SUBSURFACE DENSITY STRUCTURE OF TAURUS LITTROW VALLEY

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1. INTRODUCTION

- The "Traverse Gravimeter Experiment" (TGE) from Apollo 17 is the first and only successful gravity survey on the surface of the moon to date
- Measured gravity across Taurus Littrow Valley (TLV) located on the south-eastern rim of the Serenitatis basin [1][2]
- Dataset was first analyzed by Talwani et al. in 1972 [1]

2. QUESTIONS

1. How does using an updated, high-resolution elevation model and 3D corrections change the corrected data?
2. Can we determine the angle of the subsurface valley walls using a more complex model?

3. TAURUS LITTROW VALLEY (TLV)

FORMATION HISTORY [3][4]:

- Formation of Serenitatis basin, with circular rings of ejecta around the basin
- Radial normal fault formed the valley of TLV and cross-cut one ejecta ring
- At a later time, basaltic lava flooded the graben and surrounding region
- Ejecta ring material on the northern and southern flanks of the valley formed the North and South Massifs

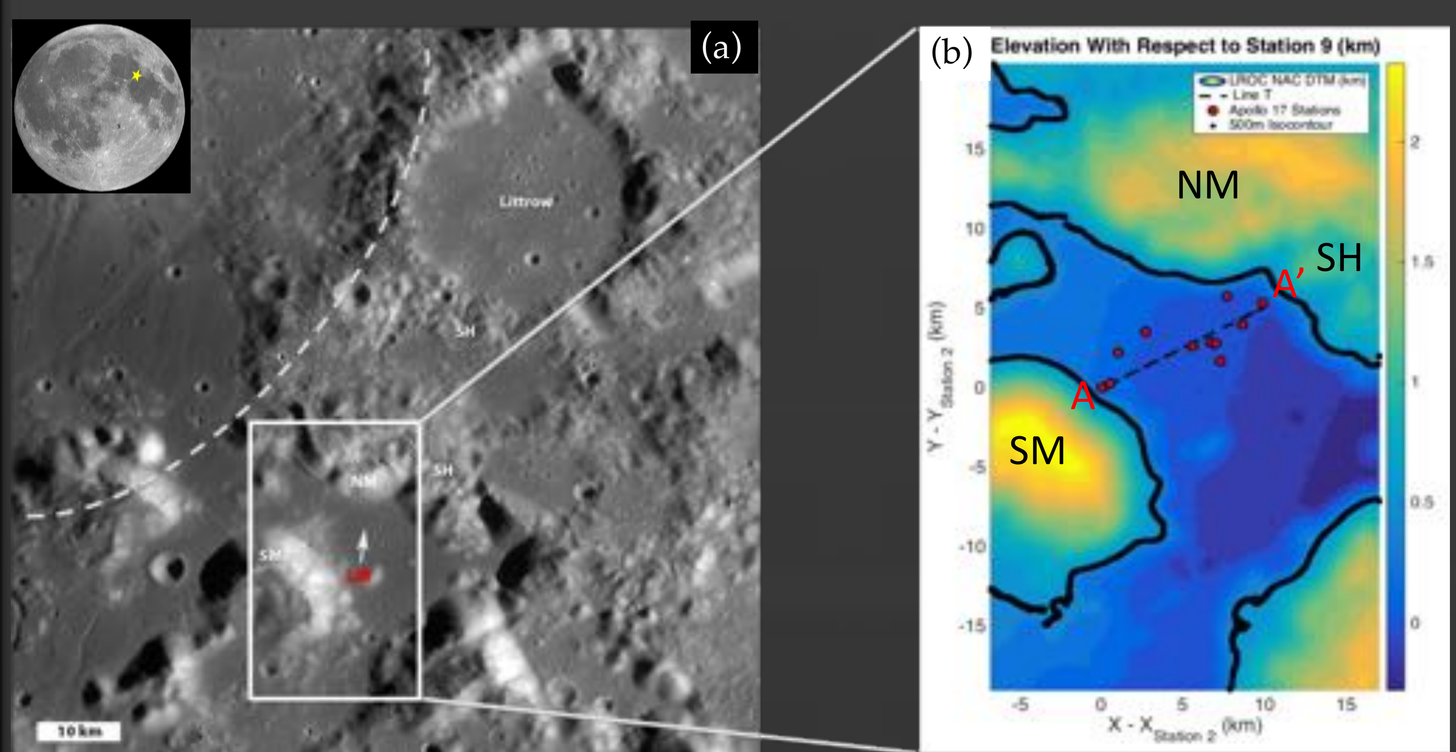


