GROUND GRAVITY CORRECTIONS

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July, 2016

GRAVITY CORRECTIONS – 1 - Blakely pg 144

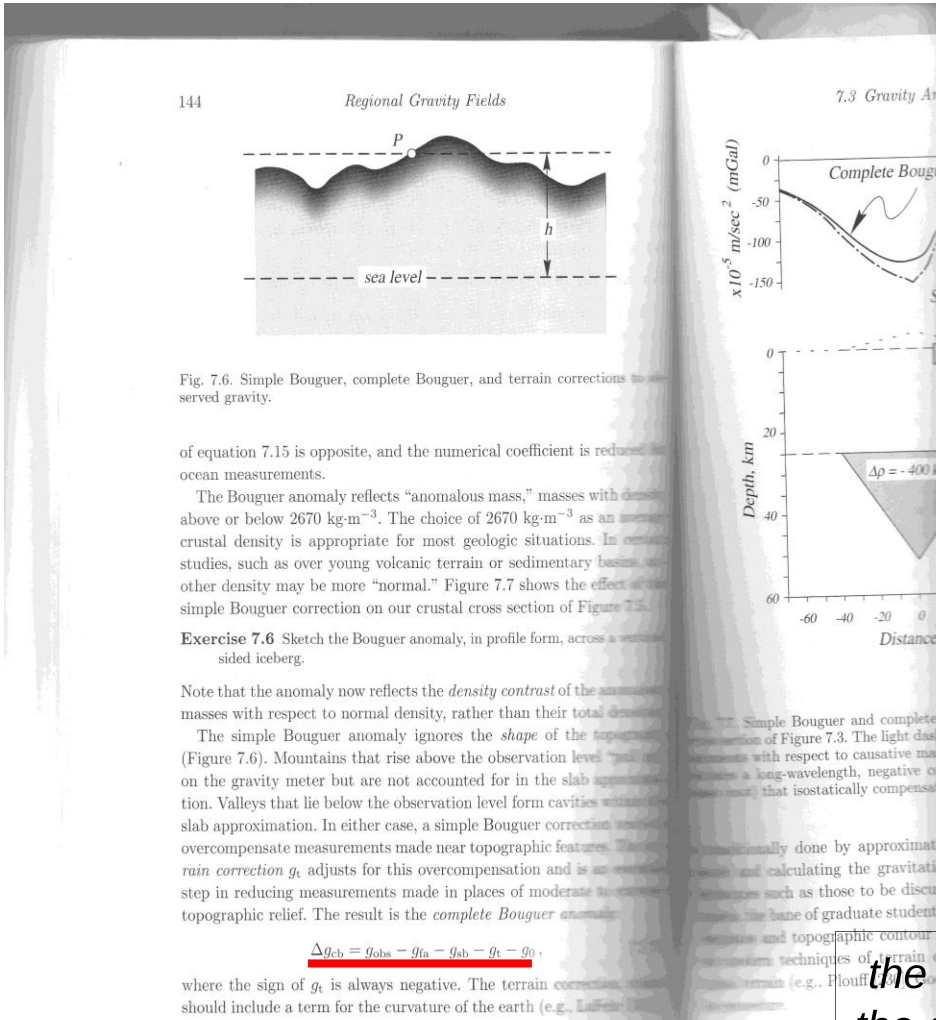


Fig. 7.6. Simple Bouguer, complete Bouguer, and terrain corrections to ob-served gravity.

of equation 7.15 is opposite, and the numerical coefficient is reduced for ocean measurements.

The Bouguer anomaly reflects "anomalous mass," masses with density above or below 2670 kg·m^{-3}. The choice of 2670 kg·m^{-3} as an average crustal density is appropriate for most geologic situations. In certain studies, such as over young volcanic terrain or sedimentary basins, other density may be more "normal." Figure 7.7 shows the effect of the simple Bouguer correction on our crustal cross section of Figure 7.3.

Exercise 7.6 Sketch the Bouguer anomaly, in profile form, across a vertical-sided iceberg.

Note that the anomaly now reflects the *density contrast* of the anomalous masses with respect to normal density, rather than their total density.

