Appendix A

Supplementary materials

Decadal Trends and Drivers of Dust Emissions in East Asia: Integrating Statistical and SHAP-Based Interpretability Approaches

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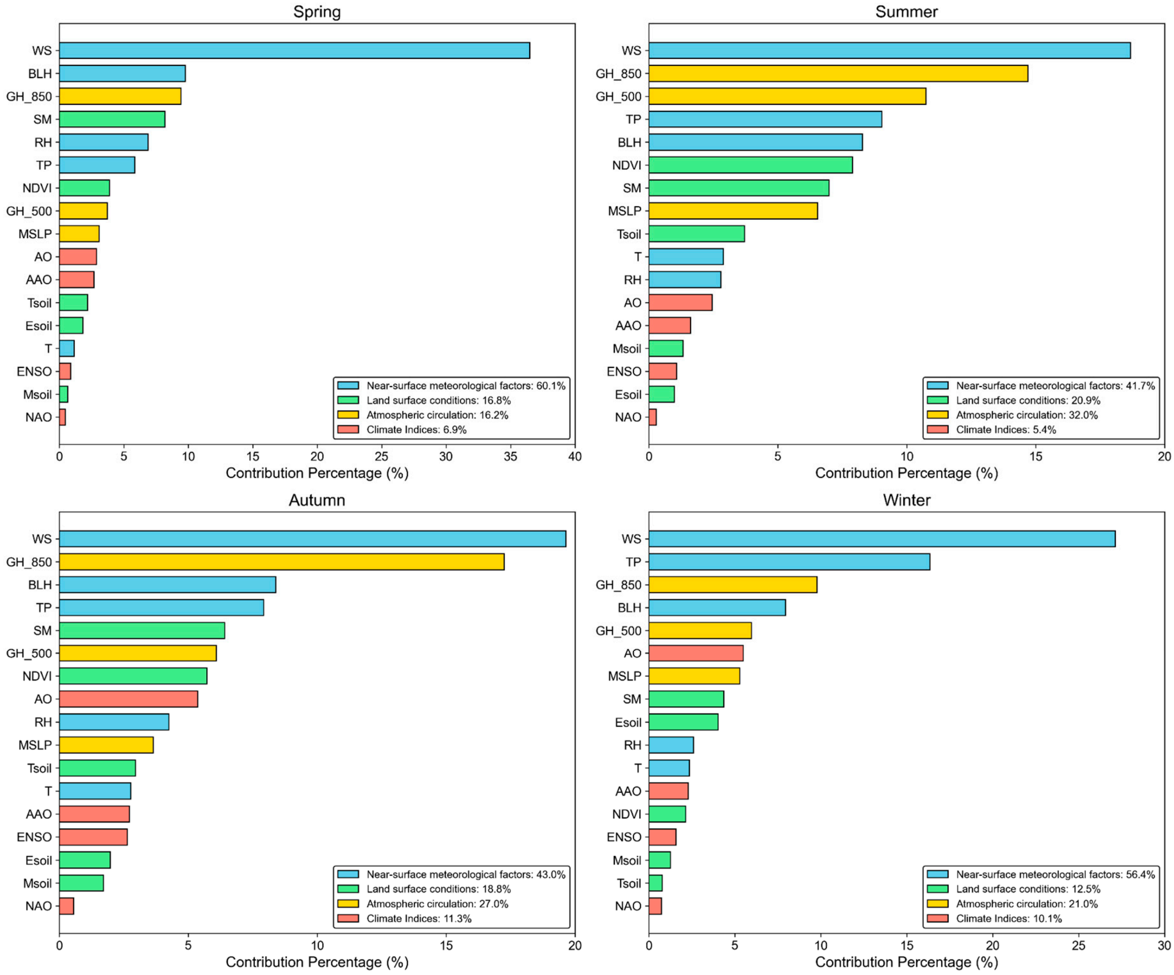

