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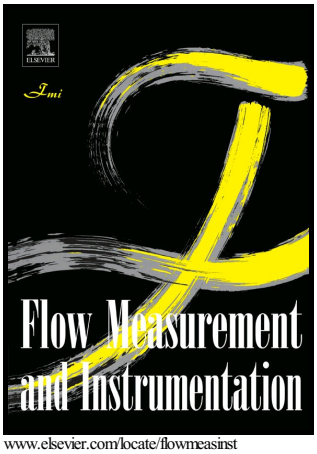

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Abstract

This paper presents a new analytical model for estimating the random uncertainty of moving-boat ADCP streamflow measurements. The presented model is developed based on the law of propagation of variances. It accounts for an important phenomenon, the dilation of velocity errors due to measurement made on a moving-platform, which is referred to as the 'error dilation' in this paper. The equation of the error dilation is analogous to the well-known time dilation equation in the theory of special relativity. The error dilation increases with increasing the ratio between the boat and water velocities and becomes significant when the ratio is greater than unity. The presented model may be considered as a modified Simpson model that does not account for the error dilation. The presented model helps gain insights into the effects of major parameters or error sources on the measurement uncertainty. The error dilation is confirmed and the presented model is verified with the field data obtained from the moving-boat ADCP streamflow measurements on an irrigation canal in California.

Keywords

ADCP; discharge measurement; error dilation; uncertainty.

1. Introduction

Acoustic Doppler Current Profiler (ADCP) was first introduced to hydrologists in early 1980's (e.g. Christensen and Herrick 1982). It is a revolutionary tool and has been gradually replacing traditional current meters in streamflow measurements. An ADCP is mostly mounted on a survey boat or small float when making measurements, transecting from one bank to the other. This deployment is commonly known as the moving-boat ADCP method, in contrast to the stationary ADCP method, with which an ADCP is stationary when making measurements (Huang 2012).

Like any other measurement, moving-boat ADCP streamflow measurements contain errors: systematic and random. The systematic error (also known as bias error) is mainly due to the calibration errors of an ADCP and its internal sensors and application errors (Huang in press). The random error is mainly due to ADCP system noise in velocity and depth measurements, ambient turbulence, and pitch, roll and heading variation/errors (Huang 2016). According to the "Guide to the Expression of Uncertainty in Measurement (GUM)" [Joint Committee for Guides in Metrology (JCGM) 2008], either systematic or random error can be characterized by the standard uncertainty, i.e. the standard deviation of the distribution of systematic or random error. The random standard uncertainty is also known as the precision limit and the systematic standard uncertainty is known as the bias limit (Huang in press). The total standard uncertainty (i.e. the total error limit) is the square root of the sum of squared systematic and random standard uncertainties. This paper considers the random standard uncertainty only. For simplicity, "standard" is omitted hereafter.

A number of studies focus on the development of mathematical models or computer