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

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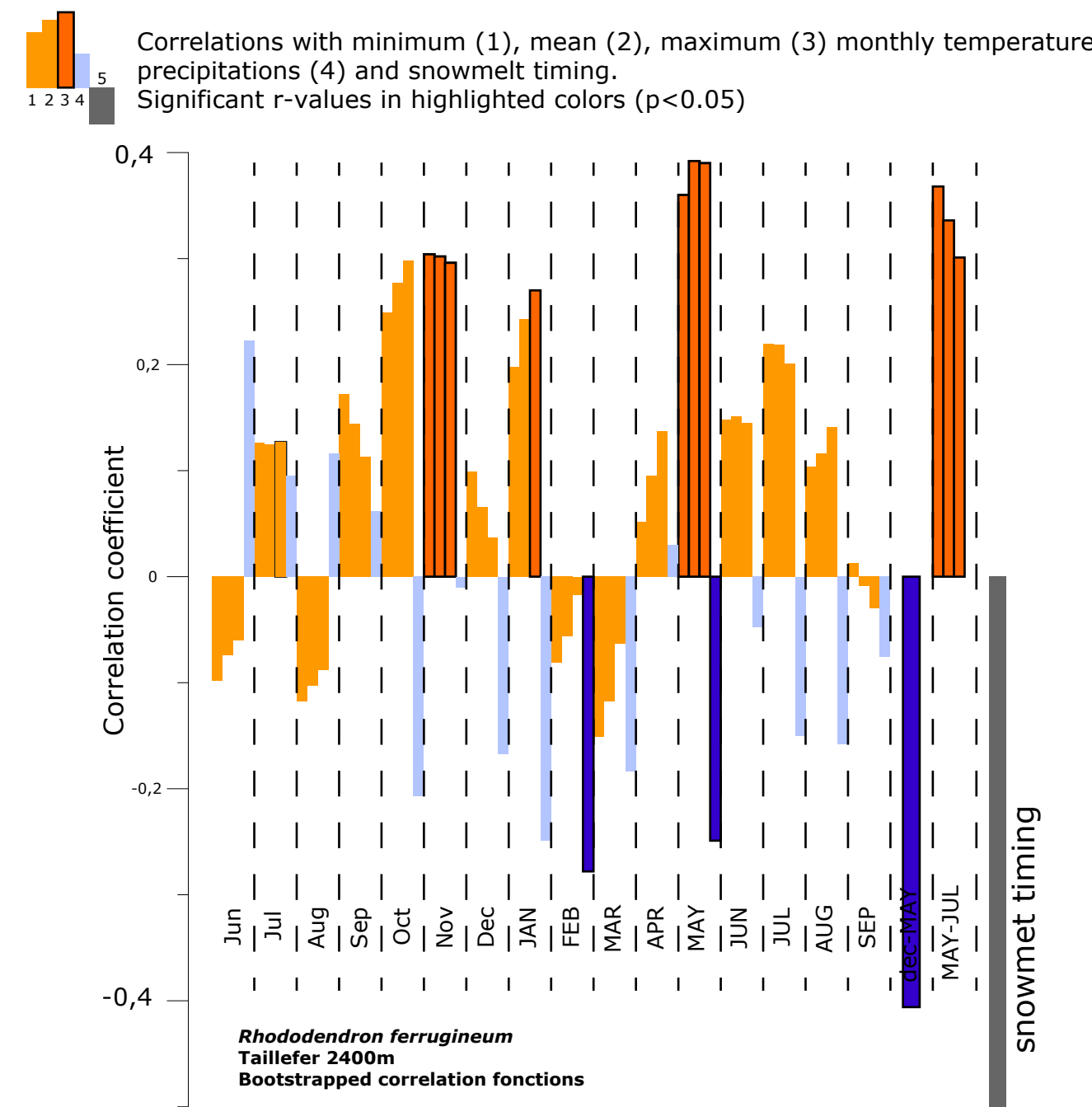
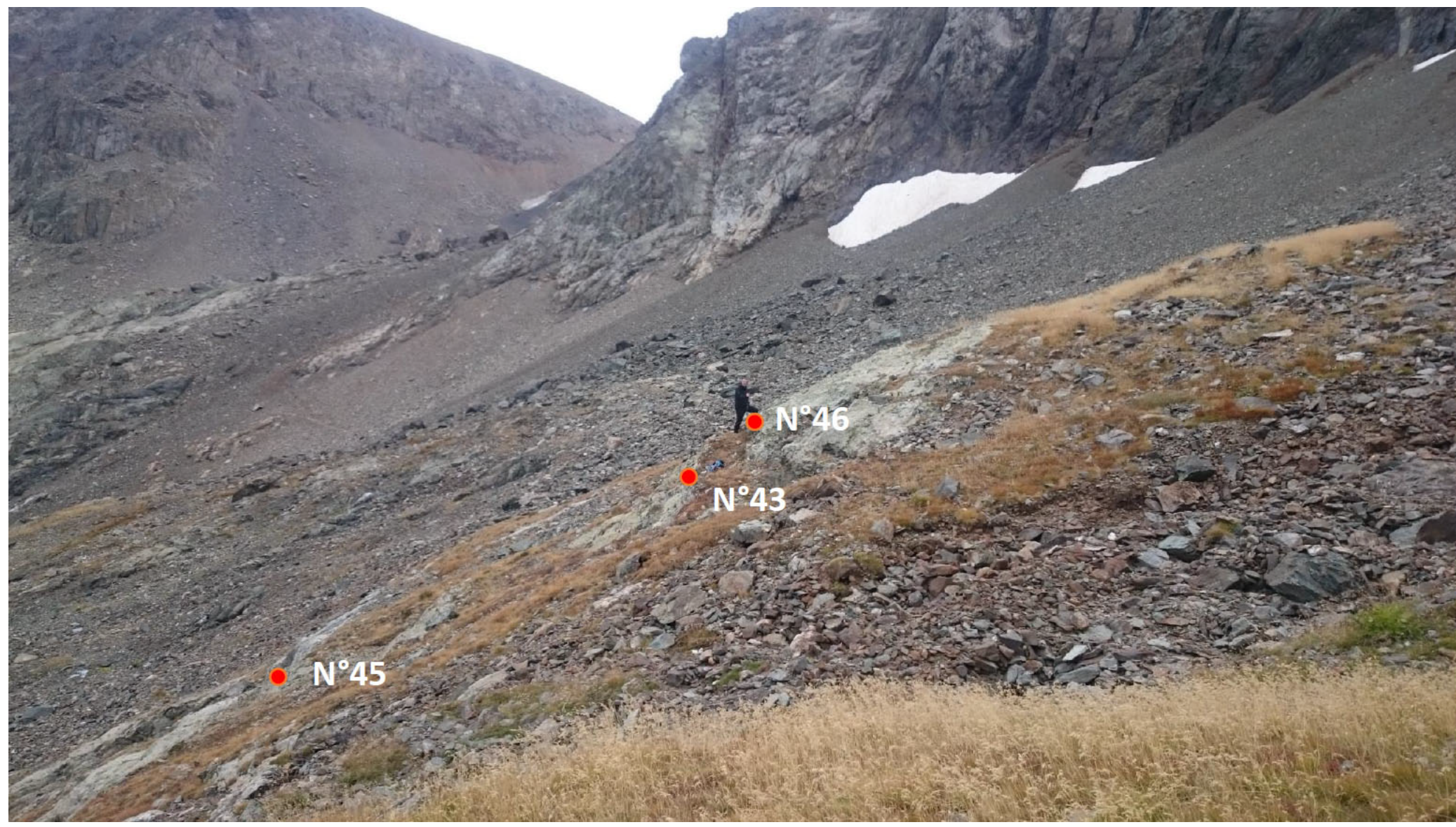
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In this study, **electronic micro-dendrometers** were used to monitor the **variations in stem diameter** of 11 *Rhododendron ferrugineum* (Rf) individuals located at 1800, 2100 and 2500m asl in the Taillefer Massif (French Alps) and at 1700m asl at Videssos (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.

