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Do Southern Hemisphere tree rings record past volcanic events? A case study from New Zealand

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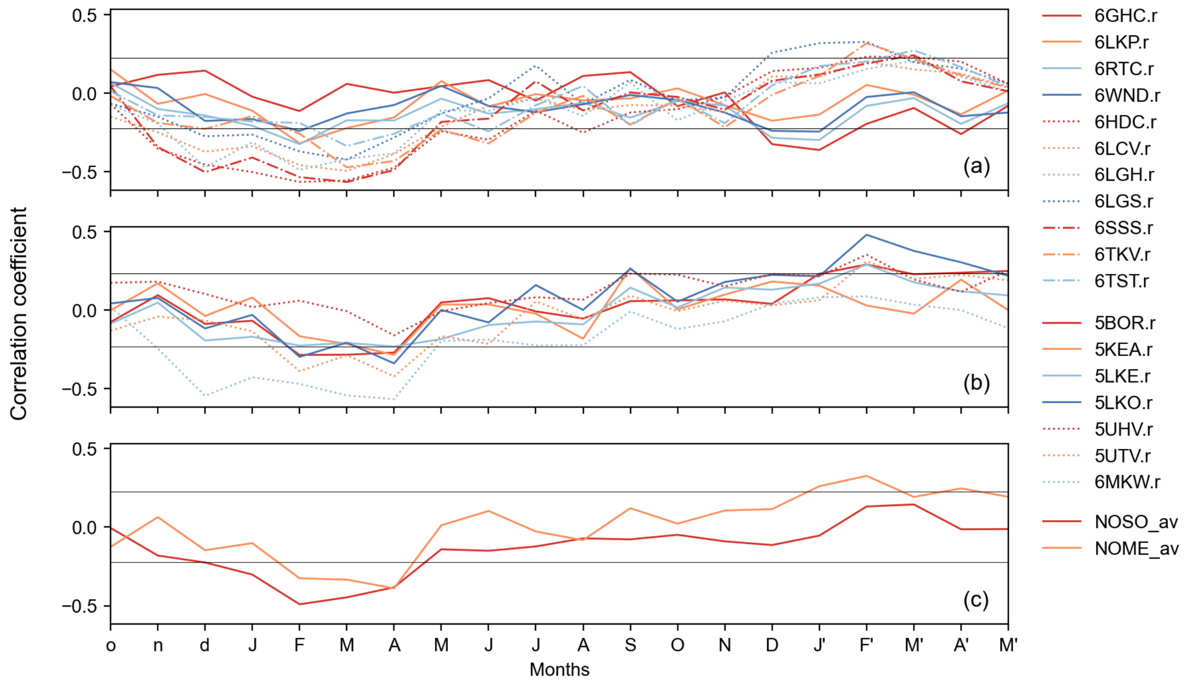

Figure S1 – Correlation between beech ring widths and monthly New Zealand seven-station average monthly temperature from for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season: a) Mountain beech (*Fuscopora cliffortioides*), b) Silver beech (*Lophozonia menziesii*), c) Average of all mountain beech chronologies (NOSO_av) and average of all silver beech chronologies (NOME_av). Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 73$ for mountain beech, $n = 78$ for silver beech) although series have different lengths and thus thresholds for significance.

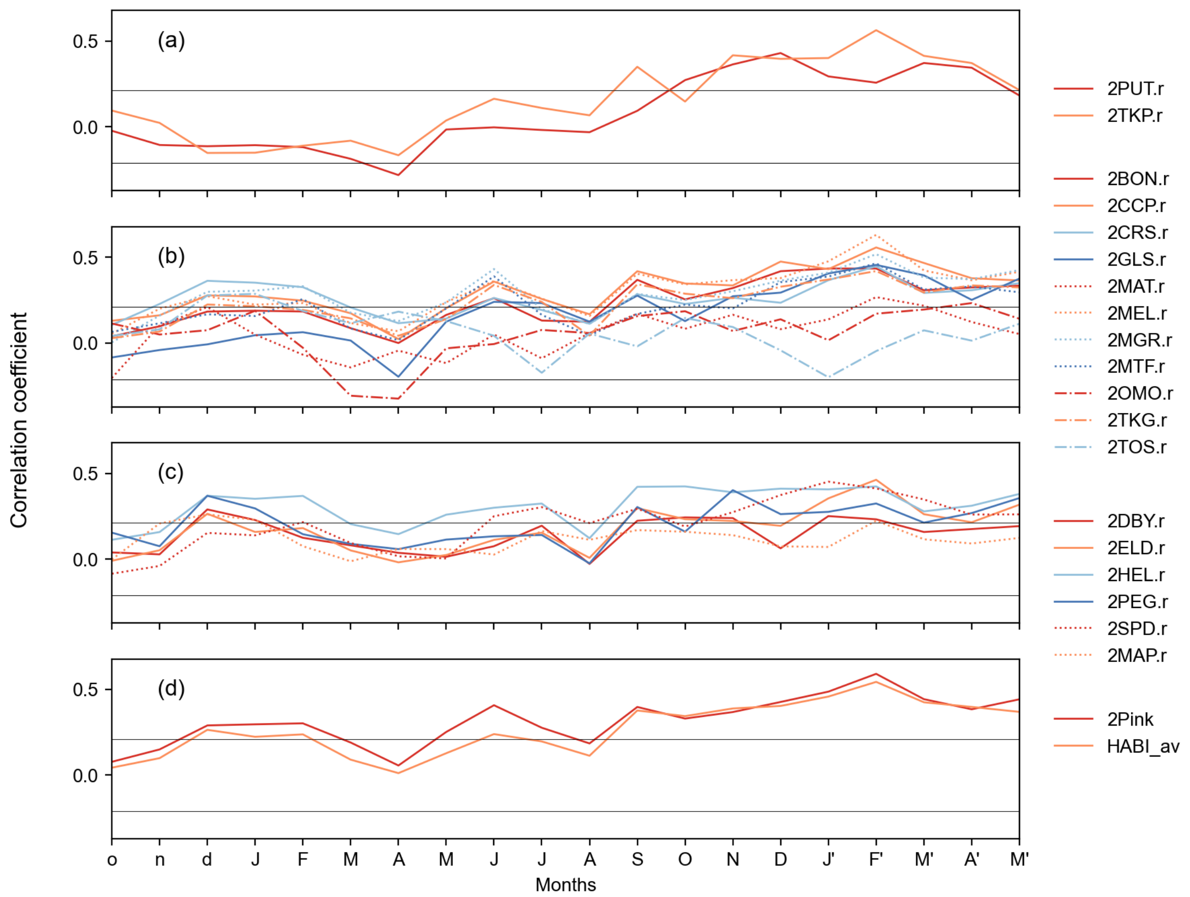

Figure S2 – Correlation between pink pine (*Halocarpus biformis*) ring widths and monthly New Zealand seven-station average monthly temperature for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season: a) Chronologies from the North Island, b) Chronologies from the western coast of the South Island, c) Chronologies south of latitude -45° on the South Island, d) Pink pine master chronology (2Pink) and average of all chronologies (HABI_av). Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 87$) although series have different lengths and thus thresholds for significance.

