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Research Interests

I am interested in the intersection of geoscience questions, data science techniques, and computing. Questions that cross disciplinary lines and include multiple data-types (e.g. geophysical, geologic, hydrologic and petrophysical) are of particular interest to me. As a mechanism to facilitate collaboration between researchers in different disciplines, I contribute to open-source scientific software and open educational resources. My background is in geophysical simulations and inversions.

Current Projects

- Exploring the principled application of machine learning to problems constrained by physical models.
- Interactive, high-performance computing for geophysical simulations and inversions with the Jupyter and Pangeo projects.
- Numerical methods for simulations and parameter estimation in geophysics.
- Electromagnetic geophysical methods in settings with large contrasts in electrical and magnetic physical properties.
- Joint inversions of geophysical data and incorporating geologic information in inversions with petrophysical constraints.

Education

2012 – 2018 **PhD** in Geophysics, University of British Columbia
Thesis: *Electromagnetic imaging for subsurface injections*
Advisor: Douglas Oldenburg
Themes: inverse problems, numerical simulations, electromagnetics

2008 – 2012 **BSc** with First Class Honors in Geophysics, University of Alberta

Appointments

Nov. 2018 – present **Postdoctoral Researcher**, Department of Statistics, University of California, Berkeley
Advisor: Fernando Pérez
Themes: Machine learning in the physical sciences, interactive computing, statistical techniques for geoscience, open and reproducible research, data science education

Professional Experience

2016 – 2017 **Aranz Geo Canada Limited** (Calgary, AB)
Computational Geophysics Consultant (part-time)

2015 – 2016 **3point Science Inc** (Calgary, AB)
Computational Geophysicist (part-time)

2014 Jun. – Aug. **Schlumberger Doll Research** (Boston, MA)
Geophysics Intern

2013 Jun. – Aug. **Schlumberger Electromagnetic Imaging** (Richmond, CA)
Geophysics Intern

2012 **ConocoPhillips Canada** (Calgary, AB)
May – Aug. Geophysics Summer Student

2011 **Alfred Wegener Institute of Polar and Marine Research** (Bremerhaven, Germany)
May – Aug. Geophysics Summer Student

Leadership in Open Science

Project co-creator: SimPEG

SimPEG is an open-source software project for simulation and parameter estimation in geophysics (simpeg.xyz) that I co-founded with Rowan Cockett and Seogi Kang. I continue to serve in a leadership role with the development, maintenance, and community support of the project. I review suggested changes to the code, advise on new developments, respond to issues, and lead weekly team meetings that discuss research and software development. Beyond research publications that include the founding team, SimPEG has been used in at least 6 peer-reviewed publications, 8 conference proceedings, 1 thesis at the Colorado School of Mines, and 3 in-progress theses at the University of British Columbia.

Project co-creator: GeoSci.xyz

In 2013, I started the GeoSci.xyz project with Douglas Oldenburg, and Rowan Cockett. This collection of open-source educational materials includes web-based textbooks, such as *Geophysics for Practicing Geoscientists (GPG)* and *Electromagnetic Geophysics* , and interactive Jupyter notebooks for geophysics[1]. I continue to serve as a content editor: I help outline material to be created and review updates and new submissions. GeoSci.xyz resources are used as course material in at least 5 different universities and have been viewed by more than 200,000 users worldwide.

Project Jupyter participation

I participate in Project Jupyter and have attended the invitation-only annual team meetings since 2017 as well as community workshops on Jupyter at HPC Facilities[2] and Dashboarding with Project Jupyter[3]. I also attended the Jupyter in Education workshop and am a co-author of the *Teaching and Learning with Jupyter* book project[4]. I lead the geophysics component of the *Jupyter meets the Earth*[5] project, which is a collaboration between members of the Pangeo Project[6], Project Jupyter and geoscience researchers at the National Center for Atmospheric Research (NCAR) and UC Berkeley. I am also helping facilitate conversations and providing input on the development of an organization that could grow out of the federated JupyterHub deployment in Canada: Syzygy[7].

Open science community development and best practices

I was an editor with the Journal of Open Source Software (JOSS) from 2017 to 2019, where I facilitated peer-review of scientific software contributions for 23 submissions. I have co-taught workshops on best practices in open source software development at the AGU annual meeting as well as at GeoHackweek [8].

[1] https://github.com/geoscixyz/geosci-labs
[2] https://blog.jupyter.org/jupyter-for-science-user-facilities-and-high-performance-computing-de178106872
[3] https://blog.jupyter.org/jupyter-community-workshop-dashboarding-with-project-jupyter-b0e421bdf164
[4] https://jupyter4edu.github.io/jupyter-edu-book
[5] https://blog.jupyter.org/jupyter-meets-the-earth-1b0eb33c83f
[6] https://pangeo.io
[7] https://blog.jupyter.org/national-scale-interactive-computing-2c104455e062
[8] http://geohackweek.github.io

Metrics of Broad Impact

My scientific career, by nature of investing significant effort in the creation of open tools for geophysics that are used internationally by researchers, industry professionals, and educators, has a different impact profile than that of a researcher whose main output is purely publication-based. Here, I outline a few metrics of this broader impact.

