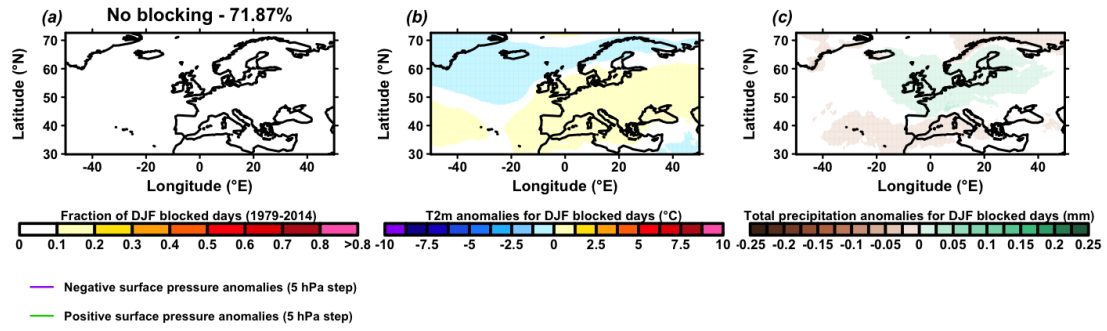
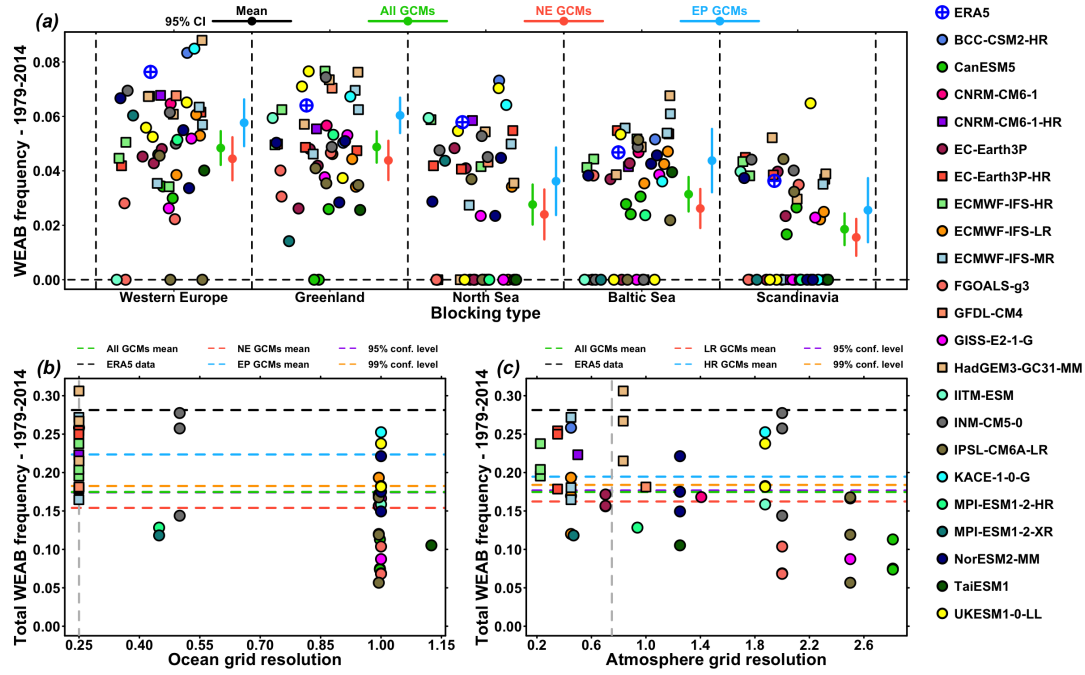


Supplementary Figures for "Increased wintertime European
atmospheric blocking frequencies in General Circulation
Models with an eddy-permitting ocean" from Michel et al.

