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BAGC.m: Three Dimensional Gravity Modeling Software with an Application in Death Valley, CA

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This Work is Dedicated to the Light of My Life, My Dear Lucy

BAGC.M: THREE DIMENSIONAL GRAVITY MODELING SOFTWARE WITH AN APPLICATION IN SOUTHERN DEATH VALLEY, CA

by

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I would to offer thanks for assistance in this research. To my advisor Dr. Laura Serpa, I am grateful for your unending patience and guidance. The next time I put pen to paper, I will think of you. To my committee, Dr. Diane Doser, Dr. Eric Haggedorn, and Dr. Richard Langford, I am thankful for your support and technical guidance. To Galen Kaip, I thank you for the guidance that helped me complete my field work. I would like to thank my field assistants, Niti Mankhemthong, Pawan Budhathoki, and my wife Agueda Lucinda Ozambela who traipsed across the desert for no pay and little thanks. Lastly, I would like to thank my sounding board, Shane Carley who worked with me on more than a few projects.

Abstract

Basin Anomaly Gravity Calculator (BAGC.m) is a 3D interactive gravity modeling package designed to create, edit, and calculate the gravitational attraction of basin models entirely within the MATLAB™ environment. Gravity anomalies are calculated using the Rectangular Prism Method (Bott, 1960; Kane, 1962; and Plouff, 1966) which subdivides earth models into regularly spaced rectangular prisms. This approach requires large 3D matrices to store most realistic earth models. The process of model editing is simplified by storing basins as 2D gridded files which define the depth to the boundary between basement rock and sedimentary fill for each model cell. In order to minimize computation time, BAGC.m calculates and stores the gravitational attraction of each cell so that when the model is edited only those cells that change need to be recalculated.

The performance of BAGC.m was tested by comparing the gravity anomaly produced by a modeled sphere of radius 4.5 km at a depth of 4.5 km with its analytical solution. The tests indicate that BAGC.m reproduces the analytical solution with an error of 0.6% for a sample spacing of 60 m which corresponds to 7.07×10^{-6} % of the volume of the sphere. BAGC.m was used to calculate the gravitational attraction of a regional basin depth model of Death Valley developed by Blakely and Ponce (2001). Results were compared to a new high precision gravity data set and indicate that the structures within the Southern Death Valley Fault Zone (SDVFZ) are more complex than predicted by the regional basin depth model. However, the program did calculate the contributions of the basin fill to the regional gravity field based on that depth model.

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Introduction

The forward calculation of gravity anomalies in three-dimensions (3D) increases the accuracy of calculated anomalies and allows for more complex structures to be modeled than are possible with traditional two-dimensional modeling techniques. Several different 3D gravity modeling algorithms (e.g. Bott, 1960; Talwani and Ewing, 1960) have been developed but it was not until the advent of improved computer processing speed and memory that realistic earth models could be computed on a standard computer. Since that time, a variety of applications including terrain correction (Plouff, 1966; Plouff, 1976) and forward computation software (Talwani and Ewing, 1960; Cordell and Henderson, 1968) have been developed. These programs utilize different data storage and importation schemes which not only impact the type of geologic structures that can be modeled but also the method by which earth models are created, edited, and stored.

Since I am interested in determining the geometry of the basin surrounding Southern Death Valley, I used the Rectangular Prism Method to create a 3D gravity modeling package specifically designed for basins. Basin Anomaly Gravity Calculator (BAGC.m) is an interactive software package which allows users to create, edit, and calculate the gravitational attraction of basin models entirely within the MATLAB™ environment. BAGC.m inputs 2D depth to interface files and outputs the gravitational attraction of predefined gravity station locations (latitude/longitude) as .dat files. Output files can be imported into an excel spreadsheet to be gridded using software packages such as Golden Software's Surfer™.

The Rectangular Prism Method (Bott, 1960; Kane, 1962; and Plouff, 1966) defines geologic structures by subdividing them into a series of regularly spaced rectangular prisms (Figure 1.1). The vertical gravitational attraction (g) of an earth model is determined by calculating the contribution of each prism and summing the results together to produce a final anomaly. The disadvantage of this approach is that large 3D matrices are required to store earth models which makes it problematic to

track, edit, and assign density values to multiple prisms during model editing. In addition, large storage matrices also require large blocks of memory.

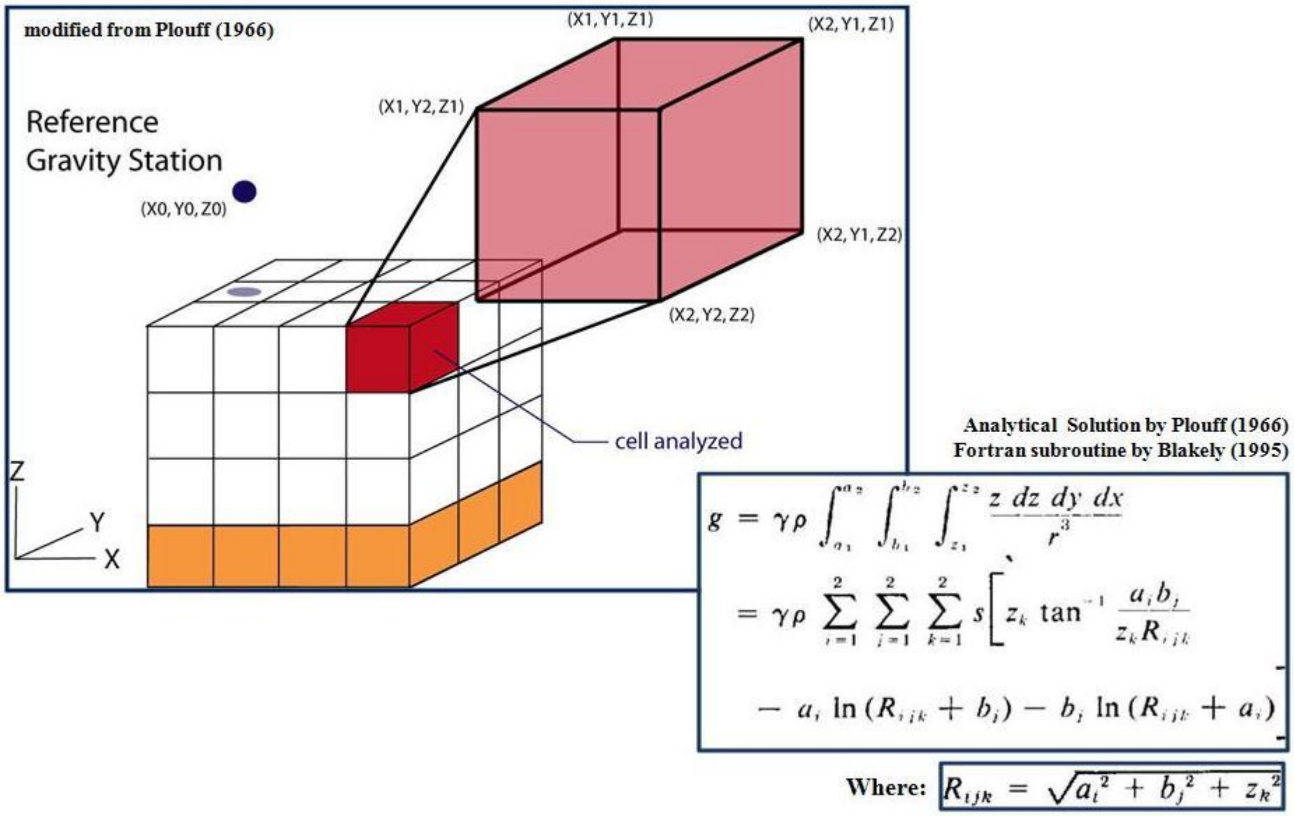


Figure 1.1: The Rectangular Prism Method. The gravitational attraction of a geologic earth model is determined by (1) assigning a density value to individual prisms, (2) calculating the gravitational attraction of each prism, and (3) summing the contributions of all prisms to produce a final anomaly. The analytical solution for gravitational attraction of a single prism was derived by Plouff (1966). The fortran77 subroutine was developed by Blakely (1995).

To simplify model editing and limit the memory required to store earth models, 3D basins are stored as 2D depth to interface files (Figure 1.2). It is a technique commonly used by earth scientists to define the elevation of topography using 2D Digital Elevation Models (DEM). Two dimensional depth to interface files are geo-referenced gridded matrices that define the depth between basement rock and sedimentary fill for each cell. Three dimensional earth models (x, y, z) are defined by importing the gridded file and assigning a density value to all prisms which lie above the interface.

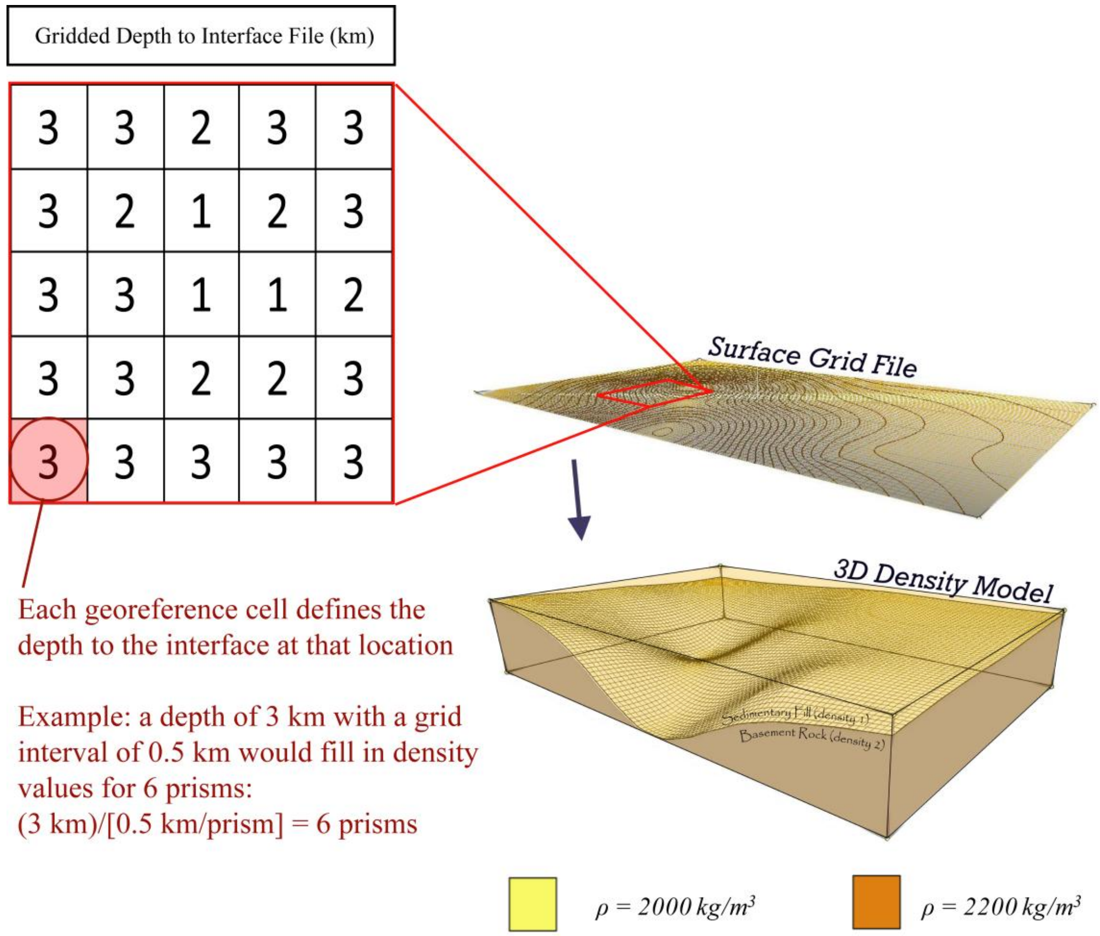


Figure 1.2: Simplification of model creation using 2D depth to interface files. 2D depth to interface files are imported by BAGC.m and converted to 3D earth models by assigning density values to all prisms which lie above the boundary.

I tested the performance of BAGC.m against the analytical solution of a sphere and the gravity modeling program Talwani version 2.2 (Olaya and Salayandia, 2004). In the first case, I verified the accuracy of BAGC.m by calculating the gravitational attraction of a sphere with varying size, density contrast, and sample spacing and compared the results to its analytical solution. The tests indicate that BAGC.m reproduces the analytical solution with an error of 0.6% for a sample spacing of 30 m, which corresponds to 7.07×10^{-6} % the volume of a buried sphere of radius 4.5 km at a depth of 4.5 km. I verified the ability of BAGC.m to accurately determine the gravitational attraction of a basin by comparing results with the 2.5 D software package Talwani version 2.2. BAGC.m was able to reproduce the Talwani 2.2 solution within 0.0691 mGal for 90% of the calculations.

Based on these results, BAGC.m was used to calculate the gravitational attraction of a regional Death Valley basin depth model developed by Blakely and Ponce (2001) to investigate structures along the Southern Death Valley Fault Zone (SDVFZ). Results were compared to a new high precision gravity data set and indicate that the structures within the SDVFZ are more complex than predicted by the regional basin depth model. However, the program performed well in showing the contributions of the basin fill to the regional gravity field.

Development of the Rectangular Prism Method

Initial 2D gravity modeling utilized polygonal prisms which were assumed to extend to infinity perpendicular to the model profile (Talwani et al, 1959; Talwani and Heirtzler, 1964). The method has the advantage of rapid calculation of common 2D structures such as fracture zones, anticlines, faults, and dikes but it could not accommodate structures extending less than 5 times the length of its maximum width (Gotze, 1988). In order to provide more realistic models with finite strikes, a 2.5D method was developed by Cady (1977) and Shuey and Pasquale (1973) which is still the primary computation method used for 2D gravity modeling software packages. Though this method was an improvement on 2D models, it still did not allow for computation of structures finite in all directions such as sinuous basins and salt diapirs.

Talwani and Ewing (1960) developed the first method to model geology in 3D using a series of stacked laminas intended to approximate contour lines. Though this method allowed for rapid calculation of geologic structures in 3D, it could not accurately represent and, thus, determine the gravitational attraction of variations within the lamina (Plouff, 1976). A second method was developed by Bott (1960) and Kane (1962) which subdivides geologic structures into regularly spaced cells so that their gravitational attraction can be calculated separately and summed together to produce a final anomaly. Several solutions have been developed for these cells including vertical cylinders (Bott, 1960), rectangular prisms (Plouff, 1966), polygonal faceted prisms (Barnett, 1976), and triangular faceted prisms (Brebbia 1978; Okabe, 1979). The solution developed by Plouff (1966) was implemented into terrain correction software by Plouff (1976). Gotze (1988) and Zhou (1990) developed a method which utilizes triangulated polyhedrons. This method has the advantage of improved speed of calculation but I did not have enough information on their method to implement it for my study. Therefore, I choose to work with the method developed by Bott (1960) and further refined by Plouff (1966).

The general integral for the vertical attraction (g) of a single rectangular prism is defined as (Blakely, 1995):

$$g = \gamma\rho \int_{z_1}^{z_2} \int_{y_1}^{y_2} \int_{x_1}^{x_2} \frac{z'}{[x'^2 + y'^2 + z'^2]^{\frac{3}{2}}} dx\, dy\, dz$$

where (‘) denotes a variable to be integrated, γ is the gravitational constant, ρ is the density, and x_1, x_2, y_1, y_2, z_1, and z_2 are distances from the observation point to the vertices of the prism. In order to provide a simplified and efficient solution for this general integral which can be adapted for use in computer software, Plouff (1966) moved the point of observation to the origin of the coordinate system. Plouff’s (1966) solution is as follows:

$$g = \gamma\rho \sum_{i=1}^{2}\sum_{j=1}^{2}\sum_{k=1}^{2} \mu_{ijk} \left[z_k \tan^{-1} \frac{x y_j}{z_k R_{ijk}} - x_i \ln(R_{ijk} + y_j) - b_j \ln(R_{ijk} + x_i) \right]$$

$$\textit{Where } R_{ijk} = \sqrt{x_i^2 + y_j^2 + z_k^2} \quad \textit{and} \quad \mu_{ijk} = (-1)^i(-1)^j(-1)^k$$

Where R_{ijk} defines the distance to the four prism edges and $\boldsymbol{\mu}_{ijk}$ controls the sign of the equation. Using Plouff’s (1966) solution, Blakely (1995) developed a Fortan 77 subroutine gbox (Appendix B) which acts as the core computational function for BAGC.m.

Three dimensional earth models are defined using the rectangular prism method by assigning density values to all prisms incorporated by the targeted structure. The disadvantage to this approach is that it requires a large number of computations and a great deal of time for most realistic models. To calculate the vertical gravitational attraction (g) of a single station, the contribution of each prism is determined individually and the results are summed together. For example, a 10 km x 10 km x 10 km (x, y, z) earth model subdivided into 0.05 km (x, y, z) rectangular prisms requires a 200 x 200 x 200 storage matrix and 8,000,000 computations to determine the gravitational attraction of a single gravity

station. This process must be repeated for every gravity station within the dataset to produce an estimate of the vertical gravity field for the entire survey area.

A common technique to reduce computations is to replace prisms along the vertical (z) axis with depth to density functions (Zhou, 2009). Depth to density functions describe changes in density using linear (Nagy, 1966), quadratic (Gallardo-Delgado et al., 2003), and cubic polynomials (García-Abdeslem, 2005). The disadvantage of this approach is that it cannot account for punctuated density variations due to volcanics, material changes, or arbitrary variations in sediment. To maintain flexibility, I chose to limit computations by cropping large model files into smaller subgrids. This allows subgrids that do not include portions of the targeted basin to be omitted from computation (Figure 2.1). In addition, the depth of each subgrid is determined individually so that shallow portions of the basin will require fewer vertical (z) prisms than do deeper ones.

An additional approach to improve efficiency is to reduce the time required to determine the contribution of a single prism. Snopk (2006) identified that gravity anomalies (Plouff, 1966) can be separated into two components: a nonlinear function of geometry linear function of density (Figure 2.2). The geometric component requires the most computation time because it sums location vectors over three spatial coordinates. I chose to limit computation time by pre-calculating and storing the geometric component of gravitational attraction for each prism prior to model editing. Earth models can then be edited and their gravitational attraction rapidly calculated by simple matrix multiplication.

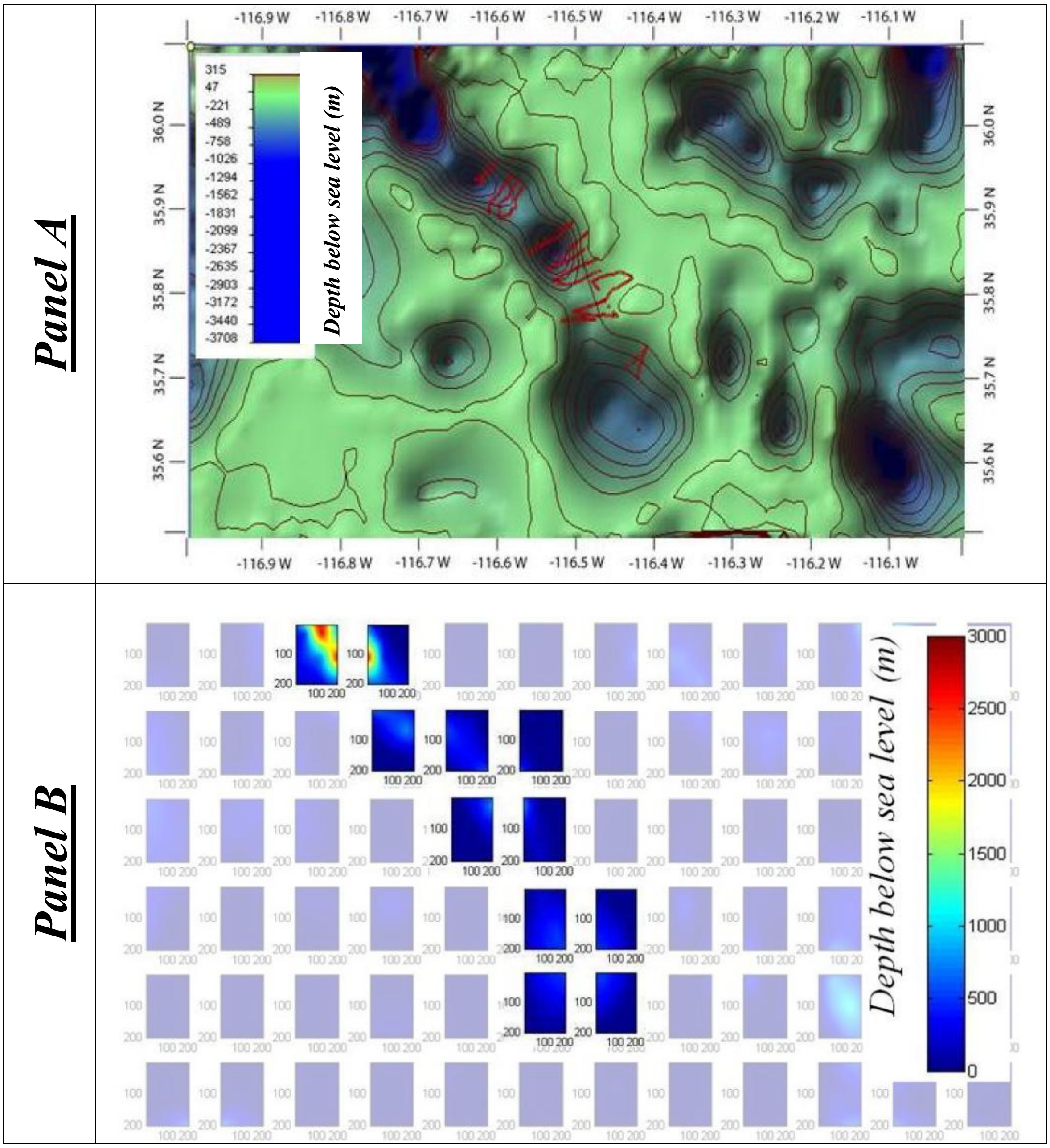


Figure 2.1: Minimizing computations by cutting large basin files into smaller subgrids. A large 2400 x 1200 basin model (Panel A) with a maximum depth of 6.5 km and a vertical sample spacing of 60 m requires 3.12 x 10^8 computations to determine the vertical attraction for a single gravity station. To limit the total computations, the basin model (Panel B) was cut into 72 175 x 125 separate subgrids and stored as 2D depth to interface files. Of the 72 subgrids, only the eleven which incorporate the targeted structure were used to determine the gravity anomaly. Of the 11 subgrids, 2 grids had a maximum depth of 6.5 km and 9 had a maximum depth of 0.5 km. The cut grids required 1.23 x 10^7 computations to calculate the vertical attraction for a single gravity station. Total computations were reduced by 3.00 x 10^8 (96%).

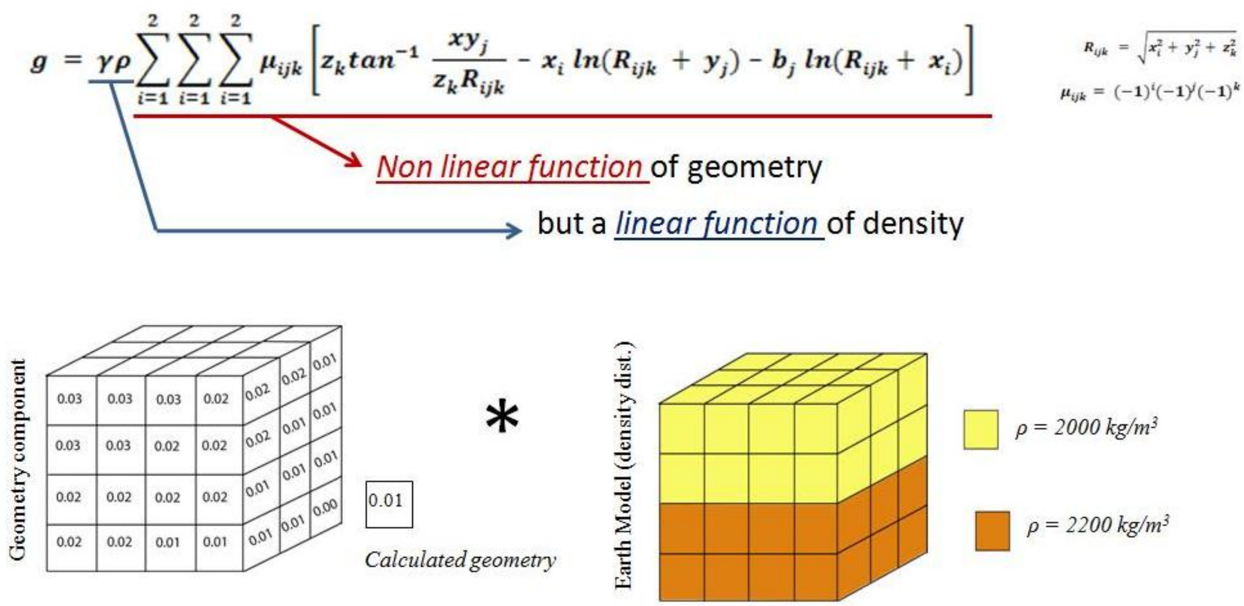


Figure 2.2: Minimizing computation time by pre-calculating geometric component. The computation of gravity anomalies are a nonlinear function of geometry (red) and linear function of density (blue). The time consuming geometric component of gravity modeling is precalculated and stored as a .bsq file. Gravity anomalies can then be calculated using simple matrix multiplication. The advantage of this approach is that density models can readily be edited and multiplied by the stored geometric files.

Software

BAGC.m (Appendices A and B) is a computer program based on the Rectangular Prism Method employed by Plouff (1976) to compute terrain corrections and the Fortran 77 script developed by Blakely (1995). BAGC.m is a command line software package comprised of eighteen functions and subroutines that import, crop, and edit gridded (x, y, z) surface files, define density to depth relationships, and calculate gravitational attraction. It can be used to calculate terrain corrections and isostatic corrections. The software was written to be used on any type of computer with MATLAB™ and is not proprietary. BAGC.m inputs 2D depth to interface files and outputs the gravitational attraction of predefined gravity station locations (latitude/longitude) for every grid as .dat files (Figure 3.1). Output files can be imported into an excel spreadsheet to be gridded using software packages such as Golden software's Surfer™.

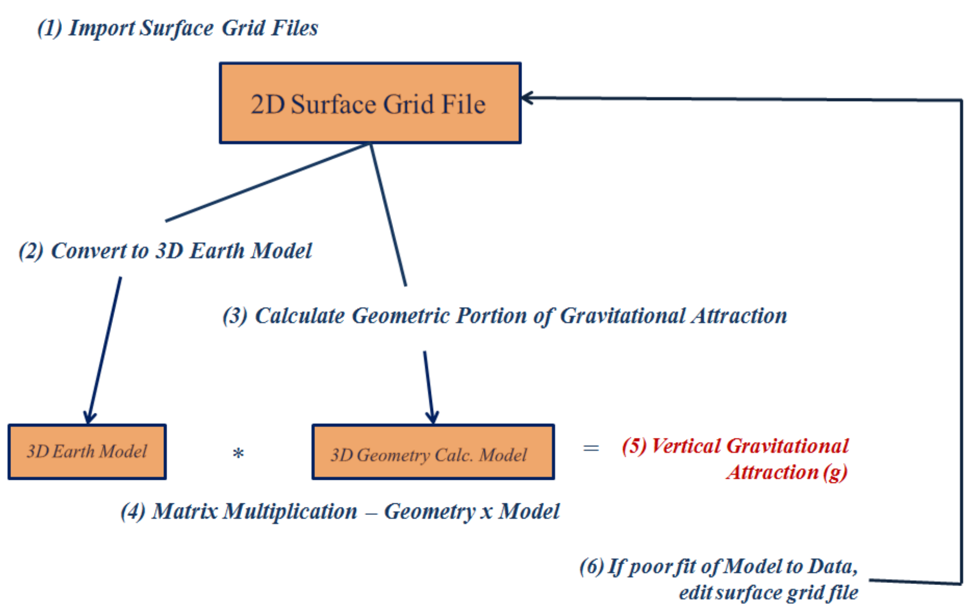


Figure 3.1: BAGC.m work flow. Two dimensional surface grid files are imported and converted to 3D earth models. The geometric component is pre-calculated and stored as a .bsq fie. The gravitational attraction of the 3D earth model is determined and compared to an existing data set. Models with large misfits are reopened as 2D surface files, edited, and recalculated.

There are three sources of error inherent in BAGC.m: (1) aliasing of curved geologic surfaces due to under sampling (sample spacing error), (2) truncation of anomalies due to the limited significant digits carried by MATLAB^{TM} (round off error), and (3) gravity stations cannot be placed directly on a prism edge due to a division by zero (NaN) error. In order to incorporate these stations, their elevations must be adjusted by a very small number, e.g. 1e-6 km. To quantify these errors, I tested the performance of BAGC.m against the analytical solution of a sphere (Griffiths and King, 1981) and the gravity modeling program Talwani version 2.2 (Olaya and Salayandia, 2004).

In the first case, I verified the accuracy of BAGC.m by calculating the gravitational attraction of a sphere with varying size, density contrast, and sample spacing and compared the results to its analytical solution. A sphere was chosen because it is finite in all directions (x, y, z) and its gravitational attraction can be calculated in three dimensions by reduction to a point mass. In the second test, I verified the ability of BAGC.m to accurately determine the gravitational attraction of a basin by comparing results with the 2.5 D software package Talwani version 2.2. In general, the misfit between the solution provided by BAGC.m and the analytical solution varies spatially with a maximum near the structures edge and a minimum directly over center (Figure 3.2).

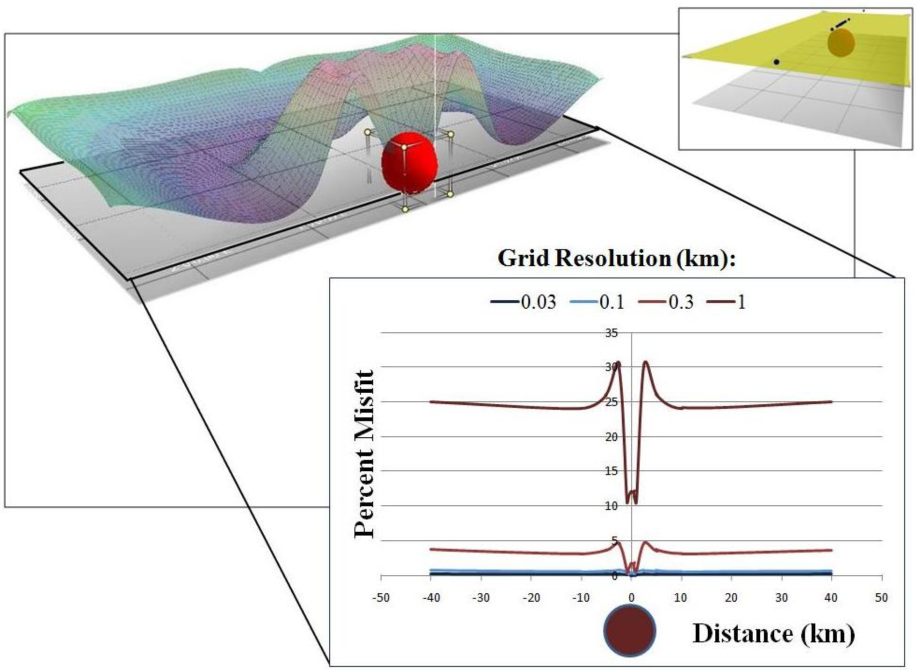


Figure 3.2: Difference between BAGC.m modeled sphere and its analytical solution. (Radius = 4.5 km, Depth of Center = 4.5 km, and Density Contrast = 2670 kg/m^3) The gravitational attraction of the sphere was calculated at 0, 0.03, 0.1, 0.3, 0.5, and 1 km.

PRISM SIZE AND SAMPLE SPACING ERROR

Sample spacing is the primary control on model error for BAGC.m. Sample spacing error is caused by regions of deficient mass at the boundary of an under sampled object. It is analogous to the blurring of low resolution digital images due to an inadequate number of samples or "mega pixels" (Figure 3.3 – Panel A). In order to provide a better quality image, photographers increase the number of samples per area. Similarly, the gravitational attraction of a geologic structure is better approximated by decreasing the size of prisms (Figure 3.3 – Panel B). The disadvantage of this approach is that it also increases the total number computations required for a solution. In the case of the modeled sphere embedded in a cubic earth model (x, y, z) the total number of computations is given by (Figure 3.4):

$$\left[\frac{2 \times radius}{grid\ spacing}\right]^3$$

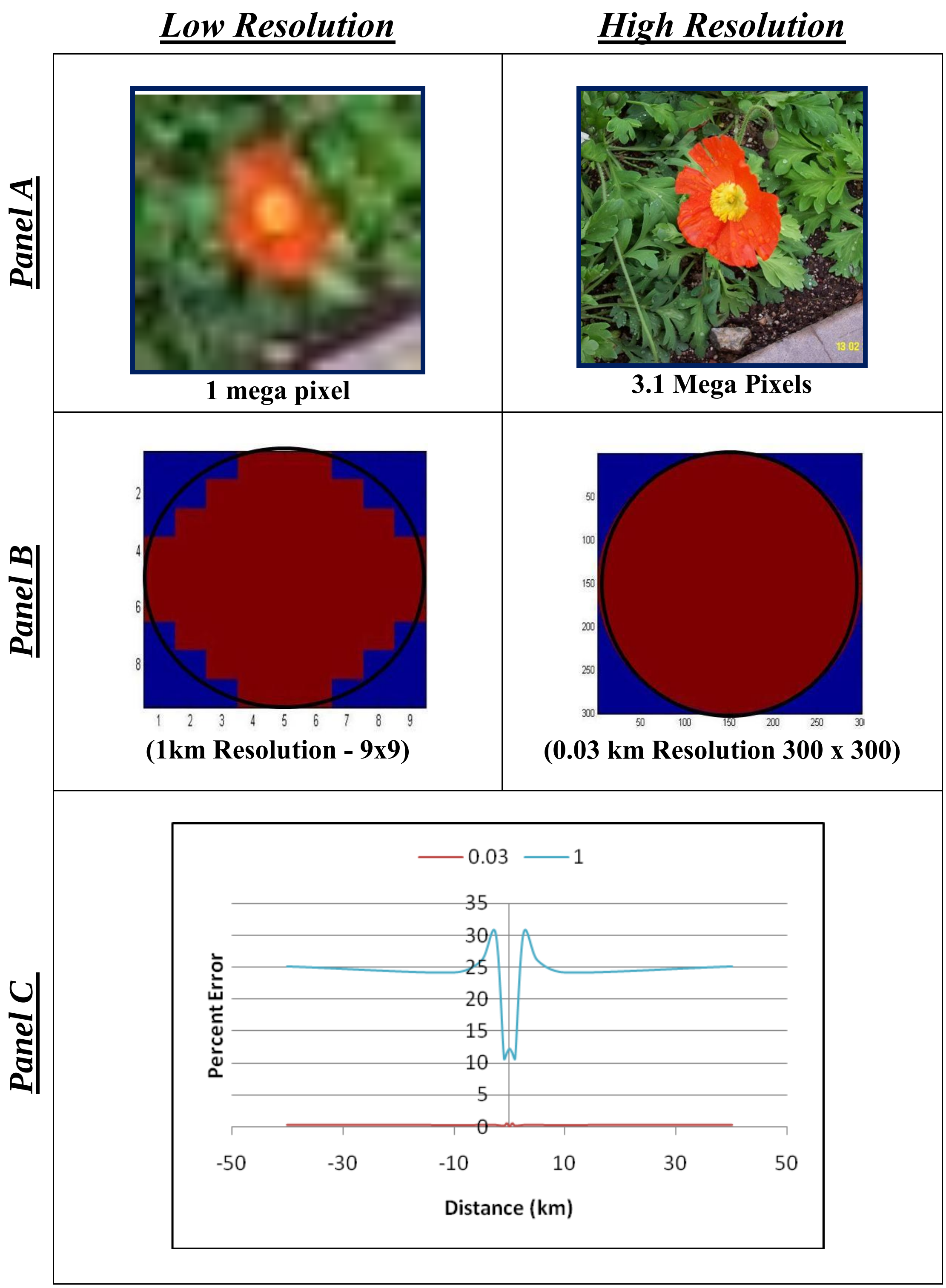


Figure 3.3: Reducing sample spacing to improve misfit between a BAGC.m modeled sphere and its analytical solution. Panel A shows a comparison of low resolution to high resolution digital photographs. Panel B shows a comparison of low resolution to high resolution cross sections of sphere. Panel C depicts the percent error vs. distance from center of sphere for 1 km resolution and 0.03 km resolution spheres.

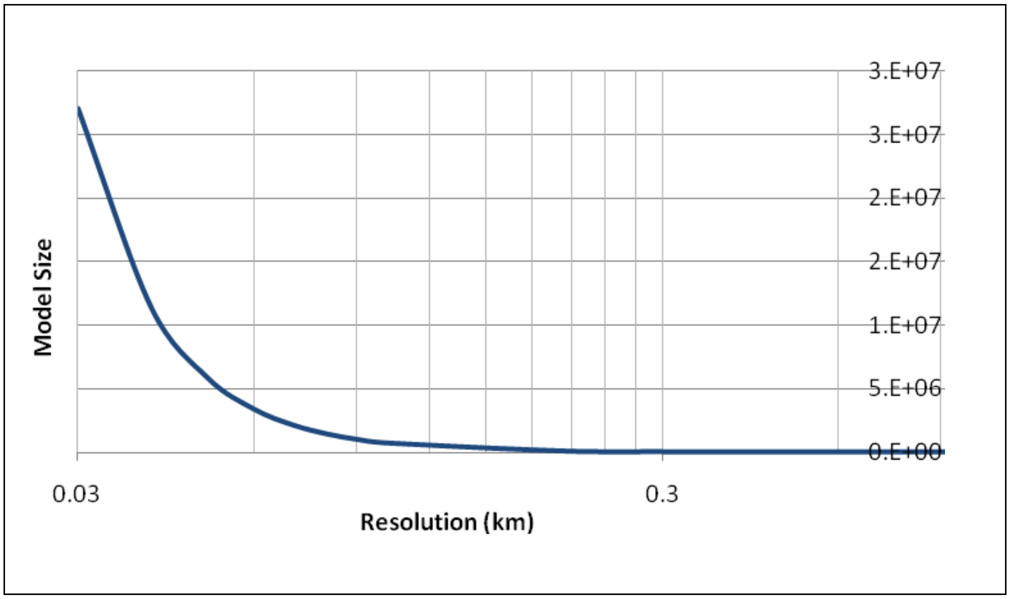


Figure 3.4: Number of computations required to determine the gravitational attraction of a sphere (radius = 4.5 km) embedded in a cubic earth model (Appendix D.1).

To determine the minimum number of computations required to accurately define an earth model, I calculated the gravitational attraction of a sphere with varying prism size and compared the results to its analytical solution. The modeled sphere was 9 km wide, 4.5 km deep, and had a density contrast of 2670 kg/m^3. Prism sizes ranged from 1 km (x, y, z) to 0.03 km (x, y, z). The total computations ranged from 729 (1 km) to 27,000,000 (0.03 km). Results indicate that BAGC.m was able to reproduce the gravitational attraction of the analytical solution within 0.6% for sample spacings less than 0.05 km (Figure 3.5 and Appendix D.2). For the modeled sphere, computational expense increases dramatically for prism sizes less than 0.03 km (Figure 3.4). This suggests an optimal prism size range between 0.03 km and 0.05 km. To incorporate this study into basin models, I converted prism size to percent volume of the total structure using:

$$\frac{volume\ of\ prism\ (km)}{volume\ of\ sphere\ (km)}\ x\ 100$$

The optimal volume percent ranged from 3.27x10^{-5} % to 7.07x10^{-6} %.

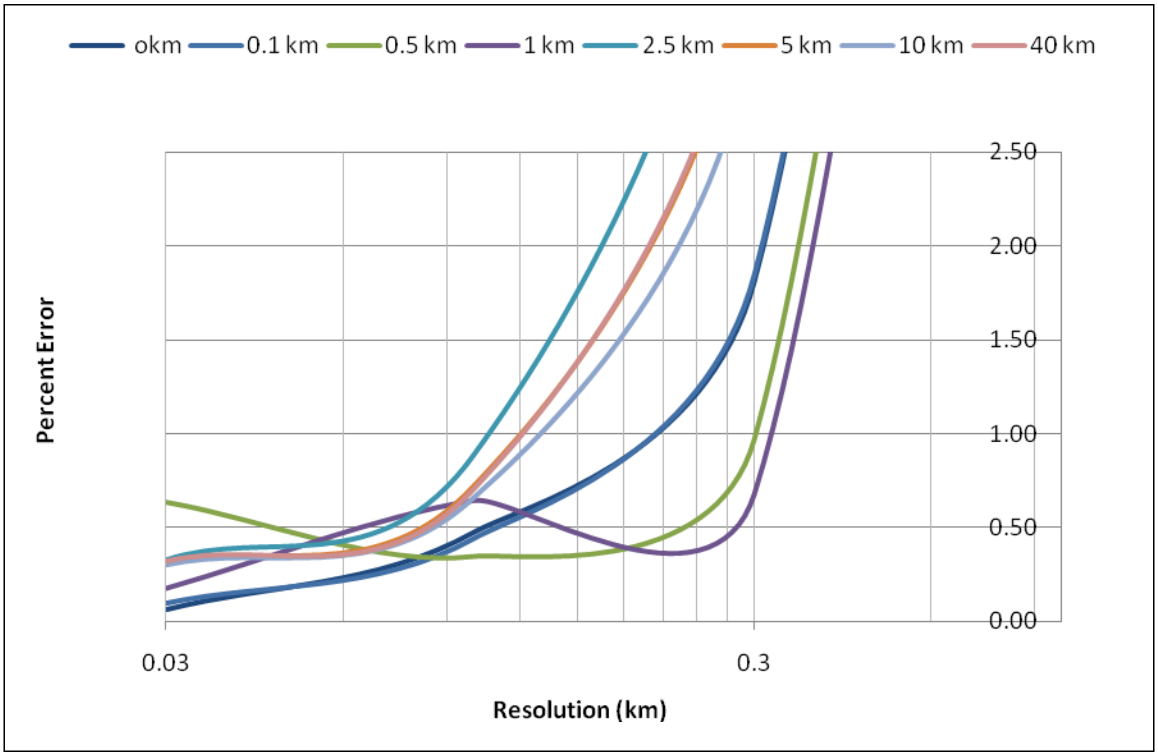


Figure 3.5: Percent difference between BAGC.m calculated sphere and its analytical solution for varying prism sizes. Percent difference was calculated for distances of 0, 0.1, 0.5, 1, 2.5, 5, 10, and 40 km from center of sphere. The density contrast was 2670 kg/m^3. Sphere size was 4.5 km and was buried 4.5 km to its center. Calculated values are included in Appendix D.2.

SIGNIFICANT DIGITS AND ROUND OFF ERROR

Though decreasing sample spacing improves the misfit between the modeled sphere and its analytical solution, it also reduces the gravitational attraction of an individual prism which introduces round off error. Round off error occurs when the gravitational contribution of a single prism is truncated by the total number of significant digits carried by MATLAB™ (64 total bits or 11 exponent bits). As the gravitational attraction of a prism approaches $1x10^{-9}$, the proportion of truncated digits to the total anomaly and percentage of misfit is increased. Because the gravitational attraction of an individual prism is a function of prism size, density, and distance from the observation point, a small prism at a large distance from the observation point will have the greatest proportion of misfit. To determine if BAGC.m can accurately model real world structures, I calculated the gravitational attraction of a modeled sphere with varying size, density contrast, and distance from the point of observation and compared the results to the analytical solution (Table 3.1).

Table 3.1: Sphere Parameters used to test round off error.

Tested Metric	***Radius (km)***	***Density Contrast (kg/m^3)***	***Vertical Distance (km)***
Structure size	0.002 to 4.5	2670	0.00001
Vertical Distance	4.5	2670	0.00001 to 40
Density Contrast	4.5	2670e-11 to 2670	0.00001

The test for minimum resolvable structure size was conducted using a sphere buried at the surface with a density contrast of 2670 kg/m^3 and an observation point 0.00001 km above the surface. Though the density contrast used was larger than can be expected in nature, this test can be used with a density appropriate to the targeted basin in order to determine minimum resolvable structure prior to modeling. The misfit between the BAGC.m modeled sphere and the analytical solution increased to 191% at a distance of 0.002 km as the contribution of each prism approached zero (Figure 3.6).

The test for minimum resolvable density contrast was conducted using a sphere with a 4.5 km radius buried at a depth of 4.5 km and an observation point at 0.00001 km above the surface. The sample spacing was set to 0.1 km. Density values for the modeled sphere ranged from 2.670 x 10^{-11} kg/m^3 to 2670 kg/m^3. Though the total misfit between the BAGC.m calculated sphere and the analytical solution changed, the percent misfit did not (Figure 3.7).

The test for minimum resolvable vertical distance was conducted using a sphere with a 4.5 km radius buried at a depth of 4.5. The distance above the center of the sphere was varied from 0 km to 10,000,000 km. The density contrast was set at 2670 kg/m^3. The misfit between the BAGC.m calculated sphere and the analytical solution increased exponentially for distances greater than 30,000 km (Figure 3.8). Results of this analysis indicate that BAGC.m can accurately determine the gravitational attraction of structures expected in nature.

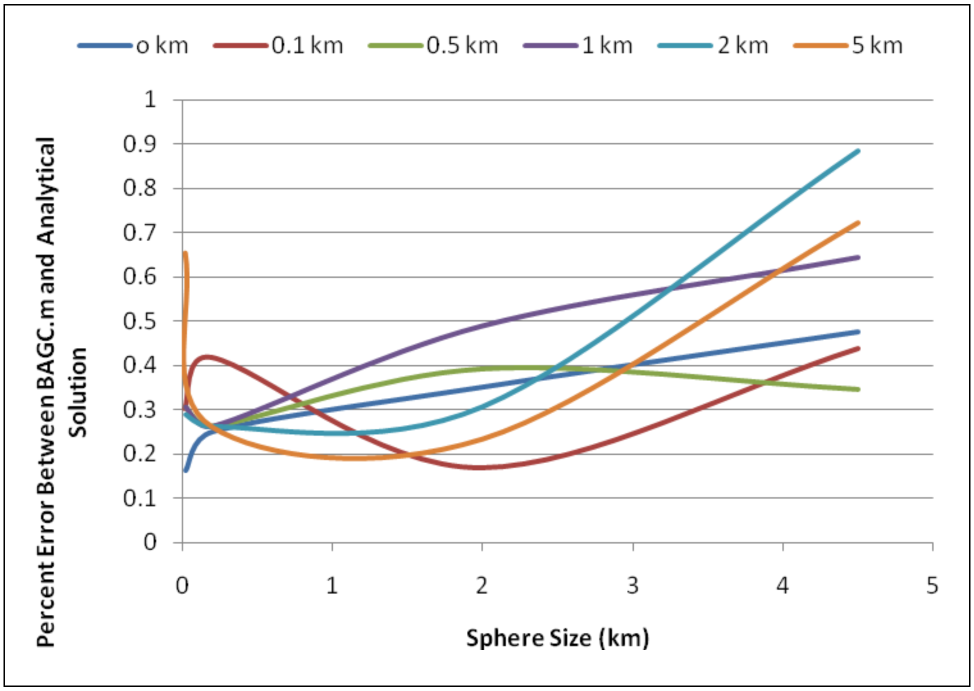


Figure 3.6: Minimum resolvable structure size. Percent difference was calculated for distances of 0, 0.1, 0.5, 1, 2.5, 5, 10, and 40 km from center of sphere. The density contrast was 2670 kg/m^3. The density contrast was 2670 kg/m^3. Sphere size was 4.5 km and was buried 4.5 km to its center. (Appendix D.3)

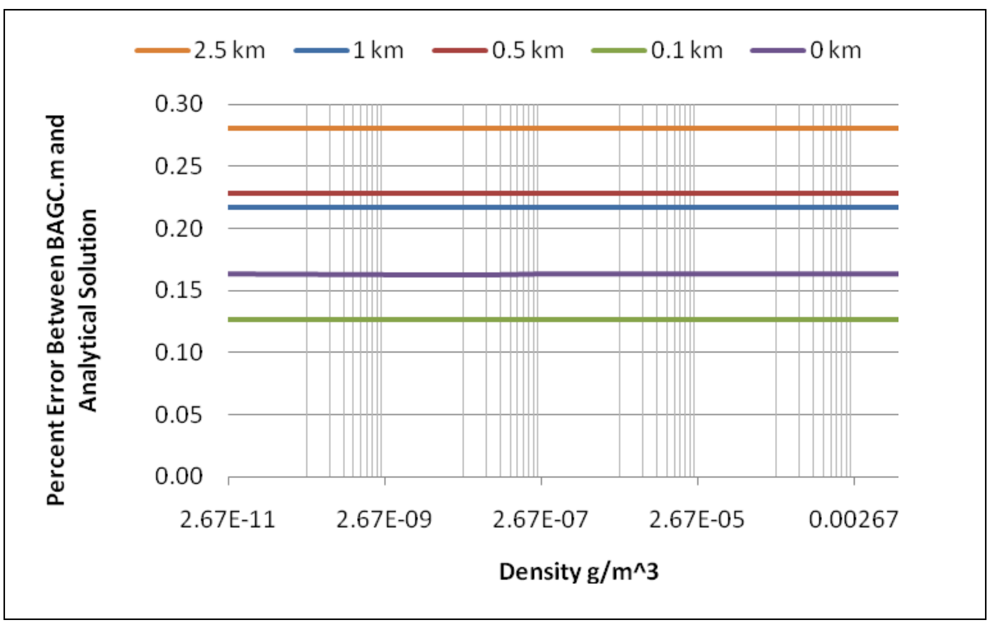


Figure 3.7: Minimum resolvable density contrast. Percent difference was calculated for distances of 0, 0.1, 0.5, 1, 2.5, 5, 10, and 40 km from center of sphere. The density contrast was 2670 kg/m^3. Sphere size was 4.5 km and was buried 4.5 km to its center. (Appendix D.4)

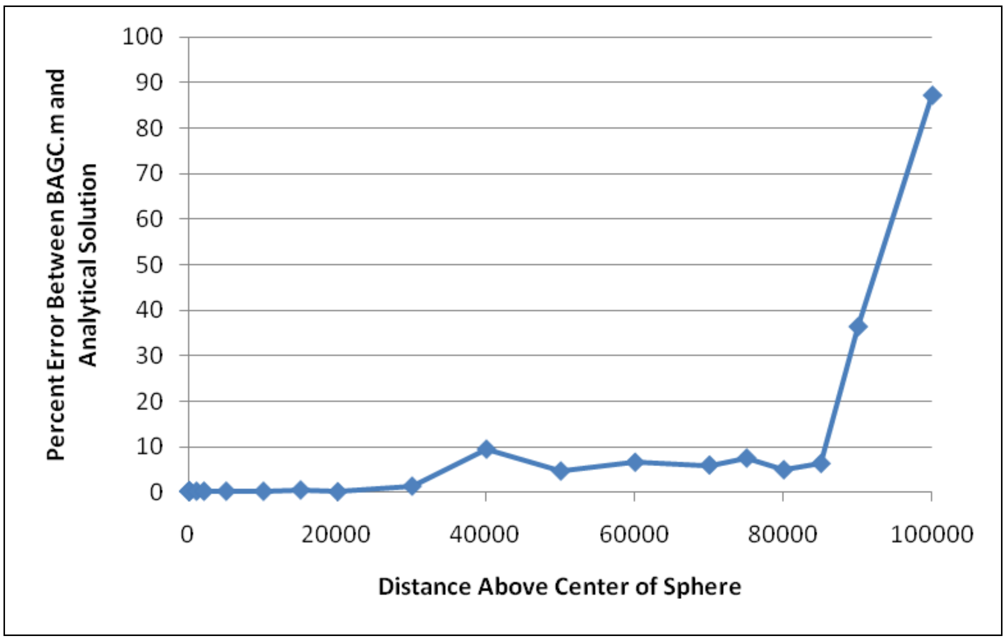


Figure 3.8: Minimum Resolvable Vertical Distance above Sphere. Percent difference was calculated for distances of 0, 0.1, 0.5, 1, 2.5, 5, 10, and 40 km from center of sphere. The density contrast was 2670 kg/m^3. Sphere size was 4.5 km and was buried 4.5 km to its center. (Appendix D.5)

Comparison with 2.5 D methods using Talwani version 2.2

Following the verification of computational accuracy, I tested the ability of BAGC.m to determine the gravitational attraction of a basin model by comparison with Talwani version 2.2 (Olaya and Salayandia, 2004). Talwani version 2.2 is a 2.5D gravity modeling program that uses polygonal prisms (Talwani et al., 1959; Shuey and Pasquale, 1973; Cady, 1977) to determine the gravitational attraction of perturbing bodies. The primary limitation to the 2.5D method is that it assumes geologic models extend a finite distance along strike. To directly compare BAGC.m to Talwani 2.2, I generated a 3D basin model that mimics the computational geometry of 2.5D methods by extending a cross section 40 km. The cross section was extracted from a regional basin model developed by Blakely and Ponce (2001) and interpolated using Surfer™ to a sample spacing of 0.003691 km (x). The interpolated cross section was then imported into MATLAB™ to generate the 3D basin and calculate its gravitational attraction.

