Consiglio Nazionale delle Ricerche

CNR IRPI Istituto di Ricerca per la Protezione Idrogeologica

III Workshop CNR IRPI

Monitoraggio, modelli, tecnologie e trasferimento nel campo della previsione e prevenzione dei fenomeni geo-idrologici

Area di Ricerca Torino, 25-27 novembre 2024

TECH4YOU

SESSIONI

- Infrastrutture e standard per la gestione e condivisione di dati della ricerca
- Droni: gestione sinergica e prospettive scientifiche per il monitoraggio e la previsione di fenomeni geo-idrologici
- Trasferimento dei risultati della ricerca ad enti territoriali, istituzionali, stakeholders: realtà a confronto con l'ecosistema Tech4You
- Aree attrezzate e tecniche di misura al suolo e da remoto: esperienze di gestione dei dati
- Contratti e procedure amministrative

Infrastrutture e standard per la gestione e condivisione di dati della ricerca

Il GOT ha l'obiettivo di raccogliere esempi ed esperienze di produzione di dataset derivanti da attività di ricerca, pubblicati o resi disponibili sia in modo indipendente, sia all'interno di infrastrutture interne o nazionali/internazionali. Invitiamo i partecipanti a presentare contributi che esplorino non solo le metodologie di raccolta e gestione dei dati, ma anche eventuali approcci interdisciplinari, esempi di collaborazione con altri istituti o gruppi di ricerca, pratiche di disseminazione efficaci che hanno facilitato l'accesso e l'utilizzo dei dataset da parte della comunità scientifica e del pubblico, anche tramite l'uso di social network. Il confronto tra le diverse tipologie di dati prodotti nel nostro istituto e tra le varie modalità di gestione e disseminazione del dato potrà permettere un arricchimento reciproco e l'individuazione di buoni esempi e pratiche, da valorizzare anche all'interno del catalogo di metadati di IRPI.

The session aims to gather examples and experiences of producing datasets derived from research activities, published or made available either independently or within internal or national/international infrastructures. We invite participants to submit contributions that explore not only data collection and management methodologies, but also any interdisciplinary approaches, examples of collaboration with other institutes or research groups, effective dissemination practices that have facilitated access to and use of datasets by the scientific community and the public, including the use of social media. Comparison between the different types of data produced in our institute and between the various data management and dissemination approaches may allow for mutual enrichment and the selection of good examples and practices, which can also be enhanced within IRPI's metadata catalog.

SESSIONE ORALE

ADVANCING OPEN SCIENCE: IRPI'S METADATA CATALOG, INTEROPERABILITY STANDARDS, AND STRATEGIES FOR OPEN RESEARCH OUTPUTS

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ABSTRACT

In recent years, the sharing of scientific data has become essential for promoting transparency, innovation, and interdisciplinary collaboration in research. Three different presentations highlight possible future perspectives of the Research Institute for Geo-Hydrological Protection (IRPI) in fostering openness in research data, focusing first on strategies for open publishing, then on the adoption of interoperability standards, and finally on the development of the IRPI metadata catalog.

The discussion begins with strategies for publishing research outputs more openly, in line with the principles of Open Science. These strategies include the dissemination of data and publications through open-access repositories and sharing platforms, ensuring broader accessibility and fostering greater impact. These efforts aim to bridge gaps between research producers and users, enhancing the visibility and utility of scientific data.

The discussion then moves to the adoption of interoperability standards, which serve as a cornerstone for enabling seamless data sharing and accessibility across platforms and disciplines. Key standards, such as those established by the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO), play a vital role in ensuring compatibility among diverse data infrastructures.

Lastly, the presentations explore the motivations behind the development of the IRPI metadata catalog, an essential tool for organizing, preserving, and providing access to the Institute's datasets. The current status of the catalog will be analyzed, highlighting the challenges addressed and the solutions adopted to create a standardized, user-friendly resource.

These contributions seeks to inspire a dialogue on how openness, interoperability, and effective data management can drive a more collaborative, inclusive, and forward-looking research ecosystem. By presenting experiences and initiatives, it aims to encourage researchers to adopt best practices in data sharing, fostering a culture of transparency and cooperation that benefits both the Institute and the broader scientific community.

Infrastrutture e standard per la gestione e condivisione di dati della ricerca

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SESSIONE POSTER PICO

MULTI-DISCIPLINARY APPROACH TO SUPPORT GEO-HYDROLOGICAL RISK ASSESSMENT IN THE FLUVIAL ENVIRONMENT ON A HISTORICAL BASIS

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ABSTRACT

The historical-geographical information derived from geo-iconographic resources acquired through a broad process of research and selection of cartographies and historical documents made possible an in-depth study of the main phases that contributed to the natural and anthropic transformations of a territory that is particularly significant from a historical, cultural and environmental point of view. The focus is the Po River in the Parma floodplain. The entity of the modifications is such that it has obliterated the original flow pattern of the watercourses, reducing or cancelling the perception of risk. This study aims to examine the floods of the Po River from 1800 to nowadays, with particular attention to historical riverbeds and relict morphologies, analysing significant flood events and their impact on the environment and man also analysed trough Lidar images.

The study aims to demonstrate the importance of historical studies that complement each other in different disciplines, in order to interpret river dynamics in the event of potentially damaging flood events and latent hazards in a deeply transformed river environment.

Various experts with different multidisciplinary competences (archaeologists, archivists, city planners, geographers, geologists, geomorphologists) have contributed to the research. They were involved in the PRIN FONTES Project, with the aim of making the knowledge deriving from multidisciplinary studies converging in geographical, geocartographic and geohistorical in-depth studies consultable, implementable and operational in the geological and hydraulic fields.

Thanks to the different competences of the authors, it was possible to reconstruct the geopolitical aspect of feudal and state borders, the role of defence and mitigation structures in response to the fluvial behaviour of the Po River, often harmful to human activity, such as flood events and river routes.

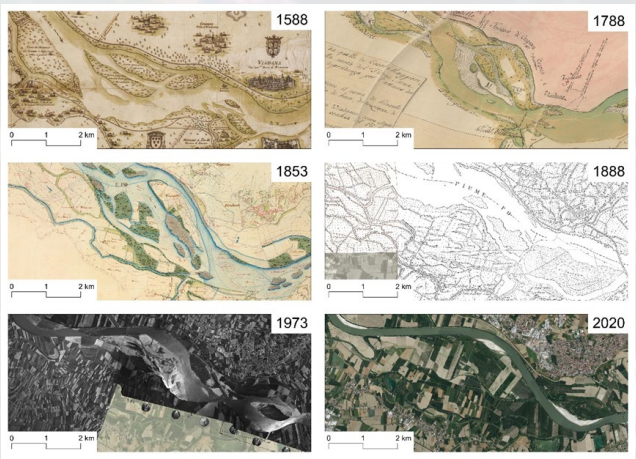
The FONTES project and the derived FONTES Inter-Academy Centre (https://fontes.univr.it/il-centro-studi/) aim to develop organisation, filing and localisation systems that can provide decision support for the identification, evaluation and management of recognisable environmental and cultural vulnerability elements in river regions, in particular the middle course of the Po River and some of its tributaries. In the identification of these elements, the interpretation of historical documentary sources (textual, cartographic and iconographic) plays a fundamental role; these analyses are supplemented by those deriving from the current observation of the territory in order to develop integrated cognitive and evaluation procedures.

The project, synthesis of research in the geographical, historical-architectural and geological fields, focuses on the search, identification, systematisation and valorisation of the historical-cartographic sources relating to the area under examination, confirming that only a multidisciplinary approach can provide a correct cognitive process of the river territory.

In addition, a further objective of the research was to create a geographical database aimed at their cataloguing, consultation and analysis by different types of users in order to enable their functional use by land managers and planners.

The importance of historical data is referable in different territorial contexts; in this research is the starting point, but also the goal to increase knowledge and its dissemination by enhancing their availability through digital repositories.

Historical maps used for the analysis of the Po River variations in the Parma area, through the use of GIS software.



DIGITAL GEOSPATIAL ECOSYSTEM AND DECISION SUPPORT SYSTEM FOR DISASTER PREPAREDNESS AND RESPONSE

Ivan Marchesini[1], Debora Voltolina[2], Paola Reichenbach([1] Ginevra Chelli[2], Massimo Melillo[1], Mauro Rossi[1], Paola Salvati[1], Lorenzo Massucchielli[3] Simone Sterlacchini[2]

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ABSTRACT

We present the development status of a Digital Geospatial Ecosystem (DGE) and its integration with an innovative Decision Support System (DSS), both designed in the framework of the DG ECHO RED ROSES Project, to support emergency preparedness and response. This system, structured around a containerized architecture with three Docker modules, aims to serve the French and Italian Red Cross by automating the ingestion, storage, analysis, and visualization of diverse data types. These include satellite imagery, updated landslide catalogues, meteorological forecasts, real-time radar data, and field reports collected through Volunteered Geographic Information (VGI) web apps.

The core DGE architecture comprises three key components:

- Central Data Node: Hosts and manages geospatial data, publishes QGIS projects as web services, and enables automatic ingestion of external datasets.
- Local Nodes: Replicate central node data nightly to ensure offline access in emergency scenarios.
- Administrative Node: Facilitates data management and visualization preparation, empowering users with limited IT skills to create and publish QGIS-based web maps.

Data stored within the DGE is dynamically visualized through intuitive web applications, ensuring real-time access to critical information. This capability was tested successfully in the RedLex exercise (an international RED CROSS exercise), where the system demonstrated its ability to enhance situational awareness and resource allocation.

To further support decision-makers, the integrated RED ROSES DSS leverages procedural workflows formalized through Petri nets. These workflows guide disaster managers through a sequence of recommended actions tailored to the type and scale of the emergency. The DSS combines existing data (e.g., hazard maps) with new-generation event scenarios derived from satellite data and field reports. This dual input system allows for real-time updates and actionable insights, improving the efficiency of response strategies.

The DSS supports decision makers in disaster-related emergency management by providing them with a selection of possible actions, both recommended or compulsory, together with:

- detailed instructions of execution;
- contacts of area managers in charge of performing each action;
- legal documents or pre-filled forms to be issued at each stage;
- real-time reports of resources and structures availability;
- event scenarios and inventories of exposed assets.

In the specific case of the Italian Red Cross, four emergency phases (called “configuration states”) are provided: Normal State, Pre-Alert State, Alert State, and Emergency State.

The DSS played a central role during the RedLex exercise, supporting disaster managers in adapting response actions to evolving scenarios. It demonstrated its value in managing multi-hazard emergencies, optimizing cross-border collaboration, and improving the overall decision-making process.

In conclusion, the integration of the DGE and DSS provides a comprehensive framework for disaster preparedness and response. This system represents a significant step forward in leveraging automation, data sharing, and real-time visualization to enhance operational resilience and emergency management effectiveness.

DATA FROM POST-FLOOD SURVEYS AND FIELD OBSERVATIONS FOR 12 RECENT EVENTS IN ITALY (2011-2024)

Marchi Lorenzo[(1)], Crema Stefano[(1)], Fiorucci Federica[(2)], Sarretta Alessandro[(1)], Ballaera Angelo[(1)], Barizza Antonella[(1)], Bossi Giulia[(1)], Maio Donato[(3)], Piantini Marco[(1)], Rocca Jacopo[(1)], Cavalli Marco[(1)]

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ABSTRACT

The APPARE Project (financed by a cascade call issued by the "Multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate (RETURN)" project[1] , funded in the frame of Italy's recovery and resilience plan (PNRR) of Next Generation Europe) focuses on the documentation of flash floods in mountainous and hilly catchments.

One of the objectives of the APPARE project is the collection and a structured reanalysis of data on flash floods in Italy for which CNR-IRPI (often in collaboration with other institutions) carried out post-flood surveys.

The dataset comprises historical records (2011-2022) and recent floods (2023-2024), documented through Intensive Post-Event Campaigns (IPECs) (Bonnifait et al., 2009). Data was gathered following standardized field protocols, utilizing the Manning-Strickler slope-conveyance method (Gaume and Borga, 2008), which involves surveying at least one cross-section per event and identifying flood marks to calculate peak discharge values in ungauged channels, supported by geomorphological surveys to document channel and slope changes.

The data of the flash floods have been organized into a dataset listing the information collected for each channel cross-section where the flood peak discharge has been estimated.

Key variables collected include mean flow velocity, channel slope, peak discharge values, geomorphic effects assessments, and Froude number, which are crucial for evaluating flood dynamics in ungauged catchments.

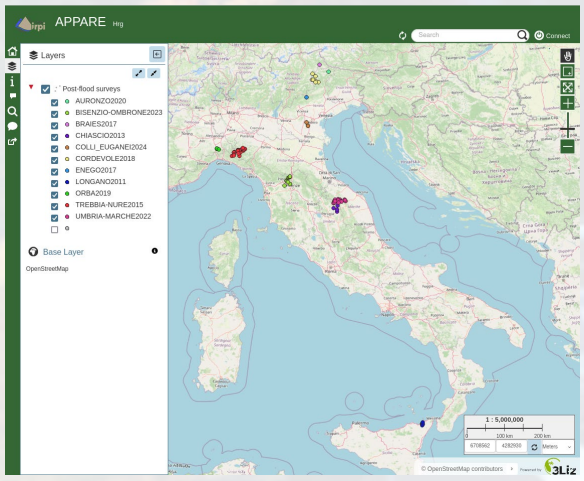
One of the objectives of the APPARE project is also to facilitate the search, visualisation, analysis, and reuse of data collected and produced during the project via web interfaces and interoperable services.

For this purpose, a geospatial infrastructure has been designed and implemented including:

- a QGIS Server, creating interoperable geospatial services through an easy-to-use integration with the desktop application QGIS;
- a LizMap web client, to navigate, visualize and interact via web browser with the services provided by QGIS Server;
- a Postgres/PostGis database for geospatial data management;
- an OwnCloud storage system to manage additional information integrated with other datasets (e.g. images and documentation related to surveys).

The spatial infrastructure acts as a WebGIS interface[2] where project partners and general users can dynamically interact with the information collected or organised by the project.

[1] https://www.fondazionereturn.it/
[2] https://hydrogeo-gis.irpi.cnr.it/index.php/view/map?repository=hrg&project=APPARE



References

Bonnifait, L., Delrieu, G., Lay, M.L., Boudevillain, B., Masson, A., Belleudy, P., Gaume, E., Saulnier, G.-M., 2009. Distributed hydrologic and hydraulic modelling with radar rainfall input: Reconstruction of the 8-9 September 2002 catastrophic flood event in the Gard region, France. Advances in Water Resources, 32 (7), 1077-1089, DOI: 10.1016/j.advwatres.2009.03.007.

Gaume, E., Borga, M., 2008. Post-flood field investigations in upland catchments after major flash floods: proposal of a methodology and illustrations. J. Flood Risk Manage., 1, 175–189, https://doi.org/10.1111/j.1753-318X.2008.00023.x.

FIRST ITALIAN INVENTORY OF HIGH-ELEVATION MASS MOVEMENTS IN THE ALPS: FROM DATASET TO SMARTPHONE

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ABSTRACT

In a context of a climate change that affects the Alps, high-altitude environments are evolving fast and new hazards are emerging. For example, changes in air temperature and precipitation, seems to be two of the most important preparatory and triggering factors of the mass movements increase, that occur in the mountain during the last twenty years. In order to improve knowledge on these aspects, it is essential to collect detailed and updated information on mass movements that occur in the Alps.

In Italy, there are already some landslide inventories. However, there isn't a mass movements inventory that responds to all the following characteristics: i) Which collects events that occurred throughout the Italian Alps, ii) Which includes all types of processes (except for snow avalanches); iii) That contains only mass movements with information on date of occurrence; iv) That it is updated to 2023; v) That it is available free and online; vi) That can be used online and offline; vii) That it is not only available for consultation but also editable.

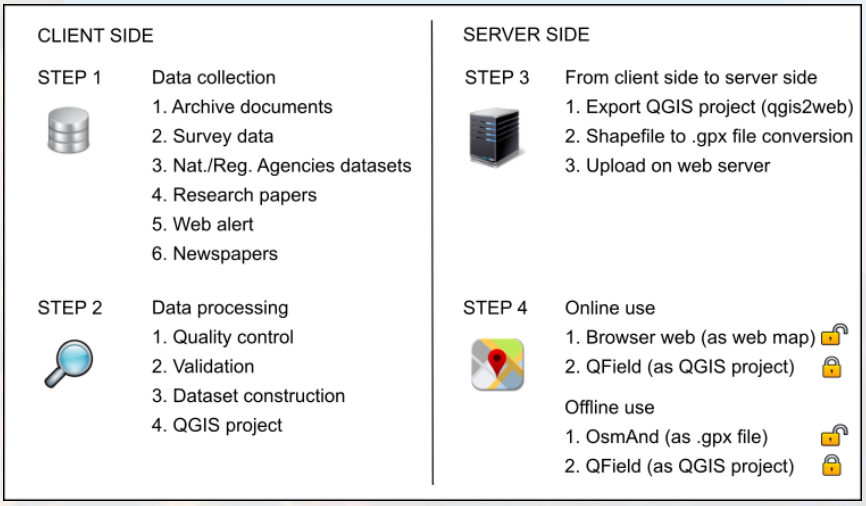
To try to fill these gaps, this mass movements inventory (hereinafter Inventory) was implemented (Nigrelli et al. 2024). The methodology applied for the construction of the Inventory consists of four steps (Fig. 1):

Step 1. Data collection regarding mass movements events occurred in the Alps at an elevation above 1500 meters. This elevation threshold was identified because alpine environments located above it are responding more rapidly and intensely to climate change.

Step 2. Quality control and validation of the mass movements collected, dataset construction and inserting the dataset in QGIS.

Step 3. Export of the QGIS project, shapefile conversion from ".shp" to ".gpx" file, upload on web server of the ".gpx" file.

Step 4. Use of the Inventory, both online and offline. The Inventory can be consulted online with a simple web browser. The Inventory can be consulted offline with smartphone, using OsmAnd and QField apps. For more details see https://geoclimalp.irpi.cnr.it/catasto-frane-alpi/.



The Inventory is an excellent support tool for many activities that take place in and for the mountains. Through this simple inventory we want to provide, on the one hand, a practical tool to the scientific community and to government bodies engaged in the study of the effects of climate change on high-altitude environments and, on the other, a tangible example towards the construction of an European mass movements inventory occurred in the Alps.

Currently, the Inventory contains information relating to 1120 mass movements.

Future developments include the digitization of mass movements that occurred before 2000 and the search for new IT solutions, to be applied in order to improve the usability of the Inventory, also in terms of EU data requirements and FAIR data directives.

References

Nigrelli G., Paranunzio R., Turconi L., Luino F., Mortara G., Guerini M., Giardino M., Chiarle M. (2024) – First national inventory of high-elevation mass movements in the Italian Alps. Computers and Geosciences, vol. 184, February 2024, 105520. DOI https://doi.org/10.1016/j.cageo.2024.105520

FLOOD DAMAGE EFFECTS IN HIGHLY URBANISED MEDITERRANEAN AREAS

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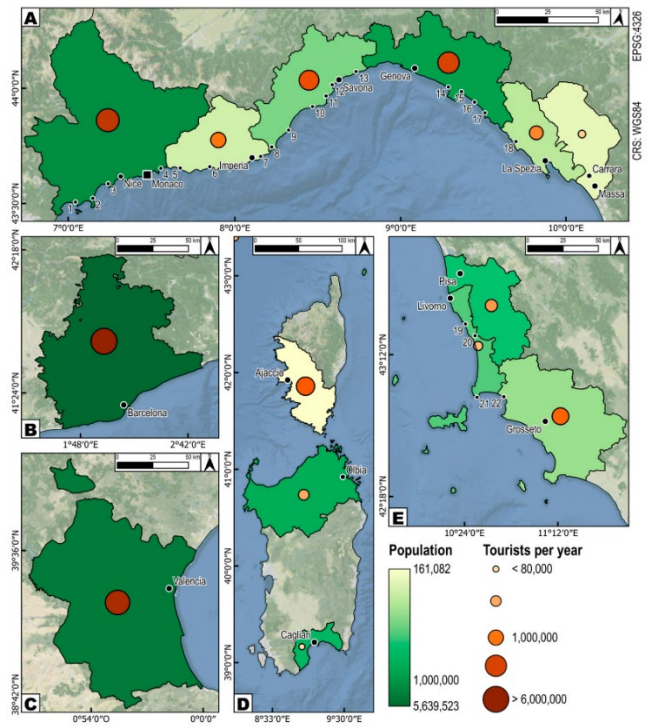
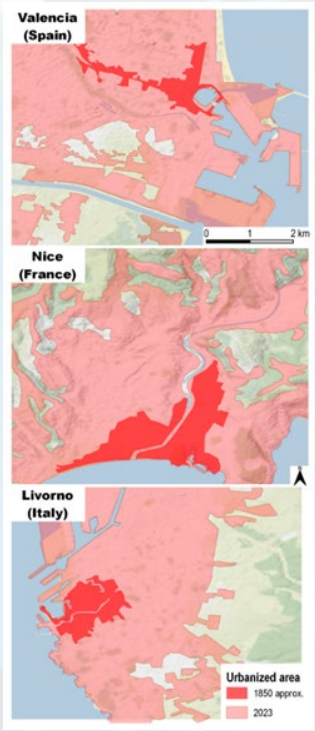
ABSTRACT

Numerous riverbeds and floodplains in the Western Mediterranean Area (WMA) have been affected by anthropogenic modifications during the last centuries. In recent decades, an increase in floods in the coastal WMA has been observed, in particular in Italy, France, and Spain. Variations in the rainfall regime and anthropisation have influenced the relevant geomorphological processes. Geomorphological and land use changes that occurred in the last two centuries were examined using historical and recent maps, historical data, and European big data since the 1800s for 65 basins, for which over 670 flood events and more than 1500 victims were identified. Anthropogenic activities have changed the patterns of floodplains.