Figure S1: Seasonal feature contribution for dust emission in S1 region

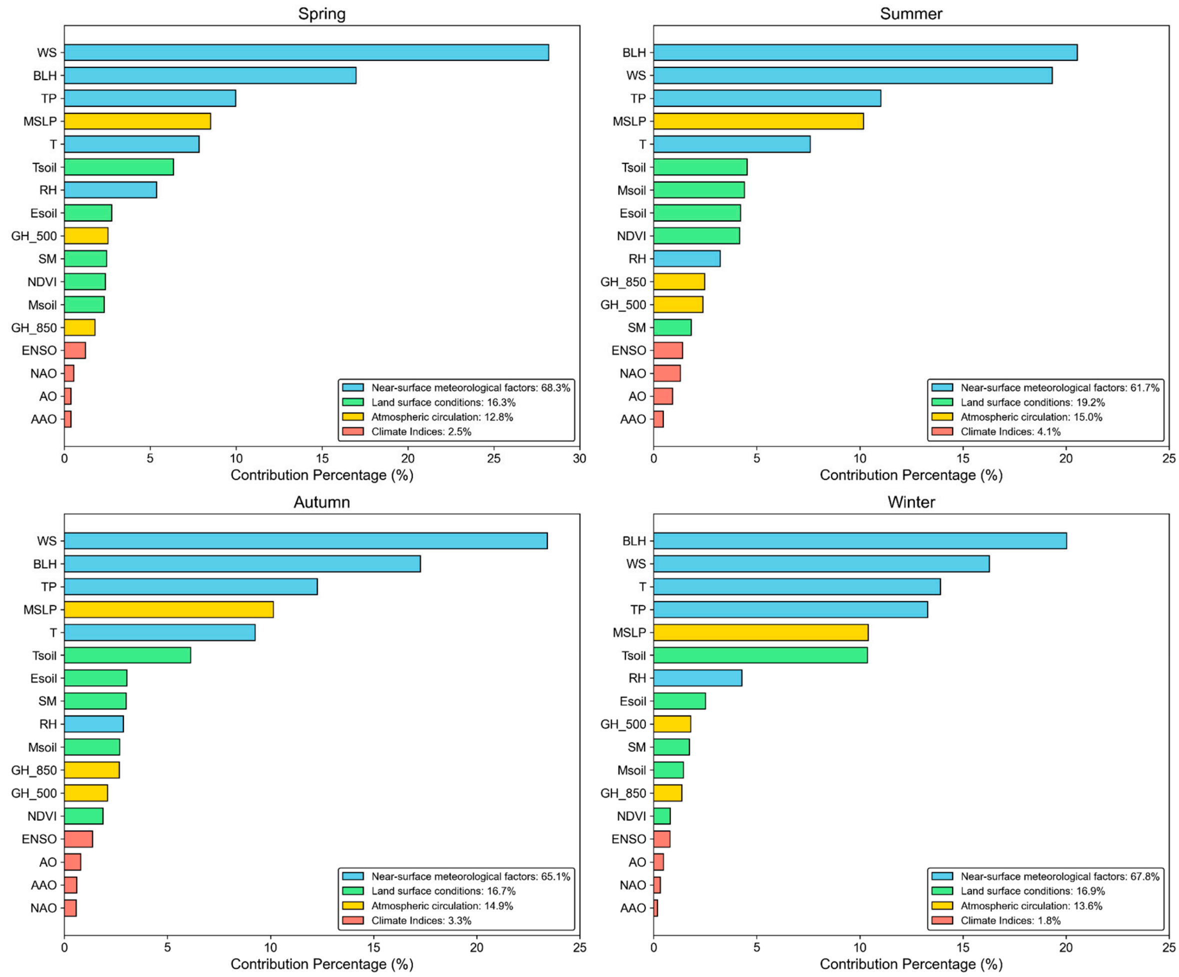

Figure S2: Seasonal feature contribution for dust emission in S4 region

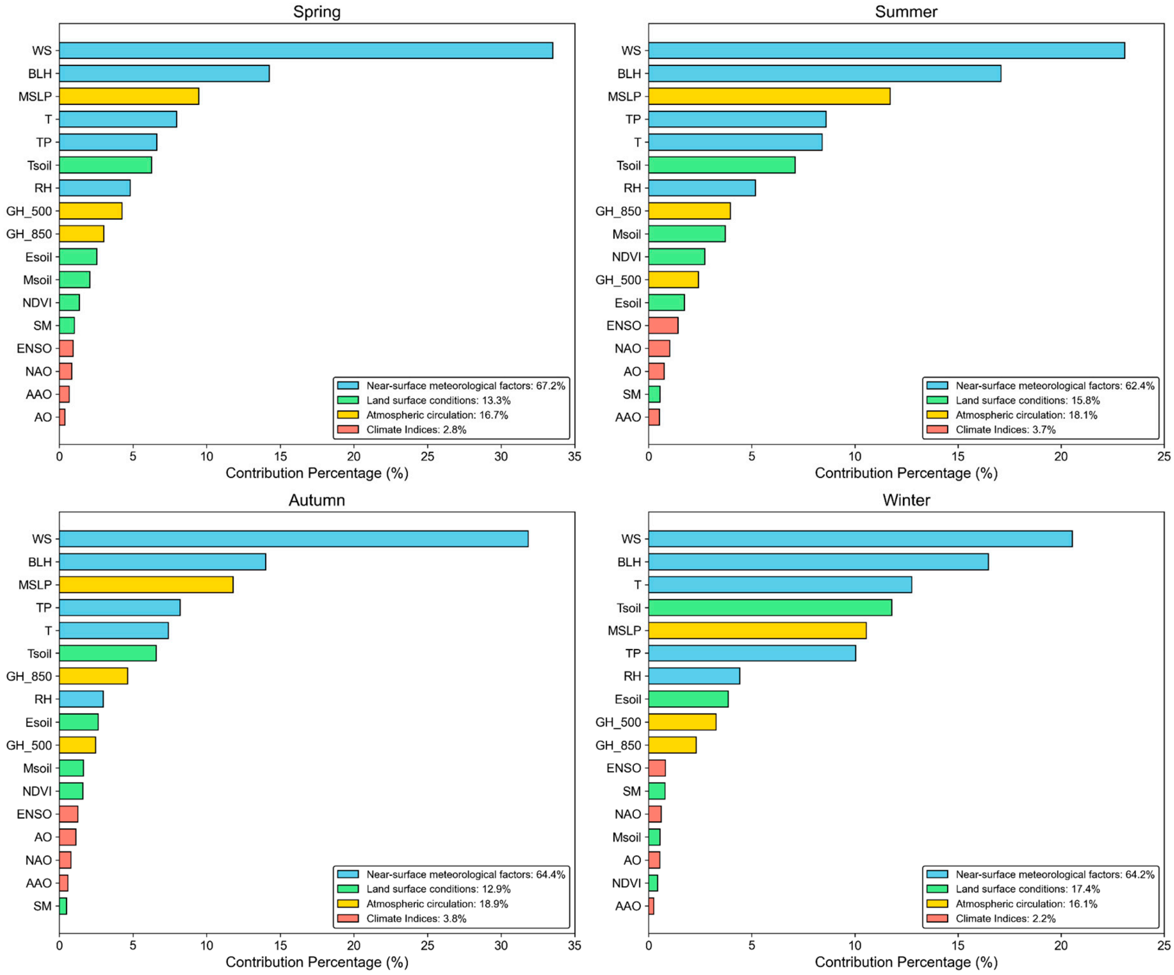

Figure S3: Seasonal feature contribution for dust emission in S5 region

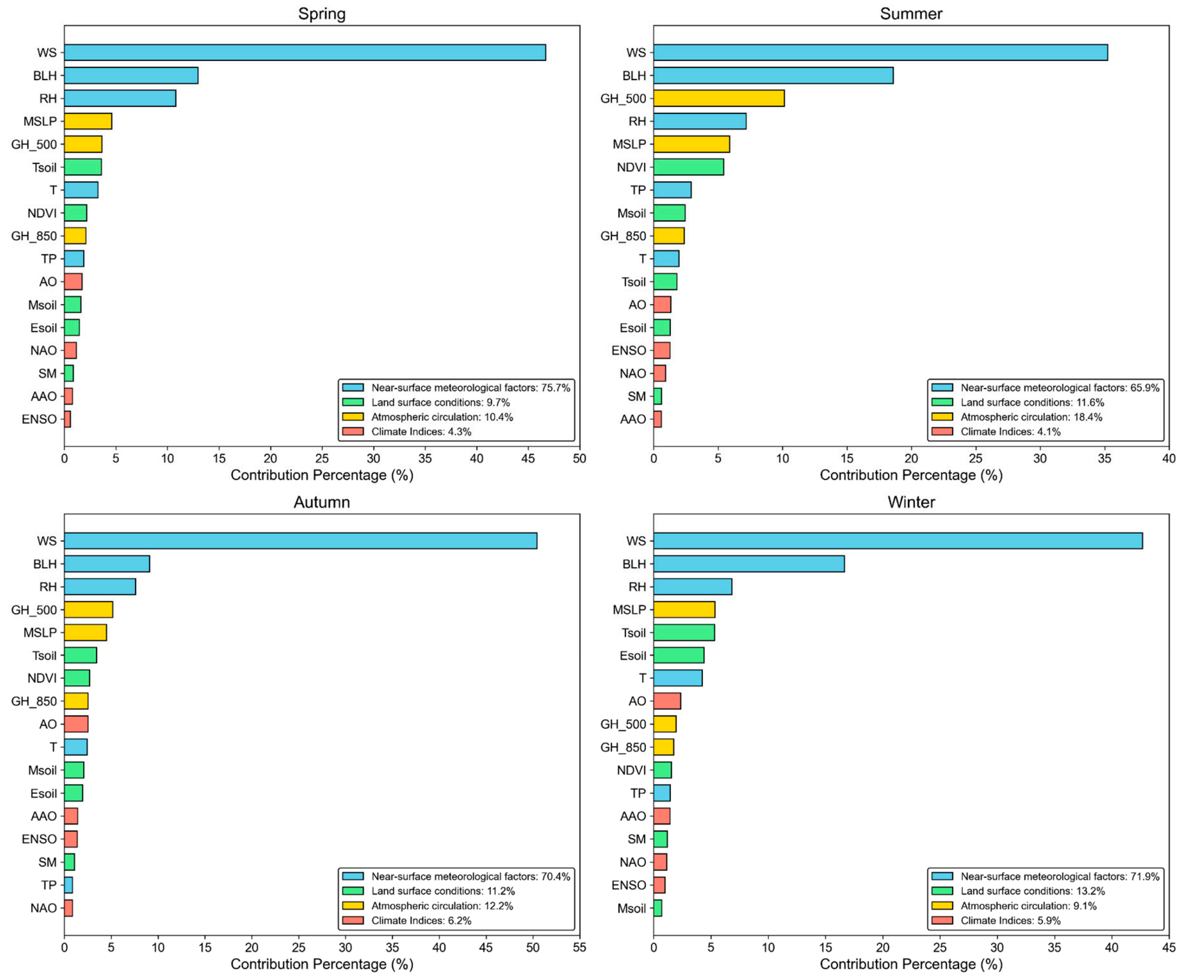

Figure S4: Seasonal feature contribution for dust emission in S6 region

Text S1. As shown in Figure S5, the impact of snowmelt on dust emissions varies significantly across different regions. The correlation is strongest in the S4 region (R = 0.719), indicating that snowmelt significantly promotes dust emissions. This may be due to the short-term increase in soil moisture following snowmelt, which is then followed by rapid evaporation that weakens the cohesion between soil particles, making the surface more susceptible to wind erosion. In the S1 region, although the correlation (R = 0.527) is higher than that in the S5 region (R = 0.508), the underlying mechanisms may differ. The S1 region may experience a certain amount of snowmelt, but due to surface conditions or other environmental factors, the promoting effect of snowmelt on dust emissions may not be fully realized. In contrast, the slightly lower correlation in the S5 region may be attributed to smaller amounts of snowmelt and more stable soil structures, which limit the influence of snowmelt on dust emissions. The correlation is weakest in the S6 region (R = 0.211), suggesting that the regulatory effect of snowmelt on dust emissions is minimal and may be overshadowed by other dominant factors.

