

## Referee 2 Holly Winton

Vance et al. present the chronology for a new ~300 m ice core recovered from Mount Brown South in East Antarctica filling a void in the spatial array of ice core records in the region. The manuscript describes the drilling, processing and analytical procedures and presents the age-depth model. The core was dated using a range of annually resolved chemical species and a number of volcanic tie points. I enjoyed reading about the group approach to annual layer counting and the use of two independent annual layer counts to derive the final age-depth model. The authors also describe the seasonality of fluoride in the core. Fluoride is rarely detected in Antarctic ice cores and in the atmosphere over the Southern Ocean and thus the sources and atmospheric processes of fluoride in the region are not well understood. Below are suggestions that I hope will improve the manuscript before publication in *Climate of the Past*.

### Main comments

#### Ice chemistry analysis and figures of merit

The ICP-MS methods section reports figures of merit including LOD and reproducibility. Some LOD data are presented in Table 4. Please report accuracy of the ICP-MS measurements. Did you measure sulphur or aluminium via ICP-MS? As you have done for the ICP-MS, please report figures of merit for IC and CFA measurements including blank concentrations, accuracy, precision and also note the concentration range of calibration standards. How do sodium and calcium concentrations compare between ICP-MS, IC and CFA measurements?

There are multiple aspects to this comment, which we have separated out to address individually below (in italics). Because this paper uses data from already published methods, we opted to refer the reader to the publications that detail these methods, including the full figures of merit. We don't think it is within the scope of this work to reproduce the full figures of merit (such as calibration ranges and blank concentrations). However, we acknowledge the captions for Table 4, and the discussion around concentrations didn't clearly identify where these figures of merit from the method development papers could be found. We will re-write these sections to make this clearer and include figures of merit for the IC data where it makes sense.

*Please report accuracy of the ICP-MS measurements.*

These are reported in Vallelonga et al., 2017 and associated previous publications for the method. Note that the ICP-MS data was not used to develop the chronology reported here, so we don't think it appropriate to report in detail in this work (the ICP-MS data is being prepared for publication elsewhere). We will revise the caption to ensure the reader is clearly directed to the appropriate publications for details around the analytical method and associated accuracy.

*Did you measure sulphur or aluminium via ICP-MS?*

No we didn't.

*As you have done for the ICP-MS, please report figures of merit for IC and CFA measurements including blank concentrations, accuracy, precision and also note the concentration range of calibration standards.*

We don't report CFA impurities measurements in this manuscript, as the CFA data is being prepared for publication elsewhere, and the data was not ready for use. We used the discretely derived chemistry and stable water isotope ratios exclusively for dating and development of the chronologies here (with the bulk of emphasis on the chemistry, as it contained the clearest annual layers). We also looked at an interim CFA water isotope ratios dataset for confirmatory purposes during dating, but this was not on a finalised depth scale, so it wasn't specifically investigated in the matchmaker dataset. The figures of merit for the IC data

will be reported in this new CFA data paper, which will be a comprehensive analysis of the current (modified) UCPH / Niels Bohr CFA system used. We will ensure the reader is clearly directed to the figures of merit for IC data.

*How do sodium and calcium concentrations compare between ICP-MS, IC and CFA measurements?*

We suggest this would be better explored in the MBS ICP-MS paper that is being developed by the co-authors here that have developed that dataset, as there is likely to be some measure of discrepancies between the three techniques (ICP-MS\IC\CFA sodium and calcium). This is because IC and CFA determine only the soluble fraction, while ICP-MS can determine also a fraction of the insoluble\mineral component for these elements. The reasons behind these discrepancies deserve a full analysis, including any difference between soluble and insoluble fractions. The point of showing the mean concentrations here is to have a brief discussion around any similarities and differences between the two sites (Law Dome and MBS) as the datasets from both sites have been measured using the same methods. Thus, they are directly comparable across sites, but not necessarily across analytical techniques.

As above the CFA impurities data is under development. The MBS chronology was primarily developed using the discrete chemistry data measured in Hobart. It should also be noted that the different analyses have been measured at very different resolutions (~25 cm for ICP-MS, compared to 3cm for discrete chemistry).

#### Depth scale

As the focus of this manuscript is the age-depth scale of the MBS core, I encourage the authors to include the description of the scaling and shift factors. This would be useful for the community as discrepancies between field and lab depth scales and core breakage is not unique to the MBS core. Can you estimate a depth uncertainty of the master depth model?

Scaling and shift factors are being actively employed in the development of the CFA impurities and CFA isotopes datasets, which will both be published as data descriptor papers. For this study we can certainly include a description of how the Hobart depth model was aligned to the UCPH CFA stick lengths in the revised document. We propose this to be in the form of a simple shift/scale correction (equation) that will describe how a discrepancy in (Hobart) core lengths and (UCPH) CFA stick lengths was solved for each core / bag.

By depth uncertainty, we assume the reviewer means the differences between field (drilling) depths and bag lengths recorded during discrete sample processing? This is detailed in section 2.7, lines 248-250:

*To solve the length discrepancies and derive a master depth model, we compared field and lab measurements to the ILCS scans to derive the correct length of each core. This painstaking process was then used to determine the full drilled depth of 294.785 metres, which is 18.5 cm different from the field measured depth of 294.6 metres (i.e. a 0.003% error).*

#### Age uncertainty

An age uncertainty of  $\pm 2$  years is reported in the conclusions. How was this derived? Please report in the abstract and main text.

