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How to See from Far Away: Engaging Young Minds in Geodesy and Environmental Awareness Through Remote Sensing

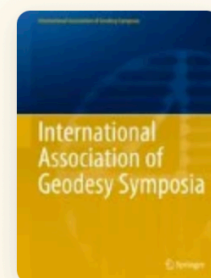
Chapter | Open Access | First Online: 14 May 2026

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How to See from Far Away: Engaging Young Minds in Geodesy and Environmental Awareness Through Remote Sensing

Sabina Mammadova, Saba Gachpaz, and Matteo Bozzano

Abstract

The increasing occurrence of flood events in Liguria has highlighted not only the importance of effective techniques for monitoring and preventing such events, but also the need to raise public awareness of these hazards. Moving towards a sustainable future, the importance of educating the younger generation on this topic is becoming increasingly evident as a key agent in the decision-making process. **As part of the Outreach group of the Department of Civil, Chemical, and Environmental Engineering at the University of Genoa, we designed hands-on activities for high school students focused on the principles of remote sensing, dedicated to monitoring environmental conditions over time and space, with a focus on vegetation for environmental hazard monitoring as a theme of the Outreach group. The outreach activity is organized in two parts.** The first introduces basic concepts of geodesy and Earth observation, including geographic reference systems, positioning, and the role of satellites in determining location and observing the Earth's surface. The second part involves a hands-on experiment in which students photographed the arrangement of natural objects they had created and computed a simple vegetation index (Green Leaf Index, GLI) to provide an indirect measure of vegetation health condition as a proxy for flood susceptibility. The initiative aims to stimulate curiosity, foster discussion on environmental monitoring, and present remote sensing as an accessible tool for understanding environmental change. **The activity has so far been implemented in six scientific high schools in Genoa. An informal post-activity questionnaire and observations by the instructors indicate a high level of student engagement and interest in similar initiatives. While the evaluation is exploratory, the results suggest that simple, low-cost experiments can effectively support outreach in geodesy and environmental monitoring.**

Keywords

Environmental education · Geospatial activity · Hands-on activities · High school · Outreach · Space technology awareness · Student engagement

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1 Introduction

Different educational programs are designed for youths to inspire and encourage them as they are the key agents to achieve sustainable development goals. Creative thinking represents the ability of generating novel ideas and is the cornerstone of innovation and problem-solving capabilities, which can be improved during school time (Jiali et al. 2025). Extra-curricular activities (ECA) mostly take place outside the regular academic program, include a wide range of activities, and are seen as an important part of students' education program. These extracurricular activities provide opportunities for students to develop skills such as team work and time managements and personal growth opportunities (Iqra et al. 2024). ECA, commonly designed and guided by College students or other social organizations, offer a variety of activities and learning programs. For instance Education for sustainable program as a form of dynamic learning was done in collaboration with the French Office of Biodiversity and some other municipalities, such as educational areas to deepen the knowledge of mid school and high school students about their local marine and terrestrial ecosystem (French Office for Biodiversity 2022). Academic engagement, as one of these activities, provides the opportunity for students to apply classroom learning to real-life situations (Iqra et al. 2024). Many researchers have shown the positive correlation between extracurricular activities to the educational outcomes, such as college retention, students satisfaction, personal development, and inter-personal skills (You 2020). The outreach initiative was launched to introduce the engineering disciplines offered by University of Genoa Department of Civil, Chemical, and Environmental Engineering (DICCA), in particularly, to final-year high school students. Its aim is to familiarize them with the research currently being carried out at DICCA, in four different disciplines, helping them develop a clearer vision of their future career paths, better understand their interests, and connect these choices with the needs of everyday life (DICCA, University of Genoa 2025). In this context, the Monitoring Group from the Geomatics Lab at the University of Genoa, as one of the subgroups involved in the DICCA outreach initiative, began its collaboration with the aim of introducing high school students to the applications of geomatics. In the Monitoring group, we aimed to provide students with an idea of the application of satellite imagery in today's life, with the emphasis on the changed environment after natural hazards, like fire or floods. The structure of the paper is as follows. First, we provide a detailed description of the experimental setup that was presented to the high school students. Next, we outline the post-processing methods applied in the experiment. Finally, we discuss the results of the activity and reflect on the outcomes of this outreach initiative.

