Sphere-ob

Release 0.1

Anthony Zamperoni

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CONTENTS

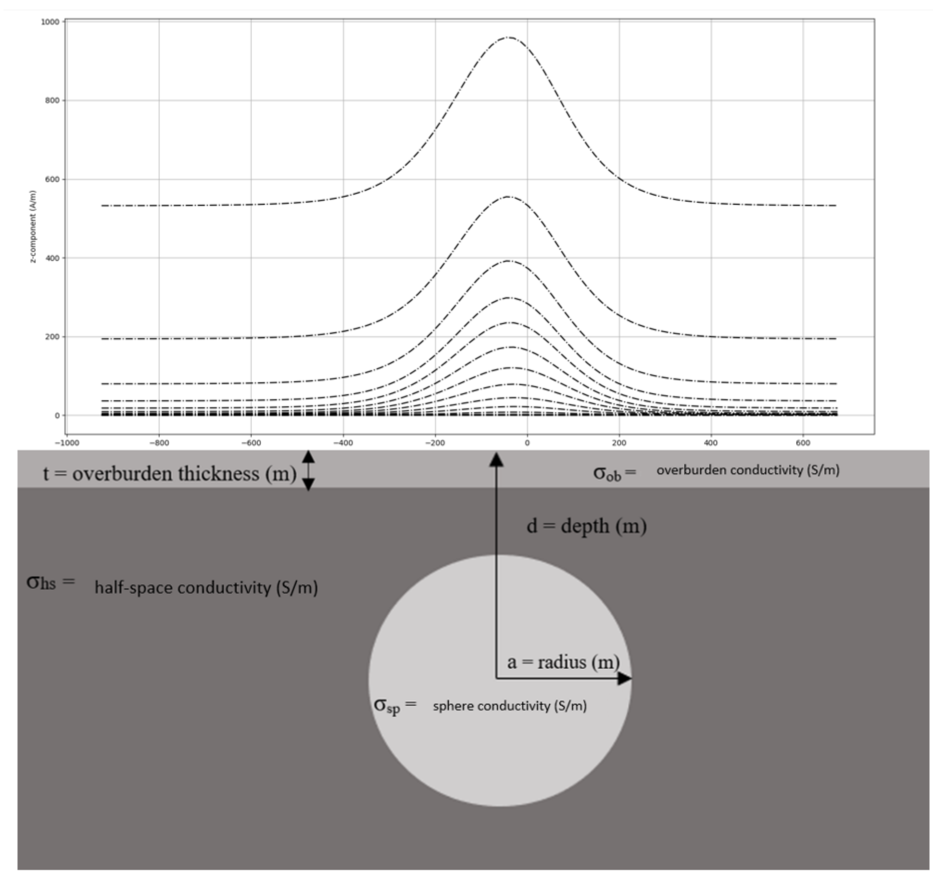
CHAPTER

ONE

GETTING STARTED

1.1 Overview

Sphere-ob (sphere-overburden) is a python program developed to calculate and plot the airborne TDEM response of a sphere or 'dipping sphere' underlying conductive overburden. The response is calculated using the semi-analytic solution set presented in Desmerais & Smith (2016), the solution assumes that the response due to the sphere interacting with conductive overburden may be written as the first order pertubation of the overburden field plus a sum of terms accounting for the inductive interaction between the sphere and overburden. This routine is utilized for its computation efficiency and ability to model a dipping plate in addition to a traditional sphere. To model a thin sheet, the sphere overburden algorithm restricts current flow to parallel planes within an anisotropic sphere. A Simplified synthetic model of a sphere underlying conductive overburden is shown below.



1.2 Installation

1.2.1 Installing Sphere-ob

Installation was tested using the Anaconda Python distribution for Windows (click here to download if needed). A python compatible terminal is also needed (e.g., git-bash, Anaconda Prompt, Windows Powershell, etc.). Ensure that python - and conda, if needed - are on the path for the terminal you are using. Note that the standard Windows command window will not work.

If using Anaconda, you may want to install sphere-ob into a separate Anaconda environment. A new environment can be created using, for example:

```
conda create -n sphereob pip git
```

You can then switch to that environment using:

```
conda activate sphereob
```

Or, if using git-bash:

```
source activate sphereob
```

Note: By default, new terminals start in the 'base' environment, so you will have to enter the above command each time you open a new terminal. Alternatively, you may add the command to your ~/.bashrc file to have it run automatically. See the the Anaconda Environemnent documentation for more details.

