Peer Reviewer Comments for Williams et al.

First Round Review Comments

Comments From Reviewer #1:
The manuscript by Williams et al. is a well-written contribution that I feel does an excellent job working with limited age constraints and cautiously extending these results to generate broader interpretations about the fault system and segmented reverse faults. In addition, the authors do a nice job of checking, integrating, and updating previous work done on this fault system using modern datasets and methods.

I have very few suggestions, nearly all grammatical. I think this may be the first manuscript that I've ever scored as 'Accept' following the first review - congrats!

Line 55-56: add 's' to make earthquakes

Line 78-83: by the final usage, I figured out that the use of 'faults' was foreshadowing that what was previously called separate faults are in fact only one fault. I don't think that the usage in Line 78 or Line 81 should include the quotes because you are referring to the prior convention - and if the convention did not use 'faults', it shouldn't be included there. I think the point is made sufficiently in lines 83-85.

Line 151: underlie?

Lines 209-210: I generally encourage authors to avoid the 'unmanned' term here in favor of 'uncrewed' if you still like the 'UAV' acronym. I think 'drone' works just as well. It's not a substantive concern though.

Line 266: " . . from the folding, and thickening of the Unit . . "

Line 299: " . . Section 3.1, the timing's of surface ruptures . . "

Line 416: are you intending 'underlie' to equal 'support' or 'contribute to' in this context?

Figure 1: Caption: I'm not sure what you're saying by 'In (c) surrounding fault names are shown in white.' There are no fault names in white on that panel.

Figure 2: The level of transparency of the aerial image in panel (a) makes the underlying hillshade more prominent than any details of the imagery itself.

Figure 4: 'As for Fig. 3 but for the German Creek trench site' - awkward, as it leads the reader to go back to the other figure to review that caption. I'd suggest just repeating any relevant information that is required to interpret this figure.

Figure 5: why is the vertical scale not indicated on (a)? And why do the photomosaics and log cover different areas? I suspect it might be because the photomosaics are poorly resolved at the bench, but I'd like to see a comment in the caption for why the log covers more area.

Figure 6: same questions as for Figure 5.

Figure 12: Just noting that I have to zoom in to 200% to be able to distinguish between the mean line and gray standard deviation on profiles a-c. Also the axis labels on those plots are really small.

Supplement S1:

- the annotations and axis labeling needs to be bigger for a number of the profile plots

Supplement S2:

- I think you have the essentials in here for the luminescence dating information. However, I often prefer to examine DE data distribution plots, such as radial plots, when authors make arguments about excluding samples as outliers or when samples are out of sequence, to help think about possible causes for the spurious ages. While I don't object with the arguments made in the text regarding choices made with luminescence dates, seeing something like a radial plot helps me to feel like I'm being presented with the full picture.

- I find that the Mahan et al. (2022) article is a handy reference to make sure that everything that needs to be included is accounted for:

Mahan, S.A. et al., 2022, Guide for interpreting and reporting luminescence dating results: GSA Bulletin, doi:10.1130/B36404.1.

Comments From Reviewer #2: Nicolas Harrichhausen

Williams et al. use geomorphic mapping and paleoseismic trenching in conjunction with OSL dating to constrain earthquake ages and slip rates on the Nevis-Cardona fault on the South Island of New Zealand. The trenches were excavated close to previous trenches, but have different results, thus the authors have interpreted that the fault system has a lower slip rate than was suggested in previous work. Additionally, they use their results to assess the possibility of multi-segment ruptures along the fault system, concluding they are unlikely but cannot be ruled out due to data uncertainty.

Given the results and their impact on understanding active faulting and hazard on the South Island of New Zealand, this publication will be a great contribution to *Seismica*. The manuscript could be improved with some further analyses and discussion of the trench

results, and some reorganization of the text to make it easier to read. Therefore I recommend it be returned to the authors for some revisions. Below, I will first highlight my main comments then provide some line-by-line comments and suggestions.

