Spatial relations between Normalized Vegetation Index and thermal data in Geneva

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Introduction

Vegetation in cities is generally very appreciated but not always considered as a priority by the land use planning services. Should one now define green areas installations in cities as priority need ? Indeed this interesting question needs to be approached from different viewpoints. Vegetation in urban zones is important for the population comfort as it can provides relaxation and recreational areas and also a scenic beauty. But according to several recent studies, urban vegetation could also have real benefits on several Environmental health criteria[1]. For example, the Urban Heat Island as an urban area that is significantly warmer than its rural surrounding (due tu human activities) could possibly aggravate the situation about global warming. This phenomenon could eventually be better controled thanks to green roofs or gardens. This study aim to caracterize the relation between a vegetation index and thermal data in the city of Geneva, Swtizerland, in order to see if vegetation can be an efficient answer to overheating in cities.

Data

The data used here come from a Landsat image from 2015. Bands 4, 5 and 11 have been used to compute two variables. The Normalized Vegetation Index (NDVI), from bands 4 (Red) and 5 (Near Infra-Red), according to the following equation : $NDVI = \frac{NIR - Red}{NIR + Red}$.

Thermal data from band 11 has been used as it was, and considered as an indicator about the ground surface temperature. We'll assume that high values imply high ground surface temperatures and low values imply low ground surface temperatures.

Methods

We will start by visualizing the aforementioned datasets to obtain an understanding of the data as a whole. General trends and first observations about spatial distribution of each dataset will be noted and we will then try to find relevant relations between them. In partical we will try to evaluate the correlation between vegetation and ground temperature.

Results

The Fig 1. shows a map of NDVI spatial distribution according to natural breaks classes. It shows a red zone in the city center at the lake's end which is probably completely built-up and contains no green areas at all. Now, the question raised is : does this area show particularly high values for the thermal data ? This was precisely the case: all the areas which have values of NDVI inferior to 0.180 (two lowest classes) correspond to the category of highest themal values for the same classification (Natural breaks map with 4 classes). In order to know if this relation between the two datasats could be generalized and remains in non extreme values, we made a LISA scatter plot (visible in the Fig 2). which allows us to analyze the spatial correlation between the variables of interest. The negative slope (Moran's I equal to -0.56 approximately) expresses the negative correlation between NDVI and thermal data. Regarding the contiguity, we used a queen weighting scheme of order 1. Moreover a randomization of 999 permtutations gave a p-value of 0.001 so the results can be considered really significant.

Discussion

We found that there was a negative autocorrelation between the vegetation abundance and the land surface temperature in the city of Geneva. It seems acceptable to state that adding more green areas in cities would prevent cities from excessive land surface temperature, and thus from excessive radiative cooling during the night. Indeed, ground's heat is usually released to the atmosphere through radiations during the night and can be very important in urban zones. In this case, the city of Geneva showed a sensitive area in the city center which has a very low vegetation abundance. This suggests that it could be important to focus efforts on the localization and development of these sensitive areas in cities. The data used were not complete : there are some areas in which only a few measurements have been made but the trends were still understandable. One might wonder which type of green areas would be the most efficient to control heat excess in urban areas and it would be interesting to do some experiments and measurements about this in the future.

References

[1]Exploring the relationship between land surface temperature and vegetation abundance for urban heat island mitigation in Seville, Spain - A. Farina, Lund University, 2012

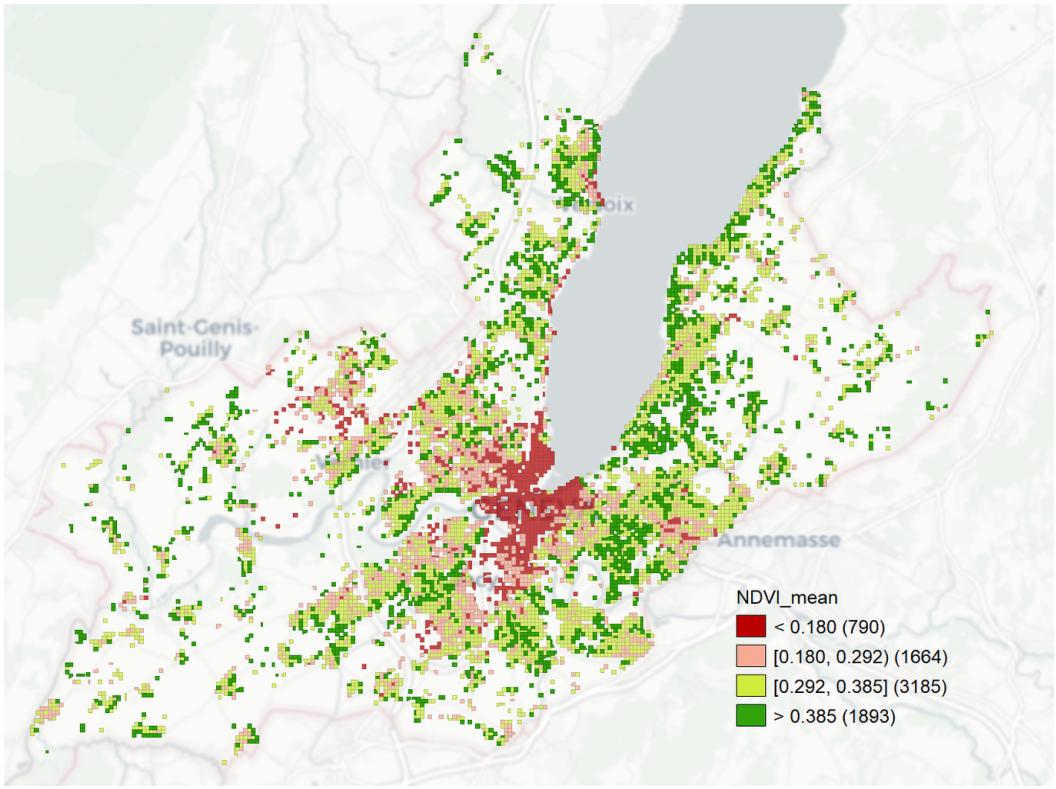

Figure 1: Natural breaks map of NDVI mean in Geneva

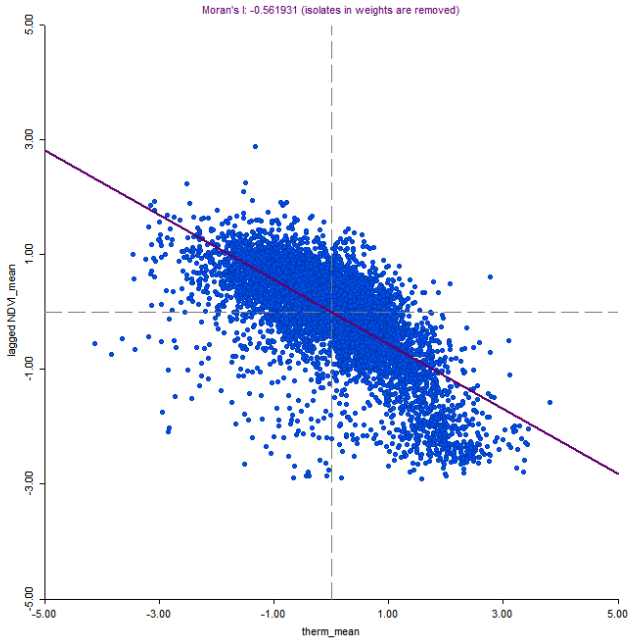

Figure 2: LISA Scatter plot (Bivariate Moran's I) between NDVI mean and thermal data