Survey on trees in urban parks in Marcallo

Istituto Comprensivo Statale "E. DE AMICIS"
Marcallo con Casone (MI, Italy)

School year 2025-2026

Summary

The aim of the presentation is to share with the GLOBE community thes results of a survey on trees in urban green areas of Marcallo con Casone, a small town in the surroundings of Milan, Italy.

The research project has been carried out in October -December 2025 by K-8 students of the MIddle School L. da Vinci in Marcallo and by the GLOBE teachers of the same school.

Students measured all the broadleaf trees located in two selected urban green areas (San Marco and Madunina parks), recording the trunk circumference at 1.35 metres from the ground, the tree height both by handmade and professional clinometer and by the GLOBE Observer app. Measurements were taken with some field trips in different seasonal conditions: in October, with leaves on trees; in December with bare trees. This field campaign joined the last Trees around the GLOBE Student Research Campaign IOP (21 November - 21 December 2025).

Recorded data have been used to estimate the biomass, the stored carbon and the amount of CO_2 absorbed. We compared the total carbon storage with the amount stored in a class of 20 students: this comparison clearly showed the large storage capacity of trees and, consequently, their essential relevant role in the carbon cycle and in climate change mitigation.

A productive discussion among students and teachers concerning the different methods to measure tree height brought out critical observations on the practical factors that can have a relevant impact on measured values: a good training, a lot of practice is necessary to get accurate and precise data, even if the operating process looks simple (for example, with the Globe Observer app tools).

Finally, a comparison between our tree height measurements and satellite data (Open Altimetry tool to access ICESat2 dataset), highlighting a rather good match.

Students and teachers of the Middle School L. Da Vinci intend to extend their future surveys to other green areas of Marcallo, to improve their skills in taking ground based observations and measurements, and to deepen their knowledge about satellite data.

Introducing ourselves

- ★ Middle school L. Da Vinci - Marcallo con Casone (Italy)
- ★ 6 classes involved in the GLOBE program (120 students, 11-14 years old)
- ★ 3 classes involved in this survey (about 60 students, 13-14 years old)
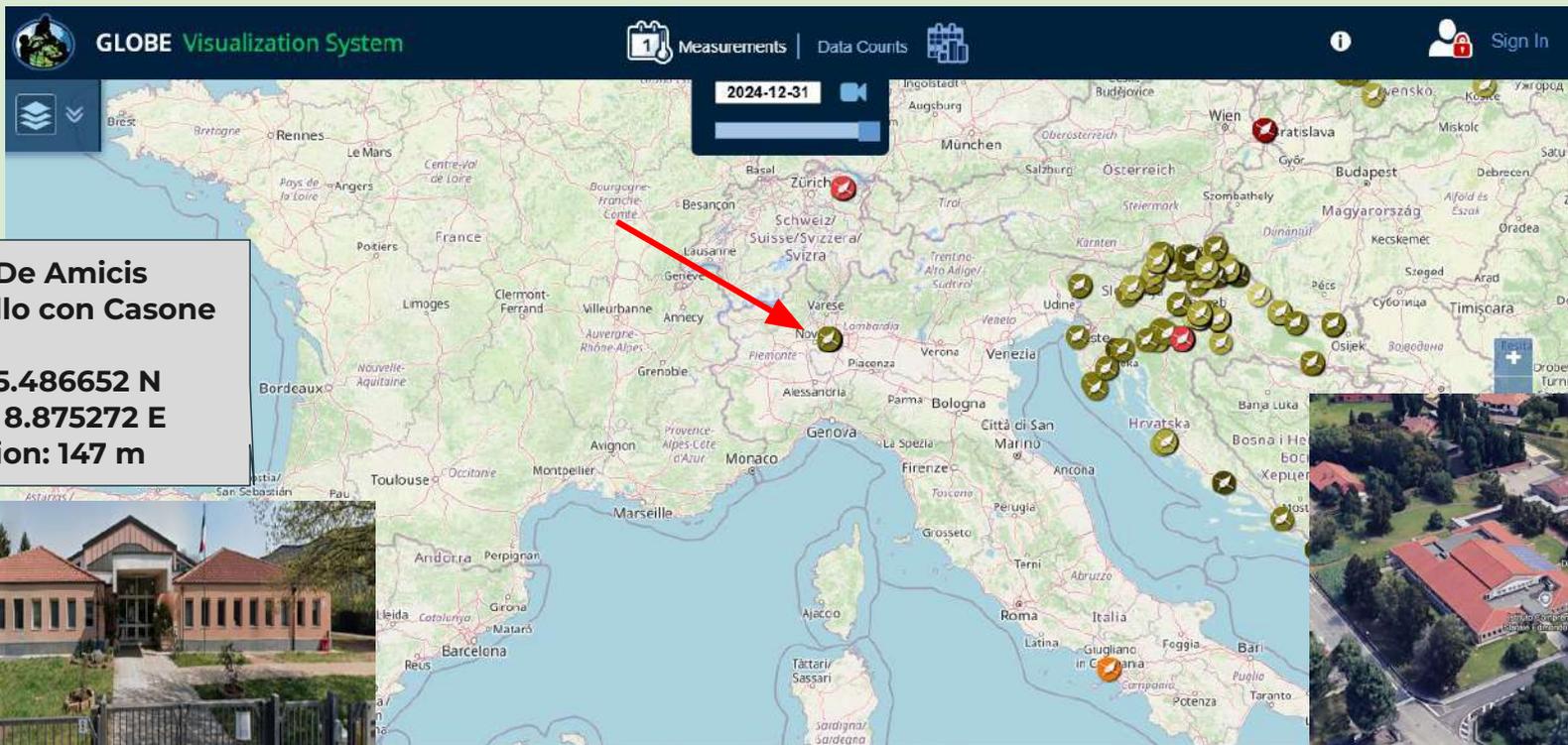- ★ 3 GLOBE educators

