

Supplementary Materials for

Response time of global deltas to changes in fluvial sediment supply

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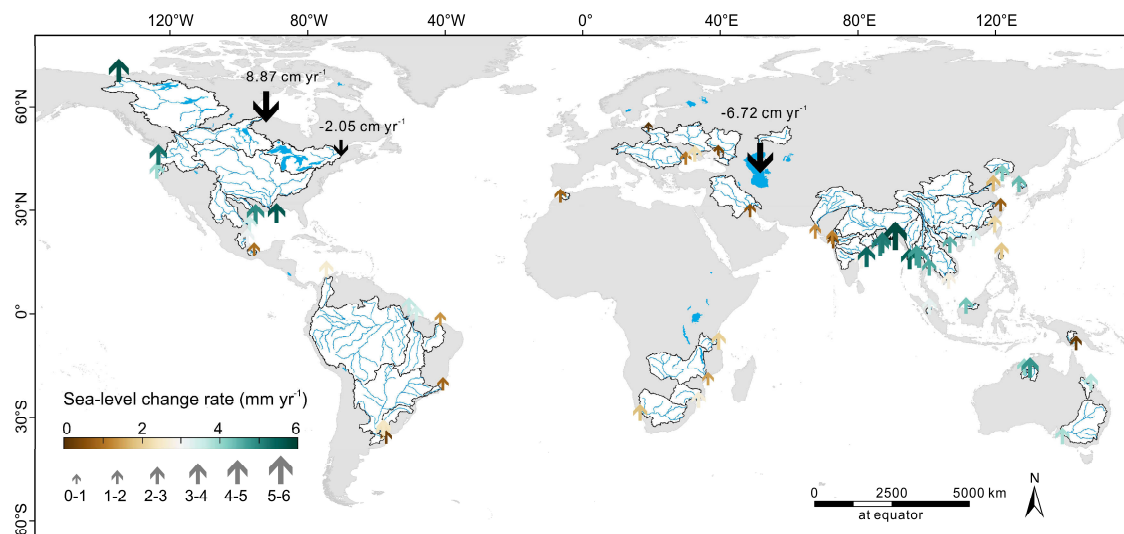
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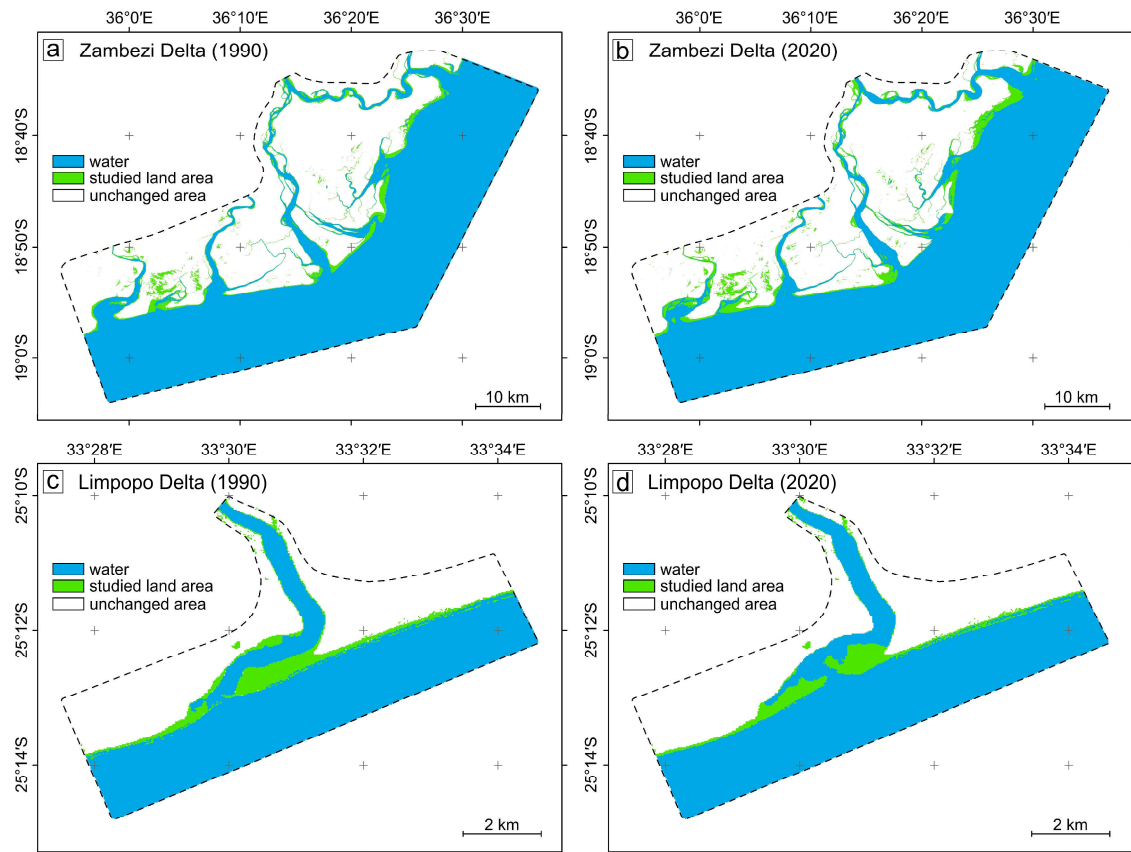


Supplementary Figure 1. Some anthropogenic processes influence fluvial sediment yields and budgets in the basins. (a) The Three Gorges Dam on the Yangtze (Changjiang) River, China. (b) The Itaipu Dam on the Parana River, Brazil and Paraguay. (c) The Mica Dam on the Columbia River, Canada. (d) Soil conservation forests in the upper Yangtze River Basin, China. (e) Reforestation on the Loess Plateau in the middle Yellow (Huanghe) River Basin, China. (f) Riverbank hardening and levees' construction on the Mississippi River, USA. (g) Sand mining along the lower Mekong River channel, Vietnam. (h) Destruction of the tropical rainforests in the Amazon Basin, Brazil. (i) Mining and land exposure in the Zambian River Basin, Zambia. *Note: All of the above images were obtained from internet sources.*

