Spring phenology was not consistently related to winter warming on the Tibetan Plateau

Yu et al. (1) reported that the beginning of vegetation growing season (BGS) of the alpine steppe and meadow on the Tibetan Plateau was delayed since the mid-1990s under warming winter and spring (1). They wrote that "this delay appeared to be related to later fulfillment of chilling requirements," and they suggested that "continued warming may strengthen this effect or even reverse the advancing trend in spring phenology" (1).

This idea was proposed earlier for phenology of some species (2) and was tested on the alpine vegetations at the regional level. Using this idea, if winter warming continues and spring warming does not accelerate, the delaying trend should continue. We found, however, that, despite the continued winter warming and the fluctuating spring temperature (T_{spring} is the mean temperature of April, May, and June) during the period from 1998 to 2009, BGS calculated from Systeme Probatoire d'Observation dela Tarre Normalized Difference Vegetation Index (NDVI) showed no continued delaying trend (Fig. 1). Actually, for the period 1998–2009, T_{spring} first decreased before 2003 and increased thereafter. In response, BGS was first delayed and then advanced (Fig. 1), showing considerable negative relationship with T_{spring} for the period and subperiods of 1998–2003 and 2003–2009 (Table 1). In Yu et al. (1), T_{spring} (calculated from data in tables S1 and S2 in ref. 1) increased 0.066 °C/y ($P = 0.13$) for the steppe and 0.058 °C/y ($P < 0.07$) for the meadow from 1982 to 1998 and decreased 0.229 °C/y ($P < 0.04$) for the steppe and 0.107 °C/y ($P = 0.18$) for the meadow from 1998 to 2006. Consequently, BGS showed a retreat around 1998 from advance to delay (figure 3 in ref. 1). These phenomena indicate that BGS is significantly regulated by T_{spring}.

Contrastingly, BGS was not significantly related to winter temperature (T_{winter} is the mean temperature of December, January, and February), and the relationship was either positive or negative (Table 1). As shown in Fig. 1 and Table 1, the positive BGS–T_{winter} relationship was statistically resulted from the delay in BGS and increase in T_{winter} from 1998 to 2003 when there was decreasing T_{spring}. In Yu et al. (1), because T_{winter} was relatively stable for the subperiod before 1998 ($P > 0.87$ in both linear regression between T_{winter} and year order), the positive BGS–T_{winter} relationship from 1982 to 2006 might be mainly caused by the evident delay in BGS (figure 3 in ref. 1) and the sharp increase in T_{winter} (0.304 °C/y for steppe and 0.321 °C/y for meadow; both $P < 0.04$) during the subperiod 1998–2006. Thus, the positive BGS–T_{winter} relationship was observed only when BGS was delayed under decreasing T_{spring} and increasing T_{winter}. Therefore, the effect of winter warming on the spring phenology does not follow a simple correlation and should not be extrapolated based on the currently limited evidence; further analysis using a dataset for a longer period is needed to address this effect.

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Fig. 1. The beginning of vegetation growing season (BGS) averaged for alpine meadow and steppe on the Tibetan Plateau. Zhang and White labels indicate that BGS was calculated by the methods proposed by Zhang et al. (3) and White et al. (4), respectively. BGS by the White et al. (4) method was used for further analyses (Table 1). T_{winter} and T_{spring} labeled as Yu were from the supporting material in the work by Yu et al. (1).

Table 1. Linear regression between beginning of vegetation growing season (BGS) and temperature

Regression model	r^2	P	Period
Steppe			
$BGS = -6.21 \times T_{spring} + 197.1$	0.43	0.02	1998–2009
$BGS = -5.46 \times T_{spring} + 193.3$	0.63	0.06	1998–2003
$BGS = -10.08 \times T_{spring} + 227.1$	0.49	0.08	2003–2009
$BGS = -1.83 \times T_{winter} + 136.3$	0.08	0.37	1998–2009
$BGS = 4.01 \times T_{winter} + 175.7$	0.34	0.23	1998–2003
$BGS = -4.54 \times T_{winter} + 120.6$	0.32	0.19	2003–2009
Meadow			
$BGS = -8.21 \times T_{spring} + 204.9$	0.69	<0.01	1998–2009
$BGS = -8.00 \times T_{spring} + 204.1$	0.72	0.03	1998–2003
$BGS = -10.80 \times T_{spring} + 225.0$	0.58	0.05	2003–2009
$BGS = -1.05 \times T_{winter} + 136.3$	0.02	0.64	1998–2009
$BGS = 3.37 \times T_{winter} + 164.9$	0.10	0.55	1998–2003
$BGS = -3.36 \times T_{winter} + 124.2$	0.20	0.32	2003–2009

T_{sping}, mean temperature of spring (April, May, and June); T_{winter}, mean temperature of winter (January, February, and the former December). Temperature was averaged from 29 meteorological stations for steppe and 40 stations for meadow.