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Terrestrial surface temperature through orbital data of the TIRS/Landsat-8 sensor: A case study of the neighborhood Cidade Operária and surroundings

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ABSTRACT

The study of urban climate is an area of knowledge inherent to climatology that benefits from remote sensing, since it is possible to map the thermal behavior of the terrestrial surface through the thermal bands. This study aimed to identify and analyze the behavior of the Superficial Superficial Terrestrial (TST), in the neighborhood of the Operational City and in the surroundings. To obtain the proposals, the following materials and procedures were required: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) scenes from 07/2018, related to the infrared, red, green and thermal bands; Field recognition with photographic record; Extraction of thermal values and Supervised classification. Through field incursion, reduce the presence of two representative classes of local use and coverage: Vegetation and Urban Area. The maximum and minimum TST values were 19.7°C and 27.5°C, so in the southeastern neighborhood of the Working City, check to see if there is an extension of the area with higher values, including if you understand the neighbors Janaína and Jardim América. The lowest TST values are related to vegetation cover or thin cloud cover when in densely populated areas, while the highest values are directly related to urban density.
Keywords: OLI Landsat-8; Thermal; Classification

1 INTRODUCTION

Technological development has enabled scientific advances in many areas of knowledge, for example, as regards the recognition and mapping of events in the earth's surface, and in turn has helped environmental studies on large and small scales. Empirically, two important tools can be cited as coming from the technology and important in monitoring urban climate: (1) automatic weather stations and (2) the use of free thermal satellite images (SILVA *et al*., 2017)

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Earth observation satellites of, orbital imagers, have made it possible, according to Florenzano (2002), a comprehensive vision and multi-temporal large areas of the earth's surface, as well as carrying out various comparative studies, and therefore application various fields of earth sciences.

There are several applications of remote sensing in environmental studies. Coelho and Corrêa (2013) point out that, from the emergence of satellites for monitoring on a regional scale climatic conditions such as the GOES (Geostationary Operational Environmental Satellite), METEOSAT (Meteorological Satellite) and others managed by the NOAA (National Oceanic and Atmospheric Administration) under the jurisdiction NASA (National Aeronautics and Space Administration), The weather came to prominence in these applications.

It is important to note that among the climatology study of scales, is urban climatology that sticks to micro scales, closely related to the environments of intense human change, which sometimes are observed heat islands, originated from human alteration without urban planning (MONTEIRO, 2003).

The study of urban climate, in spite of the spatial distribution of the Earth's surface temperature has been benefited from remote sensing, especially for applications in Brazil, where we highlight the work of Barbosa and Vechia (2006) in São Carlos, Nascimento (2001) in Goiania, all mapping the temperature distribution and heat islands in urban environments; Andrade (2007) compared the accuracy of information between different orbital thermal sensors TM and HSS; Bias *et al*. (2003) mapping heat islands.

According to Albuquerque (2012), urbanization inevitably causes changes in the micro climate, the atmosphere of the city, the water cycle, in relief, vegetation and fauna. Green areas have acted as moderator temperature. As a result of unplanned urbanization process, follows the intense suppression of vegetation, giving way to homes, roads with asphalt coating providing waterproofing large areas. This process of replacing the vegetation by an artificial waterproofing covering the micro climate will accentuate those areas, with as a result, in general, a higher TST (ARAÚJO, 2014).

Thermal applications of remote sensing are also observed in the city of São Luiz, capital of Maranhão, where Araújo and Rangel (2012) monitored the use and land cover in São Luiz correlating it with the distribution of surface temperature (TST). These evaluated yet determined as the urban growth urban temperature variations from 1992 to 2010, using the TM/Landsat-5, and the results showed a strong correlation between the urban space and growth temperatures during this period. Rangel and Silva (2017) conducted a survey of 1999 to 2015 temperatures in the city of São Luiz, as well as the thermal characteristics of each land use for years searched.

