# Correlation between noise and vegetation in urban areas

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## Introduction

In populated areas noise can be one of the major sources of pollution. If the presence of noise seems to go hand in hand with urban areas the introduction of vegetation could possibly reduce the discomfort it can cause to people and the possible effects it has on their health. The aim of this paper is therefore to study the correlation, which exists between greenness in urban areas and noise levels that can be measured both during day and night.

As of now several studies have been published, which try to relate the presence of vegetation noise levels and the impact both have on the population. One work by Donald Aylor (Aylor, 1972) explored the way different types of vegetation hindered the effects of noise in the presence of different environmental factors (Wind, soil among others). After the observations, models were developed to further enlarge the scope of the study. Results showed vegetation could effectively reduce loudness. The effectiveness of this reduction relied heavily on the vegetation's structure: foliage, stems, ground structure.

Another work (Dzhambov and Dimitrova, 2015) aimed to link the presence of green areas with the attenuation of both psychological stress and physical health issues related to noise pollution. A survey was conducted correlating the presence of greenness and the perception of noise the population had. Results showed that the "Noise sensitivity" was clearly reduced when the access to green spaces was increased.

For the present study the initial statement is that in areas with elevated greenness the noise decreases. The area of study is the municipality of Vernier (Geneva, Switzerland). Day and night levels of noise were measured and a correlation was established with the green areas of the municipality based on satellite pictures in order to verify the hypothesis mentionned above.

## Data

Several raster and vector layers around the municipality of Vernier were used.

Four orthophotos cover the zone of interest. They are RVB images already georeferenced and have a ground resolution of 0.5 meter. They probably originate from the federal office of topography Swisstopo but this is not clearly mentioned in the data, likewise for the height model. This height model has a ground resolution of 1 meter.

The noise data is provided by the Swiss noise databas (sonBase, 2010). The information is given in a raster file. It contains values of noise that were predicted by models and calculations based on noise sources data, traffic, urban fabric and terrain configuration (Reto Höin, 2009). Noise attenuation due to vegetation has not been taken into account to produce this database

The boundary of the municipality is stored in a shapefile as a polygon. It is projected according to the Swiss coordinates system SCR EPSG21781 as all the other georeferenced files used here.

## Methods

In order to obtain the results needed to do the study, both QGIS and GeoDa softwares were used following the respective "QGIS User Guide"(Athan, 2017) and "GeoDa User Guide" (Anselin, 2003).

The data needed for the analysis was obtained from four RVB satellite images encompassing the municipality of Vernier, two raster layers with the sound levels around the municipality of interest, and one vector layer defining the boundaries of Vernier. All this content was imported to QGIS. A Virtual Raster Catalogue was then created to merge the four RVB images. Using the style properties of the catalog, both Red and Blue bands were removed so that only the green band remained visible. This allowed to keep only the reflectance information of the area, which is important to detect the vegetation.

After that a 50x50m grid was created with its extent around the limits of the municipality of Vernier. With this grid all information contained in the green band raster and the day and night rasters was gathered in one single attribute table: levels of sound during day and night and of greenness in the area selected. This task was performed using the zonal statistical tool.

Then, the main tool of analysis was created, namely selecting only the cells confined within the boundaries of the municipality to extract precisely the information of interest. This operation was made possible with the "Spatial Query" tool available in QGIS.

In GeoDa this finer grid was exploited to extract both box maps and scatter plots. Those allow to establish comparisons between the different values of greenness and sound. They are also of interest to verify the spatial correlation between the levels of vegetation and noise, which allow for the verification of the hypothesis.

## Results

The average values of each dataset for the commune of Vernier are shown in table 1. There is quite a high range of values for the vegetation indicator, while the sound values for both day and night vary less. The data obtained during nighttime shows lower values as during daytime. The box plot analyses conducted

| | Greeennes | Sound day | Sound night |
|---|---|---|---|
| Minimum | 25.53 | 46.01 | 36.72 |
| Maximum | 228.19 | 54.41 | 44.91 |
| Mean | 113.65 | 50.21 | 40.78 |

Table 1: Important values of the given datasets

separately on the different data sets are represented in the figures below. Figure 1 represents the mean greenness index distribution in the commune of Vernier. The box map shows how the data is categorized into 6 fixed classes, with quite a few upper outliers and some rare lower outliers. The greennes index varies quite a lot from one grid cell to the other, with a sole large zone of consistency in the middle of the commune showing values contained in the first quartile of the greenness levels.