Ensure you are in the 'sphere-ob' environment as described above, if using Anaconda. sphere-ob can then be installed with pip and git using:

```
pip install git+https://github.com/adzamper71/SPHEREOB
```

Alternatively, users may wish to manually download the repository (https://github.com/adzamper71/SPHEREOB) using the green 'Code' button, or by cloning the repository using a git-bash terminal. After downloading the code, the package can be installed by navigating to the sphere-ob folder and running (in your git + python compatible terminal):

```
python setup.py install
```

CHAPTER

TWO

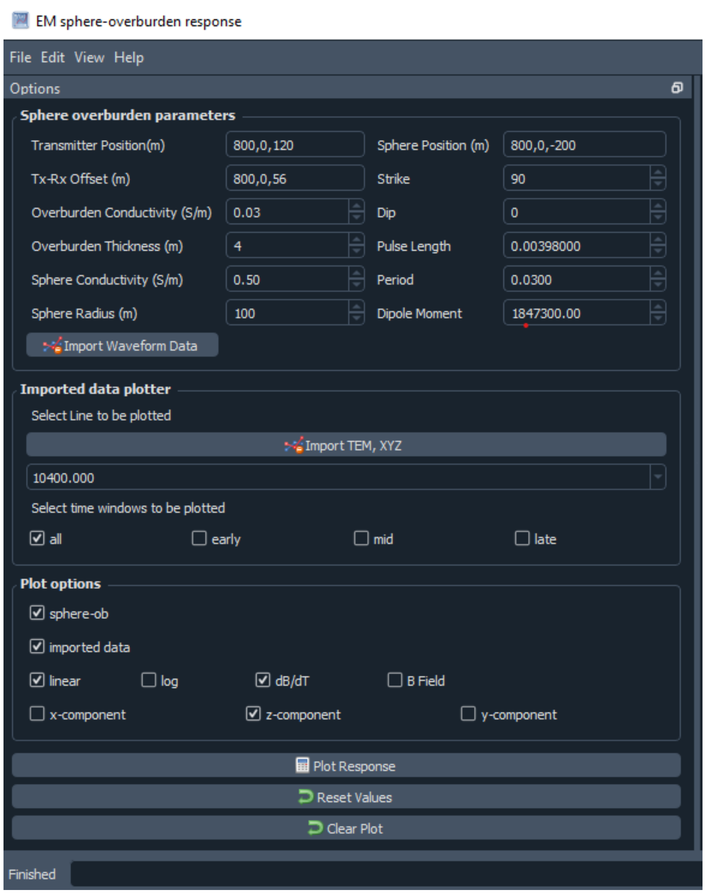
OVERVIEW OF SPHERE-OB GUI

2.1 Launching Sphere-ob

Once installed, the program can be launched from the terminal used during the installation process (also ensure you are in the same conda environment that sphere-ob was installed in) as:

```
sphereob
```

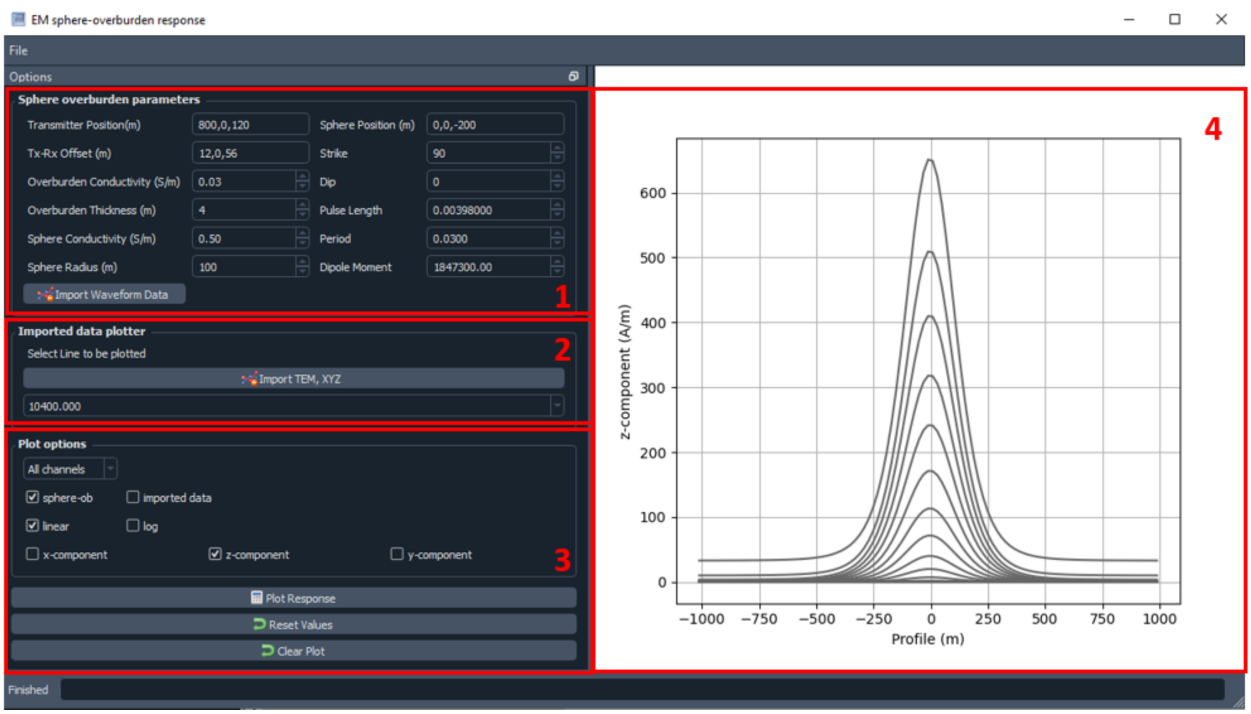
Upon successfully launching sphere-ob you will be met with the following UI:



2.2 Sphere-ob GUI

The sphere-ob program was written in python and the PyQt5 framework was utilized to build the programs GUI. The sphere-ob program has 4 main areas that the user will interact with. Each area of the GUI is detailed below with a description of the use cases and different parameters included in each area:

1. *Sphere overburden parameters*
2. *Imported Data*
3. *Plot Options*
4. *Plot Window*



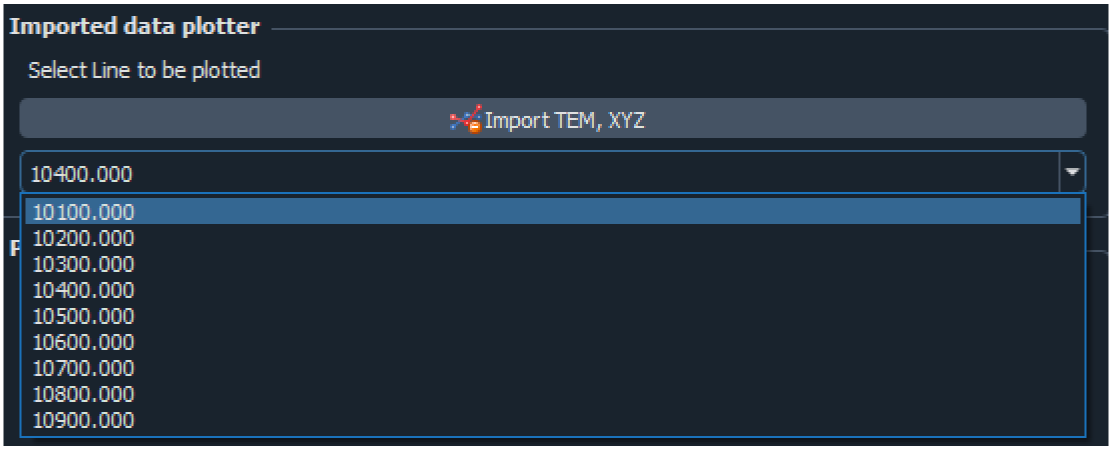
2.2.1 Sphere overburden parameters

This section of the widget is where the user will input all the parameters of the sphere overburden model, a description of the parameter and the expected input format are listed below:

- Transmitter Position
  - The transmitter position in meters, z co-ord is positive for distance above ground. Input is three values for x,y,z seperated by commas (ie. 0,0,60 for a receiver 60m above ground with no offset in x,y).
- Tx-Rx Offset
  - The transmitter offset relative to the receiver, left & down are positive. Input is three values for x,y,z seperated by commas (ie. 12.5,0,25) for a transmitter that is 12.5m behind and 25m below the receiver).
- Overburden Conductivity
  - The conductivity of the overburden in Seimens per meter (S/m).
- Overburden Thickness
  - The thickness of the overburden in meters.
- Sphere Conductivity
  - The conductivity of the sphere in Seimens per meter (S/m).
- Sphere Radius
  - The radius of the sphere in meters.
- Sphere Position
  - x,y,z co-ordinates of the sphere up is considered positive, input is three values for x,y,z seperated by commas (ie. 0,0,-200) for a sphere of 200m depth in the center of the profile with no offset in the y axis).
- Strike & Dip
  - The strike & dip of the sphere in degrees, if this value is non zero the response will be representative of a dipping plate.
- Pulse Length
  - The pulse length of the transmitter waveform in seconds.
- Period
  - Period of the transmitter waveform in seconds
- Dipole Moment
  - The dipole moment of the transmitter (A/m)
- Import Waveform Data
  - This button will open an instance of windows exporer for the user to navigate to the csv file containing transmitter waveform data, an example of the expected csv format is shown below and the file is provided in the example directory.

2.2.2 Imported Data

This section of the widget allows the user to import tdem data such as tem files from maxwell of xyz files. The user may then select the line to be plotted from the dropdown menu underneath the import button.



2.2.3 Plot Options

Here the user will determine what will be plotted in the plot window, there are options in this section of the widget to select the response components to be plotted, the y-axis scale and the data to be plotted(sphere-ob model, imported data or both).

