

Open Source



Tools?

- Want software for...
 - EM Simulations: FDEM, TDEM
 - Inversions: 1D, 3D, parametric
- Intended use?
 - Production scale inversion
 - Survey design
 - Research
 - Inversion methodology
 - Understanding the physics
- Two options:
 - 1) use existing software
 - 2) develop your own tools



Option 1: use existing software

- Purchase license for software
- request academic license

Pros:

- Reduce development overhead
- May have been tested / used for other data sets
- Often fit-for-purpose

Cons:

- Proprietary and not accessible
 - Available as executable
- Source code may be impenetrable:
 - optimized and written by one (maybe two) people
 - spaghetti code in a foreign language
- Often fit-for-purpose: rigid and not easily extensible
- Restrictive use (licensing)

Option 2: build your own

- Gather historic codes and merge/modify
- Start from scratch

Pros:

- Flexibility
- Knowledge of structure / layout of the code
- Knowledge of which aspects are tested (and not)
- Extensibility
 - Can be designed with future development / research questions in mind

Cons:

- Daunting! Need strong background in scientific computing
 - And software engineering skills
- Time commitment
 - Esp. if transferability is a priority
- Challenging to publish
- It is not regarded as a scientific contribution

Option 3??

Option 3: wish-list

- Collaboration
 - Development of software
 - Implementing and applying
- Development practices
 - Shared repository
 - Version control
 - Automated testing
 - User and developer documentation
 - Peer review of code
 - Issue tracking
 - Attribution for contributors
 - Licensing

Option 3: Open Source

- Collaboration
 - Development of software
 - Implementing and applying
- Development practices
 - Shared repository
 - Version control
 - Automated testing
 - User and developer documentation
 - Peer review of code
 - Issue tracking
 - Attribution for contributors
 - Licensing

Open source communities already doing this:



Tools in the open source ecosystem



Read the Docs



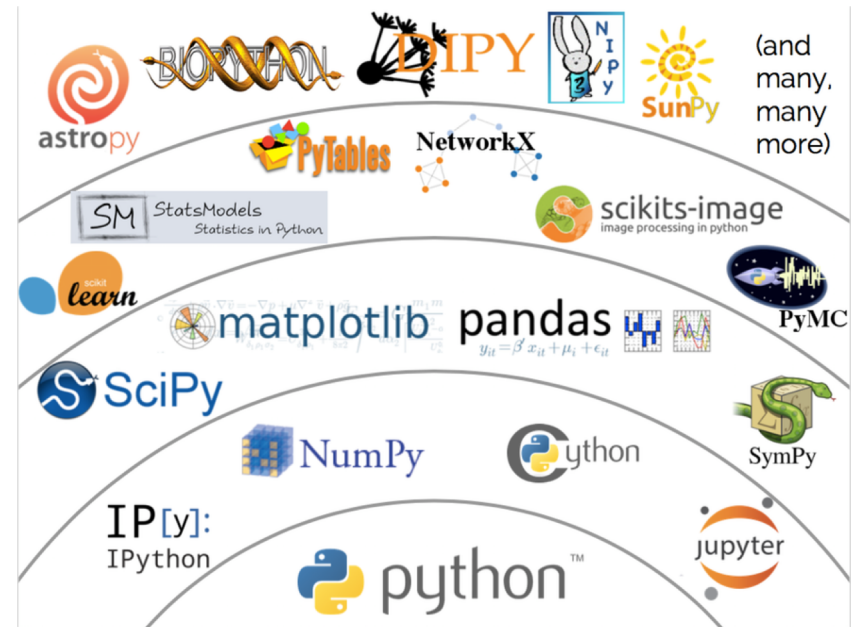
and many more ...

Freely available modern languages



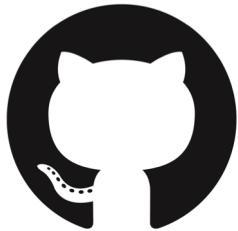
- Facilitates collaboration and reproducibility (by anyone!)
- Easier on-boarding of new users / graduate students
- Communities developing core-packages that can be re-used

