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Supplementary Materials for

Skillful multiyear prediction of flood frequency along the US Northeast Coast using a high-resolution modeling system

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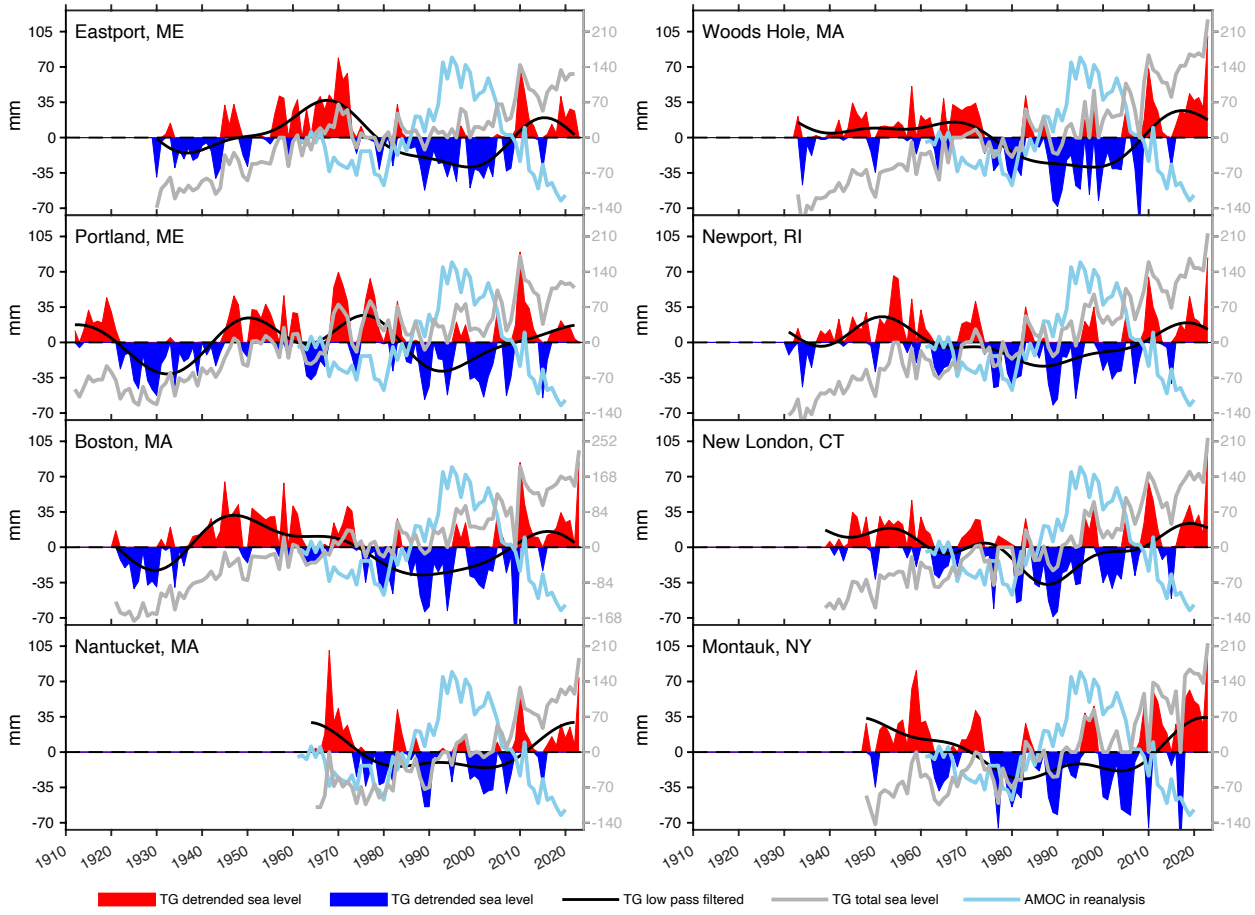

Figure S1. Multidecadal sea level variability (mm) at each Tide Gauge (TG) station along the USNEC. Shown are the annual mean total sea level (gray line), detrended sea level (red and blue shadings) and 15-year low-pass filtered sea level timeseries (black line) at the Eastport, Portland, Boston, Nantucket, Woods Hole, Newport, New London and Montauk stations, along with the AMOC index (light blue line) in SPEAR global reanalysis. The AMOC index is defined as the maximum value of the Atlantic streamfunction below 500m within the 20º-60ºN latitude band in depth space. The AMOC index here represents the AMOC anomaly relative to the long-term mean and is scaled by a factor of 20 for visual display.