The simple Bouguer anomaly ignores the *shape* of the topography (Figure 7.6). Mountains that rise above the observation level "pull" up on the gravity meter but are not accounted for in the slab approximation. Valleys that lie below the observation level form cavities within the slab approximation. In either case, a simple Bouguer correction will overcompensate measurements made near topographic features. The *terrain correction* g_t adjusts for this overcompensation and is an essential step in reducing measurements made in places of moderate to extreme topographic relief. The result is the *complete Bouguer anomaly*,

$$\Delta g_{cb} = g_{obs} - g_{fa} - g_{sb} - g_t - g_0 ,$$

where the sign of g_t is always negative. The terrain correction should include a term for the curvature of the earth (e.g., LaFehr ...

Simple Bouguer and complete ... of Figure 7.3. The light dash ... with respect to causative mas ... a long-wavelength, negative co ... that isostatically compensat ...

... done by approximati ... and calculating the gravitatio ... such as those to be discuss ... the bane of graduate students ... and topographic contour ... techniques of terrain c ... (e.g., Plouff ...

$$\Delta g_{cb} = g_{obs} - g_{fa} - g_{sb} - g_t - g_0 ,$$

g_{fa} – free air correction
g_{sb} – Bouguer slab
g_t – terrain correction
g_0 – latitude

g_t is a compensation term to correct for the bouguer slab

$g_t < 0$

the purpose of these corrections is to reduce the effects of latitude, elevation and topography so that as much as possible all stations are at the same altitude with no latitude, altitude or topography effects

GRAVITY CORRECTIONS – 1 Note - Blakely pg 144

Note on gravity corrections as laid out in QCTools

$$\Delta g_{cb} = g_{obs} - g_{fa} - g_{sb} - g_t - g_0 \, ,$$

g_{fa} – *free air correction*
g_{sb} – *Bouguer slab*
g_t – *terrain correction*
g_0 – *latitude*

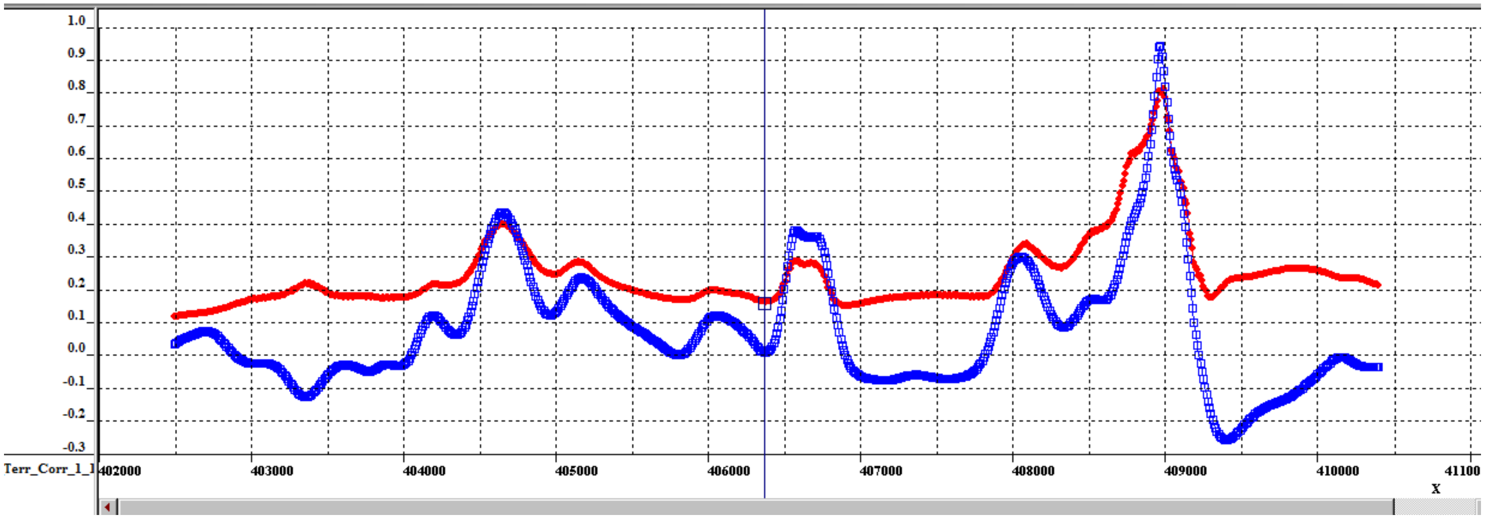
traditionally, for ground data, the object of the gravity corrections was to remove several effects - latitude, elevation, topography.

The theoretical or latitude corrections and the free-air correction were easily applied by hand as was the Bouguer slab. The Bouguer slab correction, generally, overcompensated for terrain and thus several manual techniques were devised to correct for this overcompensation locally dependent upon surveying locally about each station with some type of theodolite.

