Spectral Bidirectional Reflectance Factor Measurements of Two Dwarf Shrub Species

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Most natural material surfaces appear different when viewed from different directions or illuminated from different angles. This reflectance anisotropy has inspired many to study the underlying reasons by developing new measurement methods and by analyzing the obtained multidirectional data for spectral characteristics. Vegetation canopies represent complex multiple scattering environments where both the optical properties of the contributing components (e.g. leaves, stems, flowers, fruits, and understory) and their spatial arrangement and orientation, i.e. structure determine the spectral response. We conducted a research effort over the growing season of 2017 for obtaining multitemporal ground truth data for spectral characterization of two economically most important dwarf shrub species in Finland: lingonberry (*Vaccinium vitis-idaea*) and blueberry (*Vaccinium myrtillus*). We present the first empirical evidence of the seasonal spectral dynamics of these species in spectral region from 400 to 2200 nm. Multiangular spectral bidirectional reflectance factors (BRFs) were measured using the Finnish Geospatial Research Institute's FIGIFIGO goniospectrometer in standardized laboratory conditions. The obtained BRF data were analyzed for wavelength and view- and illumination angle dependencies and for seasonal dynamics. Ancillary leaf-level reflectance and transmittance spectra were collected as well on two occasions to support the discussion of the results. Both species were observed to scattered strongly into backward direction towards the illumination source and notably into forward direction on the principal plane. Interspecies comparison showed lingonberry to be brighter of the two species into all applied view directions in visible and near infrared regions but darker in the short-wave infrared. Changing the illumination zenith angle from 40° to 55° improved separability of the species. Vegetation indices that are commonly used in remote sensing of forests (NDVI, NDVI705, MSI, and PSRI) showed low sensitivity to both view- and illumination angles, but high temporal dependence, which coincided with the observed phenological stages. The presence of lingonberries was shown to induce a spectral peak around 680 nm in the ratio of samples-with-berries to samples-without-berries. Our results indicate that multidirectional data improves the spectral discrimination of lingonberry and blueberry, and justifies further studies on berry and flower detection from airborne (e.g. UAV) platforms.