



Supplement of

A multi-method Antarctic atmospheric blocking dataset (1979–2024)

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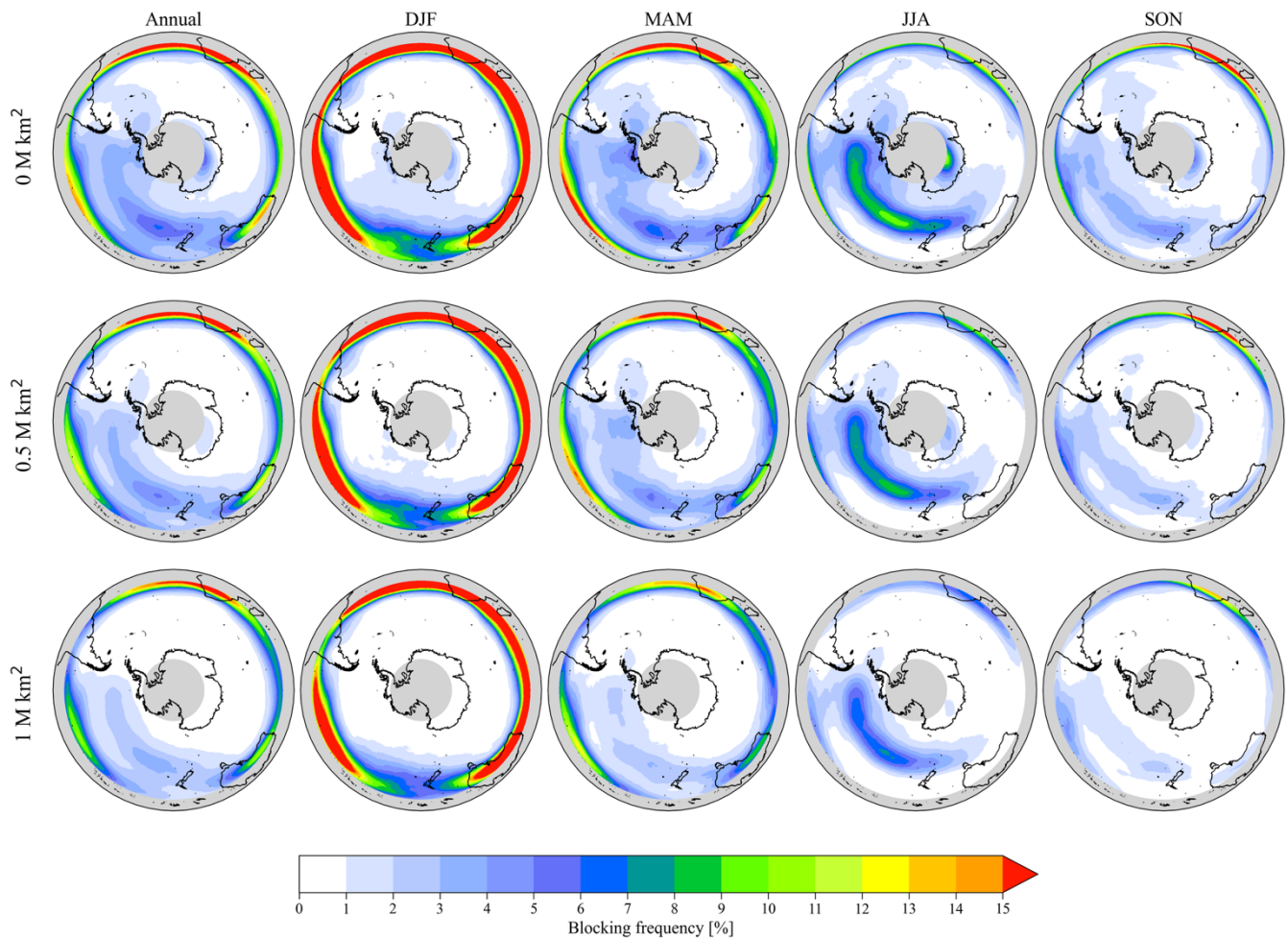
Supplement S1: Threshold Sensitivity Analysis

S1.1 Sensitivity of the Z500-Grad method

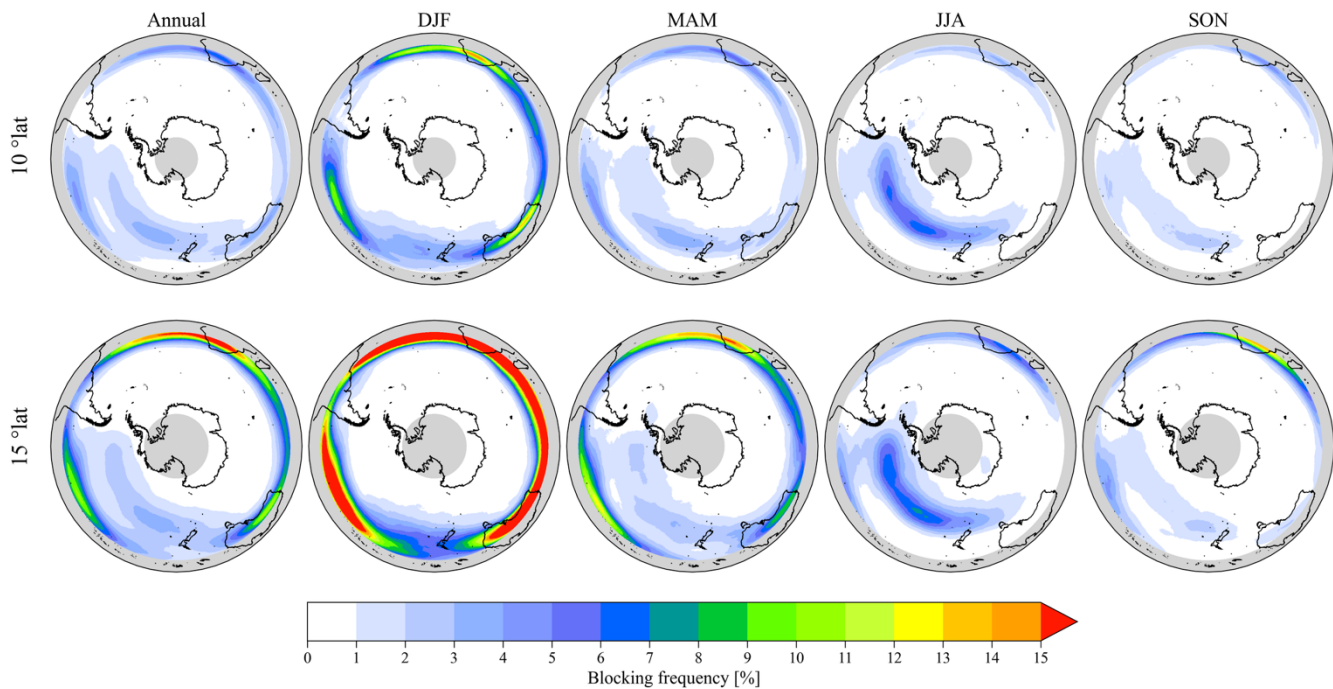
For the gradient reversal method (Z500-Grad), three sets of sensitivity experiments were conducted: (1) varying the minimum area filter (0, 0.5, and $1.0 \times 10^6 \text{ km}^2$); (2) varying the latitudinal spacing used to compute meridional gradients ($\Delta\text{lat} = 10^\circ$ and 15°); and (3) varying the southern gradient threshold (GHGS = 0, 5, and $10 \text{ m } ^\circ\text{lat}^{-1}$), with the latter conducted at both area filter levels (0.5 and $1.0 \times 10^6 \text{ km}^2$).

The area filter has a modest effect: reducing it from 1.0 to $0.5 \times 10^6 \text{ km}^2$ increases the retained event count, particularly through additional detection of smaller features near the domain boundary, but does not substantially alter the overall spatial pattern of blocking frequency (Fig. S1). The choice of Δlat primarily affects blocking frequency in the subtropical and mid-latitude belt, where $\Delta\text{lat} = 15^\circ$ produces a broader and more intense signal. Over the Southern Ocean and Antarctic domain, which is the focus of this dataset, the two configurations yield broadly similar results (Fig. S2), and $\Delta\text{lat} = 15^\circ$ is retained as the published setting consistent with Pinheiro et al. (2019).

