Weather and Climate Dynamics

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Supplement of

The role of large-scale atmospheric patterns for recent warming periods in Greenland from 1900–2015

Florina Roana Schalamon et al.

Correspondence to: Florina Roana Schalamon (florina.schalamon@uni-graz.at)

S1. Consideration for the chosen SOM Parameters

In the following we show different parameters we tested for the SOM method. We tested different number of nodes – 6,7,8,9,10,15,20,25,30. As an example we added here the results with 20 nodes. As we wanted to avoid the manual regrouping after SOM as done by Schmidt et al. (2023) and Schuenemann and Cassano (2009) we concluded that eight clusters are sufficient to show the expected large-scale patterns over Greenland and that they show the expected warm and cold patterns. More clusters do not result in more details. We further found that the key results are not sensitive to the number of clusters.

We tested different domain sizes for the SOM analysis, including domains extending further south to 30°N and even covering the entire Northern Hemisphere. However, these broader domains produced less meaningful patterns in the context of Greenland, often introducing LSPs with little relevance to regional conditions. The domain selected for our main analysis—spanning 0–90°W and 55–90°N—captures the synoptic-scale circulation most relevant for Greenland. To illustrate the effect of domain choice, we also show results from a slightly extended domain (120°W to 20°E and 50°N to 90°N) using both eight and 20 SOM nodes. While using more clusters may offer finer distinctions, it also introduces interpretation challenges: for example, LSP 19 and 20 would need to be regrouped to allow for meaningful conclusions. Additionally, some patterns occur very rarely—LSP 19 appears on only 138/12/26 days (0.3/0.3/0.5%) during the full study period (1900–2015), WP1, and WP2 respectively—limiting the statistical robustness of their associated AT anomalies.

