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Managing changing rivers

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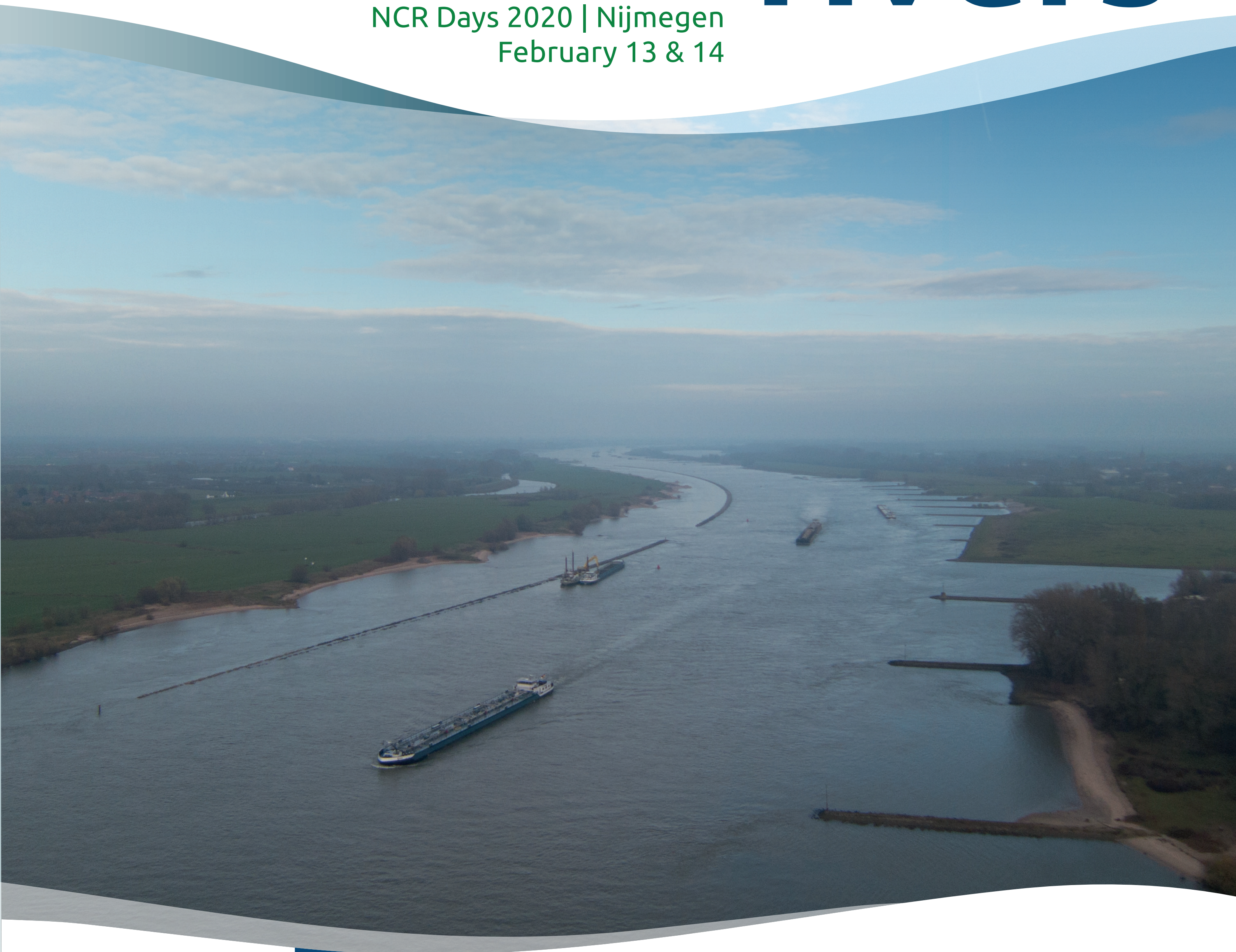

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Obtaining suspended sediment concentration in the water column from existing boat observations

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Introduction

In order to manage the river, Rijkswaterstaat wants to know the sediment balance for river reaches. To obtain such a balance, the sediment transported in the water column needs to be considered. Rijkswaterstaat often obtains the spatial variation in flow velocity by ADCP observations from a boat (e.g. for determining river discharge). The sediment transport in a cross section is monitored occasionally at certain points, using an Optical Backscatter Sensor (OBS), calibrated by water samples.

