EGUsphere, author comment AC2
https://doi.org/10.5194/egusphere-2022-643-AC2, 2023

Reply on RC2

Colin K. Bloom et al.

Author comment on "Earthquake contributions to coastal cliff retreat" by Colin K. Bloom et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-643-AC2, 2023

Dear Professor Murray-Wallace,

Thank you for your constructive comments. We have responded to your suggestions below (our responses are in italics), and we have made some additional changes to the manuscript.

This is a very interesting manuscript on the nuanced issue to quantifying historical records of coastal cliff retreat based on an example from the Conway Flat area on the South Island of New Zealand. The manuscript is well-written and addresses many of the conceptual and methodological issues of quantifying coastal cliff retreat from time-series images.

For people unfamiliar with the area, it would be nice to have a few photographs illustrating the general nature of the coastal cliffs. This would help in part to understand the physical nature of the cliffs and for the reader to infer potential coastal processes responsible for the changing form of the cliffs through time. This would be good particularly for people unfamiliar with this coastal sector.

We agree that additional photos may add value for some readers and have included a selection of photos in Appendix C. Figure 6 in the manuscript includes before and after photos from the 2016 Kaikōura earthquake that should allow more expeditious readers to evaluate the nature of the Conway Flat cliffs.

The manuscript could potentially be strengthened by some description and discussion of the inherent structural integrity of the lithological units on which the cliffs have developed. Apart from the deltaic succesions, can some commentary be made about the other bedrock units in terms of the broad, regional-scale structural characteristics such as fault , joint or cleavage density and trends? Some discussion on whether some lithologies

breakup in a predictable manner or in a more random fashion? - Unilinear or non-linear response to strain irrespective to earthquakes?

Some additional information on the underlying Greta formation bedrock will be added to the manuscript in section 2.2: "At Conway Flat, situated between the Conway and Waiau river mouths (Figure 2), weak Neogene Greta Formation mudstone (Uniaxial Compressive Strength <2 MPa) with massive near horizontal bedding (Rattenbury et al., 2006; Massey et al., 2018) is overlain by…" and section 5.1 as follows: "In the Kaikōura region and across New Zealand, failures in tertiary sediment including the Greta Formation mudstone tend to occur as large planar slides often failing along preferentially oriented bedding planes (Pettinga, 1987; Mountjoy and Pettinga, 2006; Singeisen et al., 2022) or as shallow debris avalanches in more weathered sections of the rock mass (Massey et al., 2018). We do not observe evidence of planar sliding at Conway Flat over the historical record and most retreat of the underlying Greta formation appears to result from shallow debris avalanching, observed in some aerial imagery, alongside more gradual erosion due to wave action."

Perhaps modify Section header 5.1 as 'Geology' is a discipline rather than a descriptor of bedrock characteristics or lithologies.

We will modify the Section 5.1 header to read: "Cliff Retreat and Lithology"

I wondered if some commentary can be made where the sediment ends up post cliff collapse? It may be useful to have some commentary on this matter. Does the sediment end up on the continental shelf below storm weather wave base, or is it in part, transported along shore? If the latter, does beach nourishment protect the backing cliffs in some localities.

The nature of sediment transport at Conway Flat is an interesting question with no clear answer given our current analysis. Targeted field and remote sensing investigation, largely beyond the scope of this work, would likely be required to robustly evaluate sediment transport along the Conway coast. This being said, we do believe that this is an important topic to acknowledge, and we will add the following text in Sections 1 and 5.2 respectively:

"The response of individual coastal cliffs to sea level rise is complicated by a range of feedbacks and site specific conditions, for example changing beach volume, the transport of failed material from more erosive sections of coastline, and cliff material strength (e.g., Dickson et al., 2007; Ashton et al., 2011) as well as by the temporal variability of cliff retreat (e.g., Hall et al., 2002; Hapke and Plant 2010)."

"The extent to which storm surge from events like Ex-tropical cyclone Gita (Figure 7) and

variability in longshore sediment transport (Larson and Kraus, 1993; Dickson et al., 2007; Karunarathna et al., 2014) influence the removal of failed debris at Conway Flat remains largely unclear due to our limited number of image epochs…".

I also wondered if it is appropriate to have some commentary on the general aspect of the coastline at a more detailed level to consider contrasting wave attack and erosion? Are some sectors of the coastline more prone to erosion, therefore increasing the likelihood of coastal retreat irrespective of the influence of earthquakes?

Aspect of the coastal cliffs at Conway Flat likely has some influence on wave attack and erosion. In concert with variability in lithology, this may help to explain some local variability in retreat rate but does little to explain widespread retreat observed following earthquake events. We will add the following text in Section 5.1. as follows: "Likewise, local aspect of the cliff face in relation to variable incoming wave direction may influence the rate of cliff retreat but information on changes in wave direction through time are unavailable."

Line 393 - can some supporting information be provided about the validity of the estimate of long-term cliff-top retreat?

As discussed in more detail in our response to Reviewer 1, we will change 'long-term' to 'multidecadal' throughout the manuscript as this better represents the timescales over which cliff-top retreat may vary from overall cliff position. Given the average return interval of shaking at Conway Flat (c. 50 years), including retreat from two earthquakes is unlikely to be representative of true multidecadal retreat.

Line 406 '... compared with retreat ...'

We will revise this statement accordingly.

Indicate place name 'Conway Flat' on Figure 1.

A label will be added.