20. From Hazard Mapping to WebGIS Decision Support: Integrating Multiscale Geospatial Data for the Documentation of Small Mountain Rural Settlements (SMRS) in the Italian Alps

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Small Mountain Rural Settlements (SMRS) in the Italian Alps combine demographic fragility, accessibility constraints, and exposure to hydrogeological hazards. This paper presents a multiscale GIS workflow for integrating heterogeneous institutional geodata and transforming them into comparable decision-support information. The method combines settlement, hazard, road-network, and building-footprint datasets across four nested scales: national, regional, territorial, and settlement. Particular attention is given to the data harmonization from multiple sources and the structural incompatibility of avalanche datasets from Piedmont and Valle d'Aosta. Rather than imposing a common ordinal classification, the workflow preserves native attributes and derives binary exposure indicators that can be compared across regions. These indicators are combined with access-corridor exposure in a Hazard Constraint Score (HCS, 0-6). The workflow is tested in Ollomont, Macugnaga, and Elva and operationalized through a WebGIS proof of concept. Results show that the approach supports cross-regional comparison while retaining building-level detail and makes explicit the trade-offs introduced by data harmonization.

Integrating GIS, Impact Chains and Participatory Mapping for Territorial Vulnerability Assessment in Castel Volturno

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Abstract. This paper presents an integrated geomatics framework for assessing territorial vulnerability in Castel Volturno, a low-lying coastal and riverine municipality in southern Italy. It combines GIS-based spatial analysis, a qualitative Impact Chain and a participatory mapping protocol designed in ArcGIS Survey123. The framework distinguishes mapped hazard and potential exposure from interpretative impact pathways and social dimensions requiring additional evidence. The empirical GIS analysis uses updated Flood Risk Management Plan (PGRA) hazard data and Campania Region DBT/CTR 2020 building and road-network layers. River-flood scenarios cover substantial portions of the municipality and intersect a large share of mapped buildings and road infrastructure; the PGRA Sea Water component, representing marine inundation, is restricted to the coastal sector and involves comparatively limited exposure. The Impact Chain relates these spatial conditions to possible mobility disruption, housing damage, temporary isolation, economic loss and recovery processes. Its relationships are qualitative and have not been independently validated as a causal model. Coastal erosion remains conceptual and is not quantitatively assessed. Survey123 is a protocol for a subsequent empirical phase: participatory data are not yet available for empirical analysis. The framework supports interpretation and the identification of candidate adaptation options without inferring actual impacts or measured vulnerability from spatial intersections.

Keywords: GIS, Impact Chains, Participatory Mapping, Territorial Vulnerability, Castel Volturno, Coastal Risk.

38. UAV-Based Through-Water Photogrammetry of Submerged Archaeological Structures: Effects of Ground Control and Refraction Correction

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Abstract non presente nel PDF.

147. Tuning Composite2Change for Forest Disturbance Detection across Europe

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Satellite observations support forest disturbance monitoring over large areas, but the identification of disturbance events from spectral time series is sensitive to methodological choices. This study examines how temporal segmentation parameters and disturbance magnitude thresholds influence the performance of Composite2Change (C2C) across European forests. Using annual Landsat Normalized Burn Ratio (NBR) time series, we evaluated ten segmentation configurations and five magnitude thresholds against a photointerpreted reference dataset for 2000–2023. Performance was assessed using annual pixel-level confusion matrices, summarised through overall accuracy (OA) and the Matthews correlation coefficient (MCC). The highest mean annual MCC (0.404) was obtained with a maximum fitting error of 0.055, a spike tolerance of 0.85 and an NBR magnitude threshold of −0.3, yielding a mean OA of 90.58%. Configuration rankings varied with the magnitude threshold, while less restrictive thresholds reduced omission errors at the expense of increased commission. These findings highlight the interaction between trajectory fitting and event selection in C2C and support their joint evaluation when selecting parameters for forest disturbance monitoring.

52. Beyond BIM modeling: from 3D survey to Environmental Sensor Data Integration for Building Monitoring. The Case Study of Energy Center

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The increasing availability of reality-capture technologies and environmental monitoring systems offers new opportunities to develop integrated digital environments for building management. However, geometric survey data, Building Information Models (BIM), and sensor measurements are frequently managed as separate information layers, resulting in limited interoperability. This research presents a workflow that integrates 3D metric survey, Scan-to-BIM methodologies, and a simulated time-varying exchange of environmental data within a BIM-based framework. The selected case study is the Energy Center building of Politecnico di Torino, where 63 virtual sensor instances were configured with room assignments, dedicated parameters, and unique Registry IDs. At this stage, no live sensor streams or historical Energy Center measurements were used. A local MQTT-JSON-Dynamo chain was tested with simulated temperature, humidity, and air-quality values in a conference-room demonstrator. The results verify identifier-based association, parameter updating, and colorbased visualization without claiming an operational monitoring deployment. The study provides a methodological basis for future integration of physical sensor streams and for the development of accessible three-dimensional building-monitoring environments.

14. Coastline Dynamics and Urban Erosion Risk Assessment in Reggio Calabria Using Sentinel-2 Data and Artificial Intelligence

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Italian coastal areas, especially those located in Southern Italy, are increasingly affected by degradation processes that influence shoreline stability and coastal landscape evolution. The Strait of Messina, due to its strong marine currents, wind exposure, and intense coastal urbanization, is highly vulnerable to coastal erosion, which causes significant variations in shoreline position and may increase risk for urbanized areas. In this context, the present study aims to develop an integrated approach to analyze and predict coastline dynamics and to assess erosion-related risk along the urban coast of Reggio Calabria, also considering possible scenarios of future coastal morphological evolution. The proposed methodology combines multitemporal remote sensing analysis, shoreline change assessment, and AI-based predictive modeling. Multitemporal analysis was carried out using Google Earth Engine (GEE) and QGIS software. Within GEE, median Sentinel-2 composite images were generated for the summer period, from June to August, for each year between 2018 and 2025. The Normalized Difference Water Index (NDWI) was applied to enhance the distinction between water and land surfaces and to obtain binary water/land masks. These masks were then converted into vector layers and compared with a reference shoreline shapefile to reconstruct historical shoreline positions. Starting from the extracted shoreline layers, transects perpendicular to the reference shoreline were generated to quantify shoreline displacement over time. Several shorelines change indicators were calculated, including Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR). These indicators provided the basis for developing a predictive dataset aimed at estimating future coastline dynamics Future scenarios were also evaluated, including increased coastal urbanization, coastal protection measures, and renaturalization strategies. The proposed approach supports the identification of high-risk areas and mitigation measures for sustainable coastal management in Reggio Calabria.

148. Multi-Robot Systems and Edge Computing for Dynamic Collaborative Geo-Mapping

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Fleets of robots can map areas that are hard to reach, but their shared map changes constantly as the robots explore and the environment changes. Keeping only the current map loses the earlier maps on which decisions were taken, together with the robot data behind them. This paper proposes a three-layer framework that keeps this history. Robots run Simultaneous Localization and Mapping onboard and send their maps to edge servers. Each edge server fuses the maps of its robots, and a mission service fuses the edge maps into a global map. Edge servers and the mission service publish versions of their maps that never change, and each version records the versions it was built from. Any global version can therefore be retrieved by time and traced back to the robot maps behind it. Publication policies decide when a new version is published, either at regular intervals or after a given amount of change. The framework was tested in 20 simulated scenarios with three robots. Every checked global version could be rebuilt from its sources and no edge version was lost during network outages.

150. Dafne: A Digital Archive and WebGIS for the Historical Management of Minor Hydrographic Networks in Central Tuscany

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The DAFNE (Documents and Historical Cartography of Watercourses in Central Tuscany: A Digital Archive and WebGIS for the History of Water Governance in Support of Sustainable Water Resources Management and the Protection of Cultural and Landscape Heritage) research project, funded by the Tuscany Region and the Medio Valdarno Land Reclamation Consortium, aims to undertake a diachronic reconstruction of the minor hydrographic network of central Tuscany through the examination of historical documentary sources, primarily institutional records, with the ultimate objective of supporting sustainable land management and landscape conservation The reconstruction of the historical hydrographic network relies on the integration of contemporary geospatial data with information extracted from archival sources that differ in format, document type, and originating institution. This process presents four main methodological and technical challenges: (1) identifying and cataloguing relevant historical sources; (2) digitising and standardising the information they contain; (3) designing and implementing an integrated geodatabase capable of linking historical and contemporary geospatial data; and (4) developing a WebGIS interface to support diachronic analysis of the hydrographic network..

71. The military terrain lexicon at El Alamein: a Vision- Language Model analysis of the multi-national WWII cartographic corpus

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The El Alamein battlefield (Western Desert, Egypt) was mapped between July and November 1942 by every belligerent, and its cartography offers an unusual opportunity to compare how different armies described the same desert terrain. This paper analyses a corpus of 21 German, British and Commonwealth, Italian and post-war US maps through a workflow based on multimodal Vision-Language Models. The maps were cut into 679 tiles and processed with a fixed prompt returning every terrain term in structured form; the reliability of the extraction was measured against a model-assisted reference set of 342 terms from six maps, checked blind by one of the authors. Claude Opus 5.5 reached an F1 score of 0.94 with a character error rate of 3%, and two independent runs agreed on 94% of the terms, while Claude Sonnet 5.5, a lowertier model of the same family, came close with an F1 of 0.91. The 4,277 terms extracted from the corpus show that a single descriptive repertoire, inherited from the Survey of Egypt and from Arabic geomorphological vocabulary, circulated among the armies through captured base maps, reprints and translations, and that German cartography enriched it with observations by its military geologists. A georeferencing of three sheets and a comparison with the geomorphological map show that depression and ridge terms fall near the corresponding landforms about six and four times more often than expected from their area.

72. Mapping the cancellation of the El Alamein conflict landscape through a multi-temporal assessment of anthropogenic impacts based on open-access satellite imagery

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Publicly accessible satellite imagery offers opportunities to document anthropogenic transformations in desert landscapes where field monitoring is limited. This study aims to identify the main processes at work in the northern Egyptian Western Desert, quantify their spatial development and classify their (i) environmental, (ii) morphological and (iii) cultural or archaeological implications. The analysis focuses on urban expansion, irrigated agriculture, oil extraction, quarrying and transport infrastructure, including their interaction with desert landforms and World War II remains. The method combines satellite repeat photography and GIS analysis across eight study areas and one comparison area. Historical Google Earth Pro imagery and Esri World Imagery Wayback were integrated with Sentinel-2 Level-2A data. Images were georeferenced and organized in a multi-temporal geodatabase, from which feature counts, lengths and areas were derived to describe the extent and evolution of anthropogenic interventions. The Normalized Difference Vegetation Index (NDVI) supported the identification of cultivated surfaces, while spatial overlay assessed the overlap between construction or quarrying footprints and possible military remains. These observations were interpreted through three complementary impact categories, distinguishing measurable surface changes from inferred environmental degradation and heritage loss. In the New Alamein study area, mapped agricultural land increased from 3.28 to 135.58 km² between 2007 and 2025, while along the Rod El Farag–El Dabaa corridor 285 of the 741 possible wartime positions mapped in 2012 (38.5%) lay within construction or quarry footprints by 2025. The results reveal spatially uneven transformations and show that combining image comparison with GIS indicators supports preliminary impact assessment.

