Climate of the Past Discussions

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Comment on cp-2021-154

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Referee comment on "Palaeobiological evidence for Southern Hemisphere Younger Dryas and volcanogenic cold periods" by Richard N. Holdaway, Clim. Past Discuss., https://doi.org/10.5194/cp-2021-154-RC1, 2022

General

This ms compiles and analyses previously published data on the occurrence of moa in cave deposits from the northern half of the South Island of New Zealand. On the basis of the assumed high habitat specificity of the moa species, and with reference to local d O18 speleothem records, a sequence of vegetation and climate change is deduced for the Late Pleistocene-early Holocene. In contrast to the developing consensus derived from New Zealand marine cores, glacial advances and pollen sequences from the South Island, it is claimed on basis of the moa dates that the Antarctic Cold Reversal (ACR: c. 14.5 – 12.8 kyr) was represented by a local warming and that the Younger Dryas (YD: 12.8-11.5 kyr) by a return to glacial conditions. While the author is to be congratulated on bringing together a comprehensive fossil moa data set to address the question of Late Pleistocene climate change, his failure to discuss or even cite the relatively large amount of detailed paleoclimatic data from this region which would lead to diametrically opposed conclusions makes his case untenable.

Specific comments

1*Speleothem interpretation*

The interpretation of the speleothem records in this paper assumes that they are entirely driven by local temperature change. This is a flawed assumption, as speleothem records are influenced by many factors ranging from distant oceanic moisture sources, rainout through to those affecting soil infiltration and precipitation in the cave system. “The immediate forcing factors for the observed palaeoclimatic variations are therefore most likely related mainly to changes in ocean source waters of precipitation, transmitted by westerly winds." (Williams et al. 2010). As the late Pleistocene was a time of major changes in wind and oceanic water masses, it is highly likely that these rather than local temperature drove the changes. The current ms suggests that there was a warming between 14 and 13 ka followed by a cooling between 13 and 12 ka (Fig. 12). The interpretation given by those who generated the speleothem data does not entirely support this interpretation: "Late-glacial warming commenced between 18.2 and 17.8 ka and accelerated after 16.7 ka, culminating in a positive excursion between 14.70 and 13.53 ka. This was followed by a significant negative excursion between 13.53 and 11.14 ka of up to 0.55‰ depth that overlapped the Antarctic Cold Reversal (ACR) and spanned the Younger Dryas (YD). Positive δ18O excursions at 11.14 ka and 6.91–6.47 ka represent the warmest parts of the Holocene." (Williams et al. 2005). Moreover, a careful examination of the curves in Williams et al. (2005) show that it was a period of warming, as those authors state: "We agree with the conclusion of Turney et al. that the YD chronozone in New Zealand was a period of resumed warming, because d18Oc values show an upwards trend after ~12.7 ka."

2 *Quality of the moa fossil record versus the pollen and macrofossil record*

Some extraordinary claims are made in the ms on the value of the moa record versus the other palaeoclimatic indicators from the South Island and the surrounding ocean (lines 385-391):

"Unlike indirect proxies such as oxygen isotope ratios and pollen samples from a few sites, moa were on-ground real-time witnesses to the vegetation (and hence climate) at the time and place they lived and died. The congruence of the high spatial and temporal resolution record of vegetation based on 14 C ages of individual moa, each characteristic of a particular vegetation (Fig. 12) with the local speleothem δ18 O record suggest that both proxies accurately reflect the timing of changes in the New Zealand glacial and post-glacial climate. However, the postglacial return to cold climate in both records is later than the ACR. Instead, the moa sequence accords with the δ18 O record in showing that interval to be one of warming climate at these southern latitudes." I make the following comments on these claims:

- The moa record is not particularly high resolution given that the dated remains are scattered through numerous cave systems.
- The argument that moa are a direct indicator of vegetation composition while pollen and macrofossils derived from that vegetation are indirect, is without merit. Moa like most large vertebrates would have used a variety of vegetation types and, rather than a documented analysis of the occurrence of moa in relation to vegetation, we have impressionistic claims. In contrast there is a long history in New Zealand of quantitative assessments of pollen rain versus vegetation type. Marine isotope and alkenone proxies likewise have an impressive, well understood, quantitative and physical basis.
- Interpolation of ages from dated horizons (which is critiqued here as inferior to inferences made on the basis of individual fossil dates as per the current ms) is a well established procedure and, although it can involve some inaccuracies, the mass of data now accumulated in the New Zealand region from dated cores is such that we can high confidence that the ACR was not a period of strong warming, whereas the YD was.

