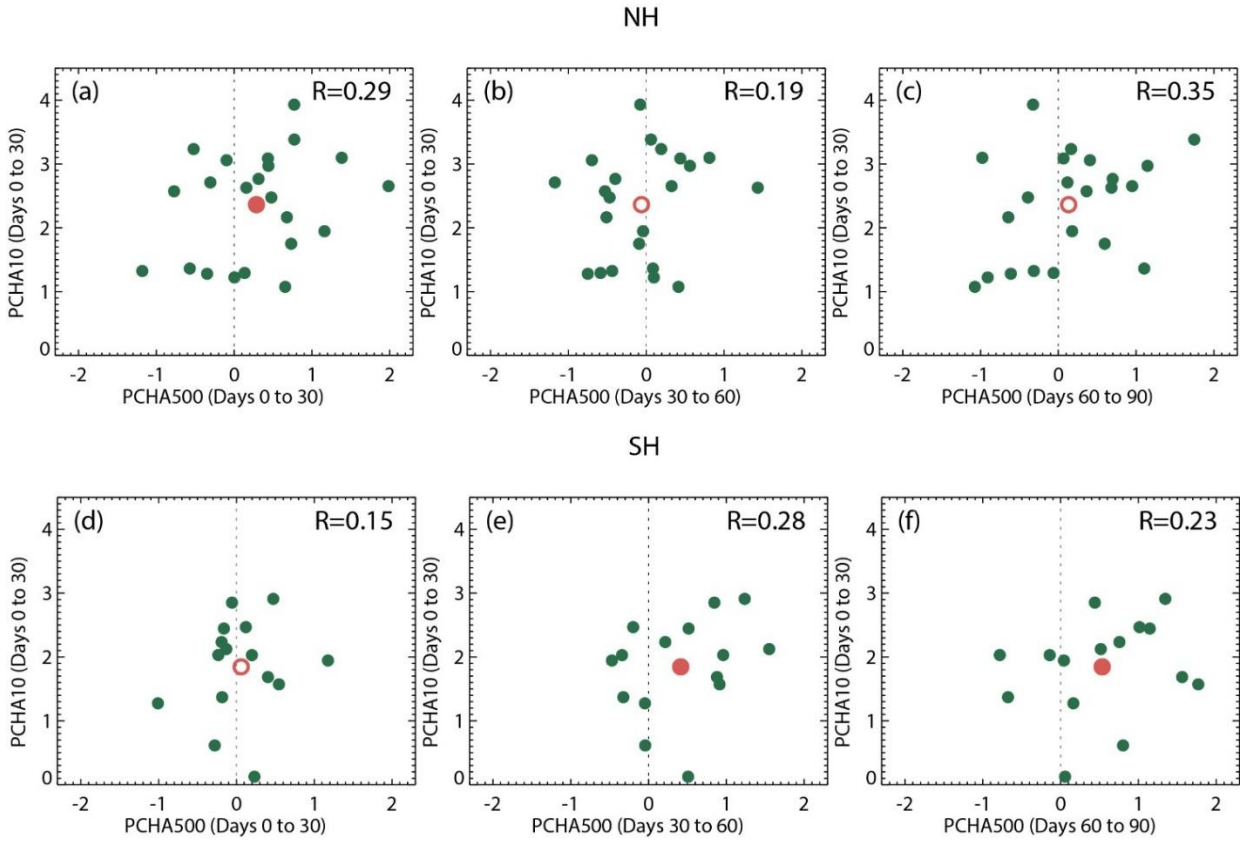
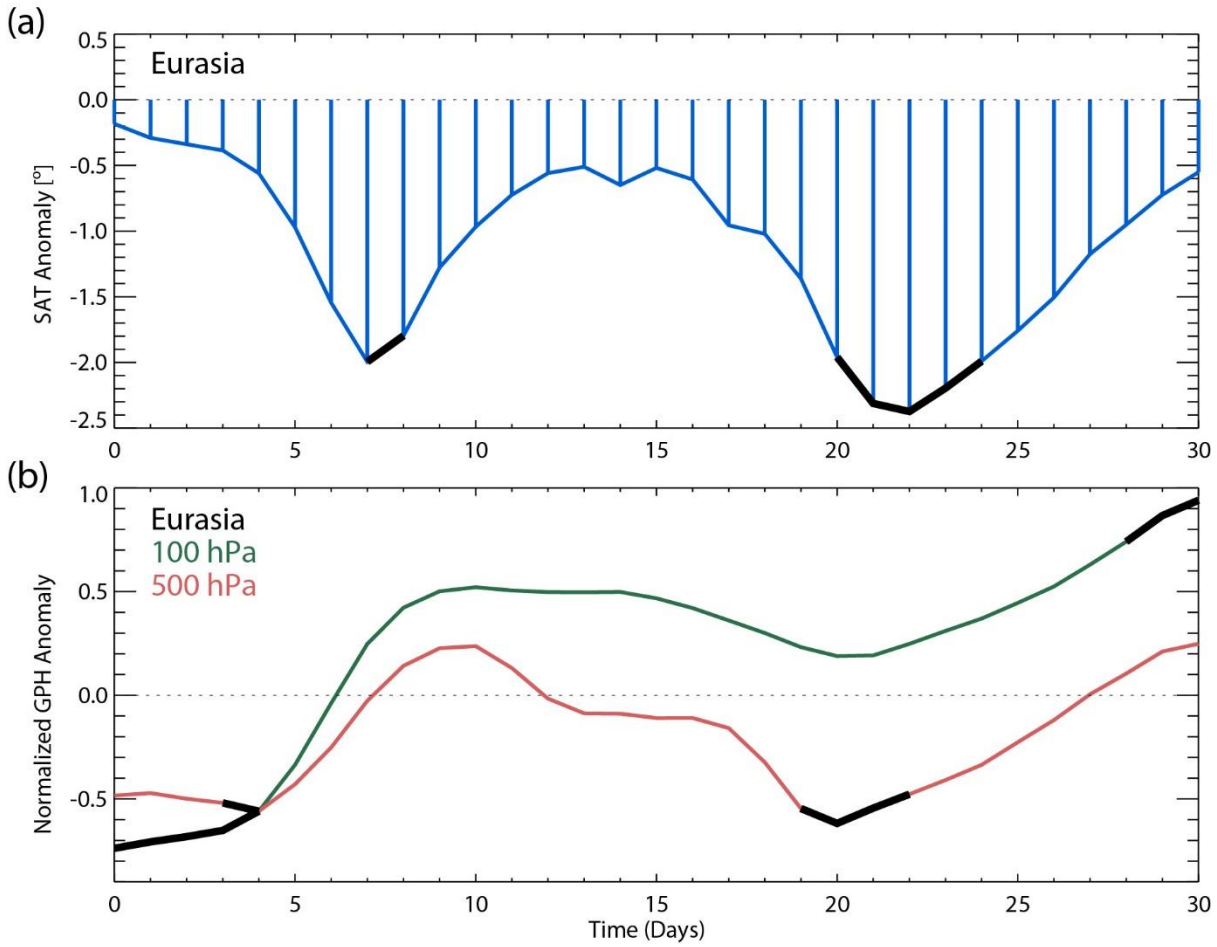
Supplementary material for: Kim S.-J. & Choi H. 2024. Polar vortex weakening and its impact on surface temperature in recent decades. *Polar Research 43*. Correspondence: Hyesun Choi, Division of Atmospheric Sciences, Korea Polar Research Institute, 26 Songdomirae-ro, Yeonsu-gu, Incheon, 21990, Republic of Korea. E-mail: hschoi@kopri.re.kr