Scientific Python Ecosystem

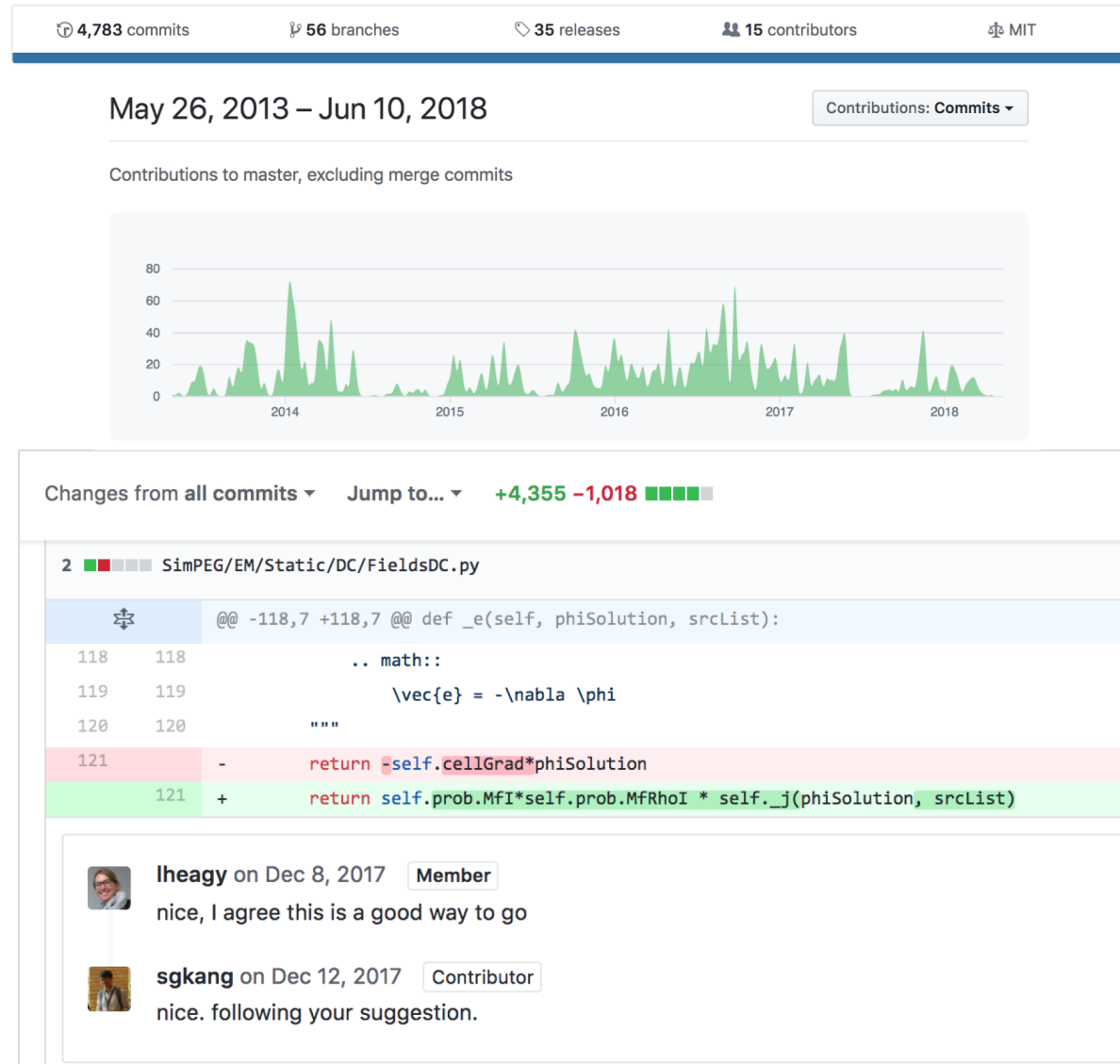


From Jake VanderPlas “[State of the Tools](#)”, SciPy 2015

GitHub



- Version control
- Issue tracking
- Code-reviews
- Attribution



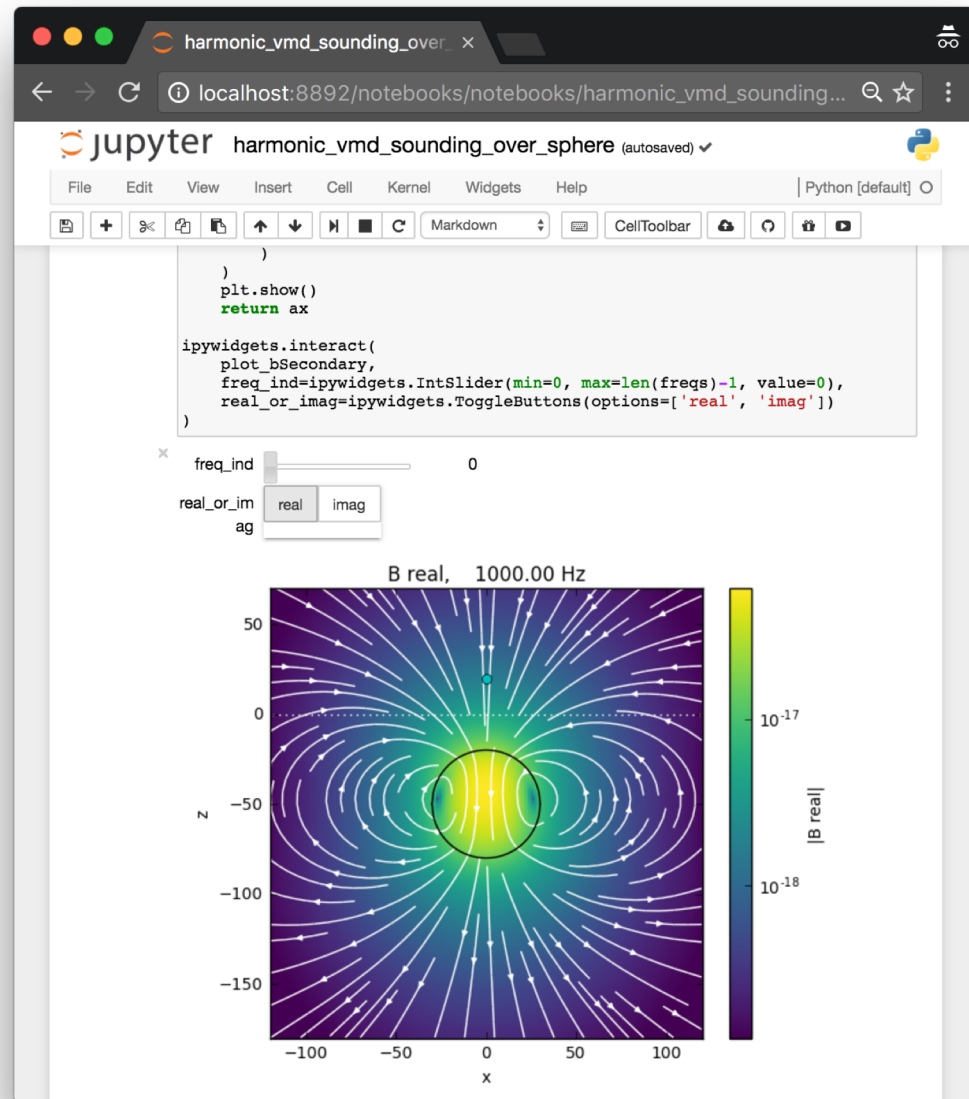
Jupyter notebooks



- Computational narratives / documented workflows
- Interactive computing
- Widgets
- Resources to distribute reproducible notebooks



Microsoft Azure Notebooks



Testing



- TravisCI, CircleCI, ...
- Automated testing
- Runs on every change to the codebase
- Test changes / new contributions before distributing

