

Supplementary Material of “Effects of internal climate variability on historical ocean wave height trend assessment”

Mercè Casas-Prat^{1,*}, Xiaolan L. Wang¹, Nobuhito Mori², Yang Feng¹, Rodney Chan¹, and Tomoya Shimura²

¹ *Climate Research Division, Science and Technology Branch, Environment and Climate Change Canada, Toronto, Ontario, Canada*

² *Disaster Prevention Research Institute, Kyoto University, Japan*

Correspondence*: Mercè Casas-Prat merce.casasprat@ec.gc.ca

1 SUPPLEMENTARY TABLES AND FIGURES

Included here are Supplementary Figures S1-S25 that were referred to in the manuscript.

1.1 Figures

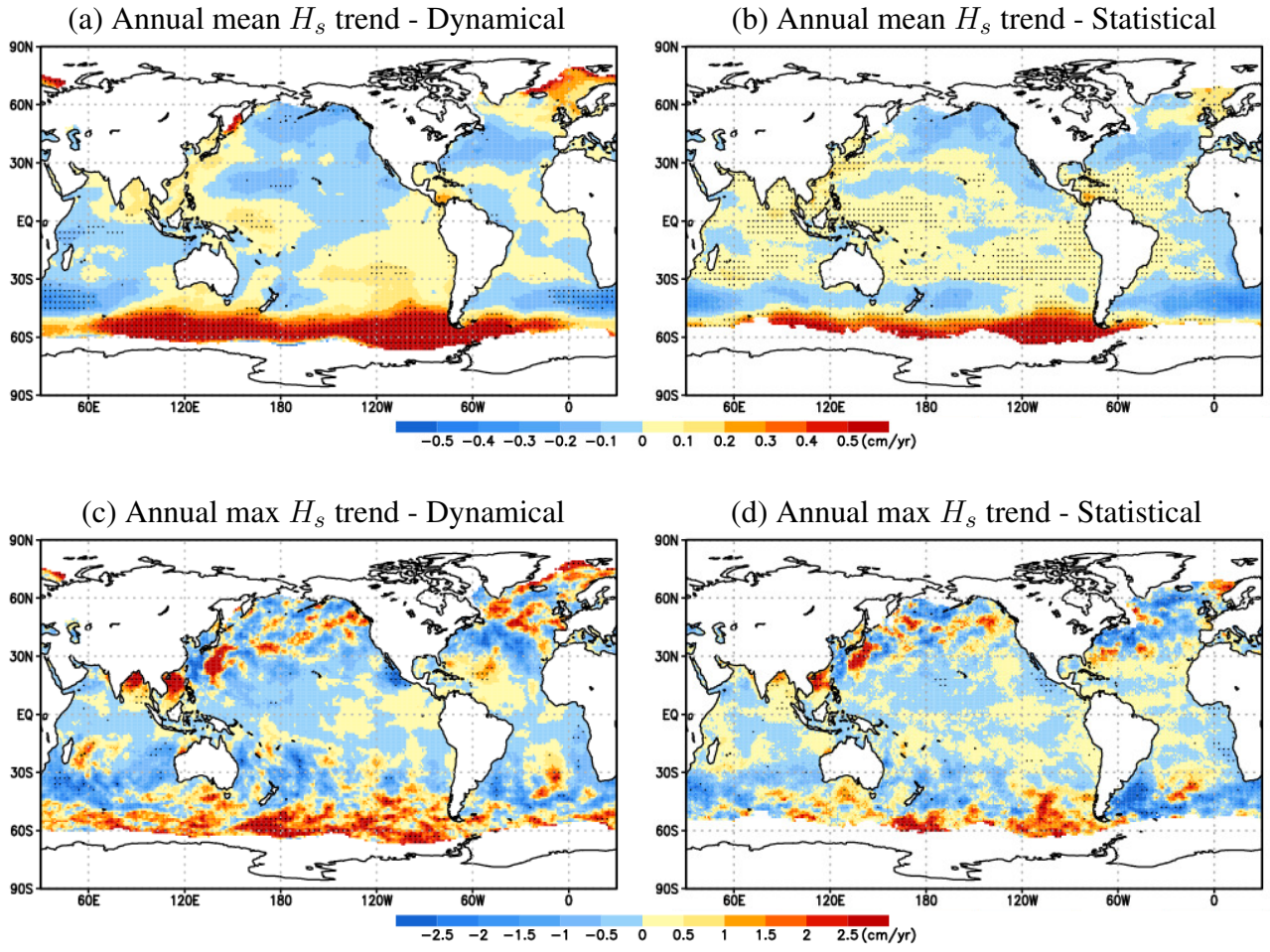


Figure S1. Annual mean H_s (a,b) and max H_s (c,d) trend (cm/yr) for the period 1951–2010, as obtained from the first d4PDF-WaveHs ensemble member with the dynamical (a,c) and statistical (b,d) approach, respectively.

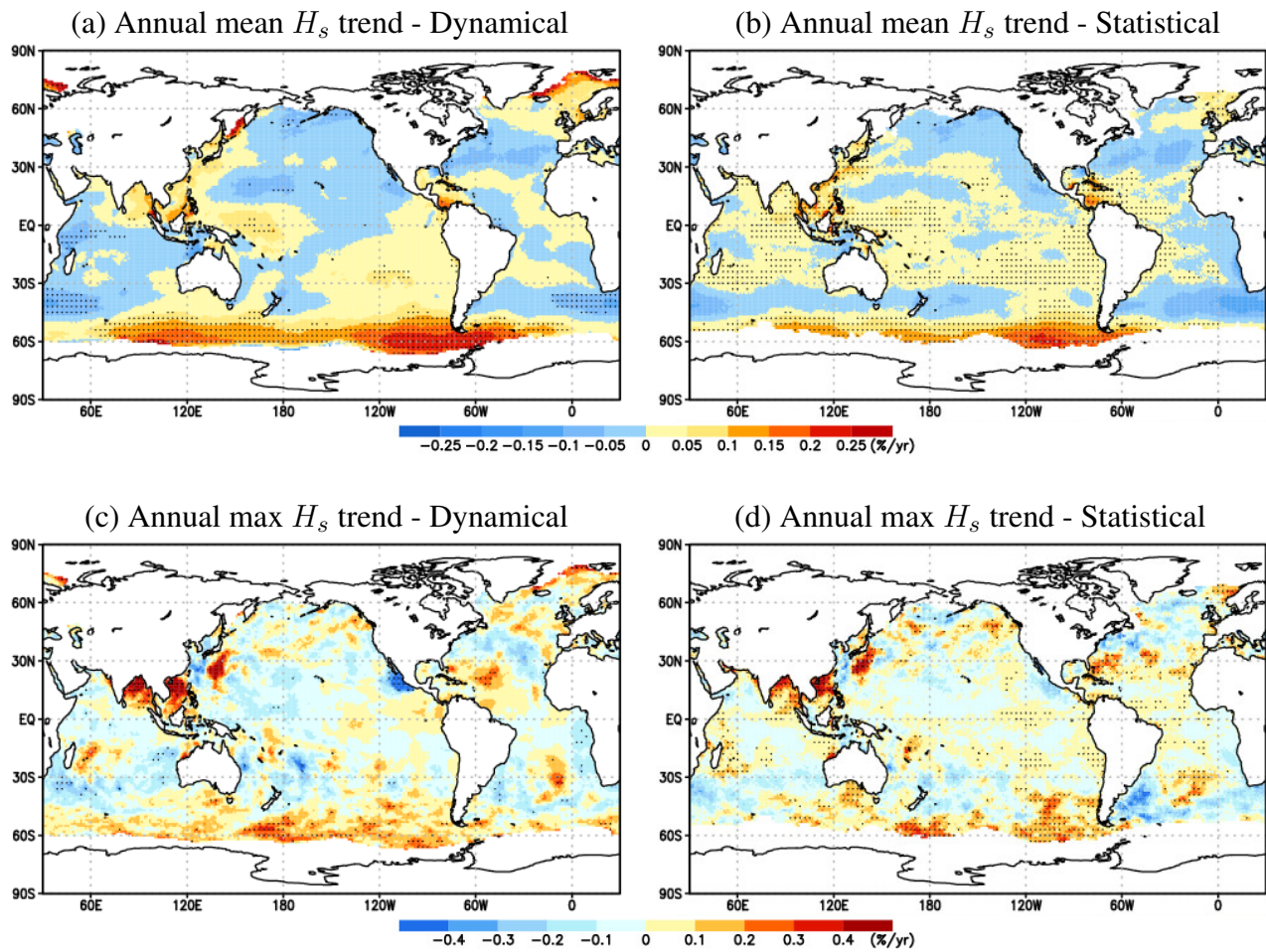


Figure S2. Annual mean H_s (a,b) and max H_s (c,d) trend (%/yr) for the period 1951–2010 (relative to the 1951–2010 climatology), as obtained from the first d4PDF-WaveHs ensemble member with the dynamical (a,c) and statistical (b,d) approach, respectively.

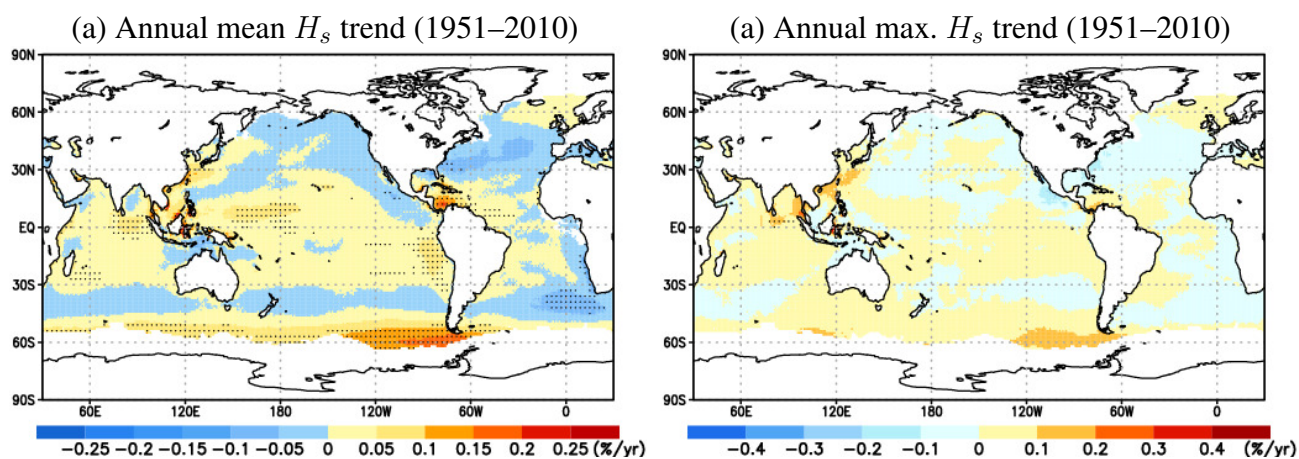


Figure S3. Ensemble average of the annual mean H_s (a) and maximum H_s (b) trend (%/yr) for 1951–2010, relative to the climatological 1951–2010 mean. Stippling indicates the ensemble mean trend is statistically significant.

