WATER AND SOIL TEMPERATURE INVESTIGATION - DISCOVERS RELIABLE CONNECTION

Abstract

This project investigated whether water affects: the oscillations of soil temperature and surface temperature of the surrounding soil; temperatures of soil at different depths depending on the season; correlation between air temperature and soil surface temperature in the autumn period. We confirmed that water affects the oscillation of soil temperature; the temperature in autumn is higher at greater depths, opposite in winter; the proximity of the lake affects the surface temperature of the soil. We also confirmed that the surface soil temperature is higher than the air temperature in the autumn, but we did not confirm the opposite in the winter. We used GLOBE protocols for measuring water temperature with a digital thermometer, air with a classical meteorological thermometer, soil at depths of 5, 10 and 20 cm with a sting thermometer and soil surface temperature with an IR thermometer. Measurements were performed in autumn and winter, at the station Veliko Trgovišće 45.9868 N and 15.8329 E at 160 m above sea level. For comparison, we used data for Maksimir station, 45.8211 N and 16.0334 E at 130 m above sea level. We entered the collected data into an Excel spreadsheet and statistically analyzed them. All was interrupted due to COVID-19 epidemic and several massive and minor earthquakes in Zagreb and sorrounding.

Key words: water, surface, soil, depth, temperature

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1. Introduction

While studying our previous projects we discovered the subject of research often was water. Therefore, we studied protocols in hydrology, our database as well as the GLOBE's and DHMZ's.

We also learned almost every project was related to human health. Human body is like Earth, mostly fluids. From former projects we discover the intention to remove water bodies from urban areas. But, Microcosmos has to be self-sustaining in order for life as a whole to be sustainable. Therefore we believe that every natural habitat should be preserved because it serves the whole system of life. We decided to investigate the relationship between water and soil temperature.

After reading some GLOBE Protocols and Bundles we focused on few citations from them.

1. „Air temperature affects the temperature and evaporation of water bodies.“

2. „The contamination and loss of healthy soils and the drying of soils due to increasing temperatures can affect food production and ecosystem function. It is therefore of extreme importance to manage and protect soils wisely.“

3. „Measurements of soil characteristics are critical to identify factors that influence the health of the soil and impact ecosystem function, as well as hydrological, meteorological, and carbon storage processes.“

4. „The amount of water in the soil … can play a large role in cloud formation, air temperature, and relative humidity.

5. „Soil temperature is required for calculating most belowground ecosystem processes, etc.“

The initial setting is that the energy of solar radiation taken up by the ground is converted into thermal energy. It heats the surface layer of the soil. The soil is then cooled by long-wave radiation and the air is heated. Part of the heat of the surface soil descends to depth. The conduction of heat lasts until thermal equilibrium is established between the layers. The deeper layers will later be heated relative to the shallower ones. Heat exchange between moist soils is smaller.[1] Considering that we are well aware of the high specific heat capacity of water, ie the fact that water heats up slowly but also cools down slowly, we were interested in whether water in the soil, ie the proximity of a water body, affects surface temperature and soil temperatures at depths of 5 , 10 and 20 cm.

Also, value of the soil temperature near the water surface is higher than the value of the soil temperature further away from the water mass. We red about the characteristics of soil temperature in Croatia by D. Kaučić :„in continental regions the soil temperature at a depth of 5 cm is always higher than the air temperature at 2 m altitude and that heat exchange between wet layers soil smaller.“[1]

As water in the ecosystem is a regulator of temperature, this topic particularly interested us due to the fact that in most of urban areas watercourses are buried or concreted, and lakes and wetlands are drained. Our goal was to test whether the existence of water can serve as a positive regulator of the microclimate.

2. Research Questions and Hypothesis

RQ 1. Does water in the soil affect soil temperature oscillations?

H 1 We expect that the presence of water in the soil affects the oscillations of soil temperature in such a way that due to the high specific water capacity [3] at the station closest to the lake (1 m from the water) there are smaller differences in soil temperature values. Larger oscillations in soil temperature values are expected at the Maksimir station, which does not have a water body (lake or stream) in the immediate vicinity.

RQ 2. Is there a difference in soil temperature at depths of 5, 10 and 20 cm depending on the season?

H 2: We expect that at the greatest soil depth (20 cm) the soil temperature at all stations in the autumn part of the year will be higher than at smaller depths, while in the winter part of the year we expect the opposite situation. We expect such results due to slower cooling or warming of the soil at greater depths. In the autumn period, we believe that the soil has still not cooled enough after the summer warming, so the temperatures at lower depths are lower. In winter, we expect the opposite situation, ie we believe that the soil heats up more slowly at greater depths than at shallower depths.

RQ 3. Does the proximity of the lake affect the surface temperature of the surrounding soil?

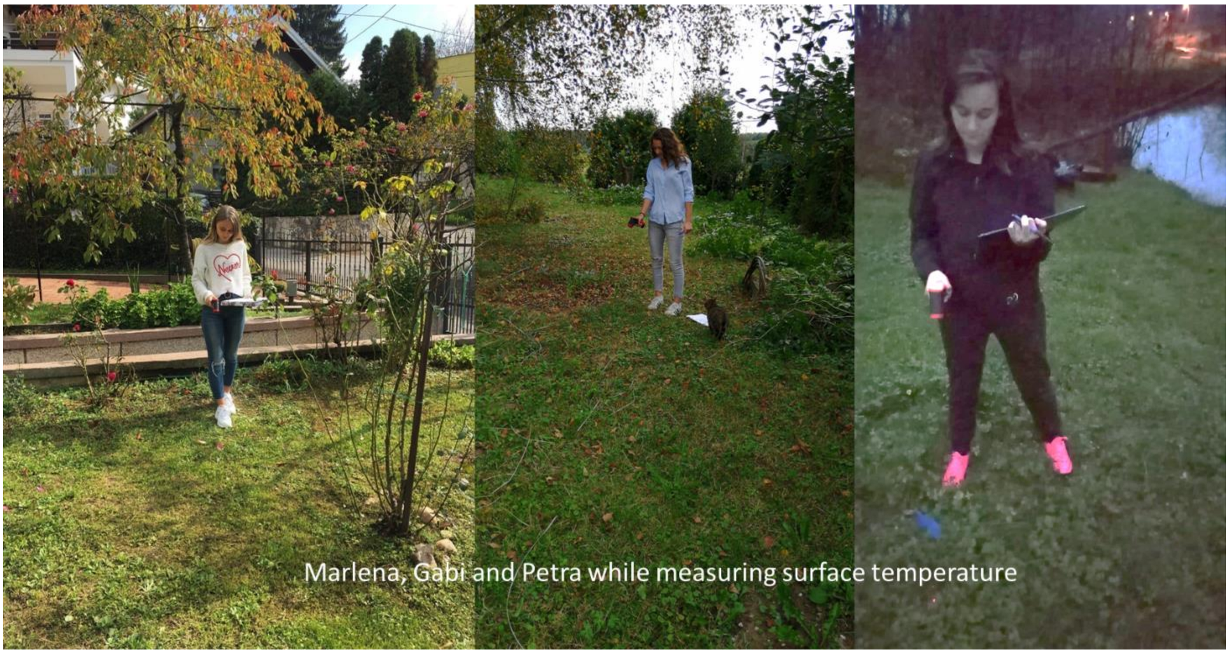
H 3: We expect that the proximity of the lake affects the surface temperature of the soil, ie that the values of surface soil temperature will be lower at the station closer to the lake in autumn and higher in winter, compared to the values measured at other stations farther from water. We expect this result due to the high specific capacity of the water in the lake, which will heat up slowly and thus affect the air temperature, and indirectly the surface temperature of the soil closer to the lake.