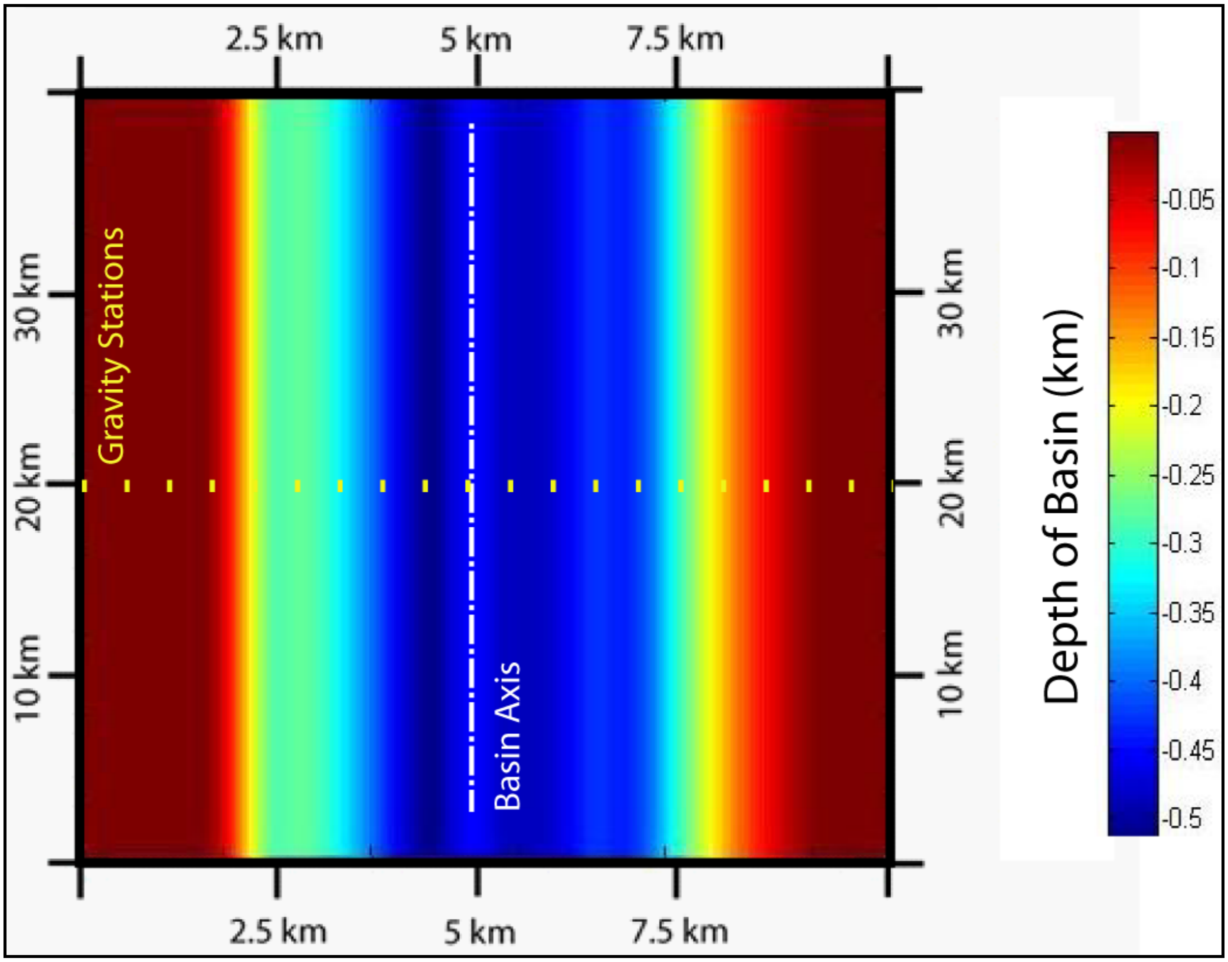
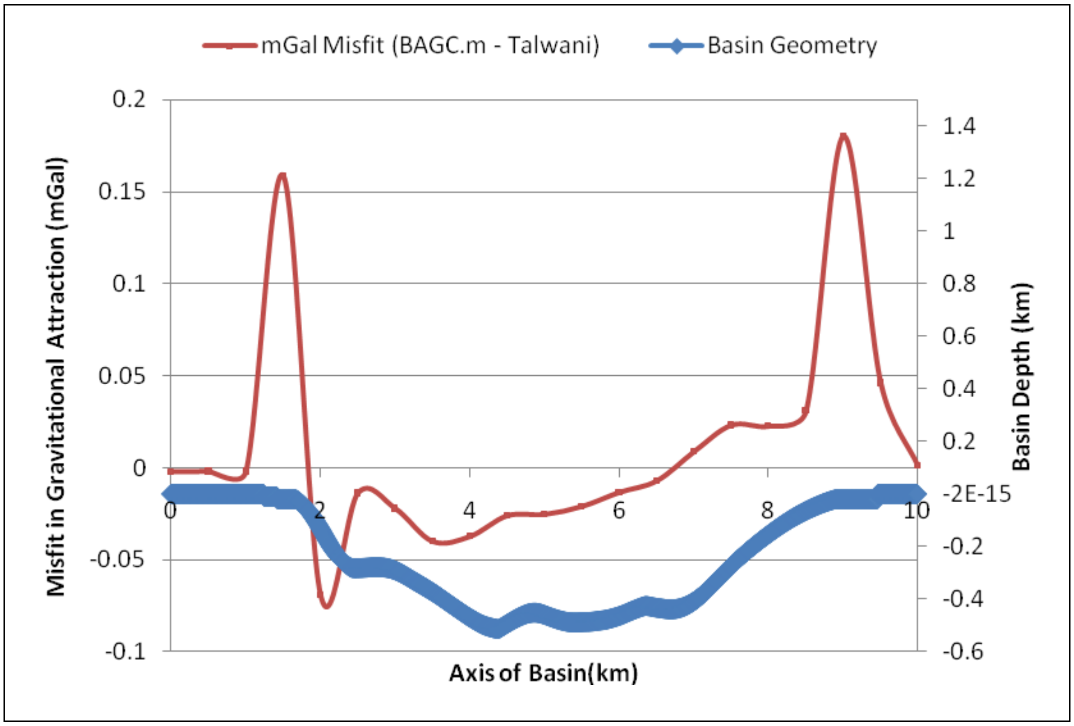


Figure 3.9: Map of generated 3D basin model. Basin was generated by extending a 2D cross section 40 km along the valley axis. The generated basin had a sample spacing of 0.0036 (x, y, z). Gravity stations were located every 0.5 km perpendicular to the basin axis (yellow). Model geometry is included in Appendix D.6.

The gravitational attraction of the basin was determined every 0.5 km perpendicular to its axis for a total of 21 stations. The basin fill was assigned a positive density contrast of 2670 kg/m^3. The generated 3D basin model had a sample spacing (x, y, z) of 0.003691 km. The total volume of the basin was estimated using Surfer™ (94.1 km^3) and compared to the model sample spacing (x, y, z) in order to determine the percent volume of a single prism (1.18x10^{-2}%).

The difference in calculated gravitational attraction between BAGC.m and Talwani 2.2 ranged from 0.0011 mGal to 0.1804 mGal with a mean of 0.0358 mGal and a standard deviation of 0.0477 mGal (Figure 3.10). However, the degree of misfit was dependent on station location. All stations (3/21) with a misfit in excess of 0.0463 mGal were located within 0.25 km of the basin edge. The misfit for stations (13/21) located directly over the basin ranged from 0.0070 (0.015%) mGal to 0.0399 (0.098%) mGal while those outside the basin (5/21) ranged from 0.0011 (11.4%) mGal to 0.0020 (17.0%) mGal. This range is less than that estimated by the modeled sphere (0.6%) because the generated basin geometry was not fully 3D. In addition, gravity stations located directly over the basin were further from edge effects due to the width of the basin. This suggests that the magnitude of expected error depends on the proximity of a gravity station to the model boundary. Complex 3D basins will have more error than do ones that extend along strike for some distance. Using the combined results of the analytical solution and the 2.5D modeled basin, the expected error associated with BAGC.m has both a high range for fully 3D models (0.6%) and a low range (0.015% to 0.098%) for models that extend along strike.

Panel A –Misfit (mGal)



Panel B – Percent Misfit

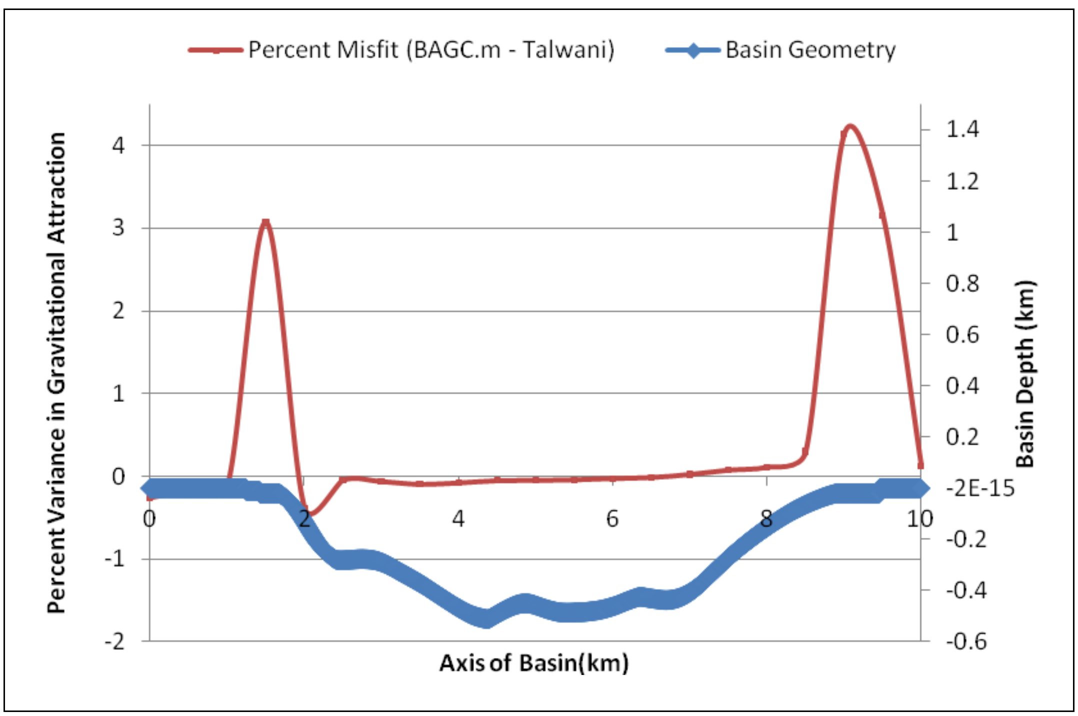


Figure 3.10: Difference in the gravitational attraction of a 3D generated model determined using BAGC.m and Talwani version 2.2 (Olaya and Salayandia, 2004). Misfit is expressed in terms of mGal (red) in Panel A and as a percent difference (red) in Panel B. Valley dimensions are depicted in blue for both panels. Results included in Appendix D.7

In addition to testing accuracy, I used Talwani 2.2 to evaluate the 3D capability of BAGC.m. Because 2.5D methods assume earth models extend a finite distance along strike, 3D deviations from modeled cross sections introduce error into gravity computations. To quantify this error, I calculated the gravitational attraction of three profiles using BAGC.m and compared the results to Talwani 2.2. The three profiles were extracted from a regional depth model developed by Blakely and Ponce (2001) (Figure 3.11 – Appendix D.5). Two of the cross sections had significant 3D geometric deviations. Line A was located in the deepest portion of the basin. Line B was located in a saddle between two sub-basins. The third cross section, Line C, was located in a portion of the basin that was more or less consistent.

The gravitational attraction of the basin was determined at 19 locations. The basin fill was assigned a positive density contrast of 2670 kg/m^3. The extracted basin model had a sample spacing of 0.0408 km x 0.0560 km x 0.0050 (x, y, z). The total volume was estimated using Surfer™ (92.7 km^3) and compared to the model sample spacing (x, y, z) in order to determine the percent volume of a single prism (1.23x10^{-4}%). The maximum misfit between BAGC.m and Talwani 2.2 was 13.23 mGal (19.5%) for Line A, -0.89 mGal (29.7%) for Line B, and 0.73 mGal (1.7%) for Line C (Figure 3.12 and Figure 3.13 – Appendix D.8). Though, misfit was similar for Line B and Line C, the percentage of difference was much greater for Line B. Results suggest that the degree of misfit depends upon the depth of the cross section relative to the surrounding basin. Cross sections that bisect portions of the basin deeper than the surrounding area are overestimated by 2.5D methods while shallow cross sections are underestimated. Two and a half dimensional methods perform best when the selected cross section is perpendicular to a basin that extends along strike.

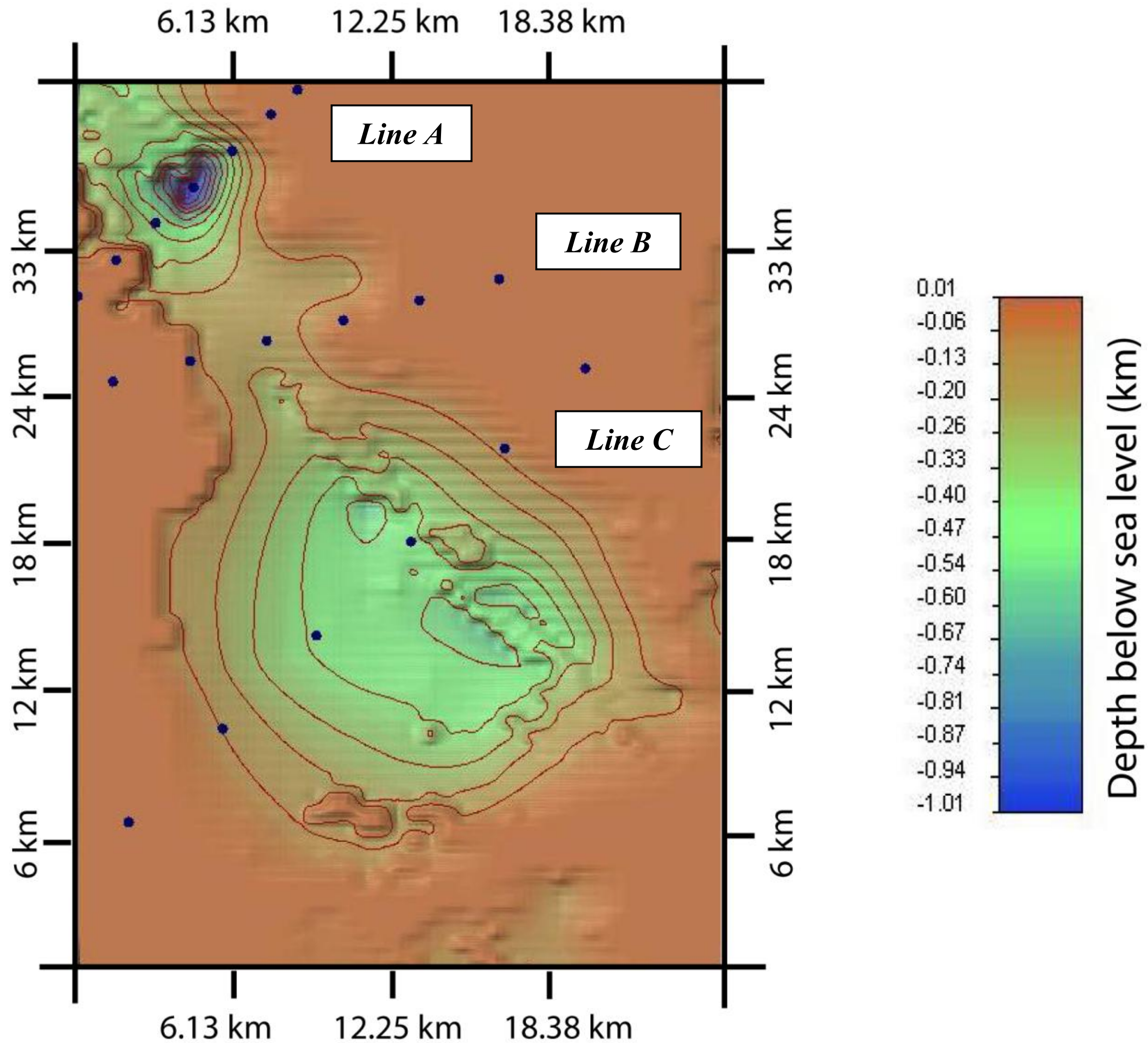
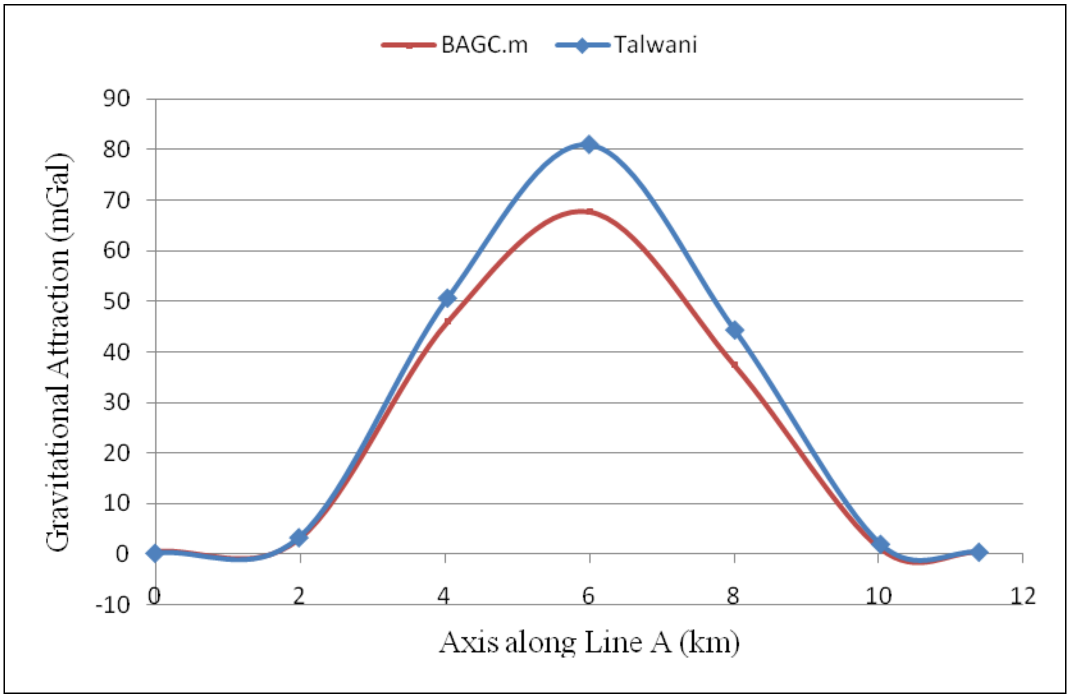


Figure 3.11: Map view of basin used to test the 3D capability of BAGC.m. Contour interval is 0.1 mGal. The basin was extracted from a regional basin depth model developed by Blakely and Ponce (2001). The extracted basin had a sample spacing of 0.0408 km x 0.0560 km x 0.0050 (x, y, z). The gravitational attraction of the basin was calculated at 19 locations along three separate cross sections. Gravity stations are depicted in blue. Cross section locations are labeled Line A through C.

Line A – Gravitational Attraction (mGal)



Line B – Gravitational Attraction (mGal)

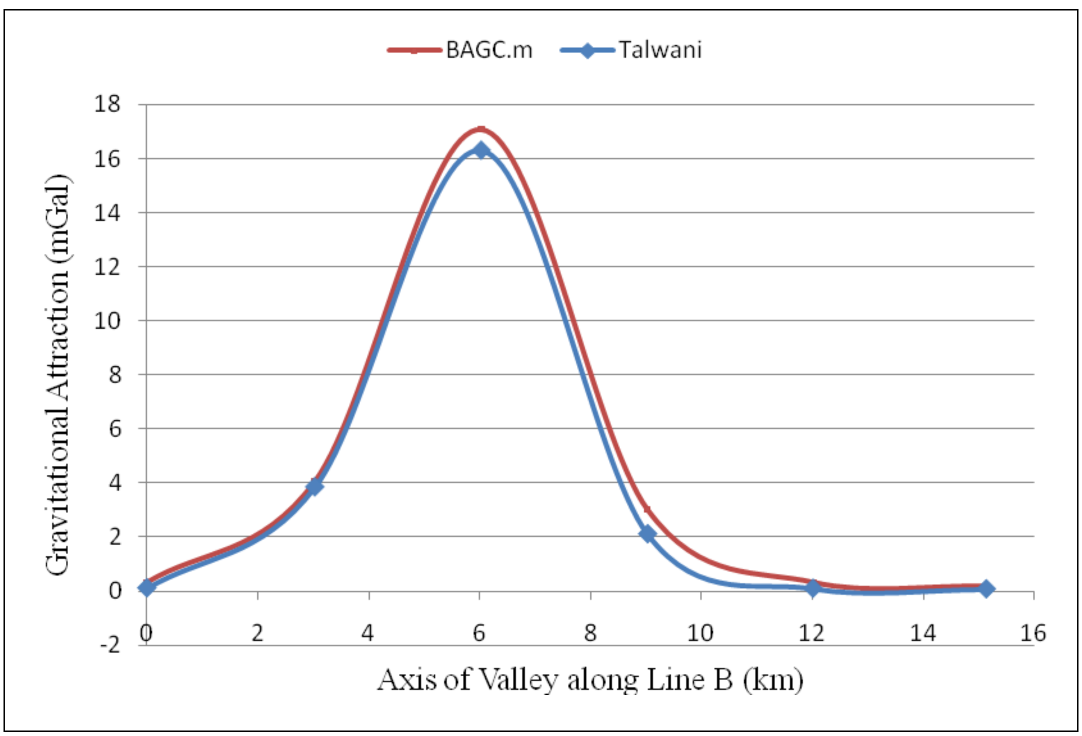


Figure 3.12: Gravitational attraction of the extracted basin determined along Line A and Line B using BAGC.m (red) and Talwani 2.2 (blue). Line A was located in the deepest portion of the basin resulting in an overestimation of mass. Line B was located in a saddle between two basins resulting in a underestimate of mass. Results included in Appendix D.8.

Line C – Gravitational Attraction (mGal)

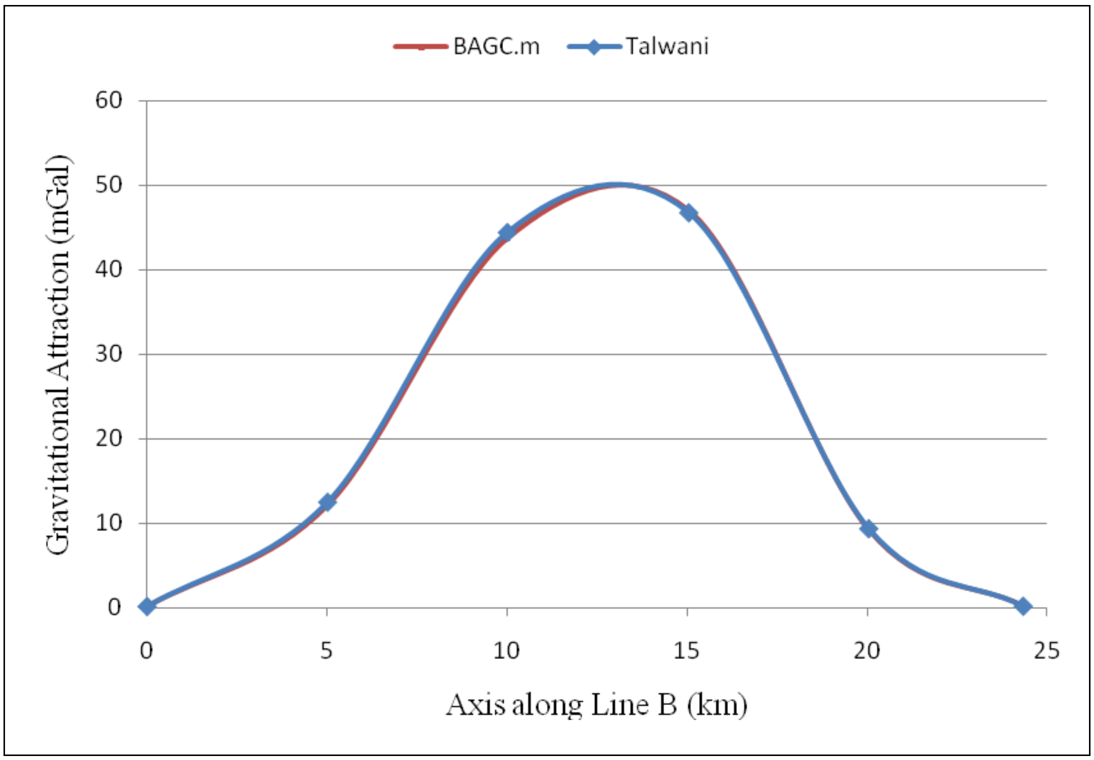


Figure 3.13: Gravitational attraction of the extracted basin determined along Line C using BAGC.m (red) and Talwani 2.2 (blue). Line C was located within a consistent basin resulting in a matching estimate of mass. Results included in Appendix D.8.

Application of BAGC.m in Southern Death Valley, CA

Death Valley is a northwest-trending pull-apart basin (Burchfiel and Stewart, 1966) in southeastern California (Figure 4.1) defined by two right-lateral strike-slip faults zones; the Northern Death Valley Fault Zone and the Southern Death Valley Fault Zone (SDVFZ). Transpression along the SDVFZ is clearly related to the formation of the Noble Hills and the Confidence Hills (Dooley and McClay, 1996) but their subsurface structure is not well understood (Figure 4.2). Previous studies (e.g. Hill and Troxel, 1966; Stewart, 1983; Prave et al., 1986; Dokka and Travis, 1990; Mckenna et al., 1990; Serpa and Pavlis, 1996) have defined the surface structures but there is only poor agreement regarding the overall style of deformation in the region (e.g. Wernicke, 1992; Serpa and Pavlis, 1996).

Gravity anomalies (Figure 4.3) in Southern Death Valley are largely controlled by the sharp contrast in density between pre-Cenozoic basement rocks (>2650 kg/m^3) exposed in the mountain ranges and alluvial fill deposits (<2450 kg m^3) comprising the basins (Blakely, 1999). Jachens and Moring (1990) developed an inversion method that separates the total gravity anomaly into two components. The basin component is inverted to determine the depth of basement rock. Using this inversion method, Blakely and Ponce (2001) developed a regional basement model for eastern California and Nevada.

The characteristic gravity signature and availability of the Blakely (2001) basement depth model makes Southern Death Valley ideally suited to provide a real world test of BAGC.m. I calculated the gravitational attraction of the Blakely (2001) depth model with the assumption that the surrounding rock is of uniform granitic density (Figure 4.4). Density constraints for basin fill were taken from a density depth model developed for Nevada and eastern California by Jachens and Moring (1990) using borehole data from Healey (1968, 1970, and 1984) and Ponce et al., (1982) (Figure 4.5). Results were compared to a new gravity data set I collected during the winter of 2010.

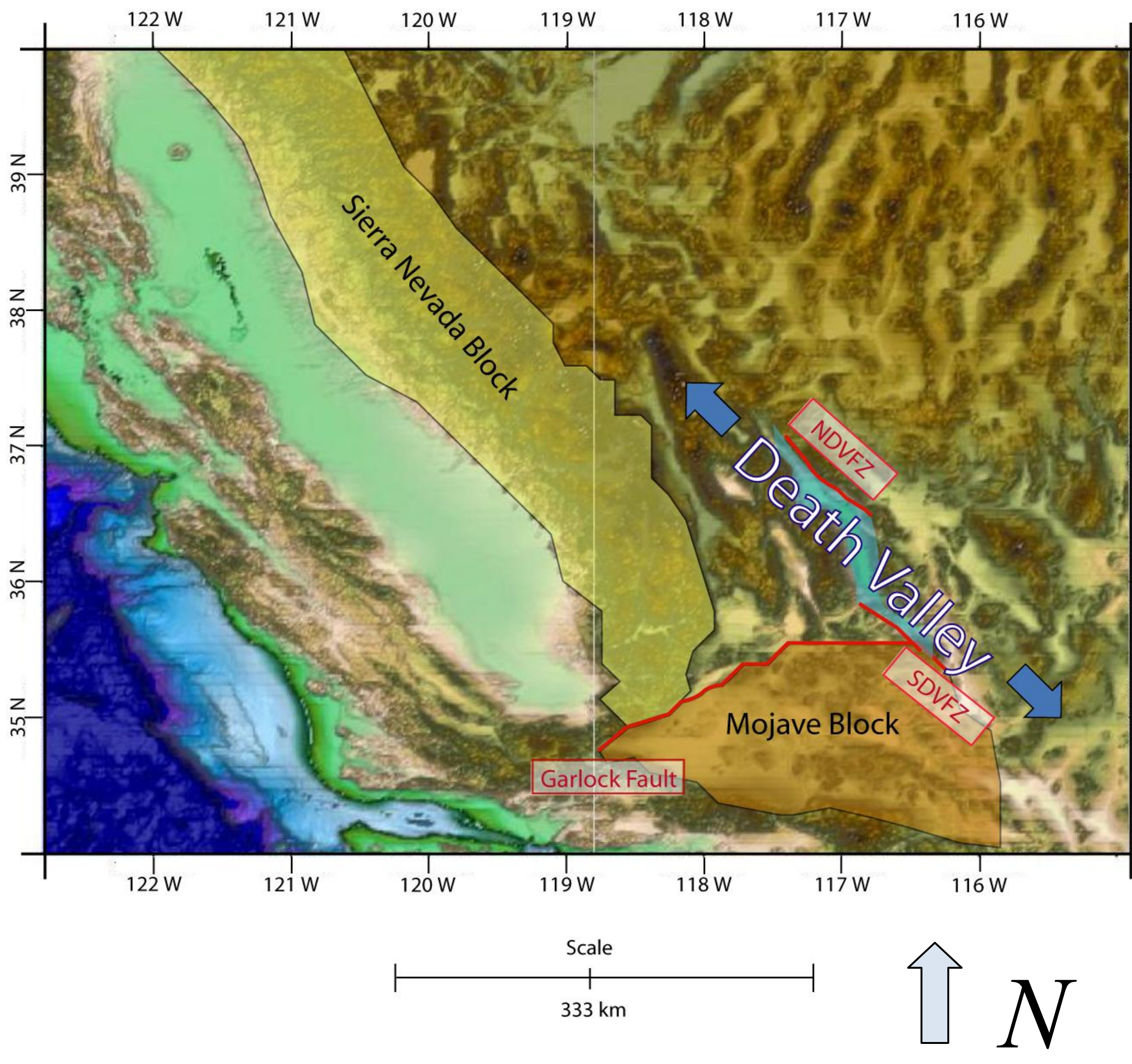


Figure 4.1: Map showing the location of Death Valley, the Northern Death Valley Fault Zone (NDVFZ), Southern Death Valley Fault Zone (SDVFZ), and Garlock Fault Zone. Areas in blue and purple indicate water. Areas in green indicate low elevation.*(SRTM digital elevation model provided by CIAT [Jachens, 2008])*

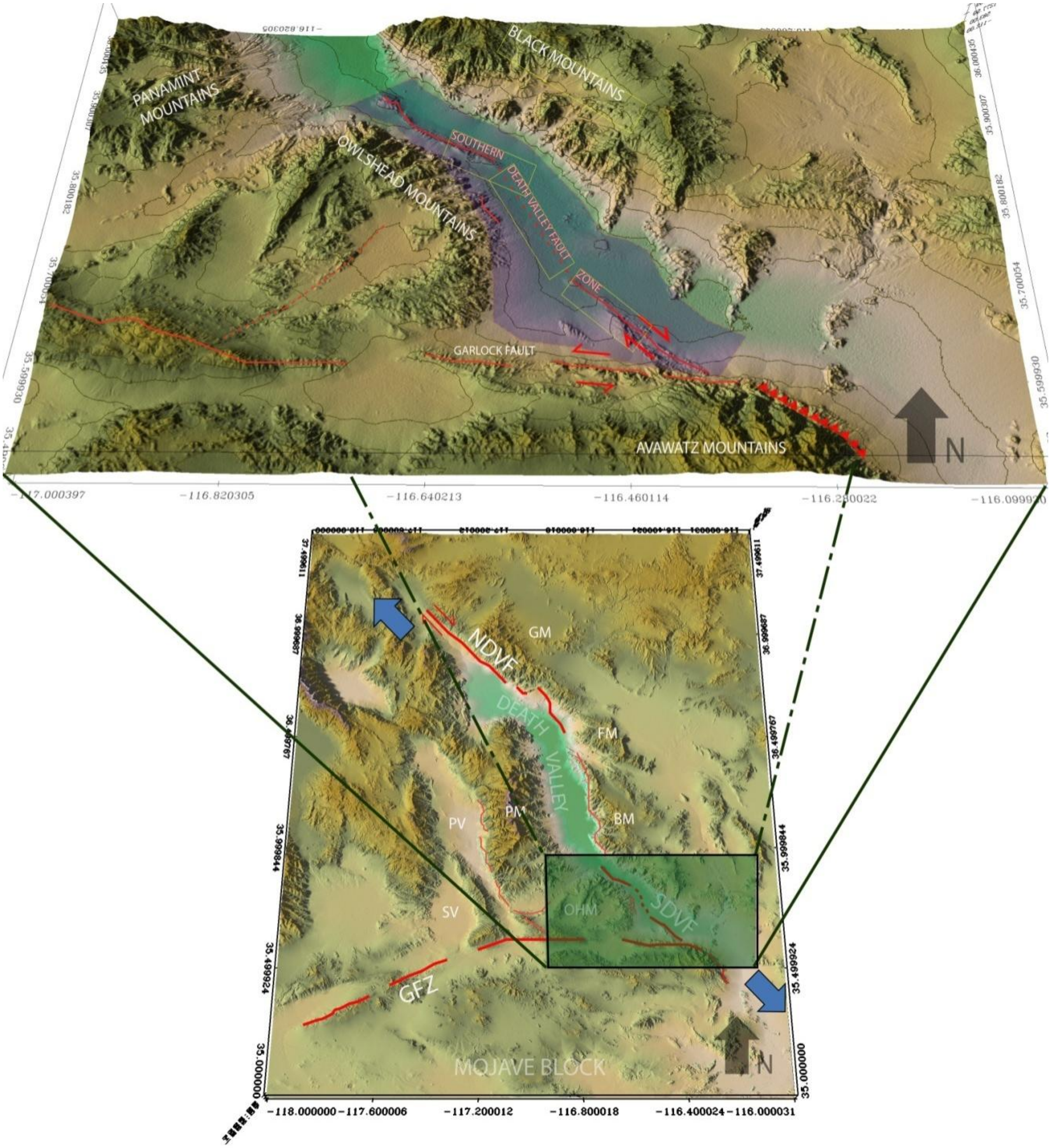


Figure 4.2: Site Map of the Southern Death Valley Fault Zone. Areas highlighted in green red indicate location of the study area. The following are abbreviations are used: Black Mountains (BM), Funeral Mountains (FM), Garlock Fault Zone (GFZ), Granite Mountains (GM), Northern Death Valley Fault Zone (NDVFZ), Owls Head Mountains (OHM), Panamint Mountains (PM), Panamint Valley (PV), Searles Valley, Southern Death Valley Fault Zone (SDVFZ)

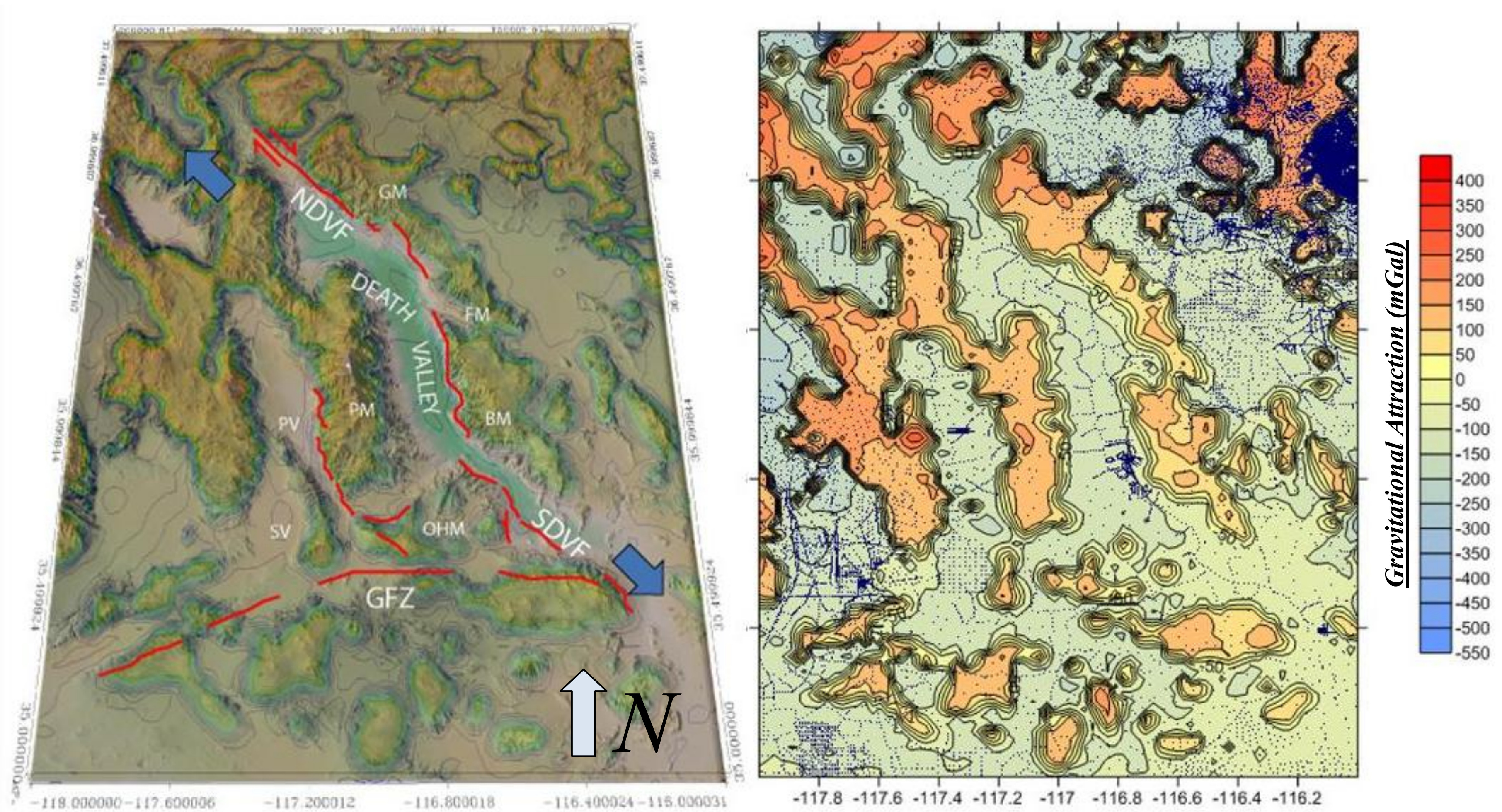


Figure 4.3: Bouguer anomaly map of the region around Death Valley, Ca (A) overlain on digital elevation model and (B) showing locations of gravity stations in PACES network. Gravity anomalies in Southern Death Valley are largely controlled by the sharp contrast in density between pre-Cenozoic basement rocks (>2650 kg/m^3) exposed in the mountain ranges and alluvial fill deposits (<2450 kg m^3) comprising the basins (Blakely, 1999).

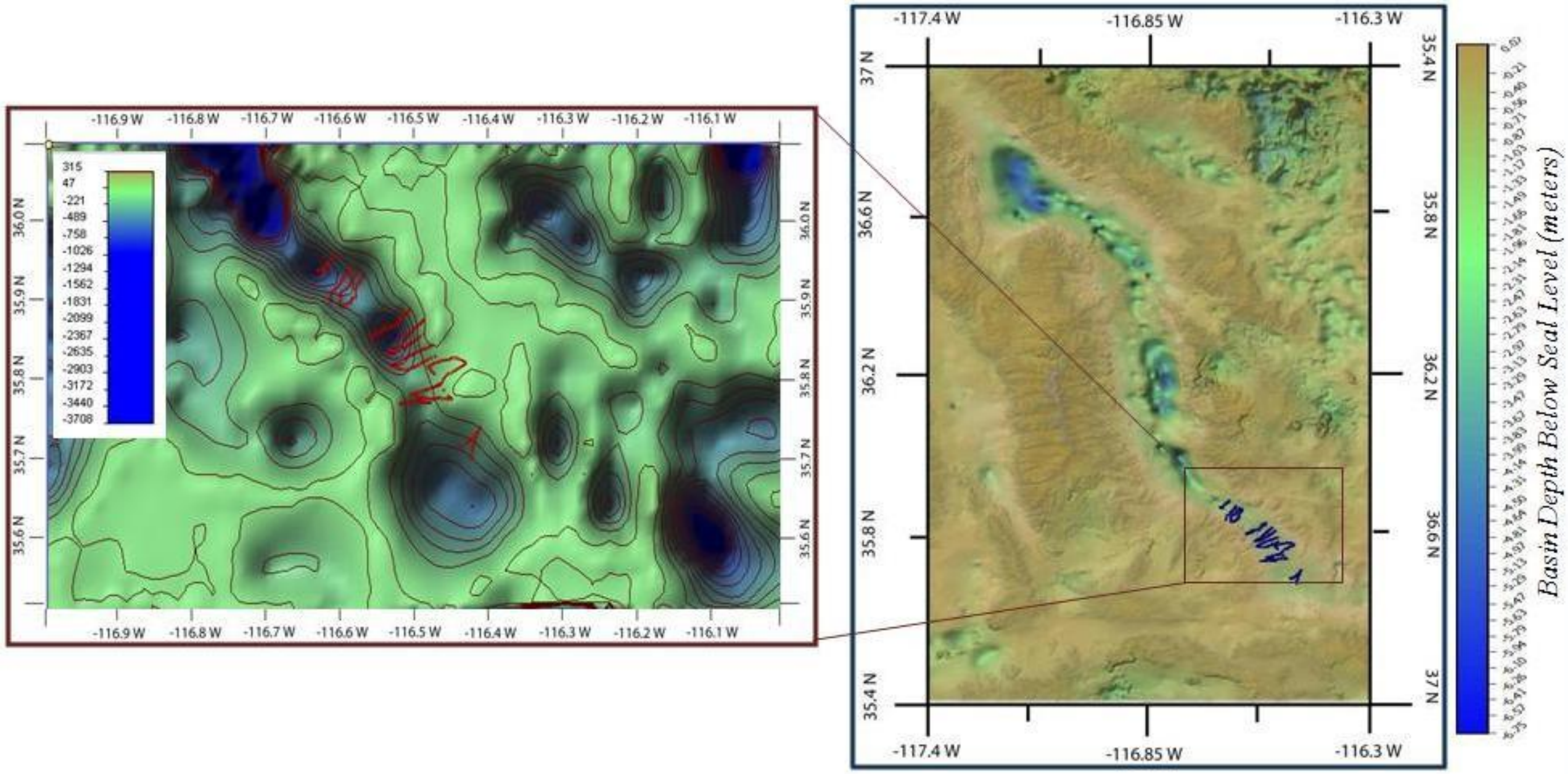
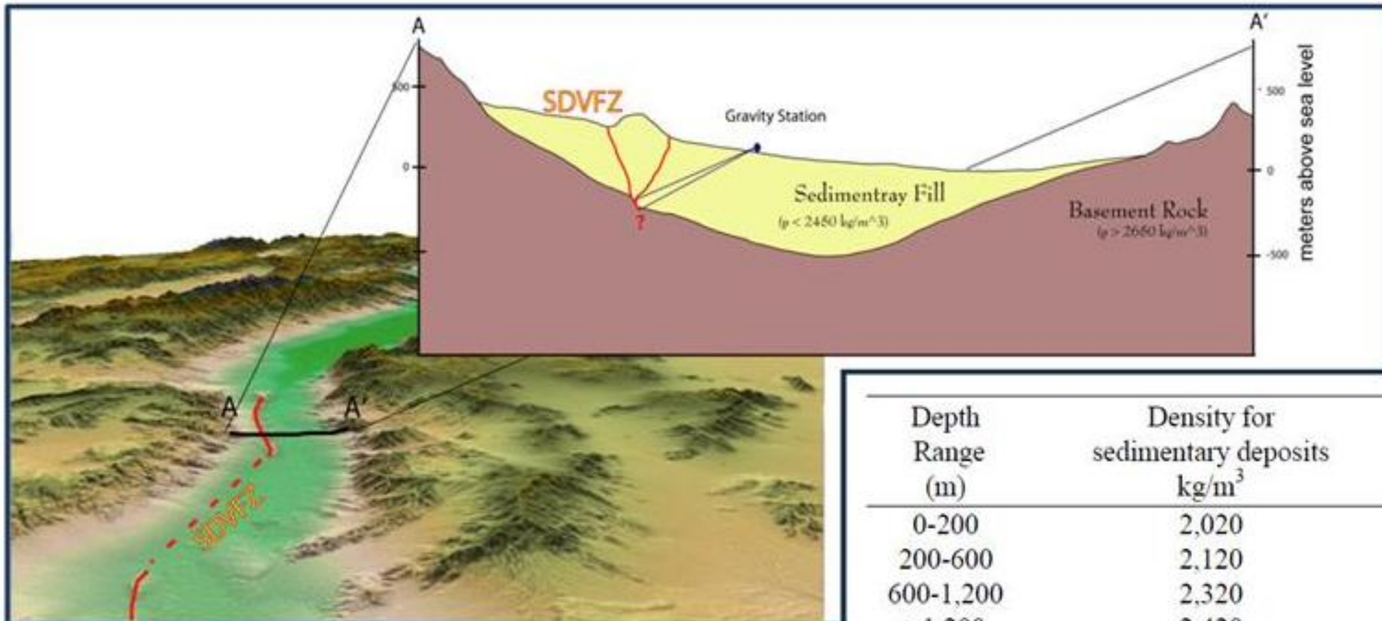


Figure 4.4: Map of the Blakely and Ponce (2001) regional depth to bedrock model used for geometric constraints. The basement was created using an inversion scheme by Jachens and Moring (1990).



Depth Range (m)	Density for sedimentary deposits kg/m^3	Density for volcanic deposits kg/m^3
0-200	2,020	1,900
200-600	2,120	2,100
600-1,200	2,320	2,300
>1,200	2,420	2,420

Densities after Jachens and Moring (1990)

Figure 4.5: Density constraints for calculated model assuming a two component model comprising of basement rock (2670 kg/m^3) and alluvial fill (see table).

GRAVITY DATA SET

53,508 gravity stations were downloaded from the *Pan-American Center for Earth and Environmental Studies (PACES).* In addition, 341 additional stations were collected for this study during the winter field season (January 6th to 17th 2010) (Figure 4.6). Location data were collected using two TOPCON GB-1000™ GPS units. Accurate and precise vertical and horizontal positions were determined using differential post processing of the rover (field) unit against a known base (reference) unit using the TOPCON TOOLS™ software package. This processing technique is used to eliminate both system wide and environmental errors including: multipathing, poor satellite geometry (spacing between satellites), and atmospheric effects. The base station was installed approximately 29 to 37 km from the field area at the Shoshone Education and Research (SHEAR) Center in Shoshone, CA. Daily occupation data from the base station was processed against three known reference stations within the Nation's Continuously Operating Reference Station (CORS) network maintained by the National Geodetic Survey through the Online Positioning User Service (OPUS) (http://www.ngs.noaa.gov/OPUS/index.jsp).

The estimated accuracy of processed gravity station vertical locations ranged from 0.021 m to 0.322 m with a mean of 0.048 m. The estimated accuracy of gravity station horizontal locations ranged from 0.010 m to 0.162 m with a mean of 0.024 m. However, the majority of stations with uncertainty (20/27 stations) in excess of 0.05 m are in gravity line 2. Excluding line 2, accuracy for the vertical component ranges from 0.021 m to 0.115 m (mean 0.028 m) while the horizontal component ranged from 0.010 m to 0.032 m (mean 0.016). In all, 95% of vertical precisions lines within an estimated error of 0.05 m.

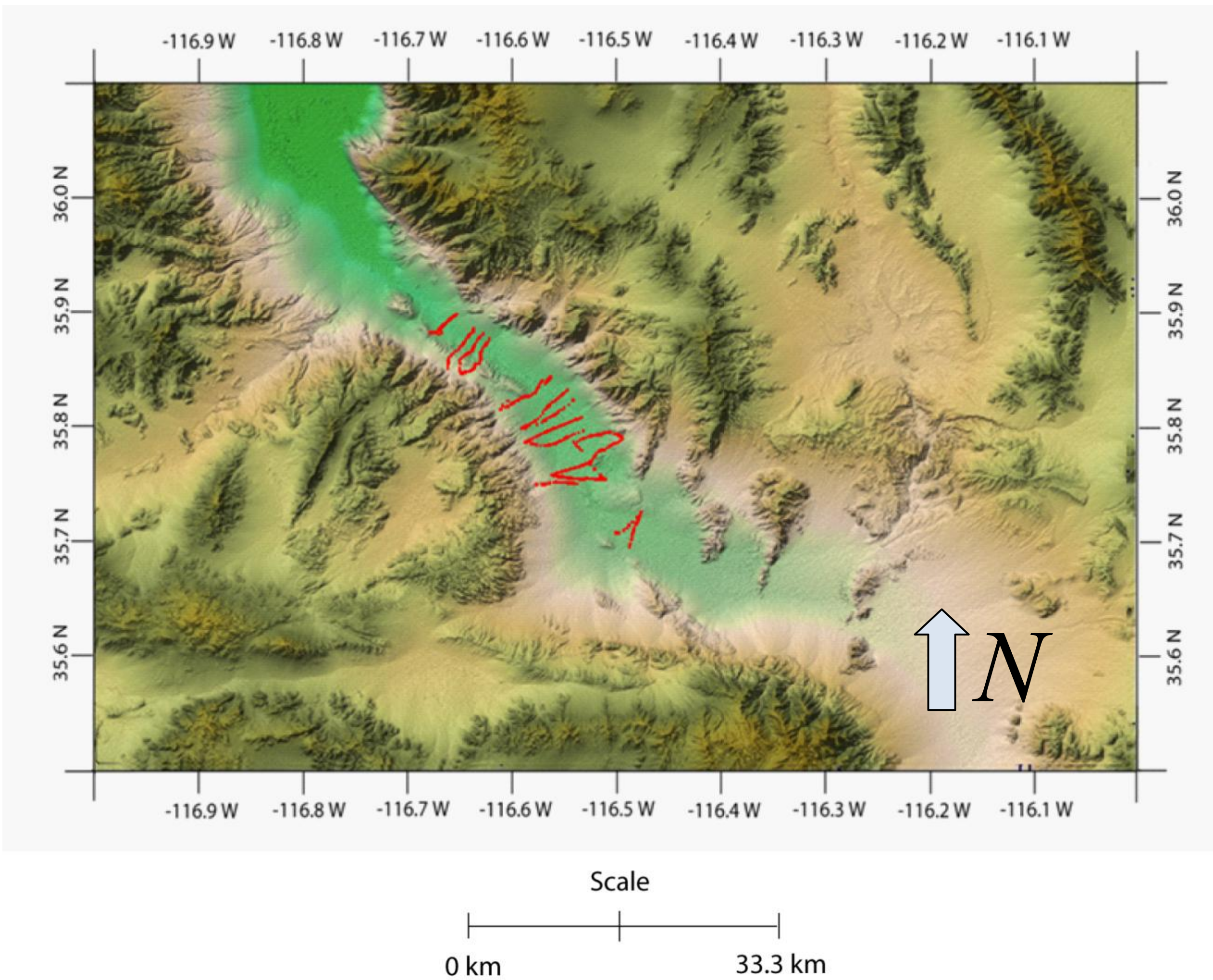


Figure 4.6: Location map of 341 gravity gtations installed during the winter field season (January 6th to 17th 2010)

MODEL PARAMETERS

The gravitational attraction of the regional basin model developed by Blakely and Ponce (2001) was calculated for 341 newly installed gravity stations and their residual calculated (Figure 4.4). Density constraints for basin fill were taken from a density depth model developed for Nevada and eastern California by Jachens and Moring (1990) using borehole data from Healey (1968, 1970, and 1984) and Ponce et al., (1982) (Table 4.1) (Figure 4.5). Surrounding basement rock was assumed to have a density of granite (2,670 kg/m^3).

