COMPARING THREE SOIL EROSION ESTIMATION METHODS IN A SMALL WATERSHED DURING FLASH FLOODS

COMPARAISON DE TROIS MÉTHODES D'ESTIMATION DE L'ÉROSION DU SOL LORS DE CRUES SOUDAINES SUR UN PETIT BASSIN VERSANT

Atiyeh Hosseinzadeh*, **Hélène Roux**, **Ludovic Cassan** (Institut de Mécanique des Fluides de Toulouse (IMFT), Université de Toulouse, CNRS, Toulouse, France).
* corresponding author

1. Introduction

Flash floods can produce intense soil erosion and sediment transport, which can result in permanent soil loss from a region, depending on major flash floods elements like rainfall intensity and watershed characteristics. Estimates of event-based soil loss are essential for comprehending the temporal variation of erosion. For regions that frequently undergo extreme events, event-based soil loss modeling is crucial since these might result in large-scale sediment transport and mass wasting.

It is crucial to assess a geographically distributed risk of erosion to prevent the degradation of the land and ensure sustainable management of soil resources. Erosion risk assessment is also of utmost importance for biodiversity.

This work would aim to estimate soil erosion from the different methods of USLE for single events and compare them to the output of the soil erosion module of a rainfall-runoff model dedicated to flash floods. This soil erosion estimation is the primary step to output erosion risk map at the catchment scale to evaluate the influence of this erosion on biodiversity and habitat type and conservation practice.

1. Material and methods

The study site is the Claduegne catchment (42.3 km^2) located in the south of France. The elevation of this catchment varies from 230 m to 820 m. The northern area has basaltic geology while clay and limestone are in the southern area. This catchment has both oceanic and Mediterranean climate influences with heavy rainfall and flash floods in autumn. Three major land use types are pastures, vineyards, and forests [1]. Data used in this study are taken from Nord [2] and Uber [1].

The MARINE is a rainfall-runoff distributed hydrological model dedicated to flash floods and including suspended sediment transport. It simulates the key physical process in flash floods including infiltration, overland flow, and lateral flow. The computation of the suspended load is based on the depth-averaged scalar transport equation including source terms to account for the production and deposition of suspended sediment and raindrop [3]. The eroded volumes simulated with the MARINE model will be compared with the ones estimated using USLE [4] and MUSLE [5].

The MARINE model is calibrated with the measurement of solid concentration recorded during a flash flood at the watershed outlet [3]. The MUSLE model used the runoff calculation from MARINE whereas the USLE is only based on precipitation.

2. Primary results and discussion

MARINE erosion estimation is considered as the reference to evaluate the application of USLE formulations. Both MUSLE and USLE simulated higher erosion than MARINE (Fig. 1) on the hillslopes. The range of estimated eroded volumes is wider in MUSLE than in USLE because erosion estimation in MUSLE is based on peak discharge and these values are high in the drainage network. As the concentration of suspended sediment simulated by MARINE at the basin outlet is corroborated by the observed concentration values, it can be deduced that the transport yield is overestimated on hillslopes by MUSLE and USLE models. The erosion parameters (erodibility, runoff factor) can be adjusted thanks to a comparison with the MARINE results.

This wide range of estimated eroded volumes with higher values in the drainage network is the same for all events in the Claduegne catchment. Figure 2 illustrates the erosion-deposition [tons] during one of the extreme events for these three methods. It shows that the highest rates of erosion and deposition are located in the drainage network for MARINE and MUSLE. USLE erosion estimation is based on rainfall intensity and for this event, the northern part of the catchment experiences high rainfall rates. The MARINE model is then an additional means to determine the location of large morphodynamic evolution in the drainage network whereas the MUSLE model is not able to do it. In direct relationship with the rainfall-runoff dynamics, such a model will allow access to the spatial variability of erosion and deposition phenomena on the hillslopes and in the drainage network and thus to the areas at risk of degradation.

