Results from SGL's AIRGrav airborne gravity system over the Kauring airborne gravity test site

Stefan Elieff, Luise Sander, Sander Geophysics, Ottawa, Canada

1. INTRODUCTION

The relative performance of airborne gravity (AG) systems and airborne gravity gradiometer (AGG) systems is a recurring subject. In the broadest terms, AGG systems are best suited to shorter wavelength shallower features while AG systems hold an advantage at longer wavelength deeper targets. There is a wide range of opinion on what exactly 'shorter' and 'longer' wavelengths mean, however, and the characteristics of specific AG and AGG systems vary, limiting the usefulness of such broad generalizations. System performance tests can provide some clarity.

- Side-by-side testing provides the most direct comparison of instruments, eliminating variability created by different survey design and flying conditions. For example, a side-by-side independent test of Sander Geophysics' AIRGrav and Canadian Micrograwity GT-1A gravimeters was conducted which demonstrated the AIRGrav system was able to acquire higher quality data and was able to do so in a wider range of flight conditions (Studinger, Bell, and Frearson, 2008). The practical difficulties in arranging these kinds of tests make them rare.

- Repeatability tests are more commonly used as they are relatively easy to perform. The noise characteristics of the AIRGrav system were examined using 100 repeat lines acquired over 10 years in Elieff and Ferguson (2008) and compared with noise estimates from survey data. Both consistently show accuracies in the 0.1-0.3 mGal range for spatial resolutions of 1.4-4.5 km, depending on survey design.

- Comparisons with ground measurements allow direct comparisons to be made to an independent "ground truth" data set and between instruments flown over the site. The gravity test site at Kauring in Western Australia is an excellent tool for the analysis of airborne gravity and gradiometer systems because of the high quality independently acquired ground gravity data at the site (Howard, Grujic, and Lane, 2010).

2. METHOD

A Sander Geophysics AIRGrav airborne gravity system was flown over Geoscience Australia's Kauring airborne gravity test site. Comparisons with both Geoscience Australia ground data and airborne gravity gradiometer data (Christensen, 2013) acquired by CGG using the Falcon system are presented.

- Kauring site: Detailed ground data sampled in the inner-most 5x5 km region (the "AGG area"), semi-detailed 500 m stations in a wider 20x20 km region (the "AG" area).
- AGG area flown with 50 m line spacing (AIRGrav and Falcon).
- AG area flown with 200 m line spacing (AIRGrav only).
- AIRGrav acquired using drape flying surface, minimum clearance 80 m, normal daytime turbulence conditions.
- A 600 m (AGG area) / 1000 m (AG area) half-wavelength low pass filter was employed for the AIRGrav data.