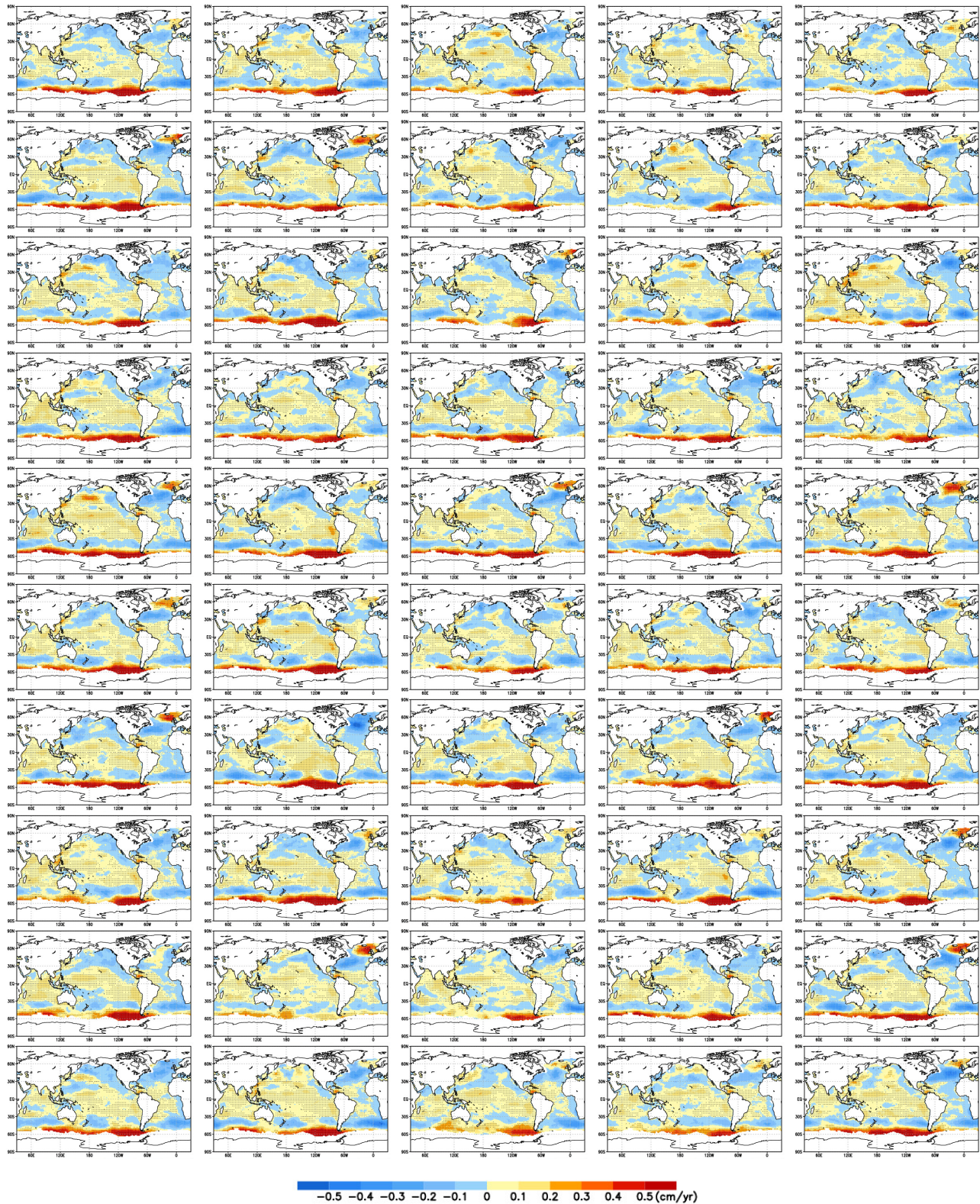


Figure S4. Annual mean H_s trend (cm/yr) as derived from the 1st to 50th d4PDF-WaveHs ensemble members. Stippling indicates the trend for the corresponding member is statistically significant.

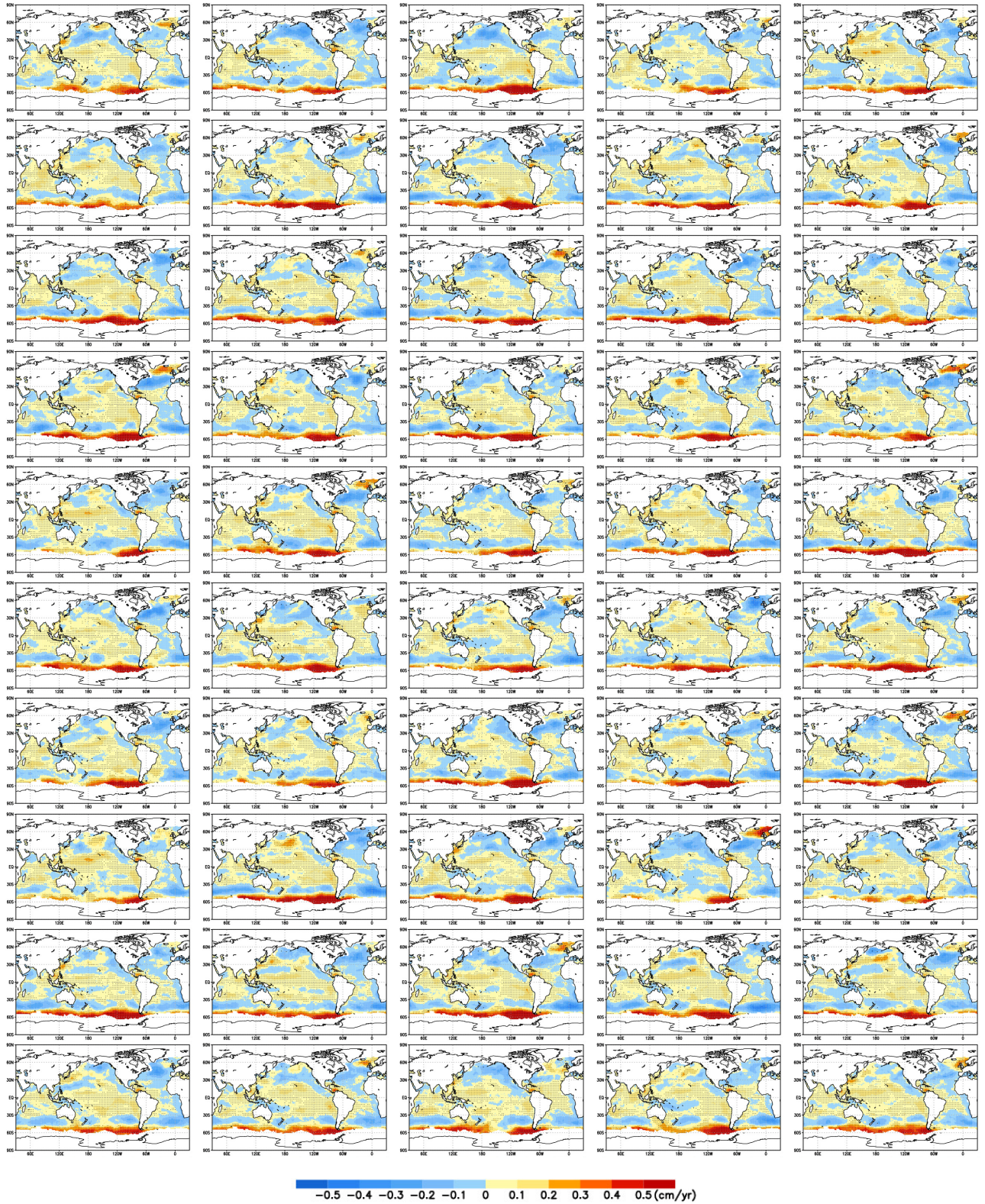


Figure S5. Annual mean H_s trend (cm/yr) as derived from the 51th to 100th d4PDF-WaveHs ensemble members. Stippling indicates the trend for the corresponding member is statistically significant.

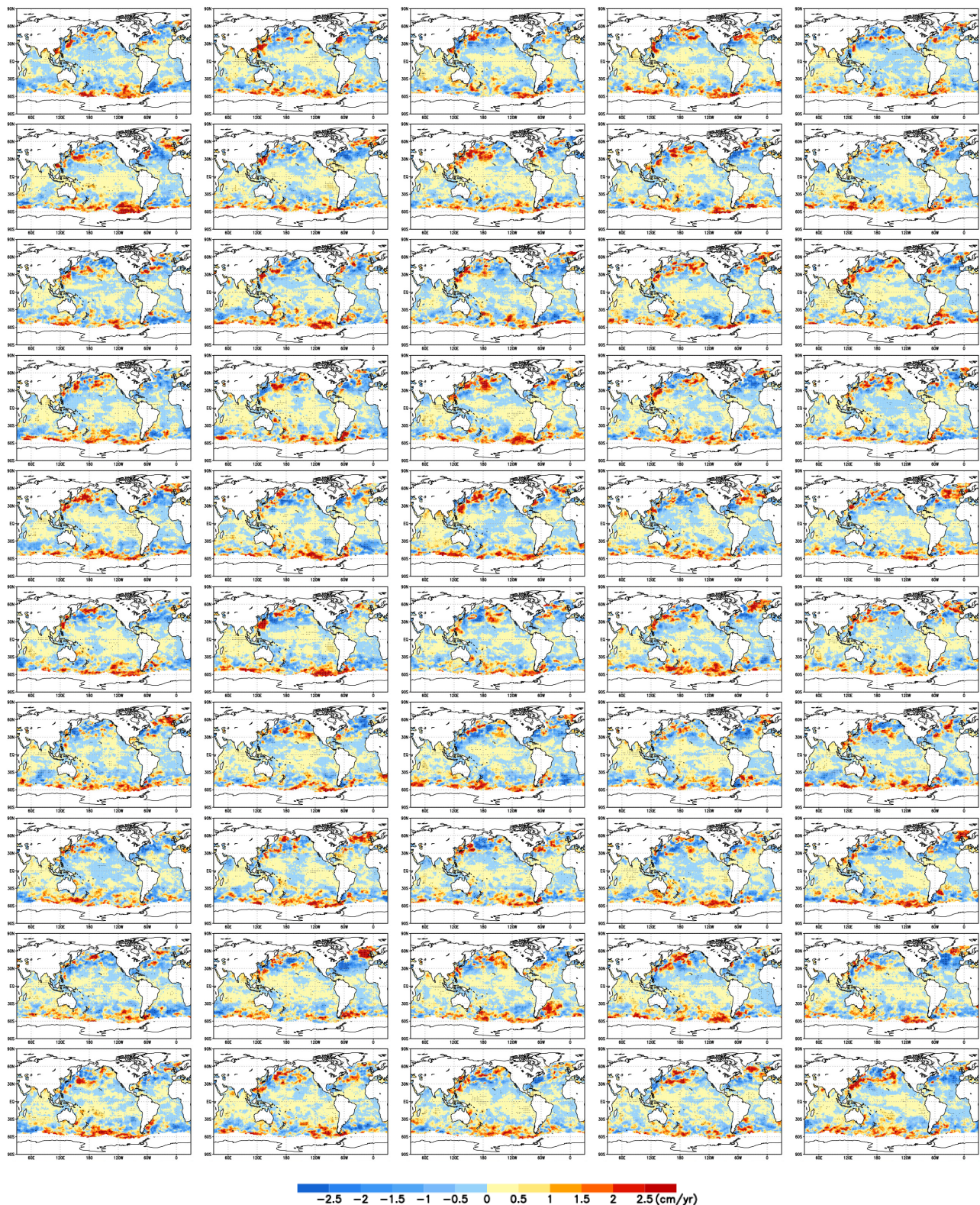


Figure S6. Annual maximum H_s trend (cm/yr) as derived from 1st to 50th d4PDF-WaveHs ensemble members. Stippling indicates the trend for the corresponding member is statistically significant.

