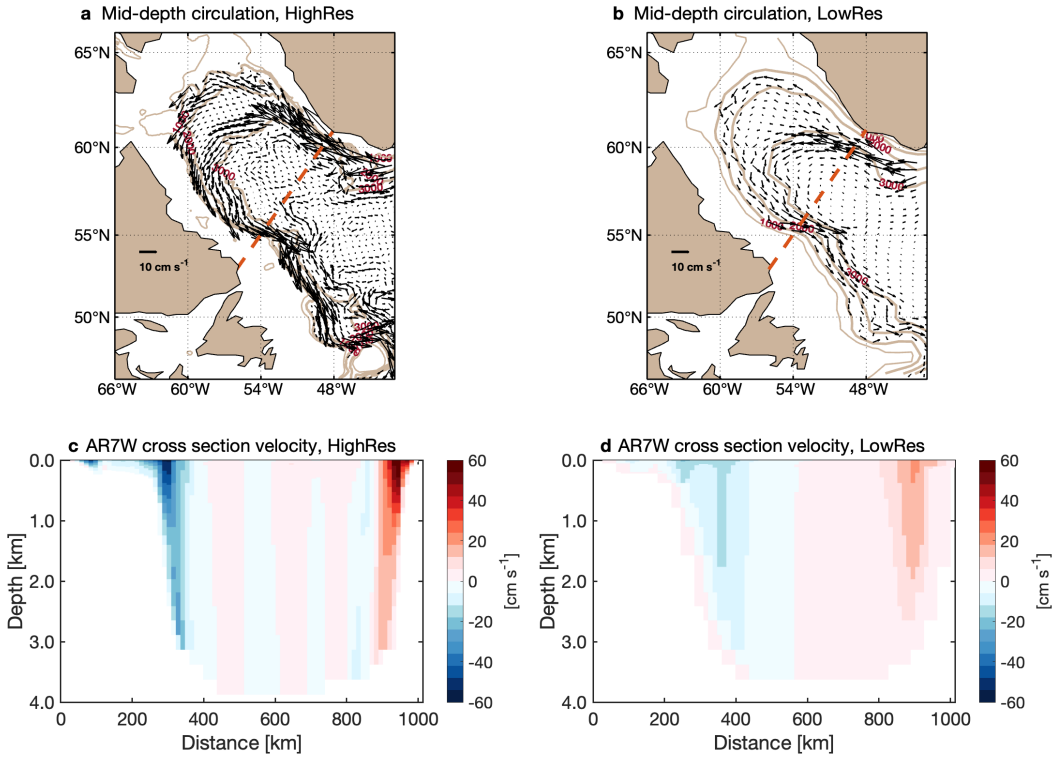

Figure S1. Mid-depth circulation at 1000 m in 2005-2016 in (a) HighRes and (b) LowRes. The velocities are subsampled every 5 grid points for HighRes. (c, d) Same as (a) and (b) but for velocity cross AR7W. Positive (negative) velocities are poleward (equatorward). The location of AR7W is indicated by dashed lines in (a) and (b). Current fields in HighRes are well consistent with observation results[46, 47].

