

## “Dating of an East Antarctic ice core (GV7) by high resolution chemical stratigraphies”

Nardin et al. (2021)

Climate of the Past

5 Referee: D Emanuelsson

### Summary

The age scale for a new ice core GV7, Oates Land, is presented.

The paper needs major revisions. There is no clear display material from which the reader can gain confidence in the age scale. This can be addressed by showing a figure with nssSO<sub>4</sub> versus  
10 time and indicate volcanic events that stand out from the background any by updating Table 1.

The novel aspects of the core, deepest and oldest core in the Oates region, the trace element records can be highlighted to increase the impact of this study. The writing needs to be improved and checked for clarity.

### Comments to the authors

15 This is interesting work with some unique aspects. I hope the number of comments doesn't discourage you. Keep at it and this study will provide important records that can be used in future studies.

### Major comments:

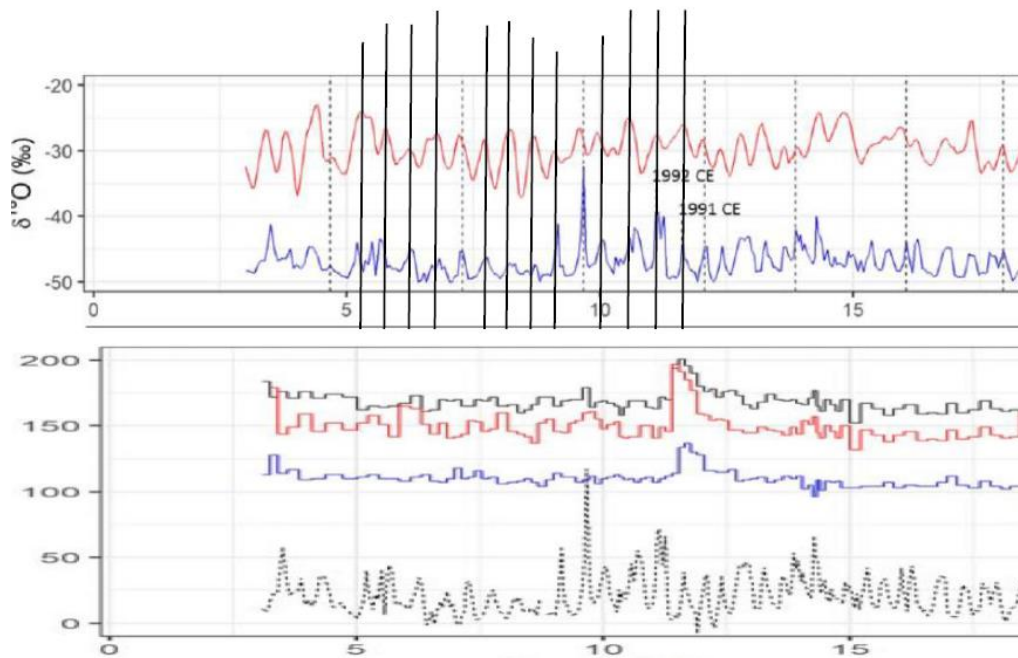
Be clearer about the method you use. You use nssSO<sub>4</sub> peaks as your main indicator for assigning annual-layer counts, and you have  $\delta^{18}\text{O}$  as additional support. Then this method is evaluated by  
20 checking the dates against the volcanic events horizons. If they do not agree, you will have to check if your method is wrong, perhaps another chemical works better.

- Your pick at 4.67m (2005) could be questionable. As it is on a shoulder of the isotopes and the nssSO<sub>4</sub> is low. Close to the surface, it is easy to overcount using the isotopes, as diffusion has not smoothed the signal as it has for a deeper section. Are there any other  
25 impurities to look at? It almost looks like the trace elements could be helpful for the annual-layer counts. Check the figure that I merged below. (and the trace elements would maybe indicate that this is a pick?).

If you remove this pick, the years that you have marked with text around the Pinatubo eruption will be 1993 and 1992. Then the rise in the trace elements does not occur before the eruption.

30 The depths that you report for the trace element rise seem wrong (11.0 and 12.5 m). If you correct them (11.6 to 12.2 m) the trace element increase will not occur before the eruption. Don't eyeball this, use the criteria that you used in your earlier paper (2std or 3std above background), to find the exact depth/timing for these events.

Merge figures 2 and 3. Align b (now figure 3) with depth axis in the top panel of a (similar to  
35 like I've done below). How does it look for Agung and other volcanic events? Or even better if there are trace elements for all the depths add two panels with trace elements (b, d). If there are trace elements for the core. It would be interesting to look at this closer and it could increase the impact of the paper.



40

**Fig. R1**

- How do the gaps in the gaps affect the accuracy of the dating? Add a supplementary table that provides % missing for each record.
- For uncertainty estimates, I prefer a method that compares ice core ages at volcanic event horizons.

45

- Does the accumulation record have a correction for ice layer thinning? Please provide details. A long-term trend might be introduced by not making this correction.

