GLOBE Estonia Learning Expedition 2025

Temperature and humidity measurements at Jõulumäe

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Abstract

The study was conducted at Jõulumäe on August 17, 2025, as part of a GLOBE Program educational field expedition. The aim of the work was to investigate how surface temperature affects air temperature and air humidity under different landscape conditions and how these factors are interrelated within the local microclimate. Measurements were taken at ten locations in the vicinity of the Jõulumäe Recreational Sports Center, including sandy areas, pine forest, and the surroundings of a pond and a ditch.

Data were collected in accordance with the GLOBE atmosphere protocols, using a psychrometer, an infrared thermometer, and a cloud chart. The results showed that higher surface temperatures are associated with higher air temperatures, while in more humid and shaded locations the temperature is lower and air humidity is higher. The warmest readings were recorded in open areas, such as near the parking lot and on sandy ground, whereas the most humid conditions were found in the ditch and along the edge of the pond.

The study emphasizes that solar radiation, vegetation, and surface characteristics play an important role in the formation of microclimates. The results help to better understand the development of local climatic conditions and support the goals of the GLOBE Program to promote scientific thinking and environmental awareness among young people.

Introduction and literature review

Temperature and air humidity are two key factors in the formation of both local weather and broader climate processes. Surface temperature influences air temperature through heat transfer and vertical mixing processes, and this relationship may vary depending on surface type, vegetation, and weather conditions. Previous studies indicate that surface temperature and air temperature are closely related, but the strength of this relationship depends on seasonality, surface heterogeneity, and local landscape structure (Adão et al., 2023; Naserikia, 2023).

Vegetation and surface structure affect the microclimate in several ways—shading reduces direct solar heating, while plant transpiration cools the air and increases humidity. In open areas, such as sandy surfaces, warming occurs more rapidly and surface temperature readings are higher. Previous research has demonstrated the importance of vegetation cover in regulating both cooling and moisture in urban and rural environments (Mughal et al., 2021).

The aim of the GLOBE Program is to standardize field methods for measuring atmospheric and surface parameters and to involve students in scientific data collection and analysis (GLOBE Program, 2025).

Research methods

How did we conduct our investigation?

We wanted to find out:

- Does surface temperature affect air temperature?
- How does air humidity vary in different locations?
- How are surface temperature, air temperature, and air humidity related to one another?

To answer these questions, we conducted measurements of temperature and humidity at different locations in Jõulumäe. In addition, we observed cloud cover and whether the sun was shining, and recorded the characteristics of the landscape.

Where did we take measurements?

Jõulumäe is located at the edge of a pine forest. We selected different measurement sites to observe a variety of conditions.

- **Next to the parking lot near the Jõulumäe Recreational Sports Center** – an open area.
- **Beside the artificial snow hill** – a small hill, sunny.
- **Pine forest on the crest of a sand dune** – the highest point on the dune.
- **Ditch** – water present, a humid location.
- **Moist mixed forest** – many trees, shaded.
- **Edge of the sandy area** – sand with some grass.
- **Lowest point of the sandy area** – the lowest location on the sand.
- **Small pond** – humid and shaded along the shore.
- **Dense mixed forest** – many trees, quite dark.
- **Next to the parking lot** – measured again to compare with the starting point.

We followed a hiking trail of approximately 10 km in length in order to reach all measurement locations. The exact sites are listed in the table (Appendix 1). Figure 1 shows our route, with the starting and ending points marked in green.

Which protocols and instruments did we use?

- **GLOBE Surface Temperature Protocol** – for measuring surface temperature.
- **GLOBE Relative Humidity / Sling Psychrometer Protocol** – for measuring air temperature and air humidity.
- **GLOBE Cloud Protocol** – for observing cloud cover and cloud types.

Instruments (figure 2):

- Psychrometer
- Infrared thermometer for surface temperature
- Cloud chart
- Notebook and pencil

How did we collect and analyze the data?

We recorded the type of landscape and whether the location was sunny or shaded.
We measured surface temperature using an infrared thermometer.
We measured air temperature and humidity with a psychrometer: the wet thermometer was moistened, the instrument was rotated for 2–3 minutes, and the readings were recorded.
All data were entered into a table (Figure 4). Later, we created graphs and calculated whether surface temperature and air temperature were related.

Our route

Jõulumäe is located at the edge of a pine forest. We took measurements at various locations: next to the parking lot, near the artificial snow hill, on the crest and in the lowest part of the sand dune, in a ditch, in a moist mixed forest, at the edge of the sandy area, along the shore of a pond, and in a dense mixed forest. The final measurement was taken again near the parking lot. We walked along a hiking trail of approximately 10 km.

