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EVALUATION SUSPENDED SEDIMENT LOAD IN A SMALL WATERSHED USING ECO-HYDROLOGICAL MODEL SWAT

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Scientifical Context: Nowadays, the main threat to the water body's damage comes from non-point sources of pollution, as result of intensive agriculture and urban development (Boskidis et al., 2012). All of these sources, sediment represents the highest volume for weight of material transported to the sea. Others contaminants can be transported in association with the sediment (adsorbed) or in solution (soluble contaminants) (FAO, 1993, Boithias et al., 2012). The fine sediment could be an important vector for nutrients and pollutants transport such as heavy metals (Ankers et al., 2003).

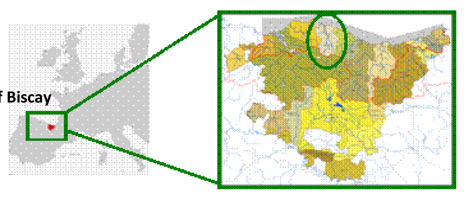
Sediment transport to the sea in the North Spain is produced at the scale of small catchments. Authors as Zabaleta et al. (2007), Montoya et al. (2013) have quantified the sediment load into two small basins Basque Country and conclude that the increased transport of sediment occurs in flood events. Quantify the amounts of sediments transports between the land to the sea and identity the erosion zones is a very important challenge to improve the measured to regulate pollutants to the land to the river. In this sense, modeling is useful in assessing the impact of climate scenarios, agricultural management and land use changes on water and sediment yield without altering the physical environment in the catchments.

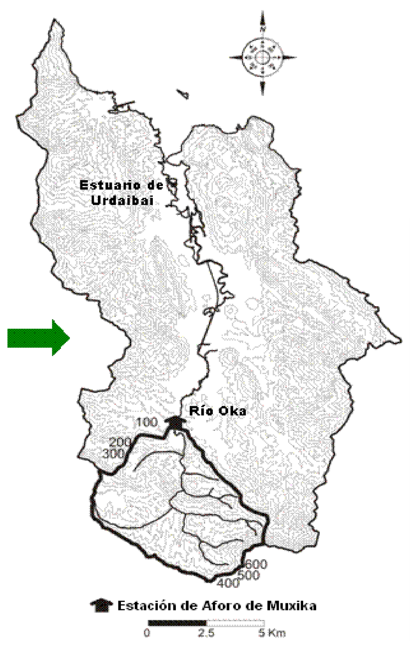
Objective: Quantify the suspended sediment load from the lands to the Bay of Biscay based in the study of a small catchment representative of the Basque Country rivers.

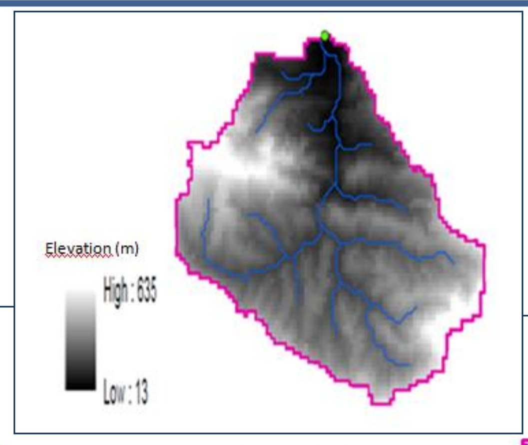
Study area and data

The Oka River basin (43º 20' N 3º W) is located in the Basque Country, northern Spain. The Oka river basin was declared in 1984 a National Biosphere Reserve (UNESCO): Urdaibai.

