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Snow melt modeling calibrated through simplex flexible algorithm: application to rainfall thresholds for landslides forecasting

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In temperate or cold climate regions a not negligible part of precipitation may be withhold in a snow cover until a temperature change that triggers a sudden water input in the ground. The study area, Northern Apennines of Italy, is no exception to this rule as demonstrated by the recent seasonal event of last decade in which several shallow landslides have been triggered by a rapid snow melt in Tuscany and Emilia-Romagna regions.

In order to integrate snow precipitation within existing statistical models for landslide prediction, a simple grey dynamic model for the snow melting, is proposed: it takes into account the buildup and melting of the snow cover in time. This model is based on two equations: the conservation of mass (input-output balance) and an empirical equation for modeling the snow density variation. From the conservation of mass a differential equation of snow cover depth can be obtained: in the proposed model the latter is a function of snow cover density, temperature of the air and rainfall (if present). The second equation is an empirical function for the density variation in time and depends on the snow cover depth (gravity effect) and the temperature of the air. Then to take into account the snow melt phenomena we use an empirical functional based on chemical kinetics depending on the air temperature, depth and density of snow cover and rainfall (other effects like for example wind, air humidity and radiation, as data are not available, cannot be considered). In the present form, this model depends on 13 empirical parameters including a threshold temperature between snowfall and rainfall and the density of newly fallen snow. In order to the modeling identification, employing empirical data of depth of snow cover obtained through sensors in the study area, we use an optimization algorithm (simplex flexible) to deduce the optimal values of the model parameters to reduce the errors between experimental measures and output of the model. The static and dynamic sensitivity analysis show a good resilience of the model. The final objective of the work is to increase the predictive capacity of the statistical models for landslide prediction based on rainfall thresholds. In the study area an improvement was achieved: several landslides, caused by melting, are correctly detected and then in an integrated system for landslides prediction false alarms are reduced due to re-distribution of water input in the ground.