Dear Rick Saltus,

we thank for the very constructive feedback and to rise questions about the important aspect of the data uncertainties in the magnetic anomaly compilation. Implementing your comments and corrections clearly improves the quality of our manuscript.

We address your various comments and questions individually, beginning with your review letter and subsequently the annotations made directly in the manuscript.

Best Regards

Björn Heincke

Responses to the main reviewer letter:

This is an excellent presentation of a state of the art compilation of magnetic survey data to produce a comprehensive data grid. The authors provide clear discussion of the approach and rationale for their modeling decisions.

I have made a few comments and suggestions as shown in the attached annotated manuscript.

One recurring comment deals with the use of the term "error" when "uncertainty" is meant. Errors can be positive or negative whereas uncertainty indicates the probable range in which the true value is likely to occur. You can only know error if you know the truth for comparison.

ANSWER: We fully agree that we used an oversimplified terminology by not distinguishing “error” from “uncertainty”. This is now corrected in the manuscript.

The authors deal with uncertainty in a general probabilistic way - they mention the initial data uncertainty attributed to the original survey data (ranging from 5 to 50 nT as an average attribute per survey). This value is used for weighting of the data in the inversion for equivalent source values. They mention the overall goodness of fit for the equivalent source combined model relative to the original data. They also explain the method for solving in the inversion for the probable DC offset between the individual surveys. An addition source of uncertainty is the long wavelength uncertainty in the LCS-1 model incorporated in the final grid. I realize it is difficult to propagate uncertainty through all these steps, but I think it is worth some discussion and, ideally, the authors would produce some sort of overall uncertainty grid to accompany the data grid.

ANSWER: We fully understand this concern and we have added some more discussions about the data uncertainty for individual steps:

- We now include an additional figure in the Appendix illustrating the distribution of uncertainties when no shift correction is applied in the equivalent source modelling. It reveals pronounced systematic errors along individual survey lines, which lead to visible artifacts in the resulting magnetic anomaly map. In contrast, the same test performed with a constant shift correction enabled (see Figure 5) demonstrates that most of these systematic errors are effectively mitigated, and no apparent artifacts remain. This highlights the critical importance of applying shift corrections in the inversion.
- We describe now that also the satellite model contains errors and that these can be significant for high latitude regions. Since we incorporate the long wavelength components of the satellite model after the equivalent source modelling (inversion) is performed, uncertainties in the satellite model can be currently not evaluated or mitigated in our current approach. We therefore propose in the discussion that it is useful to modify the setup in a way that satellite data are added also at the inversion stage in future.

Another approach to validating the grid and uncertainty would be to identify trusted long survey lines that were not included in the model for comparison with values extracted from the grid.

ANSWER: There is a long survey line that is not used in the compilation extending offshore Greenland from the northwest, across the southern region, to the central eastern coast. Unfortunately, this line dates back to the early 1980s and was acquired without GPS positioning. Furthermore, it appears that no proper base station correction was applied to its data. A comparison of this line with all three compilations (GREENMAG, CAMP-M and GAMMA-5) reveals anomalies that are absent in any of the three compilations. We conclude therefore that the line cannot be trusted.

However, even without additional discussion/assessment of grid uncertainty, this paper is excellent and worthy of publication. Similar scale data compilations to date have generally not included detailed uncertainty assessment. Similarly, many authors conflate the terms error and uncertainty and most readers can discern the difference.

Responses to comments made in the manuscript:

Line 104: The equivalent source method allows for propagation of uncertainty from data to models - did you consider using weighted least squares to propagate uncertainty on a cell by cell basis?

ANSWER: Yes. We apply weighted least squares to the data term of the inversion's objective function to estimate the susceptibilities (of unit volumes) for the equivalent sources. During

inversion stochastic data errors are reduced, but systematic errors are assigned to the equivalent sources. Systematic errors can then be diminished by some adaption of the inversion setup (e.g., by implementing some shift corrections as done in our approach).

Line 138: I don't think this is correct - I think that both the vector mag data and gradients were used.

ANSWER: We checked the publication of Olsen et al (2017) once again. They indeed only use gradient data from Swarm and CHAMP satellites to build the LCS-1 model.

Line 152: Is there a reason that the computationally much simpler monopole source was not selected?

