

Supplementary Materials

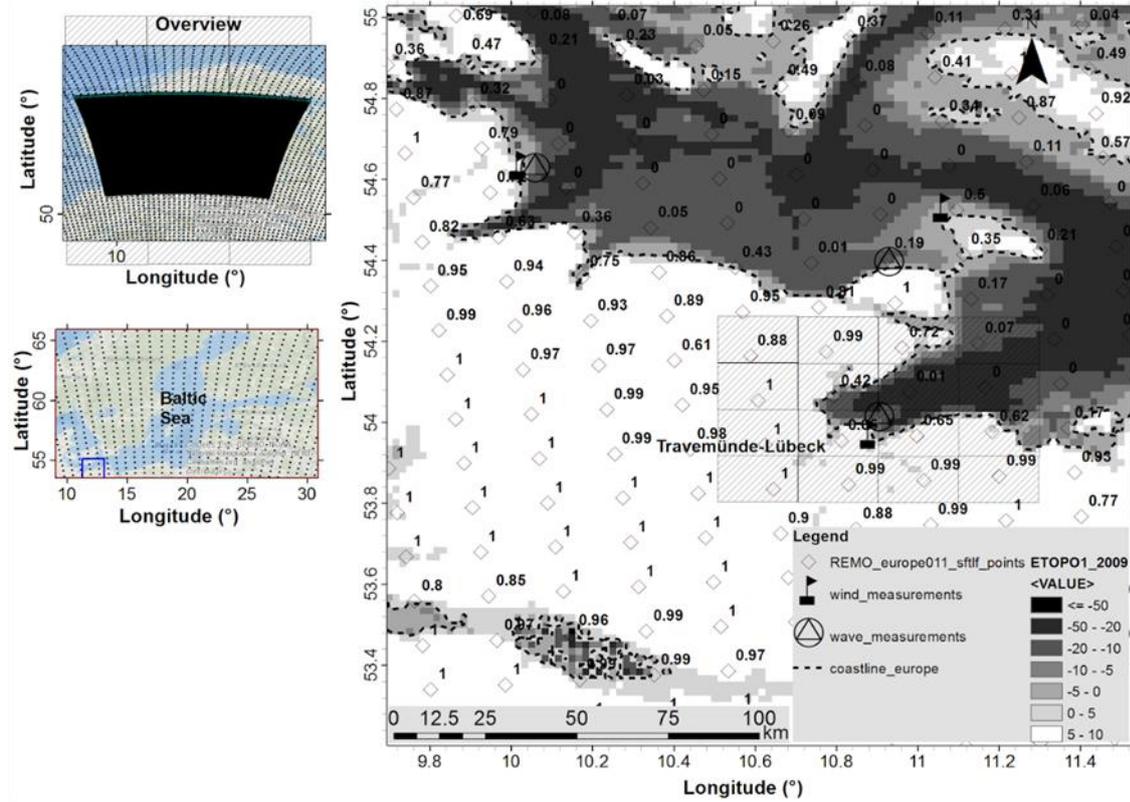


Figure S1. Grid points of the subdomain of the REMO model output (upper left), the Baltic Sea area (left) and near the complex topography of the German Baltic Sea coast near the selected location of “Lübeck -Travemünde” in combination with the land-fraction values of the “europe011” grid (right). The matrix of 4x4 grid points is indicated by boxes filled with strokes.

Table S1. Mean absolute errors (MAE) of significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) between wind-wave correlation results and measurements. n = number of hourly measurements.

