Exercise 3 – magnetometry

A steel drum is approximately located at 5 m depth (*d*), as depicted in Figure 1. Please, use matlab to plot the Vertical (H_x) and Horizontal (H_z) components of the magnetic field due to the steel drum, assuming that it is located in Vienna (Inclination of ~64°31'). Please assume perfect magnetization. The shape of the drum, for simplicity can be approximated to the one of a sphere with a radius (*r*) of 0.2 m. The steel drum is located at the middle of a profile which goes from -100m to 100m. For the simulation, please assume that the data are collected at a height (*h*) of 2 m over the surface every 30 centimeter.

Hint: the Vertical and Horizontal components of the magnetic field of a sphere for readings at the surface along a profile going from–x to x and the center of a sphere located at x=0 (as indicated in Figure 1) - can be computed as:

$$H_x(x) = \frac{m}{4\pi}\frac{(2x^2 - z^2)(cosI) - 3xz\,(\sin I)}{(z^2 + x^2)^{\frac{5}{2}}}$$

$$H_z(x) = \frac{m}{4\pi}\frac{(2z^2 - x^2)(sinI) - 3xz\,(\cos I)}{(z^2 + x^2)^{\frac{5}{2}}}$$

Where *I* is the magnetic inclination, z is the sum of the depth of the anomaly and the height of the magnetometer, and *m* is the dipole moment given by

$$m = k_{eff}|B_{ext}|\frac{V}{\mu_o}$$

Where B_{ext} is the magnitude of the external field (~ 48589.9 nT for Vienna), *V* is the volume of the sphere, μ_o is the permittivity of vacuum ($\mu_o = 4\pi \times 10^{-7}$ [Wb/Am]) and k_{eff} is the effective permeability of an object, which can be written in terms of the magnetic permeability (μ) and the demagnetization factor (N_{geom}) as:

$$k_{eff} = \frac{\mu}{1 + \mu N_{geom}}$$

The magnetic permeability of iron (100% pure) is ~5×10^3 (Wb/A). The demagnetization factor may be considered with a value of 1, as we assume a perfect magnetization.

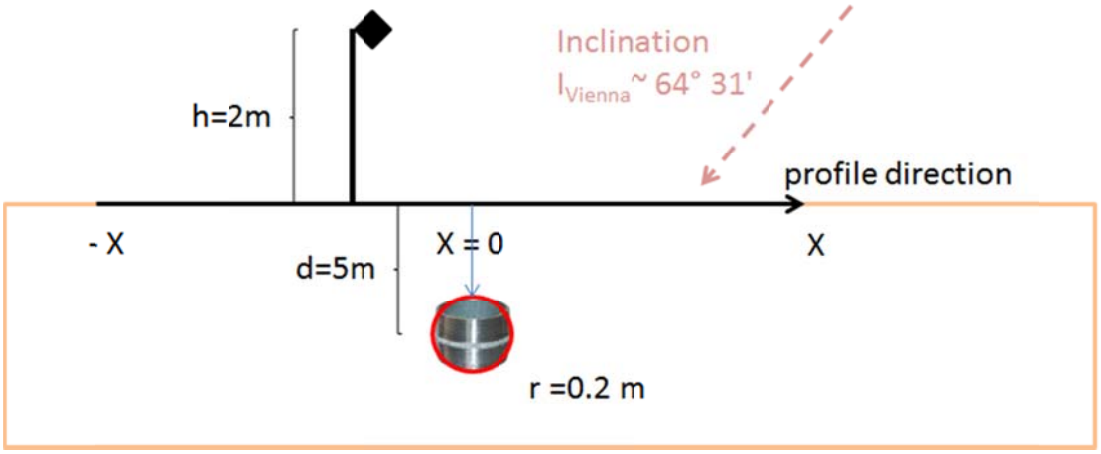

Figure 1

Tasks

1) Plot the Horizontal and Vertical components of the magnetic field (in Vienna) for the steel drum as depicted in Figure 1.
2) Plot the Horizontal and Vertical components assuming that the magnetometer is now used at a height of 0.5m.
3) Plot the Total field measured at the surface for the same steel drum but buried at a depth of 3m (a height of 2m for the magnetometer)
4) Plot the vertical, horizontal and total field for the same steel drum from Question 1, but assuming that the measurements were performed at 1) the magnetic North pole and 2) the Equator.

Information about the geomagnetic field (Inclination, magnitude) can be obtained in:

http://www.ngdc.noaa.gov/geomag-web/#declination