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Reply on RC2

Qiong Zhang et al.

Author comment on "Leveling airborne geophysical data using a unidirectional variational model" by Qiong Zhang et al., Geosci. Instrum. Method. Data Syst. Discuss., https://doi.org/10.5194/gi-2021-33-AC2, 2022

Many thanks for your significant comments on our manuscript. The response to each comment is listed as followings.

1. In the manuscript, we leveled the geophysical data based on image space properties. The gradients are calculated and understood from the point of image processing. In digital image processing, image is deemed as two-dimensional discrete function. The image gradient is approximately calculated by the finite difference method (Bouali and Ladjal, 2011).

As the referee suggested, we have supplied the calculation formulas of horizontal gradient and vertical gradient to better explain the method. The supplied introductions are given as below shown.

Assuming there are L flight lines and N survey points in each line, expressed as

$\boldsymbol{D}(N\times L)=[\mathbf{D}^1\mathbf{D}^2\ \ldots\ \mathbf{D}^L]=[\mathbf{D}_1\ \mathbf{D}_2\ \ldots\ \mathbf{D}_N]^{\mathrm{T}}$,

where $\mathbf{D}^L$ are the Lth flight line data, $\mathbf{D}_N$ are the Nth pseudo tie-line data, and T abbreviates transpose.

The gradient of the survey data in horizontal direction are $\mathbf{G}_x=[0\ \mathbf{D}^2\text{-}\mathbf{D}^1\ \ldots\ \mathbf{D}^L\text{-}\mathbf{D}^{L-1}]$.

The gradient of the survey data in vertical direction are $\mathbf{G}_y=[0\ \mathbf{D}_2\text{-}\mathbf{D}_1\ \ldots\ \mathbf{D}_N\text{-}\mathbf{D}_{N-1}]^{\mathrm{T}}$.

2. As the referee suggested, a reasonable and quantitative estimate can help to validate the efficiency of proposed algorithm. However, it is hard to set up an evaluation criterion by accurate calculation formulas. There are two reasons for missing quantitative comparison.

(1) As introduced in the manuscript, there are a variety of unmeasurable factors contributing to the leveling errors in the geophysical surveys. The leveling errors are difficult to analysis quantitatively in forward modeling.

Some published papers display the advantages of the proposed leveling algorithm by synthetic data examples. Geophysicists add generated leveling errors on the field data to conduct synthetic experiments (Davydenko and Grayver, 2014; Fan et al., 2016). Beiki et al. (2009) numerically calculate the magnetic field and illustrate a realistic case by adding diurnal variations from a real data set. In addition, the statistical data of the crossover differences are used to compare results in magnetic data leveling (Quesnel et al., 2009; Ishihara, 2015) and frequency-domain electromagnetic data leveling (Siemon, 2009). There are no available evaluation parameters to compare various leveling algorithms in multi-type geophysical data.

(2) In our manuscript, we compared the leveling results with the processed data published by the geophysical companies. In the leveling example of airborne electromagnetic data, we compared the leveling results with the data processed by Fugro Airborne Surveys. Based on the data report, the personnel process the airborne electromagnetic data through multiple steps, including lag adjustment, drift adjustments, spike editing for spheric events, the correction for coherent noise, and adaptive filtering (Ontario Geological Survey 2007). To present the leveling effects, we only conduct the data leveling algorithm on the raw data. So the leveling results are hardly to be quantitatively compared.

The similar situation occurs with the leveling example of airborne magnetic data. The manuscript compared the leveled data in tie-line leveling method performed by the Geophysics Leveling module of Oasis montaj software. The main data processing includes lag correction, heading correction, statistical leveling, and tie-line leveling. When we showed the leveled data in the manuscript, the raw data are processed by single leveling algorithm.

In the next work, we will build synthetic model to validate the efficiency of a new algorithm. Thank you for your comments.

3. We have modified the manuscript as the referee suggested. The detailed changes are listed as following. A native speaker is helping us to modify the grammar and expression of the manuscript. We will carefully and repeatedly check the manuscript to improve the quality of English language.

(1) Line 26: "... temperature has seasonal fluctuations even regional fluctuations" has been replaced as "... temperature has seasonal fluctuations and even regional fluctuations".

(2) Thank you again for your revisions to the manuscript.

Line 26: "Temperature variations can change the configuration of used survey aircraft, and the collected data as well..." has been changed to "Temperature variations can change the configuration of the used survey aircraft, affect its measuring hardware and the collected data".

(3) Line 33: "The temperature fluctuations are also happened" has been replaced as "The temperature fluctuations also take place".

(4) Line 39: "AEM data are relatively sensitive to altitude" has been replaced as "AEM data are relatively more sensitive to altitude".

(5) Line 41: "the leveling errors are difficulty to quantitatively calculate in accurate error equations" has been rewritten as "it is hard to quantitatively calculate the leveling errors in accurate error equations".

(6) Line 120: "the discontinuity of anomaly may be regarded as leveling errors which has considerable impact on the data leveling" has been rewritten as "the discontinuity of anomaly may be regarded as leveling errors which have considerable impact on the data leveling".

(7) Line 137: “If the vertical gradient of the survey point data greater than the average values of its horizontal or vertical directions” has been rewritten as “If the vertical gradient of the survey point data is greater than the average values of its horizontal or vertical directions”.

(8) Line 146: “the unidirectional variational model and spatially adaptive multi-scale model” has been rewritten as “the unidirectional variational model and the spatially adaptive multi-scale model”.

(9) Line 168-169: “Bouali and Ladjal (2011) proposed the unidirectional variational” has been replaced as “Bouali and Ladjal (2011) proposed the unidirectional variational model”.

(10) Line 185: “In unidirectional variational method” has been changed to “In the unidirectional variational method”.

(11) Line 194: “The calculated result data” has been changed to “The calculated resulting data”.

(12) Line 215: “data.Figure 3” has been changed to “data. Figure 3”.

(13) Line 228: “Both the leveling methods” has been rewritten as “Both leveling methods”.

(14) Line 241: “the parameters of unidirectional variational model algorithm” has been rewritten as “the parameters of the unidirectional variational model algorithm”.

(15) Line 266: “Figure 7(a) presented” has been changed to “Figure 7(a) presents”.

(16) Line 291-292: “Then unidirectional variational model is applied on the smooth field, considering that the directional distribution property discussed above” has been rewritten as “Then the unidirectional variational model is applied to the smooth field, taking into account the directional distribution property discussed above”.

We tried our best to improve the manuscript and made some revisions in the manuscript. These revisions will not influence the content and framework of the paper. And here we did not list the changes but marked in red in revised manuscript.

Experienced Editors and Referees really help to improve the manuscript. We appreciate for Editors and Referees’ warm work earnestly, and hope that the correction will meet with approval. Once again, thank you very much for your comments and suggestions.

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