



Cartography M.Sc.

Analysing the Potential of Network Kernel Density Estimation for the Study of Tourism based on Geosocial Media Data

Marko Tošić

1. Introduction and Motivation
2. Research questions and objectives
3. Literature review
4. Methodology
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6. Discussion and Conclusion

1. Introduction and Motivation

- Methods in tourism are more subjective.
- Social media has an important role in promoting tourist destinations.
- Geosocial media data can give insight into tourists' behaviour and patterns.
- Possibility of using density analyses in tourism.
- Flickr dataset of Brussels, Belgium.

2. Research questions

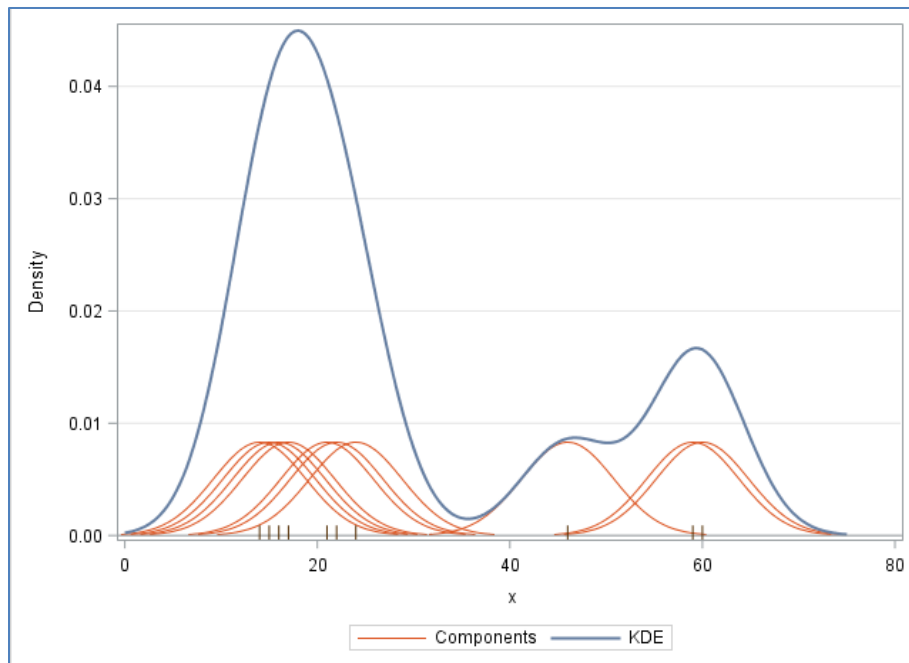
- Can the NKDE analysis of Flickr datasets be a suitable technique to identify touristic streets in a city?
- Which are the main differences in the results of an analysis based on KDE vs. NKDE?
- Which are the pros and cons of both approaches for this type of analysis?
- Is there a possibility to integrate both: KDE for areas of interest (AOIs) and NKDE for street segments of interest (SSOIs)? How would such integration look?

2. Research objectives

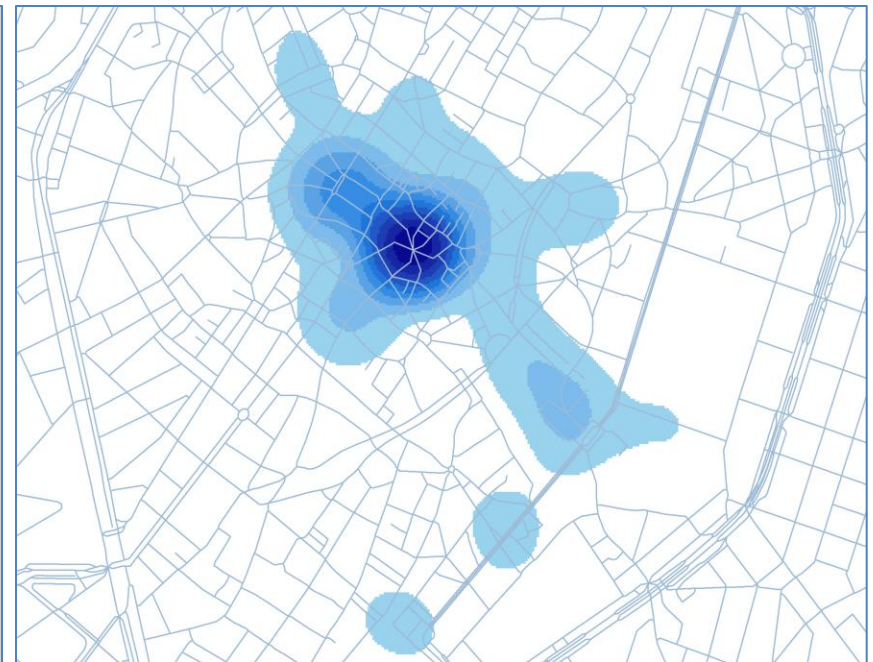
- Identify areas of interest (AOIs) and streets segments of interest (SSOIs) of Brussels based on the use of KDE and NKDE.
- Collect touristic information from different sources of Brussels and compare them with the results of the KDE and NKDE analysis.
- Determine areas of interests (AOIs) and street segments of interest (SSOIs) for visitors from different countries of origin.
- Generate city maps with tourist routes and areas of interest according to the results of previous analyses.

3. Literature review

- Kernel Density Estimation



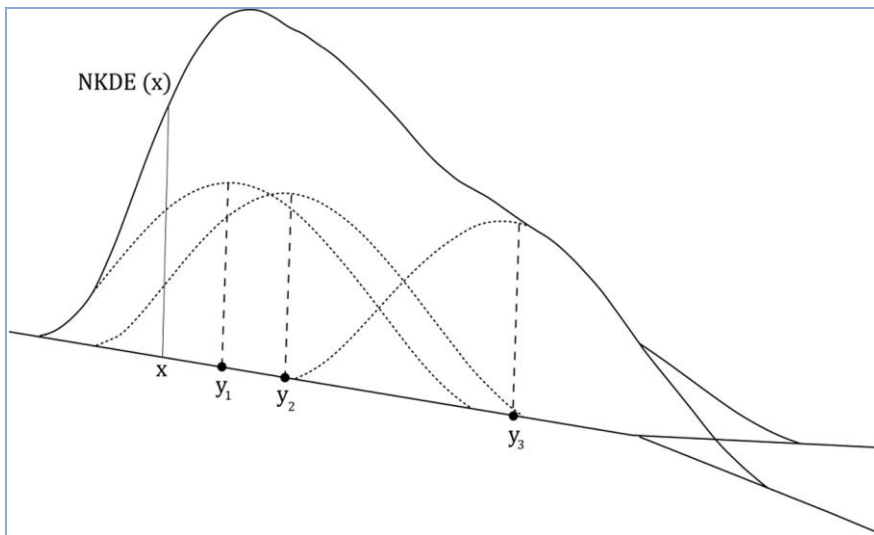
Kernel Density Estimate as Weighted Sum of Component Densities (Wicklin, 2016)



