Comparison of measurement techniques for monitoring sediment transport, under field conditions, in the Scheldt estuary

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Introduction: In 2001, the Dutch and Flemish Governments agreed on a Long Term Vision for the Scheldt Estuary. This long term vision is based around three major themes: port accessibility, safety against flooding and protection of the natural system of the estuary. It forms the basis for policies and strategies regarding the Scheldt in both countries. A joint integrated monitoring program, MONEOS, was set up around the long term vision's goals, as well as the Water Framework Directive and Bird and Habitat Directive. MONEOS will follow up on the development of physical and ecological system characteristics of the Scheldt estuary. An important part of the program focuses on the quantification of the sediment transport. Within the program, a wide variety of sediment transport measurement devices is available, both for near-bed and suspended sediment transport. However, for practical reasons, it is preferable to work with a limited set of equipment only. This study aims to (1) evaluate the performance of different sediment transport measurement devices available, under field conditions, and (2) determine an optimal equipment configuration for monitoring purposes in the Scheldt estuary.

Methods: The standard measurement protocol for sediment transport currently used on the Western Scheldt by Rijkswaterstaat Zeeland consists of point measurements with an ASTM (Acoustic Sand Transport Meter) for measuring near-bed and suspended sand concentrations and velocities, and a MEX (optical sensor based on transmission) for silt concentrations. In combination with this, flow velocity profiles are recorded along a transect near the measurement point through a ship-mounted ADCP (Acoustic Doppler Current Profiler).
In order to allow for different devices measuring sediment transport to be compared, Rijkswaterstaat Zeeland and Flanders Hydraulic Research organized a 13 hour measurement campaign (spanning a full tidal cycle) on the Western Scheldt on the 4th of June 2008, during which the available equipment was deployed. Three measuring ships were mobilized, equipped with a total of 12 devices for measuring flow velocities, sediment concentration or sediment transport. Sediment concentration and transport measurements included mechanical methods (Delft Bottle), acoustic techniques based on transmission and scattering of sound (ADCP, ASTM) and optical methods based on transmission (MEX), backscatter (Aanderaa RCM-9, OBS) or diffraction (LISST25-X) of light. Pump samples were taken during the measurements and their silt and sand concentrations determined. Analysis of measurement data consisted of calibration of the continuous measurements with the results of the pump samples and comparison of the silt and sand transport rates obtained with the different methods. Calibration comprised statistical analysis of the relationship between measurements and pump samples: identifying outliers, comparison of goodness-of-fit (R^2) for the different devices and determining confidence intervals on the resulting transport rates.

Results: Interpretation of the measurements from individual instruments was complicated by the presence of both sand and silt, variation in particle size over time and the occurrence of flocs during most of the experiment. Preliminary results show similar trends in transport and concentration time series for nearly all instruments. However, large differences exist in absolute transport and concentration values, especially for peak-concentrations. Optical methods such as the OBS, MEX and Aanderaa give good results for silt, but due to the amount of silt present, perform poorly when it comes to sand transport. The Delft Bottle seems to overestimate sand transport somewhat, but has the advantage of providing a sample for analysis. The LISST-25X measurements suffer from the presence/absence of flocs: separate sand and silt concentrations cannot be obtained and a single calibration to total sediment mass concentration for the entire experiment is not possible. However, the LISST-25X does provide useful information with regards to the density of the flocs and their distribution in time. AZTM measurements seem unaffected by flocs. Measured concentration values, based on a laboratory calibration with sand correspond very well to sand concentrations in pump samples. The effect of flocs and combination of sand and silt on the ADCP measurements is yet unclear.