Supplementary Information

Near-term future sea level projections supported by extrapolation of tide-gauge observations

Jinping Wang[1,*], Xuebin Zhang[2], John A. Church[3,4], Matt King[5,6], and Xianyao Chen[1]

[1] Frontier Science Center for Deep Ocean Multispheres and Earth System / Key Laboratory of Physical Oceanography, Ocean University of China, Qingdao, China

[2] Climate Science Centre, CSIRO Environment, Hobart, Australia

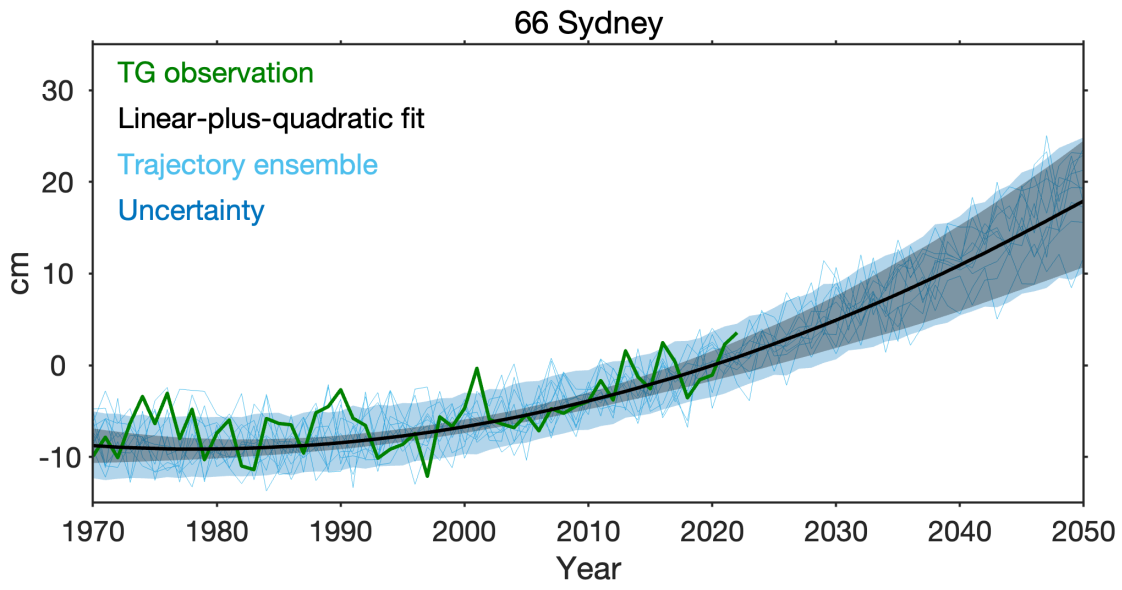
[3] Climate Change Research Centre, University of New South Wales, Sydney, Australia

[4] The Australian Centre for Excellence in Antarctic Science, University of New South Wales Sydney, Australia

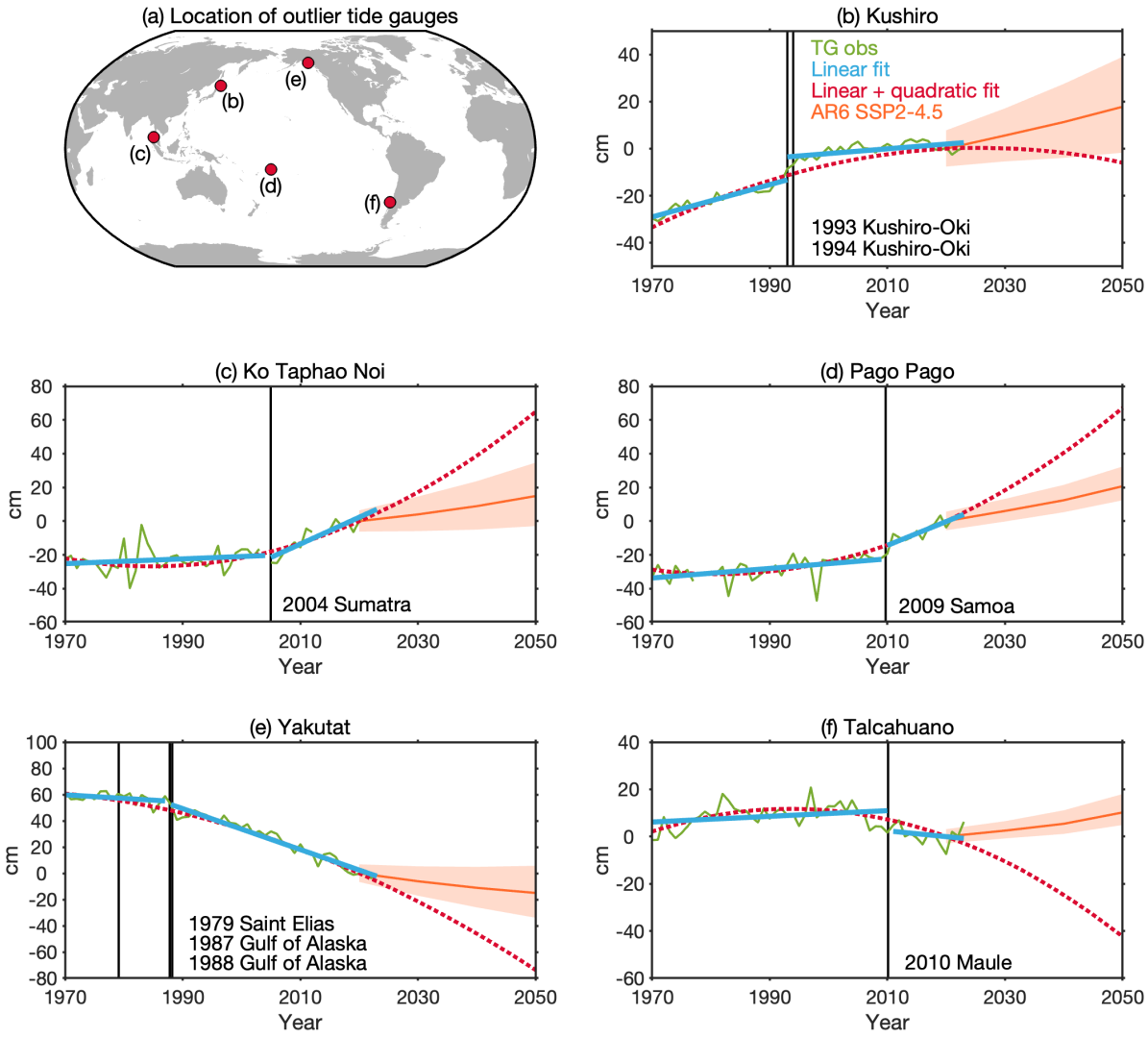
[5] School of Geography, Planning, and Spatial Sciences, University of Tasmania, Tasmania, Australia

