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DEWS: a QGIS tool pack for the automatic selection of reference rain gauges for landslide-triggering rainfall thresholds

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Several territorial landslide early warning systems in different parts of the world are based on empirical rainfall thresholds for landslide triggering. The calculation of such thresholds, using rainfall measurements gathered from rain gauges, has been examined frequently, especially considering uncertainties, modeling complexity, spatial assumptions, and analytical tools. Installed rain gauge networks that are spatially clustered in crowded areas have different spatial and attribute settings based on landslide occurrence conditions, such as rainfall record accessibility, processing, and usability, as well as specific locational, morphological, and hydrological settings.

In this research work, we introduce an automatic tool called DEWS (Distance, Elevation, Watershed, and Slope unit) for rainfall-induced landslide spatial reference rain gauge selection. DEWS can be considered supplementary and complementary to the CTRL-T tool (Calculation of Thresholds for Rainfall-induced Landslides Tool) developed earlier, and works on a macro-to-micro scale of the spatial components of CTRL-T rain gauge selections. The output information, i.e. the list of selected reference rain gauges, can be used as input for CTRL-T to calculate frequentist rainfall thresholds at different non-exceedance probabilities. The DEWS tool fills the gap of the current literature, where the selection of reference rain gauges is mostly based on the nearest distance location and on statistical or manual procedures, without considering the morphological and hydrological settings of the area in which landslides occurred.

The tool allows extracting rain gauges referring to landslide locations by employing four spatial filters: F1 (Distance), F2 (Elevation), F3 (Watershed), F4 (Slope unit), needing only a DEM, the coordinates of landslide and rain gauge locations and the parameters of the filter's algorithms as inputs. More in detail, F1 selects rain gauges within a specified buffer distance from the landslide locations using the setting parameters and the coordinates of the landslides and rain gauges.

Then, F2 uses the DEM to extract the elevation of the rain gauges and the landslides and then calculates the differences within each buffer circle; therefore, the filter keeps only the rain gauge with closest elevation values to each landslide (within F1 results) using the recommended/preferred/ or allowable elevation difference defined by the parameter's settings. In F3, the rain gauges falling in the watershed that contains the landslide locations are extracted (within F1 and F2 results). F4, which is the smallest and most focused filter, uses a previously developed tool pack (within F1, F2, and F3 results) to extract the slope units associated with each landslide. Consequently, only the rain gauges falling within these slope units are selected.

DEWS was implemented in a free tool pack in QGIS software, with default parameter values for non-expert users. The tool pack is divided into three main blocks following the filter structure (F1 and F2 are kept together). The reliability of DEWS was tested at a territorial scale in South Korea, using 223 landslides and 328 rain gauges. As a second step, frequentist rainfall thresholds were calculated in the study area.