Figure 1: (a) Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) [4] for TLV and surrounding region and (b) LROC NAC Digital Terrain Model (DTM) [5] for TLV, along with the location of the stations (red circles), the boundary between valley and massif material, the line "T" (dashed black line) which was used for the 2D analysis in [1], and the locations of the mountains: North Massif (NM), South Massif (SM) and Sculptured Hills (SH).

4. TRAVERSE GRAVIMETER EXPERIMENT

DATASET:

- Highest resolution lunar gravity measurements to date
- Reveals fine-scale (<1km) subsurface structure below TLV
- Instrumental uncertainty of ± 0.6 mgals [2]
- Know station locations to ± 5m

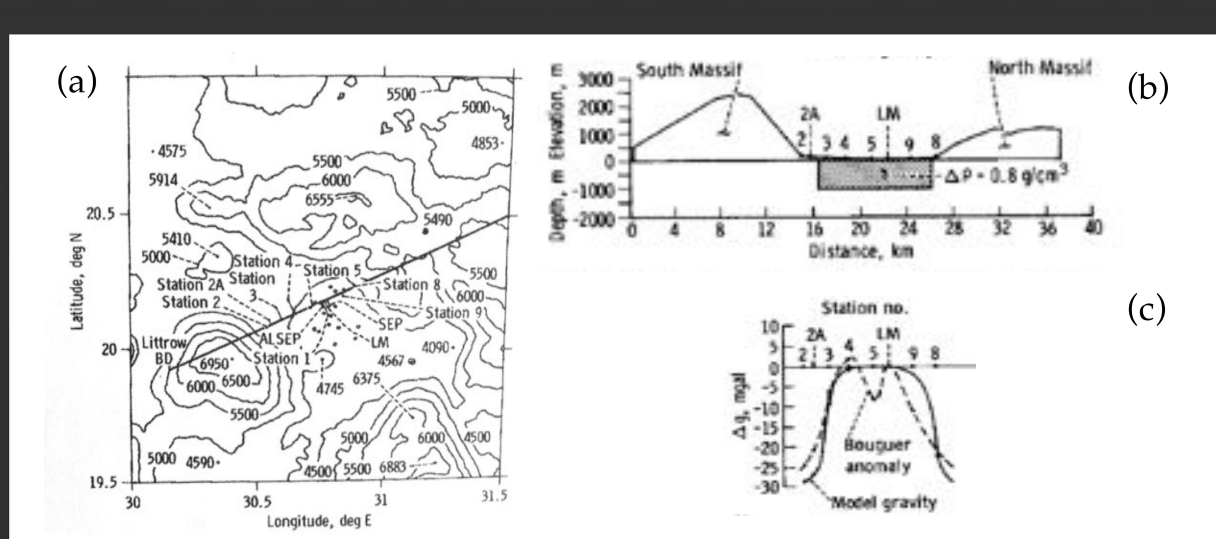


Figure 2: Figures taken from Talwani et al. (1972) [1] (a) Contour map of TLV (500m contours) and line T (b) Best fitting rectangular model (t=1km) overlain on the topographic profile along line T and (c) Corrected gravity profile along line T (dashed black line) as well as the gravity profile from the best fitting model (solid black line) [1].

