remote sensing

Spring Phenological Sensitivity to Climate Change in the Northern Hemisphere: Comprehensive Evaluation and Driving Force Analysis

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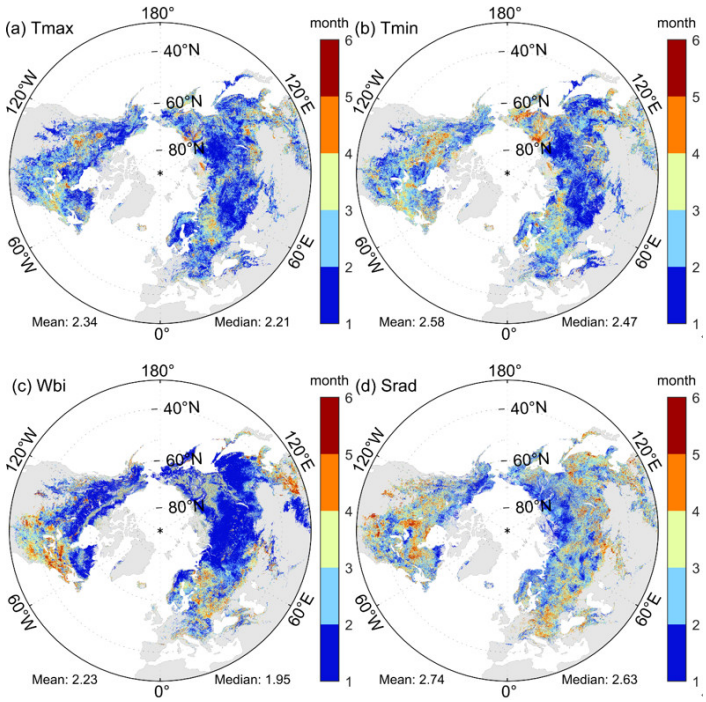

Figure S1. Average optimal preseason duration of Tmax (**a**), Tmin (**b**), Wbi (**c**), Srad (**d**) for SOS in the north during 1982–2014.

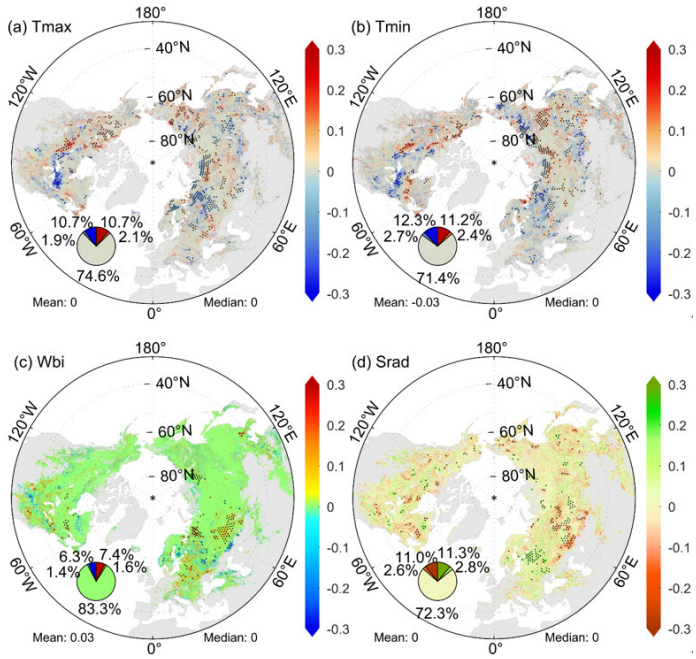

Figure S2. Spatial distribution of optimal preseason duration trends in SOS on Tmax (**a**), Tmin (**b**), Wbi (**c**), Srad (**d**) in the north during 1982–2014. The dotted regions indicate a significant change in preseason duration (|Z| > 1.95). The five parts of the pie chart in a clockwise direction represent the proportion of pixels that show significant positive, positive, negligible, negative, and significant negative changes.

