

Supplementary Information

The Pacific Decadal Oscillation modulated marine heatwaves in the Northeast Pacific during past decades

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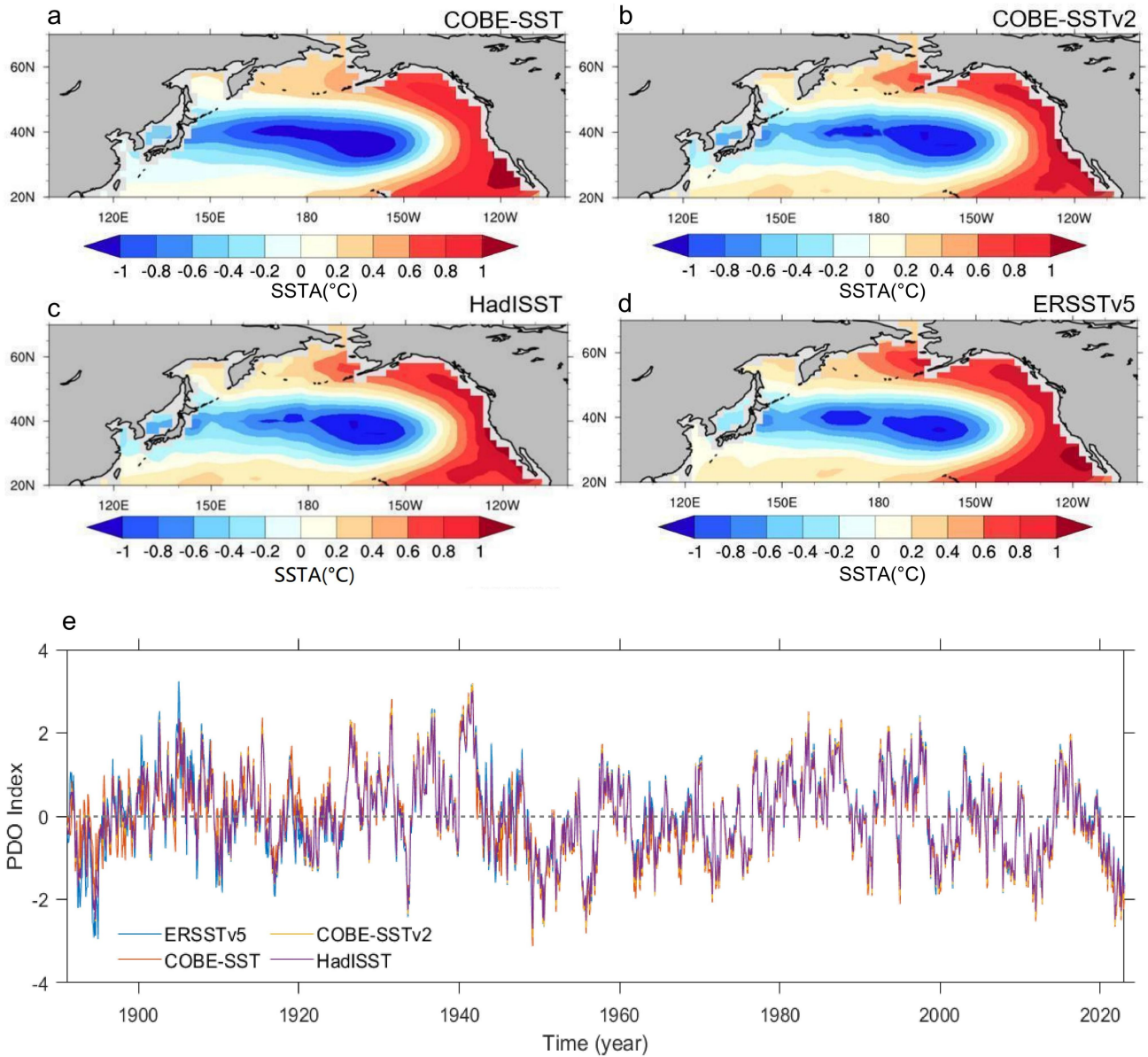
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