Location	MAE H_{m0} (m) ¹	MAE T_{m02} (s) ²	MAE Θ_m (°) ³
Warnemünde (1998-2002)	0.11, n=21416	0.44, n=21420	6.8, n=7242
Warnemünde (2011-2014)	0.11, n=16121	0.57, n=16184	7.8, n=4864
Travemünde (1997-1999)	0.09, n=9002	0.45, n=9002	7.3, n=1477

¹ for significant wave heights ≥ 0.05 m, ² for mean wave periods ≤ 10 s, ³ for significant wave heights > 0.5 m

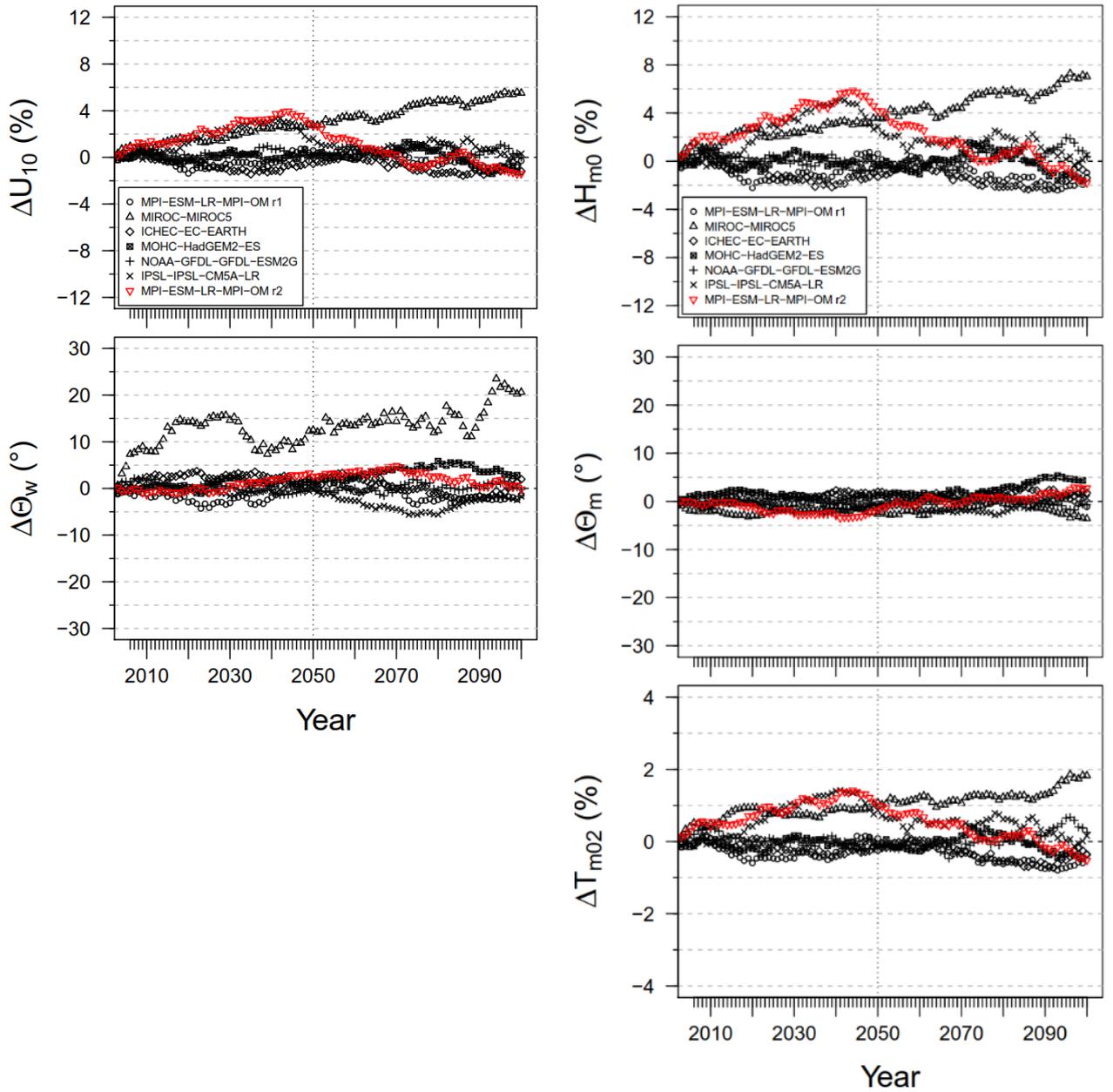


Figure S2. 30-year running mean of the future relative / absolute changes Δ (%) / Δ ($^\circ$) of the mean wind speed U_{10} , wind direction Θ_w (left) and significant wave height H_{m0} , mean wave period T_{m02} , mean wave direction Θ_m (right) compared to the reference period 1971-2000 and for the ensemble members of the forcing scenario RCP2.6 near “Rostock-Warnemünde”.

