Response to Reviewer Document for Pierce & Koehler manuscript now titled "3D Paleoseismology of the Dog Valley Fault (California, USA) from iOS Lidar and Structure-from-Motion Photogrammetry" and submitted for consideration of publication to *Seismica*

Seismica Review for Dog Valley Paper

Ian Pierce, Rich Koehler:

We have reached a decision regarding your submission to Seismica, "3D Paleoseismology from iOS Lidar and Structure from Motion Photogrammetry: a case study on the Dog Valley fault, California".

Your manuscript will be considered further for publication in Seismica following the completion of some revisions.

I have now received input from two reveiwers regarding your manuscript. Both feel that the content of the manuscript is appropriate for eventual publication in Seismica. They also both mention that they feel the scientific aspects of the work to be relatively sound (with a few minor exceptions noted in their detailed comments). The reveiwers are also consistent, however, in feeling that the presentation of the manuscript could be improved in the interest of broader accessibility and impact within Seismica's diverse audience. There are consistent remarks that touch on a question of "what does this manuscript want to be"? On one hand, there is a data set here that describes new observations for the paleoseismology and thus seismic hazard of a previously unstudied fault system with a clear history of surface rupturing earthquakes. Reviewer #2 notes, however, that in that case the overall systematics of conjugate fault systems and their implications for seismic hazards are not sufficiently addressed. On the other, the manuscript in current form seems to present itself as more of a "methods" paper that seeks to propose and establish some new approaches for broader community consideration. Both reviewers note, however, that this approach does not provide a sufficient overview and comparison with other predominate methods in use within the field today. In short, the current version of the manuscript on a certain level attempts to "split the difference" between these two end-member presentations, resulting in neither being as robust as might otherwise be possible. Reviewer #1 offers a variety of very specific suggestions for addressing these issues, which I would encourage you to examine closely.

I would describe the level of revision required to adequately address the reviewer's criticisms as somewhere between minor and moderate. Given that they are focused overwhelmingly on issues of presentation rather than detailed aspects of the science, however, I do not anticipate sending the revised manuscript out for additional peer review (but I reserve the right to do so if issues arrise). I will assess the revised manuscript and your response to the reviewer comments when it arrives. Seismica does not place an explicit time limit on the submission of revisions, but I would certainly encourage you to submit these as soon as you are able.

As part of your revision, please include: 1) a revised version of your manuscript; 2) a "tracked changes" version of your manuscript ; and 3) a detailed response to all reviewer comments. All of these should be in PDF format.

In the text below you will find the comments of Reviewer #1. You will also find files attached to this message, specifically an annotated PDF provided by Reviewer #1 and a PDF of general comments provided by Reviewer #2.

Apologies again for the delay in reaching this initial decision. Feel free to contact me if you have questions regarding your revision.

Sincerely,

Randy Williams

Thanks for this summary review. We are grateful to the very thorough, detailed and helpful reviews that have served to significantly improve our manuscript. We have carefully considered and incorporated the reviewers suggestions throughout the manuscript (See review responses below by item). We have added additional text to credit earlier methods and to compare our new method to these methods, and have heavily rewritten our introduction and discussion sections.

Comments from Reviewer #1

This manuscript got me thinking about what it means to provide a ‘case study’ in our field. Specifically, what is the difference between a ‘case study’ and an ‘example’ or ‘demonstration’? Is there a difference? From my own frame of reference, the impression that I had going into this based on the title and the beginning of the abstract was that the manuscript would provide a strong use case for combined lidar and photogrammetry for 3D excavations. Instead, it reads as more of paper that is contributing new paleoearthquake data that happened to benefit from a new method you deployed. What particularly drives home this impression is that your assessment of the method only receives a short paragraph at the end of the discussion, and two of the sentences are specific to the merits of 3D trenching in general, not necessarily the method you’ve described.

As a reviewer, I don’t want to tell you what your paper *should* be, so please take my comments as seeking to help you take what you want your paper to be, and shape it so that the reader sees it in the same way as you do.

If you want it to lean towards more of a case study that lays out a methodology for others to adopt, it would benefit from more discussion on specifically how this method compares to alternative methods and why you made the specific choices that you did. And any effort to generalize the method is typically appreciated by your audience. Here is a list of questions/comments that you should consider if you want to make the case for others to adopt your method as well as ways to generalize the method:

Following this comment and those of the other reviewer, we have added a lengthy discussion showing how this method relates to other methods. During this process we also generalize the method.

