Supplementary Material

1 Mean N2, AMOC and density profiles

We present the mean fields for the N2 for the boundaries (Fig. S1) for the three forced experiments together with GC2 and RAPID data. AMOC is compared for the CTRL and BUOY forced experiments in Fig. S2 to conclude that the similar variability is present when linear trend is removed.

Boundary profiles are described with density anomalies versus time for the three forced experiments (Fig. S3). The linearity of the density anomalies is represented comparing CTRL and SUM (BUOY+WIND). Mean currents in the CTRL at deeper levels is illustrated in Fig. S4.

2 Wind forced coherent signal in CTRL experiment at upper levels

We look here at the spatial density anomalies regressed onto the PC1-WB for the CTRL at the density averaged over 900-1300m (suggested by the maximum in the EOF profiles in Fig. 3). Density anomalies begin in the Labrador Sea, leading PC1-WB by 30months (Fig. S5). A pattern of equatorial Kelvin and Rossby- as in Johnson and Marshall (2002) - is also visible up to lag 0, suggesting a coherent wind-driven signal in the CTRL experiment (Fig. S5).

In CTRL (Fig. S5) the equatorial signal appears 10 months earlier than in BUOY (not shown) and therefore seems to occur before the propagating WB signal could reach the equator. The explanation lies with large-scale northerly winds in the western Atlantic at ~15N which correlate with PC1-WB from lags -30 months, and which strengthen into a clear +NAO-like signature at lag 0 (Fig. S6). The Ekman divergence would generate upwelling density anomalies around 60W along the South American coast (Fig. S6c-d), triggering Kelvin waves that then initiate the earlier equatorial signals in CTRL. Wind signals are also important along the African coast (between 0-15N Fig. S6c-d). These wind-forced signals at low latitudes explain the main differences between CTRL and BUOY at upper levels. We conclude that the buoyancy forced signals do reach the EB at upper levels at 26N but that wind forced signals generated near the equator in the CTRL experiment, can misleadingly suggest that they do. This explains the shorter EB phase lags identified for the joint boundary EOFs in section 3 and correlations in Fig. 4.