That is why we opted for eight cluster centers and the selected domain, as this combination offers a robust and interpretable set of large-scale patterns that are both relevant for Greenland and statistically meaningful across the study period.
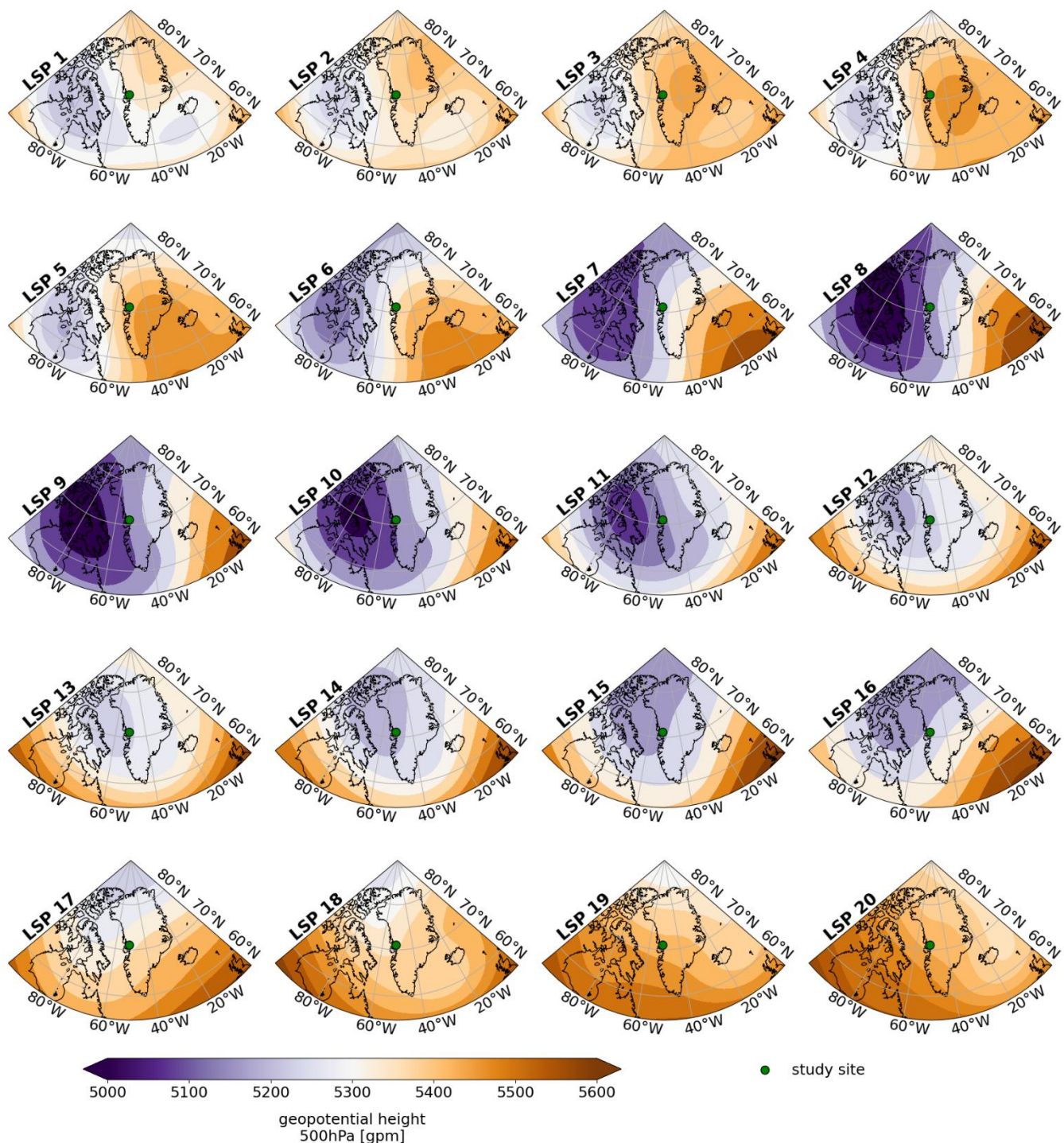
Figure S1: Geopotential height of the 500 hPa pressure level of the 20 LSPs as defined by SOM with an input domain of (0-90° W and 55-90° N). The study site is marked with a green dot. For visual clarity, the SOM patterns are displayed in a 2D matrix; however, the underlying topology is one-dimensional, with neighbourhood relations applying only sequentially along a single line from the top left to the bottom right, i.e., following the numbering of the LSPs.