- Make a clear argument for the value of 3D trenching in general, then make the case for how your method will simplify the process for more paleoseismologists to do 3D trenching.
- Does it have to be an iOS laser scanner? (no) What factors might one need to consider if their laser scanner would work for this method? Scanning range? Point density?
- Invoking a term like ‘handheld’ or ‘close-range’ is a simple way to generalize
- Does the laser scanner need to capture RGB values for the points? Can the method be executed without? (seems like it should work) Would anything need to be done differently?
    - I have a long-range handheld lidar scanner that does not capture RGB. I can still ‘see’ markers I’ve placed on the exposure as long as they will produce a strong contrast in intensity - black and white squares in a checkerboard pattern work fine, but the little circle patterns that Agisoft makes for reference markers might be harder to resolve, depending on the resolution.

Added a paragraph to this section describing the accuracy of the iOS scanner and describing requirements for an alternative scanner. The iOS scanner (particularly with newer apps like 3D Scanner App) can produce photo textured 3D surface models with little user input that make this workflow even easier than we describe here.

- Why not do this all with photogrammetry? (It seems that method could be used to capture the overall 3D geometry of the trench exposure in addition to the textured 3D model of the faces)

We’ve added a lengthy discussion comparing the advantages of this method to prior SfM methods (e.g. Delano 2021; Reitman 2015). While not directly answering this question, it should be sufficient. To address this question: in our experience it is really difficult to produce a 3D model of a complicated scene like a trench network with multiple sub-orthogonal surfaces. Getting models to properly align around sharp corners is challenging. Issues like bowl effects and angle/alignment issues resulting from wrapping models around corners become really problematic. Furthermore, without scale bars, a total station or dGPS (which wouldn’t work well in our forested environment) scaling the model properly would be difficult. As mentioned in the new expanded discussion section, scale bars alone don’t mitigate bowl effects (nor these alignment issues).

- The point-matching of point cloud registration seems straightforward - but do you think ICP registration of undisturbed portions of the wall would work as well? Or would that likely be more tedious?

We briefly tried (unsuccessfully) using ICP registration of the SfM models to the lidar scans, but since there is a need to scale and warp these as well as translate & rotate it didn't work very well. We didn't try it for matching lidar-lidar but presumably that could work.

- Try to emphasize the accessibility of using CloudCompare to extract the 3D structural (as opposed to other structural geology software) as a part of your method. Free software! (but, I imagine other point cloud manipulation software can do this as well!) Also, how are the contact line points being extracted? Is there a buffer selection, or is this done manually?

Added verbiage clarifying that CloudCompare is freely available. We manually extracted the contact line points (this was extremely tedious, which is why we only show one displaced feature).

On the other hand, maybe you really just want to show off a cool technique that you used in the course of your paleoseismic investigation.

- A revised title that would place more emphasis on the paleoseismology and dial back the emphasis on the lidar/photogrammetry could look like:
  - 3D paleoseismology on the Dog Valley fault, California, USA, aided by handheld lidar and photogrammetry
  - Improved earthquake timing and displacement constraints for the Dog Valley fault, California, USA, through the use of handheld lidar and photogrammetry
  - Rapid construction of 3D models for improved paleoseismic interpretations, an example from the Dog Valley fault, California, USA

Additional Comments:

- In general, this paper is a tad thin on details. I do like conciseness - it's better than providing some long drawn out story going back to the beginning of the evolution of the Pacific-North American plate boundary when your study is on a single fault, for example, but do look for opportunities to provide more useful geologic and methodologic context for the reader as you're revising the manuscript.
- Most captions could be enhanced with a few more details to help guide the reader to features important to the story.
- There is a mix of active and passive voice throughout the manuscript. Trying to focus on an active voice would tighten up the text (in my opinion…)

I like where this manuscript is going. I think with some straightforward revisions you can eliminate a lot of the 'but what about ___?'-type of questions that popped up while reading the text and make this a widely accessible use case. Then, the next thing for us/our community to figure out is a good interactive online viewer where we can put these 3D trench models in, turn layers on/off, measure things, etc., etc. Something like Sketchfab that doesn't require special software, but is also able to handle higher resolution and more interactivity.

Thanks Sean, we really agree here. We think V3Geo and Lime are the best candidates we have found for this role, but they still lack some features we'd like to see. Another issue is really the lack of 3D functionality in the PDF format.

Below are my comments keyed to lines of the manuscript text. For most of these, I've highlighted the corresponding text in the associated manuscript PDF. I've also made a few minor grammatical suggestions directly in that PDF as well.

Cheers,

Sean Bemis

Line-by-line comments:

Abstract:

Line 23: Awkward phrasing. For one, 'trenching excavations' seems somewhat redundant, especially when followed with another use of excavation at the end of the sentence.

We have rewritten this sentence.

Line 24: Be more specific. Utilizing *what* from lidar and photogrammetry? Something like the following will provide a more complete picture for readers:

- "Here we demonstrate a new methodology using co-registered, photorealistic 3D models derived from an iOS-based laser scanner and structure-from-motion photogrammetry to reconstruct stratigraphy and trace a displaced channel . . . "

Changed verbiage.

