Geophysical Research Abstracts
Vol. 14, EGU2012-11373, 2012
EGU General Assembly 2012

On the evaluation of sediment transport in gravel-bed rivers with alternate bars

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In natural gravel-bed streams, the complex topography of the bed can cause variation of flow resistance and sediment transport. Previous studies have shown that in addition to grain resistance (skin friction), flow resistance is also caused by bank roughness, channel bars, bed undulations and channel curvature. Sediment transport is similarly influenced by the complex topography, and the transport rate can vary spatially. A 3D numerical models was used to generate a detailed description of the flow and bedload transport fields in gravel bed rivers. Here we quantify the reach-averaged hydraulic resistance and sediment transport regime that prevails when self-formed alternate river bars are present, and compare with the regime that would prevail were no bars are present. We do this by comparing the results of (a) a 3D morphodynamic model in which bars form as a consequence of flow-bed interaction and (b) an “equivalent” 1D case, which refers to flat bed conditions, but otherwise corresponding to identical average velocity and bed slope. The 3D numerical model is applied to generate different bed topographies of alternate bars at regime morphological equilibrium, then extended to non equilibrium conditions for decreasing shear stress within a sensitivity analysis context. The contribution of grain resistance is estimated with the local values of the bed shear stress, while bar resistance results from the overall deviation of the flow field from that occurring in the flat bed configuration. The local sediment transport in both the longitudinal and transverse directions is computed with the local Shields stress and local bed inclination. The calculations result in a method for correcting 1D models to account for the total sediment transport and resistance in a cross-section due to 3D effects of alternate bars. We term the resulting relations “morphologically averaged” sediment transport and resistance equations.