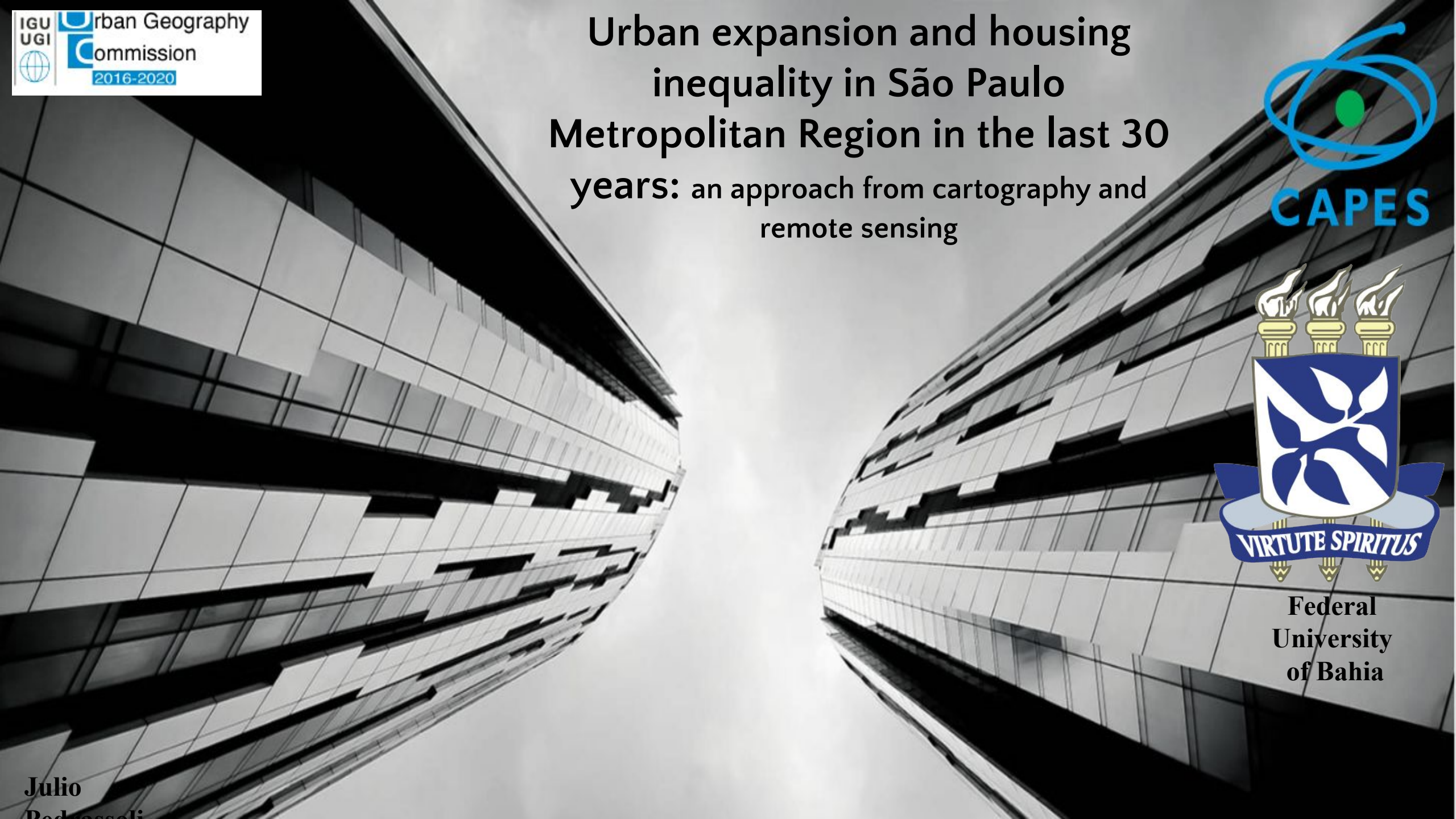


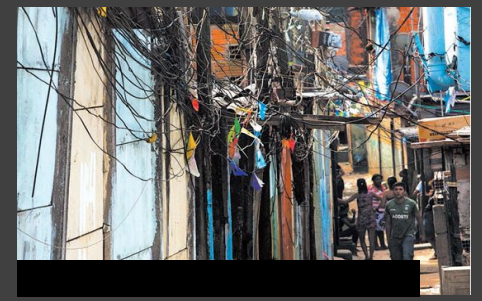
Urban expansion and housing inequality in São Paulo Metropolitan Region in the last 30 years: an approach from cartography and remote sensing

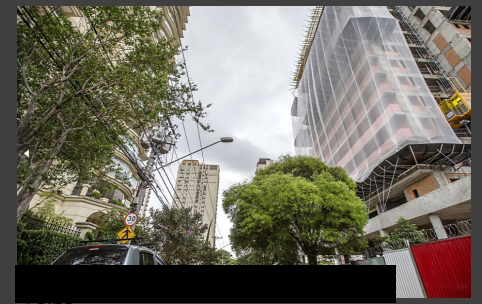
Julio

Federal University of Bahia

Housing and inequality

margins

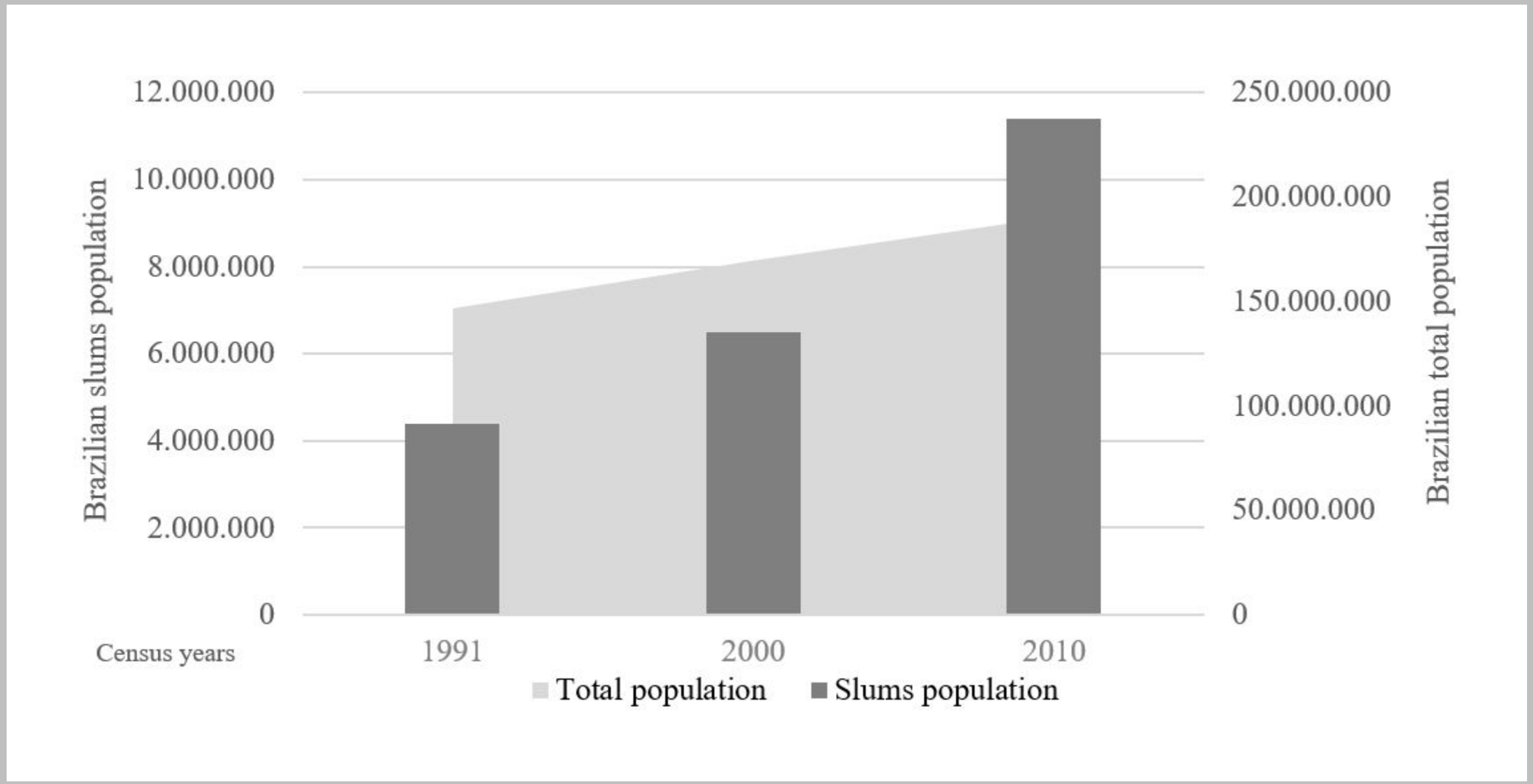




Folha.

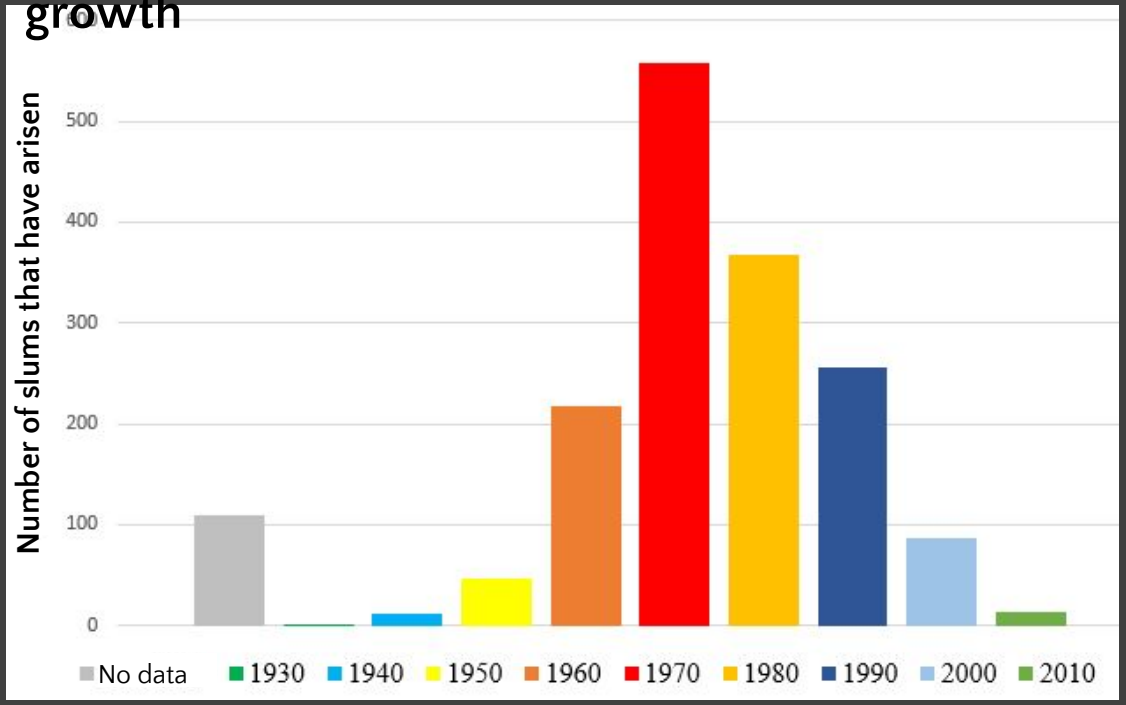
Picture: Tuca

Slums population *versus* Total population increase in Brazil (1991 – 2010)