Major comments:

My first major comment concerns the trench interpretation. The descriptions and interpretations of deformation in the trenches are very brief and there seems to be more to interpret. The faults in the Stoney Creek trench are not that well described. The lack of clear measurable offsets in the Stoney Creek trench suggests that most of the deformation was taken up by folding, which is briefly mentioned, and that the main fault is probably buried. Can the shape of the fold, orientation of observed faults, or the trace of the scarp across topography be used to understand to estimate assess the fault dip? Detailed uninterpreted orthophotomosaics of the trench walls should be provided in the data supplement to allow the reviewers and readers to assess the authors' interpretations. Finally, the discrepancy in number of earthquake events is mainly attributed to advances in paleoseismology since the last trenches were excavated. What particular advances could result the different interpretations? The interpretations are based on field observations, so they are not necessarily technological advances. The reproducibility, or lack thereof, in paleoseismic investigations warrants some further discussion as it represents a major source of uncertainty in the data used in seismic hazard analyses. Adding some discussion on this topic could broaden the impact of this publication.

The second major comments addresses the section on vertical separation of the terraces at Drummond and Coal Creeks. This section is fairly hard to follow and the text could use some reorganization. At Drummond Creek, it is not clear if the lower, middle, and upper (or highest?) T1 surface represent different terraces or not? They are separated by risers, suggesting different terraces? The comparison between offsets is does not seem robust, given that there are no reported uncertainties on the offsets. Finally, it is not very clear how the authors conclude the terraces represent two earthquakes.

The third major comment is on the calculation and discussion of slip rates in the Discussion section. Given the number of calculated slip rates, it is hard as the reader to understand which data is being used for each slip rate, and where and when these slip rates were measured. A figure showing slip rate measurement locations and comparing the slip rates could be helpful here. This will help highlight the reduction in slip rate on the western faults of the Otago reverse fault province.

Line by line comments:

Line 13 (abstract): There is a big jump between the first and second sentence and the link between them is not clear. Suggest rephrasing.

Line 21 (abstract): "surface rupture timings from two trenches" - Could change to "to the ages of surface ruptures observed in two trenches"

Line 22: Where does the "Nevis single event" come from? Previous research?

Line 47: citation needed after "multi-fault ruptures".

Line 52: the SHERIFS code is another method of integrating fault segmentation in fault-source models for PSHA (see Chartier et al., 2017, 2019).

Line 135: "speciation of galaxxid fish" - This reasoning might not be familiar to many Seismica readers and some further explanation is required.

Line 152: "T1-T4 surfaces represent alluvial fans" - Why are they labelled as terraces in the map if they are interpreted as alluvial fans, these are different geomorphological features.

Line 168 (and throughout the rest of the manuscript): "degraded surfaces" - Does this mean eroded? If so, suggest changing to eroded throughout the rest of the manuscript.

Line 191: Change "wall" to "walls".

Line 203: For those who are not familiar with OxCal, what does the 'Combine' function do?

Line 207: Using this method, would 2 ruptures <100 years apart be statistically distinct given the uncertainty (both the analytical and epistemic) on the OSL dates and the stratigraphic interpretations?

Line 283: This slope angle is very low, but could it be a result of erosion and was previously steep enough to produce a wedge?

Line 288: Good interpretation, could the scarp have focused the deposition of the Unit 2 gravels (e.g., a small channel formed against the scarp)?

Line 324: "offsets of the Nevis strand scarp" - or "offsets of a geomorphic surface resulting in a scarp"? suggest rewording as it is written as the scarp is offset by another structure.

Line 336: How is the offset in Profile B-B' (0.3 m) comparable to the 0.6 m and 0.7 m in Profiles D-D' and E-E'? It is half the magnitude. Maybe the uncertainties overlap, but these need to be reported.

Line 407: Using the total height of the mountains above the valley floor to estimate offset is ignoring erosion on the mountains? Shouldn't there be a large uncertainty on this value? What evidence is used to say the offset initiated at 4.5 Ma?

Line 426: "low strain fault networks" - could name an example here. Sentence is quite long, suggest breaking it up into two.

Line 438: "SED" needs to be defined. Delete the second use of the word "estimate".

Figures:

Fig. 1: Is panel 1d necessary? It is not clear how it is used to determine throw. It could be moved to a supplement and the space could be used to 1b larger, as it is the main reference figure for the names in the study area. 1c caption: include "underlain by the hillshaded New Zealand..."

Fig. 3c and 4c: There should be an uncertainty reported on the vertical offsets.

Fig.5 and 6: I think the German Creek figure is called in the text first and should be placed first.

Fig. 6: The vertical displacement of Unit 3 could be shown with some bars.

Fig. 9L: Suggest putting the age ranges directly on the figure beside the PDFs.

