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Real-time forecasting of shallow, rainfall-triggered landslides in New Zealand

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New Zealand, located at the interface between the Pacific and Australian crustal plates, is characterized by a dynamic active landscape - mountainous and hilly regions with steep slopes cover large areas of the country. Uplifted and dissected sedimentary and volcanic rocks with low strength properties are widespread in the North Island of New Zealand. New Zealand's location in the South-western Pacific, on the other hand, means that sub-tropical cyclones hit the land mass of New Zealand on a regular basis creating heavy rainfall in the affected areas. New Zealand's settlement history has seen major shifts in land use and therefore land coverage, beginning with Maori settlement several thousand years ago and continuing with European settlement. Large land areas have been cleared of indigenous forest and converted into crop land and pasture, therefore exposing large areas of weak parent material to the actions of weather and climate.

These factors contribute to the pronounced landslide susceptibility of New Zealand landscapes. Landslides of different nature are common features in New Zealand's mountain areas and hill country. In particular the North Island of New Zealand is affected by high rainfall events triggering widespread failure in shallow soils - especially if they are exposed such as pastoral areas. Landslide hazard therefore is a significant threat to New Zealand economy and society. It is necessary to develop landslide hazard management strategies, including landslide forecasting technologies.

A project established at NIWA in New Zealand is aiming to develop a prototype of a real-time landslide forecasting system. The objective is to predict temporal changes in regional landslide probability for shallow, rainfall-triggered landslides, based on weather forecasts as they are delivered by global and regional weather models. We use

global weather forecasts from the United Kingdom Meteorological Office (UKMO) global-scale Numerical Weather Prediction model. Global weather forecasts are coupled with a regional model for New Zealand, a data assimilating limited area atmospheric model (New Zealand Limited Area Model, NZLAM) to forecast atmospheric variables as precipitation and temperature on a 12km grid and for 48 hours ahead for any point in New Zealand. The atmospheric forecasts are fed into a regional hydrologic model to predict soil moistures and groundwater heights. We use a hydrological model based on the Topmodel approach to simulate regional changes in soil moisture and soil saturation. The forecasted regional patterns in soil moisture and soil saturation are then downscaled using a steady-state soil water model to predict soil moisture status at the local scale. A simple infinite slope stability model is applied to determine triggering soil water threshold at a local scale. The final output of the coupled system is then a probabilistic model forecasting spatio-temporal landslide occurrence for several regions in New Zealand.

The used soil mechanical model is very initial and is based on existing (weak) data sources for New Zealand. It is planned to refine that model part at a later stage to come to a more credible system. The inherent uncertainties in weather simulation, hydrological modelling, and geotechnical models means that the landslide forecast results contain high degrees of uncertainties, in particular if verified on a local scale, hence, the forecast results need to be up-scaled to a regional level to be useful for applied purposes.