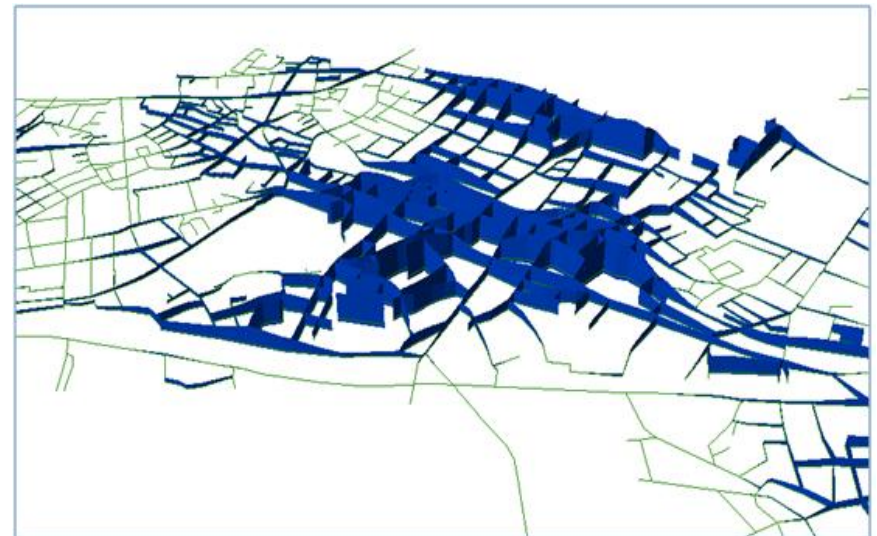
2D visualization of KDE analysis results for Brussels' city centre (Screenshot by author)

3. Literature review

- Network Kernel Density Estimation



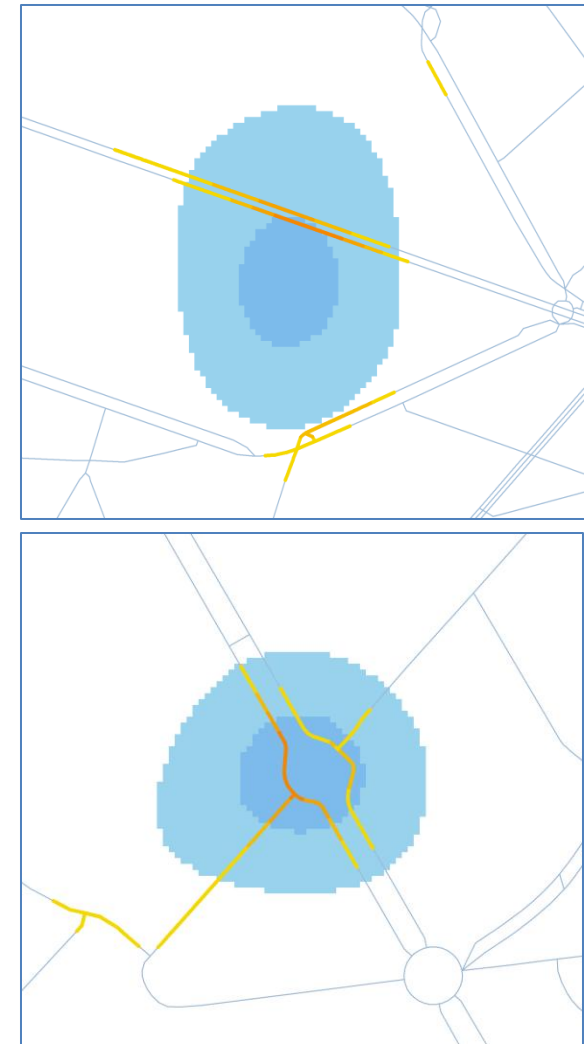
NKDE example performed with the continuous equal-split kernel function for three point events (y_i), dashed lines present the individually calculated three kernel estimations (Delso et al., 2018)



3D visualization of NKDE analysis results ("What can SANET", 2009)

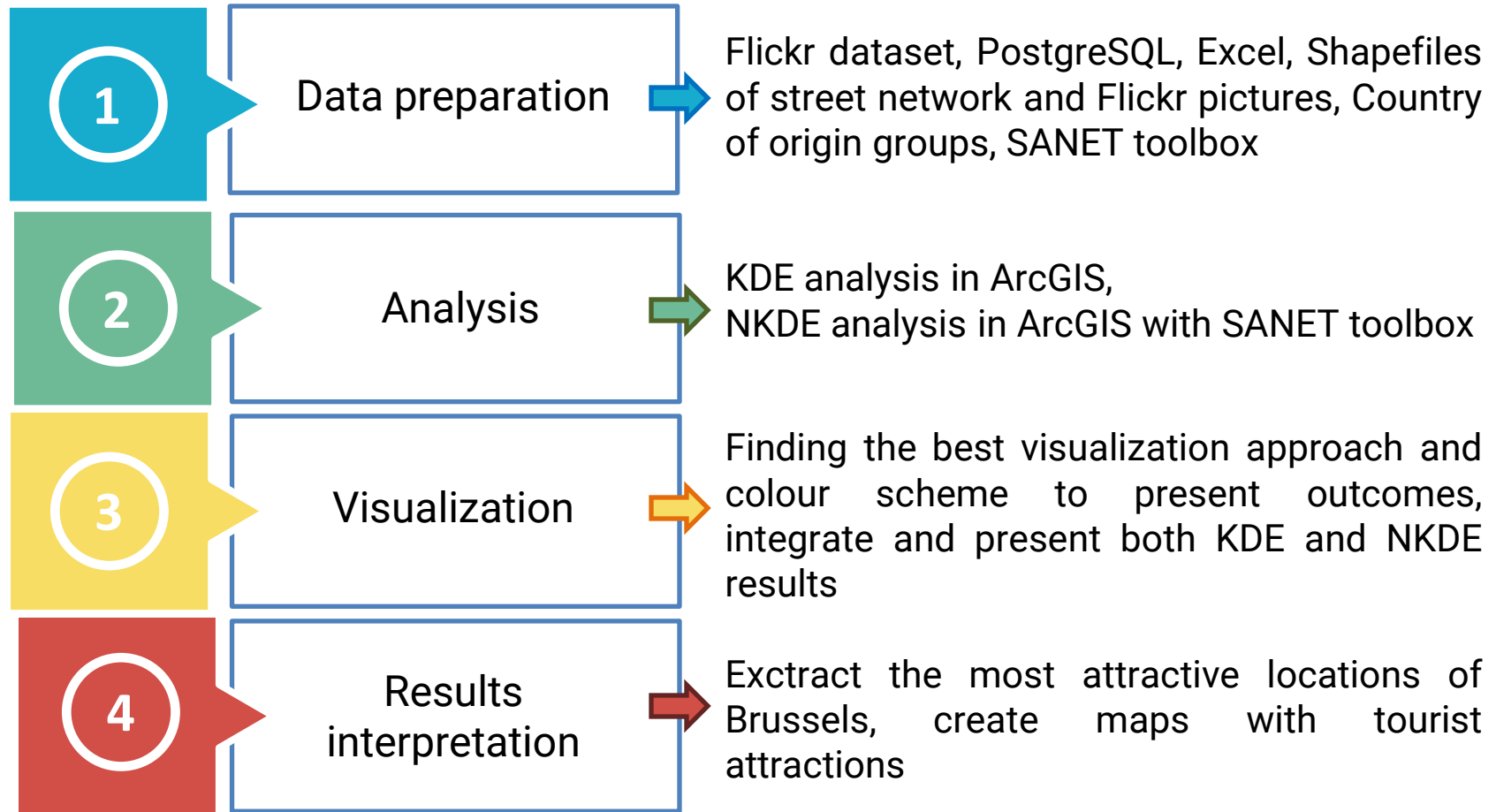
3. Literature review

- Areas of Interest (AOIs)
 - Urban environment that attract attention, formed by people's interest and behaviours, popular on social networks.
- Street Segments of Interest (SSOIs)
 - Attractive parts of streets that intrigue locals and tourists, location of popular city attractions.



