Figures in Supplementary Material

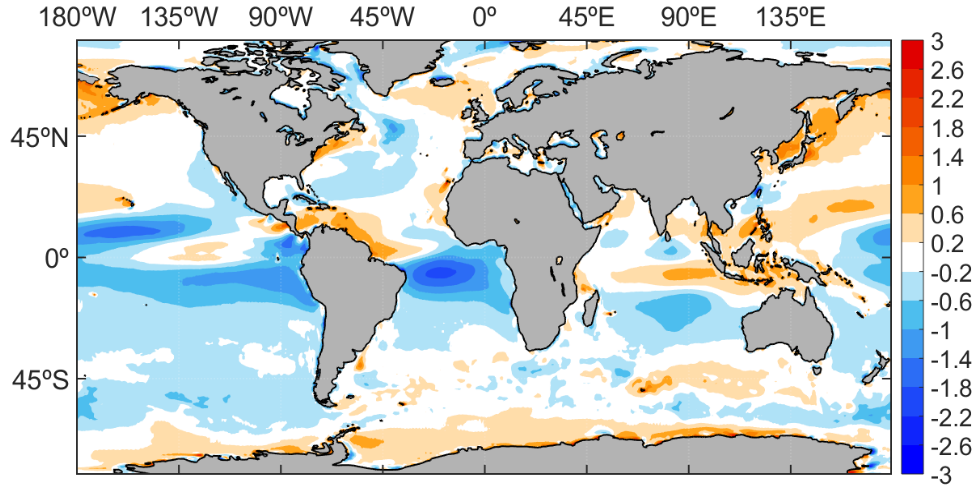

Figure S1. Absolute differences between EC-EARTH and ERA5 for the annual mean U_{10} (m/s) for the present climate (1995-2014).