TGE Analysis:	Talwani et al. (1972) [1] (§4)	Our Analysis
DTM (§3)	Satellite derived DTM (500m)	LROC NAC DTM [4] (2m)
Corrections (§5)	• Free-air correction • 2D, multi-density, combined bouguer & terrain correction (2D Gravity Method [6])	• Free-air correction • 3D, multi-density, combined bouguer & terrain correction (Right Rectangular Prism Method [7])
Modelling (§6 & 7)	• Forward 2D modelling of profile along line T using [6] • Density contrast of 0.8 g/cm^3 • Use a rectangular shape • Vary depth and location from stations	• Forward 2D modelling of profile along line T using Model Vision Pro [8] • Density contrast of 0.8 g/cm^3 • Vary angle of walls, depth and location from stations

5. CORRECTIONS

CORRECTIONS ALONG LINE T:

1. Free-Air: compensate for the height of stations above the baseline (at st. 9)
2. Combined Bouguer and Terrain: subtract the gravitational contribution due to mass above the baseline

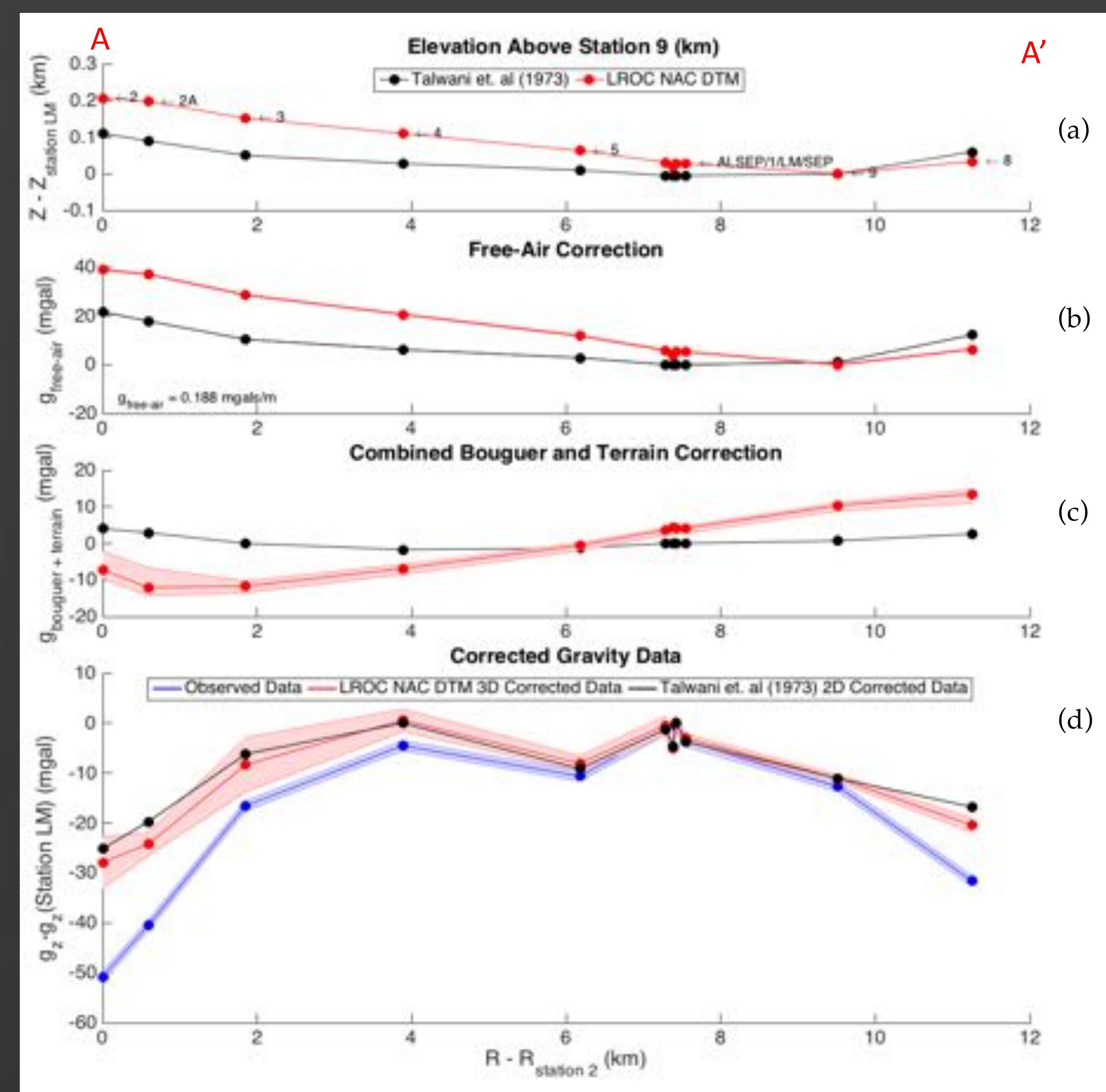


Figure 3: (a) LROC NAC DTM elevation measurements used in our analysis (red) compared to elevation measurements used in [1] (black), (b) and (c) Free-air ($g_{free-air}$) and combined bouguer and terrain ($g_{bouguer+terrain}$) corrections (d) Corrected gravity values with respect to the lunar module (LM) compared to original uncorrected data (blue).

6. VALLEY GEOMETRY

PARAMETERS:

Wall Positions (W_L and W_R): Width between outside stations and subsurface basalt walls

Valley Thickness (t): Thickness of the subsurface basalt

Angle of Walls (θ): Dip of the graben forming the subsurface basalt walls

CROSS SECTION:

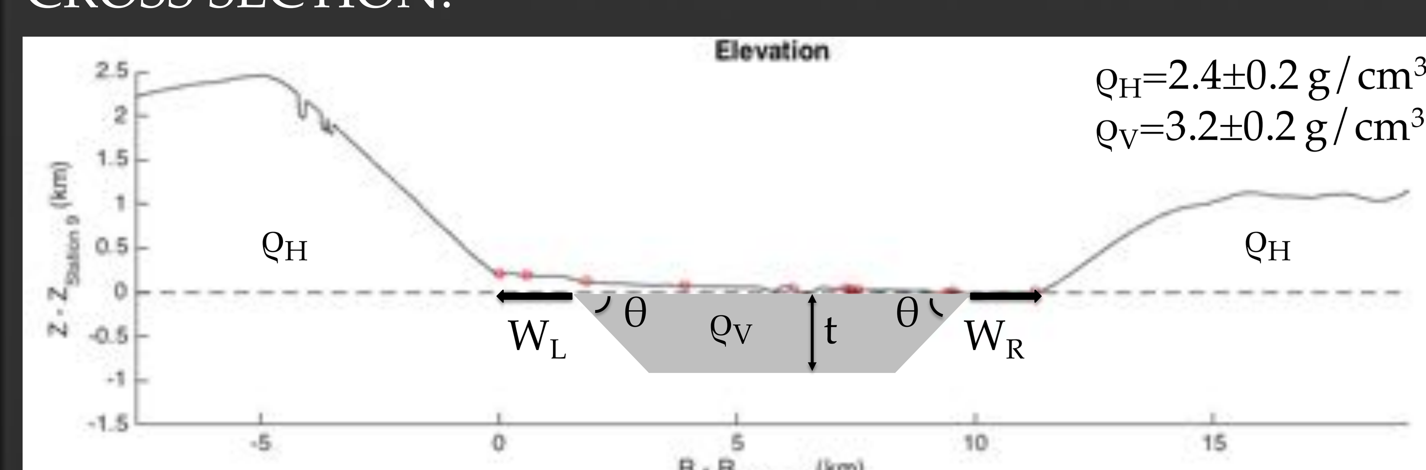
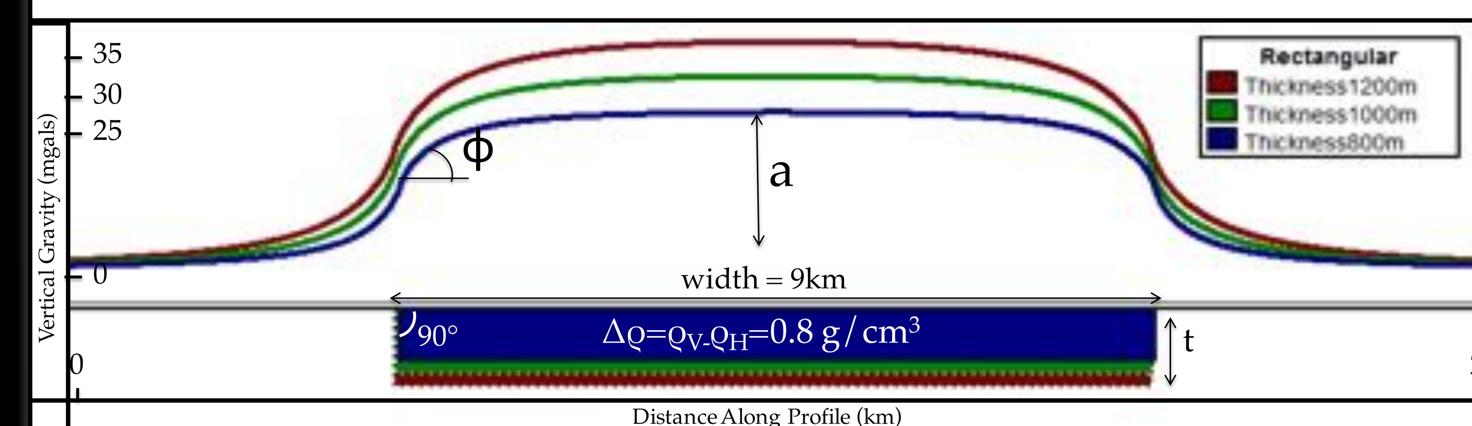


