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Use of digital images to observe forest phenology and drought stress

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Phenological data that complement research studies of climate impacts on ecosystems need to be estimated with both temporal and spatial accuracy. Forest phenology can be monitored by satellite, but the realism of remote sensing products such as the NDVI (Normalized Difference Vegetation Index) still heavily depends on ground based validation data. Ground based data is often observer-biased and the number of observations strongly varies in time and space. Recent studies have demonstrated the successful application of digital camera images for spring phenological monitoring in ecosystem studies. Objective of the present study therefore was to test the application of digital images from standard RGB-cameras for regional monitoring and modelling the seasonality of forest physiology and for detecting species-specific reactions on environmental impacts such as drought.

A digital camera was mounted on the uppermost platform of a fluxtower at the CarboEurope site Lägeren (northern Switzerland). Daily images of the mixed forest from four years were used to derive the timing of greenup, leaf maturity, senescence and dormancy of two different tree species (beech and ash) between 2005 and 2008. Based on the image color values a vegetation index was computed. Time series of the vegetation index were jointly analyzed with standard meteorological data and eddy covariance measurements of ecosystem carbon dioxide and water vapour exchange.

Generally the observation of phenologial phases was successful but complex for the end of the vegetation period, e.g. due to early leaf coloring caused by summer heat, and a less pronounced starting date of leaf senescence compared with spring greenup. Spring CO_2 flux characteristics could be explained by leaf emergence dates of dominant tree species. A drought period in 2006 influenced index values for beech but not for the highly drought-tolerant ash trees. Phenological data showed significant correlation with carbon dioxide exchange measurements and the computed index largely explained the seasonal and interannual variability of the forests gross primary productivity. We conclude good applicability of digital cameras for a) observing phenological phases and b) complementing data to model ecophysiological processes of a forest.