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Non-destructive measurements for destructive experiments: how to assess damages ?

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Guillaume Charrier, Thierry Ameglio. Non-destructive measurements for destructive experiments: how to assess damages ?. Journée thématique CEFÉ - Survie au stress, Centre d'Ecologie Fonctionnelle et Evolutive (CEFE). FRA., Sep 2019, Montpellier, France. 15 p. hal-02444443

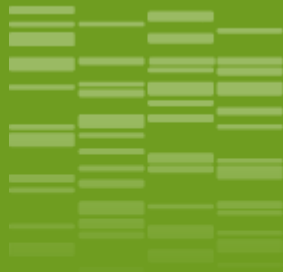
HAL Id: hal-02444443

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Submitted on 5 Jun 2020

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Survie au stress – Stress survival

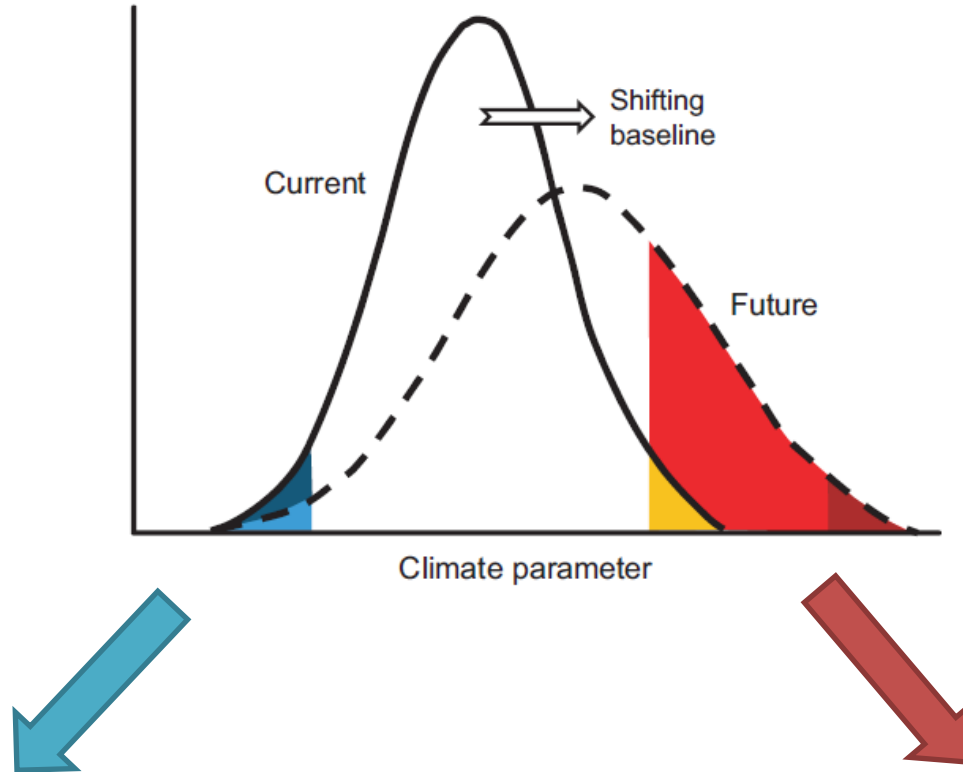
Journée thématique CEFE



Non-destructive measurements for destructive experiments: how to assess damages?