Source: Brazilian Institute of Geography and Statistics (IBGE 1991, 2000 and 2010)

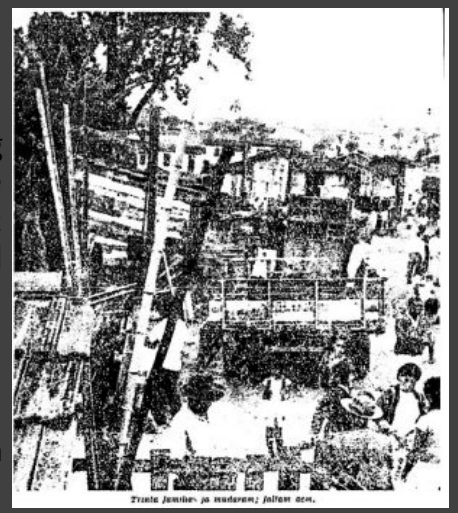
Slums growth



Emergence of new favelas (slums) for decennial periods. Source: HABISP, 2015. Organization of the author.

Slum of Várzea do Penteado, near the State Avenue and the central area of the city of São Paulo. 1940s. Source: Sebastião Pereira's photo of the collection of iconography and museum.

Slum of Vergueiro between 1965 and 1968. Original legend "the farms lived with the favela". Source: Lacoste, 1975 apud De Lara, 2012.



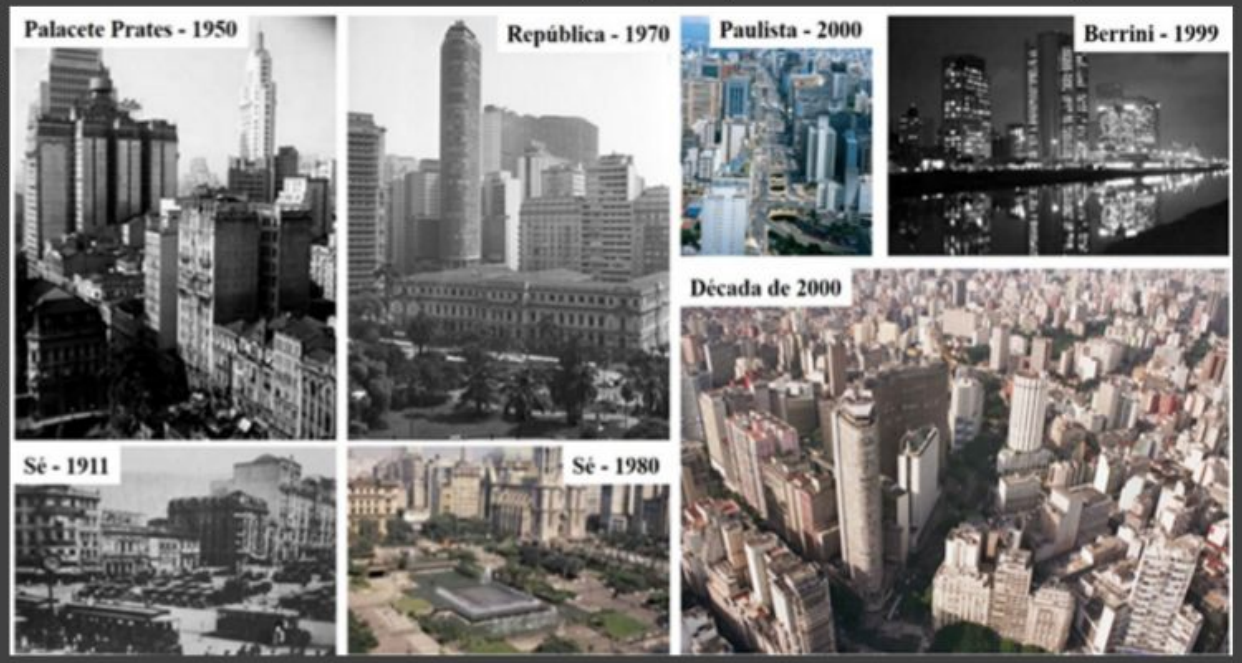
Slum dwellers being removed from the Vergueiro (first eviction) in 1962 and sent back to the origin in 1968. Source: Folha de São Paulo of April 18, 1962 and May 9, 1968, adapted from De Lara (2012).

Verticalizatio n

Verticalization in São Paulo - 1940 to 2011. Adapted from Someck and Gagliotti

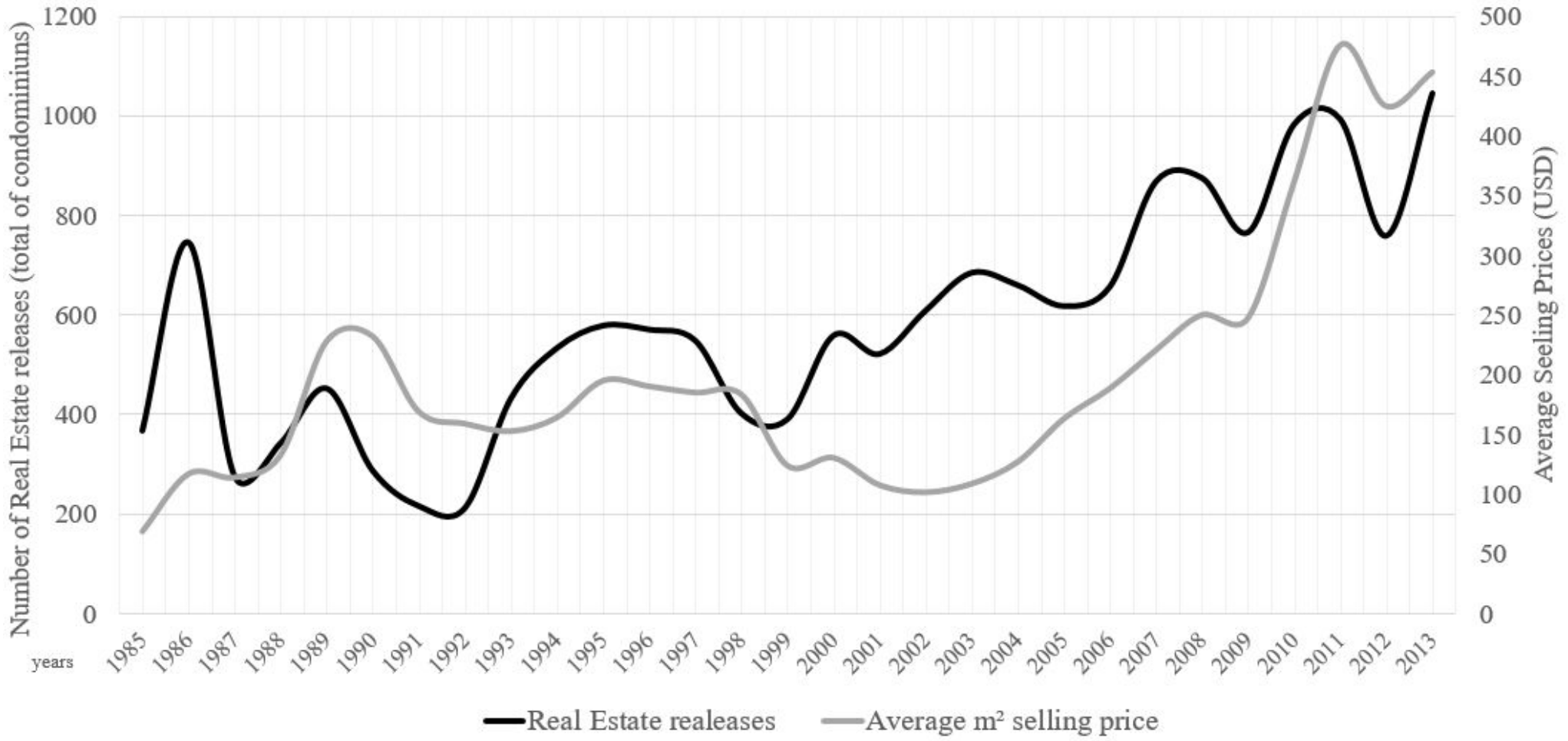
Verticalization of the center of São Paulo between 1911 and 1929. From left to right: Sé square (1911), Direita St. (1928) and Patriarca square (1925). Adapted from "Demographic History of the Municipality of São Paulo".

View of the city center of São Paulo. On the left the street Tabatinguera, the Forum João Mendes and the works of the Cathedral. To the right, Rangel Pestana Avenue and Carmo Church. Source: "Demographic History of the Municipality of São Paulo".



Images of Verticalization in the city of São Paulo between the 1950s and 2000s. Adapted from "Demographic History of the city of São Paulo".

Vertical Real Estate releases *versus* average raw selling prices by year in SPMR (1991 – 2010)



Source: CEM (2015), organized by the author.