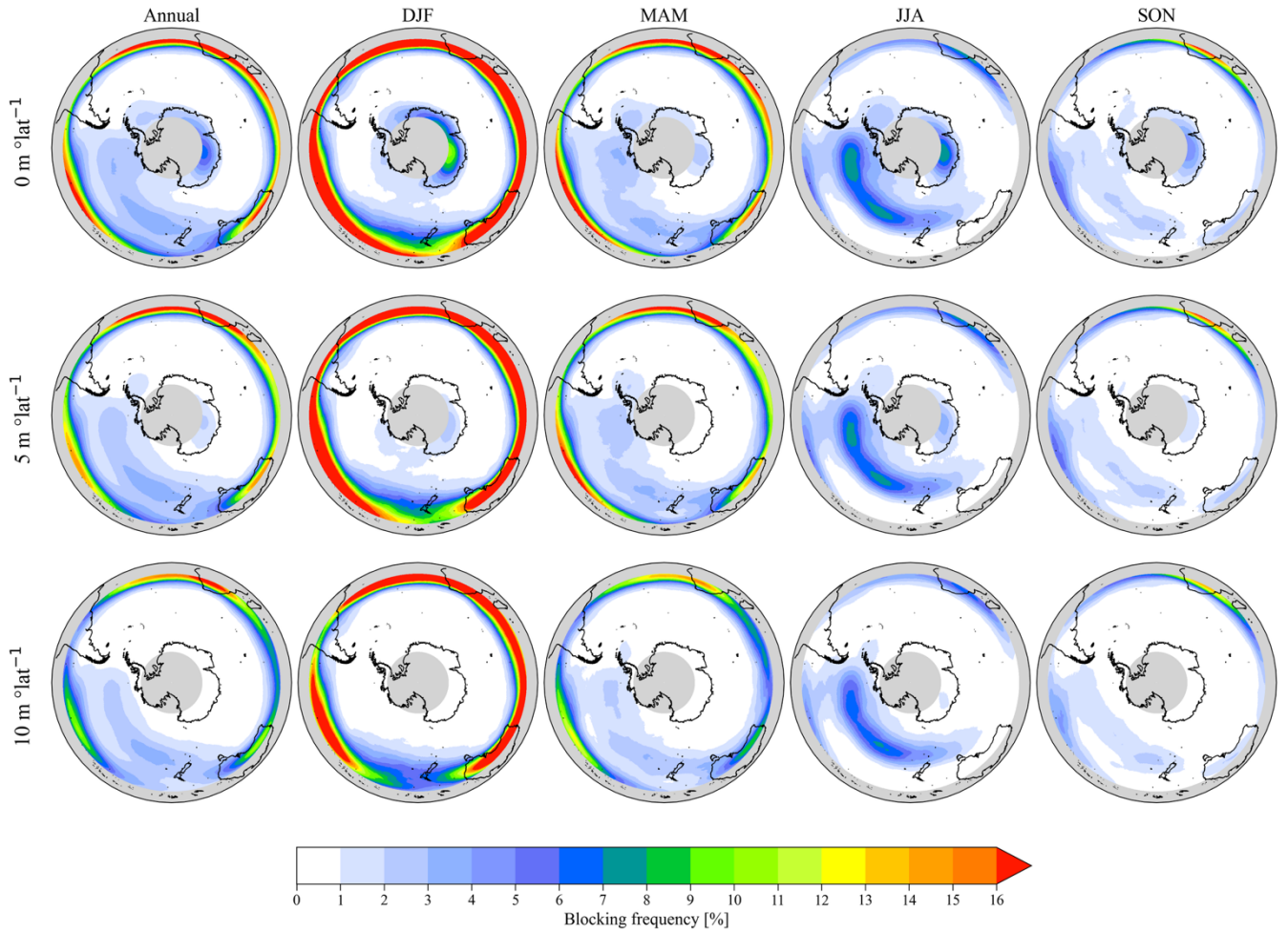
The GHGS threshold has a more pronounced effect. At the standard area filter of $1.0 \times 10^6 \text{ km}^2$, relaxing GHGS from 10 to $0 \text{ m } ^\circ\text{lat}^{-1}$ substantially increases detection along the mid-latitude storm track belt, particularly in DJF and MAM, but produces very little additional detection over the Southern Ocean and Antarctic continent (Fig. S3). When the area filter is reduced to $0.5 \times 10^6 \text{ km}^2$, the sensitivity to GHGS increases markedly. At GHGS = $0 \text{ m } ^\circ\text{lat}^{-1}$, blocking frequencies over the Antarctic continent and circumpolar belt increase notably, with the most pronounced signal in DJF and JJA (Fig. S4). This signal is absent or very weak at GHGS = 5 and $10 \text{ m } ^\circ\text{lat}^{-1}$ even at the smaller area filter, confirming that both conditions must be relaxed together to detect blocking over the continental interior. We retain GHGS = $10 \text{ m } ^\circ\text{lat}^{-1}$ and an area filter of $1.0 \times 10^6 \text{ km}^2$ as the published settings to maintain consistency with Pinheiro et al. (2019) and to preserve the gradient method's role as a conservative flow geometry baseline.



45 **Figure S1: Annual and seasonal blocking frequency (%) from the Z500-Grad method for minimum area filter (0, 0.5, and 1.0×10^6 km²). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



50 **Figure S2: Annual and seasonal blocking frequency (%) from the Z500-Grad method for $\Delta\text{lat} = 10^\circ$ and 15° . Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



55 **Figure S3: Annual and seasonal blocking frequency (%) from the Z500-Grad method for varying the southern gradient threshold (GHGS = 0, 5, and 10 m °lat⁻¹) with minimum area filter of 1.0×10^6 km². Regions shown in gray correspond to latitudes where blocking detection is not applied.**

S1.2 Sensitivity to thresholds for standard deviation-based methods

60 The threshold for the Z500 and PV anomaly methods is defined as the maximum of a fixed minimum value and a variability term (1.5 times the local standard deviation). To assess the robustness of the selected parameters, we conducted sensitivity tests varying (1) the fixed minimum threshold and (2) the variability factor.

65 For the Z500 minimum threshold, we tested values of 50, 100, and 150 m (Fig. S5). At 50 m, blocking
frequency is substantially elevated across all seasons and regions, including broad and spatially noisy
signals over the Antarctic continent and Southern Ocean, reflecting clear over-detection of transient
features. At 150 m, the signal contracts markedly and misses substantial blocking over the Southern Ocean
and continental East Antarctica, particularly in DJF and MAM. The 100 m value produces a spatially
70 coherent and physically reasonable pattern and is retained as the published setting.

