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On the Reconstruction of Paleo-hydrology: a Foundation for More Reliable Water Resources Management

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The design and management of water resource infrastructure have been generally based on the information available in the periods of observational record with the central, default assumption of stationarity. It is well known that this assumption is not true in general and the common practice of relying on the periods of observational record for the analysis of water resources is flawed. To understand and address the climate-driven non-stationarities in hydrologic variables in a region, one approach, which is still largely unexplored in many regions, is to analyse natural proxy records of hydroclimatic behaviour (such as tree-ring chronologies) over the past several centuries or millennia. There have been research activities in this "paleo-hydrology" field across the world demonstrating the existence of significant non-stationarities and extreme behaviours in climate and hydrology over the past couple of centuries, in the absence of greenhouse gas emissions.

On the basis of the science of dendrohydrology, which mainly aims to reconstruct paleo-hydrology, this study follows three objectives: (1) the identification of non-stationarities in different statistical properties of paleo-hydrologic time series, mainly the mean and covariance, (2) more effective quantification of uncertainties associated with the reconstructions of streamflow time series based on tree-ring chronologies, and (3) the generation of an ensemble of basin-wide paleo-hydrologic time series data. The Alberta portion of the Saskatchewan River basin (SRB), Canada, is used as a case study. Results indicate that the statistical properties of annual paleo-hydrologic time series in the basin, particularly the covariance structure, have undergone significant changes at different points in the history. The results also demonstrate that the reliability of tree-ring chronologies as proxies for hydrologic variables in the basin differs for different periods in time, as the range of uncertainty produced based on these proxies is variable over the decadal time scale. The reconstructed streamflow time series in this study provide a foundation for more reliable water resources management in the Saskatchewan River basin.