Response to Reviewer #4

In this paper the authors use polarimetric radar sounding to characterize the Antarctic ice sheet at South Pole. Since they are cosmic ray physicists, Besson et al. use specialized radio equipment that differs somewhat from that normally used for glaciology. An interesting aspect of the ice which the authors have been able to probe is fabric, or a preferred orientation of the c-axes of the ice grains. The authors have detected birefringence correlated with ice flow direction, though they point to the synchronicity of radio echoes from the top half of the 850 m ice sheet as evidence against any appreciable birefringence there. As the authors point out, reorientation of fabric typically occurs over tens of meters. However, ice grain size can vary considerably over only centimeters, which can affect fabric development. Fabric can also depend on the specifics of the ice flow, for example, whether the flow is convergent or divergent. South Pole is an unusual and potentially intriguing study site since it is not an ice dome or an ice divide. It isnt too surprising to find different fabric at South Pole than at Fuji since SP is "off-axis" and Fuji is a dome. The ice at SP is thought to be in convergent flow and undergoing uniaxial extension, so a vertical girdle fabric would be expected at intermediate depths. The typical transition to vertical single pole which the authors mention may not happen until the deepest 10% or so of the ice sheet, which would be in the echo free zone of radio. The ice at the WAIS Divide site is also in pure shear and exhibits a vertical girdle fabric, with c-axis orientation nearly random for the first 1000 m before developing into a strong girdle, and then into vertical single pole indicative of simple shear in the bottom 15% (Don Voigt, pers. comm.).

We thank the reviewer for her/his insights to our results, to which we, admittedly, had not necessarily given as much thought.

The authors mention "implied" depths based on reflection times, why not include this information for the reader?

Okay, we have now included that information which, as mentioned in the text, is derived from Dowdeswell (2004), for propagation below the firn, and our own firn measurements, made for the RICE experiment at South Pole. That figure is reproduced below:

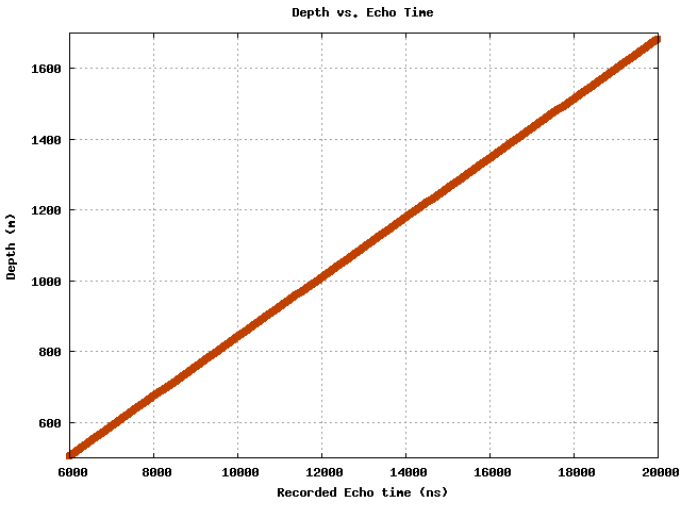

FIG. 1: Implied depth vs. measured echo time, in nanoseconds.

Where do the authors get temperature at depth for the temperature-weighted velocity?

This comes from Price et al (see our response to reviewer #5's comments). The revised text now reads: ''... we neglect the 6° K difference in layer temperature between the depth implied for the 13.9 μs reflection vs. the 19.6 μs reflection (roughly 1150 and 1650 meters, respectively), based on the model of Price et al[?]. For this translation, we use a temperature-weighted...''

In their conclusions the authors claim to see cross-polarized signals which exceed co polarized ones and that this suggests some curious effects may be going on in the ice. It isnt clear from the paper that the authors have eliminated all systematics and put forward clear definitive evidence of this, so some additional material would seem warranted on this point if it is going to be a bullet in their conclusions.

Although we were unable to come up with a convincing rationale for this observation, the discussion has at least been considerably extended (two paragraphs) in the text to include consideration of such effects as inclined basal scattering, circular birefringence, etc.

We do recognize that this is an unexpected result, although the fact that this is observed, for the 6 microsecond reflection, consistently, for all three cross-polarization orientations indicates to us that this is some real physics effect. Apropos of this, a new data sample was taken recently at South Pole to specifically address this question.

In any case, as per the reviewer's wishes, although it is still mentioned in the paper, this has been demoted from a 'conclusions bullet'.

An intermediate depth (1500 m) ice core is being planned at South Pole. Unfortunately the azimuth of the core will likely not be preserved; this is technically challenging and not considered high enough priority to justify the extra trouble when designing coring drills.

We have 'lightened' the comment about the ice core in the text, as per the reviewer's comments.

The revised text now reads: ''Two additional inputs could significantly clarify the association between Radar Echo Sounding measurements and ice chemistry, either: 1) an ice core taken at South Pole, preferably retaining the azimuthal information of the extracted core itself (perhaps unlikely given the operational challenge this presents)''...

Small points... page 4697, line 1: "..work in this subject has been done based..." is awkward.

Yes, in retrospect, admittedly so. Now changed to: ''The most extensive (and, to a large extent, defining) relevant field work has been performed in East Antarctica using an apparatus with somewhat poorer depth resolution than employed in our measurements.''

page 4698, line 12: there is no Fujita reference from 1996.

Yes, this was noted by reviewer #5, and is due to our incorrectly listing the date as 1993. Now corrected.

page 4703, line 10: synchronousness ¿ synchronicity, simultaneity

We believe this is a stylistic question, and that either 'sychronousness' or 'sychronicity' are technically acceptable, (http://dictionary.reference.com/browse/synchronousness?s=t), but will defer to the reviewer's wishes, in any case.

page 4706: "index-of-refraction of refraction"

Now stricken, as, in accordance with the wishes of reviewer #5, we have

dropped the text related to the depth measurement, which will be spun off and form the basis of a separate paper.

page 4708: parallel not perpendicular, pg. 4708 line 11, should be "propagation parallel (i.e. along z)"

Yes, correct, reviewer #5 also noted this; now corrected, thank you.