Technical Report

ISPRS 2024 ISPRS Educational and Capacity Initiatives

From Forests to 3D Digital Models: training new generations on 3D geodata surveying and analysis (3DForTrain)

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Abstract

The Earth Sensing Summer School 2025, funded by the ISPRS Education and Capacity Building Initiative (ECBI), was held in San Vito di Cadore, among the Dolomites, from 7 to 13 September 2025. The event offered an immersive and hands-on learning experience in geomatics, remote sensing, and Earth observation for environmental and forestry applications. Early-career researchers and advanced students participated in a week of intensive field and laboratory activities focused on data collection, processing, and analysis using a wide range of sensors and methods — including surveys with Remotely Piloted Aircraft System (RPAS), mobile mapping, portable laser scanning, InSAR, and satellite optical and radar data.

Guided by international experts, participants worked in six assignments in multidisciplinary teams addressing real-world challenges such as 3D forest modelling with laser scanning and Nerf/Gaussian Splats, ecosystem mapping, Earth surface movement and landscape monitoring. The programme combined expert seminars, collaborative work, and field campaigns in a stimulating alpine environment. By promoting technical skills, teamwork, and open exchange of knowledge, the Earth Sensing Summer School successfully advanced the ECBI mission of strengthening global capacity in photogrammetry, remote sensing, and spatial information sciences — empowering a new generation of researchers to map and understand the Earth's dynamic systems.

Report

Training new generations on 3D geodata surveying and analysis (3DForTrain) project main outcome was the Earth Sensing Summer School 2025. The summer school took place in the Dolomites (Eastern Italian Alps), in the municipality of San Vito di Cadore (Province of Belluno). Located at approximately 1010 m a.s.l. San Vito lies at the foot of two Dolomite peaks, Mount Antelao (3.264 m) and Mount Pelmo (3.168 m)

In the year 2024 some pre-sampling was carried out with RPAS lidar flights and portable lasers scanners. Some possible study areas were surveyed. This was necessary to have data also in case of bad weather conditions during the summer school.

The activities were postponed to 2025 for two main limitations: (i) weather conditions that did not allow to carry out the destructive sampling in the time-window desired and (ii) bark beetle (*Ips typographus*) attacks that imposed to limit the destructive sampling only on trees that are affected by this insect. As a matter of fact, the initial regulations in the area imposed not to cut any healthy trees. In our proposed activities, destructive sampling must be carried out on healthy trees so that the modelling of taper, volume and biomass at tree components equations (e.g., trunk, branches, leaves, etc.) reflects a healthy tree.

