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^{17}O-excess of tropical forest and savanna phytoliths record diurnal atmospheric relative humidity of the growing season: implications for paleoclimate reconstructions and model-data comparisons

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In a changing climate, continental relative humidity (RH) is a key determinant of changes in surface water evaporation and ecosystem functioning. Accumulating evidence indicates that RH has been decreasing on a global scale over the continents since the late 20th century. However, the variability between Earth System Models (ESMs) for the prediction of RH is very large, especially for the intertropical zone. A comparison between models and data, applicable beyond the instrumental period, is therefore essential to improve the accuracy of RH estimates in ESMs. Here we present a synthesis of recent calibrations of a new proxy for past RH: the ^{17}O-excess of phytoliths ($^{17}O\text{-excess}_{phyto}$), which are micrometric particles of plant silica preserved in soils and sediments. We answer key questions: Are the calibrations performed to date applicable to the intertropical zone? Do soil phytoliths, which feed the sedimentary record, record daily or diurnal, annual or seasonal RH? Does this depend on the type of vegetation? What are the implications for the production of RH records to be used for model-data comparison?

For this purpose, we examine the seasonal evolution of the triple oxygen isotopic composition of plant water and phytoliths of three vegetation types at two sites of the AMMA-CATCH eco-hydrological observatory in the sub-humid zone of Benin and in the Sahelian zone of Senegal. The observatory provides unique data from long-term monitoring of vegetation, hydrology and meteorology. The isotopic compositions of stem and leaf water are compared to those of rainwater collected regularly over several years. The apparent isotopic fractionation between plant water and phytoliths is measured. The isotopic composition of leaf phytoliths is related to the average RH over the growth period of the collected plants. The isotopic composition of the soil phytolith is related to the daily and diurnal averages of annual and seasonal RH. The relationship is compared to the calibration equation. The local RH measured values are compared to the RH estimates from the WFDE5 bias-corrected ERA5 reanalysis, to provide a methodology for producing past relative humidity records usable for model-data comparisons. This study is part of the project HUMI-17 (ANR-17-CE01-0002-0).