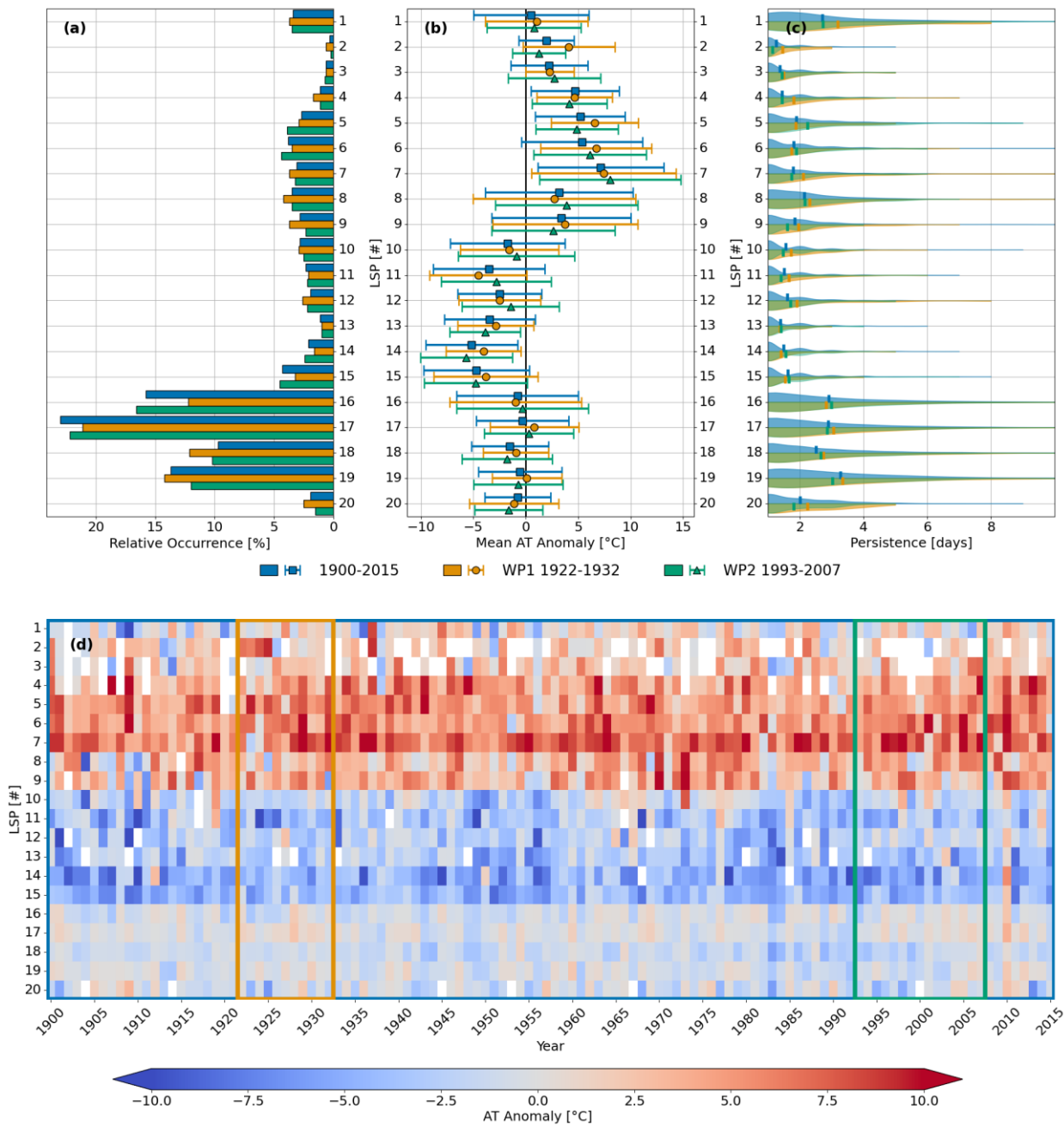
Figure S2: Summary of the evaluation of the 20 LSPs examined across the study periods. The study periods are color-coded throughout the plot as follows: WP1 (1922–1932) in orange, WP2 (1993–2007) in green, and the full period (1900–2015) in blue. (a) Distribution of relative occurrence of each LSP across the study periods. (b) Average AT anomaly per LSP, with markers indicating the mean anomaly and whiskers representing ±1 standard deviation. (c) Distribution of persistence in days per LSP, with bold lines indicating mean lengths. The full period is at the top and both WPs at the bottom. (d) Annual average AT anomaly per LSP, with coloured frames representing the study periods.
