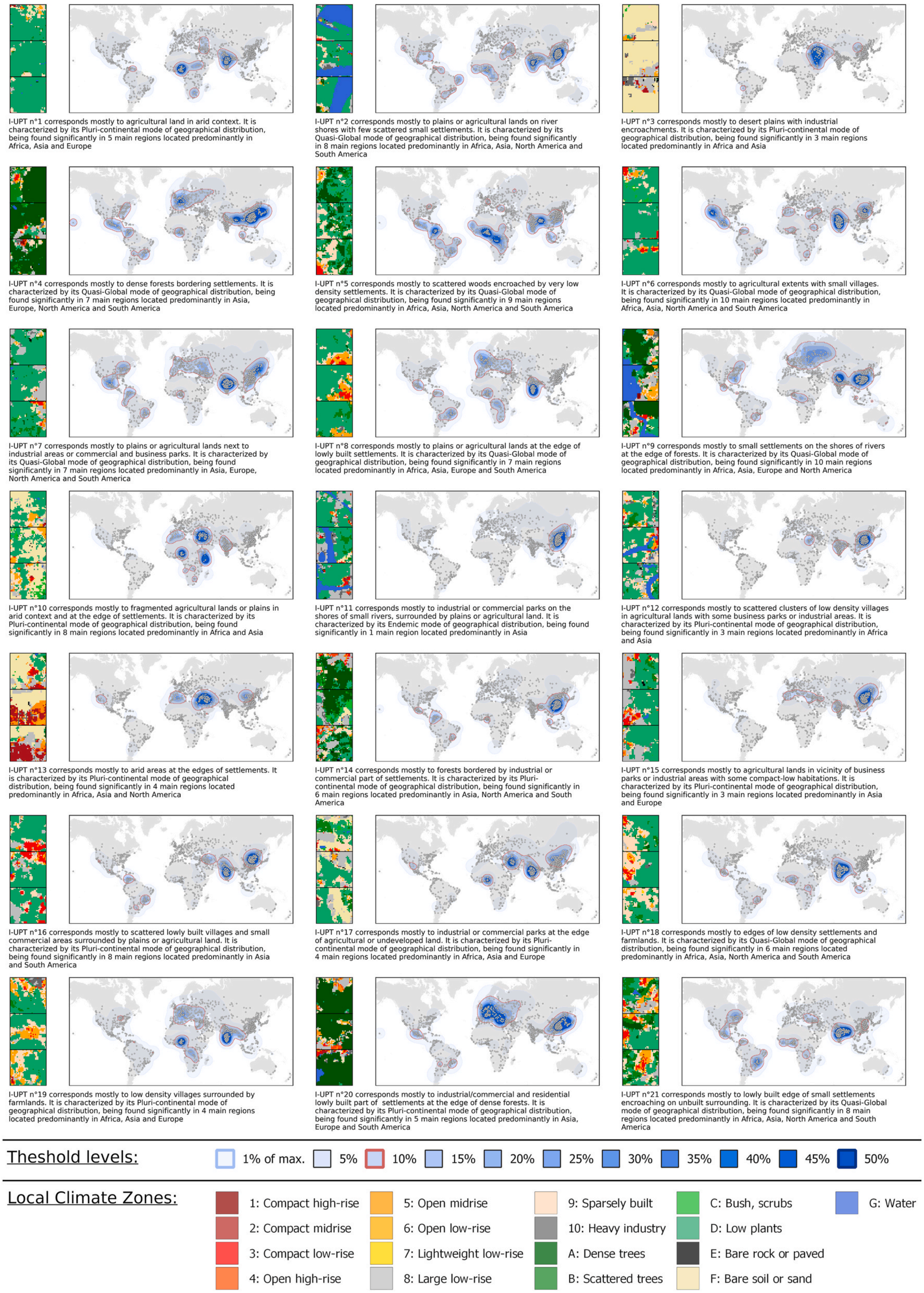
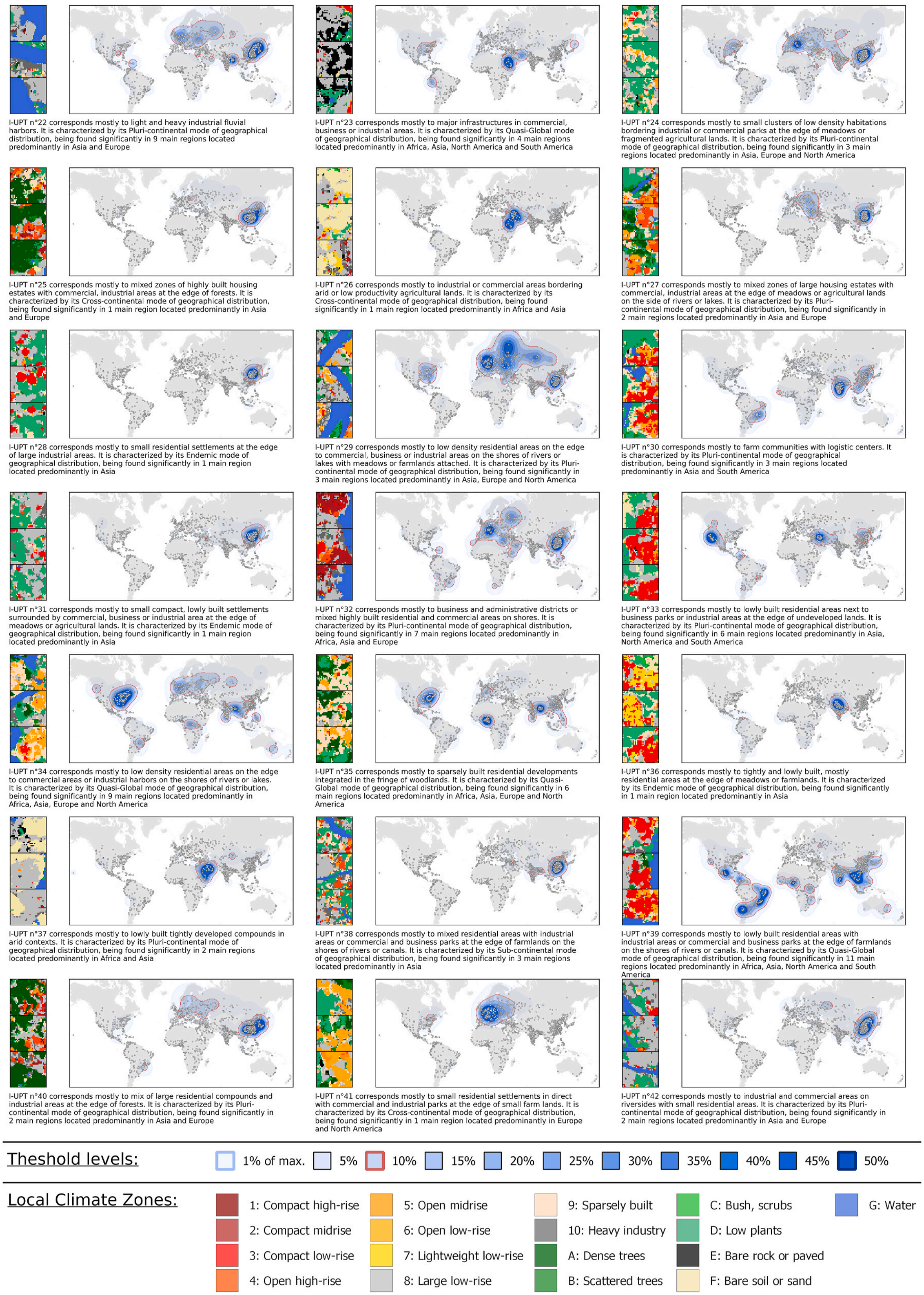
This work has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No [714087]-So2Sat).

