# Can NMR become a tool of choice to study ecosystems directly in the fields?

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**Abstract**

Grasslands and forests are the two main terrestrial ecosystems limiting the global warming thanks to their high capability to store carbon. Sap flows are playing a critical role by bringing the water and mineral salts used for transpiration and photosynthesis (xylem) and transporting the photosynthetic carbons (phloem) to the carbon sinks (e.g., wood, roots, soil). In the context of global warming, a fine understanding of these transport mechanisms is necessary. However, a sensor able to locally probe water content and its movement directly on the plants in their ecosystem (i.e., *in situ*) does not exist yet.
To measure non-invasively and in a given spatial volume water properties, MRI is the analytical tool of choice. However, such instrument cannot be moved and only laboratory experiments can be performed. Recently, portable MRI have been developed. To be able to move the MRI system, the magnetic field intensity is significantly decreased. Thanks to special design and tricks, few portable sensors can record the MRI signal in a slice having a thickness of few tenths of micrometers. After choosing one of these devices, the NMR-MOUSE, we designed a vector allowing to move it and to position it directly against the plant in any positions.

Our objective is then to evaluate the capabilities of this MRI sensor to measure water both repartition and flow in plants inside their natural environment. Before reaching this aim, it is necessary on one hand, to work on the MRI system to insure robustness of *in situ* measurements and on the other hand, to gain knowledge on the sensor capabilities on model systems.

The magnetic field of such low-field MRI systems is highly sensitive to temperature fluctuations. This is a critical point as a variation of the magnetic field leads to a change in the slice position, i.e. the measurement is not performed inside the same volume. Such a problem is limited for indoor measurements where the temperature is regulated. However, for outdoor experiments it has to be corrected. We characterized the shift induced by a change of the temperature magnet and we are now developing solutions to correct it in real time.

Our first experiments on agroecophysiological systems were performed on root systems of different grassland species. We demonstrated that the MRI sensor was able to detect water content variation during the cycle day /night. These circadian variations matched the reference methods used to obtain information on the root hydratation: soil relative humidity and leaf water potential. These data were completed by local transversal relaxation time measurements. We were then able to explain the variation observed with the MRI sensor by the plant water demand due to transpiration. Before measuring the xylem and phloem flows on trees, it is important to locate the position of the slice inside the tree. To do so, a good understanding of the MRI profiles (MRI signal *vs* measurement depth) is mandatory. Such measurements were performed on different tree species in order to characterize the reaction, soft and hardwood on branches.
In this presentation, I will give an overview of our progress on these different parts of the project.