Spatial and temporal variations in tree growth in subtropical montane forests

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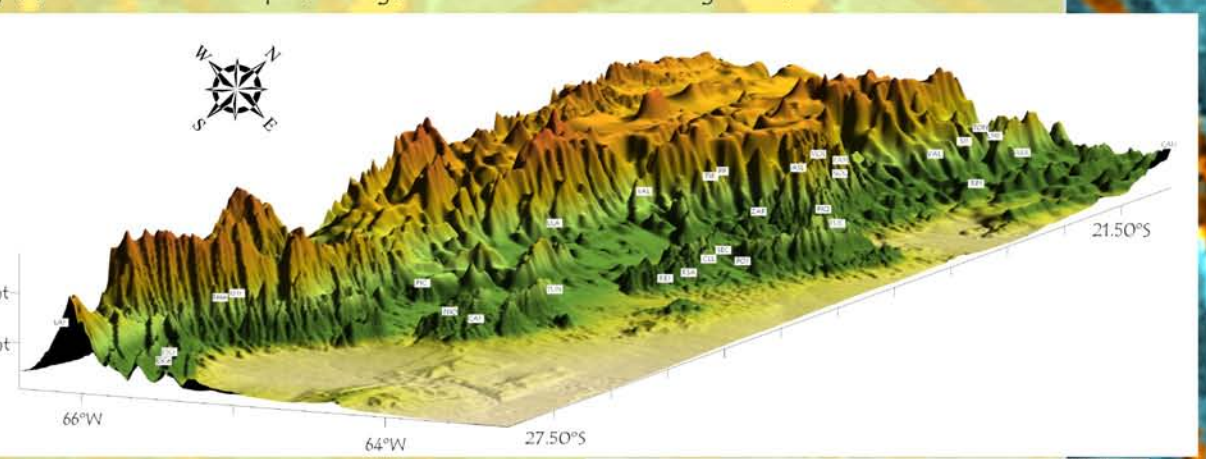
The Andes steep topography generates a wide range of different environments for the development of subtropical montane forests. We analyze the diversity in climate-tree growth responses along the precipitation gradients in the subtropical Yungas from Northwestern Argentina (NOA)



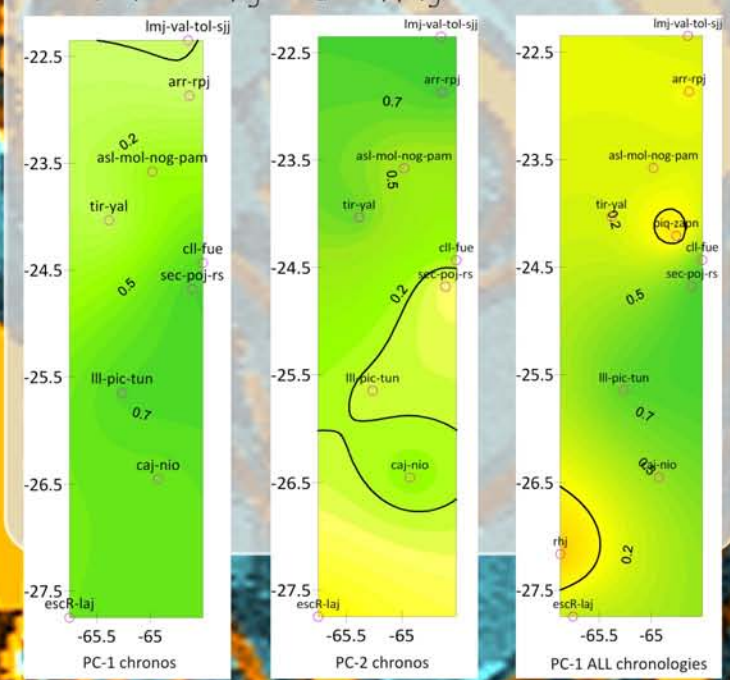
STUDY REGION
Geographical location of subtropical montane forest (22°-28° S) in NOA. Sampling was conducted from low, semiarid sites in transition to the xeric Parque Chaqueño, to high-elevation, moist sites in the upper treelines. To enhance the climatic signal present in the records, 32 tree-ring chronologies of Juglans australis in the montane forests we merged into 10 regional chronologies. Chronology grouping was based on sampling site proximities and similarities in environmental conditions. Series intercorrelation between trees in the composite chronologies was controlled with the program COFECHA, and standardization conducted with the program ARSTAN. Regional composite chronologies were compared to precipitation and temperature to determine the climatic signal present in the tree-ring records.