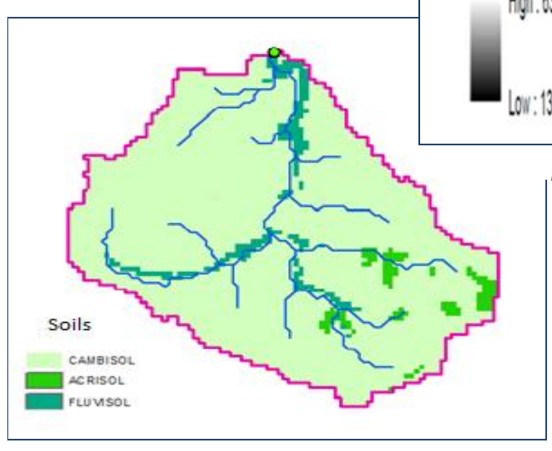
Drainage basin: 31 km²
Elevation: 13 m to 605 m
Gentle slope
Average annual precipitation: 1238 mm
Vegetation: pasture, pinus, eucalyptus
Main bedrock: Calcareous Flysch



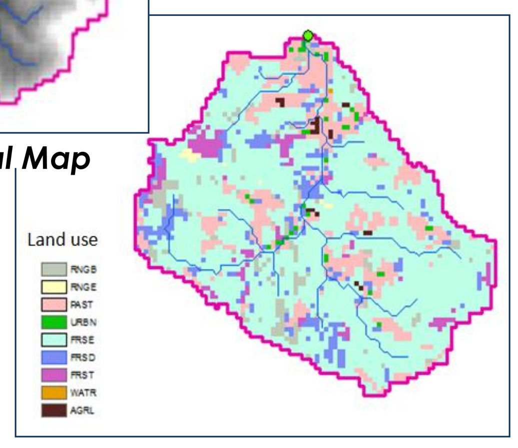




Elevation digital Map



Soil Map



Landuse Map

1 metereological and gauging station.

3 hydrological years for running SWAT (2009 – 2012) at daily scale.

Flow (m³/s) 10 min.
Turbidity (NTU) 10 min.
Suspended Sediments (mg/L)10 min.

23 sub-basins and 260 HRU.

Modelling approach

Soil and Water Assessment Tool (SWAT)

- Watershed-scale hydrologic model developed by USDA Agricultural Research Service (ARS).
- Free available from Texas A&M at: www.brc.tamus.edu/swat/soft_model.html
- Uses physically based input such as weather , soils, land use and topographic data (DEM) to predict the impact of land management practices on water, sediment and agricultural chemical yields.
- Continuous long term simulation on a daily time step for predicting discharge, sediment, nutrient and pesticide yields from agricultural/forest watersheds.

Calibration

Parameters used in the manual calibration

Parameters used to calibrate flow

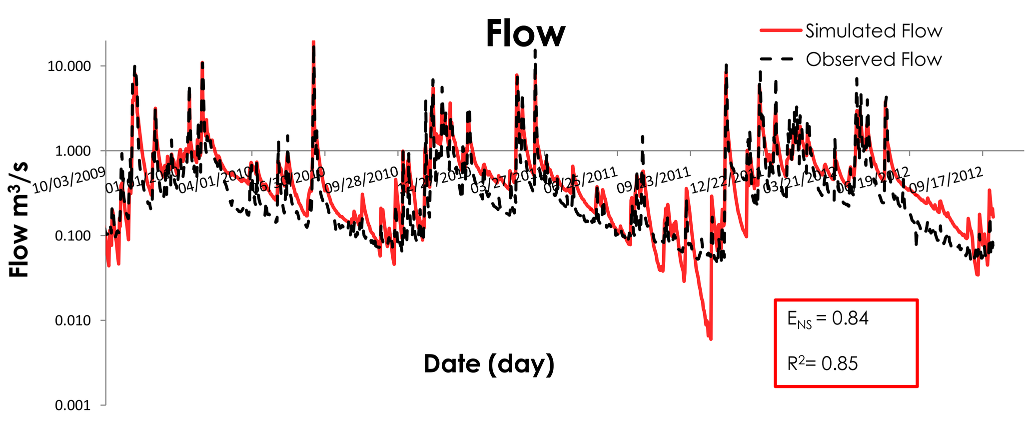
File	Parameter	Definition	Min. Value	Max. Value	Calibrated Value
.bsn	SURLAG	Surface runoff lag time	0	24	1
.GW	ALPHA_BF	Baseflow alpha factor	0	1	0.021
.mgt	CN2	SCS Curve number			↓10%
.soil	SOL_AWC	Available water capacity of the soil layer	0	1	0.26
	SOL_K	Satured hydraulic conductivity	0	400	↑10%

