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Statistical analysis of present and future river water temperature in cold regions using downscaled GCMs data

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As a fundamental physical characteristic describing properties of surface waters, stream water temperature has a direct impact on the flora and fauna of aquatic systems through its influences on heat balance and many chemical processes in river systems. High stream temperatures can have adverse effects on fisheries resources by limiting fish habitat and mortality. Most of the variations in stream water temperatures is affected by a number of variables such as the depth of water, cloud cover, solar radiation, low flow, etc. In recent decades, climate change has been reported as an important source of aquatic disturbance at global scale. A good knowledge of stream water temperature is therefore essential in the management of stream water and aquatic resources. The main objectives of this study is to investigate the long term monthly and yearly variation of stream water temperatures in cold regions for both historical and future periods.

Firstly, the long-term trends (1961-2001) in the monthly and yearly time series of water temperature at Sapporo (Hokkaido, Japan) were identified. Using the multiple regression techniques, an empirical relationship is derived between monthly stream water temperatures and monthly atmospheric temperatures, monthly discharge, and some other factors as well, using the observed data between 1961 and 2001.

Furthermore, to predict the future stream water temperatures, the approach of downscaling the outputs of a global climate model (GCM) to a local scale is investigated by employing the Statistical Downscaling Model (SDSM) to downscale air temperature (T) in both the present and future climate scenarios (IPCC scenarios A2).

The above approach were applied to the Sapporo meteorological station in Japan by simulating the local scale daily temperature based on large scale atmospheric variables including National Center for Environmental Prediction (NCEP) reanalysis datasets (1961-2000) and a general circulation model (HadCM3) outputs (1961-2099) with a coarse spatial resolution of 2.5º latitude by 3.75º longitude. Results show that atmospheric predictors such as surface specific humidity, mean air T at 2 meter, and 500 hPa geopotential height are identified as the most relevant inputs to the downscaling model. Furthermore, the performance of the downscaling methods is compared for both calibration period (1961-1990) and validation period (1991-2000). The downscaling model's performance shows that SDSM is efficient for downscaling daily air T with R^2 index higher than 90%. The simulated yearly average air T (1961-2000) by using HadCM3 datasets also reproduced well the observed ones in the local station. Finally, based on the downscaled air temperature (2015-2039 and 2075-2099), the future river water temperature was predicted and its extreme value was statistically analyzed.