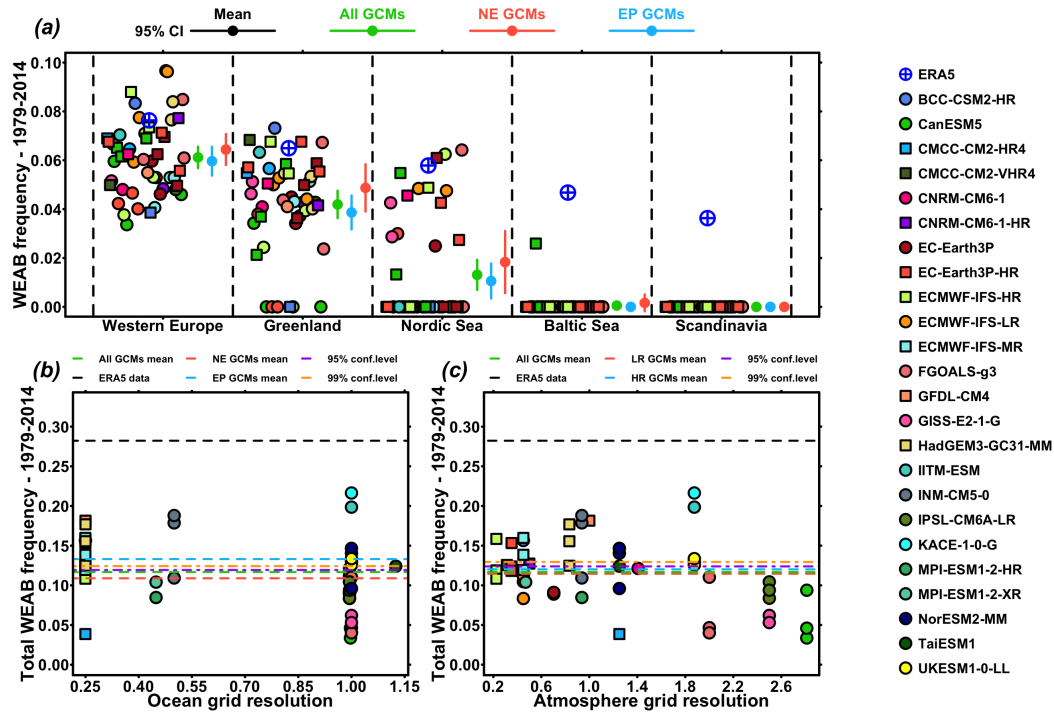
April 3, 2023



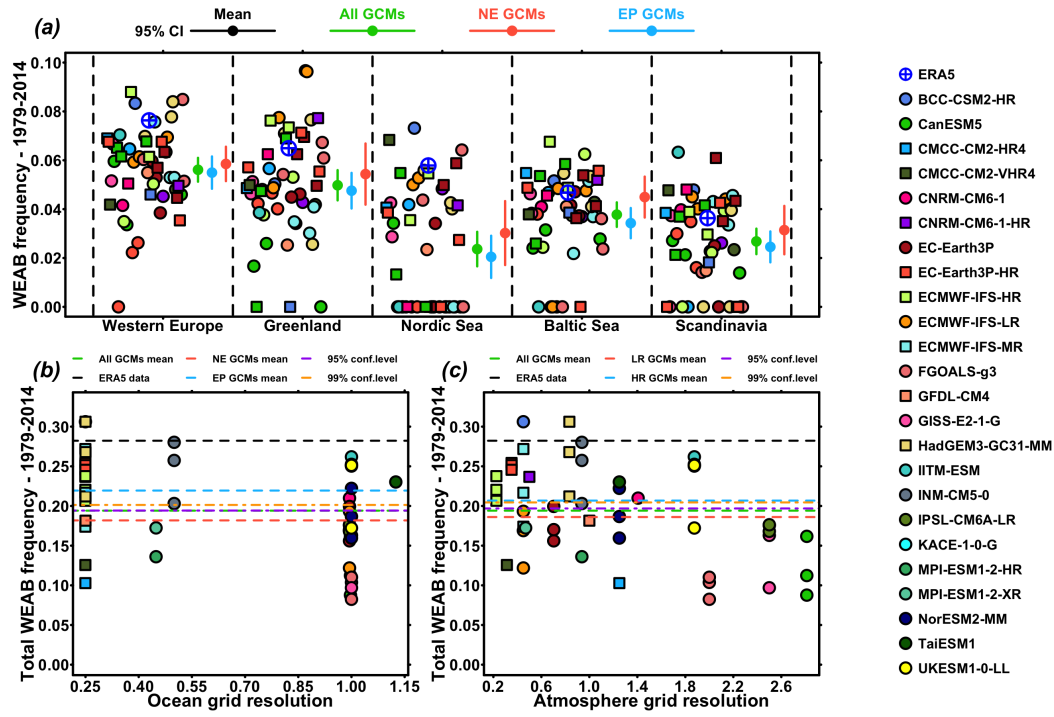
Supplementary Figure 1: Blocking frequencies and climate fingerprints for the non-blocking situation. Same as Fig. 1, but for the "non-blocking" situation. Of note, no averaged blocking frequencies appear on (a) (only white colors) since the highest only reaches the color scale returns other colors than white for blocking frequencies exceeding 10%. In the same way no surface pressure contour line appear since averaged anomalies range between -4.46 hPa and 1.47 hPa.