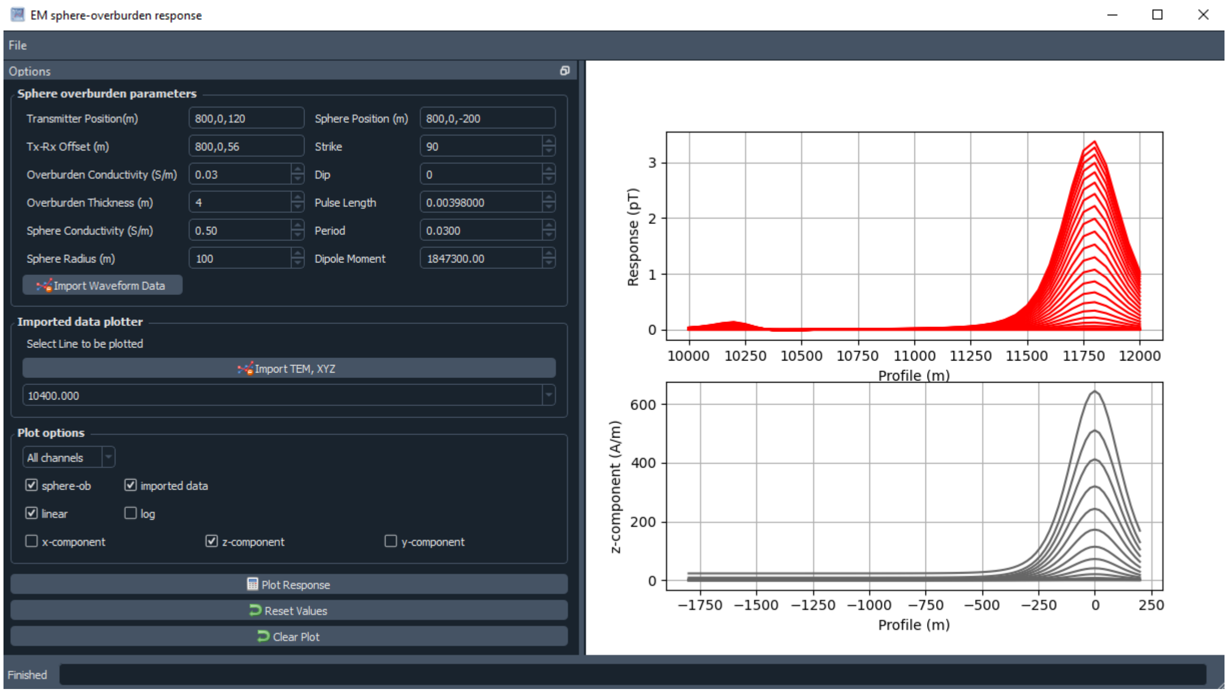
The time channel dropdown box offers users the following options:

- When selected, “all” will plot all channels in the profile
- When selected, “early” will plot the earliest 1/3 of channels in the profile
- When selected, “middle” will plot the middle 1/3 of channels in the profile
- When selected, “late” will plot the latest 1/3 of channels in the profile

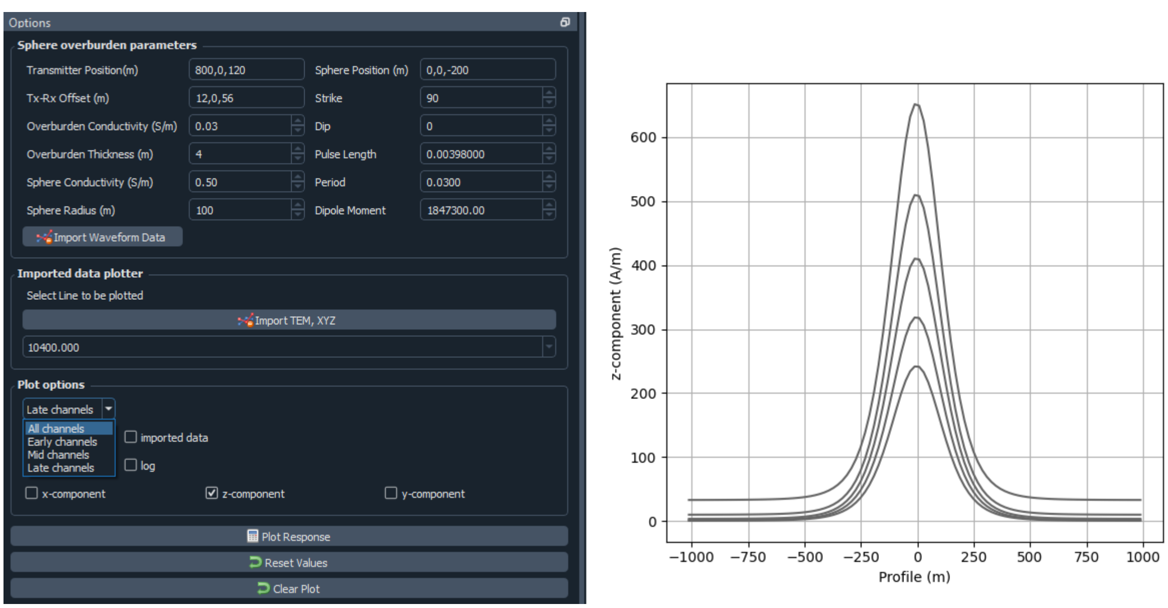
Underlying the time channel dropdown box is a set of checkboxes that allow the users to choose what is displayed in the plot windows

- If checked, the “sphere-ob” checkbox will plot all time windows in the tem / xyz file
- If checked, the “imported data” checkbox will plot the response for the chosen line of imported data
- The x,y and z checkboxes correspond to the components of the response to be plotted (multiple may be selected at once)
- The ‘log’ and ‘linear’ checkboxes allow the user to change the y-axis scale
- The ‘Plot response’ button will generate and plot the response for the given parameters that the user has outlined
- The ‘Reset values’ button when clicked will reset the model parameters to the default values
- The ‘Clear plot’ button will clear any existing plots in the plot window

- This feature can be useful when using the sphere-ob program to model real data. You can read in the real data and plot it side by side with the modelled response when trying to achieve a fit to the data. Below is an example of the sphere-ob program plotting imported tem data (red) alongside the generated sphere-ob response (black).