Context – Facing extreme climatic events

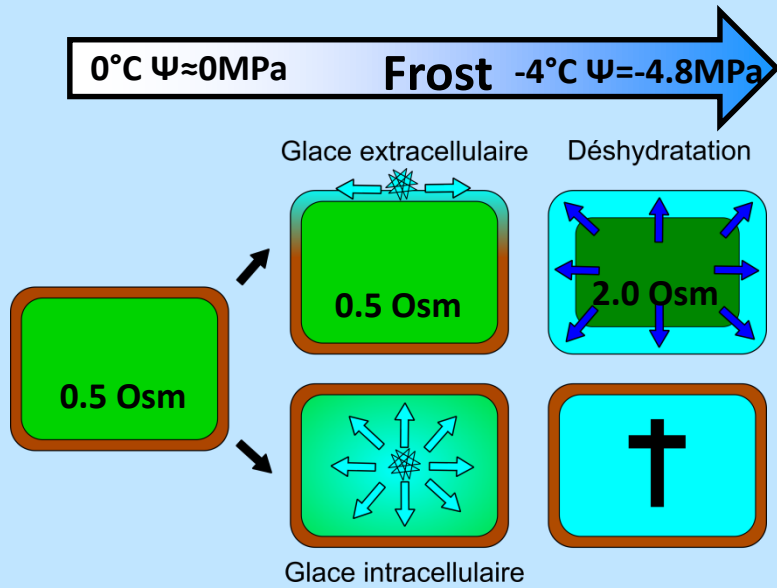


Still some frost events

More heat-waves and drought events

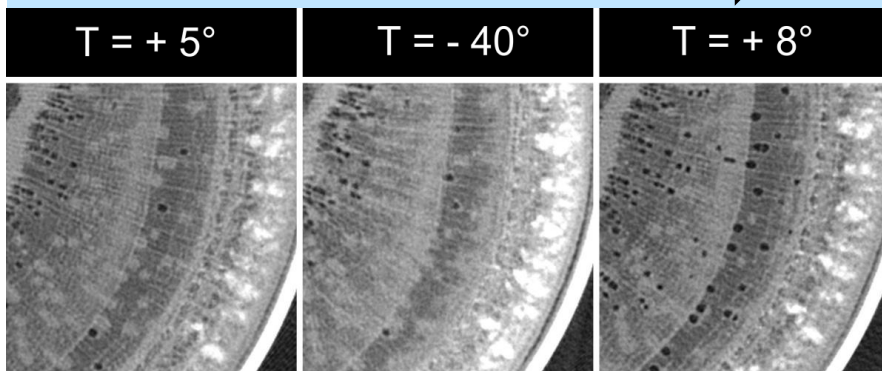
Abiotic stress – Physiological damages

Living cells



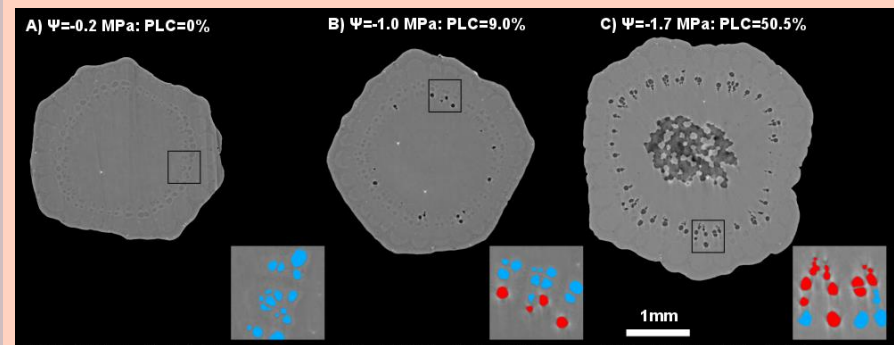
Freezing/Thawing

Hydraulic system



Charra-Vaskou *et al.*, J. Exp. Bot. 2015

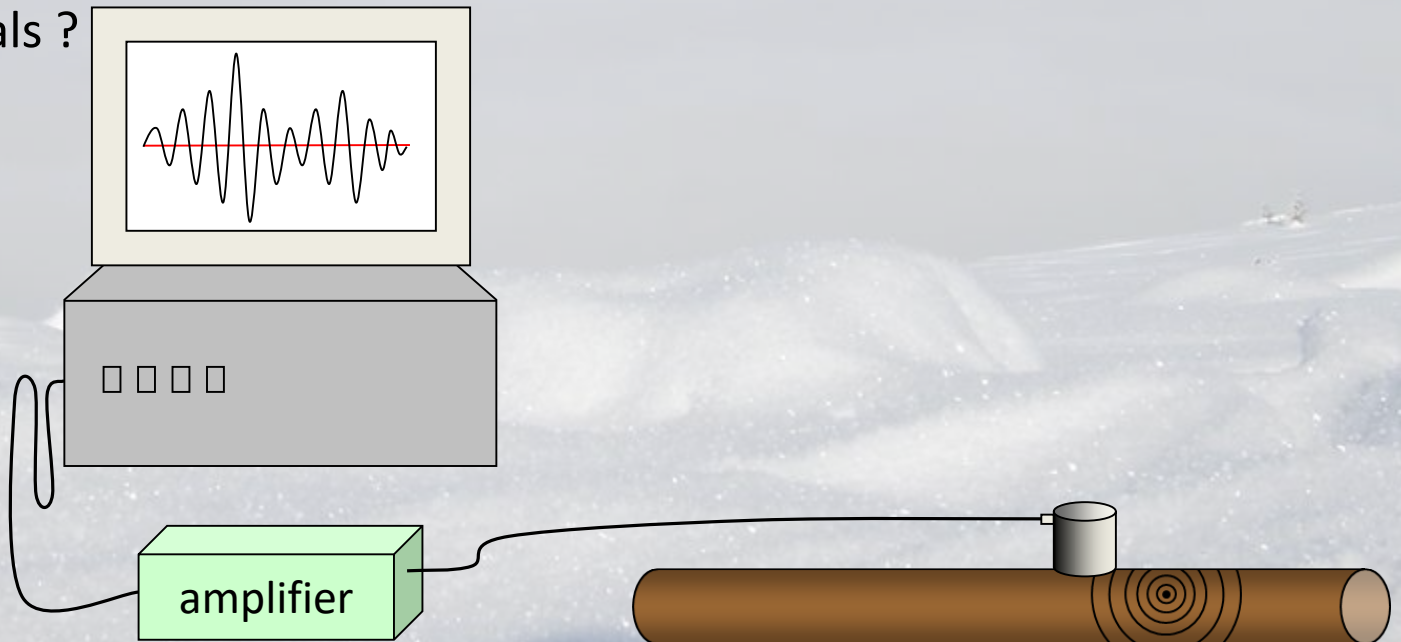
Drought



Charrier *et al.*, Plant Physiology 2016

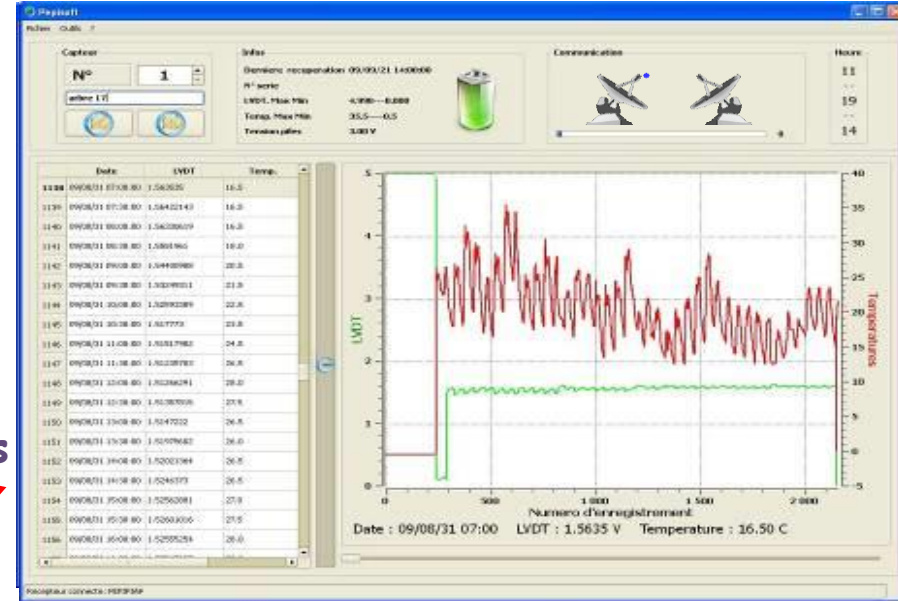
Non-invasive techniques to monitor damages *in situ*

- Dendrometer
