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Intensive phenological monitoring of deciduous trees by phenological cameras

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Phenological observations of forest plants are time demanding and labor-intensive, the automated monitoring with digital cameras can serve as an alternative to substitute traditional phenological observations by human observers. The sensing with fixed cameras allows to obtain continuous data with high resolution and to describe the dynamics of canopy development by using simple vegetation indices (proportion of each colour) in deciduous trees. The objective of this study was to investigate the utilization of digital cameras for long-term phenological observations of particular trees (e.g. hazel, aspen, birch and rowan) based on images taken 24 times a day (period 2007–2012) obtained at the International Phenology Garden in Doksany (Czech Republic, 50°27'31" N,14°10'14" E, 158 m asl). Canon Power Shot S3 IS and Olympus E-410 cameras made images in the automatic mode every hour during the whole vegetation period. This monitoring was supplemented by measurements of CO_2 (LI-6252) and Normalized Difference Vegetation Index (sensor Skye SKR-1800). Red-green-blue (RGB) colour channel information from digital images can be separately extracted in digital form (by using Sigma Scan Pro 5.0 software) and subsequently summarized through Green Index (GI = G/[R+G+B]). The relationship between Green Index and optimized Growing Season Index (iGSI) was found ($R2 = 0.92$, $p<0.01$). Subsequently the relationship between iGSI and Normalized Difference Vegetation Index ($R2 = 0.7$, $p< 0.01$) and Net Ecosystem Exchange ($R2 = 0.81$, $p< 0.01$) was analysed. Our results demonstrate the possibility of using models as an appropriate tool for monitoring temporal changes in canopy development and phenological events. It also provides data required for the calibration and direct validation of satellite observations and products. The high correlation between the iGSI and the net ecosystem carbon exchange proved that CO_2 exchange processes depend significantly on the canopy development.