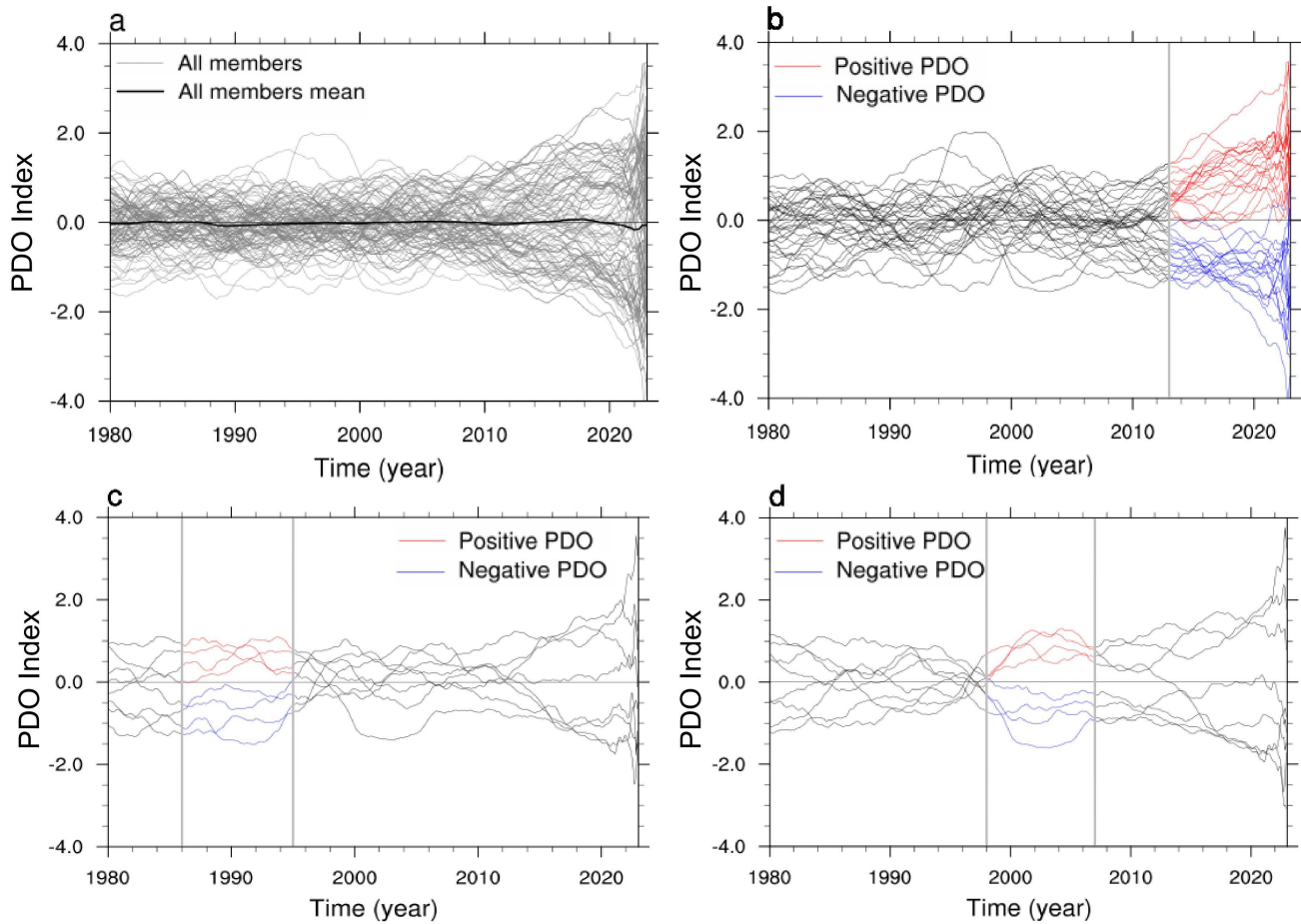
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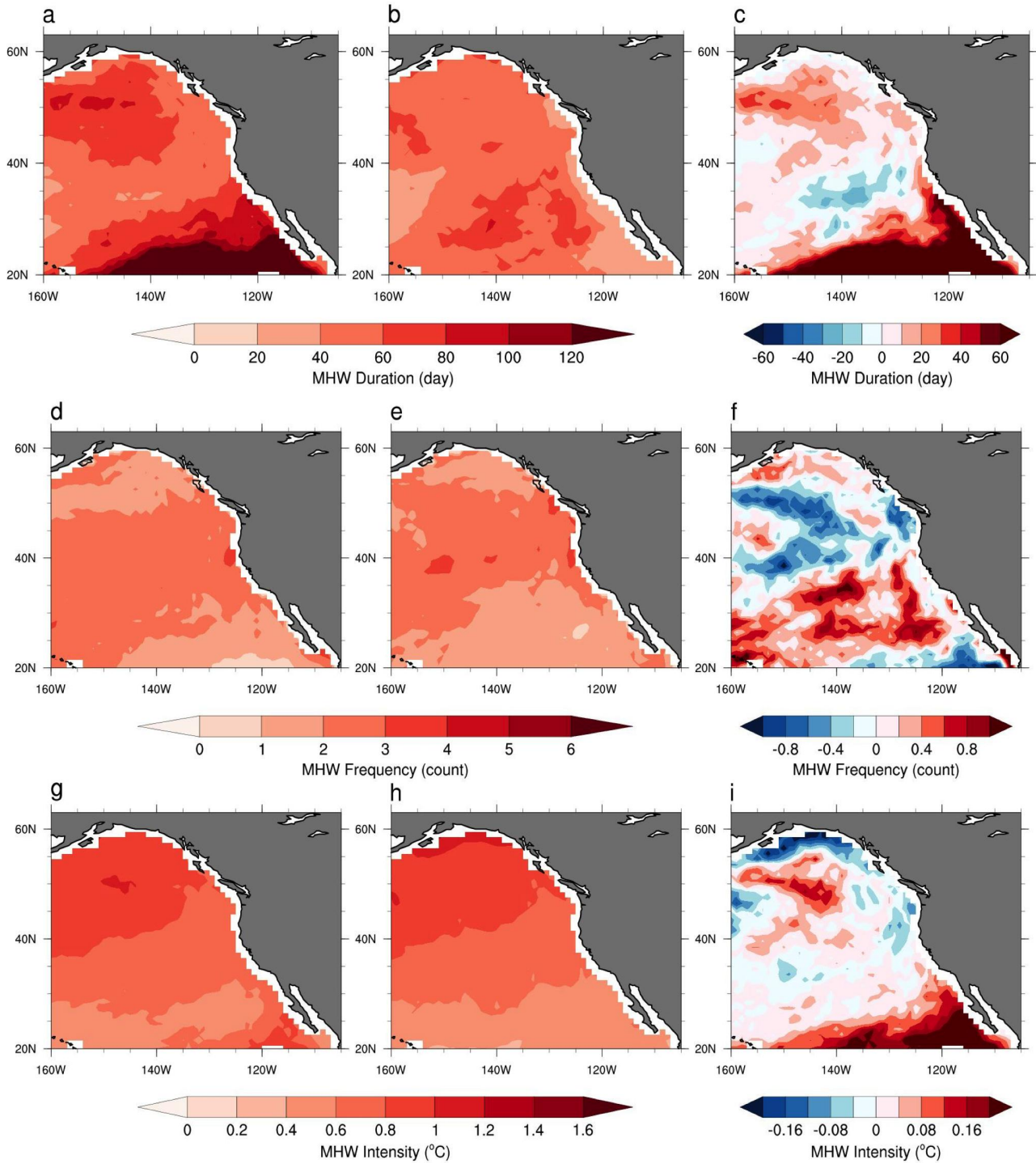
Supplementary Figures



