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Modelling interannual and spatial variability of leaf senescence for three deciduous tree species in France

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The annual timing of temperate forest leaf colouring is affected by climate change; to date, its modelling remains a challenge. We take advantage of a ca. 400 leaf colouring observations database acquired in France during the period of 1997-2006 in order to develop a new modelling framework aimed at predicting the spatial and year-to-year variability of leaf colouring in European beech and oak (Fagus sylvatica, L., Quercus petraea, Matt. Liebl. and Quercus robur, L.). We postulate colouring to be the outcome of a one-way process triggered by photoperiod and progressing through a photoperiod-sensitive cold-degree day summation procedure. Observations were pooled according to genus for the fitting and ensuing validation procedures.

Parameters of the model suggest that colouring processes start earlier, and are sensitive to higher temperatures for Quercus than for Fagus. Errors associated with the modelled predictions are up to 13.0 days in Fagus and 10.3 days in Quercus, which are significantly lower than errors associated with (1) the overall mean (null model) or (2) previously published modelling frameworks. When averaged on a site basis, model predictions reproduced spatial variability of leaf colouring over the French territory with good efficiency (modelling efficiencies: 0.44 for Fagus, 0.45 for Quercus). The interannual variability of leaf colouring over France was fairly reproduced (R^2=0.74 for Fagus, 0.83 for Quercus). On that basis, we claim that the modelling framework developed herein can be efficiently integrated into more general schemes aimed at simulating matter and energy fluxes on a regional scale, and we provide a generic parameterisation of the model to be integrated into such schemes. When used in a prospective analysis, the model predicts a trend towards delay in leaf colouring of 1.4 and 1.7 days per decade in Fagus and Quercus, respectively, over the period of 1951-2099 in France.