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Seasonal Variability of Land Surface Temperature in Halych National Nature Park

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SUMMARY

This study investigates the seasonal variability of Land Surface Temperature (LST) within the Halych National Nature Park (Ukraine) using Landsat 8 OLI/TIRS data for 2023. Monthly LST maps were generated through the split-window algorithm, with emissivity estimated via NDVI thresholding. Zonal statistics revealed a clear seasonal pattern: colder months (January–March) were dominated by below-average temperature zones, while near-average conditions prevailed in spring and summer. The proportion of the park covered by average LST values peaked in May (56.5%) and August (68.2%). Localized anomalies of ±3 °C affected up to 8% of the territory, indicating areas potentially vulnerable to overheating or cooling. Despite their limited spatial extent, these anomalies have significant ecological implications, as they highlight zones prone to overheating, excessive cooling, drought, vegetation degradation, and increased fire risk. Long-term satellite-based monitoring of LST thus provides a robust framework for detecting microclimatic anomalies and assessing risks to temperature-sensitive species.

Keywords: Halych National Nature Park; Landsat 8; LST; Monitoring; Remote sensing; Seasonal variability; Thermal anomalies.

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Introduction

Land Surface Temperature (LST), defined as the temperature perceived when touching the ground surface, is a key parameter in remote sensing methodology development and plays a critical role in studies of global climate change, hydrological and agricultural processes, and urban land use and land cover (Avdan & Jovanovska, 2016). LST is a crucial geophysical parameter related to surface energy and water balance of the land-atmosphere system and satellite remote sensing provides the best way to measure LST and generate various LST products at regional and global scales (Li et al., 2013). Land Surface Temperature derived from medium- to high-resolution remote sensing data plays a crucial role in various environmental applications, particularly in water resource management over agricultural areas. This importance was a key factor in the decision to include a Thermal Infrared Sensor (TIRS) on board the Landsat Data Continuity Mission (Landsat-8). Unlike previous Landsat missions equipped with a single thermal band, Landsat-8's TIRS features two bands within the atmospheric window (10-12 µm). This configuration enables the use of split-window (SW) algorithms, which offer improved atmospheric correction compared to single-channel methods or direct inversion of the radiative transfer equation (Jimenez-Munoz et al., 2014; Hulley et al., 2019).

In this study, LST for Halych National Nature Park, Ukraine, was derived using the SW algorithm with the use of Landsat 8 Optical Land Imager (OLI) of 30 m resolution and TIRS data of 100 m resolution. The spectral radiance was estimated using TIR bands 10 and 11. Emissivity was obtained using the Normalized Difference Vegetation Index (NDVI) thresholding method, which used OLI bands 4 and 5 based on the study of Rajeshwari and Mani (2014) and Abidin et al. (2021).

Method and Theory

This research takes place in the territory of the Halych National Nature Park (located at approximately 49°07′N latitude and 24°43′E longitude), situated in western Ukraine within Ivano-Frankivsk district. The park is bordered by the city of Halych to the west, Burshtyn Reservoir to the north, forested and agricultural lands of Rohatyn district to the east, and the Dniester River valley to the south. Covering an area of approximately 14,685 hectares, the park encompasses diverse landscapes including floodplain forests, wetlands, and steppe meadows, and serves as a site for biodiversity conservation and ecological research in the region.

