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ASSESSING MICROSCALE ENVIRONMENTAL CHANGES: CORINE VS. THE URBAN ATLAS

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Abstract. Applying geostatistical approaches to spatial data is a common method for assessing the transitional dynamics of land cover and use changes induced by human activities. However, the relevance of results depends largely on the quality of data. CORINE data have showed their utility in assessing long term changes at the macro-scale, but their use at the micro-scale is impeded by the spatial resolution and changes in the methodology of obtaining them. Recently, new data from the Urban Atlas were provided at a greater resolution for urban areas. In an attempt to assess their potential for analyzing transitional dynamics at the micro-scale, this paper compared the two data sets using the case study of Bucharest. The results indicate that the Urban Atlas does a better job in surprising the fragmentation of land in urban areas, and providing the real extent of specific features diminished by CORINE.

Introduction

The importance of land cover and landuse changes results from the fact that, as a component of global changes (Dale, Virginia H. *et al*., 2011), they reflect the anthropogenic impacts on the environment, especially those induced by socio-economic drivers (Petrişor *et al*., 2010b), and particularly those resulting from the competition for space (Petrişor, 2012). In general, land cover reflects the biophysical coverage, while land use shows how land is used by human communities (Jensen, 2000), or provides a fine-tuned classification of natural systems (Petrişor *et al*., 2010b).

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In order to asses land cover and use and their changes, the European Union uses CORINE Land Cover and Use classification, consisting of three levels (de Lima, 2005). Generally the first level corresponds to land cover, whilst the second and third detail it into land uses (Petrişor *et al.*, 2014). Given the need for a detailed mapping of a whole continent using a unitary methodology, the process of generating new data takes 5-10 years. There are three CORINE data sets (available for 1990, 2000, and 2006). Due to the time covered and spatial resolution – minimum mapping unit of 25 hectare and minimum width of linear elements of 100 meters (Hagenauer and Helbich, 2012), they are useful for describing long term structural changes of ecological complexes (Petrişor *et al.*, 2010b, 2014), but not necessarily at the micro-scale, due to limitations including, without limiting to, misclassification or use of different classification schemes or resolutions during the different periods, resulting into some classes that appear or disappear from one period to another (Jansen, 2007; Pelorosso *et al.*, 2009; Verburg *et al.*, 2011; Petrişor *et al.*, 2014).

Since over 50% of current population lives in cities, which grow and change fast and are the main drivers of environmental changes (Lavalle *et al.*, 2002; Peptenatu *et al.*, 2010), the European Union has recently made available a new data set, the Urban Atlas, covering for the period 2005-2007 urban areas with over 100,000 inhabitants at a better resolution – linear elements with a width of 10 m and a minimum mapping unit of 0.25 ha for urban areas and 0.55 ha for non-urban areas (Hagenauer and Helbich, 2012) in order to properly assess changes occurred in urban areas.

This paper aims to employ geostatistical approaches to compare the usefulness of the two datasets in assessing specific urban features, starting from the hypothesis that, due to their spatial resolution, CORINE data tend to mask certain categories.

2. Data and methods

CORINE and Urban Atlas data are freely provided by the European Environment Agency at http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-3 and, respectively, http://www.eea.europa.eu/data-and-maps/data/urban-atlas. Data are provided in a shape file format, usable by ArcView/ArcGIS. The projection is ETRS 1989 Lambert Azimuthal Equal Area L52 M10. In order to use the data, they were re-projected to Stereo 1970 and clipped by the administrative limits of Bucharest (data owned by NIRD URBAN-INCERC).

Since the classification scheme differs for the two data sets, a common classification was generated in a two-stage iterative process: (1) classes were joined if one of the datasets provided a more detailed classification scheme, (2) if some classes were not found in one of the datasets, similar classes were merged such that the two datasets could be compared.

The total area covered by each class was computed using the X-Tools extension of ArcView 3.X, and each class was 'exploded' into separate polygons in order to assess its fragmentation using the Edit Tools (ET) extension of ArcView 3.X. The results were analyzed using the software Buser (Dragomirescu, 2003), freely available at the addresses http://projects.bioinformatics.ro/taxonomy/BUSER.zip or http://app.inthelrom.ro/histo/BUSER.zip. The program provides classification trees using the following measures, called homogeneities (Dragomirescu, 1987, 2003; Dragomirescu and Postelnicu, 1994; Petrişor *et al*., 2010a):

1. Buser's hI homogeneity (for binary tables)
2. Dragomirescu's h* homogeneity (for binary tables)
3. Dragomirescu's H* homogeneity (for tables containing positive values)
4. p(chi2) – p-value associated with a χ^2 test for contingency tables
5. Dragomirescu's M1 homogeneity (for tables containing positive values)
6. Dragomirescu's M2 homogeneity (for tables containing positive values)

In all cases, the program provides a unique solution (classification tree). The program was applied for comparing the methods, but also the classes.