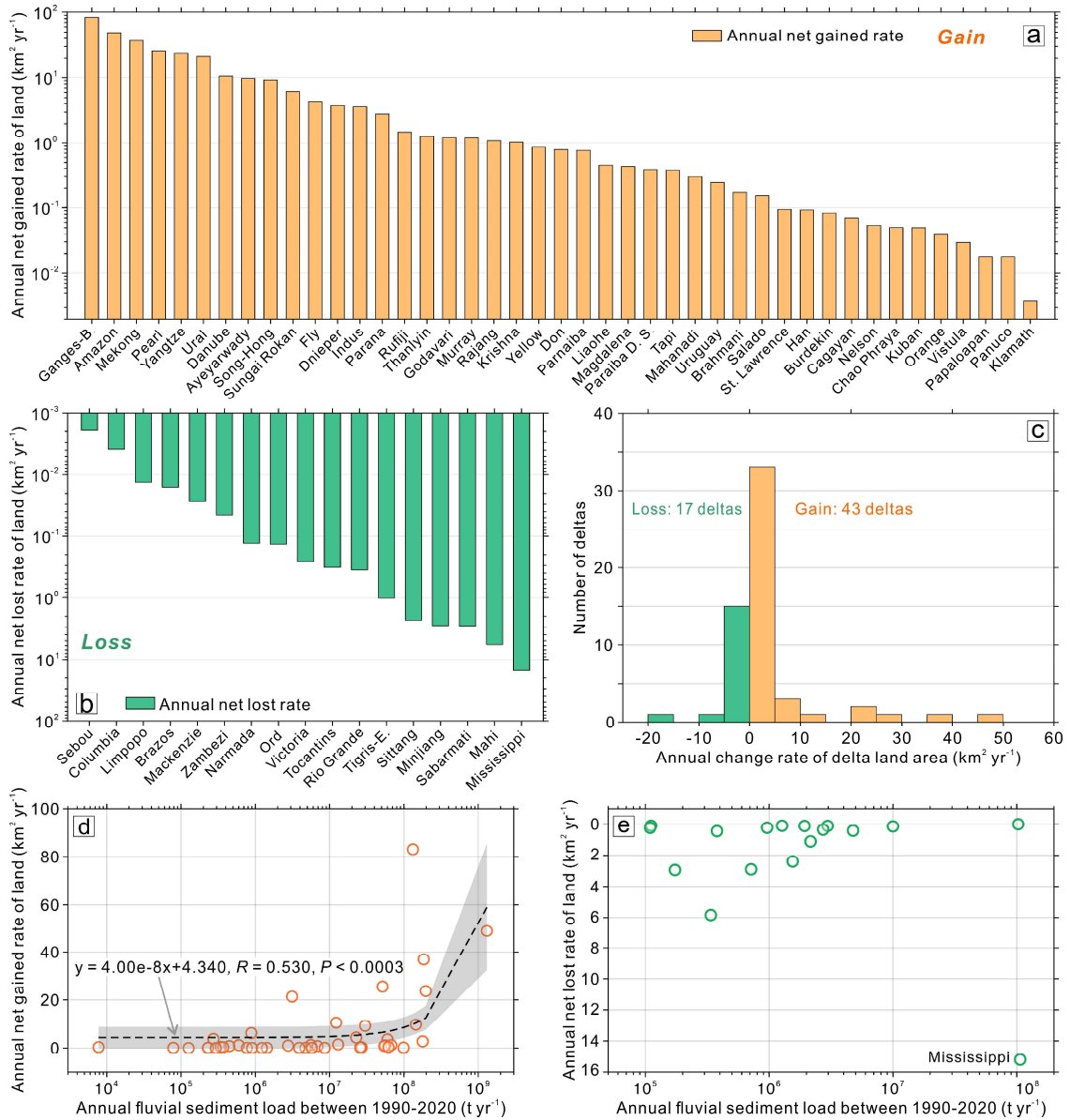


Supplementary Figure 2. Relative sea-level change rates in the 60 studied deltas.

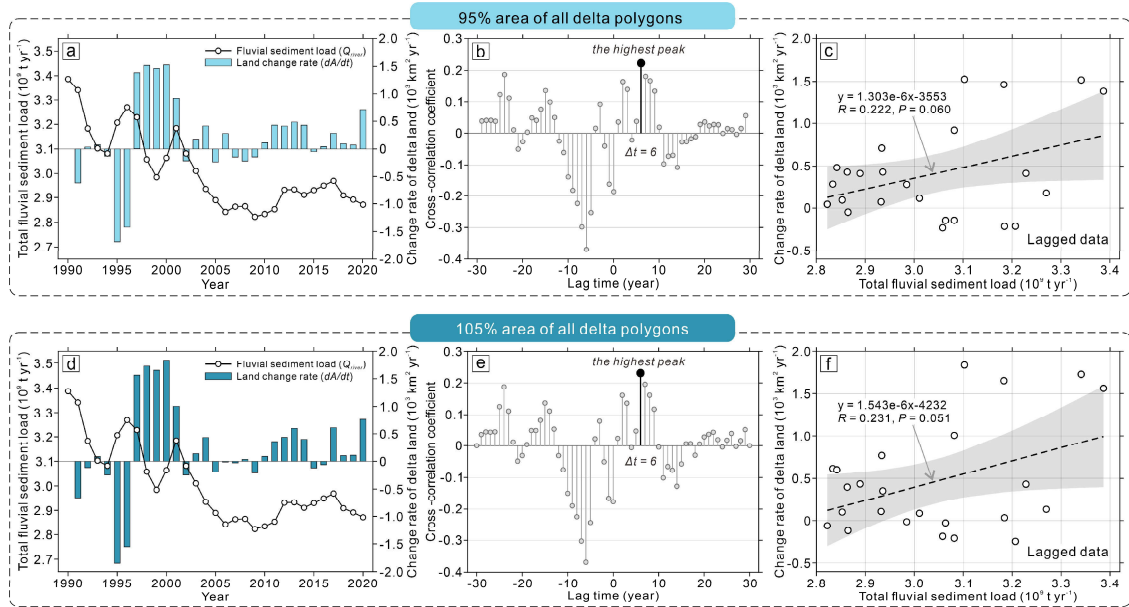
These data were available from *Nienhuis et al. (2023)*.