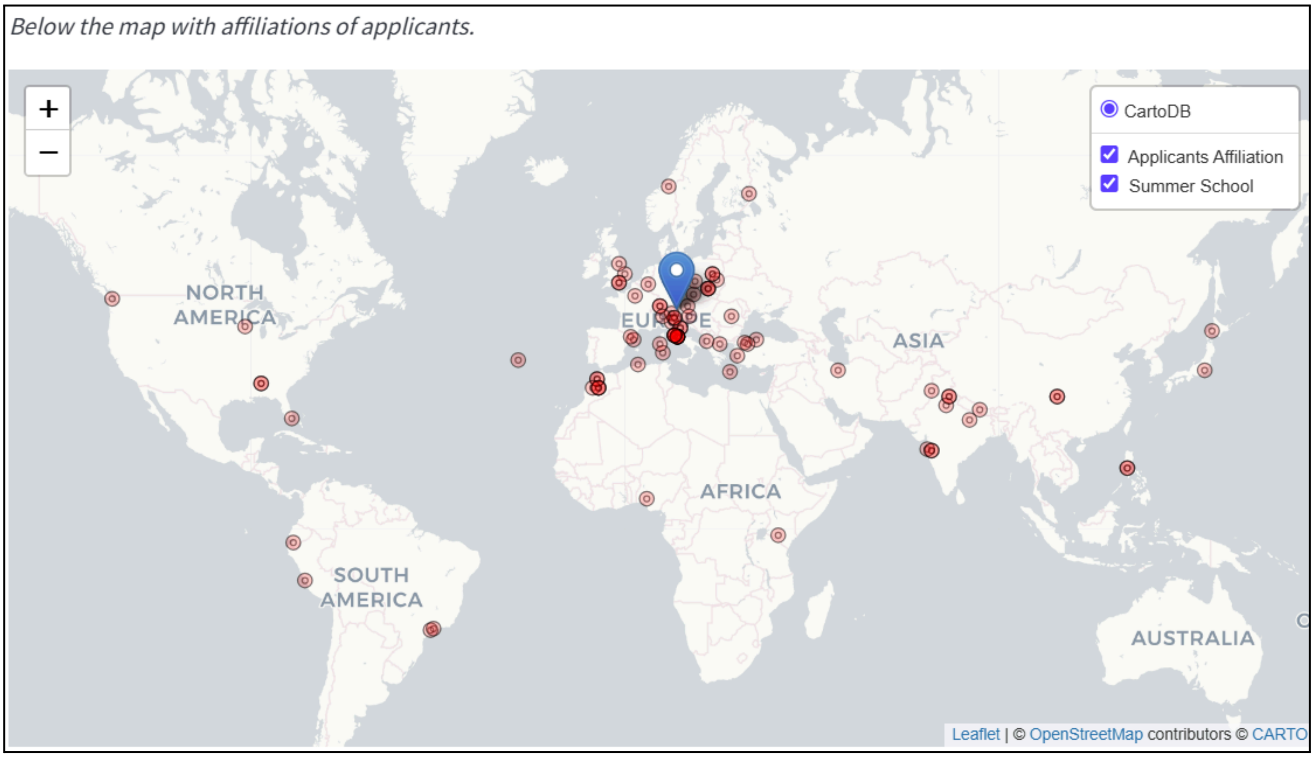
Summer school

The Summer School was thus re-scheduled for September 2025 and took place from 7 to 13 September 2025.

Official website https://www.cirgeo.unipd.it/est/earth-sensing-summer-school.html

Photo Album https://photos.app.goo.gl/BjRqdXSnGC9Az8yi6

More than 100 applications arrived and the shortlisted candidates were globally distributed and their characteristics are illustrated in the tables and figures below.

