Comment on esurf-2021-37
Ajay Limaye (Referee)


Hassenruck-Gudipati et al. use morphometric analyses of alluvial terraces and associated paleochannels along the Trinity River, Texas, to test end-member hypotheses for river terrace formation. These end-member scenarios are (1) autogenic terrace formation and (2) terrace formation driven by episodic incision caused by sea-level change. The analysis informs the interpretation that the terraces record past base-level fall (for the highest terrace) and autogenic processes (for lower terraces). The study treats a timely question and applies creative approaches to the data analysis, including Monte Carlo simulation to interpret both the terrace and paleochannel datasets. The study site is well justified based on prior terrace studies and paleodischarge reconstructions in the Texas Coastal Plain region.

I have three main comments. First, the geologic context for the analysis could be further developed. For readers without extensive prior knowledge of the studies on the Colorado and Brazos Rivers, it may be difficult to place the new analyses in perspective. I made several suggestions in the line-by-line comments to address this gap, including adding an area map, an alluvial stratigraphic column, and a sea-level curve – any of which would help to evaluate and contextualize the interpretations in this study.

Second, the manuscript focuses on two terrace formation pathways; however, the analysis points to third important factor, namely, large-magnitude changes in discharge (L353-370). The implications of this finding can be further developed. If sediment discharge increased at the same time to maintain a consistent channel slope (as proposed in L375-376), can you test this hypothesis using other sedimentary data? Moreover, the paleodischarge reconstruction, which indicates much larger discharges during the formation of the intermediate Deweyville terraces, also seems to complicate the story of the intermediate terraces being autogenic. What does it mean for the terraces to be autogenic if they formed during a period of significantly higher water discharge? Does it mean that terraces in general are not faithful proxies for paleoclimate? Squaring the
terrace interpretations with the paleodischarge interpretations would be a very helpful contribution, and based on these data, might even push us to refine what we mean by “autogenic” terraces.

Third, the terrace analysis centers on the hypothesis that the variance in elevations on a terrace results from formation mechanism (i.e., autogenic versus allogenic). However, there is a significant potential source of variance in the terrace elevations that is not sufficiently described: dissection of the terraces after formation. For example, Figure 7D shows a gully eroded into terrace T6, which presumably increases the variability in elevation on that terrace surface. Does the analysis account for or exclude this additional source of elevation variance that is unrelated to the main hypothesis? Further explanation of the mapping methods might address this point.

Overall, this is an ambitious and exciting study. With revisions to deepen the geologic context, reconciliation of the competing hypotheses, and justification for the mapping methods, I think this work can make an important contribution to current debates regarding alluvial rivers and paleoenvironmental reconstruction.

Line-by-line comments:

L25-27: “often host remnant river-channel segments": The paleochannels for the Trinity River terraces are exceptionally well expressed compared to many other locations. Add this context, or references to indicate how common these types of paleochannels are.

L27-29: “terrace formation requires…“: other mechanisms include alluviation and incision caused by valley damming (e.g., Mackey et al., 2011, doi: 10.1073/pnas.1110445108), land-use change (Womack and Schumm, 1977, doi:10.1130/0091-7613(1977)5%3C72:TODCNC%3E2.0.CO;2), and perhaps others. Consider using a more general definition for the required conditions to form a terrace.

L36: Which coastal deposits, specifically?

L63: “Allogroup”: Define what this is or replace with a more widely known term.

L64-66: As a foundation for these hypotheses, introduce the observation that the three sets of terraces occur at different elevations. L55-56 could be a good place.

L73: Check grammar, currently reads as if the hydrograph is prone to flooding.
Figure 1: Beautiful data, might look even better with some adjustments to the figure layout. Placing the legend between the two maps distracts somewhat from the maps. One alternative idea is to rotate the maps so that they go left-to-right, then place the annotations on the side.

Figure 1 caption: The (A) and (B) labels seem to be misplaced. More common to put the label ahead of the thing it describes.