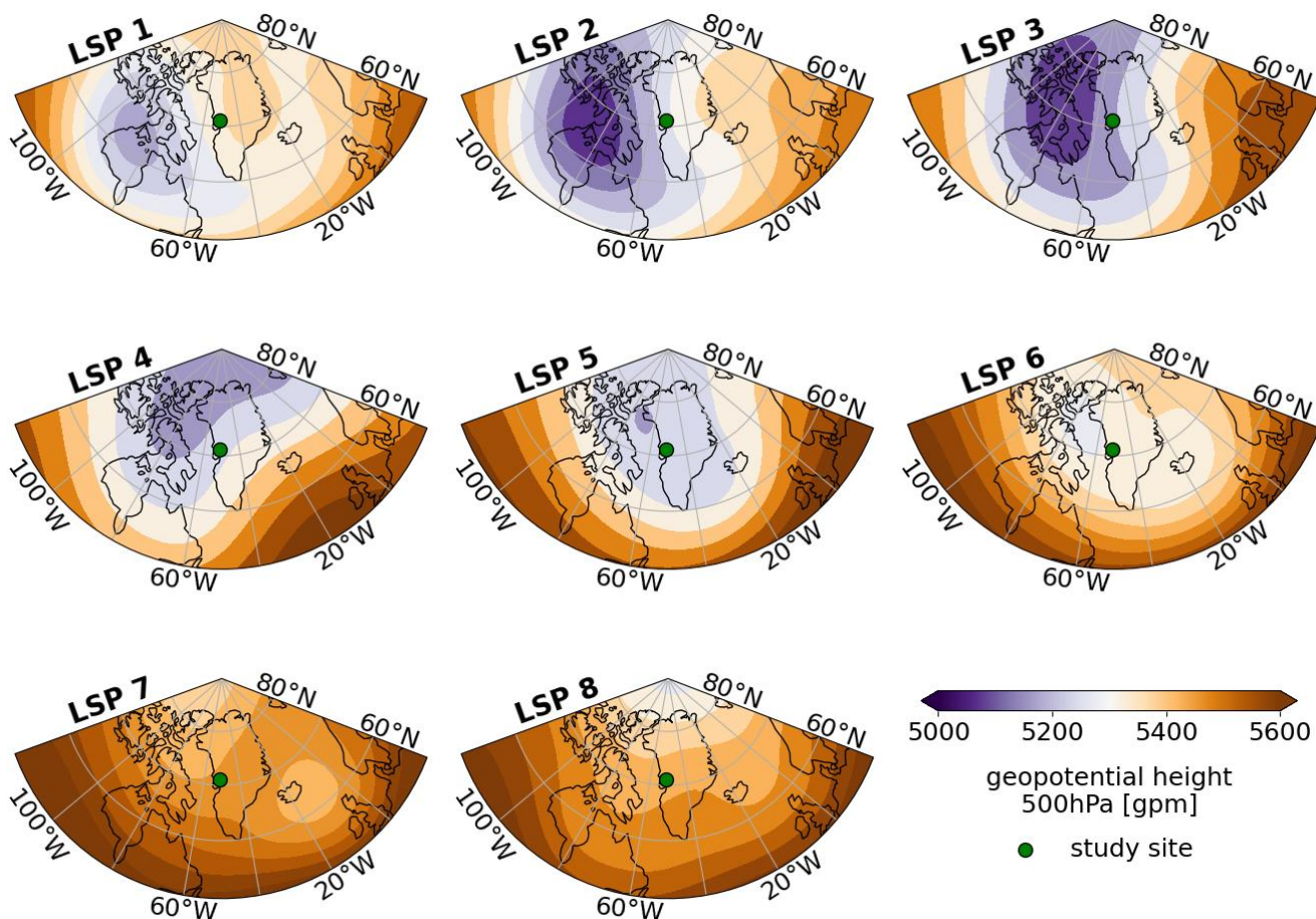
Figure S3: Geopotential height of the 500 hPa pressure level of the eight LSPs as defined by SOM with a larger input domain of 120°W -20°E and 50-90°N. The study site is marked with a green dot. For visual clarity, the SOM patterns are displayed in a 2D matrix; however, the underlying topology is one-dimensional, with neighbourhood relations applying only sequentially along a single line from the top left to the bottom right, i.e., following the numbering of the LSPs.
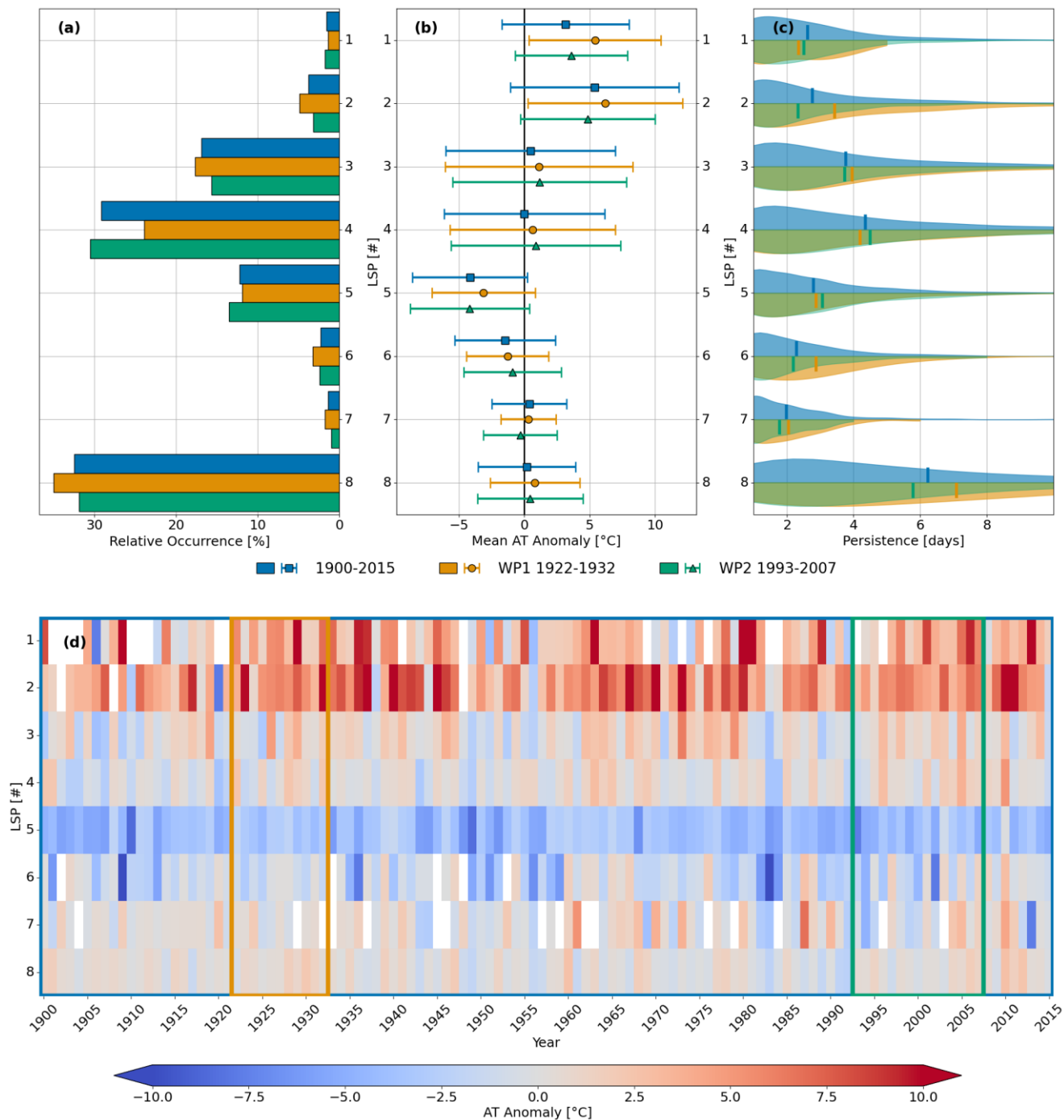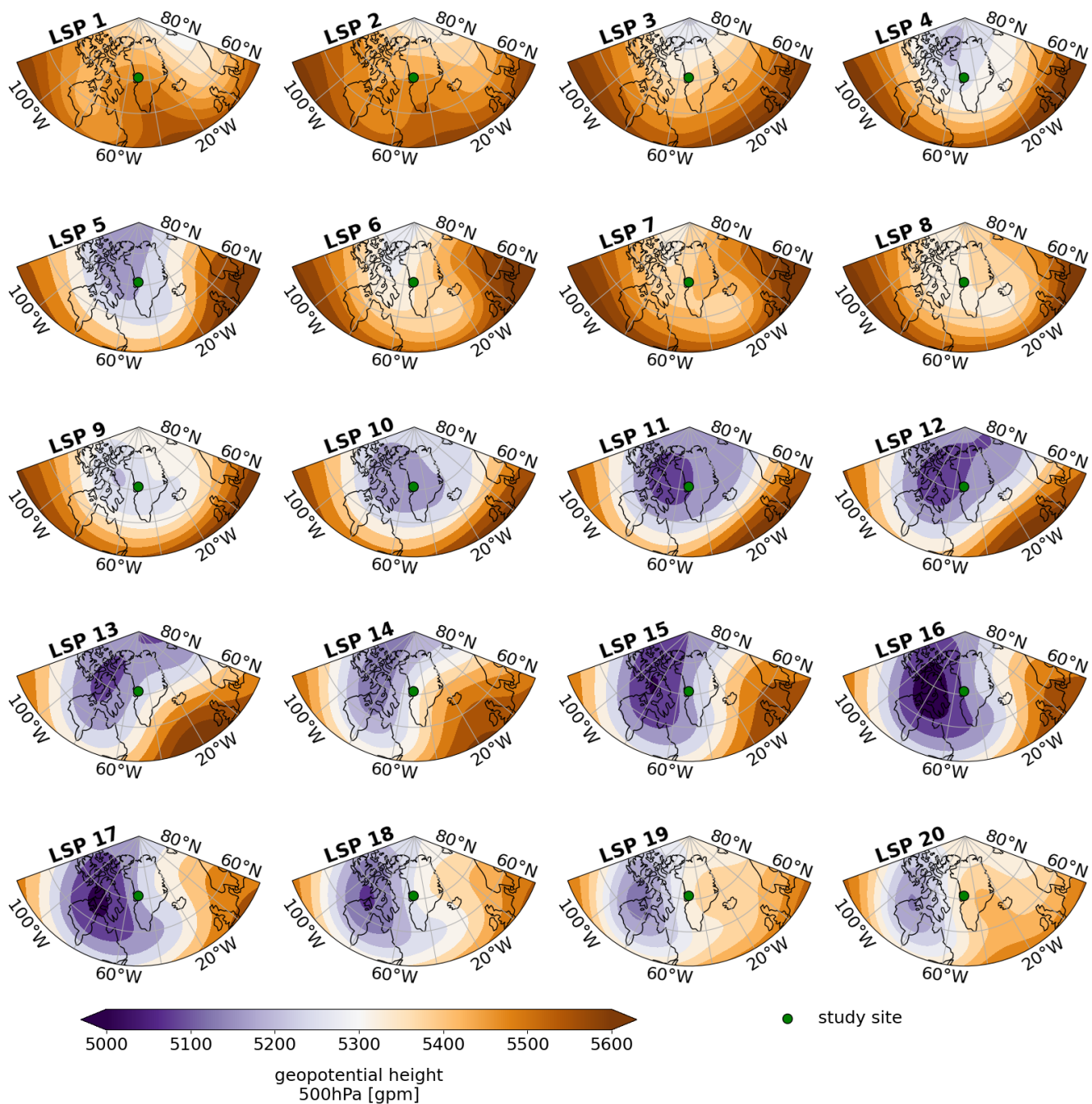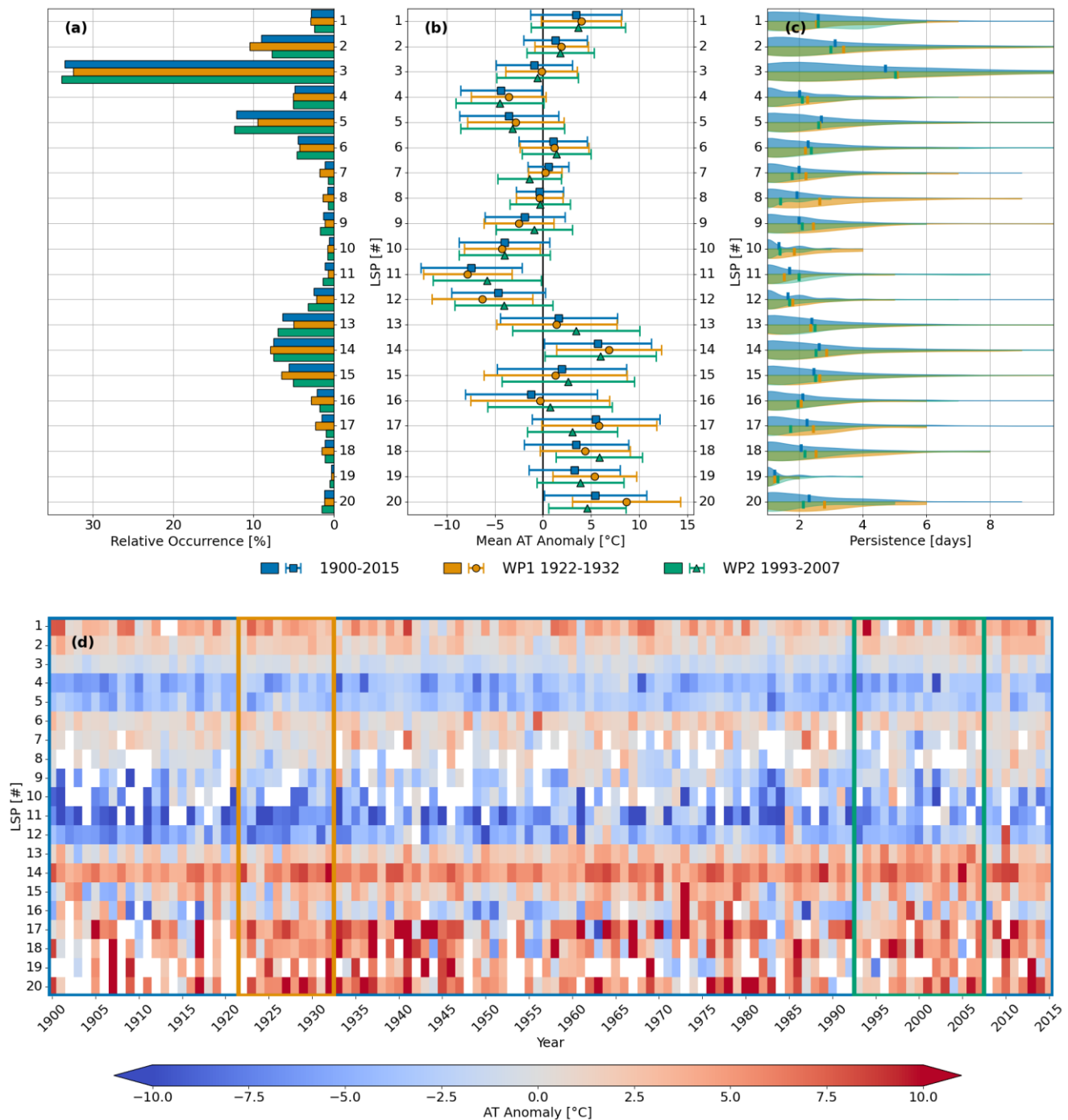
Figure S4: Summary of the evaluation of the eight LSPs within the larger domain (120°W -20°E and 50-90°N) examined across the study periods. The study periods are color-coded throughout the plot as follows: WP1 (1922–1932) in orange, WP2 (1993–2007) in green, and the full period (1900–2015) in blue. (a) Distribution of relative occurrence of each LSP across the study periods. (b) Average AT anomaly per LSP, with markers indicating the mean anomaly and whiskers representing ±1 standard deviation. (c) Distribution of persistence in days per LSP, with bold lines indicating mean lengths. The full period is at the top and both WPs at the bottom. (d) Annual average AT anomaly per LSP, with coloured frames representing the study periods.