But, removing these factors was necessary as interpretation was done with hand calculated formulas based upon being at z=0 and with no elevation variation in the earth's surface.

However, if the target of the gravity surface is within the elevation variation as for example within a mountain range then this approach is no longer appropriate.
In this case, we offer different approaches through simulation of the topographic effect and only applying the latitude and free air corrections prior to applying these approaches.

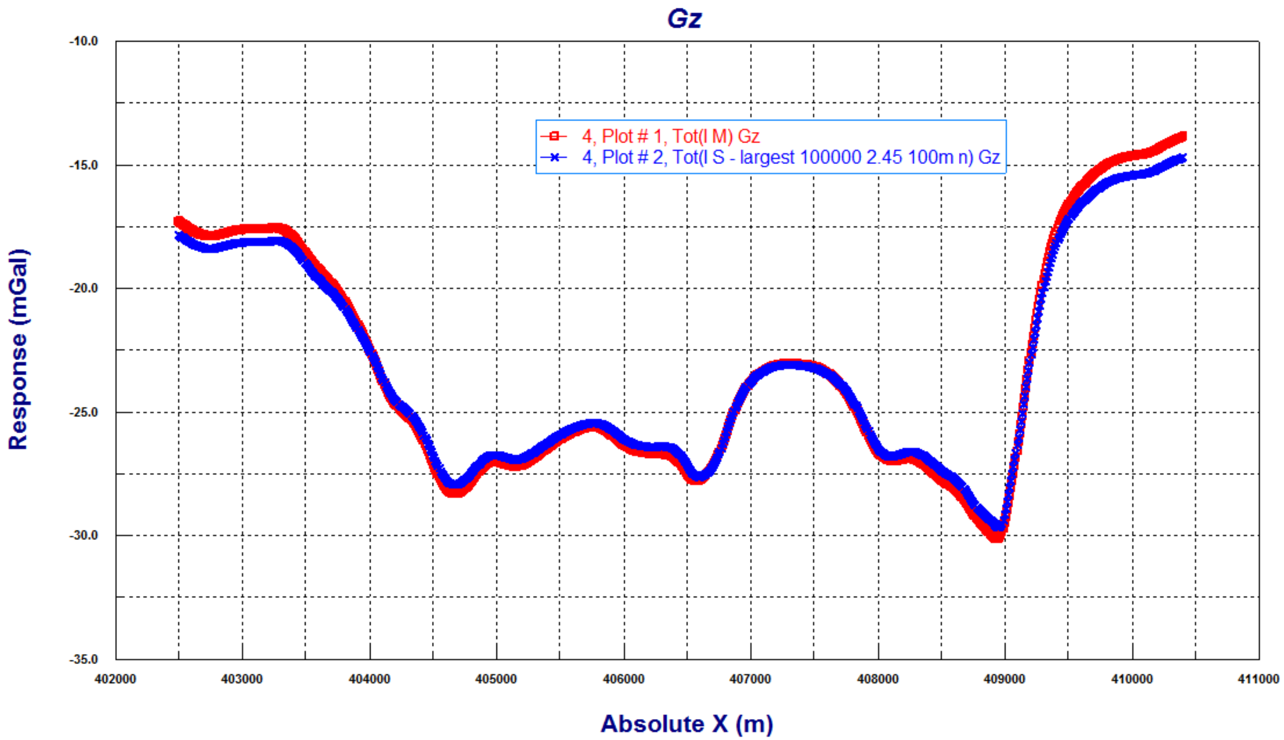
GRAVITY CORRECTIONS – 2 g_{zz} *vs* g_t



Here, we have reduced g_{zz} by a factor of 500, in order to plot g_t *and* g_{zz} *on the same scale.*

Note 1: There are some similarities in the spatial variation of g_{zz} *to* g_t there are also significant differences. As both g_{zz} and g_t are, by their definitions, affected by lateral variations in the topography, it should not be surprising that there is some correlation between these two functions.