28. Assessing Railway Vulnerability to Flooding via Flow- Based Temporal Betweenness Centrality: Evidence from the Italian Network

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This study proposes a GIS-based, flow-aware and time-sensitive framework for identifying flood exposed elements of systemic importance in the Italian railway network, integrating the national timetable, the infrastructure model and the ISPRA high-probability flood-hazard map. Scheduled train movements are represented as a temporal graph, and node importance is measured through a Flow-Based Temporal Betweenness Centrality. Earliest-arrival paths capture timetable feasibility, while each origin-destination relation is weighted by the number of daily direct services connecting its endpoints. Centrality is estimated at national scale through importance sampling with Horvitz-Thompson correction, computed on the intact network and subsequently intersected with flood exposure. The results show a geographically concentrated hierarchy of systemically important nodes, whereas exposed high-centrality nodes form a distinct spatial pattern. The network-wide ranking is strongly stable between a weekday and a non-working day. The spatial analysis further shows that 1,114.66 km, corresponding to 6.01% of the analysed network, intersect the P3 hazard layer, while most exposed sections are affected along less than one quarter of their length. A preliminary damage scenario, removing the 2.3% of track sections with at least half of their length exposed to flooding, leaves the top of the ranking intact but removes most critical nodes from the functional network, shifting the rerouted demand onto adjacent corridors. The framework provides an ex-ante indicator of flood-exposed systemic criticality and supports the prioritisation of detailed asset assessment and resilience interventions.

30. Integrated Aerial and Terrestrial Mapping for OpenDRIVE-Based High-Definition Road Maps

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High-definition road maps require consistent geometry and semantics, yet no single survey platform guarantees complete observations of an urban road environment. An integrated workflow was developed at the Mostra d'Oltremare in Naples to evaluate acquisition and processing methods for high-definition road maps generation. UAV photogrammetry and airborne LiDAR were combined with vehicle-based mobile mapping and portable simultaneous localization and mapping systems. A GNSS control frame-work supported georeferencing and comparison of the datasets. Processing comprised point-cloud cleaning and integration, terrain and orthophoto production, road-element classification, and controlled compilation of an ASAM OpenDRIVE network in RoadRunner. The mobile mapping provided the operational basis for road-corridor acquisition. Automation was most useful in preprocessing and candidate extraction; road connectivity and semantic attribution required supervised modelling. The results support an acquisition strategy centred on mobile mapping, with aerial and portable systems selected according to coverage and accessibility requirements.

2. Automated Streetlight Census from Street-Level Imagery: Integrating Computer Vision, Depth Estimation and Geospatial Processing

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Public lighting is one of the most pervasive urban infrastructures, playing a crucial role in urban management, yet it remains largely undocumented in digital form: no extended catalogues of street poles and lamps currently exist, and their mapping and maintenance still rely on time-consuming and costly field surveys, dependent on manual data collection, integration of heterogeneous sources (GIS, street-view imagery, satellite data) and extensive post-processing. This work presents StreetLightScanner, an automated pipeline for detecting, classifying and geolocating streetlight infrastructure from street-level images collected with a smartphone or a camera-car. Unlike traditional photogrammetric approaches, focused on rigorous geometric reconstruction through calibrated metric cameras and bundle adjustment, the proposed framework adopts a geometry-relaxed paradigm, achieving operational robustness through redundancy, semantic segmentation and probabilistic aggregation across heterogeneous observations, and thus reducing the dependence on controlled acquisition geometry and explicit camera calibration. Methodologically, the system is built around a mask-aware classification core: streetlight components are detected and segmented with SAM3, exploiting its open-vocabulary, text-driven Promptable Concept Segmentation, and the resulting masks are propagated into a custom ConvNeXt V2 classifier implementing masked pooling. This design preserves the structural cues of thin, elongated poles and suppresses the background clutter that degrades naive crop-and-classify pipelines. Two dedicated classifiers, for pole geometry and luminaire typology, are trained on a custom-annotated dataset and matched to the categories of the target municipal lighting register. Around this core, a modular architecture adds AI-based monocular depth estimation and GPS-based geometric modelling, supporting three operational modes - single-image campaigns, crowdsourced street-view imagery and full Structure-from-Motion reconstruction. Redundant observations are consolidated through a statistical ⋆Corresponding author. eandreotti@fbk.eu L. Bridi et al. consensus mechanism and exported as GIS-compatible assets. Validated on a real-world case study in Mattarello (Trento, Italy), the system substantially reduced field-survey effort while detecting streetlights at ∼ 93% F1 and geolocating them within ∼1 m (median) after a lightweight GT-anchored correction. Future developments will address dynamic acquisition scenarios and additional classes of urban assets.

64. EO4Des: From Earth Observation to Decision Support for Desertification Risk Management in Mediterranean Landscapes

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Desertification monitoring in Mediterranean environments requires the interpretation of land-surface responses generated by interacting climatic forcing, vegetation dynamics, soil conditions and land management. The resulting spectral and thermal signals vary with season, spatial support and observation conditions, which limits the reliability of approaches based on isolated indicators or direct aggregation of heterogeneous satellite variables. The Earth Observation for Desertification project develops a process-based multivariate framework in which Principal Component Analysis constitutes the proposed integration mechanism. The methodological design constrains each candidate variable according to its physical relationship with the degradation process, temporal representativeness, spatial support and reference conditions before multivariate analysis is performed. Standardized observations are represented in a common feature space in which component loadings describe the contribution of the original variables to the dominant covariance structures, whereas component scores characterize the multivariate state of each observation. The resulting latent gradients are intended to support the identification of recurrent environmental stress configurations, whose relevance to land degradation must subsequently be tested against independent information on soil condition, vegetation functioning, water availability and land management. Project activities in Sicily and Apulia provide empirical evidence of the temporal and reference-condition controls required before multivariate integration. The proposed geospatial infrastructure preserves analytical provenance throughout processing and dissemination. The contribution therefore defines the methodological basis for a multivariate transition from satellite observations to independently corroborated evidence of land stress and, subsequently, to desertification susceptibility assessment; a project-wide multivariate solution is not presented because the harmonized analytical dataset is still under development.

29. Nadir and Oblique Photogrammetry and High-Density LiDAR for Urban Mapping: Evolution of Validation Workflows from Milan to LiDAR-ITA and Pavia

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This paper discusses the evolution of quality-assessment procedures for high-resolution aerial photogrammetry and airborne LiDAR through two complementary operational contexts: successive aerial survey projects in Milan and the nationwide LiDAR-ITA program. Rather than focussing on a single survey, the contribution examines how validation strategies have progressively evolved across different operational conditions. The Milan Project1 comprised two aerial acquisition campaigns, both completed and validated, involving nadir and oblique imagery, high-density LiDAR, and several derived products for urban mapping. Experience gained during these activities led to a progressive shift from project-specific and partly manual checks towards more systematic, repeatable and increasingly automated procedures. LiDAR-ITA provides a complementary national setting in which the extent and volume of airborne pointcloud data require systematic and highly automated approaches to internal consistency and absolute accuracy assessment. The same experience now informs Milan Project 2, whose acquisition has not yet started, and which will test the established procedures on higher-resolution data and textured 3D mesh products while reusing and re-verifying the existing control infrastructure. Recent aerial acquisitions over Pavia provide an additional application context linked to the Laboratory's long-standing experience in aerial photogrammetry and LiDAR. By comparing these contexts, the paper identifies a procedural evolution from project-specific validation to reusable and scalable workflows, while preserving independent reference information, separation between adjustment and control data, spatially explicit indicators, and targeted expert interpretation.

48. Multi-source Explained Data Fusion for Predawn Leaf Water Potential Estimation in Rain-fed Mediterranean Vineyards under Spatial Cross-validation

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Water stress monitoring is a key driver of irrigation and canopy management decisions in viticulture. The reference indicator, predawn leaf water potential (Ψpd), is usually measured manually with an invasive, time-consuming protocol and instruments (e.g. Scholander Pressure Chamber) that do not scale to operational vineyard management. Remote-sensing proxies based on Sentinel-2 (publicly available data) are an attractive alternative due to its frequent revisit and wide spectral coverage. In this work we adopted a multi-source data fusion approach to estimate Ψpd from Sentinel-2 imagery, evaluated on the open dataset by Zhang et al., which provided Ψpd measurements collected across two vineyards and 12 acquisition dates between June and August 2022. Complementary sources of information were combined for each plot: the 10 raw Sentinel-2 L2A bands, a panel of 13 vegetation indices, and daily weather variables (relative humidity, maximum temperature, etc.). We trained four machine learning (ML) models and evaluated them under a leave-one-plot-out cross-validation scheme. This protocol prevented the vines of the same plot from appearing in both training and test sets, a leakage source often underestimated when random validation splits are used. The fusion of these sources outperformed the use of spectral bands alone, suggesting that these features were complementary and could capture additional information relevant for water-status estimation. We further analysed the models through interpretability techniques. Future research would try to fuse other sources of information, leverage other AI/ML sensor fusion schemes and eventually extend the validation to unseen acquisition dates, additional cultivars and climates.

43. Satellite data and neural network algorithms for Urban Heat Island forecast

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This study investigates the urban heat island (UHI) phenomenon in the metropolitan area of Catania (Sicily, Italy), focusing on selected urban sectors to characterize thermal contrasts between densely built-up areas and green spaces. Landsat 8 imagery was used to derive the Normalized Difference Vegetation Index (NDVI) and land surface temperature (LST), supporting the spatial characterization and mapping of UHI patterns. Land use and land cover (LULC) were mapped through supervised classification of Sentinel-2 imagery and subsequently analysed in relation to these patterns. Future LULC scenarios were simulated using a modelling framework incorporating multilayer perceptron neural networks and cellular automata. Predictive performance was evaluated by comparing simulated LULC with observed data for a reference year, using kappa statistics to quantify agreement. The relationship between LULC and UHI was then used to assess potential future UHI conditions under the projected land-cover scenarios. By integrating satellite observations with predictive spatial modelling, this approach provides a tool to support environmental planning and decisionmaking, enabling the assessment of potential urbanization-related thermal impacts and their implications for residents' quality of life.

34. WebGIS Systems and Spatial Data Infrastructures for High-Resolution Temporal Analysis of Urban Air Quality: The UISH Project

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Urban air quality assessment needs resolutions that monitoring networks cannot provide, and downscaled fields whose local reliability must be demonstrated. This paper presents the geospatial architecture of the Urban Intelligence Science Hub for City Network (UISH) project for Catania, Italy, where a PostgreSQL/PostGIS geodatabase and a QGIS Server/Lizmap front end are used both as visualisation tools and as the control interface of asynchronous computation. The portal is publicly accessible at https://uish.ifac.cnr.it. Two years of hourly fields for NO2, O3, SO2, PM10 and PM2.5, downscaled from the Copernicus CAMS European air-quality analyses, are compared against the ARPA Sicilia network over 160,539 valid pairs. Model evaluation is configured as data: metrics, thresholds, scaling functions and expert weights are database rows. At background sites the normalised mean bias of the four species measured at more than one site lies between −28 % and +3 % with positive efficiency; at traffic sites NO2 is underestimated by 56–57 % and efficiency turns negative, while the correlation varies far less. The platform is then set against the European and Italian rules for spatial data infrastructures and Urban Digital Twins (INSPIRE, the High-Value Datasets regime and national open-data obligations), separating the requirements it already meets from those still to be demonstrated.