Besides the flow velocity profile, ADCP observations, can also provide an accurate vertical profile of SSC, using backscatter intensity (Hoitink, 2004; Sassiet al. 2012; 2013). However, the method to obtain SSC from acoustic backscatter is not yet applied by Rijkswaterstaat, because it is advanced, laborious by the necessary postprocessing steps and not in every condition good results are obtained.

The primary objective of this project is to show the added value of determining SSC from ADCP observations in Dutch rivers. Furthermore, the code is generalized, and documentation is written, such that these can be used by consultants and knowledge institutes as well.

Methods

In the joint project of the Port of Rotterdam and Deltares, a pilot is carried out to demonstrate and evaluate innovative sediment reuse solutions. For this, 200.000 tons of sediment dredged in the Nieuwe Waterweg and harbours in Rotterdam is reallocated into a designated area. The monitoring campaign of 11 July 2019 has been carried out from a Port of Rotterdam vessel, monitoring turbidity using OBS profiles and flow using a 600 kHz ADCP. Besides these profiles, 11 water samples were taken. The mass concentration [g/l] was determined using a Whatman OE66 0.2 μm diameter 50mm filter. Two methods are selected to obtain sediment concentration from ADCP backscatter measurements. The first method is based on a power law fit (Hoitink, 2004). A regression with two parameters is made of the observed backscatter strength and suspended sediment concentration from water samples. The second method uses a two-step calibration, assuming a constant grain size distribution in the measuring volume (CGSD-method). First, background backscatter strength is determined by comparing ADCP backscatter information and water samples from close to the ADCP. In the second step the sediment attenuation is estimated, using ADCP backscatter information and water samples lower in the water column (Sassi et al. 2012). For CGSD-method more choices can and must be made than for the power law method.

Results

Power law method

Fig. 1 shows the SSC (plotted as log10 (SSC/1000)), of the water samples as a function of the backscatter strength with a regression fit R2 = 0.51. The water samples taken at 12:29, 12:42, and 14:18 hours all plot below the trendline. These sample where taken relatively close to the water surface

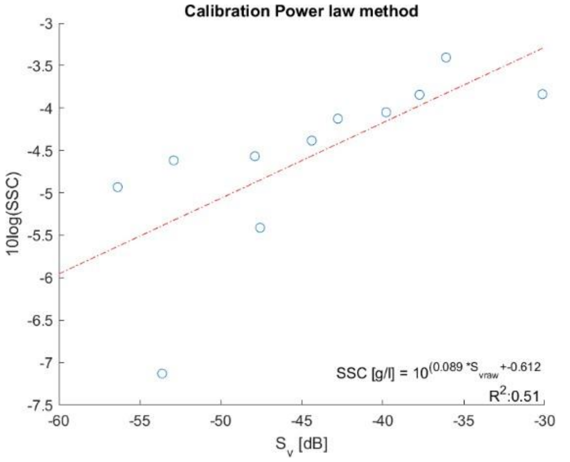

Figure 1 Regression between the SSC of water samples and backscatter strength without sediment attenuation considered. Sv is the average backscatter strength at the depth of the water sample for a period of 1.5 minutes before to 1.5 minutes after the water sample was taken.

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Fig. 2A shows a profile with a relatively good match between the OBS- and ADCP-derived SSC, based on the first method. At around 4-6 m depth both the OBS observations and the ADCP-derived SSC are maximal, whereas in the rest of the profile they are lower than 0.3 g/l.