Resident populations (2022) and tourist presence (2019) in the study areas. Resident The 1–22 numbers refer to major coastal cities.



Comparison of urbanised areas derived from old maps and recent cartograph.

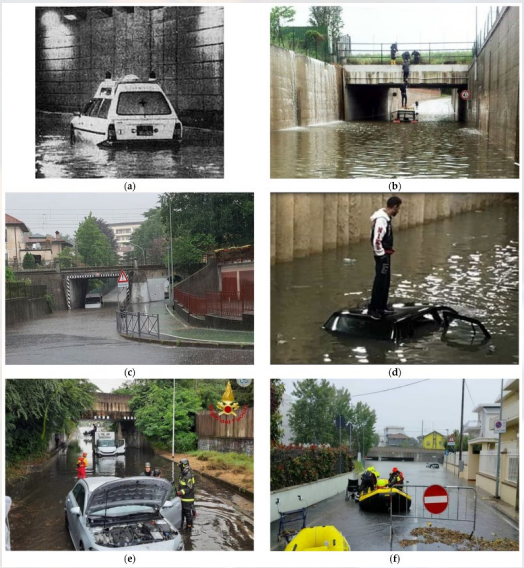
In most cases, narrowing of the riverbeds, especially in the lower river sections, has been observed. Reductions in the coastal watercourse widths range from 10% to 95%, with an average of 55% [1]. Other changes are related to the deviation in the watercourses, with trends that did not respect the natural river flow. In some cases, the watercourses were covered and have vanished from recent maps. This aspect has reduced or eliminated the perception of the risk not only for the residents but also for land planners.

Several researches confirms the increased frequency of extreme flooding along the Mediterranean Sea coasts. Recent examples are Valencia 2024, or 2019 Cecilia storm struck the Spain, France, and Italy, where several deaths were reported. If they are concentrated on reliefs close to the coasts, then these precipitations characterised by convective events (cumulative rainfall >100 mm in a few hours) can generate flash floods. Coastal urban flooding is a complex process that may be the result of high-intensity rainfall, inadequate drainage, and the overtopping of containable floods in channels or watercourses. Losses suffered due to flooding can be reduced with adequate knowledge of the expected processes and their impacts.

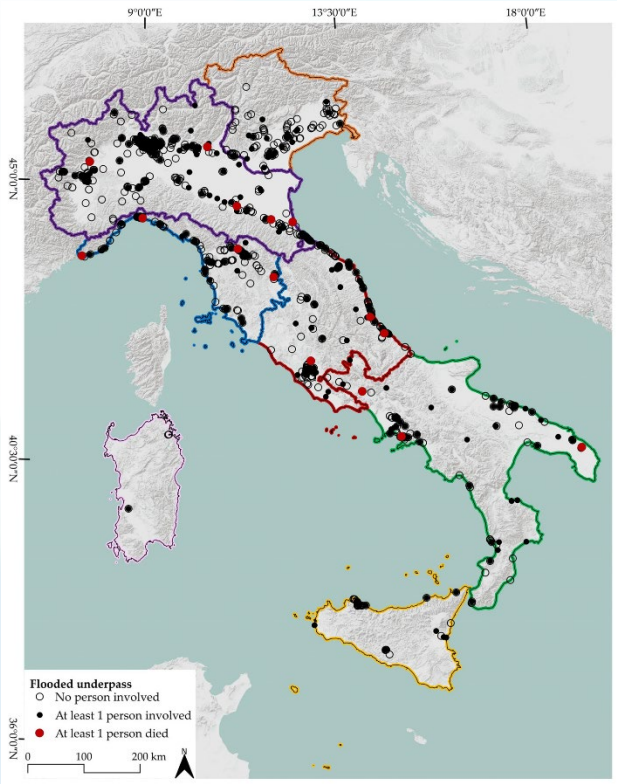
The consequences of flash floods and ground effects in densely urbanised areas are amplified by the large number of vulnerable elements that may occur.

Examples of diachronic built-up area mapping in three representative urban contexts of the study: Valencia (Spain), Saint Laurent du Var (France) and Ventimiglia (Italy). Width reductions in the terminal stretches of watercourses in coastal plains was measured via GIS using historical maps and current satellite images.

These areas are usually intersected by channelled watercourses that have been narrowed over time through infrastructure to acquire new urban spaces, making the river space inadequate for floodwater runoff. An example is done by analysing the underpasses flood risk conditions in Italy [2]. In road underpasses drivers are unlikely to perceive a real risk due to the high degree of confidence that comes from the habit of driving. Several hundred pieces of data were selected and cataloged in a thematic database. The behavioral aspects in the face of risk were also examined in order to provide a better understanding and raise awareness for preventive purposes. The results confirm the exposure of underpasses to extreme risk events, affecting road users. Between 1942 and 2023, 698 underpasses were identified as having experienced a flooding event at least once. The database shows that 680 vehicles were involved, with a total of at least 812 individuals, of whom 19 died. Despite incomplete and uneven information, the findings of the analysis regarding the increment in underpasses flooding and the drivers action in front of a flooded underpass may be useful for undertaking the appropriate mitigation strategies.



Flooded underpasses analyzed in the dataset that occurred in Italian areas in the past and in recent years.



Distribution of flooded underpasses in River Basin District (in different outline color) areas, 1942–2023.

References

[1] Turconi, L.; Bono, B.; Faccini, F.; Luino, F. Anthropic Constraint Dynamics in European Western Mediterranean Floodplains Related to Floods Events. Remote Sens. 2023, 15, 4798. https://doi.org/10.3390/rs15194798

[2] Turconi, L.; Bono, B.; Genta, R.; Luino, F. The Effects of Flood Damage on Urban Road Networks in Italy: The Critical Function of Underpasses. Land 2024, 13, 1493. https://doi.org/10.3390/land13091493

Droni: gestione sinergica e prospettive scientifiche per il monitoraggio e la previsione di fenomeni geo-idrologici

Negli ultimi anni, l'IRPI ha investito in modo significativo nell'acquisizione di droni e sensori, strumenti diventati essenziali per la mappatura, la misurazione e il monitoraggio dei processi geo-idrologici e dei loro impatti, sia a scala di versante che di piccolo bacino idrografico. Il GOT si propone di affrontare le questioni tecniche e pratiche relative alla gestione e all'uso sinergico dei droni e delle licenze software per l'elaborazione dei dati attualmente disponibili su diverse piattaforme. Nella presentazione principale verrà presentata una panoramica dei droni, dei possibili campi di applicazione con esempi pratici, mentre le presentazioni brevi dei rappresentanti del GOT illustreranno gli strumenti e le attrezzature hardware e software disponibili, con particolare attenzione alle competenze necessarie per una condivisione efficace delle risorse esistenti. Nella sessione PICO, sono benvenuti contributi che mostrino applicazione di droni in contesti diversificati, evidenziando casi di studio didattici e le attuali sfide scientifiche legate alla mappatura, alla misurazione e al monitoraggio di processi geo-idrologici. Durante la sessione di discussione, i partecipanti saranno impegnati nella individuazione e condivisione di pratiche per l'uso ottimale dei droni, dei sensori e dei software disponibili, nonché a migliorare il trasferimento di conoscenze nella preparazione e nella gestione dei dati raccolti da drone. A seguito di queste attività, verrà presentata una sintesi dei risultati e delle strategie future, concentrandosi sull'utilizzo e sul miglioramento della strumentazione hardware e software esistente, nonché sulla condivisione di temi scientifici comuni.

In recent years, IRPI has made significant investments in the acquisition of drones and sensors, which have become essential tools for mapping, measurement, and monitoring of geohydrological processes and their impacts at the scale of slopes and small catchments. The GOT aims to address both technical and practical issues related to the management and synergistic use of drones and software licenses for processing the data currently available across various platforms. In the keynote presentation, an overview of drones, possible fields of application, and practical examples will be presented, whereas shorter presentations by the GOT representatives will illustrate the instruments and hardware and software equipment available, with a particular focus on the competencies necessary for effective sharing of existing resources. In the PICO session, we welcome presentations that demonstrate the application of drones in diverse contexts, highlighting didactic case studies and addressing current scientific challenges related to the mapping, measurement, and monitoring of geo-hydrological processes. During the discussion session, participants will engage in sharing insights regarding the optimal use of available drones, sensors, and software, as well as enhancing knowledge transfer in the preparation and management of data collected by drones. Following these activities, a summary of the results and future strategies will be presented, focusing on the utilization and enhancement of existing hardware and software instrumentation, as well as the sharing of common scientific themes.

SESSIONE ORALE

IRPI UAV'S FLEET: STATE OF THE ART INSIDE OUR INSTITUTE; EUROPEAN REGULATIONS; SURVEYS TECHNIQUES; DATA ANALYSIS AND POST-PROCESSING

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ABSTRACT

Drones in our Institute made their official entry in 2016, over an historical moment rich of innovation and opportunities for the use of this new technology for mapping purposes and reconstruction of 3-dimensional models for geomorphological studies.
This particular moment, which sees the birth of self-construction projects fixed-wing, is also characterized by great uncertainties regarding aerial regulations, operational limits, safety, security and risk management.
Also a very fast evolution of technological innovation of these aerial vectors introduces on the following years much more complex systems in terms of aerial sensors; capabilities and performances, consequently introducing increasing levels of complexity both in the management of mission parameters and on data processing field.
Furthermore, the pilot is not always able to effectively cover roles of supervision and correct flight-planning of the aerial operations; to be an expert over the geodetic and photogrammetric field in the context of aerial survey technology and managing correctly geographic data for a post-analysis.
In this perspective, this presentation aims to provide a snapshot of the current state of our fleet and qualifications of our pilots providing, with the help of practical examples, the most common operational scenarios in the context of our research activities.
However, it is necessary to delve, through some theoretical references, into the various surveying disciplines of aerial photogrammetry, geodesy and GNSS positioning, since it is essential that the surveying technician is aware of these concepts in order to be able to successfully manage the survey and post-processing phases, with a critical eye on costs-benefits; operational limits and their related problems /(and how to fix it).

CNR IRPI DRONES' FLEET: CHALLENGES AND OPPORTUNITIES FOR A SHARED MANAGEMENT

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ABSTRACT

Drones and UAVs have become invaluable tools for natural hazard monitoring, enabling rapid, flexible, and detailed data collection at hillslope-to-small basin scale.
This contribution provides a preliminary overview of the CNR IRPI drone fleet and its supporting instrumentation, focusing on the sensors and acquisition support devices that enable comprehensive data collection and analysis.
The CNR IRPI fleet includes various drones available in different CNR IRPI seats, equipped with advanced sensors, such as high-resolution cameras, LiDAR, multispectral, and thermal sensors, offering extensive environmental monitoring and surveying capabilities. Supporting devices like GPS RTK antenna ensure accurate and precise data acquisition and enhance the operational reliability of the fleet.
The overview will have the primary objective of stimulating and agreeing a shared management of CNR IRPI fleet and related instruments for research investigation on geo-hydrological processes occurrence and dynamics, but also for emergency response after natural disasters.
Key discussion points will cover:
(i) drones' availability and related operative capabilities.
(ii) supporting instruments availability.
(iii) sensors availability and related monitoring and surveying capabilities.
(iv) drones binding legislation and insurance requirements.
(v) opportunities and modalities for a shared instruments management.
(vi) instrumentation sharing protocols to facilitate efficient use across teams and projects,
(vii) routine and specialized maintenance practices essential for sustaining operational readiness and prolonging equipment lifespan.

HARDWARE AND SOFTWARE FOR DRONES' DATA ANALYSIS

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ABSTRACT

The use of UAVs (Unmanned Aerial Vehicles) provides critical tools for collecting and analyzing environmental data essential for monitoring and mapping phenomena such as landslides, floods, and erosion. In emergency scenarios, UAVs enable rapid and accurate surveys, generating crucial data for real-time mapping and the production of Digital Elevation Models (DEMs). Furthermore, the integration of diverse sensors—such as RGB and multispectral cameras, thermal sensors, and LiDAR—allows the acquisition of high-resolution data, enabling a detailed analysis of the landscape and significantly enhancing the capacity for risk prevention and emergency response.

Efficiently processing this UAV-derived data demands specialized hardware and software infrastructure. High-performance workstations, shared servers, and optimized computing resources are essential for handling large datasets, particularly for photogrammetric analysis and the processing of point clouds. IRPI employs a mix of open-source tools, where feasible, and specialized commercial software to manage the complex requirements of 3D modelling, orthophoto generation, and multi-temporal DEM comparisons. Open-source software enables cost-effective and flexible solutions, while licensed commercial tools remain indispensable for certain advanced analyses, necessitating a strategic approach to resource allocation.

To optimize these computational resources and foster interdisciplinary collaboration, there is a pressing need for initiatives aimed at shared knowledge and expertise across research teams. While positive experiences with inter-departmental collaboration have occurred in the past, there is significant potential to formalize and expand these efforts. Building a cohesive environment for shared access to computational resources, knowledge-sharing workshops, and collaborative workflows can drive improvements in data processing, accelerate response times, and enhance overall research productivity.

This presentation highlights the strategic value of enhancing resource-sharing practices within the institute. By pooling know-how, sharing computational capacities, and coordinating on licensing costs, the institute can strengthen its analytical capabilities. Such an approach not only optimizes internal resources but also ensures more reliable outputs. Ultimately, this collaborative model seeks to lay the groundwork for a more resilient and integrated research infrastructure capable of responding effectively to complex environmental challenges.

LOGISTICAL NEEDS AND SKILLS FOR FLY WITH DRONES

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ABSTRACT

The use of drones in various industries has transformed data collection, offering efficiency and precision in tasks such as surveying, mapping, and inspections. Drones can easily access regions that are difficult or dangerous for humans to reach. Additionally, they are cost-effective and time-efficient, capable of obtaining high-resolution images, videos, and multispectral data on large areas in a short amount of time. However, the successful deployment of drones requires comprehensive logistical planning and specialized skills to ensure compliance, efficiency, and safety.

This presentation explores the critical components of drone operations: the logistical needs and specialized skills required to conduct safe and efficient drone flights within the European regulatory framework. Operating drones in Europe involves adhering to the rules established by the European Union Aviation Safety Agency (EASA), which classify operations into Open, Specific, and Certified categories. Each category comes with specific requirements for pilot licensing, operational authorizations, and airspace management, demanding thorough logistical preparation.

Additionally, effective drone deployment relies on managing team roles, such as pilots, visual observers, and data analysts, and ensuring the availability of necessary equipment and maintenance protocols. Operators must also secure liability insurance to mitigate financial risks and comply with legal obligations. From a skills perspective, operators require a strong grasp of regulations, risk assessment, technical expertise in flight planning and data analysis, and the ability to adapt to environmental and operational challenges. Together, these logistical and skill-based components are essential for the successful and compliant use of drones across diverse operations.

The regulations and legal requirements for drone operations in Europe will be briefly introduced and explained, providing an overview of the essential rules that govern drone flights. In addition to explaining these regulations, the presentation will draw from practical insights gained through flight experience at IRPI, which has carried out various drone-based surveys and research missions over the last years.

Droni: gestione sinergica e prospettive scientifiche per il monitoraggio e la previsione di fenomeni geo-idrologici

Negli ultimi anni, l'IRPI ha investito in modo significativo nell'acquisizione di droni e sensori, strumenti diventati essenziali per la mappatura, la misurazione e il monitoraggio dei processi geo-idrologici e dei loro impatti, sia a scala di versante che di piccolo bacino idrografico. Il GOT si propone di affrontare le questioni tecniche e pratiche relative alla gestione e all'uso sinergico dei droni e delle licenze software per l'elaborazione dei dati attualmente disponibili su diverse piattaforme. Nella presentazione principale verrà presentata una panoramica dei droni, dei possibili campi di applicazione con esempi pratici, mentre le presentazioni brevi dei rappresentanti del GOT illustreranno gli strumenti e le attrezzature hardware e software disponibili, con particolare attenzione alle competenze necessarie per una condivisione efficace delle risorse esistenti. Nella sessione PICO, sono benvenuti contributi che mostrino applicazione di droni in contesti diversificati, evidenziando casi di studio didattici e le attuali sfide scientifiche legate alla mappatura, alla misurazione e al monitoraggio di processi geo-idrologici. Durante la sessione di discussione, i partecipanti saranno impegnati nella individuazione e condivisione di pratiche per l'uso ottimale dei droni, dei sensori e dei software disponibili, nonché a migliorare il trasferimento di conoscenze nella preparazione e nella gestione dei dati raccolti da drone. A seguito di queste attività, verrà presentata una sintesi dei risultati e delle strategie future, concentrandosi sull'utilizzo e sul miglioramento della strumentazione hardware e software esistente, nonché sulla condivisione di temi scientifici comuni.

In recent years, IRPI has made significant investments in the acquisition of drones and sensors, which have become essential tools for mapping, measurement, and monitoring of geohydrological processes and their impacts at the scale of slopes and small catchments. The GOT aims to address both technical and practical issues related to the management and synergistic use of drones and software licenses for processing the data currently available across various platforms. In the keynote presentation, an overview of drones, possible fields of application, and practical examples will be presented, whereas shorter presentations by the GOT representatives will illustrate the instruments and hardware and software equipment available, with a particular focus on the competencies necessary for effective sharing of existing resources. In the PICO session, we welcome presentations that demonstrate the application of drones in diverse contexts, highlighting didactic case studies and addressing current scientific challenges related to the mapping, measurement, and monitoring of geo-hydrological processes. During the discussion session, participants will engage in sharing insights regarding the optimal use of available drones, sensors, and software, as well as enhancing knowledge transfer in the preparation and management of data collected by drones. Following these activities, a summary of the results and future strategies will be presented, focusing on the utilization and enhancement of existing hardware and software instrumentation, as well as the sharing of common scientific themes.

SESSIONE POSTER PICO

NEW PROCEDURES FOR GEOMORPHOLOGICAL MAPPING: MULTI-SOURCE APPROACH FOR MORPHO-EVOLUTION LANDSCAPE CHARACTERIZATION

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ABSTRACT

The Italian territory proves to be an extremely fragile territory, largely affected by gravitational and running water-based processes, with significant implications on human life and costs for environmental remediation. In this scenario, traditional geomorphological maps have been used for a long time for the description of the different processes acting on a landscape, representing a basic tool for the assessment of geomorphological hazards and the initiation on any management and mitigation strategy useful for land use planning. However, new paradigms for geomorphological mapping, useful to modernize the creation of geomorphological maps, by integrating traditional methods with multi-source advanced analysis, become necessary for the creation of scalable digital representation of processes and landforms. A methodology based on multi-source data and multi-sensor application was implemented to a spatial and temporal recognition of landforms and processes, structured in diverse steps: (i) collection of historical orthophotos to a multi-temporal investigation of the landscape evolution; (ii) application and testing of semi-automatic landforms classification approach, by exploiting regional LiDAR data, to a slope-scale investigation and extraction of landforms; (iii) ad hoc Unmanned Aerial Vehicles surveys, to a local-scale geomorphological characterization. The proposed approach was tested in two Apennines basins located respectively in Val d'Arda, Emilia-Romagna Region and, Val d'Orcia, Tuscany Region, in which prevailing erosional and gravitative morphogenetic processes, mainly represented, respectively, by badland landforms, i.e., 'calanchi', and widespread landslides, primarily earthflow, mudflow and large slides. By exploiting the growing availability of orthophotos, online available, a multi-temporal analysis of the geomorphological evolution of the territory investigated was carried out. Operating in a GIS-environment, the collected images are analyses to identify the geometrically identifiable entities, i.e. polygons, polylines, points. A hierarchy of the recognized landforms could be defined, distinguishing the relative age of the identified phenomena and landforms, principally for gravitative and erosional processes, to a multi-decade mapping of landforms and deposits. Leveraging on the free available regional Digital Terrain Models LiDAR-derived, an Automated Landforms Classification, i.e., Geomorphons (Jasiewicz et. al. 2013) was tested to recognize and remotely extract the most common landform types at the slope-scale. A preliminary map of the investigated basins was obtained, highlighting the noticeable remodelling mainly due to running water-based processes and local shallow landslides, mainly associated to calanchi areas.

