24th Electromagnetic Induction Workshop

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Abstracts Session 8

SESSIONS DESCRIPTION

Session 8. EM Induction Education and Outreach (Poster session)

In addition to the advancement and application of electromagnetic induction science, members of IAGA Division VI play critical roles in education and outreach. In terms of education, this work may involve teaching undergraduate or graduate students, supervision of undergraduate or graduate research, or training new scientists how to use electromagnetic equipment. In terms of outreach, it may involve promoting large-scale electromagnetic projects to senior officials or other scientists, writing statements on the socioeconomic importance of electromagnetic induction studies, or providing entertaining visits to high school students. This session, the second of its kind at our electromagnetic workshops, is intended to collect posters highlighting novel, interesting, and/or important experiences from the teaching and outreach of electromagnetic induction. The sharing of ideas and information in these areas will help contribute to the overall public understanding of electromagnetic induction studies.

Convener: Nikolay Palshin

Aleksandrovka Geophysical Field Camp: a place for probing new EM technologies

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SUMMARY

The Aleksandrovka geophysical field camp is located in a picturesque area 250 km to the south-west of Moscow on the territory of the National Park "Ugra". For a long time the field camp has been used for testing new equipment and developing new EM technologies. Since 1990-es Aleksandrovka has been an inter-university educational and research geophysical center (field camp), where students from several Russian universities and Strasburg University are trained geophysical prospecting methods. Also Aleksandrovka is used for testing and calibrating EM instrumentation used by Nord-West Ltd.

During the summer (Bachelor level) and the autumn (Magister level) geophysical field courses the students have a unique opportunity to get acquainted with the modern instruments and methods of field surveys using gravimetry, magnetometry, electric prospecting and shallow seismic exploration methods.

The main specialty of Aleksandrovka field courses is electric prospecting methods, which includes georadar, classic DC-IP and SP methods, electric resistivity tomography, TDEM and magnetotellurics (modern instrumentation is provided by Nord-West Ltd).

During the winter student's holidays, specialized winter field practices are traditionally held. On them, students of different levels can learn more about geophysical methods. At this time, field experiments are conducted: new methods and equipment are tested, various ideas are tested and new electromagnetic technologies are worked out.

Keywords: Geophysical Field Camp, EM methods courses

Creating a Virtual Research Environment for online discovery, access and processing of magnetotelluric (MT) data in data-intensive environments

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SUMMARY

Geophysical research is currently undergoing a substantial computational transformation. Traditionally, data providers made geophysical data accessible as files from individual surveys that could be downloaded for local processing. Increasingly, online availability of data and associated High Performance Computing (HPC) resources is enabling a move to server-side discovery, data subsetting and processing. As a result, it is now possible to analyse much larger data volumes over wider areas and from multiple geophysical surveys.

Ready access to HPC and cloud resources has meant that geophysicists can access massive compute power to solve increasingly more complex problems. However, much of the existing geophysical software has been written with single servers in mind, and tightly coupled with specific geophysical data formats (e.g., EDI). For more efficient use in modern computational environments, MT data needs to be standardised, programmatically discoverable and accessible as high-performance data services. Using open scientific self-describing data formats (e.g., Hierarchical Data Format (HDF), Network Common Data Form (netCDF)) opens up the potential for use of a much wider range of sophisticated software for analysis, including software that has been developed in other scientific fields. Furthermore, these open data formats allow for cross-disciplinary analysis to take place rather than being constrained by disciplinary specific data formats.

To encourage community participation in developing new data formats and online processing tools, we present initial findings from the 2017-2018 AuScope-ANDS-NeCTAR-RDS funded Geoscience Data Enhanced Virtual Laboratory (DeVL) project, whose objectives are to enable both discovery of and access to The University of Adelaide MT datasets as services, expose a variety of processing tools in online virtual environments, and enable processing on the National Computational Infrastructure (NCI) Raijin Supercomputer. Initial results have already shown a significant reduction in the time taken to discover, access and process MT data in online Cloud/HPC environments.

Keywords: Geoscience DeVL, HPC, netCDF, Raijin Supercomputer, Virtual Research Environments

CrowdMag: An Opportunity for Science and Outreach

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SUMMARY

The NOAA/CIRES CrowdMag app allows citizen scientists to collect magnetic field data using the 3-component magnetometers built in to all modern smartphones. The primary goal of the app is to provide crowd-sourced regional measurements of the Earth's magnetic field in support of global field models. For example, the NOAA/CIRES geomagnetism team produces the World Magnetic Model (WMM), the official military spec model (degree and order 12) used by the US Government. The WMM is also embedded in virtually every smartphone and is used to make declination corrections for digital compass orientation. There are currently 24K+ enthusiastic CrowdMag users worldwide who have so far contributed >30 million magnetic measurements to the NOAA archives. We have successfully constructed a global magnetic field model (accurate to degree and order 4) based only on CrowdMag data.

