AEMPY: A Python Toolbox for Frequency- and Time-Domain Electromagnetic Data from the TELLUS Surveys

Duygu Kiyan[1]*, Volker Rath[1], and Robert Delhaye[1]

[1]Dublin Institute for Advanced Studies, Geophysics Section, 5 Merrion Square, Dublin 2.

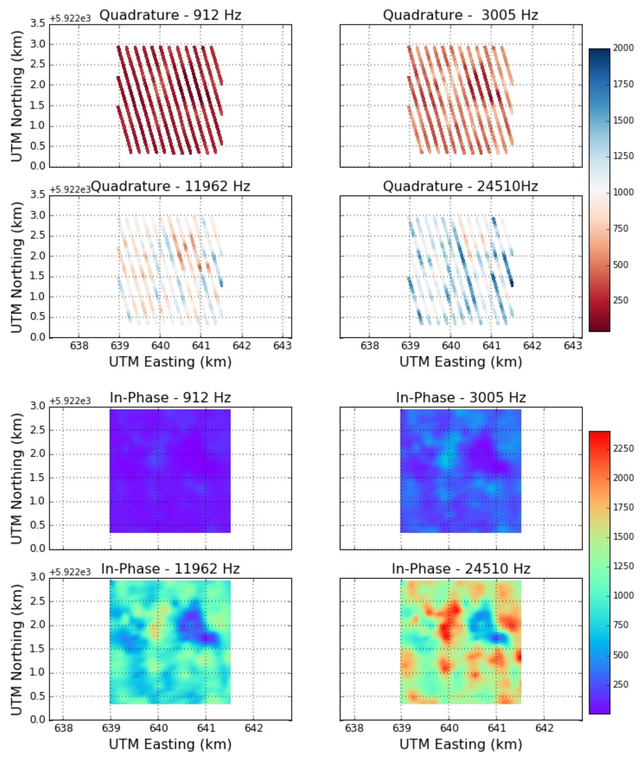
*duygu@cp.dias.ie

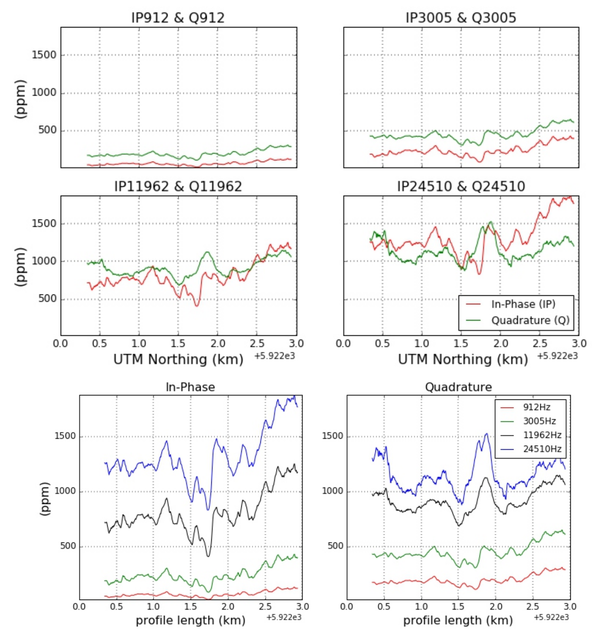
ABSTRACT

The frequency- and time-domain Airborne ElectroMagnetic (AEM) data collected under the Tellus surveys of the Geological Survey of Ireland (GSI) represent a wealth of information on the multi-dimensional electrical structure of Ireland's near-surface. Our project, which was funded by the Short Call Research Programme of the GSI (sc2015-004), aims to develop and implement inverse techniques based on various Bayesian methods for the densely sampled Tellus data.

We have developed a highly flexible toolbox using Python language for the one-dimensional inversion of AEM data along the flight lines. The computational core is based on an adapted frequency- and time-domain forward modelling core derived from the well-tested open-source code AirBeo, which was developed by the CSIRO (Australia) and the AMIRA consortium. Three different methods have been implemented: (i) Tikhonov-type inversion including optimal regularisation methods (Aster et al., 2012; Zhdanov, 2015), (ii) Bayesian MAP inversion in parameter and data space (e.g. Tarantola, 2015), and (iii) Full Bayesian inversion with Markov Chain Monte Carlo (e.g. Sambridge and Mosegaard, 2002), all including different forms of spatial constraints. The methods have been tested on synthetic and field data. This contribution will introduce the toolbox and present case studies on the AEM data from the Tellus surveys.