RQ 4. What is the correlation between air temperature and soil surface temperature in the autumn period?

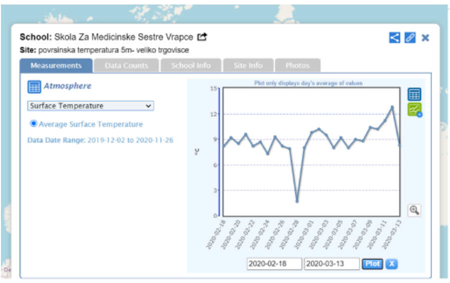
H 4 We expect that the values of surface soil temperature will be higher than the values of air temperature in the autumn period, and vice versa we expect in the winter period, at all distances from the water mass. We expect this result due to the difference in the amount of water in the soil and air that affects their temperature. We expect that there is more water in the soil than in the air, so the soil cools more slowly in autumn, but also heats up more slowly in winter.

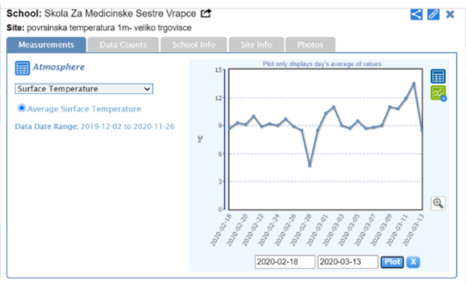
3. Materials and method

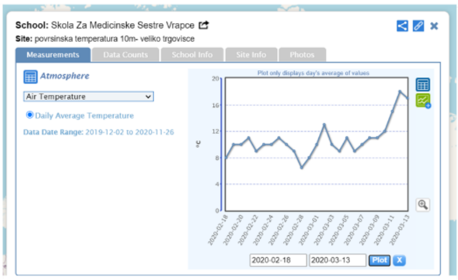
First we made a plan where and what to do and divided duties among team members. Petra lives in Veliko Trgovišće, urban area near lake and for some years now collects data regarding hydrology issues so she was logical choice to be the one who will take the data at our research area. Gabrijela is our IT expert so she took care about that aspect. She also organized some video contacts with other specialists for particular topics, and she is the main graphic editor. Marlena searched for literature and compared some of our hypothesis with some results in similar scientific researches. When COVID-19 and earthquakes disturbed our plans we had to regrupe but we managed to cooperate somehow. Our mentors were always ready to support any of our new ideas how to comunicate at distance and finish our work. We had lot one to one video chats or all together. We even sometimes get together in vivo - undercover, under masks. When ever was possible we did a little bit of work in order to get the job done.



Marlena, Gabi and Petra while measuring surface temperature





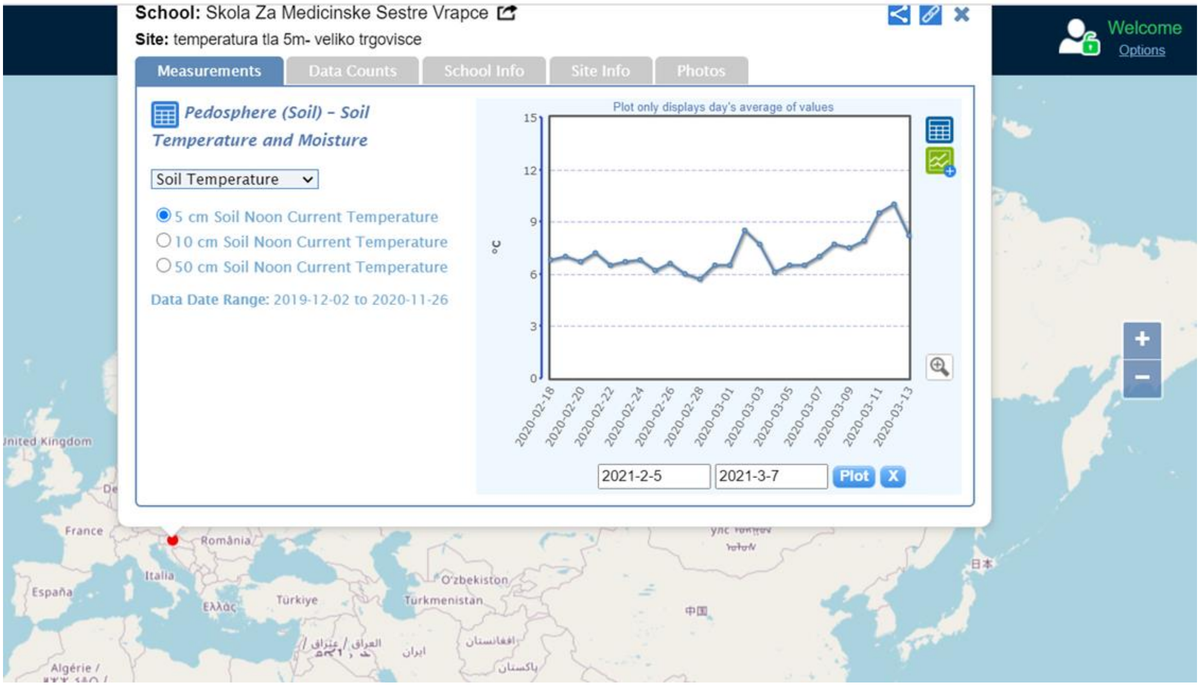


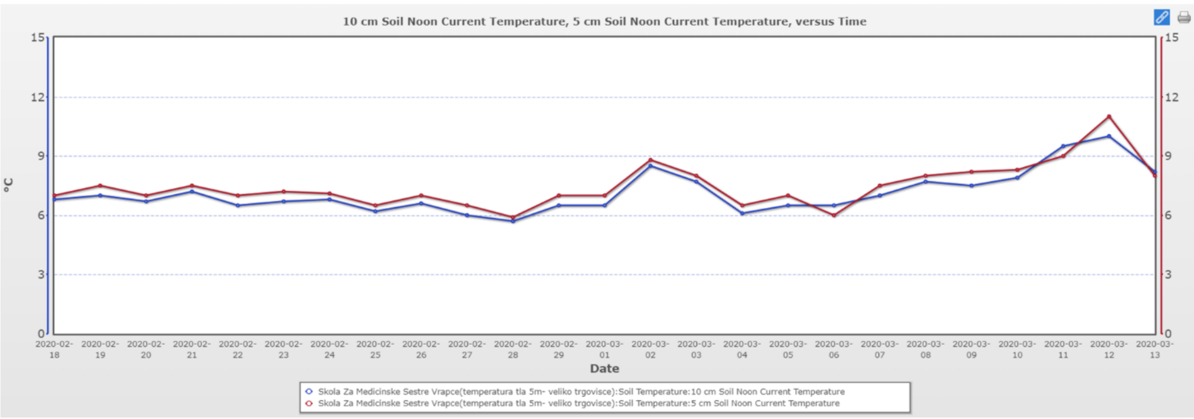
In our work, we used varoius GLOBE protocols (Rivers and Lakes Protocol Bundle, Relative Humidity; Soil bundle Atmospheric Protocols: air temperature + Pedosphere Protocols: soil temperature; The Urban Bundle Protocol: Pedosphere) for measuring water, air, soil temperature at depths of 5, 10 and 20 cm and surface temperature. We also used DHMZ data for Maksimir station. DHMZ - Maksimir station, unlike our station by the lake, is not located in the immediate vicinity of the water body, so it serves as a station for comparing data. To display the data and their use, we used Excel tables and graphs and formulas for calculating the mean values, we also calculated the differences in the values of soil temperature at 5 and 20 cm and thus obtained the relevant values.