SimPEG user base: The SimPEG Slack community has over 200 members, which represents the most committed and engaged SimPEG users. The full user base is likely much larger but this is difficult to quantify because of the open-source nature of the code.

Institutions and companies using SimPEG: Below is a sampling of some universities, national labs, geologic surveys, and companies that use SimPEG. Where applicable, I have also included example publications where SimPEG is used.

- **Colorado School of Mines**: The DC resistivity and electromagnetic simulation and inversion are used by researchers in the Center for Gravity, Electrical, and Magnetic Studies (CGEM). For example, Paré & Li (2017) examine the impact of different regularization choices in a DC resistivity inversion and Maag-Capriotti & Li (2018) use the induced polarization simulation to develop an inversion approach that includes a clustering term in the regularization. doi: 10.1190/segam2017-17739005.1, doi: 10.1190/segam2018-2998500.1.
- **Dias Geophysical**: SimPEG is used for data processing, survey planning, and inversion of field data. In particular, they make extensive use of the 3D inversion capabilities for DC Resistivity and Induced Polarization data.
- **Geologic Survey of New Zealand**: The potential fields codes (gravity, magnetics, self-potential) have been used in volcanology studies (Miller et al., 2017; Miller et al., 2018), doi: 10.1016/j.epsl.2016.11.007, doi: 10.1029/2018GL078780
- **Lawrence Berkeley National Laboratory**: The electromagnetic simulations are used by researchers in the geophysics group to simulate how currents behave in settings with steel-cased wells (Wilt et al., 2018) doi: 10.1190/segam2018-2983425.1
- **Rural Research Institute, Korea**: The DC resistivity code has been used for Dam integrity monitoring applications (Lim, 2017) doi: 10.7582/GGE.2018.21.1.008.
- **University of British Columbia**: Many of the researchers in Geophysical Inversion Facility contribute to the code-base and use it daily as a part of their research. For example, Abediab et al. (2018) invert magnetic data in a tectonic study; Astic & Oldenburg (2017) develop an inversion approach which incorporates petrophysical information; and Kang et al. (2017) invert airborne electromagnetic data for electrical conductivity and chargeability. doi: 10.1016/j.tecto.2017.10.012, doi: 10.1190/segam2018-2995155.1, doi: 10.1190/INT-2016-0141.1

Universities using GeoSci.xyz: Below, I provide a sampling of courses where GeoSci.xyz resources are a significant component of the course material.

- **Fresno State**: The GPG was used in EES 118/250T: Applied Geophysics in 2017
- **Southern University of Science and Technology (China)**: The GPG is used in ESS302: Applied Geophysics II (Gravity, Magnetic, Electrical and Well Logging)
- **University of Alabama**: The GPG is used in GEO 369: Introduction Geophysics
- **University of British Columbia**: The GPG is used in EOSC 350: Environmental, Geotechnical, and Exploration Geophysics I
- **University of Houston**: EM GeoSci is used in GEOL 4397-03: Electromagnetic Methods for Exploration

Society of Exploration Geophysics Distinguished Instructor Short Course: EM GeoSci was the primary resource for the 2017 SEG DISC course on "Geophysical Electromagnetics: Fundamentals and Applications," led by Douglas Oldenburg and co-instructed with myself and Seogi Kang. The course ran in 25 locations worldwide with ∼40 participants at each location.

GeoSci.xyz web-traffic: We began tracking metrics of use in April, 2016 using Google Analytics. The values below indicate views and new users since then.

- **Geophysics for Practicing Geoscientists (GPG)**: over 400,000 page-views and 90,000 users
- **Electromagnetic Geophysics**: over 500,000 page-views and 200,000 users

Publication Highlights

Here, I provide a description of a few publications that reflect key topics in my research career. A full list of papers, keynotes, and other presentations begins on page 11.

Machine learning in the physical sciences

- [in prep] Heagy, L. J., Bloom, J., Oldenburg, D. W., & Pérez, F., 2019. A machine learning approach for modelling across scales in electromagnetic geophysics.

This paper outlines an approach for using a neural net to estimate and capture the fine-scale physics that is "missing" from numerical simulations performed on a grid coarser than the variations of physical properties. We enforce that the solutions are physical by construction; rather than having the neural net predict the missing current density or electric fields directly, we estimate a source term that encodes this discrepancy. By solving a second coarse-scale simulation of Maxwell's equations with the estimated source term, we then obtain the correction term. The application we consider is a time-domain electromagnetic simulation in settings with steel-cased wells.

