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Interactive comment on "Development of a multi-method chronology spanning the Last Glacial Interval from Orakei maar lake, Auckland, New Zealand" *by* Leonie Peti et al.

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We thank Referee #3 for their constructive and helpful review and address the raised points below. RC3 = reviewer comment from reviewer 3. C1-C16 = comments 1 to 16 followed by our response.

General comments (RC3-C1) Test of the model: The authors do an admirable job of stitching together the various chronological threads. However, I would like to have seen a test of the age-depth model. If this were published with a pollen record, for instance, we could see if the appearance of critical taxa corresponds with other records from the northern North Island. As is, the reliability of the reconstruction is hard to gauge. One

option could be to remove a tephra, run the model, and compare the model's estimated age of the tephra to the tephra's actual age, then repeat. Response to (RC3-C1): Unfortunately, publishing a pollen record alongside the age model is beyond the scope of this paper. However, this is also somewhat circular since if we were to only trust the age model if it matches the ages inferred from expected ages of changes in proxies (i.e., MIS stages) we would fail to recognise local variability so that the inferred model age-proxy correlations are in error. The test via removing tephra ages and comparing the modelled age to the published age is part of a paper currently in review in New Zealand Journal of Geology and Geophysics (alongside resulting new tephra ages for previously undated tephra layers) but gives a high degree of confidence in the age model. It also doesn't work for a long section of the record where no (previously dated) tephra layers were found. In order to avoid inflating the current manuscript even more, we decided to use the investigation of the resulting sedimentation rates in comparison with the lithology as the test for the age model's reliability.

(RC3-C2) Dynamic time warping: This is an interesting technique that I have not seen applied to matching proxy records. While creative, I wonder about the heavy-handedness of the warping function on the original data. The stepwise pattern in the RPI data implies the algorithm expands and compresses the record quite regularly. Further, the VADM reference curve is interpolated from a data point every 1000 yr to 200-yr resolution. All of this results in an uncertainty that is seemingly not transferred to the age-depth model. The stock +/- 1000 years does not seem realistic given the uncertainty of the Rotoehu. The authors should consider a meaningful exercise in quantifying this error. Perhaps randomly sampling 13 data points could be repeated multiple times to estimate uncertainty? From a different angle, are there RPI measurements from the top 40 m? If so, the DTW technique could be compared to the chronology established with radiocarbon and tephrochronology. Response to (RC3-C2): The manuscript urges the need for more realistic errors already in point 2 of section 6 (conclusions) but we expand on this in section 5.1 (as a weakness of the age model). We have updated the errors on the tuning points to reflect the match from the DTW alignment (compare new

Fig. 8; Tab. 5) such that points that are matched to more than one age have a higher uncertainty spanning the range of ages that they are matched to. Repeated sampling of the points will result in various points over the same curve but not produce different age estimates for the same depth point (which would be necessary for the uncertainty). As stated in section 3.4 there are no RPI measurements above 40 m depth as the sequence contains frequent basaltic tephra layers that obviate development of a reliable paleomagnetic signal from this section of the sequence.

(RC3-C3) Changing sedimentation rate: I think strong caveats need to be stated when highlighting the major trends in sedimentation rate. The authors rightly point out that the changes are not strongly related to stratigraphy. However, change in sedimentation rate is related to a change in dating technique (from RPI matching to radiocarbon and tephrochronology). Response to (RC3-C3): We have added the following paragraph to section 4.8 "The stepwise increase in sedimentation rate at $\sim$ 45 m nearly coincides with the change in chronometer from RPI tuning points to tephra and 14C ages. Whilst we cannot entirely disprove an influence of the chronometer change on the increase in sedimentation rate, we do note several observations that support this sedimentation rate change to be method-independent: (1) It is a stepwise change not a sudden change at the exact change point in chronometer. (2) In the interval where both chronometers overlap, albeit very short, the Rotoehu tephra and the uppermost RPI running point agree well (Fig. 8). (3) The increase in sedimentation rate does occur at the transition from facies unit 8b to 8a. These sub-facies differ in their colour contrasts between the laminations potentially indicating slightly different chemical composition, thus a slightly different depositional context which may well agree with a different sedimentation rate. (4) Further changes in sedimentation rate, even larger in magnitude than at $\sim$ 45 m occur at other positions in the sediment sequence independent of strong lithological/facies changes (and independent of chronometer changes) such as at $\sim$39 m and within facies unit 4 (Fig. 9)."

