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Comparison of Satellite Altimeter-derived Gravity Data and Marine Gravity Data

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SUMMARY

Several new satellite altimetry missions have started delivering data that will seriously improve global high resolution gravity fields. The impact of these new geodetic mission data is significant with the quality of the altimetric gravity field nearing that of marine gravity observations in many regions. We demonstrate the quality of the new satellite altimetry data by comparison to high quality marine gravity data over the Capel and Faust basins, offshore Eastern Australia. An improvement of 10% is seen in the region in comparison with vintage altimetric gravity fields. Over the sampled wavelengths, the DTU13 gravity data appears to have the best resemblance to the reference marine gravity data, exhibiting the overall least difference amplitude over most wavelengths.

Marine Gravity Surveying covering the Capel and Faust Basins.

In 2007, Geoscience Australia obtained pre-competitive geoscience data to aid assessments of the petroleum prospectivity and seabed environments of the Capel and Faust basins, two under-explored basin provinces that lie offshore eastern Australia about 800 km east of Brisbane. The basins are part of the Lord Howe Rise, a continental ribbon that separated from the Australian continent during Cretaceous rifting and opening of the Tasman Sea. The early 2007 marine cruise (survey GA-2436) acquired nearly 17,000 line km of swath bathymetry and potential-field (gravity and magnetic) data over the Capel and Faust basins. Figure 1 shows the location of the GA-2436 survey area. The marine gravity data acquired was of excellent quality and has been levelled to an extensive net of marine gravity lines in Australian waters (Hackney, 2010). The resulting marine free-air gravity data is shown in Figure **2(a)**. The N-S main marine traverses are recorded at 3km line spacing, with an N-S extent of 110km. Hence the smallest un-aliased wavelengths of acquired gravity is 6km (twice the traverse line spacing) and the largest un-aliased wavelength of acquired gravity is 110km. The marine gravity data provides an excellent reference data set to evaluate and compare the various altimetric gravity data sets.

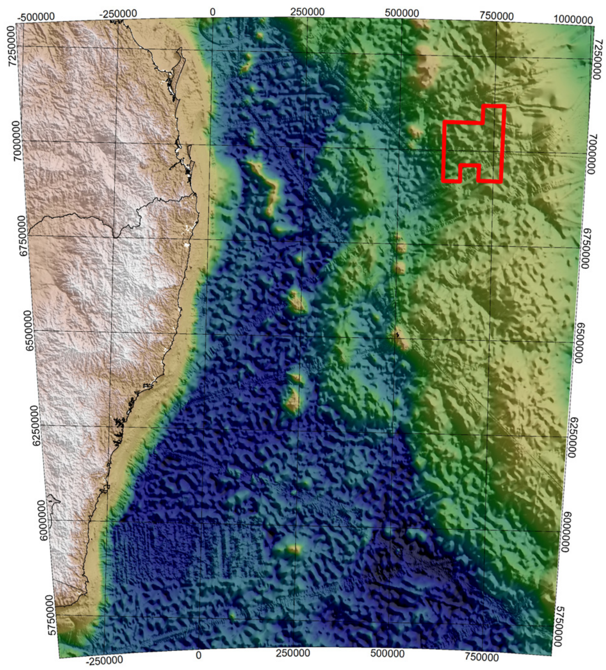

Figure 1 *Location map of the GA-2436 marine gravity survey off the east coast of Australia.*

Satellite Altimeter Derived Gravity Data

A number of new new satellite altimetry missions have been executed in the past few years: GOCE delivers unprecedented accurate geoid/gravity field data in the 200-400 km wavelength range, Cryosat-2 delivers new high resolution sea surface height observation, and since May 2012 the Jason-1 satellite has been operating in geodetic mission as part it end of life mission.With the launch of the Jason-1 and the Cryosat-2 satellite altimeter systems three times as much altimetric data have become available to marine gravity field determination using satellite altimetry. The impact of these new geodetic mission data is significant, with the quality of the altimetric gravity field nearing that of marine gravity observations in many regions (Andersen *et al.*, 2014).

Two satellite-altimetry-derived gravity datasets include the new mission data from Jason-1 and Cryosat-2: those from the Danish Technical University (DTU) and those provided from the Scripps Institution of Oceanography (SIO).

Figure **2(b)** shows the satellite-altimetry-derived free-air gravity from the DTU13 data set (Andersen *et al*., 2014). Figure **2(c)** shows the satellite-altimetry-derived free-air gravity from Sandwell *et al*., (2013 and 2014) – version 23.1 – hereafter referred as "*SSv23p1*". For comparison we have also included in Figure **2(d)** the historical satellite-altimetry-derived free-air gravity dataset DNSC08 from the Danish National Space Centre (Andersen *et al*, 2010).

