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Holocene and future response of suspended sediment yield to land use and climate change: a case study for the Meuse basin

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The suspended sediment yields (SY) of rivers are affected by changes in both land use and climate. However, the relative influence of these factors is poorly understood, partly due to the scarcity of observations of SY. In this study we investigate the relative importance of changes in land use and climate (represented by the rainfall erosivity factor) on millennial timescales in the Meuse basin (northwest Europe). We use a spatially distributed soil erosion and sediment delivery model (WATEM/SEDEM) to simulate long-term (50-year) SYs in two time-periods: (a) 4000-3000 BP (minimal anthropogenic influence), and (b) 1000-2100 AD (includes land use change and human induced climate change). Changes in rainfall erosivity are based on the output of a climate model (ECBilt-CLIO-VECODE); for the period 2001-2100 AD the model is forced in line with the SRES A2 and B1 emissions scenarios of the IPCC. These scenarios lie towards the higher and lower end of the full SRES scenario range respectively. For the period 4000-3000 BP the basin is assumed to be almost fully forested; for 1000-2000 AD land use is reconstructed using CORINE data, historical sources, and a simple land use model; for the future scenarios land use is based on future scenario data from EURURALIS. Whilst rainfall erosivity increases by only 3% between the periods 4000-3000 BP and 1000-2000 AD, mean annual SY shows more than a three-fold increase (from 91,513 Mg.a^{-1} to 306,040 Mg.a^{-1} respectively). For the older time-period the results are consistent with geological data. Almost all of this increase can be attributed to the large scale conversion from forest to agriculture between the two time-periods. Furthermore, SY shows a significant increasing trend over the period 1000-1900 AD (Mann-Kendall, $p<0.0001$), with a peak SY value of 388,062 $Mg.a^{-1}$ in the 19^{th} Century in response to continuing deforestation. In the 20^{th} Century, reforestation and rapid urbanisation resulted in a decrease in SY to 281,163 $Mg.a^{-1}$. Sensitivity analyses, whereby rainfall erosivity and the percentage of forest were altered individually, show that as the percentage cover of forest decreases, the relative effects of changes in rainfall erosivity increase. For the near-future (21^{st} Century) the results are highly sensitive to the scenario (climate and land use) used; the A2 climate change scenarios lead to higher SYs than the B1 scenarios. However, whilst rainfall erosivity is expected to rise rapidly over the coming century, our simulations using future climate and land use scenarios suggest that SY will decrease in relation to the 20^{th} Century. On the other hand, if changes in future land use are excluded, significant increases in SY can be expected under both climate change scenarios. Interestingly, in none of the future simulations is the modelled SY greater than the peak value of the 19^{th} Century.