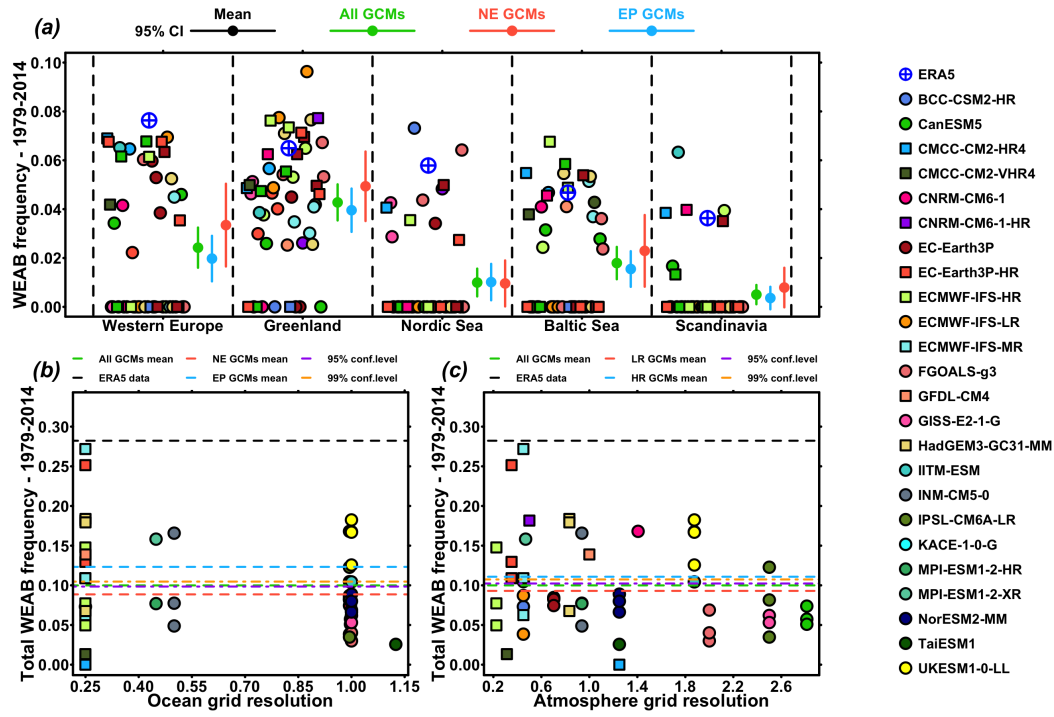
Supplementary Figure 2: Same as Fig. 3 but with excluding CMCC outliers (*i.e.*, CMCC-CM2-HR4 and CMCC-CM2-VHR4). (a) WEAB frequencies calculated from ERA5 reanalysis (blue target) data and 47 historical simulations from 22 CMIP6 GCMs (other symbols) for each of the 5 main blocking types clustered by the *k-means* algorithm. Green, red, and blue dots on the right side indicate the average of the GCM ensemble, GCMs with no-eddy (NE) ocean grids, and GCMs with eddy-premitting (EP) ocean grids, respectively. Each line crossing these points on the right side give the respective 95% confidence intervals. The same black-colored ensemble of symbols shown at the top-left schematizes the statistics they give (Mean and 95% confidence interval, CI). (b) Total frequencies of clustered WEABs plotted against zonal ocean grid resolution at the Equator for the 47 simulations from the 22 GCMs. Vertical dashed grey line indicates the resolution at which GCMs have EP ocean grid resolutions. Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with EP (resp. NE) ocean grid resolutions. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 16 NE GCMs, respectively. (c) Total frequencies of clustered WEABs plotted against zonal atmospheric grid resolution at the Equator for the 47 simulations from the 22 GCMs. Vertical grey dashed line indicates the resolution at which GCMs have high-resolution atmosphere (0.75°). Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with high-resolution (resp. low-resolution) atmospheric grids. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 29 GCMs with low-resolution (LR) atmosphere, respectively. In (a-c), circles indicate GCMs with NE ocean resolution whereas squares indicate GCMs with EP ocean resolution.



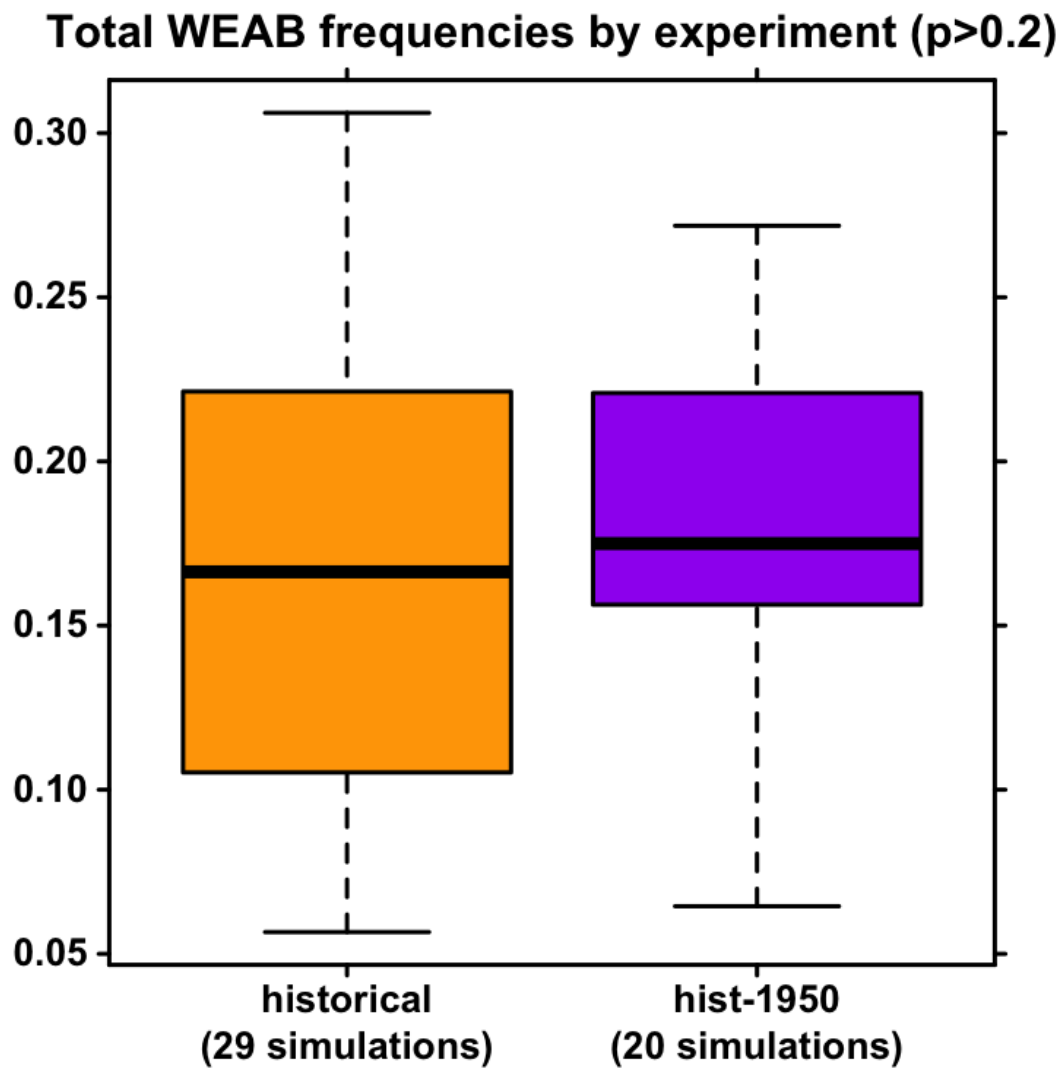
Supplementary Figure 3: Same as Fig. 3 but with correlation test for Western European Atmospheric Blocking (WEAB) attribution. (a) WEAB frequencies calculated from ERA5 reanalysis (blue target) data and 49 historical simulations from 24 CMIP6 GCMs (other symbols) for each of the 5 main blocking types clustered by the *k-means* algorithm. Green, red, and blue dots on the right side indicate the average of the GCM ensemble, GCMs with no-eddy (NE) ocean grids, and GCMs with eddy-premitting (EP) ocean grids, respectively. Each line crossing these points on the right side give the respective 95% confidence intervals. The same black-colored ensemble of symbols shown at the top-left schematizes the statistics they give (Mean and 95% confidence interval, CI). (b) Total frequencies of clustered WEABs plotted against zonal ocean grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical dashed grey line indicates the resolution at which GCMs have EP ocean grid resolutions. Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with EP (resp. NE) ocean grid resolutions. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 16 NE GCMs, respectively. (c) Total frequencies of clustered WEABs plotted against zonal atmospheric grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical grey dashed line indicates the resolution at which GCMs have high-resolution atmosphere (0.75°). Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with high-resolution (resp. low-resolution) atmospheric grids. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 30 GCMs with low-resolution (LR) atmosphere, respectively. In (a-c), circles indicate GCMs with NE ocean resolution whereas squares indicate GCMs with EP ocean resolution.



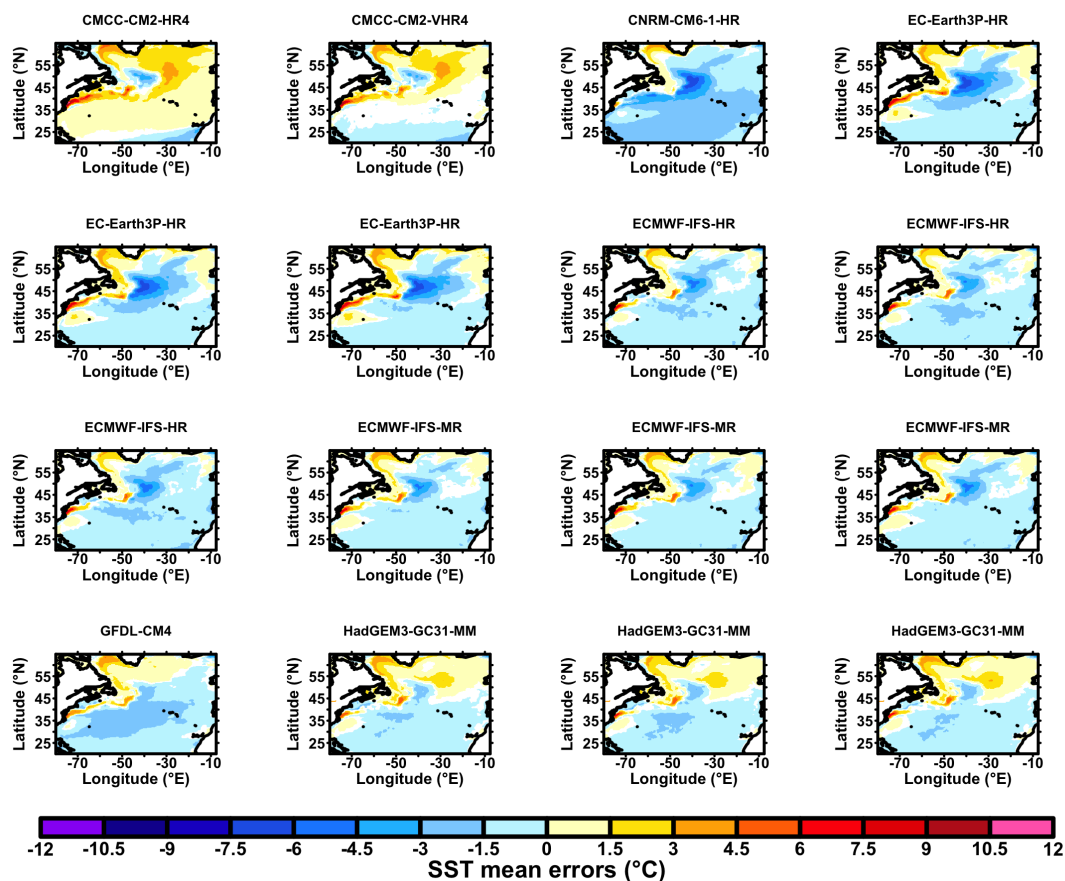
Supplementary Figure 4: Same as Fig. 3 with a threshold of spatial correlations of 0.2 for Western European Atmospheric Blocking (WEAB) attribution. (a) WEAB frequencies calculated from ERA5 reanalysis (blue target) data and 49 historical simulations from 24 CMIP6 GCMs (other symbols) for each of the 5 main blocking types clustered by the *k-means* algorithm. Green, red, and blue dots on the right side indicate the average of the GCM ensemble, GCMs with no-eddy (NE) ocean grids, and GCMs with eddy-premitting (EP) ocean grids, respectively. Each line crossing these points on the right side give the respective 95% confidence intervals. The same black-colored ensemble of symbols shown at the top-left schematizes the statistics they give (Mean and 95% confidence interval, CI). (b) Total frequencies of clustered WEABs plotted against zonal ocean grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical dashed grey line indicates the resolution at which GCMs have EP ocean grid resolutions. Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with EP (resp. NE) ocean grid resolutions. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 16 NE GCMs, respectively. (c) Total frequencies of clustered WEABs plotted against zonal atmospheric grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical grey dashed line indicates the resolution at which GCMs have high-resolution atmosphere (0.75°). Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with high-resolution (resp. low-resolution) atmospheric grids. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 30 GCMs with low-resolution (LR) atmosphere, respectively. In (a-c), circles indicate GCMs with NE ocean resolution whereas squares indicate GCMs with EP ocean resolution.