Simulations and inversions in geophysics

- Cockett, R., Kang, S., Heagy, L. J., Pidlisecky, A. & Oldenburg, D. W., 2015. SimPEG: An open source framework for simulation and gradient based parameter estimation in geophysical applications. *Computers & Geosciences*. doi: 10.1016/j.cageo.2015.09.015
- Heagy, L. J., Cockett, R., Kang, S., Rosenkjaer, G. K., & Oldenburg, D. W., 2017. A framework for simulation and inversion in electromagnetics. *Computers & Geosciences*. doi: 10.1016/j.cageo.2017.06.018

These two papers outline a common framework for simulations and inversions across geophysical methods and discuss its implementation in the `SimPEG` project. The first paper (Cockett et al., 2015) introduces a modular structure for inverse problems that facilitates methods-based research for individual, joint, and co-operative inversions. The second paper (Heagy et al., 2017) discusses details of the forward simulation and sensitivity calculations in the context of electromagnetic simulations, including time-domain, frequency-domain and natural-source methods. This structure has since been adopted for all geophysical methods included in SimPEG.

Electromagnetic geophysics

- Heagy, L. J. & Oldenburg, D. W., 2019a. Modeling electromagnetics on cylindrical meshes with applications to steel-cased wells. *Computers & Geosciences*. doi: 10.1016/j.cageo.2018.11.010. arXiv: 1804.07991
- Heagy, L. J. & Oldenburg, D. W., 2019b. Direct current resistivity with steel-cased wells. *Geophysical Journal International*. doi: 10.1093/gji/ggz281. arXiv: 1810.12446

These papers examine aspects of the fundamental physics of electromagnetics in settings with steel-cased wells that are highly conductive and magnetic. The first paper (Heagy & Oldenburg, 2019a)

presents an implementation of finite-volume modeling for time and frequency domain electromagnetics on 3D cylindrical meshes. The second paper (Heagy & Oldenburg, 2019b) uses simulations to present physics-based considerations for survey design in casing integrity experiments, where the aim is to detect flaws of breaks along a wellbore, as well as injection experiments such as carbon capture and storage or hydraulic fracturing.

Numerical methods

- Caudillo-Mata, L. A., Haber, E., Heagy, L. J. & Schwarzbach, C., 2017. A framework for the upscaling of the electrical conductivity in the quasi-static Maxwell's equations. *Journal of Computational and Applied Mathematics*. doi: 10.1016/j.cam.2016.11.051

In this paper, we introduce an approach for estimating a coarse-scale electrical conductivity model from a fine-scale model. We solve a series of small, local inverse problems that aim to preserve physical responses between the two scales. The recovered coarse-scale model can then be used to perform numerical simulations of geophysical experiments. We demonstrate that the upscaling procedure is non-unique and that the recovered coarse-scale model depends upon the source-terms and boundary conditions used to define the local inverse problems.

- Cockett, R., Heagy, L. J. & Haber, E., 2018. Efficient 3D inversions using the Richards equation. *Computers & Geosciences*. doi: 10.1016/j.cageo.2018.04.006

The Richards equation is a non-linear time-domain equation for flow in the vadose zone – the region of the Earth between the surface and the fully saturated zone. In this paper, we present an efficient approach for solving and inverting the Richards equation to estimate distributed hydraulic parameters in 1D, 2D or 3D. We use sensitivity-vector products to compute gradients which substantially reduces the memory and computational requirements as compared to the typical approach where the dense sensitivity matrix is computed explicitly using finite difference or automatic differentiation.

Applied geophysics

- [in review] Fournier, D., Heagy, L. J. & Oldenburg, D. W., 2019. Sparse magnetic vector inversion in spherical coordinates: Application to the Kevitsa Ni-Cu-PGE magnetic anomaly, Finland. *Geophysics*

This paper introduces an approach for inverting magnetic data to recover compact geologic targets that have both induced and remnant magnetizations. The inversion is performed in spherical coordinates which allows us to impose sparsity assumptions on the magnitude and direction of magnetization independently. We demonstrate our approach in a mineral exploration case-study in Finland; the magnetization we recover is consistent with laboratory measurements and provides evidence for tectonic deformation.

- [in press] Kang, S., Oldenburg, D. W. & Heagy, L. J., 2019. Detecting induced polarization effects in time-domain data: a modeling study using stretched exponentials. *Exploration Geophysics*. arXiv: 1909.12993

In this paper, we perform numerical simulations to examine the detectability of chargeable targets in airborne time-domain electromagnetic surveys for mineral exploration. Our analysis examines the impact of the background conductivity, the conductivity of the target, its geometry, and its depth on the strength of the induced-polarization signal we observe in airborne data.

Open science and education

- Oldenburg, D. W., Heagy, L. J., Kang, S., Cockett, R., 2019. 3D electromagnetic modelling and inversion: a case for open source. *Exploration Geophysics*. doi: 10.1080/08123985.2019.1580118. arXiv: 1902.08245

This paper presents an argument for open-source software and open science practices to advance collaborative, multidisciplinary research in the geosciences. We provide examples of the benefits of

adopting this model based on our experience with the SimPEG project. These include streamlined collaboration and transfer of methodological advances between domains of geophysics, reduced implementation overhead for students and researchers interested in building upon previous work and the ability to quickly disseminate reproducible results.