STUDENTS (TEAM GLOBE PLUS 2025)
- ★ Federico Chiodini
- ★ Vittoria Gargioni
- ★ Valentina Mereghetti

MENTORS - TEACHERS
- ★ Sabrina Pelizzari
- ★ Laura Colombo

Our school

ICS E. De Amicis
Marcallo con Casone

LAT: 45.486652 N
LONG: 8.875272 E
Elevation: 147 m

Where we live
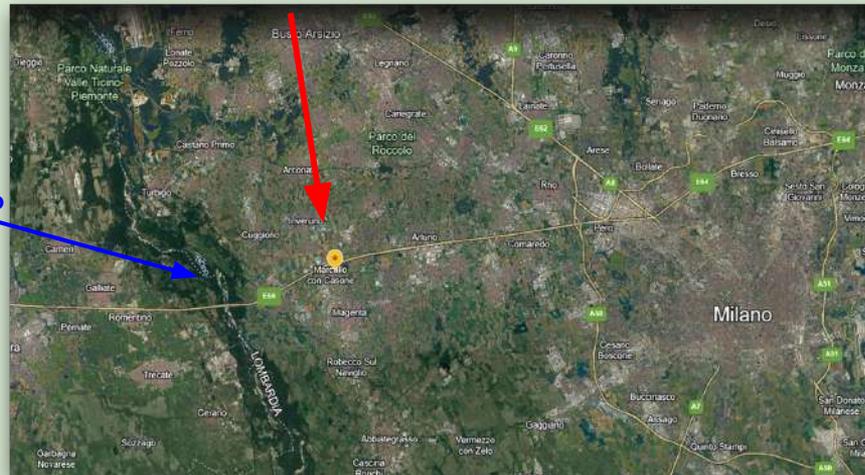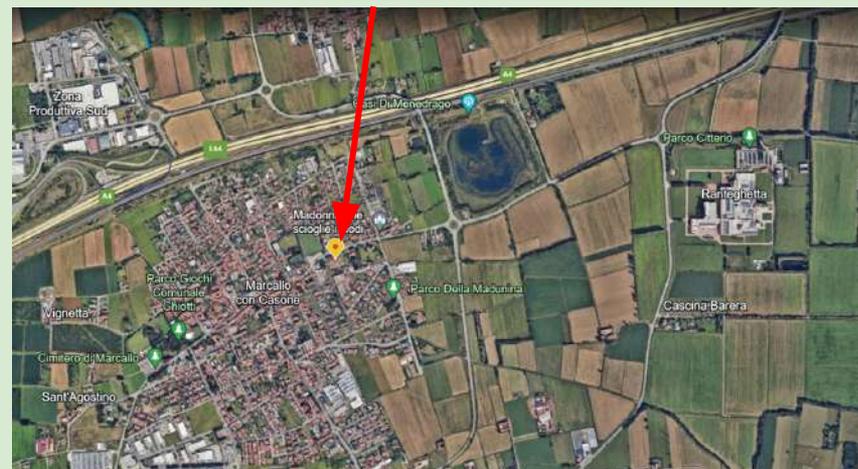

Physical map of Northern Italy

Marcallo con Casone is a small town 30 km west off Milan (in Lombardia region) with about 6000 inhabitants. It's located in the natural park of River Ticino.

Research questions

PART 1 - CARBON STORAGE

How much carbon is stored in the urban parks in Marcallo?

Why are trees important in reducing climate change?

PART 2 - MEASURING TREE HEIGHT

How tall are trees in the urban parks in Marcallo?

Which is the best method to measure tree height?