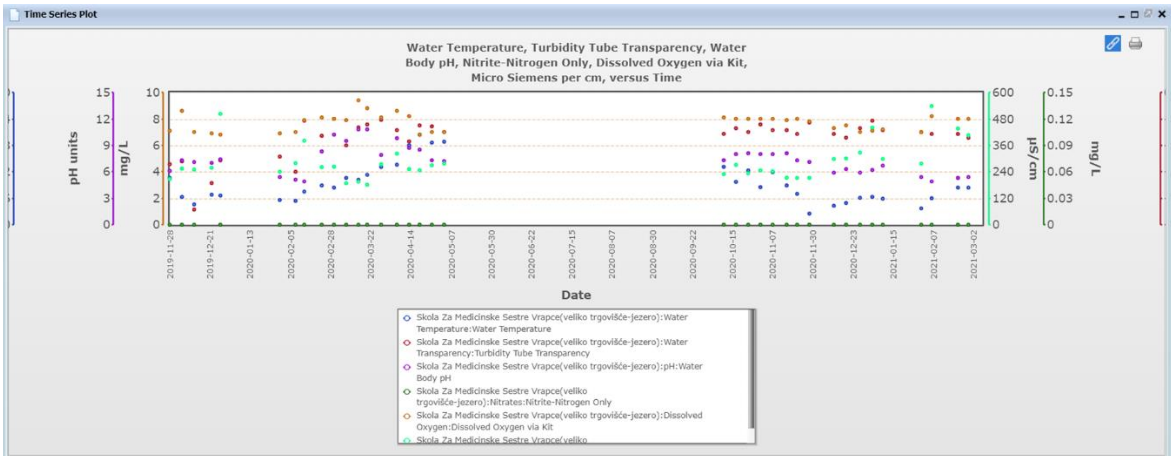
Measuring stations along the natural lake are located in Veliko Trgovišće, Hrvatsko Zagorje, 45.9868 N and 15.8329 E at 160 m altitude (Google Earth). MUC Descrption is Cultivated Land around the lake, but near the lake is Woodlenad, Mainly Deciduous.


Ul. Andrije Hebranga 6B
Our Lake
Image © 2021 Maxar Technologies
Google Earth
79 m
1985
Datumi slika: 6/11/2020 45°59'12.91" S 15°49'58.64" I podizanje 162 m visina pogleda 562 m


Our site: Lake (Veliko Trgovišće)







The climatic area of this area according to Koeppen is characterized as" Cfb moderately warm humid climate with warm summers"[2]. Maksimir station is in the eastern part of Zagreb, 45.8211 N and 16.0334 E at 130 m altitude (Google Earth) and this area is climatically characterized the same as the area of Veliki Trgovišće.

We collected data in 2 periods, in the autumn from 2.12. to 11.12.2029. (10 days) and winter from 18.02. to 13.03.2020. (24 days). Measurement was performed once a day between 16.00 and 17.00 p.m.

4. Data summary, analysis and results

Comparing the relationship between water temperature and air temperature in Figures 1 and 2, it can be seen how slowly the water temperature changes even when there are large differences in air temperature from day to day in both measurement periods.

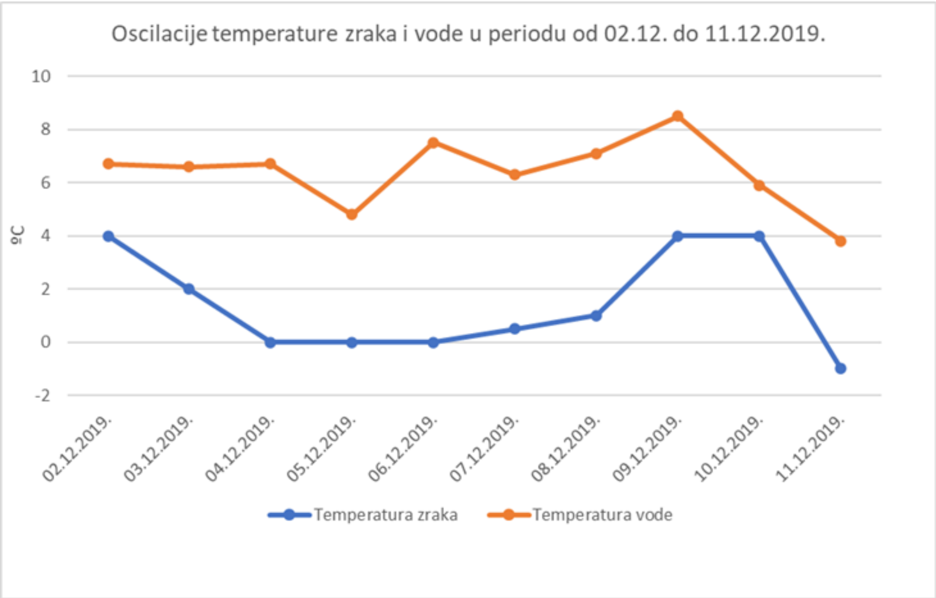


Figure 1. Oscillations of air and water temperatures at our station in the autumn period

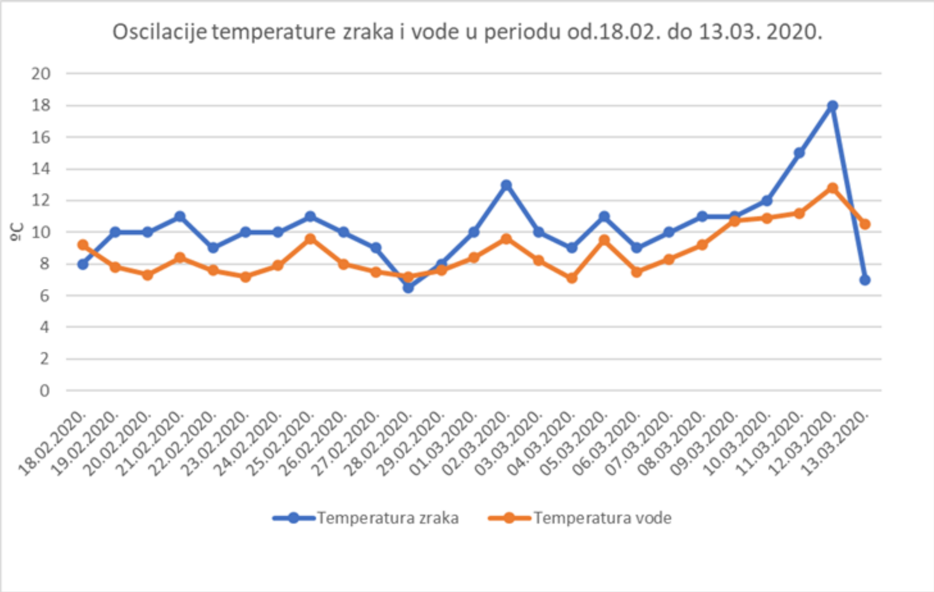


Figure 2. Oscillations of air and water temperatures at our station in winter

In the autumn period from 2.12. until 11 December 2019, the amplitude at our station 1 m away from the lake is 5 ° C (Figure 3), at the station 5 m away from the lake the amplitude is 4.5 ° C (Figure 4), and at 10 m distance from the lake amplitude is 4 ° C (Figure 5). So, the farther we are from the lake, the smaller the temperature amplitudes. The amplitude in the same period at the station DHMZ - Maksimir is 5 ° C, the same as at our station 1 m away from the lake. (Figure 6)

