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Modelling tillage and water erosion by using WATEM/SEDEM and 137Cs measurements at field scale

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The estimation of soil redistribution rates is necessary to evaluate the environmental impact of soil erosion including the loss of fertile topsoil which is one of the main soil degradation problems in agricultural landscapes. Modelling approach offers a potential tool for quantifying soil redistribution and to propose site-specific control measures to minimize soil degradation in agroecosystems. Studies at field scale using spatially distributed data of 137Cs derived soil redistribution rates to calibrate and evaluate the uncertainties of distributed models are required but are still scarcely implemented.

This study applies the WATEM/SEDEM model to estimate soil redistribution rates after calibration with 137Cs measurements. Furthermore, soil redistribution rates by tillage were estimated using the Mass Balance Model 3 (MBM3). A representative Mediterranean cultivated field located in the central part of the Ebro basin (NE Spain) was selected to conduct the study. A digital elevation model (DEM) at high resolution (2.5 m) of the study field was generated to characterize the land surface. The elevation of a total of 617 points was measured on a 5 m grid using a total topographic station and 156 bulk soil samples were collected on a 10 m grid for soil analysis. According to field observations and topographical surveys four hydrological units were identified within the study field characterized by different hydrological behavior. The results indicated that soil erosion predominated over soil deposition. Mean values of 137Cs derived soil erosion and deposition rates were 19.7 Mg ha-1 yr-1 and 12.6 Mg ha-1 yr-1, respectively. The rates obtained with WATEM/SEDEM model were lower; mean erosion was 3.9 Mg ha-1 yr-1 and mean deposition rates that occurred in 35% of the grid cells was 5.8 Mg ha-1 yr-1. Water erosion was the major factor controlling soil redistribution whereas tillage erosion was almost negligible. These results are in line with the tillage rates obtained from MBM3. Sediment sorting processes took place within the field with the exportation of finer and relatively rich organic soil particles out of the field, due to the wash off, favoring the presence of enriched sediment in coarse and sand fractions at depositional sites. The efficiency of model simulation depends on DEM quality and resolution and was sensitive to topographic changes from human activity and impact of heavy machinery. The simulated soil redistribution rates were found to be more reliable when considering each hydrological unit separately than the entire study field. The results confirm the potential of using 137Cs derived estimates to calibrate models.

The knowledge about the spatial distribution of soil redistribution is useful to identify suitable locations for the application of effective soil erosion controls and prevention strategies on water and tillage erosion on Mediterranean agroecosystems.