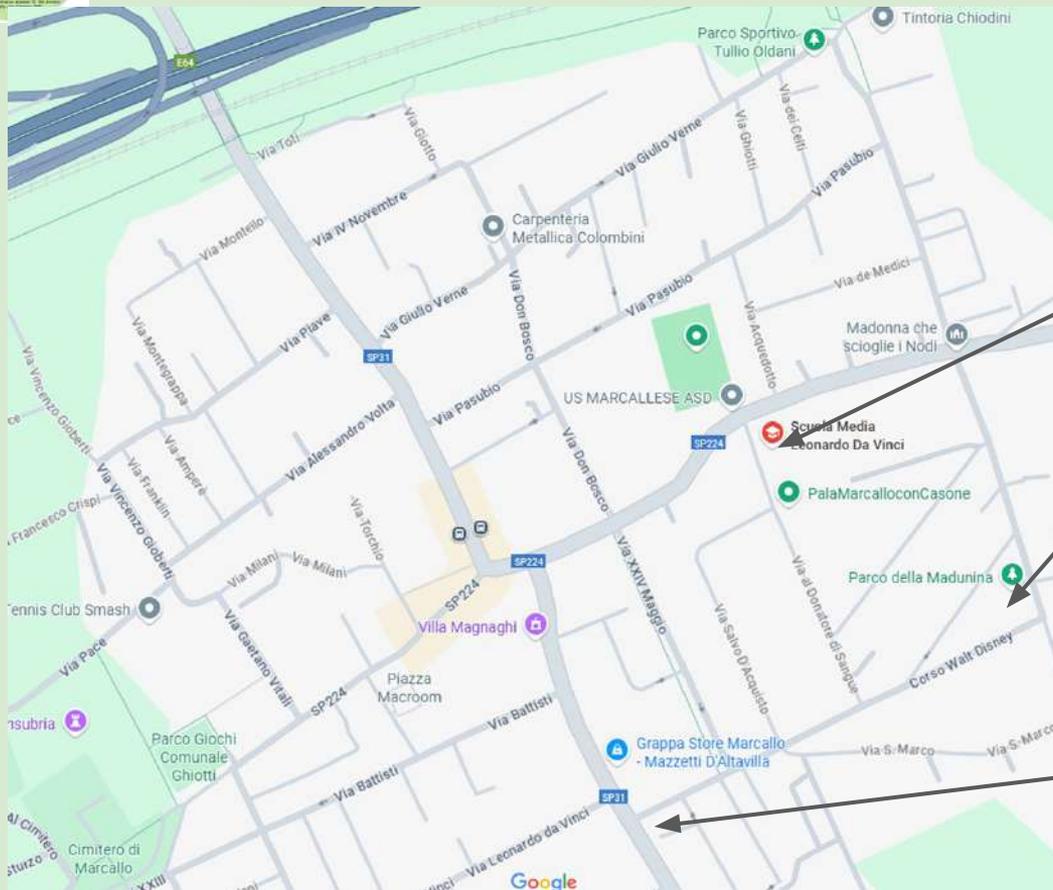Which are the sources of possible significant errors and how can we reduce them?

PART 3 - COMPARING OUR MEASUREMENTS WITH SATELLITE DATA

How accurate are our ground-based observations if compared with satellite data?

Sites of investigation

★ San Marco urban park

★ Madunina urban park

Middle school L. Da Vinci

Madunina urban park

San Marco urban park

Site of investigation 1

Birch

Lime 1

Lime 2

Lime 3 3

Lime 4

Birch = *Betula pendula*

Lime = *Tilia europaea*

SAN MARCO URBAN PARK

★ Location: 45.482714 N; 8.872769 E

★ 5 broadleaf trees measured

★ 2 outings on field to measure trees:
  ○ October 25th, 2025
  ○ December 4th, 2025

★ Tree species:
  ○ Betula pendula
  ○ Tilia europaea

Site of investigation 2

Siberian elm

Elm

Numbered lime trees

Sugar maple

Japanese cherry

Black walnut 1

Black walnut 2

Black walnut 3

Black walnut 4

Siberian elm = *Ulmus pumila*
Lime = *Tilia europaea*
Black walnut = *Juglans nigra* (da confermare)

Sugar maple = *Acer saccharinum*
Japanese cherry = *Prunus serrulata*
Elm = *Ulmus minor*

Numbered lime trees

MADUNINA URBAN PARK

★ Location: 45.48508 N; 8.87782 E

★ Measured trees: 29 broadleaf trees of different species (21 *Tilia europaea*)

★ 3 outings on field to measure trees:
  ○ October 25th, 2025
  ○ December 4th, 2025
  ○ December 11th, 2025

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Land Cover classification

Land Cover Observation taken on December 4th, 2025 - Madunina urban park:

❖ Urban, residential property

December 4th, 2025

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Methods and materials: collecting data

by GLOBE Observer app

1. Measure the observer's eye height
2. Describe the surface conditions
3. Tilt the mobile phone to measure the angles created to the base and to the top of the tree
4. Take a picture of the whole tree
5. Count the steps from the point you are to the base of the tree
6. Measure the circumference of the tree (by a measuring tape)
7. Specify the species of the tree
8. Measure the distance from the observer to the base of the tree (by a measuring tape) and insert it manually in the Trees app
9. Repeat measurement three times.
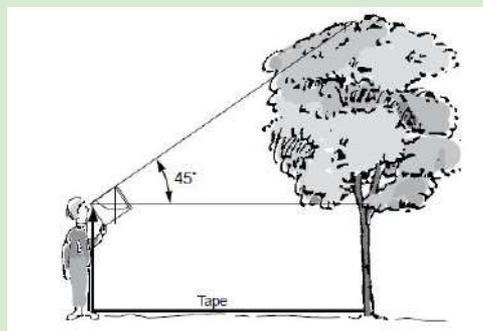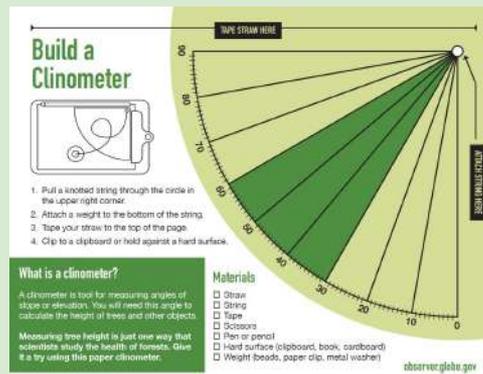
by clinometer

