GLOBE Estonia Learning Expedition

Variations in the Atmospheric Measurement Data of Different Weather Stations in Tartu

Kaisa Tullus (Miina Härma Gümnaasium)

Lille-Mai Kangur (Miina Härma Gümnaasium)

Marta Ruthe (Kääpa Põhikool)

Rebeka Plaan (Palupera Põhikool)

Miia Kalnapenkis (Kääpa Põhikool)

Mikk Mattias Mahla (Tartu Tamme Kool)

Jan Mihhailov (Narva Vanalinna Riigikool)

Supervisors: Merli Ilves, Kent Gregor Mahla

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Abstract

We did atmospheric measurements at two different locations: Tähtvere Park and Ülejõe Park during the GLOBE Estonia Learning Expedition in Tartu, Estonia on 8 August 2023. Our main goal was to find out how the data of various weather stations differs from our measurements. We were curious if the observed two parks would have different results in atmospheric indicators. We also wanted to find out how long it would take for atmospheric indicators to show any notable changes.

Our hypotheses were:

- The results from the weather stations will show some variance, but generally, the indicators will be quite similar.
- The data from the two parks will be different.
- The indicators will not change notably in half an hour.

We discovered that all the weather stations, we compared, had some variances in their atmospheric data. This could be because of the different locations of the stations, the different equipment which was used to make the measurements and so on. We also realised that half an hour is enough time for atmospheric indicators to change notably and we did in fact see differences between the data from the two parks.

Studying the atmosphere is important because it helps us predict the weather and see how the climate is changing, which in turn makes it easier to protect the climate. Comparing and researching different weather stations and equipment, used to measure the atmosphere, helps us study local weather variability as well as find flaws and make sure that all the measurements are accurate.

Keywords: air temperature, air pressure, air humidity, clouds

1. Introduction

1.1. What Is the Atmosphere?

The atmosphere is a mixture of gases surrounding the Earth. It consists of nitrogen (78%), oxygen (21%), argon (0.9%) and other gases (0.1%) (1). The Atmosphere is one of the things that makes life on Earth possible, by providing us with air to breathe, protecting us from harmful UV rays and keeping the Earth warm by trapping the heat from the Sun (2).

1.2. Where Did We Go?

During the GLOBE Estonia Learning Expedition (7. to 10. August 2023), we made atmospheric measurements in two parks in Tartu: Tähtvere and Ülejõe.

Ülejõe Park is located in the district of Ülejõe. The name Ülejõe, which in Estonian means "over the river", was given to the district by locals, due to it being situated on the right bank of river Emajõgi and the livelier side of Tartu (like the city centre, old town, etc.) being on the left bank of the river. The Ülejõe district was severely damaged during World War II. The destruction was especially bad near the river, leaving big areas to be later transformed into parks and new residential areas (3).

Tähtvere Park is located in the district of Tähtvere. It is divided into three sections: the dog park, the sports park and the recreation park. The Tartu song festival arch is also located in Tähtvere Park (4).

1.3. Our Mission

The purpose of our research was to find out whether there would be any differences between the data collected by us and the data from different weather stations in Tartu. Our research took place on the 8th of August 2023.

We had three research questions:

1. How much will the weather indicators change in 30 minutes?
2. How does the data of weather stations (including our own data) vary?
3. How will the data from the two locations, Ülejõe Park and Tähtvere Park, compare?

Our hypotheses were:

- The indicators will not change notably in half an hour.
- The results from the weather stations will show some variance, but generally, the indicators will be quite similar.
- The data from the two parks will be different.

1.4. Other Studies on This Topic

There have been other similar studies before which have compared different weather stations and weather measuring equipment. In one of these studies, a researcher compared the performance of two differently priced weather stations (a VP2 unit and a FO unit). They concluded that both units had differences in their measured data (5).

1.5. Why Do We Need to Research the Atmosphere?

Researching and studying the atmosphere is important because the atmosphere affects us constantly. The more we know about the atmosphere, the easier it is to:

- Predict the weather

Predicting the weather helps us to be prepared for extreme weather conditions. It helps us develop agriculture by knowing when to plant crops, for example. It also simply tells us what clothes to wear tomorrow.

- Protect the climate

By collecting data, we can see how the climate is changing and how it might change over time. We can work out ways to preserve our climate and deal with climate change.

- Reduce air pollution

We can see how much pollution is in the air and figure out how to reduce it (6).

2. Methodology and Research Equipment

2.1. Research Sites

The research was conducted in the city of Tartu, Tartu County, on two different sites. Site one (58.38513 N 26.70463 E), which was in Tähtvere Park, had short grass, gravel paths, some blooming flowers and different species of trees, mostly lindens.

Figure 1. Panorama view of the measurement site in Tähtvere.