Examples of AOIs and SSOIs
(Screenshot by author)

4. Methodology



4. Methodology

- Flickr dataset of Brussels-Capital Region.
- 150,002 pictures, 12,261 users.
- 9,987 users with country of origin (138,999 pictures)
- EPSG: 3857 – WGS84 Web Mercator (Auxiliary Sphere)

	photo_owner character varying (30)	agg_tags text	point geometry	country text
588	61207823@N05	be belgium ...	0101000020E61...	Spain
589	61321277@N03	brussels br...	0101000020E61...	United Ki...
590	61322060@N00		0101000020E61...	United St...
591	61322060@N00	belgium br...	0101000020E61...	United St...
592	61332108@N02		0101000020E61...	Russia
593	61340363@N05	bruxelles ta...	0101000020E61...	Ireland
594	61340363@N05		0101000020E61...	Ireland
595	61340363@N05		0101000020E61...	Ireland
596	61348943@N04	11 1182 23...	0101000020E61...	Belgium
597	61348943@N04	21 2141 21...	0101000020E61...	Belgium
598	61387758@N00	1958 1958...	0101000020E61...	Canada
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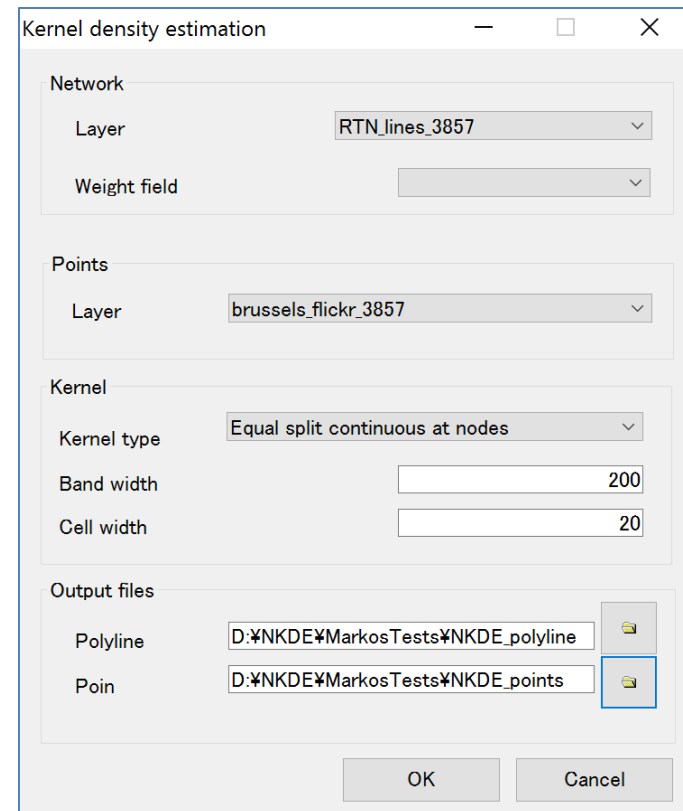
Screenshots of dataset in PgAdmin 4 and the distribution of Flickr pictures



4. Methodology

- SANET toolbox – ArcGIS-based tool that analyzes events that occur on or alongside a network (“What can SANET”, 2009).
 - Developed in Tokyo, Japan
 - 16 tools
 - Bandwidth 200 m
 - Cell width 20 m

Steps in calculating Network Kernel Density (Screenshot by author)



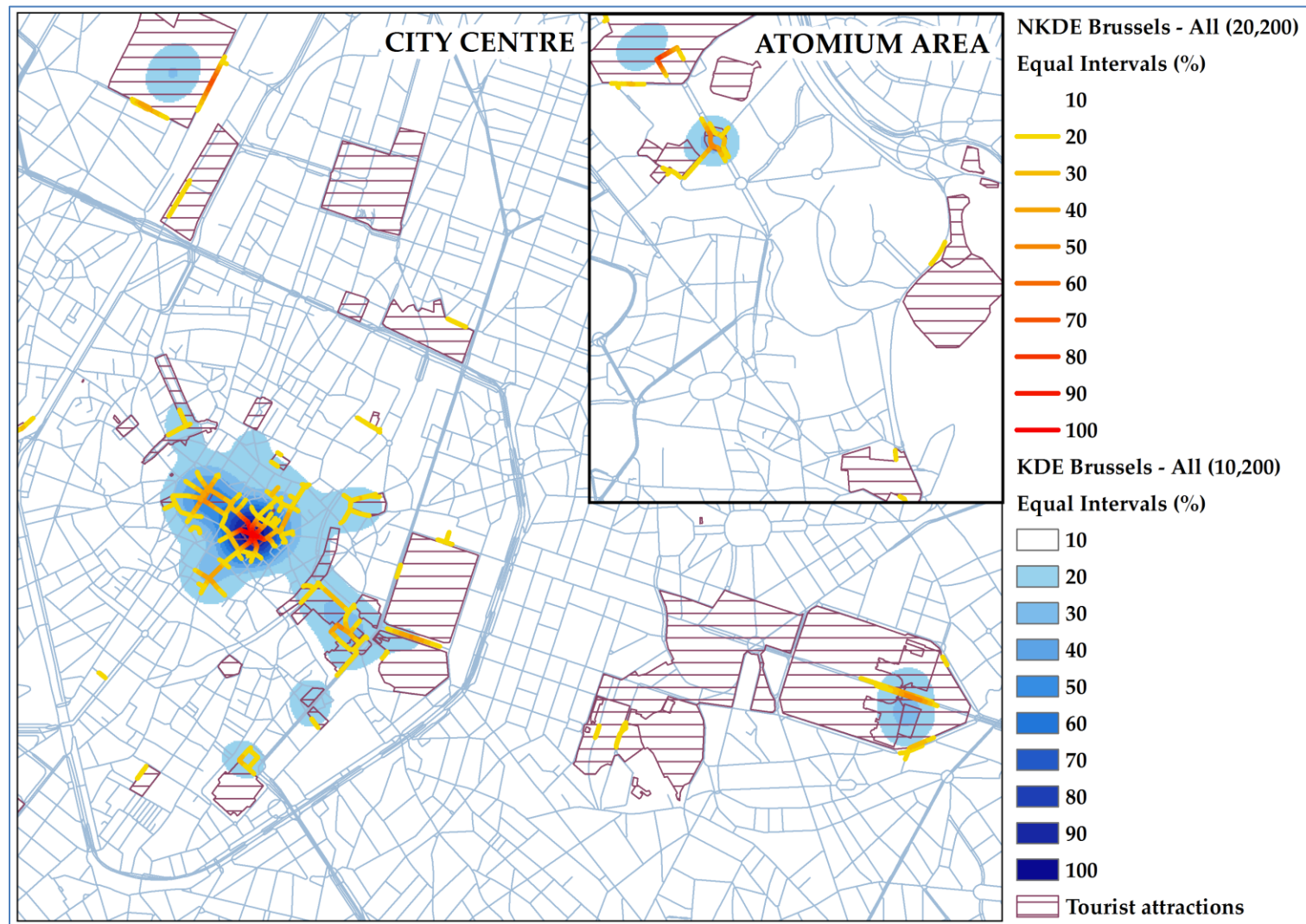
4. Methodology

- 81 Brussels' tourist attractions
 - Collected from 8 sources – official travel agency of Brussels, online travel guides, travel magazines.
- 121 countries of origin
 - 12 groups - West Europe, South Europe, Central Europe, North Europe, Southeast Europe, East Europe, Asia, Middle East, Africa, Anglo-America, Latin America, and Oceania
 - Belgium is separate (highest number of users and pictures)

