



capturing knowledge in code

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UC Berkeley & Project Jupyter

@lindsey_jh

Thank you!



Gonzalo
Peña



Carlos
Córdoba



Fernando
Pérez



Rowan
Cockett



Seogi
Kang

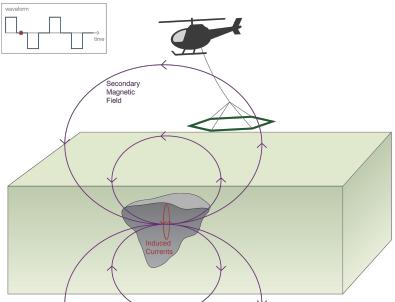


Doug
Oldenburg



hello (a bit about me)

geophysical inversions



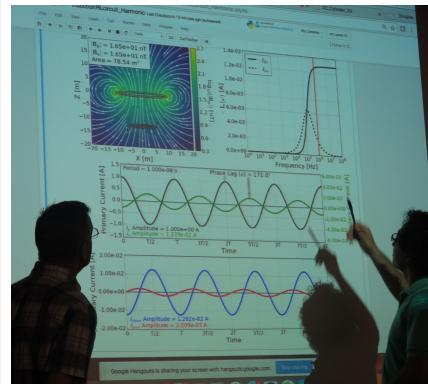
THE UNIVERSITY
OF BRITISH COLUMBIA

open-source software



simpeg

open research &
education



GeoSci
•xyz

Jupyter, geoscience + data science



Berkeley
UNIVERSITY OF CALIFORNIA

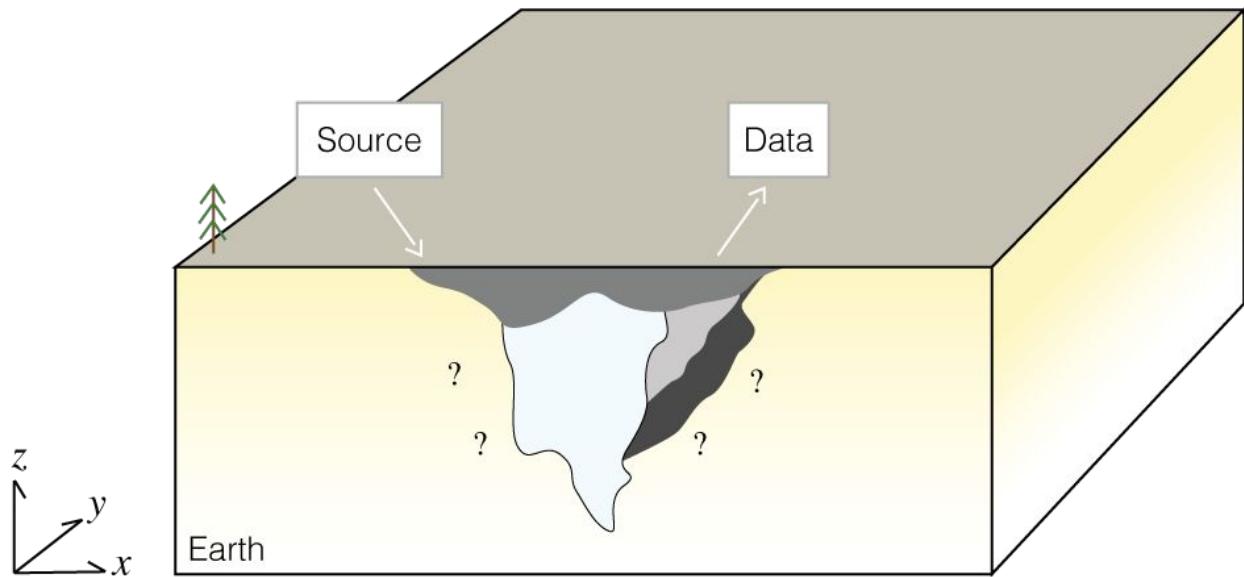
geophysics!

?