GRAVITY CORRECTIONS – 3 Simulations of g_{zz} *and* g_z

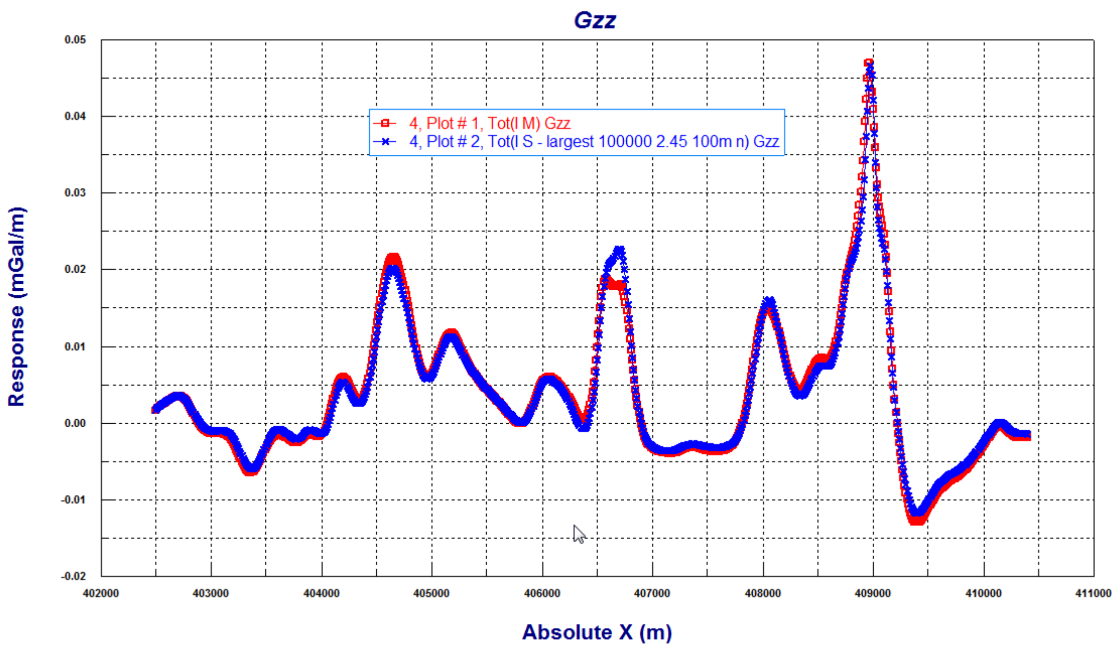


g_z
Red – GravMod
Blue - EMIGMA

We compare the GravMod g_z value to a simulation of the topography at instrument height . We use a modern definition of Z which is upwards to be consistent with the GPS axes definitions. Thus the GravMod values are not g_t as defined classically but rather the vertical component response to the topography.

Note: We have utilized the entire gdem grid and a density of 2.45 g/cm^3. However, we have utilized the depth to the base of the topography as 100m GPSZ. This was an attempt to match the ends of the lines but even for this depth the simulation is too large causing us to question the values of the gravmod channel. Attempting to match the gravmod simulation using the topography down to 0 – GPSZ provided to be irreconcilable.

GRAVITY CORRECTIONS – 3 Simulations of g_{zz} *and* g_z



g_{zz}
Red – AGG model
Blue - EMIGMA

We compare the AGG g_{zz} values to a simulation of the topography at instrument height . We use a modern definition of Z which is upwards to be consistent with the GPS axes definitions. Theoretically, a change in the definition of Z does not change the value of g_{zz}.

Note: Here, we have divided the AGG g_{zz} channel by 10,000 thus implying the units of this channel are in the unit of 10's of µgal. We have utilized the entire gdem grid and a density of 2.45 g/cm^3. However, we have utilized the depth to the base of the topography as 100m GPSZ. This matches the g_{zz} data.
This was the only model that we could find that matched both g_{zz} *and* g_z .

