Supporting Information for "Exploring Sediment Compaction in Experimental Deltas: towards a meso-scale understanding of coastal subsidence patterns"

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Introduction

This supplement describes the procedure for generating the surface subsidence and marsh deposit thickness maps from sequential lidar scans collected during the control (TDB-18) and treatment (TDWB-19-2) experiments. Uncertainties associated with those products are also discussed.

Text S1. Digital Elevation and Subsidence Maps Digital elevation maps (DEMs) of the basin were collected using a stationary FARO LiDAR scanner similar to Straub, Li, and Benson (2015) and Li et al. (2017). For the control experiment, “dry” scans were collected at the beginning of each run hour while fluvial input was paused, and “wet” scans were collected 48 minutes into each hour while the fluvial system was active. For the treatment experiment, dry scans were collected every even hour of runtime and wet scans 48 minutes into each run hour. LiDAR generated point clouds were cleaned in MATLAB and gridded into 5x5 mm raster pixels, each representing the median value of all points within the pixel. Each pixel has a vertical uncertainty of approximately 0.71 mm, which is discussed in the following error propagation section.

Ringing artifacts due to angular measurement error were present in the DEMs of both experiments. Banding was somewhat more pronounced in the treatment experiment subsidence maps, possibly because the magnitudes of all values were multiplied by the previously discussed correction factor. These artifacts were mitigated by running each two-hour DEM of difference through a cleaning script before applying any screens. This script identified the center of ringing as the location of the LiDAR scanner relative to the basin. It then broke each map into a series of radial bands with a width of five pixels (2.5 mm). The median value all pixels within each band was subtracted from the initial value of each pixel within a given band to remove the artifact. Real subsidence patterns did not align with the orientation of these bands, so they are assumed to be relatively unchanged. Subsidence rates with and without ringing removed were similar, suggesting that this cleaning step did not bias subsidence rates. Additionally, overall subsidence rates throughout the experiments were nearly unchanged, though local subsidence rates at a given time and location were often altered, presumably now reflecting actual elevation changes rather than instrument artifacts. Due to the slightly elliptical shape of the bands, and the irregularity of their magnitudes and locations, some ringing remains in both datasets.

Text S2. Error Propagation The FARO uncertainty in ranging measurement is listed as +/- 1 mm. The FARO was positioned above the deposit and collected returns at an approximately 45-degree angle, so vertical uncertainty can be estimated as $1/\sqrt{2}$, or 0.71 mm. This number is conservative because the reported measurement for each pixel is the median value of typically multiple measurements. The standard error of the mean on each pixel of a difference map can be described by the equation,

$$S_z = \sqrt{(S_{z1})^2 + (S_{z2})^2} \tag{1}$$

where S_{z1} and S_{z2} are the vertical uncertainty on one point at two different instances. The standard error on each pixel of the difference map comes out to +/- 1 mm. This is larger than almost all observed subsidence magnitudes over timescales of interest in the experimental setting, so values need to be spatially averaged over many pixels to yield workable error bars. Average uncertainty over a number of individual pixel measurements ($S_{z,n}$) is described by the equation,

$$S_z = \sqrt{(1/n) * \sqrt{S_z}^2} \tag{2}$$

where n is the number of pixels averaged. Error decreases as n increases. For S_z = +/- 1 mm and n = 1000, $S_{z,n}$ is .001 mm or 1 μm. Delta-wide average subsidence values at the two and ten hour time steps calculated in Section 3.1 always average over at least this many pixels, so uncertainty is assumed to be minimal. All spatially distributed subsidence measurements in Figure 5 are created by averaging over 10x10 pixel areas (50 x 50 mm) with at least 40 non-NaN values ($n >= 40$). In this case, $S_{z,n}$ = 0.025 mm or 25 μm.

This is significantly smaller than the range of typically measured values and assures the validity of correlations drawn in those analyses.

The error propagation technique outlined in this section assumes a lack of spatial or temporal correlation in errors. We make this assumption only after applying the ringing artifact mitigation script described in the previous section. These artifacts are an example of spatially correlated error. For this reason, anomalous subsidence measurements calculated over a small number of pixels should be met with skepticism.

Movie S1. Movie of TDB-18-1 (control experiment) overlaid with subsidence maps spanning the two hours prior to each frame.

Movie S2. Movie of TDWB-19-2 (treatment experiment) overlaid with subsidence maps spanning the two hours prior to each frame.

References

Li, Q., Matthew Benson, W., Harlan, M., Robichaux, P., Sha, X., Xu, K., & Straub, K. M. (2017). Influence of Sediment Cohesion on Deltaic Morphodynamics and Stratigraphy Over Basin-Filling Time Scales. *Journal of Geophysical Research: Earth Surface*, *122*(10), 1808–1826. Retrieved 2022-10-10, from `https://onlinelibrary.wiley.com/doi/abs/10.1002/2017JF004216` (_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/2017JF004216) doi: 10.1002/2017JF004216

Straub, K. M., Li, Q., & Benson, W. M. (2015). Influence of sediment cohesion on deltaic shoreline dynamics and bulk sediment retention: A laboratory study. *Geophysical Research Letters*, *42*(22), 9808–9815. Retrieved 2022-10-10, from `https://onlinelibrary.wiley.com/doi/abs/10.1002/2015GL066131`

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