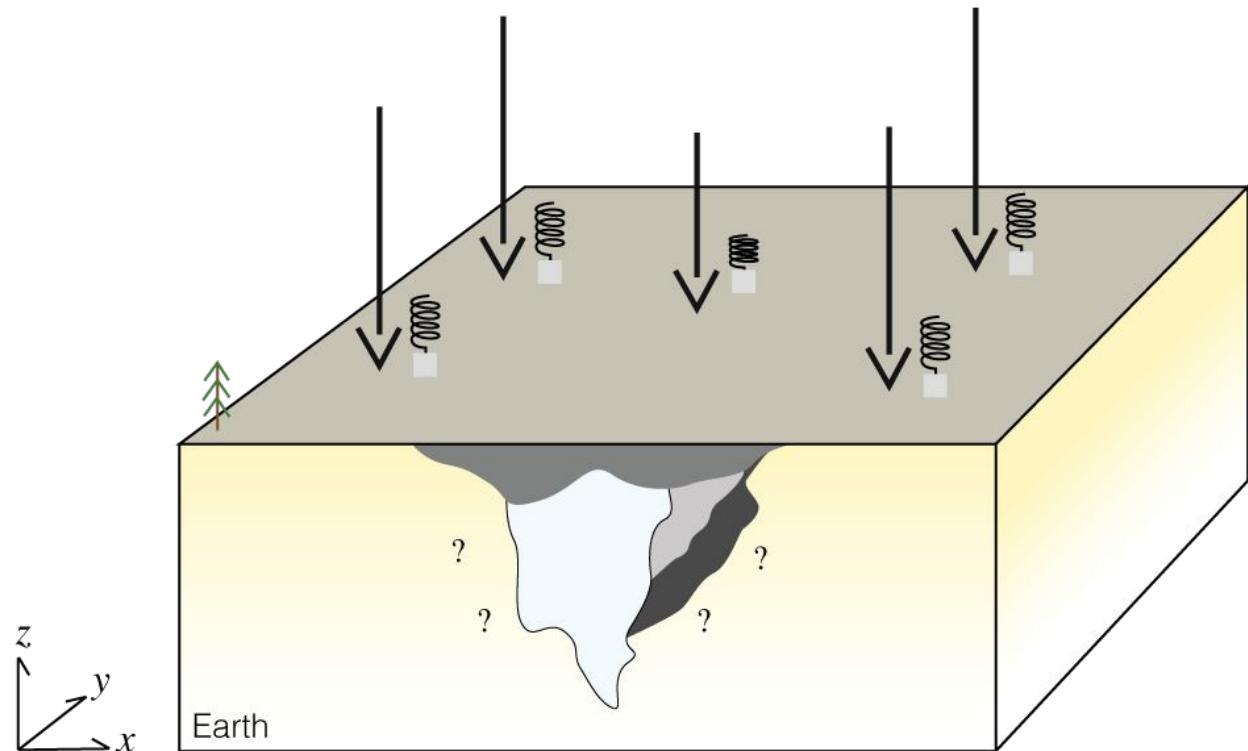
imaging the subsurface



imaging the subsurface

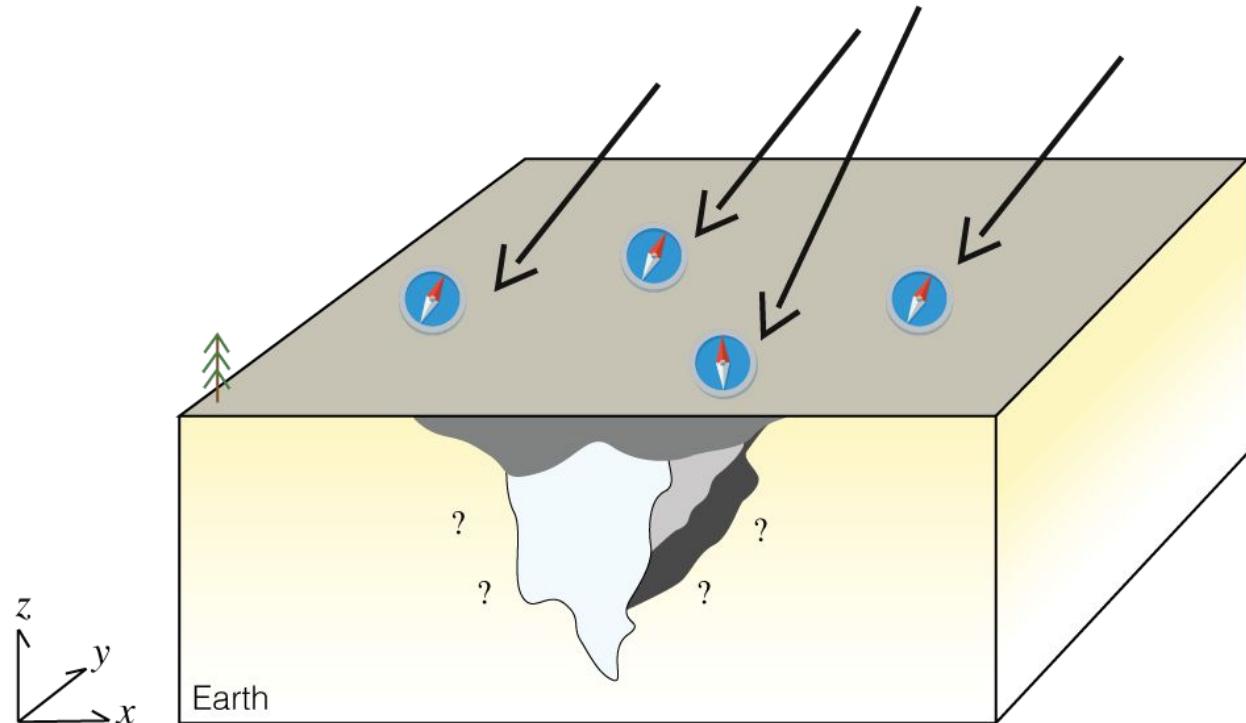


imaging the subsurface



Gravity

imaging the subsurface

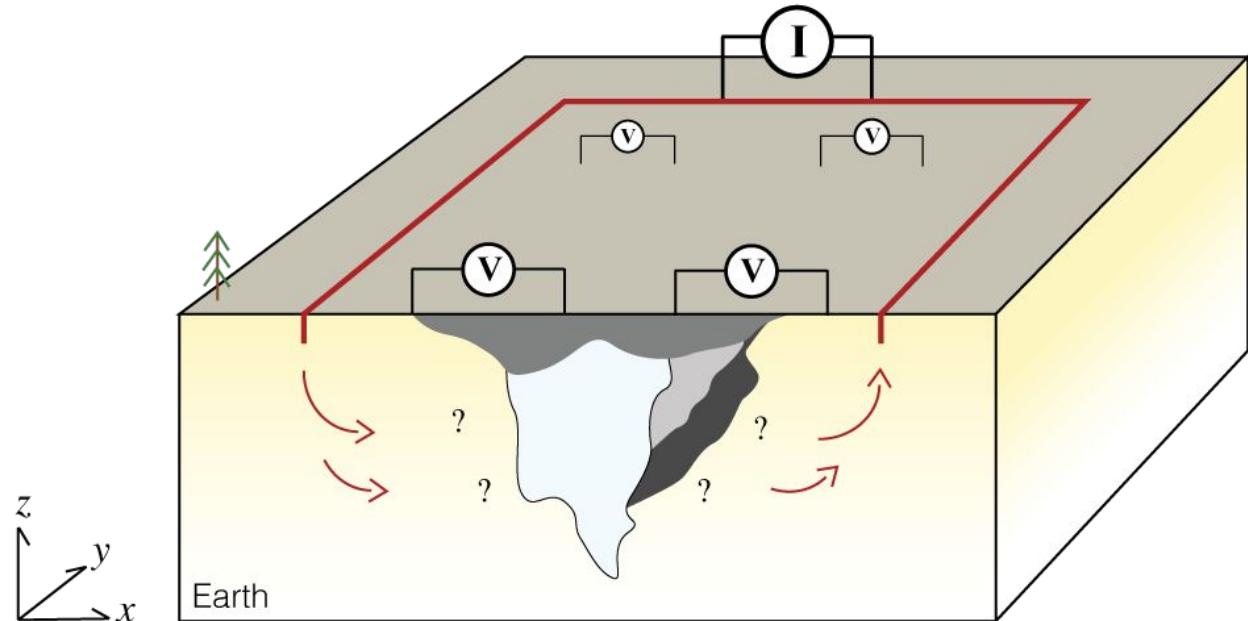


x
 y
 z

Earth

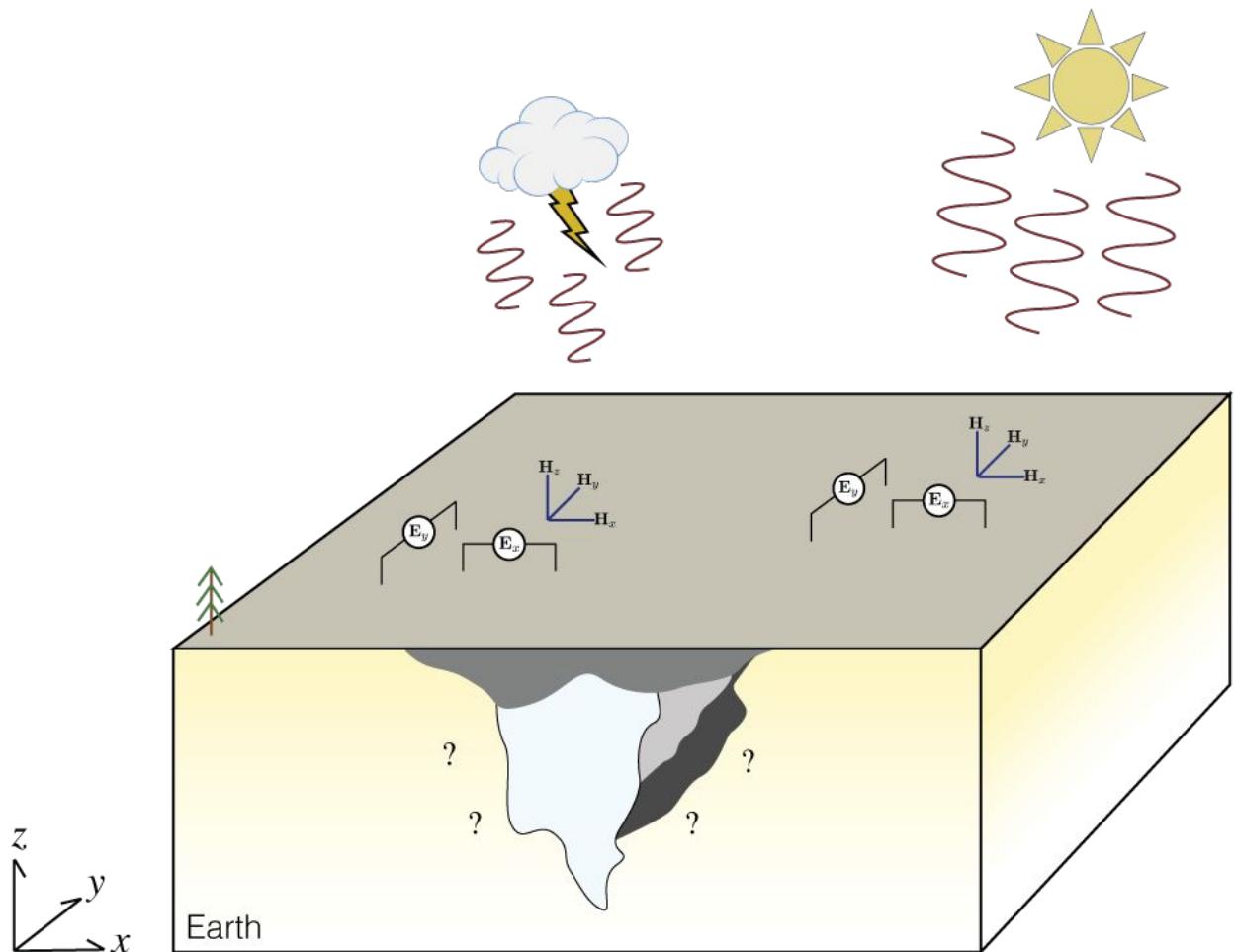
Magnetics

imaging the subsurface

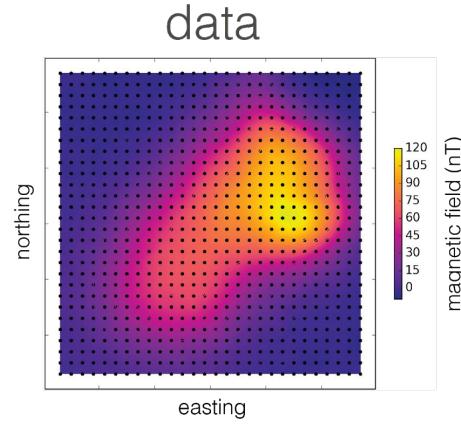
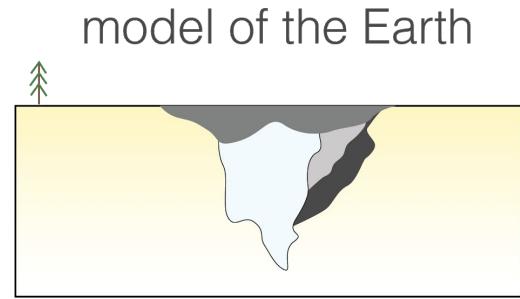