GRAVITY CORRECTIONS – 4 Ground Simulations and Corrections

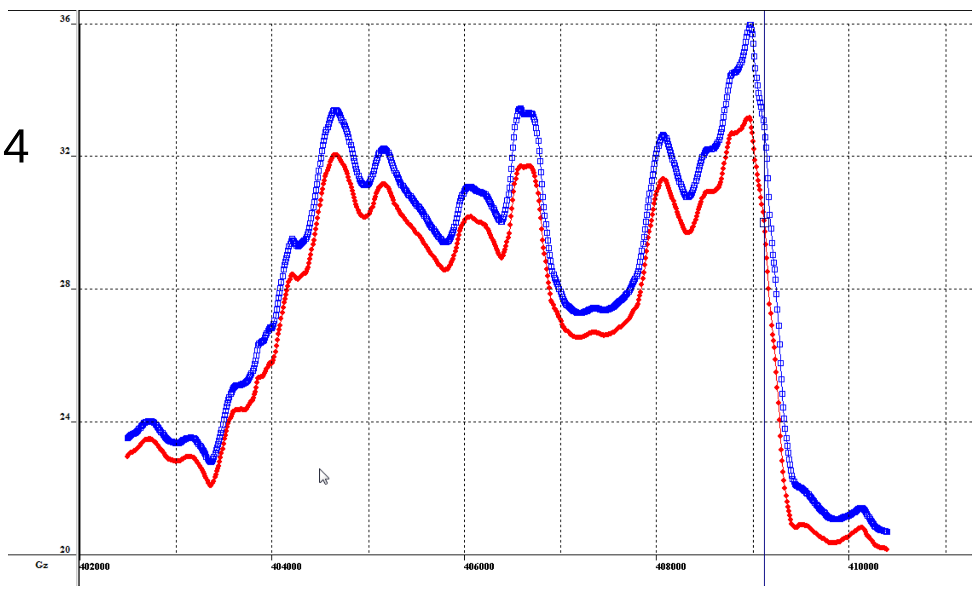
Terrain corrections were initially designed in QCTools :

1. *For stations at ground level only*
2. *To perform in a traditional manner where the principle topo correction is the Bouguer slab followed by an overcompensation correction for the topography*

The result is that the corrections will not be correct for airborne or marine data.

The following is an illustration of the use of QCTools for ground gravity corrections

Line 4



g_z
Red – Simulation
Blue - Slab

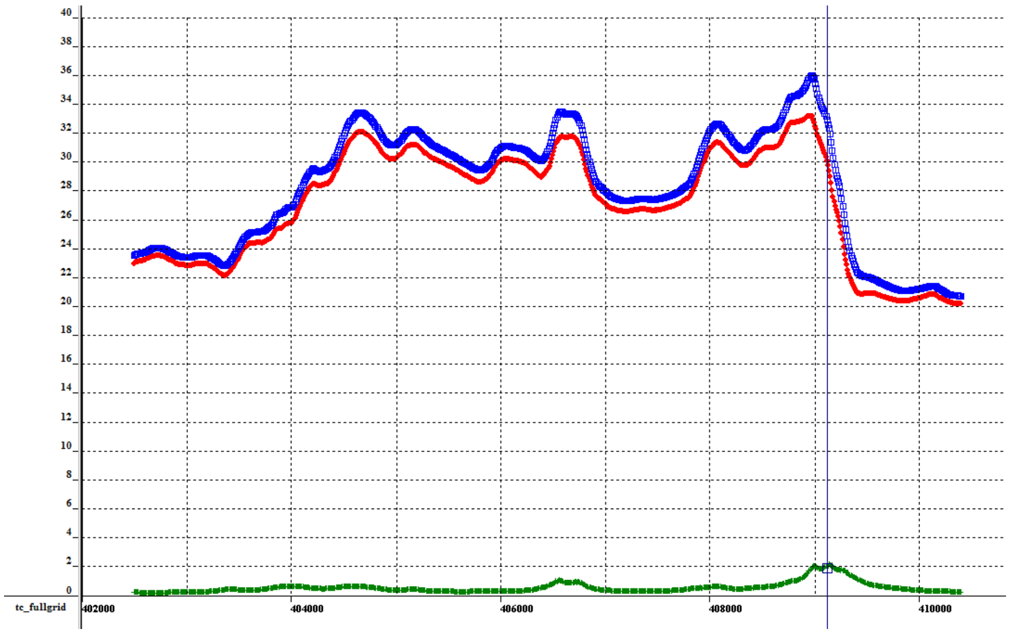
The red curve is the simulation of the .qdem grid where stations are on the topography. The 3D volume was from the surface down to GPSZ=0. The convergence of the simulation was tested up to 250,000 cells. The density is 2 g/cm^3. Blue is the Bouguer slab Note: the bouguer slab corrections over-compensates for the terrain as the elevation is constant and extends to infinity.

GRAVITY CORRECTIONS – 4 Ground Simulations and Corrections

Terrain corrections were initially designed in QCTools :

1. Bouguer

2. Terrain compensation – note: this is traditional compensation whereby the difference grid is determined for each location which is the difference : $z_{sl} - z_t$: the effect of the difference grid is calculated thus adding or subtracting locally the actual terrain.