Figure 2. Picture of measurements.

Site two (58.38110 N 26.72730 E), which was in Ülejõe Park, also had short grass, birch and willow trees and brick paths. It was also next to the river Emajõgi.

Figure 3. Panorama view of Ülejõe measuring station.

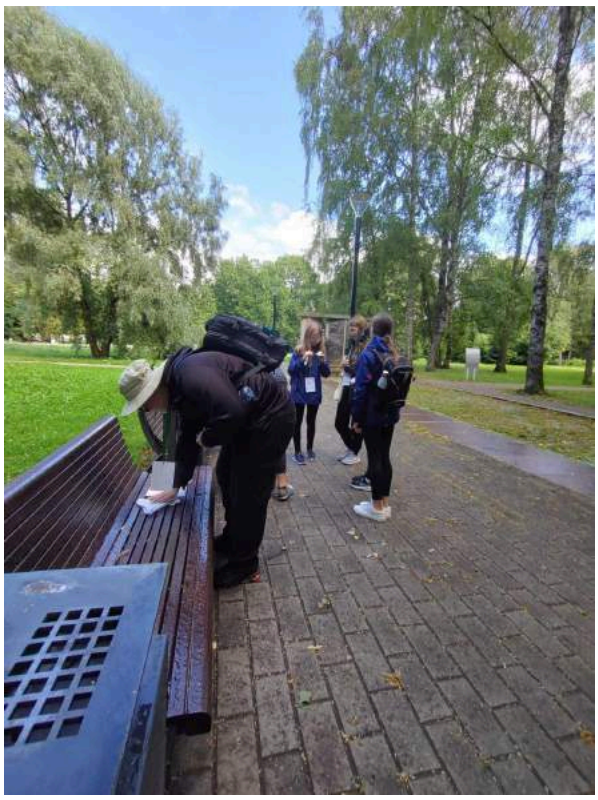

Figure 4. Picture of Ülejõe measuring station.

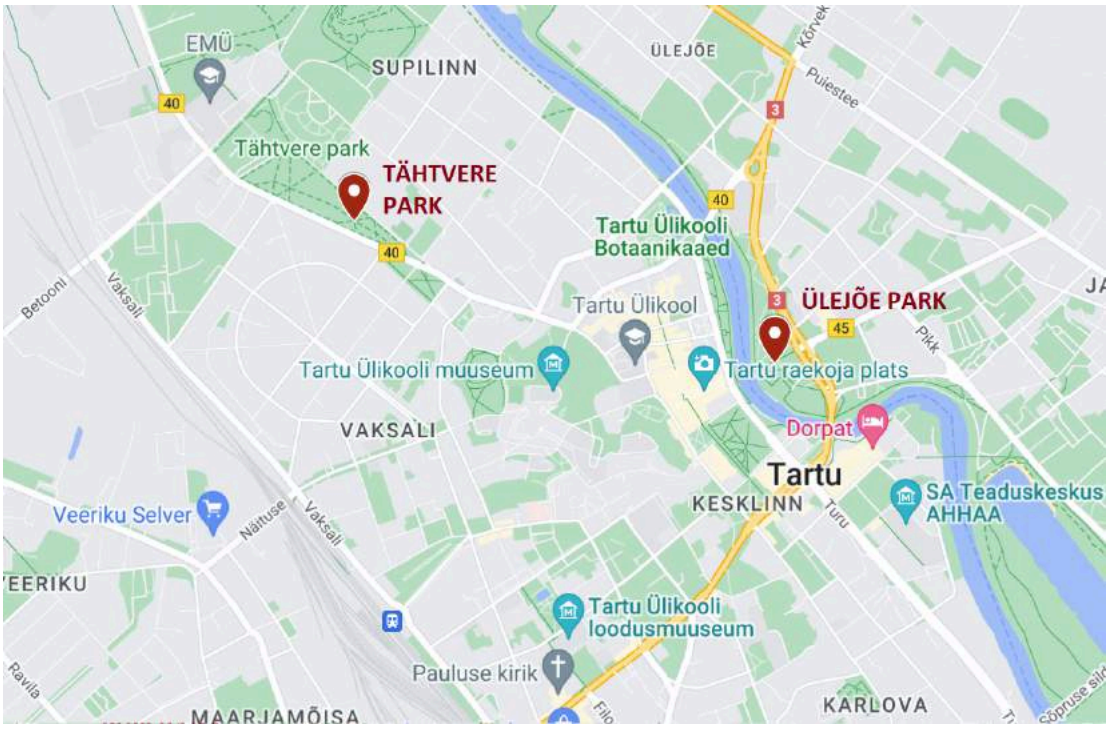

Figure 5. Map overview of the parks that were measured: Tähtvere and Ülejõe. (Map taken from Google Maps)

Tähtvere Park - 56.5 m height from sea level (observation time 14:15–15:30 GMT +3)

Ülejõe Park - 35 m height from sea level (observation time 16:00-17:15 GMT +3)

2.2. Measurements

To answer research question one, we made three measurements in both parks at 30-minute intervals because we wanted to find out if and how the indicators would change in that time frame. Since we had limited time during the expedition, we were only able to do three measurements at both sites. The observation time in Tähtvere Park was 14:15–15:30 and in Ülejõe Park 16:00-17:15.

