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Evaluation of the change of Istanbul Anatolian Side land surface temperature values with CORINE data

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ABSTRACT

Socio-economic developments, diversity of employment opportunities, proximity to city functions such as education, health, and social services make cities the focus of people's attention. Consequently, in order to serve all functions such as industry, trade, accommodation, education, entertainment and transportation, a very dense impervious surface structures occur in cities. The increase in these uncontrolled artificial impervious areas causes changes in the urban climate and land surface temperature (LST). Remote sensing technologies have been frequently preferred in recent years to monitoring and detecting these changes quickly. In this study, using Landsat 8 OLI images, the temperature changes on the surfaces in the Anatolian Side of Istanbul, whose surface temperature values were obtained, were evaluated. In the study, LST values of Landsat 8 OLI satellite images of 23 April 2018 and 28 April 2020 were obtained and analyzed with the help of 2018 CORINE data. The Anatolian Side of Istanbul shows an intense urbanization tendency, especially in the coastal part. Special focus has been placed on the temperature changes of the impervious surfaces used in this region. It has emerged that these surfaces should be especially evaluated in planning and design studies due to their effect on city surface temperature changes.

1. INTRODUCTION

In the determination of surface temperatures, remote sensing technologies have been used in different scales and in many different interdisciplinary studies in recent years. There are both regional (Weng, 2001; Chen et al. 2006; Luan et al. 2020) and structure-based studies (Qiao et al. 2020; Aboelata and Sodoudi, 2020).

In addition, studies on global warming and climate change have increased remarkably today. A large part of the human population that will be most affected by these changes live in cities. This situation reveals the necessity of examining the temperature changes in cities and monitoring them in more detail within the framework of cause and effect relationships (Kusak and Kucukali, 2018). When temperature changes in cities are examined in the context of cause and effect relationships (Zhao et al. 2006; Wang et al. 2008; Deng et al. 2009; Liu et al. 2017), multiple parameters affect urban ecology with a complex network of relationships (Vlahov and Galea, 2002; Liao et al. 2017) and different ecological, physical and environmental characteristics of that area (Nacef et al. 2016; El Helew, 2018) and different anthropogenic effects (Shen et al. 2016) in each geographical area.

Morphological changes in the topography of cities, qualitative and quantitative decreases in green areas, increases in impermeable man-made surfaces such as concrete, asphalt and roof materials change the ecology of cities and create a unique microclimatic area under the influence of natural-artificial factors. The main determinant of these phenomena is urbanization and unplanned settlements and unsuitable land use. Although the relationship between land use and temperature difference has been investigated in many studies on land use and related temperature changes in cities, the choice and properties of materials used on artificial surfaces (Okeil, 2010), roof materials (Al-Obaidi et al. 2014), orientation of buildings Criteria such as their conditions and building form (O-Malley et al. 2014) and the relationship of climatic data, building sizes (Li et al. 2019), location selection of heat-discharging outdoor units of artificial ventilation elements (Kikegawa et al. 2006; Kusak and Kucukali, 2018) have also taken place in the literature as subjects of study .

There are many studies in which LST and CORINE data set were used together. The spatial distribution of surface temperature and land use (Lai et al. 2020; Alvi et al. 2019) and for the detection of cold and hot poles in

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cities (Lemus-Canovas et al. 2020) are some of these studies, LST and CORINE have been evaluated together.

Anatolian Side, or Asian Side of Istanbul, which is the region where approximately one third of the population in Istanbul lives, has experienced a rapid increase in terms of urbanization in recent years. For this reason, the region has been taken under the scrutiny in terms of urban planning, and the surface temperature changes of the land, especially in the last two years, are evaluated in this study. The obtained findings were interpreted in terms of urban planning with the CORINE data set.

