SphereOverburden

Release 0.1

Anon

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CONTENTS

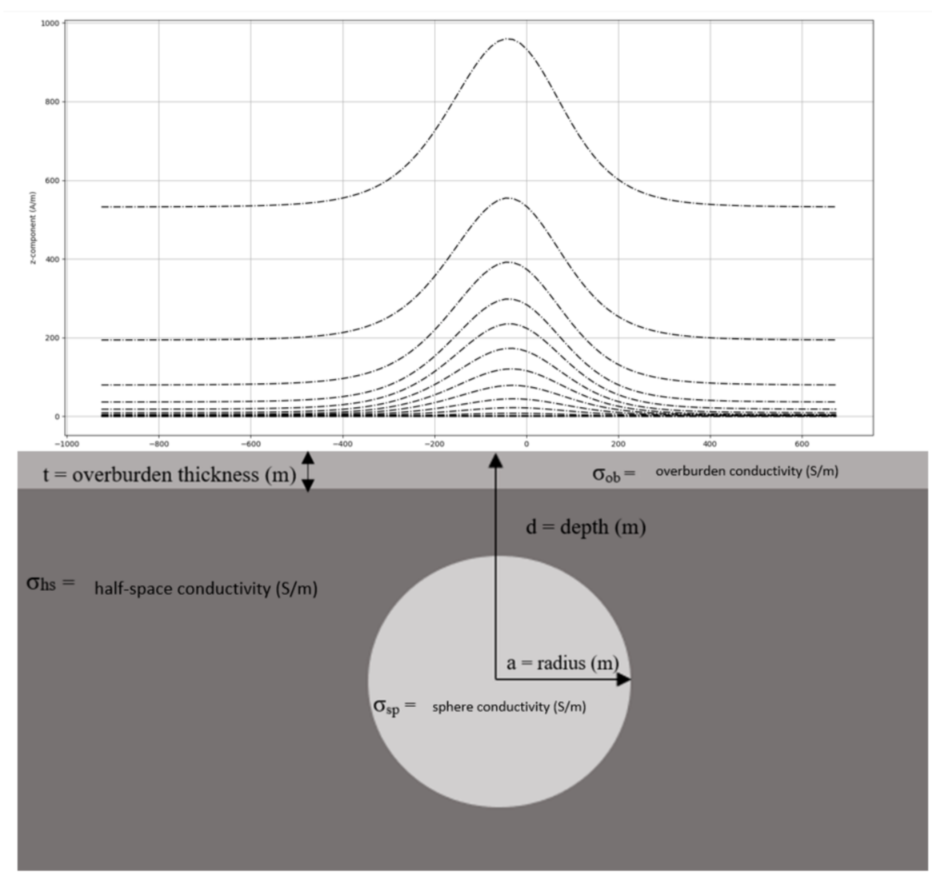
CHAPTER

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 or thin sheet 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

If you have python added to path and are familiar with pip, Sphere-ob may be installed with pip + git by opening a comand prompt as administrator and using:

```
pip install git+https://github.com/anonseg2023/sphereob
```

Alternatively, the repository can be manually downloaded and installed using the install script, i.e., by navigating to the ShereOverburdenProject folder, opening a python / anaconda prompt in administrator and running:

```
python setup.py install
```

Once these steps have been completed the program can be launched from the command line using:

```
sphereob
```

For anaconda users or users who do not have python added to path, you may want to install sphere-ob into a separate Anaconda environment, this can be done easily by running the install_or_update.bat.

You can then switch to the newly installed 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.

Once the environment has been activated the user may then navigate to the project directory in an anaconda prompt then launch the program using:

```
python sphereob.py
```