Direct current resistivity

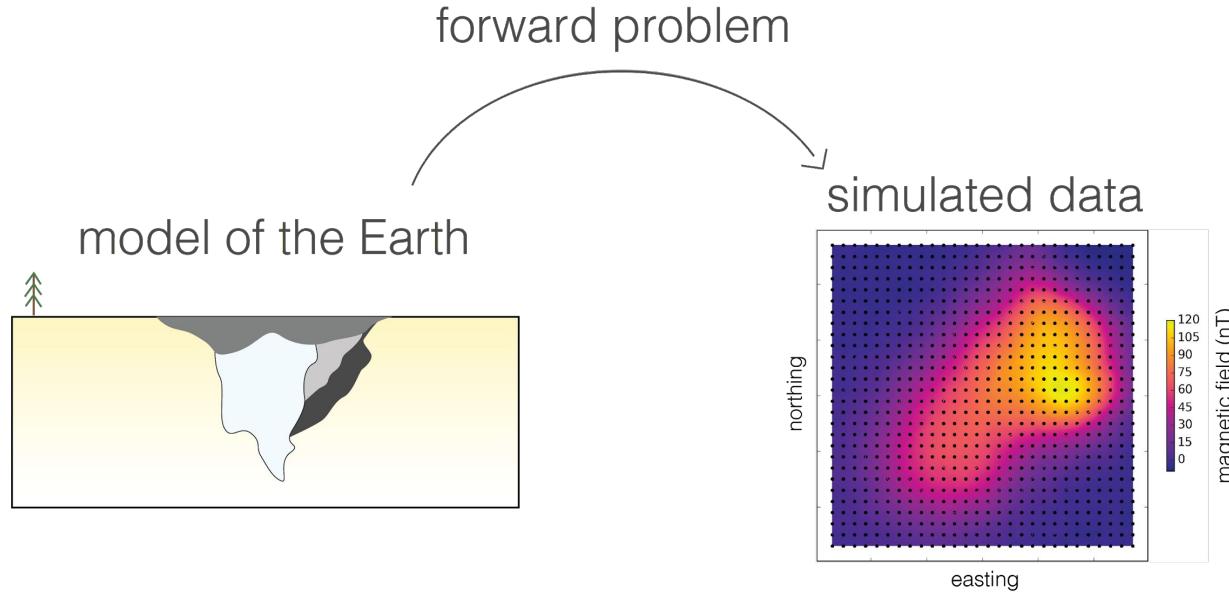
imaging the subsurface



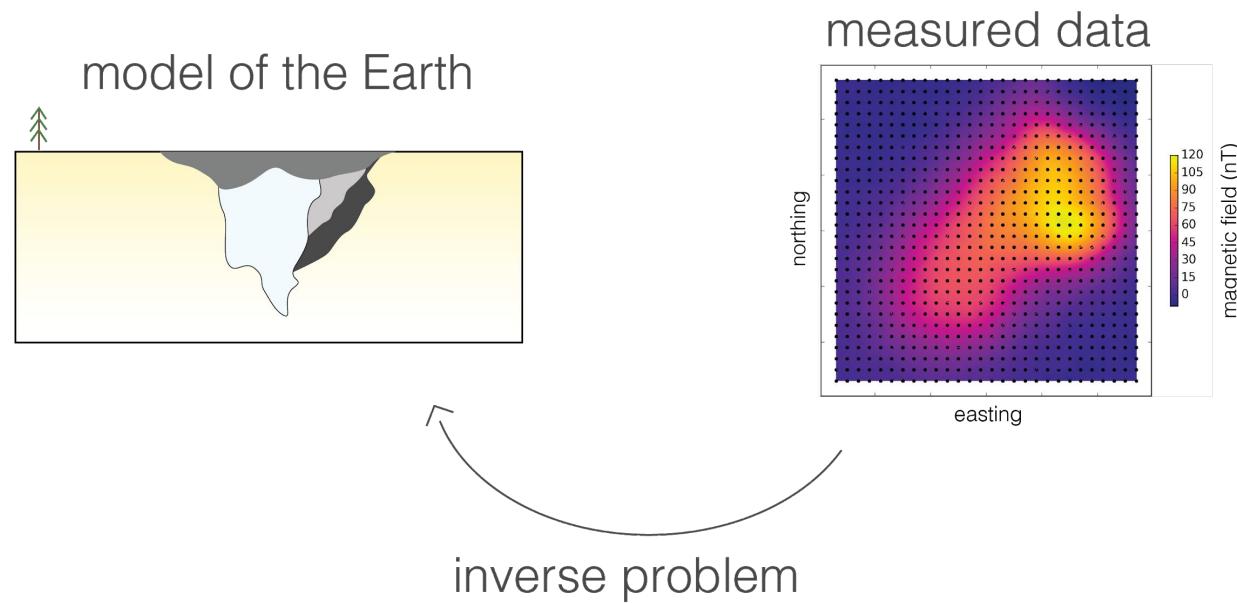
forward and inverse problems



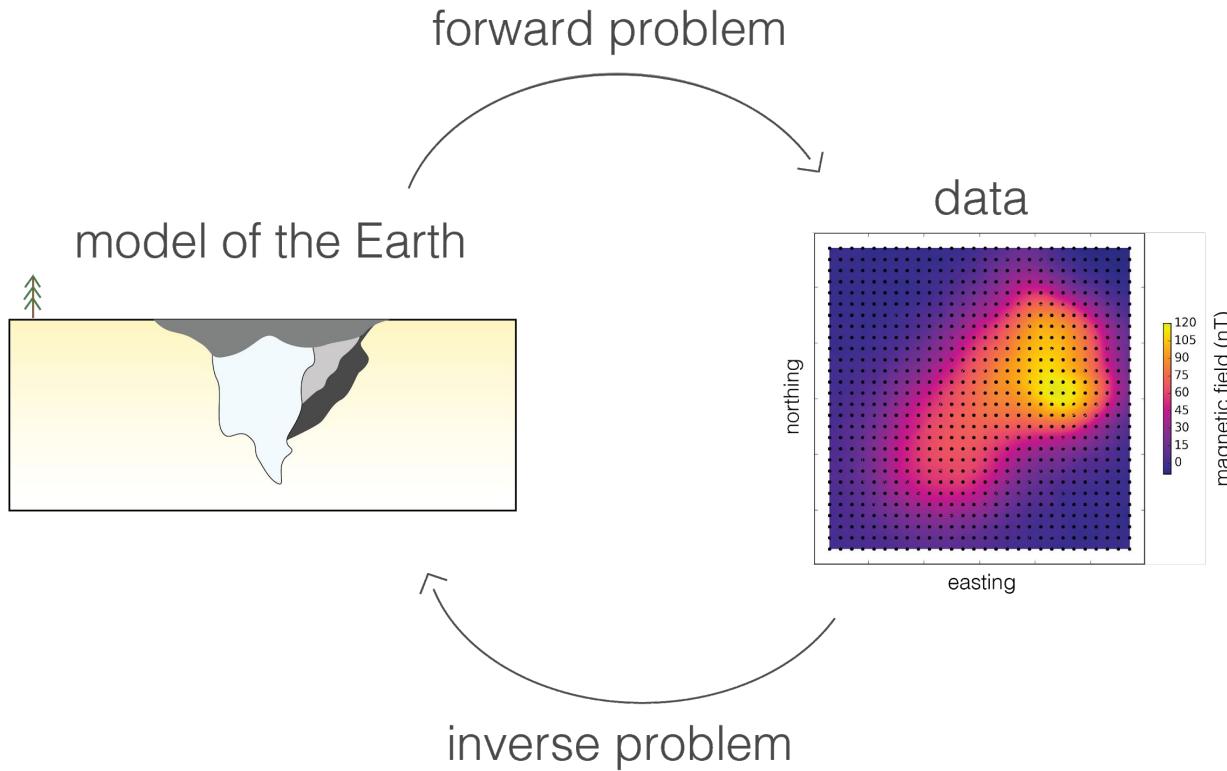
forward and inverse problems



forward and inverse problems

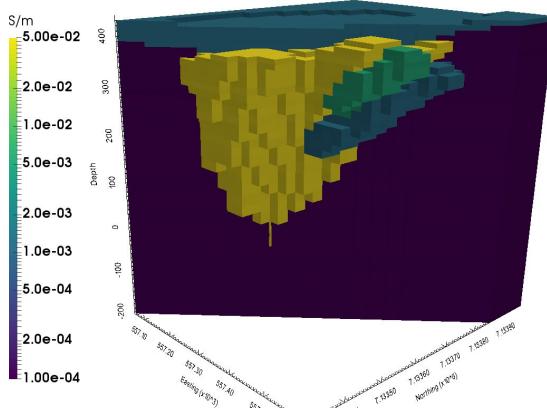


forward and inverse problems



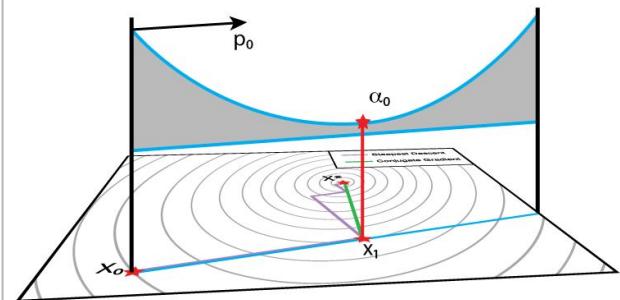
tools

Numerical simulations:
predict data



$$\nabla \cdot \sigma \nabla \phi = q$$

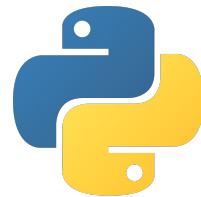
Optimization:
estimate a model



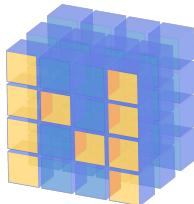
$$\underset{\mathbf{m}}{\text{minimize}} \quad \phi(\mathbf{m}) = \phi_d(\mathbf{m}) + \beta\phi_m(\mathbf{m})$$

$$\text{s.t.} \quad \phi_d \leq \phi_d^*, \quad \mathbf{m}_i^L \leq \mathbf{m}_i \leq \mathbf{m}_i^H$$