Parameters used to calibrate Suspended Sediments

File	Parameter	Definition	Min. Value	Max. Value	Calibrated Value
.bsn	SPEXP	Exponent parameter for calculating the channel sediment routing	1	2	1.6
	PRF	Peak rate adjustment factor for sediment routing	0	2	0.60

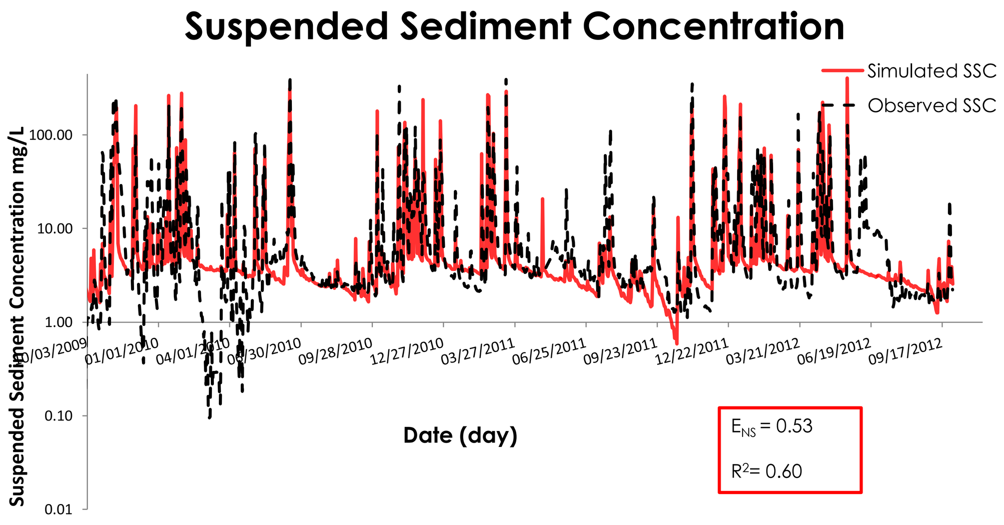
- In this study, the calibration was done manually based on physical catchment understanding and sensitive parameters from published literature (e.g. Meaurio, 2012) and calibration techniques from the SWAT user manual.
- Calibration is performed with daily data flow ($m^3 s^{-1}$) and sediment (mg/L) measured in Muxica gauging station (located at the basin outlet) during the three hydrological years from 2009 al 2012.
- Because sediments are dependent of water fluxes, parameters controlling hydrology were calibrated as the first step and then sediments.
- To evaluate the model performance with respect to the simulation of flow and sediment load using statistical methods (Moriasi et al., 2007), such as coefficient of determination (R^2) and Nash-Sutcliffe efficiency (ENS).

Results



The model predicted a mean annual rainfall for the total simulation period of 1103.6mm, which 646mm (58%) is water yield and 467mm (42%) is removed by evapotranspiration. The simulated flow follows a similar trend to the rate observed. However, the simulated flow does not have sufficient intensity to achieve the flow peaks observed, for example 16/03/2011, 08/11/2009 and 06/01/2012. The underestimation of peak flows may be due to localized rainfall event was not properly represented by the rainfall data used in hydrologic simulation. The simulated flow was also overestimated, the 16/6/2010 was presented the maximum flow simulated 19.60 m³/s while the flow rate observed was 18.25 m³/s at the gauging station. Simulated base flow is greater than that observed, in other words, the model responds slowly to the absence of precipitation.

