

**Year of CfP: 2007**

**Project No: 07059 Completed**

<b>Project title:</b> Canopy Architecture modelling for improvement of Genotype-environment description from remote sensing
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**Unit managing the project:** EMMAH (Mediterranean environment and modelling of agri-hydrosystems) (INRA)

**Project leader:** Frédéric Baret (baret(a)avignon.inra.fr)

**Country involved in the project:** Spain

**Research units from the Foundation's scientific network involved:** LEPSE, LISAH

**Subthematic axes:** STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

**Objectives:**

Sustainable development relies on application of techniques that will preserve the environment while ensuring the basic human activities to fulfil their needs. Agriculture and ecosystem management plays obviously a central position in such a framework. Canopy functioning models provide very convenient and efficient tools for evaluating environmental footprints of landscape management and agricultural practices. They can be run both in diagnostic and prognostic modes over large areas and provide unique information. However, their use is currently limited because they need numerous inputs, many of them being poorly known and for some of them varying with space and time. Remote sensing offers the capacity to monitor frequently (1/5 1/10 days) wide areas at decametric spatial resolution. Although the road towards combining crop models and remote sensing observations is well defined, advances have been limited by the adequacy between the simple way crop models describe canopy architecture and its dynamic on one hand, and the higher requirements needed for transforming the remote sensing signal into actual canopy state variables through the use of radiative transfer models on the other hand.

The objectives of this project are to develop and evaluate the interest of coupling form (canopy architecture) and function (canopy functioning) models to better relate remote sensing observations to canopy functioning and allow more efficient description of genotype environment over large areas. This will contribute to provide tools for decision making in agriculture and landscape management for sustainable development. This will also prepare interpretation algorithms for the exploitation of the future generation of Earth resources satellites that will be operational at the beginning of next decade within the European Global Monitoring of the Environment and Security (GMES) initiative framework.

The project will focus on a Mediterranean crop to demonstrate the pertinence of the proposed approach: vineyards. This crop has already received attention by the partners from the canopy modelling aspect (STICS-vineyard), canopy architecture description and remote sensing. It presents the interest of having medium complexity architecture. The project will mainly build up the chain of coupled models: radiative transfer, canopy architecture and canopy functioning

**Action carried-out and results obtained:**

Literature review about two main subjects: (i) Vineyard architecture modeling and (ii) adaptation of crop models to vineyard. The review allowed to find important references for the proposed objectives, that made possible the results retrieved in the activities described below.

Development of a vineyard architecture model: Starting from the architecture measurements of vineyards reported in Louarn (2005), it has been developed a vineyard canopy architecture model. The model describes a 3D scene of vineyard plants taking as input variables architectural and physiological parameters. The actual version is able to describe the 3D architecture of vineyard canopies from burst to maximum leaf area development (not senescence), allowing to introduce agricultural practices such as pruning.

Development of a radiative transfer model based on parametrization of scattering coefficients derived from ray tracing over the 4D canopy architecture model.

Coupling of a functioning model (water balance) accounting for vineyard water stress with the proposed vineyard architecture model; The resulting architecture+water stress model allows the modeling of leaf area dynamics of vineyard under different water stress scenarios.

Validation of architecture+functioning model in direct mode with measured data of leaf area index collected over experimental fields. The results provided by the model were coherent, demonstrating the capability of the proposed models in the prediction of vineyard LAI dynamics

Exploratory analysis about the contribution of vineyard architectural parameters in light interception and reflectance at the canopy scale under different water stress scenario. This analysis highlighted the effect of leaf area management strategies (pruning, trellis system) in the spectral response of vineyard canopies.

#### **Publications :**

F. Baret, B. de Solan, R. Lopez-Lozano, Kai Maa, M. Weiss. 2010 GAI estimates of row crops from downward looking digital photos taken perpendicular to rows at 57.5° zenith angle: Theoretical considerations based on 3D architecture models and application to wheat crops. *Agricultural and Forest Meteorology* 150 (2010) 1393–1401

Lopez-Lozano, R., Baret, F., Garcia de Cortazar, I., Bertrand, N. and Casterad, M. A. 2009: Optimal geometric configuration and algorithms for LAI indirect estimates under row canopies: The case of vineyards. *Agricultural and Forest Meteorology*, 149: 1307-1316.

R. Casa, F. Baret, S. Buis, R. Lopez-Lozano, S. Pascucci, A. Palombo and H. G. Jones. 2009 Estimation of maize canopy properties from remote sensing by inversion of 1-D and 4-D models. *Volume 11, Number 4*, 319-334, DOI: 10.1007/s11119-010-9162-9

R. López-Lozano, F. Baret, I. García de Cortázar Aauri, B. Tisseyre and E. Lebon, "Reflectance modeling of vineyards under water stress based on the coupling between 3D architecture and water balance model", *Proc. SPIE 7472, 74720H* (2009); doi:10.1117/12.830057

#### **Prospects for the future:**

Within the framework of Vinnotec project, coordinated by B. Tisseyre (UMR ITAP) and P. Zarco-Tejada (IAS/CSIC, Cordoba) the study will continue towards the operation application of 3D models in the estimation of vineyards vigour from remote sensing, more specifically:

- Analysis of uncertainties associated to vineyard architecture in the estimation of canopy biophysical parameters (LAI, porosity, fAPAR...) from reflectance measurements.
- Proposition of an operational methods for canopy vigour estimation from remote sensing imagery over vineyard experimental fields.

**Total Agropolis Fondation funding:** € 59,746 (salary for a post-doctoral fellow, running costs)

**Funding categorie(s):** Agropolis Fondation post-doctoral fellowship

**Project duration:** 2 January 2008 – 30 September 2009

**Keywords:** canopy – modelling – genotype – remote sensing – vineyard – architecture – sustainable management