[6] The Australian Centre for Excellence in Antarctic Science, University of Tasmania, Tasmania, Australia

* Corresponding author. E-mail: wangjinping@ouc.edu.cn

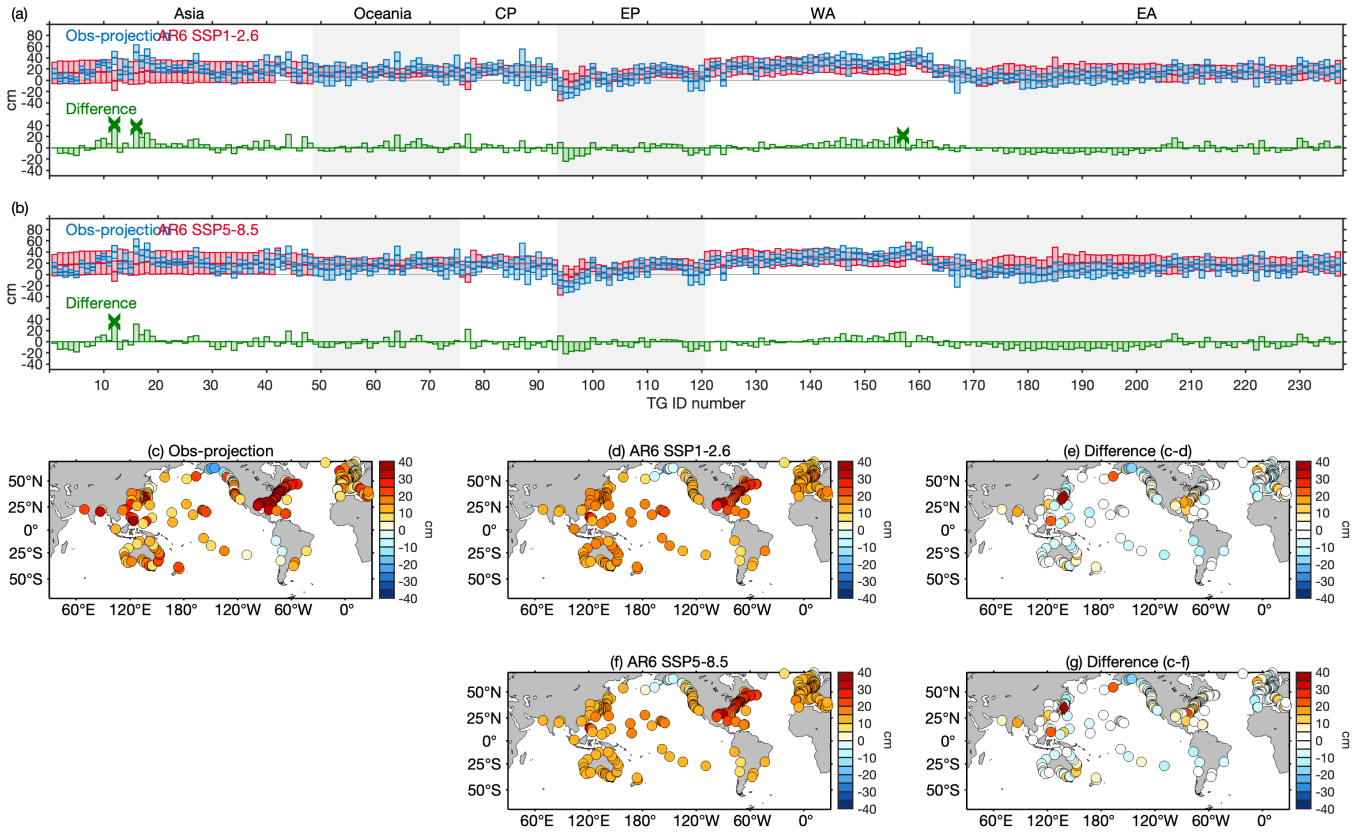


Supplementary Figure 1. An example of observation-based projection for Sydney. The green curve shows annual mean tide gauge observations, while the black curve denotes the estimated observation-based projection. The gray shading denotes the 90% confidence level uncertainty for linear-plus-quadratic fit based on multiple variable linear regression. The blue shading indicates the total uncertainty including considering both the uncertainty due to internal variability on the estimated trend and acceleration, and the uncertainty of unforced sea level variability in the future. The light blue curves show some example ensemble members of the observation-based projection realizations.