Abbreviations

GPH: geopotential height
NH: Northern Hemisphere
PCH: polar cap height
SAT: surface air temperature
SCE: snow cover extent
SH: Southern Hemisphere
SPV: stratospheric polar vortex
SPVI: stratospheric polar vortex index
SSW: sudden stratospheric warming event



Supplementary Fig. S1. Scatterplots of PCH anomalies at 10 hPa (PCHA10) averaged over days 0 to 30 and PCH anomalies at 500 hPa (PCHA500) averaged over three different periods after the onset date of SPV weakening events in the (a-c) NH and (d-f) SH. The mean PCHA10 and mean PCHA500 are indicated by a pink circle in each panel. A pink dot (filled circle) represents that the mean PCHA500 is statistically significant from zero at the 95% confidence level. Results are shown for (a, d) days 0 to 30, (b, e) days 30 to 60, and (c, f) days 60 to 90. A correlation coefficient (R) between the PCHA10 and PCHA500 is shown in the upper corner of each panel.



Supplementary Fig. S2. (a) Time series of the SAT anomaly averaged over Eurasia region (45°E–135°E, 55°N–75°N) from days 0 to 30. (b) Same as (a) but showing the GPH anomaly at 100 hPa (green) and 500 hPa (red). The thick black segments of the lines indicate statistically significant periods from a zero at the 95% confidence level. The normalized GPH anomaly of 1 refers to the standard deviation of the GPH anomaly for the entire analysis period at each altitude, which is about 97.73 m at 100 hPa and about 64.71 m at 500 hPa, respectively.

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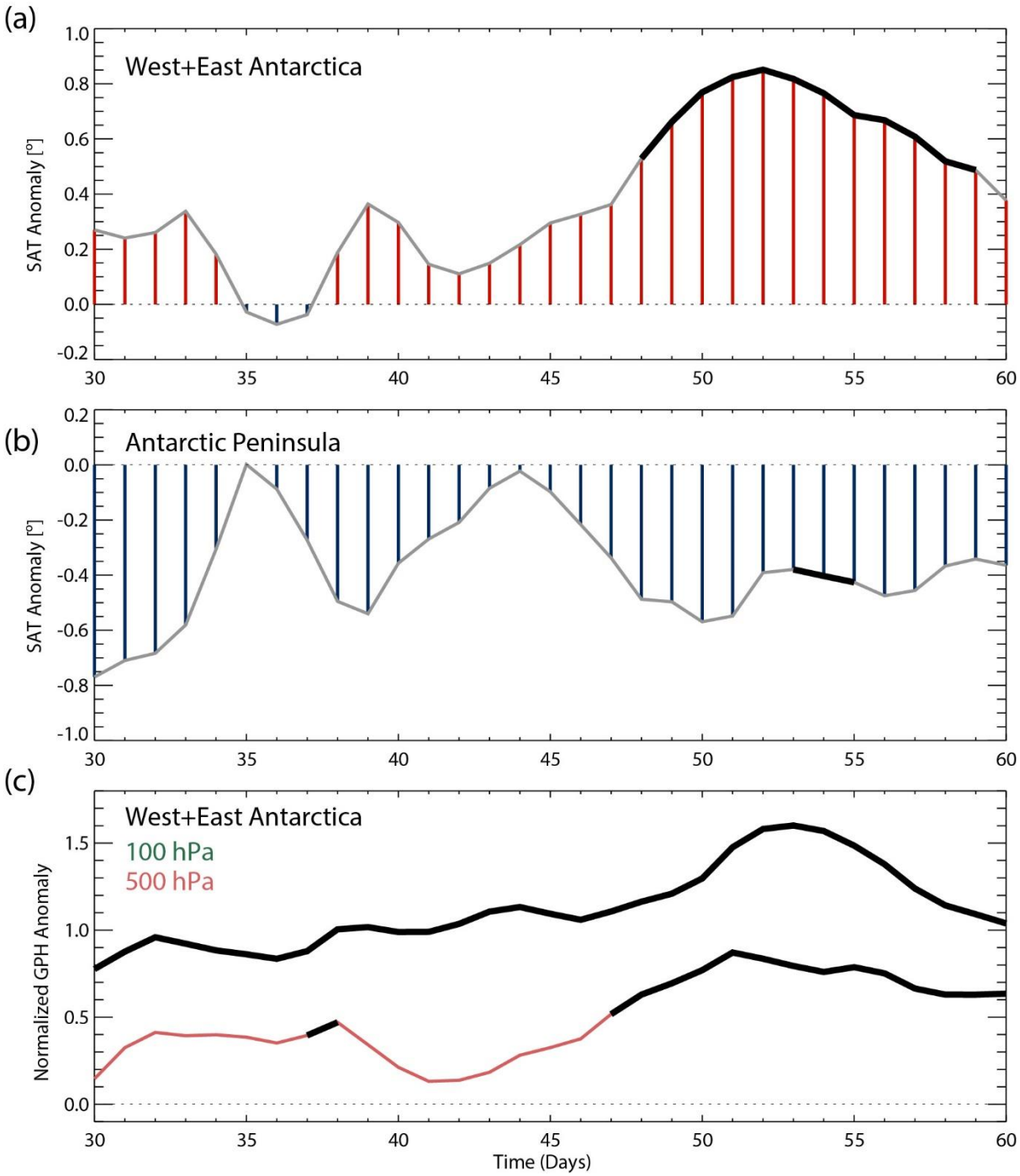

Supplementary Fig. S3. (a) Same as Supplementary Fig. S2 but showing the western and eastern Antarctic sectors (0°E–270°E, 55S°S–90°S) from days 30 to 60. (b) Same as (a) but showing the Antarctic Peninsula (270°E–315°E, 50°S–80°S). (c) Same as (a) but showing the GPH anomaly averaged over West and East Antarctica at 100 hPa (green) and 500 hPa (red). The standard deviation of the West and East Antarctic GPH anomaly is about 83.67 m at 100 hPa and about 49.06 m at 500 hPa, respectively.