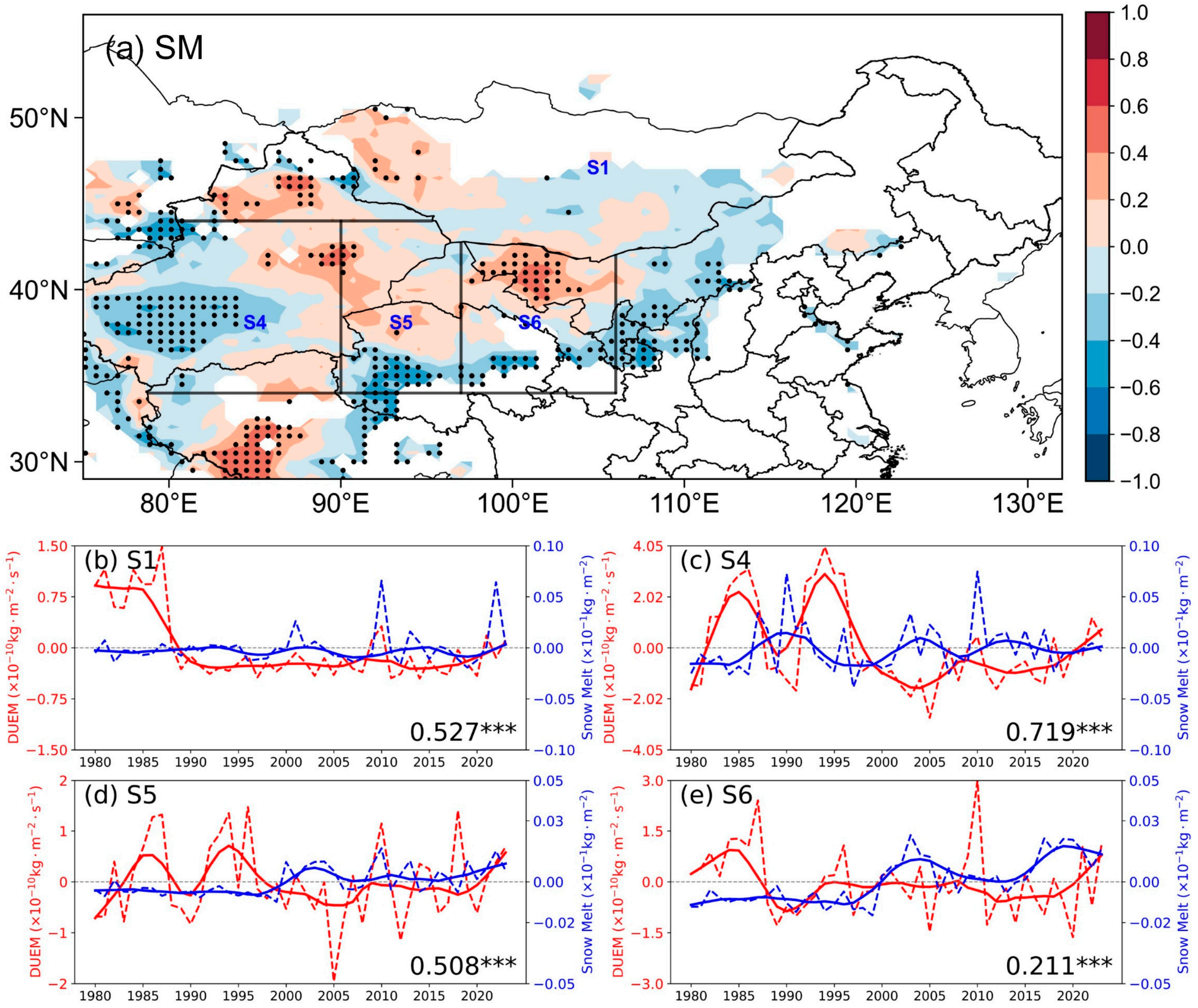

Figure S5. (a) Spatial distribution of correlation coefficients between snow melt. and dust emission from 1980 to 2023. (b)-(e) Interannual variations of dust emission (red lines) and soil temperature (blue lines) in regions S1, S4, S5, and S6, respectively. The solid lines represent LOWESS trends. Correlation coefficients are shown in the upper right corners of panels (b)-(e); *** indicates sig-nificance at the 99% confidence level. Dotted regions in (a) represent correlations significant at the 95% confidence level.