(RC3-C4) Reservoir effect: If this was a known problem, then why only have two cou-

plets of macrofossil/tephra and bulk sediment? It is beyond the scope to resample in the current paper, but perhaps more extensive comparisons between macrofossil and bulk sediment ages would be worth investigating in a future publication. Response to (RC3-C4): This was, unfortunately, not known beforehand. The couplets of dates were intended to show that this is no/a minor problem but gave a larger difference than expected. More couplets however are very difficult to achieve (over the entire sequence/in representative places) as no macrofossils were found in long parts of the record within the limit of radiocarbon dating.

(RC3-C5) SHCal20: Given this will be the age-depth model for many proxy records to come, along with associated inter-hemispheric comparisons, I reluctantly suggest the authors recalibrate their age-depth models with this new curve. Response to (RC3-C5): The age model has been updated using SHCal20.

Specific comments

(RC3-C6) Define "high resolution" Response to (RC3-C6): (sedimentation rate above $\sim$1m/ka) added to abstract

(RC3-C7) Typically, errors are reported as 2 sigma, but here they are reported as 1 sigma. Please explain why this is the case or change to 2 sigma. Response to (RC3-C7): Thank you for catching this, they were actually reported as a mix of both depending on how the respective literature reported them and because input values to Bacon are required to be 1 sigma. We have now changed them all to 2 sigma (or 95% confidence ranges).

(RC3-C8) Hyphenate units and value when acting as adjective. E.g., change, ": : :using wireline drilling in 1 m-length sections" to ": : :using wireline drilling in 1-m sections". Response to (RC3-C8): Changed.

(RC3-C9) P1L30: Change "spall" to "span" Response to (RC3-C9): Changed.

(RC3-C10) P2L45: New Zealand does not need to be possessive Response to (RC3-

C10): Removed possessive " 's ".

(RC3-C11) P3L85: Delete "of" before "paleoclimatic" Response to (RC3-C11): Deleted "of".

(RC3-C12) P3 Regional setting: Influx of erosional material is often invoked as a confounding factor throughout the manuscript. However, the catchment of Orakei is very small and crater wall slumps were presumably removed from the stratigraphy. Please explain potential sources of the erosional influx. Response to (RC3-C12): The crater is the catchment but undetected (small) debris flows from the crater wall were invoked as a reason for potentially problematic data whilst larger flows have been removed from the stratigraphy.

(RC3-C13) P7L274: Add ")" after "Accumulation model" Response to (RC3-C13): Added ")"

(RC3-C14) P8L316: Change ": : :as identified by (Molloy et al., 2009): to ": : :as identified by Molloy et al. (2009)" Response to (RC3-C14): Changed as suggested.

(RC3-C15) P16L648: Delete second "associated" Response to (RC3-C15): deleted first "associated" as it preserves the flow of the sentence better.

(RC3-C16) Figure 8: Interestingly, the age-depth model underestimates most radiocarbon dates between the Rotorua and Okareka tephras and overestimates most ages between the Okareka and Rotoehu tephras. Any thoughts on this? Response to (RC3-C16): See discussion of the outliers in the manuscript. The interval between Rotorua and Okareka is dominated by fluvial inwash following a crater rim breach by a stream which has likely transported macrofossils of an older age into the lake basin. The younger-than-the-model ages between the Okareka and Rotoehu tephras may have to do with small sample masses as larger macrofossils could not be found and thus smaller samples had to be used and/or with not fully captured reservoir corrections. The Okareka age is not as well constrained as the KOT age, an adjustment of the

Okareka age would potentially allow the model to include more of the older-than-the-model ages but 1) at this stage we have no indication that the used Okareka tephra age is in error and 2) it would still mean that several clearly too old outliers remain in the fluvial facies.

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