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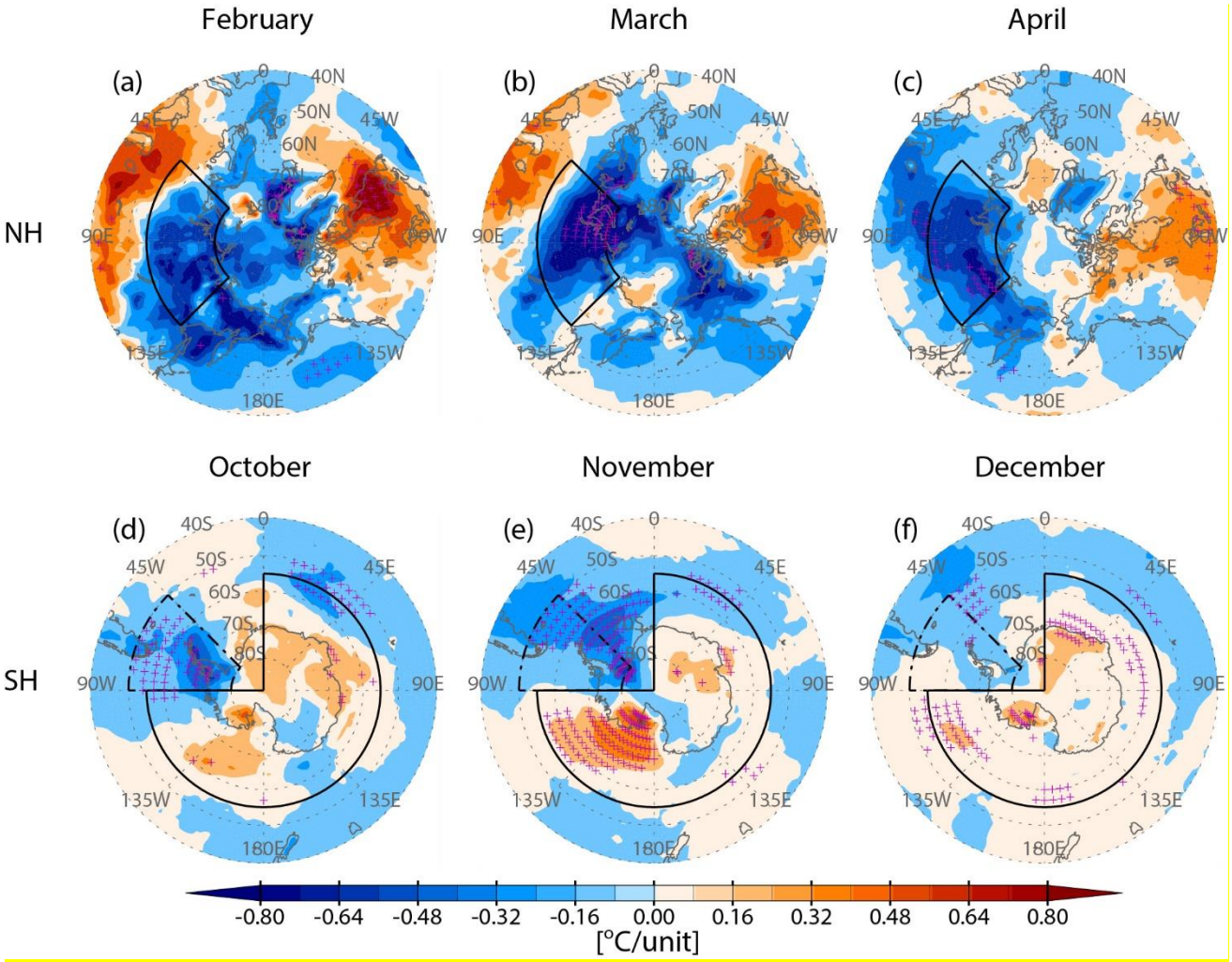

Supplementary Fig. S4. Spatial distributions of linear regression coefficient between the SAT anomaly in three calendar months and (a-c) the NH SPVI and (d-f) SH SPVI. SPVI was defined as the average of the PCH anomaly at 10 hPa (PCHA10) in February in the NH and October in the SH. The results are shown for (a-c) February, March, April in the NH and (d-f) October, November, December in the SH. Pink crosses indicate significant values at the 95% confidence level. Linear trends in the SAT anomaly and SPVI in each hemisphere are removed before the calculation. Black solid boxes in (a-c) mark the Eurasia region (45°E–135°E, 55°N–75°N), while black dashed-dotted and black solid boxes in (d-f) indicate the Antarctic Peninsula region (270°E-315°E, 50°S-80°S) and the rest of Antarctica (0°E-270°E, 55°S-90°S), respectively.

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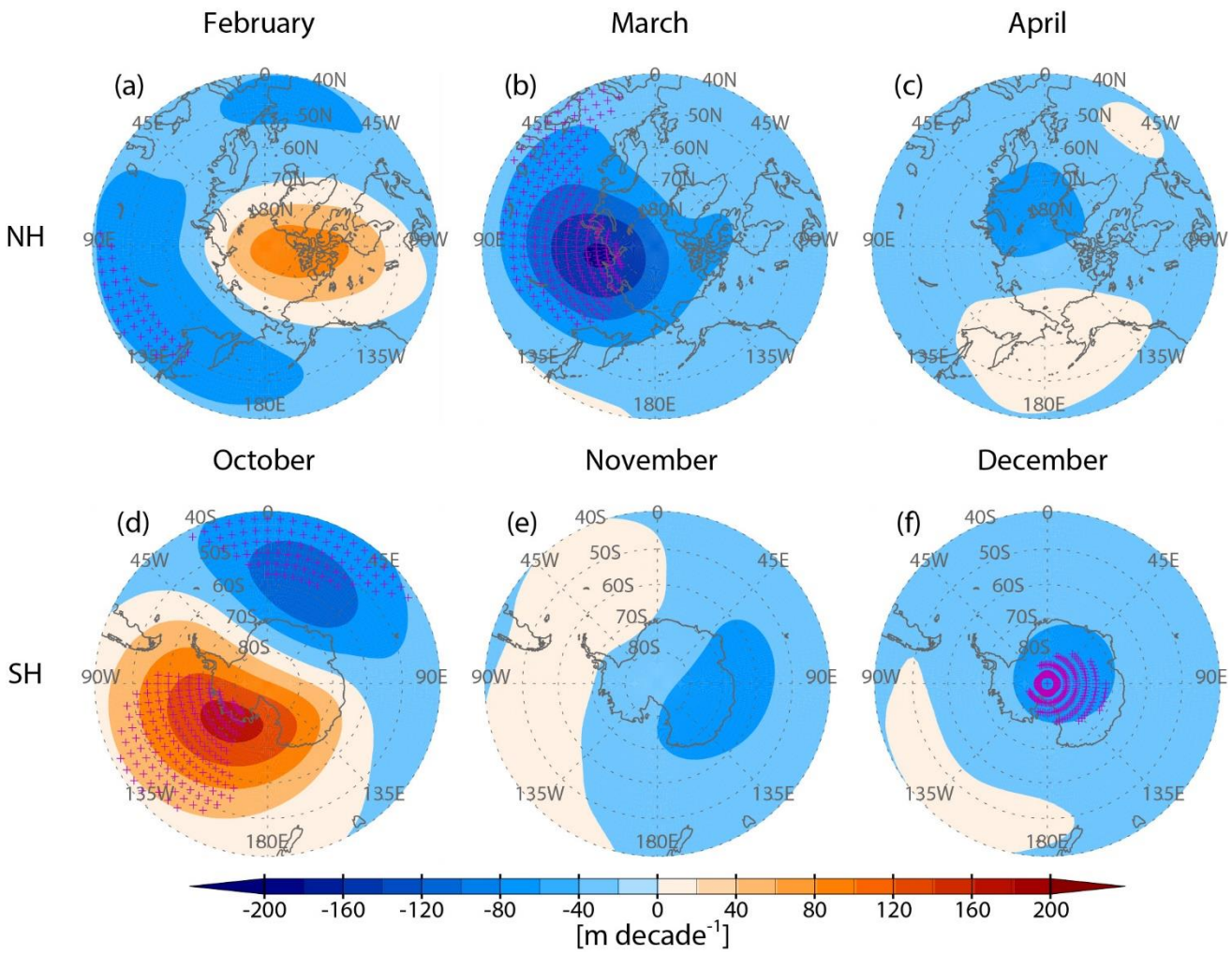

