Peculiarities of urban heat island in Vilnius

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SCREEN CAPTURE WELCOME

Introduction.
Heat island is a phenomenon where the average air temperature in a particular region is higher than in surrounding areas. The aim of the study is to determine largest temperature differences in Vilnius city and its suburbs (*Fig. 1 and Fig. 2*) based on daily average, maximum and minimum temperature data during 2012–2019 period. This work also determines the effect that atmospheric circulation has on temperature difference between Vilnius city and its suburbs.

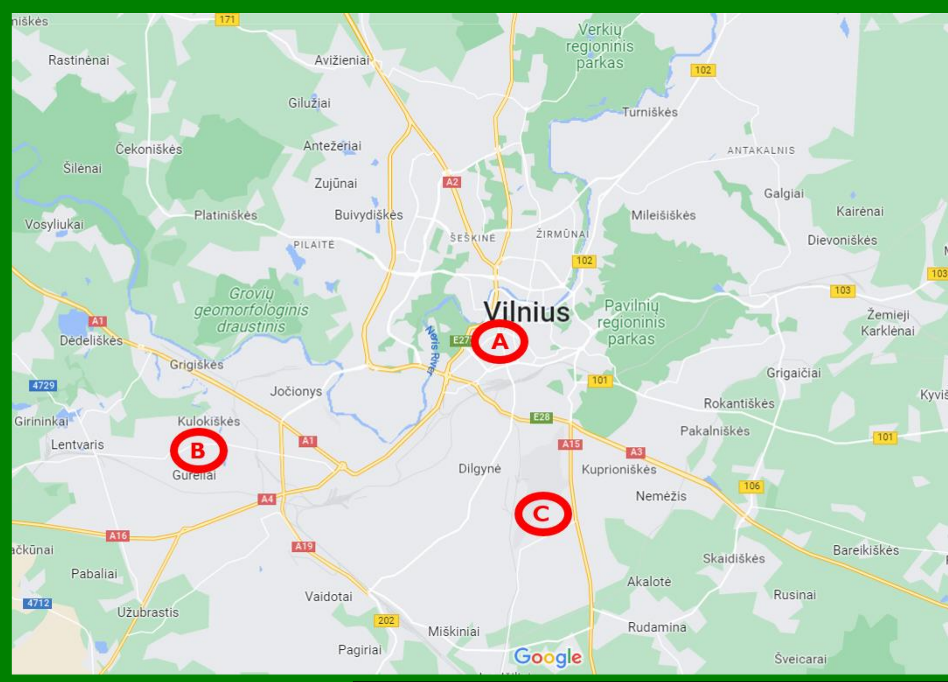


Fig. 2. *Locations of meteorological stations (MS) from which the data were used in the present study.*
A – Vilnius University MS (VU)
B – Trakų Vokė MS
C – Civil aviation MS (CAMS)

Fig. 1. *Vilnius is the capital and largest city of Lithuania, with a population of 592,389 as of 2022.*

First mentioned 1323.
The area of Vilnius is 402 km².
Buildings occupy 29.1% of the city;
green spaces occupy 68.8%;
and waters occupy 2.1%.
Population density 1392/km².
In Vilnius city suburbs the average air temperature of the coldest month (January) is about –3,7°C, and the warmest (July) is 18,5°C.