Appendix AA collage of all the 138 I-UPTs semantically described, mapped with their respective zones of presence and their modes of geographical distribution

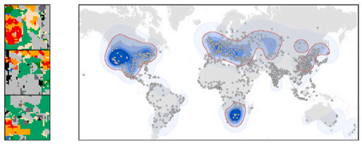
Appendix A1I-UPTs 1-21



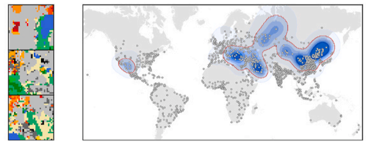
Appendix A2I-UPTs 22-42


I-UPT n°22 corresponds mostly to light and heavy industrial fluvial harbors. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 9 main regions located predominantly in Asia and Europe
I-UPT n°23 corresponds mostly to major infrastructures in commercial, business or industrial areas. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 4 main regions located predominantly in Africa, Asia, North America and South America
I-UPT n°24 corresponds mostly to small clusters of low density habitations bordering industrial or commercial parks at the edge of meadows or fragmented agricultural lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia, Europe and North America
I-UPT n°25 corresponds mostly to mixed zones of highly built housing estates with commercial, industrial areas at the edge of forests. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia and Europe
I-UPT n°26 corresponds mostly to industrial or commercial areas bordering arid or low productivity agricultural lands. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Africa and Asia
I-UPT n°27 corresponds mostly to mixed zones of large housing estates with commercial, industrial areas at the edge of meadows or agricultural lands on the side of rivers or lakes. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe
I-UPT n°28 corresponds mostly to small residential settlements at the edge of large industrial areas. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia
I-UPT n°29 corresponds mostly to low density residential areas on the edge to commercial, business or industrial areas on the shores of rivers or lakes with meadows or farmlands attached. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia, Europe and North America
I-UPT n°30 corresponds mostly to farm communities with logistic centers. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia and South America
I-UPT n°31 corresponds mostly to small compact, lowly built settlements surrounded by commercial, business or industrial area at the edge of meadows or agricultural lands. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia
I-UPT n°32 corresponds mostly to business and administrative districts or mixed highly built residential and commercial areas on shores. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 7 main regions located predominantly in Africa, Asia and Europe
I-UPT n°33 corresponds mostly to lowly built residential areas next to business parks or industrial areas at the edge of undeveloped lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Asia, North America and South America
I-UPT n°34 corresponds mostly to low density residential areas on the edge to commercial areas or industrial harbors on the shores of rivers or lakes. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 9 main regions located predominantly in Africa, Asia, Europe and North America
I-UPT n°35 corresponds mostly to sparsely built residential developments integrated in the fringe of woodlands. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 6 main regions located predominantly in Africa, Asia, Europe and North America
I-UPT n°36 corresponds mostly to tightly and lowly built, mostly residential areas at the edge of meadows or farmlands. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia
I-UPT n°37 corresponds mostly to lowly built tightly developed compounds in arid contexts. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Africa and Asia
I-UPT n°38 corresponds mostly to mixed residential areas with industrial areas or commercial and business parks at the edge of farmlands on the shores of rivers or canals. It is characterized by its Sub-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia
I-UPT n°39 corresponds mostly to lowly built residential areas with industrial areas or commercial and business parks at the edge of farmlands on the shores of rivers or canals. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 11 main regions located predominantly in Africa, Asia, North America and South America
I-UPT n°40 corresponds mostly to mix of large residential compounds and industrial areas at the edge of forests. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe
I-UPT n°41 corresponds mostly to small residential settlements in direct with commercial and industrial parks at the edge of small farm lands. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Europe and North America
I-UPT n°42 corresponds mostly to industrial and commercial areas on riversides with small residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe
Theshold levels:
1% of max.
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
Local Climate Zones:
1: Compact high-rise
2: Compact midrise
3: Compact low-rise
4: Open high-rise
5: Open midrise
6: Open low-rise
7: Lightweight low-rise
8: Large low-rise
9: Sparsely built
10: Heavy industry
A: Dense trees
B: Scattered trees
C: Bush, scrubs
D: Low plants
E: Bare rock or paved
F: Bare soil or sand
G: Water

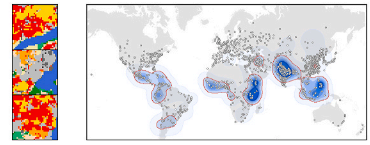
Appendix A3I-UPTs 43-63



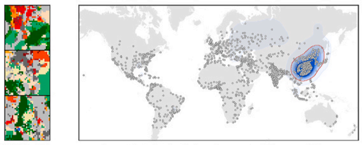
I-UPT n°43 corresponds mostly to commercial, business or industrial areas bordered by lowly built residential areas at the edge of meadows or agricultural lands. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 5 main regions located predominantly in Africa, Asia, Europe and North America



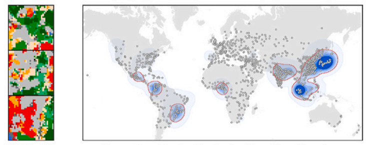
I-UPT n°44 corresponds mostly to industrial and commercial areas on banks of canals or lakes with few small residential areas and some undeveloped banks. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia, Europe and North America