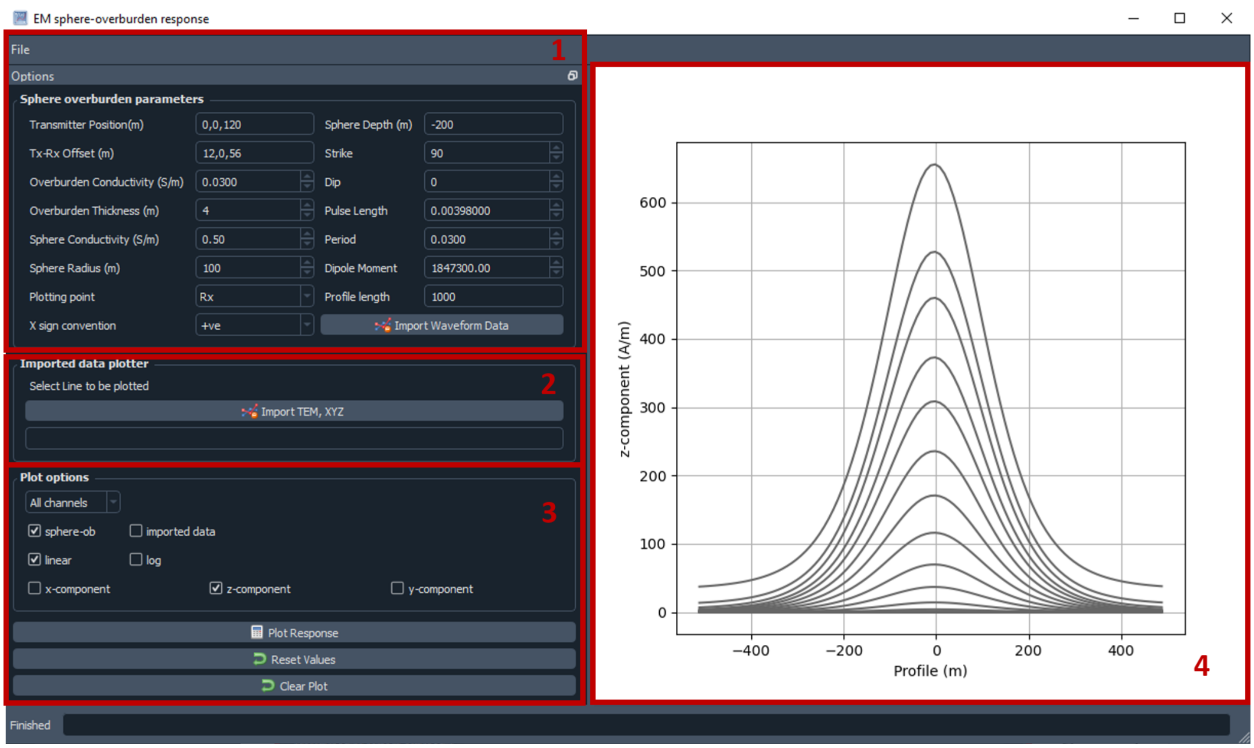
CHAPTER

TWO

GUI OVERVIEW

2.1 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*

2.1.1 Sphere overburden parameters

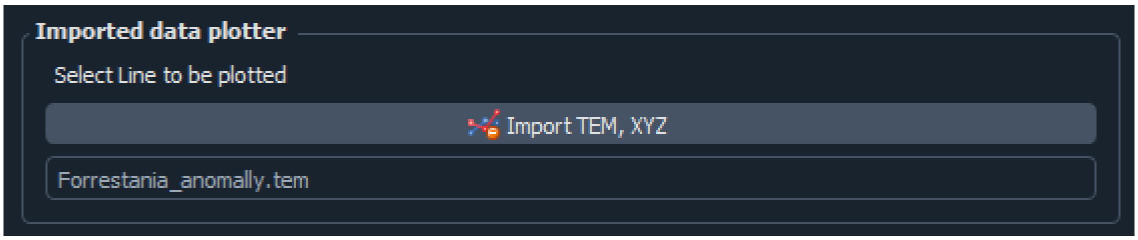
This section of the widget is where the user will input all the parameters of the sphere overburden model, a description of the parameter and the expected input format are listed below:

- 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.
- Plotting point
  - User can choose where the plotting point of the response coincides (at the transmitter, at the receiver or the midpoint).
- X sign convention
  - The sign convention of the x component may be flipped using this parameter if the flight lines are opposite the data.
- Sphere Depth
  - The depth of the sphere below ground surface in meters, up is considered positive.
- 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. The strike and dip positive counter clockwise.
- Pulse Length
  - The pulse length of the transmitter waveform in seconds.
- Period
  - The period of the transmitter waveform in seconds.
- Dipole Moment
  - The dipole moment of the transmitter (A/m)
- Profile Length
  - 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.

2.1.2 Imported Data

This section of the widget allows the user to import tdem for a given line in the form of a .tem file.



2.1.3 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).