Line 30: fault; however, right-stepping

Fixed

Line 37: possibly corresponding with up to an M6.7 earthquake

Accepted this change, but it is difficult to say if this is a maximum magnitude given the propensity for multifault ruptures in the Walker Lane.

Introduction:

Lines 51-53: Could benefit from some more background on modern paleoseismology methods, You could include (e.g., Bemis et al., 2014; Reitman et al., 2015) to substitute for detailed background on SfM-MVS methods in paleoseismology. Also Haddad et al. (2012) for prior use cases of lidar for paleoseismology

Thanks for suggesting these references. As suggested we have added these references as a substitute for a detailed background on SfM methods in paleoseismology. We've also updated the introduction with a bit more background about the methods. We compare our method to these prior studies later in the discussion.

Lines 53-61: The end of the introduction lacks impact. You accomplish two things with this manuscript, a methodological demonstration, and paleoseismic results that demonstrate the value of the new method. You can make a better case for this

We've rewritten and expanded the latter half of the introduction to address both this and the preceding comment.

Geologic Setting:

The first couple paragraphs communicate the key points, but flow could be improved. It would help to start with the bigger-scale context (Walker Lane and its role as part of the plate boundary), then progressively step down to smaller, more detailed components (place the Truckee basin and the Polaris/Truckee/Dog Valley faults in Walker Lane context, then describe details of Dog Valley fault).

As suggested, section was reorganized to move from Walker Lane, to context of the Truckee basin in the Walker Lane, to details of the faults in the basin.

Line 74: What is "this deformation" referring to here. The context needs to be re-established for a new paragraph.

Added clarification "Walker Lane deformation".

Line 85-86: How this sentence relates to the preceding or following sentences is unclear.

Rewrote this sentence and added some detail to make it more clear. This paragraph is summarizing details of other faults in the basin. To make that more clear we combined it with the previous paragraph.

Fault Mapping:

Focusing on active voice, and preferably 1st-person language would help tighten up this section.

Section was updated to emphasize active voice. (i.e. 'Our field observations…' and 'We mapped…', etc.)

Trench Wall Imaging:

This section starts with “Prior to imaging each trench exposure . . . “ prior to your description of how and what you excavated. Describing your excavation strategy first will help your description of imaging procedures make more sense - consider switching the order of this and the following section

Swapped these sections.

Trench Excavation and Imaging Process:

Line 165: Generally I’d like to see the first sentence of a paragraph/section provide context for the rest of the paragraph/section. Noting the presence of a small excavator doesn’t do that here.

Deleted this sentence since it isn’t really relevant.

3D Model Construction:

Line 186-189: This seems more like a footnote than a standalone paragraph. But we don’t typically have footnotes in our articles - so maybe this could be shortened and inserted (parenthetically) in where you mention the use of the SiteScape app up on line 158. Or, if you made a schematic/flowchart of your workflow to supplement the text, it could be added to a caption there. As it is, it doesn’t seem particularly relevant to the 3D Model Construction section.

Agreed that this paragraph is not the best paragragh to start the section. We moved it down in the section to follow the mention of the use of SiteScape as suggested.

Line 190: Be sure to give a shout-out to cloudcompare’s website, and look into citing them - here’s some comments on citations in the CC forums: https://www.danielgm.net/cc/forum/viewtopic.php?f=2&t=146&sid=bdfcb7200a1ba9f830154d9de05dcc6e

We’ve added this reference.

Line 190: ‘lidar scans’ instead of ‘iOS scans’ - because fundamentally, the operating system has little to do with the data

We want to keep iOS scan verbiage since we are trying to highlight the utility of this particular tool and most other handheld laser scanners are much more expensive and/or more difficult to use. We added a note that a similar methodology should be applicable with other laser scanning systems.

Line 191: How did you establish your reference frame? Were you able to directly measure the x,y,z positions of each reference marker based on some arbitrary origin? Or did you survey these points with GNSS or total station? This seems like an important step that must be set up at the outset, so be sure to provide sufficient details.

We used an arbitrary common reference, and added clarifying text. Also added text stating that it could be referenced to real coordinates using GPS.

3D Stratigraphic-Structural Interpretation:

Line 212-213: How did you select these points in CloudCompare? Were the 2D logs draped on the 3D model? Or did you simply look at the 2D log on one screen while grabbing points in 3D on another screen in CloudCompare?

We exported the photo-textured 3D surface models (.obj not orthomosaics) from Agisoft into CloudCompare and aligned them using the point alignment tools in CloudCompare. We did not use the 2D logs/orthoimages except in construction of the 2D logs shown in Figure 5. Adding a note that we did not use the orthomosaics. We then manually selected points along the contacts from the SfM photo-textured 3D surface models.