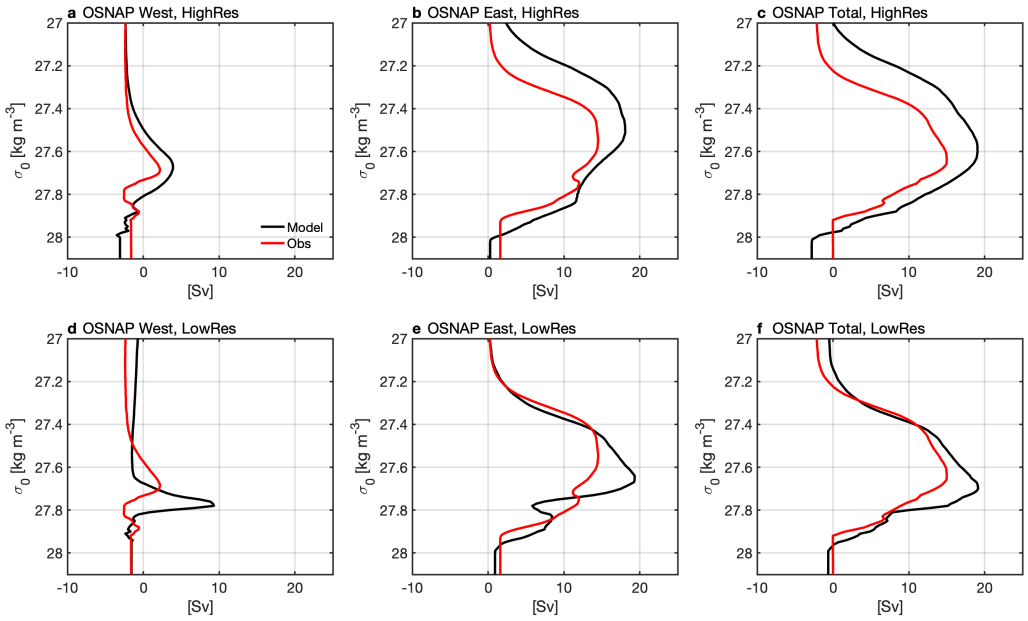

Figure S2. climatology (year 2006-2015) overturning across (a) OSNAP West, (b) OSNAP East and (c) OSNAP full array lines in HighRes (black lines) compared to 2014-2020 observation results (red lines). (d–f) Same as (a)-(c) but for LowRes. For direct comparison to observations, simulated OSNAP overturning is calculated in σ_0 (density referenced to sea surface, after subtracting 1000 kg m^{-3}) coordinate with volume fluxes integrated from west to east and from lower to higher density.

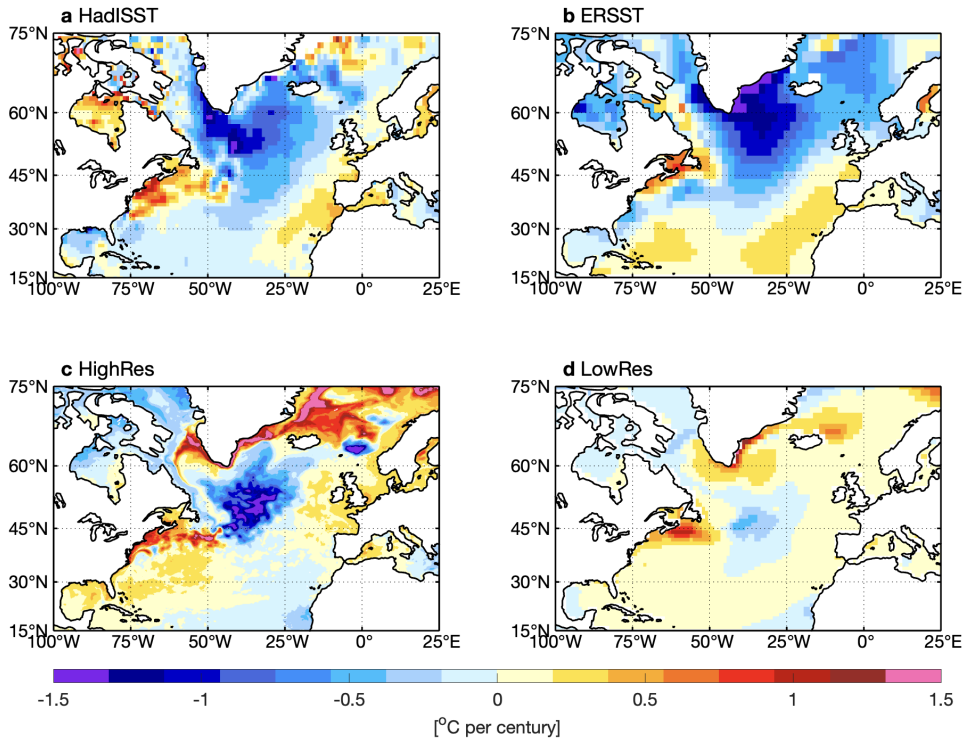

Figure S3. Linear SST trend in the 20th century for (a) HadISST1, (b) ERSST, (c) HighRes and (d) LowRes. The corresponding global mean SST trend has been subtracted.