Finally, to a local-scale geomorphological investigation, UAV surveys were carried out, in order to identify evidence and potential dynamic acting in the investigated basins. The very-high resolution RGB orthomosaic (centimetric resolution) supplied a detailed view of the surveyed areas, allowing to map all the recent morphological features visible. Jointly, by comparing DEMs derivative products, e.g. shaded relief, slope, and contour with orthoimage, a detailed investigation and mapping of the morphological features occurred was obtained. Overall, the proposed approach guarantees a multi-scale and multi-temporal cartography model, digitally manageable, to a full-coverage representation of landforms, representable via scalable geomorphological maps of the main landforms and processes operating over time, representing a useful tool for technicians and decision-maker in every action and decision on the territory, from land planning to civil engineering applications.

References

Jasiewicz, J., & Stepinski, T. F. (2013). Geomorphons — a pattern recognition approach to classification and mapping of landforms. Geomorphology, 182, 147–156. https://doi.org/10.1016/j.geomorph.2012.11.005

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HIGH-RESOLUTION DIGITAL TERRAIN MODEL FOR THE NATIONAL TERRITORY (ITALY)

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ABSTRACT

This paper presents the methodology and preliminary results, used to create a high-resolution (5 m) digital terrain model (DTM) for the Italian territory developed within the PNRR project "National Centre for HPC, Big Data and Quantum Computing - HPC" – CN00000013 – CUP B93C22000620006, Spoke 5 – Environment & Natural Disasters, Task 1.1 & Task 1.2.

The methodology used LiDAR and other DTM data from multiple sources. The primary goal was to enhance the resolution and accuracy of existing models, such as TINITALY (Tarquini et al., 2009; Tarquini & Nannipieri, 2017; Tarquini et al., 2023), by integrating data collected by the Ministry of the Environment and Energy Security (https://gn.mase.gov.it/portale/pst-dati-lidar) with those provided by regional bodies.

The calculus infrastructure of CNR IRPI in Perugia was utilized to store, process, and organize these data, employing open-source tools like GRASS GIS and Linux shell scripts. The methodology involved several stages: (i) the retrieval, cataloging, and organization of LiDAR data by region and province; (ii) the creation of scripts to automate downloading from official websites; (iii) the extraction of relevant metadata to manage the numerous raster tiles efficiently.

A major challenges was identifying, converting and homogenizing the different data coordinate reference systems (CRSs) to ensure spatial coherence within a single GRASS GIS environment compatible with the RDN2008 "Zone 122 system (EPSH: 6876), as mandated by national regulations (Baroni et al., 2009). After import, the data were mosaicked to merge individual raster tiles, with processing parallelized to optimize computation time. Additionally, integration of data from the TINITALY dataset was planned for areas with insufficient LiDAR coverage.

To address visible discontinuities between tiles from different sources, smoothing commands (Petrasova et al., 2017) were applied. These commands facilitated interpolation techniques that enhanced contiguous data areas, ensuring a smooth transition across datasets. The smoothing techniques enabled the production of a continuous, high-quality model essential for detailed territorial analysis.

To assess the applicability of the methodology across the national territory, an initial test was carried out in the Emilia-Romagna region. The area was selected for its geomorphological diversity and LiDAR data availability. During this phase, critical issues arose, including the need to harmonize data of varying origins and resolutions and correct metadata errors, such as incorrect EPSG codes attributions. These were addressed through re-projection and detailed verification of tile coverages, and filling gaps with complementary data where necessary.

Following successful validation in the sample area, the procedure was extended nationwide, resulting in a 5-meter resolution DTM. In the final phase, validation was conducted to ensure the model's accuracy and reliability. This high-resolution DTM will provide valuable support for applications in scientific, environmental, and infrastructural fields. Its enhanced resolution enables more precise and detailed analyses compared to lower-resolution models, supporting sustainable and safe land management.

REFERENCES

Baroni, L, F Cauli, D Donatelli, G Farolfi, e R Maseroli. 2009. «LA RETE DINAMICA NAZIONALE (RDN) ED IL NUOVO SISTEMA DI RIFERIMENTO ETRF2000».

Petrasova, Anna, Helena Mitasova, Vaclav Petras, e Justyna Jeziorska. 2017. «Fusion of high-resolution DEMs for water flow modeling». Open Geospatial Data, Software and Standards 2 (marzo). https://doi.org/10.1186/s40965-017-0019-2.

S. Tarquini, I. Isola, M. Favalli, F. Mazzarini, M. Bisson, M. T. Pareschi, e E. Boschi. 2009. «TINITALY/01: a new Triangular Irregular Network of Italy». Annals of Geophysics 50 (3). https://doi.org/10.4401/ag-4424.

Tarquini, Simone, e Luca Nannipieri. 2017. «The 10 M-Resolution TINITALY DEM as a Trans-Disciplinary Basis for the Analysis of the Italian Territory: Current Trends and New Perspectives». Geomorphology 281 (marzo):108–15. https://doi.org/10.1016/j.geomorph.2016.12.022.

Tarquini, Simone, Ilaria Isola, Massimiliano Favalli, Alessandro Battistini, e Giulia Dotta. 2023. «TINITALY, a Digital Elevation Model of Italy with a 10 Meters Cell Size (Version 1.1)». Application/zip,image/tiff. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/TINITALY/1.1.

MULTI-TEMPORAL GEOMORPHIC ANALYSIS TO EVALUATE EVENT-DRIVEN HILLSLOPE SEDIMENT SUPPLY TO DRAINAGE IN A CLAY-RICH BASIN

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ABSTRACT

The characterization of the landslide sediment supply within the river networks is still an open research problem. The LASST (evaluating LAndslide Sediment Supply to sTreams and connectivity for sustainable, basin-wide sediment management) project, funded within the PRIN 2022 program, which built on the outcomes of the S2S (Slope to Stream) project funded by the Italian National Research Council aims to characterize landslide sediment supply to stream channels and evaluate hillslope-channel feedback mechanisms in small- (e.g., 5-10 km2) to medium-(e.g., 100-200 km2) sized drainage basins. This objective is pursued through integration of hillslope and channel geomorphic components within the framework of sediment connectivity in the context of sediment management plans. The research relies on a set of data already available and new original data collected during the project. Data include: (i) a multi-temporal landslide inventory (1954-2018), which is currently being compiled; (ii) historical documentation of planform channel changes (1954-2021); (iii) an airborne LiDAR survey conducted along the entire channel main stem in February 2021; and (iv) geomorphic change detection and bedload monitoring performed in one channel reach through UAV photogrammetric surveys and RFID particle tracking (in progress since Novembre 2019).

This study investigates the sediment contributions of hillslope processes to drainage during two extreme rainfall events in May 2023 hitting the River Sillaro project study area, an earthflow-dominated basin in the Italian Northern Apennines. In the area, tectonized clays of the Ligurian Unit (Cretaceous-Eocene), which underlain most part of the landscape, incorporate large limestone blocks and exhibit chaotic texture (Argille a Palombini Fm). Foredeep turbidites of the Umbro-Marchean-Romagna succession (Marnoso-Arenacea Formation, Serravallian-Tortonian), consisting of sandstone-pelite alternations, outcrop on the south-eastern part.

We acquired three UAV-based LiDAR DTMs using the DJI M300 RTK drone and the L1 sensor on four areas to measure geomorphic changes and bedload variations. The three acquisitions were taken before the first event, few days after the first event and few days after the second event. The comparison between the three acquisitions allowed to measure geomorphic changes within the earthflows, the interaction between the landslide deposits and and the river and to monitor the downstream bedload variation. These preliminary results will contribute to the understanding of hillslope/streams interactions and to drive possible future river sediment management planning.

SHORT-TERM EVOLUTION DETECTION OF A LARGE EARTHFLOW BY UAV

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ABSTRACT

The use of unmanned aerial vehicles (UAVs) for studying and characterizing landslide phenomena has proven to be a valuable and evolving support tool in landslide monitoring. UAVs offer numerous advantages over traditional methods especially in terms of efficiency, cost and safety.

In this study, the short-term evolution of the Vomice Landslide, a large earthflow located on the right bank of the Straface River in northeastern Calabria, southern Italy, was examined by analysing data acquired from two UAV flights performed in February 2019 and June 2022, combined with field survey data.

The data collected from the two UAV flights enabled the creation of high-resolution 3D models, orthophotos, Digital Surface Models (DSMs), and Digital Terrain Models (DTMs) with centimeter-level resolution. Comparing data from the two flights allowed to assess both spatial-temporal changes and accurate volumetric calculations.

The results of the study involved the identification and delineation of all landslide bodies within the Vomice Earth Flow. This included the classification of landslide type, assessing their current state of activity, and the analysis of spatial and volumetric changes over time.

The Vomice Landslide covers an area of about 3.64 x 105 m2 with a maximum length of 1.92 x 103 m. The landslide consists of distinct zones: a depletion zone with two main source areas, a narrow and elongated transport zone, and a lobate accumulation zone. The depletion zone and the transition zone represent the active part of the landslide whereas the accumulation zone appears dormant.

During the study period, the depletion zone experienced localized collapses in the main scarps, with several slides evolving into earthflows, resulting in over 20 meters of retrogressive upslope failure. The maximum observed elevation changes in these areas reached up ±5 m.

The mass movement mobilised approximately 114.2 x 103 m3 of material, with about 92.7 x 103 m3 accumulation in the deposition area. The transition zone experienced multiple slow-moving earthflows which re-mobilized previously displaced materials located in the central part of the landslide, ultimately transporting them to the accumulation area.

This study highlights the practicality and effectiveness of using UAV technology in monitoring the short-term evolution of a large landslide, providing valuable data on spatial and volumetric changes.

GLACIOLOGICAL SURVEYS WITH AN UNMANNED AERIAL VEHICLE (UAV): POSITIVES AND NEGATIVES ASPECTS

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ABSTRACT

The alpine glaciers are directly suffering the effects of climate change, as we can see during the annual glaciological surveys organized by the Italian Glaciological Committee. The aim of these surveys mainly consists to measure the variation of the glacial front, at the end of each summer season. But, in many cases, it's becoming even more difficult to take the measurement, due to the strong retreat of these fronts.

In these contexts, drones can be helpful by monitoring areas occupied by glaciers. In this way it is possible to carry out an area survey that can be integrated with the punctual surveys carried out to measure the variations of the glacial fronts.

This year, during the monitoring of the Ghiacciaio di Arguerey Meridionale and of the Ghiacciaio di Arguerey Settentrionale (La Thuile, Aosta Valley, Italy), an Unnamed Aerial Vehicle (UAV), in particular the DJI Mini 4 Pro has been used (Fig. 1).

This type of drone has many positive aspects that allow the consumers for a semi-professional use. In fact, his weight is under 250 grams, so it can be classified in the "C0" category, which stands for inoffensive that's why everyone can use them. It is very easy to handle and intuitive, with a big precision of landing and take-off, it has a very accurate GPS, so when the photos are taken, they are already georeferenced.

Since the camera has a high quality, the photos that we take are very detailed and colors are almost as the natural one. The camera is also equipped with a stabilizer which permits to take videos also in adverse conditions such as strong winds, situations that are often found in glacial and periglacial environments. Another positive aspect is the possibility to use this type of drones for photogrammetric surveys, in order to create 3D images. On the contrary, there are as well negative aspects which relate to battery life, above all in severe cold conditions and/or to the presence of wind. Furthermore, the drone has some limitations during high-altitude flights.

Figure 1 - Image of the Ghiacciaio di Arguerey Settentrionale, from DJI Mini 4 Pro

Trasferimento dei risultati della ricerca ad enti territoriali, istituzionali, stakeholders: realtà a confronto con l'ecosistema Tech4You

L'IRPI, per le tematiche oggetto delle sue ricerche, ha da sempre condotto, nell'ambito di opportune convenzioni o di progetti, attività di studio, di analisi e di ricerca, di elevata qualità ed utili per Enti Territoriali e Nazionali. Dal gennaio 2023 l'Istituto è, inoltre, coinvolto nell'Ecosistema dell'Innovazione "Tech4You- Technologies for climate change adaptation and quality of life improvement", che vede la presenza, come affiliati, oltre alle tre Università calabresi, a quella della Basilicata e ad altri Istituti CNR, anche di Soggetti privati. In Tech4You l'IRPI coordina lo Spoke 1 "Circular technologies to mitigate geo-hydrological and forest fire risks", che, come l'intero Ecosistema, si prefigge di produrre risultati, piattaforme, prodotti, che potranno essere di largo utilizzo anche da parte di Enti Pubblici Territoriali e Nazionali. Dalle attività citate, sia in ambito dell'Ecosistema, sia in ambito delle Convenzioni e dei Progetti in essere, nasce la necessità che i risultati prodotti ricevano la giusta attenzione da parte dei Soggetti Pubblici citati. L'obiettivo del GOT è quello di confrontare le esperienze dell'Istituto nell'ambito del trasferimento dei risultati a partire dall'Ecosistema Tech4You, per evidenziare le difficoltà incontrate e, con l'aiuto di un esperto esterno, redigere, anche successivamente al WS, delle "Linee Guida Primarie", per migliorare il trasferimento dei risultati, promuovere la collaborazione intersettoriale, incoraggiare l'adozione di pratiche di comunicazione chiara e trasparente, stabilire protocolli per la condivisione tempestiva e accessibile dei dati. Inoltre, potranno favorire la formazione continua e lo scambio di competenze, assicurando che le scoperte scientifiche siano integrate efficacemente nelle politiche e nelle strategie operative, migliorando così l'impatto sociale ed economico.

IRPI, due to the topics covered by its research, has always conducted, within the framework of appropriate agreements or projects, high-quality studies, analyses, and research activities, which have been useful for Territorial and National Entities. Since January 2023, the Institute has also been involved in the Innovation Ecosystem "Tech4You - Technologies for climate change adaptation and quality of life improvement," which includes, as affiliates, in addition to the three Calabrian Universities, the University of Basilicata, other CNR Institutes, and private entities. In Tech4You, IRPI coordinates Spoke 1, "Circular technologies to mitigate geo-hydrological and forest fire risks," which, coherent with Ecosystem's goals, aims to produce results, platforms, and products that can also be widely used by Territorial and National Public Entities. From the activities mentioned, both within the T4Y framework and within the usual Agreements and ongoing Projects, arises the need for the results produced to receive appropriate attention from the aforementioned Public Entities. The GOT's objective is to compare the Institute's experiences in the transfer of results, to highlight the difficulties encountered, and, with the help of an external expert, to draft, even after the WS, "Primary Guidelines" to improve the transfer of results, promote cross-sectoral collaboration, encourage the adoption of clear and transparent communication practices, and establish protocols for timely and accessible data sharing. Additionally, these Guidelines could foster continuous training and the exchange of expertise, ensuring that scientific discoveries are effectively integrated into policies and operational strategies, thereby enhancing social and economic impact.

SESSIONE ORALE

Trasferimento dei risultati della ricerca ad enti territoriali, istituzionali, stakeholders: realtà a confronto con l'ecosistema Tech4You

L'IRPI, per le tematiche oggetto delle sue ricerche, ha da sempre condotto, nell'ambito di opportune convenzioni o di progetti, attività di studio, di analisi e di ricerca, di elevata qualità ed utili per Enti Territoriali e Nazionali. Dal gennaio 2023 l'Istituto è, inoltre, coinvolto nell'Ecosistema dell'Innovazione "Tech4You- Technologies for climate change adaptation and quality of life improvement", che vede la presenza, come affiliati, oltre alle tre Università calabresi, a quella della Basilicata e ad altri Istituti CNR, anche di Soggetti privati. In Tech4You l'IRPI coordina lo Spoke 1 "Circular technologies to mitigate geo-hydrological and forest fire risks", che, come l'intero Ecosistema, si prefigge di produrre risultati, piattaforme, prodotti, che potranno essere di largo utilizzo anche da parte di Enti Pubblici Territoriali e Nazionali. Dalle attività citate, sia in ambito dell'Ecosistema, sia in ambito delle Convenzioni e dei Progetti in essere, nasce la necessità che i risultati prodotti ricevano la giusta attenzione da parte dei Soggetti Pubblici citati. L'obiettivo del GOT è quello di confrontare le esperienze dell'Istituto nell'ambito del trasferimento dei risultati a partire dall'Ecosistema Tech4You, per evidenziare le difficoltà incontrate e, con l'aiuto di un esperto esterno, redigere, anche successivamente al WS, delle "Linee Guida Primarie", per migliorare il trasferimento dei risultati, promuovere la collaborazione intersettoriale, incoraggiare l'adozione di pratiche di comunicazione chiara e trasparente, stabilire protocolli per la condivisione tempestiva e accessibile dei dati. Inoltre, potranno favorire la formazione continua e lo scambio di competenze, assicurando che le scoperte scientifiche siano integrate efficacemente nelle politiche e nelle strategie operative, migliorando così l'impatto sociale ed economico.

IRPI, due to the topics covered by its research, has always conducted, within the framework of appropriate agreements or projects, high-quality studies, analyses, and research activities, which have been useful for Territorial and National Entities. Since January 2023, the Institute has also been involved in the Innovation Ecosystem "Tech4You - Technologies for climate change adaptation and quality of life improvement," which includes, as affiliates, in addition to the three Calabrian Universities, the University of Basilicata, other CNR Institutes, and private entities. In Tech4You, IRPI coordinates Spoke 1, "Circular technologies to mitigate geo-hydrological and forest fire risks," which, coherent with Ecosystem's goals, aims to produce results, platforms, and products that can also be widely used by Territorial and National Public Entities. From the activities mentioned, both within the T4Y framework and within the usual Agreements and ongoing Projects, arises the need for the results produced to receive appropriate attention from the aforementioned Public Entities. The GOT's objective is to compare the Institute's experiences in the transfer of results, to highlight the difficulties encountered, and, with the help of an external expert, to draft, even after the WS, "Primary Guidelines" to improve the transfer of results, promote cross-sectoral collaboration, encourage the adoption of clear and transparent communication practices, and establish protocols for timely and accessible data sharing. Additionally, these Guidelines could foster continuous training and the exchange of expertise, ensuring that scientific discoveries are effectively integrated into policies and operational strategies, thereby enhancing social and economic impact.

SESSIONE POSTER PICO

FLOOD MONITORING, EARLY WARNING AND RISK COMMUNICATION SYSTEM IN MATERA CITY

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ABSTRACT

According to the Atlas of Human Planet (Carniero et al., 2019) exposed areas to major hazards have considerably increased around the entire globe due to the prompt increase of urbanization. Thus, it is imperative to determine effective mitigation measures to anticipate and lessen the consequences of the potential risk associated with extreme events in the context of climate change. Existing communication strategies about flood risk dangers did not succeed to provide sufficient comprehension to enable the user to act proactively. Relying on simple and alerting communications leads to either excessive reliance on defense and emergency organizations or denial and belief in helplessness. For this reason, within the "Tech4You- Technologies for climate change adaptation and quality of life improvement" (project n. ECS00000009) Goal 1.2 Pilot Project 1 Action 9, a prototype of a non-conventional rainfall monitoring network based on artificial intelligence (AI) techniques will be developed to support traditional monitoring and flood early-warning systems, and to provide citizens with real, clear, and useful information so that they become active, aware and resilient. The prototype does not intend to replace the devices set up by the competent institutions but rather to be of support, contributing to the development of a process of "flood literacy", where communities and individuals have the power to develop their own knowledge on local flood risk and actions for its management. Matera has experienced in recent years e.g. 2014, 2018, 2019, and 2023 many episodes of recurring floods and also urban expansions of the municipality induced significant transformations of the water-soil-urban balance that led into modifications of the natural routing of the rain flows as well as the hydrological-hydraulic response of the entire urban areas. In light of the central city districts was chosen as the pilot areas where experiment some innovative approaches. In order to comprehensively characterize the hydrological process, the city of Matera has been subdivided into several urban basins. taking into account the modification that occurred in terms of slope, permeability, runoff velocity, direction, and so on. knowing that at these small hydrological units, the microtopography and the impervious areas are determinants in the genesis and the propagation of the rainfall floods (Ermini & Albano, 2023). In the same framework, a two-dimensional hydrodynamic model has been used to map and assess the flood dynamics in order to obtain information about the local-scale effects and the potential critical situations on the historical center of the city. This modeling process besides the monitoring network and predictive techniques, is expected to improve the understanding of how floods might occur based on a better knowledge of the dynamics of predicted or ongoing events related to potential impacts, thereby, enabling citizens to decide the right action to take in response and the right time. At the same time, the ways of assessing critical issues related to the instability of vehicles, objects, and people affected by surface runoff are explored in depth in order to define specific risk classes related to the situations found in any different areas.

