Review of "Multi-year analysis of distributed glacier mass balance modelling and equilibrium line altitude on King George Island, Antarctic Peninsula", by Falk *et al*. (tc-2017-232)

Recommendation: Requires major revision – not suitable for publication in current form.

General

This paper reports observation and model calculations of surface mass balance and meltwater production on a small glacier on King George Island, South Shetland Island. This glacier is situated in a region that has undergone rapid climate change in recent decades that has caused marked changes in the regional cryosphere. Cryospheric change provides useful information on climate change as it is an integrated response to a number of climatic variables. Furthermore, cryospheric change in this region has significant implications for terrestrial and marine ecosystems. The measurements reported in the paper have been made carefully and analysed in an appropriate fashion. Together with the model calculations of glacier mass balance and meltwater production, they provide a reliable indication of the "state of health" of Fourcade Glacier, and an indication of how its mass balance responds to short-term climate variability. These are useful and valuable results and are worthy of publication. However, I found the paper quite difficult to read because it is poorly structured. The motivation for the study is poorly presented, there is no clear statement of the scientific objectives (other than gathering data and carrying out a model study) and it is not clear what the major conclusions are. Furthermore, the authors have a tendency to include material on "methods" and "results" within the same section of the manuscript, which detracts from the clarity of the presentation. Below, I make some suggestions for restructuring and list some specific points that need attention to make the paper suitable for publication.

Major (structural) points

1. The scientific objectives of the study need to be clearly set out towards the end of the Introduction. At present there is just a list of the work that has been done. These objectives should be revisited in the Conclusions section.
2. Following section 2, "Study Area", I suggest a "Data and Methods" section structured as follows: (a) Meteorological measurements (AWS/Carlini/Bellingshausen), (b) Mass balance data, (c) Description of the GMM and its setup for this study. The long section on meteorological gap filling breaks the flow of this section – I would move it to an appendix or supplementary material. Note that the Data and Methods section should not include results (e.g. material on p11, lines 7-17) – such material belongs in the next section.
3. Next, a "Results" section presenting the main findings from the observations and model. As calibration of the model is reliant on the mass balance observations, I think it would be appropriate to discuss model calibration in this section.
4. Finally a Discussion/Conclusions section, framed in the context of the scientific objectives set out in the Introduction.

Specific points

P1 Abstract, l13: What do you mean by "no drift"?

P2, l1: Quantify "large fraction".

P2, l26: Sentence starting "The seasonal variability…" needs clarification. SAM needs to be defined.

P3, l12-16: Present as continuous text rather than a numbered list.

P3, l18: Give lat/lon for KGI. Refer to Fig 1 at this point (figure should ideally include a further map locating KGI with respect to the Antarctic Peninsula, South America, etc.).

P3 l30: Delete “in” before “especially”.

P4, section 3.1.1: Mark AWS and temperature sensor locations on Fig. 1. Need to reference figures 2 and 3 (photographs) in this section.

P 4, l15: Insert “with” after “equipped”.

P5, l6+: Discussion of the effects of pyroclastic debris does not belong in this section describing the measurements – move to the results section. Figure 4 also belongs in the results section, not here.

P7, l20: I don’t understand why you applied a 48-hour smoothing to the cloud observations after interpolating to 1-hourly data. Surely you should use these data at the highest temporal resolution available (to make them compatible with your other driving data)?

P8, l9: Surely m=Pa/(99*cos(ψ)) (assuming m is defined relative to 99 kPa) ?

P8, eqn. (9): Should also include a term for reflected longwave radiation = (1-ε)*LW↓

P8, l25+: Give values for RMS differences between measured and modelled radiation components, as well as mean bias and r values. During winter Rn is typically in the range +/- 50 Wm^{-2}, the offset of 15.9 Wm^{-2} apparent in eqn. (11) is really quite significant at this time of year.

P9, section 3.3: This section describes results so really belongs in section 4. (but needs to come before the section on model calibration). Include a table giving the elevations of the stakes.

P10, l30, and Fig. 8: What do the broken lines on Fig. 8 signify? The figure caption should state the reference date from which CMB has been calculated (i.e. the start date of the calculation, where CMB=0 for all stakes). You say that PG04 is in the accumulation zone, but there are hardly any measurements shown from this site and above – why not show results from at least one stake that is clearly within the accumulation zone? The overall trend at PG05 looks pretty close to zero, suggesting that this site is more or less on the equilibrium line.

P11, l10-17: Section 3.3 is concerned with surface mass balance observations. I think it is confusing to start talking about GMM results here before the GMM has been properly described.

P11, section 3.4: What is needed here is a section describing the GMM. Start by describing the model, then say how the model domain/catchment was set up and finish with a section on model validation against stake measurements.

P13, l17+: How can you be certain that the model error results form an underestimate of accumulation rather than an overestimate of ablation?

P13, l30: What do you mean by “a drift or disagreement … cannot be seen in the data”? Figs. 10 and 11 clearly show disagreement (hence drift) over the lower part of the catchment.

P14, eqn 14: Not sure why you show this equation – you are only able to measure the surface mass balance components.

P14,l24: “coverage”. Why does high cloud coverage imply less precipitation and low ablation?

P16, l6: Briefly explain how you calculated ELA from observations and model.

P17, l24: I don’t understand the sentence starting “If underneath the glacier is mountainous terrain…”. The time taken for the glacier to disappear after the accumulation zone disappears depends on the magnitude of the ablation and the thickness of the glacier.