

General comment from *Oelkers et al.* 2025: We have **numbered the suggestions by RC#2 (1-34)** and responded **using bold “Times New Roman text**. The numbers that correspond to potential major revisions of the manuscript have been **highlighted**. This includes:

- 1.) Reorganizing the introduction
- 2.) Updating climate data and re-arranging figures 4 and 5
- 3.) Generating a summary table of chronology statistics and general map of sites

We agree these changes are necessary to improve the quality of the manuscript overall.

1. Terminology: please be careful with word choice, e.g., “shift in tree-ring width” (line 39), “common radial growth” (line 42).

Thank you for this suggestion. Although we intend to remove this paragraph during the revision stage, we will make sure the word choice is accurate, and the quality of grammar is improved overall.

2. Authorship: the 'Author Contributions' section does not list all authors. Please revise this section and check the grammar throughout.

We appreciate the reviewer’s observation and will update this during the revision stage.

Abstract

3. The first sentence mentions tree growth dynamics over “a few centuries and present,” yet the study focuses on the past 40 years. Please revise it.

Thank-you for pointing this out. This sentence will need to be updated. Although the climate data was limited to 40 years, the tree-ring width chronology extends further in time. Nevertheless, we are including a proposed revision (red text) of L18-19 to accurately reflect the focus of this study:

Original L 18/19

*“Relative to research efforts in higher latitudes, the impact of **climate shifts rising temperatures** in the tropical treeline remains understudied. Little is known about the longterm **growth history and climate response** at this treeline **over the past few centuries**, and at present under a rapidly changing environment. Here we provide information on recent changes in tree-ring patterns of *Polylepis pepeii*.”*

4. Avoid unnecessary acronyms, e.g., delete “RW” for ring width.

This is a good suggestion as it is repeated twice. We can remove the second abbreviation.

5. Lines 24–25: I suggest moving the phrase “a trend that mirrors a decrease reported in other *Polylepis*” to the end of the sentence “...tropical Andean treeline, shows a recent decline...”. I recommend removing the data logger results from the Abstract, as these are weak given the data quality.

Thank-you for the suggestions. We are willing to make these changes to improve grammar and clarity in the Abstract.

Introduction

6. Please consider restructuring the Introduction. My suggestion is to start with tropical treelines in the Andes, then the main species, especially *P. pepei*, the disturbances (anthropogenic and climatic), and finally the previous dendrochronological studies in similar areas.

7. Lines 37–49: Remove the discussion of Northern Hemisphere treelines; it is misleading, and references are outdated.

8. Line 39: Clarify what is meant by “shifts in tree-ring width have been linked to upward recruitment.”

9. Line 53: Specify why tropical treelines, more than other ecosystems, are of great concern, and explain the link with anthropogenic influences.

#6-9: We appreciate your comments regarding the inclusion of Northern Hemisphere treeline studies in the introduction. The original intent was to emphasize the lack of information in the tropics by citing well-known studies in the higher latitudes and their findings. We agree this can be minimized to focus on tropical/Andean treelines as suggested. Overall, we agree with the proposed structure and the need to add further information on the value and vulnerability of tropical treeline ecosystems.

10. Line 65: Clarify the use of the term “timberline.”

We will add the definition based on the authors referenced here (Rehm and Feeley 2013, <https://doi.org/10.1016/j.foreco.2013.05.041>) who defined the timberline as “the upper elevational limit of closed canopy forests”.

11. Lines 69–72: Add the time period of the correlation analysis and discuss how your results compare to Morales et al. (2004) in the Discussion.

This is a great idea and will be implemented during the revision stage.

12. Line 78: Clarify what “respectively” refers to.

This needs to be rephased for clarity. For context I have included the original text from L78 here:

In the temperate Nothofagus pumilio (Poepp. & Endl.) Cuatrec. Andean treeline, temperature variability facilitates tree recruitment in northern and southern Patagonia, while the rate of seedling establishment can be strongly modulated by the interaction between temperature and precipitation driven by the Pacific Decadal Oscillation and the Southern Annular Mode, respectively (Sruur et al., 2018, 2016).

With the reformatting of the Introduction, we propose the PDO and SAM should be removed from this sentence and added elsewhere as a brief introduction to the South American drivers of hydroclimate variability in the tropical Andes. The original purpose of this paragraph was to identify the limiting climate factors of the growth rings at treeline found in literature. This sentence should be rewritten to emphasize: Although seedling recruitment of *Nothofagus pumilio* is driven by temperature variability, the rate of seedling establishment was limited by overall moisture conditions in Patagonia.

