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Channel incision at the Danube River east of Vienna: verifying bed-load transport rates by different methods

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The gravel-bed section of the Danube River east of Vienna, located along 48 km between Vienna and Bratislava, is one of only two free-flowing reaches at the Danube in Austria. Long-term analyses of gauge water levels have indicated a trend towards incision of the river bed, which has been lasting for several decades and is still ongoing. Lack of sediment continuity due to retention by upstream power plants and a sediment deficit caused by bank protection measures causing channelization and preventing lateral erosion were identified as the main causes for erosion. This study aims at determining the current erosion rate from the annual bed-load transport during the years 2005 through 2009 by applying two different methods: (i) calculation of volume differences from Digital Elevation Models (DEMs); (ii) upscaling of bed-load basket sampler measurements. Each of the two methods was analyzed in terms of accuracy and associated methodical errors.

Four different interpolation methods to calculate DEMs from single-beam bathymetric measurements were statistically compared to a DEM originating from a multi-beam survey. It was found that streamline-based interpolation algorithms were associated with the highest accuracy. Using this technique, DEMs for each of the monitoring years were compiled and differential models could be derived, showing an annual sediment deficit due to erosion of approximately 360,000 m^3. By applying Richardson extrapolation it was found that the potential error of this estimate due to a single-beam cross-section distance of 50 m was only 1.1 %.

Numerous bed-load transport measurements were conducted in the monitoring period by lowering a heavy-load basket sampler along a cross section from a road bridge to the river bed. This allowed for sampling to be conducted during the entire discharge spectrum, covering low flows as well as a 15-year flood. Based on these data, a bed-load rating curve following a sigma function was compiled. By linking this rating curve to the discharge hydrograph and considering the documented sediment allowances by the upstream hydropower station operators, an annual sediment deficit amounting to around 90% of the value corresponding to the bathymetric surveys was obtained. This trend towards a sediment deficit, confirmed by two independent methods, was found for several years during the monitoring period, corresponding to an annual erosion of approximately 2 cm, which is in accordance with the historical trend of the gauge water levels.