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Opportunities to investigate the functional phenology of ecosystems using a European Phenology Camera Network

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Plant phenology is orchestrated through subtle changes in photoperiod, temperature and soil moisture. Presently, the exact timing of plant development stages and their response to climate and management practices are crudely represented in land surface models. As visual observations of phenology are laborious, there is a need to supplement long-term observations with automated techniques such as those provided by digital repeat photography at high temporal and spatial resolution. We present the first synthesis from a growing observational network of digital cameras installed on flux towers across Europe above deciduous and evergreen forests as well as grasslands and croplands. Using colour indices from digital images and newly developed algorithms, we explored whether key changes in canopy phenology could be detected automatically across different land use types in the network. Our initial results indicate that a piecewise regression approach can capture the start and end of the growing season well, in addition to striking changes in colour signals caused by flowering and management practices such as mowing. We also investigated whether the seasonal patterns of red, green and blue colour fractions derived from digital images could be modelled mechanistically using the canopy radiative transfer model PROSAIL. This model can be used to simulate the RGB signal at the canopy scale when parameterised with quantitative information on seasonal changes in canopy leaf area and leaf pigment content (chlorophyll and carotenoid concentrations). From a model sensitivity analysis we found that variations in colour fractions, and in particular the spring 'green hump' observed repeatedly in deciduous broadleaf canopies across the network, seem essentially dominated by changes in pigment concentrations (chlorophyll and carotenoids). Using the model we were also able to explain why this spring maximum in green signal is often observed out of phase with the maximum period of canopy photosynthesis in ecosystems across Europe. Coupling such quasi-continuous digital records of canopy colours with co-located eddy flux measurements will improve our understanding of how changes in growing season length are likely to shape the capacity of European ecosystems to sequester CO_2 in the future.