nature portfolio

Peer Review File

Response time of global deltas to changes in fluvial sediment supply

Corresponding Author: Professor Zhijun Dai

This file contains all reviewer reports in order by version, followed by all author rebuttals in order by version.

Version 0:

Reviewer comments:

Reviewer #1

(Remarks to the Author)
This paper is quite interesting because it discusses time lags in the response of the world's major deltas to changes in fluvial sediment supply. This paper will contribute to our better understanding of the delta's landform and its response to rapid environmental change induced by human activities.

My major concerns are as follows.

Only 23 of the 60 deltas taken in the study had lag times longer than 0 years and P-values less than 0.10 (Fig. S10), so it is questionable whether the results obtained are reliable or not. Of the data used, the delta area change seems to be probably less problematic, but the estimation of fluvial sediment supply at a delta apex based on Dethier et al. 2022 might have significant problems.

Figure 4 shows that Irrawaddy and Indus rivers have very short lag times of 0 and 1 year, respectively, despite the relatively strong tidal influence. Is it correct to assume that this is because fluvial sediment supply is more effective in these rivers, unlike the Yangtze and Columbia rivers in the lower right of the ternary diagram?

Lines 155–157 (the overall net growth rate of delta land has slowed ...)
Since deltas typically prograde deeper seaward and the area to be filled is larger, isn't it normal for deltas to slowly expand over time without any change in fluvial sediment input?

Other minor comments are listed below.

Line 191 (Supplementary Fig. 4A)
"Supplementary" may be unnecessary.

Figure 4 etc. (Irrawaddy)
Ayeyarwady may be a better choice for Irrawaddy.

Supplementary Fig. S10
Zhujiang should be labeled as Pearl as in Fig. 4.

Reviewer #2

(Remarks to the Author)
Reviewed by Brad Murray

This manuscript presents interesting, timely, and societally relevant results. The analyses are solid, the conclusions warranted, and the discussion is thoughtful and illuminating. I think with relatively straightforward revisions this will be appropriate for publication in this journal. Below I offer two comments about how the presentation should, in my estimation, be revised. And I will attach a pdf with a number of minor suggested edits.

The main and most substantive change I think need to be made is to expand the conceptual model presented in the Introduction to include sea-level rise. Presently, the conceptual model has the rate of change of delta area being proportional to fluvial sediment flux to the delta. This is the simplest model. However, a slightly more complicated model would make the results easier to interpret, especially for a broad audience. The alternative (well accepted) model applies when sea-level rise is considered. In this model, delta area can reach a steady state in which the fluvial sediment flux to (and retained on) the delta allows the delta, at that area, to keep up with sea-level rise. In this case, the rate of change of delta area is proportional to changes in fluvial sediment flux, and both quantities can be negative. This conceptual framework makes it easier to understand the shrinking deltas (where fluvial sediment flux has decreased), while a shrinking delta doesn't fit naturally into the present conceptual model (without sea-level rise). All of the correlation analyses and results remain unaffected by this change in conceptual model, so all that is required is to rewrite the introduction and look through the paper to change all related statements.

My second comment involves the distinction between finding a time lag using the globally aggregated data, versus analyzing the lag for each delta individually (and then summarizing/averaging those results). The latter seems more meaningful, giving the widely variable types of delta, and associated mechanisms and lags. The results (and discussion) of the two approaches should be separated more completely, to increase clarity. In addition, it would be useful to explain early in the paper (e.g. the Introduction) why the globally aggregated analysis was done. Until I reached the statement in the final section that explained that the time lag as easier to identify when using globally aggregated data, I wondered whether it was worth including in the main body of the paper.

Version 1:

Reviewer comments:

Reviewer #1

(Remarks to the Author)
The manuscript has been appropriately revised in response to the reviewers' comments.
The overall argument has become clearer.

A minor error still appears to remain, as described below.
The captions for Figure 3 (D–F) and (G–I) do not seem to correspond correctly to the figures; it appears that they might be reversed.
For example:
Line 211:
24 deltas with increased ... → Is this "36 deltas with decreased ..." ?

Line 214:
36 deltas with decreased ... → Is this "24 deltas with increased ..." ?

Reviewer #2

(Remarks to the Author)
re-review of 'Response time of global deltas...'

re-reviewed by Brad Murray

Thank you to the authors for responding thoroughly to my comments and suggestions. The paper is ready for publication, from my point of view.

I did, however, notice one place where the text needs to be changed to correct the grammar: The sentence "Rather than first analyzing the lag times of 60
396 individual deltas and then averaging these results to achieve the delayed time." can not stand by itself. (I suspect it had been connected to the previous sentence by a comma, which would make it work grammatically--though it would make the sentence quite long, of course.)

Reviewers' or editors' comments are in black font, responses are in blue.

Previous manuscript ID: NCOMMS-24-70742

Title: Response time of global deltas to changes in fluvial sediment supply

Reviewer #1 (Remarks to the Author):

This paper is quite interesting because it discusses time lags in the response of the world's major deltas to changes in fluvial sediment supply. This paper will contribute to our better understanding of the delta's landform and its response to rapid environmental change induced by human activities.

My major concerns are as follows.

1. Only 23 of the 60 deltas taken in the study had lag times longer than 0 years and P-values less than 0.10 (Fig. S10), so it is questionable whether the results obtained are reliable or not. Of the data used, the delta area change seems to be probably less problematic, but the estimation of fluvial sediment supply at a delta apex based on *Dethier et al. 2022* might have significant problems.

***Response*:** We highly appreciate your insightful and constructive comments.

i)* Data availability from *Dethier et al., 2022: Based on long time-series Landsat satellite imagery and more than 130,000 ground in-situ measurements, *Dethier et al. (2022)* estimated the pixel-level suspended sediment concentrations (SSCs) for 414 major global rivers. Then, the monthly suspended sediment flux (Q_{river}) was calculated by multiplying the monthly mean riverine flow discharge at downstream monitoring stations adjacent to the delta. On the global scale, the estimated annual Q_{river} was highly consistent with the in-situ measured Q_{river} published by *Milliman & Farnsworth (2013)*; the existing errors are not systematic (*Dethier et al., 2022*). Specifically, in the typical three mega-rivers with robust observational records, i.e., the Mississippi, Yangtze (Changjiang), and Pearl (Zhujiang) rivers, the estimated Q_{river} and measured Q_{river} hold similar magnitudes and tendencies between 1984 and 2020, with a difference of cumulative Q_{river} of 6%, 4%, and 11%, respectively (Figure R1). Thus, we compiled the estimated annual Q_{river} to examine the lagged time of delta land change rate (dA/dt) to fluctuations in fluvial sediment supply in 60 river deltas.

***ii)* Results reliability:** To re-verify the effectiveness of calculated delta-scale lag times, we additionally collected the in-situ measured Q_{river} in five rivers with better observational records. These include two rivers in the USA, i.e., the Brazos and Mississippi rivers, and three rivers in China, i.e., the Liaohe, Yellow, and Yangtze rivers. Water and sediment discharges in the above five rivers of the two countries are officially recorded and released by the *United States Geological Survey* and the *Ministry of Water Resources of China*, respectively. These validations and comparisons of lag times in the above five rivers were supplemented as new Supplementary Fig. S12-S13 and Supplementary Table S3 in the revised version.

First, in the Brazos and Mississippi deltas, the lag times calculated using measured Q_{river} were 1 and 0 years, respectively, and the corresponding P-values for linear fitting of the lagged Q_{river} and dA/dt are 0.005 and 0.018 (Supplementary Fig. S12). So, the newly calculated lag years are the same as those results using the estimated Q_{river} (Supplementary Table S3). ***Second***, land growth rate changes in the Liaohe, Yellow, and Yangtze deltas, recalculated based on measured Q_{river}, also respond to the fluctuations in Q_{river} with a time lag of 2, 4, and 21 years, respectively; the lagged data are linearly correlated (Supplementary Fig. S13 and Supplementary Table S3), indicating the reliability of estimated Q_{river} from *Dethier et al. (2022)*.

iii)* Uncertainty of calculated lag times: *First, the remote sensing-based estimate of Q_{river} is strongly influenced by the satellite revisit period, cloud cover and cloud shading, and the accuracy of using riverine flow discharge, although this released dataset was carefully tested/validated. In particular, most downstream monitoring stations are some distance away from the delta (Table R1). Sediment deposition or replenishment along downstream reaches will affect the actual Q_{river}. Meanwhile, *Dethier et al. (2022)* scaled the flow discharge by watershed area to compensate for underestimation, which may lead to potential errors. ***Second***, regarding the delta land change rate, limited by the spatial resolution of the Landsat imagery of 30 m, in some deltas with small-scale or weakly dynamic changes, this may not properly capture the land area change process between 1990 and 2020. ***Third***, the response behavior of land area change to fluctuations in fluvial sediment inputs in different deltas is complex and variable. Your subsequent comments also raise concerns about this. For instance, the lag times of the four deltas, i.e., the Ayeyarwady, Indus, Yangtze, and Columbia deltas, show large differences in Figure 4B, even though they are all distributed at the stronger tide-dominated end, with a calculated lag time of 0, 1, 21, and 22 years, respectively. Hence, in the deltas with stronger winds, waves, and alongshore currents, delta land growth rates are not solely controlled by upstream sediment loads. In addition, the eco-geomorphic feedback on sediment trapping by salt marshes, the flooding tides can landward transport sediment, and strong waves will increase the net sediment export from the delta, which would disturb the $\frac{dA}{dt} \propto Q_{river}$ relationship to some extent. ***Therefore***, the above reasons can mostly account for why only 23 of the 60 studied deltas exhibited lag times longer than 0 years and P-values ≤ 0.10 in our study, as you indicated here.

iv) Your constructive comments provide very important insights for future studies of the hydro-morphodynamic response of more deltas. ***Therefore***, in the revised **Introduction, Results 2.3** and **Discussion 3.3** sections, we have supplemented the comparison of the two methods and discussion of the uncertainty in calculating the lag time, which may result from using an over- or under-estimated Q_{river} (See tracked version, Line 153-156, 246-252, and 407-426). In addition, in the revised **Methods 4.1**, we added the global consistency and difference of cumulative Q_{river}

in three rivers (the Mississippi, Yangtze, and Pearl rivers) with robust observational records (See tracked version, Line 464-469).