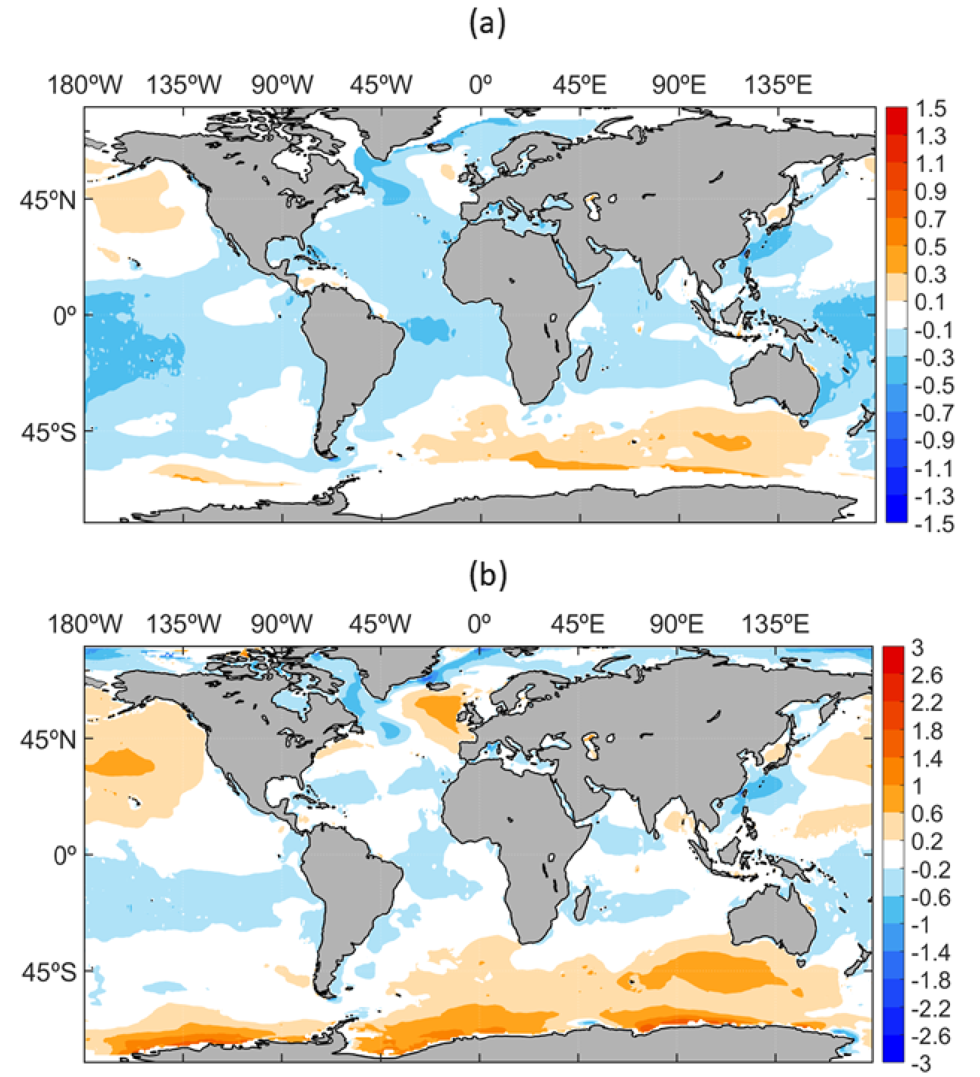

Figure S2. Mean absolute differences between present climate historical ensemble (PC20-E; 1995-2014) and ERA5 for (a) H_s (m) and (b) 95% percentile H_s (m).