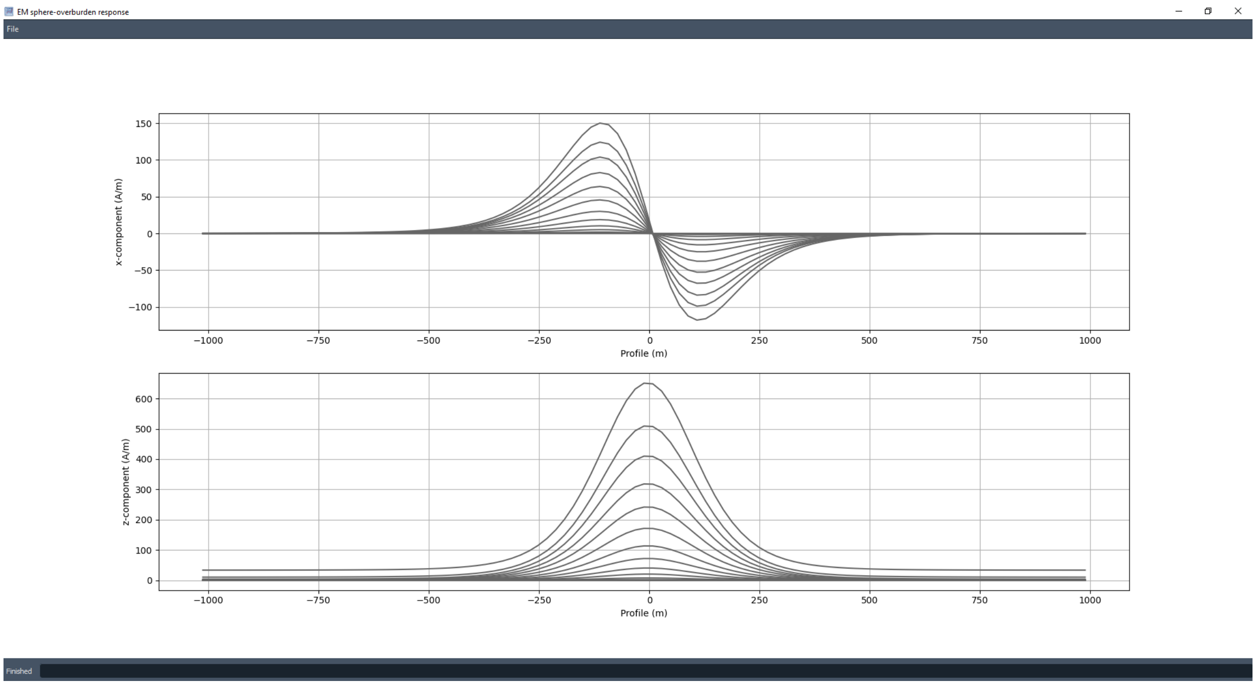


- It can be difficult to interpret data on specific channels if there is a large discrepancy in noise or amplitude between channels, interpretation can be made easier by selecting a specific group of time channels to be plotted. Below is an example of the sphere-ob program plotting user selected time channels.



2.2.4 Plot Window

The plotting window is where all responses will be plotted, the plotting window can be cleared using the 'clear plot' button. It is also possible to 'undock' the parameters widget and maximize the plotting window for increased visibility as seen below.