1. Measure the observer's eye height
2. Point the clinometer at the top of the tree and move until the angle measured is 45°
3. Measure the distance from the observer to the base of the tree (by a measuring tape)
4. Calculate tree height as follow:

Tree height (cm) = distance from tree (cm) + eye height (cm)

5. Repeat measurement three times.

Methods and materials: on field activities

October 25th, 2025

December 4th, 2025

Methods and materials: calculation

- To estimate the biomass, we measured the trunk circumference to calculate the DBH.
- Biomass has been estimated using both the manual method (Predicted Biomass Graph) and the Carbon Storage Calculator (Excel sheet).
- For some trees, whose circumference was greater than 50 cm, we used only the Carbon Storage Calculator.
- Biomass was used to estimate the amount of carbon stored in the trees and then the amount of CO_2 absorbed in their live.
- Equations:

Carbon Storage Calculator

Biomass (kg) = e^(β_0+ β_1*lnDBH)

Carbon (kg) = Biomass (kg) * 50%

Adsorbed CO_2 (kg) = Carbon (kg) * 3,67
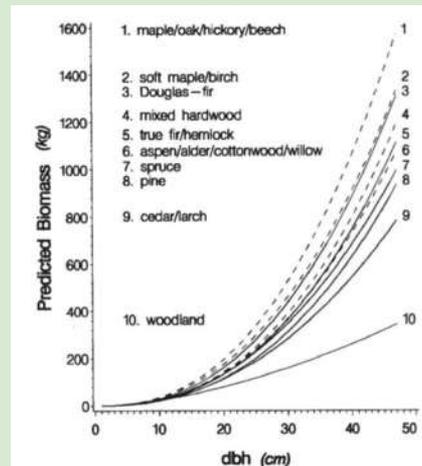
Figure 1. Graphs of ten equations for predicting total aboveground biomass by species group. Hardwoods are represented by dashed lines, softwoods by solid lines.

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PART 1
THE ROLE OF TREES IN THE EARTH SYSTEM: CARBON STORAGE

SAN MARCO URBAN PARK

Tree	Circumf. (cm)	Diameter (cm)	Total Biomass (kg)	Total Carbon storage (kg)	CO_2 (kg)
Birch (Betula pendula)	33	10.50	34.5	17.3	63.4
Lime 1 (Tilia europaea)	230	73.21	4244.8	2122.4	7789.2
Lime 2 (Tilia europaea)	210	66.85	3386.9	1693.5	6215.0
Lime 3 (Tilia europaea)	175	55.70	2154.4	1077.2	3953.3
Lime 4 (Tilia europaea)	220	70.03	3801.4	1900.7	6975.6
			TOTAL	**6811 kg**	**24996 kg**

Lime 2

Results and data: carbon storage 2

MADUNINA URBAN PARK

Tree	Circumf. (cm)	Diameter (cm)	Total Biomass (kg)	Total Carbon storage (kg)	CO_2 (kg)
Siberian elm (Ulmus pumila)	247	78.62	5066,5	2533,3	9297,1
Elm (Ulmus minor)	174	55.39	2124,0	1062,0	3897,5
Black walnut 1 (Juglans nigra)	140	44.56	1238,5	619,2	2272,7
Black walnut 2 (Juglans nigra)	105	33.42	606,8	303,3	1113.5
Black walnut 3 (Juglans nigra)	105	33.42	606,8	303,3	1113.5
Black walnut 4 (Juglans nigra)	131	41.70	1050,3	525,1	1927.3
Sugar maple (Acer saccharinum) *	175+95	55.70 + 30.24	2919,2	1459,6	5356.8
Japanese cherry (Prunus serrulata)**	ND	ND	ND	ND	ND

The main trunk forks into 2 parts
* *Shrub structure, circumference not measured*

Results and data: carbon storage 3

MADUNINA URBAN PARK

Tree	Circumf. (cm)	Diameter (cm)	Total Biomass (kg)	Total Carbon storage (kg)	CO_2 (kg)
Lime 1 (Tilia europaea)	133	42.34	1090.5	545.3	2001.2
Lime 2 (Tilia europaea)	117	37.24	793.6	396.8	1456.2
Lime 3 (Tilia europaea)	106	33.74	621.2	310.6	1139.9
Lime 4 (Tilia europaea)	107	34.06	635.8	317.9	1166.8
Lime 5 (Tilia europaea)	118	37.56	810.5	405.2	1487.3
Lime 6 (Tilia europaea)	123	39.15	898.3	449.2	1648.5
Lime 7 (Tilia europaea)	137	43.61	1173.7	586.9	2153.8
Lime 8 (Tilia europaea)	106	33.74	621.2	310.6	1139.9
Lime 9 (Tilia europaea)	109	34.70	665.7	332.9	1221.6
Lime 10 (Tilia europaea)	150	47.75	1469.7	734.9	2696.9
Lime 11 (Tilia europaea)	140	44.56	1238.5	619.2	2272.7