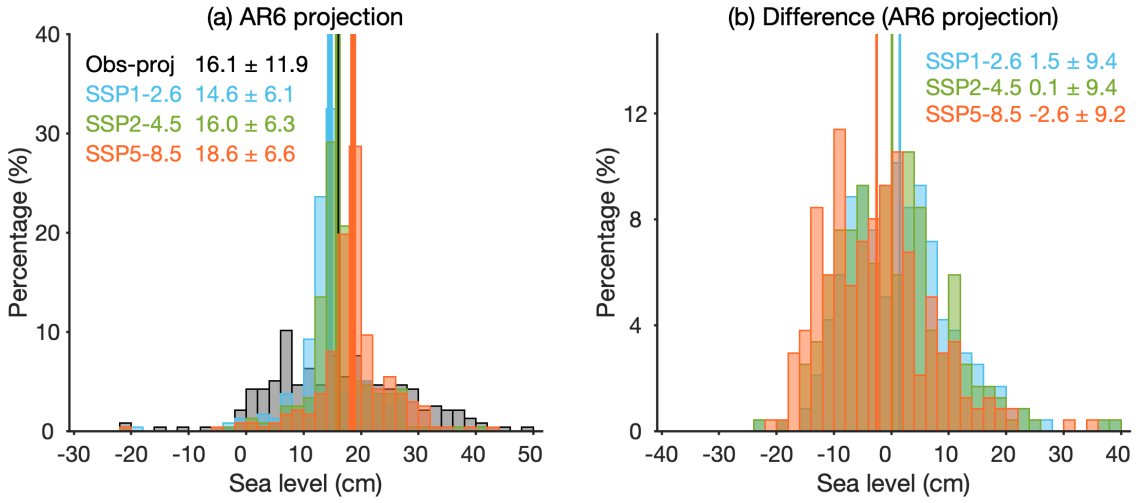
Supplementary Figure 2. Removed tide gauge stations. a Locations of removed tide gauges. Sea level change (cm) at removed tide gauges with the changed sea-level rise rate after he respective major earthquakes, including **b** Kushiro with, **c** Ko Taphao Noi, **d** Pago Pago with, **e** Yakutat. **f** Talcahuano. The black vertical lines indicate years of major earthquakes in the vicinity of the station. The green curves are annual mean tide gauge observations. The blue lines denote the linear fits before and after major earthquakes. The red lines represent the linear-plus-quadratic fit during the

whole research period 1970-2023 and extrapolated to 2050. The orange lines are from AR6 projection under SSP2-4.5, and the shadings are the associated 90% uncertainty range.

