ERASMUS+ KA220-SCH - Cooperation partnerships in school education

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Promoting STEAM through participatory urban regeneration

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Laboratory

How hot is your city?

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FREELAND laboratories follow the structure of Inquiry Based Learning (IBL), in 5 steps (orientation, conceptualization, investigation, conclusion and discussion), and for each step we suggest activities and methodological approaches that are engaging for the students such as brainstorming, hands-on, creative works. The activities described in the laboratory are suggestions that teachers can adapt or replace with similar activities suitable to students' age and school type.

Laboratory	**How hot is your city?**
Duration:	About 10 hours, but the activity will last about 10-20 days, as the students will spend 30 minutes per day outdoors for taking measurements for 10-20 days
Tools:	• Worksheet to print, pen, colours, billboards • Excel for data elaboration • Online open software to make charts
Technologies:	• Non-contact infrared (IR) thermometers or hand-held IR cameras to measure the temperature of different surfaces (concrete, asphalt, vegetation, etc.). • Computer to download and elaborate data. • Mobile phones for photos and videos.
Subjects:	Physics, Biology, Maths, Art
Students' age	Any
School type	Any

Disciplinary contents:	This laboratory allows the assessment of climate trends in an urban space, the "heat island" phenomenon, and mitigation options (garden, park, abandoned area with spontaneous vegetation). Cities are one of the most vulnerable areas to Climate Change. Due to the shape and materials, this environment undergoes a greater increase in temperatures, with consequences that can affect human activities and health. This laboratory aims to raise awareness of: ● the "*heat island*" phenomenon by applying scientific methods of climatic data analysis and its evaluation ● understanding the effectiveness of vegetation to mitigate this problem. The laboratory includes the manipulation of different data formats and the calculation of some basic statistical formulas that are clearly explained, for which the math teacher can give students support.
Learning objectives:	Students will be able to: ● Make observations of the urban climate and environment ● Do hands-on computer work ● Learn climate terminologies ● Manipulate data and make graphs ● Discuss scientific results and make relationships between diverse disciplines, in connection with climate change

For each phase of the IBL we provide a description of the suggested activities.

Orientation

Duration:	30 minutes outdoors
Tools:	No specific tools
Technologies:	No
Subjects:	Physics, Biology

Method:	Brainstorming

The teachers take the students outdoor to the neglected built space (e.g. abandoned buildings, squares with some green areas, etc.) which should have some trees and invite them to walk around trying to perceive the changes in temperature from one area to another.

"What is the difference between climate and weather?"

"What is Climate Change? Does it have a greater or lesser impact on the cities?"

"Did you feel some difference in temperature between vegetated and built-up areas?"

Students should recall their prior knowledge to answer questions.

Conceptualization

This phase concerns the creation of the question to be answered by an investigation.

Duration:	15 minutes outdoors
Tools:	No specific tools
Technologies:	No
Subjects:	Physics, Biology
Method:	Brainstorming

Following orientation, teachers pose students some questions:

"What is the temperature trend in your city?"

"Do you know the meaning of Urban Heat Island (UHI) effect? What are its causes?"

"What is the role of vegetation respect to the temperature?"

"Green areas can help to mitigate the urban heat island phenomenon?"

Investigation

The investigation includes both outdoor and indoor activities to answer the questions posed in the Conceptualization phase.

Duration:	● 30 minutes outdoors (repeated at different times of the year) ● 2 hours indoors
Tools:	● Worksheet, pen ● Spreadsheet software's (e.g.: Excel) for data organization
Technologies:	● Non-contact infrared (IR) thermometers or hand-held IR cameras to measure temperature of different surfaces (concrete, asphalt, vegetation, etc.) ● Mobile phones for photos ● Computer to download and elaborate climate data
Subjects:	Physics, Biology, Math's
Method:	● Hands-on surface temperature measurements. ● Long-term temperature data series searching, downloading and organization.

To assess climate trends and evaluate how much climate change is impacting their cities, students need to collect datasets from official local, national or global open databases. Data search, download and organization can be done during Math (or Informatic if present).

Planning and performing the activity

The activity is divided in two parts.

1) *Long-term temperature data series searching, downloading and organization:*

   Students need to find air temperature data series of their cities as much as possible updated (lag of few months before) and over a period of at least 30 years in order to calculate a robust climatology.

   They can seek information from regional or national weather service's websites or explore global datasets (see examples in the "Additional reading materials" section), learning how many types of data exist and how to select and download them, under the guidance of their science teachers and/or computer science technicians.

   Data should be organized on a spreadsheet software (Excel or similar tools) to be elaborated (Example 1 - Appendix).