Build #5348 - simpeg/simpeg

Travis CI GmbH [DE] | <https://travis-ci.org/simpeg/simpeg/builds/387449003>

simpeg / simpeg build passing

Current Branches Build History Pull Requests > Build #5348 More options

✓ master CRON Merge pull request #696 from simpeg/typo-sorce 🚀 #5348 passed

Minor typo in docs 🕒 Ran for 36 min 8 sec

🔗 Commit 9429510 🕒 Total time 2 hrs 33 min 8 sec

🔗 Branch master 📅 7 days ago

Lindsey Heagy authored 📄 GitHub committed

Build Jobs

✓ # 5348.1	Python: 3.6	TEST_DIR=tests/em/fdem/inverse/derivs	🕒 5 min 16 sec
✓ # 5348.2	Python: 2.7	TEST_DIR=tests/em/fdem/inverse/derivs	🕒 5 min 16 sec
✓ # 5348.3	Python: 3.6	TEST_DIR=tests/em/tdem	🕒 9 min 15 sec
✓ # 5348.4	Python: 2.7	TEST_DIR=tests/em/tdem	🕒 8 min 51 sec
✓ # 5348.5	Python: 3.6	TEST_DIR="tests/em/static tests/seis tests/..."	🕒 7 min 53 sec
✓ # 5348.6	Python: 2.7	TEST_DIR="tests/em/static tests/seis tests/..."	🕒 6 min 47 sec
✓ # 5348.7	Python: 3.6	TEST_DIR=tests/flow	🕒 8 min 51 sec
✓ # 5348.8	Python: 2.7	TEST_DIR=tests/flow	🕒 10 min 42 sec
✓ # 5348.9	Python: 3.6	TEST_DIR="tests/em/nsem/forward tests/e..."	🕒 7 min 45 sec
✓ # 5348.10	Python: 2.7	TEST_DIR="tests/em/nsem/forward tests/e..."	🕒 7 min 9 sec
✓ # 5348.11	Python: 3.6	TEST_DIR=tests/em/fdem/inverse/adjoint	🕒 7 min 35 sec

Documentation



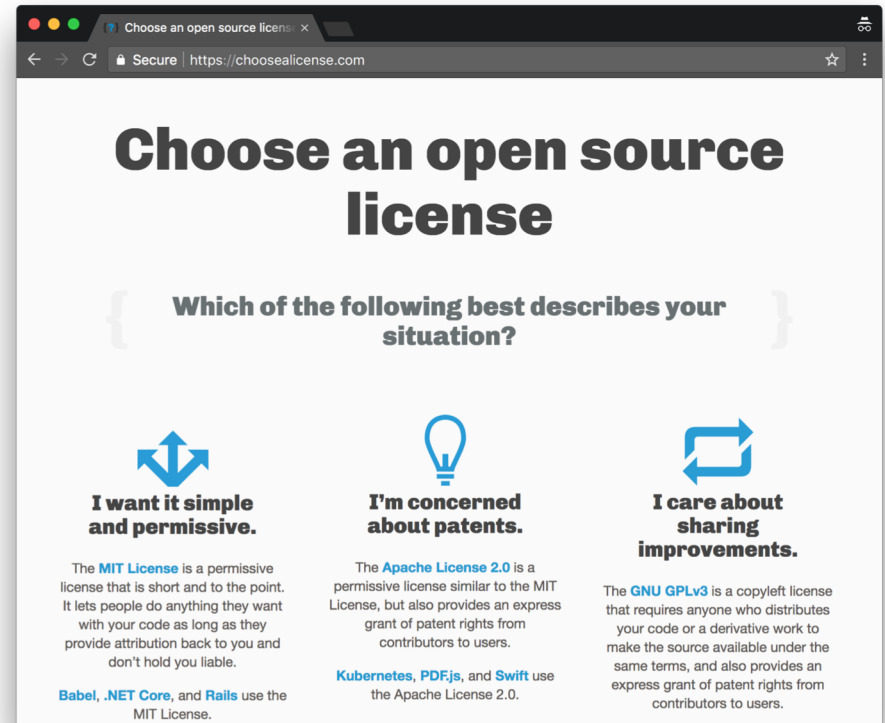
- Read the Docs
- Documentation hosting
- Updated with changes to distributed version of code
- Searchable
- uses documentation strings within codebase



Licenses



- Specifies how others can use / adapt software
- Most Python projects use permissive licenses (MIT or BSD-3)
 - Facilitates collaboration
 - allows industry and academic use



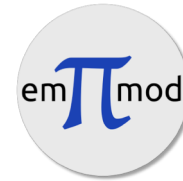
<https://choosealicense.com>

Some big benefits

- Collaboration
- Ease of testing
- Useable software
- Problem solved faster
- Modification is easier
- Learn by reading existing codes
- Share analysis and results
- Reproducibility
- Attribution
- Continually improving set of tools in the open-source ecosystem
- Building a community

Sampling of modern open-source projects

- For EM
 - empymod
 - jInv
 - pyGIMLi
 - Fatiando
 - SimPEG
 - ...



pyGIMLi

Geophysical Inversion & Modelling Library



fatiando a terra

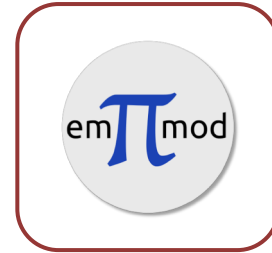


simpeg

Sampling of modern open-source projects

- For EM
 - empymod
 - jInv
 - pyGIMLi
 - Fatiando
 - SimPEG
 - ...

EM forward modelling of 1D
VTI media with 3D EM
sources in Python



py**GIMLi**

Geophysical Inversion & Modelling Library



fatiando a terra

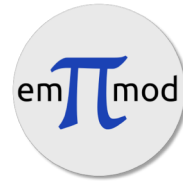


simpeg

Sampling of modern open-source projects

- For EM
 - empymod
 - jInv
 - pyGIMLi
 - Fatiando
 - SimPEG
 - ...

Framework for PDE parameter estimation in Julia. Contains building blocks to assemble your own simulation and inversion.

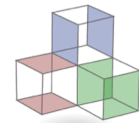


pyGIMLi

Geophysical Inversion & Modelling Library



fatiando a terra

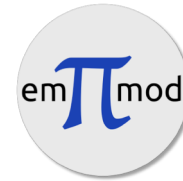


simpeg

Sampling of modern open-source projects

- For EM
 - empymod
 - jlnv
 - **pyGIMLi**
 - Fatiando
 - SimPEG
 - ...

