General Comments

Higgins et al. show that New Zealand tree rings can indeed record past volcanic events. They effectively address the research questions they set out to answer. They find that the nature of the response to volcanic dimming varies across species, categorizing species as either "fast responders" of "stress tolerant." With this mixed response between species, they find that site-related factors are more important to the displayed volcanic response in tree-ring width. They additional develop two austral summer temperature reconstructions for New Zealand, which show evidence of cooling from past volcanic events. The response to past volcanic eruptions in these reconstructions shows good agreement with climate model temperature anomalies following volcanic eruptions. The authors competently shows that New Zealand tree-ring width is a reliable regional indicator of volcanic climate response. They add further nuance however and underline the importance of species/site selection, which will be very useful for future studies in this region that wish to optimize sample selection. I believe this publication is fit for publication after minor revisions and will be useful to the research community.

Thank you for your review. Please find the responses to your specific comments in blue below.

Specific Comments

In general I think you need to be more specific with the use of the term "dimming". I'm assuming you're using this term to refer to the increase in SAOD but this should be clearly stated to avoid confusion. The "dimming" term is used throughout the text as a catch all for the effects that could affect tree-ring width, but add specificity where you can. There also needs to be more discussion on the effect of light availability changes, or dimming, and how it could effect final tree-ring width. Particularly in your discussion of the kauri growth benefit (line 393-394). Line 62-63 is another part of the text with opportunity to add more discussion on effects of radiation changes from volcanic eruptions. Here are some references you could use to expand this discussion:

Robock, A. (2005). Cooling following large volcanic eruptions corrected for the effect of diffuse radiation on tree rings. Geophysical Research Letters, 32(6). https://doi.org/10.1029/2004gl022116
Tingley, M. P., Stine, A. R., & Huybers, P. (2014). Temperature reconstructions from tree- ring densities overestimate volcanic cooling. Geophysical Research Letters, 41(22), 7838– 7845.

Thank you for the comment and additional references. In terms of dimming, we will clarify wherever possible whether we are referring specifically to the increase in SAOD or to cooler temperatures because of dimming.

Our assumption that kauri receives a growth benefit from decreased evaporative demand following volcanic events is due to previous studies using dendrometer bands and the results of this study. Fowler et al. (2005) show that kauri growth rates are greatest over the austral spring (Sept-Nov), declining steeply over the summer months when evapotranspiration exceeds precipitation. Their results are not entirely consistent with an earlier study by Palmer & Ogden (1983), which showed peak growth continuing until the mid-summer before declining steeply. However, the sites included in Palmer & Ogden were at a higher altitude (245–720 m) than the site in Fowler et al., which could explain the delay in timing. Critical to our moisture stress hypothesis, Palmer & Ogden did not see a summer cessation of growth in their highest altitude site, Mt Moehau, which receives moisture from condensation and fog drip as well as rainfall. This additional information should be included in the discussion to support our assertions.

Nevertheless, we agree with the reviewer that our discussion neglects the potential benefit of light availability changes, which should also be included.

Line 109-114 How robust is this event list? Is there a secondary dataset you could use to test? Would you get the same events with the same SAOD thresholds? If there isn't a comparable dataset, I'm not too concerned with this, but I think the choice of this dataset over potential others needs to be explained if it can change the final list of events used.

Yes, other datasets exist, for example, Crowley & Unterman (2012) and Gao et al. (2008). We used Toohey & Sigl (2017) as it is the most recent compilation of ice core data and has been used in other tree-ring studies of volcanic impacts, e.g., (Rao et al., 2019; Zhu et al., 2020). Here, we compare the event selection from our study with the SAOD estimates of Crowley & Unterman. We have not used Gao et al. for comparison because their spatially resolved dataset is provided as stratospheric loading and needs to be converted to SAOD. Selecting suitable conversion parameters for this dataset is beyond our expertise.

Crowley & Unterman provide their estimates of SAOD in two latitudinal bands for the Southern Hemisphere (0-30°S and 30-90°S), and thus we cannot select the same regional threshold (30-50°S) used in the main paper. Instead, we have chosen the Southern Hemisphere average across the two bands, as this was the most consistent with our original threshold. As Table 1 shows, event selection between the two datasets is largely consistent. Potential reasons for the differences, including the underlying ice core data and differences in methodology, are discussed in Toohey & Sigl (2017).

Table 1 - Comparison of event years selected from two ice core datasets.