Suspended Sediment Concentration

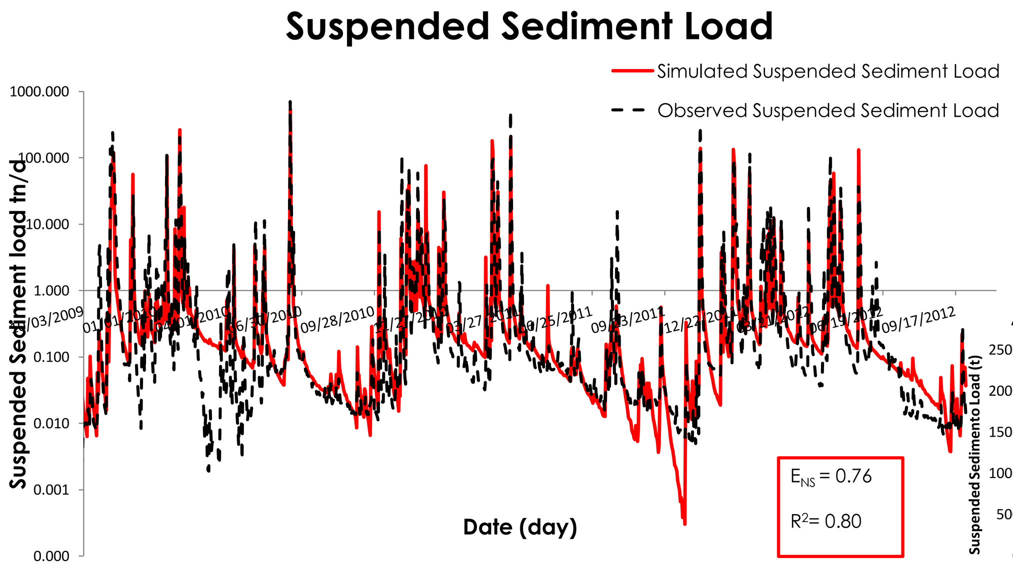


Similar trends were found between the observed and simulated data. Simulated sediment during some floods presents underestimation and overestimation. The underestimation occurs for four events described by Montoya, L., 2013, dragging most sediment suspended: 01/11/2009, 15/06/2010, 16/03/2011 and 06/11/2011.

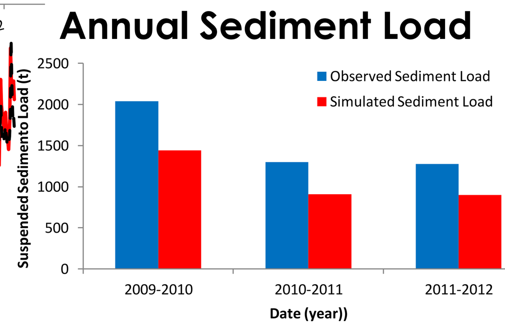
In practice, precipitation of high intensity and even short duration rainfall can generate more sediment than simulated by the model based on daily rainfall (Xu et al., 2009).

Daily suspended sediment concentration ranges from 0.59 mg/L to 404 mg/L, representing a mean specific of 10.65 mg/L.

Suspended Sediment Load



Annual Sediment Load



Simulated annual sediment load showed a variability ranging from 898 t to1441 t, representing a mean specific sediment yield of 34 t $km^{-2} y^{-1}$.

Highest sediment yield occurred in the year 2009/2010 and could be attributed to it was the period in which there were two of high intensity flood export more sediment and also was the year with highest precipitation volume.

The year with the lowest sediment yield was 2011/2012.

Conclusions

- ♦ The statistical indices indicate that the daily-scale simulation is satisfactory.
- ♦ The simulation of daily flow was better than suspended sediment yield.
- ♦ The model underestimated the flow and overestimated the suspended sediments concentration for some flood events.
- ♦ Annual sediment load varied from 848 t to 1441 t, representing a mean of 34 t $km^{-2} y^{-1}$
- ♦ Flow and suspended sediment load modeling is important because it helps to understand the basin behavior in terms oh hydrologic response and mechanical soil erosion.

References

- Moriasi D.N., J.G. Arnold, M.W. Van Liew, R.L. Binger, R.D. Harmel, and T.L. Veith. 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. American Society of Agricultural and Biological Engineers. 50(3): 885-900.
- Oeurng C, Sauvage S, Sanchez JM. 2010. Dynamics of suspended sediment transport and yield in a large agricultural catchment, southwest France. Earth Surface Processes and Lanforms 35: 1289–1301.
- Zabaleta, A., M. Meaurio, E. Ruiz and I. Antigüedad. 2013. Simulation climate change impact on runoff and sediment yield in a small watershed in the Basque Country, northern Spain. Journal of Environmental Quality. doi 10.2234/jeq2012.0209.

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