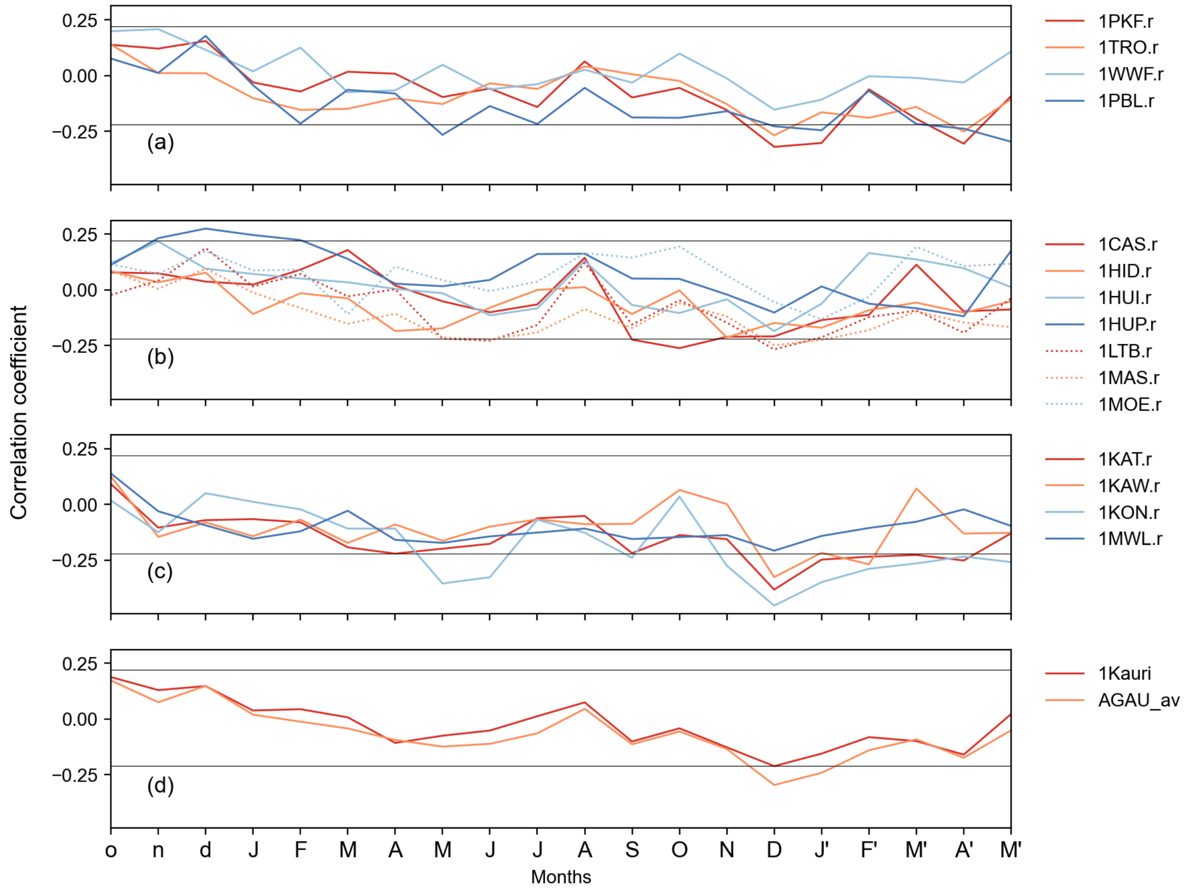

Figure S3 – Correlation between kauri (*Agathis australis*) ring widths and monthly New Zealand seven-station average monthly temperature for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season: a) Chronologies north of latitude -36° on the North Island, b) Chronologies south of -36° but north of 37°, latitude c) Chronologies south of -37°, d) Kauri master chronology (1Kauri) and average of all chronologies (AGAU_av). Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 80$) although series have different lengths and thus thresholds for significance. Chronologies 1HUI.r, 1MOE.r, and 1MWL.r are not significantly correlated with New Zealand average temperatures in any month. Chronology 1WFD.r does not overlap with instrumental temperature and is not plotted.

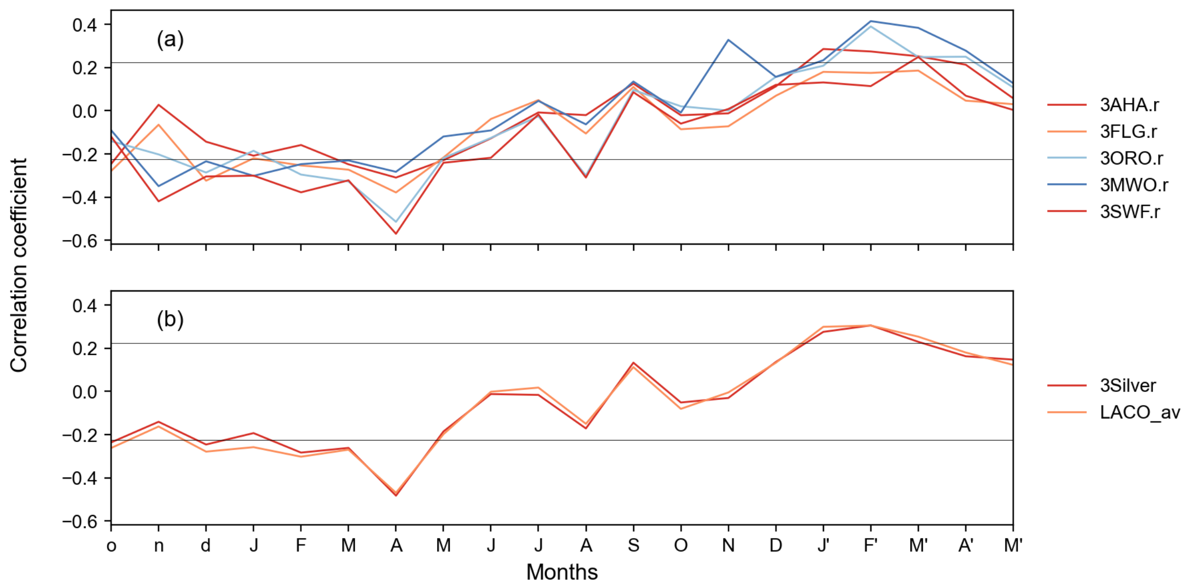

Figure S4 – Correlation between silver pine (*Manoao colensoi*) ring widths and monthly New Zealand seven-station average monthly temperature for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season. a) All silver pine chronologies, b) Silver pine master chronology (3Silver) and average of all chronologies (LACO_av). Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 78$) although series have different lengths and thus thresholds for significance.