Line 223-224: This is kinda lost here at the end of the paragraph as the ‘second’ of ‘two different methods for structural analysis’. Can you provide more details? It comes across as a bit of a throw-away here, like - sure, you can do this other thing too if you want…

Added another sentence detailing the method of how the isopach map was constructed.

Paleoseismic Results:

Line 237: Not clear what you mean by a ‘cap of buried meadow soils’. Cap suggests on top, buried suggests *not* on top.

Agreed, we clarified the sentence to indicate that the peats in the stratigraphy were buried soils, and the modern soil caps the exposure.

Line 249: It’s really hard to have more than one ‘most recent earthquake’... Do you mean evidence for a single earthquake, and that it is the MRE, or that there is only one fault trace associated with the MRE, or something else?

Edited text to clarify.

Line 255: please make a more specific connection to which of the three methods you’re talking about here.

Adjusted figure referencing to clarify.

Line 256: Please clarify this statement. Matching strata using that method produces slip estimates between ____.

Rewrote this sentence for clarity.

Line 257-258: could you be more specific? Something phrased like, “We estimate this uncertainty based on . . . “ would be more confidence-inspiring.

Rewrote this last sentence and added another sentence for clarity.

Line 261: should be Figure 5

Fixed

Line 264: I believe this is Figure 6

Fixed.

Line 269-270: Ok, perhaps not surprising for a peat to be out of order. So now, did you just get lucky with the other peats?? Can you describe what the peat you submitted was composed of? Was is just brown/black muck, or where there fibrous plant material? Microchar? If you didn’t have a wood and charcoal sample to bracket those peat ages, I’d especially want to see more description of the sampled material.

More details on the type of material sampled and analyzed was added to Table 1

Line 274: more precisely in the OxCal parlance, a sequence model, right??

This is now clarified as a sequence model.

Line 273-275: This needs to be re-phrased, and should be expanded on. As written, it says that by calibrating the ages, you built a ‘temporal’ model. Instead, you used the relative stratigraphic position of your samples and event horizons to build a sequence model to determine the timing . . .

Reworded as suggested

Line 275: Note, your sequence model in Figure 7 has a pdf for Event 1 that doesn’t reflect the age you describe here. I think it comes out that way with the sequence model as a bit of an artifact of the model construction. You should either put a post-E1 young bounding constraint into your OxCal model code so that it produces a representative pdf, or otherwise annotate the model to show that the pdf shown is the max age of E1 and not the age range.

We redid the model in Figure 7 (now figure 8). You are correct that this was an artifact in how the model was constructed and it has now been corrected following your suggestion.

Line 276: I think this should be Figure 7

Fixed

Line 278: Does this have a unit # assignment? Provide it here.

Added reference to Unit 20 to this line.

Line 278: You could highlight some important nuances here. While perhaps the long-term average sedimentation rate may be low, there seems to have been a high rate of sedimentation around 8000 years ago, and something between very little sedimentation and erosion + soil processes + bioturbation of the top 5-20 cm. Why do you think this abrupt change in sedimentation occurred here? Did the channel that I think I see in the lidar on Figure 3A entrench across the scarp sometime after E1? Also, it could be read as saying that you infer that E1 occurred at maybe 5000 bp (several thousand years after 8000 bp) - whereas I think you mean E1 occurred *within* the several thousand years after 8000 bp, such that your suspicion is the age range could be 5000-8000 bp. Please clarify this text.

Added a few sentences to clarify what the sedimentation rates at the site were like through the Holocene to support the inference that earthquake E1 occurred within a few thousand years after 8 ka but not yesterday.

Line 287: How was this uncertainty determined? I see the input uncertainty on the displacement input. How negligible is the uncertainty of your other assumptions?

The uncertainty in the mag estimate is due to the uncertainty in the displacement input. The other assumptions (length and width) are relatively well constrained based on mapping (lidar does not indicate the fault is any longer) and the results of Rhul et al., 2020. We do not consider a range of seismogenic depths because the data in Rhul et al. (2020) clearly show that the majority of seismic moment release occurs at the base of the seismogenic zone around 17 km (although it shallows to the east into the Basin and Range). ***As it turns out if we assume rupture lengths of 20-25 km, widths from 15-19 km, and the same displacement uncertainty, the magnitude estimate remains 6.5-6.8.***

Discussion:

Lines 295-309: This first paragraph is well suited to the subheading above it, further placing the Dog Valley, Polaris, Truckee faults into the Walker Lane. As presented, none of the data derived in the study particularly contributes to this interpretation - it is an interpretation that exists without 3D models and paleoseismology. But to that effect, it could be used as the set up to regional insights from the new data.