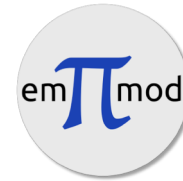
Multi-method library for solving inverse and forward tasks related to geophysical problems in C++ and Python. 3D DC/IP, potential fields are highlights



Sampling of modern open-source projects

- For EM
 - empymod
 - jInv
 - pyGIMLi
 - Fatiando
 - **SimPEG**
 - ...

Simulation and gradient based parameter estimation in geophysical applications, including DC/IP, EM. Written in Python



py**GIMLi**

Geophysical Inversion & Modelling Library



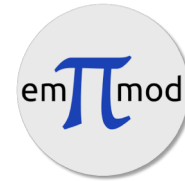
fatiando a terra



simpeg

Sampling of modern open-source projects

- For EM
 - empymod
 - jInv
 - pyGIMLi
 - Fatiando
 - SimPEG
 - ...
- They differ in objectives, capabilities, structure, interactivity, license, and language



py**GIMLi**

Geophysical Inversion & Modelling Library



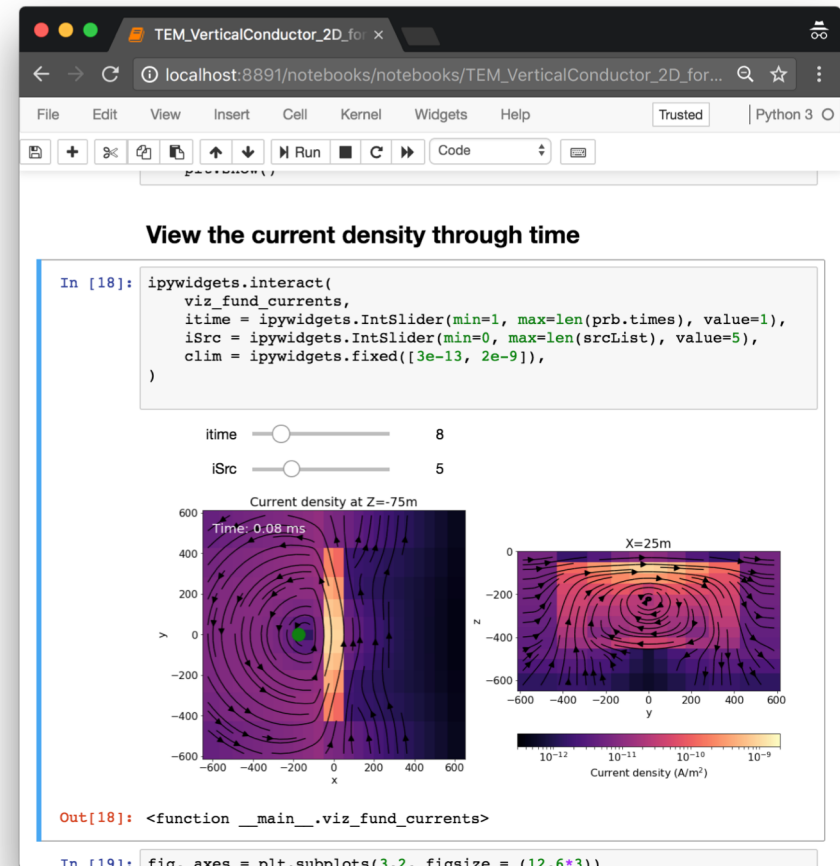
fatiando a terra



simpeg

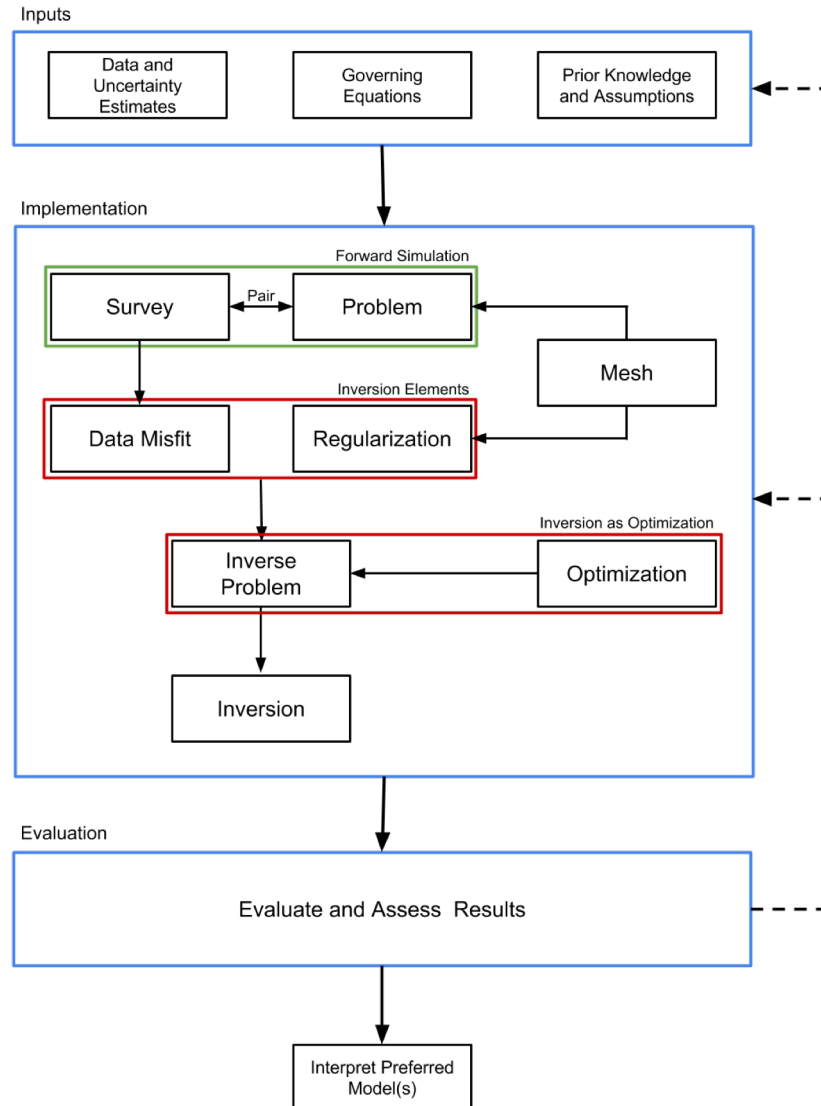


- Modular framework for simulation and inversion of geophysical data
 - gravity, magnetics, vadose flow, DC/IP, FDEM, TDEM
- Open source
- Written in Python
- Specific to electromagnetics
 - Quasi-static Maxwell
 - Tensor, OcTree, Curvilinear and Cylindrical meshes
 - Easily visualize fields, fluxes, charges