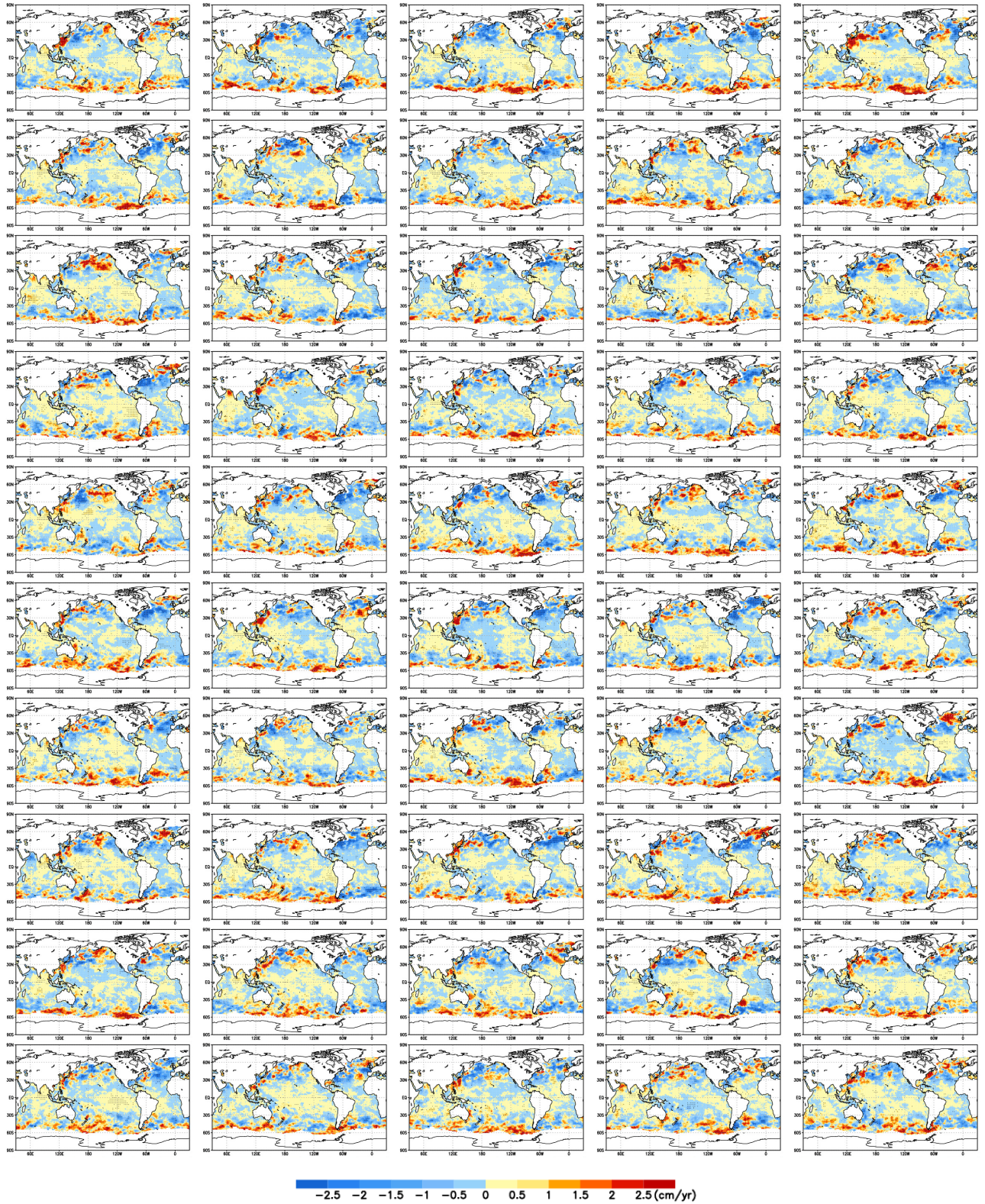


Figure S7. Annual maximum H_s trend (cm/yr) as derived from the 51th to 100th d4PDF-WaveHs ensemble members. Stippling indicates the trend for the corresponding member is statistically significant.

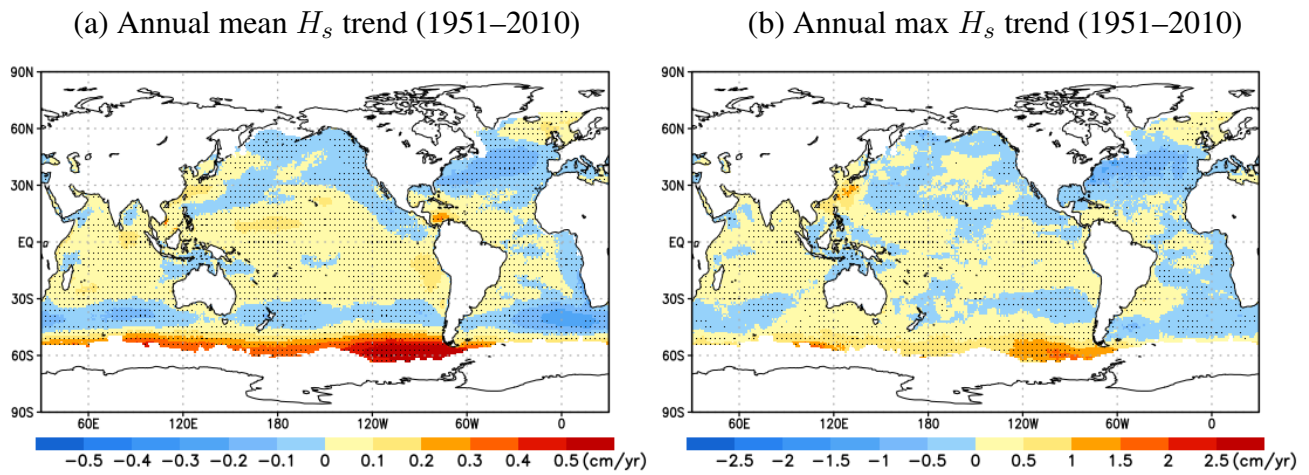


Figure S8. Ensemble average of the annual mean H_s (a) and maximum H_s (b) trend (cm/yr) for 1951–2010. Stippling indicates the ensemble mean trend is statistically significant using a t-test on the ensemble mean (5% significance level).

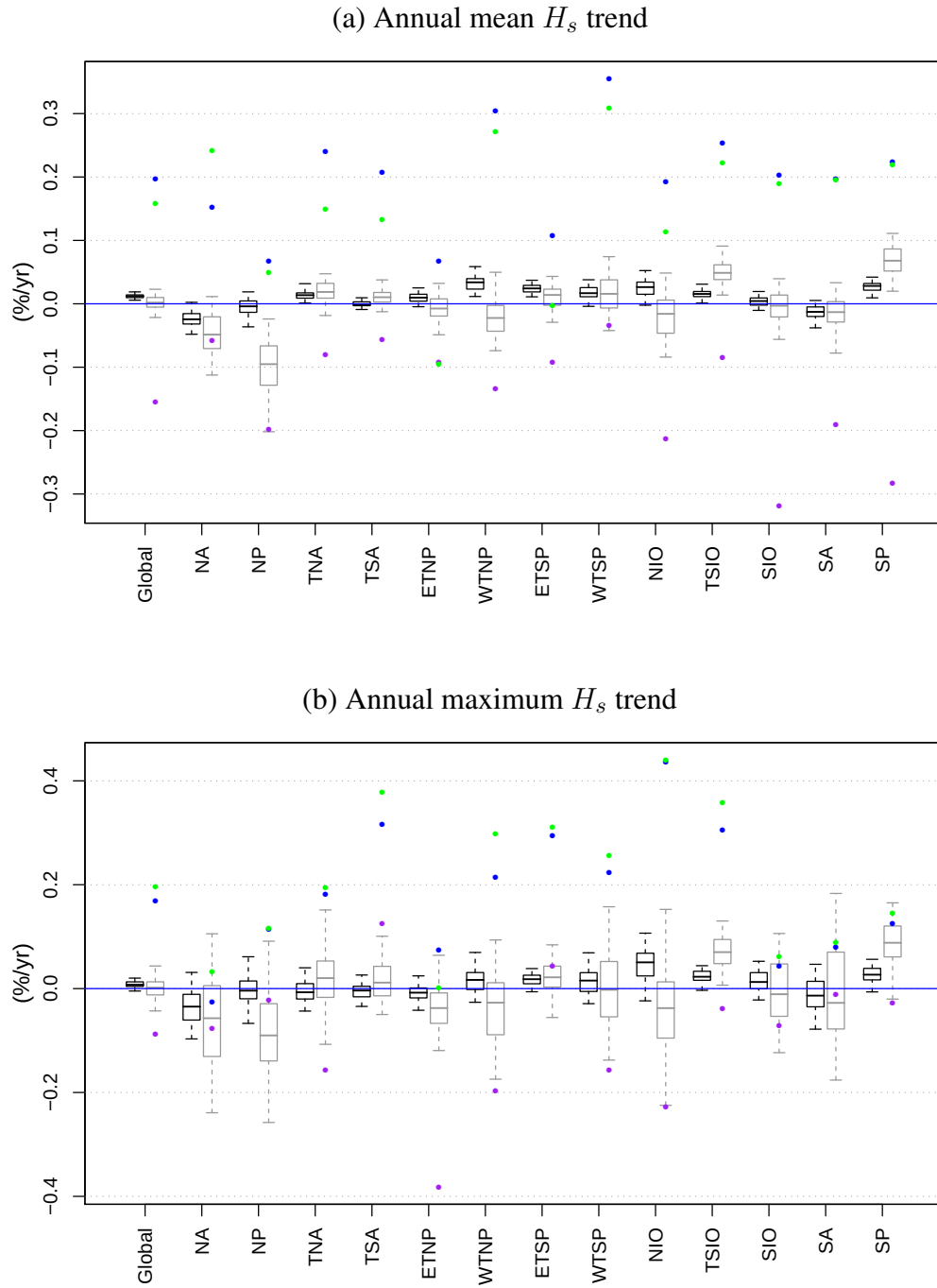


Figure S9. Ensemble average of the regional relative trend (%/yr) of the annual mean (a) and maximum (b) H_s averaged over the indicated area (see Figure 1 of the main manuscript), corresponding to the 1951–2010 (black) and 1979–2009 (gray) periods. Dots indicate: ERA5 (blue), ERA-I (green) and CFSR (purple) corresponding values for 1979–2009. Box plot illustrates the 2.5%, 25%, 50%, 75% and 97.5% percentiles. Trend is calculated relative to the climatological 1951–2010 mean.

