

Exploring spatial and temporal patterns of Tourism in Barcelona using Social Media



Tourists in Park Güell, Barcelona. (Finnigan, 2014).

Summary

In this thesis spatial and temporal patterns of tourists in Barcelona are explored. Barcelona being a popular tourist destination with a high annual number of tourists, tensions in the city are created. Therefore, planners and policy-makers need to gain insights about where tourists are in the urban environment to be able to improve it in a possible sustainable way. By extracting metadata from social media platform Flickr such as: times, dates and coordinates, insights for planners and policy-makers can be created by visualizing spatial patterns and analyzing the temporal distributions. This method delivered a dataset with lots of possibilities for future research and opportunities to study more in depth the tourists' temporal and spatial patterns in Barcelona.

Colophon

Title: Exploring spatial and temporal patterns of Tourism in Barcelona using Social Media
Keywords: Flickr, Social media, Spatial patterns, Temporal distribution, Urban tourism.
Version: Final
Words: 6589
Date: 11-06-2018
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wetenschappen**

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1. Background

Barcelona is one of the world's leading tourist, economic and cultural centres. Being easily accessible, having favourable weather conditions, located next to the Mediterranean Sea, a buzzing nightlife and a rich culture and history influenced by great architects like Gaudí. Barcelona has many attributes that make it a perfect holiday destination. According to travel website Touropia (2018) some of the most popular tourist attractions include the Sagrada Família, La Ramblas, Parc Guèll, Barceloneta, Font Màgica and Montjuïc besides one of the world's biggest football clubs. This makes Barcelona a popular destination for many visitors. And there are many that do visit, as Barcelona had a record of 75.6 million tourists in the year 2016 (Coldwell, 2017). But with so many tourists in a city once founded by Romans, with a network of small streets, residents start to get the sense that they're being taken over (Coldwell, 2017). And it's not strange that a protest movement has formed against the mass-tourism in Barcelona. According to the inhabitants the city is losing its soul (Ensing, 2016). These tensions have been rising over the years between inhabitants and visitors (Finnigan, 2014). With the recent rise of sites such as Airbnb the situation has only worsened as locals are now even repressed on the housing markets due to housing speculations of investors, driving up the prices and making it unpayable for the locals (Coldwell, 2017; Díaz, 2017). The Mayor of Barcelona, Ada Colau, has used several measures to limit tourism, via a municipal advisory board and district organizations, the residents of the city talk about making the city more sustainable (Ensing, 2016). The aim is to distribute tourists more evenly throughout the city and decongest the most central and affected districts (Díaz, 2017). And for a city where tourism represents the main source of income generating more than twenty million euros per day from tourism and providing around 100.000 jobs according to a report from the municipality (Coldwell, 2017). There are still 86.7 per cent of locals which see tourism as a positive thing, but many think it needs to be further regulated (Coldwell, 2017).

2. Research Problem

Ashworth and Page (2011) mentioned that it is curious how little attention has been given to questions about how tourists use cities. Most municipalities have very detailed statistics about hotels and controlled touristic sites such as attractions and museums (Ashworth & Page, 2011). But to cope with these problems, planners and policy-makers need detailed information about the whereabouts of tourists in a city (Girardin et al., 2007; Edwards et al., 2010). Locations where people have been at specific moments in time are traditionally studied by expensive and time-consuming fieldwork methods like questionnaires, people counts and travel diaries. Also gathering knowledge with these techniques provides limited coverage in both space and time (Wood et al., 2013). Nowadays social media has gained widespread popularity. Every day, users around the world generate a vast amount of content on social media platforms and this amount is expected to grow significantly in the years to come (Xiang & Gretzel, 2010; Croitoru et al., 2013; Gössling, 2017). As Wood et al. (2013) have shown in their study social media, in their case Flickr, can help provide spatial and temporal behaviour of tourists. As a substantial part of the content posted on social media includes geographical components, where locations are stored in the form of a geotag or a textual description. However, what lacks is detailed information about the spatial and temporal behaviour of a tourist in public urban spaces. The rise of geographical data locations provides new ways of gathering knowledge about tourists that can be used for decision making and planning purposes with sustainability in mind (Ashworth & Page, 2011).

This rises the main research question: *How can Flickr (social media) contribute in providing spatial and temporal patterns of tourism for decision-making in Barcelona?*

Additionally, questions are needed to answer the main research question, the following sub-questions are formulated:

- *Which social media are suitable as a source to use, what are the advantages, disadvantages and possible risks?*
- *What methods are available for planners and policy-makers to detect spatial and temporal patterns and improve the urban environment?*
- *What methods need to be implemented to identify spatial patterns and temporal distributions of tourists from the metadata of Flickr photos?*
- *What can spatial and temporal data from Flickr offer for planners and policy-makers in Barcelona?*

3. Structure of the thesis

In this section there will be an explanation of what will come next. First off, the literary study where, the main concepts around providing spatial and temporal patterns from social media will be researched. Also, the answering of the first two sub-questions will be done in this section: *Which social media are suitable as a source to use, what are the advantages, disadvantages and possible risks? & What methods are available for planners and policy-makers to detect spatial and temporal patterns and improve the urban environment?*

The second section will cover the methodology, after exploring which methods were available in the first section. Here will be a brief explanation about the chosen methods and the general implementation of all steps that had to be taken. It covers the third sub-question: *What methods need to be implemented to identify spatial patterns and temporal distributions of tourists from the metadata of Flickr photos?*

Together with the implemented methods the third section will show the results of spatial and temporal patterns of tourists in Barcelona. It will cover the final sub-question: *What can geospatial and temporal data from Flickr offer for planners and policy-makers in Barcelona?*

And for the final section the conclusion and further research improvements as well as the hypotheses will be discussed.

4. Theoretical Framework

Only a few authors have discussed the interrelationships of information technologies (IT), tourism and sustainability (Gössling, 2017). Understanding the places tourists visit, the time they spend and the services they utilize can provide valuable information for many engaged in the management or study of tourism (Edwards et al., 2010). What we do know is that social media are playing an increasingly important role as information sources for travellers (Xiang & Gretzel, 2010). This remarkable success of online social media marks a shift in the way people connect and share information. Much of this information now contains some form of geographical content and for the first time we can observe human activities in scales and resolutions that were so far unavailable (Croitoru et al., 2013). Social media has attracted tourism researchers by generating interests in understanding the role of this type of social media content in transforming travel experiences (Xiang & Gretzel, 2010). But as Girardin et al. (2007), Hollenstein & Purves (2010), Wood et al. (2013) and Croitoru et al. (2013) have shown is that it can also help in multiple other ways. Such as, collecting geospatial information about the whereabouts of the tourists themselves. Opening new doorways for planners and policy-makers to improve their city in a possible sustainable way (Ashworth & Page, 2011). For this article tourists' patterns, both spatial and temporal, will be explored with IT, using new ways of data collection methods. The importance of both space- and time-coordinates when studying the problems of people, in this case tourists, is that the location in space cannot effectively be separated from the flow of time (Hägerstrand, 1970). Therefore, it is important to take both spatial and temporal patterns into consideration with the importance of informing decision making. But also, the results can encourage principles of sustainability for planners and policy-makers to help develop cities (Gössling, 2017). Here sustainability can contribute to a proper balance between the increase in tourism and the quality of life of the residents.

4.1 Urban Tourism

Urban tourism is an extremely important, world-wide form of tourism. But despite its significance urban tourism has remained only imprecisely defined and vaguely demarcated with little development of a systematic structure of understanding (Ashworth & Page, 2011). There are many reasons why tourists visit cities. The cities that accommodate most tourists are large multifunctional entities and tourists are insignificant in comparison and can be seen as economically and physically invisible (Ashworth & Page, 2011). While tourists make an intensive use of many urban facilities and services but little of the city has been created specifically for tourist use (Ashworth & Page, 2011). The article of Ashworth & Page (2011) contributes to our current understanding of urban tourism in an engagement with urban theory in order to explain some of the processes and patterns of urban tourism that dominate the landscape of cities. Tourism is one among many social and economic forces in the urban environment (Edwards et al., 2010). Cities are expanding, and the world is urbanizing, tourism presents itself as a major avenue for people to satisfy the cultural imperative to consume (Ashworth & Page, 2011). Cities are characterized by density and diversity, whether of functions, facilities, built forms, cultures or peoples, this is what distinguishes from the rural and characterizes the urban way of life (Ashworth & Page, 2011).