As: *"In addition, to verify the effectiveness of the analyzed delta-scale lag times, we have recalculated lag times using in-situ measured* Q_{river} *with better observational records in five rivers (Brazos, Mississippi, Liaohe, Yellow, and Yangtze) and found identical results (Supplementary Table S3)."* (See tracked version, Line 153-156)

As: *"The average lag time across all deltas is 2.9 years. But, this average includes some deltas where the lag time is negative (and therefore unphysical) and some are not statistically significant (*$P > 0.10$*) (Supplementary Fig. S6-S13). For the remaining 23 deltas with positive lag times and P-value of the lagged data* ≤ 0.10*, we find an average lag time of 6.8 years, similar to the results (i.e., 6 years) when using the globally aggregated data. Lag times varied between 0 and 22 years (Fig. 4A; Supplementary Table S1)."* (See tracked version, Line 246-252)

As: *"There is uncertainty in the estimates of time lags. First, the annual fluvial sediment load used was obtained from Dethier et al. (2022). Their Landsat-obtained surface sediment flux trends might differ from those further down in the water column, especially in some river reaches with strong (tidal) circulation. Second, gaps in the original monthly flow discharges were filled with different time-running windows to generate time series of the discharge, which may be limited by low data availability (Dethier et al., 2022). Third, most downstream hydrologic monitoring stations are still some distance away from the delta, in these areas, this study partly scaled the flow discharge by watershed area to compensate for underestimation. Therefore, there remains a large gap in fully developing an evaluation of the replenishment of suspended/bed sediment along the downstream reaches and tidal rivers (McManus, 2002; Kondolf et al., 2014; Dai et al., 2018; Hoitink et al., 2020). Despite these uncertainties, a comparison of time lag calculations using in-situ data gave identical results (Supplementary Fig. S12-S13 and Table S3). Concerning delta area change, these data are limited by satellite* *revisit periods, cloud cover, cloud shadows, and spatial resolution of Landsat satellite observations, leading to possible errors and underestimates/overestimates at the individual delta scale (Pekel et al., 2016; McCabe et al., 2017; Nienhuis et al., 2020; Almar et al., 2023). These offsets/errors may pose some uncertainties for lagged responses and time scales between Q_{river} and dA/dt in individual deltas in our study, which may lead to negative lag times (15 of 60 deltas) and weak correlations (Supplementary Fig. S11 and Table S1).”* (See tracked version, Line 407-426)

As: *“Satellite-based estimated annual sediment load (Q_{river}) in this dataset showed high global consistency with in-situ measured records; the potential errors are not systematic (Dethier et al., 2022). For instance, in three mega rivers with well-observed records, i.e., the Mississippi, Yangtze, and Pearl Rivers, the overall differences in cumulative Q_{river} in 1984-2020 were 6%, 4%, and 11%, respectively. Therefore, the estimated Q_{river} can provide important insights into the geophysical changes of modern river deltas.”* (See tracked version, Line 464-469)

References

Dethier, E. N., Renshaw, C. E., & Magilligan, F. J. (2022). Rapid changes to global river suspended sediment flux by humans. Science, 376(6600), 1447-1452.

Milliman, J. D., & Farnsworth, K. L. (2013). River discharge to the coastal ocean: a global synthesis. Cambridge University Press.

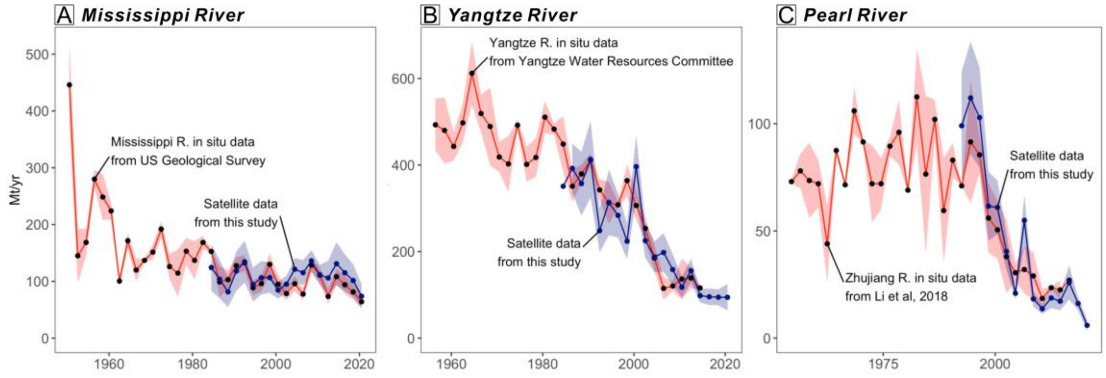
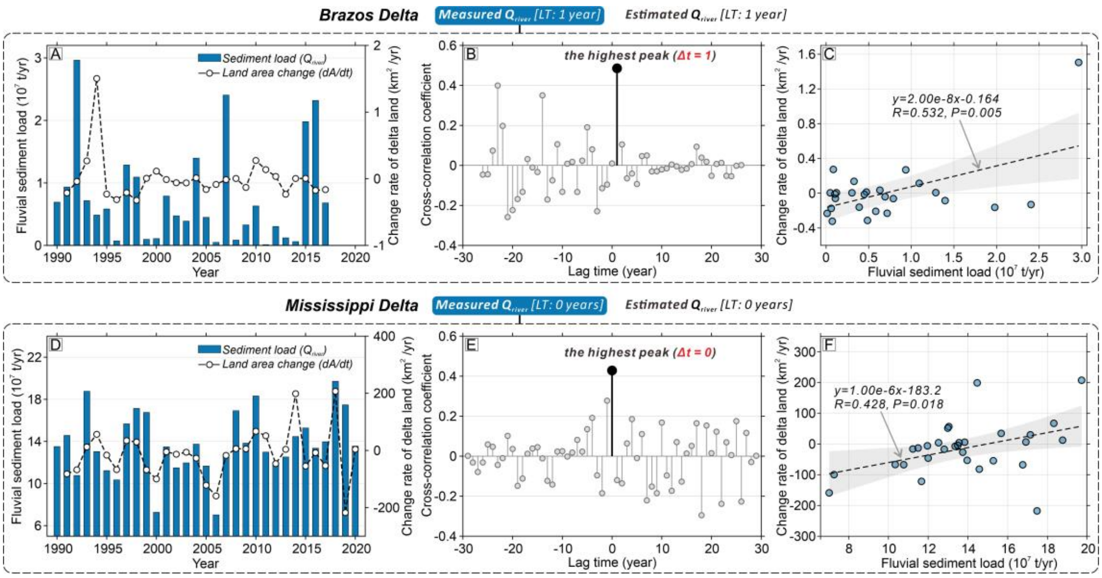
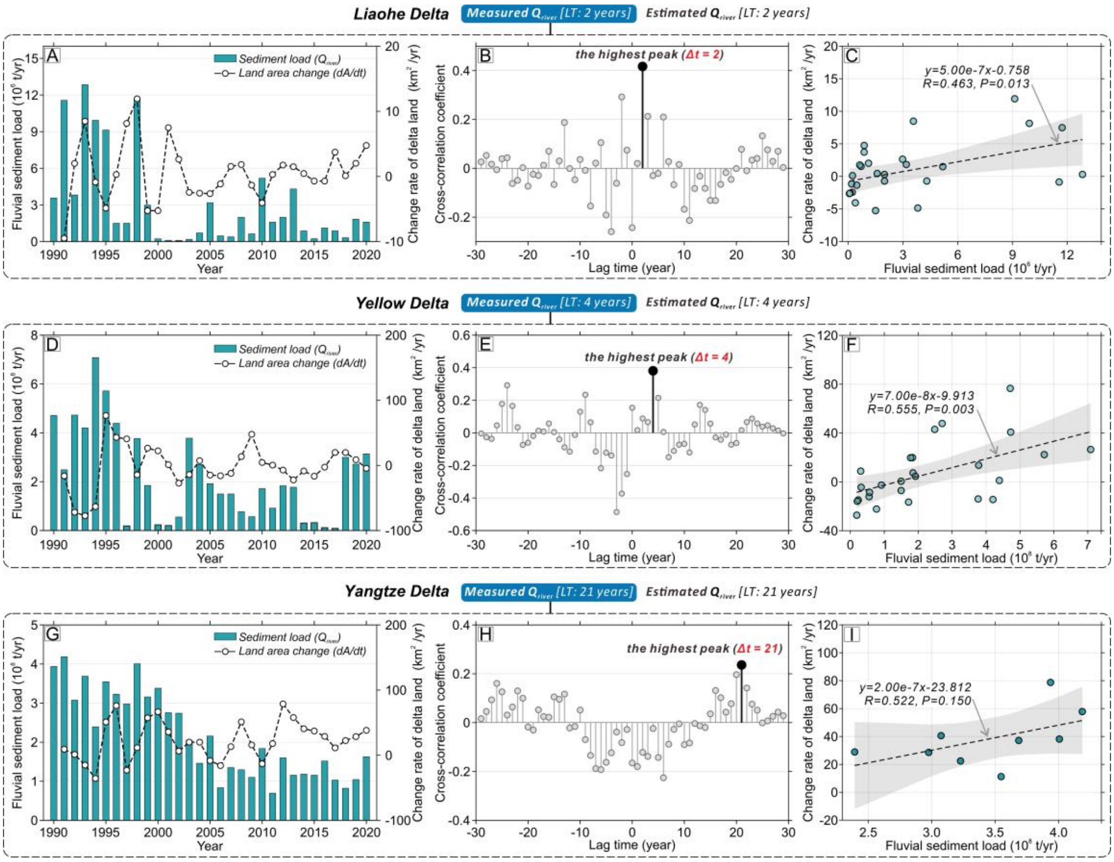


Fig. R1. Comparison of satellite-estimated and measured annual fluvial suspended sediment loads in three rivers with robust observational records, in the (A) Mississippi, (B) Yangtze (Changjiang), and (C) Pearl (Zhujiang) Rivers. (This figure was quoted from Supplementary Figure S8 in *Dethier et al. (2022)*).