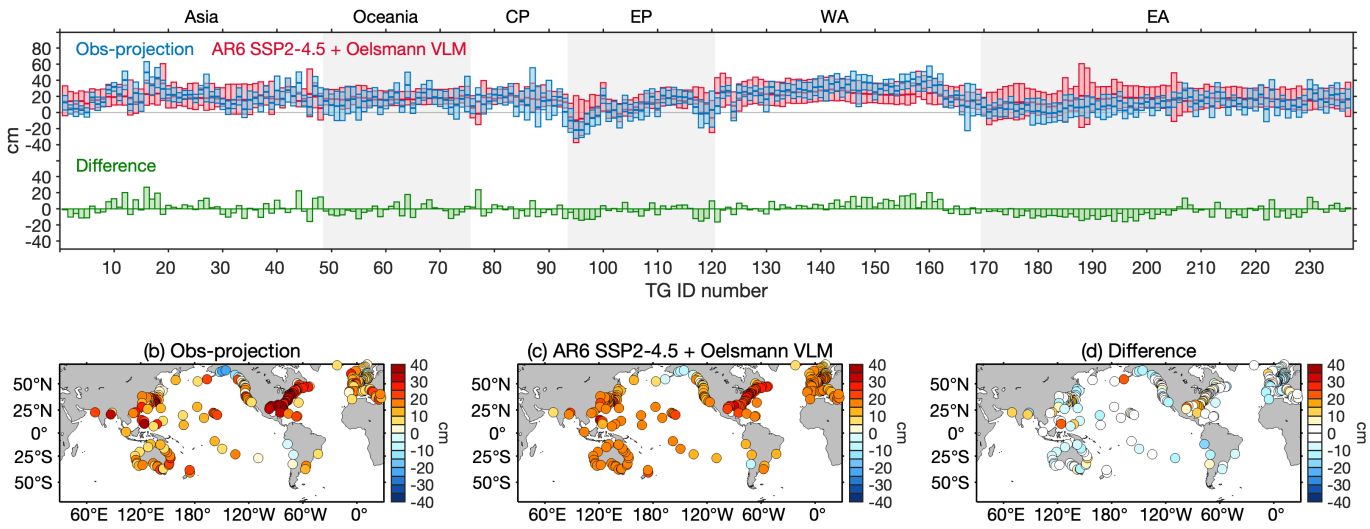


Supplementary Figure 3. Comparison of sea-level rise at individual tide gauges from observation-based projection and AR6 projections under SSP1-2.6 and SSP5-8.5. **a** The sea-level rise in 2050 relative to 2020 (cm) from observation-based projections (blue), AR6 projections under SSP1-2.6 scenario (red), and their difference (observation-based projection minus AR6 projection; green). The error bars denote the 90% uncertainty range. The cross symbols denote the sea-level rise from observation-based projection are significantly different from the projection. **b** The same as (**a**), but comparing with the AR6 projection under SSP5-8.5. Spatial distribution from (**c**) observation-based projection, (**d**) AR6 projection under SSP1-2.6, and (**e**) their difference (observation-based projection minus AR6 projection). Spatial distribution from (**f**) AR6 projection under SSP5-8.5, and (**g**) the difference (observation-based projection minus AR6 projection). In (**e**) and (**g**), the diamond

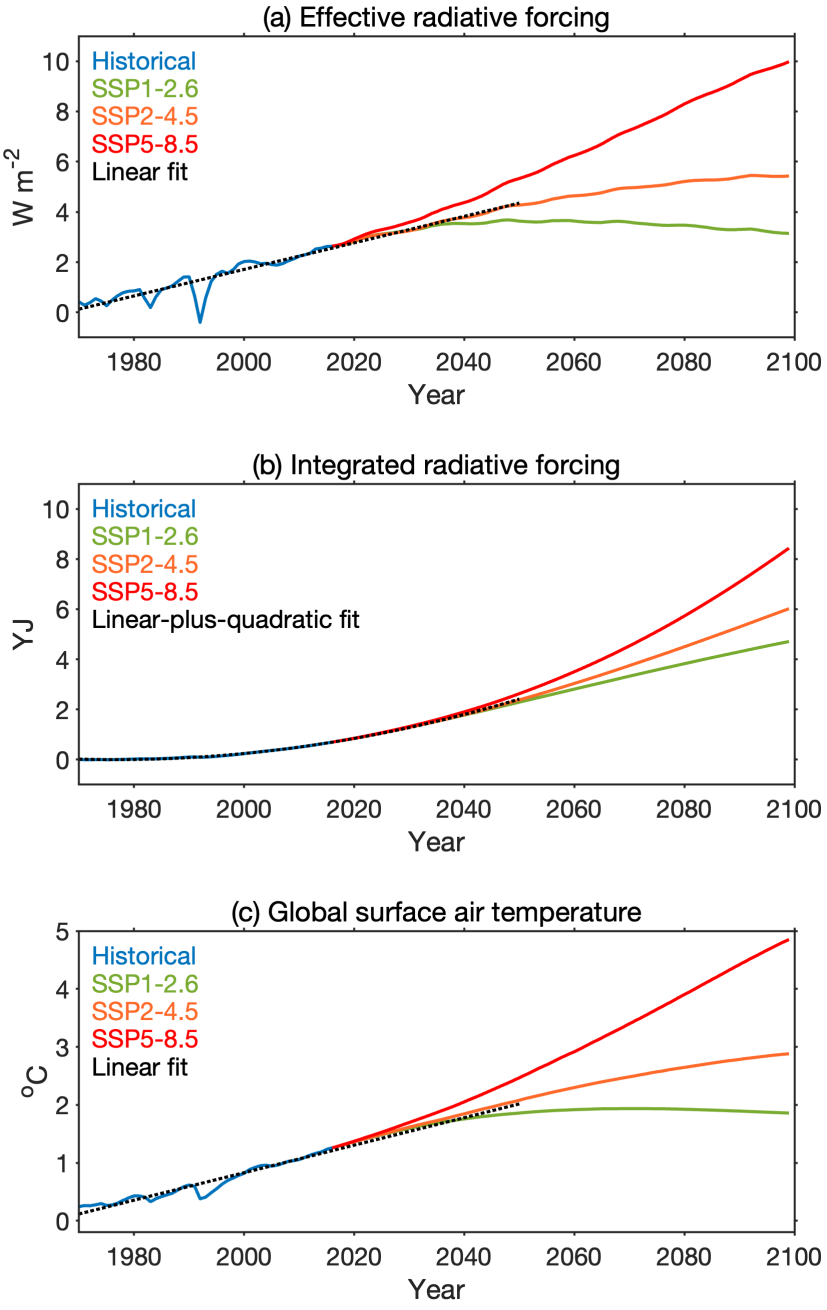
symbols denote the sea level rise from observation-based projection are significantly different from the projection.