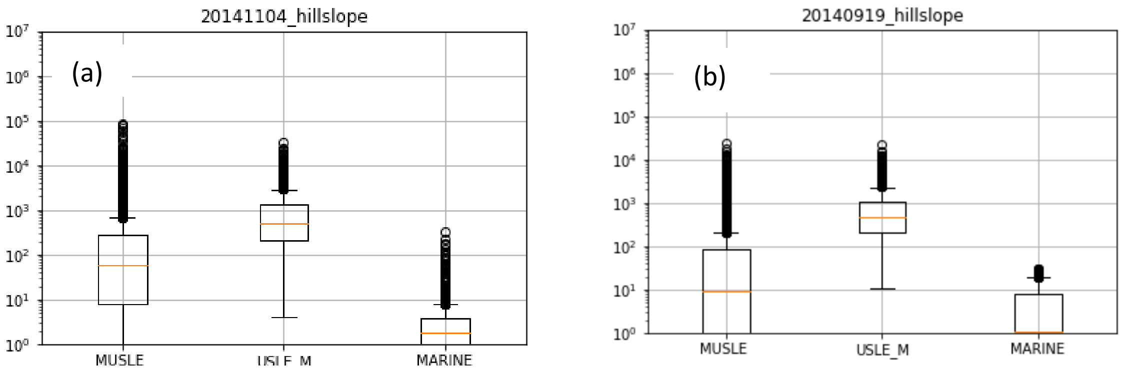

Figure 1: Boxplot of erosion estimation (t/ha) for three different approaches in log scale(a) for the extreme event (2014/11/04), (b) 2014/09/19

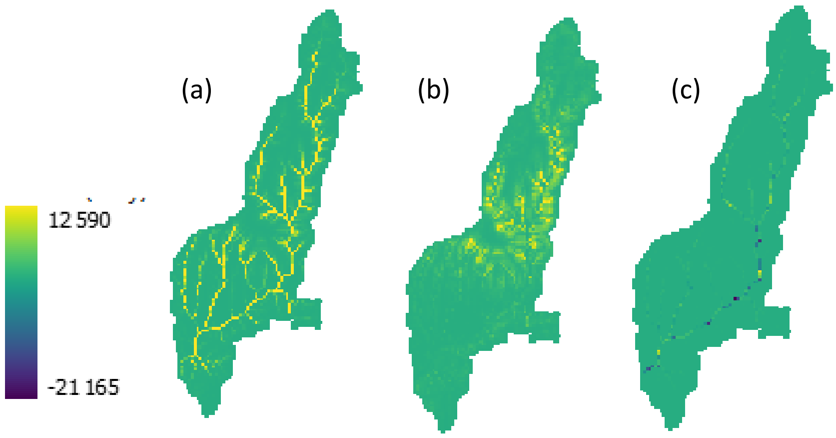

Figure 2: Erosion estimation for the extreme event (2014/11/04) in tons (a) MUSLE, (b) USLE, (c) MARINE erosion-deposition map. Negative values correspond to deposition.

REFERENCES

[1] Uber, M. (2020). Suspended Sediment Production and Transfer in Mesoscale Catchments: A New Approach Combining Flux Monitoring, Fingerprinting and Distributed Numerical Modeling. Phd Thesis, Université Grenoble Alpes. https://tel.archives-ouvertes.fr/tel-02926078.

[2] Nord, G., et al. (2017). A High Space–Time Resolution Dataset Linking Meteorological Forcing and Hydro-Sedimentary Response in a Mesoscale Mediterranean Catchment (Auzon) of the Ardèche Region, France. Earth System Science Data, 9(1), 221 49. https://doi.org/10.5194/essd-9-221-2017.

[3] Hosseinzadeh, A. et al. (2022) 'Application of GSA/GLUE methods to evaluate the representation of suspended sediment transport during flash floods in a rainfall-runoff model', IFAC-PapersOnLine, 55(5), pp. 90–95. Available at: https://doi.org/10.1016/j.ifacol.2022.07.645.

[4] Wischmeier, W.H. and Smith, D.D. (1965) Predicting Rainfall-erosion Losses from Cropland East of the Rocky Mountains: Guide for Selection of Practices for Soil and Water Conservation. Agricultural Research Service, U.S. Department of Agriculture.

[5] J. R. Williams and H. D. Berndt (1977) 'Sediment Yield Prediction Based on Watershed Hydrology', *Transactions of the ASAE*, 20(6), pp. 1100–1104. Available at: https://doi.org/10.13031/2013.35710.