Modelling event scale rainfall erosivity across European climate regions

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The characteristics (magnitude and timing) of individual rainfall erosivity (RE) events in Europe strongly control soil loss at timescales from the individual event to long term annual average. While annual averages of soil erosion encompass the long-term variability of the event-based drivers of soil erosion (soil condition, water kinetic energy, vegetation properties), they provide both little direct information on the timing of soil loss or capacity to fully understand future erosion. Across the spectrum of empirical to physically based process models, event-scale estimates of rainfall energy are vital. The (R)USLE EI₃₀ index is a popular description of the combined effect of rainfall kinetic energy and the maximum 30-minute intensity of a rainfall event on soil loss. Modelling RE from daily or event rainfall accumulation seeks to capture the intra-annual meteorological controls on the EI₃₀ index, with the goal of utilising rainfall data with higher abundance (eg daily) than conventional but less common hyetograph data. To date, no systematic study has provided model parameter surfaces for Europe’s climatic regions and investigated their spatial configuration. For each of 74 relevant environmental strata (EnS) within 13 broader environmental zones, we calibrate and validate 5 power-law based models with monthly and annual parameter sets using the REDES dataset, composed of over 300,000 RE events from national gauge networks.

We demonstrate the applicability of delineated environmental strata for subsampling and modelling event rainfall erosivity with heterogeneous national gauge data coverage and extent. Power-law model fits with 12 individual monthly parameter sets outperformed annual models with periodic cosine functions. The power-law α and β parameters are generally correlated through space (r = 0.66) and follow the general European trend of long-term annual average RE, increasing from North-West to South-East. The average annual Nash-Sutcliffe model efficiency for all strata increased from 0.427 (max: 0.76, min: 0.21) to 0.437 when the top 1 percentile of events were removed, which contribute between 8 and 27% of the total RE per stratum. The prediction capacity was higher in autumn and winter than in spring and summer when rainfall holds generally higher unit kinetic energy. Average model efficiency per environmental zone depended on both the rainfall stochasticity and size of the national data sample within each stratum, highlighting the importance of ample data extents for predicting event rainfall erosivity in Europe.