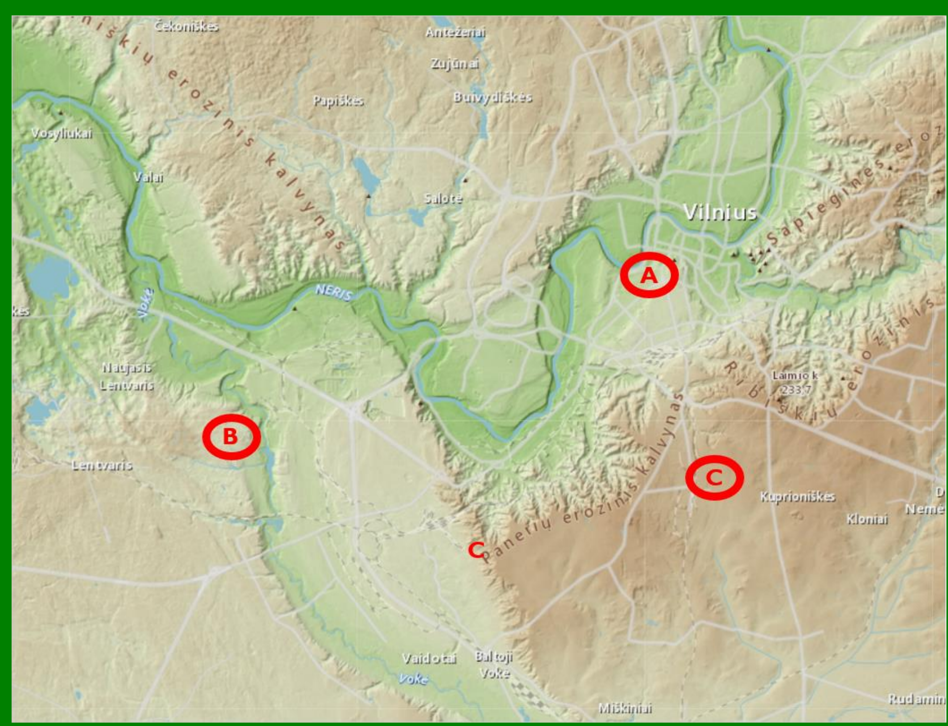


Fig. 3. *Vilnius city relief and height of stations above mean sea level.*
A – 128 m MSL
B – 156 m MSL
C – 190 m MSL

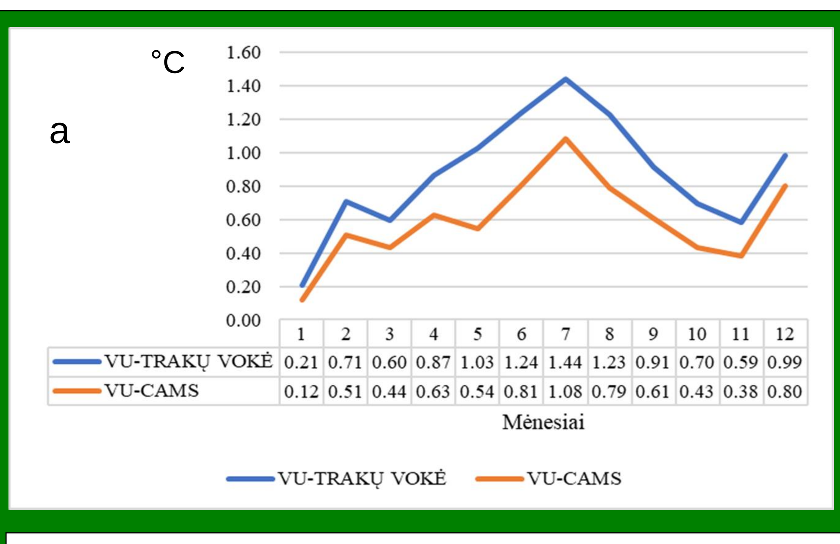
Data and methods.
In this study data from Vilnius University, Trakų Vokė and Civil aviation meteorological stations of 2012-2019 period were collected and analyzed, such as hourly, daily and monthly temperature averages, maximum and minimum temperature averages (measured at the height of 2 metres), wind speed parameters, cloud coverage and atmospheric circulation data. The Urban Heat Island Intensity (UHII) is determined as the temperature difference between an urban (represents Vilnius University MS) and its surrounding suburbs/rural area (representsTrakų Vokė MS and CAMS) (*Fig. 2 and Fig. 3*).
Also, in this paper, the five strongest cases of heat island formation in the months of January, April, July and October were analyzed: the synoptic situation was determined and what baric formation of atmospheric pressure at sea level determined the weather on those days. The synoptic map database "Reanalysis archives" was used for the analysis (synoptic situation on a specific day at 00:00 in UTC time).