To answer research question two, we made atmospheric measurements and took data from the Physicum weather station, Miina Härma Gymnasium's automatic weather station and Miina Härma Gymnasium's GLOBE station.

To answer research question three, we compared our measurement data from the two parks.
We used the following GLOBE protocols:

- **Air temperature**

To measure air temperature, we used the average of two digital thermometers (Figure 6) for maximum accuracy.

- **Air pressure**

To measure air pressure (also known as barometric pressure), we used a barometer (Figure 7).

- **Air humidity**

To measure air humidity, we used a sling psychrometer (Figure 8).

- **Observed clouds**

To identify the cloud types, we used the GLOBE cloud chart (Figure 9).

Figure 6.
Thermometers

Figure 7.
Barometer

Figure 8.
Psychrometer

Figure 9.
Cloud chart

These are the weather stations, from which we took the data:

- Physicum automatic weather station (measurements every 30 min, 14.15-17.15)
    - Meteo.physic.ut.ee

Figure 10. Overview of the online platform for the Physicum weather station.

- Miina Härma GLOBE station (measurements 14-17, only on full hours)
    - Student measurements done next to the Miina Härma Gymnasium using GLOBE equipment

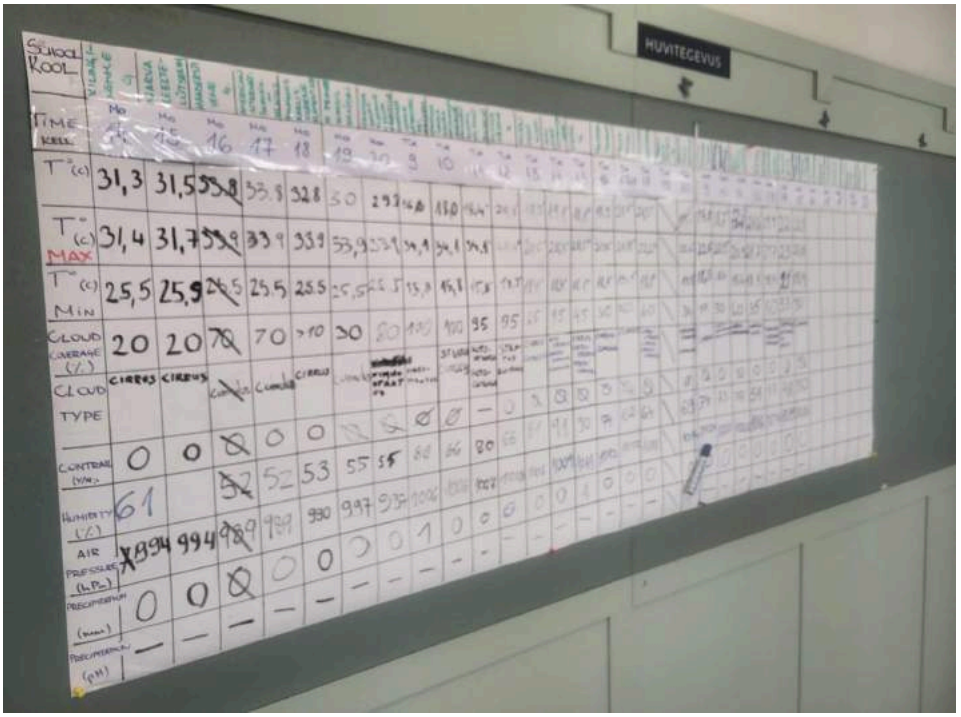

Figure 11. Overview of the GLOBE measurements at Miina Härma Gymnasium during the expedition.