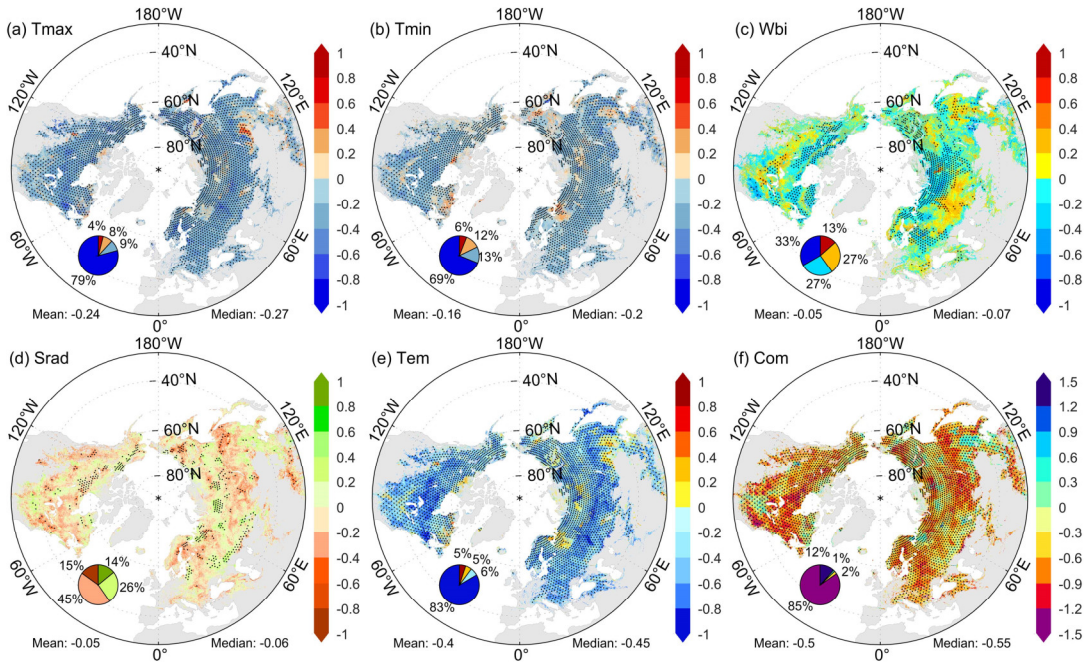

Figure S3. Spatial distribution of SOS sensitivity to Tmax (**a**), Tmin (**b**), Wbi (**c**), Srad (**d**), Tem (**e**), and Com (**f**). Dotted regions indicate significant effects of climate factors on SOS (VIP ≥ 1). The four sections of the pie chart in a clockwise direction represent the proportion of pixels with significant positive, positive, negative, and significant negative sensitivity.

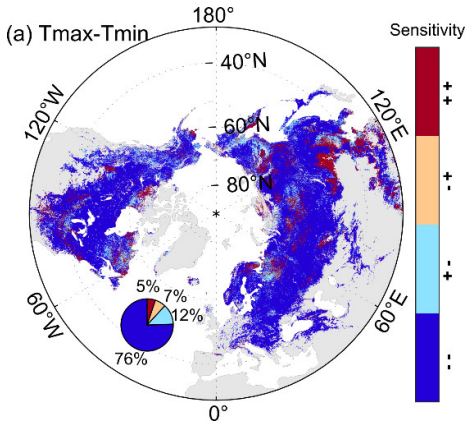

Figure S4. Asymmetric effects of preseason Tmax and Tmin on SOS. '+ +' indicates positive S_{Tmax} and positive S_{Tmin}, '+ -' indicates positive S_{Tmax} and negative S_{Tmin}, '- +' indicates negative S_{Tmax} and positive S_{Tmin}, and '- -' indicates negative S_{Tmax} and negative S_{Tmin}.