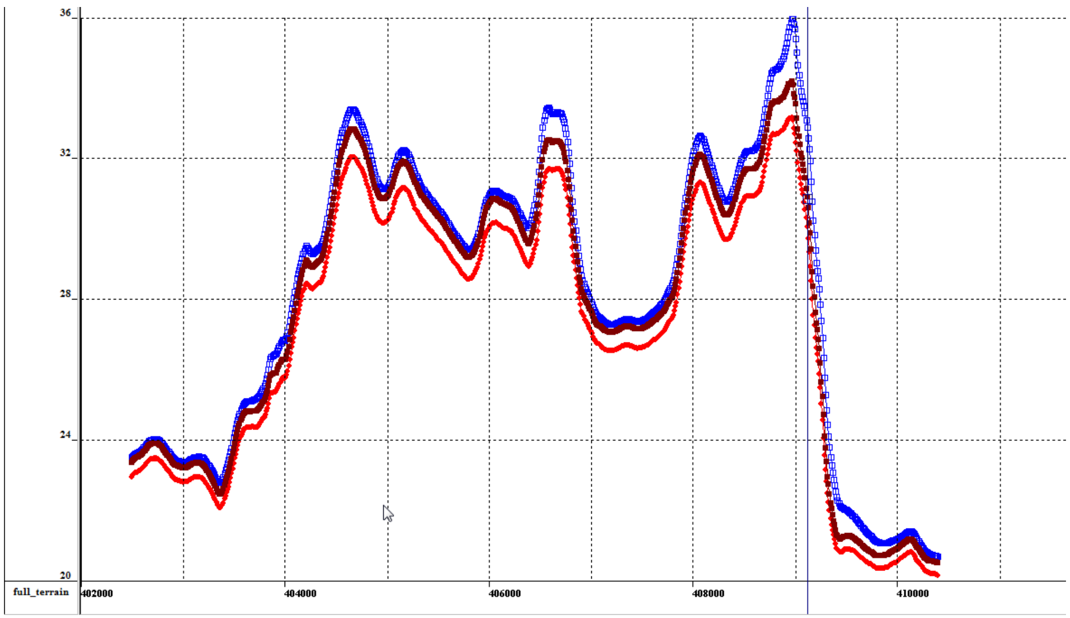
g_z
Red – Simulation
Blue – Slab
Green – terrain compensation

The red curve is the simulation of the .qdem grid when stations are on the topography. The density is 2 g/cm^3. Blue is the bouguer slab corrections for an elevation on the topography. Green is the terrain compensation of the difference grid or theoretically the over-compensation of the slab correction.

GRAVITY CORRECTIONS – 4 Ground Simulations and Corrections

Terrain corrections were initially designed in QCTools :

1. *Bouguer*
2. *Terrain compensation – note: this is traditional compensation whereby the difference grid is determined for each location which is the difference :* $z_{sl} - z_t$ *: the effect of the difference grid is calculated.*
3. *Total Terrain is thus Bouguer slab minus the terrain correction.*



g_z

Red – Simulation

Blue – Slab

Brown – total terrain

Brown is the calculated total terrain correction. The difference between red and brown is the effect of the Bouguer slab from outside the topo model to infinity. In this approach to terrain corrections, additional long grids are used to correct this virtually DC shift and extended outside radii are used to determine when the total terrain corrections converges. OR if the user only needs a relative value, the correction can be used for interpretation at this stage.

GRAVITY CORRECTIONS – 5 Another Approach

The classical approach has obvious benefits. As the majority of the terrain effect can be accounted for by the bouguer slab correction, we have only to compute a much smaller terrain compensation term which is due to a much more complicated computation and thus subject to larger percentage errors. Secondly, the terrain compensation can be computed in stages or radii. The very local terrain compensation can be the largest factor and thus we need only a very small grid to do this correction which is beneficial as this is normally collected by the gravity surveyor. The intermediate grid does not have to be extremely large as its density and size will cause the longest compensation. Finally, the very outer radii need only be on a very rough grid and thus reduce the compensation time.

The classical approach, however, is not designed for airborne or marine data. Thus, one possible solution is a direct computation of the total terrain effect. This is rather dangerous, however, as very few software developers have good mathematicians and mathematical programmers and performing this calculation properly is not trivial.

In your original file, the terrain correction was obviously a direct terrain computation or more classically the total bouguer. However, it does not appear that the calculation is good at the edges of the profile lines.

We have undertaken two (2) additional approaches. One being the direct calculation as mentioned above and the other a modification of the classical approach which will work for airborne and marine. These approaches should be released near the end of July, 2016.