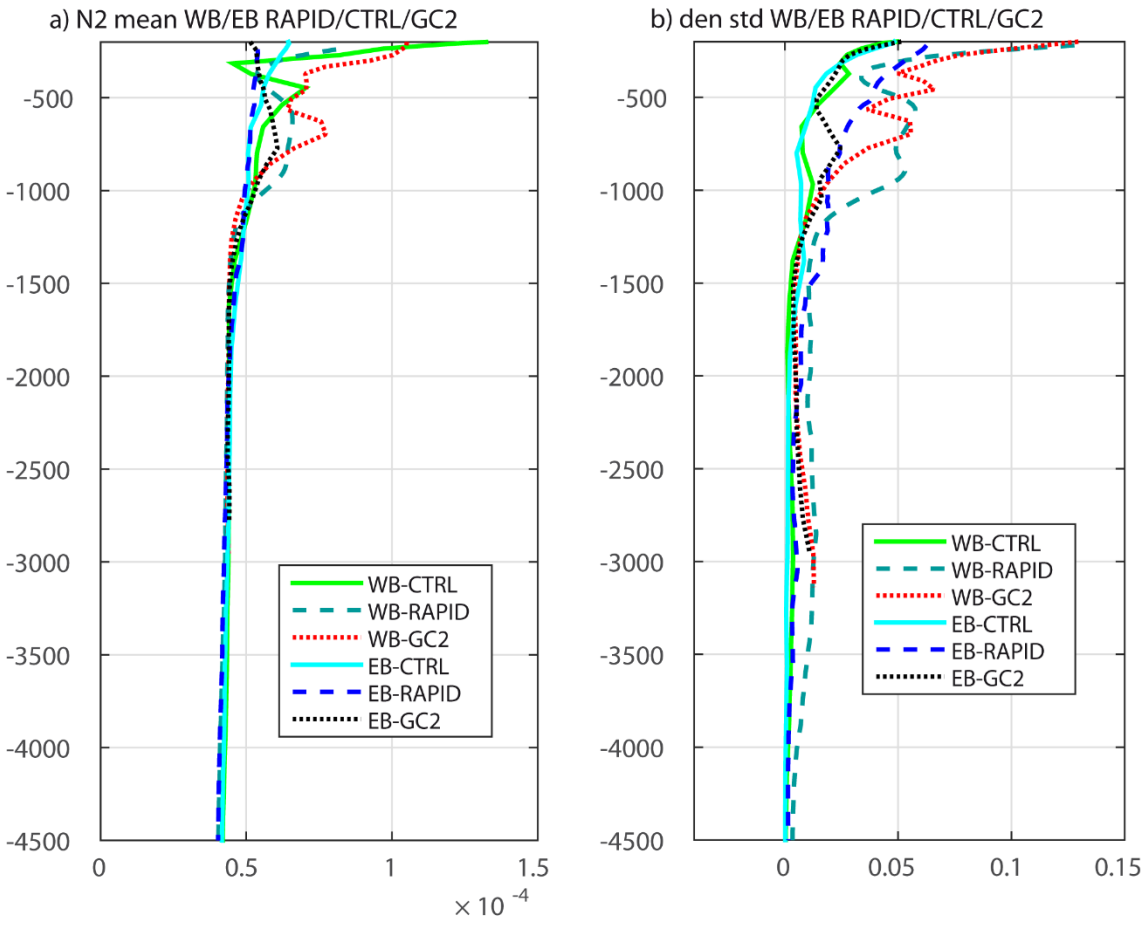

Figure S1. Density vertical gradients NEMO1, GC2 and RAPID. a) Brunt-Väisälä frequency (N^2) of the WB and EB simulated by CTRL run, GC2 and observed by RAPID array. The mean has been chosen to be computed for the common period 2004-2010. b) Standard deviation of the density profiles at the boundaries for the CTRL run and rapid.

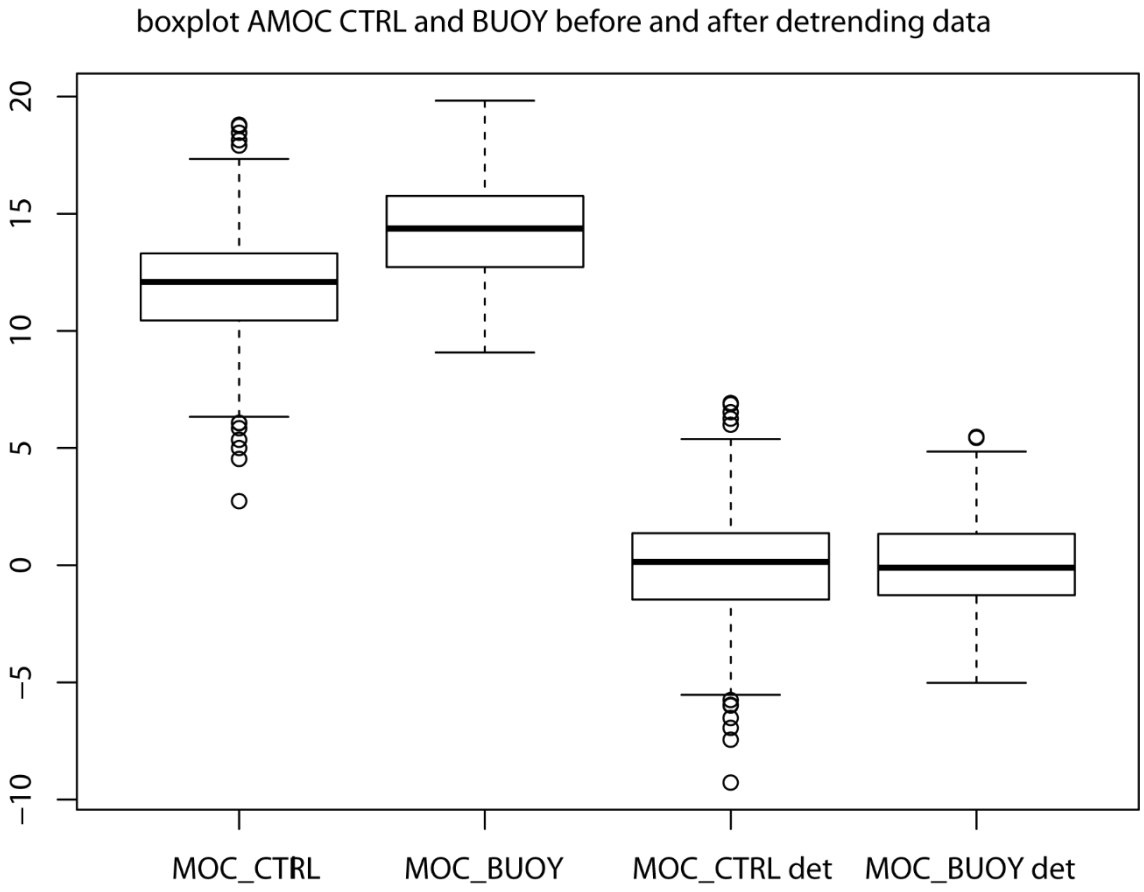

Figure S2. Mean AMOC in CTRL and BUOY experiments. Boxplot for the mean AMOC at 26N and 1160m before and after removing the linear trend, showing similar variability after detrending data.

