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New morphometric properties for channel network classification using the graph theory and DEM

R. Moussa (1), F. Colin (2), M. Rabotin (1), and A; Crabit (1)

(1) Institut National de la Recherche Agronomique, UMR LISAH, Montpellier Cedex 1, France (moussa@supagro.inra.fr, 0033-4-67-63-26-14), (2) Montpellier SupAgro, UMR LISAH, 2 Place Pierre Viala, 34060 Montpellier, France

The channel network controls the spatial pattern of hydrological processes within a catchment. Hence the identification of key hydrological features characterising the channel network can contribute to a rational classification of catchments. This presentation aims to investigate morphometric properties of the channel network derived from DEM using the graph theory, and estimate whether these properties can be used as similarity indices for the classification of channel networks. The graph theory was used in order to represent the contributing drainage area which has properties of a scale free network, and was subsequently characterised by highly connected nodes called hubs. The method involves ranking the hubs of a channel network according to the contributing drainage area and the distance to the outlet. The hubs' characteristics can be considered as morphometric descriptors of the channel network and are used to compare and classify channel network. Applications were conducted on 788 French catchments with the same area (between 100 and 105 km^2) and on 18 catchments having an area between 43 and 116450 km^2.

First, we present some newly found invariance properties of headwater subcatchments and show that some invariant morphometric properties characterize only natural channel networks verifying Optimal Channel Networks (OCN) properties, but are not verified for non-OCN (Moussa et al., 2011, Water Resources Research, 47, W08518). A new empirical model based on self-affine properties was developed in order to calculate the number N and the total headwater area H as a function of the cutoff area S used to extract the channel network from DEM. Results show that H(S) / S0 (S0 being the catchment area) is independent from S and seems constant (0.29 +/- 0.03) for various shapes and sizes of channel networks, and consequently can be considered as invariant general descriptor of natural channel networks. On the contrary, this is not the case when the approach is applied on virtual non-OCN.

Second, we define new morphometric descriptors on the basis of hub's properties in order to compare channel networks and to answer the following questions: are there any similar channel networks referred as 'twins'? and what channel network resembles most to an other given channel network? (Moussa et al., Water Resources Research, submitted). Two ways of classifications are proposed: the first one according a supervised procedure based on 8 types and a second one according a nested hierarchy considering the main hub as the key factor of the classification. Hence, we identify twelve twins networks among the 788 studied.

These results show that the knowledge of six morphometric indices enable to calculate both functions N(S) and H(S) for all values of S < S0. These indices can be considered as geometric and topological properties of channel networks, and are useful for studying the effects of cutoffs on self-affine river networks or as similarity indices for channel network comparison.