2) *Surface temperature measurements:*

Through non-contact infrared (IR) thermometers (Fig. 1) or hand-held IR cameras (Fig. 2) (P.S.: these types of tools can cost from a few tens to several thousands of euros, depending on their technical features and purposes) students will measure temperature of different surfaces and materials, following the worksheet organization in two types (Example 2 - Appendix), vegetation and urban manufactured surfaces. Measurements should be repeated several times in different moments of the year, to have enough data to analyze and to reduce errors or outliers.

Fig.1 – Example of non-contact infra-red (IR) thermometer.

Fig.2 – Example of hand-held IR camera.

Print two copies of the worksheet “Surface Temperature” (Example 2 - Appendix), one for each group of students that will fill in the form the surface temperature, referring to one of the two surface types, “vegetation” or “urban manufactured”.

Students must choose a certain number of surface sub-types, assign each one a unique code, and take photos so they can carry out measurements throughout the year, always at the same locations.

Transcribe all data from the worksheets into a spreadsheet software (eg.: Excel), to better analyse and visualise the information.

Notes: teachers, together with the students, should select several areas and make field visits before the laboratory to choose the best for comparisons between different surface types (e.g. lawns, asphalted parking, buildings with different sun exposure, woody areas, deciduous or evergreen trees, etc.). Furthermore, to perform the measurements, teachers will have previously explained to the students how to use the tools (non-contact infrared (IR) thermometers or hand-held IR cameras).

Conclusion

This phase concerns the analysis of the data to obtain the results that will be discussed in the next phase.

Duration:	2 hours indoors at the end of the measurement period (10-15 days)
Tools:	● Spreadsheet software (e.g.: Excel) ● Open web applications to create charts, presentations, etc.
Technologies:	● PC or notebook
Subjects:	Math
Method:	Basic statistics for data analysis (mean, anomalies, trends, etc.)

Notes: to calculate climatology and temperature anomalies, teachers will have to provide knowledge of basic statistics (average, anomalies, etc.) in advance, in order to highlight the temperature trends of the cities.

Open web-apps could be used to make more attractive charts (see examples in the "Additional reading materials" section).

1- Long-term temperature analysis

To assess the monthly or annual temperature trend of a location, students have to follow some basic steps on the spreadsheets (e.g.: Excel):

- Calculate the monthly or annual "*climatology*": gathering data for a specific time period (at least 30 years, e.g. 1991-2020), aggregating daily data into monthly or annual mean value, and then computing the monthly (e.g., for January, February, etc.) or annual mean temperature.
- Calculate the monthly or annual "*temperature anomaly*": comparing the temperature of a single month or year with the corresponding climatology

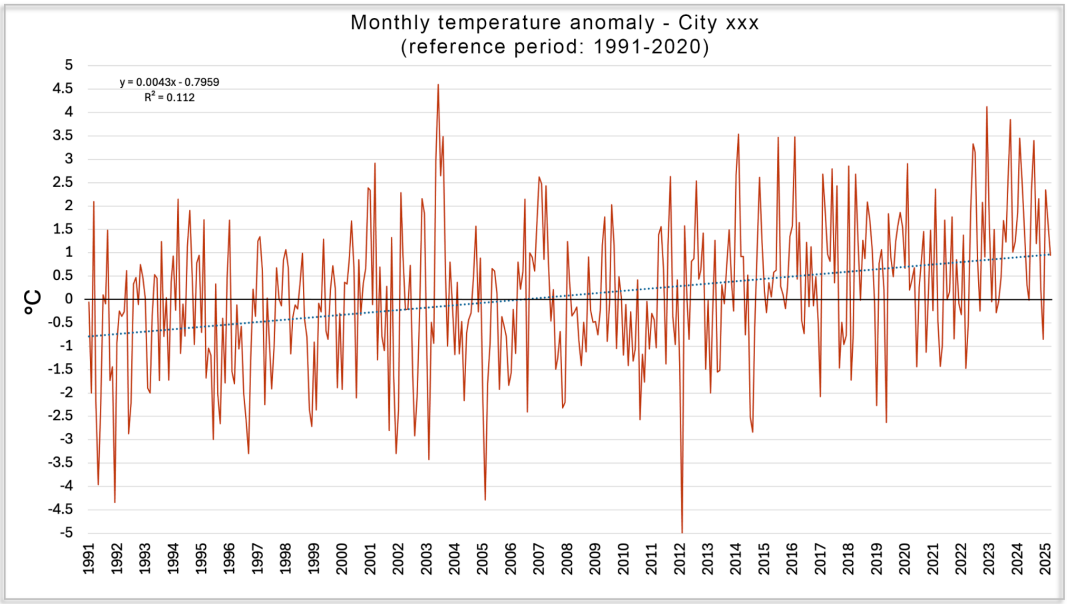
$$Tanom_i = T_i - Tclim$$

being $Tanom_i$ the temperature anomaly of a specific month (e.g., January 2024) or year (e.g., year 2024), T_i the mean temperature of the corresponding month or year (e.g., January 2024 or year 2024), and T_{clim} the climatology of the corresponding month or year (e.g., January, or 1991-2020 annual mean).

