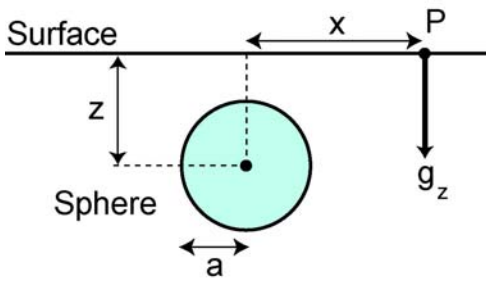
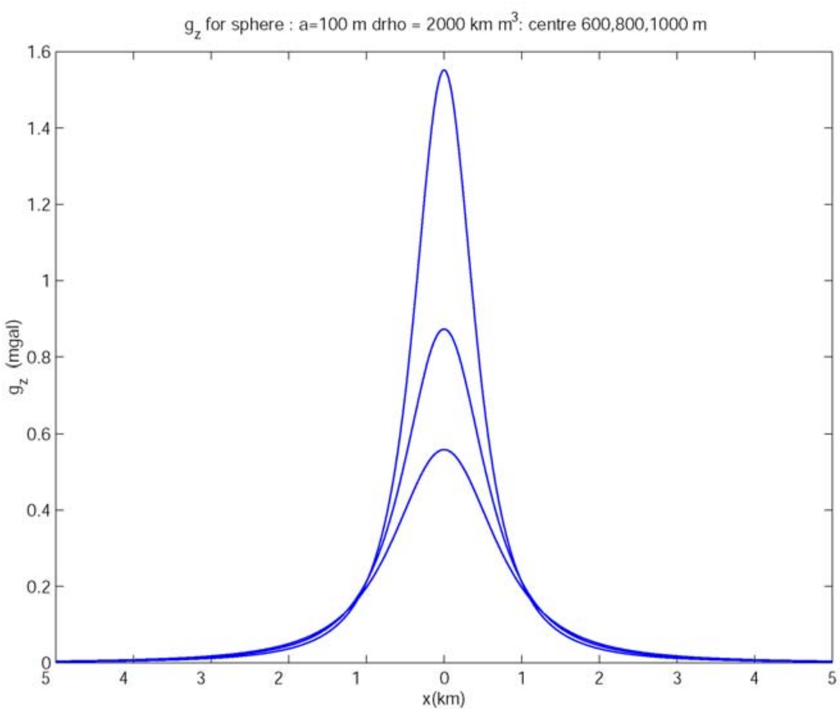
Geophysics 325

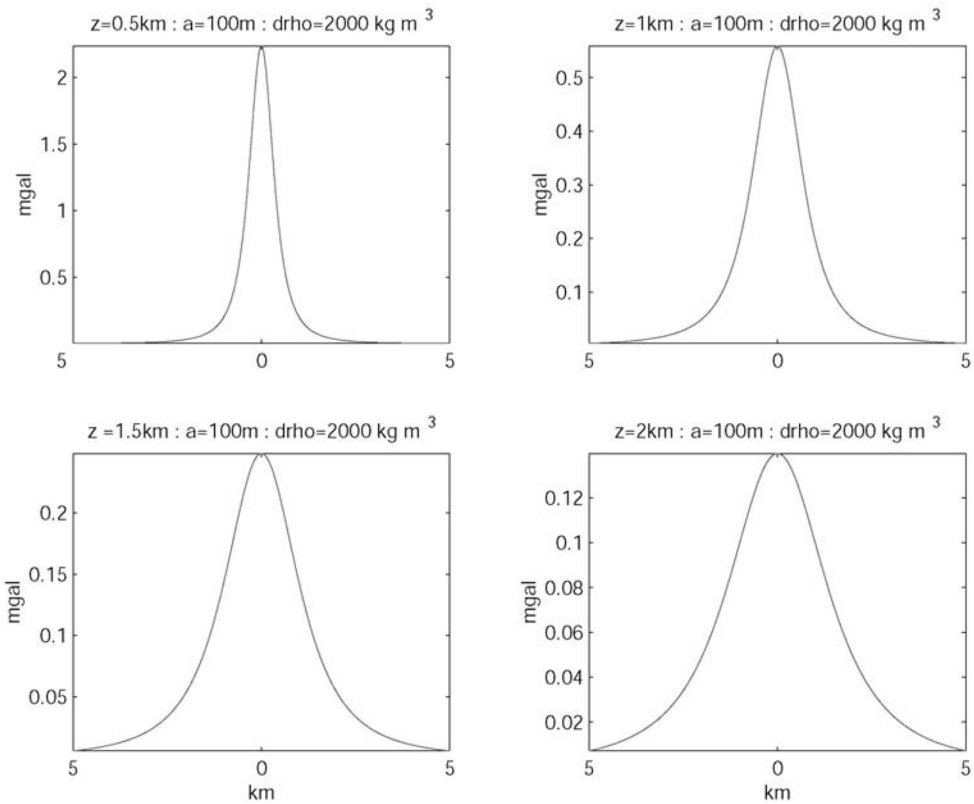
B3.1 Gravitational acceleration due to a thin rod