DATA VISUALISATION





IMPLEMENTATION

Python Modules and Scripts
Numpy, Scipy, Matplotlib

DIAS GIT Repository
Free Access (Coming Soon!)

AEMPY

Input File
Tellus
FDEM & TDEM Data

Conversion to Internal Data Format

FDEM Format
XUTM, YUTM, GPS, RADAR, IP912-24510Hz, Q912-24510Hz, PWLM

TDEM Format
XUTM, YUYM, GPS, RADAR, X1-X11, Z1-Z11

Define Dataset:
flightline, polygon, profile projection

Pre-processing

- Flag negative values & high fly areas
- Interpolate
- Average/Block data over a number of stations

Bayesian Inversion along Flightline

Deterministic Approach
Tikhonov-type inversion
MAP inversion
Truncated SVD inversion

Stochastic Approach
Markov Chain Monte Carlo

DATA INVERSION

THE METROPOLIS-HASTINGS ALGORITHM

Synthetic Data - Frequency-Domain Results

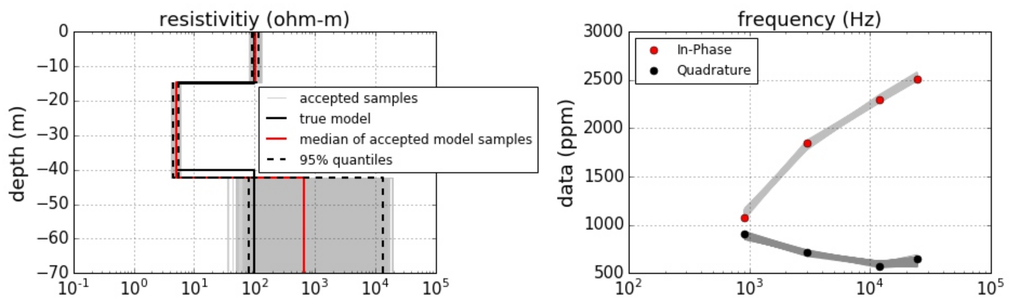
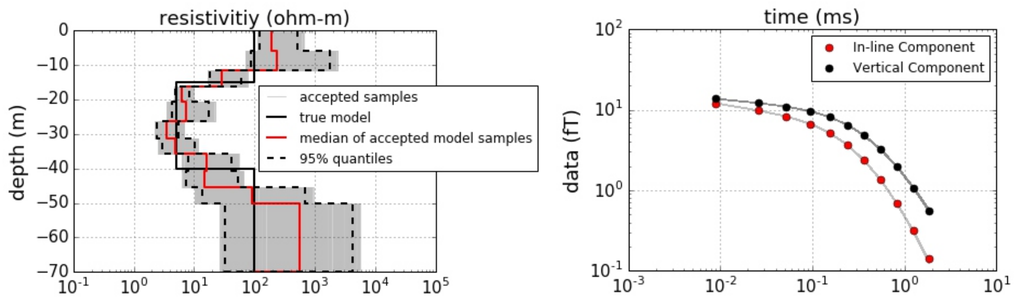
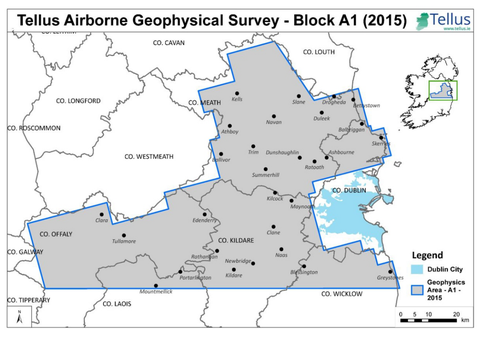


Figure *shows a summary of the output from the Metropolis-Hastings (MH) simulation. The MH algorithm was run for 100,000 model samples and 1,000,000 model samples for frequency- and time-domain, respectively.* ***The left panel*** *shows every 50th and 500th of accepted sample models (light grey lines) for frequency- and time-domain, respectively. Superimposed are the true model (black line), bounds that contain 95 per cent of the accepted models (black dashed lines), and the median resistivity values (red line).* ***The right panel*** *illustrates the data fit in which the predicted data are represented with light and dark grey lines, and the observed data are represented with the solid circles.*