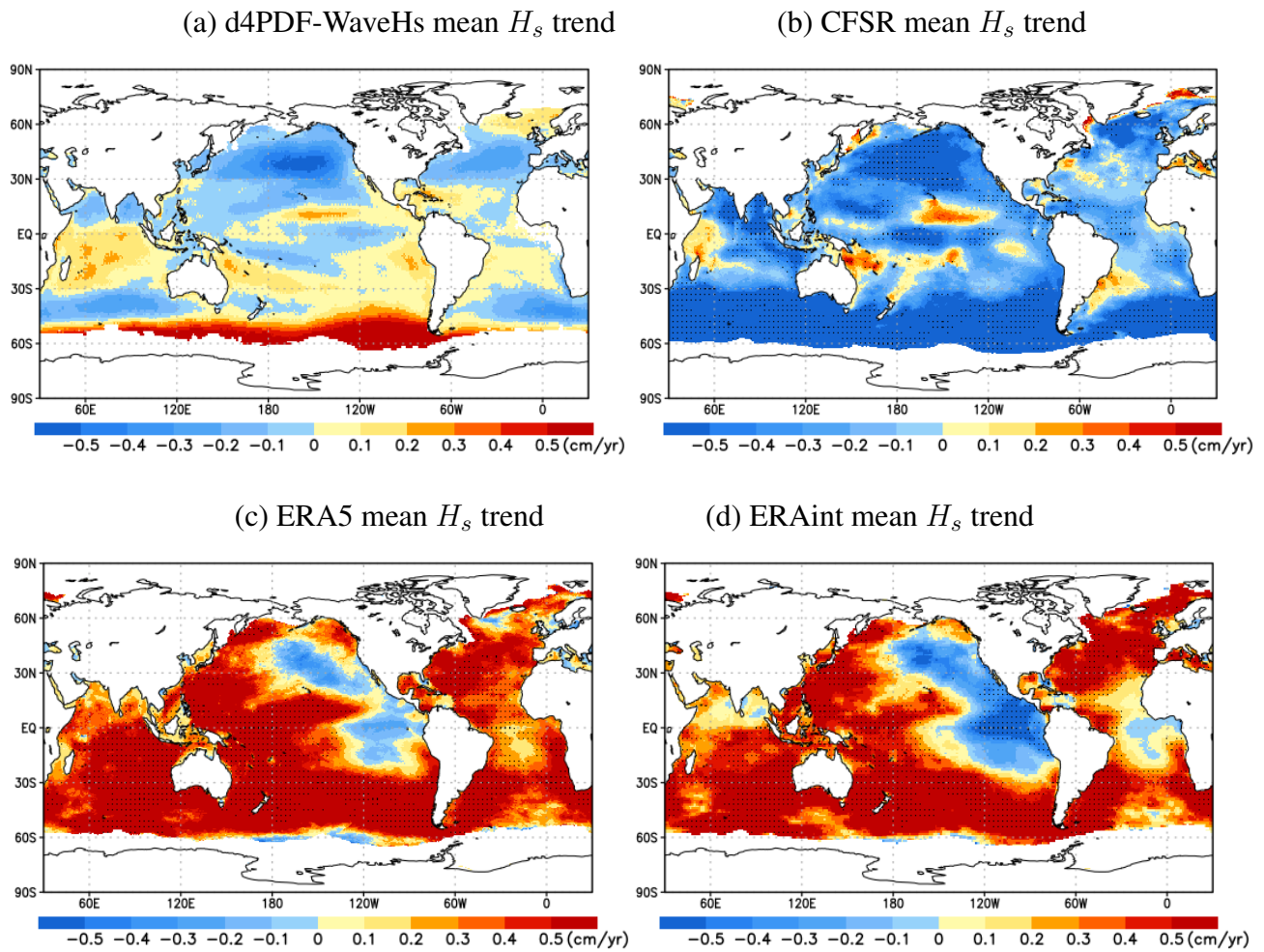


Figure S10. Annual mean H_s trend (cm/yr) for 1979–2009, as obtained by d4PDF-WaveHs (ensemble average) (a), CFSR (b), ERA5 (c), and ERAint (d). Stippling indicates the trend is statistically significant.

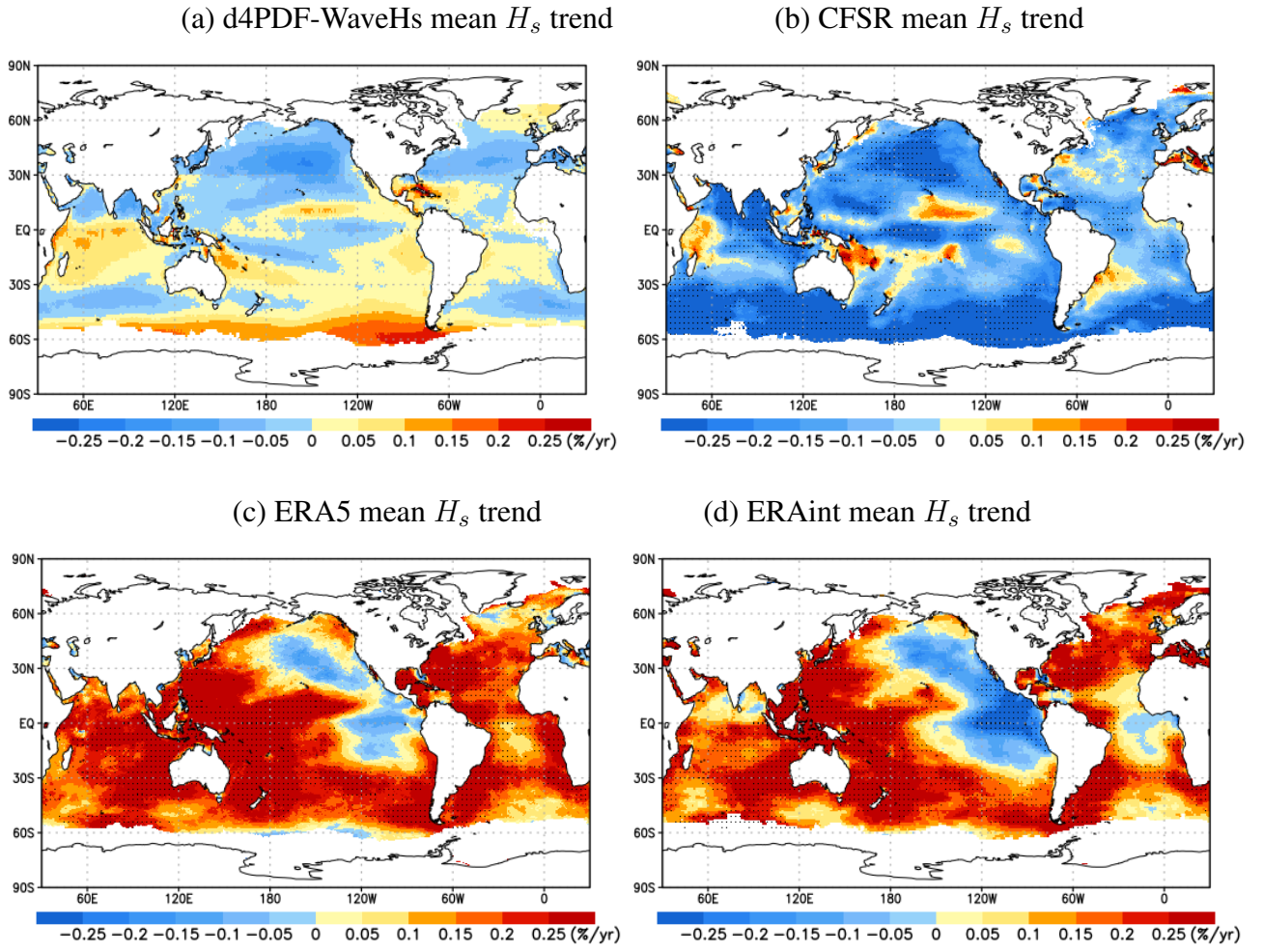


Figure S11. Annual mean H_s trend (%/yr) for 1979–2009 (relative to the climatological 1979–2009 mean), as obtained by d4PDF-WaveHs (ensemble average) (a), CFSR (b), ERA5 (c), and ERAint (d). Stippling indicates the trend is statistically significant.

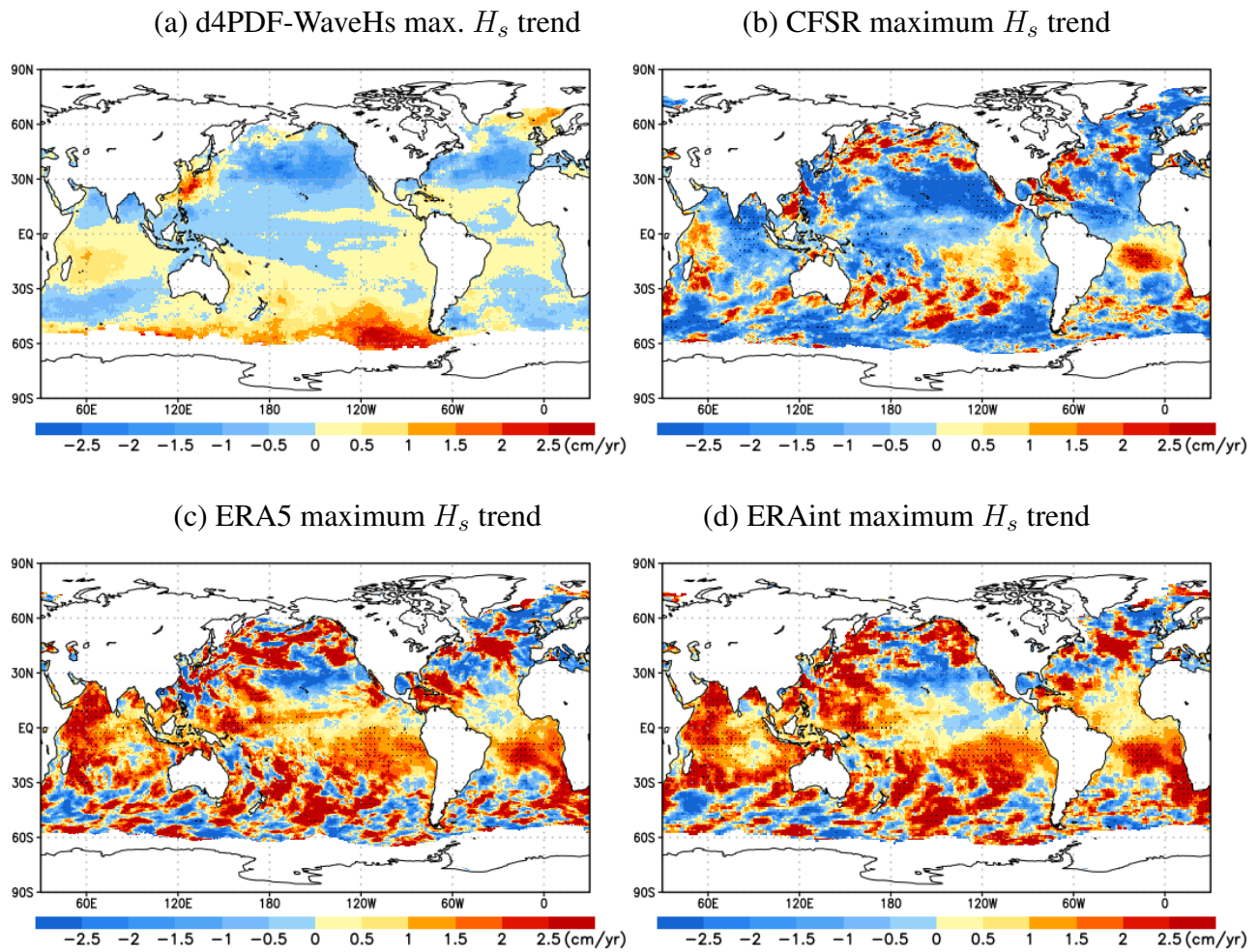


Figure S12. Annual maximum H_s (cm/yr) trend for 1979–2009, as obtained by d4PDF-WaveHs (ensemble average) (a), CFSR (b), ERA5 (c), and ERAint (d). Stippling indicates the trend is statistically significant.