- Barba, L. A., Barker, L. J., Blank, D. S., Brown, J., Downey, A. B., George, T., Heagy, L. J., Mandli, K. T., Moore, J. K., Lippert, D., Niemeyer, K. E., Watkins, R. R., West, R. H., Wickes, E., Willing, C., & Zingale M., 2018. Teaching and Learning with Jupyter. https://jupyter4edu.github.io/jupyter-edu-book/

My contributions to this book on the use of Jupyter in the classroom are primarily in Chapter 4: *A catalog of pedagogical patterns*. In this chapter, we outline strategies for structuring notebooks in a range of classroom activities, from teaching students concepts in computer science to connecting computations with interactive visualizations to allow students to explore systems or physical simulations.

Funding

Pending

2020 – 2023 **Co-Investigator**: Open-Source Software to Support Research with ICESat-2 Data. *NASA NSPIRES: Studies with ICESat-2*. ($\sim$ \$800,000)
PIs: Anthony Arendt (University of Washington), Fernando Pérez (UC Berkeley)

Awarded

2019 – 2022 **Senior Personnel**: Jupyter meets the Earth: Enabling discovery in geoscience through interactive computing at scale *NSF - EarthCube Data Capabilities: Collaborative Proposal*. doi: 10.5281/zenodo.3369938. (\$1,960,000)
PIs: Fernando Pérez (UC Berkeley), Laurel Larsen (UC Berkeley), Joe Hamman (NCAR)

2019 **External Collaborator**: Improving Water Security in Mon State, Myanmar via Geophysical Capacity Building. *Geoscientists Without Borders* (\$50,000)
PI: Douglas Oldenburg (UBC)

Completed

2014 **Senior Personnel**: Science Center for Learning and Teaching - Development Grant for the development of online interactive resources for undergraduate geophysics. *University of British Columbia Science Center for Learning and Teaching Fund* (\$2,500)
PI: Douglas Oldenburg (UBC)

Unsuccessful Proposals

The following are proposals that were submitted but not awarded. I include these as they demonstrate collaborations that have been initiated and project ideas that have been formulated to the point of pursuing funding.

2018 **Senior Personnel**: Research Coordination Network to facilitate collaboration through the sharing of Food Energy Water (FEW) data and methods. *NSF Innovations at the Nexus of Food Energy Water Systems INFEWS/T3 Research Coordination Network*
PIs: Rosemary Knight (Stanford), Fernando Pérez (UC Berkeley), Isha Ray (UC Berkeley), Mark Lubell (UC Davis), Kate Maher (Stanford)

2015 **Co-PI**: Enhancing applied, interdisciplinary learning with online, interactive case history modules that bridge undergraduate geoscience courses. *University of British Columbia Teaching and Learning Enhancement Fund.* doi: 10.5281/zenodo.3472158
PI: Douglas Oldenburg (UBC), Co-PI: Rowan Cockett (UBC)

Software and Open Science

I contribute to a number of open-source software projects, all of which are accessible through my GitHub profile (https://github.com/lheagy). Some of the larger projects include:

2014 – present **GeoSci.xyz**
Core maintainer and contributor to online interactive textbooks for geophysics. Resources include:

- **Geophysics for Practicing Geoscientists:** an introductory resource on applied geophysics (http://gpg.geosci.xyz)
- **Electromagnetic Geophysics:** a graduate level resource on the theory and application of electromagnetic geophysical methods (http://em.geosci.xyz)
- **GeoSci Labs:** a collection of Jupyter notebooks for exploring concepts in geophysics (https://github.com/geoscixyz/geosci-labs)

2014 – present **SimPEG**
Core maintainer and community developer. Software repositories include:

- **SimPEG:** software for numerical simulations and inversions in geophysics (https://github.com/simpeg/simpeg)
- **discretize:** meshing and discretization tools for finite volume and inverse problems (https://github.com/simpeg/discretize)
- **geoana:** analytic solutions for common physics problems relevant to geophysics (https://github.com/simpeg/geoana)

Teaching

Undergraduate Courses

2013 – 2016 **Teaching Assistant:** EOSC 350: Environmental, Geotechnical, and Exploration Geophysics.
University of British Columbia
Instructor: Douglas Oldenburg

2015 **Teaching Assistant:** Directed Studies: Inversion in Applied Geophysics.
University of British Columbia
Instructor: Douglas Oldenburg

2012 **Teaching Assistant:** EOSC 354: Analysis of Time Series and Inverse Theory for Earth Scientists.
University of British Columbia
Instructor: Michael Bostock

Workshops & Short Courses

2019 **Instructor:** Best Practices for Developing and Sustaining Your Open-Source Research Software
AGU Fall Meeting 2019

with Instructors: Rene Gassmoeller, Lion Krischer, Leonardo Uieda, Bane Sullivan, Timo Heister and Wolfgang Bangerth

Instructor: Data sharing and collaboration tools; Steps to reproducible research
Geohackweek 2019
with Instructors: Don Setiawan and Joe Meyer
(https://geohackweek.github.io)