Figure 4: LROC NAC DTM elevation along line T, and cross section of model of the valley.

7. MODELLING

TRADE-OFFS AMONG PARAMETERS:

DEPTH (a)



WALL ANGLE AND POSITION (b)

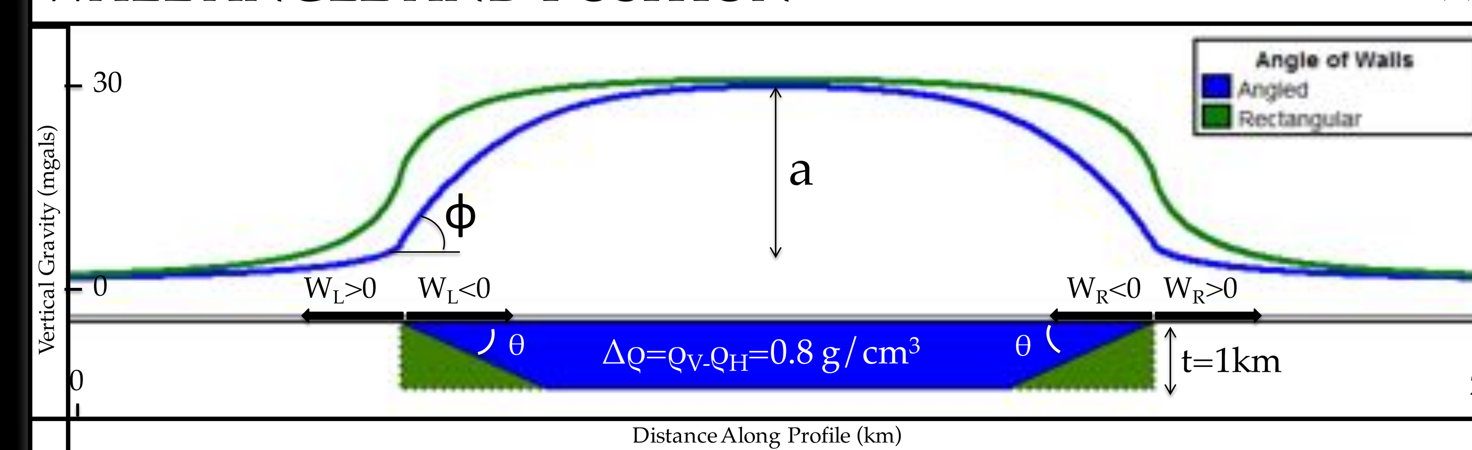


Figure 6: Model examples to demonstrate the trade-offs among model parameters. (a) Gravity profiles from 2D rectangular models with various thicknesses (b) Gravity profiles from 2D models with flat walls (green) and 30° dipping walls (blue).

