Climate of the Past Discussions

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Comment on cp-2022-20

Joseph R. McConnell (Referee)

Referee comment on "A multimillennial mid-latitude ice core chronology by synchronization with a polar Pb record combined with other empirical dating methods" by Paolo Gabrielli et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-20-RC1, 2022

- Does the paper address relevant scientific questions within the scope of CP? **Yes.**
- Does the paper present novel concepts, ideas, tools, or data? **Yes, but the approach is not as novel as implied in the manuscript.**
- Are substantial conclusions reached? **Yes, although the focus of this manuscript is only on establishing a new core chronology for the Alto dell'Ortles cores. The interpretation of the new Alpine lead record is reserved for a subsequent manuscript**.
- Are the scientific methods and assumptions valid and clearly outlined? **Yes.**
- Are the results sufficient to support the interpretations and conclusions? **More or less. The main advance in dating is the use of a relatively new technique where a poorly dated lead record (in this case from Alto dell'Ortles) is synchronized to a well-dated lead record (in this case a previously published record from the Russian Arctic). The wiggle matching between the records is somewhat arbitrary, however, and difficult to assess objectively. Here the authors use radiocarbon dating to assess the wiggle matching but the radiocarbon dates are too few and have too large uncertainties to allow a quantitative assessment of the wiggle matching. I don't mean to be too critical since the problem of quantitatively assessing wiggle matching is not unique to this study, but the subjective nature of the tie points should be openly acknowledged.**
- Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? Yes.
- Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Improvements suggested including additional citations and acknowledgement of prior similar work.
- Does the title clearly reflect the contents of the paper? **Yes, although it describes only one component of what was reported.**
- Does the abstract provide a concise and complete summary? **Yes.**
- Is the overall presentation well structured and clear? **Fairly clear. The text could be improved for readability and shortened.**
- Is the language fluent and precise? **For the most part, yes. The text in the Supplement could be edited to be more understandable in English**.
- Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? **Yes.**
- Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced,

combined, or eliminated? **Some of the figures are primitive by today's standards and could be improved. For example, I found the comparison of the synchronized Russian Arctic and Alto dell'Ortles lead records in the Supplement (Fig. 2 bottom) to more compelling than the same presentation in Fig. 4 (bottom).**

- Are the number and quality of references appropriate? **Yes, but important corrections and additional references are needed.**
- Is the amount and quality of supplementary material appropriate? **Yes.**

Overview

Development of well-dated historical records of human impacts and climate are important for a broad range of disciplines, including the natural, physical, and social sciences, as well as the humanities. Polar and alpine ice cores record provide direct, often highly resolved records of past atmospheric and precipitation chemistry that reflect both natural and anthropogenic emissions. The caveat is that they are most useful only if the records can be properly dated.

This manuscript describes the use of standard and non-standard dating techniques to develop a new chronology for the Alto dell'Ortles cores from the Italian Alps. As is typical of cores from relatively thin alpine glaciers, annual layer counting is used in the upper section with constraints provided by known time horizons (e.g., fallout from 1950s and 1960s atmospheric thermonuclear testing, as well as fallout from volcanic eruptions or other highly unusual but well-dated events such as major forest fires or Saharan dust events). In deeper sections of such cores, annual layer counting generally is not possible because of extreme flow thinning and strain so other techniques are needed for establishing the ice age. Here the authors used measurements of lead concentrations in two of the four (or maybe three) Alto dell'Ortles cores collected in 2011 to synchronize the deeper sections to a well-dated, previously published lead record from the Russian Arctic. Additional constraints were provided by radiocarbon dates of both water insoluble organic carbon and discrete organic material from the basal section of one of the cores. The lead synchronization technique used here is relatively new and this is the first effort that I'm aware of to use annual layer counting based on seasonal pollen variations and extreme pollen events as specific time markers. While I support publication and am especially enthusiastic about the better-dated records of climate and human impacts in Europe that will result from the improved chronology, there are number of important issues that need to be resolved first.