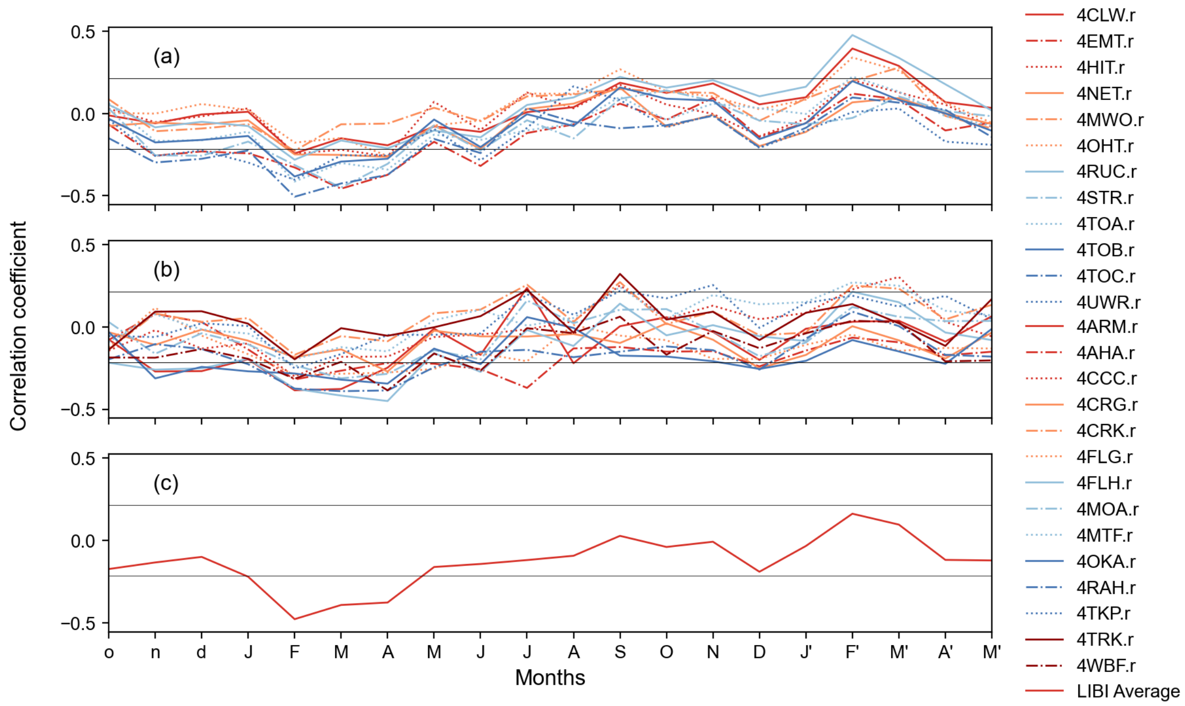

Figure S5 – Correlation between cedar (*Libocedrus bidwillii*) ring widths and monthly New Zealand seven-station average monthly temperature for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season: a) Chronologies from the North Island, b) Chronologies from the South Island, c) average of all cedar chronologies. Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 84$) although series have different lengths and thus thresholds for significance.

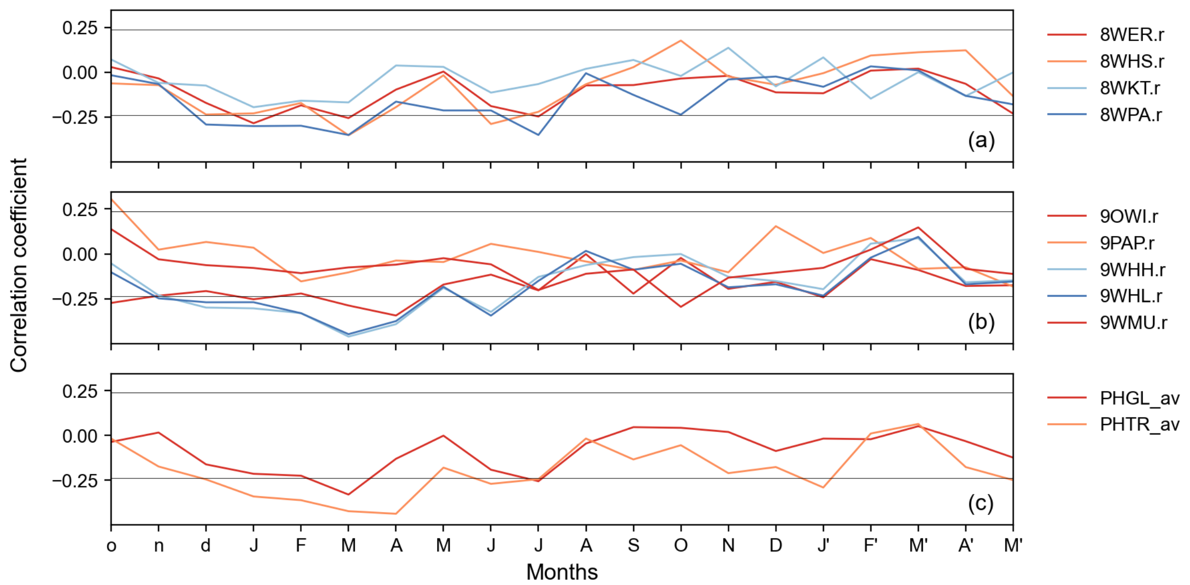

Figure S6 – Correlation between *Phyllocladus* ring widths and monthly New Zealand seven-station average monthly temperature for the 20-month window extending from October of the previous growing season to May at the end of the current austral growing season: a) Toatoa (*Phyllocladus toatoa*), b) Tanekaha (*Phyllocladus trichomanoides*), c) Average of all toatoa chronologies (PHGL_av) and average of all tanekaha chronologies (PHTR_av). Horizontal lines indicate the approximate threshold for significance at $p < 0.05$ calculated for the average length of all chronologies intersecting with the temperature data ($n = 68$ for toatoa, $n = 69$ for tanekaha) although series have different lengths and thus thresholds for significance. Chronology 8WKT.r is not significantly correlated with New Zealand average temperatures in any month.

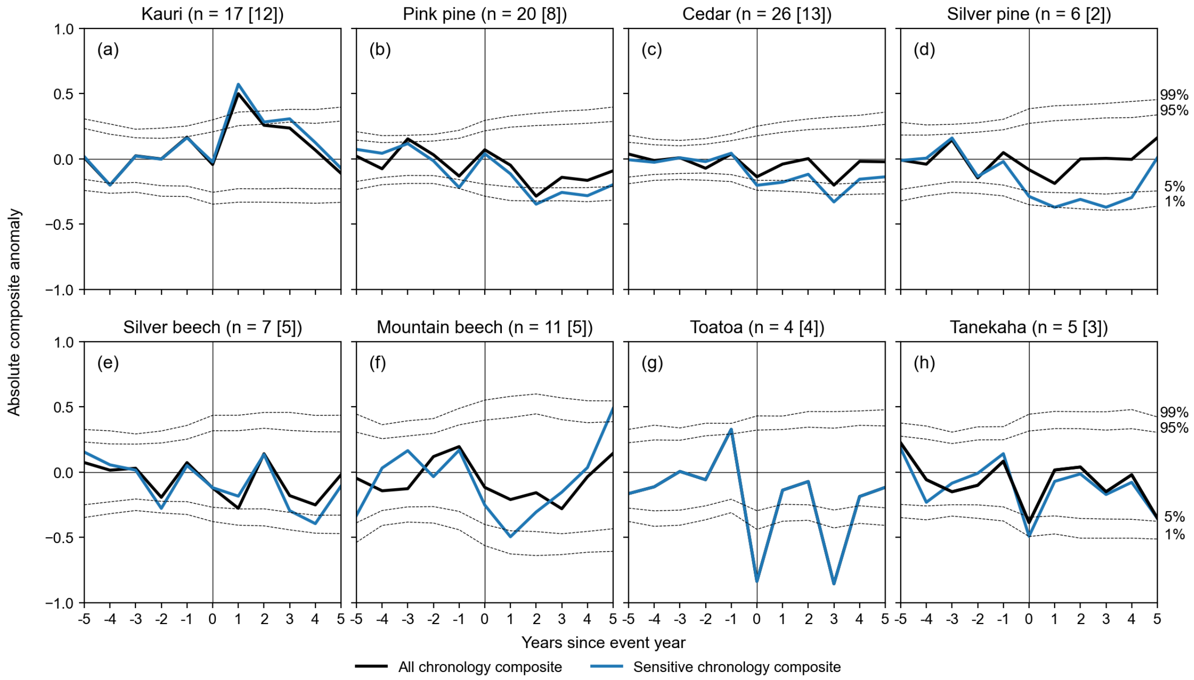

Figure S7 – Mean chronology departures five years before and after 21 eruption years with SAOD > 0.04 (year 0), separated by tree species. The chronologies contributing to the species-wide composite are shown in black, with the number of chronologies indicated in the round brackets. The sensitive chronology composite in shown in blue and the number of contributing chronologies is shown in the square brackets. Significance bands (dotted grey lines) are the 1st, 5th, 95th, and 99th percentile of 10,000 random samples of non-event years from the species-wide composite.