Eruption date (month/year)	**Eruption**	**Toohey & Sigl (30-50°S)**	**Crowley & Unterman (0-90°S)**
1441	Unknown	*Not selected*	> 0.04
1452	Kuwae	> 0.04	*Not selected*
1457	Unknown	> 0.08	> 0.08
2/1477	Bárðarbunga	> 0.04	> 0.08
1588	Unknown	*Not selected*	> 0.04
1595	Unknown	> 0.08	> 0.08
2/1600	Huaynaputina	> 0.08	> 0.08
1620	Unknown	> 0.04	> 0.04
†12/1640	Parker	> 0.08	> 0.08
1653	Unknown	> 0.04	*Not selected*
1673	Gamnokara	> 0.04	> 0.08
1694	Unknown	> 0.08	> 0.08
1761	Unknown	> 0.04	*Not selected*
5/1783	Grímsvötn Asama	> 0.08	*Not selected*
1804	Unknown	*Not selected*	> 0.04
1809	Unknown	> 0.08	> 0.08
4/1815	Tambora	> 0.08	> 0.08
1831	Babuyan Claro	> 0.04	Not selected
1/1835	Cosigüina	> 0.08	> 0.08
†12/1861	Makian	> 0.04	> 0.04
8/1883	Krakatau	> 0.08	> 0.08
10/1902	Santa Maria	not modelled	> 0.04
3/1963	Agung	not modelled	> 0.08
3/1982	El Chicon	not modelled	> 0.04

In Figure 1, we compare the two NZ temperature reconstructions using both datasets. There are some differences, as can be expected from averaging over a different subset of events, most notable a larger response to the Toohey & Sigl event list in b). There are also some issues with the compositing in c), with values in the normalisation period not close to 0, due to the small number of events in the Crowley & Unterman event list and noise in the NZall reconstruction. However, the results are unchanged; the NZ temperature reconstructions significantly respond to volcanic events in year t+1.

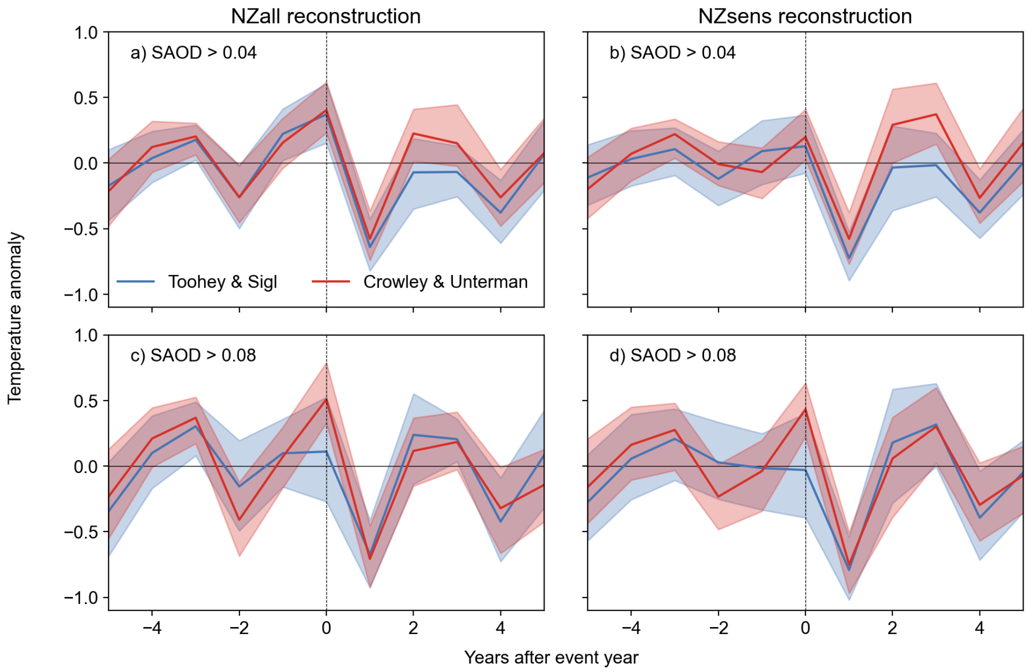

Figure 1 - Comparison of SEA analysis using the two event years sets (Table 1) for the NZall and NZsens reconstructions.

We believe that we have adequately accounted for the uncertainty around event selection by calculating confidence intervals as described in lines 162-165 of the main manuscript. We used bootstrapping to calculate the confidence intervals from 1000 replications of a subset of the events selected under the two SAOD thresholds. Note that as there are fewer events in Crowley & Unterman, the confidence intervals for eruptions with SAOD > 0.08 were constructed from only 200 bootstrap replications. This analysis provides an indication of how selecting a different event list could have affected the results.