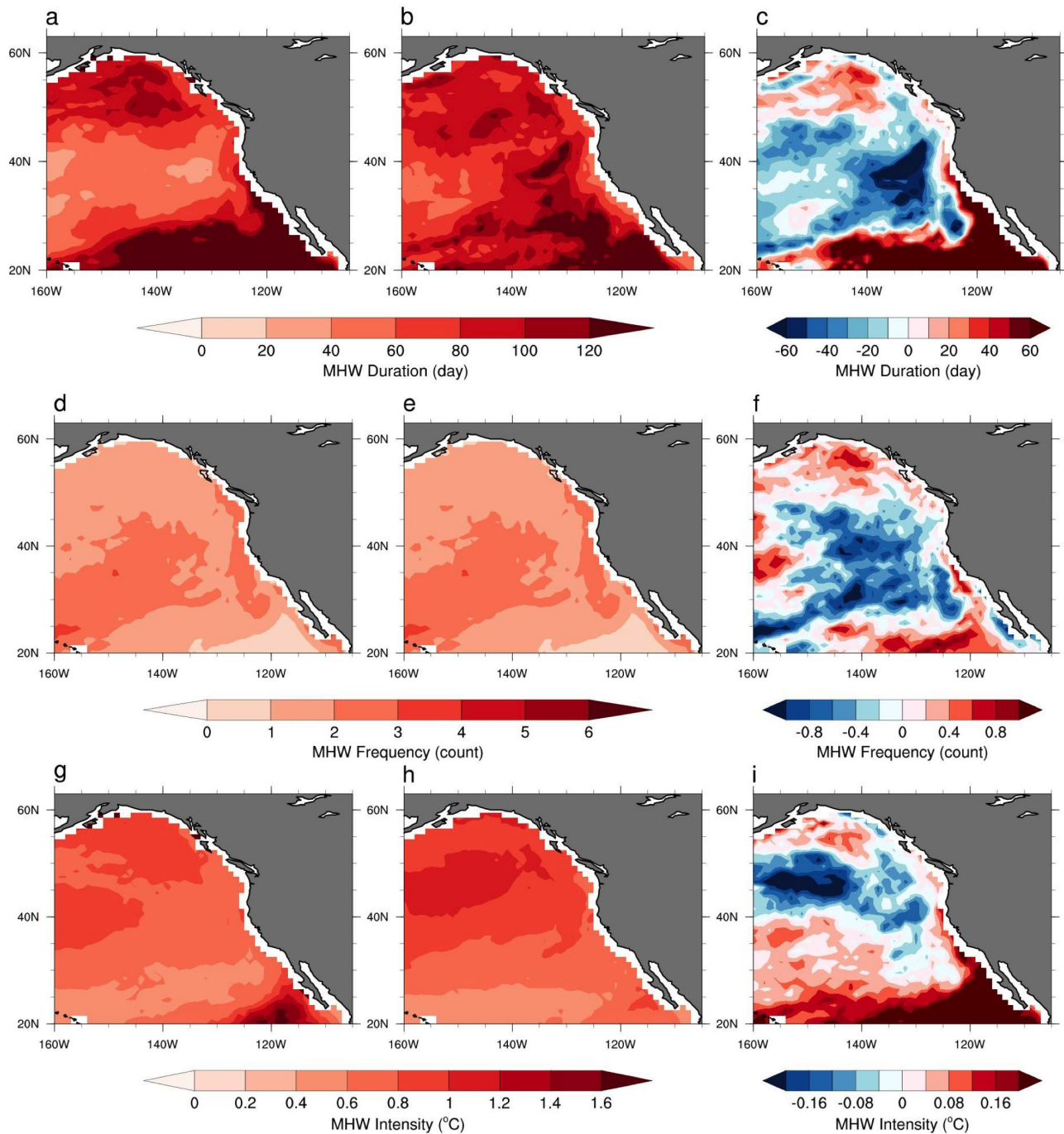
Supplementary Figure 1: Observed PDO pattern and index. (a-e) Observed PDO patterns from (a) COBE-SST, (b) COBE-SSTv2, (c) HadISST and (d) ERSSTv5 during 1891-2022. (e) PDO indices over the period 1891-2022 from these four observation datasets.