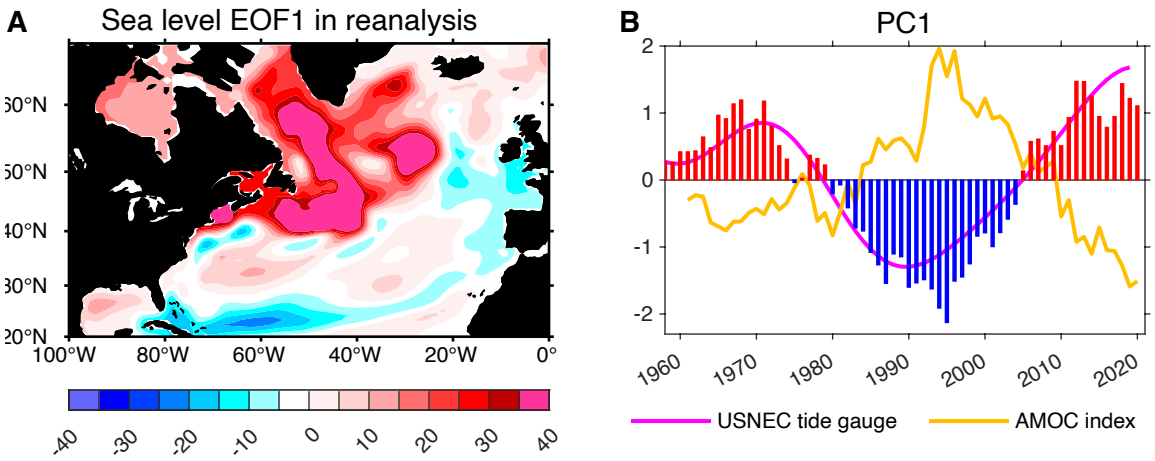

Figure S2. The Empirical Orthogonal Function (EOF) analysis of detrended annual mean North Atlantic (NA) sea level in SPEAR global reanalysis. (**A**) Spatial pattern of the leading EOF component (EOF1) of sea level (mm). (**B**) Normalized timeseries of the first principal component (PC1) (red and blue bars), 15-year low-pass filtered sea level timeseries in Tide Gauge observations composited along the USNEC (pink line) and the normalized AMOC index in SPEAR global reanalysis.

