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Vertical and lateral variability of suspended sediment in cross-sections at the river Rhine

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Monitoring suspended sediment transported in fluvial systems is of major importance regarding natural hazards, water quality, and sustainable river management. However, monitoring is challenged by the spatial and temporal variability of suspended sediment transport and thus time consuming and costly. Here we analyze the spatial variability of suspended sediment in the German waterways using data from suspended monitoring networks of the German water and shipping authority (WSV). The data consists of four stations with cross-sectional measurements (isokinetic sampling with 20-25 samples/sampling campaign and 3-4 campaigns per cross-section/year) along with three stations with frequent (daily) point measurements. As the distribution of SSC with water depth is well established through the Rouse profile, uncertainties are induced through the determination of the settling velocity and the assumption of suspended sediment being transported as primary particles.

The lateral and vertical variability are quantified through the mean standard deviation for each vertical profile and sampling depth for each sampling campaign respectively. First, we investigate general patterns (including the vertical and lateral variability) of suspended sediment concentration (SSC) in the four different cross-sections. Second, we link the lateral and vertical variability with discharge, the magnitude of SSC, and flow velocity. Third, we estimate differences between the cross-sectional sampling and single point sampling.

Our preliminary results indicate an increase of vertical and lateral variability with average SSC in the cross-section. This involves a strong vertical gradient at high average SSC and increased variability at the bottom compared to near-surface SSC. As the flow velocity is smaller at the bottom, we detect a decrease in variability with higher flow velocity. These general patterns are present at each cross-section. However, site specific variations are abundant; caused by site specific properties, such as local morphology, lithology, and the impact of tributaries. Mean standard deviation of laterals and verticals shows the strongest connection to SSC, rather than discharge and flow velocity. Comparing cross-sectional average SSC with surface-sampling from the middle of the river ranges from strong underestimations (> 70 %) to strong overestimations (> 100 %) for single years with an average underestimation of approx. 11 % for all three stations over the 30-year sampling period used in this study. Thereby, incorporating cross-sectional measurements reduce uncertainties induced by point-sampling. Further, site specific adaptations regarding the sample location and an optimization of the sampling process utilizing simultaneous

sampling could improve cross-sectional sampling.