05-05: Establishment of a field spectral library of agricultural crops in Germany for monitoring biophysical parameters at different spatial scales

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Leaf area index, above ground biomass, chlorophyll content or the amount of absorbed nitrogen are key variables for precision farming applications, crop growth predictions and yield estimations. Remote sensing systems provide spatially differentiated information over large areas at regular intervals. They offer the potential for rapid, spatial and non-destructive assessment of these crop parameters. The spectrally differentiated mapping of the absorption and reflection properties of crop stands by hyperspectral systems opens up new perspectives in terms of parameter quality and type [1].

In the past, two different types of approaches have established for the estimation of crop parameters from remotely sensed image data: the inversion of physically based radiative transfer models, and empirical–statistical modeling based on in-situ measurements of vegetation parameters and its reflectance properties [2].

An intrinsic problem of empirical approaches is the transferability in space and time. To overcome this issue, we established a field spectral library of agricultural crops in Germany containing measurements from different geographic regions which were taken at various dates during the growing season. Data was acquired over a time period of eight years, from 2011 to 2018. By now, the data set consists of more than 1100 reflectance measurements of the most common crop types in Germany (winter cereals, winter rape, spring barley, oats, sugar beet, potato, horse bean). Canopy reflectance was recorded with field spectrometers (ASD Fieldspec Pro, SVC HR1024) ranging from 350nm to 2500nm on plots of 0.25x0.25m^2. Thereafter, crop parameters (e.g. biomass, leaf area index, phenological stage, nitrogen content) were determined for each sample plot using destructive and non-destructive techniques.

Quantitative relationships between canopy reflectance and crop parameters were established by means of non-parametric regression methods (partial least squares). Crop-specific models were set up with respect to different spectral configuration and spatial resolution (<1m – 30m) of various point and imaging spectrometers. These are a ground based, mobile hyperspectral system (PentaSpek) [3], the airborne HySpex sensor (NEO) [4] and the forthcoming German hyperspectral EnMAP mission [5]. Further, a model was build to fit data of the superspectral Sentinel-2 system [6], an earth observation mission which provides freely available image data over Germany every 2-5 days.

Prediction accuracy of the models varied with respect to spectral configuration, crop type and parameter of interest. Models based on hyperspectral information generally performed best, but root-mean-square error was only slightly higher for Sentinel-2.

The best models were applied to image data of the PentaSpek system and the EnMAP mission (simulated) acquired during growth period in 2011 and 2012 (1), and to image data from HySpex and Sentinel-2 acquired in the growth period 2017 (2). Parameter maps displayed a similar pattern of the intra-field variability and a good absolute agreement. They underpin the potential of the field spectral library for monitoring biophysical parameters of crops with different sensing systems, at different spatial scales.

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