Frontiers in Marine Science

Supporting information for

Analysis and prediction of marine heatwaves in the Western North Pacific and Chinese Coast Region

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Table S1. Basic information of three MHW events.

Var. / Name	Start time (yyyymmdd)	End time (yyyymmdd)	Duration (day)	MaxInt (℃)	MeanInt ± std (℃)	CumInt (℃days)
MHW1	20120808	20120814	7	4.19	2.95 ± 0.98	20.67
MHW2	20120827	20121020	55	3.36	1.98 ± 0.52	108.75
MHW3	20121026	20121120	26	2.74	2.01 ± 0.44	52.24

Table S2. Extreme values of the spatial distribution for MHWs characteristics in the historical period (1982 ~ 2014).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	1.95 ± 0.21	2.73	122.125, 24.125	1.18	158.125, 44.125
Duration (day)	11.38 ± 1.96	21.26	158.125, 44.125	6.88	100.125, 4.125
Days (day)	22.06 ± 3.84	31.79	143.125, 37.125	12.36	151.125, 8.125
CumInt (℃ day)	18.06 ± 7.67	61.46	143.125, 37.125	7.28	173.125, 8.125
MaxInt (℃)	1.84 ± 0.50	4.08	143.125, 37.125	1.06	180.125, 14.125
MeanInt (℃)	1.49 ± 0.42	3.29	143.125, 37.125	0.87	180.125, 14.125

Table S3. Extreme values of the spatial distribution for MHWs characteristics multi-year average trend in the historical period (1982 ~ 2014).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	0.08 ± 0.04	0.20	168.125, 57.125	-0.05	148.125, 41.125
Duration (day/year)	0.15 ± 0.16	0.90	178.125, 18.125	-0.70	144.125, 57.125
Days (day/year)	1.17 ± 0.50	3.68	164.125, 62.125	-1.07	148.125, 41.125
CumInt (℃days/year)	0.26 ± 0.32	2.24	160.125, 40.125	-1.69	144.125, 57.125
MaxInt (℃/year)	0.003 ± 0.015	0.104	162.125, 58.125	-0.04	133.125, 30.125
MeanInt (℃/year)	0.001 ± 0.010	0.080	162.125, 58.125	-0.03	137.125, 54.125

Table S4. Extreme values of the spatial distribution for MHWs characteristics from 2015 to 2100 under the SSP1-2.6 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	3.94 ± 0.95	7.20	120.125, 24.125	1.94	160.125, 43.125
Duration (day)	54.89 ± 23.40	193.88	152.125, 47.125	20.84	104.125, 0.125
Days (day)	184.93 ± 32.73	268.49	176.125, 51.125	79.14	142.125, 51.125
CumInt (℃ days)	96.36 ± 56.30	411.80	152.125, 47.125	24.61	129.125, 0.125
MaxInt (℃)	2.13 ± 0.74	5.73	139.125, 54.125	1.08	170.125, 7.125
MeanInt (℃)	1.57 ± 0.54	4.20	145.125, 40.125	0.80	170.125, 7.125

Table S5. Extreme values of the spatial distribution for MHWs characteristics from 2015 to 2100 under the SSP2-4.5 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number (year^{-1})	3.33 ± 0.87	6.56	110.125, 20.125	1.60	180.125, 56.125
Duration (day)	86.83 ± 35.58	238.49	152.125, 47.125	25.68	118.125, 24.125
Days (day)	236.50 ± 29.28	302.81	156.125, 50.1250	117.16	142.125, 50.125
CumInt (℃days)	175.44 ± 92.62	603.92	151.125, 47.1250	51.12	117.125, 7.125
MaxInt (℃)	2.34 ± 0.76	6.56	139.125, 54.125	1.22	179.125, 7.125
MeanInt (℃)	1.66 ± 0.53	4.34	145.125, 41.125	0.88	180.125, 8.125

Table S6. Extreme values of the spatial distribution for MHWs characteristics from 2015 to 2100 under the SSP5-8.5 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number (year^{-1})	2.34 ± 0.59	5.22	118.125, 24.125	1.17	178.125, 50.125
Duration (day)	138.66 ± 43.03	301.27	124.125, 37.125	37.68	118.125, 24.125
Days (day)	271.59 ± 18.50	310.10	170.125, 60.125	154.06	137.125, 54.125
CumInt (℃ days)	385.22 ± 168.00	1094.23	151.125, 47.125	97.36	164.125, 62.125
MaxInt (℃)	2.44 ± 0.83	6.60	137.125, 54.125	1.23	179.125, 8.125
MeanInt (℃)	1.70 ± 0.57	4.55	145.125, 41.125	0.88	179.125, 8.125

