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Evaluating long-term gully dynamics by data fusion from field measurements, photogrammetry and modelling

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Gully erosion is now widely recognized as a key process contributing to land degradation, especially in Mediterranean landscapes. However, in spite of numerous studies detailing gully volumes and growth rates, the underlying physical controls are still poorly understood, especially on longer time scales.
This study focuses on analysing gully dynamics over decadal time scales. The aim is to determine the contribution of gully erosion to the overall sediment budget from 1956-2013 and to analyse the relation between gully retreat rates and changes in rainfall, land use or management.
Gully evolution was measured between 1956 and 2013 by photointerpretation and digitization of a series of historical aerial photographs in a 2000ha area in SW Spain. These measurements were completed by a field survey of important morphological variables, such as top width, flow width, depth or headcut morphology. Finally, repeated ground-based LiDAR surveys were done between 2011-2014 to generate a fine-resolution map of gully evolution of a representative section.
The analysis of gully length indicated that in a period of about 50 years, the gully network expanded rapidly at first, with an increase in gully density from 2.7 to 3.7 km km-2, but has remained stable over the last two decades. However, gully erosion is still very active in the study area, mainly because of a continued increase in gully width. Average increase of gully width was 0.05 m yr-1. Repeated LiDAR surveys allowed to determine that the main process responsible for gully evolution was undercutting followed by wall failures. In terms of controlling processes, the analysis of critical area-slope threshold relation showed that land use, resulted in significantly different gully initiation thresholds with a higher threshold for olive orchards compared to cereal crops. This low to high-resolution input data was then used to run two gully erosion models (REGEM and an own model) and evaluate their performance. This work shows the power of combining data from different sources in order to elucidate complex geomorphic processes, such as long-term gully erosion dynamics, where information from individual sources limits our understanding.