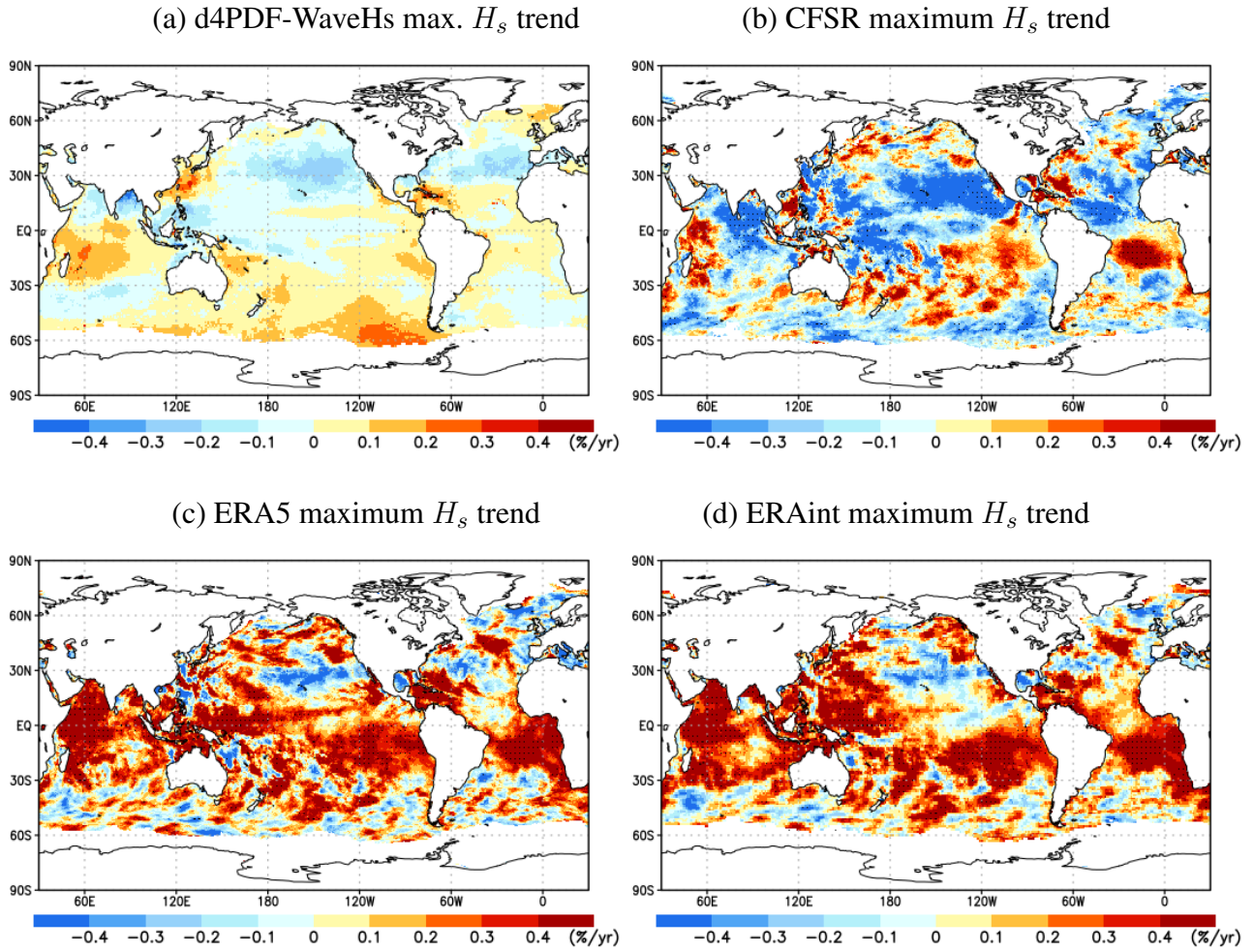


Figure S13. Annual maximum H_s (%/yr) trend for 1979–2009 (relative to the climatological 1979–2009 mean), as obtained by d4PDF-WaveHs (ensemble average) (a), CFSR (b), ERA5 (c), and ERAint (d). Stippling indicates the trend is statistically significant.

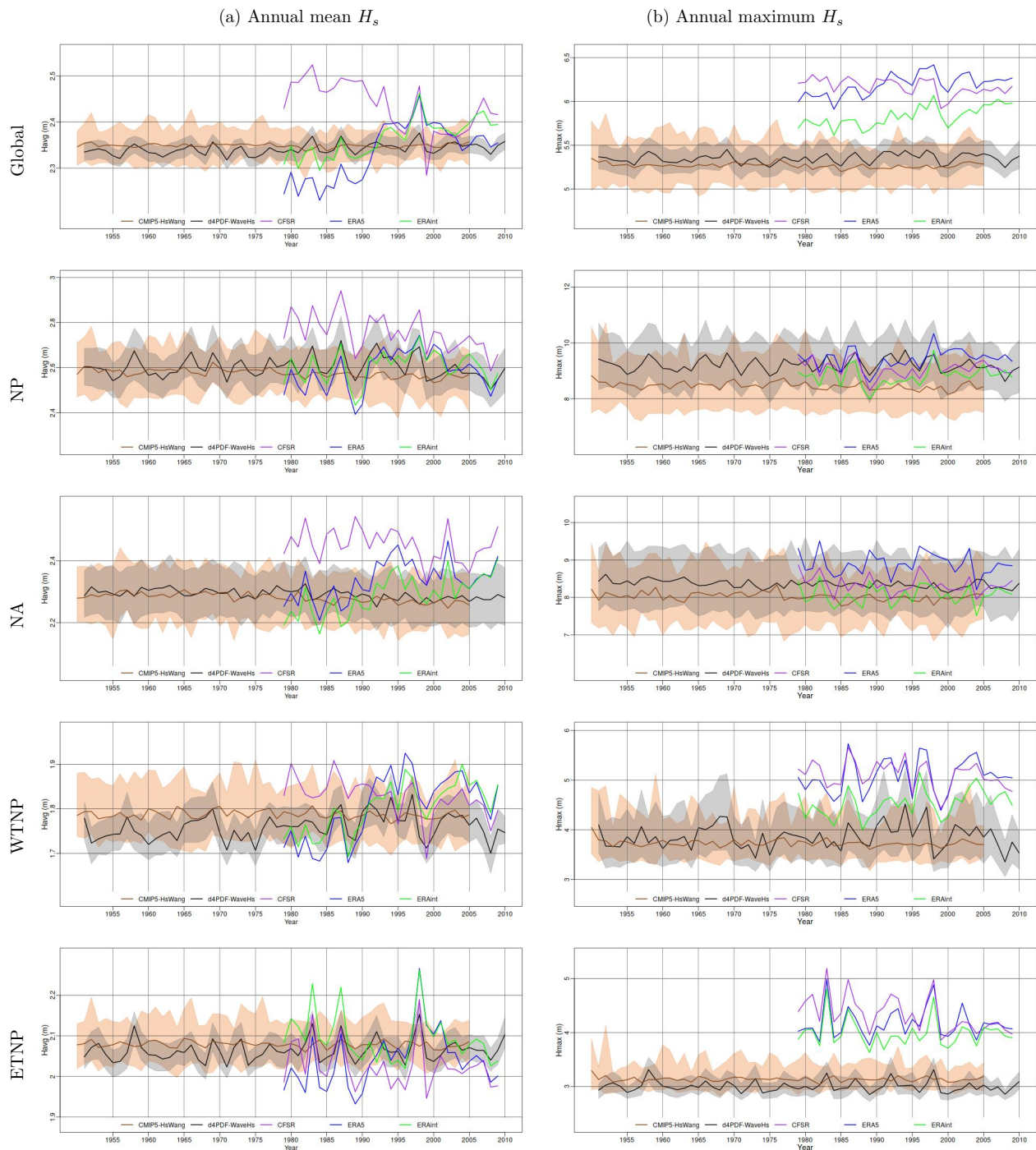


Figure S14. Regional time series of the annual mean H_s (a) and annual maximum H_s (b), in m, for the indicated areas (see Figure 1 of the main manuscript), as derived from d4PDF-WaveHs (black), CMIP5-HsWang (brown), CFSR (purple), ERA5 (blue), ERAint (green). For the d4PDF-WaveHs and CMIP5-HsWang ensembles we show the ensemble mean (thick lines) and the range between the 2.5% and 97.5% percentiles (shaded area).

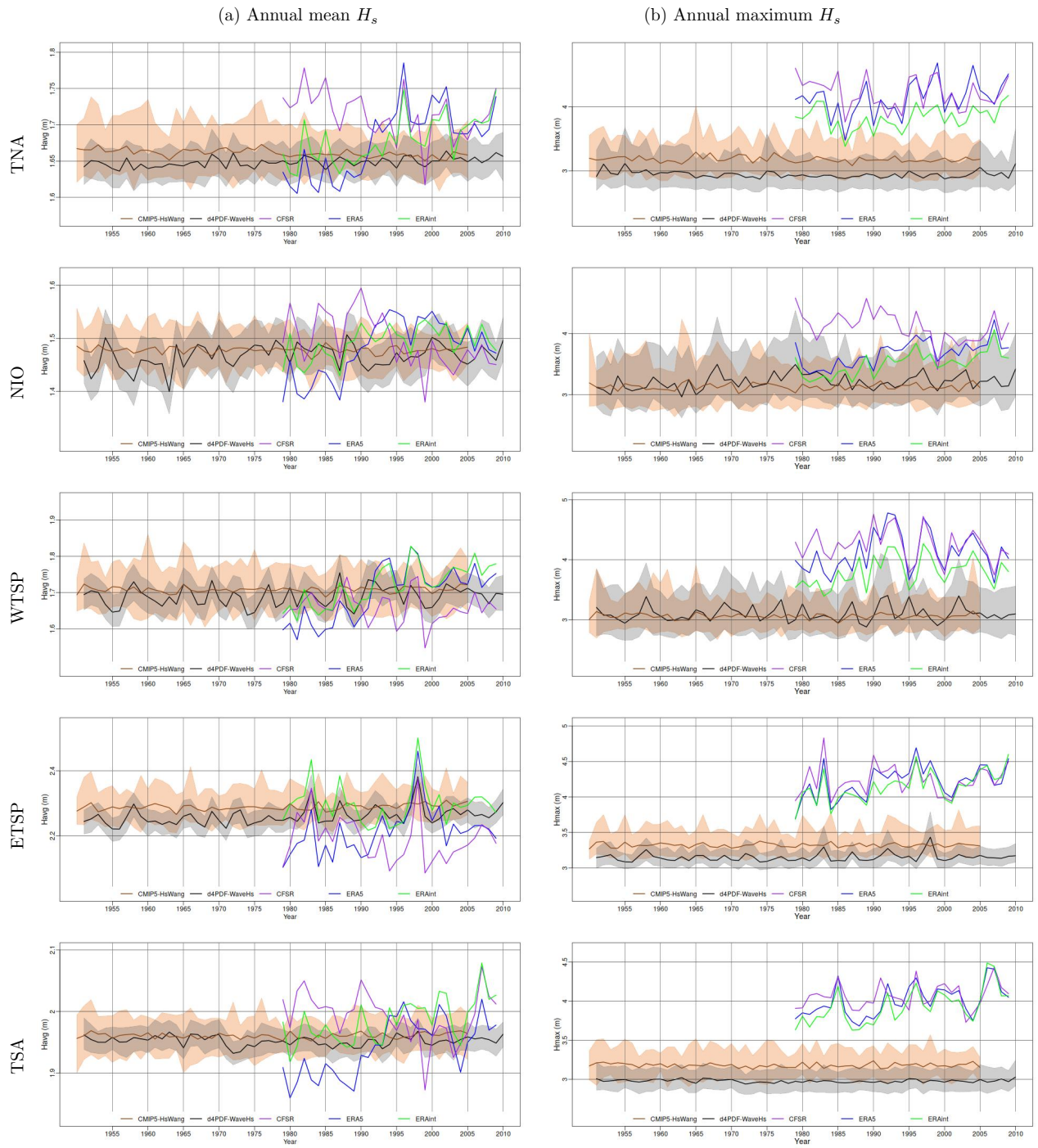


Figure S15. Regional time series of the annual mean H_s (a) and annual maximum H_s (b), in m, for the indicated areas (see Figure 1 of the main manuscript), as derived from d4PDF-WaveHs (black), CMIP5-HsWang (brown), CFSR (purple), ERA5 (blue), ERAInt (green). For the d4PDF-WaveHs and CMIP5-HsWang ensembles we show the ensemble mean (thick lines) and the range between the 2.5% and 97.5% percentiles (shaded area).



Figure S16. Regional time series of the annual mean H_s (a) and annual maximum H_s (b), in m, for the indicated areas (see Figure 1 of the main manuscript), as derived from d4PDF-WaveHs (black), CMIP5-HsWang (brown), CFSR (purple), ERA5 (blue), ERAint (green). For the d4PDF-WaveHs and CMIP5-HsWang ensembles we show the ensemble mean (thick lines) and the range between the 2.5% and 97.5% percentiles (shaded area).