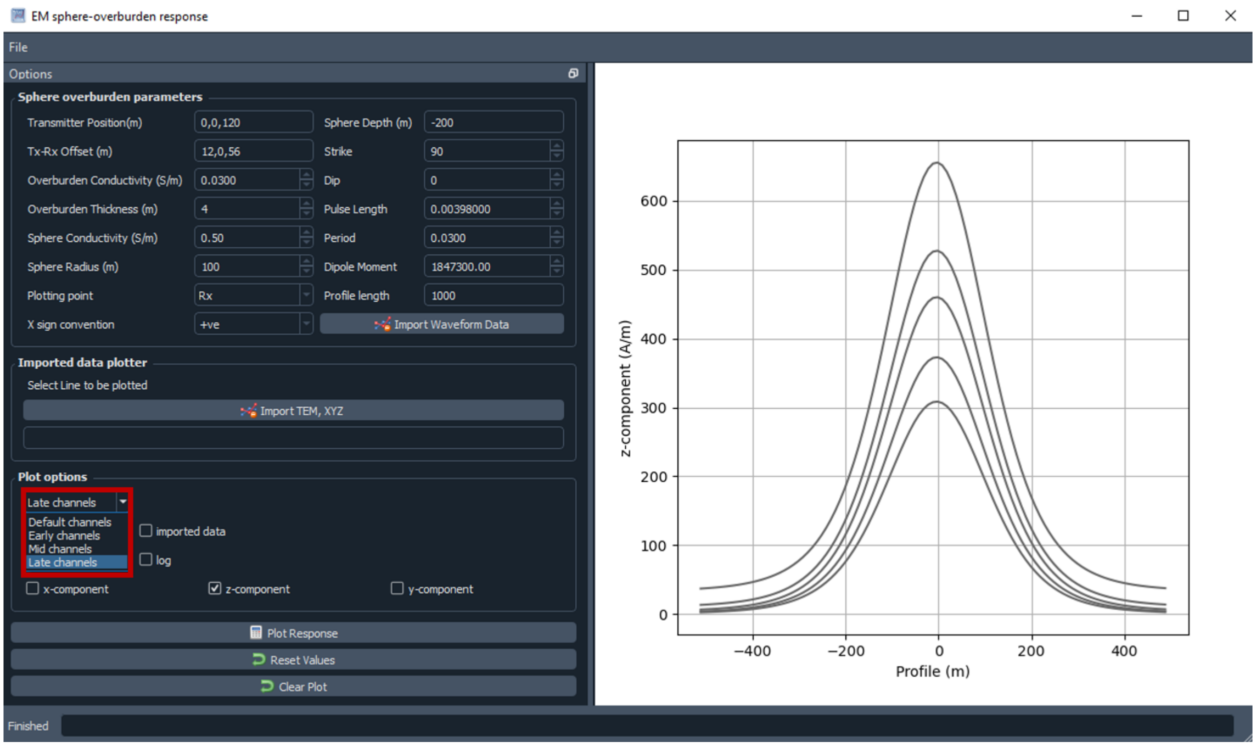
The time channel dropdown box offers users the following options:

- When selected, "defualt" will plot all channels of the response.
- When selected, "early" will plot the earliest 1/3 of channels in the response.
- When selected, "middle" will plot the middle 1/3 of channels in the response.
- When selected, "late" will plot the latest 1/3 of channels in the response.

