1 Experimental Design

1.1 Boundary Conditions

The control and treatment experiments were conducted in the Tulane Sediment Dynamics laboratory. The control experiment was conducted in the delta basin in 2018 and the treatment experiment was conducted in the deep water basin in 2019. Both the control and treatment experiments had the exact same boundary conditions, except the treatment experiment had marsh deposition and the control experiment did not (Table 1). Thus, any changes between the two experiments can be attributed directly to the addition of the marsh.

Table 1: Experiment boundary conditions. The experimental conditions for both the control (no marsh) and treatment (marsh deposition) experiments used for comparison in this study.

Boundary Condition	**Control**	**Treatment**
Sediment Mixture	Hoyal and Sheets (2009)	Hoyal and Sheets (2009)
Realtive Sea Level Rise ($RSLR_b$)	0.25 mm/hr	0.25 mm/hr
Riverine Sediment Discharge (Q_s)	1.41 kg/hr	1.41 kg/hr
Riverine Water Discharge (Q_w)	$1.72*10^{-4}$ m^3/s	$1.72*10^{-4}$ m^3/s
In-situ Marsh Deposition (Q_m)	None	150 g/hr (total) 3.7 g/hex (max production) 1.7 g/hex (stable/unstable)

1.2 Data and Marsh Proxy

We expand here on details of the data collection and marsh distribution. Because the treatment experiment was not fully automated, we paused the experiment for ∼10 hours each night. During the progradation phase, overnight subsidence was tested by taking a LiDAR scan at the end of the day and beginning of the next day to observe changes in elevation. No detectable subsidence was observed when the experiments were paused overnight, thus pausing of the experiment did not impact the elevation data collected in comparison to the control.

We deposited the marsh sediment with about 50% accuracy. An average of 200 g of kaolinite was deposited per deposition hour, which is less than the average ideal deposition rate (calculated via the model) of 260 g per deposition (main text Figure 1d). The reasons for this were (1) compaction of the kaolinite in the sieve and (2) dampening of the ButtKicker™ signal that caused apparent uneven deposition through time. We mitigated this by switching the direction of the deposition every two hours (e.g., the first hour the sieve moved from left to right across the basin to deposit marsh and the second hour the sieve moved from right to left). We also re-calibrated the sediment dispenser after each depositional cycle. Though less accurate than anticipated, the deposition of marsh proxy altered the morphology and surface processes of the delta.

2 Deltaic sediment balance

We calculate the sediment volume balance for both the control and treatment experiments in order to directly compare the volume and rate of sediment storage throughout the delta. While this comparison is revealing, we are specifically interested in the influence of marsh sedimentation on delta volume balance; thus, we need to quantify the volume of the riverine and marsh sediment (kaolinite clay) in the treatment experiment throughout its entirety. Due to compaction of the marsh sediment, erosion, and deposition of both marsh and river sediment in the same area on the delta top, we cannot directly quantify the sediment accumulation using the LiDAR scans. Instead, we take advantage of the preserved stratigraphy to determine the marsh volume.

2.1 Stratigraphic Interpolation

The resulting stratigraphy was split into two sections to acquire one cross-section along dip. Then the deposit was sectioned from distal to proximal along strike every 10 cm. Photographs were taken of each section and color image processing was used to obtain a marsh fraction and thickness roughly every 10 cm (Figure 1a).

Using this gridded stratigraphic data, we use Bayesian kriging techniques ("Bayesian inference", 2007) to interpolate a pixel (5 mm x 5 mm) marsh fraction and marsh thickness for the entire delta basin (Figure 1b and c). Bayesian kriging is a useful interpolation technique because it integrates data and model to predict values and uncertainty on those predicted values ("Bayesian inference", 2007). Further, it is less likely to be biased than traditional interpolation techniques, producing a more accurate model ("Bayesian inference", 2007).

