



University of Genoa
Department of Earth, Environmental
and Life Sciences
Doctorate Course in Earth and
Environmental Science and
Technology
Earth Science Curriculum



Research Theme n. 3

Titolo: Sviluppo di approcci di deep learning per la previsione di frane superficiali pluvio-indotte mediante integrazione di dati geo-ambientali

Title: Development of deep learning frameworks integrating geo-environmental data for the prediction of rainfall-induced shallow landslides

Tutor (name and e-mail): Prof. Giacomo Pepe (giacomo.pepe@unige.it)

Co-tutors (name and e-mail): Dr. Ph.D. Alessandro Mondini (alessandro.mondini@ge.imati.cnr.it), Dr. Ph.D. Massimo Melillo (massimo.melillo@cnr.it)

Program description including the formation program abroad

Rainfall-triggered landslides represent significant hazards, imposing substantial worldwide financial, societal, and environmental costs. In recent years, machine learning-based approaches to landslide forecasting have gained increasing attention within the scientific community, owing to their potential to develop early warning systems to support civil protection strategies and decision makers.

The PhD program focuses on developing advanced deep learning-based frameworks for the spatio-temporal prediction of rapid-moving, rainfall-induced shallow landslides at multiple scales (i.e., from basin to geographic scale). The main goals of the research activity are to develop, train, and test deep learning models using multi-source landslide predictors. Special emphasis will be placed on the integration of geo-environmental landslide predictor datasets, including morphometric, geological, hydro-geotechnical, land use and land cover terrain conditions, to improve the understanding and prediction of rainfall-driven landslides. Equally important will be the integration of multi-source precipitation datasets (e.g., ground-based rain gauge networks, weather radar products, and satellite-derived rainfall estimates), to capture the spatial and temporal variability of rainfall triggering conditions at different scales and resolutions. The research activities will adopt a multidisciplinary approach, integrating data-driven and deep learning-based modelling approaches with the management and processing of geo-environmental data from multiple sources and across different spatial scales.

The PhD candidate will have the opportunity to spend research periods at both international (e.g., at the King's College in London or at the WSL Institute for Snow and Avalanche Research SLF in Switzerland) and national (e.g., at the Research Institute for Geo-Hydrological Protection in Perugia) institutions.

Tutors' publications

Raimondi, L., **Pepe, G.**, Firpo, M., Calcaterra, D., & Cevasco, A. (2023). An open-source and QGIS-integrated physically based model for Spatial Prediction of Rainfall-Induced Shallow Landslides (SPRIIn-SL). *Environmental Modelling & Software*, 160, 105587.

Mondini, A.C., Guzzetti, F. & **Melillo, M.** (2023). Deep learning forecast of rainfall-induced shallow landslides. *Nature Communications* 14, 2466.

Mondini, A.C., Guzzetti, F., **Melillo, M.**, & Pievatolo, A. (2025). Short to long term space-time prediction of rain-induced landslides under uncertainty. *Science of the Total Environment*, 984, 179453.