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Tree ring-width study of conifers from the western Himalaya (India) and its relationship with climate fluctuations

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ABSTRACT

Tree-ring width studies have been carried out in different locations of the western Himalayas in relation to climate variability. The significant relationship between tree ring chronology and monthly climate variable, indicates that rising potential evapotranspiration over the region, may lead to insufficient moisture supply, resulting in increased moisture stress conditions over the region for trees, whereas, increased rainfall and frequent wet day frequency may work as a booster to sufficient moisture supply which promotes tree growth during the subsequent growing season. The study highlights an important role of spring season moisture availability in the development of annual ring width. The analysis of the relationship between tree growth and climate shows that the potential evapotranspiration (PET) over the region, has a stronger limiting impact on the development of tree growth than the temperature.

Keywords: Western Himalaya, Tree ring-width, Temperature**,** Potential evapotranspiration, Rainfall, Wet day frequency

INTRODUCTION

The mountain ranges across the Himalayan region form the highest topography barrier on the earth, playing a crucial role in controlling the monsoon rainfall across the Asian region. This region shows the vast diversity of climate at short distances. Particularly in terms of rainfall, it showed high variability in rainfall due to complex and diverse mountainous terrain. In contrast, temperature pattern trend, indicates a strong spatial coherence across the region (Yadav et al., 1999)

However, to understand the long-term climate fluctuations across the Himalaya, several dendroclimatic studies have been performed in absence of observed climatic data over the region (Hughes, 1992; Pant et al., 1998; Borgaonkar et al., 1999; Chaudhary et al., 1999; Cook et al., 2003, 2010; Yadav et al., 2004; Ram and Borgaonkar, 2013, 2014, 2016, 2017; Singh et al., 2017; Shah et al. 2018; Ram et al., 2018, 2019, 2020, 2024). They showed that the tree growth from the western Himalayas, have a very good potential to extend the climatic data before the instrumental period, indicating the significant relationship of tree growth with various climatic parameters in the Himalayan region. Moreover, Borgaonkar et al. (2011) have shown that the warmth winter has significant role in boosting of soil moisture for the growth of the trees. Singh and Yadav (2000, 2005) have further revealed the strong relationship between tree growth and warmth winter. Similarly, Cook et al. (2010) reported that the trees growth is more influenced by the soil moisture availability.

Nevertheless, most of the dendroclimatic studies over the Himalaya have been concentrated based on rainfall and temperature relationship with tree growth. In the present study, an attempt is made to understand the influence of regional climate on tree growth across the mountainous region utilizing several meteorological parameters (e.g., rainfall, wet day frequency, temperature, and potential evapotranspiration) and examining their impacts on tree growth processes. This study could be useful in identifying the dominant climate that influences tree growth, providing a better understanding of climate affecting tree growth development.

METHODOLOGY

Tree ring-width data

Cedrus deodara tree ring-width data from the Bhairoghati (Ram, 2022) and Jangla, located in the western Himalaya near the Gangotri region (Borgaonkar et al., 2009; Ram et al., 2018), have been analysed to examine the relation with climate (Figure 1), which are sourced from International tree ring data bank (ITRDB), (http://www.ncdc. noaa.gov/paleo/treering.html/). Dating errors in growth rings were verified using the standard cross-dating techniques with the help of specialized software (Stoke and Smiley, 1968; Holmes, 1983). Tree ring-width data were processed using the signal-free regional curve standardization technique (Cook et al., 2011) to preserve low- frequency climate signals in the series. The RCS_Sig Free software was used (Melvin and Briffia, 2008) to produce signal-free functions during standardizing. The resulting detrended series were averaged by using the bi-weight robust mean method to compute a site mean chronology. The Bhairoghati chronology extends to the period 1738-2004, while the Jangla chronology from 1538-2004 (Figure 1).

Climatic data

Due to the sparse distribution of meteorological stations in and around the sampling area, monthly data on rainfall, temperature, wet day frequency, and potential