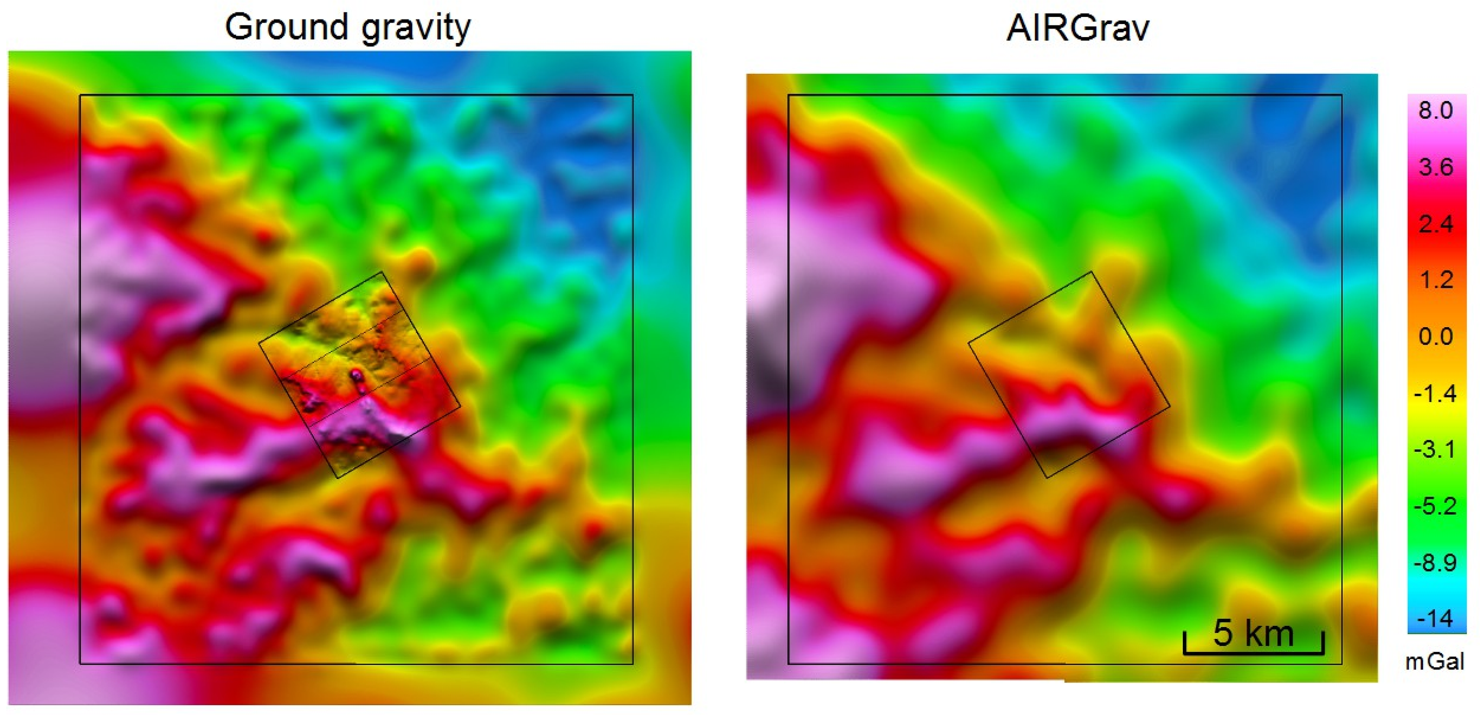

Figure 1: Free air vertical gravity (gD) at the Kauring test site. The outer square is the 20x20 km AG area, the inner square is the 5x5 km AGG area.

3. RESULTS

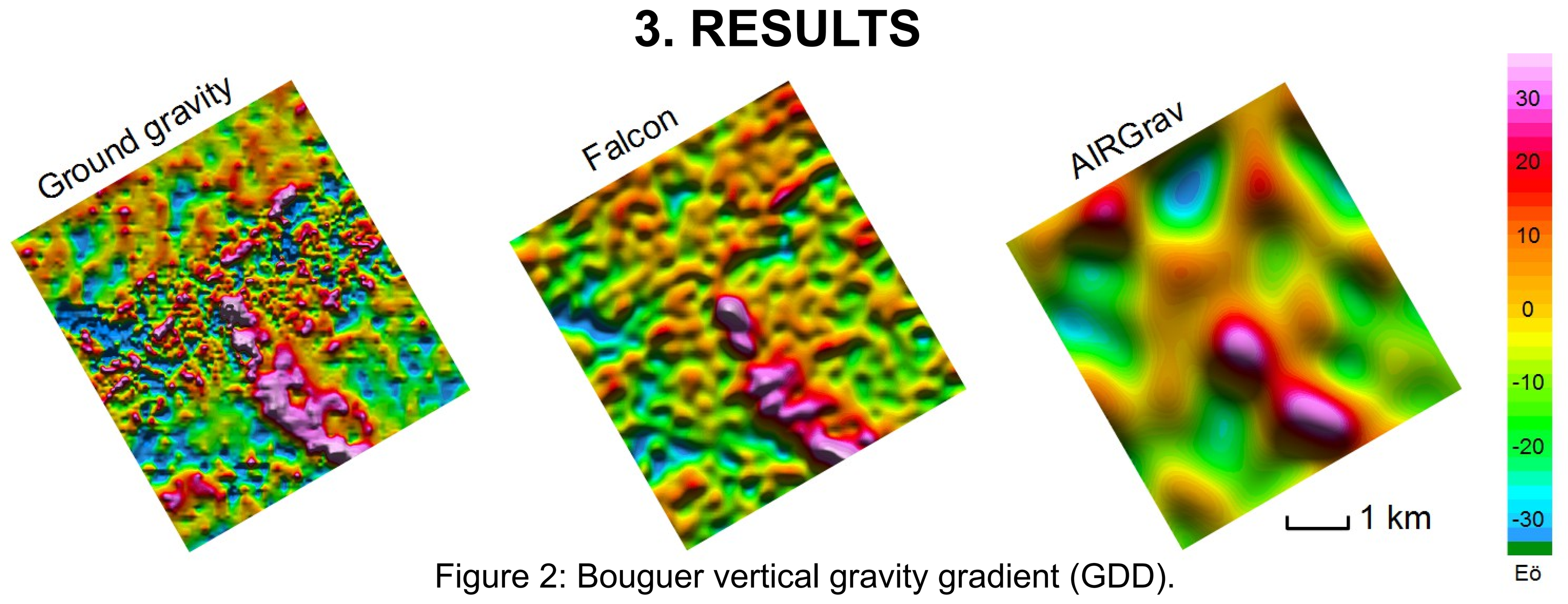

Figure 2: Bouguer vertical gravity gradient (GDD).