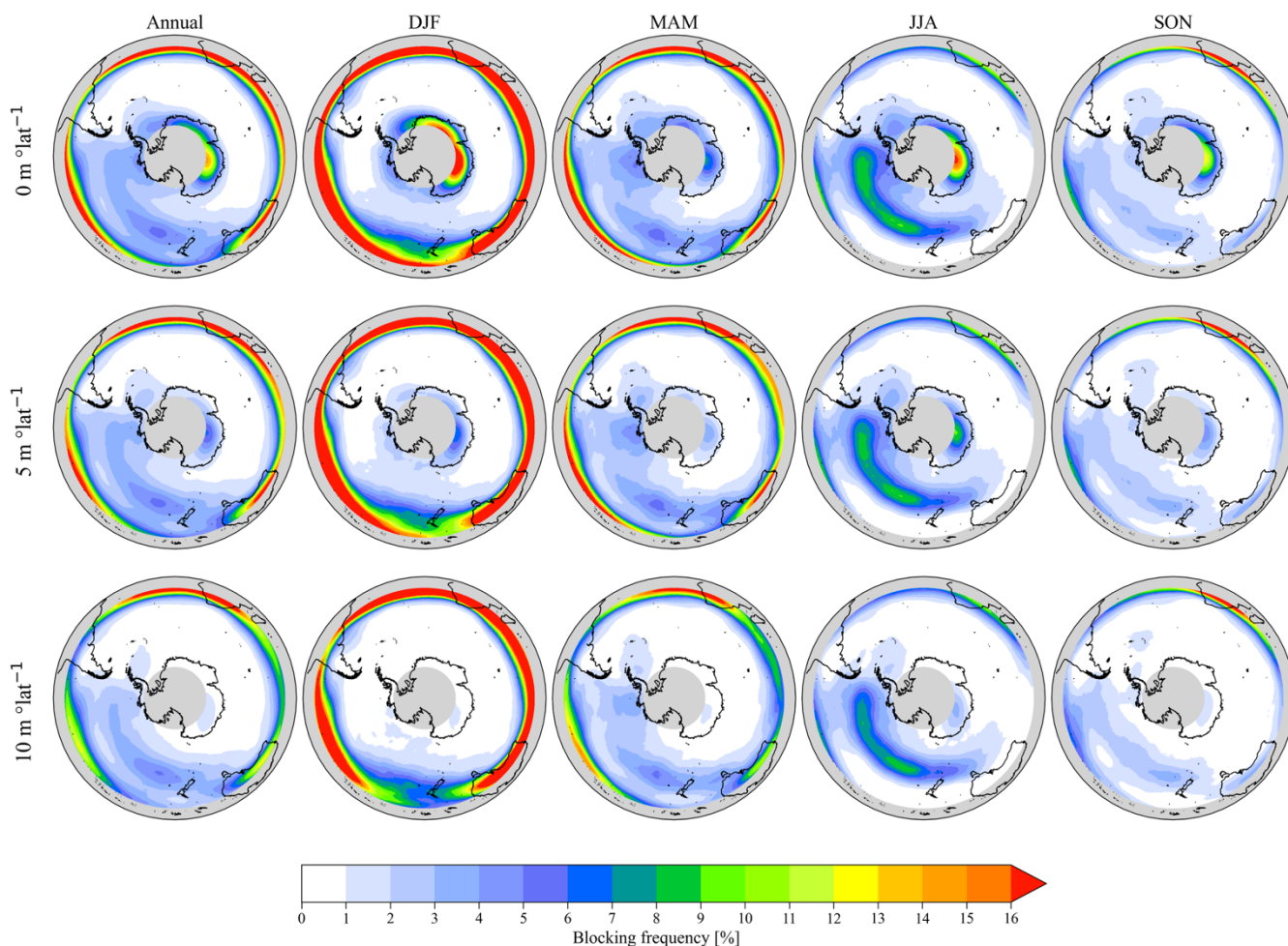
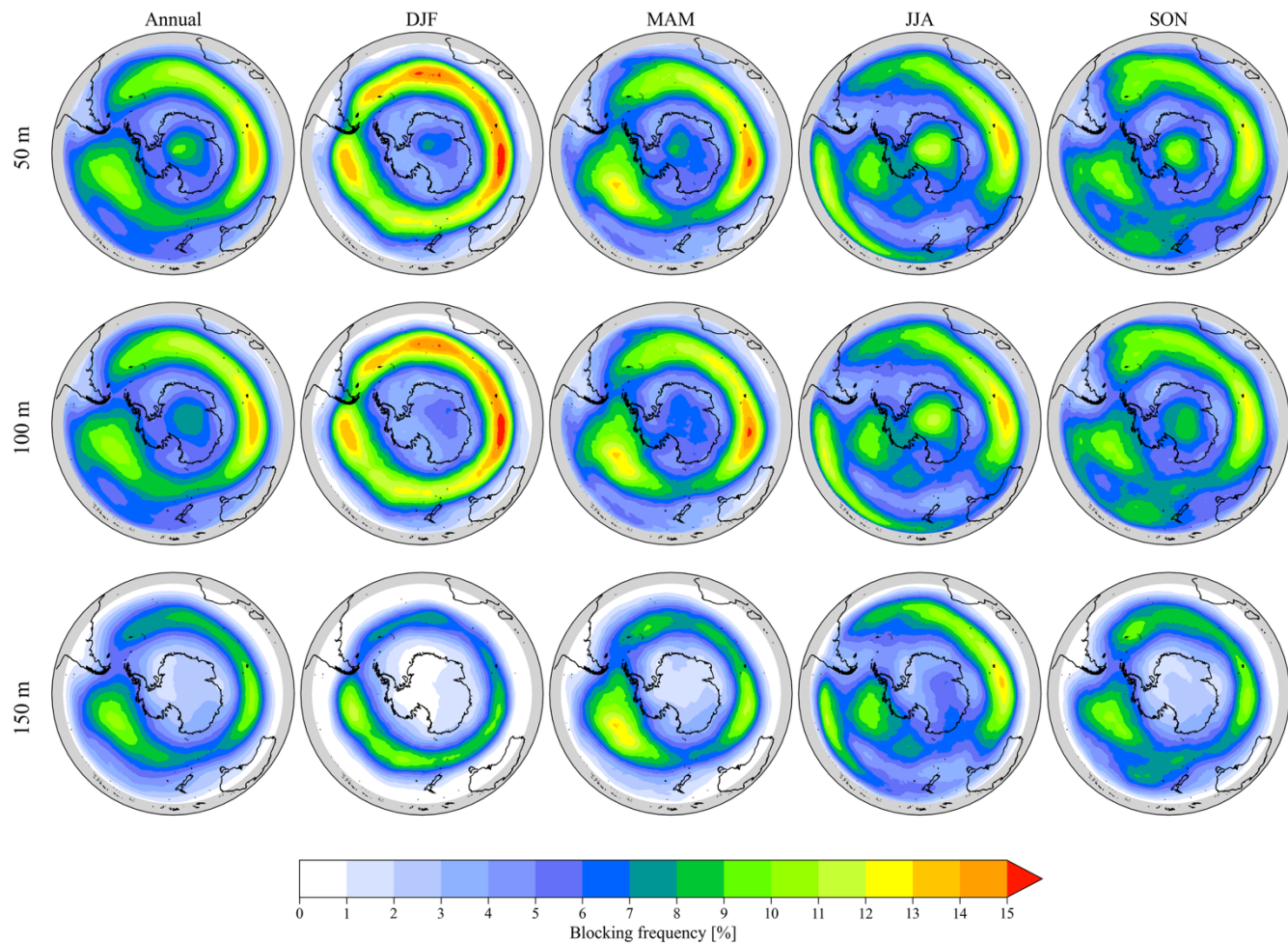


Figure S4: Same as Fig. S3 but with minimum area filter of $0.5 \times 10^6 \text{ km}^2$.

75 For the PV minimum threshold, we tested values of 0.6, 1.1, and 1.6 PVU (Fig. S6). The 0.6 PVU threshold produces high blocking frequencies across the Southern Ocean and over the Antarctic interior in all seasons, with particularly strong signals in JJA and SON, indicating over-detection. The 1.6 PVU threshold is highly restrictive, retaining only a faint signal confined to the mid-latitude belt in DJF. The 1.1 PVU value provides a physically coherent balance between sensitivity and selectivity and is retained
80 as the published setting.



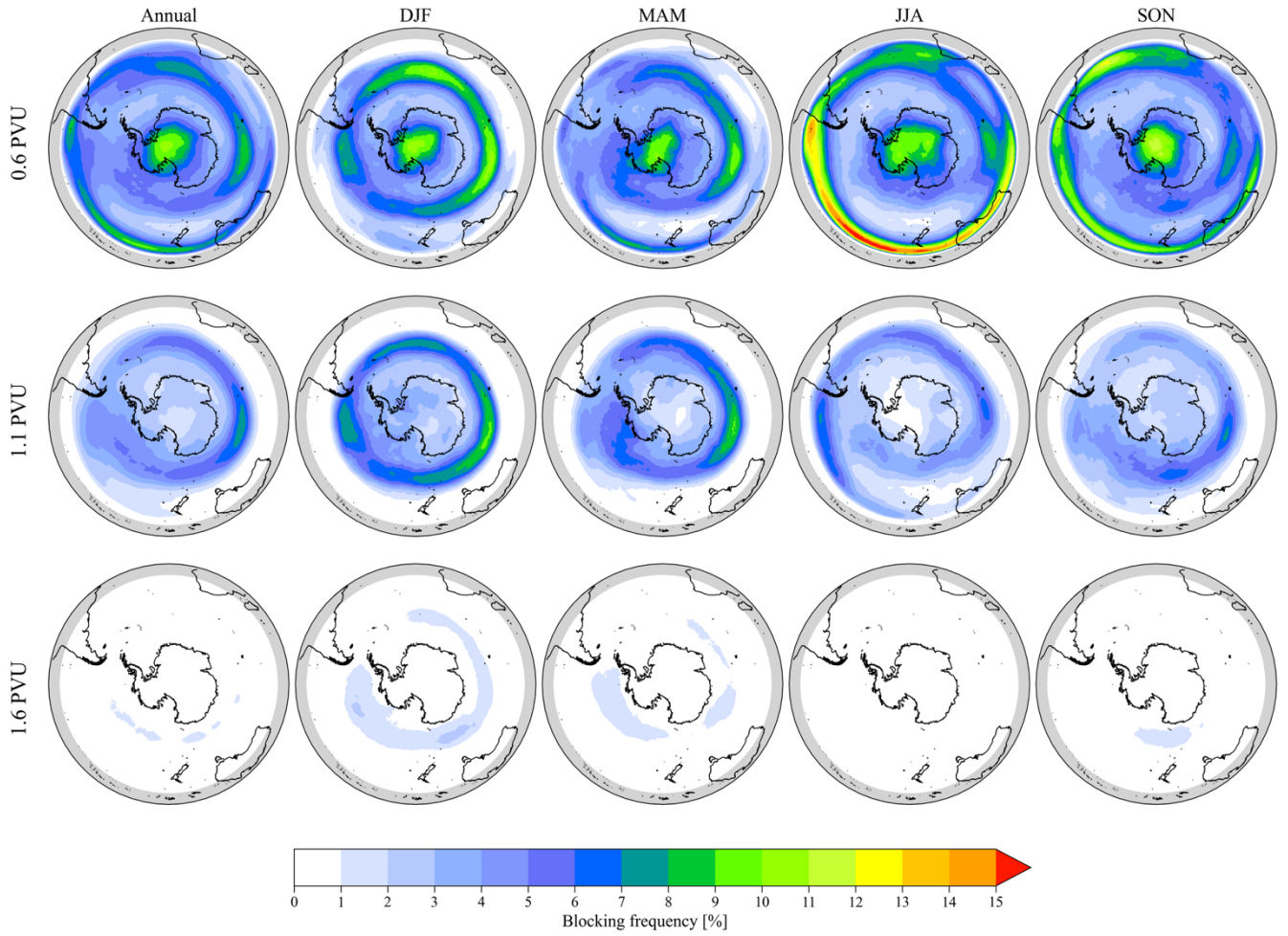
85 **Figure S5: Annual and seasonal blocking frequency (%) from the Z500-SD method using three minimum threshold values: 50 m (top), 100 m (middle, selected), and 150 m (bottom). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**