Supplementary Fig. S12. Cross-correlation analyses using measured Q_{river} of two deltas in the USA. (A-C) Time series of the measured Q_{river} and land area change rate (*dA/dt*) and linear correlation between the lagged data in the Brazos Delta, the primary lag time is 1 year. (D-F) Time series of the measured Q_{river} and *dA/dt* and linear correlation between the lagged data in the Mississippi Delta, the primary lag time is 0 years.



Supplementary Fig. S13. Cross-correlation analyses using measured Q_{river} of three deltas in China. Time series of the measured Q_{river} and land area change rate (dA/dt) in the Liaohe, Yellow (Huanghe), and Yangtze (Changjiang) Deltas, the primary lag times are 2, 4, and 21 years, respectively, which are the same as the results using satellite-estimated Q_{river}.

Supplementary Table S3. Comparison of calculated lag times in 6 deltas using estimated and in-situ measured Q_{river}.

Delta name	Calculated lag time using estimated Q_{river} form *Dethier et al. 2022*	Calculated lag time using in-situ measured Q_{river}
Brazos	1	1
Mississippi	0	0
Liaohe	2	2
Yellow	4	4
Yangtze	21	21

Table R1. Global large rivers with their farthest downstream gauging stations.

Delta name	The farthest downstream station	Lat (°)	Lon (°)	Distance to the delta (km)
Amazon	Obidos	-1.95	-55.5	900
Ayeyarwady	Seiktha	18.53	95.07	363
Columbia	The Dalles	45.6	-121.17	304
Danube	Ceatal Izmail	45.33	28.8	94
Fly	Everill Junction	-7.58	141.39	380
Ganges-Brahmaputra	Mawa	23.26	90.19	300
Indus	Kotri	25.22	68.22	200
Magdalena	Calamar	10.25	-74.91	112
Mekong	Kratie	12.47	106.02	558
Mississippi	Baton Rouge	30.45	-91.19	450
Niger	Onitsha	6.15	6.77	220
Parana	Corrientes	-27.97	-58.85	550
Pearl	Gaoyao	22.95	112.07	167
St. Lawrence	Port St. Francois	46.28	-72.61	139
Tocantins	Maraba	-5.37	-49.12	392
Yangtze	Datong	30.8	117.6	600
Yellow	Lijin	37.48	118.27	94
Zambezi	Tete	-16.15	33.59	308

2. Figure 4 shows that Irrawaddy and Indus rivers have very short lag times of 0 and 1 year, respectively, despite the relatively strong tidal influence. Is it correct to assume that this is because fluvial sediment supply is more effective in these rivers, unlike the Yangtze and Columbia rivers in the lower right of the ternary diagram?

Response**:** We sincerely appreciate your incisive comments. The calculated lag time in the Ayeyarwady and Indus deltas are 0 and 1 year, respectively, although they are distributed in the lower right corner of the ternary diagram (Fig.4B) with stronger tidal dominance. They differ significantly from the Yangtze and Columbia deltas. We suggest the following reasons related to sediment retention efficiency that led to this variability and have added discussion in the revised **Discussion 3.3**.

i) **In the inner delta channel**: Compared to the Yangtze and Columbia deltas, the upper channels of the Ayeyarwady and Indus deltas are dominated by stronger river forcing, developing complicated bifurcated configurations. Extensive salt marshes and mangroves grow in deltaic plains and tidal flats. Part of the upstream input of fine-grained sediment will be trapped and deposited in/adjacent to dense vegetation stems and leaves (Supplementary Fig. S15A-A15D, Fig. S16A-S16H). Therefore, the changes in delta land growth rate are sensitive to upstream sediment inputs.

ii) **In the offshore area**: The prevailing wind and wave climates outside of the four deltas also affect the sediment budget and morphodynamics around the coastlines. Wave climate in the Ayeyarwady and Indus deltas is largely controlled by the southwest monsoon (Supplementary Fig. S15E-S15F and S15I-S15J). The satellite imagery shows the coarse-grained sediments accumulated along the delta margins and shaped the straight sandy shorelines, confirming that fine-grained sediments are removed from the outer delta by strong wind waves (Supplementary Fig. S16A-S16B and S16E-S16F) (Syvitski et al., 2013; Chen et al., 2020). Such hydrological conditions are not conducive to sediment retention along the open coasts. In other words, accretion and retreat of the shorelines are highly correlated with fluctuations in the amount of upstream sediment input. However, in the Yangtze Delta, large amounts of fine-grained sediment input from river accumulate in the deltaic areas, developing wide salt marshes and muddy flats, which can capture more terrestrial sediment (Supplementary Fig. S16C and S16G) (Lou et al., 2022; Wang et al., 2024). In the Columbia Delta, the larger-scale low-lying shoals and tidal wetlands are distributed within the sheltered areas, capturing most of the fluvial sediments (Supplementary Fig. S16D and S16H) (Gelfenbaum and Kaminsky, 2010).

iii) **Subaqueous topographic condition**: The subaqueous topographic slope in the offshore Ayeyarwady and Indus deltas is steeper, and there are strong and single directionally dominant alongshore tidal currents (Supplementary Fig. S15M-S15N and S16A-S16B). Such hydrodynamic and topographic conditions can exacerbate sediment removal from the delta, reducing the overall sediment retention efficiency (Kuehl et al., 2019). In contrast, the subaqueous bar developed in the Yangtze Delta, and sand spit formed outside the Columbia Delta, promoting the sedimentation rate of fluvial sediments within the delta channel and tidal wetlands (Supplementary Fig. S16C-S16D). During low runoff periods, intense waves-tides can erode more marine-sourced sediments from the delta front and then transport landward, which can mitigate the net sediment output during high runoff (Wang et al., 2022).

Therefore, the sediment retention efficiency in the Yangtze and Columbia deltas is higher than that of the Ayeyarwady and Indus deltas. As a result, the land growth rate in the first two deltas responded more slowly to fluctuations in fluvial sediment supply, while the latter two deltas had shorter lag times. In the revised manuscript, we have fully addressed the above issues and added some texts in **Discussion 3.2** to discuss the lag times variability among different river deltas (See tracked version, Line 388-405).

As: *"Moreover, sediment retention in delta plain is also highly variable, which will also affect delta response lag times (Goodbred & Saito, 2011; Hoitink et al., 2020; Törnqvist et al., 2020). Deltas that retain a large fraction of their supply could act as a buffer, such that delta land changes do not respond immediately to the short-*

term fluctuations in fluvial sediment supply (Tessler et al., 2018). For example, the long time lag of 21 years in the Yangtze Delta may have been caused by extensive tidal wetlands and mouth bars (Yang et al., 2020; Lou et al., 2022; Mei et al., 2023; Wang et al., 2024) (Supplementary Fig. S11, S15-S16, Supplementary Table S1). Similarly, sheltered by sand spits on either side in the Columbia Delta, fluvial sediment trapping is more efficient in the low-lying shoals and salt marshes, thus, we detected a longer lag time of up to 22 years (Supplementary Fig. S15-S16) (Gelfenbaum & Kaminsky, 2010). In contrast, in the Ayeyarwady and Indus deltas, strong prevailing winds, waves, and alongshore currents exacerbate coastal land erosion and net sediment loss, thereby forming smoothed and coarse-grained sandy beaches, even though some of the riverine sediment inputs can accumulate within the inner delta channels and wetlands (Supplementary Fig. S15-S16) (Syvitski et al., 2013; Kuehl et al., 2019). Such low sediment retention efficiencies could have enabled the land area changes in both deltas to respond rapidly to fluctuations in upstream sediment supply, lagging 0 and 1 year, respectively (Supplementary Table S1).” (See tracked version, Line 388-405)

References

Chen, D., Li, X., Saito, Y., Liu, J. P., Duan, Y., & Zhang, L. (2020). Recent evolution of the Irrawaddy (Ayeyarwady) Delta and the impacts of anthropogenic activities: A review and remote sensing survey. Geomorphology, 365, 107231.

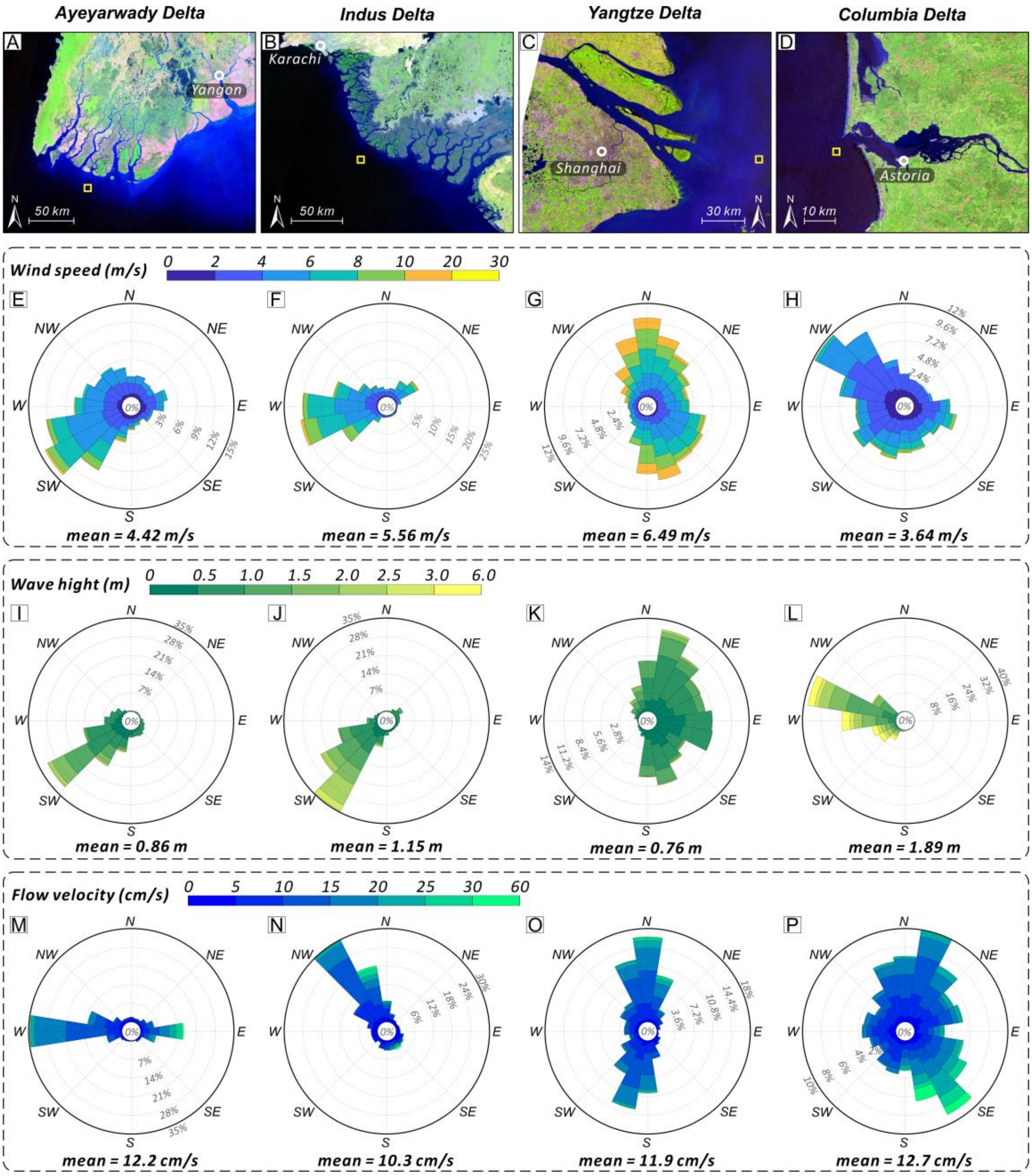
Gelfenbaum, G., & Kaminsky, G. M. (2010). Large-scale coastal change in the Columbia River littoral cell: An overview. Marine Geology, 273(1-4), 1-10.

