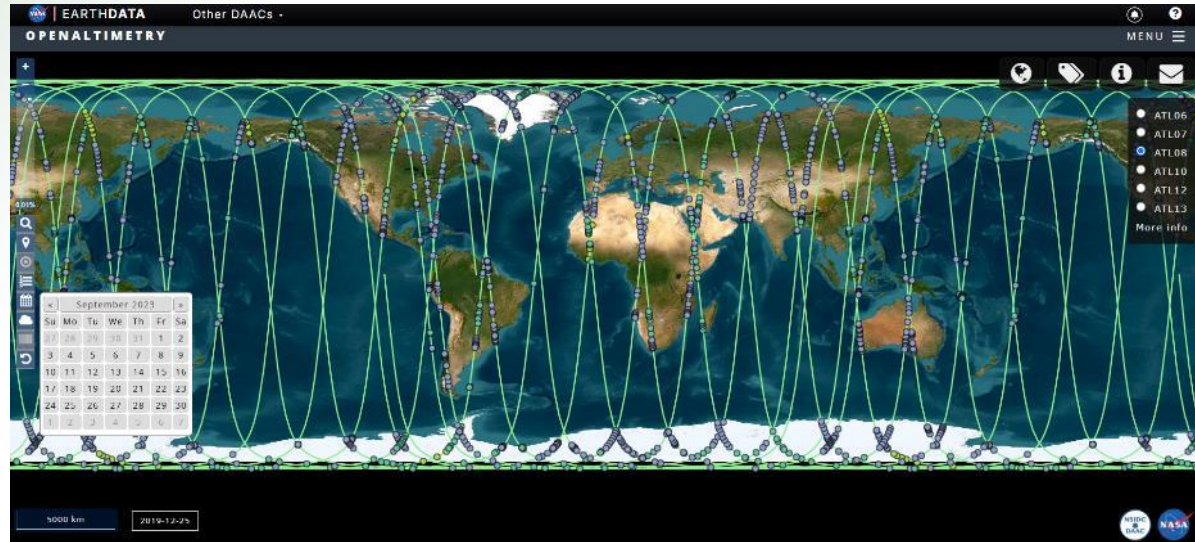


Analysis of biometry measurements in Karlovac Promenade



Mentors to students:
Snježana Marković – Zoraja, Kristina Fratrović
Dubovac Primary school, Karlovac, Croatia

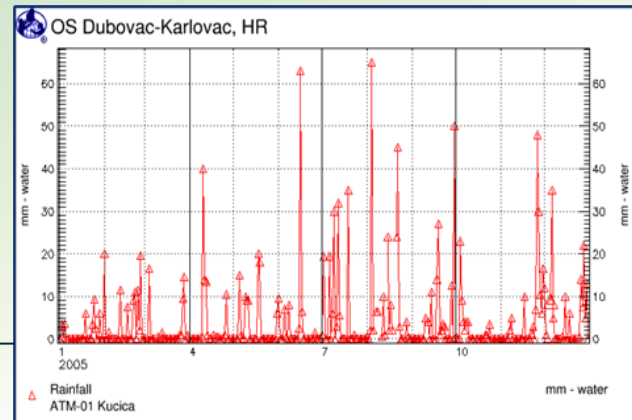
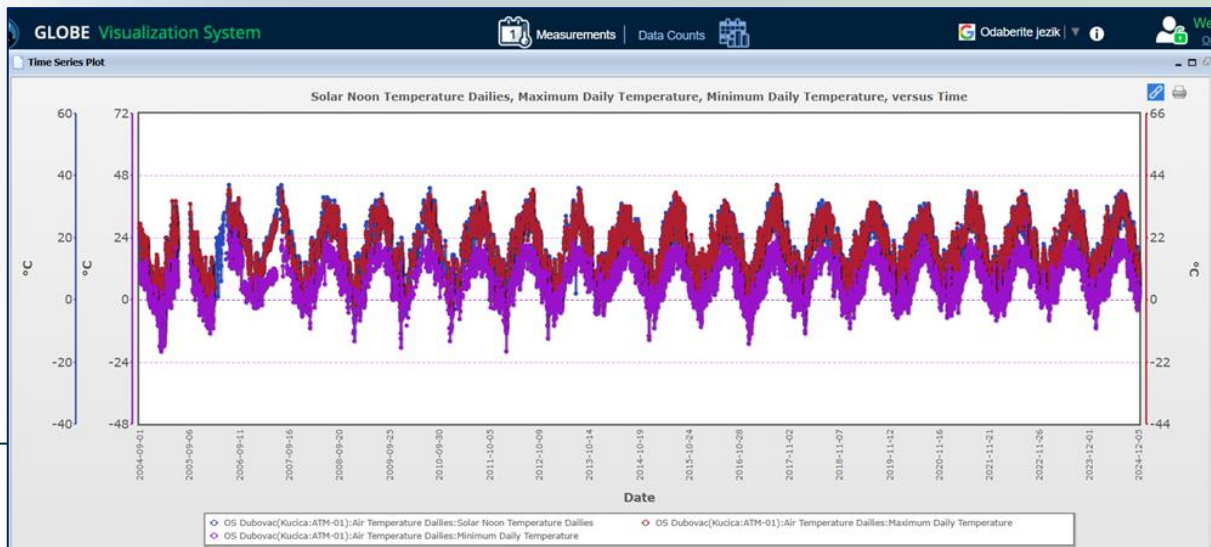
Students:

- Zoea Benković
- Esma Šabanović
- Lana Blažan

We joined GLOBE in 2004

First GLOBE generation 2004.

- atmospheric measurements
- hydrological measurements



Last generation, 2024 – research projects in the alleys of the city of Karlovac

Monitoring and protection Marmont Alley

Introduction

Marmont alley is a plane tree alley near the Dubovac Primary school. Planted from 1808. to 1811. (Karlovac - Dubovac, Grobnico Polje, Rijeka) during the construction of the Louisiana Road (Karlovac - Rijeka).

The road in Karlovac begins with the plane tree line, named in the honour of the Marshal Marmont (1774 - 1852) from the Napoleon Bonapartes age.

The alley is a monument of park architecture from 1968.


In June 2019 the construction work had begun on the national road D6 which begins with the Marmont alley in Karlovac and concerns the community about possible tree damage.

Research questions:

What is the importance of Marmont alley for Dubovac and the City of Karlovac in the carbon cycle?

How much carbon dioxide is absorbed during the life of trees and what is the amount of carbon stored in trees?

What is the amount of gas pollution?



Research methods

Research period: December 2021 - December 2023.
Total number of trees in the alley : 102

1.GLOBE protocols:

- location administration - GLOBE Observer App
- tree height - GLOBE Observer App
- tree circumference - measuring tape
- atmospheric station GLOBE: air humidity, precipitation



2. meteor station Arduino with sensor MQ135

(CO2, NH3, smoke, other gasses)

3. meteor station Arduino with sensors MG131, MQ7 (CO, ozone)

4. Calculations

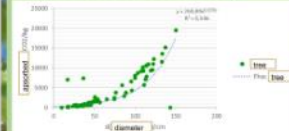
Tree age = tree circumference/ 1 year growth
1 year growth of the plane tree: 2.75 cm/year
Green weight-GW) kg
 $GW = 0.0346 \cdot d^2 \cdot h$ (if the d= 28 cm)
or $GW = 0.0577 \cdot d^2 \cdot h$ (if the d= 25 cm)
Dry weight -DW = GW/2
Carbon storage) = DW/2
Absorbed CO2 in the lifetime of a tree = Carbon storage * 3.67
Chest diameter of a tree / cm = tree circumference / π

Results

| Mark of tree | Age of tree | circumference | chest diameter | tree height | Living mass (kg) | DW (kg) | Carbon storage (kg) | Absorbed CO2 (kg) |
|--------------|-------------|---------------|----------------|-------------|------------------|----------|---------------------|-------------------|
| 01 | 17 | 8 | 104 | 35.1 | 18.67 | 708.64 | 354.32 | 177.16 |
| 02 | 17 | 8 | 170 | 54.11 | 22.91 | 2303.48 | 1151.74 | 580.87 |
| 03 | 18 | 7 | 400 | 133.7 | 23.92 | 14807.32 | 7403.66 | 3701.83 |

Comparison of three plane trees of different ages

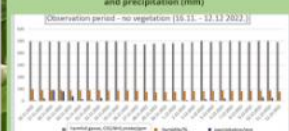


Amount of absorbed CO2 for all plane trees in the Marmont Alley(102)

total mass of a greenweight (GW)= 333132 kg
total dry mass (DW)=256545 kg
total mass of carbonstorage (CC)= 85027 kg
total mass of stored CO2= 297589 kg


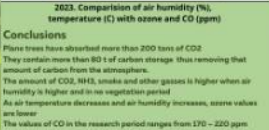
2022. Comparison of air humidity (%), amount of gasses (ppm) and precipitation (mm)

Observation period - no vegetation (16.11 - 13.12 2022.)