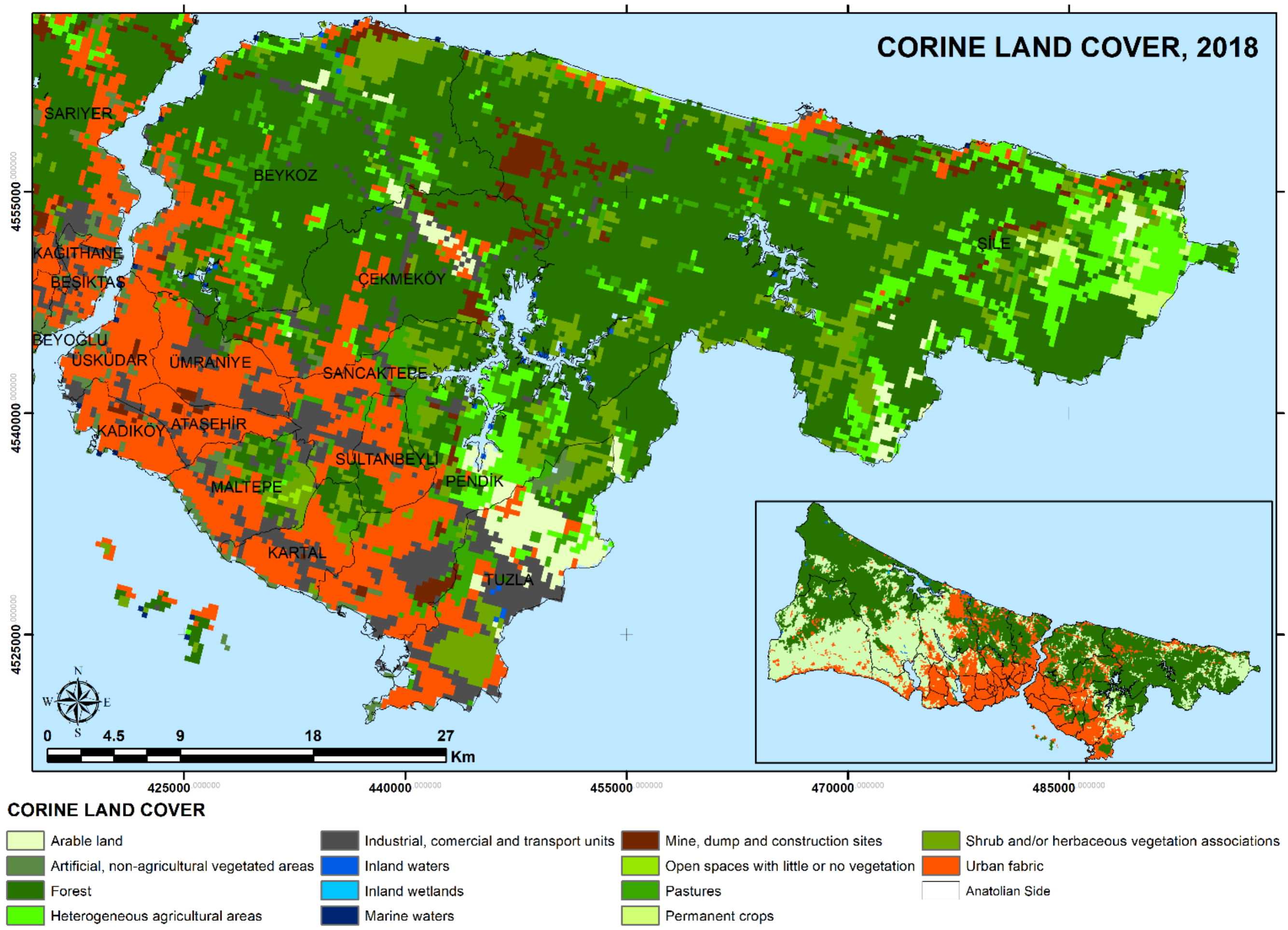

Figure 1. CORINE Land Cover (2018), Anatolian Side, Istanbul

2. MATERIALS AND METHOD

2.1. Study Area

Istanbul Anatolian Side has been studied as the study area. Anatolian Side is the eastern half of the city of Istanbul, located east of Bosphorus and geographically on the Asian mainland. Consisting of 38 districts in total, 14 districts of Istanbul are on the Anatolian side. Another airport in Istanbul, which also provides international transportation like Sabiha Gökçen Airport, is on this side. With the recent migrations and urbanization, the population on the Anatolian Side has reached approximately 4.3 million according to 2019 data. 1/3 of the population of Istanbul lives here. The increase in the population has led to an increase in residential areas, as well as an increase in places such as shopping centers where people can spend their daily time. Urbanization and gigantic structures have led to an increase in impermeable surfaces in the area, which was mostly green areas (Figure 1).

All these changes have brought about a change in the city temperature.

2.2. Data

In the study, April 23, 2018 and April 28, 2020 Landsat 8 OLI images were used to obtain LST values. Using Landsat 8 OLI images, the April 23, 2018 and April 28, 2020 images were prepared by the EROS Science Processing Architecture (ESPA) on-demand interface that provides Landsat higher-level science data products, including Climate Data Records (top of atmosphere (TOA) reflectance, brightness temperature, and spectral index which is NDVI. Additionally, 2018 CORINE data set was employed to interpret the relationship between LST and land use.