4.2 Social media

There are many ways and lots of different platforms to harvest data from. This section will include the first sub-question: *Which social media are suitable as a source to use, what are the advantages, disadvantages and possible risks?*

Nowadays social media has become increasingly popular and the content that is being created by its users on social media platforms is increasing significantly (Xiang & Gretzel, 2010; Batty, 2013; Croitoru

et al., 2013; Gössling, 2017). Flickr users alone upload more than 3000 images per minute, these are remarkable volumes of user generated data, signifying the shift that has occurred in recent years in digital data production (Croitoru et al., 2013). It is this kind of (big) data that can be used as an advantage to help better understand the world around us (Batty, 2013). Making Flickr an ideal platform to use in the research of this thesis, as it is a photo sharing platform from which the photos can contain geospatial data, which is data with a geographical component to it. This trend is coincident with the increase in location-aware devices. Which makes user generated content to be geolocated with a new type of geospatial information (Croitoru et al., 2013). Girardin et al. (2007) considers that uploading, tagging and disclosing the location of a photo can be interpreted as an act of physical presence in time. GPS offers several advantages over the traditional methods, as it allows the precise and continuous tracking of individuals and provides spatially rich data (Edwards et al., 2010). Making it possible to derive underlying information on the social structure of the user community, which can provide additional context to the data analysis (Croitoru et al., 2013).

The article of Croitoru et al. (2013) addresses challenges with geospatial information and presents a prototype for harvesting, processing, modelling and integrating heterogeneous social media feeds. Here, besides Flickr, other suitable social media sources were used such as: Twitter and YouTube, while other social media were an option as well. Whereas Edwards et al. (2010) were interested in increasing the understanding of tourists' spatial behaviour in urban environments. The main risks, and also one of its disadvantages doing research with a relatively new method, are within the ethical considerations, both from the researcher and from the social media side. As this is data which relies upon being publicly shared by the people who use the social media platforms. As Clifford et al. (2012) and Batty (2013) mention that the ethics for internet research are in its infancy and can be seen as a work in progress regarding questions of privacy and confidentiality. Another risk would be that big data currently, often needs the requirement to augment and synthesize the data with other independent data sets to create a good estimation, and in this human handling there is chance for error (Batty, 2013).

4.3 Analysing Methods

Harvesting metadata from photos is the first step in the process, however once completed there are multiple ways to analyse the retrieved data. This section will include the second research sub-question: *What methods are available for planners and policy-makers to detect spatial and temporal patterns from social media to improve the urban environment?*

Girardin et al. (2007) were one of the first to study the behaviour of tourists by identifying spatial and temporal features from Flickr photos. They used a visual analytics approach and explored temporal distributions of tourists in Florence at three different temporal granularities: days of the week, months of the year and days of the year. Other researchers tested the spatial accuracy. Wood et al. (2013) used Flickr to approximate visitation rates, with success, instead of using traditional surveys. And Hollenstein & Purves (2010) tested location accuracy of user generated tags in London and concluded that Flickr's accuracy value is useful for filtering out images that are placed at a wrong location. Spatial clustering methods can be used to detect hotspots and landmarks in geospatial datasets. Although one important distinction needs to be made beforehand, between tourists and locals.

Girardin et al. (2007) classified photographers as tourists if all their photos in the study area were taken in a short period of time. However, most users also have nationalities linked to their user profile at Flickr. Wood et al. (2013) verified that the entered location information given by Flickr users is generally correct. In their study they concluded that geospatial data can be a useful source for studying the nationalities of visitors. With the emergence of spatially rich data, researchers are enabled to discover new methods to interpret data. The information can be used for informing location choices for restaurants, accommodations or attractions in order to maximize exposure to visitor traffic. For

planners and decision-makers new information can lead to inform planning decisions, redirect visitor flows to avoid overcrowding, minimize adverse impacts on sensitive sites, concentrate marketing activities, inform transport policies and more broadly distribute expected benefits (Edwards et al. 2013). According to Batty (2013) the challenge lies in big data being able to push the world even further into short termism. What this means is that big data can enrich our experience of how cities function in short-term thinking and planning, whereas before planning was done ad hoc and more long-term over years, decades, where now is an opportunity to get involved within hours, days, weeks. Also, there are many opportunities for social interaction and more informed decision-making with new theories on how best to interact with cities (Batty, 2013).

Of course, outcomes depend on the methods used. But as Ashworth & Page (2011) mentioned there is very little known about how tourists use cities. So, for this thesis temporal and spatial patterns of tourists in Barcelona will be explored by use of Flickr photo sharing website to get an insight of tourist locations in the urban area. As most other researchers used visual representations to analyse their results (Girardin et al., 2007; Hollenstein & Purves, 2010). This thesis will follow their footsteps and make use of geospatial visualizations and tables to find spatial and temporal patterns and draw conclusions from its outcomes. To summarize the theoretical framework, a graphical display is made of my conceptual model which can be seen in figure (1).

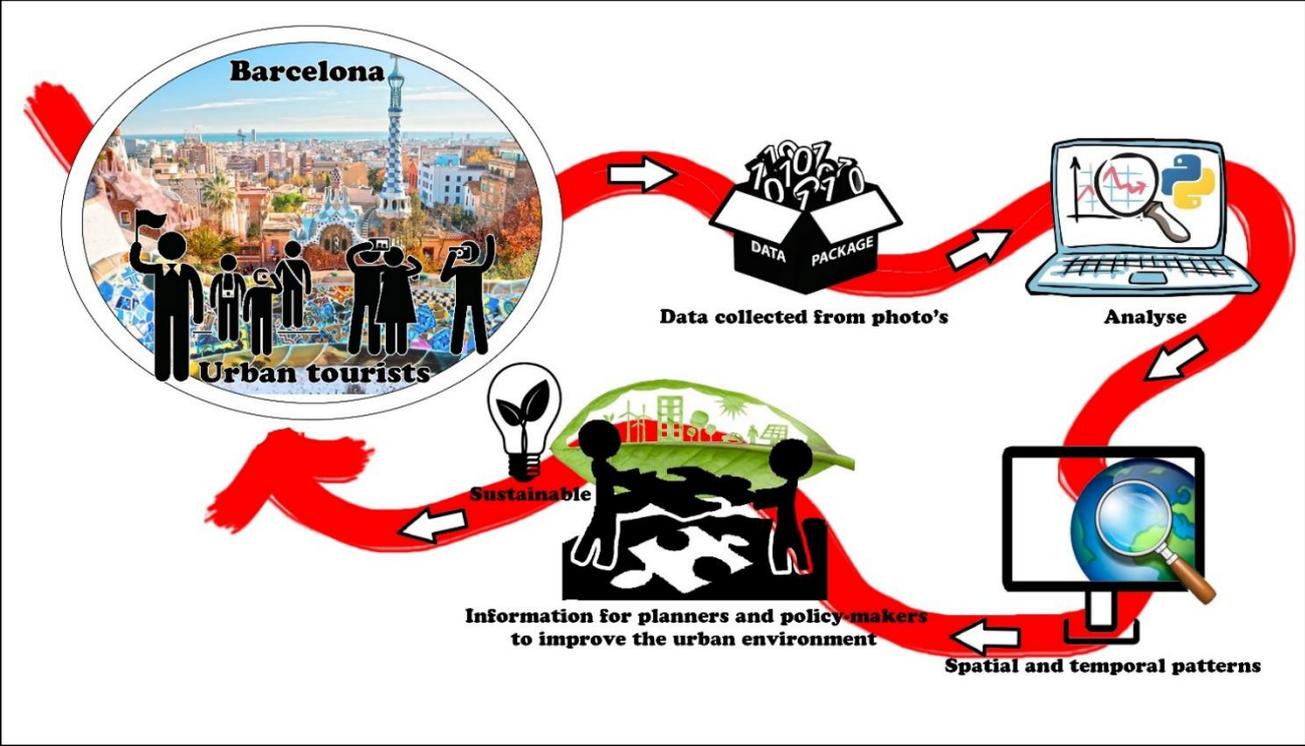


Figure 1: Conceptual Model.