For the variability factor, we tested values of 1.0, 1.5, and 2.0 times the local standard deviation for both Z500 and PV methods (Figs. S7 and S8). A factor of 1.0 substantially over-estimates blocking frequency, with high values extending across the Southern Ocean and into the Antarctic interior in most seasons, consistent with detection of transient ridging rather than persistent blocking. A factor of 2.0 is overly restrictive and captures only the most extreme events, leaving most of the domain near zero frequency. The 1.5 value, consistent with Pinheiro et al. (2019), produces the most physically reasonable spatial distribution across all seasons and is retained as the published setting.

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Regarding which threshold component dominates spatially: the fixed minimum threshold (100 m for Z500 and 1.1 PVU for PV) controls detection primarily over the Antarctic interior and other regions of weak climatological variability, where 1.5 times the local standard deviation falls below the fixed floor. The variability term dominates over the Southern Ocean and storm track belt where synoptic variability is large. This spatial partitioning is physically consistent with the rationale for using a combined threshold and confirms that the two components serve complementary roles in the detection scheme.

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105 **Figure S6: Annual and seasonal blocking frequency (%) from the PV-SD method using three minimum threshold values: 0.6 PVU (top), 1.1 PVU (middle, selected), and 1.6 PVU (bottom). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**

S1.3 Sensitivity to the minimum area filter for standard deviation-based methods

To assess the effect of the common area filter on the standard deviation-based methods, we repeated the
 110 Z500-SD and PV-SD calculations using minimum area filters of 0.5 and $1.0 \times 10^6 \text{ km}^2$. Reducing the area filter produces only minor changes in the spatial blocking-frequency patterns for both methods (Figs. S9 and S10), supporting the use of a common $1.0 \times 10^6 \text{ km}^2$ threshold for the intercomparison.

S1.4 Sensitivity to the minimum overlap criterion

The StitchBlobs tracking algorithm requires a minimum spatial overlap between blocked regions at consecutive time steps. We tested the sensitivity of blocking detection to this parameter by varying the minimum overlap fraction for Z500-Grad, Z500-SD, and PV-SD. No significant change was found in the
120 resulting blocking frequency patterns across all tested configurations (Figs. S11, S12, and S13). This confirms that the tracking results are robust to the choice of overlap criterion.