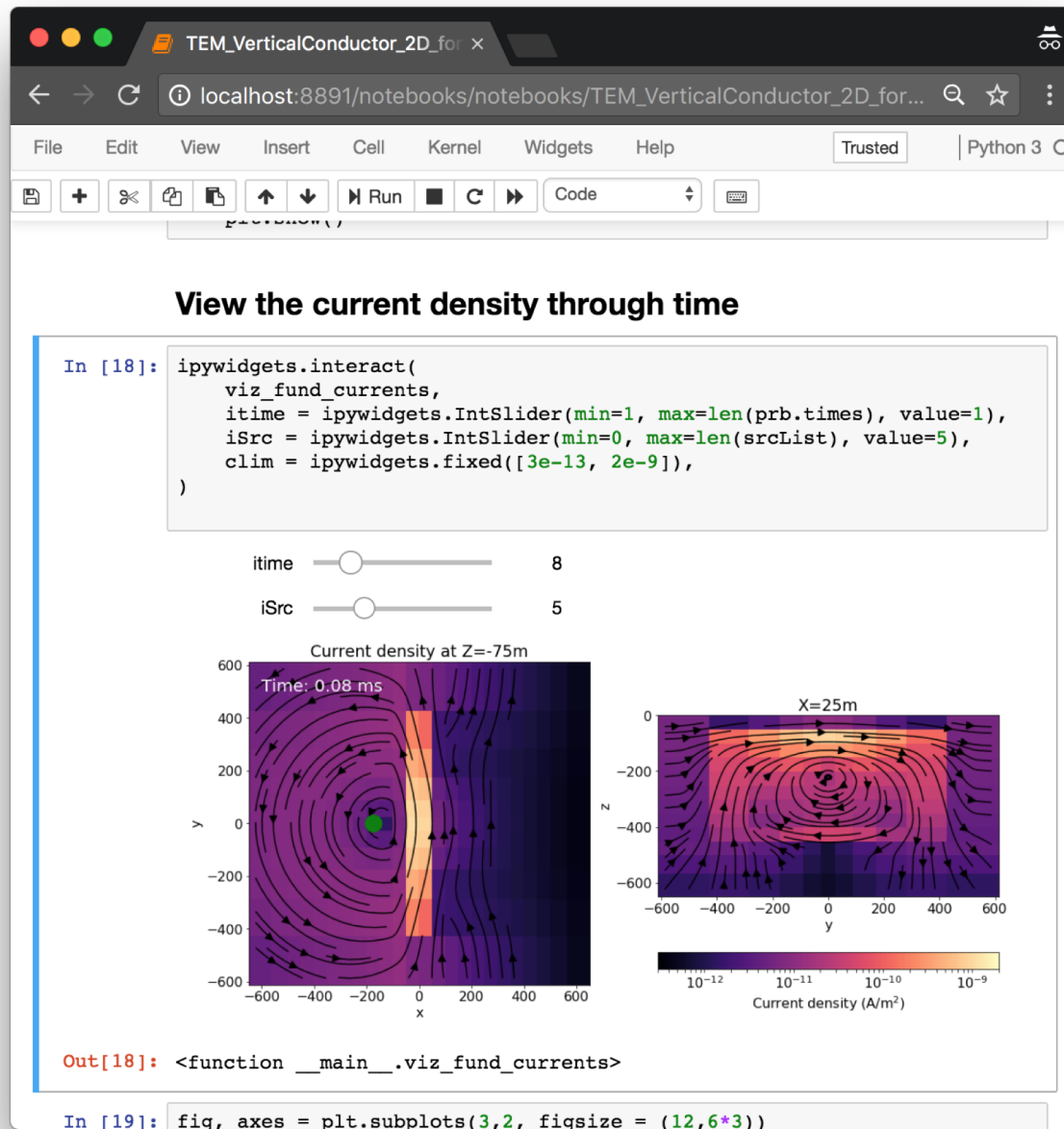


<http://simpeg.xyz>

SimPEG: Inversion framework

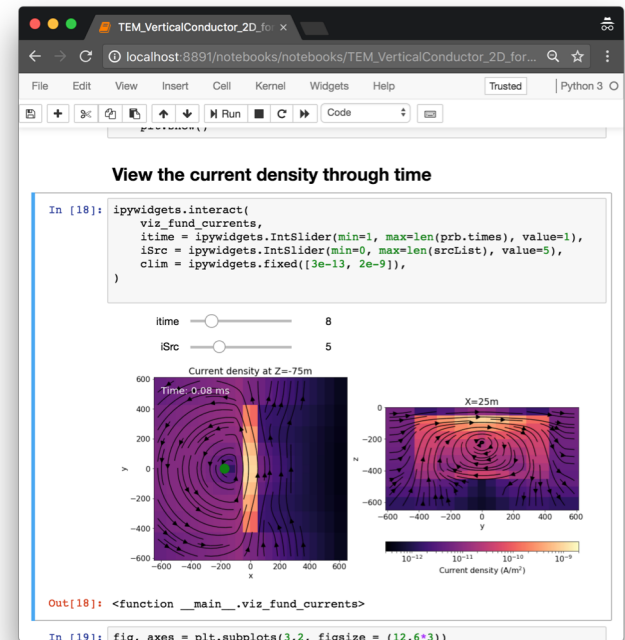


Notebook Demo: Plate in a Halfspace



Summary

- Need for Open source
- Open source eco-system
- SimPEG
- Jupyter notebooks and demos
 - Forward simulation
 - Inversion
- Benefits
 - Collaborating
 - Reproducibility,
 - Learning



