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Laboratory and field monitoring of bedload transport rates by means of hydro-acoustic techniques

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The local sediment discharge of particles of bedload size has been an engineering and scientific challenge for several decades. The direct conventional trap-type samplers suffer from uncertainty caused by the samplers efficiency and placement, as well as from the oscillatory variation from the bedload discharge. On the other hand, statistically valid measurements are extremely important for the evaluation of the sediment transport masses, especially in large navigable or heavily exploited rivers.

Some new modern apparatus and means for measuring and aiding the measuring of the bedload transport rate have been proposed lately and are promising significant improvement of the bedload data. Passive and active ultrasonic sounders, pressure transducers and photography are the most popular techniques in the recent studies. Each techniques has pros and cons depending of the particle size distributions (PSD), field conditions, their installation, etc.

For large sand bed or gravel bed rivers, the use of the acoustic Doppler current profilers (ADCP) emerges into a promising technique for bedload quantification. Beside using the Doppler effect and estimation of the apparent bedload velocity, these instruments register the back-scattering strength from the riverbed. Different beam slant angles and different frequencies of the ADCPs can be used to estimate the PSD and the concentration of the bedload. In fact, the average bedload concentration, velocity and PSD are the main parameters used for calculation of the bedload transport rate.

This study aims to examine all these parameters and deliver more accurate and statistically valid information about the bedload sediment discharge. Six frequencies (0.5 MHz, 0.6 MHz 1 MHz, 1.2 MHz, 2 MHz, 3 MHz) from four commercial ADCPs were used to measure different bedload transport conditions in laboratory and field conditions.

The laboratory experiments included with top and side view monitoring of the bedload using high speed cameras and continuous measurement of the transport rate using bedload trap at the end of the flume. Additionally, several experiments were conducted using monostatic ultrasonic velocity profilers to examine several acoustic parameters, simulating one beam of the ADCP. On the other hand, the field data was supported with bedload transport rate measurements using pressure difference direct samplers. Cameras mounted on the samplers monitored the physical sampling in order to decrease the uncertainty caused by the sampler placement.

Merging the field and the laboratory data obtained very important information about the usage of different ADCPs for bedload measurements. Specifically the acoustic sampling sampling of each ADCP and the importance of the frequency and the slanting angle in distinguishing between the mobile and immobile bedload particles were elaborated in details.

The final goal of this study is to develop a site-independent methodology for measuring the bedload transport rate using an ADCP. The developed methodology is expected to depend only on the specific ADCP instrument. Further experiments will aim to explore the acoustic response to different bedload materials in laboratory conditions and finally to implement this methodology on field data.