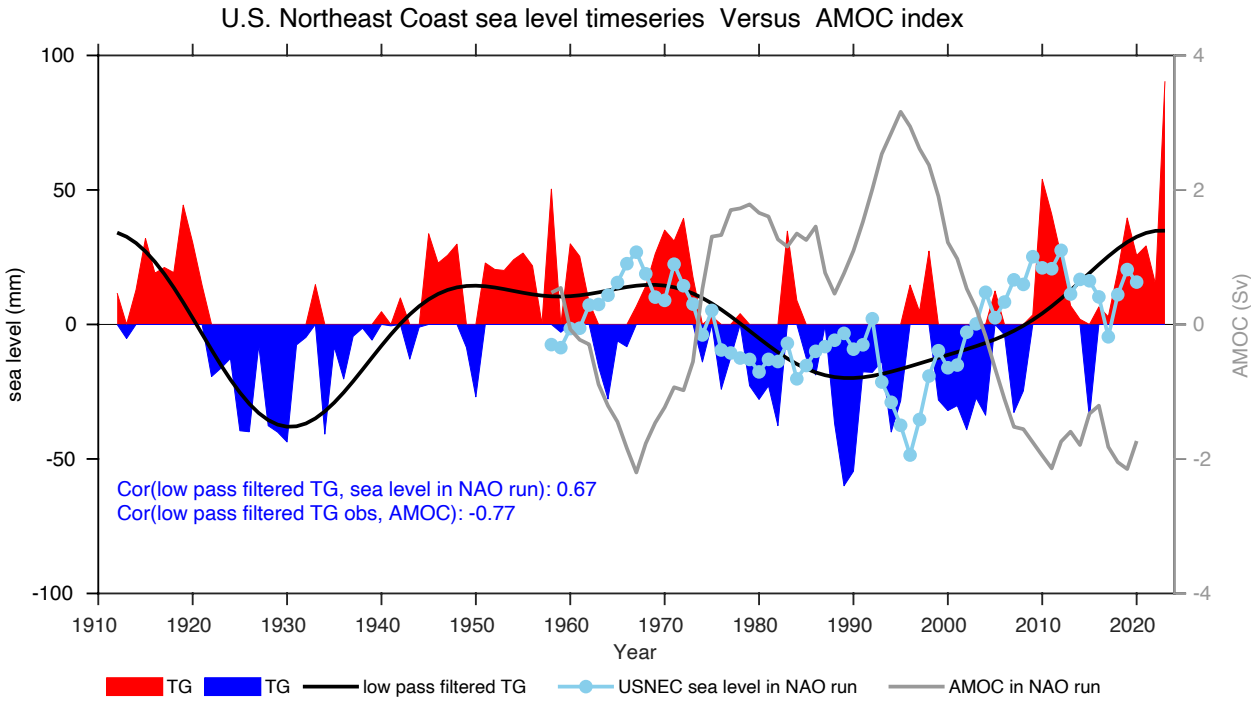

Figure S3. AMOC and the USNEC sea level responses to the observed North Atlantic Oscillation (NAO) variations. Shown are the annual mean detrended sea level anomalies composited along the USNEC in Tide Gauge (TG) observations (blue and red shadings), 15-year low-pass filtered sea level anomalies in TG observations (black line), annual mean sea level along the USNEC (light blue line) and AMOC (gray line) anomalies to the observed NAO forcing. Unit is mm for the sea level and Sv for the AMOC index. The AMOC index is defined as the maximum value of the Atlantic streamfunction below 500m within the 20°-60°N latitude band in depth space. We conduct ensemble of NAO sensitivity simulations, which is identical to the classic historical runs, except that at each time step an extra pattern of observed NAO-related surface heat flux is added to force the ocean component of model. This anomalous heat flux has the same spatial pattern as the observed NAO, which was obtained by regressing the timeseries of winter season surface heat flux anomalies in reanalysis against the observed NAO index at each grid. This pattern therefore generates the surface heat flux anomaly pattern associated with a unit change in the observed NAO index. The differences between the ensemble mean NAO forcing run and the historical run represent the climate system responses to the realistic NAO forcing. Further details regarding these sensitivity runs with additional NAO forcing can be found in a previous paper (*31*).