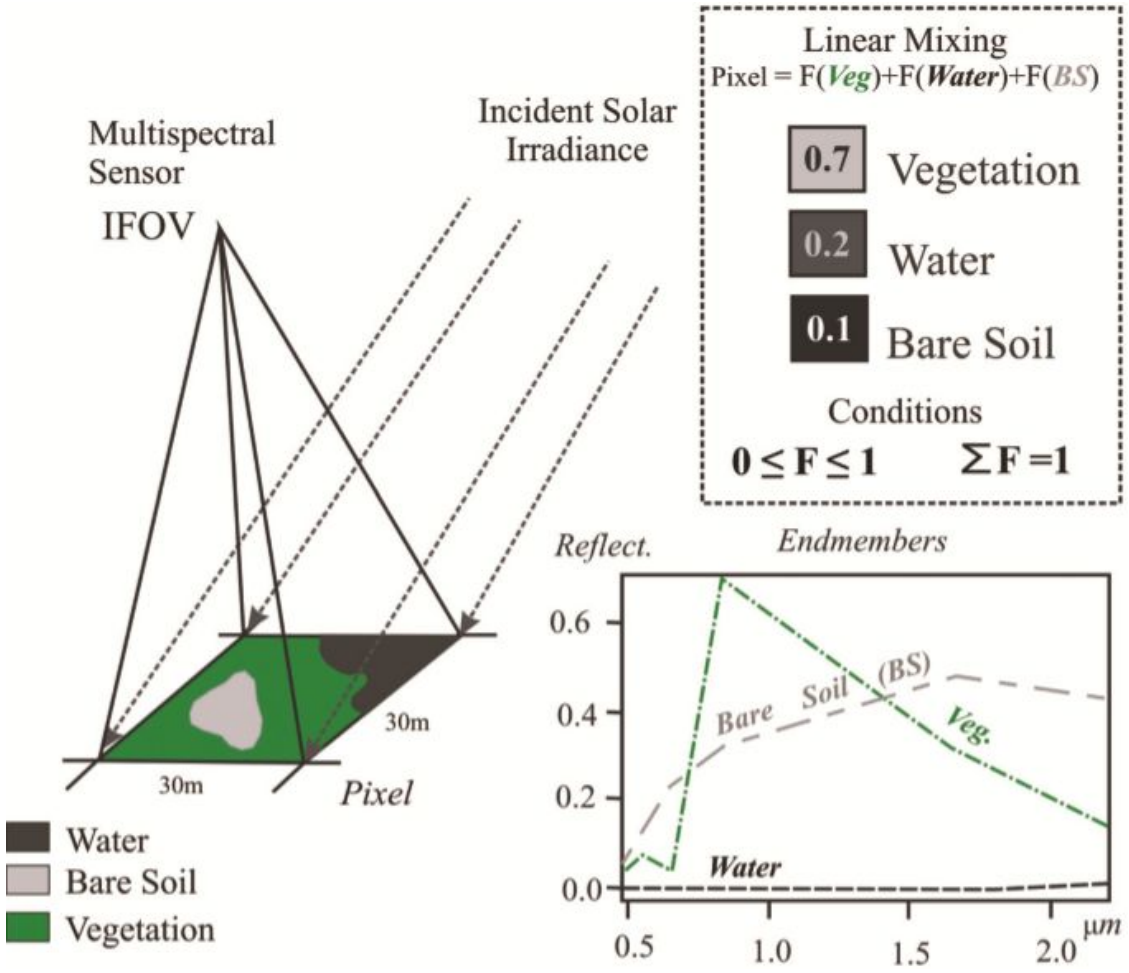
The pixels of the Ibirapuera Park in São Paulo in a Landsat 8 image of 01/09/2013. Adapted from NASA, 2013 (Growth of São Paulo, Brazil, July 9, 2014 - http://earthobservatory.nasa.gov/IOTD/view.php?id=83987).

Is it possible to relate these physical records of the changes, accumulations and ruptures in the urban space that the orbital images capture, to the socio-political processes that direct them?

How the changes in the spatial patterns of formal and informal housing over time in the São Paulo Metropolitan Region (SPMR) are detected and recorded by satellite images?

Hypothesi

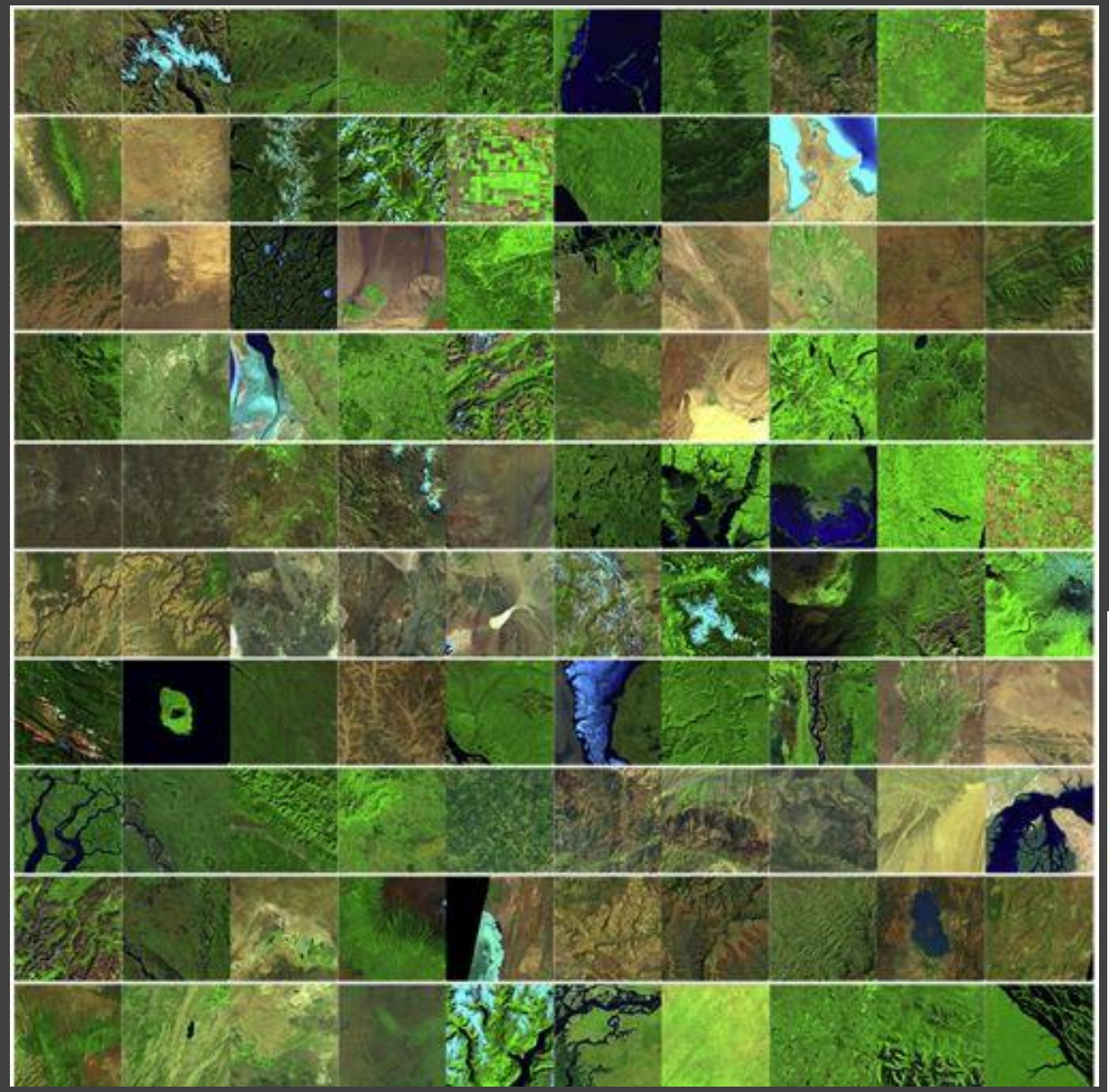
Perfect decomposition with a Linear Spectral Mixture Model (LSMM) on a 30m pixel formed by a mixture of 3 components: vegetation, water and soil. On this case, the residual is zero.



$$\begin{bmatrix} f_1 C_{1\lambda 1} \\ f_1 C_{1\lambda 2} \\ f_1 C_{1\lambda 3} \\ f_1 C_{1\lambda 4} \\ f_1 C_{1\lambda 5} \\ f_1 C_{1\lambda 6} \end{bmatrix} + \begin{bmatrix} f_2 C_{2\lambda 1} \\ f_2 C_{2\lambda 2} \\ f_2 C_{2\lambda 3} \\ f_2 C_{2\lambda 4} \\ f_2 C_{2\lambda 5} \\ f_2 C_{2\lambda 6} \end{bmatrix} \cdots + \begin{bmatrix} f_n C_{n\lambda 1} \\ f_n C_{n\lambda 2} \\ f_n C_{n\lambda 3} \\ f_n C_{n\lambda 4} \\ f_n C_{n\lambda 5} \\ f_n C_{n\lambda 6} \end{bmatrix} = \begin{bmatrix} R_{\lambda 1} \\ R_{\lambda 2} \\ R_{\lambda 3} \\ R_{\lambda 4} \\ R_{\lambda 5} \\ R_{\lambda 6} \end{bmatrix}$$

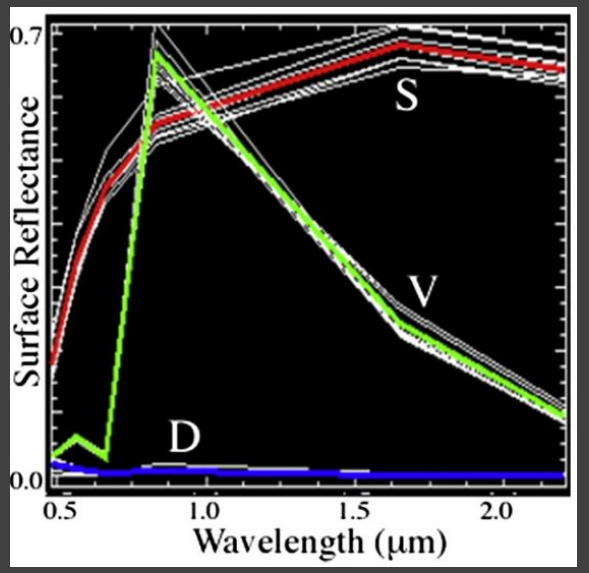
Source: Kawakubo, F. S. (2010)

