

Radiative Transfer in Coniferous Trees

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In the theory of the radiation transfer in coniferous trees the concept of homogeneous turbid medium is not applicable. It is due to the nonuniform spatial distribution of scattering elements needles. Their clumping is caused by tree shape, branching structure of the tree, architecture of the branches consisting of shoots and internal structure of shoots. The smallest optical element of the tree is a needle but constructing the radiative transport theory on the bases of needles is practically unrealistic. More realistic seems to start with one year shoot and scattering phase function (SPF) of the shoot should be given. In comparison with leaf the shoot is more complicated scattering unit and its SPF is determined by optical properties of the individual needles and by architecture of the one year shoot which is given by needle length, width and thickness, the needle density on twig, the twig length and diameter and by angle between shoot and needles. Model calculating the SPF is complicated due to needles mutual shading and penumbra effect.

Ross, Sulev and Meinander^[1] have made an attempt of determining one year scots pine shoot SPF experimentally using a spectrogoniometer. The measurements have been carried out at wavelengths 485, 555, 650 and 790 nm and show that the shoot SPF is variable and have complicated shape. The most important factor is the angle between incident beam and shoot axis. When the shoot axis is perpendicular to the incident beam in all wavelengths the maximum scattering is in backscattering direction. Moving off from the backscattering direction, the phase function decreases. In the blue and red light the scattering is very low between the scattering angles 80° and 170° . In the green and near infrared regions the decrease in

SPF is slower. The angular dependence can be explained by changes in the ratio of illuminated ("reflection") and shaded ("transmission") part of needles, i.e. a phenomenon that may be treated as the hot spot effect. In the green and near infrared regions the brightness contrast between the illuminated and the shaded parts of needles is relatively lower than in the blue and red parts of the spectrum, and, respectively, the angular dependence of SPF less significant.

The results of measurements have demonstrated that the shoot SPF is a rather variable quantity that depends on the internal structure of the shoot, the geometry of illumination and the wavelength. The shape of SPF is greatly influenced by the proportion of illuminated and shaded needles visible in the view direction (the hot spot phenomenon), by the brightness contrast in needle reflectance and transmittance and by the specular reflectance from individual needles. The latter can be visually observed as small bright flecks at certain view directions. In spectral regions where needles practically do not transmit radiation (blue and red) the angular course of SPF is very sensitive to hot spot and specular reflection. These effects are less notable in the green region and especially in the near infrared. In the near infrared, because of considerable transmission of radiation through needles and multiple scattering of radiation inside the shoot, the angular dependence of SPF is remarkably lower. The shoot SPF is a rather variable quantity that depends on the internal structure of the shoot, the geometry of illumination and the wavelength. The shape of SPF is greatly influenced by the proportion of illuminated and shaded needles visible in the view

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