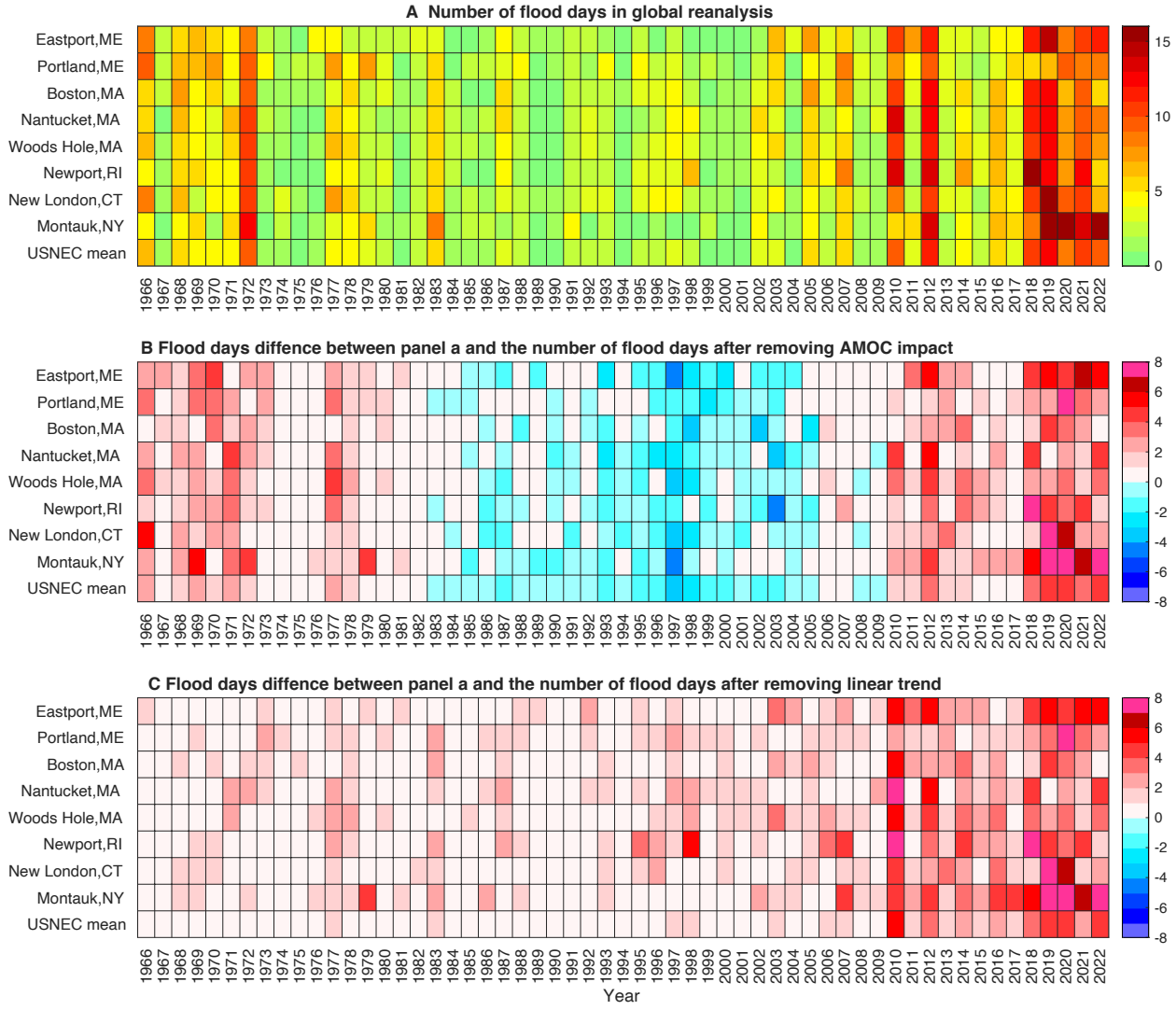

Figure S4. Influence of the AMOC and linear trend on the number of flood days along the USNEC in SPEAR global reanalysis. Same as Figure 3 in the article except for the SPEAR global reanalysis. Note that the minor flood threshold at each station in reanalysis is defined as the 99th-percentile threshold of the daily maxima water level distribution from all days and years during 1965–2022. A day is classified as a flood day when the daily maximum water level exceeds the minor flood threshold. We then count the number of flood days each year, as illustrated in A-C.

