

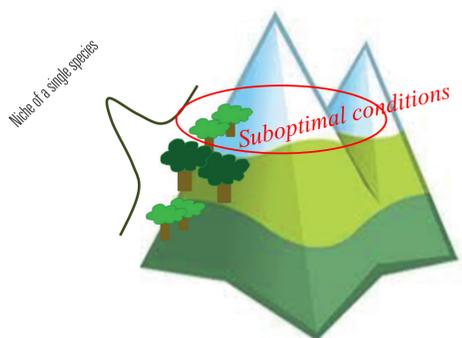
Leaf Water Content and Leaf Morphology Signal Stress in Infrared Spectra

Introduction

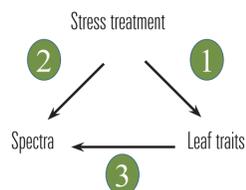
Alpine ecosystems have a clear distribution of species that are limited by their environment. Climate change can alter the bio-climatic zones and change the distribution of some species. Trees of a single species have different physiognomy at the optimal conditions than at the extremes of their niche (smaller and more stressed trees).

Most research on plant stress detection with remote sensing has been focusing on visible-near infrared (VISNIR). However, the thermal infrared (TIR) seems to contain valuable information on Leaf Water Content (LWC) and structural and microstructural traits of leaves, which could be used as proxies for plant stress detection. This study explores changes in the TIR in relation to imposed plant stress.

Stress in alpine ecosystems

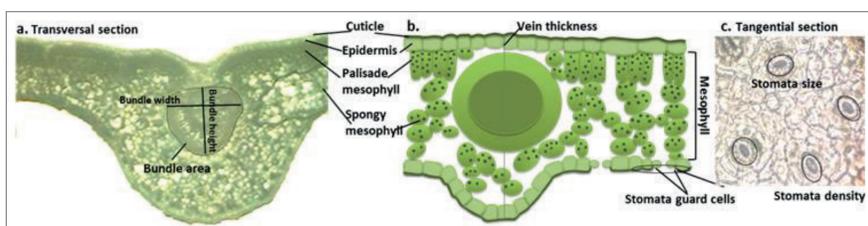


Hypothesis: Stress changes leaf traits and the TIR spectra in leaves.



1

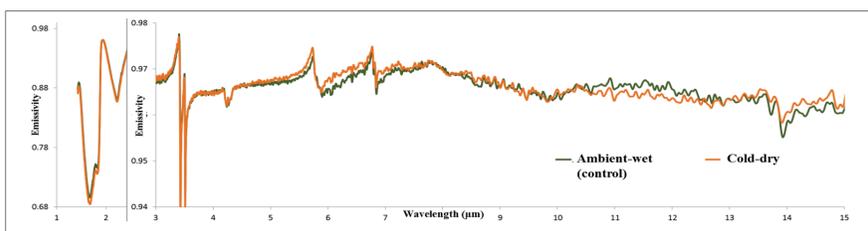
Leaf traits change with stress



Leaf anatomical traits were measured from transversal sections and tangential sections. Leaf water content (LWC), lignin, cellulose, leaf area and stomata density changed the most under the stress treatments compared with the control (AW). Cuticle, stomata size and leaf thickness showed statistical differences but changed less. Other traits didn't change with stress.

2

TIR spectra change with stress



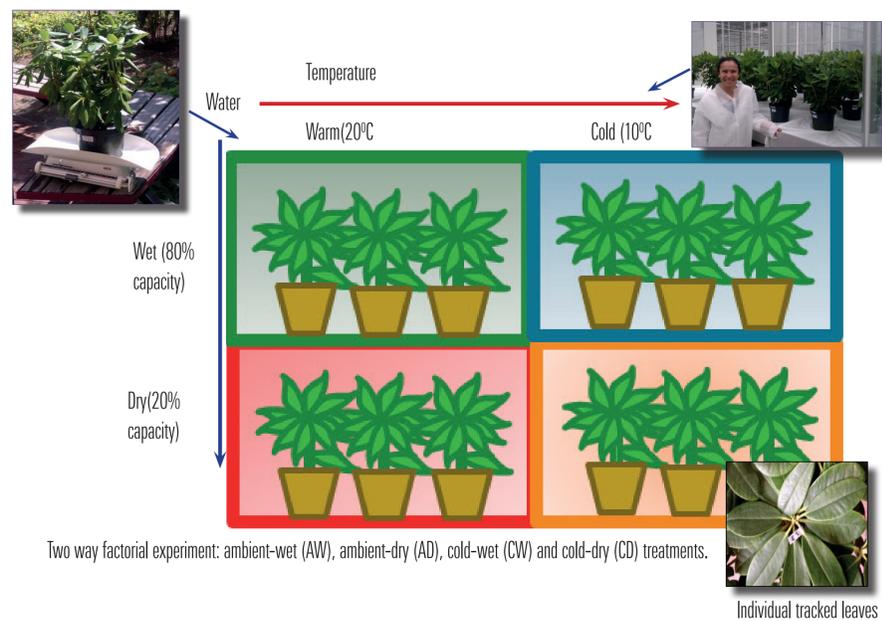
Spectral differences in the TIR can be seen between the control (normal growing conditions - AW) and the stress treatments (e.g. CD). Emissivity has a significant change in most of the TIR spectrum.

