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Leveling Aeromagnetic Data without Tie Lines

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Extended Abstract

Summary

Temporal changes in the earth magnetic field occur in the frequency band of millihertz to a few hertz. Amplitudes of variations above 0.1 Hz are usually much smaller than 1 nT, changes of 50-100 nT over periods of a few hours are not uncommon. Total-field aeromagnetic surveys typically require days or weeks to complete. An airborne magnetometer measures variations in the magnetic field caused by flying over magnetic geological structures and by temporal variations in the earth magnetic field. The most common method of estimating and removing the effects of time variations is called leveling. The standard procedure of leveling the data requires additional tie-lines flown perpendicularly to the original lines. In this study, a leveling approach is used without the need for tie-lines. The method, used in this paper, utilizes nine-point Hanning filter to creat a smooth representation of the regional magnetic field. The leveling errors are the difference between the flight-line raw magnetic data and the derived regional magnetic field. The magnitude of the error is minimized through least square method with a first-degree function, and the correction involves only a diurnal correction (DC) shift. The technique is applied to the aeromagnetic data set acquired in Moalleman area, Semnan, Iran. The results show that the stripy effects are removed and the unleveled data is improved.

Introduction

Aeromagnetic data have to be leveled for removing temporal variation effects from the observed anomalies. The leveling of aeromagnetic data is an important step in interpretation procedure. We can assume that the total magnetic intensity is invariant within the altitude variations of the aircraft. As such, measured data at intersection points, should record same values. Differences at cross points (where tie-lines intersect the flight lines) are attributed to leveling errors. The flight-lines are then leveled using leveling errors. Due to strong gradients in the anomaly magnetic field and the low flight altitude at modern surveys, errors at intersection points are commonly larger than the potential accuracy of modern high-resolution aeromagnetic surveys (e.g., < 1 nT). Hautaniemi (2005) has presented a leveling approach using the synthetic virtual tie-lines that are obtained from the main line survey data, so that the profile lines are designed to be perpendicular to the primary main lines direction. Nelson (1994) has used the horizontal magnetic gradient data to level total magnetic field data. Fedi and Felorio (2003) have utilized the wavelet transform to decorrugated magnetic data. A new leveling procedure has been introduced by Bastani, Beiki and Pedersen (2010). This technique is based on one-dimensional (1-D) and two-dimensional (2-D) polynomial fitting in sliding windows. Hung (2008) has proposed a new approach to level airborne geophysical data based on line to line correlations. White and Beamish (2015) have described a technique in which data can be leveled without the need for tie-lines using a regional grid.

Methodology and Approaches

Leveling aeromagnetic data can be carried out using two methods. In the first method, leveling the data is made using tie-line. Leveling the data in the second method is carried out without the need to tie-lines. Corrections, which have to be performed before leveling, include diurnal and heading corrections. If required, an international geomagnetic reference field (IGRF) correction has to be applied. By using a nine-point Hanning (3*3 convolution) filter, any high-frequency noise is removed, and the regional magnetic field data, which are free of leveling errors, are derived. The differences between unleveled magnetic data and derived regional magnetic field data should be minimal. Therefore, we can write:

$M_r=(mr_1, mr_2, \dots, mr_N)^T$

$M_d=(md_1, md_2, \dots, md_N)^T$

$X= (x_1, x_2, \dots, x_N)$

$\Delta d = m_d - m_r$

$|\Delta d\text{-}f(x)|^2 = \min$

where M_r is the derived regional magnetic field data, M_d is unleveled magnetic line data and f(x) is the error function. The function f(x) can be defined as first-degree polynomial and is determined in a least-square sense along each line in the survey.

Results and Conclusions

leveling is necessary before processing and interpretation of aeromagnetic data. The standard procedure of leveling the data is performed using tie lines. The acquisition of aeromagnetic data over the tie lines are expensive. In this paper, the aeromagnetic data have been leveled using a new approach without the need for tie lines. It has also been shown that this approach can save about 10% of the operational cost. This scheme has the major advantages such as leveling is done computationally, not manually, and also, leveling large data set is made in less than an hour. This technique has been tested on a real aeromagnetic data set acquired from an area in north of Moalleman, Semnan, Iran. In the analysis of the two applied leveling techniques, we see that the least square method improves the quality of the unleveled raw data better than in the tie line technique.