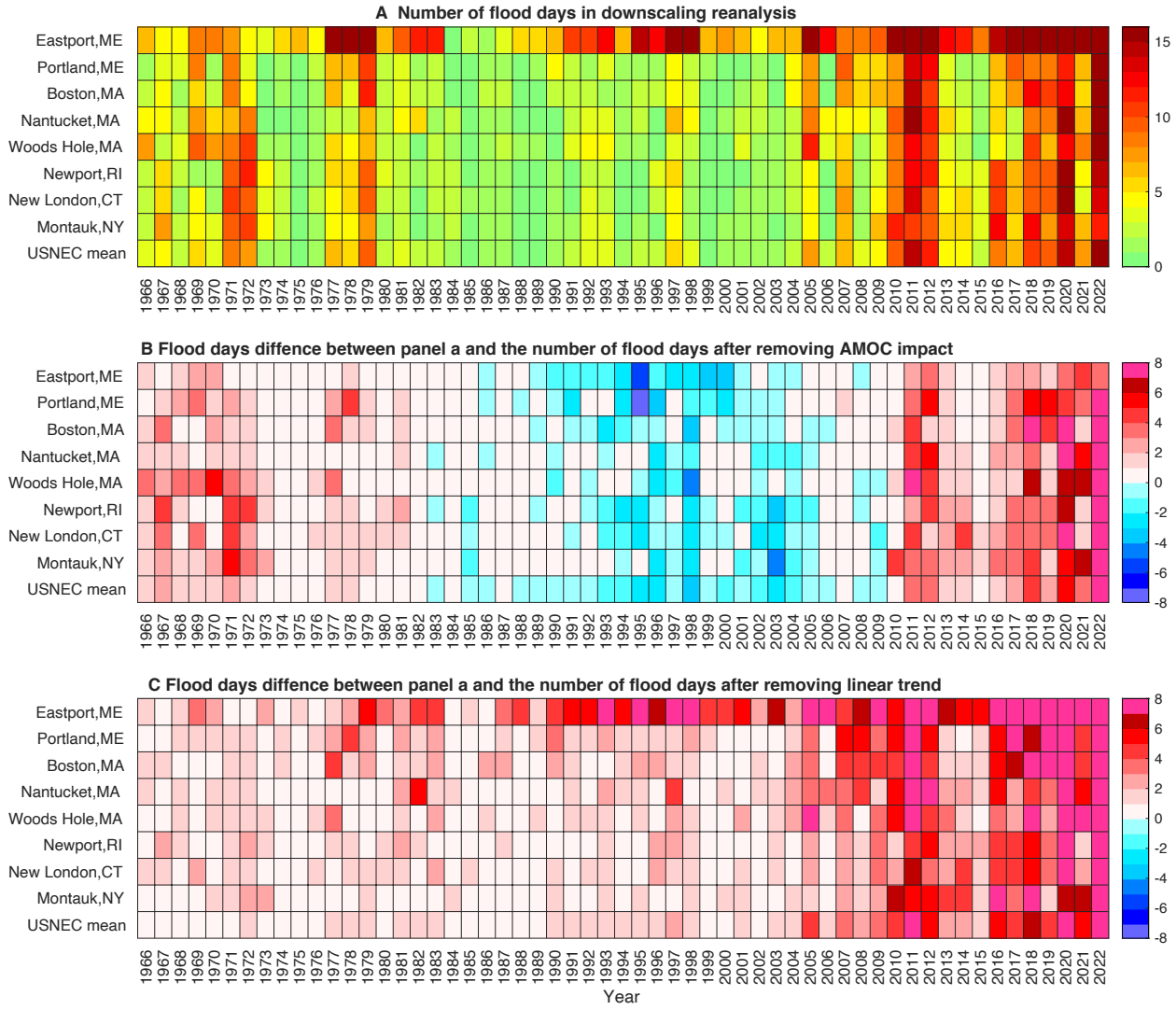

Figure S5. Influence of the AMOC and linear trend on the number of flood days along the USNEC in dynamically downscaled reanalysis. Same as Supplementary Figure S4 above except for the dynamically downscaled reanalysis.