2018 **Instructor:** Best Practices for Modern Open-Source Research Codes
AGU Fall Meeting 2018
with Instructors: Leonardo Uieda, Lion Krischer, and Florian Wagner
(https://github.com/agu-ossi/2018-agu-oss)

Co-Instructor: EM methods in exploration.
University of Houston Petroleum Geophysics - Summer 2018 Short Course
Lead Instructor: Douglas Oldenburg, Co-Instructor: Seogi Kang
(https://courses.geosci.xyz/houston2018)

Co-Instructor: 3D EM Modelling and Inversion with Open Source Resources.
AEM 2018: 7th International Workshop on Airborne Electromagnetics in Kolding, Denmark
Lead instructor: Douglas Oldenburg, Co-Instructor: Seogi Kang
(https://courses.geosci.xyz/aem2018)

2017 **Co-Instructor:** Geophysical Electromagnetics: Fundamentals and Applications
Society of Exploration Geophysics Distinguished Instructor Short Course
Lead instructor: Douglas Oldenburg, Co-Instructor: Seogi Kang
(http://disc2017.geosci.xyz)

- Locations:
  - Denver, USA (January 30-31, 2017)
  - Perth, Australia (July 27-28, 2017)
  - Adelaide, Australia (August 2-3, 2017)
  - Brisbane, Austraila (August 7-8, 2017)
  - Delft, Netherlands (September 11-12, 2017)
  - Bonn, Germany (September 18-19, 2017)
  - Vienna, Austria (September 21-22, 2017)
  - Zurich, Switzerland (September 26-27, 2017)
  - Aarhus, Denmark (October 2-3, 2017)
  - Toronto, Canada (October 27, 2017)
  - Mexico City, Mexico (November 6-7, 2017)
  - Buenos Aires, Argentina (November 13-14, 2017)
  - Santiago, Chile (November 16-17, 2017)
  - Santa Cruz de la Sierra, Bolivia (November 22-23, 2017) - Canceled
  - Rio de Janeiro, Brazil (November 28-29, 2017)
  - Calgary, Canada (December 5-6, 2017)
  - Vancouver, Canada (December 12-13, 2017)

2016 **Organizer:** Geophysical Simulation and Inversion (August 19-21, 2016)
Banff International Research Station,
Organized with Douglas Oldenburg, Adam Pidlisecky and Rowan Cockett
(http://www.birs.ca/events/2016/2-day-workshops/16w2695)

Service

Editorial

2017 – 2019 **Editor:** Journal of Open Source Software
Topics: geoscience, geophysics (http://joss.theoj.org/about)

Conferences & Workshops

2019 **Session Co-Convener:** Communities of Practice for Jupyter Notebooks.
Moore-Sloan Data Science Environments Summit
Organized with: James Colliander and Fernando Pérez

Session Co-Convener: Collecting resources on best practices for scientific software development.
Moore-Sloan Data Science Environments Summit
Organized with: Fernando Pérez

Chair: SciPy Birds of a Feather (BoF) Sessions.
SciPy Conference
(https://www.scipy2019.scipy.org/bof-sessions)

2018 **Town Hall Organizer:** Community Forum: The role of an open-source software initiative within the AGU.
American Geophysical Union (AGU) Annual Meeting
Co-organized with: Lion Krischer and Leonardo Uieda

Session Convener: Short Talks: A tour of open-source software packages for the geosciences.
American Geophysical Union (AGU) Annual Meeting
Co-organized with Florian Wagner, Jens Klump and Lion Krischer

2017 **Panel Discussion Organizer:** Open Source Software in the Geosciences.
American Geophysical Union (AGU) Annual Meeting
Co-organized with Anna Kelbert, Luz Andelica Caudillo Mata, Jared Peacock, Suzan van der Lee, Juan Lorenzo
(https://youtu.be/0GO4ZZ5Ry6M))

Program Committee Member: JupyterCon, August 22-25, New York, NY
(https://conferences.oreilly.com/jupyter/jup-ny)

Mentoring

2014 – 2015 **Undergraduate Research Mentor** Research Experience Program at the University of British Columbia
Student: Mohamed Rassas
Project: A comparison of conventional and open channel hydraulic fracturing and the importance of imaging to optimize the fracturing process

Reviewing

- American Geophysical Union (AGU) book proposal
- Computers & Geosciences
- Exploration Geophysics

- Geophysical Journal International (GJI)
- The Leading Edge
- Society of Exploration Geophysics Abstracts

Awards

2019 **Gerald W. Hohmann Career Achievement Award: Outstanding Junior Scientist**
Awarded for advances in simulation and inversion of electromagnetic data and promotion of an open source culture for collaborative, inclusive and reproducible research. ($2,500)

Graduate

2016 **UBC Library: Innovative Dissemination of Research Award**
Awarded for the SimPEG framework and community development. With Rowan Cockett and Seogi Kang. ($1,000)