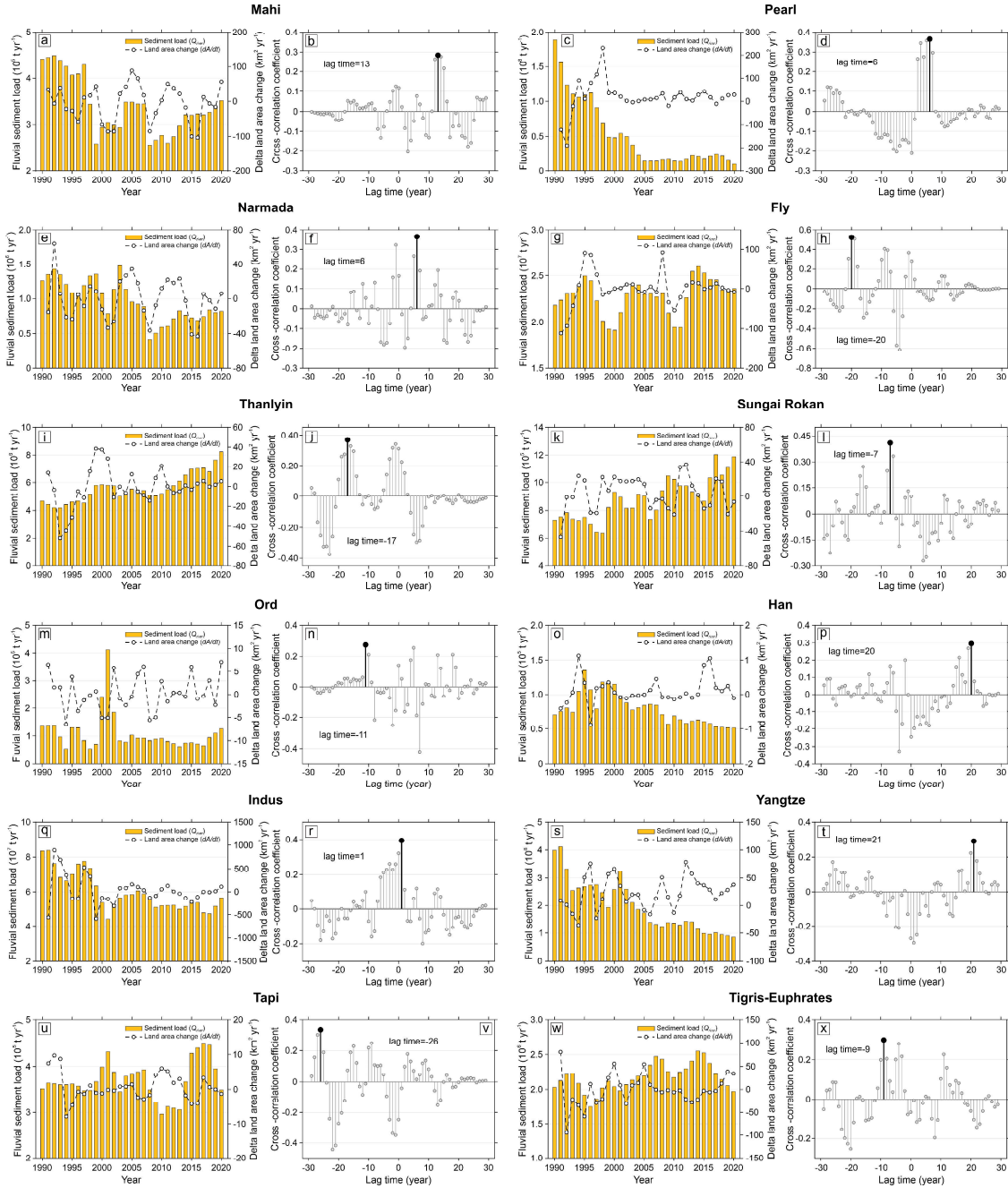
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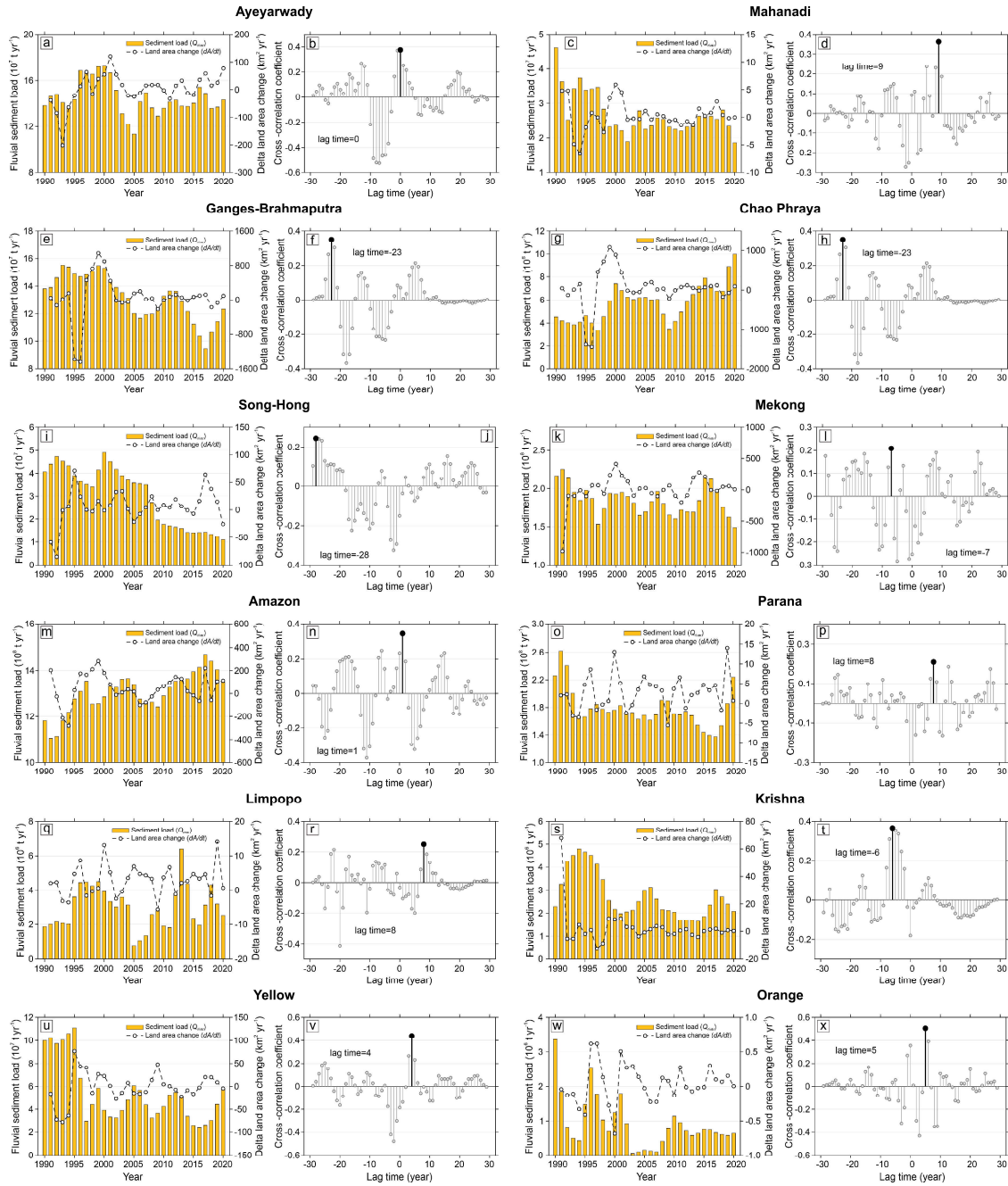
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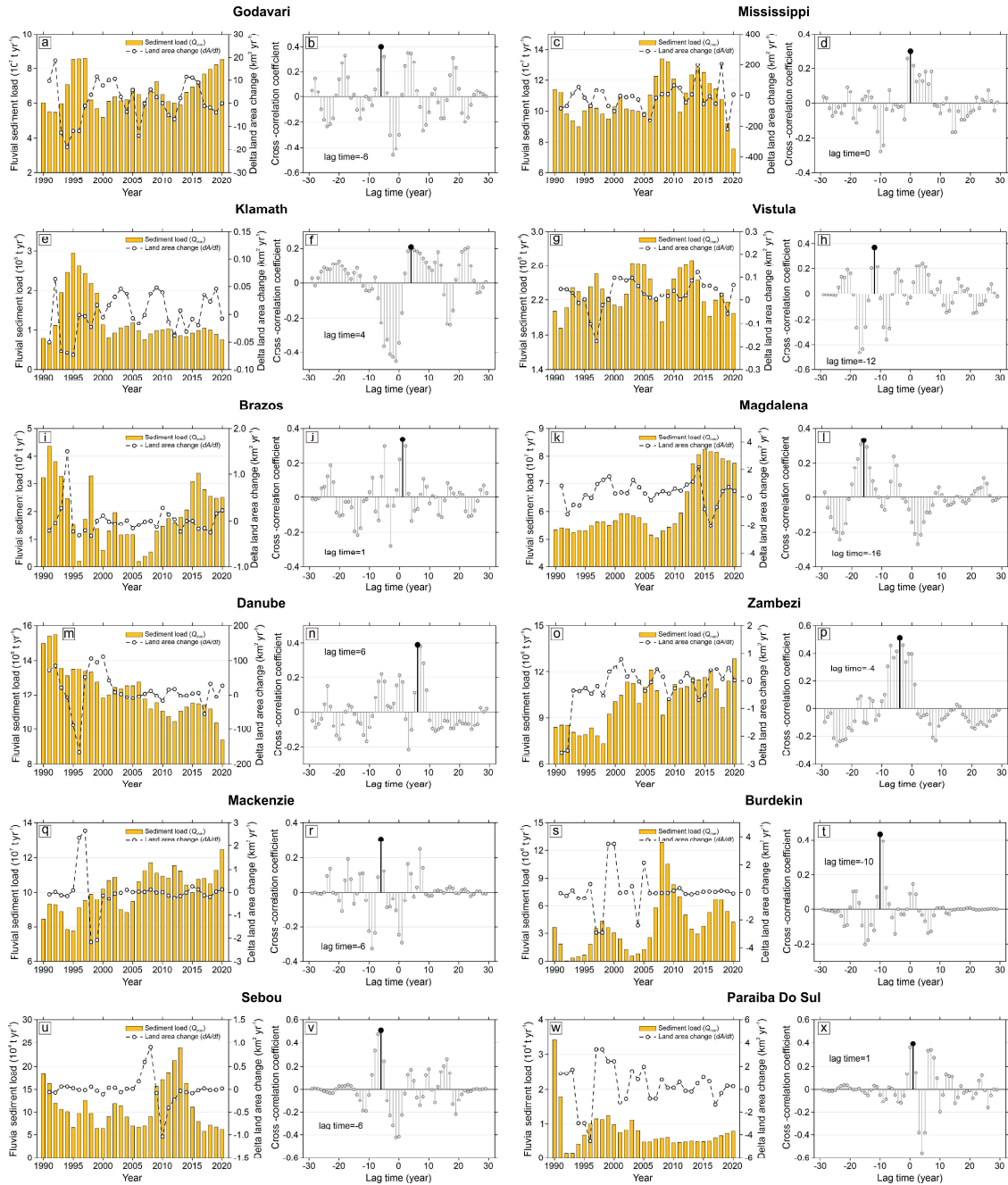
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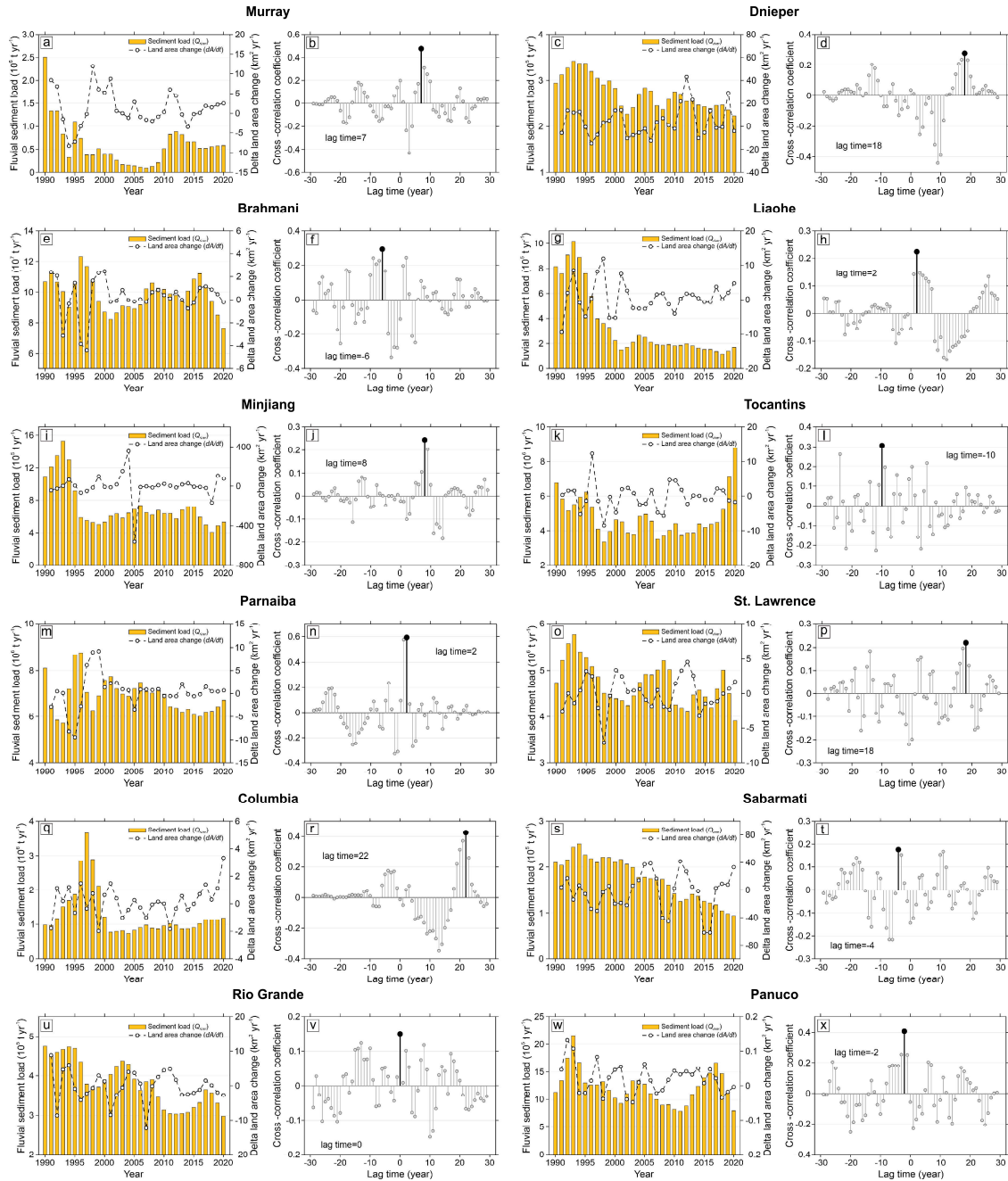