Table 4.1: Depth/Density Relationship

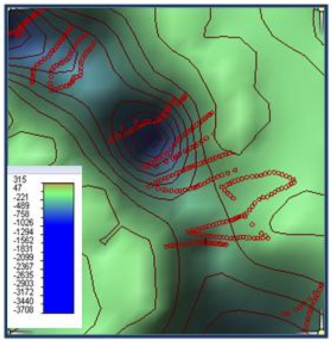
Depth Range (m)	***Assigned Density (kg/m^3)***
0 – 200	2,020
200 – 600	2,120
600 – 1,200	2,320
➢ 1,200	2,420

Densities from Healey (1968, 1970, and 1984) and Ponce et al., (1982), compiled by Jachens and Moring (1990)

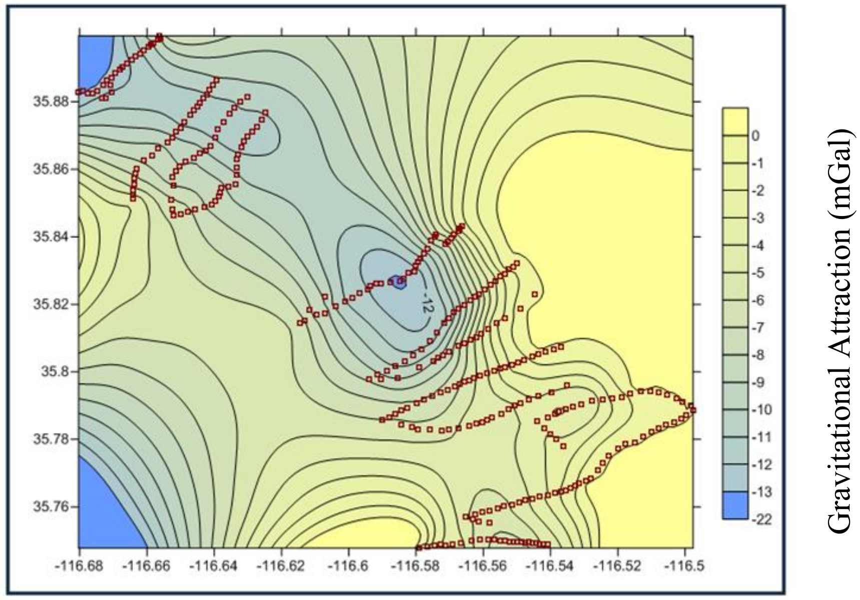
The regional model was imported into BAGC.m as a 3500 x 2500 2D depth to interface file with a sample spacing of 50 m (x, y, z). The large model was subdivided into 400 subgrids which were stored as 175 x 125 2D depth to interface files. Of the 400 subgrids, 86 included the main valley and were incorporated in the calculation of gravity anomalies. Maximum subgrid depths ranged from 0.09 km to 6.752 km for a total of 3.29×10^9 computations per gravity station. The geometric component of the gravity anomaly was pre-calculated for all 341 locations using 6 separate computers for a total computation time of 48 hours. Computation time to determine gravitational attraction for all 341 gravity stations required 45 minutes on 6 computers.

RESULTS

Output files were exported from BAGC.m as a .dat file, which was then imported into excel and gridded in using the minimum curvature method in Surfer™ at a contour interval of 2 mGals (Figure 4.7). A text file would work as well as an export format, but excel allows manipulation of the data and more rapid regridding. For example, when the densities or depths of part of the depth valley model were changed, only the altered portion of the model was recalculated in BAGC.m and then only those cells were exported and replaced in the excel spreadsheet. This allowed for much more efficient model manipulation. The maximum modeled anomaly (13.175 mGal) corresponded to the deepest portion of the basin. Based on precision testing using the analytical solution of a modeled sphere and the 2.5D basin, the expected error range is 0.011 mGal to 0.08 mGals. The minimum modeled anomalies (0.067 mGal) were located >0.25 km away from the basin edges.



Basin Depth Model



Gravitational Attraction of Basin Depth Model

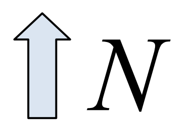


Figure 4.7: Gravitational attraction of the Blakely basin depth model (2001) calculated using BAGC.m. Density constraints were taken from a density depth relationship by Jachens and Moring (1990) (Table 4.1 and Figure 4.5). Results were gridded in Surfer™ using the Minimum Curvature Method at a contour interval of 2 mGals The basin depth model is inset in the upper left with contours in 0.1 km.

The gravity dataset was reduced to a simple bouguer anomaly using techniques outlined by Blakely (1995) (Appendix C.1). To determine the absolute gravity value, I reduced the data set to the United States Geological Survey (USGS) absolute gravity station BM S672. Absolute gravity station BM S672 was also used as a reference location to determine the misfit between the reduced data set and modeled gravity values. Free air and bouguer slab corrections reduced the data to sea level. The simple bouguer correction assumed an infinite slab with a density of 2670 kg/m^3.

To remove the impact of local terrain on the data set, I calculated terrain corrections for all 341 locations using BAGC.m (Figure 4.8). The terrain corrections were computed using a 30 m Digital Elevation Model (DEM) imported from NASA Shuttle Radar Topographic Mission (SRTM) (Jarvis, 2008) for distances less than 100 km. For distances greater than 100 km, a 1 km resolution DEM imported from SRTM (Jarvis, 2008). All terrain was assigned a density of 2670 kg/m^3. The magnitude of terrain corrections ranged from 1.73 mGal to 6.49 mGal. Results indicate that topographic corrections were primarily controlled by the Black Mountains to the north east and the confidence hills which bisected the study area from the north west to south east. Topographic corrections were applied to the dataset to determine the complete bouguer anomaly (Figure 4.9).

The complete bouguer anomaly was determined by applying terrain corrections to the simple bouguer reduced dataset. The complete bouguer anomaly was gridded using the minimum curvature method at a contour interval of 2 mGal using Surfer™. Complete bouguer anomalies ranged from -89.81 mGal to 69.81 mGal. These results are consistent with previous studies in Death Valley, Ca by Blakely (1999). Maximum gravity values are located adjacent to the mountains while minimum values are located within valleys.

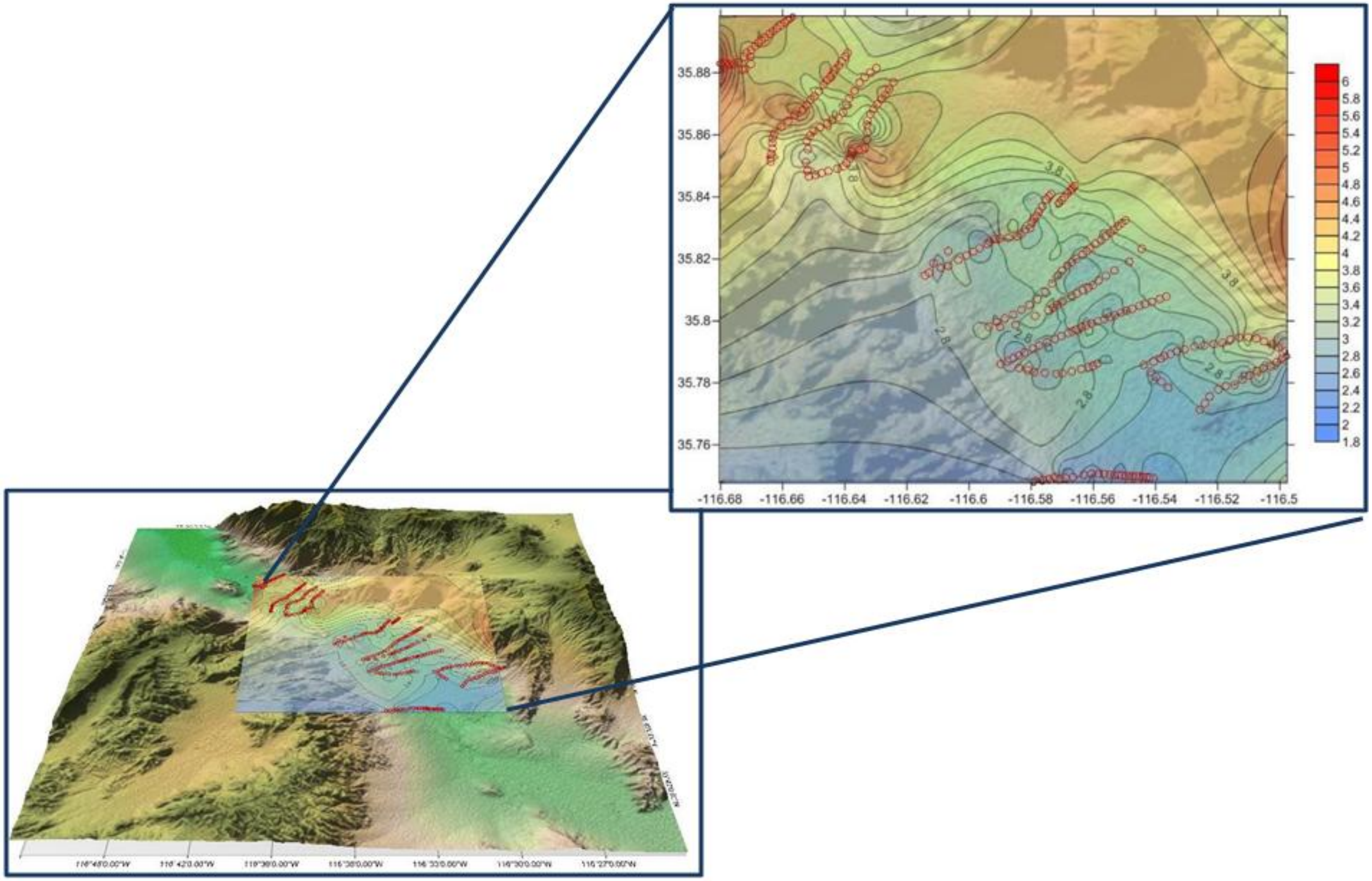


Figure 4.8: Calculated terrain corrections for 341 gravity stations using BAGC.m. Terrain was assumed to have a density of 2670 kg/m^3. Terrain corrections were gridded at 0.2 mGal contours using the minimum curvature method in Surfer^{TM}.

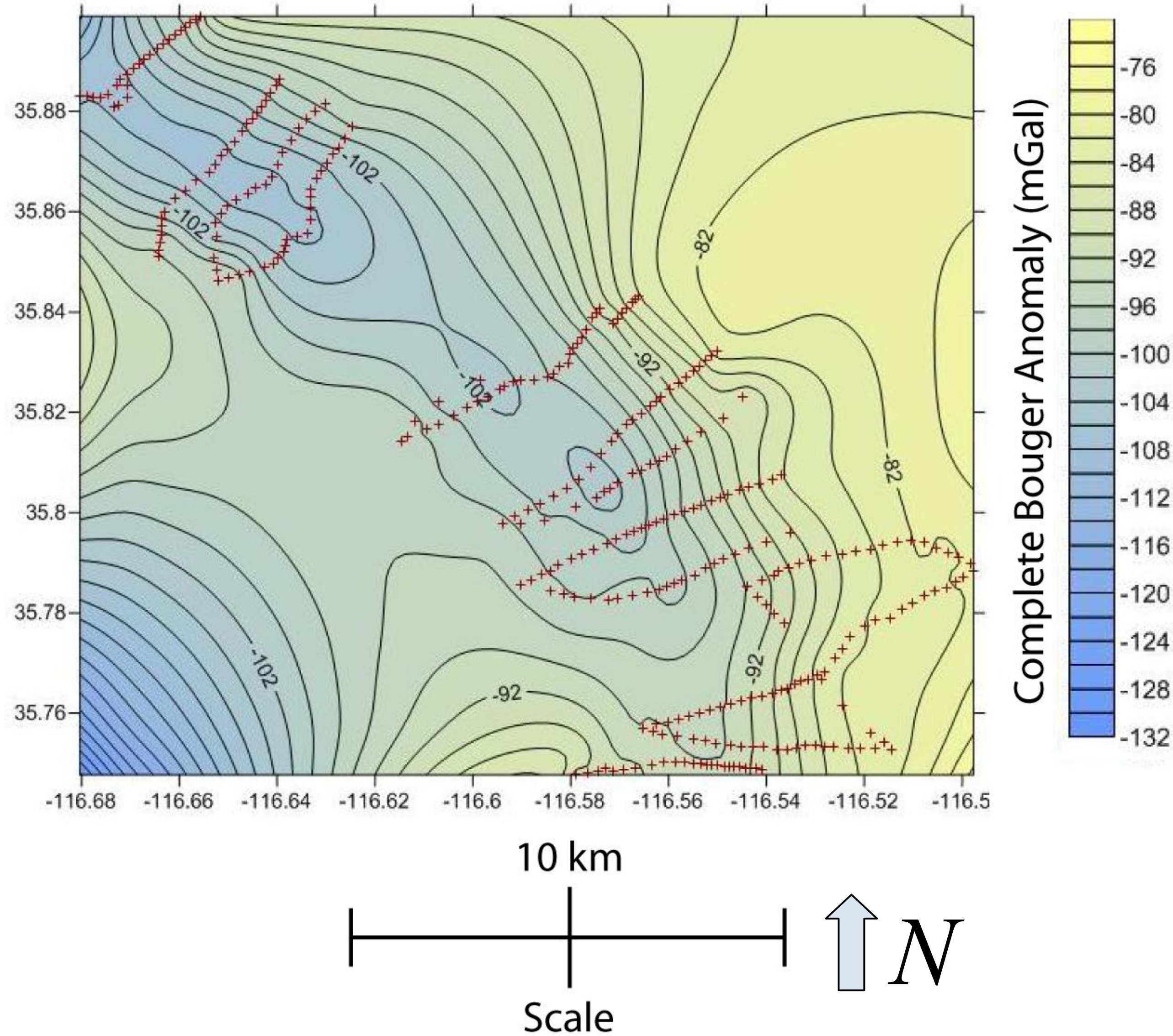


Figure 4.9: Complete bouguer anomaly plot of data set used for gravity modeling. Absolute gravity station BM S672 was used as a reference location for comparison with modeled gravity results. The data set was reduced to simple bouguer anomaly assuming an infinite slab with a density of 2670 kg/m^3. Topographic corrections (figure 4.8) were applied. Complete bouguer Anomaly values were gridded at 2 mGal contours using the minimum curvature method in Surfer^{TM}.

I calculated the misfit between the BAGC.m generated model (Figure 4.7) and the complete bouguer anomaly of the data set (Figure 4.10). In order to directly compare the BAGC.m generated model and the data set; all stations were tied to the USGS absolute gravity station BM 672. Misfit was determined by subtracting the complete bouguer anomaly of the data set from the BAGC.m generated anomaly. The difference in gravitational attraction between the modeled basin and the data set ranged from -9.13 mGal to 10.86 mGal. This range of values was highly variable with a mean of 1.05 mGal and a standard deviation of 4.42 mGal. Regions in blue indicate that the BAGC.m generated model had a more negative anomaly than the dataset due to an over estimation of basin depth or underestimation of density. Regions in red indicate that BAGC.m generated model had a less negative anomaly than did the data set due to an underestimation of basin depth or over estimation of density.

Results suggest that the degree of misfit depends on the location of gravity stations to the both the basin model and the topography. This can be attributed to an incorrect estimate of basin geometry by the Blakely model (2001) or an incorrect estimate of density for the topography. For example, the Blakely model (2001) over predicted basin depth for stations located over the two main sub basins (Figure 4.7). However, stations along the sub basin to the northwest were collected within the confidence hills. I reduced the topography using a standard density of 2670 kg/m^3 but the sediment in the confidence hills is comprised of loose lacustrine sediments with an expected density less than 2670 kg/m^3. This suggests structures in the SDVFZ are more complex than predicted by the regional depth model.

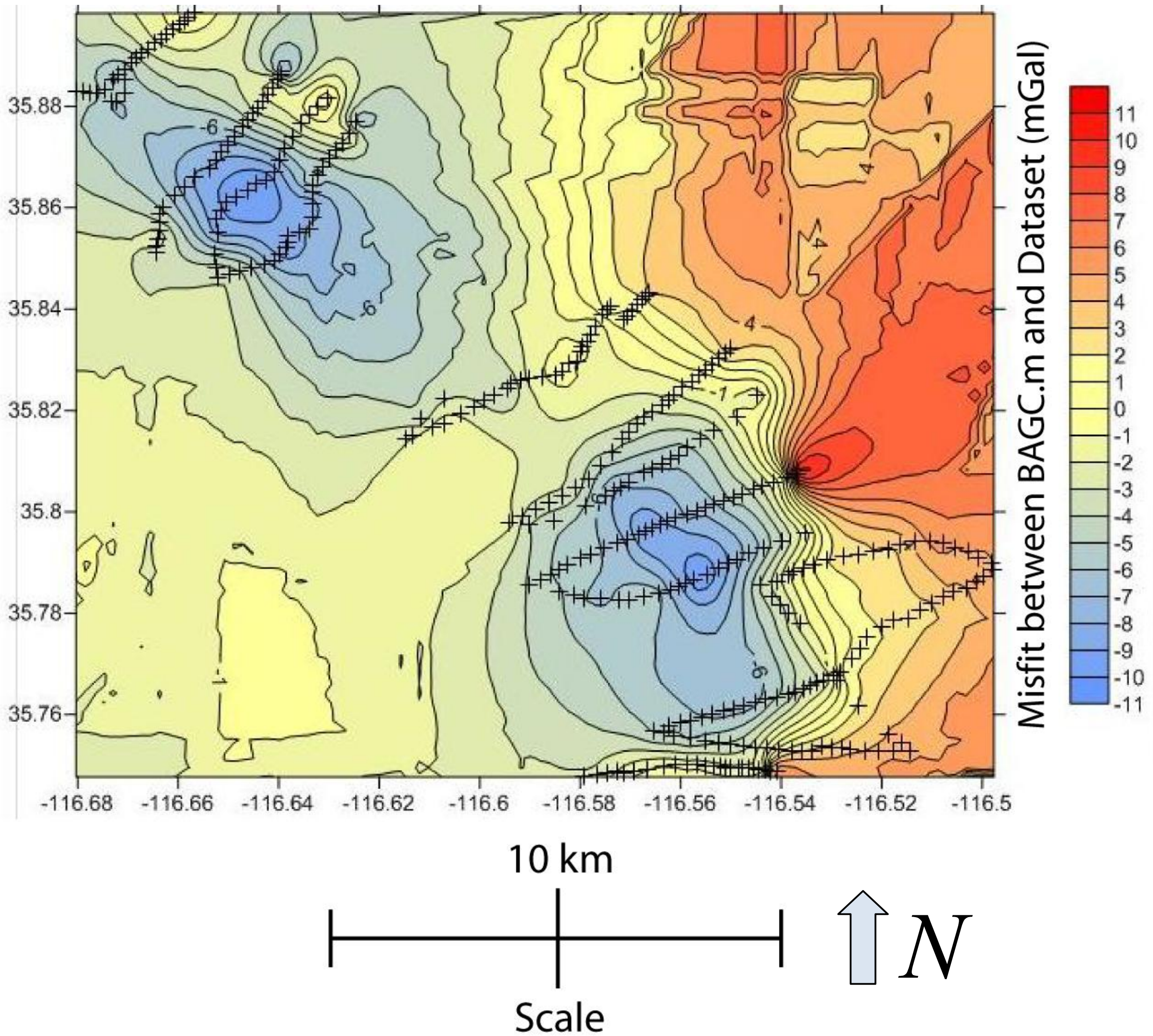


Figure 4.10: Misfit between BAGC.m generated model (see Figure 4.7) and the complete bouguer reduced data set. In order to directly compare the BAGC.m generated model and the data set; all stations were tied to the USGS absolute gravity station BM 672. Misfit was determined by subtracting the complete bouguer anomaly of the data set from the BAGC.m generated anomaly. Regions in blue indicate that the BAGC.m generated model had a more negative anomaly than the dataset due to an over estimation of basin depth or underestimation of density. Regions in red indicate that BAGC.m generated model had a less negative anomaly than did the data set due to an underestimation of basin depth or over estimation of density.

Conclusion

I have developed a 3D gravity modeling software package designed specifically for basin analysis titled Basin Anomaly Gravity Calculator (BAGC.m). The computational speed of the program is sufficient to provide practical applications in modeling basins. BAGC.m was tested against the analytical solution of a sphere and the 2.5D modeling software Talwani 2.2. The tests indicate that BAGC.m reproduces the analytical solution with an error of 0.6% for a sample spacing of 30 m, which corresponds to 7.07×10^{-6} % the volume of a buried sphere of radius 4.5 km at a depth of 4.5 km. BAGC.m was able to reproduce the Talwani 2.2 solution within 0.0691 mGal for 90% of the calculations. In addition, BAGC.m was effectively used to calculate the gravitational attraction of a regional basin depth model developed by Blakely and Ponce (2001). Results were compared to a new high precision gravity data set and indicate that the structures within the SDVFZ are more complex than predicted by the regional basin depth model.

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Appendix A: BAGC.m MATLAB^{TM} Scripts

calc_component.m

```
function [density_prism] = density_component(grid_interval_r, grid_interval_c, grid_interval_z,basin_depth, basinrows,basincolumns,numdatapoints,numcolumns,g_locations, ul_north, ul_east,d_dist, dsize, num_grid_in_use,x0,y0,z0,grids_for_model)

%brian eslick: 3-12-2010:
%this function will take in grid parameters from g_calcs and pass them into the calculation funciton %gbox.  it will (1) designate location data of gravity calculation points and grids(x0,x1,x2...z0,z1,z2), %(2) will develop 3-D rho (model) from surface depth files, and (3) send location data %into calculation %funciton gbox.  read in location data for gravity data


%-------------------------------------------------------------------------------------------------------------------
%                                    define depth of model
%-------------------------------------------------------------------------------------------------------------------
%to determine total depth of model in 500 m increments, divides by 500 rounds and multiply by 500
%min_required = max(max(basin_depth))+500; %determines the minimum needed for model - in meters

model_depth = min_required/500;
model_depth = ceil(model_depth);
model_depth = model_depth*500;
grid_depth = ceil(model_depth/grid_interval_z); %determines how many grids in z direction

%----------------------- converts basin_depths to grids------------------------------------------------------------
%rounds basin depth to resolution of model define size of model for later

size_northing = basinrows;
size_easting = basincolumns;
depth = grid_depth;

%converts grid_interval to define depths of grid
grid_interval_r = grid_interval_r/1000;
grid_interval_z = grid_interval_z/1000;
grid_interval_c = grid_interval_c/1000;
for i = 1:grid_depth
z1(i) = (i*grid_interval_z-grid_interval_z);
z2(i) = (i*grid_interval_z);
end

%-------------------------------------------------------------------------------------------------------------------
%                                    Determining Location of grid
%-------------------------------------------------------------------------------------------------------------------

%using if statements to determine location rather than radious vectors
for i = 1:numdatapoints
%--------------upper right hand quadrant----------------------------------
```

```
if (ul_north > y0(i)) & (ul_east > x0(i))
for x_change = 1:size_easting
   x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
   x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
   y2(y_change) = ul_north - grid_interval_r*y_change+grid_interval_r;
   y1(y_change) = ul_north - grid_interval_r*y_change;
end


%----------------upper left hand quadrant----------------------------------
else if (ul_north > y0(i)) & (ul_east < x0(i))
  for x_change = 1:size_easting
   x2(x_change) = (ul_east + (grid_interval_c*x_change)-grid_interval_c);
   x1(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y2(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y1(y_change) = (ul_north - grid_interval_r*y_change);
end

%----------------lower right hand quadrant---------------------------------
else if (ul_north < y0(i)) & (ul_east > x0(i))
 for x_change = 1:size_easting
    x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
    x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
y1(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north - grid_interval_r*y_change);
end

%----------------lower left hand quadrant----------------------------------
else if (ul_north < y0(i)) & (ul_east < x0(i))
for x_change = 1:size_easting
   x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
   x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
   y1(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north - grid_interval_r*y_change);
end
    end
    end
    end
end
```

```
%-----------------------------------------------------------------------
% Sending location and density info to gbox calcualtions
%-----------------------------------------------------------------------

density_prism = zeros(size_northing, size_easting, depth);
for h = 1:numdatapoints

for i = 1:size_easting
   for j = 1:size_northing
       for k = 1:depth
           if basin_depth(j,i)<0
          'awesome'
           end
           if basin_depth(j,i) > 0.000001
          [density_prism(j,i,k)] = gbox(x0(h),y0(h),0,x1(i),y1(j),z1(k)+0.0001,x2(i),y2(j),z2(k)+.0001);
           end
       end
   end
end

 d_results = [cd '\densities\grid_' int2str(grids_for_model(num_grid_in_use)) '_data_point_' int2str(h)
'.bsq'];
 multibandwrite(density_prism,d_results,'bsq');


end
clear density_prism
 density_prism = 1;
end
```

cross_sect.m

```
figure(1)
imagesc(depth)
display('pick zoom section for cross sections')
[x1,y1]=ginput(2); %ginput takes in your two points
cs1 = [round(x1),round(y1)]; %assigns locations to cs1

%smooth_temp will open and save the depths you just selected while temp opens a dummy matrix.
%smooth_temp will be used for display purposes temp will hold the values you will add and will be the
%matrix you will filter and add to your original depth file
    for i = cs1(1,2):cs1(2,2)
        for j = cs1(1,1):cs1(2,1)
            smooth_temp(i-cs1(1,2)+1,j-cs1(1,1)+1)=depth(i,j);
            temp(i-cs1(1,2)+1,j-cs1(1,1)+1)=0;
        end
    end


%displays your input file and the file you just cut for reference
display('select points of cross section')
figure, imagesc(smooth_temp);
colorbar
h = impoly
 position = wait(h);
pos = getPosition(h)

%important: this will be the region you smooth over your new edits.  You will select two points which
%will be the total area the filter will cover when editing.  i recomend having an area considerably larger
%than your desired edits

row = round(pos(:,2));
col = round(pos(:,1));
[m,n]=size(row)
m = m-1;
for i = 1:m-1
hope(i) = smooth_temp(row(i),col(i));
end
hope = hope';

for i = 1:m-1
x(i) = ((row(i+1)-row(i))^2+(col(i+1)-col(i))^2)^.5;
end

%plotting
temp = 1;
distance(1) = x(1);
while temp < m-1
temp=temp+1;
```

```
distance(temp) = distance(temp-1)+x(temp);
end

xi = 0:.5:distance(m-1);
yi = spline(distance,hope(1:m-1),xi);
y2 = pchip(distance,hope(1:m-1),xi);
titling=['Cross Section for ' gopen];
figure(3)
subplot(3,1,1)
plot(distance,hope(1:m-1))
axis([distance(1) distance(m-1) min(hope) max(hope)])
title('selected points')
subplot(3,1,2)
plot(xi,yi,'o')
axis([distance(1) distance(m-1) min(hope) max(hope)])
title('spline cubic fitting')
subplot(3,1,3)
plot(xi,y2,'o')
axis([distance(1) distance(m-1) min(hope) max(hope)])
title('Piecewise Cubic Hermite Interpolating Polynomial')
hout=suptitle2(titling)
 [ax4,h3]=suplabel('Depth (km)','y');
[ax4,h3]=suplabel('Distance (grids)','x');

for i = 1:m-1
row_dist = abs(row(i+1)-row(i));
col_dist = abs(col(i+1)-col(i));
angle = atan(row_dist/col_dist);
distance_increment_col = 0.5*cos(angle);
distance_increment_row = 0.5*sin(angle);
eval(['col_vector_temp' num2str(i) ' = col(i):distance_increment_col:col(i+1)']);
eval(['row_vector_temp' num2str(i) ' = row(i):distance_increment_row:row(i+1)']);
end

for i = 1:m-1
counter(i)=length(eval(['col_vector_temp' num2str(i)]))
counterr(i) = length(eval(['row_vector_temp' num2str(i)]))
end
temp = 1;
tempr =1;
temp2 = counter(1);
temp2r = counterr(1);
while temp < m-1
   temp = temp+1;
   tempr = tempr+1;
   temp2(temp)=temp2(temp-1)+counter(temp)-1;
   temp2r(tempr)=temp2r(tempr-1)+counterr(tempr)-1;
end
```

```
temp2(2:m) = temp2;
temp2(1) = 1;
temp2r(2:m) = temp2r;
temp2r(1) = 1;

for i = 1:m-1
  col_final(temp2(i):temp2(i+1))=eval(['col_vector_temp' num2str(i)]);
  row_final(temp2r(i):temp2r(i+1))=eval(['row_vector_temp' num2str(i)]);
end

final = [col_final;row_final;yi(1:length(col_final));y2(1:length(col_final))];
saving = input('would you like to save your cross sections (y for yes, n for no) \ns','s');
if saving == 'y'
scross = input('name to save your cross section \n' , 's');
output_cross = [cd '\results\' scross '.dat'];

fid=fopen(output_cross, 'wt');
 fprintf(fid,'%6.5f %6.5f %6.5f %6.5f \n', final);
fclose(fid);
end

clear hope
clear cs1
clear x1
clear y1
clear x
clear temp
clear distance
clear smooth_temp
clear final
```

cut_grid.m

```
%by brian eslick 3-9-2010 function designed to take surfer gridded x,y,z file (lat and long go from least
%to greatest) and crop it down to I grid files to import into gravity model.  will also, export upper left
%hand corners of grids to upper_left_corners.dat for use in gravity computations. method is to (1) intake
%x,y,z, cut into z file export to directory, (2) reimport and place into matrix (row x col)then (3) cut into
%subgrids (4) define upper left hand corners and export to a .dat file

%example:
%r=1200; %#rows, how many grids
%c=2400;%#columns, how many grids
%grids_r = 6; %how many sub grids in row direction
%grids_c = 12;%how many sub grids in col direction
%length_r = r/grids_r;%how many grids in each sub grid
%length_c = c/grids_c;


%-----------------------------------------------------------------------------------------------------------------------
%                                                  PART 1
%-----------------------------------------------------------------------------------------------------------------------
%read in surfer gridded x,y,z file.  For other grids may need to change [0,2,r*c-1,2] component
%depending on indexing, will need to change directory location and .dat file name

grid_loc = [cd '\grids\'];
big_grid_loc_temp = input('what is the name your large gridded \n','s');
big_grid_loc =[cd '\grids\' big_grid_loc_temp]
grid_name = input('what would you like to title your grids \n','s');

%must be a .dat file
r=input('how many rows are present in the large grid');% ex 200
c=input('how many columns are present in the large grid');% ex 200
ul_corner = input('input lat,long (decimal degrees) of upper left hand corner of your grid file, ex. 35.5,-
117.0 \n', 's');
br_corner = input('input lat,long (decimal degrees) of bottom right hand corner of your grid file, ex.
35.0,-116.0 \n','s');
grids_r=input('how many sub grids do you want in the y direction \n'); %ex 4
grids_c=input('how many sub grids do you want in the x direction \n'); %ex 4
length_r = r/grids_r;%how many grids in each sub grid
length_c = c/grids_c;

%columns and rows start at 0          [row 1, column 3 to last row column 3]
depth_temp = dlmread(big_grid_loc, '', [0, 2,r*c-1,2]); %set up for a surfer grid

%outputing results to a .dat file titled depth2.dat
basin_depth=[cd '\grids\depth2.dat']; %ex:
fid=fopen(basin_depth, 'w');
 fprintf(fid,'%6.5f\n',depth_temp);
fclose(fid);
```

```
clear depth_temp %clear to save memory

%-----------------------------------------------------------------------------------------------------------------------
%                                                   PART 2
%-----------------------------------------------------------------------------------------------------------------------
depth=basin_depth;
   fid=fopen(depth);
 basin_depth=fscanf(fid,’%f’,[c r]);%open the input DEM file, read it and stores it in variable ‘DEM’
   fclose(fid)
basin_depth=basin_depth’;%transpose b/c matlab imports backwards

%plot large grid for comparisons, will be upside down b/c surfer places data in rows and cols from least
%to greatest

figure(1)
   imagesc(basin_depth)
   title(‘uncut surface’)
   colorbar
counter_col=0:length_c:c;%vector holds starting value for the subgrids in columns
counter_row=r:length_r*-1:1; %vector holds starting value for the subgrids in

 %rows, backwards to remedy upside down nature of large grid
%-----------------------------------------------------------------------------------------------------------------------
%                                                    PART 3
%-----------------------------------------------------------------------------------------------------------------------

%crops into sub grids
   for cr = 1:grids_r
   for n = 1:grids_c
     for I =1:length_r
       for j =1:length_c
          eval([‘grid’    num2str(n+(cr*grids_r)-grids_r)    ‘(I,j)=    basin_depth(counter_row(cr)
i+1,counter_col(n)+j);’]);
       end
     end
   end
 end

 %plot results of cropping for comparison
 figure(2)
 for I = 1:grids_r*grids_c
     subplot(grids_r,grids_c,i)
     imagesc(eval([‘grid’ num2str(i) ‘(:,☺’]))
 end

 %write the grid files to .dat files for importation later
 for I = 1:grids_r*grids_c
gridding = [grid_loc ‘\’ grid_name num2str(i) ‘.dat’];
```

```
fid=fopen(gridding, ‘w’);
 fprintf(fid,’%6.5f \n’, eval([‘grid’ num2str(i)]));
fclose(fid);
 end
 a = 1;


 %------------------------------------------------------------------------------------------------------------------------
 %                                                                   part 4
 %------------------------------------------------------------------------------------------------------------------------
%create a .dat file while holds the upper left hand location of the grid
 %files for use in gravity computation

 corner_locations = [str2num(ul_corner);str2num(br_corner)];
 ul_corner_increment_row = (corner_locations(1,1)-corner_locations(2,1))/(grids_r);
 ul_corner_increment_col = (corner_locations(1,2)-corner_locations(2,2))/(grids_c);
 for I = 0:grids_r-1
 ul_locations_row(i+1)=corner_locations(1,1)-ul_corner_increment_row*I;
 end
 for I = 0:grids_c-1
    ul_locations_col(i+1)=corner_locations(1,2)-ul_corner_increment_col*I;
 end

 for I = 1:grids_r
    temp_row(i+(grids_c*i)-(grids_c+i)+1:grids_c*i)=ul_locations_row(i);
 end
  for I = 1:grids_r
    temp_col(i+(grids_c*i)-(grids_c+i)+1:grids_c*i)=ul_locations_col(1:grids_c);
 end
ul_temps = [temp_row;temp_col];
 ul_corner_location = [grid_loc ‘\upper_left_corners.dat’];
 fid = fopen(ul_corner_location, ‘wt’);
 fprintf(fid,’%6.9f  %6.9f\n’,ul_temps);
fclose(fid);
```

d_calcs.m

```
%Brian Eslick 2-28-2010
%reading in location of grids:
ul_corners = ul_location_new*111;

%Reads in the basin depth files and stores them in basin_bepth
for i = 1:numdatapoints
z0(i) = g_locations(i,3)/111;%multiplied to make in km in load_g_calcs but depth was originally in km
x0(i) = g_locations(i,1);
y0(i) = g_locations(i,2);
end

for i = 1:num_grids
blakeley_basin=[cd '\grids\' begin_string num2str(grids_for_model(i)) '.dat'];
fid=fopen(blakeley_basin);
basin_depth=fscanf(fid,'%f',[basinrows basincolumns]);%open the input DEM file, read it and stores it in variable 'DEM'
fclose(fid)
basin_depth=basin_depth*1000;

%plots basin_depth for reference
for ii = 1:basinrows
   for jj = 1:basincolumns
      if basin_depth(ii,jj) < 0;
         basin_depth(ii,jj) = 0;
      else
         basin_depth(ii,jj) = basin_depth(ii,jj);
      end
   end
end
figure(2)
subplot(gridrows,gridcols,grids_for_model(i))
imagesc(basin_depth)
g_interval_temp = load(ul_loc)*111;
grid_interval_r = ([g_interval_temp(1,1)-g_interval_temp(gridcols+1,1)]*1000)/basinrows;
grid_interval_c = ([g_interval_temp(2,2)-g_interval_temp(1,2)]*1000)/basincolumns;
grid_interval_z = grid_interval_z;
num_grid_in_use = (i);

%sends variable into function for computation
[density_prism_holder] = density_component(grid_interval_r, grid_interval_c, grid_interval_z,basin_depth, basinrows,basincolumns,numdatapoints,numcolumns,g_locations, ul_corners(i,2), ul_corners(i,1), d_dist, dsize,num_grid_in_use,x0,y0,z0,grids_for_model, gravity_location_holder);

clear grid_interval_r
clear grid_interval_c
```

```
clear basin_depth
clear output_temp
percent_done = (i/(num_grids))*100
end
```

density_component.m

```
function [density_prism] = density_component(grid_interval_r, grid_interval_c, grid_interval_z,basin_depth, basinrows,basincolumns,numdatapoints,numcolumns,g_locations, ul_north, ul_east,d_dist, dsize, num_grid_in_use,x0,y0,z0,grids_for_model, gravity_location_holder)

%brian eslick: 3-12-2010:
%this function will take in grid parameters from g_calcs and pass them into
%the calculation funciton gbox.  it will (1) designate location data of gravity calculation points and
%grids(x0,x1,x2...z0,z1,z2), (2) will develop 3-D rho (model) from surface depth files, and (3) send
%location data into calculation funciton gbox.
%read in location data for gravity data


%-------------------------------------------------------------------------------------------------------------------
%                                          define depth of model
%-------------------------------------------------------------------------------------------------------------------
%to determine total depth of model in 500 m increments, divides by 500 rounds and multiply by 500

min_required = max(max(basin_depth))+500; %determines the minimum needed for model - in meters
model_depth = min_required/500;
model_depth = ceil(model_depth);
model_depth = model_depth*500;
grid_depth = ceil(model_depth/grid_interval_z); %determines how many grids in z direction

%----------------------- converts basin_depths to grids rounds basin depth to resolution of model
%define size of model for later

size_northing = basinrows;
size_easting = basincolumns;
depth = grid_depth;

%converts grid_interval to define depths of grid
grid_interval_r = grid_interval_r/1000;
grid_interval_z = grid_interval_z/1000;
grid_interval_c = grid_interval_c/1000;
for i = 1:grid_depth
z1(i) = (i*grid_interval_z-grid_interval_z);
z2(i) = (i*grid_interval_z);
end

%------------------------------------------------------------------------------------------------------------------
%                                     Determining Location of grid
%------------------------------------------------------------------------------------------------------------------

%using if statements to determine location rather than radious vectors
for i = 1:numdatapoints
%--------------upper right hand quadrant----------------------------------
```

```
if (ul_north > y0(i)) & (ul_east > x0(i))
for x_change = 1:size_easting
   x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
   x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
   y2(y_change) = ul_north - grid_interval_r*y_change+grid_interval_r;
   y1(y_change) = ul_north - grid_interval_r*y_change;
end


%----------------upper left hand quadrant----------------------------------
else if (ul_north > y0(i)) & (ul_east < x0(i))
  for x_change = 1:size_easting
   x2(x_change) = (ul_east + (grid_interval_c*x_change)-grid_interval_c);
   x1(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y2(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y1(y_change) = (ul_north - grid_interval_r*y_change);
end

%----------------lower right hand quadrant---------------------------------
else if (ul_north < y0(i)) & (ul_east > x0(i))
for x_change = 1:size_easting
    x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
    x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y1(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north - grid_interval_r*y_change);
end

%----------------lower left hand quadrant----------------------------------
else if (ul_north < y0(i)) & (ul_east < x0(i))
for x_change = 1:size_easting
   x1(x_change) = (ul_east + grid_interval_c*x_change-grid_interval_c);
   x2(x_change) = (ul_east + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y1(y_change) = (ul_north - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north - grid_interval_r*y_change);
end
    end
    end
    end
end
```

```
%-----------------------------------------------------------------------------------------------------------------------
%                                  Sending location and density info to gbox calcualtions
%-----------------------------------------------------------------------------------------------------------------------

density_prism = zeros(size_northing, size_easting, depth);
for h = 1:numdatapoints
   for i = 1:size_easting
   for j = 1:size_northing
       for k = 1:depth
            if basin_depth(j,i) < 0
           a = 'yes';
            end
            if basin_depth(j,i) > 0
           [density_prism(j,i,k)] = gbox(x0(h),y0(h),0,x1(i),y1(j),z1(k)+0.0001,x2(i),y2(j),z2(k)+.0001);
            end
       end
   end
end

d_results = [cd '\densities\grid_' int2str(grids_for_model(num_grid_in_use)) '_data_point_'
int2str(gravity_location_holder(h))  '.bsq'];
      multibandwrite(density_prism,d_results,'bsq');
end
clear density_prism
 density_prism = 1;
end
```

depth_edit.m

```
%-------------------------------------------------------------------------------------------------------------------
%                                    Edits the depths of your grid files
%-------------------------------------------------------------------------------------------------------------------

%brian eslick 3-12-2010: script will edit the depths of grid file opened using open_grid.m

all_filtered = zeros(size(depth));

%displays your grid file
answer = 'y';
while answer =='y'
figure(1)
imagesc(depth)
display('select a zoomed view: upper left corner first/lower right second')

%important: this will be the region you smooth over your new edits.  You will select two points which
%will be the total area the filter will cover when editing.  i recomend having an area considerably larger
%than your desired edits

[x1,y1]=ginput(2); %ginput takes in your two points
cs1 = [round(x1),round(y1)]; %assigns locations to cs1

%smooth_temp will open and save the depths you just selected while temp opens a dummy matrix.
%smooth_temp will be used for display purposes temp will hold the values you will add and will be the
%matrix you will filter and add to your original depth file

for i = cs1(1,2):cs1(2,2)
   for j = cs1(1,1):cs1(2,1)
       smooth_temp(i-cs1(1,2)+1,j-cs1(1,1)+1)=depth(i,j);
   end
end

%displays your input file and the file you just cut for reference while loop: this will keep editing
%window open if you use y for yes, i.e. you answer that you want to continue editing.

display('left click to define region to edit')
figure(2)
imagesc(depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)))
colorbar
h2 = impoly;
position = wait(h2);

temp = createMask(h2);
temp_neg = (temp-1)*-1;
```

```
%allows user to select region to add, returns BW which is all ones

exact = input('would you like to set an exact elevation - y (yes) n (no)?','s');
if exact == 'y'
    exact_set = input('what depth do you want');
    temp = (temp.*exact_set)+temp_neg;

%adds the edits to depth file
depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)) = depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)).*temp;
all_filtered(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)) = depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1));
figure(3)
subplot(2,2,1)
imagesc(depth)
title('Grid with All Edits')
colorbar
subplot(2,2,2)
imagesc(depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)))
title('Zoomed Section of Previous Edits')
colorbar
subplot(2,2,3)
imagesc(all_filtered)
title('Edited Depths After Filtering')
colorbar
end

if exact == 'n'
add=input('how much do you want to add \n'); %important, in units the grid is in
temp = temp.*add;

%determines which filter to use, low pass or high pass to smooth over your edits
filter_kind = input('low pass (lp) or high pass (hp) filter? \n', 's');
if filter_kind == 'lp'
  lowpassfilter = input('what size of low pass filter do you want? \n');
  smooth_filter = ones(lowpassfilter,lowpassfilter)/(lowpassfilter^2)
            elseif filter_kind == 'hp'
               highpassfilter = input('what size of high pass filter do you want \n');
               smooth_filter = ones(highpassfilter,highpassfilter)*-1;
               smooth_filter(round(highpassfilter/2),round(highpassfilter/2))=highpassfilter^2
            else
               display('need to enter lp for low pass or hp for high pass')
            end
%applies filter
 filtered_added = imfilter(temp,smooth_filter);

 %adds the edits to depth file
depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)) = depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1))+filtered_added;
all_filtered(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1))                                         =
all_filtered(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1))+filtered_added;
```

```
%displays results
figure(3)
subplot(2,2,1)
imagesc(depth)
title('Grid with All Edits')
colorbar
subplot(2,2,2)
imagesc(depth(cs1(1,2):cs1(2,2),cs1(1,1):cs1(2,1)))
title('Zoomed Section of Previous Edits')
colorbar
subplot(2,2,3)
imagesc(all_filtered)
title('Edited Depths After Filtering')
colorbar
subplot(2,2,4)
imagesc(smooth_filter)
title('Previous Filter')
colorbar
end

answer = input('continue editing? (y for yes, n for no) \n','s')
end

%clears out variables, for use in additional edits.  from this point, you can either continue editing via
%depth_edit.m, start over with reopen_grid.m, or save progress with save_grid.m

clear smooth_temp
clear temp
clear add
clear temp_neg
clear lp
clear hope
```

g_calc.m

```
%applies calculation of density to model earth
ul_corners = ul_location_new*111;

%Reads in the basin depth files and stores them in basin_bepth
for i = 1:num_grids
blakeley_basin=[cd '\grids\' begin_string num2str(grids_for_model(i)) '.dat'];
fid=fopen(blakeley_basin);
basin_depth=fscanf(fid,'%f',[basinrows basincolumns]);%open the input DEM file, read it and stores it
in variable 'DEM'
fclose(fid)
basin_depth=basin_depth*1000;

%plots basin_depth for reference
for ii = 1:basinrows
   for jj = 1:basincolumns
      if basin_depth(ii,jj) < 0;
         basin_depth(ii,jj) = 0;
      else
         basin_depth(ii,jj) = basin_depth(ii,jj);
      end
   end
end
figure(2)
subplot(gridrows,gridcols,grids_for_model(i))
imagesc(basin_depth)
g_interval_temp = load(ul_loc)*111;


%---------------------------------------------------------------------------------------------------------------------
%                                    define depth of model
%---------------------------------------------------------------------------------------------------------------------

%to determine total depth of model in 500 m increments, divides by 500 rounds and multiply by 500

min_required = max(max(basin_depth))+500; %determines the minimum needed for model - in meters
model_depth = min_required/500;
model_depth = ceil(model_depth);
model_depth = model_depth*500;
grid_depth = ceil(model_depth/grid_interval_z); %determines how many grids in z direction
depth = grid_depth;

%------------------------ converts basin_depths to grids rounds basin depth to resolution of model
basin_depth = basin_depth/(grid_interval_z);
basin_depth = round(basin_depth)

%-------------------------------------------------------------------------
```

```
% Building the Model
%-----------------------------------------------------------------------

%creates empty matrix of 2670 or basement values
rho(1:basinrows,1:basincolumns,1:grid_depth)=0;

%defines basin component and puts in 2000 density, i.e. uses new basin depth grid matrix to define how
%deep to put density distribution defined in location_gravity_calc.m into model for computation

%k is intended to index the density distribution variable defined in location_gravity_calcs.m to vary
%how density is distributed in your surface
for k =1:dsize
for ii = 1:basinrows
   for j = 1:basincolumns
      if d_dist(k,1)/grid_interval_z == 0;%incase grid starts at 0, replaces with 1 b/c grid starts at 1
   d_dist(k,1)=1
end
      if basin_depth(ii,j) > (d_dist(k,1)/grid_interval_z)
            rho(ii,j,round((d_dist(k,1)/grid_interval_z)+1):basin_depth(ii,j))=d_dist(k,2);
      end
   end
end
end

for h = 1:numdatapoints
d_results = [cd '\densities\grid_' int2str(grids_for_model(i)) '_data_point_' int2str(gravity_location_holder(h)) '.bsq'];
density_calculated = multibandread(d_results, [basinrows basincolumns depth],'double', 0, 'bsq','ieee-le' );


g_temp = density_calculated .*rho;
g(i,h) = sum(sum(sum(g_temp)));
clear g_temp
clear density_calculated
end
clear rho
end
```

g_box.m

```
function [density_prism] = gbox(x0,y0,z0,x1,y1,z1,x2,y2,z2) %subroutine based on blakely

isign = [-1,1];
gamma = 6.67e-11;
twopi = 6.2831853;
si2mg = 1e5;
km2m = 1e3;

x(1) = x0-x1;
y(1) = y0-y1;
z(1) = z0-z1;
x(2) = x0-x2;
y(2) = y0-y2;
z(2) = z0-z2;
sum = 0;
for i =1:2
    for j = 1:2
        for k = 1:2
            r = sqrt(x(i)^2+y(j)^2+z(k)^2);
            ijk = isign(i)*isign(j)*isign(k);
            arg1 = atan2((x(i)*y(j)),(z(k)*r));
            if arg1 < 0
                arg1 = arg1+twopi;
            end
            arg2 = r+y(j);
            if arg2 <= 0
                 error('Passband edge must be larger than 0:arg2')
            end
            arg3 = r+x(i);
            if arg3 <= 0
                 error('Passband edge must be larger than 0:arg3')
            end
            arg2=log(arg2);
            arg3=log(arg3);
            sum = sum+ijk*(z(k)*arg1-x(i)*arg2-y(j)*arg3);
                end
                    end
            end

             density_prism = gamma*sum*si2mg*km2m;
            density_prism=abs(density_prism);
            end
```

