SUSTech Southern University of Science and Technology

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

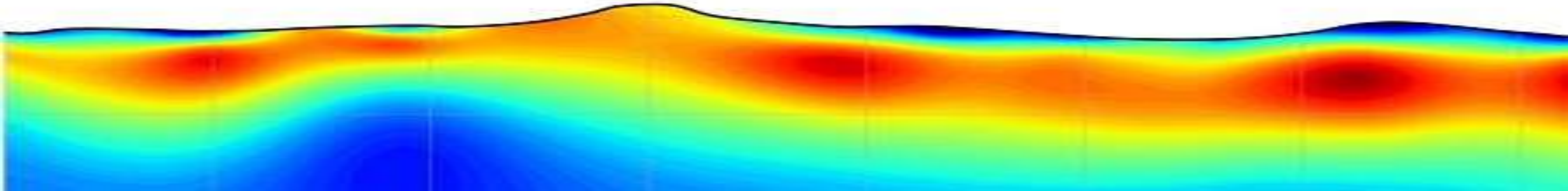
地球与空间科学系 DEPARTMENT OF EARTH AND SPACE SCIENCES

ESS302 Applied Geophysics II

Gravity, Magnetic, Electrical, Electromagnetic and Well Logging

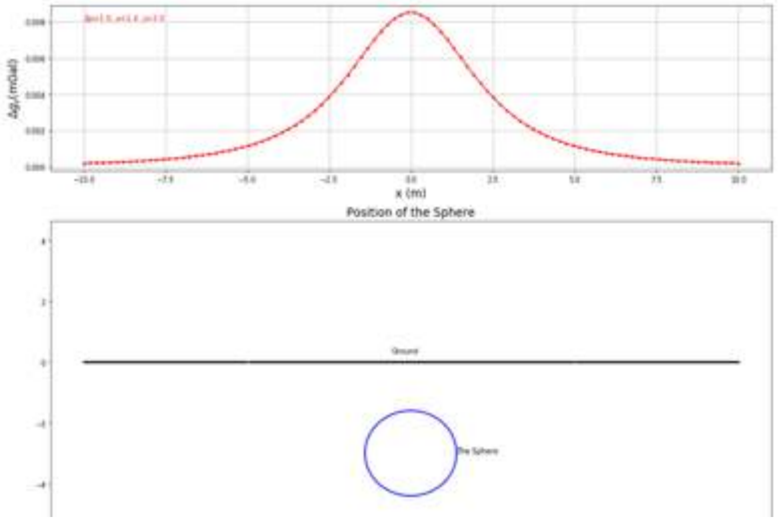
Gravity 2: Survey and Data

Instructor: Dikun Yang Feb – May, 2019



Quiz

- Sort the items below from low to high in their densities:
  - Igneous rock, water, sandstone, natural gas, ice, iron rod
- True or false and why: The gravity effect of any sphere-shaped object can be treated as from a point with the same total mass at the sphere's center.
- A sphere buried below surface is specified by its density contrast, radius and depth. How would you change those three parameters so the observed gravity anomaly on the surface becomes "flatter"?



Contents

Unit of gravity field

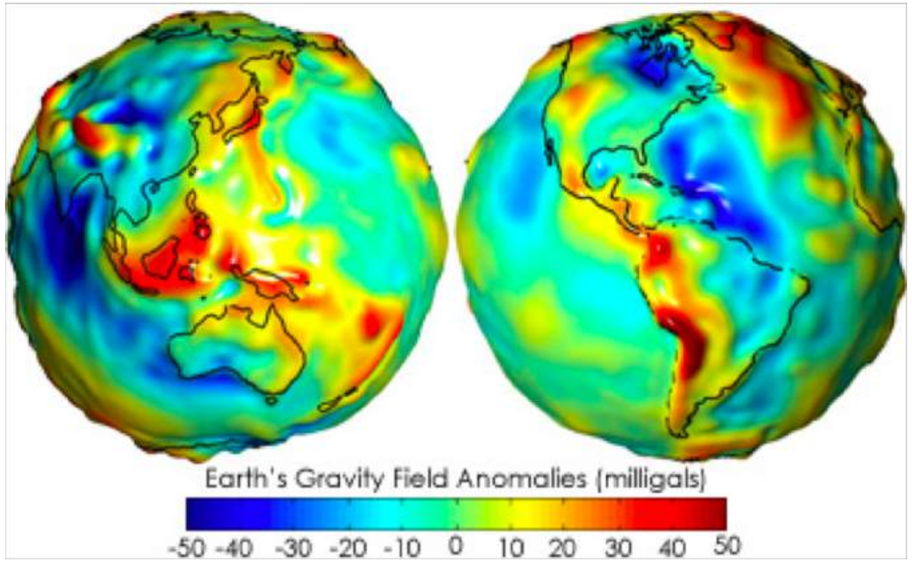
$$G \approx 6.674 \times 10^{-8}\ \mathrm{cm^3 \cdot g^{-1} \cdot s^{-2}}$$

$$\boldsymbol{g} = \frac{GM}{r^3}\vec{\boldsymbol{r}} = \boldsymbol{F}$$

$$\frac{\mathrm{cm^3}}{\mathrm{g \cdot s^2}} \quad \frac{\mathrm{g \cdot m^3}}{\mathrm{cm^3}} \quad \frac{\mathrm{m}}{\mathrm{m^3}} \quad = \quad \frac{\mathrm{m}}{\mathrm{s^2}}$$

(unit of acceleration or gravity in SI)

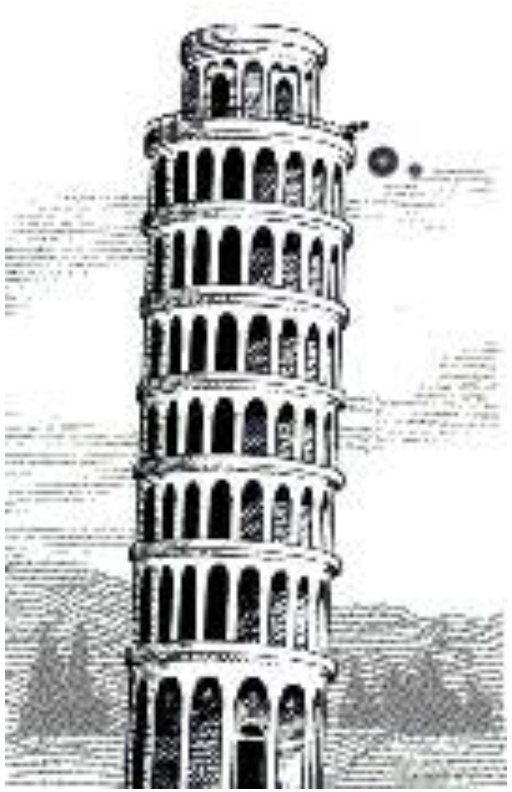
The magnitude of gravity anomaly in applied geophysics is much smaller than 9.8 m/s^2, so we need a “smaller” unit.