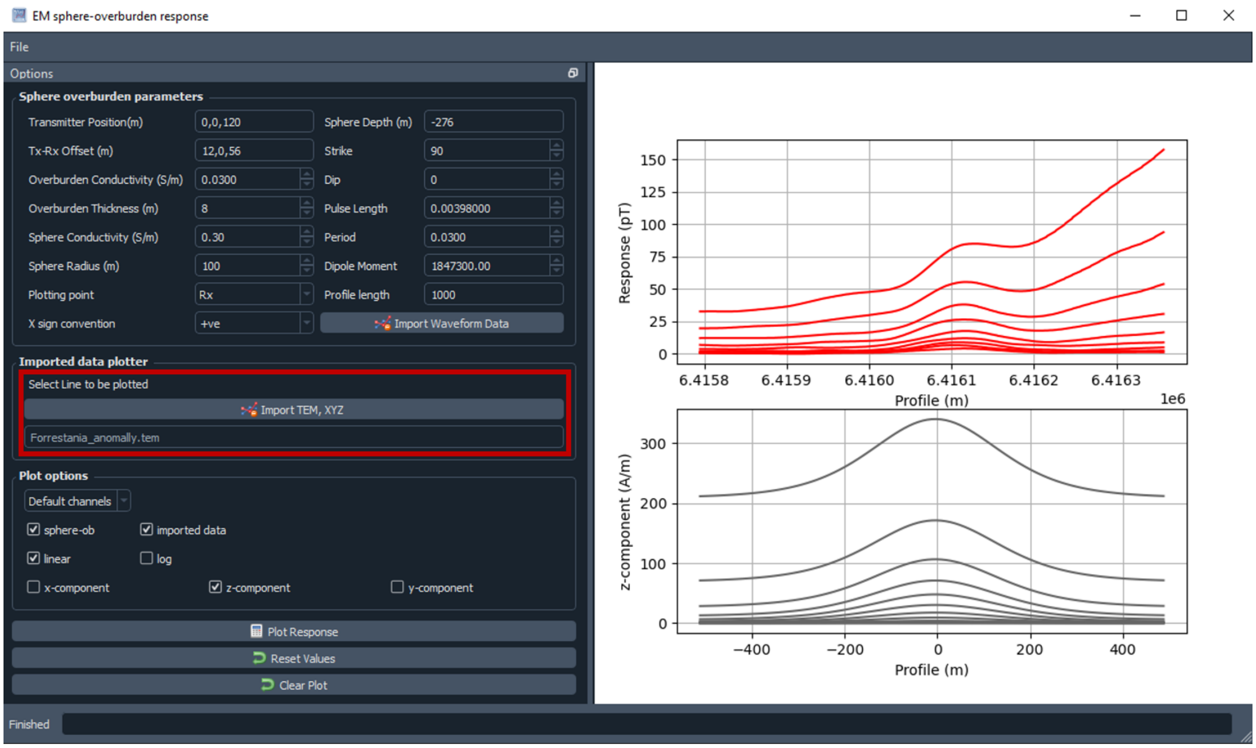
Underlying the time channel dropdown box is a set of checkboxes that allow the users to choose what is displayed in the plot windows

- If checked, the "sphere-ob" checkbox will plot all time windows in the tem 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.
- 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.

- 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.

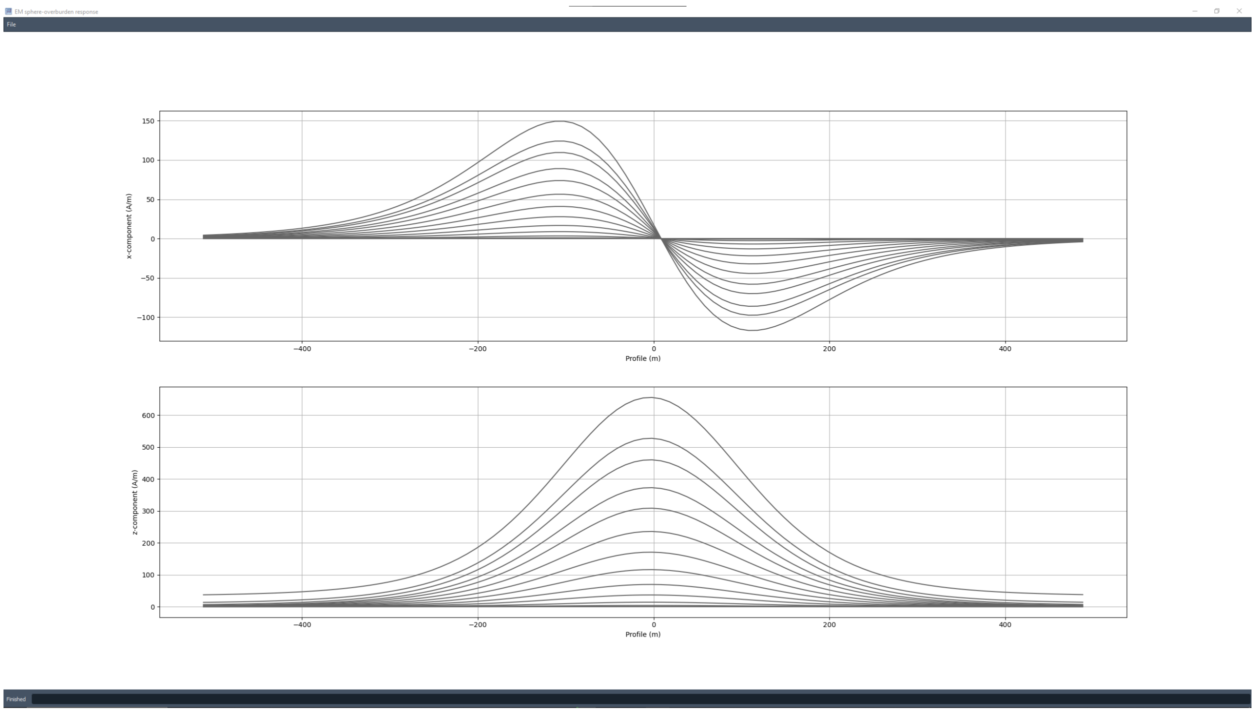


- This feature can be useful when using the sphere-ob program to model real data. You can read in the real data and plot it side by side with the modelled response when trying to achieve a fit to the data. Below is an example of the sphere-ob program plotting imported tem data (red) alongside the generated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



