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Atmospheric dryness recorded in tree rings of *Araucaria araucana* from the northwest of the Patagonian Steppe

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Dr. Jorge A. Giraldo, from Colombia, visited the Laboratorio de Dendrocronología de Zonas Áridas, Ladeza-CIGEOBIO (CONICET-UNSJ) in San Juan, Argentina, as a PAGES-IAI International Mobility Research Fellow (1 June–31 July 2023) to explore the dendrochronological potential of tree species from xeric ecosystems in South America to record vapor pressure deficit (VPD). Within this project, Jorge and his collaborators aim to increase knowledge of the long-term variability of VPD and its effects on tree growth over time.

Motivation

The sensitivity of forests to climate change in South America has been of interest to the scientific community over the past decades (Morales et al. 2020; Villalba et al. 2011). However, the scarcity of climatic records from field stations in this region limits our ability to detect the effect of climate change (Garreaud et al. 2009). Dendrochronology can provide valuable climate proxy records over long periods derived from annual tree rings. Therefore, extensive geographic sampling of old trees across an ecosystem can improve current climate databases and refine our inference ability about the role of climate on South American forests (Morales et al. 2020). Under global warming, air dryness (i.e. vapor pressure deficit: VPD) has markedly increased around the globe (Grossiord et al. 2020). VPD is a multidimensional variable combining temperature and relative humidity, enabling measurement of the atmospheric water demand from plants (Yuan et al. 2019). While much attention has been directed towards plant responses to temperature and precipitation independently (i.e. reconstructions of these variables), few studies have isolated the response of plant functioning toward reconstructions of VPD variability using tree-ring width.

Thanks to the support from this mobility research fellowship, it was possible to strengthen a collaborative network between tree-ring research groups from Colombia and Argentina, enabling the investigation of the dendrochronological potential of *Araucaria araucana*, a tree species from the northwest of Patagonia, to reconstruct VPD variation using tree-ring width.

Analysis

Applying standard dendrochronology techniques (i.e statistical and graphical cross dating), we analyzed available samples from three populations of *A. araucana* growing in xeric sites in Argentina (i.e. 131 trees and 244 cores; Fig. 1a), collected by Dr. M. Hadad and colleagues. The similarity between sites (i.e. climate and topography) and the crossdating allowed us to combine them into a single representative chronology for the area (Fig. 1b). Although the oldest tree dates back to 1190 CE, we built a chronology represented by more than five tree series which span from 1377–2019 CE. The measured subsample signal strength (SSS), which is a measure of the variance in common between a subset of samples and master chronology, was higher than 0.85, suggesting the suitability of the dendrochronological chronology for climate reconstructions (1588–2019 CE; Fig. 1b). We compared tree-ring chronology with VPD series estimated from the Climate Research Unit products (CRU). We found significant ($p < 0.05$) correlations between tree-ring chronology and monthly VPD from December ($r = -0.18$), January ($r = -0.38$), February ($r = -0.35$), March ($r = -0.30$), and the mean January–February VPD ($r = -0.46$) of the previous growing season. We compared the tree-ring width index to the mean January–February VPD record using the split calibration/verification method to test the reconstruction potential of this species. The chronology accounted for 55% of the variance in the calibration period (1982–2016 CE; $r = -0.76$, $p < 0.05$; Fig. 1c), while the full calibration period (1969–2016 CE) explained 44% of the variance (Fig. 1d). In addition, the positive values of reduction of error (RE: 0.64), and the coefficient of efficiency (CE: 0.36) indicate a stability of the relationship, which suggests the suitability of the chronology to be used in reconstructions of VPD back in time.

In conclusion, the results of this mobility research fellowship demonstrate a strong potential of *A. araucana* growing in xeric sites of South America to reconstruct VPD during its growing season. Currently, we are preparing a manuscript to show a reconstruction of the VPD following standard methods. This can improve our understanding of regional/continental VPD variation in Northern Patagonia under the ongoing climate situation.

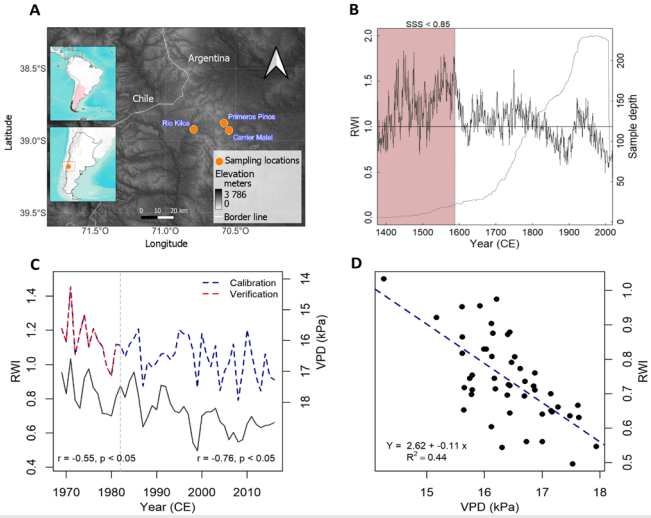

Figure 1: (A) Location of the tree-ring sampling; and **(B)** combined ring width index (RWI) chronology for three sites. SSS: subsample signal strength. **(C)** Graphical relationship between RWI and mean January–February VPD over time and its correlation divided into calibration and verification period. **(D)** Scatter plot of the relationship between RWI and the mean January–February VPD.

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