In this paper, alpine dwarf shrubs are studied with the help of point dendrometers and micrometeorological measurements. The work definitely has a certain novelty, as the application of this set of methods to an alpine shrub is new, as well as the attempt to study dendrometer data on an hourly resolution. The work and its results fit into the current attempts to understand growth processes at high temporal resolution and thus get closer to the underlying physiological mechanisms (see also Zweifel et al., 2021).

I support the publication of the paper in Biogeosciences Discussions, however the current version of the manuscript suffers from some shortcomings that need to be addressed first.

1)

The title is far too bold and needs to be changed, as the paper does not present a new mechanistic understanding of ecophysiolopgical patterns (what is even meant by this term?). Novel aspects of the work are: the application of automated point dendrometers to shrubs and the approach of converting stem radius data into high temporal resolution growth data. It is a case study with limited general relevance, but nicely demonstrates the potential of the methods used.

A title such as the following proposal would better fit the content of the paper:

The application of point dendrometers to alpine dwarf shrubs - a case study to investigate stem growth responses to environmental conditions.

Thank you for your thoughts on the title, we changed it to the suggested title: “The application of dendrometers to alpine dwarf shrubs - a case study to investigate stem growth responses to environmental conditions.”
We removed “point” in accordance with Review1.

2)

The authors mix three currently available methods to separate dendrometer data into the components of irreversible growth and reversible water-related stem tissue dynamics.

First, there is the approach of Deslauriers et al. 2007 and Van der Maaten et al. 2016, which treat each individual day independently of the historical evolution of stem radius changes. Therefore, this approach records any absolute increase in stem size over 24 hours as growth.

This is in contrast to the zero-growth approach of Zweifel et al. 2016, where accumulated shrinkage must be replenished over longer periods of time (days and weeks) before any additional stem increase is considered growth. Essentially, the zero-growth approach assumes that no growth is possible during periods of stem shrinkage. All daily increments add up to an annual increment represented by the total annual stem size change measured by the dendrometer. In the case of the Deslauriers et al. approach, daily increments sum to more than the increment measured by the dendrometer over one year. The reason for this is that stem size increases during periods of stem shrinkage are counted as growth.

The third approach is the Gompertz growth function, which takes up the commonly assumed growth form over a season. The Gompertz function assumes constant and uniform growth throughout the growing season, which is clearly not true, as shown in Zweifel et al. 2021 and also in this paper (Fig. 3).

Further, the Gompertz function is not a reliable way to find the onset of growth because the Gompertz function is fitted to the original dendrometer curve and thus neglects that the stem is first rehydrated before growth begins. Furthermore, the nature of the Gompertz function implies a slow growth start at the beginning of the season, which obviously does not fit the growth pattern, as can be well seen in Fig. 3b. This approach leads to too early growth starts in spring and might also be the reason why the authors set a threshold for initial growth at 20% of annual ring growth.

Anyway, all approaches may have advantages and disadvantages, the problem with this work is that there is no clear line that tells me as a reader which analyses and which figures are based on which approach. Also, I don't see how the Deslauriers approach and the zero growth approach are compatible in the same study.

Thank you for the comprehensive summary of the three approaches. This is indeed missing from our text. In general, the zero-growth approach proposed by Zweifel et al. 2016 was the main approach we used to calculate growth parameters. We did, however, apply the “daily mean” approach described by Deslauriers to calculate daily values from our measured hourly data. Following the zero growth assumption, we account for the fact that rehydrating before growth begins occurs by excluding this additional increment and starting to measure growth when the stem diameter exceeded the previous year's maximum (Fig. 3b). The Gompertz curve thus does not fit the pattern perfectly in winter when we recorded stem shrinking, but describes growth processes during the main growing season fairly accurately, which is why we think its use is justified to derive information on timing from the fitted models (Fig. 3b shows that the growth start suggested by our calculations from the Gompertz curves is reasonable). The use of the Gompertz approach to define growth start and end is well tested for dendrometer measurements (e.g. Duchesne et al., 2012; Liu et al., 2018; Drew and Downes, 2018; van der Maaten et al., 2018).

We made sure to clearly state (and justify) the use of these approaches in the Material and Methods section: “There are several methods currently available to separate growth from water-related expansion and contraction of the stem. To define total annual growth, we chose the approach proposed by Zweifel (2016), which excludes reversible shrinking and swelling associated with stem water fluctuations, assuming zero growth during periods of stem shrinkage. Total annual growth is thus derived from the original measured data by calculating the cumulative maxima (Zweifel et al., 2014a; Zweifel, 2016). We recorded additional stem increment before the start of the growing season in spring. Because this increment did not exceed the previous year’s maximum stem diameter, we assumed that it might be related to refilling processes rather than formation of new xylem and cambial growth (see Mayr et al., 2006) and therefore, in accordance with the previously described zero growth assumption, did not define those processes as growth. Following this approach, we were able to define growth-induced stem increment during the main growing season. To further define this growing season and derive accurate dates for growth start and end, we fitted sigmoid Gompertz models to the resulting growth curves."