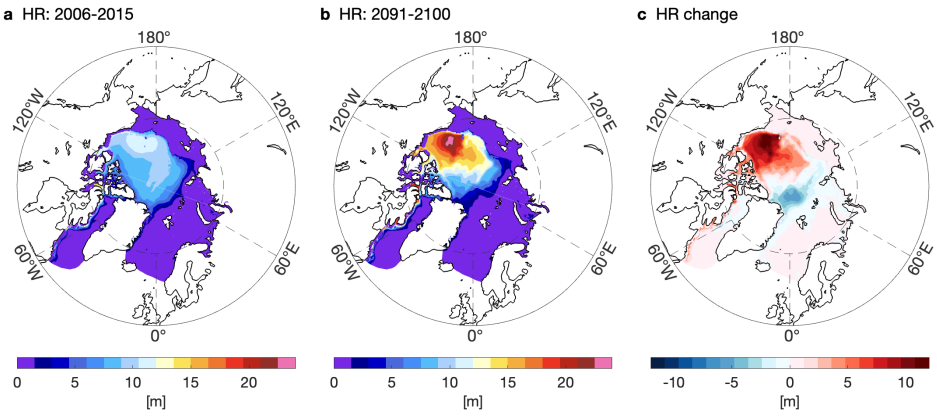

Figure S4. Liquid freshwater content (LFWC) in HighRes in (a) 2006-2015, (b) 2091-2100, and (c) 2091-2100 minus 2006-2015. LFWC is calculated as $\mathrm{LFWC} = \int_{D}^{0} \left(S_{\mathrm{ref}} - S_{w} \right) / S_{\mathrm{ref}} dz$ where S_{ref} = 33.77 psu is the reference salinity, set as mean salinity in the Arctic Ocean in 2006-2100, S_w is water salinity, D is the isohaline depth for $S_{\mathrm{w}} = S_{\mathrm{ref}}$ (or the ocean bottom depth if salinity in the whole column is lower than S_{ref}).

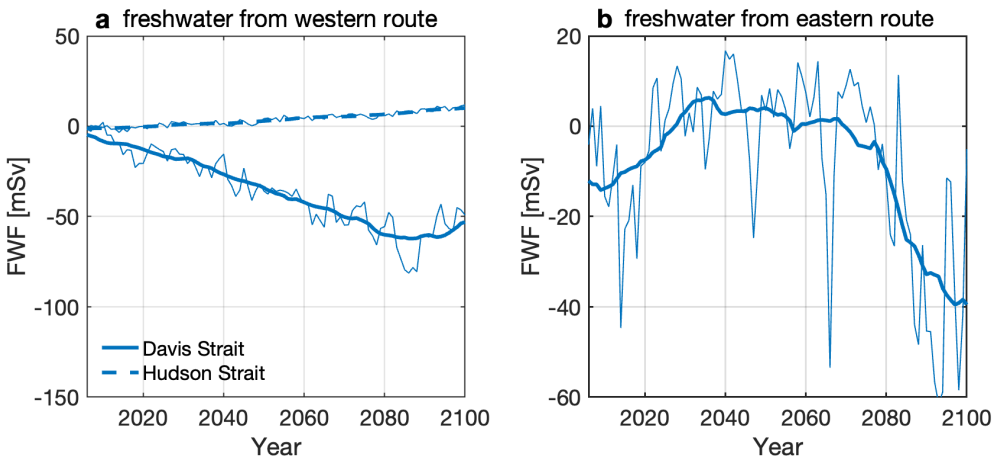

Figure S5. Time series of upper-250 m freshwater flux into the Labrador Sea in LowRes from (a) the west of Greenland across Davis Strait (solid line, negative values for freshwater input into the Labrador Sea) and Hudson Strait (dashed lines, positive values freshwater input into the Labrador Sea) and (b) from the east of Greenland. Thin lines show annual-mean freshwater flux. Thick lines represent 20-year running mean.

