Response to Review #2

We thank anonymous referee #2 for his/her positive and constructive comments. Below, the referee's comments (written in bold) are addressed with a response. We revised the manuscript accordingly.

This paper addresses an important and interesting topic regarding the estimation of sub-glacial bed topography from combined geophysical methods: combination of airborne gravity measurements with magnetic data. The authors compare their results to previous estimations obtained from GPR measurements. They found clear discrepancies in area with previous poor coverage and provide improvements in the overall estimation of the bedrock topography. An important improvement also concerns a fine description of the physical properties of the bedrock (lithology, roughness, density, thermal conductivity…) which are of prime interest to describe and predict the dynamics of the ice cap.
This paper has been carefully prepared, is well written with figures of high quality. The context of the study is well presented. The readers will certainly appreciate the detailed analysis provided regarding the multiple geophysical methods used with systematic estimation of their uncertainties and discussion of their limitations. The geological interpretation presented by the authors is rigorous (I am not familiar with the area though), supported by both geophysical data and field observations.

We are grateful that the referee appreciated our manuscript.

I only found that a more detailed discussion on the implications of having such improved estimations of sub-glacial bed topography on our understanding of the dynamics and evolution of the ice cap is missing. I would recommend to provide a dedicated paragraph with perspectives.

The referee raised an interesting point. The current gravity data does allow to improve the accuracy, but the resolution of the entire area is not yet high enough to make a robust 3D model of the bed topography. A study of the dynamics and evolution of the ice is currently beyond the focus of this manuscript.

In the following I raise few additional minor points.
Pg1, Line 29: The distribution of rheological properties of the ice might also play a critical role.

We agree with the referee. This has been added to the text.

Pg6, Line 13: typo

The text *"to the minimum size of the required for this depth"* has been modified to *"to the minimum size required for this depth".*

Pg6, Line 31: Provide mean and std values of density for granites from the literature?

Granite densities are expected to vary between 2500 – 2810 kg m^{-1} with an average of 2640 kg m^{-1} (Tellford, 1990). The text now includes this information.

Pg6, Line 40: Please provide more arguments to justify the link of this granite intrusion with the observed Caledonian Rijpfjorden.

On the magnetic map with the geological background, the high anomalies correspond to the geological mapping of the observed granites as well as the susceptibility and density modeled suggest affinities with granites. We modified the text accordingly.

Pg 7, Line 41: What do you mean by "Calcite precipitation influences the bed roughness and the water film[…]". Please clarify.

As the glacial basal temperature is near the pressure-melting point, the water film, created through that process, causes the dissolution of calcite from the carbonate bed on the upglacier side of the bed obstacles. During the regelation on the lee side of the bed obstacles, the calcite is chemically precipitated. Subglacial dissolution and precipitation processes of the calcite on the bed regulate the calcite saturation of the water film and modify the bed morphology and roughness. We suggest modifying the text as:

"*Calcite dissolution and precipitation chemical processes have a role on the calcite saturation of the water film that lubricates the bed-glacier interface and modify the bed morphology and roughness through melting and regelation processes*."

Pg8, Line 9: Do you have local evidences/estimations of this heat flux?

On Austfonna, only one borehole has been drilled to reach the bedrock and provide heat flux information in the summit area (Ignatieve and Macheret, 1991; Zagorodnov et al., 1989). There are no other direct observations available to estimate this heat flux. Our study suggests that this value may not reflect the entire bed underlying Austfonna. We modified the text with this comment.

Figure 4: Same color scale for all panels.

This has been modified accordingly.

Figure 5: Radar topography is missing in profile B.

We did not recreate the experiment with Profile B as Profile A was sufficient to demonstrate the advantage of using gravity to correct the GPR measurements and largely discussed in the previous section. The radar gravity response is used in Profile A to explain our choice to modify the bed topography as no other bed density could explain the gravity signature.

Some captions could be improved by providing more information with major observation/interpretation/messages (i.e. Figures 2, 3 and 6).

We modified the captions accordingly:
Figure 2: *The interpreted profiles have been chosen to cover a large area of Austfonna and to capture important geological trend.*

Figure 3: *The gravity data are sensitive to an excess or loss of mass. Lower gravity data are often linked to sedimentary basins. The magnetic data show important N-S trending anomalies crossing Nordaustlandet and intersecting with the Caledonian Rijpforden granites*.

Figure 6: *Sills bodies located on the North-East onshore and offshore are generally shallower than the large and deep NS trending granitic intrusions crossing Austfonna.*