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Figure S5: Geopotential height of the 500 hPa pressure level of the 20 LSPs as defined by SOM with a larger input domain of 120°W -20°E and 50-90°N. The study site is marked with a green dot. For visual clarity, the SOM patterns are displayed in a 2D matrix; however, the underlying topology is one-dimensional, with neighbourhood relations applying only sequentially along a single line from the top left to the bottom right, i.e., following the numbering of the LSPs.

Figure S6: Summary of the evaluation of the 20 LSPs with the larger domain (120°W -20°E and 50-90°N) examined across the study periods. The study periods are color-coded throughout the plot as follows: WP1 (1922–1932) in orange, WP2 (1993–2007) in green, and the full period (1900–2015) in blue. (a) Distribution of relative occurrence of each LSP across the study periods. (b) Average AT anomaly per LSP, with markers indicating the mean anomaly and whiskers representing ±1 standard deviation. (c) Distribution of persistence in days per LSP, with bold lines indicating mean lengths. The full period is at the top and both WPs at the bottom. (d) Annual average AT anomaly per LSP, with coloured frames representing the study periods.

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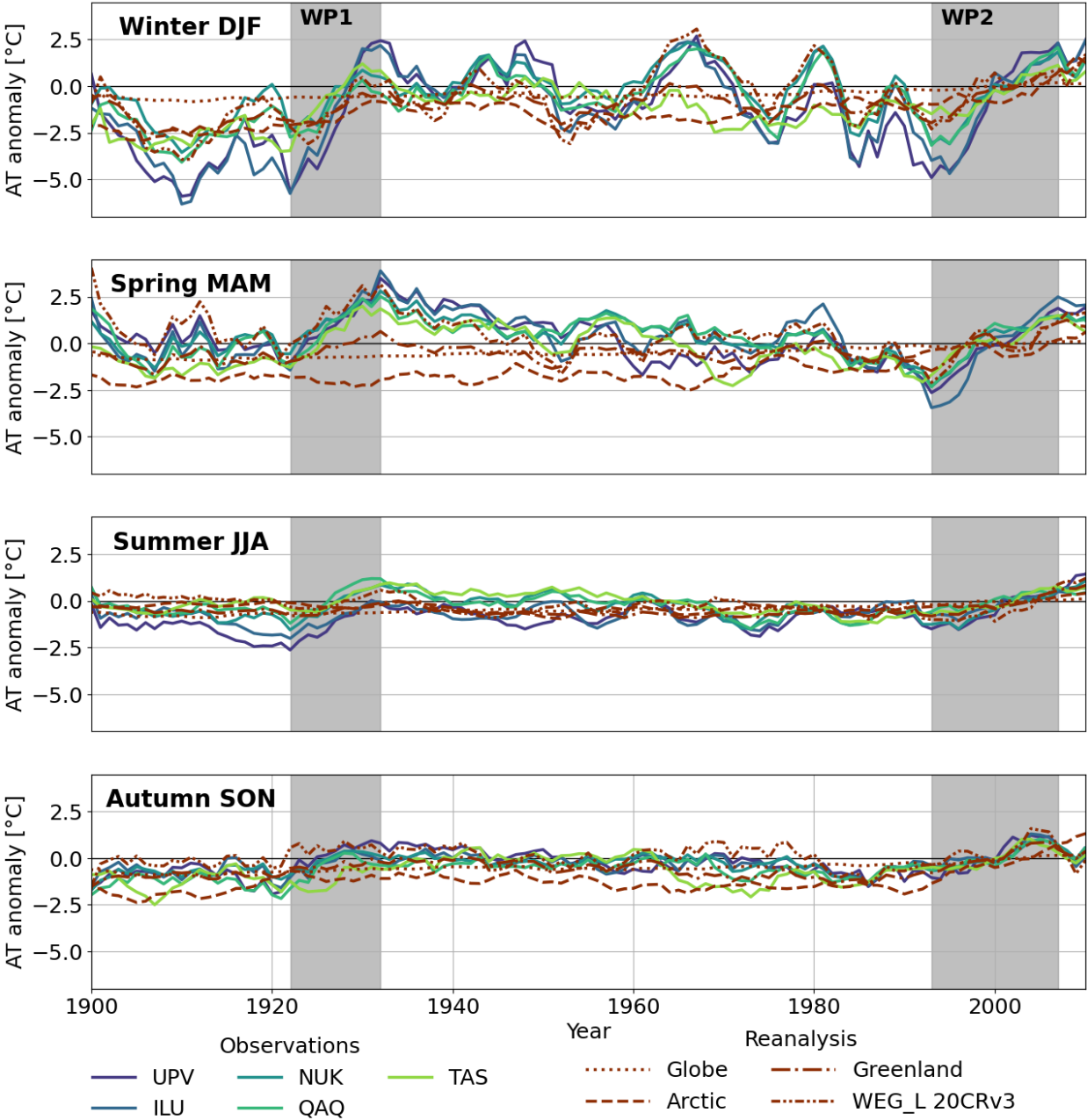
Figure S7. Seasonal annual AT anomaly with respect to reference period 1986-2015 at weather stations (Upernavik (UPV), Illulisaat (ILU), Nuuk (NUK), Qaqortoq (QAQ), Tasiilaq (TAS)), of 20CRv3 as spatial average of the Arctic, Greenland, globally and interpolated to the study site WEG_L, smoothed with a 5-year window rolling mean. The two defined WPs are marked with the grey background.
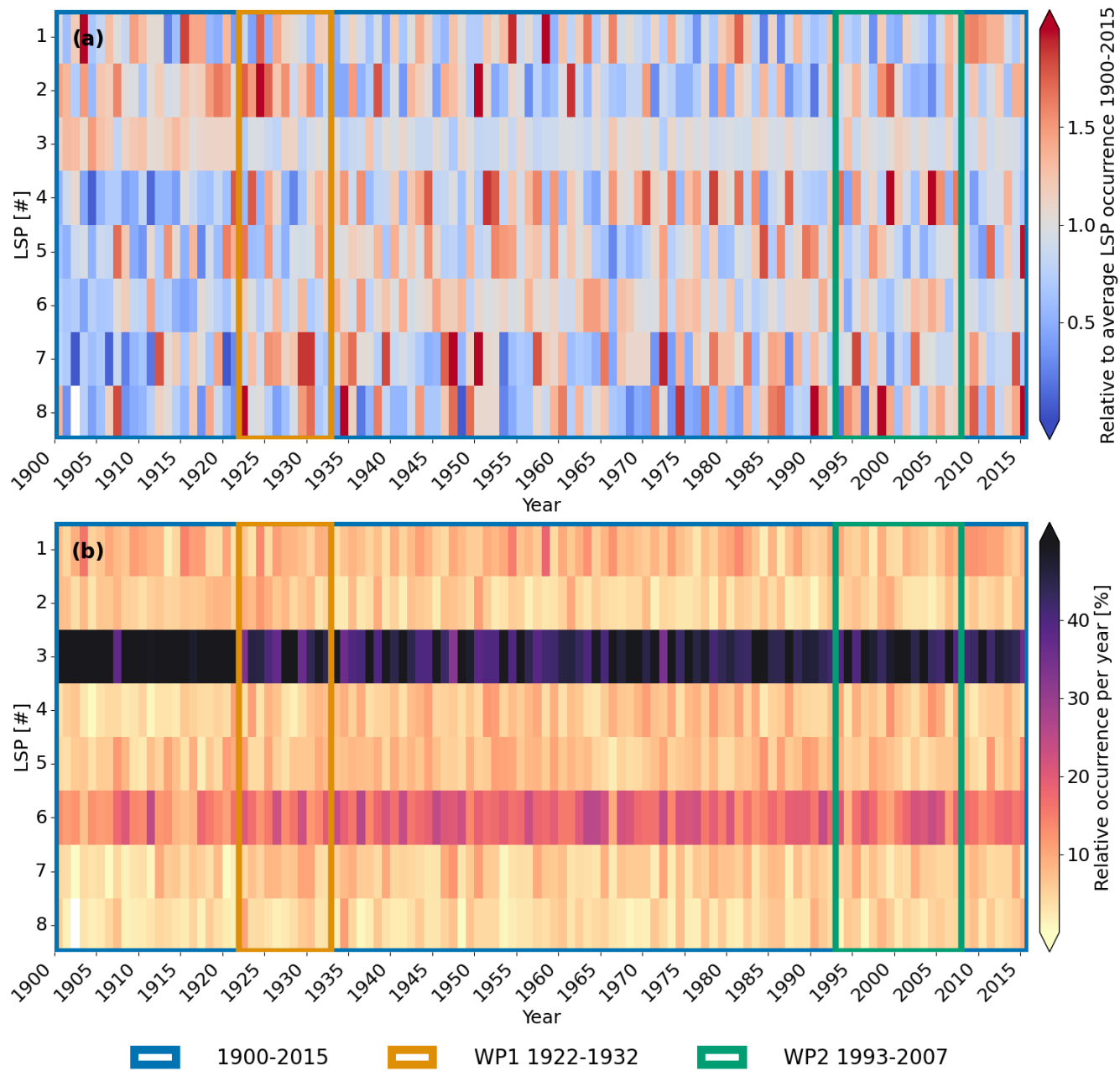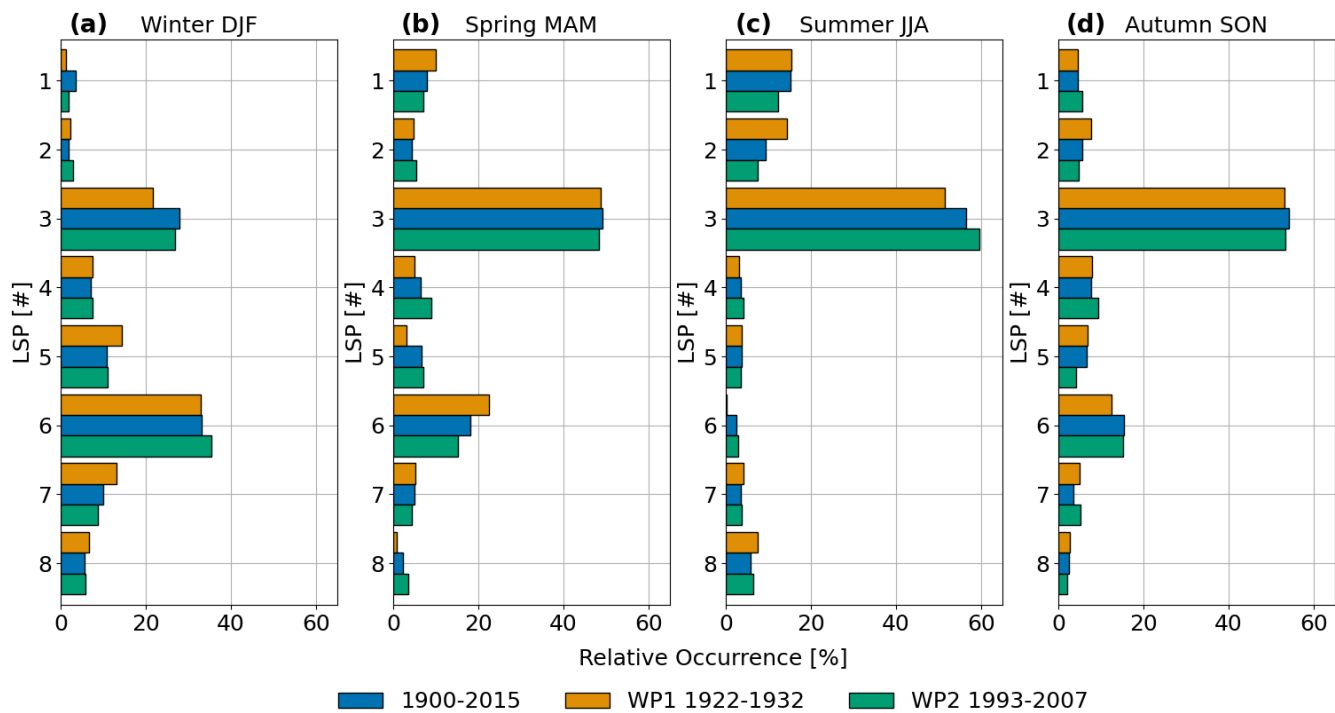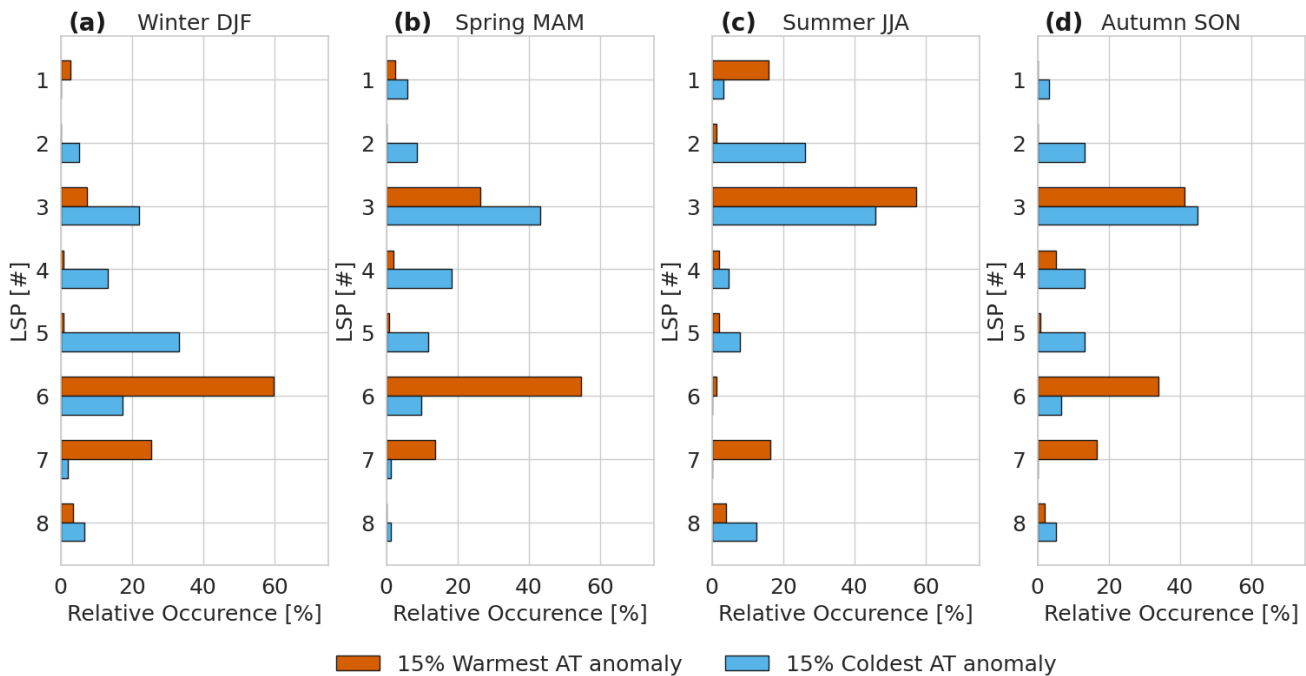
S3. Relative LSP occurrence