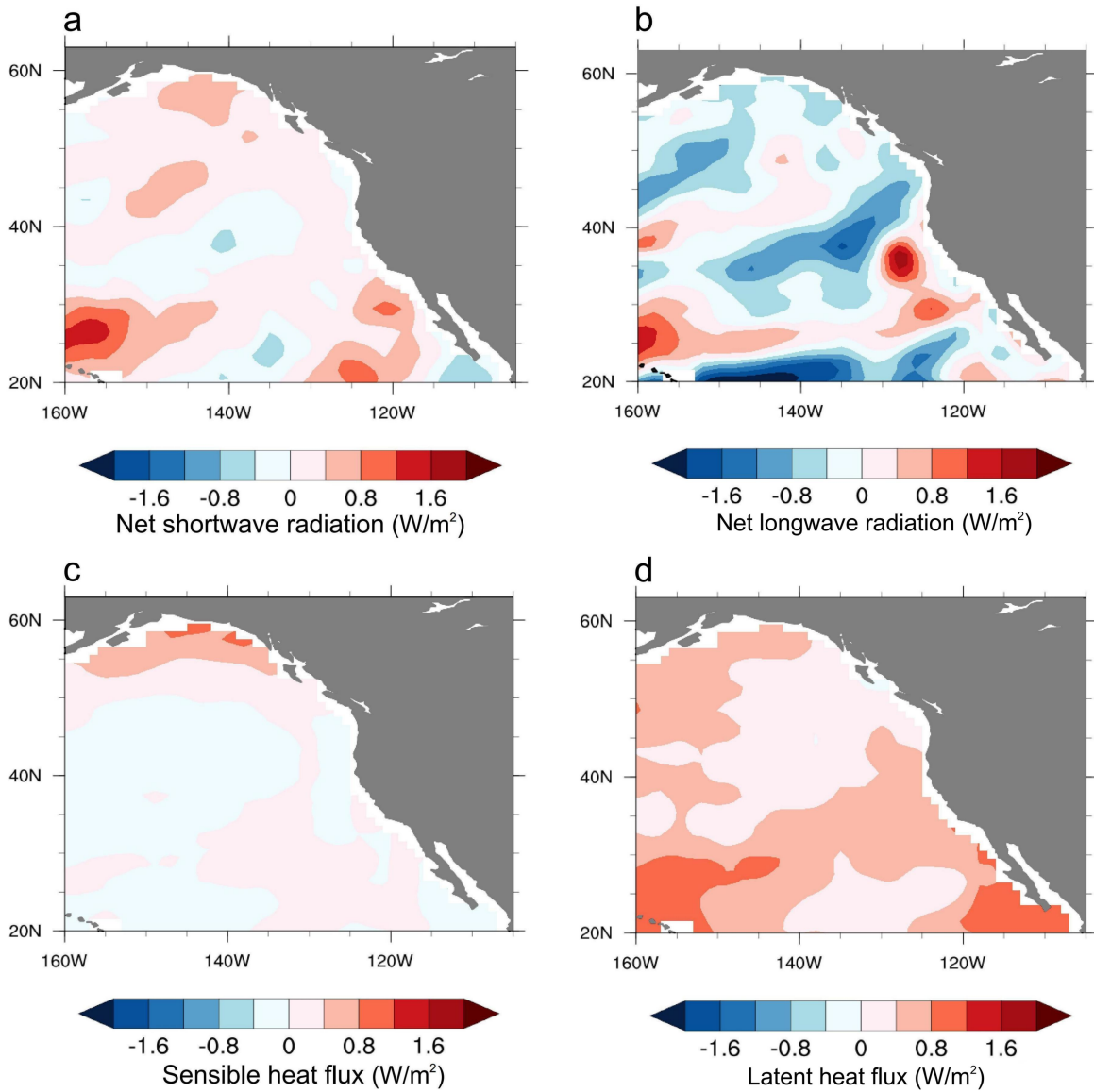
Supplementary Figure 2: Simulated PDO index and positive and negative PDO groups. (a) PDO indices during 1980-2022 for all the ensemble members from historical and RCP/SSP simulations with the five climate models (ensemble member, gray; ensemble mean, black). (b-d) The positive (red) and negative (blue) PDO groups during (b) 2013-2022, (c) 1986-1995 and (d) 1998-2007 from the historical and RCP/SSP simulations with the five climate models.