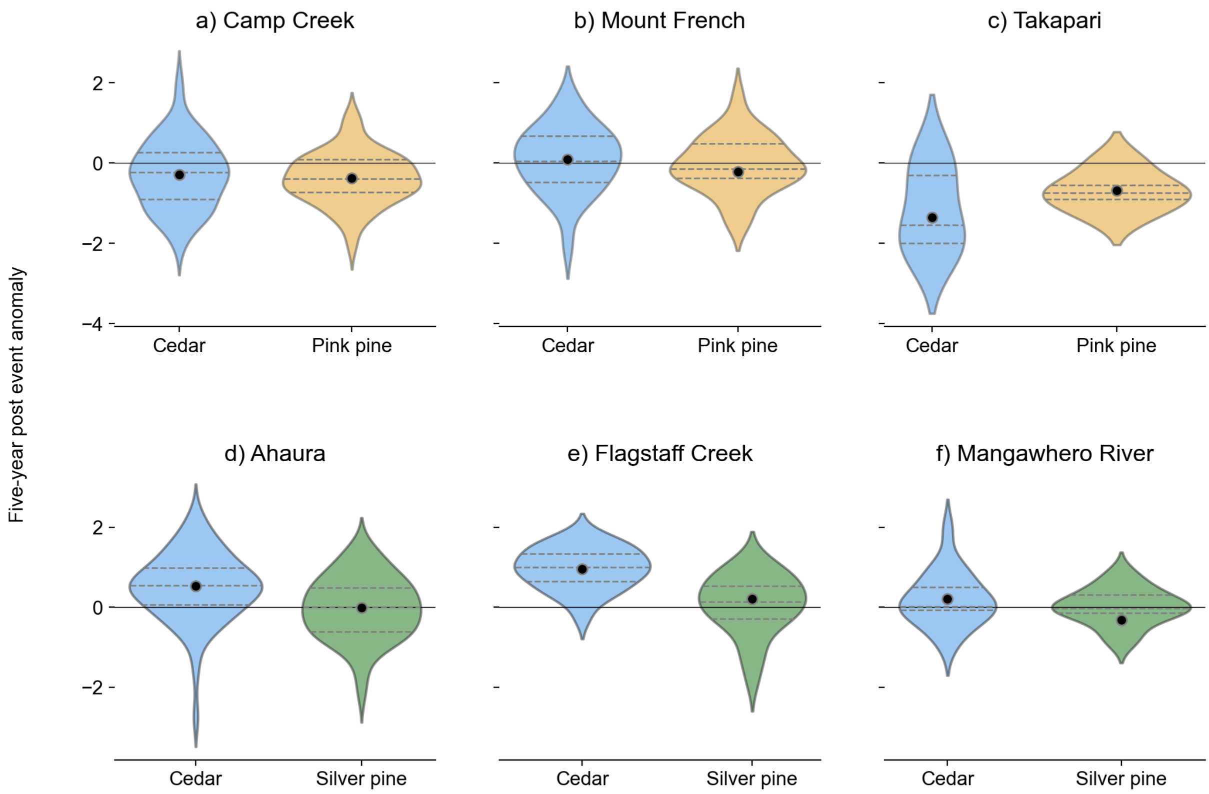

Figure S8 – Kernel density (violin) plots of the five-year post event anomaly for the standardised ring-width series contributing to the chronologies at six sites, three sites where cedar is co-located with pink pine (a-c) and three sites where cedar is co-located with silver pine (d-f). Dashed lines indicate the 25th, 50th, and 75th percentiles of the distributions of the response to the 21-volcanic event series, with the mean series response shown by the black dot. At some sites (a - Camp Creek, b - Mount French, f - Mangawhero River) neither species shows a significant volcanic response, indicating that the change in conditions following an eruption is not sufficient to be recorded. At the remaining three sites, significant responses are recorded by one or both species. Both pink pine and cedar recorded significant negative volcanic responses at Takapari (c), with a significantly larger response from cedar (Mann-Whitney U-test, $p < 0.05$). At Ahaura and Flagstaff Creek, only cedar recorded a significant positive growth response compared to a neutral silver pine response. At both these sites, the difference between the species' response is significant (Mann-Whitney U-test, $p < 0.001$; d-e).

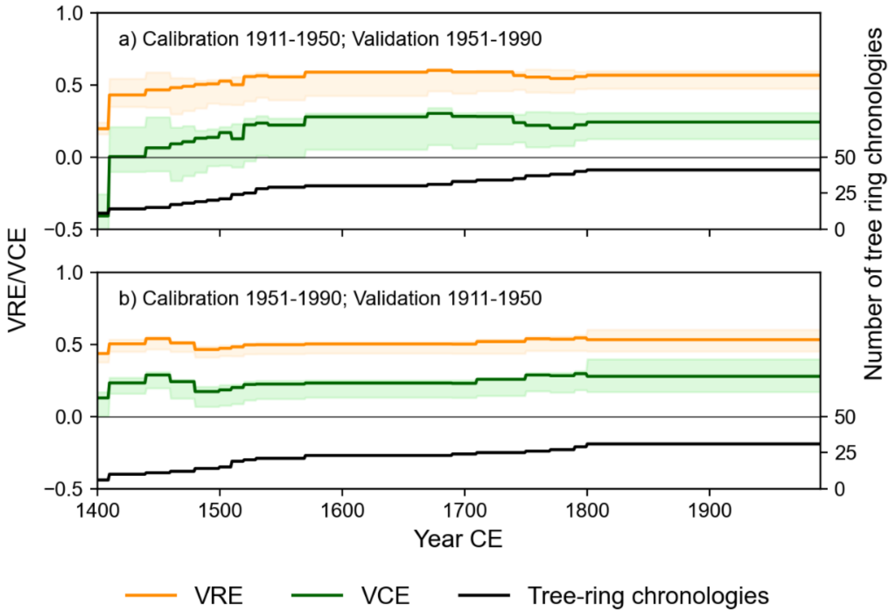

Figure S9 – Verification statistics for the NZall temperature reconstruction: a) using the early calibration window and b) using the late calibration window. The 90% uncertainty interval around the verification period reduction of error (VRE; orange) and verification period coefficient of efficiency (VCE; green) were calculated from 300 maximum entropy bootstrap replications. The secondary axis shows the number of tree-ring chronologies contributing to the reconstruction over time.

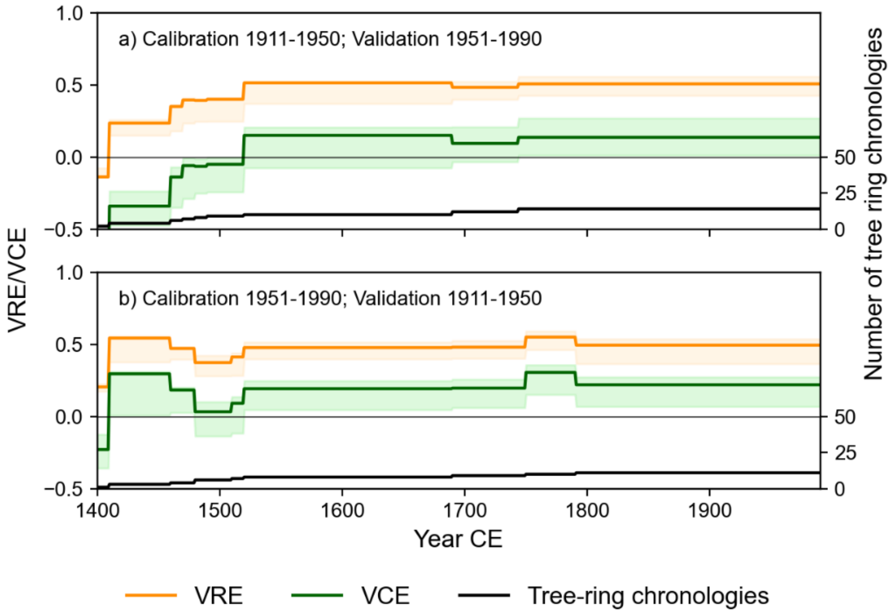

Figure S10 – Verification statistics for the NZsens temperature reconstruction: a) using the early calibration window and b) using the late calibration window. The 90% uncertainty interval around the verification period reduction of error (VRE; orange) and verification period coefficient of efficiency (VCE; green) were calculated from 300 maximum entropy bootstrap replications. The secondary axis shows the number of tree-ring chronologies contributing to the reconstruction over time.