Table S7. Extreme values of the spatial distribution for the difference of MHWs characteristics between the SSP1-2.6 and SSP2-4.5 scenarios (SSP2-4.5 minus SSP1-2.6)

Var. / Var.	Mean±Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number (year^{-1})	-0.612 ±0.36	1.70	142.125, 51.125	-2.43	100.125, 3.125
Duration (day)	31.94 ±15.56	92.96	124.125, 38.125	-1.20	120.125, 35.125
Days (day)	51.57 ±14.65	116.97	144.125, 50.125	0.76	120.125, 35.125
CumInt (℃ days)	79.07 ±41.39	290.53	147.125, 51.125	6.76	118.125, 24.125
MaxInt (℃)	0.21 ±0.10	0.84	139.125, 54.125	-0.98	138.125, 54.125
MeanInt (℃)	0.09 ±0.06	0.52	143.125, 39.125	-1.01	138.125, 54.125

Table S8. Extreme values of the spatial distribution for the difference of MHWs characteristics between the SSP1-2.6 and SSP5-8.5 scenarios (SSP5-8.5 minus SSP1-2.6).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number (year^{-1})	-1.60 ± 0.58	0.84	142.125, 51.125	-3.85	129.125, 0.125
Duration (day)	83.77 ± 24.31	181.40	124.125, 37.125	14.63	118.125, 24.125
Days (day)	86.66 ± 19.48	155.58	122.125, 14.125	24.63	120.125, 35.125
CumInt (℃ days)	288.85 ± 116.97	737.52	150.125, 45.125	51.52	118.125, 24.125
MaxInt (℃)	0.31 ± 0.18	1.63	137.125, 54.125	-0.73	138.125, 54.125
MeanInt (℃)	0.13 ± 0.09	0.71	142.125, 39.125	-1.12	138.125, 54.125

Table S9. Extreme values of the spatial distribution for the difference of MHWs characteristics between the SSP2-4.5 and SSP5-8.5 scenarios (SSP5-8.5 minus SSP2-4.5).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number (year^{-1})	-0.99 ± 0.37	-0.12	144.125, 39.125	-2.22	122.125, 6.125
Duration (day)	51.82 ± 14.32	143.69	124.125, 37.125	12.00	118.125, 24.125
Days (day)	35.09 ± 12.55	76.91	142.125, 39.125	3.31	170.125, 54.125
CumInt (℃ days)	209.78 ± 86.67	590.91	124.125, 37.125	37.50	164.125, 62.125
MaxInt (℃)	0.10 ± 0.14	1.00	137.125, 54.125	-0.67	139.125, 54.125
MeanInt (℃)	0.05 ± 0.07	0.41	142.125, 39.125	-0.21	140.125, 54.125

Table S10. Extreme values of the spatial distribution for MHWs characteristics multi-year average trend from 2015 ~ 2100 under the SSP1-2.6 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	0.001 ± 0.01	0.04	107.125, 20.125	-0.03	104.125, 1.125
Duration (day/year)	0.51 ± 0.34	2.09	174.125, 53.125	-0.20	152.125, 41.125
Days (day/year)	1.21 ± 0.49	2.78	179.125, 55.125	-0.21	150.125, 41.125
CumInt (℃days/year)	1.02 ± 0.83	5.80	120.125, 35.125	-0.84	144.125, 40.125
MaxInt (℃/year)	0.01 ± 0.004	0.09	139.125, 54.125	-0.003	166.125, 60.125
MeanInt (℃/year)	0.002 ± 0.002	0.02	139.125, 54.125	-0.004	166.125, 60.125

Table S11. Extreme values of the spatial distribution for MHWs characteristics multi-year average trend from 2015 ~ 2100 under the SSP2-4.5 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	-0.03 ± 0.01	0.04	118.125, 24.125	-0.09	131.125, 0.125
Duration (day/year)	1.62 ± 0.44	4.78	119.125, 37.125	0.24	142.125, 50.125
Days (day/year)	2.85 ± 0.28	3.49	118.125, 2.125	0.94	142.125, 50.125
CumInt (℃days/year)	3.83 ± 1.43	16.72	119.125, 37.125	0.78	163.125, 62.125
MaxInt (℃/year)	0.018 ± 0.008	0.144	139.125, 54.125	0.004	142.125, 48.125
MeanInt (℃/year)	0.008 ± 0.003	0.033	139.125, 54.125	-0.002	143.125, 49.125

Table S12. Extreme values of the spatial distribution for MHWs characteristics multi-year average trend from 2015 ~ 2100 under the SSP5-8.5 scenario.

