The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-294

Anonymous Referee #1

Referee comment on "Chronostratigraphy of the Larsen blue-ice area in northern Victoria Land, East Antarctica, and its implications for paleoclimate" by Giyoon Lee et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-294-RC1, 2021

Lee et al establishes the chronology of a blue ice field at the Larsen Glacier in north Victoria Land, East Antarctica by cross-correlating properties recorded in the ice (and the enclosed air). Further aided by absolute radiometric 81Kr dating, the authors report the discovery of a horizontally continuous ice section spanning from the early Holocene through the Last Glacial Maximum, with the age gets progressively older downstream. It is therefore concluded that Larsen Glacier could serve as a paleoclimate archive to study the transition from the Last Glacial Maximum to the Holocene. While the study subject of this manuscript (blue ice) is clearly part of the cryosphere, hence making the manuscript within the scope and aim of the journal The Cryosphere, the manuscript would benefit from more in-depth discussion on the glaciological or climatic implications of the discovery of stratigraphically continuous blue ice at the Larsen Glacier: what does it mean for the local ice dynamics, East Antarctic Ice Sheet, or paleoclimate (given the authors argue this blue ice field could be utilized to study climate changes across the Last Deglaciation)?

It must be acknowledged that a continuous blue ice section is exciting and rewarding for all the field and lab work that was done, but LGM (or Termination I) isn't a particularly understudied interval. A large number of deep ice cores from Greenland and Antarctica have provided a detailed record of atmospheric composition and local to regional climate. A blue ice field in Taylor Glacier in the Dry Valleys, less than 500 km away from the Larsen Glacier, provides a near continuous surface ice record already providing large-volume samples for various novel geochemical analyses. Therefore one has to wonder what new information blue ice field in Larsen Glacier could bring about. A few questions that may be worthy of consideration: Can you trace the original deposition site by GPR and dust bands? Or if you already know where the ice was deposited, could you estimate the velocity of ice motion? In terms of climate, presumably you could infer annual layer thickness from GPR and that should provide information about past accumulation rates and ice thinning function. If so, what does it mean for the local climate and ice dynamics? Since both hydrogen and oxygen isotopes in water have been measured, could you

calculate the deuterium excess and what does that tell us about the hydrological changes in north Victoria Land on glacial-interglacial timescales?

This is not to say that these are the only questions that must be answered here. The bottom line is that as a reader of The Cryosphere I am hoping to see what new scientific discovery is being made. It might be an abrupt change in accumulation rates, or a different local precipitation regime. The current manuscript feels to me more like a detailed progress report without firm conclusion on what new is being presented. Of course it could be argued that the discovery of a potentially useful paleoclimate archive itself is an achievement, but back to my earlier points, the Last Glacial Maximum is already an intensively studied interval.

Finally, before proceeding to detailed comments, I feel a bit confused why the manuscript does not present the absolute dating results first. 81Kr is a well-established absolute dating method for glacial ice and underground water. Unless the authors are worried about contamination of modern air (a hypothesis that was later rejected based on undetectable 85Kr), the results of absolute dating (high accuracy, low precision) should come before the cross-dating efforts that have a high level of precision. In doing so you could easily narrow the range of age search to the last glacial cycle and therefore shorten a considerable portion of the current discussion (in particular 3.5) that might be devoted to more glaciological-focused discussion.

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Specific comments:

Line 18: the claim of a “simple stratigraphy of ice” seems to contradict the description that the ice upstream has age repetitions (i.e. is folded). Perhaps you could rephrase it into something like “Here we report a surface transect of ice that has a simple horizontal stratigraphy.” This would exclusively correspond to the downstream section described in the current manuscript.

Line 32: please add Lüthi et al (2008) Nature and Bereiter et al (2015) GRL to the citation.

Line 49: it is necessary to point out that the current longest continuous ice core record stops at 800,000 years.

Line 60: this sentence is equivocal. Does “globally well-mixed” also apply to glaciological records? Based on the nature of stable water isotopes I don’t the authors imply that the glaciological records are also globally mixed (in fact, they are not). Please (1) consider splitting the gas age and ice age synchronization methods and (2) point out that the age of the gas is different from the age of the ice at the same depth.

Line 61 & 81: please add Yan et al (2021) Clim. Past to the citation.

Line 62: if absolute dating methods are effective, readers without sufficient knowledge on their limits may why bother correlating gas-phase and ice-phase properties? It may be better to introduce absolute dating methods first, then acknowledge their uncertainties, and finally introduce a more precise way of age synchronization.

Line 85: please specify which “area” you are referring to (north Victoria Land?).

Fig 1: Is there a particular reason for the current orientation of the Antarctic continent?

Line 154: could you please evaluate the potential of in situ methane production in ice cores with high dust concentrations (Lee et al 2020 GCA)?

Line 157: please specify what 2nd gas extraction means. Does it imply the refrozen meltwater is melted once again?

Line 169: please specify the temperature of the water trap.

Line 189: what does “unclear ice” mean? It is not a common word to describe ice cores. Please elaborate.

Line 240: could you define the origin to which downstream and upstream are referenced

against?

Line 261: the possibility of large variations in temperature and vapor sources is an interesting one. Perhaps you could quickly test them using deuterium excess data.

Line 289: why aren't d15N-N2 and d18O-O2 expected not to be altered substantially? The intrusion of modern air might not be a problem, but there could be gas loss from the ice and hence fractionation.

Line 300: the depth at which d15N-N2 and d18O-O2 no longer vary appears to be different at different sites. In Allan Hills BIA gas composition is stabilized below 7 to 10 m (Spaulding et al 2013, Quaternary Res). Can you comment on this variability?

Line 303: it seems that this section could be simplified given your 81Kr dating results.

Line 374-375: the origin of ice age-gas age difference should be introduced in the earlier section.

Line 385: the maximum delta-age at 17.5 ka is another interesting observation that could have important paleoclimate implications (Buizert et al 2021, Science).

Line 403 & 414: it would be worthwhile to calculate the temporal resolution of the Larsen BIA samples, especially in the horizontal dimension (easy to do given Fig A7). How does that compare to, for example, the Talos Dome ice core record nearby?

Line 405: the word “chemical” usually refers to ions in ice cores.

Line 406: again please provide a clear reference point against which downstream and upstream are defined.

Line 412: can you provide more proof to back the claim of “high-precision ages”? It would be helpful if errors associated with cross-correlating different properties could be presented, like what Menking et al (2019) Clim. Past did.

References:

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