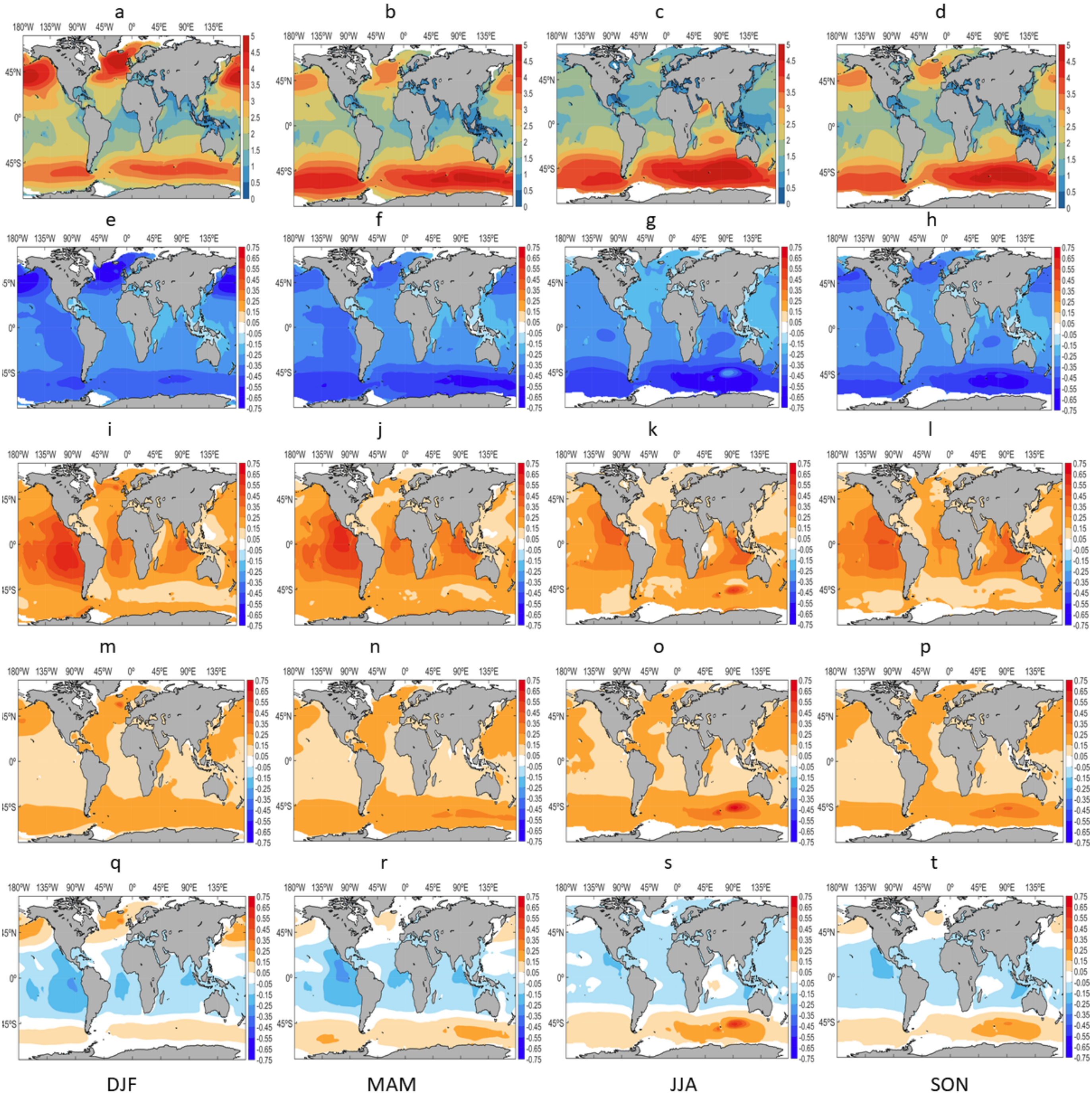

Figure S3. Seasonal global ensemble means of H_S (m) for PC20-E (a-d) and the anomaly from the ensemble mean for (e-h) PC20-ST2, (i-l) PC20-ST3, (m-p) PC20-ST4 and (q-t) PC20-ST6.

Figure S4. Seasonal mean anomalies of ST2, ST3, ST4 and ST6 from its ensemble mean (PC20-E (a-d) and FC21-E (e-h)) for global and 13 sub regions during DJF (a and e), MAM (b and f), JJA (c and g) and SON (d and h) for H_S.

