Water fluxes and embolism formation during freeze-thaw cycle

CHARRA-VASKOU Katline[1,2], BADEL Eric[1,2], CHARRIER Guillaume[3], BONHOMME Marc[1,2], COCHARD Hervé[1,2], MAYR Stefan[3], AMEGLIO Thierry[1,2]

[1]INRA Clermont-Ferrand UMR PIAF, France/ [2]Institute of Botany, University of Innsbruck, Austria

On trees, freeze-thaw cycles induce injury, which can lead to death of plant. Ice formation induces drastic dehydration on living cells creating water fluxes and on dead water transport system cells causing embolism. If damages after a complete freeze-thaw cycle were reported in many studies, mechanisms and events occurring during either freezing or thawing are totally unknown.

Methods:

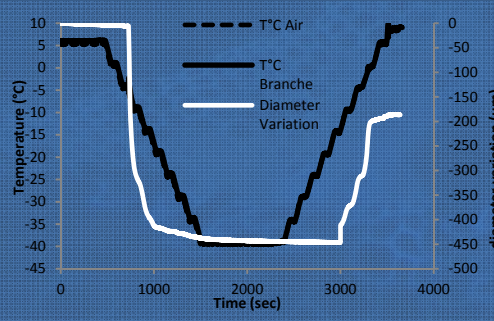


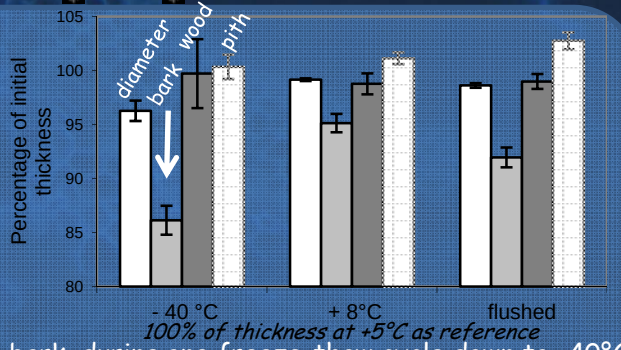
Juglans regia samples (x 5) and controls (x 3)

Samples were subjected **to freeze-thaw treatment (+5/ -40/ +8°C)** in climatic chamber and controls stayed at constant temperature (+5°C)

Sample diameter was continuously measured and for each temperature step, the embolism was observed in the sample by **x-ray microtomography**

Water fluxes:





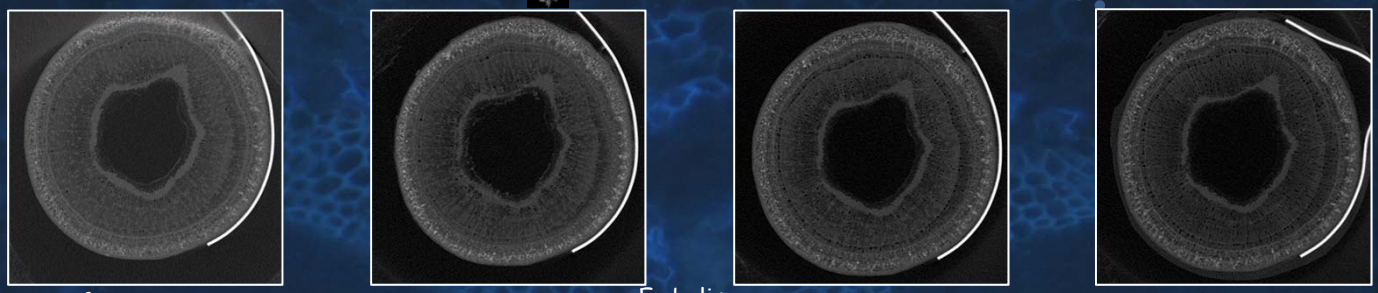
100% of thickness at +5°C as reference

Shrinkage of stem is mainly due to shrinkage of bark, during one freeze-thaw cycle down to -40°C

Embolism formation:

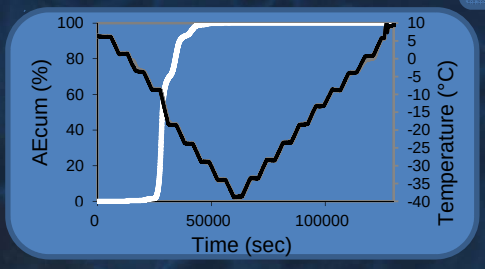
X-ray microtomography observations

+5°C — freezing → -40°C — thawing → +8°C → air → Flushed with air



Percent of embolism: 18,4% — 21,0% — Embolism events → 66,3% — 100,0%

Significant increase of embolism during thawing



Acoustic Emission (AE) Analysis

Acoustic Emissions (AE) analysis is a common method to measure cavitation (air bubble formation) and embolism during drought stress. During freeze-thaw event, AE are recorded only during freezing which suggests that cavitation events emitted AE and embolism development not. This also suggests that cavitation only occurred during freezing.

Conclusion:

While water fluxes were observed during both freezing and thawing, cavitation seemed to be acoustically detected during freezing. Embolism events occurred only during thawing without any AE. Details of mechanisms inducing water fluxes, cavitation and embolism events should be considered in further studies.

