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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Estimation of the total magnetization direction of approximately spherical bodies" *by* V. C. Oliveira Jr. et al.

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We would like to thank the Anonymous Referee for his constructive comments. Below we present our comments on his recommendations.

General comments

<u>Referee's comment</u>: *"In addition, I appreciate what is, to my knowledge, a rather comprehensive literature review."*

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Referee's comment: *"The use of Euler Deconvolution to compute the center of the sources, however, I believe is a dubious method given the extension of the method to non-spherical sources. Their comments regarding the usefulness of the technique to horizontal location is appreciated, but the example only shows the technique applied to spherical bodies. I'd like an example of an off-center prism."*

Thank you very much. To adress this suggestion, we have proceeded in the same way as described in the response to the Referee J. Ebbing. We have applied our method to estimate the magnetization direction of a synthetic igneous intrusion formed by a sill which is fed by a vertical pipe. The numerical code used to produce this test can be found here. The simulated geomagnetic field has inclination $-39.8°$ and declination $-22.5°$. The synthetic intrusion has a reversed magnetization with inclination $I = 39.8°$ and declination $D = 157.5°$. This intrusion is emplaced in weakly magnetized sediments that are overlaying a basement which is magnetized by induction. In this example, the total-field anomaly predicted by the intrusion overlaps the one produced by the basement. Our method is applied to the noise-corrupted total-field anomaly produced by both the intrusion and the basement on a regular grid with constant vertical coordinate. The position of the synthetic intrusion is estimated by Euler Deconvolution. The synthetic intrusion is not an ideal source and then does not have a characteristic structural index. In this case, we presume that the noise-corrupted total-field anomaly is produced by an spherical body and use a structural index equal to 3. As shown here, the estimated location of the body obtained by Euler Deconvolution is placed outside the synthetic intrusion. Even using this poor estimation of the location of the source, our method obtained the estimated inclinations $\hat{I} = 37.50377° \pm 0.00035°$ and $\tilde{I} = 40.25973° \pm 0.04392°$ and declinations $\hat{D} = 167.61518° \pm 0.00060°$ and $\tilde{D} = 164.58968° \pm 0.09092°$. The caret (^) and tilde (~) denote the results computed by using, respectively, the least-squares and robust estimates. This numerical test shows the robustness of our method when applied to retrieve the magnetization direction of a complex source whose centre is poorly estimated by Euler Deconvolution. We also illustrate the use of the reduction to the pole to verify the quality of the estimated magnetization direction. The reduction to the pole calculated with the magnetization direction obtained by our method leads to a predominantly positive field, which is very close to the true pole field (see here).

We have also run several additional tests showing the application of our method to estimate the magnetization direction of different synthetic sources with known and estimated centres (by using Euler Deconvolution). The results obtained with the least-squares approach can be found here and the results obtained with the robust approach can be found here. One of these tests show the influence of a superposed constant-regional field (50 nT) on the estimated magnetization direction. The superposed constant-regional field does not lead to wrong estimates of the centres of the sources by Euler Deconvolution because, in this case, this technique estimates a non-null base level. On the other hand, this regional-constant field misleads the magnetization direction obtained by our method. To overcome this problem, a regional-residual separation should be previously done. Finally, these additional tests also show the performance of our method in estimating the magnetization direction of synthetic models similar to that ones presented by Lelièvre and Oldenburg (2009) and Ellis, Wet and Macleod (2012).

Referee's comment: *"It's fine to show the L2 results, but I'm not sure when one would not use the L1 in field data."*

The numerical results shown in our manuscript suggest the use of the L1 norm in the presence of interfering magnetic anomalies (section 3.2 - Robustness against interfering anomalies) and in dealing with non-dipolar total-field anomalies (section 3.3 - Robustness against non-spherical sources). On the other hand, the results shown in section 3.4 (Robustness against errors in the centre location) suggest that the L2-norm approach is slightly better than the L1-norm approach if there are errors in the vertical position of the centre of the source (Figures 7e and 7f of our manuscript). The presence of errors in the horizontal position of the source misleads the results obtained with both L1- and L2-approaches. In our opinion, the L1-norm approach should be used to interpret field data.

Referee's comment: *"If there is room, I'd like to see the total field data in the field example reduced to pole as well, just for comparison."*

Figure 10 of our manuscript shows the comparison between the reduced to pole anomalies obtained with L1- and L2-norm appraches on a region of the Goiás Alkaline Province, Brazil.

References

Lelièvre, P. G. and D. Oldenburg, 2009, A 3D total magnetization inversion applicable when significant, complicated remanence is present. Geophysics, 74(3), L21–L30, doi: 10.1190/1.3103249

Ellis, R. G., B. Wet and I. N. Macleod, 2012, Inversion of magnetic data from remanent and induced sources: 22nd International geophysical conferenceand exhibition, ASEG, Expanded Abrastracts, 1-4.

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