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Soil erosion rates (particulate and dissolved fluxes) variations in a temperate river basin

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Soil erosion is one of the major drivers of landscape evolution in Western Europe. However, depending on the land use characteristics and on the geological and topographical settings, miscellaneous forms of erosion may lead to a very diverse morphological evolution. To understand these landscape evolutions different scientific questions remain to be answered or quantified. The main difficulty arises from the nonlinear interactions between different erosional processes that act at different temporal and spatial scales. This study proposes to investigate different datasets describing particulate and dissolved sediment fluxes within a French River basin (The Loire River) at different spatial scales and at temporal scales ranging from the flood event to several decades.

The particulate sediment load values at the outlet of the catchments range from 2.5 102 to 8.6 105 t yr-1, and the sediment yield values range from 2.9 to 32.4 t km 2 yr-1. Sediment exports from the Loire and Brittany river basins are low compared with mountainous regions and European exports. However, a strong spatial variability within this territory exists. The expected results on the sediment yield spatial pattern distribution and the correlation between SY values and basin sizes are not observed. An analysis of the sediment yield values at different time steps shows a strong effect of the seasonal availability of detached particles to be transported. High concentrations of suspended sediments during the winter and lower values during the summer and autumn are observed. Inter-annual variations are also observed, with export values varying by a factor 2 to 10 between years for one catchment. The influence of rainfall on the sediment exports is predominant, but investigations on physical characteristics of each catchment (e.g., lithology, slope, land use) are required to better understand the production and transfer processes within a drainage basin. These inter-annual variations imply that long-term data are required to provide mean SY values representative of the catchment functioning. From our calculations, 18 complete years of data are required to obtain a mean sediment yield value with less than 10% of variation on average around the mean.

The specific dissolved fluxes vary from 13.7 to 199.9 t.km-2. t yr-1. Contrary to particulate matters, the impact of the lithology is illustrated by higher total dissolved solid fluxes on limestone catchments compared with graniteous or schisteous catchments. Nitrates and ammonium are indicators of anthropogenic perturbation and their fluxes vary respectively from 0.4 to 31.4 t.km-2. yr-1 and from 7.8*10-3 to 7.7 t.km-2. yr-1 and evolve differently according to land uses: nitrates fluxes are lower in the upstream Loire and higher downstream in the region where agricultural pressure is higher.

The analysis of these datasets at different spatial and temporal scales permits to identify some of the dominant processes, and also to distinguish natural from anthropogenic influences. Concerning upland physical soil surface erosion rates, we find that the average travel distance of eroded particles may be limited, implying a strong decrease in physical erosion rates when moving from the local scale (m^2) to the river basin scale (> 103 km^2). Chemical erosion rates are less sensitive to scale and can either decrease or increase with increasing area in function of lithology, land management and topography. The results also highlight the predominant role of surface connectivity to characterize the fraction of sediment exported out of river drainage areas by physical soil surface erosion. For the export of dissolved sediment originating from weathering processes, the catchment physiography and connectivity does no longer play the dominant role. A direct link between soil production rates and exported dissolved fluxes tends to show that, contrary to the suspended particles, which are transport-limited, the dissolved matter seems to be supply-limited.