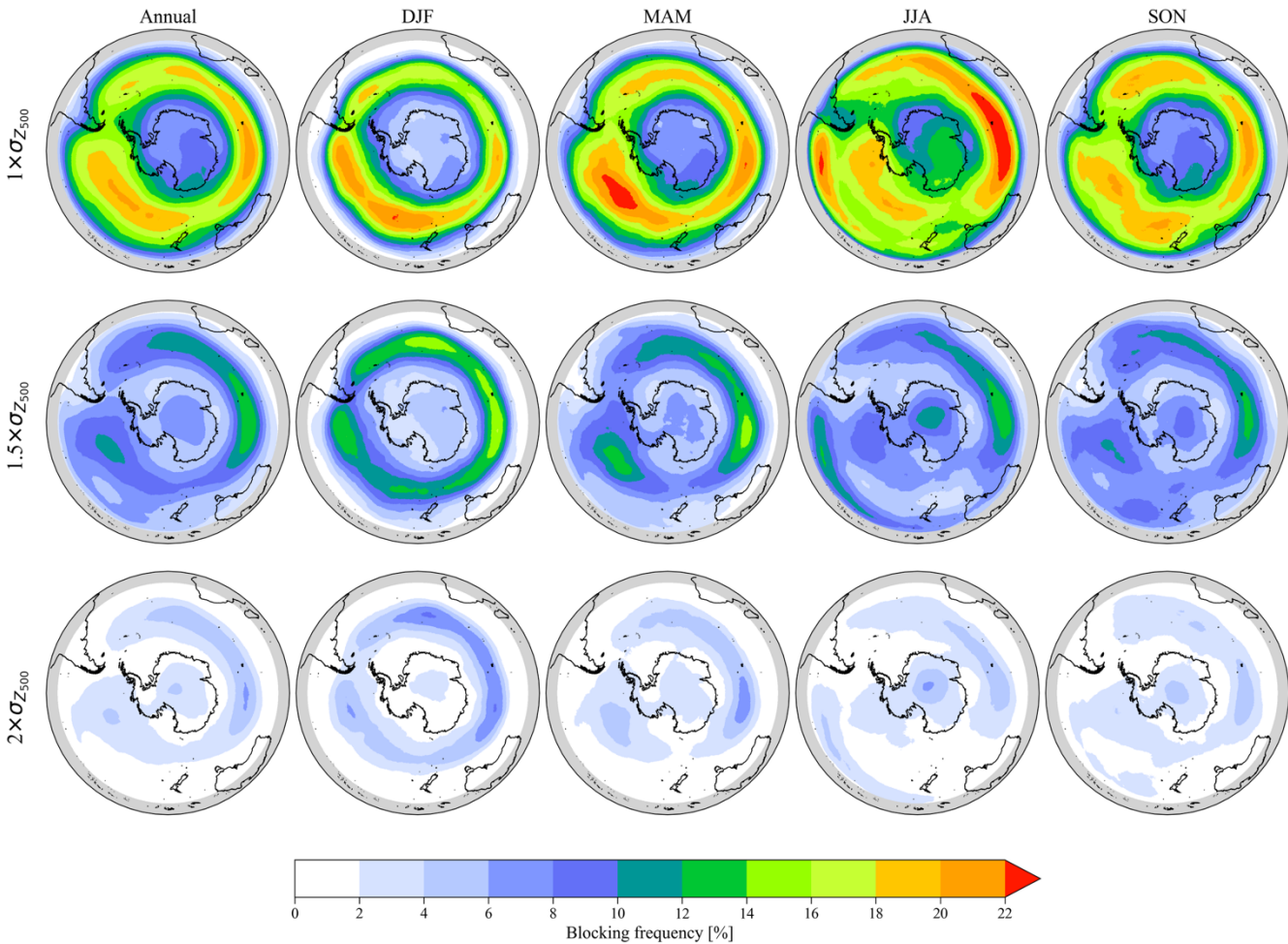
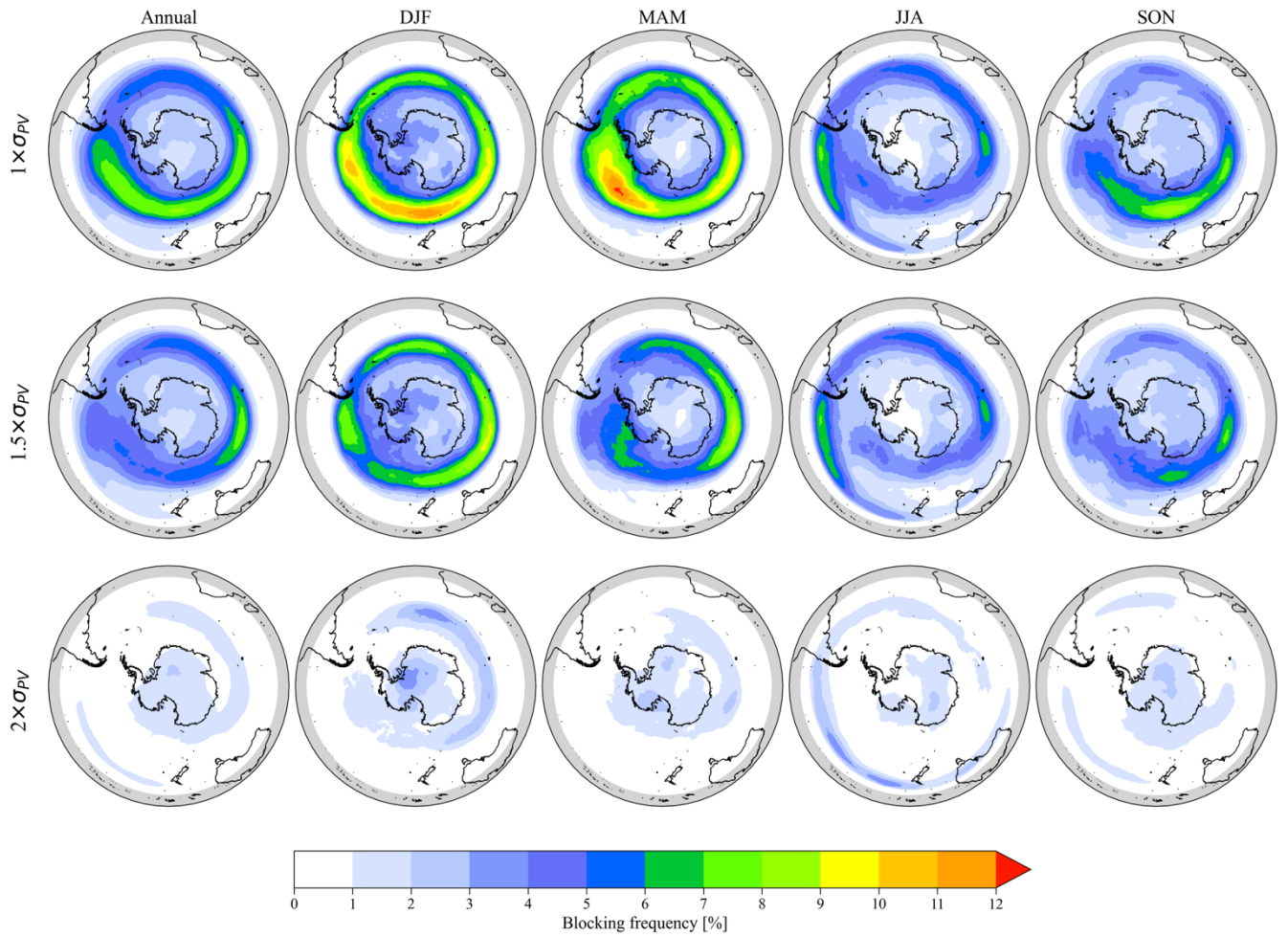
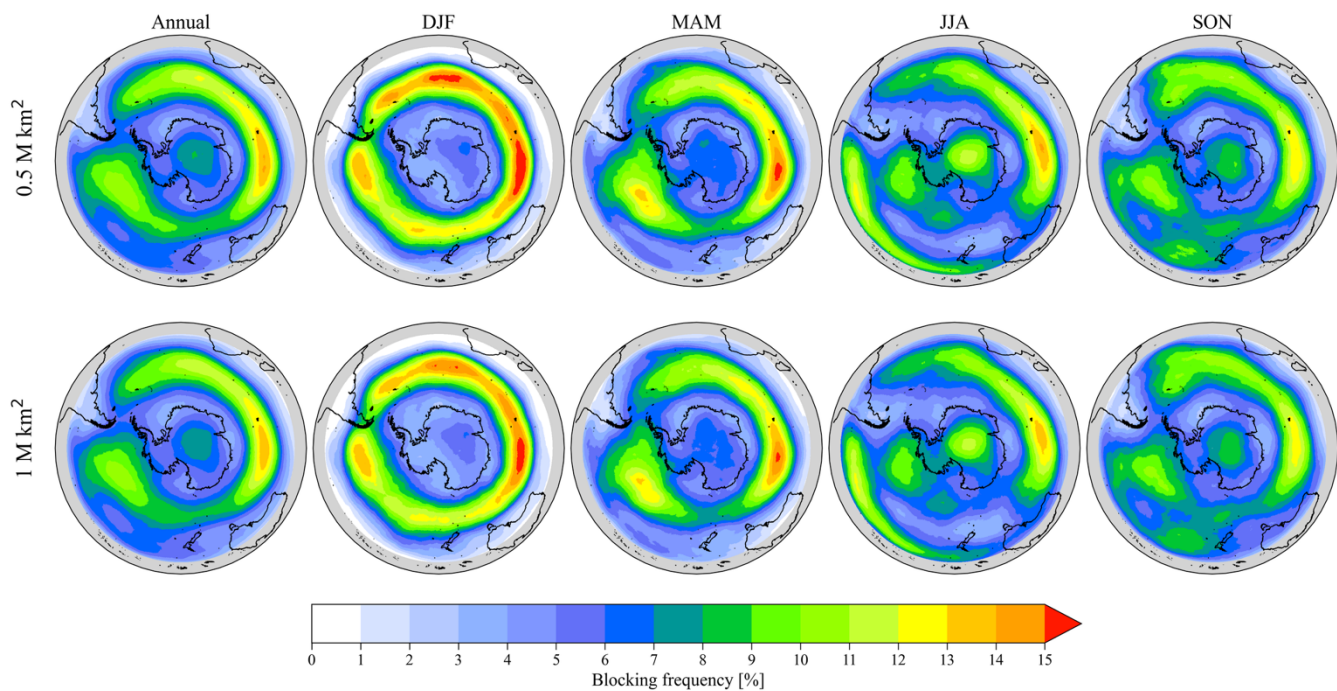


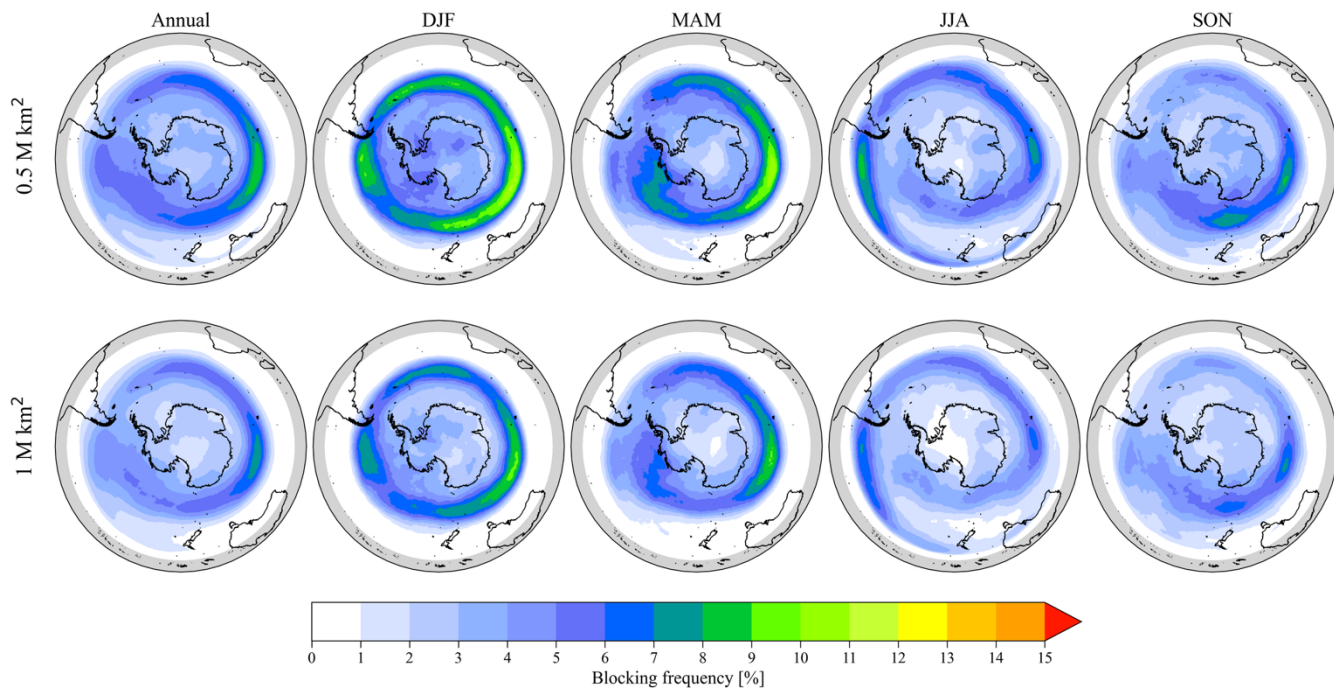
Figure S7: Annual and seasonal blocking frequency (%) from the Z500-SD method using three 1.0 (top), 1.5 (middle, selected), and 2.0 (bottom) times the local standard deviation. Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.