Supplementary Fig. S5. Spatial distributions of the monthly GPH anomaly trend during the 1979-2017. (a-c) February, March, April in the NH and (d-f) October, November, December in the SH. Pink crosses indicate significant values at the 95% confidence level.

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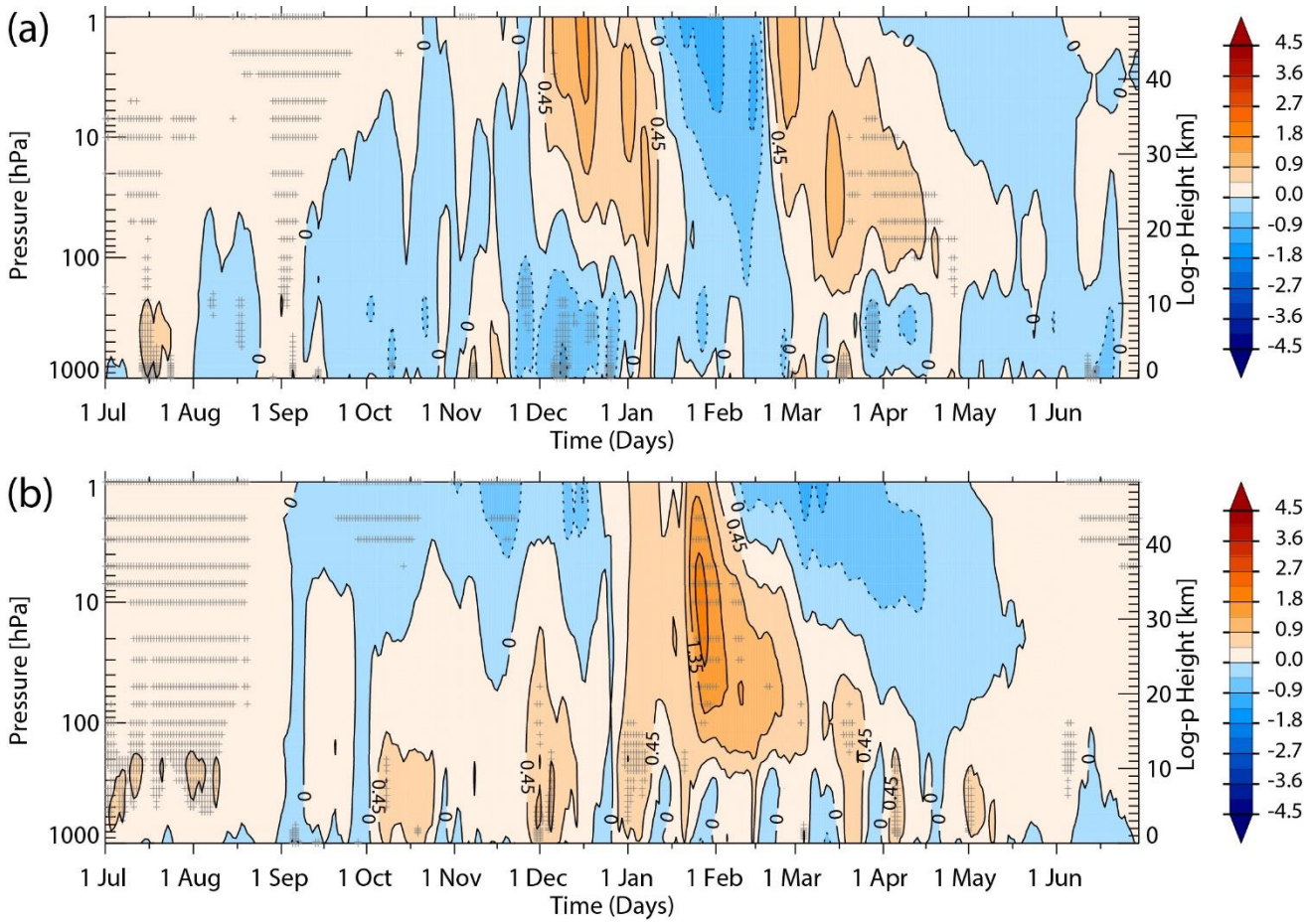

Supplementary Fig. S6. Composite of the NH PCH anomaly based on 1 July in years corresponding to NH SPV weakening events that occurred (a) before 2000 and (b) after 2000. Eleven events before 2000 and 11 events after 2000 were used (Table 1). Grey crosses indicate statistically significant regions at the 95% confidence level.

