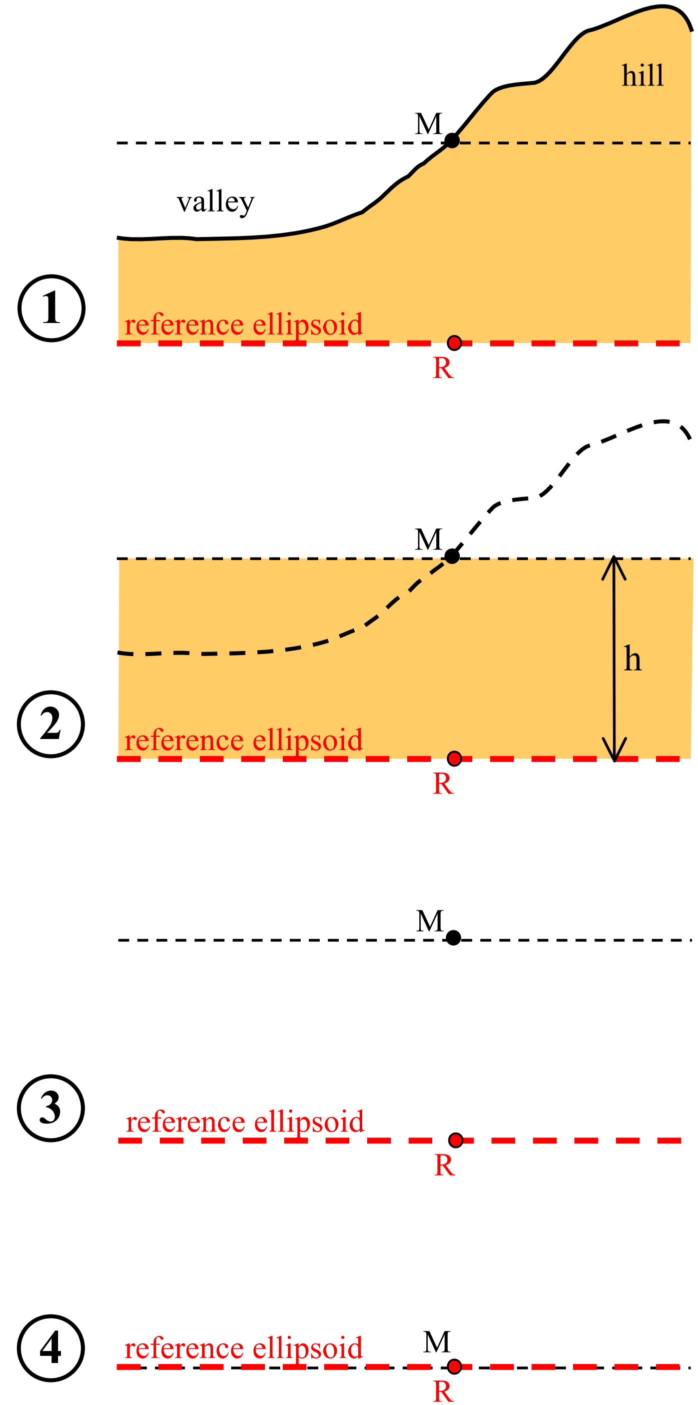
Reduction of gravity measurements

- Recall that, if the Earth was an homogeneous ellipsoid:

$$g = g_o(1 + k_1 \sin^2 \Phi - k_2 \sin^2 2\Phi)$$

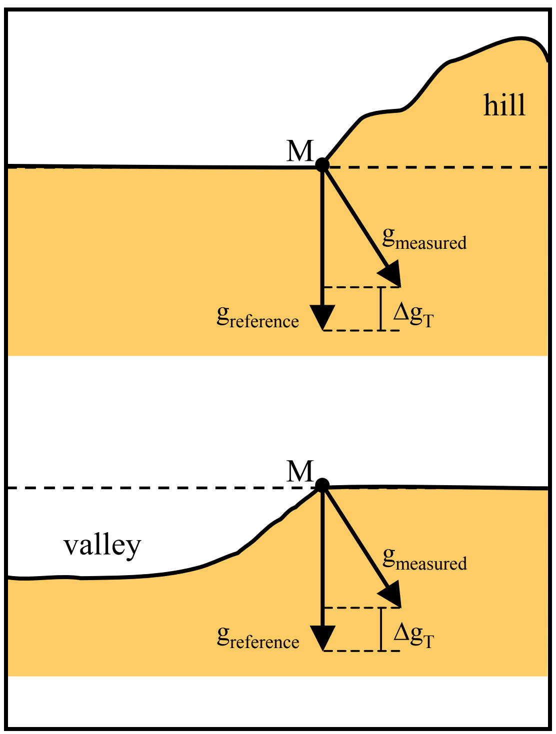
- Gravity measurements:
  - Objective: look for deviations from this reference value
  - Problem: measurements are (usually) not made on the reference ellipsoid…
  - Solution: "reduce" the measurements to "bring" then on the ellipsoid
- Reduction = "correct" the measurements from the effect of:
  - Attraction of terrain around the measurement site: 1 → 2
  - Attraction of rock mass between *M* and *R*: 2 → 3
  - Elevation of *M* w.r.t. reference ellipsoid: 3 → 4
- What do we learn if:
  - $g_{reduced} = g_{reference}$?
  - $g_{reduced} \neq g_{reference}$?



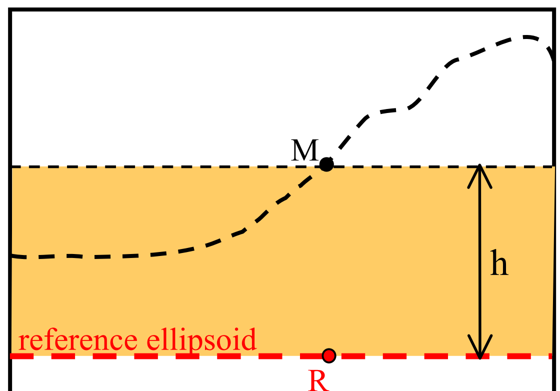
Gravity corrections

Terrain correction:
Compensates for the reduction of *g* due to terrain around the measurement site

- Always added to $g_{measured}$
- Complex calculation: discretize topographic map or use DEM



Bouguer plate correction:
Compensate for the gravitational attraction of a plate of constant thickness h

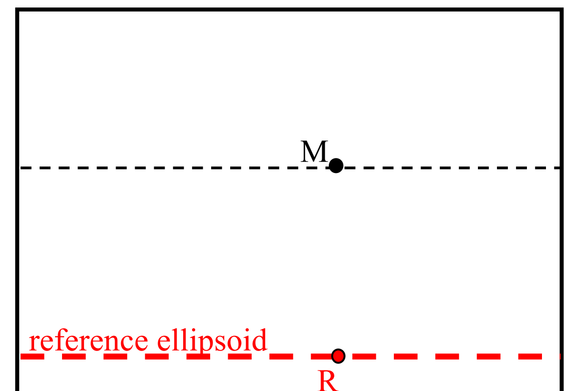


$$\Delta g_{BP} = 2\pi G \rho h$$

$$\Rightarrow \Delta g_{BP} = 0.0419\ \rho h$$

ρ = plate density (e.g. 2.67)
h = plate thickness

Free-air correction:
Compensates for the elevation of the measurement site w.r.t. the ellipsoid



$$\frac{dg}{dr} = -2\frac{g}{R}$$

$$\Delta g_{FA} = 0.3086\ mGal/m$$

(with g = 981,000 mGal and R = 6371 km)

