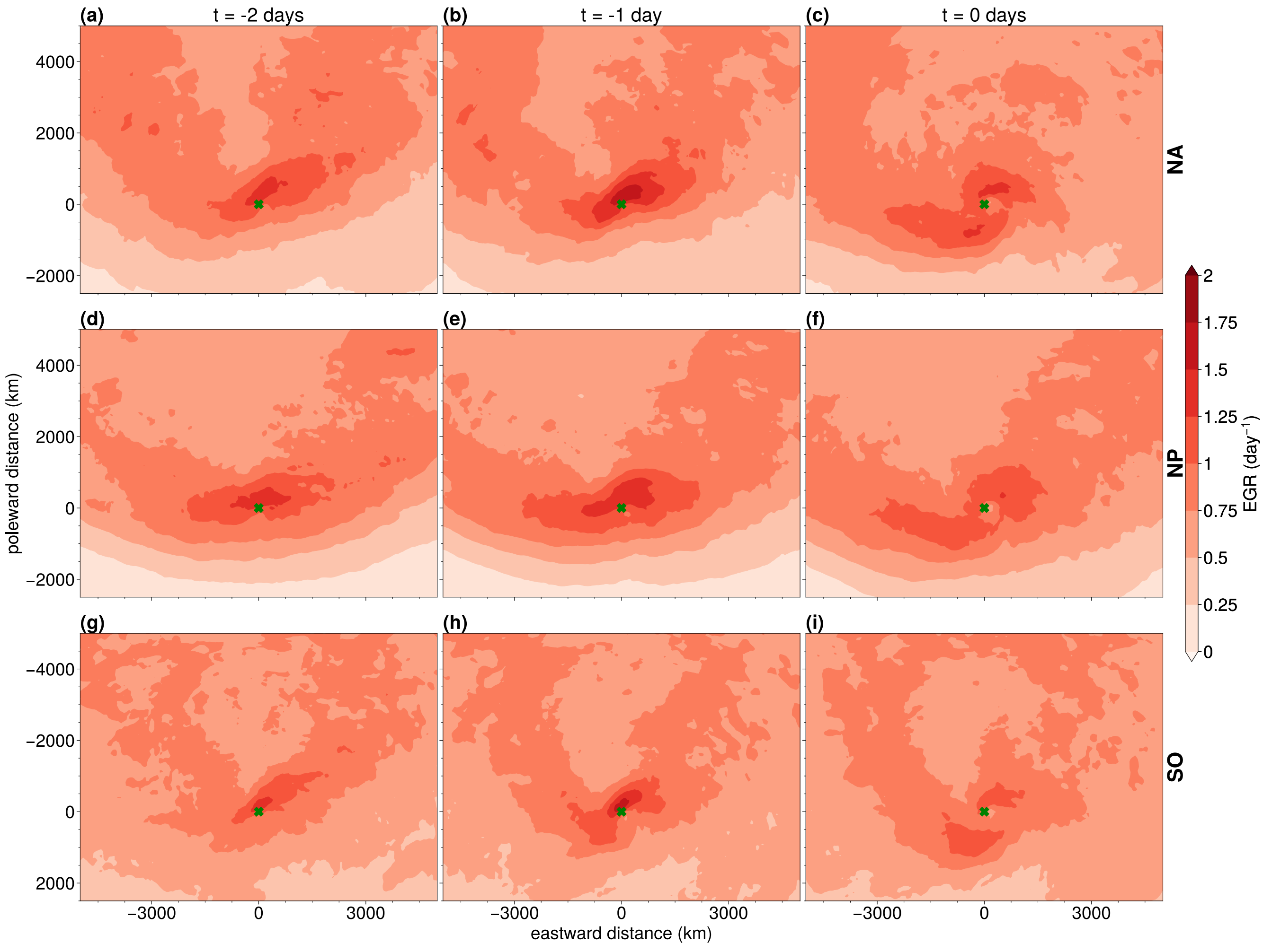

Figure S1. Composites of mid-tropospheric EGRs for top 100 extremes in the NA (a-c), NP (d-f) and SO (g-i) centered on the cyclone locations from $t = -2$ days to $t = 0$ days. Green crosses have the same meaning as in Figures 2, 3.

