Replies to Shen, Chen et al., and Yi and Zhou: Linear regression analysis misses effects of winter temperature on Tibetan vegetation

We are happy to see that our article (1) has stirred some interest, and we thank the authors of the three letters for their valuable comments (2–4).

Shen (2) writes that linear regression could not detect a clear relationship between winter temperatures and beginning of growing season (BGS). This is not surprising. As has been shown many times, the primary driver of spring phenology is spring temperature, and this effect overlays smaller effects of temperature during other parts of the year. To tease such minor effects out of our dataset, we used partial least squares regression, which analyzed the impacts of both winter and spring temperatures on BGS dates. The results of this analysis showed that changes in spring greening resulted from the combined effects of winter and spring warming and not from winter warming alone. Linear regression is unlikely to detect minor effects. We do not understand the reasoning behind separately analyzing subperiods, because the same fundamental processes should determine BGS dates during the entire period, and a model of spring phenology should explain all green-up dates rather than only a selection.

Chen et al. (3) contend that, in addition to climate change, grassland degradation and thawing–freezing processes may have affected the phenology of Tibetan Plateau vegetation. These processes may play a role, but we doubt that they can explain the regional scale trends in BGS and end of the growing season (EGS) dates that we observed. Neither our dataset nor the reference given in the letter (3, 5) provides evidence of long-term and large-scale grassland degradation that could explain our results. Nevertheless, a comprehensive functional model of grassland phenology will likely have to consider such processes.

Chen et al. (3) suggest that reduction in vegetation cover may have led to an increased albedo, which may have cooled the region. We do not find this very convincing, because (*i*) our temperature records clearly show a warming of the region, (*ii*) bare soil may have a lower albedo than vegetation, and (*iii*) such effects should be reflected in the mean snowmelt date, which was relatively constant over most of the study period.

Finally, Yi and Zhou (4) voice concerns that increasing aerosol concentrations over the Tibetan Plateau may have affected our remotely sensed vegetation data. We were unable to reproduce their figure in which aerosol index (AI) values up to 12 indicated extreme aerosol pollution in this remote region. After excluding all missing values and averaging all remaining data for each month from the Total Ozone Mapping Spectrometer (TOMS) dataset, we produced Fig. 1, which shows low AI values, peaking at 1.3. The real values are likely lower, because the dataset registers all AI values <0.5 as missing data. Such low AI values should not influence Normalized Difference Vegetation Index (NDVI) measurements to an extent that could distort our results (6). Moreover, the NDVI ratio method includes normalization by the maximum NDVI for the season. Derived BGS and EGS dates should, thus, only be affected by aerosols if aerosol concentrations showed much stronger increases during certain parts of the growing season than during others. We found no evidence of such trends.

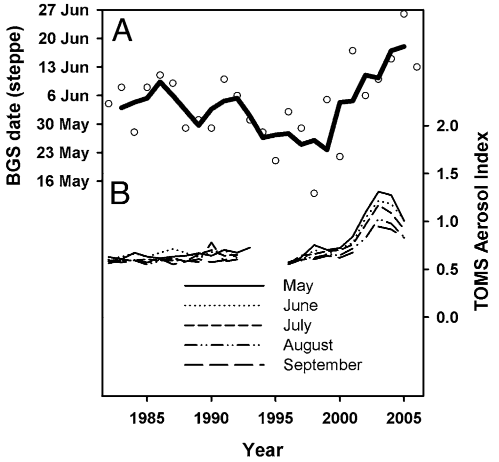

Fig. 1. Changes in the beginning of the growing season in the steppe region of the Tibetan Plateau (*A*) and the Aerosol Index derived from the Total Ozone Mapping Spectrometer (TOMS) for all months of the growing season (*B*).

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The authors declare no conflict of interest.

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