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The performance of different landform classification methods as assessed by their relationship with geotemathic variables

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In this study, we present a comprehensive analysis of landforms derived from a 10-meter resolution digital terrain model (DTM) using unsupervised classification with different combination of morphometric variables and established algorithms, including the Topographic Position Index (TPI; Weiss, 2001) and Geomorphons (Jasiewicz & Stepinski, 2013). These methodologies allowed us to delineate distinct landforms, which were subsequently subjected to detailed spatial and statistical analyses to evaluate their geomorphological characteristics and interrelationships. Specifically, we aim to compare how different landform classifications, derived from these approaches, correlate with geothematic variables such as lithology, engineering geological characteristics, and the distribution of shallow landslides. To statistically assess the congruence between landform classifications and geothematic variables, we applied statistical tests such as chi-square tests for independence (for categorical variables) which is used to determine whether there is a significant relationship between landform classes and categorical geothematic variables. Moreover, the strength and direction of these relationships are further evaluated using Cramér's V. These tests provided insights into the relative effectiveness of each different landform classification in describing the variability of geothematic variables. The study was conducted in northern Tuscany, a region characterized by a complex interplay of geological, morphological, and climatic factors that make it particularly susceptible to shallow landslides and debris flows. These phenomena are frequently triggered by intense rainfall events, which highlight the importance of understanding the distribution of predisposing factors for slope instability in such areas. In conclusion, this study explores different methods to perform the landform classification and establishes a framework to evaluate how they are related to independent geothematic variables, which may be used to assess landslide susceptibility and hazard.