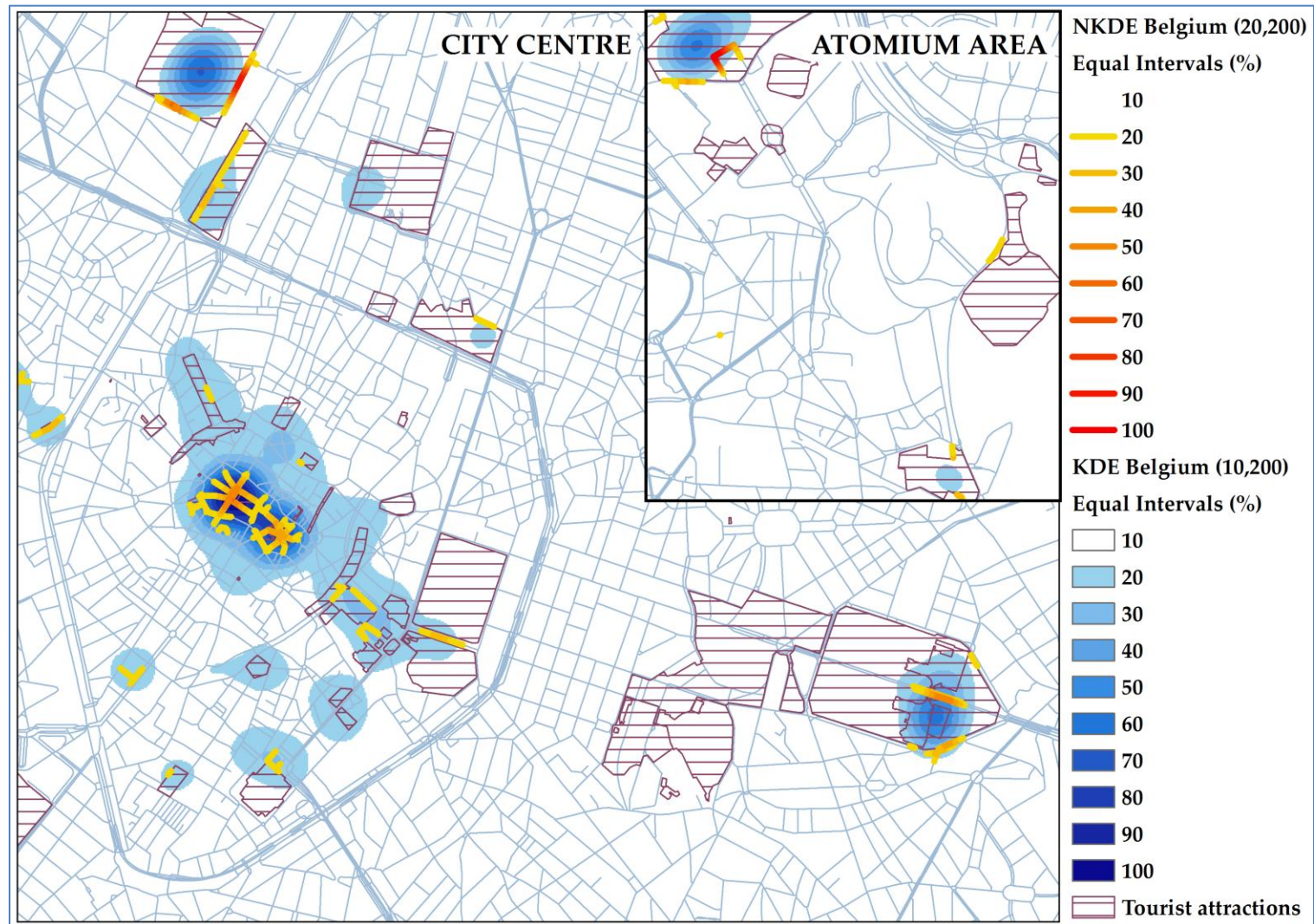
5. Results

- KDE and NKDE results (14 maps)
- Maps with tourist attractions (13 maps)