Kuehl, S. A., Williams, J., Liu, J. P., Harris, C., Aung, D. W., Tarpley, D., Goodwyn, M., & Aye, Y. Y. (2019). Sediment dispersal and accumulation off the Ayeyarwady delta–Tectonic and oceanographic controls. Marine Geology, 417, 106000.

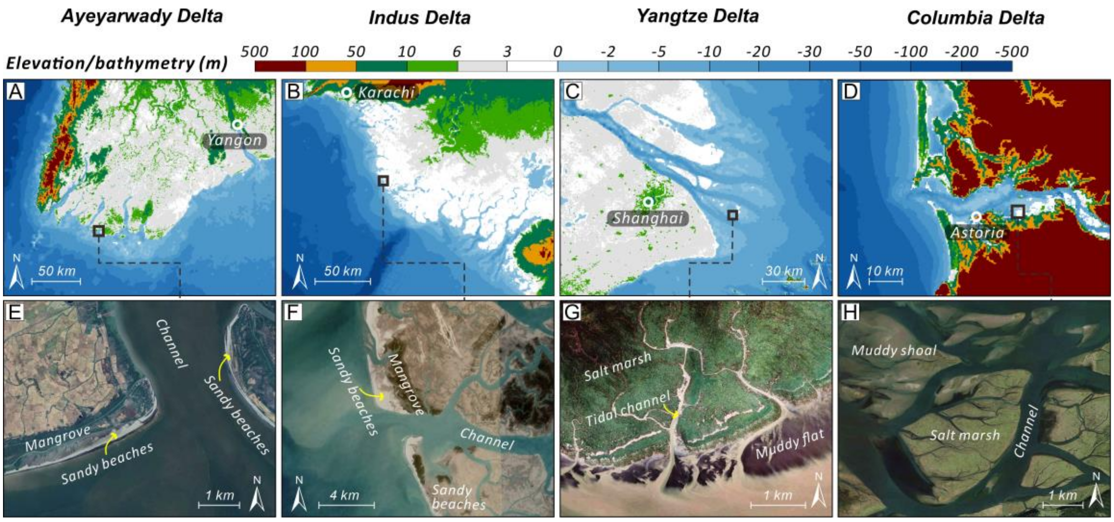
Lou, Y., Dai, Z., Long, C., Dong, H., Wei, W., & Ge, Z. (2022). Image-based machine learning for monitoring the dynamics of the largest salt marsh in the Yangtze River Delta. Journal of Hydrology, 608, 127681.

Syvitski, J. P., Kettner, A. J., Overeem, I., Giosan, L., Brakenridge, G. R., Hannon, M., & Bilham, R. (2013). Anthropocene metamorphosis of the Indus Delta and lower floodplain. Anthropocene, 3, 24-35.

Wang, J., Dai, Z., Fagherazzi, S., Zhang, X., & Liu, X. (2022). Hydro-morphodynamics triggered by extreme riverine floods in a mega fluvial-tidal delta. Science of The Total Environment, 809, 152076.



Supplementary Fig. S15. 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 Fig. S16. 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 vegetation and sandy/muddy flat.

3. Lines 155-157 (the overall net growth rate of delta land has slowed ...). Since deltas typically prograde deeper seaward and the area to be filled is larger, isn't it normal for deltas to slowly expand over time without any change in fluvial sediment input?

Response**:** Thanks a lot for your valuable comments. On millennial scales, the seaward progradation rate of the delta decreases over time because the subaqueous areas are larger and deeper. In this study, we focus on the lagged response time between 1990 and 2020, which can be considered linear over the past 31 years. Thus, in the revised **Introduction**, we have added some texts to clarify this issue to avoid potential ambiguity for the reader. (See tracked version, Line 141-145)

As: *"By doing this analysis, we simplify the relationship between Q_{river} and dA/dt as being linear, which does not apply on longer (millennial) timescales because of increasing basin depths and increasing delta surface area (Roberts, 1997; Goodbred & Saito, 2011; Nienhuis et al., 2020). We also assume that year-to-year changes in the SLRR are small compared to Q_{river} variability (Supplementary Fig. S2) (Tessler et al., 2018; Nienhuis et al., 2023)."* (See tracked version, Line 141-145)

<u>Other minor comments are listed below.</u>

4. Line 191 (Supplementary Fig. 4A), “Supplementary” may be unnecessary.

Response**:** It has been removed in the revised main text. (See tracked version, Line 252)

5. Figure 4 etc. (Irrawaddy), Ayeyarwady may be a better choice for Irrawaddy.

Response**:** Thanks for this precise reminder. In the revised main text/figures/tables and supplementary materials, all ‘Irrawaddy’ has been replaced with ‘Ayeyarwady’ as you suggested. The revised Figure 4 and Figure 5 are shown below.

6. Supplementary Fig. S10, Zhujiang should be labeled as Pearl as in Fig. 4.

Response**:** Many thanks for your reminder. The ‘Zhujiang’ has been revised to ‘Pearl’ in previous Supplementary Fig. S10, in the revised version as new Supplementary Figure S11. Moreover, we have thoroughly checked the spelling of other river deltas with aliases to keep them consistent in the revised manuscript, figures, and tables.

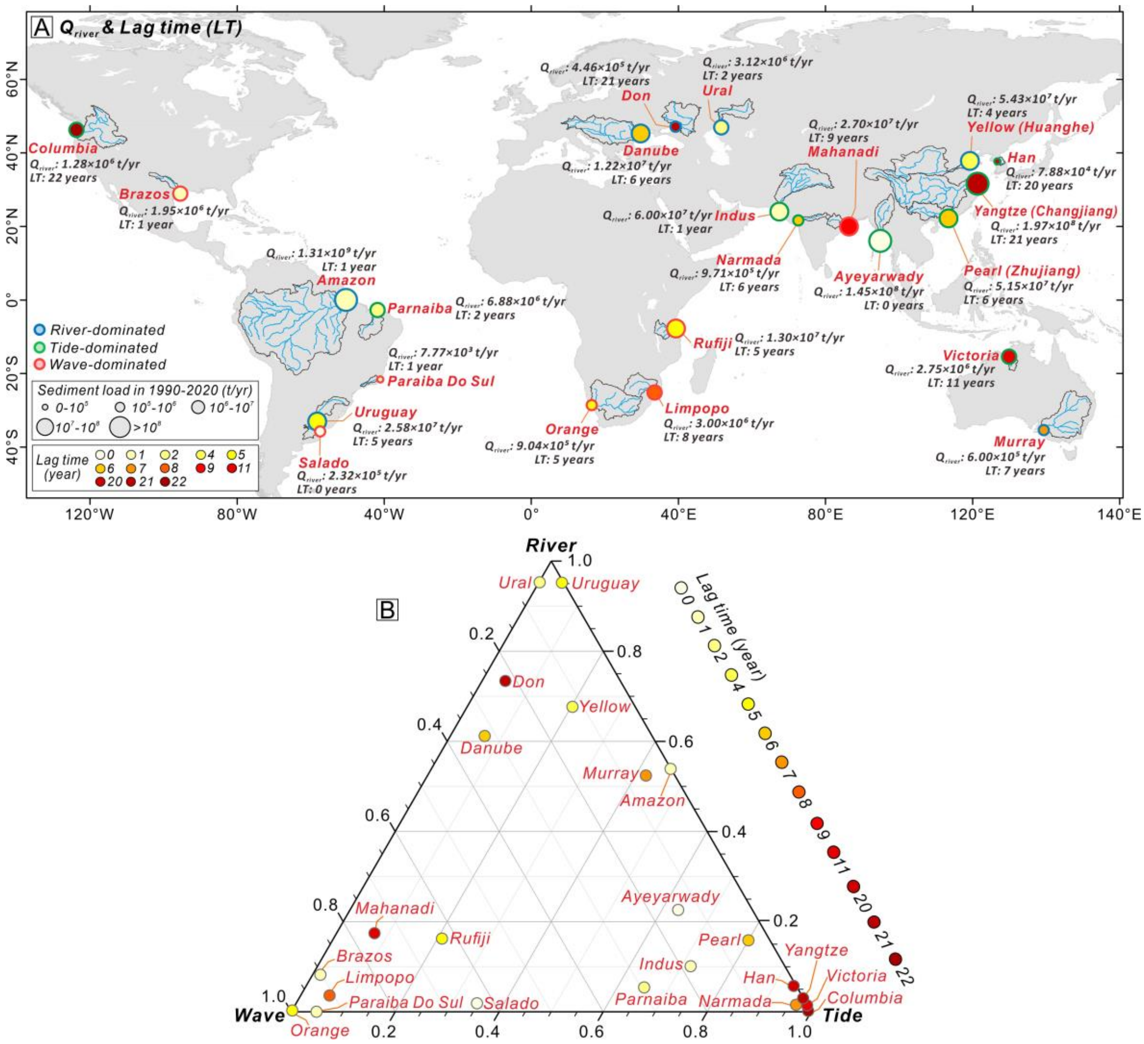


Fig. 4. Delta-scale lag response timescales. (A) The global distribution of the 23 classified deltas, shows the annual Q_{river} and the studied lag time (Δt) between 1990 and 2020. (B) A ternary diagram of 23 deltas with different relative river (Q_{river}), tidal (Q_{tide}), and wave (Q_{wave}) forcings, the corresponding color of the solid circle represents lag time in this study.

