REQUIREMENTS ON SPECTRAL RESOLUTION OF REMOTE SENSING DATA FOR CROP STRESS DETECTION

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Abstract

In contrast to multispectral remote sensing data, airborne hyperspectral data showed to be highly suitable to identify areas of crop growth anomalies resulted from stress impact (e.g., nitrogen deficiency, fungal infections etc.) within agricultural plots. Resulting stress symptoms are changes in plant-physiology, whose characteristics affect the spectral signature of crop canopies and consequently are detectable via spectral measurements. Typical stress-related spectral changes in plant canopy signatures do not cause narrow spectral features but rather influence certain wavelength ranges in the VIS and NIR. Sensor-based crop stress detection thus has, on the one hand, requirements on the minimum spectral resolution of sensor systems, the questions arise, however, if the plentitude of narrow spectral bands of hyperspectral sensors is essential and how is the required minimum spectral resolution for proper crop stress detection. An accompanied study was addressing the first question (additional abstract submitted), whereby the second issue was subject for the present study.

In 2008, a field experiment at a research farm of the University of Bonn in Germany was set up. In order to ensure a variety of crop stress severity, the field with 6ha in size was subdivided in plots that retrieved different fungicide treatments. Severe leaf rust infections occurred in those plots which have not received any fungicide treatments; other stress factors were controlled by appropriate treatments. Each of the 11 sub-plots was 40 X 80m in size. At 80 randomly distributed points in field, differential GPS measurements were collected and relevant plant parameters such as plant height, canopy density and severity of fungal infection etc. were measured.

On July 1st 2008, a flight campaign with the Airborne Imaging Spectroradiometer for Applications (AISA) was realized in cooperation with the Hyperspectral Research Unit of the University Debrecen, Hungary. AISA consists of two spectroradiometers: ‘Eagle’ covers the VNIR from 400-970nm in 244 spectral bands with a spectral resolution of 2.5nm and ‘Hawk’ covers the SWIR with 254 spectral bands in the spectral range from 970-2450nm and a spectral resolution of 5.8nm. With the chosen flight altitude above ground of 2300m, a spatial resolution of 1.5m could be achieved.

To analyze on which spectral scales stress symptoms can be detected, the AISA data with high spectral resolution was stepwise spectrally resampled and used for classification of stressed wheat areas. The spectral resampling was realized in 8 steps whereby the data was resampled by factor 2 respectively. Resulting resampled data sets had spectral resolutions of 2.5nm, 5nm, 10nm, 20nm, 40nm and 80nm in the VNIR and 5.8nm, 11.6nm, 23.2nm, 46.4nm, 92.8nm and 185.6nm in the SWIR. For a binary discrimination of infected and healthy wheat areas, each data set was afterwards classified by the use of support vector machines (SVM). In previous studies, SVM's seemed to be a superior classifier, particularly for data sets with a low training sample size. For validation, classification results were compared to in-field sampled stress severity data. Results showed that highest spectral resolution (2.5 and 5.8nm) is actually not necessary to discriminate stressed and healthy wheat areas.