2 Methods

The general idea of Monitoring group hands-on activity is rooted in three foundational principles: simplicity, repeatability, and student engagement. The activity is deliberately designed to focus on basic concepts that resonate with everyday experiences, thereby fostering intuitive understanding and encouraging active participation. Within this framework, optical remote sensing was selected as an introductory tool, as it represents a widely used geodetic observation technique for monitoring environmental variables when integrated within spatial reference systems (Pepe 2025). To address these constraints, a targeted activity was developed that introduces students to the fundamentals of optical remote sensing within a context that is both scientifically significant and locally relevant. The city of Genoa, together with the broader Ligurian region (Italy), serves as an exemplary case study due to its documented susceptibility to hydrological hazards, such as floods and landslides (Faccini et al. 2015). The complex history of geo-hydrological events in this region makes it an ideal setting for exploring the applications of remote sensing in hazard monitoring and environmental assessment.

2.1 Set-Up Preparation

Because flooding is one of the main natural hazards in the Liguria region, and vegetation plays a key role in mitigating flood impacts by slowing surface runoff and enhancing soil infiltration, we chose to focus the experiment on vegetation monitoring (Zhou et al. 2025). Due to the strong absorption properties in the optical wavelength, which are related to the biochemical properties such as pigment and water content, led to many researchers use optical sensors for vegetation monitoring and mitigating the need for direct measurements. Over the past two decades, different satellites with different spatial and temporal resolutions in optical range of the electromagnetic spectrum have been used widely for vegetation monitoring (Kooistra et al. 2024). Since the hue color of leaves is mainly determined by the absorption of chlorophyll, vegetation leaf color is a common indicator of plant nutrition and stress level, with greener hues generally signifying better health condition or green-yellow, for example, is a sign of reduced chlorophyll (Signorelli et al. 2023). These kinds of information can be acquired from conventional images, either growing in the lab conditions or aerial photos to evaluate changes in the greenness associated with pathogen infection, environmental stress, nutrient deficiency, and senescence (Signorelli et al. 2023; Kooistra et al. 2024). Although the experiment was performed at a laboratory scale, it was explicitly linked to geodetic Earth observation concepts, such as repeated measurements over time, spatial

