Catch the drift!

– A quick and easy method to quantify sensor related thermal expansion effects on dendrometer measurements –

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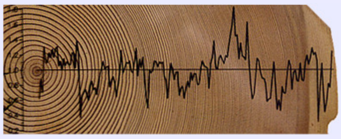
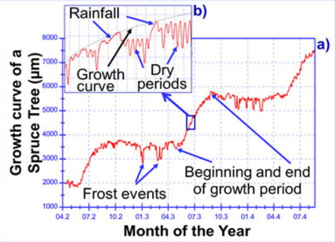
Introduction

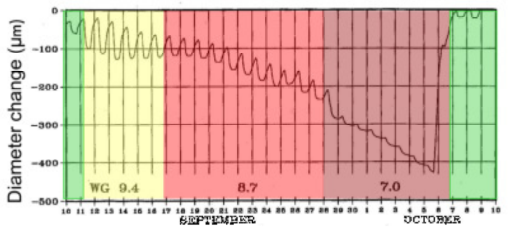
The tree ring archive contains valuable information to investigate tree growth and past biotic/abiotic growth conditions.

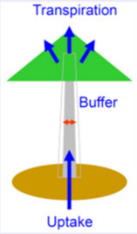




Continuous data on current tree growth and water status, as derived from electronic precision dendrometry, bridges the gap between long- and mid-term effects as recoded in the woody biomass and the plant's response to instantaneous growth conditions (cf. Worbes et al., 1999).

Precision dendrometry is hence a valuable tool to gain a deeper mechanistic understanding of stem growth dynamics and formation of the tree ring archive (De Swaef et al., 2015; Zweifel et al., 2016; Zuidema et al., 2018).





However, diurnal diameter variations, e.g. as related to plant hydration status, can be very small and thermal expansion effects on dendrometer measurements should be taken into account.

Objective

Here we introduce a reliable, quick and easy-to-reproduce method to test the magnitude of sensor-related temperature effects on dendrometer measurements.

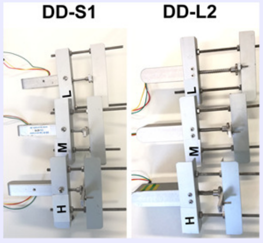
The aims are thereby:

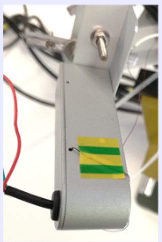
- to enable the verifiability of the technical specifications of the various dendrometer products available on the market
- to facilitate the comparability within and between datasets of particular dendrometer studies.

Methods

In our test setup dendrometers were clamped in empty state, only by adjusting the dendrometer frame. Tested were two different models of dendrometers, the DD-S1 with 11 mm and the DD-L2 with 25 mm measurement range (both from Ecomatik, Germany).

Three dendrometers of each model were clamped at three different excitation positions:
- **Low (L)**: at ca. 10% of the total measurement range
- **Middle (M)**: at ca. 50% of the total measurement range
- **High (H)**: at ca. 90% of the total measurement range





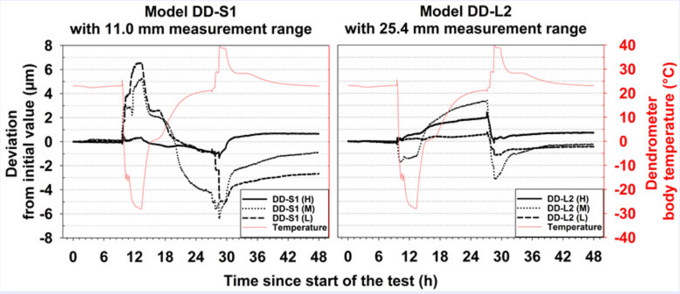
Only dendrometers where subjected to a large temperature range of 68 °C between -28 and +40 °C. The logging device (CR1000X, Campell Scientific, Logan, USA) was kept at ambient temperature of 23.5°C (± 1.5 °C).

This way, apart from the temperature response of the dendrometers themselves, all other possible sources of uncertainty were excluded, e.g. temperature effects on a measured test body, or temperature response of the logging device.

Results

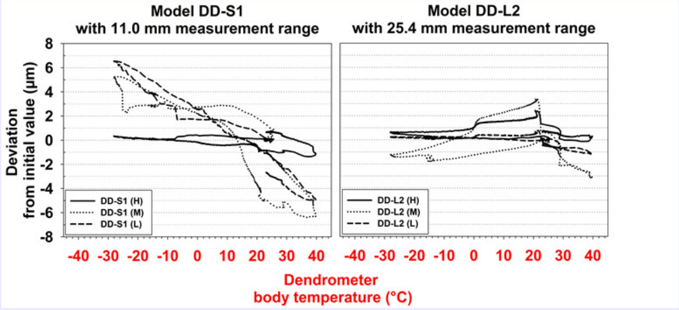
Within the induced total temperature range of 68°C, the temperature-related deviation of all dendrometer readings was in the range of +6.5 µm to -6.4 µm (<± 0.096 µm/K).

The temperature effect was somewhat larger in case of the DD-S1 model, than for the DD-L2 model with only +3.4 µm to – 3.2 µm (< ±0.050 µm/K).



After passing through the whole range of the temperature stress test, dendrometers showed a minor deviation from the initial value of before the stress test. This deviation was somewhat larger in case of the DD-S1 model (-2.6 to +0.6 µm) than for the DD-L2 model (-0.46 to +0.7 µm).

In case of the DD-S1, lower excitation levels L and M showed a greater deviation from the initial measurement value than the strongly deflected variant H. This pattern, however, was not observed for the DD-L2 model.



In the performed rapid test, the course of the individual measurement series did not result in simple linear correlations, but appeared to be superimposed by varying degrees of hysteresis and randomly directed effects.

Most likely, this complex behaviour was the result of high rates of temperature changes of up to ±2.4 °C/min, which caused strong temperature gradients within dendrometer frames and bodies. Similar non-steady-state conditions are also to be expected under field conditions with natural radiation and temperature dynamics.

Conclusions

- The overall magnitude of temperature effects on tested dendrometers is in accordance with the sensors temperature response specification of <0.2 µm/°C.
- Different dendrometer excitation positions showed no systematic effect on the temperature behaviour of the dendrometers.
- Hysteresis effects under dynamic temperature conditions, such as prevailing under field conditions, preclude a simple linear temperature correction of thermal expansion.
- The conducted rapid test is a very easy-to-reproduce, low-tech method to quantify the overall magnitude of sensor-related temperature effects on dendrometer measurements and may insofar facilitate the comparability within and between different dendrometer datasets and studies.

Bibliography

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