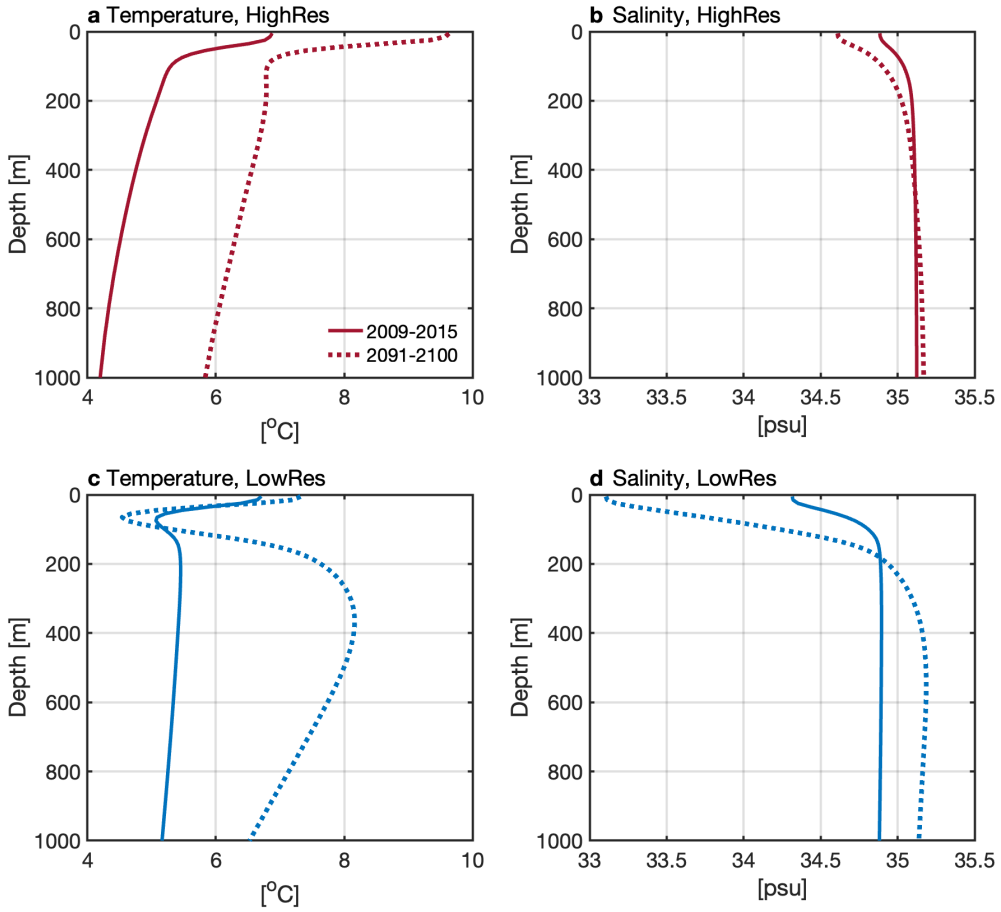

Figure S6. Vertical profile of (a) temperature and (b) salinity in the central Labrador Sea in HighRes. (c, d) Same as (a) and (b) but for LowRes. Solid (dashed) lines indicate the mean in 2006-2015 (2091-2100). Only regions in the Labrador Sea deeper than 2000 m are considered here.

