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Cavitation in trees monitored using simultaneously acoustics and optics

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Abstract

Under hydric stress, the water column in trees, which is under tension in the conducting element (vessels or tracheids resp. for angiosperms and gymnosperms); can cavitate: bubbles appear and eventually cause an embolism in the circulation. It has been shown that cavitation is associated with short acoustic emissions, and they can be recorded in the ultrasound range. However the precise origin of each acoustic emission is still not clear. In particular, the acoustic emissions could be not only the consequence of cavitation, but also of the collapse of xylem conduits, or of fractures in the wood.

Here we present an original set-up where we can simultaneously record (i) the acoustic emissions, (ii) the location of cavitation events, by imaging the sap channels under light transmission microscopy. We are then able to correlate the sounds to the visible changes in channels, such as the appearance of cavitation bubbles. For fast phenomena, we can use a high-speed camera in the optical set-up, so as to resolve the dynamics of propagation of cavitation events.

We consider two types of sap channels: biomimetic ones made of hydrogel, and real wood xylem conduits embedded in hydrogel. The hydrogel is set into a low humidity atmosphere so as to generate negative pressures in the liquid filled cavities. The biomimetic channels will be helpful to calibrate the acoustic and optical set-up, and to resolve temporally cavitation events. The real xylem conduits will be tested so as to obtain the acoustic signature of each cavitation event, and try to discriminate it from other events.

We hope the results of the present study might help to better understand the acoustic signals emitted by trees, and to obtain further information in the evolution of wood under dry stress conditions.

Keywords

acoustics, ultrasound, cavitation, xylem, dry stress