

Biogeosciences Discuss., referee comment RC2  
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## Reply on AC1

Anonymous Referee #1

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Referee comment on "The application of dendrometers to alpine dwarf shrubs – a case study to investigate stem growth responses to environmental conditions" by Svenja Dobbert et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-99-RC2>, 2021

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### **Recommendation to revised version of the manuscript:** Reject

Authors substantially revised their manuscript, clarified inconsistencies and they supplemented the text when this was necessary for a better understanding. However, I have still major concerns regarding methodological aspects as well as data interpretation, which need to be resolved to warrant publication.

### **Response to general argumentation of the authors:**

"The authors are convinced that their extensive changes now justify publication in Biogeosciences, and by its a novel approach, strong methodology, unique dataset and unexpected results the paper will stimulate the discussion on our physiological understanding of arctic-alpine shrubs growth."

I readily agree with the authors that current knowledge should be questioned and discussed to enable scientific progress. But this discussion can only take place on the basis of solidly collected data. In the following I will once again present my arguments against the publication of this manuscript in its present (revised) form, as there are methodological deficiencies that significantly affected data collection and subsequent analysis.

### **Response to authors' comments on my previous specific points of concern** (line numbers refer to the manuscript before revision):

- Averaging of dendrometer records: Authors clarified this point and they have sufficiently complemented the methods section.
- Mounting of diameter dendrometers: The authors now give more detailed information on mounting of dendrometers. Authors add in the Materials and Methods section that the dendrometers were not mounted on bark as I previously assumed from their description ("We mounted our dendrometers on one major above-ground stem..."), but "...we removed the outer bark to place the sensor directly on the cambium."

In this regard, I ask for clarification or elaboration on the following points:

**First**, please cite a study showing that dendrometers can be mounted directly on the cambial tissue without seriously affecting it. For several reasons, it is standard to mount point dendrometers on the living phloem, not on cambial tissue, which consists of a few cell layers only. Mounting on the cambium - if you can manage to do it that way - would inevitably lead to damage, mechanically or through dehydration. Furthermore, "girdling" of the phloem would block transport of carbon and hormones, which are necessary for cambium activity to occur.

**Secondly**, Figure A2 shows a photo of the way diameter dendrometers were assembled in this study. I admit that the resolution does not allow a clear statement, but it looks like that the diameter dendrometer was mounted directly on the stem without removing the outer bark. However, authors state in their reply that "In general, *Empetrum hermaphroditum* has a very thin bark, which is easily removed without the danger of damaging the cambium." That's fine, but I wonder, how authors could manage to mount DRO diameter dendrometers directly on the cambium. This type of dendrometer consists not only of a circular sensor head with a diameter of c. 5 mm, but also of a rectangular fixing plate to be mounted on the opposite side of the sensor head. By default this plate is c. 2 cm long and 5 mm wide. Hence, this part of the stem should also have been removed (without damaging the cambium!) to ensure that hygroscopic effects are not influencing dendrometer records.

- Limited sample size, i.e., one dendrometer record per plant and elevation: In their reply to this major issue, authors argued that "Actually, our result regarding the elevational gradient was that there was no thermally driven growth gradient."

The presentation of unexpected results is not an argument in favour of the small sample size. Furthermore, dendroecological studies on *E. hermaphroditum*, which two of the authors of this manuscript co-authored (Löffler was co-author in all papers cited below), revealed high intra-plant growth variability and authors also pointed out the necessity of a high number of samples for determining radial growth of the dwarf shrub under study.

Main points of previous dendroecological (i.e., tree ring) studies:

Bär et al. (2006) found that "***E. hermaphroditum* shows highly individual growth histories**. Thus, cross-dating of growth curves is restricted to several radii within an individual and to mean curves of individuals growing at the same micro-site. Wedging rings and missing rings as well as eccentricity and asymmetric geometry of the stem constrict the synchronisation of growth curves."

Bär et al. (2007) pointed out that "For a proper synchronization of the growth rings, serial sectioning was applied **in order to deal with the high internal growth variability and the high proportion of discontinuous rings.**"

Bär et al. (2008) stated in their last sentence: "Hence, **carefully synchronized and well replicated ring-width series of dwarf shrubs** from alpine regions can be used as sensitive indicators for reconstructing past climate in vast regions beyond the polar and alpine tree limits."

Furthermore, in lines 336ff of the study under review authors state that "In contrast to the oceanic-continental gradient, our study showed **high inter-plant growth variability** (Fig. A1 and Fig. A3), which has been previously described in *E. hermaphroditum* (Bär et al., 2008) and could be a result **of the nanoscale of internal growth variability within the multi-stemmed plant itself** (Bär et al., 2007)."

Therefore, it seems to be quite obvious that a **single point measurement** (or diameter record in this case) **does not represent radial growth** (and hence intra-annual growth patterns derived from it) **of a multi-stemmed shrub at a given elevation**. Extremely low growth rates ( $< 100 \mu\text{m}$ ) are likely to increase the uncertainties of a "single measurement".

- Frost drought as a major determinant of shrub growth: In their reply authors state that "we here show that frost droughts during winter are obviously restricting our shrub species, and that this phenomenon is similarly represented along all alpine ridges despite elevational and regional climate differences."

If frost drought in late winter is a major issue, which significantly affects growth of *E. hermaphroditum*, how can it be that at the same time this shrub species "remains photosynthetically active during the snow-free period" (see lines 18ff)? As a result of freezing temperatures water transport is either severely reduced or completely interrupted – this would certainly impair carbon assimilation. I would also expect that stomata are closed to prevent excessive water loss as long as soils are frozen. Authors are also stating in their reply that "intensive soil freezing" occurs during winter months. Therefore, please show data or cite a paper that supports your interpretation, i.e., relevant carbon assimilation is possible during periods when soils are frozen.

Furthermore, did authors observe any leaf damages caused by frost drought, i.e., browning and subsequent shedding of leaves in spring, which would indicate that severe drought stress occurred during winter (lines 344ff: "...and frost-triggered droughts might result in tissue damage caused by an internal water deficit.") . If winter drought is an important issue for this shrub species as suggested by authors, I would expect that at least at the highest elevation and in the more continental study region signs of frost drought are clearly visible.

- A clarification is needed as to why in a previous dendroecological study co-authored by Pape and Löffler contradictory results regarding growth limitation of *hermaphroditum* by climate factors were found. Bär et al. (2008) reported that "This study indicates that mean summer (June–August) temperatures determine the width of the growth rings of *Empetrum hermaphroditum* irrespective of topoclimate."

It is highly implausible that determination of climate-growth relationships based on dendroecological techniques (inter-annual) vs. dendrometer records (intra-annual) lead to such contrary results as reported in this study. Please clarify and discuss this issue in a revision.

References cited:

Bär, A., Bräuning, A., and Löffler, J (2006): Dendroecology of dwarf shrubs in the high mountains of Norway – A methodological approach, *Dendrochronologia*, 24, 17–27

Bär, A., Bräuning, A., and Löffler, J. (2007): Ring -width chronologies of the alpine dwarf shrub *Empetrum hermaphroditum* from the Norwegian mountains. *IAWA J*, 28, 325–338.

Bär, A., Pape, R., Bräuning, A., and Löffler, J. (2008): Growth -ring variations of dwarf shrubs reflect regional climate signals in alpine environments rather than topoclimatic differences, *J Biogeogr*, 35, 625–636.