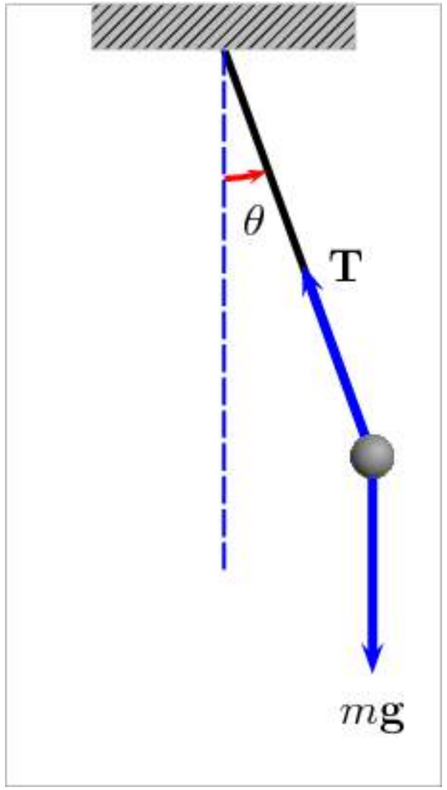
1 **Gal** = 1 cm/s^2 = 10^{-2} m/s^2

1 **mGal** or **milligal** = 10^{-5} m/s^2

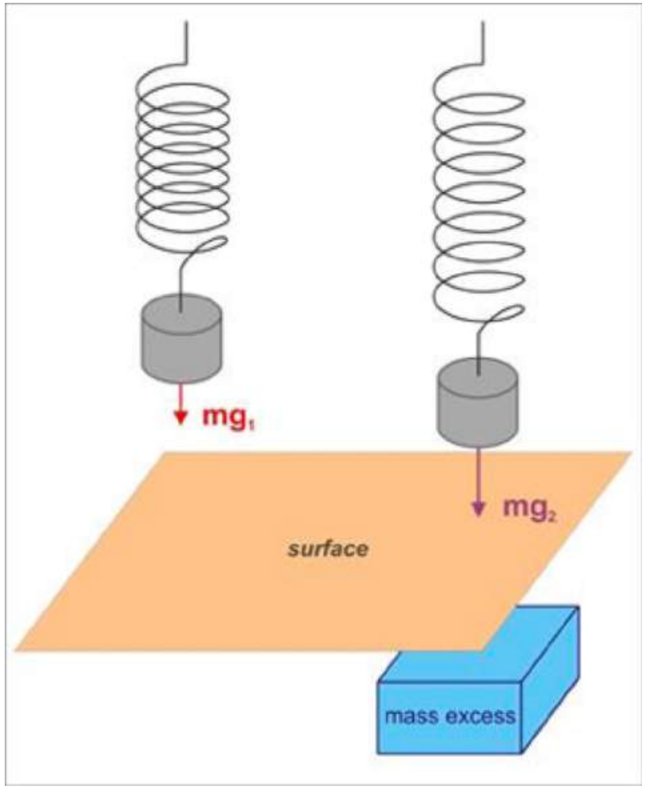
Measurement of gravity field



Free fall
(absolute)

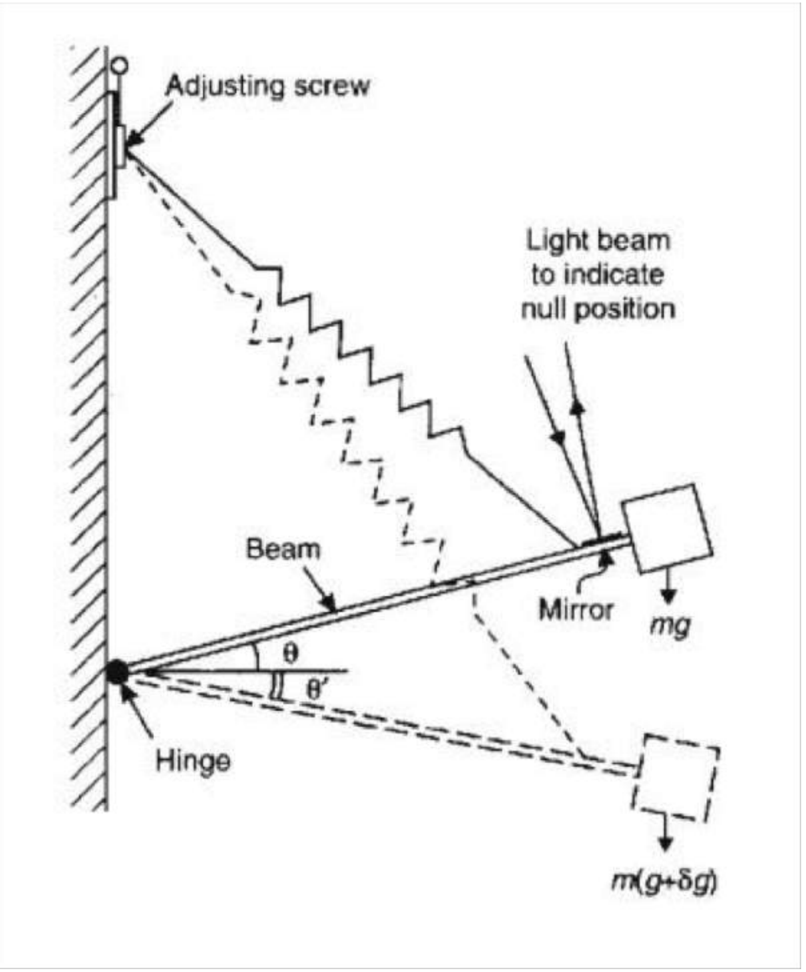


Pendulum
(absolute)



Spring
(relative)

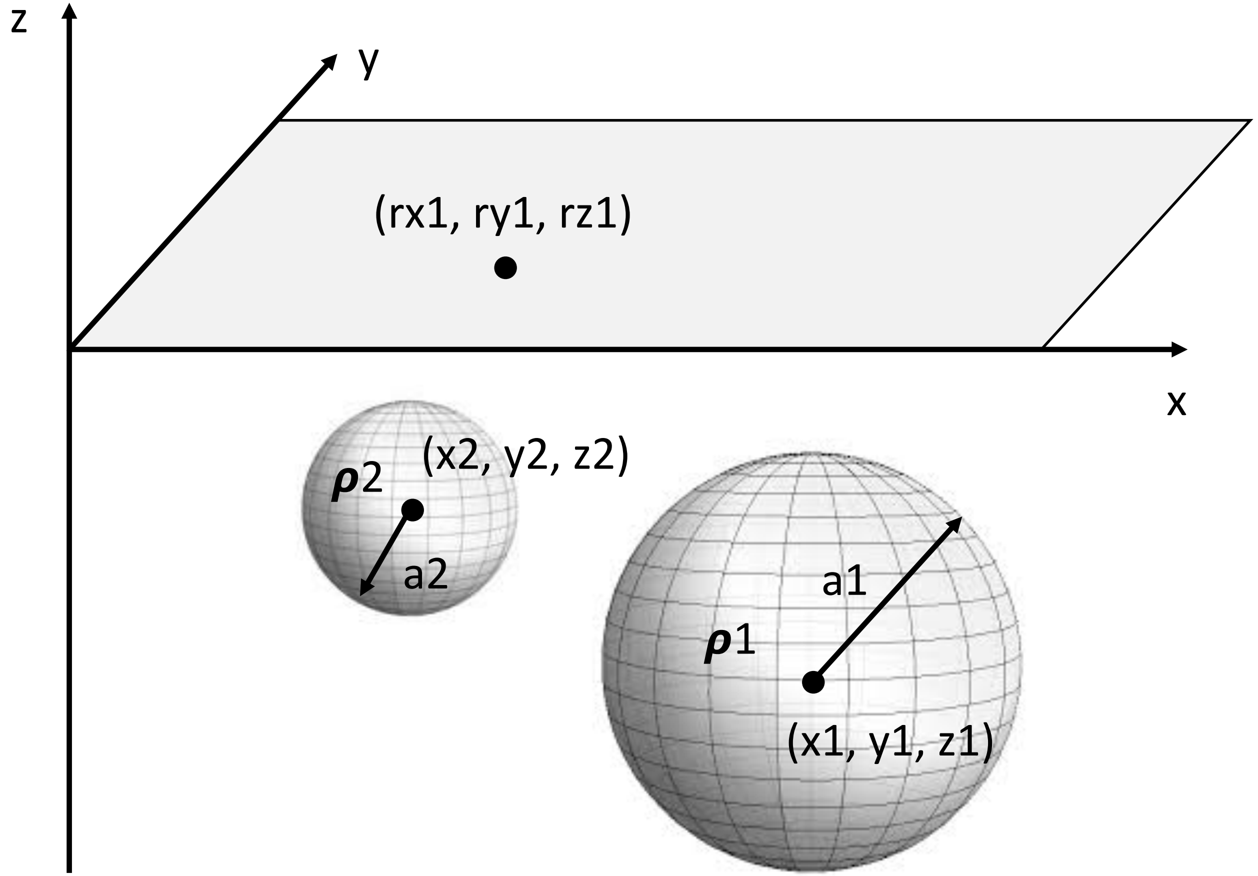
LaCoste-Romberg gravimeter



Two Sphere Gravity Problem

Programming assignment

Gravity of two (or N) spheres



N uniform spheres of different densities located in the 3D space

Be able to calculate the gravitational field F anywhere in the 3D space outside of the spheres