13. Line 83 and elsewhere: Standardise the expression for meters above sea level (“m asl” or “m a.s.l.”).

14. Lines 84–85: Add the link to Figure 1 in the text.

15. Lines 93–94: Avoid acronyms that are not used later (e.g., TNA, TSA, MNP).

#13-15: This will be reviewed and corrected in an updated version.

16. Lines 96–98: Rewrite for clarity; the current sentence is vague and overly complex.

This can be shortened for brevity and combined with the second sentence. The main idea is: Complex topography in the Andes-Amazon region contributes to diverse rainfall and vegetation gradients. Due to the local orography, it is difficult to tease out the influence of large-scale hydroclimate patterns on regional tree-growth.

17. Lines 108–112: Consider whether these sentences are relevant.

These lines can be shortened and reframed. They describe the effects of temperature shifts on carbon sequestration and tree recruitment near our site, in Madidi National Park.

Materials and Methods

18. Lines 129–131: Rewrite for clarity and avoid repeating “dendrochronological” twice.

Thank-you, this will be fixed.

19. Lines 134–140: Clarify if two different climate datasets were used for temperature and precipitation, whether they were compared, and if the climate–growth correlation was conducted for the same period.

We will clarify here in section 2.1 that the period of climate-growth correlations for the *P. pepei* chronology (last ring completed in 2019) was between 1981–2019. We described that one climate dataset was used for temperature (CRU) and another dataset was used for precipitation (CHIRPS). Due to the extreme spatial variability of precipitation in the eastern Andes, the higher resolution CHIRPS dataset (0.05°) instead of CRU precipitation (0.5°) was selected for analyses, but it only extends until 1981. We understand it is not an ideal situation, particularly since this site is largely temperature limited. The lack of continuous, in situ station data has been a problem in South American climate and tree-ring research.

However, since submission of this manuscript a new precipitation database SC-PREC4SA was published for South America (Huerta et al. 2025: <https://doi-org.proxy2.library.illinois.edu/10.1038/s41597-025-05312-1>). It includes continuous (gap-filled) and bias-corrected station data covering the period 1960–2015. We propose utilizing both the SC-PREC4SA for precipitation and the CRU temperature (Tmin, tmax, tmp) in an attempt to extend the common period of analyses for climate. However, the caveat of poor-quality station data (missing data and short timespan) remains.

In summary:

- The monthly (Fig. 4A) and seasonal (Fig. 5A) precipitation data will be tested with SC-PREC4SA to extend climate analyses before 1981.
- The spatial correlations using gridded CHIRPS (Figure 5C) and CRU (5D) will remain but only cover 1981–2019

Please also see [response to #32 below](#) that suggests rearranging the monthly/seasonal figure in general.

20. Lines 183–188: Move this ecological description of *P. pepei* to the species ecology paragraph.

Here is the original text for context of L183-188:

*To aid in identifying anatomical properties in the wood, histological (micro) cuts were performed according to techniques described in von Arx et al. (2016) using a WSL Core microtome (<https://www.wsl.ch/en/services-produkte/microtomes/>). *P. pepei* is an angiosperm with diffuse porous wood anatomy, which is typically harder to date than ‘ring porous’ wood, due to less distinct boundaries between the latewood of the prior year and the earlywood of the current year. *P. pepei* tree rings feature large, semicircular vessel elements in the earlywood that taper tangentially in size towards the transition to latewood, which has thicker, fiber-like tracheid cells (Fig. 2B; Roig et al. 2001).*

We feel that the identification of ring-boundaries belongs in the wood processing section instead of site description. However, we agree the citation referencing general wood description may be best placed elsewhere.

21. Figure 2: Add a photo of the whole plant. If possible, compare phenological and growth differences between the open-canopy south-facing slope and the closed-canopy west-facing slope.

We can replace this photo in Figure 2 with the photo of the entire tree. Although we do not have DBH data for the 2012 samples, the differences in age and sample size can potentially be added to the results section with the addition of the new table (see responses in numbers 24 and 34 below.)

22. Line 214: Check the reported correlation values. Consider omitting the section on chronology correction, as the issue appears not to be ring detection but miscounting an incomplete ring, if I understood correctly.