2.3. Methods

In the study, first LST values were obtained and then evaluations were made with the analyzed CORINE data.

The LST values are calculated using brightness temperature (BT) values. As the file prepared by ESPA contains TOA reflectance, BT, and surface reflectance NDVI, these steps were omitted. LST based on satellite brightness temperature (BT) was computed using the following equation Eq. (1). Therefore, emissivity values are also defined in the study.

$$LST = \frac{BT}{1+(\lambda+\frac{BT}{\alpha})ln ln \varepsilon} \quad (1)$$

BT is the effective at satellite temperature in Kelvin, λ is the wavelength of the emitted radiance in meters, α=1.438 x 10-2mK, and ε is the surface emissivity.

Since each object has a emissivity, the relationship between land cover and emissivity has been studied for many years (Van de Griend and Owe 1993; Valor and Caselles, 1996).

NDVI-based studies have been developed for the use of the obtained values in satellite images and land cover classes and emissivity values have been defined (Sobrino et al. 2004; Stathopoulou and Cartalis 2007; Tang et al. 2015).

In this study, the method used in the previous study (Kusak and Kucukali, 2018) and developed by Shen was preferred in LST calculation. Here, emissivity values of 0.9923 for water areas, 0.923 for urban impervious and bare soil areas, and 0.986 for vegetation areas are accepted. The formula in Eq. (2) for mixed areas is also used (Shen et al. 2016).

$$\varepsilon = 1.0094 + 0.047 \; ln \; ln \; (NDVI) \quad (2)$$

3. RESULTS

The CORINE 2018 data set was cut for the Anatolian Side of Istanbul and evaluated using ArcGIS 10.5. According to the results of the evaluation, it has been determined that 23.02% of these areas are artificial surfaces, 30.02% are agricultural areas, 46.38% are forest and semi-natural areas and the remaining areas are wetlands or water bodies.

In addition, the percentage distributions of temperature values for 2018 and 2020 in these areas were calculated and these results are presented (Table 1). LST values were divided into 5 different classes as <25°C, 25-30°C, 30-35°C, 35-40°C and> 40°C. Using the 2018 CORINE data, the areal distributions of LST values classified for 4 main areas were calculated and then their percentage values were obtained. Although there was a decrease in regions higher than 40 degrees in 4 different regions, it was ignored because it was meaningless in the percentage presentation in the table.

When the evaluation is made between 2018 and 2020, it is seen that the regions with surface temperature values less than 25 °C in total have increased. In addition, there is a decrease in surface temperature values on artificial surfaces.

In the comparison made using satellite images dated 23 April 2018 and 28 April 2020, it is thought that the temporary closure measures experienced in many sectors and sub-sectors due to the COVID-19 pandemic experienced worldwide are effective.

Table 1. Land Surface Temperature (LST) (%)

	2018	2020	2018	2020	2018	2020	2018	2020
	<25 °C		25-30 °C		30-35 °C		35-40 °C	
Total Surface	58.27	72.82	38.94	24.49	2.77	2.67	0.02	0.02
Artificial Surface	4.33	5.85	18.98	17.43	2.59	2.61	0.02	0.02
Agricultural Area	7.59	12.49	8.75	3.88	0.07	0.03	0.00	0.00
Forest and Seminatural Areas	46.28	54.40	11.18	3.15	0.11	0.02	0.00	0.00
Wetlands and Water Bodies	0.08	0.08	0.04	0.03	0.00	0.00	0.00	0.00

4. DISCUSSION

LST values were calculated for the Anatolian side of Istanbul, which is an important region that has an intense urbanization phenomenon, urban development and growth dynamics, which covers a large area and should be kept under constant observation after the 1950s, and analyzed with the CORINE data set, and the results were discussed. Accordingly, cooling is observed in artificial areas in 2020. As emphasized before, the pandemic is thought to be effective in this. However, it should be observed whether this effect is permanent or temporary.

5. CONCLUSION

Remote sensing technologies have been used for a long time to monitor surface temperature changes in cities. The fact that remote sensing technologies have high resolutions in terms of spatial, temporal and spectral means that these technologies are preferred. In spite of their sensitivity, studies conducted with local methods at the city scale are long-term and costly. In addition, since climate change is a global phenomenon, its impact area includes wide areas beyond the scale of the building. In this study, it is suggested to benefit from easy, fast and cost-reducing supports to identify and monitor all these processes from urban planning to building production scale. For this purpose, Landsat 8 OLI satellite images and existing CORINE data set were used. In future studies, UAVs with thermal and multispectral sensor support can be used to examine smaller areas. In this way, problem areas can be focused and monitored.

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