

Scratching Earth's surface: understanding how humans affect sediment mobilisation and transfers at a global scale.

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Over half of Earth's surface is now being used for agricultural activities. Within this agricultural space, humans have to a large extent removed the natural permanent cover and replaced it with a system mimicking semi-arid conditions: crops are grown over a relatively brief time period in spring and summer and fields are semi-bare for most of the year. Pastures often retain a permanent vegetation cover, but the latter is often strongly degraded due to overgrazing or overstocking, sometimes leading to excessive runoff and erosion. There can therefore be no doubt that humans have substantially affected erosion and transport of sediments at the global scale.

Despite this massive impact, we still struggle to identify precisely how humans have affected sediment fluxes and how these alterations in sediment fluxes may affect biogeochemical cycling: the interpretation of sediment archives is often ambiguous (e.g. climate change vs. human impact) and models of sediment yield often perform well in one area and not in another. Here we investigate why this is the case and where further research is needed to further complement our understanding.

The key reason why the identification of human impact in sediment production and transfer is so difficult is that the mobilisation of sediments by humans differs fundamentally from the mobilisation through natural processes. Under natural conditions, the main driver for sediment mobilisation is often tectonic uplift, the effects of which are first noted at the catchment outlet. Humans, on the other hand, mobilise sediment on the hillslopes in the catchment headwaters. It is the latter that has inspired most of our conceptual thinking and modelling of sediment fluxes and transfers within catchments. The erosion and sediment yield models we currently have derive fluxes from catchment state variables, which can be assumed to drive sediment mobilisation on hillslopes. Some of these models are spatially explicit and also contain the algorithms allowing to route the mobilised sediment to the river network.

Such models do allow to capture human impact in landscapes where human disturbance is indeed the main driver of the production of sediment that is then cascading downstream through a series of sediment buffers. Such models also appear to perform relatively well on large scales. However, the sediment cascade has a large buffering capacity: this does not only explain why sediment yield is generally declining with catchment area, but it also poses fundamental limits on what may be achieved by such catchment state driven models. Furthermore, when sediment production is driven by tectonic uplift an entirely different spatial pattern emerges. This pattern cannot correctly be captured by current catchment state driven models, making it impossible to assess the overall effect of human disturbance on sediment yield. Thus, improving our understanding of human effects on sediment mobilisation, transfer and deposition, may depend in the first place on the progress we can make in understanding how such systems operate under natural conditions. A better quantification of sediment generation and transfer by tectonically driven river incision as well as a better understanding of the role of sediment buffers in the system appear of crucial importance to fundamental progress. Recent advances suggest that promising avenues for such advances do indeed exist.