 - Water fluxes (drought and frost stress)
 - Growth (resilience to stress)
- Ultrasonic acoustic analysis
 - Cavitation events (drought and frost stress)
 - Other signals ?



From the Pépista to the PepiPIAF

A LVDT sensor and a sensor holder (invar)

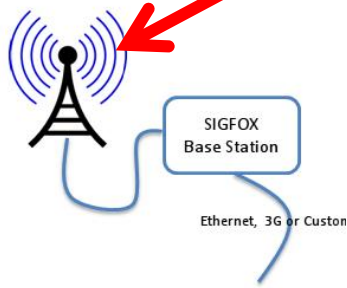


Acquisition of data
Measurement of T_{air} °C
Power supply (2 AA)
2.4 GHz Radio Transmitter
and Sigfox or LoRa networks

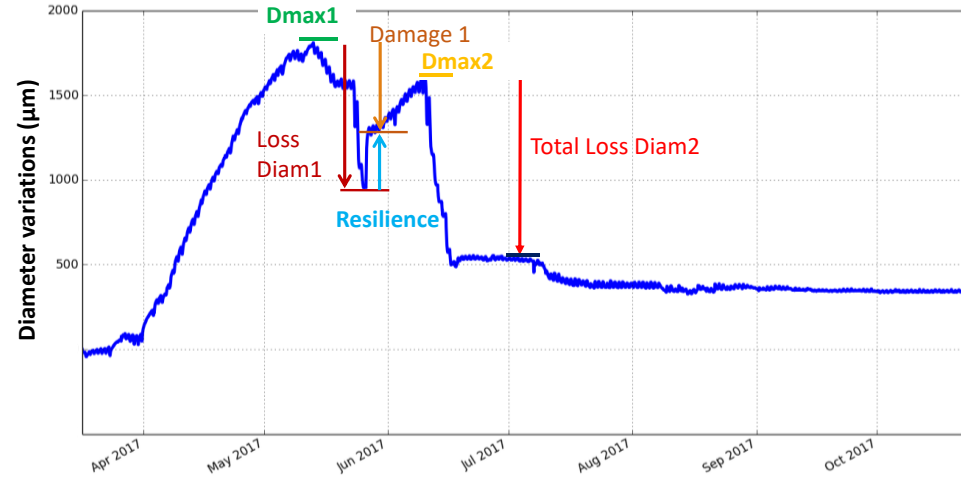
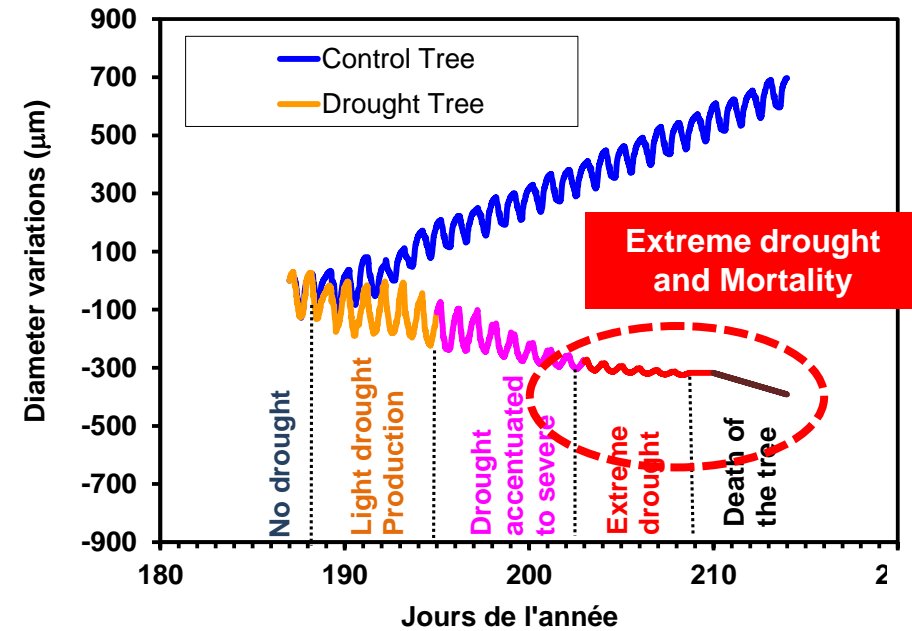
Receiver USB
Pépidatasoft software

Mini data logger integrated :