Supplementary Figure 4. The histogram of sea-level rise in 2050 relative to 2020 from observation-based projection and AR6 process-based projections. a Sea-level rise from observation-based projections (gray), and AR6 projections under a low emissions scenario SSP1-2.6 (blue), intermediate emissions scenario SSP2-4.5 (green), and high emissions scenario SSP5-8.5 (orange). The bin width is 1.5 cm, and the vertical lines present the mean sea-level rise at all tide gauge stations. **b** The corresponding differences between the observation-based projections and AR6 projections under three emission scenarios.

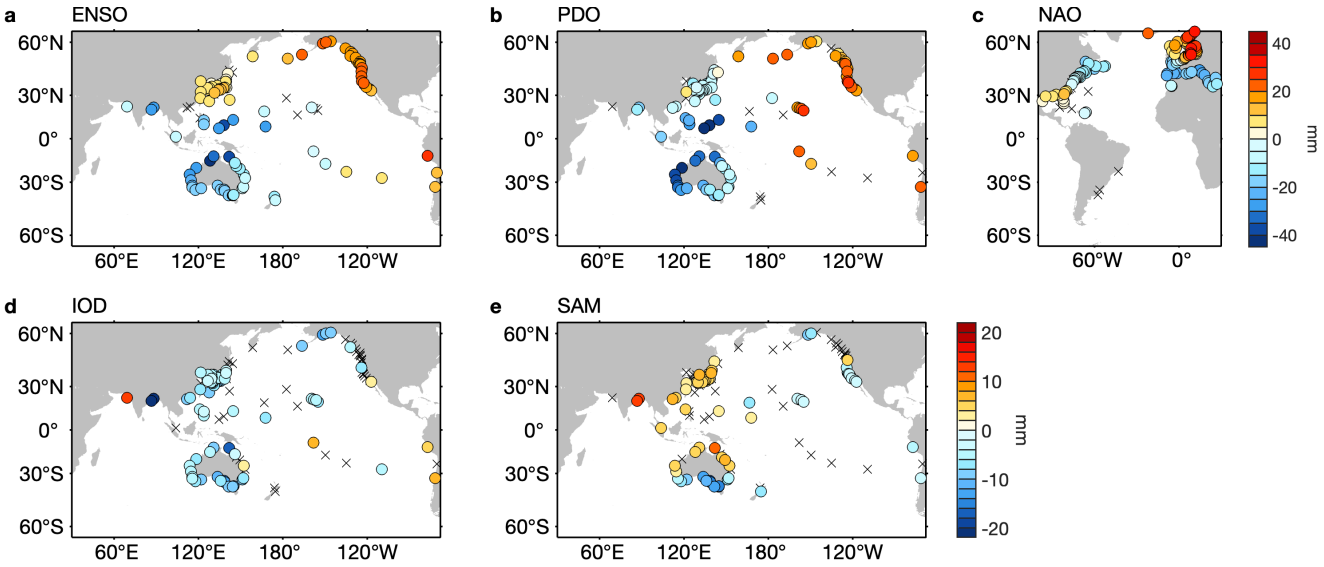


Supplementary Figure 5. Comparison of sea-level rise from observation-based and VLM-adjusted AR6 projections under SSP2-4.5 at individual tide gauges. a The sea-level rise in 2050 relative to 2020 (cm) from observation-based projection (blue), AR6-adjust projection by using the VLM from Oelsmann et al. (2024) under SSP2-4.5 scenario (red), and their difference (observation-based projection minus AR6 projection; green). The error bars denote the 90% uncertainty range. Spatial distribution from (**b**) observation-based projection, (**c**) AR6-adjust projection under SSP2-4.5, and (**d**) their difference (observation-based projection minus AR6-adjust projection).



Supplementary Figure 6. a Global effective radiative forcing (W m^{-2}) from CMIP6 used in IPCC AR6 report. The time series are provided for all forcing together (natural plus anthropogenic changes), encompassing the historical period (blue), SSP1-2.6 (green), SSP2-4.5 (orange), and SSP5-8.5 (red). Black dotted line indicates the linear fit

estimated from 1970 to 2023 and extrapolated to 2050. **b** Time-integrated effective radiative forcing (YJ = 10^{24} Joules). Black dotted line indicates the linear-plus-quadratic fit estimated from 1970-2023 and extrapolated to 2050. **c** Global surface air temperature (^{o}C) from CMIP6 used IPCC AR6 report. Black dotted line indicates the linear fit estimated from 1970 to 2023 and extrapolated to 2050.



Supplementary Figure 7. Regression coefficient maps from the multiple variable linear regression (MVLR) analysis. Colored circles indicate significant regression coefficients of tide-gauge records (1970–2023) related to the (a) high-passed ENSO, (b) low-passed PDO, (c) NAO, (d) IOD, and (e) SAM index. Regression coefficients of tide-gauge records, which are not significant at 90% confidence level are denoted as cross symbols. Note that the colorbar differs between panel a-c and panel d-e.

