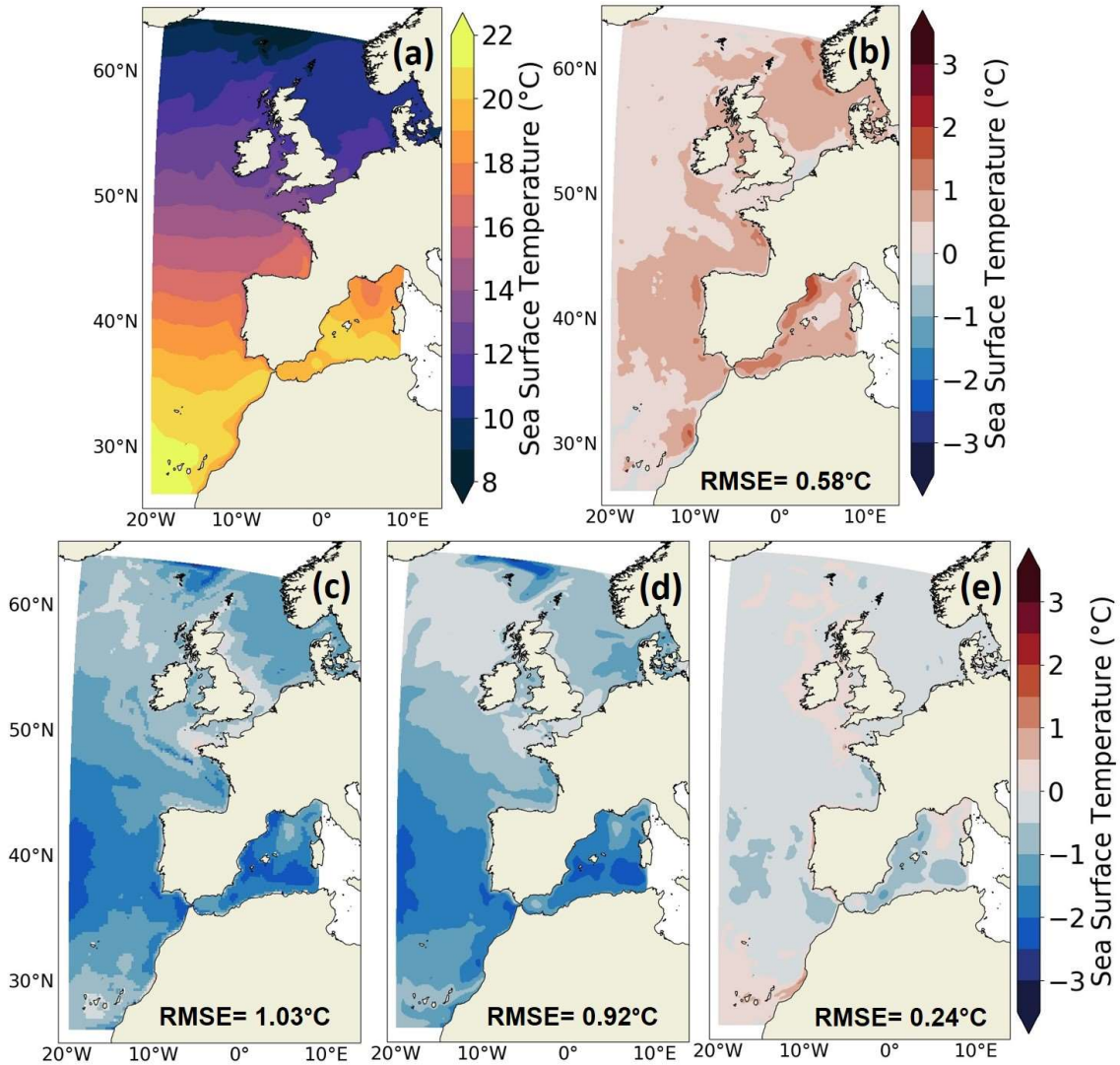


Supplementary Materials:

S1 Sea Surface Temperature



5 **Figure S1: (a) Sea Surface Temperature in IBIRYS over the 1993-2014 period. (b) Sea Surface Temperature bias between IBI-ERAi and IBIRYS over the 1993-2014 period. Biases over the 1993-2014 period between (c) CNRM-CM6-1-HR and IBI-ERAi (d) IBI-CCS_raw and IBI-ERAi (e) IBI-CCS_corr and IBI-ERAi.**

Figure S1 shows the Sea Surface Temperature (SST) bias over the 1993-2014 period between the different simulations and the reference regional IBI-ERAi simulation. The GCM and IBI-CSS_raw simulations generally exhibit a cold bias, except on the wide continental shelf in the north of the domain where the bias is relatively small. This cold bias can reach -2.5°C in the south-western and northern frontiers of the domain and in the Mediterranean Sea in both simulations. The IBI-CSS_raw RMSE is 0.1°C lower than the GCM one because the IBI-CSS_raw simulation slightly improved the cold bias in the North Sea and northern Atlantic Ocean. In the IBI-CCS_corr simulation, the seasonal-bias correction allows a strong reduction of the general cold bias of the GCM, resulting in a lower RMSE and a SST close to IBI-ERAi (Fig. S1). The reduction of the bias in IBI-CCS_corr is consistent with the bias correction method used to correct the GCM forcings. Indeed, the 1993-2014 period has been used to compute the biases between the GCM and the ocean and atmospheric reanalyses used to force IBI-ERAi. The corrections applied have therefore been well integrated into the model as the results for the 1993-2014 period are close to those of IBI-ERAi.

