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Assessing the effects of climate change on the phenology of European temperate trees

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Modelling phenology is crucial to assess the impact of climate change on the length of the canopy duration and the productivity of terrestrial ecosystems. Focusing on six dominant European tree species, the aims of this study were (i) to examine the accuracy of different leaf phenology models to simulate the onset and ending of the leafy season, with particular emphasis on the putative role of chilling to release winter bud dormancy, (ii) to predict seasonal shifts for the 21st century in response to climate warming.
Models testing and validation were done for each species considering two or three years of phenological observations acquired over a large altitudinal gradient (1500 m range, 57 populations). Flushing models were either based solely on forcing temperatures (1-phase models) or both on chilling and forcing temperatures (2-phases models). Leaf senescence models were based on both autumn temperature and photoperiod.
We show that most flushing models are able to predict accurately the observed flushing dates. The 1-phase models (based on forcing temperatures) are as efficient as 2-phases models (based both on forcing and chilling temperatures) for most species suggesting that chilling temperatures are currently sufficient to fully release bud dormancy. However, our predictions for the 21st century highlight that chilling temperature could be insufficient for some species at low altitude. Overall, flushing is expected to advance in the next decades but this trend substantially differed between species (from 0 to 2.4 days per decade). The prediction of leaf senescence appears more challenging, as the proposed models work properly for only two out of four deciduous species, for which senescence is expected to be delayed in the future (from 1.4 to 2.3 days per decade). These trends to earlier spring leafing and later autumn senescence are likely to affect the competitive balance between species. For instance, simulations over the 21st century predict a stronger lengthening of the canopy duration for Quercus petraea than for Fagus sylvatica, suggesting that shifts in the altitudinal distributions of these species might occur.