Response to Anonymous Referee #2

Thank you kindly for taking the time to provide a thoughtful review of our manuscript.
Please find:

- Reviewer comments in back
- Responses in blue
- *Proposed changes to manuscript in italics*

This study is a useful benchmark contribution to Antarctic mass balance research in particular because it uses very large data archives to achieve high-resolution, near-comprehensive coverage and improved uncertainty reduction in ice flow measurements. In this way (and with updated SMB products and a new approach to flux gate comparisons), it compliments and improves upon earlier pioneering continent-scale flux studies, and allows recent flux changes to be calculated. As such, it marks a maturation in mass-balance auditing and points the way towards the regular, operational big-data measurement of Antarctic mass change.
Specific comments: Most of my queries have been covered in the authors' responses to the other review.

In title and throughout: I suggest avoiding using the term stability (or stable, re-stabilization) to mean unchanging flux because stability has other particular connotations for ice sheet mass balance.

The title of our manuscript was "Increased West Antarctic ice discharge and East Antarctic stability over the last seven years". We understand the reviewers concern with the usage of the term "stability", particularly that it could be taken out of context to infer that the mass balance of East Antarctic Ice Sheet will be resistant to future environmental change. We felt that we had provided sufficient context for correct interpretation of "stability" by indicating the quantity (discharge) and period of time (7 years) that "stability" is referring to. Given the reviewer's comments *we have changed the title to "Increased West Antarctic and unchanged East Antarctic ice discharge over the last seven years". We have also modified text in the main manuscript changing "stable" to "steady", "constant", and "unchanged".*

Abstract: I suggest rewording the final sentences, e.g. "The modest increase in ice discharge over the past 7 years but ongoing high rates of ice sheet mass loss and distinct patterns of elevation lowering suggest that the recent pattern of mass loss

in Antarctica is part of a longer-term phase of enhanced glacier flow initiated in the decades leading up to the first continent-wide radar mapping of ice flow."

We will change the text to the following:

The West Antarctic ice sheet is experiencing high rates of mass loss and displays distinct patterns of elevation lowering that point to a dynamic imbalance. We find modest increase in ice discharge over the past 7 years that suggest that the recent pattern of mass loss in Antarctica is part of a longer-term phase of enhanced glacier flow initiated in the decades leading up to the first continent-wide radar mapping of ice flow.

For the uncertainty associated with the assumption of surface velocity being equal to depth-averaged velocity (σF v-bar), the authors convincingly explain that this term is small, however it is a bias term of a particular sign which suggests that it should be corrected for or otherwise added to one side of the uncertainty range rather than being combined in quadrature.

Good point. We have added this term as a bias to both sides of the error budget to retain symmetry… this has little impact on our total error budget.

Section 3.1.2: line 405, replace 'certainty' with 'confidence'. Can the authors please be more specific in this section – do they consider the 56 Gt to be incorrect and the real imbalance to be close to zero?

This is a good question. We can say with confidence that any mass anomaly observed by satellite gravimeters or altimeters was not the consequence of a change in ice flow over our period of study. We also find that the net mass balance of Basins 23 and 24 to be negative, though the uncertainty is large (-27 +/- 24 Gt/yr.). An estimated loss of 56 G/yr. falls slightly outside of our uncertainty envelope.

We have changed certainty to confidence and added a reference to a recent paper that examines longer-term changes in ice dynamics of this region:

This result agrees with a recent investigation of longer-term (1995-2016) changes in ice discharge for this region (Hogg et al., 2017). In that study they found that the region's glacier experienced an increase in ice discharge between 1995 and 2008 and almost no change in discharge between 2008 and 2016.

Figure 4 caption: Please clarify the y-axis units.

We have modified the caption to:

Histograms of ice equivalent thickness (a), uncertainty in ice equivalent thickness (b), year of ice thickness measurement (c), Firn Air Content (d), uncertainty in Firn Air

Content (e), surface velocity (f), change rate of ice equivalent thickness (g), and uncertainty in change rate of ice equivalent thickness (h) for GL0, FG1 and FG2 flux gates. The y-axis is the percentage of flux nodes that fall within each histogram bin.

There are two Figure 6s. The second one (now Figure 7) needs a legend and also more discussion of the range of values yielded by the various tracking methods for some basins, e.g. 13 (as mentioned in the response to the other review).
Thank you for catching this! In the revised manuscript we will add a legend to the *new* Figure 7 for the bar plots and we will expand our discussion of the flux change differences between results as per our response to Reviewer 1's point number 5.

Conclusions: I suggest adding a statement on how best to improve and continue ice sheet mass balance monitoring in this way, e.g., by adding to the time series of high-resolution Peninsula velocity fields, improving the flux-gate RES coverage, improving the SMB fields, continuing Landsat-like and Cryosat/ICESat-like datasets etc. – where do the biggest potential improvements lie? Emphasise the value of this study as the potential starting point for routine ongoing assessments, and the potential importance of this in diagnosing unstable behaviour.
Thank you for the suggestion.

We have added the following paragraph to the conclusions:
Glaciology is rapidly transitioning from an observationally constrained environment to one with ample high quality, high volume satellite datasets suitable for mapping ice flow on continental scales (e.g. Landsat 8, Sentinel 2a/b, Sentinel 1a/b). This study provides a foundation for continued assessment of ice sheet flow and discharge that will allow researches to observe both large and subtle changes ice sheet flow that may indicate early signs of ice sheet instability with low latency. Such a capability would help to diagnose unstable flow behavior and, in conjunction with high accuracy measurements of ice sheet elevation and mass change, would lead to improved assessment ice sheet surface mass balance and ice shelf melt rates. Low latency monitoring of ice flow and discharge would also allow field programs, flight planning and satellite tasking to coordinate the collection complimentary observations in areas of changing ice behavior. These advances will ultimately lead to a deeper understanding of the causal mechanisms resulting in observed and future ice sheet instabilities. Any substantial improvement in our assessment of ice sheet discharge will require more detailed knowledge of ice thickness just upstream of the grounding line, particularly for areas of complex flow such as the Antarctic Peninsula and Victoria Land. Errors in discharge estimates can be greatly reduced if thickness profiles are

acquired perpendicular to ice flow. Improved estimates of net mass change calculated using the mass budget approach will come from continued refinement of regional climate models and better estimates of basal melt.

Detailed comments:
Line 182: 'mean mean'
Corrected.

Line 272: 'See appendix A for the ...'
Corrected.

Line 383 and onwards: Figure 7 instead of 6 etc.
Corrected.

Line 431: 'Groundling'
Corrected.

Line 440: '...Totten Glacier increased in ...'
Corrected.

Line 445: '79% of the increase comes from glaciers. . .and another 11% comes from. . .'
Corrected.

Line 509: 'that that'
Corrected.

References: Fretwell et al repeated.
Corrected.

Figure 5 caption: '. . .along-flux-gate. . .'
Changed.

Figure 9 caption: '. . .all 2015 image-pair displacements. . .'
Corrected.

Line 819: '. . .assumed to be indicative of. . .'
Corrected.