gravity_dist.m

```
%-------------------------------------------------------------------------------------------------------------------------
%                                          locations for gravity calcualtions
%-------------------------------------------------------------------------------------------------------------------------

%script to handle locations for gravity calculations location files should be in x,y,z format of long and
%lat

g_l = input('which gravity location to use');

de_temp = input('depth to examine (m)');
de = ceil(de_temp/grid_interval_z);
counter = zeros(1,num_grids);
for i = 1:num_grids
column_fig(i) = rem(grids_for_model(i),gridcols);
end
column_fig2 = max(column_fig);

for i = 1:num_grids
temp(i) = (grids_for_model(i));
while temp(i) > gridcols;
   temp(i) = temp(i)-gridcols;
   counter(i) = counter(i)+1;
end
end
fig_location_vector = (counter*column_fig2)+column_fig;

ul_loc = [cd '\grids\upper_left_corners.dat'];
    uls1 = dlmread(ul_loc, '', [0, 0,total_grids-1,0]);
    uls2 = dlmread(ul_loc, '', [0, 1,total_grids-1,1]);
for i = 1:num_grids
      ul_location_new_row(i) = uls1(grids_for_model(i));
      ul_location_new_col(i) = uls2(grids_for_model(i));
  end

ul_location_new = [ul_location_new_col',ul_location_new_row'];
for i = 1:num_grids
ul_corners = ul_location_new*111;
ul_north(i) =ul_corners(i,2);
ul_east(i)=ul_corners(i,1);
end

%read in location data for gravity data
z0(1) = g_locations(g_l,3);
x0(1) = g_locations(g_l,1);
y0(1) = g_locations(g_l,2);
```

```
titling = ['Density Distribution at a depth of ' num2str(de_temp) '(m) from ' num2str(x0/111) ', ' num2str(y0/111) ', ' num2str(z0/111)];
titling2 = ['Scaled Gravity Distribution at a depth of ' num2str(de_temp) '(m) from ' num2str(x0/111) ', ' num2str(y0/111) ', ' num2str(z0/111)];
titling3 = ['Un-Scaled Gravity Distribution at a depth of ' num2str(de_temp) '(m) from ' num2str(x0/111) ', ' num2str(y0/111) ', ' num2str(z0/111)];

scrsz = get(0,'ScreenSize');
figure('Position',[scrsz(3)*.01 scrsz(4)*.05 scrsz(3)*.98 scrsz(4)*.85])
hout=suptitle(titling);
fig10 = gcf
figure('Position',[scrsz(3)*.01 scrsz(4)*.05 scrsz(3)*.98 scrsz(4)*.85])
hout=suptitle(titling2);
fig11 = gcf
figure('Position',[scrsz(3)*.01 scrsz(4)*.05 scrsz(3)*.98 scrsz(4)*.85])
hout=suptitle(titling3);
fig12 = gcf


for p = 1:num_grids
blakeley_basin=[cd '\grids\' begin_string num2str(grids_for_model(p)) '.dat'];
fid=fopen(blakeley_basin);
basin_depth=fscanf(fid,'%f',[basinrows basincolumns]);
%open the input DEM file, read it and stores it in variable 'DEM'
fclose(fid)
basin_depth=basin_depth%*-1;%turns to positive to enter in z vectors
basin_depth=basin_depth*1000;
basin_depth2 = basin_depth;

g_interval_temp = load(ul_loc)*111;
grid_interval_r = ([g_interval_temp(1,1)-g_interval_temp(gridcols+1,1)]*1000)/basinrows;
grid_interval_c = ([g_interval_temp(2,2)-g_interval_temp(1,2)]*1000)/basincolumns;

%------------------------------------------------------------------------------------------------------------------
%                                              define depth of model
%------------------------------------------------------------------------------------------------------------------

%to determine total depth of model in 500 m increments, divides by 500 rounds and multiply by 500
min_required = max(max(basin_depth)); %determines the minimum needed for model
model_depth = min_required/500;
model_depth = ceil(model_depth);
model_depth = model_depth*500;
grid_depth = ceil(model_depth/grid_interval_z); %determines how many grids in z direction

%------------------------ converts basin_depths to grids rounds basin depth to resolution of model
basin_depth = basin_depth/(grid_interval_z);
basin_depth = round(basin_depth);
basin_depth = basin_depth;
```

```
%------------------------------------------------------------------------
% Building the Model
%------------------------------------------------------------------------

%creates empty matrix of 2670 or basement values
rho(1:basinrows,1:basincolumns,1:grid_depth)=0;
%defines basin component and puts in 2000 density, i.e. uses new basin
%depth grid matrix to define how deep to put density distribution defined
%in location_gravity_calc.m into model for computation

%k is intended to index the density distribution variable defined in
%location_gravity_calcs.m to vary how density is distributed in your
%surface
for k =1:dsize
for i = 1:basinrows
   for j = 1:basincolumns
      if d_dist(k,1)/grid_interval_z == 0;%incase grid starts at 0, replaces with 1 b/c grid starts at 1
   d_dist(k,1)=1;
end
      if basin_depth2(i,j) > (d_dist(k,1)/grid_interval_z);
            rho(i,j,round((d_dist(k,1)/grid_interval_z)+1):basin_depth(i,j))=d_dist(k,2);
      end
   end
end
end

%define size of model for later
[size_northing, size_easting, depth] = size(rho);

%converts grid_interval to define depths of grid
grid_interval_r = grid_interval_r/1000;
grid_interval_z = grid_interval_z/1000;
grid_interval_c = grid_interval_c/1000;
for i = 1:grid_depth
z1(i) = (i*grid_interval_z-grid_interval_z);
z2(i) = (i*grid_interval_z);
end

%------------------------------------------------------------------------
% Determining Location of grid
%------------------------------------------------------------------------

%using if statements to determine location rather than radious vectors

%--------------upper right hand quadrant----------------------------------
if (ul_north(p) > y0(1)) & (ul_east(p) > x0(1))
for x_change = 1:size_easting
  x1(x_change) = (ul_east(p) + grid_interval_c*x_change-grid_interval_c);
```

```
   x2(x_change) = (ul_east(p) + grid_interval_c*x_change);
end
for y_change = 1:size_northing
   y2(y_change) = ul_north(p) - grid_interval_r*y_change+grid_interval_r;
   y1(y_change) = ul_north(p) - grid_interval_r*y_change;
end


%----------------upper left hand quadrant----------------------------------
else if (ul_north(p) > y0(1)) & (ul_east(p) < x0(1))
 for x_change = 1:size_easting
  x2(x_change) = (ul_east(p) + (grid_interval_c*x_change)-grid_interval_c);
   x1(x_change) = (ul_east(p) + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y2(y_change) = (ul_north(p) - grid_interval_r*y_change+grid_interval_r);
    y1(y_change) = (ul_north(p) - grid_interval_r*y_change);
end

%----------------lower right hand quadrant---------------------------------
else if (ul_north(p) < y0(1)) & (ul_east(p) > x0(1))
for x_change = 1:size_easting
    x1(x_change) = (ul_east(p) + grid_interval_c*x_change-grid_interval_c);
    x2(x_change) = (ul_east(p) + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y1(y_change) = (ul_north(p) - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north(p) - grid_interval_r*y_change);
end

%----------------lower left hand quadrant----------------------------------
else if (ul_north(p) < y0(1)) & (ul_east(p) < x0(1))
for x_change = 1:size_easting
   x1(x_change) = (ul_east(p) + grid_interval_c*x_change-grid_interval_c);
   x2(x_change) = (ul_east(p) + grid_interval_c*x_change);
end
for y_change = 1:size_northing
    y1(y_change) = (ul_north(p) - grid_interval_r*y_change+grid_interval_r);
    y2(y_change) = (ul_north(p) - grid_interval_r*y_change);
end
    end
    end
    end
end

%-----------------------------------------------------------------------
% Sending location and density info to gbox calcualtions
%-----------------------------------------------------------------------
```

```
for i = 1:size_easting
   for j = 1:size_northing
               [gravity_prism(i,j)] = gbox(x0(1),y0(1),z0(1),x1(i),y1(j),z1(k),x2(i),y2(j),z2(k),rho(j,i,de));
end
end

clim=[1e-10 1e-4];
clim2=[0 d_dist(dsize,2)];
 figure(fig10)
 subplot(ceil(grids_for_model(num_grids)/gridcols),column_fig2,fig_location_vector(p))
imagesc(rho(:,:,de), clim2)

   figure(fig11)
   subplot(ceil(grids_for_model(num_grids)/gridcols),column_fig2,fig_location_vector(p))
     imagesc(gravity_prism(:,:)', clim)

   figure(fig12)
   subplot(ceil(grids_for_model(num_grids)/gridcols),column_fig2,fig_location_vector(p))
     imagesc(gravity_prism(:,:)')

clear grid_depth
grid_interval_z = grid_interval_z *1000;
clear gravity_prism
end
figure(fig11)
colorbar
figure(fig10)
colorbar
```

load_depth_edit.m

```
%------------------------------------------------------------------------
%                    opens the location of grid
%------------------------------------------------------------------------
%brian eslick 3-12-2010: script will open the location of grid files in order to edit depths.
%script is designed to enter locations once to save in matlabs variables for use by other programs

%------------------------------------------------------------------------
%                     locations for depth editing
%------------------------------------------------------------------------
grid_loc = [cd '\grids\xxx.dat'];
```

load_g_calc.m

```
%-------------------------------------------------------------------------
%                  locations for gravity calcualtions
%-------------------------------------------------------------------------
%script to handle locations for gravity calculations location files should be in x,y,z format of long and
%lat

gravity_locations=[cd '\gravity_files\gravity_location.dat'];
g_locations_temp = load(gravity_locations);
g_locations=g_locations_temp(:,1:3)*111;%multiply by 111 to transform from lat/long to km
[numdatapoints, numcolumns] = size(g_locations);
gravity_location_holder = g_locations_temp(:,4);

begin_string = input('what is the file name of your grids, ex: blakely_basin_grid \n', 's');
total_grids = input('how many subgrids are there \n');
basinrows= input('how many rows in your grid files \n');    %tells matlab how many rows
basincolumns=input('how many columns in your grid files \n');        % tells matlab how many collumns
gridrows = input('how many rows of grids \n');
gridcols = input('how many colums of grids \n');
clim1 = input('what is the max depth of basin [ex: -12000 for 12 km] \n');
clim2 = input('what is the min depth of basin [ex: 0 for 0 km] \n');
clim = [clim1 clim2];

grids_for_model_string = input('which grid numbers would you like to incorporate into the model, ex:
1,2,3 \n', 's');
grids_for_model = [str2num(grids_for_model_string)];
clear grids_for_model_string
[n,num_grids] = size(grids_for_model);

grid_interval_z = 50;
ul_loc = [cd '\grids\upper_left_corners.dat'];
    uls1 = dlmread(ul_loc, '', [0, 0,total_grids-1,0]);
    uls2 = dlmread(ul_loc, '', [0, 1,total_grids-1,1]);
for i = 1:num_grids
      ul_location_new_row(i) = uls1(grids_for_model(i));
      ul_location_new_col(i) = uls2(grids_for_model(i));
  end

  ul_location_new = [ul_location_new_col',ul_location_new_row'];

 d_dist_str = input('input density distribution [depth (m), density (kg/m^3)], ex: 0,2000;200,4000 for 0-
200 = 2000 and > 200 = 4000 \n', 's');
d_dist = [str2num(d_dist_str)];
 [dsize,h]=size(d_dist);
  for i = 1:num_grids
blakeley_basin=[cd '\grids\' begin_string num2str(grids_for_model(i)) '.dat'];
```

```
fid=fopen(blakeley_basin);
basin_depth=fscanf(fid,'%f',[basinrows basincolumns]);
%open the input DEM file, read it and stores it in variable 'DEM'
fclose(fid);
basin_depth=basin_depth;%turns to positive to enter in z vectors
basin_depth=basin_depth*1000;

%plots basin_depth for reference
figure(1);
subplot(gridrows,gridcols,grids_for_model(i));
imagesc(basin_depth, clim);
end
```

make_dir.m

```
%------------------------------------------------------------------------------------------------------------------------
%                                                 Creates subdirectories for output files
%-----------------------------------------------------------------------------------------------------------------------

%brian eslick: 3-21-2010; script will create subfolders in working folder
[s, mess, messid] = mkdir(cd, 'gravity_files')
[s, mess, messid] = mkdir(cd, 'grids')
[s, mess, messid] = mkdir(cd, 'results')
```

open_grid.m

```
%-------------------------------------------------------------------------------------------------------------------------
%                                        Open the Grid File to Edit
%-------------------------------------------------------------------------------------------------------------------------

%brian eslick 3-12-2010: script will open a .dat file for grid cut by cut_grid.m file in order to edit depths

c = input('how many columns in your grid \n');
r = input('how many rows in your grid \n');
pat = 'x(\w*)x';
gopen = input('what grid would you like to edit \n','s');%gopen records your desired grid
basin_depth = regexprep(grid_loc, pat, gopen);

%assigns your grid to the variable depth
fid=fopen(basin_depth);
depth=fscanf(fid,'%f',[r c]);%open the input DEM file, read it and stores it in variable 'DEM'
fclose(fid)

%displays your grid file
figure(1)
imagesc(depth)
title(gopen)
colorbar
```

reopen_grid.m

```
%------------------------------------------------------------------------------------------------------------------
%                                          reopen grid
%------------------------------------------------------------------------------------------------------------------

%brian eslick 3-12-2010: scipt will reopen the grid opened by open_grid.m in order to restart changes
%made prior to saving with save_grid.m
fid=fopen(basin_depth);
depth=fscanf(fid,'%f',[c r]);%open the input DEM file, read it and stores it in variable 'DEM'
fclose(fid)

%displays your grid file
figure(1)
imagesc(depth)
```

save_grid.m

```
%----------------------------------------------------------------------------------------------------------------------
%                                     save the Grid File to Edit
%----------------------------------------------------------------------------------------------------------------------

%brian eslick 3-12-2010: script will save the current grid you are workig on as a .dat file
sgrid = input('name to save your grid \n' , 's');
pat = 'x(\w*)x';
output_grid = regexprep(grid_loc, pat, sgrid);

fid=fopen(output_grid, 'w');
 fprintf(fid,'%6.5f \n', depth);
fclose(fid);
```

suplabel.m

```
function [ax,h]=suplabel(text,whichLabel,supAxes)
% PLaces text as a title, xlabel, or ylabel on a group of subplots.
% Returns a handle to the label and a handle to the axis.
%  [ax,h]=suplabel(text,whichLabel,supAxes)
% returns handles to both the axis and the label.
%  ax=suplabel(text,whichLabel,supAxes)
% returns a handle to the axis only.
%  suplabel(text) with one input argument assumes whichLabel='x'
% whichLabel is any of 'x', 'y', 'yy', or 't', specifying whether the
% text is to be the xlable, ylabel, right side y-label,
% or title respectively
% supAxes is an optional argument specifying the Position of the
%  "super" axes surrounding the subplots.
%  supAxes defaults to [.08 .08 .84 .84]
%  specify supAxes if labels get chopped or overlay subplots
% EXAMPLE:
%  subplot(2,2,1);ylabel('ylabel1');title('title1')
%  subplot(2,2,2);ylabel('ylabel2');title('title2')
%  subplot(2,2,3);ylabel('ylabel3');xlabel('xlabel3')
%  subplot(2,2,4);ylabel('ylabel4');xlabel('xlabel4')
%  [ax1,h1]=suplabel('super X label');
%  [ax2,h2]=suplabel('super Y label','y');
%  [ax3,h2]=suplabel('super Y label (right)','yy');
%  [ax4,h3]=suplabel('super Title'  ,'t');
%  set(h3,'FontSize',30)
%
% SEE ALSO: text, title, xlabel, ylabel, zlabel, subplot,
%           suptitle (Matlab Central)
% Author: Ben Barrowes <barrowes@alum.mit.edu>
%modified 3/16/2010 by IJW to make axis behavior re "zoom" on exit same as
%at beginning. Requires adding tag to the invisible axes

currax=findobj(gcf,'type','axes','-not','tag','suplabel');
if nargin < 3
 supAxes=[.08 .08 .84 .84];
 ah=findall(gcf,'type','axes');
if ~isempty(ah)
  supAxes=[inf,inf,0,0];
  leftMin=inf;  bottomMin=inf;  leftMax=0;  bottomMax=0;
  axBuf=.04;
  set(ah,'units','normalized')
  ah=findall(gcf,'type','axes');
  for ii=1:length(ah)
   if strcmp(get(ah(ii),'Visible'),'on')
    thisPos=get(ah(ii),'Position');
    leftMin=min(leftMin,thisPos(1));
```

```
    bottomMin=min(bottomMin,thisPos(2));
    leftMax=max(leftMax,thisPos(1)+thisPos(3));
    bottomMax=max(bottomMax,thisPos(2)+thisPos(4));
   end
  end
  supAxes=[leftMin-axBuf,bottomMin-axBuf,leftMax-leftMin+axBuf*2,bottomMax-
bottomMin+axBuf*2];
 end
end
if nargin < 2, whichLabel = 'x';  end
if nargin < 1, help(mfilename); return; end

if ~isstr(text) | ~isstr(whichLabel)
  error('text and whichLabel must be strings')
end
whichLabel=lower(whichLabel);

ax=axes('Units','Normal','Position',supAxes,'Visible','off','tag','suplabel');
if strcmp('t',whichLabel)
  set(get(ax,'Title'),'Visible','on')
  title(text);
elseif strcmp('x',whichLabel)
  set(get(ax,'XLabel'),'Visible','on')
  xlabel(text);
elseif strcmp('y',whichLabel)
  set(get(ax,'YLabel'),'Visible','on')
  ylabel(text);
elseif strcmp('yy',whichLabel)
  set(get(ax,'YLabel'),'Visible','on')
  ylabel(text);
  set(ax,'YAxisLocation','right')
end

for k=1:length(currax), axes(currax(k));end % restore all other axes
if (nargout < 2)
  return
end
if strcmp('t',whichLabel)
  h=get(ax,'Title');
  set(h,'VerticalAlignment','middle')
elseif strcmp('x',whichLabel)
  h=get(ax,'XLabel');
elseif strcmp('y',whichLabel) | strcmp('yy',whichLabel)
  h=get(ax,'YLabel');
end

%%%ah=findall(gcf,'type','axes');
%%%'sssssssss',kb
```

suptitle.m

```
function hout=suptitle(str)
%SUPTITLE Puts a title above all subplots.
%	SUPTITLE('text') adds text to the top of the figure
%	above all subplots (a "super title"). Use this function
%	after all subplot commands.

% Drea Thomas 6/15/95 drea@mathworks.com

% Warning: If the figure or axis units are non-default, this will break.

% Parameters used to position the supertitle.
% Amount of the figure window devoted to subplots
plotregion = .65;

% Y position of title in normalized coordinates
titleypos  = .95;

% Fontsize for supertitle
fs = get(gcf,'defaultaxesfontsize')+4;

% Fudge factor to adjust y spacing between subplots
fudge=1;

haold = gca;
figunits = get(gcf,'units');

% Get the (approximate) difference between full height (plot + title
% + xlabel) and bounding rectangle.

	if (~strcmp(figunits,'pixels')),
		set(gcf,'units','pixels');
		pos = get(gcf,'position');
		set(gcf,'units',figunits);
	else,
		pos = get(gcf,'position');
	end
	ff = (fs-4)*1.27*5/pos(4)*fudge;

      % The 5 here reflects about 3 characters of height below
      % an axis and 2 above. 1.27 is pixels per point.

% Determine the bounding rectange for all the plots

% h = findobj('Type','axes');

% findobj is a 4.2 thing.. if you don't have 4.2 comment out
```

```
% the next line and uncomment the following block.

h = findobj(gcf,'Type','axes');  % Change suggested by Stacy J. Hills

% If you don't have 4.2, use this code instead
%ch = get(gcf,'children');
%h=[];
%for i=1:length(ch),
%  if strcmp(get(ch(i),'type'),'axes'),
%    h=[h,ch(i)];
%  end
%end

max_y=0;
min_y=1;
oldtitle =0;
for i=1:length(h),
	if (~strcmp(get(h(i),'Tag'),'suptitle')),
		pos=get(h(i),'pos');
		if (pos(2) < min_y), min_y=pos(2)-ff/5*3;end;
		if (pos(4)+pos(2) > max_y), max_y=pos(4)+pos(2)+ff/5*2;end;
	else,
		oldtitle = h(i);
	end
end

if max_y > plotregion,
	scale = (plotregion-min_y)/(max_y-min_y);
	for i=1:length(h),
		pos = get(h(i),'position');
		pos(2) = (pos(2)-min_y)*scale+min_y;
		pos(4) = pos(4)*scale-(1-scale)*ff/5*3;
		set(h(i),'position',pos);
	end
end
np = get(gcf,'nextplot');
set(gcf,'nextplot','add');
if (oldtitle),
	delete(oldtitle);
end
ha=axes('pos',[0 1 1 1],'visible','off','Tag','suptitle');
ht=text(.5,titleypos-1,str);set(ht,'horizontalalignment','center','fontsize',fs);
set(gcf,'nextplot',np);
axes(haold);
if nargout,
	hout=ht;
end
```

suptitle2.m

```
function hout=suptitle2(str)
%SUPTITLE Puts a title above all subplots.
%	SUPTITLE('text') adds text to the top of the figure
%	above all subplots (a "super title"). Use this function
%	after all subplot commands.

% Drea Thomas 6/15/95 drea@mathworks.com

% Warning: If the figure or axis units are non-default, this
% will break.

% Parameters used to position the supertitle.

% Amount of the figure window devoted to subplots
plotregion = .92;
% Y position of title in normalized coordinates
titleypos  = .95;
% Fontize for supertitle
fs = get(gcf,'defaultaxesfontsize')+4;

% Fudge factor to adjust y spacing between subplots
fudge=1;
haold = gca;
figunits = get(gcf,'units');

% Get the (approximate) difference between full height (plot + title
% + xlabel) and bounding rectangle.

	if (~strcmp(figunits,'pixels')),
		set(gcf,'units','pixels');
		pos = get(gcf,'position');
		set(gcf,'units',figunits);
	else,
		pos = get(gcf,'position');
	end
	ff = (fs-4)*1.27*5/pos(4)*fudge;

       % The 5 here reflects about 3 characters of height below
       % an axis and 2 above. 1.27 is pixels per point.

% Determine the bounding rectange for all the plots

% h = findobj('Type','axes');

% findobj is a 4.2 thing.. if you don't have 4.2 comment out
% the next line and uncomment the following block.
```

```
h = findobj(gcf,'Type','axes');  % Change suggested by Stacy J. Hills

% If you don't have 4.2, use this code instead
%ch = get(gcf,'children');
%h=[];
%for i=1:length(ch),
%  if strcmp(get(ch(i),'type'),'axes'),
%    h=[h,ch(i)];
%  end
%end

max_y=0;
min_y=1;

oldtitle =0;
for i=1:length(h),
	if (~strcmp(get(h(i),'Tag'),'suptitle')),
		pos=get(h(i),'pos');
		if (pos(2) < min_y), min_y=pos(2)-ff/5*3;end;
		if (pos(4)+pos(2) > max_y), max_y=pos(4)+pos(2)+ff/5*2;end;
	else,
		oldtitle = h(i);
	end
end

if max_y > plotregion,
	scale = (plotregion-min_y)/(max_y-min_y);
	for i=1:length(h),
		pos = get(h(i),'position');
		pos(2) = (pos(2)-min_y)*scale+min_y;
		pos(4) = pos(4)*scale-(1-scale)*ff/5*3;
		set(h(i),'position',pos);
	end
end

np = get(gcf,'nextplot');
set(gcf,'nextplot','add');
if (oldtitle),
	delete(oldtitle);
end
ha=axes('pos',[0 1 1 1],'visible','off','Tag','suptitle');
ht=text(.5,titleypos-1,str);set(ht,'horizontalalignment','center','fontsize',fs);
set(gcf,'nextplot',np);
axes(haold);
if nargout,
	hout=ht;
end
```

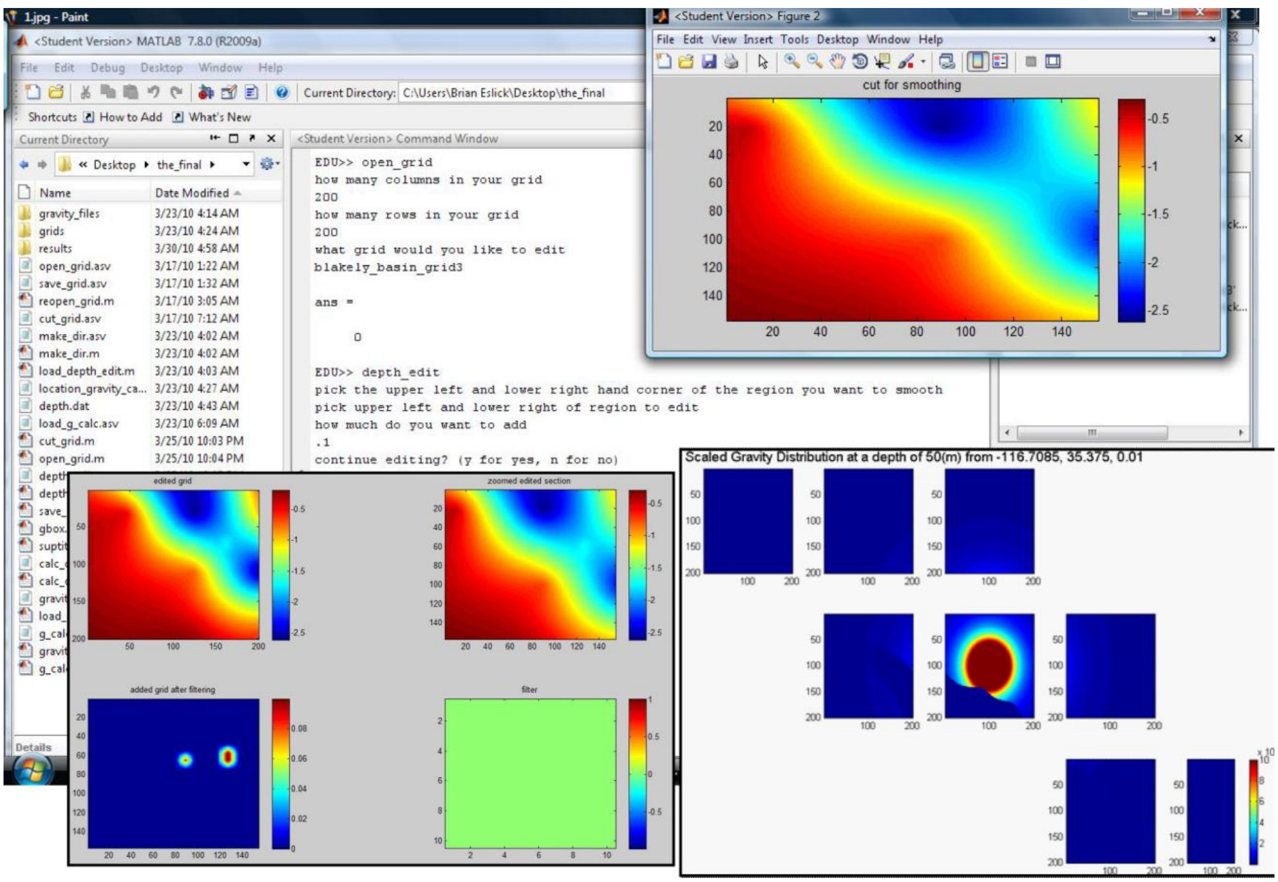
Appendix B: User's Guide

BAGC.m

Three Dimensional Gravity Modeling Software

User's Guide

Version 1.0



Brian E. Eslick

University of Texas El Paso (UTEP)

I: Introduction

BAGC.m is a three-dimensional (3D) surface grid based program which calculates the vertical gravitational attraction of user defined density distributions. BAGC.m is comprised of fifteen (15) functions and subroutines that import, crop, and edit gridded (x,y,z .dat format) surface files, define density to depth relationships, and calculate gravitational attraction entirely within the MATLAB ® environment. Though, some visualization is provided using MATLAB® built in plotting functions, I recommend exporting grid files to produce publishable figures within another software package. The software maintains full 3D flexibility with no along strike or gradient restrictions. Version 1.0 was developed to provide forward modeling of the Southern Death Valley Fault Zone making it readily adaptable to basin modeling. Modifications will need to be incorporated to define finite bodies and lateral variations in density.

This user's guide accompanies a thesis by Eslick (2010) titled 3D gravity modeling of the Southern Death Valley Fault Zone. It is intended to provide an overview of the functionality of BAGC.m and should not be used as an instructional tool for 3D gravity modeling. The user guide integrates theoretical background behind the software with instructions for use. For those familiar with 3D prism style gravity modeling, flow charts are provided which outline the implementation of the software.

BAGC.m has been written using MATLAB® version 7.8.0. I have attempted to use raw programming language where available, however, some built in functions have been employed which may not operate on earlier versions.

II: Modeling Concepts

Computational Methods

The computational algorithm at the core of BAGC.m is a modification Blakely's (1995) Fortran 77 subroutine (gbox) which defines the gravitational contribution of a single 3D prism with respect to its size, location, and density. The analytical solution for the 3D prism was derived by Plouff in 1966. BAGC.m allows users to construct complex earth models and calculate their gravitational attraction by defining density distributions for multiple prisms, registering their location, and determining distance from gravity stations. The gravity anomaly at each point of observation is the sum of the individual anomaly contributions of all the grid cells in the model (Figure 1). Because this method linearizes computation, it allows users to:

- define geologic earth models without spatial/density restrictions,
- examine how gravitational attraction varies spatially
- shorten computation time by introducing parallel processing techniques

limitations of this method:

- observations cannot be placed at prism edges due to floating point NaN
- computationaly expensive and time consuming
- introduces round off error for grids with gravity values below MATLAB® significant digits (1e-9) [see uncertainty and error]

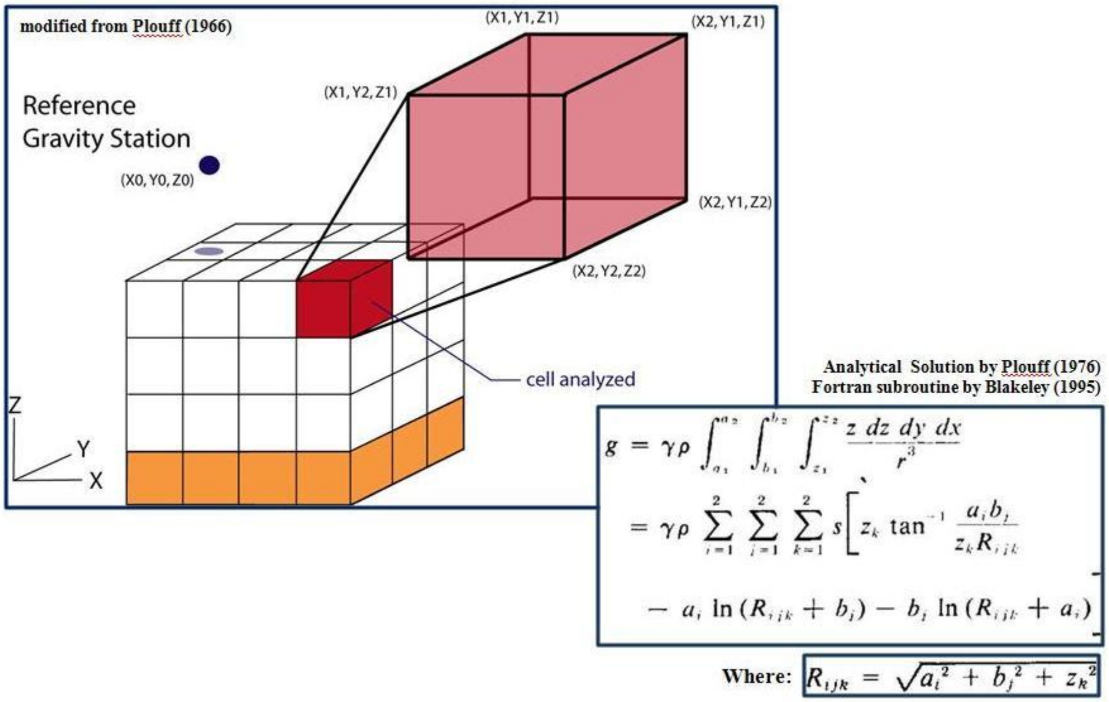


Figure A.1: Computational Method for BAGC.m. The vertical gravitational attraction of prisms which comprise of user defined densities are determined and summed

Model Development

Model creation and editing is performed in two dimensions using depth to surface grid files. This allows users to incorporate surfaces from gridding programs including Goldensoftware's Surfer ® as well as export edited files to visualization software such as Fledermaus®. In addition, this method reduces computation expense during model editing and allows for large grid files to be separated into smaller subgrids in order to improve model resolution. A detailed discussion of importing grid files is provided as cutting grids within Getting Started. Surface grid files are transformed to 3D density distributions within the computation phase of the program (Figure 2).

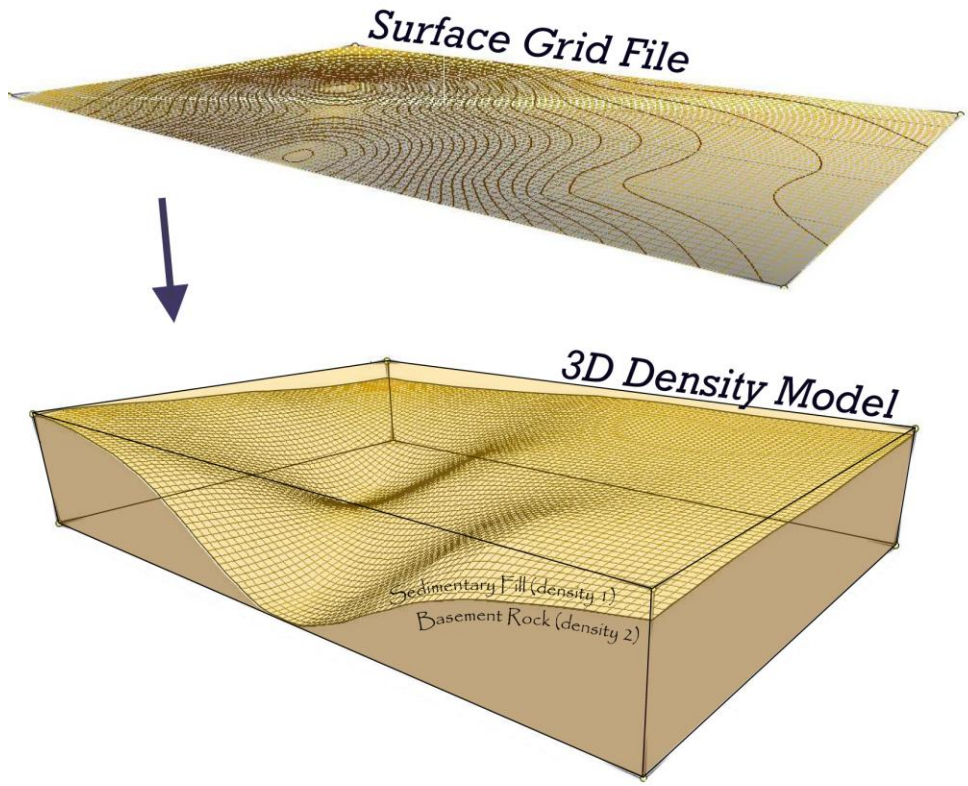


Figure A.2: Transformation of 2D Depth to Interface File to 3D Density Distribution

Workflow

BAGC.m uses a command line interface comprised of MATLAB ® script files with the exception of model editing which incorporates elements of a graphical user interface to define regions of interest. Workflow within BAGC.m is partitioned into three working environments which manipulate different aspects of gravity modeling (figure 3):

- ***Defining Directories/Creating Subgrids***: creates directories and crops large surface grid files into smaller subgrids.
- ***Model Editing:*** edits geometry of model (surface depth files),

- ***Gravity Computation:*** define density to depth relationship, compute gravity anomaly, and examine spatial distribution of anomalies.

The three working environments are initiated by running their corresponding loading functions which import locations of .dat files into variables within MATLAB®.

- ***Defining Directories/Creating Subgrids***: make_dir.m
- ***Model Editing:*** load_depth_edit.m
- ***Gravity Computation:*** load_gravity_calc.m

Working environments are designed to operate independently of one another; failure to reference loading functions will result in errors. A detailed description of each working environment is provided in subsequent sections.

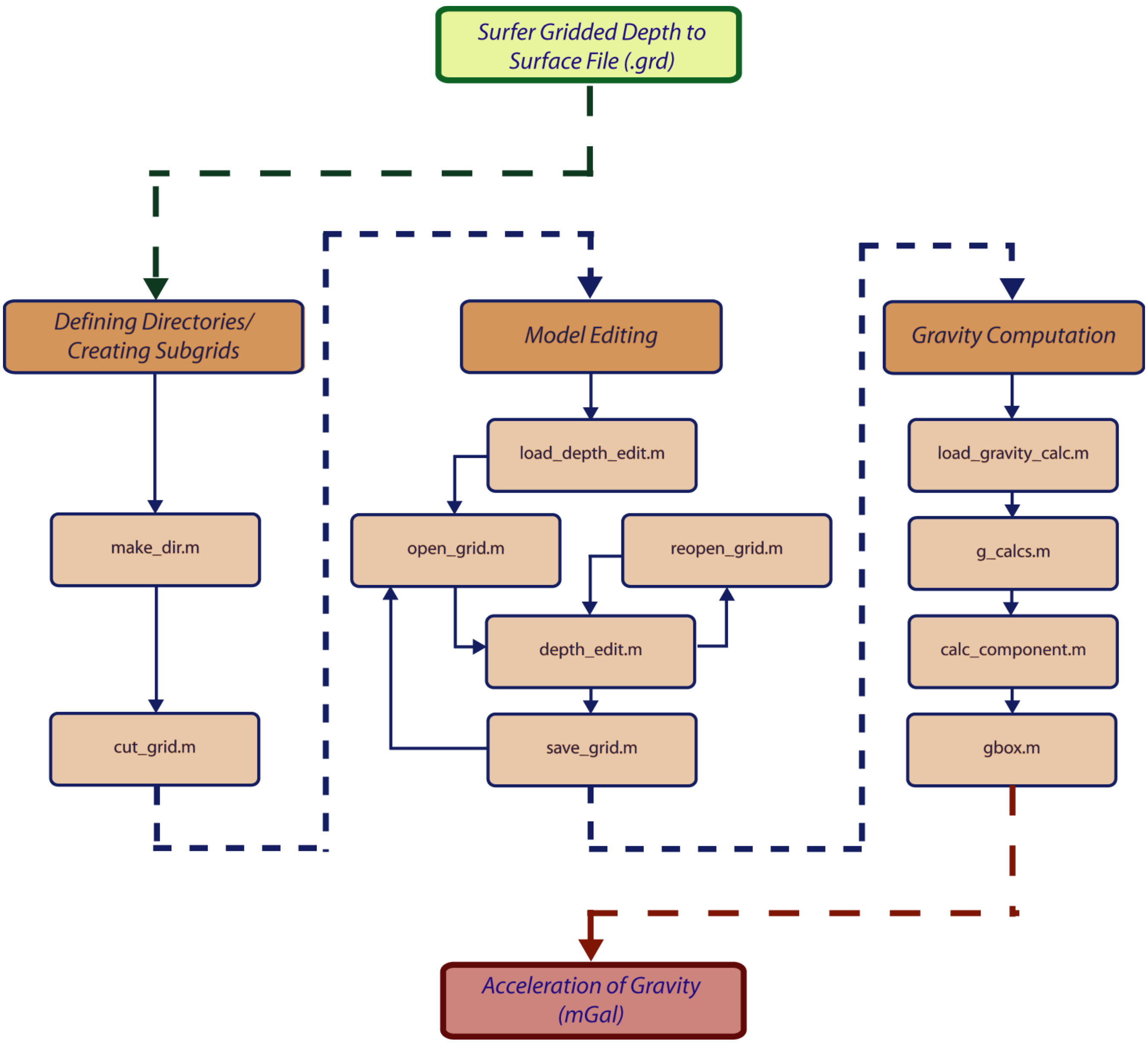


Figure A.3: Generalized Flow Chart of Primary Files for BAGC.m
(note: subroutines and visualization files may not be incorporated)
Imported data into MATLAB® scripts in green with a dashed line
Output data files from MATLAB® in red with a dashed line
Communication between script files (solid) and between working environments (dashed) blue line

Computational Units

BAGC.m combines both the Centimeter-Gram-Second (cgs) and the International System of Units (SI) for computation of gravity anomalies (Table 1). I do not recommend editing script files to incorporate a different set of computational units. Where available, user prompts include computational units requested.

Table B.1: BAGC.m Computational Units	
Grid Interval	meters
Surface Grid Files	km
Gravitational Attraction	mGal
Observational Location	latitude, longitude, elevation (m)
Output Files	km
gbox Calculations	km
Density	kg/m^3

Uncertainty and Error

The following is an introductory discussion intended to provide users with a guide to controlling error and uncertainly for earth models using BAGC.m software. A detailed analysis as well as theoretical background is provided in Eslick (2010). Error was constrained by calculating the gravitational attraction of a finite sphere using BAGC.m at distances of 0, 0.1, 0.5, 1, 2.5, 5, and 10 km and comparing the results with the analytical solution defined by Griffiths and King (1981). A finite sphere of radius of 4.5 km with varying density and distance was selected because it maximizes error in all directions. Four metrics were considered:

- Grid resolution - how small do prisms need to be to achieve acceptable error
- Vertical distance above structures – how does error vary with distance from sphere
- Structure size – how does size affect error
- Density Contrast – how much variance between structures is required

In general, error varies spatially (figure 4) with a maximum at structure boundaries (edge effect), minimum directly over center, and becomes asymptotic away from the structure. Though the location of observation points (vertical distance above structures) cannot be controlled, resolution, size, and density

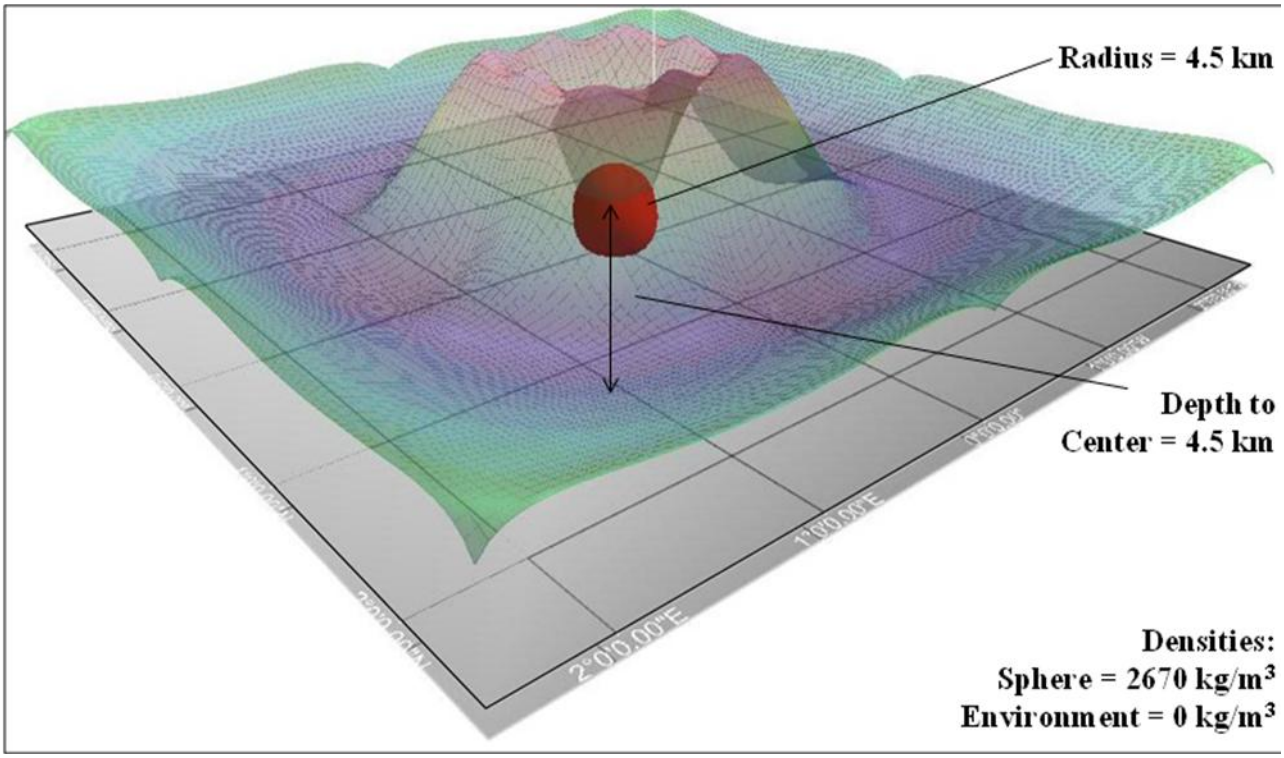


Figure A.4: Error vx. Distance from Finite Sphere with Radius of 4.5 km and Density Contrast of 2670 kg/m^3 Resolution = 0.03 km (0.6% Sphere Size)

contrast of modeled structures can be modified to minimize error. In order to achieve optimum performance, error can be controlled by subdividing it into two categories:

- Resolution: size of individual prisms needs to be 0.6% the size of structures to obtain errors less than 0.6%
- Round off error: structure size, density contrast, and distance introduce round off error due to limited significant digits carried by MATLAB® (1E-9)

Resolution

Error associated with resolution is analogous to pixilation effects in digital photography (figure 5). Pixilation is caused when curved surfaces are approximated using square pixels. In order to provide a better quality representation of an object, photographers increase the resolution or number of grids per area ('mega pixels") to a level which is finer than the desired view. Low resolution images (Figure 5 – Panel A) have regions which either overlap or are not included in the curved objects resulting in a blurring of the image. In the 3D prism method employed by BAGC.m, models with limited resolution have areas of added or missing mass resulting in improper estimation of gravitational attraction (Figure 5 – Panel B). In order to provide a better estimate, the user can increase the resolution of the earth model to a level smaller then the desired gravitation error. Increases in resolution have the disadvantage of increasing the amount of computations required for a solution. For a sphere, the increase in computations is at a rate of [(2 x radius)/resolution] ^{3} (figure 6). Computational increases for earth models are a function of both horizontal and vertical resolution. Horizontal resolution is defined by spacing of input grids while vertical resolution is user defined within the BAGC.m software. Initial tests using a 2.0 GHz processor with 1 GB of RAM stalled for models with > 27,000,000 computations.

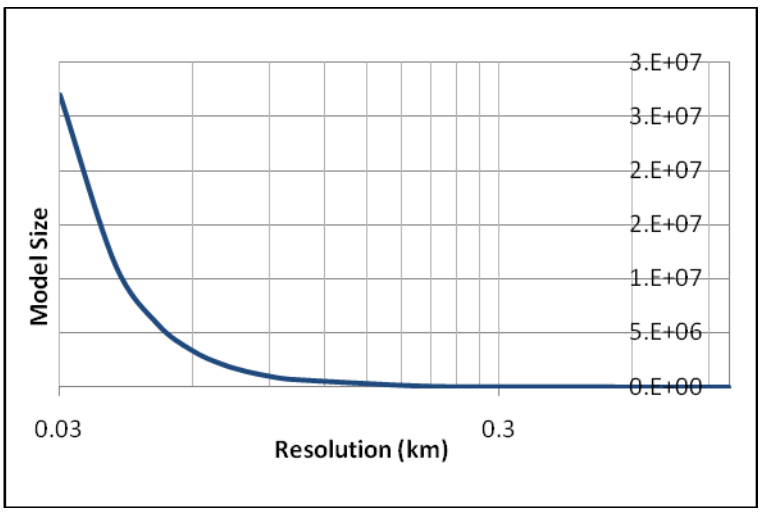


Figure A.6: Increase in Computation with Decreasing Sample Interval

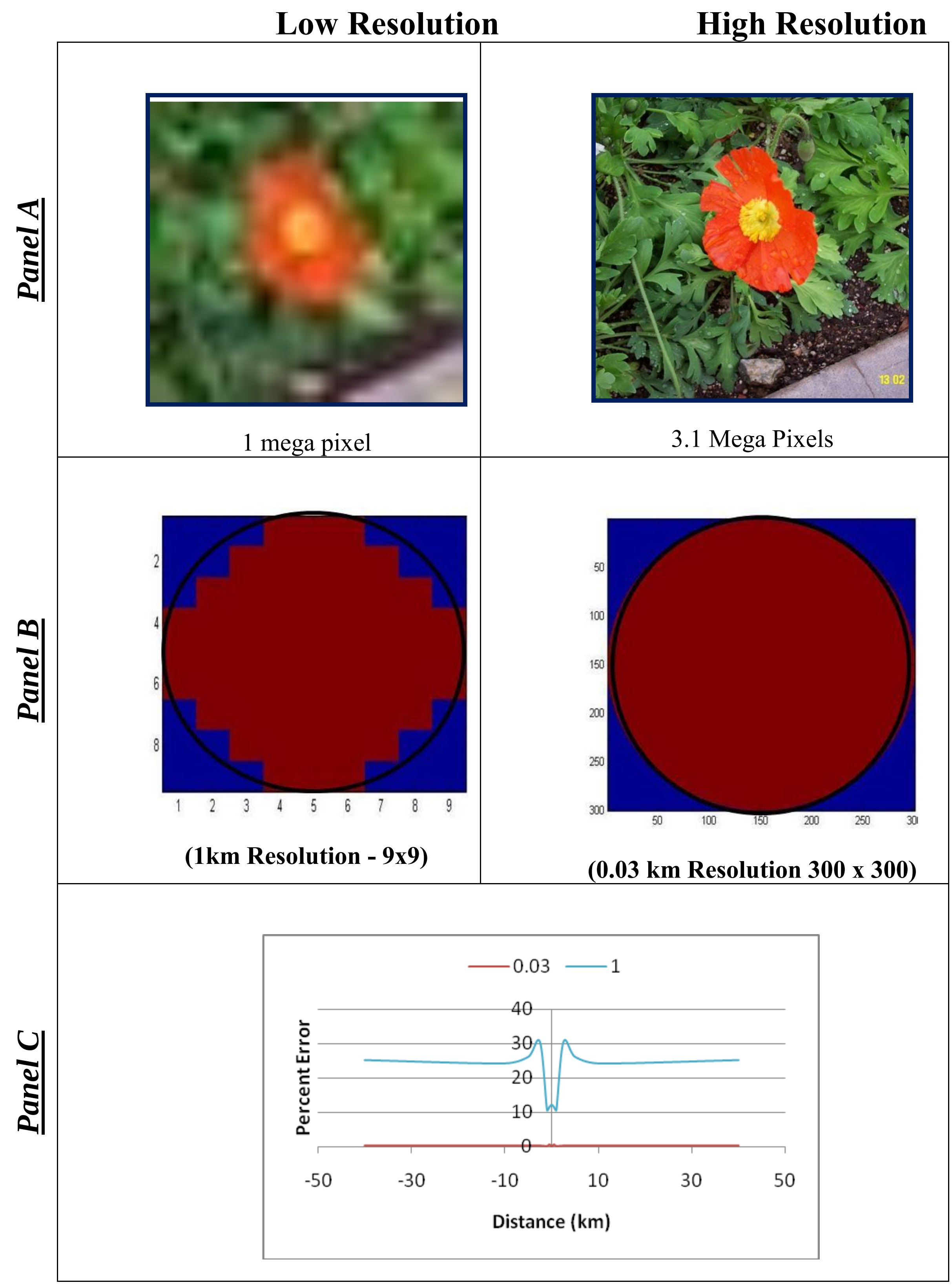


Figure A.5: Comparison of Digital Photography (panel A) to Model Resolution (panel B) and Variation between BAGC.m and Analytical Solution for a Sphere of Radius 4.5 km with a Density Contrast of 2670 kg/m^3

A resolution analysis of BAGC.m was conducted using grid sizes ranging from 0.03 km (27,000,000 computations) to 1 km (729 computations). In order to achieve errors less than 0.6% for all distances, the recommended minimum resolution must be less than 0.6% the size of the modeled structure (Figure 7). For a 10 km wide basin with a maximum depth of 1 km, model resolution must be smaller than 60 m or 167 x 167 x 17 resulting in 474,113 computations.

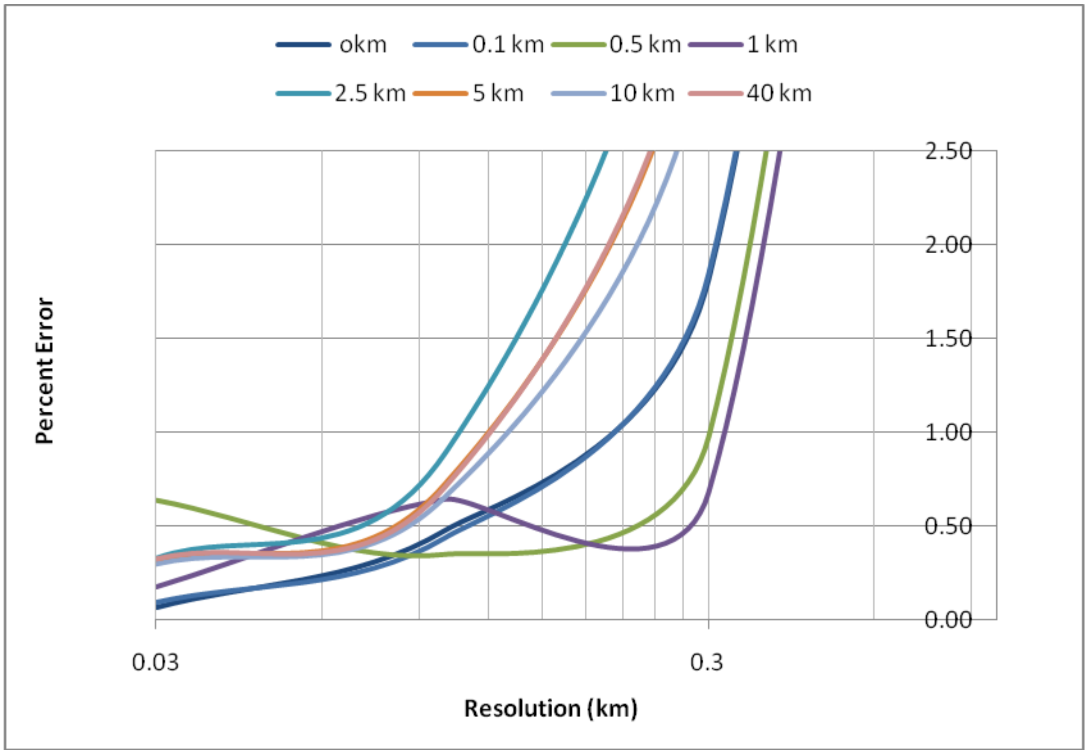


Figure A.7: Percent Error vs. Grid Resolution
Lines represent distances from center of sphere

Significant Digits and Round off Error

The primary limitation to the linearization of computations is round off error. Round off error results when the contribution of an individual prism is less than the maximum significant digits carried by MATLAB®. MATLAB® limits double precision floating point variables to 64 total bits (11 exponent bits). The contribution of an individual prism is a convolution of input parameters for the core algorithm gbox.m, i.e. prism size, density, and distance from the observational point. In order to

identify and control round off error, BAGC.m allows users to forward model potential earth models using sphere.m. Sphere.m creates a finite sphere of varying depth, density, and size, determines its gravitational attraction, and compares results to the analytical solution. Initial testing to characterize the

Table B.2: General Modeling Using sphere.m

Tested Metric	*Size (km)*	*Density Contrast (kg/m^3)*	*Vertical Distance (km)*
Structure size	0.002 to 4.5	2670	0.00001
Vertical Distance	4.5	2670	0.00001 to 40
Density Contrast	4.5	2670e-14 to 2670	0.00001

general solution space of round off error was conducted by varying parameters (table 2) independently of one another. However, individual earth models are a convolution of all variables. In order to properly define their error solution space, forward modeling using a combination of all parameters must be conducted.