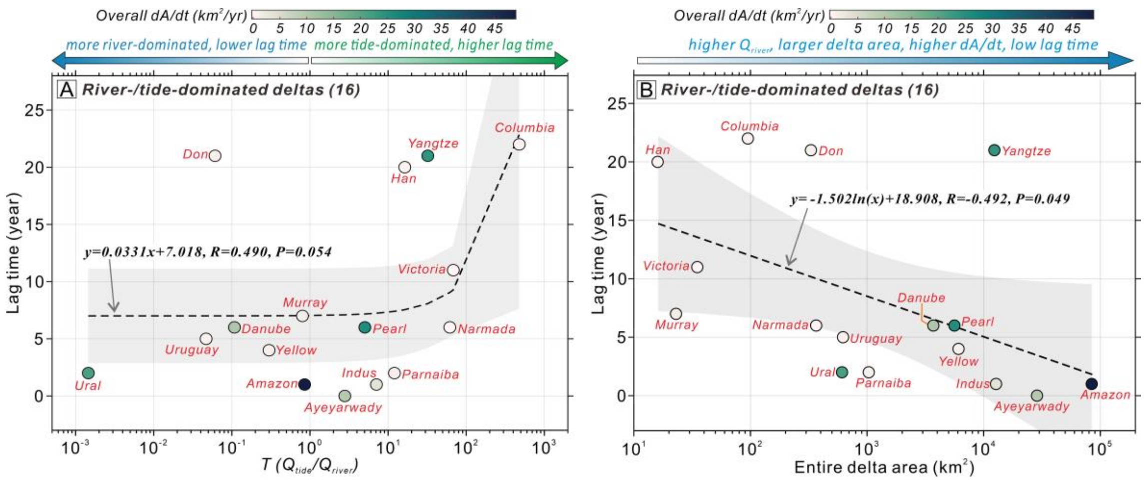
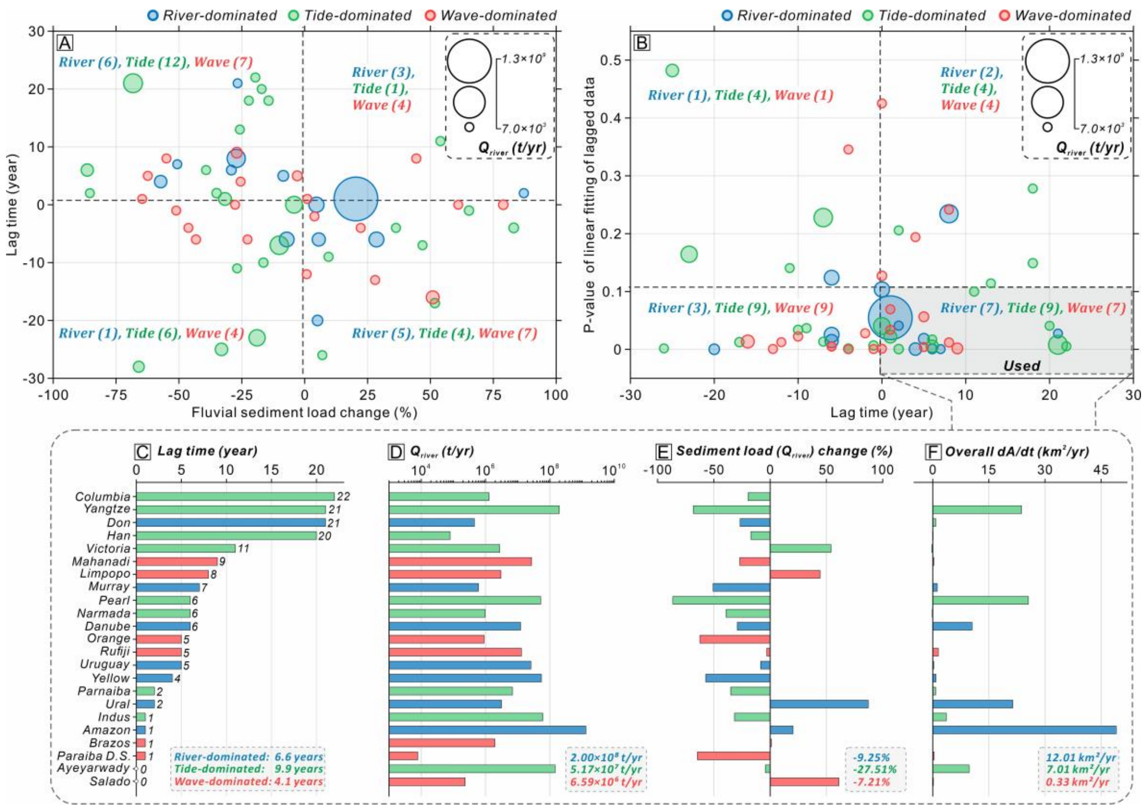


Fig. 5. Lag times and the relative fluvial-marine forcings in deltas. (A) The relationship between the T-value (Q_{tide}/Q_{river}, the ratio of river and tidal forcings) and lag time in 16 river-/tide-dominated deltas, shows an overall significant positive linear fitting trend. (B) The relationship between the entire delta area and lag time in 16 river-/tide-dominated deltas indicates that a larger delta responds faster to changes in Q_{river} between 1990 and 2020.



Supplementary Fig. S11. Lag times and changes in sediment load and land area of individual deltas. (A) 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 (Q_{river}) and change proportions, and the overall change rates of delta land area (dA/dt) for 23 classified deltas with lag times ≥ 0 and P-values ≤ 0.10, showing the means.

Reviewer #2 (Remarks to the Author):

Reviewed by Brad Murray

This manuscript presents interesting, timely, and societally relevant results. The analyses are solid, the conclusions warranted, and the discussion is thoughtful and illuminating. I think with relatively straightforward revisions this will be appropriate for publication in this journal.

1. The main and most substantive change I think needs to be made is to expand the conceptual model presented in the Introduction to include sea-level rise. Presently, the conceptual model has the rate of change of delta area being proportional to fluvial sediment flux to the delta. This is the simplest model. However, a slightly more complicated model would make the results easier to interpret, especially for a broad audience. The alternative (well accepted) model applies when sea-level rise is considered. In this model, delta area can reach a steady state in which the fluvial sediment flux to (and retained on) the delta allows the delta, at that area, to keep up with sea-level rise. In this case, the rate of change of delta area is proportional to changes in fluvial sediment flux, and both quantities can be negative. This conceptual framework makes it easier to understand the shrinking deltas (where fluvial sediment flux has decreased), while a shrinking delta doesn't fit naturally into the present conceptual model (without sea-level rise). All of the correlation analyses and results

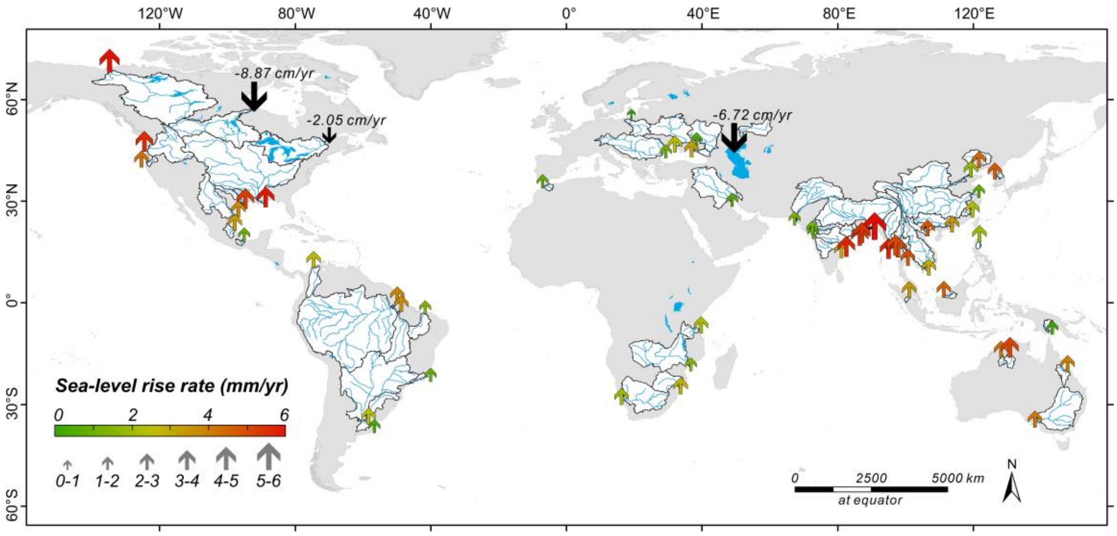
remain unaffected by this change in conceptual model, so all that is required is to rewrite the introduction and look through the paper to change all related statements.

***Response*:** We highly appreciate your constructive suggestions and comments. In the revised manuscript, we have expanded the conceptual model to fully consider the effects of relative sea-level rise (SLR) on the delta land growth change over time.

