Geophysical Research Abstracts
Vol. 12, EGU2010-10251, 2010
EGU General Assembly 2010

What controls the width function shape, and can it be used for channel network comparison and regionalization ?

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The width function captures the essential features of the catchment's Geomorphologic Instantaneous Unit Hydrograph (GIUH) response. This paper aims to identify the morphometric properties which control the shape of the width function, and assess whether these properties can be used as similarity indices for catchment comparison (see Moussa R. 2008. What controls the width function shape, and can it be used for channel network comparison and regionalization?. Water Resources Research, 44, 20 p., W08456, doi:10.1029/2007WR006118). A new deterministic iterative model of the width function is proposed on the basis of a conceptualization of the topology of the channel network, and exploiting the morphometric characteristics of internal and external nodes. Tests are carried out on eleven French catchments and compared to the reference Peano catchment. Results show that the morphometric properties of three main internal and external nodes such as the drained area, the distance to the outlet and the position on the channel network, are useful descriptors for modeling the width function and for representing the scaling properties of a channel network. While the GIUHs based on Horton-Strahler ratios are strongly related to the method used to extract the channel network from the DEM, the new indices defined herein are independent of the method used. They are sufficient descriptors to reproduce the main shape of the width function, the peak, the time to peak, and the main properties such as non-negativity, non-stationarity and power law decay of the spectrum. They may be used to establish catchment typology, to compare catchments, and to classify the width function peaks for catchment regionalization.

Despite its simple conceptual structure, the width function model developed in this paper seems to capture the main morphometric factors which control the width function shape. The morphometric properties of both internal and external nodes of the channel network, are characteristic descriptors of the channel network topology and consequently of the resulting width function. They can also be integrated in an iterative modeling approach and be used to generate the width function, on the basis of a simple conceptualization of the geometrical structure of the channel network and exploiting few and easily accessible data from DEM analysis. The paper shows also that the coarse-grain of the width function can be captured by a few characteristics of the channel network. The results show that the width function is controlled by the morphometric properties of the three main internal nodes (noted I1, I2 and I3 chosen to be the nodes whose tributaries drain the largest areas) : the associated three threshold areas (S1, S2, S3), the distances to the outlet (OI1, OI2, OI3; O being the outlet) and the catchment type. Alternatively, the details of the channel network can be modeled statistically using self-similar properties of the channel network. Hence one may view the proposed model as intermediate between completely deterministic calculation and a completely stochastic characterization of the width function. The applications show that the model verifies the known self-similarity properties of the channel network such as non-negativity, non-stationarity and power law decay of the spectrum.

It is also suggested that the characteristics that determine the coarse-grain properties of the width function can be used to define new indices for channel network comparison and regionalization. Non-dimensionalized new indices were defined on the basis of the properties of internal and external nodes (S1/S0, S2/S0, S3/S0, , OE/S0**0.5, OI1/S0**0.5, OI2/S0**0.5, OI3/S0**0.5, S0 being the catchment area). These indices are useful for modeling the width function, and for representing scaling properties of a channel network. The new indices were used for catchment comparison, for establishing a catchment typology, and for comparing and classifying the width function peaks of various channel networks. Automated classification offers a large number of advantages

such as rapidity, objectivity, reproducibility and precision.

The width function is important for hydrologic applications. It can be used as a transfer function in lumped hydrologic models, under the assumption of uniformly spatially distributed effective rainfall, especially for flood modeling when surface runoff is the main component of the hydrograph at the outlet. It can be used to guide the hydrologist in comparing ungauged catchments for regionalization, in establishing experimental designs (i.e. choice of streamflow monitoring location) and/or distributed modeling (i.e. catchement subdivision into subcatchments). Finally, the width function model presented herein represents a new approach for understanding and capturing the complexity of natural width functions at any given resolution.