BOOK OF ABSTRACTS

13th EARSeL

16 - 19 April 2024, València, Spain

EARSeL
EUROPEAN ASSOCIATION
OF REMOTE SENSING LABORATORIES

IPL IMAGE PROCESSING LABORATORY

VNIVERSITAT DE VALÈNCIA

Laboratory for Earth Observation

Leaf Spectroscopy of Foliar Defensive Traits in Temperate Forests

EARSeL Valencia 2024
Abstract
Corresponding Author: [r.xie@utwente.nl]

Rui Xie[1], Roshanak Darvishzadeh[1], Andrew Skidmore[1,2], Freek van der Meer[1]

[1] University of Twente, Faculty of Geo-information Science and Earth Observation, The Netherlands

[2] Macquarie University, Department of Environmental Science, Australia

Keywords: Leaf Spectroscopy, Total Phenolics, Temperate Forests, Continuum Removal, PLSR

Challenge

Total phenolics are an important group of secondary metabolites universally distributed in vascular plants and play an essential role in the defence of plants against biotic and abiotic stressors (also known as "defence traits"). Accurate quantification of total phenolics is key for understanding the phytochemical diversity and plant response to environmental changes. Leaf spectroscopy offers a great opportunity for predicting foliar traits in a non-destructive and cost-effective way. However, previous studies using spectroscopy have been mainly limited to leaf primary biochemical traits, with few focus on plant defence traits. In particular, it remains to be explored how total phenolics vary among temperate tree species and whether they can be assessed using the leaf spectral signature.

Methodology

The objective of this study is to use leaf spectroscopy to examine the retrieval and absorption features of an ecologically important biochemical (i.e., total phenolics) in temperate forests. To achieve this, the leaf samples over four dominant species (i.e., English oak, European beech, Norway spruce and Scots pine) were collected during fieldwork in 2021 summer from two European temperate forests. Leaf reflectance was measured using ASD FieldSpec3 equipped with an integrating sphere, after which the concentrations of total phenolics were determined using the standard Folin–Ciocalteu method in the laboratory.

Continuum removal was applied to the leaf reflectance spectra in order to enhance the assessment of the subtle absorption features relevant to total phenolics in four temperate species. Further, we performed the Partial Least Square Regression (PLSR) to estimate the content of total phenolics from continuum-removed reflectance. Predictive models were built using the SWIR region of the spectrum (1000–2200 nm). Model performance was assessed using coefficient of determination (R^2) and normalised root-mean-square error (NRMSE%). The contribution bands were evaluated by computing the variable importance projection (VIP) and PLSR standard coefficients, respectively.

Results

The chemical analysis demonstrated significant differences in the concentration of total phenolics across four temperate species ($p < 0.05$), indicating a potential of total phenolics for species discrimination. We observed the concentrations of total phenolics are generally higher in broadleaf species (i.e., English oak and European beech) than in coniferous species (i.e., Norway spruce and Scots pine). The spectral analysis revealed persistent and distinct phenolic absorption features near 1666 nm in the continuum-removed spectra of English oak, Norway spruce and European beech. While the reflectance of Scots pine needles showed a weaker absorption feature near 1653 nm, shorter ward of phenolic features of other species.

Our modelling results show that the total phenolics can be accurately estimated using PLSR with R^2 of 0.79 and NRMSE of 9.95% (Fig. 1a). As shown in Fig. 1b, the identified informative bands are well corresponded between PLSR standard coefficients and VIP measures. Specifically, the spectral bands that are significant for predicting total phenolics are situated in 1400–1500, 1640–1680, 1700–1730 and 2090–2180 nm, matched with known features that are characteristic of phenolic compounds.

Outlook for the future

Our study extended our understanding of absorption features of total phenolics in temperate tree species as well as demonstrated the potential of spectroscopy to accurately predict phenolic compounds across temperate forests at the leaf level. The findings of this study paved the way for mapping and monitoring phenolic compounds in temperate forests at the canopy or landscape level using the next generation of air- and spaceborne spectroscopy imaging, such as DESIS, PRISMA and EnMAP. In addition, it is important to understand the impact of changing environmental conditions on the variation of phenolic compounds. In future studies, we will also investigate the retrieval of specific phenolic compounds that play influential roles in ecosystem functioning in other vegetation types or biomes to promote the characterization of vegetation properties.

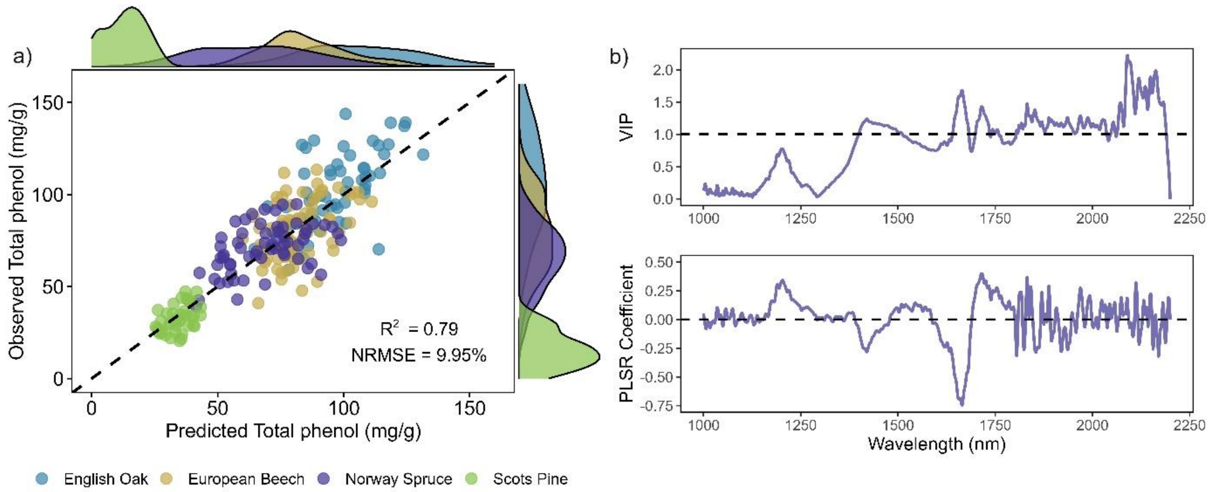

Figure 1 a) Observed versus predicted total phenolics and b) Variable importance projection (VIP, top panel) and PLSR coefficients (bottom panel) for total phenolics predicted using the PLSR model. Marginal plots show kernel density distribution for observed and predicted total phenolics.

Thank you to our sponsors and participants who were part of the 13th EARSeL.

PLATINO SPONSORS

esa

ReSe APPLICATIONS

Headwall Grupo Álava

HySpex by neo

GOLD SPONSORS

ITRES

SPECTRAL EVOLUTION
The Future of Field Spectroscopy is Now!

SILVER SPONSORS

EUFAR
European Facility for Airborne Research

BRONZE SPONSORS

remote sensing

Journal of Imaging