The exact locations are listed in the table later on.

The map is taken from a loquiz that saved our exact route.

Figure 1. Measurement route. The starting and ending points are indicated with a green dot.

Foto: Ketly Meitsar

Figure 2. Measurement instruments: sling psychrometer, water bottle for the wet-bulb test, infrared thermometer, cloud chart.

We measured air temperature, air humidity, and surface temperature. We assessed the amount and type of cloud cover, and recorded whether the sun was shining or not, as well as describing the landscape at each measurement site. We used the GLOBE atmosphere protocols for humidity, cloud cover, and temperature.

Temperature is a physical quantity that characterizes the thermal state of an object. Temperature is measured with a thermometer, and we used degrees Celsius as the unit of measurement. Surface temperature was measured using an infrared thermometer. The infrared thermometer was aimed at the object being measured, such as grass, and the reading was recorded. Air temperature was determined using the dry-bulb thermometer reading of the psychrometer.

Air humidity was measured with a psychrometer. The wet-bulb thermometer was moistened with test water, after which the psychrometer was rotated in the air to

promote evaporation. The rotation lasted 2–3 minutes, after which the readings of the dry and wet thermometers were recorded; the wet-bulb reading must be lower than the dry-bulb reading. Air humidity was determined based on the readings of the dry and wet thermometers. Air humidity refers to the amount of water vapor in the atmosphere, which influences weather conditions.

The measurement data were compiled into a table. The table is presented in Appendix 1.

Results

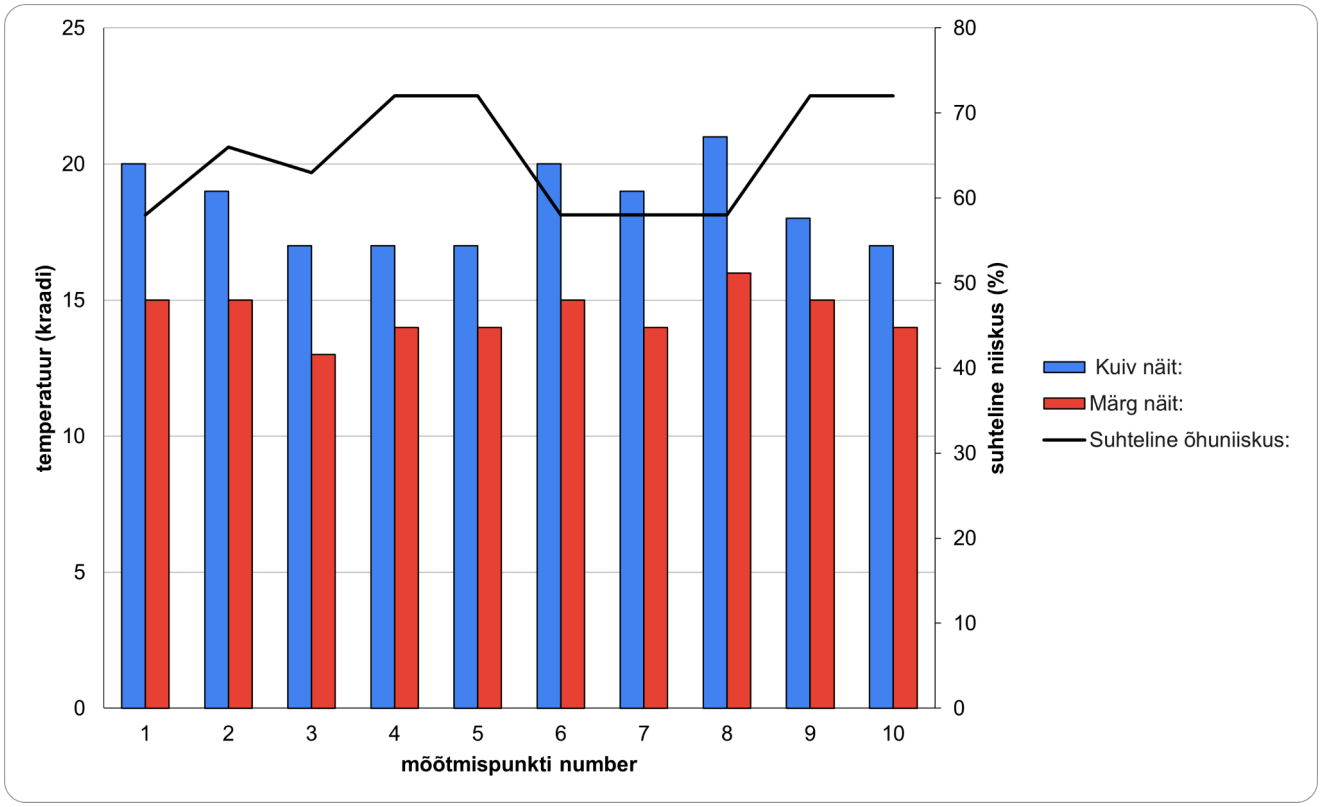

Figure 3. Air temperature in Celcius and relative humidity readings at the measurement points. Blue - dry; red - wet; black line - relative humidity

