Supplement of Geosci. Model Dev., 15, 2035–2062, 2022
https://doi.org/10.5194/gmd-15-2035-2022-supplement
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Geoscientific Model Development
Open Access

Supplement of

IBI-CCS: a regional high-resolution model to simulate sea level in western Europe

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S1 Sea Surface Temperature

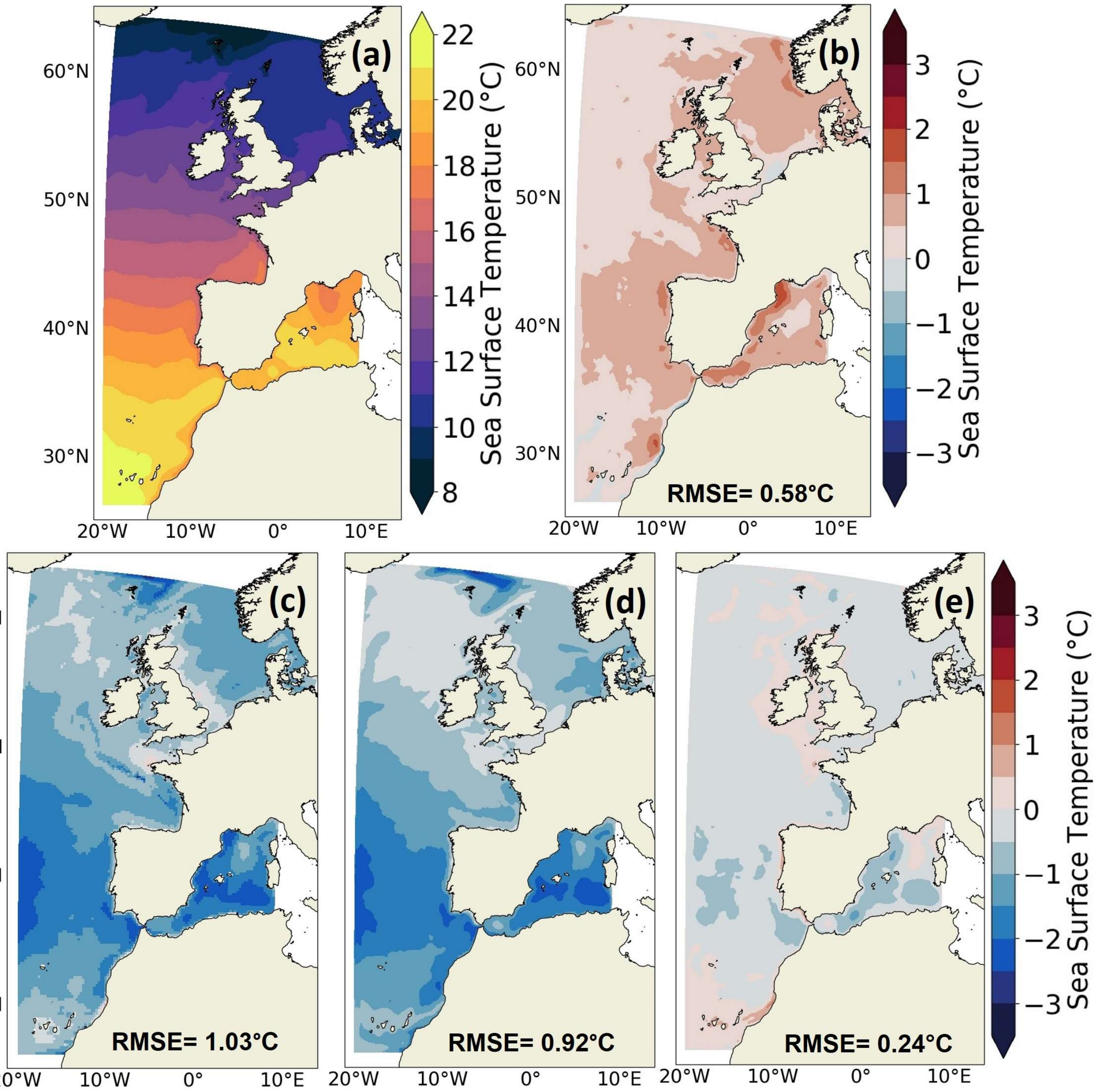

Figure S1: (a) Sea Surface Temperature in IBIRYS over the 1993-2014 period. (b) Sea Surface Temperature bias between IBI-ERAi and IBIRYS over the 1993-2014 period. Biases over the 1993-2014 period between (c) CNRM-CM6-1-HR and IBI-ERAi (d) IBI-CCS_raw and IBI-ERAi (e) IBI-CCS_corr and IBI-ERAi.