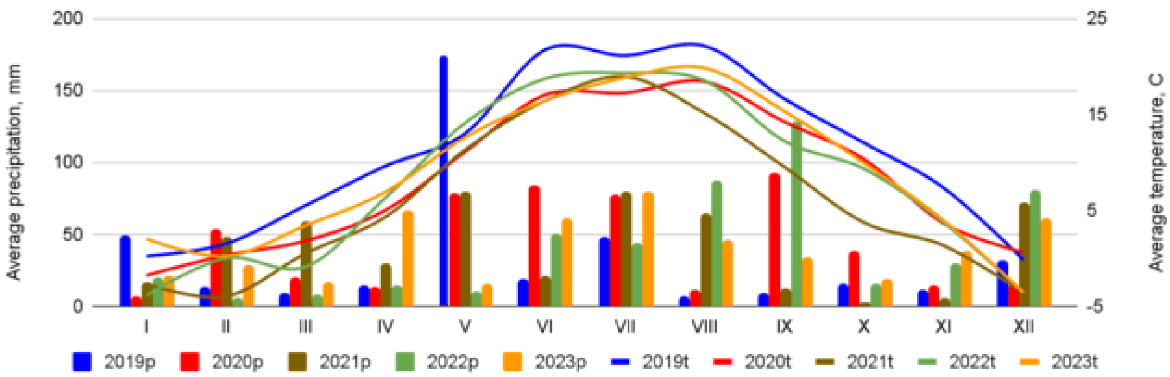

Figure 1. *Average climate indicators for 2019-2023. Months are indicated in Roman numerals. The index "p" after the year indicates precipitation, the index "t" - temperature*

The climate of Halych National Nature Park is moderately continental with distinct seasons. Winters are mild with frequent thaws, while summers are warm. Average temperatures range from –4 to –4.5 °C in January and +18 to +19.9 °C in July. The period with temperatures above +10 °C lasts 155-170 days, with a frost-free span of 150-155 days. Annual precipitation ranges from 600 to 800 mm, about 70% of which falls during the warm season. Summer months are the wettest, often bringing heavy rains that can cause flooding in the Dniester River basin. The moisture coefficient averages around 1.1%, indicating sufficient humidity (Chronicle of nature of Halych National Nature Park, 2019–2023). Figure 1 presents the annual climatic characteristics of Halych National Nature Park, including temperature dynamics and precipitation pattern.

The data in this research employed Landsat 8 OLI TIRS satellite images with 30-meter spatial resolution (Path = 184-185, Row = 26) acquired in different time from January to December 2023; downloaded from https://earthexplorer.usgs.gov). Reliable estimation of LST from satellite-derived brightness temperature typically involves four correction steps: radiance-to-temperature conversion, atmospheric effects adjustment, surface emissivity correction, and surface roughness consideration (Voog, & Okeb, 2003; Zhang et al., 2014). The calculation of the LST index is described in detail in the works of Patz et al. (2008), Zhang et al. (2018) and Abidin et al. (2021).

Results

For each month of 2023, a separate LST map was generated to visualize the spatial distribution of surface temperatures across the Halych National Nature Park (Figure 2). This monthly mapping enabled the monitoring of seasonal dynamics, detection of localized thermal anomalies, and assessment of emerging climate-related trends within the park's diverse landscapes.

