# Data processing requirements for an 1 Eö/√Hz AGG system

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## SUMMARY

A step-change evolution of airborne gravity gradiometry (AGG) instruments will enable the rapid acquisition of high quality and high resolution geophysical datasets. On top of the advances in the instrument hardware, the nature of the uncertainties that each stage of data processing introduces must be understood so that there is a high level of confidence in the deliverable result. This paper introduces a dataset that aims to facilitate the comparison of terrain correction and 3D inversion packages, using a combination of real and synthetic data from the Kauring airborne gravity test site.

**Key words:** Kauring, inversion, terrain correction, airborne gravity gradiometry

## INTRODUCTION

The aim of the VK1 gravity gradiometer, being jointly developed by *Rio Tinto Exploration* (RTX) and the *University of Western Australia*, is to deliver data with a sensitivity of 1 Eö/√Hz. When flying at a speed of 60 m/s in a fixed wing platform, this equates to data with a standard deviation of 1 Eö with a cut off wavelength of 120 m. This compares favourably with existing AGG technologies that typically operate at around 10 Eö/√Hz (Dransfield, 2010). The difference in data quality for these sensitivities is clear, as seen in a case of an array of synthetic kimberlites after Hinks et al (2004) in Figure 1.

In order to both achieve the desired sensitivity and to utilise this improved data quality, *RTX* has been addressing aspects of data processing and interpretation. Processing is generally directed at removing correlated noise (Johnston, 2011) or unwanted components of the response (e.g. terrain effects), often leading up to data presentation in useful grid images.

## KAURING INVERSION CHALLENGE

For quantitative interpretation, 3D inversion is becoming widely used. Although any model which fits the observed data is a valid solution, there are many different inversion programs available and they approach the search for a solution in different ways. To facilitate the testing and comparison of 3D inversion processes, a standard synthetic dataset is being proposed. The response of a number of density anomalies buried within a homogeneous background terrain with a density of 2.67 g/cc has been modelled along a realistic flight drape with a mean terrain clearance of 80 m over the Kauring test range (location in Figure 2).

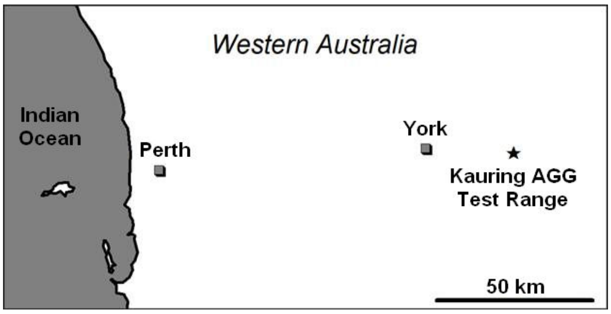


**Figure 2. The location of the central zone of the Kauring test range, where LiDAR is available.**

The anomalous bodies were chosen so that the nature of the responses (wavelength, magnitude, symmetry) was varied. The anomalies simulate a range of geological situations from discrete nickel sulphide deposits to intrusive dykes and kimberlites. Complete details of each density anomaly will be available from the Kauring airborne gravity test site website, hosted by *Geoscience Australia*. The anomalous bodies are summarised in Figure 3 and Table 1.

Noise representing a 1 Eö/√Hz AGG instrument has been added to the response of the model, simulating the observed AGG response for the VK1 system. The Gzz response of the anomalies with this noise, the accurate Gzz response of the terrain without noise and the addition of these (synthetic total observed Gzz) can be seen in Figure 4.

VK1 measures the difference between two independent gravity tensor components and can be configured to be sensitive either along some nominal flight direction or perpendicular to that nominal flight direction (or any other desired direction). As well as the standard gravity tensor components, the response that the VK1 instrument measures is included in the dataset along with a detailed description of the tensor components to allow vendors to modify the inversion and terrain correction codes to be able to process VK1 data.

## TERRAIN CORRECTIONS

The ground surface is generally the primary source of signal in airborne gravity gradiometry surveys, owing to its irregular geometry and significant density contrast with the air. As this response is unwanted, accurately accounting for it is essential. One such requirement for highly precise terrain modelling is that the uncertainty inherent in the digital terrain model (DTM) data is sufficiently low, so that it does not significantly alter the calculated response of the terrain. Knowledge of the characteristics of the uncertainty in a range of DEMs has lead to an understanding of the effects of these uncertainties on terrain corrections. The relationship between these effects and the clearance of the aircraft above the ground is shown for a high resolution (LiDAR) DEM and a regionally available (SRTM) DEM in Figure 5.

