Impact of meteorological forcing data on snowpack and streamflow simulations in the Canadian Rockies

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Abstract

This study evaluates hydrological simulations of streamflow and snowpack regimes in the Canadian Rockies using various sources of meteorological forcing data. Hydrological models were created using the Cold Regions Hydrological Modelling platform (CRHM) for two mountain forest headwater basins: Marmot Creek Research Basin (~9.4 km^2) and Fortress Mountain Basin (~5.9 km^2). These models were parameterized from local field research findings to represent the relevant streamflow generation processes: wind redistribution of alpine snow, snow avalanching on steep alpine slopes, snow interception, sublimation, drip and unloading from forest canopies, infiltration to frozen and unfrozen soils, overland and detention flow, hillslope sub-surface water redistribution, and evapotranspiration from forests, clearings and alpine tundra. In-situ hourly observations from 14 high altitude weather stations, near-surface output from Environment and Climate Change Canada's 2.5-km Global Environmental Multiscale (GEM) atmospheric model in forecast mode (no bias correction), and bias corrected near-surface outputs from the 4-km Weather Research and Forecasting (WRF) model were used to drive the hydrological models. Air temperature, relative humidity, wind speed, incoming shortwave radiation, and precipitation were extracted from stations and atmospheric models over each basin, and then interpolated by elevation to hydrological response units within each basin to drive the hydrological models over November 2014 to August 2017. Simulations of snowpack and streamflow using station data were acceptably good without calibration of model parameters. The snowpack simulations using GEM showed errors as modelled wind fields did not reflect the high wind speeds measured over ridges and GEM misrepresented winter precipitation dynamics. Streamflow simulation using GEM output for Marmot Creek was impacted by overestimation of late-lying snowcovers in the alpine due to overestimation of precipitation, while underestimation of precipitation from GEM output caused poor streamflow simulation for Fortress Mountain Basin. GEM-driven models therefore missed both the timing and magnitude of seasonal streamflow. WRF outputs were bias corrected using the quantile delta mapping (QDM) method with respect to station data during October 2005-September 2013 at Marmot Creek. Snowpack and streamflow simulations using the bias-corrected WRF outputs were much better than these using uncorrected outputs and achieved comparable predictability to simulations driven by station data.