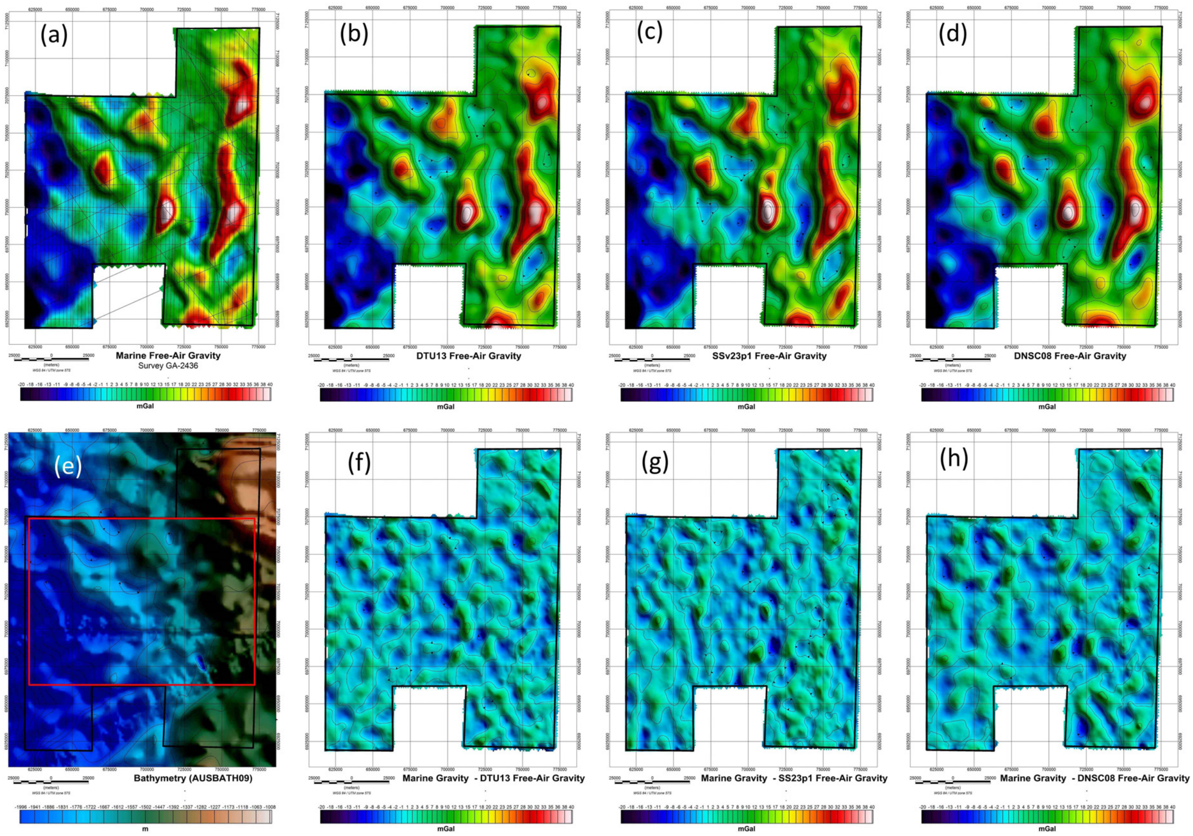

Figure 2 *(a) Marine free-air gravity with GA-2436 survey lines, (b) DTU13 altimetric free-air gravity, (c) Sandwell et al. altrimetric free-air gravity - version 23.1 (SSv23p1), (d) DNSC08 altimetric free-air gravity, (e) bathymetry – areal extent used for spectral analysis shown in red, (f) difference between marine free-air gravity and DTU13 altimetric free-air gravity, (g) difference between marine free-air gravity and SSv23p1 altimetric free-air gravity,(h) difference between marine free-air gravity and DNSC08 altimetric free-air gravity*

Analysis of satellite gravity data using reference marine gravity data.

Figure **2(e)** shows the bathymetry variations in the survey area, which partly explains the general increase in free-air gravity from the west to the east. In order to highlight the subtle differences in the high-quality marine gravity data and the satellite-altimeter-derived gravity data sets, Figures **2(f)**, **2(g)**, and **2(h)** show the difference plots between the marine free-air data and the DTU13, the SSv23p1, and the DNSC08 free-air gravity data, respectively. Table 1 summaries the key statistics of the three difference plots. Both of the new data sets, DTU13 and SSv23p1, exhibit a 10% improvement (reduction) in noise when compared with the earlier DNSC08 data, which did not include the recent Jason-1 and Cryosat-2 satellite altimeter data. The DTU13 data set appears to have the least error, when compared to the reference marine gravity free-air data.