standing on
shoulders



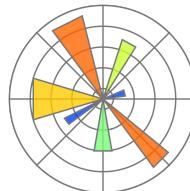
language, object-oriented structure



arrays, linear algebra

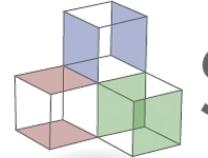


sparse matrices, interpolation

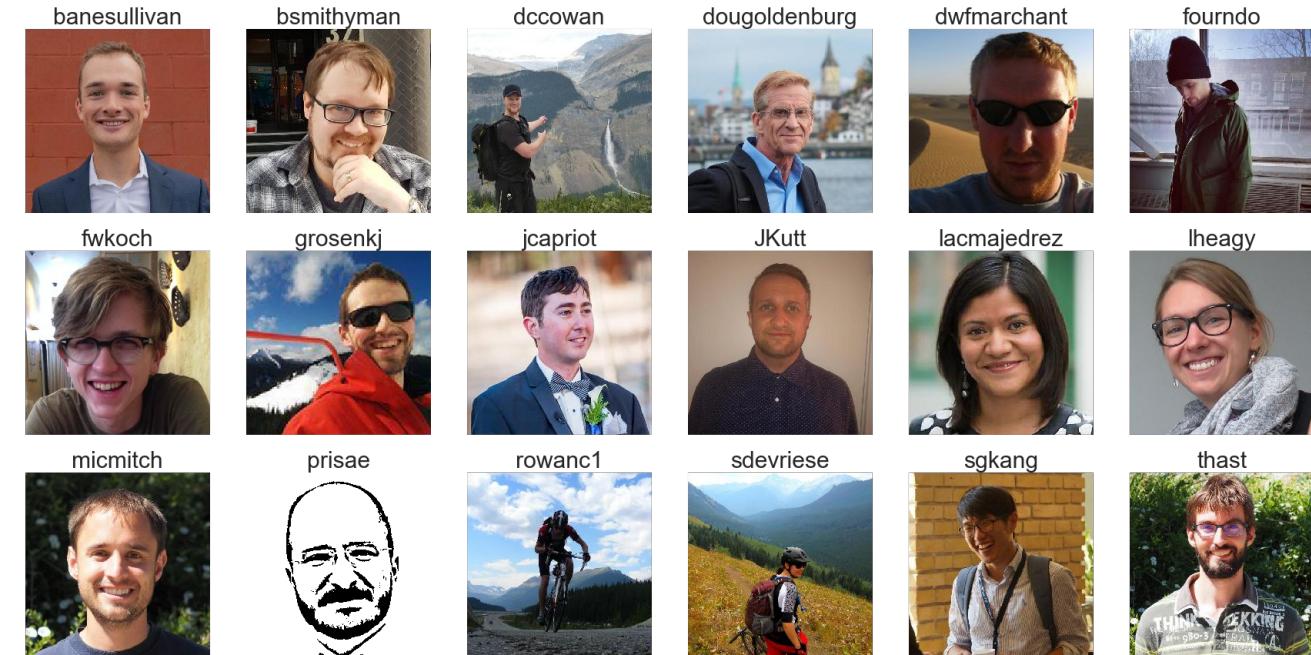


visualization

a common framework for geophysics



simpeg



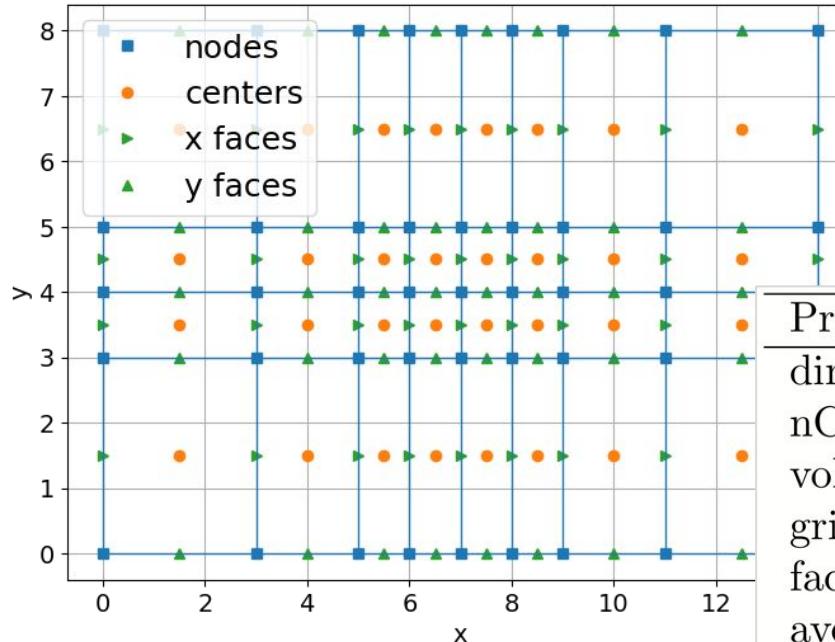
gravity, magnetics, electromagnetics, fluid flow...

```

hx = [3, 2, 1, 1, 1, 1, 2, 3]
hy = [3, 1, 1, 3]
mesh = discretize.TensorMesh([hx, hy])
mesh.plotGrid(faces=True, nodes=True, centers=True)

```

simulation



Property or Function
dim, x0
nC, nN, nF, nE
vol, area, edge
gridN, gridCC, ...
faceDiv, edgeCurl, cellGrad
aveF2CC, aveN2CC, etc.
getEdgeInnerProduct()
getInterpolationMat(loc)

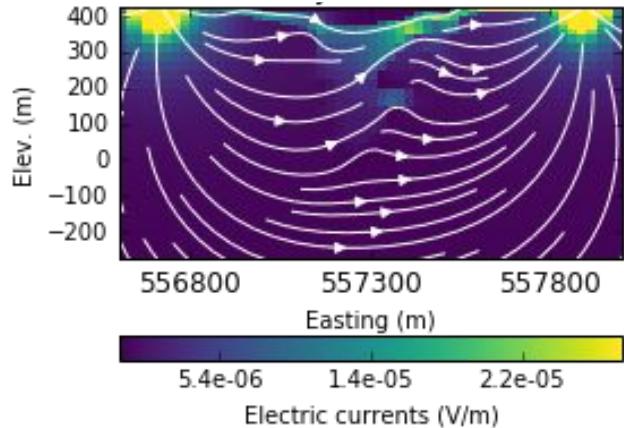
simulation

DC resistivity

$$\nabla \cdot \sigma \nabla \phi = q$$

discrete equations

$$\mathbf{DM}_\sigma^f \mathbf{G} \phi = \mathbf{q}$$



```
D = mesh.faceDiv
```

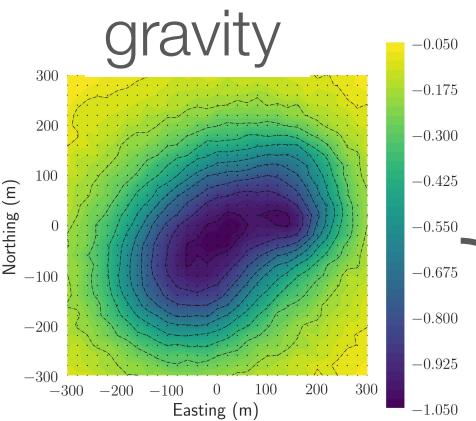
```
Mfσ = mesh.getFaceInnerProduct(sigma)
```

```
G = mesh.faceDiv.T
```

```
A = D * Mfσ * G
```

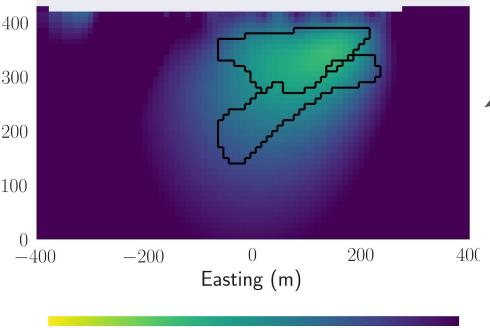
```
Ainv = Solver(A) # acts like A inverse  
phi = Ainv * q
```

inversion

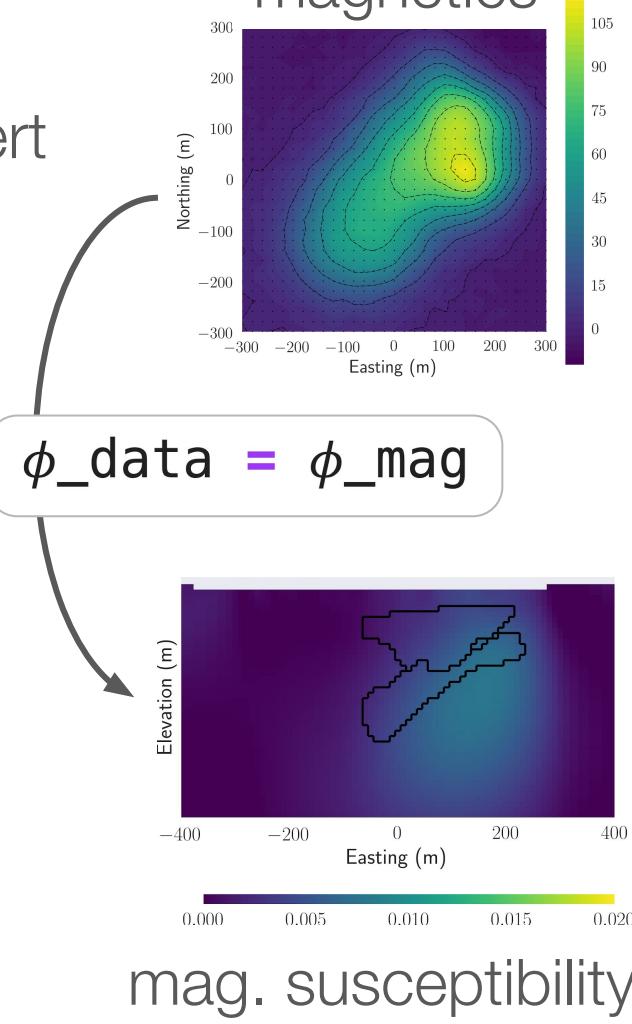
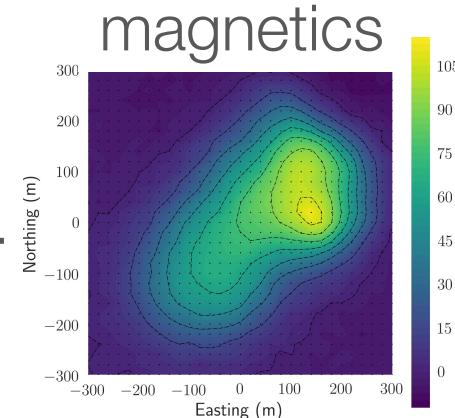