12. DELTA: A Multimodal, Multitemporal Copernicus Dataset for Italian River Segmentation

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Watercourse monitoring underpins land management, hydrogeological risk prevention and the assessment of climate-change impacts. Deep learning applied to Earth observation is a promising route to mapping river areas, yet its effectiveness is bounded by the extent, quality and representativeness of the training data, and no such resource exists for Italy, whose morphology, climate and hydrology vary sharply across a comparatively small territory. This paper introduces DELTA, a preliminary release of a multimodal and multitemporal dataset for the semantic segmentation of rivers at the national scale. DELTA brings together three Copernicus sources (Sentinel-2 multispectral optical imagery, Sentinel-1 synthetic aperture radar and the Copernicus Digital Elevation Model) co-registered on a national grid of 64 tiles of 100 km at 10 m ground sampling, with acquisitions spread over the four meteorological seasons so that hydrological and vegetation variability is represented. The binary river/non-river reference is obtained from the GRIT global river topology by a width-aware vectorisation and rasterisation procedure. We describe the tiling scheme, the automated selection and download pipeline, the generation of the reference masks, and the composition of the resulting collection (64 elevation, 250 optical and 498 radar rasters, plus 250 river masks; about 1.6 TB). We then examine the three issues that shape how the dataset should be used and outline the segmentation benchmarks planned for the full release. The dataset will be published under an open research licence consistent with the GRIT terms.

80. MAPPING THE GEOGRAPHIES OF POWER: A SPATIAL PATTERN ANALYSIS OF LANDOWNERSHIP DYNAMICS IN AOSTA (1730– 1898) THROUGH HISTORICAL GIS

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Within the Historic Urban Landscape (HUL)framework, cities can be interpreted as dynamic palimpsests in which successive social, institutional, economic, and environmental processes remain embedded within the urban fabric. This study examines Aosta old town (north-western Italy) to investigate relationships between power structures, land-use patterns, and urban morphology between the eighteenth and nineteenth centuries. The research develops a Historical GIS (HGIS) integrating heterogeneous cadastral, cartographic, archival, and toponymic evidence within a harmonised spatial framework. The reconstruction draws principally on eighteenth- and nineteenth-century cadastral sources; where cartographic evidence is incomplete, historical toponymy, ownership relationships, parcel dimensions, and later cadastral geometry support the spatial reconstruction. Local entropy was mapped for quantifying spatial heterogeneity in social-group ownership and land use, while multivariate clustering was adopted for exploring recurrent socio-functional configurations. Finally, a diachronic comparison was performed for assessing transformations between the late Ancien Régime and the late nineteenth century. Results reveal persistent geographies of power associated with ecclesiastical precincts, aristocratic properties, productive corridors, and agricultural enclaves, alongside differentiated patterns of socio-functional heterogeneity. The persistence of gardens, orchards, agricultural outbuildings, and mixed residential-productive properties further reveals the enduring interweaving of agricultural and urban functions, demonstrating the potential of HGIS for quantitatively interpreting historical urban landscape transformations.

51. Multimodal Deep Learning for Alpine Land Cover: Benchmarking Foundation Encoders for Very-High-Resolution Multi-Sensor LULC Classification

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Mapping land cover in mid- to high-altitude terrain of the European Alps is difficult because the classes environmental agencies monitor, among them dwarf shrub, wetland, exposed rock and seasonal snow, form mosaics only a few metres across and fall below what tenmetre satellite products resolve. Sub-metre airborne multi-sensor survey resolves them, at the cost of a processing chain whose components are seldom weighed against one another. Seven configurations of a weakly supervised network were compared. The network fuses airborne RGB, six-band multispectral imagery, spectral indices and a photogrammetric surface model into a fourteen-class product nested in the CORINE hierarchy. Only the image encoder differs between configurations; the sensor streams, the fusion stage and the training recipe are held fixed. The payload itself is assessed on the same imagery using standard radiometric and spatial quality measures. The best configuration maps the fourteen classes at a mean Intersectionover-Union of 0.727 on held-out tiles, with snow, water bodies, roads and buildings above 0.85 and dwarf shrub below 0.30. Under a fixed and equal training budget, substituting the image encoder, over a range from 28 to 636 million parameters and three architectural families, moves that mean by less than the variation the pipeline shows between consecutive training epochs. Of the six spectral bands, the three visible ones carry nearly the same information, leaving about three independent channels. The quality of the resulting land-cover product is therefore governed by the sensor payload and the annotation rather than by the size of the image encoder.

35. GeoAI and Foundation Models Embeddings: new data for new challenges

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In recent years, Earth Observation (EO) has seen growing adoption of Geospatial Artificial Intelligence (GeoAI). The scale of geospatial data has pushed the scientific community toward Deep Learning (DL) and Geospatial Foundation Models (GFMs) trained on large, heterogeneous EO datasets to learn general patterns transferable across tasks. Beyond using pre-trained GFMs directly, an emerging perspective is the use of precomputed embeddings generated by these models as input features for lighter, task-specific DL networks, exploiting powerful GFM feature extractors without the cost of training or fine-tuning the full model. Despite this potential, the usability of embeddings for EO applications remains unclear: how much information they encode and how reliably downstream models can learn from them are open questions, particularly for tasks beyond classification and segmentation, such as height estimation. Research initiatives and international challenges are increasingly exploring this topic. In particular, the ESA Φ-lab challenge “Reaching New Heights with GeoFM” focuses on embeddings from popular GFMs, including TerraMind, AlphaEarth, TESSERA, and THOR, aiming to foster new approaches to their exploitation. This contribution investigates the use of precomputed GFM embeddings to train task-specific DL networks, presenting preliminary results developed by a team within the ESA Φ-lab challenge. The work uses embedding products as input features for models targeting fractional cover and height estimation. The challenge provides a useful test bed for investigating how precomputed GFM embeddings can be adapted to pixel-level prediction and regression, as well as a benchmark for comparison with the results obtained by other competing teams.

60. Satellite Photogrammetry for Multitemporal Monitoring in Alpine Environments: Ground Control Network Design, Implementation, and Accuracy Assessment

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Alpine valleys are particularly sensitive to climate change, which intensifies glacier retreat, slope instability and hydrogeological hazards, threatening ecosystems, water resources, communities and infrastructure. Their continuous monitoring is essential for environmental management and risk assessment. Very-high-resolution satellite photogrammetry can support this task by providing spatially continuous observations over extensive and hardly accessible mountain areas. Within the MOHYCAM project (Modified HYdrogeological hazards under complex ClimAte and environmental conditions: Monitoring activities and mitigation strategies), an in-track Pléiades Neo stereo pair acquired in July 2026 was used to investigate the upper Anzasca Valley, including Macugnaga and the Belvedere Glacier. The panchromatic images have a nominal Ground Sampling Distance (GSD) of 0.30 m and cover approximately 100 km². A field campaign provided accurately surveyed natural and artificial ground-reference points with homogeneous planimetric and altimetric coverage. The study assessed how the number of Ground Control Points (GCPs) affected Rational Polynomial Coefficient (RPC)-based image orientation in two off-the-shelf softwares, namely CATALYST Professional and Agisoft Metashape. The influence of the numerosity of GCPs on the orientation accuracy was assessed against a fixed subset of independent Check Points (CPs). Both workflows showed that most of the improvement was achieved with the first few GCPs, with planimetric accuracy approaching a plateau at three well-distributed points. Once stabilized, both software packages achieved CP errors below twice the nominal GSD. The results demonstrate the potential of Pléiades Neo photogrammetry for accurate 3D geometric monitoring in complex alpine environments and highlight the importance of GCP distribution and software-specific RPC refinement strategies.

33. Mapping Tree-Related Microhabitats in Italian Forests through Remote Sensing and Spatial Modeling

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Tree-related microhabitats (TreMs) are field-observed indicators of forest structural complexity and habitat availability whose direct assessment remains labor-intensive and spatially discontinuous. This study evaluates a conservation application of a national 30-m map of predicted TreM abundance by examining its spatial relationship with the Italian Natura 2000 network. The map, which covered 10.33 million ha of Italian forest and had a median predicted abundance of 274 MH ha^{-1}, was generated by combining multisite field observations with Landsat and Sentinel-2 time-series predictors. The Natura 2000 network contained about 2.89 million ha of forest. It included 32.0% and 33.7% of the national forest area above the P90 and P95 prediction thresholds, corresponding to 748 and 971 MH ha^{-1}, respectively. These classes occupied 11.44% and 6.03% of mapped Natura 2000 forest, compared with 10% and 5% of the national forest domain, producing enrichment ratios of 1.14 and 1.20. At P99 (1,973 MH ha^{-1}), Natura 2000 contained 25.2% of the corresponding national area, and the enrichment ratio decreased to 0.90. Among the 1707 sites analyzed, site means were markedly asymmetric, with a median of 327 MH ha^{-1} and a small number of sites reaching substantially higher values. These percentile classes are relative components of the national prediction distribution and should not be interpreted as ecological thresholds. Because the underlying model showed moderate within-domain performance but weak transferability to forest landscapes not present in the calibration set, the resulting summaries are intended for spatial screening and field-survey prioritization rather than site-condition certification.

23. Evaluating Conversational Interfaces in WebGIS Applications: A Case Study on Forest CO2 Sequestration Valuation

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This study investigates how Large Language Model (LLM)- mediated conversational interaction affects usability, workload, and task performance in an environmental WebGIS for the economic valuation of forest CO2 sequestration. The existing Carta Natura application was extended with a conversational interface that maps natural-language requests to predefined tools, while spatial processing and economic valuation remain delegated to deterministic backend services shared with the graphical interface. A controlled study involved 40 participants, equally divided between those with and without prior GIS experience. Each participant performed two environmental-analysis tasks, one with each interface. Perceived usability, workload, completion time, and interaction errors were assessed using questionnaires, observations, and semi-structured interviews. Results showed that participants without prior GIS experience reported significantly higher usability, lower workload, and fewer interaction errors with the conversational interface. No significant usability or workload benefits were found among experienced participants, while completion times increased for both groups. Despite this, interviews indicated that conversational interaction was often perceived as faster and less demanding. Participants with GIS experience generally preferred the graphical interface, whereas those without prior GIS experience favored conversational access. These findings suggest that conversational interaction can improve access to existing WebGIS analytical functions for less experienced users, but does not necessarily increase task efficiency.

47. Monitoring Building Deformations from PS-InSAR Data and Integration into the MEDUSA Digital Twin

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The study, developed within the MEDUSA project (MEDiterraneo: Uso Sostenibile dell'Ambiente), funded by ASI (Boosting Future in Space @ Matera Space Center Lab call, Complementary Fund to the PNRR), proposes a methodology to estimate the structural vulnerability of buildings in urbanized coastal areas from COSMO-SkyMed interferometric stacks (first and second generation, 2015-2025). Persistent Scatterers (PS), identified via PS-InSAR™ in ascending and descending geometries, are combined to retrieve the vertical displacement component. After selection through a coherence threshold, the irregularly sampled time series are resampled at 14 days with PCHIP interpolation, which preserves local monotonicity and avoids overshooting, and decomposed into trend, seasonality (analyzed through the ACF) and residual; predictive validation follows a backtesting protocol with additive Holt-Winters. RBF interpolation, with smoothing weighted by the standard deviation of the PS and post-interpolation clipping to local values, generates continuous surfaces organized into a NetCDF raster cube. A Python algorithm (OOP, multithreading, CustomTkinter) integrates these surfaces with building footprints from the Regional Topographic Geodatabase (TGDB), extracting from the long-term trend mean cumulative displacement, differential range and maximum spatial gradient. Based on configurable thresholds, each building is classified as stable, with functional criticality or with structural criticality; a robust linear regression projects its evolution over three years, constrained not to fall below historical maxima to reflect the irreversibility of damage. The procedure is implemented in the bidirectional MEDUSA Digital Twin, which allows interactive modification of thresholds and instant recalibration of criticalities, with GeoPackage output compatible with the GIS Temporal Controller.

