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Changes in diurnal temperature range and in spring frost risk to trees in Switzerland during the last 4 decades

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Global warming has been shown to cause earlier development in most plants of mid-latitudes, but there is no consensus about how the occurrence of late spring frosts will change. Vulnerable plant organs such as flowers or emerging leaves may be more exposed to frost damage if the frequency and the severity of late spring frosts remain unchanged in the future or if they advance less than plant spring phenology.

Here we analyzed long-term series of minimum and maximum temperature data during the period 1975–2016 from 50 sites in Switzerland located at elevations from 203 to 2283 m. We used different phenological models calibrated on long-term series of the flowering and leaf-out timing of two fruit trees (apple tree and cherry tree) and two forest trees (Norway spruce and European beech) as a proxy for spring vulnerable phenophases in orchards and mixed temperate forests. We then tested whether the time lag between predicted spring phenology and the latest occurrence of frost has changed over the study period.

Overall, in spite of the substantial temperature increase during the study period, the risk of frost damage was not reduced and has even increased at higher elevation, because spring phenology has advanced at a faster rate than spring frost events during the last decades. This may possibly be connected to an increasing diurnal temperature range (DTR) during that period, as a result of the faster increase of maximum over minimum temperatures. We found for all four species that the frost risk has increased in the vast majority of stations located at elevations higher than 800 m and remained unchanged at lower elevations.

Our results suggest to carefully consider promoting the introduction of new varieties of fruit or exotic forest tree species adapted to warmer and drier climate in regards to their spring phenology.