Modelling soil redistribution in a hydrologically defined crop field with WATEM/SEDEM

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Introduction

Soil degradation and depletion of soil nutrients is a main effect of soil erosion. Areal land tillage practices produce erosion of fertile topsoil from up slope positions, the subsequent transport of soil and nutrients and their accumulation at depositional sites.

The loss of topsoil by tillage and water erosion may affect important soil properties such as nutrient levels, water holding capacity and soil stability thus reducing the productivity of agricultural systems.

Erosion models that simulate soil erosion rates allow obtaining the spatial distribution of soil loss and deposition, which is useful to identify the areas that might require the application of soil conservation practices.

In this study, the soil erosion and sediment delivery of WATEM/SEDEM 2004 model was applied in a cultivated field of winter cereals in order to map, evaluate and compare with soil redistribution rates derived from 137Cs.

Materials and methods

The study area is a hydrological unit (3846 m²) which forms a defined drainage area. It is located in NE Spain and represents a typical mountain rainfed Mediterranean agrosystem (Figure 1).

The area was delimited on the basis of a detailed digital elevation model (1x1 m of cell size) as well as field observations. Elevation data were obtained using a total topographic station on a grid of 5x5 m (n=154).

A total of 40 sampling points (10x10 m grid) were collected to analyze 137Cs activity (gamma spectrometry, Canberra Xtra, Ge detector, 50% eff. 86000 c.p.m., 2 – 5 % analytical precision), soil texture (laser Coulter) and organic matter content (Leica).

The soil redistribution rates were estimated from 137Cs inventories (Bq/m²) using the models by Soto and Navas (2004, 2008).

WATEM/SEDEM model was based on Water Tillage Erosion Model (Van Oost, 2000) and Sedimentary Delivery Model (Van Rompay et al., 2001; Verstraeten et al., 2002). This model calculates water and tillage erosion and sediment delivery to rivers.

Results

Primary terrain attributes derived directly from the DEM included elevation, slope, aspect, plan curvature and flow pathways.

The elevation decreases from north to south. The lower slope gradients are negative values of the plan curvature which corresponds to concavities with SE facing slope.

Positive plan curvature values correspond to convexities with E, NE and S, SW facing slopes and higher slope values.

The spatial pattern of soil redistribution rates derived from 137Cs (Figure 2) and WATEM/SEDEM (Figure 3) were mapped using a kriging interpolation method in ArcGIS 10. In both, soil erosion (negative values of soil redistribution rates) mainly occurs on convexities located at up slope positions. On the contrary soil deposition (positive values) occurs on concavities with lower slope values and where the flow lines converge. For the same land use, topography is a major factor controlling hydrological and soil processes at landscape scale (Navas et al., 2012).

The tillage transport coefficient has been calibrated using the erosion and sedimentation rates obtained from 137Cs measurements. WATEM/SEDEM model overestimated slightly both erosion and deposition rates.

Comparing the spatial patterns of soil redistribution by water and tillage erosion derived from WATEM/SEDEM (Figures 4 and 5) tillage erosion is more intense than water induced erosion, as found also by Govers et al. (1994) on arable land. Tillage erosion predominates at up slope positions and sedimentation occurs where there is flow convergence. Water erosion is more important on concavities where the water flow accumulation is higher and water induced soil deposition does not take place in the area investigated.

The results have been validated with 137Cs measurements. Maps of Figures 2 & 3 shows close agreement between the spatial pattern of 137Cs rates and the total soil redistribution by WATEM/SEDEM.

Conclusions

• The spatial pattern of soil redistribution rates shows the variability of soil erosion processes which are mainly influenced by tillage.

• WATEM/SEDEM model was found a valuable tool to represent the soil erosion and deposition in rainfed Mediterranean agrosystems. The total soil redistribution is consistent with estimates from 137Cs measurements and both soil redistribution patterns are in close agreement.

• Tillage causes intense soil redistribution, both erosion and deposition, across the study area and differs from the generalized erosion pattern induced by water.

• Comparison with estimates derived from 137Cs is necessary for future model testing and validation of WATEM/SEDEM in Mediterranean agrosystems and especially in intensively anthropized landscapes.

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References


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References