This work was funded by the Next Generation EU - Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of 'Innovation Ecosystems', building 'Territorial R&D Leaders' (Directorial Decree n. 2021/3277) - project Tech4You - Technologies for climate change adaptation and quality of life improvement, n. ECS0000009. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

Reference
Carneiro Freire, S., Corban, C., Ehrlich, D., Florczyk, A., Kemper, T., Maffenini, L., Melchiorri, M., Pesaresi, M., Schiavina, M. and Tommasi, P., Atlas of the Human Planet EUR 30010 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-17418-9, doi:10.2760/014159, JRC118979.
Ermini R. and Albano R., Hydromorphic analysis of urban areas transformations: The case study of the Matera city, IOP Conference Series: Earth and Environmental Science, 2023, 1196(1), 012026

OPERATIONAL TOOLS FOR A BETTER AND MORE EFFECTIVE COMMUNICATION OF RESEARCH RESULTS: INITIATIVES WITHIN THE TECH4YOU PROJECT

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ABSTRACT

The dissemination of research results, as well as their communication to stakeholders, constitutes one of the fundamental tasks that a researcher is constantly engaged in: the Tech4You project, therefore, places specific attention on this issue. An insidious obstacle that one may encounter in fulfilling this task is the widespread functional illiteracy that permeates and afflicts our entire culture, affecting even vital sectors such as universities and research centers. Every year, OECD surveys monitor this phenomenon at an international level, and the statistics that emerge are merciless: according to data from Inapp (2024), the OECD-PIAAC surveys show that only 26.5% of the Italian population between 16 and 65 years old reaches level 3 of literacy, considered essential by the OECD for effectively living and working in the 21st century. Therefore, it should be taken into account, when communicating research, that three out of four people will probably not be able to understand what is being said to them. The term "functional illiteracy" was coined by UNESCO only in 1984, but the phenomenon was, of course, pre-existing. Clear warnings of it can, in fact, be found, for example, in the writings of Gustavo Colonnetti (1978) dating back to 1926 and in the preface of the famous physics books by Richard Feynman (2005) published in the 1960s. It is therefore important that anyone involved in research be aware of the phenomenon, understand its contours and possess some tools to address it. In the early 1990s, a research project was launched by CNR-IRPI in Turin to identify which metacognitive tools could be used to improve the expressive and communication skills of undergraduates attending the institute. It had become clear that they had significant gaps in this regard, and the aim was to see if it was possible to remedy them. This project also had the side effect of revealing how the phenomenon of functional illiteracy had spread to reach university classrooms and even affect us researchers. Fortunately, the first tools developed to enhance expressive skills proved also useful in effectively combating the phenomenon. We were able to confirm this, thanks also to a collaboration with the Foundation of the Order of Engineers of Turin (FOIT), which allowed us to offer our courses within the training program for obtaining the Continuing Professional Development (CPD) credits required by law. The courses, delivered continuously between 2015 and 2019, were met with great enthusiasm by FOIT students, proving to be extremely useful tools in everyday professional practice (Arattano et al, 2018). As part of the Tech4You project, the same courses will be made available to project participants and institute staff, contributing to further verification and experimentation of the educational materials developed for a more effective communication of research results coming from the Tech4You project and also for an active fight against functional illiteracy.

REFERENCES

Arattano, M., Peppoloni, S., & Gatti, A. (2018). The ethical duty to divulge geosciences and the improvement of communication skills to fulfil it. Episodes Journal of International Geoscience, 41(2), 97-103.

Colonnetti, G., 1978, Colonnetti inedito. Sandro Maria Rosso Editore e Stampatore, Biella, 29 p. (in Italian) .

Feynman, R.P., Leighton, R., and Sands, M., 2005, The Feynman Lectures on Physics: The Definitive and Extended Edition (second edition). Addison-Wesley Longman, ISBN 0-8053-9045-6.

Inapp (2024) dati al link: https://www.inapp.gov.it/piaac/dati-e-risultati/highlights-ciclo-i/le-competenze-dei-16-65enni-il-gap-italia-nel-confronto-internazionale.

SHALLOW LANDSLIDE INVENTORY MAP FOR INTEGRATION INTO A MEDIUM-SCALE INFORMATICS PLATFORM DATABASE: A LABSIT CASE STUDY (KNOWLEDGE GENERATOR)

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ABSTRACT

This work describes part of the activities carried out for the development of the Tech4You ecosystem, aimed at providing digital decision support for landslide risk management. It materializes through Specific Informatique Platforms (PIS), one for each scale of analysis (small, medium and large), that will interface and flow into a Transversal Informatique Platform (PIT), according to a circular approach. Each PIS is composed of a GIS database containing all the sectoral information that characterizes a specific site/area, thus giving it the role of knowledge generator (LabSit).

The Catanzaro Strait (Calabria) is selected in this phase as one of the on-site laboratories at medium scale (LabSitMS) "demonstrator", having been previously examined by the CNR-IRPI of Rende (CS). For this LabSitMS, the study effort focused on systematizing the digital archive containing the data available at CNR-IRPI (such as topographical data, geological information layers, landslide inventory map), while also upgrading the data for future expansion. One of the upgraded data is the landslide inventory map, where the most recent data in this archive documented landslide that occurred following the 2008-2010 rainfall events, recording a total of 3,483 shallow landslides. The update to the shallow landslide (SHL) inventory was carried out by incorporating landslides that occurred after the 2023 rainfall events.

The methodology used to pursue this aim is based on the interpretation of Google Earth high-resolution satellite images, followed by processing and management of the collected data through a geographic information system. To compile the SHL inventory, the following data were used: topographic data from a 5 m resolution digital elevation model (DEM) and a LIDAR digital terrain model (DTM) with 2 meter ground resolution. Additionally, satellite images from Google Earth, dated May, June, and September 2023, were analyzed and compared with previous images to identify landslides that occurred throughout 2023.

The inventory covers an extensive area (about 1147 km2) and includes 677 shallow landslides, distinguished in 386 flows, 222 slides, 115 complex landslides, and 19 superficial landslide zones. These shallow landslides, with small to medium size, affect about 1.9 km2, the 0.16% of the study area. These landslides are distributed over the study area, with a predominant concentration in the municipal territories of Cropani and Tiriolo.

Typically, affecting the soil mantle and upper regolith, the majority of these shallow landslides involve mainly the conglomerates and breccias (79.59%) and granitoid rocks (9.96%) with lesser occurrence in sands (2.97%), clays (2.66%), medium-high grade metamorphic rocks with high or limited schistosity (respectively 2.11% and 0.87%), evaporitic limestones (0.66%), colluvium, debris and soil (0.54%), sandstones (0.52%), gravels (0.08%) and low-grade metamorphic rocks (0.03%).

The current inventory supports the enhancement of the GIS database, which was previously created and structured into separate folders according to thematic data. The catalogued information includes all data deemed essential for the medium-scale typifying procedure consisting in grouping landslides on type, state of activity, morphometric parameters, geology, lithology and fault data. Through the PIT, this inventory will be instrumental in landslide risk management and in the development of predictive models.

This work was funded by the Next Generation EU—Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of 'Innovation Ecosystems', building 'Territorial R&D Leaders' (Directorial Decree n. 2021/3277)—project Tech4You—Technologies for climate change adaptation and quality of life improvement, n. ECS0000009. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

COLLABORATIVE ACTIVITIES BETWEEN THE ITALIAN CIVIL PROTECTION DEPARTMENT (DPC) AND CNR-IRPI ON GLACIER AND PERMAFROST HAZARD ASSESSMENT AND RISK MITIGATION IN THE ITALIAN ALPS

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ABSTRACT

In the context of current and future climate change, human activities and infrastructure will be increasingly challenged by extreme meteorological events (see the flood of 29-30 June 2024 which seriously damaged several municipalities in the Val d'Aosta and Piemonte regions). These events can trigger chain processes that can threaten mountain communities and beyond. Glaciated and permafrost alpine environments are in fact responding surprisingly rapidly to ongoing global-scale climate warming due to the sensitivity of the cryosphere to climatic factors. The extraordinary changes taking place at high altitudes as a consequence of cryosphere degradation are causing a readjustment of natural systems, which is also occurring through increased natural instability, affecting glaciers, rock slopes and debris accumulations, documented on a global scale. Many of the dynamics going on in these environments are still little known, and new hazards are emerging as climate and environmental conditions rapidly change, posing at risk mountain communities and tourists, and beyond.

This is the context in which the collaboration between DPC and CNR-IRPI was established (collaboration agreement 2023-2024, WP5), with the aim of providing knowledge and methodological/technological tools to support hazard assessment and risk mitigation in the glaciated and permafrost alpine environments. In this framework, the "Guidelines for the risk assessment of glaciers and permafrost" (drafted in 2017 by the international working group GAPHAZ, of which IRPI is a member) were translated into Italian (Fig. 1). This document can be a basis for future investigations on risks in the glaciated and permafrost areas of Italian Alps. In order to facilitate the reading of this document, a glossary has been realized in which concise explanations of some terms typical of the high mountain environment and instability processes that can develop in such environments are given. In addition, in order to make future research activities more accessible, a catalog was created regarding scientific articles dealing with the previously mentioned topics (published from 2017 to the present, to update the GAPHAZ Guidelines). The growing needs of innovative solution for the study of the evolution of instabilities that affected glaciated and permafrost alpine environment, create the opportunity for the redaction of the "guidelines of low-cost monitoring solution of glacier and periglacial related instabilities".

The joint technical visits which took place in summer 2024 in Courmayeur and Macugnaga (Western Italian Alps) with the participation of Fondazione Montagna Sicura, Regione Valle d'Aosta and ARPA Piemonte, were an opportunity for a fruitful exchange, aimed at bringing scientific research activities into dialogue with the needs of risk assessment and mitigation.

The results and products of this collaboration will also be used within the activities carried out by the Working Group on "Risk associated with instability processes in glacial and periglacial environments" – established on 20 May 2024 by Decree of the Head of DPC and whose activity will last 12 months – which has among its priorities that of sharing guidelines for the implementation of knowledge, training, information and awareness-raising activities on risks in Alpine areas, in the context of climate change.

Fig. 1: Document header page of "Guidelines for the Assessment of Glacier and Permafrost Hazards" fully translated into Italian, and the the "guidelines of low-cost monitoring solution of glacier and periglacial related instabilities".

References

GAPHAZ, "Guidelines for the Assessment of Glacier and Permafrost Hazards", https://www.gaphaz.org/

LEARNING PLATFORMS, A POWERFUL TOOL FOR EFFECTIVE CLIMATE CHANGE COMMUNICATION

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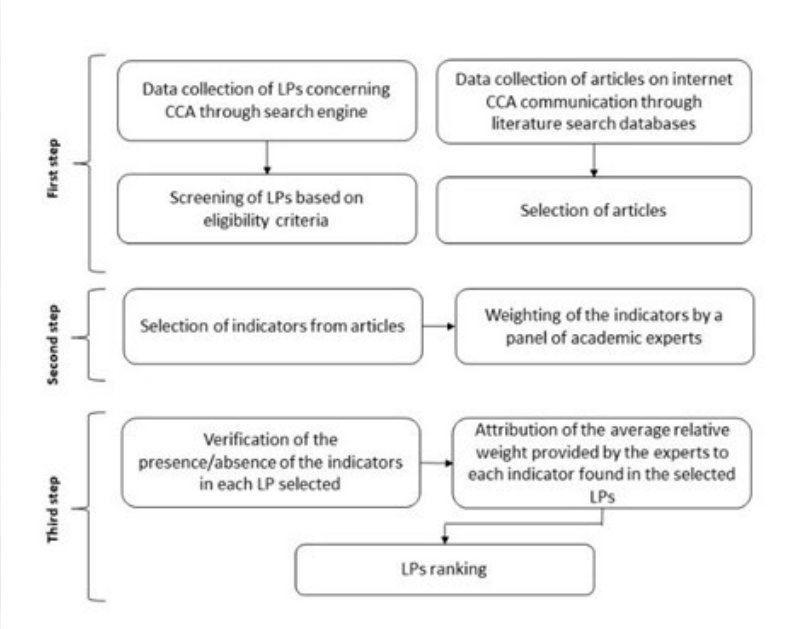
ABSTRACT

Among several non-structural approaches for preventing and managing the consequences of climate change related events, people-centered approaches are becoming increasingly popular. They, in fact, are considered promising for improving knowledge and awareness of disasters and promote mitigation and risk reduction actions. For this type of approach, effective communication is crucial. In recent years, technological innovations have profoundly changed the way of communicating, making room for diversified forms of e-learning. Digital tools as online Learning platforms (LP) have therefore become increasingly important. In these virtual places, multiple learning tools can be integrated, extensive knowledge can be shared, and, more significantly, active user participation can be implemented. In this panorama, however, it is not clear what elements an LP should have, to be considered effective.

In the framework of the PNRR Ecosystem of Innovation project - T4YOU 'TECHNOLOGIES FOR CLIMATE CHANGE ADAPTATION AND QUALITY OF LIFE IMPROVEMENT' a work to fill this this gap has been carried out.

The activity has been realized following different steps, as described in the following figure 1.



The first step of the protocol was a) to identify what elements scholars consider crucial for good digital communication, and b) to make a list of the LP easier to find for a final user coming from lay-people.

The first point was performed searching one of the most widely used repositories of scientific articles (Web of Science), the second one by using one of the most popular search engines (Google). For both, the same keywords were used (Italian Learning Platforms, European Learning Platforms, International Learning Platforms).

From the articles from Web of Science a list of elements characterizing an effective digital communication was derived. All these elements were considered good indicators for a successful LP, and the relative importance that each of them should have, was carried out by asking an international panel of experts to weigh them, following a Delphi approach. The list of the existing LPs has been taken from the first ten pages of the Google search engine.

Based on the weighted indicators, only those LPs with both technical and didactic content were evaluated, resulting in a ranking of the selected LPs. The top five ranked LPs were then subjected to further evaluation by different categories of stakeholders (students, lay-people, experts/academics) through the administration of a specific questionnaire. In the questionnaire, the three categories of possible final users, among the other questions, also had the opportunity to enter comments on what they liked and disliked about the LPs they were evaluating. The comments were analyzed using a specific software (AtlasTi). In Figure 2 are represented the word clouds for concept that represent what final user like/dislike for each selected LP.

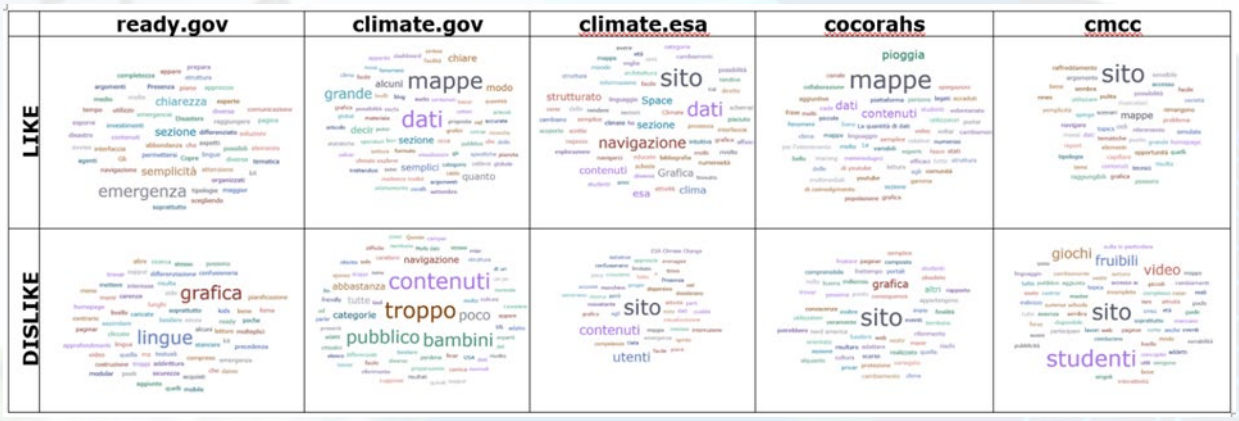


Figure 2

The procedure, then, made it possible to identify strengths and weaknesses for each of the five best LPs based on stakeholders' specific considerations.
This last conceptual step is a crucial starting point, since a precise customization of communication on Climate Change effects is mandatory to involve people based on their attitudes.

References
1. Carone M.T., Antronico L., Coscarelli R., 2024. Learning Platforms for Climate Change Adaptation: the importance of effective communication. Submitted to Humanities & Social Sciences Communications (under review).
2. ATLAS.ti Scientific Software Development GmbH, 2024

CLIMATE DATABASES FOR SUPPORTING STAKEHOLDERS IN THE VARIOUS PHASES OF AN EMERGENCY EVENT

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ABSTRACT

In Pilot Project 1, titled Multiscale and Interdisciplinary On-Site Laboratories as Demonstration Systems and Knowledge Generators in Decision Support for Landslide Risk Management: Adaptation, Mitigation, Reduction, part of Goal 1 - Spoke 1 within the Innovation Ecosystem "Tech4You - Technologies for Climate Change Adaptation and Quality of Life Improvement," a key initiative involves consolidating multiple databases specific to the Calabria and Basilicata regions. Action 1 is aimed at creating a robust and accessible climatic database tool to support stakeholders by integrating various available data sources to improve landslide risk management.

The project includes the development of an automated tool, facilitated by an external Partner selected through a Cascade Call process. This tool aims to make all relevant data on a selected site easily accessible, particularly focusing on rainfall data. The available databases, including the data collected by the ARPACAL Centro Multirischio, consist of a diverse range of data types, including satellite-derived information, radar observations, and re-analysis data. Due to the unique and variable morphological characteristics across Calabria and Basilicata, rainfall distribution patterns can differ significantly across the territory, even within a single extreme weather event. This variability creates challenges in accurately modeling or predicting localized impacts of such events.

For emergency stakeholders, such a tool will provide essential support, enabling them to quickly access, compare, and analyze climate data during different phases of emergency management. It could construct the rainfall scenario that triggered a specific extreme events and could also aid in constructing predictive future rainfall scenarios. In the first half of the T4Y project, the comprehensive database was successfully completed, and the tool design has been presented to the external Partner. The databases were also tested using several recent severe rainfall events that caused significant damages and injuries in Calabria:

- 12 August 2015 – Corigliano-Rossano event
- 30 October - 2 November 2015 – Locride event
- 20 August 2018 – Raganello Torrent event

The findings underscored that traditional rain-gauge data alone were often insufficient to accurately capture the spatial distribution of rainfall during these events. Alternative data sources, such as radar or satellite information, provided a more accurate representation of the rainfall spread and its impact.

Upon completion of the project, the mentioned tool, integrated with other resources in the T4Y project, will offer a comprehensive decision-support system for landslide risk management, specifically addressing adaptation, mitigation, and reduction of landslide hazards. This aligns directly with the objectives of Goal 1 - Spoke 1, ultimately advancing regional resilience against climate-driven challenges.

This work was funded by the Next Generation EU - Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of 'Innovation Ecosystems', building 'Territorial R&D Leaders' (Directorial Decree n. 2021/3277) - project Tech4You – Technologies for climate change adaptation and quality of life improvement, n. ECS0000009. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

TOWARD A MULTI-MODEL REAL-TIME FLOOD FORECASTING SYSTEM ON THE CRATI RIVER BASIN

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ABSTRACT

In river basins with short response times, the availability of probabilistic streamflow forecasts can be essential for a more effective flood emergency management. As part of project "Tech4You - Technologies for climate change adaptation and quality of life improvement", a flood forecasting system is being developed, aimed to usefully support the stakeholders in risk assessment. A multi-hydrological model approach is used, with the selection of conceptual models addressed to a differentiated and exhaustive representation of the main hydrological processes and the various flow pathways that contribute to the total river discharge during extreme events. The forecasts provided by the different hydrological models will be then synergistically combined to obtain probabilistic streamflow forecasting by applying the Model Conditional Processor (MCP) for predictive uncertainty estimate [1].

The main characteristics of the streamflow forecasting system and a preliminary assessment of the selected hydrological models are presented. The Crati River basin, the largest in Calabria in terms of discharge and drainage area, was chosen as a case study. Hydrological modelling was performed on an hourly time resolution and at sub-basin scale. The following conceptual models were considered: MISDc-2L [2, 3], HBV-96 [4], GR6H [5, 6], and SMART [7].

