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3-D Velocities in a Bore: Comparison of an Electromagentic Current Meter (ECM) and an Acoustic Doppler Velocimeter (ADV)

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Abstract

An experimental flume study was undertaken to compare water velocity in a bore for a given cross section using an Acoustic Doppler Velocimeter (ADV) and an Electromagnetic Current Meter (ECM). We present a comparison of two among nine elevations above the flume bed. Average and standard deviation of ECM velocities are somewhat higher than those of ADV. However, ADV vertical velocities showed an unexpected trend for the first 4 s after bore arrival when turbulent intensity (TI) from ECM varied from 8% to 2%.

Keywords: flash flood, velocimeter, time-averaged velocity.

1. INTRODUCTION

Measuring of water velocity allows characterizing the hydro-dynamics of flood bores. Acoustic Doppler Velocimeters (ADV) and Electromagnetic Current Meters (ECM) are the most widely used instruments for velocity measurements (Buffin-Belanger and Roy 2005). These instruments respectively operate on the Doppler shift and Faraday principle of electromagnetic induction.

A bore over a dry bed was generated in a $32 \times 0.5 \times 0.8$ m flume by sudden release of water using a computer-controlled lift gate. Water velocity was measured using down-looking ADV (N4000-72, Nortek, USA) and ECM (ACM3-RS, Alec Electronics, Japan) at 0.04 and 0.10 m above the bed at 27.1 m downstream from the gate. The ADV and ECM data were collected at respective sampling frequencies and voulmes of 50 Hz/0.03 m, 40 Hz/0.34 m at the same cross section. Measurements at each elevation were obtained by repeating the hydrograph. Water depth was monitored using temperature-corrected ultrasonic distance transducers (M-5000, Massa, USA).

2. RESULTS

Unsteady flow occurred during the first ~30 s, quasi-steady flow followed during ~30 to ~60 s after bore arrival, with a following recession. Respective time-averaged velocities (using Fourier Component Method) Uavg, Vavg, and Wavg were monitored in the streamwise, vertical and lateral directions (Fig. 1). As reported elsewhere ECM velocities were considerably larger than comparable ones by ADV. A significant inconsistency occurred between the ADV and the ECM time-averaged vertical velocities during the initial 4 seconds (Fig. 1; Table 1), when flow was very unsteady. Turbulent intensity (TI) was calculated using turbulent fluctuations and time-averaged velocities; a difference in TI (~5–7.8%) was observed between ADV and ECM data at the same elevation, which can be due to (i) different measurement principles and (ii) low correlation of ADV measurements. For example: ADV data are based on velocities of small particles passing through a sampling volume and based on two correlated measurements for a time interval. At high turbulent intensities, the correlation can be reduced (MacVicar et al. 2007), thus measurement accuracy is reduced.

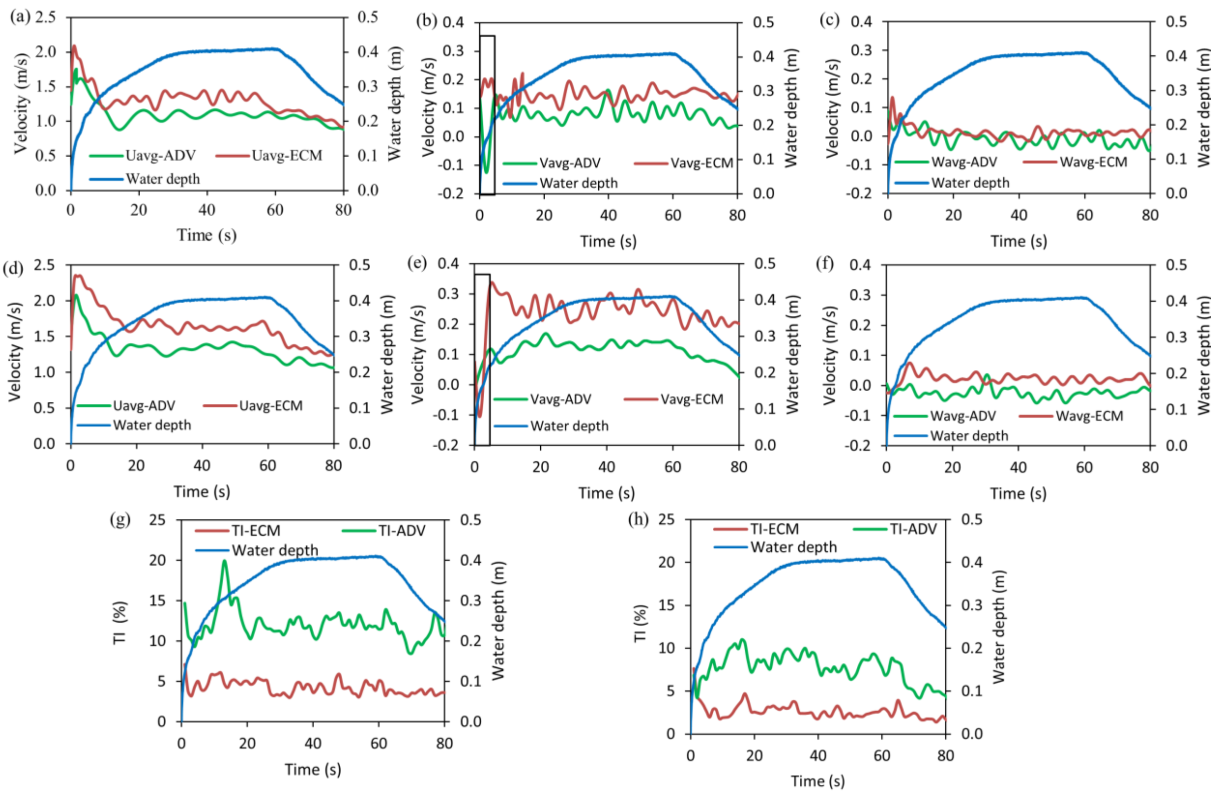

Fig. 1. ADV and ECM three dimensional time averaged velocities at: (a)–(c) 0.04 m, (d)–(f) 0.10 m, and turbulent intensity –TI at: (g) 0.04 m, and (h) at 0.10 m.

A similar inconsistency with ADV signals at high turbulent intensities for field data were observed elsewhere (MacVicar et al. 2007). The standard deviations about the average velocities are shown in Table 1.

Table 1

Average and standard deviation of ADV and ECM

Height above bed	Velocimeter	Average ± standard deviation			
		Uavg	Vavg	Wavg	TI
		m/s			%
0.04 m	ADV	1.10±0.20	0.10±0.04	–0.01±0.02	12.01±1.87
	ECM	1.20±0.30	0.15±0.02	0.01±0.02	4.23±0.85
0.10 m	ADV	1.30±0.20	0.10±0.06	–0.02±0.02	7.73±1.68
	ECM	1.50±0.30	0.20±0.06	0.02±0.02	2.64±0.88

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