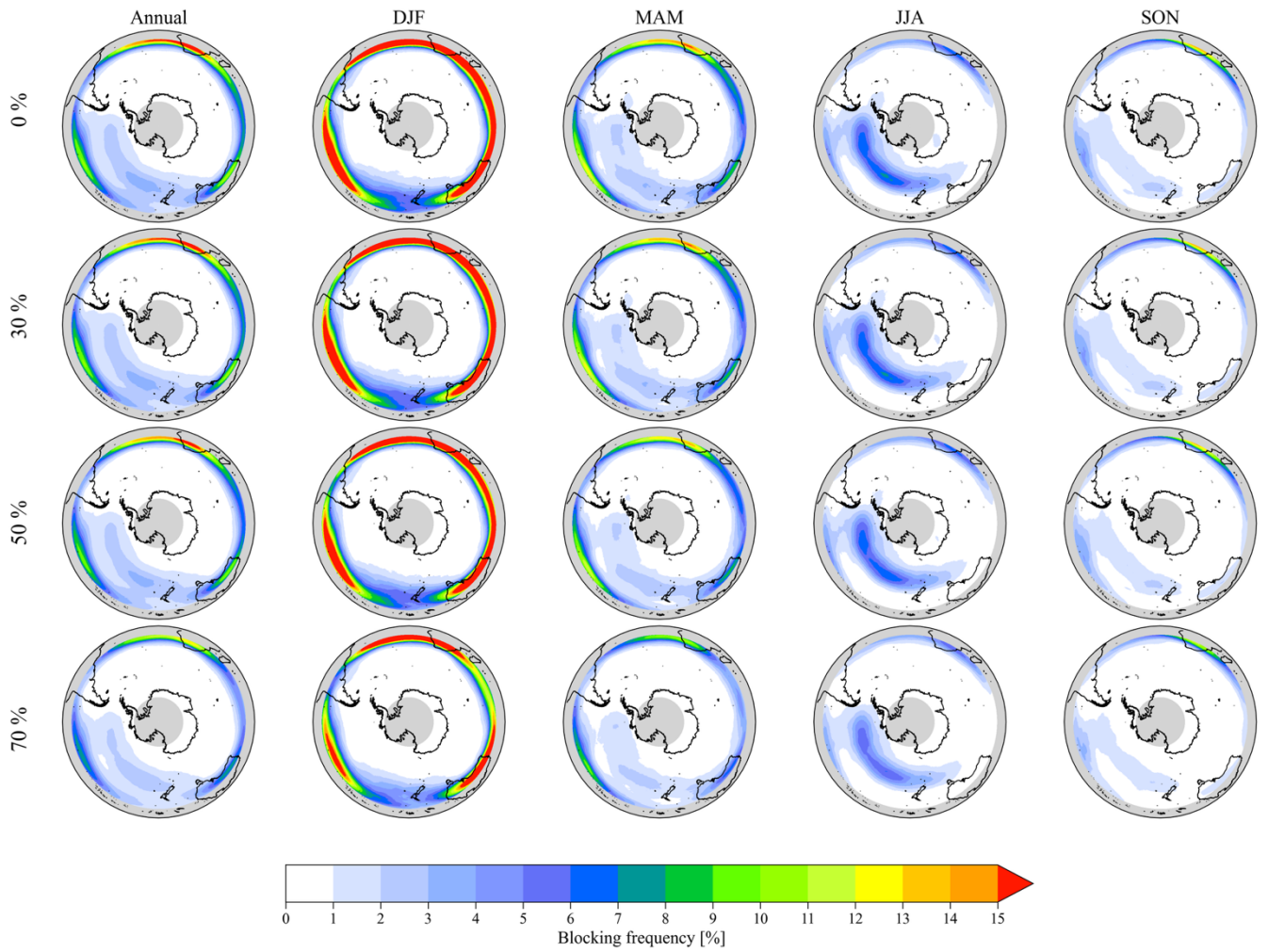
130 **Figure S8: Annual and seasonal blocking frequency (%) from the PV-SD method using three 1.0 (top), 1.5 (middle, selected), and 2.0 (bottom) times the local standard deviation. Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



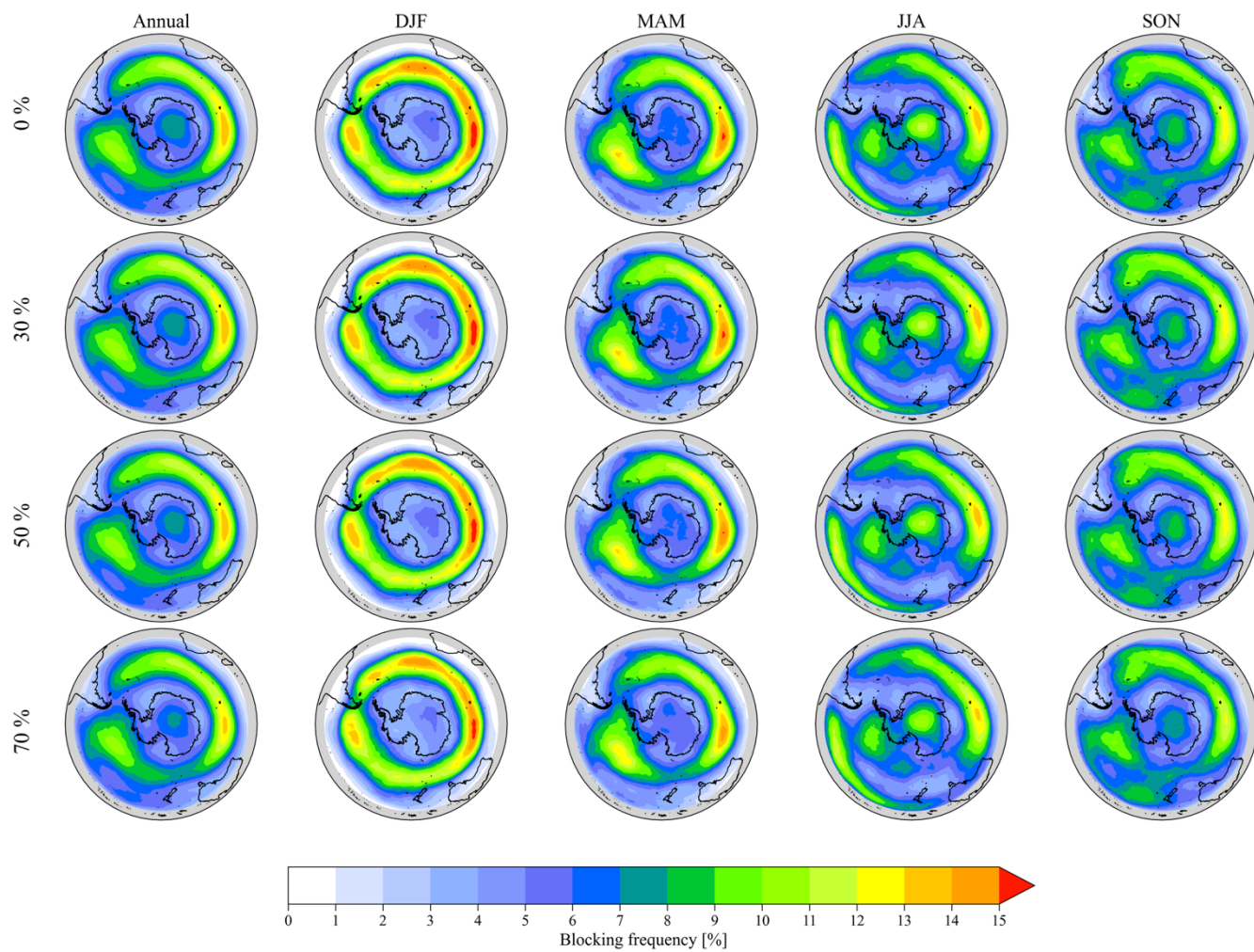
135 **Figure S9: Annual and seasonal blocking frequency (%) from the Z500-SD method for minimum area filters of $0.5 \times 10^6 \text{ km}^2$ (top) and $1.0 \times 10^6 \text{ km}^2$ (bottom). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



