This paper is a rather straightforward extension of previous work that suggested using dust records to date new, old, ice cores. For complete transparency, I was the lead author of that previous paper.

The most important addition of this paper is comparison with a new marine dust record which shows a different pattern in the pre-MPT era and therefore suggests a different template to that proposed so far. This is certainly worth pointing out and the authors make a good, though not cast-iron, case that the new record would be a better template. The second addition is the use of dust data obtained by downhole optical logging, opening up the possibility to date ice rapidly and before a full drilling campaign. This again seems valuable, and is perhaps underplayed in this paper. Finally the authors discuss how the dust templates might be used in practice – this section is less insightful, and quite hard to follow. Taking the paper as a whole, it is worthwhile (and I thank the authors for keeping it short in proportion to its findings), but does need some clarifications and minor additions.

Thank you for your thoughtful assessment. We will further emphasize the rapid dating application of our approach where appropriate throughout the paper and revise the section on using the dust templates for clarity.

Larger issues:
Line 135-140. Clearly the two marine dust records do diverge considerably before 800 ka. While you present reasons why 1537 should be the better template, I'd like to see a more subtle discussion. I think one could equally make the argument the other way, that 1090 more obviously integrates dust emissions from across South America, while 1537 is likely only to see the southernmost Patagonian emissions. Dust geochemistry does suggest a preponderance of Patagonian emissions in EDC dust, but it is not really clearcut, and who knows if this is true before 800 ka? I am not arguing for a major change but I think it would be better to leave it slightly open as to which dust record is the better template and let us decide once we have the ice! I do think you could though make more of the fact that 1537 is much better resolved (I think ~200 m of core for 1.5Ma cf 40 m at 1090).

We appreciate this nuance and will rework the section accordingly.

Line 141-9. I think it is a bit dangerous to imply that you expect LR04 to look like dust. The point about using dust records as a template (and other records we might choose as templates) is that there is a good theoretical reason (same source and transport pathways) to expect them to look the same under most circumstances. This was our justification for proposing extending the match beyond 800 ka (even if 1537 suggests that may also be tricky). There is no similar theoretical reason (other than that all records show glacial cycles) to expect LR04 to look similar, or to propose that the match should extend into the 40 ka world, and using it as a template would be circular reasoning when we want to use the ice record to understand climate. By all means point out the similarities but then I would strongly recommend not using LR04 any further and not recommending that it forms any part of a template. In particular I would not show it in Fig 4.

This is a good point, although LR04 has already been used to establish the U1537 chronology (along with biostratigraphy and magnetostratigraphy). We will remove LR04 from Fig 4 and most of the analysis.

Optical dust record, section 4.1 and Fig 5. To my knowledge this is the first time the EDC optical dust record has been shown, so you need to do more to show that it matches the laser dust record. Before playing with age scales, you should show both on a depth scale where there is no alignment issue. I suggest adding a figure where you show the whole record and some detailed parts so the reader can judge to what extent the optical record captures both the shape and amplitude of dust peaks. (Minor point: if this is indeed the first outing for these data then there should be an acknowledgment to EPICA!). In addition to this Fig 5 is confusing: panel a and b say they are the optical log but they have a colour that says (legend) they are laser dust. Please alter this.

We will add a figure and more discussion of the EDC optical dust record with appropriate acknowledgement to EPICA. We apologize for the error in the legend and will correct it for the revised manuscript.

Section 4.2 and Fig 6. I have now read this several ties and I'm afraid I can't understand what you have done. "such that the peaks in the artificial record (Fig 6c top) appeared older than they originally were". I just can't see in the figure what it is you claim to have done, or where the supposed mismatches are. You seem to have exactly the same peaks in exactly the same places. You appear to be suggesting that the peak at 1050 ka is displaced by 200 ka, but I am not seeing it. I imagine I have misunderstood the figure but I think others will too, so please make a new attempt to explain this perhaps highlighting using the curves in b and c exactly what the mismatches are.

If DTW were totally accurate, the black and blue lines would lie exactly on top of each other, with the same amplitudes at each peak. However, as an example, the highest amplitude peak in the black line (on the DTW timescale) within the orange shaded area occurs at appx 1200 ka, while the highest amplitude peak in the blue line (on the original time scale) occurs at appx 1050 ka. We will rework this section and figure for clarity with additional suggestions from reviewer Lorraine Lisiecki.

