Solid Earth Discussions

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Reply on RC1

Duan Li et al.

Author comment on "Interpolation of magnetic anomalies over an oceanic ridge region using an equivalent source technique and crust age model constraint" by Duan Li et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-117-AC2, 2022

We are also grateful to the reviewers for the assessments, comments, suggestion and recommendations. All of them are carefully considered while revising the manuscript. Below we provide a point-by-point response to all pieces of suggestion and comments.

Reviewer #1:

The manuscript proposes a space-domain method that uses a pair of equivalent layers for interpolating sparse total-field anomaly data on the oceanic crust by using an age model as a constraint. Although not clearly specified in the manuscript, the method is developed in a topocentric Cartesian Coordinate system with x, y, and z axes pointing, respectively, to North, East, and down. The method consists in solving a constrained-linear inverse problem for simultaneously estimating the physical property distribution on the two layers that yields an acceptable total-field anomaly data fit. The method imposes smoothness along isochrons of oceanic crust only on the physical property distribution of the shallow layer with the purpose of filling the gaps of total-field anomaly data. For me, the manuscript needs to be significantly improved before being considered for publication. The main problems are listed below:

(1) The equivalent-layer technique is offered as a better alternative to kriging, minimum curvature, cubic spline interpolation, and inverse distance weighting methods for interpolating sparse total-field anomaly data on oceanic crust because "these methods might not be optimal for the data prediction in areas with insufficient data" (page 4). The problem here is that the equivalent-layer technique is also negatively affected by insufficient data.

Reply: We agree with this comment. Insufficient data is a limitation for any method, and our work is to compare the accuracy of each method for data prediction in the same situation. The equivalent source (ES) method is to transform observed data into source, and then make data prediction through the source. Thus, the ES method is better in physical principle than the method based on morphological characteristics of data, and the calculation results also support the conclusion.

(2) At the end of page 4, beginning of page 5, it is written that the equivalent-layer technique may provide a more accurate magnetic field because it is possible to improve its structure and distribution. In my opinion, this justification should be considerably improved. It is not clear how the structure and distribution of the equivalent layer can be

modified to produce a more accurate field at the interpolating points. I understand that, by increasing the number of sources composing the equivalent layer, it is possible to obtain an exact data fit at the observation points because the inverse problem becomes underdetermined.

Reply: It is an expression of the research result of Li et al. (2020, GRL), indicating that the calculation accuracy can be effectively improved by improving the structure and distribution of the ES. Therefore, in our work, a similar technique is expected to achieve better interpolation result, which has also been proved in the synthetic model test.

(3) The proposed method uses the crustal age model of Müller et al. (2008) as a priori information for constraining the linear inversion of total-field anomaly data on oceanic crust. This model, in turn, was obtained on the basis of marine magnetic anomaly identifications. It seems that there is a circular reasoning problem here. Because the age model depends on the magnetic data, it does not necessarily introduce new information into the inverse problem and apparently cannot be used as a constraint.

Reply: The crustal age model is only used to provide constraints on the direction trend, so that the equivalent source could extends in a specific direction, which does not affect the data fitting. What we provided in this work is a constraint method or idea. In addition to crustal age, other directional constraint information can also be converted into the weighting factors to participate in the inversion. Moreover, we want to recover the magnetic anomaly field which is helpful to construct the global lithospheric magnetic field, such as the EMAG2v3 (Dyment et al., EPSL, 2015; Lesur et al., EPS, 2016) and WDMAMv2 (Meyer et al., G3, 2017). These models also used the crustal age model of Müller et al. (2008).

(4) Matrices **Wx** and **Wy** (eq. 3) impose smoothness along x and y directions. However, the isochrons are not necessarily aligned with x or y directions. So, it is important to clearly explain how the proposed method deals with isochrons that are not aligned with the x or y directions.

Reply: Since the isochron or boundary of lineation is discretized and corresponds to the equivalent-source cell one by one. Whether the lineation is aligned with the x or y direction, large values of w_x or w_y are taken for cell inside the lineation, small values of w_x or w_y are taken for cell at the boundary of lineation, or small values are taken for both w_x or w_y.

(5) The simulated crust (Figure 1) has isochrons that are perfectly aligned with the North-South direction (x-axis). In this case, matrix **Wx** (eq. 3) can be used to impose a strong smoothness along the x-direction. However, this model represents a very ideal situation. The simulated survey lines (Figure 2) are perfectly orthogonal to the simulated isochrons. This is also a very ideal situation. For me, the test with synthetic data presented in Section 3 should be used as an initial validation test. The conclusions obtained from this test cannot fully support the interpretation of real data. In my opinion, additional tests with synthetic data produced by models reproducing or at least approximating the complexity of a real magnetic survey on oceanic crust should be included in the manuscript.

Reply: We agree with this comment. As we answered in the last question, the constraint principle is the same regardless of whether the lineation changes are complex or not.