49. MoISTuRE: a Digital Twin platform for integrated drought monitoring of agro-forest systems, wetlands and river network

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The growing recurrence and severity of drought events in the Mediterranean area call for integrated monitoring and decision-support tools. This paper presents the methodological framework and architecture of the platform developed within the DiTwin MoISTuRE (Monitoraggio Integrato della Siccità a Tutela della Resilienza Ecologica - A Digital Twin for the Integrated Monitoring of Drought in Support of Ecological Resilience) project, funded by the Italian Space Agency (ASI) under the I4DP_PA programme, with the University of Salerno as lead institution and the Carabinieri Forest, Environmental and Agri-food Units Command (CUFAA) as partner and end user. The platform integrates satellite data (Landsat, Sentinel, COSMO-SkyMed, PRISMA and the national IRIDE constellation), in-situ surveys and a network of Tree Talker IoT sensors, which constantly record plant physiological parameters to calibrate and validate satellite-derived stress indicators. On this basis, the platform computes multi-scale drought indicators (SPI, SPEI, SMA, fAPAR, CDI), classifies the most vulnerable areas using machine learning techniques, and forecasts short-term evolution with ARIMA/SARIMA models and uses Copernicus Climate Change Service (C3S) seasonal outlooks to outline extendedterm projections. The pilot areas cover three study sites spanning two distinct ecosystem types: the Valle delle Ferriere State Nature Reserve (Municipality of Scala), for drought effects on spring-fed wetlands, and the Bianco and Calore Lucano river basins within the Sele hydrographic system, for effects on perennial and intermittent watercourses respectively - distinct hydrological contexts of high ecological value. The paper describes the processing chain, the initial morphometric and forest characterisation of the study areas, and the platform validation plan, conceived as a Decision Support System for early warning.

57. Development of a Historical GIS of the Bologna's Medieval Towers

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This work presents the development of a Historical Geographic Information System (HGIS) for the spatial and temporal analysis of Bologna's medieval towers, which constitute a distinctive feature of the city. The research addresses the challenge of reconstructing a largely transformed architectural system whose surviving structures represent only a fraction of the historical phenomenon. The study used a corpus of 100 towers, whose historical existence was established through cross-analysis of bibliographic, cartographic, and documentary sources, as the basis for the system. Historical maps dating from the sixteenth to the nineteenth century were georeferenced within a common projected reference system and critically assessed according to their geometric characteristics and correspondence with the present urban fabric. In parallel, a structured database was created to manage spatial, chronological, architectural, and historical information for each tower. Particular attention was devoted to positional and temporal uncertainty, especially for disappeared towers whose locations are often inferred from indirect references such as buildings, streets, intersections, or historical toponyms. The integration of georeferenced cartography and the tower database within a GIS platform enabled the validation of existing coordinates, the correction of inconsistent locations, attribute-based analysis, and the diachronic visualization of tower appearance, persistence, transformation, and disappearance. The resulting HGIS, still in development, therefore, moves beyond a static inventory and provides a critical framework for interpreting Bologna's towered landscape through space and time. The approach demonstrates the potential of geomatics for integrating heterogeneous historical sources while preserving different levels of data reliability and offers a transferable methodology for the study of lost or substantially transformed urban heritage.

17. Spatio-temporal variability of water quality derived from Sentinel-2: the Po River case study

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For centuries, human activities have heavily altered river systems, driving widespread restoration efforts across Europe, such as the Italian "Action Programme for the restoration of the Po River Area". In this study, we present a satellite-based framework using 509 Sentinel- 2 (Level-1C) images, atmospherically corrected via RAdCor algorithm (ACOLITE v2025), to assess water quality across six representative areas of the Po River over four years (2018, 2022, 2024, and 2025) characterised by both dry and wet conditions. The analysis focused on four key parameters: dominant wavelength, optical water types, suspended particulate matter concentration, and trophic status derived from chlorophyll-a levels. The results reveal a highly dynamic environment, where water quality exhibits strong coupling with spatial and seasonal patterns, river discharge, and the resulting hydrological fluctuations of the river. Overall, this study establishes a comprehensive water quality baseline for the Po River and provides a satellite-based monitoring approach to assess the effects of upcoming river restoration measures.

73. Estimation of transformation parameters from the ITRF2020 reference frame to the Italian Reference Frame (ETRF2000 at epoch 2008.0)

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This study evaluates different procedures for estimating the 14 parameters of a similarity transformation from coordinates expressed in ITRS– ITRF2020 at epoch t to ETRS89–ETRF2000 at epoch 2008.0. Three approaches are proposed and applied to the coordinates of permanent GNSS stations belonging to the Italian National Dynamic Network (RDN), which has officially realised the national reference system in Italy since 2012. The paper describes the dataset, the processing strategy used to estimate the GNSS station coordinates, the three transformation parameter estimation approaches and analyses the differences between the resulting solutions.

13. Geospatial Indicators for Assessing Reuse Scenarios of Disused Railway Corridors: the 'Potenza Inferiore Scalo' - 'Laurenzana' Line in Southern Italy

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Disused railway corridors are complex spatial systems in which infrastructural continuity, railway assets, terrain topography and morphology, environmental values, settlement patterns and functional relations interact. However, early-stage assessment often addresses them as homogeneous linear infrastructures or focuses on a single reuse option. This paper proposes a segment-based geospatial screening framework for the preliminary assessment of alternative reuse scenarios along disused railway corridors. The framework integrates railway, morphological, environmental, socio-territorial and functional indicators and interprets them through a scenario-specific evidence-based approach. Four reuse scenarios are considered: (i) ordinary railway reactivation; (ii) tourist or heritage railway reuse; (iii) greenway and slow-mobility conversion; and (iv) distributed territorial reuse of railway assets. The method is applied to the former 'Potenza Inferiore Scalo' – 'Laurenzana' railway corridor in Basilicata, Southern Italy. Results show strong internal differentiation among the five railway sections: greenway and slow-mobility conversion provide the most continuous spatial support at corridor scale, while tourist/heritage and distributed asset-based reuse emerge selectively in sections with stronger landscape, cultural or asset-related evidence. Ordinary railway reactivation remains weak and highly conditional. The study demonstrates that geospatial indicators can support differentiated, section-based reuse strategies for disused railway infrastructures.

42. Spatial mismatch in coastal and marine protected areas: an Earth Observation framework for the diachronic assessment of institutional governance and spatial coherence

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Coastal and marine protected areas are typically defined by administrative boundaries fixed at a given historical moment, while the ecological processes they are meant to safeguard evolve continuously and on timescales that rarely coincide with regulatory review cycles. This divergence, known in the literature as spatial mismatch, is especially acute at the land-sea interface, where climatic and anthropogenic pressures interact on a space simultaneously regulated by multiple, historically stratified protection regimes. This paper proposes and tests a methodological framework that renders this divergence spatially explicit and quantifiable, combining twenty-five years of multi-sensor satellite monitoring with a systematic conservation-planning algorithm (Marxan), originally developed for biodiversity conservation and here repurposed for territorial governance assessment. The framework is applied to the Miramare Marine Protected Area (Gulf of Trieste, northern Adriatic Sea), where a national marine reserve, the Natura 2000 network and the UNESCO Man and the Biosphere Reserve overlap on the same land-sea transect. Results show a persistent and, in places, widening divergence between institutional zoning and the spatial distribution of ecological priorities, with 171 cells, approximately 1.5 km², classified as permanently unprotected ecological gaps across all six analysed time windows, and a structural decoupling between vegetation vigour and biomass water content emerging after 2013. The paper argues that periodic, satellite-informed revision of protection perimeters is a necessary complement to fixed zoning, and that the proposed protocol, built entirely on open-source data and cloud computing platforms, is transferable to other Mediterranean and European coastal contexts with comparable regulatory stratification.

58. A Spatial Decision Support System Integrating Generative AI for Participatory Urban Regeneration

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Urban planning decisions require planners to reconcile many constraints and heterogeneous data, while citizens often struggle to understand the two-dimensional drawings through which plan provisions are communicated. This paper proposes an AI-based decision support framework that translates the guidelines of strategic and municipal plans into geolocated, street-level scenarios that are both perceivable and measurable. The workflow combines 360° streetview imagery, semantic segmentation with cubemap re-projection to quantify the visible composition of each scene, and a multimodal generative model constrained by binary masks, reference images and a prompt split into a fixed part (format, context, plan rules) and a variable part driven by participants' choices. Scenarios are delivered through a WebGIS prototype that juxtaposes the plan layer, the current state and the simulated state, and compares their landcover composition. The approach was tested in Pontecagnano Faiano (Salerno, Italy) on actions foreseen by the Masterplan of the Salerno South coastline and by the strategic document of the municipal plan, namely the downgrading of the SP175 coastal road into a cycle-pedestrian axis, the renaturalisation of illegal settlements and green filters along the urban–rural edge. The paper then formalises evaluation criteria covering plan coherence, accessibility, liveability, sustainability and user comprehension, and discusses the gap between what is visible in an image and actual land use.

130. Hyperspectral Unmixing and High-Resolution Subpixel Land-Cover Mapping

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This study evaluates Environmental Mapping and Analysis Program (EnMAP) hyperspectral data acquired over the basin study area in 2022 for ne-resolution land-cover mapping. The pure-pixel spectra from landcover classes were extracted and clustered using K-meansbased factorization to construct class-speci c spectral bundles, which were re ned using Spectral Angle Mapper (SAM) similarity to manually selected reference spectra. The spectral unmixing integrated fully constrained least squares (FCLS), multiple endmember spectral mixture analysis (MESMA), and multi-objective endmember optimization. The resulting abundance estimates were classi ed using the Unmixing Optimization and Classi cation (UOC) work ow to generate 5 m maps, with and without mode ltering, for high vegetation, low vegetation, and bare terrain. The evaluation against reference polygon data yielded normalized confusion-matrix accuracies of 80.47%, 70.88%, and 75.54% for these classes, respectively, without mode ltering, increasing to 80.70%, 71.70%, and 76.78% after ltering. The mode ltering produced modest improvements in class-wise agreement, particularly for low vegetation and bare terrain, while high vegetation remained the most accurately classi ed class. These results demonstrate the potential of combining hyperspectral spectral-bundle construction, spectral unmixing, and subpixel mapping for ne-resolution land-cover classi cation. · · · ·

16. Spatiotemporal Analysis of Wildfire Risk Dynamics Using Multi-Source Remote Sensing Data in the Campania Region, Italy

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Wildfires pose a major environmental risk in Mediterranean regions, where their occurrence and spatial distribution are influenced by interacting climatic, topographic, vegetation, and anthropogenic conditions. This study develops an integrated Remote Sensing (RS) and Geographic Information System (GIS) framework to assess wildfire risk in the Campania Region, Italy. Four factor categories comprising 14 indicators—anthropogenic, topographic, meteorological, and vegetation and land cover—were standardized and integrated using the Analytic Hierarchy Process (AHP) and Entropy Weight Method. Monthly comprehensive wildfire-risk maps were generated for January–June 2024 using multi-source remote sensing data, meteorological observations, digital elevation data, LULC, and anthropogenic factors. FIRMS active-fire detection were used for spatial comparison, while official wildfire records from 2014– 2024 were used for historical spatial assessment. The results show that topographic factors had the highest category-level weight (0.352), followed by vegetation and land cover (0.282), meteorological factors (0.210), and anthropogenic factors (0.155). At the indicator level, LULC (0.585), slope (0.531), and maximum wind speed (0.316) received the highest combined weights within their respective categories. The comprehensive wildfire-risk index ranged from 0.31 to 0.83 across the monthly assessments, with the highest observed maximum in February 2024 (0.83). Historical spatial assessment showed that 78.38% of the total burned area (60,262.74 ha) occurred within the High and Very High-risk classes. These findings demonstrate the applicability of an integrated multi-source RS-GIS framework for characterizing spatial and temporal wildfire-risk patterns and supporting wildfire monitoring and risk-informed environmental planning in Mediterranean regions.

