

Interactive comment on “Radar stratigraphy connecting Lake Vostok and Dome C, East Antarctica, constrains the EPICA/DMC ice core time scale” by M. G. P. Cavitte et al.

Anonymous Referee #1

Received and published: 20 March 2013

Cavitte et al. tracked isochronous englacial radar reflectors between EPICA Dome C and Vostok ice cores, in order to better constrain the depth-age relationship of the Dome C ice core. In general, this manuscript is not well organized so hard to follow. The title says that radar constraints of ice-core time scales are reported, but the abstract says no specific results how this method improved the ice-core time scales. In section 2 (data and methods), it is said that the propagation speed is assumed to be 169 m/usec citing Carter et al. but without any further justifications of this assumption. Nothing is said that this propagation speed is further examined later. Suddenly, uncertainty of this assumption is discussed very end of Section 3.1.

C172

[Major points]

1. The weakest point of this paper is that a uniform radio-wave propagation speed of 169 m/usec is assumed. The propagation speed is a function of density (i.e. firn thickness), ice temperature, and ice fabrics. This study accounts for the firn effects; the other two affect less but significant. The deepest tracked radar reflector is 2300 m deep at Dome C ice core site, which corresponds to the two-way travel time of 27.2 usec if the speed is 169 m/usec. The speed in "pure" ice can vary between 168 and 169.5 m/usec (Fujita et al., 2000, Physics of Ice Core Records). This speed range gives the depth uncertainty of 21 m. According to Figure 5, this depth uncertainty gives the age uncertainty of 3-5 ka. It is possible to accurately estimate the depth profiles of the propagation speed, in terms of firn density (this is done using Equation 1), ice temperature, and fabrics, using the ice-core data. Propagation speed dependences on these factors are not unique but it is reasonable to assume that the same dependences can be applied to these two ice cores. This assumption is valid if the same physical mechanisms control the dielectric processes in these ice cores. Such analysis is necessary to define the uncertainties of this radar-based chronology.
2. The radar instruments used for this study have 100-250 nsec pulse widths, which correspond to the vertical resolutions of 8-21 m. In other words, a single radar reflector is made up with interference of the radio waves reflected from individual interfaces of the dielectric conductivity over this depth range. The depth of a radar reflector at the core site does not necessarily give the accurate depth of the reflection origin. Practically speaking, it is necessary to examine depth profiles of DEP (or similar dielectric conductivity) records in order to find the dominant source of each radar reflector. If there are multiple DEP peaks with similar magnitudes, it is impossible to identify the single source of the reflection origin, so the chronology uncertainty should be equivalent to the radar resolution, 8-21 m. The authors present these resolution ranges in Section 3.1 but do not estimate uncertainty in depth and corresponding age, associated with the resolution, digitizing, and reflector-pick uncertainties. More importantly, dielec-

C173

tric profiles and radar reflector depths are not examined together. Resolving these two issues is necessary, before Sections 3 and 4 are fully evaluated.

[Editorial issues]

- "Horizon" is used frequently, to refer radar reflector(s). However, a reflector is not a horizon. Also "layer" is used many times casually. A layer refers a unit of the ice that has a certain thickness. I think that "reflector" is a better word to describe what was observed in the radar data. The use of "layering" is acceptable, but please consider using "reflector stratigraphy" instead.
- Page 322 line 21. The reference should be Suwa and Bender, not Bender and Suwa.
- Page 322 line 24. Kawamura (2009) is a newsletter article, not peer-reviewed. Please make every effort to cite peer-reviewed paper.
- Figure 1: what is the yellow line between C and C'?
- Figure 2: It is quite hard to understand. Please rewrite the caption.
- Figures 3 and 4: it is critical for this manuscript to show how these radar reflectors are tracked. Current figures show the radar images and picked reflectors together so it is hard to see how these picks are valid. Please show two radar image and picked reflectors in separate panels placed next to each other.
- Figure 5: I cannot see any justification to use a simple cubic-spline interpolation to tie spontaneous radar-constrained depth-age points.

Interactive comment on The Cryosphere Discuss., 7, 321, 2013.