Problems now largely centre not on the dating, but on the interpretation of how the various proxies react to climate forcing. For instance, some proxies represent a seasonal signal rather than an annual one.

3 *Lack of discussion of other relevant climate proxies*

The only local climate proxies discussed in detail here are dO18 speleothem records and moa fossils. I here briefly discuss some of the most relevant that are missing from such a discussion.

The results from glacier advance investigations are unequivocal (Doughty et al. 2013): "The modelling results presented in this paper supports the idea that the temperature during the ACR was 2-3 ^{o}C cooler than today in New Zealand. This temperature change estimate overlaps, within error, with a temperature change estimate of 3-4 ^{o}C cooler than today, reported by Anderson and Mackintosh (2006) for the Franz Josef Glacier advance to the Waiho Loop during the Lateglacial. Our results are also consistent with published pollen studies (Newnham and Lowe, 2000; Turney et al., 2003; Vandergoes and Fitzsimons, 2003; Hajdas et al., 2006), and regional sea-surface temperature records (Carter and Cortese, 2009; Sikes et al., 2009) that suggest a temporary reversal of the deglaciation warming trend occurred in New Zealand during the Lateglacial"

Marine core palaeoclimatic analyses directly to the west of the northern South Island also support the concept of an ACR cool period and strong warming during the YD: "There are no short-term fluctuations late in the Pleistocene that could potentially be a YD cooling event, even allowing for generous errors in the age model. Consistent with warming in the SST series, the YD interval appears to be associated locally with a period of maximum forest growth (increasing abundance of podocarps and hardwoods, Fig. 1), not cooling." (Barrows et al. 2007).

A detailed pollen and macrofossil study (Jara et al. 2015) near treeline in Northwest Nelson, close to the moa caves that provide most of evidence in the current ms, also does not support the interpretation of a warm ACR and a cold YD. Temperatures modelled on the basis of pollen from Adelaide Tarn are well below current during the ACR, whereas the YD chronozone sees a rapid rise in temperature to above present day levels. On the central-eastern flank of the Southern Alps, pollen and macrofossil evidence point to a cool ACR and strong warming during the YD (McGlone et al. 2004).

Further south to the east of the South Island, marine core evidence (Pahnke et al. 2006; Pahnke, 2003) indicates continuous warming from 18 ka, but with a steep acceleration during the YD chronozone. The subantarctic Campbell Island pollen record immediately to the south of the South Island shows cool conditions during the ACR followed by steep warming during the YD (McGlone et al. 2010, McGlone, et al. 2019).

Concluding remarks

Overturning a broad consensus (based on numerous New Zealand late Pleistocene-early Holocene investigations of glacial moraines, deep sea cores and pollen and macrofossil cores) that the ACR in this region of the southwest Pacific was either cool or warming at a slower rate than the subsequent rapid temperature increase during the YD, requires much more substantial evidence than that presented here. The speleothem evidence cannot be attributed directly to temperate alone, and the most parsimonious explanation for the mis-match of the dO18 results from this source with other proxies is changing oceanic sources and wind flow. Moreover, even if it could be demonstrated that the moa fossils are reliable indicators of changing vegetation, given the low temporal resolution of the evidence presented and the fact that these were large, highly mobile animals, this evidence does not undermine the solid, well replicated, well dated paleotemperature records derived from moraines, deep-sea cores and pollen and macrofossils from adjacent South Island sites. Some reconciliation would be needed if the re-interpretation suggested were to be accepted, but this current ms barely recognizes the existence of this data, let alone attempts to discuss it.

I therefore see no reason based on the results in this ms to abandon the concept that temperature trends during the late Pleistocene-early Holocene in the New Zealand region were roughly in antiphase with those in the mid to high latitudes of Northern Hemisphere.

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