31. Temporal Reliability and Spatial Error Patterns of the GLC-FCS30D Land Cover Product: A Multi-Temporal Assessment in Bari, Southern Italy

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Reliable land-cover information is essential for environmental monitoring and spatial planning, yet the thematic performance of annual global landcover products may vary across classes, locations, and observation years. This study evaluates the multi-temporal thematic accuracy and spatial structure of classification errors in the GLC-FCS30D product across the Metropolitan City of Bari, Southern Italy, for nine reference years between 2000 and 2022. The original legend was harmonized into six land-cover classes, while reference samples were generated through visual interpretation and manual digitization of Landsat imagery. Classification performance was assessed using confusion-matrix metrics, including Overall Accuracy, Producer's Accuracy, User's Accuracy, and Cohen's Kappa. The spatial organization of classification errors was investigated through multi-scale Global Moran's I and class-specific Local Getis–Ord Gi∗statistics. OverallAccuracy remained relatively stable, ranging from 79.49% to 81.34%, with Kappa values between 0.71 and 0.75. However, this aggregate stability concealed substantial differences among land-cover classes. Cropland, woody vegetation, built-up areas, and water generally showed comparatively high accuracy, whereas grassland and bare land exhibited persistent omission errors and greater temporal variability. At the selected 1000 m aggregation scale, classification errors exhibited positive spatial autocorrelation in all assessment years, with the magnitude varying substantially through time. Moran's I increased from 0.061 in 2000 to 0.109 in 2003, 0.142 in 2006, and 0.210 in 2013, reaching a maximum of 0.274 in 2020 before declining to 0.211 in 2022. Multi-scale comparison further demonstrated sensitivity of Moran's I to the spatial aggregation scale, although the direction and magnitude of this effect varied among assessment years. Local hotspot analysis revealed geographically restricted and class-dependent concentrations of errors, with statistically significant hotspots detected only in selected assessment years and particularly localized patterns for different land-cover classes. These findings demonstrate that temporally stable aggregate accuracy does not necessarily imply uniform reliability across land-cover classes or geographic areas. The integration of conventional accuracy metrics with global and local spatial statistics therefore provides a more complete assessment of the suitability and limitations of annual global land-cover products for regional applications.

15. Remote sensing multispectral semi-automated analysis of Sentinel-2 satellite data with open-source solutions.

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The open availability of multispectral imagery provided by the Sentinel-2 mission has significantly improved access to Earth Observation data (shorter temporal intervals, cloud-free acquisitions and minimized atmospheric disturbances). At the same time, even more the challenges associated with the acquisition, management, storage, and analysis of large geospatial datasets are spread. Recent advances in computer science and geospatial programming have made it possible to automate and optimize these workflows through scriptingbased solutions. This contribution, developed within the EO4Des (Earth Observation for Desertification) PRIN research project, investigates the integration of different open-source technologies aimed at improving the efficiency of multispectral data processing from Sentinel-2 imagery. The proposed strategy consists of three main phases: the search and acquisition of multispectral satellite imagery – based on the Google Earth Engine (GEE) platform; the analysis and processing of the acquired geospatial datasets – developed on Python-based workflow working in Anaconda platform; the integration in a WebGIS platform – based on Leaflet JavaScript libraries. The proposed workflow simplifies and accelerates traditional approaches based on manual desktop-based geospatial processing. Furthermore, it optimizes data transfer and storage requirements by reducing the amount of imagery that needs to be downloaded and managed locally. Despite these advantages, the adoption of the proposed solution limits its functionalities on two times selection and requires soft programming skills. Future developments will focus on the automation of a full processing chain capable of performing faster and more efficient multispectral analyses from satellite imagery. A demo version of the platform is freely available at the link: https://github.com/marcellolg1987/semi-automated-Sentine-2-WebGIS-analyzer.

53. An OpenStreetMap Mapathon as an Open Geomatics Laboratory: Education and Crowdmapping

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Since 2010, the University of Bologna's DICAM Geomatics team has organised mapathons involving engineering students and welcoming anyone regardless of expertise. Through interpretation of high-resolution satellite imagery, participants enrich OpenStreetMap (OSM) vector data in areas with absent, outdated or incomplete mapping worldwide, supporting responses to actual or potential natural or human-induced disaster risks. This combines technical practice with social relevance in university education. After twenty editions, this paper describes the adopted format and investigates its effectiveness, by analysing the data collected during the last event, held in spring 2026. Introductory teaching and guided editor training preceded autonomous building digitisation with instructor support, combining image interpretation, geometric delineation, attribute assignment and open geographic data publication. PRE and POST questionnaires with aggregate project-level contribution statistics reveal that participants' confidence in OSM editing and in tracing building geometry increased significantly (respectively, from 3.0 to 4.3 and from 3.5 to 4.1 on a five-point Likert scale). Ratings of humanitarian usefulness and data quality responsibility remained high from baseline. Project records documented substantial building creation or modification. Imagery interpretability was the principal reported technical limitation, emphasising the importance of building awareness about uncertainty management and critical judgment in geomatics. Despite the limitations due to small sample size, self-reported outcomes and absence of independent validation, this study provides a documented, potentially transferable format for integrating collaborative mapping into geomatics curricula, connecting practical geospatial workflows with reflection on geographic representation and the societal responsibilities of mapping.

93. Multisource Data Integration for Spatial Prediction in Air Quality Monitoring

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Continuous air-quality monitoring and spatial reconstruction provide a basis for future pollution early warning services. Integrating regulatory measurements and low-cost observations with meteorological variables and atmospheric-model outputs can support these tasks, while accounting for data quality and uncertainty. The research conducted at the LabGIS laboratory, University of Salerno, is oriented towards intelligent Digital Twins for complex environmental and urban systems. A key challenge is to make heterogeneous, multi-scale information flows interoperable and coherent while preserving data quality, traceability, and uncertainty throughout the data life cycle. Within this framework, the paper describes a multisource geospatial pipeline for daily spatial reconstruction of particulate matter with aerodynamic diameters up to 2.5 and 10 µm (PM2.5 and PM10) in the municipality of Milan. The pipeline integrates regional environmental protection agency (ARPA) measurements and Sensy sensor data with meteorological variables and Copernicus atmospheric-model outputs, accounting for different spatial and temporal support and preserving source provenance. Integrated observations and derived features support reconstruction at unobserved locations through machine learning models, including Random Forest. Evaluation combines spatial exclusion and temporal separation, baseline comparisons, and feature ablations. An independent regulatory replication in Campania and an internal consistency assessment of the University of Salerno campus sensor network extend the evaluation. Future work will address forecasting and strengthen the integration of physical and data-driven approaches, supporting hybrid, interpretable solutions through geovisual analytics and reproducible assessment protocols.

40. Integrating georeferenced information for Situational Awareness in Hydrogeological Emergencies: Case Study in Verbano-Cusio-Ossola area

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At the end of August 2025, a wave of severe weather hit the Verbano-Cusio-Ossola area, creating significant inconveniences. During the event, numerous hydrogeological disorder events occurred, resulting in precautionary evacuations of people and in partial isolation of some localities. The levels of the Toce River's drainage network and the remarks of the firefighters involved in the assessment operations were constantly monitored by the VCO Fire Brigade Operations Room using a specific GIS asset. In the late afternoon of August 29, when the situation seemed to be improving, a further hydrogeological instability occurred in the Municipality of Varzo, with mud, water, and debris, some of considerable size, pouring into the streets. The firefighters' response to the emergency was also prepared thanks to the detailed collection of georeferenced information that populated the GIS asset. An Advanced Command Post was established to coordinate the firefighting teams and those of other agencies and volunteers, and the rescue operations were supported by a firefighter drone crew that flown for a post-event mapping; this product was used to assess the changes caused by the event and to manage the strategy of activities implemented.

39. An open-access platform for spatial data processing and harmonization to support wildfire simulation

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Wildfires are increasing in frequency, extent, duration, and impacts on natural resources, as well as agricultural and urban infrastructures [1]. These trends highlight the need for accurate, up-to-date information on ecosystems and vegetation fuels, alongside integrated approaches, harmonised protocols, and shared risk governance mechanisms [2,3]. Advances in remote sensing and simulation models support these needs, with wildfire behaviour modelling becoming essential to risk assessment and management [4,5]. The European context, in particular, with environmental heterogeneity and increasingly frequent and severe wildfires driven by climate change, land-use changes, fuel accumulation, and prolonged drought, highlights the need for reliable tools to simulate fire spread under varying conditions [5]. Integrated and dynamic fire behaviour models support operational wildfire management, emergency planning, fuel-reduction interventions, and long-term landscape management by estimating fire spread, intensity, and potential burned areas under varying weather, topographic, and fuel conditions [4,6,7]. However, operational use remains constrained by data accessibility, harmonisation, complex preprocessing, and integration with simulation platforms. Required inputs include surface fuel models, canopy fuels, topography, weather scenarios, and ignition coordinates [8]. This work presents an open-access digital platform developed in R to facilitate the import, parametrisation, preprocessing, and harmonisation of spatial and non-spatial inputs for wildfire simulations. Intended for local operational, academic, and educational use, the interface guides users through dataset selection and upload, checks formats, consistency, and completeness prior to export, and flags potential issues that could affect subsequent simulations. Inputs include fuel maps, terrain data, meteorological information, and ignition coordinates. Users can configure real or virtual scenarios using observed data or manually specified parameters, including simulation dates, duration, weather, and fuel conditions. The platform currently focuses on input preparation, while future developments aim to enable model selection and simulation execution directly through the interface.

59. A GIS-based methodology to support Green Infrastructure spatial planning for biodiversity improvement

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Under the “umbrella concept” of Nature-Based Solutions (NBS), Green Infrastructures (GIs) are of particular interest to integrate the spatial benefits of NBS into spatial planning processes. The literature reveals a lack of quantitative approaches for assessing the benefits associated with Gis, in particular for the biodiversity, which can be measured through the analysis of the Ecological Connectivity (EC). The aim of this work is to propose a model with a dual purpose: (i) to identify the most relevant components of the GI network for EC; (ii) to quantitatively and spatially assess how land-cover changes affect EC at both network and patch levels. The proposed methodology, based on Geographic Information System (GIS), consists of resistance mapping, identification of the GI network, construction of the graph and calculation of global and local network metrics, and comparison of the metrics in different temporal scenarios. The knowledge base that can be produced, by applying these methodological steps, is useful for identifying particularly problematic areas in which to intervene as a priority for the improvement of biodiversity. The proposed model is applied to the Metropolitan City of Naples (Italy), a densely urbanized and infrastructural area, characterized by significant fragmentation of habitats, considering 2006 and 2018 as temporal scenarios. The results show an overall reduction in EC and make it possible to identify the most critical areas, supporting GI spatial planning for biodiversity improvement.