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	-0.06 ± 0.01	-0.0003	163.125, 62.125	-0.11	119.125, 1.125
Duration (day/year)	2.56 ± 0.70	5.64	100.125, 5.125	0.05	177.125, 3.125
Days (day/year)	3.38 ± 0.24	4.49	160.125, 54.125	2.36	142.125, 37.125
CumInt (℃days/year)	6.70 ± 2.61	20.86	121.125, 39.125	0.67	177.125, 3.125
MaxInt (℃/year)	0.03 ± 0.01	0.20	139.125, 54.125	0.01	164.125, 1.125
MeanInt (℃/year)	0.01 ± 0.01	0.05	139.125, 54.125	-0.002	139.125, 57.125

Table S13. Extreme values of the spatial distribution for the difference of MHWs characteristics multi-year average trend between the SSP2-4.5 and SSP1-2.6 scenarios (SSP2-4.5 minus SSP1-2.6).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	-0.03 ± 0.01	0.02	164.125, 62.125	-0.09	129.125, 0.125
Duration (day/year)	1.11 ± 0.37	2.54	121.125, 40.125	-0.65	154.125, 49.125
Days (day/year)	1.65 ± 0.46	2.93	119.125, 5.125	0.02	170.125, 60.125
CumInt (℃days/year)	2.81 ± 1.05	8.78	121.125, 40.125	-0.43	154.125, 49.125
MaxInt (℃/year)	0.01 ± 0.01	0.06	139.125, 54.125	-0.002	142.125, 48.125
MeanInt (℃/year)	0.01 ± 0.002	0.02	144.125, 42.125	-0.004	139.125, 57.125

Table S14. Extreme values of the spatial distribution for the difference of MHWs characteristics multi-year average trend between the SSP1-2.6 and SSP5-8.5 scenarios (SSP5-8.5 minus SSP1-2.6).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	-0.06 ± 0.02	0.001	140.125, 54.125	-0.12	129.125, 0.125
Duration (day/year)	2.06 ± 0.65	5.23	100.125, 5.125	-0.26	170.125, 3.125
Days (day/year)	2.17 ± 0.62	3.84	139.125, 35.125	0.12	170.125, 60.125
CumInt (℃day/year)	5.68 ± 2.40	19.60	137.125, 54.125	0.15	170.125, 3.125
MaxInt (℃/year)	0.03 ± 0.01	0.12	137.125, 54.125	0.003	179.125, 12.125
MeanInt (℃/year)	0.01 ± 0.01	0.03	139.125, 54.125	-0.004	139.125, 57.125

Table S15. Extreme values of the spatial distribution for the difference of MHWs characteristics multi-year average trend between the SSP2-4.5 and SSP5-8.5 scenarios (SSP5-8.5 minus SSP2-4.5).

Var. / Var.	Mean ± Std	Max	Max-Location (Lon, Lat)	Min	Min-Location (Lon, Lat)
Number ($year^{-1}$)	-0.03 ± 0.01	0.001	180.125, 50.125	-0.08	139.125, 47.125
Duration (day/year)	0.94 ± 0.61	3.36	125.125, 39.125	-1.03	177.125, 3.125
Days (day/year)	0.53 ± 0.32	2.84	142.125, 50.125	-0.34	180.125, 59.125
CumInt (℃day/year)	2.87 ± 2.01	16.24	137.125, 54.125	-2.69	179.125, 59.125
MaxInt (℃/year)	0.01 ± 0.01	0.10	137.125, 54.125	-0.01	179.125, 59.125
MeanInt (℃/year)	0.01 ± 0.003	0.02	137.125, 54.125	-0.01	140.125, 54.125

Table S16. Slope (k), change interval of slope (bint), intercept, and the goodness of fit (R^2) of regression equation obtained by linear regression for the time series of MHWs characteristics under the SSP1-2.6, 2-4.5 and 5-8.5 scenarios.

Var. / Var.	k ± bint			Intercept			R^2		
	SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Number ($year^{-1}$) (2015~2036)	0.01±0.01	0.03±0.01	0.03±0.01	-20.95	-52.54	-58.28	0.23	0.80	0.84
Number ($year^{-1}$) (2037-2100)	-0.002±0.002	-0.03±0.002	-0.04±0.003	8.04	55.36	76.48	0.08	0.90	0.92
Duration (days)	0.49±0.06	1.34±0.05	1.76±0.10	-956.52	-2682.67	-3530.96	0.77	0.98	0.95
Days (day) (2015-2060)	2.19±0.21	3.53±0.12	4.64±0.16	-4313.45	-7031.51	-9275.53	0.92	0.99	0.99
Days (day) (2061-2100)	-0.51±0.15	1.03±0.14	0.77±0.10	1244.16	-1887.83	-1307.44	0.61	0.89	0.88
CumInt (°Cday/year)	0.96±0.11	3.07±0.12	5.41±0.21	-1893.32	-6170.29	-10896.97	0.81	0.97	0.98
MaxInt (°C/year)	0.005±0.001	0.02±0.001	0.03±0.001	-7.88	-33.56	-63.43	0.77	0.98	0.98
MeanInt (°C/year)	0.002± 0.0002	0.01±0.0003	0.02±0.001	-3.00	-15.05	-33.01	0.80	0.98	0.97