This study aimed to analyze the behavior of TST in the neighborhood of the Cidade Operária and surroundings, in São Luiz city, and relate it to the land use characteristics in the year 2018 from the use of thermal data TIRS sensor satellite Landsat-8.

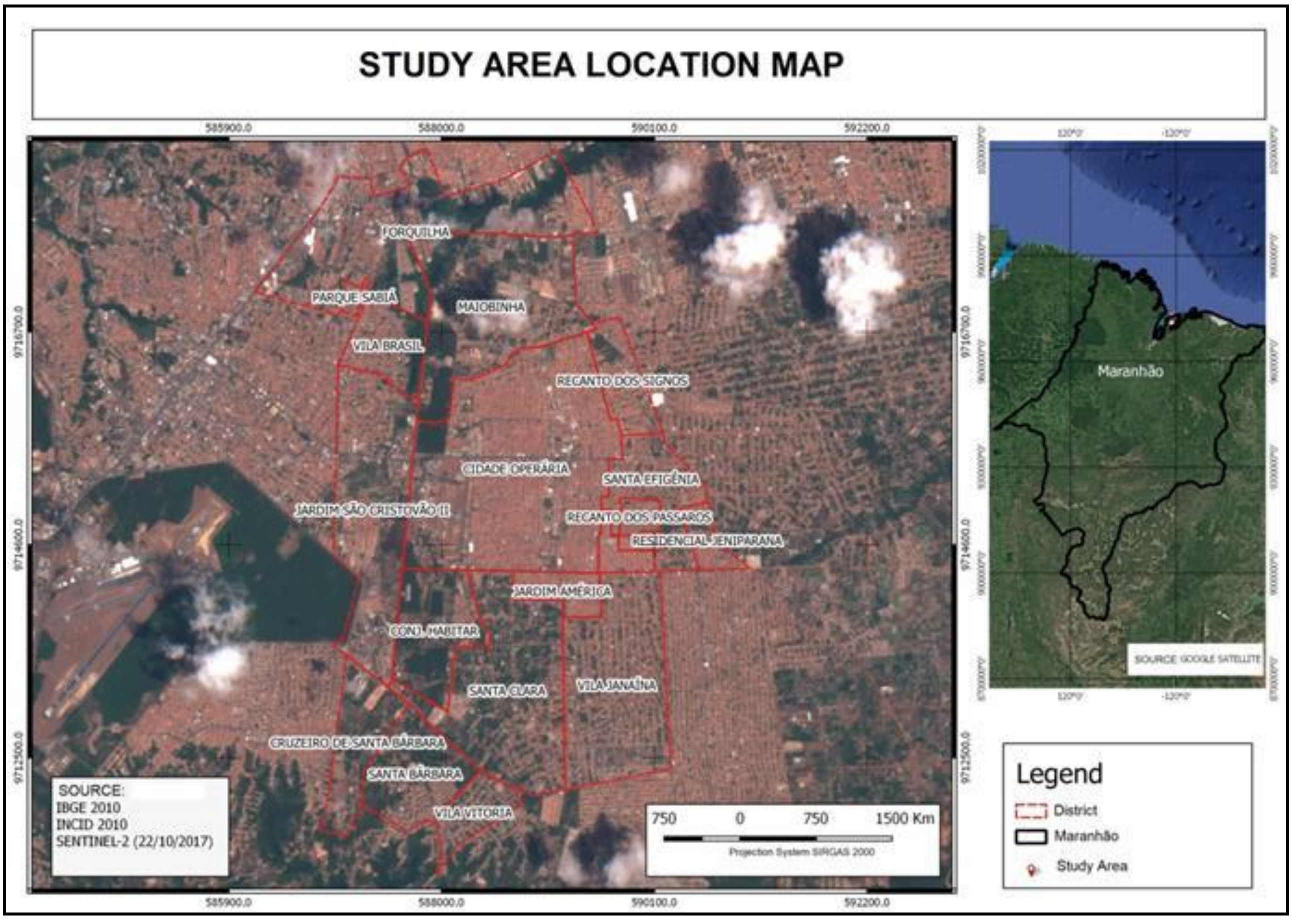
2 METHODOLOGY

2.1 Study Area

The Cidade Operária is a neighborhood located in the central-eastern portion of the city of São Luiz and the central portion of the large island of Maranhão, and that, along with its neighboring districts has an area of approximately 23.82 km (Figure 1). The neighborhoods surrounding the Cidade Operária are: Forquilha, Vila Brazil, Jardim São Cristóvão, Maiobinha, Recanto dos Signos, Recanto dos Pássaros, Residencial Jeniparana, Conjunto Habitar, Santa Clara, Vila Janaína, Santa Bárbara, Villa Vitória and Cruzeiro de Santa Bárbara. The occupation of this portion of the island has its origin in 1986, with the rise of housing Cidade Operária, managed by COHAB[1] for buyers of up to five minimum wages. The town also suffered from spontaneous occupations over her bangs, which, in turn, gave the various neighborhoods of its surroundings, as highlighted Silva (2016).

[1] Company of the State of Maranhão Popular Housing - COHAB

Figure 1 - Map location of the study area



2.2 Materials and Methods

One satellite image Landsat-8/OLI and TIRS referring to orbit point 219 and 062, which covers the area of study, was used. The greatest difficulty that the study of thermal images for monitoring TST presents is undoubtedly cloud cover, because this factor limits the choice of scenes to study. Therefore, the chosen scene for study was dated June 25, 2018, by presenting the gap of rainy and dry seasons.