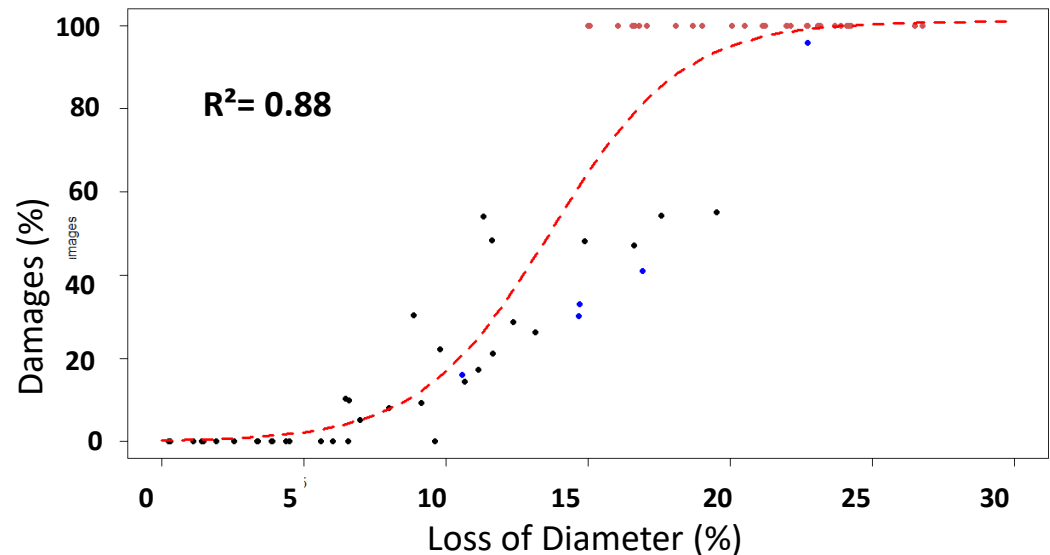
- LVDT (resolution $1\mu\text{m}$ (16 bit acquisition) & Temperature sensor ($\pm 0.5^\circ\text{C}</math>)
Power Supply: 2 AA Autonomy for 12 months)$
- Memorization: average according to selected frequency (1, 5, 10, 15, 30 mn, 1h, 3h)
- Memorization: from 2160 to 10800 measurements (ex, for 30 mn = a history over 45 to 225 days)
- Authorized distributor: Hydrasol licensed INRA Transfert
- PépiDataSoft remote download software, allowing to view and dialogue with the PépiPIAF and to edit the data in txt or excel format and to interpret them)
- PC Transmission; Radio HF 43.3 Mhz: range of 150 m to PS and Sigfox or LoRa



Extreme drought conditions to determine mortality



Dégâts en fonction perte de diam



Work in progress of a PhD student Lia Lamacque (UMR PIAF- Iteipmai) on the links between extreme drought and mortality on Lavanda