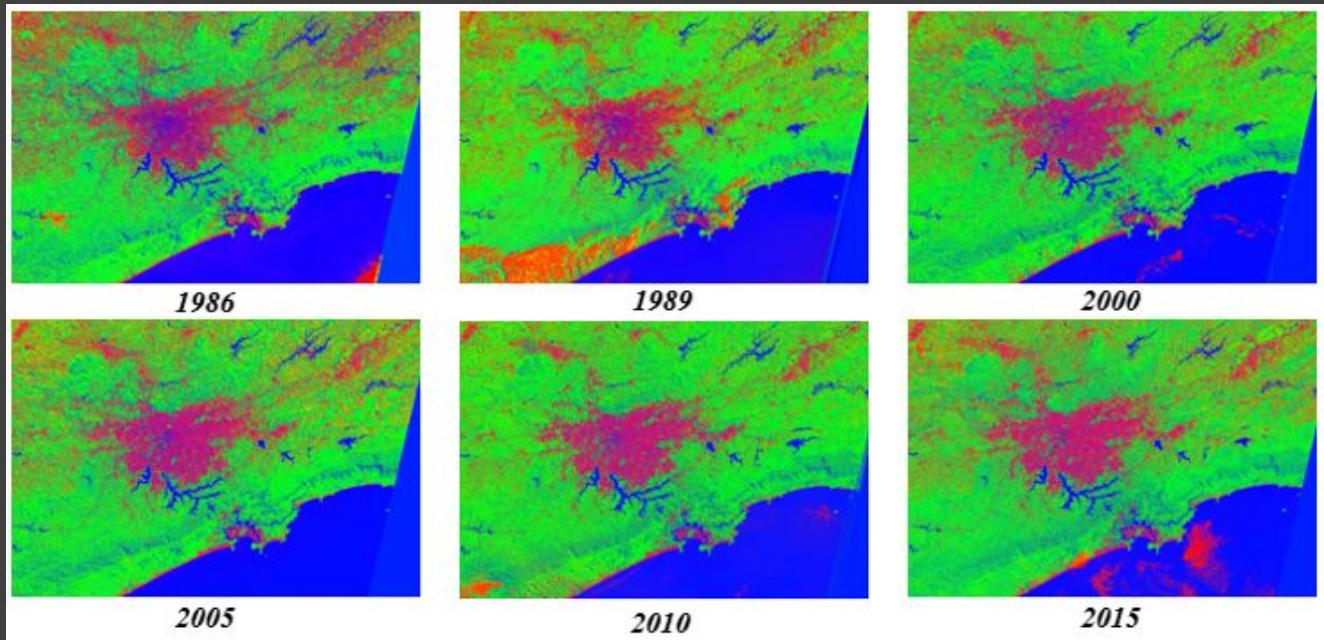
Global Endmenbers



Average of the three main dimensions (98%) of the global land cover spectrum. Source: Small & Millesi, 2013

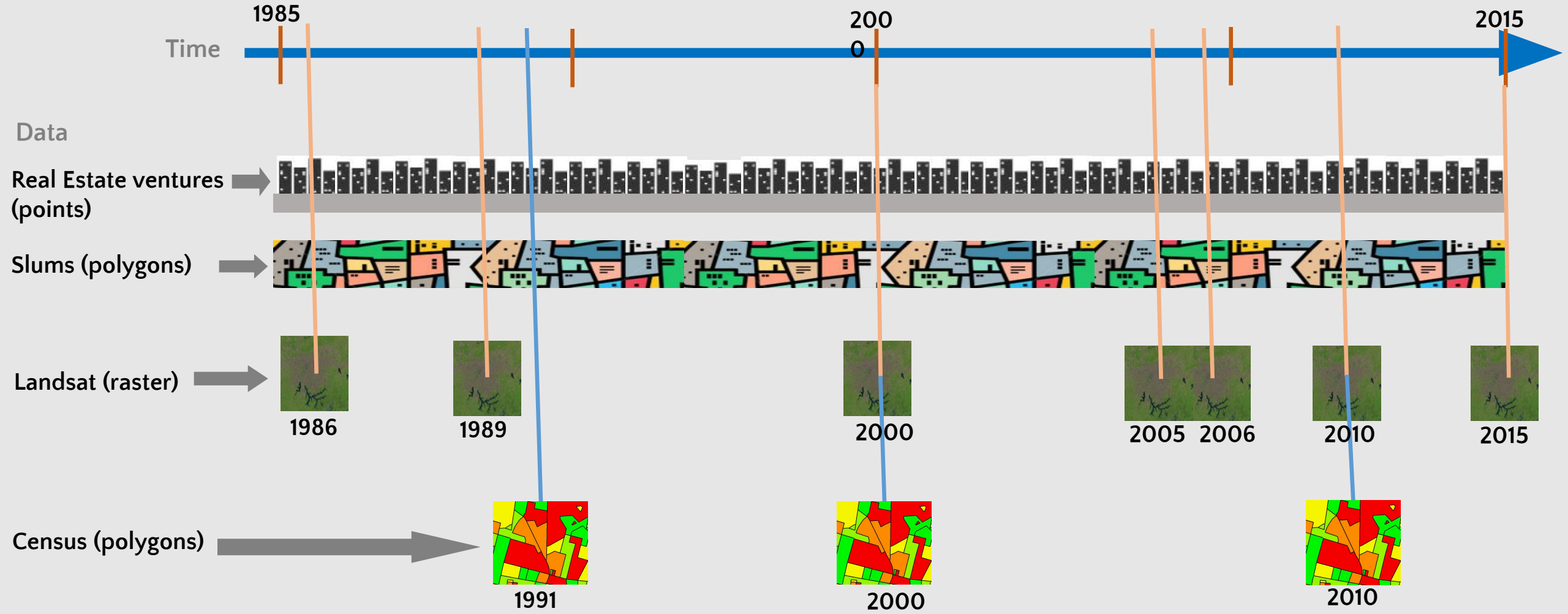
Linear Spectral Unmixing





Global Endmenbers

Linear Spectral Unmixing



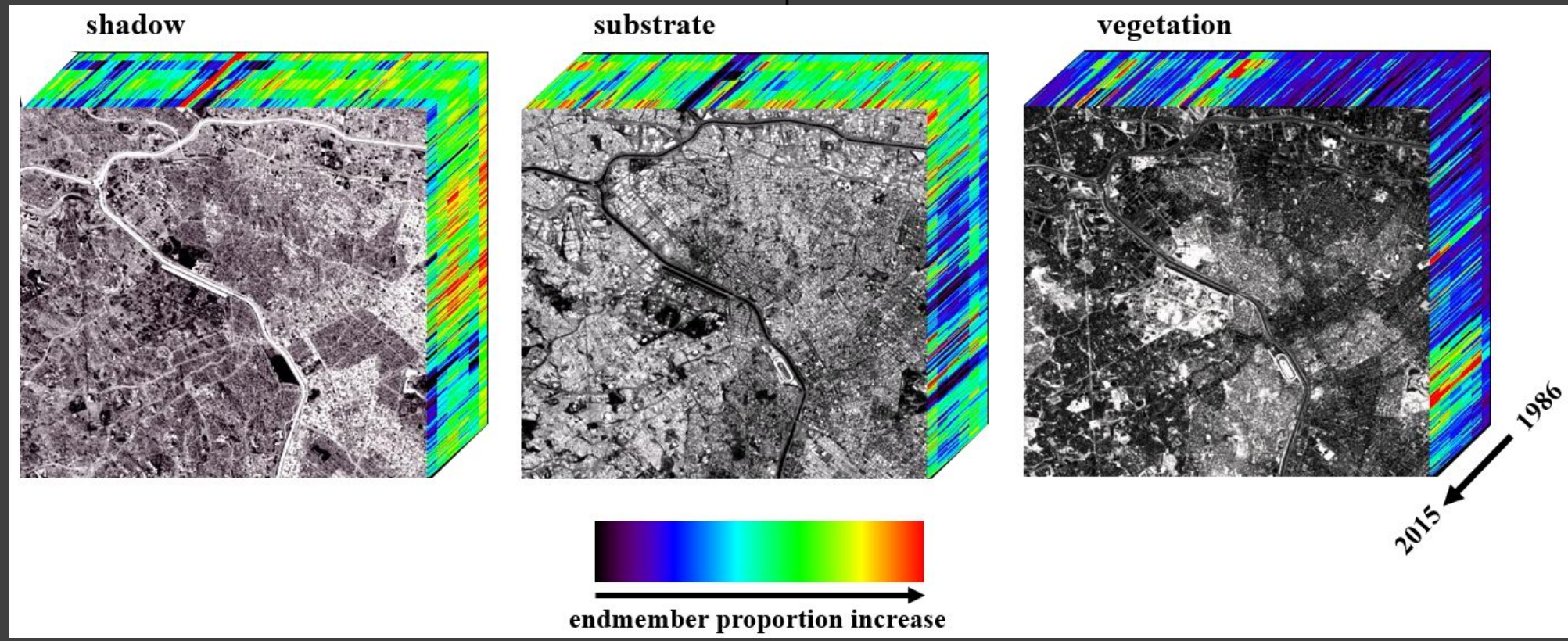
São Paulo city downtown temporal-spectral