The age uncertainty is derived from the WAIS Divide uncertainty, given we have synchronised MBS to WAIS (Table 3 and section 3.1) We will report the synchronization in the abstract as well.

#### Fluoride

The detection of fluoride and its seasonality is an interesting finding. Given fluoride has a different seasonality to the other markers, it is helpful to identify the annual layers and thus useful in this context. Yet, fluoride is largely unexplored in Antarctic ice cores and the modern atmosphere over the Southern Ocean so much so that we know little about the sources and photochemical processes in this unique and pristine environment and without this understanding, interpreting ice core fluoride is largely speculative. A study understanding the air-snow transfer of fluoride and the post-depositional processes along with exploring ice core fluoride relationships with a range of climate variables over the instrumental era would be incredibly valuable to further understand the potential as a sea ice proxy. Given fluoride is volatile, the first step is to understand how photochemistry between the atmosphere and surface snow impacts the archived fluoride signal. For example, over a decade has been dedicated to understanding these processes for ice core nitrate. Since this information is currently lacking for ice core fluoride, I suggest focussing manuscript on the use of fluoride as an annual marker and moving the discussion on fluoride as a potential sea ice proxy to a separate manuscript dedicated to understanding fluoride deposition at the MBS south.

[Noted, as with the other reviewer, we will comprehensively shorten and revise this fluoride section to remove speculation around the sources of fluoride.](#)

The detection of fluoride in MBS raises many questions. For example, what were the summer and winter concentrations of fluoride in the MSB core and how do they compare to Severi et al. (2014) and Morganti et al. (2007). Is the seasonality the same between the three studies? How does the seasonality of fluoride compare to nitrate, bromine and iodine which also undergo photochemical/ post-depositional processes? What information is known about fluoride from Southern Ocean aerosol studies? I understand, from personal communication, aerosol fluoride also exhibits a seasonal cycle at the Cape Grim Baseline Air Pollution Station.

[These are excellent questions for a manuscript focussed on the fluoride data. As suggested we will greatly reduce this section in a revised manuscript and focus on the dating here. We thank the reviewer for the questions they pose that could be explored. I was not aware of the fluoride sampling at Cape Grim!](#)

#### Data availability

Note that the age-depth model not supplied and not yet available on the Australian Antarctic Data Centre.

[This data will be uploaded to the Australian Antarctic Data Centre prior to the submission of the revised manuscript, such that a doi / link is available for the data if the manuscript is accepted.](#)

#### **Specific comments**

L78 water isotopic ratios (here and throughout) [We will correct this](#)

L105 and L120 how are the 3 cm resolution chemistry samples mentioned here different to the 3.5 cm chemistry samples mentioned in L107? [We will re-write this – we acknowledge it is quite confusing as it is currently written. The 3.5 cm sample refers to the analysed section of the final 4cm sample in a 1 metre bag \(e.g 1 metre if ice yields 32 x 3 cm samples \(96cm\) plus 1 x 4cm sample, which becomes 3.5 cm after sampling in our laminar flow vice system.](#)

L105-117 how many samples per year result from this sampling resolution? [This is written at line 111 – 10 samples per year. As with reviewer one, we will provide a range for this annual sample resolution.](#)

L124-125 how did you mitigate this? This organic contamination could be drill fluid contamination which has been observed in some ice core samples where drill fluid has contaminated the core through micro fractures and impacts the shoulder of the MSA peak. [We think this was laboratory contamination. It is](#)

unlikely to have been drill fluid, as this contamination occurred in the dry drilled section of the core (~20-93 metres). We will modify this sentence to be clear where we think the contamination came from.

L154 hydrogen peroxide We will correct this

L167 sodium We will correct this

L170 number of particles. Add reference. We will correct this

L172 add resistivity of Milli-Q water. We will correct this

L173 calibration standards Noted, we will revise accordingly

L177 manuscript uses both “mL” and “ml” We will correct this

L180 CRDS We will define this acronym

L185 delete ‘halogens’? We will correct this

L185 how were these sub-sampled? Noted, we will revise accordingly.

L195 ICP-MS tubing? Noted, we will revise accordingly

L205-206 reported in Table 4 Noted, we will revise accordingly

L268-270 references required here to justify assignment of these peaks to 1 January. We think this is explained in the following sentences about the difference between Law Dome and MBS annual horizon dates. We will revisit this section to ensure clarity.

L313 in the case of an uncertain counted year, where did you place the annual marker? e.g. on the nss-sulphate or water isotope peak? This depended on the available evidence in each case. We will revise to make this clear.

L330 e.g., extreme precipitation events (Turner et al. 2019) Noted, we will revise accordingly

L423 which is the “prior study”? Foster et al., 2006 (already cited here and in introduction).

L429 MSA is a proxy of sea ice in some regions of Antarctica. Noted, we will revise accordingly

Figure 1 A scale bar on panel b would be helpful to see the extent of the snow features. Add snow pit label to panel b. We will correct this

Figure 3 Add dimensions We will correct this

Figure 4 Y-axis label missing We will correct this