Low frequency investigations on wood and trees

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The interest in non-destructive tomographical methods for tree investigations is growing since years. Geophysical methods can be an alternative to detect internal defects and assess tree failure. In addition to geoelectrical methods, which are already used, the low frequency investigation method SIP (spectral induced polarization) can provide information about cell structure and condition.

Starting with field application a multiplicity of tomographical measurements at different tree species and for different temperature conditions were carried out. With the SIP256c device (Radic 2008) up to 24 stainless steel nails could be used as electrodes. For the tomographical reconstruction of the data the modified inversion program DC2dTree was used, based on the algorithm by Günther et al. (2006).

To understand these field data and the various influencing factors, a considerable amount of laboratory measurements were arranged. Mainly, the SIP characteristics as function of anisotropy, saturation, fungal decay and wood species were investigated. For these purposes fresh and seasoned small wood samples are measured with the SIP-measurement device from Zimmermann et al. (2008). To provide constant temperature the measurements were conducted in a climate chamber.

Figure 1 shows exemplary laboratory results from different European wood species. The amplitude values differ between 10 and 200 Ωm. Owing to the different wood moisture content mostly due to seasonal influences the species can hardly be differentiated with regard to the amplitude. A differentiation seems to be possible using in phase. Due to the different cell structures of the particularly wood species, the phase characteristics are much more variable in both, phase amplitude and frequency of the phase maximum, respectively. Poplar shows the highest phase effect (~ |40| mrad), but the oak species show the phase maximum at the lowest frequency (~ 0.01 Hz). The imaginary parts of conductivity (σ'' in Fig. 1) show that oak and lime, which have approx. the same maximum phase magnitude (~ |25| mrad), differ clearly with regard to σ''. So, the polarization structure in lime is higher than in oak.

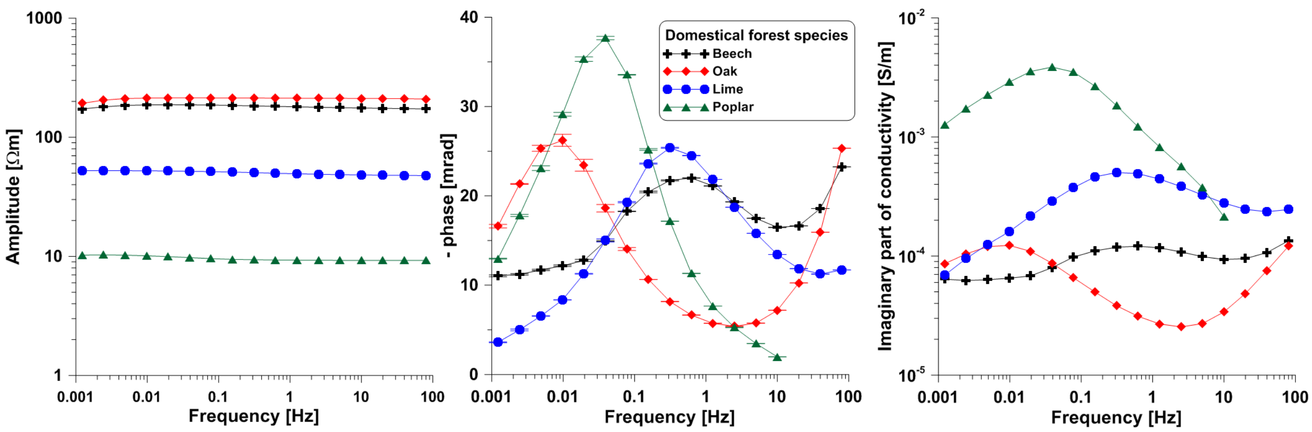

Fig. 1: Amplitude (left), phase spectra (middle) and imaginary part of conductivity (right) for different European wood species. Clear differences between the species can be found.

Figure 2 shows exemplary results of a tomographical field measurement at a lime tree for $f = 0.15$ Hz. The seasonal influence becomes very important for these field measurements. The tree changes with the season and, consequently, resistivity and phase change as well. In winter the tree stopped the water and nutrient transport, therefore, the sapwood is much drier. In early spring the sap flow starts again.