Honestly I don't find section 4.2 very useful or enlightening, but I think this is because I am imagining a situation where we have a core with multiple dating aids (gases with insolation cycles, dust, 10Be etc), while you are considering the case of a raid access hole with only the dust record available. I think the more likely problem for a core is not that peaks in good order are misidentified: the issue is how to know whether there has been folding putting peaks in the ice in the wrong order, and this is not addressed here. Maybe this could be mentioned as a potential hazard!

Our approach is really intended for rapid dating in the field using only the dust record, as you note. We will emphasize this application in the introduction and where appropriate throughout the manuscript. Per your and Lorraine Lisiecki's suggestion, we will explore whether folding could be detected using our method.

Detailed comments

Line 12. I am not sure why "surprisingly" is used. At EDC at least there is melting at the bed so it's not a surprise that it's not so old. Perhaps just remove this word unless you had something specific in mind.

Removed "surprisingly."

Line 10 and 47. Sorry to be picky but IPICS is International Partnerships (plural) in Ice Core Sciences.

Corrected.

Line 90 (also 106). It's a shame you are using the very old EDC3 age model, especially as you use the AICC2012 alignment for Dome Fuji. I appreciate that ODP1090 was compared to an EDC3 age model as that was still the standard in 2012, but it should be quite straightforward to translate both EDC and EDC1090 to AICC2012, thus removing one unintended source of minor mismatch between the records you use. If you do stay with EDC3 perhaps you need to add a line pointing out that there are minor differences between EDC3 and AICC2012, but that they don't affect the pattern of glacial cycles being used in the template.

We will put EDC and ODP1090 on the AICC2012 chronology.

Line 113: "the aridity (due to temperature) and circulation of the atmosphere, which influences the production and transport of dust". I suggest adding "and atmospheric lifetime". This is probably more important than the transport itself.

Added "and atmospheric lifetime."

Section 2.4, Table 1, etc. You use dust itself in 1090, whereas our previous paper used Fe_MAR. I think your dust record is OK, and it seems to give a good result in the last 800 kyr, and a very similar pattern before that. But it would be good if you just point this difference out so people can understand why the units are a little different. Similarly (and I know you have discussed this) it might need an extra line in 2.3 to explain that MS has been empirically shown to be more like EDC and ODP1090 than what might seem more direct measures of dust.

We will clarify these details, thank you for pointing them out.

Line 155. Of course the reason why the log records work better is because the dynamic range of the different records is different. (I think less so for EDC and 1537 but still the principle holds). Add a few words?

We will add a brief comment on the log records.

Fig. 5 – see comments above about the colours in panels a and b, which are confusing. In addition it should not go beyond 800 ka in panels b and c – this is as far as the EPICA age scale goes and beyond that it is assumed that the ice is disturbed and not necessarily in age order.

We apologize for the error in the legend colors that caused confusion. The exercise shown in Fig 5 pretends that we only have the dust-depth record, not an established age scale, as would be the case for an Oldest Ice site; therefore we do not limit the age of U1537 marine dust shown in panel C to only 800 ka.

Lines 185-6. I found this confusing, and couldn't quite work out what you did (especially what you mean by "scaling the smoothed record by random factors between 0.4 - 0.7 linearly interpolated between 500 kyr intervals"), although I understand the intention. Please spell it out more clearly. I wonder why you smoothed with a 20 kyr running mean – this means that by design you have taken out some of the multimillennial features that might have been used to identify the correct peaks to tie records together.

We will revise this section for clarity, as well as implement suggestions from Lorraine Lisiecki to reduce the amplitude of the artificial record farther back in time and compare multiple versions of an artificial record. The thought behind smoothing with a 20 kyr running mean was that some lower amplitude millennial scale features that are recorded in marine sediments may not make it to the ice sheet, but we will try it both with and without this smoothing.

Discussion: Last para of discussion, you might add some thoughts about dating with multiple datasets in a full core and about the hazards of folding, as per my earlier comment.

Per our response to the earlier comment, we will assess whether our approach can detect folding and add to the discussion here.

Line 265. I'm sorry but I think the optical dust record needs to be made publicly available, not just on request, to meet the journal rules.

We will make the optical dust record available in a data repository.