Dimensional analysis and intercomparison of the basin time of concentration formulas

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A wide literature dealing with the assessment of the critical time scale for basin hydrologic response exist worldwide. The time of concentration (t_C) is recognized as the most frequently used time parameter, followed by the lag time (t_L). However, despite the high sensitivity of design flood peaks to the estimated time parameter values, there is still no agreement on the conceptual and operational definitions of these two parameters, resulting in several different approaches and formulations available.

In our work, we suggest a conceptual approach to validate formulas of the basin time of concentration, with the aim of drawing some guidance in the choice of a robust formulation to be used in hydrological modelling and hydrograph design. To this end, 47 empirical and semi-empirical formulations to quantify t_C have been selected and their structure compared in dimensional terms, using the hydraulic Chezy formula as a litmus paper. Using the river network morphology of 197 watersheds in north-western Italy we have then examined and compared the variability of the estimated average flow velocity within the most hydraulically compatible formulas.

Mindful of recent outcomes on tracer studies (see Azizian, 2019), our results lead to justify some of the coefficients of just a few of the empirical expressions of the critical basin travel time and to further clarify the distinction between t_C and t_L, according to some theoretical justifications discussed in Beven (2020).