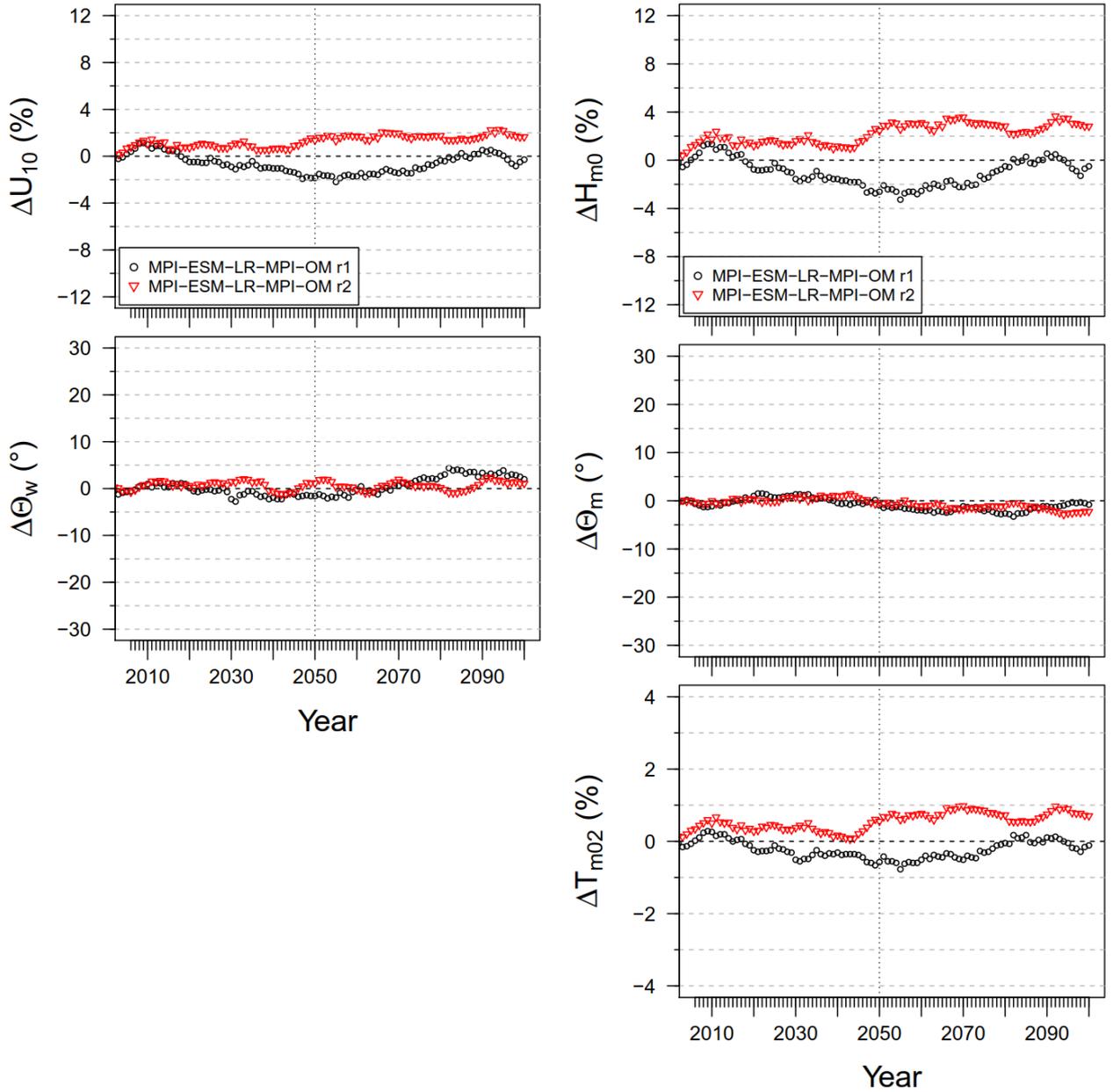


Figure S3. 30-year running mean of the future relative / absolute changes Δ (%) / Δ ($^\circ$) of the mean wind speed U_{10} , wind direction Θ_w (left) and significant wave height H_{m0} , mean wave period T_{m02} , mean wave direction Θ_m (right) compared to the reference period 1971-2000 and for the ensemble members of the forcing scenario RCP4.5 near “Rostock-Warnemünde”.

Table S2. Absolute minimum and maximum thresholds for relative respectively absolute changes (in percent respectively in degrees) of the future 30-year annual or seasonal averages