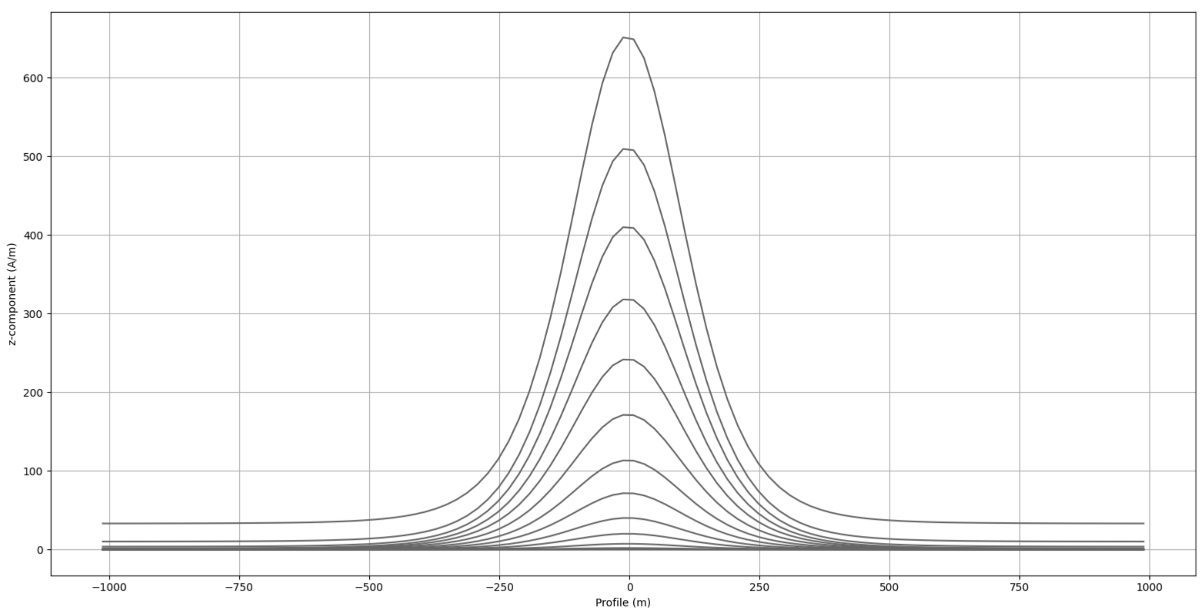
CHAPTER THREE

MODELLING WITH SPHERE-OB

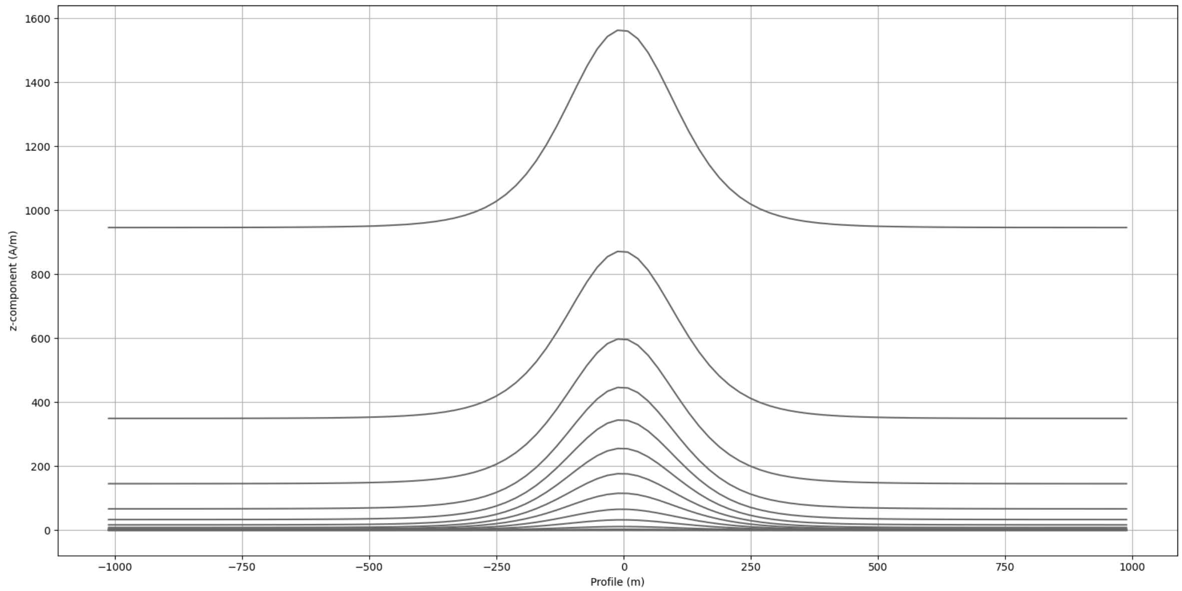
3.1 Examples

Below are some sample EM responses generated with the sphere-ob program. The responses display the programs ability to account for conductive overburden and the ability to model both, sphere and plate responses.

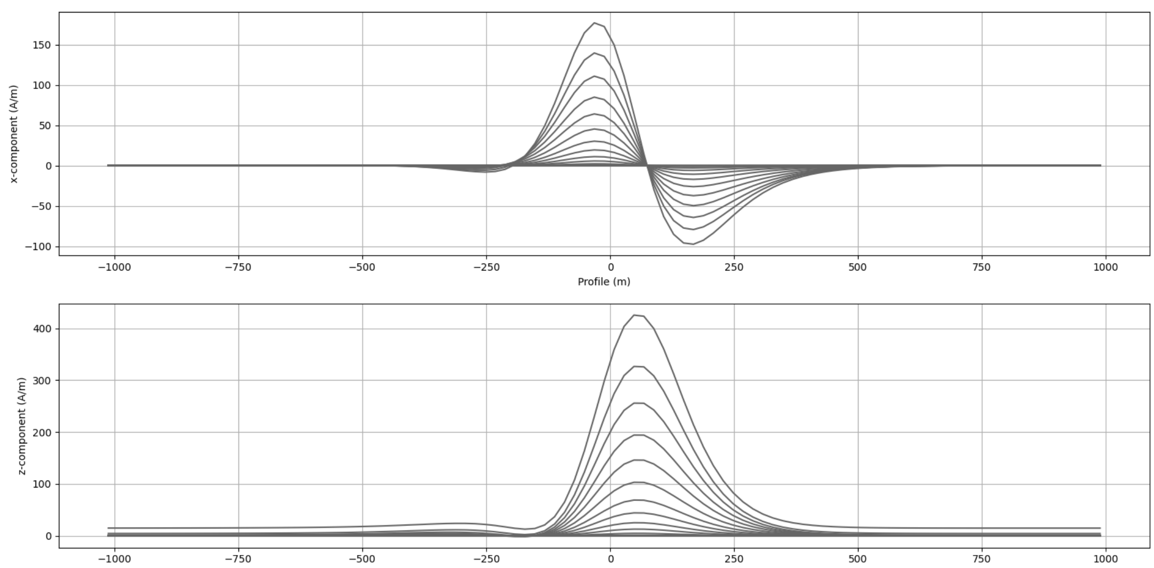
- z component for a sphere 200m below surface with negligible overburden