2023. Comparison of air humidity (%), temperature (C) with ozone and CO (ppm)

Observation period - with vegetation (14.3 - 23.10 2023.)

Conclusions

Plane trees have absorbed more than 200 tons of CO2. They contain more than 80 t of carbon storage, thus removing that amount of carbon from the atmosphere.

The amount of CO2, NH3, smoke and other gasses is higher when air humidity is higher and in no-vegetation period.

As air temperature decreases and air humidity increases, ozone values are lower.

The values of CO in the research period ranges from 170 – 220 ppm. We plan to install sensors for PM 2.5 and PM 10 to monitor more air pollution parameters.

Students: Josip Ferencina, Maksim Stanković Sprajc, Marta Rupres

Dubovac primary school, Karlovac, Croatia

Teachers: Snježana Marković-Zorjak, Biology and Chemistry teacher, Kristina Fratović, Math and Informatics teacher

Dubovac Primary school, Karlovac, Croatia



The beginning of measuring air quality with devices and Arduino systems

IVSS 2024.

Introduction in research project 2024

- Karlovac Promenade – the alley located on the west side of Karlovac Star




- treeline consisting of wild chestnut trees (*Aesculus hippocastanum* L.) and a few linden trees (*Tilia* sp.)
- place of city manifestations
- place of citizen gathering who enjoy the city greenery


- on the manifestation „Karlovac carousel”, our GLOBE students with teachers have a biometry workshops on the Promenade ewery year




Radionica: Zašto su nam važna stabla kestena na promenadi



Mjerenje visine pomoću stieva



Mjerenje visine pomoću sjedila



Pretpost:

- Prva učionica postavlja sjedalo na tlo iznad stabla i drugu učionica.
- Druga učionica se penja na stievanj svoj stieva na sjedalo u sjedalu.
- Učionice uočavaju da od učionice do vrha stabla u sjedalu: $h_1 = \dots$
- Učionice uočavaju da od podnožja stabla do vrha stabla u sjedalu: $h_2 = \dots$
- Učionice vrše uočavanje: $h = \dots$
- Učionice vrše i stabla pomoću formule $h = \frac{h_1}{\sin \alpha}$

| Broj stabla | Visina (m) u stievanj | Visina sjedala (m) sjedala (m) | Visina pomoću stieva (m) | Učionice (m - h) |
|-------------|-----------------------|--------------------------------|--------------------------|------------------|
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- because of student interest, the workshop became a research project of biometry for all 190 trees on the Promenade
- we worked on the project from March to May 2024 and it was presented at the National competition