iteipmai

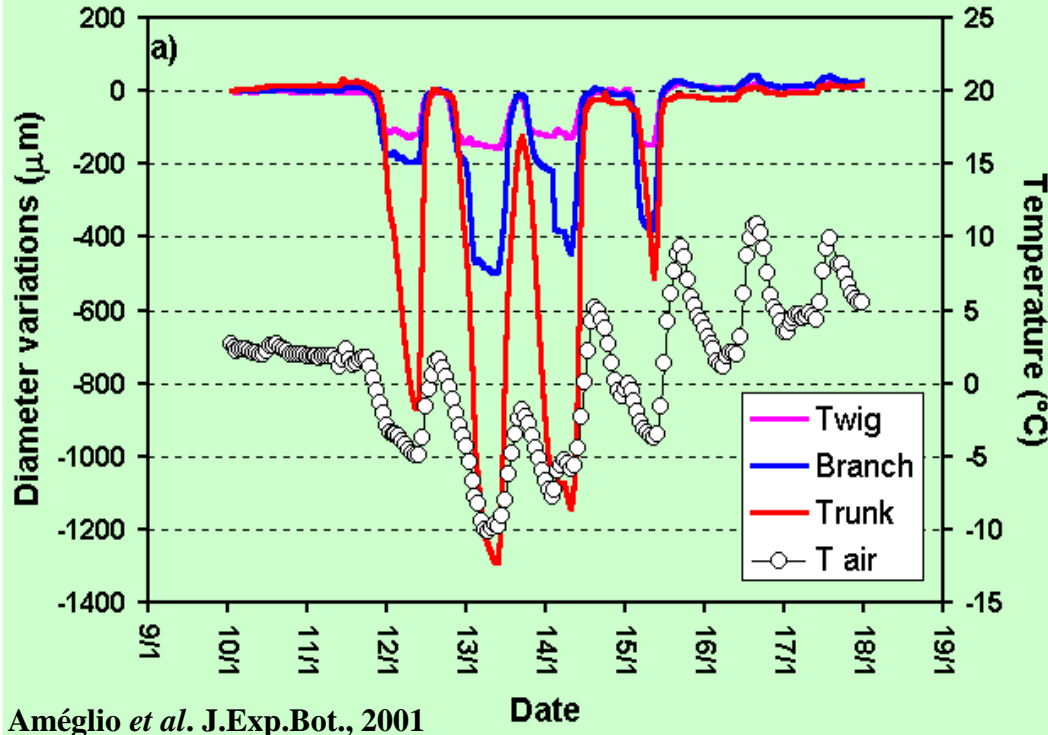


Winter damages

Journal of Experimental Botany, Vol. 52, No. 364, pp. 2135–2142, November 2001

Stem diameter variations and cold hardiness in walnut trees

Thierry Améglio^{1,3}, Hervé Cochard¹ and Frank W. Ewers²



Améglio et al. J.Exp.Bot., 2001

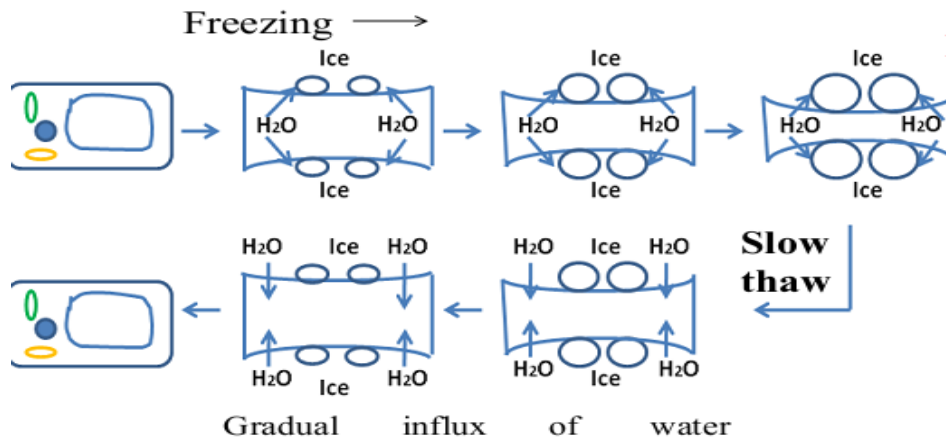
The Ψ of ice changes at about $1.16 \text{ MPa} \cdot \text{K}^{-1}$ decrease in temperature.

Rajashekar and Burke (1982)

Rajashekar et al. (1983),

If the ice formation start at -5°C when the temperature decrease at -10°C , the Ψ decrease about $\approx -6,0 \text{ Mpa}$

Similar to Extreme drought stress!



Extreme stress at the treeline: Winter drought

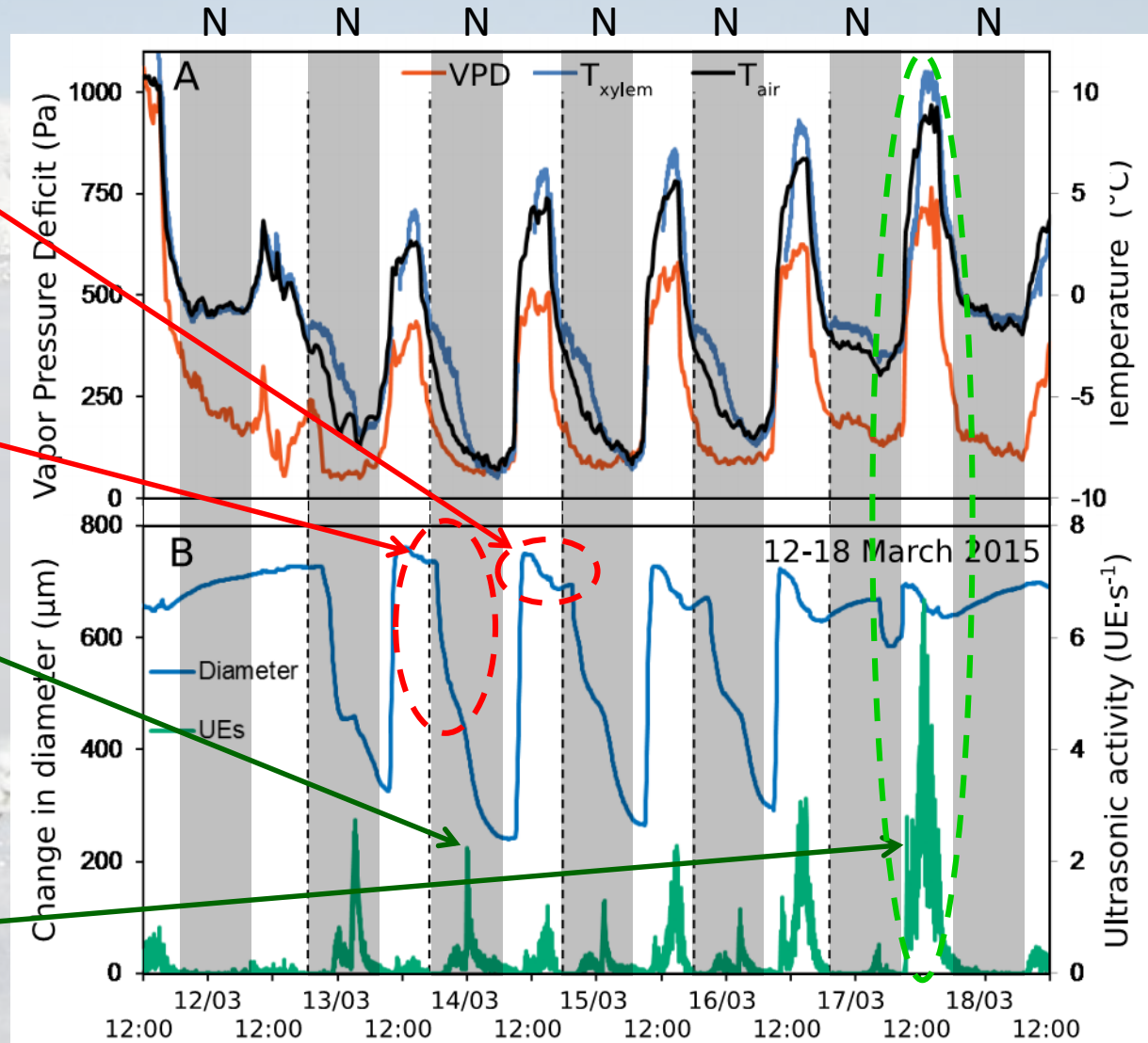
Daytime shrinkage (E)