Table 1 *Key statistical parameters from the difference grids between the reference marine gravity free-air data and the DTU13, the SSv23p1, and the DNSC08 free-air gravity data, respectively.*

Satellite Gravity Data Set	Mean [mGal]	Standard Deviation [mGal]	Mimimum Difference [mGal]	Maximum Difference [mGal]
DTU13	**-0.05**	**2.0**	**-6.1**	**8.6**
Sandwell *et al.* version 23.1	**-0.14**	**1.9**	**-9.7**	**10.3**
DNSC08	**-0.05**	**2.2**	**-8.7**	**11.3**

Spectral Analysis Results

For each of the satellite-altimeter derived data sets we have computed power spectra of the differences between the reference marine free-air gravity data and the satellite-altimeter-derived free-air data. The resultant 2-D power spectral densities were radially averaged and translated into a single dimension, to indicate the contribution to the variance of the error grids as a function of wavelength only. The results are shown in Figure 3.

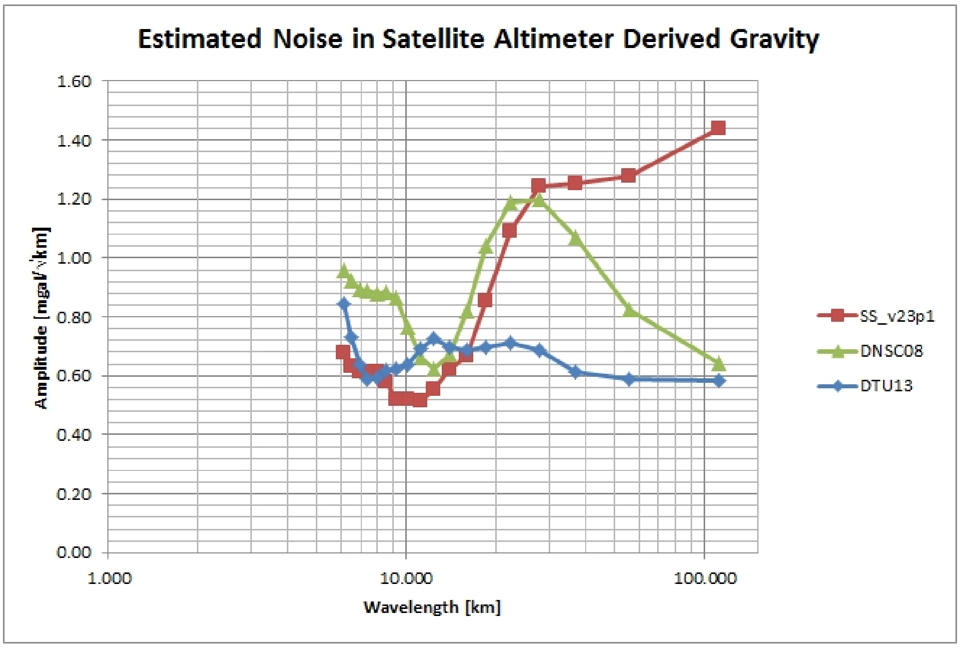

Figure 3 *Radially averaged amplitude spectra of the estimated noise in the satellite gravity data sets. The noise was estimated by differencing the satellite gravity data from the marine gravity data. The spectra have been clipped to wavelengths corresponding to the content of the reference marine gravity data (6km to 110km).*

Conclusions

The ready availability of a high-quality marine gravity data over the Capel and Faust basins has allowed us to examine the accuracy of both newly released, as well as vintage, satellite-altimeter-derived gravity data.

Statistical analysis of the difference plots show, that over the survey area the newer DTU13 and SSv23p1 gravity data sets have 10% less noise than the vintage DNSC08 data.

The spectral analysis shows that for shorter wavelengths (7km-15km) the newer DTU13 and SSv23p1 gravity data have less noise than the historical DNSC08 data. This is primarily due to the recent inclusion of the Jason-1 and Cryosat-2 satellite altimeter data.

Over the sampled wavelengths, the DTU13 gravity data appears to have the best resemblance to the reference marine gravity data, exhibiting the overall least difference amplitude over most wavlengths.

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