Response to interactive comments on "Initial results from geophysical surveys and shallow coring of the Northeast Greenland Ice Stream (NEGIS)" by P. Vallelonga et al.

In the response below, the reviewers' comments are in standard text and our responses are in bold.

Both reviewers stressed that information in this paper is difficult to fully assess without reading the companion paper on surface geophysical surveys (Christianson et al., 2014). We believe these papers to be complementary because the presentation of all details of this large field effort in a single paper would create a long, convoluted manuscript that is difficult to read, as well as detracting from the topical focus of the current manuscript. We acknowledge that information about the geophysical dataset is not fully presented in this manuscript. Inclusion of such detailed information would result in a fundamental shift in the focus of this paper, which is to present the viability of future ice-core/climate studies in NEGIS.
Hence we opted on a publication strategy of three manuscripts focusing on three different topics: (1) direct examination of the basal interface with several geophysical techniques (Christianson et al., 2014), (2) tracing internal reflecting horizons in radar data from NGRIP to NEGIS and interpretation of radar internal stratigraphy (Keisling et al., 2014), and (3) a synthesis paper that presents the shallow core results with the necessary geophysical background to understand ice dynamics at the core site (this manuscript). Journals were selected by appropriateness of subject matter. The full details of the geophysical surveys are presented in Christianson et al. (2014) and Keisling et al. (2014). We have, however, attempted to clarify details and revise figures as much as possible following reviewer suggestions. Additionally, we now supply a paragraph at the start of section 2.2 where we outline the publication strategy so readers know where to find additional information. We supplied all three manuscripts to the editors of each respective journal as supplementary documents. Keisling et al. (2014) is now in press and Christianson et al. (2014) is in a very similar stage of review to this article. We anticipate that Christianson et al. (2014) will be published almost contemporaneously with this article.

Anonymous Referee #2
Received and published: 11 March 2014

This paper presents important results from a 67m firn core drilled into the upper part of the Northeast Greenland Ice Stream and ground based radio echo-sounding and seismic surveys conducted in the area. Annual cycles of accumulation and climate variables including insoluble dust, sodium and ammonium concentrations and electrolytic conductivity are resolved in the firn core for the past 400 yr. An RES profile dated using NGRIP ice core reveals that climate records are preserved for this site for at least 51 Kyr. The datasets presented in this study are important for further study of past climate and ice dynamics and firn densification process around a shear zone. I support the publication of this paper after the revisions detailed below:

The paper is generally well written but some parts should be improved. For example, an important reference in this paper is under review (Christianson et al., 2014). It is hard to review some important parts of this paper without reading the other paper. The authors should include more discussions in context of the Christianson paper. I find including an additional zoomed-in figure with the survey lines located on a velocity map with the shear margins included will put the RES image (Fig 4) and Fig7 in context. Fig 4 should also be accompanied by a surface elevation profile for the RES image extent in order to locate the topographic depressions mentioned in the paper. The interpretations of these figures in terms of accumulation and flow-induced strain rates should be discussed in the main text.
We have included an additional panel to figure 4 with a velocity map and shear margins

marked as areas where longitudinal strain rate magnitude is greater than 2e-3 a^{-1}. We also mark shear margins in all local map figures.
A surface elevation profile is included in (revised) Figure 6 and the shear-margin locations are marked.
We have added several references to clarify accumulation and flow-induced strain in the text.

In Basal lithology section, the authors mention that their radar indicates that the central portion of the ice stream bed is wet with water oriented along flow. How did the authors come to this conclusion? I assume it is in the companion Christianson et al (2014) paper? This is an important statement and some general discussions about the radar processing to derive the bed wetness should be included.

We have expanded this section slightly to more directly reference the companion paper and added an introductory paragraph where we clarify information included in each publication. We note that the full discussion is beyond the scope of this paper, but have tried to strengthen this publication to allow direct comparison to other studies of dilatant till under ice streams. The conclusion that the bed is wet is from bright radar reflectivity and seismic AVO analysis.

Specific comments:

L 21: Introductory sentence and L22 does not read well. I suggest combing
"Although. . .not fully understood " part of L22 with L21.
This sentence has been changed to: Mass loss of the Greenland Ice Sheet (GIS) is accelerating (Rignot et al., 2011) due to multiple processes that are not fully understood (Wouters et al., 2013). We then go on to describe these processes in the following text.

P 694, L 22: ". . .whose great. . .respond . . .." should this be "response"?
Corrected.

