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Characterizing intra-annual density fluctuations using fine-spatial resolution blue intensity profiles

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Rapidly rising evaporative demand threatens forests in semi-arid areas around the world, but the timing of stem growth response to drought is often coarsely known. This is partly due to a shortage of sub-annual growth records, particularly outside the Mediterranean region where most intra-annual density fluctuation (IADF) chronologies are based. We anticipate that an automated, cost-effective, and easily implementable method to characterize IADFs could foster more widespread development of sub-annual chronologies. Here, we applied a peak detection algorithm to fine-spatial resolution blue intensity (BI) profiles of Ponderosa pine tree rings from two sites located in neighboring mountain ranges in southern Arizona (∼300 m elevation difference). This automated procedure proved reliable to isolate and characterize IADFs, thus offering an efficient and objective alternative to visual identification. Out of seven investigated BI parameters, peak height, width, and area showed satisfactory chronology statistics. We assessed the response of these BI and radial growth parameters to six monthly-resolved climate variables and to the onset date of the North American summer monsoon (NAM). The NAM is an atmospheric mode that provides a clear time marker for the termination of a pre-summer drought period (May-June) causing regular IADFs in trees growing near the dry margin of their distribution range. We observed divergent water limitation at the two sites, despite comparable site characteristics. Radial growth at the lower-elevation site depended mainly on winter precipitation, whereas the higher site relied on spring and monsoon precipitation. The pre-summer drought period indeed promoted IADFs in early ring portions at both sites. Yet, IADFs at the higher site were only formed, if spring was sufficiently humid to assume enough radial growth. Late-position IADFs were caused by a weak monsoon and additionally promoted by favorable conditions towards the end of the growing season. The contrast between sites is likely attributable to a three-week difference in the growing season onset, emphasizing the importance of growth phenology for drought impacts on forests in the US Southwest.