First calibration experiments investigated the potential of the selected models to simulate the observed discharge in the downstream course of the Crati River, where significant floods occurred in recent years. In this preliminary evaluation, the set of hydrological models provided acceptable performance overall. An example of streamflow results is reported in Fig. 1 for the MISDc-2L model: time series for the simulation period are represented in Fig. 1a, while Fig. 1b focuses on the January 2013 event, which caused extensive damage in the archaeological site of the ancient Sybaris and is well modelled in terms of peak flood.

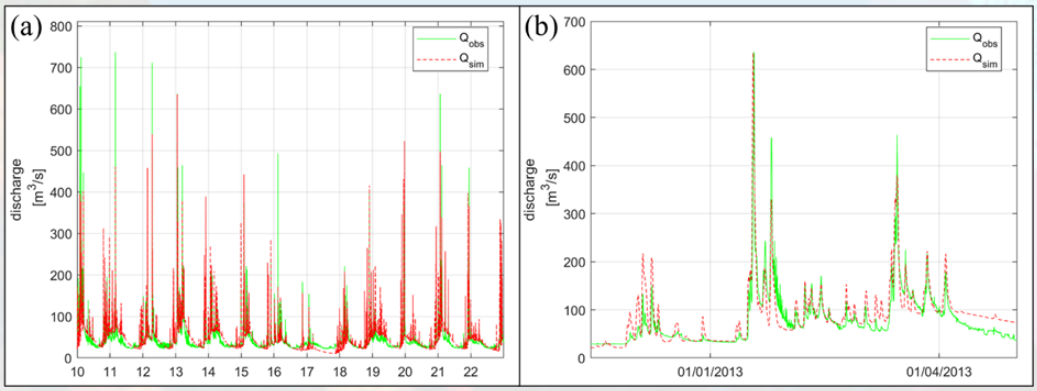

Figure 1. MISDc-2L hydrological model: in panel (a) time series of observed (green) and simulated (red) hourly streamflow in the years 2010-2022 for the Crati River at Sibari gauge, in panel (b) focus on the significant flood event of January 2013.

Data from additional internal gauges will be integrated in the reference observational dataset to improve the calibration of the flood forecasting system. In this perception, to overcome issues related to availability and quality of rating curves at gauging stations, a model for reconstructing the discharge hydrograph [8] will be employed on selected flood events, once an accurate stage-area relationship is assessed by surveying the river cross sections. Finally, single models' predictions will be integrated by using MCP to obtain probabilistic discharge forecasting.

Acknowledgements

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References
[1] Barbetta, S., Coccia, G., Moramarco, T., Brocca, L. and Todini, E., 2017. The multi temporal/multi-model approach to predictive uncertainty assessment in real-time flood forecasting. Journal of Hydrology, 551, 555-576.
[2] Brocca, L., Moramarco, T., Melone, F., Wagner, W., Hasenauer, S. and Hahn, S., 2012. Assimilation of surface- and root-zone ASCAT soil moisture products into rainfall–runoff modelling. IEEE Transactions on Geoscience and Remote Sensing, 50(7), 2542-2555.
[3] Massari, C., Camici, S., Ciabatta, L. and Brocca, L., 2018. Exploiting satellite-based surface soil moisture for flood forecasting in the Mediterranean area: state update versus rainfall correction. Remote Sensing, 10(2), 292.
[4] Lindström, G., Johansson, B., Persson, M., Gardelin, M. and Bergström, S., 1997. Development and test of the distributed HBV-96 hydrological model. Journal of Hydrology, 201(1-4), 272-288.
[5] Pushpalatha, R., Perrin, C., Moine, N.L., Mathevet, T. and Andréassian, V., 2011. A downward structural sensitivity analysis of hydrological models to improve low-flow simulation. Journal of Hydrology, 411(1-2), 66-76.
[6] Ficchì, A., Perrin, C. and Andréassian, V., 2019. Hydrological modelling at multiple sub-daily time steps: Model improvement via flux-matching. Journal of Hydrology, 575, 1308-1327.
[7] Mockler, E.M., O'Loughlin, F.E. and Bruen, M., 2016. Understanding hydrological flow paths in conceptual catchment models using uncertainty and sensitivity analysis. Computers & Geosciences, 90, 66-77.
[8] Moramarco, T., Barbetta, S., Melone, F. and Singh, V.P., 2005. Relating local stage and remote discharge with significant lateral inflow. Journal of Hydrologic Engineering, 10(1), 58-69

MORPHOMETRIC ANALYSIS AND LANDSLIDE TYPIFYING: THE "LANDSLIDE METRICS" PLUGIN IN THE TECH4YOU PROJECT

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ABSTRACT

A thorough understanding of landslide dynamics and the development of effective management strategies begin with analysing the processes and the mechanisms that govern these phenomena. Categorizing landslides based on key characteristics – known as "typifying" - offers valuable insights in this field (Gullà et al., 2017). In line with this approach, within the project "Tech4You - Technologies for climate change adaptation and quality of life improvement" (project no. ECS00000009), Goal 1.1 Pilot Project 1, Action 2, a regional-scale landslide typifying path is under development. This system identifies key parameters for classification (typifying keys) and their ranges or classes (typifying frameworks).

The typifying keys include several morphometric features, which have been standardized, and the computation of these characteristics has been automated using a Python-based algorithm. This algorithm is implemented as a QGIS plugin called "Landslide Metrics", specifically developed within the project to automate this process. Currently in beta, the plugin allows users to calculate morphometric characteristics using as input data a digital elevation model (DEM) and a vector file of landslide polygons. It computes features for each landslide, such as maximum and minimum elevation, length, width, area, volume, estimated thickness, depth category, and average slope, giving as output a vector file with all the computed parameters.

Maximum and minimum elevations are determined along each landslide's perimeter from DEM data; landslide length is calculated as the distance from the maximum elevation point through the polygon's internal centroid to the minimum elevation point, while width is measured as length of the segment within the landslide polygon, passing through its internal centroid and perpendicular to the line connecting the highest elevation point to the landslide's internal centroid.

The estimated thickness is calculated as a function of landslide length; from this value the landslide category is determined as shallow (0–3 m), medium-depth (3–30 m), or deep (over 30 m).

Additionally, the average slope is derived from landslide length and elevation differences.

The plugin calculates even the landslide area, from which it estimates the landslide volume following the formulas proposed by Guzzetti et al. (2009) and Larsen et al. (2010).

Tests on various datasets at different scales, from regional to detailed, show promising results for most parameters. Current limitations include thickness overestimation in large flows and debris flows, where further calibration is needed.

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Reference

Gullà, G., Peduto, D., Borrelli, L., Antronico, L., Fornaro, G. Geometric and kinematic characterization of landslides affecting urban areas: the Lungro case study (Calabria, Southern Italy). Landslides 14, 171–188 (2017). https://doi.org/10.1007/s10346-015-0676-0

Guzzetti, G., Ardizzone, F., Cardinali, M., Rossi, M., Valigi, D. Landslide volumes and landslide mobilization rates in Umbria, central Italy. Earth and Planetary Science Letters 279 (3-4), 222-229 (2009). https://doi.org/10.1016/j.epsl.2009.01.005

Larsen, I., Montgomery, D., Korup, O. Landslide erosion controlled by hillslope material. Nature Geoscience 3, 247–251 (2010). https://doi.org/10.1038/ngeo776

LANDSLIDE MAPPING IN EMERGENCY AND LANDSLIDE ANALYSIS BY UNMANNED AERIAL VEHICLES: THE SAN GIOVANNI IN FIORE LANDSLIDE

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ABSTRACT

Landslides are complex phenomena that pose significant risks to both populations and infrastructures. Therefore, understanding landslide predisposing factors is essential for developing effective management and mitigation strategies. Integrating unmanned aerial vehicles (UAVs) with traditional methods in landslide studies provides new opportunity for detailed analysis, monitoring, and risk mitigation, both in ordinary and emergency conditions.

In emergency condition, UAVs facilitate rapid and detailed mapping even in areas where site access is limited or dangerous.

This study used a UAV for an immediate response in detecting a first-failure flow type landslide occurred in the municipality of San Giovanni in Fiore, Calabria (Southern Italy). The location is being evaluated for its potential as an in-situ Laboratory (LabSit), to be used in the validation phase of both Specific and Transversal Informatic Platforms (PIS and PIT) within Pilot Project 1, Goal 1.1, Spoke 1 of the "Tech4You - Technologies for climate change adaptation and quality of life improvement" project (no. ECS00000009).

The landslide was triggered by intense rainfall and influenced by local geomorphological and geotechnical conditions. It involved highly weathered and tectonized granitoid rocks, and during the propagation phase it affected the 'Serra' tunnel and the State Road 107 'Silana-Crotonese' causing the interruption of the road for several days. Three days after the landslide triggering, a UAV flight was carried out to map landslide boundaries and morphological features in areas that were otherwise inaccessible, providing essential data for emergency assessment and event characterization.

The UAV-generated orthophotos and Digital Terrain Model (DTM) were used in mapping the landslide and revealed significant topographic changes. Particularly, the flow-type landslide covered a total length of 240 m, a maximum width of 70 m, and a maximum depth of about 6.5 m. It exhibited distinct zones, including the source area, transportation zone, and accumulation zone.

Topographical change detections were performed by using a Digital Elevation Model of Difference (DoD) analysis, comparing pre and post landslide DTMs. One of the DTMs was generated from the UAV flight, while the other was derived from a LIDAR-DTM dated 2012.

The most significant topographic changes include: material removal at the source area, with a minimum negative value of −6.3 m; bed erosion and material displacement in the transportation area, with approximate value of −2 m; and material accumulation in the deposition area, with a maximum positive value of 4.2 m. The total estimated volume of landslide is approximately 6000 m3.

These findings demonstrate the effectiveness of UAVs in landslide detection and in quickly and safely documenting erosional features and debris deposition patterns.

This study highlights the utility of UAVs in performing precise, real-time analyses under emergency conditions, supporting landslide hazard mitigation by rapidly characterizing landslide dynamics and spatial impact extent. Integrating UAV surveys into a circular risk management approach provides valuable insights for future mitigation planning, especially in geologically complex areas, offering a reliable solution in urgent and otherwise inaccessible situations.

This work was funded by the Next Generation EU—Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of 'Innovation Ecosystems', building 'Territorial R&D Leaders' (Directorial Decree n. 2021/3277)—project Tech4You—Technologies for climate change adaptation and quality of life improvement, n. ECS0000009. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

DATABASE OF GEOTECHNICAL PARAMETERS AS VALUABLE TOOL OF CIRCULAR KNOWLEDGE FOR LANDSLIDE RISK MANAGEMENT

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ABSTRACT

Landslide occurrence is on the rise globally due to the effects of climate change and increasing structure and infrastructure built in unstable areas, causing damage to both natural and human-made environments and killing people. The occurrence of the landslides is related to numerous geo-environmental factors, such as geological, geomorphological, hydrological, geotechnical, in particular geomaterial parameters, as well as land use and conservation practices.
In the context highlighted in general terms, the realisation of large-scale on-site laboratories (LabSitLS) can provide a decisive contribution to define strategies for sustainable landslide risk management.
In this perspective, within Goal 1-Spoke 1 of the Tech4You Innovation Ecosystem, the Pilot Project 1 envisages the design and implementation of a specific informatic platform (PIS) for the analysis, synthesis, representation and processing of data, accessible to a wide range of stakeholders (researchers, professionals, territorial administrations, public agencies and citizens) aimed to support in assessing susceptibility, vulnerability and landslide risk, and to allow circular upgrading of the knowledge.
Utilizing a database of landslide phenomena studied in the "TIPIZZAN" research project, we identified, in this phase, three “demonstrators” LabSitLS, in the Calabria region. For each, geotechnical characterisation data of the unstable geomaterials, which represent a key cognitive element, were grouped by type of laboratory test (oedometric, grain size, indices, Atterberg limits, specific gravity, direct shear and triaxial tests). We uploaded these data in a geotechnical database, called GeoDataTech vers. 2.0, which is an update of the one created by Gullà et al. 2005, testing the correct functioning (display, query, extraction data) with a significant sample of data.
GeoDataTech vers. 2.0 contains 764 laboratory tests to date: 18 oedometric tests, 192 grain size, 176 indices, 20 Atterberg limits, 108 specific gravity, 197 direct shear tests and 53 triaxial tests.
Furthermore, we gathered available data related to cartography, geological and geothematic maps, in situ and geophysical surveys, existing monitoring instruments, subsequently systematised according to type and format (geospatial data in raster and/or vector format, image and pdf data).
All data will be transferred to a PIS that will provide a wide range of users with basic functionalities such as acquisition, querying and export of data. In addition, users will be able to upload their file for integration into the platform, allowing them to identify sites with sufficient knowledge to generate further LabSitLS and perform advanced analysis with reference to the definition of the geotechnical model and geomaterials typing in similar geo-environmental contexts. Designed with these purposes in mind, it represents an important tool of circular knowledge useful to support the landslide risk management in both emergency and ordinary conditions.
This work was funded by the Next Generation EU—Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of ‘Innovation Ecosystems’, building ‘Territorial R&D Leaders’ (Directorial Decree n. 2021/3277)—project Tech4You—Technologies for climate change adaptation and quality of life improvement, n. ECS0000009. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

References

Gullà G., Terranova O., Iaquinta P., Aceto L. (2005) – GeoDataTech: visualizzazione/import dei risultati delle prove di un laboratorio di geotecnica e interrogazione della banca dati geotecnica. CNR-IRPI - Rapporto Interno - Luglio 2005.

COLLECTION AND ANALYSIS OF CASE STUDIES FOR TYPIFYING LANDSLIDE KINEMATIC: A SUPPORT FOR SUSTAINABLE RISK MANAGEMENT

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ABSTRACT

In the Innovation Ecosystem "Tech4You - Technologies for Climate Change Adaptation and Quality of Life Improvement," one key focus is the study of “Integrated and Multiscale Monitoring Systems Using In-Situ and Remote Data” (Action 5), as part of Goal 1.1 (Methods, Technologies, and Innovative Multiscale Tools for Landslide Risk Prevention), PP1 (Multiscale and Interdisciplinary On-Site Laboratories as Demonstration Systems and Knowledge Generators in Decision Support for Landslide Risk Management: Adaptation, Mitigation, Reduction). Long-term geotechnical monitoring of landslides, that concur to in situ laboratories (Gullà et al. 2022), is a key tool for sustainable risk management (Gullà, 2014). The design and implementation of integrated monitoring networks and their measurement for representative times require considerable resources. Therefore, for their progressive implementation a wide range of geological, hydrological, and geotechnical data needs to be collected (Gullà et al. 2018; 2020). Collection and analysis of displacements vs time curves are critical for understanding the landslide mechanisms and eventually warning of possible hazards (Scoppettuolo et al., 2020).

The objective is to create a catalog for typifying landslides kinematic. To this aim various sources (scientific papers and technical reports, also conducted by CNR-IRPI) have been analyzed to extract specific data.

The catalog includes landslide type, sensors details, installation year, and references. When available additional information, such as landslide dimensions (width, length, depth) and precipitation data of the study area, are also added. The case studies collected are international, and each one is georeferenced using QGis©.

The research focused on surface and depth displacement data, classified as “surface” or “depth measurements” to differentiate datasets and analyses.

One of the main difficulties encountered is the availability of numerical data, as results are often presented graphically (e.g., displacement versus depth or time). To address this issue, artificial intelligence (AI) has been employed to analyze images of published graphs. However, AI often makes significant errors when extracting numerical values, which can be problematic depending on the context.

Consequently, manual verification is required and, in some cases, specific software available online is used to extract numerical values from graphs. While this lengthens analysis, it ensures accuracy.

The activity is ongoing, and the catalog now contains landslides categorized by type and size, with displacement monitoring timeframes ranging from a few months to several years. The collected data will be integrated into a circular digital platform that can be widely used by territorial and national public entities.

The collection and availability of detailed and specific data regarding landslide monitoring is a fundamental tool for the development and management of effective landslide monitoring systems. This could also allow to foresee possible evolutions of landslides that have characteristics similar to those included in the database (landslide typification process). The collected data provide a valuable resource for territorial and national authorities in their efforts to manage and mitigate landslide risks.

References

Gullà G. (2014) – Field monitoring in sample sites: hydrological response of slopes with reference to widespread landslide events. Procedia Earth and Planetary Science 9 (2014) 44-53.

Gullà G., Aceto L.,, Borrelli B., Cofone G. (2022) – Laboratori in sito per lo studio degli eventi di frana a support della difesa del territorio. Atti del XXVII Convegno Nazionale di Geotecnica – La Geotecnica per lo Sviluppo Sostenibile del Territorio e per la Tutela dell’Ambiente, Reggio Calabria 13-15 luglio 2022, a cura di N. Moraci e C. Soccodato, Associazione Geotecnica Italiana, Volume 2, 783-790, ISBN 978-88-97517-14-6.

Gullà G., Borrelli L., Aceto L. (2020) – Frane tipizzate in rocce gneissiche: rilevanza e stato dell’arte. Atti della XLI Edizione “Tecniche per la Difesa del Suolo e dall’Inquinamento, Volume 41, 213-227 - 2020. A cura di Giuseppe Frega & Francesco Macchoine. EdiBios. ISBN: 978-88-97181-75-0 - ISSN 2282-5517.

Gullà G., Calcaterra S., Gambino P., Borrelli L., Muto F. (2018) – Long-term measurements using an integrated monitoring network to identify homogeneous landslide sectors in a complex geo-environmental context (Lago, Calabria, Italy). Landslides (2018) 15:1503–1521. DOI 10.1007/s10346-018-0974-4. Received 9 July 2017. Accepted 1 March 2018. Published online: 15 March 2018. Springer-Verlag GmbH-Germany, part of Springer Nature 2018.

Scoppettuolo M.R., Cascini L., Babilio E. (2020) – Typical displacement behaviours of slope movements. Landslides (2020) 17: 1105-1116.

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DEBRIS FLOW SUSCEPTIBILITY IN A TOURISTIC ALPINE AREA: THE CASE STUDY OF THE BARDONECCHIA TOWN (NW ITALY)

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ABSTRACT

Debris flows represent one of the most dangerous natural hazards in mountain environments due to their intensity, rapidity and difficulty in forecasting. These events are capable of causing significant destruction of structures and infrastructures located along the directions of propagation, often involving the demolition of houses, the removal of bridges, the dragging of vehicles, invading roads and entire built-up areas with thick deposits. In recent decades, due to variations in precipitation characteristics and anthropic expansion in Italian Alpine areas, many of which are of tourist interest, there has been a significant increase of the risk of debris flow.

Alluvial fans are places where debris flow sediments are deposited, but they are also the selected place for urban development, considering their elevation from the river plain and easy accessibility compared to mountainous areas. However, alluvial fans are also the areas most exposed to the risk of debris flows. In mountainous areas, the anthropization finalized to urban sprawl, sports activities, tourism, roads, and trail networks have drastically increased the instability and geo hydrological risk, demanding detailed assessment of vulnerable areas and potential mitigation strategies.

The case described represents a summary of the problems associated with an area with a high frequency of debris flows and a high tourist-economic interest. The aim of this study is to assess susceptibility to debris flows in relation to both natural and anthropogenic influences, upon the invitation of the municipality of Bardonecchia for sustainable land management, in light of recent events, particularly those of August 2023. In this regard, the work was presented at the conference organized in in August 2024, where the research findings were shared with the municipality, institutional stakeholders, and interested parties.