50 **Specific comments:**

*Title*

Change title. ‘stratigraphies’ typically is used when you refer to physical properties in a core, not chemical.

*Abstract*

55 L21. Stratigraphic dating, you could say this, but you can be misunderstood. The reader might think that you use layering in the ice from say radar scans not chemistry for dating. I suggest that you change this throughout the document.

L21. Say just ‘drill site’.

L21. Provide the region where it was drilled Oates Land, East Antarctica.

60 L23. Say ‘and water stable isotopes ( $\delta^{18}\text{O}$ )..’ instead, or

L23. Rewrite. ‘...sea salt ions contain a clear seasonal cycle and was therefore used for the annual-layer counting.’

L25. Delete ‘correlation’ say ‘age-depth relationship’ instead.

L25. ‘1179-2009’ change the type of dash you use.

65 L27-28. ‘A small, yet consistent, rise in accumulation rate was found for the last 830 years since the middle of the 18th century.’ Is it significant? If not, it is not a trend. Provide trend and p-value.

Middle 18<sup>th</sup> century, approximately 1750, now it is 2021, that is about 370 yrs, not 830 years.

*Introduction*

70

L47. PNRA explain acronyms and explain them at their first occurrence (IPICS).

L58. Mention the work that Winstup et al. has done for constraining ice core chronologies (Winstrup et al. 2012, 2017)

75 L77. A too general statement, is it true for all Antarctic cores, or for GV7? If GV7 it should be reported in the result section.

L91  $\delta^{18}\text{O}$

L92 You mean that you linearly interpolate for the dates between annual markers? You can say that, but it should be in the method section not here.

L93 Just report on the methods that was successful here.

80 ***Materials and methods***

- Why wasn't  $\delta^{18}\text{O}$  analyzed throughout the core at high resolution? It would not be affected by contamination like the ions, so you could get a record with fewer gaps.

L98 insert a space, 1700 m.

85 L104 'Estimates of snow accumulation has been calculated from GPR layers from the 2001-2002 ITASE...'

L111 '(ranging in length between 5 to 50 m)'

L112 'The 250 m deep core, GV7(B) is used in this study. The ice core (Fig. 1) was retrieved using an electromechanical drill (Eclipse Ice drill Instrument).'

90 L119. Do you mean that you kept a 4 m of fluid measured from the drill bit to have the drill submerged but not more? The drill fluid surface was not kept at 80m by adding more fluid. This practice could perhaps be better when drilling a brittle core.

L123 be concise '...only the upper 194 m were analyzed.' Should suffice.

L128 and 133. Say cubes instead. The 4x4 cm core cubes for...

95 L143 and L144 Change to 'cations' and 'anions', remove the mentioning of the pump to be brief.

L147. 'while the analytical performance of the methods was tested and described in Nardin et al., (2020).' I do not think you can claim that you did this in your paper. You showed a high-resolution record, but no specific tests of the performance.

L156. Remove the dash and add punctuation.

100 L174 and L175 Do you use these ratios in the manuscript?

L179. Rewrite this section ...was used to identify volcanic.. end sentence after 'ice cores'.

L184. Delete 'where an in-depth discussion....' While this is true, it is not relevant here. Mention it in another section.

L200. Due 'to' possible noise...

105 ***Result and discussion***

L211. You use nssSO4 and  $\delta^{18}\text{O}$  together to make a judgment for the annual marker, correct? Here it sounds like you make to age scales one using  $\delta^{18}\text{O}$  and one using nssSO4.

110 L215. You cannot expect the peaks of  $\delta^{18}\text{O}$  and nssSO4 to always align. Especially not for deeper sections when diffusion has acted on the isotopic signal. It is not caused by the different depth resolution of the records. Remove the last two sentences of this paragraph.

L256. This sentence is way too long. And the end can be misunderstood. It is enough to say. '..., suggesting a lack of seasonality.'

L271. The punctuation is missing.

115 L274. Change Factor 1 and 2 to PC1 and PC2 (principal components).

L275. The signs of the PCs are arbitrary.

L268. Delete the PCA analysis. I do not think it adds any value. Are you using it for dating?

L278 In general, you do not need to report all approaches that you try that turn out to not be fruitful, this makes the paper long and hard to read.

120 L294 Should be 'unequivocal'.

L316. Rewrite this sentence. Suggestions, 'there are fewer major eruptions in this section of the core and as they are further apart the uncertainty becomes larger.'

L328-329. The first sentences here should be in the method sections. Add a SMB section to the methods and provide more detail about thinning correction too. For example, Thomas et al. (2017) have a method section describing this correction. Present your results first here and then discuss with others' work.

L332. You use several symbols and abbreviations for standard deviation, stick to just one.

L344. Rewrite for clarity. The mixture of trends and correlations in this paragraph is confusing.