This conceptual model shows how spatial and temporal patterns can be revealed by tourists themselves by using a metadata collecting instrument. It shows how the initial problem can also be part of its solution by taking pictures made by tourists, whom initially impact the city centre, but thanks to revealing patterns from the right analysing methods planners and policy-makers will be able to make suitable strategies to mitigate the pressure on the city in a possible sustainable way.

4.4 Hypotheses

The hypotheses associated with the main research question '*How can Flickr (social media) contribute in providing spatial and temporal patterns of tourism for decision-making in Barcelona?*' is:

H0: Tourists take pictures of famous landmarks this, combined with Flickr, offers the possibility to discover relevant spatial and temporal patterns of tourists in Barcelona.

Additionally, hypotheses can be created for the remaining sub-questions:

What methods need to be implemented to identify spatial patterns and temporal distributions of tourists from the metadata of Flickr photos?

H0: Making use of big data, patterns of tourists can be identified with Flickr.

What can spatial and temporal data from Flickr offer for planners and policy-makers in Barcelona?

H0: Spatial and temporal patterns contribute to a sustainable solution and regulation of the tourists flows.

These will be reflected upon in the conclusion & discussion.

5. Methodology

In the methodology the steps to collecting metadata from Flickr will be covered. Following the multi-step approach described by Croitoru et al. (2013) from collecting data from social media, processing its contents and storing it in a dedicated database. Here decisions taken in the thesis will be explained for each approach that was taken and also cover the third sub-question of: *What methods need to be implemented to identify spatial patterns and temporal distributions of tourists from the metadata of Flickr photos?*

5.1 Collecting secondary Flickr data

It is possible to retrieve data from Flickr automatically with your computer via the Flickr API. This is a service where you send a command which then sends data back. To use and be able to make use of this, you need a so-called API key. This key is included in the command so that Flickr can see what you are doing and makes sure the servers are not overloaded by different requests. Data that is requested includes: who, when and location, along with other information which is saved but not necessarily processed or readable to ultimately use with GIS. The API key is a personal key which was requested at the Flickr website with the following letter (1):

Dear Flickr service team,

As a Bachelor student at the University of Groningen I would like to take a look at the impact tourists have in the city center of Barcelona. The mass-tourism in Barcelona is a real problem, as multiple newspapers over stories and there have been more demonstrations of the local population. While there is data available for the number of visitors that visit museums or attractions, there is little we know about how tourists use cities.

So, what I would like to do is explore spatial and temporal distributions of tourists in Barcelona using data collected from the photo's take in the city. Data such as coordinates, timestamps and I would need to be able to make a distinction between local photographers and tourists using PHP and MySQL. Of course, I'm aware of ethics and privacy concerns there are nowadays but I have no intention to publicize any photographs or actual personal information. The goal of my thesis is to use the spatial information to create an informative map using GIS, which could give possible insights for planners and policy-makers in Barcelona.

With best regards,

Robert Bekker

Letter 1: personal API-key request sent 19-03-2018.

5.2 Choice of data collection instruments

There are several ways to collect data if the program that is being used can send back commands via the internet and receive data. The received data must then be stored in a database. There are several languages available that all can communicate via the internet and with a database such as Perl, Ruby, Python and PHP. Databases include SQL, MySQL, PostgreSQL and Access. In this research there was chosen for PHP and MySQL from the package XAMPP (a webserver environment) because here it is possible to display data directly in a browser and it seemed as the least complicated language to work with.

5.3 The search for photos

Once the choice of programs is made you can now start with the first step described by Croitoru et al. (2013) collecting data via APIs. First photos need to be identified for use within our case study of Barcelona. To search in the Flickr database there are several methods available, a comprehensive manual is available here: <https://www.flickr.com/services/api/>. Collecting photos is best done with the flickr.photos.search method from the manual. In this method you can, among other things, specify for which area, also called a bounding box, as well as in which period a photograph has been made. The request to the Flickr services is the following:

```
https://api.flickr.com/services/rest/?api_key=<personalkey>&method=flickr.photos.search&min_
taken_date=1483225200&max_taken_date=1522533600&bbox=2.0525%2C41.317%2C2.07008%2
C41.3322&per_page=250&page=1&format=php_serial
```

Specified in the request to Flickr is the date from 1/1/2017 until 1/1/2018 in a Unix time format respectively 1483225200 and 1522533600. But also, for the area of Barcelona which is specified as 41.317, 2.0525 to 41.3322, 2.07008 in latitude and longitude respectively. The last thing specified in the request is the assignment to retrieve up to 250 pages as a result in the answer format PHP_serial.

```
a:2:{s:6:"photos";a:5:{s:4:"page";i:1;s:5:"pages";i:0;s:7:"perpage";i:25
0;s:5:"total";s:1:"0";s:5:"photo";a:0:{}}s:4:"stat";s:2:"ok";}
```

A difficult to read code, which can be converted to an easier to read array, which delivers the following:

```

Array
(
    [photos] => Array
        (
            [page] => 1
            [pages] => 2
            [perpage] => 250
            [total] => 438
            [photo] => Array
                (
                    [0] => Array
                        (
                            [id] => 40878374102
                            [owner] => 128528730@N04
                            [secret] => 924f0517c3
                            [server] => 803
                            [farm] => 1
                            [title] => 2018-03-20_03-33-08
                            [ispublic] => 1
                            [isfriend] => 0
                            [isfamily] => 0
                        )
                    [...] => Array (multiple)
                )
        )
)

[stat] => ok

```

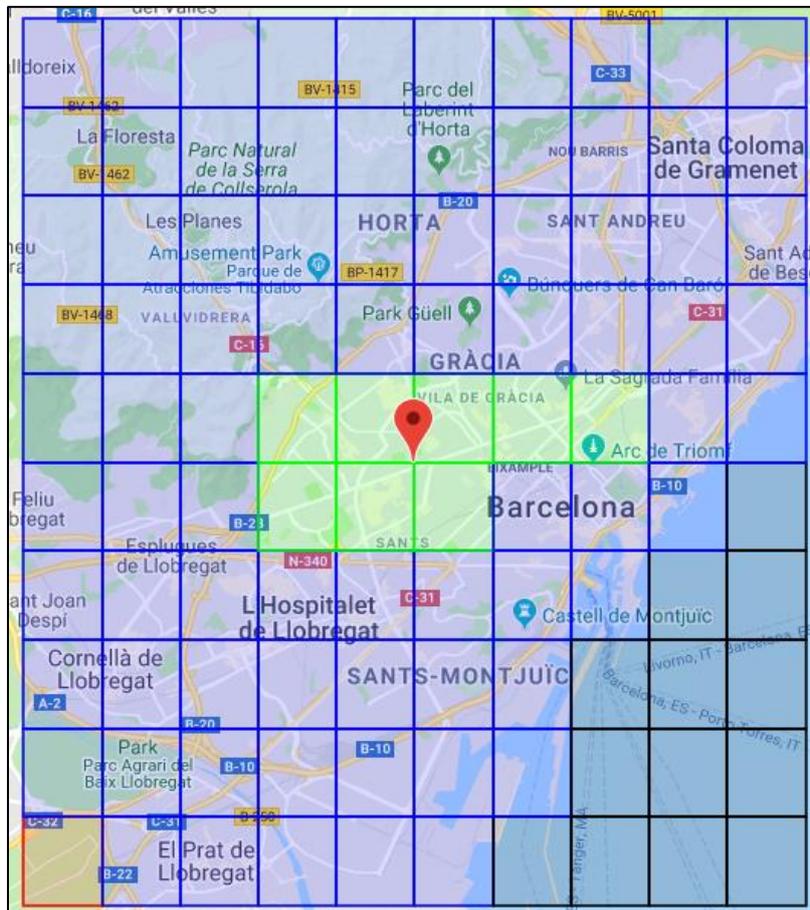
The information we need is the [photo]-array of which the [id], [owner] and [secret] data is stored and can be seen in figure (2), because later they are needed to retrieve more extensive photo information such as: the longitudes and latitudes data. Below is an example of the database table:

id	photoid	owner	secret	processed
1	30143057794	91896648@N06	52421fe56f	1
2	29200873872	15181215@N05	03c8dc66a3	1
3	25274853023	91896648@N06	c1b5f3f56d	1
4	24299812362	84489055@N00	3eda90e1d3	1

Figure 2: MySQL database of identified photos.