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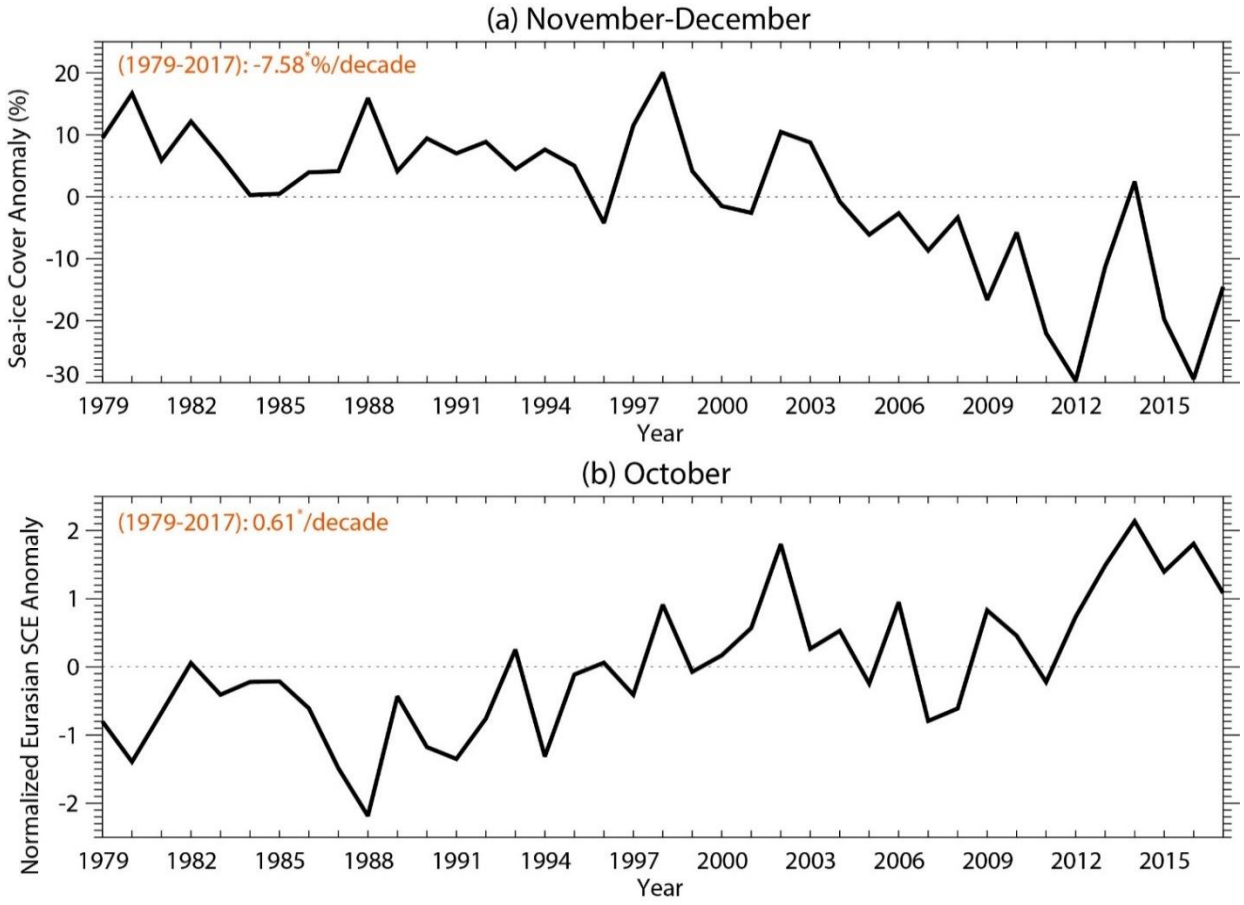
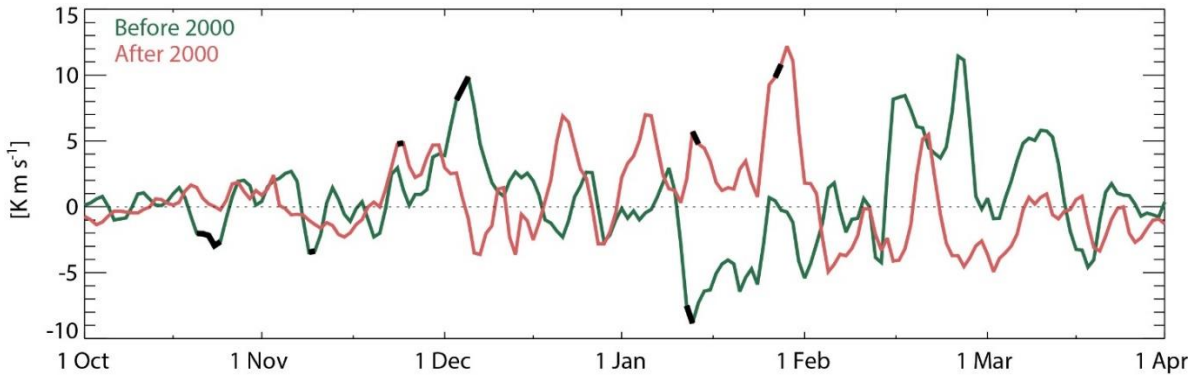


Supplementary Fig. S7. Time series of (a) November–December sea-ice cover anomaly and (b) October SCE anomaly over the Eurasian region. An asterisk marked at the top right of the trend value indicates a significant value at the 95% confidence level.



Supplementary Fig. S8. Anomalies of the meridional eddy heat flux averaged over 45°N–75°N at 100 hPa before (green) and after (red) 2000. The thick black segments of each line indicate that the heat flux anomaly is significant at the 95% confidence level from zero.