Structure Size

Error associated with increasingly small structures can be minimized by employing increasingly smaller grid spacing. However, an infinitely small structure requires an infinitely and unfeasibly small grid size to prevent an increase in error. In order to define the minimum resolvable structure, spheres ranging from 2 meters to 4.5 km were generated, their gravitational contribution

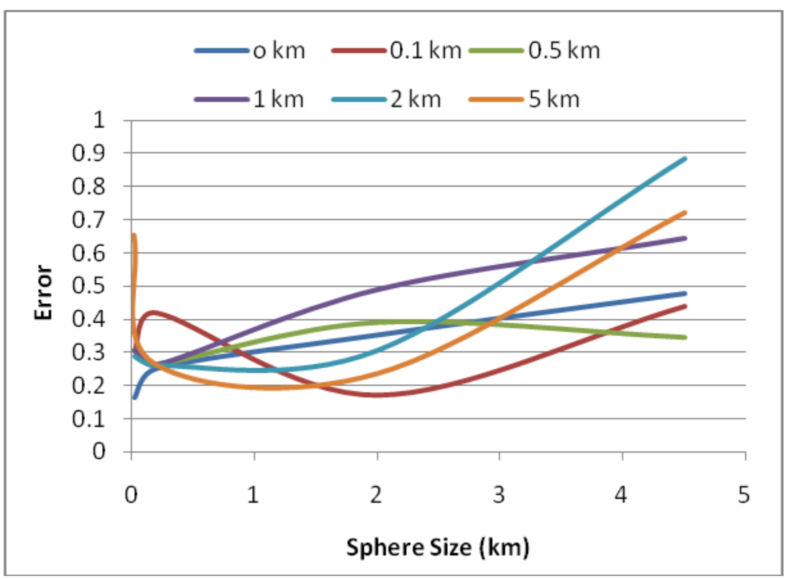


Figure A.8: Percent Error Resulting from Changes in Structure Size - Individual lines correspond to distances from sphere

calculated, and results compared with their analytical solution (Figure 8). For structures greater than 2 meters, the primary contribution of error was the result of edge effects. Note: peak at 0.1 km from the center of target structure corresponds to a sphere with a radius of 0.1 km. However, at 2m, the maximum error increased exponentially to 191% at a distance of 0.1 km due to significant digit round off error.

Vertical Distance From Sphere

In general, increasing the vertical distance from a targeted structure reduces resolvability and dampens the maximum and minimum error (Figure 9). However, if the vertical distance above a structure were increased to infinity, it would decrease the contribution of a single prism to zero resulting in an exponential increase in error. In order to define the boundary where vertical distance introduces round off error, observational data points ranging from 0 km to 1 e 9 km in elevation were used to generate forward models of a sphere.

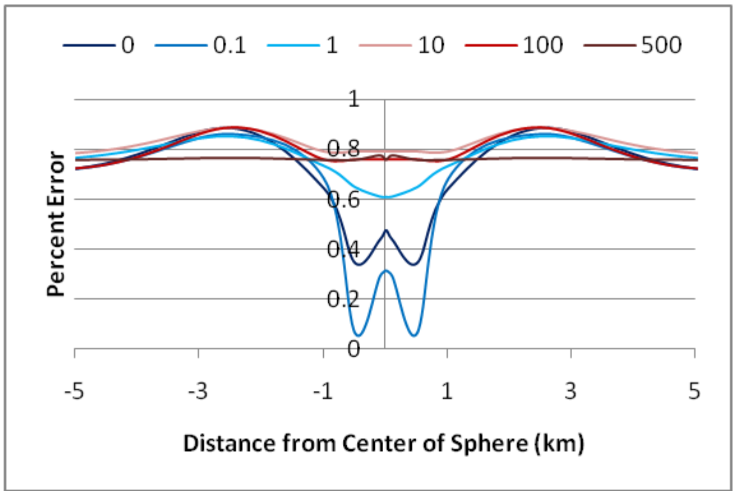


Figure A.9: Percent Error vs. Elevation Above Sphere.

To determine the minimum resolvable density difference between structures, densities ranging from 2670e-32 to 2670 were used to forward model a sphere. Results indicate that there is no variation in error for all distances from the center; however, I believe the same

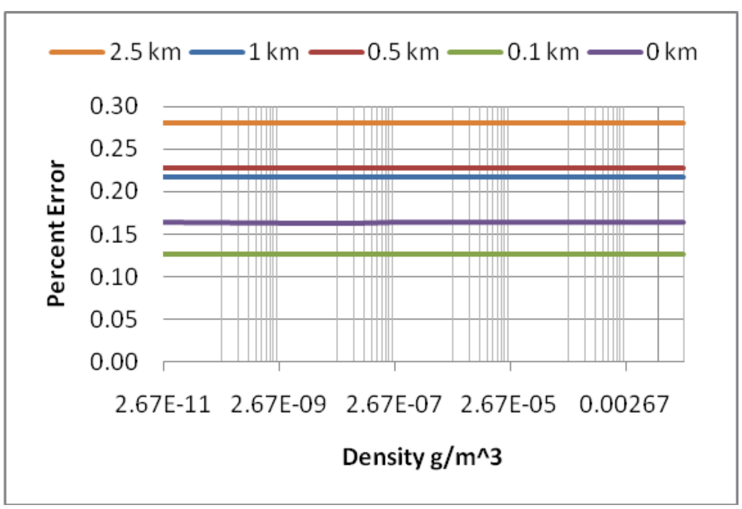


Figure A.10: Percent Error vs. Density Contrast in

significant digit limitation carries throughout all computations.

Summary of error analysis for round off error:

- Limited resolution of distant structures
- Limited to structures greater than 2 m in size
- Able to resolve all density contrasts of all earth materials
- Grid resolution needs to be 0.6% size of targeted structures

Parallel Processing

Parallel processing techniques (PPTs) subdivide large problems into discrete parts which can be solved simultaneously (in parallel) by multiple CPUs. PPTs not only minimize computation time but allow CPUs to process algorithms larger than available memory. Though, BAGC.m Version 1.0 was not developed using PPTs, its computational structure provides two opportunities for incorporation:

- subdividing input grid surface files (density model) into discrete parts
- subdividing gravity locations or observation points into discrete parts

I recommend modification of script files g_calcs.m and calc_component.m to implement PPTs. Script file g_calcs.m imports surface grid files, transforms them into 3D density distributions, sends computational variables to calc_component.m, and stores the results. Script file calc_component controls how the programs implements the computation of observational locations and sends variables to the subroutine gbox.m.

III: Getting Started

Since BAGC.m is comprised entirely of functions and subroutines written as MATLAB ® .m files, no installation is required. All required subdirectories for storing, importing, and exporting data (.dat) files are created by the function make_dir.m.

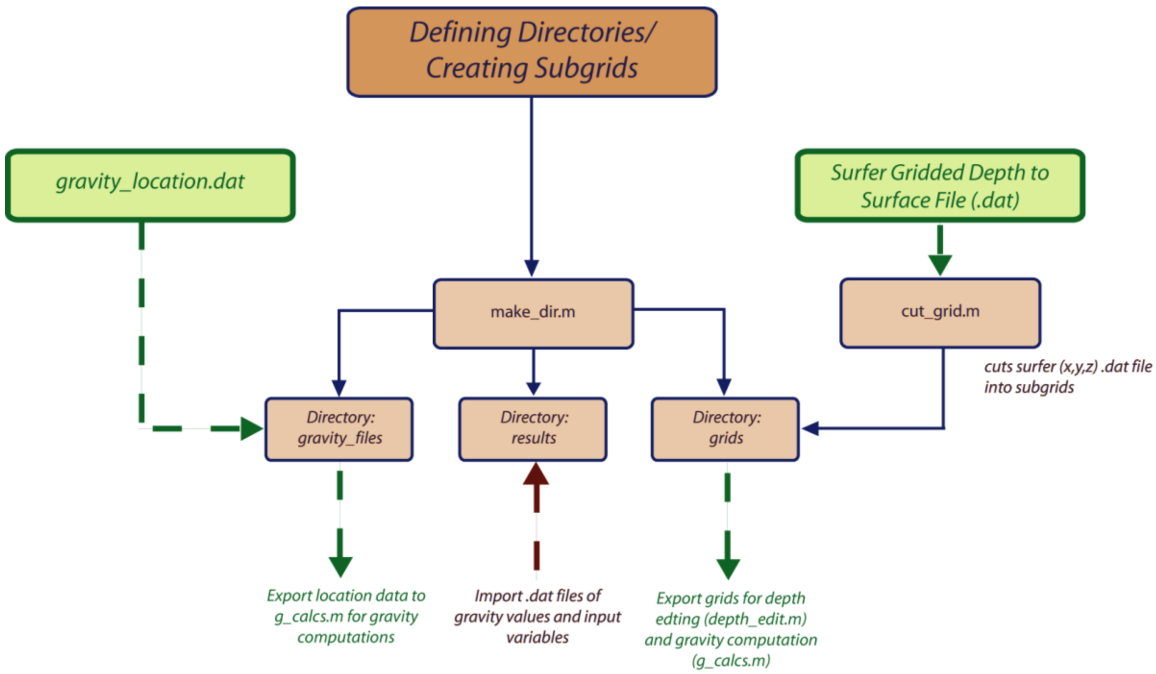


Figure A.11: Detailed Flow Chart Defining Directories and Creating Subgrids

Installation

Copy BAGC directory from disk drive to desired location. Included in the folder are fifteen (15) .m files.

- calc_component.m
- cut_grid.m
- depth_edit.m
- gbox.m
- g_calcs.m

- gravity_dist.m
- load_depth_edit.m
- load_g_calc.m
- make_dir.m
- open_grid.m
- reopen_grid.m
- save_grid.m
- suptitle.m

Creating Subdirectories

Open MATLAB ® and set the current working directory to the BAGC directory from step 1. Run make_dir.m to create three new subdirectories (Figure 11): results, grids, and gravity_files. These new directories will be used to import and export grid files, input variables, and results of gravity calculations. *NOTE*: BAGC.m scripts utilize the built in MATLAB ® function cd (current directory) to identify location. As a result, you can freely edit the main directories name and location; however, you cannot edit the location and name of subdirectories without rewriting script files to identify environmental variables rather than directory location.

Gravity Location Files:

BAGC identifies locations to calculate gravitation attraction by importing the file …\BAGC\gravity_files\gravity_location.dat. Current scripts assume that location data is stored as longitude, latitude, (decimal degrees), and elevation (meters). There are no limitations to the number of gravity locations; however, BAGC is computation intensive and the minimal possible to resolve modeled structures is recommended. Initial tests using eight (8) 200x200x30 models and three (3) data points required a minimum of thirty (30) minuets of processing time (2.0 GHz processor with 1 GB of RAM).

Longitude (x)	Latitude (y)	Elevation (z)
-116.7568	35.4583	0.01
-116.7085	35.3750	0.01
-116.6250	35.2916	0.01

Location data is transformed to km by approximating 1 degree = 111 km. Though this transformation holds for short distances, I recommend storing location data as UTM coordinates to limit error. To accommodate UTM coordinates, the following edits are required:

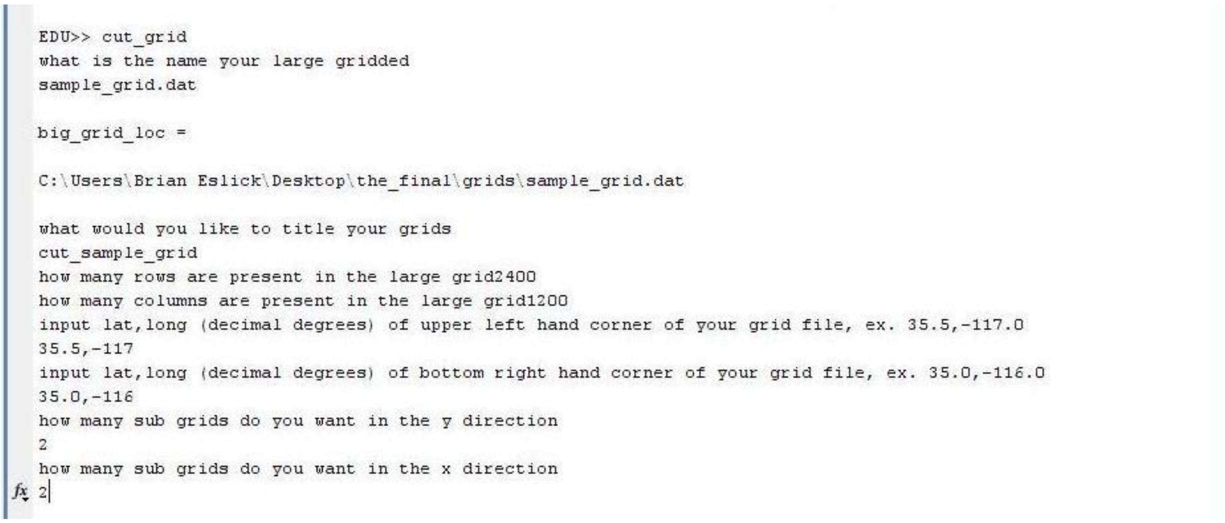
- load_g_calc.m (line 10) - g_locations = g_locations~~*111~~
- g_calcs.m (line 4) - ul_corners = ul_location_new~~*111;~~
- calc_component (lines 157-162) – delete (/111) on all lines.

As discussed earlier, because gravitational attraction is linearized, parallel processing techniques can be incorporated to greatly reduce computation time by subdividing locations and sending them to several CPUs. In addition, because gravity calculations are performed on finite cubes, gravity locations which fall on their boundaries will result in an undefined solution and an error message ("passband edge must be larger than 0").

Cutting Grids:

The function cut_grid.m will import a grid file in longitude (x), latitude (y), depth (km) format, crop it using user defined dimensions, and export cropped subgrids to the subdirectory \BAGC\grids\ (Figure 12). There are no dimensional limitations for cropping grids. BAGC.m will prompt the user to title cropped grid files and will automatically assign a sequential numerical label ex: \BAGC\grids\sample_grid1.dat. In addition, BAGC.m will prompt the user to georeference the large surface grid files but will automatically reference the upper left hand corner of subgrids for in .dat file \BAGC\grids\upper_left_hand_corners.dat. Initial tests using a 2400 x 1200 grid cut into 72 separate

subgrids of dimension 200 x 200 required a minimum computation time of 30 minutes (2.0 GHz processor with 1 GB of RAM).



```
EDU>> cut_grid
what is the name your large gridded
sample_grid.dat

big_grid_loc =

C:\Users\Brian Eslick\Desktop\the_final\grids\sample_grid.dat

what would you like to title your grids
cut_sample_grid
how many rows are present in the large grid2400
how many columns are present in the large grid1200
input lat,long (decimal degrees) of upper left hand corner of your grid file, ex. 35.5,-117.0
35.5,-117
input lat,long (decimal degrees) of bottom right hand corner of your grid file, ex. 35.0,-116.0
35.0,-116
how many sub grids do you want in the y direction
2
how many sub grids do you want in the x direction
fx 2
```

Figure A.12: Screen Shot of cut_grid.m

IV: Model Editing

The model editing environment (figure 13) allows users to interactively edit the geometry of surface to grid files. Density distributions are defined within the gravity calculation environment. Model editing, allows users to import surface grid files, edit depths, create and export cross sections, and save edited surfaces as new grid files. There are six (6) MATLAB® scripts which control this portion of the program:

- load_depth_edit.m – loads location data into MATLAB® variables
- open_grid.m – specifies grid file for editing
- reopen_grid.m – opens grid file from the last time it was saved
- depth_edit.m – edits depth of grid files
- save_grid.m – saves edits made during depth_edit.m
- cross_sect.m – views cross sections of edited files

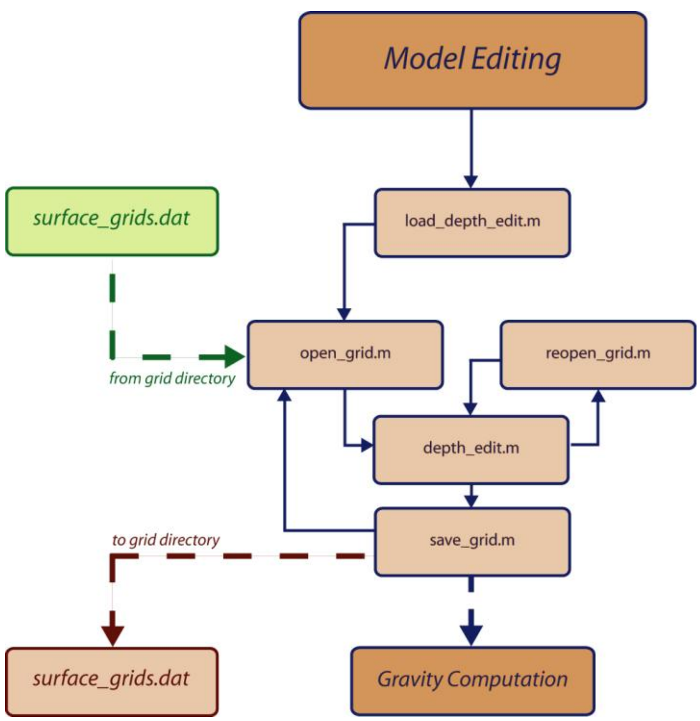


Figure A.13: Flow Chart Model Editing

Loading Location Data into MATLAB Variables:

Prior to editing models, the location of surface grid files are imported into MATLAB® variables by referencing load_depth_edit.m. load_depth_edit.m assumes surface grid files are stored in subdirectory …\BAGC\grids. Failure to load variables will result in error messages.

Opening Grid Files for Editing:

To identify which grid file to open for editing, type open_grid.m. Since cut_grid.m does not store latitude or longitude information of cropped grid files, the user must define the dimensions of the grid (rows and columns) in addition to grid name. To ensure the proper grid dimensions were selected, BAGC.m will display the opened grid as Figure 1 (Figure 14). If dimensions were not loaded correctly, the process can be restarted by re running open_grid.m.

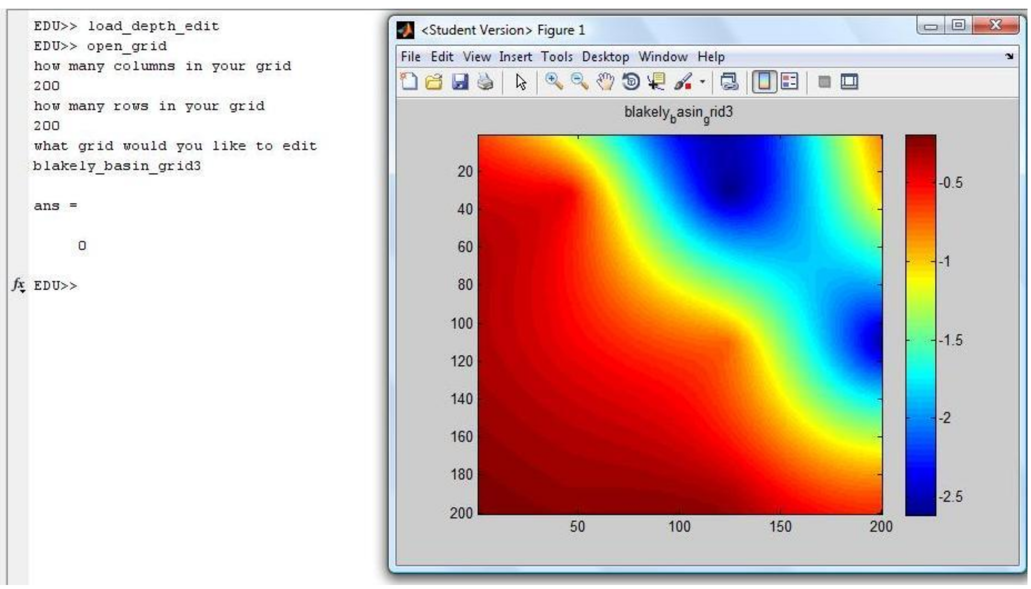


Figure A.14: Screen Shot open_grid.m

Re-opening Grid Files for Editing:

If mistakes are made during editing, reopen_grid.m will restart the editing process from the last time open_grid.m was used.

Depth Edit:

Depth_edit.m (figure 15) is an interactive visual based function to manipulate surface grid geometries by selecting regions of interest, editing their depths, and applying spatial filters to minimize sharp edges. The method was designed to imitate an artist's method for shading an object to create a seamless natural transition between boundaries. BAGC.m employs both command line prompts and a GUI to control work flow and interact with the surface file.

- ***Command line prompt***: controls flow of function and allows the user to input amount to edit as well as select type and size of filters.
- ***GUI***: defines boundaries for zoomed views and selects regions of interest for editing.

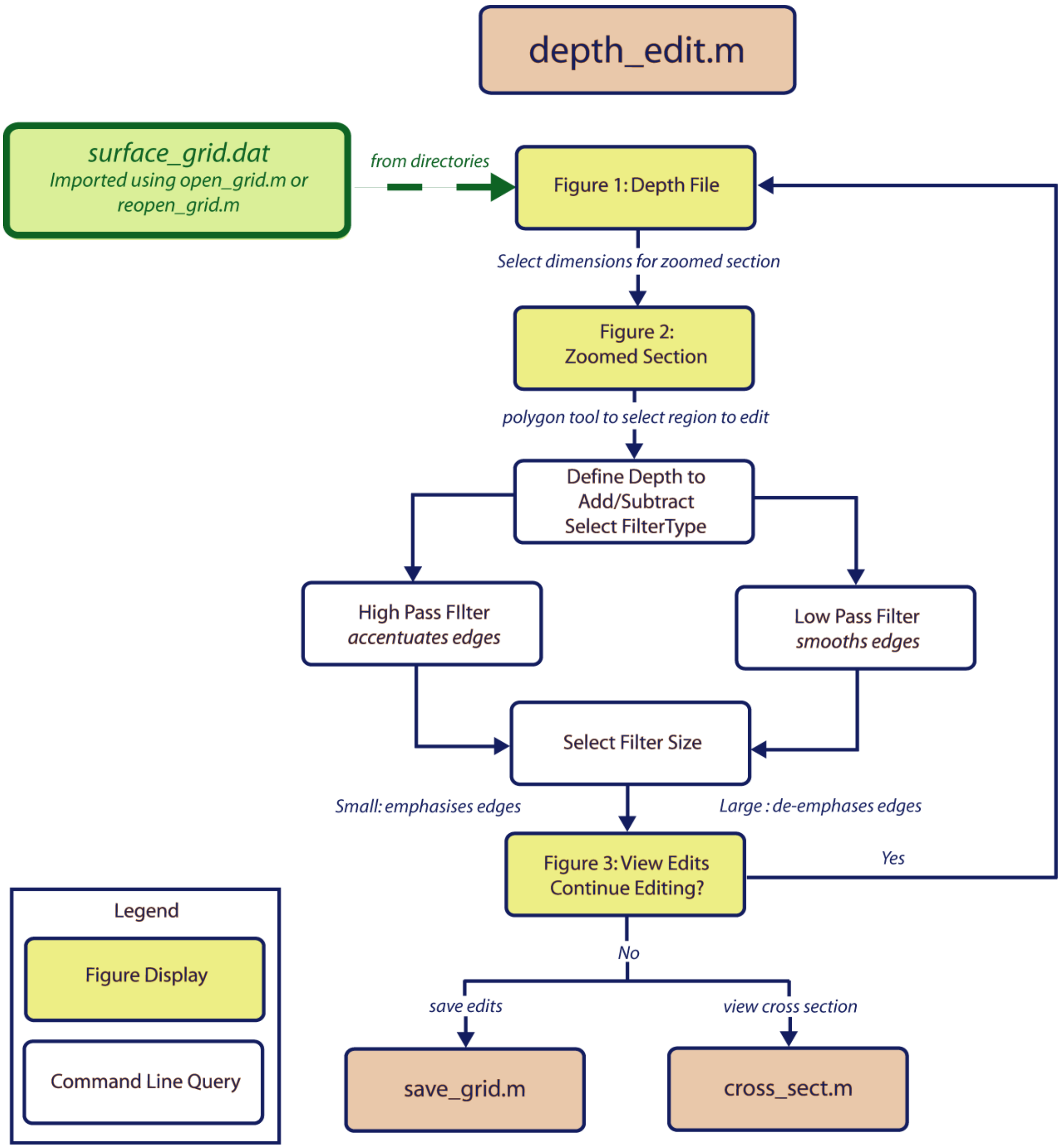


Figure A.15: Flow Chart depth_edit.m

Zooming in:

To begin the editing process, run depth_edit.m. Figure 1 will display the surface grid file selected in open_grid.m. BAGC.m will prompt the user to select "a zoomed view" by using the cursor to define the upper left and lower right hand boundaries of the target window (Figure 16). Failure to select positions in the proper order will result in an error.

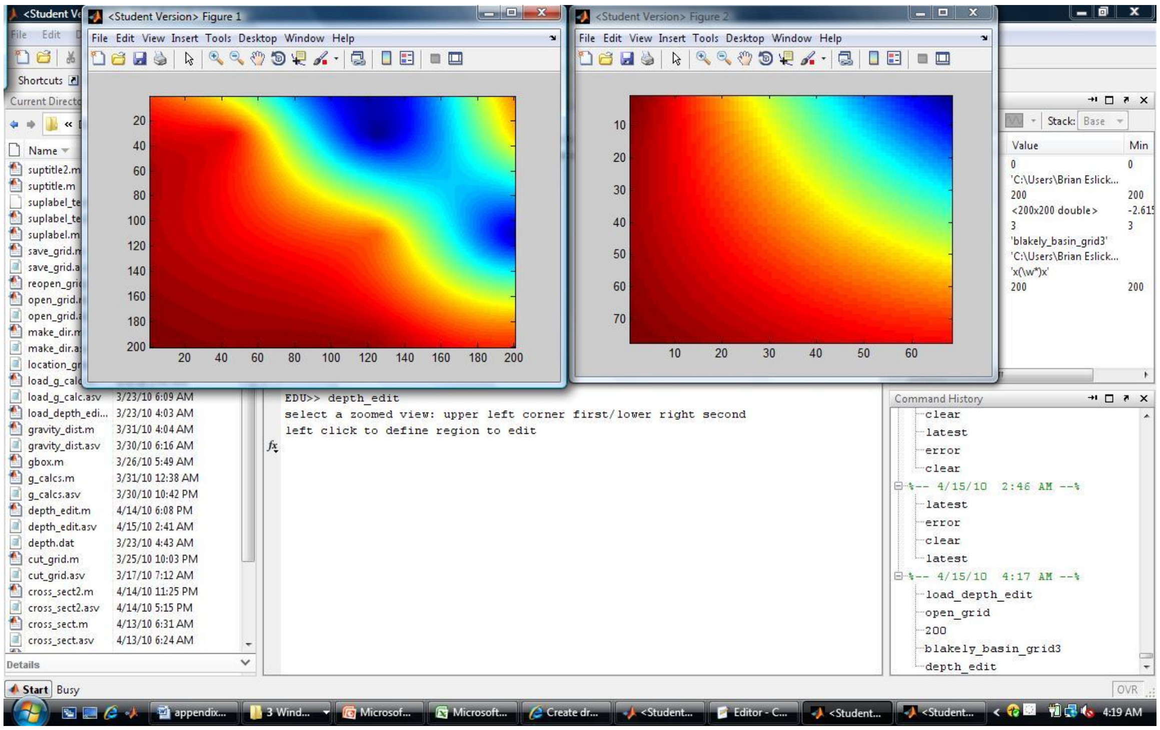


Figure A.16: Screen Shot zoomed view

Selecting Region to Edit:

Figure 2 will open and display the "zoomed view". BAGC.m will prompt the user to define a region to edit using the built in MATLAB® function impoly. Impoly is a clickable, resizable interactive tool to define a region of interest (polygono) with no size or geometric limitations. To define node points click on the left click on the mouse. In order to close the polygon, either, manually place the last cursor location on the first or right click. To finalize selection, double click in the center of the polygon.

BAGC.m will create a new "edited layer" surface with ones in the region of interest and zeros everywhere else. This edited layer will be filtered and added to the original surface depth file.

Depth Addition/Subtraction:

BAGC.m will prompt the user to define "how much you want to add or subtract." The amount defined is applied to the new edited layer. Though there are no limitations to the amount you can add or subtract, it is recommended to iteratively edit the model slowly to achieve a natural surface.

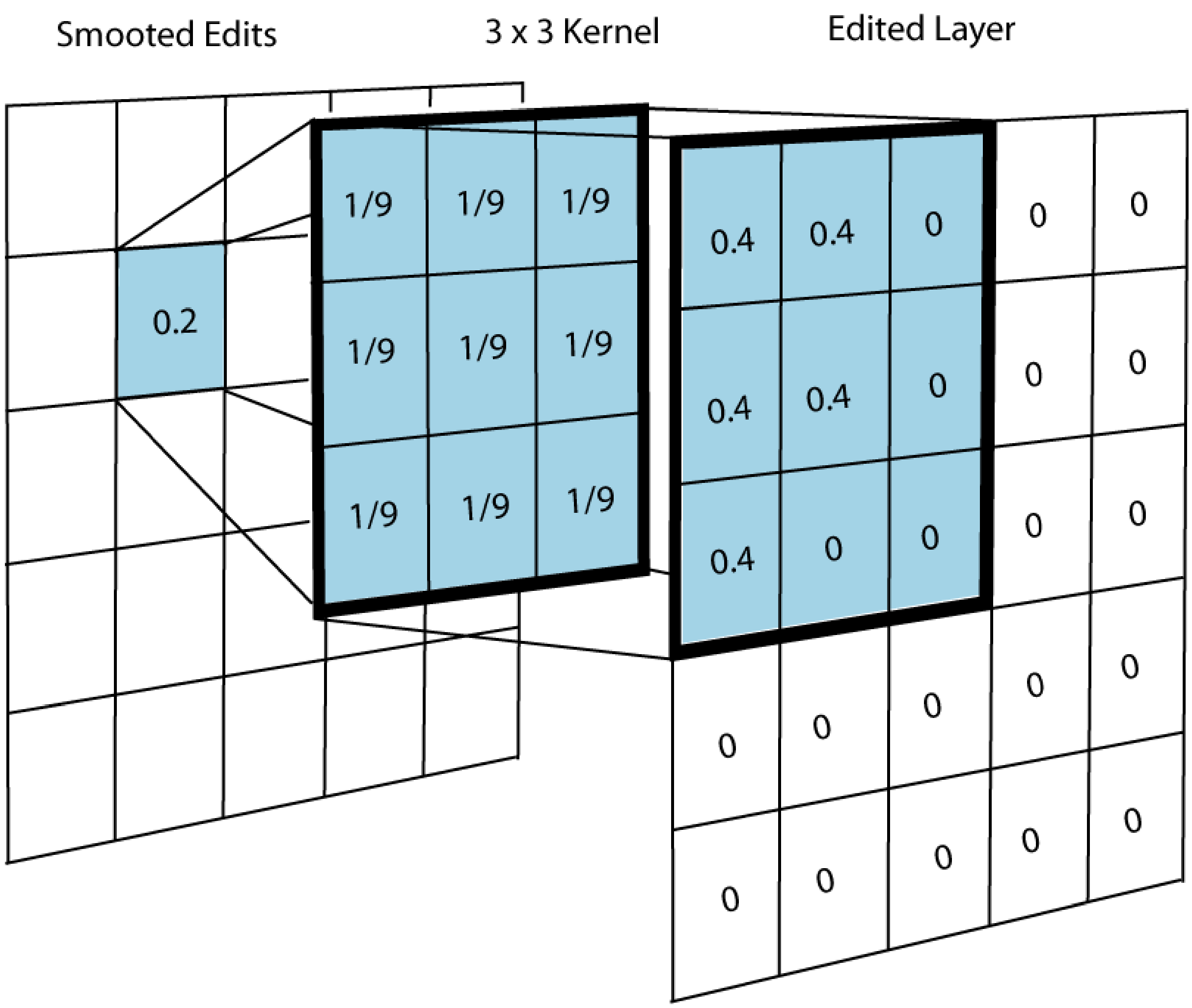


Figure A.17: Example Low Pass Filter

Filtering:

BAGC.m uses spatial convolution filtering to smooth edges from the addition and subtraction of elevations (Figure 17). A linear spatial filter applies a weighted average based on a linear combination of depth values surrounding a location. The spatial filter consists of a kernel which moves across the edited layer, calculates a weighted average, and defines a new smoothed edited layer which will be added to the surface depth file. BAGC.m allows users to vary both filter type and size.

Type of Filter

There are two types of filters currently available in BAGC.m:

- ***Low Pass Filter***: attenuates high spatial frequencies to smooth edited surfaces and create a natural earth model.
- ***High Pass Filter***: accentuates high spatial frequencies such as faults or other breaks in geometry.

Filter kernels are defined by filter size selected. Low pass filter kernels are filtersize x filtersize with weighted average of $1/\text{filtersize}^2$. The high pass filter kernel are filtersize x filtersize with a weighted average of $-1/\text{filtersize}^2$ for all cells with the exception of the center which is defined as filtersize.

Additional filters can be incorporated into depth_edit.m via modification of lines 56 through 67. The filter selection code consists of an imbedded if then statement controlled by an input string defined in line 56. Currently, there are two options lp (low pass filter) and hp (high pass filter). In order to install a new filter type, line 56 must be edited to allow a different type of filter input and an additional else if statement inserted using the new string value. Filters are defined as smooth_filter and applied to the edited layer in line 69 using the built in MATLAB® command, imfilter. In order to define a new filter, reference the new filter as smooth_filter.

Filter Size

Filter size controls the region in which the weighted average is determined as well as the degree of which smoothing or sharpening. Table 3 summarizes filter size properties while figure 17 depicts how it affects smoothing.

Table B.3: Filter Size Properties

	Large Kernel	***Small Kernel***
Low Pass Filter	smoothes edges beyond ROI/large reduction in added depths	smoothes edges within ROI/small reduction in added depths
High Pass Filter	sharpens edges beyond ROI/large increase in added depths	sharpens edges within ROI/small increase in added depths

ROI = region of interest

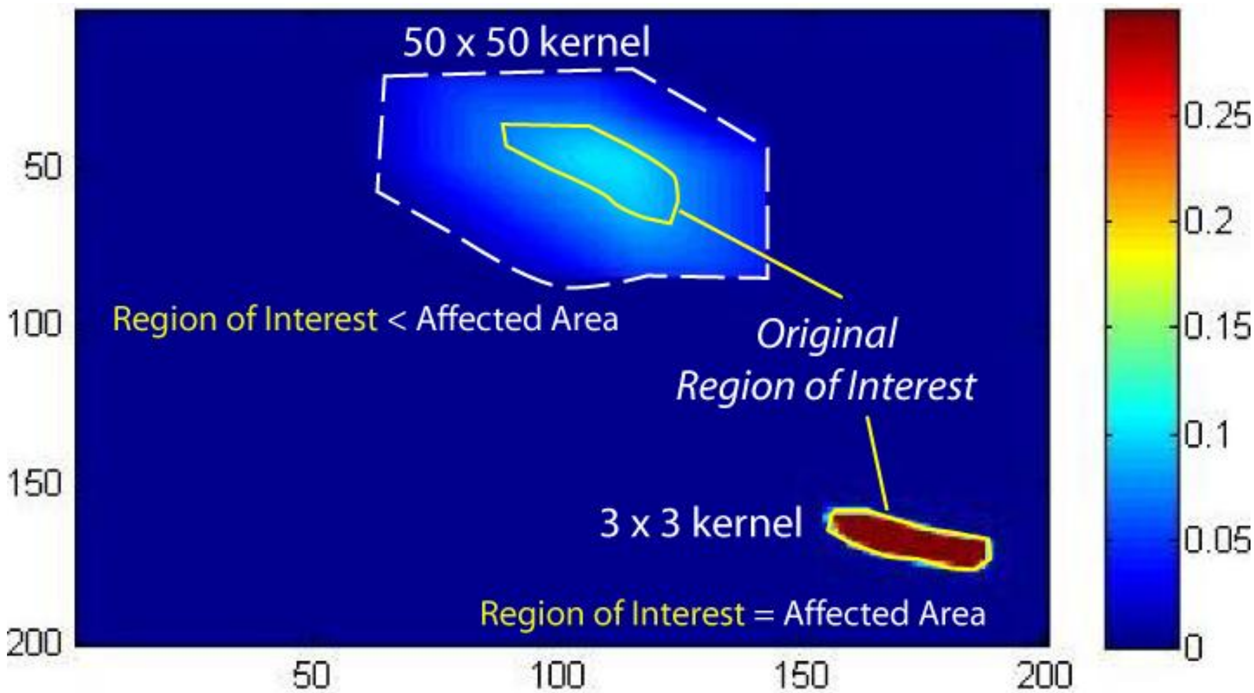


Figure A.18: Comparison of Low Pass Filter Kernel Sizes for Added Depth of 0.3 km
(A) 50 x 50 Kernel: smearing and deemphasize of added depth
(B) 3 x 3 Kernel: Preserves added depth and region of interest

Continue Editing:

Following the editing process, BAGC., will display figure 4 (Figure 18) depicting the final edited depth to surface grid, last zoomed section, final edited surface, and the last filter used. The user can continue editing or stop, view cross sections, and save edited grid file.

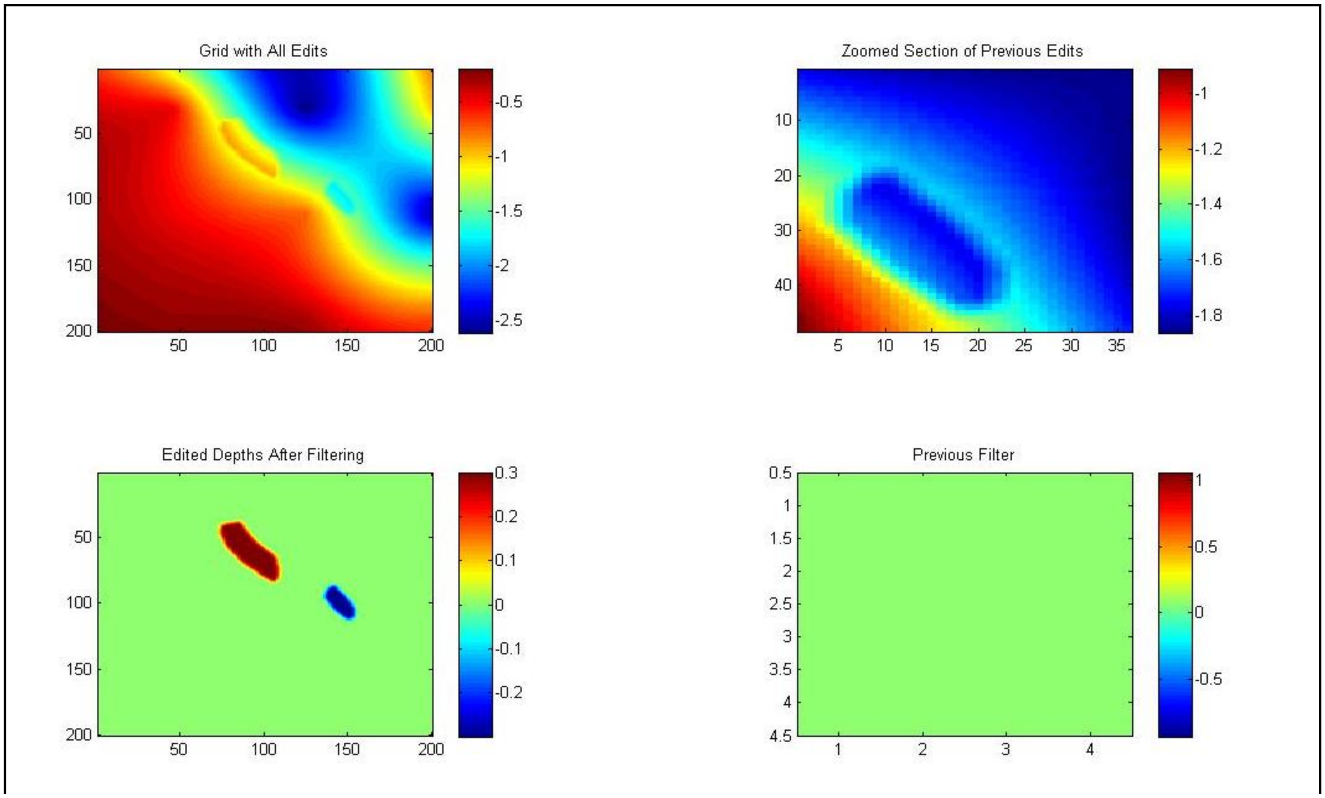


Figure A.19: Resulst of depth_edit.m
(1) final edits applied to surface depth file
(2) zoomed section of most recent edits
(3) final filtered depths applied to surface depth file
(4) previous filter utlized

Cross Sections:

To view a cross section of edited depth file, type cross_sect.m. BAGC.m will prompt the user to zoom in to desired level then select a profile to view cross section. The cross_sect.m function employs the same polygon selection tool as depth_edit.m (impoly). In order to define cross section, left click on the mouse to define desired node points. The impoly tool is designed to create a closed polygon. As before, double click in the center of the polygon but the last position will not be incorporated into the cross section. The cross section function interpolates between user selected points using the built in

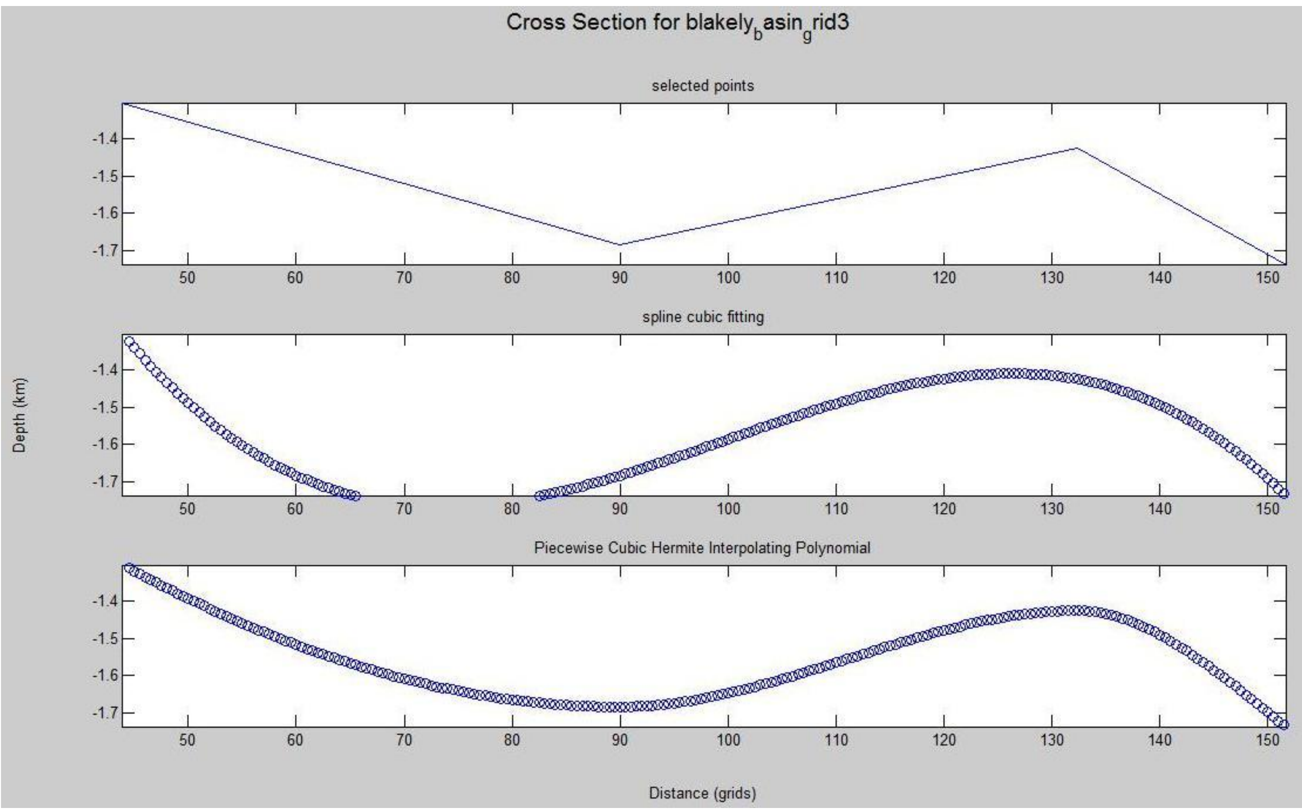


Figure A.20: Screen Shot of cross_sect.m

MATLAB® functions spline and pchip. The spline provides a smoother interpolation, however, it can over smooth results. The pchip interpolation will not smooth over the data as much but may not interpolate well for sparse data. Output cross sections (Figure 19) contain the results of both interpolations so that the user may decide which one they like. In addition, you can also export the result of the cross section to a .dat file which contains x,y,z information.

Save Grid:

To save progress type save_grid.m. BAGC.m will prompt for a file name. Important: MATLAB® will automatically save over a previous file. I recommend maintaining a separate folder with copies of original grid files and saving progress under separate names. You can easily rename a grid to incorporate it into gravity computations but cannot retrieve a file you saved over.

IV: Gravity Calculation

The gravity calculation environment determines the vertical attraction of the user defined earth model. There are five (5) MATLAB® script files which control gravity calculation:

- load_g_calcs.m – loads location data into MATLAB® variables
- g_calcs.m – imports grid files, gravity locations, sends variables to subroutines, receives results, and writes output .dat files
- calc_component .m– receives grid files and variables, defines 3D models, and sends computations to core subroutine gbox.m
- gbox.m – core subroutine, computes gravitational attraction of a single prism
- gravity_dist.m – computes the gravitational attraction of prisms in depth slices

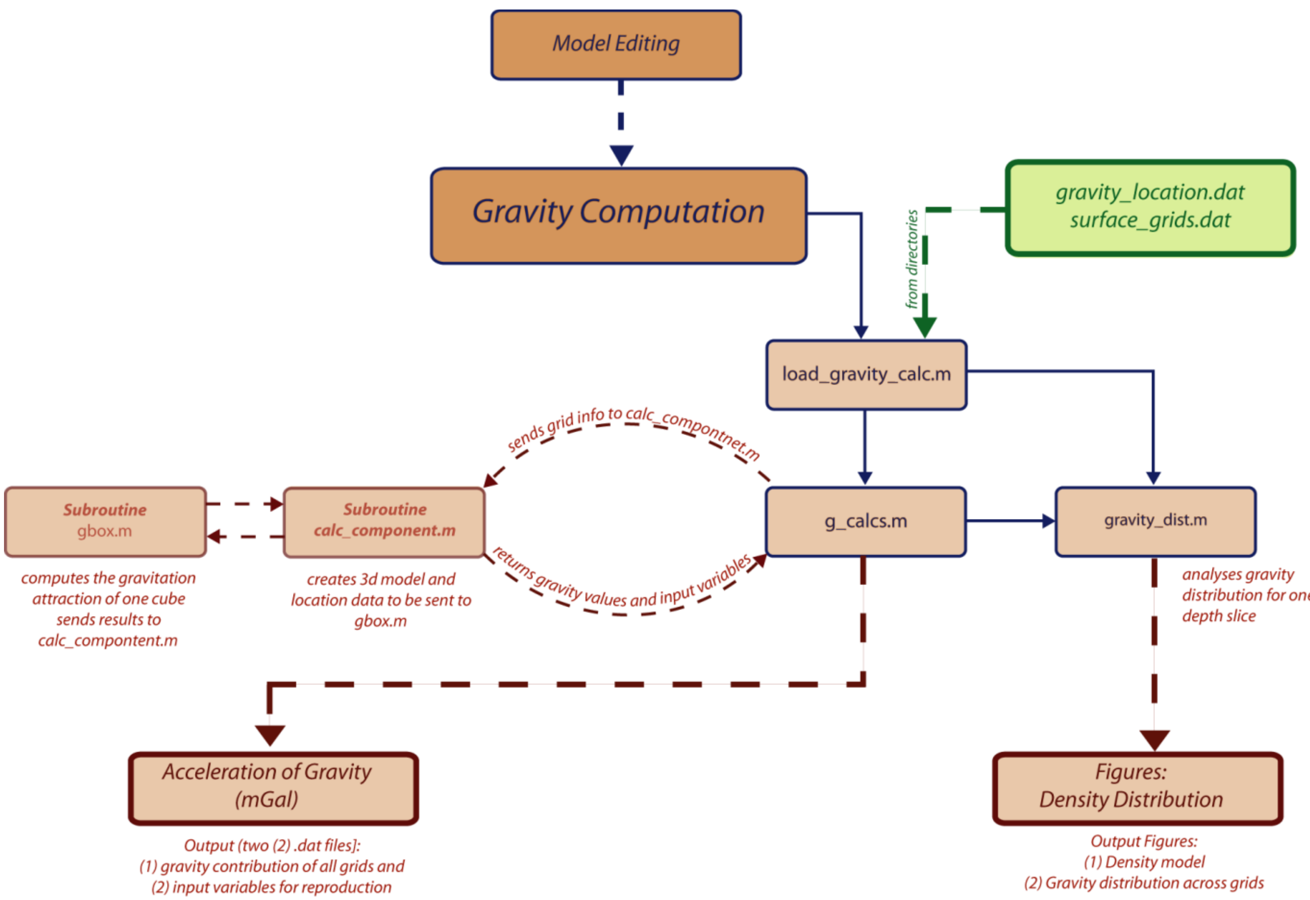


Figure A.21: Detailed Flow Chart for Gravity Computation

Loading Location Data into MATLAB Variables:

Similar to load_depth_edit.m, load_g_calc.m imports variables into the MATLAB® environment including:

- Name, location, georeferencing, and dimensions of surface grid files
- Depth resolution of model
- Density distribution with respect to depth (no lateral variation)

Load_g_calc.m assumes surface grid files are stored in subdirectory …\BAGC\grids. In addition, load_g_calc prompts the user to define the desired vertical resolution as well as the vertical density gradient.

The first set of prompts imports the name of gridded files as well as their relationship amongst one another. BAGC.m asks the user to define the name of grid files, dimension of subgrids as well as the dimension of subgrids to larger grid. It asks user to define the name of grid files. All files must be the same name for importation because individual grids are referenced by their number in addition to their name. This is to reconstruct the geometry of subgrids into the larger grid. Figure 1 (Figure 21) will display all subgrid surface files to allow the user to decide which files to incorporate in gravity calculations.

