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Changes in flowering phenology of woody plants in North China

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Over the past several decades, abundant evidences proved that the first flowering date of plants in northern hemisphere became earlier in response to climate warming. However, the existing results about impact of climate change on flowering duration are controversial. In this study, we studied temporal trends in first flowering date (FFD), end of flowering date (EFD) and flowering duration (FD) of 94 woody plants from 1963 to 2014 at three stations (Harbin, Beijing and Xi'an) in North China. Meanwhile, we analyzed the relationship between length of flowering periods and temperature using two phenological models (including regression model and growing degree day model). At all stations, more than 90% of observed species showed earlier flowering over time from 1963 to 2014. The average trends in FFD were 1.33, 1.77 and 3.01 days decade-1 at Harbin, Beijing and Xi'an, respectively. During the same period, EFD also became earlier by a mean rate of 2.19, 1.39 and 2.00 days decade-1, respectively. Regarding FD, a significant shortening of FD was observed at Harbin (-0.86 days decade-1), but FD extended by 0.37 and 1.01 days decade-1 at Beijing and Xi'an, respectively. At interspecific level, the plant species with longer FD tend to have stronger trends of FD extension. Through regression analyses, we found more than 85% of time series revealed a significant negative relationship between FFD (or EFD) and preseason temperature. The regression model could simulate the interannual changes in FFD and EFD with the mean goodness of fit (R2) ranging from 0.38 to 0.67, but failed to simulate the FD accurately, as R2 ranging from 0.09 to 0.18. Regarding to FFD and EFD, the growing degree day model could improved R2 of simuation, but also could not simulate FD accurately. Therefore, we concluded that the FFD and EFD advanced notably in recent six decades as a result of climate warming, but the direction of FD changes depended on locations and the species involved. In addition, the conventional phenological models could not explain most parts of interannual variance in FD, partly due superposition of errors caused by simultaneously simulating FFD and EFD. Therefore, the mechanism of FD changes and more drivers of FD such as soil moisture and light need to be further studied.