2014 – 2017 **NSERC Vanier Scholarship**
Vanier Scholars demonstrate leadership skills and a high standard of scholarly achievement in graduate studies in the social sciences and/or humanities, natural sciences and/or engineering and health. The Vanier Scholarship is the top graduate scholarship in Canada. ($50,000 $\times$ 3)

2014 – 2017 **Alexander Graham Bell Canada Graduate Scholarship**
Awarded to high caliber scholars who are engaged in a doctoral program in the natural sciences or engineering ($35,000 $\times$ 3, declined)

2014 – 2018 **Four Year Fellowship (FYF) for PhD Students**
Selection based on academic excellence, upon the recommendation of the graduate program at UBC ($18,000 $\times$ 4, declined 3/4)

2013 **Special UBC Graduate Scholarship - W.H. Mathews Scholarship**
Awarded for academic achievement in Earth, Ocean and Atmospheric Sciences at UBC ($5,000)

Undergraduate

2012 **Governor General's Silver Medal**
Awarded annually to the three undergraduate students (institution-wide) who achieve the highest academic standing overall upon graduation from his/her Bachelor degree program.

2012 **Lieutenant-Governor's Gold Medal**
Awarded to the convocating student from an Honours program in the Faculty of Science who has shown the highest distinction in scholarship (University of Alberta)

2012 **APEGGA Past Presidents' Medal in Geophysics**
Awarded to the convocating student who is a Canadian Citizen or Permanent Resident with the highest academic standing in a specialization or honours program in Geophysics on the basis of the final year

2011 **The APEGGA Scholarship in Geophysics**
Awarded on the basis of superior academic achievement in Honors Geophysics or Specialization in Geophysics ($3,000 $\times$ 2)

2010 – 2012 **The David K Robertson Award in Geophysics and Geology**
Awarded to a student entering the third year of a BSc Specializing in Geology or Geophysics on the basis of passion and talent in their field of study, demonstrated leadership, participation in extracurricular activities, and academic standing. ($\$5,000 \times 2$)

2010 – 2012 **The Encana Geology and Geophysics Scholarship**
Awarded to student(s) with superior academic achievement entering the third or fourth year of study for a Bachelor of Science with a major in Geology or Geophysical Sciences. ($\$3,500 \times 2$)

2009 – 2011 **Louise McKinney Post Secondary Scholarship, Government of Alberta**
Recognizes students for their academic achievements at a provincial level and encourages them to continue in their undergraduate program of study ($\$2,500 \times 3$)

2009 **Pearl Cuthbertson Memorial Award**
Awarded to a student entering the second year of study for a Bachelor of Science degree who has completed Science 100. Selection based on academic standing and demonstrated determination, curiosity and enthusiasm for science. ($\$2,000 \times 2$)

2009 **Pearson Book Prize**
Awarded for academic achievement in Writing Studies in Science 100

2008 – 2012 **Dean's Honor Roll, University of Alberta**
Awarded for academic achievement ($\times 4$)

Publications

Peer Reviewed Publications (submitted or in review)

2019 [in review] Fournier, D., **Heagy, L. J.** & Oldenburg, D. W., 2019. Sparse magnetic vector inversion in spherical coordinates: Application to the Kevitsa Ni-Cu-PGE magnetic anomaly, Finland. *Geophysics*

[in press] Kang, S., Oldenburg, D. W. & **Heagy, L. J.**, 2019. Detecting induced polarization effects in time-domain data: a modeling study using stretched exponentials. *Exploration Geophysics*. arXiv: 1909.12993

Peer Reviewed Publications

2019 **Heagy, L. J.**, Kang, S., Cockett, R. & Oldenburg, D. W., 2019. Open source software for simulations and inversions of airborne electromagnetic data. *Exploration Geophysics*. doi: 10.1080/08123985.2019.1583538. arXiv: 1902.08238

Heagy, L. J. & Oldenburg, D. W., 2019. Modeling electromagnetics on cylindrical meshes with applications to steel-cased wells. *Computers & Geosciences*. doi: 10.1016/j.cageo.2018.11.010. arXiv: 1804.07991

Heagy, L. J. & Oldenburg, D. W., 2019. Direct current resistivity with steel-cased wells. *Geophysical Journal International*. doi: 10.1093/gji/ggz281. arXiv: 1810.12446

Oldenburg, D. W., **Heagy, L. J.**, Kang, S. & Cockett, R., 2019. 3D electromagnetic modelling and inversion: a case for open source. *Exploration Geophysics*. doi: 10.1080/08123985.2019.1580118. arXiv: 1902.08245

2018 Cockett, R., **Heagy, L. J.** & Haber, E., 2018. Efficient 3D inversions using the Richards equation. *Computers & Geosciences*. doi: 10.1016/j.cageo.2018.04.006

2017 **Heagy, L. J.**, Cockett, R., Kang, S., Rosenkjaer, G. K., & Oldenburg, D. W., 2017. A framework for simulation and inversion in electromagnetics. *Computers & Geosciences*. doi: 10.1016/j.cageo.2017.06.018

