agropolis fondation

PHENOMENA

PHENOtyping Plants by Modelling their Environment and Architecture

ABSTRACT

1. NEMA hosted in OpenAlea platform
NEMA simulates the absorption and distribution within wheat plants after flowering of both dry matter and N, using soil N concentration and the daily time courses of temperature and of PAR above the canopy as driving variables. NEMA was implemented in C++. Thus, the first step was to adapt NEMA for OpenAlea. NEMA libraries were interfaced with the Python language without rewriting all the code. it is now available as a Python package which links with the dynamic C++ libraries.Tests were performed successfully by running NEMA on OpenAlea platform. Furthermore, because OpenAlea project was developed to be easily understandable and reusable by others developers,a user documentation of NEMA has been written.
In order to have a more graphic description of the coupled model hosted in OpenAlea platform, graphical nodes have been added, which contains the model parameters and the values of the initial condition variables for each organ (such as leaf, peduncle, among other). Thus, each node can be edited through a specific GUI (Graphical User Interface) by clicking on it.

2. NEMA – ADEL Coupling interests
ADEL and CARIBU could provide to NEMA, respectively, the description of the stand architecture and the absorbed PAR (Photosynthetically Active Radiation)calculation at the organ level. On the other hand, NEMA could provide to ADEL the calculation of specific leaf nitrogen (SLN) at the leaf level. The coupled model will therefore become more functional.It will also allow direct calculation of the optical properties through the radiative transfer model PROSPECT.
• Setting up of the initial condition variables in NEMA – ADEL model: initial values of organs are difficult to measure. A procedure was developed to fix these values.
• Integrate functioning aspects in the ADELmodel to simulate the effects of nitrogen and light availability at the organ scale. It's interesting to analyze ecophysiological processes occurring during two important growing stages for wheat: tillage and grain filling.

3. Experimental results.
The aim is to accomplish destructive and non-destructive measures which will be used to model initialization and evaluation (by model inversion). The vegetal material was composed of three cultivars: Hysun (planophile), CapHorn (erectophile) and Neodur with contrasted architecture, in order to highlight the effect of radiation intercepted and possible varietal parameters controlling the distribution of nitrogen in the axes.
3.1. Experiments for model initialization.
Destructive measures were used for model initialization. The following measures were made on four upper lamina and sheath as well as stem, chaff and grain: (i) Dry masses were determined after oven drying at 80 oC until constant mass. (ii) Samples were then ground and total N mass per unit dry mass (%N) was determined by the Dumas method. These destructive measures were performed at flowering, one date in the grain-filling period and harvesting. In addition, it was performed the characterization of the architecture (scans + silhouettes) of the four upper laminae at flowering and of the two upper laminae at grain-filling period.
3.2. Experiments for model evaluation
Non-destructive measures were used for model evaluation (by model inversion). Measures of reflectance spectra of four upper laminae were accomplished. Recent studies have shown that nitrogen concentration is accessible from reflectance spectra in 400-2500 nm. The next step is to calibrate a chemometrical model between nitrogen concentration (from destructive measures) and reflectance spectra of individual lamina. This procedure provides a relevant correlation to predict frequent measures of lamina nitrogen content.

4. Model inversion: Influential parameters.
An inverse model can find optimal values for the parameters (influential on intercultivar variation) that produce the closest fit between the observed and the simulated response variables of the model.
4.1. Study of the dynamical behavior of the observed model outputs.
A set of parameters was selected, which likely differ within a range according to intercultivar variation. These parameters represent a sub-set of the total number of parameters. In a first analysis, it was chosen to conduct a study of the dynamical behavior of the observed model outputs through synthetic data generation. A set of twelve output variables was selected considering a priori knowledge about the system (which is related to the convenience with which these variables can be measured through remote sensing).
The generation of synthetic data was accomplished through sampling the influential parameters. Percentile plots were created form the simulations for each output variable which helped to clarify seasonal behavior patterns in function of the influential parameters on intercultivar variation.
4.2. Model inversion.
After analyzing the dynamic behavior of the model, normal noise was added to the synthetic data, which were used in the model inversion. Thus, it was chose to conduct a study on synthetic data in order to be able to generate variability in retrieval performance as well as to illustrate the link between the observed model outputs and the parameter estimates. This inverse approach can find optimal values for the parameters that produce the closest fit between the synthetic and the simulated response variables by maximizing the probability (likelihood) of the sample data. From results, it can be noticed that the model with re-estimated parameters effectively tracks the desired trajectory of synthetic data, even when is added normal noise to them. A good quality of fit of the model to the data was assessed by visual examination of plot of observed versus predicted values for all data set (70 observations). However, estimated parameters' values differ from target values.

Keywords : Plant, Operation, Model, Phenotoping, wheat

Year : 2009
Project number : 0902-010
Type of funding : AAP INRIA
Project type : AAP
Research units in the network : DIADE ITAP
Start date : 2010-01-01
End date : 2012-07-31
Flagship project : no

Project leader : Benoit De Solan Christophe Pradal
Project leader's institution : INRA-INRAE CIRAD
Project leader's RU : AGAP EMMAH

Budget allocated : 66891.725 €
Total budget allocated (including co-financing) : 91632.5 €
Funding : RTRA

PERSPECTIVES

NEMA / ADEL-wheat: Developments and perspectives.
-Integrate at the organ level information on biophysical content in ADEL. In a sensing perspective, it is a key point to simulate reflectances at the canopy level.
- Inverse modelling approach could be applied to multi years and multi sites experiments
- Last, using the estimated parameters to identify Quantitative Trait Loci (QTL) is a further perspective.