- Miina Härma automatic station (measurements every 30 min 14.15-17.15)
    - MHG Weather (miinaharma.ee)

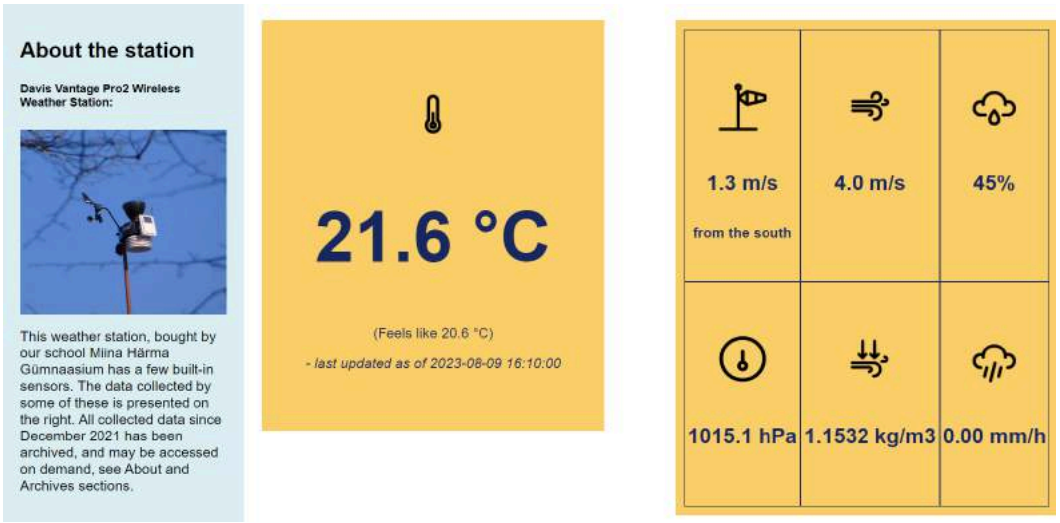

Figure 12. Overview of the online platform of the Miina Härma Gymnasium automatic weather station.

The following map shows the locations of all the weather stations that were used in this research. We can see that they are located in very different places in the city.

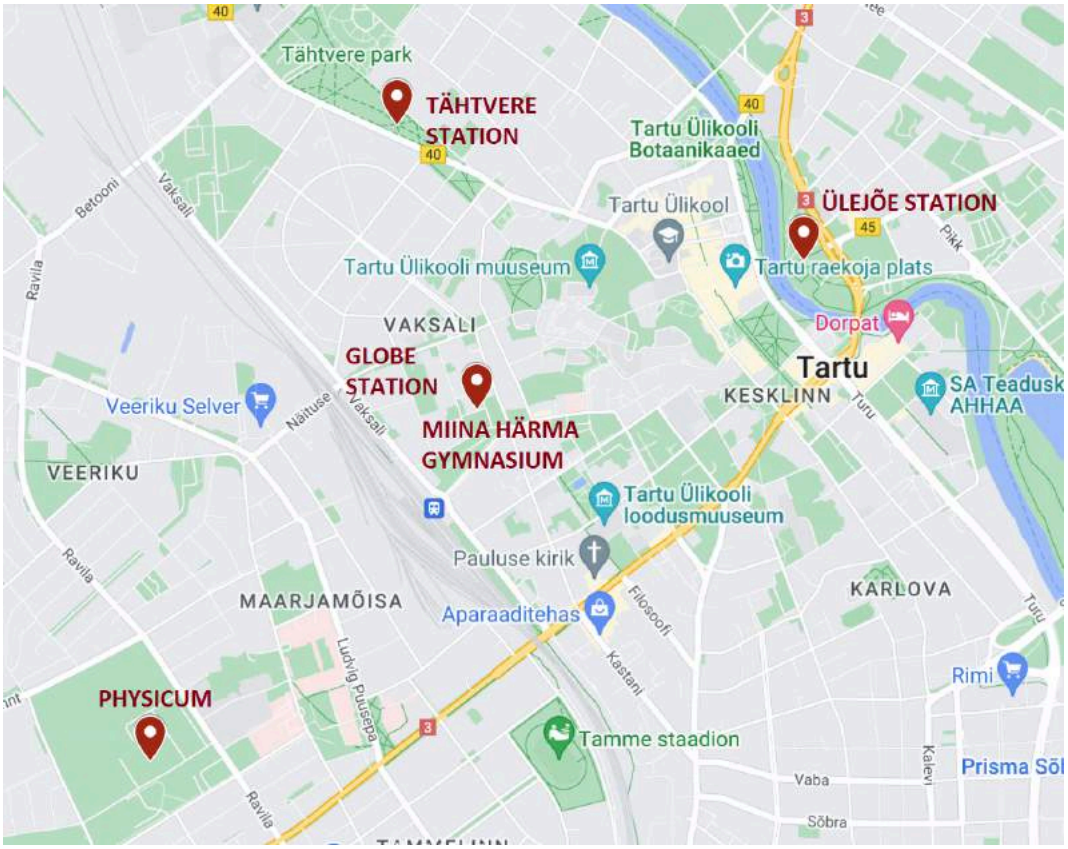

Figure 13. Map overview of all the measurement stations.