S2 Sea Surface Salinity

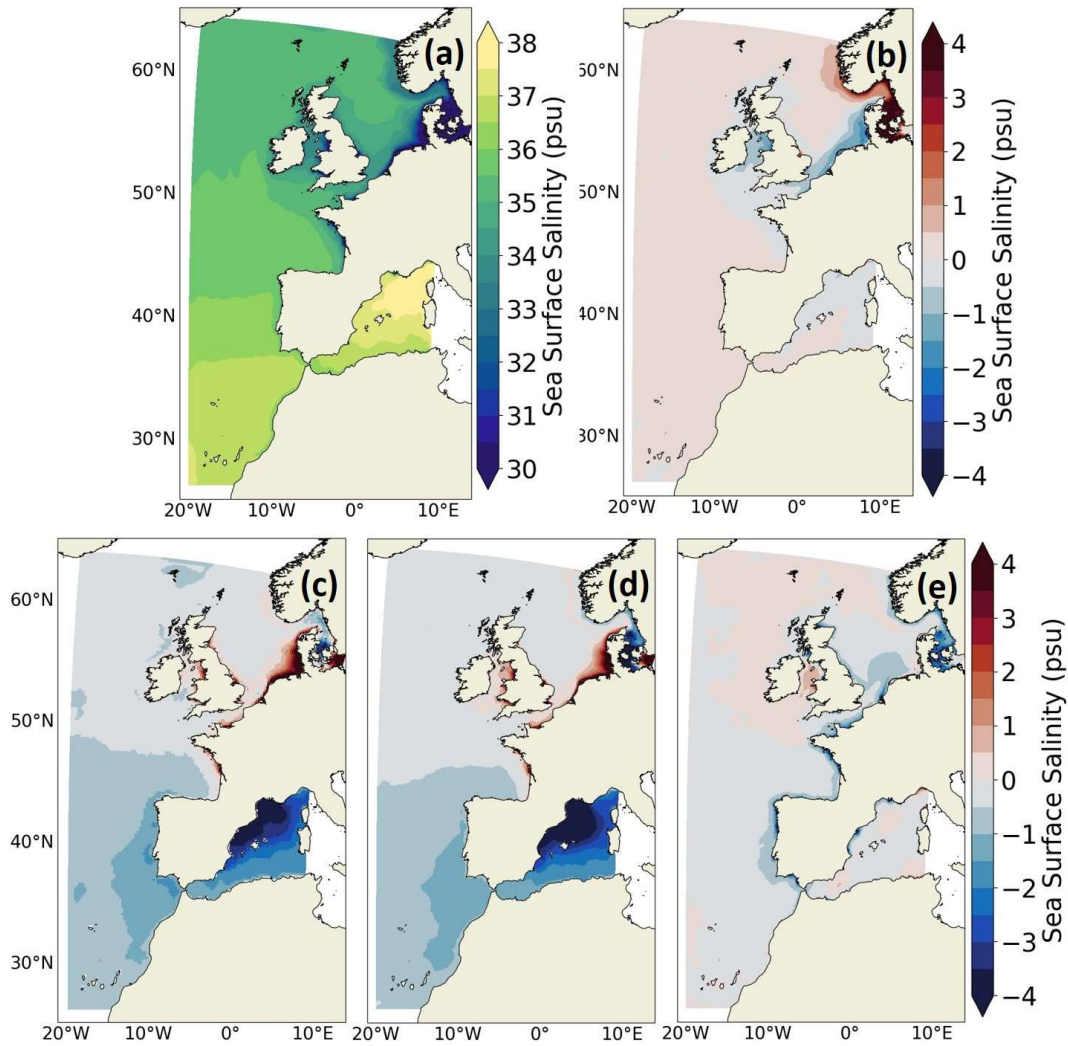


Figure S2: (a) Sea Surface Salinity in IBIRYS over the 1993-2014 period. (b) Sea Surface Salinity bias between IBI-ERAi and IBIRYS over the 1993-2014 period. Biases over the 1993-2014 period between (c) CNRM-CM6-1-HR and IBI-ERAi (d) IBI-CCS_raw and IBI-ERAi (e) IBI-CCS_corr and IBI-ERAi.

Figure S2 shows the Sea Surface Salinity (SSS) bias between the global and regionally downscaled simulations in comparison to IBI-ERAi over the 1993-2014 period. Large biases are found in the global simulation especially in the Mediterranean Sea where the water is 4 psu too fresh, leading to no difference in salinity with the Atlantic Ocean. Conversely, in the southern part of the North Sea, the water is 4 psu too saline. These biases are essentially due to the large errors in the regional runoff amounts received by the GCM's ocean component (Sect. 2.2.1), with the Rhône river runoff to the Mediterranean Sea being largely overestimated. As shown in Fig. S2, these biases propagate into the regional IBI-CCS_raw simulation. In IBI-CCS_corr, runoffs are directly taken from the river routing model to avoid regional discrepancies present in the GCM and in IBI-CCS_raw simulations (Sect. 2.2.2). This results in a considerable reduction of SSS biases both in the Mediterranean Sea and North Sea. However, some differences still exist around river mouths as river runoff in the GCM are simulated hence not perfect whereas the reanalysis is forced by observationally derived runoff data (CMEMS-IBI-PUM-005-002.pdf (copernicus.eu)).