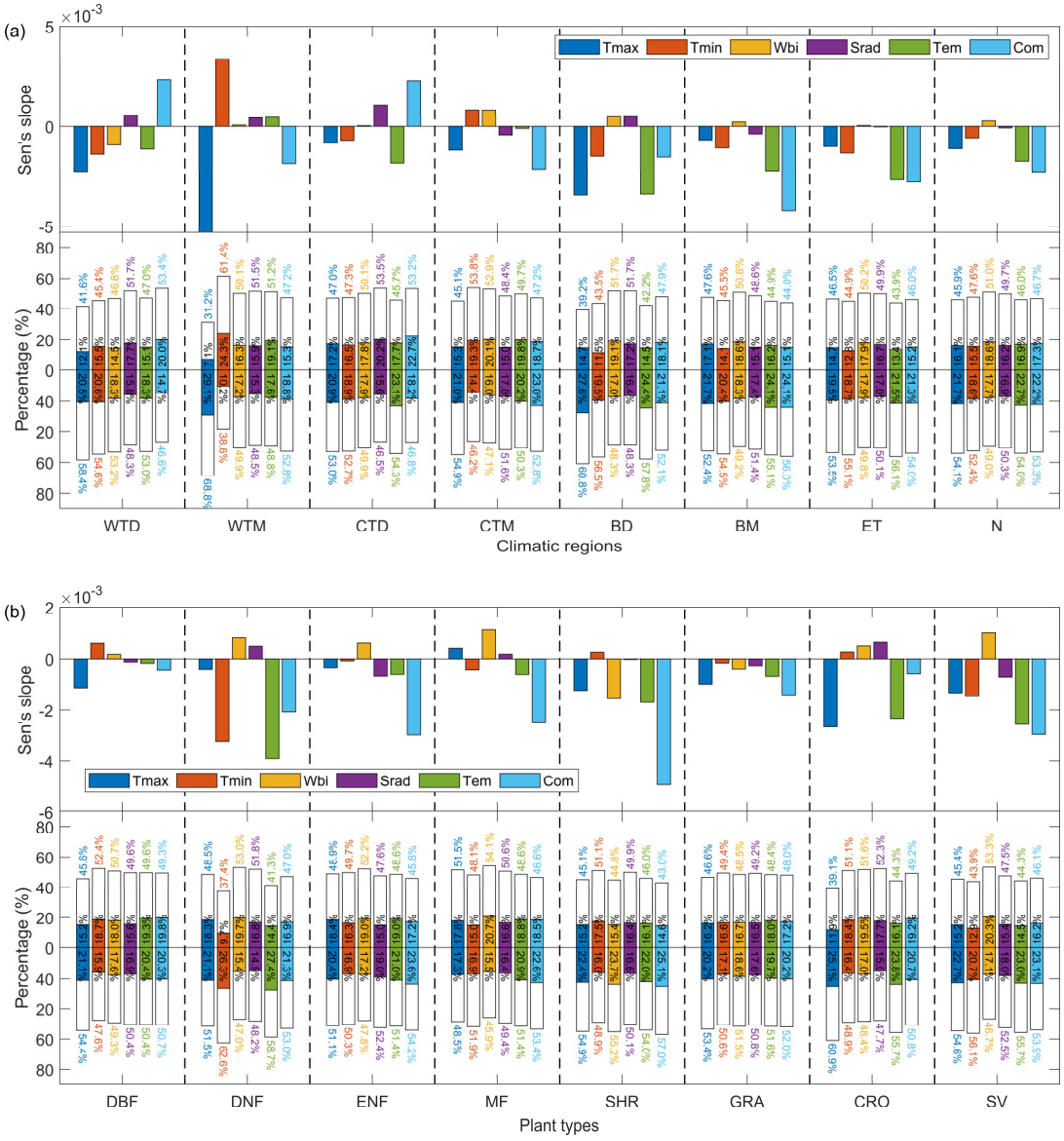

Figure S5. Statistics of the time-varying trends in SOS sensitivity to climate factors in different climatic regions (**a**) and plant types (**b**). Bars above and below 0 represent the percentage of positive and negative trends, respectively. Colored sections indicate the percentage of significant changes at |Z| > 1.95.

