Warming soil temperature and increasing baseflow in response to recent and potential future climate change across northern Manitoba, Canada

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Abstract

This study investigates the impacts of climate change on the hydrology and soil thermal regime of ten sub-arctic watersheds (northern Manitoba, Canada) using the Variable Infiltration Capacity (VIC) model. We utilize statistically downscaled and bias-corrected forcing datasets based on 17 general circulation model (GCM) - representative concentration pathways (RCP) scenarios from phase 5 of the Coupled Model Intercomparison Project (CMIP5) to run the VIC model for three 30-year periods: a historical baseline (1981–2010), and future projections (2021–2050: 2030s and 2041–2070: 2050s), under representative concentration pathways (RCPs) 4.5 and 8.5. The CMIP5 Multi-Model Ensemble (MME) mean-based VIC simulations indicate a 15–20% increase and 10% decrease in the projected annual precipitation and snowfall, respectively over the southern portion of the basin and >20% rainfall increase over the higher latitudes of the domain by the 2050s. Snow accumulation is projected to decline across all sub-basins, particularly in the lower latitudes. Projected uncertainties in major water balance components (i.e., evapotranspiration, surface runoff, and streamflow) are more substantial in the wetland and lake-dominated Grass and Gunisao watersheds than their eight counterparts. Future warming increases soil temperatures >2.5°C by the 2050s, resulting in 40–50% more baseflow. Further analyses of soil temperature trends at three different depths show the most pronounced warming in the top soil layer (1.6°C 30-year-1 in the 2050s), whereas baseflow increases substantially by 19.7% and 46.3% during the 2030s and 2050s, respectively. These results provide crucial information on the potential future impacts of warming soil temperatures on the hydrology of sub-arctic watersheds in north-central Canada and similar hydro-climatic regimes.

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