Both, resistivity (Fig. 2 left) and phase (Fig. 2 right) show a circle-concentric tree-typical setting. In contrast to oak trees the resistivity shows lower values (mainly < 200 Ωm). The phase shows a clear difference between sap- and heartwood. The "active" sapwood is characterised by low phase values whereas the "inactive" heartwood shows phase values up to |2.5|° (> |40| mrad)

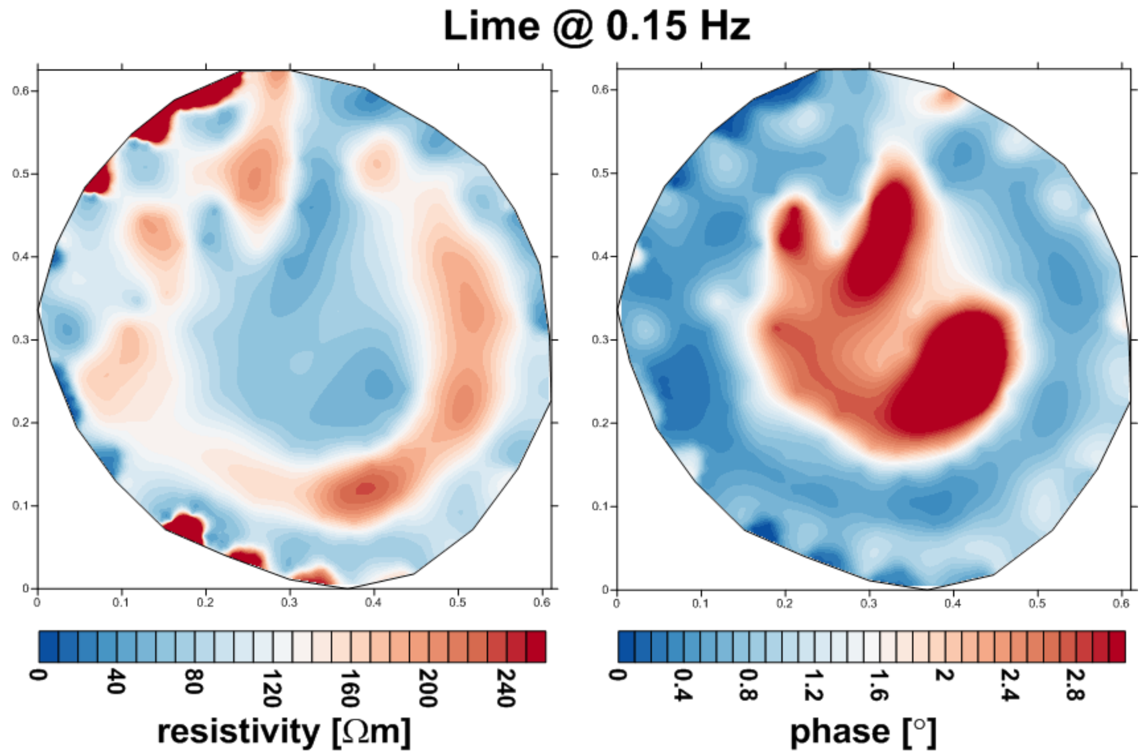

Fig. 2: Amplitude (left) and phase spectra (right) for lime (Tilia). Measurements were taken in February.

The results of these investigations can be summarized as follows:

- Anisotropy, saturation, and fungal decay influence the SIP characteristics of wood species in laboratory measurements (Martin 2012).
- Due to the different cell structures, varying tree species show very different phase behaviour.
- Tomographical field measurements show typically ring structures of heart wood trees. A differentiation between healthy and infected trees (fungal decay) could be observed (Martin and Günther 2013).

In conclusion, the SIP method seems to have potential as an additional tree investigation technique. Unfortunately, until now, it is not fully understood which factors and processes caused the polarization effect on the micro scale in wood. Further investigations are indispensable.

References

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