In addition to it, the resulting classifications were compared using the χ^2 test of goodness of fit applied to the distributions of areas per class and number of fragments per class.

3. Results and discussion

The comparison of CORINE and the Urban Atlas data using Bucharest, Romania as an example was possible because the two data sets cover almost the same period (2006 for CORINE and 2005-2007 for the Urban Atlas). However, as it has been showed before, the two datasets use different classification schemes; the result for Bucharest is displayed in Table 1. The table has three columns; the first two correspond to the different classifications used by CORINE and the Urban Atlas, and the third column has a harmonized classification, used for further comparisons. The table shows that the Urban Atlas has an in-depth classification of urban features (*e.g.*, detailed classifications of the urban fabric by density, detailed classification of transportation networks), while CORINE provides an in-depth classification of agricultural features. This can be seen as a shortcoming of the Urban Atlas, particularly in the importance of urban agriculture in the European policies (Deelstra *et al*, 2001; Popa, Andrea and Hărmănescu, Mihaela, 2013). Another difference is that some features do not appear in all classifications, although the classes exist; continuous urban fabric and mineral extraction and dump sites appear only in the Urban Atlas, and inland marshes only in CORINE. Moreover, the

Urban Atlas introduces a new category, 'land without current use'. As a consequence of these differences, the resulting harmonized classification is poor

Tab. 1. Harmonization of the classification schemes used by CORINE and the Urban Atlas

CORINE	Urban Atlas	Final Class
	Continuous Urban Fabric (soil sealing: S.L. > 80%)	Urban fabric
Discontinuous urban fabric		Urban fabric
	Discontinuous Medium Density Urban Fabric (S.L.: 30% - 50%)	Urban fabric
	Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)	Urban fabric
	Isolated Structures	Urban fabric
Construction sites	Construction sites	Construction sites
Industrial or commercial units	Industrial, commercial, public, military and private units	Industrial or commercial units
Airports	Airports	Airports
Road and rail networks and associated land		Road and rail networks
	Fast transit roads and associated land	Road and rail networks
	Other roads and associated land	Road and rail networks
	Railways and associated land	Road and rail networks
	Mineral extraction and dump sites	Industrial or commercial units
Sport and leisure facilities	Sport and leisure facilities	Sport and leisure facilities
Green urban areas	Green urban areas	Green urban areas
Complex cultivation patterns		Agricultural land
Pastures		Agricultural land
Fruit trees and berry plantations		Agricultural land
Non-irrigated arable land		Agricultural land
Land principally occupied by agriculture, with significant areas of natural vegetation	Agricultural + Semi-natural areas + Wetlands	Agricultural land
	Land without current use	Agricultural land
Broad-leaved forest	Forests	Forests
Water bodies	Water bodies	Water bodies and wetlands
Inland marshes		Water bodies and wetlands

and generalized, as it lacks the details of each classification scheme, since they cannot be found in the other one.

Table 2 shows the results of applying the harmonized classification scheme to the two datasets. For each one, the table indicates the number of parcels for each class, their total area, and the share of the total area from the total surface of Bucharest. In addition to them, the last column shows the percentage represented by each Urban Atlas class from the CORINE total area of the same class.

Tab. 2. Comparison between the CORINE and the Urban Atlas classes in Bucharest, Romania

Land use class	CORINE			Urban Atlas			Urban Atlas / CORINE (%)
	No. parcels	Area (km^2)	% total area	No. parcels	Area (km^2)	% total area	
Urban fabric	10	128.54	52.18	5544	86.67	35.18	67.42
Construction sites	1	0.32	0.13	91	2.72	1.11	843.03
Industrial or commercial units	31	27.28	11.07	1178	52.61	21.36	192.88
Airports	1	2.03	0.82	1	1.68	0.68	82.94
Road and rail networks	1	4.66	1.89	35	17.26	7.01	370.62
Sport and leisure facilities	7	2.32	0.94	106	3.84	1.56	165.29
Green urban areas	16	10.59	4.30	272	11.09	4.50	104.72
Total urban classes	*67*	*175.74*	*248.88*	*7227*	*175.87*	*249.56*	*100.07*
Agricultural land	37	51.67	20.97	473	52.25	21.21	101.12
Forests	7	6.61	2.68	24	6.95	2.82	105.13
Water bodies and wetlands	10	12.33	5.01	63	11.28	4.58	91.47

The results are, at a first glance, surprising. Despite of identifying more urban fabric classes, the Urban Atlas identifies a total surface representing 2/3 of the one identified by CORINE, but finds approximately 8.5 times more construction sites, 2 times more industrial or commercial units, and almost 4 times more road and rail infrastructure, although their total area is reduced. It is interesting to see that the differences occur only among the urban classes, as the total for the four wide classes (urban, agricultural, forest and waters or wetlands) is very similar. This remark is visible in Fig. 1, displaying Bucharest as seen by the two data sets, and in Fig. 2, using a sample area to show the micro-scale differences.