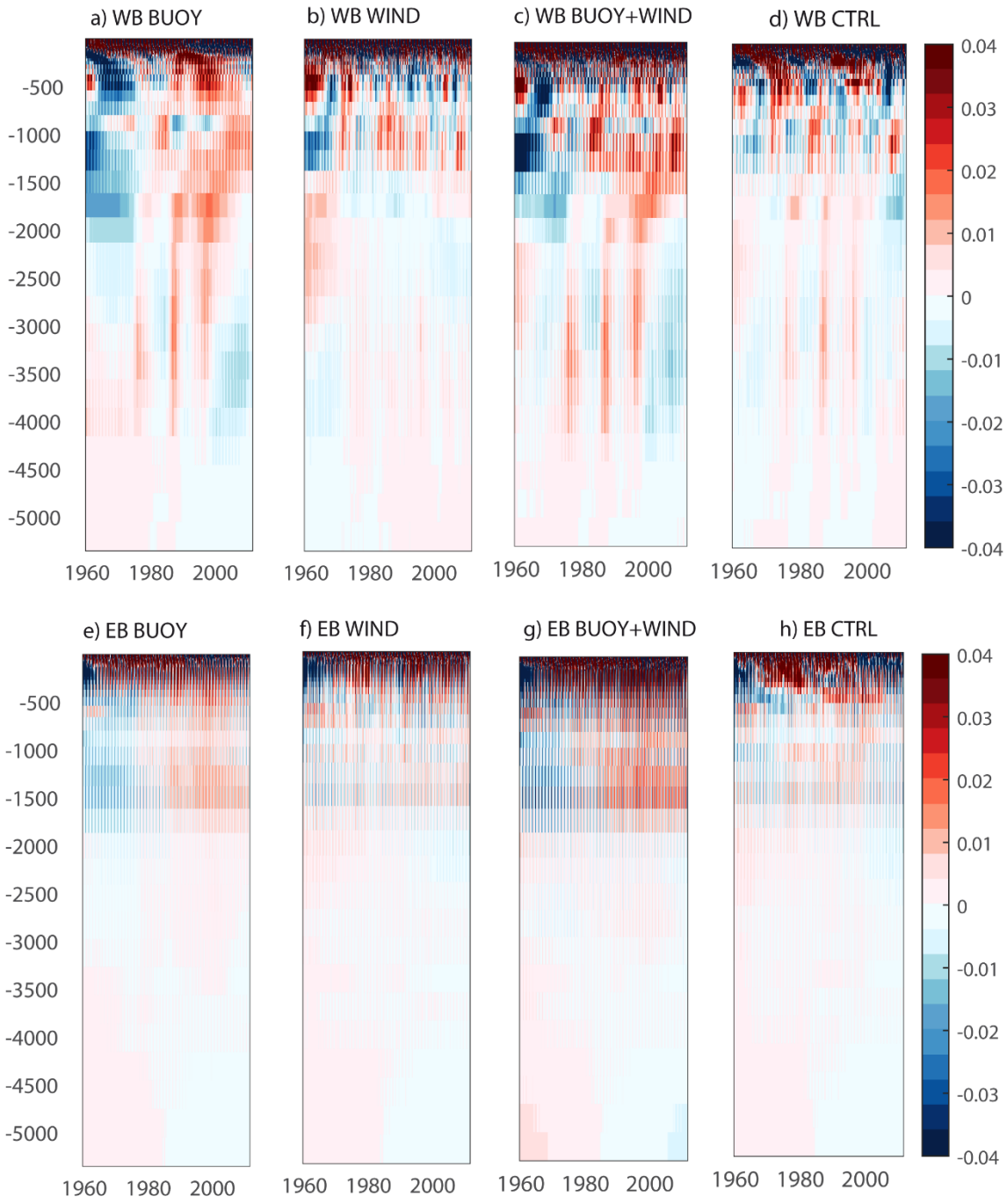

Figure S3: Hovmuller of vertical density profiles. a) Time versus vertical anomalous density WB profiles for the BUOY experiment at 26N. b) Same as a) but for the WIND, c) Same as a) but for the sum of WIND+BUOY=SUM. d) Same as a) but for the CTRL. e)-h) Same as a)-d) but for the EB.

