Comparison of 3 remote sensing sensors and 2 methods performances in the retrieval of biophysical variables on a wheat field.

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Abstract

Through a precision farming project, an intensive ground and airborne measurements campaign was performed. To address the estimation of biophysical variables related to the plant nitrogen status, 3 remote sensing sensors were utilized. The retrieval of variables was performed either via empirical relationships or through physical modeling. The drawbacks and advantages of different sensors/methods were discussed.

Keywords: remote sensing, wheat, reflectance, chlorophyll content

Introduction

In the frame of a precision farming project (Guérif, 2001), the nitrogen status of a wheat crop, and especially the characterization of field spatial heterogeneity was studied. Remote sensing measurements can help with building indicators based on the biophysical variables of the crop as green leaf area index (gLAI) and leaf chlorophyll content (Cab). The performances of 3 sensors and 2 methods in the determination of biophysical variables were compared.

Materials and methods

An experiment was conducted at Laon (North of France) on 2 winter wheat fields. Three optical domain sensors were used to overflow the fields with a 1 to 20m spatial resolution. They provided 4 images in 2000 (CASI), 4 in 2001 (SPOT), and 5 in 2002 (XYBION). SPOT satellite sensors acquired data in 3 or 4 broad bands. CASI radiometer provided hyperspectral measurements, and XYBION instrument is characterized by 6 bands. Data pre-processing was performed to account for atmospheric effects.
Two different methods were implemented to estimate gLAI and Cab depending on the data quality and the sensor characteristics. The first method consists in using empirical relations between XYBION digital numbers and biophysical variables. The choice of indices was performed by minimizing the effects of atmosphere and soil background (see Zurita et al, 2003, this issue). A method based on the inversion of radiative transfer models (PROSAIL Jacquemoud and Baret, 1990; Verhoef, 1984) was tested for SPOT and CASI reflectances by accounting for the wheat structure, leaf biochemical composition and soil background. Prior information on the investigated variables was introduced in the inversion procedure to avoid for local minimum solutions.

Results

XYBION – empirical relationships : Figure 1a shows that when using NDVI (reduced central variable), a strong linear relationship ($r^2 = 0.8$) with LAI was obtained. LAI was estimated with a 0.5 m^2/m^2 rmse. Weak relationships were found between vegetation indices and Cab, although the estimation was improved when working with Cab integrated on the canopy.

2003,4th European Conference on Precision Agriculture, 15-19 June 2003, Berlin, Germany, in press.

SPOT – physically based models : The sensor, characterized by 3 broad wavebands, is not appropriated to estimate leaf chlorophyll content. However, LAI can be estimated through inversion of radiative transfer models. Results (Fig. 1b) show the LAI was estimated with a 0.4 m^2/m^2 rmse despite a weak correlation.
CASI – physically based models : Thanks to several thin bands, the CASI hyperspectral sensor was used to retrieve most of the radiative transfer inputs (10 parameters) and in particular the leaf and plant chlorophyll contents. Figure 1c displays a good correlation ($r^2>0.8$) and an estimation with a 10% error for LAI, Cab and plant chlorophyll content (LAIxCab).

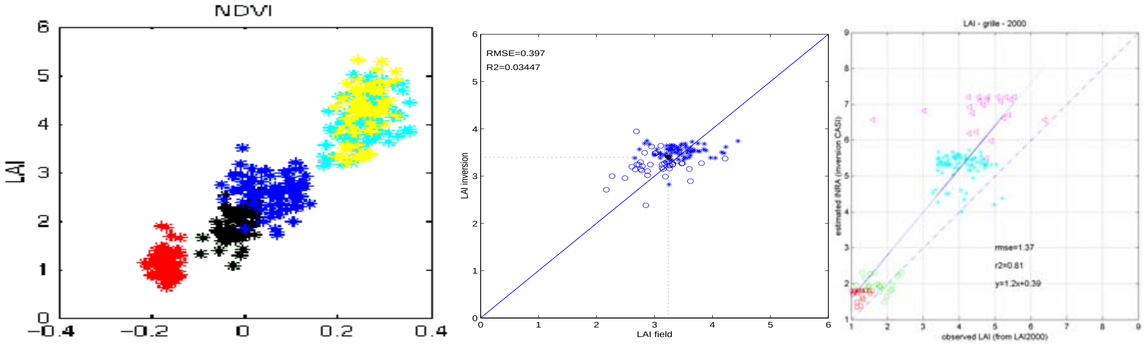

Figure 1. Comparison of retrieved gLAI estimates with field measurements : retrieval from (a) XYBION (5 dates), (b) SPOT (2 dates), (c) CASI (4 dates).

Discussion - Conclusion

gLAI and Cab were estimated with a 10% accuracy. The weakness of correlation coefficients for a given date is related to the sampling strategy. The pixel surface is bigger than the ground sampled surface (1m²). Although SPOT calibration is robust, due to the sensor spectral characteristics, few parameters were estimated. Retrieval of biophysical variables using XYBION through empirical relationship was satisfactory, though the relations must be fitted for given conditions. The use of an hyperspectral sensor is the more promising method as one can estimate several variables and in particular the plant chlorophyll content that is a powerful variable in the plant nitrogen status estimation.

References

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Acknowledgements

The authors thank Astrium for providing CASI data, M. Zago for developing a XYBION data pre-processing software, E. Pohl, N. Sanchez and M. Launay for data pre-processing.