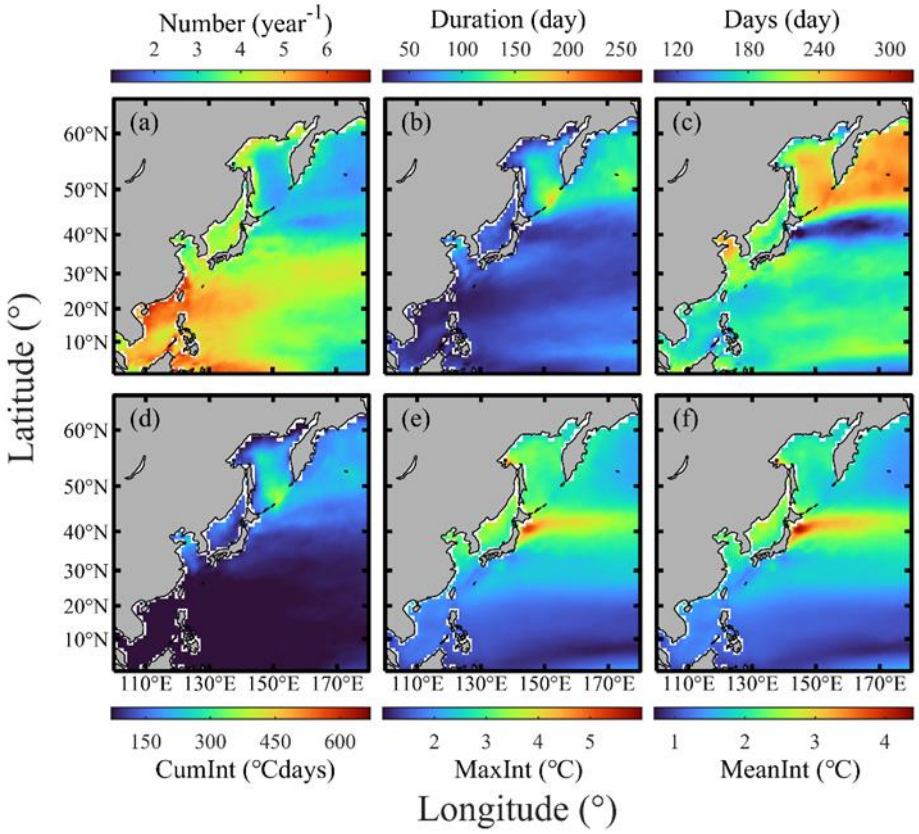

Figure S1. Spatial distribution of projected (2015 ~ 2100) MHWs characteristics in the WNPCC area under the SSP1-2.6 scenario. Multi-year average of MHWs (a) Number (units: year^{-1}), (b) Duration (units: day), (c) Days (units: day), (d) CumInt (units: ℃ days), (e) MaxInt (units: ℃), and (f) MeanInt (units: ℃).