L349. What do you mean here by 'misinterpretation'? If you show that your annual layer counting method works. That is nssSO4 peaks line up with known volcanic horizons. Then you cannot at the same time claim that you have done a misinterpretation.

L350. Switch the order of the years around.

L417. Change to 'Conclusions'.

L430. Change to 'The GV7 chronology covers the 1179-2009 CE period. The average annual snow accumulation for this period is 205 mm w.e.'

Add a data availability section.

### ***Figures***

Figure 1.

Zoom in on the region of interest. Show the whole Antarctic map as an insert. The figure will look better if you add topography (example from bedmap2).

L115 Change to '...1950 m a.s.l.) drill site...'

Figure 2.

Pinatubo is marked but not Agung.

Have you removed single value peaks, contamination? Using the code you described in (Nardin et al. 2020).

Show lines for each annual pick. Zoom in a bit, so it doesn't become too cluttered.

Change the coloring on the y-axes so they correspond to what is shown.

I prefer the figure you have in the supplementary material (Figs. S3 and S4) over this, as  $\delta^{18}\text{O}$  is only available for the top part of the core.

150 Figure 4.

‘Concentration bins have a three-month seasonal width..’. Tell the reader which intervals you use here, JFM, AMJ,...

155 ‘Upper concentration limits and bin sizes were chosen to keep between each ion’s plot the same proportions in order to facilitate the interpretation of the data.’ Do you need to say this, or do you mean that you have cut out some data with high concentrations?

As nssSO<sub>4</sub> is used as the primary chemical for pick annual layers, it will because of this choice show more seasonality. I am not questioning your choice, I’m merely pointing this out.

Figure 5. Change to: ‘Age-depth relationship...’

Figure 6.

160 Is there a periodicity in the data, is there an increase after a volcanic event?

To check this you can make a plot with all the events and put each event at time zero, so you can plot them together.

Change axis text from ‘TIME’ to Time and ACCUMULATION to Accumulation.

Add letters to the figure indicating subplots (a, b).

165 Start with the start year, i.e. 1849-2001 CE.

Indicate ‘Tephra’ with another color in the figure as it is not a well-established event.

Figure 7. Say ‘Accumulation records used for the core stack (gray lines), the stacked accumulation record (blue line)’

Add letters (a, b, c) to the figure.

170 L410. ‘a’ should not be capitalized.

Which specific ITASE core was this? There are many.

Table 1.

‘Pinatubo/Cerro Hudson’

Table captions usually go on top of the table.

175 Is it the start or end depth that you are providing? Provide an end and start date, which is more exact. You can get this from Figure S5. Pinatubo 1991.5 (start) 1993.5 (end) (e.g. from the WAIS core, (Sigl et al. 2013)).

Table 3.

Rewrite caption. ‘its’

180 If you smooth the record before the analysis that would affect the standard deviation.

Change to ‘not significant’ instead of ‘No sign.’ Or ‘No trend’.

L414. Rewrite this sentence. Suggestion: ‘the mean (M) and standard deviation (SD) of the accumulation record..’

185 It is also confusing that you call the stacked record used here the same name as the other single core.

### *Supplementary material*

Table S1 and Figure S1. Provide the same information. Stick with just the biplot.

190 Table S1 caption. The marked loading are  $>.6$ ? PC1 explain 0.40 and PC2 0.184. (= 58.6% explained together)?

Do you mean that it has been varimax rotated?

You need punctuation at the end of each caption.

Figure S3. Move one of these figures to the main text. Remove the normalized record, if it doesn’t add anything. Check with a seasonal plot if you are not sure (like Fig. 4).

195 Remove the parentheses pair after used after ‘layering (...)’.

Typo should be ‘orange line’.

Figure S4. ‘for a shallow (a) and a deep (b) section of the core’.



‘Despite showing a similar...’ remove this sentence. I would avoid having this discussion in the figure caption.

200 Figure S5.

Show the whole record. Do not start at 25 m.

Change to nssSO<sub>4</sub> versus time. What you show is the same as in Nardin et al. 2020 otherwise.

205 Add volcanic events. Like you did nicely in Nardin et al. 2020, but now do it versus time. Add the background +2std and 3std levels. This way you can evaluate the timing of the volcanic peaks and the reader can gain confidence in the age scale. It is a large figure, but important, I would consider moving it into the main text.

Increase the line thickness of the nssSO<sub>4</sub> line and the box around the figure and make the text bold. This will improve the figure quality.

‘with grey dashed and red lines, respectively.

210 ‘Other breakages are not highlighted’ remove this sentence.

## References

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- Winstrup M, Svensson a. M, Rasmussen SO, et al (2012) An automated approach for annual layer counting in ice cores. *Clim Past* 8:1881–1895. <https://doi.org/10.5194/cp-8-1881-2012>
- 225 Winstrup M, Vallenga PT, Kjær H a., et al (2017) A 2700-year timescale and accumulation reconstruction for Roosevelt Island, West Antarctica. *Clim Past Discuss* submitted