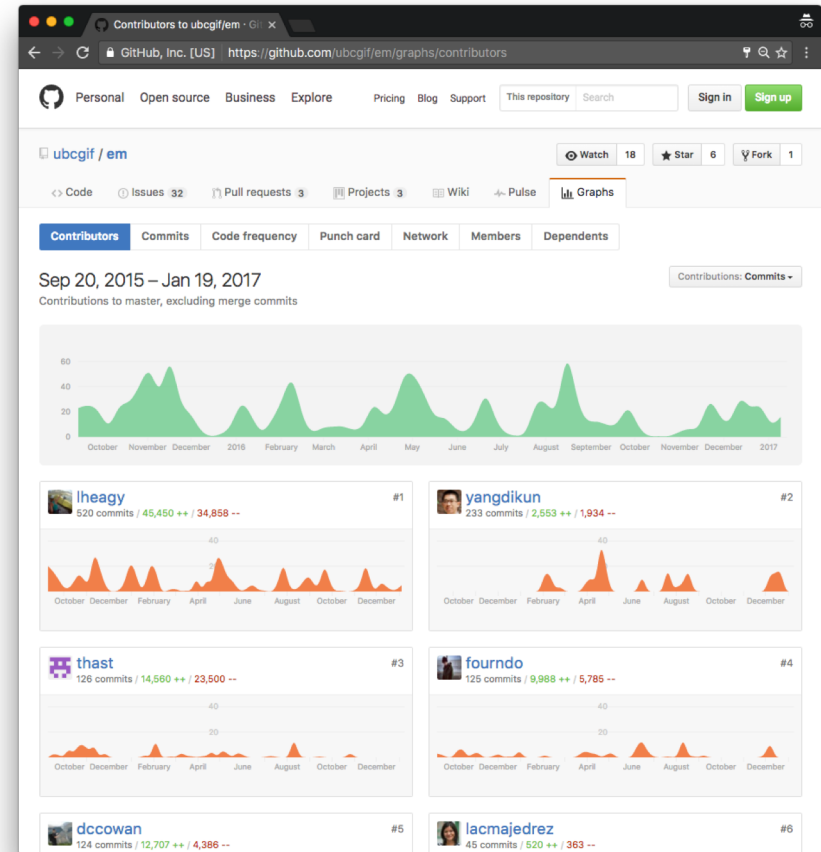
Web and Open Source Resources

- Open source development:
Software and resources
 - Collaborate
 - Share
 - Test changes
 - Interactive computing



Simulation and Parameter Estimation in Geophysics

<http://simpeg.xyz>



Github

versioning, collaborating



Travis CI

testing, deploy



Jupyter

interactive computing



Creative Commons

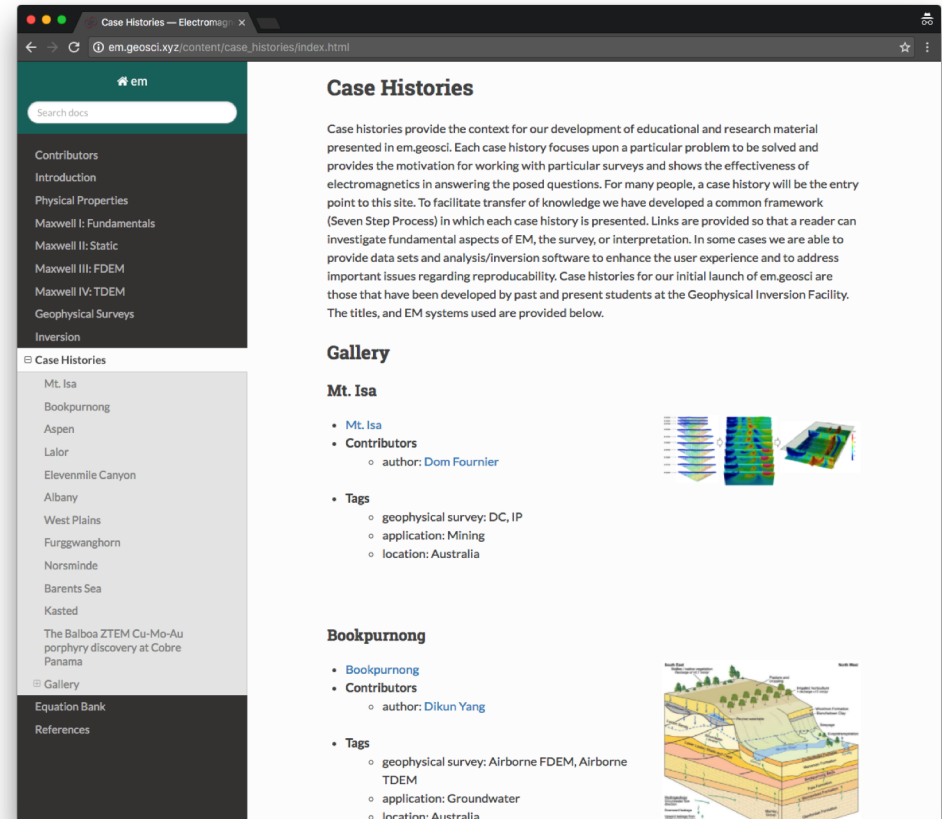
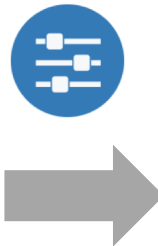
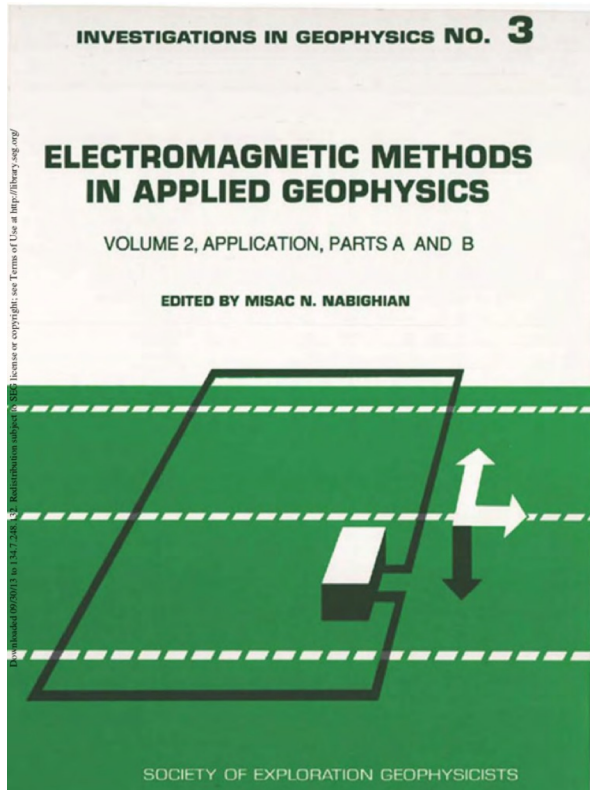
licensing, reuse