The thermal sensor TIRS-8 currently has two channels for thermal applications, namely: 10 bands (10.6 - 19.11μm) and 11 (11.5 – 12.51μm) and 11 chose to analysis the band 10, because as Pires and Ferreira Jr. (2015) is in best conditions for obtaining thermal data, since the band 11 contains physical defects, affecting the generation of information.

The extraction of thermal values was performed from the conversion of the thermal strip in QGIS 2.18 environment by implementing the application python terminal as USGS (2019). The proposal is based on radiometric calibration coefficients for the thermal infrared Landsat series of channels aimed at obtaining temperatures in Kelvin. Initially through methodological proposal USGS (2019), obtained the spectral radiance level sensor (equation 1). The constant present in the equation 1, referring to the band 10 TIRS-8 was obtained in the metadata file (MTL) of the scene. After that, the spectral radiance was converted into temperature from (equation 2).

$$L\lambda = \mathrm{ML} * \mathrm{Qcal} + \mathrm{Al} \qquad (1)$$

At where:

Spectral Radiance = Lλ in Watts opening sensor (m^2 sr μm)

ML = multiplicative factor band yield = 10 3.3420E-04

AL = Scaling factor specific additive band 10 = 0.10000

Qcal = Quantitative value calibrated by pixel DN = 10 Band

$$\mathrm{T} = \mathrm{K2ln}\left(\frac{K1}{L\lambda} + 1\right) \qquad (2)$$

At where:

Effective T = Temperature °C

K2 = calibration constant 2 (1321.08)

K1 1 = calibration constant (774.89)

Spectral Radiance = Lλ in Watts opening sensor (m^2 sr μm)