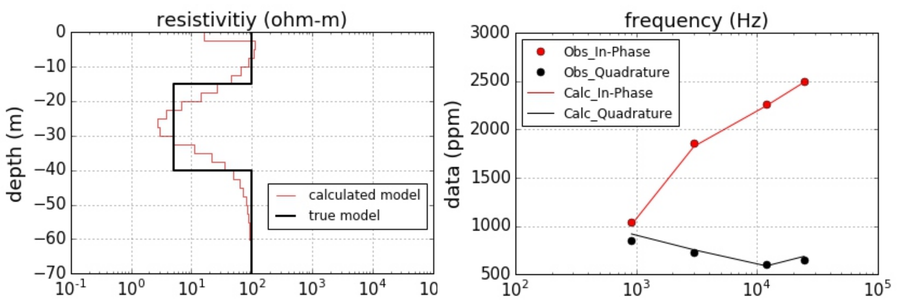
Time-Domain Results



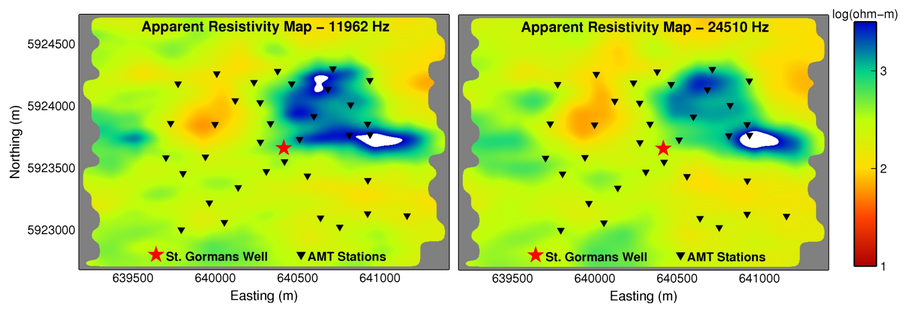


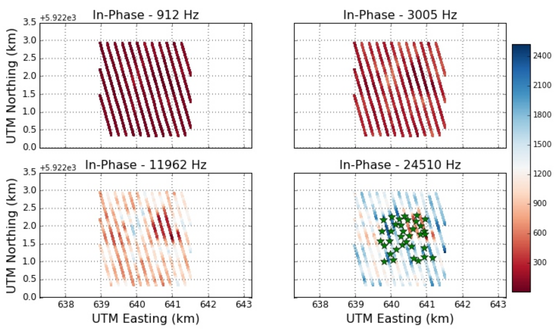
DETERMINISTIC MAP INVERSION

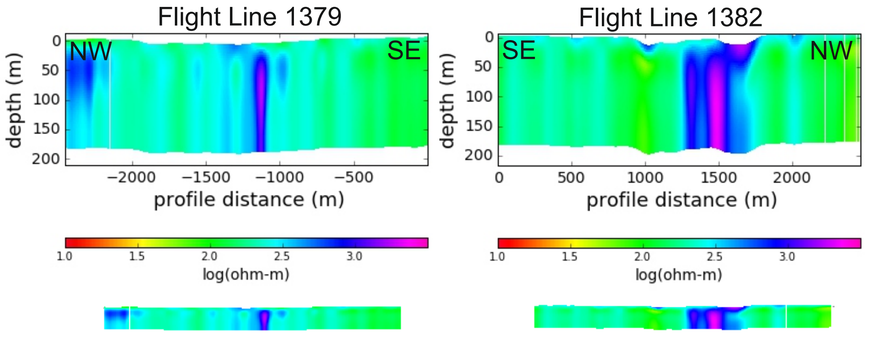
Synthetic Data - Frequency-Domain Results



TELLUS BLOCK A1 DATA







CONCLUSIONS

Framework for the state of the art forward modelling for both frequency- and time- domain.

Inverse models of different types have been implemented as stochastic (e.g. MH sampling) or deterministic (Tikhonov, MAP, and TSVD).

Algorithms were tested with synthetic and field data from Tellus Block A1.

Visualisation tools for the evaluation of the results are available in the toolbox. Basic mapping capabilities have also been implemented in the toolbox.

ACKNOWLEDGEMENTS

DK was funded by the Geological Survey of Ireland (GSI) under the grant sc2015-004. We would like to thank the GSI Tellus team, who were mosth helpful and co-operative, and thus contributed considerably to this work. Australia's CSIRO and the AMIRA International consortium is thanked for making their P223 modelling suite open access. Special thanks to the contributors of https://stackoverflow.com/.