of the mean wind speed 10 m above the surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) compared to the reference period 1971-2000.

	U_{10}	Θ_w	H_{m0}	T_{m02}	Θ_m
	(%)	($^\circ$)	(%)	(%)	($^\circ$)
Min	2	2	2	0.35	2
Max	4	4	4	0.7	4

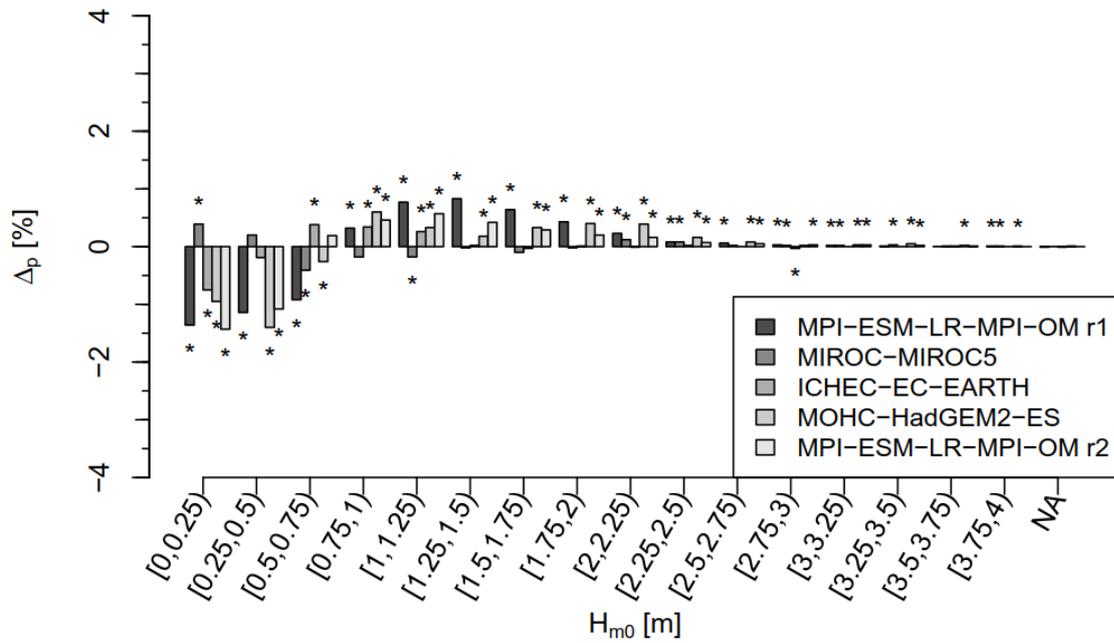


Figure S4. Differences of the annual frequency of occurrence (Δ_p) of the significant wave height (H_{m0}) between the future time period 2071-2100 and the reference period 1971-2000 for the forcing scenario RCP8.5, near "Rostock-Warnemünde". Statistical significant changes ($p=0.05$, z-test) are indicated with *.