The results indicate that, due to their resolution, CORINE data tend to generalize features, acting as a ‘majority’ filter (Jensen, 1996). As a result, sparse small features (such as construction sites, industrial or commercial facilities, sport and leisure facilities or transport infrastructure) tend to be underestimated by CORINE, in the detriment of urban fabric, which tends to be overestimated. These statements are supported by Table 2 and Fig. 1. However, Fig. 2 shows important differences at the micro-scale, such as the expansion of the green area close to the lake, of the railroad and of the continuous urban fabric, and also the elimination of another small lake, construction sites, commercial or industrial units by CORINE data. These are not general trends, and the overall situation tends to compensate, as Table 2 and Fig. 1 indicate.

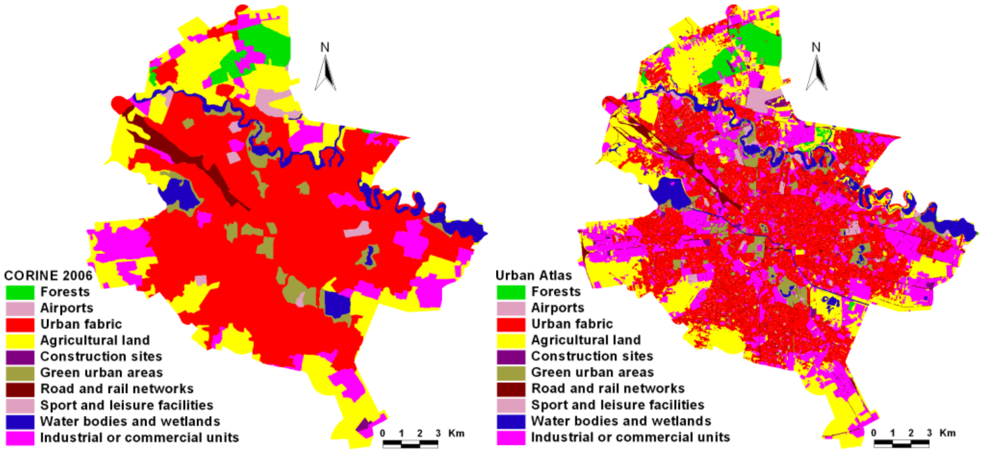


Fig. 1. View of Bucharest, Romania using CORINE (left) and the Urban Atlas (right)

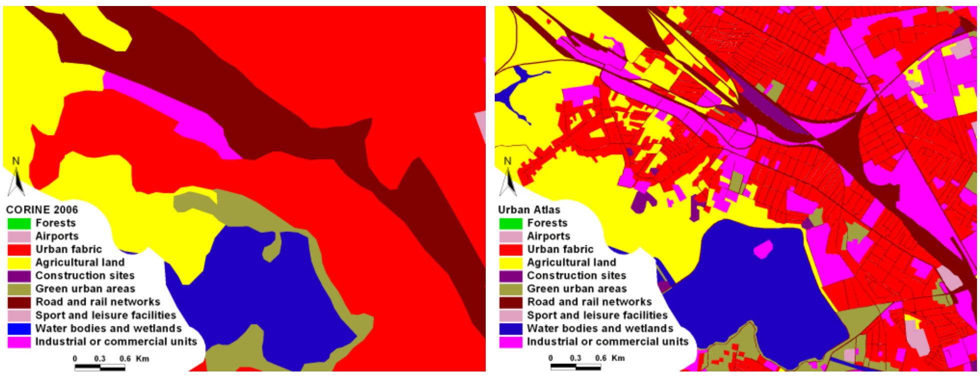
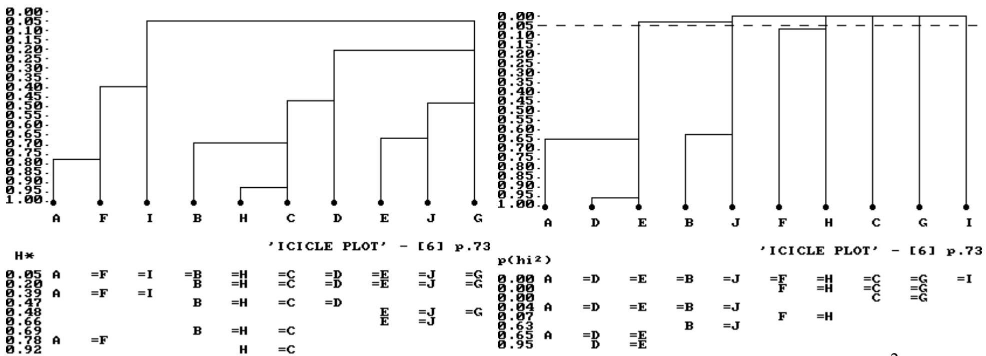


