Earth Surf. Dynam. Discuss., 2, C403–C406, 2014
www.earth-surf-dynam-discuss.net/2/C403/2014/

Earth Surface Dynamics
Discussions
Open Access

Interactive comment on "Are longitudinal ice-surface structures on the Antarctic Ice Sheet indicators of long-term ice-flow configuration?" *by* N. F. Glasser et al.

Anonymous Referee #1

Received and published: 25 September 2014

This paper presents interesting observations of the distribution of longitudinal surface structures on Antarctica, provides some useful discussion of how these features might form and insight into the potential history of the Antarctic Ice Sheet. The authors come to the significant conclusion that most of the Antarctic Ice Sheet has had broadly the same flow configuration since the end of the last glacial cycle. The main inadequacy in this paper is in the methods section, which requires detail in how the mapping was conducted (outlined below). Caveats related to these methods need to be discussed in the paper. Alternative interpretations of these features should be considered in the manuscript, and the implications these have for the interpretation of ice sheet history. The focus of this paper is also confusing, and should be narrowed or defined more

clearly. It is unclear whether the aim is to look at ice dynamics, how longitudinal surface structures form, the implications for long-term landscape evolution, or all of these. If the aim is to cover all these topics, the paper should be restructured accordingly, and contain a conclusion section which documents these topics separately to clarify the conclusions drawn in these areas. Overall, this is a worthwhile, well presented manuscript, but the following changes and points need to be addressed. The mapping methods used by the authors of this paper are unclear, and poorly described. Three sources of satellite images are used, all of which have different resolutions and record different spectral wavelengths. A comparison of the differences for mapping structures between these datasets does not occur, which is especially important considering the range of resolution between the MODIS imagery (150 m) and the Landsat imagery (15/30 m). The authors do not state in which regions the coarser imagery was used, where smaller features may be missed in the MODIS imagery or be amalgamated by the coarser resolution. Furthermore, whilst a commendable amount of mapping is shown, the claim of the authors that continent wide mapping (page 912, line 2; page 913, line 9) was achieved is unjustified. As Figure 1 shows, no mapping was done on the West-Antarctic Peninsula and surrounding regions. Consideration of the implications of not studying the longitudinal surface structures here means (i.e. not in an ice stream context) should be made. Crucially to the interpretations drawn by paper, the authors map longitudinal surface structures as smooth continuous lines, in a fashion which may not represent these features correctly. The authors claim that longitudinal surface structures can be followed "without interruption folding or buckling over their entire length" (Page 920, Lines 21-22), meaning they can be traced along entire flow-lines. However, in many instances longitudinal surface structures are actually interrupted by other features on the ice surface (e.g. transverse waves or crevassing), and also appear to fade out when examined close up. Often, a similar feature will become visible downstream of an interrupted or faded longitudinal surface structure. If the authors interpolate across these interruptions in a sensible way, this may be a valid approach, but this is should be documented, perhaps with an additional figure, in the methods section and the caveats this has for the results presented in Figure 6 should be discussed. Beyond just the mapping, the interpretation and conclusions presented relies on longitudinal surface structures being created as “point-source” features at the start of the ice stream which then propagate down-stream, allowing the residence time of the ice to be calculated. This may be the case, but alterative interpretations should be considered. For instance, if flow structures are born everywhere on the ice stream, they may eventually propagate, collide and merge, allowing them to achieve their great length in a much shorter time-frame. It may be the case that these surface features are able to adapt rapidly to changes in ice sheet configuration, especially in fast flow regions as studied here. Furthermore, any potential thinning or thickening of the ice in these regions may not have an effect upon these surface morphological features. Therefore, further considerations are required within the manuscript. Although the authors recognise regions of palaeo ice configuration in their description (the Kamb and Institute regions), no consideration is given for previously identified palaeo ice regions of the Carlson Inlet (a deep subglacial trough where fast flow is not occurring; King, 2011) and the Siple Ice Stream (Catiania et al., 2012). In addition to the above, I have the following further points: âĂć For context, reference should be made in the introduction to the geomorphological evidence that sectors of the Antarctic Ice Sheet were more extensive during the last glacial cycle. âĂć A useful summary of formation hypotheses for these features is given, but again it is unclear if and how the authors are testing these hypotheses. âĂć Page 916, line 1. The word magnitude implies that ice velocity can be calculated from these features, when they occur in a range of ice velocities. âĂć Page 916, line 18. “dynamic” implies change, but the paper argues that the ice sheet configuration has remained stable. We also knew that rapid ice flow reached the interior of the ice sheet from the velocity measurements shown here. The subsequent observations (Page 917, line 26 to Page 918, line 7) are also shown in the velocity data. âĂć Page 920, line 2. What about topographic ice streams which are bounded by topography rather than slow flowing ice shear margins? âĂć Page 921, lines 26-29. I disagree with this statement about subglacial bedforms. Cross

cutting features have been inferred for a long time to demonstrate ice divide migration (Boulton and Clark, 1990) and can occur on flat areas without deep subglacial troughs (e.g. Ross et al., 2009). They can also form rapidly, during relatively short lived events (e.g. the Dubawnt Lake Ice Stream (Stokes and Clark, 2003)) and land terminating ice streaming events which do not occur in Antarctica such as at the Southern Laurentide Lobes (e.g. Colgan and Mickelson, 1997).

References: Boulton, G. S., and C. D. Clark. "A highly mobile Laurentide ice sheet revealed by satellite images of glacial lineations." Nature 346, no. 6287 (1990): 813-817. Catania, G., Hulbe, C., Conway, H., Scambos, T. A., & Raymond, C. F. (2012). Variability in the mass flux of the Ross ice streams, West Antarctica, over the last millennium. Journal of Glaciology, 58(210), 741-752. Colgan, P. M., & Mickelson, D. M. (1997). Genesis of streamlined landforms and flow history of the Green Bay Lobe, Wisconsin, USA. Sedimentary Geology, 111(1), 7-25. King, E. C. (2011). Ice stream or not? Radio-echo sounding of Carlson Inlet, West Antarctica. The Cryosphere, 5(4), 907-916. Ross, M., Campbell, J. E., Parent, M., & Adams, R. S. (2009). PalaeoâĂŘice streams and the subglacial landscape mosaic of the North American midâĂŘcontinental prairies. Boreas, 38(3), 421-439. Stokes, C. R., & Clark, C. D. (2003). The Dubawnt Lake palaeoâĂŘice stream: evidence for dynamic ice sheet behaviour on the Canadian Shield and insights regarding the controls on iceâĂŘstream location and vigour. Boreas, 32(1), 263-279.

Interactive comment on Earth Surf. Dynam. Discuss., 2, 911, 2014.