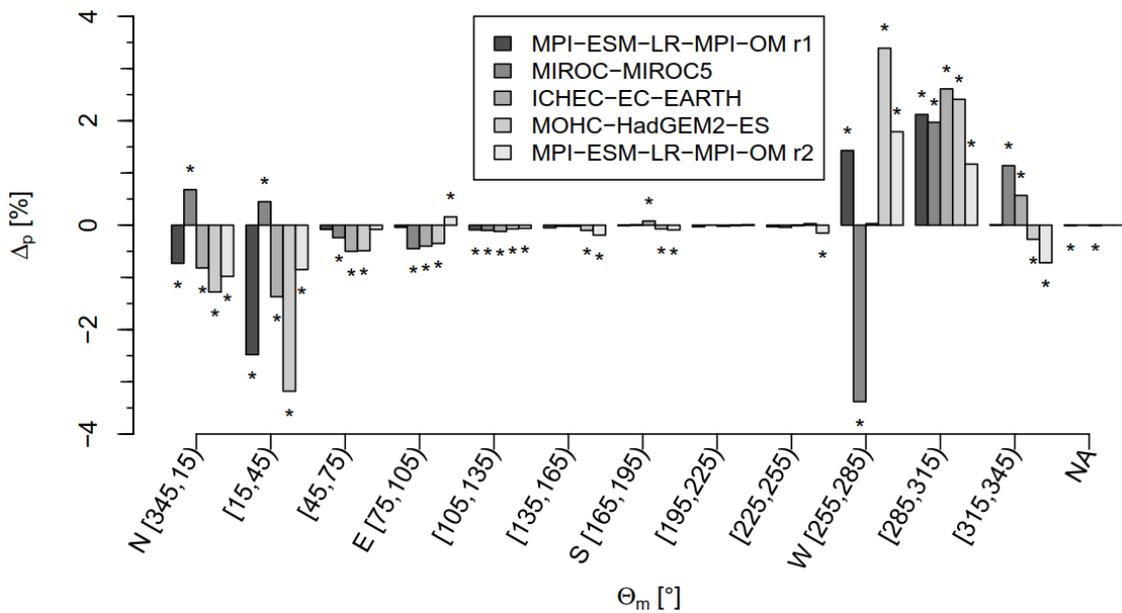


Figure S5. Differences of the annual frequency of occurrence (Δ_p) of the mean wave direction (Θ_m) between the future time period 2071-2100 and the reference period 1971-2000 for the forcing scenario RCP8.5, near "Rostock-Warnemünde". Statistical significant changes ($p=0.05$, z-test) are indicated with *.