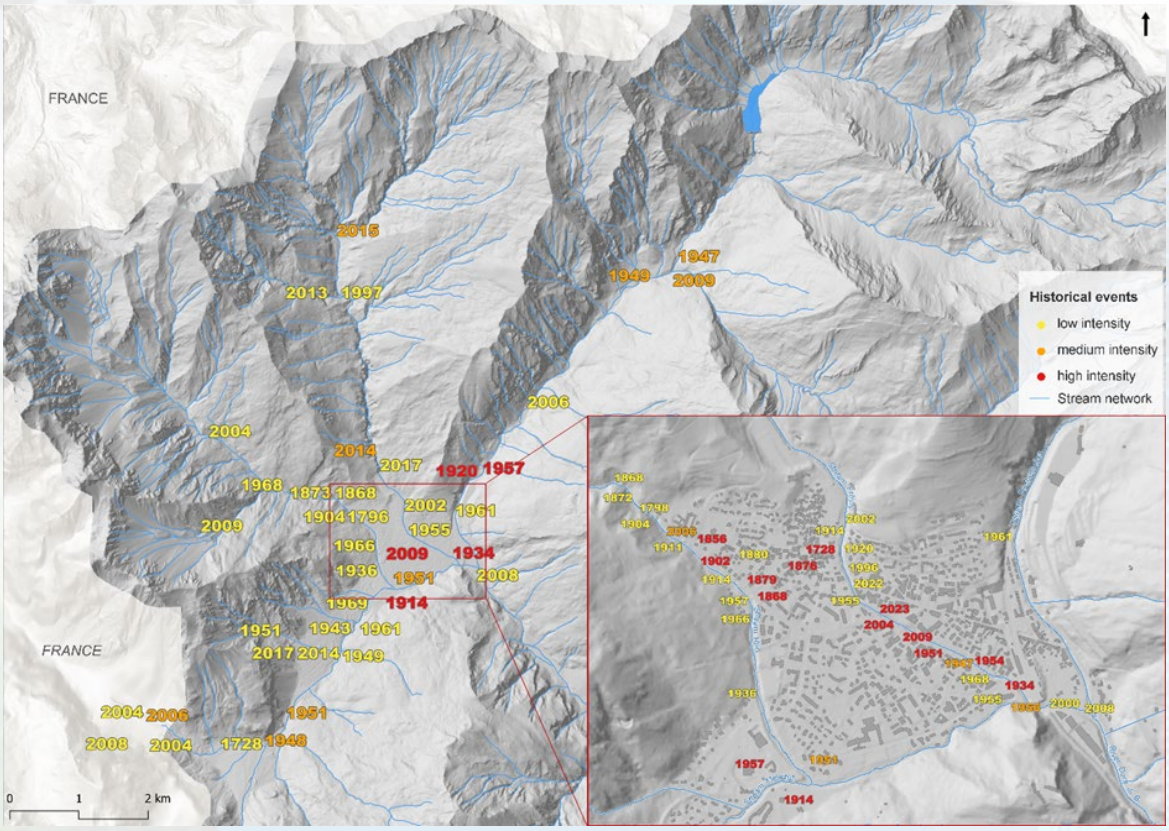
The impact of August 13, 2023, debris flow on the city center of Bardonecchia.

The case represents a complex situation from a geo-hydro-morphological point of view, also concerning the environment and land use. Moreover, the entire built-up area of Bardonecchia lies on the coalescent alluvial deposits of four minor streams, whose catchments are prone to debris flows, slope erosion, and gravity processes.

As part of this analysis, an integrated methodology is proposed that includes complementary procedures: the study of the basin's geomorphological characteristics and dynamics, expansion of anthropized areas, population data, historical analysis of past geo-hydrological events, and hydraulic forestry works.

In addition, debris-flow source areas were evaluated by integrating different data in a GIS environment, facilitating the visualization of survey fundings. Photointerpretation of aerial images and mapping of sediment source areas are essential for identifying potential debris flow trigger areas. A qualitative assessment of debris-flow availability makes it possible to draw not only its spatial distribution of the phenomenon but also the nature of the material involved. Such details are essential for the targeted design of mitigation measures.

This research is finalised for risk analysis in a Municipal territorial management plan of Bardonecchia, providing not only an assessment of the frequency and extent of events, but also a basis for the development of prevention and mitigation strategies.



Spatial representation of debris flow events occurred in the Municipality of Bardonecchia over the years.

References

Turconi, L.; Voglino, B.; Savio G.; Tropeano, D.; Bono B.; & Luino F. (2024). Debris flow susceptibility in a touristic alpine area: the case study of the Bardonecchia town (NW Italy). Journal of Map, Taylor & Francis Group [under review].

Aree attrezzate e tecniche di misura al suolo e da remoto: esperienze di gestione dei dati

L'impiego di dati di monitoraggio, siano essi acquisiti da piattaforme satellitari o attraverso sistemi di monitoraggio in situ, rivestono un ruolo sempre più centrale nello studio della dinamica di processi geo-idrologici. In tale ambito, i dati di monitoraggio sono ormai un aspetto imprescindibile per la comprensione dei fenomeni naturali finalizzata alla modellazione e alla gestione dei rischi naturali. Lo sviluppo di nuove tecniche e metodologie per l'acquisizione in situ e da satellite riveste dunque un ruolo primario nel campo della ricerca, soprattutto per comprendere quali siano gli effetti del cambiamento climatico sui processi in atto. La sessione mira a promuovere la condivisione ed il confronto tra diverse esperienze di uso di dati acquisiti con tecniche diverse al fine di individuarne i punti di forza ed i limiti così da arrivare a migliorare ed integrare i sistemi di monitoraggio.

The use of monitoring data, whether acquired from satellite platforms or through in situ monitoring systems, plays an increasingly fundamental role in the study of the dynamics of geo-hydrological processes. In this context, monitoring data is now an essential aspect for understanding natural phenomena aimed at modeling and managing natural risks. The development of new techniques and methodologies for in situ and satellite acquisition plays a primary role in the research field, especially with the aim to understand the effects of climate change on ongoing processes. The session aims to promote sharing and comparison between different experiences of using data acquired with various techniques in order to identify their strengths and limitations with the main aim to improve and integrate monitoring systems.

SESSIONE ORALE

ROLE AND IMPORTANCE OF METROLOGY FOR THE CHARACTERIZATION OF IN-FIELD MEASUREMENTS

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ABSTRACT

Metrology, the science of measurement, lays at the foundations of all the observational sciences. Its role is manifold: it keeps – and improves upon research – the 7 fundamental units of measurement and all the others which are derived from those; it studies the characterization of instruments, i.e. the behaviour of sensors in different environments and subject to different solicitations; it establishes the rules of calibrations, the ways in which instruments are set to measure correctly, and studies the ways to improve them or create fit-for-purpose procedures; it establishes traceability, i.e. the uninterrupted chain of calibrations which links any instrument to the fundamental units; it evaluates calibration and measurement uncertainties, the degree of confidence the users have in the measurement they perform.

For a very long time, metrology has been confined in laboratories, where scientists in white coats studied the ways to improve the definitions of the fundamental units employing complicated experiments in order to reduce uncertainties down to ppm or even ppb levels; while this is still the core of metrology business, so much so that in 2019 many fundamental quantities have been redefined after intensive research campaigns (Stock et al., 2019), in the last few decades metrologists started exploring the measurements made in the real world, often finding surprising things – like, for instance, the very complicated relations which link together air temperature with many other quantities of influence which have rarely been investigated, at least within a metrological framework (Coppa et al., 2021; Garcia Izquierdo et al., 2024; Musacchio et al., 2019, 2021), or that there is neither a procedure for calibration of air temperature sensors, nor even a definition of what air temperature is (Coppa et al., 2024; Merlone et al., 2024). These efforts stem from the pioneering works made under projects MeteoMet (Merlone et al., 2015, 2018).

This talk will explore some of the issues which affect in-field measurements from a metrological point of view, with a special emphasis on thermodynamic quantities, and providing a number of case studies – ranging from arctic environments (Coppa, Musacchio, Becherini, et al., 2024), to high-mountain rock faces (Nigrelli et al., 2022; Viani et al., 2020), to permafrost sites (Merlone et al., 2020; Coppa, Sanna, Paro, et al., in press) to show the crucial importance of metrology when faced with real-world scenarios, in the growing threat of climate change and for the efforts in fighting it.

Reference

Coppa, G., Musacchio, C., Becherini, F., Mazzola, M., Viola, A., & Merlone, A. (2024). On-site calibration of instruments in the Arctic: assessment of temperature records at Climate Change Tower in Ny-Ålesund, Svalbard. Arctic Science. https://doi.org/10.1139/as-2024-0008

Coppa, G., Musacchio, C., & Merlone, A. (2024). The metrology-meteorology cooperation on thermodynamic environmental issues. Il Nuovo Cimento - C, 47, 309. https://doi.org/10.1393/ncc/i2024-24309-3

Coppa, G., Quarello, A., Steeneveld, G., Jandrić, N., & Merlone, A. (2021). Metrological evaluation of the effect of the presence of a road on near-surface air temperatures. International Journal of Climatology, 41(6), 3705–3724. https://doi.org/10.1002/joc.7044

Coppa, G., Sanna, F., Paro, L., Musacchio, C., Merlone, A. (2024). Metrological approach for permafrost temperature measurements, Cold Regions Science and Technology, in press.

Garcia Izquierdo, C., Coppa, G., Hernández, S., & Merlone, A. (2024). Metrological Evaluation of the Building Influence on Air Temperature Measurements. Atmosphere, 15(2), 209. https://doi.org/10.3390/atmos15020209

Merlone, A., Coppa, G., & Musacchio, C. (2024). The air temperature conundrum. Nature Physics, 20(3), 520–520. https://doi.org/10.1038/s41567-024-02428-w

Merlone, A., Lopardo, G., Sanna, F., Bell, S., Benyon, R., Bergerud, R. A. A., Bertiglia, F., Bojkovski, J., Böse, N., Brunet, M., Cappella, A., Coppa, G., del Campo, D., Dobre, M., Dmovsek, J., Ebert, V., Emardson, R., Fernicola, V., Flakiewicz, K., … Underwood, R. (2015). The MeteoMet project - metrology for meteorology: challenges and results. Meteorological Applications, 22(January), 820–829. https://doi.org/10.1002/met.1528

Merlone, A., Sanna, F., Beges, G., Bell, S., Beltramino, G., Bojkovski, J., Brunet, M., Del Campo, D., Castrillo, A., Chiodo, N., Colli, M., Coppa, G., Cuccaro, R., Dobre, M., Drnovsek, J., Ebert, V., Fernicola, V., Garcia-Benadí, A., Garcia-Izquierdo, C., … Voldan, M. (2018). The MeteoMet2 project - Highlights and results. Measurement Science and Technology, 29(2), 025802. https://doi.org/10.1088/1361-6501/aa99fc

Musacchio, C., Coppa, G., Begeš, G., Hofstätter-Mohler, C., Massano, L., Nigrelli, G., Sanna, F., & Merlone, A. (2021). Effect of snow-covered ground albedo on the accuracy of air temperature measurements. Atmospheric Measurement Techniques, 14(9), 6195–6212. https://doi.org/10.5194/amt-14-6195-2021

Musacchio, C., Coppa, G., & Merlone, A. (2019). An experimental method for evaluation of the snow albedo effect on near-surface air temperature measurements. Meteorological Applications, 26(1), 161–170. https://doi.org/10.1002/met.1756

Nigrelli, G., Chiarle, M., Merlone, A., Coppa, G., & Musacchio, C. (2022). Rock temperature variability in high-altitude rockfall-prone areas. Journal of Mountain Science, 19(3), 798–811. https://doi.org/10.1007/s11629-021-7073-z

Stock, M., Davis, R., De Mirandés, E., & Milton, M. J. T. (2019). The revision of the SI—the result of three decades of progress in metrology. Metrologia, 56(2), 022001. https://doi.org/10.1088/1681-7575/AB0013

Viani, C., Chiarle, M., Paranunzio, R., Merlone, A., Musacchio, C., Coppa, G., & Nigrelli, G. (2020). An integrated approach to investigate climate-driven rockfall occurrence in high alpine slopes: the Bessanese glacial basin, Western Italian Alps. Journal of Mountain Science, 17(11), 2591–2610. https://doi.org/10.1007/s11629-020-6216-y

ENHANCING PREDICTIONS OF HYDROLOGICAL EXTREMES AND LAND SURFACE MODELING THROUGH THE USE OF SATELLITE AND IN-SITU DATA

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ABSTRACT

During periods of significant precipitation deficits and increased atmospheric water demand, commonly referred to as meteorological droughts (McKee, 1993), the water balance dynamics within a basin are shaped by the interactions between land surface evaporation processes and basin storage capacity. Evaporation encompasses a range of components, including vegetation transpiration, canopy interception, soil evaporation, and open water evaporation, all of which return water to the atmosphere. Basin storage, by contrast, includes key reservoirs such as soil moisture, snowpack, groundwater, and surface water bodies.

This intricate interplay between evaporation and storage is critical as it drives the transition from meteorological droughts to hydrological droughts, wherein reductions in streamflow and groundwater recharge become evident. Accurately representing evaporation fluxes, soil moisture levels, and the role of the vegetation (i.e., the carbon cycle) is thus essential for understanding and predicting hydrological fluxes within a basin, especially concerning streamflow and groundwater recharge, which are fundamental for water availability and ecosystem health. Moreover, human disturbances, including agricultural water use and land-use changes, exert significant influence on the water cycle and impact eco-hydrological responses (Modanesi et al., 2022; De Lannoy et al., 2024).

This talk will explore the role of observational data from satellite remote sensing and in situ measurements in enhancing our understanding of the complex interactions among evaporation processes, water storage dynamics, and human influences. As a key example, the SINCZONE open-air laboratory is an initiative led by CNR-IRPI within the Monti Sibillini National Park (Central Italy), where diverse aspects of the water and carbon cycles are studied under natural conditions. The environmental monitoring insights gained from both remote sensing and in situ observational data offer valuable constraints that help improve models' accuracy, particularly in predicting drought impacts on water resources and watershed hydrology.

The presentation will emphasize how Land Surface Models (LSMs), such as the Noah-MP LSM (Niu et al., 2011), implemented within the NASA Land Information System Framework (LIS; Kumar et al., 2006; Peters-Lidard et al., 2007), attempt to capture these critical interactions. Additionally, the challenges of accurately representing soil-vegetation processes at the planetary boundary layer level will be addressed, including constraints of model parameterizations that can affect hydrological predictions, particularly during drought conditions. Finally, the integration of observational data into models will be discussed to overcome these limitations, enhancing the reliability of predictions for water resource management and ecosystem health, especially in the context of increasingly frequent drought conditions.

References

De Lannoy, G. J., Bechtold, M., Busschaert, L., Heyvaert, Z., Modanesi, S., Dunmire, D., ... & Massari, C. (2024). Contributions of irrigation modeling, soil moisture and snow data assimilation to high-resolution water budget estimates over the Po basin: Progress towards digital replicas. Journal of Advances in Modeling Earth Systems, 16(10), e2024MS004433.

Kumar, S. V., Peters-Lidard, C., Tian, Y., Houser, P., Geiger, J., Olden, S., Lighty, L., Eastman, J., Doty, B., and Dirmeyer, P. (2006). Land information system: An interoperable framework for high resolution land surface modeling. Environmental Modelling & Software 21, 1402–1415. https://doi.org/10.1016/j.envsoft.2005.07.004.

McKee, T. B., Doesken, N. J., and Kleist, J. (1993). The relationship of drought frequency and duration to time scales. Proceedings of the Eighth Conference on Applied Climatology, Boston, MA: American Meteorological Society

Modanesi, S., Massari, C., Bechtold, M., Lievens, H., Tarpanelli, A., Brocca, L., Zappa, L., De Lannoy, G.J.M. (2022) Challenges and benefits of quantifying irrigation through the assimilation of Sentinel-1 backscatter observations into Noah-MP. Hydrol. Earth Syst. Sci., 26, 4685-4706. https://doi.org/10.5194/hess-26-4685-2022.

Niu, G. Y., Yang, Z. L., Mitchell, K. E., Chen, F., Ek, M. B., Barlage, M., Kumar, A., Manning, K., Niyogi, D., Rosero, E., Tewari, M., and Xia, Y. (2011). The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements, J. Geophys. Res.-Atmos., 116, 1–19, https://doi.org/10.1029/2010JD015139.

Peters-Lidard, C.D., Houser, P.R., Tian, Y., Kumar, S.V., Geiger, J., Olden, S., Lighty, L., Doty, B., Dirmeyer, P., Adams, J., Mitchell, K., Wood, E.F., and Sheffield, J (2007). High-performance Earth system modeling with NASA/GSFC's Land Information System. Innov. Syst. Softw. Eng. 3, 157–165. https://doi.org/10.1007/s11334-007-0028-x.

FROM EMERGENCY RESPONSE TO PLANNING: MULTISCALE INTEGRATION OF REMOTE SENSING DATA AND IN SITU DETECTION AND MONITORING

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ABSTRACT

In recent years, the availability of free satellite data, the improvement in computational power, and advances in big data cloud computing have enabled a wide range of users to map and study various geohazards such as floods, shallow landslides, and wildfires in relatively short timeframes. Additionally, this large volume of data can support long-term monitoring of slow-moving landslides, glacier evolution, and subsidence. As a result, remote sensing has become essential in both emergency response and natural hazard planning. However, it must be integrated with traditional field survey UAV, LiDAR data, and ground-based monitoring to understand these phenomena comprehensively. A multidisciplinary, multi-instrument approach is adopted to study processes by the geohazard monitoring group (GMG) of CNR-IRPI.

We developed a methodology for mapping flooded areas [1] based on free satellite data, including optical (Fig. 1a) and InSAR sources such as Sentinel-2, Landsat, and Sentinel-1. This approach considers the timing of peak discharge to better estimate flooded areas and reduce underestimation. In critical areas, such as densely populated urban zones where high precision is required, this data is integrated with progressively higher-resolution sources, up to UAV data and field surveys.

Using the same approach, we tested the rapid mapping of shallow landslides during the Emilia extreme rainfall events [2] using an NDVI-based change detection corrected with geomorphological parameters. Such a map based on Sentinel-2 data allowed us to map tens of thousands of landslides within a week of the event, and it was used as a help during field surveys.

The use of a multidisciplinary, multi-instrument approach has proven highly effective in studying complex landslides, as demonstrated in the case of Monesi di Mendatica [3]. This approach integrates diverse remote sensing data such as InSAR, LiDAR, and various multispectral images to analyze the reactivation of slow-moving landslides. In this study, InSAR effectively captured the landslide's slow-moving dynamics both before and after the paroxysmal phase. At the same time, digital image correlation (DIC) based on high-resolution satellite data provided valuable insights into the acceleration phase (Fig. 1b).

Combining ground-based monitoring with remote sensing data has also shown success in understanding the kinematics of slow-moving landslides across multiple case studies. For example (Fig. 1c), the integration of InSAR and GNSS data, complemented by field surveys, enabled a detailed assessment of structural damage impacts on the deep-seated gravitational slope deformation (DSGSD) at Sauze d'Oulx [4]. Additionally (Fig 1d), the combined use of borehole inclinometer and piezometer data with InSAR and GNSS proved essential for analyzing the kinematics of the Arzeno landslide [5].

Future advancements in this multidisciplinary approach will likely focus on deeper data integration through cloud-based databases, artificial intelligence, and intelligent ground-based monitoring networks

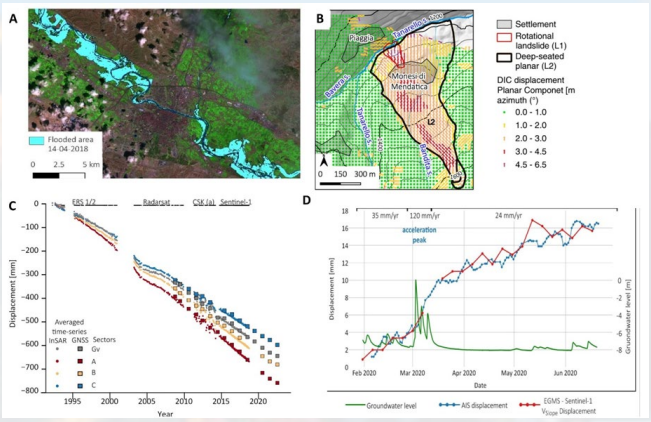

Figure 1: a) Area flooded by Ebro River (Spain) in April 2018 based on Sentinel-2 Data; b) November 2016 paroxysm Displacement mapped with DIC technique of Monesi landslide c) Displacement comparison of GNSS and InSAR data on the Sauze DsGSD; d) Displacement comparison of Inclinometers and InSAR data on the Arzeno landslide.

References

1 Giordan, D., Notti, D., Villa, A., Zucca, F., Calò, F., Pepe, A., ... & Allasia, P. (2018). Low cost, multiscale and multi-sensor application for flooded area mapping. Natural Hazards and Earth System Sciences, 18(5), 1493-1516

2 Notti, D., Cignetti, M., Godone, D., Cardone, D., & Giordan, D. (2024). The unsuPervised shAllow laNdslide rapiD mApping: PANDA method applied to severe rainfalls in northeastern Apennines (Italy). International Journal of Applied Earth Observation and Geoinformation, 129, 103806

3 Notti, D., Wrzesniak, A., Dematteis, N., Lollino, P., Fazio, N. L., Zucca, F., & Giordan, D. (2021). A multidisciplinary investigation of deep-seated landslide reactivation triggered by an extreme rainfall event: a case study of the Monesi di Mendatica landslide, Ligurian Alps. Landslides, 18, 2341-2365.

4 Cignetti, M., Godone, D., Notti, D., Lanteri, L., & Giordan, D. (2024). Impacts on mountain settlements of a large slow rock-slope deformation: A multi-temporal and multi-source investigation. Landslides, 21(2), 327-337.

5 Godone, D., Allasia, P., Notti, D., Baldo, M., Poggi, F., & Faccini, F. (2023). Coexistence of a Marginal Mountain Community with Large-Scale and Low Kinematic Landslide: The Intensive Monitoring Approach. Remote Sensing, 15(13), 3238.