Additionally, we revised the legend accompanying Fig. 3b: "(b) Averaged measured daily stem diameter variability and fitted Gompertz models (a goodness-of-fit (GoF) measure was calculated using the least-squares method). Models were fitted to zero growth curves derived from the original measurements as cumulative maxima (thin lines), assuming zero growth during phases of prolonged stem shrinkage. In this way annual growth and, consequently, growth start is directly linked to growth during the previous year and additional rehydrating processes before the start of the main growing season are excluded."

We thus clearly convey to the reader how we combined the zero growth and Gompertz model approach to separate growth-induced and water-related stem diameter variation and accurately define the main growing season.

3)

The statement (L435ff) that winter shrinkage of woody stems has never been reported is false. See e.g. Winget & Kozlowski, 1964; Zweifel & Häsler, 2000; Sevanto et al., 2012.

We included the suggested references and revised our statement from L435ff. We did not intend to state that winter shrinkage has never been reported for woody plants. However, a pronounced phase of winter stem shrinking in shrubs specifically (as found in our data) has not been described before (to our knowledge).The revised part now reads: "A phase of winter stem shrinking has been described in trees (Winget & Kozlowski, 1964; Zweifel & Häsler, 2000). The distinct and strongly pronounced phase we found in our sampled specimens, however, might be described as a unique feature of shrub growth, which we documented for the first time in this study."

4)

Legends of figures and tables must be completed with all abbreviations that occur. In addition, the data basis (model or measured data, temporal resolution) should be stated in each case. A legend must be readable on its own.

We revised tables, figures and legends, keeping this in mind.

5)

The analysis in Fig. 4 states that the authors are able to perfectly predict annual growth from radiation with 100% accuracy! This must be wrong!!!

The value R^2=1 resulted from rounding of the original value. We corrected this.

6)

Several recent studies show the importance of VPD for growth (Novick et al., 2016; Grossiord et al., 2018; Peters et al., 2021; Zweifel et al., 2021). It would add weight to this study if VPD were included. If I understand the measurement setup correctly, the authors have this data.

We did indeed measure relative air humidity at some sites, from which we could infer VPD. We have, however, only one complete series for each region, with no information on how this data might vary between the sites. One of the strong points of the current study is the fine-scale environmental data measured directly at each site. We do not think we can match this scale for the whole study period with the VPD-measurements we currently have. However, we agree that this could potentially contain novel information and therefore would like to include it in a future study.

7)

It might be a matter of style, but why are so many results shown already in M&M?

This mainly relates to the environmental data presented in chapter 2.5 Environmental data collection and growth conditions. We present this data in the Material and Methods section, since it mainly describes our collected environmental data and no results from our analysis.

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We would like to thank all three reviewers and the editor for their helpful thoughts and comments on the manuscript. In accordance with the suggestions made, our final, revised manuscript differs substantially from the original version. Therefore we would like to highlight here, which changes were made:

Clarification of the study design:

- We included details on the monitoring setup and technical implementations of the study design, and gave additional information on the placement of the dendrometers and handling of outer bark tissue.
- We also gave some additional background regarding the study design and trial periods before the start of the study period.
- We added some additional information on the position of the tree line in the studied regions and the elevational levels of our studied sites.
- To further improve clarity for the reader we included an additional Figure showing a radial micro-slide of an E. *hermaphroditum* stem with details on stem anatomy and bark structure.

Regarding methodical ambiguities:

- One of the main challenges proposed by our study design was the separation of water-related stem shrinking and swelling and growth-induced stem increment. We gave additional details on how we approached this challenge. Since our chosen approach was chosen based on visual interpretation of our data we included an additional Figure presenting exemplary raw data to the reader.
- We also addressed major concerns of one of the reviewers regarding sample size.
- We validated our chosen dendrometer approach by direct, exemplary comparison with traditional ring width data from our studied sites, presented in an additional Figure.
- We expanded on the text in the Discussion section to further explain and strengthen our interpretation of the observed results during the winter months, giving additional references, supporting this interpretation.
- We revised the Material and Methods section with special emphasis on clarity and wording.

Writing style and wording:

- We rewrote passages with imprecise wording.
- We revised the Abstract.
- We rethought our use of some of the terms used and replaced or removed them as suggested by the reviewers (e.g. point dendrometers)
- We made sure that the calculated parameters are clearly defined and consistently named throughout the text.

- We rethought the placement of some passages in the text and moved them to more appropriate chapters accordingly.

Revision of the Figures:

- We made some major and minor adjustments to the Figures and Figure legends, improving clarity.
- We added three new and relevant Figures to the supplementary material (see above).
- We added new information to Figure A1, to highlight our interpretations regarding the elevational gradient.