However, it is not possible to retrieve data for 10 years in one request when also specifying an area. Flickr has imposed a restriction on this. The method indicates how much data is available via [pages] and [total] in the answer, but if you retrieve data from an area, you will only get a maximum of 250 results per page with a total of 4000 records. For this version, the routine is made such that if the result is more than 16 pages the period to retrieve is halved just as long until the result is smaller or equal to 16 pages. Here 16 pages with 250 results gives a total of 4000 total.

Now all pages can be retrieved from the area and the calculated period where the data is stored in the table photoIDs. The period to be retrieved is then determined again, the start date becomes the calculated end date and the end date becomes the desired end date again. Once again, data is retrieved as described above, until all of the data for the desired area and period is retrieved. To be able to interrupt the retrieval of the data, the desired area to be investigated has been divided into 10x10. These areas are also stored in a table with a processed field that is set as the information of



that area and that period has been retrieved. The above procedure then goes again for the next area to retrieve the data until all areas are done. This raster of 10x10 covers the bounding box of Barcelona which is E 2°03'08"--E 2°13'42"/N 41°28'05"--N 41°19'01" and looks as the following seen in figure (3):

The colors of the squares indicate their status. Blue squares have not yet been processed. While the green squares are processed. Black squares which mostly covered the sea are not taken into consideration and the single red square gave an error during the process.

Figure 3: 10x10 raster.

5.4 Collecting photo information

The next thing what had to be done is to retrieve the actual metadata of photos which will be useable to identify temporal distributions and spatial patterns such as: title, description, time and location of data. This is done with the flickr.photos.getinfo method from the earlier mentioned manual of Flickr APIs. A note for ethical considerations is that photos collected in this way are all publicly available and users are able to change these settings to private etcetera. During the process this probably made way for some errors to occur. In this method you give the photoID and secret in the following request to Flickr:

```
https://api.flickr.com/services/rest/?api_key=<personalkey>&method=flickr.photos.getInfo&photo_id=4735277438&secret=8836eaa029&format=php_serial
```

Which gives the following response as can be seen in code snippet (1), complete response added in the appendix A:

```
a:2:{s:5:"photo";a:28:{s:2:"id";s:10:"4735277438";s:6:"secret";s:10:"8836eaa029";s:6:"server";s:4:"4076";s:4:"farm";d:5;s:12:"dateuploaded";s:10:"1277542219";s:10:"isfavorite";i:0;s:7:"license";
```

Code snippet 1: flickr.photos.getinfo API request answer.

As this is almost impossible to read this gets translated into a readable array using PHP (`print_r(answer);`) which gives the result shown in the code snippet (2), the complete array added in the appendix B:

```
[location] => Array
(
    [latitude] => 41.352481
    [longitude] => 2.132165
    [accuracy] => 16
    [context] => 0
    [neighbourhood] => Array
        (
            [_content] => Santa Eulalia de Provenciana
            [place_id] => ivbNMetWVb1OBoM
            [woeid] => 773743
        )
)
```

Code snippet 2: Array with latitude and longitude.

5.5 Processing the data

A big part of the processing process is the cleaning of errors and inconsistencies from the data. For example: some points were tagged in Barcelona, but their coordinates were from France, most of these were cleared with the selection of accuracy level 16 from Flickr itself. Hollenstein & Purves (2010) tested Flickr's accuracy level and concluded that it was useful for filtering out images that were placed at a wrong location. So, for this study, photos with an accuracy at street level have been selected for use. Since this study wants to get an insight of the spatial and temporal patterns of tourists it is now time to make a distinction between the locals and tourists. Here Girardin et al. (2007) classified photographers as tourists if all their photos in the study area were taken in a short period of time. But it is also possible to select users on nationality in the database, as most users have their profile linked to their nationality. This step was ultimately done by selecting people who had their nationality in Spain and more specifically set in Barcelona. This way also tourists from within Spain are taken into consideration.

5.6 Shapefile conversion

Now the collecting and processing is done the data is stored in the MySQL database. Information as time when a picture was taken, but also its geolocation, its accuracy, tags, titles are now all stored and ready to be further analysed in a GIS program to identify the spatial patterns and temporal distributions of tourists in Barcelona. In order to be able to use the data in GIS the database is exported into GeoJSON features file (Geographical JavaScript Object Notations). Here longitude and latitude get converted into a point feature with additional data, such as time, date and owner. This dataset is then converted to shapefiles using mapshaper.org, ready to be used in GIS.

5.7 Spatial patterns

To create spatial patterns ArcGIS offers many tools if you have the knowledge and expertise. As Ashworth & Page (2011) noted there is little insight in how tourists use cities. So, in this research there was chosen to do a Kernel Density test as it calculates the density of features and visualizes like a

heatmap. For this to be done right it was important to first project the points into a Spanish map projection. The reason is that this way the Kernel Density tool could differentiate points with distance of meters and calculate more appropriately.

5.8 Temporal distributions

To analyse the activity of tourists in time such as the seasons, weekends and weekdays. Here Girardin et al. (2007) followed the temporal granularities of days of the week, months of the year and days of the year. In addition to their work locals are added to make a comparison in behaviour. Another addition will be the hours of the day as this might reveal other interesting tourist pulses and this might be something important when transitioning planning into the short-term (Batty, 2013). Temporal distributions can be acquired from the database following a query. In the example of the code snippet (3) the request for months of the year, for all years, is made with which data can later be imported to excel for further data creation and analyzation.

```
SELECT
    MONTHNAME(taken) as Maand,
    IF(islocal, "Local", "Tourist") as Who,
    count(*) as total INTO OUTFILE "e:/xampp/htdocs/flickrgeo/tests/maand.txt"
FROM
    `localvstoerist`
GROUP BY
    MONTH(taken),
    islocal
```

Code snippet 3: Database request months of the year.

5.9 Ethical considerations

This paragraph will sum up the taken ethical considerations. For this research user data of Flickr is taken by extracting the metadata of photographs. This was only done with pictures that were publicly available from people who share their photographs with the world. The data was saved in a database and is only used for this research. The users' names are displayed as an owner number and stored anonymously. As with the implementation of new privacy laws in the European Union there is more attention for user privacy. With most companies rewriting their user agreement policies and bringing new attention to its users, as Flickr has been doing as well. For future research done this way this might be problematic, as more users can withhold their data from the public which might make researches done this way less suitable in the future.

6. Results

After studying different methods and explaining the chosen methods to explore spatial and temporal patterns from tourists in Barcelona. This section will show the results and discuss the final sub-question: *What can spatial and temporal data from Flickr offer for planners and policy-makers in Barcelona?*

6.1 Data collection

For this project the metadata of 968.929 photos of Flickr in Barcelona were collected after cleaning and selection for accuracy level as can be seen in table (1). Of these photos 35% were classified as tourists.