2.1.4 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

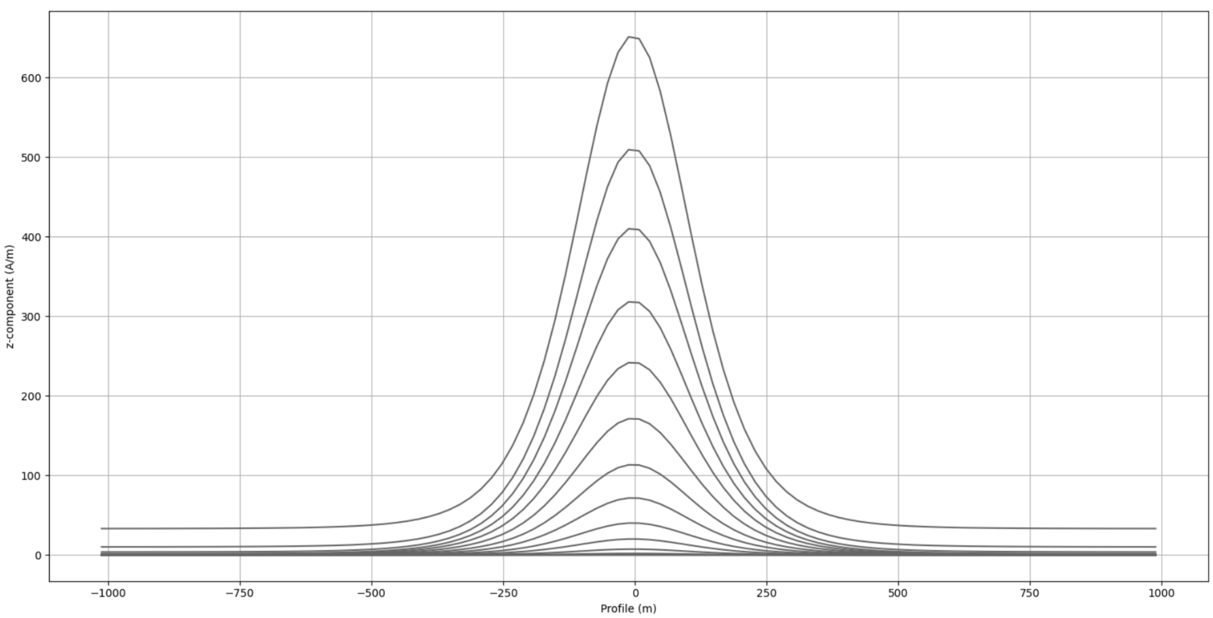
THREE

MODELLING WITH SPHERE-OB

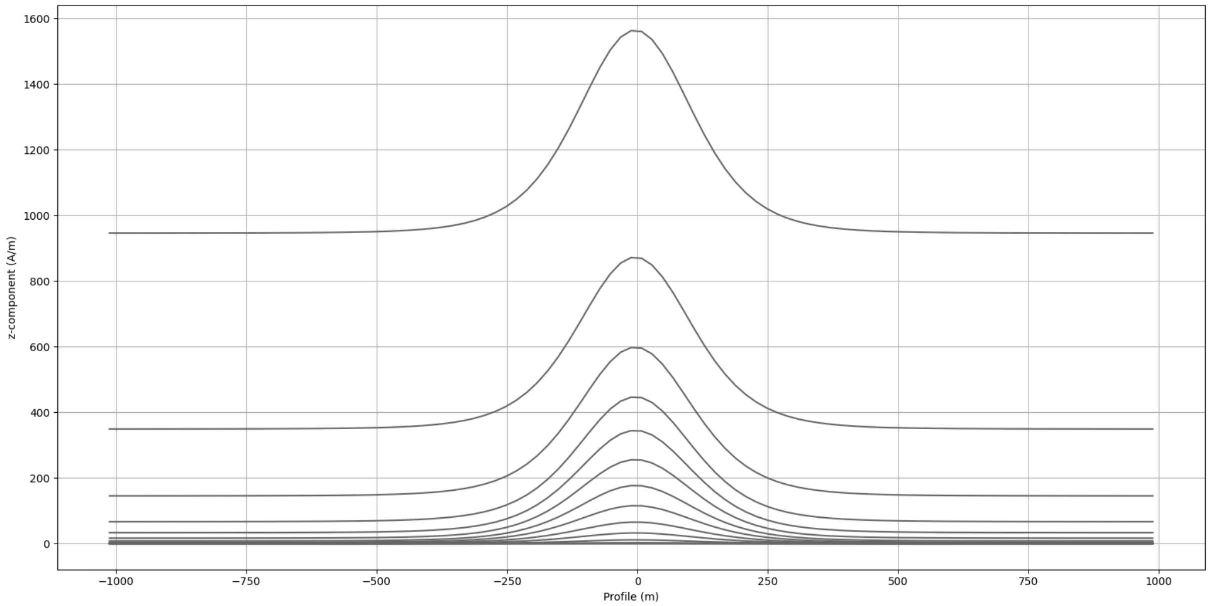