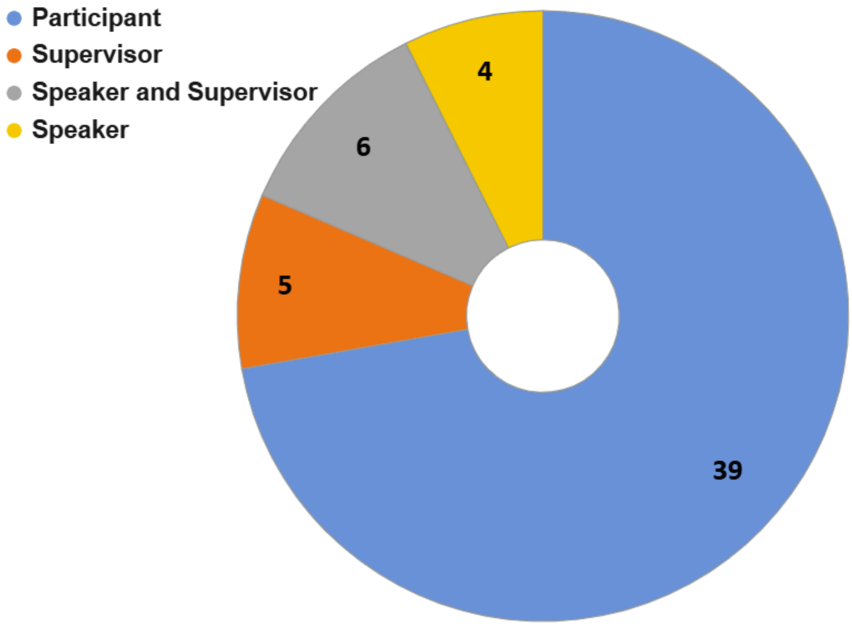


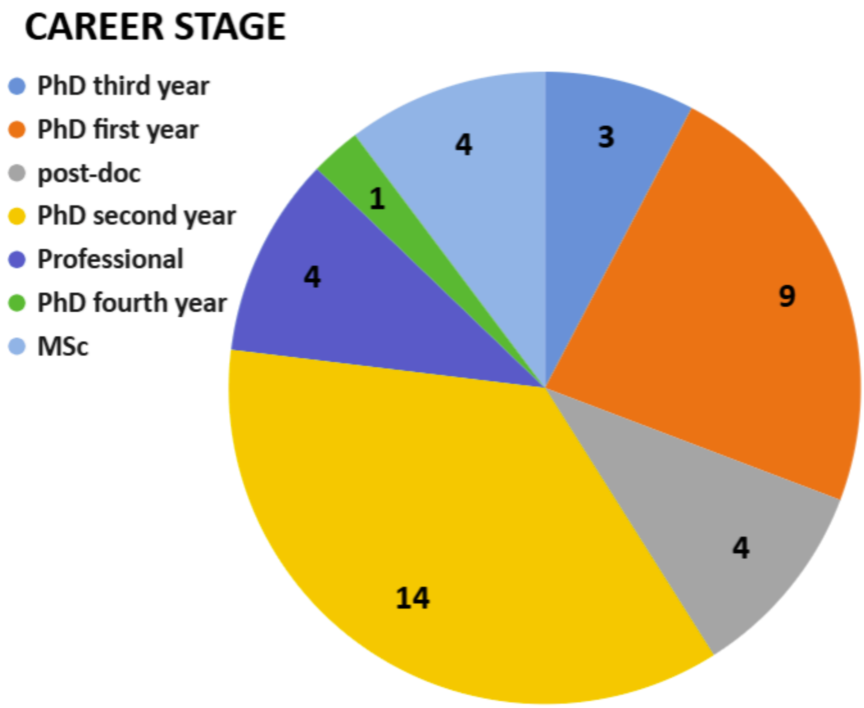
Map with applicants' affiliations locations

Overall country distribution of participants (F = female, M = male). Countries outside the continent where the school was held are highlighted in bold.

Country	F	M	Tot
Belgium	1		1
Brasil	**1**		**1**
Canada	**1**		**1**
China	**1**		**1**
Croatia		1	1
Finland		1	1
France		2	2
Germany	1		1
Ghana		**1**	**1**
Greece	2		2
India	**1**	**1**	**2**
Italy	8	5	13
Japan	**2**		**2**
Malaysia		**1**	**1**
Poland	2	4	6
Romania		1	1
Switzerland	1	1	2
TOT	**21**	**18**	**39**

NUMBER OF PARTICIPANTS AND SUPERVISORS





The objective of this summer school was to bring together early stage researchers that are interested in topics pertaining to geomatics, spatial science and remote sensing of the Earth in particular. Six different group assignments with two scientific supervisors each were implemented. The objective was to focus on different aspects of sensing technologies. The following were the topics addressed with a brief description - for further details please refer to Pirotti et al. (submitted to ISPRS 2026 Congress in Toronto) “Earth Sensing in the Dolomites: A Summer School for Capacity Building and Collaboration”:

Assignment A - The Battle of the Beams.

The Battle of the beams focused on comparing the performance of different LiDAR sensors for forest structure assessment and regeneration analysis. The activities were conducted in a mixed coniferous stand and the group compared Terrestrial Laser Scanning (TLS), Mobile Laser Scanning (MLS), and Unmanned Aerial Vehicle Laser Scanning (UAV) data collected over a representative plot of 2,500 m². The main objectives were to assess differences in spatial accuracy and coverage among sensors; to derive forest structural parameters such as stem density and canopy gap fraction; and to develop a sapling suitability map identifying potential microsites for natural regeneration based on terrain and canopy characteristics.

Assignment B - Ground movement from RADAR InSAR Challenge.

The Ground movement from RADAR InSAR Challenge aimed to familiarize participants with radar interferometry techniques for ground motion analysis and landslide monitoring. Using SARAXIO©, a newly developed InSAR processing software, the group generated and analyzed deformation time series from Sentinel-1 data over the southern slope of Mount Antelao (San Vito di Cadore, Italy), an area affected by active landslides. To assess SARAXIO© 's performance and reliability, the outputs were compared with validated products from the European Ground Motion Service (EGMS). Participants processed radar images following the main steps of InSAR workflows, co-registration, interferogram generation, phase unwrapping, and multi-temporal analysis, while testing the influence of several parameters, including velocity models, coherence and amplitude dispersion thresholds, and the selection of Persistent (PS) and Distributed Scatterers

(DS). By adjusting these parameters, they explored how different processing choices affect the detection and characterization of slope instabilities.