Conclusions

1. This study identified the leaf traits that change with stress which can be predicted from TIR spectra and also can be used to predict stress in a stress general model.
2. Leaf traits change clearly under stress, especially LWC, lignin, cellulose, leaf area and stomata density.
3. The bands selected in the stress model (multinomial model) and the individual models for leaf traits show how important the bands related to water molecular bonds are in the identification of the types of stress in this experiment. The strong effect of water in the SWIR and MWIR spectra of leaves, indicates that water could be strongly masking the signal of other leaf traits.

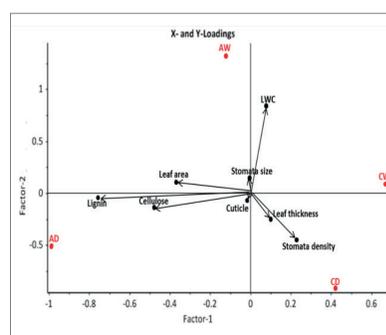
Experiment

6 months of water and temperature stress in a two way factorial experiment for 60 plants of *Rhododendron cf. catawbiense*, to identify changes in leaf's microstructure and TIR spectra (1.4 to 16 µm) in 15 plants per treatment and 5 leaves per plant.



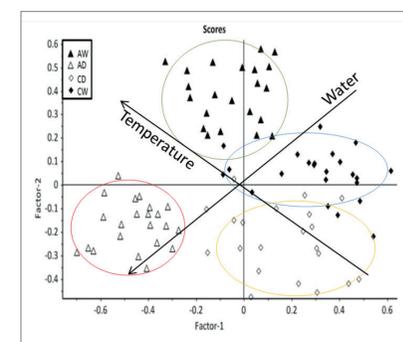
Two way factorial experiment: ambient-wet (AW), ambient-dry (AD), cold-wet (CW) and cold-dry (CD) treatments.

Results



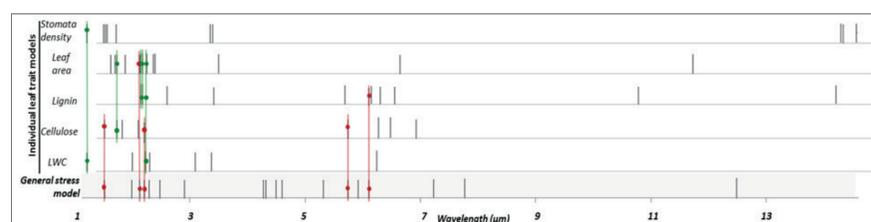
A PLS analysis identifies leaf water content (LWC), lignin, cellulose, leaf area and stomata density as the key leaf traits changing with stress.

A PLS analysis shows that from leaf traits, leaves can be differentiated according to the stress treatment, and also shows a gradient of temperature and water treatments



3

Leaf traits explain changes in spectra



PLSR models for individual traits and a multinomial model for predicting stress, selected bands which are associated to vibrational bonds of molecules of water, lignin and cellulose among other organic compounds present in leaves. The general stress model shares especially bands for cellulose and lignin identification. Although other bands in this model are associated to water molecules.

For more information

Maria F. Buitrago m.f.buitragoacevedo@utwente.nl
Thomas Groen t.a.groen@utwente.nl
Chris Hecker c.a.hecker@utwente.nl
Andrew Skidmore a.k.skidmore@utwente.nl

