Canopy structure and light interception properties of trees: in search of the missing parameters.

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Light capture by plants can be regarded as a geometrical question: photons travel along lines and collide with foliage surface elements dispersed in the vegetation volume. As a result, usual models of light interception by isolated tree canopies involve canopy geometry parameters, namely canopy volume, total leaf area and the angular distribution of leaf elements. Such light models however assume that leaf area is randomly dispersed in the canopy space. Observation of real tree canopies shows foliage clumping, e.g. leaves or needles around shoots, which demonstrates that random foliage dispersion is not true. However until now, no additional geometry parameter has been found to overpass this assumption.

Here we have used virtual trees built from either i) 3D digitising of real trees, ii) allometry rules, or iii) fractals rules to assess the effect of three possible sources of non-randomness on light interception of tree canopies. The virtual trees were used to explore geometrical properties, including fractal properties, and compute light capture properties, namely the sky-vault averaged STAR (Silhouette to Total Area Ratio). STAR values were computed from i) images of the 3D plants, and ii) from a 3D turbid medium using space discretisation at different scales.

For all trees, departure from randomness was primarily due to the spatial variations in leaf area density within the canopy volume (Sinoquet et al. 2005). For a set of plants, STAR estimations, based on turbid medium assumption, using the finest space discretisation were very close to STAR values computed from the plant images, except one fractal tree and coppice poplar trees built from allometry rules. The latter showed high clumping at fine scale. Taking into account a non-infinitely small leaf size, whose effect is theoretically to shorten self-shading, had a minor effect on STAR computations. STAR values computed from the 3D turbid medium were very sensitive to plant lacunarity, a parameter introduced in the context of fractal studies to characterize the distribution of gaps in porous media at different scales.

Further work is in progress to explore clumping with regard to the multiscale botanical structure of the trees, and relate plant lacunarity to botanical parameters.

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.