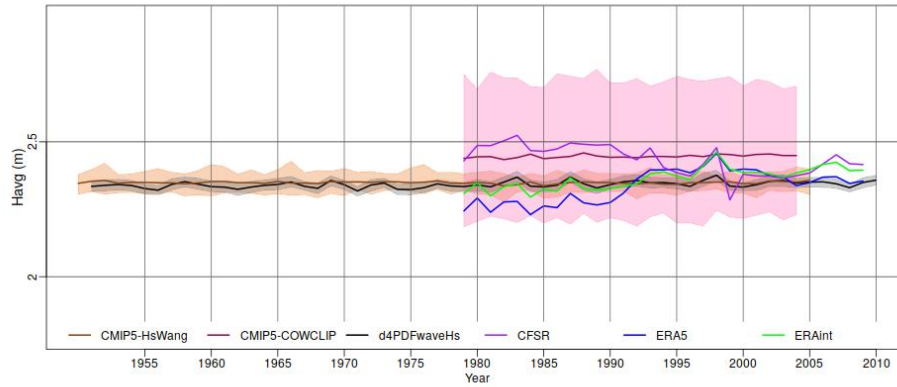
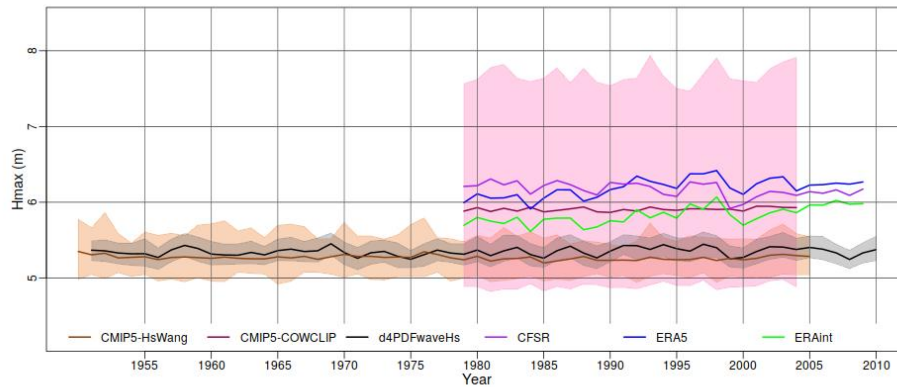
(a) Annual mean H_s (m)(b) Annual max. H_s (m)

Figure S17. Global time series of the annual mean H_s (a) and annual maximum H_s (b), in m, as derived from d4PDF-WaveHs (black), CMIP5-HsWang (brown), CMIP5-COWCLIP (magenta), CFSR (purple), ERA5 (blue), ERAInt (green). For the d4PDF-WaveHs, CMIP5-HsWang and CMIP5-COWCLIP ensembles we show the ensemble mean (thick lines) and the range between the 2.5% and 97.5% percentiles (shaded area).

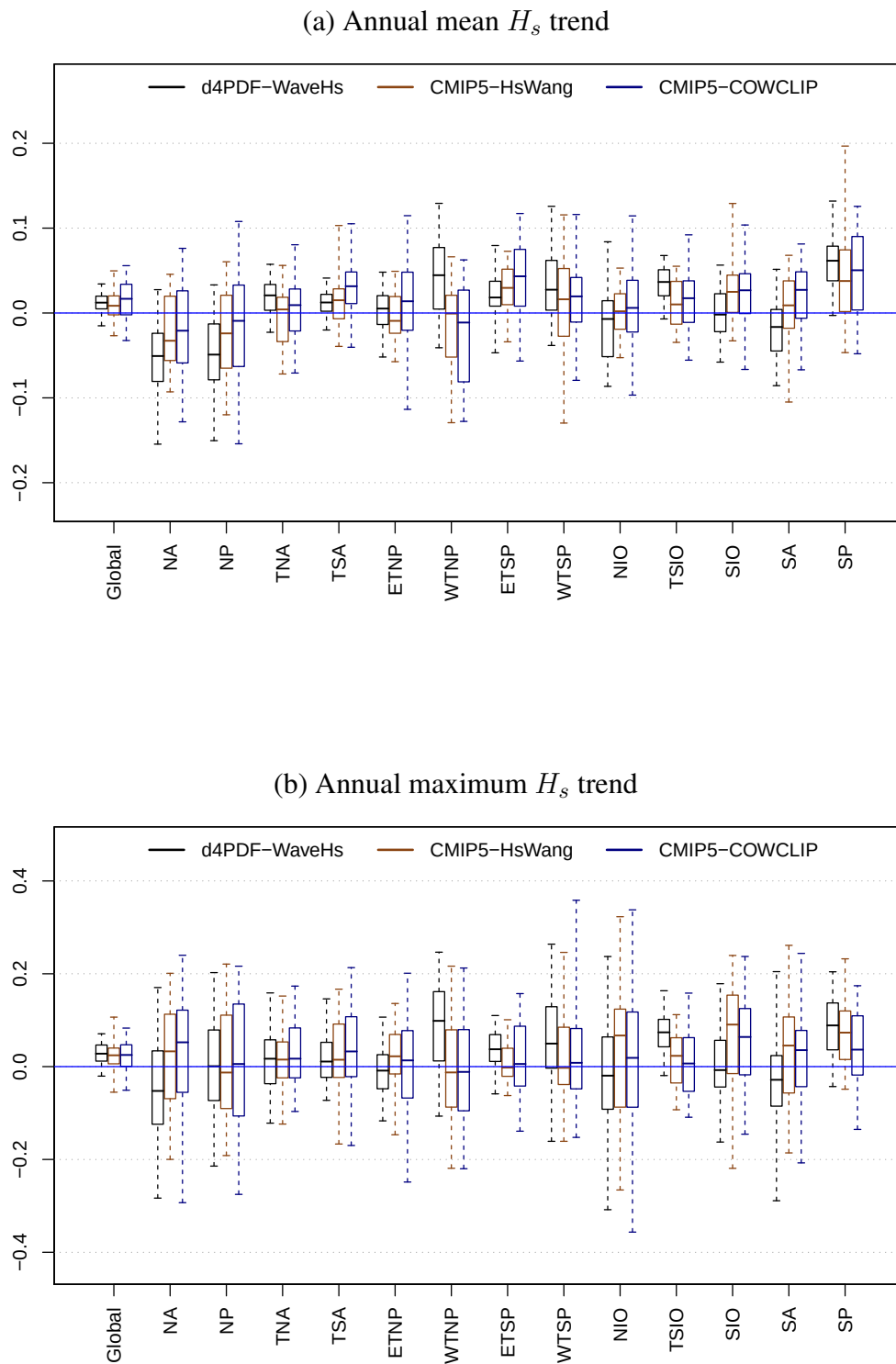


Figure S18. Ensemble average of the regional trend (%/yr) of the annual mean (a) and maximum (b) H_s averaged over the indicated areas (see Figure 1 of the main manuscript) as derived from d4PDF-WaveHs (black), CMIP5-HsWang (brown) and CMIP5-COWCLIP (dark blue). Trend is calculated relative to the climatological 1979–2004 mean. Box plot illustrates the 2.5%, 25%, 50%, 75% and 97.5% percentiles.

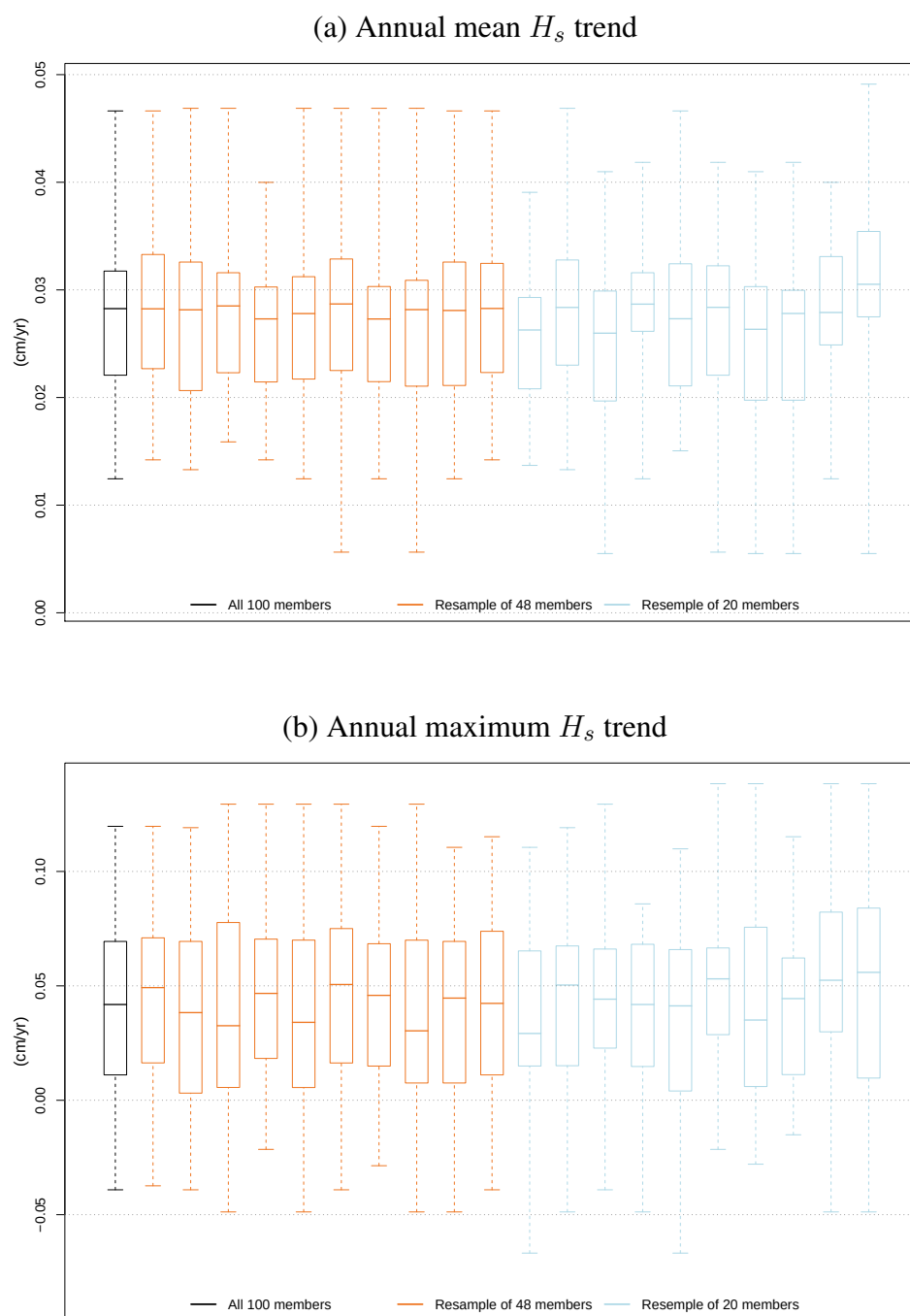


Figure S19. Boxplot of the global ensemble average trend of the annual mean (a) and maximum (b) H_s (cm/yr) for the period 1951–2010, as obtained from the whole d4PDF-WaveHs (100-size) ensemble (in black), and from 48- and 20-size sub-samples randomly sampled from d4PDF-WaveHs (in orange and blue, respectively)