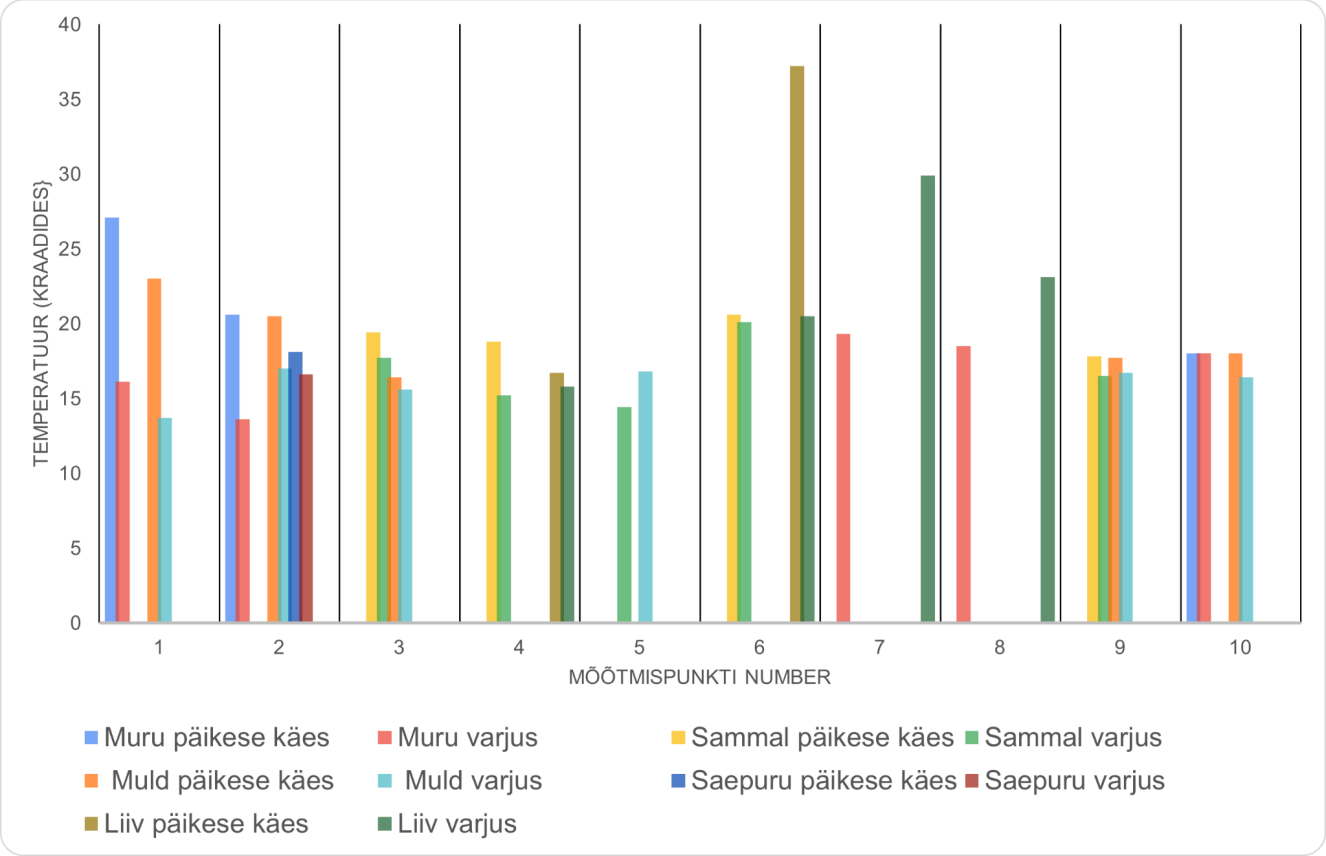

Figure 4. Surface temperatures in Celcius at the measurement points 1-10.