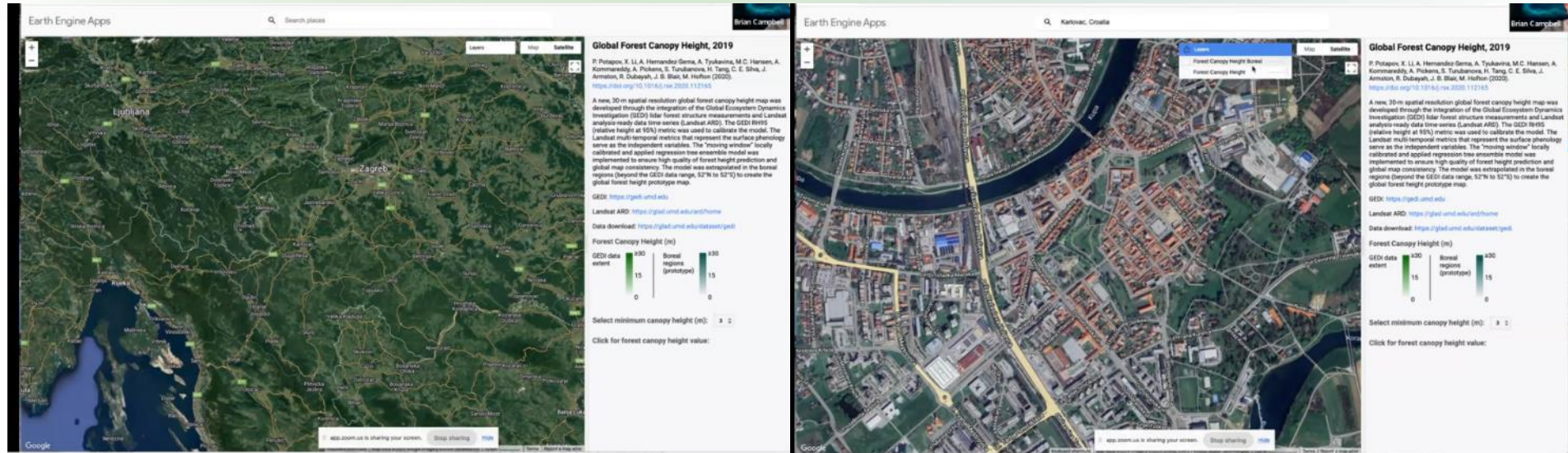
Research questions

- Can we read the height of the trees in the satellite measurement databases?
- How old are the trees in the Karlovac Promenade and when were they planted?
- How much carbon did the trees in the Karlovac Promenade store?
- How much CO₂ did the trees in Karlovac Promenade absorb?



Research methods – working on databases

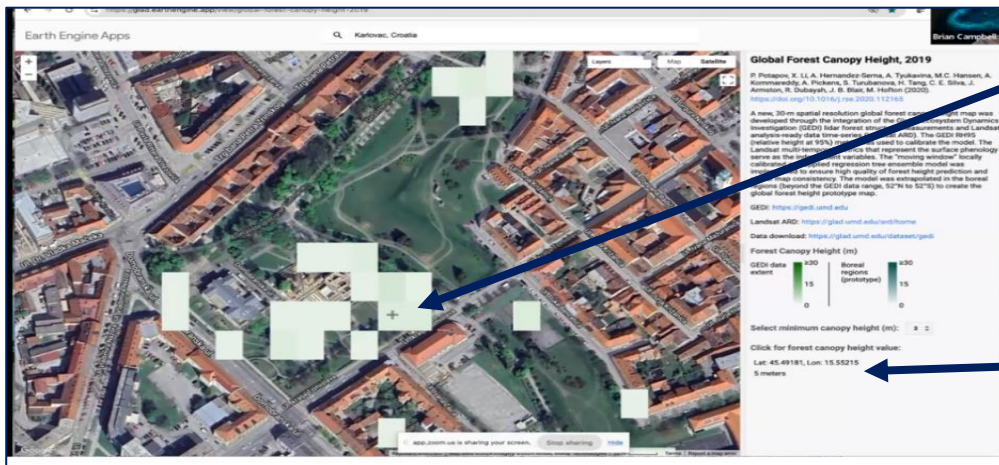
The students explore the database on platform:
Earth Engine apps
(GEDI satellite - **Global Ecosystem Dynamics Investigation**, measures canopy height)



