Author's response

The authors investigated the spatial-temporal changes in snow phenology using a high-resolution snow cover data. This study is very important for understanding the response of cryosphere to changing climate. Overall, the manuscript is well written and presented and I believe it is a good bit of work with a clear conclusion reached. I have two minor concerns:

Figure 10: First, I am not sure whether those trends with p>0.05 could still be used in such an analysis since a statistically in-significant trends are usually treated as "no change". Even we incorporate them, the controls of elevation on the SP seem to be valid only at certain elevation range. Taking Figure 10a as an example, while it is indeed clear that trends in SCP depends on elevation from ~5000 to 5800 m, the dependence becomes unclear from 50 to ~5000 m (At least I cannot see a clear pattern of "SCD decreased as elevation increased from 1200–5800 m" from 10a). The authors further stated that "At elevations above 5800 m, the elevation dependence was not significant", but Figure 10b yields a clear elevation dependence for SOD. Therefore, it may better to describe more details (e.g., the specific elevation range information) about the elevation dependence in Section 5.2. In addition, can any quantitative analysis (e.g., the correlation between the trend and elevation?) be added for such an analysis? I would say elevation dependence is true if the correlation is statically significant, otherwise not. Lastly, it would be also nice if you can tell the detailed rule of the elevation dependence, e.g., the changes in trend for every 100 m rise in elevation. By the way, for Figure 10 caption, I would suggest just using "Trends in SP……" as a start here. There is no need to say "interannual variation trend". Please revise this issue also in the main text.

Response: Thank you for the valuable suggestions, which have helped us signficiantly improve the manuscript. We agree that statistically insignificant trends are not suitable for further analysis between trends in SP and elevation. In this revision, we divided elevation into 50 m intervals, and the average trend values of statistically significant pixels ($p < 0.1$) were calculated for each elevation category. Then, we selected elevation categories with more than 50 samples to analyze the correlation between trends in SP and elevation (Figure 1).

Our finding reveals a strong negative correlation between trend in SCD and elevation, with a correlation coefficient of −0.73 (Figure 1a). This negative correlation was strongest in 0−4000 m and 4900−5900 m. A moderate positive correlation exists between the trend in SOD and elevation (R = 0.59), and this positive correlation was most significant in 4100−5800 m (Figure 1b). The correlation between SED and elevation was 0.33, which was not significant (Figure 1c). Therefore, we conclude that there exists a strong elevation dependence for the trend in SCD (R = −0.73), a moderate elevation dependence for the trend in SOD (R = 0.59), and no significant elevation dependence for the trend in SED (R = 0.33) from 2002 to 2022 on the TP.

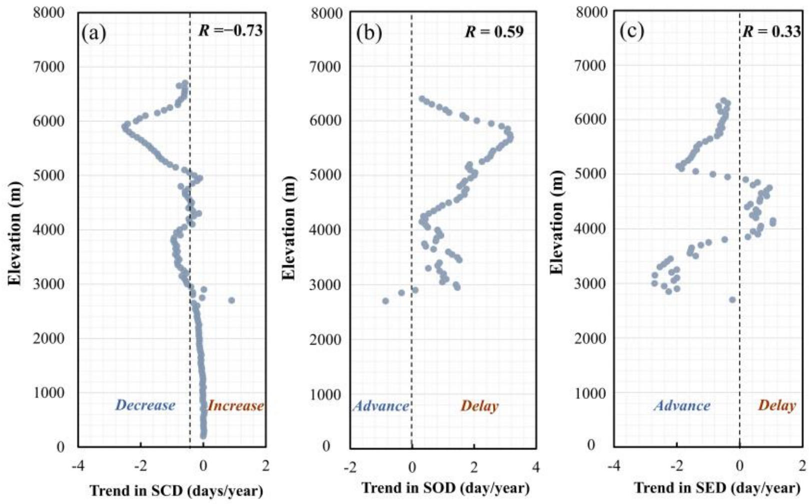

Figure 1: Scatter plot of elevation and trends in snow cover days (a), snow onset date (b), and snow end date (c) from 2002 to 2022.