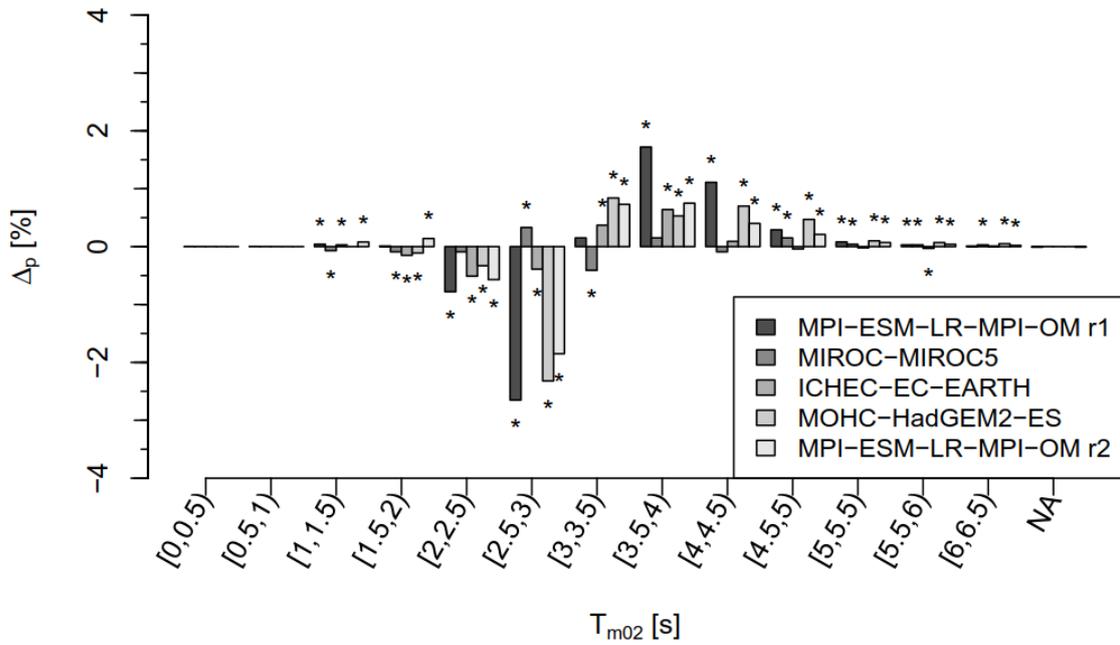


Figure S6. Differences of the annual frequency of occurrence (Δ_p) of the mean wave period (T_{m02}) between the future time period 2071-2100 and the reference period 1971-2000 for the forcing scenario RCP8.5, near "Rostock-Warnemünde". Statistical significant changes ($p=0.05$, z-test) are indicated with *.

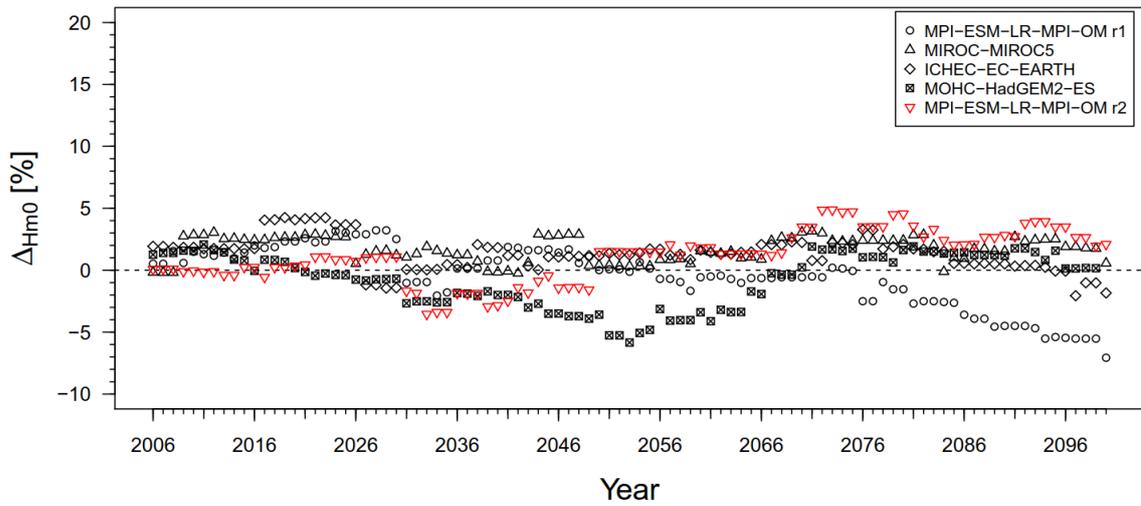


Figure S7. Future relative changes (in percent) of the significant wave height (ΔH_{m0}) for the log-normal distribution function and a return period of 200 years compared to the reference period 1961-2000 for the ensemble members of the forcing scenario RCP8.5 near "Lübeck-Travemünde".

1 **Table S3.** Bandwidth (minimum/maximum) and direction of the relative changes (in percent respectively in degree for the wind and wave direction) of the ensemble
2 members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey: false detect) of the future 30-year annual
3 (column "AVG") and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) of the wind speed 10 m above the
4 surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) and for the time periods 2021-2050 and
5 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP8.5 near "Rostock-Warnemünde". Statistical significant changes ($p=0.05$) for at least
6 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single respectively double underscore.