Assignment C - Urban 3D modelling Challenge

The Urban 3D modelling Challenge aimed to acquire and integrate point clouds from heterogeneous sources, combining Mobile Laser Scanning (MLS) sensors and Unmanned Aerial Vehicle (UAV) photogrammetry, in order to evaluate the effectiveness of this combination for creating a dense and accurate 3D representation of the urban area of San Vito di Cadore (Italy). The resulting dataset is processed and analysed in different environments to assess clearances and identify obstacles such as architectural barriers, discontinuities, slopes, bottlenecks, and street furniture. The outcomes include a replicable end-to-end workflow for survey and data processing, as well as quantitative indicators and thematic maps designed to support urban planning and decision-making. The following data were used a) Point cloud from DJI Mavic 3 b) Point cloud from DJI Matrice LiDAR c) Point cloud from Lixel L2 Pro d) Point cloud from Stonex (final merged product)

Assignment D - Remote Sensing and Environmental Modelling Challenge.

Remote Sensing and Environmental Modelling Challenge parameterised the process-based soil–vegetation–atmosphere transfer (SVAT) model LWF-Brook90, based on the original Brook90 model (Federer et al., 2003; Schmidt-Walter et al., 2020). This enabled simulation of daily stand-level water balance for a south-facing coniferous forest near San Vito di Cadore (Belluno, Italy). The model integrated local meteorological drivers, field-measured soil properties, and forest stand structure with multi-sensor remote sensing. Soil-horizon characteristics (texture, bulk density, organic carbon, coarse fragments) were used to construct the multilayer profile, with regional gridded pedology filling remaining gaps (Hengl et al., 2017) using Ad-Hoc AG Boden (2005) classification. Vegetation parameters were derived from terrestrial laser scanning and airborne LiDAR (tree IDs, height, DBH); LiDAR point clouds for the sample plot were processed in CloudCompare v2.13.12 using the 3DFin plugin v4.6.0 to extract stand-structure metrics suitable for model parameterisation (Laino et al., 2024). Optical indices (NDVI, NDMI, NDWI, MSI) from Sentinel-2 were computed to assess vegetation dynamics and water stress, and Harmonised Landsat–Sentinel-2 (HLS) surface reflectance provided a temporally dense 30-m record (2–3-day global revisit) to support time-series analysis. For radar, Sentinel-1 C-band data acquired in Interferometric Wide (IW) mode (dual polarisation VV, VH) were accessed via Google Earth Engine (COPERNICUS/S1_GRD), which supplies thermally de-noised, radiometrically calibrated, and terrain-corrected backscatter together with incidence angle; dual-polarisation metrics (e.g., cross-ratio and RVI) were derived to screen anomalies.

Assignment E - GeoAI for Environmental Analyses.

GeoAI for Environmental Analyses trained an instance-segmentation model to map forest, grassland, and related land-cover types from high-resolution aerial imagery using the Ultralytics YOLOv11 framework (Khanam et al., 2024), following the assignment workflow of image selection, class definition, annotation/augmentation, training, and evaluation on unseen areas. Training data were polygon-annotated in Roboflow (Lin et al., 2022) and augmented (rotations, flips, illumination changes) to improve class balance and diversity; inference and visualisation were carried out in QGIS after exporting the trained network to ONNX (via the DEEPNESS plugin/auxiliary scripts). Three incremental experiments were run in total.

Assignment F - Photogrammetry and Nerf-Gaussian Splats in Forest Environments.

The Photogrammetry and Nerf-Gaussian Splats in Forest Environments assignment aimed to explore, apply, and compare three advanced 3D reconstruction techniques, Photogrammetry, Neural Radiance Fields (NeRF), and Gaussian Splatting, for use in forest environments. NerF Model - Nerfacto, Splatfacto and PostShot - 3D Gaussian Splatting were tested against classical photogrammetry processing and portable laser scanning with Stonex x120go SLAM.

References

Pirotti et al. (submitted to ISPRS 2026 Congress in Toronto) “Earth Sensing in the Dolomites: A Summer School for Capacity Building and Collaboration”