Nighttime shrinkage (Ψ_{ice})

Nighttime AEs:
Freezing-cavitation =
bubbles formation

Daytime AEs:
Embolism development due
to transpiration

Ψ_{stem}

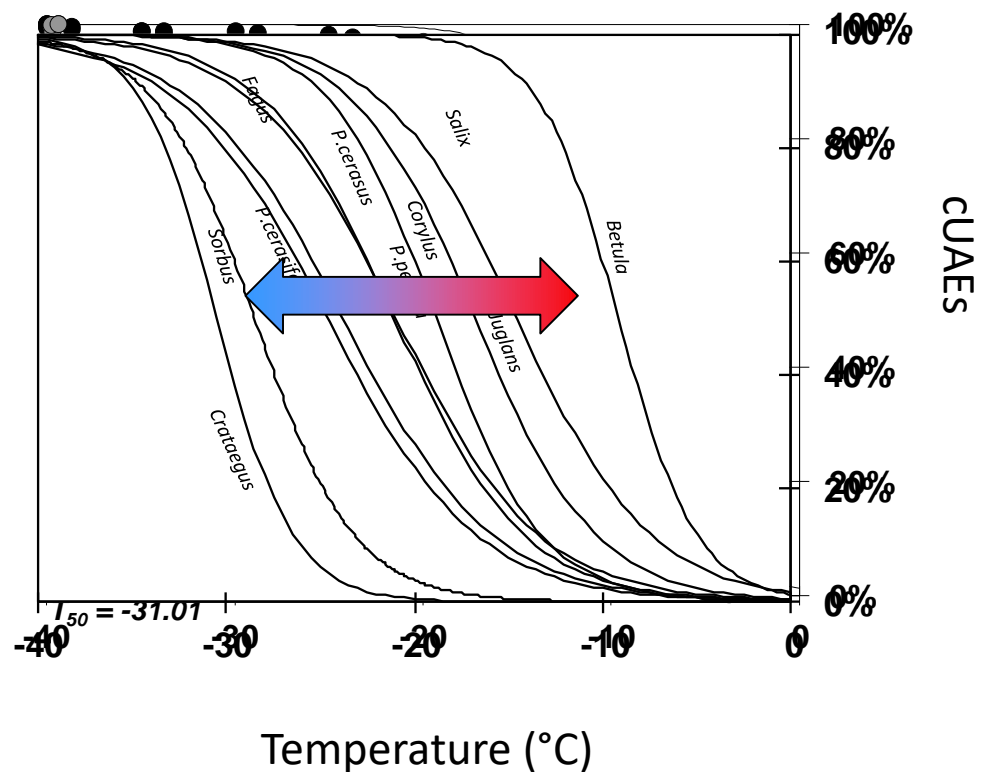


Frost-induced acoustic emissions

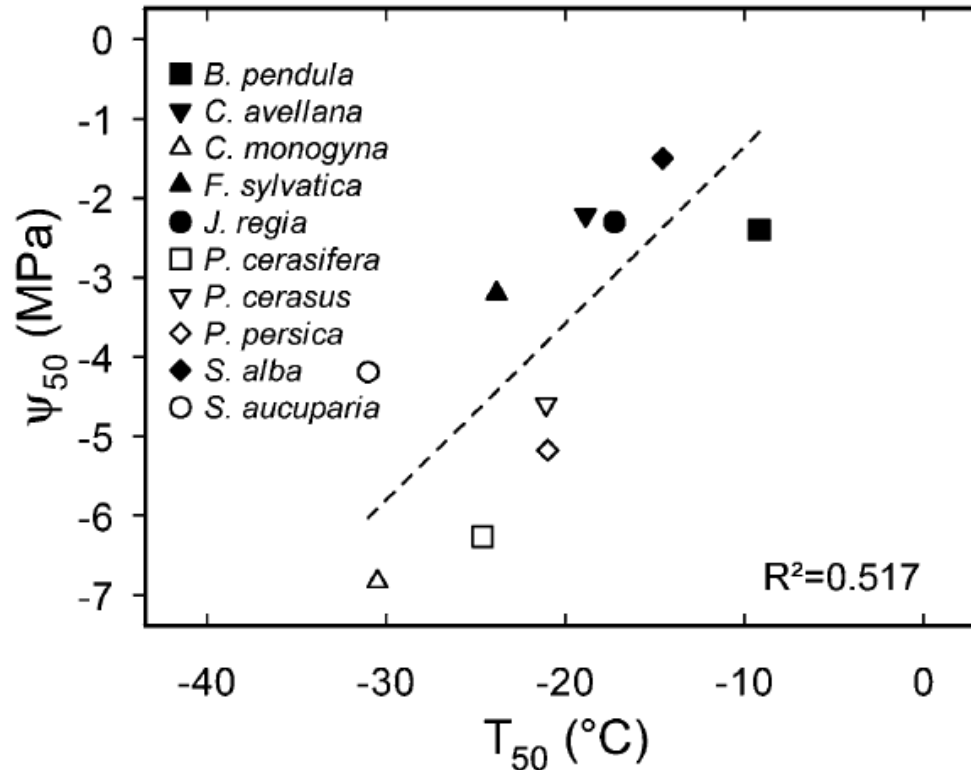
Interspecific variability

Sigmoid relation with temperature,
($0.928 < R^2 < 0.994$)

