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Integration between regional and local monitoring data for weather-induced landslides in Norway

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In Norway weather-induced landslides in loose soils (such as debris flows, debris slides, debris avalanches, and slush flows) are common throughout the country. Since 2013, a national early warning system addressing these landslides is operational. The system, managed by the Norwegian Water Resources and Energy Directorate, is based on real-time hydro-meteorological measurements used as input to a spatially distributed precipitation-runoff model covering the whole country with 1 km by 1 km grid (about 330,000 cells). The thresholds for issuing the warnings have been defined within the model as a combination of relative water supply and relative groundwater conditions. This study presents a methodology aiming at integrating the model results already used by the national LEWS operational in Norway with monitoring data collected at local scale. To this aim, pore water pressure measurements, acquired by the Norwegian Geotechnical Institute in a number of boreholes for a variety of projects, have been herein considered. The analyses have been carried out using the hydrological basins defined at national scale as territorial units (about 23,000 basins, area ranging from 0.00001 to 45,000 km2). Given the characteristics of the landslides of interest, the most susceptible basins have been identified considering the area covered by sandy and silty sediments. Thereafter, a further selection has been carried out using information related to historical landslide events that occurred in recent years, retrieved from a national database containing more than 4.000 records from 2000 to 2017, and the availability of a significant number of pore water pressure measurements. Following these criteria, 30 basins were finally selected as the most significant ones for the study aiming at evaluating the influence of the groundwater levels measured at local scale within a basin on landslide triggering conditions in slopes of the same territorial unit. A probabilistic analysis of the temporal and spatial distribution of the landslide events in relation to the modelled territorial data and the local monitoring data has been implemented within each basin, highlighting the additional contribution of the latter for early warning purposes. The preliminary results of the research presented herein may be considered as a first attempt to integrate regional and local monitoring data within a warning model for landslides. Local observations may be extremely helpful to complement the gridded data, if collected within basins representative of the main geo-environmental conditions and highly susceptible to weather-induced landslides. They may indeed be used to collect information quantifying the effect of rainfall or snowmelt on the groundwater regime, thus helping design a more effective operational territorial landslide model for the area of interest.