Line 438-439 You need to support the statement that sites with high exposure to prevailing winds are more sensitive to low growing season temperatures, either from the literature or from your own analysis.

Line 444 Similar to the point above, you need to support this statement.

These points are made in reference to the conditions at the individual kauri sites, and this can be made clearer. However, evidence to support the lower sensitivity of sites experiencing mesic conditions and closed-canopy forests can be added with reference to Phipps (1982), and many previous studies support the difference in climate sensitivity due to aspect (e.g., Dang et al., 2007), especially when windward sites are exposed to prevailing winds (e.g., Rozas et al., 2013).

Figure 1 Add a legend for the elevation. This is important context for your conclusions as elevation is an important site characteristic.

An elevation legend can be added. Also, in response to RC1 and CC1, we have proposed the addition of a table of site metadata, which will allow readers to cross-reference the results with the coordinates and elevation data.

Figure 3 Caption "...the number of chronologies are shown in brackets/square brackets." Make it clear which bracket type refers to which chronology. Adding the word "respectively" will work.

Agreed.

Technical

Line 22 proxy --> site/species Using proxy sounds like you are expanding into non tree- ring proxies like coral for example.

Perhaps 'chronology' is best to capture both sites and species.

Line 46-49 Awkward sentence structure

This can be revised to improve readability, a proposed change to:

There are several potential explanations for the considerable discrepancy between proxy reconstructions and climate models in the Southern Hemisphere. These include the underestimation of the moderating effects of the ocean on post-eruption cooling in climate models, changes to the hydrological cycle in response to volcanic cooling, uncertainties in volcanic forcing data, and/or proxy noise and spatial distribution (Neukom et al., 2018; Zhu et al., 2020).

Line 51-52 tree-ring data

Agreed.

Line 89 proxy --> site/species

As per line 22, propose a change to 'chronology'.

Line 114-115 awkward sentence structure

This can be revised to improve readability, a proposed change to:

The SAOD magnitude corresponding to a substantial temperature response is unknown before analysis. However, selecting a magnitude post-analysis based on the observed response risks biasing the results (Haurwitz and Brier, 1981). Therefore, two different SAOD thresholds were selected.

Line 140 specify season

Agreed, DJF to be specified.

Line 436 add a call to Figure 5

Agreed.

Line 458-460 awkward sentence structure

This can be revised to improve readability, a proposed change to:

We expected to find a substantially greater volcanic response in NZsens compared to NZall. However, while NZsens does show a larger post-volcanic temperature response, the overlap in the confidence intervals for both reconstructions indicates that the difference between their responses is not significant.

Line 478 MDX-->MXD typo

Yes, thank you.

Line 482 Add call to Figure 7

Agreed.

Line 508 proxy --> species/site

Agreed.

References used in this response

Crowley, T. J., & Unterman, M. B. (2012). Technical details concerning development of a 1200-yr proxy index for global volcanism. *Earth System Science Data Discussions*, *5*(1), 1–28. https://doi.org/10.5194/essdd-5-1-2012

Dang, H., Jiang, M., Zhang, Q., & Zhang, Y. (2007). Growth responses of subalpine fir (Abies fargesii) to climate variability in the Qinling Mountain, China. *Forest Ecology and Management*, *240*(1–3), 143–150. https://doi.org/10.1016/j.foreco.2006.12.021

Fowler, A. M., Lorrey, A., & Crossley, P. (2005). Seasonal growth characteristics of kauri. *Tree-Ring Research*, *61*(1), 3–19. https://doi.org/10.3959/1536-1098-61.1.3

Gao, C., Robock, A., & Ammann, C. (2008). Volcanic forcing of climate over the past 1500 years: An improved ice core-based index for climate models. *Journal of Geophysical Research Atmospheres*, *113*(23). https://doi.org/10.1029/2008JD010239

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Rozas, V., García-González, I., Pérez-De-Lis, G., & Arévalo, J. R. (2013). Local and large-scale climatic factors controlling tree-ring growth of Pinus canariensis on an oceanic island. *Climate Research*, *56*(3), 197–207. https://doi.org/10.3354/cr01158

Toohey, M., & Sigl, M. (2017). Volcanic stratospheric sulfur injections and aerosol optical depth from 500BCE to 1900CE Matthew. *Earth Syst. Sci. Data*, *9*, 809–831. https://doi.org/10.1108/eb058541

Zhu, F., Emile-Geay, J., Hakim, G. J., King, J., & Anchukaitis, K. J. (2020). Resolving the Differences in the Simulated and Reconstructed Temperature Response to Volcanism. *Geophysical Research Letters*, *47*(8), 1–12. https://doi.org/10.1029/2019GL086908