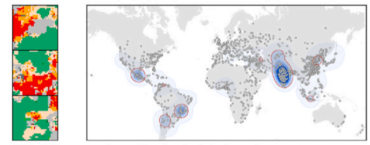
I-UPT n°45 corresponds mostly to densely and very tightly developed river banks with mixed developments. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 7 main regions located predominantly in Africa, Asia, North America and South America



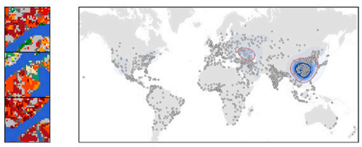
I-UPT n°46 corresponds mostly to industrial and commercial areas with some high built residential areas at the edge of woodlands. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia and Europe



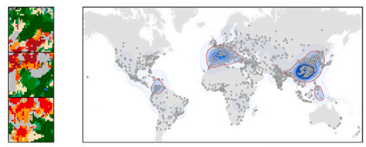
I-UPT n°47 corresponds mostly to farmlands mixed with residential and industrial extensions at the edge of woodlands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Africa, Asia and South America



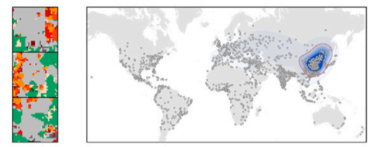
I-UPT n°48 corresponds mostly to farmland at edges of compact to open settlements with industrial areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 8 main regions located predominantly in Asia, North America and South America



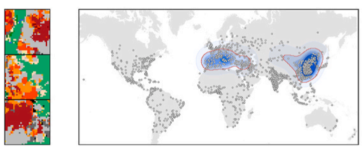
I-UPT n°49 corresponds mostly to river shores developed with high density mixed residential and industrial areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe



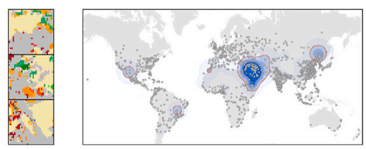
I-UPT n°50 corresponds mostly to high density mixed residential and industrial areas at the edge of woodlands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 4 main regions located predominantly in Asia, Europe and South America



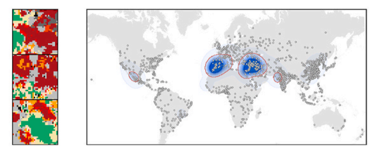
I-UPT n°51 corresponds mostly to residential areas around industrial areas at the edge of farmlands. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia and Europe



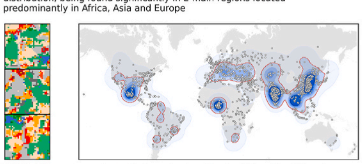
I-UPT n°52 corresponds mostly to densely mid-rise built town centers surrounded by commercial and industrial parks at the edge of agricultural lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Africa, Asia and Europe



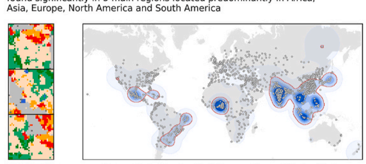
I-UPT n°53 corresponds mostly to lowly built tightly developed compounds mixed with industrial and commercial areas in arid contexts. It is characterized by its Cosmopolitan mode of geographical distribution, being found significantly in 5 main regions located predominantly in Africa, Asia, Europe, North America and South America



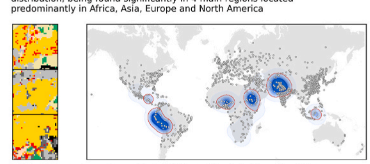
I-UPT n°54 corresponds mostly to densely built compounds mixed with industrial and commercial areas surrounded by agricultural lands in arid contexts. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 4 main regions located predominantly in Africa, Asia, Europe and North America



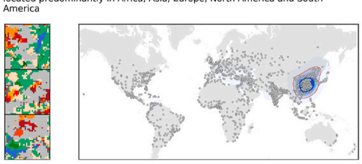
I-UPT n°55 corresponds mostly to agricultural lands with residential and industrial encroachments. It is characterized by its Cosmopolitan mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia, Europe, North America and South America



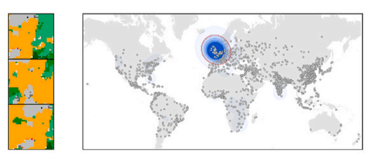
I-UPT n°56 corresponds mostly to farmlands villages with small industrial areas. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 4 main regions located predominantly in Africa, Asia, North America and South America



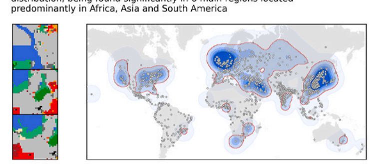
I-UPT n°57 corresponds mostly to tightly and lowly built residential areas at the edge of industrial areas or commercial and business parks in arid context. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Africa, Asia and South America



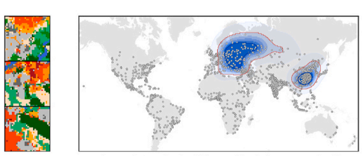
I-UPT n°58 corresponds mostly to farmlands at the edges of industrial areas. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia



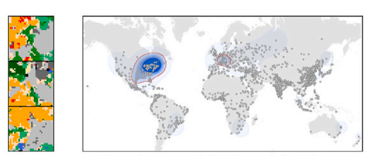
I-UPT n°59 corresponds mostly to low density homogeneous settlements with integrated commercial area surrounded by meadows. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Europe



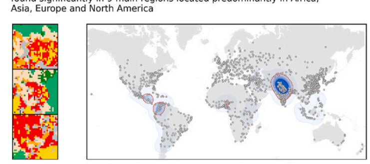
I-UPT n°60 corresponds mostly to industrial or commercial areas and harbors bordered by residential area or farmlands on the shore of rivers. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 9 main regions located predominantly in Africa, Asia, Europe and North America



I-UPT n°61 corresponds mostly to mixed midrise residential compounds with industrial areas or commercial and business parks at the edge of meadows or woods. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe



I-UPT n°62 corresponds mostly to commercial, business or industrial areas bordered by lowly built low density residential areas at the edge of meadows or agricultural lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Europe and North America