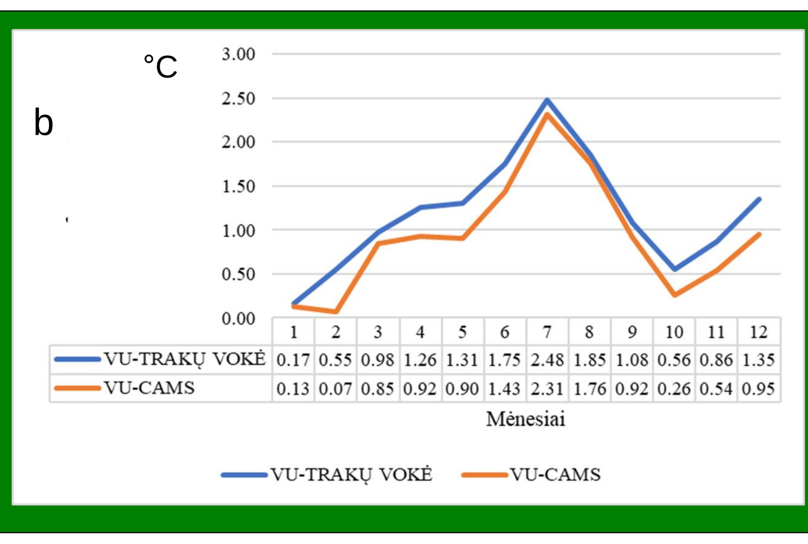
Results.
The monthly mean temperature in Vilnius is 0,12–1,44 °C higher than in the surrounding areas. The UHII maximum were found in July, and the weakest in January (Fig. 4a). The largest temperature differences in mean daily miximum temperature (Fig. 4b) were found also in July (2,5 °C), and the smallest in October, January and February (0,56–0,07 °C).

The largest temperature differences in mean daily minimum temperature (Fig. 4c) were found in May (1,89°C), and the smallest in October and January (0,47–0,12°C). The UHII maximum during the warm season may be related to high amounts of solar radiation and warming urban artificial surfaces.
As can be seen in the Figure 5, the biggest daily variation of UHII were found in July and the smallest – in January. The UHII maximum were found in the afternoon hours and UHII minimum and in the morning.

An analysis of atmospheric circulation during the strongest UHII has shown that in 50 % of cases, the strongest heat island is formed by anticyclonic atmospheric circulation, 30 % of cases – by cyclonic atmospheric circulation and 20 % – by small gradient fields. Examples of synoptic situations are presented in Fig. 6.

The heat island that's formed in Vilnius city is dependent on wind speed, e.g., weaker winds cause a stronger heat island. Cloud cover does not have such a significant impact on the formation of the heat island in Vilnius, but the trend shows that higher cloud coverage may form a weaker heat island.
Under favourable conditions, the maximum UHII in Vilnius can reach as much as 4,6–5,8°C.





