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Phenological changes in Europe are still attributable to climate change induced warming

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During 1971-2000 phenological responses of wild species in spring and summer matched the warming pattern in Europe, whereas timing of farming activities as well as autumnal leaf colouring did not mirror climate change to the same extent (Menzel et al. GCB 2006). These findings were a backbone of the corresponding global attribution study of the IPCC AR4 (Rosenzweig et al. 2007, 2008). Two decades of warming later, however, new phenological findings suggest that especially a lack of chilling and / or increasing influence of photoperiod may have lowered the phenological temperature response and that adaptation in agricultural management is taking place. We therefore updated the GCB 2006 study by asking three questions: What drives the inherent variation of trends? Can we now detect a warming signal in “false” agricultural (i.e. those being directly or indirectly determined by farmers’ management) and autumn phases? Is there still an attributable warming signal in phenology?

The complete phenological dataset of Germany, Austria and Switzerland (1951-2018, ~97.000 times series, corresponding to 96.3% of PEP725 data) was analysed. We determined linear trends, studied their variation by plant traits / phenogroups, across season and time, and followed IPCC methodology for attributing phenological changes to warming patterns.

For spring and summer phases of wild plants we found more (significantly) advancing trends (~90% and ~60% sign.) which were stronger in early spring, at higher elevations, but smaller for non-woody insect-pollinated species. Although mean trend strength decreased, changes in spring were strongly attributable to warming in spring and winter. We had similar but less strong findings for agricultural crops in these seasons. In contrast only ~75% of phenological phases set by farmers’ decisions were advancing, however this was the only phenological group for which the mean advance increased, indicating adaptation. Equally trends in farming phases in spring and summer were attributable to warming in winter and summer, respectively. Leaf coloring and fall

was now predominantly delayed (57%) which was attributable to winter and spring warming, too.

Thus, this update of the GCB2006 study demonstrates that there is still a significant and attributable phenological change pattern in Europe, in which number of (significant) trends pointing into the direction of warming increased, but mean trend strength mostly decreased, probably due to a lack of chilling and smaller forcing trends. More attention should be paid to the inherent variability of trends with traits / species groups, season and time triggering divers (e.g. ecological) consequences of these phenological shifts. Still existing differences between the generative period of crops and wild species as well as between the farming season and the general growing season call for more research in this area.