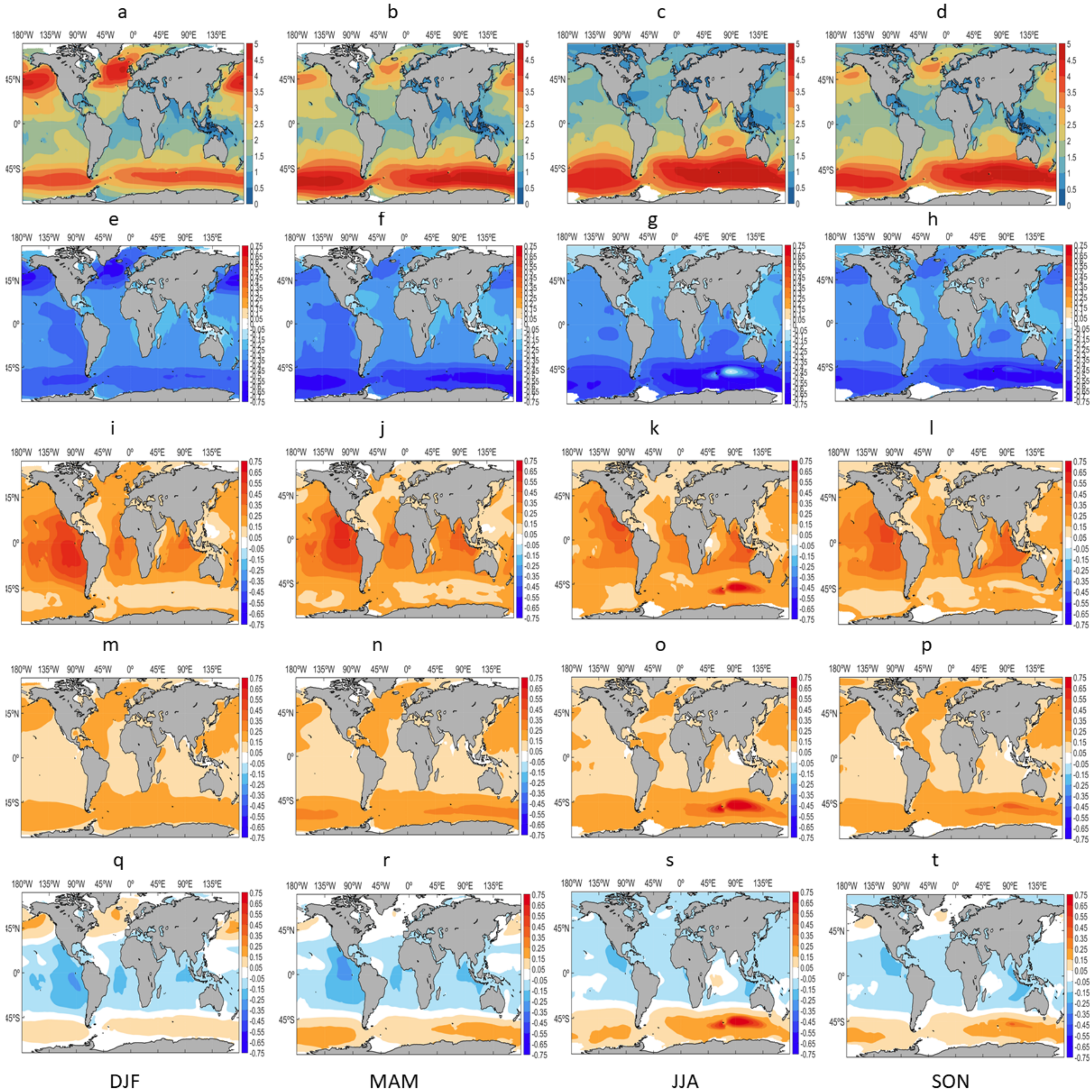

Figure S5. Same as Figure S3, but for FC21.