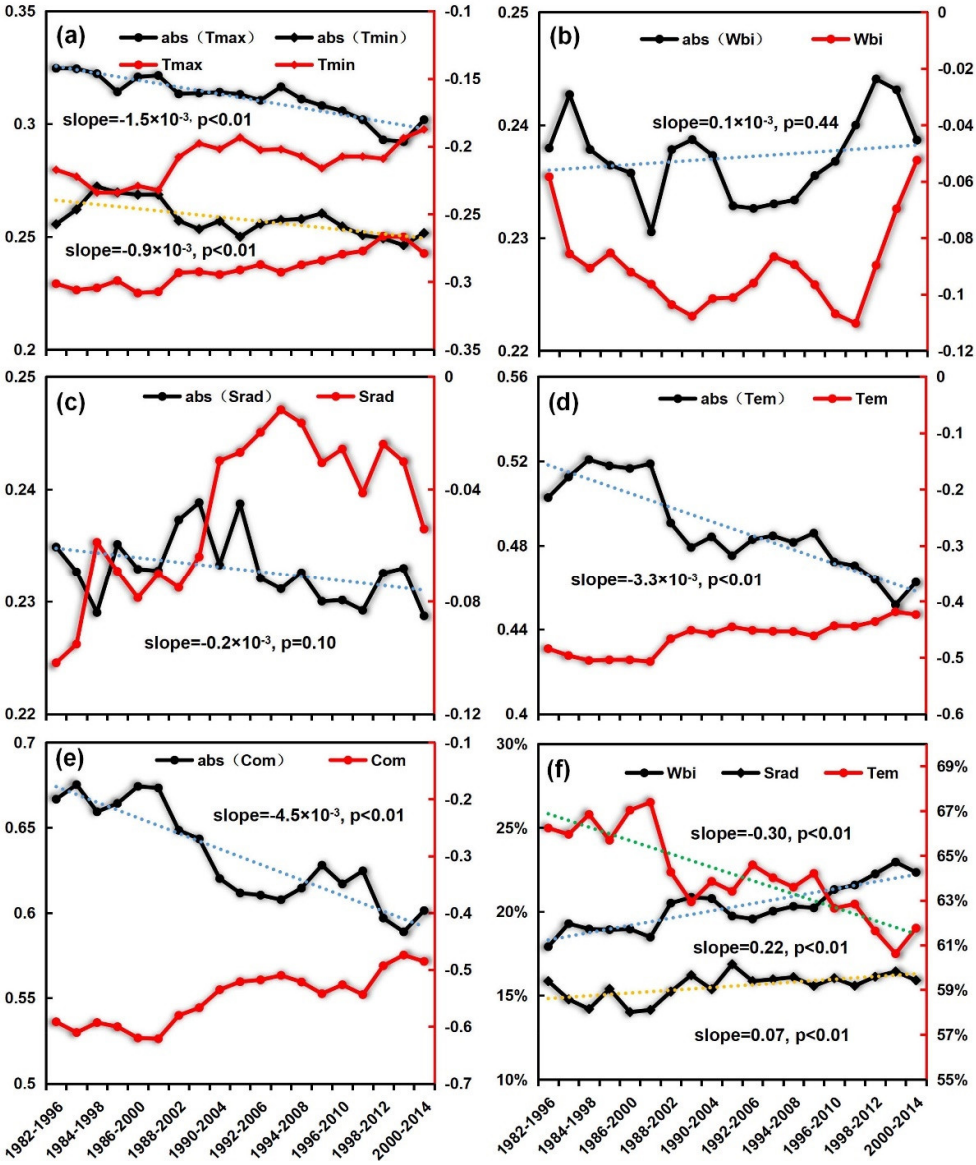

Figure S6. Temporal changes in SOS sensitivity to climate factors in the north (**a–e**) and the proportion of climate factors dominating sensitivity (**f**). The red and black lines indicate the median SOS sensitivity and the median absolute sensitivity for vegetation in the north (**a–e**), respectively. Trends in units of ' / a' (a-e) and '% / a' (**f**), respectively. There was a positive and negative split in the sensitivity of SOS to climate change in the Northern Hemisphere, so we counted the temporal variation in sensitivity by median of all pixels sensitivity and median of absolute value of sensitivity.

