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Editorial: Developments of remote sensing and numerical modeling applications for landslide analysis

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Editorial on the Research Topic
Developments of remote sensing and numerical modeling applications for landslide analysis

The Research Topic "Developments of Remote Sensing and Numerical Modeling Applications for Landslide Analysis" gathers high-quality original research articles on case studies covering a broad spectrum of subaerial landslide types from a wide range of places throughout the world. The common factor of these contributions is the application of state-of-the-art and new remote sensing techniques, numerical modeling methods, and their combination, for the characterization, monitoring and simulation of the behaviour and the geomorphic evolution of landslides. Where traditional survey methods are used, the Research Topic of geological data required to characterize landslides may be limited or prevented by difficult terrain and the state of activity of the slopes. The use of remote sensing techniques can help overcome these challenges, at the same time allowing monitoring of surface slope displacements and mapping of slope damage features. Multi-sensor, multi-platform, and multi-temporal datasets and approaches maximize the quality and the quantity of remotely sensed data to better characterize the behaviour and the spatial-temporal evolution of landslides. Identification and interpretation of the mechanism and factors controlling the behaviour and the evolution of the landslide can be tested using numerical modelling analyses. Simulations conducted using continuous, discontinuous, and hybrid numerical analyses can be validated and constrained against field and monitoring data, thereby making them an important tool to support and substantiate hypotheses and geological interpretations of the mechanisms and factors influencing the behavior of landslides in both natural and engineered slopes. Addressing these Research Topic requires a multidisciplinary approach encompassing engineering geology, rock and soil mechanics, structural geology, and geomorphology. This Research Topic adds to the state of knowledge of landslides (*s.l.*) through contributions dealing with case studies of landslide that employ or combine different remote sensing and/or numerical modelling methods to investigate the behavior and evolution of present and past landslides.

Research Topic addressed in this Research Topic include the application of state-of-the-art remote sensing techniques for landslide mapping and characterization at various scales (Donati et al., Rouhi et al. Muhammad et al.), landslide susceptibility mapping (Titti et al.), landslide and landslide dam evolution analysis (Bonneau et al., Rabus et al., Wolter et al.), and numerical modelling of landslides based on and constrained using field and monitoring data (Livio et al.). The contributions to this Research Topic investigate case studies located in several continents, including New Zealand (Wolter et al.), Italy (Livio et al.), Canada and the United States (Rabus et al., Donati et al., Muhammad et al., Bonneau et al.), Iran (Rouhi et al.), and India (Titti et al.).

In their study, Wolter et al. use pre- and post failure remote sensing data, together with *in situ* and geophysical surveys, to investigate the evolution and breaching of the landslide dam generated by the Hapuku landslide, the largest rock avalanche in New Zealand, triggered by the 2016 Kaikōura earthquake. Notably, Wolter et al. obtained a detailed timeline of how the Hapuku landslide dam has evolved over the past 6 years, and demonstrated the complex correlation between landslide source, deposit materials, and fluvial systems.

Livio et al. describe the geomechanical characterization of the crown area of the Masiere di Vedana historical rock avalanche (eastern Italian Alps) based on UAV-based photogrammetric surveys and 3D distinct element numerical modelling. The niche area is a sub-vertical rock cliff, ca. 800 m wide and 500 m high, that poses a significant landslide hazard due to impending blocks prone to rockfalls. The study investigated the stability of the three potentially unstable pillars that constitute the niche area.

Rabus et al. exploit an innovative methodology based on SAR data, that allows for the identification of the environmental factors that control the behavior, evolution, and displacement of slowly moving landslides. They apply the technique in the investigation of the Fels landslide (Alaska, US), demonstrating that rainfall regime and infiltration, seismic activity, and deglaciation affected different sectors of the landslide area differently, suggesting that the landslide behavior results from a complex interaction between separate structurally controlled domains.

Donati et al. use remote sensing datasets to perform a structural and engineering characterization of the Elliot Creek slide, which caused a landslide-induced glacial lake outburst in 2020. They highlighted that glacial thinning and retreat, together with an older landslide, likely enhanced the kinematic freedom of the slope, promoting the detachment of the landslide.

Muhammad et al. describe a novel python-based script, called Akh-Defo, which combines InSAR, satellite image correlation, and ground-based imagery allowing for the preliminary identification and potential monitoring of landslides and unstable slopes. In their paper, they apply the developed technique in the analysis of an unstable slope in Canada, the Plynth Peak in British Columbia, and a landslide in the United States, the Mud Creek landslide in California.

Rouhi et al. present a novel approach for interpreting the emplacement kinematics of the giant prehistoric Seymareh landslide in the Zagros Mountains (Iran), one of the largest known landslides on the planet, which dammed two rivers and generated three lakes that survived for about 3 ka after the event. In their paper, Rouhi et al. used statistical spatial zoned models to distinguish not only primary landforms, obliterated with time by erosional processes, but also to infer the emplacements kinematics of the landslide.

Bonneau et al. use multi-temporal terrestrial laser scanning surveys to investigate the rockfall source area of the White Canyon, in British Columbia (Canada). The investigated slope is considered as an analogue to larger scale, steep catchments that commonly constitute debris flow source areas in high mountain regions, and it is used to investigate the role and effects of sediment supply and debris transfer. By performing monthly to quarterly surveys, Bonneau et al. noted that the sediment transport changes seasonally, as a function of environmental conditions, including precipitation and temperature. The paper highlights the importance of survey frequency and resolution for an improved understanding of the mechanisms controlling sediment and debris transfer, with important implications for debris flow hazard management.

Finally, Titti et al. describe the newly developed SZ (susceptibility zonation) plugin for QGIS, which allows the creation of susceptibility maps by guiding the user through a series of processes and functions coded in *Python*, and using lithology, morphology, land use, precipitation as input datasets. They demonstrated the application of the SZ plugin for mapping the landslide susceptibility in a region in northeast India, and validated the results using a quality assessment tool, available within the same plugin, as well as regional landslide databases.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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