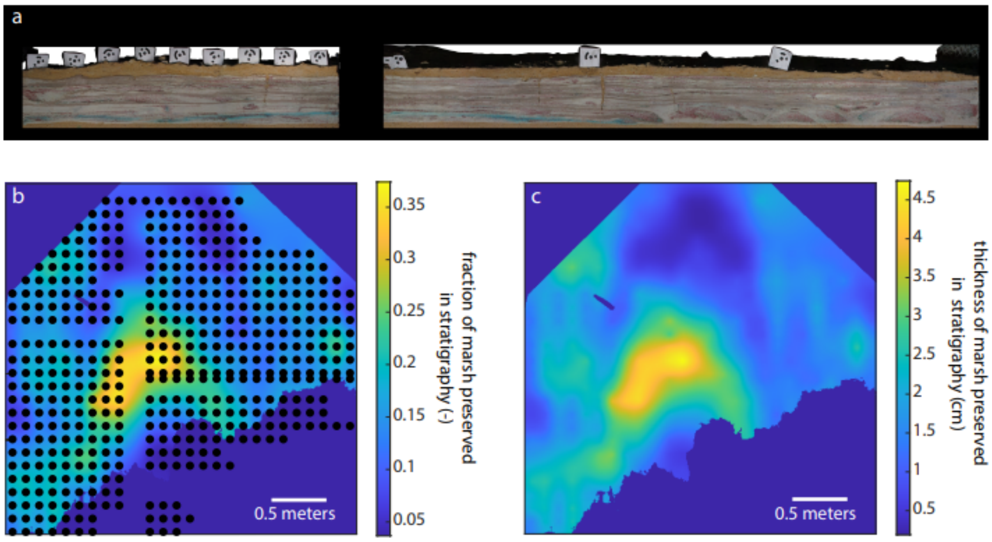

Figure 1: Stratigraphic Interpolation. (a) An along strike section of the treatment experiment at 1.1 m from the entrance channel. The targets on the left one-third of the image are spaced 10 cm apart and thickness and fraction of marsh was collected for the entire deposit below each target. The red sediment is channel sand, white is channel floodplain, and brown is marsh. The tan sediment above and below the section is play sand and not part of the delta deposit. (b) The interpolated fraction of marsh sediment that is preserved in stratigraphy for the area above -9 mm relative to seal level for at least 10% of the experiment. The black dots represent the measured values of marsh fraction and thickness and are roughly 10 cm apart. The raw data (black dots) was interpolated using a 5 mm x 5 mm grid (the resolution of the LiDAR data). (c) The intepolated thickness of marsh sediment that is preserved in the stratigraphy (cm) using a 5 mm x 5 mm grid.

2.2 Volume Balance

The volume balance for the different zones (e.g., above marsh, marsh window, delta top) was calculated using the final resulting stratigraphy. We define the region above the marsh as the area that is above 5 mm relative to sea level (rsl) for at least 90% of the experiment to minimize the influence of marsh on sedimentation of this region in the treatment experiment. The marsh window is the area $\leq$5 mm rsl and $\geq$-9 mm rsl for greater than 10% of the experiment. By using this criteria, the marsh window begins exactly where the above marsh zone ends. Finally, we define the delta top as the area that is $\geq$ -9 mm rsl for at least 50% of the experiment. This region then encompasses a smaller extent than the combined above marsh and marsh window area. However, we use this region to compare the average delta top area and volume of the two experiments.

We calculate the volume balance for all three zones using the following logic. Total sediment accumulated (V_T; mm^3) at each pixel (i) is given by:

$$V_T = (Z_{final} - Z_{initial}) * A_{pixel}, \qquad (1)$$

where z_{final} is the pixel elevation of the last LiDAR scan, $z_{initial}$ is the pixel elevation of the first LiDAR scan, and A_{pixel} is the area of one pixel (25 mm^2). From there, we multiply by the interpolated marsh fraction (f_m; -) to determine the marsh sediment accumulated (V_m; mm^3), given by:

$$V_m = f_m * V_T. \qquad (2)$$

The clastic (riverine) sediment accumulated (V_c; mm^3) is then:

$$V_c = V_T - V_m. \tag{3}$$

Note that because the control experiment has no marsh deposition, V_m is 0 and V_c is simply equal to V_T. Refer to Table 1 in the main text for the zonal volume balance.

We compared the zonal mass balance for the area above the marsh to a mass balance calculated using a moving average above the marsh window. The moving window shows a sediment accumulation rate of 0.202 m^3 and 0.0655 m^3 for the control and treatment experiments, respectively. While this is about a 40% difference from the integrated zonal volume, both methods show a similar percent difference in volume between the two experiments. We integrated through time for each of the three zones (above marsh, marsh, and delta top) because even though the delta is in equilibrium, autogenic variability impacts short-term sediment depositon and resulting stratigraphy (i.e., the moving average does not account for long- or short-term compactional subsidence) (Jerolmack & Sadler, 2007).

The trapping efficiency (TE; %) is defined by:

$$TE = \frac{V_c}{V_D} * 100, \tag{4}$$

where V_D (a constant 0.660 m^3) is the clastic sediment delivered to the delta top and calculated by:

$$V_D = (\frac{flux}{\rho} * t) * 10^{-6}, \tag{5}$$

where flux is the sediment being delivered to the system by the river (a constant 1406.14 g/hr), t is the entire run time of the experiment (560 hrs), and ρ is the bulk density of the clastic sediment (a constant 1.19 g/cm^3), assuming an average 55% porosity (mean of cores taken from the control experiment) and a particle density of 2.65 g/cm^3.

In Table 1 of the main text, we calculate two TE for the marsh window. The TE descried by footnote a in Table 1 is the TE calculated using the clastic sediment delivered to the marsh window (V_{Dm}) instead of the clastic sediment delivered to the delta top (V_D):

$$V_{Dm} = V_D - V_{am}, \tag{6}$$

where V_{am} is the total clastic sediment accumulated above the marsh window.