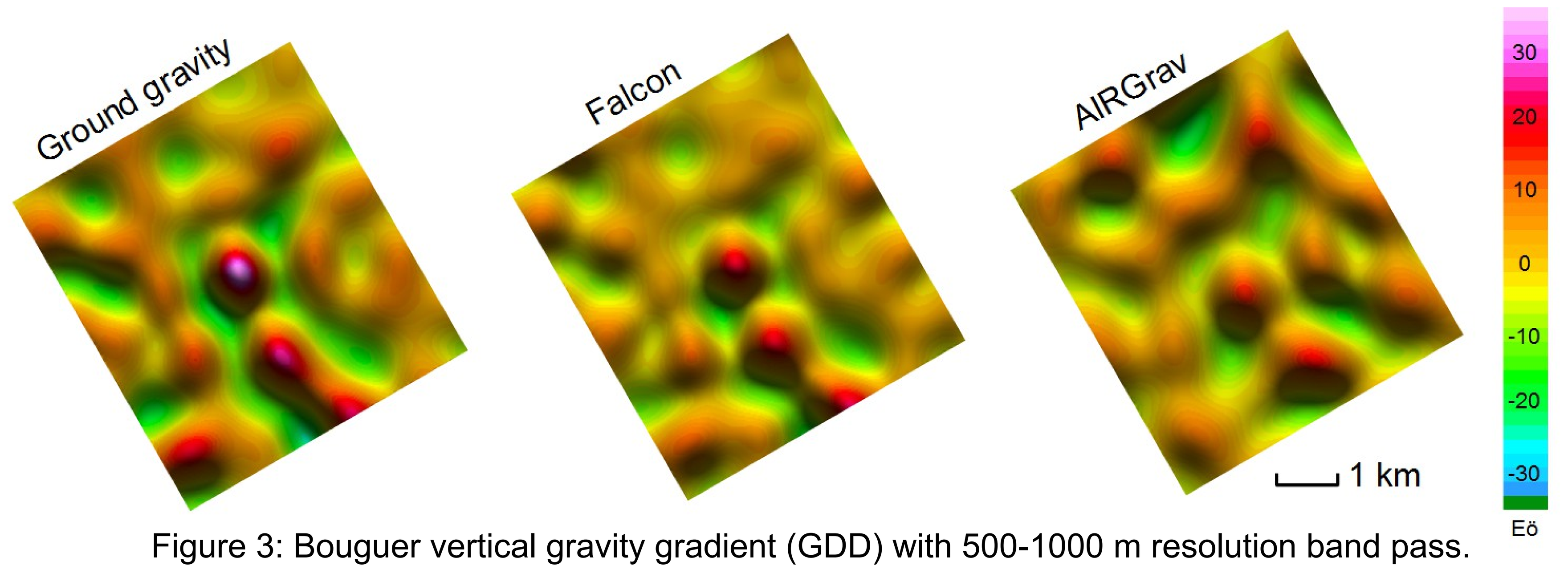

Figure 3: Bouguer vertical gravity gradient (GDD) with 500-1000 m resolution band pass.

