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Regional tree-ring oxygen isotope deduced summer monsoon drought variability for Kumaun-Gharwal Himalaya

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ABSTRACT

The precipitation in the Kumaun-Gharwal (Uttarakhand) Himalaya (KGH) is predominantly regulated by the Indian summer monsoon (ISM) and has been declining over the last century. However, because of limited historical data, it is difficult to place this recent decreasing trend in the context of pre-anthropogenic influences and understand a fuller range of hydroclimate scenarios for the region. Thus, we developed a 508-year regional tree-ring stable oxygen isotope ($\delta^{18}O_{TR}$) record for multiple coniferous taxa (*Abies spectabilis*, *Cedrus deodara* and *Picea smithiana)* for the KGH, which spanned 1508–2015 CE. The $\delta^{18}O_{TR}$ record explained 35.8% of instrumental June–August Palmer Drought Severity Index (JJA_{PDSI}) variance modelled from a nearby meteorological station. The JJA_{PDSI} reconstruction shows regional coherency with both instrumental and proxy-based independent hydroclimatic records providing confidence that it is a reliable proxy to assess the long term hydroclimatic variability of the region. We identified decreasing strength of JJA_{PDSI} reconstruction in KGH during recent decades indicating intensified drought. This is in the context of pre-anthropogenic influences and understand a fuller range of hydroclimate scenarios for the region. The $\delta^{18}O_{TR}$ also has coherency with Pacific and Indian Ocean sea surface temperature variability illustrating the broader teleconnections that influence the regional hydroclimate.

1. Introduction

The development of long-term hydroclimatic record is essential for formulating comprehensive water management, agriculture-food security and adaptation strategies for different sectors in the Indian Himalayan region (Bhatt et al., 2015; Carvalho et al., 2020; Mal et al., 2022). To understand the present hydroclimate dynamics of the region, its future development and projection, it is important to determine the possible causes and forcing factors of existing changes and its trends. The hydroclimate of the Indian Himalayan region depends strongly on large-scale atmospheric circulation (Dimri et al., 2018; Rangwala et al., 2020) such as El Niño southern Oscillation (ENSO), which can be classified with the help of long-term records with its statistical properties. A study on spatial and temporal variation in daily precipitation indices over Western Himalayas comprising three sub-divisions by Indian Meteorological Department (IMD) viz., Jammu & Kashmir and Ladakh, Himachal Pradesh and Uttarakhand was carried out by Kumar et al. (2021). This study showed increasing trends in maximum accumulated precipitation in lower altitude stations and decreasing trends in higher altitude stations, which are observed in the monsoon season and vice-versa in the winter season during 1981–2014 CE.

The network of instrumental rainfall records of the Kumaun-Gharwal Himalaya (henceforth, KGH) are sparsely distributed and only few records cover the last century. A study was carried out by Basistha et al. (2009) to explore changes in rainfall pattern in the Uttarakhand State of Indian Himalayas during the 20th century

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