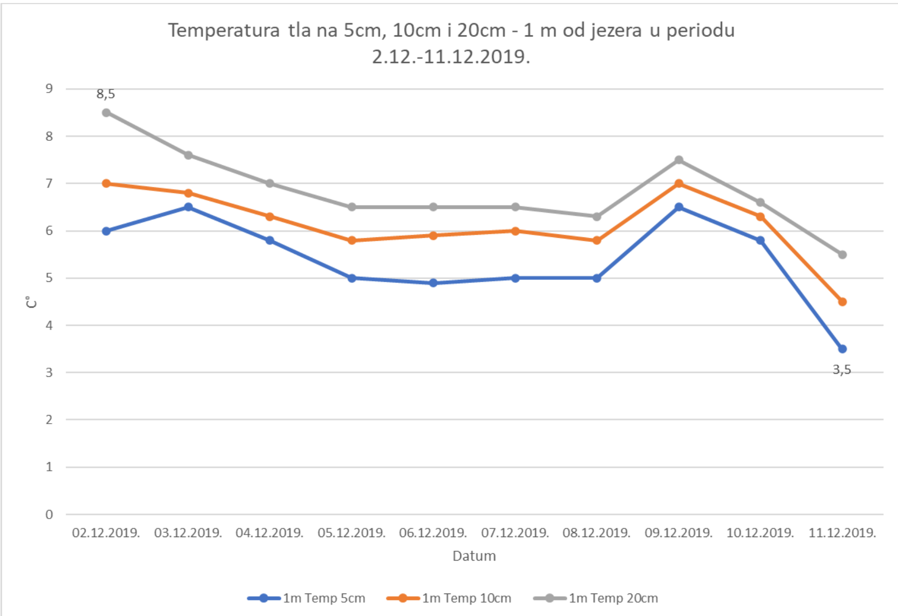


Figure 3. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 1 m from the lake in the autumn

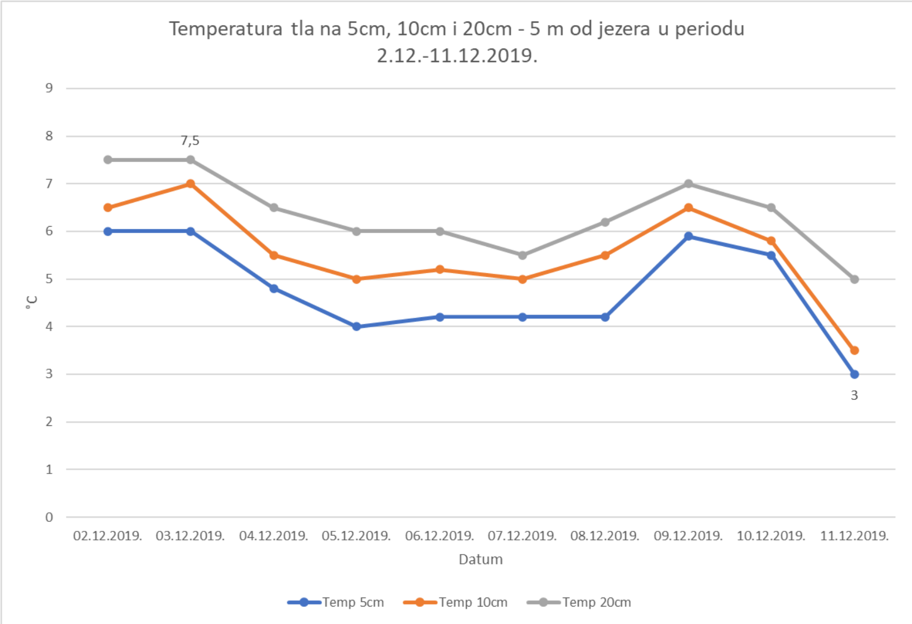


Figure 4. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 5 m from the lake in the autumn

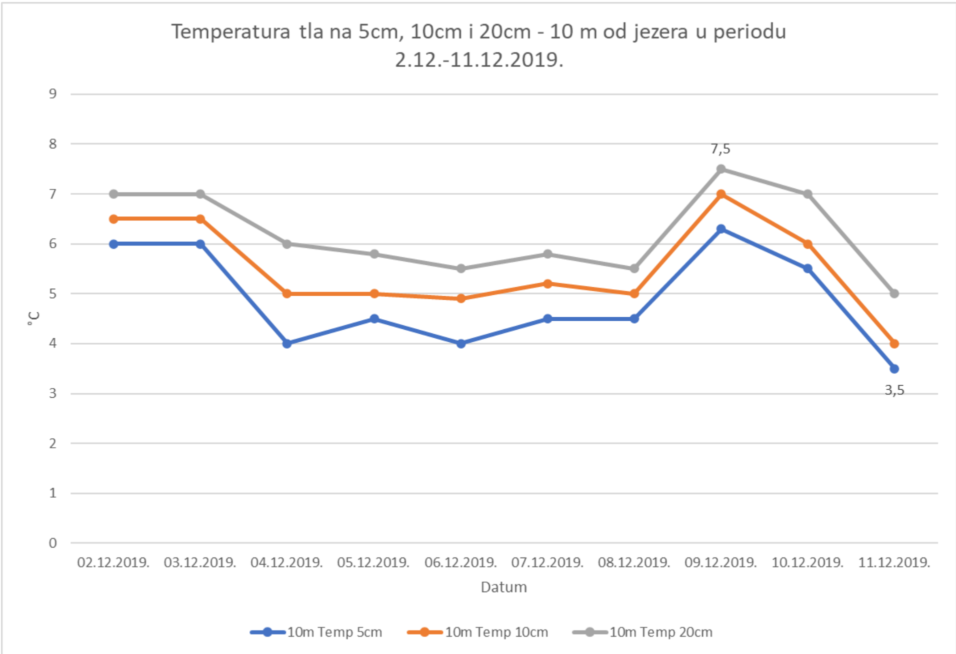


Figure 5. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 10m from the lake in autumn