Table S1. Tide gauge stations list. The tide gauge stations are divided into six regions according to the geographical locations, including the Asia nearby coastline (TG ID 1-48), the Oceania coastline (TG ID 49-75), the central Pacific Ocean (CP, TG ID 76-93), the east coast of the Pacific Ocean (EP, TG ID 94-120), the west coast of the Atlantic Ocean (WA, TG ID 121-169), and the east coast of the Atlantic Ocean (EA, TG ID 170-237).

	TG ID	Longitude	Latitude	Name	PSMSL/ ANCHORS
Asia	1	158.65	52.98	PETROPAVLOVSK-KAMCHATSKY	P
	2	141.69	45.41	WAKKANAI	P
	3	144.29	44.02	ABASHIRI	P
	4	140.86	43.21	OSHORO II	P
	5	139.71	39.94	OGA	P
	6	139.55	38.56	NEZUGASEKI	P
	7	139.26	38.47	AWA SIMA	P
	8	136.90	37.41	WAJIMA; TOYAMA	P
	9	133.33	36.2	SAIGO; SAKAI	P
	10	134.32	35.59	TAJIRI	P
	11	136.15	36.25	MIKUNI	P
	12	138.52	35.01	MINAMI IZU; OKADA; ITO II; TAGO; UCHIURA; SHIMIZU-MINATO	P
	13	139.82	34.92	KATSUURA; ABURATSUBO; MERA; YOKOSUKA	P
	14	137.61	34.68	MAISAKA; OMAEZAKI II; YAIZU	P
	15	135.15	34.22	SUMOTO; SHIRAHAMA; KAINAN; KOMATSUSHIMA; WAKAYAMA; TAN-NOWA	P
	16	135.90	33.56	URAGAMI; OWASE	P
	17	135.77	33.48	KUSHIMOTO	P
	18	134.16	33.27	MUROTOMISAKI; KOCHI III	P

Asia	19	132.96	32.78	UWAJIMA II; KURE I; TOSA SHIMIZU	P
	20	131.67	32.43	HOSOJIMA	P
	21	131.41	31.58	ABURATSU	P
	22	130.99	30.74	NISINOOMOTE; ODOMARI	P
	23	130.19	32.02	AKUNE	P
	24	129.87	32.74	NAGASAKI; OURA; SASEBO II; KARIYA; KUCHINOTSU; MISUMI	P
	25	128.85	32.7	FUKUE	P
	26	130.41	33.62	HAKATA	P
	27	130.91	37.49	ULLEUNG	P
	28	129.12	37.55	MUKHO; SOKCHO	P
	29	129.39	35.5	POHANG; ULSAN	P
	30	129.04	35.1	GADEOKDO; BUSAN	P
	31	127.77	34.75	YEOSU; TONGYEONG	P
	32	126.54	33.53	JEJU; GEOMUNDO; WANDO	P
	33	126.38	34.78	MOKPO	P
	34	125.44	34.68	HEUKSANDO	P
	35	126.59	37.45	INCHEON	P
	36	121.68	38.87	DALIAN	P
	37	121.62	32.13	LUSI	P
	38	121.28	28.08	KANMEN	P
	39	127.67	26.21	NAHA; OKINAWA	P
	40	114.18	22.44	TAI PO KAU, TOLO HARBOUR; TSIM BEI TSUI	P
	41	111.82	21.58	ZHAPO	P
	42	120.97	14.58	MANILA, S. HARBOR	P
	43	123.75	13.15	LEGASPI, ALBAY	P
	44	123.92	10.30	CEBU	P
	45	103.83	1.47	SULTAN SHOAL; RAFFLES LIGHT HOUSE; SEMBAWANG	P
	46	88.10	22.03	HALDIA; DIAMOND HARBOUR	P
	47	86.70	20.27	PARADIP	P
	48	69.08	22.47	OKHA	P
Oceania	49	130.85	-12.47	Darwin	A
	50	128.10	-15.45	Wyndham	A
	51	118.57	-20.32	PORT HEDLAND	P
	52	113.65	-24.90	Carnarvon	A

Oceania	53	114.60	-28.78	Geraldton	A
	54	115.74	-32.06	FREMANTLE	P
	55	115.66	-33.32	BUNBURY	P
	56	117.89	-35.03	Albany	A
	57	121.90	-33.87	Esperance	A
	58	133.64	-32.15	Thevenard	A
	59	135.87	-34.72	PORT LINCOLN	P
	60	138.48	-34.78	PORT ADELAIDE (OUTER HARBOR)	P
	61	138.64	-35.56	Victor Harbor	A
	62	141.62	-38.35	Portland	A
	63	144.36	-38.15	Geelong	A
	64	144.61	-38.29	Point Lonsdale	A
	65	144.92	-37.87	Melbourne	A
	66	151.23	-33.85	SYDNEY, FORT DENISON 2	P
	67	151.79	-32.92	Newcastle	A
	68	153.17	-27.37	BRISBANE (WEST INNER BAR)	P
	69	152.38	-24.77	Bundaberg	A
	70	149.23	-21.12	Mackay	A
	71	146.83	-19.25	TOWNSVILLE I	P
	72	145.78	-16.93	Cairns	A
	73	141.86	-12.67	Weipa	A
	74	174.78	-41.28	WELLINGTON HARBOUR	P
	75	174.03	-39.06	PORT TARANAKI	P
CP	76	183.37	51.86	ADAK SWEEPER COVE	P
	77	193.46	53.88	UNALASKA	P
	78	142.18	27.08	CHICHIJIMA	P
	79	182.64	28.21	MIDWAY ISLAND	P
	80	200.65	21.95	NAWILIWILI BAY, KAUAI ISLAND	P
	81	202.13	21.31	HONOLULU; MOKUOLOE ISLAND	P
	82	203.52	20.90	KAHULUI HARBOR, MAUI ISLAND	P
	83	204.95	19.73	HILO, HAWAII ISLAND	P
	84	166.62	19.29	WAKE ISLAND	P
	85	190.47	16.74	JOHNSTON ISLAND	P
	86	144.65	13.44	APRA HARBOR	P
	87	138.13	9.52	YAP B	P
	88	134.47	7.33	MALAKAL-B	P