Parameter	2021-2050					2071-2100				
	AVG	DJF	MAM	JJA	SON	AVG	DJF	MAM	JJA	SON
U_{10} (%)	0	0	0	0	<u>+2.6/+4.1</u>	<u>+2.8/+3.8</u>	0	<u>+2.8/+4.0</u>	<u>+3.6/+5.5</u>	<u>+3.8/+6.7</u>
Θ_w (°)	<u>+5.2/+7.5</u>	<u>+2.9/+3.9</u>	-26.9/-4.8	<u>+3.4/+9.5</u>	<u>+8.5/+30.9</u>	<u>+5.4/+16.7</u>	<u>-8.2/-4.0</u>	<u>-54.2/-14.7</u>	<u>+5.2/+10.3</u>	<u>+3.1/+40.0</u>
H_{m0} (%)	0	0	+2.2/+5.8	0	+4.2/4.7	<u>+4.0/+5.6</u>	<u>+2.3/+2.7</u>	<u>+4.2/+5.8</u>	<u>+5.4/7.0</u>	<u>+6.0/+10.8</u>
T_{m02} (%)	<u>+0.4/+1.0</u>	0	+0.9/+1.2	<u>+0.4/+1.5</u>	<u>+1.0/+1.5</u>	<u>+0.9/+1.6</u>	0	<u>+0.8/+1.4</u>	<u>+1.2/+1.5</u>	<u>+1.5/+3.6</u>
Θ_m (°)	0	<u>+2.6/+6.2</u>	0	<u>-5.5/-2.8</u>	<u>-6.0/-2.7</u>	<u>-7.4/-3.0</u>	0	<u>-9.8/-4.0</u>	<u>-5.6/-2.7</u>	<u>-18.9/-2.2</u>

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8 **Table S4.** Bandwidth (minimum/maximum) and direction of the relative changes (in percent respectively in degree for the wind and wave direction) of the ensemble
9 members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey: false detect) of the future 30-year annual
10 (column "AVG") and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) of the wind speed 10 m above the
11 surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) and for the time periods 2021-2050 and
12 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP4.5 near "Rostock-Warnemünde". Statistical significant changes ($p=0.05$) for at least
13 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single respectively double underscore.

Parameter	2050					2100				
	AVG	DJF	MAM	JJA	SON	AVG	DJF	MAM	JJA	SON
U_{10} (%)	0	0	0	0	0	0	0	0	0	0
Θ_w (°)	0	0	0	0	0	0	<u>-5.7/-2.9</u>	0	0	0
H_{m0} (%)	0	0	<u>-2.2/-2.1</u>	0	0	0	0	0	0	0
T_{m02} (%)	0	0	<u>-0.6/-0.4</u>	0	<u>+0.6/+1.8</u>	0	<u>-0.8/0.7</u>	0	0	<u>+0.7/+1.1</u>
Θ_m (°)	0	0	0	0	<u>-3.1/-3.0</u>	0	<u>+2.4/+5.4</u>	<u>-5.4/-2.1</u>	0	<u>-2.9/-2.5</u>

14 **Table S5.** Bandwidth (minimum/maximum) and direction of the relative changes (in percent respectively in degree for the wind and wave direction) of the ensemble
 15 members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey: false detect) of the future 30-year annual
 16 (column “AVG”) and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) of the wind speed 10 m above the
 17 surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) and for the time periods 2021-2050 and
 18 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP2.6 near “Rostock-Warnemünde”. Statistical significant changes ($p=0.05$) for at least
 19 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single respectively double underscore.

Parameter	2021-2050					2071-2100				
	AVG	DJF	MAM	JJA	SON	AVG	DJF	MAM	JJA	SON
U_{10} (%)	0	0	0	+3.0/+6.4	0	0	0	0	0	0
Θ_w (°)	0	0	-116.2/-2.5	+2.1/+7.5	0	0	-7.7/-3.1	+3.1/+18.6	0	+3.0/+32.2
H_{m0} (%)	0	0	0	+3.3/+6.8	0	0	0	0	+3.0/+10.7	0
T_{m02} (%)	0	0	0	+1.0/+1.4	+0.6/+1.9	0	-1.7/-0.6	0	+0.6/+2.5	0
Θ_m (°)	0	0	0	0	0	0	-5.2/-2.3	0	0	+2.7/+5.9

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21 **Table S6.** 30-year annual (column “AVG”) and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) and
 22 direction of the changes of the ensemble members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey:
 23 false detect) of the wind speed 10 m above the surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction
 24 (Θ_m) and for the time periods 2021-2050 and 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP8.5 near “Rostock-Warnemünde”. Statistical
 25 significant changes ($p=0.05$) for at least 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single
 26 respectively double underscore.