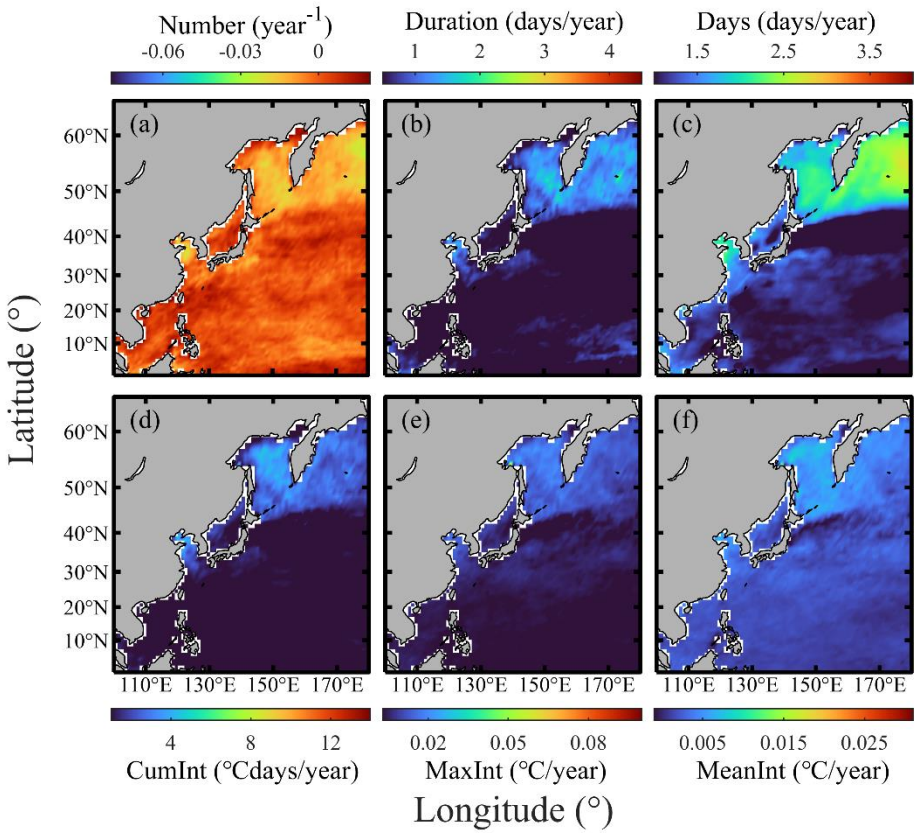

Figure S2. Spatial distribution of average annual variation ratio for MHWs characteristics under the SSP1-2.6 scenario. Average of annual variation ratio for MHWs (a) Number (units: year^{-1}), (b) Duration (units: day/year), (c) Days (units: day/year), (d) CumInt (units: ℃ days/year), (e) MaxInt (units: ℃/year) and (f) MeanInt (units: ℃/year).

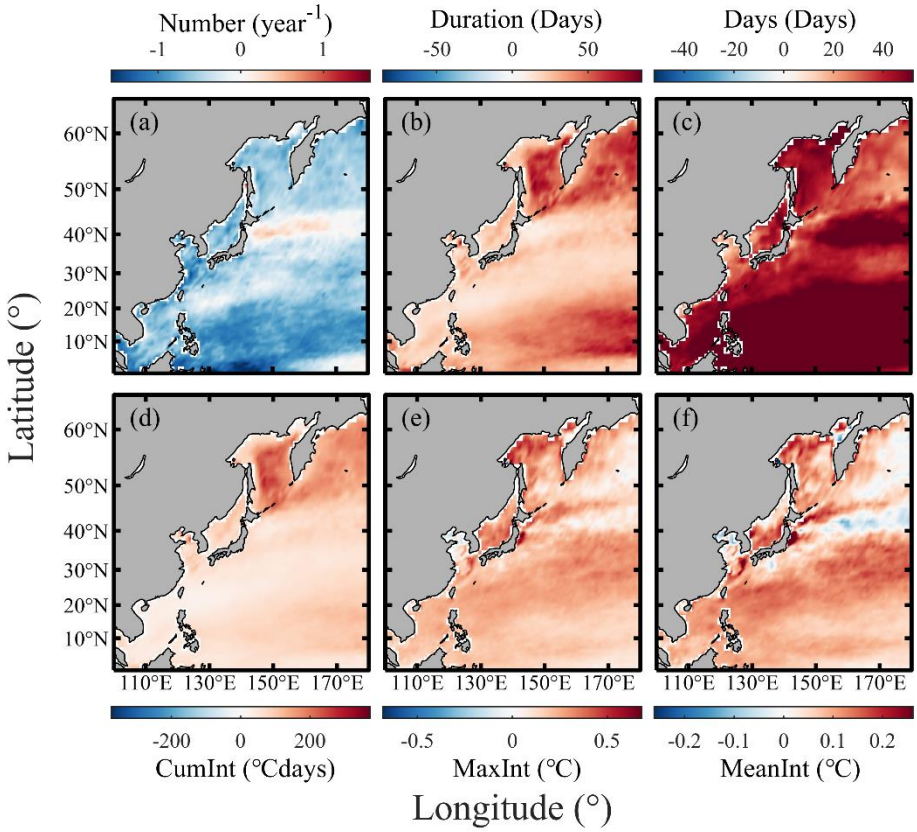

Figure S3. Spatial distribution of differences in projected MHWs' characteristics under SSP1-2.6 and SSP2-4.5 scenarios (SSP2-4.5 minus SSP1-2.6). Multi-year average of annual (a) MHWs' Number (unit: year^{-1}), (b) Duration (unit: day), (c) Days (unit: day), (d) CumInt (unit: ℃ days), (e) MaxInt (unit: ℃) and (f) MeanInt (unit: ℃).