Lime 9

MADUNINA URBAN PARK

Tree	Circumf. (cm)	Diameter (cm)	Total Biomass (kg)	Total Carbon storage (kg)	CO_2 (kg)
Lime 12 (Tilia europaea)	116	36.92	776.8	388.4	1425.5
Lime 13 (Tilia europaea)	115	36.61	760.3	380.2	1395.2
Lime 14 (Tilia europaea)	115	36.61	760.3	380.2	1395.2
Lime 15 (Tilia europaea)	107	34.06	635.8	317.9	1166.8
Lime 16 (Tilia europaea)	112	35.65	712.1	356.0	1306.7
Lime 17 (Tilia europaea)	123	39.15	898.3	449.2	1648.5
Lime 18 (Tilia europaea)	148	47.11	1421.6	710.8	2608.6
Lime 19 (Tilia europaea)	127	40.43	972.6	486.3	1784.7
Lime 20 (Tilia europaea)	130	41.38	1030.5	515.3	1891.1
Lime 21 (Tilia europaea)	123	39.15	898.3	449.2	1648.5

TOTAL CARBON STORAGE: 16249 kg

CO2: 59634 kg

Lime 13

	Area (m2)	Description of trees	Total Carbon storage (kg)	Total adsorbed CO_2 (kg)
San Marco urban park		4 lime trees (average age: 80) 1 young birch	6811 kg *(6794 kg only lime trees)*	24996 kg *(24933 kg only lime trees)*
Madunina urban park		21 lime trees (average age 50) 2 old elm trees 4 black walnut trees 2 other broadleaf trees	16249 kg *(9443 kg only lime trees)*	59634 kg *(34655 kg only lime trees)*

Trees absorb carbon dioxide (CO_2) from the atmosphere through their leaves and convert it into biomass (wood, leaves, roots) through photosynthesis, thus storing carbon. About 50% of a tree dry mass is carbon. This carbon is stored for decades or centuries, making forests crucial for climate regulation.
After calculating the amount of carbon in the trees of the two urban parks, we noticed that in San Marco Park the values are rather higher if compared to Madunina Park, despite the lower number of trees. The dominant tree species is the same (Tilia europaea), but lime trees in San Marco Park have a larger circumference. It means that the 4 lime trees in San Marco park are older (about 80 years old as average) and consequently contain more carbon, compared to those in Madunina park (about 50 years old). As average, a 80 years old lime tree stores 1700 kg of carbon, while a 50 years old lime tree stores only 450 kg of carbon.

Humans consume organic compounds and release CO_2 through respiration. Carbon is a fundamental building block of the human body (proteins, fats, carbohydrates), and unlike trees, which take carbon dioxide from the atmosphere,, humans release CO_2. Excess CO_2 contributes to global warming, while healthy trees help fighting against climate change.

We calculated that in our class (20 students, 13 years old), estimating the biomass as the 35% of the total weight of students, the total carbon storage is 194 kg.

Carbon stored in 4 old lime trees is about 35 times greater than the carbon stored in our class of 20 students!

PART 2
MEASURING TREE HEIGHT

SAN MARCO URBAN PARK

	Leaves on trees
	Bare trees

Tree	Clinometer (m) October 25th, 2025	GLOBE Observer (m) December 4th, 2025	Difference (m) (GO app - clinometer)
Birch (Betula pendula)	8.01	6.87	*-1.14*
Lime 1 (Tilia europaea)	11.65	11.21	*-0.44*
Lime 2 (Tilia europaea)	9.94	9.24	*-0.70*
Lime 3 (Tilia europaea)	10.20	9.61	*-0.59*
Lime 4 (Tilia europaea)	11.18	9.60	*-1.58*

Average values of at least 2 different measurements

Lime 3

Results and data: tree height 2

MADUNINA URBAN PARK

Tree	Clinometer (m) October 25th, 2025	GLOBE Observer (m) October 25th, 2025	Difference (m) (GO app - clinometer) October 25th, 2025	GLOBE Observer (m) December 4th-11th, 2025	Difference (m) (GO app December - GO app October)
Siberian elm (Ulmus pumila)	22.71	23.75	+1.04	29.75	+6
Elm (Ulmus minor)	21.27	ND	—	22.56	—
Black walnut 1 (Juglans nigra)	15.08	16.54	+1.46	16.99	+0.45
Black walnut 2 (Juglans nigra)	16.24	16.09	-0.15	15.04	-1.05
Black walnut 3 (Juglans nigra)	13.70	14.09	+0.39	12.68	-1.41
Black walnut 4 (Juglans nigra)	14.59	16.56	+1.97	15.57	-0.99
Sugar maple (Acer saccharinum)	ND	15.89	–	15.44	-0.45
Japanese cherry (Prunus serrulata)	8.17	8.79	+0.62	7.02	-1.77

Leaves on trees

Bare trees

Average values of at least 2 different measurements

MADUNINA URBAN PARK

Tree	Clinometer (m) October 25th, 2025	GLOBE Observer (m) October 25th,, 2025	Difference (m) (GO app - clinometer) October 25th, 2025	GLOBE Observer (m) December 4th-11th, 2025	Difference (m) (GO app December - GO app October)
Lime 1 (Tilia europaea)	17.22	15.83	*-1.39*	16.35	*+0.52*
Lime 2 (Tilia europaea)	16.20	15.91	*-0.29*	16.70	*+0.79*
Lime 3 (Tilia europaea)	16.95	15.61	*-1.34*	16.14	*+0.53*
Lime 4 (Tilia europaea)	16.62	16.78	*+0.16*	17.52	*+0.74*
Lime 5 (Tilia europaea)	14.97	ND	—	14.49	—
Lime 6 (Tilia europaea)	14.97	ND	—	16.92	—
Lime 7 (Tilia europaea)	17.35	17.63	*+0.28*	17.63	*0*
Lime 8 (Tilia europaea)	15.71	17.75	*+2.04*	16.17	*-1.58*
Lime 9 (Tilia europaea)	15.79	17.76	*+1.97*	15.92	*-1.84*
Lime 10 (Tilia europaea)	15.00	16.51	*+1.51*	17.10	*+0.59*
Lime 11 (Tilia europaea)	15.35	16.70	*+1.35*	16.12	*-0.58*