Parameter	2021-2050					2071-2100				
	AVG	DJF	MAM	JJA	SON	AVG	DJF	MAM	JJA	SON
U_{10} (m/s)	0	0	0	0	<u>7.3</u>	<u>6.8</u>	0	<u>6.1</u>	<u>5.7</u>	<u>7.4</u>
Θ_w (°)	<u>246.1</u>	<u>238.9</u>	308.6	<u>275.8</u>	<u>223.3</u>	<u>246.1</u>	<u>241.2</u>	<u>308.6</u>	<u>268.3</u>	<u>227.9</u>
H_{m0} (m)	0	0	0.6	0	0.8	<u>0.7</u>	<u>0.9</u>	<u>0.6</u>	<u>0.6</u>	<u>0.8</u>
T_{m02} (s)	<u>3.1</u>	0	3.0	<u>3.0</u>	<u>3.1</u>	<u>3.1</u>	0	<u>3.0</u>	<u>3.0</u>	<u>3.1</u>
Θ_m (°)	0	<u>305.7</u>	0	<u>319.1</u>	<u>316.4</u>	<u>322.6</u>	0	<u>336.3</u>	<u>323.0</u>	<u>316.4</u>

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Table S7. 30-year annual (column “AVG”) and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) and direction of the changes of the ensemble members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey: false detect) of the wind speed 10 m above the surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) and for the time periods 2021-2050 and 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP4.5 near “Rostock-Warnemünde”. Statistical significant changes ($p=0.05$) for at least 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single respectively double underscore.

Parameter	AVG	2050				AVG	2100			
		DJF	MAM	JJA	SON		DJF	MAM	JJA	SON
U_{10} (m/s)	0	0	0	0	0	0	0	0	0	0
Θ_w (°)	0	0	0	0	0	237.0	0	0	0	0
H_{m0} (m)	0	0	0.6	0	0	0	0	0	0	0
T_{m02} (s)	0	0	3.0	0	3.1	0	3.2	0	0	3.1
Θ_m (°)	0	0	0	0	307.9	0	307.6	336.4	0	307.9

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Table S8. 30-year annual (column “AVG”) and seasonal averages (over three months periods, columns DJF=winter, MAM=spring, JJA=summer, SON=autumn) and direction of the changes of the ensemble members which agree on the direction of the changes (indicated by colors red: increase, blue: decrease, white: no agreement, grey: false detect) of the wind speed 10 m above the surface (U_{10}), mean wind direction (Θ_w), significant wave height (H_{m0}), mean wave period (T_{m02}) and mean wave direction (Θ_m) and for the time periods 2021-2050 and 2071-2100 compared to the reference period 1971-2000 and the forcing scenario RCP2.6 near “Rostock-Warnemünde”. Statistical significant changes ($p=0.05$) for at least 50 % of the selected classes of the frequency distribution in bold and for more than 50 % respectively 67 % in bold with single respectively double underscore.

Parameter	AVG	2050				AVG	2100			
		DJF	MAM	JJA	SON		DJF	MAM	JJA	SON
U_{10} (m/s)	0	0	0	5.7	0	0	0	0	0	0
Θ_w (°)	0	0	255.7	267.2	0	0	235.8	244.5	0	225.8
H_{m0} (m)	0	0	0	0.6	0	0	0	0	0.6	0
T_{m02} (s)	0	0	0	3.0	3.1	0	3.2	0	3.0	0
Θ_m (°)	0	0	0	0	0	0	308.5	0	0	307.8

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