140 **Figure S10: Annual and seasonal blocking frequency (%) from the PV-SD method for minimum area filters of $0.5 \times 10^6 \text{ km}^2$ (top) and $1.0 \times 10^6 \text{ km}^2$ (bottom). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



145 **Figure S11: Annual and seasonal blocking frequency (%) from the Z500-Grad method using four minimum overlap fractions between consecutive time steps: 0% (top), 30%, 50%, and 70% (bottom). Columns show annual, DJF, MAM, JJA, and SON means for 1979 to 2024. Regions shown in gray correspond to latitudes where blocking detection is not applied.**



150 **Figure S12: Same as Fig. S11 but for Z500-SD.**

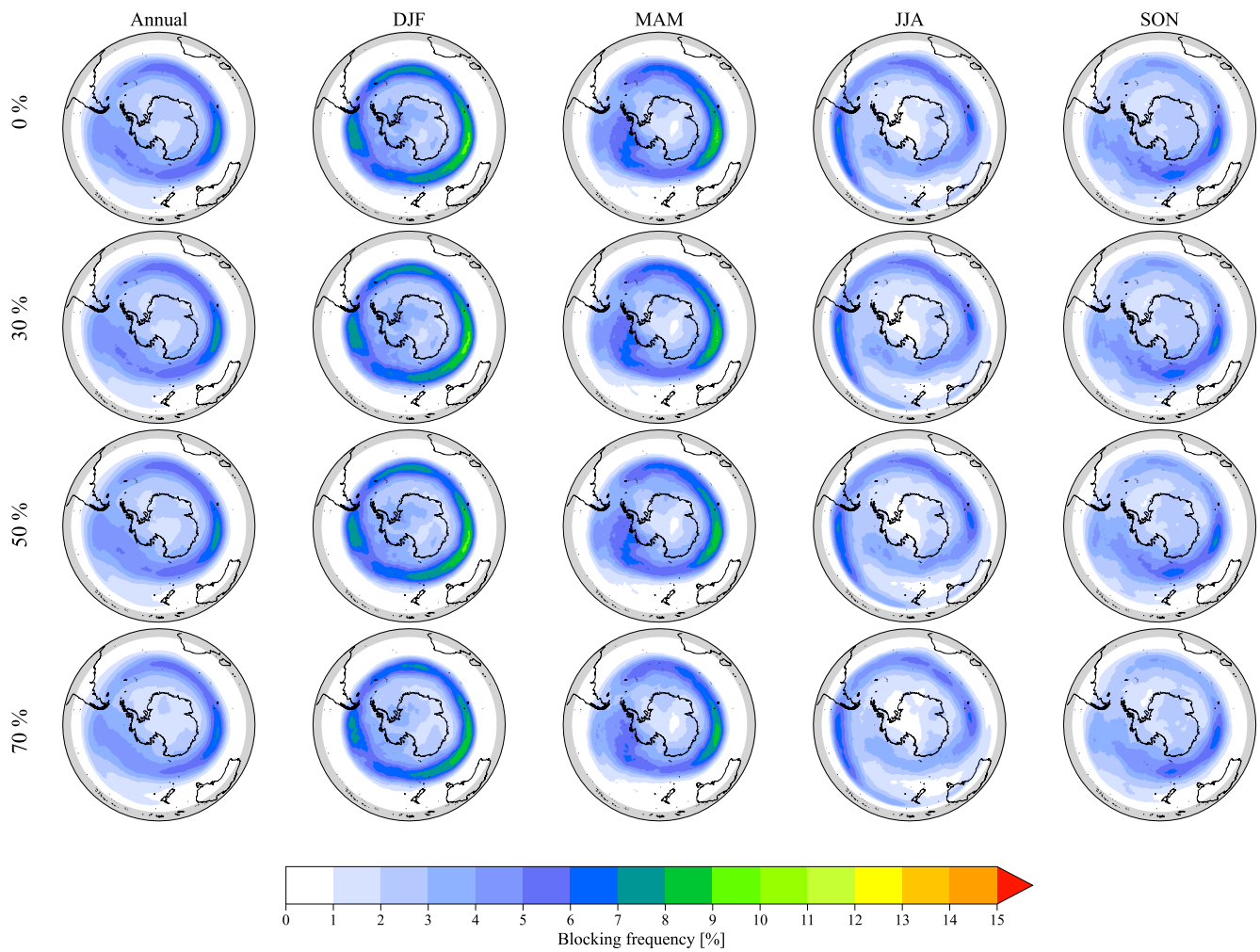


Figure S13: Same as Fig. S11 but for PV-SD.

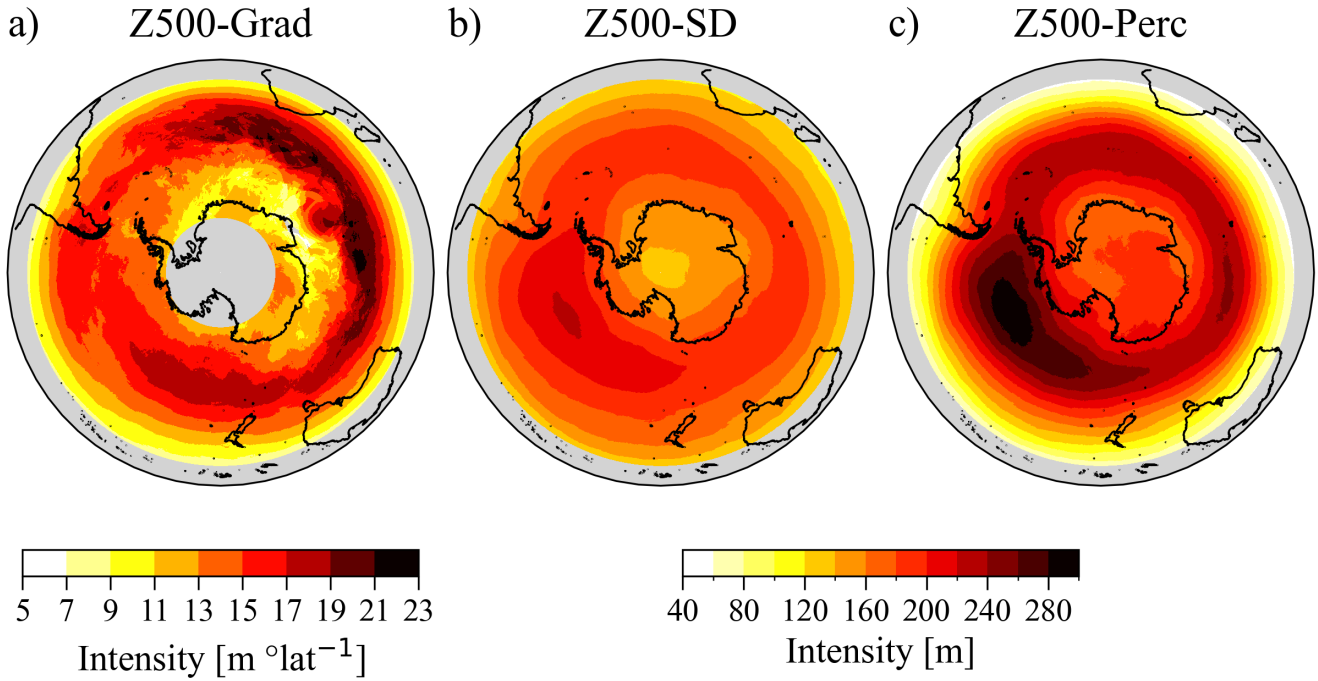


Figure S14: Annual climatology of blocking intensity derived from Z500-based detection methods. Panels a) to c) show the mean blocking intensity for Z500 gradient (Z500-Grad), Z500 standard deviation-based anomaly (Z500-SD), and Z500 percentile-based anomaly (Z500-Perc), respectively. Intensity is defined following the native formulation of each method, with units indicated in the color bars. Regions shown in gray correspond to latitudes where blocking detection is not applied.