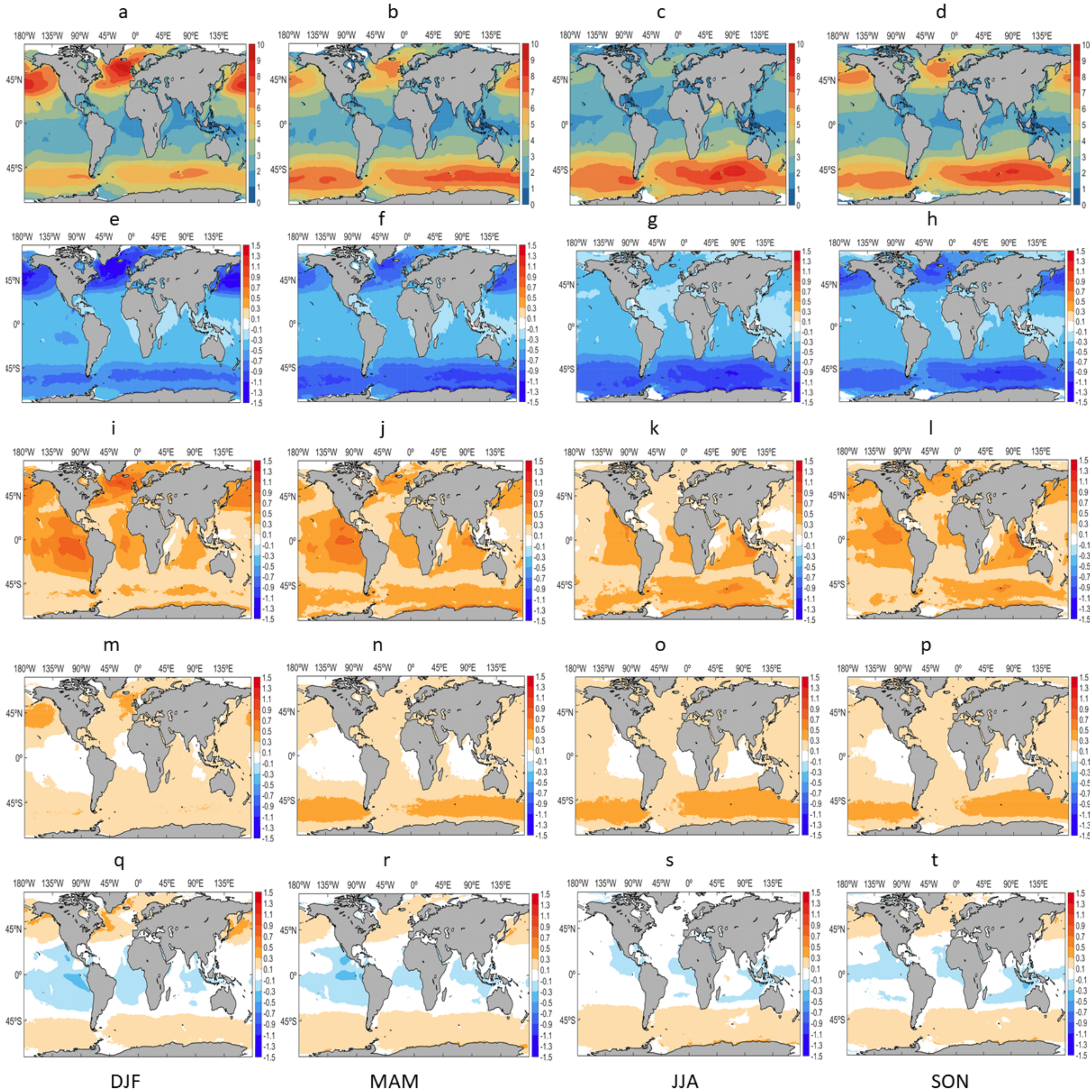

Figure S6. Same as Figure S3, but for H_s^{95}.

