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Estimation of Fine Sediment Stocks in Embanked Alpine Rivers

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Fine sediment is a fundamental component of the river system. Fine sediment conditions support good ecological status in different environments since they can affect river habitat and also transport pollutants and nutrients. Moreover, fine sediments can lead to security issues for hydroelectric buildings in the river channel, i.e. sedimentation in reservoirs, turbine erosion, etc. In alpine rivers, a large amount of fine sediments travels over the gravel-bed system as suspension and interacts with the gravel matrix (deposition, infiltration, resuspension). Recent studies highlight that fine sediment stocks in the river bed can be a significant source of suspended load at the event scale, and can have a non-negligible effect on sediment budget estimation. However, there exists no proper estimation of fine sediment stocks in gravel-bed rivers, especially for the sand fraction. One can also question the spatial and temporal variability of these stocks, which makes the estimation of such source of fine sediments challenging.

In this study, we intend to quantify fine sediment stocks in an Alpine river system (Arc-Isère in the French Alps) characterized by the presence of alternate bars. We estimate the potentially resuspended fine stocks from the gravel bar matrix for different discharges by coupling field measurements, GIS spatial analysis, and 1D modelling. Fine sediment stocks in the gravel bars are firstly measured using a field protocol optimized from the one proposed by Misset et al. (2021). The evaluation of the total stocks of fine sediments is made by combining these local measurements to GIS spatial analysis based on LiDAR data. Then, in order to predict the resuspended fine stocks, a 1D numerical hydraulic model is used to calculate bed shear stresses on the bar surface and evaluate the thickness of the potential remobilized coarse sediments. Having the volume of sediments remobilized, one can evaluate the potentially re-suspended fine stocks for different discharges. The measured fine stocks show a significant amount of sand present in the river bed, which was rarely if not measured in most studies. The silt-clay part of the calculated re-suspended stocks is found equivalent to around 30% of annual Suspended Sediment Matter (SSM) flux for a 15-year return period flood event, which appears consistent since such a large event may yield up to 50% of the annual SSM flux. However, the silt-clay stocks represent around 20% of the total fine stocks only, 80% corresponding to sand. Therefore, a large amount of sand could be re-suspended from the gravel bar matrix and should not be neglected when estimating the downstream sediment budget.