Review of "Halley Research Station, Antarctica: calving risks and monitoring strategies", by R. Anderson, D. H. Jones and G. H. Gudmundsson, submitted to Natural Hazards and Earth System Sciences (NHESS)

Reviewer: Ala Khazendar (ala@jpl.nasa.gov)

Summary:

This work can be viewed as having two main parts: the first considers the different calving scenarios that can pose a risk to Halley Station. The second part describes the monitoring techniques being applied to provide a measure of advanced warning of a potentially hazardous calving event.
I believe that this is a valuable effort. The analysis that the authors present of the historical evidence will be useful not only for the purposes of hazard assessment (the focus of this work) but also for glaciological research and questions of ice-shelf flow and stability. In their analysis of the historical evidence, the authors are careful to identify the limitations of the available observations, and they are to be commended for that. On the other hand, the authors could improve and expand the description of their data analyses and monitoring techniques to better support the results they present, and to make a more persuasive case of the suitability of the monitoring program to the task of hazard detection.
The manuscript is generally well structured, and the figures helpful. In particular, Fig. 4 nicely presents the historical evidence.
I recommend this paper for publication after the implementation of the suggestions below.

Main issues:

P. 6232 L. 26-27: "On Brunt Ice Shelf surface temperatures are well below the freezing point throughout the year, and surface melting does not occur."
Given that the main concern of this work is hazard assessment, noting that currently Brunt's surface temperatures are below freezing is insufficient to conclude that it will not be susceptible to a Larsen-B type disintegration. Has the surface temperature been showing any rising trend over the past years that could, if continued, increase the likelihood of this type of event? For this purpose, the authors could analyze the available Halley temperature time series, and/or examine the findings of published work (e.g., Screen and Simmonds, 2012).

P. 6236 L. 9-10: "The BIS has two natural protections against iceberg collisions: a shallow 300m plateau in the sea bed that extends approximately 50 km out from the ice front,"
Could the authors please cite a reference of the presence of this plateau, and perhaps show its location on the map in one of the figures.
More substantively, I would think that many, if not most, Antarctic icebergs are less than 300 m in draft, so I do not see how the presence of this plateau can afford protection. Could the authors please elaborate?

P. 6237 L. 20-27 and Fig. 7, 8: "The long term progress of this rift can be seen in Figs. 7 and 8 ..."
- In this paragraph and the figure captions there is no description at all of the data used, and analysis methods applied, to obtain these figures and the conclusions drawn from them about the Brunt-Stancomb Chasm. Could the authors please provide those details?

- Why is the method used here (Fig. 7) not considered part of the monitoring program, given that it allows tracking the evolution of potentially threating fractures?
- In our work (Khazendar et al., 2009; section 4.3) we explicitly proposed, and explored in detail, the possibility that this rift will widen and lengthen, and that the rift in the south will also widen. The results there largely support the findings here, so the authors could consider citing that work in this context.

P. 6238 Section 4.1.1: "Velocity calculation"
Could the authors please address the following questions:
- What is the spatial resolution of the inferred velocity fields? What is the uncertainty?
- Why are the speed values shown in Fig. 10 much smaller than published speeds in, for example, Wuite and Jezek (2009; Fig. 2) and Khazendar et al. (2009; Fig.2)?
- Why does the speed profile of Fig. 10 appear to be cut off at the eastern and southern margins of the ice shelves? Does the method fail in those areas because of extensive crevasse presence? If yes, how would that affect the utility of this method for detecting potentially hazardous fracture?
- Are there particular advantages for using the NCC method over other techniques (e.g., InSAR) for the purposes of hazard detection?
- If the purpose of finding the velocity fields is to derive strains rates and determine which rifts are active, why have the method not been tested on, for example, the case of the Brunt-Stancomb Chasm (Fig. 7), to demonstrate its effectiveness?

P. 6241 L. 18-20: "Before 2020, there is a high probability that the SWGT ice shelf will have a large calving event, as evidenced by the steady advancement of a rift in the west, and a widening rift in the south."
This is the first time in the manuscript that the widening of the rift in the south is mentioned. Could the authors please explain how the widening was detected?