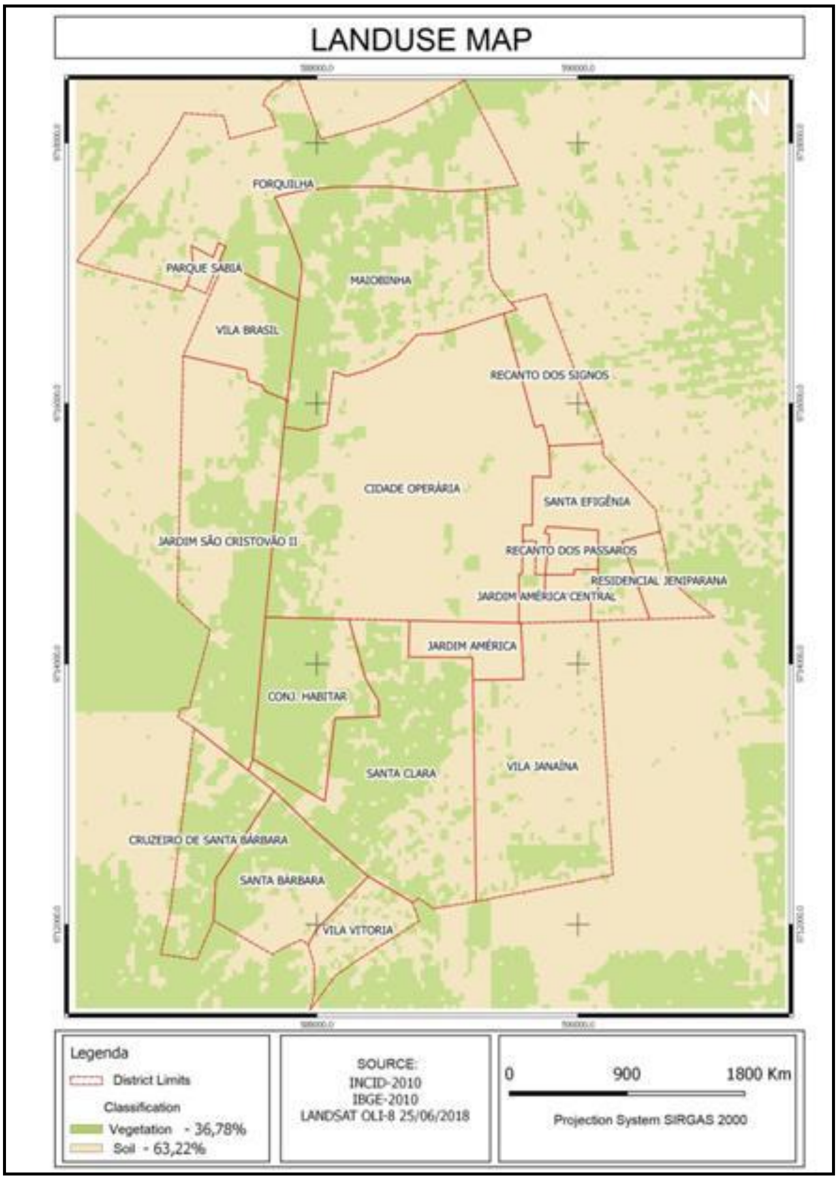
In order to support thermal analysis, carried out a mapping of different types of uses and soil cover by supervised classification of MaxVer, based on field mission carried out on 14 March 2019. The supervised classification was carried out at room QGis through Semi-Automatic Classification complement, and had the composition bands R (6) G (5) B (4) of the same scene, since, as highlighted Moreira (2012), the wavelengths associated with these channels they are the most representative for identification and use of ground cover. Subsequently, performed is a thermal statistic values for each class in the search of the total thermal obtaining average values of the reference class.

3 RESULTS AND DISCUSSION

The Housing Complex of the Cidade Operária and surrounding neighborhoods, especially, have the characteristics presented by Albuquerque (2012), where there is change in land cover, linked to the development and consolidation of the site for housing and economic purposes, scored by Silva (2016).

Through the course of the mission, it was found that the use and occupation of land is made by buildings without an integration plan to the existing environment to minimize negative impacts of these, since they hinder the dispersion of heat, retaining - o and providing noticeable temperature increase by thermal discomfort (ARAÚJO, 2014). In addition, localities with vegetation cover ranging from modest to dense were found. The latter is associated with the rivers and/or drainage courses that cut the study area and that make up the Geniparana and Paciência. These characteristics allowed us to classify the use and occupation of the study area into two classes: anthropized area and vegetation cover (figure 2), so that, for the study area, the proportion of anthropogenic cover is almost double the vegetation cover of the study area.