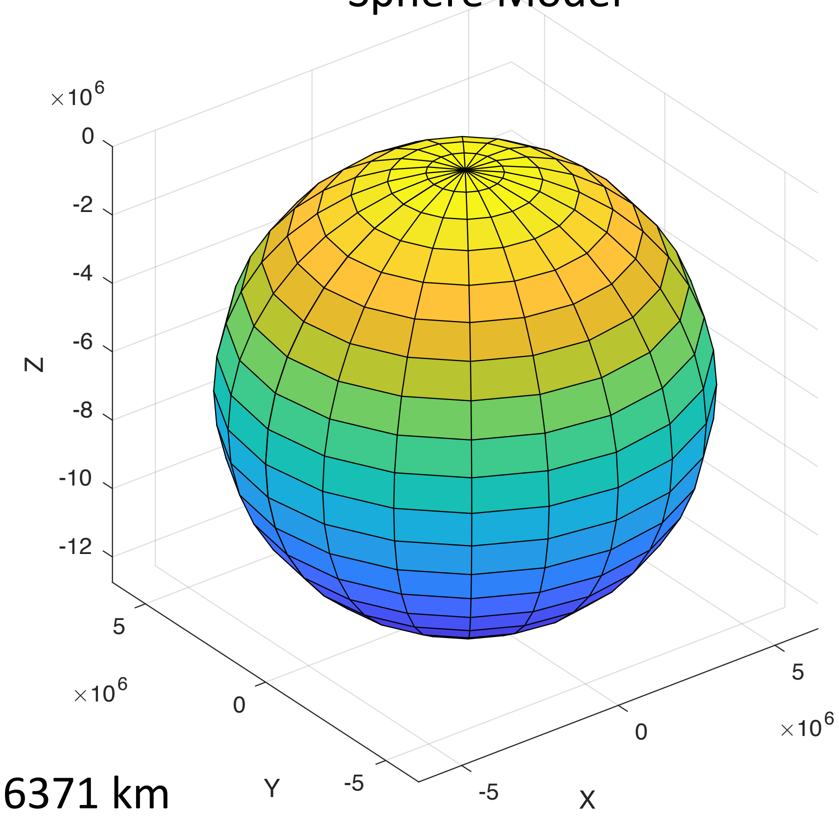
Bury the two spheres underground and compute g_z over a data grid on the surface and make the plot

Compute the potential U over the data grid and make the plot

Finish before next class

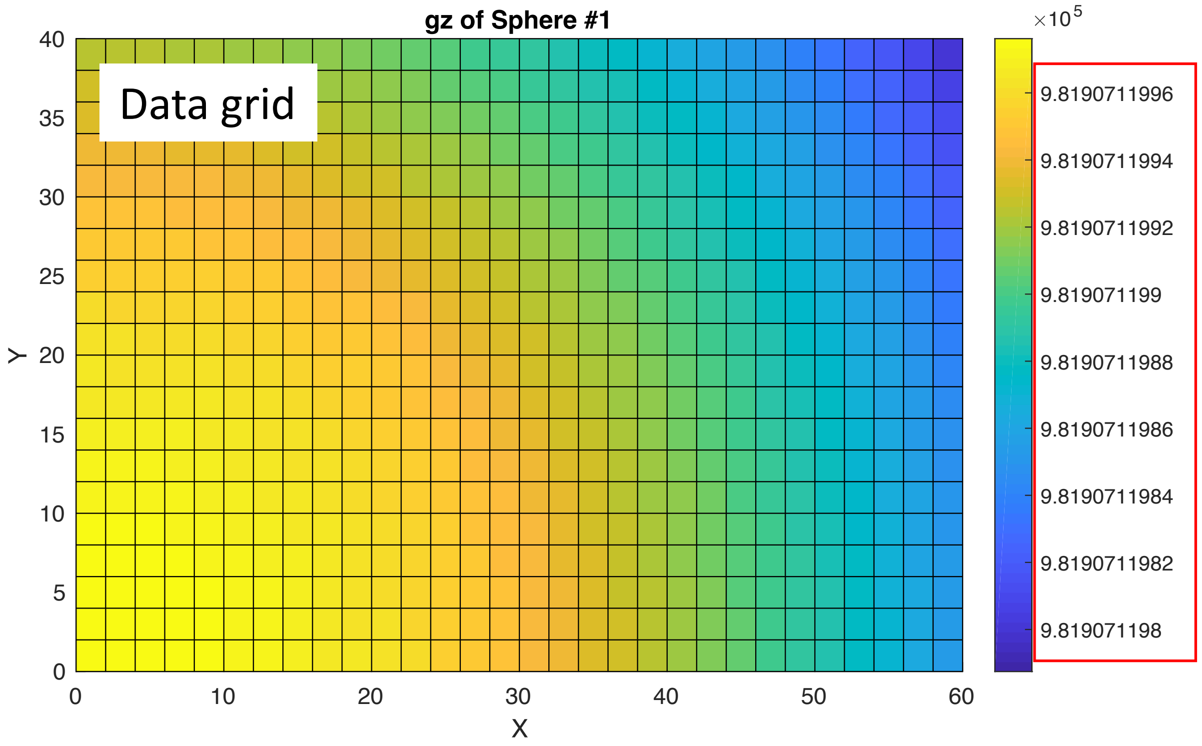
Experiment 1: One really big sphere

Sphere Model



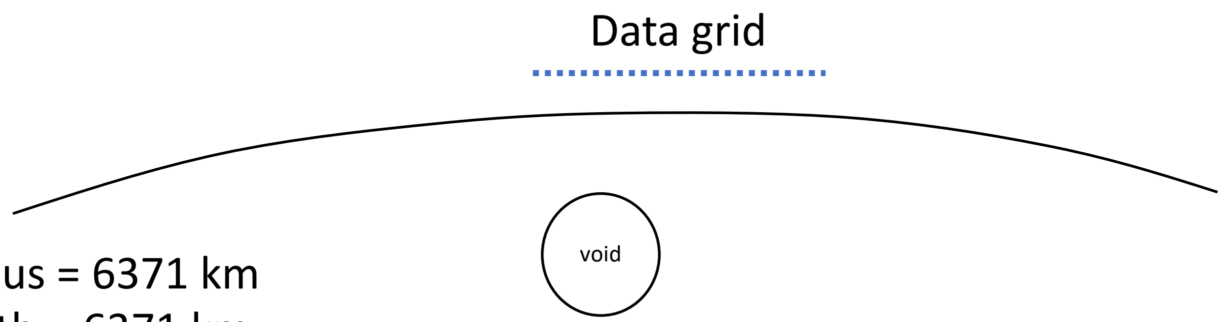
Radius = 6371 km
Depth = 6371 km
Density = 5.513 g/cm^3

Gravity Data (mGal)



Conclusion: Big numbers but almost constant

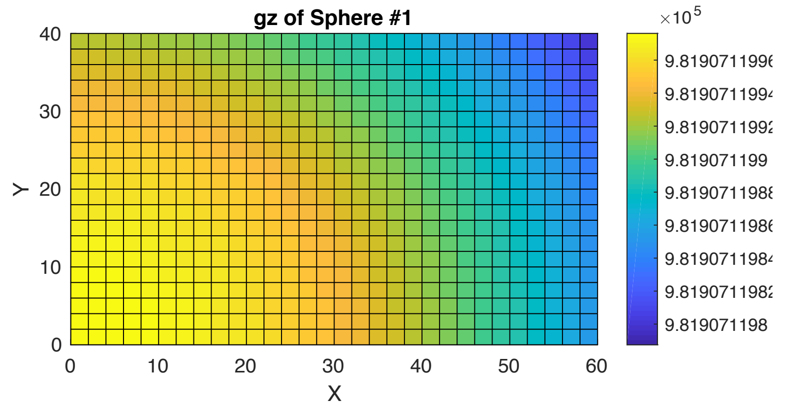
Experiment 2: A small sphere in a large sphere