Caudillo-Mata, L. A., Haber, E., **Heagy, L. J.** & Schwarzbach, C., 2017. A framework for the upscaling of the electrical conductivity in the quasi-static Maxwell's equations. *Journal of Computational and Applied Mathematics*. doi: 10.1016/j.cam.2016.11.051

2015 Cockett, R., Kang, S., **Heagy, L. J.**, Pidlisecky, A. & Oldenburg, D. W., 2015. SimPEG: An open source framework for simulation and gradient based parameter estimation in geophysical applications. *Computers & Geosciences*. doi: 10.1016/j.cageo.2015.09.015

Non Peer Reviewed Publications

2019 Barba, L. A., Bazán, J., Brown, J., Guimera, R. V., Gymrek, M., Hanna, A., **Heagy, L. J.**, Huff, K. D., Katz, D. S., Madan, C., Moerman, K., Niemeyer, K., Poulson, J. L., and Prins, P., Ram, K., Rokem, A., Smith, A. M., Thiruvathukal, G. K., Thyng, K., Uieda, L., Wilson, B. & Yehudi, Y., 2019. Giving software its due through community-driven review and publication. *OSF Preprints*. doi: 10.31219/osf.io/f4vx6,

2018 Barba, L. A., Barker, L. J., Blank, D. S., Brown, J., Downey, A. B., George, T., **Heagy, L. J.**, Mandli, K. T., Moore, J. K., Lippert, D., Niemeyer, K. E., Watkins, R. R., West, R. H., Wickes, E., Willing, C., & Zingale M., 2018. Teaching and Learning with Jupyter. https://jupyter4edu.github.io/jupyter-edu-book/

2017 Kang, S., **Heagy, L. J.**, Cockett, R., & Oldenburg, D. W., 2017. Exploring nonlinear inversions: A 1D magnetotelluric example. *The Leading Edge*. doi: 10.1190/tle36080696.1

2016 Cockett, R., **Heagy, L. J.** & Oldenburg D. W., 2016. Pixels and their neighbors: Finite volume. *The Leading Edge*. doi: 10.1190/tle35080703.1

Patents

2014 Wilt, M., Cuevas, N., & **Heagy L. J.**, 2014. Determining proppant and fluid distribution. *US Patent App. 14/494,313*

Presentations

Keynote or Invited

2020 [upcoming] **Heagy, L. J.** *Canadian Mathematical Society (CMS) 75th Anniversary Summer Meeting, session on Numerical Analysis and Computational Geophysics*. Ottawa, ON

2019 **Heagy, L. J.** *Colorado School of Mines Heiland Lecture*. Golden, CO

Heagy, L. J. Jupyter meets the Earth: from geophysical inversions to open, collaborative geoscience. *Women In Data Science Stanford Earth*. Stanford, CA

Heagy, L. J. Keynote: Capturing knowledge in code. *7th Latin American Conference for Scientific Python*. Bogotá, Colombia. youtube: https://youtu.be/cb-gFHRZCIc

Heagy, L. J. Keynote: Science enabled by open source tools and communities: Geophysical simulations and inversions. *Pangeo annual meeting*. Seattle, WA.

Heagy, L. J. & Oldenburg, D. W., Exploring the Physics of Electromagnetics with Steel-Cased Wells Using Open-Source Tools. *International Union of Geodesy and Geophysics (IUGG)*. Montreal, Canada.

Heagy, L. J., Sharing Reproducible Computations on Binder. *Symposium on Data Science and Statistics (SDSS)*. Seattle, WA.

2016 **Heagy, L. J.**, Cockett, R., & Oldenburg, D. W., 2016. GeoSci: practices to collaboratively build online resources for geophysics education. *AGU Fall Meeting*

Heagy, L. J. & Oldenburg, D. W., 2016. Examining the impact of steel cased wells on electromagnetic signals. *AGU Fall Meeting*

2014 **Heagy, L. J.** & Oldenburg, D. W., 2014. Using electromagnetics to delineate proppant distribution in a hydraulically fractured reservoir. *SEG Development and Production Forum, Santa Rosa CA*.

Other Presentations

(† : award)

2018 **Heagy, L. J.**, Kang, S., Cockett, R., & Oldenburg, D. W., 2018. Open source software for simulations and inversions of airborne electromagnetic data. *AEM 2018: 7th International Workshop on Airborne Electromagnetics*

2017 **Heagy, L. J.**, Cockett, R. & Oldenburg, D. W., 2017. Modular electromagnetic simulations with applications to steel cased wells. *6th International Symposium on Three-Dimensional Electromagnetics*.