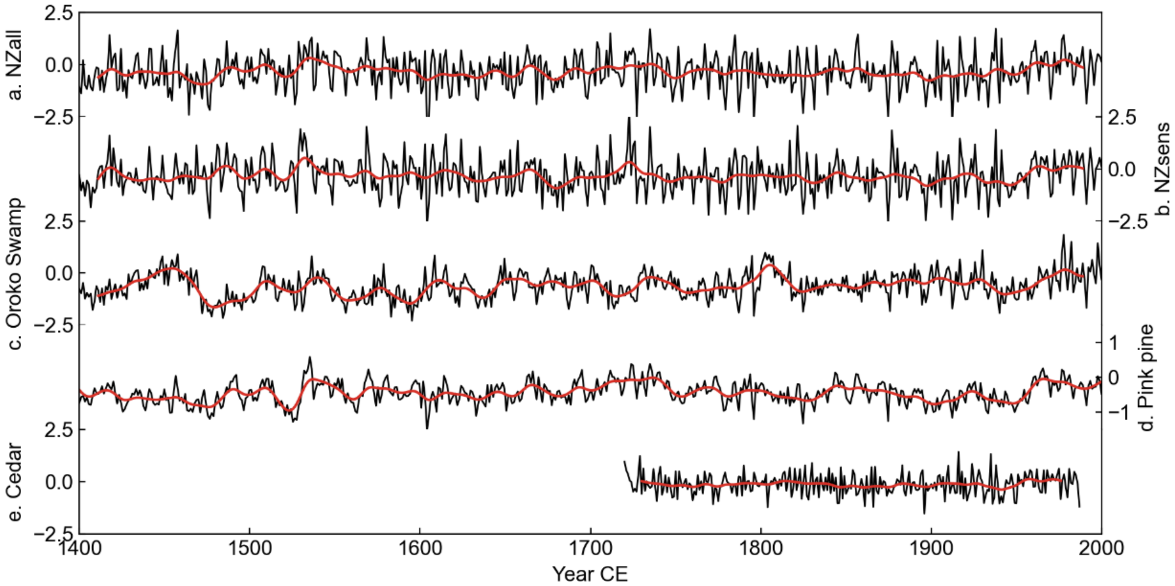

Figure S11 - New Zealand summer temperature reconstructions: a, b) DJF New Zealand average temperatures (this study) for all (a) and sensitive chronologies (b); c) January-March temperature at Hokitika, Westland, based on Oroko Swamp silver pine (Cook et al., 2002); d) Annual average New Zealand temperature based on pink pine chronologies (Duncan et al., 2010); e) February-March average New Zealand temperature based on cedar chronologies (Palmer & Xiong, 2004). Reconstructed temperature is shown in black, and the 20-year filtered series is in red. All series were transformed into anomalies using a baseline of reconstructed temperature over 1961-1990, except for the pink pine reconstruction which was calibrated directly against instrumental temperature anomalies for the same period and therefore not transformed.

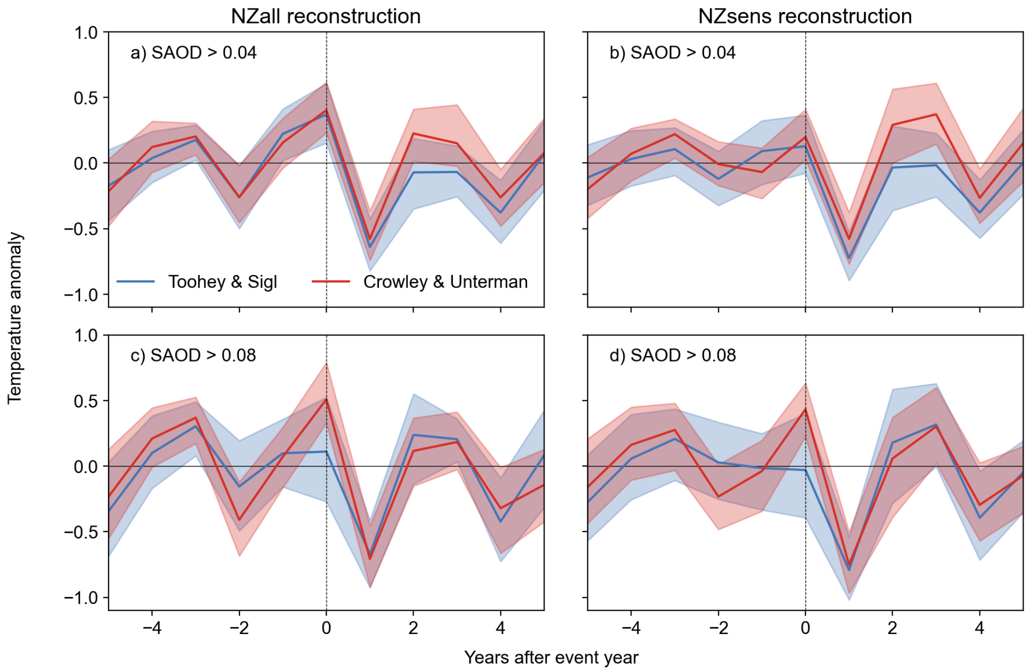

Figure S12 – Comparison of SEA analysis of the NZall and NZsens temperature reconstructions use two sets of volcanic event years (Table S3): a) the ice core analysis of Toohey and Sigl (2017) using a regional threshold of SAOD > 0.04 or 0.08 averaged over the New Zealand latitudinal range (30-50°S), and b) the ice core analysis of Crowley and Unterman (2013) using a threshold of SAOD > 0.04 or 0.08 averaged over the Southern Hemisphere (0-90°S). Both datasets show that the New Zealand temperature reconstructions significantly respond to volcanic events in year t+1. However, there are some differences, most notably 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, and the volcanic response of NZall is not significant at $p < 0.05$ when tested against the event list of Crowley and Unterman (2013).