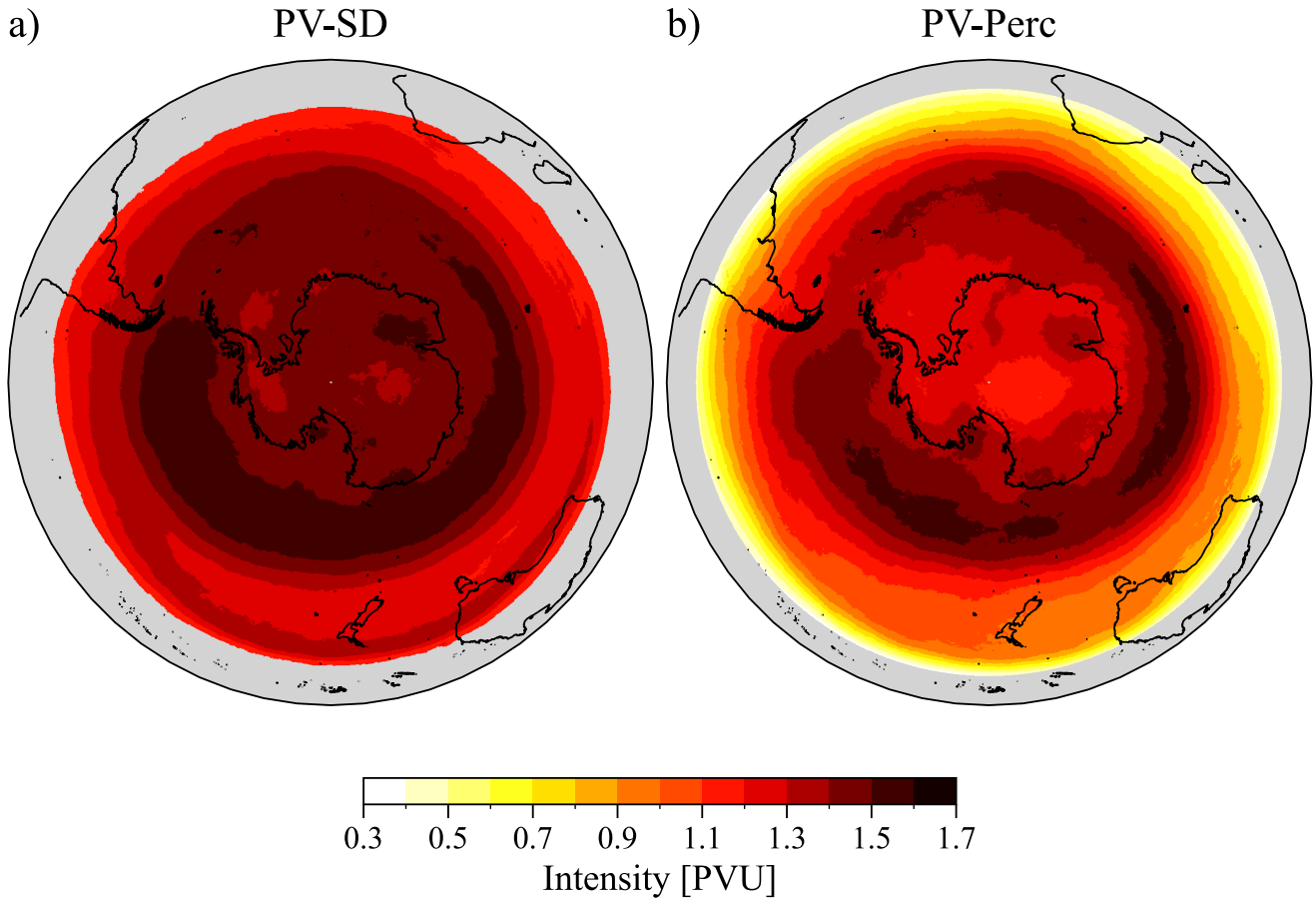
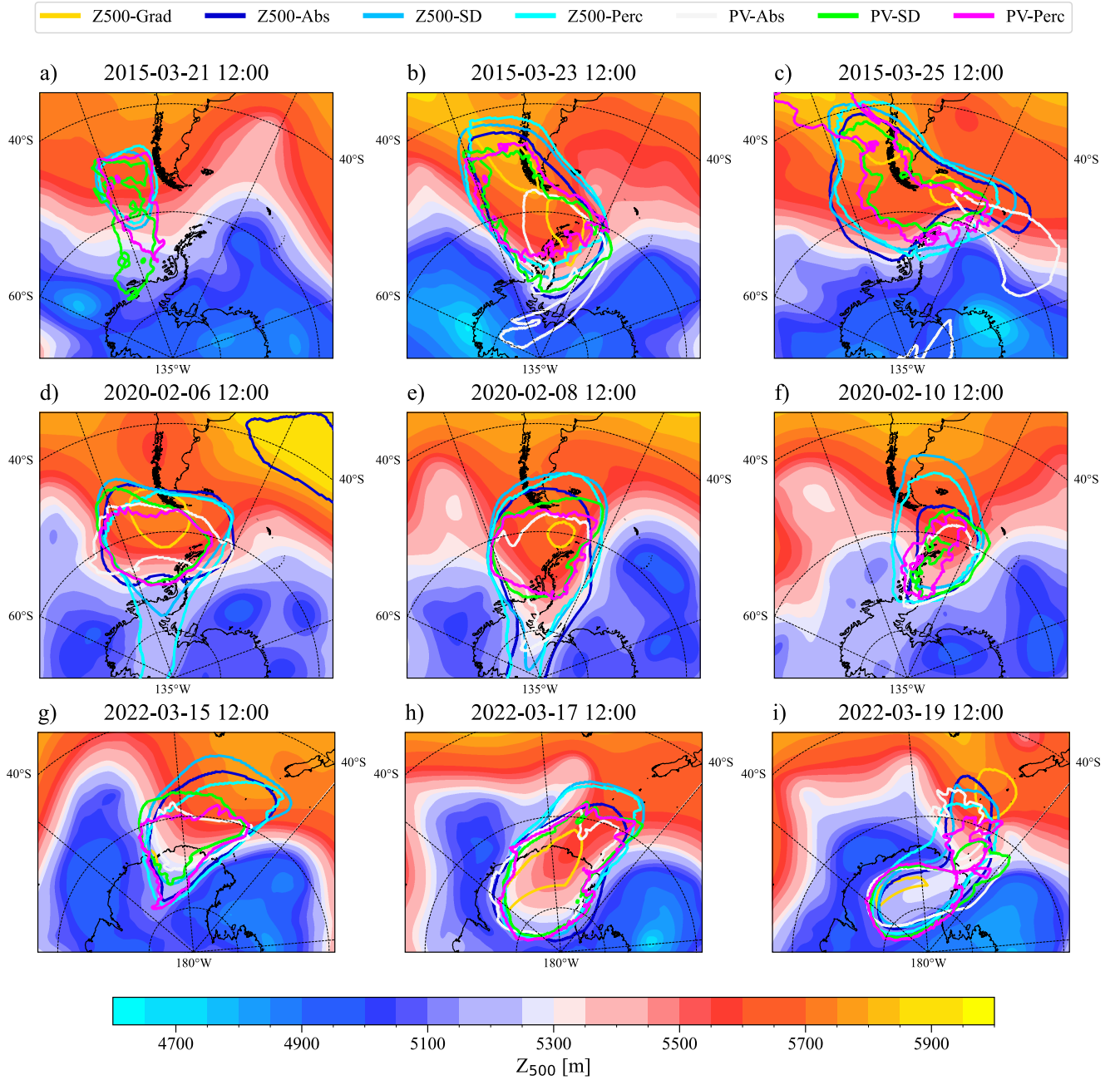


Figure S15: Annual climatology of blocking intensity derived from PV-based detection methods. Panels a) and b) show the mean blocking intensity for the standard deviation–based anomaly method (PV-SD) and the percentile-based anomaly method (PV-Perc), respectively. Intensity is expressed in potential vorticity units (PVU), as indicated by the color bar. Regions shown in gray correspond to latitudes where blocking detection is not applied.

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170 **Figure S16: Comparison of blocking events detected by different methodologies for three representative cases, shown prior to the application of any areal filtering. Panels a) to c) show the evolution of a blocking event in March 2015 over the Antarctic Peninsula, panels d) to f) show a blocking event in February 2020 over the Antarctic Peninsula, and panels g) to i) show a blocking event in March 2022 over East Antarctica. Colored contours indicate blocking regions detected by each method, as identified in the legend. Background color corresponds to 500 hPa geopotential height.**