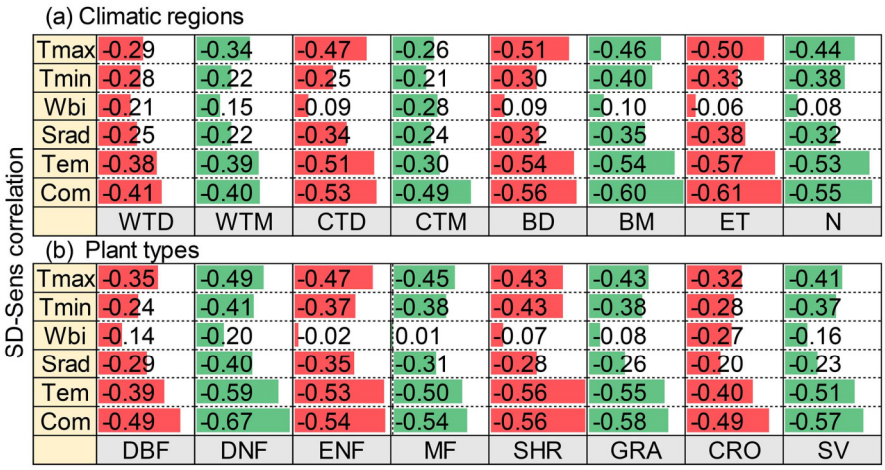

Figure S7. Correlation between the standardized sensitivity index and SD index in different climate regions (**a**) and plant types (**b**). All correlations were significant ($P < 0.05$).

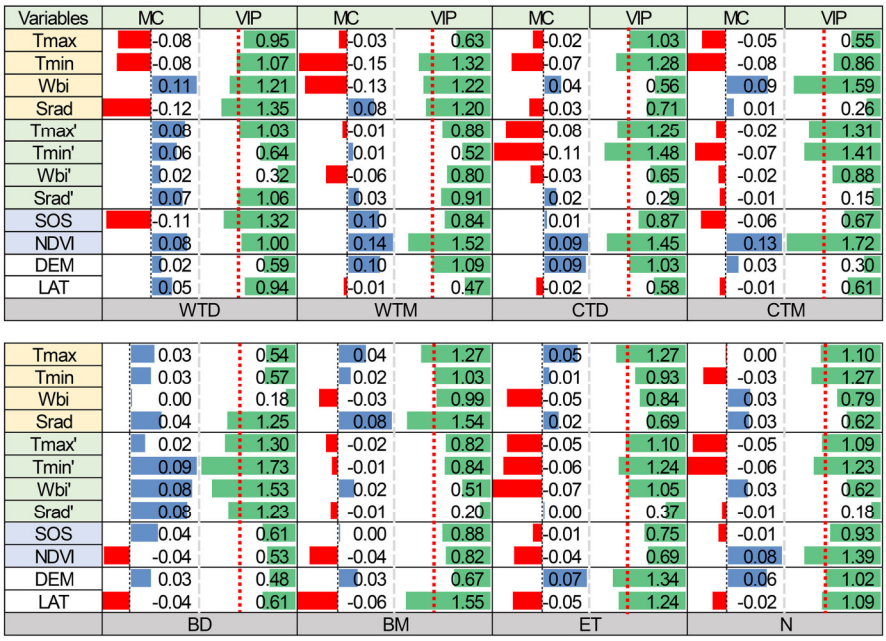

Figure S8. Driving force analysis of the spatial pattern of S_{Com} during 1982–2014 (on a 33–year time scale) in different climatic regions and the Northern Hemisphere based on PLSR. The red dotted lines indicate VIP = 1.

