Application of remote sensing analysis of the surface temperature for management and evaluation the state of environment in Pushkin town, Saint-Petersburg city, Russia

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Abstract. GIS and Remote sensing are now being used in many fields, especially in the field of agriculture and the environment. The results of the paper have built the land surface heat map of Pushkin district with detailed heat scales, which is the optimal way to solve more specifically the changes in heat and its effects. move on ecosystems that other common tools can't solve.

1. Introduction
Pushkinsky District is an administrative and territorial unit of St. Petersburg, located in the southern part of the city. Within the boundaries of the district there are 5 municipalities, which include 2 cities, 3 villages, 14 historical zones and 12 territorial zones. The total territory of the Pushkin District is 24011.6 hectares (16.7% of the area of St. Petersburg) [1, 2]. Pushkin's climate is temperate and humid, transitional from sea to continental. The length of the day varies from 5 hours 51 minutes at the winter solstice to 18 hours and 50 minutes at the summer solstice. The summer is short, moderately warm, the winter is long and unstable, with frequent thaws. Spring and autumn are protracted. Positive air temperatures prevail from the beginning of April to the end of the first decade of November [3, 4]. The coldest month is February. The average annual precipitation is 590 mm. Therefore, the mapping of soil surface temperature helps determine the temperature distribution in different areas, thereby assessing the correlation between temperature factors and fluctuations of vegetation cover. Provide data for managers in forest fire management and environmental impact assessment [5].

2. Methods and Materials
Landsat satellite images were collected on May 31, 2019. For Landsat 8, the band 10 (Thermal Infrared (TIR) band) has a wavelength of 10.3 to 11.3 micrometers. Temperature data is shown in figure 1.
Convert the numerical value (DN) to the spectral value ($L_\lambda$). Landsat TM and Landsat 8 data are captured as digital images, so it is necessary to convert the value of this digital image data to the spectral value as a reflection of the energy emitted by each object heat channel. This conversion is done by the following expression [6]:

$$L = \left\{ \frac{L_{\text{max}} - L_{\text{min}}}{Q_{\text{calmax}} - Q_{\text{calmin}}} \right\} \cdot \left[ Q_{\text{cal}} \ast (B_1 - Q_{\text{calmin}}) + L_{\text{min}} \right]$$

(1.1)

where, $Q_{\text{cal}}$ value radiation corrected and quantified in the form of integer; $Q_{\text{calmin}} = 1$; $Q_{\text{calmax}} = 65535$. $L_{\text{min}}$ and $L_{\text{max}}$ are spectral values in the form of integers, for channel 10 are 0.10033 and 22.00180 (Radiance_maximum_band_10 = 22.00180; Radiance_minimum_band_10 = 0.10033). The unit of $L_\lambda$ is $W/(m^2.sr.µm)$.

Convert the spectrum to temperature. The band 10 of Landsat 8 can be converted from the spectral value into a more useful physical variable. This is the effective temperature on the satellite (black body temperature) of the system viewed from Earth - the atmosphere under assumption of emission by 1 [7, 8].

Conversion formula calculated by Planck formula [9]

$$T = \frac{K_2}{L_n(\frac{K_1}{L_\lambda + 1})}$$

(1.2)

where, $T$ = Effective temperature on satellite (Kelvin Unit), $K_1 = 774.8853$ $W/m^2.sr.µm$ ; correction coefficient 1, $K_2 = 1321.0789$ K; correction coefficient 2; ($K_{1\_constant\_band\_10} = 774.8853$; $K_{2\_constant\_band\_10} = 1321.0789$); $L_\lambda$: Spectral radiation value ($W/m^2.Ster.µm$). (The parameters are taken from the file: * MTL.txt of the satellite image 2017)

Moved Kelvin temperature to Celcius unit ($^0$C). Temperature value in $^0$C.

$T (^0C) = T (Kelvin) - 273.16$

Transfer the heat value to the integer form.

$\text{Fix}(T) = T (^0C)$ [10, 11].

3. Results and Discussion

The mapping of the surface temperature, especially forest conditions, has a great effect on predicting the change in surface temperature, which is an important basis for determining the intensity of the precipitation. The temperature of different vegetation cover in different parts of the city is also the
basis for analyzing the degree of environmental pollution of the substances corresponding to the heat channels.

Each area of the town of Pushkin will have a different thermal amplitude, the study determined the average temperature of the city of Pushkin in 2019 on image Landsat 8 in 2019 is 27.47°C. In the Landat 8 image of 2019, a surface heating algorithm based on channel 10 is used, with radian values, at the Kenvil temperature, and then converted to C temperature. Calculate the lowest temperature is 5.77°C, and the highest temperature is 39.66°C, the average temperature is 27.47°C. The results are shown in figure 2.

![Temperature map by geographic region of Pushkin district in 2019.](image)

**Figure 2.** Temperature map by geographic region of Pushkin district in 2019.

Looking at figure 2 shows, the color distribution of soil surface temperature compared to different types of land cover is different. The concentration of industrial zones, inert rocky areas, sandy areas, bare land is shown in red with the highest temperature (from 34°C – 39°C) due to corrugated roof
material with thermal energy from production activities, heat radiation of bare land and sandy soil is quite large. Most of these areas are distributed in the North and South-East of Pushkin District with a total area of 130.22 hectares; accounting for 0.54% of the total area of the region.

