Session 4 - FTIR Spectroscopy / Imaging (Co-chairs: Krähmer/Schulz)

04-01: Plant roots and FTIR – analyzing species composition and root biomass in peat soil

Petra Straková[1,2], Tuula Larmola[1], Raija Laiho[1]

[1]Natural Resources Institute Finland (LUKE), Helsinki, Finland
[2]University of Helsinki, Helsinki, Finland
E-mail: petra.strakova@helsinki.fi

Estimation of root-mediated carbon fluxes in peatlands is needed for understanding ecosystem functioning and supporting greenhouse gas inventories. Fine root biomass and production data at the level of plant species or plant functional type are very limited due to methodological difficulties. Recently, applications for identifying roots of different plant species in root mixture using spectroscopy methods have been reported [1,2]. Our main objective was to build FTIR based calibration models for predicting mass proportions of 22 common forest and peatland plant species (graminoids, herbs, shrubs and trees) in root mixtures. We also tested the possibility to measure the root mass proportions directly in soil samples, i.e. without separating the roots.

FTIR-ATR spectra were measured from dried and powdered samples. About 1200 of artificial mixed samples containing known amounts of fine roots of different plant species (and peat soil) were prepared for model calibration and validation purposes. Partial least squares (PLS) regression was used to build the calibration models. The general applicability of the species-level models in other studies was tested using about 700 external validation root and peat samples obtained from a separate study on 3 peatland sites, different from the sites where the calibration samples were collected.

The FTIR based calibration models at the level of plant species performed well for graminoids and herbs, with root mean square error (RMSE) of prediction < 7.5% (Fig 1.). For shrubs and trees the estimations were less accurate due to rather high intraspecific heterogeneity that was partly related to the variation in root diameter, but still the RMSE of prediction was generally < 10% for tree and shrub species. When the species-level models were validated on external samples, the predictions were unacceptable, however, as the models did not distinguish species of the same plant functional type (PFT). But predictions at the level of PFT were accurate for the external validation, with RMSE 6.4% for graminoids and 11.6% for shrubs and trees (Fig 2.). The models also provided satisfactory estimates of total root mass directly in peat soil samples, with RMSE < 5%.

Our results demonstrate that FTIR has a great potential in large-scale studies that require low cost and high throughput techniques, but species-level models are hardly applicable on samples outside the calibration set where only estimations at the level of PFT were reliable.

References

[1] Rewald, B., and C. Meinen, 2013: Frontiers in Plant Science, **4**, 1.
[2] Laiho, R., et al., 2014: Plant and Soil, **385**, 311.

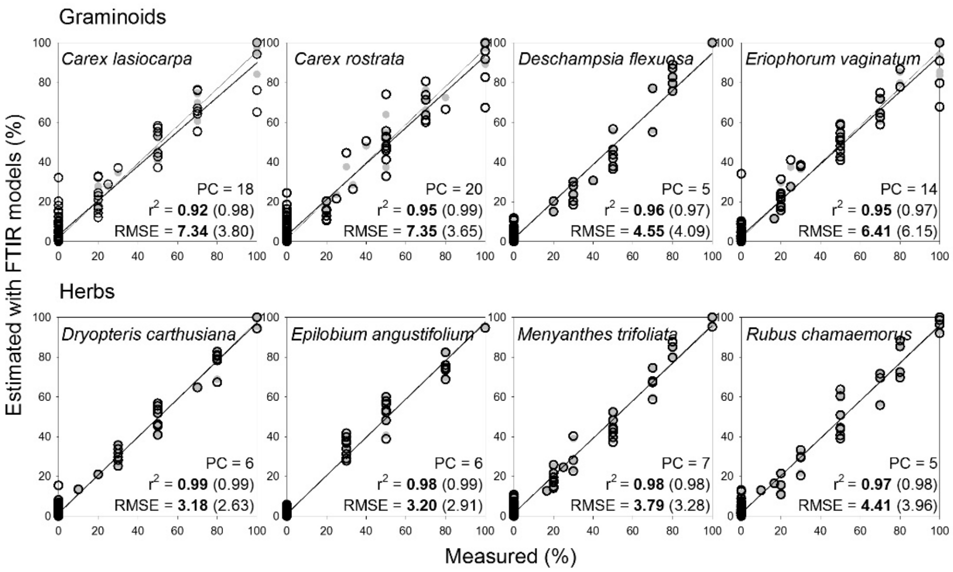

Fig 1. Examples of FTIR calibration models for graminoids and herbs at the level of plant species. PC indicates the number of terms used in the PLS regression model. R^2 and root mean square error (RMSE) values for calibration are written in parentheses and samples are visualized in graphs by gray symbols; values for one-leave-out cross validation are written by bold letters and samples are visualized in graphs by open symbols.

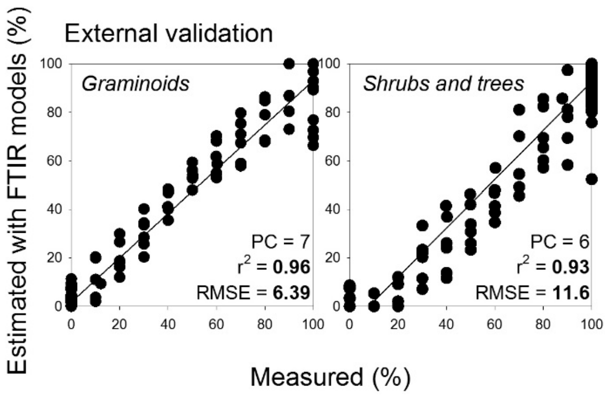

Fig 2. External validation of the plant functional type (PFT) level models on root samples obtained from a separate study on 3 peatland sites that were different from the sites where the calibration samples were collected. PC indicates the number of terms used in the PLS regression model and RMSE the root mean square error of prediction.