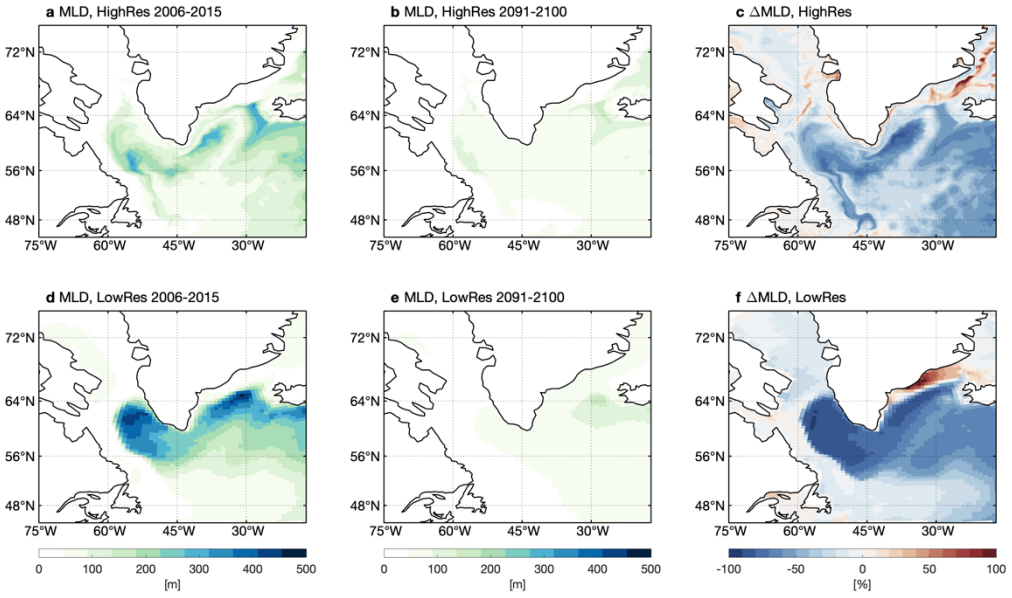

Figure S7. March mixed layer depth in HighRes in (a) 2006-2015, (b) 2091-2100, and (c) 2091-2100 minus 2006-2015. (d-f) Same as (a)-(c) but for LowRes.