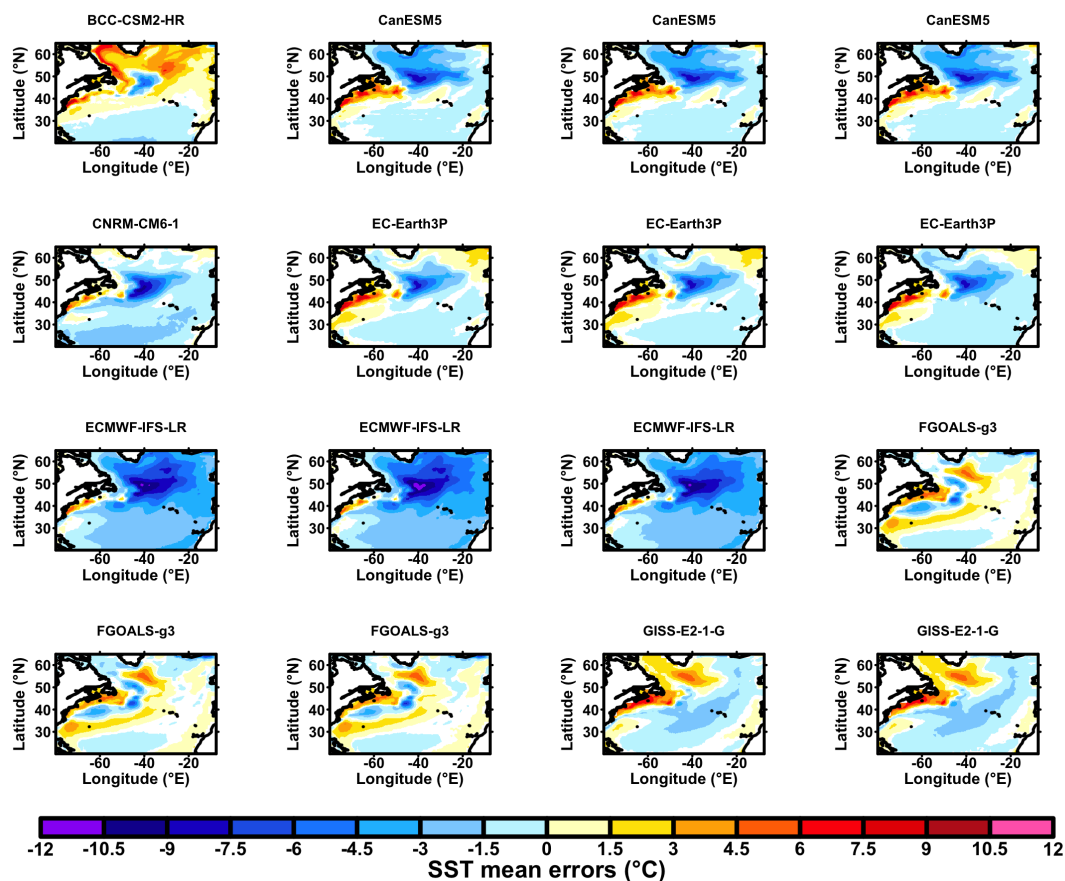
Supplementary Figure 5: Same as Fig. 3 with a threshold of spatial correlations of 0.8 for Western European Atmospheric Blocking (WEAB) attribution. (a) WEAB frequencies calculated from ERA5 reanalysis (blue target) data and 49 historical simulations from 24 CMIP6 GCMs (other symbols) for each of the 5 main blocking types clustered by the *k-means* algorithm. Green, red, and blue dots on the right side indicate the average of the GCM ensemble, GCMs with no-eddy (NE) ocean grids, and GCMs with eddy-premitting (EP) ocean grids, respectively. Each line crossing these points on the right side give the respective 95% confidence intervals. The same black-colored ensemble of symbols shown at the top-left schematizes the statistics they give (Mean and 95% confidence interval, CI). (b) Total frequencies of clustered WEABs plotted against zonal ocean grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical dashed grey line indicates the resolution at which GCMs have EP ocean grid resolutions. Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with EP (resp. NE) ocean grid resolutions. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 16 NE GCMs, respectively. (c) Total frequencies of clustered WEABs plotted against zonal atmospheric grid resolution at the Equator for the 49 simulations from the 24 GCMs. Vertical grey dashed line indicates the resolution at which GCMs have high-resolution atmosphere (0.75°). Horizontal black dashed line indicates the total WEAB frequencies for ERA5. Horizontal blue (resp. red) dashed line indicates the average of total WEAB frequencies for GCMs with high-resolution (resp. low-resolution) atmospheric grids. Horizontal green dashed line indicates the average of total WEAB frequencies for all GCMs. Horizontal purple and orange dashed lines indicate 95% and 99% confidence levels calculated as the percentiles of total blocking frequencies obtained from 5000 random Monte-Carlo samples of 30 GCMs with low-resolution (LR) atmosphere, respectively. In (a-c), circles indicate GCMs with NE ocean resolution whereas squares indicate GCMs with EP ocean resolution.