In the second and third paragraphs of the revised **Introduction**, we present the conceptual model to show that changes in delta surface area are linearly dependent on the fluvial sediment supply (Q_{river}) and relative sea-level rise rate (SLRR). During the study period of 31 years (1990-2020), the SLRR can be considered to keep a constant rate on the delta scale. We indicate that fluctuations in annual Q_{river} can alter the delta land growth rate over time. Even when the Q_{river} drops to a level insufficient to cope with the stress of SLR, the total delta surface area will shrink (See tracked version, Line 39-49, 50-56). Therefore, a constant SLRR is added for each delta and compiled into the new Supplementary Table S1, which is derived from *Nienhuis et al. (2023)*. In addition, a new Supplementary Figure S2 is drawn to more visually examine and compare the SLRR differences in global 60 deltas (See new Supplementary Table S1 and Supplementary Figure S2).

As: *"To a first order, changes in delta surface area are linearly dependent on fluvial sediment supply and relative sea-level change, with* $\frac{dA_{delta}}{dt} \propto Q_{river} - A_{delta}SLRR$*, where* A_{delta} *is the delta land area (m*^{2}*), t is a unit of time (yr),* Q_{river} *is the fluvial sediment supply at the delta apex (m*^{3}*/yr), and SLRR is the relative sea-level rise rate (m/yr) (Wolinsky & Murray, 2009; Paola et al., 2011). Results of experimental and numerical simulations support this theory and show that the delta land area will grow at a constant rate under stable sea level, while the deltaic channel-edge length extends more rapidly (Wolinsky et al., 2010). A study analyzing surface area changes in deltas on a global scale also confirms* *that deltas that receive greater fluvial sediment supply generally grow faster (Nienhuis et al., 2020).”* (See tracked version, Line 39-49)

As: *“A logical, and practical, consequence of this relation is that deltas are expected to have altered rates of land area change in response to fluctuations in Q_{river}, i.e., $\frac{d^2A_{delta}}{dt^2} \propto \frac{dQ_{river}}{dt}$, under a constant SLRR. For example, if a delta experiences a large decline in Q_{river}, their surface area growth rate will decline, even may lead to land loss over time if the fluvial sediment supply cannot keep up with the SLRR.”* (See tracked version, Line 50-56)



Supplementary Fig. S2. Relative sea-level change rates in the 60 river deltas studied.

2. My second comment involves the distinction between finding a time lag using the globally aggregated data, versus analyzing the lag for each delta individually (and then summarizing/averaging those results). The latter seems more meaningful, giving the widely variable types of delta, and associated mechanisms and lags. The results (and discussion) of the two approaches should be separated more completely, to increase clarity. In addition, it would be useful to explain early in the paper (e.g. the Introduction) why the globally aggregated analysis was done. Until I reached the statement in the final section that explained that the time lag as easier to identify when using globally

aggregated data, I wondered whether it was worth including in the main body of the paper.

***Response*:** We highly appreciate your great comments and suggestions. Considering the study objectives and data availability/quality in this study, we selected a total of 60 deltas to examine the response time scales of the land area changes (*dA/dt*) to fluctuations in fluvial sediment supply (Q_{river}) between 1990 and 2020. Therefore, we use the globally aggregated data of Q_{river} and *dA/dt* to analyze the overall lag time rather than averaging those lag times in individual delta. Results show that 15 of the 60 deltas hold negative lag times, which did not align with the conceptual model shown in the **Introduction** and were unphysical. Therefore, the analyzing method we adopted in this study can minimize the possible uncertainties caused by small-scale deltas that are not easily detected by Landsat satellite imagery. Thus, we have made the following revisions to address the above concerns:

i) In the **Introduction**, more explanations are added regarding why this approach uses globally aggregated data. This would reduce possible ambiguity and make the entire paper more logical and structured. (See tracked version, Line 146-151)

ii) In the **Results 2.1**, the previous text structures are reorganized. Changes in fluvial sediment supply and delta land area between 1990 and 2020 are sequentially presented in the first and second paragraphs. In each paragraph, we first describe the changing tendencies of globally aggregated data and then compare the variation differences at the individual delta scale. (See tracked version, Line 175-193 & 194-213)

iii) In the **Results 2.3** and **Discussion 3.3**, we indicate the uncertainty that could result from using different calculation approaches. The overall lagged times for using the globally aggregated data and averaging all individual delta results were 6.0 and 6.8 years, respectively. The similar order of magnitude of both time scales suggests a rapid response of delta land changes to changes in external drivers on a global scale. (See tracked version, Line 246-252 & 435-442)

As: *"Further, because of the large diversity in governing hydrodynamics, geomorphology, and size of the 60 river deltas ultimately selected, we primarily analyze globally aggregated fluvial sediment load and land area in all deltas to test the overall lagged time. Rather than first analyzing the lag times of 60 individual deltas and then averaging these results to achieve the delayed time. This method avoids, to a certain extent, the possible errors caused by biased estimations in some deltas with low data quality and small size."* (See tracked version, Line 146-151)

As: *"We find large changes in fluvial sediment supply to deltas between 1990 and 2020. The total annual fluvial sediment load delivered into all studied deltas decreased by 15% from 1990-2020 at a rate of 1.38×10^7 t/yr^2 (Fig. 1C). Much of this decline occurred before 2010, with the total fluxes lowered by 12% from 3.22×10^9 t/yr in 1990-1996 to 2.85×10^9 t/yr in 2006-2010 (Fig. 1C, Supplementary Table S2). Individually, over these 31 years, the annual fluvial sediment loads decreased in 36 of the 60 rivers in this study, with a decline of over 20% in 26 rivers (Fig. 1A-1B). Among them, four rivers that experienced the greatest declines were all located in Asia, i.e., the Pearl (Zhujiang) River, Liaohe River, Yangtze (Changjiang) River, and Song-Hong (Red) River, with reductions of -86%, -85%, -68%, and -66%, respectively (Fig. 1A; Supplementary Table S1). In contrast, the annual sediment supply increased in 24 rivers, with increases of over 20% in 16 rivers (Fig. 1A-1B). The Burdekin River (Australia), Ural River (Caspian Sea), Zambezi River (Africa), and Nelson River (Canada) showed the highest increased proportion up to 264%, 87%, 83%, and 79%, respectively (Fig. 1A; Supplementary Table S1)."* (See tracked version, Line 175-193)

As: *"Delta surface area expanded at a rate of 271 km^2/yr between 1990-2020, albeit with some temporal fluctuations (Fig. 1D). Expressed as a fraction of their total* *area, delta lands experienced the greatest net gain proportion of 1.98‰/yr between 2001 and 2005 compared to that in 1990-1995 (Supplementary Table S2). Since then, the overall net growth rate of delta land has slowed, especially, it was only 0.03‰/yr between 2006 and 2010, potentially associated with the most dramatic reductions in fluvial sediment inputs (Fig. 1C-1D) (Supplementary Table S2). Delta land area change analysis showed that 43 of the 60 deltas grew after 1990, with larger deltas growing faster (Supplementary Fig. S4A). The mega Ganges-Brahmaputra, Amazon, and Mekong deltas gained 83 km^2/yr, 49 km^2/yr, and 37 km^2/yr between 1990 and 2020, respectively (Supplementary Table S1). The remaining 17 deltas experienced net land loss, with the Mississippi Delta shrinking the fastest at 15 km^2/yr (Supplementary Fig. S4B-S4C). Overall, rates of land gain are strongly tied to annual fluvial sediment supply. There is a significant linear dependency ($R=0.530$, $P<0.001$) (Supplementary Fig. S4D) that was also found in earlier studies (Nienhuis et al., 2020).”* (See tracked version, Line 194-213)

As: *“The average lag time across all deltas is 2.9 years. But, this average includes some deltas where the lag time is negative (and therefore unphysical) and some are not statistically significant ($P > 0.10$) (Supplementary Fig. S6-S13). For the remaining 23 deltas with positive lag times and P-value of the lagged data ≤ 0.10, we find an average lag time of 6.8 years, similar to the results (i.e., 6 years) when using the globally aggregated data. Lag times varied between 0 and 22 years (Fig. 4A; Supplementary Table S1).”* (See tracked version, Line 246-252)

As: *“Furthermore, herein, we used the globally aggregated fluvial sediment load and land change rates in 60 deltas, then calculated an overall lag time of 6 years on a global scale, which may slightly differ from the average lag time (2.9 years) of all individual river deltas. However, this method can avoid to some extent the errors arising from delta-scale uncertainties, including low remote sensing-based detectability and negative lag time (unphysical) in some deltas. Even so, both lag times for all studied deltas keep a similar order of magnitude, indicating the high* *vulnerability of delta land to the lowering fluvial sediment supply."* (See tracked version, Line 435-442)

Comments in the attached manuscript:

3. Line 24: Reword the "the relatively short resilience".

Response: It has been replaced with "the high vulnerability". (See tracked version, Line 26)

4. Line 32: Rephrase the "by varied natural and anthropogenic reasons".

Response: As you suggested, this expression has been rephrased to "varied natural and anthropogenic change". (See tracked version, Line 35)

5. Line 40-41: About the conceptual model used in this study, "the delta land area will grow at a constant rate under stable sea level (SLR)". Do you need to talk about SLR here? (Constant SLR -> equilibrium delta area, prop. to Q_{river}). Leads to the same dA/dt prop. to Q, but now it is Q-$Q0$.

After reading into next para, yes, need to add SLR into the conceptual model at this point, so that shrinking deltas can be understood more easily (rather than expecting only growth, with variations in the rates).

