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Long-term turbidity measurements for quantification of the SPM variability in the Weser and Elbe estuaries

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The environmental impact of human interventions in estuaries (e. g. deepening of a shipping channel) has to be assessed due to governmental regulations. Hence, the German Federal Waterways and Shipping Administration (WSV) is operating a monitoring network to carry out long-term and high-frequency measurements of e. g. water levels, salinity and turbidity in the North Sea and estuaries. These data not only allow to assess changes in estuarine dynamics but also present a valuable data base for model validation and calibration. The objective of this work is to quantify the long-term multi-site turbidity measurements (2007-2015) to estimate suspended particle matter (SPM) time series, and to track the dynamics of the estuarine turbidity maxima (ETM) in the Weser and Elbe estuaries.

The long-term monitoring network infrastructure consists of different turbidity sensors, different maintenance procedure are applied and different measurement data handling procedures. Therefore, we will discuss practical aspects of the necessary extensive quality assurance of the turbidity data. Furthermore, the turbidity signal strongly varies in time and space depending on environmental conditions as freshwater discharge and tidal forcing. In order to get reliable model parameter calibrations for SPM concentration based on turbidity measurements, a multi-sensor calibration (six different optical backscatter sensors, OBS) at long-term monitoring stations are carried out. Data of 35 repeated field surveys of OBS, CTD measurements and water sampling allow to record the effect of tidal phases, seasons and meteorological conditions on model parameter calibrations. Applying these results and associated measurement uncertainties to the monitored turbidity data, a reliable SPM time series could be obtained.

In terms of measurement uncertainties, the estimated SPMs based on turbidity measurements exhibit maximum measurement uncertainties in the range of 14 % to 26 %, depending on tidal phases and monitoring position.

Based on these results the subtidal SPM and ETM variability is analysed and the effects of freshwater discharge and tidal forcing are quantified. The data reveal a clear dependence of ETM location and magnitude from freshwater discharge. During mean low-water discharge and mean-water discharge conditions the ETM develops at the position between 0.4-0.55 in the Weser and 0.4-0.7 in the Elbe estuary. During mean-water discharge and mean high-water discharge the ETM shifts downstream of approximately 20 km in the Weser and up to 40 km in the Elbe estuary.

For river floods and times of relatively low mean water levels the ETM in the Weser is flushed to the outer estuary and needs about half a year to reach SPM magnitudes and position to comparable values to the situation before the event occurs. These findings confirm the earlier assumption by Grabemann and Krause (2001) of the fate of the ETM in the outer estuary, because data for this region are now available.