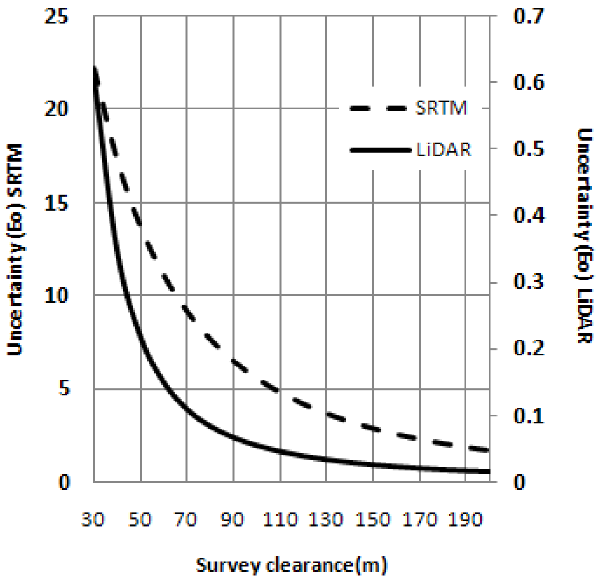


**Figure 5. The effect of DEM uncertainty of terrain corrections for a range of clearances.**

These relationships are generally concordant with prior research (Dransfield and Zeng, 2009); however differences are apparent and likely due to different terrain effect calculation algorithms.

A high resolution satellite based DEM surrounding the Kauring airborne gravity test site has been provided by *Geoimage* (September 2011). This DEM will be compared to other available terrain models at the test site and a comparison between terrain corrections using this terrain model and those performed using other high resolution models will be presented.

There are a number of other factors that influence the validity of terrain corrections, including the accuracy of the aircraft positions, the way the terrain is approximated and the methods used to filter the signal to match the data acquisition. The effect of these factors on terrain corrections will be explored and the requirements for reducing the uncertainty of terrain corrections to sub Eötvös levels will be presented, using data from the Kauring airborne gravity test site.

The datasets used in the examples will be made available on the Kauring airborne gravity test site and provides a common means to test and compare terrain correction codes.

## HEIGHT CORRECTIONS

Surveys are generally flown in a way that introduces irregularities in ground clearance that can introduce unwanted striping in a terrain corrected dataset. To minimise these features, a height correction can be typically performed to recreate the data as if it were collected along some smoothly varying drape. The height correction process has inherent uncertainties and the nature of these uncertainties will be explored with the aid of a combination of real and synthetic data over the Kauring airborne gravity test site. Some alternate methods to mitigate the unwanted striping will be presented.

## VK1 TEST FLIGHTS

To date, Rio Tinto has flown 5 test flights over the Kauring test range. At the time of writing this paper, there is no plan to present the data from the test flights at the 2011 ASEG conference; however this may change at a later date.

## CONCLUSIONS

To get the most out of a 1 Eö/√Hz airborne gravity gradiometer, data processing methods must evolve to levels of precision beyond the current offerings. Some of the shortcomings in current methods will be presented, along with a means for testing and comparing AGG terrain correction and 3D inversion code, using a combination of real data from the Kauring airborne gravity test site and the responses of synthetic anomalies.

All required datasets including the terrain models, simulated flight path and AGG responses as well as a description of the synthetic anomalies used in the inversion challenge can be found on the Kauring airborne gravity test site website. Users of the publically available dataset are encouraged to share the results of their studies on the website.

## ACKNOWLEDGEMENTS

The author would like to acknowledge Theo Aravanis (*Rio Tinto Exploration Pty Ltd, theo.aravanis@riotinto.com*) and Bob Smith (*Greenfields Geophysics, greengeo@bigpond.net.au*) for their contributions and review of this paper, and David Howard (*Geological Survey of Western Australia, david.howard@dmp.wa.gov.au*) for enabling the datasets to be made available on the Kauring airborne gravity test site website, hosted by *Geoscience Australia*. Thanks also go to *Geoimage* for providing a DEM over the Kauring test site.