Response: Many thanks for your insightful comments. In the revised manuscript, we added a constant relative sea-level rise rate (SLRR) for each delta as you indicated, which indeed allows the conceptual model of delta land growth change to be more comprehensive and reasonable. Thus, river delta land would retreat when fluvial sediment inputs cannot keep up with the SLRR. The current version makes it easier to understand the shrinking delta land over time, which can arouse the attention of a wider audience in *Nature Communications* (See tracked version, Line 39-49 and Line 50-56). The revised descriptions of the conceptual model and its implications in the main text are as follows:

As**:** *"To a first order, changes in delta surface area are linearly dependent on fluvial sediment supply and relative sea-level change, with* $\frac{dA_{delta}}{dt} \propto Q_{river} - A_{delta}SLRR$*, where* A_{delta} *is the delta land area (m*^{2}*), t is a unit of time (yr),* Q_{river} *is the fluvial sediment supply at the delta apex (m*^{3}*/yr), and SLRR is the relative sea-level rise rate (m/yr) (Wolinsky & Murray, 2009; Paola et al., 2011). Results of experimental and numerical simulations support this theory and show that the delta land area will grow at a constant rate under stable sea level, while the deltaic channel-edge length extends more rapidly (Wolinsky et al., 2010). A study analyzing surface area changes in deltas on a global scale also confirms that deltas that receive greater fluvial sediment supply generally grow faster (Nienhuis et al., 2020)."* (See tracked version, Line 39-49)

As**:** *"A logical, and practical, consequence of this relation is that deltas are expected to have altered rates of land area change in response to fluctuations in* Q_{river}*, i.e.,* $\frac{d^2A_{delta}}{dt^2} \propto \frac{dQ_{river}}{dt}$*, under a constant SLRR. For example, if a delta experiences a large decline in* Q_{river}*, their surface area growth rate will decline, even may lead to land loss over time if the fluvial sediment supply cannot keep up with the SLRR."* (See tracked version, Line 50-56)

6. Line 42-43: Rephrase the "It is also supported across global deltas, meaning that deltas that receive greater sediment supply generally grow faster (Nienhuis et al., 2020)".

Response: This sentence used to show more terrestrial sediment input will accelerate delta land growth rate is rephrased as *"A study analyzing surface area changes in deltas on a global scale also confirms that deltas that receive greater fluvial sediment supply generally grow faster (Nienhuis et al., 2020).".* (See tracked version, Line 46-49)

7. Line 44: Clarify what you mean of "A logical, and actionable, consequence of this relation is that".

Response: Many thanks for your kind comment. The sentence has been rewritten more specifically, as *"A logical, and practical, consequence of this relation is that…"*. (See tracked version, Line 50)

8. Line 48: "and up to".

Response: It has been revised to "*at rates up to …*". (See tracked version, Line 60)

9. Line 58-62: Can this be explained/expanded/clarified briefly, "Many (45%) of the 349 deltaic coasts they studied had increasing sediment concentration under conditions of decreased fluvial sediment inputs between 2000 and 2020, which highlights the local hydrodynamic conditions may affect delta growth rate over time, complicating direct observations of the relation between fluvial sediment supply and delta area change.".

Response: Many thanks for your precise comments. We have supplemented the reasons for the asynchronous changes in fluvial sediment inputs and suspended sediment concentrations in deltas. We also pointed out the potential impacts on complicating the relationship between delta sediment availability and land area change. (See tracked version, Line 69-76)

As: *"Many (45%) of the 349 deltaic coasts they studied had increasing sediment concentration under conditions of decreased fluvial sediment inputs between 2000 and 2020. This highlights one of the potentially many factors that affect delta land growth rate, complicating direct observations of the relation between fluvial sediment supply and delta surface area change."*. (See tracked version, Line 69-76)

10. Line 69: The "to delta area …".

Response: It has been revised to "*to the delta …*". (See tracked version, Line 83)

11. Line 69-72: Rewrite to make it clear that this is an example of a lag. (As written, it seems to highlight how quickly the delta responded). "Observations from the Elwha River (USA), where sediment supply increased after two large dams were removed in 2011-2014, show that the delta grew by 0.6 km^2 within 5 years; and geomorphic response signals were found most significant after 1-2 years (Ritchie et al., 2018)".

Response: Thanks a lot for your careful reminders. This sentence has been revised to highlight the lag time of deltaic geomorphic changes to increased upstream fluvial sediment supply. (See tracked version, Line 84-89)

As: *"Observations from the Elwha River (USA), where two large dams were removed in 2011-2014 that released significant amounts of trapped sediment, showed that the delta grew by 0.6 km^2 within 5 years. The delta geomorphic response signal with a lag of 1-2 years was most significant (Ritchie et al., 2018).".* (See tracked version, Line 84-89)

12. Line 75-76: Rewrite the "Dominguez & Guimarães (2021) thus stressed the importance of delayed effect and upstream hydrodynamic regulation for a synchronism".

Response: It has been revised to *"Dominguez & Guimarães (2021) stressed that the time lag resulted from river regulation which triggered coastal erosion through its influence on the deltaic backwater effect.".* (See tracked version, Line 92-93)

13. Line 83-91: Reorganize: this paragraph could be incorporated with the list of examples of lags above, with summary statements at the end (rather than summary statements, and then more examples).

Response: We highly appreciate your comments. In this paragraph, we mainly indicated that lag times for deltas are less well studied and show related examples from the Yangtze and Red River deltas. The intention of these texts is partly different from the previous paragraph. Therefore, we kept the previous structure in the revised manuscript. Thanks again for your nice suggestions.

14. Line 94: Revise "delta land growth".

Response: It has been revised to "*delta area change*". (See tracked version, Line 112)

15. Line 98: Delete "also".

Response: It has been deleted. (See tracked version, Line 116)

16. Line 99-101: This can be moved to Methods, "We draw boundary polygons that cover the subaerial delta surface (see "Method") and classify the non-water and seasonal waters as delta land area herein, using data from Pekel et al. (2016) (Fig. 2A, Supplementary Fig. S2)."

Response: The sentence has been removed from the introduction. The definition of river delta polygons in our study and the calculation of delta land area between 1990 and 2020 are addressed in detail in the **Methods** section. (See tracked version, Methods)

17. Line 111: Change to: "commonly used method".

Response: It has been revised to *"method commonly used"*. (See tracked version, Line 134)

18. Line 114-116: Reword "this method enables calculation of correlations of lagged data with different delay times, and the highest peak of correlation coefficient corresponds to the most pronounced lag time (Δt) (Fig. 2B-2C).".

Response: To introduce the cross-correlation methodology more clearly, the sentence has been revised to *"Specifically, when the fluvial sediment supply (Q_{river}) and delta land growth rate (dA/dt) changed at t1 and t2, respectively; the cross-correlation method first calculates the correlation coefficients of two lagged data of Q_{river} and dA/dt with different delayed time steps (years), then the primary lag* *time (Δt) can be determined depending on the highest peak of the correlation coefficient (Fig. 2B-2C).”*. (See tracked version, Line 136-140)

19. Line 124: Reword “varied at t1 and t2, respectively, there was a primary lag time (*Δt*)”.

Response: It has been revised to *“A conceptual diagram showing the fluvial sediment load (Q_{river}) and delta land change rate (dA/dt) with illustrated change at t1 and t2 and their lag time (Δt).”*. (See tracked version, Line 166-169)

20. Line 125-126: Reword “the highest peak here corresponded to the primary lag time (*Δt*).”.

Response: It has been revised to *“Calculated cross-correlation coefficients of different lag times and the primary lag time (Δt) corresponded to the position of the highest correlation coefficient.”*. (See tracked version, Line 169-172)

21. Line 134-135: Rephrase. “Besides, annual sediment supply”.

Response: It has been revised to *“In contrast, annual sediment supply”*. (See tracked version, Line 184)

22. Line 144-146: I would separate in the text the globally aggregated data and the data analyzing each delta individually (and then summarized as they are here).

Response: Many thanks for your precise comments. In the revised **Introduction** section, we have more specifically clarified the reasons for using integrated data (Q_{river} and delta land change rate) to analyze the global-scale lag time. In the first and second paragraphs of the revised **Result 2.1**, we described the changing trends in fluvial sediment supply and total delta land area between 1990 and 2020. In particular, in each paragraph, the global aggregated data and differences between individual deltas are presented in turn. The current writing structure presents the results and associated influences more clearly than previous versions. (See tracked version, Line 175-193 and Line 194-213)

As: *"We find large changes in fluvial sediment supply to deltas between 1990 and 2020. The total annual fluvial sediment load delivered into all studied deltas decreased by 15% from 1990-2020 at a rate of 1.38×10^7 t/yr^2 (Fig. 1C). Much of this decline occurred before 2010, with the total fluxes lowered by 12% from 3.22×10^9 t/yr in 1990-1996 to 2.85×10^9 t/yr in 2006-2010 (Fig. 1C, Supplementary Table S2). Individually, over these 31 years, the annual fluvial sediment loads decreased in 36 of the 60 rivers in this study, with a decline of over 20% in 26 rivers (Fig. 1A-1B). Among them, four rivers that experienced the greatest declines were all located in Asia, i.e., the Pearl (Zhujiang) River, Liaohe River, Yangtze (Changjiang) River, and Song-Hong (Red) River, with reductions of -86%, -85%, -68%, and -66%, respectively (Fig. 1A; Supplementary Table S1). In contrast, the annual sediment supply increased in 24 rivers, with increases of over 20% in 16 rivers (Fig. 1A-1B). The Burdekin River (Australia), Ural River (Caspian Sea), Zambezi River (Africa), and Nelson River (Canada) showed the highest increased proportion up to 264%, 87%, 83%, and 79%, respectively (Fig. 1A; Supplementary Table S1)."* (See tracked version, Line 175-193)

As: *"Delta surface area expanded at a rate of 271 km^2/yr between 1990-2020, albeit with some temporal fluctuations (Fig. 1D). Expressed as a fraction of their total area, delta lands experienced the greatest net gain proportion of 1.98‰/yr between 2001 and 2005 compared to that in 1990-1995 (Supplementary Table S2). Since then, the overall net growth rate of delta land has slowed, especially, it was only 0.03‰/yr between 2006 and 2010, potentially associated with the most dramatic reductions in fluvial sediment inputs (Fig. 1C-1D) (Supplementary Table S2). Delta land area change analysis showed that 43 of the 60 deltas grew after 1990, with larger deltas growing faster (Supplementary Fig. S4A). The mega Ganges-Brahmaputra, Amazon, and Mekong deltas gained 83 km^2/yr, 49 km^2/yr, and 37 km^2/yr between 1990 and 2020, respectively (Supplementary Table S1). The remaining 17 deltas experienced net land loss, with the Mississippi Delta shrinking* *the fastest at 15 km^2/yr (Supplementary Fig. S4B-S4C). Overall, rates of land gain are strongly tied to annual fluvial sediment supply. There is a significant linear dependency (R=0.530, P<0.001) (Supplementary Fig. S4D) that was also found in earlier studies (Nienhuis et al., 2020).”* (See tracked version, Line 194-213)

23. Line 150: “Despite these exceptions,”. Which are exceptions? (with SLR in mind, negative rates of area change are not surprising, or exceptions)

Response: Thanks for this precise reminder. It has been removed as you indicated and revised to “*Overall, rates of land gain*”. (See tracked version, Line 205-206)

24. Line 153-157: Following on the earlier comment: separate the analysis of correlations between globally summed discharge and globally summed area-change rate from the results in which each delta is analyzed individually. Separating them will increase clarity. However, the meaningfulness of the globally summed analysis isn’t clear to me.