invert

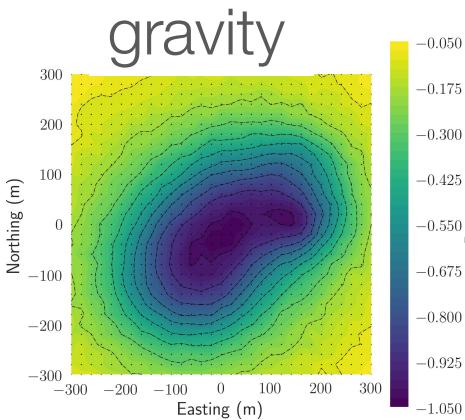
$$\phi_{\text{data}} = \phi_{\text{grav}}$$



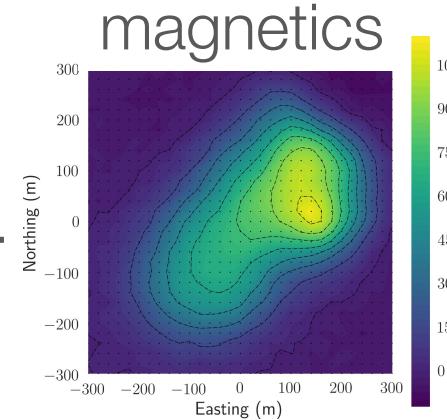
density



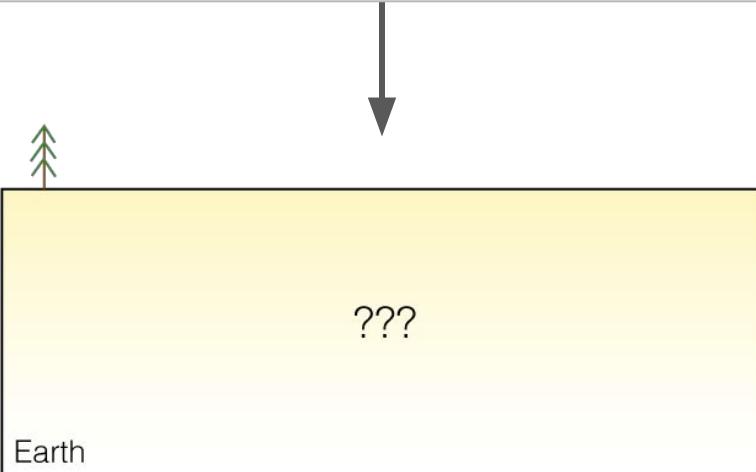
inversion



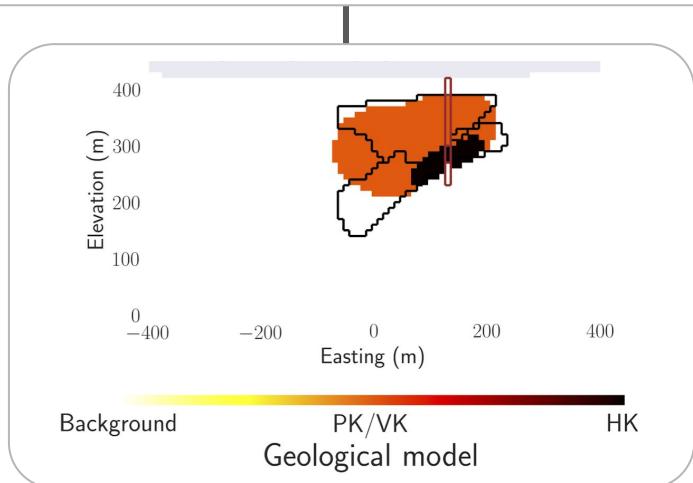
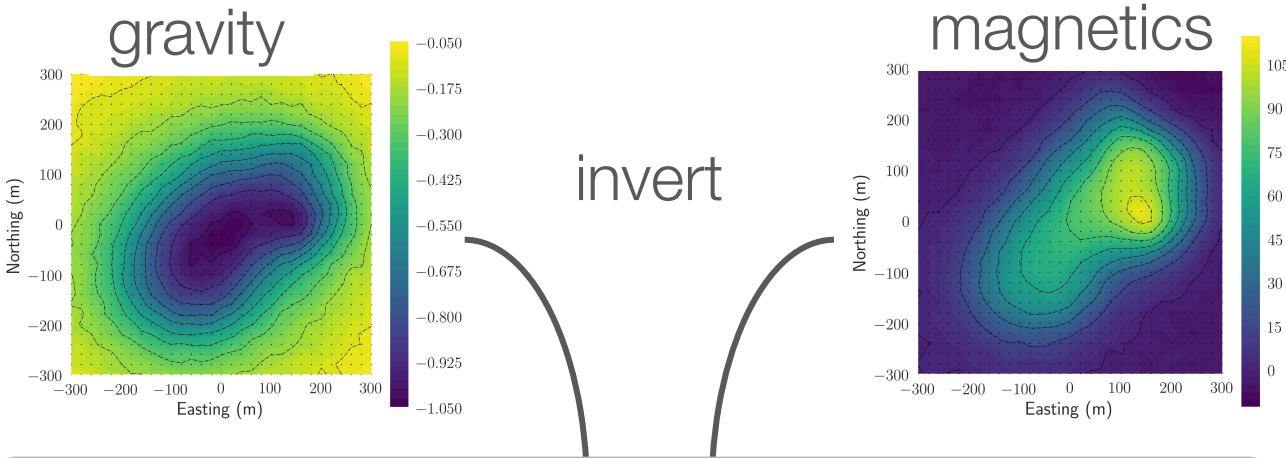
invert



$$\phi_{\text{data}} = \phi_{\text{grav}} + \phi_{\text{mag}} \quad \# \text{ one earth?}$$