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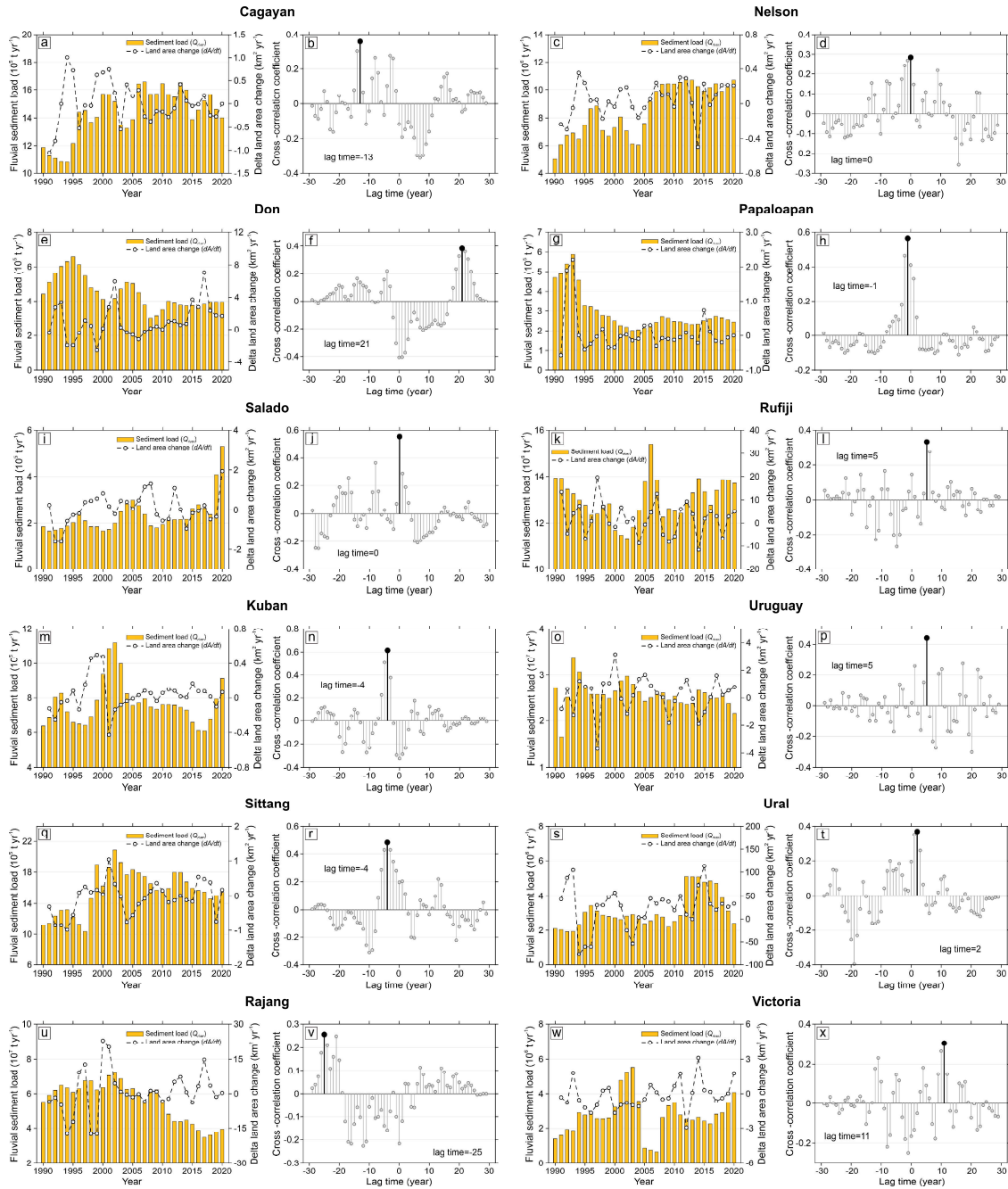