Heagy, L. J. & Cockett, R., 2017. Deploying a reproducible course. *JupyterCon 2017*. youtube: https://youtu.be/XY3Tq9Wd1_A

Heagy, L. J. & Cockett, R., 2017. Interactive Geophysics. *SciPy Conference*. youtube: https://youtu.be/NuUe2ja5LCE

Heagy L. J., Fournier, D., Kang, S. & Miller, C., 2017. Simulation and parameter estimation in geophysics. *British Columbia Geophysical Society Meeting*

2016 **Heagy, L. J.**, Using open source tools to refactor geoscience education. *SciPy Conference*. youtube: https://youtu.be/IW2LDsevvDk

Kang, S., Cockett, R., **Heagy, L. J.** and Oldenburg, D. W., 2016. Practices to enable the geophysical research spectrum: from fundamentals to applications. *AGU Fall Meeting*

Yang, D., Oldenburg, D. W. & **Heagy, L. J.**, 2016. 3D DC resistivity modeling of steel casing for reservoir monitoring using equivalent resistor network. *SEG Annual Meeting*. doi: 10.1190/segam2016-13868475.1

2015 Cockett, R., **Heagy, L. J.**, Kang, S. & Rosenkjaer, G. K., 2015. Development practices and lessons learned in developing SimPEG. *AGU Fall Meeting*

Heagy, L. J., 2015. Using Python to Span the Gap between Education, Research, and Industry Applications in Geophysics. *SciPy Conference*. youtube: https://youtu.be/4msHJMBvzaI

Heagy, L. J., Cockett, R., Kang, S., Rosenkjaer, G. K. & Oldenburg, D. W., 2015. simpegEM: An open-source resource for simulation and parameter estimation problems in electromagnetic geophysics. *AGU Fall Meeting*

Heagy, L. J., Cockett, R., Kang, S. & Oldenburg, D. W., 2015. Real simulation tools in introductory courses: packaging and repurposing our research code. *AGU Fall Meeting*

Heagy, L. J., Cockett, R., Oldenburg, D. W. & Wilt, M., 2015. Modelling electromagnetic problems in the presence of cased wells. *SEG Annual Meeting*. doi: 10.1190/segam2015-5931035.1

Kang, S., Cockett, R., **Heagy, L. J.**, & Oldenburg, D. W., 2015. Moving between dimensions in electromagnetic inversions. *SEG Annual Meeting*. doi: 10.1190/segam2015-5930379.1

2014 Caudillo-Mata, L. A., Haber, E., **Heagy, L. J.**, & Oldenburg, D. W., 2014. Numerical upscaling of electrical conductivity: A problem specific approach to generate coarse-scale models. *SEG Annual Meeting*. doi: 10.1190/segam2014-1488.1

Devriese, S. G. R., Corcoran, N., Cowan, D., Davis, K., Bild-Enkin, D., Fournier, D., **Heagy, L. J.**, Kang, S., Marchant, D., McMillan, M. S., Mitchell, M., Rosenkjar, G. K., Yang, D. & Oldenburg, D. W., 2014. Magnetic inversion of three airborne data sets over the Tli Kwi Cho kimberlite complex. *SEG Annual Meeting*. doi: 10.1190/segam2014-1205.1

Fournier, D., **Heagy, L. J.**, Corcoran, N., Cowan, D., Devriese, S. G. R., Bild-Enkin, D., Davis, K., Kang, S., Marchant, D., McMillan, M. S., Mitchell, M., Rosenkjar, G. K., Yang, D., Oldenburg, D. W., 2014. Multi-EM systems inversion - Towards a common conductivity model for the Tli Kwi Cho complex. *SEG Annual Meeting*. doi: 10.1190/segam2014-1110.1

Heagy, L. J., Cockett, R., & Oldenburg, D. W., 2014. Parametrized inversion framework for proppant volume in a hydraulically fractured reservoir. *SEG Annual Meeting*. doi: 10.1190/segam2014-1639.1

†**Heagy, L. J.**, Oldenburg, D. W. & Chen, J., 2014. Where does the proppant go? Examining the application of electromagnetic methods for hydraulic fracture characterization. *CSEG GeoConvention*

† Student Honourable Mention: Integrated Poster

Wilt, M., **Heagy, L. J.** & Chen, J., 2014. Hydrofracture Mapping and Monitoring with Borehole Electromagnetic (EM) Methods. *76th EAGE Conference and Exhibition*

2013 † **Heagy L. J.** & Oldenburg, D. W., 2013. Investigating the potential of using conductive or permeable proppant particles for hydraulic fracture characterization. *SEG Annual Meeting*. doi: 10.1190/segam2013-1372.1

† Award of Merit (Best Student Paper, Annual Meeting)

Media

2018 Guest on Episode 163: Python in Geoscience, May 25, 2018. *Talk Python to Me* by Michael Kennedy (https://talkpython.fm/)

2017 Guest on Episode 41, Apr. 24, 2017. *Undersampled Radio* by Graham Ganssle and Matt Hall (https://undersampledrad.io)

Guest on Episode 11, Jan. 24, 2017. *Seismic Soundoff* by the Society of Exploration Geophysicists (http://seg.org/podcast)

2012 Article: Science 100 pioneer grounded in geophysics. *University of Alberta Spring Convocation 2012: Celebrating Talented People* (https://www.ualberta.ca/news-and-events/newsarticles)