6. Gaussian Splatting for the Documentation of Complex Architectural Environments: A Multi-Platform Sensor Comparison at La Scarzuola

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Three-dimensional documentation of architectural and landscape contexts characterised by high geometric complexity and rich surface detail poses significant challenges to traditional surveying methodologies. 3D Gaussian Splatting (3DGS), a volumetric representation technique based on Gaussian primitives optimised through machine learning, is emerging as a promising solution to simplify and accelerate documentation workflows while ensuring high visual and geometric quality. This contribution presents the case study of La Scarzuola (Montegabbione, TR), a visionary architectural complex designed by Tomaso Buzzi from 1958 onwards, whose dense layering of theatrical, sculptural and architectural elements makes it an ideal testbed for advanced acquisition technologies The acquisition campaign compared three workflows: XGRIDS PortalCam, a Stonex X120GO SLAM scanner coupled with Insta360 X5 panoramic imagery, and a DJI Matrice 4E UAV image-based workflow. The three 3DGS models were evaluated against an independent Leica RTC360 TLS reference using site-wide and local M3C2 analyses. Results show similar site-wide dispersion but clearer local differences, together with distinct trade-offs in workflow integration and processing flexibility, confirming 3DGS as a versatile technology capable of integrating heterogeneous sensor systems and delivering models suited both to immersive visualisation and to metric analysis in cultural heritage (CH) documentation.

37. Multitemporal GIS Monitoring of Agricultural Plastic Covers for Land Management in the Metapontino District

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Agricultural plastics used for crop protection and soil covering are a structural component of intensive Mediterranean cropping systems, yet they also represent a potential source of soil pollution, associated with their progressive degradation and the dispersion of fragments into the environment. Effective territorial management therefore requires operational tools capable of locating plastic-covered surfaces, quantifying the environmental pressure they exert, and tracking their evolution over time. This study develops a multitemporal GIS-based framework for monitorning greenhouse and tunnel covers detected from Sentinel-2 imagery in the Metapontino district (Basilicata, Southern Italy). Building on a methodology previously consolidated by the authors and based on spectral indices applied to Sentinel-2 imagery, the GIS implementation combines the comparison of plastic-cover distribution between two winter reference periods, the aggregation of plastic pressure indicators at the municipal scale, and the dissemination of results through a WebGIS prototype, conceived as a decision-support tool for public administrations and stakeholders involved in collection planning. The locally calibrated classification achieved an overall accuracy of 92.52%, while an independent assessment of the second reference period yielded an area-weighted overall accuracy of 94.0%. Detected greenhouse and tunnel cover increased from 1,959.8 ha in 2018 to 2,394.2 ha in 2024 (+22.2%), although only 56.4% of the 2018 detected surface persisted at the same locations in 2024, indicating substantial spatial turnover. Estimated agricultural plastic waste increased from 13,597.6 to 13,712.6 t yr^{-1} (+0.85%). The proposed framework provides a replicable approach for integrating remote sensing and GIS to support spatially explicit monitoring and management of agricultural plastics in intensive Mediterranean farming areas.

69. Geomatics for social inclusion: low-cost 3D heritage reconstruction and immersive telepresence for elder guides

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Contemporary frameworks recognize cultural heritage as a key driver of human well-being and social inclusion. However, ageing populations with mobility constraints often face barriers to accessing heritage sites, leading to social isolation. This paper presents a methodological framework that leverages low-cost, scalable geomatics workflows and eXtended reality (XR) to bridge these physical barriers. Using the CLIO project as a case study, focusing on minor Waldensian heritage in remote alpine areas, the study explores how immersive telepresence can transform older adults from passive users into active memory guides. The proposed pipeline integrates rapid surveying techniques, such as Mobile Mapping Systems (MMS), Unmanned Aerial Vehicles (UAV), smartphones and 360° cameras, to generate immersive virtual environments. Specifically, a novel 360° video to 3D Gaussian Splatting (3D Gaussian Splatting (3DGS)) workflow is detailed alongside a traditional photogrammetric workflow and compared to ground truth data. A participatory co-design approach was employed to validate the technology from user experience and psychological well-being perspectives. Beyond immediate social outcomes, such as reduced loneliness and digital empowerment, the research highlights the value of accessible geomatics data for preserving intangible heritage and supporting future object-oriented conservation models. The study demonstrates that geomatics, combined with human-computer interaction principles, can serve as the basis for building socially oriented tools to enhance the well-being of vulnerable communities while ensuring the scalable documentation of tangible heritage.

27. Antarctic Pseudo-Invariant Reference Sites for IRIDE Radiometric Calibration and Polar Earth-Observation Consistency

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Optical Earth observation at high latitudes, essential for monitoring the polar cryosphere, is where sensor radiometry is least verified, because conventional vicarious-calibration sites are low-latitude deserts. Motivated by the IRIDE constellation, whose Multispectral (MS) payload requires an independent radiometric reference, we develop a vicarious-calibration pipeline on Sentinel-2 as a proxy and characterise Dome C (East Antarctic plateau) as a pseudo-invariant calibration site. Level-1C top-of-atmosphere reflectance is compared with the 6SV2.1 radiative-transfer code over 399 austral-summer acquisitions (2018–2025). The per-band gains are 1.061 (B2), 1.038 (B3), 1.025 (B4) and 0.942 (B8), with an expanded uncertainty (k = 2) of 2.2–2.5 %, dominated by the assumed surface reflectance. A drift of the gain with solar zenith angle, caused by the Lambertian surface assumption, is removed by a Ross–Li bidirectional reflectance normalisation. Dome C proves temporally stable, and the pipeline is ready to be transferred to IRIDE MS.

1. Integrating remote sensing and ground metrics to assess post-coppicing soil displacement and canopy recovery in a Mediterranean forest

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Coppicing has recently become a topic of discussion in scientific literature, primarily due to its potential link with soil erosion. Implementing a long-term monitoring program could help to resolve these issues. This study therefore aims to evaluate the effectiveness of combining remote sensing and field data to monitor changes in coppiced forest stands related to soil erosion in southwestern Sardinia. To this end, an erosion monitoring network was set up and satellite data covering the period 2018–2020 was used. Using this dataset, we calculated a set of vegetation indices and compared them with the morphological and topographic parameters of the study area. Furthermore, we compared the indices with soil data collected during fieldwork. Multivariate statistical methods (Random Forest and Piecewise Structural Equation Modelling) were employed to investigate the relationships between the matrix of vegetation indices, topographic and vegetation parameters, and the collected soil data. This analysis described the evolution of forest stands in the study area in relation to soil loss. The results emphasise the site-specific nature of the soil displacement process and demonstrate the effectiveness of integrating multi-source data to describe the dynamics of vegetation in post-coppicing areas.

74. Un approccio geomatico multipiattaforma per il monitoraggio degli habitat marini: risultati del progetto MANATEE

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Il contributo presenta l'approccio integrato sviluppato nell'ambito del progetto MANATEE (Monitoring and mApping of mariNe hAbitat with inTegrated gEomatics technologiEs) per il monitoraggio tridimensionale non invasivo del coralligeno, con particolare riferimento ai talli dell'alga corallina incrostante Lithophyllum stictiforme. L'acquisizione dei dati è affidata a tre piattaforme subacquee complementari, che integrano fotogrammetria ravvicinata, vincoli pressori e navigazione acustica. Le prove metrologiche e la co-registrazione dei modelli mostrano una ripetibilità geometrica dell'ordine di 0,3–0,5 mm nelle configurazioni validate. Le prime analisi multitemporali evidenziano variazioni locali superiori a 5 mm in alcuni campioni, la cui interpretazione biologica richiede un confronto con osservazioni ecologiche indipendenti. Sono discusse la complementarità delle piattaforme e le condizioni di applicabilità della procedura ai fini di un monitoraggio quantitativo ripetibile.

10. Volumetric Urban Growth Modelling in Sub-Saharan Africa: An Integrated Statistical and Deep Learning Pipeline for Nairobi Metropolitan Region (2016–2030)

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Rapid urbanisation in Sub-Saharan Africa is increasingly expressed through vertical densification, yet geospatial monitoring frameworks remain anchored to two-dimensional footprint metrics, limiting quantification of built-environment change and infrastructure demand. The Nairobi Metropolitan Region, with 26 administrative subcounties spanning 5,114 km2, exemplifies heterogeneous growth trajectories that aggregate indicators obscure. This study develops a reproducible threedimensional volumetric monitoring pipeline quantifying annual building volume at subcounty level from 2016 to 2023, with planning-oriented business-as-usual (BAU) scenario projections to 2030. Annual 4 m resolution building height rasters from the Google Earth Engine Open Buildings collection were aggregated to volumetric grids intersected with subcounty boundaries; per-subcounty Ordinary Least Squares regression with significance gating and 90% prediction intervals constitutes the projection core, with ConvLSTM spatial validation confirming that the underlying densification patterns are spatially coherent and learnable (r = 0.937, SSIM = 0.995). Metro-level volume grew from 0.795 to 1.113 km3 (+40.0%, 2016–2023); 19 of 26 subcounties exhibit statistically significant upward trends, yielding a 2030 BAU projection of 1.352 km3 (90% PI: 1.140–1.564 km3). Floor Space Index analysis identifies Kamukunji as the sole subcounty exceeding the high-density threshold by 2023, with Makadara and Starehe projected to cross it within the 2030 horizon, providing 4–7 years of advance warning for infrastructure capacity planning. The reproducible pipeline, transferable across continental Africa via the same data infrastructure, delivers subcounty volumetric projections that complement SDG 11.3.1 monitoring by quantifying insitu vertical densification alongside horizontal land consumption. 2 E. O. Otieno and P. Boccardo

63. Accuracy and Repeatability of Smartphone Photogrammetry: A Comparison with TLS in a Cultural Heritage Case Study

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The protection of cultural heritage and the documentation of its geometric and material details are extremely important, holding a deep value of both economic and social, nowadays particularly precious to Italy. Technology is undoubtedly a reliable source for data collection, and the widespread use of mobile devices serves as a pervasive and democratic tool for information, transforming millions of users into potential producers of three-dimensional data. The latest research frontiers have shifted the focus from the feasibility of three-dimensional object reproduction to the metric evaluation of data, as demonstrated by current publications in the fields of Digital Twins and data fusion. Thus, the evaluation of the precision and accuracy of data is therefore a topic of ongoing scientific interest. In this context, the work presented here analyses the variability associated with photogrammetric reconstruction performed using mobile devices, distinguishing the error components attributable to the acquisition phase from those introduced during data processing. To achieve this objective, a rigorously controlled experimental protocol was defined, based on the repeated acquisition of the same object by different devices while keeping the shooting geometry, distance from the object, and operating modes constant. The research subject is a statue placed on the campus of the Polytechnic University of Bari, characterized by a complex geometry and numerous surface irregularities. The devices considered in the study were Apple iPhone released between 2019 and 2023 and equipped with sensors that all have a camera resolution from 12MP to 48MP. For each device, a dual dataset is available, captured by different operators simultaneously. To rule out variability and subjective bias in the subsequent processing stage, all datasets were processed through a fully automated pipeline developed in Agisoft Metashape using Python scripts, thereby standardizing the alignment and reconstruction parameters. Alongside the data collection phase, a survey was conducted using a Terrestrial Laser Scanner (TLS), taken as the ground truth. The purpose of this study is to analyze the errors and statistical metrics by comparing each point cloud dataset generated by smartphones with the TLS, thereby providing an assessment of the final model’s metric reliability. 2

9. Sensor-Agnostic Soil Sealing Segmentation: Cross-Sensor Generalization of Transformer and Foundation Models on Very-High-Resolution Imagery

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Operational soil sealing monitoring must run on a heterogeneous and evolving set of satellite sensors, yet segmentation models are typically trained and selected on a single sensor. We study how well models trained on one sensor transfer to others without any target adaptation. Framing soil sealing as binary semantic segmentation (sealed versus unsealed), we train three Transformer-based architectures on four-band SPOT imagery at 1.5 m resolution: a specialized SegFormer extended with a spectral awareness embedding, the DINOv2-based foundation model CrossEarth, and the wavelength-aware foundation model DOFA. As a second architectural family and a strong reference we add a convolutional U-Net baseline trained under the same budget. All models are integrated into a unified, sensor-agnostic training, inference, and evaluation framework, and are evaluated cross-sensor on five Italian coastal cities acquired by different platforms at resolutions never seen in training. The in-domain ranking and the cross-sensor ranking are decoupled: the convolutional U-Net baseline leads in domain (mIoU 0.834), yet CrossEarth, last in domain, generalizes best across sensors (average mIoU 0.84), while U-Net, SegFormer-SAE, and DOFA drop sharply on the most dissimilar sensors, at times failing to detect the sealed class while retaining high aggregate accuracy driven by class imbalance. The results indicate that in-domain accuracy is not predictive of cross-sensor transfer, and that spectral-agnostic foundation models are a more reliable basis for operational, multi-sensor soil sealing monitoring.