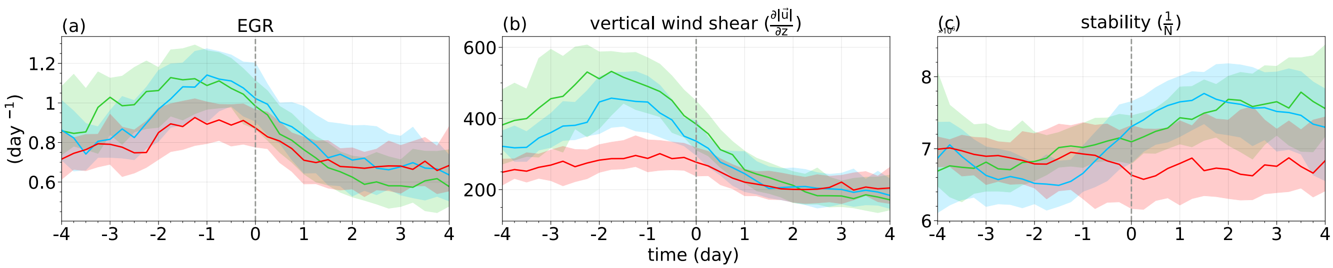

Figure S2. Time-evolution of median values in the 1000-km footprint around top 100 extremes of mid-troposhperic Eady growth rate (a), and contributions to it from the vertical wind shear (b) and stability terms (c). Shading in (a-c) shows the area between 25th and 75th percentiles.

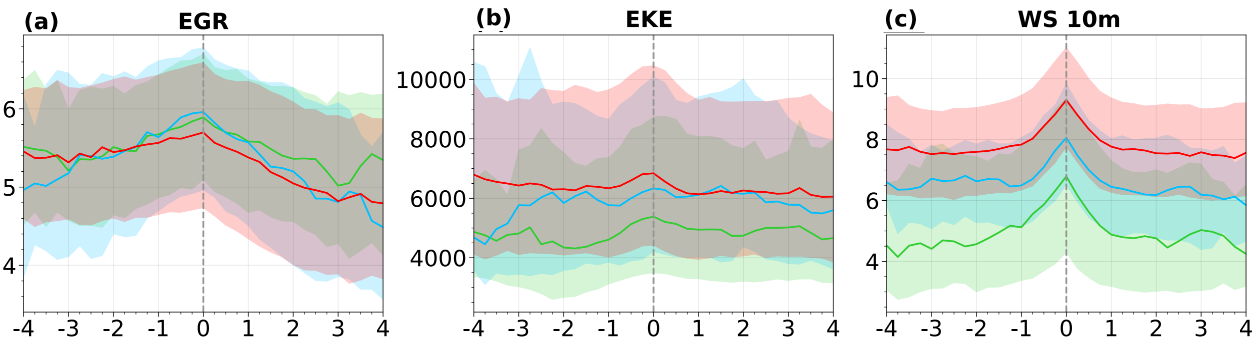

Figure S3. Time-evolution of median values of mid-troposhperic Eady growth rate (a), vertically integrated eddy kinetic energy (b) and 10-w wind speed (c) in the 1000-km footprint around winter cyclones where the maximum EGR during their life-cycle is restricted to be 30 % lower than that of top 100 extremes. Shading in (a-c) shows the area between 25th and 75th percentiles.