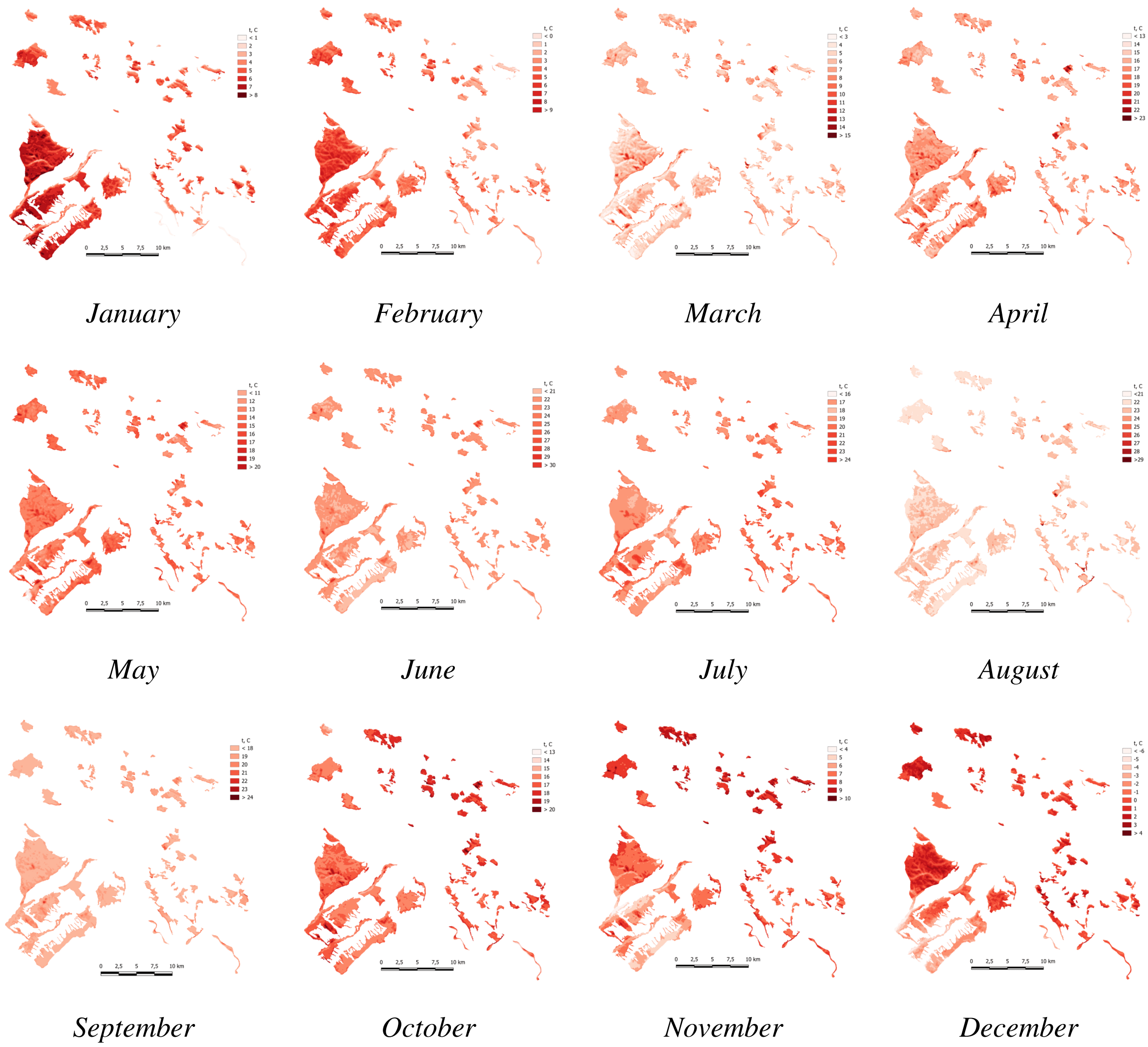

Figure 2. *Monthly land surface temperature maps for the Halych National Nature Park in 2023, derived from Landsat 8 OLI/TIRS data*

For each monthly LST raster, zonal statistics were performed within the delineated boundary of the park. Temperature values were classified into seven intervals: three below the monthly average (–1 °C, –2 °C, –3 °C), the average itself, and three above it (+1 °C, +2 °C, +3 °C). The area covered by each temperature zone was calculated in hectares and expressed as a percentage of the park's total surface (Figure 3).

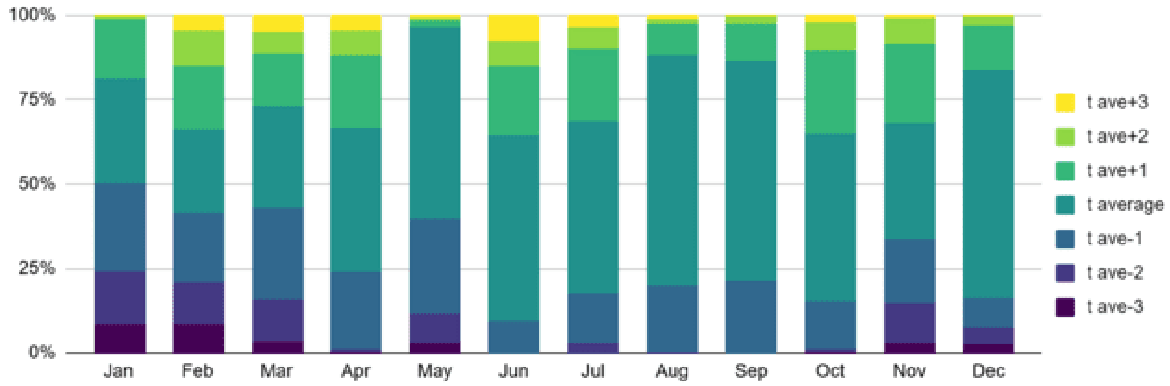

Figure 3. *Monthly distribution of land surface temperature zones within Halych National Nature Park in 2023, based on zonal statistics*