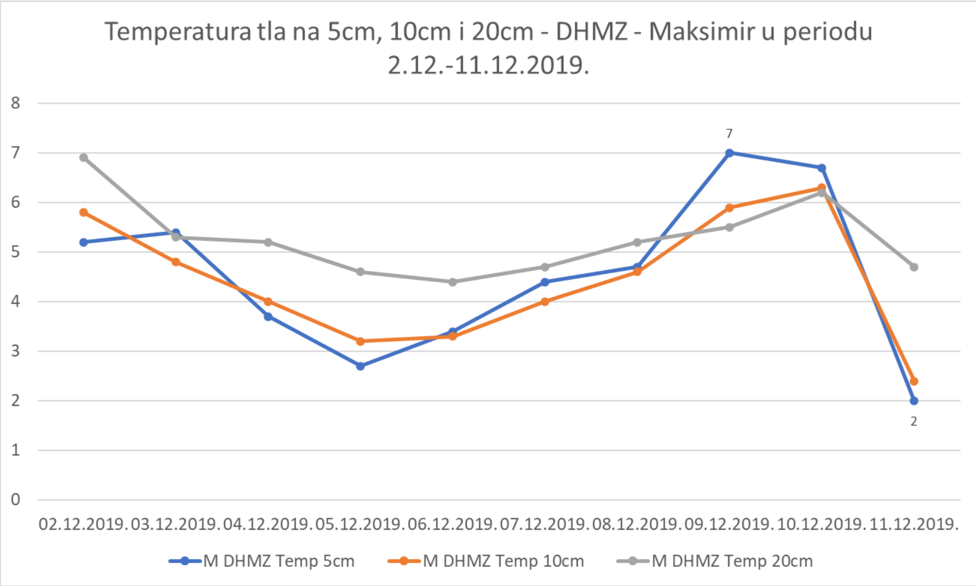


Figure 6. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station DHMZ - Maksimir in the autumn

In the winter period from 18.2. to 13.3.2020. amplitude at our station 1 m away from the lake is 6.9 ° C (Figure 7) and at the station DHMZ - Maksimir it is 10.5 ° C, which we assumed in our hypothesis. (Figure 8)

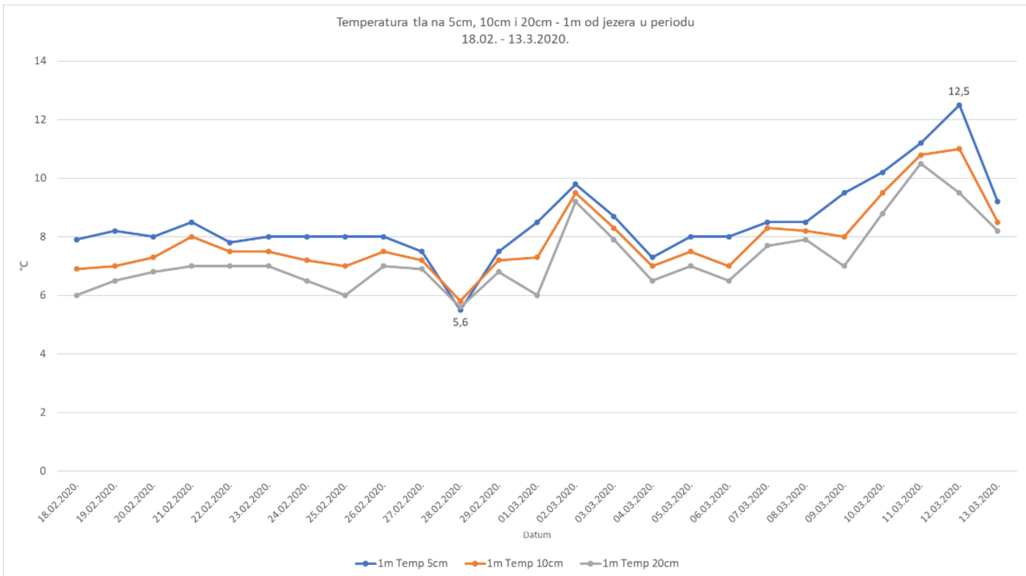


Figure 7. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 1 m from the lake in winter

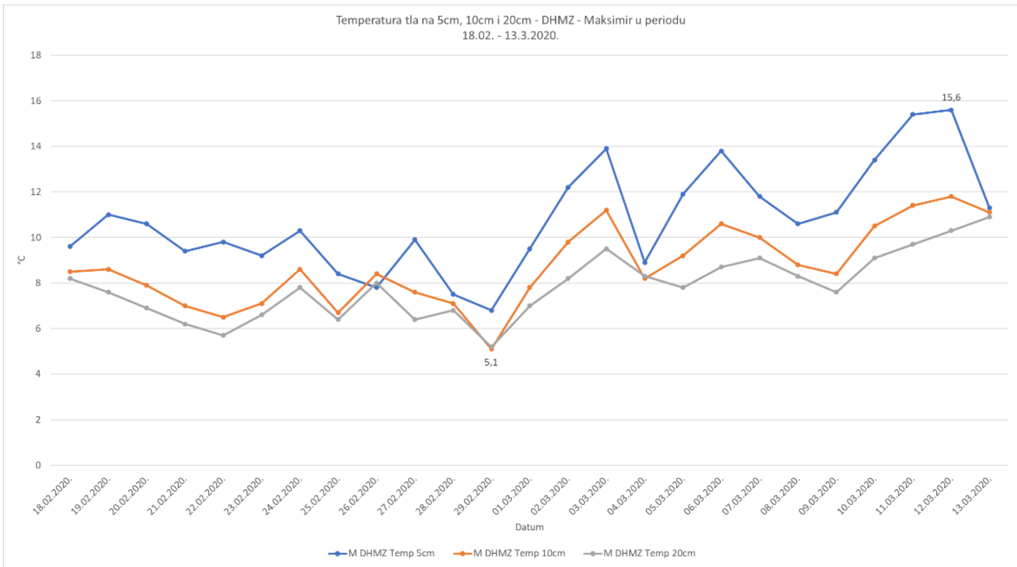


Figure 8. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station DHMZ - Maksimir in winter

The charts in Figures 9 and 10 show the oscillations in the soil temperature and how it varies the most at the DHMZ - Maksimir station, which has no water surface near it. Some colors indicate the distance of our stations from the lake.

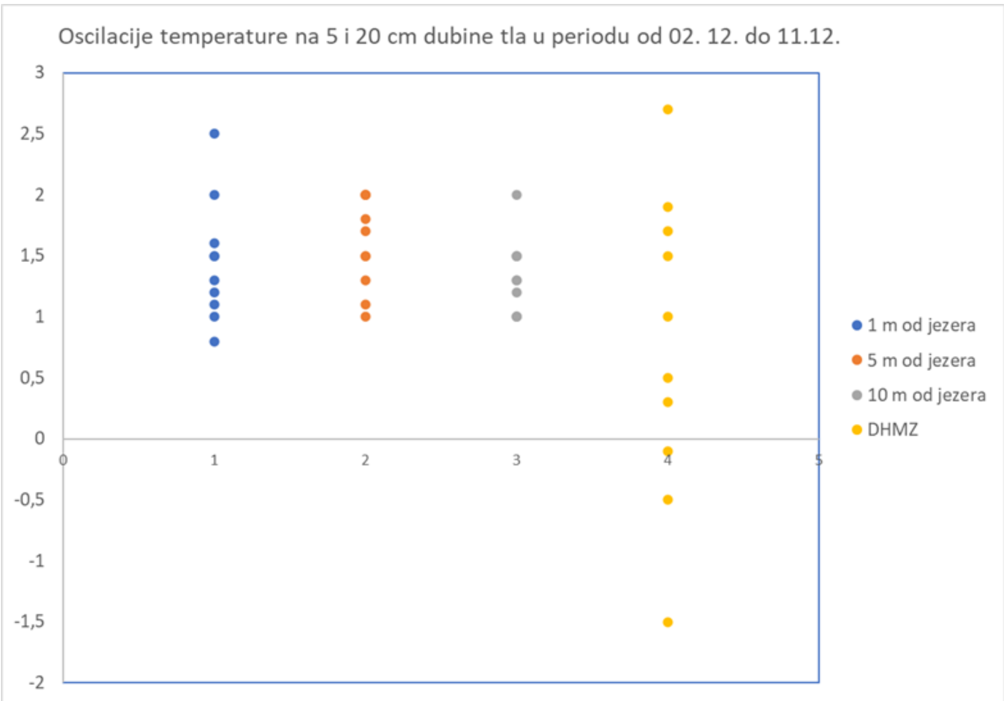


Figure 9. Temperature oscillations at 5 and 20 cm at our station and DHMZ station - Maksimir in the autumn period