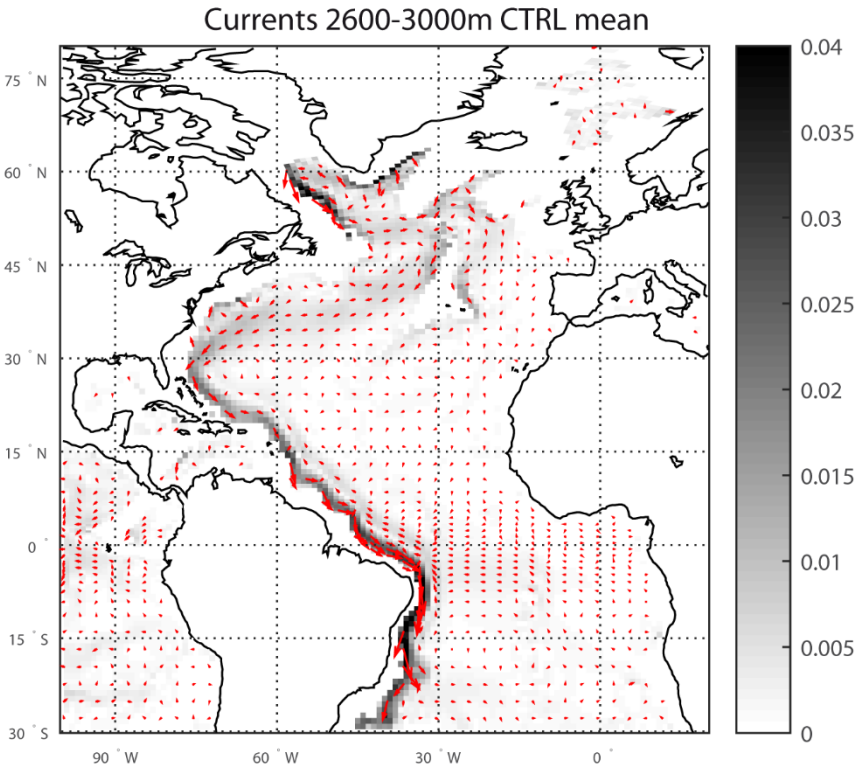

Figure S4. Currents in NEMO1 CTRL experiment. a) current (vectors) and speed (grey scale) at 2700-3000m level in the CTRL experiment.

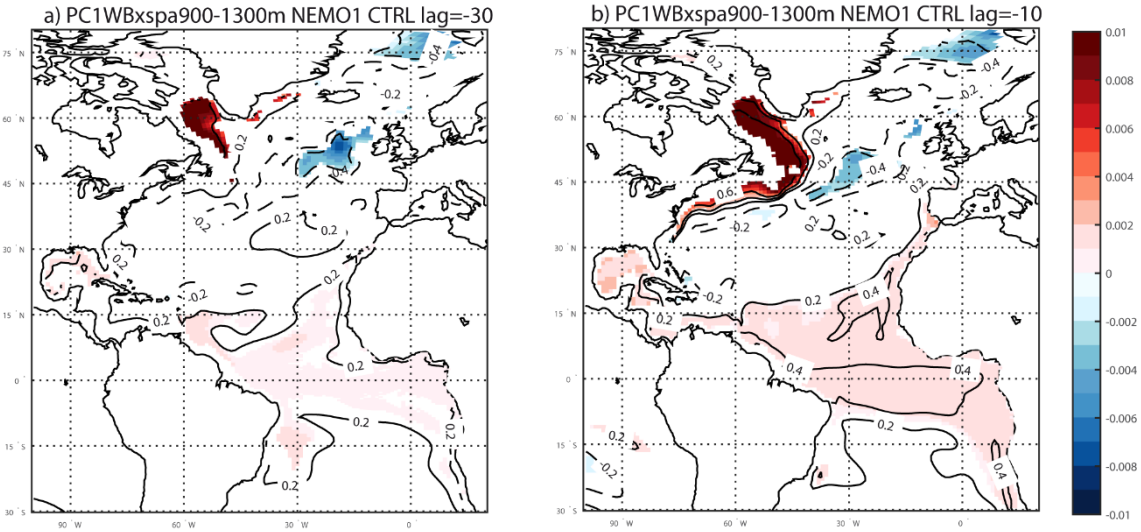

Figure S5. The spatial relationship of density anomalies with PC1-WB in the CTRL at upper levels. a) Density anomalies averaged from 900m to 1300m levels, 30 months in advance projected onto PC1-WB (in kg/m^3) for the CTRL experiment. Black lines corresponds to the correlation every 0.2. Only significant areas are plotted with a Student's t-test with alpha=0.1 considering only effective degrees of freedom according to Metz (1991). b) Same as a) but for lags -10months.