Space

And

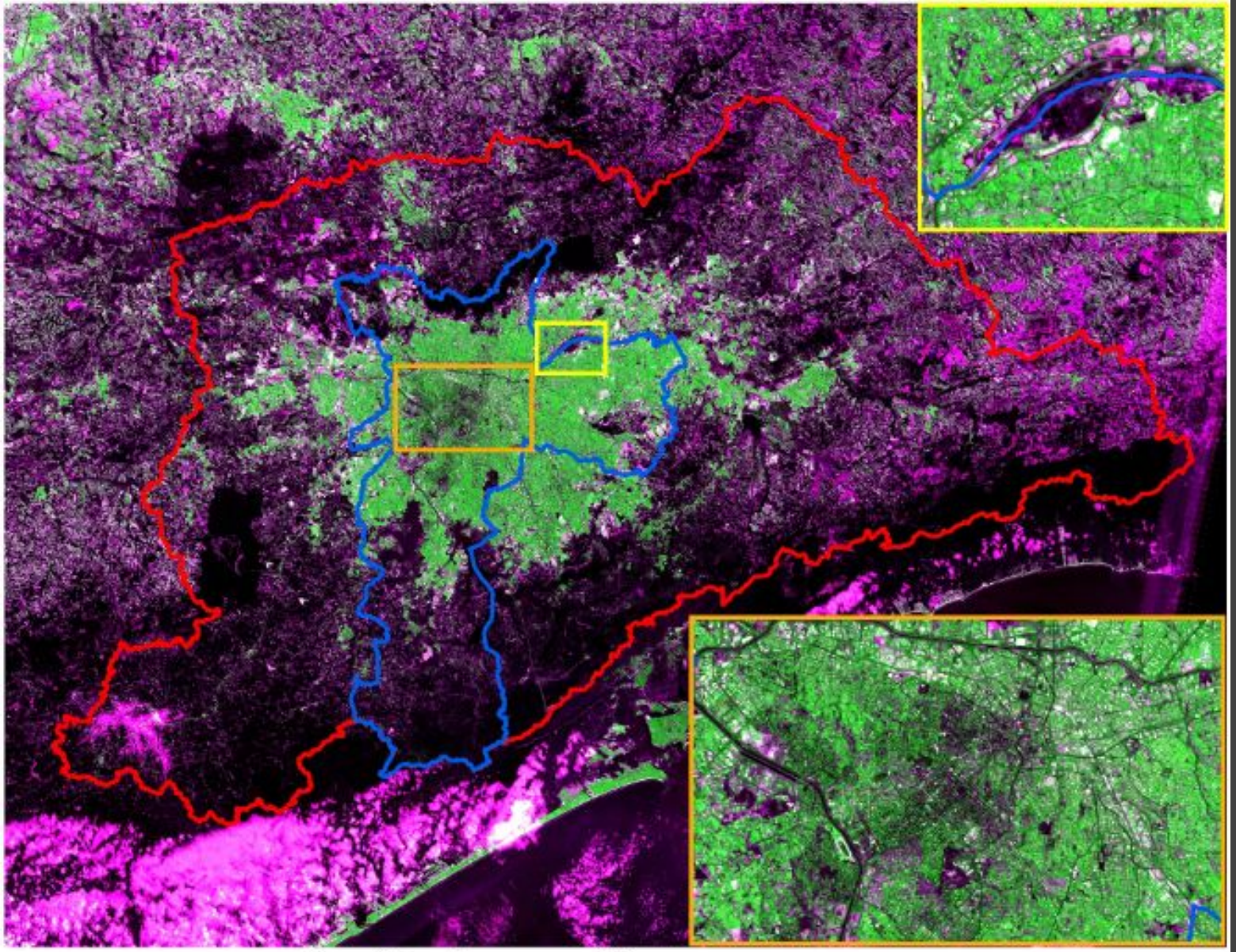
Time

Fractions variability



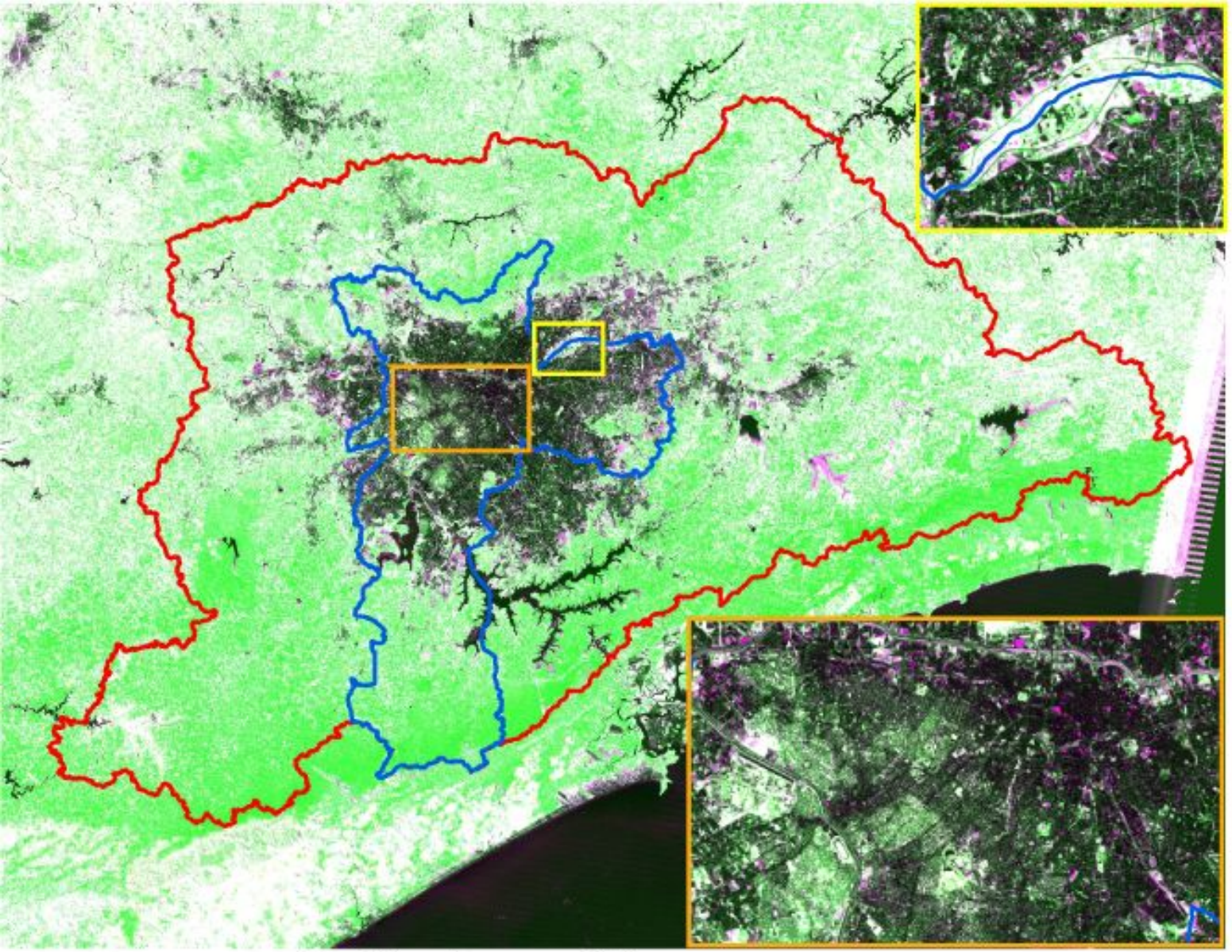
Source: the author, from Landsat images digital image processing.

Result



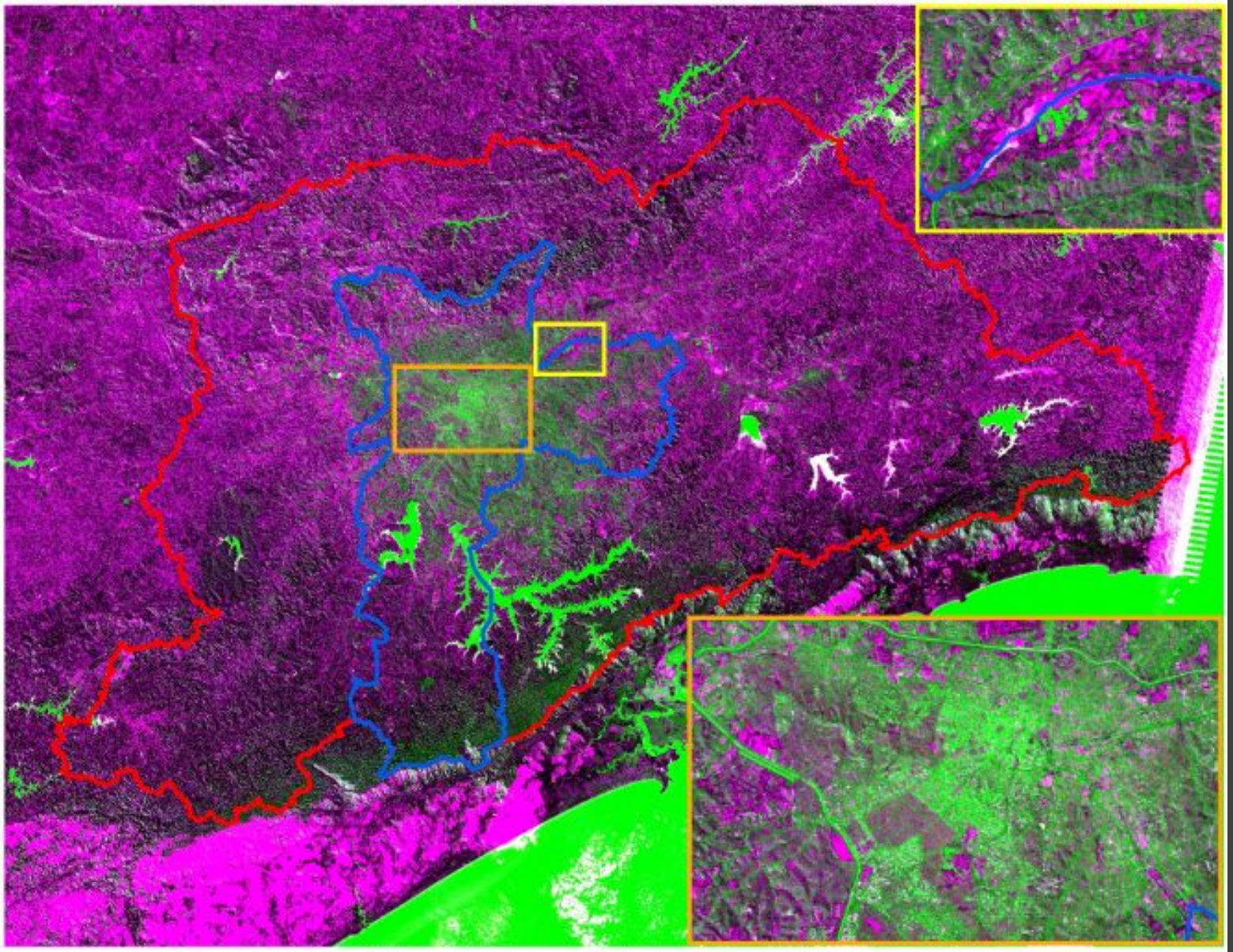
Temporal Variability
Substrate fraction: 1986 – 2015

