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Freezing of water in capillary tubes

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> Context - Motivation

Trees are able to undergo several months of cold temperatures every year. This is very surprising since the temperature may go down to -30°C , far below the freezing temperature of water. A direct consequence is the tree line, the limit in altitude where trees can survive.



Tree in cold condition
Charrier (2014)



Tree line
Macias-Fauria (2013)

How do trees survive the negative temperatures, until which critical temperature? What sets the critical temperature? What are the freezing dynamics of water in a tree?

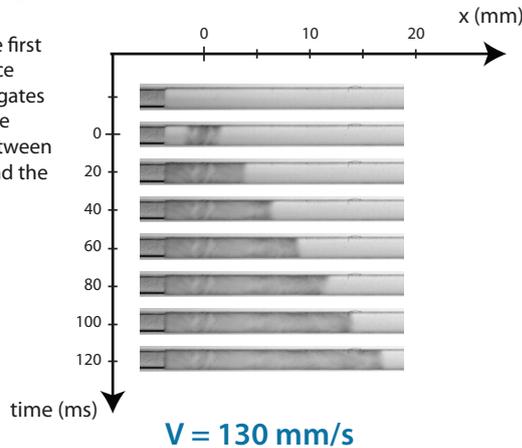
Since trees are not transparent, recording acoustic events is a promising technique to resolve those questions.

> Here we present some aspects of freezing of water in capillary tubes, monitored both with optics and acoustics.

FREEZING: TWO DIFFERENT TIME SCALES

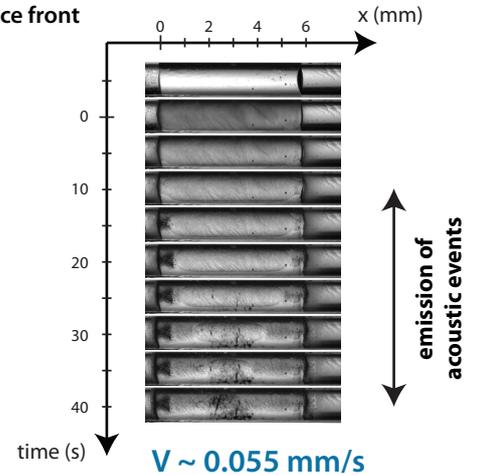
Quick propagation of an ice sheet

> During the first 100 ms, an ice sheet propagates quickly at the interface between the liquid and the tube.



Slow propagation of the ice front

> On a time scale of the order of 1 minute, the entire volume of the drop freezes. The freezing front first closes the drop at both ends (1-10s) and then propagates to the center (10-40s). Acoustic events are emitted only in the second step.

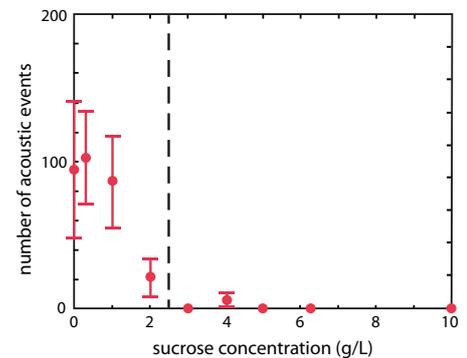
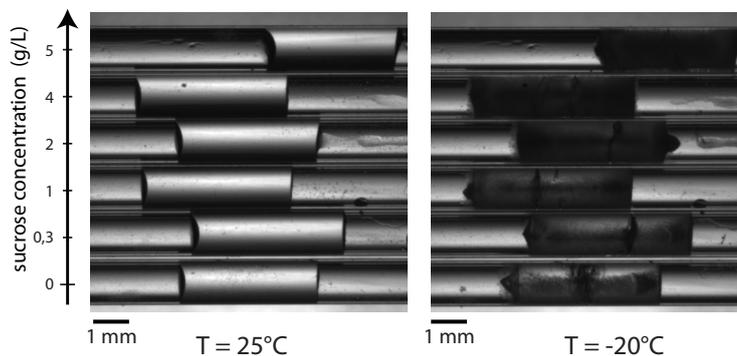


SUCROSE CONCENTRATION EFFECT

> Here we quantify the influence of sucrose concentration on the quantity of acoustic events.

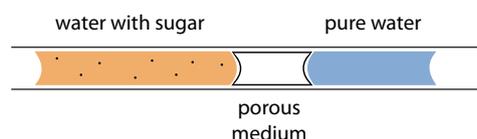
The experiment shows a critical sucrose concentration above which there is no more acoustic emissions during freezing.

In a tree, acoustic emission would only reflect freezing in the cells below this concentration.



> A variation

As in a tree undergoing freezing, we want to observe the freezing dynamics of a system where water with sugar and pure water are connected by a porous medium.



> Perspectives

Explore different kind of tubes : open and closed geometries, rigid and flexible tubes, hydrophilic hydrophobe surfaces.

Work with porous media to understand propagation of freeze between cells and tissues in a tree.