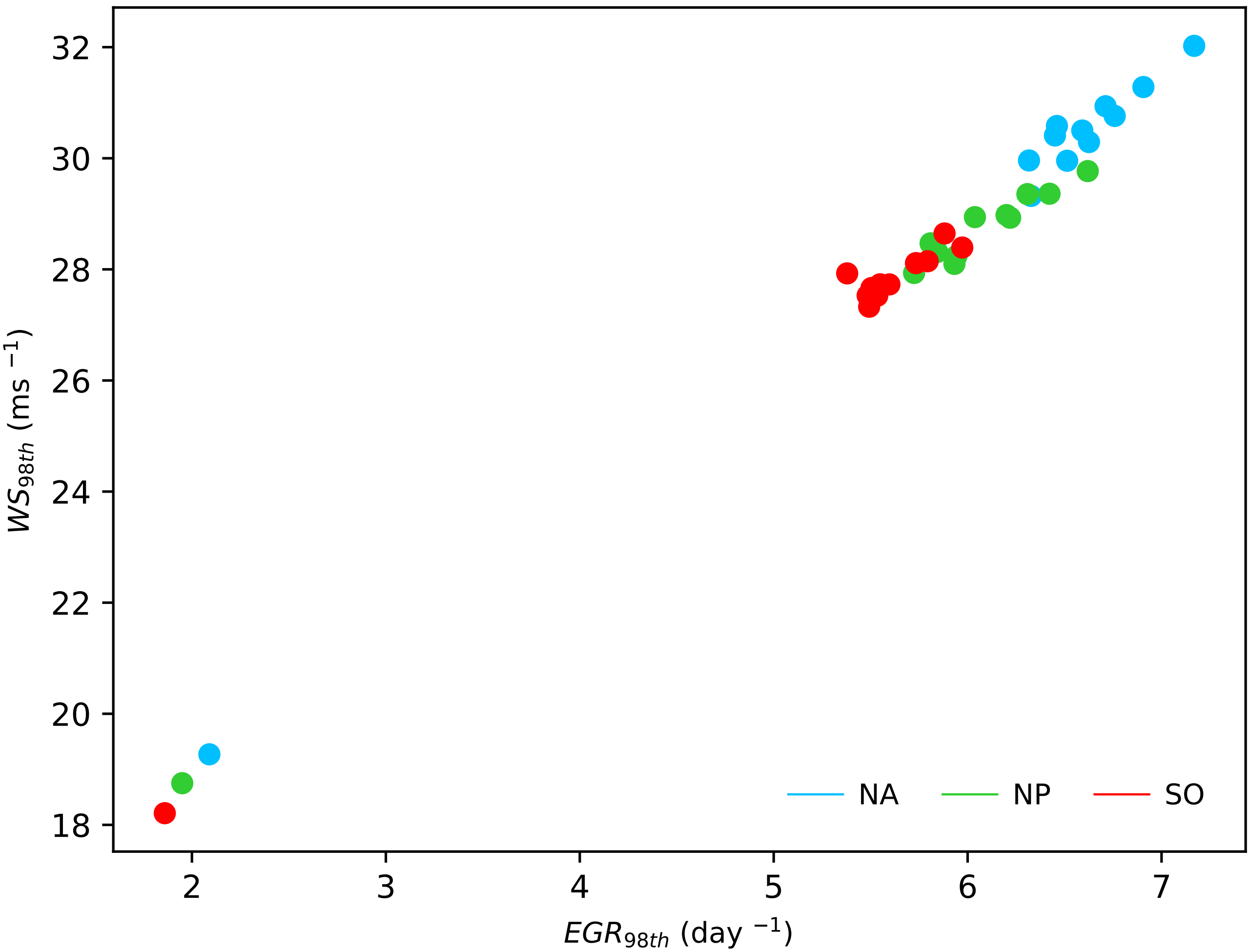

Figure S4. Scatterplot of winter basin-wide 98th percentiles of near-surface wind speed (y-axis) versus winter basin-wide 98th percentiles of mid-tropospheric Eady growth rates (x-axis) across 11 different ISCA experiments (upper-right corner) and ERA5 (lower-left corner). Different colors represent different basins (same colors as in Fig. 1c, 4, 5a)

experiments	SSTs	orography
1 (Full)	climatological	full
2	climatological	flat
3	zonalized across midlatitudes	full
4	zonalized across midlatitudes	flat
5	zonalized across tropics	full
6	zonalized across tropics	flat
7	zonalized across midlatitudes	full + flat Greenland
8	zonalized across midlatitudes	full + no Greenland
9 (ZonalSSTs)	zonalized everywhere	full
10	zonalized everywhere + hem. symmetrized	full
11 (HemSymFlat)	zonalized everywhere + hem. symmetrized	flat

Table S1. Descriptions of experiments run with ISCA used to produce scatterplot in Fig. 6. The experiments selected for the analysis in manuscript have their names in the parentheses next to the experiment numbers.