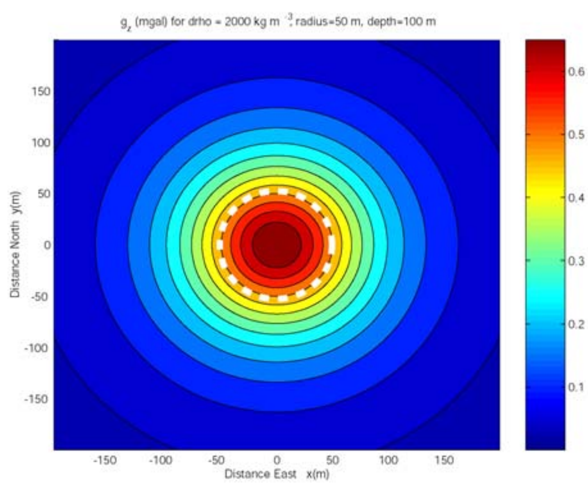
B3.2 Gravitational acceleration due to a thin sheet

B3.3 Gravitational acceleration due to a buried sphere



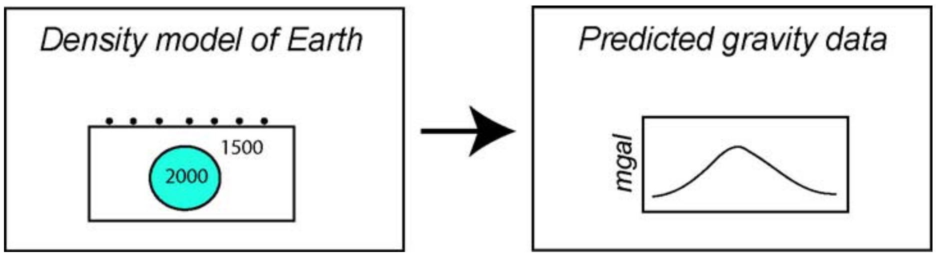



z=0.5km : a=100m : drho=2000 kg m 3
z=1km : a=100m : drho=2000 kg m 3
z =1.5km : a=100m : drho=2000 kg m 3
z=2km : a=100m : drho=2000 kg m 3
mgal
km


g_z (mgal) for drho = 2000 kg m -3, radius=50 m, depth=100 m
Distance North y(m)
Distance East x(m)