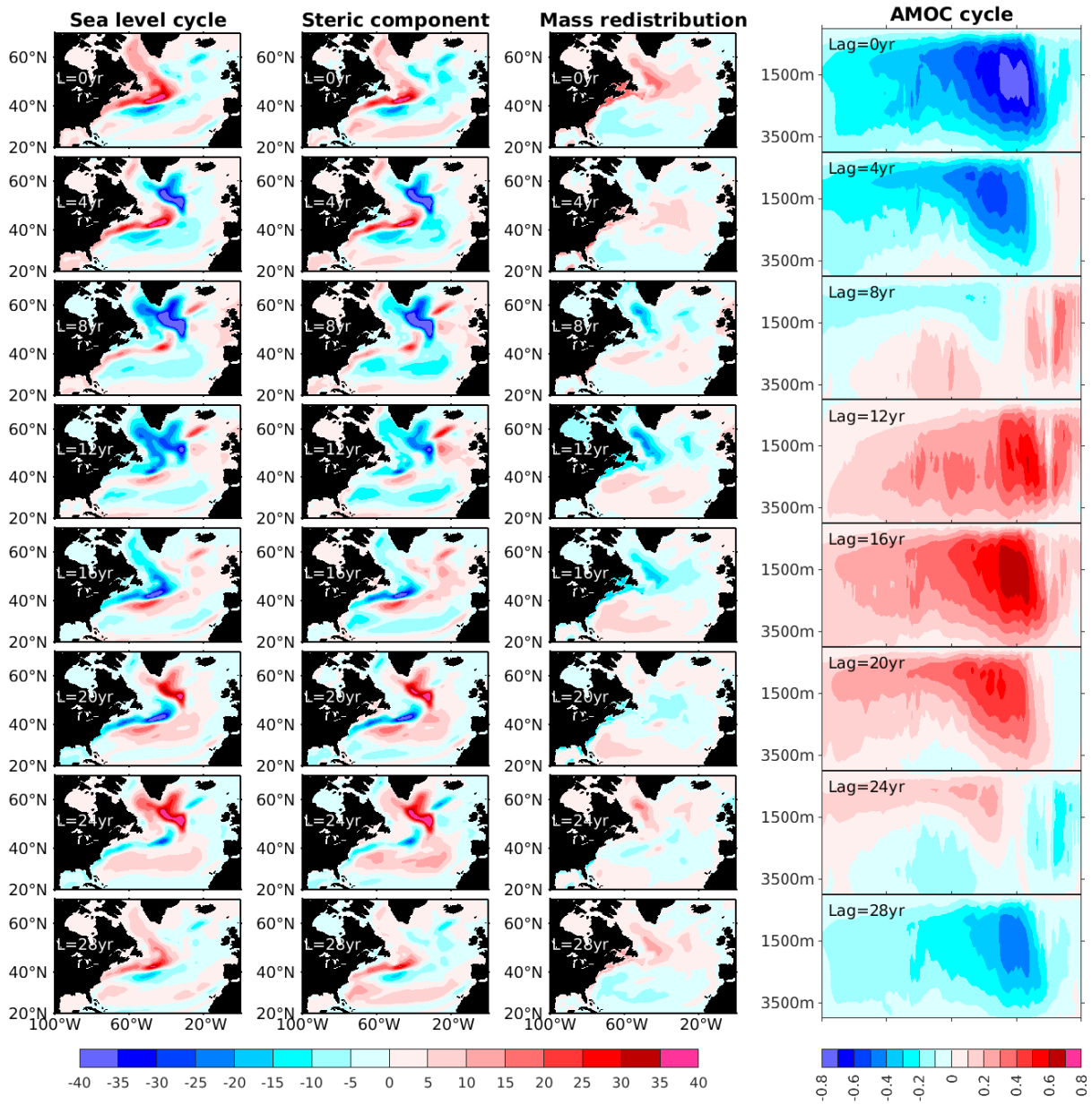

Figure S6. The multidecadal AMOC and North Atlantic (NA) sea level cycle in SPEAR control run. Lagged regression of the NA sea level (1st column), steric sea level component (2nd column), ocean mass redistribution (3rd column) and Atlantic streamfunction (4th column) against the normalized AMOC index, multiplied by a factor of -1. The AMOC index is defined as the maximum streamfunction below 500 m and within 20^{o}-60^{o}N in depth space. The lag years denote the other variables lag the AMOC index by 0-28 years. Units are mm and Sv for the sea level and the AMOC streamfunction regressions, respectively.