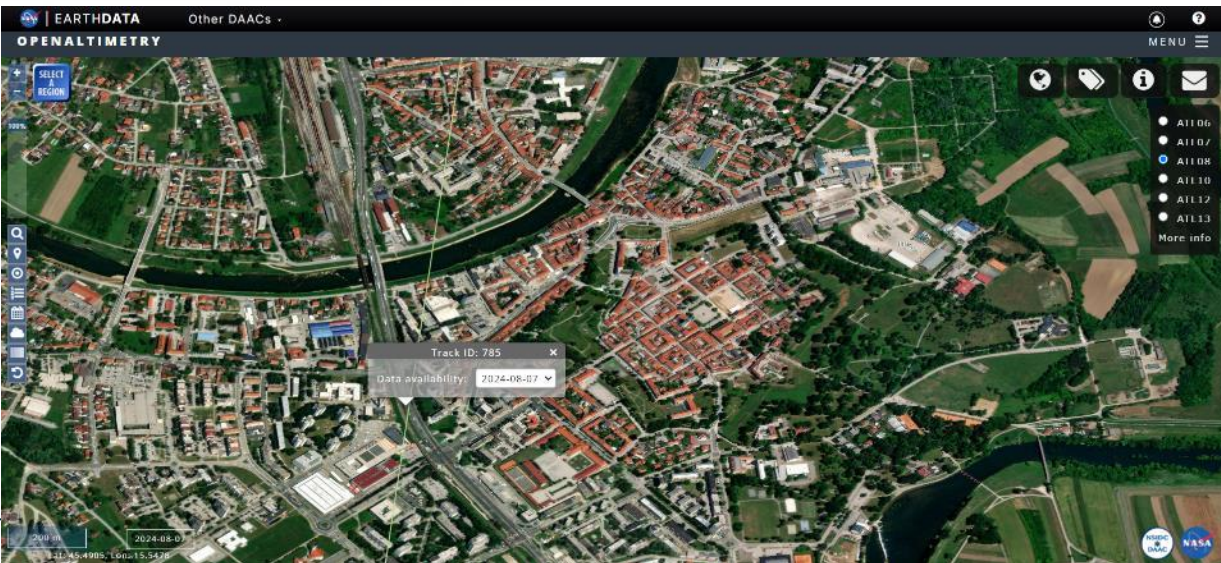
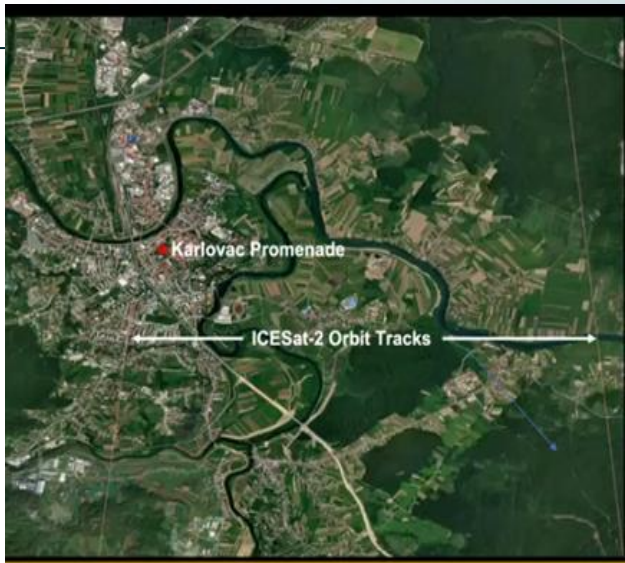
<https://glad.earthengine.app/view/global-forest-canopy-height-2019>



By zooming in on the map, pixels in varying shades of green appear, representing canopy height



