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Approaches to including forest effects in avalanche hazard indication maps in Norway

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Avalanche hazard indication maps (AHIM) delineate areas that[U+2015]pending a detailed hazard assessment[U+2015]should be considered endangered by avalanches. AHIMs can be an important and cost-effective tool for land-use planning. The present Norwegian AHIM was automatically generated based on a DEM with 25 m resolution, using a topographic-statistical run-out model and release areas within a certain slope-angle range. Experience shows that the potential hazard areas are much too large in many cases, yet too small in others. The shortcomings of these maps have significant economic consequences. More accurate maps should result from (i) using a higher-resolution DEM, (ii) applying additional topographic criteria for release areas, (iii) taking into account climatic conditions and forest cover for eliminating release areas with very low release probability, and (iv) using a dynamical model for run-out calculation. A 10-m DEM and comprehensive forest-cover data on a 25-m raster have become available for the entire country. However, the forest data is based on somewhat outdated imagery and has fairly large uncertainties at the cell level. Curvature and connectivity criteria were found to improve the selection of release areas considerably. However, compelling criteria for dividing extremely large potential release zones still have to be identified. Work on downscaling interpolated climatic data from a 1 km^2 grid to the DEM resolution is ongoing. Based on mechanical and statistical considerations, a method for estimating the release probability in forested and non-forested areas has been proposed. It appears to give plausible results, but needs to be tested extensively. For the run-out calculations, a simple depth-averaged 2D Voellmy-type model proved to be sufficiently fast and robust. The model takes the braking effect of forests into account by making the friction parameters linear functions of the product of average tree diameter, forest density and flow depth. The preliminary code has been tested in a number of regions with different topography and climate where detailed hazard maps are available. In most cases, the new model predicts much more realistic run-out zones than the current aHIM, but particularly in high-mountain areas with continental climate, the predicted run-out distances may be too short with the adopted model calibration. Another important task of future work is to find a way to include the hazard due to powder-snow avalanches.