The time of concentration, \( t_c \), is a key hydrological concept and often is an essential parameter of rainfall-runoff modelling, which has been traditionally tackled as a characteristic property of the river basin. However, both theoretical proof and empirical evidence implicate that \( t_c \) is a hydraulic quantity that depends on flow, and thus it should be considered as variable and not as constant parameter. Using a kinematic method approach, easily implemented in GIS environment, we illustrate that the relationship between \( t_c \) and the effective rainfall produced over the catchment is well-approximated by a power-type law, the exponent of which is associated with the slope of the longest flow path of the river basin. Next, we take advantage of this relationship to adapt the concept of varying time of concentration within flood modelling, and particularly the well-known SCS-CN approach. In this context, the initial abstraction ratio is also considered varying, while the propagation of the effective rainfall is performed through a parametric unit hydrograph, the shape of which is dynamically adjusted according to the runoff produced during the flood event. The above framework is tested in a number of Mediterranean river basins in Greece, Italy and Cyprus, ensuring faithful representation of most of the observed flood events. Based on the outcomes of this extended analysis, we provide guidance for employing this methodology for flood design studies in ungauged basins.

2. The time of concentration enigma

- Mainstream (one out of many) definition: Longest travel time of surface runoff to the basin outlet, where surface runoff initially appears as floodwaters, thus \( t_c \) is considered as constant (Efratadiadis et al., 2014).
- Early attempts to associate \( t_c \) to rainfall intensity are attributed to Izzard (1946).

Exponent \( \beta \) is a key hydrological concept and often is an essential parameter of rainfall-runoff models, thus it should be considered as variable and not as constant parameter. Using a kinematic method approach, easily implemented in GIS environment, we illustrate that the relationship between \( t_c \) and the effective rainfall produced over the catchment is well-approximated by a power-type law, the exponent of which is associated with the slope of the longest flow path of the river basin. Next, we take advantage of this relationship to adapt the concept of varying time of concentration within flood modelling, and particularly the well-known SCS-CN approach. In this context, the initial abstraction ratio is also considered varying, while the propagation of the effective rainfall is performed through a parametric unit hydrograph, the shape of which is dynamically adjusted according to the runoff produced during the flood event. The above framework is tested in a number of Mediterranean river basins in Greece, Italy and Cyprus, ensuring faithful representation of most of the observed flood events. Based on the outcomes of this extended analysis, we provide guidance for employing this methodology for flood design studies in ungauged basins.

3. GIS-based hybrid approach for associating basin’s response time to rainfall

- Kinematic approach, employed along the mainstream of the basin, discretized into a relatively small number of segments according to a user-specified flow accumulation threshold (Fig. 3).

4. Study basins and input data

- The method was tested at 24 small to medium-sized Mediterranean river basins in Italy, Greece and Cyprus (Table 1).

5. Investigation of response time vs. runoff intensity relationships across basins

- At each basin, we ran the algorithm for six fixed values of runoff depth, \( i = P - P_c \) (i.e. 0.1 for concrete, 0.03 for earth channels).

6. Towards establishing a regional formula for varying \( t_c \)

- After testing various parametrizations, we concluded that the time of concentration can be expressed by a generalized power-type model, whose parameters \( a \) and \( b \) are expressed as functions of basin’s characteristics, i.e. \( t_c = a i^b \).

7. 7. Tinkering the Synthetic Unit Hydrograph and the SCS-CN method

- The unit hydrograph approach allows implementing the concept of varying \( t_c \) within flood modelling.

8. Model validation

- Calibration of initial loss, time to peak and base time parameters in 70 events of various basins, i.e. by considering a varying \( t_c \) within the same event dependent on the effective rainfall intensity of each time step.

9. Conclusions

- Recent advances in literature argue that \( t_c \) depends not only on the hydraulic characteristics of the basin but also on rainfall intensity.

10. References


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