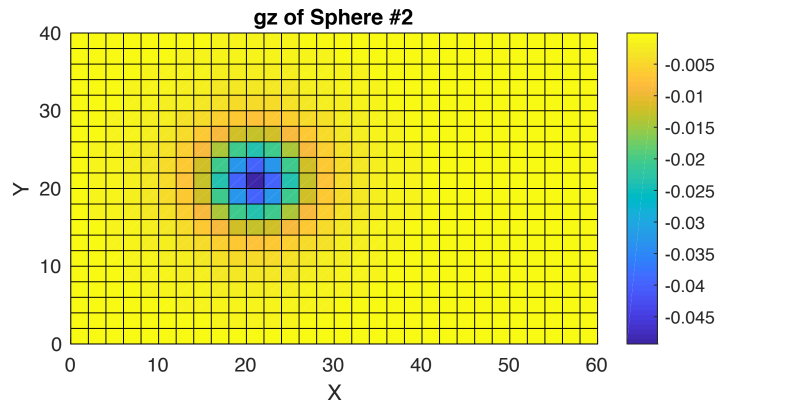


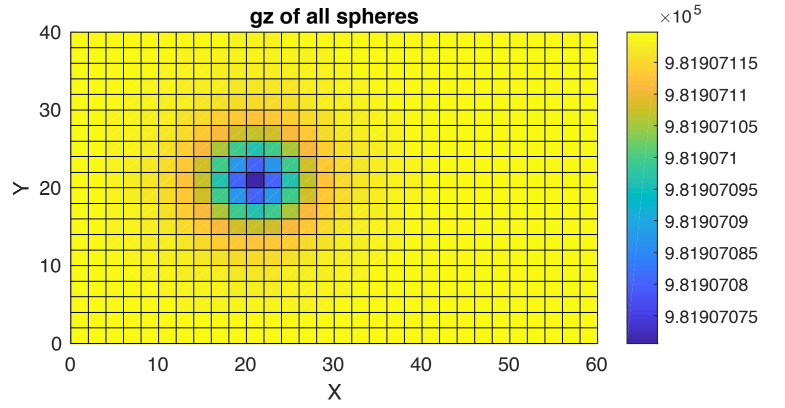
Radius = 6371 km
Depth = 6371 km
Density = 5.513 g/cm^3

Radius = 2 m
Depth = 5 m
Density = -5.513 g/cm^3

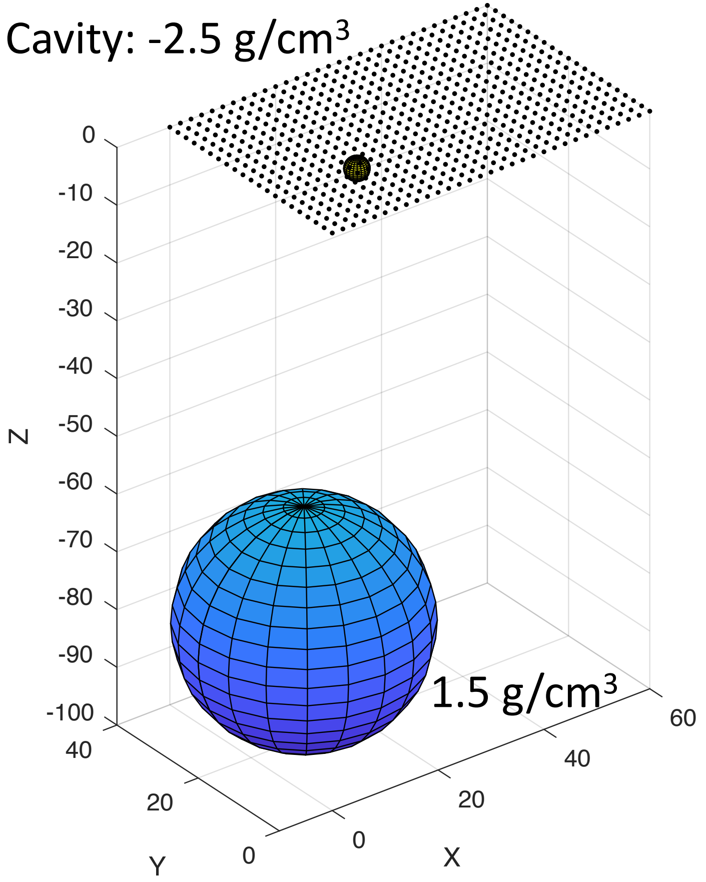
Conclusion: The field from the entire earth does not help us in finding buried objects