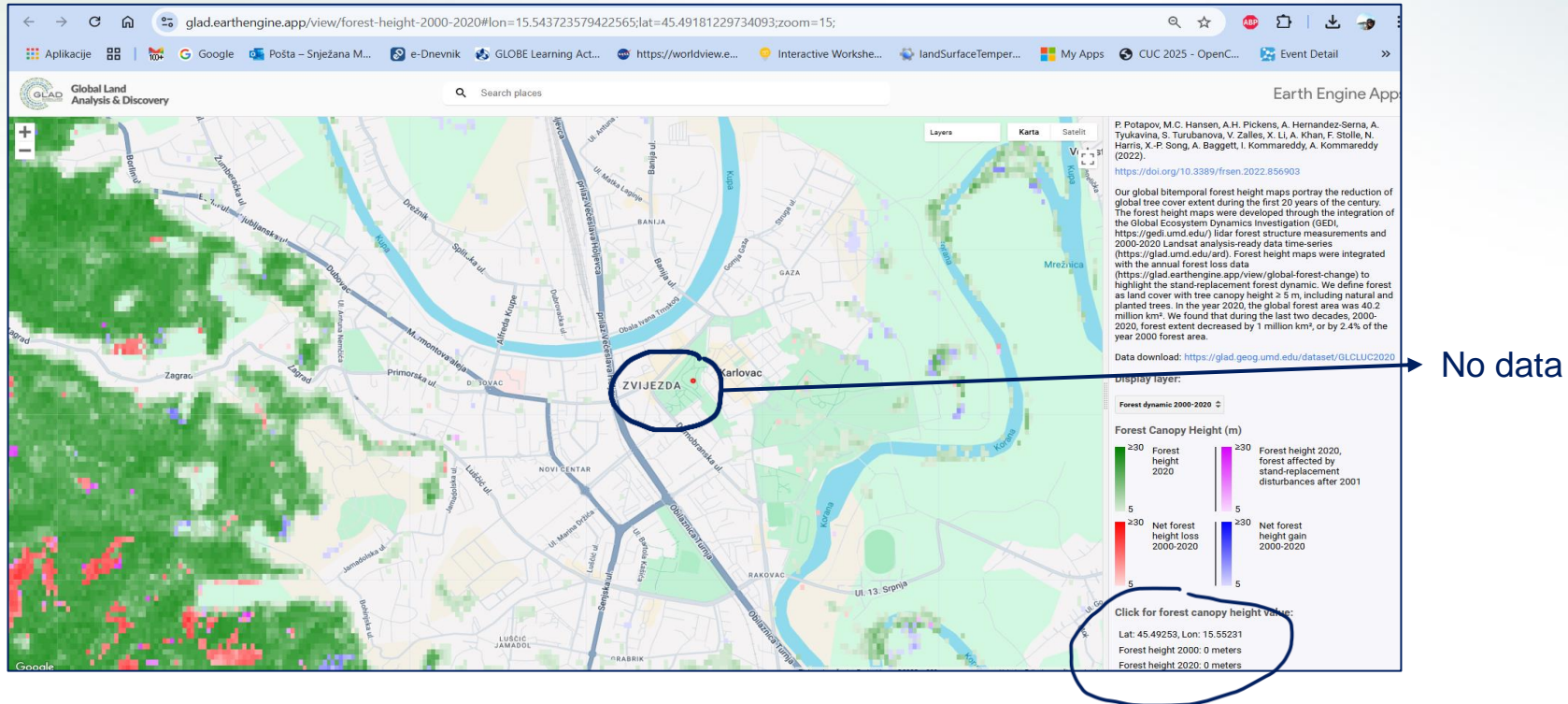
By selecting and marking a pixel, only the average height of the entire pixel is obtained, not that of specific tree



The satellite paths did not capture the canopy over the area of the Karlovac Promenade

The students explore the database on platform: Earth Engine apps

- the dynamics of the global tree cover 2000.- 2020



Did satellites capture and measure the height of trees in the Karlovac Promenade?



Talking with Brian Campbell (NASA scientist) on webinar how satellites record the Earth surface

ICE Sat 2 : **NO**, as the recording lines were not on the location.
GEDI: **PARTIALLY**, measuring the average canopy height per pixel.

Research methods on the field

Biometry measurements were conducted on all 120 trees on the Promenade

GLOBE protocols:

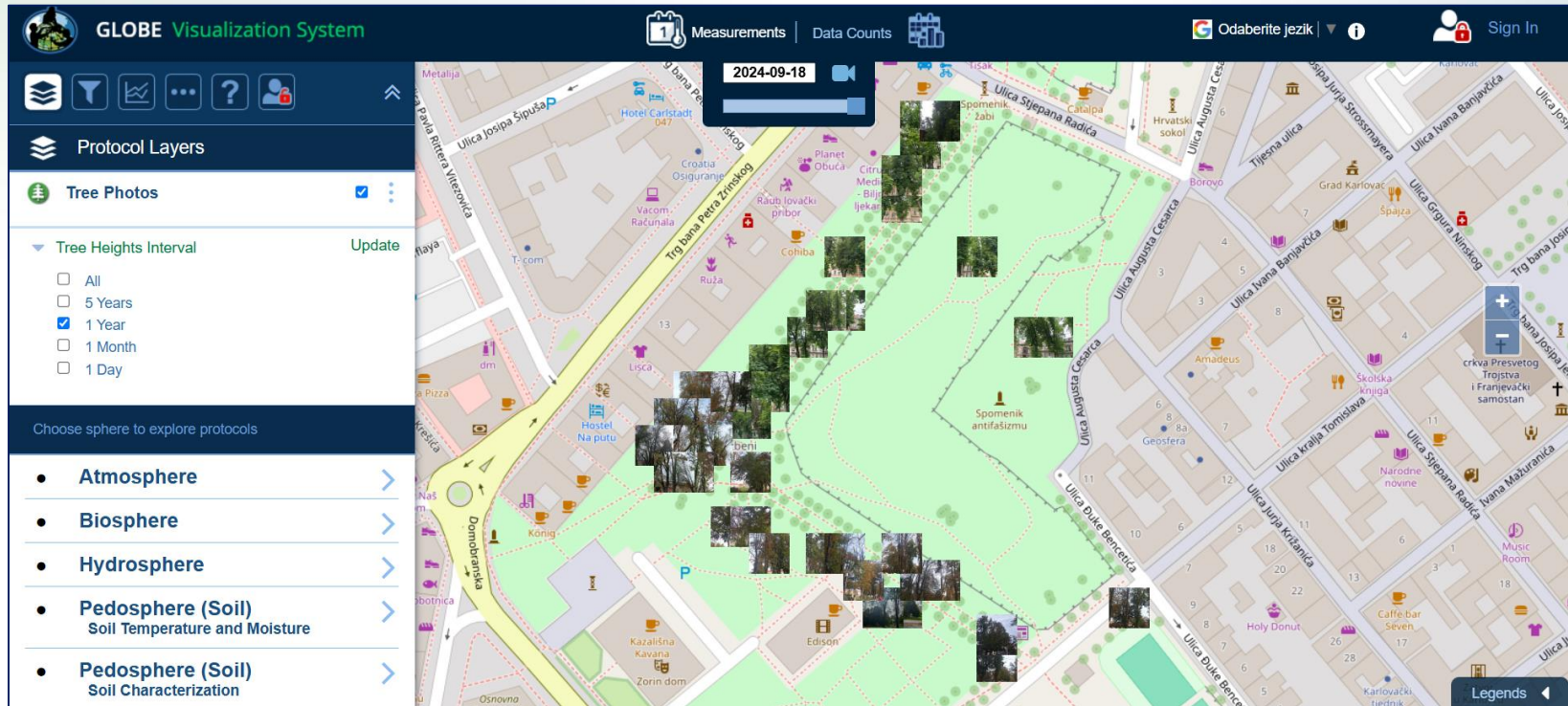
- tree circumference
- tree age

GLOBE *Observer*

- tree height and location

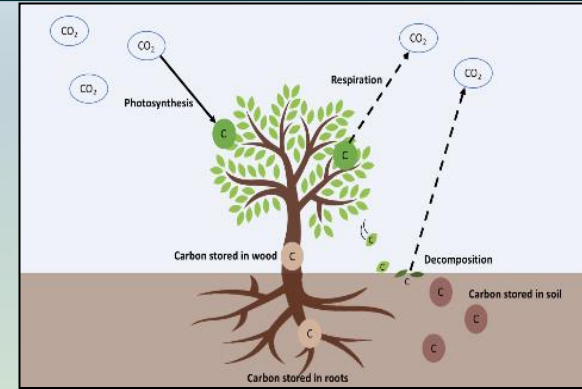


The measured values can be accessed in the GLOBE database



The following values were calculated in the classroom

- **diameter/cm** = $\frac{\text{circumference of tree}}{\pi}$
- **green weight - GW/ kg**
 $GW = 0.0346 \cdot d^2 \cdot h$ (if the $d > 28 \text{ cm}$)
 $GW = 0.0577 \cdot d^2 \cdot h$ (if the $d < 28 \text{ cm}$)
- **dry weight - DW/kg** = $\frac{GW}{2}$
- **carbon storage - CC/kg** = $\frac{DW}{2}$
- **absorbed CO₂/kg**
Carbon storage $\cdot 3.67$ jer je $\frac{Mr(CO_2)}{Ar(C)} = 3.67$