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

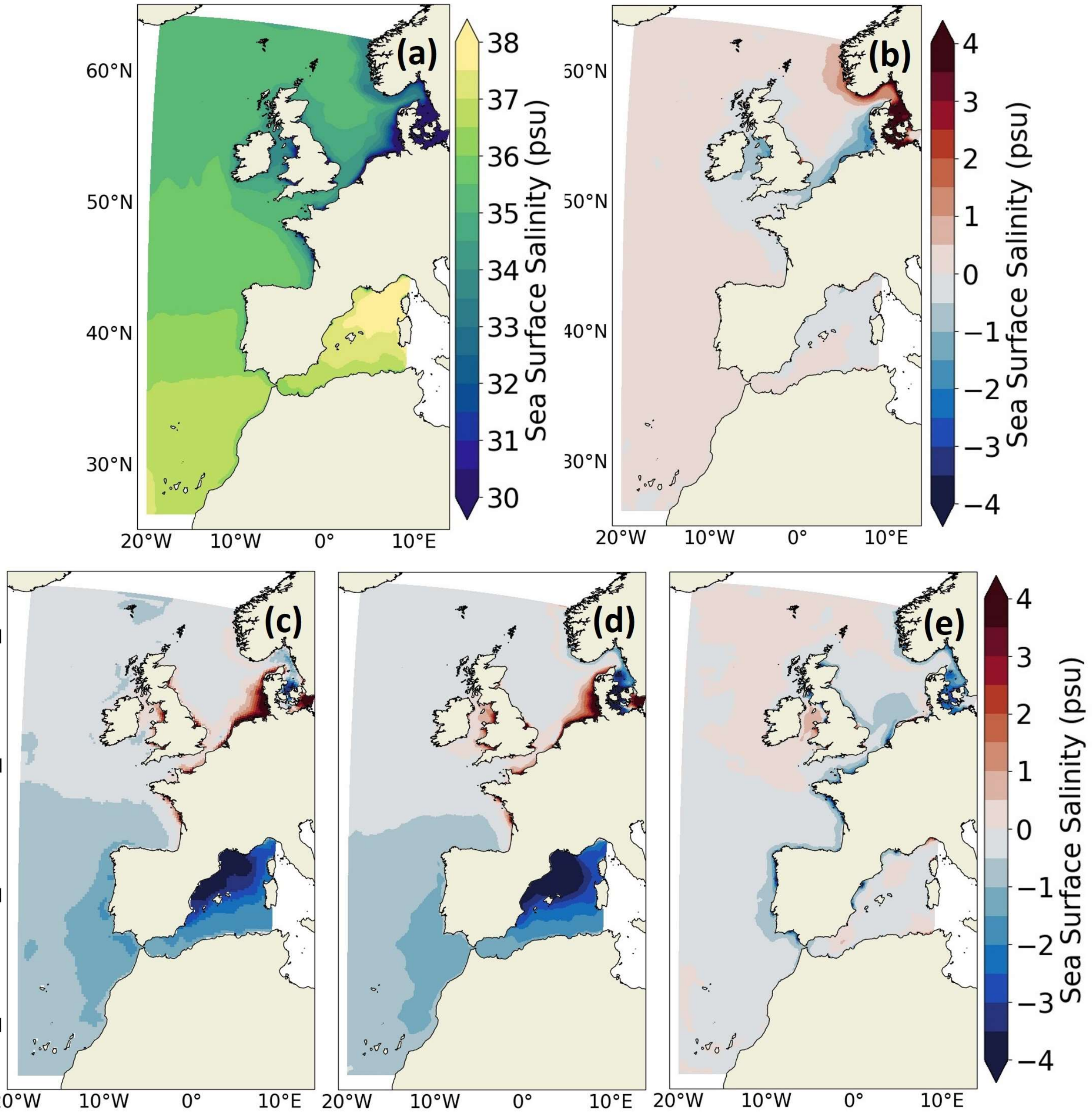

Figure S2: (a) Sea Surface Salinity in IBIRYS over the 1993-2014 period. (b) Sea Surface Salinity bias between IBI-ERAi and IBIRYS over the 1993-2014 period. Biases over the 1993-2014 period between (c) CNRM-CM6-1-HR and IBI-ERAi (d) IBI-CCS_raw and IBI-ERAi (e) IBI-CCS_corr and IBI-ERAi.

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)).

