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Wood formation in rhododendrons at the stress line: take a shrub to the limit

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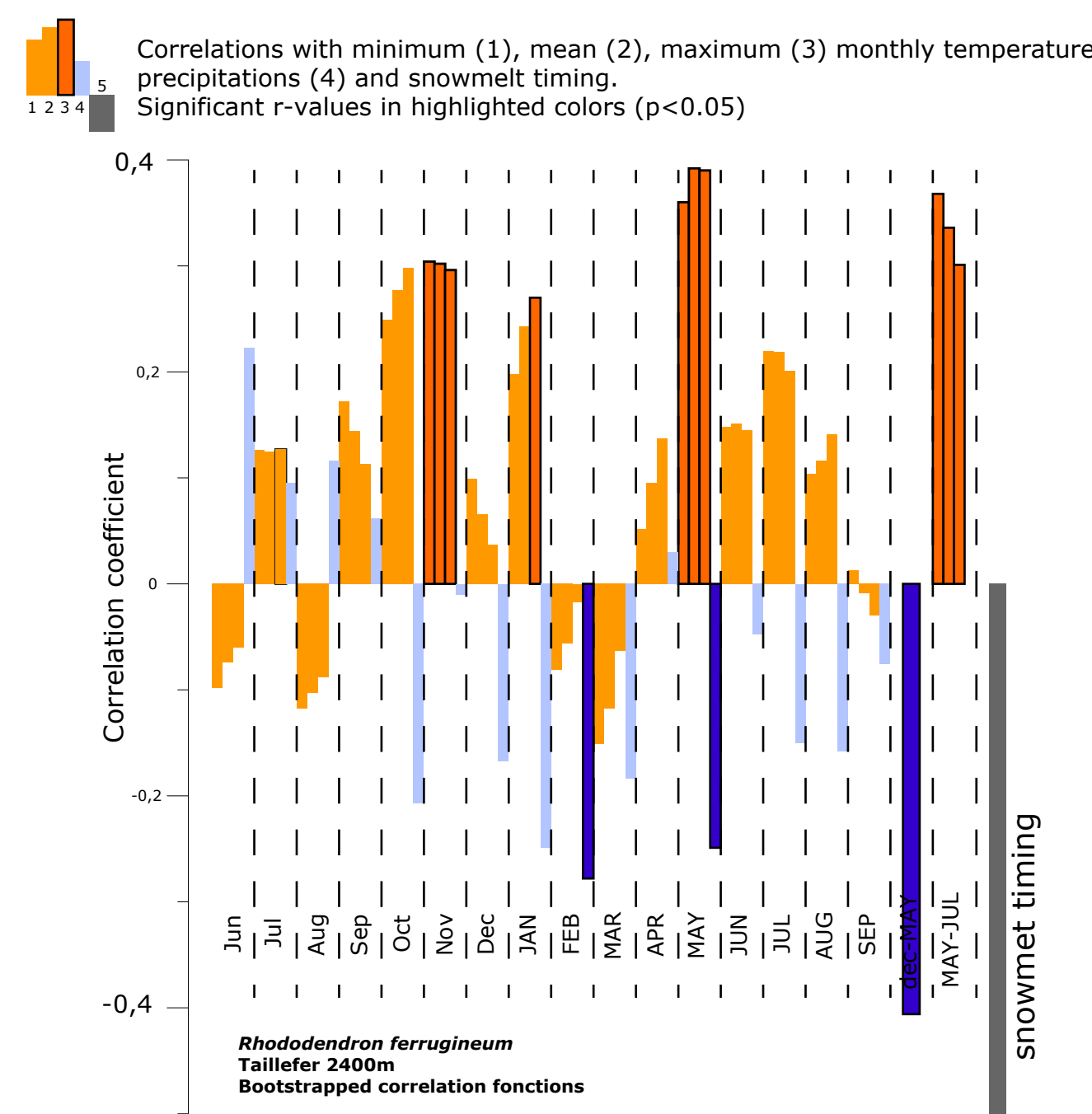
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In this study, **electronic micro-dendrometers** were used to monitor the **variations in stem diameter** of 11 *Rhododendron ferrugineum* (Rf) individuals located at 1800, 2100 and 2500m asl in the Taillefer Massif (French Alps) and at 1700m asl at Vicdessos (French Pyrenees). In addition, ground-level temperature was recorded for each individual. The results presented here are focused on **the 2500m site**. They cover the period October 2016 - October 2017.