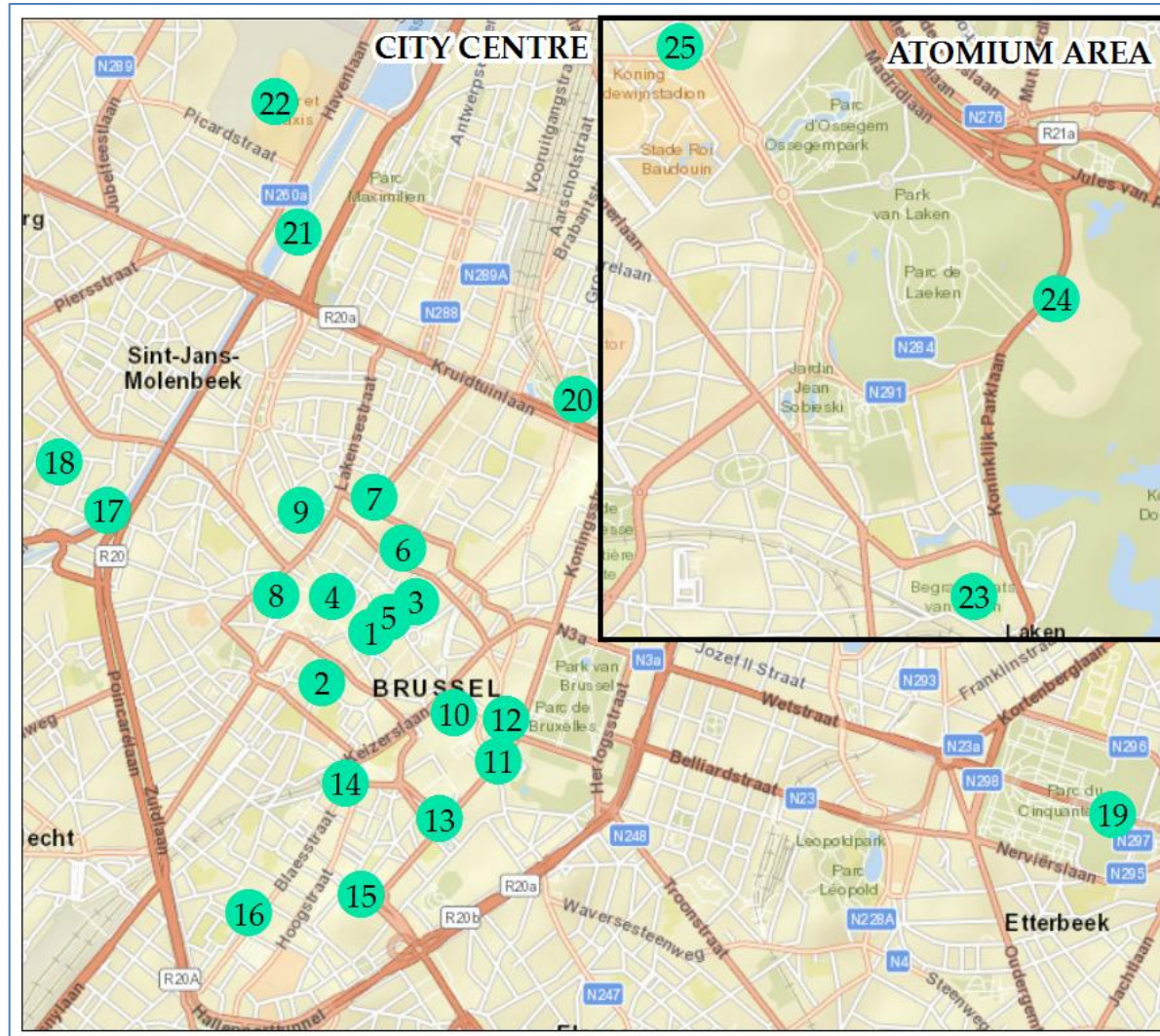
5. Results



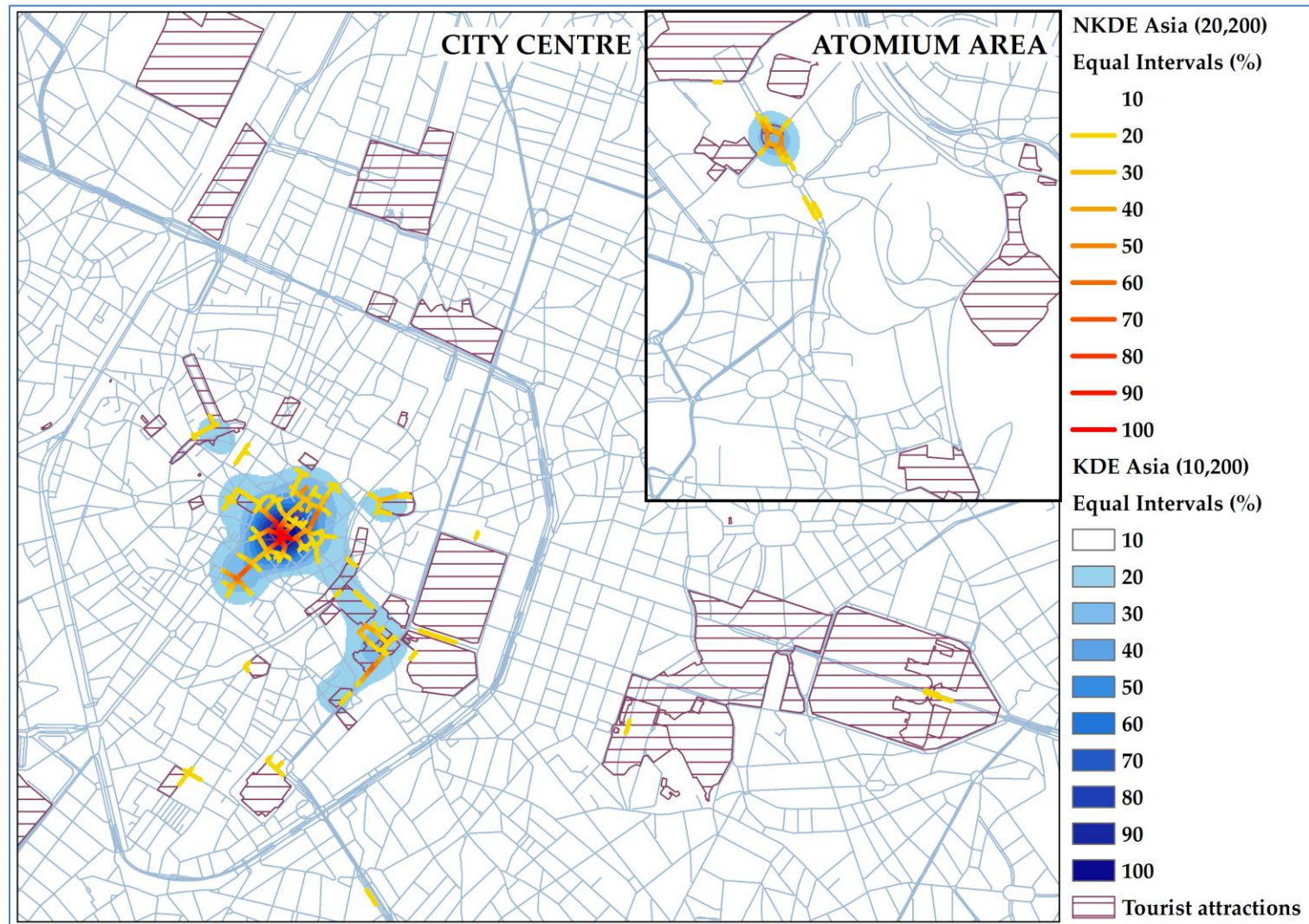
5. Results



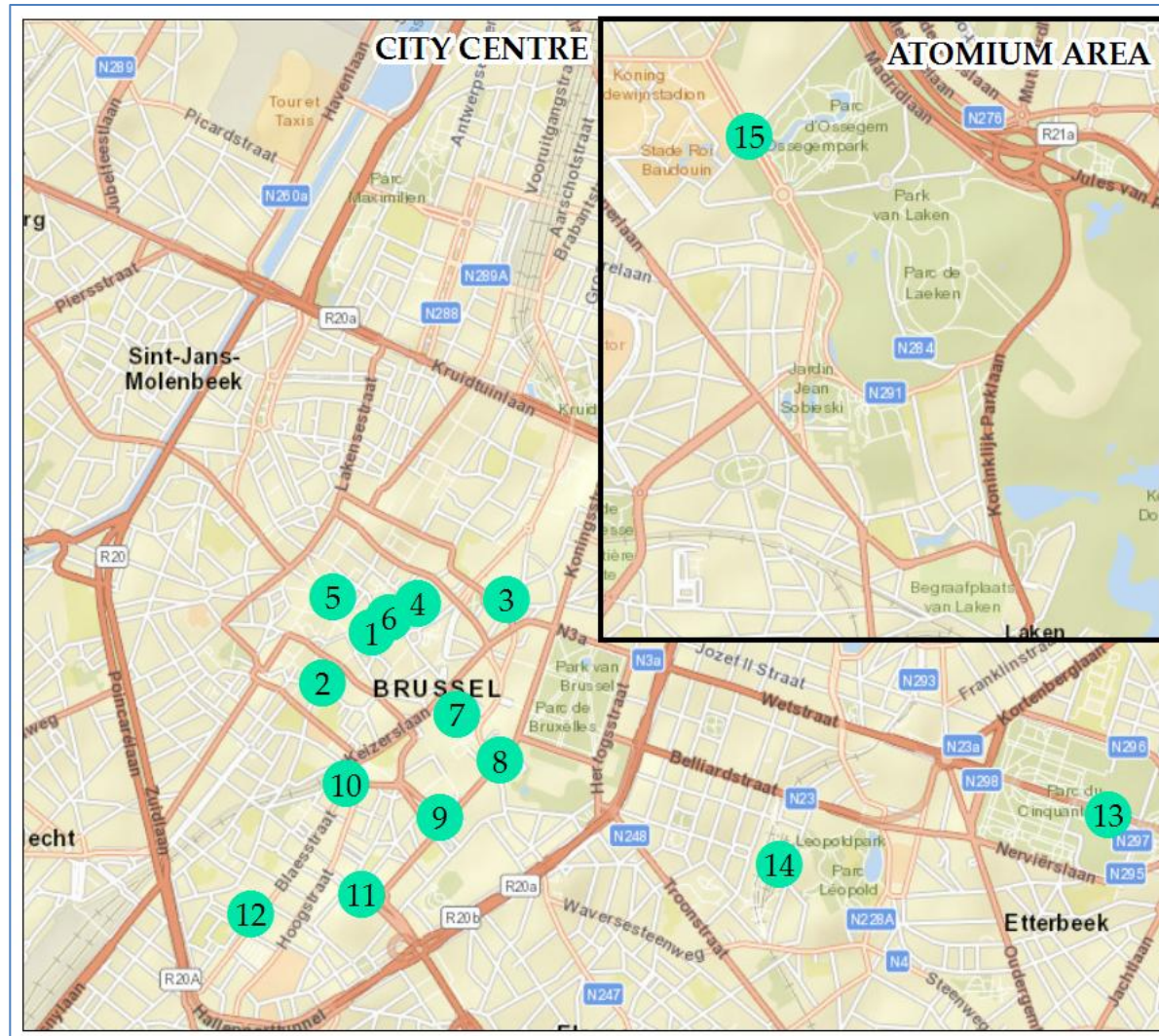
5. Results



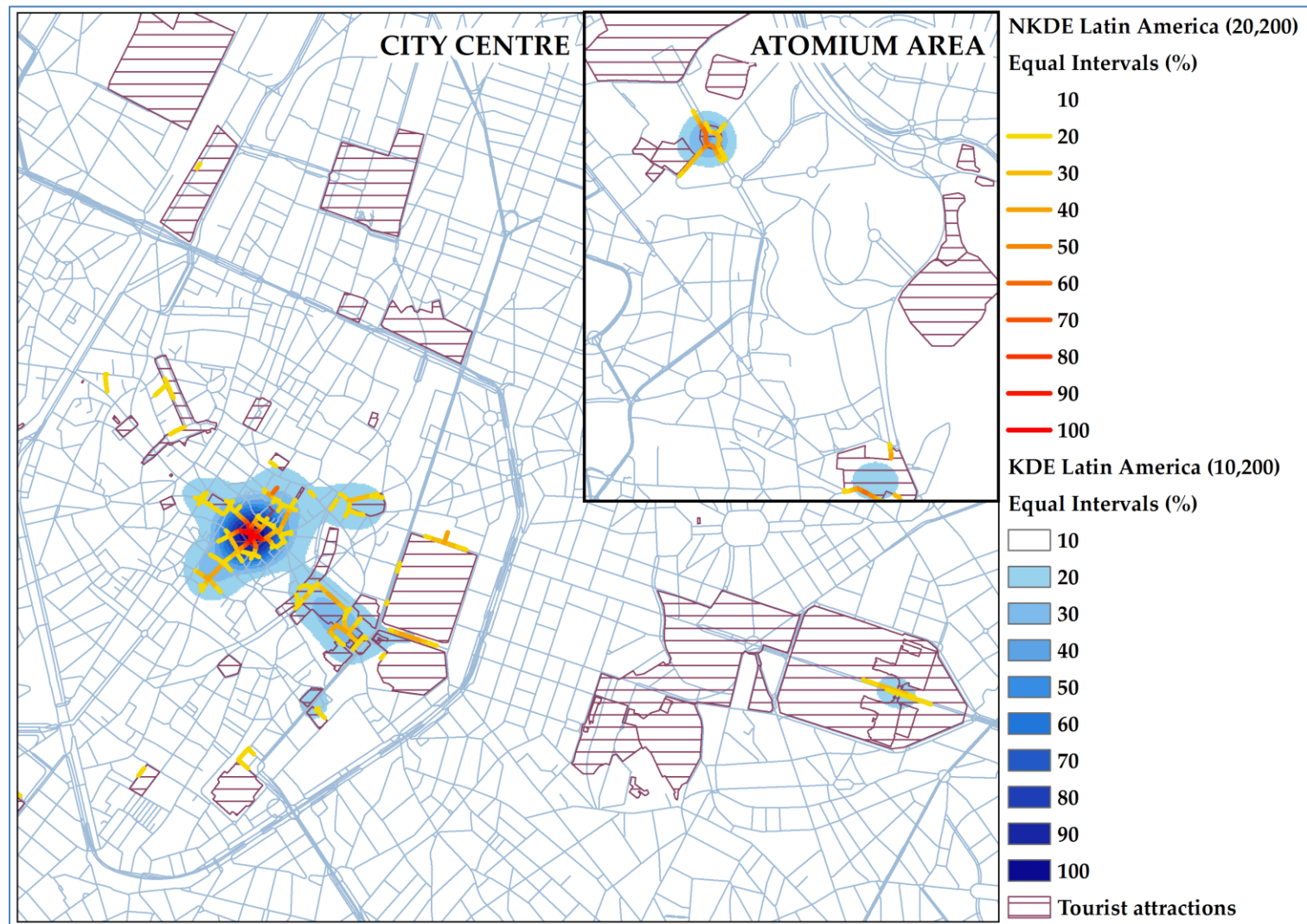
5. Results



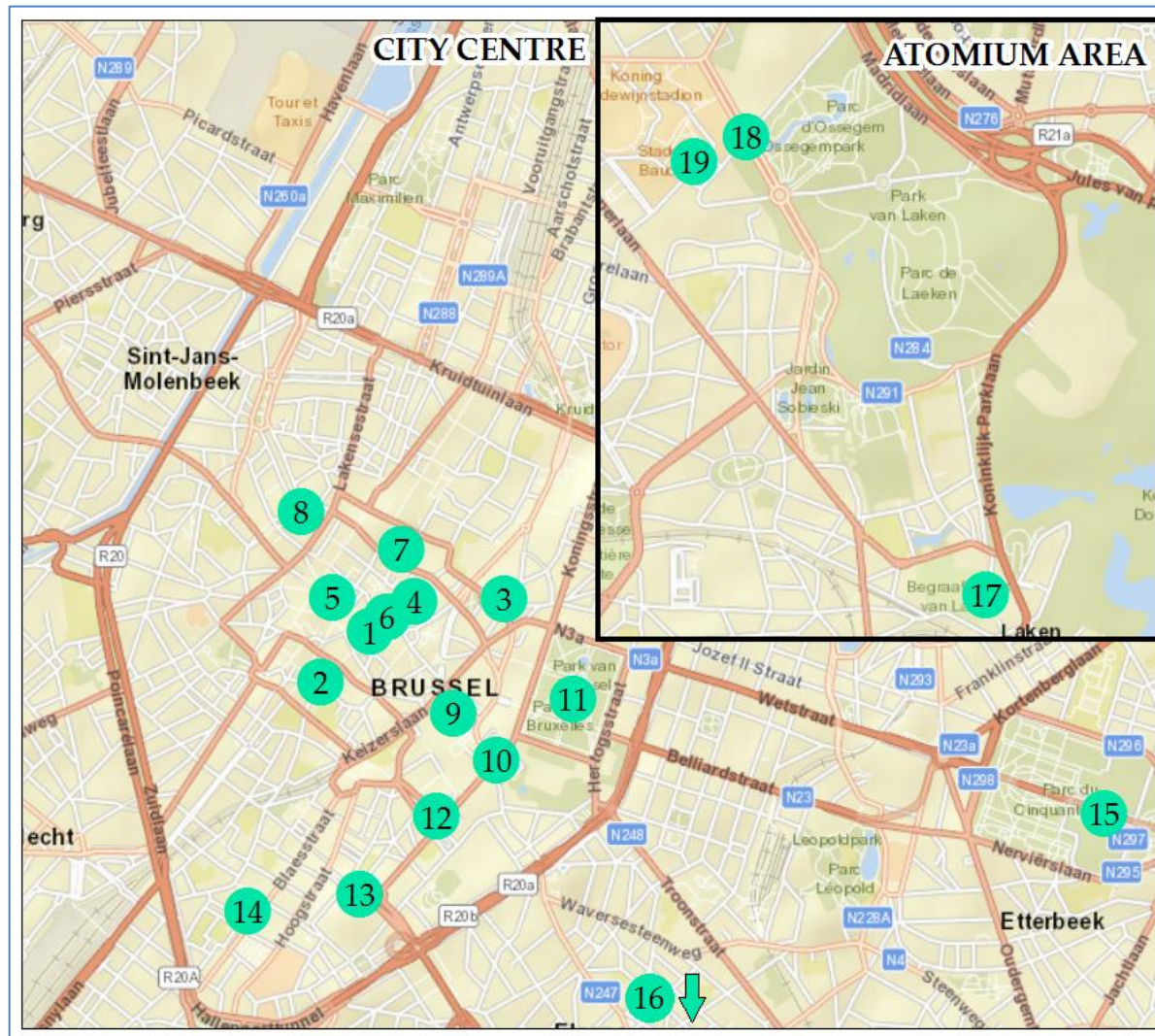
5. Results



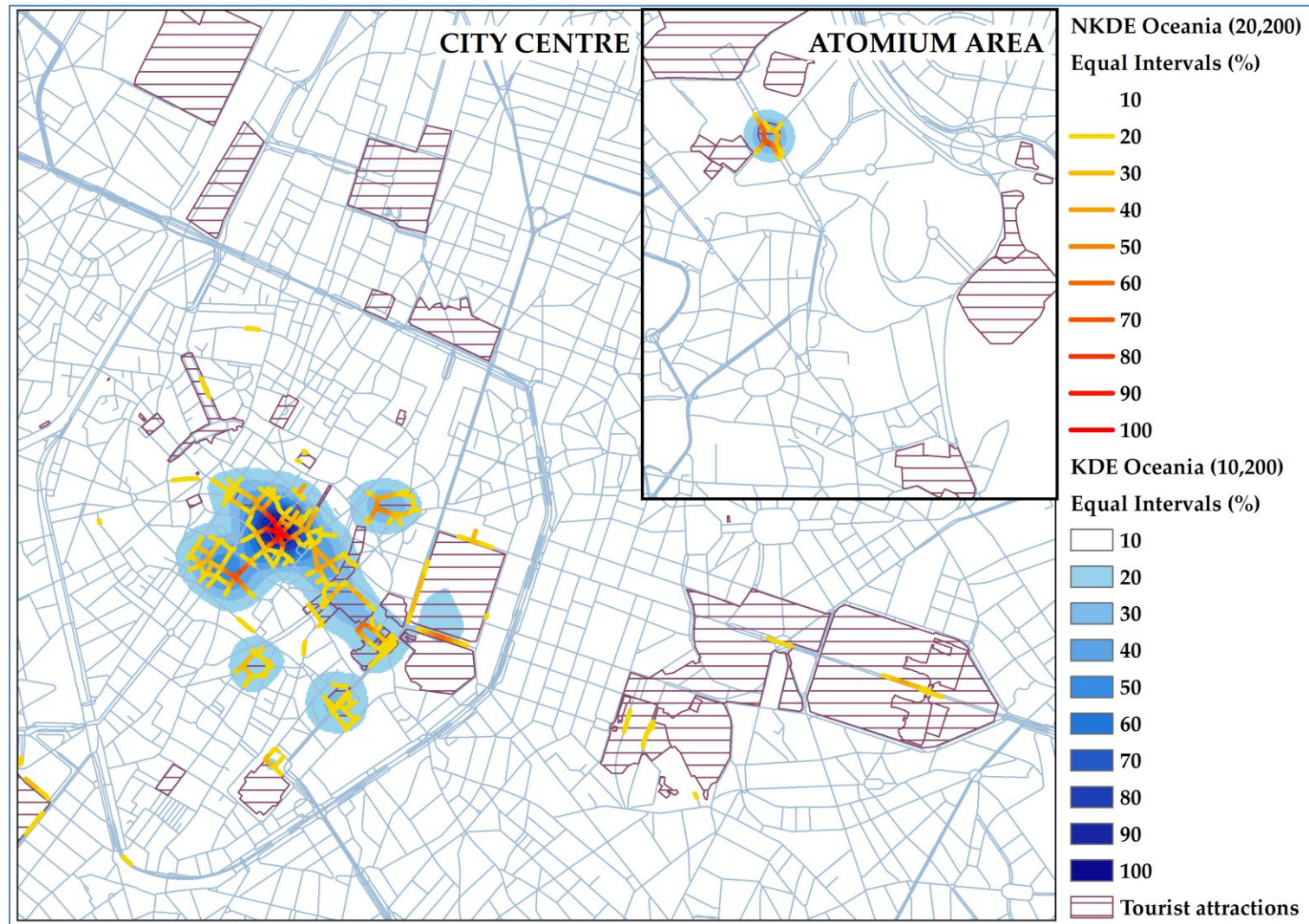
5. Results



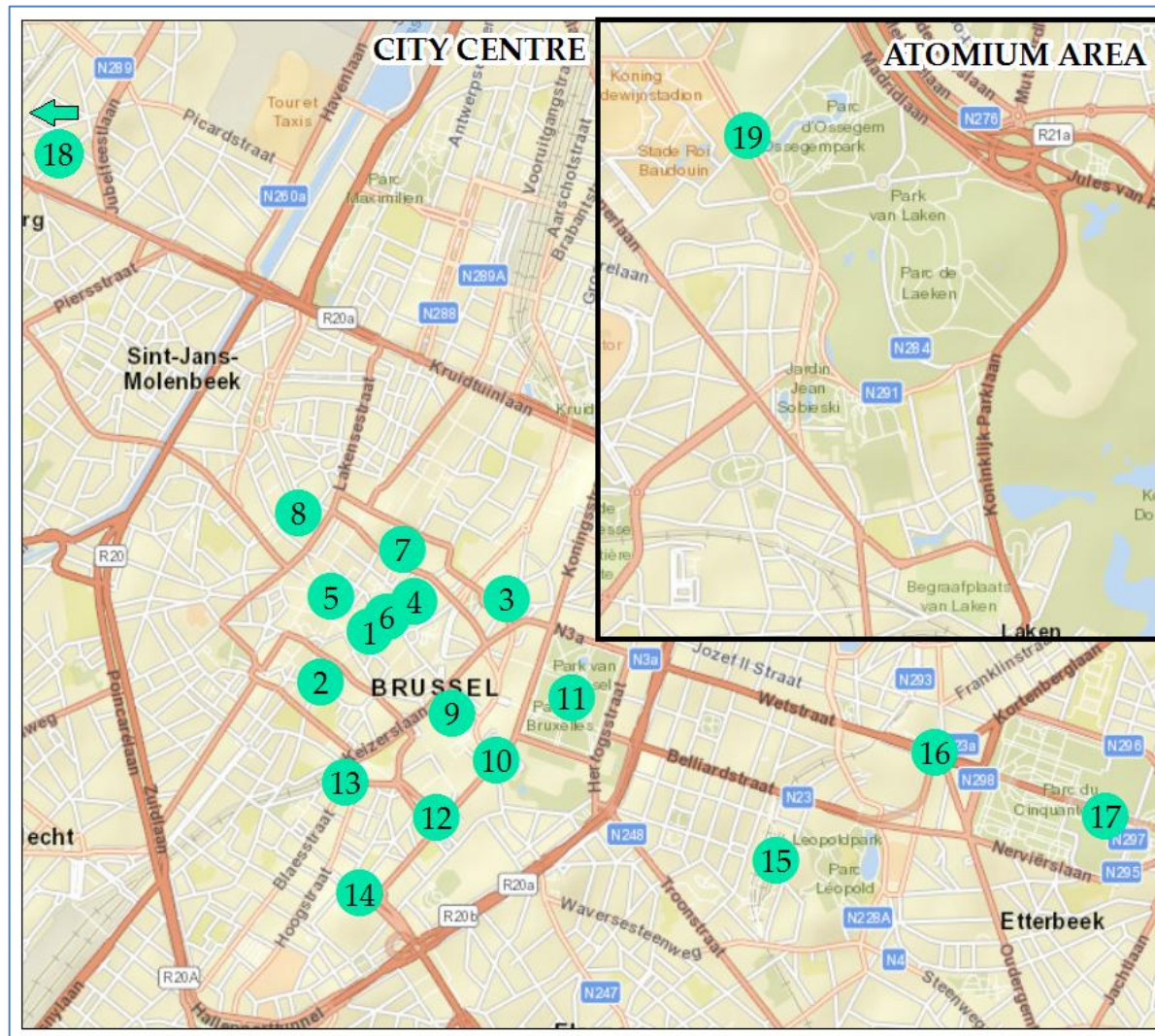
5. Results



5. Results



5. Results



- *Can the NKDE analysis of Flickr datasets be a suitable technique to identify touristic streets in a city?*

Yes. NKDE analysis gave precise results and calculations. NKDE results can give information about the most occupied street segments around a tourist attraction. NKDE can be used in defining security measures on destination.

- *Which are the main differences in the results of an analysis based on KDE vs. NKDE?*

Differences in results between these analyses are mostly in density. Densities do not visually match in all cases, because of the bandwidths. In the research, the bandwidth for both density analyses was 200 meters. Calculating density with the same bandwidth on a surface and on a network will give different results.