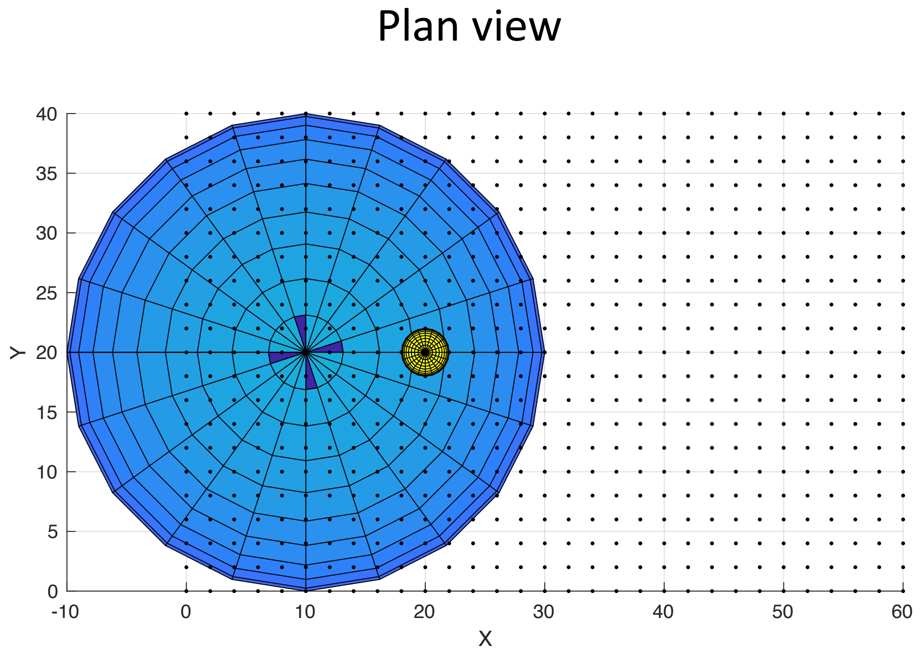


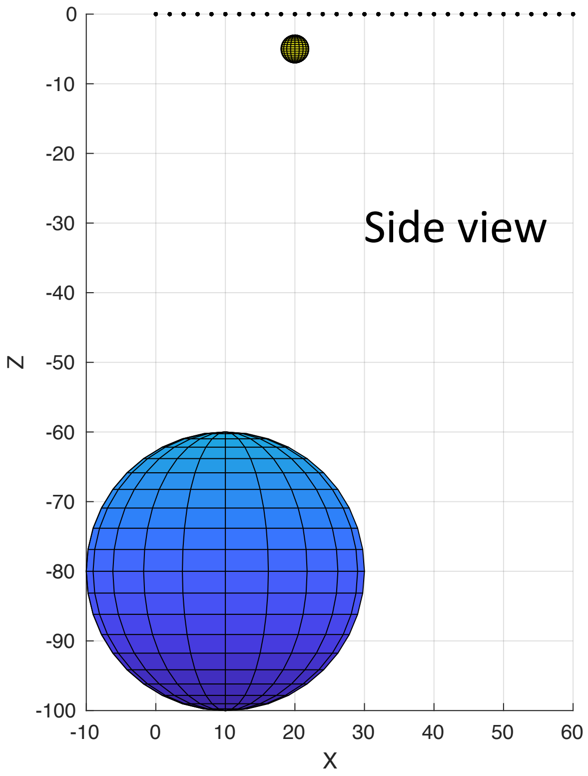


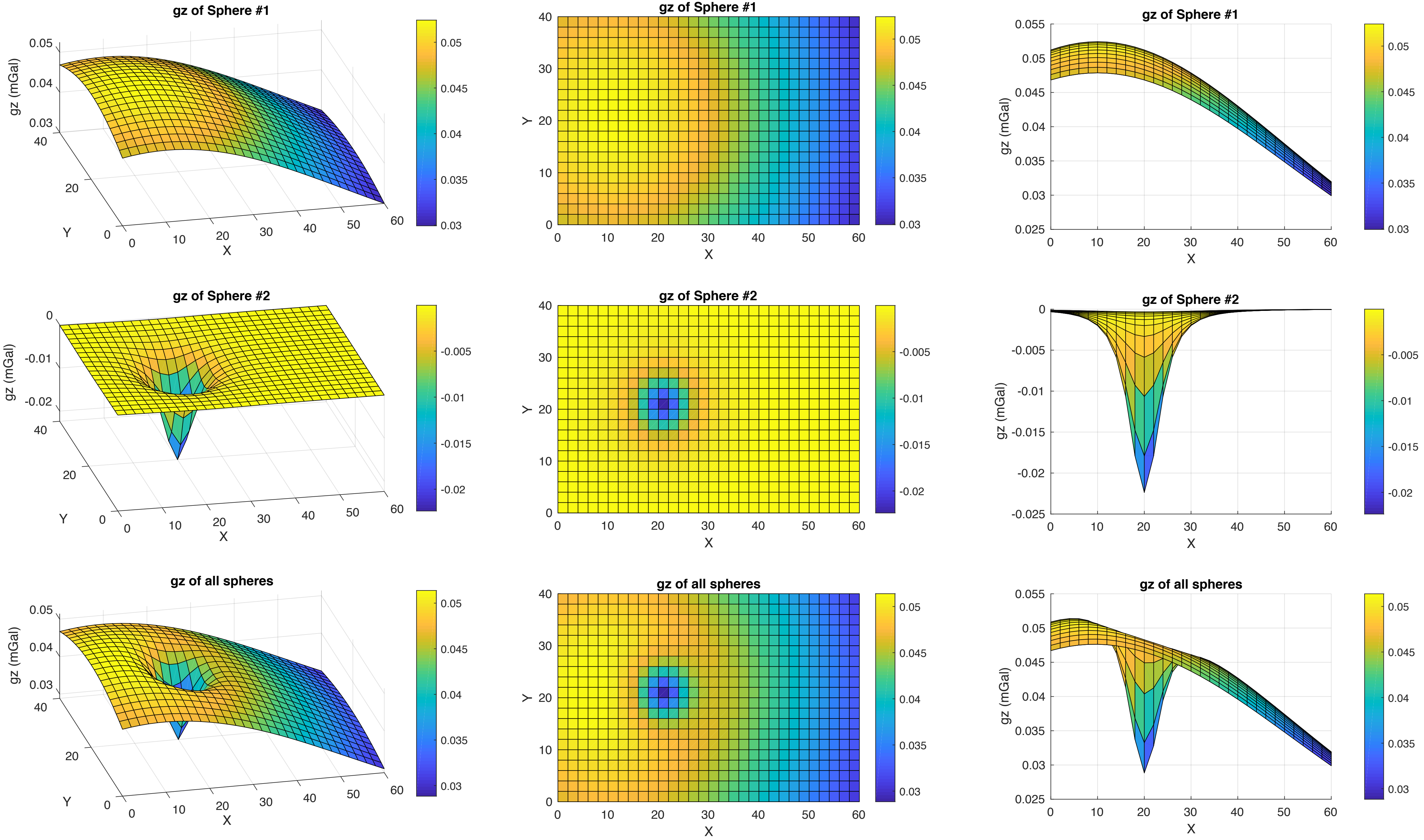


Experiment 3: Two spheres in different sizes



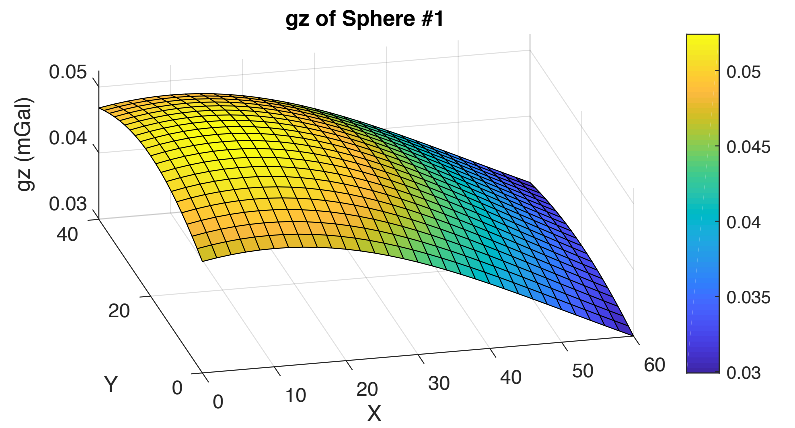


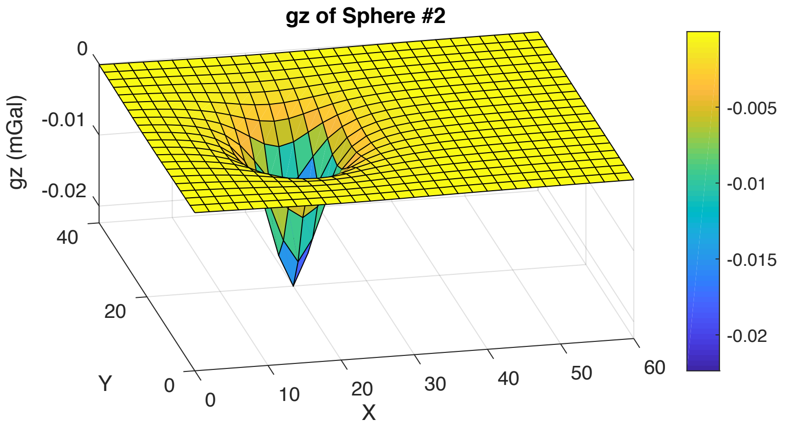


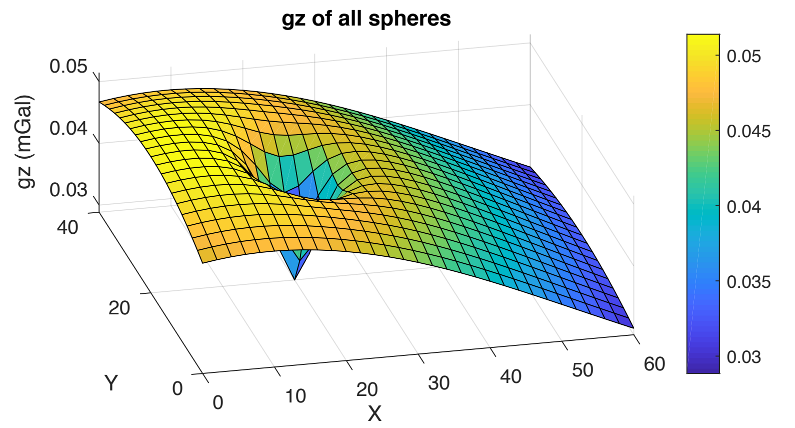

gz of Sphere #1
gz (mGal)
X
Y
gz of Sphere #2
gz (mGal)
X
Y
gz of all spheres
gz (mGal)
X
Y