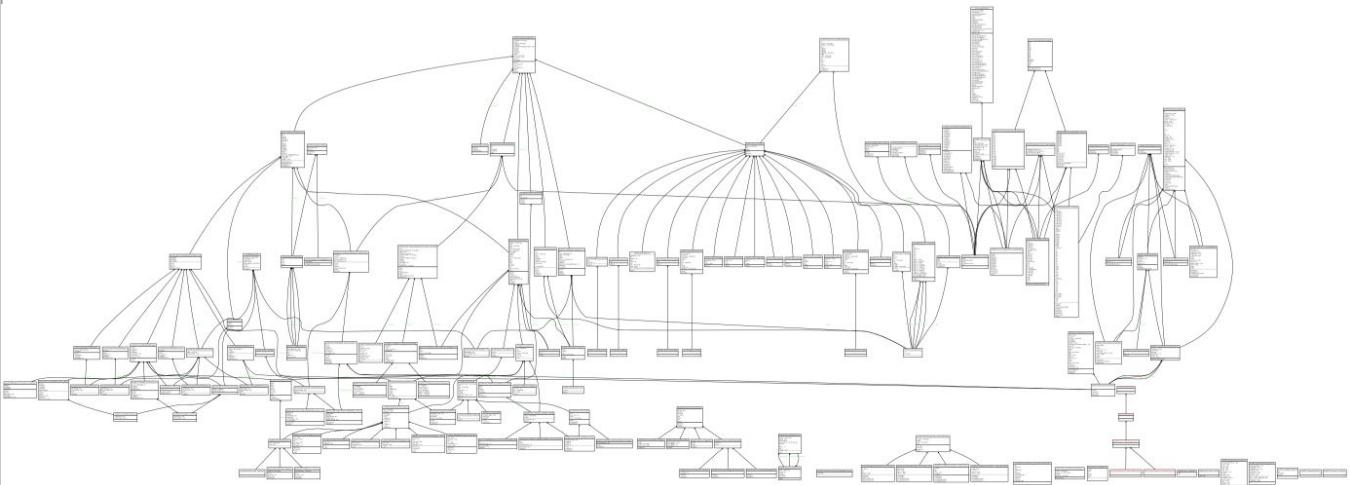


inversion



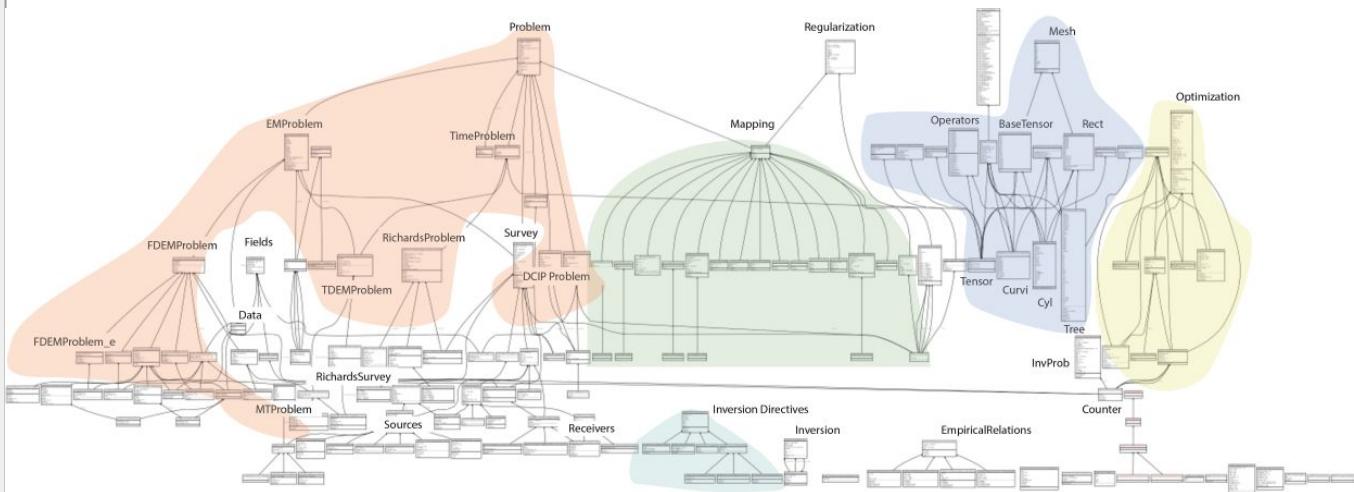
class inheritance diagram

modular,
object
oriented



class inheritance diagram

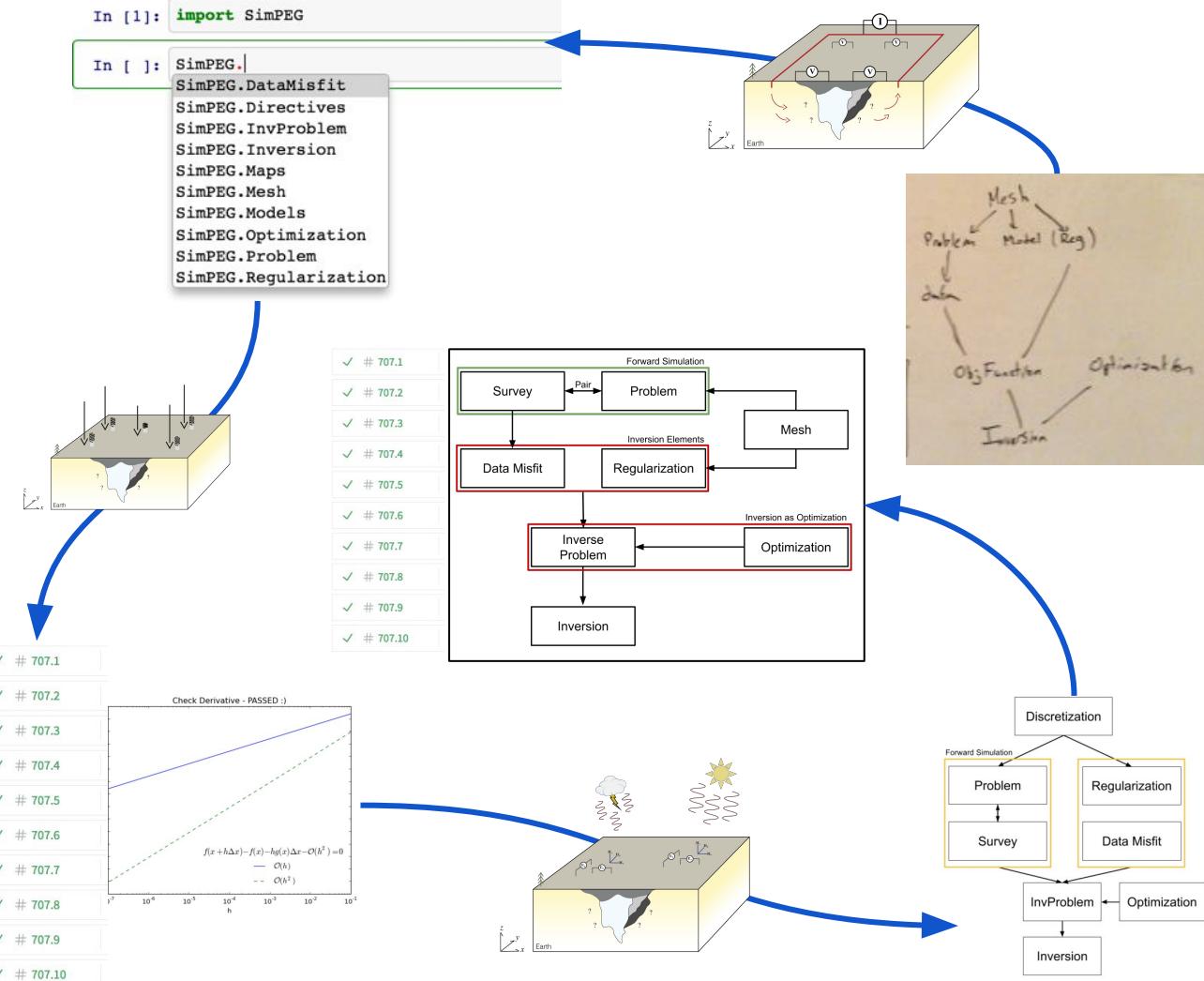
modular,
object
oriented



267,614 → 59,111

4.5x

testing & refactoring



testing & refactoring

code
comparisons



mathematical
properties

analytic
solutions

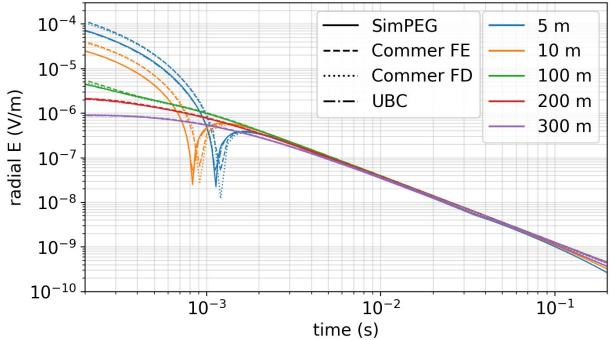
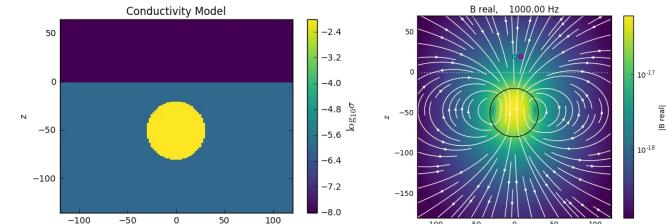
confidence



vector identity: $\nabla \cdot \nabla \times \vec{v} = 0$

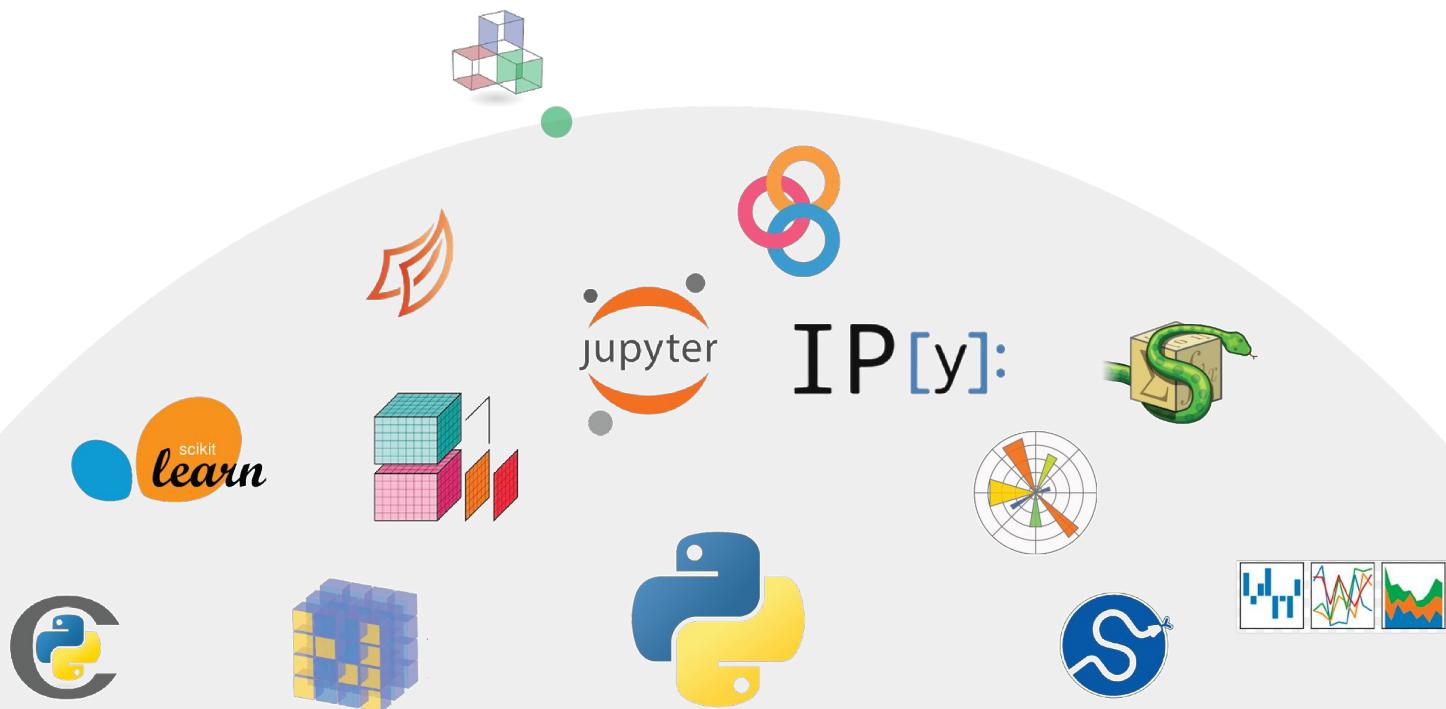
```
[2]: v = np.random.rand(mesh.nE)  
np.all(mesh.faceDiv * mesh.edgeCurl * v == 0)
```

```
[2]: True
```