The sound box maps show similar results for both day (figure 2) and night data (figure 3). One can see a pattern of the distribution of higher noise values which form straight lines crossing the commune from part to part in different directions.

More upper outliers are noticeable in figure 3, which represents the distribution of sound during the night. Those are mainly aligned on a curved line North of the commune.

# Discussion

The upper outliers of figure 3 are aligned and thus probably correlated spatially. This may contradict the first interpretation saying that they result of simple errors. Looking at the map shown in figure 4 one notices directly that indeed the outliers coincide with the end of the highway arriving in Vernier. The cells of the grid with values superior to the median also correspond to roads with important traffic such as primary or secondary roads.

The remaining cells, which indicate lower sound values, could correspond to areas less exposed to traffic and urban life, and it might thus be where a higher concentration of vegetation could occur. Nonetheless when looking at the satellite image of the commune we only notice one main green area, corresponding to the forest 'Nant de la Noire' (figure 5).

This does not really correspond to the results shown in figure 1, which indicate much higher green values at other places. This results from the fact that the greenness index also takes into account the reflectance of urban objects such as mirrors, glass or even asphalt for example, in such a way that the results do not only show vegetation presence. This bias can also be seen in the scatter plot in figure 6 showing the values of greenness and the sound values at night. Indeed, no clear correlation can be seen between those two datasets, as indicated by the p-value of 1 (meaning that almost all other random combinations showed more correlation than our datasets did). The slope of the fitted line is not negative, as would be expected if an inverse correlation was in place.

In order to test the correlation between vegetation and noise a smaller zone was selected to conduct some further analysis. A zoom on the forest 'Nant de la Noire' allowed to be certain that the values obtained for this region actually corresponded to the presence of vegetation and not some urban reflectance. This new region was defined as shown in figure 7.

A new scatter plot (figure 8) was done using this restricted area. The results of this secondary analysis are much more coherent with what one would expect when testing for inverse correlation of noise and greenness. The fitted line has indeed a negative slope, which indicates an inverse correlation. The p-value of 0.01 is also an indication that the pair of sound and greenness values are not put together randomly but respects some kind of a logic, that is, the greener the area, the less noisy it is.

# Conclusion

The purpose of this short exercise was to use different tools to analyse geodata. It was about analysing correlations between noise and vegetation in the municipality of Vernier. This problematic is perturbed with other environmental factors as settlement form or population density (Margaritis and Kang, 2016) and (Riedel et al., 2013). For such a study there are some issues that must be addressed as the importance to have appropriate data and to use the right information. Instead of taking the green band of an orthophoto, one would need to filter it or directly take a map of vegetation from Swisstopo. Moreover a map representing the real noise instead of a model of noise prediction is necessary to assess vegetation effect on noise dampening.

## Contributions of the authors

All three author had to elaborate maps and statistical representation of data. Here we took the illustration and results obtained by MR. The report has been prepared by MR for the introduction and the methods. The part of data presentation has been written by RL. The results and discussion have been synthesised by CN. Finally the conclusion and references were done by RL.

## References


Anselin. GeoDaTM 0.9 User's Guide. Technical report, 2003.

Athan. QGIS User Guide. 2017.

Donald Aylor. Noise Reduction by Vegetation and Ground. *The Journal of the Acoustical Society of America*, 51(1B):197–205, jan 1972. doi: 10.1121/1.1912830. URL https://doi.org/10.1121%2F1.1912830.

Angel M. Dzhambov and Donka D. Dimitrova. Green spaces and environmental noise perception. *Urban Forestry & Urban Greening*, 14(4):1000–1008, 2015. doi: 10.1016/j.ufug.2015.09.006. URL https://doi.org/10.1016%2Fj.ufug.2015.09.006.