Regional removal

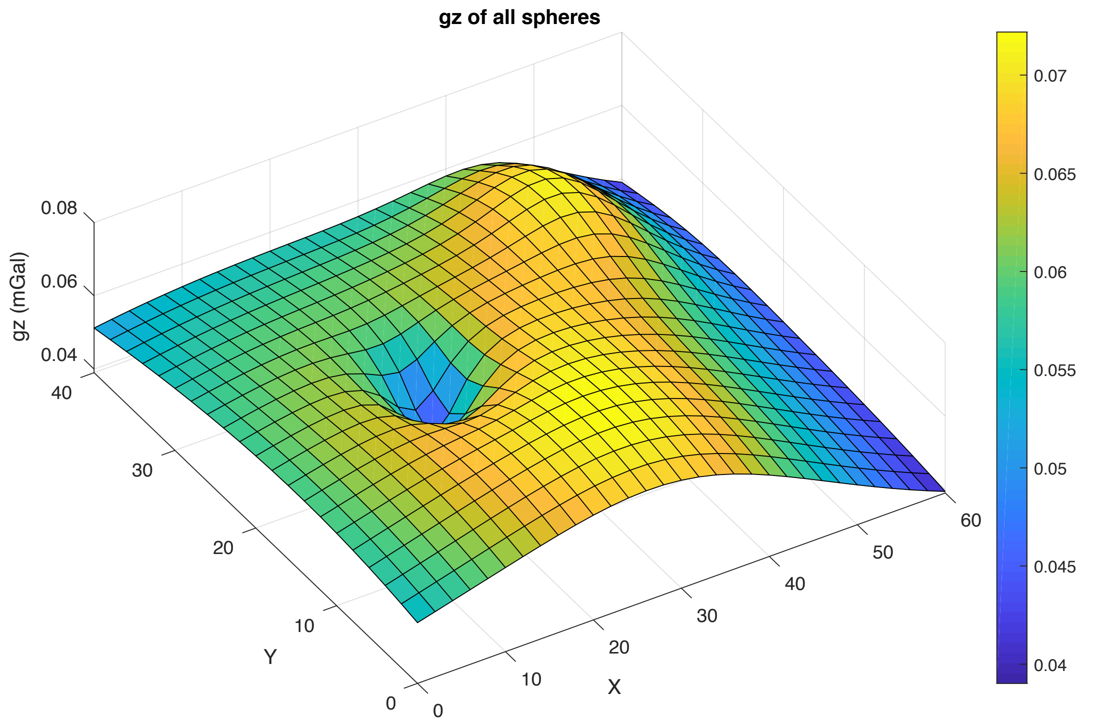
- Separate signals with different wavelengths
- Isolate anomalies at the scales of our interest
  - Small and shallow: Near-surface cavity
  - Large and deep: Basin basement
- What are the approaches that can be used to carry out regional removal?
  - Moving window averaging
  - Wavenumber domain filtering
  - Best-fitting large sphere
  - Surface fitting – low-order polynomials

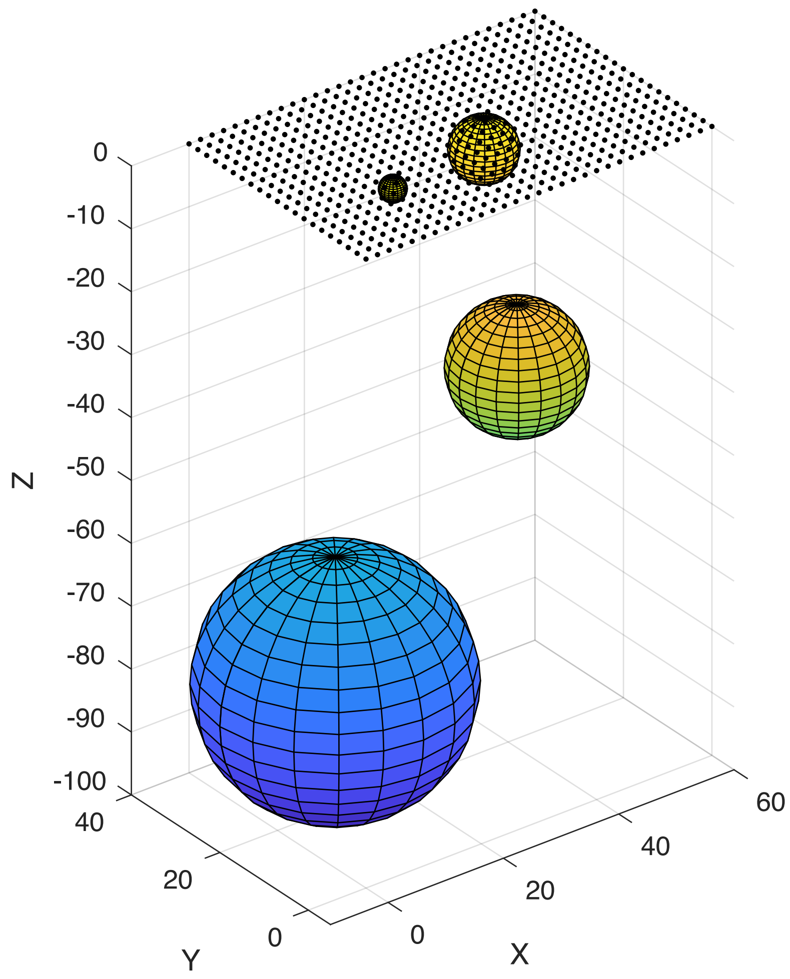






Experiment 4: Many spheres



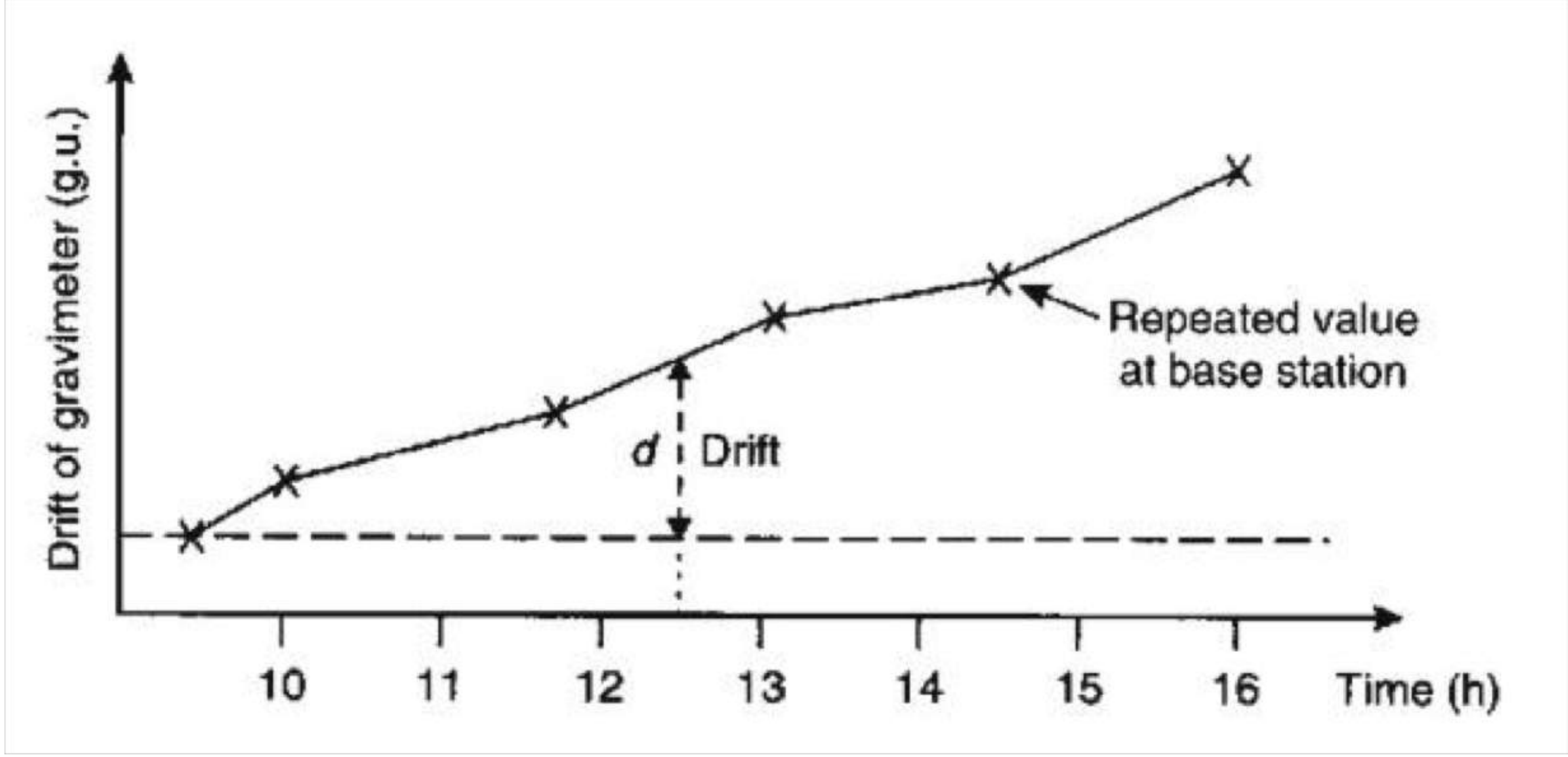


How many spheres are there?
Create your own "puzzle"!