Wide variability in T_{50} ,
($-10 < T_{50} < -32^{\circ}\text{C}$)



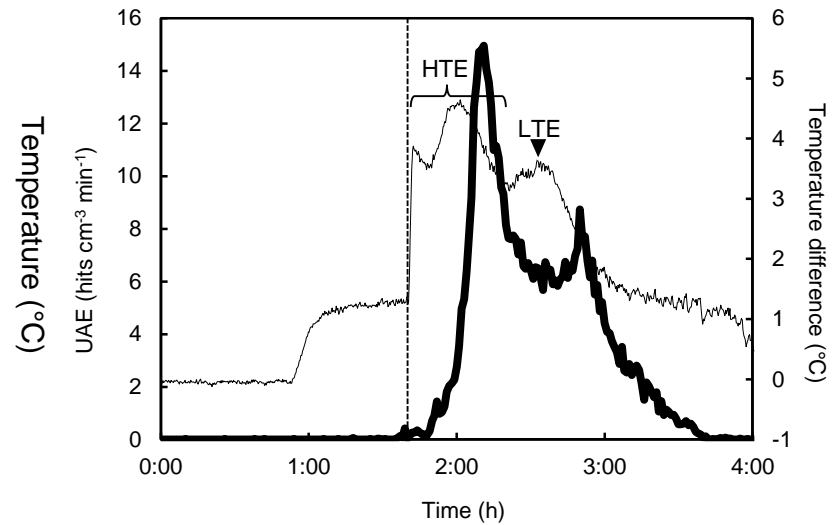
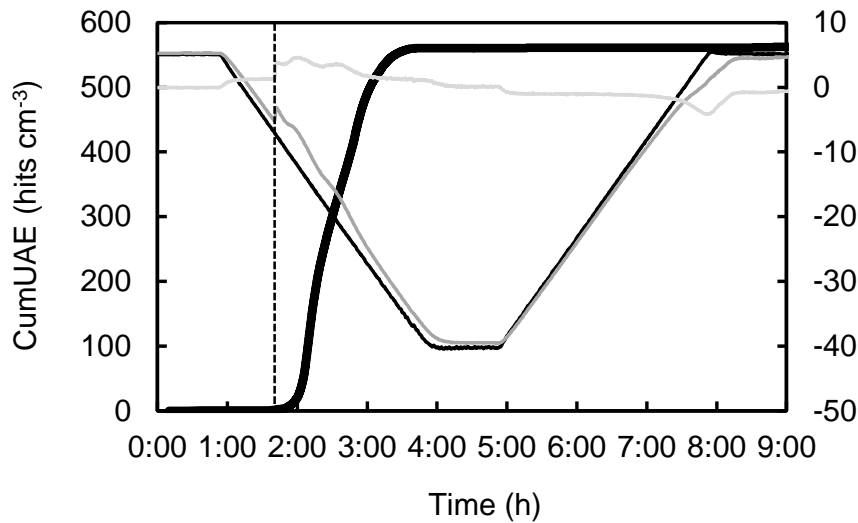
Frost-induced acoustic emissions is related to drought resistance



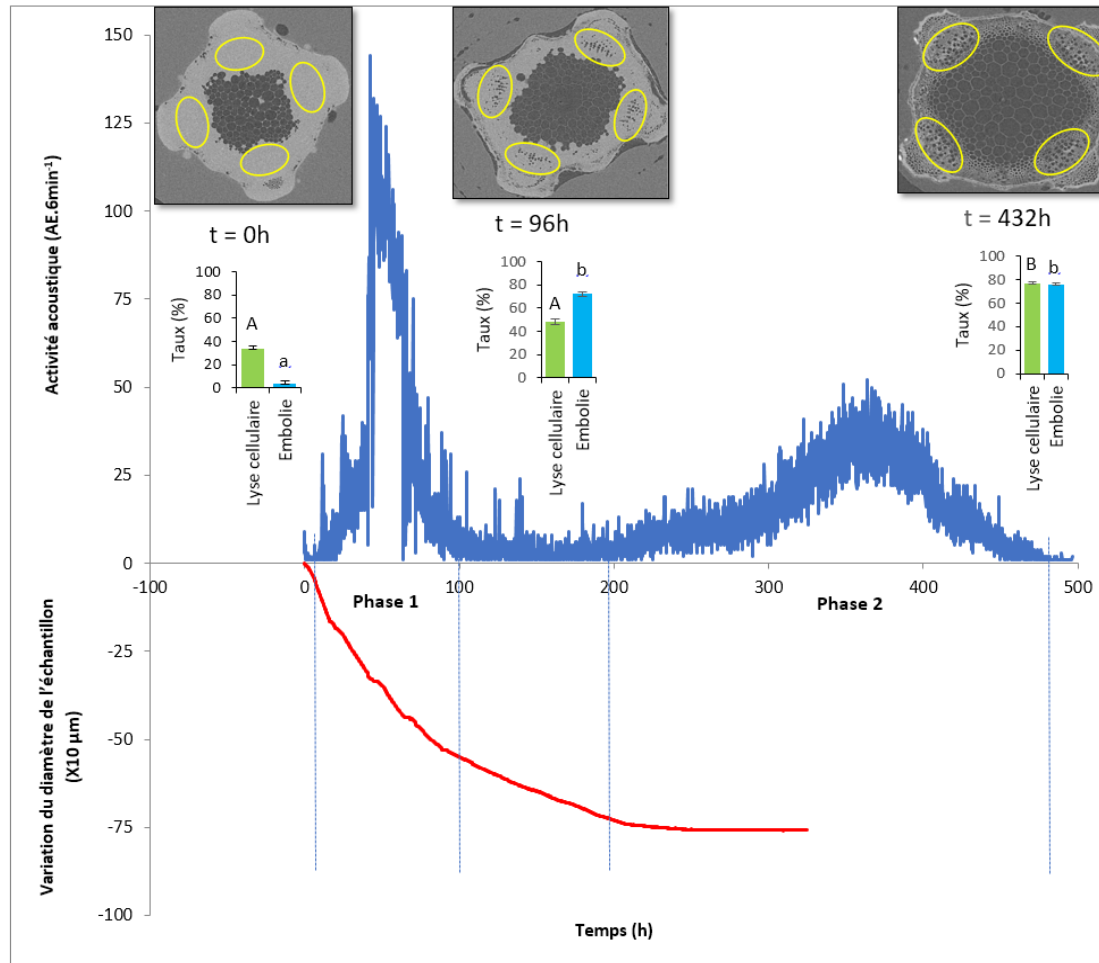
Freeze-Thaw expansion hypothesis with Ψ_{ice} as driving force:
=> displacement of the air-water menisci in pits
=> cause bubble to expand or collapse