ROCKFALL RISK MITIGATION IN THE ALPS: A PRIN 2022 PROJECT

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ABSTRACT

The main focus of the project is the development of accurate and exportable heat transfer models of rock, specific for different lithotypes, to be used for risk mitigation in high-elevation rockfall-prone areas.
The project (20223MKEMB_PE10_PRIN2022, PNRR M4.C2.1.1, Next Generation EU, CUP B53D23006710006) is developing in the already-instrumented alpine area of the Bessanese glacier basin, which in the past years has been the testbed of research on rockfall monitoring by innovative techniques and a strict cooperation with metrology and with the contribution of INRiM, during the CNR IRPI-led projects RIST, RIST2 and GioMon of the GeoClimAlp research group. These projects proposed a metrologically-driven approach to temperature measurements in high-elevation sites, in order to characterize the meteorological and geological conditions that trigger rock falls in the Alps.
The PRIN 2022 project refine the approach already applied in the past with new instrumentation, more lithotypes and different rock faces with different solar exposures, in order to extend the knowledge of the mechanisms that are crucial to the development of rock instabilities.
The GeoClimAlp research group has installed all the instrumentation in the Bessanese glacier basin and perform the analysis, and will also identify a second alpine site suitable for new instrumentation, that will come into play in the second part of this project (Fig. 1).
All the instrumentation is accurately calibrated and characterized by INRiM. On the basis of this thermal characterization, Politecnico di Torino is building a numerical model that will simulate and explain the thermal behavior of these different lithotypes subjected to these conditions.

Fig. 1 – IoT sensors for rock temperature, solar radiation and other parameters made by lab3841, https://pera.lab3841.it/home .

Aree attrezzate e tecniche di misura al suolo e da remoto: esperienze di gestione dei dati

L'impiego di dati di monitoraggio, siano essi acquisiti da piattaforme satellitari o attraverso sistemi di monitoraggio in situ, rivestono un ruolo sempre più centrale nello studio della dinamica di processi geo-idrologici. In tale ambito, i dati di monitoraggio sono ormai un aspetto imprescindibile per la comprensione dei fenomeni naturali finalizzata alla modellazione e alla gestione dei rischi naturali. Lo sviluppo di nuove tecniche e metodologie per l'acquisizione in situ e da satellite riveste dunque un ruolo primario nel campo della ricerca, soprattutto per comprendere quali siano gli effetti del cambiamento climatico sui processi in atto. La sessione mira a promuovere la condivisione ed il confronto tra diverse esperienze di uso di dati acquisiti con tecniche diverse al fine di individuarne i punti di forza ed i limiti così da arrivare a migliorare ed integrare i sistemi di monitoraggio.

The use of monitoring data, whether acquired from satellite platforms or through in situ monitoring systems, plays an increasingly fundamental role in the study of the dynamics of geo-hydrological processes. In this context, monitoring data is now an essential aspect for understanding natural phenomena aimed at modeling and managing natural risks. The development of new techniques and methodologies for in situ and satellite acquisition plays a primary role in the research field, especially with the aim to understand the effects of climate change on ongoing processes. The session aims to promote sharing and comparison between different experiences of using data acquired with various techniques in order to identify their strengths and limitations with the main aim to improve and integrate monitoring systems.

SESSIONE POSTER PICO

PANDA: A TWO-PHASE NDVI-BASED METHOD FOR SHALLOW LANDSLIDE RAPID MAPPING WITH SPACEBORNE IMAGERY

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ABSTRACT

Heavy rainfalls, fast snowmelt, or seismic activity can trigger shallow landslides impacting large areas and severely damaging the socio-economic landscape of the affected region. In the immediate aftermath of such events, a rapid assessment of landslide distribution is essential to prioritize damage assessment and manage field surveys effectively. Additionally, in the post-emergency phase, it is important to enhance shallow landslide inventory accuracy for comprehensive event analysis.

This study introduces the PANDA (unsuPervised shAllow laNdslide rapiD mApping) method, an unsupervised, semi-automatic approach for the rapid mapping of shallow landslides (Notti et al., 2024). PANDA, building on a refined version of the method proposed by Notti et al., (2023), is a cost-effective, two-phase methodology based on the Differenced Normalized Difference Vegetation Index (dNDVI) between pre- and post- event satellite images. After dNDVI computation, various filters (e.g., morphological and hydrological) and cloud masking are applied to minimize false positives. The first phase, PANDA-E, is applied during the emergency phase as a survey management tool. PANDA-E produces a preliminary inventory of potential landslide (PL) immediately following the triggered event, to support first survey operations and risk management. The second phase, PANDA-PE, is designed for the post-emergency phase to improve the PL inventory using updated satellite images and ancillary data (e.g., high-resolution DTM, UAV surveys, and field data). The availability of progressively more detailed and higher-resolution data, allows the initial mapping to be enhanced, identifying the false positive and resolving the eventual gap of cloud cover of the preliminary map. The PANDA-PE aims to obtain a reliable inventory tool for the subsequent phase of validation, risk mitigation and action planning.

We applied PANDA to the rainfall events that occurred in May 2023 affecting the northeastern Apennine. Within five days of the availability of Sentinel-2 post-event imagery, we prepared a reliable and ready-to-use map covering an area of around 4000 km2 of the potential shallow landslides.

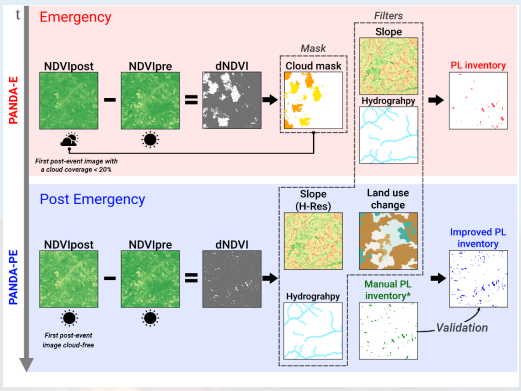

Fig. 1 Flow chart of PANDA method showing emergency and post-emergency phases applications

This map proved suitable during emergency field surveys. During the post-emergency phase, we applied PANDA-PE to enhance the accuracy of the PL inventory using the available cloud-free Sentinel-2 imagery, a high-resolution DTM, and a filter to identify false positives associated with land use changes. We also integrated an iterative process to optimize NDVI and slope thresholds in the PANDA-PE phase. The results obtained with the PANDA method indicate that the most severely affected region attained a density of approximately 50 landslides/km2. The availability of a manual inventory based on high-resolution PlanetScope imagery (Ferrario, 2023) enabled us to validate our semi-automated inventory, demonstrating a marked improvement in accuracy. The F1 score increased from 0.40 for the PANDA-E inventory to 0.59 for the PANDA-PE version. Future improvements to PANDA will include the automated analysis of shallow landslide shape factor aimed at reducing false positives, and developing a PANDA tool integrated with image data cloud platforms designed for use by stakeholders. This tool will support risk management and mitigation in both emergency and post-emergency phases related to shallow-landslides activation.

References

Ferrario, M.F., 2023. Inventory of landslides triggered by heavy rainfall in the Emilia-Romagna region (Italy) in May 2023. https://doi.org/10.5281/ZENODO.8102429

Notti, D., Cignetti, M., Godone, D., Cardone, D., Giordan, D., 2024. The unsuPervised shAllow laNdslide rapiD mApping: PANDA method applied to severe rainfalls in northeastern Apennines (Italy). International Journal of Applied Earth Observation and Geoinformation 129, 103806. https://doi.org/10.1016/j.jag.2024.103806

Notti, D., Cignetti, M., Godone, D., Giordan, D., 2023. Semi-automatic mapping of shallow landslides using free Sentinel-2 images and Google Earth Engine. Natural Hazards and Earth System Sciences 23, 2625–2648. https://doi.org/10.5194/NHESS-23-2625-2023

THE USE OF TERRESTRIAL TIME-LAPSE CAMERA TO MONITOR GLACIER VELOCITY

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ABSTRACT

Glacier surface velocity is a critical metric for understanding the impacts of global warming on glaciers, as it is linked to ice thickness variations, which in turn reflect mass balance and the overall "health" of glaciers. Velocity anomalies can also signal glacier instability. As a result, there has been increasing interest in monitoring glacier kinematics. Surface velocity measurements were historically among the first quantitative data collected on glaciers using theodolites, dating back to the 19th century. In recent decades, terrestrial monoscopic time-lapse cameras have enabled high-resolution, automated monitoring of glaciers, using digital image correlation, for both spatial and temporal analysis. While terrestrial time-lapse imaging is now a well-established technique in glacier monitoring, the strategies, limitations, and potential of this approach have not been systematically reviewed. This study aims to outline the standard procedures for measuring glacier surface velocity with terrestrial time-lapse cameras, focusing particularly on the hardware used. We present data from seven sites across the Mont Blanc, Monte Rosa (in the framework of the HIKE project), and Bernina massifs, each showcasing different monitoring setups, site conditions, and glacier characteristics (Figure 1). These cases demonstrate the range of solutions available for terrestrial image-based monitoring (Dematteis et al., 2024). Our findings emphasize that various models of time-lapse cameras yield different levels of data quality, but overall, the use of terrestrial time-lapse cameras offers a high benefit-to-cost ratio for glacier velocity monitoring.

Figure 1. Installations of the time-lapse stations monitoring the glaciers of a) Brenva, b) Western Fellaria (the Vivotek FD9380-H camera adopted into this study is indicated by a yellow arrow, c) Eastern Fellaria, d) Grandes Jorasses, e) Lys, and f) Planpincieux

This map proved suitable during emergency field surveys. During the post-emergency phase, we applied PANDA-PE to enhance the accuracy of the PL inventory using the available cloud-free Sentinel-2 imagery, a high-resolution DTM, and a filter to identify false positives associated with land use changes. We also integrated an iterative process to optimize NDVI and slope thresholds in the PANDA-PE phase. The results obtained with the PANDA method indicate that the most severely affected region attained a density of approximately 50 landslides/km2. The availability of a manual inventory based on high-resolution PlanetScope imagery (Ferrario, 2023) enabled us to validate our semi-automated inventory, demonstrating a marked improvement in accuracy. The F1 score increased from 0.40 for the PANDA-E inventory to 0.59 for the PANDA-PE version. Future improvements to PANDA will include the automated analysis of shallow landslide shape factor aimed at reducing false positives, and developing a PANDA tool integrated with image data cloud platforms designed for use by stakeholders. This tool will support risk management and mitigation in both emergency and post-emergency phases related to shallow-landslides activation.

References
Dematteis, N., Troilo, F., Scotti, R., Colombarolli, D., Giordan, D., & Maggi, V. (2024). The use of terrestrial monoscopic time-lapse cameras for surveying glacier flow velocity. Cold Regions Science and Technology, 222, 104185.
HIKE Observing alpine cryosphere: advanced monitoring network at High elevations to Improve Knowledge of a susceptible tErritory. Progetto NODES - Nord Ovest Digitale e Sostenibile – Linea A

USING DIFFERENT MONITORING TECHNIQUES TO ASSESS EARTHEN LEVEES' STATUS AND VULENRABILITY: PRELIMINARY RESULTS FROM THE EXPERIMENTAL SITE ALONG THE TATARENA STREAM

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ABSTRACT

Earthen levees are one of the most widely used structural measures to mitigate the severe impacts of flooding. Hydraulic risk assessments in flood-prone areas typically assume that levee systems remain intact during flood events. However, levees are susceptible to failure through various mechanisms, with overtopping and seepage/piping being the most common causes. These failures often result from infiltration processes occurring through the levee structure and its foundation. Monitoring the condition of levees with techniques such as geophysical methods is crucial for collecting data needed for vulnerability analysis. In this context, this study presents an on-going experimental activity addressed to monitor a selected earthen levee stretch by using different techniques. The experimental system has been developed based on findings from a characterization analysis using a combination of geophysical techniques, including Ground Penetrating Radar (GPR), Electrical Resistivity Tomography (ERT), and Frequency Domain Electromagnetic Methods (FDEM). The characterization step allowed to produce geophysical images for an interpretation of the site (see figure 1) and the design of the monitoring system recently implemented. It comprises a longitudinal ERT, consisting of 96 electrodes spaced 0.5 m (total length 47.5 m). Cross-sectional ERTs are installed along two sections, located 19 m and 28.5 m from the beginning of the longitudinal ERT, consisting of 24 electrodes spaced 0.5 m (total length 11.5 m).
In addition, a continuous self-potential measurement system has been developed (40 electrodes, system length 60 m).
The scheme of the on-site implemented monitoring system is shown in figure 2.

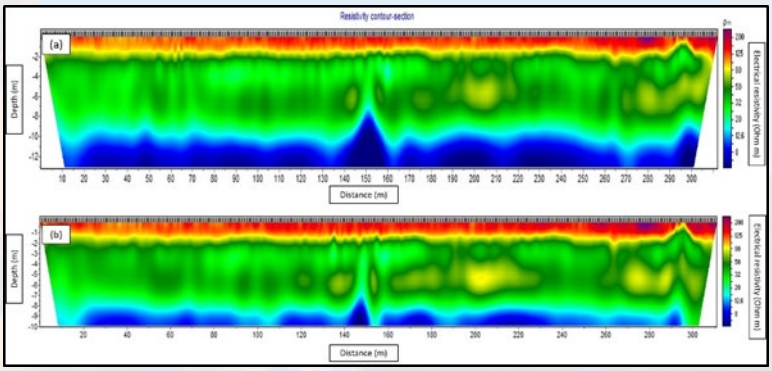

Figure 1. Characterization analysis: a) GPR results, evidence of the reflections hyperbole in the upper 30cm of soil; b) FDEM results: Inversion model obtained with EMTomo software; c) ERT results, inversion model of geoelectrical data: Wenner-Schlumberger method (1c), dipole-dipole method (2c)

Figure 2. Schematic map of the implemented monitoring system and aerial photo of the installation.

The measurements offer valuable insights into infiltration processes and the hydraulic status of the levees, essential for identifying vulnerable conditions.
The levee vulnerability to seepage has been investigated by using a practical procedure (Barbetta et al., 2017) that assumes an undamaged and homogeneous levee. The results indicate that assuming a water level in the channel equal to 0.5, 0.75 and 0.9 of the levee height, the selected levee is found to be characterized by a seepage probability equal to 25%, 35% and 42%, respectively when a flood duration of 12 hs is considered. The probability increases up to 34%, 46% and 56%, respectively, when a duration equal to 24 hs is investigated. The results will be verified and improved based on the monitoring outcomes.
Moreover, the levee is simulated by using the two-dimensional (2D) numerical model SEEP/W solving equations for unsaturated flow in porous media in transient conditions. SEEP/W allows to simulate the actual terrain stratigraphy of the levee identified through geognostic surveys. In this way, structural disomogeneity, soil heterogeneities and damaged areas can be simulated and their effects on the levee vulnerability can be investigated.

References
Barbetta, S., Camici, S., Bertuccioli, P., Palladino, M. R., & Moramarco, T. (2017). Refinement of seepage vulnerability assessment for different flood magnitude in national levee database of Italy. Hydrology Research, 48(3), 763–775.

SINCZONE: AN OPEN-AIR LABORATORY FOR ECO-PHYSIOLOGICAL AND GEO-HYDROLOGICAL MONITORING PROCESSES IN THE SIBILLINI NATIONAL PARK

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ABSTRACT

Forest and mountainous basins are crucial in maintaining water security, with over 75% of renewable water supply originating from these areas (Wilkie & Liu, 2021). However, these environments are increasingly at risk due to anthropogenic factors and competition for water among urban, agricultural, and environmental demands. Research has shown that interception losses significantly impact water yield in forested areas compared to deforested regions and other types of vegetation (Crockford & Richardson, 2000).

To explore the interactions between the carbon and water cycles, and their role in propagating of meteorological drought into eco-hydrological systems, the CNR IRPI Perugia built, within the three funded projects WATERSTEM, WAFER and Hydro-4C (www.waterstem.org - https://hydro4c-project.irpi.cnr.it), the Sibillini National park Critical ZONE observatory (SINCZONE) for the study of drought and the conservation of water and forest resources.

SINCZONE extends 44 km2 and is located in the the Ussita River catchment, a tributary of the Nera River located in the Apennines chain in the Monti Sibillini National Park (Central Italy). The area is characterized by fractured calcareous rocks reflecting a groundwater – dominated hydrological regime. The lower part of the catchment is heavily forested with oaks (Quercus Robur) on southern faces and beech trees (Fagus Sylvatica) on northern hillslopes whereas higher elevations (>1400 m a.s.l.) are characterized by grassland and junipers (Juniperus sp.).

The catchment is equipped with two weather stations, four stream gauges from upstream to downstream, three soil lysimeters for extracting water at 30 cm, 60 cm and 90 cm depths, one 10 m deep piezometer equipped with a pressure transducer and probes for temperature, electrical conductivity, pH, dissolved oxygen and redox potential, one turbidimeter, 18 soil moisture probes measuring soil moisture at five locations at 10 and 30 cm depths (under different land covers, e.g., beech trees, oak trees), four throughfall automatic collectors and a forest monitoring system consisting of twenty “tree talkers” to monitor sap flow in oaks and beech trees: indicating tree transpiration and xylem transport functionality (Figure 1).

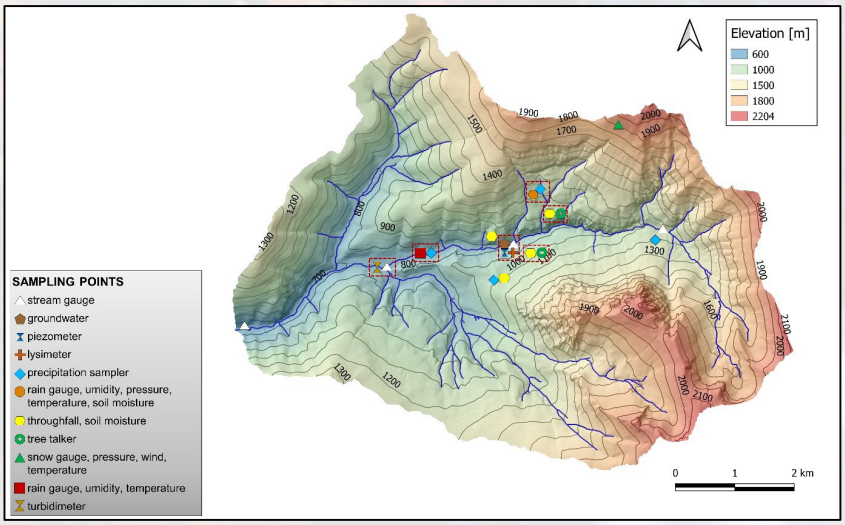

Figure 1. map of the SINCZONE monitoring system.

Streamflow measurements are carried out using Acoustic Doppler Velocimeter (ADV) technology to develop rating curves. Through the data collected, important insights are being gained regarding the eco-physiological aspects of the ecosystem under study. Throughfall analyses are already
providing valuable insights which enhance the accuracy of Tf modeling in Mediterranean forest ecosystems by considering not only parameters derived from the
canopy, such as Leaf Area Index (LAI) and canopy cover (Gash, 1995), but also the structural and compositional characteristics of the forest species.
This information can be crucial for optimizing water management and understanding ecosystem dynamics.

REFERENCES
Crockford, R.H. & Richardson, D.P., 2000. Partitioning of rainfall into throughfall, stemflow and interception: Effect of forest type, ground cover and climate. Hydrol. Process. 2000, 14(16-17), 2903–2920.
Wilkie, M., & Liu, S., 2021. A guide to forest – water management. FAO Forestry Paper No. 185. Rome.
Gash, J.H., Lloyd., C.R., & Lachaud, G., 1995. Estimating sparse forest rainfall interception with an analytical model. J. Hydrol. 170, 79–86.

IMPLEMENTATION OF A PROTOTYPE MONITORING SYSTEM TO INVESTIGATE POST-FIRE GEOMORPHIC PROCESSES

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ABSTRACT

In the framework of the PNRR project "Tech4You", multidisciplinary experimental analyses, monitoring and quantification of the ecological and environmental effects of forest fires are being carried out by a team collaboration between the University of Reggio Calabria - Department of Agriculture, and CNR-IRPI. IRPI activities are focused on the analysis of post-fire geomorphic processes, a potential indirect effect of wildfires. The main task is to identify environmental parameters that can be considered as proxies for the triggering of post-fire soil erosion and mass wasting processes in mountain watersheds. With this aim, the first part of the project was structured to identify: (1) pilot sites; (2) environmental parameters to monitor in the field; (3) sensors to employ; (4) experts to recruit; (5) financial planning.