Bouguer and free-air gravity anomalies

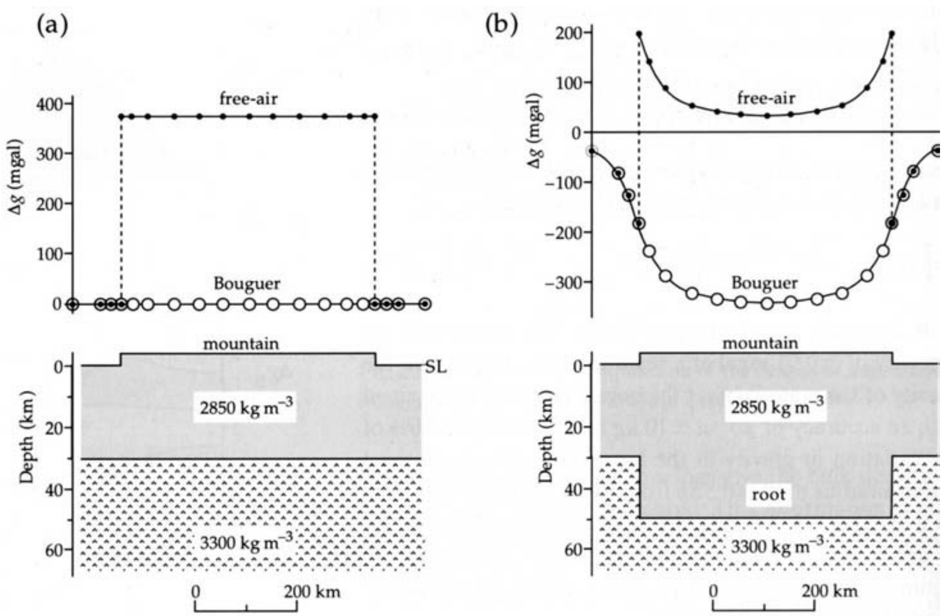
- **Free-air anomaly** = difference between $g_{measured}$ and $g_{reference}$ corrected for elevation:

$$A_{FA} = g_m - (g_r - 0.3086\ h)$$

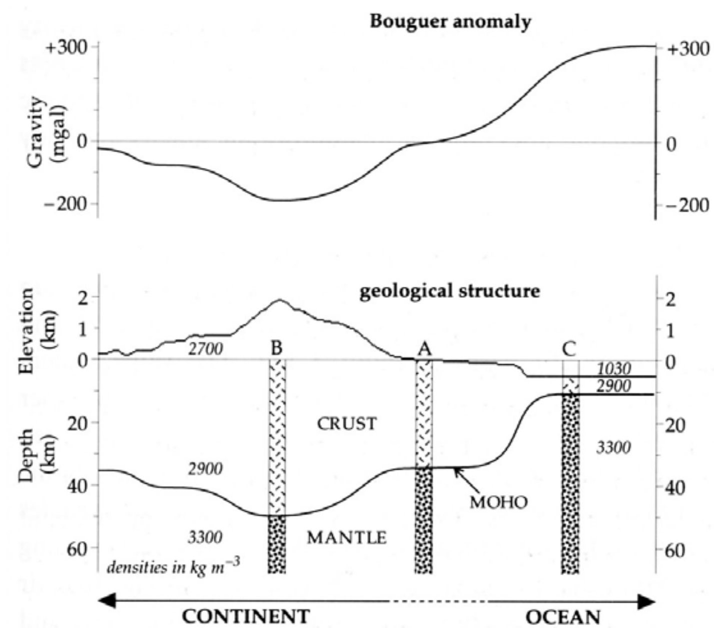
- **Bouguer anomaly** = difference between $g_{measured}$ and $g_{reference}$ corrected for elevation, plate, and terrain:

$$A_B = g_m - (g_r - 0.3086\ h) - (0.049\ \rho\ h) + \rho T$$

Bouguer and free-air gravity anomalies

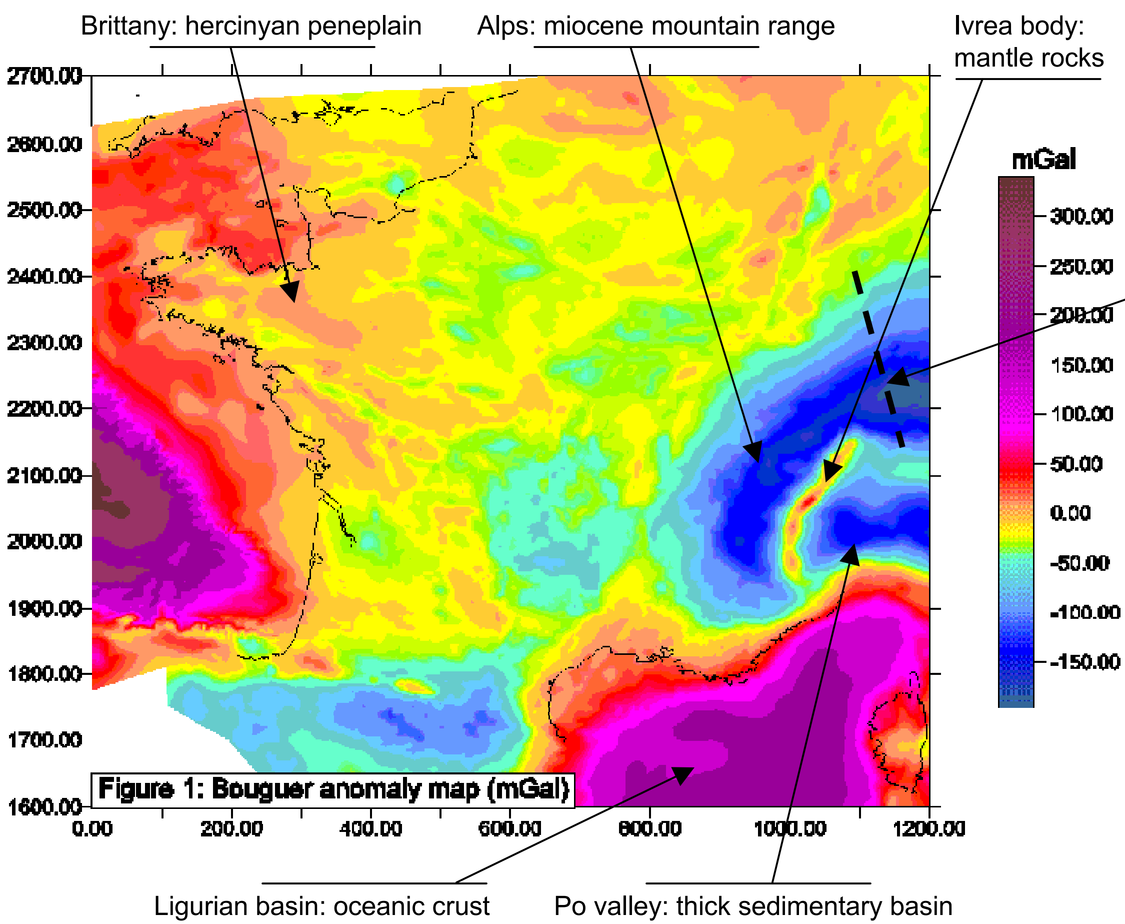


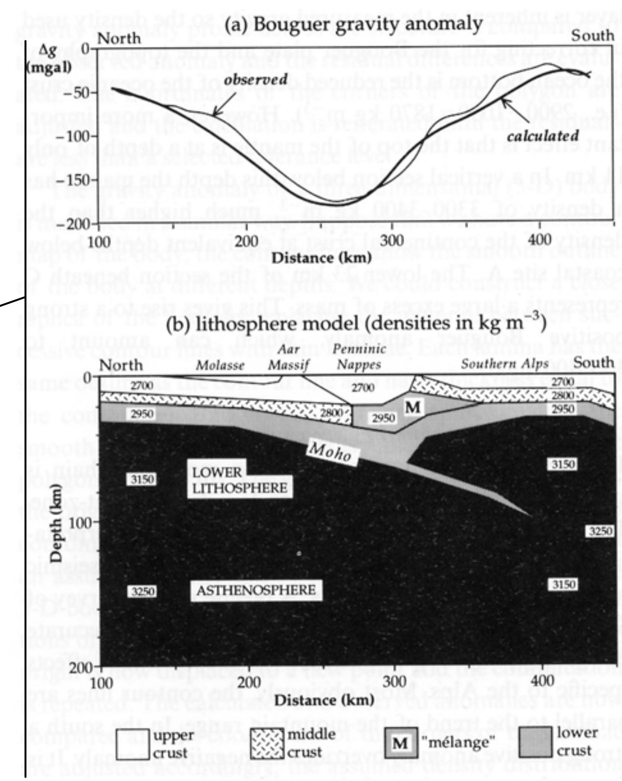
(a) Mountain is supported by the strength of the crust
(b) Mountain is supported by a crustal root that projects into the denser mantle



Hypothetical Bouguer anomaly over continental and oceanic areas.

Gravity anomalies across mountains





Lithosphere density model across the Swiss Alps. The geometry of the structures is derived from seismic reflection and refraction profiles.