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Temporal and Spatial Variability in Landslide Susceptibility Analyses

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The geomorphic processes in landscape evolution are commonly assumed deterministic, although their high variability in rates and time. As the stability analyses of slopes are concerned, the classical methods consider threshold values of the different elements (slope angle, friction angle, climatic conditions, hydrogeological conditions, seismicity) that condition the safety factors, but often widespread landscape instabilities occur when the threshold values are not exceeded. To analyze these phenomena we studied a model for defining an "average" pattern of landscape evolution starting from the single deterministic process. Many previous studies demonstrated the driving role of weathering and erosion processes in landslide evolution. Among these, the "instability principle of geomorphic equilibrium" (Scheidegger, 1983) stated the relevancy of exogenic processes (weathering, erosion, etc.) particularly in those places where preexisting micro topographic irregularities or lithological variations are recognizable. The present paper gives an example of the unstable growth of small perturbations from the initial conditions up to the landslide initiation, even if there were no measurable variations in external controls. In this analysis the geomaterials are considered as a weathering system mathematically depicted as an n-components nonlinear dynamical system. A hierarchical multiscale model of instability is applied. The model treats four spatial scales: 1) local regolith scale (weathering processes, in situ breakdown of geo-materials), 2) hill slope scale (allocation of weathered products: soil removal in solid form, via erosion and mass wasting, or in dissolved form via surface water flow), 3) landscape units (relationships between weathering and denudation), 4) broadest landscape scale (topographic and isostatic response to weathering-limited denudation, unloading or depositional loading). The landslide susceptibility analysis for the present study is located in the south of Italy, in the Apulian Tavoliere,in front of the Southern portion of Apennine Chain. We focus on the town of Troia (in the Foggia province) which is representative of a typical geomorphological situation of the Daunian Subapennine villages. The main outcropping rocks are made of silty clay sediments, well known as "Subapennine Clays", and superimposed clastic deposits of coarse-grained conglomerates. There, the landscape is characterized by low hills and intervening wide alluvial valleys. On the top of the flat ridges are located several old towns and the bordering slopes are affected by continuous geomorphological evolution governed by erosion and weathering. So, several landslides take place on the borders of the villages. To analyse the stability conditions of the area we considered a local scale weathering system mathematically treated as a 5-components nonlinear system. Applying the dynamical instability principle and solving the system throughout the first Routh-Hurwitz criterion, we obtained that in the case studied preexisting lithological deviations and changes in geomorphic boundary conditions lead to a divergent non-equilibrium response that resulted in instability of the whole territory under study.