	Leaves on trees
	Bare trees

Lime 10

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MADUNINA URBAN PARK

Tree	Clinometer (m) October 25th, 2025	GLOBE Observer (m) October 25th,, 2025	GLOBE Observer (m) December 4th-11th, 2025	Difference (m) (GO app December - clinometer October)
Lime 12 (Tilia europaea)	ND	ND	10.81	—
Lime 13 (Tilia europaea)	16.78	16.05	16.11	*-0.67*
Lime 14 (Tilia europaea)	ND	ND	16.43	—
Lime 15 (Tilia europaea)	*11.91*	ND	16.43	—
Lime 16 (Tilia europaea)	*10.72*	ND	16.63	—
Lime 17 (Tilia europaea)	ND	ND	17.83	—
Lime 18 (Tilia europaea)	16.87	ND	18.51	*+1.64*
Lime 19 (Tilia europaea)	16.78	ND	18.62	*+1.84*
Lime 20 (Tilia europaea)	16.63	ND	15.49	*-1.14*
Lime 21 (Tilia europaea)	16.76	ND	17.03	*+0.27*

	Leaves on trees
	Bare trees

Lime 19

Average values of at least 2 different measurements

Discussion:
analysis of our tree height measurements by different methods

by handmade CLINOMETERS

- Measuring tree height by handmade or professional clinometer is very <u>useful for students or beginners</u>, as they can understand the geometric properties concerning this method.
- To get precision and accuracy <u>a lot of practice</u> is necessary, as well as a great care in every step of the measuring process.
- Using <u>a measuring tape</u> instead of counting the number of step is useful to increase precision.
- <u>Care in reading the angle</u> on the clinometer is the other factor that can give more accurate and precise measurements.
- The previous items can give reason of the variability in our dataset, even if each tree height measurement has been repeated at least three times (to get an average value).

by GO app

- Measuring tree height by the GO app is fast and easy, but <u>care is necessary</u>, as well, especially in <u>the following stages</u>:
  - holding the mobile phone always at eye level;
  - tilting the mobile phone without changing the position at eye level;
  - detecting the tree top of a specific tree, if there are more closely spaced trees sharing their canopies;
  - walking to the tree base with regular stride length.
- Using <u>a measuring tape</u> instead of counting the number of step is useful (we've manually edited the distance of the observer to the tree base instead of the value obtained by counting the number of steps).
- Larger errors can be noticed in measuring the <u>height of very tall trees</u> (for example, the Siberian elm in Madunina park), because of reduced precision in reading the angle to the top of the tree by the mobile device.

❖ In October the trees still had their leaves on, slowly changing their autumn colors. For some of the trees in our investigation sites it has been quite complicated to clearly see the top of individual tree, as they were closely spaced and similar in height.

❖ In December all broadleaf trees in both the sites of investigation had completely lost their canopy. It was easier to identify the top of individual trees.

❖ This obvious difference can be another reason of the variability in tree height between measurements in October and in December. In general, we think that more precise measurements can be obtained when the tree is bare.

Lime 1
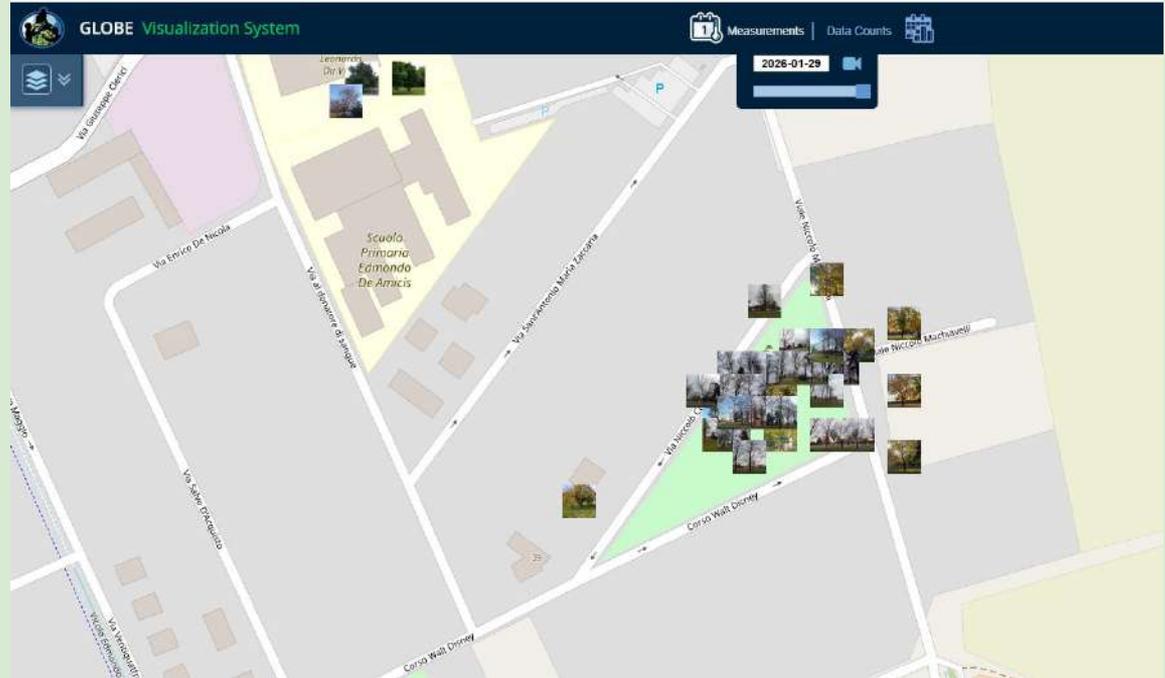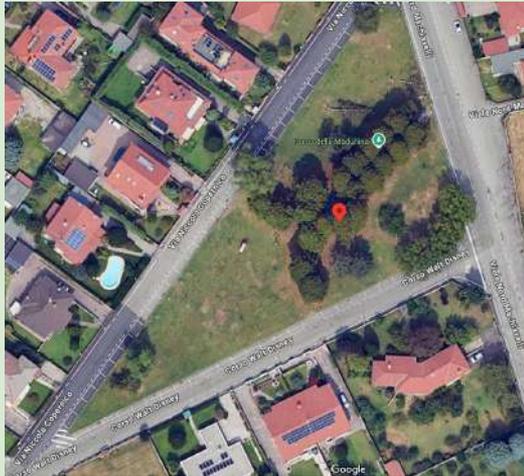*October 25th, 2025*