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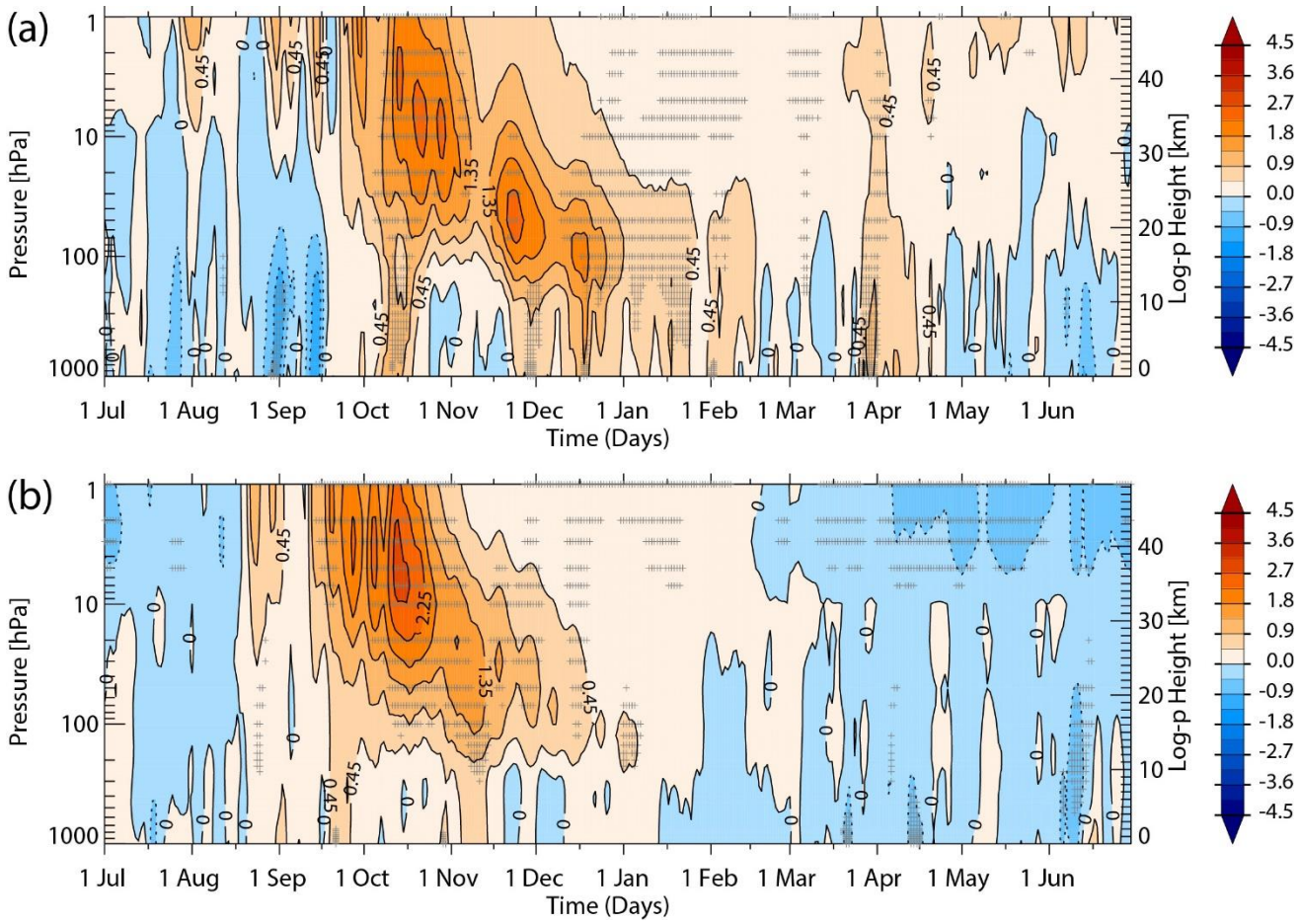
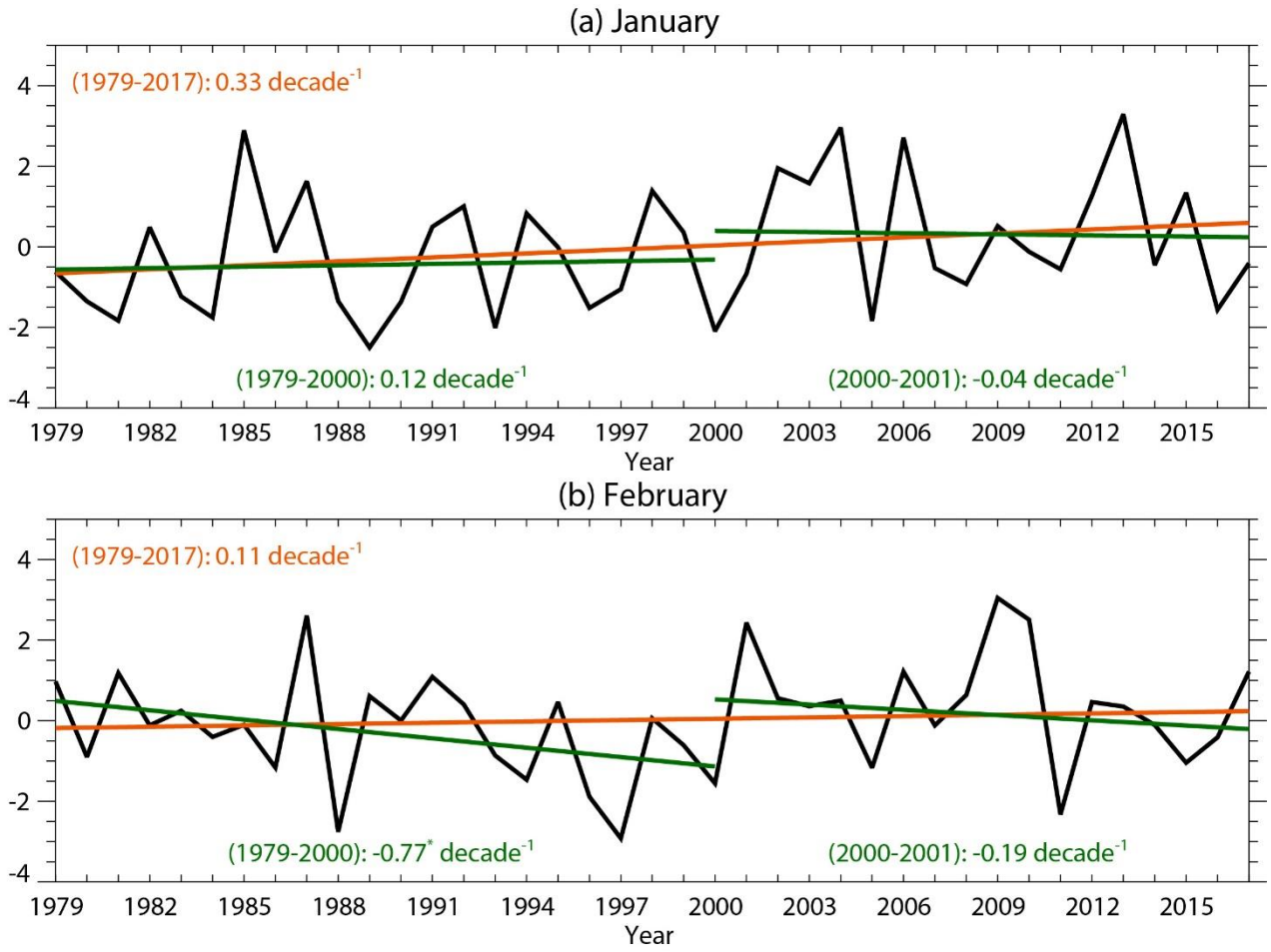
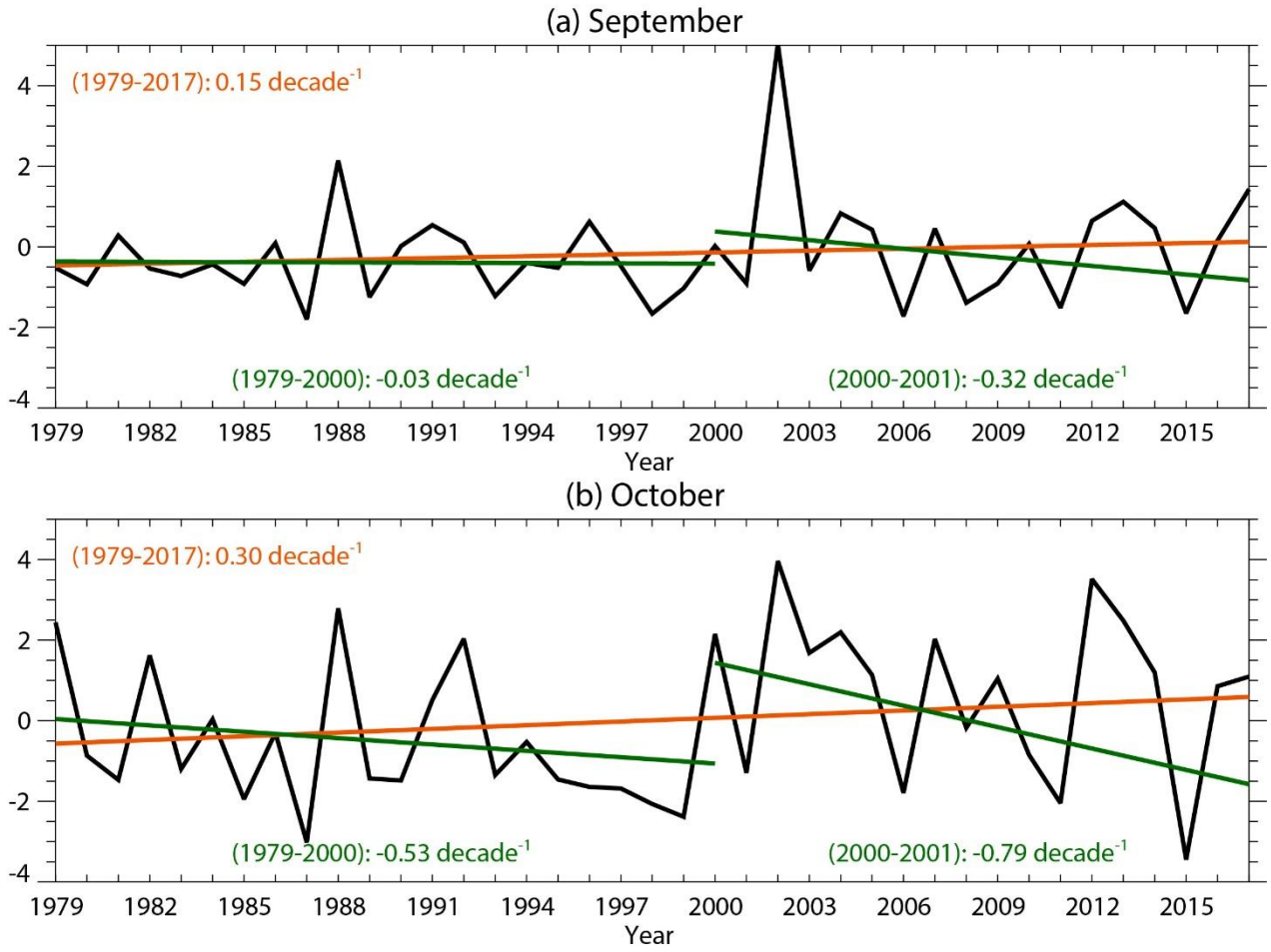