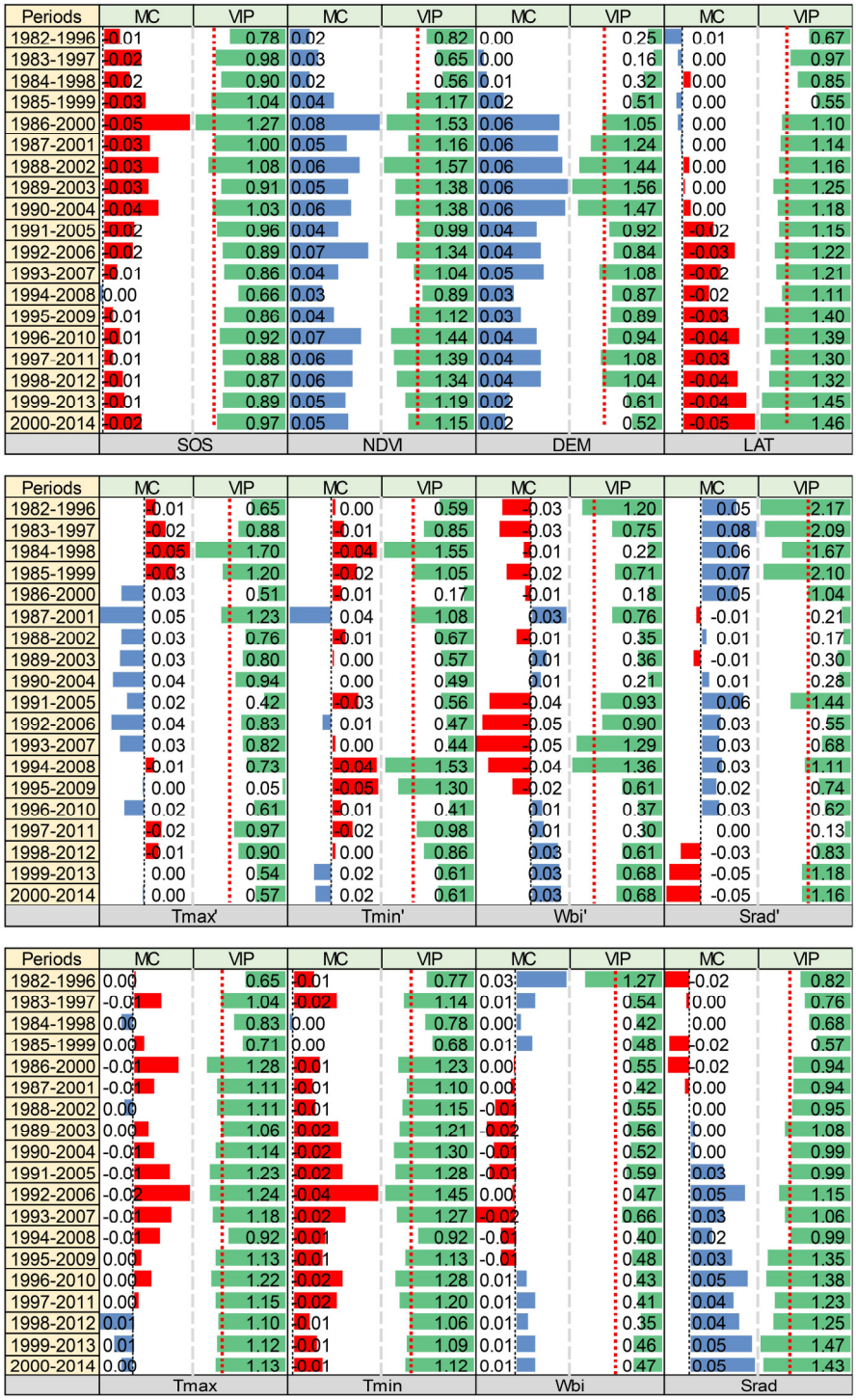

Figure S9. Changes in the influence of drivers on the spatial pattern of S_{Com} in the Northern Hemisphere during 1982–2014 (on a 15–year time scale). The red dotted lines indicate VIP = 1.