The first paragraph is on conjugate faults accommodating regional deformation, and what follows is just a list of conjugate earthquake sequences. without a clear connection. If you're trying to make the point that the Dog Valley/Polaris/Truckee faults could rupture over a short period of time as a conjugate earthquake sequence, make this argument in the second paragraph, instead of waiting until the seventh and eighth paragraphs of this section to provide that critical context. Then, with that context, you could synthesize what you have in paragraphs 3-5 into a more concise and to-the-point single paragraph, largely citing the work done by others and extracting a few details to support your argument.

We moved the description of the Dog Valley and Polaris faults to the second paragraph and condensed the information in paragraphs 3-5 into one paragraph.

Line 359-361: Wait, are you saying that an earthquake at 13100 bp and at 8400 bp are 'closely spaced in time'. Please clarify, because this doesn't seem right.

Updated text to clarify here. Agreed that this statement is confusing. The 13100 bp date refers to the date of the penultimate event on the Polaris fault from the Melody study. We opted to delete this statement as we do not have a similarly constrained event on the Dog Valley fault.

Lines 366-373: As described in my general comments, this section feels tacked on. I feel like you're trying to emphasize two separate points, 1) the value of 3D paleoseismology investigations, and 2) new methods that make 3D paleoseismology investigations easier, faster, more robust. I'd recommend first highlighting the benefits and challenges of 3D paleoseismic investigations, then swoop in with specific examples of how the method you deploy enables these investigations in a way that is widely accessible. It doesn't have to be a lot, but it should go beyond the assertions of 'greatly enhanced' and 'greatly improved'.

Agreed. We've greatly expanded this discussion section and moved the assertion that the method enhances trenching methods to the end of the section..

Conclusion:

Line 382: What do you mean by 'occurred from'? Between, since, after, before?

Clarified, between.

Line 383-384: But didn't you argue that the MRE on the Polaris and Dog Valley faults have overlapping ranges, and thus could be contemporaneous? You can say here that your data permits the scenario that at least some ruptures on the dog valley occur near contemporaneous with the polaris.

Expanded this sentence to add this possibility.

Figure 1:

- I feel like an inset at least showing this figure location on California would be appropriate here for the international audience.
- Is there a citation for the QFF?

Added both inset & citation for QFF.

Figure 2:

- could you add a “and this study” to the “Trench site of Hawkins et al. (1986)” label?

Done

Figure 3:

- Just as a check - have you verified that the color scale on part D is linear from 0-30?
- The text on the scale bars is really small
- Part A: Are there some simple annotations you can add to help the reader understand the surficial geology here? How about labeling roads/trails and channels?
- Part C: I’d really like to see a 3D perspective of your model, but this one is really hard to interpret. For one, you haven’t provided any orientation guidance. What does the 1.16 in the middle mean? Something with an oblique overhead perspective might be more interpretable for readers who don’t have a fraction of the familiarity that you do.
- Part D: In the caption, finish the thought, “ . . . 110 cm left lateral offset *of the* ______”

Added annotations to A-C. Part C is difficult to show in a 2D format and this is the best we could come up with. Fixed caption for part D.

Figure 5:

- Part B - your RC 40 label is black where the rest are white

This was done to improve contrast/visibility, but we’ve now changed all to black to avoid confusion.

Figure 6:

- This would benefit greatly from more details in the caption. Otherwise, these are just floating orthomosaics with number labels. Keep in mind that some people will try to get most of the story from looking at the captions.

Now Figure 7. **We’ve improved the caption to better explain the method being shown.**

Figure 7:

- It took me an embarrassing amount of time to realize that your Oxcal model is stratigraphically upside down. It'll be much more intuitive if you put the younger samples/events at the top of this plot and the older at the bottom.
- Was this set up as a sequence model in OxCal? Tell us that in the caption. What version of OxCal? What calibration curve did you use?
- Is the code for this model in your supplement?

Now Figure 8. We've reversed the order of the model and clarified that it is a sequence model. We added more details regarding the calibration curve to Table 1.

Table 1:

- What lab were these measured at? Also, please include the standard calibration info that would be required to reproduce these ages as footnotes in the table. Was 13C measured, or is the typical -25 value assumed?
- Wait - you report a modeled age here for RC18, but this sample is not included in the sequence model in Figure 7. Is this simply an independent *calibrated* age? Are the other ages in this column derived from the model results in Figure 7, or are they independently calibrated ages? You might want another column that provides calibrated ages to separate those ages from sequence modeling ages.

Changed the column name to state Calibrated (not modeled) as these are the independently OxCal calibrated ages and added a separate Modeled column. Added 13C values. Cleaned up table formatting and added footnotes for clarity.

