Supporting information/Supplementary

The discrepancies found in the NSIDC datasets compared to our previous study (Burada et al., 2023) revealed advantages and disadvantages of all three datasets (NSIDC, AMSRE/2, Sentinel-1), leading to the selection of AMSRE/2. As shown in the figure below, coastal pixel contamination (middle row) results in an overestimation of low-concentration sea-ice pixels. Despite some limitations, AMSRE/2 is preferred over Sentinel-1 for understanding links to large-scale circulation variability, given its continous longer time period.

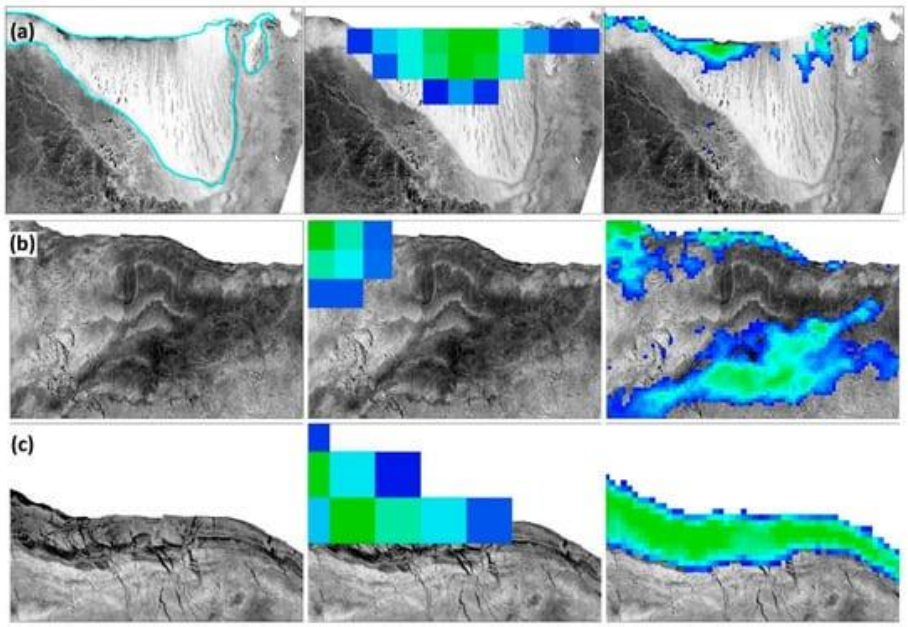

Figure S1: Adapted from (Burada et al., 2023). All the background figures are of processed Sentinel-1. Cases of underestimation and overestimation of RSP (left column represents the manually delineated result) as referenced in cyan (no markings when there are no active polynyas) from S1. Middle column images represent the result from NSIDC, rightmost is the result of AMSR2 with processed S1 in the background. Concentration of green to blue represents low to high concentrations. Dates of scenes displayed (a) 25 July 2020, (b) 10 September 2018, and (c) 18 September 2017

Significance test for EOF analysis on SIC:

We assessed the uniqueness of EOF modes (a significance test) through assumptions of error on singular values as described by North et al (1982). Overlapping error limits between neighbouring Lambda values indicates a possible mixture of signals, as in modes 2 and 3. Yet, the spatial patterns indicate physically meaningful patterns, therefore both the modes are considered for further analysis.