BEST FITTING MODELS:

1. Best fitting rectangular model agrees with [1]
2. Best fitting angular model for zone 1 is 30°
3. No best fitting model for zones 2 & 3
   - Zone 3 has a complicated geometry (where two mountains meet) that is not captured by our models

Model Parameters	ϕ	a
θ↓ ($W_{L/R}$>0)	↑	↑
θ↓ ($W_{L/R}$<0)	↓	↑
t↑	↑	↑

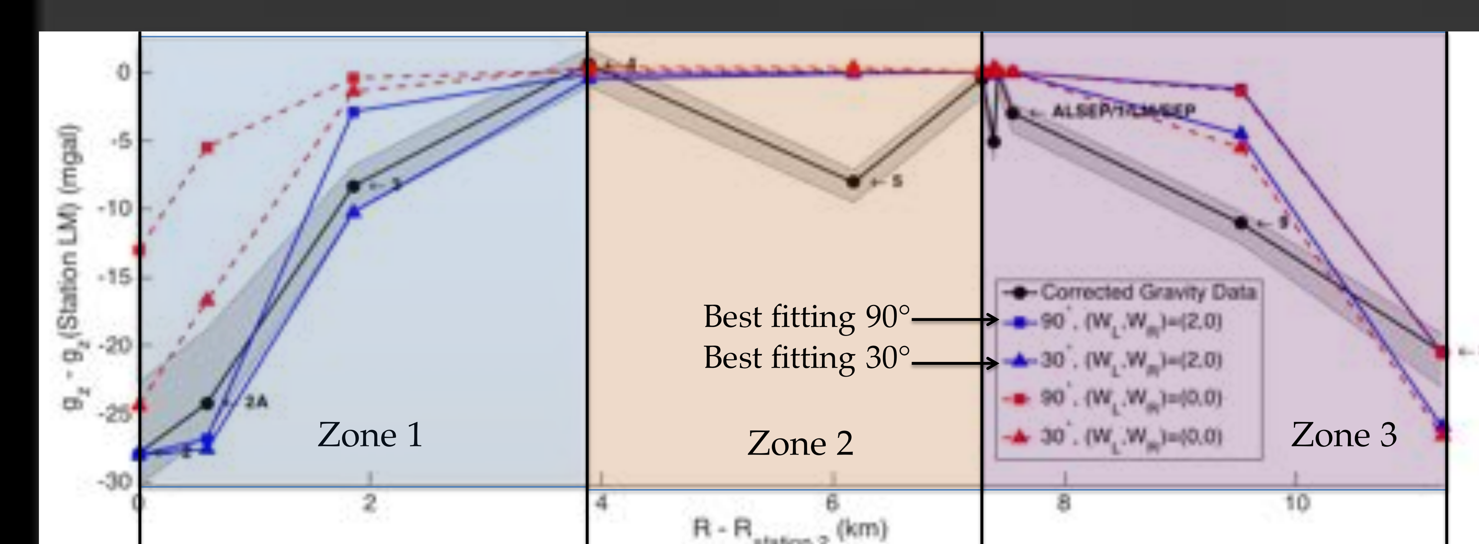


Figure 7: Gravity generated from a 1km thick, 2D flat walls model (squares) and a 30° dipping walls model (triangles), for different wall positions (W_L,W_R) = (0km,0km) (red) and (2km,0km) (blue), compared to the corrected gravity profile from Figure 3(d).

8. CONCLUSIONS

1. Using an updated, high resolution elevation model and 3D corrections, our individual corrections are significantly different from [1], but our corrected data agrees with [1].
2. Our best fitting rectangular model agrees with [1]. Angular models are heavily unconstrained, but we can bracket the range in angles to >30° on the south wall of the valley (zone 1).
   - In order to concretely determine a more complex geometric model for the valley, we need improved resolution, lower noise and tighter constraints on the densities in the region.

9. OUTSTANDING QUESTIONS

1. How does sampling density affect the models we can recover?
2. What is the underlying subsurface structure in zone 3?
3. Why is our best fitting angle 30° in zone 1? (e.g. colluvium wedge, listric faults, etc.)

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