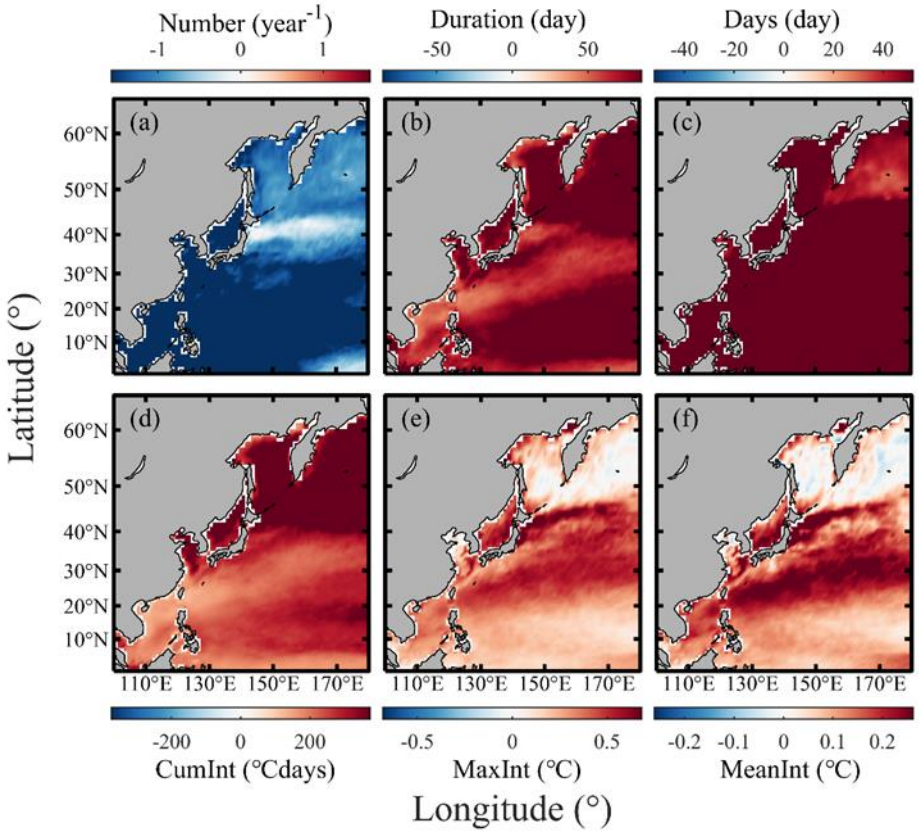

Figure S4. Spatial distribution of differences in projected MHWs characteristics under SSP1-2.6 and SSP5-8.5 scenarios (SSP5-8.5 minus SSP1-2.6). Multi-year average of annual MHWs (a) Number (units: year^{-1}), (b) Duration (units: day), (c) Days (units: day), (d) CumInt (units: ℃ days), (e) MaxInt (units: ℃) and (f) MeanInt (units: ℃).