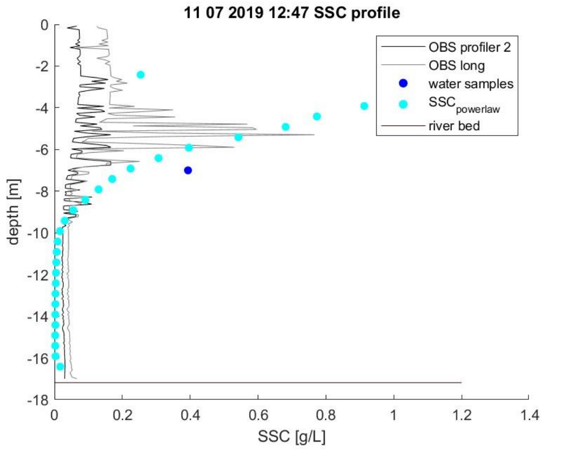

Figure 2 Profiles of SSC as determined from the ADCP dataset using the power law method, and from two OBS devices (OBS2 is more sensitive than OBSlong), and the water sample for the profiler transects of 11-07-2019 12:47

Generally, the ADCP power law results underpredict when the SSC from the water samples is lower than 0.1 g/l. All in all, the ADCP derived SSC varies more within the vertical than the OBS derived SSC, and the highest values within a profile occur at similar depth.

Fig. 3 shows the resulting SSC for the survey. A maximum of 0.8 g/l is observed near the water surface, related to the higher SSC in the south near the reallocation area. Furthermore, the sediment plume can be identified.

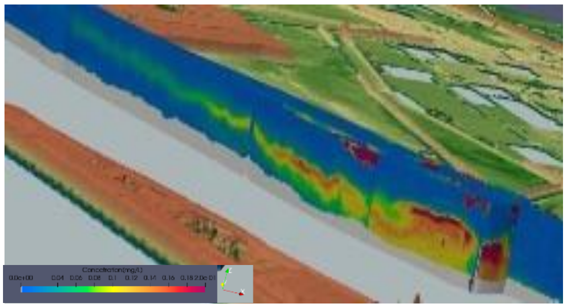

Figure 3 SSC (g/l) from the power law calibration of the ADCP backscatter over the entire survey (before and after reallocation) plotted along the boat track; The reallocation area is located in the east.

Constant grain size distribution method

For the CGSD method, 3 shallow water samples were selected to estimate parameter b. This parameter and the other samples resulted in 8 different values for specific attenuation (γe). Fig 4. Shows that these values for γe are high and therefore result in a too strong correction for attenuation by the sediment in the calculation of SSC. As a result, even negative concentrations are visible in the dataset.

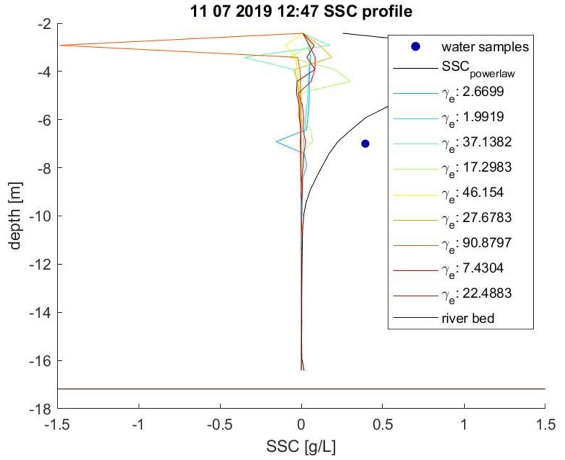

Figure 4 Profiles of SSC as determined from the ADCP dataset using the power law method, the CGSD-method using the values for γe as found in the calibration, the CGSD-method with a median γe (22.4883), and the water sample for the profiler transect of 11-07-2019 12:47..

Conclusions

- Using sediment concentrations from water samples, Matlab software and raw (binary) data of an ADCP manufactured by RD Instruments, the SSC can be obtained by running the code developed within the framework of this project without spending too much time.
- Generally, the ADCP-derived SSC was similar as the OBS-derived SSC with similar trends in the vertical variation for the powerlaw method. The results based on this method are promising and yield the spatial variation of sediment plumes.
- The total of 11 water samples is limited for the calibration with the constant grain size distribution method. This method requires more choices for the calibration and no reliable results were obtained yet.

References

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