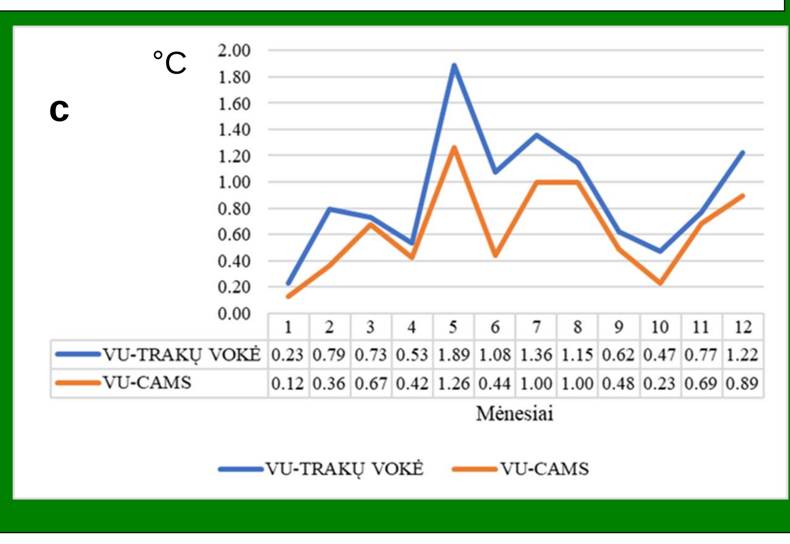
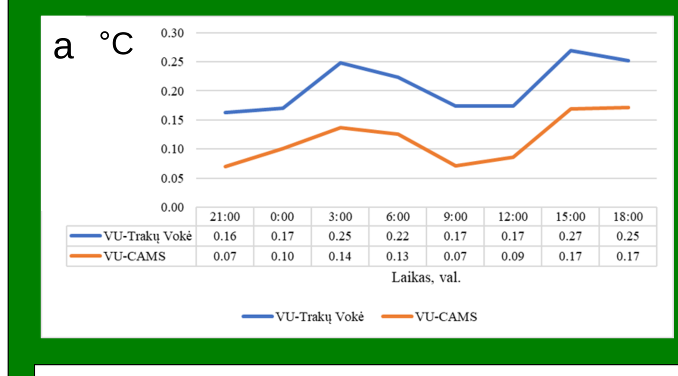
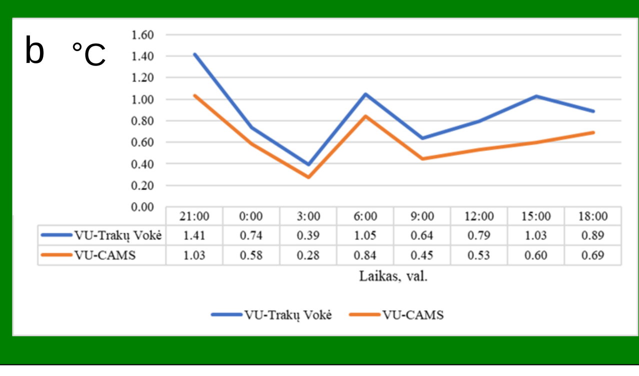
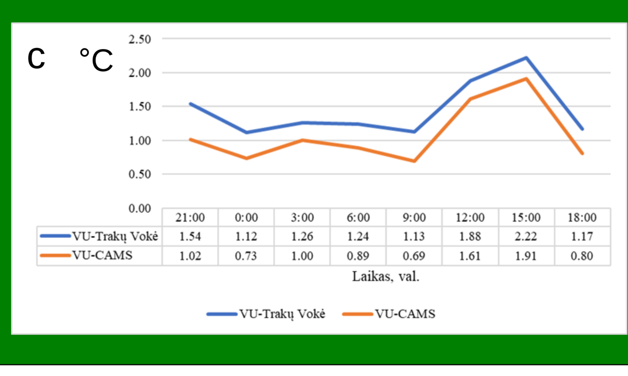


Fig. 4. *The Urban Heat Island Intensity (UHII) as the monthly air temperature difference between an urban (represents VU) and suburbs area (represents Trakų Vokė and CAMS).*
a – difference in mean temperature, b – difference in mean daily miximum temperature, c – difference in mean daily minimum temperature