Python

computation

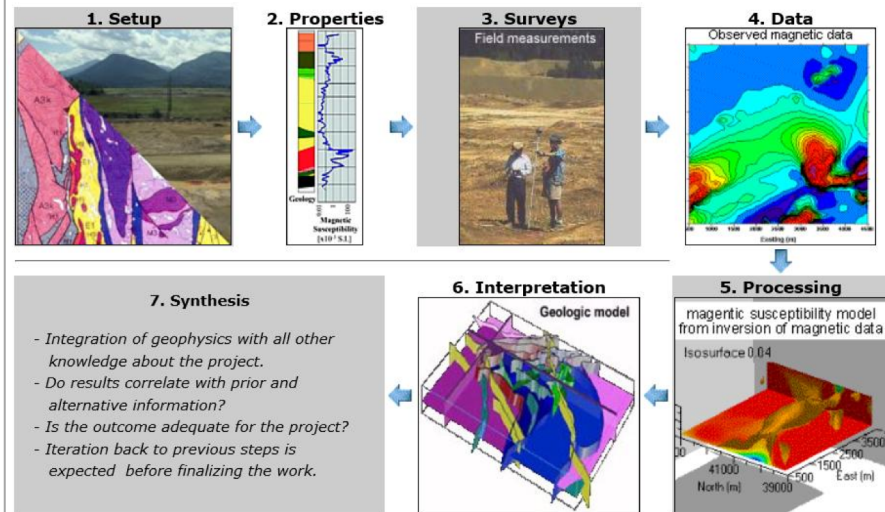
Resources: EM.geosci



<http://em.geosci.xyz>

Resources: EM.geosci

7 step framework for Case Histories



Case Histories — Electromag: x

em.geosci.xyz/content/case_histories/index.html

em

Search docs

Contributors

Introduction

Physical Properties

Maxwell I: Fundamentals

Maxwell II: Static

Maxwell III: FDEM

Maxwell IV: TDEM

Geophysical Surveys

Inversion

Case Histories

Mt. Isa

Bookpurnong

Aspen

Lalor

Elevenmile Canyon

Albany

West Plains

Furggswanghorn

Norsminde

Barents Sea

Kasted

The Balboa ZTEM Cu-Mo-Au porphyry discovery at Cobre Panama

Gallery

Equation Bank

References

Case Histories

Case histories provide the context for our development of educational and research material presented in em.geosci. Each case history focuses upon a particular problem to be solved and provides the motivation for working with particular surveys and shows the effectiveness of electromagnetics in answering the posed questions. For many people, a case history will be the entry point to this site. To facilitate transfer of knowledge we have developed a common framework (Seven Step Process) in which each case history is presented. Links are provided so that a reader can investigate fundamental aspects of EM, the survey, or interpretation. In some cases we are able to provide data sets and analysis/inversion software to enhance the user experience and to address important issues regarding reproducibility. Case histories for our initial launch of em.geosci are those that have been developed by past and present students at the Geophysical Inversion Facility. The titles, and EM systems used are provided below.

Gallery

Mt. Isa

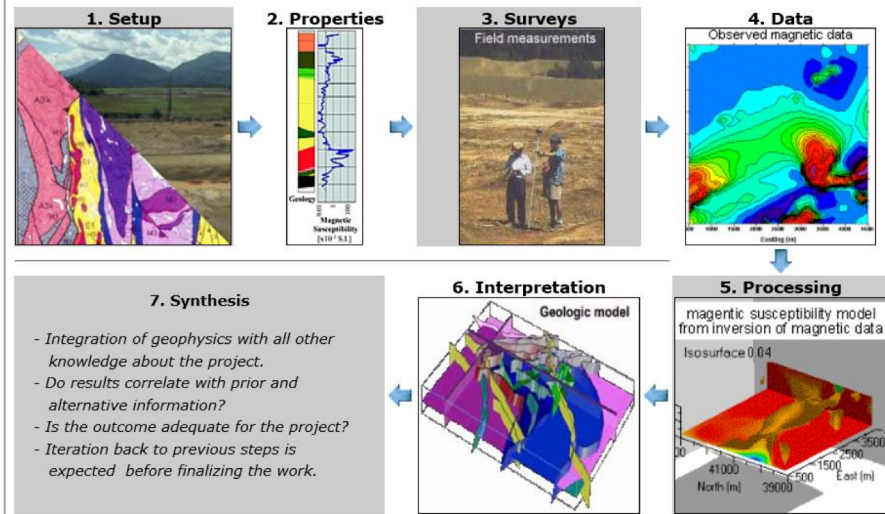
- [Mt. Isa](#)
- [Contributors](#)
 - author: Dom Fournier
- [Tags](#)
 - geophysical survey: DC, IP
 - application: Mining
 - location: Australia

Bookpurnong

- [Bookpurnong](#)
- [Contributors](#)
 - author: Dikun Yang
- [Tags](#)
 - geophysical survey: Airborne FDEM, Airborne TDEM
 - application: Groundwater
 - location: Australia