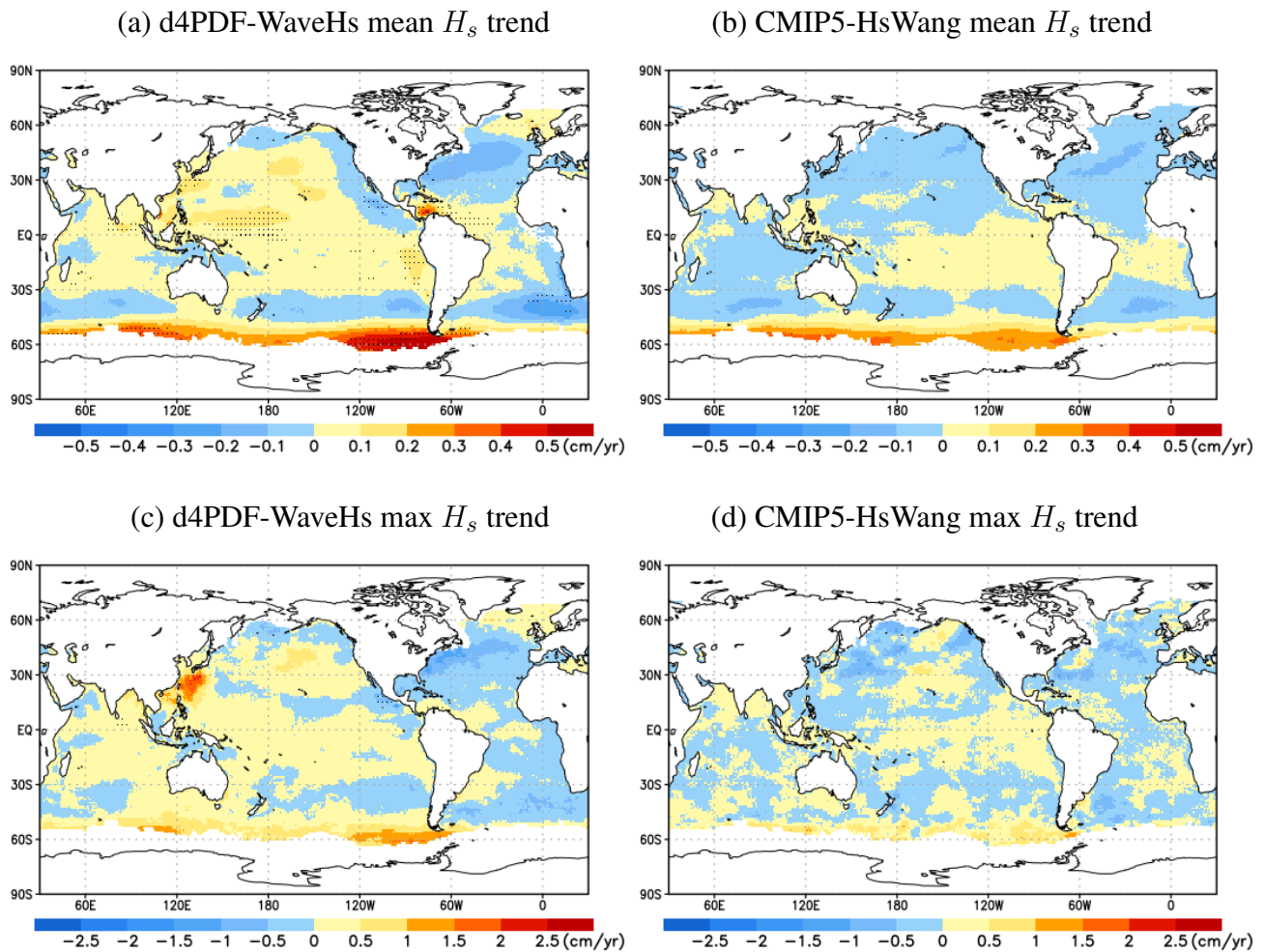


Figure S20. Ensemble average of the annual mean H_s trend (cm/yr) (a-b) and the annual maximum H_s trend (cm/yr) (c-d) for 1951–2005, as obtained from d4PDF-WaveHs (a,c) and CMIP5-HsWang (b,d). Stippling indicates the trend is statistically significant.

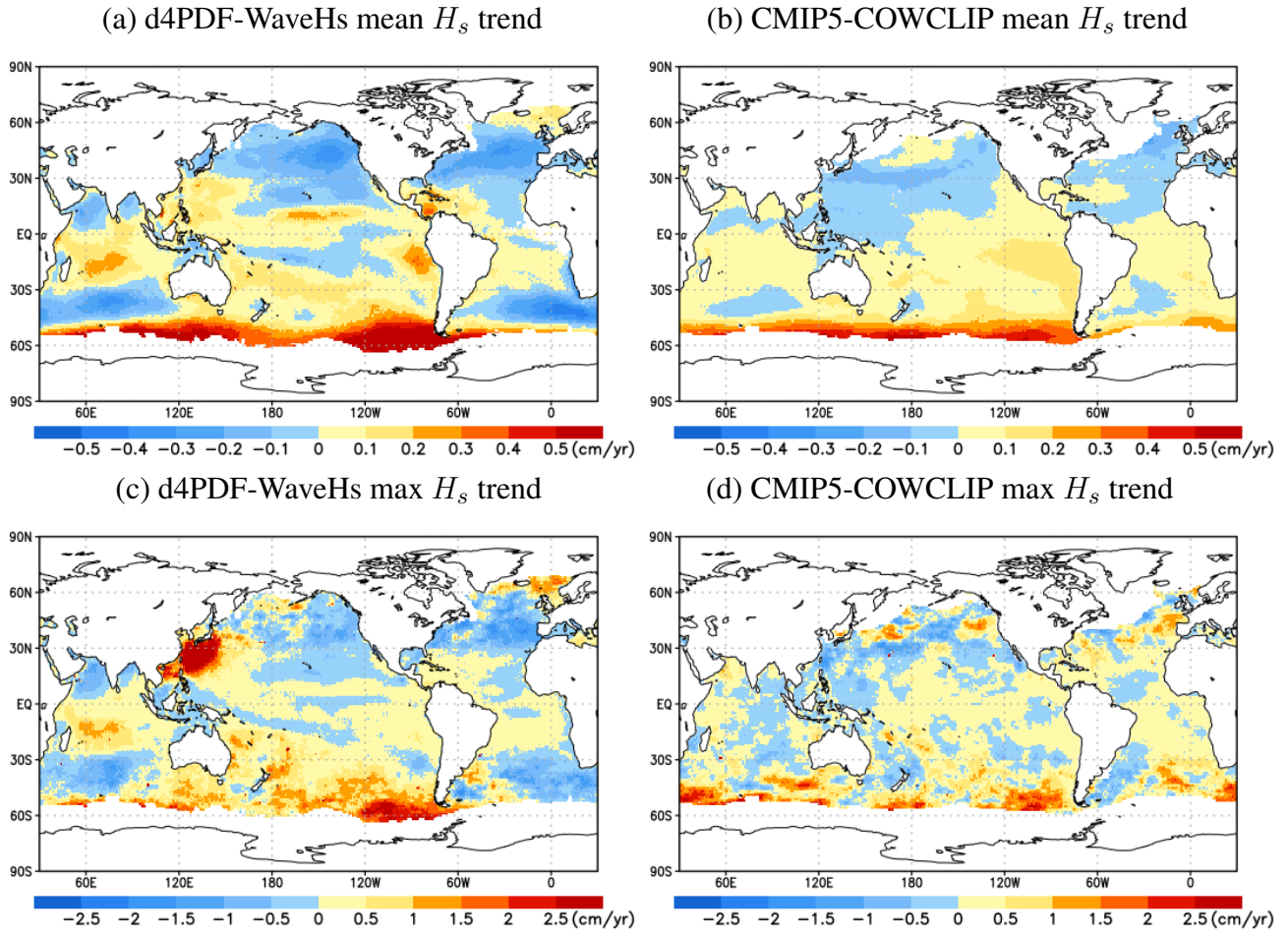


Figure S21. Ensemble average of the annual mean H_s trend (cm/yr) (a-b) and the annual maximum H_s trend (cm/yr) (c-d) for 1979–2004, as obtained from d4PDF-WaveHs (a,c) and CMIP5-COWCLIP (b,d). Stippling indicates the trend is statistically significant.

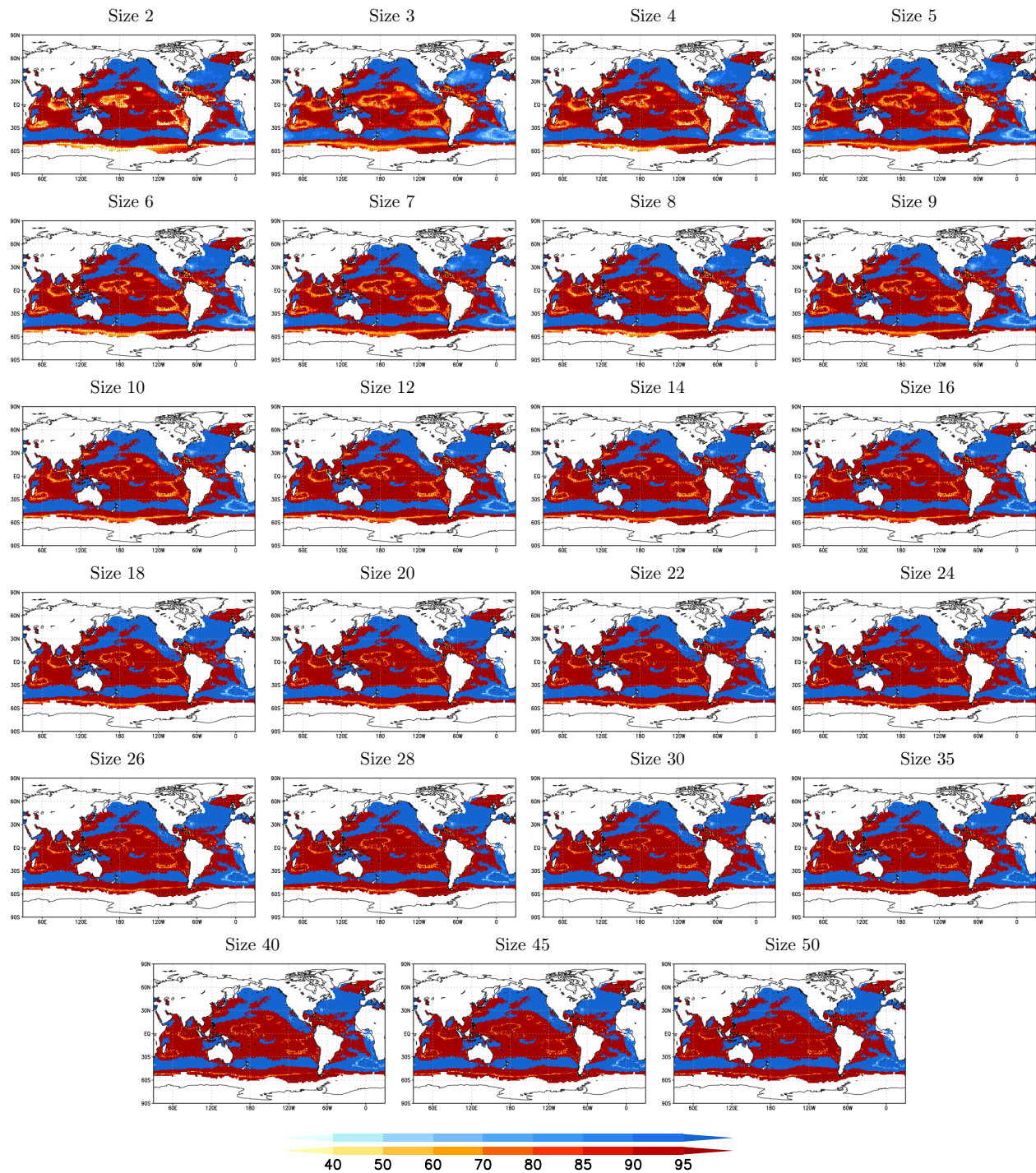


Figure S22. Fraction (%) of x -size sub-ensembles (randomly sampled from d4PDF-WaveHs and where x goes from 2 to 50) with the same annual mean H_s trend conclusion as the whole d4PDF-WaveHs (100-size) ensemble. Warm(cold) shades indicate the ensemble mean trend of the 100-size ensemble is positive(negative). Stippling indicates the 100-size ensemble mean trend is statistically significant.