The CrowdMag app also has great potential as a teaching and learning tool. The app allows users to collect magnetic data values "in the field" – for example, on walking or bicycling traverses. The user can analyze their own data to learn about signal-to-noise evaluation and about variations in the magnetic field caused by both natural and man-made objects. Users can also use the app as a tool for introducing others to the unseen magnetic world around us.

Keywords: citizen science, phone application, outreach, geomagnetism, education

Imaging of near-surface structures and their properties using reflected electromagnetic waves

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SUMMARY

The method we have used is based on electromagnetic waves reflected from target regions. The main aim is to get high-resolution images (maps) of the targeted LBP-features. LBPs are regions of low-relief basement plateaus, i.e. usually shield areas where long erosion processes have resulted in flat surface and where only mountain roots are preserved. In LBPs, we can therefore image the properties of deep roots of orogens as well as deep roots of human beings. In several cases, we have excluded peripheral regions in order to avoid distortion of the main features. We have used, so called, subjective elimination / subjective discrimination process.

In data processing and analysis, 2-D image processing methods have extensively been used to further enhance the resolution of LBP images. We have also repeated the study several times over the years. This has accumulated into extensive time series imaging the evolution of LPB features. We have applied robust processing methods such as principal component analysis on the data set.

LBPs have been detected in various environments and in various temperature regimes. The presentation will further illuminate the results.

Keywords: EM waves, reflections, LBP-features, near-surface, image processing

Making geo-electromagnetic (magnetotelluric) data accessible via EPOS portal

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In the recent years a number of efforts have been made to archive and make various electromagnetic (EM) data accessible via open web services. A good example is the IRIS portal, where USA magnetotelluric (MT) data became available for the scientific community. This project was complemented by a proposal aimed at development of a new data format for MT transfer functions and time series. In particular, XML container was used to describe all relevant metadata and to store transfer functions. However, this data format did not become a standard among MT community.
European funded project took the lead to establish a similar database, archiving facilities and services within the EU. It is foreseen that the service will not be limited to store only European but world-wide metadata. The European Plate Observing System (EPOS) is a European Research Infrastructure through which science communities will make data and services available in a way that simplifies cross-disciplinary research. Geo-electromagnetic data are currently held in a variety of formats, software and locations, which creates a barrier to access. Data provided through EPOS will conform to common standards and be available from a single portal, opening up cross-disciplinary research possibilities for academics and the public. Geo-electromagnetic data that will be available through EPOS includes but not limited to: observatory data from INTERMAGNET; dense magnetometer network observations IMAGE; maps of the crustal magnetic field (MagNetE); geomagnetic activity data from ESGI; magnetotelluric data and conductivity models.
The least developed service among those is magnetotelluric data and models. There are a number of issues on the way to implement the service among which establishing infrastructure to store data and developing commonly acceptable data exchange format. Until now there has been no central server for data storage, therefore this service will rely on data providers facilities. Number of preliminary agreements are obtained (GFZ, Swedish National Data Centre) to test and use their facilities for data storage and access via EPOS portal.
Extensive discussion on GFZ hosted GitLab and Google group lead to a new proposal to store MT transfer functions and time series using JSON data format. JSON is similar to XML, because it is "self describing" (human readable), hierarchical (values within values), can super easily be parsed and fused by lots of programming languages. However, there are also a number of differences like: JSON doesn't use end tag, is shorter and is significantly quicker to read and write. Another advantage that JSON has over XML is that its representation of objects and arrays allows for direct mapping onto the corresponding data structures in the host language, such as objects, records, structs, dictionaries, hash tables, keyed lists, and associative arrays for objects, and arrays, vectors, lists, and sequences for arrays. As a result a complete data structure is created containing, for example, transfer functions as arrays and corresponding metadata, which requires no extra efforts to decode.Among other advantagesfor MT practitioners might be similarities to EDI standard keyword,values structure. For example, JSON file can be parsed in MATLAB using following expression:
`data = jsondecode(fileread(fname)).`
Finally, another topic, related to licensing and referencing of the data, is currently extensively discussed within the EPOS. The current consensus is to use the Creative Commons license CC:BY or CC:BY:NC for the published through EPOS data. Referencing will be done by assigning DOI to each data set. More information can be found on EPOS web site: https://www.epos-ip.org