an open, modular ecosystem

remix for diverse use-cases: research & education



repurposing:
education

$$\nabla \cdot \sigma \nabla \phi = q \rightarrow$$

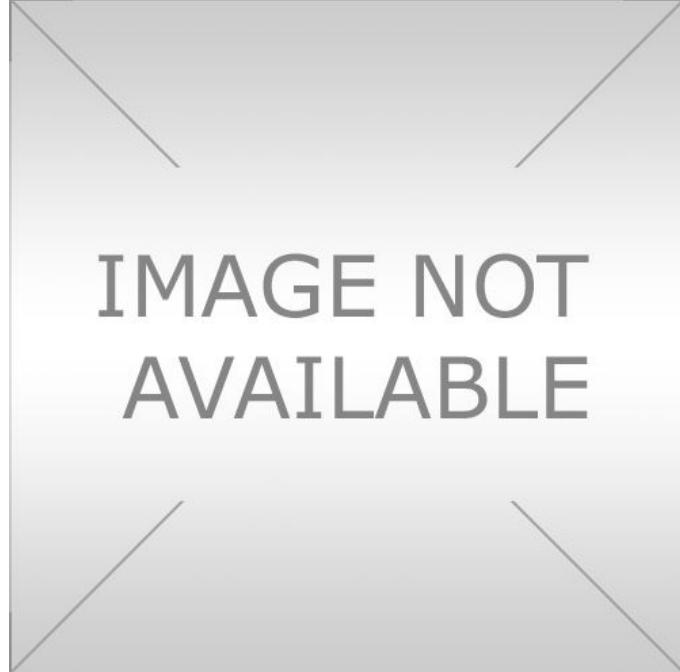
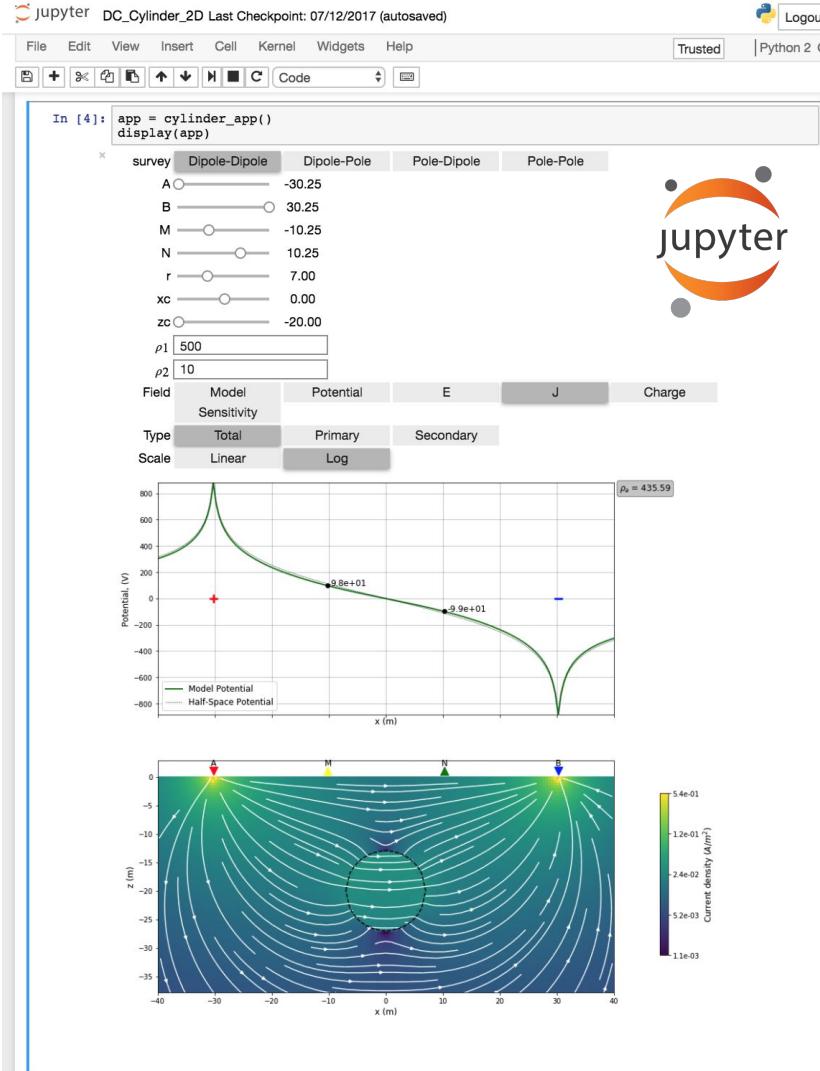


