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Measuring the uncertainties of discharge measurements: interlaboratory experiments in hydrometry

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Quantifying the uncertainty of streamflow data is key for hydrological sciences. The conventional uncertainty analysis based on error propagation techniques is restricted by the absence of traceable discharge standards and by the weight of difficult-to-predict errors related to the operator, procedure and measurement environment. Field interlaboratory experiments recently emerged as an efficient, standardized method to 'measure' the uncertainties of a given streamgauging technique in given measurement conditions. Both uncertainty approaches are compatible and should be developed jointly in the field of hydrometry.

In the recent years, several interlaboratory experiments have been reported by different hydrological services. They involved different streamgauging techniques, including acoustic profilers (ADCP), current-meters and handheld radars (SVR). Uncertainty analysis was not always their primary goal: most often, testing the proficiency and homogeneity of instruments, makes and models, procedures and operators was the original motivation. When interlaboratory experiments are processed for uncertainty analysis, once outliers have been discarded all participants are assumed to be equally skilled and to apply the same streamgauging technique in equivalent conditions. A universal requirement is that all participants simultaneously measure the same discharge, which shall be kept constant within negligible variations.

To our best knowledge, we were the first to apply the interlaboratory method for computing the uncertainties of streamgauging techniques, according to the authoritative international documents (ISO standards). Several specific issues arise due to the measurements conditions in outdoor canals and rivers. The main limitation is that the best available river discharge references are usually too uncertain to quantify the bias of the streamgauging technique, i.e. the systematic errors that are common to all participants in the experiment. A reference or a sensitivity analysis to the fixed parameters of the streamgauging technique remain very useful for estimating the uncertainty related to the (non quantified) bias correction. In the absence of a reference, the uncertainty estimate is referenced to the average of all discharge measurements in the interlaboratory experiment, ignoring the technique bias. Simple equations can be used to assess the uncertainty of the uncertainty results, as a function of the number of participants and of repeated measurements.

The interlaboratory method was applied to several interlaboratory experiments on ADCPs and current-meters mounted on wading rods, in streams of different sizes and aspects, with 10 to 30 instruments, typically. The uncertainty results were consistent with the usual expert judgment and highly depended on the measurement environment. Approximately, the expanded uncertainties (within the 95% probability interval) were $\pm$5% to $\pm$10% for ADCPs in good or poor conditions, and $\pm$10% to $\pm$15% for currentmeters in shallow creeks. Due to the specific limitations related to a slow measurement process and to small, natural streams, uncertainty results for currentmeters were more uncertain than for ADCPs, for which the site-specific errors were significantly evidenced.

The proposed method can be applied to a wide range of interlaboratory experiments conducted in contrasted environments for different streamgauging techniques, in a standardized way. Ideally, an international open database would enhance the investigation of hydrological data uncertainties, according to the characteristics of the measurement conditions and procedures. Such a dataset could be used for implementing and validating uncertainty propagation methods in hydrometry.