36. Influence of UAV-Borne LiDAR Scanning Modes on Ground-Point Sampling and DTM Completeness: A Preliminary Evaluation of the DJI Zenmuse L3

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Recent advances in miniaturization and integration of commercial airborne Light Detection and Ranging (LiDAR) have enabled their deployment on Unmanned Aerial Vehicle (UAV) platforms. Compared with conventional crewed-aircraft systems, UAV-borne LiDAR offers greater operational flexibility for high-resolution survey and is adopted in geomatics applications, including 3D surveying, infrastructure inspection, environmental monitoring and forestry, where vegetation penetration offers advantages over passive sensing techniques. Commercial UAV-borne LiDAR systems often operate as black-box solutions, where acquisition settings directly determine the resulting point cloud. Independent evaluations are therefore needed to understand how scanning configurations affect point distribution and terrain sampling. This study presents a preliminary evaluation of the DJI Zenmuse L3, focusing on the influence of scanning mode and pulse repetition frequency on groundpoint sampling and Digital Terrain Model (DTM) completeness in a forested test area. Three scanning modes (Linear, Star-shaped and Non-repetitive) were compared at 100 kHz under equivalent flight conditions, while an additional Starshaped acquisition at 350 kHz explored the effect of increased pulse rate. Ground-classified point clouds were analysed considering spatial distribution, point density, grid completeness and sampling redundancy at grid steps of 0.05, 0.10 and 0.20 m. At 100 kHz, Linear scanning provided the highest ground-point density and completeness at 0.05 m, whereas Star-shaped scanning achieved slightly higher completeness at 0.10 m. At 0.20 m, all modes approached complete spatial coverage. Increasing the pulse rate to 350 kHz improved groundpoint availability, finer-resolution completeness and sampling redundancy. Overall, DTM support depended on scanning geometry, pulse rate and target raster resolution.

26. The AMIS Coastal Risk Atlas: A Transboundary Web Platform for Multi-Hazard Assessment and Climate Adaptation

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Coastal areas of the Western Mediterranean are exposed to interacting hazards, including erosion, marine flooding, extreme waves, cliff instability and ground deformation. Their assessment is often hindered by fragmented datasets, heterogeneous spatial units and different information standards across administrative boundaries. This paper presents the AMIS Coastal Risk Atlas, an open-access bilingual web platform developed within the Interreg Italy-France Maritime Programme. The Atlas integrates morphological, meteo-marine, geological, land-use and satellite-derived information for Tuscany, Liguria, Sardinia, Corsica and the French departments of Alpes-Maritimes and Var. Coastal sectors provide a shared spatial framework through which information on beach width, shoreline evolution, coastal type, susceptibility and urban exposure is organised. Scenario-dependent layers represent significant wave height, storm surge, run-up and wave power under RCP4.5 and RCP8.5 climate pathways and for multiple return periods. The platform also incorporates selected historical storms, EMODnet coastal products, Copernicus Coastal Zones land cover and European Ground Motion Service observations. A modular architecture based on interoperable geospatial services enables interactive mapping, technical pop-ups, time-series visualisation and structured natural-language queries of storm-wave statistics. The Atlas provides a consistent transboundary screening environment and an entry point to coastal digital twins while supporting research, risk communication and evidence-informed adaptation planning.

19. Multitemporal Analysis of Ionian Coastal Dunes Using UAV Surveys and Historical Geospatial Data

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Coastal dune ecosystems provide essential ecological and socio-economic services. However, they are increasingly threatened by erosion, urbanization, and anthropogenic pressure, particularly within the Mediterranean context. Long-term monitoring of these fragile environments is therefore essential, although traditional field-based approaches can be costly and difficult to apply consistently over time. This study presents a preliminary GIS-based methodological framework for the multitemporal monitoring of a small coastal dune system located at Lido Conchiglie (Gallipoli, Puglia, Italy). Historical aerial photographs (1954, 1972), multi-year orthophotos covering the period 1988–2023, and a highresolution multispectral UAV survey conducted in 2026, were integrated within an open-source GIS environment. The analysis focused on three main components: qualitative shoreline evolution, land-cover transformation in the area surrounding the dune, and the diachronic assessment of a conservation-relevant Juniperus spp. dune habitat. Results suggest an overall, spatially uneven tendency toward shoreline retreat and a marked increase in artificial land cover around the dune, largely at the expense of natural and agricultural areas. Despite increasing anthropogenic pressure, several Juniperus spp. habitat patches show substantial spatial continuity across the available historical imagery. These findings highlight the potential of integrating historical and UAV-derived geospatial data within an open-source GIS framework as a cost-effective and replicable firstlevel screening approach for assessing dune vulnerability. The proposed workflow provides a methodological basis for future quantitative monitoring and restoration-oriented studies in similarly threatened coastal environments.

24. Statistical Containers and the Spatiality of Heat: How Spatial Aggregation Changes Who Counts as Heat-Exposed in Bologna

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Heat exposure maps combine thermal and demographic information to describe a population and to target interventions. When population is available only for aggregated units, the choice of geography can change the exposure assigned to individual residents. We quantify this effect, distinguishing the aggregate estimate of exposure from the identification of exposed residents. For Bologna, we link register data for 390,337 residents to the building where they live and use a Landsat 9 scene acquired during a heat wave in August 2025. Exposure is computed at building scale and recomputed after aggregating population into grids from 30 to 1,000 m, each in 16 configurations, census tracts and statistical areas. Mean population-weighted exposure is stable: the bias does not exceed 0.13 °C in any of the 98 partitions. The temperature assigned to an individual departs from the building-scale reference by 0.37 °C on average at the census tract and by 0.81 °C at the statistical area. Identification is affected most: at the census tract, where the city mean is off by only 0.007 °C, 25.8 % of the residents classified as exposed at building scale are no longer identified; at the statistical area, 69.8 %. At constant resolution, the configuration of units alone moves the number classified as exposed across a range of 20 % of its mean at 250 m. The stability of an aggregate exposure estimate does not imply stability in the identification of exposed individuals. The spatial unit should therefore be chosen for the scale of the phenomenon and the use of the map.

25. Machine Learning-Assisted Photo-Interpretation as a Tool for Surveying Invasive Benthic Species in Marine Biodiversity Conservation: The Case of Caulerpa cylindracea Sonder, 1845

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Mediterranean benthic assemblages are sensitive indicators of ecosystem condition, yet image-based monitoring is often constrained by the time required for taxonomic interpretation and cover estimation. This study develops a reproducible machine-learning workflow for benthic photointerpretation, using the invasive green alga Caulerpa cylindracea Sonder, 1845 as a challenging test case. Over three years, 1,763 photo-quadrats were acquired seasonally by SCUBA and free-diving at six shallow infralittoral sites around Culuccia Island (northern Sardinia, Italy), including three invaded and three non-invaded sites. Approximately 10% of the images were manually annotated; after quality control, 158 image-mask pairs were retained. Dense annotations included 13 benthic classes comprising C. cylindracea, other representative taxa or morphological groups, and background. A SegFormer-B0 semantic segmentation model was trained using class-balanced crop sampling, inverse-squareroot class weighting, background down-weighting, conservative image augmentation, and grouped train-validation splitting. The selected model achieved a foreground mIoU of 0.455 and a mean foreground F1/Dice of 0.584 on 47 independently held-out images. The trained model was then applied to 600 unannotated images, generating class-specific pixel counts and mean predicted imagearea fractions at image, folder, site, and whole-dataset levels. This workflow provides a practical and reproducible bridge between expert annotation and scalable quantitative monitoring of benthic communities.

62. AI-assisted 2D-to-3D crack mapping for structural assessment and planned maintenance across underground, infrastructure and Cultural Heritage assets

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Reliable crack mapping is essential for structural assessment and planned maintenance, yet image-based detections remain difficult to interpret metrically when assets present complex geometries, heterogeneous materials and variable acquisition conditions. This study presents a prompt-based multi-view workflow that transfers crack detections from an oriented photogrammetric image block onto the reconstructed surface. Text-prompted masks generated with Segment Anything Model 3 are projected through the calibrated camera geometry and integrated into a surface-constrained automatic 3D crack support. Recovery, metric correspondence and continuity are assessed against manually traced 3D references. The workflow was evaluated on an underground calcarenite chamber, a masonry bridge and a decorated heritage vault. All references in the underground and masonry datasets were substantially recovered. In the more demanding decorated-vault dataset, characterized by millimeter-scale cracks and a radiometrically complex surface, six of thirteen traces were substantially recovered, including three completely recovered within 10 mm. The results demonstrate the potential of combining complementary observations from the complete image block to generate metrically assessable 3D crack representations for documentation, targeted inspection and maintenance planning.

5. Underwater Photogrammetric Acquisition across Different Archaeological Scenarios: Evaluation of a Stereoscopic Workflow for Submerged Cultural Heritage Documentation

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Underwater photogrammetry is widely used for documenting submerged cultural heritage, supporting the generation of high-resolution 2D and 3D products for archaeological interpretation, conservation, and dissemination. Its effectiveness, however, is strongly influenced by acquisition geometry, environmental conditions, metric control, radiometric quality, and site configuration. This paper evaluates the transferability of a controlled stereoscopic underwater photogrammetric workflow across two markedly different archaeological scenarios along the Apulian coast in southern Italy. The Cesine Cannons Shipwreck was documented through separate survey areas at approximately 2.5–3 m depth, whereas the Novaglie Cannons Shipwreck extends across a wider and morphologically complex seabed at depths of approximately 25–30 m. The workflow is based on CRAB (Calibrated Rig for Aquatic photogrammetric Bicamera system), a diver-operated calibrated stereoscopic platform with two synchronised high-resolution cameras and a controlled baseline. The comparison examines how acquisition geometry, metric control and georeferencing, radiometric enhancement, photogrammetric processing, and final products respond to the different spatial and operational requirements of the two surveys. The results show that the same stereoscopic framework can support both localised and site-scale archaeological documentation, provided that its operational components are adapted to the environmental conditions, spatial extent, and documentation objectives of each context.