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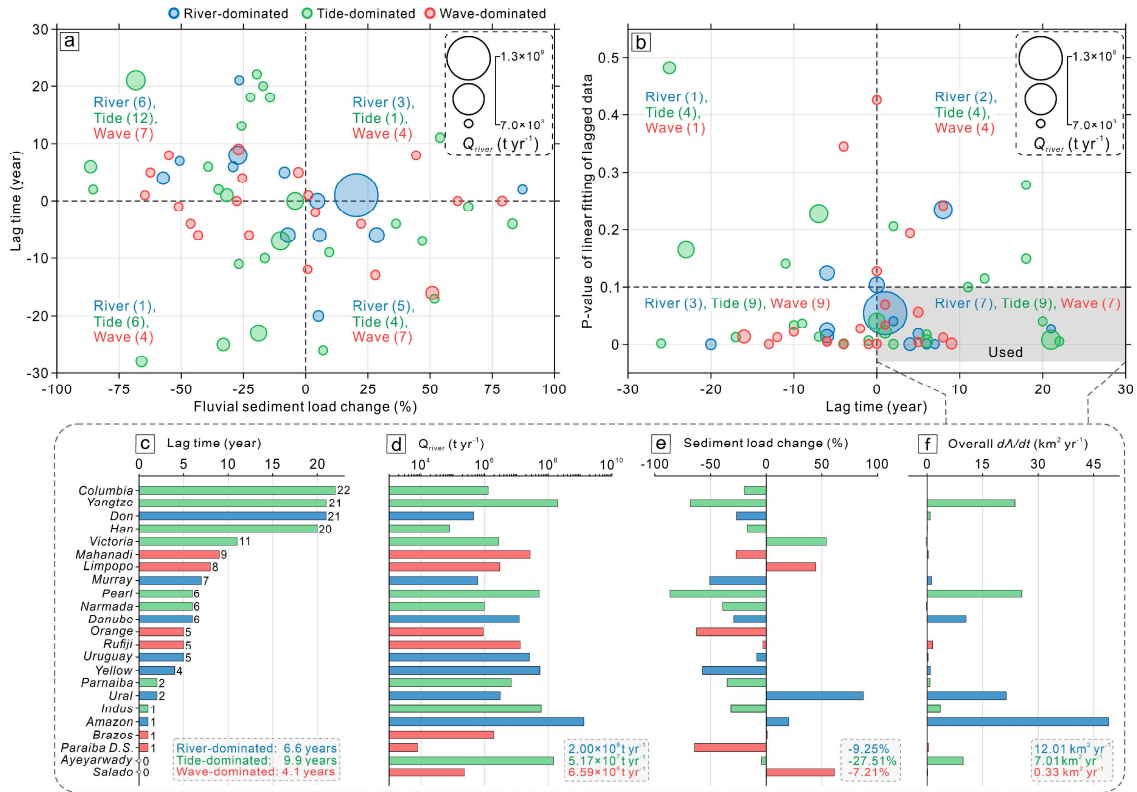
65 **Supplementary Figure 8. Time series and the cross-correlation analyses of annual**
 66 **fluvial sediment loads and delta land change rates in 25-36 individual deltas. (a-b)**
 67 **Godavari Delta; (c-d) Mississippi Delta; (e-f) Klamath Delta; (g-h) Vistula Delta; (i-j)**
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 69 **Mahakam Delta; (s-t) Burdekin Delta; (u-v) Sebou Delta; (w-x) Paraiba Do Sul Delta.**



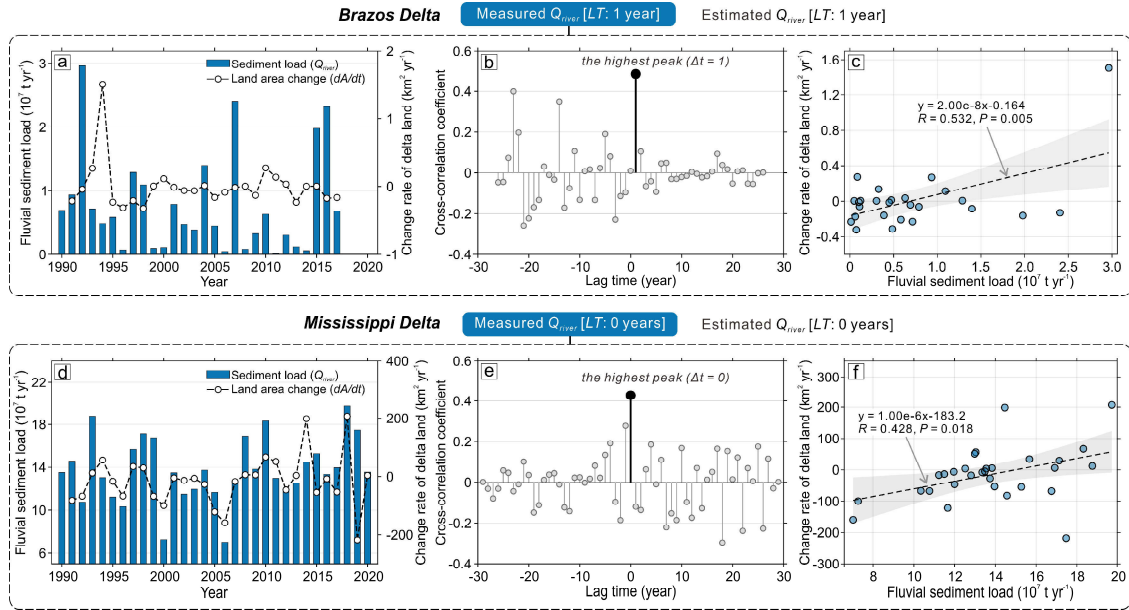
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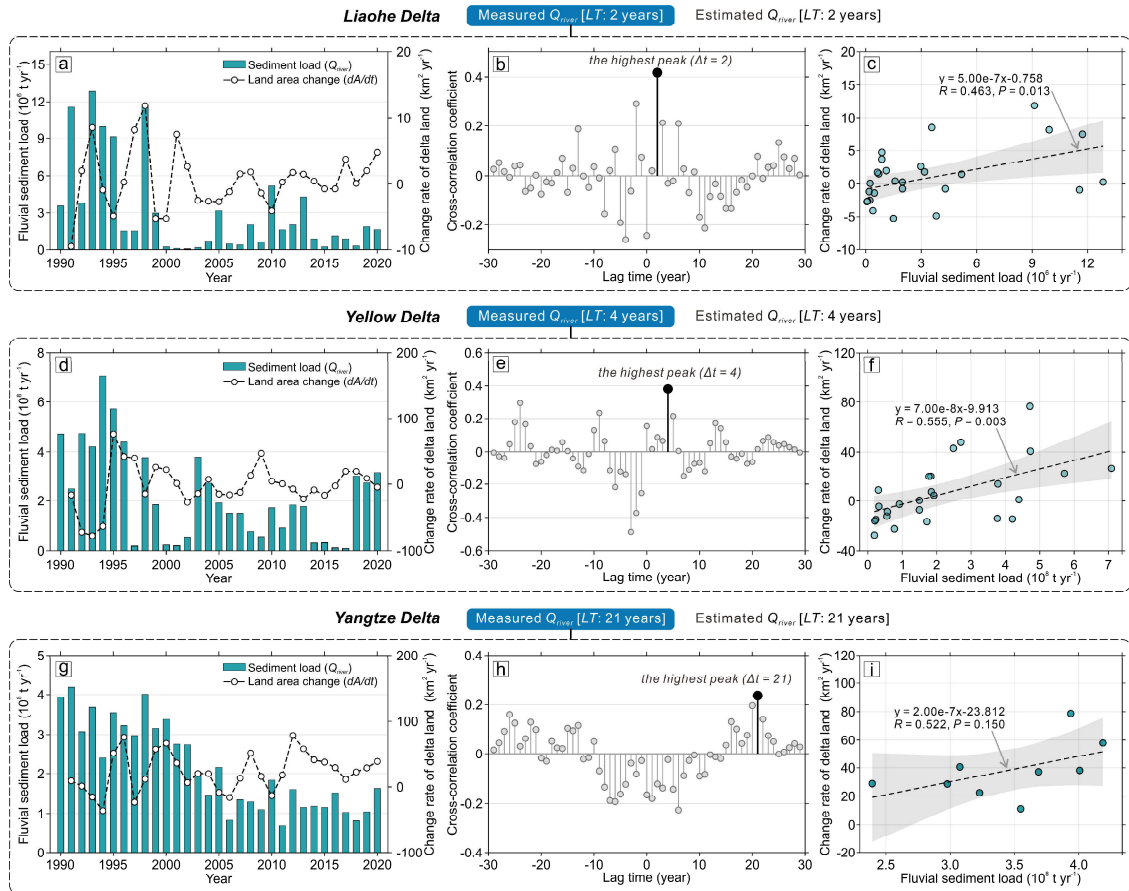
Supplementary Figure 10. Time series and the cross-correlation analyses of annual fluvial sediment loads and delta land area change rates in 49-60 individual deltas. (a-b) Cagayan Delta; (c-d) Nelson Delta; (e-f) Don Delta; (g-h) Papaloapan Delta; (i-j) Salado Delta; (k-l) Rufiji Delta; (m-n) Kuban Delta; (o-p) Uruguay Delta; (q-r) Sittang Delta; (s-t) Ural Delta; (u-v) Rajang Delta; (w-x) Victoria Delta.



