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# Evaluation of a gully headcut retreat model with a field data set

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Gully erosion can cause severe land degradation and contribute significantly to total soil losses in different areas. To address this problem we may use modelling as a tool to study the phenomenon and predict future erosion. In this paper, through the long-term monitoring of gullying we calibrate and validate the Channel-Hillslope Integrated Landscape Development (CHILD) Model handling of gullying. We evaluate CHILD with field data from Bardenas, North-eastern Spain.

Our field data consists of topographic maps of four watersheds containing a total of six gullies with contributing areas between 0.1 ha and 8 ha. The topographic maps were constructed by manual restitutions from conventional aerial pictures for three different dates: 1967, 1982, and 2003. Our data set has sub-meter accuracy in the vertical and horizontal directions. This allows us to monitor retreat rates and erosion volumes with a very high spatial resolution.

CHILD simulates multiple bifurcating gullies with headcut retreat resulting from plunge pool erosion and bank failures, along with typical fluvial and diffusion erosion processes in a simulated topographic suface. In this work bank failures are not considered. The model estimates horizontal headcut retreat as a function of water discharge, height of the headcut, upstream slope, and relevant land surface and soil properties for soil erosion. Retreat rate is computed as the rate of the vertical plunge pool deepening divided by a shape factor of the pool. Plunge pool deepening is estimated as a function of the maximum shear stress produced at the bottom of the pool in excess of a critical value.

Within this modelling framework we simulated rainfall using a Barlett-Lewis rainfall algorithm to simulate the interstorm rainfall variability that is important in the region of study. Rainfall variability results in intense bursts of rainfall that are responsible for most of the rainfall generated runoff. We estimated the rainfall parameters required for Bardenas from rainfall records.

We calibrated the headcut retreat module of CHILD by adjusting the shape factor parameter. A shape factor of 0.5 produced the observed 4 m retreat in 36 years in the monitored gully selected to calibrate the headcut retreat module. Due to the model set up, the gully headcut width is constant throughout our simulations and we set it to 2 m. The rest of the erosion parameters were obtained from literature. With the calibrated model we ran simulations corresponding to the other 4 gullies with the aim of validating our modelling tool. We found that differences in retreat rates between the model and observations for these five gullies, on average, were less than 5 cm/year. The standard deviation of these differences was 10 cm/year.

From this validation exercise we conclude that the headut retreat module implemented in CHILD represents well the headcut retreat rates in the region of Bardenas. The shape factor estimated during the calibration still needs to be corroborated with field measurements. For this validation exercise, the detailed initial topography used in the simulations and the monitoring of gully development during a span of 36 years were essential to capture the geometry of headcuts and estimate their retreat rates.