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Comparison of imaging and non-imaging hyperspectral sensors observing vegetation in the laboratory

Daniel Doktor, Arlena Brosinsky, Angela Lausch, and Ines Merbach
Helmholtz Zentrum für Umweltforschung, Leipzig, Germany (daniel.doktor@ufz.de)

Non-imaging spectrometers are widely used gathering ground truth data for e.g. airborne hyperspectral imaging campaigns. Often ground measurements cannot be taken at exactly the same time of the overflight and therefore atmospheric and illumination conditions between the two kinds of measurements may vary considerably. In many cases lacking men power or difficult terrain limits the number of ground measurements such that representative ground sampling is difficult to achieve. Furthermore, the two kinds of spectrometers are technically different although capturing the same physical phenomenon. Consequently, there are doubts as to what the sources of potential differences between imaging and non-imaging measurements are.

As a result, we performed a comparative study under controlled laboratory conditions. The behaviour of two spectrometers was tested measuring canopy reflectance properties of stressed and unstressed vegetation together with in-situ plant observations. Ash (Fraxinus excelsior L.) seedlings were grown in containers in a shade house over a four month period and exposed to drought stress and flooding treatments. Hyperspectral measurements were performed in a dark room with artificial illumination conditions using AISA Eagle imaging spectrometer and non-imaging ASD Field spectrometer on a semi-weekly basis. For determination of the plant's physiological status, leaf chlorophyll content, leaf area index (LAI), plant height, leaf water content, C and N content of leaves and soil moisture measurements were also conducted. Vegetation indices known to be sensitive to plant stress were calculated from AISA and ASD data. Relationships between vegetation indices and plant physiological parameters were analysed using a Generalized Additive Model (GAM).

Radiance spectra derived from AISA and ASD measurements per container per sampling day were highly correlated ($R^2 > 0.98$). Single wavebands over time exhibited diverging correlations between 0.01 and 0.98 (low for the intervals 650-680 and 900-970 nm). Only measurements of water stressed plants showed high correlations between 900-970 nm. Relationships were similar for water and drought stress scenarios, even though on a different magnitude. Correlation generally decreased around the red edge region for all scenarios.

Indices calculated from AISA and ASD data showed similar behaviour. NDVI 670, PRI and Vogelmann 2 seem to react strongly to reduced biomass, while WI corresponds to increased water levels in the containers during flooding periods. Results derived from the Generalized Additive Model suggest a moderate positive relationship between vegetation indices and plant physiological parameters (LAI). A slightly lower positive relationship was found for indices and growth height as well as C/N contents. Vegetation indices and chlorophyll / plant water content showed little or no correlation. AISA indices met slightly higher correlations with LAI and growth height while ASD indices exhibited a slightly higher correlation with C/N contents.