Evaluation of a turbid medium model to simulate light interception by plant canopies at three spatial scales

D. COMBES[1], M. CHELLE[2], H. SINOQUET[3] , A.J. ESCOBAR-GUTIERREZ[1], C. VARLET-GRANCHER[1]

(1) INRA, UR4 Unité d'Ecophysiologie des Plantes Fourragères, BP 6, F-86600 Lusignan, France
(2) INRA, UMR1091 Environnement et Grandes cultures, F-78850 Thiverval-Grignon – France
(3) UMR547 PIAF, INRA, Université Blaise Pascal, F-63100 Clermont Ferrand, France
didier.combes@lusignan.inra.fr

Keywords: Radiative Transfer, Turbid Medium, Computer Model

Light is one of the most important environmental factors to be included in functional-structural models of plants and plant communities to simulate key biophysical processes involved in plant growth and development, such as photosynthesis, evapotranspiration, and photomorphogenesis. Such inclusion would require the simulation of light interception at organ scale. To achieve this goal, two approaches are possible.

The first way is to consider the plant canopy as a turbid medium in which radiation attenuation is described by the Beer-Lambert law (NILSON, 1971; ROSS, 1981). The second way is based on virtual representation of plants where light interception is computed from the projection of vegetation components in a given direction (Chelle et al, 1998) (i.e. without light scattering).

Only few studies have shown the comparison between turbid medium and computer simulation models (CHEN *et al.*, 1997; PINTY *et al.*, 2000; SINOQUET et al., 2005).

In this study, we assessed the hypothesis of leaf random dispersion in the Beer-Lambert law at three scales (the whole canopy, horizontal layers and local scale). We compared two calculation methods of radiation interception: one using the Beer-Lambert law (with three dimensional turbid medium model; RIRI, SINOQUET and BONHOMME, 1992) and the other based on simulation models (CANESTRA, Chelle et al, 1998); multiple scattering having not been taken into account in this study. The two models were compared by applying the calculations to two walnut trees and two sorghum canopies which present contrasted structure characteristics. The structures of these canopies were measured in three dimensions in order to take into account the arrangement and orientation features of the plant elements. Main results were that interception computations were satisfying at the whole canopy and layer scale whatever the canopy considered. However, at locale scale, discrepancies turbid medium showed high difficulty in estimating light interception.

References

CHELLE M., ANDRIEU B., BOUATOUCH K. 1998 Nested radiosity for plant canopies. The Visual Computer, 14:109-125

CHEN, J. M., BLANKEN, P. D., BLACK, T. A., GUILBEAULT, M. and CHEN, S. (1997). “Radiation regime and canopy architecture in a boreal aspen forest.” Agricultural and Forest Meteorology **86**: 107-125.

NILSON, T. (1971). “A theoretical analysis of the frequency of gaps in plant stands.” Agricultural and Forest Meteorology **8**: 25-38.

PINTY, B., GODRON, N., WIDLOWSKI, J.-L., BACOUR, C., GASCON, F., et al. (2000). “The RAdiation transfer Model Intercomparison (RAMI) Exercise.” Journal of Geophysical Research **in press**.

ROSS, J. (1981). The Radiation regime and architecture of plant stands. The Hague, Dr Junk Publishers.

SINOQUET, H. and BONHOMME, R. (1992). “Modeling radiative transfer in mixed and row intercropping systems.” Agric. For. Meteorol. **62**: 219-240.

SINOQUET, H., SONOHAT, G., PHATTARALERPHONG, J., GODIN, C. (2005). Foliage randomness and light interception in 3D digitised trees: an analysis from multiscale discretisation of the canopy. Plant Cell and Environment, 28, 1158-1170.