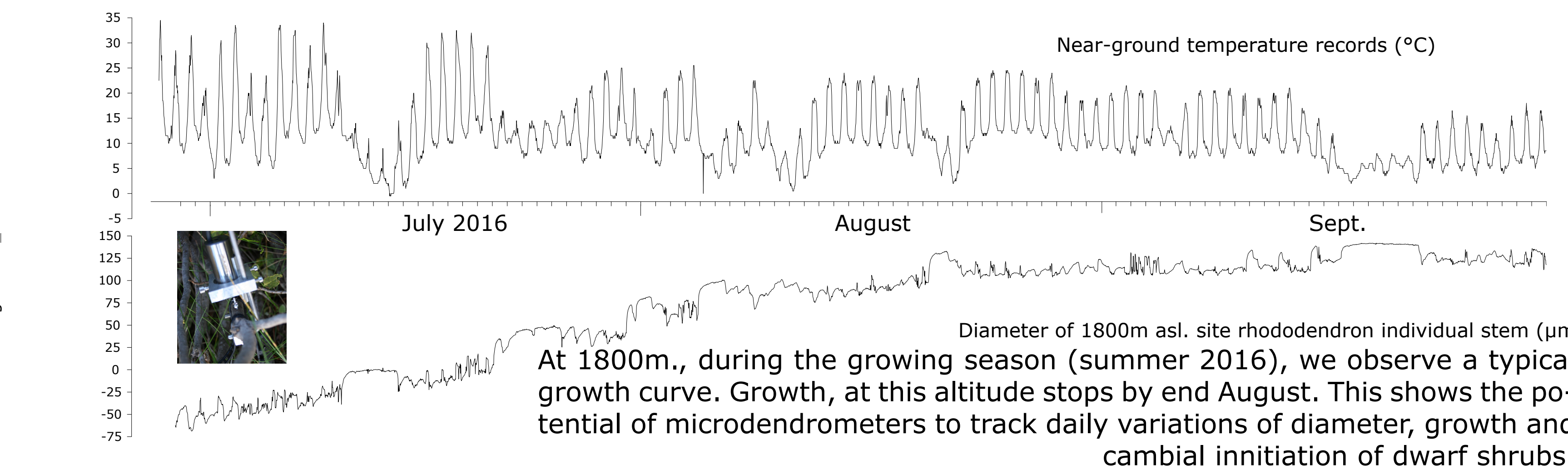
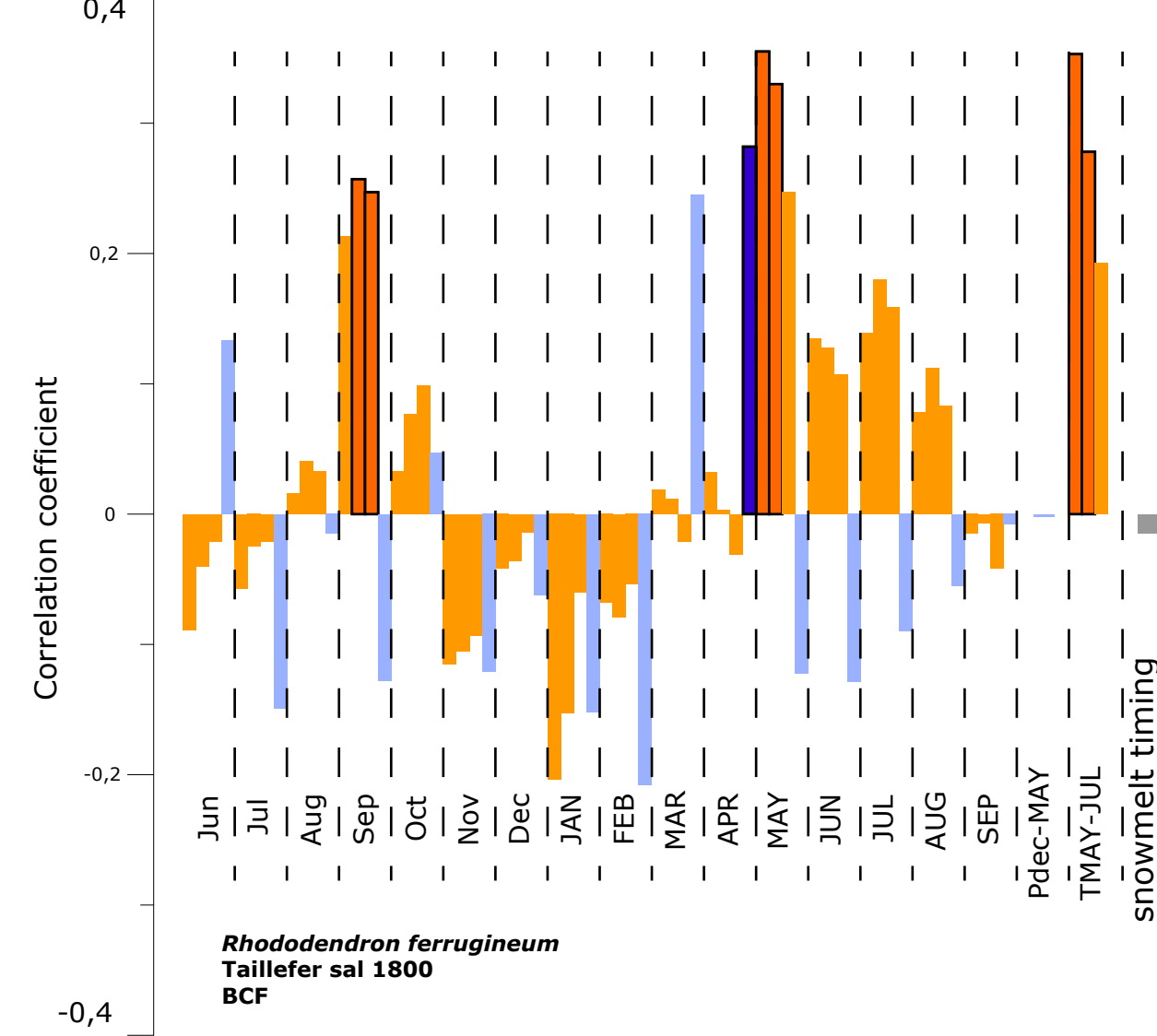
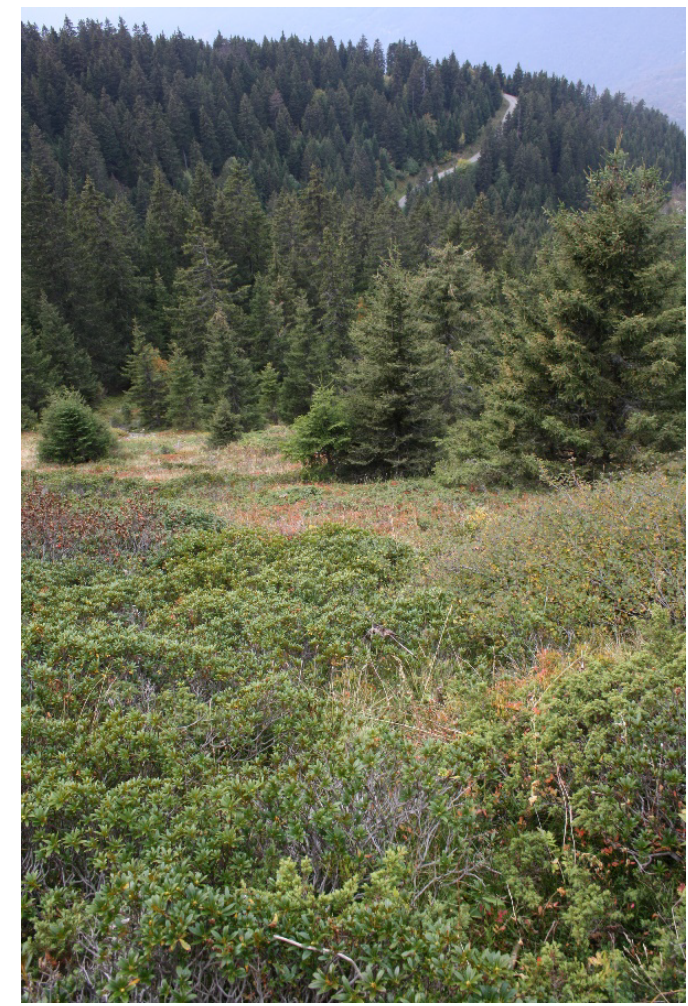
## 1- Results of the dendroecological approach: Climate-growth relationships (1960-2016)



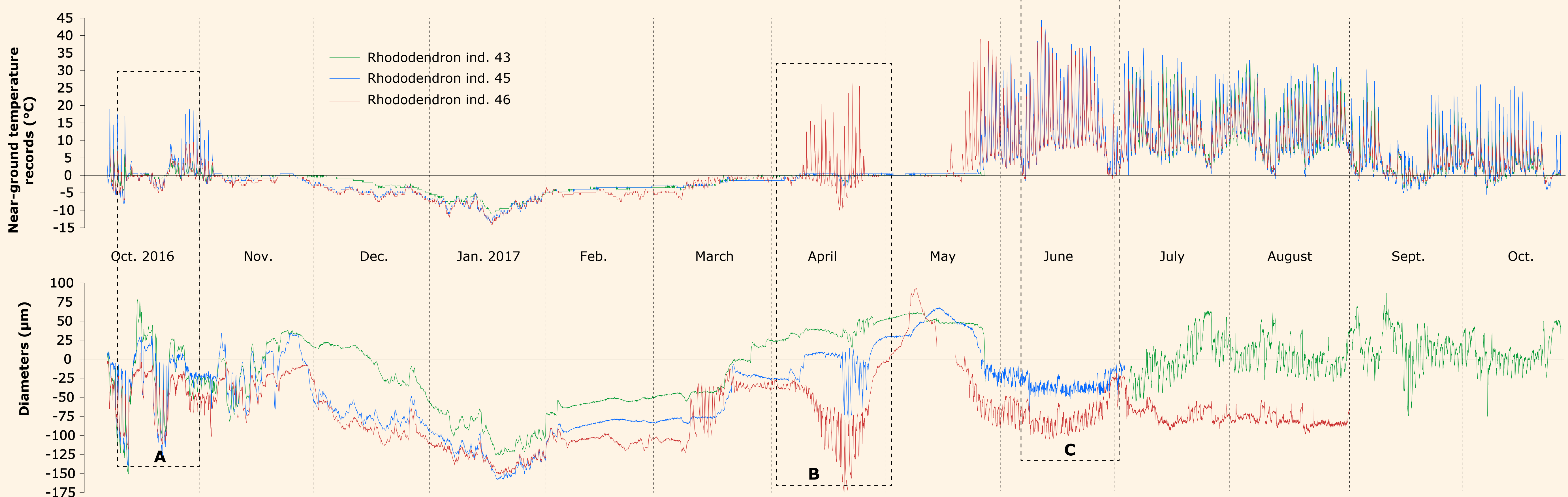
### Context:

- 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.