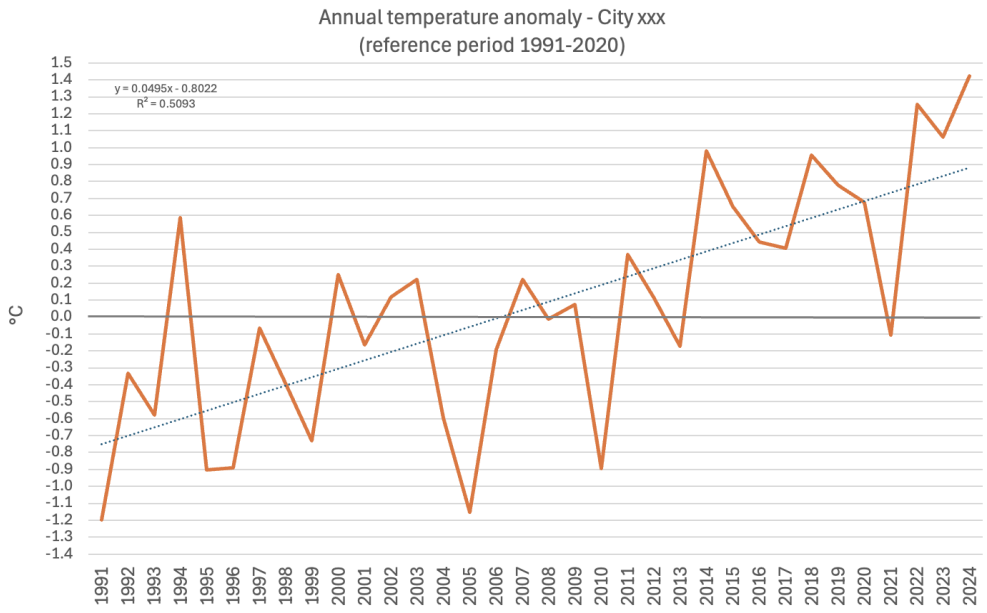
- All calculated anomalies (see table below) will be plotted to identify possible negative or positive trends occurring in the city over the last decades (see the graph below).

Students can use an open web-app to create graphs or insert the final data in the Platform to visualise the results.

Year	Month	Temperature anomaly (°C)
1991	1	0.2
1991	2	-0.1
1991	3	0.3
…	…	…
2025	10	1.2



Year	Temperature anomaly (°C)
1991	-0.8
1991	-0.4
1991	0.1
…	…
2025	1.2



2- Surface temperature analysis

Temperate data collected for vegetation and urban manufactured surfaces will be analysed and compared to identify differences.

Several types of analysis and aggregations can be done:

- A comparison between the two types of surfaces (“vegetation” vs “urban manufactured”), averaging the sub-types (Tab. A)

- A comparison between different sub-types of surfaces (Tab. B)
- A comparison between morning and midday temperatures for each sub-type (Tab. C)

Students can use an open web-app to create graphs or insert the final data in the Platform to visualise the results.

Tab. A

Surface type	Temperature (°C)
urban manufactured	**15.2**
vegetation	**12.4**

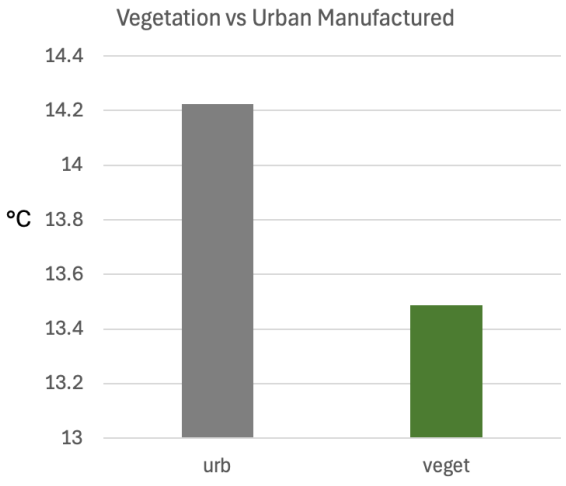
(Tab. B)

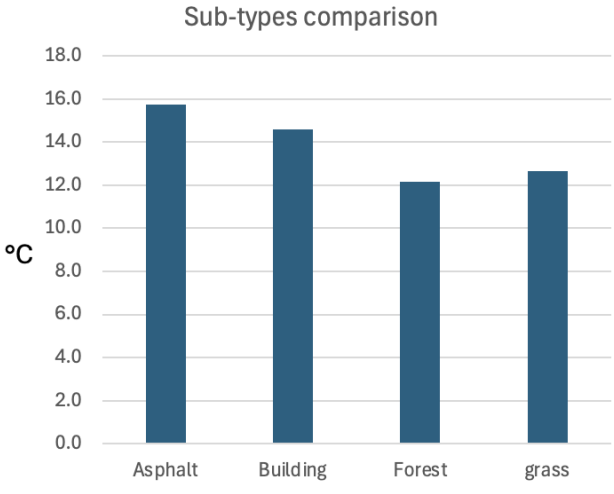
Surface sub-type	Temperature (°C)
Asphalt	**15.7**
Building	**14.6**
Forest	**12.2**
Grass	**12.6**