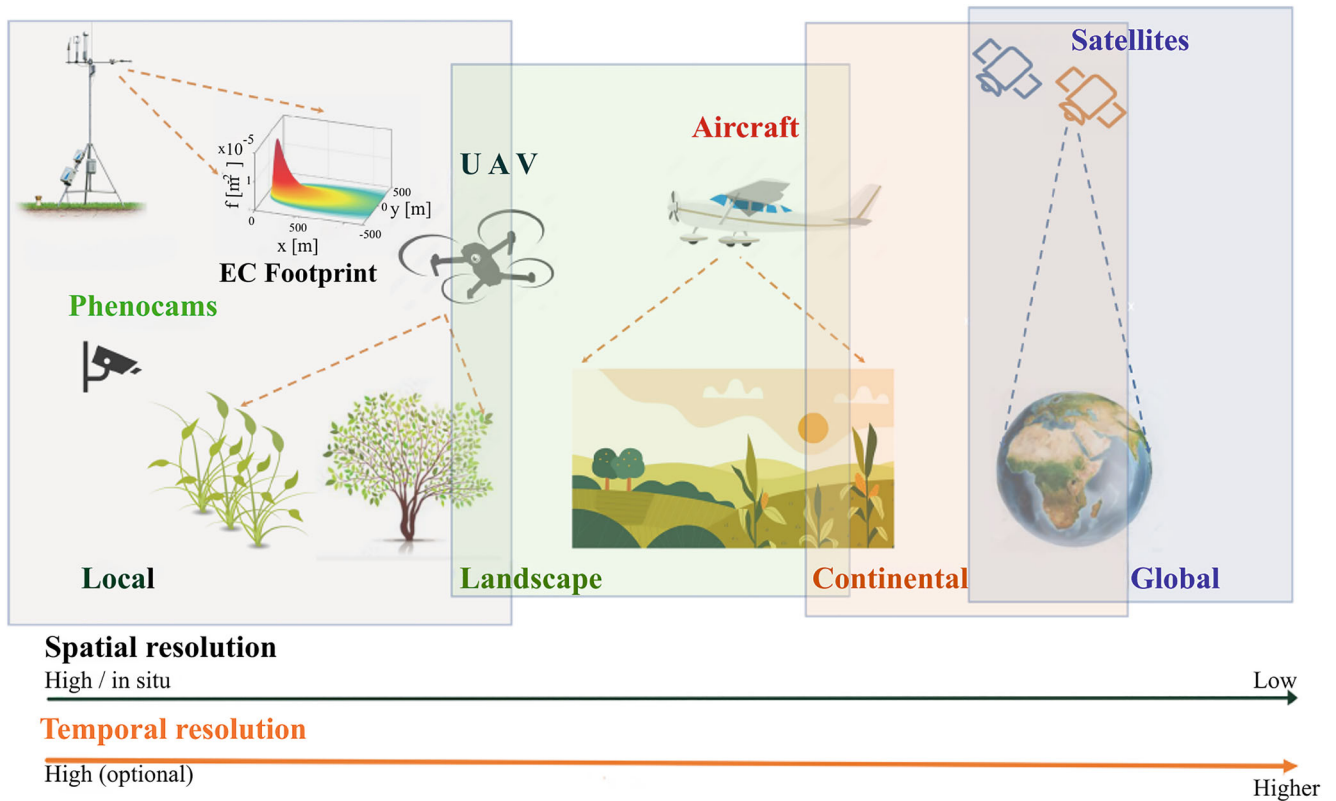


Fig. 1 Remote Sensing for vegetation monitoring. (Source: Kooistra et al. 2024)

referencing, and the comparison between in-situ, airborne, and satellite-based observations. Figure 1 summarizes the available optical sensors for capturing vegetation dynamics:

2.2 Digital Analysis and GLI Computation

After a brief introduction to the fundamentals of geodesy and remote sensing, including the role of satellite observations in measuring and monitoring the Earth’s surface and environmental changes, students were allowed to freely conduct experiments using digital imagery. Particular attention was given to vegetation as a key component of the Earth system, highlighting its importance for ecosystem health, climate regulation, and its role in reducing hydrological risks such as soil erosion and flooding. Through this approach, students were encouraged to understand how vegetation monitoring using remote sensing can support environmental management and disaster risk mitigation. To simulate optical sensors, we provided an experimental setup consisting of a height-adjustable tripod, a floor lamp, a table lamp, and various background materials such as a wooden board and pieces of cardboard (one glossy and one matte). Students were then asked to design their preferred setup by selecting a background, adjusting light intensity, choosing the camera angle, and selecting the target object for observation. Vari-

ous vegetation samples were provided, representing different conditions—healthy, unhealthy, and dead. Examples of student-made settings are visible in Figs. 2a and b. Students experimented with capturing images of different objects and under different conditions. Figure 3 shows the scenario chosen by students as black background, different leaves in different state of health. The captured images were subsequently transferred to computers for analysis.

2.3 Digital Analysis and GLI Computation

After acquiring the RGB¹ images, the students performed a basic analysis of the photos to characterize the different elements in the scenes, such as grass, leaves, stones, and reflective objects. This initial step provided a visual color map of each image, allowing them to observe how the reflectance values differ between green vegetation and other materials. As an example of real remote sensing monitoring of vegetation indices, we used the GLI,² defined as Eq. (1).

$$GLI = \frac{2G - R - B}{2R + G + B} \quad (1)$$

¹RGB: Red, Green, Blue image composition.

²GLI: Green Leaf Index.

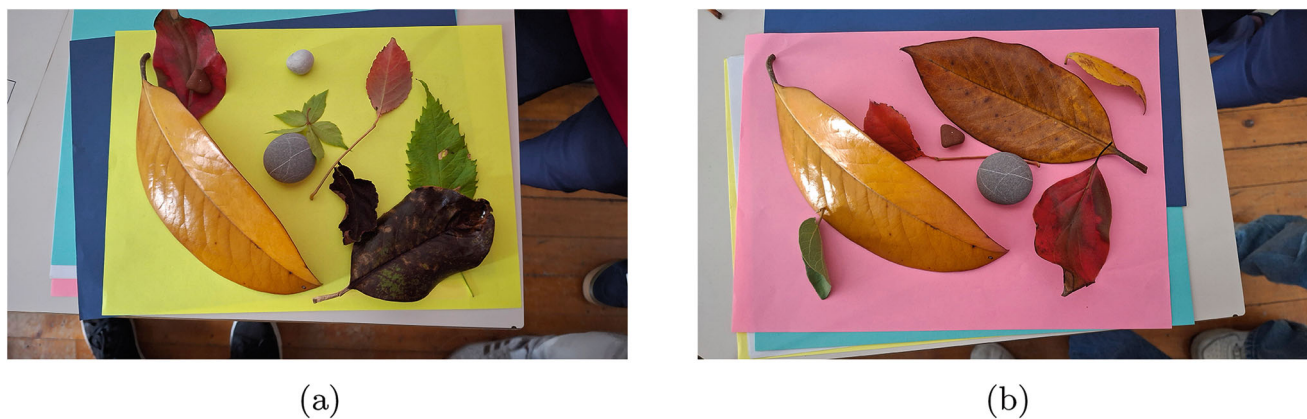


Fig. 2 Students-made setting examples, using different objects and backgrounds



Fig. 3 Near and RS platforms used for vegetation monitoring

where R , G and B are the red, green and blue channels of the image, respectively. This index is a simple calculation based on RGB values of pixels for input image and does not require advanced computational skills (Signorelli et al. 2023). The students, working in groups on classroom computers, imported their images into QGIS and computed the GLI using the Raster Calculator processing tool. An equivalent workflow was also provided in Python, beginning with reading the RGB image and then calculating the GLI, with the result displayed as a color map. This