Data Availability:

- This is a great start with the orthoimages and fault traces, but the statement "All data used in this study are publicly available and listed below" is not accurate. What you listed doesn't include anything that you used to construct the 3D models of the site, which is the core of this study. The code for the OxCal sequence model is also not available.
- Probably want to clarify that it's the *airborne* lidar data used in the study that is available on OpenTopo, as phone-based lidar scans aren't there.

We added links to a repository with the 3D models and put the OxCal model code text into an Appendix. We clarified that this is the airborne lidar data.

Reviewer #2:

Summary:

In this article, Pierce and Koehler describe the results of a trenching study they undertook on the Dog Valley fault near Truckee, California. They describe their methods for combining photo orthomosaics and lidar point clouds measured using an iPad to create a detailed set of trench photos and measure stratigraphic offset in excavations crossing and parallel to the Dog Valley fault. They present new radiocarbon ages to constrain earthquake timing along the fault and describe two earthquake events observed in their excavations. The authors propose that the Dog Valley fault is part of a possible conjugate strike-slip fault system and may have ruptured contemporaneously with the Polaris fault sometime after ~8 ka.

Overall, I think this work represents a useful contribution to Seismica and is certainly worth publishing. Prior to publishing, I encourage the authors to revise their manuscript to benefit the broad Seismica audience. I had no trouble understanding their methods and results, but a lack of citations, figure annotations, and background information would make this a less accessible paper to other readers outside of the active tectonics field.

My biggest concerns regarding the content are: 1) in abstract and title, the authors suggest that their methods are entirely novel and the focus of the study, but do not provide sufficient comparison to similar methods, and 2) a significant focus of the discussion section of the manuscript is conjugate faulting, but there is no introduction to this topic or its relevance to fault hazard or mechanics prior to line 292.

We've heavily rewritten the manuscript, particularly the introduction and discussion to address these fundamental issues.

With moderate revisions and a slight refocusing of the manuscript's focus, I think this will be a good contribution to Seismica. More detailed comments are listed below.

Line comments:

Line 46: I suggest softening the language a bit here – piercing lines can be found along strike-slip faults without 3D trenching.
Clarified by adding 'subsurface'.

Line 77: Noted some citations are missing regarding prior events along fault system, but found the citations at line 101. Some reorganization may be needed.

Added reference.

Cite figure 2 at line 133 for reader clarity.
Done

Line 146: I suggest reordering the "Trenching Excavation and Imaging Process" and "Trench Wall Imaging" sections for reader clarity, excavation would be more useful before imaging.

Could these two sections be combined? I'd like to know in one these sections how the site was selected for trenching.

Swapped the order of the two sections. We moved text from the introduction to this section that describes the trench site.

3D Model Construction section (line 186):

- I think this section needs more background information on how the proposed methods compare to SfM. As I understand it, you're using the lidar scans combined with the higher resolution photomosaics derived from Metashape to create 3D models of the trench wall. This is different from "standard" SfM, and I think readers who are not familiar with these procedures would benefit from on how what you're doing here is different.
We added an introduction to this section defining and describing the different types of data used and the uncertainties in the scanning. We are using the photo-textured 3D models from Agisoft, which is different from the standard 2D orthophoto mosaics that most people use. Added text throughout this section to clarify

- Following up on the comment above, I think it would be beneficial to the audience if you explain why you chose to undertake this new set of methods, rather using traditional SfM modeling. As described, these methods seem like quite a bit of work for little improvement compared to standard point clouds and Metashape orthomosaics. I don't feel that the case has fully been made here or later in the discussion section that these methods provide significant benefit.
We have greatly expanded the discussion on the methods. We added more background about the other common methods and discussed issues with existing methods. We then compare our method to these prior methods and show how it builds on them.

- I'd like to hear what the specs of your field computer were for completing processing in the field– this has been challenging for other researchers.
I am not sure if this belongs in the text, but most contemporary mid-spec laptops should have no problem field processing SfM data for trenching studies. For field orthomosaic production, and since the orthoimage we're interested in is a mosaic of the photos, the resulting resolution isn't dependent on the quality/point density of the sparse cloud (this is also discussed in Bemis et al. 2014). Thus, low settings on the align-photos step can be used, and a dense cloud (typically the longest processing step) is not required for building an orthophoto. From the sparse cloud one can quickly build a mesh and then orthoimage. The result is quite good and satisfactory for the field. Higher settings can be used in the office if desired, and will result in improved scene geometry. For reference we used a Dell Precision laptop with i7-9850 CPU, 32GB RAM, SSD drive, and Quatro RTX 3000 GPU.