ANSWER: We chose dipoles as equivalent sources since they provide a more realistic physical representation of the true magnetic behaviour than monopoles (this benefit is mentioned now in Section 3.1).

Moreover, the use of magnetic dipoles enables consideration of temporal variations in both the amplitude and direction of Earth's main magnetic field. This, in turn, allows to reduce during the inversion process inconsistencies between datasets that are associated with their different acquisition times. Such adjustments are not feasible when magnetic monopoles would be used.

Since we did not describe this benefit, we have now added a short subsection (Section 3.3.4) that describes how Earth's main magnetic fields at different times are implemented in the inversion for both the equivalent sources and measurement locations.

Line 247: It would be awesome to produce and distribute grids with specifications consistent with the global grids such as EMAG and WDMAM - this would aid in the incorporation of this new compilation into the next updates of these grids.

ANSWER: We fully agree that this is a great benefit. We added a sentence that it is possible to use parameters that are consistent with the ones of the global magnetic compilations such that it can be optimally integrated into them.

Line 254: It would be good to note here that while the satellite derived spherical harmonic models are good on average for the globe, there is poorly defined local uncertainty for these models, especially at higher latitudes. It would be good to produce a version of GREENMAG that only includes the wavelengths shorter than the satellite reference model.

ANSWER: We discuss now uncertainties of the satellite model in section “5.3 Replacement with satellite data” (see answer to comment “*Line 392: While ...*”).

It would be straightforward to construct a version of the GREENMAG model that includes only shorter wavelengths than the satellite model by simply removing degrees n < 133 from the aeromagnetic model. However, we do not see any clear applications that would require such a short-wavelength model, and therefore we have chosen not to present it here.

Line 305: errors can be positive or negative - you are referring to uncertainty

ANSWER: We agree that we had not used the correct terminology here.

Line 307: again, you mean uncertainty, not error

ANSWER: Done

Caption of Figure 3: Line uncertainty

ANSWER: Done

Line 324: missing word "height"

ANSWER: Done

Figure 4: I suggest making the color scale labels even numbers between + and - 250 nT. This is a nearly linear ramp with 51 and 52 nT intervals - labeling on even numbers would be much easier to understand.

ANSWER: We agree with the reviewer. We have changed the color scale labels for all figures (5, 6, 7, 8, 9, C1, D1 and E1), where this color scale was used.

Line 373: Uncertainty

ANSWER: Done

Caption of Figure 5: uncertainty - error is plus or minus and you only know it if you have the truth for comparison

ANSWER: In this case, it should be errors since the histogram presents positive and negative values.

Line 388: This is not the correct word - use "shows the most southern block" instead

ANSWER: Done

Line 392: While the LCS-1 model achieves a good global fit to the satellite data, local features have uncertainty that is not well characterized, particularly at high latitude. I think it is worth pointing out that there is some uncertainty in the model, especially for relatively localized features...

ANSWER: We agree that it is inappropriate to omit the uncertainties associated with the satellite model. This aspect is particularly critical, as our approach does not fit the long-wavelength components of the satellite data during inversion, but instead, these are directly substituted within the spherical harmonic (SH) expansion. This means that the data uncertainties of the satellite data were not evaluated (or reduced) in our approach.

We have therefore added now a section pointing out that satellite-based models have uncertainties for small-scale lithospheric magnetic features and that these are especially high in the polar regions.

Figure 8: I suggest mentioning the direction of shading used as this affects the trends that are enhanced

ANSWER: We mention now the illumination direction in the caption.

Figure 8: I suggest fixing this color scale to have regular 50 nT intervals between + - 250

ANSWER: We agree with the reviewer (see above). We have changed the color scale labels for all figures (5, 6, 7, 8, 9, C1, D1 and E1), where this color scale was used.

Figure 9: ditto comments on color scale and mention of shading direction

ANSWER: We mention now the illumination direction in the caption.

Appendix D: This heading is in the wrong place

ANSWER: The LaTeX compiler did here strange things. We have moved the heading to the right place.

Other changes made in the manuscript:

Only parts of the shift correction implementation were originally presented in the Appendix B. Specifically, we described its integration within the data term of the objective function, but omitted its role in the regularization term to keep the methodological section concise.

However, given the importance of shift correction for eliminating systematic inconsistencies between datasets, we now consider it more appropriate to present the full implementation. Accordingly, we have added the corresponding modifications to the regularization term.