was offered as an optional advanced activity to illustrate how quantitative information can be extracted from imagery programmatically. The proposed activity aimed to illustrate how remote-sensing software (QGIS in the specific case) and simple Python scripts can support environmental monitoring.

3 Results

The GLI values were first constrained to the valid range of -1 to 1 and then normalized for visualization. Based on these pixel values, a color-coded map was produced to indicate vegetation status, ranging from healthy to stressed or absent vegetation, providing students with an intuitive representation of plant health derived from simple RGB imagery (Zhao et al. 2018). As the last step of the processing part, students got the colored representation of their images and compared the GLI values with the objects they took photo of them. This comparison shows how indices can be used for vegetation monitoring. This project is fairly recent, and therefore it has only been proposed in six scientific high school in Genova so far. Our assessments up to this point is only based on our observation through the completed activities. At the end of each session, students were invited to complete an anonymous feedback questionnaire via a QR code displayed in class (Google Forms). The questionnaire was used as an informal evaluation tool to collect perceptions of all activities (e.g., organization, interest, clarity, and willingness to participate again) carried out by four thematic groups. A total of 129 responses were collected (some questions received 128 responses). Most students (87%) said they had no language-related problems during the activity. However, this should not be interpreted as a measure of satisfaction, since satisfaction was not directly assessed. On a scale from 1 to 5, where 5 represents the highest level of satisfaction, the results of the survey are reported in Table 1.

Table 1 Students' satisfaction level with the activities

No	Survey question	No idea	Unsat.	Neutral	Sat.	Very sat.
1	Rate the organization of the initiative	–	–	14%	53.5%	32.6%
2	Rate your overall satisfaction with the initiative	–	0.8%	17.8%	45.7%	35.7%
3	Rate the explanatory skills of the researchers involved	–	4.7%	20.9%	48.8%	25.6%
4	Rate your interest in the topic	–	7.8%	29.5%	39.5%	21.7%
5	Did the initiative help you decide what to study at university	12.4%	30.2%	32.6%	15.5%	9.3%

Note: Unsat. = Unsatisfied; Sat. = Satisfied; Very sat. = Very satisfied

In addition to the satisfaction assessment reported in Table 1, the survey included further questions aimed at exploring students' perceptions of engineering fields and their interest in engineering studies. The open-ended responses reflected students' personal perspectives on the engineering topics. However, a detailed qualitative analysis of these comments was beyond the scope of this paper. In addition, some responses were too brief, unclear, or irrelevant to be meaningfully analyzed.

4 Conclusion

While the hands-on activity focused on optical imagery, it was framed within a broader geodetic perspective, highlighting how remote sensing measurements rely on geodetic reference systems to support environmental monitoring, including vegetation dynamics and flood-related hazards (Pepe 2025). The outreach initiative was designed to introduce high-school students to geodesy, remote sensing, and environmental monitoring through a short, hands-on activity centered on optical imaging and simple data analysis. By linking local geo-hydrological hazards to practical experimental tasks, the project made abstract concepts, such as satellite sensing, vegetation indices, and change detection, more tangible and relevant for students. The student-centered and project-based structure also created space for teamwork, discussion, and creativity, which are key components of STEM competence. The fact that the vast majority of participants expressed willingness to join similar events again suggests that the activity was successful in motivating students and in presenting engineering and earth observation as accessible and meaningful career paths. Beyond the impact on school students, the initiative also provided valuable training for the involved PhD candidates and young researchers, who had the opportunity to develop their skills in science communication, instructional design, and interaction with non-specialist audiences. This dual benefit—for both learners and early-career scientists highlights the role of outreach activities as an integral component of university missions in STEM. Overall, the survey results suggest that simple, low-cost outreach activities can effectively engage young people

with geosciences and support informed, sustainable future career aspirations.

Competing Interests The author(s) has no competing interests to declare that are relevant to the content of this manuscript.

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