Expectations for Exercises

Exercises are an important part of the Geophysics lecture. They will treat some aspects of the lecture in more detail, but also cover new ground. We expect that you work on the exercises at home and we will discuss questions and solutions interactively together. Questions that are marked with 'Extra' are not required but geared to stir your further interest. We will surely support you if you tackle those as well.

4 Exercises for Magnetics 2

Version: May 11, 2022
Context: Magnetics 01 + 02
Timing: All magnetics exercises should be completed by Thursday in week 5.

4.1 Natural Magnetic Remanence

Some rocks and other materials show a remanent magnetization additional to the induced magnetization by the contemporary Earth's magnetic field. The total magnetic moment is the superposition of the two. This has important implications for the interpretation of magnetic anomalies (see below), but can also be exploited for a number of important findings in paleomagnetics shaping our understanding of processes in the Earth System. Find an applications in which remanence helps us to understand the Earth's history (e.g., in terms of plate tectonics or dating) and post a short snapshot (pictures, key messages) of this in the forum. Don't post it if somebody else already did.

4.2 Forward Modelling of Magnetic Anomalies

In order to improve our intuitive understanding of magnetic surveying we will employ some forward simulations using the GeoSci.xyz package which has been developed by a number of contributors (e.g., Lindsey Heagy) and is available for all to use. If you are somewhat computer affine, you can install the required packages locally on your computer as described on their GitHub page. Alternatively, we will use *binder* where you can run the corresponding notebooks via a web-browser.

Try clicking here:
`https://notebooks.gesis.org/binder/jupyter/user/geoscixyz-geosci-labs-j7mdlcx3/notebooks/notebooks/index.ipynb`
or copy the web-address into your browser.

(a) Navigate to the *MagneticDipoleApplet.ipynb* which is the notebook that we already discussed in class. Use this model of a magnetic dipole in the surface to familiarize yourself with the expected magnetic anomalies at different locations in the world.

(b) Navigate to the *MagneticPrismApplet.ipynb*. First choose a small, symmetrical prism and make sure that the simulated results are similar to those obtained for a idealize dipole. Then start changing the geometry, e.g., approximating a pipeline in the subsurface. Can you come up with a somewhat realistic expectation for a case in Tübingen?

(c) Navigate to the *Mag_Induced2D.ipynb*. This example contains some field data in a ASCII txt file (not collected by us) and shows one way how these data can be visualized. It then extends the MagneticPrismApplet by including the effects of a remanent magnetization. Investigate how a remanent magnetization superimposes with the induced magnetization. How many free parameters does this forward model have? Will there also be possibilities for non-uniquness as already seen in the Gravity exercises?

Solutions

Tübingen (Morgenstelle) is located at 48.537624 N 9.031300 E (342 m.a.s.l.). Using NOAA's magnetic field calculator (`https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#igrfwmm`) we obtain a declination of D=3.3°, inclination of I=64.4° and T=48500 nT. The python notebooks are quite self-explanatory, not hard solutions provided here. Ambiguities clearly exists, as always.

4.3 General Questions

(a) In magnetic surveys often the vertical gradient is determined by measuring with two sensors installed at different heights let's say 0.5 meters apart. Develop an argument (including drawings or results from forward modeling) why this type of survey emphasizes near-surface targets.

(b) Compare the gravity method with the magnetic method using the table below.

	Gravity Method	Magnetic Method
active or passive		
geophysical parameter		
potential field		
time variability of earth's field		
typical data processing		
basic source types		
field characteristics		
force characterisitcs		
sensors		
use of reference station		
applications		

Solutions

(a) In general, the deeper the magnetic source, the broader and gentler the gradients of the resulting anomaly will be (see forward modeling). Also, in general, the shallower the magnetic object, the sharper and narrower the resulting anomaly. The gradient picks this rapid changes up an amplifies them.

(b)

	Gravity Method	Magnetic Method
active or passive	passive	passive
geophysical parameter	density (ρ)	magnetic susceptibility (χ)
potential field	$\vec{g} = -\nabla\phi$	$\vec{B} = -\nabla A$
time variability of earth's field	slow & small (e.g. tides)	strong & fast (e.g., space weather)
typical data processing	latitudinal, elevation, terrain, bouger corrections	interpretation in terms of ambient field, gradiometry
basic source types	point mass	magnetic dipole from current loop
field characteristics	spherically symmetric, $1/r^2$ decay	dipole field, closed field lines, $1/r^2$ decay for monopole, $1/r^3$ for dipoles
force characterisitcs	attractive	attractive or repulsive
sensors	springs, free-fall, pendulum	proton precession T, fluxgate $\vec{B}$, optically pumped
use of reference station	yes, mostly due to sensor drift	yes, due to secular variability
applications	ice-sheet mass balance, groundwater variability, sediment infill valley,..	mid-ocean ridges, pipes, paleochronology, tectonics

4.4 Interpolation of scattered data

Download the datafile *LonLatXYZ.txt* from Ilias. This is data collected witha GPS from a topographic survey in Antarctica. It is an ASCII txt file with longitude, latitude, polar sterographic, polar stereographic y, and elevation (relative to ellipsoid). Find a way how you can interpolate the data to visualize the landscape. You could use Matlab, Python or a GIS. We try to help where we can.

Solutions

```
clear all
close all

data = load('../../../Exercises/Ex4/LonLatXYZ.txt');

x = data(:,3);y=data(:,4);z=data(:,5);


xlin = linspace(min(x), max(x), 100);
ylin = linspace(min(y), max(y), 100);
[X,Y] = meshgrid(xlin, ylin);
Z = griddata(x,y,z,X,Y,'natural');
mesh(X,Y,Z)
axis tight; hold on
plot3(x,y,z,'.','MarkerSize',15)
```

../../Src/Exercises/Magnetics/GriddingRD.m