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Flow-Py: Identifying protection forests and their effects on gravitational natural hazard processes on a regional scale

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Recently, strong wind storms have caused large-scale damages in Alpine mountain forests, leaving the underlying infrastructure exposed. These forests often provide protection against gravitational natural hazard processes such as avalanches, rockfall and soil slides. To manage these disturbed forests efficiently and effectively, it is important to know 1) which forest areas serve a protective function to the underlying infrastructure, 2) what is the actual protective effect of these forests on the hazard process, and 3) how one could improve this effect.

To define protective functions and to quantify the protective effects of forests, we created the Flow-Py model that identifies process areas of gravitational hazards, including avalanches, rockfall and debris slides. The model is written in Python to keep it easy adjustable. The run out routine of Flow-Py is based on the principles of energy conservation including frictional dissipation assuming simple coulomb friction, leading to constant travel-angle. Potential release areas and the corresponding travel angle have to be adapted for each type of gravitational mass movements. A important improvement, compared to similar models, is that it can handle mass movement in flat and uphill terrain. One major advantage of this model is its simplicity, resulting in a computationally inexpensive implementation, which allows for an application on a regional scale, covering large simulation areas. The adaptivity of the model further allows to consider existing infrastructure and to detect starting zones endangering the corresponding areas in a back-calculation step. Additionally, by adding forest cover to the simulations we can identify which forest area has a protective function and, based on information about forest structure, calculate the protective effect this forest provides to down slope infrastructure.

Flow-Py is a useful tool to identify forest areas that are important for hazard protection (protective function) and to quantify their protective effect. The model can be applied in protection forest management to prioritize measures in wind throw areas. Furthermore, it is possible to use this tool for analyzing the protective functions and effects of different forest extents and structural conditions, for example, caused by climate change or forest disturbances. In this work we elaborate the potential of Flow-Py by presenting an avalanche case study in the central alpine region of Austria (Gries/Vals, Tyrol, AT). For this case the simulation results indicate a process area affected by avalanches of ~65% with respect to the total area of ~ 195 km².