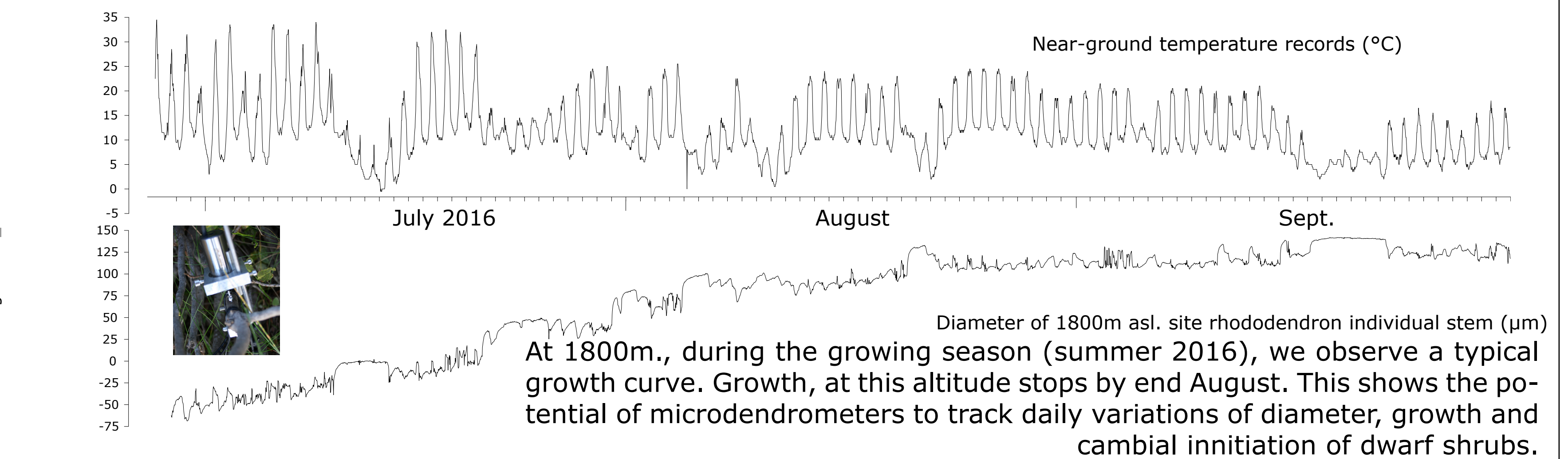
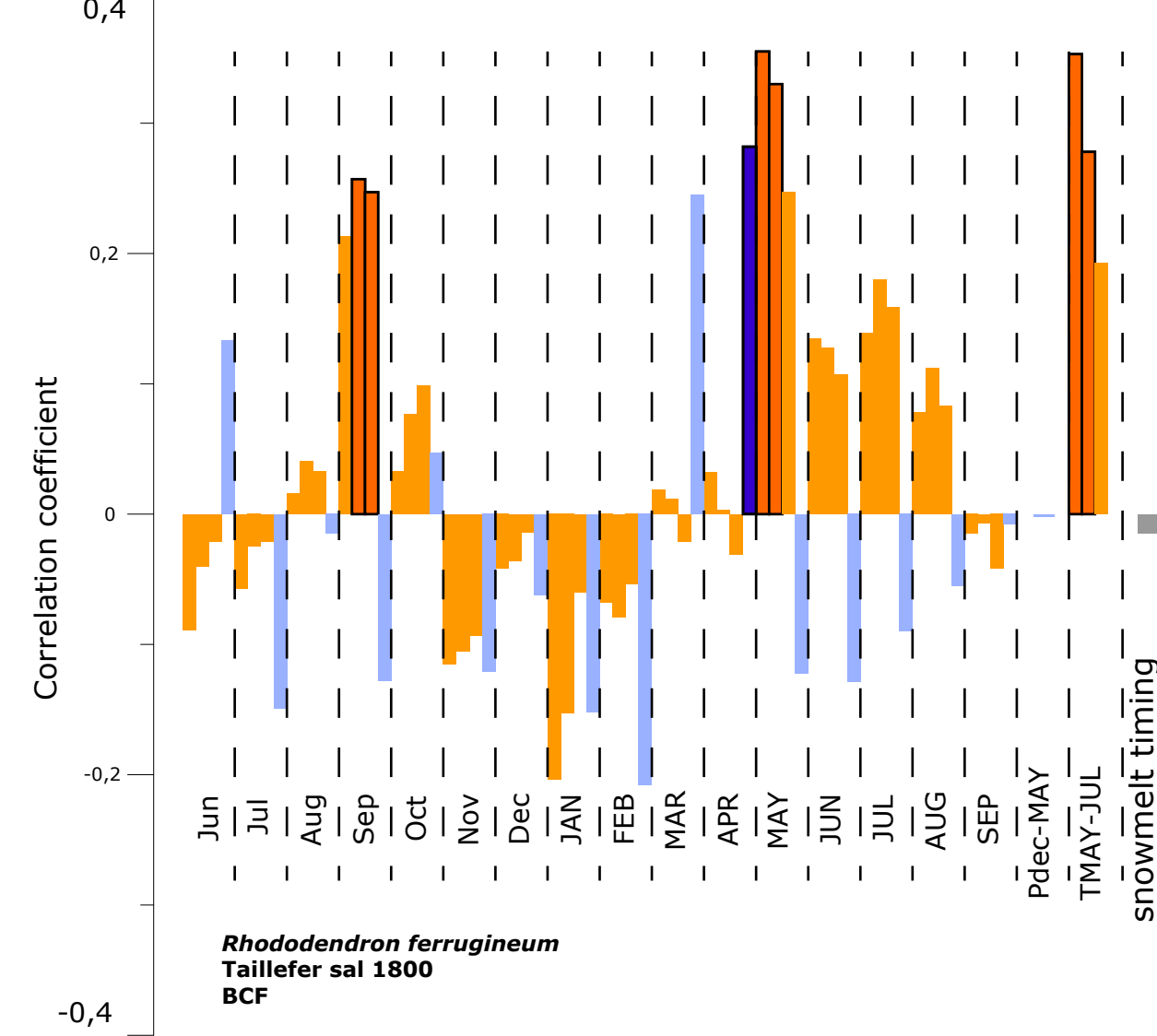
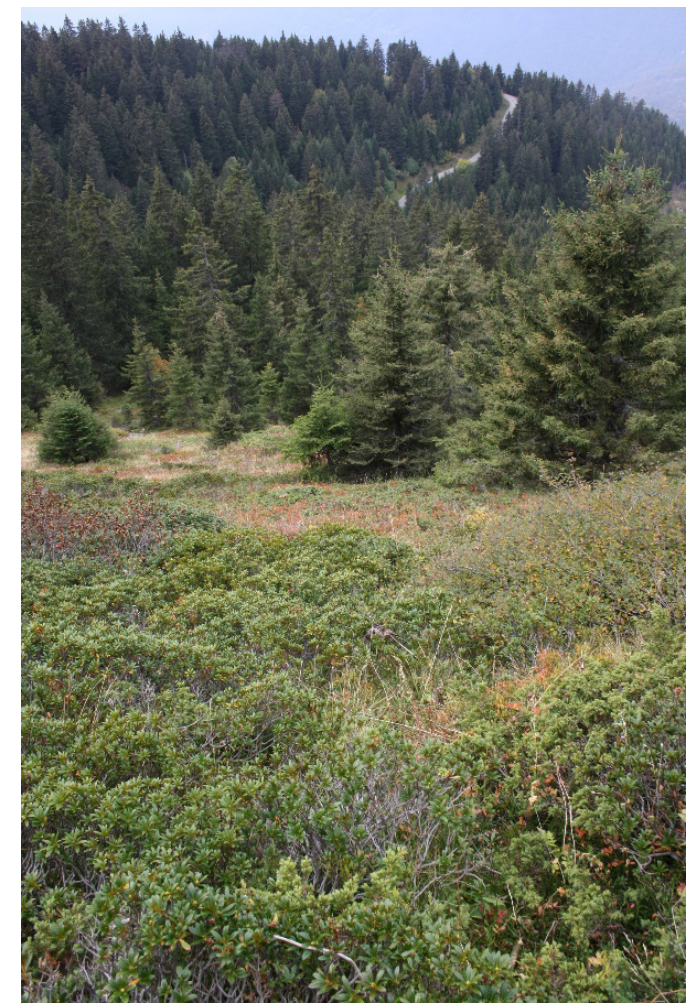
1- Results of the dendroecological approach: Climate-growth relationships (1960-2016)