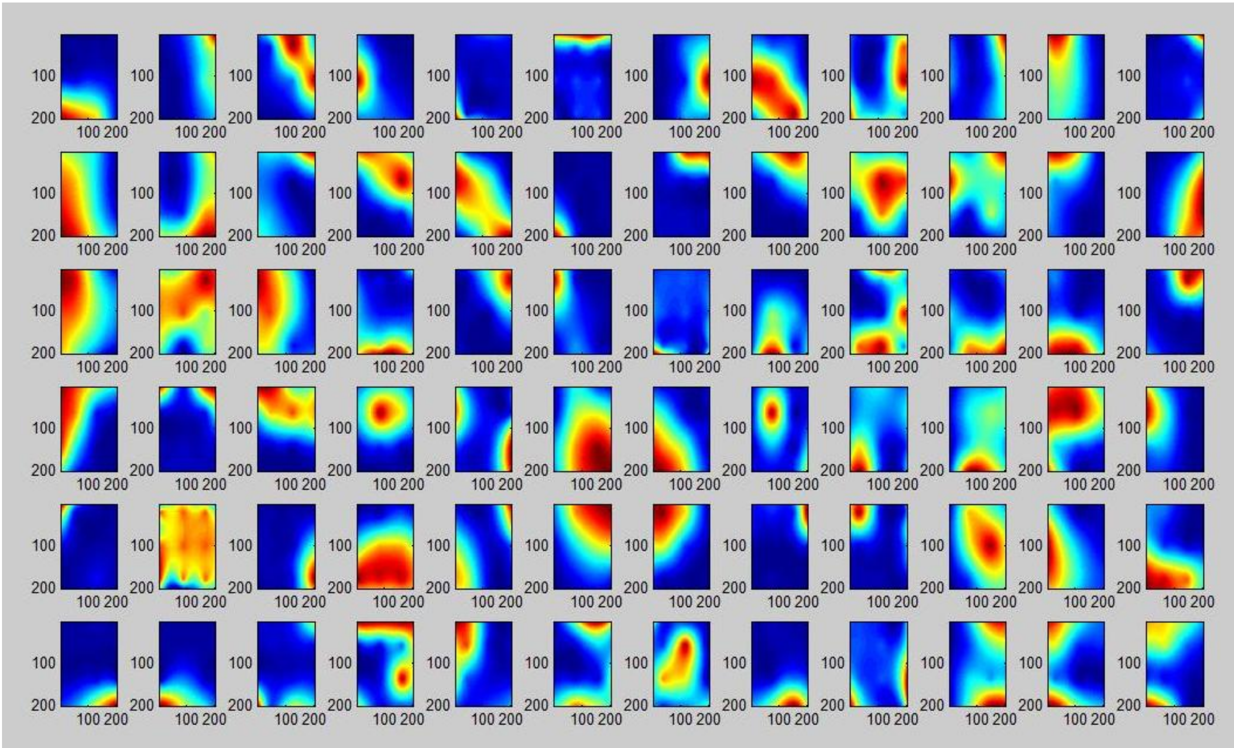


Figure A.22: Screen Shot – Reconstructed Subgrids for Model Selection

Computing Gravitational Attraction:

Once subgrids for modeling are selected, BAGC.m prompts the user to define desired vertical resolution and gravity distribution. The vertical resolution will be incorporated throughout all grids and similar to constraints on horizontal resolution, smaller structures require smaller grid intervals. To define a gravity distribution of:

Table B.4: Density Distribution

Depth	***Density***
0-200	2000
200-400	2010
400-800	2050
>800	2080

Type 0,2000;200,2010;400;2050,800;2080.

Computing Gravitational Attraction

To determine the gravitational attraction of user defined subgrids, type g_calcs.m. BAGC.m will import surface depth files, install density distributions, and determine the gravitational attraction. BAGC.m will output the gravitational attraction of each grid for all gravity locations as well as the input variables into subfolder …\BAGC\results\xxx.dat. BAGC.m allows users to define the name of each file.

Examining Spatial Variation of Gravity Anomalies:

The primary benefit of the linearization of computations is that the user can analysis the spatial variation of gravity anomalies. In order to investigate, type gravity_dist.m. This function will calculate the gravitational attraction of all prisms for a user defined surface depth and display results alongside the density model. The function will output two density distributions, a scaled version which has the same contribution for each grid and an unscaled one which varies from grid to grid.

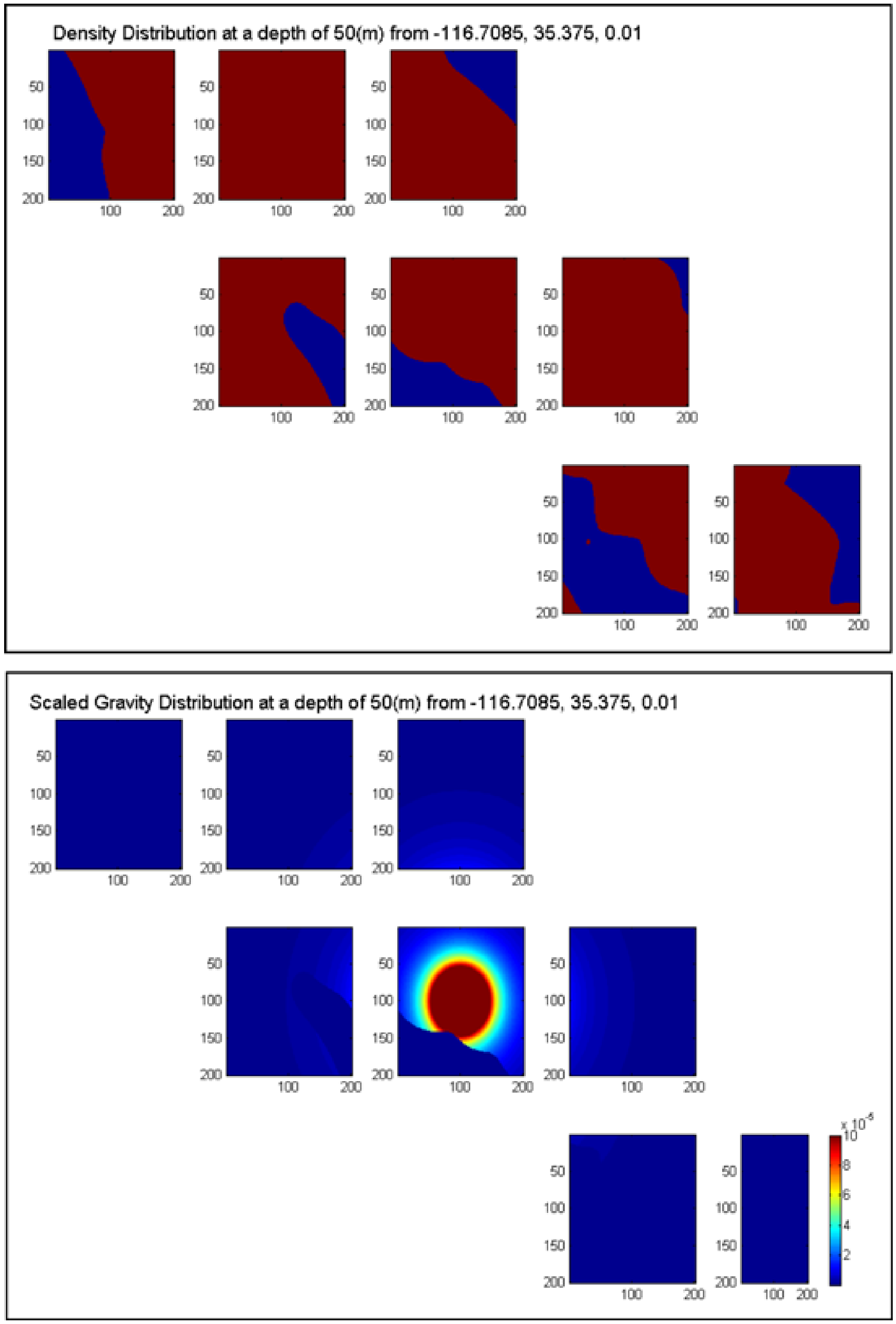


Figure A.23: Screen Shot – gravity_dist.m

Appendix C: Gravity Data

Table C.1: Gravity Data Set

Station (#)	***(hrs)***	***Gravity (DD)***	***Lat (m)***	***Long (m)***	***Elevation NAD 83(m) GRS80 (ell. Height)***	***Elevation Precision (m)***	***drift corrected (mGal)***	***Absolute (mGal)***	***Simple BA (mGal)***
Line1-1	8.63	3234.59	35.89893503	-116.6558227	7.541	0.027	3284.46	979711.92494	*-96.2448*
line1-2	8.73	3234.80	35.89831487	-116.6567228	3.035	0.029	3284.675	979712.13991	*-96.8633*
line1-3	8.85	3235.30	35.89753202	-116.6579318	-2.924	0.031	3285.185	979712.64988	*-97.4589*
line1-4	8.93	3235.53	35.89685364	-116.6587519	-7.133	0.028	3285.42	979712.88492	*-97.9939*
line1-5	9.03	3235.91	35.89613484	-116.6596984	-12.145	0.023	3285.808	979713.27267	*-98.5308*
line1-6	9.17	3236.32	35.89515033	-116.6610064	-18.263	0.038	3286.226	979713.69142	*-99.2316*
line1-7	9.30	3236.62	35.89423682	-116.6621761	-23.65	0.026	3286.533	979713.99837	*-99.9063*
line1-8	9.38	3236.90	35.8933034	-116.6634287	-29.47	0.028	3286.819	979714.28423	*-100.686*
line1-9	9.53	3236.97	35.89245841	-116.6645296	-34.145	0.028	3286.893	979714.35768	*-101.46*
line1-10	9.68	3235.93	35.89125136	-116.6660077	-35.149	0.033	3285.838	979713.30299	*-102.608*
line1-11	9.87	3234.40	35.89040492	-116.6671575	-32.07	0.037	3284.286	979711.75081	*-103.482*
line1-12	10.10	3232.59	35.88953808	-116.6681793	-27.913	0.059	3282.45	979709.91483	*-104.425*
line1-13	10.22	3230.53	35.88843842	-116.6692739	-21.701	0.063	3280.358	979707.82296	*-105.2*
line1-14	10.43	3228.12	35.8872631	-116.6705105	-13.889	0.027	3277.912	979705.37692	*-106.008*
line1-15	10.58	3225.94	35.88632361	-116.6720377	-5.388	0.026	3275.698	979703.16360	*-106.468*
line1-16	10.75	3223.60	35.88509569	-116.6728281	2.576	0.026	3273.323	979700.78793	*-107.171*
line1-17	10.98	3221.02	35.88328908	-116.6746325	18.134	0.026	3270.704	979698.16936	*-106.572*
line1-18	11.12	3219.44	35.88258096	-116.6761215	27.189	0.031	3269.1	979696.56560	*-106.333*
line1-19	11.32	3217.77	35.88261308	-116.6774805	37.635	0.026	3267.406	979694.87139	*-105.975*
line1-20	11.70	3215.04	35.88304245	-116.6789617	51.333	0.024	3264.638	979692.10268	*-106.084*
line1-21	11.95	3212.05	35.88293882	-116.6803145	65.209	0.025	3261.603	979689.06767	*-106.38*
line1-22	13.12	3225.11	35.88510256	-116.6706995	-1.819	0.025	3274.894	979702.35902	*-106.465*
line1-23	13.32	3221.3	35.88272647	-116.670549	15.173	0.025	3271.025	979698.48984	*-106.786*
line1-24	13.48	3218.54	35.88107293	-116.6724301	30.267	0.026	3268.222	979695.68730	*-106.476*

line1-25	13.63	3217.79	35.88090639	-116.6733146	34.828	0.025	3267.462	979694.92736	*-106.324*
Line2-1	10.25	3219.72	35.74881779	-116.5409476	44.078	0.046	3269.354	979696.80860	*-91.2925*
Line2-2	10.33	3218.95	35.74894315	-116.5421103	46.405	0.032	3268.573	979696.02830	*-91.6256*
line2-3	10.47	3217.95	35.74902796	-116.5431697	49.661	0.031	3267.561	979695.01561	*-92.0048*
line2-4	10.62	3216.74	35.74917898	-116.5443738	54.147	0.03	3266.335	979693.78994	*-92.3605*
line2-5	10.73	3216.12	35.74934008	-116.5453586	55.68	0.212	3265.708	979693.16300	*-92.6996*
line2-6	10.93	3215.17	35.74945487	-116.5465166	58.763	0.203	3264.748	979692.20296	*-93.0627*
line2-7	11.72	3214.69	35.74932941	-116.5476262	60.684	0.157	3264.282	979691.73656	*-93.1403*
line2-8	11.88	3214.18	35.74942821	-116.5485863	62.54	0.144	3263.768	979691.22279	*-93.2973*
line2-9	11.05	3213.12	35.74949731	-116.5499845	67.383	0.132	3262.668	979690.12265	*-93.4502*
line2-10	12.25	3212.20	35.74963481	-116.551137	72.054	0.157	3261.766	979689.22048	*-93.445*
line2-11	12.42	3211.28	35.74971883	-116.5520694	76.332	0.213	3260.835	979688.29001	*-93.5407*
line2-12	12.60	3209.91	35.74980485	-116.5535029	82.693	0.23	3259.448	979686.90264	*-93.6836*
line2-13	13.58	3208.64	35.74990107	-116.5550207	89.531	0.265	3258.184	979685.63881	*-93.61*
line2-14	13.83	3207.74	35.75010793	-116.556831	95.158	0.299	3257.276	979684.73095	*-93.4282*
line2-15	13.93	3206.53	35.75016446	-116.558548	101.109	0.231	3256.049	979683.50392	*-93.4889*
line2-16	14.07	3204.26	35.75020756	-116.5609693	115.41	0.222	3253.746	979681.20048	*-92.9816*
line2-17	14.25	3202.05	35.74977643	-116.5634408	128.21	0.202	3251.504	979678.95938	*-92.6667*
line2-18	14.40	3199.70	35.74909278	-116.5667054	142.904	0.181	3249.125	979676.58012	*-92.0956*
line2-19	14.60	3198.08	35.74879977	-116.5692801	153.114	0.208	3247.484	979674.93927	*-91.702*
line2-20	14.77	3196.51	35.74840388	-116.5711919	161.602	0.206	3245.893	979673.34832	*-91.5886*
line2-21	14.92	3196.65	35.74896616	-116.572719	161.143	0.197	3246.04	979673.49470	*-91.5807*
line2-22	15.07	3195.21	35.74839534	-116.5744392	168.724	0.346	3244.58	979672.03541	*-91.4991*
line2-23	15.27	3193.04	35.74813981	-116.5764962	179.541	0.322	3242.381	979669.83562	*-91.5482*
line2-24	15.45	3189.96	35.74773103	-116.5790802	196.351	0.287	3239.256	979666.71059	*-91.33*
line3-1	9.52	3240.99	35.84325453	-116.5662836	1.009	0.028	3290.959	979718.63734	*-86.0386*
line3-2	9.62	3241.07	35.84259931	-116.5668877	-2.161	0.031	3291.04	979718.71849	*-86.525*
line3-3	9.78	3240.80	35.84182878	-116.5674974	-4.74	0.032	3290.765	979718.44382	*-87.2411*
line3-4	10.00	3240.00	35.84080716	-116.5686657	-6.921	0.043	3289.952	979717.63042	*-88.3961*
line3-5	10.10	3238.74	35.83966005	-116.5696043	-7.01	0.049	3288.671	979716.34967	*-89.5959*

line3-6	10.25	3237.51	35.83860361	-116.5705201	-7.118	0.023	3287.421	979715.09935	*-90.7769*
line3-7	10.62	3236.22	35.83774852	-116.5713491	-7.225	0.023	3286.109	979713.78770	*-92.0362*
line3-8	9.55	*3237.00*	35.84066227	-116.5739594	-7.438	0.068	3286.957	979714.65637	*-91.4595*
line3-9	9.75	*3236.26*	35.83985151	-116.5745457	-7.841	0.089	3286.217	979713.91626	*-92.2093*
line3-10	9.88	*3235.07*	35.83891472	-116.5755006	-7.352	0.121	3285.016	979712.71480	*-93.2342*
line3-11	10.30	*3232.79*	35.83657709	-116.5767628	-7.201	0.042	3282.724	979710.42250	*-95.2962*
line3-12	10.57	*3231.63*	35.83495272	-116.5778094	-6.883	0.035	3281.561	979709.25951	*-96.2572*
line3-13	10.72	3230.10	35.83358406	-116.5785619	-4.011	0.038	3280.015	979707.71350	*-97.1206*
line3-14	10.93	3228.41	35.83264303	-116.5794048	0.874	0.035	3278.31	979706.00886	*-97.7831*
line3-15	11.10	3226.59	35.83144095	-116.5800504	5.49	0.035	3276.47	979704.16910	*-98.6113*
line3-16	11.38	3225.00	35.82966168	-116.5806013	9.638	0.035	3274.871	979702.57009	*-99.2413*
line3-17	11.60	3223.53	35.82914987	-116.5821866	15.393	0.038	3273.39	979701.08905	*-99.5459*
line3-18	11.82	3222.87	35.82765696	-116.5836256	16.949	0.029	3272.732	979700.43124	*-99.7694*
line3-19	11.98	3221.58	35.82686787	-116.5848537	21.412	0.030	3271.431	979699.13014	*-100.124*
line3-20	12.17	3219.74	35.82647135	-116.5875518	26.981	0.028	3269.572	979697.27106	*-100.854*
line3-21	12.30	3217.90	35.82628952	-116.5903165	32.407	0.030	3267.71	979695.40898	*-101.632*
line3-22	12.48	3216.79	35.82612319	-116.591857	35.929	0.027	3266.593	979694.29182	*-102.042*
line3-23	13.28	3215.35	35.82524497	-116.5936771	40.419	0.038	3265.177	979692.87620	*-102.499*
line3-24	13.45	3214.38	35.82446854	-116.5944071	43.526	0.040	3264.201	979691.90033	*-102.796*
line3-25	13.62	3213.21	35.82311932	-116.5969546	52.111	0.029	3263.022	979690.72120	*-102.17*
line3-26	13.82	3212.13	35.82205111	-116.5989463	60.007	0.028	3261.937	979689.63553	*-101.61*
line3-27	14.02	3210.91	35.82078226	-116.6011272	69.112	0.026	3260.709	979688.40757	*-100.938*
line3-28	14.18	3209.12	35.81929899	-116.6037679	82.035	0.027	3258.899	979686.59831	*-100.076*
line3-29	14.43	3206.13	35.81740406	-116.6069666	103.583	0.026	3255.876	979683.57442	*-98.6971*
line3-30	14.70	3202.85	35.81677364	-116.6094785	123.98	0.026	3252.558	979680.25680	*-97.9465*
line3-31	14.95	3199.10	35.81517084	-116.6132042	146.583	0.030	3248.767	979676.46558	*-97.152*
line3-32	15.23	3197.22	35.81433891	-116.6145325	158.705	0.037	3246.873	979674.57200	*-96.5886*
line3-33	15.52	3202.39	35.81829217	-116.6118233	129.517	0.034	3252.139	979679.83819	*-97.4057*
line3-34	15.85	3206.60	35.82217743	-116.6070168	93.246	0.030	3256.438	979684.13695	*-100.578*
line3-35	16.32	3202.56	35.82640985	-116.5984004	48.679	0.028	3252.36	979680.05888	*-113.79*

line4-1	10.98	3243.7	35.83215775	-116.5499494	-4.741	0.037	3293.725	979721.56644	*-83.2889*
line4-2	10.23	3242.82	35.83117486	-116.5512041	-5.75	0.029	3292.827	979720.66815	*-84.3015*
line4-3	10.37	3241.29	35.8302598	-116.552361	-5.114	0.031	3291.273	979719.11384	*-85.6521*
line4-4	10.52	3239.81	35.82907558	-116.5536964	-4.827	0.029	3289.769	979717.61044	*-86.9974*
line4-5	10.68	3238.71	35.82807912	-116.554904	-4.924	0.031	3288.652	979716.49334	*-88.0481*
line4-6	10.88	3237.30	35.82694206	-116.5563149	-5.036	0.026	3287.22	979715.06134	*-89.4046*
line4-7	11.05	3236.31	35.8257751	-116.5577886	-5.072	0.026	3286.215	979714.05603	*-90.3169*
line4-8	11.23	3234.43	35.8245232	-116.559641	-5.061	0.025	3284.305	979712.14627	*-92.1171*
line4-9	11.38	3232.67	35.82305756	-116.5614728	-5.01	0.023	3282.517	979710.35829	*-93.7693*
line4-10	11.65	3231.77	35.8221446	-116.5624261	-4.958	0.023	3281.604	979709.44497	*-94.5941*
line4-11	11.80	3230.81	35.82107935	-116.5637755	-4.81	0.023	3280.629	979708.47007	*-95.4485*
line4-12	11.95	3229.19	35.8197442	-116.5656749	-4.588	0.026	3278.983	979706.82438	*-96.9359*
line4-13	12.13	3228.07	35.81856931	-116.5672584	-4.517	0.025	3277.846	979705.68704	*-97.9585*
line4-14	12.33	3227.01	35.81745178	-116.5686779	-4.084	0.024	3276.77	979704.61076	*-98.8537*
line4-15	12.50	3225.89	35.81584888	-116.570364	-4.062	0.025	3275.632	979703.47333	*-99.8493*
line4-16	12.67	3224.98	35.81426339	-116.5717535	-3.865	0.026	3274.708	979702.54932	*-100.599*
line4-17	12.88	3223.57	35.81169856	-116.5736424	-3.386	0.026	3273.276	979701.11741	*-101.716*
line4-18	13.15	3222.31	35.80898881	-116.5757953	-1.956	0.024	3271.997	979699.83822	*-102.482*
line4-19	13.45	3221.83	35.80657799	-116.5782548	0.87	0.03	3271.511	979699.35194	*-102.205*
line4-20	13.65	3221.51	35.80479509	-116.5808953	9.054	0.023	3271.187	979699.02775	*-100.766*
line4-21	14.33	3219.04	35.80324013	-116.5834199	22.605	0.026	3268.68	979696.52095	*-100.472*
line4-22	14.80	3215.46	35.80164598	-116.5861619	41.332	0.027	3265.044	979692.88489	*-100.286*
line4-23	14.97	3212.02	35.80041305	-116.5887902	60.619	0.025	3261.548	979689.38955	*-99.8799*
line4-24	15.12	3209.33	35.79927245	-116.591335	79.598	0.022	3258.815	979686.65637	*-98.7802*
line4-25	15.40	3206.90	35.79777423	-116.5939903	99.833	0.024	3256.347	979684.18814	*-97.1377*
line4-26	15.58	3209.78	35.79764775	-116.5903214	77.757	0.029	3259.275	979687.11616	*-98.5434*
line4-27	15.82	3214.79	35.79830068	-116.5852843	45.768	0.024	3264.368	979692.20924	*-99.8017*
line4-28	16.35	3221.21	35.80121491	-116.5790337	9.508	0.031	3270.896	979698.73692	*-100.66*
line4-29	16.55	3221.59	35.80304458	-116.5748087	-2.38	0.024	3271.283	979699.12417	*-102.769*
line4-30	16.68	3221.67	35.80400133	-116.5732272	-2.511	0.022	3271.365	979699.20617	*-102.795*

line4-31	16.80	3222.02	35.80484021	-116.5718976	-2.539	0.031	3271.721	979699.56250	*-102.516*
line4-32	17.02	3222.67	35.80587545	-116.5702988	-2.656	0.031	3272.383	979700.22425	*-101.966*
line4-33	17.20	3223.57	(2)	0	(2)	(2)	3273.299	979701.13991	*-101.226*
line4-34	17.38	3224.21	35.80774605	-116.5672457	-2.733	0.027	3273.95	979701.79133	*-100.667*
line4-35	17.57	3225.12	35.80843854	-116.5655913	-2.901	0.068	3274.876	979702.71715	*-99.8703*
line4-36	17.77	3226.32	35.80952653	-116.5636953	-3.082	0.044	3276.097	979703.93780	*-98.7319*
line4-37	17.95	3227.36	35.810334	-116.5619655	-3.148	0.035	3277.155	979704.99575	*-97.787*
line4-38	18.13	3228.32	35.81116818	-116.5604995	-3.359	0.04	3278.131	979705.97239	*-96.9652*
line4-39	18.30	3229.78	35.81266554	-116.5586577	-3.493	0.041	3279.616	979707.45712	*-95.6312*
line4-40	18.50	3231.56	35.81426406	-116.5561889	-3.562	0.041	3281.426	979709.26725	*-93.9781*
line4-41	18.73	3233.46	35.81591145	-116.5534928	-3.642	0.029	3283.358	979711.19951	*-92.3037*
line4-42	19.02	3236.98	35.818794	-116.5487861	-3.696	0.026	3286.937	979714.77850	*-89.0506*
line4-43	19.27	3240.85	35.82292947	-116.5447146	-3.549	0.027	3290.872	979718.71304	*-89.2481*
line5-1	10.12	3234.55	35.77087466	-116.5259811	9.029	0.027	3284.424	979712.19370	*-84.6958*
line5-2	10.38	3234.82	35.77291518	-116.5243713	7.931	0.032	3284.701	979712.47067	*-84.8099*
line5-3	10.57	3235.32	35.77514304	-116.5228391	7.074	0.027	3285.211	979712.98060	*-84.6596*
line5-4	10.82	3236.20	35.77736155	-116.5200096	6.174	0.026	3286.107	979713.87738	*-84.1301*
line5-5	10.95	3236.40	35.77853562	-116.5176023	8.225	0.027	3286.312	979714.08193	*-83.6226*
line5-6	11.18	3235.46	35.77896064	-116.5147652	12.467	0.025	3285.359	979713.12881	*-83.7774*
line5-7	11.38	3234.07	35.78067053	-116.5123452	21.248	0.034	3283.948	979711.71802	*-83.6067*
line5-8	11.57	3232.15	35.78201256	-116.5100298	33.123	0.025	3281.998	979709.76841	*-83.3343*
line5-9	11.77	3230.19	35.78340327	-116.5077746	46.173	0.025	3280.008	979707.77830	*-82.8755*
line5-10	11.97	3228.40	35.78427192	-116.5056169	56.457	0.025	3278.191	979705.96097	*-82.7434*
line5-11	12.15	3226.26	35.7849813	-116.5031425	68.907	0.035	3276.018	979703.78777	*-82.5273*
line5-12	12.33	3224.88	35.78624533	-116.5012341	81.049	0.033	3274.617	979702.38698	*-81.6469*
line5-13	12.50	3222.64	35.78720268	-116.4996995	92.118	0.028	3272.342	979700.11198	*-81.8256*
line5-14	12.68	3220.97	35.7883924	-116.4976712	103.613	0.035	3270.646	979698.41645	*-81.3609*
line5-15	13.48	3220.46	35.78982177	-116.4982305	104.848	0.034	3270.136	979697.90580	*-81.7511*
line5-16	13.67	3222.84	35.79100195	-116.5006476	91.152	0.032	3272.556	979700.32645	*-82.127*
line5-17	13.83	3225.55	35.79205991	-116.502669	77.449	0.031	3275.312	979703.08233	*-82.1586*

line5-18	14.02	3228.94	35.79300598	-116.5053045	59.734	0.028	3278.759	979706.52948	*-82.2789*
line5-19	14.18	3232.99	35.7939637	-116.5078193	44.959	0.029	3282.877	979710.64726	*-81.151*
line5-20	14.35	3233.79	35.79431134	-116.5104826	34.912	0.034	3283.692	979711.46193	*-82.3434*
line5-21	14.50	3234.57	35.7942279	-116.5132904	29.008	0.032	3284.486	979712.25612	*-82.704*
line5-22	14.72	3235.72	35.79357708	-116.51616	19.306	0.029	3285.657	979713.42699	*-83.3866*
line5-23	14.87	3236.31	35.79252392	-116.5186873	11.472	0.044	3286.258	979714.02807	*-84.237*
line5-24	15.13	3236.60	35.79213024	-116.5215821	5.878	0.039	3286.555	979714.32537	*-85.0068*
line5-25	15.30	3236.48	35.7916786	-116.5244703	2.294	0.046	3286.435	979714.20501	*-85.7938*
line5-26	15.48	3235.60	35.79132066	-116.5277053	2.246	0.041	3285.542	979713.31239	*-86.6651*
line5-27	15.70	3234.27	35.79043574	-116.5308952	2.738	0.034	3284.193	979711.96274	*-87.8421*
line5-28	15.88	3233.06	35.78970029	-116.5333915	3.092	0.032	3282.965	979710.73473	*-88.9373*
line5-29	16.07	3232.09	35.78889209	-116.5354191	2.977	0.033	3281.981	979709.75064	*-89.8748*
line5-30	16.22	3231.19	35.78830084	-116.5374537	2.969	0.027	3281.067	979708.83738	*-90.7389*
line5-31	16.42	3230.48	35.78742022	-116.5385823	3.051	0.035	3280.348	979708.11769	*-91.3669*
line5-32	16.88	3229.25	35.78636274	-116.5408722	3.249	0.024	3279.102	979706.87208	*-92.4829*
line5-33	17.07	3227.88	35.78540351	-116.5440522	2.929	0.022	3277.711	979705.48145	*-93.8542*
line5-34	17.25	3228.25	35.78316571	-116.5417573	4.174	0.025	3278.089	979705.85926	*-93.0395*
line5-35	17.48	3228.79	35.78150019	-116.5400995	4.205	0.027	3278.64	979706.41032	*-92.3396*
line5-36	17.63	3229.12	35.77990229	-116.538405	5.619	0.028	3278.977	979706.74716	*-91.5874*
line5-37	17.53	3230.02	35.77800528	-116.5362511	6.065	0.025	3279.891	979707.66090	*-90.4233*
line6-1	9.87	3229.02	35.88624197	-116.6394252	20.885	0.034	3278.8	979706.62043	*-97.8334*
line6-2	10.07	3229.57	35.88510338	-116.6402207	13.624	0.022	3279.361	979707.18145	*-98.6036*
line6-3	10.20	3230.40	35.8835934	-116.6413114	4.296	0.022	3280.206	979708.02636	*-99.4648*
line6-4	10.42	3231.10	35.88216032	-116.6422913	-4.301	0.021	3280.919	979708.73999	*-100.32*
line6-5	10.58	3231.84	35.88100071	-116.6432492	-12.552	0.022	3281.673	979709.49377	*-101.091*
line6-6	10.77	3232.25	35.87960728	-116.6441743	-19.667	0.023	3282.091	979709.91233	*-101.953*
line6-7	10.90	3232.92	35.87859361	-116.6449879	-26.474	0.022	3282.774	979710.59463	*-102.523*
line6-8	11.08	3229.77	35.87743254	-116.6461821	-15.172	0.025	3279.574	979707.39501	*-103.399*
linr6-9	11.23	3226.60	35.87598484	-116.6472075	-4.64	0.025	3276.354	979704.17474	*-104.422*
line6-10	11.43	3222.55	35.87381549	-116.6487393	9.776	0.025	3272.24	979700.06058	*-105.513*

line6-11	11.60	3219.48	35.87224875	-116.6501056	22.153	0.024	3269.121	979696.94211	*-106.061*
line6-12	11.78	3218.02	35.87113636	-116.651346	27.736	0.024	3267.639	979695.46011	*-106.349*
line6-13	11.93	3215.18	35.86944646	-116.6525372	40.327	0.024	3264.754	979692.57522	*-106.611*
line6-14	12.13	3212.22	35.86778971	-116.6538291	54.905	0.028	3261.748	979689.56888	*-106.606*
line6-15	12.32	3209.02	35.86615267	-116.6565509	75.214	0.026	3258.498	979686.31845	*-105.719*
line6-16	12.53	3206.35	35.86419499	-116.6585738	95.061	0.026	3255.786	979683.60702	*-104.356*
line6-17	12.70	3204.42	35.86246652	-116.6608477	112.011	0.028	3253.826	979681.64717	*-102.832*
line6-18	14.00	3201.91	35.85999388	-116.6631052	133.618	0.024	3251.288	979679.10933	*-100.906*
line6-19	15.75	3201.21	35.85867051	-116.6635552	142.291	0.023	3250.595	979678.41562	*-99.7789*
line6-20	16.03	3200.48	35.85716701	-116.6636676	152.637	0.023	3249.856	979677.67656	*-98.3528*
line6-21	16.27	3199.50	35.85544616	-116.6636529	164.363	0.021	3248.867	979676.68795	*-96.8861*
line6-22	16.43	3197.77	35.85369687	-116.6639851	176.326	0.026	3247.111	979674.93153	*-96.1381*
line6-23	16.55	3195.30	35.85233076	-116.664186	188.605	0.027	3244.602	979672.42257	*-96.1133*
line6-24	16.67	3193.03	35.85116708	-116.6642383	200.083	0.025	3242.296	979670.11687	*-96.0602*
line7-1	10.13	3234.04	35.87686856	-116.6246921	-10.015	0.026	3283.891	979711.67084	*-98.0595*
line7-2	10.30	3233.14	35.87458241	-116.626001	-15.627	0.029	3282.975	979710.75492	*-99.8836*
line7-3	10.52	3231.73	35.87255431	-116.6273152	-18.31	0.028	3281.54	979709.32031	*-101.672*
line7-4	10.67	3231.03	35.87131344	-116.6285388	-20.093	0.03	3280.828	979708.60778	*-102.629*
line7-5	10.83	3227.76	35.86967962	-116.6299305	-9.627	0.028	3277.503	979705.28314	*-103.754*
line7-6	11.00	3224.84	35.8681578	-116.6310579	0.808	0.029	3274.534	979702.31422	*-104.538*
line7-7	11.20	3221.93	35.86651246	-116.6320526	11.879	0.03	3271.575	979699.35522	*-105.177*
line7-8	11.37	3221.71	35.86440963	-116.633102	24.703	0.03	3271.35	979699.13041	*-102.698*
line7-9	11.50	3216.85	35.86301979	-116.6332172	32.622	0.028	3266.41	979694.19003	*-105.961*
line7-10	11.70	3213.76	35.86064381	-116.6331467	46.379	0.027	3263.268	979691.04809	*-106.191*
line7-11	11.93	3210.88	35.85822241	-116.6332039	59.797	0.03	3260.339	979688.11934	*-106.272*
line7-12	12.17	3207.75	35.85571008	-116.6337475	74.026	0.034	3257.156	979684.93650	*-106.438*
line7-13	12.33	3205.12	35.85493686	-116.6358473	88.147	0.032	3254.482	979682.26232	*-106.267*
line7-14	12.55	3203.57	35.85444319	-116.6380333	98.738	0.032	3252.905	979680.68542	*-105.718*
line7-15	13.20	3202.64	35.85320943	-116.6381719	105.895	0.029	3251.955	979679.73550	*-105.153*
line7-16	13.35	3201.75	35.85207884	-116.6386598	112.52	0.027	3251.05	979678.82987	*-104.658*

line7-17	13.48	3200.72	35.85075431	-116.6397783	121.247	0.025	3250.002	979677.78207	*-103.875*
line7-18	13.60	3200.02	35.84963452	-116.6407384	128.015	0.027	3249.29	979677.06979	*-103.159*
line7-19	13.77	3199.5	35.84886982	-116.6426988	136.767	0.025	3248.765	979676.54512	*-101.895*
line7-20	13.97	3198.96	35.84808605	-116.6456112	151.565	0.026	3248.215	979675.99490	*-99.4662*
line7-21	14.10	3197.59	35.84745406	-116.6477629	164.092	0.028	3246.821	979674.60167	*-98.3398*
line7-22	14.30	3195.98	35.84681866	-116.6498188	177.163	0.026	3245.184	979672.96405	*-97.3506*
line7-23	14.47	3193.82	35.84625557	-116.6519336	190.398	0.027	3242.988	979670.76774	*-96.8939*
line7-24	14.60	3195.13	35.84817859	-116.6523005	183.332	0.028	3244.318	979672.09806	*-97.1192*
line7-25	14.80	3195.65	35.85087738	-116.652871	174.246	0.026	3244.845	979672.62506	*-98.6119*
line7-26	15.03	3197.04	35.85509951	-116.6522288	149.633	0.029	3246.256	979674.03595	*-102.407*
line7-27	15.25	3200.62	35.85784668	-116.6525639	125.71	0.028	3249.887	979677.66761	*-103.719*
line7-28	15.38	3202.52	35.85955589	-116.6515076	110.995	0.028	3251.817	979679.59769	*-104.832*
line7-29	15.53	3204.22	35.86099158	-116.6503021	98.017	0.027	3253.544	979681.32438	*-105.782*
line7-30	15.72	3206.47	35.86217061	-116.6484253	84.269	0.025	3255.83	979683.60981	*-106.304*
line7-31	15.85	3209.57	35.86345769	-116.6459523	66.822	0.025	3258.979	979686.75950	*-106.698*
line7-32	16.02	3212.14	35.8645954	-116.6443316	53.739	0.027	3261.59	979689.37028	*-106.76*
line7-33	16.17	3214.95	35.86537661	-116.6423376	40.681	0.028	3264.445	979692.22511	*-106.542*
line7-34	16.32	3218.29	35.86697024	-116.6409226	26.024	0.028	3267.838	979695.61860	*-106.17*
line7-35	16.53	3223.03	35.86943671	-116.639842	6.33	0.031	3272.654	979700.43447	*-105.441*
line7-36	16.67	3226.69	35.87167305	-116.6388786	-6.898	0.034	3276.373	979704.15331	*-104.518*
line7-37	16.87	3230.69	35.87406	-116.6371831	-18.464	0.027	3280.437	979708.21722	*-102.935*
line7-38	17.05	3232.28	35.87662714	-116.6355461	-16.014	0.028	3282.052	979709.83187	*-101.058*
line7-39	17.23	3231.79	35.87835036	-116.6339356	-6.358	0.039	3281.552	979709.33253	*-99.8053*
line7-40	17.42	3231.88	35.87990414	-116.6321576	1.154	0.04	3281.642	979709.42267	*-98.3701*
line7-41	17.58	3231.13	35.88142927	-116.6301411	10.965	0.039	3280.879	979708.65921	*-97.3337*
line8-1	10.13	3238.47	35.80747806	-116.5367815	-1.817	0.027	3288.403	979716.11193	*-86.0509*
line8-2	10.27	3237.52	35.80669918	-116.5388802	-2.105	0.03	3287.438	979715.14713	*-87.0056*
line8-3	10.38	3236.29	35.80577888	-116.5413955	-2.071	0.034	3286.189	979713.89765	*-88.1694*
line8-4	10.48	3234.94	35.80507086	-116.5436636	-1.891	0.035	3284.817	979712.52613	*-89.4448*
line8-5	10.63	3234.05	35.804426	-116.5454092	-1.662	0.028	3283.913	979711.62239	*-90.2482*

line8-6	10.87	3232.66	35.80349124	-116.5477647	-1.463	0.024	3282.502	979710.21093	*-91.5403*
line8-7	11.02	3231.77	35.80287584	-116.5494861	-1.544	0.032	3281.598	979709.30719	*-92.4072*
line8-8	11.15	3230.77	35.80219575	-116.5513825	-1.51	0.037	3280.583	979708.29156	*-93.3578*
line8-9	11.27	3229.75	35.80141136	-116.5534127	-1.533	0.038	3279.546	979707.25552	*-94.3311*
line8-10	11.40	3228.92	35.80083851	-116.5550062	-1.428	0.033	3278.704	979706.41267	*-95.1041*
line8-11	11.52	3228.03	35.80021942	-116.5567216	-1.267	0.031	3277.8	979705.50876	*-95.9233*
line8-12	11.63	3227.78	35.7994718	-116.5588491	-1.492	0.038	3277.546	979705.25530	*-96.1569*
line8-13	11.82	3225.72	35.79879095	-116.5608653	-1.513	0.029	3275.454	979703.16262	*-98.1953*
line8-14	11.95	3224.86	35.79813715	-116.5626268	-1.567	0.032	3274.58	979702.28928	*-99.0232*
line8-15	12.08	3224.07	35.79754667	-116.5641559	-1.386	0.036	3273.778	979701.48709	*-99.7391*
line8-16	12.23	3223.27	35.7969096	-116.5656936	-1.361	0.028	3272.966	979700.67482	*-100.492*
line8-17	12.37	3222.08	35.79621639	-116.5670475	-1.443	0.039	3271.757	979699.46609	*-101.657*
line8-18	12.48	3222.61	35.79564525	-116.5684405	-0.652	0.038	3272.296	979700.00537	*-100.913*
line8-19	12.75	3222.04	35.79463284	-116.5705916	6.895	0.031	3271.718	979699.42749	*-99.9191*
line8-20	12.93	3220.37	35.79375933	-116.5726447	18.758	0.031	3270.022	979697.73118	*-99.2059*
line8-21	13.08	3217.06	35.79269319	-116.5752245	36.132	0.028	3266.659	979694.36790	*-99.0586*
line8-22	13.25	3213.62	35.79165792	-116.5777714	54.388	0.03	3263.164	979690.87259	*-98.8723*
line8-23	13.43	3210.91	35.79070471	-116.5797521	67.823	0.028	3260.41	979688.11929	*-98.8999*
line8-24	13.60	3207.07	35.78944313	-116.5824545	88.204	0.03	3256.508	979684.21743	*-98.6825*
line8-25	14.40	3204.81	35.78840074	-116.5842724	102.244	0.023	3254.216	979681.92479	*-98.1227*
line8-26	14.57	3202.79	35.78766456	-116.5860045	115.062	0.024	3252.164	979679.87268	*-97.5891*
line8-27	14.72	3200.27	35.78653146	-116.5880029	130.34	0.024	3249.603	979677.31231	*-97.0456*
line8-28	14.83	3198.04	35.78560566	-116.590083	143.452	0.026	3247.343	979675.05167	*-96.6464*
line8-29	15.17	3203.79	35.78433713	-116.5842598	110.916	0.028	3253.183	979680.89223	*-97.1002*
line8-30	15.28	3205.66	35.78365301	-116.5813543	97.199	0.027	3255.084	979682.79342	*-97.8398*
line8-31	15.42	3207.61	35.78304419	-116.5792924	86.184	0.025	3257.067	979684.77599	*-97.9728*
line8-32	15.57	3211.34	35.78282047	-116.5758803	66.406	0.026	3260.859	979688.56775	*-98.0542*
line8-33	15.73	3215.31	35.78251068	-116.5722008	47.763	0.023	3264.894	979692.60351	*-97.6608*
line8-34	15.83	3217.51	35.78271919	-116.5703066	37.964	0.024	3267.131	979694.83999	*-97.3706*
line8-35	15.97	3220.99	35.78329537	-116.5672452	21.802	0.024	3270.669	979698.37757	*-97.0632*

line8-36	16.12	3223.44	35.78406347	-116.5642307	8.572	0.024	3273.159	979700.86841	*-97.2418*
line8-37	16.22	3223.75	35.78466131	-116.5619251	1.674	0.026	3273.475	979701.18401	*-98.335*
line8-38	16.33	3223.71	35.78514564	-116.5604395	0.54	0.028	3273.435	979701.14398	*-98.6398*
line8-39	16.43	3223.86	35.78584492	-116.5589666	0.567	0.03	3273.588	979701.29697	*-98.5414*
line8-40	16.53	3224.25	35.78649907	-116.5574488	0.559	0.035	3273.985	979701.69387	*-98.2022*
line8-41	16.90	3224.95	35.78748986	-116.5545721	1.303	0.028	3274.698	979702.40728	*-97.4273*
line8-42	17.05	3225.91	35.78884185	-116.5525306	1.254	0.031	3275.675	979703.38377	*-96.5764*
line8-43	17.20	3226.81	35.78998129	-116.550551	1.38	0.039	3276.59	979704.29928	*-95.7338*
line8-44	17.32	3227.74	35.79067266	-116.548804	1.221	0.033	3277.536	979705.24510	*-94.8786*
line8-45	17.43	3228.94	35.79170008	-116.5464512	1.336	0.033	3278.756	979706.46533	*-93.7238*
line8-46	17.57	3230.39	35.79276601	-116.5436053	1.162	0.032	3280.231	979707.93974	*-92.3751*
line8-47	17.72	3232.14	35.79402159	-116.5398592	1.266	0.029	3282.01	979709.71914	*-90.6829*
line8-48	17.93	3234.68	35.79582661	-116.5352396	1.259	0.026	3284.593	979712.30180	*-88.2564*
line9-1	11.72	481.6	35.76834519	-116.5281239	8.767	0.027	47.31648	979711.82	*-84.9024*
line9-2	11.88	472.2	35.76771991	-116.5295311	10.428	0.023	46.39574	979710.90	*-85.4426*
line9-3	12.08	461	35.7668099	-116.5314757	10.911	0.031	45.29872	979709.80	*-86.3666*
line9-4	12.18	455.5	35.76624221	-116.5328129	10.589	0.029	44.76005	979709.27	*-86.9199*
line9-5	12.28	445.2	35.76565099	-116.5341996	11.067	0.026	43.74906	979708.25	*-87.7862*
line9-6	12.38	443.2	35.7649753	-116.5356028	11.021	0.027	43.55479	979708.06	*-87.9316*
line9-7	12.48	433.4	35.7644244	-116.5370177	10.771	0.026	42.593	979707.10	*-88.8953*
line9-8	12.63	419.5	35.76398891	-116.5386604	11.38	0.027	41.22904	979705.73	*-90.1021*
line9-9	12.70	402.3	35.76347125	-116.540811	15.858	0.029	39.53824	979704.04	*-90.8673*
line9-10	12.82	376.7	35.76292598	-116.5431581	22.087	0.026	37.02216	979701.53	*-92.1107*
line9-11	12.95	353.4	35.76238686	-116.5452468	28.709	0.027	34.73281	979699.24	*-93.0506*
line9-12	13.68	329.2	35.76182933	-116.5473737	36.296	0.022	32.37009	979696.88	*-93.8725*
line9-13	13.77	309.4	35.76119279	-116.5494371	44.759	0.023	30.42387	979694.93	*-94.0986*
line9-14	13.87	292.7	35.76072943	-116.5515844	51.565	0.023	28.78312	979693.29	*-94.3602*
line9-15	14.00	274.5	35.76002847	-116.5537785	59.209	0.023	26.99562	979691.50	*-94.5833*
line9-16	14.12	257	35.75942896	-116.555822	67.619	0.023	25.27657	979689.78	*-94.5958*
line9-17	14.23	240.1	35.75874897	-116.5580245	76.011	0.023	23.61656	979688.12	*-94.546*

line9-18	14.38	229.3	35.75831206	-116.560168	82.619	0.023	22.55764	979687.06	*-94.267*
line9-19	14.50	208.9	35.75776258	-116.5623907	95.241	0.024	20.55323	979685.06	*-93.7403*
line9-20	14.70	167.6	35.75686137	-116.5653333	115.027	0.029	16.49437	979681.00	*-93.828*
line9-21	14.80	188.4	35.75630741	-116.5632066	107.411	0.026	18.54362	979683.05	*-93.2301*
line9-22	14.92	204.9	35.75561227	-116.5612183	98.356	0.025	20.17017	979684.68	*-93.326*
line9-23	15.13	214.5	35.75528127	-116.558132	89.369	0.027	21.12029	979685.63	*-94.1162*
line9-24	15.28	228.8	35.75478764	-116.5549175	80.053	0.025	22.53121	979687.04	*-94.4963*
line9-25	15.43	241.8	35.75438001	-116.5525514	72.878	0.023	23.81421	979688.32	*-94.5904*
line9-26	15.58	255.7	35.75402707	-116.5501839	64.781	0.026	25.18576	979689.69	*-94.7821*
line9-27	15.68	291.9	35.75371288	-116.5473082	54.346	0.025	28.75037	979693.26	*-93.2442*
line9-28	15.82	313.6	35.75335346	-116.5450261	47.897	0.024	30.88903	979695.39	*-92.3439*
line9-29	15.93	325.5	35.75331181	-116.5427852	43.573	0.025	32.06294	979696.57	*-92.0174*
line9-30	16.05	339.4	35.75320153	-116.540595	39.274	0.024	33.43365	979697.94	*-91.4832*
line9-31	16.17	360.2	35.75277149	-116.5379326	34.866	0.025	35.48332	979699.99	*-90.2642*
line9-32	16.30	372.7	35.75274572	-116.5358283	33.189	0.025	36.71669	979701.22	*-89.3587*
line9-33	16.40	397.7	35.75292281	-116.5339551	25.292	0.026	39.17923	979703.68	*-88.4654*
line9-34	16.53	433.5	35.75366689	-116.5320238	12.63	0.027	42.70532	979707.21	*-87.495*
line9-35	16.67	436.1	35.75357474	-116.5300137	15.68	0.025	42.96453	979707.47	*-86.6277*
line9-36	16.75	446	35.75331114	-116.5280367	15.283	0.024	43.9408	979708.45	*-85.7069*
line9-37	16.87	443.1	35.75318555	-116.526143	19.068	0.024	43.65839	979708.16	*-85.2337*
line9-38	17.00	451.9	35.75291901	-116.5232571	18.66	0.031	44.52769	979709.03	*-84.4218*
line9-39	17.12	458.7	35.75293675	-116.5207909	19.399	0.036	45.19976	979709.71	*-83.6058*
line9-40	17.27	451.4	35.75289637	-116.5177029	24.181	0.029	44.48523	979708.99	*-83.3758*
line9-41	17.48	443.6	35.75281547	-116.5143943	30.974	0.027	43.7232	979708.23	*-82.794*
line9-42	17.62	457.7	35.75432581	-116.5159633	23.784	0.035	45.11401	979709.62	*-82.9477*
line9-43	17.78	472.2	35.75603925	-116.5185948	17.346	0.028	46.54503	979711.05	*-82.9305*
line9-44	18.10	475.8	35.76161151	-116.5244575	11.873	0.034	46.90728	979711.41	*-84.123*
line9-45	18.33	470.3	35.76657621	-116.5288099	10.685	0.115	46.37198	979710.88	*-85.3177*
line10-1	11.13	301.8	35.69289633	-116.4913453	44.349	0.027	29.68519	979694.19	*-89.0657*
line10-2	11.50	303.1	35.69580457	-116.4903299	45.973	0.029	29.807	979694.31	*-88.8734*

line10-3	11.63	301.4	35.69908659	-116.4895742	44.312	0.027	29.6375	979694.14	*-89.6509*
line10-4	11.82	307.6	35.70196849	-116.4890087	40.552	0.027	30.24453	979694.75	*-90.0307*
line10-5	11.98	321.5	35.70494785	-116.4880502	38.053	0.035	31.60951	979696.11	*-89.4127*
line10-6	12.13	339.1	35.70776958	-116.487142	37.498	0.033	33.33885	979697.84	*-88.0344*
line10-7	12.30	352.5	35.71009542	-116.4863713	36.967	0.025	34.65464	979699.16	*-87.0223*
line10-8	12.55	381.9	35.71290075	-116.4848005	36.073	0.028	37.54344	979702.05	*-84.5498*
line10-9	12.77	399	35.71513695	-116.4836327	36.223	0.03	39.22247	979703.73	*-83.0329*
line10-10	12.92	413	35.71746787	-116.4826308	36.555	0.034	40.59757	979705.10	*-81.7921*
line10-11	13.07	414.2	35.72040385	-116.4815047	37.143	0.027	40.71315	979705.22	*-81.8124*
line10-12	13.27	408.9	35.72298586	-116.4806548	47.494	0.029	40.1883	979704.69	*-80.5214*
line10-13	13.38	388.9	35.72397314	-116.4802424	58.208	0.031	38.21836	979702.72	*-80.4674*
line10-14	14.38	407.7	35.71854679	-116.4845205	36.064	0.025	40.05163	979704.56	*-82.5271*
line10-15	14.53	391.8	35.71468039	-116.4880149	35.533	0.036	38.48457	979702.99	*-83.8674*
line10-16	14.78	350	35.71179458	-116.491627	35.936	0.03	34.36728	979698.87	*-87.6582*
line10-17	14.97	324.2	35.70938239	-116.4939313	36.679	0.03	31.82551	979696.33	*-89.847*
line10-18	15.13	315.6	35.70779198	-116.4967221	37.285	0.029	30.9765	979695.48	*-90.4405*
line10-19	15.35	304.9	35.70524128	-116.5016089	40.243	0.025	29.92001	979694.43	*-90.6964*
line10-20	15.50	302.8	35.70539887	-116.5046216	39.796	0.026	29.71087	979694.22	*-91.007*

Appendix D: Error Analysis Computations

Table D.1: Number of computations required to determine the gravitational attraction of a sphere embedded in a cubic earth model

Sample Spacing	***Number of Computations***
1	729
0.9	1000
0.8	1423.828
0.7	2125.364
0.6	3375
0.5	5832
0.4	11390.63
0.3	27000
0.2	91125
0.1	729000
0.09	1000000
0.08	1423828
0.07	2125364
0.06	3375000
0.05	5832000
0.04	11390625
0.03	27000000
0.02	91125000
0.01	7.29E+08
0.009	1E+09
0.008	1.42E+09
0.007	2.13E+09
0.006	3.37E+09
0.005	5.83E+09
0.004	1.14E+10
0.003	2.7E+10
0.002	9.11E+10
0.001	7.29E+11

Assuming the edge of the sphere defines the model edge, the number of computations are:

$$\left[\frac{2 \times radius}{grid\ spacing}\right]^3$$

Table D.2: Difference in sphere calculated using BAGC.m and its analytical solution

		Distance From Center of Sphere (km)							
		-40	***-10***	***-5***	***-2.5***	***-1***	***-0.5***	***-0.1***	***0***
		Difference in Absolute Value (mGal)							
Sample Spacing	***0.1***	2.522466	2.286821	2.334019	2.58454	1.248817	0.408577	0.089771	0.001994
	0.03	1.085828	1.010118	1.013063	1.014354	0.393437	0.638106	0.021883	0.000305
	0.05	1.007106	0.972815	1.054656	1.093002	0.493337	0.663291	0.039437	0.000985
	0.08	7.721148	5.702711	3.954959	3.091634	1.16607	0.150748	0.192548	0.004127
	0.1	2.377812	2.212719	2.384972	2.766044	1.443214	0.347826	0.101902	0.002238
	0.3	12.53206	10.83622	12.16483	14.58906	1.52439	0.977249	0.428622	0.008523
	1	84.40014	81.14129	86.03792	94.74222	23.89123	11.60358	2.825308	0.057257
		Difference in Percent							
Sample Spacing	***0.1***	0.7514	0.68171	0.70818	0.827619	0.5569	0.40655	0.38697	0.42522
	0.03	0.32345	0.30112	0.30738	0.324815	0.17545	0.63494	0.09433	0.06508
	0.05	0.3	0.29	0.32	0.35	0.22	0.66	0.17	0.21
	0.08	2.3	1.7	1.2	0.99	0.52	0.15	0.83	0.88
	0.1	0.70831	0.65962	0.72364	0.88574	0.64359	0.3461	0.43926	0.47729
	0.3	3.73309	3.23032	3.69101	4.671693	0.67979	0.9724	1.84763	1.81724
	1	25.14138	24.18853	26.10533	30.33826	10.65411	11.546	12.17884	12.20824
Absolute Value		***335.7021***	***335.4536***	***329.5799***	***312.2863***	***224.2443***	***100.4987***	***23.1985***	***0.469***

Table D.3: Percent difference in gravitational attraction with varying density contrast (Referenced to Figure 3.6).