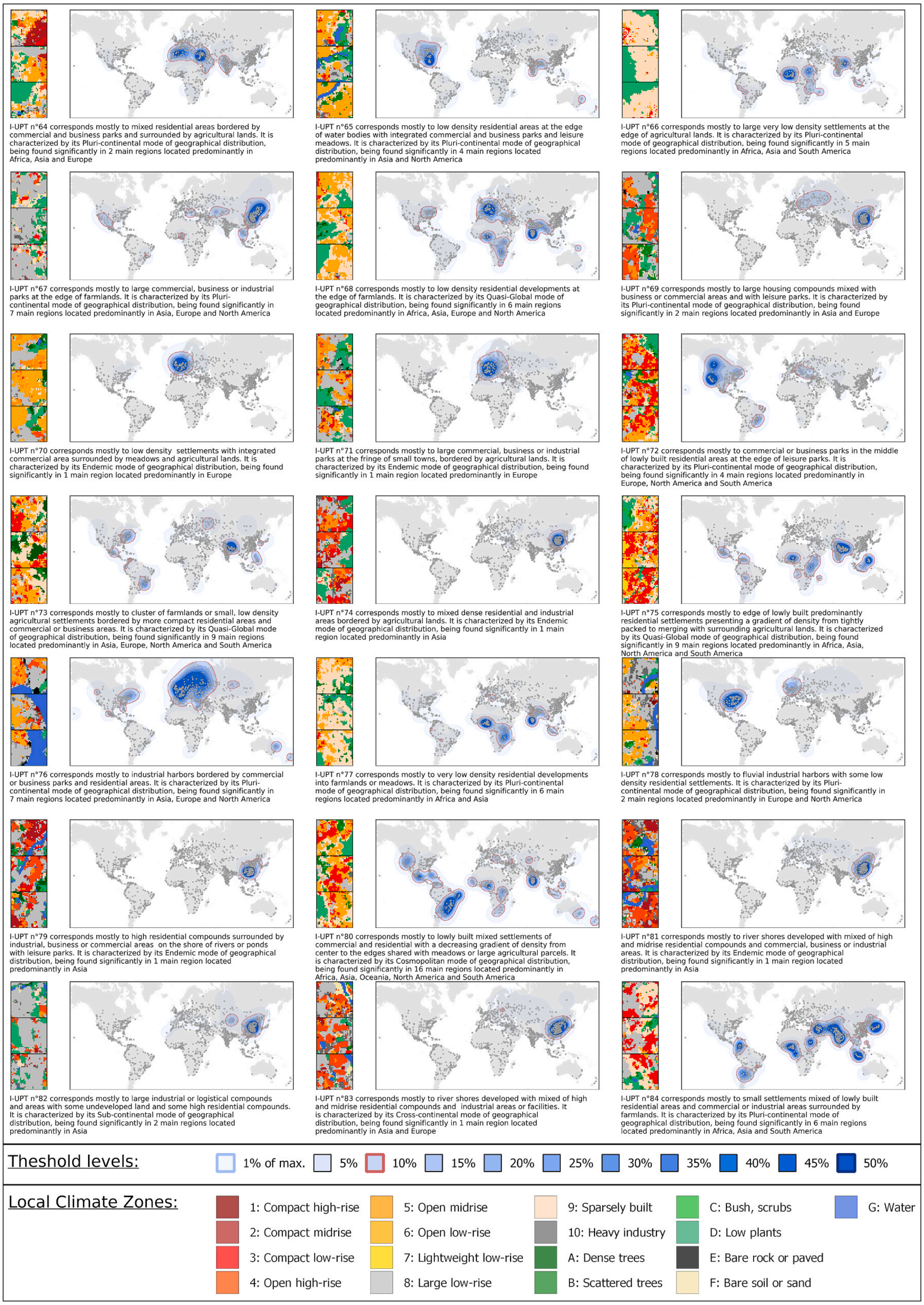
I-UPT n°63 corresponds mostly to compact low settlements with a part of makeshift habitations around industrial areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 4 main regions located predominantly in Asia, North America and South America

Theshold levels: 1% of max. 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%

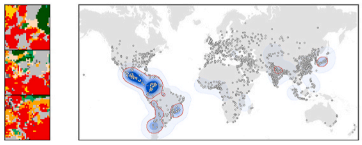
Local Climate Zones:

1: Compact high-rise
2: Compact midrise
3: Compact low-rise
4: Open high-rise
5: Open midrise
6: Open low-rise
7: Lightweight low-rise
8: Large low-rise
9: Sparsely built
10: Heavy industry
A: Dense trees
B: Scattered trees
C: Bush, scrubs
D: Low plants
E: Bare rock or paved
F: Bare soil or sand
G: Water

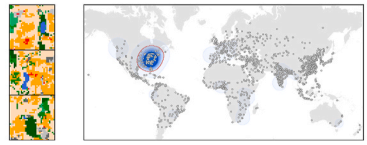
Appendix A4I-UPTs 64-84



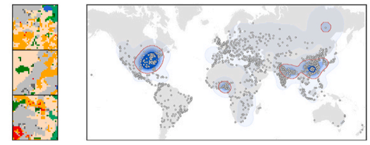
Appendix A5I-UPTs 85-105



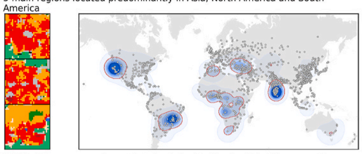
I-UPT n°85 corresponds mostly to tightly and lowly built residential areas surrounding industrial areas or commercial or business parks at the edge of forests and meadows or leisure parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 5 main regions located predominantly in Asia, North America and South America



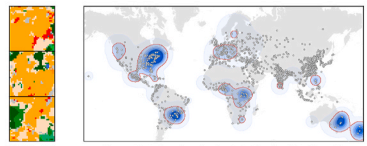
I-UPT n°86 corresponds mostly to low density and lowly built residential areas surrounding commercial or business parks at the edge of woodlands and meadows or leisure parks. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in North America



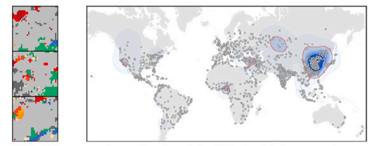
I-UPT n°87 corresponds mostly to low density and lowly built residential areas surrounding commercial or business arteries with some meadows or leisure parks. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 4 main regions located predominantly in Africa, Asia, Europe and North America



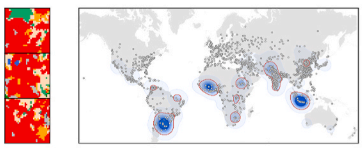
I-UPT n°88 corresponds mostly to lowly built mixed residential areas with some small commercial or business areas bordered by meadows, leisure parks or agricultural lands. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 9 main regions located predominantly in Africa, Asia, North America and South America