3. Results

The following chapter gives an overview of the results achieved during the research. We collected all our measurements in an Excel table and visualised them in a graph to analyse our data. Lines with triangles represent the measurements we carried out, and lines with dots represent the measurements taken from the GLOBE weather station, MHG Automatic weather station and Physicum Automatic weather station.

3.1. Air Temperature

The following graph displays the air temperature data we collected.

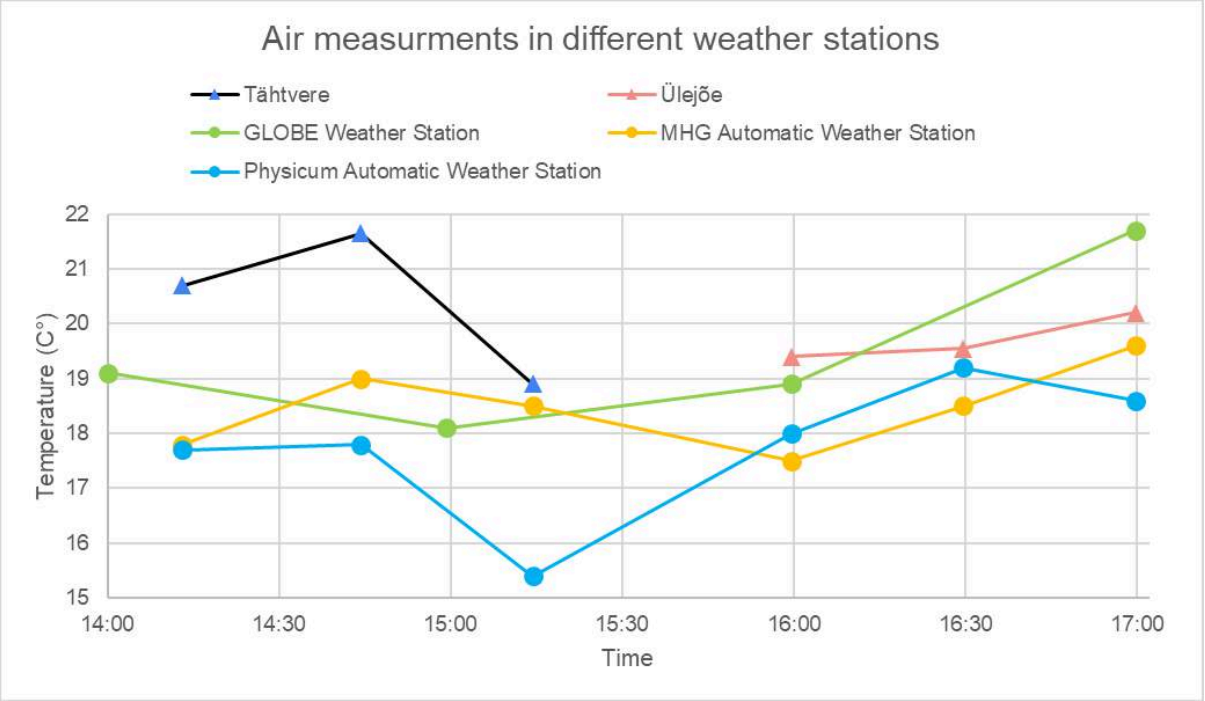

Figure 14. Air temperature measurements in different weather stations

Results:

- Minimum temperature: 15.5°C
- Maximum temperature: 22°C
- Average temperature: 18.9°C
- The biggest difference in temperature: 3.7 degrees between Physicum and temperature from Tähtvere Park at 14.45.

3.2. Relative Humidity

The following graph displays the relative humidity data we collected.