Note on Forward and inverse problems in Geophysics

Forward problems

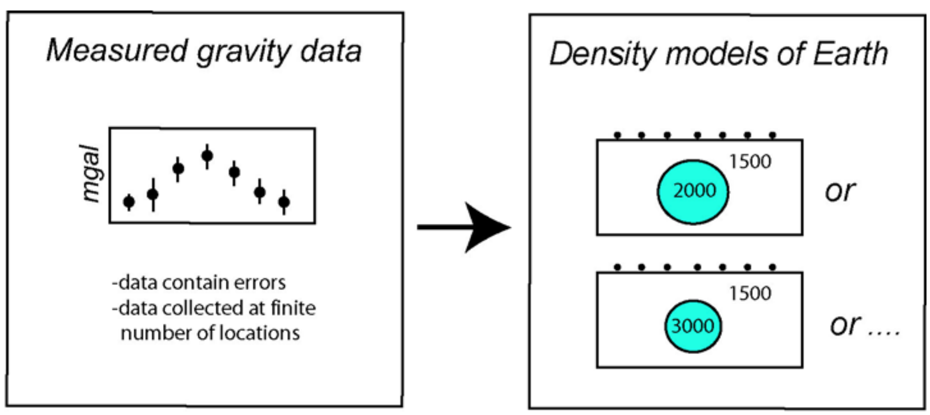


-start with a model of the Earth and compute predicted data

-unique solution

-calculating the predicted data can be a simple equation or a complex computer algorithm

Inverse problems



-start with measured data and compute a model of the Earth (density, velocity etc)

-non-unique with many solutions

-solving the inverse problem can involve a trial-and-error approach or an automated inversion algorithm

Non-uniqueness can arise from two distinct factors

(1) The basic physics

Example : In gravity exploration, we can only determine the excess mass of a buried sphere. We cannot determine the density and radius that combine to give this value of excess mass.

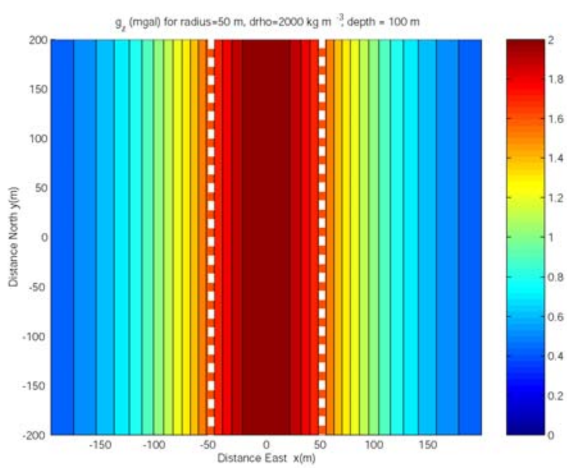
This type of non-uniqueness cannot be overcome, not even with expensive computer packages. However, additional (independent) data can be used to address non-uniqueness. For example, if we have density measurements of the target, we could determine the radius of the sphere.

(2) Noise in data

Example: In gravity exploration noise in the data will introduce errors when we determine the half width ($x_{½}$). Errors in the half width will introduce errors into estimates of the depth of sphere.

This type of non-uniqueness can be overcome by improving data quality and quantity.

B3.4 Gravitational acceleration due to a buried cylinder



B3.5 Gravitational acceleration of a 2-D polygon

Integration is needed to compute the gravitational acceleration of an arbitrary shape. If the density is a function of x,y and z, then the approach in B2.1 must be used (integrate over each cubic cell). However, if a body has a uniform density contrast, Δρ, then this can be reduced to a surface integral. In the case of a 2-D structure, the body will be a prism that is invariant in the y-direction. Talwani (1959) showed that the gravity acceleration can be computed from a line integral around the perimeter.

$$g_z = 2G\Delta\rho \oint \tan^{-1}\left(\frac{x}{z}\right) dz$$

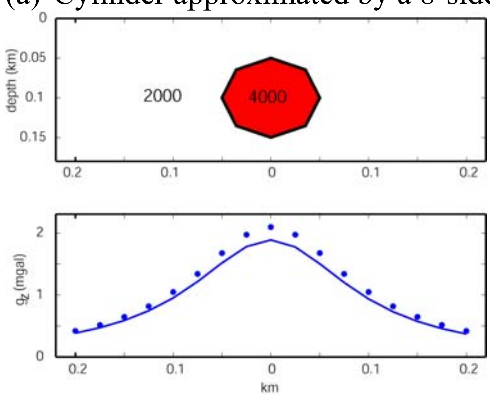
This algorithm was implemented in a MATLAB script **g_polygon_N.m**