Two pilot sites were selected in the Calabria region. The first one was identified within the municipality of Roccaforte del Greco, affected by a megafire in 2021; the second one was chosen in the municipality of Montebello Jonico, hit by the largest wildfire occurred in Italy in 2023. The two sites were selected after a series of field surveys, observation of satellite imagery, and intense discussion in the research team. Similarly, the following environmental parameters to be monitored were discussed and selected: soil moisture content and temperature; rainfall; lightning; air temperature; wind gusts and direction; solar radiation; barometric pressure; seismicity; visual and thermographic properties of the hillslopes. The monitoring is supported by traditional and advanced sensors (Fig. 1) consisting of: (i) cameras providing a combination of visual and thermal video streams of the hillslopes; (ii) advanced soil moisture sensors based on the Cosmic Ray Neutron Sensing and traditional TDR technologies; (iii) traditional tipping bucket rain gauges coupled with new all-in-one weather stations; (iv) seismic station equipped with 3-components geophone.

This effort will be used to answer a series of research questions, as well as to propose an innovative and reliable monitoring system for supporting public authorities in charge of the post-fire risk management. Among the key points under testing there are potentialities offered by: 1) application of image change detection technique to analyze runoff, soil erosion and landslide processes occurring during post-fire rainstorms, by means of coupled visual and thermal imagery; 2) use of a triaxial seismic sensor to measure and record ground vibrations to characterize sediment-laden turbulent flows; 3) spatial estimation of the soil moisture conditions preceding the activation of post-fire geomorphic processes; 4) use of lightnings to detect in advance convective cells approaching the monitored sites. Besides these positive elements, different critical issues are being also faced by the research team. Among them, the security of the two stations against vandalism and animals' activity, the remote control and communication, data storage in local supports and transmission, and the power supply system are under inspection to find suitable solutions.

After the installation, a few rainfall events capable of stressing the system took place activating runoff, soil erosion and sediment transport. Such events will be characterized to deepen the current knowledge on post-fire sediment dynamics.

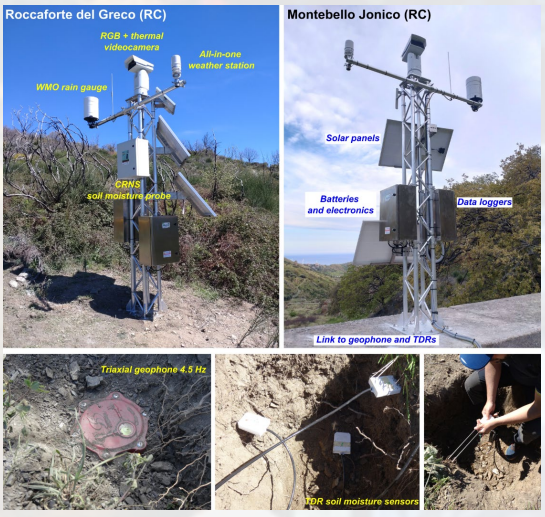

Figure 1: Photographs of the two prototype monitoring stations

SATELLITE BASED ANALYSIS OF THE JUNE 29TH-30TH 2024 FLOOD EVENT IN THE NORTH-WESTERN ITALIAN ALPS

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ABSTRACT

During the last twenty years various hazardous geomorphic processes occurred in high mountain environments as a consequence of climate change (Nigrelli et al., 2024). Their common trait is the entrainment and deposition of debris along their path. These processes concentrate mainly during warmer months, when 1) heavy rainfall or melt-related processes occur; and 2) unfrozen sediments provide availability of material for erosion. Monitoring such events and mapping their environmental effects has a twofold importance: 1) the increase in the number of studied events help to understand more deeply the underlying processes; 2) the knowledge of their location and the areas affected are crucial to the identification of the consequent damages.

This contribute exploits satellite derived products for the analysis of landscape changes following a flood event. To this aim the event occurred on June 29th-30th 2024 in the north-western Italian alps was considered. During such extreme event, peaks of more than 100 mm of rainfall occurred in one day in some sectors of Aosta Valley and Piedmont regions. The rainfall event, coupled with intense snowmelt, activated several spatially distributed torrential processes and shallow landslides. Derived impacts include damage to housing and infrastructure, considerable overflow, erosion, transport and deposition of unconsolidated material downstream, and a marked increase in water turbidity.

A map showing the change of lake and river water colour (particularly a shift of dominant water reflectance through longer wavelengths) as a proxy of increased water turbidity, was produced using pre- and post-event Sentinel-2 images. The Water Colour Change Detection (WCCD) map shows an overall shift towards more turbid waters, and spatial differences which follow the bad weather front. This analysis alone is not exhaustive to fully understand the impacts of the flood event, because it focuses only on mappable (larger than 300 m2 and not covered by snow) water bodies, leaving out areas far from lakes or large rivers, where damages occurred. Hence, the WCCD map was coupled with a Land Cover Change Detection (LCCD) map produced for the identification of areas interested by debris transport and accumulation: the method is illustrated in detail in Zittlau et al. (this workshop).

A catchment-based analysis for the Aosta Valley region reveals both similarities and differences between the two change detection products (Figure 1). The combined use of WCCD and LCCD overcome the limitations of each method and provide an integrated final product that can be compared with the map of instability events (RAVDA, 2024).

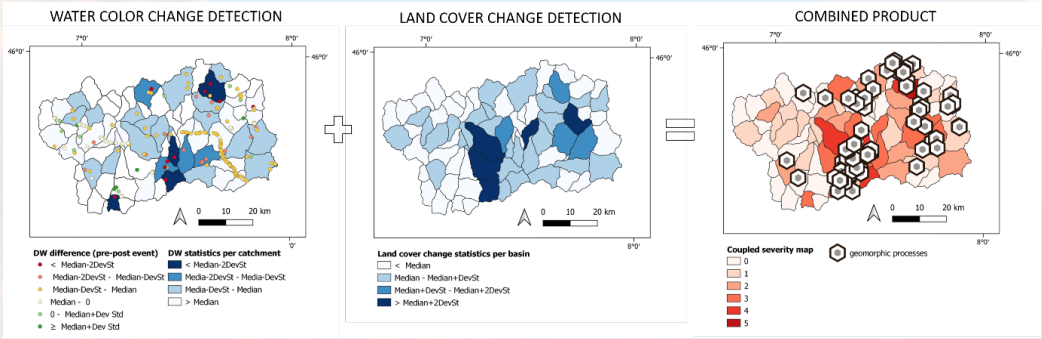

Figure 1: WCCD map (on the left), coupled with the LCCD map (in the middle), provides a combined product (on the right) more consistent with the instability events mapped by the Aosta Valley Region (RAVDA 2024).

Such an approach seems promising for identifying at least the catchments most affected by the flood event. Despite some limitations (e.g. the need of cloud free optical images), this could be a good and relatively fast computing analysis for targeting ground survey efforts, addressing a more detailed detection of the impacts of a meteorological event, beyond damage recorded in inhabited areas.

References

Nigrelli G., Paranunzio R., Turconi L., Luino F., Mortara G., Guerini M., Giardino M., Chiarle M. (2024) – First national inventory of high-elevation mass movements in the Italian Alps. Computers and Geosciences, vol. 184, February 2024, 105520. DOI https://doi.org/10.1016/j.cageo.2024.105520.

Regione Autonoma Valle D'Aosta (RAVDA) 2024 – Analisi dell'evento alluvionale del 29-30 giugno 2024. https://cf.regione.vda.it/cf_scripts/archive/it/06_Rapporti-di-fine-evento/rapporto-evento-2024-06-29-alluvione.pdf.

10 YEARS OF RESEARCH IN THE BESSANESE HIGH-ELEVATION EXPERIMENTAL SITE

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ABSTRACT

The Alpine environment, and in particular the high-altitude one, is responding quickly and with great intensity to climate change, through evidence of geomorphological, hydrological and ecological type. Mountain glacier shrinkage and related outcropping of rock walls and debris, changes of the precipitation and temperature patterns and of the hydrological regimes, the shift of flora and fauna species to higher altitudes than the habitat they belong to, are some of the main terrestrial indicators of climate change. The impact of these changes on slope stability, water resources and human activities is remarkable: however, the understanding of the ongoing phenomena and the forecasting of future scenarios still show large uncertainty.

In order to contribute to the development of knowledge on these topics, in 2015 we selected the Bessanese glacial basin to established an open-air instrumented area.

The Bessanese high-elevation experimental site is located in the Western European Alps (Graian Alps, municipality of Balme, Italy). This site is representative of the glacial and periglacial environments of the Alps (Fig. 1). In this site, glaciers have been the main morphogenetic agent: the head of the basin hosts a well-developed glacial cirque, while the LIA has left an imposing moraine on the left side of the glacier as an indelible mark in the landscape. Additional cryogenic and atmospheric processes, running waters and gravity have contributed to shape the study area. These latter processes are becoming more and more important, compared to glacier shaping, in the present context of climate change, which led to an impressive areal and volume reduction of the glacier. Most of the area once occupied by the glacier is now covered with debris which, in many cases, is ice-cored, or contains ice lenses. Downstream of the main lake of the basin, located at an elevation of about 2580 m, the debris forms a large and characteristic rock glacier. Among gravitative processes, rockfalls are particularly common and relevant from the hazard point of view in the study area. The Bessanese high-elevation experimental site is included in DEIMS-SDR (Dynamic Ecological Information Management System - Site and dataset registry).

In this experimental site, for 10 years we have been carrying out research, training and scientific dissemination activities. This contribution summarizes the activities carried out and which are in progress, through a brief photographic review.

Fig. 1 - The Bessanese high-elevation experimental site.

INVESTIGATING BEDLOAD TRANSPORT IN MOUNTAIN RIVERS THROUGH SEISMIC METHODS: THE NEW MONITORING STATION IN THE SOLDA RIVER (SOUTH TYROL, ITALY)

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ABSTRACT

Bedload transport plays a key role in the morphodynamics of mountain rivers by regulating erosion and aggradation processes. However, it is still challenging to estimate and predict bedload transport rates with reliability because of a complex interplay between different types of sediment supply, hydrological forcing, and fluvial morphologies. In the last two decades, passive sensors recording the seismic signals generated by coarse particles impacting the riverbed have been proposed to provide a continuous indirect measure of bedload transport. Among them, geophone plates have been demonstrated to be valid tools.

Here, we present the preliminary results from the new monitoring station of Stilfserbrücke/Ponte Stelvio designed and built to monitor both water and sediment fluxes in the Solda River (Italian Alps). The station, mainly financed through two ERDF 2014-2020 projects of the Autonomous Province of Bolzano South-Tyrol, is part of the operational gauging network of the Civil Protection Agency of Bolzano (Italy). Bedload transport is indirectly monitored by sixteen geophone plates covering the downstream side of a consolidation check dam. The signal associated with the vibrations generated by particle impacts on the steel plates is recorded continuously with a sampling

frequency of 5 kHz. In order to calibrate the instruments, direct bedload measurements have been carried out through an innovative bridge-like structure (BLS) consisting of an electronically controlled mobile trap. The collected samples have been sieved by hand to characterize their grain size distribution.

We have analyzed the signal from the geophone plates by counting the number of times its amplitude exceeds a preselected threshold expressed in volts (i.e. the impulses, Rickenmann et al., 2014), and by computing its power (Coviello et al., 2022).

The best correlation is found between impulses (threshold of 0.04 V) and the bedload transport rates of particles larger than 16 mm, with a power law regression characterized by a coefficient of determination (R2) of 0.85 and a low root mean square error (RMSE) of 4.4 kg/min against peak bedload transport rates reaching values an order of magnitude higher.

These findings pave the way towards ensuring the continuous quantification of coarse sediment transport in the Solda River, allowing for the evaluation of the impact of glacier retreat and slope instabilities associated with global warming on river dynamics.

References

Coviello, V., Vignoli, G., Simoni, S., Bertoldi, W., Engel, M., Buter, A., et al. (2022). Bedload fluxes in a glacier-fed river at multiple temporal scales. Water Resources Research, 58, e2021WR031873.

Rickenmann, D., Turowski, J.M., Fritschi, B., Wyss, C., Laronne, J., Barzilai, R., Reid, I., Kreisler, A., Aigner, J., Seitz, H. and Habersack, H. (2014), Bedload transport measurements with impact plate geophones: comparison of sensor calibration in different gravel-bed streams. Earth Surf. Process. Landforms, 39: 928-942.

MORPHEUS – GEOMORFHOMETRY THROUGH SCALES FOR A RESILIENT LANDSCAPE

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ABSTRACT

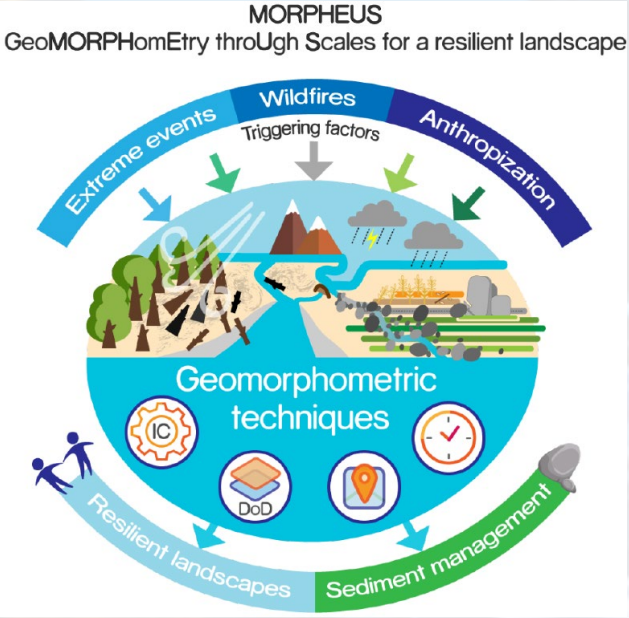
The ongoing increasing frequency of extreme events is expected to impact more severely on the environment and the infrastructures. Understanding sediment dynamics, considering these forcings, is thus of extreme importance for putting into place effective risk mitigation measures for a more resilient landscape. To address such an issue, in recent years, the combination of DoD (Dem of Difference) and Sediment Connectivity (SC) has emerged as a keys property of geomorphic systems to understand the sediment dynamics in the basins at different scale. To this end, several techniques are being applied from data collection (pre-processing LiDAR data, collection of SfM datasets) and high-resolution data will be analysed through geomorphometric techniques (DoD and SC) to depict sediment dynamics with respect to different natural and anthropic targets of interest. Moreover, the results of the analyses will be validated based on field surveys aimed at quantifying the effect of geomorphic and connectivity variations in the study areas.

The present contribution is related to the PRIN 2022 MORPHEUS project, that aims to study the evolution of the landscape over time through the use of remote imagery, geomorphometric analyses and indexes, sediment sources mapping and DoD analyses, to advance our knowledge for increasing landscape resilience and for a new sediment management perspective.

The project study areas range from the local-catchment scale (< 15 km2) to the regional scale (> 200 km2) to have a whole spectrum of applications encompassing Large Infrequent Disturbances (LIDs, i.e. Vaia storm) impact assessment and contrasting semi-natural and anthropized environments.

The selected study areas encompass several catchments located in contrasting (morphological and anthropic pressure diversity) landscapes of northern Italy and featuring different sediment transport processes (e.g., bedload, debris flows). The variable scale of the analyses leads to the choice of different types of areas for an investigation related to the reach, catchment, and regional scale.

The present work reports the state of the art of the analyses carried out in selected study areas of the project. In particular, we will contrast the results obtained in catchment impacted by the above-mentioned different forcings, in order to understand sediment dynamics spatio-temporal variation, both at basin scale and at regional scale.



DETECTING LAND COVER CHANGE AFTER THE JUNE 29TH-30TH 2024 FLOOD EVENT IN NORTH-WESTERN ITALIAN ALPS, AS A TOOL TO MAP THE ACTIVATION OF GEOMORPHOLOGICAL PROCESSES

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ABSTRACT

In recent years, there has been a notable increase in the frequency of extreme rainfall events, which have gained significant public attention due to their destructive potential. In mountainous regions, extreme precipitation can cause a range of natural processes, including debris flows, landslides, and torrential and fluvial floods. These events can cause significant damage to both the natural environment and human-made infrastructure. The analysis of past events is of great importance for an understanding of the occurring processes, which in turn is essential for better forecasting, mitigation and adaptation strategies.

This contribution presents an analysis, using remote sensing data, of an extreme rainfall event that occurred on 29th and 30th June of 2024 in the Aosta Valley and northwestern Piedmont, NW Italy. With cumulated rainfall of up to partly more than 200 mm in 24 hours (ARPA Piemonte), numerous mass movements were triggered across multiple catchment basins. The objective is to identify areas where these natural instability processes took place through the utilization of open-source Sentinel-2 satellite imagery. A land cover change detection (LCCD) methodology was first tested and validated on two of the most hit sites (Macugnaga (VB) and Valnontey, Cogne (AO)), and then applied to the entire Aosta Valley.

The methodology is based on the comparison of pre- and post-event Normalized Difference Vegetation Index (NDVI) images, derived from Sentinel-2 data. The NDVI spectral index highlights the presence of vegetation and calculating its temporal difference is useful to detect changes due to the occurrence of instability processes (Deijns et al., 2024), such as transport and accumulation of debris. Pre- and post-event NDVI maps were normalized to minimize phenological differences between the two acquisitions, while snow cover was masked in order to exclude land cover changes due to different snow conditions. The NDVI difference map (NDVI_d) was computed subtracting the post-event NDVI map from the pre-event NDVI map, so that negative values indicate a temporal reduction of vegetation cover. Two NDVI_d classes: 1 high change (values < -0.2), and 2 low change (values between -0.1 and -0.2) were determined with the help of statistical calculations and based on literature. The NDVI_d classification was validated with the results of the event mapping derived from field investigations. The percentages of true positives (TP), false positives (FP), and false negative (FN) within the two classes were calculated.

The methodology showed satisfying results for detecting land cover change in certain catchment basins and can thus be considered a useful tool for preliminary mapping of geomorphological processes activated by heavy rainfalls, and for integrating and refining data collected in the field.

The same approach was applied on the entire Aosta Valley, adding further processing steps such as cloud and cloud shadow masking. NDVI_d values of class 1 (i.e. high change) were grouped at catchment level, providing a final value of total area of land cover change per basin. The final product was integrated in the work of Matta et al. (this workshop) to get a severity map of the rainfall event.

	Macugnaga	Valnontey
TP class 1 in % (overlapping class-1-pixels of satellite analysis and field investigations)	74.75	52.73
TP class 2 in % (overlapping class-2-pixels of satellite analysis and field investigations)	24.03	19.3
FP class 1 in % (class-1-pixels of satellite analysis not overlapping pixels of field investigations)	25.2	47.3
FP class 2 in % (class-2-pixels of satellite analysis not overlapping pixels of field investigations)	76.0	80.7
FN in % (pixels of field investigations not overlapping class-1-and-2-pixels of satellite analysis)	42.7	53.8

Table 1. Calculation of TP and FP areas for class 1 and 2, and TN areas, for Macugnaga and Valnontey. The class 1 includes values below -0.2 in the NDVI_d image, class 2 includes all values between -0.1 and -0.2 in the NDVI_d image

ARPA Piemonte. "Rapporto Evento 29-30 Giugno 2024. Aggiornamento settembre 2024". (2024). https://www.arpa.piemonte.it/media/6150.
Deijns, Axel AJ, et al. "A semi-supervised multi-temporal landslide and flash flood event detection methodology for unexplored regions using massive satellite image time series." ISPRS Journal of Photogrammetry and Remote Sensing 215 (2024): 400-418

Contratti e procedure amministrative

Si intende creare un momento di confronto trasversale tra la compagine tecnico amministrativa e quella dei ricercatori. L'obiettivo è quindi quello di stringere sinergie e foraggiare momenti di confronto tra tutto il personale IRPI. Attraverso l'analisi delle procedure in modo condiviso e con il chiaro obiettivo di foraggiare il confronto, si pone come risultato non solo il fluidificare il rapporto e il dialogo tra i tecnici, amministrativi e ricercatori, ma anche quello di facilitare le procedure per gli stessi amministrativi. Si punta, quindi, ad avere due risultati paralleli: da un lato l'aumento del dialogo e del confronto sulle procedure tecnico/amministrative tra tutto il personale IRPI, dall'altro un aiuto più tecnico e operativo sulle procedure (es. Acquisti) che risultano essere, da mesi, a complicazione incrementale e di difficile gestione

The aim is to create a moment of cross-cutting confrontation between technical-administrative and research staff. The aim is to create synergies and moments of confrontation between all IRPI staff. By analysing procedures jointly and with the clear aim of promoting confrontation, the result is not only to facilitate relations and dialogue between technicians, administrators and researchers, but also to simplify procedures for the administrators themselves. The goal is therefore to achieve two parallel results: on the one hand, an increase in the dialogue and comparison of technical/administrative procedures between all IRPI staff, and on the other hand, more technical and operational support for procedures (e.g. purchasing procedures) that have become increasingly complicated and difficult to manage over the past few months.

SESSIONE ORALE