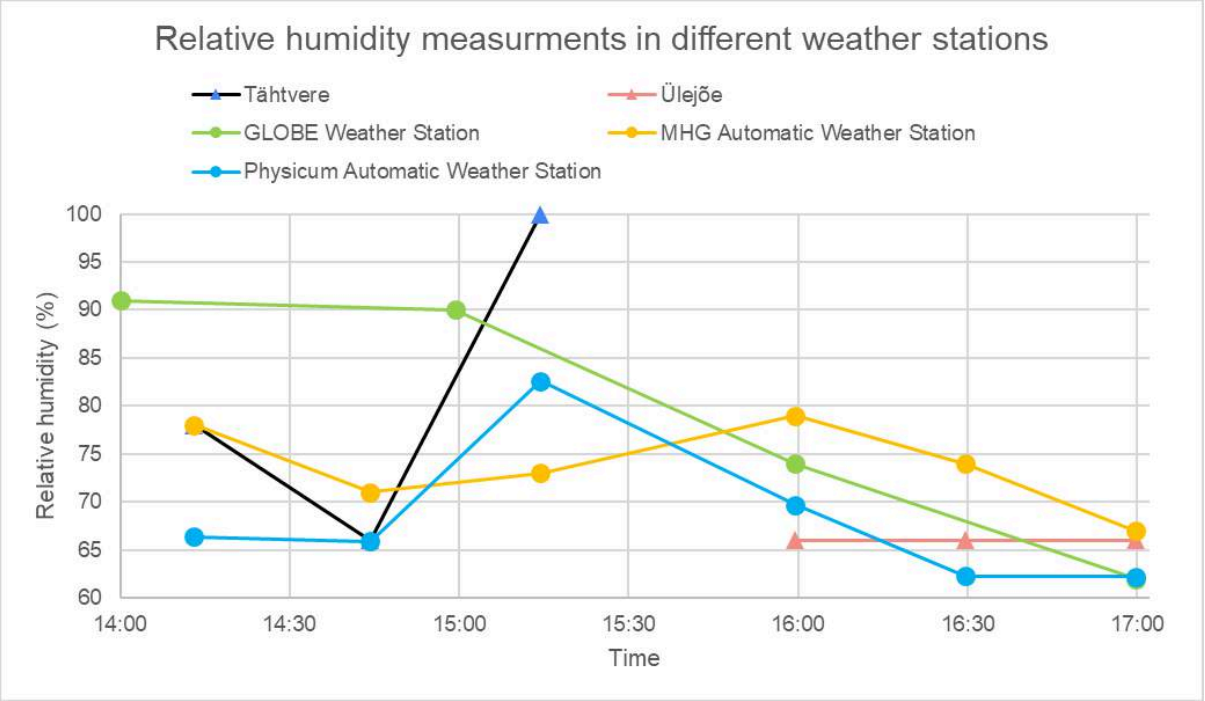

Figure 15. Relative humidity measurements from different weather stations

Results:

- Minimum humidity: 62%
- Maximum humidity: 100%
- Average humidity: ca 73%
- The biggest difference in humidity: 29.7% between MHG automatic and humidity from Tähtvere Park at 15.15.

Note: It was raining during the third measurement in Tähtvere Park.

3.3. Air Pressure

The following graph displays the air pressure data we collected.

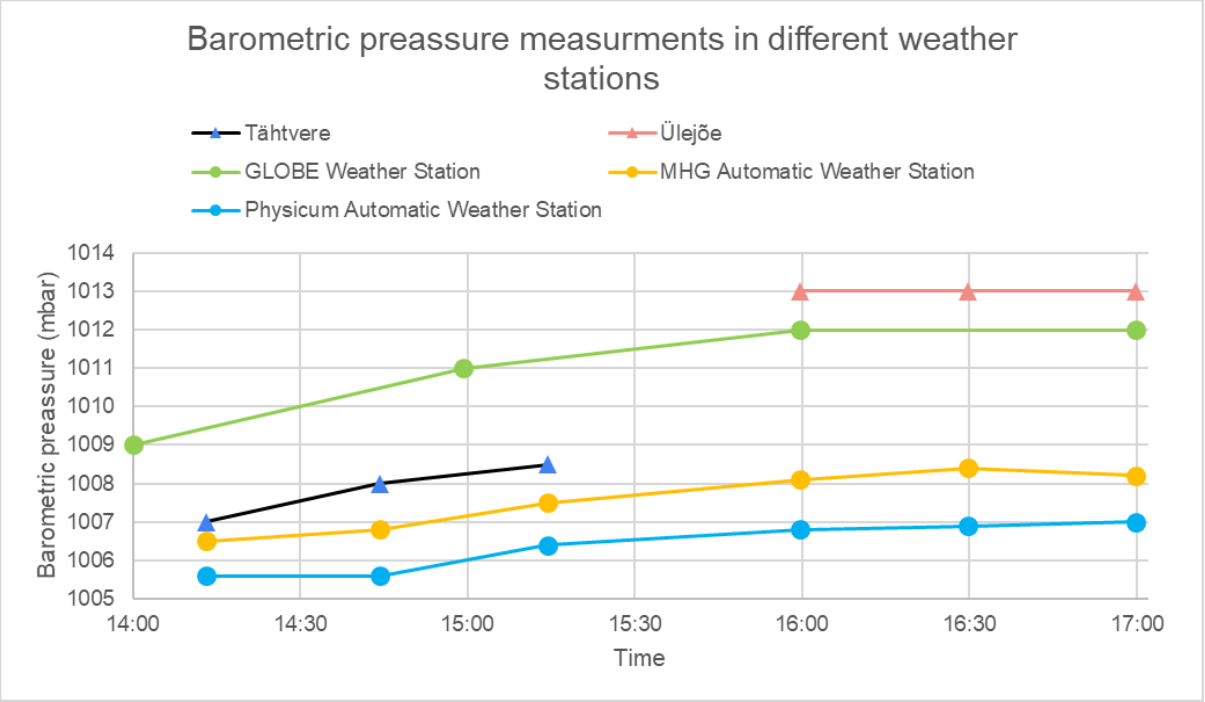

Figure 16. Barometric pressure measurements in different weather stations

Results:

- Minimum air pressure: 1005.6 mbar
- Maximum air pressure: 1013 mbar
- Average air pressure: ca 1008.7 mbar
- The biggest difference in air pressure: 6.2 mbar between Physicum Automatic Weather Station and barometric pressure from Ülejõe Park at 16.00.