	Users	Photos	Photos/Users
Local	1 519	164 899	108,6
Tourist	10 223	341 618	33,4
Unclassified	15 818	462 411	29,2

Table 1: Number of photos and unique users collected.

6.2 Spatial patterns

In figure (4) all 341.618 points who resemble a presence of time and location as tourists in Barcelona are loaded into ArcMap (Girardin et al. 2007). In figure (5) the colours are from green, almost no photographs taken, to red, which are popular spots to take pictures. Together with the earlier explained methodology the following maps are created (full-size included in Appendix C):

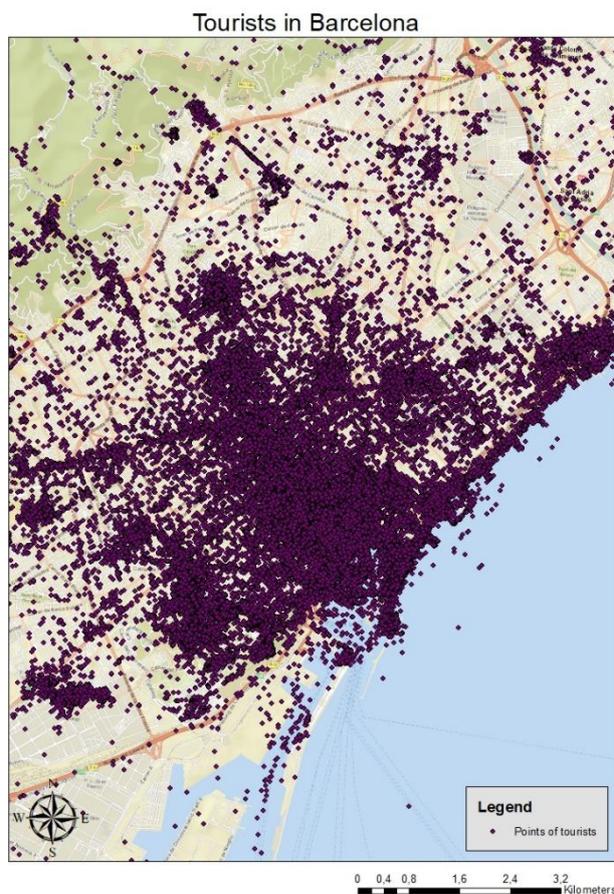


Figure 4: Tourists as point data.

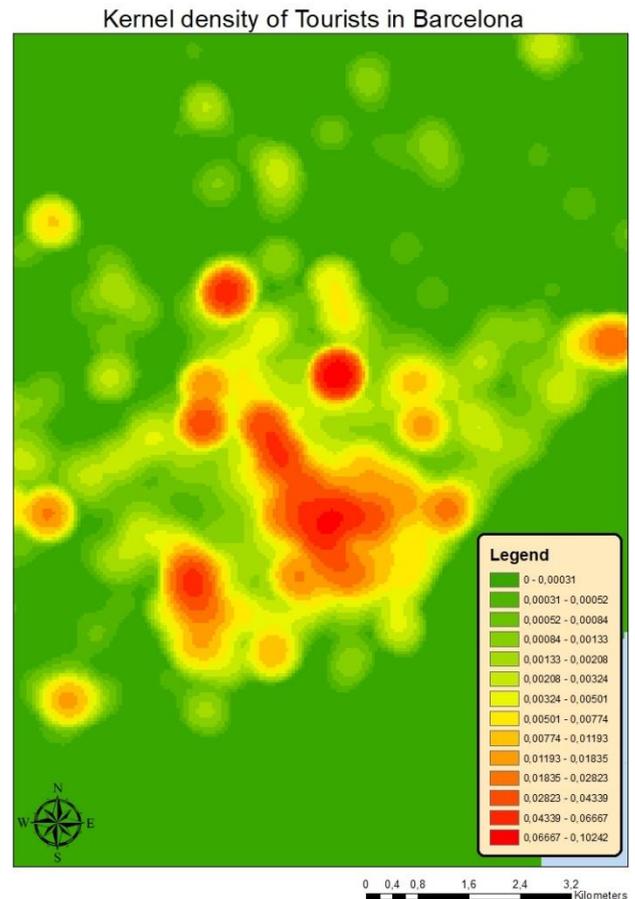


Figure 5: Kernel density of tourists.

Of course, the outcomes of the density map could have been visualized differently. As for this thesis was chosen for a geometric interval as the data concerns population data and was not normal distributed. But to add some sort of validation locations of the identified densities were added manually.

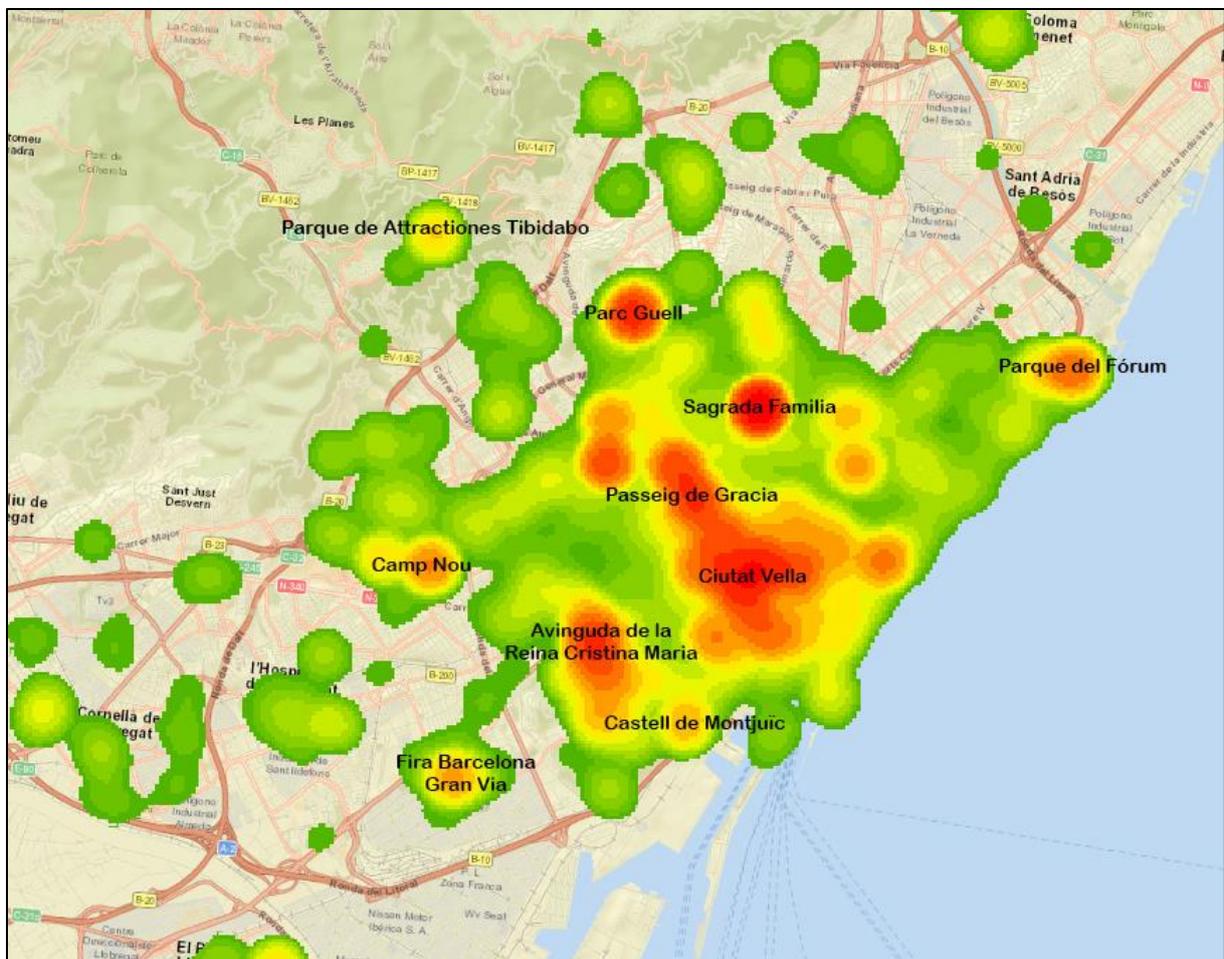


Figure 6: Kernel density map edited in Adobe Photoshop.