CP	89	167.74	8.73	KWAJALEIN	P
	90	201.93	-9.02	PENRHYN	P
	91	210.43	-17.53	PAPEETE-B, FARE UTE POINT, SOC.IS.	P
	92	225.03	-23.12	RIKITEA	P
	93	250.53	-27.15	EASTER ISLAND-E	P
EP	94	208.28	59.44	SELDOVIA	P
	95	210.57	60.12	SEWARD	P
	96	214.25	60.56	VALDEZ; CORDOVA	P
	97	224.66	57.05	SITKA	P
	98	228.38	55.33	KETCHIKAN	P
	99	229.67	54.32	PRINCE RUPERT	P
	100	227.93	53.25	QUEEN CHARLOTTE CITY	P
	101	231.87	52.17	BELLA BELLA	P
	102	232.52	50.72	PORT HARDY	P
	103	234.77	50.02	CAMPBELL RIVER	P
	104	234.08	49.15	TOFINO	P
	105	234.87	48.85	BAMFIELD	P
	106	235.39	48.37	NEAH BAY	P
	107	236.03	46.71	TOKE POINT, WILLIPA BAY, WA	P
	108	236.23	46.21	ASTORIA (TONGUE POINT)	P
	109	235.96	44.63	SOUTH BEACH	P
	110	235.82	41.75	CRESCENT CITY	P
	111	236.29	38.91	ARENA COVE, CALIFORNIA	P
	112	237.02	37.99	POINT REYES	P
	113	237.54	37.81	SAN FRANCISCO; PORT CHICAGO, CALIFORNIA; ALAMEDA (NAVAL AIR STATION)	P
	114	238.11	36.60	MONTEREY	P
	115	239.24	35.18	PORT SAN LUIS	P
	116	241.73	33.72	LOS ANGELES; SANTA MONICA (MUNICIPAL PIER)	P
	117	242.74	32.87	SAN DIEGO (QUARANTINE STATION); LA JOLLA (SCRIPPS PIER)	P
	118	282.85	-12.05	CALLAO 2	P
	119	289.60	-23.65	ANTOFAGASTA 2	P

EP	120	288.37	-33.03	VALPARAISO	P
WA	121	307.28	47.57	ST. JOHNS, NFLD.	P
	122	306.02	47.30	ARGENTIA	P
	123	300.87	47.57	PORT AUX BASQUES	P
	124	293.60	50.2	SEPT-ILES	P
	125	295.62	49.00	RIVIERE-AU-RENARD	P
	126	295.12	47.08	LOWER ESCUMINAC	P
	127	296.88	46.23	CHARLOTTETOWN	P
	128	299.75	46.22	NORTH SYDNEY	P
	129	293.87	43.83	YARMOUTH	P
	130	293.93	45.27	SAINT JOHN, N.B.	P
	131	293.02	44.90	EASTPORT	P
	132	291.80	44.39	BAR HARBOR, FRENCHMAN BAY, ME	P
	133	289.75	43.66	PORTLAND (MAINE)	P
	134	289.90	41.29	NANTUCKET ISLAND	P
	135	288.67	41.51	BOSTON; NEWPORT; WOODS HOLE (OCEAN. INST.); PROVIDENCE (STATE PIER)	P
	136	287.91	41.36	NEW LONDON; MONTAUK	P
	137	286.82	41.17	BRIDGEPORT	P
	138	285.99	40.70	NEW YORK (THE BATTERY)	P
	139	285.99	40.47	SANDY HOOK	P
	140	284.86	39.93	PHILADELPHIA (PIER 9N)	P
	141	285.58	39.35	ATLANTIC CITY	P
	142	284.88	38.78	CAPE MAY; LEWES (BREAKWATER HARBOR)	P
	143	283.53	37.99	LEWISETTA, VIRGINIA; SOLOMONS ISLAND (BIOL. LAB.)	P
	144	283.67	36.95	SEWELLS POINT, HAMPTON ROADS; KIPTOPEKE BEACH	P
	145	283.33	34.72	BEAUFORT, NORTH CAROLINA	P
	146	282.05	34.23	WILMINGTON	P
	147	281.08	33.66	SPRINGMAID PIER	P