Substrat e



Temporal Variability
Vegetation fraction: 1986 - 2015

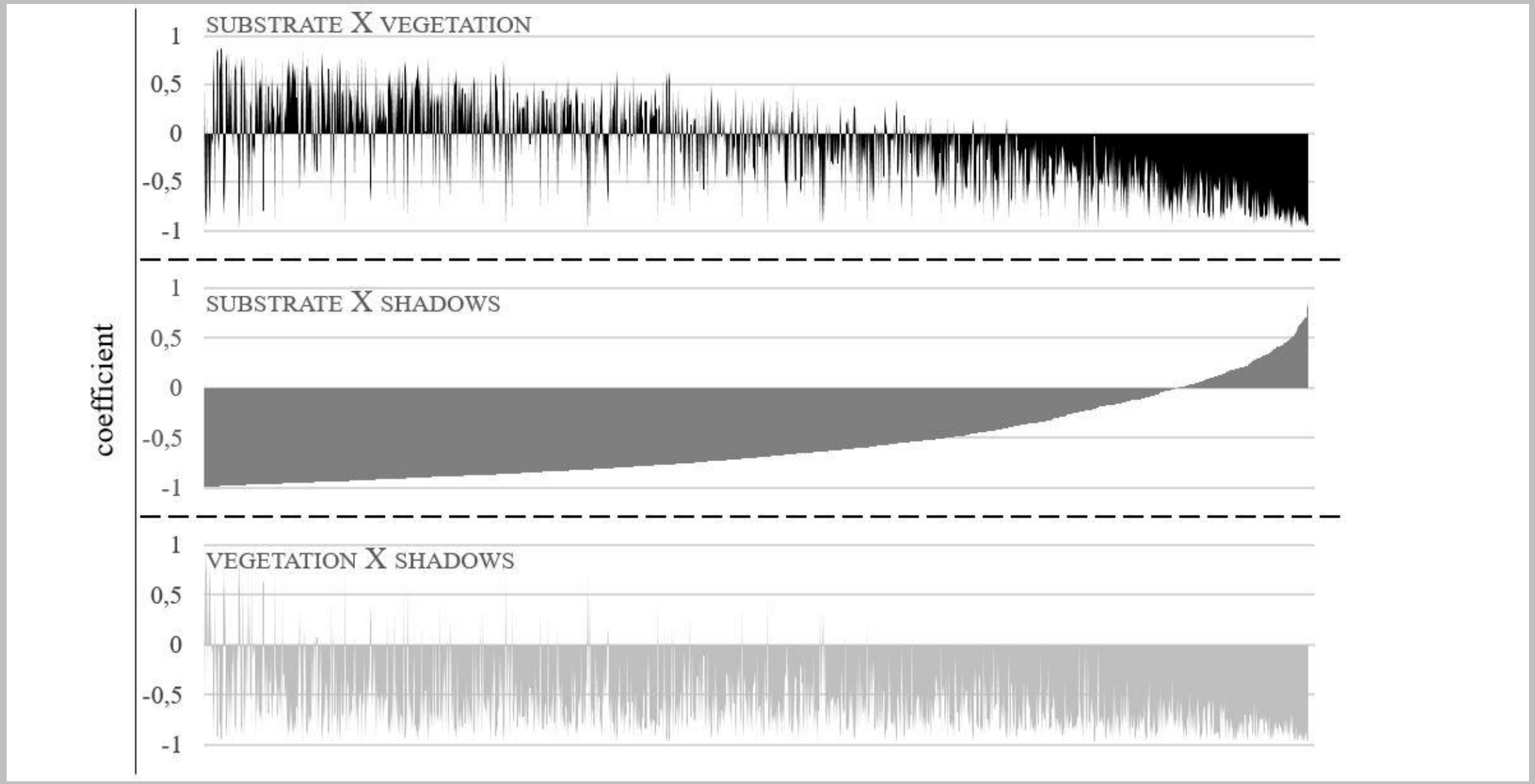
Vegetation



Temporal Variability
Shadow fraction: 1986 – 2015

Shadow

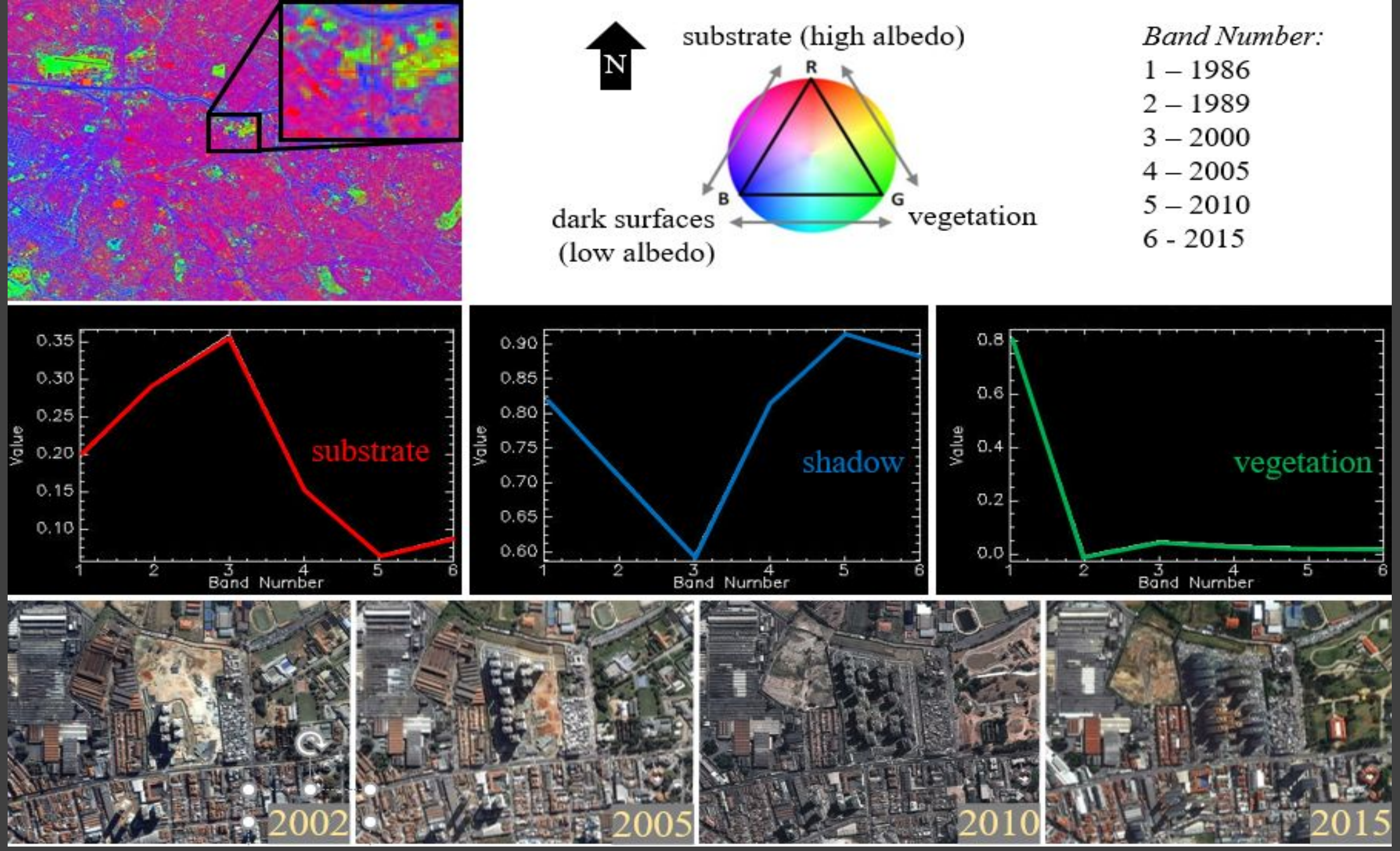
Correlations between the extracted Endmembers (aggregated by census tracts): 1986 – 2015



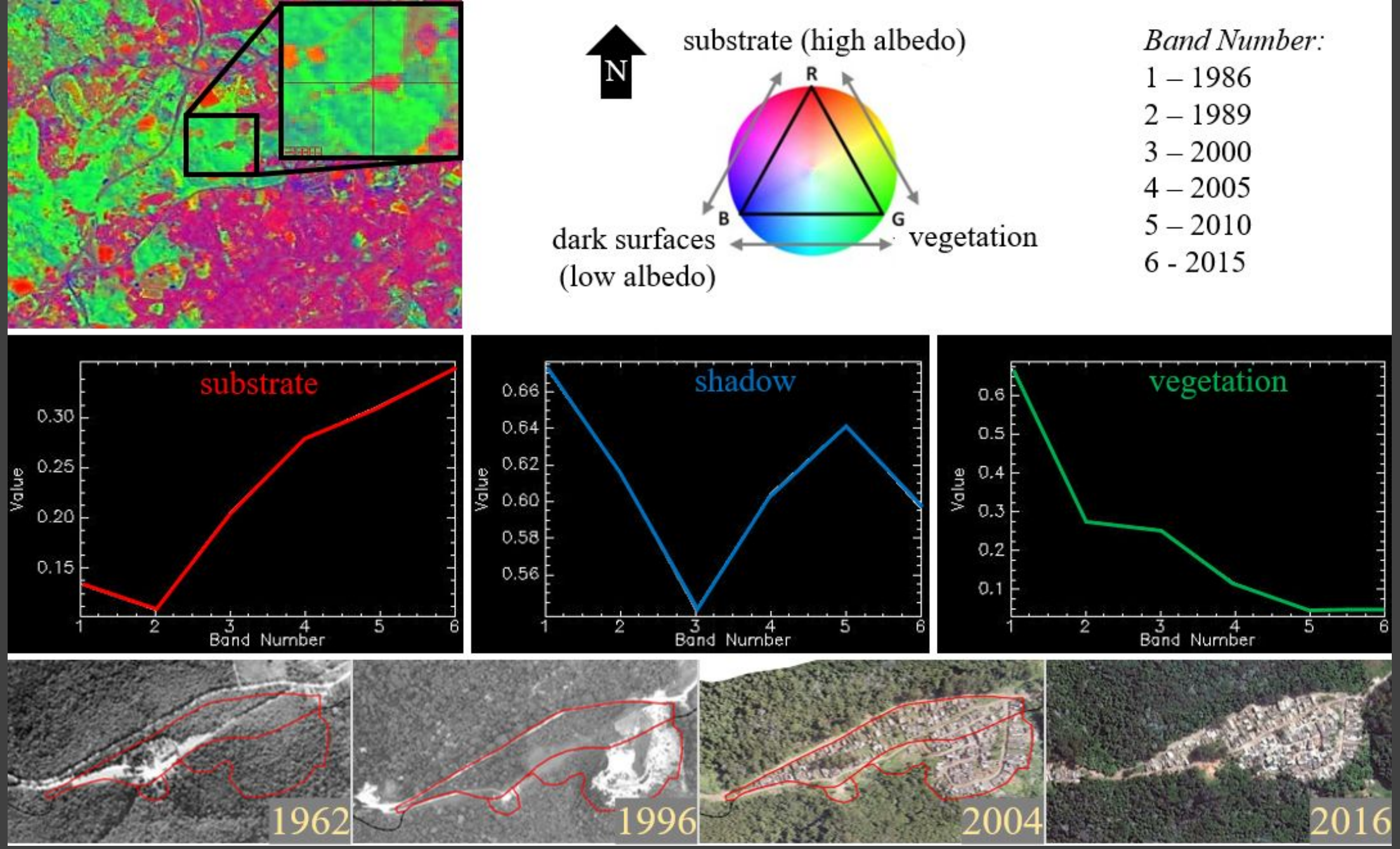
Source: the

Correlations between the extracted Endmembers and apartment-type houses (aggregated by census tracts): 1986 – 2015

Source: the



Fractions variance profile in a verticalization area (Maria Zélia Neighbourhood/São Paulo city)