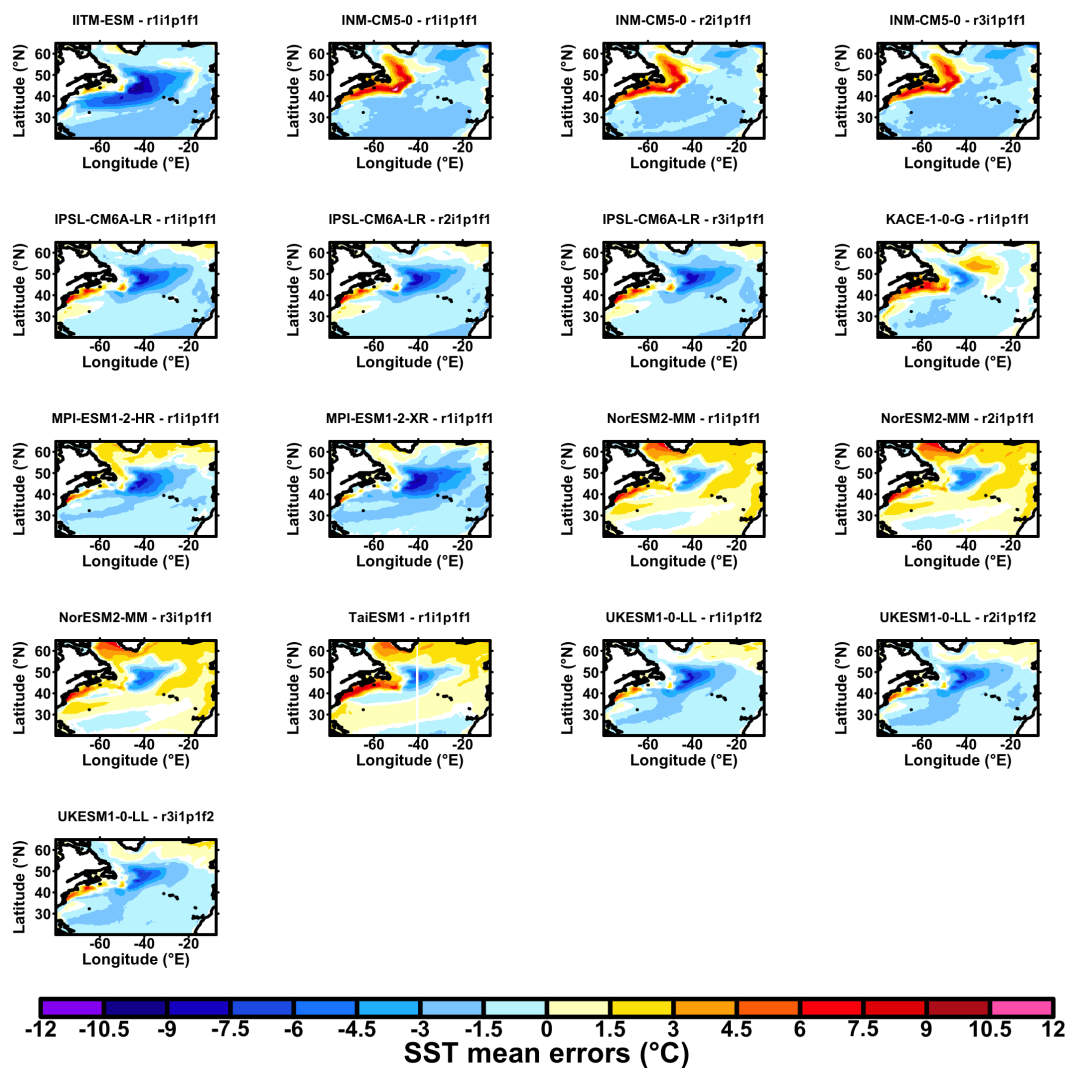
Supplementary Figure 6: Comparison of total Western European Atmospheric Blocking (WEAB) frequencies for historical simulations (orange, 29 simulations) and hist-1950 historical simulations (purple, 20 simulations). For boxplots, the median is shown as a heavy darkline, edges give first and third quartiles, and “whiskers” gives the full range of distributions.