WA	148	280.08	32.78	CHARLESTON I	P
	149	279.10	32.03	FORT PULASKI	P
	150	278.53	30.67	FERNANDINA BEACH	P
	151	278.19	24.56	KEY WEST	P
	152	278.19	26.13	NAPLES	P
	153	278.13	26.65	FORT MYERS	P
	154	277.37	27.76	ST. PETERSBURG	P
	155	276.97	29.14	CEDAR KEY II	P
	156	275.02	29.73	APALACHICOLA	P
	157	272.79	30.4	PENSACOLA	P
	158	270.04	29.26	GRAND ISLE	P
	159	265.21	29.31	GALVESTON II, PIER 21, TX	P
	160	262.95	28.02	ROCKPORT	P
	161	262.78	26.06	PORT ISABEL	P
	162	275.10	21.90	CABO DE SAN ANTONIO	P
	163	283.88	21.11	GIBARA	P
	164	293.89	18.46	SAN JUAN	P
	165	292.96	17.97	MAGUEYES ISLAND	P
	166	295.30	32.37	ST. GEORGES / ESSO PIER (BERMUDA)	P
	167	316.83	-22.9	ILHA FISCAL	P
	168	303.75	-34.9	MONTEVIDEO (PUNTA LOBOS)	P
	169	302.48	-38.03	MAR DEL PLATA (CLUB)	P
EA	170	338.06	64.15	REYKJAVIK	P
	171	11.23	64.86	RORVIK	P
	172	9.10	63.43	HEIMSJOEN	P
	173	7.73	63.11	KRISTIANSUND	P
	174	6.15	62.47	ALESUND	P
	175	5.11	61.93	MALOY	P
	176	5.32	60.40	BERGEN	P
	177	5.73	58.97	STAVANGER	P
	178	7.55	58.01	TREGDE	P
	179	8.60	57.12	HANSTHOLM	P
	180	9.96	57.60	HIRTSHALS	P
	181	10.55	57.44	FREDERIKSHAVN	P
	182	11.22	58.35	SMOGEN	P
	183	11.83	58.09	GOTEBORG – TORSHAMNEN; STENUNGSUND	P
	184	12.11	57.25	RINGHALS	P
	185	12.46	56.09	HORNBAEK	P

EA	186	12.89	55.52	VIKEN; KLAGSHAMN; KOBENHAVN	P
	187	10.83	55.29	KORSOR; SLIPSHAVN	P
	188	12.10	54.17	WARNEMUNDE 2	P
	189	11.93	54.57	GEDSER	P
	190	10.87	53.96	TRAVEMUNDE; WISMAR 2	P
	191	10.16	54.37	KIEL-HOLTENAU	P
	192	8.38	54.62	AMRUM (WITTDUEN); ESBJERG	P
	193	8.72	53.87	CUXHAVEN 2	P
	194	6.75	53.56	BORKUM (FISCHERBALJE)	P
	195	6.93	53.33	DELFZIJL	P
	196	4.75	52.96	DEN HELDER; WEST-TERSCHELLING; ARLINGEN	P
	197	4.55	52.46	IJMUIDEN	P
	198	4.12	51.98	HOEK VAN HOLLAND; MAASSLUIS	P
	199	3.60	51.44	VLISSINGEN	P
	200	2.92	51.23	OOSTENDE; ZEEBRUGGE; NIEUWPOORT	P
	201	2.37	51.05	CALAIS; DUNKERQUE	P
	202	1.32	51.11	DOVER; SHEERNESS	P
	203	1.75	52.47	LOWESTOFT	P
	204	357.92	57.14	ABERDEEN I	P
	205	356.91	58.44	WICK	P
	206	358.86	60.15	LERWICK	P
	207	353.61	58.21	STORNOWAY	P
	208	355.09	55.75	MILLPORT	P
	209	357.08	54.03	HEYSHAM	P
	210	355.38	53.31	HOLYHEAD	P
	211	354.46	50.10	NEWLYN	P
	212	355.81	50.37	DEVONPORT	P
	213	358.89	50.80	PORTSMOUTH	P
	214	358.36	49.65	CHERBOURG	P
	215	356.03	48.72	ROSCOFF	P
	216	355.22	48.36	LE CONQUET	P
	217	355.51	48.38	BREST	P
	218	356.55	47.64	PORT TUDY	P

EA	219	358.49	43.53	BOUCAU	P
	220	356.21	43.46	SANTANDER I	P
	221	351.60	43.37	LA CORUÑA I; LA CORUÑA II	P
	222	351.27	42.24	VIGO	P
	223	354.40	36.01	TARIFA	P
	224	354.68	35.89	CEUTA	P
	225	5.35	43.28	MARSEILLE	P
	226	7.29	43.70	NICE	P
	227	8.90	44.40	GENOVA	P
	228	13.63	45.08	ROVINJ	P
	229	14.54	45.31	BAKAR	P
	230	16.44	43.51	SPLIT - GRADSKA LUKA; SPLIT RT MARJANA	P
	231	18.06	42.66	DUBROVNIK	P
	232	20.71	38.83	LEVKAS; PREVEZA	P
	233	21.32	37.64	KATAKOLON	P
	234	24.08	35.49	SOUDHAS	P
	235	24.95	37.44	SIROS	P
	236	26.85	37.13	LEROS	P
	237	25.88	40.84	ALEXANDROUPOLIS	P