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Evaluation of ship-based sediment flux measurements by ADCPs in tidal flows

Marius Becker (1), Christian Maushake (2), Steffen Grünler (2), and Christian Winter (1)

(1) Marum - Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany, (2) BAW - Federal Waterways Engineering and Research Institute, Hamburg, Germany

In the past decades acoustic backscatter calibration developed into a frequently applied technique to measure fluxes of suspended sediments in rivers and estuaries. Data is mainly acquired using single-frequency profiling devices, such as ADCPs. In this case, variations of acoustic particle properties may have a significant impact on the calibration with respect to suspended sediment concentration, but associated effects are rarely considered. Further challenges regarding flux determination arise from incomplete vertical and lateral coverage of the cross-section, and the small ratio of the residual transport to the tidal transport, depending on the tidal prism. We analyzed four sets of 13h cross-sectional ADCP data, collected at different locations in the range of the turbidity zone of the Weser estuary, North Sea, Germany. Vertical LISST, OBS and CTD measurements were taken very hour. During the calibration sediment absorption was taken into account. First, acoustic properties were estimated using LISST particle size distributions. Due to the tidal excursion and displacement of the turbidity zone, acoustic properties of particles changed during the tidal cycle, at all locations. Applying empirical functions, the lowest backscattering cross-section and highest sediment absorption coefficient were found in the center of the turbidity zone. Outside the tidally averaged location of the turbidity zone, changes of acoustic parameters were caused mainly by advection. In the turbidity zone, these properties were also affected by settling and entrainment, inducing vertical differences and systematic errors in concentration. In general, due to the iterative correction of sediment absorption along the acoustic path, local errors in concentration propagate and amplify exponentially. Based on reference concentration obtained from water samples and OBS data, we quantified these errors and their effect on cross-sectional averaged concentration and sediment flux. We found that errors are effectively decreased by applying calibration parameters interpolated in time, and by an optimization of the sediment absorption coefficient. We further discuss practical aspects of residual flux determination in tidal environments and of measuring strategies in relation to site-specific tidal dynamics.