3 Delta Hypsometry

We compare the hypsometry (elevation distribution) of the control and treatment experiments to the hypsometry of three vegetated and one non-vegetated field-scale deltas. In order to compare the experimental scale to the field scale, we non-dimensionalize the elevations of the delta top by dividing elevation by one average channel depth for the given system. The channel depths used are 15 mm for the experiments, 30 m for the Missississippi River Delta (MRD) and the Ganges Brahamaputra Meghna Delta (GBMD), 10 m for the Mekong River Delta, and 15 m for the Rio Grande River Delta. Notably, we see a more similar hypsometric signature between the treatment and global deltas, as compared to the control. The treatment and gloabl deltas have >30% of their elevations between 0 and 0.5 channel depths above sea level. Specifically, the treatment experiment has 31%, MRD has 44%, GBMD has 64%, Mekong River Delta has 50%, and Rio Grande River Delta has 38% of elevations here. Comparatively, the control only has 17% of elevations in this 0 to 0.5 channel depths above sea level window. Rather, the control has a bi-modal distribution with peaks at 0.06 channel depths below sea level and 0.733 channel depths above sea level.

The elevation data for the field scale deltas was collected using ETOPO Global Relief Model (NOAA) in Google Earth Engine (GEE). GEE provides an interactive software, which we used to create polygons of the delta tops of three vegetated deltas (the Mississippi River Delta, Ganges Brahamaputra Meghna Delta, and Mekong River Delta), and one mostly unvegetated delta (the Rio Grande River Delta) (Figure 2).

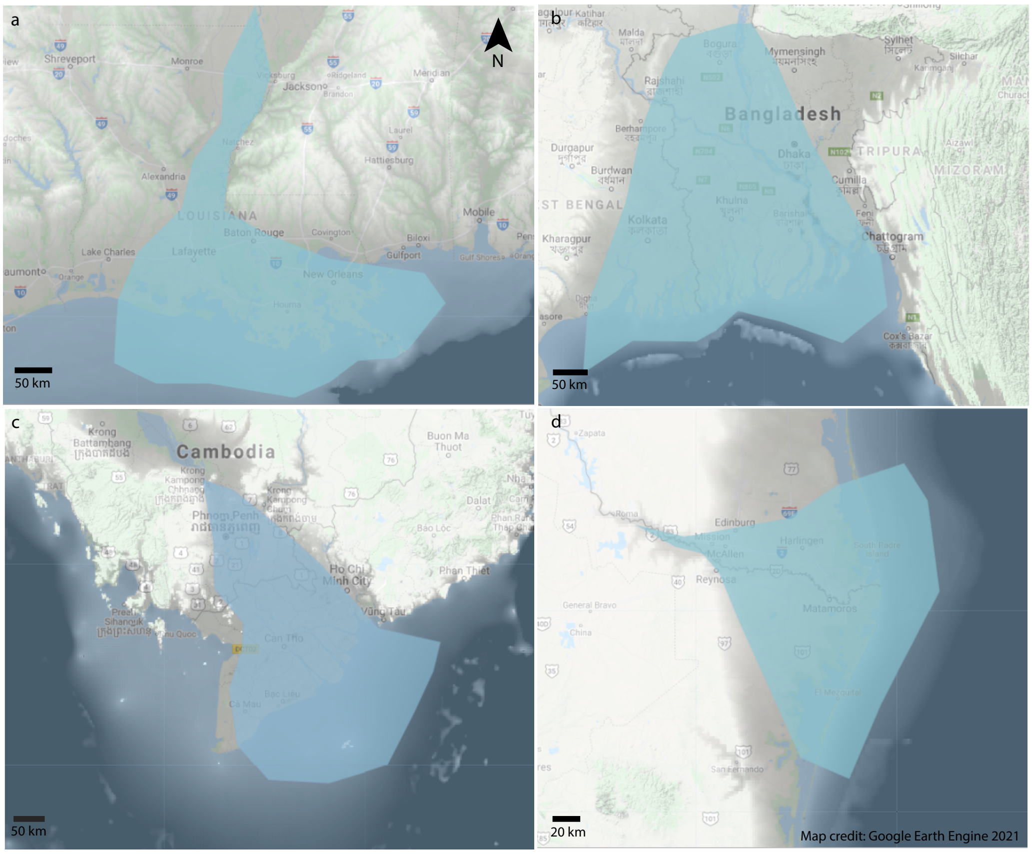

Figure 2: Delta polygons. The satellite and topographic data for the field-scale deltas used in the hypsometric analysis and the corresponding polygons (blue) used to obtain elevation data. (a) The Mississippi River Delta located in Louisiana, USA. (b) The Ganges Brahamaputra Meghna Delta located in Bangladesh and West Bengal, India. (c) The Mekong River Delta located in Cambodia and Vietnam. (d) The Rio Grande River Delta located on the border of southeast Texas, USA and northeast Mexico. The scales vary on each map, but the north arrow and credits are the same for all.

The polygons were created with the following rules. (1) We avoided locations that were greater than 3 channel depths above to sea level and less than 1 channel depth below sea level, (2) we attempted to determine the entrance of the channel into the "delta top", and (3) we made sure to include the main distributary channels within the polygon area. While the areas were chosen somewhat arbitrarily, we tested different polygons for the same delta and did not observe a significant difference in the histogram distribution shape, thus we are confident in the patterns observed in Figure 4 (main text).

References

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