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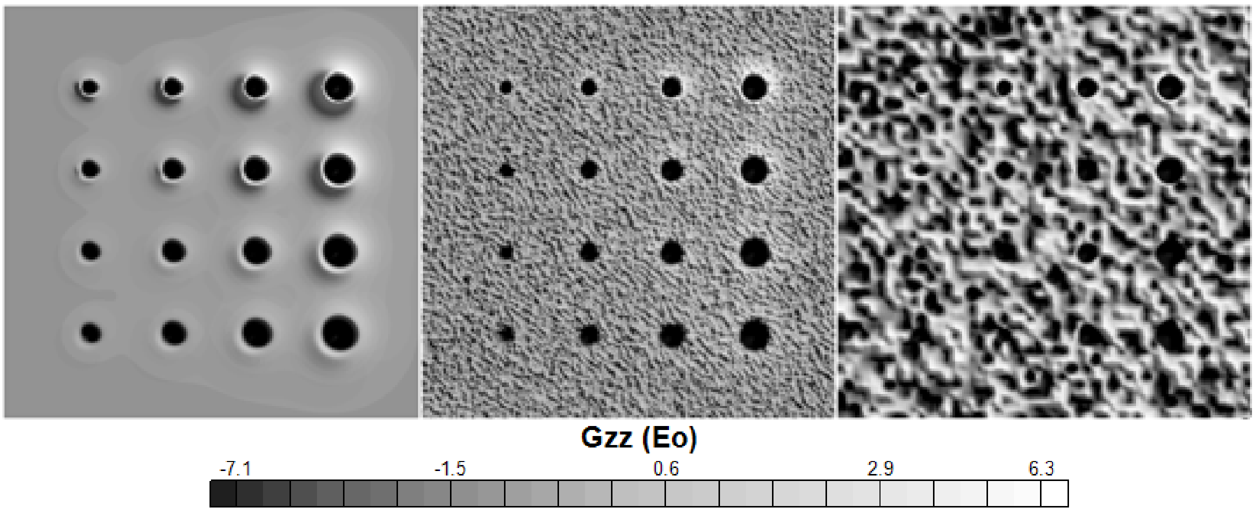


**Figure 1. Left: The Gzz response of a synthetic kimberlite plantation after Hinks et al (2004). Centre: 1 Eö/√Hz noise added to the exact response. Right: 10 Eö/√Hz noise added to the exact response. The anomalies are separated by 3 km.**

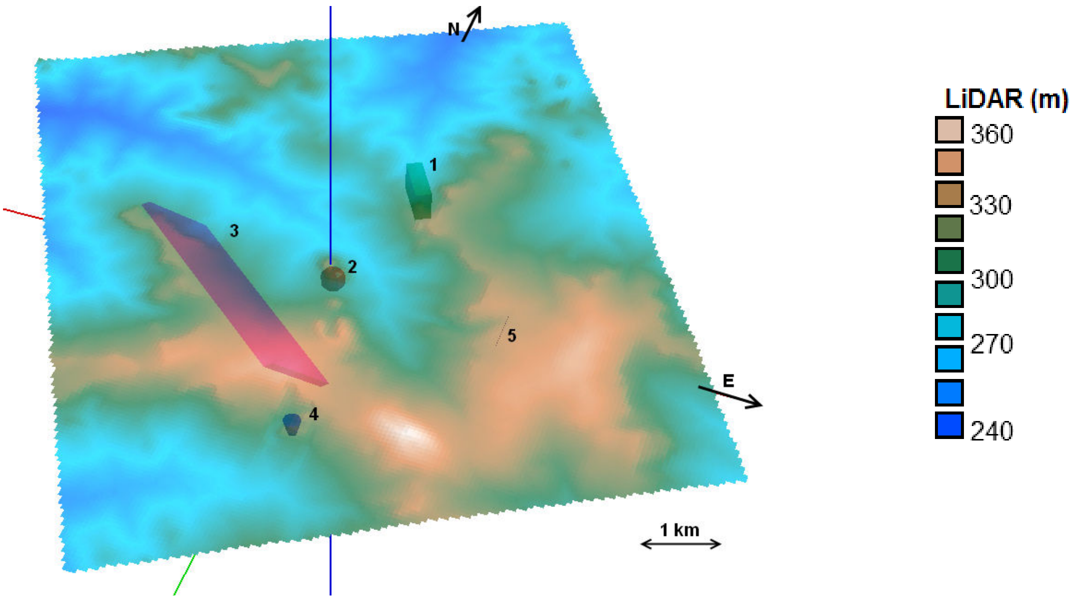


**Figure 3. The locations and geometries of the density anomalies of the Kauring inversion challenge. The grid is of the LiDAR bare-earth elevation.**

