Assessing the relationship between human activity and outgoing thermal radiation in Geneva, Switzerland

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Introduction

It is a well known fact that our planet is experiencing a climatic change that is starting to show its effect in many regions of the earth. The global warming is only called "global" because it is a mean of the change of temperature that humans and animals will experience around the globe. For it to be an accurate description of the situation, it would require humans to be well distributed on the surface of the earth. However a large percentage of the population now gather in cities, 74% in Switzerland(sta), and the effect of the warming inside those clusters of human acvtivity might be even more dramatic.

It has been theorized that the cities will be experiencing a much harder warming than rural regions, creating litteral "heat islands" during warm periods,(Mika et al., 2018) during which the temperature will rise higher. The study was conducted using the 1.5K scenario of the IPCC and studied its effect on the urban air pollution and the urban heat island. In conclusion, they observed that, although a direct impact of global warming was not clear on the urban heat island phenomenon, it still appeared that heat islands were more present and stayed longer than they were in the past. In an other study, (Gozalo et al., 2016), the noise in urban areas was modeled using different factors depending, for example, on the street type, the vegetation, the type of buildings and the activity in the area. This shows how the daily noise is a good indicator of the human activity. The article also underlines the importance of traffic in the urban noise, with nearly 50% of the variables being linked to vehicles or streets.

In this study, we will analyze the relationship between the daily noise observed in Geneva and the outgoing long-wave thermal radiation emitted in the city. The hypothesis is that there is a positive correlation between the noise and the thermal radiation. The noisier the environment is, the more active it is and thus, the thermal radiation will go up. We will check if the location experiencing high noise are the same as the ones emitting strong radiation and study how they are distributed in Geneva.

Data

The dataset(Buchwalder) is a hectometric grid of the variables in Geneva which was provided by the Swiss federal office. The thermal data was acquired by the Landsat 8 satellite on 26.06.2018, while the noise data was downloaded from the swiss confederation website(god). In this study, the values of the variables were attributed to each hectometric cell and then the sum, mean, median and standard deviation were calculated using the zonal statistics tool from QGIS. The noise data is measured in dB and the thermal radiation are given in Digital numbers, which can then be converted to different values. The projection used in this project is the one from the swiss coordinate system: ESPG 21781.

Methods

The Software used to perform the exploratory data analysis is GeoDa (geo), a free open source software that provides tools for geospatial analysis. We will first make a basic statistical analysis of the data distribution using a scatter plot of the thermal radiation versus the noise experienced during the day. However, this method only lists the point and does not give an idea of the spatial distribution of the data.

For this reason we will add a co-location map of the two variables. To create a co-location map, we first need to divide each set of data into quantiles. We decided to use four quantiles, as a bigger number would lead to spreading the data too much to be relevant, while a lower number has the risk of grouping together points that could be very different, depending on the repartition inside the dataset. This co-location map will then show which points of each variable appear in the same quantile. This is a very useful tool to assess the correlation between two variables while also showing their location, allowing the reader to pick out different regions of the town. This will be useful because the population and activity are not spread out evenly across Geneva. The analysis will focus on finding hot spots in the city where the correlation might be significantly high or low.

Results

The scatter plot (Fig.1) Shows us a low correlation between the two variables, with an R^2 of only 0.062, it tells us that the variables are very close to being independent. We can see that the data are very clustered towards the center, having a very high number of observation in the middle of the graph, while the points on the outside are more spread out and in much lower number. We also see that the regression curve has a positive slope, implying a positive correlation.

In the co-location map, however, the correlation is more visible. There is a total of 2302 observations that share the same quantile, which makes out roughly one third of the data. They are more or less evenly spread out between them, with number a little higher in the extremes. The locations in Geneva that appear in the lower quantiles, in blue, are grouped mainly in the eastern part and on the lake shore. The high values however, are shown to appear in the city center, which is situated at the tip of the lake and around the south-western part of the city, close to where the airport is located.

Discussion

The low correlation showed in the scatterplot is mainly due to the repartition of the observation. They are gathered around a middle ground and this clustering influences heavily the regression line. The slightly positive relationship however, is a good sign that we are heading in the same direction. It shows that we are in a situation where there is a trend suggesting that there is a relationship between our variables, but the scatter plot shows correlation too weak to assert it definitively.

The co-location map, however, shows a really clear separation of the quantiles between the different parts of the city. The eastern part, mainly composed of smaller, less dense villages is clearly a different entity than the densely populated and built center. The human activity, which is the underlying indicator that is measured through the noise follows this trend well. It is interesting to note the pattern of how the red squares are distributed. We can see that they often follow straight lines, indicating big roads with a lot of traffic. The roads tend to heat up and radiate a lot due to the flow of vehicles and this is shown in the data.

The data also shows that day noise is a good enough indicator of the human activity. As expected, areas with high density of population, businesses, traffic and buildings are mostly clustered at the center of the town, where the noise during the day is the highest. That leads to the conclusion that, while activity itself is hard to quantify, the noise it produces can be a good indicator of how it is laid out in an urban area.

Conclusion

Overall, the hypothesis that there is a positive correlation between noise and thermal radiation is hard to verify directly, especially when looking at all the observations at once. However, once it is analyzed spatially, it is possible to define areas in which the correlation is clear. The article shows that the thermal radiation as well as the noise rise when you are around a populated center, and that it is especially related to roads and traffic. The urban planning of the city must take this phenomenon into account, otherwise, the probability of a heat island occurring can become very realistic and the quality of life in the city will deplete accordingly.

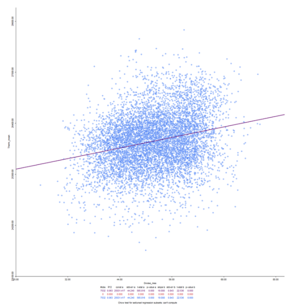

Figure 1: Scatterplot of Thermal radiation vs Day noise

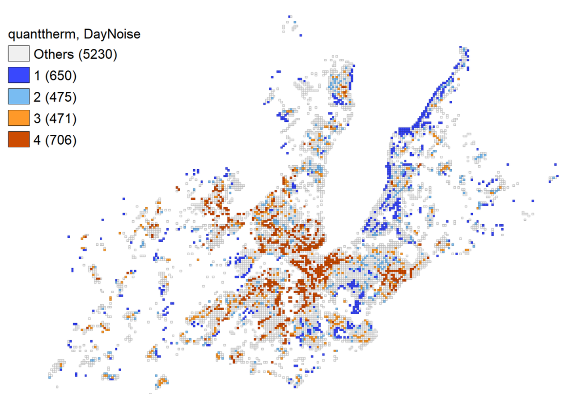

Figure 2: Co-location map of 4 quantiles between Day noise and Thermal radiation

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