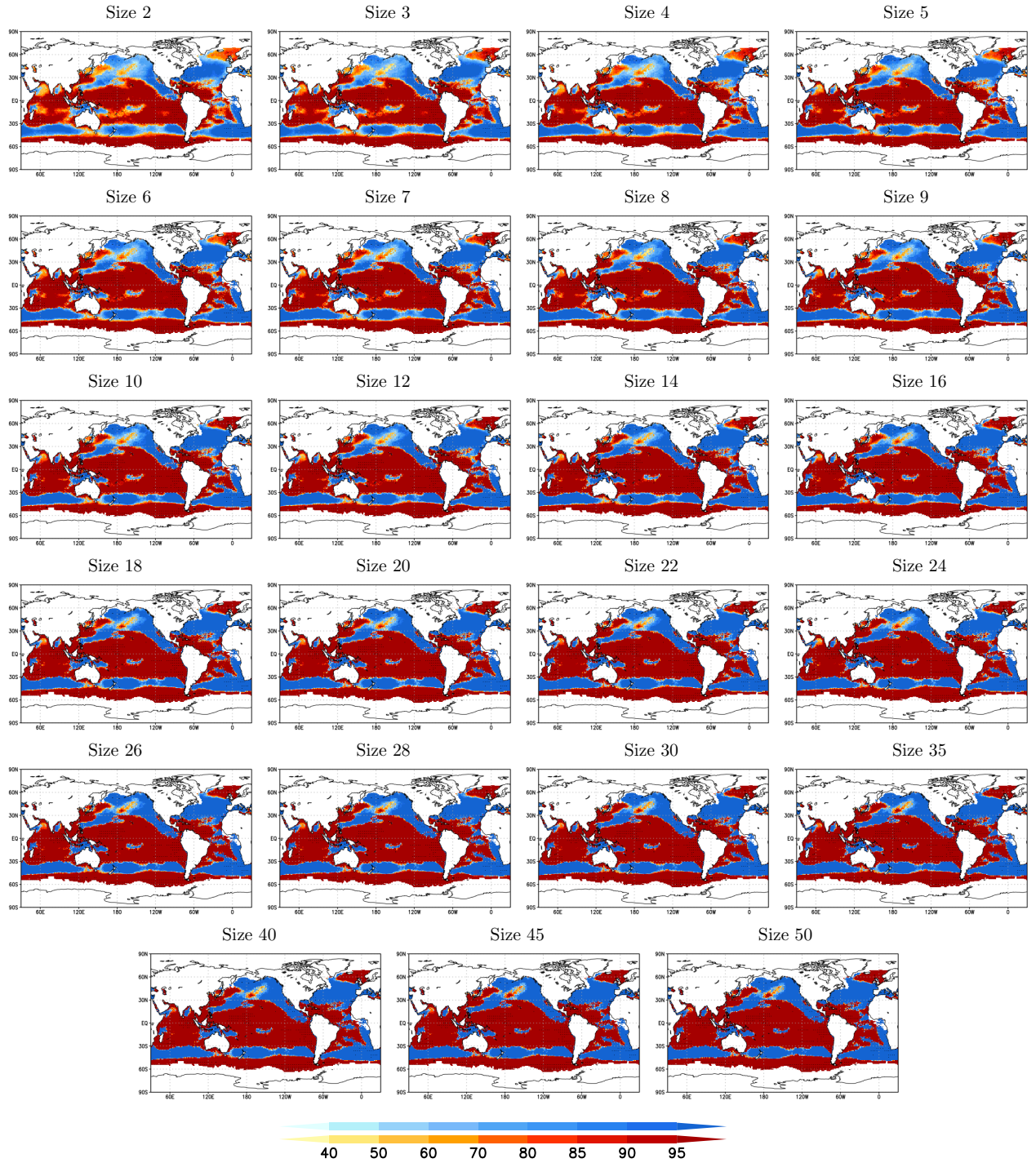


Figure S23. Fraction (%) of x -size sub-ensembles (randomly sampled from d4PDF-WaveHs and where x goes from 2 to 50) with the same annual mean H_s trend sign as the whole d4PDF-WaveHs (100-size) ensemble. Warm(cold) shades indicate the ensemble mean trend of the 100-size ensemble is positive(negative). Stippling indicates the 100-size ensemble mean trend is statistically significant.

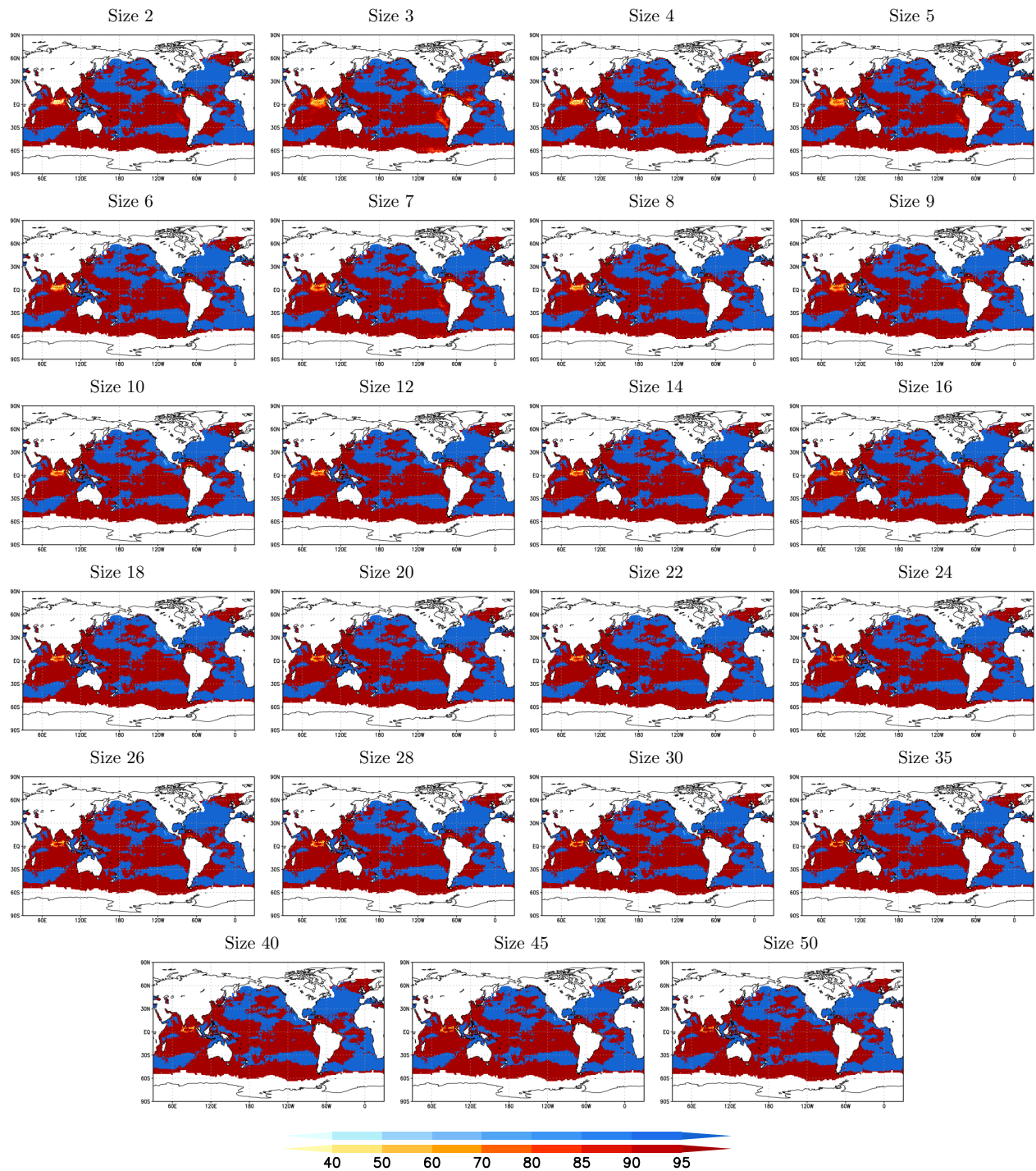


Figure S24. Fraction (%) of x -size sub-ensembles (randomly sampled from d4PDF-WaveHs and where x goes from 2 to 50) with the same annual maximum H_s trend conclusion as the whole d4PDF-WaveHs (100-size) ensemble. Warm(cold) shades indicate the ensemble mean trend of the 100-size ensemble is positive(negative). Stippling indicates the 100-size ensemble mean trend is statistically significant.

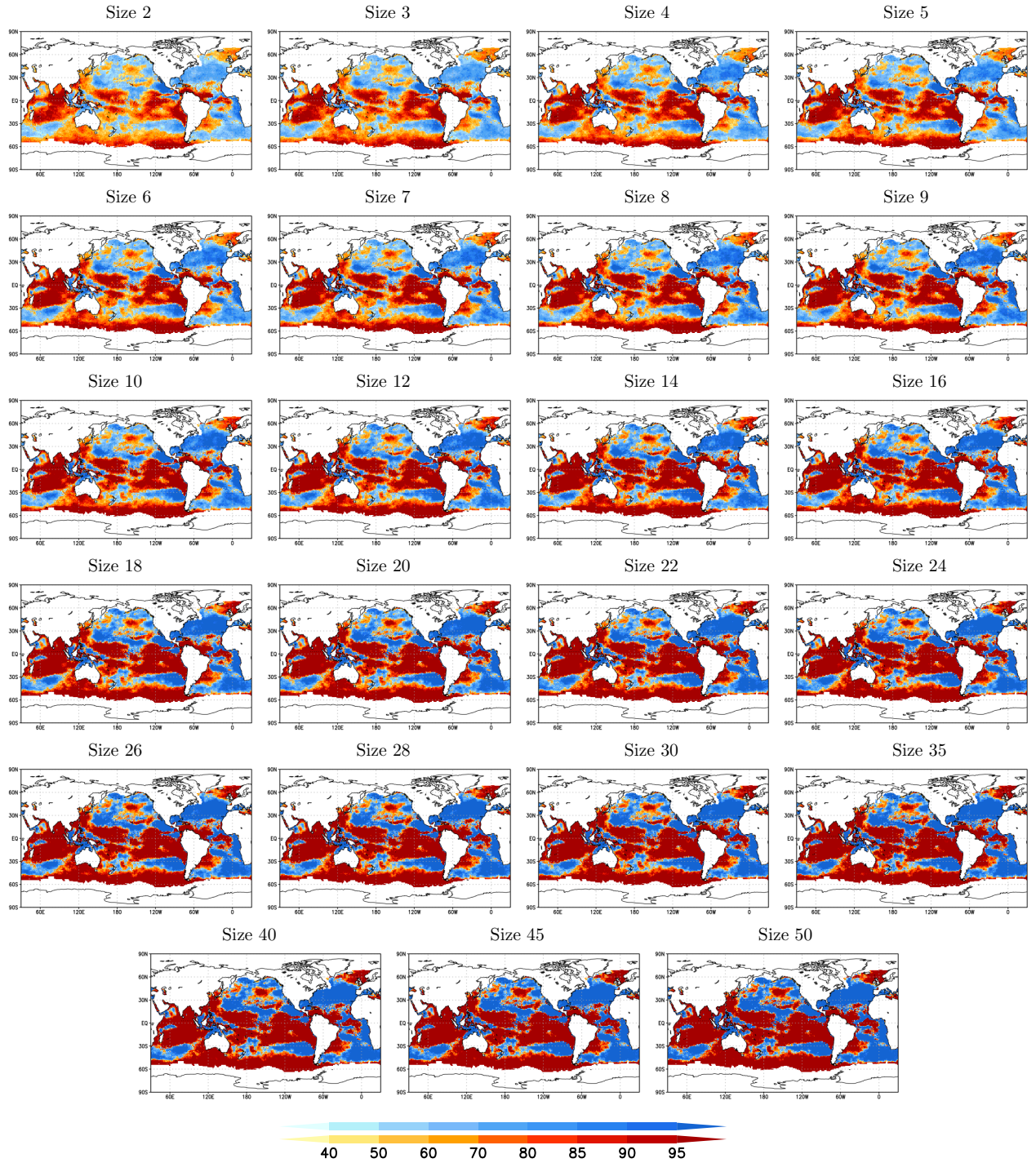


Figure S25. Fraction (%) of x -size sub-ensembles (randomly sampled from d4PDF-WaveHs and where x goes from 2 to 50) with the same annual maximum H_s trend sign as the whole d4PDF-WaveHs (100-size) ensemble. Warm(cold) shades indicate the ensemble mean trend of the 100-size ensemble is positive(negative). Stippling indicates the 100-size ensemble mean trend is statistically significant.