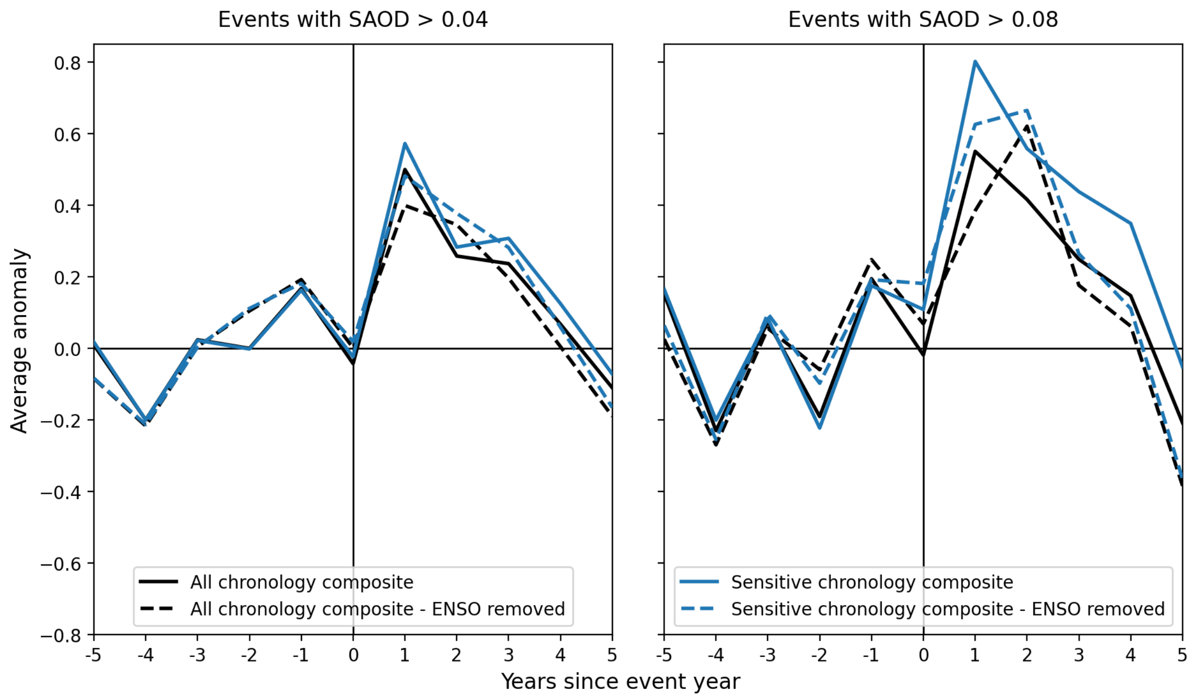

Figure S13 – Impact of removing volcanic events occurring simultaneously with a known El Niño event (1902, 1963, and 1982) from the key event list on the SEA results for kauri. All results are significant in year t+1 except for the 'All chronology composite' for the events with SAOD > 0.08 after the known El Niño events are removed (n = 10). For this series, only the t+2 anomaly is significant.

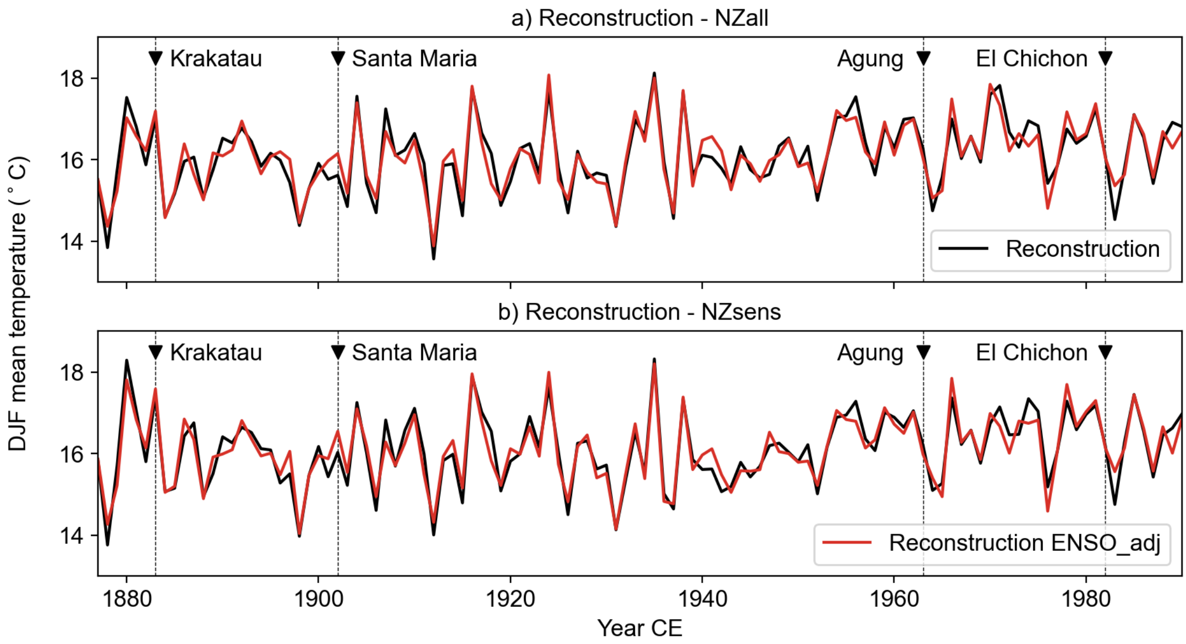

Figure S14 – Reconstructed temperatures in black and the same data with ENSO removed in red for a) reconstruction NZall and b) reconstruction NZsens. The eruption years for the four large volcanic eruptions occurring during the period for which instrumental ENSO indices are available (Southern Oscillation Index; 1778 CE to present) are also shown.

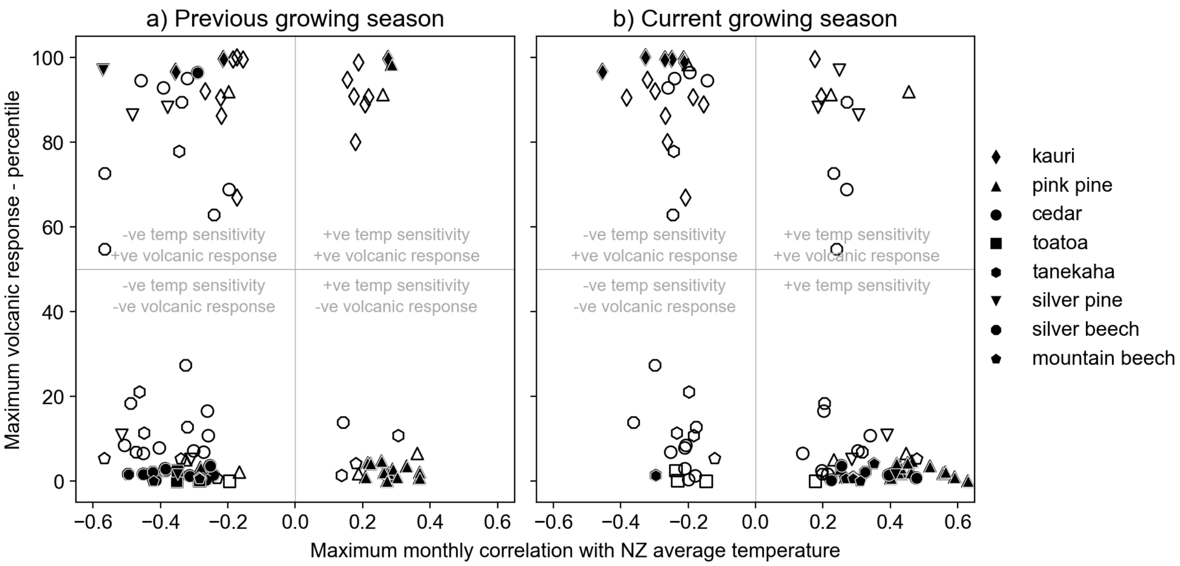

Figure S15 – Summary of the relationship between sensitivity to temperature and magnitude of the volcanic response for the eight species. Left: maximum temperature correlation in any month of the prior growing season against maximum volcanic response in the five years following an eruption for the 13 largest events. Right: Same plot but for the current growing season. Filled markers indicate that a site has a significant temperature correlation ($p < 0.05$) and a significant volcanic response (< 5[th] or > 95[th] percentile of bootstrapped responses). Open markers are not significant for either the temperature or volcanic response, or both.

