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Entropy-maximization method of discharge determination revisited: a stochastic-deterministic framework for estimating spatial velocity profiles in open-channel flow and its implications for sampling

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In this work, we investigate how a stochastic approach for discharge determination can balance, and eventually optimize the effort expended on the velocity measurements with the statistical accuracy and confidence level of the estimated discharge.
A standard practice for estimating the discharge at a cross-section of a channel is to point-sample the velocity field, assuming steady-state hydraulics and stable channel geometry (measurable with good accuracy over short times). Such a practice is tedious, often dangerous, and even infeasible under high flows; the non-uniform longitudinal velocity is sampled at multiple locations in a cross-section, commonly at 20%, ∼60% and 80% of the depth on a number of verticals. The selection of those locations is semi-empirical; it is guided by an idealized deterministic model, e.g. the Prandl-von Karman logarithmic velocity profile of normal, turbulent flow in an infinitely wide channel.
Here, we revisit the maximum-entropy based stochastic framework for discharge estimation in natural open channels and show specifically how it can be linked to deterministic velocity distributions. Also, we discuss options of velocity-depth sampling in which the locations of verticals and points on them can be selected based on mathematically convenient and suitable for practice probability density distribution functions (pdf) as well as on the chosen stochastic model.
We demonstrate, with laboratory and field data, applications for channels of different cross-sectional shapes with relatively large mean-width to depth ratio. Using the theory of entropy maximization, we compare results for the longitudinal velocity and for the velocity sampling locations characterized by uniform, exponential –with and without maximum-velocity restriction– or Gaussian pdf.
We find that the velocity's pdf is closely Gaussian. Therefore, the confidence intervals of the sampling characteristics can be determined according to the selected confidence level and the desired statistical accuracy. Regarding the sampling strategy, we show that the choice of a uniform distribution of sampling points is both convenient and adequate.

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