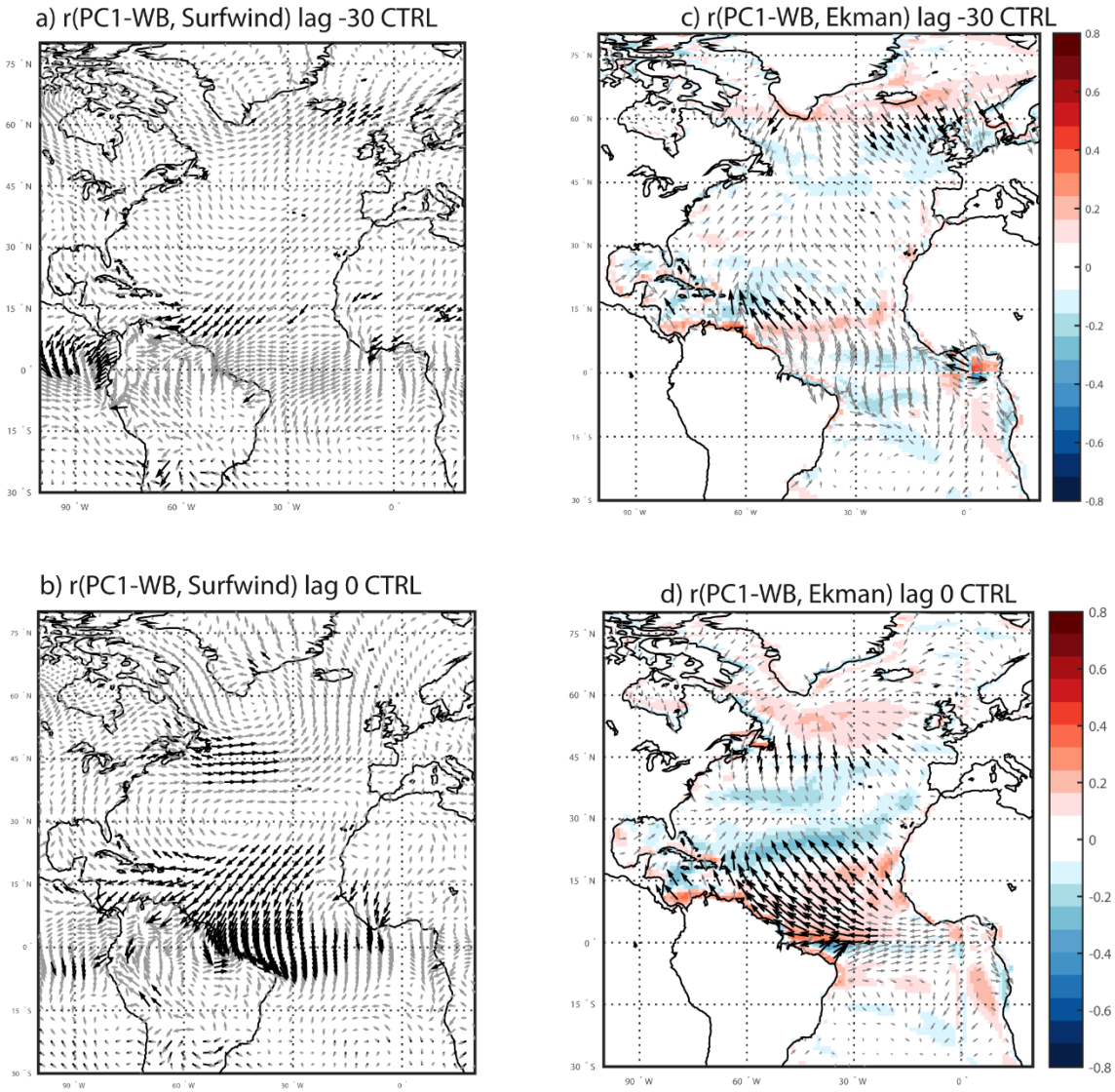

Figure S6. Correlation PC1-WB and surface winds in the CTRL experiment. a) Correlation of PC1-WB and the surface winds for lag -30 months for the CTRL experiment. b) Same as a) but for lag 0. c) Correlation of PC1-WB and Ekman transport components (vectors) and the Ekman divergence (shaded) for lag -30 months. d) Same as c) but for lag 0 months respectively. Only significant areas are plotted with a Student's t-test with alpha=0.1, similarly, surface wind vector and Ekman vector are shown in bold black when it is significant.