Keywords: EPOS, magnetotelluric data, database, data format

ModEMM: Object Oriented MATLAB Codes for student projects in 3D EM Modeling

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SUMMARY

We have developed a flexible set of object oriented Matlab® codes for 3D EM forward modeling, using a staggered grid finite difference/finite volume approach. The code has been used extensively for development and testing of improved forward modeling for the ModEM 3D inversion, and hence has been called "ModEMM". More broadly, because the code is in Matlab®, it is easily accessible to students, and has been by now used in a number of education/research projects. Basic modules for 1D, 2D, and 3D modeling are included as a stable core, with the capability to build extensions for more specialized cases, based on this core. Examples of projects (mostly by students) pursued so far include MT forward modeling for general anisotropy (1D,2D,3D), EM modeling in spherical coordinates (regional and full globe) with applications to motional induction by ocean tides, and forward modeling with multi-resolution grids based on a quad-tree approach. The system makes it quite easy to explore different solution approaches (e.g., multigrid; regularization of the system equations to remove singularity of the curl-curl operator), different boundary conditions, different sources (controlled source, tides), etc. We provide an overview of the object oriented structure of the system, and give example applications to diverse problems, MT, CSEM, and local and regional modeling of EM fields due to ocean tides. Ongoing extension to sensitivity calculations and inversion will be briefly discussed as space permits. We plan to release ModEMM as an open-source code in the near future.

Keywords: Numerical Modelling, Software, Induction

The Frank Arnott Award: Data visualisation and integration

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SUMMARY

Background

The Frank Arnott Award (www.frankarnottaward.com) was a global geophysical challenge to develop new visualization techniques to large and complex data sets from multiple sources. The prize was an industry-focused initiative, looking for paradigm shifts rather than incremental change. Thus, emphasis was on novel and exciting ideas, using innovative technologies rather than being necessarily a finished and polished output. Data were provided from five geological surveys and an industry body in Canada, Australia and Finland. The project was open to 'experienced' geoscientists and to 'apprentices', with prizes for the top two in each category and presentation at the Exploration 17 conference in Toronto in October 2017. The brief was open ended: ***teams could use the data in any way they liked.***

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The University of Adelaide team

In 2016, I invited a group of students to participate. Ten students from all year levels, diverse ages, and different academic backgrounds and life experiences formed a team. The students broke up the FAA data sets up into smaller tasks, based on their strengths and backgrounds. Scientific outputs of the project were twofold:

1. Firstly, a novel approach to data visualization using a continuous wavelet transform was developed. Students developed their own approach to produce animations of the outputs;
2. Secondly, the team came up with an exciting new approach to 3D print topographic maps and then project on to the surface other data sets. The approach required research in developing data formats for printing, experimenting with the right types of plastics, engineering of the visualization platform and executing a working model.

Why the FAA is a great project for students

As a group, we have reflected on why the Frank Arnott Award worked so well, and how these learnings can be transferred to future teaching. <u>The key conclusion is that many of the core skills developed in this project are not routinely part of undergraduate courses, but which are in high demand from employers</u>.

1. Rather than content-based geoscience skills, the team had to learn transformative scientific skills outside their normal experience. These include programming in Matlab and Python, application of mathematics for real world problems and complex problem solving.
2. In terms of real-world project management skills, the team had to come to terms with problems that have no clear-cut outcomes. They developed an excellent dynamic to split problems between themselves, working to their strengths.
3. The team learnt to appreciate the value of creativity in the process, with no penalty for failure. No formal assessment was a great benefit and mirrors real-world problem solving. In conventional teaching, students will trade creativity and risk for certainty to achieve the best possible mask, but when decoupled from an assessment framework there was much more scope to try out ideas.
4. Communications skills were key to the team dynamic. These included the communications outputs of the final submission to Frank Arnott Award judging panel, which involved clearly explaining the rationale, narrative and outcomes to a wide audience. Moreover, communication was required daily through Asana and Facebook Messenger to keep conversations and progress current.
5. The sense of the unknown and excitement of discovery was a major incentive. That the unknown was shared between the team and me as mentor meant that the students felt they were central and important to the process. A sense of fun and adventure was key.
6. Finally, students saw this was a genuine industry problem. They networked with a wide range of professionals, and saw the context of their project. It gave them a profound sense of opportunity for the future that they would not have had elsewhere.

Keywords: Data visualization, 3D data projection, continuous wavelet transform, fractal dimension

The National Exploration Undercover School (NExUS)

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SUMMARY

The National Exploration Undercover School (NExUS; www.nexus.org.au) is a new initiative to provide world-class training in mineral exploration. The three week summer school is funded by the Minerals Council of Australia (MCA) and run by the University of Adelaide. Students from the full range of Australian Universities, along with early career staff in industry and government geological surveys applied for entry. Numbers are limited to 30 placements so attendance at NExUS is considered competitive and prestigious.

