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Estimating population and energy consumption in Brazilian Amazonia using DMSP night-time satellite data

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Abstract

This paper describes a methodology to assess the evidence of human presence and human activities in the Brazilian Amazonia region using DMSP/OLS night-time satellite sensor imagery. It consists on exploring the potential of the sensor data for regional studies analysing the correlation between DMSP night-time light foci and population, and the correlation between DMSP night-time light foci and electrical power consumption. In the mosaic of DMSP/OLS night-time light imagery from September 1999, 248 towns were detected from a total of 749 *municípios* in Amazonia. It was found that the night-time light foci were related to human presence in the region, including urban settlements, mining, industries, and civil construction, observed in ancillary Landsat TM and JERS imagery data. The analysis considering only the state of Pará revealed a linear relation ($R^2 = 0.79$) between urban population from the 1996 census data and DMSP night-time light foci. Similarly, electrical power consumption for 1999 was linearly correlated with DMSP night-time light foci. Thus the DMSP/OLS imagery can be used as an indicator of human presence in the analysis of spatial–temporal patterns in the Amazonia region. These results are very useful considering the continental dimension of Amazonia, the absence of demographic information between the official population census (every 10 years), and the dynamics and complexity of human activities in the region. Therefore

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DMSP night-time light foci are a valuable data source for global studies, modelling, and planning activities when the human dimension must be considered throughout Amazonia.

Keywords: DMSP/OLS night-time light; Human settlements; Urban population; Electrical power consumption; Urban Amazonia; Spatial analysis; Regional scale

1. Introduction

The Brazilian Amazonia supports the world's largest contiguous area of untouched tropical forest. However, recent estimates show deforestation rates of 1–3 million ha year^{-1} for the period of 1991–1999 and the loss of approximately 60 million ha of forest by 2000 (INPE, 2002). The deforested area of the Brazilian Amazonia has increased from 10 million ha in the 1970s to nearly 59 million ha in 2000, as a consequence of the construction of an extensive road network and government-assisted migration and agrarian projects. Alves (1999) showed that 90% of the total deforestation in Amazonia has been concentrated within a 100 km^2 land zone around major roads, increasing the environmental and social impact in such areas.

During the last three decades, the Amazonia region has experienced the highest urban growth rates in Brazil. [1] In 1970, urban population comprised 35.5% of the total population. This proportion increased to 44.6% in 1980, to 58% in 1991, to 61% in 1996, and to 68% in 2000. [2] The increasing diversity in economic activities and the subsequent increase in the population density have reorganized the network of human settlements all over the region. Current 21st century data show patterns and spatial arrangements that reveal a different Amazonia from the last decades. This new Amazonia emerges as a tropical forest with a complex urban system, a perspective that has led some researchers to put forward the claim for an "urbanized forest" (Becker, 1995).

Measures of urban growth and population in Amazonia however have been dependent on census data, collected typically on a 10-year interval. Additionally, census tracts in the region frequently cover a mixture of urbanized areas and large uninhabited ones, making it difficult to produce realistic representations of the spatial distribution of the population. The spatial and temporal dimensions of the occupation processes in Amazonia suggest the use of remote sensing data provided by the Defense Meteorological Satellite Program (DMSP), with the Operational Linescan System (OLS). The OLS sensor is particularly interesting because it is

[1] For this paper, we adopted the IBGE (Brazil's Census Bureau) surveys definition for *urban population*: every people which domicile is located inside of urban perimeter (defined by law) are counted as urban population (IBGE, 1995).

[2] Population data for this paper was obtained from IBGE surveys.