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Spatiotemporal climate and atmospheric circulation variability in Asia inferred from tree rings

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Abstract

Observed 20th century warming trends accompanied by more frequent weather extremes such as droughts or intense rainfall events have consequences for societies and environments alike. In Asia, where the majority of the population depend on agricultural productivity, recent climate change is likely to increase societal hardships. In order to quantify future climate variability, it is vital to understand past climate variability with respect to its magnitude, frequency and more importantly, its underlying physical processes. Since instrumental data scarcely extends into the pre-1950 era in Asia, annually resolved proxy data such as tree rings provide unique and continuous estimates of past climate and atmospheric circulation variability.

This thesis presents a comprehensive assessment of the relationship between tree growth and environmental factors using local to continental-scale tree-ring networks in Asia. In this regard, new tree-ring chronologies were developed for Central Asia in order to increase the spatial coverage of the existing proxy network. Analyses of five tree-ring width networks were conducted to identify the dominant climate and atmospheric circulation patterns that influence tree growth in Asia.

Based on 38 newly developed juniper (*Juniperus* sp.) tree-ring chronologies including 1069 trees from the northern Pamir-Alay and Tien Shan mountain ranges in Central Asia, the first detailed study of spatial patterns and temporal trends in species- and site-specific climate response was conducted. Our results show that juniper growth at lower elevation sites was significantly limited by drought conditions, which has increased in intensity over the past decades, hence, making those sites highly suitable for drought reconstructions. The majority of juniper trees at high elevation sites, however, showed a distinct growth-climate response shift. In the early to mid- 20th century, juniper growth was favored by warm summer temperatures, while in the most recent decades, it was negatively affected by increasing summer aridity.

By calculating a new index that represents the tree growth relevant circulation pattern at the site during the summer, it was possible to describe leading patterns of the atmospheric circulation for a regional- and a continental-scale tree-ring network in Asia. The main results indicate that pressure anomalies over northwestern Russia had a major impact on tree growth not only in continental regions but also in monsoon influenced parts of Asia. The identified tree growth relevant circulation patterns show a significant spatiotemporal resemblance to leading patterns of pressure anomalies from climate data. Furthermore, the tree growth derived circulation patterns show strong linkages to the North Atlantic sector even further back in time (as far as AD 1600), and can be linked to the Northern Hemisphere atmospheric circulation system.

The findings presented in this thesis enhance our understanding of the influence of environmental factors on tree growth in Asia. Moreover, tree rings are shown to be a highly suitable proxy for reconstructing and investigating past climate and atmospheric circulation variability in Asia.

Keywords Asia, atmospheric circulation, Central Asia, dendroclimatology, growth-climate relationship, objectively classified weather types, teleconnections, tree-ring networks.