Areas with pink color within the thermal range of 30°C - 34°C are distributed evenly throughout the area of the district, where the composition is mainly agricultural land plowed, unused plowed land, bare grassland, sparse, vacant land of parks, gardens without vegetation, some dry pine forests and sometimes intermingled vacant lands interspersed in dense forests. These are the objects often distributed near roads, near residential areas, much distributed in the village Tyarlevo, Shushary... With a total area of 831.36 hectares; accounting for 3.46% of the total natural area of the region. This is an area that is prone to fire risks during the hot and sunny season, which is a basis for planning forest fire prevention and fighting measures.

The blue-colored area has a common thermal range between 26 and 28 degrees Celsius and evenly distributed over 2 districts and 3 villages: Pushkin district, Pavlovsk district; village Aleksandrovsky, Tyarlevo, Shushary, with a total area of 6925.85 ha; accounting for 28.84% of the total area of the region. The covers in these areas are mainly in the field of harvest, dry grass, gardens in table 1.

| Range of temperatures (°C) | Area (ha) | %     |
|---------------------------|----------|-------|
| 0–5                       | -        | -     |
| 5–7                       | 0.99     | 0.0041|
| 7–9                       | 1.08     | 0.0045|
| 9–13                      | 1.23     | 0.0100|
| 13–17                     | 5.24     | 0.0218|
| 17–20                     | 72.08    | 0.3002|
| 20–22                     | 3057.13  | 12.7300|
| 22–24                     | 3635.20  | 15.1400|
| 24–26                     | 5168.77  | 21.5300|
| 26–28                     | 6925.85  | 28.8400|
| 28–38                     | 2515.20  | 10.4800|
| 30–32                     | 1667.25  | 6.9400 |
| 32–34                     | 831.36   | 3.4600 |
| 34–39                     | 130.22   | 0.5424|

| Total                     | 24011.60 | 100   |

The correlation between vegetation cover (current land use status) and heat amplitude is in the positive direction. In areas with high temperature amplitude, the vegetation cover is relatively small, or bare lands, urban areas, newly exploited forests, newly plowed agricultural land, and no crops. These areas are relatively large, distributed mainly on the outskirts of the city. The result is shown in figure 3 and table 2.
Figure 3. Distribution map vegetation cover under by temperature band.

Table 2. Forest conditions by administrative units in Pushkin districts.

| Status of land use     | Area (ha) | Percent (%) | Pushkin City | Pavlovsk Village | Alexandrovsky Village | Tyarlyovo Village | Shushary Village |
|------------------------|-----------|-------------|--------------|-----------------|----------------------|------------------|------------------|
| Reed and Reed          | 3.64      | 0.02        | 0            | 0               | 0                    | 0                | 3.64             |
| Clearing               | 1.96      | 0.01        | 0            | 0               | 0                    | 0                | 1.96             |
| Uncovered land         | 9.54      | 0.04        | 1.01         | 0.53            | 0                    | 0                | 8                |
| Moss vegetation        | 6.75      | 0.03        | 0            | 0               | 0                    | 0                | 6.75             |
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4. Conclusion
It can be said that the change in soil surface temperature depends on many causes, excluding changes due to the law of the universe such as the cycle of the earth, the sun's cycle of activity. The human contribution contributes most to changing the surface temperature. The most unfavorable from an environmental point of view is the north-eastern part of the region - large industrial enterprises are concentrated there, and motorways pass. The relatively low heat radiation areas are distributed in the sub-regions with the palace complex, the ecosystem is close to the ideal, including due to a large number of parks and green areas. Determining the soil surface temperature helps forestry planners to zone areas where greenery is needed, thereby reducing solar radiation in hot seasons, ensuring ecological balance.

By determining the surface temperature of vegetation cover in different areas, it will help to plan urban urban greenery easily, through the determination of the cover temperature threshold. Helps to rationalize the tree crop.

| Vegetation Type          | Temperature (°C) |
|--------------------------|------------------|
| Thick forest             | 1170.30          |
| Sparse forest stands     | 1.36             |
| Humming grassy vegetation| 3440.49          |
| Wasteland                | 288.13           |
| Green area               | 422.06           |
| Shrub thickets           | 293.53           |
| A park                   | 693.98           |
| Arable land              | 11855.2          |
| Thickets of Forests are  | 146.59           |
| dense                    |                  |
| Felled Forest            | 4.03             |
| Apiary                   | 1.90             |
| Fortified slope          | 0.59             |
| Watery grassy            | 40.45            |
| Garden                   | 344.97           |
| Lawn                     | 135.29           |
| Fruit Berry Garden       | 727.47           |
| Gardening                | 1372.88          |
| Cemetery                 | 36.55            |
| Residential area         | 2787.97          |
| Pond, Rivers and Lake    | 225.90           |

| Soil Type                | Temperature (°C) |
|--------------------------|------------------|
| Arable land              | 3518.1           |
| Felled Forest            | 5318.1           |
| Fortified slope          | 3518.1           |
| Watery grassy            | 3518.1           |
| Garden                   | 3518.1           |
| Lawn                     | 3518.1           |
| Fruit Berry Garden       | 3518.1           |
| Gardening                | 3518.1           |
| Cemetery                 | 3518.1           |
| Residential area         | 3518.1           |
| Pond, Rivers and Lake    | 3518.1           |
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