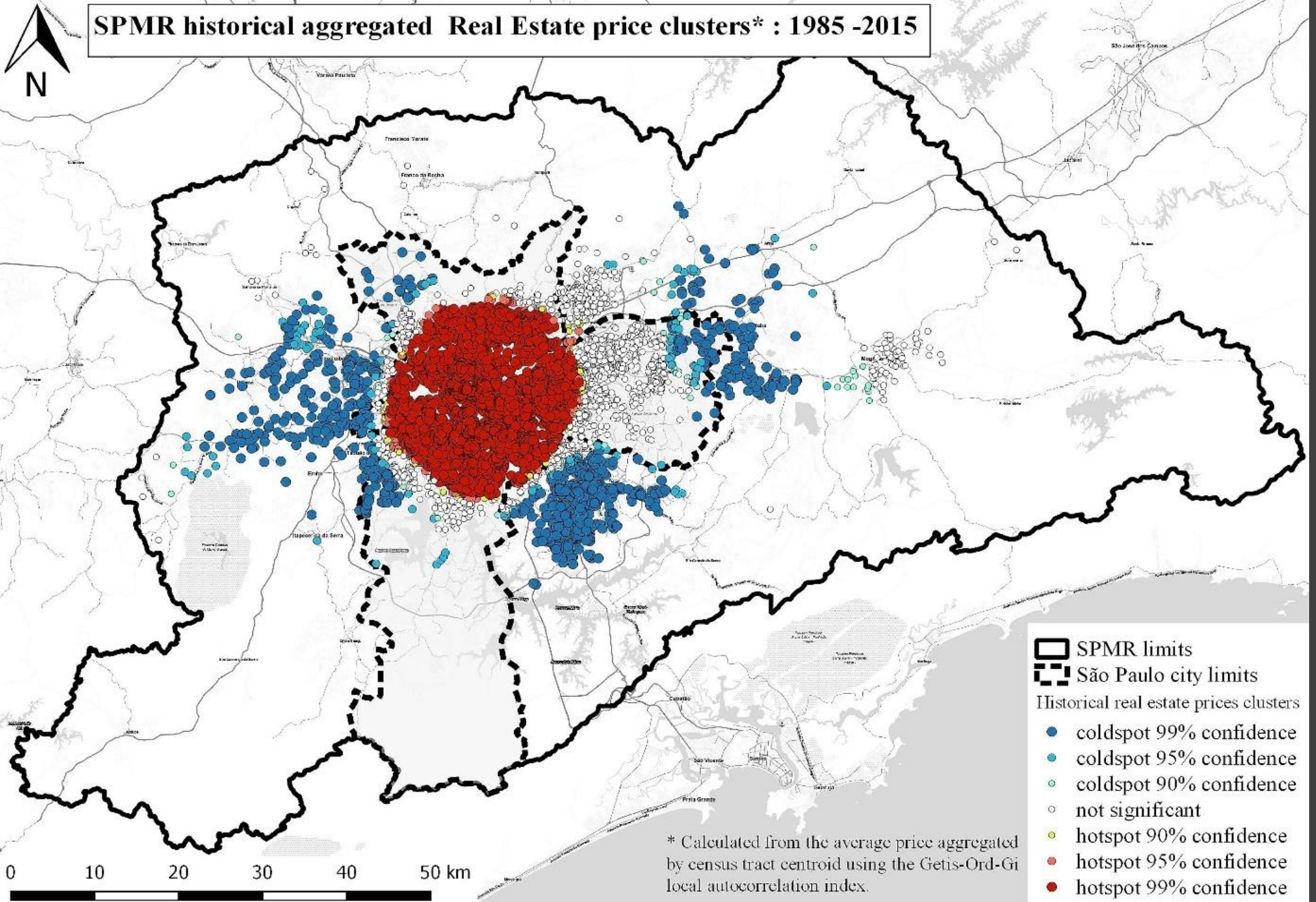


Fractions variance profile in a slum area (Favela Nova Esperança/Taboão da Serra city)

But the underlying question is: Are these remote sensing based patterns related to well-known urban geography issues? The short answer is yes. The logic that drives the poverty peripheralization of the SPMR results, at the end, in the singular urban structures that are registered along the time by the satellite sensors.

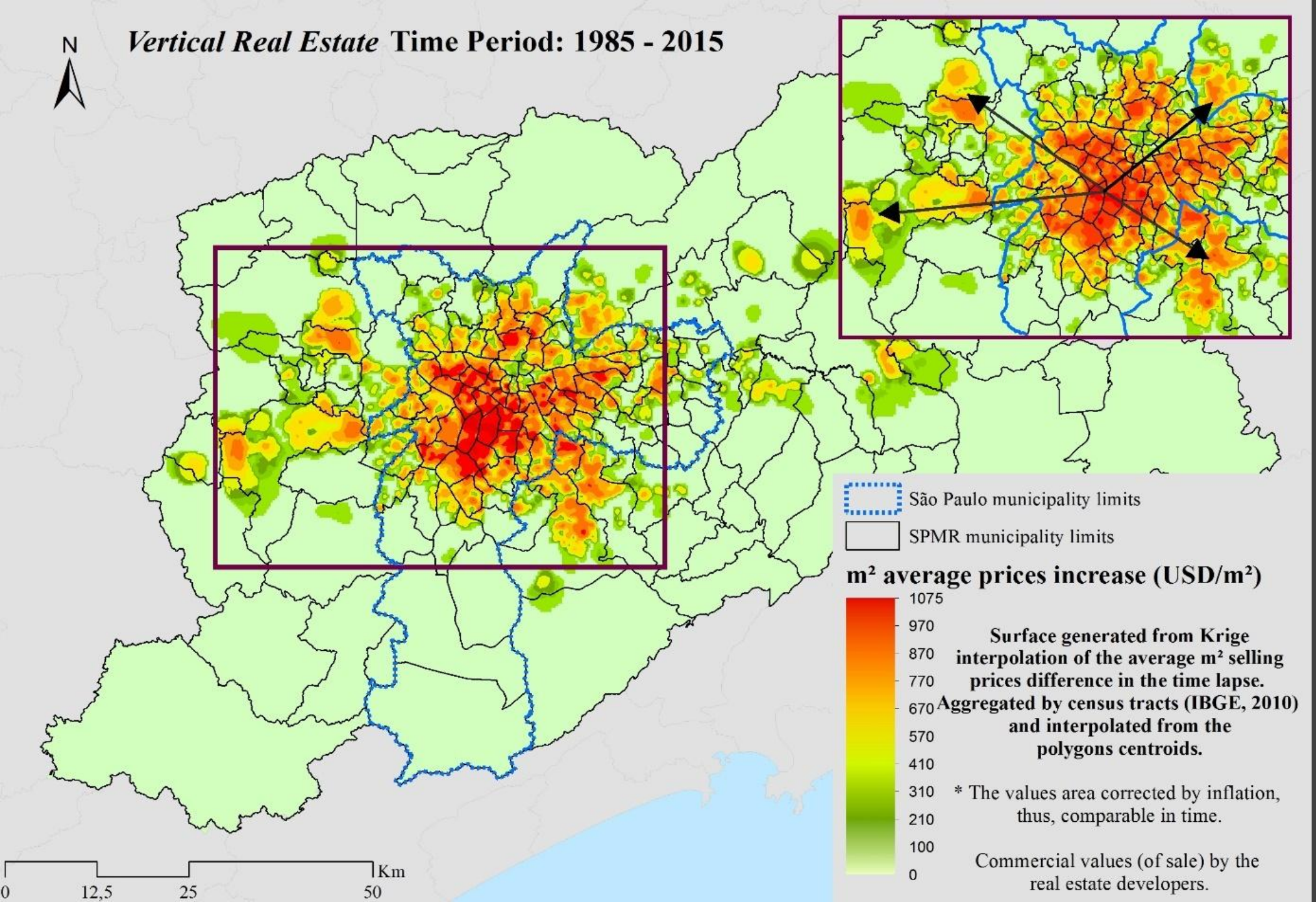
The land price spatial distribution is one of these evidences that connect human geography and remote sensing in this experiment. Pasternack (2004) synthesize the persistent poverty peripheralization in the São Paulo city as “city of the rings”, where there were defined five “circular rings” from the city center outwards that show how life and housing conditions get worse as they get farther away from the central ring.

Is possible to expand Pasternack`s idea to coarse scales and suggest a “region of the rings”, referring to the SPMR. In this case the real estate venture prices, historically aggregated, can show how the São Paulo City and the SPMR economic power was capable to get rid of the poverty in the center, and how accurate the idea of rings, in a spatial-time accumulation, is well shaped in the metropolitan scale too.



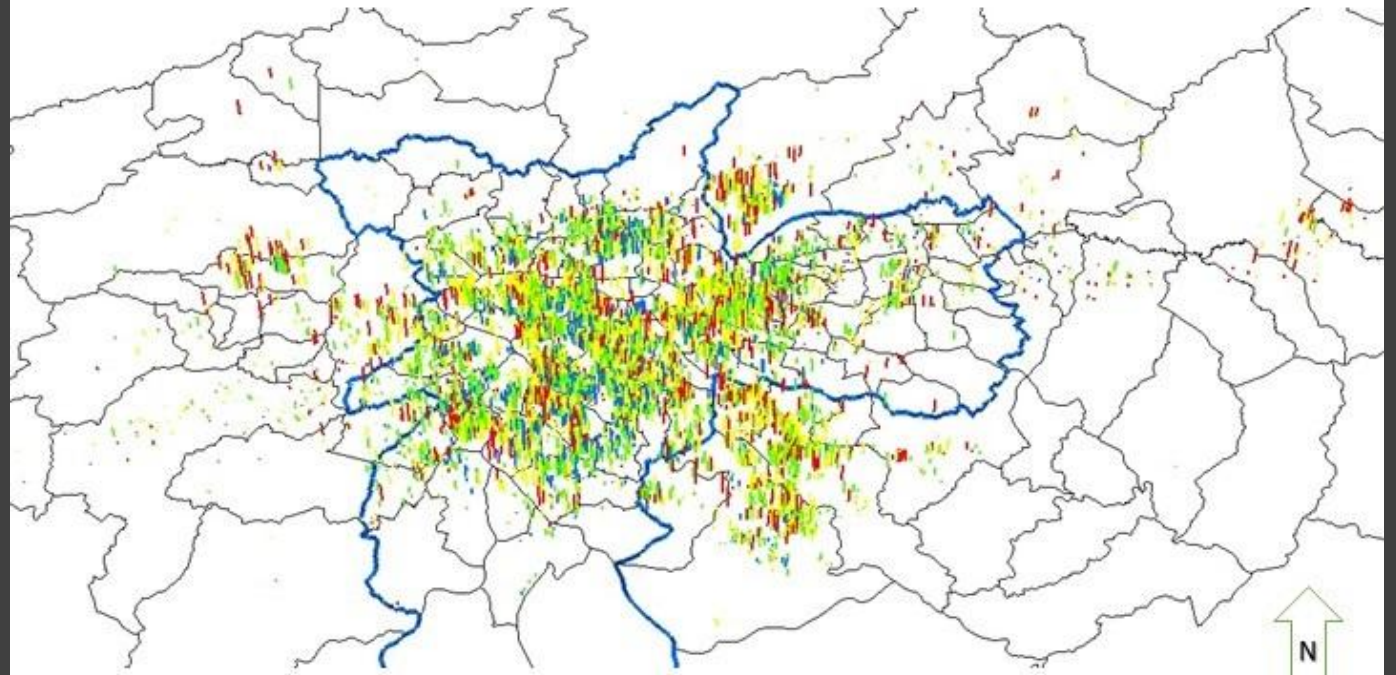
Historical price clusters in the SPMR by the Getis-Ord-Gi2 algorithm