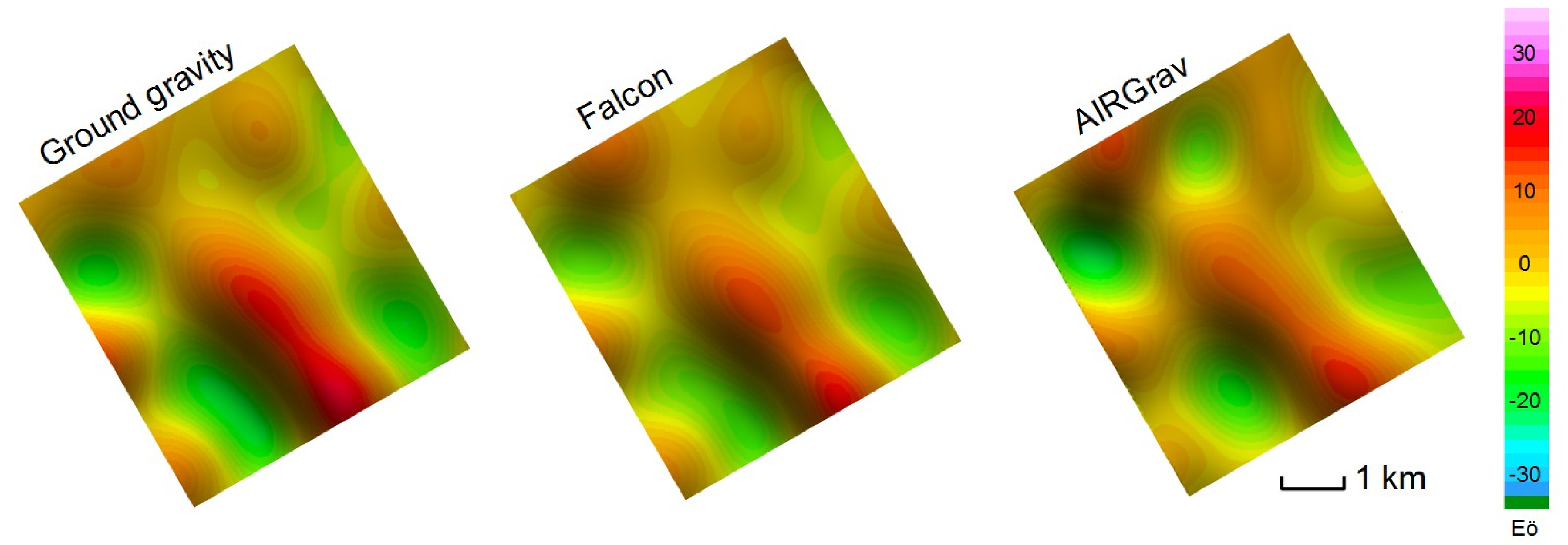

Figure 4: Bouguer vertical gravity gradient (GDD) 1000-2000 m resolution band pass.

- AGG area represents an ideal target for an AGG system; Falcon AGG reproduces these shortest wavelengths well.
- Smallest anomalies are removed by the low pass filter employed by AIRGrav, but band pass filters show AIRGrav still captures relatively short wavelengths of the gravity field with improving accuracy as wavelength increases.