P. 6242 L. 2-17: "The Brunt itself may yet calve between the Halley station and the mainland, due to its own natural tidal flexing cycle."
Brunt might also calve between Halley station and the grounding line (or mainland) along First or Second chasms, or another rift there resulting from changes in the flow regime after a calving at the front (e.g., N9) or an iceberg collision, as the authors describe on P. 6231 L.19-23 and elsewhere in the manuscript. Given the possible consequences of such an event, are there plans to extend the GPS network to cover that area? Are the other components of the monitoring program sufficient to provide enough warning of such an event?

Other issues:

P. 6229 L. 11: "The surface mass balance of BIS is positive"
Please provide a reference to support this statement.

P. 6229 L. 11-12: "The surface mass balance of BIS is positive, and the mass loss of BIS therefore happens exclusively through calving"
This statement ignores the possibility of basal melting at the ice-ocean interface. The authors are probably right in assuming that most mass loss of BIS happens through calving. Examining the results of recent papers by Depoorter et al. (2013) and Rignot et al. (2013) should resolve this issue.

P. 6231 L. 9-11: “All three Brunt rifts are located between the Halley locations (both V and VI) and the mainland.”
- That is not case of the N9 Chasm.
- The term “grounding line” would be clearer than “mainland” here and elsewhere in the manuscript.

P. 6234 L. 1-8: “Ice front positions …”
- Could the authors please explain why do they consider the 1956 front position less reliable?
- Could they also please give the references reporting the findings of the Argentinean ship, and those of the 1958 survey?

P. 6235 L. 14-16: “BIS is grounded on the MacDonald Ice Rumples and the GPS measurements of ice velocity conducted in 2009 showed the ice at the top of the MIR to be stagnant.”
Could the authors please clarify whether they conducted these 2009 GPS measurements, or otherwise give a relevant reference.

P. 6237 L. 17-18: “On the south side, another 100 km rift runs parallel to the Brunt–Stancomb chasm.”
It runs parallel to the grounding line, rather than to the chasm.

P. 6242 L. 10-11: “The GPS network continues to provide short-term data on the movements and internal strains of both ice shelves.”
Yet, as the authors explain earlier in the text, only Brunt has a GPS network, not “both” ice shelves.

Fig. 3: It would be useful here to show the 2009 location of Halley V and the flow line going through it, both of which are mentioned in the caption of Fig. 4.

Fig. 6: The legend mentions a “1955” front, this probably should be 1956 according to the main text.
Furthermore, could the authors please explain why are they showing here the 1956 front, which they consider unreliable, and not the 1958 front?

Fig. 7: Please show the labels on the axes.
In the legend, what do the figures in km signify?

Fig. 9: In the top panel, please explain in the caption the red, dotted line?

<u>Typos, etc.:</u>

P. 6233 L. 23: “between the 1986 and 2008 ice fronts on Fig. 3 3.2.”
In Fig. 3 there is no “2008” ice front.
Also, “3.2” at the end of the sentence is superfluous.

P. 6237 L. 15: “the much-slower Riiser–Larseninen Shelf”
Larsenisen not “Larseninen”.

References:

Depoorter, M. A., et al. (2013), Calving fluxes and basal melt rates of Antarctic ice shelves, Nature, doi:10.1038/nature12567.

Khazendar, A., et al., (2009), Roles of marine ice, rheology, and fracture in the flow and stability of the Brunt/Stancomb-Wills Ice Shelf, J. Geophys. Res., 114.

Rignot, E., et al. (2013), Ice-Shelf Melting Around Antarctica, Science, 341.

Screen, J. A., and I. Simmonds (2012), Half-century air temperature change above Antarctica: Observed trends and spatial reconstructions, J. Geophys. Res., 117.

Wuite, J., K. C. Jezek (2009), Evidence of past fluctuations on Stancomb-Wills Ice Tongue, Antarctica, preserved by relict flow stripes, J. Glaciol, 55.