Gravity Data:
Separate known and unknown

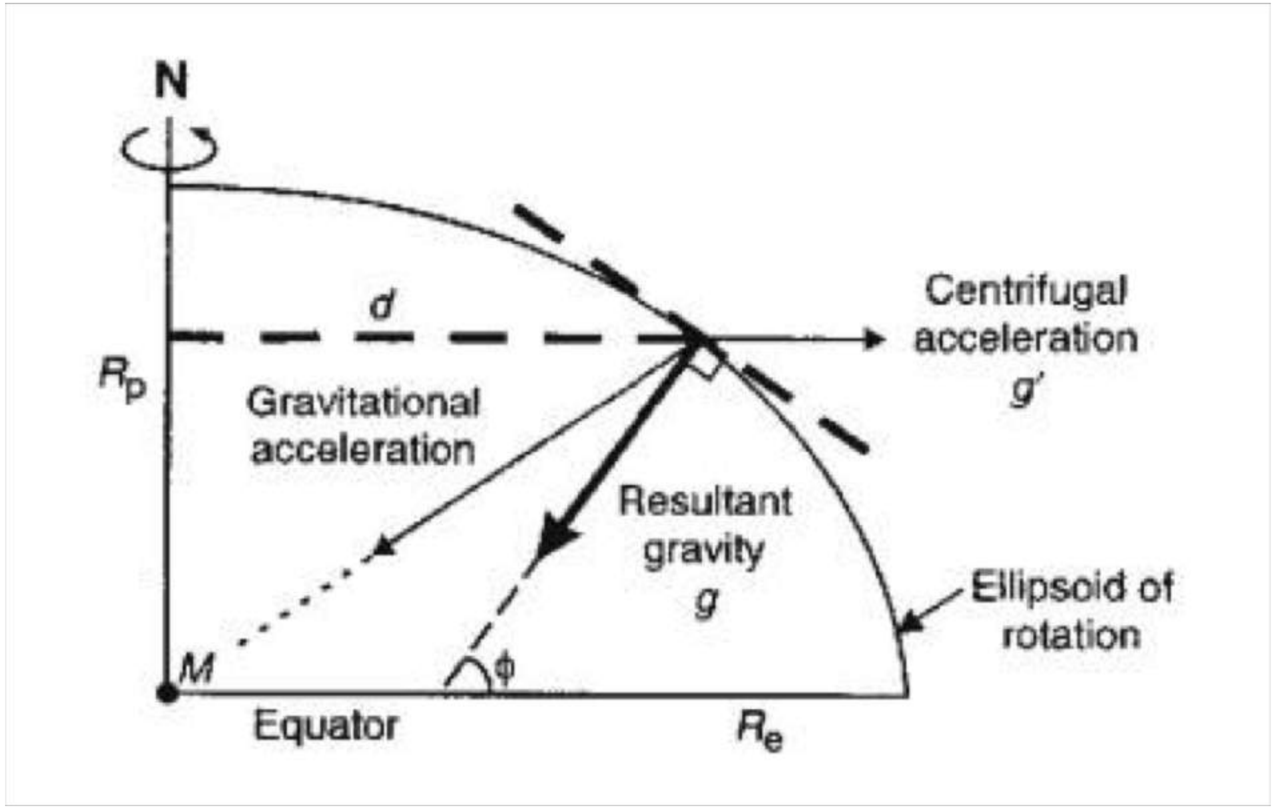
Gravity data reduction

- Drift correction



Gravity data reduction

- Drift correction
- Latitude correction



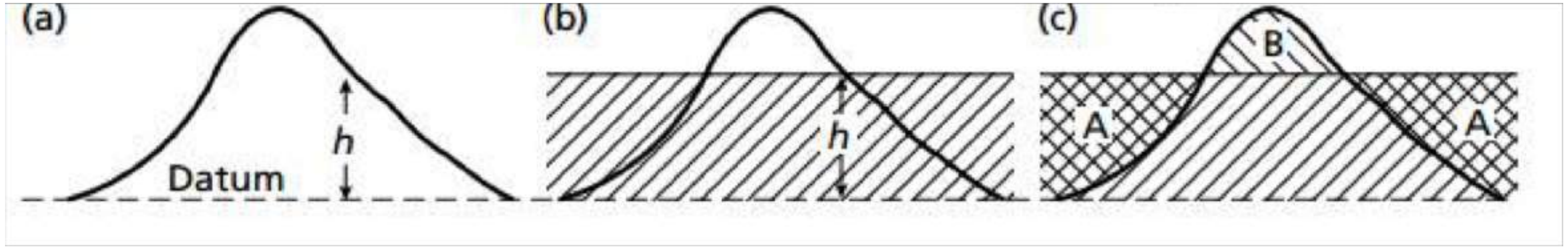
Earth: A spinning ellipsoid

Gravity data reduction

- Drift correction
- Latitude correction
- Elevation correction

Gravity data reduction

- Drift correction
- Latitude correction
- Elevation correction
  a) Free-air
  b) Bouguer
  c) Terrain



Gravity data reduction

- Drift correction
- Latitude correction
- Elevation correction
    a) Free-air
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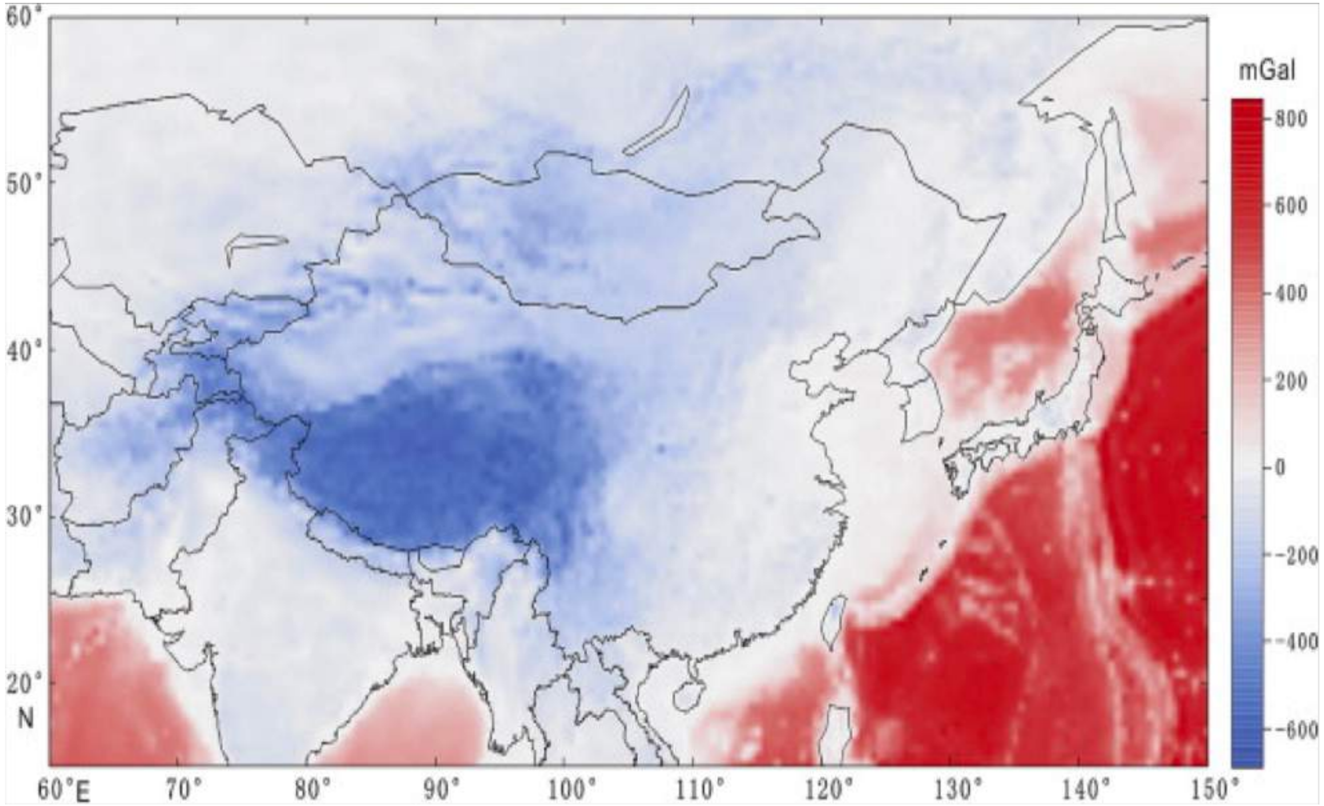
    c) Terrain