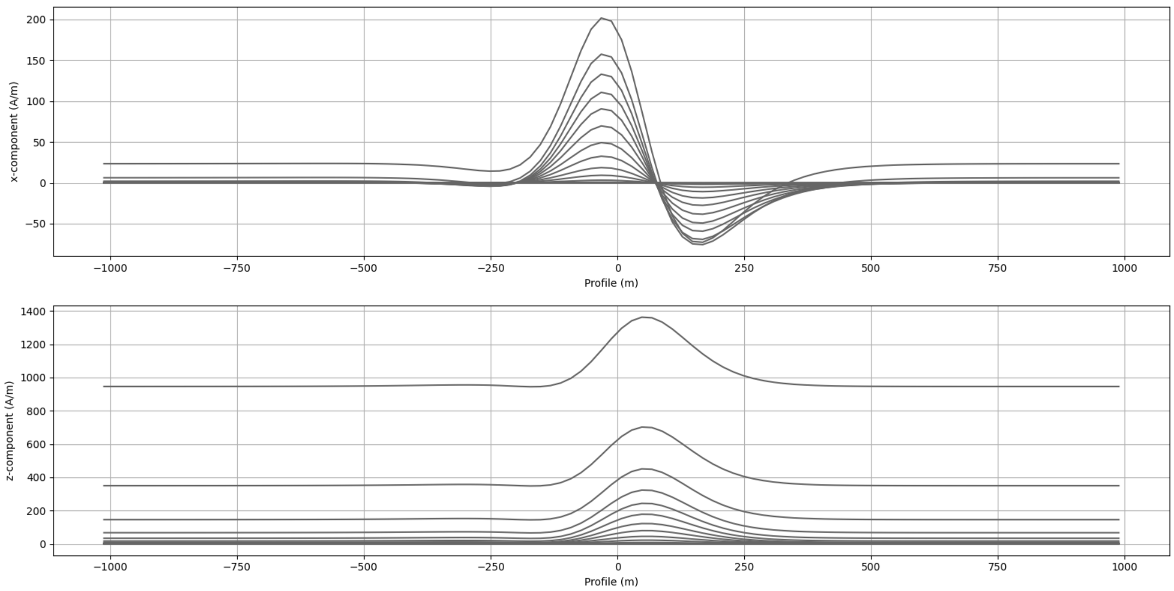
- z component for a sphere 200m below surface under 15m of conductive cover



- x,z component for a plate 200m below surface dipping at 45 degrees with negligible overburden



- x,z component for a plate 200m below surface dipping at 45 degrees under 15m of conductive cover



3.2 Import tem/xyz data

The import data button allows the user to import and plot TDEM responses from a Maxwell file (tem) or an xyz file. Shown below is an example of the expected format of the tem/xyz file and an example of the imported data being plotted against a sphere-overburden model.

