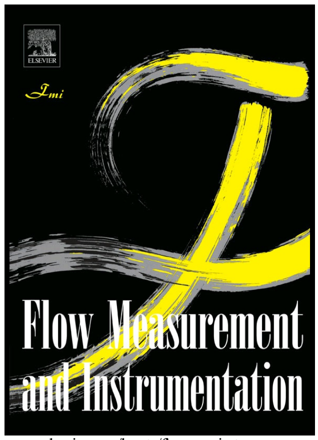
# Author's Accepted Manuscript



www.elsevier.com/locate/flowmeasinst

Estimating random uncertainty of depth-averaged velocities measured by moving-boat acoustic Doppler current profilers

Hening Huang

PII: S0955-5986(17)30064-X
DOI: http://dx.doi.org/10.1016/j.flowmeasinst.2017.09.001
Reference: JFMI1351

To appear in: *Flow Measurement and Instrumentation*

Received date: 13 February 2017
Revised date: 20 July 2017
Accepted date: 10 September 2017

Cite this article as: Hening Huang, Estimating random uncertainty of depth-averaged velocities measured by moving-boat acoustic Doppler current profilers, *Flow Measurement and Instrumentation,* http://dx.doi.org/10.1016/j.flowmeasinst.2017.09.001

# Estimating random uncertainty of depth-averaged velocities measured by moving-boat acoustic Doppler current profilers

Hening Huang
Teledyne RD Instruments, 14020 Stowe Drive, Poway, CA. 92064. E-mail: hhuang@teledyne.com

**Abstract:** This paper presents a mathematical model for estimating the standard uncertainty of depth-averaged velocities measured by moving-boat acoustic Doppler current profilers. A general form of the presented uncertainty model was developed based on the law of propagation of variances and dimensional analysis. It was then calibrated using 30 datasets of stationary ADCP measurements, in which standard uncertainties were available from statistical analysis of the data. Because the model utilizes velocity data collected at a site, it accounts for all random error sources including ADCP system noise and ambient turbulence encountered at the site; it also accounts for the cross-correlation of ADCP depth cells in velocity measurements. The presented uncertainty model can be used in field surveys or data post-processing. It provides a useful tool for assessing the quality of ADCP measured depth-averaged velocities. A moving-boat ADCP measurement on the Mississippi River is presented as an application example. This paper also explores some insights on ADCP velocity profile and time series data.

**Keywords**: ADCP; cross-correlation; depth-averaged velocity; uncertainty.

## 1. Introduction

An acoustic Doppler current profiler (ADCP), mounted on a moving-boat, can continuously collect water velocity profile data along the boat's track during field operation. In addition to its wide use for streamflow measurements (e.g. Simpson 2001; Oberg et al. 2005; Mueller et al. 2013), an ADCP is an efficient tool for velocity mapping in a large area in estuarine, lakes, rivers, or coastal waters (e.g. Rennie and Church 2010; Parsons et al. 2013). ADCP spatially distributed velocity data are essential for river hydrodynamic modeling. For example, a 2D model requires depth-averaged velocity measurements throughout the study reach for model calibration (Stone and Hotchkiss 2007).

Depth-averaged velocities along the boat's track are often calculated by an ADCP operation or data post-processing software system. The uncertainty of the depth-averaged velocity is of great concern because it is an indicator of the measurement quality. For a measured depth-averaged velocity to be meaningful, it must be accompanied with a statement of its uncertainty. Moreover, the uncertainty is an important consideration when planning a field survey. For a pre-specified spatial resolution of velocity mapping (say, 10 m), given site conditions (such as water depth, velocity, and turbulence intensity level) and ADCP model (or frequency), the decision on boat speed depends on the required measurement quality level for depth-averaged velocities. Low boat speed allows collecting more ensembles that can be averaged to reduce random noise and obtain high quality measurements. However, it is always a tradeoff between boat speed (or survey duration) and measurement quality.

In spite of the importance of assessing the measurement quality, few studies have been conducted on the uncertainty estimation of depth-averaged velocities measured by a