Bouguer Anomaly



Gravity data reduction

- Drift correction
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    a) Free-air
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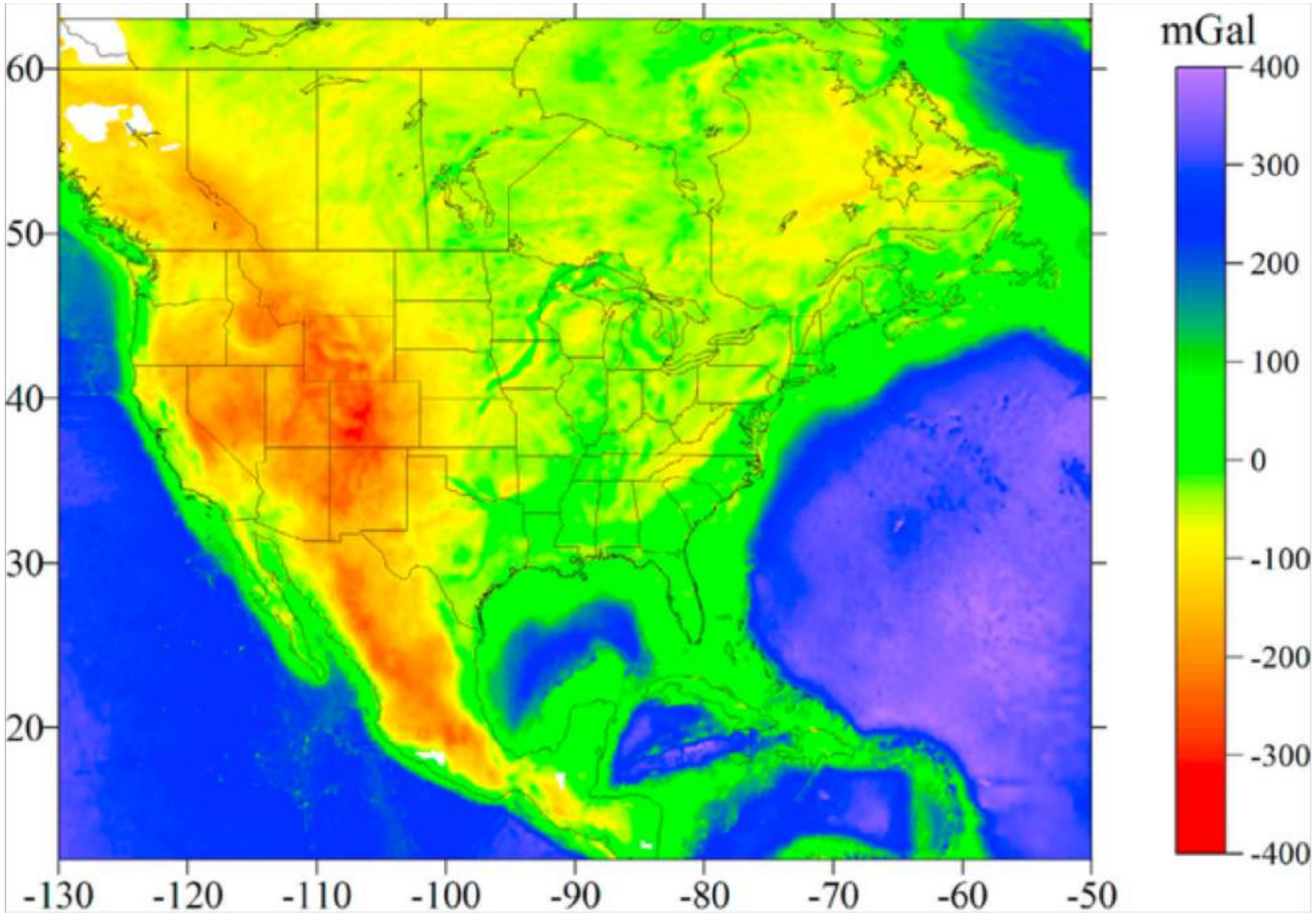
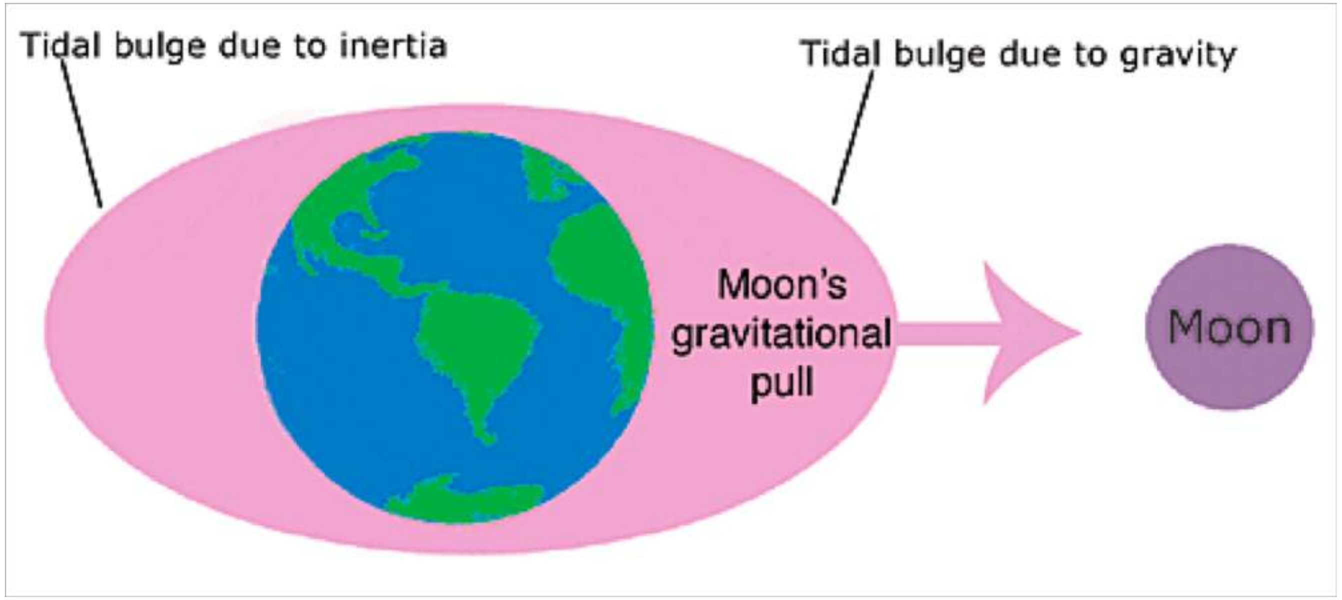
Bouguer Anomaly



Gravity data reduction

- Drift correction
- Latitude correction
- Elevation correction
  a) Free-air
  b) Bouguer
  c) Terrain
- Tidal correction



Gravity data reduction

- Drift correction
- Latitude correction
- Elevation correction
    a) Free-air
    b) Bouguer
    c) Terrain
- Tidal correction
- Eötvös correction

Summary

- Unit and instrument
- Forward modeling of spheres: Superposition
- Regional removal: Concept of scale
- Gravity data correction