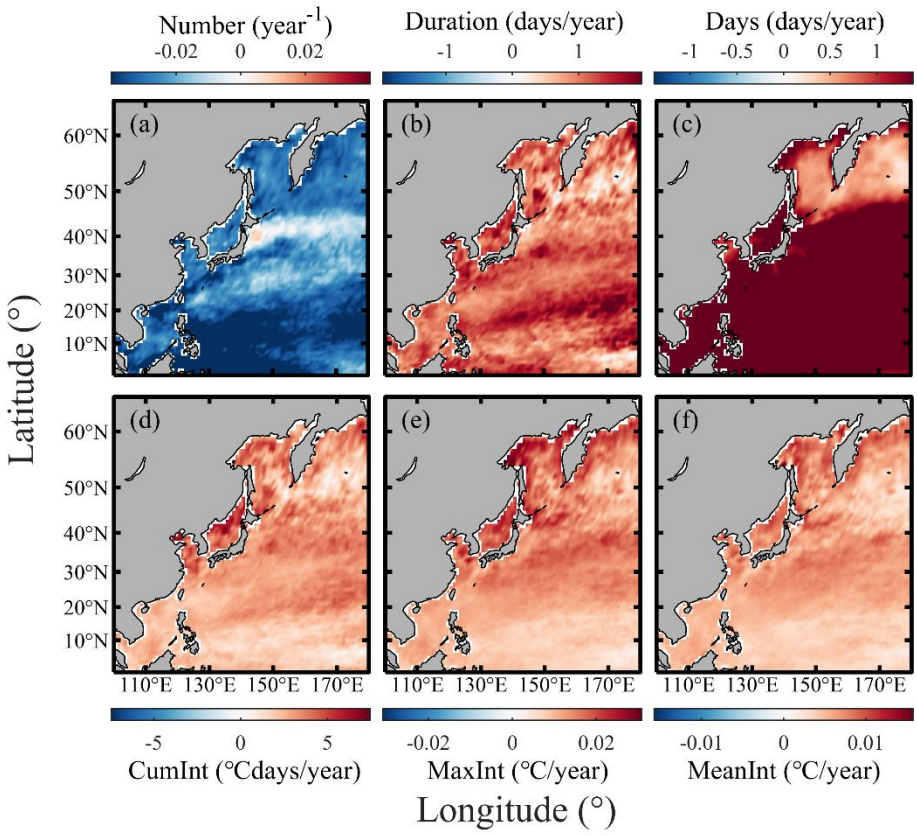

Figure S5. Spatial distribution of differences in projected annual variation ratio of MHWs characteristics for the SSP2-4.5 and SSP1-2.6 (SSP2-4.5 minus SSP1-2.6). Average annual variation ratio for MHWs (a) Number (units: year^{-1}), (b) Duration (units: day/year), (c) Days (units: day/year), (d) CumInt (units: °Cdays/year), (e) MaxInt (units: °C/year) and (f) MeanInt (units: °C/year).

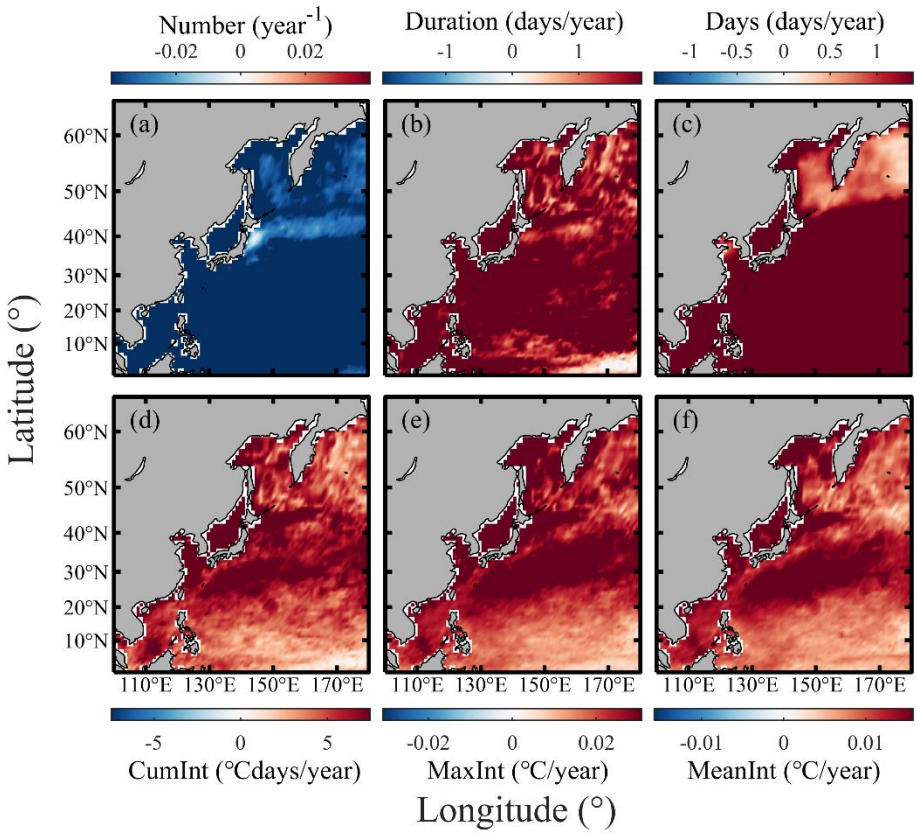

Figure S6. Spatial distribution of differences in projected annual variation ratio of MHWs characteristics for the SSP5-8.5 and SSP1-2.6 (SSP5-8.5 minus SSP1-2.6). Average annual variation ratio for MHWs (a) Number (units: year^{-1}), (b) Duration (units: day/year), (c) Days (units: day/year), (d) CumInt (units: ℃days/year), (e) MaxInt (units: ℃/year) and (f) MeanInt (units: ℃/year).