Efstathios Margaritis and Jian Kang. Relationship between urban green spaces and other features of urban morphology with traffic noise distribution. *Urban Forestry & Urban Greening*, 15:174–185, 2016. doi: 10.1016/j.ufug.2015.12.009. URL https://doi.org/10.1016%2Fj.ufug.2015.12.009.

Micha Köpfli Thomas Minder Reto Höin, Kirk Ingold. SonBase - The GIS Noise Database of Switzerland. Technical report, 2009.

Natalie Riedel, Heike Köckler, Joachim Scheiner, and Klaus Berger. Objective exposure to road traffic noise noise annoyance and self-rated poor health – framing the relationship between noise and health as a matter of multiple stressors and resources in urban neighbourhoods. *Journal of Environmental Planning and Management*, 58(2):336–356, dec 2013. doi: 10.1080/09640568.2013.859129. URL https://doi.org/10.1080%2F09640568.2013.859129.

sonBase. - Swiss noise database, Federal Office for the Environment (FOEN). Technical report, 2010.

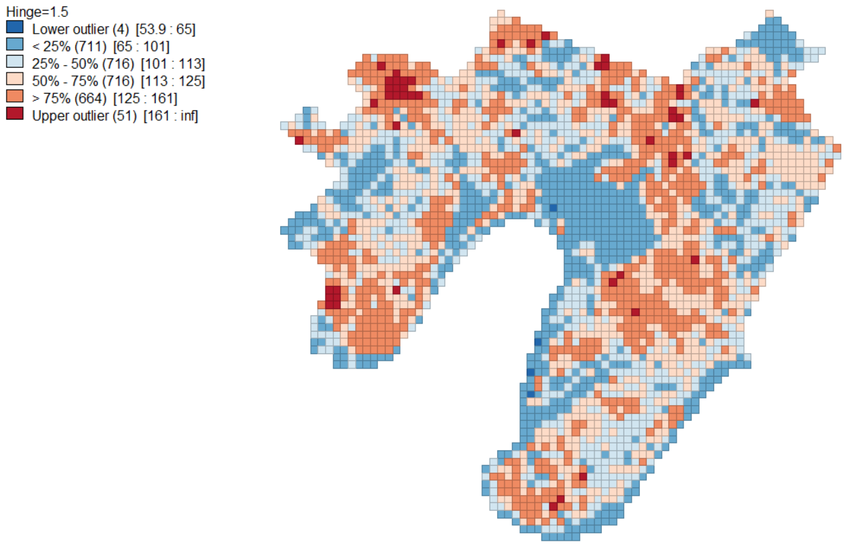



Figure 1: Box plot analysis of the greenness index

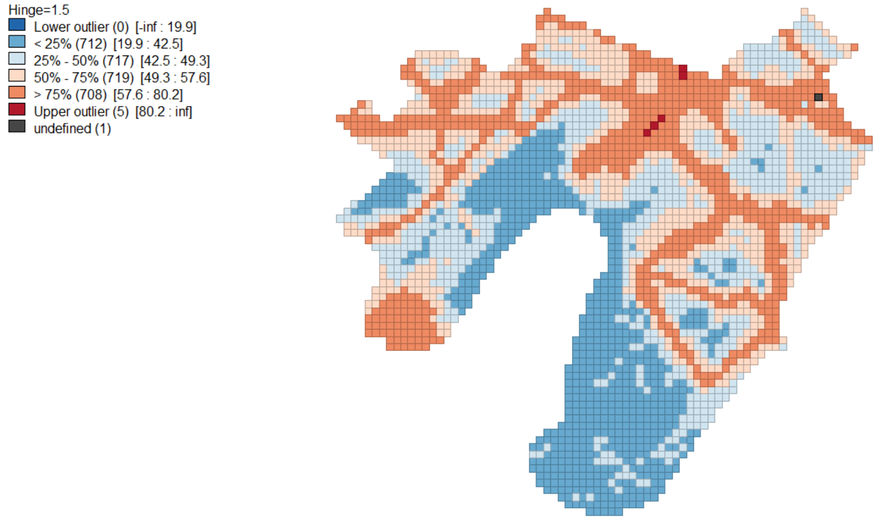



Figure 2: Box plot analysis of the sound during the day