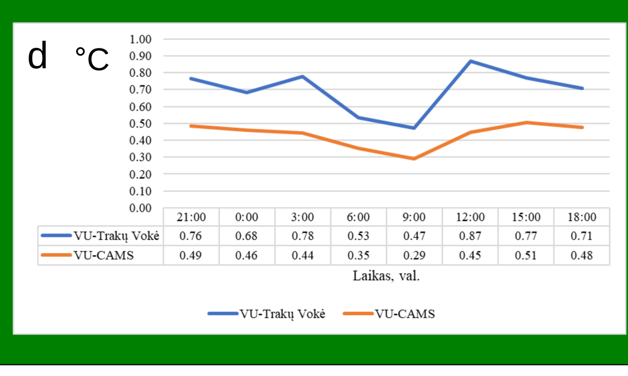
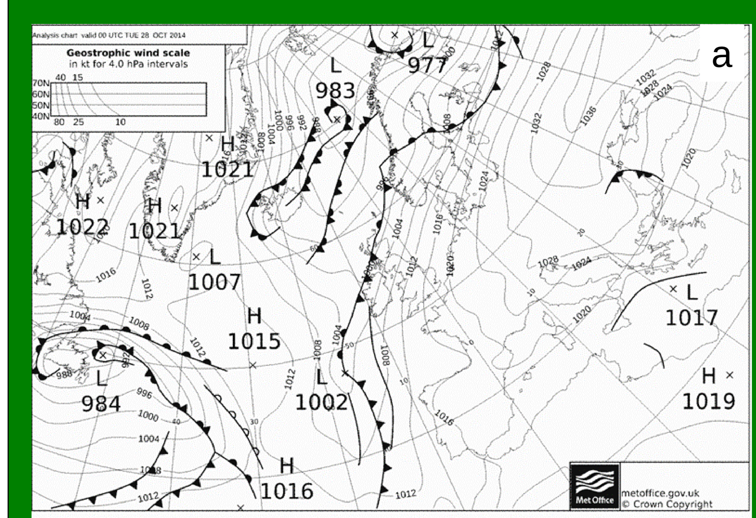
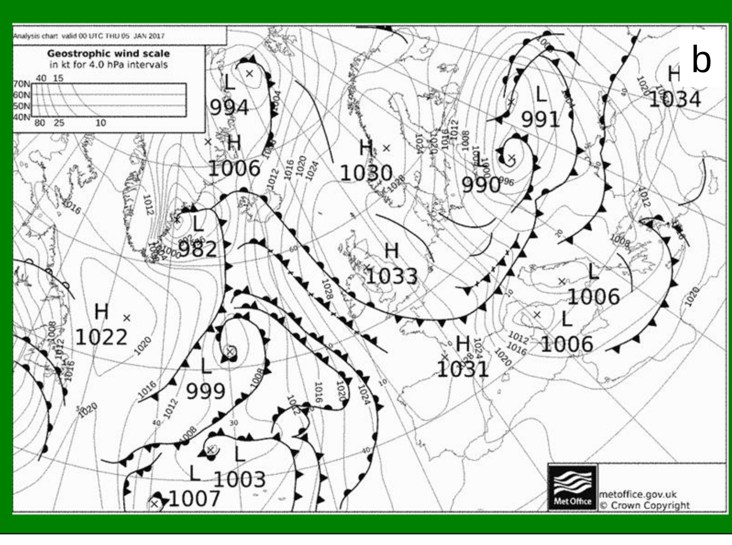


Fig. 5. *Daily variation of UHII as the air temperature difference between an urban (represents VU) and suburbs area (represents Trakų Vokė and CAMS). a – January, b – April, c – July, d – October*





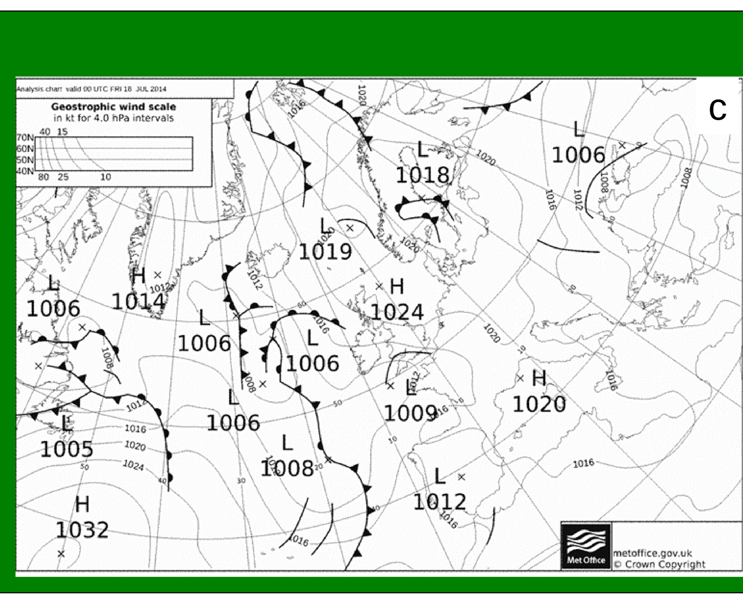


Fig. 6. *Typical atmospheric circulation atmospheric circulation during the strongest UHII.*
a – anticyclonic circulation, b – cyclonic circulation, c – small gradient fields