- Line 190: what reference frame did you use? Local? I didn't see much information about how you derived a local reference frame if so. If everything was done using device-internal

GPS/GNSS accuracies, this should be described (as should the associated errors). It seems to me that the lidar is providing you with your referencing – please elaborate on this.
Exactly, the lidar provides us with our local reference frame and everything here is referenced to the lidar. We added text here to detail this use of a local reference frame. The device doesn't actually rely on its internal GNSS accuracy, I don't fully understand the technology, but I believe it relies on its IMU and processing to locate points in an arbitrary local reference frame (the iPad we used doesn't even have a GPS chip). If the iOS device is GPS enabled it can roughly locate the scan using GNSS. The iOS lidar accuracy is explored in the Luetzenburg et al. 2021 paper and we've added text summarizing their results in our discussion.

Line 220: The derivation of piercing lines using the technique you're describing isn't necessarily novel per se, but the "digitized" way you're approaching this derivation is exciting and could be very useful. I don't feel that you highlighted the utility and reproducibility aspects of this approach sufficiently. I don't think your figures are doing your methods justice. Fig 3C attempts to demonstrate the methods, but I don't find it to be very approachable to the reader. The many overlapping red planes make it difficult to understand, and the figure lacks sufficient captioning and annotations.
Unfortunately, and not for lack of trying, we haven't been able to really show the 3D model in a convincing way in a static 2D print format. It works best in a video tour where it can be rotated and layers turned on and off. I think this might be a limitation of journal format that we can't avoid. We have added another new figure and added captions to existing Figure 3C.

Line 223: How did you create the isopach map (figure 3D)? I don't see that included anywhere in the text.
We've added text describing how the isopach map was constructed at the end of the first 3D Stratigraphic-Structural Interpretation section.

Line 229: I don't see how figure 5 demonstrates your "less accurate" backslip model. Did you mean Figure 6?
Yes, typo, now corrected to refer to Figure 6.

Paleoseismic results section, starting Line 234: Your discussion here is good, but I think it would help to annotate your trench photos or interpretations to highlight the key observations. For most readers of Seismica, I don't think that the fault and stratigraphy details will be immediately apparent without some annotation assistance. Examples of trench observations that would be clearer if labeled:
- Earthquake events (e.g., which truncations are correlative with E1 and E1?)
- Sand dike
- Stratigraphic warping (line 241)

Added labels on Figure 5.

Line 241: Your analysis hasn't conclusively demonstrated that there isn't vertical deformation along the fault. Is there a table of offsets or something similar you could cite or include here to help the reader?
Slices A09-A14 clearly show negligible vertical deformation across units 50/60/70.

Line 256: Your uncertainty is the spacing between trench excavations and is not tied to any feature of the stratigraphy. I don't find it to be particularly robust. Is there an uncertainty you could derive from the various lidar scans you created?
The uncertainty reported (115 +/- 30 cm) is based on the midpoint and range of the various offsets that are measured from backslipping (89-146 cm), matching the isopach (110 cm), and matching the 3D piercing point reconstruction (114 cm). We qualify this uncertainty by stating that it is likely reasonable because our resolution is limited by the excavation spacing. We rewrote this sentence to clarify.

Line 266/Event Timing section:
- Some details missing here. No description of sampling methodology. Where were samples processed? Should be in text and summarizing table.

Added sentence and updated table stating that samples were analyzed at Beta Analytic.
- Radiocarbon sample count is low (5). Please discuss why – were you sample-limited in the Trench?

We did not process more samples as the results from these initial 5 were consistent and closely spaced.
Line 281/Paleoearthquake magnitude estimate
- I'm not sure that this section adds much to your assessment. You did not describe any evidence for possible maximum rupture lengths – presumably the 25 km length encompasses one mapped edge of the fault to the other. Nothing in your timing information suggests that whole-fault rupture is a possibility. I am also still uncomfortable with the 30 cm uncertainty estimate. I think you can keep this section, but it needs more details on the assumptions and uncertainties you're making.

We want to keep this section as a magnitude assessment is an important piece of information for people who might want to use this work for other purposes. 25-km is a pretty short surface rupture, and we don't see any evidence suggesting fault segmentation. We really don't know if this fault ruptures with other faults in larger earthquakes, as a full independent fault rupture, or independently in smaller segments, so it is hard to clarify whether this is a maximum or minimum or average magnitude expectation.

- 287: Is the error of 0.1 on 6.7 Mw from your 30 cm displacement estimate?

Yes 0.1 Magnitude error is the result of +/- 30 cm displacement.

Line 292/Discussion section
- This discussion section did not clearly follow the focus of the rest of the manuscript. In particular, the reader is not prepared for the in-depth discussion of conjugate faulting in the Walker Lane before this section. The word "conjugate" appears only once before the discussion

section (line 75), and the mechanical significance of conjugate faulting is not introduced at that time, only mentioned in passing. I encourage the authors to incorporate this theme throughout the rest of the manuscript. A start would be to move the paragraph starting at 295 to the introduction section, but I think a more detailed incorporation is warranted.

