Evaluation of the Expansion of Brazilian Urban Areas and its Social and Environmental Impacts by means of Integration of NTL and NDVI indexes

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INTRODUCTION

The increasing urbanization process results in high rates of vegetal suppression and brings with it an intense population flow, contributing to the formation of the so-called metropolitan regions.

In this context, knowledge about the increase of the urban sprawl in large cities such as São Paulo, Rio de Janeiro and Belo Horizonte becomes fundamental, since it can contribute not only to urban planning but also to predict future growth scenarios of these cities.

Nighttime satellite imagery is a way for mapping how urban growth is changing Earth's landscape.

In the field of remote sensing, the MODIS sensor stands out for the ability to collect continuously high-frequency data on the Earth's surface. Meanwhile the nighttime images of the globe are created by the Defense Meteorological Satellite Program (DMSP) with the OLS (Operational Linescan System) sensor that produce the images in NTL (Night Time Light). It captures images with low light intensity, being able to capture the unlit face of the planet only with the light of the Moon. The sensor can detect lights from various sources such as human occupations, fires, gas explosions, lightning and so on.

Areas of study – Brazil:

- The Metropolitan region of São Paulo has a population of almost 20 million inhabitants in a territory of 7,947 km²;
- The Metropolitan region of Rio de Janeiro has an estimated population of more than 11 million residents in an area of 6,737 km²;
- Belo Horizonte is relatively a new city, with only 118 years. It has approximately 5 million inhabitants in its metropolitan area of 9,473 km² (PNUD, 2014).

METHODS

Indexes

NDVI (Rouse *et al.,* 1973)

It is the most used for studies of vegetation behavior. It estimates the biomass with the variables in the red band and near infrared.

$$NDVI = \frac{(R_{NIR} - R_{Red})}{(R_{NIR} + R_{Red})}$$

VANUI (Zhang *et al.,* 2013)

The VANUI index is based on the fact that vegetation and urban surfaces are inversely correlated. It uses vegetation data (NDVI) to reduce saturation and increase intercity variability in nighttime brightness values.

$$VANUI = (1 - NDVI) * NTL$$

Flowchart

1. Acquisition of Images
468 monthly scenes MOD13A3 – 2001 to 2013;
13 images NTL – 2001 to 2013;

2. Pre-processing
Mosaic of the scenes for the Metropolitan Region of Rio de Janeiro and Belo Horizonte;
Reprojection;
Cuts in the studied area.

3. Processing
Annual average of NDVI;
NTL data normalization;
VANUI

4. Evaluation
Slicing;
Area calculation;
Mask

RESULTS

A growth pattern was observed in all the studied sites, although the visual change was not very noticeable in the case of Rio de Janeiro. In the Metropolitan Area of Belo Horizonte, the visual change was quite evident. This can be explained by the fact that it is a new city, which makes its urbanization process more recent.

Zhang (2013) has proved the effectiveness of the VANUI index for the reduction of urban sprawl saturation which can be applied as a new tool in the analysis of urban growth.

São Paulo

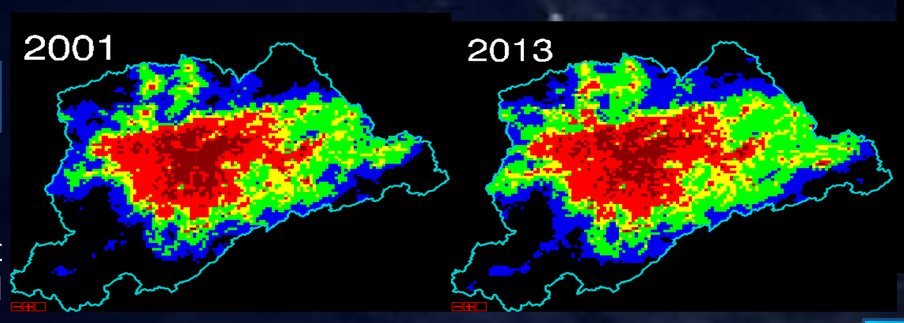

Figure 1. Time variation in the Metropolitan Area of São Paulo, using the VANUI index

Figure 2. Observed growth throughout the period

Rio de Janeiro

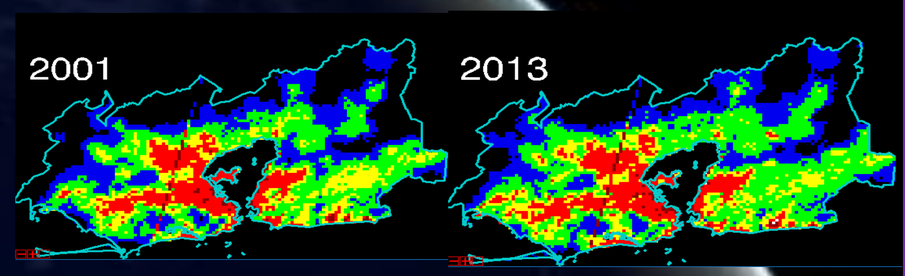

Figure 3. Time variation in the Metropolitan Area of Rio de Janeiro, by means of the VANUI index

Figure 4. Observed growth throughout the period

Belo Horizonte

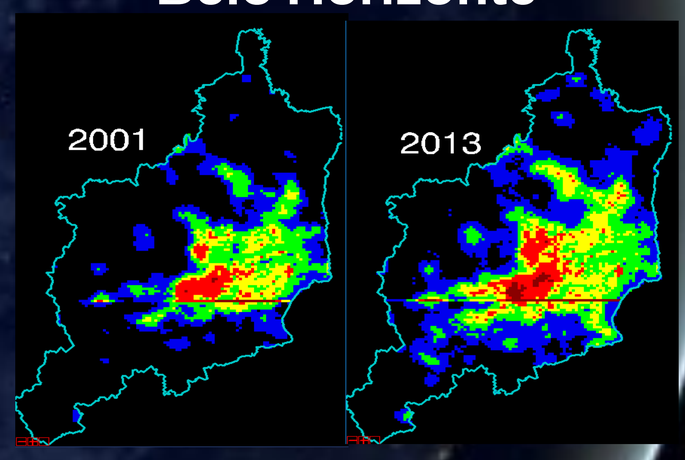

Figure 5. Time variation in the Metropolitan Area of Belo Horizonte, using the VANUI index

Figure 6. Observed growth throughout the period

CONCLUSION

1. The present study demonstrated that it is possible to use night-light data from the DMSP-OLS satellite to determine the growth of the urban sprawl by applying the VANUI index for the correction of saturation.
2. The data presented reliability and it is possible to perceive growth of the urban sprawl in the three Metropolitan Regions analyzed.