Slow-moving landslides are large-scale gravitational phenomena governed by complex hydro-mechanical dynamics due to the interaction of multiple involved factors. Their long-term evolution could pose a significant geohazard to nearby settlements and infrastructure. Understanding the processes that cause these deformations is crucial for the development of effective monitoring and mitigation strategies. Furthermore, high climate variability makes landslide detection challenging. In mountainous regions, extreme hydroclimatic events, such as heavy and prolonged rainfall or snowmelt, can accelerate the transition from slow creep to significant landslide reactivations. In this framework, a detail investigation of the relationship between groundwater regimes and landslide behaviour is needed.

This work focuses on a few representative landslide sites located in the Western Alps (Piedmont region, Italy), an area highly prone to hydrogeological instability. The research proposed an integrated workflow combining displacement measurements, hydro-meteorological observations and hydrogeological indicators to quantify climate-driven controls on slope deformation and to improve predictive capability in changing conditions.

Landslide displacements are firstly analysed in response to significant climatic events, contextualised against normal precipitation and temperature values over the 1991–2020 reference period. Furthermore, the advantages of integrating monitoring techniques are highlighted by comparing displacement time series derived from in situ instruments (inclinometers) and remote sensing products (InSAR), showing how a ground-based network supported by satellite observations enhances the detection of long-term slope deformation patterns.

A core contribution of this dissertation is the investigation of mountain springs as indicators of aquifer dynamics and as proxies for landslide behaviour. The research aims to demonstrate that spring water levels can be used as a powerful tool for detecting slow-moving landslide displacements and establishing thresholds for early warning and risk mitigation. At the Thures and Champlas du Col landslide sites in the Susa Valley, a statistical approach based on cross-correlation and spectral analyses was employed to explore the relationship between groundwater level fluctuations and slope displacements.

Results showed that when springs and inclinometers are in proximity and belong to the same landslide dynamics, the spring trend can reliably predict conditions triggering movement. However, the limited spatial distribution of springs over large areas, as well as their location with respect to other instruments, can represent a constraint for this analysis. Hydrochemical analyses were performed on a set of water spring samples to infer groundwater pathways within the landslide body, with the aim of reconstructing a conceptual hydrogeological model of the slope as well as the aquifer setting.

A data-driven predictive model was also developed to estimate displacement patterns by identifying the most impactful predictors. Leveraging the STL decomposition method for the time series involved and regression analysis, the proposed methodology enabled the definition of a preliminary but promising forecasting model to describe landslide kinematics.

Finally, a numerical analysis was carried out on the Champlas du Col landslide to evaluate the hydro-mechanical response of the slope under transient pore pressure variations resulting from a gradual rise in the groundwater table coupled with infiltration, in order to assess soil saturation conditions under different scenarios.

While this dissertation supports landslide acceleration forecasting, a more robust monitoring network is essential for detecting deformation phases. Nevertheless, this study lays the foundation for an alternative use of deep displacement monitoring integrated with transversal analytical tools, which can be further applied to similar landslide settings to improve site-scale hydrogeological characterization.