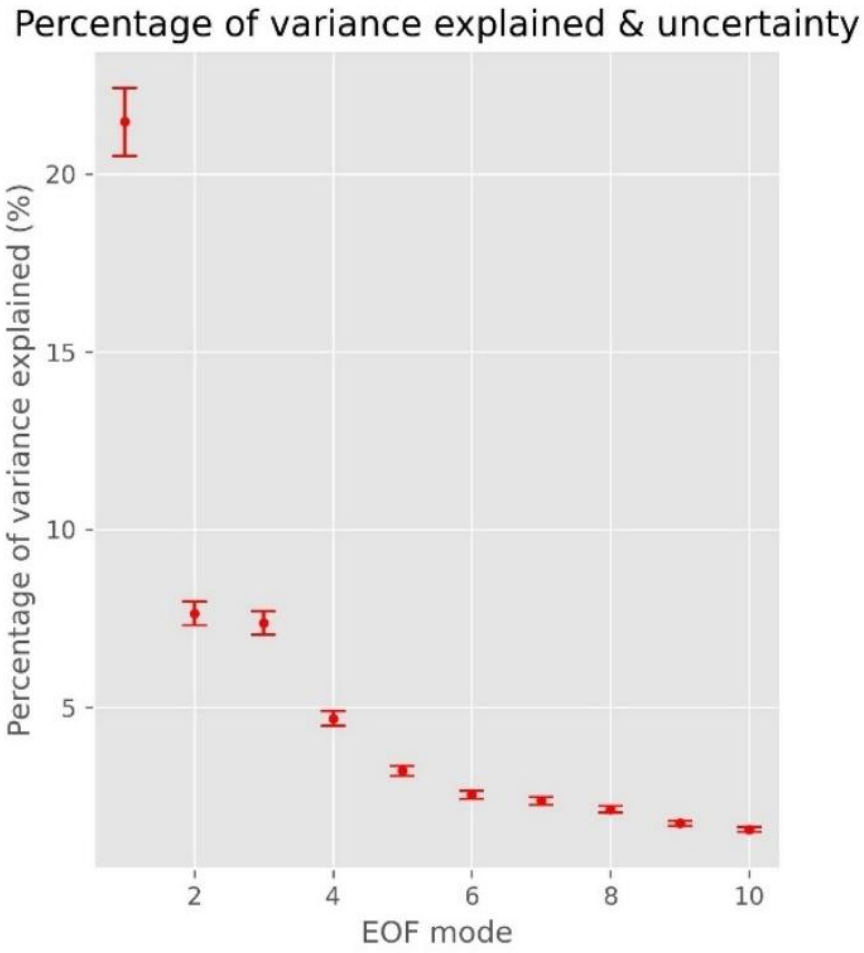

Figure S2: Significance test using North's Rule of Thumb (North et al., 1982) for measuring the uncertainty of modes

Rotated EOFs for SIC:

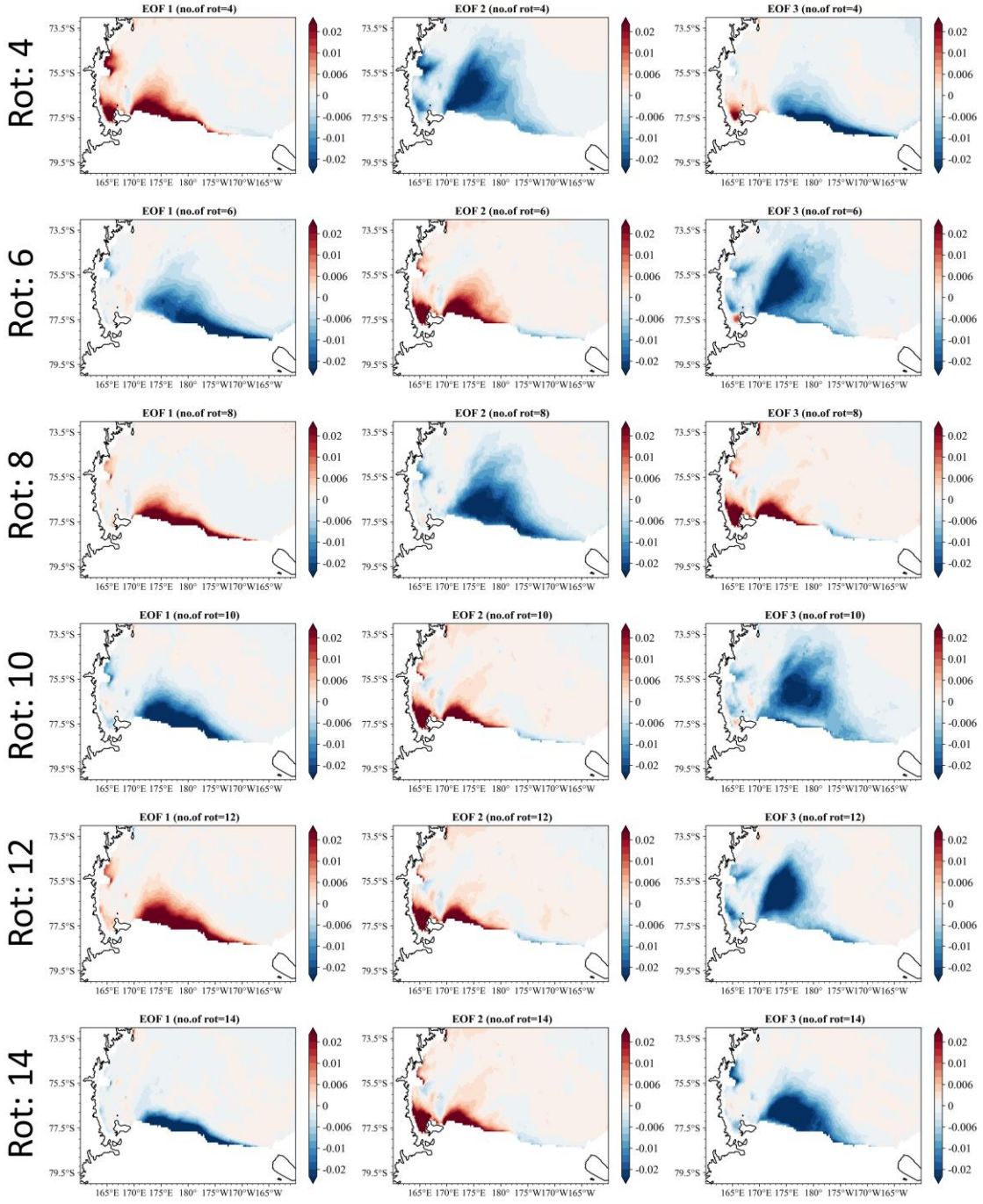

Figure S3: Leading three rotated (Varimax Rotation applied) EOFs for a range of dimensions from 4 to 14 on the SIC variable used in the study

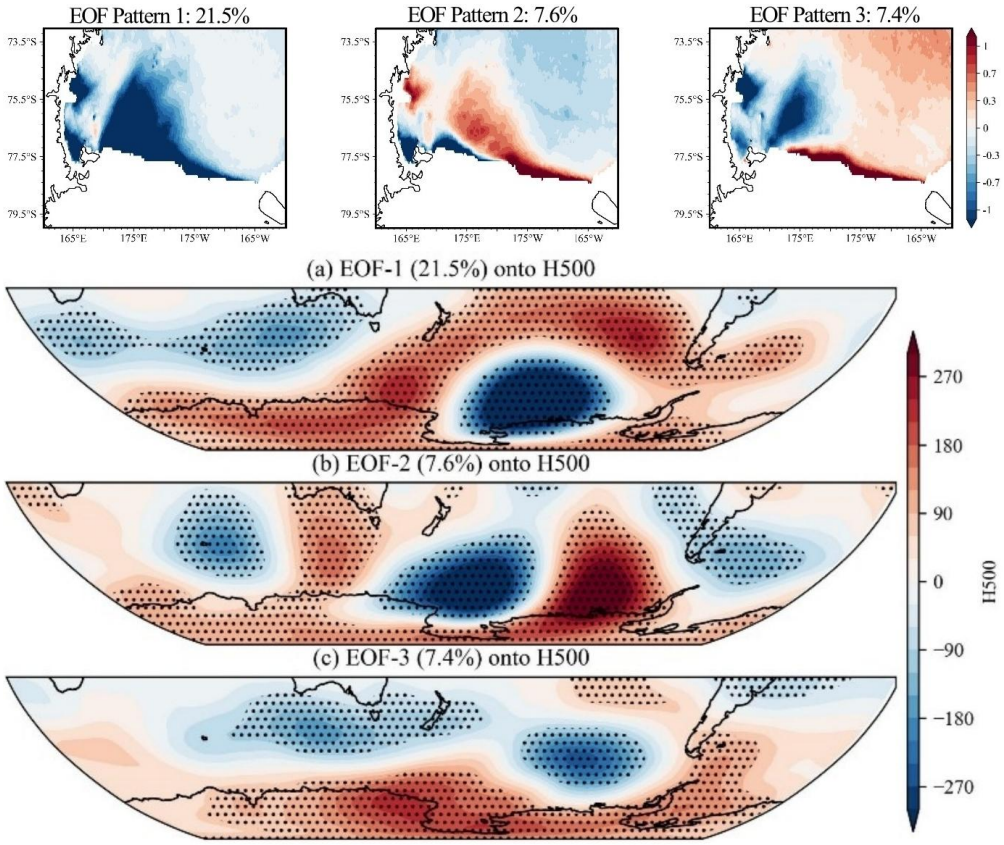

Figure S4: Regression of the first three PCs of SIC (proxy for polynyas on the top row) onto the H500 of West Antarctica

MCA analysis between Wind Vectors (surface winds at 10m) with Extreme Wind patterns:

Large scale-scale wind vectors at surface level with ExWinds

Table 1: Correlations of PCs of Extreme Winds from MCA of SIC/ExWinds in figure 3 (main article) with PCs of Large-scale wind vectors in Figure S5 Winds from MCA of Wind vectors over West Antarctica and ExWinds (over same domain)

PCs of Extreme Winds (SIC/ExWin, Figure 3) and PCs of Wind Vectors (ExWin/Wind Vectors, Figure S5)	Correlation Coefficient
PC1	0.83
PC2	0.67
PC3	0.56