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Influence of geomorphological properties and stage on in-stream travel time

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The travel time distribution within stream channels is known to vary non-linearly with stage (discharge), depending on the combined effects of geomorphologic, hydrodynamic and kinematic dispersions. This non-linearity, implying that stream network travel time generally decreases with increasing discharge is a factor that is important to account for in hydrological modelling – especially when making peak flow predictions where uncertainty is often high and large values can be at risk.
Through hydraulic analysis of several stream networks, we analyse how travel time distributions varies with discharge. The principal focus is the coupling to the geomorphologic properties of stream networks with the final goal being to use this physically based information as a parameterisation tool of the streamflow component of hydrologic models.

For each of the studied stream networks, a 1D, steady-state, distributed routing model was set up to determine the velocities in each reach during different flow conditions. Although the model (based in the Manning friction formula) is built on the presence of uniform conditions within sub-reaches, the model can in the stream network scale be considered to include effects of non-uniformity as supercritical conditions in sections of the stream network give rise to backwater effects that reduce the flow velocities in upstream reaches in the stream.
By coupling the routing model to a particle tracking routine tracing water "parcels" through the stream network, the average travel time within the stream network can be determined quantitatively for different flow conditions.
The data used to drive the model is digitised stream network maps, topographical data (DEMs). The model is not calibrated in any way, but is run for with different sets of parameters representing a span of possible friction coefficients and cross-sectional geometries as this information is not generally known.
The routing model is implemented in several different stream networks (representing catchments of the spatial scale of a few hundred km2) in different geographic regions in Sweden displaying different geomorphological properties.

Results show that the geomorphological properties (data that is often available in the form of maps and/or DEMs) of individual stream networks have major influence on the stream network travel times. By coupling the geomorphological information to general expressions for stage dependency, catchment-specific relationships of how the travel times within stream networks can be determined.
Basing the parameterisation procedure of a hydrological model in physical catchment properties and process understanding rather than statistical parameterisation (based in how a catchment has responded in the past) – is believed to lead to more reliable hydrological predictions - during extreme conditions as well as during changing conditions such as climate change and landscape modifications, and/or when making predictions in ungauged basins.