PC-1 Rainfall
t: Nov-Jan temperature

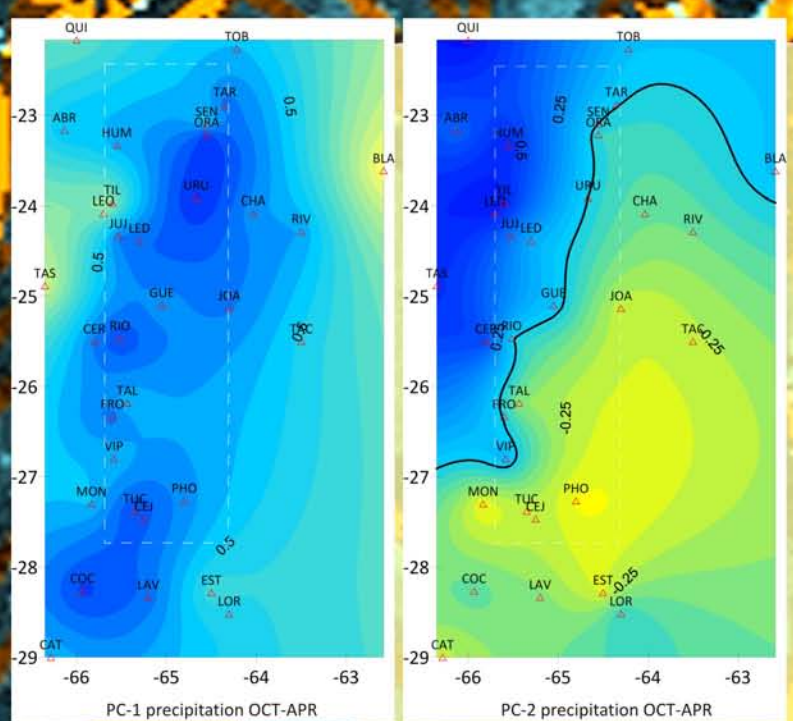
REGIONS	Altitude (m)	Nº series	Series intercorrel	S	O	N	D	E	F	M	A	t
LMJ-VAL-TOJ-SJJ	1760	83	0.461									
ARR-RPJ	1040	51	0.468									
MOL-PAM-NOG-ASL	1800	205	0.558									
TIR-YAL	1780	71	0.541									
CLL-FUE	1100	89	0.475									
SEC-POJ-RS	760	60	0.442									
CAJ-NIO	1070	41	0.451									
ESC-LAJ	1040	51	0.577									
LLL-PIC-TUN	1170	63	0.420									
PIQ-ZAP	1900	62	0.522									
RHNr-RHNm	1800	105	0.622									

Positive correlation ● negative correlation ●

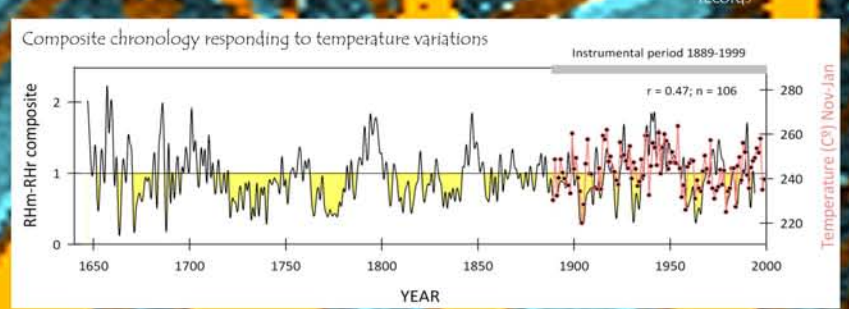
Tree growth variability is highly related to precipitation for most composite chronologies, except for the temperature-sensitive RHN and PIQ-ZAP records.
Dominant patterns of tree growth in the precipitation-sensitive chronologies were identified using PCA. All chronologies in PC-1 (31.23% of total variation) display positive factor loadings, suggesting a similar response to precipitation across the region. Chronologies located in the eastern transition to the xeric Parque Chaqueño (CLL-FUE, SEC-POJ-RS, LLL-PIC-TUN) have the larger contribution to PC-1.
The PC-2 (18.57% of growth variability) separates low- from high-elevation sites. The chronologies at the upper slopes of montane forest (LMJ-VAL-TOJ-SJJ, ARR-RPJ, TIR-YAL) show larger PCA loadings.