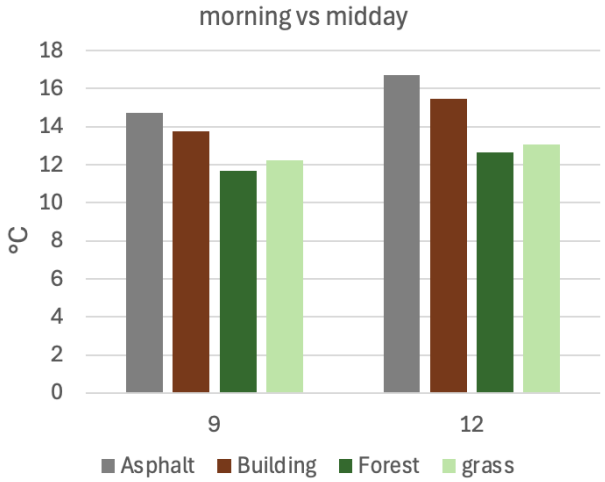
Tab. C

Surface sub-type	Hour	Temperature (°C)
Asphalt	**9**	**14.75**

	12	16.7
Building	9	13.75
	12	15.45
Forest	9	11.7
	12	12.65
Grass	9	12.25
	12	13.05







Discussion

In this phase, students reflect on the findings. They should be able to answer the original questions and reflect on them.

Duration:	3-4 hours indoors
Tools:	● Pen ● Notes ● Software's for presentations ● Video making
Technologies:	● PC ● Mobile phones
Subjects:	Science, Math, Art
Method:	Brainstorming, Working groups

Circle time or brainstorming can be useful to involve the students in the discussion phase, which will finally answer the initial questions.

Based on the results obtained by the two data analyses, each student will be able to characterise the temperature changes in their city (eventually in different areas of the city), trying to explain the reasons of the changes by bibliographical research.

Moreover, they can be able to tell if vegetation (eventually indicating which type is more effective by bibliographical research) or some characteristics of manufactured surfaces (e.g., colour, material, etc.) can be possible solutions to reduce local temperature, making cities more resilient to Climate Change.

This information can be added in the 3D model.

Outcomes:

- 3D visualisation of the project (one student group will recreate places virtually with the support of the **Platform**).
- Report, presentation, video or artistic products that can be evaluated by teachers following the school's evaluation grid

Additional materials:

- Climate datasets:

  https://era-explorer.climate.copernicus.eu/?lat=43.94&lng=11.09&plot=2

- Web-apps to create charts and maps:

  https://www.datawrapper.de/

  https://www.tableau.com/en-gb

- Web-app to create mind maps, podcasts, video and reports:

  https://notebooklm.google/

- Web-app for graphic design and creation of presentations:

  https://www.canva.com/

  https://www.mentimeter.com/

  https://kahoot.com/

- What makes cities hot? An urban Heat Island activity:

  https://mynasadata.larc.nasa.gov/lesson-plans/what-makes-cities-hot-urban-heat-island-activity

- What makes cities hot? An urban Heat Island activity:

  https://www.pbslearningmedia.org/resource/heat-islands-and-trees-interactive-lesson/pbs-nc-science/

- My NASA data: urban Heat Islands:

  https://mynasadata.larc.nasa.gov/phenomenon/creation-of-urban-heat-islands/lesson-plans

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Appendix:

Example 1

Air temperature Worksheet - Example of collection and analysis

Year	Month	Day	Mean daily temperature (°C)
1991	1	1	2.5
1991	1	2	4.2
1991	1	3	3.3
…	…	…	…
2025	10	31	
…	…	…	…

Example 2

Surface Temperature Worksheet - Example for data collection

Date	Place code	Surface types	Surface sub-types	Shade (Yes/No)	Surface temperature (°C)	Sky (Clear/Cloudy)
2025/07/05 09:00	A	Vegetation	Forest	Yes	23.4	Clear
2025/07/05 09:00	B	Urban manufactured	Asphalt	No	24.1	Clear
2025/07/05 09:00	C	Urban manufactured	Building (N exposure)	Yes	22.6	Clear
2025/07/05 09:00	D	Vegetation	grass	No	22.2	Clear
2025/07/05 12:00	A	Vegetation	Forest	No	26.3	Clear
…	…	…	…	…	…	…