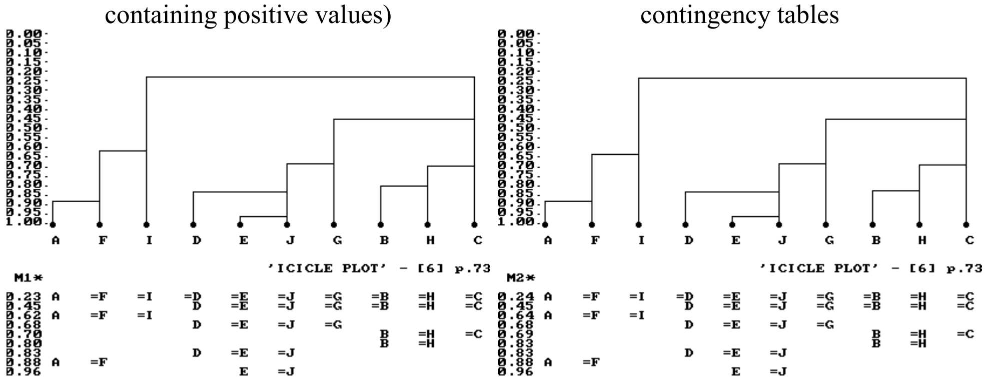
Fig. 2. View of a sample area in Bucharest, Romania using CORINE (left) and the Urban Atlas (right)

The results of using Buser to compare the two datasets show very important differences: hI = 1, h* = 1, H* = 0.72, M1* = 0.85, M2* = 0.84, and $p(\chi^2) = 0$. They are supported by the values of the χ^2 test of goodness of fit: 90.30 when comparing the surfaces and 3,125,166.66 when looking at the number of parcel per feature; in each case, $p \leq 0.001$ indicated very significant differences. Particularly the second result indicates that Urban Atlas does an excellent job in pinpointing the fragmentation of land in urban areas (Herold *et al*., 2002; Nagendra *et al*., 2004; Irwin, Elena and Bockstael, Nancy, 2007).



Dragomirescu's H*homogeneity (for tables containing positive values)

p(chi2) – p-value associated with a χ^2 test for contingency tables



Dragomirescu's M1 homogeneity (for tables containing positive values)

Dragomirescu's M2 homogeneity (for tables containing positive values)

Fig. 3. Comparison between CORINE and the Urban Atlas using Buser (A – agricultural land, B – airports, C – construction sites, D – forests, E – green urban areas, F – industrial or commercial units, G – road and rail networks, H – sport and leisure facilities, I – urban fabric, and J – water bodies and wetlands)

Fig. 3 shows the results of using Buser to compare the classes in terms of how the two methods tend to find them. Not all indices could be computed; for those computed, the results differ. However, three of the four methods identify three groups of classes: (1) agricultural land, industrial or commercial units and urban fabric, (2) airports, sport and leisure facilities, and construction sites, and (3) forests, green urban spaces, water bodies and wetlands, and road and rail networks. The other method identifies three groups – (1) agricultural land, forests and green urban areas (interestingly, forming together the green infrastructure (Benedict and McMahon, 2002; Gill *et al*., 2007); Tzoulas *et al*., 2007)), (2) airports and water bodies and wetlands, and (3) industrial or commercial units and sport and leisure facilities, and in addition to these places each remaining class in a separate group.

Conclusions

The study aimed to compare CORINE and the Urban Atlas using Bucharest, Romania as a case study, hypothesizing that the first dataset is the result of an approach working as a 'majority' filter. The underlying hypothesis was confirmed only partially, meaning that both methods provide similar results in terms of land cover, but differ in terms of land use. When looking at land use classes, statistically significant differences show that the Urban Atlas 'sees' small and sparse features better than CORINE. Other important differences appear in the classification schemes; the Urban Atlas offers an in-depth classification of urban features, but not of the agricultural ones, which can acquire urban relevance with respect to urban agriculture. In addition to having a more detailed classification for non-urban features, CORINE data cover more periods and allow for comparisons, under the caveats of resolution and different methodologies in obtaining the data. If the Urban Atlas data are obtained often, they can become an important instrument for pinpointing urban changes at their appropriate temporal and spatial scales.

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