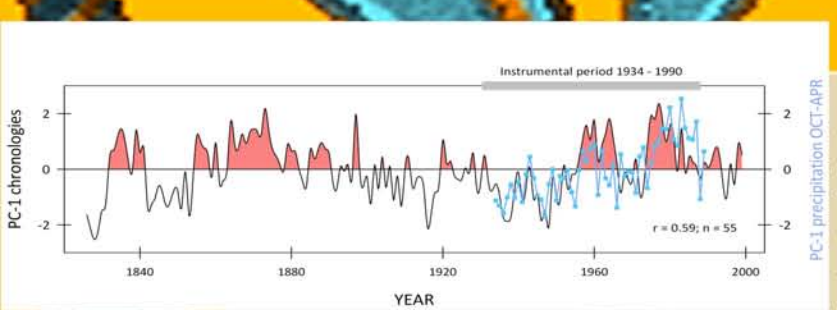


PCA separates precipitation- to temperature-sensitive tree-ring records

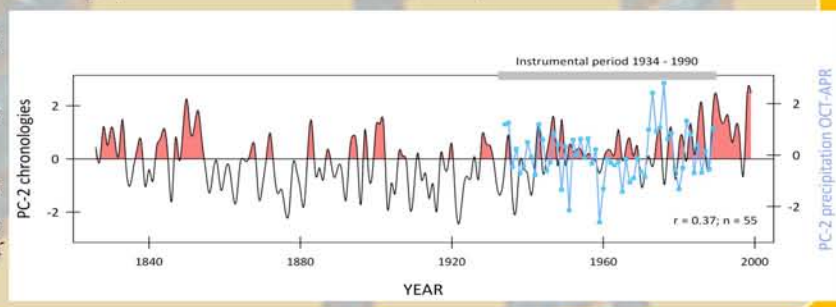


Precipitation records from 32 meteorological stations △ in NOA were used to identify the dominant patterns of spring-summer (October-April) precipitation variations, which account for almost 90% of total annual precipitation. The dominant patterns of precipitation variations were determined using Principal Components Analysis (PCA).
Two principal patterns explain 45% of total variations in summer precipitation: PC-1 (34.91%) is characterized by a uniform pattern across the region, whereas PC-2 (9.82%) shows differences in precipitation between lowlands and upper montane sites
White lines areas correspond to chronologies sites





Correlation analysis shows a strong relationship between the first PCs of tree growth and precipitation; the PC-2 of precipitation and PC-2 of tree growth also show a positive association, although weaker. Annual variations in the RHN chronology are consistently related to late spring-early summer (Nov-Jan) temperatures (above).
Three dominant patterns of tree growth have been identified in the subtropical montane forests from NOA. The main pattern of tree growth is characterized by similar responses in the whole region. Relatively uniform October-April precipitations are strongly related to this spatial pattern, largely associated with the chronologies at low-elevations in the semiarid sites
The second dominant pattern emphasizes tree-growth differences between low- and high-elevation sites and it is associated with precipitation differences across the elevation gradient.
Finally, the third pattern is related to temperature-sensitive chronologies from high, moist sites in the Yungas.
The Yungas, representing the southernmost expansion of the tropical montane forests in NOA, shows large a variety in site conditions and provides tree-ring records sensitive to both precipitation and temperature variations. Quantitative reconstructions from those records will contribute to a better understanding of climate variations in the subtropics from South America.



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