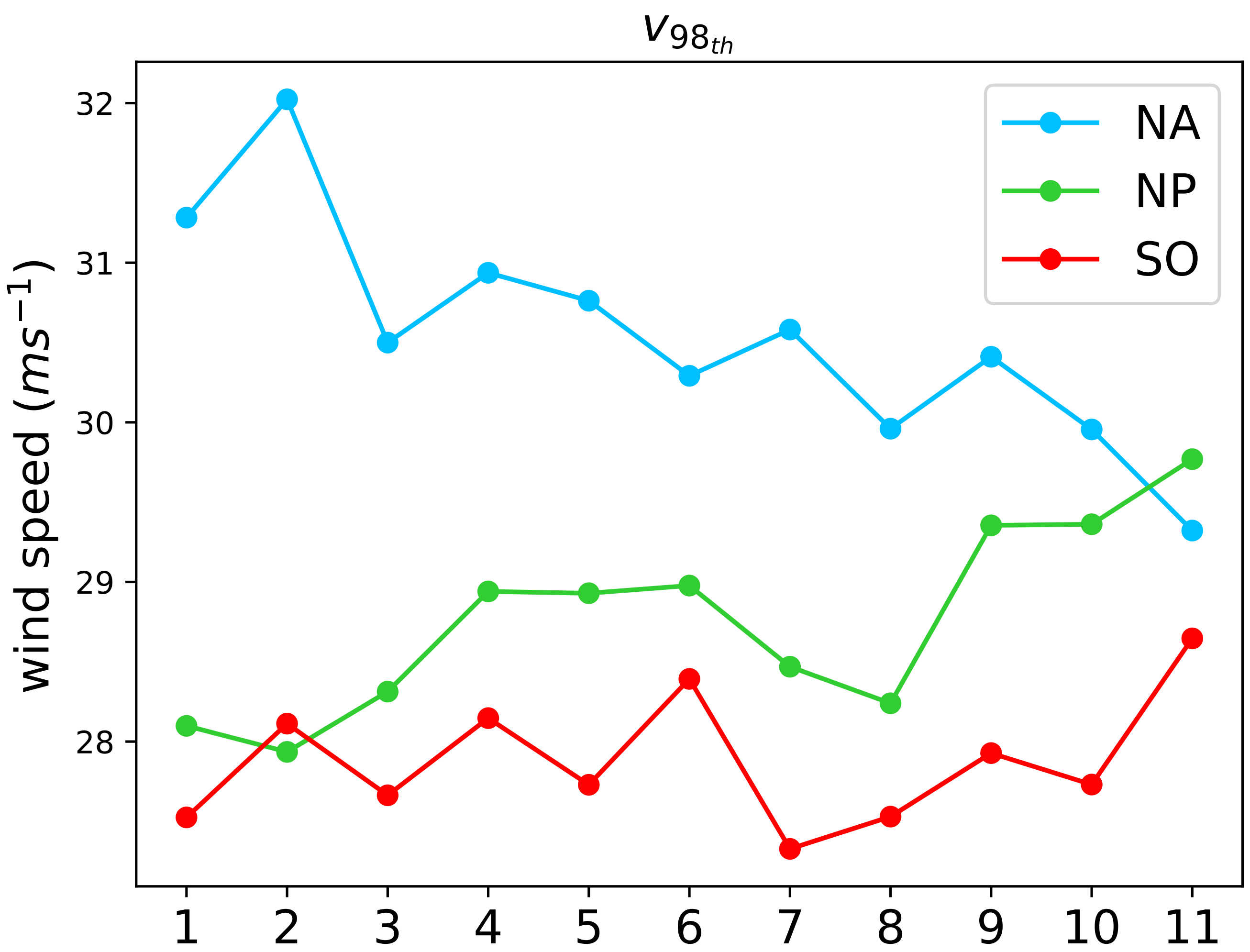

Figure S5. Winter basin-wide 98th percentiles of near-surface wind speed (y-axis) across 11 different ISCA experiment runs used to produce scatterplot in Fig. 6. Numbers on x-axis correspond to the experiments named in Table S1. Among other things, a consideration of the experiments that are not further analyzed in Fig. 7 shows strong nonlinear response to the flattening of orography. For example, flattening orography while SSTs keep the climatological distribution (experiment 2) does not reduce the asymmetry between the North Atlantic and the Southern Ocean. Moreover, the winter basin-wide 98th percentiles in the North Atlantic and North Pacific have the opposite response to flat orography when SSTs have climatological distribution (experiment 2) compared to the case when SSTs are zonalized (experiment 11 - HemSymFlat). It could also be interesting to point out that, once the SSTs are zonalized across midlatitudes (experiment 3), the 98th percentile in the North Atlantic is not heavily influenced by the presence of orography on Greenland (experiment 7) or the existence of Greenland (experiment 8) in ISCA model.