Density Contrast	Distance from Center of Sphere*: -2.5 (km)	-1 (km)	-0.5 (km)	-0.1 (km)	0 (km)
2.67 g/m^3	0.28	0.22	0.23	0.13	0.16
0.267 g/m^3	0.28	0.22	0.23	0.13	0.16
0.0267 g/m^3	0.28	0.22	0.23	0.13	0.16
0.00267 g/m^3	0.28	0.22	0.23	0.13	0.16
0.000267 g/m^3	0.28	0.22	0.23	0.13	0.16
0.0000267 g/m^3	0.28	0.22	0.23	0.13	0.16
0.00000267 g/m^3	0.28	0.22	0.23	0.13	0.16
2.67E-09 g/m^3	0.28	0.22	0.23	0.13	0.16

*Sphere of radius 4.5 km was buried at 4.5 km with a sample spacing of 0.1 km.

Table D.4: Percent difference in gravitational attraction with varying density contrast (Referenced to Figure 3.7).

Sphere Size*

Distance from Center	4.5 (km)	2 (km)	0.2 (km)	0.02 (km)	0.002 (km)
0.1 (km)	0.43926	0.1697	0.4193	0.3032	0.2644
0.5 (km)	0.3461	0.3919	0.2646	0.3068	0.9171
1 (km)	0.64359	0.4897	0.2633	0.3068	191.6558
2 (km)	0.88574	0.3075	0.2621	0.2895	92.0189
5 (km)	0.72364	0.2352	0.2619	0.6555	99.5119

*Sphere of radius 4.5 km was buried at 4.5 km with a sample spacing of 0.1 km. The density contrast was 2670 kg/m^3

Table D.5: Gravitational attraction with varying density contrast (Referenced to Figure 3.8).

Distance from Center (km)	***Difference in Gravitational Attraction (%)***
0	0.1197
10	0.2473
20	0.345
60	0.2343
1000	0.2439
2000	0.2433
5000	0.2399
10000	0.2269
15000	0.506
20000	0.1344
30000	1.3497
40000	9.49
50000	4.69
60000	6.62
70000	5.99
75000	7.53
80000	4.97
85000	6.34
90000	36.45
100000	87.34
10,000,000	100
1000000000	100

Table D.6: Geometry of generated 3D basin* (referenced to Figure 3.9)

Horizontal Distance (km)	***basin depth (km)***	***Horizontal Distance (km)***	***basin depth (km)***	***Horizontal Distance (km)***	***basin depth (km)***	***Horizontal Distance (km)***	***basin depth (km)***
0.0000	0.0000	2.5009	0.2813	5.0018	0.4580	7.5027	0.2723
0.0036	0.0000	2.5045	0.2812	5.0054	0.4586	7.5063	0.2722
0.0072	0.0000	2.5081	0.2812	5.0090	0.4587	7.5099	0.2707
0.0109	0.0000	2.5118	0.2812	5.0127	0.4592	7.5136	0.2696
0.0145	0.0000	2.5154	0.2811	5.0163	0.4597	7.5172	0.2692
0.0181	0.0000	2.5190	0.2810	5.0199	0.4598	7.5208	0.2676
0.0217	0.0000	2.5226	0.2810	5.0235	0.4604	7.5244	0.2670
0.0253	0.0000	2.5262	0.2809	5.0271	0.4607	7.5280	0.2661
0.0290	0.0000	2.5299	0.2809	5.0308	0.4610	7.5317	0.2645
0.0326	0.0000	2.5335	0.2809	5.0344	0.4616	7.5353	0.2643
0.0362	0.0000	2.5371	0.2808	5.0380	0.4617	7.5389	0.2631
0.0398	0.0000	2.5407	0.2808	5.0416	0.4622	7.5425	0.2618
0.0434	0.0000	2.5443	0.2807	5.0452	0.4628	7.5461	0.2615
0.0471	0.0000	2.5480	0.2806	5.0489	0.4628	7.5498	0.2600
0.0507	0.0000	2.5516	0.2806	5.0525	0.4634	7.5534	0.2592
0.0543	0.0000	2.5552	0.2805	5.0561	0.4638	7.5570	0.2586
0.0579	0.0000	2.5588	0.2805	5.0597	0.4641	7.5606	0.2571
0.0615	0.0000	2.5624	0.2804	5.0633	0.4647	7.5642	0.2567
0.0651	0.0000	2.5660	0.2804	5.0669	0.4649	7.5679	0.2556
0.0688	0.0000	2.5697	0.2803	5.0706	0.4653	7.5715	0.2541
0.0724	0.0000	2.5733	0.2803	5.0742	0.4659	7.5751	0.2541
0.0760	0.0000	2.5769	0.2802	5.0778	0.4659	7.5787	0.2526
0.0796	0.0000	2.5805	0.2802	5.0814	0.4665	7.5823	0.2516
0.0832	0.0000	2.5841	0.2801	5.0850	0.4670	7.5859	0.2511
0.0869	0.0000	2.5878	0.2800	5.0887	0.4671	7.5896	0.2497
0.0905	0.0000	2.5914	0.2800	5.0923	0.4677	7.5932	0.2491
0.0941	0.0000	2.5950	0.2798	5.0959	0.4680	7.5968	0.2482
0.0977	0.0000	2.5986	0.2798	5.0995	0.4683	7.6004	0.2467
0.1013	0.0000	2.6022	0.2797	5.1031	0.4689	7.6040	0.2466
0.1050	0.0000	2.6059	0.2796	5.1068	0.4690	7.6077	0.2452
0.1086	0.0000	2.6095	0.2796	5.1104	0.4695	7.6113	0.2440
0.1122	0.0000	2.6131	0.2795	5.1140	0.4700	7.6149	0.2437
0.1158	0.0000	2.6167	0.2794	5.1176	0.4701	7.6185	0.2423
0.1194	0.0000	2.6203	0.2794	5.1212	0.4707	7.6221	0.2416
0.1231	0.0000	2.6240	0.2792	5.1249	0.4710	7.6258	0.2408
0.1267	0.0000	2.6276	0.2792	5.1285	0.4713	7.6294	0.2394
0.1303	0.0000	2.6312	0.2791	5.1321	0.4718	7.6330	0.2391

0.1339	0.0000	2.6348	0.2790	5.1357	0.4720	7.6366	0.2379
0.1375	0.0000	2.6384	0.2789	5.1393	0.4724	7.6402	0.2366
0.1412	0.0000	2.6421	0.2788	5.1430	0.4729	7.6439	0.2365
0.1448	0.0000	2.6457	0.2787	5.1466	0.4729	7.6475	0.2350
0.1484	0.0000	2.6493	0.2787	5.1502	0.4735	7.6511	0.2341
0.1520	0.0000	2.6529	0.2785	5.1538	0.4738	7.6547	0.2336
0.1556	0.0000	2.6565	0.2784	5.1574	0.4740	7.6583	0.2321
0.1592	0.0000	2.6601	0.2784	5.1611	0.4745	7.6620	0.2317
0.1629	0.0000	2.6638	0.2783	5.1647	0.4747	7.6656	0.2307
0.1665	0.0000	2.6674	0.2782	5.1683	0.4750	7.6692	0.2293
0.1701	0.0000	2.6710	0.2781	5.1719	0.4755	7.6728	0.2292
0.1737	0.0000	2.6746	0.2780	5.1755	0.4756	7.6764	0.2278
0.1773	0.0000	2.6782	0.2779	5.1791	0.4760	7.6800	0.2268
0.1810	0.0000	2.6819	0.2778	5.1828	0.4764	7.6837	0.2264
0.1846	0.0000	2.6855	0.2777	5.1864	0.4765	7.6873	0.2250
0.1882	0.0000	2.6891	0.2777	5.1900	0.4770	7.6909	0.2244
0.1918	0.0000	2.6927	0.2776	5.1936	0.4772	7.6945	0.2236
0.1954	0.0000	2.6963	0.2775	5.1972	0.4774	7.6981	0.2222
0.1991	0.0000	2.7000	0.2775	5.2009	0.4779	7.7018	0.2220
0.2027	0.0000	2.7036	0.2773	5.2045	0.4780	7.7054	0.2208
0.2063	0.0000	2.7072	0.2773	5.2081	0.4783	7.7090	0.2196
0.2099	0.0000	2.7108	0.2772	5.2117	0.4787	7.7126	0.2194
0.2135	0.0000	2.7144	0.2772	5.2153	0.4788	7.7162	0.2180
0.2172	0.0000	2.7181	0.2772	5.2190	0.4792	7.7199	0.2173
0.2208	0.0000	2.7217	0.2771	5.2226	0.4795	7.7235	0.2167
0.2244	0.0000	2.7253	0.2771	5.2262	0.4797	7.7271	0.2153
0.2280	0.0000	2.7289	0.2770	5.2298	0.4801	7.7307	0.2149
0.2316	0.0000	2.7325	0.2770	5.2334	0.4803	7.7343	0.2139
0.2353	0.0000	2.7362	0.2770	5.2371	0.4806	7.7380	0.2126
0.2389	0.0000	2.7398	0.2770	5.2407	0.4810	7.7416	0.2126
0.2425	0.0000	2.7434	0.2770	5.2443	0.4810	7.7452	0.2112
0.2461	0.0000	2.7470	0.2770	5.2479	0.4814	7.7488	0.2103
0.2497	0.0000	2.7506	0.2770	5.2515	0.4817	7.7524	0.2099
0.2533	0.0000	2.7542	0.2770	5.2552	0.4818	7.7561	0.2085
0.2570	0.0000	2.7579	0.2770	5.2588	0.4822	7.7597	0.2080
0.2606	0.0000	2.7615	0.2770	5.2624	0.4823	7.7633	0.2071
0.2642	0.0000	2.7651	0.2770	5.2660	0.4825	7.7669	0.2058
0.2678	0.0000	2.7687	0.2771	5.2696	0.4829	7.7705	0.2057
0.2714	0.0000	2.7723	0.2771	5.2732	0.4830	7.7741	0.2045
0.2751	0.0000	2.7760	0.2771	5.2769	0.4832	7.7778	0.2034
0.2787	0.0000	2.7796	0.2772	5.2805	0.4835	7.7814	0.2032
0.2823	0.0000	2.7832	0.2772	5.2841	0.4836	7.7850	0.2018
0.2859	0.0000	2.7868	0.2773	5.2877	0.4839	7.7886	0.2012

0.2895	0.0000	2.7904	0.2773	5.2913	0.4840	7.7922	0.2005
0.2932	0.0000	2.7941	0.2774	5.2950	0.4842	7.7959	0.1992
0.2968	0.0000	2.7977	0.2774	5.2986	0.4845	7.7995	0.1989
0.3004	0.0000	2.8013	0.2775	5.3022	0.4845	7.8031	0.1979
0.3040	0.0000	2.8049	0.2776	5.3058	0.4847	7.8067	0.1967
0.3076	0.0000	2.8085	0.2777	5.3094	0.4850	7.8103	0.1965
0.3113	0.0000	2.8122	0.2778	5.3131	0.4850	7.8140	0.1952
0.3149	0.0000	2.8158	0.2778	5.3167	0.4852	7.8176	0.1944
0.3185	0.0000	2.8194	0.2779	5.3203	0.4853	7.8212	0.1939
0.3221	0.0000	2.8230	0.2781	5.3239	0.4854	7.8248	0.1926
0.3257	0.0000	2.8266	0.2781	5.3275	0.4856	7.8284	0.1922
0.3294	0.0000	2.8303	0.2783	5.3312	0.4857	7.8321	0.1913
0.3330	0.0000	2.8339	0.2783	5.3348	0.4858	7.8357	0.1899
0.3366	0.0000	2.8375	0.2784	5.3384	0.4860	7.8393	0.1899
0.3402	0.0000	2.8411	0.2786	5.3420	0.4860	7.8429	0.1886
0.3438	0.0000	2.8447	0.2786	5.3456	0.4862	7.8465	0.1877
0.3474	0.0000	2.8483	0.2787	5.3493	0.4863	7.8502	0.1873
0.3511	0.0000	2.8520	0.2789	5.3529	0.4863	7.8538	0.1860
0.3547	0.0000	2.8556	0.2789	5.3565	0.4864	7.8574	0.1854
0.3583	0.0000	2.8592	0.2791	5.3601	0.4865	7.8610	0.1847
0.3619	0.0000	2.8628	0.2792	5.3637	0.4866	7.8646	0.1834
0.3655	0.0000	2.8664	0.2793	5.3673	0.4867	7.8682	0.1832
0.3692	0.0000	2.8701	0.2796	5.3710	0.4867	7.8719	0.1821
0.3728	0.0000	2.8737	0.2796	5.3746	0.4868	7.8755	0.1810
0.3764	0.0000	2.8773	0.2798	5.3782	0.4868	7.8791	0.1808
0.3800	0.0000	2.8809	0.2801	5.3818	0.4868	7.8827	0.1795
0.3836	0.0000	2.8845	0.2801	5.3854	0.4869	7.8863	0.1788
0.3873	0.0000	2.8882	0.2803	5.3891	0.4869	7.8900	0.1782
0.3909	0.0000	2.8918	0.2805	5.3927	0.4869	7.8936	0.1769
0.3945	0.0000	2.8954	0.2806	5.3963	0.4870	7.8972	0.1766
0.3981	0.0000	2.8990	0.2809	5.3999	0.4870	7.9008	0.1757
0.4017	0.0000	2.9026	0.2810	5.4035	0.4870	7.9044	0.1745
0.4054	0.0000	2.9063	0.2812	5.4072	0.4870	7.9081	0.1744
0.4090	0.0000	2.9099	0.2816	5.4108	0.4870	7.9117	0.1732
0.4126	0.0000	2.9135	0.2816	5.4144	0.4870	7.9153	0.1723
0.4162	0.0000	2.9171	0.2819	5.4180	0.4870	7.9189	0.1719
0.4198	0.0000	2.9207	0.2822	5.4216	0.4870	7.9225	0.1706
0.4235	0.0000	2.9244	0.2823	5.4253	0.4870	7.9262	0.1702
0.4271	0.0000	2.9280	0.2827	5.4289	0.4870	7.9298	0.1694
0.4307	0.0000	2.9316	0.2829	5.4325	0.4870	7.9334	0.1681
0.4343	0.0000	2.9352	0.2831	5.4361	0.4870	7.9370	0.1680
0.4379	0.0000	2.9388	0.2836	5.4397	0.4870	7.9406	0.1669
0.4415	0.0000	2.9425	0.2837	5.4434	0.4869	7.9443	0.1659

0.4452	0.0000	2.9461	0.2840	5.4470	0.4869	7.9479	0.1657
0.4488	0.0000	2.9497	0.2845	5.4506	0.4869	7.9515	0.1645
0.4524	0.0000	2.9533	0.2845	5.4542	0.4868	7.9551	0.1639
0.4560	0.0000	2.9569	0.2850	5.4578	0.4868	7.9587	0.1632
0.4596	0.0000	2.9605	0.2854	5.4614	0.4867	7.9623	0.1620
0.4633	0.0000	2.9642	0.2856	5.4651	0.4867	7.9660	0.1618
0.4669	0.0000	2.9678	0.2861	5.4687	0.4866	7.9696	0.1608
0.4705	0.0000	2.9714	0.2863	5.4723	0.4866	7.9732	0.1597
0.4741	0.0000	2.9750	0.2867	5.4759	0.4865	7.9768	0.1596
0.4777	0.0000	2.9786	0.2873	5.4795	0.4865	7.9804	0.1584
0.4814	0.0000	2.9823	0.2873	5.4832	0.4864	7.9841	0.1577
0.4850	0.0000	2.9859	0.2879	5.4868	0.4863	7.9877	0.1572
0.4886	0.0000	2.9895	0.2883	5.4904	0.4863	7.9913	0.1560
0.4922	0.0000	2.9931	0.2885	5.4940	0.4861	7.9949	0.1556
0.4958	0.0000	2.9967	0.2892	5.4976	0.4861	7.9985	0.1548
0.4995	0.0000	3.0004	0.2894	5.5013	0.4860	8.0022	0.1536
0.5031	0.0000	3.0040	0.2898	5.5049	0.4859	8.0058	0.1536
0.5067	0.0000	3.0076	0.2905	5.5085	0.4859	8.0094	0.1524
0.5103	0.0000	3.0112	0.2906	5.5121	0.4858	8.0130	0.1515
0.5139	0.0000	3.0148	0.2912	5.5157	0.4857	8.0166	0.1512
0.5176	0.0000	3.0185	0.2918	5.5194	0.4857	8.0203	0.1500
0.5212	0.0000	3.0221	0.2919	5.5230	0.4856	8.0239	0.1495
0.5248	0.0000	3.0257	0.2927	5.5266	0.4856	8.0275	0.1488
0.5284	0.0000	3.0293	0.2931	5.5302	0.4855	8.0311	0.1476
0.5320	0.0000	3.0329	0.2934	5.5338	0.4855	8.0347	0.1474
0.5356	0.0000	3.0366	0.2942	5.5375	0.4855	8.0384	0.1464
0.5393	0.0000	3.0402	0.2944	5.5411	0.4854	8.0420	0.1454
0.5429	0.0000	3.0438	0.2949	5.5447	0.4854	8.0456	0.1452
0.5465	0.0000	3.0474	0.2957	5.5483	0.4854	8.0492	0.1440
0.5501	0.0000	3.0510	0.2957	5.5519	0.4854	8.0528	0.1433
0.5537	0.0000	3.0546	0.2965	5.5555	0.4853	8.0565	0.1428
0.5574	0.0000	3.0583	0.2971	5.5592	0.4853	8.0601	0.1416
0.5610	0.0000	3.0619	0.2973	5.5628	0.4853	8.0637	0.1413
0.5646	0.0000	3.0655	0.2982	5.5664	0.4853	8.0673	0.1404
0.5682	0.0000	3.0691	0.2985	5.5700	0.4852	8.0709	0.1392
0.5718	0.0000	3.0727	0.2990	5.5736	0.4852	8.0745	0.1392
0.5755	0.0000	3.0764	0.2999	5.5773	0.4852	8.0782	0.1380
0.5791	0.0000	3.0800	0.2999	5.5809	0.4852	8.0818	0.1372
0.5827	0.0000	3.0836	0.3007	5.5845	0.4851	8.0854	0.1368
0.5863	0.0000	3.0872	0.3014	5.5881	0.4851	8.0890	0.1356
0.5899	0.0000	3.0908	0.3016	5.5917	0.4850	8.0926	0.1352
0.5936	0.0000	3.0945	0.3025	5.5954	0.4850	8.0963	0.1345
0.5972	0.0000	3.0981	0.3029	5.5990	0.4850	8.0999	0.1333

0.6008	0.0000	3.1017	0.3034	5.6026	0.4849	8.1035	0.1332
0.6044	0.0000	3.1053	0.3043	5.6062	0.4849	8.1071	0.1321
0.6080	0.0000	3.1089	0.3045	5.6098	0.4848	8.1107	0.1312
0.6117	0.0000	3.1126	0.3052	5.6135	0.4847	8.1144	0.1310
0.6153	0.0000	3.1162	0.3060	5.6171	0.4847	8.1180	0.1298
0.6189	0.0000	3.1198	0.3061	5.6207	0.4846	8.1216	0.1293
0.6225	0.0000	3.1234	0.3071	5.6243	0.4845	8.1252	0.1287
0.6261	0.0000	3.1270	0.3076	5.6279	0.4844	8.1288	0.1276
0.6297	0.0000	3.1307	0.3080	5.6316	0.4843	8.1325	0.1274
0.6334	0.0000	3.1343	0.3089	5.6352	0.4843	8.1361	0.1265
0.6370	0.0000	3.1379	0.3092	5.6388	0.4842	8.1397	0.1255
0.6406	0.0000	3.1415	0.3099	5.6424	0.4840	8.1433	0.1254
0.6442	0.0000	3.1451	0.3108	5.6460	0.4840	8.1469	0.1243
0.6478	0.0000	3.1487	0.3109	5.6496	0.4838	8.1506	0.1236
0.6515	0.0000	3.1524	0.3118	5.6533	0.4837	8.1542	0.1231
0.6551	0.0000	3.1560	0.3125	5.6569	0.4837	8.1578	0.1220
0.6587	0.0000	3.1596	0.3128	5.6605	0.4835	8.1614	0.1217
0.6623	0.0000	3.1632	0.3138	5.6641	0.4834	8.1650	0.1209
0.6659	0.0000	3.1668	0.3142	5.6677	0.4833	8.1686	0.1198
0.6696	0.0000	3.1705	0.3147	5.6714	0.4831	8.1723	0.1198
0.6732	0.0000	3.1741	0.3157	5.6750	0.4831	8.1759	0.1187
0.6768	0.0000	3.1777	0.3159	5.6786	0.4829	8.1795	0.1180
0.6804	0.0000	3.1813	0.3167	5.6822	0.4827	8.1831	0.1177
0.6840	0.0000	3.1849	0.3176	5.6858	0.4826	8.1867	0.1166
0.6877	0.0000	3.1886	0.3177	5.6895	0.4824	8.1904	0.1161
0.6913	0.0000	3.1922	0.3187	5.6931	0.4823	8.1940	0.1155
0.6949	0.0000	3.1958	0.3193	5.6967	0.4822	8.1976	0.1145
0.6985	0.0000	3.1994	0.3197	5.7003	0.4820	8.2012	0.1143
0.7021	0.0000	3.2030	0.3207	5.7039	0.4819	8.2048	0.1134
0.7058	0.0000	3.2067	0.3210	5.7076	0.4818	8.2085	0.1125
0.7094	0.0000	3.2103	0.3217	5.7112	0.4816	8.2121	0.1123
0.7130	0.0000	3.2139	0.3227	5.7148	0.4816	8.2157	0.1113
0.7166	0.0000	3.2175	0.3227	5.7184	0.4814	8.2193	0.1107
0.7202	0.0000	3.2211	0.3237	5.7220	0.4813	8.2229	0.1102
0.7238	0.0000	3.2248	0.3244	5.7257	0.4812	8.2266	0.1092
0.7275	0.0000	3.2284	0.3247	5.7293	0.4810	8.2302	0.1089
0.7311	0.0000	3.2320	0.3257	5.7329	0.4809	8.2338	0.1081
0.7347	0.0000	3.2356	0.3261	5.7365	0.4807	8.2374	0.1071
0.7383	0.0000	3.2392	0.3267	5.7401	0.4805	8.2410	0.1071
0.7419	0.0000	3.2428	0.3277	5.7437	0.4805	8.2447	0.1060
0.7456	0.0000	3.2465	0.3277	5.7474	0.4803	8.2483	0.1053
0.7492	0.0000	3.2501	0.3286	5.7510	0.4801	8.2519	0.1050
0.7528	0.0000	3.2537	0.3294	5.7546	0.4801	8.2555	0.1039

0.7564	0.0000	3.2573	0.3296	5.7582	0.4798	8.2591	0.1035
0.7600	0.0000	3.2609	0.3306	5.7618	0.4797	8.2627	0.1029
0.7637	0.0000	3.2646	0.3310	5.7655	0.4796	8.2664	0.1018
0.7673	0.0000	3.2682	0.3315	5.7691	0.4794	8.2700	0.1018
0.7709	0.0000	3.2718	0.3325	5.7727	0.4794	8.2736	0.1008
0.7745	0.0000	3.2754	0.3326	5.7763	0.4792	8.2772	0.1000
0.7781	0.0000	3.2790	0.3334	5.7799	0.4789	8.2808	0.0998
0.7818	0.0000	3.2827	0.3342	5.7836	0.4789	8.2845	0.0987
0.7854	0.0000	3.2863	0.3343	5.7872	0.4787	8.2881	0.0982
0.7890	0.0000	3.2899	0.3353	5.7908	0.4785	8.2917	0.0977
0.7926	0.0000	3.2935	0.3358	5.7944	0.4784	8.2953	0.0967
0.7962	0.0000	3.2971	0.3362	5.7980	0.4781	8.2989	0.0965
0.7999	0.0000	3.3008	0.3372	5.8017	0.4781	8.3026	0.0957
0.8035	0.0000	3.3044	0.3375	5.8053	0.4779	8.3062	0.0948
0.8071	0.0000	3.3080	0.3381	5.8089	0.4776	8.3098	0.0947
0.8107	0.0000	3.3116	0.3391	5.8125	0.4776	8.3134	0.0937
0.8143	0.0000	3.3152	0.3391	5.8161	0.4773	8.3170	0.0931
0.8180	0.0000	3.3189	0.3400	5.8198	0.4771	8.3207	0.0927
0.8216	0.0000	3.3225	0.3407	5.8234	0.4770	8.3243	0.0917
0.8252	0.0000	3.3261	0.3410	5.8270	0.4767	8.3279	0.0914
0.8288	0.0000	3.3297	0.3419	5.8306	0.4766	8.3315	0.0908
0.8324	0.0000	3.3333	0.3423	5.8342	0.4764	8.3351	0.0898
0.8360	0.0000	3.3369	0.3429	5.8379	0.4760	8.3388	0.0898
0.8397	0.0000	3.3406	0.3438	5.8415	0.4760	8.3424	0.0889
0.8433	0.0000	3.3442	0.3439	5.8451	0.4757	8.3460	0.0882
0.8469	0.0000	3.3478	0.3448	5.8487	0.4754	8.3496	0.0879
0.8505	0.0000	3.3514	0.3456	5.8523	0.4753	8.3532	0.0870
0.8541	0.0000	3.3550	0.3457	5.8559	0.4750	8.3568	0.0866
0.8578	0.0000	3.3587	0.3467	5.8596	0.4748	8.3605	0.0861
0.8614	0.0000	3.3623	0.3472	5.8632	0.4746	8.3641	0.0852
0.8650	0.0000	3.3659	0.3477	5.8668	0.4742	8.3677	0.0851
0.8686	0.0000	3.3695	0.3486	5.8704	0.4741	8.3713	0.0843
0.8722	0.0000	3.3731	0.3489	5.8740	0.4738	8.3749	0.0835
0.8759	0.0000	3.3768	0.3496	5.8777	0.4734	8.3786	0.0834
0.8795	0.0000	3.3804	0.3505	5.8813	0.4733	8.3822	0.0825
0.8831	0.0000	3.3840	0.3506	5.8849	0.4729	8.3858	0.0820
0.8867	0.0000	3.3876	0.3516	5.8885	0.4726	8.3894	0.0816
0.8903	0.0000	3.3912	0.3522	5.8921	0.4725	8.3930	0.0807
0.8940	0.0000	3.3949	0.3525	5.8958	0.4720	8.3967	0.0805
0.8976	0.0000	3.3985	0.3535	5.8994	0.4719	8.4003	0.0798
0.9012	0.0000	3.4021	0.3539	5.9030	0.4716	8.4039	0.0790
0.9048	0.0000	3.4057	0.3545	5.9066	0.4711	8.4075	0.0789
0.9084	0.0000	3.4093	0.3555	5.9102	0.4711	8.4111	0.0781

0.9121	0.0000	3.4130	0.3556	5.9139	0.4706	8.4148	0.0775
0.9157	0.0000	3.4166	0.3565	5.9175	0.4703	8.4184	0.0772
0.9193	0.0000	3.4202	0.3573	5.9211	0.4702	8.4220	0.0763
0.9229	0.0000	3.4238	0.3575	5.9247	0.4697	8.4256	0.0760
0.9265	0.0000	3.4274	0.3585	5.9283	0.4695	8.4292	0.0755
0.9301	0.0000	3.4310	0.3590	5.9320	0.4692	8.4329	0.0746
0.9338	0.0000	3.4347	0.3595	5.9356	0.4687	8.4365	0.0745
0.9374	0.0000	3.4383	0.3605	5.9392	0.4687	8.4401	0.0737
0.9410	0.0000	3.4419	0.3607	5.9428	0.4682	8.4437	0.0731
0.9446	0.0000	3.4455	0.3615	5.9464	0.4678	8.4473	0.0729
0.9482	0.0000	3.4491	0.3624	5.9500	0.4677	8.4509	0.0720
0.9519	0.0000	3.4528	0.3625	5.9537	0.4672	8.4546	0.0716
0.9555	0.0000	3.4564	0.3635	5.9573	0.4670	8.4582	0.0711
0.9591	0.0000	3.4600	0.3641	5.9609	0.4667	8.4618	0.0703
0.9627	0.0000	3.4636	0.3645	5.9645	0.4662	8.4654	0.0701
0.9663	0.0000	3.4672	0.3655	5.9681	0.4661	8.4690	0.0694
0.9700	0.0000	3.4709	0.3658	5.9718	0.4657	8.4727	0.0687
0.9736	0.0000	3.4745	0.3665	5.9754	0.4652	8.4763	0.0686
0.9772	0.0000	3.4781	0.3675	5.9790	0.4652	8.4799	0.0677
0.9808	0.0000	3.4817	0.3675	5.9826	0.4647	8.4835	0.0672
0.9844	0.0000	3.4853	0.3685	5.9862	0.4643	8.4871	0.0669
0.9881	0.0000	3.4890	0.3693	5.9899	0.4642	8.4908	0.0661
0.9917	0.0000	3.4926	0.3696	5.9935	0.4636	8.4944	0.0658
0.9953	0.0000	3.4962	0.3706	5.9971	0.4634	8.4980	0.0652
0.9989	0.0000	3.4998	0.3710	6.0007	0.4631	8.5016	0.0644
1.0025	0.0000	3.5034	0.3716	6.0043	0.4626	8.5052	0.0644
1.0062	0.0000	3.5071	0.3726	6.0080	0.4625	8.5089	0.0636
1.0098	0.0000	3.5107	0.3728	6.0116	0.4620	8.5125	0.0630
1.0134	0.0000	3.5143	0.3737	6.0152	0.4616	8.5161	0.0628
1.0170	0.0000	3.5179	0.3745	6.0188	0.4614	8.5197	0.0620
1.0206	0.0000	3.5215	0.3747	6.0224	0.4609	8.5233	0.0616
1.0242	0.0000	3.5251	0.3758	6.0261	0.4606	8.5270	0.0612
1.0279	0.0000	3.5288	0.3763	6.0297	0.4603	8.5306	0.0604
1.0315	0.0000	3.5324	0.3768	6.0333	0.4597	8.5342	0.0603
1.0351	0.0000	3.5360	0.3779	6.0369	0.4596	8.5378	0.0596
1.0387	0.0000	3.5396	0.3781	6.0405	0.4591	8.5414	0.0589
1.0423	0.0000	3.5432	0.3789	6.0441	0.4585	8.5450	0.0588
1.0460	0.0000	3.5469	0.3799	6.0478	0.4585	8.5487	0.0580
1.0496	0.0000	3.5505	0.3800	6.0514	0.4578	8.5523	0.0576
1.0532	0.0000	3.5541	0.3811	6.0550	0.4574	8.5559	0.0572
1.0568	0.0000	3.5577	0.3818	6.0586	0.4572	8.5595	0.0565
1.0604	0.0000	3.5613	0.3822	6.0622	0.4565	8.5631	0.0563
1.0641	0.0000	3.5650	0.3833	6.0659	0.4563	8.5668	0.0557

1.0677	0.0000	3.5686	0.3837	6.0695	0.4558	8.5704	0.0550
1.0713	0.0000	3.5722	0.3844	6.0731	0.4551	8.5740	0.0550
1.0749	0.0000	3.5758	0.3855	6.0767	0.4551	8.5776	0.0542
1.0785	0.0000	3.5794	0.3856	6.0803	0.4544	8.5812	0.0537
1.0822	0.0000	3.5831	0.3866	6.0840	0.4539	8.5849	0.0535
1.0858	0.0000	3.5867	0.3875	6.0876	0.4537	8.5885	0.0528
1.0894	0.0000	3.5903	0.3878	6.0912	0.4530	8.5921	0.0525
1.0930	0.0000	3.5939	0.3889	6.0948	0.4527	8.5957	0.0520
1.0966	0.0000	3.5975	0.3895	6.0984	0.4523	8.5993	0.0513
1.1003	0.0000	3.6012	0.3901	6.1021	0.4516	8.6030	0.0513
1.1039	0.0000	3.6048	0.3912	6.1057	0.4515	8.6066	0.0506
1.1075	0.0000	3.6084	0.3914	6.1093	0.4508	8.6102	0.0500
1.1111	0.0000	3.6120	0.3924	6.1129	0.4502	8.6138	0.0499
1.1147	0.0000	3.6156	0.3934	6.1165	0.4501	8.6174	0.0492
1.1183	0.0000	3.6192	0.3935	6.1202	0.4494	8.6211	0.0488
1.1220	0.0000	3.6229	0.3947	6.1238	0.4490	8.6247	0.0485
1.1256	0.0000	3.6265	0.3953	6.1274	0.4487	8.6283	0.0478
1.1292	0.0000	3.6301	0.3958	6.1310	0.4480	8.6319	0.0476
1.1328	0.0000	3.6337	0.3970	6.1346	0.4478	8.6355	0.0471
1.1364	0.0000	3.6373	0.3973	6.1382	0.4473	8.6391	0.0464
1.1401	0.0000	3.6410	0.3981	6.1419	0.4466	8.6428	0.0464
1.1437	0.0000	3.6446	0.3992	6.1455	0.4466	8.6464	0.0457
1.1473	0.0000	3.6482	0.3993	6.1491	0.4459	8.6500	0.0453
1.1509	0.0000	3.6518	0.4004	6.1527	0.4454	8.6536	0.0450
1.1545	0.0000	3.6554	0.4012	6.1563	0.4452	8.6572	0.0443
1.1582	0.0000	3.6591	0.4015	6.1600	0.4445	8.6609	0.0441
1.1618	0.0000	3.6627	0.4027	6.1636	0.4443	8.6645	0.0436
1.1654	0.0000	3.6663	0.4032	6.1672	0.4438	8.6681	0.0429
1.1690	0.0000	3.6699	0.4038	6.1708	0.4431	8.6717	0.0429
1.1726	0.0000	3.6735	0.4050	6.1744	0.4431	8.6753	0.0422
1.1763	0.0000	3.6772	0.4051	6.1781	0.4425	8.6790	0.0417
1.1799	0.0000	3.6808	0.4061	6.1817	0.4419	8.6826	0.0415
1.1835	0.0000	3.6844	0.4071	6.1853	0.4418	8.6862	0.0408
1.1871	0.0000	3.6880	0.4073	6.1889	0.4411	8.6898	0.0405
1.1907	0.0000	3.6916	0.4084	6.1925	0.4408	8.6934	0.0401
1.1944	0.0000	3.6953	0.4090	6.1962	0.4405	8.6971	0.0395
1.1980	0.0000	3.6989	0.4096	6.1998	0.4398	8.7007	0.0394
1.2016	0.0000	3.7025	0.4107	6.2034	0.4397	8.7043	0.0388
1.2052	0.0000	3.7061	0.4110	6.2070	0.4392	8.7079	0.0382
1.2088	0.0000	3.7097	0.4118	6.2106	0.4386	8.7115	0.0381
1.2124	0.0000	3.7134	0.4129	6.2143	0.4385	8.7152	0.0375
1.2161	0.0000	3.7170	0.4130	6.2179	0.4379	8.7188	0.0371
1.2197	0.0000	3.7206	0.4141	6.2215	0.4375	8.7224	0.0368

1.2233	0.0000	3.7242	0.4149	6.2251	0.4372	8.7260	0.0362
1.2269	0.0000	3.7278	0.4153	6.2287	0.4366	8.7296	0.0360
1.2305	0.0000	3.7314	0.4164	6.2323	0.4364	8.7333	0.0355
1.2342	0.0000	3.7351	0.4168	6.2360	0.4360	8.7369	0.0350
1.2378	0.0000	3.7387	0.4175	6.2396	0.4353	8.7405	0.0349
1.2414	0.0000	3.7423	0.4187	6.2432	0.4353	8.7441	0.0343
1.2450	0.0000	3.7459	0.4188	6.2468	0.4347	8.7477	0.0339
1.2486	0.0100	3.7495	0.4198	6.2504	0.4343	8.7513	0.0337
1.2523	0.0100	3.7532	0.4207	6.2541	0.4341	8.7550	0.0331
1.2559	0.0100	3.7568	0.4209	6.2577	0.4335	8.7586	0.0329
1.2595	0.0100	3.7604	0.4221	6.2613	0.4332	8.7622	0.0325
1.2631	0.0100	3.7640	0.4226	6.2649	0.4328	8.7658	0.0319
1.2667	0.0100	3.7676	0.4232	6.2685	0.4322	8.7694	0.0319
1.2704	0.0100	3.7713	0.4243	6.2722	0.4321	8.7731	0.0314
1.2740	0.0100	3.7749	0.4245	6.2758	0.4316	8.7767	0.0309
1.2776	0.0100	3.7785	0.4255	6.2794	0.4311	8.7803	0.0308
1.2812	0.0100	3.7821	0.4265	6.2830	0.4310	8.7839	0.0302
1.2848	0.0100	3.7857	0.4266	6.2866	0.4304	8.7875	0.0300
1.2885	0.0100	3.7894	0.4277	6.2903	0.4301	8.7912	0.0297
1.2921	0.0100	3.7930	0.4284	6.2939	0.4298	8.7948	0.0291
1.2957	0.0100	3.7966	0.4289	6.2975	0.4293	8.7984	0.0290
1.2993	0.0100	3.8002	0.4300	6.3011	0.4291	8.8020	0.0286
1.3029	0.0100	3.8038	0.4303	6.3047	0.4287	8.8056	0.0281
1.3065	0.0100	3.8075	0.4311	6.3084	0.4281	8.8093	0.0280
1.3102	0.0100	3.8111	0.4323	6.3120	0.4281	8.8129	0.0275
1.3138	0.0100	3.8147	0.4323	6.3156	0.4276	8.8165	0.0272
1.3174	0.0100	3.8183	0.4334	6.3192	0.4272	8.8201	0.0270
1.3210	0.0100	3.8219	0.4342	6.3228	0.4270	8.8237	0.0264
1.3246	0.0100	3.8255	0.4345	6.3264	0.4265	8.8274	0.0263
1.3283	0.0100	3.8292	0.4356	6.3301	0.4263	8.8310	0.0259
1.3319	0.0100	3.8328	0.4361	6.3337	0.4260	8.8346	0.0254
1.3355	0.0100	3.8364	0.4367	6.3373	0.4255	8.8382	0.0254
1.3391	0.0100	3.8400	0.4379	6.3409	0.4255	8.8418	0.0249
1.3427	0.0100	3.8436	0.4380	6.3445	0.4251	8.8454	0.0245
1.3464	0.0100	3.8473	0.4390	6.3482	0.4249	8.8491	0.0244
1.3500	0.0100	3.8509	0.4399	6.3518	0.4248	8.8527	0.0239
1.3536	0.0100	3.8545	0.4401	6.3554	0.4245	8.8563	0.0236
1.3572	0.0100	3.8581	0.4412	6.3590	0.4245	8.8599	0.0233
1.3608	0.0100	3.8617	0.4418	6.3626	0.4245	8.8635	0.0228
1.3645	0.0100	3.8654	0.4424	6.3663	0.4245	8.8672	0.0228
1.3681	0.0100	3.8690	0.4435	6.3699	0.4246	8.8708	0.0223
1.3717	0.0100	3.8726	0.4438	6.3735	0.4247	8.8744	0.0219
1.3753	0.0100	3.8762	0.4446	6.3771	0.4248	8.8780	0.0218

1.3789	0.0100	3.8798	0.4457	6.3807	0.4249	8.8816	0.0213
1.3826	0.0100	3.8835	0.4457	6.3844	0.4251	8.8853	0.0211
1.3862	0.0100	3.8871	0.4469	6.3880	0.4252	8.8889	0.0208
1.3898	0.0100	3.8907	0.4476	6.3916	0.4253	8.8925	0.0203
1.3934	0.0100	3.8943	0.4480	6.3952	0.4256	8.8961	0.0202
1.3970	0.0100	3.8979	0.4491	6.3988	0.4256	8.8997	0.0200
1.4006	0.0100	3.9016	0.4495	6.4025	0.4258	8.9034	0.0200
1.4043	0.0100	3.9052	0.4502	6.4061	0.4262	8.9070	0.0200
1.4079	0.0100	3.9088	0.4514	6.4097	0.4262	8.9106	0.0200
1.4115	0.0100	3.9124	0.4514	6.4133	0.4265	8.9142	0.0200
1.4151	0.0100	3.9160	0.4525	6.4169	0.4267	8.9178	0.0200
1.4187	0.0100	3.9196	0.4533	6.4205	0.4268	8.9215	0.0200
1.4224	0.0200	3.9233	0.4536	6.4242	0.4272	8.9251	0.0200
1.4260	0.0200	3.9269	0.4547	6.4278	0.4273	8.9287	0.0200
1.4296	0.0200	3.9305	0.4552	6.4314	0.4275	8.9323	0.0200
1.4332	0.0200	3.9341	0.4557	6.4350	0.4278	8.9359	0.0200
1.4368	0.0200	3.9377	0.4568	6.4386	0.4279	8.9395	0.0200
1.4405	0.0200	3.9414	0.4570	6.4423	0.4282	8.9432	0.0200
1.4441	0.0200	3.9450	0.4579	6.4459	0.4284	8.9468	0.0200
1.4477	0.0200	3.9486	0.4589	6.4495	0.4285	8.9504	0.0200
1.4513	0.0200	3.9522	0.4590	6.4531	0.4288	8.9540	0.0200
1.4549	0.0200	3.9558	0.4601	6.4567	0.4290	8.9576	0.0200
1.4586	0.0200	3.9595	0.4607	6.4604	0.4291	8.9613	0.0200
1.4622	0.0200	3.9631	0.4612	6.4640	0.4294	8.9649	0.0200
1.4658	0.0200	3.9667	0.4622	6.4676	0.4295	8.9685	0.0200
1.4694	0.0200	3.9703	0.4625	6.4712	0.4297	8.9721	0.0200
1.4730	0.0200	3.9739	0.4633	6.4748	0.4299	8.9757	0.0200
1.4767	0.0200	3.9776	0.4643	6.4785	0.4300	8.9794	0.0200
1.4803	0.0200	3.9812	0.4643	6.4821	0.4302	8.9830	0.0200
1.4839	0.0200	3.9848	0.4653	6.4857	0.4304	8.9866	0.0200
1.4875	0.0200	3.9884	0.4661	6.4893	0.4305	8.9902	0.0200
1.4911	0.0200	3.9920	0.4664	6.4929	0.4308	8.9938	0.0200
1.4948	0.0200	3.9957	0.4674	6.4966	0.4309	8.9975	0.0200
1.4984	0.0200	3.9993	0.4678	6.5002	0.4310	9.0011	0.0200
1.5020	0.0200	4.0029	0.4684	6.5038	0.4313	9.0047	0.0200
1.5056	0.0200	4.0065	0.4694	6.5074	0.4313	9.0083	0.0200
1.5092	0.0200	4.0101	0.4695	6.5110	0.4315	9.0119	0.0200
1.5128	0.0200	4.0137	0.4704	6.5146	0.4317	9.0156	0.0200
1.5165	0.0200	4.0174	0.4712	6.5183	0.4318	9.0192	0.0200
1.5201	0.0200	4.0210	0.4714	6.5219	0.4320	9.0228	0.0200
1.5237	0.0200	4.0246	0.4724	6.5255	0.4321	9.0264	0.0200
1.5273	0.0200	4.0282	0.4729	6.5291	0.4323	9.0300	0.0200
1.5309	0.0200	4.0318	0.4734	6.5327	0.4325	9.0336	0.0200

1.5346	0.0200	4.0355	0.4744	6.5364	0.4326	9.0373	0.0200
1.5382	0.0200	4.0391	0.4746	6.5400	0.4328	9.0409	0.0200
1.5418	0.0200	4.0427	0.4754	6.5436	0.4330	9.0445	0.0200
1.5454	0.0200	4.0463	0.4763	6.5472	0.4330	9.0481	0.0200
1.5490	0.0200	4.0499	0.4763	6.5508	0.4332	9.0517	0.0200
1.5527	0.0200	4.0536	0.4773	6.5545	0.4334	9.0554	0.0200
1.5563	0.0200	4.0572	0.4779	6.5581	0.4335	9.0590	0.0200
1.5599	0.0200	4.0608	0.4782	6.5617	0.4337	9.0626	0.0200
1.5635	0.0200	4.0644	0.4792	6.5653	0.4338	9.0662	0.0200
1.5671	0.0200	4.0680	0.4795	6.5689	0.4339	9.0698	0.0200
1.5708	0.0200	4.0717	0.4801	6.5726	0.4342	9.0735	0.0200
1.5744	0.0200	4.0753	0.4811	6.5762	0.4342	9.0771	0.0200
1.5780	0.0200	4.0789	0.4811	6.5798	0.4344	9.0807	0.0200
1.5816	0.0200	4.0825	0.4820	6.5834	0.4346	9.0843	0.0200
1.5852	0.0200	4.0861	0.4827	6.5870	0.4346	9.0879	0.0200
1.5889	0.0200	4.0898	0.4830	6.5907	0.4349	9.0916	0.0200
1.5925	0.0200	4.0934	0.4839	6.5943	0.4350	9.0952	0.0200
1.5961	0.0200	4.0970	0.4843	6.5979	0.4351	9.0988	0.0200
1.5997	0.0200	4.1006	0.4848	6.6015	0.4353	9.1024	0.0200
1.6033	0.0200	4.1042	0.4857	6.6051	0.4354	9.1060	0.0200
1.6069	0.0200	4.1078	0.4859	6.6088	0.4356	9.1097	0.0200
1.6106	0.0200	4.1115	0.4867	6.6124	0.4357	9.1133	0.0200
1.6142	0.0200	4.1151	0.4874	6.6160	0.4358	9.1169	0.0200
1.6178	0.0200	4.1187	0.4876	6.6196	0.4360	9.1205	0.0200
1.6214	0.0200	4.1223	0.4884	6.6232	0.4361	9.1241	0.0200
1.6250	0.0200	4.1259	0.4890	6.6268	0.4362	9.1277	0.0200
1.6287	0.0200	4.1296	0.4893	6.6305	0.4364	9.1314	0.0200
1.6323	0.0200	4.1332	0.4902	6.6341	0.4364	9.1350	0.0200
1.6359	0.0200	4.1368	0.4904	6.6377	0.4366	9.1386	0.0200
1.6395	0.0200	4.1404	0.4910	6.6413	0.4367	9.1422	0.0200
1.6431	0.0200	4.1440	0.4919	6.6449	0.4367	9.1458	0.0200
1.6468	0.0200	4.1477	0.4919	6.6486	0.4369	9.1495	0.0200
1.6504	0.0200	4.1513	0.4927	6.6522	0.4370	9.1531	0.0200
1.6540	0.0200	4.1549	0.4932	6.6558	0.4370	9.1567	0.0200
1.6576	0.0200	4.1585	0.4934	6.6594	0.4371	9.1603	0.0200
1.6612	0.0200	4.1621	0.4942	6.6630	0.4372	9.1639	0.0200
1.6649	0.0200	4.1658	0.4945	6.6667	0.4372	9.1676	0.0200
1.6685	0.0200	4.1694	0.4950	6.6703	0.4373	9.1712	0.0200
1.6721	0.0200	4.1730	0.4957	6.6739	0.4373	9.1748	0.0200
1.6757	0.0205	4.1766	0.4958	6.6775	0.4374	9.1784	0.0200
1.6793	0.0207	4.1802	0.4964	6.6811	0.4374	9.1820	0.0200
1.6830	0.0216	4.1839	0.4970	6.6848	0.4375	9.1857	0.0200
1.6866	0.0226	4.1875	0.4971	6.6884	0.4375	9.1893	0.0200

1.6902	0.0227	4.1911	0.4978	6.6920	0.4375	9.1929	0.0200
1.6938	0.0238	4.1947	0.4981	6.6956	0.4375	9.1965	0.0200
1.6974	0.0245	4.1983	0.4984	6.6992	0.4375	9.2001	0.0200
1.7010	0.0250	4.2019	0.4991	6.7029	0.4375	9.2038	0.0200
1.7047	0.0262	4.2056	0.4992	6.7065	0.4374	9.2074	0.0200
1.7083	0.0266	4.2092	0.4997	6.7101	0.4374	9.2110	0.0200
1.7119	0.0275	4.2128	0.5002	6.7137	0.4374	9.2146	0.0200
1.7155	0.0287	4.2164	0.5003	6.7173	0.4373	9.2182	0.0200
1.7191	0.0287	4.2200	0.5008	6.7209	0.4372	9.2218	0.0200
1.7228	0.0301	4.2237	0.5012	6.7246	0.4372	9.2255	0.0200
1.7264	0.0310	4.2273	0.5014	6.7282	0.4371	9.2291	0.0200
1.7300	0.0314	4.2309	0.5020	6.7318	0.4370	9.2327	0.0200
1.7336	0.0328	4.2345	0.5021	6.7354	0.4369	9.2363	0.0200
1.7372	0.0333	4.2381	0.5025	6.7390	0.4368	9.2399	0.0200
1.7409	0.0342	4.2418	0.5030	6.7427	0.4368	9.2436	0.0200
1.7445	0.0356	4.2454	0.5030	6.7463	0.4366	9.2472	0.0200
1.7481	0.0358	4.2490	0.5035	6.7499	0.4365	9.2508	0.0200
1.7517	0.0371	4.2526	0.5039	6.7535	0.4364	9.2544	0.0200
1.7553	0.0383	4.2562	0.5040	6.7571	0.4362	9.2580	0.0200
1.7590	0.0386	4.2599	0.5045	6.7608	0.4361	9.2617	0.0200
1.7626	0.0401	4.2635	0.5047	6.7644	0.4360	9.2653	0.0200
1.7662	0.0409	4.2671	0.5049	6.7680	0.4357	9.2689	0.0200
1.7698	0.0417	4.2707	0.5054	6.7716	0.4357	9.2725	0.0200
1.7734	0.0433	4.2743	0.5055	6.7752	0.4355	9.2761	0.0200
1.7771	0.0437	4.2780	0.5058	6.7789	0.4352	9.2798	0.0200
1.7807	0.0449	4.2816	0.5062	6.7825	0.4352	9.2834	0.0200
1.7843	0.0465	4.2852	0.5063	6.7861	0.4349	9.2870	0.0200
1.7879	0.0466	4.2888	0.5067	6.7897	0.4347	9.2906	0.0200
1.7915	0.0483	4.2924	0.5069	6.7933	0.4345	9.2942	0.0200
1.7951	0.0495	4.2960	0.5071	6.7970	0.4342	9.2979	0.0200
1.7988	0.0502	4.2997	0.5075	6.8006	0.4341	9.3015	0.0200
1.8024	0.0519	4.3033	0.5077	6.8042	0.4338	9.3051	0.0200
1.8060	0.0525	4.3069	0.5079	6.8078	0.4334	9.3087	0.0200
1.8096	0.0536	4.3105	0.5084	6.8114	0.4334	9.3123	0.0200
1.8132	0.0555	4.3141	0.5084	6.8150	0.4330	9.3159	0.0200
1.8169	0.0556	4.3178	0.5088	6.8187	0.4327	9.3196	0.0200
1.8205	0.0573	4.3214	0.5090	6.8223	0.4325	9.3232	0.0200
1.8241	0.0588	4.3250	0.5091	6.8259	0.4321	9.3268	0.0200
1.8277	0.0592	4.3286	0.5095	6.8295	0.4319	9.3304	0.0200
1.8313	0.0612	4.3322	0.5097	6.8331	0.4316	9.3340	0.0200
1.8350	0.0621	4.3359	0.5099	6.8368	0.4311	9.3377	0.0200
1.8386	0.0631	4.3395	0.5103	6.8404	0.4310	9.3413	0.0200
1.8422	0.0651	4.3431	0.5103	6.8440	0.4305	9.3449	0.0200