I-UPT n°89 corresponds mostly to low density, lowly built mixed residential areas with some small commercial or business areas and some leisure parks or woodlands. It is characterized by its Cosmopolitan mode of geographical distribution, being found significantly in 10 main regions located predominantly in Africa, Europe, Oceania, North America and South America

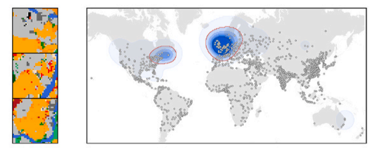


I-UPT n°90 corresponds mostly to large industrial or logistical compounds and areas with some undeveloped land and some compact and lowly built small residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 5 main regions located predominantly in Asia and Europe

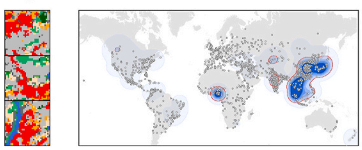


I-UPT n°91 corresponds mostly to compact residential areas with some scattered fringes at the edges of meadows or leisure parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 10 main regions located predominantly in Africa, Asia and South America

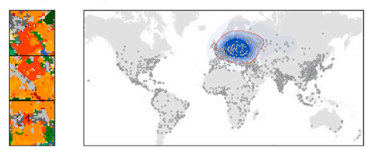
I-UPT n°92 corresponds mostly to industrial, business or commercial areas bordered by high density residential settlements with some agricultural lands or meadows. It is characterized by its Sub-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia



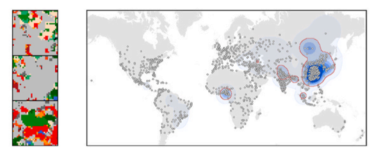
I-UPT n°93 corresponds mostly to low density residential neighborhood on canals or riversides with commercial parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Europe and North America



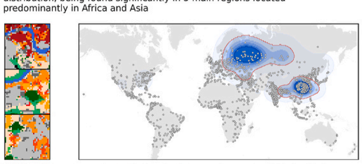
I-UPT n°94 corresponds mostly to predominantly industrial areas mixed with some dense lowly built residential areas with some agricultural lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 5 main regions located predominantly in Africa and Asia



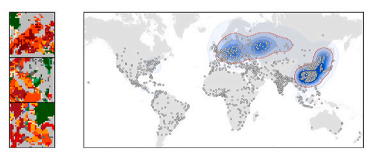
I-UPT n°95 corresponds mostly to residential compounds of mixed heights mixed with commercial, business or industrial areas and some leisure parks. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Europe



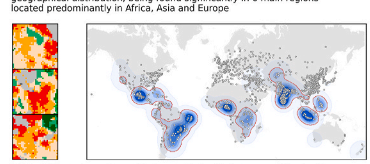
I-UPT n°96 corresponds mostly to large industrial or logistical compounds and areas with some compact and lowly built small residential areas and some leisure parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Africa, Asia and Europe



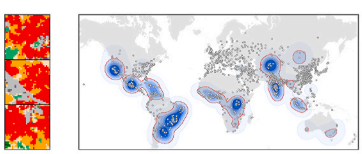
I-UPT n°97 corresponds mostly to mixed areas of commercial, industrial or business areas and diverse residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe



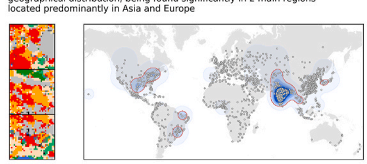
I-UPT n°98 corresponds mostly to mixed areas of commercial, industrial or business areas and highly built with mixed densities residential areas with some woodlands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia and Europe



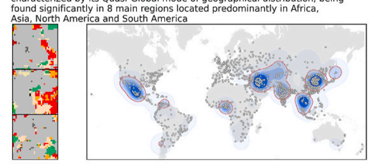
I-UPT n°99 corresponds mostly to small industrial, commercial or business parks bordered by lowly built residential areas with decreasing density from core to outskirts mixing with meadows or farmlands. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia, North America and South America



I-UPT n°100 corresponds mostly to lowly built residential areas of mixed densities bordered by some industrial, commercial or business areas and some leisure parks or meadows. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 10 main regions located predominantly in Africa, Asia, North America and South America



I-UPT n°101 corresponds mostly to lowly built residential compounds around scattered small industrial areas with some agricultural lands. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 5 main regions located predominantly in Asia, North America and South America



I-UPT n°102 corresponds mostly to large industrial or logistical compounds and areas with some undeveloped land and some lowly built small residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia and North America

I-UPT n°103 corresponds mostly to large strips of commercial or business parks in the middle of low density, lowly built residential areas with small leisure parks. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in North America

I-UPT n°104 corresponds mostly to low density, lowly built residential areas with small leisure parks around strips of commercial or business areas. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in North America

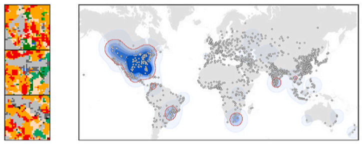
I-UPT n°105 corresponds mostly to large compact midrise predominantly residential areas with some commercial or business areas. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Africa, Asia and Europe

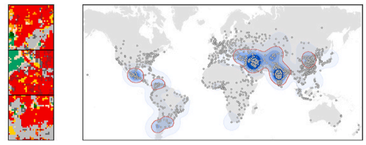
Theshold levels: 1% of max. 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%

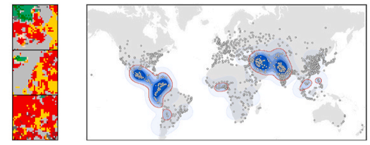
Local Climate Zones:

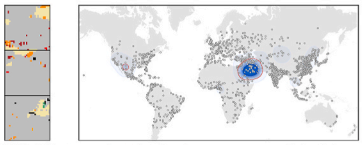
1: Compact high-rise
2: Compact midrise
3: Compact low-rise
4: Open high-rise
5: Open midrise
6: Open low-rise
7: Lightweight low-rise
8: Large low-rise
9: Sparsely built
10: Heavy industry
A: Dense trees
B: Scattered trees
C: Bush, scrubs
D: Low plants
E: Bare rock or paved
F: Bare soil or sand
G: Water

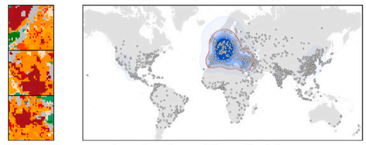
Appendix A6I-UPTs 106-126

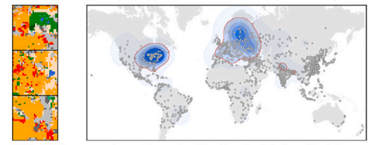

I-UPT n°106 corresponds mostly to mixed densities, lowly built residential areas with small leisure parks around strips of commercial or business areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in North America and South America