Supplementary Fig. S9. Same as Supplementary Fig. S6, but showing the SH PCH anomaly based on 1 July in years corresponding to SH SPV weakening events. Five events before 2000 and 10 events after 2000 were used (Table 1).



Supplementary Fig. S10. Time series of NH PCH anomaly at 10 hPa (PCHA10) in (a) January and (b) February. Linear trends for the entire analysis period (1979–2017) are shown in orange and the piecewise linear trends before and after 2000 are shown in green. In (b), an asterisk at the top right of the trend value before 2000 indicates a significant value at the 90% confidence level.



Supplementary Fig. S11. Time series of SH PCH anomaly at 10 hPa (PCHA10) in (a) September and (b) October. Linear trends for the entire analysis period (1979–2017) are shown in orange and the piecewise linear trends before and after 2000 are shown in green.

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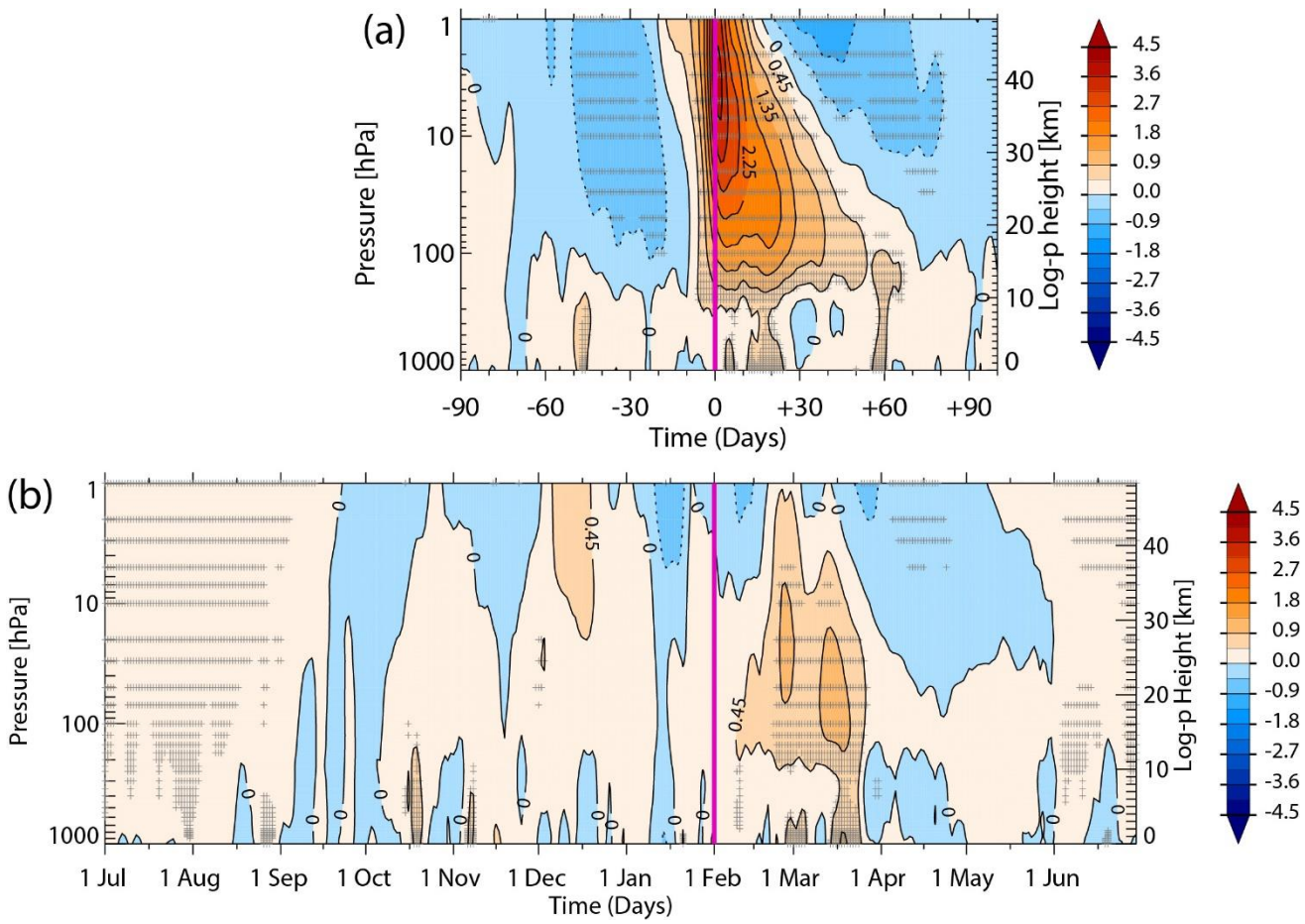

Supplementary Fig. S12. (a) Composite of PCH anomalies based on the onset date for SSWs in the NH identified using the wind reversal method. (b) Same as (a) but based on 1 July of years corresponding to SSWs. Grey crosses indicate statistically significant regions at the 95% confidence level. The pink vertical line indicates the onset date (day 0) in (a) and mean onset date (1 February) in (b).