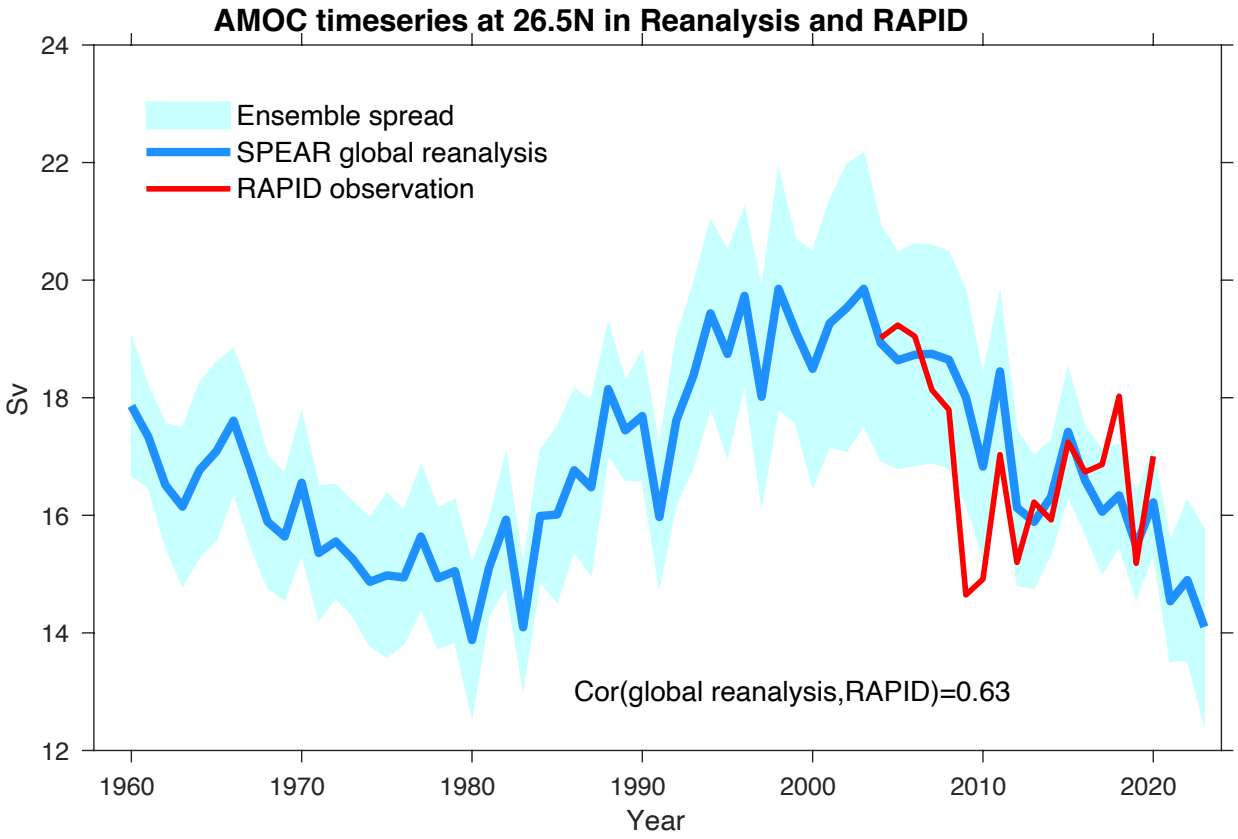

Figure S7. The AMOC value at 26.5ºN in SPEAR global reanalysis and RAPID array observation. The AMOC timeseries in SPEAR global reanalysis (thick bule line) and the ensemble spread of AMOC estimated by one standard deviation of all ensemble members (light blue shading). The thick red line denotes the annual mean values from the RAPID array at 26.5°N. Unit is Sv.

Table S1: Regional designation, tide gauge information, mean higher high water (MHHW) tidal datum and the NOAA minor flood threshold.

EWL Grid No.	NOAA ID	Location	Latitude	Longitude	Flood Index u (m, MHHW)	Epoch of u	Minor Flood threshold (m)
47859	8410140	Eastport, ME	44.90	-66.98	0.93	1983-2001	0.735
47496	8418150	Portland, ME	43.66	-70.25	0.605	1983-2001	0.621
47136	8443970	Boston, MA	42.35	-71.05	0.634	1983-2001	0.625
46778	8449130	Nantucket, MA	41.29	-70.10	0.418	1983-2001	0.544
46778	8447930	Woods Hole, MA	41.52	-70.67	0.446	1983-2001	0.527
46777	8452660	Newport, RI	41.51	-71.33	0.478	1983-2001	0.547
46776	8461490	New London, CT	41.36	-72.09	0.468	1983-2001	0.537
46777	8510560	Montauk, NY	41.05	-71.96	0.487	1983-2001	0.531