Table S1 – Metadata for New Zealand chronologies used in the analysis. The ITRDB code is the searchable chronology identifier in the International Tree Ring Data Bank accessible at www.ncei.noaa.gov/.

Site	Species	Start	End	Longitude	Latitude	Altitude (m asl)	ITRDB Code	Notes
1CAS	AGAU	1559	1982	-36.88	174.53	180	newz082	Cascades
1HID	AGAU	1679	2002	-36.20	175.43	220	newz083	Hidden Valley
1HUI	AGAU	1720	1981	-36.97	174.57	274	newz085	Huia
1HUP	AGAU	1483	1997	-36.82	174.50	90	newz084	Huapai
1KAT	AGAU	1698	1996	-37.60	175.87	350	newz091	Katikati
1KAW	AGAU	1710	1996	-37.92	174.92	80	newz087	Kawhia
1KON	AGAU	1770	1976	-37.07	175.13	335	newz008	Konini Forks
1LTB	AGAU	1790	1981	-36.20	175.13	274	newz086	Little Barrier Island
1MAS	AGAU	1269	1998	-36.90	175.55	350	newz088	Manaia Sanctuary
1MOE	AGAU	1360	1980	-36.53	175.55	630	newz089	Mount Moehau
1MWL	AGAU	1580	1981	-37.22	175.03	350	newz090	Mount William
1PBL	AGAU	1675	1981	-35.18	173.75	305	newz078	Puketi Bluff
1PKF	AGAU	1504	2002	-35.27	173.73	290	newz079	Puketi Forest
1TRO	AGAU	1408	2002	-35.72	173.65	175	2	Trounson Kauri Park
1WFD	AGAU	1628	1903	-35.65	173.57	180	newz022	Waipoua Forest
1WWF	AGAU	1462	2002	-35.37	173.28	468	newz081	Warawara Plateau
2BON	HABI	1463	1999	-43.08	170.65	850	1	Mount Bonar
2CCP	HABI	1410	1998	-42.72	171.57	970	1	Camp Creek
2CRS	HABI	1483	1999	-42.28	171.38	900	1	Croesus Track
2DBY	HABI	1457	2010	-47.03	167.72	100	newz118	Doughboy - Adams Hill
2ELD	HABI	1338	1999	-45.75	167.47	750	1	Eldrig Peak
2GLS	HABI	1461	1999	-41.62	172.03	950	1	Mount Glasgow
2HEL	HABI	1407	2013	-46.98	167.75	100	newz119	Hellfire Ruggedy Mt
2MAP	HABI	1567	1976	-45.53	167.30	305	newz010	Manapouri Dam
2MAT	HABI	1508	1999	-41.57	172.32	1060	1	Matiri Range
2MEL	HABI	1440	1999	-42.50	171.83	1050	1	Mount Elliot
2MGR	HABI	1400	1999	-42.95	170.82	865	1	Mount Greenland
2MTF	HABI	1367	1999	-42.67	171.33	750	1	Mount French
2OMO	HABI	1578	1999	-43.40	170.10	320	1	Omoeroa Saddle
2PEG	HABI	1667	1991	-46.92	167.73	450	2	Pegasus Stewart Island
2PUT	HABI	1646	1993	-40.67	175.52	650	newz010	Putara
2SPD	HABI	1447	1999	-46.37	169.05	560	1	Slopedown Hill
2TKG	HABI	1450	1999	-42.65	171.50	950	1	Mount Tekinga
2TKP	HABI	1708	1995	-40.08	176.00	800	newz076	Takapari
2TOS	HABI	1590	1998	-42.98	170.85	210	1	Totara Saddle
3AHA	LACO	1209	2000	-42.38	171.80	244	newz005	Ahaura
3FLG	LACO	1230	2003	-42.50	171.72	200	newz120	Flagstaff Creek

Site	Species	Start	End	Longitude	Latitude	Altitude (m asl)	ITRDB Code	Notes
3MWO	LACO	1464	1976	-39.35	175.48	1000	newz011	Mangawhero River Bridge
3ORO	LACO	470	1999	-43.23	170.28	110	newz121	Oroko Swamp
3SWF	LACO	1130	1969	-43.13	170.40	200	newz122	Saltwater Forest
4AHA	LIBI	1303	2009	-42.38	171.80	244	newz127	Ahaura
4ARM	LIBI	1446	1958	-43.83	173.00	731	newz007	Armstrong Reserve
4CCC	LIBI	1064	2010	-42.72	171.57	965	newz124	Camp Creek
4CLW	LIBI	1450	1991	-39.63	176.10	1220	newz064	Clearwater
4CRG	LIBI	1492	2010	-45.83	170.53	576	newz128	Mount Cargill
4CRK	LIBI	1460	1978	-43.08	170.98	800	newz039	Cream Creek
4EMT	LIBI	1616	1990	-39.25	174.08	1050	newz003	Mount Egmont
4FLG	LIBI	1464	2004	-42.50	171.72	200	newz125	Flagstaff Creek
4FLH	LIBI	1683	1991	-41.27	172.60	950	newz065	Flanagans Hut
4HIT	LIBI	1431	1991	-39.53	175.73	976	newz066	Hihitahi
4MOA	LIBI	1490	1991	-40.93	172.93	1036	newz067	Moa Park
4MTF	LIBI	1330	1999	-42.67	171.33	855	newz126	Mount French
4MWO	LIBI	1662	1976	-39.35	175.48	1000	newz012	Mangawhero River Bridge
4NET	LIBI	1625	1990	-39.28	174.10	991	newz014	North Egmont
4OHT	LIBI	1585	1991	-39.62	176.12	1140	newz068	Ohutu Ridge
4OKA	LIBI	1732	1976	-46.38	169.45	305	newz016	Owaka
4RAH	LIBI	1480	2012	-42.32	172.12	672	newz129	Rahu Saddle
4RUC	LIBI	1473	1991	-39.63	176.18	1200	newz069	Ruahine Corner
4STR	LIBI	1626	1990	-39.32	174.12	860	newz071	Stratford side - East Egmont
4TKP	LIBI	1256	1992	-40.07	175.98	838	newz062	Takapari Road
4TOA	LIBI	1511	1992	-39.23	175.43	1160	newz072	Hauhangatahi Site A
4TOB	LIBI	1332	1992	-39.23	175.43	1100	newz073	Hauhangatahi Site B
4TOC	LIBI	1213	1992	-39.23	175.43	1000	newz074	Hauhangatahi Site C
4TRK	LIBI	1526	1978	-43.08	170.97	925	newz055	Tarkus Knob
4UWR	LIBI	1140	1992	-38.68	177.20	854	newz063	Urewera
4WBF	LIBI	1674	1992	-43.07	171.28	780	newz075	Wilberforce
5BOR	NOME	1389	2007	-45.78	167.37	200	2	Borland
5KEA	NOME	1580	1980	-43.87	169.78	1150	newz036	Kea Flat
5LKE	NOME	1676	1980	-45.25	167.48	950	newz048	Lake Eyles
5LKO	NOME	1584	1980	-45.30	167.68	1000	newz051	Lake Orbell
5UHV	NOME	1710	1980	-44.77	168.00	950	newz033	Upper Hollyford Valley
5UTV	NOME	1622	1979	-45.20	167.65	1000	newz054	Upper Takahe Valley
6GHC	NOSO	1795	2006	-43.25	171.75	870	newz046	Ghost Creek
6HDC	NOSO	1730	1979	-43.13	171.60	1350	newz037	Hidden Creek
6LCV	NOSO	1730	1979	-43.08	171.72	1350	newz035	Lower Cass Valley
6LGH	NOSO	1740	1979	-43.08	171.70	1400	newz031	Logos Hill
6LGS	NOSO	1760	1979	-43.05	171.60	1300	newz024	Lagoon Saddle
6LKP	NOSO	1713	2006	-43.12	171.78	970	newz049	Lake Pearson