Specific Comments

(1) In the abstract, the authors describe as "novel" the approaches used to redate the cores. The most significant relatively new part of their approach is lead-based synchronization to a well-dated polar ice core which also is the manuscript title. In fact, exactly this lead synchronization approach has been used previously to date rapidly thinning ice cores over the Common Era and beyond. Specifically, Osman et al., (2021) used this technique of annual layer counting in the upper section and lead synchronization

in the lower section on a coastal dome core from Greenland. Similarly, Preunkert et al. (2019) used this techniques on a core from the French Alps, including additional constraints from radiocarbon dating of organic material in the deep ice corresponding to antiquity. Therefore, "novel" should be removed from the abstract and these earlier applications at least mentioned and briefly discussed to provide context for the current study. Citations to these earlier publications obviously should be added as well.

Preunkert, S., J.R. McConnell, H. Hoffmann, M. Legrand, A. Wilson, S. Eckhardt, A. Stohl, N. Chellman, M. Arienzo, & R. Friedrich (2019) Lead and antimony in basal ice from Col du Dome (French Alps) dated with radiocarbon: A record of pollution during antiquity, *Geophys Res Lett*, doi:10.1029/2019GL082641.

Osman, M., B.E. Smith, L.D. Trusel, S.B. Das, J.R. McConnell, N. Chellman, M. Arienzo, & H. Sodemann (2021)Abrupt Common Era hydroclimate shifts drive west Greenland ice cap change, *Nature Geoscience*, doi:10.1038/s41561-021-00818-w.

(2) The citation for the published Russian Arctic lead record is incorrect. It should be McConnell et al., 2019, not McConnell et al., 2018 (these are different publications and not simply the result of typos in their text).

McConnell, J.R., N.J. Chellman, A.I. Wilson, A. Stohl, M.M. Arienzo, S. Eckhardt, D. Fritzsche, S. Kipfstuhl, T. Opel, P.F. Place, & J.P. Steffensen(2019) Pervasive Arctic lead pollution suggests substantial growth in Medieval silver production modulated by plague, climate and conflict, *Proc Natl Acad Sci U.S.A.*, doi:10.1073/pnas.1904515116.

(3) The use of SZ (the island of Severnaya Zemlya) rather than AN (the ice cap Akademii Nauk which is one of several glaciers/ice caps on SZ) as the ice core name for the Russian Arctic lead record is somewhat confusing. This may be because some earlier publications from the German/Russian team that collected and first analyzed the core referred to it both as SZ (e.g., Fritzsche et al., *Annals of Glaciology*, 2006) and AN (e.g., Opel et al., *Journal of Glaciology*, 2009; Opel et al., *Climate of the Past*, 2012). However, the lead record used here was published as the AN record in McConnell et al., 2019 and so the core name AN should be used here as well.

(4) It appears from Fig. 2 (bottom graph) that there are sometimes very large differences (nearly an order of magnitude for some periods) in the lead concentrations measured in the two Alto dell'Ortles cores. These aren't just short term differences but decadal or longer differences that I find is quite unexpected in two nearby cores. Please elaborate. Do these differences mean that the lead fluxes measured in these Alpine cores are not regionally or even locally representative? In addition, the tie point at ~69.5 m between the two Alto dell'Ortles lead records is incorrect – or at least not optimal. Correcting it would improve the agreement between the lead records and so make the chronologies more consistent.

(5) The new age scale is quite different from TC2016 even in the upper 100 m where both chronologies presumably are based largely on annual layer counting (albeit with constraints). This seems quite surprising. I understand that the new chronology incorporated pollen records in the upper part of the core but what caused the annual layer counting in the original chronology to be so far off? Presumably TC2016 was based on the same $\delta^{18}O$ and dust measurements as in the current study. Please elaborate.

(6) I find the use a logarithmic age axis in the flow modeling sections (Fig. 6 showing annual layer thickness vs age) rather confusing. Why did you use a logarithmic scale? The main point of the manuscript is the redating of the deeper core (below 100 m) so shouldn't that be emphasized rather than the top 100 m?

(7) In the third paragraph of the introduction, you say that four cores were collected from the Alto dell'Ortles site in 2011. After that, however, I find only a discussion of three cores. Did I miss something?

(8) I don't find Fig. 1 particularly compelling or informative. Is the point to show that the water isotopes are in better agreement once the new lead-based and other improvements in the tie points between cores are made? If so, it would be much clearer to show this by overplotting the original and improved water isotope records or by using cross plots. Improvements could be quantified by showing how the correlations between different core records have improved either overall or for specific depth/time sections.