S3 M2 tidal amplitude validation

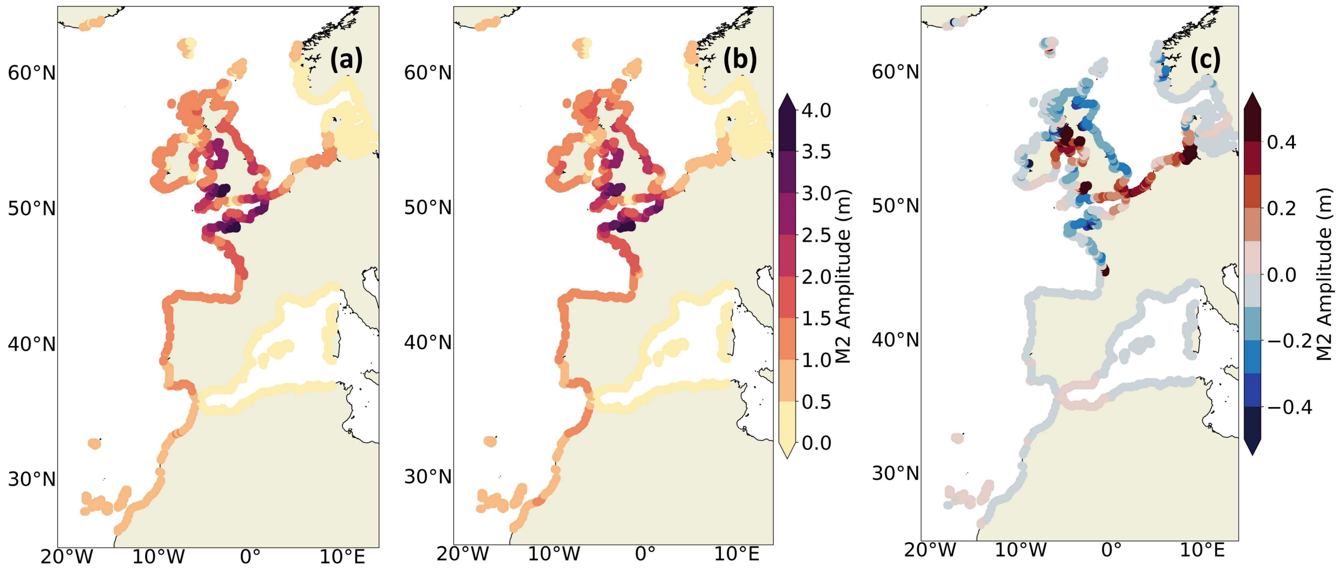

Figure S3: M2 tidal amplitude for FES2014 (a) and IBI-CCS_corr (1993-2014) (b) and the difference FES2014 minus IBI-CCS_corr (c) for the coastal points of the zone.

Figure S3 shows the validation of M2 tidal amplitude in IBI-CCS_corr in comparison to the FES2014 solution (Lyard et al., 2021). In general, the regional model is close to the FES2004 solution, except north of the Irish Sea and in the German Bight.