- *Which are the pros and cons of both approaches for this type of analysis?*

Pros: Wide use. Both analyses successfully defined AOIs and SSOIs. Could be used to improve security and administration and to set carrying capacity.

Cons: Larger bandwidth of KDE was required to make the results more recognizable on a map especially in integration with NKDE results. NKDE can create result where the segment of street will be defined as SSOI, but the street is not considered of interest in reality.

- *Is there a possibility to integrate both: KDE for areas of interest (AOIs) and NKDE for street segments of interest (SSOIs)? How would such integration look?*

Yes. With the appropriate colour schemes and numbers of intervals, the integration can be very well presented. Disadvantage is that not all details are visible, although maps look aesthetically pleasing.

6. Discussion

Data Visualization Effectiveness Profile criteria to compare and understand which of these analyses is more effective to visualize. Seven criteria are recommended by Stephen Few (Few, 2017).

	KDE					NKDE				
Usefulness	1	2	3	4	5	1	2	3	4	5
	Useless			Very useful		Useless			Very useful	
Completeness	1	2	3	4	5	1	2	3	4	5
	No relevant data			All relevant data		No relevant data			All relevant data	
Perceptibility	1	2	3	4	5	1	2	3	4	5
	Unclear and difficult			Clear and easy		Unclear and difficult			Clear and easy	
Truthfulness	1	2	3	4	5	1	2	3	4	5
	Inaccurate and/or invalid			Accurate and valid		Inaccurate and/or invalid			Accurate and valid	
Intuitiveness	1	2	3	4	5	1	2	3	4	5
	Difficult to understand			Easy to understand		Difficult to understand			Easy to understand	
Aesthetics	1	2	3	4	5	1	2	3	4	5
	Ugly			Beautiful		Ugly			Beautiful	
Engaging	1	2	3	4	5	1	2	3	4	5
	Distracts from data			Draws one into the data		Distracts from data			Draws one into the data	
Average score	4					3.6				

6. Discussion

- Study limitations
 - Flickr not widely used.
 - Number of users from different countries of origin is not evenly distributed.
 - Not defined country of origin in the dataset.
- Future improvements
 - Adding temporal components into the analysis.
 - Survey, respondents would evaluate visualization of KDE and NKDE results.

6. Conclusion

- NKDE successfully defined SSOIs, KDE defined AOIs.
- NKDE gives precise results, but its visualization is not clear to distinguish density intervals.
- NKDE cannot recognize the actual state of street network.
- NKDE can be used in tourism industry.

- Delso, J., Martín, B., & Ortega, E. (2018). A new procedure using network analysis and kernel density estimations to evaluate the effect of urban configurations on pedestrian mobility. The case study of Vitoria –Gasteiz. *Journal of Transport Geography*, 67(January), 61–72.
- Few, S. (2017). Data Visualization Effectiveness Profile. *Visual Business Intelligence Newsletter*, (March), 1–11. Retrieved from https://www.perceptualedge.com/articles/visual_business_intelligence/data_visualization_effectiveness_profile.pdf
- What can SANET tools analyze? (2009). SANET. Retrieved 25.09.2019 from http://sanet.csis.u-tokyo.ac.jp/sub_en/about_sanet.html
- Wicklin, R. (2016, July 27). How to visualize a kernel density estimate. SAS Institute. Retrieved 25.09.2019 from <https://blogs.sas.com/content/iml/2016/07/27/visualize-kernel-density-estimate.html>



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**Thank you for your
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