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Spatial and temporal variation patterns of tree ring data in the eastern Tibetan Plateau in relation to local and regional precipitation variations

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A common task in dendroclimatology is to determine the spatial scale of climate reconstruction using tree ring data. In this study, we analyzed tree ring data from a large region in the eastern Tibetan Plateau in relation to local and regional precipitation variations. The eastern Qaidam Basin of the northeastern Tibetan Plateau has produced many millennium-long moisture-sensitive tree ring chronologies. Using 49 ring-width chronologies from this region, we divided these series into 8 sub-regions based on results of rotated empirical orthogonal function analysis (REOF) refined by hierarchical clustering analysis for the common period 1801-2000. The most important factor of defining these divisions was sampling site location, although the sampling elevation (in relation to the upper and lower tree lines) also played a role. To understand how this region is featured in the context of a larger study region, we increased the analysis area to include the Qilian Mountains to the north and Animaqin Mountains and the source-region of the Yellow, Yangtze and Lancang (Mekong) Rivers to the south. This allowed us to divide 69 tree-ring series into 14 groups with 6 groups still located in the Qaidam region. Then we further expanded the analysis region to the entire eastern Tibetan Plateau with 95 tree-ring series and derived 16 sub-regions. We repeated the same process for precipitation data during 1954-2014 (current May-June and previous July to current June sums) for a dataset containing 55 weather stations in the northeastern Tibetan Plateau. We discovered that as the number of sub-regions was reduced, a core sub-region expanded from the Qaidam Basin, first to the south and southeast of the Qaidam Basin, and then enclosed the Qilian Mountains, Southern Qinghai Plateau, and the Western Sichuan Plateau. In this way, different regionalization schemes were constructed corresponding to the local and regional spatial scales of precipitation variations. Our results indicated that by combining REOF and hierarchical clustering analysis, it is possible to conduct objective regionalization with good alignment to known physiographic units in the study region. For each group (sub-region) of the tree-ring chronologies and precipitation data, we extracted the common patterns of temporal variations represented by the first EOF or principal component and then analyzed the relationships between regional precipitation and the tree-ring series. We discovered that the moisture-sensitive tree-ring series from the eastern Qaidam Basin presented the strongest spatial coherence in relation to the precipitation data in the eastern Tibetan Plateau. It is also interesting to note that some sub-regions can be grouped hierarchically into larger regions, while others tend to remain separate by themselves, suggesting different causes of regionalization at different spatial scales.