Response to reviewers

Reviewer comments: *italics*

Response: plain font

Reviewer 2

Scientific questions: Line 61: I assume this bank is hard-rock cored. Was the sediment thickness from seismic surveys used in the gravity bathymetry model?

It is unclear from the sparse relatively old seismic data if this bank is hard-rock cored or not. No sediment thicknesses from seismic data were used in the gravity inversion for bathymetry as this information was not available. However, magnetic depth to source data, and a coupled significant positive gravity anomaly in this region indicate a significant sub-surface dense body. The impact of this body is removed, based on a relatively simple 3D gravity model, prior to carrying out the bathymetric inversion. We note that the relatively large number of seismic tie points and offshore swath bathymetric data constrain the bathymetric model in the Brunt region. Discrepancies in the bathymetric results due to un-known sedimentary basins etc. should therefore be relatively limited.

Line 133 to 157: The gravity inversion technique presented here is novel, and while it makes assumptions that will reduce the predicted accuracy of the inversion they are clearly-stated and well-understood. The resulting model appears to be fit-for-purpose in identifying potential former pathways and obstacles for ice flow

Line 154: Not clear where 100 m figure comes from – can you offer a more detailed assessment of uncertainty?

It is challenging to provide a full assessment of uncertainty, as step 4 of the inversion ensures the bathymetric model matches any independent observations perfectly. The 100m error estimate stems from how much the assumption of a floating ice shelf is breached, which we consider a reasonable minimum estimate for the amount of error. Following the reviewers suggestion we provide a more detailed discussion of the possible errors and suggest an error distribution with a standard deviation of ~175 m represents a reasonable maximum error estimate.

Revised text L151-157

> Uncertainties arising from unknown and un-modelled geology are hard to quantify, as step 4 of the inversion means the model always matches the direct bathymetric observations. One estimate of the errors due to geological factors can be made by looking at the difference between the initial gravity inversion (step 3) and the direct observations. This reveals a symmetrical error distribution with ~0 mean, and a standard deviation of ~175 m, which we attributed to un-accounted geological biases, and the long wavelength of the regional gravity data. This therefore represents a worst case estimate of the expected error far from control points. Step 4 will have in-part accounted for the impact of unknown geological features, and hence reduced the overall error of the resulting inverted bathymetry. One alternative check is to compare predictions of ice shelf flotation, based on freeboard and an assumed ice shelf density, to the final inverted bathymetry (Fig. 4c). This reveals that the inversion results generally predict the grounding line well. A key discrepancy is beneath the

SWGT at 75°S, where flotation is violated by 50-100 m. We therefore consider +/- 100 m a reasonable minimum estimate of the error in the bathymetric inversion in this region. Northeast of the 2017 survey area, the inversion suggests a broad area of ice shelf should not be floating. We attribute this to a lack of high quality data coverage, and/or actual observations of bathymetry.

Line 187: the conflict between gravity-predicted and altimetry-observed grounding lines in the region described casts some doubt on the absolute depth values from the gravity inversion. While I agree that the shape of the bed has probably been properly described from the gravity, it would be useful to see on the map what areas were constrained by ship and what weren't, and whether the magnetic data identify the ridge structures as geological structures or whether these reflect surface morphology only. Is there evidence from the acoustic mapping that the gravity features do have bathymetric expression?

The extent of the swath bathymetry data is now better highlighted in Fig. 3, and is also shown in Fig. 4d. The onshore topography is also relatively well constrained by airborne radar measurements. Comparison of bathymetry/topography from direct observations only (Fig. 4a) and the free air gravity anomaly (Fig. 4b) highlights the fact that major structures such as the deep onshore basin, and the deep trough beneath the BIS are both resolved by these independent data sets. In other areas there are no direct measurements coincident with the high resolution gravity data to provide further checks on our results.

We have added an image of the aeromagnetic data across the survey region to the supplementary material. The first thing that we note from this data is that there is a clear high frequency signal beneath the main survey area. This suggests the geological basement is close to the surface, and a major thick sedimentary basin which could distort the results is not present. In addition, no clear 1:1 correlation between the inverted bathymetry and the underlying geologic (magnetic) fabric is seen. This suggests the bathymetry dominates any underlying geological signal. However, the northern part of topographic ridge 3 does appear to follow a relatively short wavelength negative magnetic anomaly, indicating geological control of this structure. The more limited data coverage in this region (Fig. 3) makes further detailed discussion of the underlying geological origin of this feature problematic.

We have added the following additional paragraph after L157 to address this point:

> In regions where both direct topographic/bathymetric observations and high resolution gravity are available (Fig. 4a and b respectively) major topographic structures, including the deep onshore basin and the trough beneath the BIS, are resolved by the gravity data. This supports the use of gravity data to fill the intervening areas where no direct measurements are available. Aeromagnetic data across the study area (SFig. XX) shows a clear high frequency signal beneath the main survey area. This suggests the geological basement is close to the surface, and a major thick sedimentary basin which could distort the results is not present. In addition no clear 1:1 correlation between the inverted bathymetry and the underlying geologic (magnetic) fabric is seen. This supports the view that the bathymetry dominates any underlying geological signal. However, the northern part of topographic ridge 3 does appear to follow a relatively short wavelength negative magnetic anomaly, indicating geological control of this structure. The more limited data coverage in this region (Fig. 3)

> makes further detailed discussion of the underlying geological origin of this feature problematic.

Line 241: What is the evidence for ice shelves occupying the Brunt Basin following grounding line retreat? Is it just that they exist in the present or are you referring to geological records?

We have changed the sentence as follows:

> Following grounding line retreat, floating ice likely occupied the Brunt Basin, as it does today.

Line 194: the west face of the Bank looks steeper in the figure – is this a trick of shading?

We now also refer to Fig. 6 where the profile is presented.

Line 200: I would help to show ice velocity on one of the figures.

This data is now added to Figure 5.

All other minor comments addressed