Supplementary Figure 3: Positive and negative PDOs modulating North Pacific MHWs during 1986-1995. (a-c) Durations of Northeast Pacific MHWs for the ensemble mean of the (a) positive and (b) negative PDO groups from the large ensemble simulations with five climate models during 1986-1995 as well as (c) the difference between the two (a minus b). (d-f) Same as (a-c) but for annual MHW frequency. (g-i) Same as (a-c) but for MHW intensity.



Supplementary Figure 4: Positive and negative PDOs modulating North Pacific MHWs during 1998-2007. (a-c) Durations of Northeast Pacific MHWs for the ensemble mean of the (a) positive and (b) negative PDO groups from the large ensemble simulations with five climate models during 1998-2007 as well as (c) the difference between the two (a minus b). (d-f) Same as (a-c) but for annual MHW frequency. (g-i) Same as (a-c) but for MHW intensity.



Supplementary Figure 5: Differences of surface heat flux components between positive and negative PDOs. The ensemble-mean differences of surface (a) shortwave and (b) longwave radiation and (c) sensible and (d) latent heat fluxes during 2013-2022 between the positive and negative PDO groups (positive minus negative) for the large ensemble simulations with the five climate models. Surface heat flux components are downward positive.

Supplementary Tables

Model	Number of members	Forcing scenarios	+PDO and –PDO members
ACCESS-ESM1.5	30	Historical + SSP245	+PDO: (r2, r23, r25, r26)i1p1f1 –PDO: (r15, r18, r24, r28)i1p1f1
CanESM5	20	Historical + SSP245	+PDO: (r2, r3, r6)i1p2f1, r10i1p1f1 –PDO: (r1,r5, r7)i1p1f1, r1i1p2f1
CESM1	40	Historical + RCP8.5	+PDO: Member (02, 23, 26, 30) –PDO: Member (06, 14, 26, 35)
CESM2	50	Historical + SSP370	+PDO: Member (05, 08, 14, 17) –PDO: Member (13, 15, 21, 29)
EC-Earth3	32	Historical + SSP245	+PDO: (r12, r17, r21, r22)i1p1f1 –PDO: (r2, r7, r10, r20)i1p1f1
Sum	172		+PDO: 20 –PDO: 20

Supplementary Table 1: Climate models, their large ensemble simulations and PDO groups.

The five climate models used in the study and the information of their large ensemble simulations: numbers of ensemble members, forcing scenarios and the ensemble members in the positive PDO and negative PDO groups for the period 2013-2022. RCP means representative concentration pathway and SSP denotes shared socio-economic pathway. The RCP8.5 scenario starts at 2006 in CESM1 simulations while the scenarios of the SSPs start at 2015 in the simulations of other models.

Period	+PDO members	-PDO members
1986-1995	ACCESS-ESM1.5: r9i1p1f1 CanESM5: r2i1p1f1 CESM1: Member (07) EC-Earth3: r11i1p1f1	ACCESS-ESM1.5: r19i1p1f1 CanESM5: r3i1p1f1 CESM1: Member (05) EC-Earth3: r6i1p1f1
1998-2007	ACCESS-ESM1.5: r36i1p1f1 CESM1: Member (05) CESM2: Member (03,10)	ACCESS-ESM1.5: r9i1p1f1 CESM1: Member (07) CESM2: Member (11) EC-Earth3: r17i1p1f1

Supplementary Table 2: PDO groups for 1986-1995 and 1998-2007. The ensemble members in the positive PDO and negative PDO groups for the periods of 1986-1995 and 1998-2007 from the five climate models.