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Estimation of low flow sensitivity to climate and land-use changes using a parsimonious water balance model

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There is considerable interest in systematically estimating the impact of climate and environmental changes to particular characteristics of hydrological regimes across large regions. This study presents the development and first application of a regionalised parsimonious model to estimate the sensitivity of the summer low flow period in British Columbia, Canada. Here, summer low flows are maintained through the release of water from groundwater storage, flow from channel banks, lakes and wetlands. Low flows are important for water-supply planning and design, and maintenance of quantity and quality of water for irrigation, recreation, and fish and wildlife conservation. There have been concerns recently that climate warming and land cover changes due to an unprecedented pine beetle epidemic may cause a deterioration of water quality during low flow periods and at certain times may become a hazard to ecosystem and to water management schemes.

A parsimonious water balance model based on a simple transfer function approach was developed to characterize the recession curve of the hydrological regime. The purpose of the model is to transform a distributed effective water input into a characteristic hydrologic regime at the outlet of the catchment. The distributed effective water input is derived from gridded 30-year mean monthly precipitation and temperature data (disaggregated to a daily resolution) that is first modified by evapotranspiration and by a degree-day based snow accumulation and snowmelt model.

The two model parameters of the non-linear transfer function were fitted to the characteristic hydrographs of a sample of gauged catchments with different size, elevation, climate, and hydrological regime. Based on their relation to catchment characteristics, the model parameters were then regionalized for a large area of British Columbia. A first application estimates the sensitivity of the low flow season to simple delta-change climate scenarios for third-order watersheds in the region. The potential of the model as low flow change prediction tool is assessed considering uncertainty estimates. In particular regions, hydrological persistence provides some limitations.