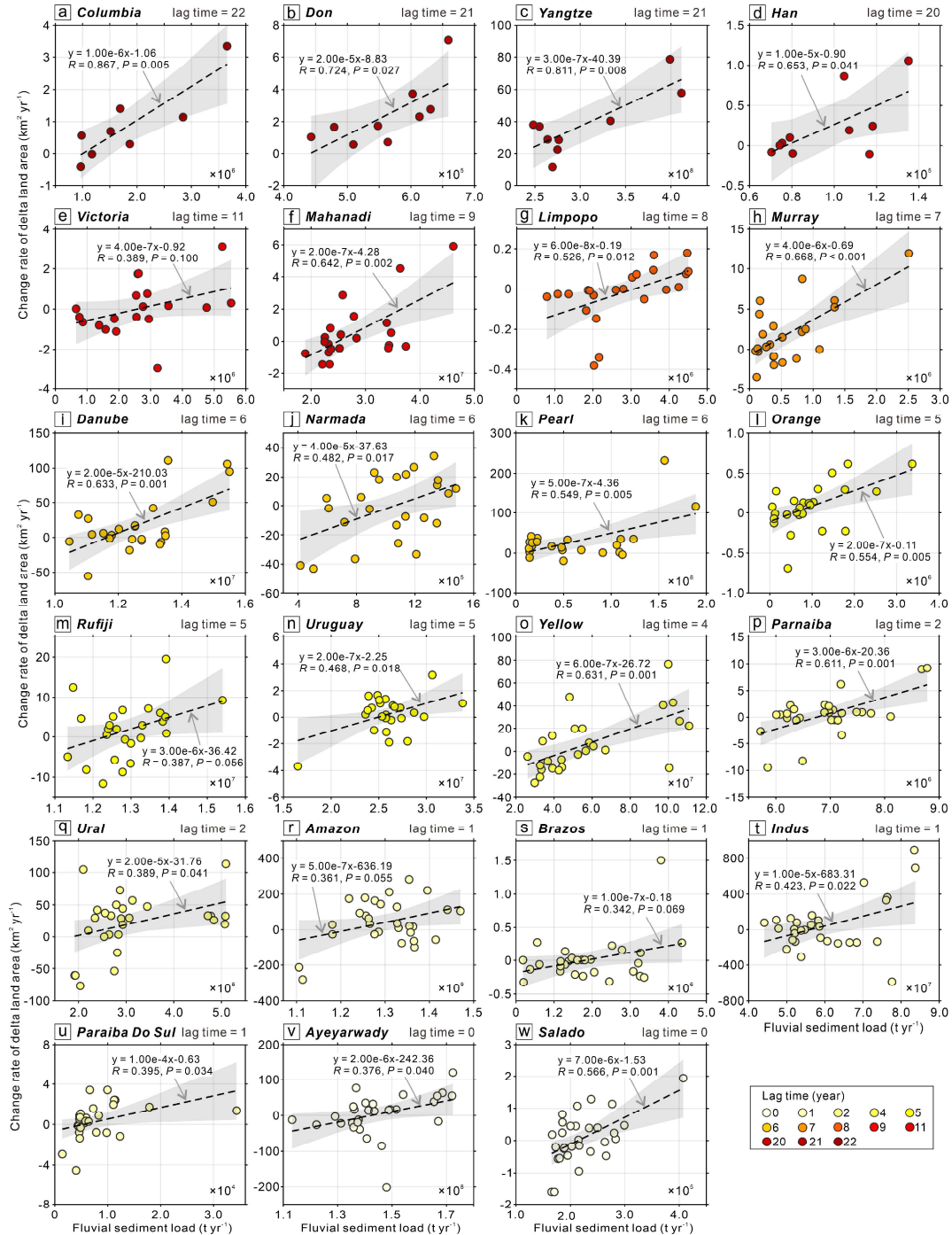
Supplementary Figure 11. Lag times and changes in sediment load and land area of individual deltas. (a) The scatter diagram of fluvial sediment load change versus lag time, three classified deltas (river-, tide-, and wave-dominated) with annual sediment load were shown in different colors and sizes. (b) Scatter diagram of lag time versus the linearly fitted P-value of lagged data for all individual deltas. (c-f) Lag times, annual sediment loads and change proportions, and the overall change rates of delta land area for 23 classified deltas with lag times ≥ 0 and P-values ≤ 0.10 , showing the means.