In figure (6) some famous locations have been highlighted. From Parc Güell and the Sagrada Família but also, some famous streets such as: the Ramblas, which is part of the Ciutat Vella. Also known as the old town where there are lots of small streets with shops, museums, and other interesting touristic attractions. Another street that shows the presence of tourists is the Passeig de Gràcia where Casa Milà, a famous apartment complex designed by Antoni Gaudí. Other things to note is that Camp Nou, the football stadium of F.C. Barcelona, shows up as an area where there are numerous pictures taken. These results match the top tourist attractions according to Touropia (2018) which gives places as Parc Güell, Sagrada Família, Casa Milà, The Ramblas and Montjuïc as some of the most attracted touristic places in Barcelona. Similar as what the Kernel density shows created from the metadata of Flickr photos.

For planners and policy-makers in Barcelona this data of a presence in space can be useful. What this method shows is that tourists are attracted to popular attractions in Barcelona, as famous landmarks show up in figure (6). This method and its results can help create a better understanding of where tourists are in the city as was earlier mentioned by Ashworth & Page (2011) as being important to help improve the urban environment. With access to the metadata of Flickr photos and the possibilities of

automation of the collection of such big data, the planners and policy-makers stand before a new era. Where thinking of cities as being plannable in short term (minutes, hours and days) instead of long term (years, decades or generations) can become a real possibility (Batty, 2013). Topics that can be improved using big data include: informing planning decisions, redirecting visitor flows, concentrate marketing activities, inform transport policies and more broadly distribute expected benefits (Edwards et al. 2013).

But having earlier mentioned the time-geography concept by Hägerstrand (1970) a presence in space cannot be excluded from the flow in time. Therefore, another part of the results are the temporal distributions that have been extracted from the metadata of Flickr photos. Now that we know where tourists are in the urban environment also an insight needs to be created as to when they are in the city of Barcelona.

6.3 Temporal distributions

In this section with the earlier explained methodology activity charts are created which show “tourist pulses” (Girardin, et al., 2007). The activity is made from all collected metadata which was classified as either tourist or locals with unique users. These following charts of days of the week, months of the year, days of the year and hours of the day are an aggregate of the last 10 years, from 2008 to 2018. Chart (3) is made with a total amount of photographs whereas the others are made with relative numbers of the total uploaded pictures in their respective time-period.

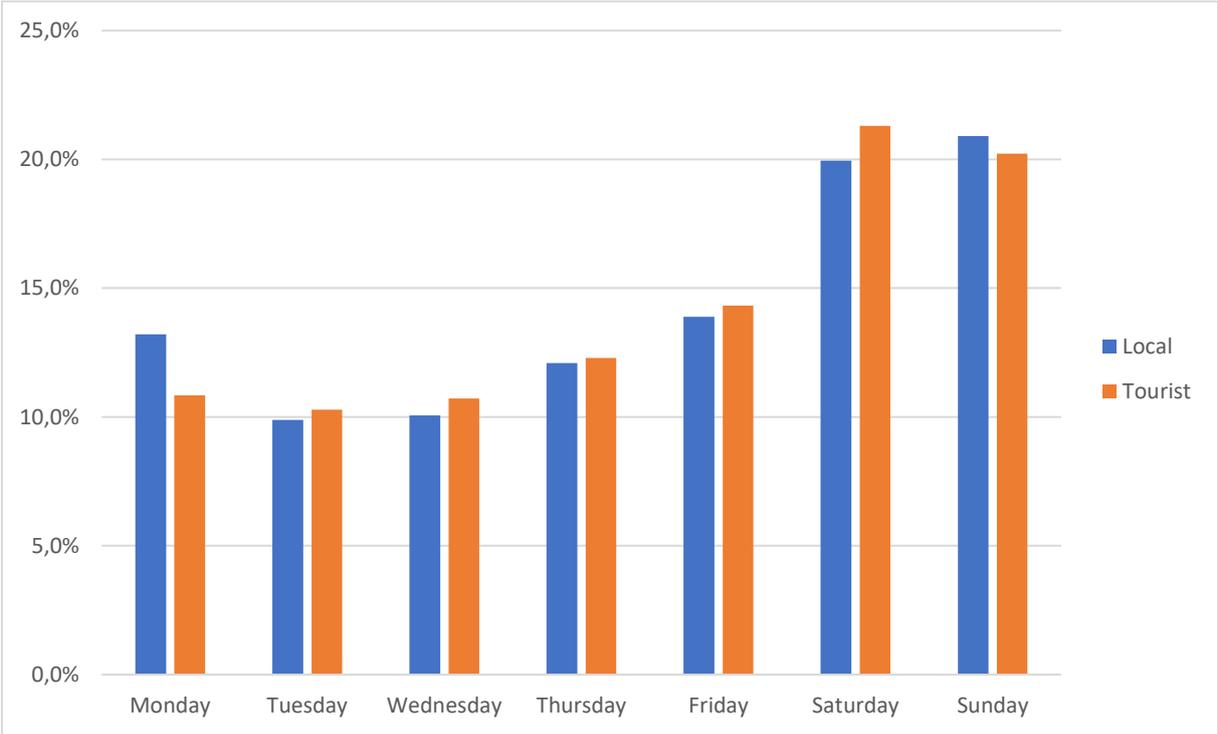


Chart 1: Days of the week.

What can be seen in chart (1) is that most pictures are taken during the weekends as the relative number of uploaded photographs during this period is higher, during these periods landmarks earlier identified are most certainly more crowded with the number of tourists present.

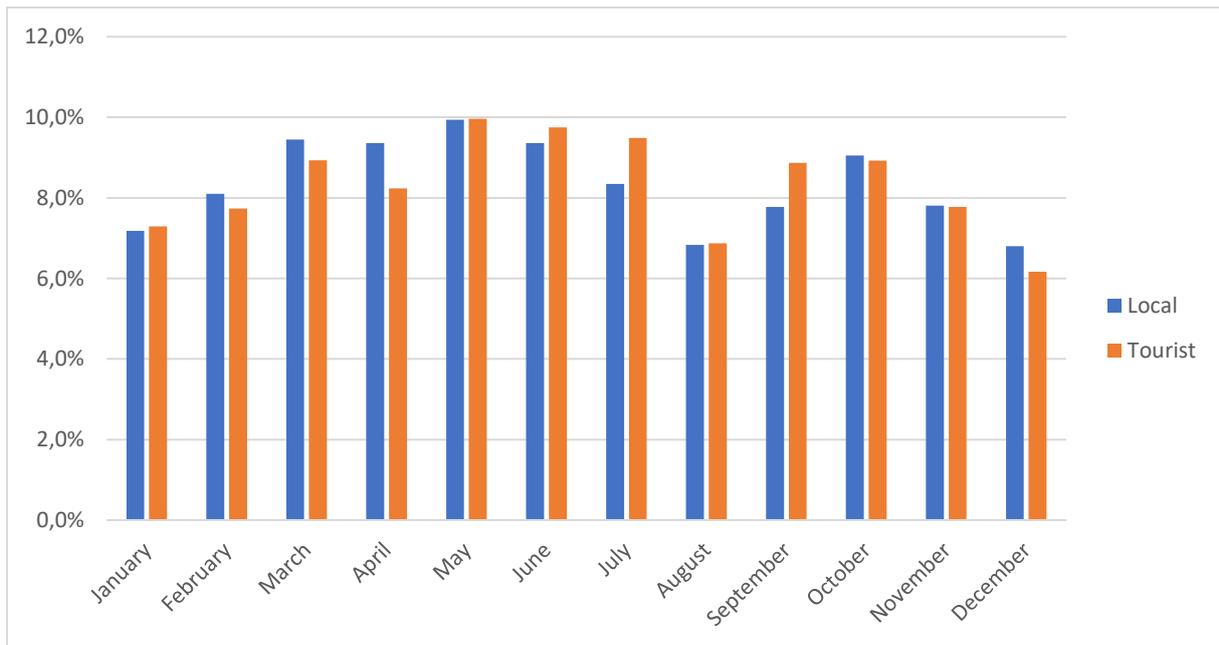


Chart 2: Months of the year.

