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Retrieving Wheat Biophysical Variables from Hyperspectral Measurements

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In the frame of a precision farming project (Guérif, 2001), we attempt to assess the nitrogen status of a wheat crop, and especially to characterize the field spatial heterogeneity. Remote sensing measurements can help with assessing the plant nitrogen status through indicators. The indicators are based on the retrieval of biophysical variables of the crop as green leaf area index (gLAI) and leaf chlorophyll content (Cab). We are especially interested in LAI and Cab retrieval, as they give access to the nitrogen status of the plant.
A method was developed to estimate gLAI and Cab by using the complementarity between hyperspectral remote sensing and radiative transfer modeling. Those models describe the radiative transfer of light through the leaf and the cover taking into account the biochemical leaf composition, the leaf and plant structure, and the soil background. By inverting the radiative transfer models, one can estimate the input parameters.
We used hyperspectral airborne CASI acquisitions to provide reflectances over 6 N test-sites. The N inputs run from 0 to 300 kgN/ha and create wheat crop in 6 different levels of nitrogen status. LAI2000 and N-tester measurements were performed over the sites to estimate gLAI and Cab, respectively. Those measurements were calibrated using destructive measurements performed on plant samples.
The method consists, for a given CASI acquisition, to minimize the difference between the simulated and observed spectral reflectances by adjusting the models input parameters. About 10 parameters are re-estimated. To minimize the number of solutions and constrain the inversion, *a priori* knowledge about the parameters is introduced in the cost function. The cost function is the sum of a term based on the radiometric information and a one based on *a priori* information on unknown parameters. Several tests were performed to point out the importance of taking into account the error on reflectances, the *a priori* information, the variables uncertainties as well as the number of wavebands.
Using this technique, gLAI and Cab are estimated with a 10% accuracy. The results are drastically improved by introducing the *a priori* information in the merit function (LAI and Cab root mean square error improvement equal 2 m^2/m^2 and 10$\mu g/cm^2$ respectively).