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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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## General comments

Referee's comment: *"The forward problem described is essentially identical to a mesh-based discretization but with the space-filling mesh cells (prisms, tetrahedra, etc) replaced with spherical (dipole) sources. Hence, the methods presented are essentially identical to those used by Lelievre and Oldenburg (2009) and Ellis et al. (2012)."*

We fully disagree with your comment that the forward problem in our method is essentially identical to the one adopted by Lelièvre and Oldenburg (2009).

The interpretation model adopted by Lelièvre and Oldenburg (2009) consists of an $m_x \times m_y \times m_z$ grid of 3D juxtaposed prisms in the horizontal and vertical directions

(Figure 1a ???). Hence, in the Lelièvre and Oldenburg (2009) the associated forward model (their equation 10) requires computing the $N$ by $3M$ full sensitivity matrix being $N$ the number of data and $M$ the number of prisms of the interpretation model. A large data set combined with the discretization of the Earth's subsurface into a fine grid of prisms results in a large-scale 3D forward model. Notice that in our method we **do not** discretize the earth's subsurface into an $m_x \times m_y \times m_z$ grid of 3D juxtaposed dipoles in the horizontal and vertical directions. Hence, our interpretation model does not consist of a 3D, equally spaced array of dipoles. Rather, the forward problem adopted by our method consists of a set of $L$ dipoles (Figure 1 of our manuscript). Hence, in our method the associated forward model (our equation 16) requires computing the $N$ by $3L$ sensitivity matrix where $L <<<<< M$. Thus, our method deals with a small-scale forward model being completely different from the one adopted by Lelièvre and Oldenburg (2009).

Referee's comment: *"The difference is that where Lelièvre, Ellis et al. develop methods to solve an underdetermined inverse problem (many more mesh cells than data observations), the authors of this manuscript only consider the solution of a simpler overdetermined problem (far fewer source parameters than data observations)."*

We agree that Lelièvre and Oldenburg' (2009) method solves an underdetermined inverse problem while our method solves an overdetermined problem. However, this characteristic is not the unique difference between these approaches. Table ??? presents a list of the characteristics found in Lelièvre and Oldenburg' (2009) method in comparison with those found in our method in this manuscript. By analyzing the Table below, we can easily conclude that these methods are substantially different. We highlighted (in green) the only two characteristics of these methods that are equal.

Table ???

**Computational efficiency**

Lelièvre and Oldenburg's (2009) methods requires a costly computational effort (a large

**Table 1.** captioncaptioncaptioncaptioncaptioncaption

| | **Lelièvre and Oldenburg' (2009) method** | **Our method** |
|---|---|---|
| Interpretation model consists of a user-specified grid of $M$ juxtaposed prisms in the horizontal and vertical directions | Yes | No |
| Interpretation model consists of a user-specified set of a few dipoles | No | Yes |

amount of memory storage and processing time). This disadvantage requires computational strategies to handle with a large-scale 3D inversion which were not mentioned by Lelièvre and Oldenburg (2009). The price paid for estimating the 3D magnetization vector distribution through the solution of a constrained nonlinear optimization problem is the disadvantage of dealing with intractable large-scale 3-D inversion. Hence, the computational inefficiency is one of the disadvantages of Lelièvre and Oldenburg's (2009) methods.

Our method estimates a single magnetization vector per magnetic anomaly through the solution of a linear inverse problem or a nonlinear inverse problem. Our method requires neither high-speed computers nor efficient computational strategies. The practical implementation of our method is very simple and its application is extremely fast. Hence, the major advantage of our method is its computational efficiency that allows a rapid estimation of the magnetization direction (inclination and declination) per magnetic anomaly. One might think that our method requires a signal separation to isolate the effect of a single well-defined peak per anomaly. This is not true. Our method requires only that each magnetic anomaly be identified by the interpreter. Thus, we can estimate the magnetization vectors of multiple sources by inverting a large magnetic data set; however each one estimate will be associated to a single magnetic anomaly previously identified by the interpreter.



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Interactive Comment

### Ill-posed vs. well-posed inverse problems

We recall that the nonuniqueness of the geophysical problem is caused by the insufficient information in the geophysical data. Particularly, the main ambiguity in geophysical interpretation is the one involving the physical property and the volume of the source. There is NO WAY to estimate both at the same time just from the data. As a result, if details about the source shape are required by the interpreter, the introduction of a large amount of strong constraints is mandatory. This is the case of the Lelièvre and Oldenburg's (2009) method. These authors are using strong constraints because they are trying to retrieve both the shapes and the magnetization directions of the sources at each small volume (prism) of the $m_x \times m_y \times m_z$ grid of 3D juxtaposed prisms in the horizontal and vertical directions (Figure 1a ????).

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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