Figure 2 - Map of use occupation area study



A distribution of TST (Figure 3) throughout the study area revealed no homogeneity in a hot area, so that it is observed a wide temperature range (at 19.5°C 27.7°C). In this regard, it is important to highlight the neighborhoods Cruzeiro de Santa Bárbara, Vila Brazil and Cidade Operária as having the largest intra-district temperature range. However, it emphasizes that neighborhood of the Cidade Operária, although keep close to the average of the observed TSTs, still has the largest area among the analyzed districts, as well as greater proportions of the lack of vegetation, factors that notably contribute in thermal gradient (table 1). Although there is no homogeneity in the overall distribution of thermal values for the study area.

Table 1 - Statistical study of the Thermal area.

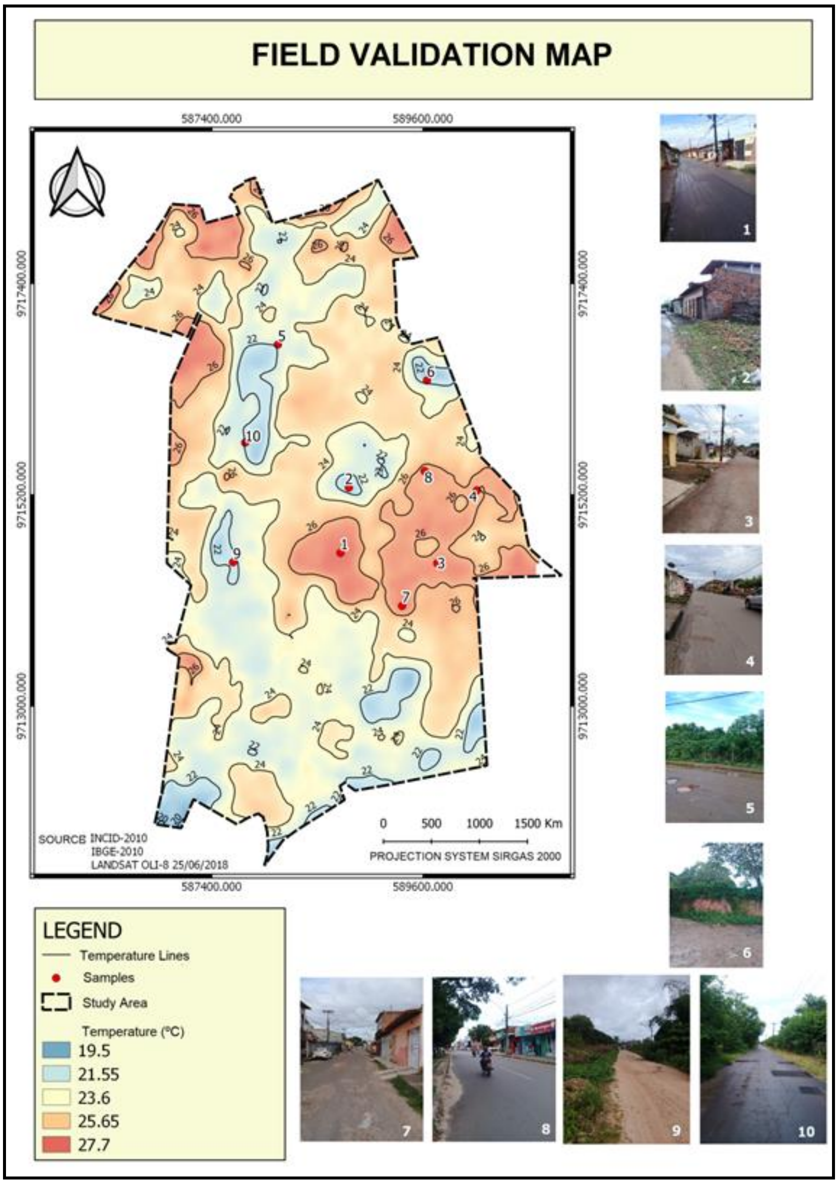
	Neighborhood	Area (square kilometers)	Average (°C)	minimum (°C)	maximum (°C)
1	Cid. Operária	3.85	24.68	20.89	27.20
2	Conj. Habitar	0.89	23.32	21.70	26,00
3	C. De Sta Bárbara	0.69	23.30	19.91	26.70
4	Forquilha	2.48	24.80	21.99	27.58
5	Jd. America	0.30	26.26	24.82	27.02
6	Jd. Central America	0.17	26.41	25.29	26.84
7	Jd. São Cristóvão II	1.88	24,00	21.03	26.81
8	Maiobinha	2.05	23.69	20.98	26.20
9	Pq. Sabiá	0.06	25.77	23.56	26.84
10	Rec. Dos Pássaros	0.13	26.18	24.61	26.70
11	Rec. Dos Signos	0.46	23.50	20.64	25.62
12	Res. Geniparana	0.21	26,00	24.69	27.09
13	Sta Barbara	0.84	23.23	20.47	25.33
14	Sta Clara	2.06	23.38	21.02	26.21
15	Sta Efigênia	0.56	25.90	23,70	26.66
16	Vila América	0.07	25.76	24.66	26.61
17	Vila Brazil	0.54	24.79	21.09	27.32
18	Vila Janaína	1.89	23,95	20.51	26,45
19	Vila Geniparana	0.17	25.53	23.87	27.00
20	Vila Vitória	0.36	23.32	20.26	25,26

