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Interactive comment on “Can we retrieve a clear paleoclimatic signal from the deeper part of the EPICA Dome C ice core?” by J.-L. Tison et al.

Anonymous Referee #3

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Tison et al. present a wide variety of geochemical measurements in an effort to understand the bottom 60m of the Dome C ice core. The climate interpretation of Dome C stops at ~3200 m even though there is another ~60 m of ice below this. Tison et al. divide the bottom 60 m into 48 m of “deep ice” and 12 m of “basal ice” based on the structure of the ice. The geochemistry of the ice is consistent with that of a cold glacial period and appears to be only minorly altered. They suggest the most likely explanation is that the deep ice has been stretched relative to the ice above due to changing stress conditions from irregular bedrock topography. This implies it may be possible to extend the climate record of EDC another few tens of thousands of years.

The science is well described and the paper is well written. The geochemical analyses are extensive and the descriptions of deep ice processes that may alter the ice are

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presented clearly. The timescale for the deep ice rests on the matching of muted peaks in the $d_{18}O_{atm}$ to insolation forcing and is not wholly convincing, as the authors acknowledge given the deuterium data. This leads to an uncertainty in whether the deep ice represents 40,000 years or only 10,000 years and highlights that stretching may be the most likely situation but is not definitive.

I recommend publishing this paper with minor revisions as described below. One other point is that the title asks a question that is not clearly answered in the paper. I think the answer to whether a clear paleoclimate signal can be recovered is “no” because there is not sufficient confidence in the timescale to be certain the geochemistry is truly preserved, but that there is hope that other sites, without complicated bedrock, could preserve paleoclimate signal to within meters of the bed. The authors may want to revise the title and paper such that the reader is not left hanging.

General Suggestions:

Stretching:

It does not seem like the mechanism of basal stretching gets sufficient discussion. Since this is the proposed mechanism, more detailed analysis is needed. I wanted to read a discussion of the magnitude of stretching the deep ice likely experienced. As a quick estimate, I compared the implied average annual layer thickness of the deep ice to that of the ice in the final glacial cycle of the climate record (using AICC2012). This suggested that the ice was thicker than might be expected by roughly a factor of 2, assuming the deep ice spanned 40,000 years. This seems within reason, but still a lot of stretching. If the ice only contains 10,000 years, then it has been stretched nearly 10X, which seems much less likely.

I would also have liked a figure of the EDC basal topography. While it is shown in referenced papers, it would be worthwhile to reproduce it here as well.

There is also surprisingly little discussion of ice-flow transients. My thought is that the

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summit of Dome C has likely migrated through time since many interior ice divides (e.g. Summit Greenland and WAIS Divide) are migrating today and I don't know of any evidence one way or the other for Dome C. Given the rough bed topography, it takes a migration of only a few ice thicknesses (~ 10 km) to change bedrock elevation by ~ 200 m. The deep ice may experience stretching because it flowed from a bedrock ridge to the current valley and only recently has the divide migrated over the top.

Implications for Old Ice:

Maybe this is beyond the scope of this paper, but I was hoping for a brief (one or two paragraph) discussion of the implications for finding million year-old or older ice. This has been identified as a major ice-core goal in the coming decades, and I think this analysis yields important insight into what might be expected. The two conclusions I drew from this paper were 1) the geochemistry likely remains relatively unaltered although there is migration of species and 2) rough bedrock greatly complicates the inference of deep timescales. But I imagine the authors have much more to add.

Specific comments:

P569,L24 – I don't understand what the sentence beginning "we also discuss" is trying to say. Maybe just deleted?

P569,L25 – See comments about final sentence of abstract above and also consider shortening this sentence into a more specific answer of the title.

Figures – more color would be helpful (and there's no extra cost!)

Figure 4 – the panels are very small and nearly unintelligible, at least as presented in the PDF. Since all of the panel have the same depth axis, the panels could be enlarged by eliminating the redundant axes labels.

Figure 5 – panels are small like in Figure 4.

Interactive comment on The Cryosphere Discuss., 9, 567, 2015.

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