3.1 Examples

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.

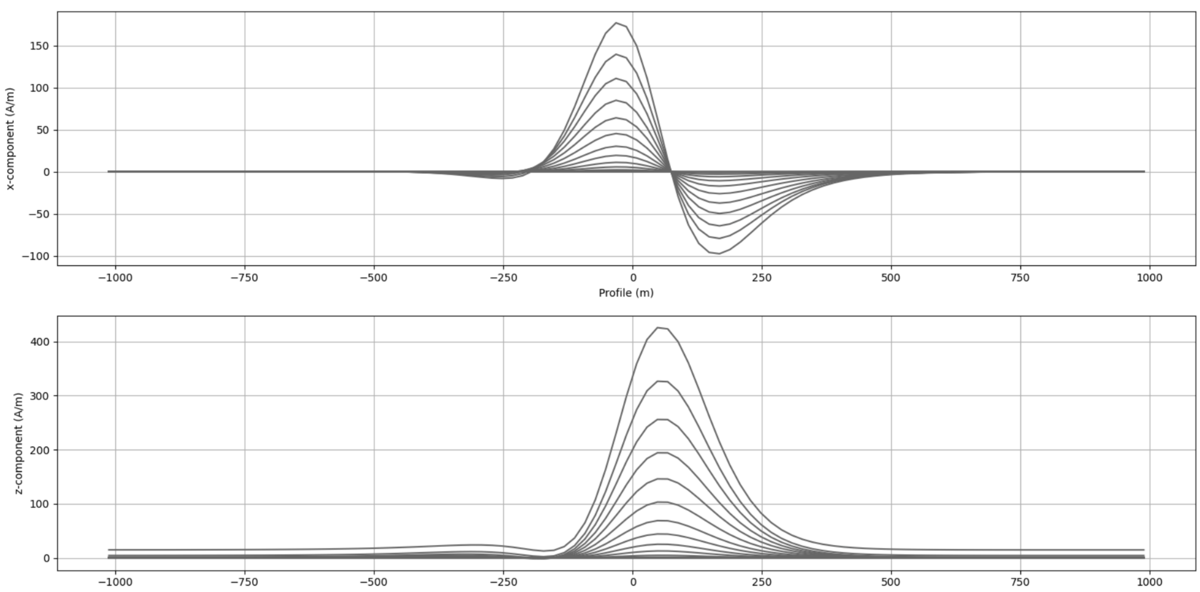
- z component for a sphere 200m below surface with negligible overburden