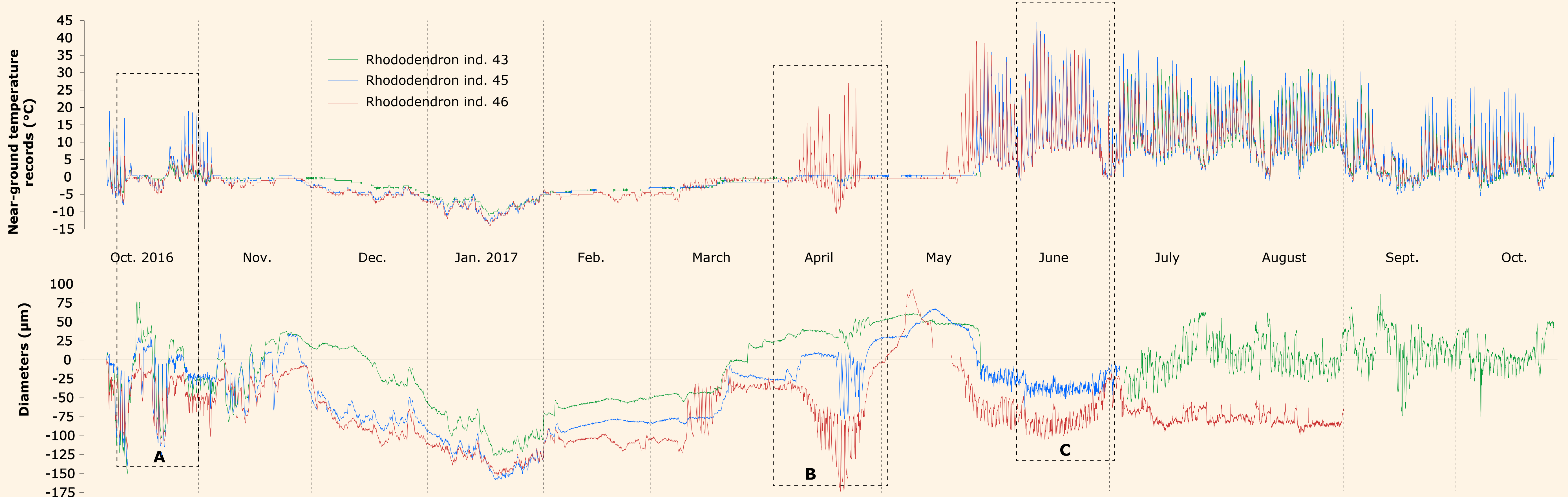
Context:

- High-latitude and **high-altitude ecosystems** are adapted to high level of environmental constraints and are therefore amongst the **most sensitive to on-going climate change**. Numerous studies demonstrated that recent global warming leads to an increase in shrubs cover and productivity at the Arctic and Alpine treelines since the 1980s (ie 'shrubification').
- Dendroecological studies along an altitudinal gradient in the Taillefer massif (French Alps) reveal that *R. ferrugineum* growth was significantly and **positively associated with May temperature and negatively correlated with winter precipitations** at 2500m asl.
- Daily-resolved and homogenized series of temperature, precipitation and snow cover depth from the SAFRAN-CROCUS datasets - for the period 1959-2016 - further confirm that both climatic parameters are the main drivers for **snowmelt** and subsequent **growing season length** at this altitude.
- However, the dendroecological analyses that approximate relationships between tree rings and climate by a time-invariant function consider the underlying processes as a black-box (Guiot et al., 2014). In this context, the monitoring approach developed here is **complementary to the correlation function** analyses to document the **ecophysiological response** of rhododendrons to meteorological/climatic fluctuations.

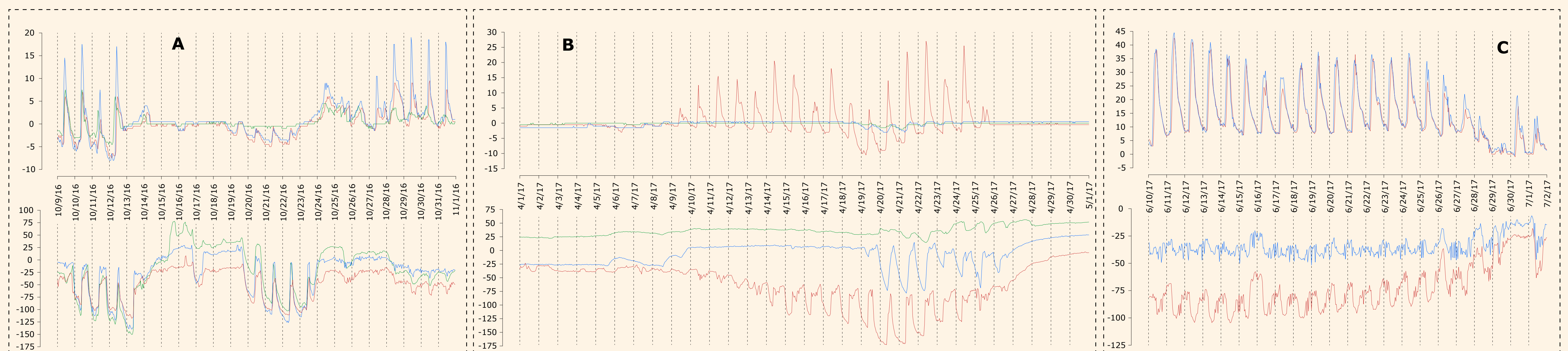
2- A first try at 1800m in summer : the potential of microdendrometers on dwarf shrubs



3- One-year hourly monitoring of three rhododendrons shrubs stem diameter variations at 2500m asl.



Raw curves of diameters variations and temperatures are strongly snowpack-dependants. The gaps in the middle or at the end of the records corresponds to (1) loss of the signal or (2) aberrant values due mechanical moving of the sensor.



October 2016: Very contrasted conditions

- No snowcover --> freeze/thaw cycles (beginning of the month)
- **High amplitude contractions (125µm)**
- First snowfalls (13th and 14th)
- **Rehydration of the stems**
- Warm temperatures during the day do not allow snowcover persistence (Only until the 19th). No snowcover --> freeze/thaw cycles (19th - 24th)
- **Moderate contractions**
- End October: positive temperatures (days and nights)
- **Transpiration for all individuals**

April 2017: The week without snow

- Warmer temperature and shallow snowpack lead to an exceptionally early snowmelt. Individuals have to endure a prolonged period without protection against frost modulated by their microtopographic position. Rf46 undergoes the longest period.
- **High amplitude contractions are observed for Rf46 and Rf45**
- Sunny days and probably frozen soil
- **Transpiration during the day -> Rf45 and Rf46 lose water.**
- Snowfalls the 27th. **Rehydration of all stems**

June 2017: Heat wave for the rhododendrons

- Globally warm temperatures
- Summer rain the 16th, the 26th and wet weather at the end of the month
- After a period directly after snowmelt when all individuals (Rf45 and Rf46) seem to lose water, they seem to recover in June.
- **Rf46 is growing (cambial initiation about the 19th) whereas Rf45 does not make wood.**

In conclusion, our study demonstrates the **complementarity of dendroecological and ecophysiological approaches** to assess the response of shrub growth to (micro)climatic variability in alpine environments. The monitoring of dwarf shrubs at high altitude/latitude yet remains a technical and scientific challenge and further investigations are needed.

From a technical point of view, the main challenges are related to the improvement of the sensor reliability - electronic components and batteries - in extreme humidity and temperature conditions. Amongst the 11 microdendrometers installed at the different sites, only 5 operated for the winter, 4 ran out of battery and two lost the data before the end of the winter.

From a scientific point of view, we expect that our approach will permit to better assess the role of microclimatic fluctuations on the ecophysiology of alpine and arctic dwarf shrubs in the continuum ground-snowpack-plant-atmosphere.