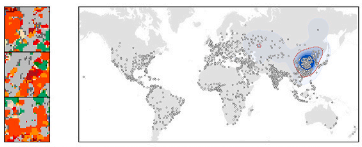

I-UPT n°107 corresponds mostly to compact mix layout with inner industrial areas. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 5 main regions located predominantly in Asia, Europe, North America and South America

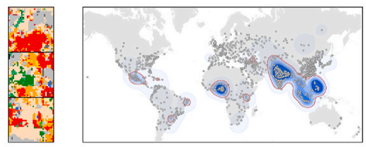

I-UPT n°108 corresponds mostly to tightly packed residential areas bordering or mixed with industrial areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Asia, North America and South America

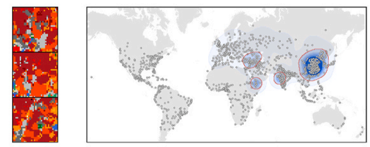

I-UPT n°109 corresponds mostly to large homogeneous areas of industrial, commercial or business compounds. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Africa, Asia and North America

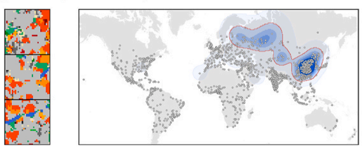

I-UPT n°110 corresponds mostly to dense midrise residential areas surrounded by less dense midrise and lowly built areas bordered by commercial or business parks. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Africa, Asia and Europe

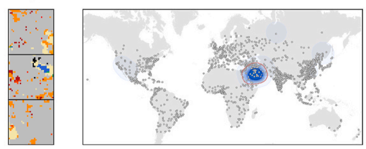

I-UPT n°111 corresponds mostly to mixed densities, lowly built residential areas around commercial or business parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia, Europe and North America

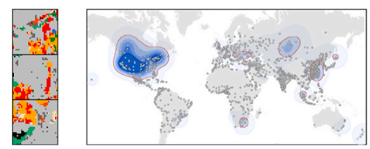

I-UPT n°112 corresponds mostly to mixed densities, midrise residential areas around commercial or business parks and with some leisure parks. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia and Europe

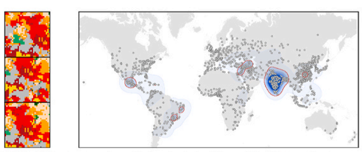

I-UPT n°113 corresponds mostly to compact low settlements at the edges of farmlands mixed with logistic centers and industrial areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia and North America

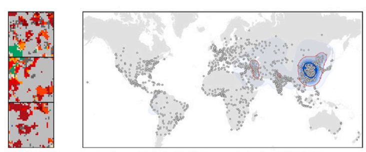

I-UPT n°114 corresponds mostly to mixed areas of high-rise and midrise compounds with compact midrise areas bordering industrial areas. It is characterized by its Sub-continental mode of geographical distribution, being found significantly in 4 main regions located predominantly in Asia

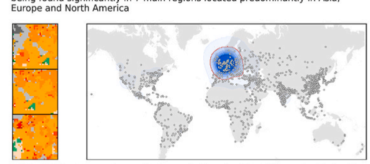

I-UPT n°115 corresponds mostly to industrial areas with midrise residential compounds. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia and Europe

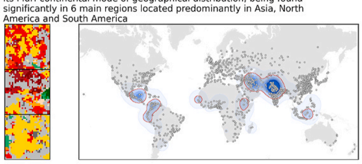

I-UPT n°116 corresponds mostly to low residential compounds in arid context. It is characterized by its Cross-continental mode of geographical distribution, being found significantly in 1 main region located predominantly in Africa and Asia

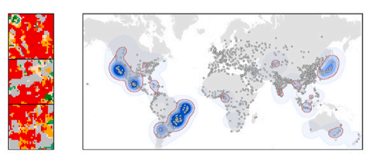

I-UPT n°117 corresponds mostly to industrial, commercial or business areas bordered by mixed densities lowly built residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 7 main regions located predominantly in Asia, Europe and North America

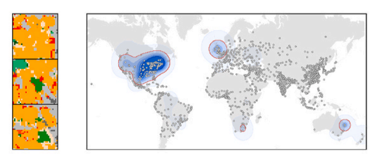

I-UPT n°118 corresponds mostly to mixed densities residential areas from tightly packed to low density bordering facilities or industrial or business areas with some leisure parks or meadows. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Asia, North America and South America

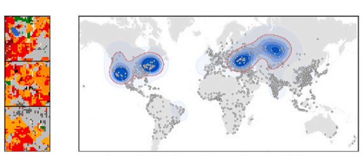

I-UPT n°119 corresponds mostly to industrial areas mixed with high-rise residential compounds and dense midrise residential areas. It is characterized by its Sub-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia

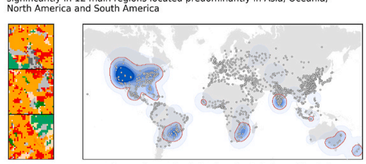

I-UPT n°120 corresponds mostly to mostly low density settlements of mixed low and medium heights around commercial or business area. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Europe


I-UPT n°121 corresponds mostly to very dense mixed layout around industrial facilities. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 6 main regions located predominantly in Africa, Asia, North America and South America


I-UPT n°122 corresponds mostly to compact low residential areas around commercial and business parks with some leisure parks. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 12 main regions located predominantly in Asia, Oceania, North America and South America


I-UPT n°123 corresponds mostly to strips and areas of commercial or business parks in the middle of low density, lowly built residential areas with small leisure parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 4 main regions located predominantly in Europe and North America


I-UPT n°124 corresponds mostly to strips and areas of commercial or business parks in the middle of highly mixed density, lowly built residential areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 2 main regions located predominantly in Asia, Europe and North America

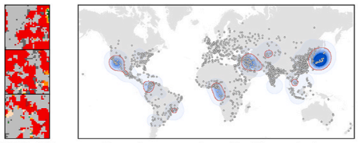

I-UPT n°125 corresponds mostly to mixed density, lowly built residential areas with commercial or business parks and some leisure parks. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Oceania, North America and South America


I-UPT n°126 corresponds mostly to large strips of commercial or business parks mixed with diversely compact residential areas of mixed heights. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia, Europe and North America