IMAGE NOT
AVAILABLE

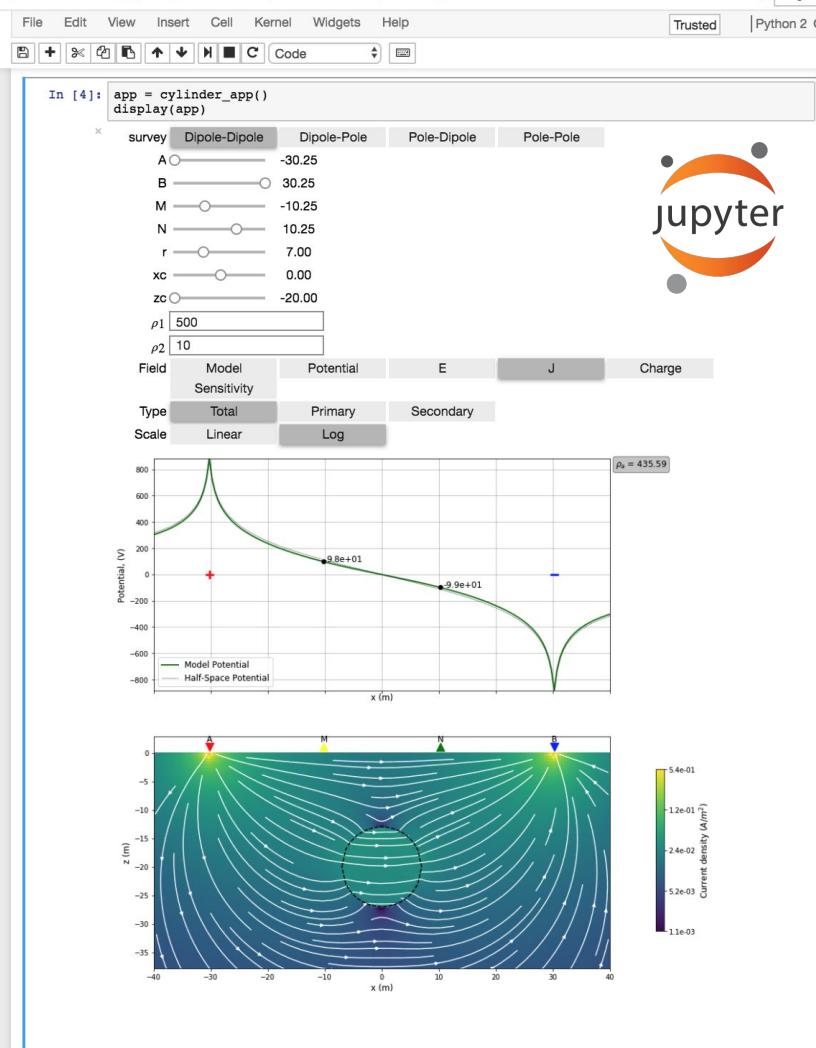
repurposing: education

$$\nabla \cdot \sigma \nabla \phi = q$$





repurposing: education

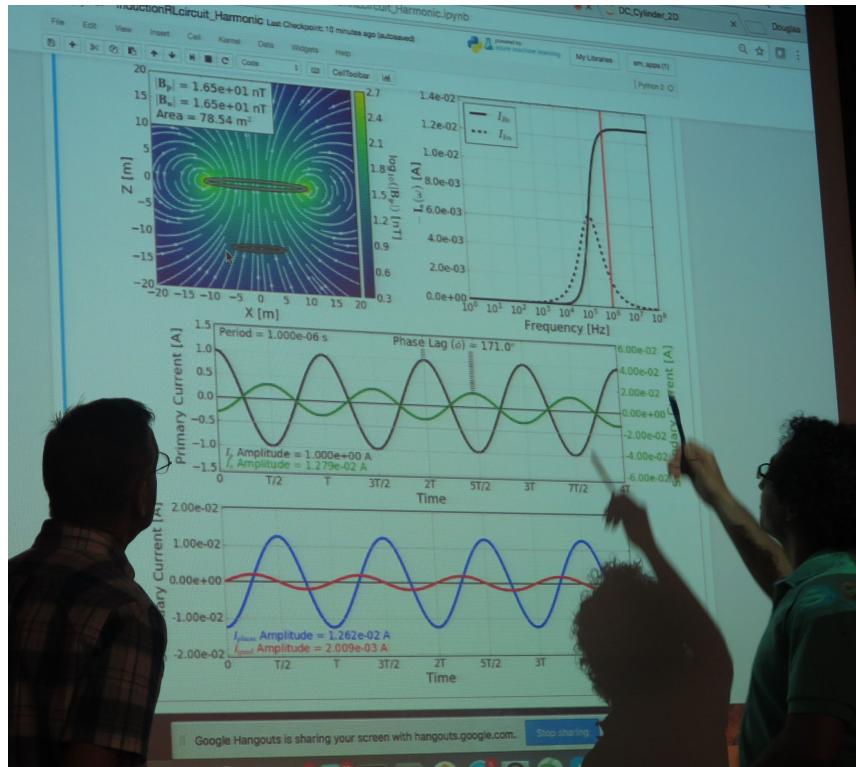


repurposing: conversation



[ipy]widgets

voila



repurposing: conversation

The screenshot shows the homepage of GeoSci.xyz. At the top, there's a navigation bar with links for 'why', 'who', 'presentations', and 'contact'. Below the navigation, there are four main service sections: 'GPG' (Geophysics for Practising Geoscientists) with a heatmap icon, 'EM' (Electromagnetic geophysics) with a magnetic field vector field icon, 'SimPEG' (Simulation and Parameter Estimation in Geophysics) with a 3D cube icon, and 'Case Histories' (Applications of EM Geophysics) with a 3D geological model icon. At the bottom left, there's a logo for 'DISC 2017' (Geophysical Electromagnetics: Fundamentals & Applications) featuring three overlapping red and black circles.

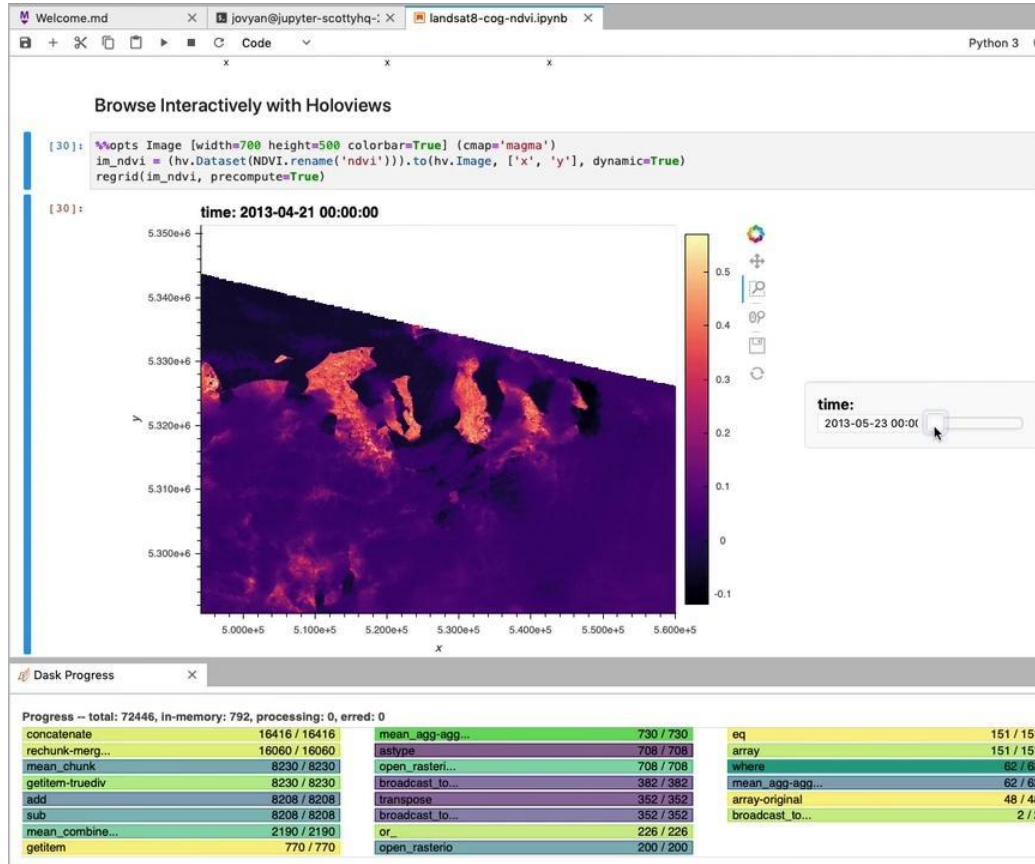
DISC 2017: 26 locations



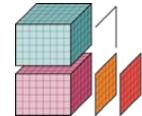


PANGEO

collaborative research

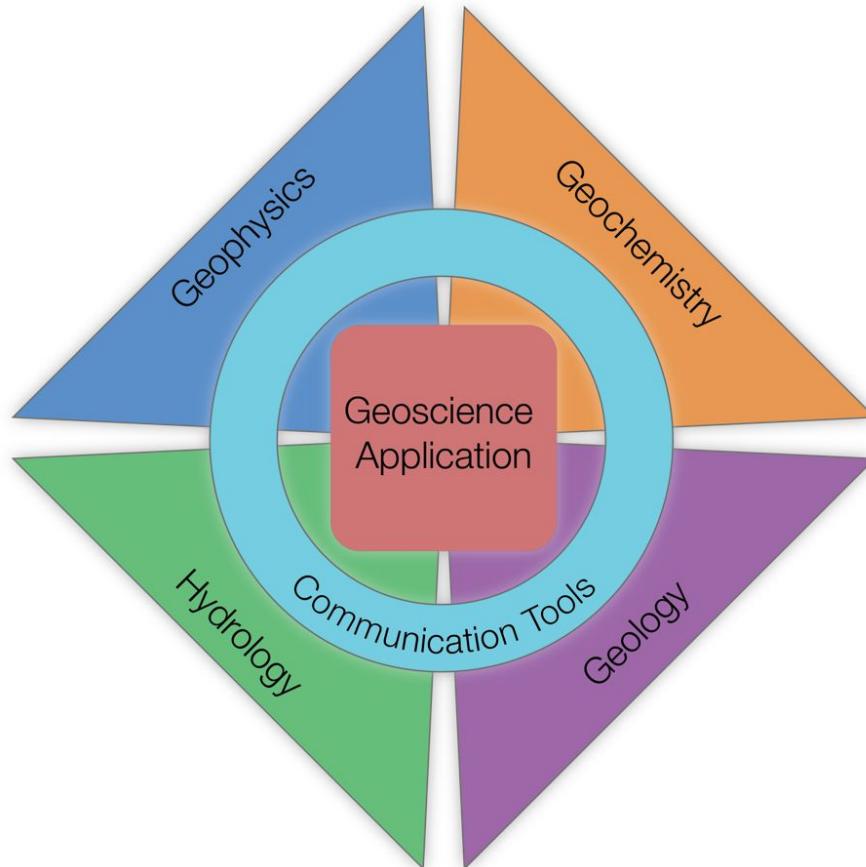


DASK

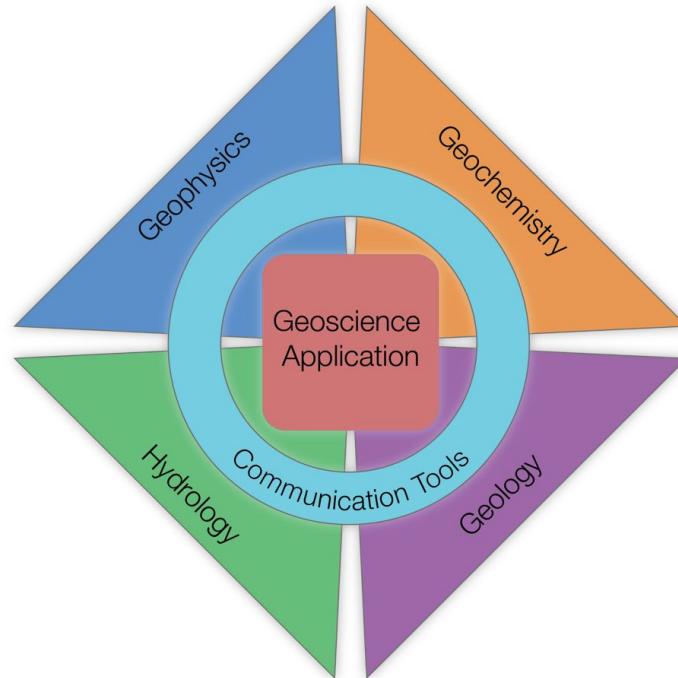


xarray

collaborative research



collaborative research



code
notebooks
documentation
domain knowledge

capturing
knowledge
in code

- build on the work of others
- organize your thoughts
- implement them
- test them
- try out a new idea
- refactor the implementation
- share with the wider community



Thank you!

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 @lindsey_jh

slides: <https://speakerdeck.com/lheagy/capturing-knowledge-in-code>

the end