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Influence of climate on multiple tree-ring parameters of *Pinus kesiya* from Manipur, Northeast India☆

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ABSTRACT

Tree-rings of *Pinus kesiya* from southern region of Manipur, Northeast India were used to develop chronologies of multiple tree-ring parameters that are: total-ring width (TRW), earlywood width (EW), latewood width (LW) and adjusted latewood (LW*adj*). The time span of these chronologies is 39 years (1980–2018 C.E.) and we compared their growth responses with monthly and daily climatic records. The comparison revealed a broadly consistent pattern of climate sensitivity with daily climate exhibiting higher correlation. The climate signals during pre-monsoon (March–May) were recorded in TRW and EW, whereas late-monsoon to post-monsoon climate signals were recorded in LW and LW*adj*. The spatial correlation analysis of tree-ring parameters and global sea surface temperature (SST) showed a positive relationship between tree growth with tropical Pacific Ocean and Indian Ocean during winter (December–February) and pre-monsoon (March–May) seasons. The LW and LW*adj* were also correlated with peak summer monsoon (July–August) SST over the tropical Pacific Ocean. IADFs observed in EW (E-IADF) were caused by dry and warm conditions during March–April. IADFs in LW (L-IADF) occurred due to a combination of enhanced rainfall and temperature during post-monsoon (October–November) season. Evidence of stand-specific micro-climatic conditions in the formation IADFs in this species was also found. This study showed that multiple parameters of *P. kesiya* provides a lucid understanding of climate response on its growth and can be considered as a proxy for studying sub-seasonal changes in past environmental conditions in longer records.

1. Introduction

The rise in global surface temperatures caused largely due to anthropogenic emission of greenhouse gases is expected to increase the intensity and frequency of extreme weather events (IPCC, 2014). In India, a rise in the frequency of warm extremes has also been recorded in the last three decades (1986–2015) with pre-monsoon season (March--May) accounting for strongest rate of warming at 0.29 °C per decade (Sanjay et al., 2020). An increase in the occurrence of dry spells accompanied by an increase in heavy rainfall events has been observed in India in the past several decades (Kulkarni et al., 2020). Intensification of droughts events, numbering over two per decade has been reported over various parts of the country during the 1951–2015 period, and is projected to increase in both space and time (Mujumdar et al., 2020).

Tree-rings are one of the most widely used high-resolution proxy for studying past environmental variability (Fritts, 1976; Speer, 2010; Bradley, 2015). The annual rings of conifers possess readily discernable bands of thin-walled cells with wide lumen called earlywood (EW), and thick-walled cells with narrow lumen called latewood (LW) that are formed during early and late growing seasons respectively (Fritts, 1976). Therefore, it has generally been observed that the EW and/or LW are more sensitive to climate compared to total ring width (TRW) and typically reflect sub-seasonal climate signals. The conifers of North America, for instance, are known to capture seasonal climatic conditions usually during late winter to early spring in the EW, and late spring to summer in the LW (Meko and Baisan, 2001; Villanueva-Diaz et al., 2007; Stahle et al., 2009; Meko et al., 2013; Crawford et al., 2015;

☆ Key Message: *Pinus kesiya* earlywood and latewood are sensitive to discrete intra-seasonal climate and the formation of intra-annual density fluctuations (IADFs) are related to site-specific climate variations.

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