Outside also observed the existence of low thermal gradient in the central portion of the Cidade Operária. In the field raid, it was found that this location, although with low thermal values, has no associated vegetation, by contrast, has a density of buildings such as houses and unpaved streets. Given the existence of localities with this land cover pattern and the existence of higher thermal values when observed this type of ground cover, meant there, at that particular point of the scene, a cloud layer or fog which interfered with obtaining the local TST.

The largest thermal values were observed in the portion south and southeast of the neighborhood of the Cidade Operária, West of Vila Brazil, Midwest Forquilha, and in most neighborhoods Santa Efigênia, Recanto dos Pássaros, Residencial

Geniparana and Jardim América. In contrast, smaller values are highlighted in the central portion of the Cidade Operária, west of Maiobinha, Jardim São Cristóvão II and much of the Conjunto Habitar, Santa Clara, Cruzeiro de Santa Bárbara, Santa Bárbara and Vila Janaína.

Figure 3 - Map of thermal and field validation



Two large groups can be observed at temperatures near 26°C and temperatures around 22°C. For the first group, there is its occurrence in areas of asphalt composition and/or the presence of masonry buildings (such as houses) and concrete (larger buildings and commercial purposes). The second temperature group occurs in ground covers with the presence of vegetation and where there are buildings; they are usually masonry and access without the presence of asphalt cover.

4 CONCLUSIONS

Images Sensor OLI-8 and TIRS-8, combined with techniques for obtaining land temperature and classification of land use and cover, have identified not only the thermal distribution of the study area, as well as trace indicators of its occurrence ratio.

The study area also caused in the 80 intended to be a residential area, consolidated so that today are seen two classes of use and the local soil coverage: Extended altered region (where noted characteristically elements heat seals, inserted along the urban consolidation, such as asphalt pavement, concrete constructions, roofing and other materials) and small plant cover (this, in turn, being proportionally lower than the anthropization class). The increase in population, in this same area, unplanned way, generated the expansion of residential areas surrounding the Cidade Operária neighborhood, as highlighted Silva (2016) incurring changes in the local environment.

Out yet been heterogeneity of the thermal distribution throughout the study area, so that in some quarters is possible to realize a large temperature range, such as in the neighborhoods of Cruzeiro Santa Bárbara (6.79º C) Cidade Operária (6.31º C) and Vila Brazil (6.23º C).