| Body | Depth to top of body (m) | Density (g/cc) | Peak Gzz response (Eö) | Comments |
|---|---|---|---|---|
| 1 | 500 | 0.20 | 2.48 | Tabular prism. Strike: 150°, 600 m (strike length) x 200 m (width) x 400 m (vertical extent) |
| 2 | 0 | 0.15 | 13.5 | Dipping sheet. 75 m thick, 1000 m down dip length, Dip: 45°, Strike: -50°, Strike length: 3000 m. |
| 3 | 50 | 0.30 | 28.6 | Sphere. Radius = 150 m |
| 4 | 150 | -0.4 | -6.0 | Kimberlite, narrows towards the base by a factor of 2 (surface area). Upper radius: 100 m, depth extent = 200 m. |
| 5 | 3 | -2.7 | -0.9 | Tunnel, 4 x 4 x 500 m, Strike: 0° |

**Table 1. A description of the anomalous bodies that are seen in Figure 3.**

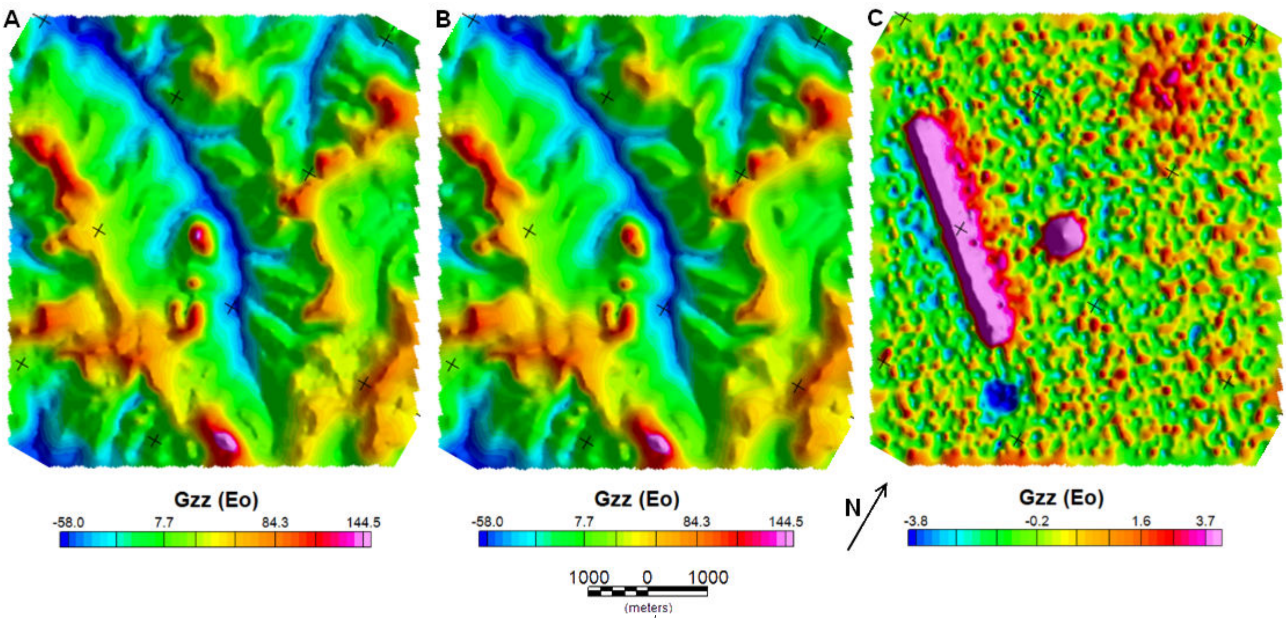


**Figure 4. A) The simulated observed Gzz response (with 1 Eö/√Hz noise). B) The terrain effect using LiDAR and SRTM with a density of 2.67 g/cc. C) Terrain corrected Gzz.**