Example 1 Horizontal cylinder

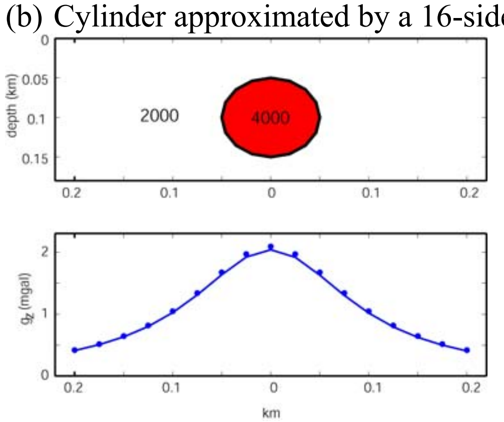
Density contrast = 2000 kg m^{-3}

Before using any software, we weed to test algorithm against a known result. Be suspicious of all software.

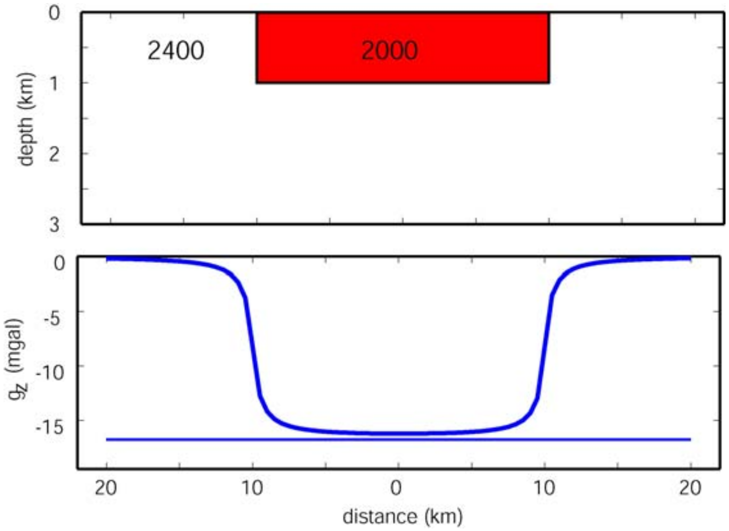
(a) Cylinder approximated by a 8-sided polygon

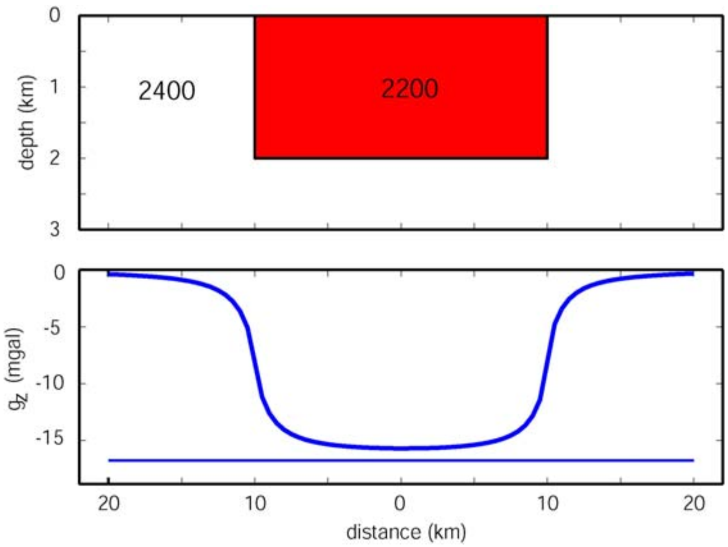


(b) Cylinder approximated by a 16-sided polygon



Example 2 : Low density basin





Horizontal line shows the value of g_z for an infinite slab, computed with the result derived in B3.2

How far from the edges do we need to be to use the formula for an infinite slab?

The 2-D line integral approach will be used later in the class to interpret some real gravity anomaly data collected in a number of locations.