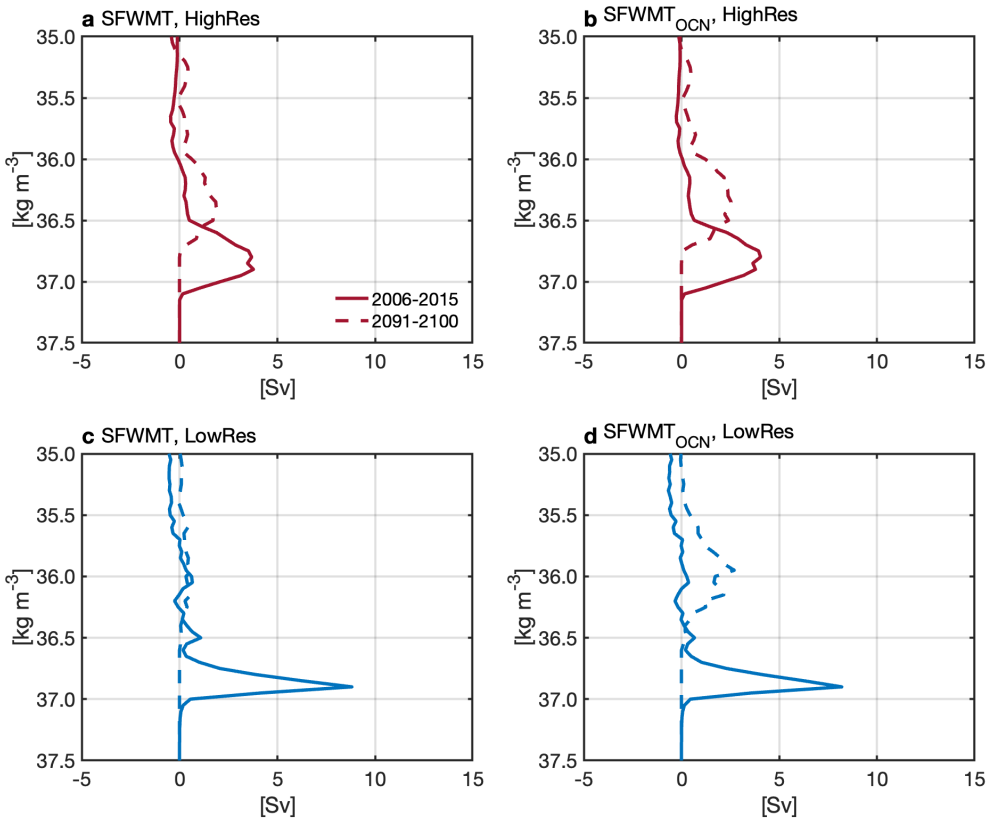

Figure S8. Surface forced water mass transformation (SFWMT) in the Labrador Sea in (a) HighRes and (c) LowRes. Solid (dashed) lines show SFWMT in 2006-2015 (2091-2100). (b, d) Same as (a) and (c) but for the SFWMT changes due to surface stratification ($SFWMT_{OCN}$). The $SFWMT_{OCN}$ is calculated with annual-mean surface buoyancy forcing in 2006 and changing surface density in 2006-2100.

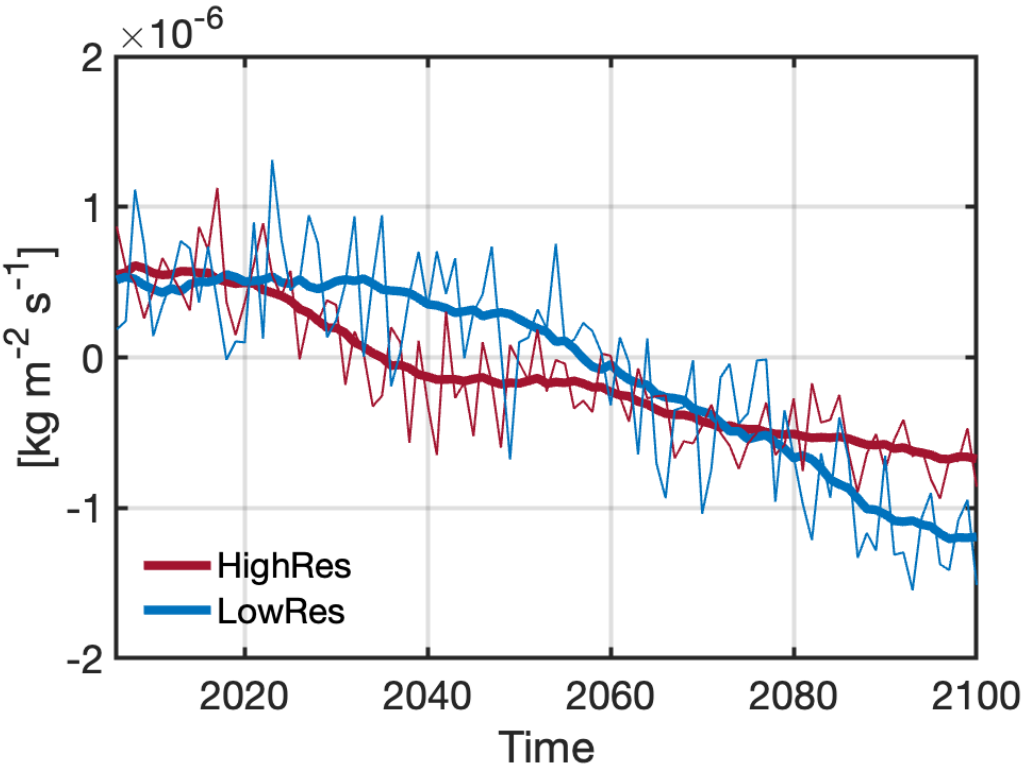

Figure S9. Time series of the surface density flux in HighRes (red lines) and LowRes (blue lines). Thin lines show annual-mean surface density flux. Thick lines represent 20-year running mean.