21. Integrated UAV LiDAR–RGB Accuracy Assessment under Reduced Ground Control: A Pilot-Scale Framework

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The integration of UAV-mounted LiDAR, RGB imaging, and RTK positioning has significantly expanded the capabilities of high-resolution 3D mapping. However, nominal positioning accuracy alone does not guarantee geometric reliability in heterogeneous built environments. This study presents a pilot-scale methodology for assessing UAV LiDAR–RGB products under reduced ground-control conditions, tested in a heterogeneous built environment at the University of Calabria campus using NRTK observations and static GNSS measurements. Five GCPs were used for photogrammetric control, and three points were retained for independent validation. The LiDAR point cloud was independently checked against static GNSS and used as a spatial benchmark. Five RGB photogrammetric scenarios were processed, combining nadir and oblique imagery, reduced GCP configurations, and low-altitude oblique imagery to enhance façade reconstruction. Validation integrated independent checkpoint residuals, pavement cloud-to-cloud comparisons, planar façade point-to-plane distances, and full-façade LiDAR-to-photogrammetric proximity metrics. Moving from the nadir-only configuration to the nadir-plus-oblique configuration reduced vertical checkpoint RMSE from 66.46 cm to 15.03 cm and pavement mean cloud-to-cloud distance from 53.83 cm to 5.27 cm. The RTK configuration with three GCPs further reduced vertical RMSE to 3.16 cm and pavement discrepancies to about 2.2 cm. The five-GCP configuration supplemented with low-altitude oblique imagery achieved a 2.50 cm vertical RMSE, 2.71 cm façade-normal RMSE, and 2.95 cm median full-façade distance, with 92.92% of LiDAR façade points having a photogrammetric neighbor within 10 cm. Under the investigated conditions, image geometry and limited ground control provided complementary benefits, supporting efficient and reproducible UAV survey design in complex built environments.

45. Assessing Agricultural Land-Cover Change and Hydroclimatic Associations in Homogeneous Mediterranean Spatial Domains

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Assessing agricultural land-cover evolution in Mediterranean landscapes requires comparable climatic and land-cover observations. This study investigates agricultural land-cover evolution and climatic associations using a Google Earth Engine (GEE)–Python methodology that addresses the spatial, thematic, and temporal heterogeneity of open raster datasets. Homogeneous raster domains in Tavoliere delle Puglie, Sibari Plain and Catania Plain were defined using one Köppen–Geiger class per domain, SRTM slopes ≤3° and ESA WorldCover (WC) 2021 cropland. CORINE Land Cover (CLC) maps for 2000, 2006, 2012 and 2018 tracked agricultural and other land-cover changes across study areas. TerraClimate data covered 2000–2021, from the first CLC date to the WC reference year; associations covered 2000–2018. Agricultural agreement at the same locations in all four CLC maps covered 98.58% of selected WC cropland in Tavoliere, 95.72% in Sibari, and 93.04% in Catania. Restricting the 2000– 2021 climatic calculations to these areas changed mean temperature by less than 0.015 °C and mean annual precipitation by less than 1.1 mm relative to all selected WC cropland. This consistency justifies retaining WC cropland for domain climatic characterization. Agricultural fractions declined in Tavoliere and Sibari and were nearly unchanged in Catania; artificial surfaces increased in all three areas. Partial least squares regression with spatial validation tested whether combined hydroclimatic period averages improved predictions beyond domain–interval mean agricultural changes. No consistent predictive improvement emerged. The methodology provides comparable climatic and land-cover observations for regional agricultural monitoring and for identifying areas and periods requiring finer-scale mapping and investigation.

32. BIM and AI for Automated Construction Scheduling: A Preliminary Integrated Framework

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The evolution of geomatic technologies and digital modelling has consolidated Building Information Modelling (BIM) as an information system for organising data useful for construction process management. Yet the potential of its geometric and semantic information remains underexploited in support of planning, since construction scheduling still relies predominantly on traditional, manual procedures and individual experience, which can prove inadequate for contemporary project complexity and limits the support offered to decision-making. To address this, the study proposes an integrated methodological framework combining BIM and Artificial Intelligence (AI) to automate the generation, prediction and optimisation of construction schedules, evolving site planning towards a fully data-driven approach. The methodology develops through three phases. First, a Generative AI application extracts geometric and semantic data from the BIM model, translating its elements into construction activities and producing a structured dataset that integrates geometric attributes with real operational variables such as labour productivity, equipment availability, execution constraints and activity dependencies. This dataset is then used to train the eXtreme Gradient Boosting (XGBoost) algorithm, which captures complex, nonlinear relationships among project variables and estimates activity durations with high accuracy (R^2 = 0.955, MAE = 0.132, RMSE = 0.858). The resulting durations feed a Genetic Algorithm (GA) that identifies the most efficient sequence and resource allocation while respecting dependencies and site limitations, compressing the overall project duration through the parallel execution of compatible activities. Validated on a reference digital model, the framework demonstrates the potential of BIM and AI to support consistent, data-driven construction planning.

50. Mapping Plastic Pollution in the Mediterranean Ionic Sea: Citizen Science Monitoring Experiences and Results from Amendolara

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Coastal ecosystems are increasingly threatened by anthropogenic pressures, particularly plastic pollution, which represents one of the most pervasive environmental challenges affecting Mediterranean marine environments. Monitoring coastal litter is essential for understanding pollution dynamics and supporting sustainable management strategies; however, conventional monitoring activities often require significant economic and technical resources. In this context, citizen science approaches provide accessible and participatory tools for long-term environmental observation while promoting local environmental awareness and stakeholder engagement. This study presents the experiences and preliminary results of a citizen science-based beach litter monitoring program conducted in Amendolara, a small coastal urban center located on the Ionian coast of Southern Italy, characterized by tourism activities, fishing communities, and proximity to the Amendolara Bank. The territory is also subject to long-term marine ecosystem monitoring activities carried out by the Stazione Zoologica Anton Dohrn. In collaboration with MOC-LLAB, the project developed and implemented simplified citizen science protocols to assess the presence and distribution of coastal plastic litter in a focal monitoring site along the Amendolara coastline. Data collection activities were conducted over a two-year period using the QField© mobile interface, which allowed participants to record and georeference beach litter observations through standardized digital protocols. The collected data were subsequently organized into georeferenced maps to visualize spatial distribution patterns and compare temporal variations between the two monitoring periods. The study particularly focuses on evaluating trends in coastal pollution, identifying the most recurrent litter categories, and assessing the effectiveness of citizen science methodologies for generating reliable environmental information at the local scale. 2 D. Vito . S. Scovazza , C. Maione, C. Giommi and T. Romeo Preliminary results indicate a significant presence of plastic waste in anthropized coastal areas, with seasonal variations likely associated with tourism pressures, marine currents, and local human activities. The comparison between the two annual datasets highlights the potential of participatory monitoring to support long-term coastal observation and contribute to environmental management strategies. It also enables the collection of useful data to understand the evolution of plastic pollution over time, to identify major sources of waste and to support research and policy decision-making. The study demonstrates how citizen science protocols can provide low-cost and scalable tools for marine litter monitoring while strengthening environmental education, community participation, and local awareness regarding coastal ecosystem conservation.

68. Reconstructing long-term snow cover dynamics in the Maritime Alps using Landsat, Sentinel-2, ancillary data and machine learning

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Mountains are among the environments most vulnerable to climate change, and its effects appear clearly in components such as snow cover and vegetation; measuring how these have changed over decades helps to quantify those effects. Satellite images are the only spatially continuous source for such longterm studies, but in mountain areas clouds and the few acquisitions of the earliest archive years leave many temporal gaps. Within the ACLIMO project, whose regional-scale component is presented here, we analyzed all usable Landsat and Sentinel-2 acquisitions from 1990 to 2025 to map snow cover at 30 m spatial resolution over a 3,218 km² area of the Maritime Alps. Snow was detected with the Normalized Difference Snow Index (NDSI). Based on recent literature, we built a daily March–April record in which clear observations are kept and every pixel not observed on a given day is filled, in turn, by i) the agreement of neighboring dates, ii) a temperature-based persistence rule and iii) a gradient-boosting classifier driven by terrain and ERA5-Land predictors. The resulting snow-covered area was corrected for classification errors. The record agreed with independent snow-depth stations, MODIS data, and the Copernicus snow product with overall accuracies of 0.86–0.95. April snow cover declined by 7.1% per decade (−83 km² per decade), three-quarters of it in the 1000–2000 m belt, consistent with warmer Aprils and less late-spring snowfall, while March showed no significant trend. The product gives protected-area managers a consistent baseline for monitoring the possible impact of climate change on snow cover.

Mappe della distribuzione delle specie arboree su scala europea: una revisione comparativa

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Abstract. Informazioni accurate e comparabili sulle specie arboree sono essenziali per il monitoraggio forestale, la valutazione della biodiversità, la contabilizzazione del carbonio e la gestione forestale sostenibile in Europa. Tuttavia, i prodotti paneuropei esistenti relativi alle specie arboree differiscono per fonti dei dati, risoluzione spaziale, struttura tassonomica e approcci di modellizzazione, con possibili effetti sulla loro concordanza e idoneità a diverse applicazioni. Questo studio ha confrontato tre prodotti paneuropei ampiamente utilizzati, di seguito denominati mappa arborea statistica (ST-Map), mappa arborea dell'atlante (AT-Map) e mappa basata sull'apprendimento automatico (ML-Map), utilizzando il database EU-Forest come insieme di dati di riferimento basato su osservazioni di presenza. Poiché EU-Forest rappresenta una raccolta armonizzata di osservazioni di presenza e non un insieme di dati di verità a terra privo di errori, l'analisi va intesa come una valutazione della concordanza, anziché dell'accuratezza. I risultati hanno evidenziato differenze sostanziali tra i tre prodotti. Sono stati utilizzati tre indicatori complementari di concordanza: valore complessivo di corrispondenza, tasso di corrispondenza a livello di punto e tasso di copertura a livello di specie. AT-Map ha ottenuto il valore complessivo di corrispondenza più elevato con EU-Forest (0,884), seguita da ML-Map (0,868) e ST-Map (0,533). A livello di punto, ML-Map ha mostrato il tasso di corrispondenza più elevato (0,588), mentre AT-Map ha raggiunto il tasso di copertura a livello di specie più alto (0,397). Dal punto di vista spaziale, i tassi di corrispondenza più elevati si concentravano principalmente nell'Europa settentrionale e sudoccidentale, soprattutto in Scandinavia e nella penisola iberica, mentre quelli più bassi erano più frequenti nell'Europa centrale, orientale e sudorientale. La validazione per singola specie ha indicato che precisione, richiamo e punteggio F1 forniscono misure più informative delle prestazioni di rilevamento a livello di specie rispetto alla sola accuratezza, poiché quest'ultima era fortemente influenzata dall'elevato numero di veri negativi. Nel complesso, AT-Map e ML-Map hanno mostrato una maggiore concordanza con il dataset EU-Forest rispetto a ST-Map. Tuttavia, ciascun prodotto presentava punti di forza e limiti specifici in funzione della scala spaziale, del dettaglio tassonomico e dell'applicazione prevista.

Parole chiave: EU-Forest; valutazione della concordanza; analisi spaziale.