Lime 1
December 4th, 2025

Lime 7
*October 25th, 2025*

Lime 7
December 4th, 2025

➔ The location of some trees is to be improved, by using the manual touchscreen map inside the GO Tree tool, instead of automatic GPS tool.

➔ This is truly important if there are many trees close to each other, as in Madunina urban park.

➔ However, location accuracy of all our observation are between 1 and 10 metres.

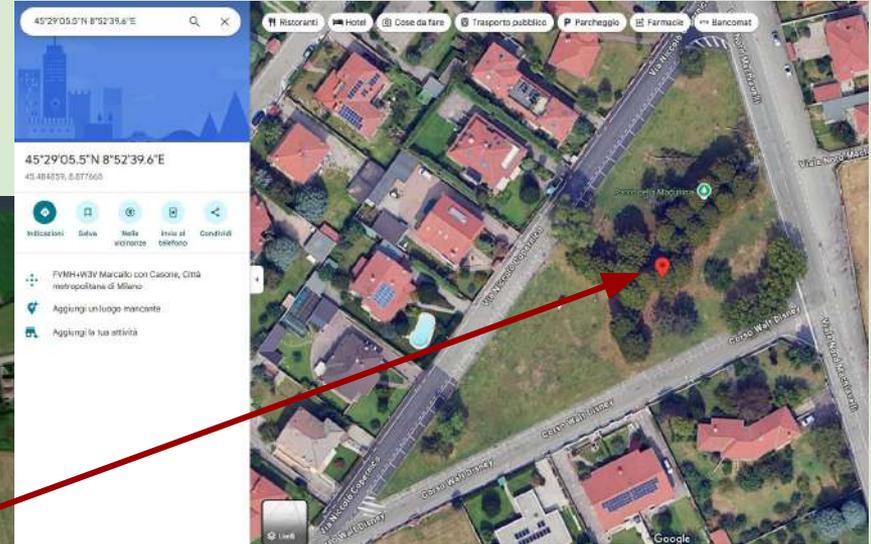*In the picture all measured trees should be located inside the green area…*

PART 3
SATELLITE DATA vs GROUND-BASED MEASUREMENTS
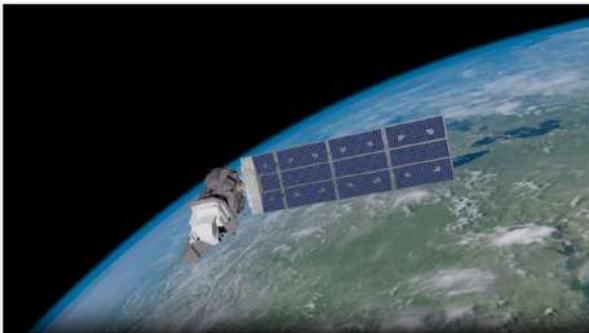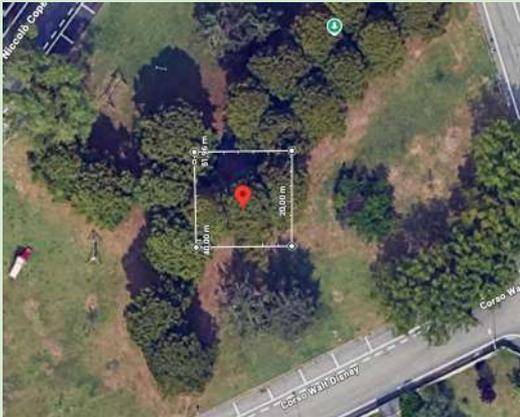
Results and data: Open Altimetry data