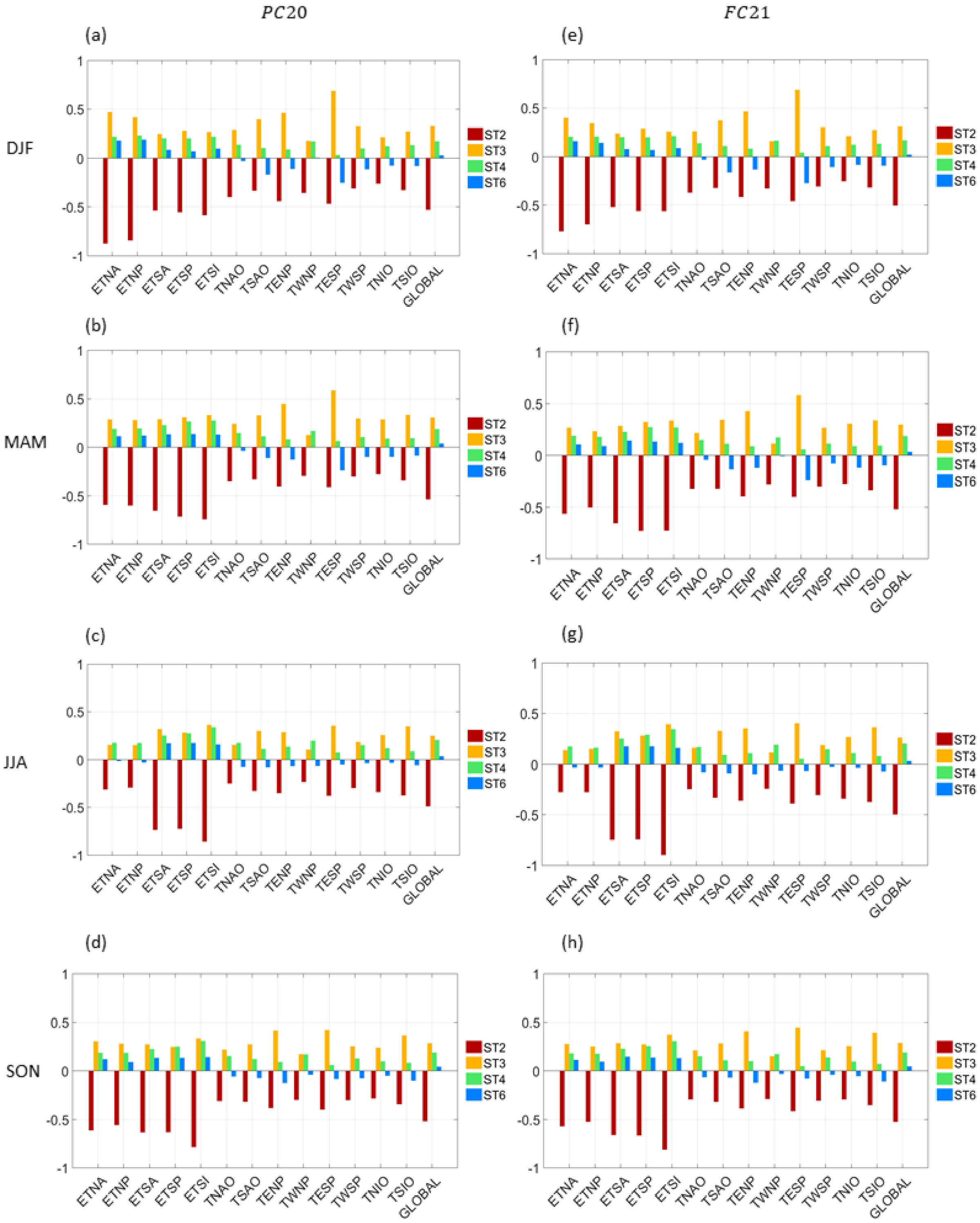

Figure S7. Same as Figure S4, but for H_s^{95}.

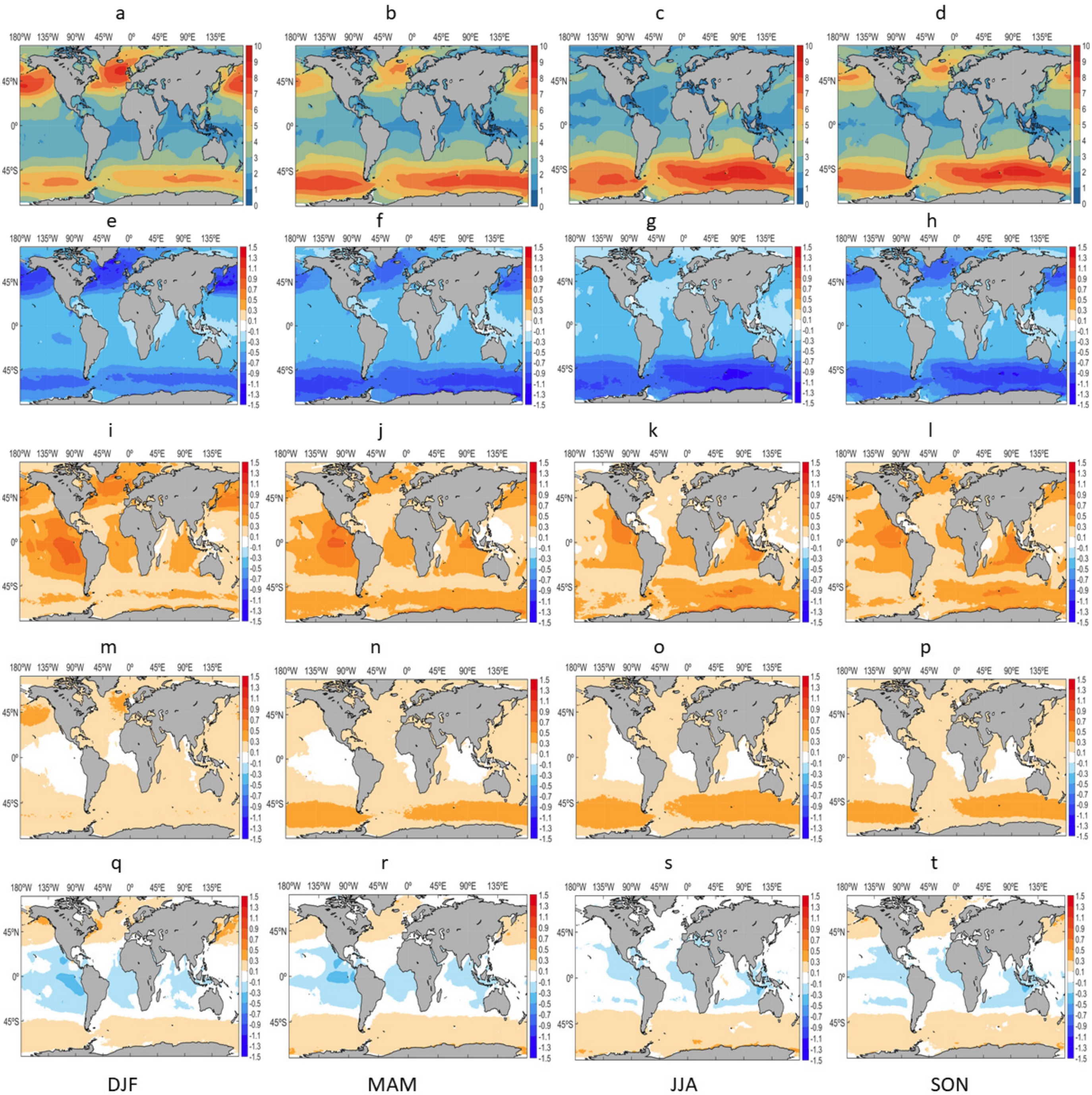

Figure S8. Same as FigureS5, but for H_s^{95}.