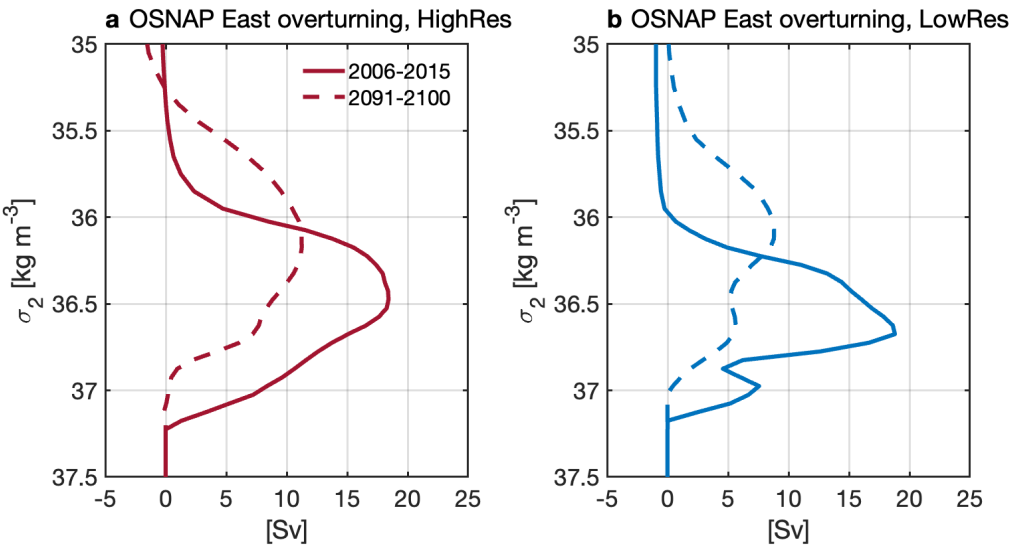

Figure S10. Overturning across OSNAP East in (a) HighRes and (b) LowRes. Solid (dashed) lines represent the overturning in 2006-2015 (2091-2100).

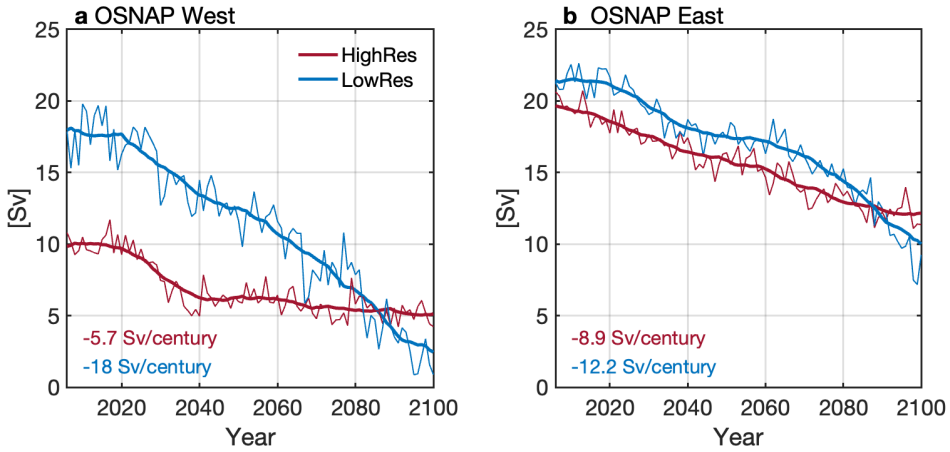

Figure S11. Time series of overturning across (a) OSNAP West and (d) OSNAP East in the 21st century. Red (blue) lines show results in HighRes (LowRes). Thin lines denote annual-mean overturning. Thick lines show 20-year running mean. Linear trends of overturning strength are indicated in each figure.