S4 Bias Corrections over the western boundary of the domain

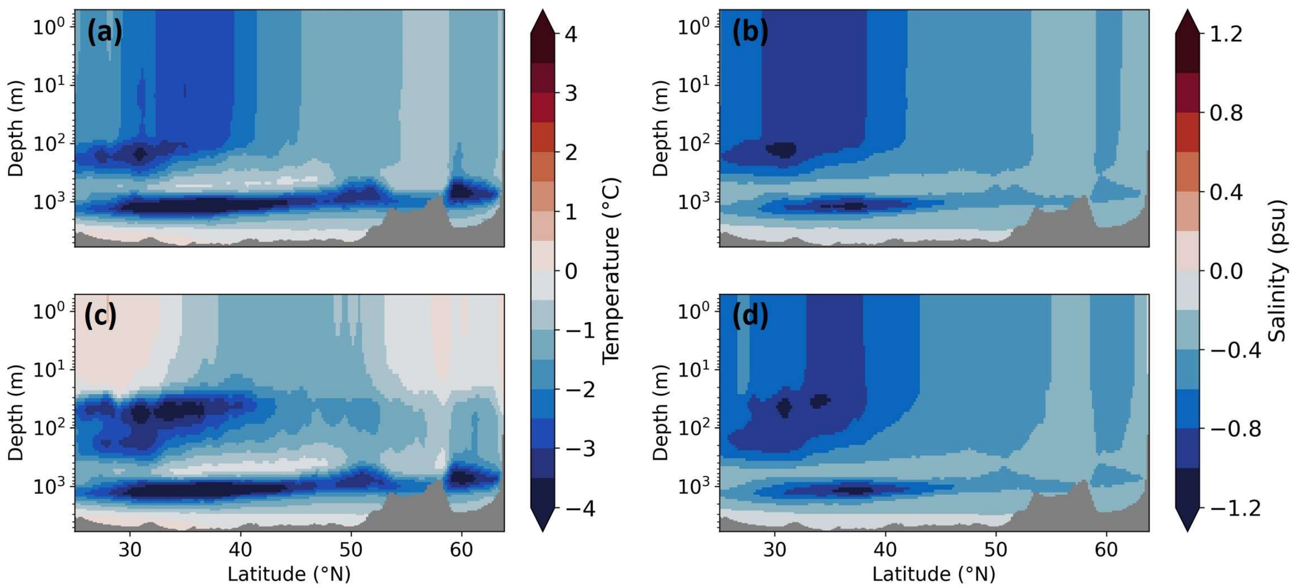

Figure S4: Temperature bias over the 1993-2014 period between CNRM-CM6-1-HR and GLORYS for the winter (a) and for the summer (c). Salinity bias over the 1993-2014 period between CNRM-CM6-1-HR and GLORYS for the winter (b) and for the summer (d). The biases are computed over the western boundary of the domain at 20°W.

Figure S4 shows the amplitude of the temperature and salinity bias corrections for the western boundary of the domain. The amplitude of the biases is very large and can reach 4.5 ° and 1.5 psu at 1500m depth. At 1500m depth, the biases of the western boundary are directly related to the Mediterranean Sea biases due to the Rhone River runoff error in the GCM. The large amplitude of the biases justified for us the corrections applied to the IBI-CCS_corr simulation for the runoffs and thus also for the boundaries for consistency reasons. The temperature bias has a strong seasonality until 200m depth (Fig. S3a and c), which is why the method of correction applied was a seasonal mean bias correction.

S5 Bias Corrections over the western boundary of the domain

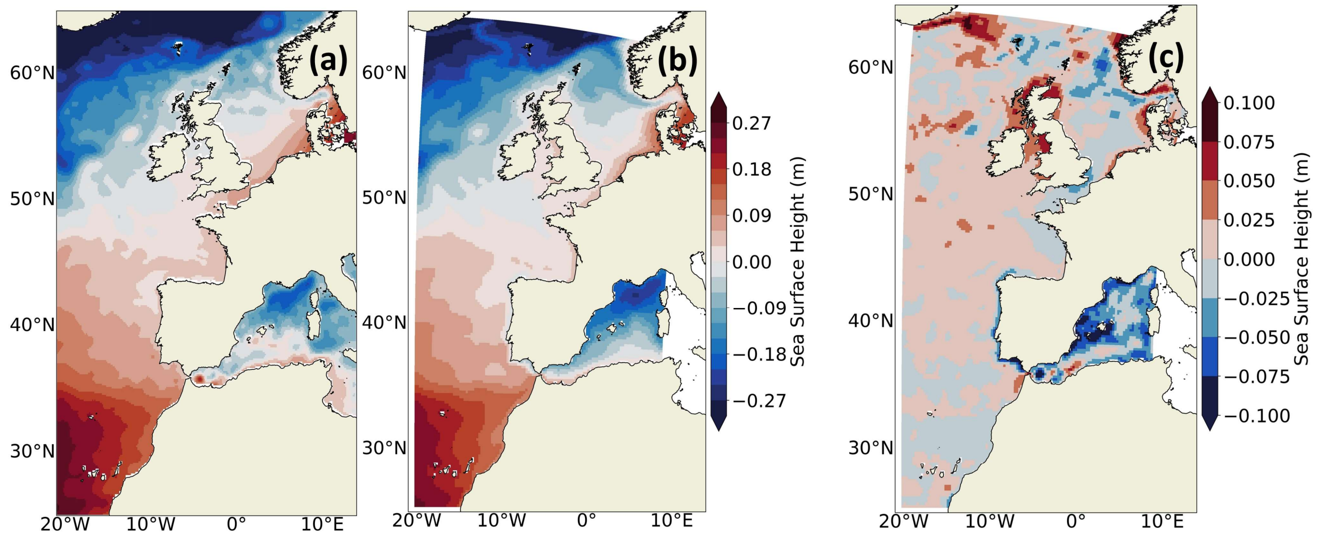

Figure S5: Sea Surface Height bias (c) between GLORYS2V4 (1993-2014) (b) and CNES-CLS-18 (1993-2012) (a).

Figure S5 shows the bias between GLORYS2V4 and CNES-CLS-18 over the entire domain. The bias in the Mediterranean Sea of approximately of +10 cm is due to the assimilation of 2 different sea level anomaly databases in GLORYS2V4: a global one for the Atlantic part and a Mediterranean one. These two databases were not aligned with each other.

References

Lyard, F. H., Allain, D. J., Cancet, M., Carrère, L., and Picot, N.: FES2014 global ocean tide atlas: design and performance, Ocean Sci., 17, 615–649, https://doi.org/10.5194/os-17-615-2021, 2021.