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Soil erosion, sediment delivery and sediment yield. 'Why scale matters'

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Sediment yield reflects the integrated effect of all erosion and sediment transport processes occurring within a catchment. However, most erosion measurements have taken place at the hillslope scale in erosion plots, at the catchment scale in reservoirs or by suspended sediment sampling. Measurements at intermediate scales are more difficult to apply and thus data are scarcer. Therefore, understanding the sediment delivery process at the catchment scale is still a major challenge in erosion and sedimentation research. The assumption that area-specific sediment yield (SSY; t/km2/yr) decreases with increasing catchment area (A) is still frequently used for prediction of SSY in un-gauged catchments. However, several studies reported a positive or non-linear relation between A and SSY for which diverse explanations were suggested. We provide an overview of different observed trends and summarise the explanations for each trend. It is emphasised that erosion and sediment deposition processes are scale dependent, and going from small (<m2) to larger areas (km2) more erosion processes become active leading to a rise in SSY with increasing A. For larger areas (>km2) erosion rates generally decrease and deposition in sediment sinks increases due to decreasing slope gradients, and consequently SSY decreases with increasing A. Beside spatial scale, land cover conditions and human impact determine if hillslope erosion is dominant over channel erosion or vice versa. Moreover, spatial patterns in lithology, land cover, climate or topography can cause SSY to increase or decrease at any catchment area and can therefore result in non-linear relations with A. Here, the importance of specific erosion and sediment transport processes like gully- and channel erosion for catchment sediment yield are illustrated with field data and modelling examples. These examples suggest that sheet- and rill erosion on hillslopes may not be the dominant source of sediment exported from catchments to reservoirs or the ocean. The large regional, local and even temporal variability in the trend between A and SSY implies that prediction of SSY based on A alone is troublesome and that spatially distributed information on land use, climate, lithology, topography and dominant erosion processes is required.