Response: As explained in **Response 2**, we have fully considered your constructive suggestions and comments in the revised manuscript. By giving more explanations of the method in the **Introduction** section and elaborating on the changes in globally aggregated data and differences of individual deltas separately in the **Results** section, the logic-coherence of the revised main text has been enhanced. In particular, the globally aggregated data and their analysis (trends and lag times) can provide a more direct understanding of the response time of land area change in 60 deltas to fluctuations in fluvial sediment supply at the global scale between 1990 and 2020. Many thanks again for your kind comments. (See tracked version, the Introduction and Results)

25. Line 167: Change “Expanding our investigation into …”.

Response: It has been revised to *“Restricting our investigation to …”*. (See tracked version, Line 223)

26. Line 167-168: “over the 31 years period”.

Response: It has been revised to *“over the 31-year period”*. (See tracked version, Line 224)

27. Line 206: “these deltas under”.

Response: It has been revised to *“the deltas under”*. (See tracked version, Line 272)

28. Line 207: “which suggesting the”.

Response: It has been revised to *“which suggests the”*. (See tracked version, Line 273)

29. Line 218: “T-values”, not introduced in main text; don’t refer to it here.

Response: Thanks for this precise reminder. The T-value is a very crucial index in this paper to represent the relative strength of riverine and tidal dynamics in the delta. Therefore, we have added its definition and meaning in the revised **Introduction** so that the main text is structured more smoothly. (See tracked version, Line 158-162)

As: *“Further, we collected the* Q_{tide} *and* Q_{wave} *to characterize the tide- and wave-driven sediment transports in a delta, and defined a dimensionless T-value (*Q_{tide}/Q_{river}*) to reflect the relative strength of the riverine and tidal forcings, with higher values representing stronger tidal dominance (Supplementary Table S1).”* (See tracked version, Line 158-162)

30. Line 236: For “reduced fluvial sediment supply at the global scale triggered a 6-year lag”. How meaningful is this statistic (globally aggregated)?

Response: Thanks for this precise reminder. This sentence has been supplemented with ‘globally aggregated’ and revised to *“Based on globally aggregated data, we found that the reduction in fluvial sediment supply triggered a 6-year lag in the slowdown of the overall delta surface area growth rate between 1990 and 2020.”*. (See tracked version, Line 304-306)

31. Line 238: For "and more difficult to detect for individual deltas". Ah, maybe this answers the previous question.

Response: Many thanks for your comments. As you pointed out and suggested, in the revised **Introduction**, we have described in more detail the methods used in this study and related data analysis. Meanwhile, in the revised **Results**, the related texts are reconstructed to better show the changes in globally aggregated data and the difference in individual deltas. We believe the current version presents the findings more clearly and minimizes confusion or misinterpretation for the readers. (See tracked version, the Introduction and Results)

32. Line 246: For "Time lags of ~1-10 years might be hidden from sparsely sampled decadal data.". This paragraph is a nice discussion.

Response: We appreciate your affirmation of our discussion here.

33. Line 262-263: For "for example, armour layers have established downstream of dams that resulted in a delayed response of sediment declines toward the delta". Explain the mechanism briefly.

Response: Many thanks for your comments. We have briefly supplemented the lagged effect of medium grain-size sediment compensation from the downstream riverbed on total sediment decline in the delta. (See tracked version, Line 333-337)

As: *"Along the Ebro River (Spain), for example, armour layers have established downstream of dams, during high flows some medium grain-size bed sediments are eroded, thereby increasing the total sediment transport; such compensation of riverbed sediment resulted in a delayed response of total fluvial sediment declines toward the delta, potentially on the order of centuries (Vericat et al., 2006)."* (See tracked version, Line 333-337)

34. Line 277-279: Explain the mechanism briefly? For "Numerical simulations and experimental results demonstrated that tides can equilibrate sediment distribution

and budgets in a delta complex when subject to changing external drivers, and thus enhance the geomorphic stability and constrain the overall distributary mobilities at the landscape scales".

Response: Many thanks for your kind comments. We have supplemented the control mechanisms that tides can enhance the geomorphologic stabilization in deltas. (See tracked version, Line 349-353)

As: *"Numerical simulations and experimental results have demonstrated that tidally dominated bi-directional flows with high turbidity and pumping effects can increase overall sediment accumulation rates within a delta complex when subject to changing external drivers (Goodbred Jr & Saito, 2011; Hoitink et al., 2017; Iwantoro et al., 2022)."* (See tracked version, Line 349-353)

35. Line 286: "thus increase…".

Response: It has been revised to *"and thus increase…"*. (See tracked version, Line 364)

36. Line 287: "disturb the $\frac{\mathrm{dA}}{\mathrm{dt}} \propto Q_{river}$"

Response: It has been revised to *"disturb the $\frac{dA}{dt} \propto Q_{river}$ relationship"*. (See tracked version, Line 364)

37. Line 301-302: Explain/unpack this a bit. For "Fine grained sediment does not directly lead to land growth and growth, yet this fine-grained fraction of Q_{river} is captured by *Dethier et al. (2022)*."

Response: Thanks for this precise reminder. In the revised **Discussion**, we have added more explanation for the effects of different sediment fractions on changes in delta land area. (See tracked version, Line 380-385)

As: *"Therefore, most of the fine-grained sediment does not directly lead to land growth, and the medium-/coarse-grained fraction of Q_{river} is primarily associated with land changes in river deltas; however, the Q_{river} captured by Dethier et al. (2022)*

includes a significant fine-grained fraction. In addition, the coarse-grained fraction would likely have a longer delay time in the upstream fluvial domain (Nienhuis et al., 2017; Nittrouer & Viparelli, 2014)." (See tracked version, Line 380-385)

38. Line 307: Change "of time lag".

Response: It has been revised to *"of time lags"*. (See tracked version, Line 407)

39. Line 317: Reword the "errors and data noise remained at the delta scale".

Response: It has been revised to *"possible errors and underestimates/overestimates at the individual delta scale"*. (See tracked version, Line 421-422)

40. Line 331: "delta adaptive strategies in coping with".

Response: It has been revised to *"delta adaptive strategies for coping with"*. (See tracked version, Line 444)

41. The edits, issues, and concerns indicated in the manuscript have been thoroughly revised and explained. Indeed, your constructive comments and suggestions have contributed greatly to further improving the quality of the paper. Again, all authors sincerely thank you for your time and attention.

Reviewers' comments are in black font, responses are in blue.

Previous manuscript ID: NCOMMS-24-70742A

Title: Response time of global deltas to changes in fluvial sediment supply

Reviewer #1 (Remarks to the Author):

The manuscript has been appropriately revised in response to the reviewers' comments. The overall argument has become clearer.

A minor error still appears to remain, as described below.

1. The captions for Figure 3 (D–F) and (G–I) do not seem to correspond correctly to the figures; it appears that they might be reversed.

For example:

Line 211: 24 deltas with increased ... → Is this "36 deltas with decreased ..." ?

Line 214: 36 deltas with decreased ... → Is this "24 deltas with increased ..." ?

***Response*:** Many thanks for your precise comments. The captions for Figure 3d-3f and 3g-3i were indeed written reversed in the previous manuscript, and they have been corrected in the revised version. Here, they mainly indicated the differences in the lagged response time scales of the deltas with decreasing and increasing fluvial sediment supply, respectively. (See tracked version, Line 195-205)

As: *"**Fig. 3 | Cross-correlation analyses of fluvial sediment load and delta land area change rates. a** Time series of total annual fluvial sediment load and delta land area change rate in all deltas during 1990-2020. **b** Cross-correlation coefficients of different lag times in 60 deltas with a primary lag time of 6 years. **c** Linear correlation between the lagged total sediment load and land area change rate in 60 deltas. **d-f** The time series of annual total fluvial sediment load and land area change rate in 36 deltas with decreased sediment supply, shows cross-correlation analyses with a primary lag time of 1 year, the linear fitting of lagged data is also* *significant.* ***g-i*** *Time series of total fluvial sediment load and land area change rate in 24 deltas with increased fluvial sediment input, shows cross-correlation analyses with a lag time of 6 years and the linear fitting of lagged data.”.* (See tracked version, Line 195-205)

Reviewer #2 (Remarks to the Author):

Re-review of 'Response time of global deltas...'

Re-reviewed by Brad Murray

Thank you to the authors for responding thoroughly to my comments and suggestions. The paper is ready for publication, from my point of view.

1. I did, however, notice one place where the text needs to be changed to correct the grammar: The sentence “Rather than first analyzing the lag times of 60 individual deltas and then averaging these results to achieve the delayed time.” can not stand by itself. (I suspect it had been connected to the previous sentence by a comma, which would make it work grammatically-though it would make the sentence quite long, of course.)

Response**:** Thanks a lot for your great suggestions. In order to make the meaning of the sentence more coherent and grammatical, we have revised the previous period to a comma. (See tracked version, Line 121-125)

As: *“Further, because of the large diversity in governing hydrodynamics, geomorphology, and size of the 60 river deltas ultimately selected, we primarily analyze globally aggregated fluvial sediment load and land area in all deltas to test the overall lagged time, rather than first analyzing the lag times of 60 individual deltas and then averaging these results to achieve the delayed time.”.* (See tracked version, Line 121-125)