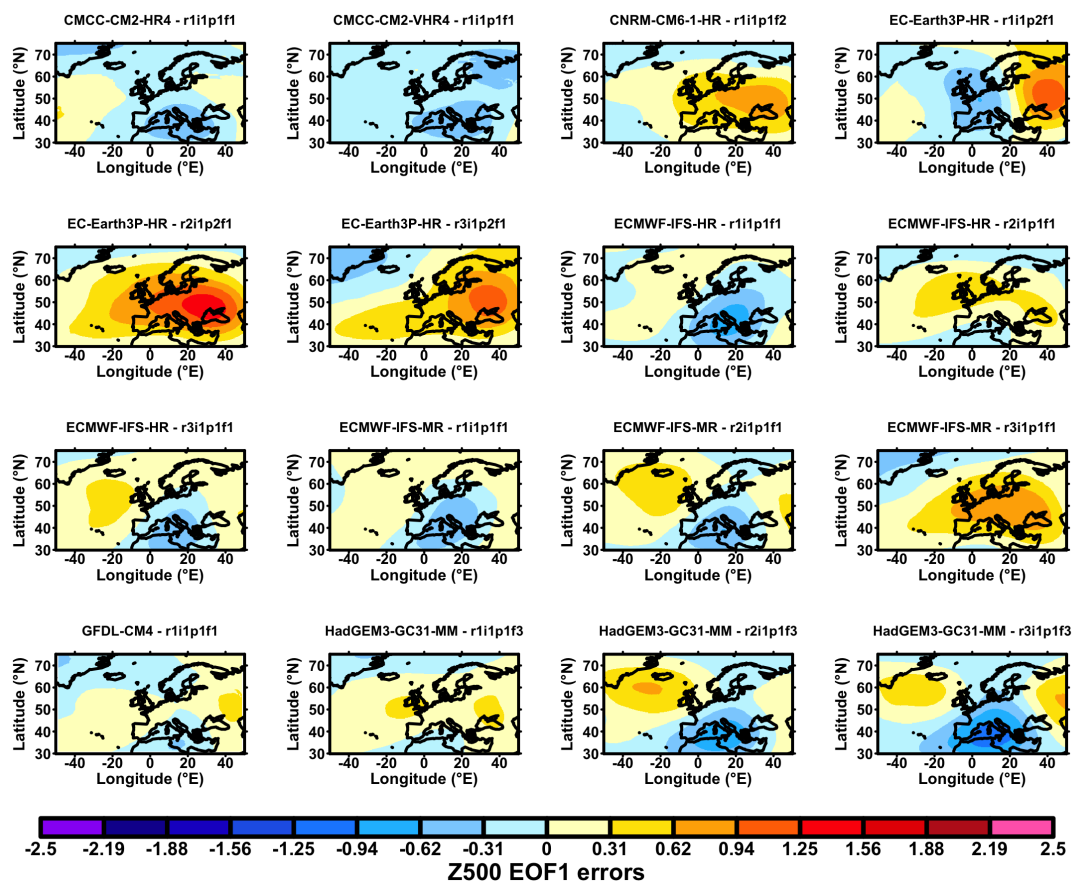
Supplementary Figure 7: Mean errors of sea surface temperatures (in °C) for eddy-permitting (EP) GCMs. White grid points indicate that the bias is not significant at the 95% confidence level.



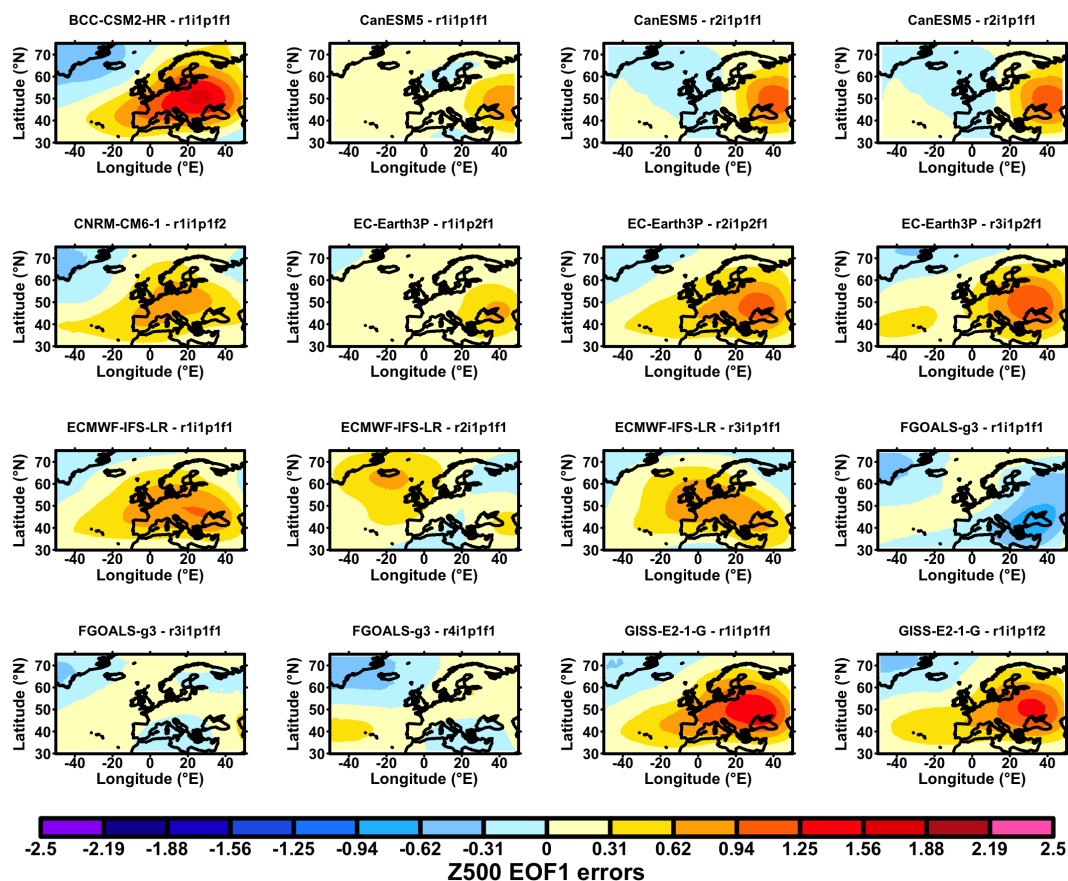
Supplementary Figure 8: Mean errors of sea surface temperatures (in °C) for no-eddy (NE) GCMs (part 1). White grid points indicate that the bias is not significant at the 95% confidence level.