- Example of expected format for the import of a tem/xyz file, the data being read from the file includes Easting, Northing, station location, line number and channel data

```
TEM File Created by MAXWELL 7.12.146.52868
LINE:MULTI DATATYPE:TEM CONFIG:FIXEDLOOP ELEV:0.000 UNITS:(uV/A) NORMTXAREA:YES CURRENT:20.000 TXTURNS:1.000 BFREQ:4.000000 DUTYCYCLE:
OFFTIME:62.500 TURNON:0.500 TURNOFF:0.100 TIMINGMARK:62.520 RXAREAZ:10000.000 RXAREAX:10000.000 RXAREAY:10000.000 RXDIPOLE:YES TXDIPOL
LOOP:loop6 &
LV1X:10000.00 LV1Y:11300.00 LV1Z:0.00 &
LV2X:10400.00 LV2Y:11300.00 LV2Z:0.00 &
LV3X:10400.00 LV3Y:10950.00 LV3Z:0.00 &
LV4X:10000.00 LV4Y:10950.00 LV4Z:0.00
/TIMES(ms)=0.1000,0.1241,0.1541,0.1913,0.2375,0.2949,0.3661,0.4545,0.5643,0.7005,0.8697,1.0797,1.3404,1.6641,2.0660,2.5649,3.1842,3.95
/TIMESWIDTH(ms)=0.0250,0.0310,0.0385,0.0478,0.0594,0.0737,0.0915,0.1136,0.1411,0.1751,0.2174,0.2699,0.3351,0.4160,0.5165,0.6412,0.7960
          EAST          NORTH          LEVEL        STATION     COMPONENT          CH1          CH2          CH3
LINE:10100N
/PROFILEX:EAST
      10000.000     10100.000          0.000          0.000             Z    -0.119051    -0.114898    -0.110065
      10000.000     10100.000          0.000          0.000             X     0.718069     0.693502     0.664901
      10000.000     10100.000          0.000          0.000             Y    -0.287133    -0.277459    -0.266193
      10050.000     10100.000          0.000         50.000             Z    -0.235090    -0.226880    -0.217325
      10050.000     10100.000          0.000         50.000             X     0.918268     0.886861     0.850296
      10050.000     10100.000          0.000         50.000             Y    -0.138863    -0.134401    -0.129196
      10100.000     10100.000          0.000        100.000             Z    -0.395614    -0.381810    -0.365744
      10100.000     10100.000          0.000        100.000             X     1.094183     1.056897     1.013482
      10100.000     10100.000          0.000        100.000             Y     0.104094     0.100050     0.095355
      10150.000     10100.000          0.000        150.000             Z    -0.590369    -0.569846    -0.545957
      10150.000     10100.000          0.000        150.000             X     1.191171     1.150911     1.104023
      10150.000     10100.000          0.000        150.000             Y     0.435575     0.420037     0.401967
      10200.000     10100.000          0.000        200.000             Z    -0.790516    -0.763221    -0.731445
      10200.000     10100.000          0.000        200.000             X     1.158594     1.119967     1.074963
      10200.000     10100.000          0.000        200.000             Y     0.812451     0.784083     0.751073
      10250.000     10100.000          0.000        250.000             Z    -0.956117    -0.923410    -0.885325
      10250.000     10100.000          0.000        250.000             X     0.980398     0.948360     0.911015
      10250.000     10100.000          0.000        250.000             Y     1.162182     1.122249     1.075761
      10300.000     10100.000          0.000        300.000             Z    -1.054191    -1.018506    -0.976944
      10300.000     10100.000          0.000        300.000             X     0.689770     0.667887     0.642360
      10300.000     10100.000          0.000        300.000             Y     1.414213     1.366323     1.310552
      10350.000     10100.000          0.000        350.000             Z    -1.073288    -1.037323    -0.995426
      10350.000     10100.000          0.000        350.000             X     0.352056     0.341541     0.329256
      10350.000     10100.000          0.000        350.000             Y     1.531777     1.480557     1.420889
      10400.000     10100.000          0.000        400.000             Z    -1.023766    -0.989751    -0.950118
      10400.000     10100.000          0.000        400.000             X     0.032160     0.032100     0.032002
      10400.000     10100.000          0.000        400.000             Y     1.519768     1.469442     1.410803
      10450.000     10100.000          0.000        450.000             Z    -0.927677    -0.897045    -0.861350
      10450.000     10100.000          0.000        450.000             X    -0.227583    -0.219347    -0.209770
```

3.3 Importing transmitter waveform data

- Importing transmitter waveform data and time windows is useful when modelling the response of specific types of TDEM systems. An example of the expected CSV formatting for the import of transmitter data, left column consists of window centers in seconds, right column is transmitter pulse data.

1	Windows	Pulse
2	0.00017	3.529755
3	0.000194	3.53051
4	0.000229	3.52982
5	0.000268	3.522055
6	0.000312	3.438914
7	0.000365	3.438615
8	0.000434	3.180218
9	0.000517	3.620623
10	0.000609	8.111896
11	0.000722	13.25749
12	0.000863	23.243578
13	0.001034	34.688308
14	0.001239	46.160297
15	0.001488	57.717269
16	0.001786	69.170396
17	0.002147	80.81755
18	0.002582	92.317359
19	0.003104	103.892144
20	0.003739	115.375932
21	0.004506	126.893182
22	0.005429	138.374916
23	0.00654	149.873152
24	0.00789	161.322748
25	0.00951	172.773439
26	0.01147	184.188102
27	0.01427	195.605994
28		206.999266
29		218.376225
30		229.728083
31		241.062202
32		252.373354
33		263.668651
34		274.939412
35		286.187665
36		297.410538
37		308.612662
38		319.788914

CHAPTER

FOUR

OTHER INFO

4.1 References

Desmarais, J. K., and Smith, R. S.,2016, Approximate semianalytical solutions for the electromagnetic response of a dipping-sphere interacting with conductive overburden: Geophysics, 81(4). DOI: 10.1190/geo2015-0597.1

4.2 Help

For feature requests, bug fixes, design suggestions, an issue or pull request can be made through the github page.

4.3 License