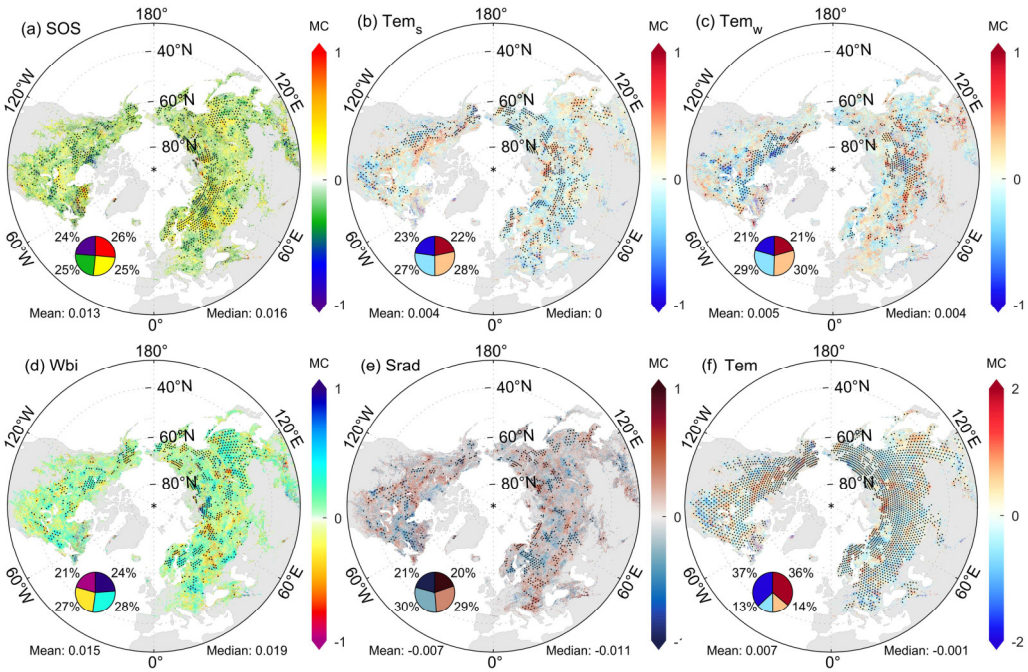

Figure S10. The spatial distribution of the driving forces influencing the temporal variability of S_{Com} in the Northern Hemisphere. Driving forces showed as the standardized model regression coefficient (MC) of Mean SOS (**a**), spring temperature (**b**), Winter temperatures (**c**), Cumulative water balance in winter and spring (**d**), Cumulative radiation in winter and spring (**e**). Tem (**f**) was the superposition of Tem_s and Tem_w. The dotted regions indicate significant influences of climatic or biological factors on S_{Com} (VIP ≥ 1). The four parts of the pie chart in a clockwise direction represent the proportion of pixels with significant positive, positive, negative, and significant negative sensitivity.

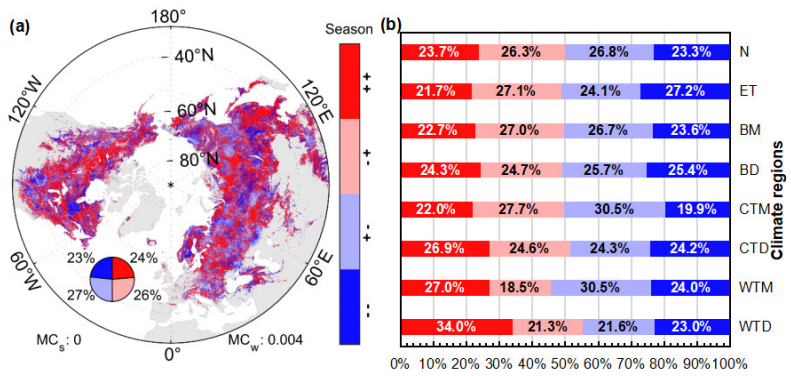

Figure S11. Effects of asymmetric warming in spring and winter on the temporal variation of S_{Com}: (**a**) is the spatial distribution of the positive and negative effects of average temperature in spring and winter on sensitivity, and (**b**) is the proportion of positive and negative pixels in each climatic region and the north. '+ +' indicates positive effects of both spring and winter; '+ -' indicates positive spring effects and negative winter effects; '- +' indicates negative spring effects and positive winter effects; and '- -' indicates negative effects of both spring and winter.