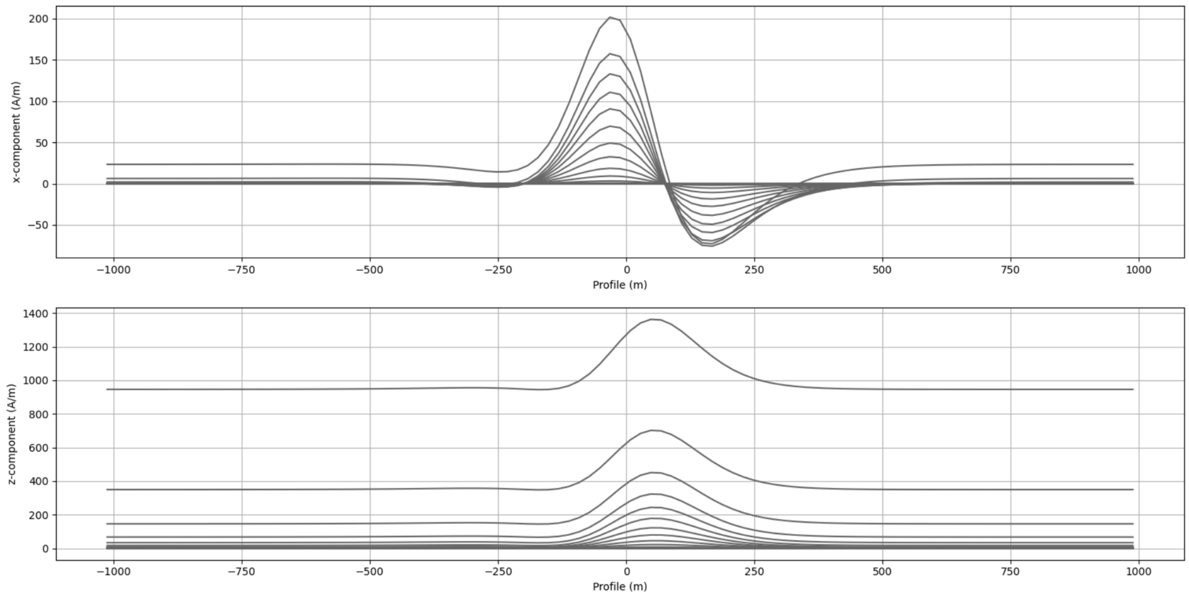
- z component for a sphere 200m below surface under 15m of conductive cover



- 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). Shown below is an example of the expected format of the tem file and an example of the imported data being plotted against a sphere-overburden model.

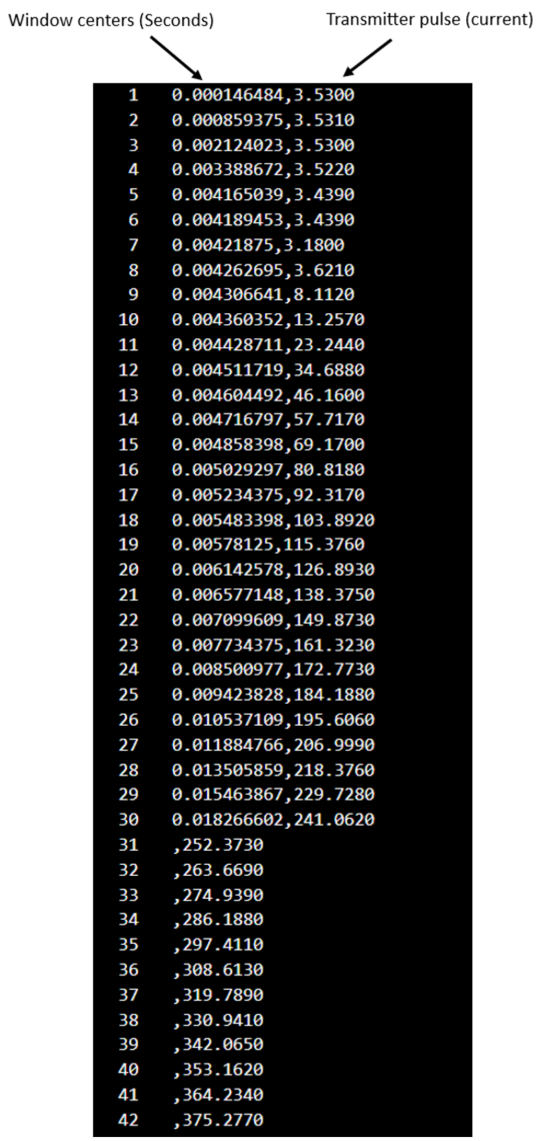
- Example of expected format for the import of a tem file, the data being read from the file includes Easting,