Drought-induced and frost-induced embolisms may share the same mechanism.

Are UEs only from vessel origin?

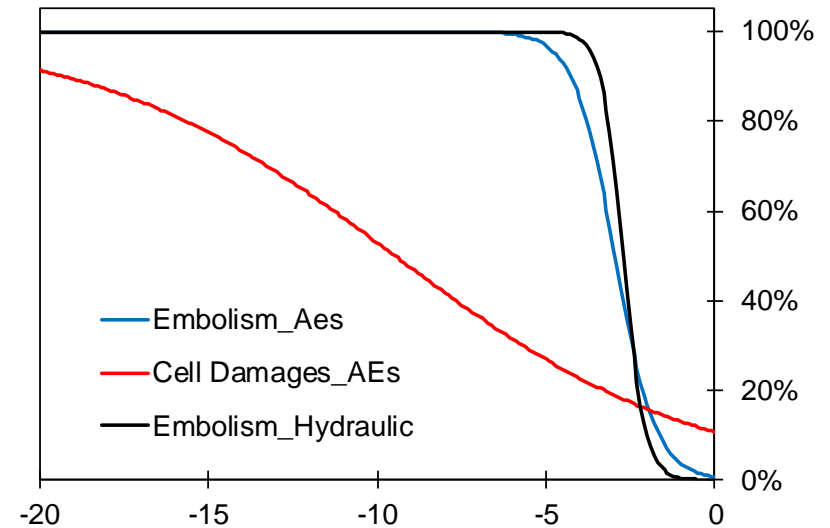
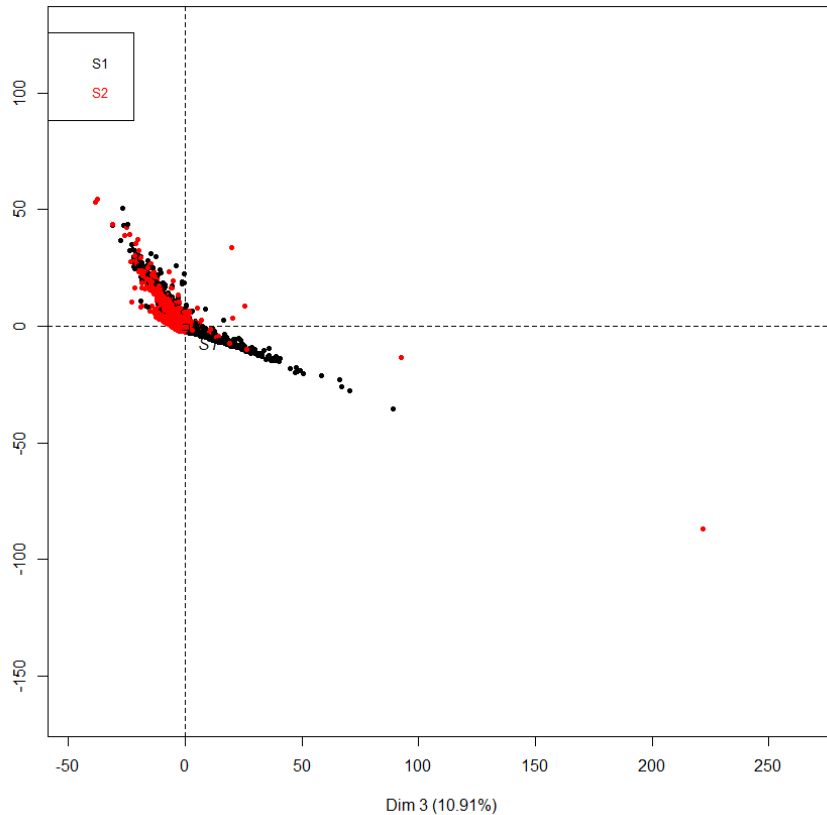


Are AEs only from vessel origin?



- 2 stages of AEs
 - 1st => embolism & cell damages
 - 2nd => cell damages

Capturing acoustic parameters across stages to predict PLC and cell damages



Sounds promising !

Thank you for
your attention



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