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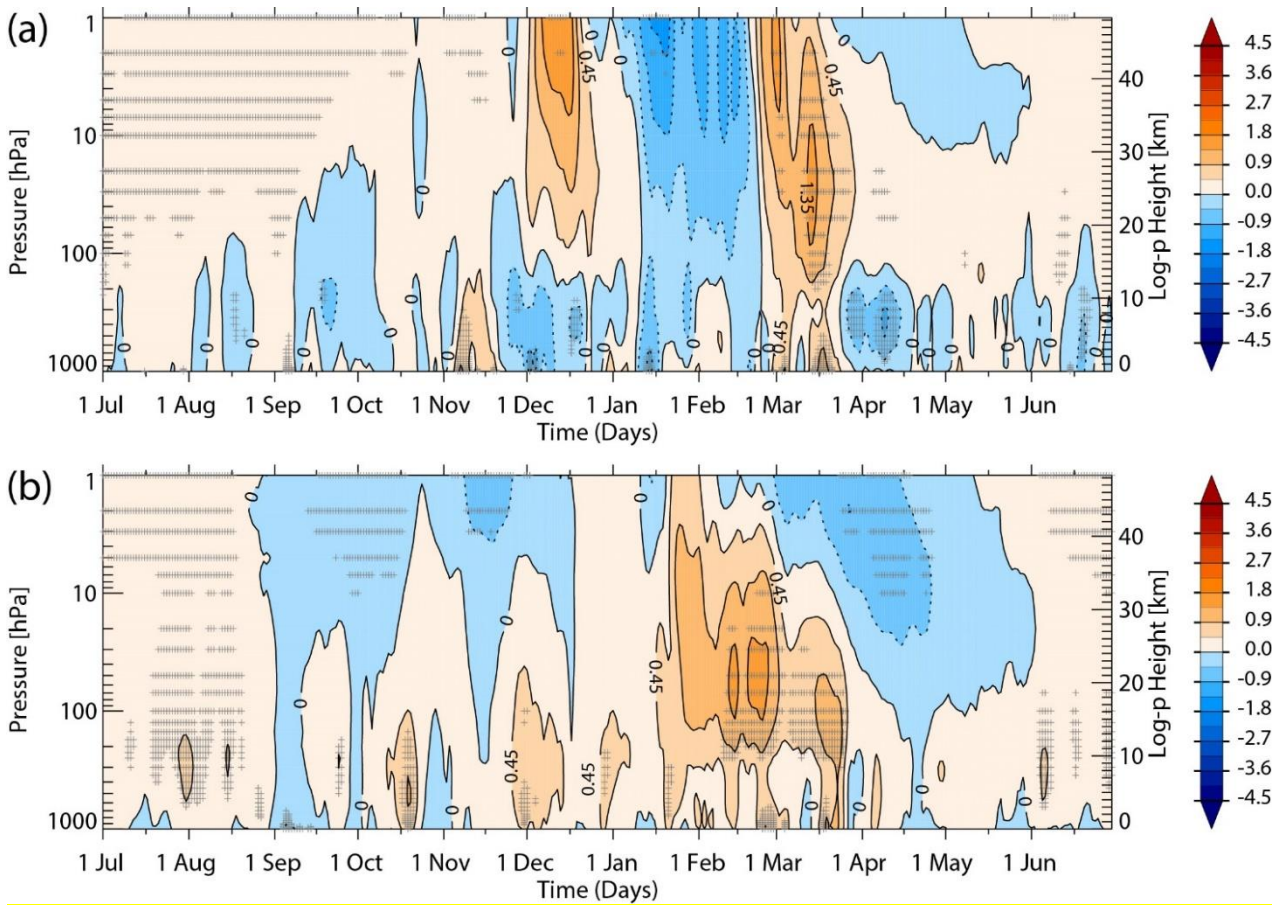

Supplementary Fig. S13. Composite of the NH PCH anomaly based on 1 July in years corresponding to NH SSWs identified using the wind reversal method that occurred (a) before 2000 and (b) after 2000. Eleven events before 2000 and 13 events after 2000 were used (Table 1). Grey crosses indicate statistically significant regions at the 95% confidence level.

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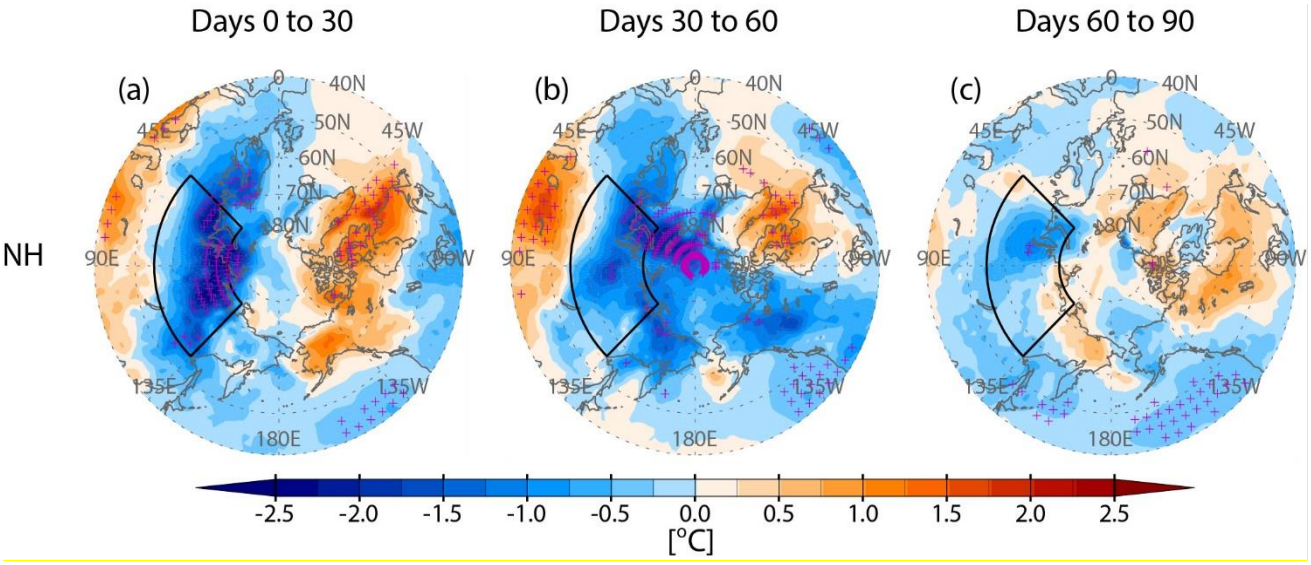

Supplementary Fig. S14. SAT anomalies averaged over three different periods after the onset date of SSWs identified using the wind reversal method in the NH. Results are shown for (a) days 0 to 30, (b) days 30 to 60, and (c) days 60 to 90. Pink crosses indicate significant values at the 95% confidence level. Black solid boxes mark the Eurasia region (45°E–135°E, 55°N–75°N).

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