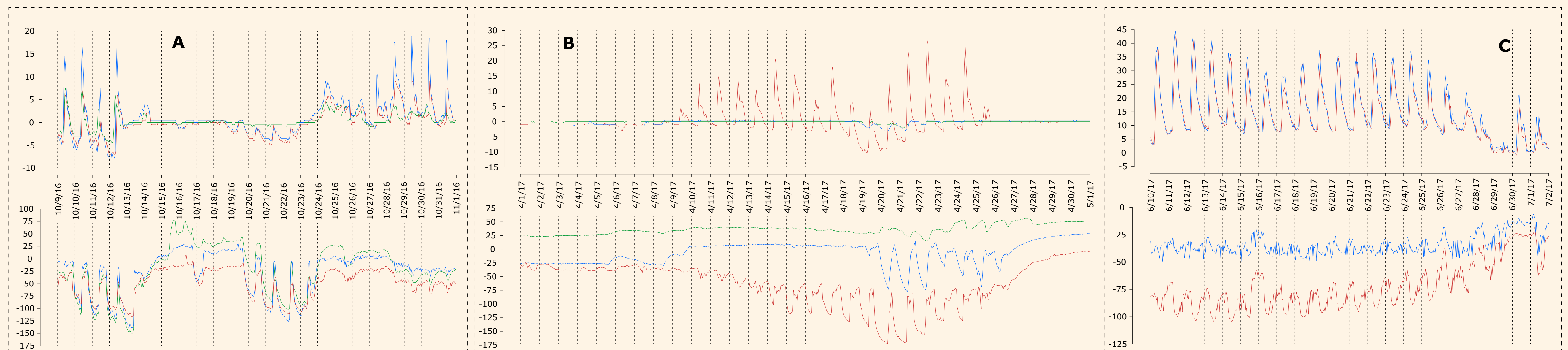
## 2- A first try at 1800m in summer : the potential of microdendrometers on dwarf shrubs



## 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.