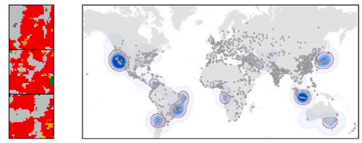
Theshold levels: 1% of max. 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%

Local Climate Zones: 1: Compact high-rise; 2: Compact midrise; 3: Compact low-rise; 4: Open high-rise; 5: Open midrise; 6: Open low-rise; 7: Lightweight low-rise; 8: Large low-rise; 9: Sparsely built; 10: Heavy industry; A: Dense trees; B: Scattered trees; C: Bush, scrubs; D: Low plants; E: Bare rock or paved; F: Bare soil or sand; G: Water

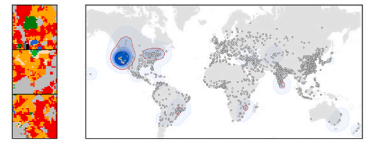
Appendix A7I-UPTs 127-138



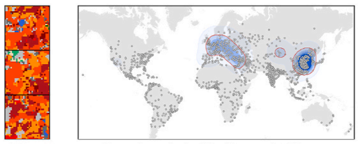
I-UPT n°127 corresponds mostly to compact low residential areas in the middle of industrial, commercial or business areas. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia, North America and South America



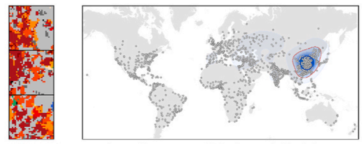
I-UPT n°128 corresponds mostly to compact low residential areas bordering strips and areas of industrial, commercial or business parks. It is characterized by its Cosmopolitan mode of geographical distribution, being found significantly in 9 main regions located predominantly in Africa, Asia, Oceania, North America and South America



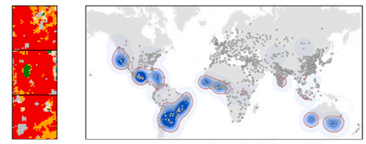
I-UPT n°129 corresponds mostly to lowly built residential areas of mixed density bordering strips and areas of industrial, commercial or business parks. It is characterized by its Sub-continental mode of geographical distribution, being found significantly in 5 main regions located predominantly in North America



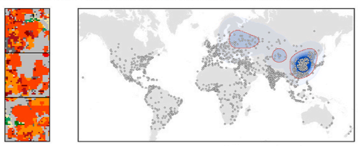
I-UPT n°130 corresponds mostly to mixed residential areas of midrise compact parts and of midrise and high-rise compounds mixed with some small scattered commercial, business or industrial parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia and Europe



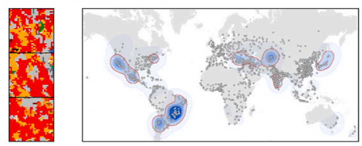
I-UPT n°131 corresponds mostly to commercial, business or industrial areas bordering or mixed with mixed residential areas of midrise compact parts and of midrise and high-rise compounds. It is characterized by its Endemic mode of geographical distribution, being found significantly in 1 main region located predominantly in Asia



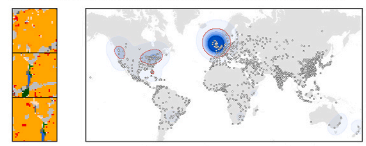
I-UPT n°132 corresponds mostly to compact low residential areas with some lower density parts and with some small areas of facilities or commercial, business or industrial parks. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 9 main regions located predominantly in Africa, Oceania, North America and South America



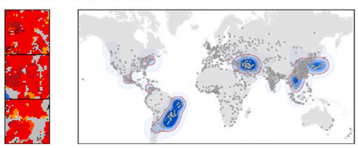
I-UPT n°133 corresponds mostly to mixed residential areas of midrise and high-rise compounds mixed with industrial, commercial or business areas. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Asia and Europe



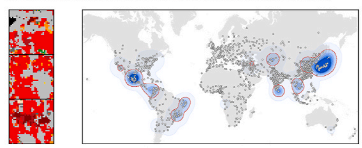
I-UPT n°134 corresponds mostly to mostly compact lowly built residential areas mixed with lower densities density bordering areas of industrial, commercial or business parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Asia, North America and South America



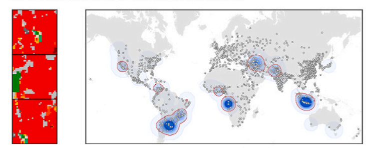
I-UPT n°135 corresponds mostly to low density, lowly built residential areas around thin strips of commercial or business areas and with some leisure parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 3 main regions located predominantly in Europe and North America



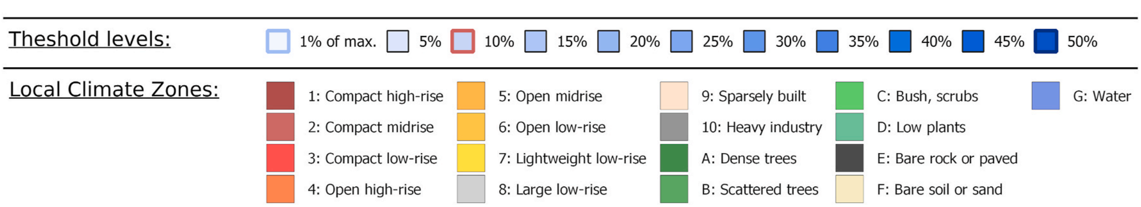
I-UPT n°136 corresponds mostly to compact-low residential areas with thin stripes or small areas of higher buildings and mixed with areas of commercial, business or industrial parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 6 main regions located predominantly in Asia, North America and South America



I-UPT n°137 corresponds mostly to compact-low residential areas mixed with small areas of higher buildings and with commercial, business or industrial parks. It is characterized by its Pluri-continental mode of geographical distribution, being found significantly in 8 main regions located predominantly in Asia, North America and South America