Fig. 11c: Uncertainties are needed on the vertical displacements. Profile F: What does "water race" mean? The highest T1 is labelled as "Upper" when it is referred to "highest" in the text and in Fig. 11b. Suggest renaming the surfaces to T1a, T1b, T1c.. etc for clarity.

Fig. 12b: Needs a north arrow as it is oriented differently than is shown on 12a.

Fig. 12c: The ridge interpretation is clear for profiles B and C, but there looks like there is vertical separation in profile A. Maybe some more discussion of this is required in the text.

If the authors have any questions about my comments and suggestions they are welcome to contact me directly.

Regards,
Nicolas Harrichhausen

First Decision Letter

Dear Jack Williams, Mark Stirling, Robert Langridge, Govinda Niroula, Ashleigh Vause, James Stewart, Andy Nicol, Ninghseng Wang:

I hope this email finds you well. I have reached a decision regarding your submission to Seismica, "Along-strike extent of earthquakes on multi-segment reverse faults; insights from the Nevis-Cardrona Fault, Aotearoa New Zealand". Thank you once again for submitting your work to Seismica.

Based on reviews I have received, your manuscript will likely be suitable for publication after some revisions.

I have now received two reviews for your manuscript. As you will see, both reviewers are generally positive about the work, and think that it will eventually make for a good contribution as a publication in Seismica. The first reviewer primarily offers suggestions for grammar and clarity, explicitly noting that they feel the science is in excellent shape. The second reviewer is a bit more critical, noting that there are perhaps a few avenues of discussion of the primary data that have gone unexplored, and that the manuscript would be substantially improved by revisiting a few key topics for added nuance. The second reviewer also requests that full resolution, unannotated orthophotos of the trenches be provided such that the readers can better assess the presented interpretations. I concur with the thoughts of both reviewers, specifically with the first in that this manuscript is generally in excellent shape, and with the second that there is perhaps some "low hanging fruit" for discussion that could make for a still stronger publication. As such, I am requesting that you submit a revised version of this manuscript after carefully considering the reviewers' comments.

When you are ready to resubmit the revised version of your manuscript, please upload:

- A 'cleaned' version of the revised manuscript, without any markup/changes highlighted.
- A pdf version of the revised manuscript clearly highlighting changes/markup/edits.
- A 'response-to-reviewers' letter that shows your response to each of the reviewers' points, together with a summary of the resulting changes made to the manuscript.

If you deem it appropriate, please check that the revised version of your manuscript recognises the work of the reviewers in the Acknowledgements section.

Please note that Seismica does not have any strict deadlines for submitting revisions, but naturally, it is likely to be in your best interest to submit these fairly promptly, and please let me know of any expected delays.

I wish you the best with working on the revisions. Please don't hesitate to contact me with any questions or comments about your submission, or if you have any feedback about your experience with Seismica.

Kind regards,

Randy Williams

Second Round Review Comments

Comments of Reviewer #2: Nicholas Harrichhausen
Dear Editor and Williams et al.,

I have received the revised manuscript "Along-strike extend of earthquakes on multi-segment reverse faults; Insights from the Nevis-Cardona Fault, Aotearoa New Zealand" and recommend it be published without further revisions. The authors have done an impressive job responding to my, and the other reviewers earlier comments and suggestions.

I did not notice minor typos or grammatical errors.

Best,

Nicolas Harrichhausen

Second Decision Letter

Dear Jack Williams, Mark Stirling, Robert Langridge, Govinda Niroula, Ashleigh Vause, James Stewart, Andy Nicol, Ninghseng Wang:

I hope this email finds you well. I have reached a decision regarding your submission to Seismica, "Along-strike extent of earthquakes on multi-segment reverse faults; insights from the Nevis-Cardrona Fault, Aotearoa New Zealand". Thank you once again for submitting your work to Seismica.

I have now received additional reviewer input on your revised manuscript. As you can see, the reviewer is satisfied with the changes made in response to their comments. We are just about ready to proceed forward with publication. When convenient, please compile fully editable versions of your manuscript text within one of Seismica's templates (.docx or latex) and upload them as a revision along with high resolution versions of all figures. Once I have received those, I will officially accept your manuscript and pass it along to the copy editing team.

Thank you again for considering Seismica for publication of your work. I look forward to seeing this in print.

Cheers,

Randy Williams