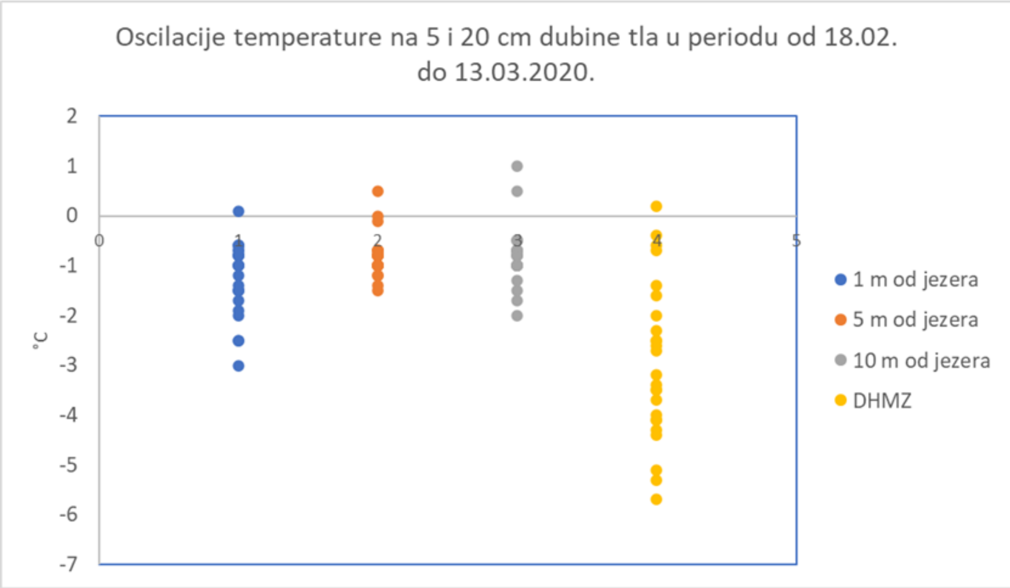


Figure 10. Temperature oscillations at 5 and 20 cm at our station and DHMZ station - Maksimir in the autumn period

Charts in Figures 3, 4, and 5 also prove our expectation that in the autumn part of the year at the greatest soil depth (20 cm) the values of soil temperature at our station will be higher than at smaller soil depths (5 cm and 10 cm). The graph in Figure 6 confirms the same with minor deviations for the DHMZ - Maksimir station.

In the winter part of the year, charts in Figures 11, 12, 13 prove that the values of soil temperature at the maximum soil depth of 20 cm are lower than the values of soil temperature at 10 cm and 5 cm. Also, the values of soil temperature at the DHMZ - Maksimir station confirm this (Figure 8).

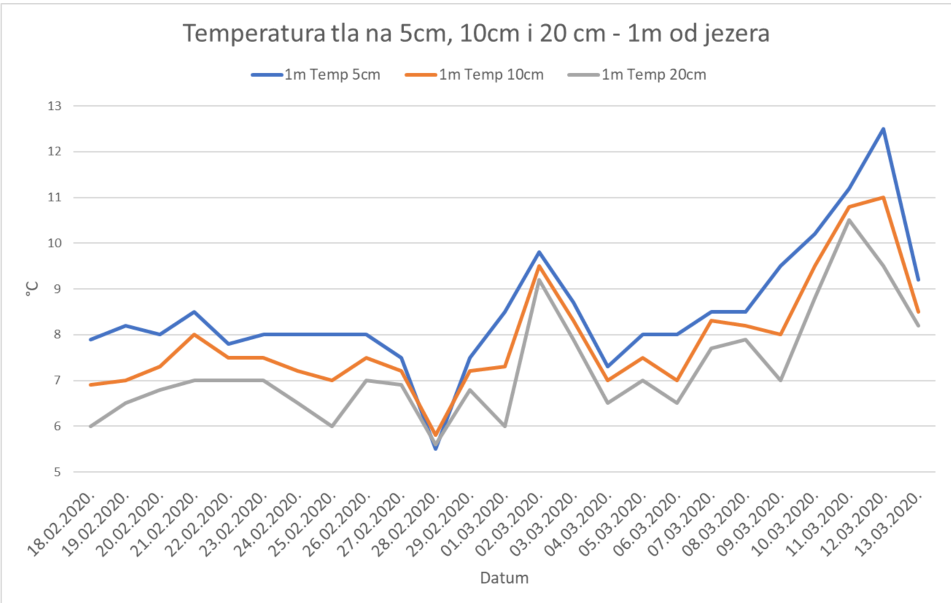


Figure 11. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 1 m from the lake in winter

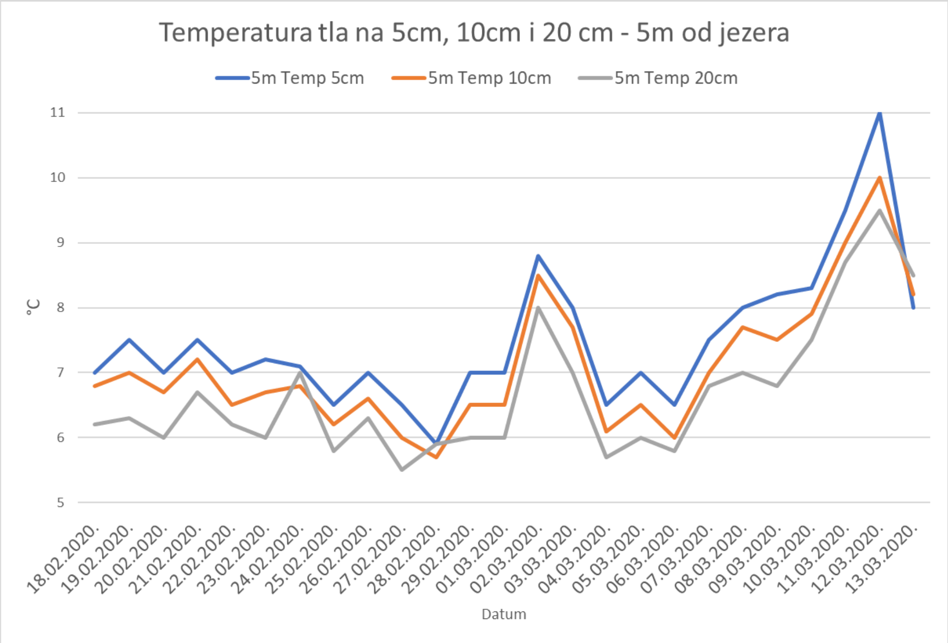


Figure 12. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 5 m from the lake in winter