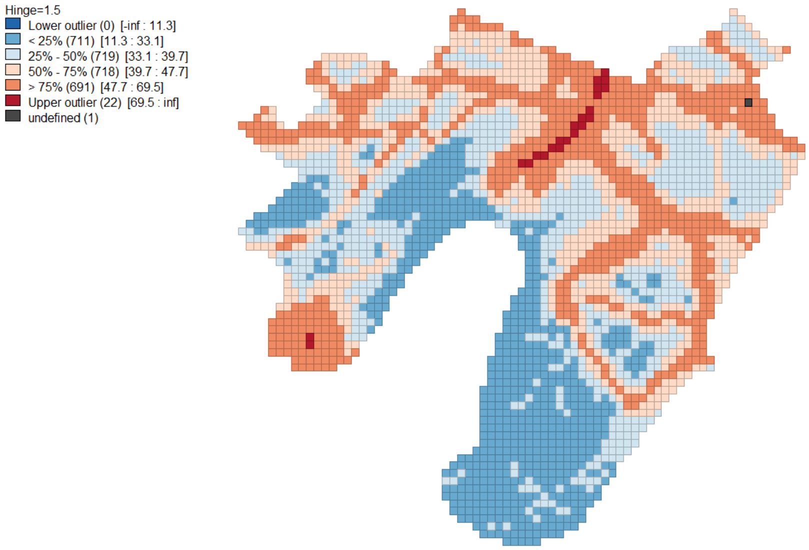



Figure 3: Box plot analysis of the sound during the night

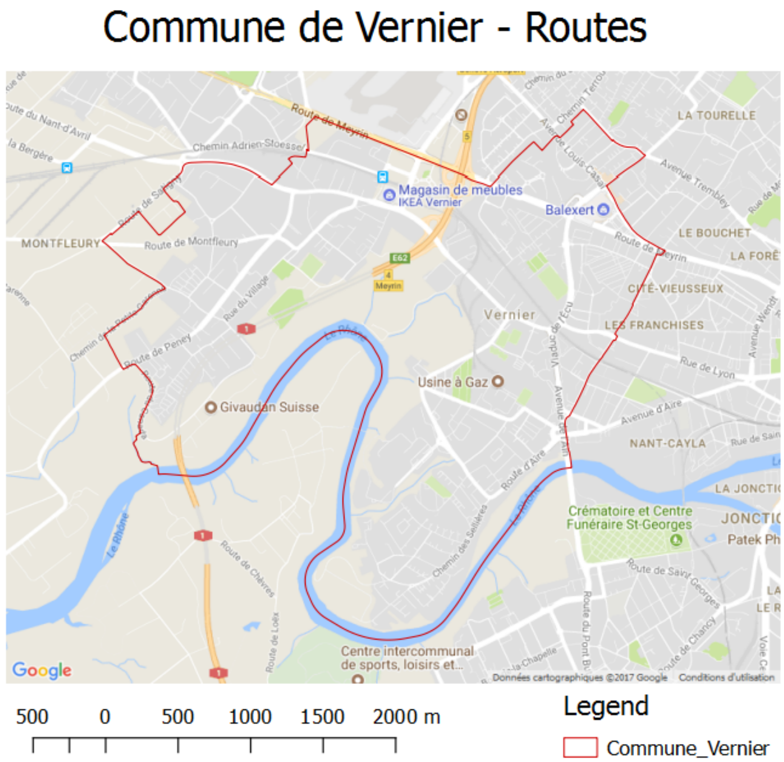



Figure 4: Roadmap of Vernier - Google Maps

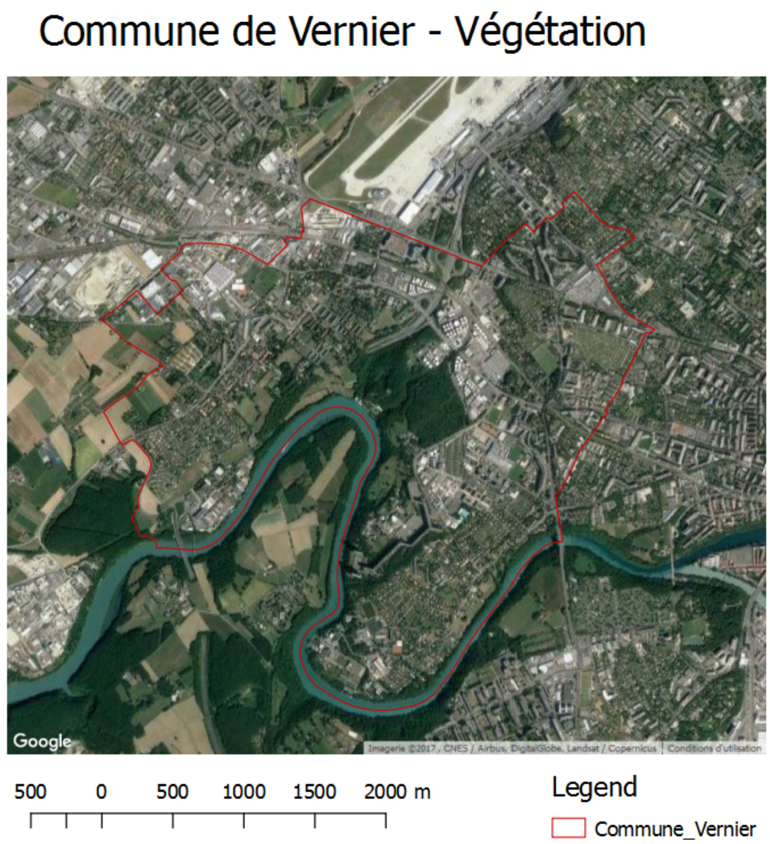



Figure 5: Satellite image of Vernier - Google Satellite

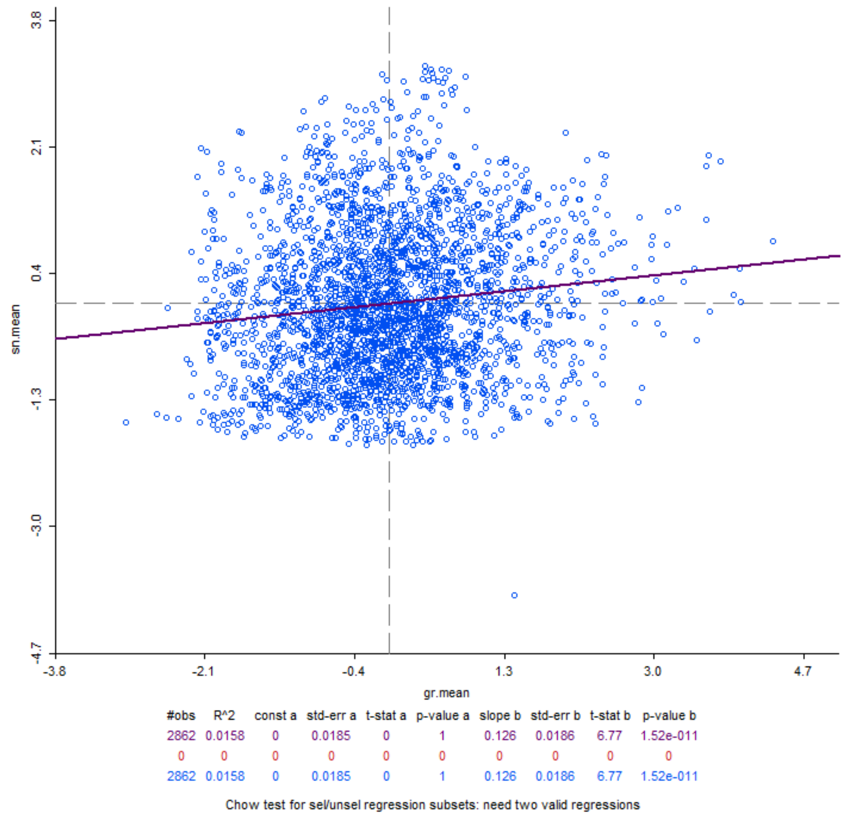



Figure 6: Scatter plot greenness index vs sound data during the night

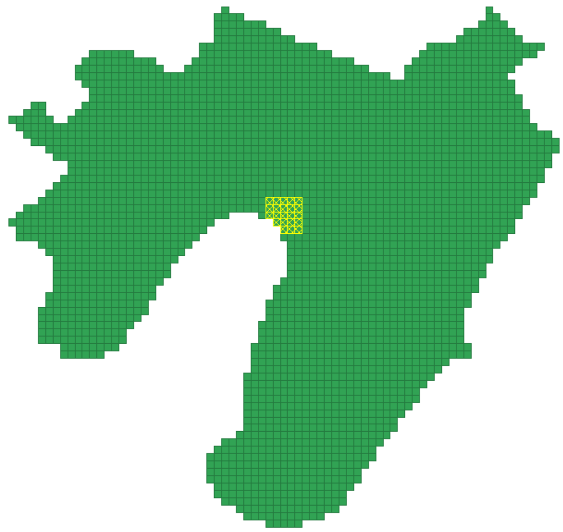
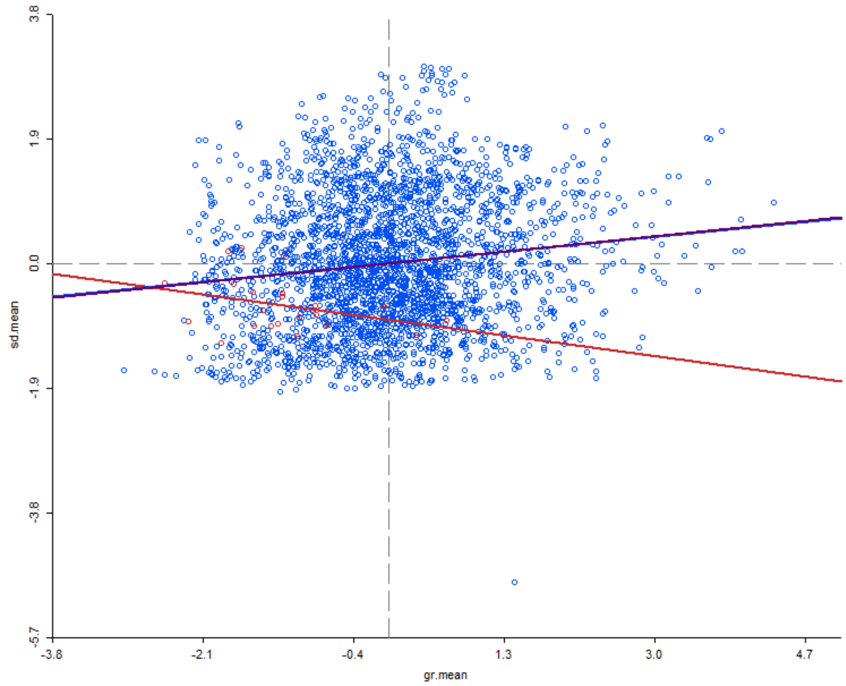


Figure 7: New selection with cells containing the forest ‘Nant de la Noire’




| #obs | R^2 | const a | std-err a | t-stat a | p-value a | slope b | std-err b | t-stat b | p-value b |
|---|---|---|---|---|---|---|---|---|---|
| 2862 | 0.0189 | 0 | 0.0185 | 0 | 1 | 0.137 | 0.0185 | 7.41 | 1.62e-013 |
| 22 | 0.113 | -0.86 | 0.161 | -5.33 | 3.26e-005 | -0.184 | 0.116 | -1.59 | 0.127 |
| 2840 | 0.0178 | 0.00375 | 0.0186 | 0.201 | 0.841 | 0.134 | 0.0187 | 7.18 | 9.1e-013 |

Chow test for sel/unsel regression subsets: distrib=F(2,2858), ratio=3.257, p-val=0.03864

Figure 8: Scatter plot greenness index vs sound data during the night Restricted zone analysis (22 data points)