



Time of concentration of small sub-tropical basins

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The time of concentration (T_c) can be defined as the time a particle of water takes to travel from the hydraulically most distant point to the watershed outlet. The T_c is frequently used as input parameter in hydrological models and flood control alert systems. Usually the T_c equations such as Dooge and Kirpich are empirical and their constituent parameters are physical characteristics of watershed, not considering events characteristics, as soil moisture and rainfall volume. The event characteristics can infer two points: i) the definition of the hydraulically most distant point; and ii) the mean velocity. In Brazil, the Kirpich equation is widely used. During the XXII Brazilian Symposium of Water Resources in 2017, there was a debate about T_c on tropical and sub-tropical region carried out by government officers and researchers. The debate conclusions were: i) Kirpich equation can be reformulated for tropical and sub-tropical watersheds, because the fault reaches 500%; and ii) As T_c values largely vary for different events, the determination of only a single T_c value for a watershed is not appropriate. Based on these conclusions, we proposed an empirical equation calibrated in three watersheds (64.4, 11.4 and 6.9 km²) located in the sub-tropical region, southern Brazil. The procedures adopted to determinate T_c value for each event were: i) determination of baseflow using digital filter; ii) determination of excess rainfall using the Curve Number; and iii) determination of T_c as the time from the center of mass of excess rainfall to the time of the peak of total runoff. Totally 24 events were analyzed. The equation, including events characteristics and physical watershed characteristics has the following configuration: $T_c = a \left(\frac{L}{\sqrt{S}} \right)^b P^c$, where T_c is the time of concentration (hour); L is the length of main channel (km); S is the slope (m/m); P is excess rainfall; and a , b and c are dimensionless parameters with values of 1.5, 0.3 and 0.2, respectively. The evaluation of the equation efficiency was made using objective function Nash-Sutcliffe. It is noticed that the physical characteristics of the watershed exert a greater weight in the equation than the event characteristics, indicating that the watershed structure is more relevant than the event. The errors of T_c values estimated with Kirpich equation in relation to those with the proposed equation is 277% higher. The errors regarding T_c tend to decrease as excess rainfall increases. This fact confirms the reason to insert the event characteristics into the T_c equation.