Geophysical Research Abstracts
Vol. 19, EGU2017-12230, 2017
EGU General Assembly 2017

Application of global datasets for hydrological modelling of a remote, snowmelt driven catchment in the Canadian Sub-Arctic

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Hydrological modelling in the Canadian Sub-Arctic is hindered by the limited spatial and temporal coverage of local meteorological data. Local watershed modelling often relies on data from a sparse network of meteorological stations with a rough density of 3 active stations per 100,000 km^2. Global datasets hold great promise for application due to more comprehensive spatial and extended temporal coverage.

A key objective of this study is to demonstrate the application of global datasets and data assimilation techniques for hydrological modelling of a data sparse, Sub-Arctic watershed. Application of available datasets and modelling techniques is currently limited in practice due to a lack of local capacity and understanding of available tools. Due to the importance of snow processes in the region, this study also aims to evaluate the performance of global SWE products for snowpack modelling.

The Snare Watershed is a 13,300 km^2 snowmelt driven sub-basin of the Mackenzie River Basin, Northwest Territories, Canada. The Snare watershed is data sparse in terms of meteorological data, but is well gauged with consistent discharge records since the late 1970s. End of winter snowpack surveys have been conducted every year from 1978-present.

The application of global re-analysis datasets from the EU FP7 eartH2Observe project are investigated in this study. Precipitation data are taken from Multi-Source Weighted-Ensemble Precipitation (MSWEP) and temperature data from Watch Forcing Data applied to European Reanalysis (ERA)-Interim data (WFDEI). GlobSnow-2 is a global Snow Water Equivalent (SWE) measurement product funded by the European Space Agency (ESA) and is also evaluated over the local watershed. Downscaled precipitation, temperature and potential evaporation datasets are used as forcing data in a distributed version of the HBV model implemented in the WFLOW framework.

Results demonstrate the successful application of global datasets in local watershed modelling, but that validation of actual frozen precipitation and snowpack conditions is very difficult. The distributed hydrological model shows good streamflow simulation performance based on statistical model evaluation techniques. Results are also promising for inter-annual variability, spring snowmelt onset and time to peak flows. It is expected that data assimilation of stream flow using an Ensemble Kalman Filter will further improve model performance.

This study shows that global re-analysis datasets hold great potential for understanding the hydrology and snowpack dynamics of the expansive and data sparse sub-Arctic. However, global SWE products will require further validation and algorithm improvements, particularly over boreal forest and lake-rich regions.