Geophysical Research Abstracts
Vol. 16, EGU2014-4731, 2014
EGU General Assembly 2014

Performance assessment of Saskatchewan's water resource system under uncertain inter-provincial water supply

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The trans-boundary Saskatchewan River Basin supports livelihoods and the economy of the province of Saskatchewan, Canada. Water users include irrigated agriculture, hydropower, potash mining, urban centers, and ecosystem services. Water availability in Saskatchewan is highly dependent on the flows from the upstream province of Alberta. These flows mostly originate from the Rocky Mountains headwaters and are highly regulated, due to intensive water use and redistribution before they get to the Alberta/Saskatchewan border. Warming climate and increasing water demands in Alberta have changed the incoming flow characteristics from Alberta to Saskatchewan. It is critical to assess the performance and the viability of Saskatchewan's water resources system under uncertain future inter-provincial inflows. For this purpose, a possible range of future changes in the inflows from Alberta to Saskatchewan is considered in this study. The considered changes include various combinations of shifts in the timing of the annual peak and volumetric change in the annual flow volumes. These shifts are implemented using a copula-based stochastic simulation method to generate multiple realizations of weekly flow series at two key locations of inflow to Saskatchewan's water resources system, in a way that the spatial dependencies between weekly inflows are maintained. Each flow series is of 31-years length and constitutes a possible long term water availability scenario. The stochastically generated flows are introduced as an alternative to the historical inflows for water resources planning and management purposes in Saskatchewan. Both historical and reconstructed inflows are fed into a Sustainability-oriented Water Allocation, Management, and Planning (SWAMP) model to analyze the effects of inflow changes on Saskatchewan's water resources system. The SWAMP model was developed using the System Dynamics approach and entails irrigation/soil moisture, non-irrigation uses and economic evaluation sub-models, with the capacity to investigate alternative environmental flow requirements. The long term changes in the performance of the Saskatchewan's water resources system with respect to the considered shifts in the inflow regime are quantified using different assessment indices. Indices, such as vulnerability and reliability, are visualized in 2D maps in which the axes are describing the shifts in streamflow characteristics. Results indicate that the economy and environment in Saskatchewan are sensitive to the shifts in Alberta's streamflow regime. Most importantly, hydropower production, lake levels, and the apportionment to the downstream province of Manitoba are among the most sensitive components of the water resource system.