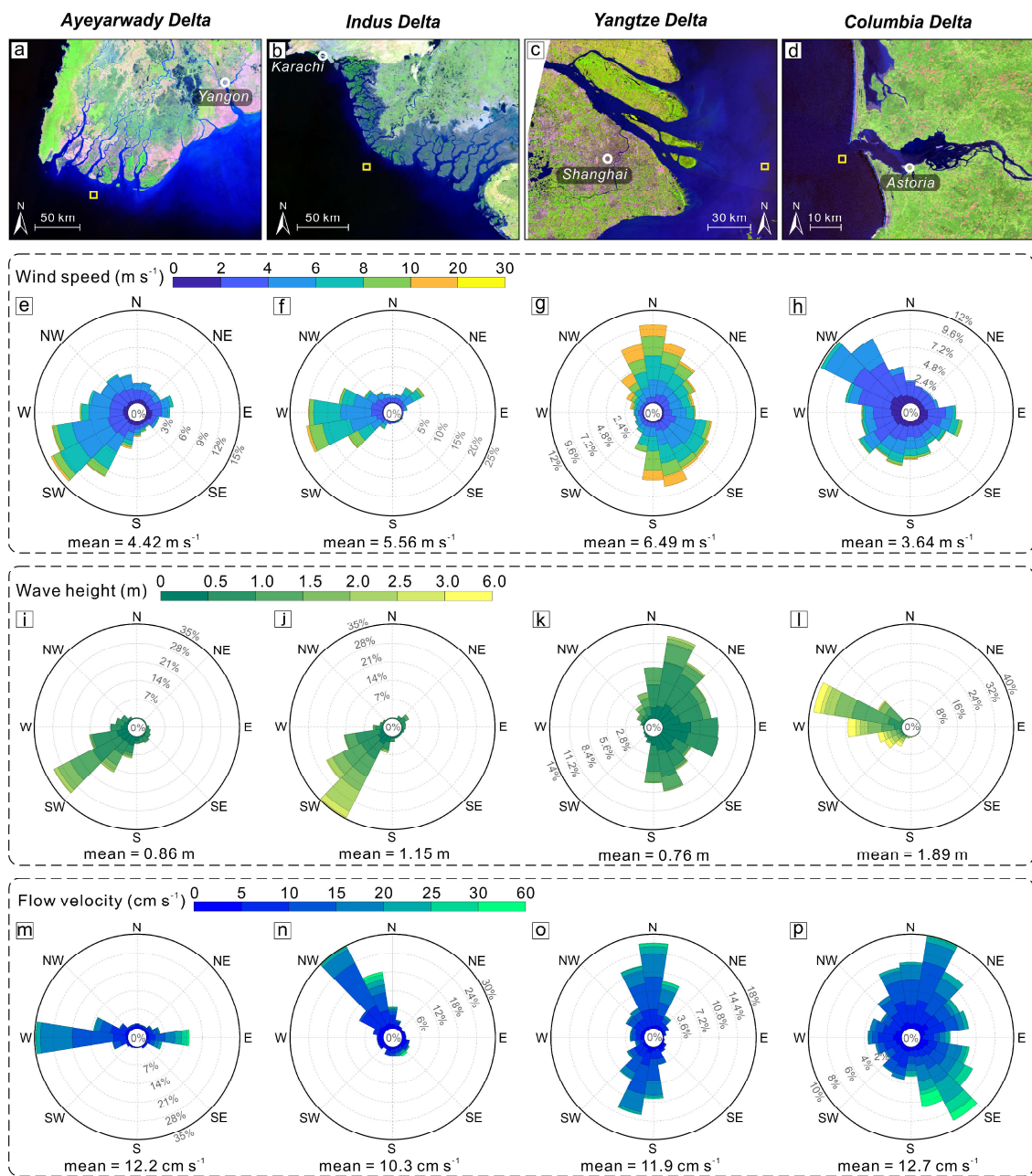
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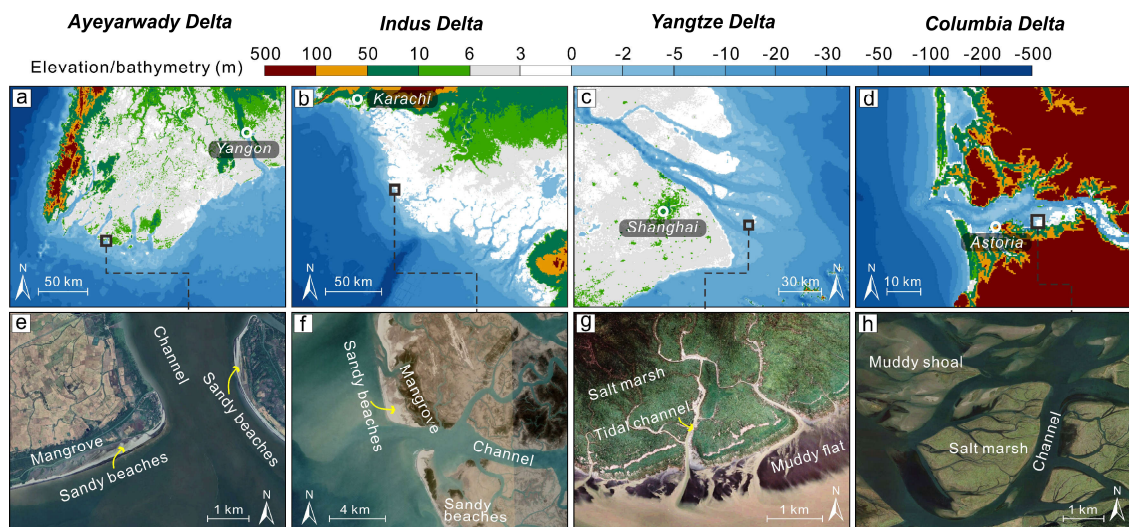
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Supplementary Figure 14. Linear fittings of the lagged fluvial sediment load and land area change rate in 23 individual deltas with significantly correlated lagged data. (a) Columbia Delta; (b) Don Delta; (c) Yangtze Delta; (d) Han Delta; (e) Victoria Delta; (f) Mahanadi Delta; (g) Limpopo Delta; (h) Murray Delta; (h) Danube Delta; (j) Narmada Delta; (k) Pearl Delta; (l) Orange Delta; (m) Rufiji Delta; (n) Uruguay Delta; (o) Yellow Delta; (p) Parnaiba Delta; (q) Ural Delta; (r) Amazon Delta; (s) Brazos Delta; (t) Indus Delta; (u) Paraiba Do Sul Delta; (v) Ayeyarwady Delta; (w) Salado Delta.



Supplementary Figure 15. Plane configurations and hydrodynamic conditions in the Ayeyarwady, Indus, Yangtze, and Columbia Deltas. (a-d) False-color Landsat satellite imagery, (e-h) wind speeds-directions, (i-l) wave heights-directions, and (m-p) offshore flow velocities-directions in 2024.



Supplementary Figure 16. Topography and tidal wetlands in the Ayeyarwady, Indus, Yangtze, and Columbia Deltas. (a-d) Elevations and bathymetries in the subaerial and subaqueous delta, and (e-h) spatial patterns of tidal vegetation and sandy/muddy flats.

Supplementary Table 1. Compilation of names, locations, annual fluvial sediment loads and changes, the overall change rates of delta land, sea-level rise rate, hydrodynamic forcings (river-/tide-/wave-driven sediment fluxes), T, and lag times between 1990-2020 in all studied deltas.

Delta name	Longitude (°)	Latitude (°)	Annual fluvial sediment load in 1990-2020 (t/yr)	Proportion in sediment load change	Overall change rate of delta land (km ² /yr)	Sea-level rise rate (mm/yr)	Q_{river} (kg/s)	Q_{tide} (kg/s)	Q_{wave} (kg/s)	T (Q_{tide}/Q_{river})	Lag time (year)
Amazon	-50.34	0.00	1.306×10^9	20.36%	49.04	2.70	41405.5	35347.3	65.6	0.85	1
Ayeyarwady (Irrawaddy)	94.87	16.06	1.449×10^8	-4.23%	9.71	3.42	4595.0	12827.8	2901.7	2.79	0
Brahmani	86.97	20.78	9.884×10^7	-7.14%	0.17	3.20	3134.3	376.5	16.2	0.12	-6
Brazos	-95.38	28.88	1.948×10^6	1.05%	-0.02	3.17	61.8	11.3	678.4	0.18	1
Burdekin	147.60	-19.64	3.899×10^6	263.61%	0.08	2.71	123.6	53.5	995.7	0.43	-10
Cagayan	121.62	18.37	1.433×10^6	28.00%	0.07	2.12	45.4	251.4	3895.5	5.53	-13
Chao Phraya	100.60	13.53	5.755×10^6	65.34%	0.05	2.99	182.5	820.8	4.8	4.50	-1
Columbia	-123.65	46.23	1.284×10^6	-19.62%	0.00	3.29	40.7	19460.8	92.9	478.14	22
Danube	29.76	45.22	1.224×10^7	-29.16%	10.51	1.79	388.2	41.9	204.3	0.11	6
Dnieper (Dnepr)	32.38	46.53	2.731×10^5	-22.19%	3.74	2.20	8.7	9.8	3.0	1.14	18
Don	39.25	47.09	4.464×10^5	-26.67%	0.79	1.31	14.2	0.9	4.3	0.06	21
Fly	143.30	-8.39	2.280×10^7	5.11%	4.38	1.24	723.1	551.9	689.3	0.76	-20
Ganges- Brahmaputra	90.72	22.69	1.321×10^8	-18.93%	83.14	5.27	4189.7	30715.8	180.6	7.33	-23
Godavari	82.33	16.72	6.733×10^7	5.60%	1.21	3.37	2135.1	560.2	1781.2	0.26	-6
Han	126.71	37.66	7.882×10^4	-17.09%	0.09	2.97	2.5	40.9	0.2	16.35	20
Indus	67.46	24.00	5.999×10^7	-31.67%	3.59	1.92	1902.3	13497.2	3409.3	7.10	1