Site	Species	Start	End	Longitude	Latitude	Altitude (m asl)	ITRDB Code	Notes
6MKW	NOME	1730	1979	-43.05	171.68	1275	newz023	Mirkwood
6RTC	NOSO	1787	2006	-43.15	171.80	950	newz052	Rata Creek
6SSS	NOSO	1760	1979	-43.05	171.72	1250	newz030	Snowslide Stream
6TKV	NOSO	1630	1979	-45.30	167.68	1100	newz031	Takahe Valley
6TST	NOSO	1840	1979	-45.28	167.65	1000	newz032	Takahe Stream
6WND	NOSO	1760	2006	-43.08	171.58	1350	newz053	Windy Creek
7PLC	PHAL	1717	2015	-42.90	171.57	915	newz130	Pegleg Creek
8WER	PHGL	1740	1976	-38.57	175.70	518	newz020	Waimanoa Ecological Reserve
8WHS	PHGL	1550	1986	-38.65	175.63	780	newz056	Waihora Stream
8WKT	PHGL	1535	1976	-38.70	177.20	853	newz009	Lake Waikareiti
8WPA	PHGL	1585	1976	-35.68	173.55	244	newz022	Waipoua Forest
9OWI	PHTR	1709	1976	-41.12	173.67	15	newz015	Okiwi
9PAP	PHTR	1779	1975	-36.12	174.25	160	newz001	Paparoa
9WHH	PHTR	1613	1986	-38.70	175.60	575	newz058	Waihaha Terrace
9WHL	PHTR	1650	1985	-38.65	175.67	640	newz057	Waihora Lagoon
9WMU	PHTR	1664	1976	-37.03	175.53	61	newz021	Waiomu
1Kauri	AGAU	0	2002	na	na	na	2	Kauri network
2Pink	HABI	1400	1999	na	na	na	2	Pink pine network
3Silver	LACO	0	2003	na	na	na	2	South Island silver pine

1 https://researcharchive.lincoln.ac.nz/handle/10182/2141

2 Private collection

Table S2 - Details of volcanic eruptions between 1400 and 1990 CE selected using the two thresholds of modelled SAOD over New Zealand (> 0.04 or > 0.08), and prior and secondary eruptions with SAOD > 0.01. Eruptions within 5 years prior to the target eruption were removed and the baseline period was selected as the closest non-volcanically disturbed period. Secondary eruptions occurring within 5 years of the target eruption were also removed prior to averaging the SEA ensemble (Büntgen et al., 2020).

Eruption date (month/year)	Eruption	Locality	Latitude	SAOD threshold	Prior Eruption	Secondary Eruption
1452	Unknown		16.8°S	> 0.04	1448 (-4)	1457 (+5)
1457	Unknown			> 0.08	1452 (-5)	
2/1477	Bárðarbunga	Iceland	64.6°N	> 0.04		
1595	Unknown			> 0.08	1590 (-5)	1600 (+5)
2/1600	Huaynaputina	Peru	16.6°S	> 0.08	1595 (-5)	
1620	Unknown			> 0.04		
†12/1640	Parker	Philippines	6.1°N	> 0.08		
1653	Unknown			> 0.04		
1673	Gamkonora	Indonesia	1.2°N	> 0.04		
1694	Unknown			> 0.08		
1761	Unknown			> 0.04		
5/1783	Grímsvötn Asama	Iceland Japan	64.4°N 36.4°N	> 0.08		
1809	Unknown			> 0.08		
4/1815	Tambora	Sundas	8.3°S	> 0.08		
1831	Unknown*	Philippines	19.5°N	> 0.04		1835 (+4)
1/1835	Cosigüina	Nicaragua	13.0°N	> 0.08	1831 (-4)	
†12/1861	Makian		0.3°N	> 0.04		
8/1883	Krakatau	Indonesia	6.1°S	> 0.08		1886 (+3)
10/1902	Santa Maria	Guatemala	14.8°N	not modelled		
3/1963	Agung	Bali	8.3°S	not modelled		
3/1982	El Chichón	México	17.4°N	not modelled		

†Eruptions occurring in December were assigned an eruption year of year+1 in the superposed epoch analysis event list for consistency with the designation of years in the temperature reconstruction (reconstruction year 1641 is Dec 1640-Feb 1641).

* Location is disputed (Garrison et al., 2018).

Table S3 - Comparison of volcanic event years between 1400 and 1990 CE selected using two different datasets: a) the ice core analysis of Toohey and Sigl (2017) using a regional threshold of SAOD > 0.04 or 0.08 averaged over the New Zealand latitudinal range (30-50°S), and b) the ice core analysis of Crowley and Unterman (2012) using a threshold of SAOD > 0.04 or 0.08 averaged over the Southern Hemisphere (0-90°S). 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 by Toohey & Sigl (2017).

Eruption date (month/year)	**Eruption**	**Toohey & Sigl threshold**	**Crowley & Unterman threshold**
1441	Unknown	*Not selected*	> 0.04
1452	Unknown	> 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	Gamkonora	> 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 Chichón	not modelled	> 0.04

Table S4 – Coupled Model Intercomparison Project 5 (CMIP5) models used in the analysis.

Model	No. of Ens	Solar	Volcanic	GHG	Land Use	Reference
GISS-E2-R 121	1	Steinhilber et al	Crowley & Unterman (2013)	Schmidt et al. (2012)	Pongratz et al. (2008)	Schmidt et al. (2014)
GISS-E2-R 124	1	Viera et al. (2011)	Crowley & Unterman (2013)	Schmidt et al. (2012)	Pongratz et al. (2008)	Schmidt et al. (2014)
GISS-E2-R 127	1	Viera et al. (2011)	Crowley & Unterman (2013)	Schmidt et al. (2012)	Kaplan et al. (2010)	Schmidt et al. (2014)
FGOALS-gl	1	Crowley (2000)	Crowley (2000)	Amman et al. (2007)	-	Guo and Zhou (2013)
MRI-CGCM3	1	Delaygue & Bard (2011) + Wang et al. (2005)	Gao et al. (2008)	Schmidt et al. (2012)	-	Yukimoto et al. (2012)
MPI-ESM-P	3	Viera et al. (2011)	Crowley & Unterman (2013)	Schmidt et al. (2012)	Pongratz et al. (2008)	Jungclaus et al. (2014)
MIROC-ESM	1	Delaygue & Bard (2011) + Wang et al. (2005)	Crowley et al. (2008)	Schmidt et al. (2012)	-	Sueyoshi et al. (2013)

Table S5 – Pearson correlations between New Zealand summer temperature reconstructions over the common reconstruction interval (1720-1987 CE): a, b) DJF New Zealand average temperatures (this study) for (a) all and (b) sensitive chronologies; c) January-March temperature at Hokitika, Westland, based on Oroko Swamp silver pine (Cook et al., 2002); d) Annual average New Zealand temperature based on pink pine chronologies (Duncan et al., 2010); e) February-March average New Zealand temperature based on cedar chronologies (Palmer & Xiong, 2004). All correlations are significant at $p < 0.001$ except for pink pine and cedar, which are not significantly correlated.

	NZall	NZsens	Oroko swamp	Pink pine
a. NZall	-	0.83	0.44	0.62
b. NZsens	0.83	-	0.33	0.52
c. Oroko swamp	0.44	0.33	-	0.23
d. Pink pine	0.62	0.52	0.23	-
e. Cedar	0.36	0.52	0.36	*0.06*