Tables in Supplementary Material

Table S1. A brief description of the main differences in the different source term packages (ST2/3/4/6) used in this study.

Source Term Package	S_{in}	S_{ds}
ST2:	The wind input term in this package uses a non-dimensional wind-wave interaction parameter based on sea surface drag coefficient, which is capped at 2.5 x 10^{-3}.	Dissipation term consists of two separate terms for both the low and high frequency waves. The (dominant) low-frequency constituent is based on energy dissipation due to turbulence. Overestimation of swell dissipation.
ST3:	Wind input term is a function of wave supported stress. Added a negative part in the wind input term to represent the liner damping of swell waves. Require a re-tuning of source term coefficients (such as BETAMAX) for different wind products.	The generic form of the WAM4 dissipation term is used Unfortunately, these parameterizations are sensitive to swell. An increase in swell height typically reduces dissipation at the wind-sea peak and increase dissipation at high frequencies.
ST4:	Positive part of the wind input term is taken from ST3. Added an ad hoc reduction of frictional velocity is implemented to allow a balance with a saturation-based dissipation of waves. This correction also reduces the drag coefficient at high winds.	A dissipation function without any prescribed spectral shape. Dissipation of swell over long distances are due to air friction. A low bias for Hs > 8 m when tested at global scale using ECMWF winds.
ST6:	The positive part of the wind input is based on measurements and the negative wind input term is based on laboratory testing. Bulk adjustment to the wind field can be achieved by re-scaling the drag parameterization through namelist parameter. This has a similar effect to tuning the BETAMAX parameter in ST3/4 source term packages.	Whitecapping dissipation source terms are based on measurements and Wave-turbulence dissipation is based on laboratory experiments and field observations of swell decay. Dissipation of swell are due to the interaction of ocean turbulence. Swell will transfer energy into the ocean when they dissipate (not to the air as in ST4)

Table S2. Regional area limits from Figure 1, as in Alves et al. 2006. LAT—latitude; LON—longitude.

Area	LAT (°)	LON (°)
ETSI	78°S – 25°S	21°E – 145°E
ETSP	78°S – 25°S	145°E – 70°W
ETSA	78°S – 25°S	69°W – 20°E
TSIO	24°S – 0°	21°E – (100°E (N); 135°E (S))
TWSP	24°S – 0°	(101°E (N); 136°E (S)) – 130°W
TESP	24°S – 0°	129°W – 65°W
TSAO	24°S – 0°	64°W – 20°E
TNIO	1°N – 30°N	41°E – 100°E
TWNP	1°N – 30°N	101°E – 180°E
TENP	1°N – 30°N	Land
TNAO	1°N – 38°N	(101°W (N); 69°W (S)) – 40°E
ETNP	31°N – 78°N	101°E – 102°W
ETNA	39°N – 78°N	101°W – 100°E

Table S3. M-Scores skill assessment of the 95% percentile PC20-E and ensemble members, against ERA5, for global and adopted sub-regions.

Area	**ST2**	**ST3**	**ST4**	**ST6**	**Ensemble**
ETSA	804	764	776	794	831
ETSP	734	799	803	817	851
ETSI	829	715	722	758	805
ETNA	798	886	897	900	901
ETNP	870	877	888	889	910
TNAO	772	931	939	895	914
TSAO	593	875	913	764	825
TENP	736	616	805	832	849
TWNP	729	834	835	828	836
TESP	387	633	777	593	706
TWSP	571	869	830	731	769
TNIO	769	864	896	869	881
TSIO	699	849	925	856	897
GLOBAL	856	878	888	893	911