Klamath	-124.08	41.54	1.264×10 ⁵	-25.47%	0.00	2.81	4.0	5.0	7446.2	1.25	4
Krishna	80.91	15.74	2.758×10 ⁶	-43.22%	1.02	2.35	87.5	509.3	1194.8	5.82	-6
Kuban	37.42	45.35	7.706×10 ⁵	22.27%	0.05	2.44	24.4	1.9	94.2	0.08	-4
Liaohe	121.81	40.87	3.431×10 ⁵	-85.41%	0.46	2.88	10.9	207.2	94.8	19.04	2
Limpopo	33.52	-25.20	2.997×10 ⁶	44.37%	-0.01	2.31	95.0	145.8	2382.8	1.53	8
Mackenzie	-135.16	69.25	1.012×10 ⁸	28.54%	-0.03	4.01	3210.1	153.5	303.8	0.05	-6
Magdalena	-74.84	11.07	6.194×10 ⁷	50.92%	0.43	2.30	1964.2	257.8	8309.5	0.13	-16
Mahanadi	86.36	19.97	2.699×10 ⁷	-27.00%	0.30	3.17	855.7	358.2	3694.5	0.42	9
Mahi	72.56	22.22	3.408×10 ⁵	-25.77%	-5.75	0.43	10.8	286.7	3.0	26.53	13
Mekong	106.25	9.61	1.847×10 ⁸	-10.10%	36.89	2.32	5855.7	61123.6	2627.0	10.44	-7
Minjiang	119.61	26.05	7.215×10 ⁵	-54.97%	-2.81	2.16	22.9	627.5	1763.8	27.43	8
Mississippi	-89.26	29.11	1.076×10 ⁸	4.67%	-15.12	3.96	3411.9	620.2	314.8	0.18	0
Murray	139.34	-35.40	6.002×10 ⁵	-50.66%	1.20	2.73	19.0	15.3	2.0	0.80	7
Narmada	72.61	21.63	9.709×10 ⁵	-39.21%	-0.13	0.43	30.8	1900.7	42.0	61.74	6
Nelson	-92.47	57.07	8.579×10 ⁶	78.96%	0.05	-8.87	272.0	70.7	628.2	0.26	0
Orange	16.46	-28.62	9.044×10 ⁵	-62.38%	0.04	2.11	28.7	5.1	9652.4	0.18	5
Ord	128.21	-15.23	1.103×10 ⁵	-26.88%	-0.14	2.86	3.5	718.8	0.3	205.56	-11
Panuco (Río de Canoas)	-97.78	22.26	1.228×10 ⁶	3.88%	0.02	2.45	38.9	30.9	715.3	0.79	-2
Papaloapan	-95.75	18.79	2.940×10 ⁵	-51.07%	0.02	1.77	9.3	55.2	712.0	5.92	-1
Paraíba Do Sul	-41.01	-21.61	7.772×10 ³	-64.60%	0.38	1.73	0.2	71.7	1407.1	290.92	1
Parana	-58.40	-34.01	1.787×10 ⁸	-27.22%	2.77	2.25	5665.7	281.1	5.5	0.05	8
Parnaíba	-41.79	-2.74	6.884×10 ⁶	-35.03%	0.77	1.95	218.3	2631.2	1188.0	12.05	2
Pearl (Zhujiang)	113.42	22.17	5.154×10 ⁷	-86.44%	25.57	2.55	1634.4	8241.4	426.2	5.04	6

Rajang	111.28	2.45	5.582×10^7	-33.07%	1.08	2.96	1770.0	2327.6	212.1	1.32	-25
Rio Grande	-97.15	25.96	3.823×10^5	-27.67%	-0.35	2.68	12.1	4.6	641.1	0.38	0
Rufiji	39.35	-7.77	1.302×10^7	-2.94%	1.49	2.15	412.8	530.6	1598.7	1.29	5
Sabarmati	72.38	22.32	1.750×10^5	-46.22%	-2.86	1.82	5.6	318.7	2461.1	57.41	-4
Salado	-57.36	-35.75	2.323×10^5	61.06%	0.16	1.28	7.4	135.9	247.4	18.45	0
Sebou	-6.68	34.28	1.122×10^5	-22.73%	0.00	1.73	3.6	567.0	4640.0	159.41	-6
Sittang	96.92	17.12	1.563×10^6	36.29%	-2.31	3.01	49.5	1457.7	4.1	29.42	-4
Song-Hong (Red)	106.58	20.26	3.007×10^7	-65.96%	9.22	2.97	953.7	1827.3	466.3	1.92	-28
St. Lawrence	-71.19	46.81	4.725×10^6	-14.35%	0.09	-2.04	149.8	8619.8	4.2	57.53	18
Sungai Rokan	100.67	2.23	8.830×10^5	46.85%	6.21	2.52	28.0	2116.5	8.4	75.59	-7
Tapi (Tapti)	72.69	21.09	3.696×10^5	7.01%	0.37	1.55	11.7	1177.7	219.2	100.49	-26
Thanlyin (Salween)	97.62	16.50	5.600×10^6	51.75%	1.27	3.01	177.6	2923.3	241.9	16.46	-17
Tigris- Euphrates	48.49	29.92	2.178×10^6	9.49%	-1.02	1.60	69.1	1609.2	79.2	23.30	-9
Tocantins	-49.27	-1.97	4.808×10^6	-16.41%	-0.32	2.61	152.4	11455.2	3.7	75.14	-10
Ural	51.64	46.91	3.123×10^6	87.14%	21.38	-6.72	99.0	0.1	4.7	0.00	2
Uruguay	-58.15	-33.08	2.578×10^7	-8.51%	0.24	2.26	817.3	38.3	2.9	0.05	5
Victoria	129.93	-15.44	2.753×10^6	53.98%	-0.26	3.13	87.3	5971.4	3.5	68.39	11
Vistula (Wisla)	18.95	54.36	2.301×10^5	0.80%	0.03	0.43	7.3	1.1	825.2	0.16	-12
Yangtze (Changjiang)	121.36	31.57	1.967×10^8	-68.25%	23.72	1.66	6238.1	200201.1	65.0	32.09	21
Yellow (Huanghe)	119.24	37.80	5.432×10^7	-57.26%	0.86	2.05	1722.6	515.6	307.3	0.30	4
Zambezi	36.26	-18.80	1.009×10^7	83.12%	-0.05	2.00	320.1	9269.9	2318.2	28.96	-4

Supplementary Table 2. Comparison of calculated lag times in 6 deltas using estimated and in-situ measured fluvial sediment load.

Delta name	Calculated lag time using estimated Q_{river} form <i>Dethier et al. 2022</i>	Calculated lag time using in-situ measured Q_{river}
Brazos	1	1
Mississippi	0	0
Liaohe	2	2
Yellow (Huanghe)	4	4
Yangtze (Changjiang)	21	21

127 **Supplementary Table 3. Changes in annual total fluvial sediment load and active land**
128 **in all deltas for six stages between 1990 and 2020.**

Stage	Annual total sediment load (t/yr)	Change in fluvial sediment load (compared to Stage I)	Change in active delta land (compared to Stage I)
I (1990-1995)	3.217×10^9	\	\
II (1996-2000)	3.121×10^9	-3.0%	0.00‰
III (2001-2005)	3.020×10^9	-6.1%	1.98‰
IV (2006-2010)	2.845×10^9	-11.6%	0.03‰
V (2011-2015)	2.912×10^9	-9.5%	0.55‰
VI (2016-2020)	2.918×10^9	-9.3%	0.49‰

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