Note: Ülejõe Park is 21.5 metres lower in altitude than Tähtvere Park. Therefore, the air pressure in Ülejõe Park was expected to be higher.

3.4. Clouds

Cloud observations were done in three stations: Tähtvere, Ülejõe and Miina Härma GLOBE station. The automatic weather stations do not record cloud coverage, nor do they determine the cloud types.

The following graph displays the cloud coverage data we collected.

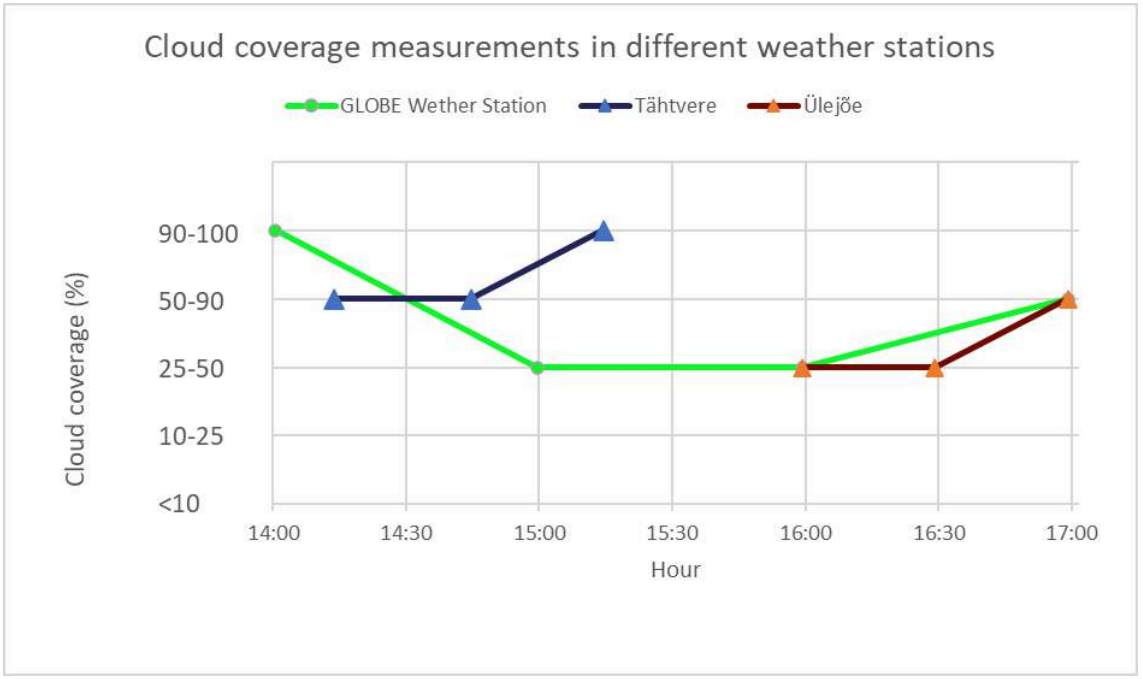

Figure 17. Cloud coverage measurements in different weather stations

Results:

- The most common cloud type: cumulus
- The least common cloud types: altostratus and cirrostratus
- Cloud coverage varied from 25% to 95%.

4. Discussion

4.1. Were Our Hypotheses Correct?

The first research question was: how much would the weather indicators change in half an hour? Our hypothesis was that it is not enough time for any notable changes to occur. However, our hypothesis was not supported as almost all of the weather conditions we measured changed within 30 minutes. The only measurements that did not change were relative humidity and air pressure in Ülejõe Park. We are not certain of what caused this; however, we think that it could have been because it was no longer raining, and the weather had stabilised by then.

Our second research question was about weather stations. We wanted to find out how the data from different weather stations would differ. Our hypothesis was that the results would show some variance, but generally, the indicators would be quite similar. We made measurements and took data from three weather stations (MHG automatic weather station, GLOBE weather station and Physicum automatic weather station) to compare the results. The hypothesis turned out to be correct, as the results were quite alike.

