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Shifts in the temperature sensitivity periods for two forest tree species under warming climatic conditions

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Spring phenology of temperate trees has advanced worldwide in response to global warming. However, increasing temperatures may not necessary lead to further phenological advance, especially in the southern part of tree species distribution because bud development may be delayed by the combination of warmer winters (insufficient chilling) and short photoperiod during the early season. Consequently, a focus on the start of the ecodormancy, i.e. when buds start to respond to warmer temperatures in early spring, is crucial to understand and predict how phenology will evolve in the future warmer climate as well as to improve carbon cycle models. Yet, the beginning of this period is not visible in the field and can so far only be derived statistically. In this study, we used leaf-out date observations of several clones of European beech (Fagus sylvatica L.) and pedonculate oak (Quercus robur L.) planted over a large latitudinal gradient (from Portugal to Sweden) at the International Phenological Gardens (IPGs) during the period 1969-2017 (>13'000 observations). The IPGs offers a unique opportunity to test the phenological plasticity of trees to contrasted climatic conditions without being affected by genetic adaptations (clones). We used Partial Least Squares Regression analyses to identify the sensitivity periods when leaf-out dates are mostly regulated by low (chilling) and warm temperatures (forcing) through space (>22° of latitudes) and time (∼5 decades). We aimed (i) to evaluate how the periods of sensitivity to forcing and chilling have changed over the last decades, and (ii) to test whether consistent patterns can be found from colder to warmer environment.
Our results suggest that the beginning of the period of sensitivity to forcing has been delayed over time and under lower (warmer) latitudes for beech, whereas no change has been detected for oak over the spatial and temporal scales. We attributed the shift of the forcing phase for beech to insufficient chilling which may have progressively delayed the dormancy release, whereas the lack of change for oak would indicate low chilling requirements. Our result suggest that global warming will likely affect the time sequence when tree species start their growing season due to substantial differences in chilling and forcing requirements among co-existing species.