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Landslide reactivation hazard: a probabilistic approach in the Oudenaarde area (W Belgium)

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In W Belgium, the hilly region of the Flemish Ardennes is known to be a place prone to landsliding in which more than one hundred big deep-seated landslides have been localised. However, no new occurrence has been observed in this area for decades, whereas the reactivation of ancient features is a more frequent phenomenon and therefore represents a higher hazard. Numerous morphological features witness to recent reactivation, not only in the landslide bodies themselves, but also in their main scarp. The scarp reactivations were identified from the comparison of stereophotogrammetrically obtained DTMs (2 m resolution) for the epochs 1952 and 1996. We localised then 14 places with horizontal scarp retreat exceeding 2 m and divided them into 26 reactivated scarp segments of similar length (˜30 meters), which we consider to correspond to the mean length of a reactivation event. The reactivated scarp segments were used as the dependent variable in the modelling. In total, the study area covers 6293 pixels (2 m resolution) among which 1268 have been reactivated.

We present here a robust and reliable probabilistic model based on the fuzzy set approach. This model is obtained with a combination of 5 quantitative variables: aspect, slope gradient, elevation, planform curvature and distance from cultivation located upstream of the main scarp. Two empirical distribution functions (EDFs) were extracted for each variables, respectively concerning the reactivated and non-reactivated areas. The model uses these EDFs as favourability values to build membership values and combines them by using the fuzzy Gamma operator. A 3 step procedure has been used to obtain the prediction map that we present here. (1) First, we built the reactivation susceptibility map on the basis of the 1952 data layers. The prediction rate of the resulting susceptibility map was estimated by a cross-validation procedure sequentially

excluding 2 of the 26 reactivation occurrences. (2) The statistics of the model computed in step 1 were applied to the data of 1996 in order to produce a susceptibility map responding to the present-day environmental conditions. (3) Finally, we estimated the conditional probabilities of occurrence of future reactivations by using the prediction rate table of the model obtained from step 2. Knowing that ˜1300 pixels of the study area have been reactivated in 44 years, and supposing that the scarps are retreating at a constant mean rate similar to that observed from 1952 to 1996, we built a hazard map for the next 40 years (1996-2036).