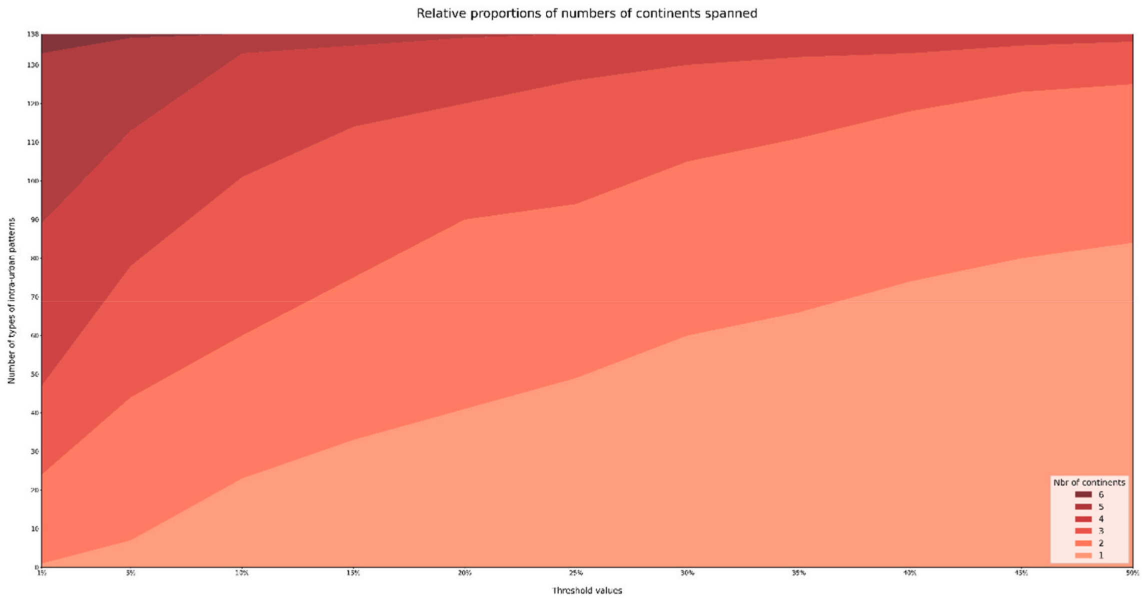


I-UPT n°138 corresponds mostly to compact-low residential areas with thin stripes of commercial, business or industrial parks. It is characterized by its Quasi-Global mode of geographical distribution, being found significantly in 8 main regions located predominantly in Africa, Asia, North America and South America

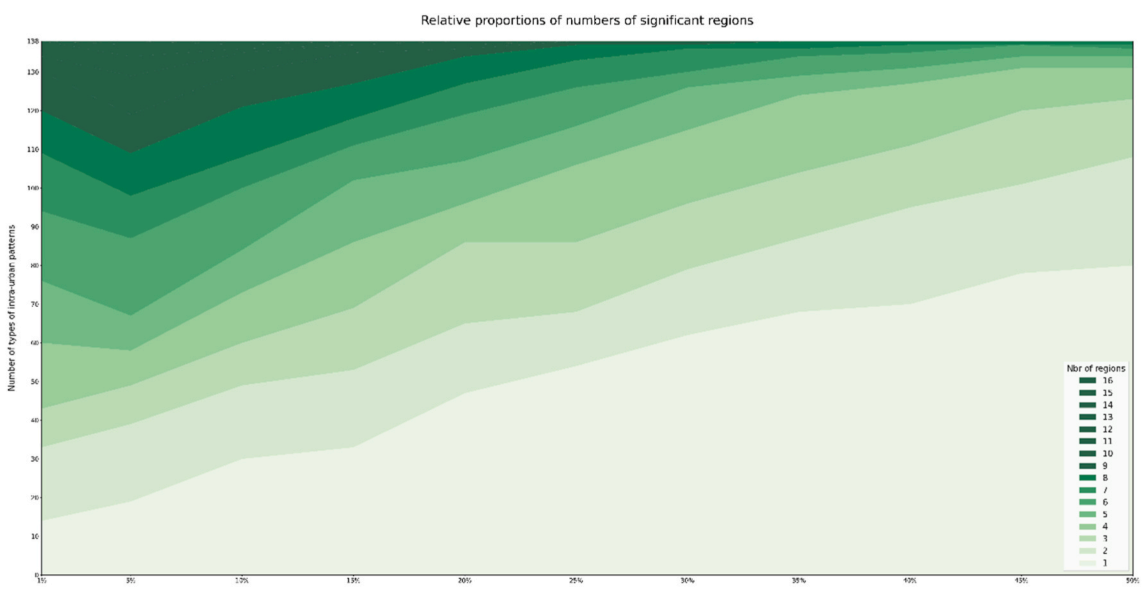


Appendix B. Results of the analysis across different levels of threshold

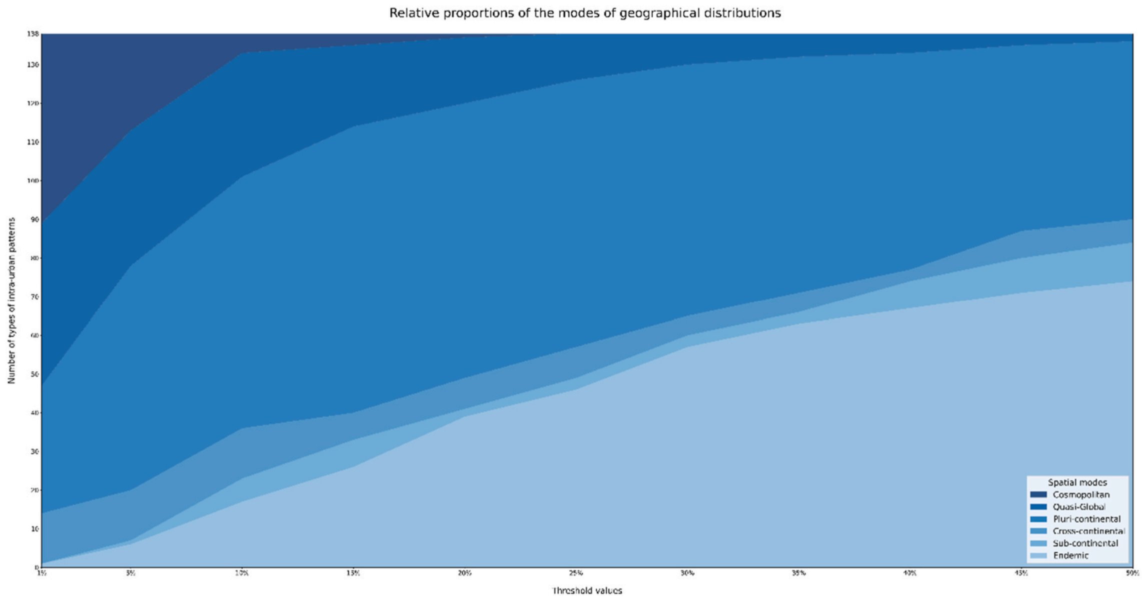
Appendix B1Effects of the threshold level on the estimated number of continents spanned



Appendix B2Effects of the threshold level on the estimated number of incontiguous regions



Appendix B3. :Effects of the threshold level on the estimated mode of geographical distribution



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