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Effect of clay content on Acoustic Doppler Velocimeter backscatter for suspended sediment concentration measurements

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The capability of ADVs (Acoustic Doppler Velocimeters) to estimate suspended sediment concentration (SSC) has been widely investigated using commercial glass microspheres of the same size or well-sorted fractions in experimental studies. In the natural environment, sediment samples may be composed of different types of sediments having various types of grain size distribution.

This study aims to analyze experimentally the effect of clay ratio in sediment content on acoustic response. Modification of scattering and attenuation characteristics for different clay ratios is evaluated theoretically. In laboratory experiments, four different sediment mixtures constituting non-cohesive sand and cohesive clay materials were prepared with clay ratios of 0, 5, 10 and 15% by dry mass. A-10 MHz acoustic Doppler velocity profiler (ADVP, The Nortek Vectrino Profiler) was used in controlled laboratory environments under a wide range of concentration conditions up to 10 g/L. Acoustic backscatter measurements were made by immersing the ADVP in a well-mixed circulation tank filled with mixtures with known concentration and sediment composition. The backscattered signals were recorded at 100 Hz, from which 1.5-min ensemble averages were obtained. For each sediment mixture, calibration curves representing the relationship between SSC and acoustic backscatter were obtained based on the sonar equation. Acoustic estimates of suspended sediment parameters obtained for mixtures with different clay contents are compared to identify the effect of increasing clay content on the acoustic signal.

The experimental results showed that the slope of the calibration curve decreases with increasing validity range as the clay ratio of the mixture increases. Under the fixed SSC condition, the backscatter strength is greater for the mixture with a lower clay ratio. The theoretical analysis indicated that changing clay content modifies the scattering and attenuation properties compared to the mono-size suspension with the same mean size. Introducing clay material in a mixture affects the scattering properties more significantly than the attenuation properties. Therefore, information on the form of the sediment distribution and the sorting of sediments in suspension is crucial for acoustic estimates of suspended sediment parameters.

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