Resources: EM.geosci

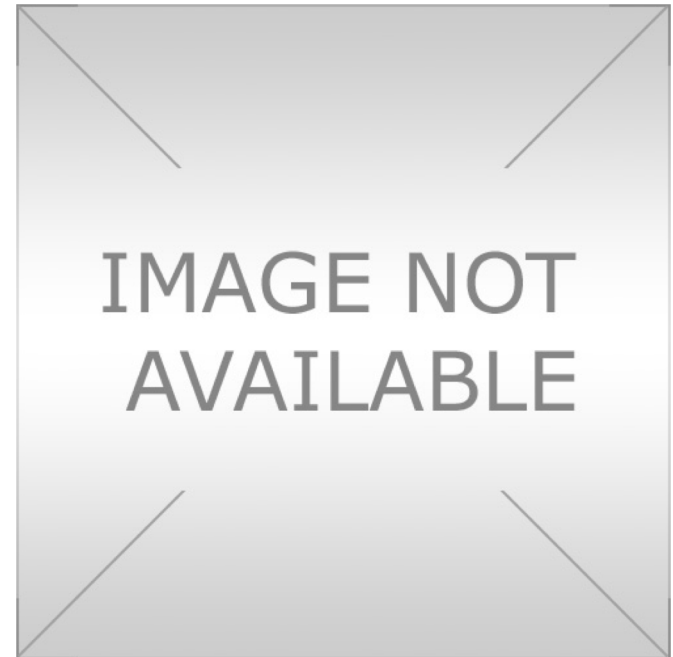
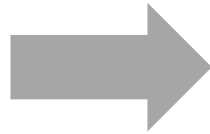
7 step framework for Case Histories



Why Apps

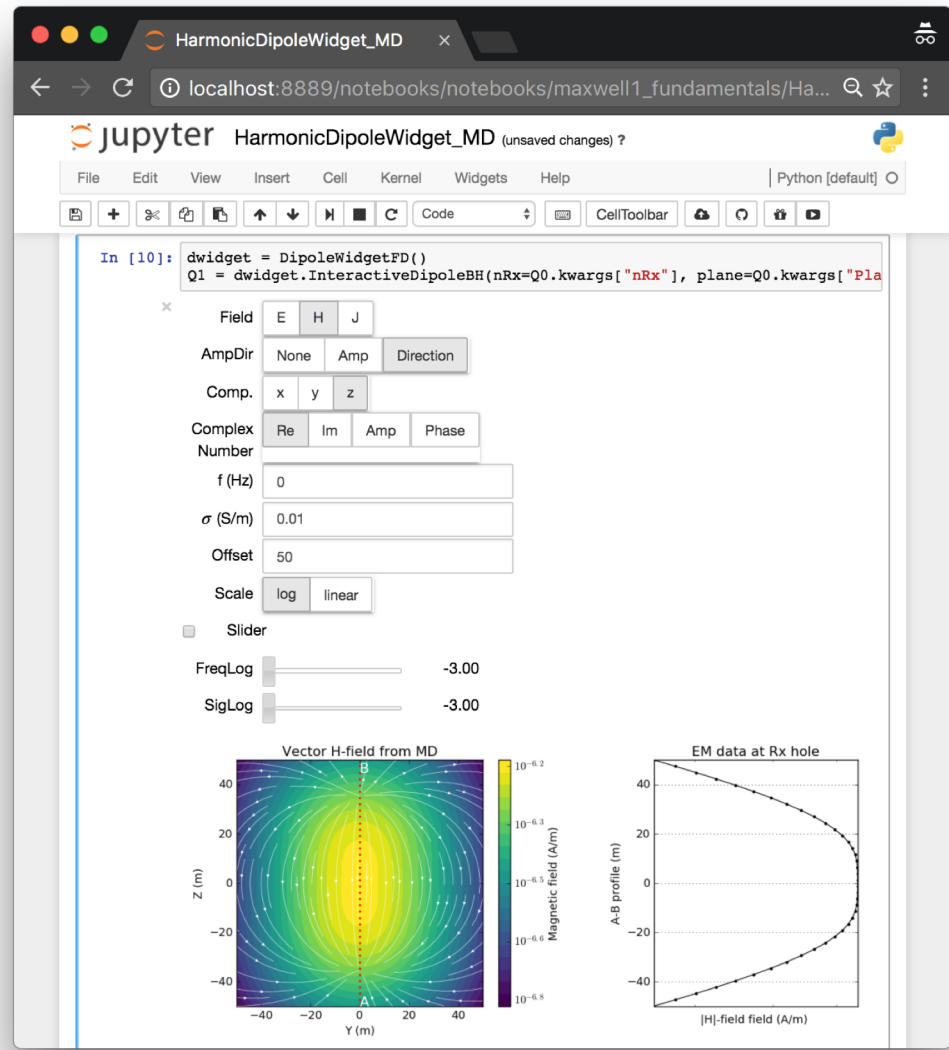
$$\nabla \times \mathbf{e} = -\frac{\partial \mathbf{b}}{\partial t}$$

$$\nabla \times \mathbf{h} = \mathbf{j} + \frac{\partial \mathbf{d}}{\partial t}$$



Why Apps

$$\nabla \times \mathbf{e} = -\frac{\partial \mathbf{b}}{\partial t}$$
$$\nabla \times \mathbf{h} = \mathbf{j} + \frac{\partial \mathbf{d}}{\partial t}$$



Goals

- Motivation (questions supplemented with images)
 - We've seen Aarhus workshop; great examples; much information obtained with LCI;
 - What happens if the situation is 3D
 - how do the fields behave; do we need to work in 3D
 - If we decide to work in 3D what are we up against;
 - Forward modelling
 - Inversion
- Open Source plays a critical role in achieving goals
 - Talk more about this on Tuesday
 - Today: illustrate the benefits and needs of adopting this paradigm

Connecting & Contributing

- Today: Slack
 - <http://slack.geosci.xyz/>



Join **GeoSci** on Slack.

3 users online now of **9** registered.

you@yourdomain.com

GET MY INVITE

- Contributing:
 - EM GeoSci
 - Case histories
 - Content
 - SimPEG
 - Software