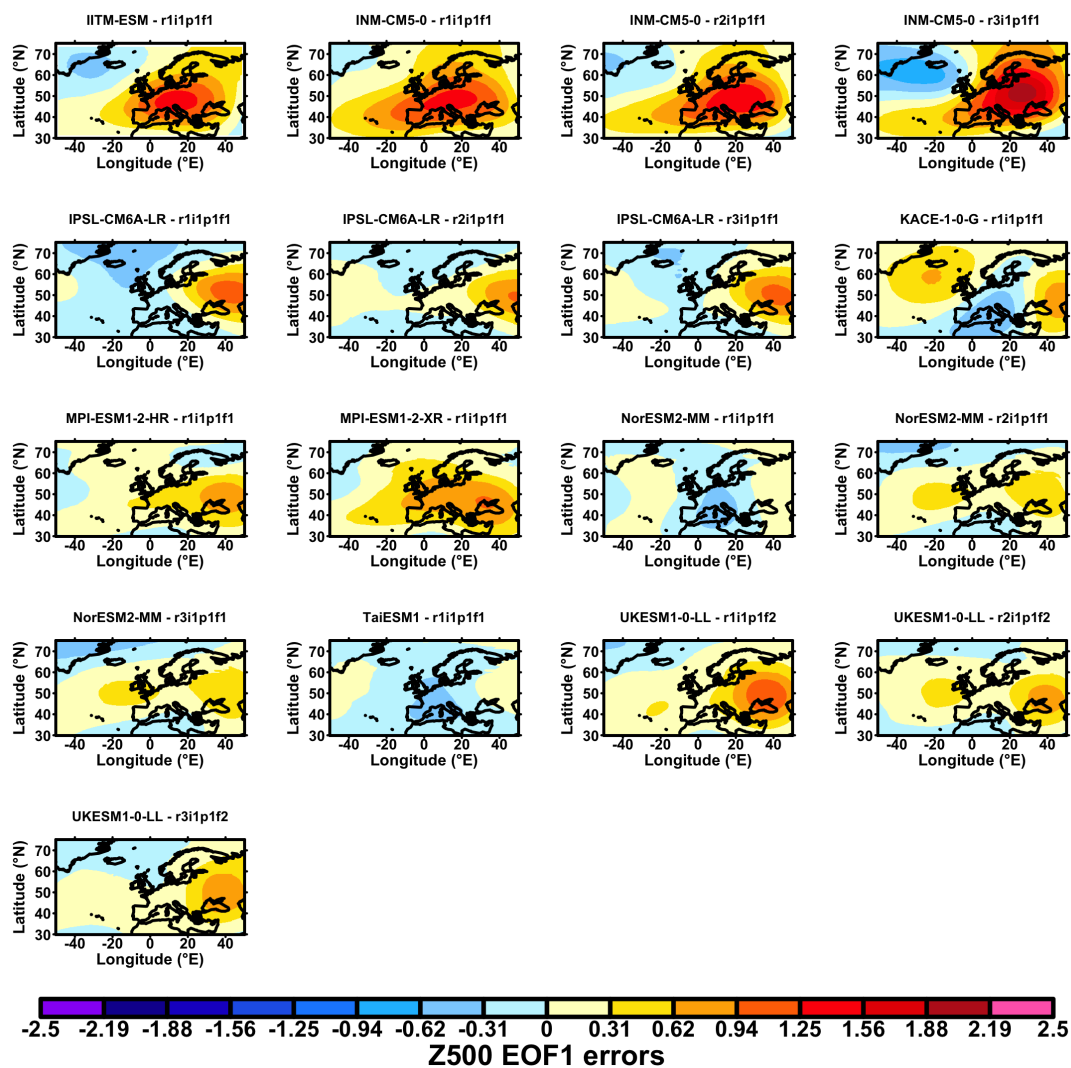
Supplementary Figure 9: Mean errors of sea surface temperatures (in °C) for no-eddy (NE) GCMs (part 2). White grid points indicate that the bias is not significant at the 95% confidence level.



Supplementary Figure 10: Mean errors of first empirical function of daily geopotential heights at 500 hPa (Z500 EOF1) for eddy-permitting (EP) GCMs.



Supplementary Figure 11: Mean errors of first empirical function of daily geopotential heights at 500 hPa (Z500 EOF1) for no-eddy (NE) GCMs (part 1).



Supplementary Figure 12: Mean errors of first empirical function of daily geopotential heights at 500 hPa (Z500 EOF1) for no-eddy (NE) GCMs (part 2).