Radiation transfer models for FSPM applications

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The simulation of radiation transfer (RT) is used in many FSPM models and applications. This preeminence is explained by the central role of light in plant growth and development, light being both the energetic source of photosynthesis and an important mediator for the adaptation of plant development to their environment (photomorphogenesis). Radiation is also a key component of the energy budget of plant organs and a factor driving stomata. Thus RT models are required to simulate organ temperature, transpiration and the simulation of water fluxes within plants. At a larger scale, radiation transfer models allow to quantify the light interception efficiency of complex tree crowns or of a canopy, which are important traits for breeding or crop modelling. They also makes it possible to determine the sharing of light between different individuals and species within natural and artificial plant communities; both in field or controlled conditions. Parallel to this variety of applications, different RT models were developed or adapted for use in the FSPM community. They differ both on the way they apprehend plant geometry (volumic vs surfacic objects) and on the way they approximate the physics of radiation transfers and light-plant interactions. The aim of this paper is to provide a practical help to modelers for choosing, correctly use and compare RT models for a given application. Based on a synthetic view of the rationale of the principal approaches used in RT models, we identified and standardised the different types of inputs of RT models, and proposed a unified interface for running them. Second, we defined several simulation scenarios that cover the main applications cited above, both for crop and tree plants (wheat, maize, apple tree, communities of grassland plants). For each scenario, four different models (Caribu, RATP, Muslim, Fractalysis), that covers a large range of approaches are run and compared on pre-defined target variables. All models and scenarios are available on the OpenAlea platform, and can be connected as components with others models. Models are provided as plugins of a common service that expose radiation models with a uniform interface. New RT models can be added dynamically and compared with others. The comparison includes an estimation of bias and errors, as well as its efficiency in terms of computational time. This work is a first initiative towards a benchmark proposal, open to the whole FSPM community, similar to the RAMI initiative for the inter-comparison of radiation transfer model for remote sensing application