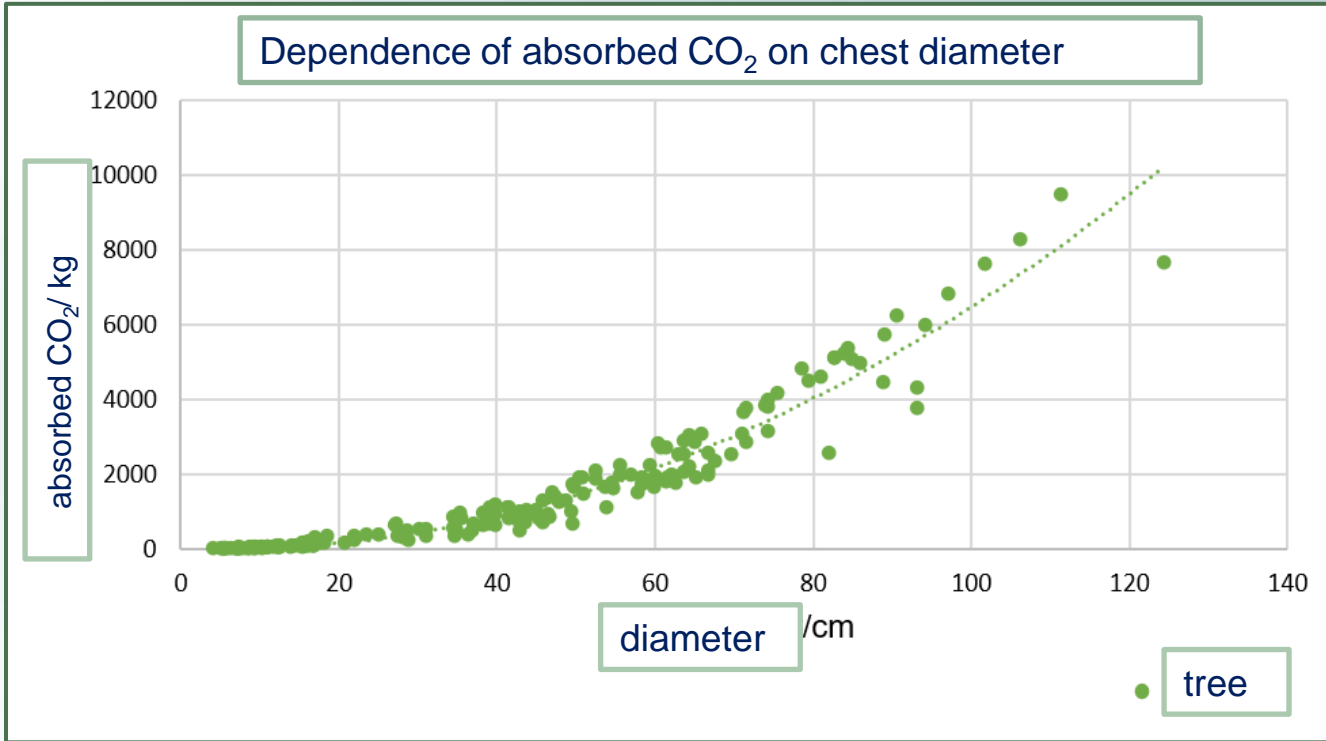
Results

- The stored carbon and absorbed CO₂ in the Promenade are presented in intervals based on tree diameter

| interval of tree diameter /cm | interval of tree age /years | number of trees | stored carbon /kg | absorbed CO ₂ /kg |
|-------------------------------|-----------------------------|-----------------|-------------------|------------------------------|
| 1 - 50 | 1 - 62.5 | 120 | 12 896 | 47 328 |
| 51 - 100 | 63 - 125 | 66 | 54 571 | 200 575 |
| 101 - 150 | > 125 | 4 | 8 966 | 32 906 |
| | | 190 | 76 433 | 280 809 |



190 trees on the Karlovac Promenade)



Discussion and conclusion

- Trees in the Promenade absorbed more than 280 t of CO₂ and contain over 76 t of stored carbon
- 2% of the trees are over 125 years
- Field measurements are crucial because satellites cannot capture all surfaces on Earth, especially in urban areas

| age | Promenade (190 trees) |
|---------------------|--------------------------|
| to 62.5 years | 64% |
| 63 - 125 years | 34% |
| more than 125 years | 2% |



- Karlovac promenade is a place for urban gatherings and events
- maintaining and caring for avenues is of great importance for the city



Generation of students 2024/2025



- GLOBE atmospheric measurements and tree monitoring
- monitors the amount of the main air pollutants in the city of Karlovac
- compares biometric measurements in the field and compares them with satellite measurement data