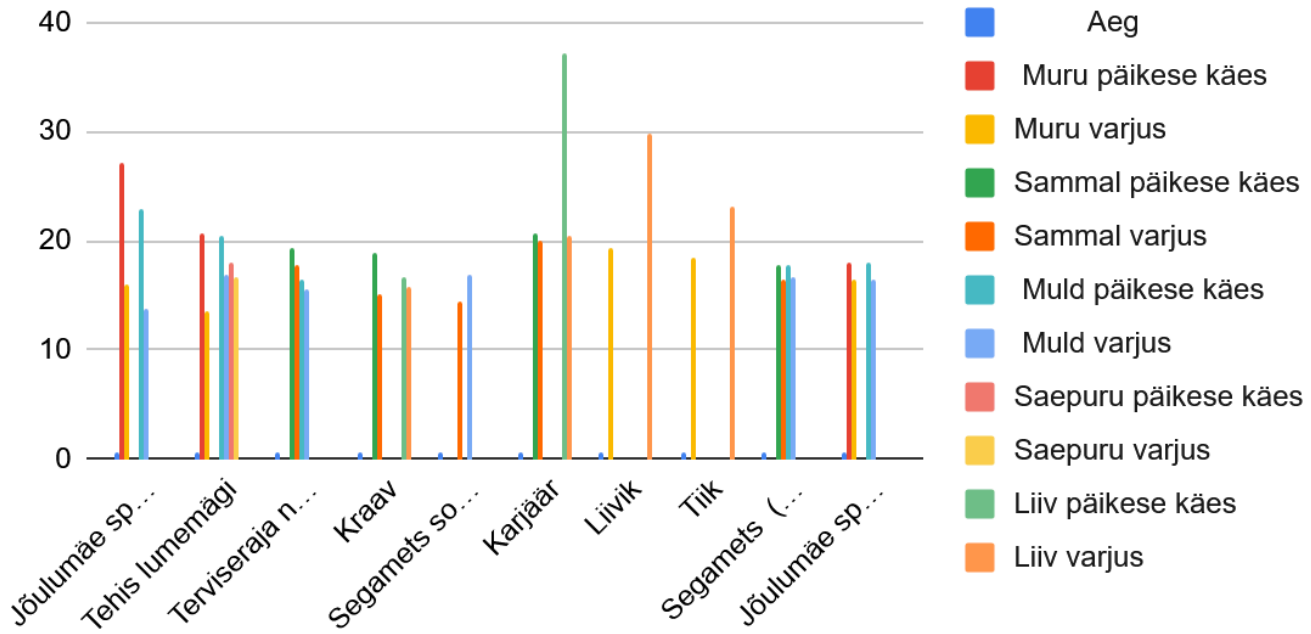

Figure 5. Overall surface Temperatures in Celcius at every point.

Discussion

The results of the study showed that surface temperature is directly related to air temperature; for example, when surface temperature was higher, air temperature was also higher. This supports the hypothesis that the warmer the ground surface is, the warmer the air above it becomes. However, this relationship was not equally strong at all measurement points, indicating that in addition to surface temperature, other factors such as shading, wind movement, and vegetation also influence air temperature.

The air humidity results confirmed that in more humid and shaded locations (the ditch, mixed forest, and pond surroundings), air humidity was higher than in open sandy areas or near the parking lot. The measurements confirmed that warming of the surface also warms the air. However, differences between measurement points show that shading and wind movement can influence both surface and air temperature. The results also confirm that in more humid and shaded areas, air humidity is higher and temperature is lower.

Studies show that when the ground surface is warmer or colder, it often affects the air as well—this effect is especially noticeable in winter.

The results support the hypothesis:
the warmer the surface, the higher the air temperature.

Conclusions

What did we learn?

We learned that when the ground surface is warmer, the air is usually warmer as well. In more humid and shaded locations, the air is more humid and cooler. Open areas, such as the highest point of the sandy area or the parking lot, are the warmest.

Global and local context

Globally, this helps us understand how surface temperature and vegetation influence air temperature and humidity around the world. Locally, at Jõulumäe, it shows which areas warm up more and which are more humid, such as the surroundings of the pond or the

ditch.

What would we do differently next time?

Next time, we would measure additional variables, such as air pressure. We could also use more measurement points to obtain a more detailed picture.

How would we investigate in the future?

In the future, we could combine our measurements with digital datasets. We could also study how weather changes or different types of surface cover affect the microclimate.

Literature review:

Adão, F., **et al.** (2023). The relationship between land surface temperature and air temperature. *Remote Sensing, 15*(22), 5373. https://doi.org/10.3390/rs15225373

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