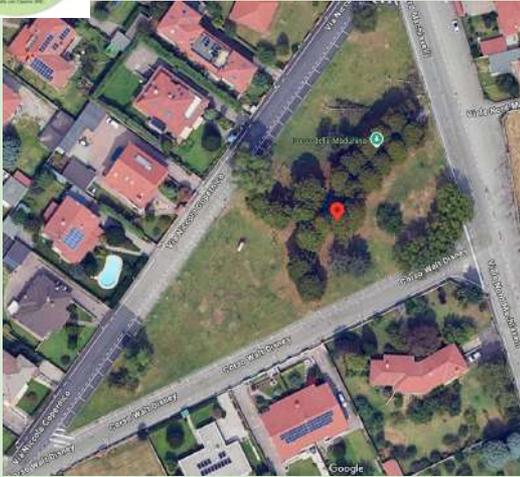- ★ **July 9th, 2023, ATL08**
- ★ Madunina urban park
- ★ Latitude: 45.484859 N
- ★ Longitude: 8.877665 E
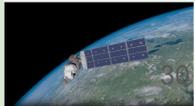
Results and data: Open Altimetry data

→ Open Altimetry - Average canopy height on July 9th, 2023: 16.68 m

→ Calculated average canopy height of lime trees n.6-7-8-9 (with leaves) on October 25th, 2025:
  ◆ by clinometer: 15.96 m
  ◆ by GO app: 17.71 m

→ Height difference (2 years later):
  ◆ referred to clinometer measures: -0.72 m (-4%)
  ◆ referred to GO app measurement: + 1.03 m (+6%)

❖ We considered a square with sides 13 metres long, centered on the location of the beam, as in the picture (yellow point).

❖ Lime trees n.6-7-8-9 are located in that square; therefore, we calculated their average canopy height.

❖ Comparing our collected data with those recorded by ICESat2 on July 2023 regarding the average canopy height, we've found out a good match between the two dataset.

Lime trees n.6-7-8-9

CONCLUSION

Trees are essential to life on Earth because they produce oxygen, absorb CO_2, mitigating climate change, and play a crucial role in regulating the water cycle and providing habitat, food, and materials.
Carbon is an essential element for all life on Earth. It is stored in the biosphere, atmosphere, ocean, soil, and crust of the Earth.

Ground-based measurements and observations can be very important to understand the local ecosystem and, in the meanwhile, to develop scientific skills in young students like us.

Working on satellite data is interesting, as well, because they help to realize that we are part of the same Earth system and that even students, teachers, schools can give their contribution to study how our "common home" works and how to protect it.

Our future plans are to collect new data concerning trees and urban areas in Marcallo, to improve accuracy and precision of observations and measurements by practicing and training on GLOBE protocols.
Besides, we intend to **share results** of the current research with the local Municipality to involve citizens and increase their awareness on the relevant role of trees and green areas as source of health for all our planet.

Citations

- www.globe.gov (protocols, data sheets, learning activities)
- Learning activity "*Comparison of tree height measurements*" (www.globe.gov)
- Learning activity "*Allometry*" (www.globe.gov)
- "*Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species*", Jennifer C. Jenkins, David C. Chojnacky, Linda S. Heath, Richard A. Birdsey, 2023
- Learning activities and training for teachers and students supplied by GLOBE Italy and GLOBE Europe and Eurasia Coordination Office
- *Globe Observer app* (Trees - Land Cover)
- *Trees around the GLOBE Campaign*
  https://www.globe.gov/web/trees-around-the-globe
- "*Carbon storage calculator*" worksheet
  https://cdn.naturalresources.wales/media/687190/eng-worksheet-carbon-storage-calculator.pdf
- https://openaltimetry.earthdatacloud.nasa.gov/data/icesat2/
  Khalsa, S.J.S., Borsa, A., Nandigam, V. *et al.* OpenAltimetry - rapid analysis and visualization of Spaceborne altimeter data. *Earth Sci Inform* (2020). https://doi.org/10.1007/s12145-020-00520-2.

- ATL08

  Neuenschwander, A. L., Pitts, K. L., Jelley, B. P., Robbins, J., Markel, J., Popescu, S. C., Nelson, R. F., Harding, D., Pederson, D., Klotz, B. & Sheridan, R. (2025). ATLAS/ICESat-2 L3A Land and Vegetation Height. (ATL08, Version 7). [Data Set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ATLAS/ATL08.007. [Date Accessed].
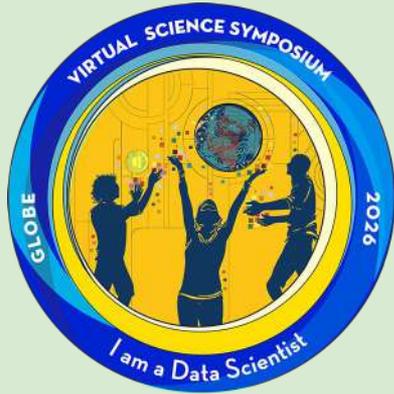
We've been working hard to collect data, organize them into tables, analyze them and answer our research questions. Collecting data through observations and measurements is essential for scientific research: as regards trees, ground-based observations can help scientists to compare satellite-based measurements.

We've tried to compare our tree height measurements with Open Altimetry-Icesat2 dataset: we're just beginners in working with satellite data, but we'll practice more

Thank you for your attention

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