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A streamflow routing approach to address temporal change in streamflow response

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Temporal variation in the statistical characteristics of the discharge time-series can be noticed in several Swedish catchments where discharge has been measured for a long time period (~100 years). As the trend and its magnitude, can be different in catchments with geographic proximity, the investigated hypothesis is that the temporal change is, at least to some extent, caused by changes in the properties of the stream network. As changing the hydraulic mechanisms within the stream network will have a profound effect on the streamflow response, the primary emphasis in this study is on how stream network structure (distribution and topology of stream reaches) has changed over time.

The study is performed by setting up a distributed routing model for the stream network in its present geographic distribution as well as for distribution which has been obtained from historic maps that has been digitized. The travel time distribution through the stream network in the past and present case can thus be used as a descriptor to partly explain how the streamflow response has changed temporally.

By use of a distributed routing model based in hydromechanical relationships of energy and momentum, applied to a stream network, velocities are derived at quasi-stationary conditions for a range of discharges, reflecting the prevailing hydraulic mechanisms within stream networks. In the proposed methodology; backwater effects are also included as the downstream boundary conditions (water levels and velocity) are used when determining the slope of the energy line.

The results from the distributed routing model are primarily used to interpret the temporal variation in the statistical characteristics of the discharge time-series. Also, the results from the distributed routing modelling can be used as physically based parameters for the streamflow component of a hydrologic model, as the routing model gives rise to a catchment-specific, unambiguous relationship between mean travel time $<\tau>$ through the system and the catchment outlet discharge. The inverse of this $<\tau>$(Q)-relationship could then be used as the rate coefficient k (s-1) of a transfer rate coefficient in a hydrological compartment model (e.g. the HBV model). Previous studies indicate that the utilization of discharge(/stage)-dependent response functions in compartmental hydrological models, as opposed to conventional, stage-independent response functions, can substantially improve discharge predictions – especially for peakflow predictions.