Prediction of changes in landslide movements induced by rainfalls: from the use of a black box model to a 1D mechanical model

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Predicting landslide surface displacements is a challenge for scientists, as it may help save human lives and protect individual housing or transport, energetic facilities. One of the main challenges in active landslide monitoring concerns the prediction of slope's movements in the near future.

This study focuses on an innovative methodology to predict landslide surface accelerations, based on a black box tool coupled to a 1D mechanical model. These models are able to predict the evolution of the daily displacements according to the variations of precipitation. More specifically, the impulse response model allows predicting the changes in the landslide movements by computing the transfer function between the input signal (precipitation in this case) and the output signal (the displacements). The second model is based on a simple 1D mechanical assumption, with considering a viscoplastic behavior of the landslide's material, and with taking into account the evolution of the pore water pressure in time.

These methods have been applied to the Super-Sauze landslide, located in the Southern French Alps, mountainous region. This site is controlled by complex hydrologic processes leading to active movements within black marls, with velocities ranging between 0.002 and 0.4 m per day. After preliminary tests, results show that the snowmelt has to be taken into account in the models, since the phenomena of freezing /thawing has an influence on the water refills, leading to movement changes. Different approaches to integrate rainfall and/or snow-melting inputs are compared and their complementarity is demonstrated. Finally, a validated methodology for predicting movement changes within landslide based on criteria of comparison between the observed and calculated velocities can be proposed. The results suggest that the impulse response model reproduces the observed data with very good accuracy, whereas the mechanical model seems to be more adapted to predict the movements within 10 days. Moreover, the RMSE criterion permits to highlight the occurrence of the flow, with considering all models, 11 days before the flow itself.