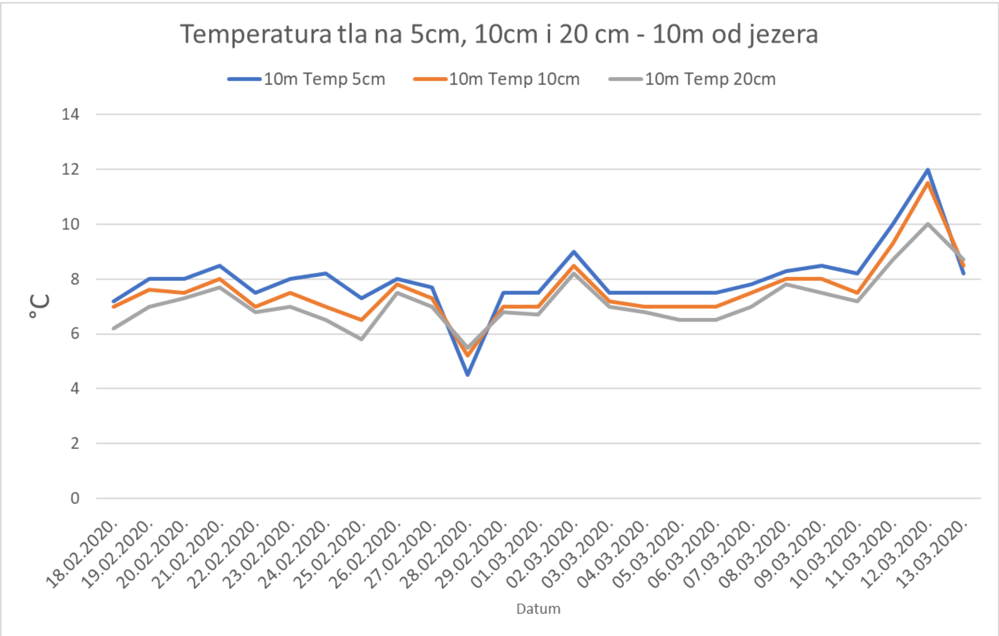


Figure 13. Soil temperature at a depth of 5 cm, 10 cm and 20 cm at the station 10 m from the lake in winter

We confirmed that the proximity of the lake affects the surface temperature of the soil, ie the surface temperature of the soil is lower at the station closer to the lake in autumn

(Figure 14) and higher in winter (Figure 15) compared to the values in those periods measured on other stations further away from the water

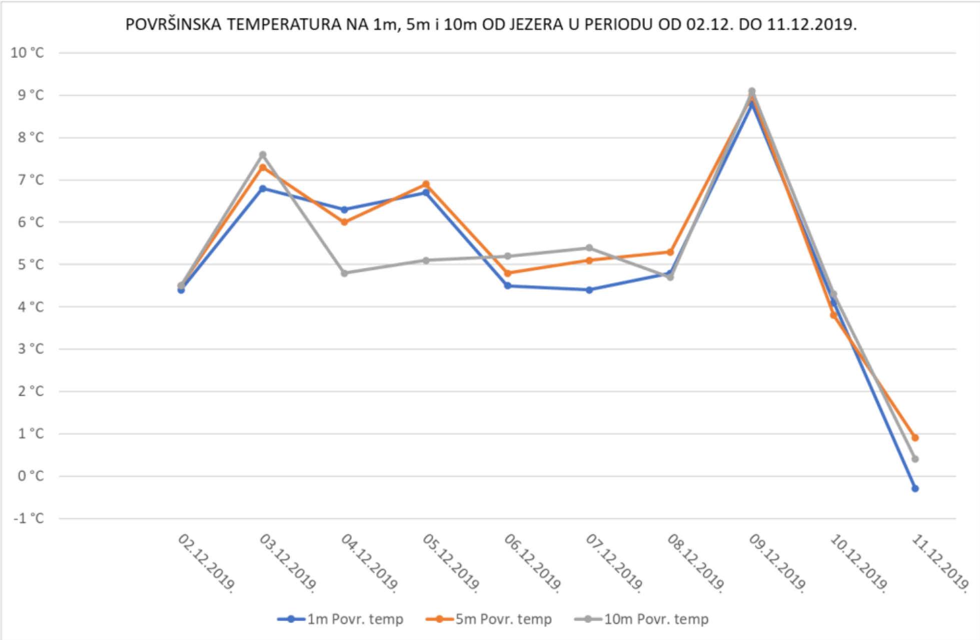


Figure 14. Soil surface temperature at stations 1 m, 5 m, and 10 m from the lake in autumn

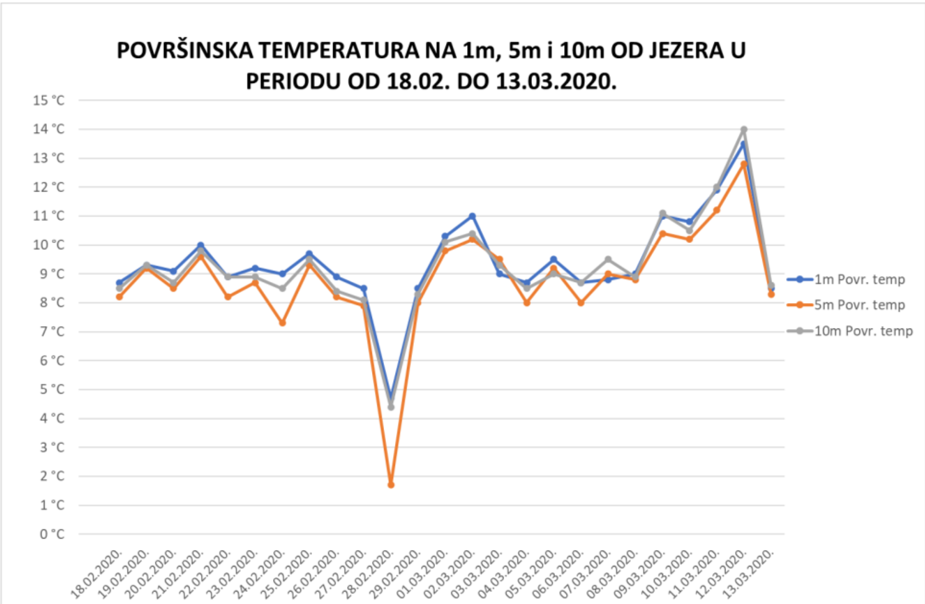


Figure 15. Soil surface temperature at stations 1 m, 5 m, and 10 m from the lake in winter

Figure 16 shows that the values of surface soil temperature are higher than the values of air temperature in the autumn period.

Figure 17 shows that the values of soil surface temperature are lower than the values of air temperature in winter.