P 695, L9: " The past and present. . .." the sentence is not clear.
We changed this sentence and the next to emphasize that the role of NEGIS in ice-sheet mass balance is not well known.

P 697, L2: The author mentions surface and bed elevation grids and 350 line km of GPS and RES data. It was not clear to me how far apart were the lines spaced? Please clarify in the text.
Cross-flow profiles are 2 km apart; along-flow profiles are ~5 km. This is now specified in the text

P697, section 2.3, paragraph heading: Suggestion : Ice core analysis using . . .
This heading has been changed to Ice-Core Continuous Flow Analysis.

P698, Section 2.4: How deep were the snow pits? Needs to be located on the map,
how far apart were they from the core?
This was an error in the manuscript – the shallow samples were obtained from tubes inserted into the snow, rather than snow pits. Proximity to the drilling location and sampling depth are now provided in the text.

P 704, L10-15: While I completely agree that surface toughs will capture drifting snow leading to increases surface accumulation, the deep ice in the radar echogram may also indicate changes in

strain rates due to ice flow. This should be discussed further.
We now include a sentence stating that crystal-orientation fabric changes may occur in deeper portions of the ice column.

Locating the extent of RES profile (Fig 4) on a velocity map with the shear margins superimposed will help. I can see that a general ice velocity figure is included, but hard to identify the extent of the RES profile from this figure.
Shear margins are now included in figures 4 and 6. Additionally, along-flow RES is shown in a new figure (Fig. 3).

Also an ice surface elevation profile is needed to locate the toughs over the radar profile in Fig 4. Please see my comments on this topic elsewhere in this review too.
Surface elevation has been added to this Figure (Fig. 6).

Figures:

General comments: The figure captions are long and difficult to read. There is also lot of flipping back and forth between the different panels of the same figures in the captions. References, unless absolutely necessary can be removed from the captions.
We have attempted to simplify figure captions when possible and remove references. If data sources are not mentioned elsewhere in the paper, we believe it is necessary to cite the source of those data in the figure captions.

Figure 2:
a and b: The color scale captions may be made Surface Elevation, Bed Elevation for ease of reading.
Changed.

2b: The white outline is hard to see.
This is changed to black.

I personally do not like any ellipsoidal or geoid information in figure captions. They make the captions long and harder to read. This info should be contained in the main text or the caption for the color scale can be something like: Surface Elevation (Ellipsoidal)
Projection information has been added to the main text (section 2.2) and removed from captions.

Figure 3(a,b) :
I had to read the figure caption several times to understand the panels. Adding the shear margins will help Fig 7 interpretation. Also, the actual figures in the journal are small and the fonts are hard to read. Please change the font size.
We have attempted to simply figure captions. We have enlarged labels/annotations and will work with the editorial staff to be sure that font sizes are readable. We identified shear margins as areas where the longitudinal strain magnitude is greater than 2e-3 a^{-1}. The shear margins are marked using these boundaries in fig. 4 as well as the radargram (Fig. 6).

3b: I assume 3b background is Bamber bed topography?
This is correct and is stated in the figure caption.

The velocity contours are hard to see and difficult to interpret. My previous suggestion of including an enlarged panel of the location of RES profiles, particularly Fig 4 on a background of ice velocity can solve this problem and the velocity contours from a and b can then be removed.

A map view figure with radar profiles plotted over velocities is included (Fig. 4) and velocity contours have been removed. Shear-margin boundaries are now marked on map figure 4 and the radargram (Fig. 6).

Fig.4: A surface elevation profile is needed to show surface undulations over the radar echogram.
Added to Figure 6.

Fig 7: Need a zoomed in figure maybe as an inset to show the survey sites with respect to the shear margin. Or adding shear margins in Fig 3 will solve the problem.
Shear margins have been denoted by high surface longitudinal strain rate and are now depicted on Figure 4 and 6. We also added a map view figure with these sites and the radar profile plotted over velocities (Figures 3 and 4).

References:

Keisling, B. A., K. Christianson, R. B. Alley, L. E. Peters, J. E. M. Christian, S. Anandakrishnan, K. L. Riverman, A. Muto, and R. W. Jacobel (2014), Basal conditions and ice dynamics inferred from radar-derived internal stratigraphy of the Northeast Greenland Ice Stream, Annals of Glaciology, 55(67), 11 pg., doi: 10.3189/2014AoG67A090.