The NExUS program addresses primary science at the interface between university research providers, government agencies, and industry end-users. The aim of the partnership is to train the next generation of students to change industry practice in mineral exploration, so as to increase mineral discovery rates beneath cover, particularly world-class deposits that provide long-term employment and prosperity.

The program is a mixture of classroom, laboratory and drill core activities in the first week, hosted at the new South Australia Drill Core Reference Library. The second week was based in the Adelaide Hills and focused on practical mineral exploration (field geochemistry, geophysics including many EM methods) in partnership with Hillgrove Resources at the Kanmantoo Copper Mine and nearby exploration targets. The final week was based on the Yorke Peninsula with Rex Minerals at the Hillside deposit and other field locations with a focus on ore textures and biogeochemistry.

Figure 1: Partipants from the NExUS 2017 program

Keywords: Mineral exploration, cover, training

The Polish contribution to EMTDAMO – Magnetotelluric data and models within the EPOS project

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SUMMARY

The Institute of Geophysics, Polish Academy of Sciences, takes part in the EPOS (European Plate Observing System) project. Currently it gets funds from grant EPOS-PL (No.POIR.04.02.00-14-A003/16). The aim of this project is creating an infrastructure for access to as well as exchange and integration of European geophysical data and metadata. The efforts and achievements in providing our archival magnetotelluric (MT) data in an appropriate shape for this database are presented on the poster.
Our data set comprehends about 250 long-period MT measurements from the last 20 years. Most sites were situated in Poland, but a number of them also in NE Germany, S Sweden, and the SW Baltic Sea including Danish Bornholm Island. Some single stations stem from the Ukraine and the Czech Republic. Sounding techniques include both MT and geomagnetic depth sounding. The measurements were performed by the IG PAS Warsaw, the Free University of Berlin and the GEOMAR Helmholtz Centre for Ocean Research Kiel. Metadata comprehend (but are not limited to) precise information on site location, measurement time and sampling, measured channels/EM-field components, instrumentation including system responses, underlying projects, and the institutions behind the data.
Currently, we have an xml time series format for internal purposes with an emphasis on compatibility with geomagnetic observatory data. Discussions with the international European community have led to an agreement on a json format for exchange of both time series and transfer function data. An appropriate time series conversion is under way. Providing json transfer functions is planned to be finished by the end of 2018. Providing conductivity models (and a decision about the appropriate exchange format) remains a task for the years to follow.

Keywords: EPOS, magnetotelluric data, data base, data exchange formats

The SAGE field program: Learning EM by doing EM

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SUMMARY

The Summer of Applied Geophysical Experience (SAGE) program was founded in 1983 to provide an applied geophysics research and education experience for college-level students in the geosciences and related fields. Since its inception, nearly 1,000 students have completed the program, with the vast majority going on to pursue professional careers in geophysics. The four-week intensive summer program is based in Santa Fe, New Mexico, and immerses students in learning geophysical theory and applications, collecting geophysical field data, data processing, modeling and interpretation, and presentation (oral and written) of research results. SAGE is distinct from other educational programs in its competitive student selection, bringing together a diverse mix of students with different academic backgrounds from numerous universities and countries. It exposes students to industry-standard instrumentation and modern software. SAGE emphasizes teamwork, mentoring and interaction between undergraduates, graduate students and faculty, and networking opportunities with enthusiastic industry professionals who also provide important financial support.

SAGE provides a significant and unique role in introducing United States (U.S.) and international students to electromagnetic (EM) geophysics. EM methods, including magnetotellurics, time-domain electromagnetics, loop-loop systems and ground-penetrating radar, are featured prominently at SAGE. This provides an unparalleled learning experience in EM techniques at a range of scales and for a wide variety of applications. Recent SAGE field studies include archaeological mapping, shallow groundwater hydrology, geothermal resource investigations, mapping volcanic cover, and constraining continental rift structures.

Many former SAGE students go on to pursue graduate studies leading to academic, government or industry careers emphasizing EM methods. SAGE also serves as an important pipeline into the NSF-funded EarthScope program; over the 10-year life of the program more than 15 former SAGE students have been involved in the collection of EarthScope magnetotelluric data. Most importantly, SAGE, together with its academic, industry, and government supporters fosters a network of EM researchers within the U.S. and abroad.

Keywords: SAGE, education, electromagnetics, field geophysics