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Solid Earth
Discussions

Interactive comment on "Constraining the geotherm beneath the British Isles from Bayesian inversion of Curie depth: Integrated modelling of magnetic, geothermal and seismic data" *by* Ben Mather and Javier Fullea

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We would like to thank the reviewer for the constructive comments and suggestions. Please find our response to each of the issues you have raised below.

General comments

A general observation by the reviewer is that Curie depths, in the synthetic tests and real magnetic data, are highly uncertain. The reason for this is because we allow beta to vary across the study area. It is common practise in most of the literature to fix the fractal parameter, beta, to a constant value. Implicit in this decision is to assume that the magnetic composition of the rocks is consistant at long wavelengths – an assumption that is less justified on continents than oceanic crust. As Bouligand et al. (2009) note: "the fractal parameter beta, which is the slope of the power spectrum in a log-log scale, is related to the geology and thus might vary geographically depending on rock types or geologic structures." We showed in our synthetic tests that the thickness of magnetic sources, dz, and beta are strongly correlated, as noted by the reviewer, thus a fixed value of beta reduces the amount of variation of dz and underestimates the uncertainty of each Curie depth determination. This explains the much higher degree of uncertainty in our Curie depth determinations compared to many other studies. Furthermore, the motivation to fix beta is problematic within a Bayesian framework where each of the parameters that control Curie depth are expressed probabilistically. In our opinion the latter arguments reasonably justify our decision to allow beta to vary across the study area. We have made this more explicit in the text where we add "Most studies fix beta to a constant value across the entire study area, but implicit in this decision is to assume that the magnetic composition of the rocks is consistent over long wavelengths. Through casting beta as an inversion variable, we retrieve a comparitively higher degree of uncertainty because our method propagates all of the errors associated with each parameter within a Bayesian framework. If this parameter is not taken into account then it is likely that all other parameters (zt, dz, and C) will be biased."

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What's the value of beta used for estimating the Curie depth in this study? Does it vary through the study area as the window sizes shown in Fig. 5? If this is the case, the authors should provide a map of various beta for comparing with Curie depths. I noted that a larger Dz can be compensated by a smaller beta (Fig. 3c). If the authors employ variable beta, the large Curie depth/uncertainty may be caused by improper beta.

Thank you for the suggestion to include a map of the variation in beta across the study area. We have included it as a subfigure (5b) adjacent to the map of window sizes

(5a). Please refer to the general discussion above for our motivations in allowing beta to vary across the study area.

Specific comments

1. P4-L15: In the centroid method (Tanaka et al., 1999), the wavenumber range is critical for the centroid depth (and therefore the Curie depth) estimation. Although the wavenumber segment selections vary in different studies, most researches took the wavenumber ranges less than âĹij0.05 km-1 (See Appendix in Wang and Li, 2018).

This is a good point, to clear up the confusion in this section we have added the following text: In this method of Curie depth estimation, the wavenumber segments over which to calculate the depth of magnetic sources varies in different studies, but is usually <0.05 km-1 (Wang and Li, 2018).

2. Eq (2): Please double check the fourth term, beta or beta-1.

Fixed. Thanks for noticing this difficult-to-spot typo!

3. P4-L22: It is difficult to estimate all the three unknown parameters simultaneously by nonlinear fitting the radial power spectrum. Bouligand et al. (2009) used a constant beta of 3.0 to obtain the Curie depth. I don't know what the value of beta is used in this study as mentioned in the above General comments. Li et al. (2013) demonstrated that the Maus and Blakely models of radial amplitude spectrum are nearly identical in shapes except for a vertical constant shift, and both are applicable to Curie depth estimation in using the centroid method.

Please refer to the general discussion above for our motivations in allowing beta to vary across the study area. Bouligand et al. (2009) fixed beta to a constant of 3.0 because it resulted in the lowest misfit out of all their forward models, but they found regions of their study area where the misfit between the radial power spectrum and their fitted curve were still very high, and would be better fitted with a different beta. There is no such problem here, because beta is allowed to vary for every centroid so the nonlinear fit to the radial power spectrum is always optimal. We have added the following comparison between both methodologies, “Li et al (2013) demonstrated that the radial power spectrum of Maus et al. (1997) and Bouligand et al. (2009) are nearly identical, except for a constant vertical shift. Because the thickness of a buried magnetic layer depends only on the slope of the power spectrum, they yield equivalent results.”

4. Fig. 2b: Please provide the inverted parameters for different window sizes on the figure or in the figure caption.

Done! We have included the inverted parameters within the figure caption.

5. Fig. 5: Please plot the centers of each window on the map.

Done!

6. Fig. 7a: Please provide the beta value on the figure and in the caption.

We have included a map of the variation in beta (Figure 5b) and included this parameter in the supplementary data table.

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