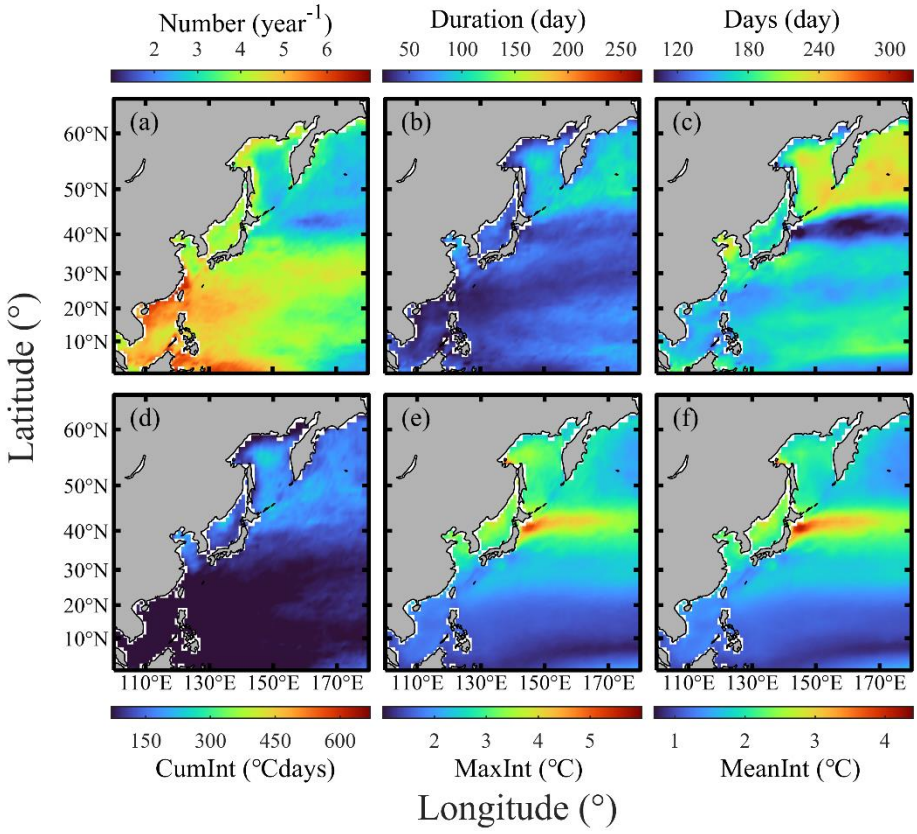

Figure S7. Spatial distribution of projected (2020 ~ 2059) MHWs characteristics in the WNPCC area under the SSP1-2.6 scenario. Multi-year average of MHWs (a) Number (units: year^{-1}), (b) Duration (units: day), (c) Days (units: day), (d) CumInt (units: °Cdays), (e) MaxInt (units: °C), and (f) MeanInt (units: °C).

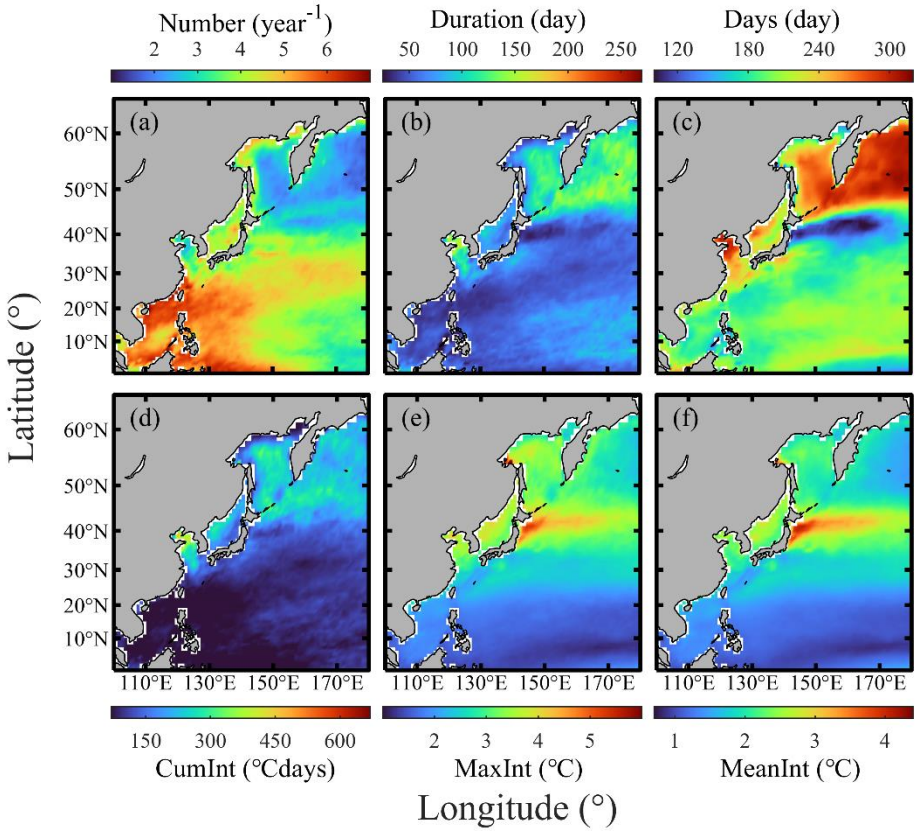

Figure S8. Spatial distribution of projected (2060 ~ 2100) MHWs characteristics in the WNPCC area under the SSP1-2.6 scenario. Multi-year average of MHWs (a) Number (units: year^{-1}), (b) Duration (units: day), (c) Days (units: day), (d) CumInt (units: °Cdays), (e) MaxInt (units: °C), and (f) MeanInt (units: °C).