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Multiple tree-ring chronologies (ring width, δ^{13}C and δ^{18}O) reveal dry and rainy season signals in Indonesia

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The tropical Indonesian region plays a key role in the global climate system because of the enormous heat and moisture exchange between ocean and atmosphere in that area. Here, we evaluate the influence of rainfall variability on multiple tree-ring parameters of Teak (Tectona grandis) trees growing in a lowland rain forest in Central Java (Indonesia). Three, annually resolved, chronologies of tree-ring width, stable carbon (δ^{13}C) and oxygen (δ^{18}O) isotopes were developed for the twentieth century (1900-2007). Climate response analysis with regional rainfall data has revealed that all three tree-ring parameters are significantly sensitive to rainfall during different intervals of the seasonal monsoon pattern. The amount of rainfall at the beginning of the rainy season (Sep-Nov) is important for tree-ring width, confirming previous studies. The stable isotope records best represent slightly different sub-periods of the prime rainy season (δ^{13}C: Dec-May; δ^{18}O: Nov-Feb) with negative correlations. Tree-ring δ^{18}O additionally responds well to peak dry season rainfall with positive correlation. The correlations of opposite sign reflect the distinct seasonal contrast of the δ^{18}O signatures of rainfall during the dry (^{18}O-enriched rain) and rainy (^{18}O-depleted rain) seasons in conjunction with changing rainfall amount. Dry season periods with rainfall amounts above average have an exceptionally strong influence on tree-ring δ^{18}O in years with below average rainy season rainfall. In such cases, the dry season signal reduces the signal strength of the prime rainy season in tree-ring δ^{18}O. However, the rainy season signal is still strong and stable over the 20th century. Further, the δ^{18}O record correlates with several ENSO events, supported by spectral analysis which reveals significant peaks on the 2-4 year band. Highly resolved intra-annual δ^{18}O isotope analyses suggest that the signals of dry and rainy season can be distinguished clearly and demonstrate a new way of improving our understanding of variations and trends of the hydrological cycle at the Indonesian archipelago.