With chart (2) months of the year activity pulses of tourists in Barcelona can be seen to be higher during the season period of June and July. During the off-seasons there are relatively more local photographers who upload their pictures of Barcelona on Flickr. Which makes sense as tourists travel mostly during summer periods because that is the time they can get time off from work. In that sense the data represents the reality.

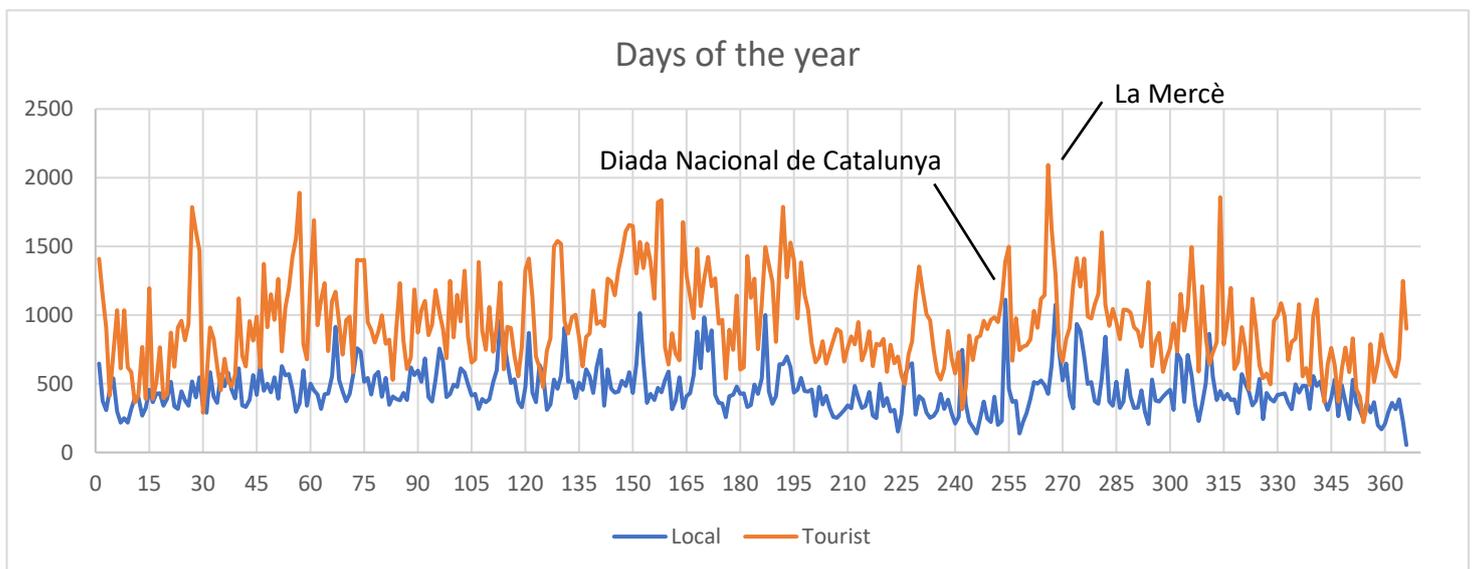


Chart 3: Days of the year.

For the analyzations of the spike of activity in chart (3) it is possible to correlate the spikes to festivities or national holidays, as they occur most often on the same day of the year. A quick note for further improvement would be to analyse per year to pin-point more specific events. However, the biggest spike is probably during the annual city festivities La Mercè which is a festival tradition since 1871. The greatest spike from the local photographers is probably around 11 September, which is the national day of Catalonia, which is a daylong festival.

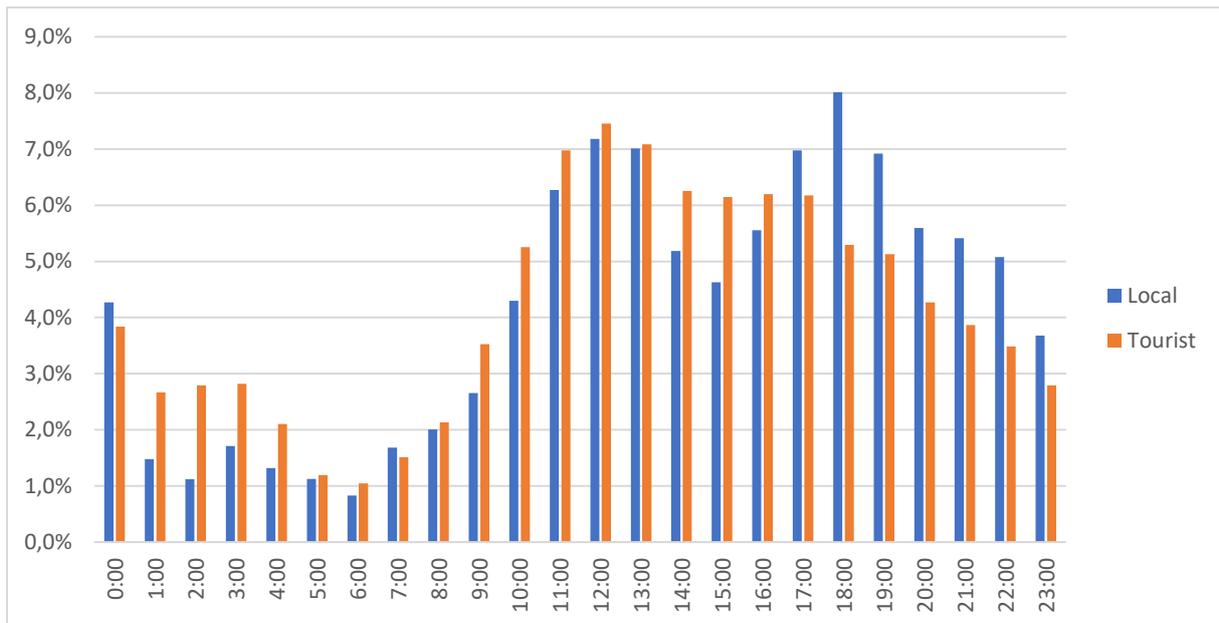


Chart 4: Hours of the day.

Now that the temporal granularities of Girardin et al. (2007) are covered it was noted by Batty (2013) that big data can make a shift for planners to more short-term planning. Therefore, in addition chart (4) of hours of the day is included to give planners and policy-makers an even greater understanding of the temporal distributions of tourists in Barcelona. What can be seen in chart (4) is the aggregate over the last 10 years, but specific days could also be analyzed. Interesting things to note is that the nightlife is dominated by tourists and that their activity peaks during noon. But also, that mainly most pictures used in this study come from day-time activities. Relatively it is the locals who spend more time making pictures during the evenings, but in sheer numbers of total uploads the small size of the local population, as earlier showed in table (1), can't match the total number of touristic photographers. With this method of extracting metadata from Flickr planners and policy-makers in Barcelona can now see when and where tourists are in the urban environment. By automating this process possibilities for short-term planning may become more realistic.