Text S2. From the analysis of interannual variation (Figure S6), dust emissions in S1 are primarily influenced by GH_500, showing the strongest negative correlation (R = −0.522), indicating that cold air activity is the main driving factor for dust emission in this area. However, in S4 and S6, the influence of GH_500 is weaker, further demonstrating the limited regulatory effect of mid-level circulation on these regions. In contrast, GH_850 exhibits more significant correlations across multiple regions, such as in S4 and S5, with correlation coefficients of −0.604 and −0.629, respectively. This indicates that lower-level circulation, through enhanced wind speed and cold air activity, significantly drives dust emissions. In S1, the correlation with GH_850 is also notable (R = −0.470), though weaker than that with GH_500, still highlighting the impact of lower-level circulation on dust emission in this region. Additionally, MSLP shows the most significant negative correlation with DUEM in S4 and S5, indicating that surface cyclone activity is a key factor in dust emission in these areas. In contrast, the influence of MSLP is weaker in S1 and S6, possibly due to local wind fields, mid-level circulation, or topographic effects.

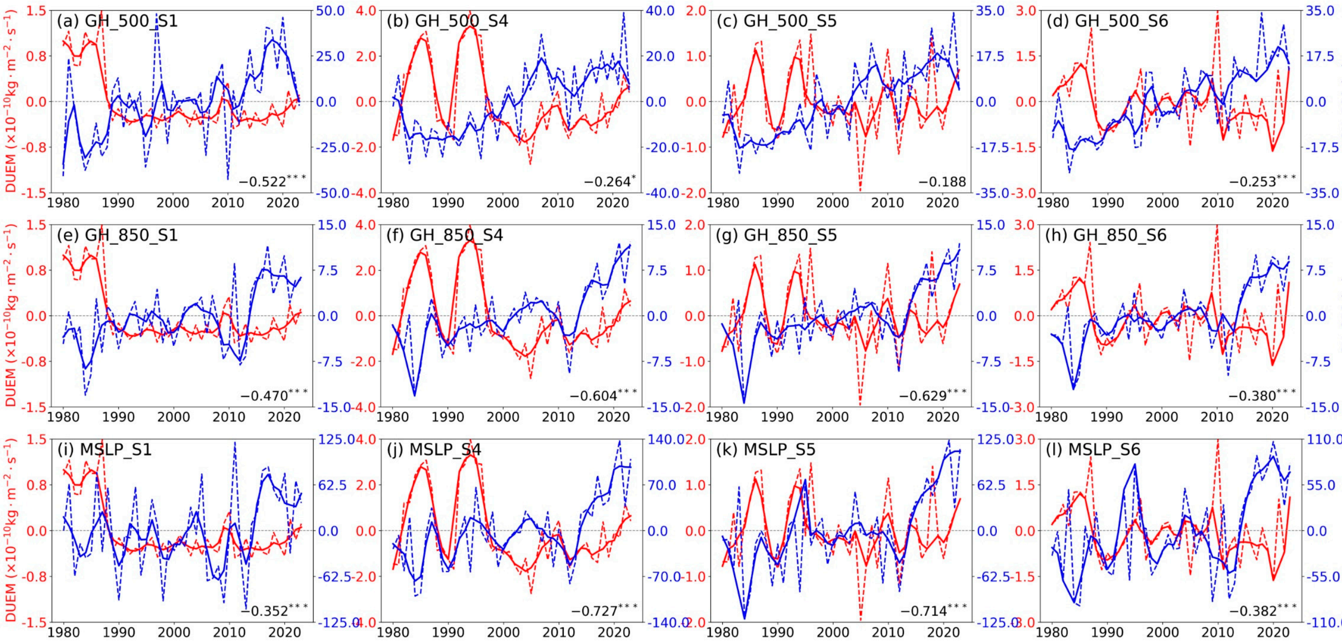

Figure S6**.** Interannual variation between atmospheric circulation factors at different heights (GH_500, GH_850, and MSLP) and dust emission anomalies. The solid lines represent LOWESS trends. Correlation coefficients are shown in the upper right corners of panels; *** indicates significance at the 99% confidence level.