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Linking a physically based model with a stochastic hollow evolution model to improve our understanding on the spatial and temporal behavior of landslide prone areas and the impact of climate change

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The spatial identification of landslide prone areas and the simulation of their response as a result of intense rainfall has been treated in many scientific papers over the last decades. Generally, the quality of these type simulations is dependent on 1) the complexity of the model, 2) the dominant physical processes assumed to be important, and 3) the amount of data measurements available to calibrate the model. For many environments, limited knowledge with respect to the latter aspect prohibits detailed small scale simulation of landslides and debris flow prone areas. However, by focusing on the most dominant physical processes only, the amount of input information needed becomes less, enabling one to simulate the impact of extreme precipitation on the triggering of landslides and debris flow within a mountainous region. Unfortunately, due to the assumed simplifications, it is difficult to identify the location of the affected areas within the landscape exactly.

In the current study, such a simplified physically based model, the LAPSUS_LS model (Claessens et al., 2007) was used to identify the dominant landslide prone areas. However, since it is unable to identify the exact locations within a landscape, instead of drawing hard conclusions, from the model results the physical characteristics of the different hollows were obtained. As such, all unstable DEM pixels as simulated by LAPSUS_LS were connected into individual areas from which different hollow characteristics could be identified (e.g. area, local slope, length, upstream area, etc.). These properties were used to initialize a temporal stochastic hollow evolution model, originally developed by D'Odorico and Fagherazzi (2003). Since this hollow evolution model is stochastic, by following this approach, we believe we are not only able to increase our understanding on the general landslide behavior within a landscape, but also obtain information about the general statistical properties involved as well as how these characteristics change as a result of precipitation regime changes. Such information could not have been obtained using a spatial physically based model only.

As an example, we present the impact of this approach for the Linth catchment in Switzerland, a basin in which landslides occur often. Based on the current climate situation, the dominant landslide prone areas were identified. For each of these region, the different physical characteristics were obtained and used to assess the general response properties of the different types of hollows involved as well as their specific statistical characteristics. For the latter, by following this approach it becomes possible to assess the impact of climate change on the occurrence of landslides during the 21st century.