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Climate warming effects on plant phenology changes in a major region of Romania

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It has been suggested that phenology, the period of life cycle events, is among the biosphere's most sensitive indicators of climate change. The analysis of phenological changes is essential not only for understanding the effects of climate change on ecosystems, but also for the adaptation of ecological systems to this highly important global environmental perturbation. This paper's objective is to analyse phenological trends in the past half century in southern and south-eastern Romania, a region currently known to be strongly affected by climate warming. The methodology entails the use of mean monthly temperatures collected from 24 weather stations, uniformly distributed in this extensive region of Romania (totaling almost 64000 km2), which were processed (for the period 1961–2010) by means of the histophenogram method in order to obtain the mean phenophases/growing season length (in days), i.e. start of vegetation season (phenophase 1 – P1), budding-leafing (phenophase 2 – P2), flowering (phenophase 3 – P3), fruiting (phenophase 4 – P4), maturing (phenophase 5 – P5), dissemination of seeds (phenophase 6 – P6), start of leaf loss (phenophase 7 – P7), end of leaf loss (phenophase 8 – P8) and the entire climatic growing season (CGS, that spans from P2 to P8). Therefore, based on temperature thresholds ranging between 5 and 25 ºC, set in the histophenograms (considering that this thermal interval is known for phenological influence and plant development for mid- and high latitudes), phenopahse and the CGS lengths were extracted for each year of the five-decade period, which were subsequently analysed in terms of trends using the established statistical tools – the Mann-Kendall test and the Sen's slope method. Our results indicated an overall expansion of phenological activity, except for two phenophases (P4 and P6), the periods of which showed dominant decreases. It was found that, over the entire 1961–2010 period, the highest statistically significant increases occurred in P5 (0.89 days/yr or 8.9 days/decade) and CGS (0.33 days/yr). However, it was noticed that these positive trends were significantly higher over the last three decades (1981–2010), when the peak Sen's slope values of 1.63 days/yr for P 5, and 1 day/yr for CGS were recorded. Also, a detailed linear regression analysis between mean annual temperatures and annual CGS length showed a high sensibility of phenological dynamics to temperature variability, i.e. an increase even over 21 days at certain weather stations for a 1 °C temperature rise. In conclusion, our results confirm the obvious impact of climate warming on phenological changes in southern and south-eastern Romania, and at the same time deliver additional insight on this ecological issue that is still understudied in this country.