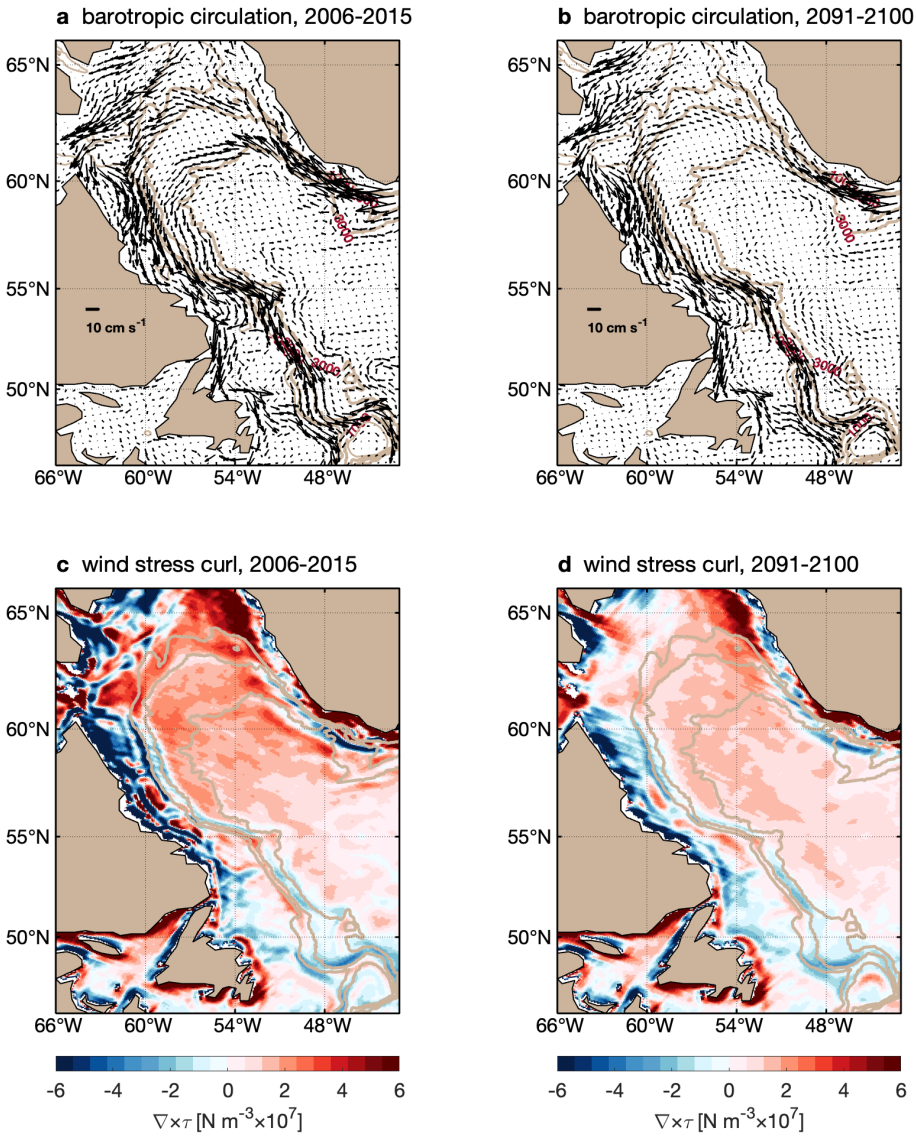

Figure S12. Labrador Sea batrotropic circulation in HighRes in (a) 2006-2015 and (b) 2091-2100. The 1000m, 2000m and 3000m isobaths are indicated by contours. (c-d) Same as (a)-(b) but for wind stress curl.

Reference

46. Hall, M. M., Torres, D. J. & Yashayaev, I. Absolute velocity along the AR7W section in the Labrador Sea. *Deep-Sea Research I*, **72**, 72–87 (2013)
47. Kieke, D. & Yashayaev, I. Studies of Labrador Sea Water formation and variability in the subpolar North Atlantic in the light of international partnership and collaboration. *Progress in Oceanography*, **132**, 220-232 (2015)