Solstice optimizes thermal growing season

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Plants generally used environmental cues, such as temperature and photoperiod, to adjust the timing of phenological events in response to environment variability within and between years. Yet, the larger mechanisms behind these cues remain largely unknown for many events.

Recently, summer solstice has been proposed as a universal trigger to modulate cues and initiate key physiological processes [**?**, **?**]. This proposed photoperiod switch, if correct, could reshape predictions of forest responses to climate change. However, using a fixed date like the solstice as a cue could limit plasticity and become less suitable in a warmer future climate [**?**]. This may in turn drive forest declines, with significant implications for carbon storage, and thus raises important questions about the suitability for plants to rely on the solstice.

The timing of major plant transitions—such as start of growth with leafout—should match development states with fitness opportunities, given no other constraints. In most environments, this will always involve a trade-off between an increased fitness (e.g. a longer window for growth) and an increased susceptibility to climatic and biotic risks (e.g. a higher exposition to late frosts). Because plants cannot know these exact opportunities and risks in advance, they should rely on the most informative cues to accurately anticipate environmental conditions and optimize their chances for growth and reproduction [**?**, **?**].

In particular, it is well established that plants respond primarily to integrated climate forcing, often measured as the accumulation of temperatures over a given period (growing degree-days, GDD). This heat accumulation is a key factor in development and growth processes for both crops (REF) and wild plants (REF). Plants are thus expected to take full advantage of warmer years (with high GDD) to maximize growth and set many flowers for the following season.

Given the importance of GDD, plants should ideally time their transitions when their ability to predict the total GDD within the growing season is maximum while still having enough potential thermal energy to complete essential growth and reproductive processes. Concretely, this trade-off means that there should be an optimal period during which the plant has accumulated enough GDD to reliably predict the total GDD by the end of the year (*environmental predictability*), while also maximizing the remaining GDD available (*growth potential*). Environmental predictability at a day d can simply be computed, across years, as the R^2 of a linear regression between the total GDD (that will be accumulated at the end of the year) and the GDD already accumulated between 1st January and d.