- I think the detailed listing of every episode of known conjugate faulting is unnecessary (lines 314-337). I suggest cutting this section down. A more detailed description of the hazard and/or mechanical significance of conjugate faulting would be more beneficial to readers of Seismica.

We condensed the examples of conjugate faulting to one paragraph and also added text pertaining to the influence of conjugate ruptures on rupture on other nearby faults (significance to seismic hazards).

- Paragraph starting at line 338 describes the patterns of cross-fault rupture, but doesn't describe the significance of the pattern differences for the reader. I suggest the authors expand on what these different fault rupture patterns imply. This paragraph also needs citations (Barnhart et al. 2019 and refs therein?).

Added some citations from Barnhart et al., 2019 and suggested that the pattern of potential rupture between the Dog Valley/Polaris faults is supported by the rupture of the Rigan, Iran earthquakes.

- Paragraph beginning at 367: Given the available discussion, I'm not convinced that iOS lidar scanning is a cost or time-effective replacement for standard SfM approaches for most researchers. If the authors want to make this point more concrete, I'd like to see a more detailed comparison between the methods proposed here and SfM results. I find the discussion here to be short compared to the significance placed on the methodology in the rest of the manuscript. The visualization seems promising, but I'm not convinced it's a significant added benefit, particularly because Metashape is still required for the orthomosaic. I would need a more concrete comparison between the methods to agree with the strength of the conclusions presented. The method, however, definitely shows promise.

We've greatly expanded this section and the new discussion should sufficiently address these points.

Figure comments:

Overall, I think all figures except for 1 and 2 need a significant amount of annotation and caption revisions to make them more approachable for the general Seismica audience. More specific suggestions for revision are described below.

Figure 1: Include an index map of California for the reader. Define all acronyms (flt. = fault) in caption.

Added index map, updated caption

How have the faults been modified from Qfaults? Any location data, or simply the color? Qfaults should be included in citations.

We have modified Q-faults in the Tahoe basin (correct mapping of west tahoe fault, deletion of east-tahoe fault) and by adding our mapping of the Dog valley, Polaris, & Truckee faults in the Truckee basin.

Figure 2: I'd personally like to see more up-close details of the various geomorphic features the authors mapped in the lidar. Given the detail described in the text about lidar mapping and geomorphic interpretation, the fault mapped in 3A seems to lack detail– is this a difference in mapping vs. figure resolution?

We prefer not to add many figures detailing the individual fault scarps. The lidar data are freely available and our line mapping is available for download.

Figure 3: Authors should include index indicators in 3A to make it clear what area(s) 3B, 3C, and 3D cover. I believe I can see the excavation lines shown in B in 3A, but I'm not entirely sure they're the same. I'm not clear on what trench excavation or areas 3C and 3D are showing. I discussed my concerns regarding 3C above – this figure is the only one that really address the lidar methods (deriving piercing lines in particular), and it's very hard to interpret. I suggest creating a figure that shows the piercing lines more clearly. Figure 3D looks like a standard geomorphic offset, but I'm interested in the use of the isopach map for the third dimension. I'd like details on how this was accomplished.

Added more labels to this figure. 3C is really difficult to show in a 2D format regardless of how we have tried to plot it. We've added more description of how the isopach map (3D) was produced in the text.

Figure 4: Nice figure. Please include annotations on both sides of the fault (left side of the figure in particular) so readers unfamiliar with trenching have an easier time understanding what they're looking at.
Added labels on the left side of Fig 4.

Figure 5: This strikes me as an appendix figure. Trench photos are lovely! The caption needs more details, and annotations in the schematics are necessary for reader clarity. For the unfamiliar reader, please detail what the various markers visible in the photos are, for example, in A07 and A08.

We have added more labels.

Figure 6: Best methods photo but needs additional detail. Can you show anywhere how the 30cm uncertainty is calculated?

Now Figure 7. 30cm uncertainty is based on the total range of offset estimates.

Figure 7: Could be made clearer for a general audience. Change coloring of Events 1 and 2 to distinguish from age dates. Include the thrown-out date, unless the sample did not survive processing. Per line 269, it appears the sample is out of stratigraphic order, would still be useful to include.

Now Figure 8. This is the plot of a sequence model from OxCal, so we are not sure how to include the excluded age without modifying the model- which then wouldn't work. We are keeping it as-is, but added more text to the figure.

Table 1: There is a lack of detail in the text and table for reporting radiocarbon ages – see Millard 2014 or other reference for current reporting standards. Treatment details in particular are lacking – where were samples processed? What methods? Etc.

Added more information to Table 1.

Table 2: Very glad to see this level of stratigraphic detail included! Text formatting issues are a bit distracting, consider reformatting for consistency.

We have Reformatted Table 2.