In the last century, many Pyrenean rivers have been dammed to provide electricity and irrigation water to the lowland areas. The abrupt topography, the regime of the rivers with frequent floods, and the changes in land use which have occurred during the past few decades have triggered soil erosion and consequently the siltation of reservoirs and derived management problems (Valero-Garcés et al. 1999; Navas et al. 2009).

Continuous direct measurements with sufficient spatial coverage are difficult to obtain in mountain ecosystems, therefore, a robust computational hydrologic model that simulates fluxes of energy and water between the atmosphere and the land surface can be an effective means for studying land-surface dynamics (Stratton et al. 2009). Modeling runoff and sediment transport at catchment scale are key tools to predict sediment yield with the purpose of preserving soil resources. This study aims to validate the Soil and Water Assessment Tool (SWAT) model for its use in an alpine catchment as a simulator of processes related to soil erosion in order to minimize indirect impacts such as reservoir siltation and loss of soil quality.

The Soil and Water Assessment Tool (SWAT) is a physical based and continuous, long-term, distributed-parameter model designed to predict land management practices on the hydrology, sediment and contaminant transport in agricultural catchments with diversity of soil types, land use, and management conditions (Arnold et al., 1998). The most current version of the model SWAT2009 was used in this work as an extension within the Environmental Systems Research Institute (ESRI) GIS software package ArcMAP (9.3).

The catchment studied corresponds to the drainage basin of the Barasona reservoir in the Central Spanish Pyrenees (Fig. 1).
The catchment (1509 km$^2$) is characterized by a rugged topography (Fig. 2) and varied lithology, composed of four principal Structural Units. The altitudinal range is of 3000 m with mean elevation of 1313 m above sea level (a.s.l.). The average catchment slope is 39 % and forest covers as much as 50 % of the total surface. The climate is mountain type, wet and cold with both Atlantic and Mediterranean influences (García-Ruiz et al., 1985). Mean annual precipitation and temperature range from 500 mm and 12ºC at the reservoir to more than 2000 mm and less than 4ºC at the areas above 2000 m a.s.l. In general, most soils are stony and alkaline, overlying fractured bedrock with textures from loam to sandy loam. The soils are generally well drained with limited average water contain and moderate to low structural stability. The distribution of land uses also varies from north to south grassland predominates in the northern areas, forest in the central part and crops occupy the southern areas of the Intermediate Depression.

The model was calibrated and validated using continuous streamflow data from two gauge stations and data of sediment yield available in the literature. The specific sediment yield of the catchment was estimated using bathymetric techniques as 350 t/km$^2$ yr. Calibration and validation results showed good agreement between simulated and measured sediment data. The specific sediment yield simulated by SWAT was 10 % higher than the estimated by bathymetric techniques. Model performance was evaluated using several statistical parameters, such as the Nash–Sutcliffe coefficient. The SUFI-2 algorithm of SWAT-CUP (Abbaspour et al., 2010) was used as the objective function for the auto-calibration of the parameters.

The information gained with this research will be of interest to assess the spatial distribution of soil erosion and the patterns of sediment transport in alpine catchments. The identification of the sources of sediments and areas of high sediment yield will be useful to establish remediation strategies.

Acknowledgements: This work was funded by the CICYT project MEDEROCAR (CGL2008-0831).

References