Source: the author



SPMR m² selling price increase: 1985 to 2015, visualized trough the *isotimas* method. USD currency exchange rate from 2015/12/31

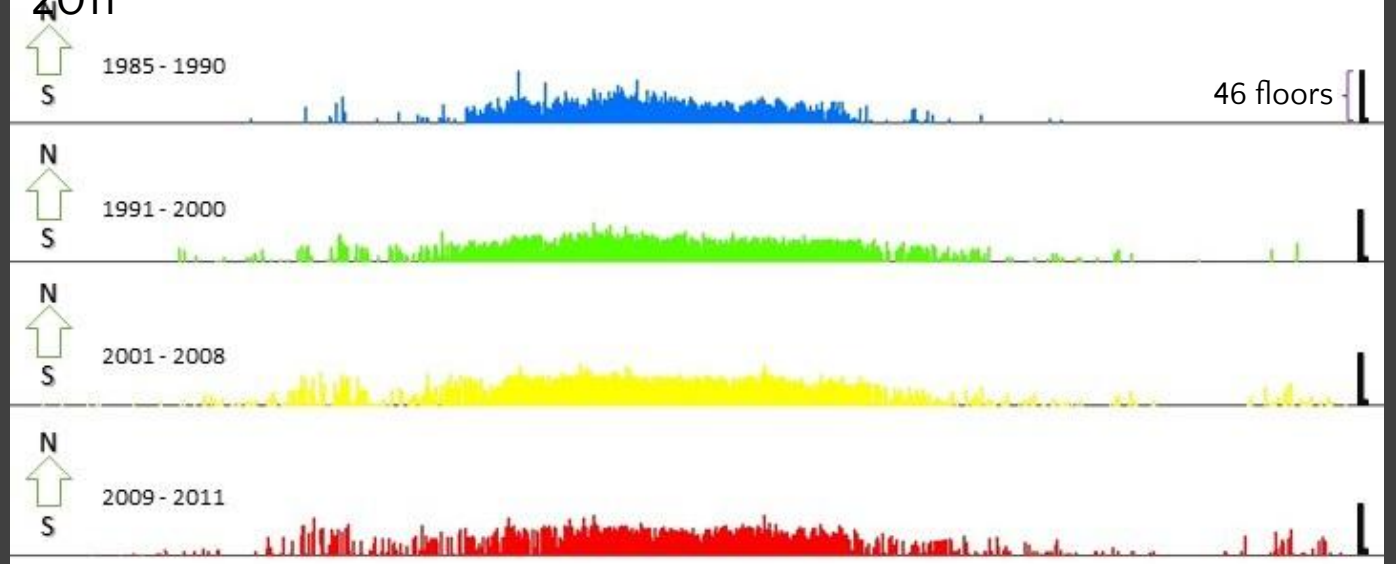
Source: the author



Legend

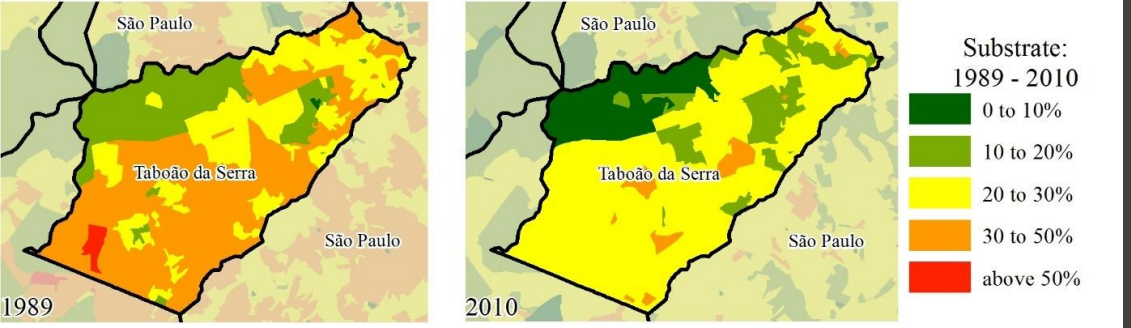
Dot weighted by number of floors

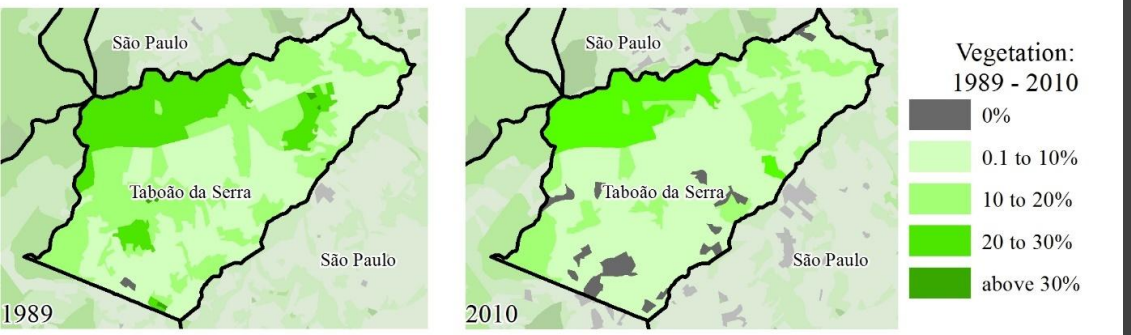
Skyline views: 1985 - 2011

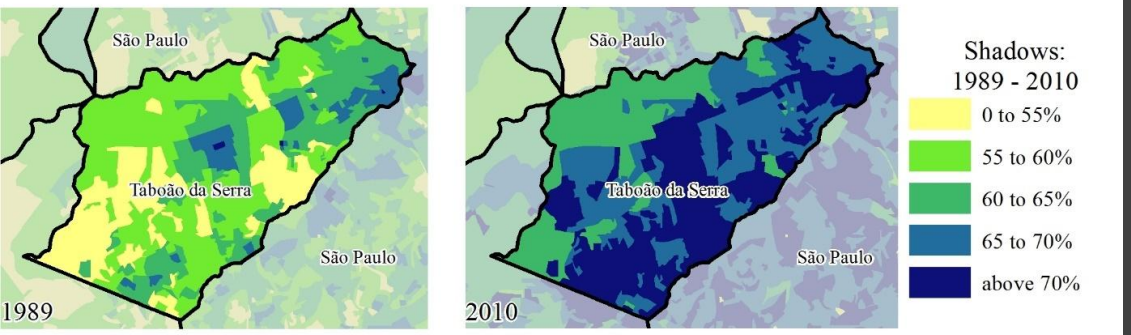


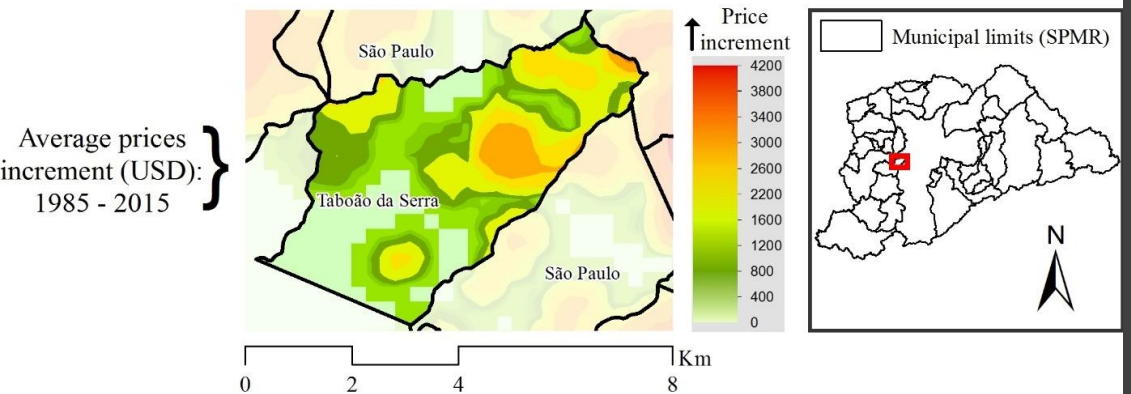
Pedrassoli, J. C,

Taboão da Serra city example: fractions alteration along the time compared to land price increase









The prices increase map shows the movement of the land speculation process. This trend showed a strong spatial correlation with the real estate high-rise building. This also explains the growing space trend eviction over the slums to the increasingly peripheral areas.

The satellite images can tell this story too. As stated, the verticalized areas show an inverse correlation between substrate and shadow fractions and, at the same time, illustrate spatial correlation to the increased prices areas. So, the urban structure change shown on the imagery reflects the social and political alteration and variability, showing it up in the urban space

Distribution of the substrate and shadow correlation from the Kernel Density, showing the contrasts in the Republica Square and overlapping the 3D constructions

Distribution of the correlation between substrate and shade from the Kernel Density, showing the contrasts in the boundary region of the Jardins overlapping the 3D constructions

Source: Google Earth 2016. Adapted by the author.

Establishing the correct relations between the physical changes in the territory (which satellites record) and the social actions and economic policies that direct such changes**, it is possible to map the nuances of urban inequality and in addition, modeling this inequality trends in space and time**. Resuming, the satellite images can be used to distinguish between regular and precarious housing areas and maps can be drawn to depict trends in urban spatial expansion, significantly increasing the empirical background to the classical urban geography analysis.

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