Geophysical Research Abstracts, Vol. 7, 04910, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04910

Climate change impacts on flooding in the Elbow River watershed

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SSARR, a lumped, black-box model developed by the USACE and a physically-based distributed model known as PRMS/MMS developed by the USGS were modified and calibrated for a 1200 km^2 watershed in the foothills of the Rocky Mountains known as the Elbow River Watershed. Calibration and verification of both of these models involved long term (April 1 – Aug. 31) and short term (single events within 10 days) simulation periods selected from five years of data at 3 hour time-steps (SSARR model) and 1 hour time-steps (PRMS). The SSARR modeled the watershed with only two subcatchments and PRMS modeled the watershed with 50 HRUs, 50 runoff planes and 64 channel segments.

The impacts of climate change on the Elbow River Watershed were investigated used scaled estimates of temperature and precipitation from the Canadian Regional Climate Model (CRCM) obtained from the Canadian Centre for Climate Modelling. Monthly normal temperatures and precipitation values for the CRCM grid cell nearest to the watershed were obtained for current CO_2 conditions (1974-1984) and a doubling of CO_2 (2040-2049). Statistical downscaling consisted of converting temperatures to Farenheit and then monthly scaling factors for the future condition were obtained by taking ratios of the $2CO_2$ temperature data to current condition temperatures. The average monthly temperature factor was 1.09. Similar factors were computed for monthly precipitation which increased in the spring but decreased in the summer to provide an average of 0.99. Simulations were conducted each with PRMS and SSARR by first using scaled temperatures, then scaled precipitation and then scaled both temperature and precipitation. While these factors were derived from monthly values, the same factors were used to scale the calibration and verification flood events at the 1

and 3 hour timesteps for PRMS and SSARR, respectively.

Peak flow rates, volumes and times to peak were documented along with the full hydrographs. When temperature changes alone were considered, the PRMS (SSARR values shown in brackets) modeled a decrease in the largest flood's peak flow of 14% (21% decrease) and an average of 12% (13% decrease) in all test years. When considering precipitation alone, PRMS modeled a decrease of 12% in the largest flood's peak (24% increase) but a significant increase of 30% (46% increase) in peak flow for all the test year events. This was believed to be due to in part to the fact that the 1995 flood event, which was one of the largest on record, occurred later in the summer than the major flood events in the other years which occurred in the spring. When both temperature and precipitation were considered, the late flood of 1995 saw a decrease in peak flow of 20% (20% decrease for SSARR) but when all test years were combined, peak flows increased on average by almost 20% (26% increase for SSARR). Both the black-box lumped model and the physically-based distributed model produced similar outcomes when combining precipitation and temperature changes, yet both models used different evapotranspiration, soil moisture and snowmelt schemes.