For our third research question, we wanted to know how the data from the two parks would compare. Unfortunately, we were unable to do the measurements at the same time, due to the size of our team, lack of time and the distance between the parks (they were a 20-minute walk apart from each other). As a result, we cannot say for sure, whether the indicators would have been different, had we taken the measurements at the same time. However, the difference in altitude and Ülejõe Park being close to a river leads us to believe that there would have still been differences.

4.2. What Could Have Influenced Our Results?

One reason differences between the data from weather stations could have occurred is because of the different equipment. We do not know exactly what kind of instruments the automatic weather stations use since we got the results from online websites.

The second thing, that may have been an influence, is the location of the weather stations. All the surrounding factors could influence the weather station's data. Is the weather station in a natural or an urban environment? Are there any obstacles, like trees and buildings, around? Are there any water bodies nearby? As an example, from our own experience during this

expedition, we saw that the air pressure in Ülejõe Park was higher than the air pressure in Tähtvere Park. The reason for this may have been the difference in altitude. Ülejõe Park is 21.5 metres lower in altitude than Tähtvere Park, it is expected for the air pressure to be higher in lower altitudes.
Another reason may be that in the automatic stations, the measurements happen automatically, whereas in the other stations, human help is required to make the measurements; thus, human errors may occur.

According to the articles we read (7, 8), it tends to be more humid in places with more vegetation and trees, like forests and parks. When looking at our data, it is not really evident if it is more humid in the investigated parks. The air humidity indicators from our research sites (which were in parks with trees) and the GLOBE one (which was in a yard) are not too different from Physicum and MHG indicators (which are on a roof). In order to make sure our research outcome was not coincidental; we would have had to conduct research over a longer period of time.

4.3. Data Comparison

Air temperature

The air temperature data, we collected, shows an overall increase in temperature during our expedition. We can see that the temperature dropped in Tähtvere's and Physicum's stations between 15.00 and 15.30. This was most likely caused by the rain. The temperature measurements could have also been influenced by the sun, as the areas in the sun would have warmer temperatures than those in the shade.

Air humidity

Our relative humidity data shows, for the most part, a steady decline of moisture in the air. We can see a jump in Tähtvere's and Physicum's data because it rained there. We assume it did not rain at the other weather stations.

Air pressure

Though the air pressure values vary in our data, we can still see a quite stable increase in air pressure. We think that some differences were associated with the locations of our weather stations. The ones that were located higher in altitude, had lower air pressure (Physicum and MHG automatic weather stations are located on roofs and Tähtvere Park is in a hilly part of Tartu) and the ones located lower in altitude showed higher air pressure (GLOBE weather

station is located 1.5 metres from the ground in MHG's yard and Ülejõe Park is located in the valley of river Emajõgi).

Clouds

There were different cloud types in all the locations, however, it is difficult to compare the data from the GLOBE weather station, as the measurements were taken only on full hours. The cloud type that we, as well as the GLOBE weather station, saw the most was cumulus and the ones that were seen the least were altostratus and cirrostratus. The GLOBE weather station data on cloud coverage was measured in exact percentages, whereas our data was measured in approximate percentage ranges; thus, we could not use exact numbers in the graph. When looking at the cloud and relative humidity graphs we can see that the cloud coverage in Tähtvere Park was higher when it was raining there.

5. Conclusion

5.1. What Did We Find in Our Study?

We found that the data was different in all of the weather stations, although we had to make assumptions when comparing the measurements from the GLOBE weather station, as they were taken only on full hours. There are many reasons why these differences could have occurred. Overall, all the different indicators measured at an individual weather station correlated.

We realised that half an hour is in fact enough time for atmospheric indicators to change notably. We also saw differences between the data from the parks. However, that could have happened because the measurements were taken at different times.

5.2. Why Is Our Research Important?

Our research is important both in a local context and in a global context because in both cases, comparing different weather stations can help to find flaws in the system. For example, automatic weather stations and manual ones can show different results, due to different instruments or human error. If we were to do this kind of research internationally, we could also figure out the best kinds of weather stations and make cohesive systems, so all the collected data becomes comparable.

5.3. What Would We Do Differently If We Were to Do This Again?

There are definitely a few things we would do differently if we were to do this again. One of the issues we came across was that we were not able to be in Tähtvere Park and Ülejõe Park at the same time, due to some of us not being from Tartu and we had only one instructor. Thus, we could not accurately compare the results between the two parks. We also could not take the measurements from Miina Härma GLOBE weather station at the same time as the other measurements because the measurements there were taken only at full hours.

5.4. How Can This Topic Be Studied in the Future?

If we were to study this topic again in the future, we would probably conduct the study over a longer period of time. We could research more aspects of the atmosphere, like the wind, precipitation and the UV index. Another thing we could do is study different weather stations in various locations (for example, in different countries) and we would like to do a more in-depth study on the factors influencing weather stations.

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