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Understanding the Combined Influence of Boreal Landuse and Climate Change on Catchment Functioning through Virtual Forest Alterations

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The available scientific literature on hydrological climate change impacts in boreal regions in northern Europe consistently suggests increasing amounts of annual river streamflow. In these regions, the present-day streamflow regimes with low winter flow and a dominating snow-melt driven spring flood peak will transform to regimes with a much lower amplitude and an earlier initiation and peaking of the spring flood. Such changes lead to alterations of flow duration curves, indicating lower chances for both high and low flows in a future warmer climate.
The question arises as to whether one can draw such generalized conclusions in terms of future hydrological changes for a larger boreal region based on a selection of representative catchment studies. One could argue that nearby catchments within the same climate zone should function in similar ways, which means that conclusions can be drawn for a larger region with the same climate conditions. It is, however, well acknowledged that present-day hydrological functioning and the variability at multiple temporal and spatial scales are not only controlled by external climatic conditions, but also by physical properties such as topographic features, soil characteristics, catchment area, land cover, vegetation type or geology. Consequently, this raises the question as to what extend variability in projected future streamflow changes is predetermined by the landscape characteristics in a catchment.
To answer this question, we explored how landscape characteristics such as topography, geology, soils and land cover influence the way boreal catchments respond to changing climate conditions. Based on an ensemble of 15 regional climate models bias-corrected with a distribution-mapping approach, present and future streamflow in 14 neighbouring and rather similar catchments in Northern Sweden was simulated with the HBV model. We established functional relationships between a range of landscape characteristics and projected future changes in streamflow signatures, which were then used to analyse hydrological consequences of physical catchment perturbations in a climate change context. We created three virtual forest change cases and made an attempt to predict the combined influence of boreal landscape forms and climate change in these cases.
Our analysis showed a strong connection between the forest cover extend and the sensitivity of different components of a catchment's hydrological regime to changing climate conditions, which emphasizes the need to redefine forestry goals and practices in advance given climate change-related risks and uncertainties.