7. Conclusion & Discussion

This section concludes my bachelors project about exploring spatial and temporal patterns of tourism in Barcelona from Flickr photographs. Along the way multiple sub-questions have helped understand and create methods to analyse a large dataset of Flickr generated data. And solely one question remains: *How can Flickr (social media) contribute in providing spatial and temporal patterns of tourism for decision-making in Barcelona?*

With Flickr being an ideal platform as it is mainly images which are suitable for extracting spatial data. And there are many researchers with interesting methods derived from the metadata of photos from Flickr. By choosing for a Kernel density and charting the temporal distributions it can at least be said that the results contain spatially rich data. And that with the extracted data there are many more possibilities for additional research in a more in-depth way. But also, this method can be applied to different case-studies.

By using 341.618 photographs taken by tourists, insights have been gained by both spatial and temporal patterns. What this means as Edwards et al. (2013) mentioned earlier, that the harvested metadata of Flickr contains a rich amount of spatial data. What planners and policy-makers lacked was the detailed whereabouts of tourists in their city (Ashworth & Page, 2011). With the collection of metadata from Flickr important locations have been recreated in the city of Barcelona by use of Kernel density and temporal granularities are shown with timings of the day. As stated in the hypothesis it was expected that tourists take pictures mostly of famous landmarks and attractions as they have a limited visiting time and do want to see the places Barcelona is known for. What this method brings for planners and policy-makers are possibilities in the short-term planning as was mentioned by Batty (2013). As for this thesis the method was mostly explored, for future studies an in-depth look in creating pathways or using more time-intensive visualization methods, better insights can be created as was stated in the hypothesis. However, regarding tourist flows as was suggested in the hypothesis, this was not achieved within this research. Combine this with some form of automation in the process there are real possibilities for a shift in the way planning has been done, not only for Barcelona but also something that can be applied to other cities. Does this method however, guarantee a possible sustainable solution for planners and policy-makers? As Wood et al. (2013) mentioned methods like these can be seen as sustainable, as there is no longer need for time consuming surveys and as stated there is a lot in this process that can be automated. Ultimately with the landmarks matching the most popular touristic attractions also described by the touristic website Touropia (2018) it's clear that this way of doing research there are a lot of opportunities for planners and policy-makers to influence the urban environment with new found knowledge. To study these touristic patterns in a way that might not have been applied within governments before, but also continue to have sustainability in mind.

7.1 Reflection

With this project a lot was learned along the way. With the large number of collected data I felt at some stages that the focus was lost and recommend focusing on less than 10 years all at once. With a collection of almost a million photographs this project became more time-consuming as the metadata became bigger and possibilities of different research steps that could be taken increased with more knowledge.

What this project lacks are some form of end validation of the results and the extent to which the outcome is representative with the real world. This validation could have been done in the form of a survey send to the municipality of Barcelona and explore in what way they agreed with the end results. But also, the accuracy of locations, the origin of countries and the large number of unclassified photographers, as seen in section 6.1 table (1), could have been further examined to increase the

projects accuracy. But, these steps could become new bachelor projects on their own. In the end, I am satisfied with the outcome of this research and all that was learned, it was a long journey with enough possibilities for follow-up research.

7.2 Future recommendations

While the findings in this thesis might be underwhelming there are a lot of follow-up research possibilities that can be done with this acquired dataset. From creating pathways of individuals, to analysing tags or descriptions to identify city cores or more time-consuming ways of visualization. This method can also be applied to other cases, as this research is not bound to Barcelona only. It can also be used to study the local residents, instead of the tourist and explore attractions in the city that the local photographers appreciate more by analysing the metadata of Flickr photos. Even on what scale this research has been done, that of one city, can be increased, of further zoomed in to districts or zoomed out nation-wide or maybe even a global scale in the future with the right amount of processing power.

8. References

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Useful tutorials and information in general:

- <http://php.net/manual/en/index.php> - Manual for programming PHP and MySQL.
- <https://www.w3schools.com> - Introduction to HTML and MySQL.
- <https://stackoverflow.com> - Forum for all kinds of programming problems.
- <https://developer.mozilla.org> - Information TCP / IP communication.
- <https://developers.google.com> - Information Google tools for websites.
- <https://community.apachefriends.org/f/> - Information source XAMPP use.

9. Appendices

9.1 Appendix A:

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9.2 Appendix B:

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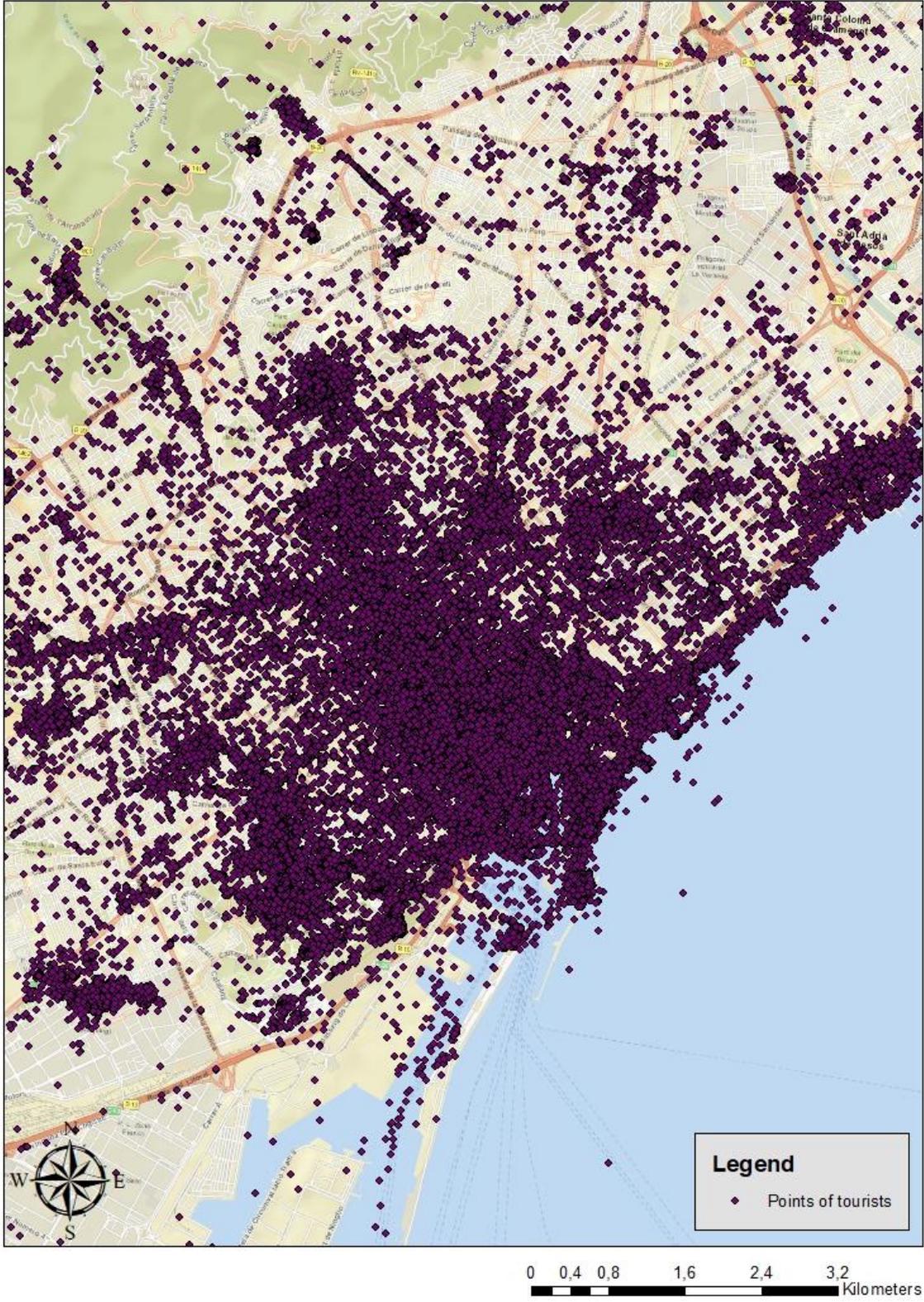
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  )
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```

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9.3 Appendix C:

Tourists in Barcelona



Kernel density of Tourists in Barcelona