Figure S8: The occurrence per LSP (a) relative to the average occurrence of a LSP in the full period 1900-2015 and (b) relative per year.

Figure S9 Seasonal relative occurrence of the LSPs in the full study period and the WPs.

S4. Seasonal distribution of LSP on the 15 % warmest and coldest days in the WPs

Figure S10: Seasonal distribution of LSPs on the 15 % warmest and coldest days of WP1.
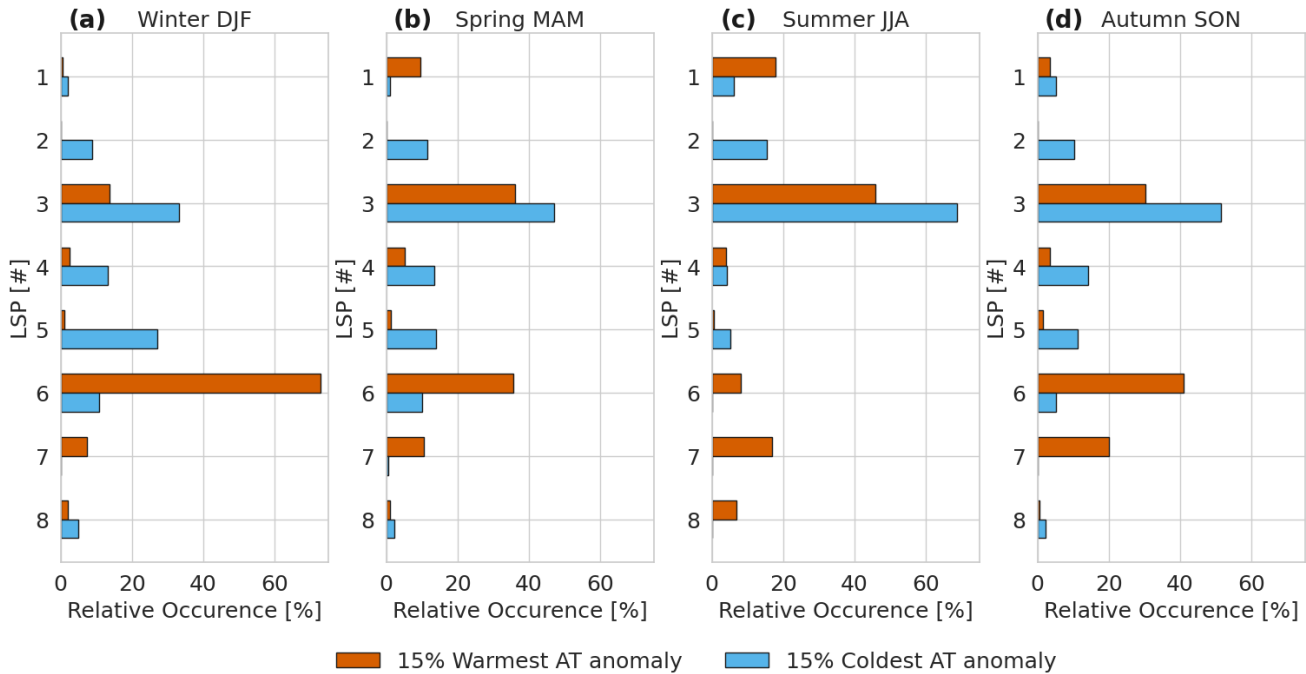

Figure S11: Seasonal distribution of LSPs on the 15 % warmest and coldest days of WP2.