

Exploring the relationship between gully erosion and rainfall erosivity

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Rainfall erosivity plays an important role in gully erosion. However, there are few studies that explore this relationship. The main purpose of this work is to analyse the link between observed gully erosion rates and rainfall erosivity. However, in order to get a suitable and comparable set of daily rainfall erosivity data, we firstly evaluate the performance of several daily rainfall erosivity models to estimate the daily accumulated RUSLE EI30 index.

One 300 ha watershed (El Cantalar) located in Navarre (Spain) was selected to carry out field studies. A meteorological station located 10 km apart from the experimental site provided daily precipitation records since 1930 to 2009 and also 10min records since 1991 to 2009. In this watershed a total of 35 gully headcuts developed in cohesive soil were monitored.

Aerial photographic stereo-pairs covering the study area were used for the survey. These were taken in five different years and at different spatial scales each time: 1956 (1: 34,000), 1967 (1:17,500), 1982 (1:13,500), 2003 (1:20,000) and 2006 (1:2000). Manual restitution of photographs was carried out. 1m resolution DEMs were obtained by triangular interpolation (Triangular Irregular Network) and then used to characterize gully headcuts. Moreover, from the aerial photos and the DEMs, ortho-photographs with a final resolution of 0.40 m were created. The geocoding of the scenes had a Root Mean Square error of less than 0.5 m both in planimetry and altimetry. Furthermore, using the DEMs and the ortho-photographs, volumetric headcut retreat rates for each period were calculated as the product of the lineal retreat and a representative section of the headcut.

Daily accumulated RUSLE EI30 index was calculated in a conventional way from records of precipitation every 10 minutes for the period 1991-2009; these results were used as reference data. In addition, for the same period, this index was estimated with daily precipitation records through several models proposed in the bibliography. Among them, Capalongo model yielded the best results, with Nash's efficiency values of 0.64 for daily erosivity.

The selected method was used to estimate the daily erosivity during the period 1956-2006; then, accumulated values for the periods 1956-1967, 1967-1982, 1982-2003, 2003-2006 were determined. This information was compared to the observed loss of soil (volumetric and lineal) obtained from DEMs and ortho-photographs.

For each time period, there was a positive relationship between lineal/ volumetric gully headcut retreat and cumulative erosivity index. The average annual values yielded the same results. The mean annual value of the erosivity index shows a clear decreasing trend with the time. The results show relevant findings in the relationships between rainfall and evolution of permanent gullies. Finally, it can be stated that the method presented here to estimate daily rainfall erosivity appears as a useful tool when the available precipitation data set has not an adequate temporal resolution.