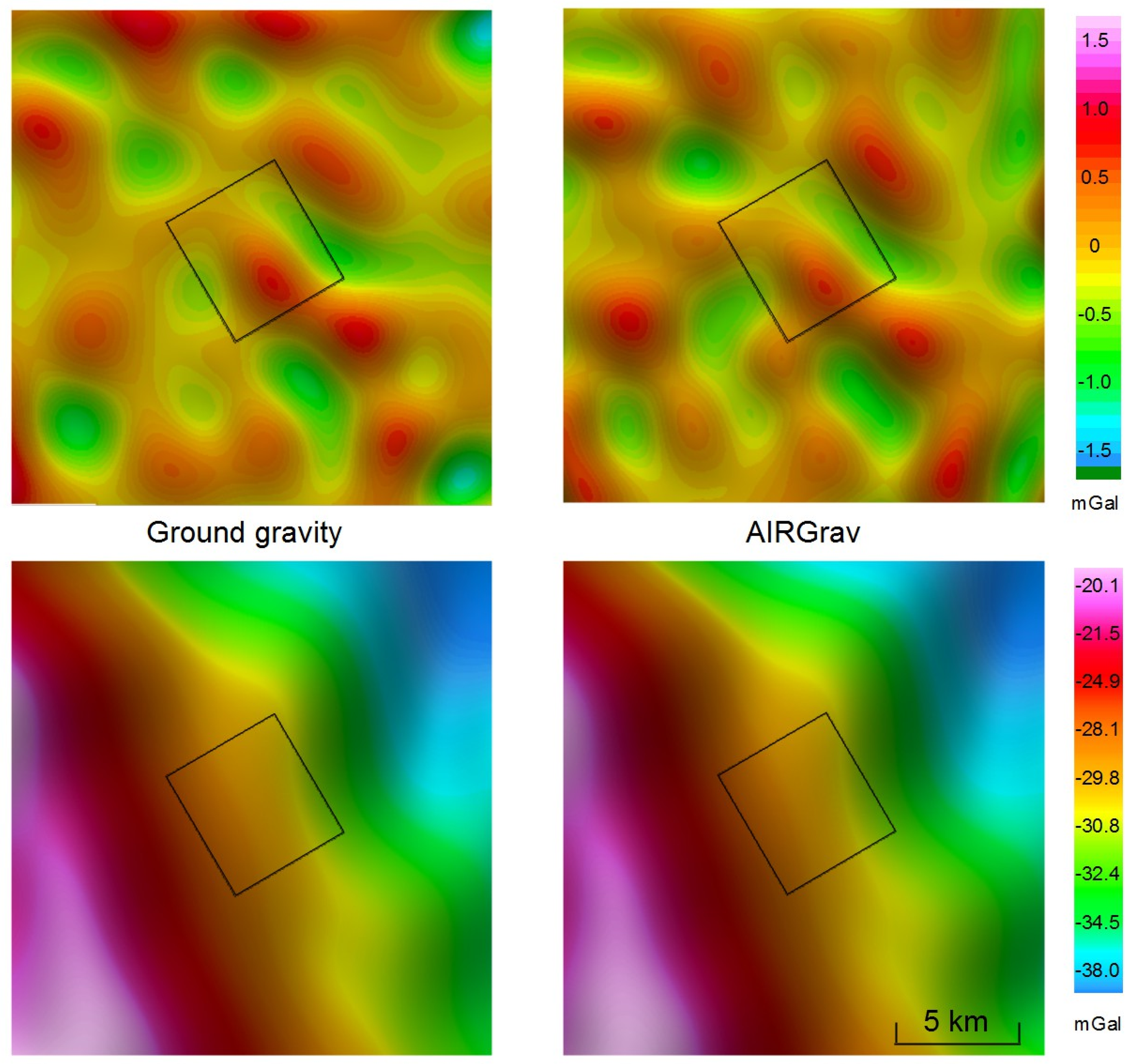

Figure 5: AG area Bouguer vertical gravity (gD). Top row is 2000-4000 m resolution band pass, and bottom row is 3333 m half-wavelength low pass filtered.

- At 2000-4000 m resolution it is more appropriate to use the entire AG area due to the small size of the AGG area relative to these wavelengths. This is displayed using Bouguer vertical gravity (gD) grids in Figure 5 instead of the vertical gravity gradient (GDD) used in Figures 2-4.
- In the AG area the station spacing of the ground data is less dense and the AIRGrav data are collected using wider 200 m line spacing.
- Falcon data are not available for the entire AG area, nor would it make sense to include it here since Falcon relies on external data sources for the long wavelength field (Dransfield, 2010) beyond the 2500-5000 m half-wavelength transition band for this specific data set.
- The standard deviations of the airborne-ground differences for the grids shown in figures 3-5 are given in the table below. Note that these are not instrument noise estimates. The ground gravity grid has not been upward continued in these comparisons, nor has any attempt been made to correct for processing differences present in each data set.

Area	Resolution	Falcon	AIRGrav
AGG	500-1000 m	3.6 Eö	7.7 Eö
AGG	1000-2000 m	2.6 Eö	4.3 Eö
AGG	2000-4000 m	n/a	0.09 mGal
AGG	> 3333 m	n/a	0.09 mGal
AG	2000-4000 m	n/a	0.18 mGal
AG	> 3333 m	n/a	0.18 mGal

4. WIDER LINE SPACING

Relatively tight line spacing of 50 m (AGG area) / 200 m (AG area) was used for AIRGrav acquisition over the Kauring test site. For longer wavelength data this is unnecessary. Accuracy improves substantially at longer wavelengths so only a modest amount of oversampling will produce accurate data.

- AIRGrav data covering the AG area were divided into five subsets of 1000 m spaced lines.
- Accuracy was estimated using difference grids to measure repeatability.
- The accuracies are 0.41 mGal (1000-2000 m band pass), 0.22 mGal (2000-4000 m band pass), and 0.14 mGal (3333 m low pass) standard deviation.
- For a survey targeting 3 km resolution, 1000 m line spacing typically produces a final filtered grid with 0.1-0.2 mGal accuracy.

SGL has flown over 100,000 km of AIRGrav surveys in Papua New Guinea. The Bouguer vertical gravity gradient for a small subsection of this data with the same parameters of 1000 m line spacing and 3000 m half-wavelength resolution covering approximately 30x30 km is shown in Figure 6. The accuracy was estimated with the method from Sander et al. (2002) using subsets of 2000 m spaced lines. The final grid has 0.15 mGal accuracy, in agreement with the data acquired at the Kauring test site.