Stands out finally that the obtained thermal values have difference with the values for the entire city, obtained by Araújo and Rangel (2012) and it is emphasized that, as the author himself, factors such as expansion of buildings/decrease of green areas and seasonality of radiation interfere directly in the thermal values of the TST.

For future work suggests the use of multi-temporal data to relate, more effectively, the urban progress at the expense of vegetation cover and its thermal impact year on year from the residential institution.

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REFERENCES

ALBUQUERQUE MM. Relationship between the use and occupation of soil and climatic variables: study districts of the city of Teresina, Piau [dissertation]. Teresina: Tropen / UFPI 2012.

ANDRADE LL. Study of heat islands in the city of São José dos Campos using the thermal infrared channel Landsat-5 and HSS airborne. In: Proceedings of the XVII Brazilian Symposium Remote Sensing [internet]; 2007 April 05-10; Belo Horizonte, Brazil. 2007. Avaliable from: http://marte.sid.inpe.br/col/dpi.inpe.br/lise/2004/08.31.09.42/doc/index.html

ARAÚJO RR. Clima and socio vulnerability: an assessment of the risk factors in the urban population of the city of São Luiz (MA). [] Dissertation]. Presidente Prudente: Faculty of Science and Technology / UNESP, 2014.

ARAÚJO RR, Rangel, MES. Urban Growth and Thermal Variations in Sao Luiz, MA. Geonorte Periodical. 2012; V2 (2): 10.

BALESTRI EL. Environmental Urban Planning. 1ed. London. Editora e Distribuidora Educacional SA, 2018.

BARBOSA RVR Vechia FAS. Studies of urban heat island through Landsat7etm + images: a case study in São Carlos (SP). Periodical Minerva - Research and Tecnology. 2013. V.6 (1) 5.

RABBIT ALN, BELT WS. The surface temperature Celsius Tirs / Landsat-8: Methodology and applications. Geographic Periodical Academic / RGA. 2013; V (1):. 14.

FLORENZANO TG. Satellite Images for Environmental Studies. 2 ed. São Paulo: Texts Workshop; 2002.

MONTEIRO, CAF. Theory and Urban Climate - A project and its ways. São Paulo: Context; 2003.

MOREIRA, MA. Remote sensing fundamentals and application of methodologies. 2nd ed. Lush: Publisher Federal University of Viçosa, 2012.

NASA. Handbook: Landsat 8 (L8) DATA USERS HANDBOOK.2019.

DTF BIRTH. Evolution Analysis phenomenon of heat islands in the city/GO (1986-2010) [dissertation]. Goiania: Institute of Social and Environmental Studies/UFG; 2011.

PIRES EG, FERREIRA JUNIOR surface temperature L. Mapping from thermal images of the satellite Landsat 7 and Landsat 8. In: XVII Brazilian Symposium Proceedings Remote Sensing [internet]; 2015 April 21-25, João Pessoa, Brazil. 2015. Avaliable from: http://marte2.sid.inpe.br/col/sid.inpe.br/marte2/2015/05.31.21.54/doc/@sumario.htm. Access: 29. Jan. 2019.

FS SILVA, Rangel MES. Evaluation of land surface temperature in São Luiz/MA using image sensor TM / Landsat-5 and OLI / Landsat-8 In: XVIII Brazilian Symposium Remote Sensing [Internet]; 2017 May 21-28; Santos, Brazil. 2002. Available from: urlib.net/rep/83LX3pFwXQZ5Jpy/CxGU3.Acesso in: 29. Jan. 2019.

SILVA PR. A look at the centrality and urbanity: Subdivision City Workers [monography]. St. Louis: Department of Architecture / UEMA; 2016.

USGS (United States Geological Survey) - 2019 [internet]. Infrared thermal sensor. Available at: https://landsat.gsfc.nasa.gov/thermal-infrared-sensor-tirs/. Access: 29. Jan. 2019.