Figure 2: color scale lacks units. Is this detrended or absolute elevation?

L84-103: The stratigraphic information is useful, but hard to digest for the uninitiated. I suggest adding a stratigraphic column to tie the work to the existing alluvial stratigraphic framework that is so well developed in this region.

L104-105: The sea-level history is central to evaluating the main claim in this manuscript, i.e., that some Trinity River terraces reflect base sea-level change while others do not. As with the stratigraphic information, it would be very helpful to show the sea-level reconstructions.

L113-121: Several of the referenced studies treat rivers in the Texas Coastal Plain, such as the Colorado River. However, none of these rivers are named in the Introduction and there is limited information to place these studies in spatial context. An overview map that includes the Trinity River and other major rivers in the region would help.

L126: More common to report grid spacing (i.e., 1 m).

L130-131: Did these previous studies map the terraces, and this study is refining those maps using high-resolution topography data? The relationship between the existing maps and this work is somewhat unclear.

L133: State the rationale for sampling the data at this lower resolution.

L135: Strictly speaking, latitude and UTM northing (Fig. 3A) are not equivalent.
L135-136: Is the plane-fitting procedure suitable for these data? Figure 3A shows the trend line from the fit but not the underlying elevation data.

Figure 3: What do the error bars in Fig. 3A represent? Also, the readability for the x-axes in both plots could be improved by plotting as distance in kilometers.

Figure 3 caption: same comment regarding labels as for Figure 1.

L155: Section 3.1: This section expresses the core hypothesis. Consider moving this section before the data in L122-154.

L163-164: Does this hypothesis consider the Finnegan and Dietrich (2011) model for terrace abandonment driven by autogenic knickpoints? It seems plausible that such knickpoints would abandon terraces with low RMSE in their plane fits.

L173: As noted above, the valley profile is not actually shown, only the linear fit to the valley profile.

Figure 3 caption: The meaning of the colored line in each plot is unclear. Does this represent the random terrace grouping, and if so, how?

L196: Note in the text that this is the sand-bed (rather than gravel-bed) version.

L234-235: These modern discharge statistics are important context for the paleodischarge estimates. Can you add the modern statistics to Figure 8?

L237: “To further test the statistical groupings within our terrace and paleo-channel data”: lost the thread regarding the specific purpose of these statistical tests. Are you testing for the existence of groupings, the number of groupings, or something else? How does this analysis contribute to testing the main hypothesis?

L264-265: The relevance of the number of paleochannel bends in the terrace is unclear. This hypothesized link is stated later, however, it’s unexplained at this point in the text.
L275: 10 figures and many results have already been presented before arriving at section 4, "Results." Based on the content, it may be more fitting to rename this section along the lines of “synthesis of observations.”

L316-323: This passage can be refined to better capture some specific points in the referenced studies. Greater precision is needed to specify which autogenic process is being discussed and to explain how that process would impact the terrace characteristics such as pairing, age, and consistency of elevations.

The model results in Limaye and Lamb (2016) indicated that a specific autogenic process – a meandering river undergoing constant vertical incision – can make terrace features typically interpreted to reflect external (allogenic) processes. Specifically, relatively low vertical incision rates (~ 0.1 mm/yr) can yield terraces that appear to be paired and are relatively long (> 10 channel widths). The current text does not capture these points. Also, in L325 only the Finnegan and Dietrich (2011) paper treated enhanced erosion rates driven by cutoffs.

L342: More specificity about the autogenic process(es) considered would be helpful.

L352: What does your new analysis mean for interpreting the geochronology data summarized in the Introduction (ca. L100)?

L355: *Phillips

L381-384: As above, a more robust argument is needed to relate the number of bends preserved to the terrace formation mechanism, as relatively long terraces have been proposed to form autogenically.

Supplementary files: It would be helpful to include a readme file to explain the purpose of each file, data formats, conventions, etc.