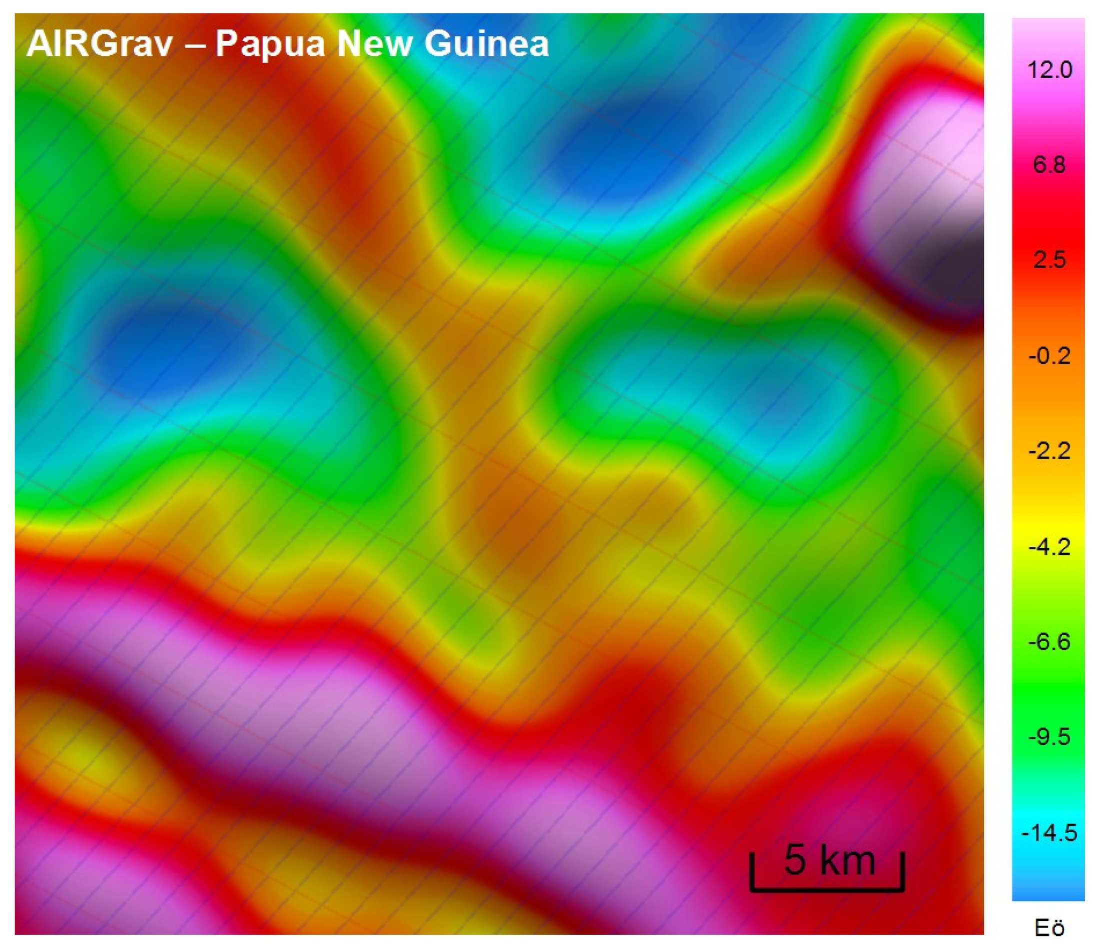

Figure 6. Bouguer vertical gravity gradient (GDD) from a survey in PNG with 1000 m flight lines superimposed. A 3000 m half-wavelength filter is applied to the grid.

5. DISCUSSION

The AIRGrav system is capable of obtaining accurate gravity grids at resolutions of a few kilometres using relatively wide 1 km line spacing. Tighter line spacing significantly extends AIRGrav's utility into shorter wavelengths through oversampling noise reduction, as is evident from the 500-2000 m resolution data acquired over the Kauring test site. The AIRGrav system is able to collect data at short wavelengths because it is essentially limited by the spectrum of GPS position noise. The instrumental errors in the gravimeter, such as those induced by flight dynamics, are comparatively small. The random GPS noise can be averaged through oversampling and grid filtering, extending the reach of the system into shorter wavelengths. In addition, advanced processing techniques have enabled noise reduction in individual lines below older theoretical GPS limits (Elieff and Ferguson, 2008).

ACKNOWLEDGEMENTS

SGL's AIRGrav Kauring data were acquired for the Victoria State Department of Primary Industries (DPI) as part of the CarbonNet Project. Falcon Kauring data were provided to SGL by CGG. Ground Kauring data were obtained through Geoscience Australia.