Northing, station location, line number and channel data. Note that the tem file must only contain one component and only that component should be selected in the UI when plotting.

```
TEM File Created by MAXWELL 7.12.146.52868
LINE:10075field DATATYPE:TEM CONFIG:AIRBORNE UNITS:(nT/s) CURRENT:1.000 TXHT:0.000 TXTURNS:1.000 TXAREA:10000.000 BFREQ:1.000000 DUTYCYCLE:50.000 ONTIME:250.000
OFFTIME:250.000 TURNON:0.000 TURNOFF:0.140 TIMINGMARK:250.000 RXAREAZ:10000.000 ABTYPE:TOWEDBIRD RXDIPOLE:YES TXDIPOLE:YES
/TIMES(ms)=0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
/TIMESWIDTH(ms)=0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
        EAST          NORTH          LEVEL          ELEV       STATION      COMPONENT         CH1          CH2          CH3          CH4
/PROFILEX:STATION
    7484000.000   6415795.600      0.000          0.000     6415795.600         Z        32.600000    19.600000    12.000000     6.800000
    7484000.000   6415797.600      0.000          0.000     6415797.600         Z        32.600000    19.600000    12.100000     6.700000
    7484000.000   6415799.700      0.000          0.000     6415799.700         Z        32.600000    19.600000    12.100000     6.700000
    7484000.000   6415801.700      0.000          0.000     6415801.700         Z        32.600000    19.600000    12.100000     6.700000
    7484000.000   6415803.700      0.000          0.000     6415803.700         Z        32.700000    19.600000    12.100000     6.600000
    7484000.000   6415805.800      0.000          0.000     6415805.800         Z        32.700000    19.600000    12.100000     6.600000
    7484000.000   6415807.800      0.000          0.000     6415807.800         Z        32.700000    19.700000    12.100000     6.500000
    7484000.000   6415809.900      0.000          0.000     6415809.900         Z        32.700000    19.700000    12.100000     6.500000
    7484000.000   6415811.900      0.000          0.000     6415811.900         Z        32.700000    19.700000    12.100000     6.400000
    7484000.000   6415814.000      0.000          0.000     6415814.000         Z        32.700000    19.700000    12.100000     6.400000
    7484000.000   6415816.000      0.000          0.000     6415816.000         Z        32.600000    19.700000    12.100000     6.400000
    7484000.000   6415818.000      0.000          0.000     6415818.000         Z        32.600000    19.800000    12.100000     6.300000
    7484000.000   6415820.100      0.000          0.000     6415820.100         Z        32.600000    19.800000    12.100000     6.300000
    7484000.000   6415822.100      0.000          0.000     6415822.100         Z        32.600000    19.800000    12.100000     6.200000
    7484000.000   6415824.100      0.000          0.000     6415824.100         Z        32.600000    19.900000    12.100000     6.200000
    7484000.000   6415826.200      0.000          0.000     6415826.200         Z        32.600000    19.900000    12.100000     6.200000
    7484000.000   6415828.200      0.000          0.000     6415828.200         Z        32.600000    20.000000    12.100000     6.200000
    7484000.000   6415830.200      0.000          0.000     6415830.200         Z        32.600000    20.100000    12.100000     6.200000
    7484000.000   6415832.200      0.000          0.000     6415832.200         Z        32.600000    20.100000    12.100000     6.200000
    7484000.000   6415834.200      0.000          0.000     6415834.200         Z        32.600000    20.200000    12.100000     6.200000
    7484000.000   6415836.200      0.000          0.000     6415836.200         Z        32.700000    20.300000    12.100000     6.200000
    7484000.000   6415838.200      0.000          0.000     6415838.200         Z        32.700000    20.300000    12.100000     6.200000
    7484000.000   6415840.200      0.000          0.000     6415840.200         Z        32.700000    20.400000    12.100000     6.200000
```

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.




```
0.000146484,3.5300
0.000859375,3.5310
0.002124023,3.5300
0.003388672,3.5220
0.004165039,3.4390
0.004189453,3.4390
0.00421875,3.1800
0.004262695,3.6210
0.004306641,8.1120
0.004360352,13.2570
0.004428711,23.2440
0.004511719,34.6880
0.004604492,46.1600
0.004716797,57.7170
0.004858398,69.1700
0.005029297,80.8180
0.005234375,92.3170
0.005483398,103.8920
0.00578125,115.3760
0.006142578,126.8930
0.006577148,138.3750
0.007099609,149.8730
0.007734375,161.3230
0.008500977,172.7730
0.009423828,184.1880
0.010537109,195.6060
0.011884766,206.9990
0.013505859,218.3760
0.015463867,229.7280
0.018266602,241.0620
,252.3730
,263.6690
,274.9390
,286.1880
,297.4110
,308.6130
,319.7890
,330.9410
,342.0650
,353.1620
,364.2340
,375.2770
```

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 License