1.8458	0.0654	4.3467	0.5106	6.8476	0.4301	9.3485	0.0200
1.8494	0.0671	4.3503	0.5109	6.8512	0.4300	9.3521	0.0200
1.8531	0.0689	4.3540	0.5110	6.8549	0.4294	9.3558	0.0200
1.8567	0.0691	4.3576	0.5114	6.8585	0.4292	9.3594	0.0200
1.8603	0.0712	4.3612	0.5115	6.8621	0.4288	9.3630	0.0200
1.8639	0.0724	4.3648	0.5117	6.8657	0.4282	9.3666	0.0200
1.8675	0.0733	4.3684	0.5120	6.8693	0.4281	9.3702	0.0200
1.8712	0.0755	4.3721	0.5120	6.8730	0.4276	9.3739	0.0200
1.8748	0.0761	4.3757	0.5122	6.8766	0.4270	9.3775	0.0200
1.8784	0.0777	4.3793	0.5123	6.8802	0.4269	9.3811	0.0200
1.8820	0.0798	4.3829	0.5123	6.8838	0.4262	9.3847	0.0200
1.8856	0.0799	4.3865	0.5120	6.8874	0.4258	9.3883	0.0200
1.8892	0.0821	4.3902	0.5116	6.8911	0.4255	9.3920	0.0200
1.8929	0.0837	4.3938	0.5113	6.8947	0.4248	9.3956	0.0200
1.8965	0.0843	4.3974	0.5106	6.8983	0.4246	9.3992	0.0200
1.9001	0.0866	4.4010	0.5103	6.9019	0.4240	9.4028	0.0200
1.9037	0.0876	4.4046	0.5097	6.9055	0.4233	9.4064	0.0200
1.9073	0.0890	4.4082	0.5088	6.9091	0.4233	9.4100	0.0200
1.9110	0.0913	4.4119	0.5087	6.9128	0.4225	9.4137	0.0200
1.9146	0.0916	4.4155	0.5078	6.9164	0.4219	9.4173	0.0200
1.9182	0.0937	4.4191	0.5070	6.9200	0.4217	9.4209	0.0200
1.9218	0.0956	4.4227	0.5068	6.9236	0.4209	9.4245	0.0200
1.9254	0.0961	4.4263	0.5058	6.9272	0.4205	9.4281	0.0200
1.9291	0.0985	4.4300	0.5053	6.9309	0.4200	9.4318	0.0200
1.9327	0.0998	4.4336	0.5047	6.9345	0.4191	9.4354	0.0200
1.9363	0.1010	4.4372	0.5037	6.9381	0.4191	9.4390	0.0200
1.9399	0.1035	4.4408	0.5036	6.9417	0.4183	9.4426	0.0200
1.9435	0.1040	4.4444	0.5027	6.9453	0.4175	9.4462	0.0200
1.9472	0.1060	4.4481	0.5019	6.9490	0.4174	9.4499	0.0200
1.9508	0.1083	4.4517	0.5017	6.9526	0.4164	9.4535	0.0200
1.9544	0.1085	4.4553	0.5007	6.9562	0.4159	9.4571	0.0200
1.9580	0.1111	4.4589	0.5001	6.9598	0.4155	9.4607	0.0200
1.9616	0.1127	4.4625	0.4997	6.9634	0.4145	9.4643	0.0200
1.9653	0.1137	4.4662	0.4987	6.9671	0.4143	9.4680	0.0000
1.9689	0.1162	4.4698	0.4984	6.9707	0.4135	9.4716	0.0000
1.9725	0.1171	4.4734	0.4977	6.9743	0.4126	9.4752	0.0000
1.9761	0.1189	4.4770	0.4967	6.9779	0.4125	9.4788	0.0000
1.9797	0.1215	4.4806	0.4967	6.9815	0.4115	9.4824	0.0000
1.9833	0.1217	4.4843	0.4957	6.9852	0.4108	9.4861	0.0000
1.9870	0.1242	4.4879	0.4950	6.9888	0.4104	9.4897	0.0000
1.9906	0.1263	4.4915	0.4947	6.9924	0.4094	9.4933	0.0000
1.9942	0.1269	4.4951	0.4937	6.9960	0.4090	9.4969	0.0000
1.9978	0.1297	4.4987	0.4933	6.9996	0.4083	9.5005	0.0000

2.0014	0.1309	4.5023	0.4927	7.0032	0.4072	9.5042	0.0000
2.0051	0.1324	4.5060	0.4917	7.0069	0.4072	9.5078	0.0000
2.0087	0.1352	4.5096	0.4916	7.0105	0.4061	9.5114	0.0000
2.0123	0.1356	4.5132	0.4907	7.0141	0.4052	9.5150	0.0000
2.0159	0.1380	4.5168	0.4899	7.0177	0.4050	9.5186	0.0000
2.0195	0.1404	4.5204	0.4897	7.0213	0.4038	9.5222	0.0000
2.0232	0.1408	4.5241	0.4888	7.0250	0.4033	9.5259	0.0000
2.0268	0.1436	4.5277	0.4883	7.0286	0.4026	9.5295	0.0000
2.0304	0.1452	4.5313	0.4878	7.0322	0.4014	9.5331	0.0000
2.0340	0.1464	4.5349	0.4868	7.0358	0.4013	9.5367	0.0000
2.0376	0.1493	4.5385	0.4866	7.0394	0.4002	9.5403	0.0000
2.0413	0.1501	4.5422	0.4859	7.0431	0.3992	9.5440	0.0000
2.0449	0.1522	4.5458	0.4850	7.0467	0.3990	9.5476	0.0000
2.0485	0.1551	4.5494	0.4849	7.0503	0.3978	9.5512	0.0000
2.0521	0.1551	4.5530	0.4840	7.0539	0.3970	9.5548	0.0000
2.0557	0.1580	4.5566	0.4834	7.0575	0.3965	9.5584	0.0000
2.0594	0.1599	4.5603	0.4830	7.0612	0.3952	9.5621	0.0000
2.0630	0.1607	4.5639	0.4821	7.0648	0.3948	9.5657	0.0000
2.0666	0.1636	4.5675	0.4818	7.0684	0.3939	9.5693	0.0000
2.0702	0.1647	4.5711	0.4811	7.0720	0.3926	9.5729	0.0000
2.0738	0.1664	4.5747	0.4802	7.0756	0.3926	9.5765	0.0000
2.0774	0.1693	4.5784	0.4802	7.0793	0.3913	9.5802	0.0000
2.0811	0.1696	4.5820	0.4793	7.0829	0.3903	9.5838	0.0000
2.0847	0.1721	4.5856	0.4786	7.0865	0.3899	9.5874	0.0000
2.0883	0.1744	4.5892	0.4784	7.0901	0.3885	9.5910	0.0000
2.0919	0.1749	4.5928	0.4775	7.0937	0.3880	9.5946	0.0000
2.0955	0.1777	4.5964	0.4771	7.0973	0.3871	9.5983	0.0000
2.0992	0.1791	4.6001	0.4766	7.1010	0.3857	9.6019	0.0000
2.1028	0.1805	4.6037	0.4757	7.1046	0.3855	9.6055	0.0000
2.1064	0.1832	4.6073	0.4756	7.1082	0.3843	9.6091	0.0000
2.1100	0.1838	4.6109	0.4748	7.1118	0.3831	9.6127	0.0000
2.1136	0.1859	4.6145	0.4741	7.1154	0.3828	9.6163	0.0000
2.1173	0.1884	4.6182	0.4739	7.1191	0.3814	9.6200	0.0000
2.1209	0.1886	4.6218	0.4731	7.1227	0.3806	9.6236	0.0000
2.1245	0.1913	4.6254	0.4726	7.1263	0.3799	9.6272	0.0000
2.1281	0.1930	4.6290	0.4722	7.1299	0.3784	9.6308	0.0000
2.1317	0.1939	4.6326	0.4714	7.1335	0.3781	9.6344	0.0000
2.1354	0.1965	4.6363	0.4711	7.1372	0.3769	9.6381	0.0000
2.1390	0.1974	4.6399	0.4705	7.1408	0.3755	9.6417	0.0000
2.1426	0.1991	4.6435	0.4697	7.1444	0.3754	9.6453	0.0000
2.1462	0.2015	4.6471	0.4697	7.1480	0.3739	9.6489	0.0000
2.1498	0.2017	4.6507	0.4689	7.1516	0.3729	9.6525	0.0000
2.1535	0.2040	4.6544	0.4683	7.1553	0.3723	9.6562	0.0000

2.1571	0.2058	4.6580	0.4681	7.1589	0.3708	9.6598	0.0000
2.1607	0.2065	4.6616	0.4673	7.1625	0.3703	9.6634	0.0000
2.1643	0.2089	4.6652	0.4670	7.1661	0.3692	9.6670	0.0000
2.1679	0.2099	4.6688	0.4665	7.1697	0.3677	9.6706	0.0000
2.1716	0.2112	4.6725	0.4657	7.1734	0.3676	9.6743	0.0000
2.1752	0.2136	4.6761	0.4656	7.1770	0.3661	9.6779	0.0000
2.1788	0.2139	4.6797	0.4650	7.1806	0.3649	9.6815	0.0000
2.1824	0.2159	4.6833	0.4643	7.1842	0.3645	9.6851	0.0000
2.1860	0.2178	4.6869	0.4642	7.1878	0.3629	9.6887	0.0000
2.1896	0.2181	4.6905	0.4634	7.1914	0.3622	9.6924	0.0000
2.1933	0.2203	4.6942	0.4631	7.1951	0.3613	9.6960	0.0000
2.1969	0.2216	4.6978	0.4627	7.1987	0.3596	9.6996	0.0000
2.2005	0.2225	4.7014	0.4620	7.2023	0.3594	9.7032	0.0000
2.2041	0.2246	4.7050	0.4618	7.2059	0.3580	9.7068	0.0000
2.2077	0.2252	4.7086	0.4613	7.2095	0.3566	9.7104	0.0000
2.2114	0.2267	4.7123	0.4606	7.2132	0.3564	9.7141	0.0000
2.2150	0.2287	4.7159	0.4605	7.2168	0.3548	9.7177	0.0000
2.2186	0.2288	4.7195	0.4599	7.2204	0.3538	9.7213	0.0000
2.2222	0.2308	4.7231	0.4594	7.2240	0.3531	9.7249	0.0000
2.2258	0.2321	4.7267	0.4592	7.2276	0.3515	9.7285	0.0000
2.2295	0.2327	4.7304	0.4585	7.2313	0.3511	9.7322	0.0000
2.2331	0.2346	4.7340	0.4583	7.2349	0.3499	9.7358	0.0000
2.2367	0.2354	4.7376	0.4579	7.2385	0.3482	9.7394	0.0000
2.2403	0.2365	4.7412	0.4573	7.2421	0.3482	9.7430	0.0000
2.2439	0.2384	4.7448	0.4572	7.2457	0.3465	9.7466	0.0000
2.2476	0.2385	4.7485	0.4567	7.2494	0.3454	9.7503	0.0000
2.2512	0.2402	4.7521	0.4562	7.2530	0.3449	9.7539	0.0000
2.2548	0.2416	4.7557	0.4561	7.2566	0.3432	9.7575	0.0000
2.2584	0.2419	4.7593	0.4555	7.2602	0.3426	9.7611	0.0000
2.2620	0.2437	4.7629	0.4553	7.2638	0.3415	9.7647	0.0000
2.2657	0.2446	4.7666	0.4550	7.2675	0.3399	9.7684	0.0000
2.2693	0.2454	4.7702	0.4545	7.2711	0.3397	9.7720	0.0000
2.2729	0.2471	4.7738	0.4544	7.2747	0.3382	9.7756	0.0000
2.2765	0.2474	4.7774	0.4540	7.2783	0.3368	9.7792	0.0000
2.2801	0.2487	4.7810	0.4536	7.2819	0.3365	9.7828	0.0000
2.2837	0.2502	4.7846	0.4535	7.2856	0.3348	9.7865	0.0000
2.2874	0.2503	4.7883	0.4531	7.2892	0.3339	9.7901	0.0000
2.2910	0.2519	4.7919	0.4529	7.2928	0.3331	9.7937	0.0000
2.2946	0.2529	4.7955	0.4527	7.2964	0.3314	9.7973	0.0000
2.2982	0.2534	4.7991	0.4523	7.3000	0.3310	9.8009	0.0000
2.3018	0.2550	4.8027	0.4522	7.3036	0.3297	9.8045	0.0000
2.3055	0.2555	4.8064	0.4520	7.3073	0.3282	9.8082	0.0000
2.3091	0.2565	4.8100	0.4517	7.3109	0.3280	9.8118	0.0000

2.3127	0.2580	4.8136	0.4517	7.3145	0.3263	9.8154	0.0000
2.3163	0.2581	4.8172	0.4514	7.3181	0.3253	9.8190	0.0000
2.3199	0.2595	4.8208	0.4512	7.3217	0.3246	9.8226	0.0000
2.3236	0.2606	4.8245	0.4511	7.3254	0.3229	9.8263	0.0000
2.3272	0.2610	4.8281	0.4509	7.3290	0.3224	9.8299	0.0000
2.3308	0.2624	4.8317	0.4508	7.3326	0.3213	9.8335	0.0000
2.3344	0.2631	4.8353	0.4506	7.3362	0.3196	9.8371	0.0000
2.3380	0.2638	4.8389	0.4505	7.3398	0.3195	9.8407	0.0000
2.3417	0.2653	4.8426	0.4505	7.3435	0.3179	9.8444	0.0000
2.3453	0.2655	4.8462	0.4503	7.3471	0.3167	9.8480	0.0000
2.3489	0.2667	4.8498	0.4502	7.3507	0.3162	9.8516	0.0000
2.3525	0.2678	4.8534	0.4502	7.3543	0.3146	9.8552	0.0000
2.3561	0.2680	4.8570	0.4501	7.3579	0.3138	9.8588	0.0000
2.3598	0.2694	4.8607	0.4501	7.3616	0.3129	9.8625	0.0000
2.3634	0.2701	4.8643	0.4501	7.3652	0.3112	9.8661	0.0000
2.3670	0.2707	4.8679	0.4501	7.3688	0.3109	9.8697	0.0000
2.3706	0.2720	4.8715	0.4501	7.3724	0.3095	9.8733	0.0000
2.3742	0.2723	4.8751	0.4501	7.3760	0.3081	9.8769	0.0000
2.3778	0.2732	4.8787	0.4501	7.3797	0.3078	9.8806	0.0000
2.3815	0.2743	4.8824	0.4501	7.3833	0.3062	9.8842	0.0000
2.3851	0.2743	4.8860	0.4502	7.3869	0.3052	9.8878	0.0000
2.3887	0.2754	4.8896	0.4503	7.3905	0.3045	9.8914	0.0000
2.3923	0.2762	4.8932	0.4503	7.3941	0.3029	9.8950	0.0000
2.3959	0.2765	4.8968	0.4505	7.3977	0.3024	9.8986	0.0000
2.3996	0.2775	4.9005	0.4505	7.4014	0.3012	9.9023	0.0000
2.4032	0.2779	4.9041	0.4507	7.4050	0.2996	9.9059	0.0000
2.4068	0.2785	4.9077	0.4509	7.4086	0.2996	9.9095	0.0000
2.4104	0.2792	4.9113	0.4509	7.4122	0.2979	9.9131	0.0000
2.4140	0.2793	4.9149	0.4512	7.4158	0.2968	9.9167	0.0000
2.4177	0.2798	4.9186	0.4514	7.4195	0.2963	9.9204	0.0000
2.4213	0.2802	4.9222	0.4514	7.4231	0.2946	9.9240	0.0000
2.4249	0.2803	4.9258	0.4518	7.4267	0.2940	9.9276	0.0000
2.4285	0.2806	4.9294	0.4519	7.4303	0.2930	9.9312	0.0000
2.4321	0.2808	4.9330	0.4521	7.4339	0.2913	9.9348	0.0000
2.4358	0.2809	4.9367	0.4525	7.4376	0.2912	9.9385	0.0000
2.4394	0.2811	4.9403	0.4525	7.4412	0.2897	9.9421	0.0000
2.4430	0.2811	4.9439	0.4529	7.4448	0.2884	9.9457	0.0000
2.4466	0.2812	4.9475	0.4532	7.4484	0.2881	9.9493	0.0000
2.4502	0.2813	4.9511	0.4533	7.4520	0.2865	9.9529	0.0000
2.4539	0.2813	4.9548	0.4538	7.4557	0.2857	9.9566	0.0000
2.4575	0.2814	4.9584	0.4540	7.4593	0.2849	9.9602	0.0000
2.4611	0.2814	4.9620	0.4542	7.4629	0.2833	9.9638	0.0000
2.4647	0.2814	4.9656	0.4547	7.4665	0.2830	9.9674	0.0000

2.4683	0.2814	4.9692	0.4549	7.4701	0.2817	9.9710	0.0000
2.4719	0.2814	4.9728	0.4552	7.4738	0.2802	9.9747	0.0000
2.4756	0.2814	4.9765	0.4558	7.4774	0.2801	9.9783	0.0000
2.4792	0.2814	4.9801	0.4558	7.4810	0.2785	9.9819	0.0000
2.4828	0.2814	4.9837	0.4563	7.4846	0.2775	9.9855	0.0000
2.4864	0.2814	4.9873	0.4567	7.4882	0.2769	9.9891	0.0000
2.4900	0.2813	4.9909	0.4569	7.4918	0.2754	9.9927	0.0000
2.4937	0.2813	4.9946	0.4574	7.4955	0.2749	9.9964	0.0000

Table D.7: Gravitational attraction of generated 3D basin determined using BAGC.m and Talwani (referenced to Figure 3.10)

Horizontal Distance (km)	***Gravity Talwani (mGal)***	***Gravity BAGC.m (mGal)***	***Difference BAGC.m – Talwani (mGal)***	***Percent Difference***
0	0.7733	0.7713	-0.002	-0.2593
0.5	1.0583	1.0565	-0.0018	-0.17037
1	1.5801	1.5783	-0.0018	-0.11405
1.5	5.0167	5.17565	0.15895	3.071112
2	18.0774	18.0083	-0.0691	-0.38371
2.5	29.3002	29.2866	-0.0136	-0.04644
3	34.0056	33.9836	-0.022	-0.06474
3.5	40.3811	40.3412	-0.0399	-0.09891
4	46.1356	46.0984	-0.0372	-0.0807
4.5	48.5398	48.5139	-0.0259	-0.05339
5	48.7144	48.6892	-0.0252	-0.05176
5.5	48.7974	48.7765	-0.0209	-0.04285
6	47.2824	47.2692	-0.0132	-0.02793
6.5	44.6702	44.6632	-0.007	-0.01567
7	40.3569	40.3658	0.0089	0.022048
7.5	31.5158	31.5391	0.0233	0.073877
8	20.4763	20.499	0.0227	0.110737
8.5	10.3238	10.3548	0.031	0.299378
9	4.1775	4.3579	0.1804	4.139609
9.5	1.4208	1.4671	0.0463	3.155886
10	0.8877	0.8888	0.0011	0.123762

Table D.8: Cross section geometries used for Talwani BAGC.m comparison (referenced to Figure 3.11)

Line A Distance Along Basin (km)	Basin Depth (km)	***Line B*** Distance Along Basin (km)	Basin Depth (km)	Distance Along Basin (km)	Basin Depth (km)
0	0.00E+00	0	0.00E+00	0	0.00E+00
0.013646	-1.30E-07	0.040608	-3.16E-10	0.026828	-4.20E-11
0.014155	-1.30E-07	0.065413	-2.05E-10	0.069089	-7.68E-11
0.069599	-6.19E-08	0.112806	0.00E+00	0.10282	-8.33E-11
0.096403	1.07E-07	0.134117	0.00E+00	0.11135	-8.39E-11
0.125552	3.24E-07	0.185004	0.00E+00	0.153611	-8.27E-11
0.17865	1.00E-06	0.202821	0.00E+00	0.195872	-6.67E-11
0.181506	1.04E-06	0.257202	-2.36E-10	0.238133	-3.15E-11
0.237459	1.46E-06	0.271525	-2.67E-10	0.280394	1.24E-11
0.260897	1.62E-06	0.3294	0.00E+00	0.322654	4.04E-11
0.293412	2.01E-06	0.340229	0.00E+00	0.323296	4.02E-11
0.343145	2.67E-06	0.401598	0.00E+00	0.364915	3.99E-11
0.349366	3.57E-06	0.408933	0.00E+00	0.407176	5.37E-11
0.405319	8.98E-06	0.473795	0.00E+00	0.449437	2.52E-11
0.425392	9.93E-06	0.477637	0.00E+00	0.491698	1.21E-12
0.461272	1.05E-05	0.545993	0.00E+00	0.533959	-6.26E-11
0.50764	1.30E-05	0.546341	0.00E+00	0.543771	-7.82E-11
0.517226	1.28E-05	0.615045	0.00E+00	0.57622	-1.25E-10
0.573179	1.91E-05	0.618191	0.00E+00	0.618481	-1.66E-10
0.589887	2.13E-05	0.68375	0.00E+00	0.660742	-1.64E-10
0.629132	2.94E-05	0.690389	0.00E+00	0.703002	-2.00E-10
0.672135	3.50E-05	0.752454	0.00E+00	0.745263	-1.93E-10
0.685086	3.85E-05	0.762587	-1.81E-10	0.764247	-1.75E-10
0.741039	4.44E-05	0.821158	-8.45E-10	0.787524	-1.49E-10
0.754382	4.42E-05	0.834785	-1.06E-09	0.829785	-1.02E-10
0.796992	3.90E-05	0.889862	-3.41E-10	0.872046	-7.59E-11
0.83663	4.00E-05	0.906983	-6.80E-11	0.914307	-1.18E-10
0.852946	3.66E-05	0.958566	0.00E+00	0.956568	-3.57E-11
0.908899	6.48E-05	0.979181	0.00E+00	0.984723	-6.38E-13
0.918877	7.06E-05	1.02727	0.00E+00	0.998829	2.14E-11
0.964852	0.0001207	1.051378	-1.20E-11	1.04109	1.46E-10
1.001125	0.0001448	1.095974	0.00E+00	1.08335	1.28E-10
1.020806	0.0001666	1.123576	0.00E+00	1.125611	3.55E-11
1.076759	0.0001855	1.164678	-1.78E-11	1.167872	-9.76E-11
1.083372	0.0001856	1.195774	0.00E+00	1.205199	-1.70E-10

1.132713	0.0001528	1.233382	0.00E+00	1.210133	-1.74E-10
1.16562	0.0001408	1.267972	0.00E+00	1.252394	-2.44E-10
1.188666	0.0001198	1.302087	0.00E+00	1.294655	-4.03E-10
1.244619	0.0002435	1.34017	0.00E+00	1.336916	-2.65E-11
1.247867	0.0002501	1.370791	0.00E+00	1.379177	5.40E-11
1.300573	0.0004387	1.412368	0.00E+00	1.421437	-6.00E-10
1.330114	0.0004754	1.439495	0.00E+00	1.425675	-5.64E-10
1.356526	0.0004714	1.484566	0.00E+00	1.463698	-9.06E-11
1.412362	0.0004143	1.508199	0.00E+00	1.505959	1.80E-10
1.412479	0.0004139	1.556763	0.00E+00	1.54822	9.33E-11
1.468433	0.0002579	1.576903	0.00E+00	1.590481	5.16E-11
1.494609	0.0002334	1.628961	0.00E+00	1.632742	1.45E-10
1.524386	0.0002354	1.645607	0.00E+00	1.646151	1.53E-10
1.576857	0.0004352	1.701159	0.00E+00	1.675003	5.94E-11
1.580339	0.0004604	1.714311	0.00E+00	1.717264	-2.17E-10
1.636293	0.0007476	1.773357	0.00E+00	1.759525	1.50E-10
1.659104	0.0008011	1.783015	0.00E+00	1.801785	-2.24E-10
1.692246	0.0008863	1.845555	0.00E+00	1.844046	-2.23E-09
1.741352	0.0008236	1.851719	0.00E+00	1.866627	-4.20E-09
1.748199	0.0008097	1.917753	0.00E+00	1.886307	-6.01E-09
1.804153	0.0004196	1.920424	0.00E+00	1.928568	-1.24E-08
1.823599	0.0003525	1.989128	-3.59E-05	1.970829	-6.10E-08
1.860106	0.00059	1.989951	-3.71E-05	2.01309	-3.21E-07
1.905847	0.0011504	2.057832	-0.00013	2.055351	5.71E-06
1.916059	0.0012565	2.062149	-0.00014	2.087102	1.13E-05
1.972013	0.0017199	2.126536	-0.00027	2.097612	1.32E-05
1.988094	0.0018069	2.134346	-0.00029	2.139872	1.73E-05
2.027966	0.0017662	2.19524	-0.00048	2.182133	1.95E-05
2.070342	0.0016056	2.206544	-0.00053	2.224394	1.85E-05
2.083919	0.0013993	2.263944	-0.0008	2.266655	1.51E-05
2.139873	0.0003485	2.278742	-0.00091	2.307578	2.09E-05
2.152589	0.0001783	2.332648	-0.00125	2.308916	2.10E-05
2.195826	-0.000777	2.35094	-0.00142	2.351177	2.84E-05
2.234836	-0.001754	2.401352	-0.00194	2.393438	3.68E-05
2.251779	-0.002911	2.423138	-0.00221	2.435699	5.17E-05
2.307733	-0.007326	2.470056	-0.00281	2.47796	7.69E-05
2.317084	-0.008031	2.495336	-0.00317	2.52022	0.000141951
2.363686	-0.014953	2.538761	-0.00383	2.528054	0.000195496
2.399331	-0.019279	2.567534	-0.00432	2.562481	0.000448782
2.419639	-0.02395	2.607465	-0.00504	2.604742	0.000951457
2.475593	-0.036277	2.639731	-0.00567	2.647003	0.001418936
2.481579	-0.037905	2.676169	-0.00638	2.689264	0.001627347
2.531546	-0.058414	2.711929	-0.00709	2.731525	0.001429008

2.563826	-0.072131	2.744873	-0.00775	2.74853	0.001098474
2.587499	-0.083226	2.784127	-0.00856	2.773786	0.000555727
2.643453	-0.109353	2.813577	-0.00918	2.816047	-0.00163822
2.646074	-0.110575	2.856325	-0.01009	2.858307	-0.005048702
2.699406	-0.137327	2.882281	-0.01065	2.900568	-0.009344016
2.728321	-0.152224	2.928523	-0.01165	2.942829	-0.014300046
2.755359	-0.166345	2.950985	-0.01216	2.969006	-0.017731599
2.810569	-0.195877	3.000721	-0.01342	2.98509	-0.019844336
2.811313	-0.196266	3.019689	-0.01393	3.027351	-0.025923452
2.867266	-0.225557	3.072919	-0.01549	3.069612	-0.03252109
2.892816	-0.238809	3.088394	-0.01594	3.111873	-0.039575157
2.923219	-0.252887	3.145117	-0.01762	3.154134	-0.046964659
2.975064	-0.276491	3.157098	-0.01797	3.189482	-0.053313927
2.979173	-0.277927	3.217314	-0.01978	3.196395	-0.054559059
3.035126	-0.299168	3.225802	-0.02004	3.238655	-0.062259637
3.057311	-0.308263	3.289512	-0.02202	3.280916	-0.069975486
3.091079	-0.318173	3.294506	-0.02218	3.323177	-0.07766039
3.139559	-0.331466	3.36171	-0.02438	3.365438	-0.085252257
3.147033	-0.33295	3.36321	-0.02443	3.407699	-0.092630393
3.202986	-0.342591	3.431914	-0.0268	3.409958	-0.093004319
3.221806	-0.34538	3.433908	-0.02687	3.44996	-0.09964953
3.258939	-0.348936	3.500618	-0.02926	3.492221	-0.106155445
3.304053	-0.352829	3.506106	-0.02947	3.534482	-0.11189761
3.314893	-0.353248	3.569322	-0.0318	3.576742	-0.116111898
3.370846	-0.355991	3.578304	-0.03214	3.619003	-0.118896526
3.386301	-0.356874	3.638026	-0.03435	3.630433	-0.119381848
3.426799	-0.358304	3.650502	-0.03481	3.661264	-0.120694447
3.468548	-0.360099	3.706731	-0.03688	3.703525	-0.121899351
3.482753	-0.360621	3.7227	-0.03748	3.745786	-0.122711353
3.538706	-0.363211	3.775435	-0.03955	3.788047	-0.123343937
3.550796	-0.363911	3.794897	-0.04034	3.830308	-0.124026341
3.594659	-0.366883	3.844139	-0.04238	3.850909	-0.124432598
3.633043	-0.369953	3.867095	-0.04334	3.872569	-0.124826969
3.650613	-0.371589	3.912843	-0.04528	3.91483	-0.125737355
3.706566	-0.377221	3.939293	-0.0464	3.95709	-0.126706365
3.715291	-0.378158	3.981547	-0.0482	3.999351	-0.127694976
3.762519	-0.383825	4.011491	-0.0495	4.041612	-0.128697417
3.797538	-0.38826	4.050251	-0.05119	4.071385	-0.129463812
3.818473	-0.391167	4.083689	-0.05272	4.083873	-0.129785128
3.874426	-0.399295	4.118955	-0.0544	4.126134	-0.131009987
3.879786	-0.400108	4.155887	-0.05617	4.168395	-0.132307633
3.93038	-0.408525	4.187659	-0.05771	4.210656	-0.133617632
3.962033	-0.413846	4.228085	-0.05967	4.252917	-0.134931869

3.986333	-0.41816	4.256363	-0.06105	4.291861	-0.136147076
4.042286	-0.428062	4.300282	-0.0632	4.295177	-0.136250211
4.044281	-0.428416	4.325068	-0.06443	4.337438	-0.137605775
4.09824	-0.43828	4.37248	-0.06681	4.379699	-0.138991486
4.126528	-0.443516	4.393772	-0.06794	4.42196	-0.140381301
4.154193	-0.448712	4.444678	-0.07074	4.464221	-0.141754621
4.208775	-0.459026	4.462476	-0.07173	4.506482	-0.14310555
4.210146	-0.459286	4.516876	-0.07475	4.512337	-0.143290838
4.2661	-0.469997	4.53118	-0.07554	4.548743	-0.14444567
4.291023	-0.474867	4.589074	-0.07874	4.591004	-0.145770757
4.322053	-0.481047	4.599884	-0.07933	4.633265	-0.147062468
4.37327	-0.491459	4.661272	-0.08273	4.675525	-0.148294734
4.378006	-0.492441	4.668588	-0.08314	4.717786	-0.149452627
4.43396	-0.504209	4.73347	-0.08675	4.732813	-0.149838733
4.455518	-0.508831	4.737292	-0.08697	4.760047	-0.150533504
4.489913	-0.51627	4.805668	-0.09086	4.802308	-0.151527227
4.537765	-0.526716	4.805996	-0.09088	4.844569	-0.152418079
4.545866	-0.528502	4.8747	-0.09492	4.88683	-0.153205431
4.60182	-0.541088	4.877865	-0.09511	4.929091	-0.153896202
4.620013	-0.545328	4.943405	-0.09906	4.953289	-0.154246919
4.657773	-0.554323	4.950063	-0.09946	4.971352	-0.154507975
4.70226	-0.565457	5.012109	-0.10323	5.013612	-0.155054823
4.713726	-0.5684	5.022261	-0.10384	5.055873	-0.15555309
4.76968	-0.583683	5.080813	-0.10738	5.098134	-0.156056504
4.784508	-0.588086	5.094459	-0.1082	5.140395	-0.15658109
4.825633	-0.601096	5.149517	-0.11157	5.173764	-0.15697521
4.866755	-0.616229	5.166657	-0.11263	5.182656	-0.157079362
4.881586	-0.621835	5.218221	-0.11584	5.224917	-0.157521176
4.93754	-0.645993	5.238855	-0.11714	5.267178	-0.157881796
4.949003	-0.651494	5.286925	-0.12022	5.309439	-0.158144959
4.993493	-0.673759	5.311053	-0.12178	5.3517	-0.158289445
5.03125	-0.694639	5.355629	-0.1247	5.39396	-0.158315984
5.049446	-0.705164	5.383251	-0.12653	5.39424	-0.158315534
5.1054	-0.739831	5.424333	-0.12929	5.436221	-0.158258594
5.113497	-0.745136	5.455448	-0.13141	5.478482	-0.15810994
5.161353	-0.777625	5.493037	-0.13404	5.520743	-0.157880681
5.195745	-0.802585	5.527646	-0.13647	5.563004	-0.157576787
5.217306	-0.818048	5.561742	-0.1389	5.605265	-0.157195033
5.27326	-0.859127	5.599844	-0.1416	5.614716	-0.157093252
5.277992	-0.862634	5.630446	-0.14379	5.647526	-0.156749304
5.329213	-0.89811	5.672042	-0.14672	5.689787	-0.156239388
5.36024	-0.919834	5.69915	-0.14865	5.732047	-0.15567289
5.385166	-0.935132	5.74424	-0.15181	5.774308	-0.155055307

5.44112	-0.967402	5.767854	-0.15349	5.816569	-0.154388679
5.442487	-0.968078	5.816438	-0.15687	5.835192	-0.154113745
5.497073	-0.988311	5.836558	-0.15828	5.85883	-0.153792236
5.524735	-0.994277	5.888636	-0.16194	5.901091	-0.153303024
5.553026	-1.00035	5.905262	-0.16313	5.943352	-0.152751775
5.606982	-1.006512	5.960833	-0.16712	5.985613	-0.152101769
5.60898	-1.006731	5.973966	-0.16808	6.027874	-0.151340522
5.664933	-1.008548	6.033031	-0.17241	6.055668	-0.150747294
5.68923	-1.007832	6.04267	-0.17312	6.070135	-0.150437926
5.720886	-1.0069	6.105229	-0.17775	6.112395	-0.149346647
5.771477	-1.003525	6.111374	-0.1782	6.154656	-0.148054937
5.77684	-1.003147	6.177427	-0.18304	6.196917	-0.146632721
5.832793	-0.998335	6.180079	-0.18324	6.239178	-0.145138527
5.853725	-0.996292	6.248783	-0.18839	6.276144	-0.143800523
5.888746	-0.991806	6.249625	-0.18845	6.281439	-0.143610381
5.935972	-0.984309	6.317487	-0.19367	6.3237	-0.142083638
5.9447	-0.982306	6.321823	-0.194	6.365961	-0.140573568
6.000653	-0.970062	6.386191	-0.19906	6.408222	-0.139098103
6.01822	-0.966697	6.394021	-0.19968	6.450482	-0.137640575
6.056606	-0.958297	6.454895	-0.20461	6.492743	-0.136176456
6.100467	-0.950336	6.466219	-0.20553	6.49662	-0.136039877
6.11256	-0.947972	6.523599	-0.21025	6.535004	-0.134699025
6.168513	-0.938844	6.538416	-0.21146	6.577265	-0.133169691
6.182714	-0.937012	6.592303	-0.21592	6.619526	-0.131534573
6.224466	-0.931833	6.610614	-0.21743	6.661787	-0.129745567
6.264962	-0.928503	6.661007	-0.22163	6.704048	-0.1278709
6.28042	-0.927477	6.682812	-0.22345	6.717095	-0.12727564
6.336373	-0.925074	6.729711	-0.22744	6.746309	-0.125963428
6.347209	-0.924682	6.75501	-0.22962	6.78857	-0.124023772
6.392326	-0.924031	6.798416	-0.23338	6.83083	-0.122052531
6.429457	-0.923424	6.827208	-0.23589	6.873091	-0.12006417
6.44828	-0.923752	6.86712	-0.23932	6.915352	-0.118064931
6.504233	-0.923951	6.899406	-0.24207	6.937571	-0.117000413
6.511704	-0.923282	6.935824	-0.24511	6.957613	-0.116057954
6.560186	-0.917378	6.971604	-0.2481	6.999874	-0.114039305
6.593952	-0.910265	7.004528	-0.25083	7.042135	-0.11198517
6.61614	-0.905555	7.043801	-0.2541	7.084396	-0.109907714
6.672093	-0.889932	7.073232	-0.25653	7.126657	-0.107853509
6.676199	-0.888613	7.115999	-0.26011	7.158047	-0.106379682
6.728046	-0.870653	7.141936	-0.26226	7.168917	-0.105884802
6.758447	-0.859522	7.188197	-0.26617	7.211178	-0.10398205
6.784	-0.848918	7.21064	-0.26809	7.253439	-0.102039063
6.839953	-0.82608	7.260395	-0.27236	7.2957	-0.100016443

6.840694	-0.825782	7.279344	-0.27399	7.337961	-0.097909258
6.895907	-0.800384	7.332593	-0.27853	7.378523	-0.095869474
6.922942	-0.7886	7.348049	-0.27985	7.380222	-0.095789035
6.95186	-0.774985	7.404791	-0.28461	7.422483	-0.093940739
7.005189	-0.751761	7.416753	-0.28562	7.464744	-0.092044206
7.007813	-0.750603	7.476989	-0.29058	7.507005	-0.090072305
7.063767	-0.726881	7.485457	-0.29126	7.549265	-0.088046006
7.087436	-0.717067	7.549187	-0.29612	7.591526	-0.086006722
7.11972	-0.704009	7.554161	-0.29649	7.598999	-0.085653466
7.169684	-0.684205	7.621384	-0.30142	7.633787	-0.084068982
7.175673	-0.681958	7.622865	-0.30153	7.676048	-0.082200728
7.231627	-0.661923	7.691569	-0.3065	7.718309	-0.080301825
7.251931	-0.654796	7.693582	-0.30664	7.76057	-0.078335556
7.28758	-0.642009	7.760273	-0.31139	7.802831	-0.076293064
7.334179	-0.625155	7.76578	-0.31178	7.819475	-0.075446076
7.343533	-0.621553	7.828977	-0.31627	7.845092	-0.074183096
7.399487	-0.600343	7.837978	-0.31691	7.887352	-0.071969911
7.416426	-0.594117	7.897681	-0.32121	7.929613	-0.069561893
7.45544	-0.578612	7.910176	-0.32212	7.971874	-0.06702968
7.498674	-0.561591	7.966386	-0.32621	8.014135	-0.064463104
7.511393	-0.556235	7.982374	-0.32738	8.039951	-0.062900745
7.567347	-0.53246	8.03509	-0.33128	8.056396	-0.061931827
7.580921	-0.526713	8.054572	-0.33271	8.098657	-0.059460561
7.6233	-0.508296	8.103794	-0.3363	8.140918	-0.057002317
7.663169	-0.491277	8.12677	-0.33792	8.183179	-0.054422429
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7.735207	-0.460281	8.198967	-0.34278	8.260426	-0.049951826
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7.827664	-0.421517	8.309906	-0.34994	8.352222	-0.045304669
7.847113	-0.413434	8.343363	-0.35205	8.394483	-0.043252112
7.903067	-0.390907	8.37861	-0.3542	8.436744	-0.041090901
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7.95902	-0.369507	8.447314	-0.35824	8.480902	-0.039002626
7.992159	-0.357426	8.487759	-0.36042	8.521266	-0.037263732
8.014973	-0.349342	8.516018	-0.36188	8.563527	-0.035657667
8.070927	-0.330044	8.559957	-0.36408	8.605787	-0.034231277
8.074406	-0.328868	8.584723	-0.36531	8.648048	-0.032861532
8.12688	-0.311421	8.632155	-0.36761	8.690309	-0.031387904
8.156653	-0.301835	8.653427	-0.36864	8.701378	-0.030984116
8.182833	-0.293487	8.704352	-0.37103	8.73257	-0.029788581
8.238787	-0.275807	8.722131	-0.37188	8.774831	-0.028120075
8.238901	-0.27577	8.77655	-0.37444	8.817092	-0.026378071

8.29474	-0.256901	8.790835	-0.37511	8.859353	-0.02452162
8.321148	-0.248034	8.848748	-0.37785	8.901614	-0.022540534
8.350693	-0.237688	8.859539	-0.37834	8.921854	-0.021561642
8.403396	-0.219904	8.920946	-0.38104	8.943875	-0.020528178
8.406647	-0.218792	8.928243	-0.38133	8.986135	-0.0184591
8.4626	-0.200031	8.993144	-0.3839	9.028396	-0.016281763
8.485643	-0.192449	8.996947	-0.38404	9.070657	-0.014037467
8.518553	-0.181693	9.065342	-0.38664	9.112918	-0.011879533
8.567891	-0.165933	9.065651	-0.38666	9.14233	-0.010707941
8.574507	-0.16385	9.134355	-0.38924	9.155179	-0.010264332
8.63046	-0.146575	9.13754	-0.38936	9.19744	-0.009581327
8.650138	-0.14069	9.20306	-0.39177	9.239701	-0.009159672
8.686413	-0.130124	9.209738	-0.39199	9.281962	-0.008807115
8.732386	-0.117295	9.271764	-0.39351	9.324223	-0.008524707
8.742367	-0.114606	9.281935	-0.39377	9.362806	-0.008438601
8.79832	-0.100099	9.340468	-0.39507	9.366483	-0.008442054
8.814633	-0.096071	9.354133	-0.39538	9.408744	-0.008762965
8.854273	-0.086619	9.409172	-0.39654	9.451005	-0.0093952
8.896881	-0.077178	9.426331	-0.39689	9.493266	-0.010188779
8.910227	-0.074398	9.477876	-0.3979	9.535527	-0.011004379
8.96618	-0.063594	9.498529	-0.39829	9.577788	-0.011792012
8.979128	-0.061247	9.54658	-0.39939	9.583282	-0.01189194
9.022133	-0.053814	9.570727	-0.40007	9.620049	-0.012600037
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9.13404	-0.037219	9.683988	-0.40313	9.746831	-0.014289186
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9.22587	-0.026404	9.78732	-0.40579	9.831353	-0.014812913
9.245947	-0.024334	9.821397	-0.40658	9.873614	-0.014903428
9.3019	-0.019075	9.859518	-0.40742	9.915875	-0.014807279
9.308118	-0.018538	9.890101	-0.40803	9.958136	-0.014483964
9.357853	-0.014552	9.931716	-0.4088	10.0004	-0.014023666
9.390365	-0.012247	9.958805	-0.40931	10.02423	-0.01371365
9.413807	-0.010724	10.00391	-0.41014	10.04266	-0.013471334
9.46976	-0.007632	10.02751	-0.41059	10.08492	-0.012848585
9.472613	-0.007494	10.07611	-0.41148	10.12718	-0.012151454
9.525713	-0.005131	10.09621	-0.41186	10.16944	-0.01136893
9.55486	-0.00398	10.14831	-0.41283	10.2117	-0.010483187
9.581667	-0.003073	10.16492	-0.41315	10.24471	-0.009724617
9.637108	-0.001511	10.22051	-0.41424	10.25396	-0.00950565
9.63762	-0.0015	10.23362	-0.41451	10.29622	-0.008482935
9.693574	-0.000576	10.29271	-0.41564	10.33848	-0.007443795

9.719355	-0.000283	10.30233	-0.41581	10.38074	-0.006424749
9.749527	-0.0001	10.3649	-0.4169	10.42301	-0.00549553
9.801603	8.05E-05	10.37103	-0.417	10.46519	-0.004745587
9.80548	8.44E-05	10.4371	-0.4181	10.46527	-0.004744154
9.861434	0.0001166	10.43973	-0.41815	10.50753	-0.004134254
9.88385	0.0001267	10.50844	-0.41931	10.54979	-0.003587536
9.917387	0.0001022	10.5093	-0.41932	10.59205	-0.003093248
9.966098	8.35E-05	10.57714	-0.42055	10.63431	-0.002653932
9.97334	7.89E-05	10.5815	-0.42064	10.67657	-0.002293342
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10.13059	2.23E-05	10.72589	-0.42479	10.80335	-0.001736042
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10.30906	2.79E-06	10.94249	-0.43366	11.01466	-0.000919083
10.36501	1.71E-06	10.98937	-0.43577	11.05692	-0.000676814
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10.53287	5.58E-07	11.15908	-0.44373	11.22596	7.99E-05
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10.78857	-8.85E-11	11.44787	-0.4566	11.52179	8.31E-06
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11.20431	-8.55E-10	11.88252	-0.4732	11.98666	-2.17E-08
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-	-	20.40183	-0.04171	-	-
-	-	20.47053	-0.03595	-	-
-	-	20.47261	-0.03578	-	-
-	-	20.53924	-0.03049	-	-
-	-	20.5448	-0.03006	-	-
-	-	20.60794	-0.02537	-	-
-	-	20.617	-0.02472	-	-
-	-	20.67665	-0.02067	-	-
-	-	20.6892	-0.01983	-	-
-	-	20.74535	-0.01636	-	-
-	-	20.7614	-0.01541	-	-
-	-	20.81405	-0.01254	-	-
-	-	20.83359	-0.01156	-	-
-	-	20.88276	-0.00935	-	-

-	-	20.90579	-0.0084	-	-
-	-	20.95146	-0.00658	-	-
-	-	20.97799	-0.00557	-	-
-	-	21.02017	-0.00421	-	-
-	-	21.05019	-0.00337	-	-
-	-	21.08887	-0.00245	-	-
-	-	21.12239	-0.00179	-	-
-	-	21.15758	-0.0012	-	-
-	-	21.19458	-0.00072	-	-
-	-	21.22628	-0.00038	-	-
-	-	21.26678	-0.00014	-	-
-	-	21.29498	0.00E+00	-	-
-	-	21.33898	0	-	-
-	-	21.36369	0	-	-
-	-	21.41118	0	-	-
-	-	21.43239	0	-	-
-	-	21.48338	0	-	-
-	-	21.5011	0	-	-
-	-	21.55557	0.00E+00	-	-
-	-	21.5698	0.00E+00	-	-
-	-	21.62777	0.00E+00	-	-
-	-	21.6385	0.00E+00	-	-
-	-	21.69997	0.00E+00	-	-
-	-	21.70721	0.00E+00	-	-
-	-	21.77217	0.00E+00	-	-
-	-	21.77591	0.00E+00	-	-
-	-	21.84436	0.00E+00	-	-
-	-	21.84462	0.00E+00	-	-
-	-	21.91332	0.00E+00	-	-
-	-	21.91656	0.00E+00	-	-
-	-	21.98202	0.00E+00	-	-
-	-	21.98876	0.00E+00	-	-
-	-	22.05073	0.00E+00	-	-
-	-	22.06096	0.00E+00	-	-
-	-	22.11943	0.00E+00	-	-
-	-	22.13316	0.00E+00	-	-
-	-	22.18814	0.00E+00	-	-
-	-	22.20535	0.00E+00	-	-
-	-	22.25684	0.00E+00	-	-
-	-	22.27755	0.00E+00	-	-
-	-	22.32555	0.00E+00	-	-
-	-	22.34975	-1.12E-11	-	-
-	-	22.39425	0.00E+00	-	-

-	-	22.42195	0.00E+00	-	-
-	-	22.46295	0.00E+00	-	-
-	-	22.49415	-5.15E-12	-	-
-	-	22.53166	0.00E+00	-	-
-	-	22.56634	0.00E+00	-	-
-	-	22.60036	0.00E+00	-	-
-	-	22.63854	-2.06E-12	-	-
-	-	22.66907	-7.07E-10	-	-
-	-	22.71074	-1.47E-09	-	-
-	-	22.73777	-8.39E-10	-	-
-	-	22.78294	0.00E+00	-	-
-	-	22.80647	-5.27E-10	-	-
-	-	22.85513	-1.07E-09	-	-
-	-	22.87518	-6.08E-10	-	-
-	-	22.92733	0.00E+00	-	-
-	-	22.94388	-9.88E-11	-	-
-	-	22.99953	-4.91E-10	-	-
-	-	23.01259	-4.16E-10	-	-
-	-	23.07173	-3.35E-11	-	-
-	-	23.08129	-3.30E-11	-	-
-	-	23.14393	-3.06E-11	-	-
-	-	23.14999	-2.69E-11	-	-
-	-	23.21612	0.00E+00	-	-
-	-	23.2187	-1.87E-12	-	-
-	-	23.2874	-1.93E-10	-	-
-	-	23.28832	-1.89E-10	-	-
-	-	23.35611	0.00E+00	-	-
-	-	23.36052	0.00E+00	-	-
-	-	23.42481	-2.50E-10	-	-
-	-	23.43272	-2.81E-10	-	-
-	-	23.49352	-4.17E-11	-	-
-	-	23.50492	0.00E+00	-	-
-	-	23.56222	0.00E+00	-	-
-	-	23.57711	0.00E+00	-	-
-	-	23.63092	0.00E+00	-	-
-	-	23.64931	-1.69E-11	-	-
-	-	23.69963	-1.41E-10	-	-
-	-	23.72151	-1.56E-10	-	-
-	-	23.76833	-3.30E-11	-	-
-	-	23.79371	-8.15E-12	-	-
-	-	23.83704	-1.04E-10	-	-
-	-	23.8659	-2.20E-10	-	-
-	-	23.90574	-1.44E-10	-	-

-	-	23.9381	-2.53E-11	-	-
-	-	23.97444	-1.12E-11	-	-
-	-	24.0103	-5.47E-11	-	-
-	-	24.04315	-9.24E-11	-	-
-	-	24.0825	-6.48E-11	-	-
-	-	24.11185	-3.45E-11	-	-
-	-	24.1547	-2.18E-12	-	-
-	-	24.18056	-2.09E-11	-	-
-	-	24.22689	-5.14E-11	-	-
-	-	24.24926	-7.12E-11	-	-
-	-	24.29909	-7.28E-11	-	-
-	-	24.31796	-5.30E-11	-	-
-	-	24.32993	0.00E+00	-	-

Table D.9: Cross section geometries used for Talwani BAGC.m comparison (referenced to Figure 3.11)

Horizontal Distance (km)	***BAGC.m (mGal)***	***Talwani (mGal)***	***Misfit (mGal)***	***Misfit (Percent)***
Line A				
0	0.55092	0.1975	-0.35342	-64.1509
1.988094	3.00613	3.2841	0.27797	9.246772
4.042286	45.97838	50.6179	4.63952	10.09066
6.000653	67.7938	81.0231	13.2293	19.51403
8.014973	37.35844	44.3342	6.97576	18.67251
10.02929	1.10221	1.9808	0.87859	79.71167
11.38963	0.4363	0.4041	-0.0322	-7.38024
Line B				
0	0.55092	0.1604	-0.35342	26.26939
5.012109	3.00613	12.5194	0.27797	3.103125
10.00391	45.97838	44.4742	4.63952	1.673999
15.04291	67.7938	46.8088	13.2293	-0.45324
20.03942	37.35844	9.3792	6.97576	1.52726
24.32993	1.10221	0.1912	0.87859	-0.00523
Line C				
0	0.12703	0.1604	0	-66.1511
5.012109	12.1426	12.5194	5.012109	-5.15264
10.00391	43.74196	44.4742	10.00391	-4.44739
15.04291	47.02192	46.8088	15.04291	-29.7067
20.03942	9.23811	9.3792	20.03942	-70.9722
24.32993	0.19121	0.1912	24.32993	-58.8433

Curriculum Vita

Brian Eugene Eslick was born on May 5th, 1980 in Riverside, Ca to parents Bobby Eugene Eslick and Laura Lynn Eslick. He atteneded high school in Whittier, Ca. He received his associate's degree from Fullerton College in December 2002 and transferred to California State University Long Beach where he majored in Geology. Brian Graduated from Long Beach State with departmental honors and moved to Indianapolis, In to begin work as an environmental consultant. After three years in industry, Brian started the Master's Program at the Univervisty of Texas El Paso (UTEP) in August 2008 under the advisory of Dr. Laura Serpa. As a graduate student, Brian participated in the Imperial Barrel Award competition sponsored by the American Associated of Petroleum Geologists (AAPG). The UTEP team was awarded first place for the South West division of AAPG and participated in the international competition in Denver, Co. Brian currently resides in Houston, Tx with his lovely wife Agueda Lucinda Ozambela where he works as a Petroleum Geophysicist.

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