The caption of Figure 10 has been changed as "Trends in SP……" , also for the main text. Related discussion has been added into *Discussion 5.2*:

To investigate the elevation effect, we divided elevation into 50 m intervals, and the average trend values of statistically significant pixels (p < 0.1) were calculated for each elevation category. Then, we selected elevation categories with more than 50 samples to analyze the correlation between trends in SP and elevation. Our finding reveals a strong negative correlation between trend in SCD and elevation, with a correlation coefficient of −0.73 (Figure 9a). This negative correlation was strongest in 0−4000 m and 4900−5900 m. A moderate positive correlation exists between the trend in SOD and elevation (R = 0.59), and this positive correlation was most significant in 4100−5800 m (Figure 9b). The correlation between SED and elevation was 0.33, which was not significant (Figure 9c). Therefore, there exists a strong elevation dependence for the trend in SCD (R = −0.73), a moderate elevation dependence for the trend in SOD (R = 0.59), and no significant elevation dependence for the trend in SED (R = 0.33) from 2002 to 2022.

Given a warming background, it is easy to understand why SOD delayed, but can you please explain why the SED delayed across most of TP (Line 233)?

Response: In this revision, we developed a structural equation model to explain the causes of the delayed trend in SED (Figure 2). The analysis shows that wind speed significantly influences delayed trend in SED, showing a strong positive correlation with a total effect of 0.497 (Figure 2). The delayed trend in SED becomes more pronounced as wind speed increases. This effect of wind speed on snow cover is mainly through blowing snow process, which lead to increased snow accumulation through snow redistribution and thus a delayed trend in SED regionally. Li et al. (2012) also found a distinct occurrence of blowing snow at an elevation of 4146 m, where pronounced redistribution of snow cover occurred.

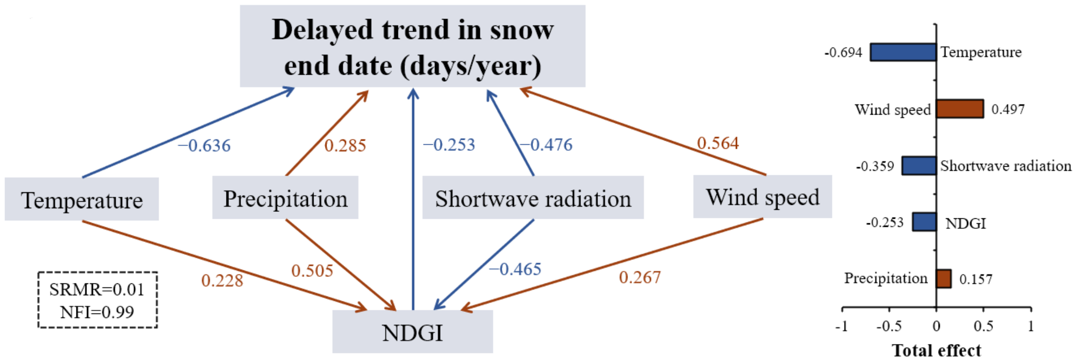

Figure 2: The structural equation model based on delayed trend in SED and influencing factors. Note: the red line implies a positive effect, while the blue line denotes a negative effect. All path coefficients are statistically significant ($p < 0.05$).

Therefore, we hypothesize that the delayed trend of SED may be due to the redistribution of snow cover caused by blowing snow. However, future studies are necessary to look into the distinctive impacts that blowing snow has on the processes of snow accumulation and subsequent melt. We have added the following content in *Discussion 5.2*:

The non-significant elevation dependence of SED is due to the competing effects of the delayed trend within 3800−4900 m elevation and the advanced trend of other elevation ranges (Figure 9c). To explain the counterintuitive delayed trend in the context of regional warming, we further applied a structural equation model to explore the causal relationships. The results indicate that wind speed significantly influences the delayed trend in SED, exhibiting a strong positive correlation with a total effect of 0.497 (Figure 9d). The delayed trend in SED becomes more pronounced as wind speed increases. This effect of wind speed on snow cover is mainly through blowing snow process, which lead to increased snow accumulation through snow redistribution and thus a delayed trend in SED regionally. Li et al. (2012) also found a distinct occurrence of blowing snow at an elevation of 4146 m, where pronounced redistribution of snow cover occurred.

References:

Li, H., Wang, J., Hao, X.: Influence of Blowing Snow on Snow Mass and Energy Exchanges in the Qilian Mountainous, Journal of Glaciology and Geocryology, 34(05),1084-1090, 2012. (in Chinese)