



HAL
open science

Measuring tree water content directly in the field with portable MRI

Shannan Blystone, Hervé Cochard, Jean-Marie Bonny, Guilhem Pagés

► **To cite this version:**

Shannan Blystone, Hervé Cochard, Jean-Marie Bonny, Guilhem Pagés. Measuring tree water content directly in the field with portable MRI. 16th Biennial International Bologna Conference Magnetic Resonance in Porous Media, Aug 2024, Tromso, Norvège, Norway. hal-04683870

HAL Id: hal-04683870

<https://hal.science/hal-04683870>

Submitted on 2 Sep 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Measuring tree water content directly in the field with portable MRI

Shannan Blystone^{a,b,c}, Hervé Cochard^c, Jean-Marie Bonny^{a,b}, Guilhem Pagés^{a,b}

^aUniversité Clermont Auvergne, INRAE, UR QuaPA, 63122, Saint-Genès Champanelle, France; ^bINRAE, PROBE research infrastructure, AgroResonance facility, 63122, Saint-Genès-Champanelle, France; ^cUniversité Clermont Auvergne, INRAE, PIAF, 63000, Clermont-Ferrand, France

Forests are one of the largest carbon sinks, playing a major role in mitigating climatic changes. The main process that sequesters carbon is photosynthesis, which converts atmospheric CO₂ into sugars using water and light. The capacity of a tree to sequester carbon is thus linked to water availability and its dynamics. It is critical to estimate water content in plants directly, in their natural environment, i.e. *in-situ*, to better understand plant water use. Most of the current methods to measure water are either invasive, indirect or limited to laboratory use. To non-invasively measure water properties, NMR and MRI are one of the analytical tools of choice. To bring the spectrometer outside the laboratory, the magnetic field must be decreased. Several groups demonstrated the feasibility of such an approach by measuring tree water content [1], flow rates in fruits [2], and imaging a tree trunk with high contrast [3]. We recently reviewed the different applications of portable MRI to study plants and compared this sensor with others [4]. One of the major limitations of portable MRI deals with the magnet design and the size of its bore, limiting the size of the plant which can fit inside to a few centimeters. To avoid this main limitation, we decided to use a unilateral magnet which can be put in contact with the plant independently of its size. Beyond the plant sciences, the interest of unilateral magnets has been demonstrated in several applications, like cement drying, polymers and painting, reviewed in [5]. The aim of our study is to evaluate the potential of a unilateral magnet to study tree water content *in-situ*.

We used the profile NMR-MOUSE PM25 (Aachen, Germany) as our MRI sensor. To test the capacity of the sensor to estimate water content, we cut branches and monitored their dehydration with the profile NMR-MOUSE and by weighing. Thirty branches were taken from 6 different species (*Abies alba*, *Betula pendula*, *Fagus sylvatica*, *Pinus sylvestris*, *Picea abies* and *Juglans regia*) belonging to two functional types (conifers and diffuse porous). NMR data consisted of CPMG decays at each depth of the profiles. To increase the SNR, we summed the signal over all depths and adjusted the CPMG signal decay by using a biexponential model. After normalisation, the amplitude of the long T_2 pool was linearly correlated to the water content obtained by weighing the branches. *In-situ* tree measurements were performed in the same way and data points were added to the graph of the linear model.

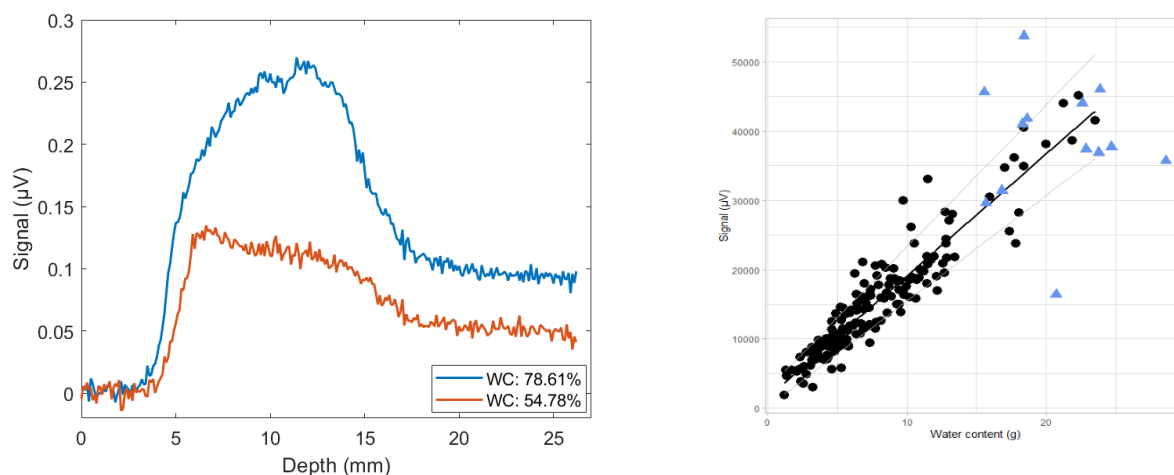


Figure 1 – (Left) NMR profiles recorded at two hydration level on the same branch coming from a *Pinus sylvestris* tree. (Right) Linear relationship obtained from the different banches. The black dots were obtained from branches and were used to build the model while the blue triangles were measurements from *in-situ* trees and were added to the plot.

The profiles obtained from the MRI sensor contained different types of information as illustrated in Figure 1 (left). First, the signal evolution in function of the depth gave information on the type of wood. Indeed, the highest signal intensity (from 5 to 15 mm in depth) was linked to active xylem tissue, while the lower intensities were linked to heartwood, or older xylem tissue, which contains significantly less water. The second information deals with the temporal evolution of the profile. A clear decrease of the NMR signal was observed in function of the branch water content. These profiles were T_2 -weighted (the sum of several echoes) and to have a quantitative estimate of water content, we adjusted the CPMG signal decay by using the best suited model, i.e. a biexponential model. We hypothesized that the fast T_2 pool represented protons from the organic matter while the long one represented the protons from water. The MRI intensity was linearly correlated to the branch water content in a general model, independent of either the species or the functional type. Most of the *in-situ* measurements fit well within the model. For the few points which were outside the model, experimental conditions explained the variations.

To conclude, we demonstrated that this unilateral magnet is an excellent candidate to study water content in trees directly in their natural environments.

References

- [1] M. Jones, P. S. Aptaker, J. Cox, B. A. Gardiner, P. J. McDonald, J. Magn. Reson.. 218 (2012) 133-140.
- [2] C.W. Windt, F.J. Vergeldt, P.A. De Jager, H. Van As, Plant Cell Environ. 29 (2006) 1715–1729.
- [3] M. Meixner, M. Tomasella, P. Foerst, C.W. Windt, New Phytol. 226 (2020) 1517-1529.
- [4] S. Blystone, M. Nuixé, A. S. Traoré, H. Cochard, C. Picon-Cochard, G. Pagés, Plant Meth. 20 (2024)
- [5] B. Blümich, J. Anders, Magn. Reson. 2 (2021) 149-160.