Thank-you for this suggestion. This paragraph is important but can be simplified. The ‘end date’ for the original dataset (KEPP) was improperly assigned to 2010/11 when it should have been 2011/12. Although it may be out of the scope of this paper- we think it’s interesting that only certain cores had partial wood formation for 2012/13 because it likely relates to the eccentricity of radial growth for *Polylepis*. [Roig et. al \(2001\)](#) also observed this in *P. pepei* core samples from Cochabamba Bolivia, which leads us to speculate if there may be differences in the timing of xylogenesis at the tree-level during the growing season.

23. Line 218: State whether the raw time series shows a negative trend.

We can add this here in the paragraph regarding detrending methods but also reiterate it in the results section 3.1.

24. Line 219: Provide the number of samples from 2012 and 2019, distinguishing between living and dead trees. A table with tree status, age, interseries correlation, number of cores, and diameter would be useful.

The generation of a summary table is a great idea and a similar request was made by Referee #1. Although we do not have DBH data from 2012 fieldwork campaign, we will make a table to clarify sample size, location, and chronology statistics. Most of the samples were living cores.

25. Lines 219–220: Use precise terminology, did the authors “compare” or “correlate” with climate data?

We will update to ‘correlate’ for consistency.

26. Line 223: Indicate which program was used to detrend the series.

We will add this. It was the “DPLR” package in R.

27. Line 233: Specify the climate variables (temperature and precipitation) used and the exact period covered.

Great suggestion. Although the variables were stated in the climate data section (L133), we should reiterate it here too and clarify the timespan for analyses.

28. Line 279/Table 1: Move this to the Results section. Clarify the years classified as ENSO events, why 13 years in each column, if there should be 24 years total?

Thank-you for pointing this out. There are 2 sets of numbers (bottom right column of El Nino and La Nina) that were repeated and should be removed. This can be reformatted and moved to the SEA figure 7 in results or included as supplementary as they can be found on the link provided as well.

Results

29. Lines 283–286: Ensure that methods are not presented here, and results are not in the Methods section.

We are including the text from L284-L287 for convenience:

(L284) "The P. pepei RW chronology from northern Bolivia (max elevation 4400 m.a.s.l.) spans from 1868-2018 is shown in Figure 3. (L285) Wood anatomy confirmed the earlywood and latewood diffuse-porous features of the rings (Fig. 2B) and radiocarbon (L286/287) measurements (Fig. 2C) in selected years before and after the radiocarbon bomb-peak confirmed that the growth periodicity is annual."

We agree the confirmation of annual growth is not the main focus of this paper and believe L285-287 may be better placed at the end of section 2.3 (Wood processing and anatomical analyses)

30. Line 288: Provide more details on the dendrochronological suitability of P. pepei.

Great idea. We can compare the metrics in L289-297 (and in the proposed table) to that of other Polylepis tree-ring studies in the discussion section to emphasize the dendrochronological suitability of this chronology overall.

31. Lines 302–306: Correct the figure caption; the current "B" panel does not match the description. Reduce the font size of the legend in panel C. Clarify whether the pointer-year analysis covers a specific period. Discuss whether reduced sample depth (2012 vs. 2019) could explain the negative trend in the raw chronology and report the age distribution of samples.

Thank-you we are willing to make these changes for this figure and add a brief sentence in the discussion regarding sample size.

32. Figure 4: Make month labels more legible. **Consider** correlating the standardised chronology with the normalised diurnal temperature range (which shows a negative trend). Also, **test correlations for November**–February minimum temperature. **Include** seasonal correlations here and keep spatial correlations in a separate figure.

We are open to re-arranging Figures 4 and 5. The current spatial correlations (Figure 5 CD) represent average temperature (CRU) and precipitation (CHIRPS) so we included the seasonal correlations for those variables accordingly. However we are willing to include seasonal correlations for Tavg, Precip, Tmin, and Tmax either below 4A-D or in an appendix. We can also test RW and DTR correlations. The annual Tmax vs. Tmin and DTR timeseries (current Fig. 4E and F) may be treated as a separate figure with the correlations for simplification.

33. Include a map of the species' spatial distribution to help interpret climate response patterns.

Please see response below in suggestion # 34.

Discussion

34. Lines 405–407: Be specific about whether growth differences exist between the south- and west-facing slopes. State the number of samples from each slope and how these differences may influence results.

We can consider generating an aerial map with general site locations to be for visualization in addition to the new summary table in the results section during the revision stage. The purpose of this paper was to assess the climate response of the mean chronology which included the entire network of *P. pepei* sampled at this treeline. However, we agree potential growth differences related to micro-site conditions should be mentioned briefly in the discussion.