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Reconstruction of paleohydrology in semi-arid regions for water resources management: Opportunities and challenges

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Tree-ring based reconstruction of paleohydrology can be a valuable and important means to extend the available hydrological records for several centuries. Such record extension, when properly done, can improve water resources management and planning by making available realistic long records that reflect past short- and long-term hydrometeorological variabilities. This research highlights some of the important, and perhaps unresolved, issues in tree-ring based reconstruction of paleohydrology, especially in semi-arid regions. The relationships between tree growth, as represented by tree-ring chronologies (TRCs), runoff (Q), precipitation (P), and evapotranspiration (ET) are discussed within both statistical and hydrological contexts. The Oldman River Basin (OMRB), Alberta, Canada, is presented as a case study, with TRCs and hydrometeorological data used to demonstrate the relevant issues. Runoff and precipitation data were available through measurements, and actual evapotranspiration was estimated using a lumped conceptual hydrological model developed in this study for the OMRB. Correlation analysis was conducted to explore the relationships between TRCs and each of Q, P, and ET over the entire historical record (globally) as well as locally within the wet and dry subperiods. Global and local correlation strengths and linear relationships appear to be significantly different, particularly affecting tree-ring based inferences about the hydrology and wet and dry episodes from reconstructions made using regression models. This finding is not typically highlighted in the available literature. Reconstruction of paleoQ may also not be as credible as paleoP and paleoET. This is discussed within the context of the watershed storage and release functions. It was also found that a moving average window, of more than one year, of P and ET time series might be necessary for reconstruction of these variables using tree-ring chronologies. This study improves our understanding of the hydrology-tree ring chronology dynamics, which is important for the use of dendrohydrology in water resources management. The findings point to the importance of considering alternative reconstruction techniques, other than global regression methods. Using the long-term mean of the reconstructed runoff, precipitation, and evapotranspiration leads us to conclude that the uncertainty about the past climate can be similar in nature to that reported in literature regarding the future projections produced by General Circulation Models.