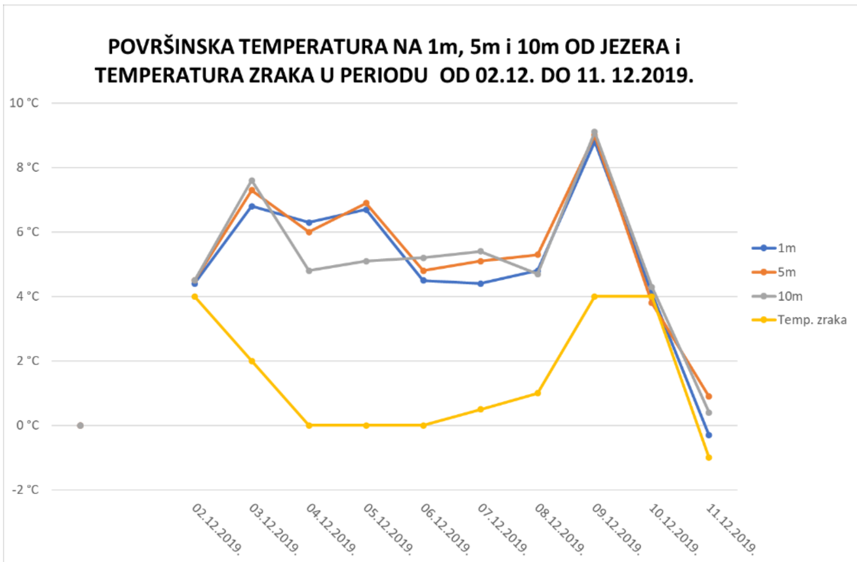


Figure 16. Soil surface temperature at stations 1 m, 5 m, and 10 m from the lake and air temperature in autumn

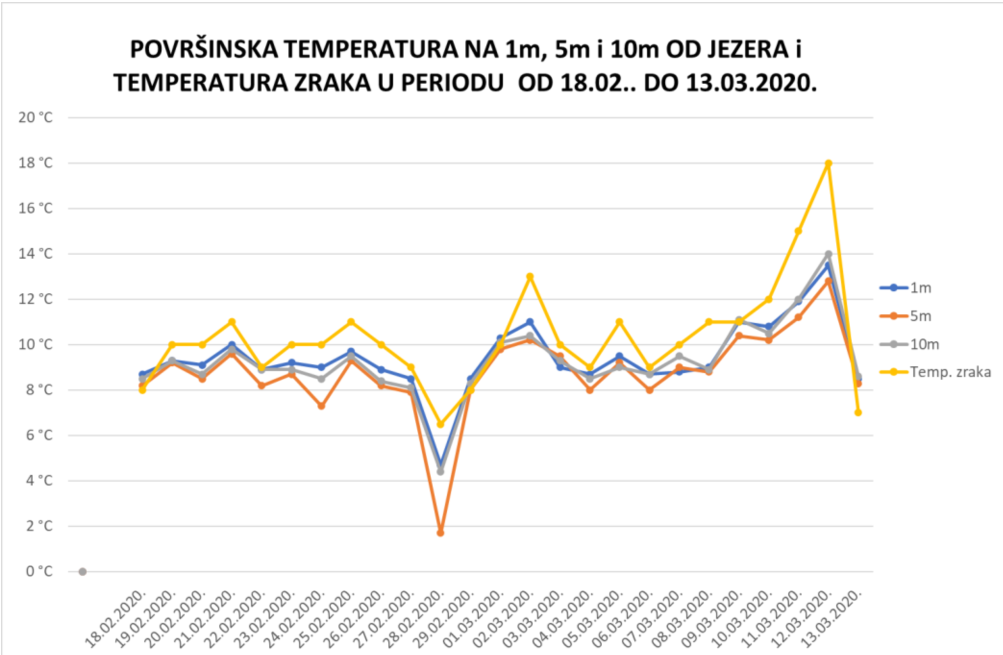


Figure 17. Soil surface temperature at stations 1 m, 5 m, and 10 m from the lake and air temperature in winter

5. Discussion and conclusions

With H 1 we have proved that water affects the oscillations of soil temperature, in both periods. For both measurement periods, it is evident how much slower the water temperature changes even when there are large differences in air temperature from day to day, which is the effect of high specific water capacity. We also proved using the difference in soil temperature at 5 and 20 cm for each day that there are less oscillations of soil temperature near the water than at the station DHMZ - Maksimir, which has no water surface.

We must note that in the winter we had a longer continuous measurement period, 24 days. The autumn period was shorter for us, 10 days. This was our first period after which we concluded that we needed to increase the number of days we would measure in order for the data to be relevant to us. This is one of the methodological limitations that we did not anticipate. We predicted that we would lack the surface temperature at the Maksimir station, which is not measured there, and data on relative soil moisture, which we are not able to perform due to the complexity of the measurement procedure. In addition to these limitations, which we were aware of at the beginning of the work, our research, ie data collection (spring measurement period), was interrupted by an epidemic that caused school closures and made it difficult for live teamwork in the field. All of our activities continued by holding meetings online and trying to compare the individual results of each team member (3). We communicated with the mentors in the same way. We also recorded video clips from the field individually, so we compared them, and then exchanged our ideas at video meetings and thus came to common conclusions.

H 2 and H 3. we confirmed the results of measurements and their analysis. We confirmed that in the autumn part of the year at the greatest soil depth (20 cm) the values of soil temperature at our station and at the DHMZ - Maksimir station will be higher than at smaller soil depths (5 cm and 10 cm). In the winter part of the value of soil temperature at the maximum soil depth of 20 cm lower than the value of soil temperature at 10 cm and 5 cm at both stations.

H 4 we confirmed because in the autumn period the surface temperature values are higher than the air temperature values while in the winter period the air temperature values are higher than the surface surface temperature values. We expected this result due to the difference in the amount of water in the soil and air that affects their temperature. Because the soil has more water than air, it cools more slowly in autumn, but also heats more slowly in winter.

Besides confirming hypopthesis we also discovered that our GLOBE team work is good for mental health. Our daily contact with our mentors helped us through the social isolation. They also encourage us to make some aditional efforts in other directions. Gabrijela made a little video-clip about using GLOBE in antiCOVID purpose. Petra also made an educational movie, too showing how self motivation, critical thinking and creativity make all the difference in every situation. Both works are published and presented at local and also international level.

6. Acknowledgements

First we would like to thank our mentors who were very patient with us and gave us a lot of their time in a moments when it was very precious. We never lost personal touch with them which was extremly important not just for this project but for our lives in general. We are also thankfull to our former biology teacher, prof. Jelka Škoton, our math teacher, prof. Latinka Križnik, her daugther, Bojana Križnik, PhD in molecular

biology. Further more we appreciate the advises from our GLOBE scientists revisors dr., sc. Mirela Sertić Perić and dr.sc. Renata Matoničkin Kepčija.

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DHMZ (Croatian Meteorological and Hydrological National Service) website and data base -2

https://meteo.hr/podaci.php?section=podaci_agro&param=agro_tz&el=saznajte_vise#sec1(23.02.2021.)

Rivers and Lakes Protocol Bundle

The Urban Bundle Protocol

Soil Bundle

GLOBE Review

http://www.ss-medicinske-vrapce-zg.skole.hr/izvannastavne_izvanucionicne_izvanskolske_aktivnosti/globe/globe-vremeplov.pdf

Educational video about water measurment (student Petra Marec)

https://drive.google.com/file/d/13V9t0E7bt7FvvmArimpyGMAm9mTo845B/view?usp=sharing

Promotional video „Why am I in GLOBE program?“ (student Gabrijela Ambriš)

Euroasia Regioal Meeting, October, 2020.

https://drive.google.com/file/d/1V7fMKm0kwmbh5AR4YVPArlNqxsb9NdA4/view?usp=sharing

Targeted Badges description:

1. Be a Collaborator

All team members are listed along with clearly defined roles, how these roles support one another, and descriptions of each student’s contribution. The descriptions clearly indicate the advantages of the collaboration.

2. Be a Data Scientist

The report includes in-depth analysis of students’ own data as well as other data sources. Students discuss limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases.

3. Be a STEM Professional

The report clearly describes collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results.