Measurements of shoot scattering phase function for Scots Pine

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Radiative transfer studies in plant canopies have suggested that the basic scattering element of a coniferous tree is a shoot, not a needle. While the optical properties of shoots depend directly on those of the needle, the special spatial arrangement of the latter makes the dependence nonlinear. Further, although the role of the shoot is widely acknowledged, very little empirical information on the scattering properties of even the most common conifer species is available. This can be explained by the relative complexity of the measurements and a lack of specialized measurement systems.

We present the results of measuring the directional scattering properties of ten Scots pine shoots. The measurements were carried in the University of Zurich facilities using the FIGOS goniometer system in March 2011. The goniometer system allows to measure radiation scattered by an object located in its center in almost any direction in the upper hemisphere. For our experiment, FIGOS was installed in a dark room with spectrally neutral black walls. The radius of the arc of the goniometer corresponding to the distance between the pine shoot sample and the radiation measurement device was 2 m. To cover the whole sphere, we rotated the shoot with a specially constructed frame to maintain alignment. Scattered radiation was recorded using an ASD FieldSpec 3 spectroradiometer and calibrated against a two-inch Spectralon reflectance panel. Goniometric measurements were accompanied by detailed measurements of shoot structure.

Our results show that the BRDF of a shoot is strongly anisotropic and has a strong backscattering component. The anisotropy depends on the wavelength as well as the orientation of the radiation receiver relative to shoot axis. We also calculated accuracy estimates for different BRDF approximations and the effect of shoot scattering anisotropy on total canopy scattering. Preliminary results on the importance of accounting for full shoot BRDF at different wavelengths are given in the presentation.