The zone corresponding to the average monthly temperature consistently occupied the largest proportion of the park area, with peak coverage in May (56.5%) and August (68.2%). Zones with below-average temperatures dominated during the colder months, especially from January to March, where the total coverage of the zones from –1°C to –3°C exceeded 50% in January and 43% in March. In contrast, zones with above-average temperatures were most prominent only in June, July, and October, where the total coverage of the zones from +1°C to +3°C reached approximately 35.5%.

Conclusions

The results obtained made it possible to assess the thermal structure of the park's landscapes and identify areas potentially vulnerable to overheating or overcooling (Figure 4). It was found that in 2023, up to 8% of the land area of the Halych National Nature Park was characterized by a deviation in surface temperature from the monthly averages of 3 °C or more. Despite the relatively small spatial extent of such thermal extremes, their analysis allows for the identification of areas potentially prone to overheating or excessive cooling, which may serve as indicators of increased vulnerability in natural ecosystems.

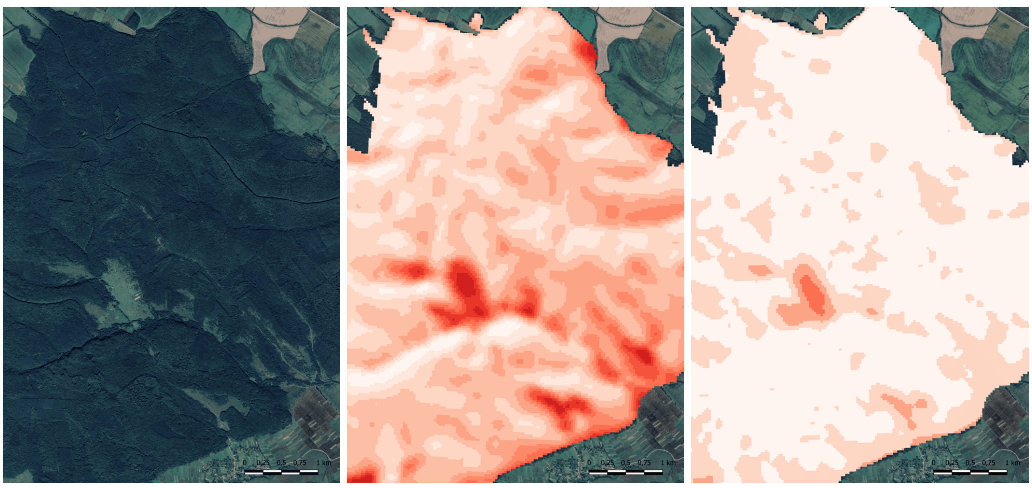

Figure 4. *Localized heat anomalies across the forest canopy: from left to right – satellite image from Google Maps, LST map for March, and LST map for September*

The use of satellite data provides regular and spatially continuous coverage of the study area, making it possible to detect local thermal anomalies and analyze spatial heterogeneity in temperature patterns between forest, meadow, wetland, and open ecosystems. LST estimates can be used to identify areas with potentially reduced moisture levels, increased heat stress, and disturbed vegetation cover.

Identifying such areas is important for monitoring microclimatic anomalies and assessing environmental risks to temperature-sensitive species of flora and fauna. In addition, analyzing temperature anomalies in combination with indicators of humidity and vegetation cover density can serve as an additional indicator of fire risk. Long-term monitoring of land surface temperature provides the basis for identifying areas vulnerable to drought, vegetation degradation, and other manifestations of climate-driven changes.

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