empymod

empymod.github.io

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Features I

- Calculates the complete (diffusion and wave phenomena) 3D electromagnetic field in a layered-earth model.
- Vertical transverse isotropic (VTI) resistivity $\rho^{h,v}$.
- VTI electric permittivity $\varepsilon_r^{h,v}$.
- VTI magnetic permeability $\mu_r^{h,v}$.
- Electric and magnetic sources and receivers.
- Wavenumber, frequency, and time domain.
- Arbitrary rotated, finite dipoles.

Features II

- Hankel transforms
  - Adaptive quadrature
  - Fast Hankel transform
  - Quadrature with extrapolation
- Fourier transforms
  - Sine/Cosine-transforms
  - Quadrature with extrapolation
  - Fast Fourier Transform
  - Logarithmic Fast Fourier Transform
- Analytical solutions
  - Complete full-space; f-domain
  - Diffusive half-space (only el. src & rec); f- & t-domains
    - Direct wave, reflected wave, airwave
    - TE-/TM-modes

Educational I: Understanding the code

Documented and referenced

Explicit, functional programming, no fancy stuff; easy to follow.

Main 4 files: 2192 lines of code; 2116 lines of comments

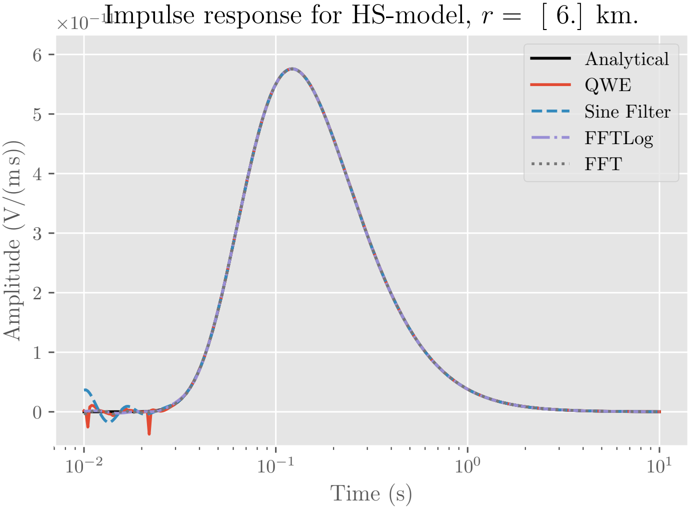
```
def reflections(depth, e_zH, Gam, lrec, lsrc, use_ne_eval):
    """Calculate Rp, Rm.

    This function corresponds to equations 64/65 and
    A-11/A-12 in [Hunziker_et_al_2015]_."""
```

```
    if lrec < lsrc:  # Rec above src layer: Pd not used
        #              Eqs 89-94, A18-A23, B13-B15
        green = Pu*(Wu + pmw*Rm[:, :, 0, :]*fexp*Wd)
```

Educational II: Hankel and Fourier transforms

github.com/empymod/example-notebooks/2a_Time_Step-and-Impulse.ipynb



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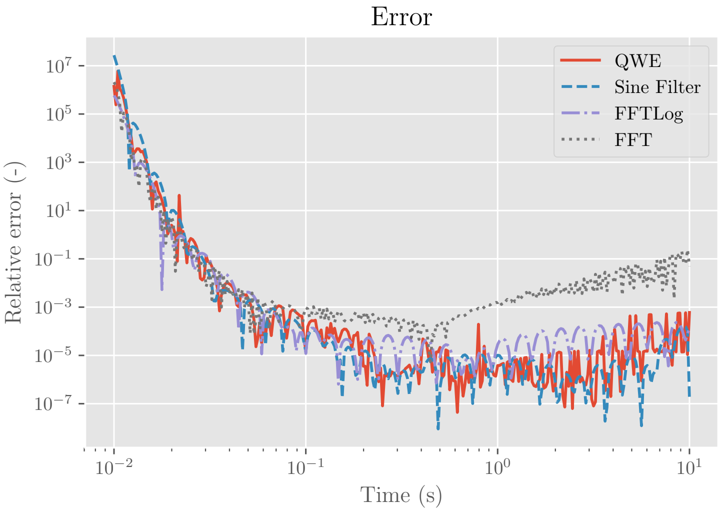


Educational II: Hankel and Fourier transforms

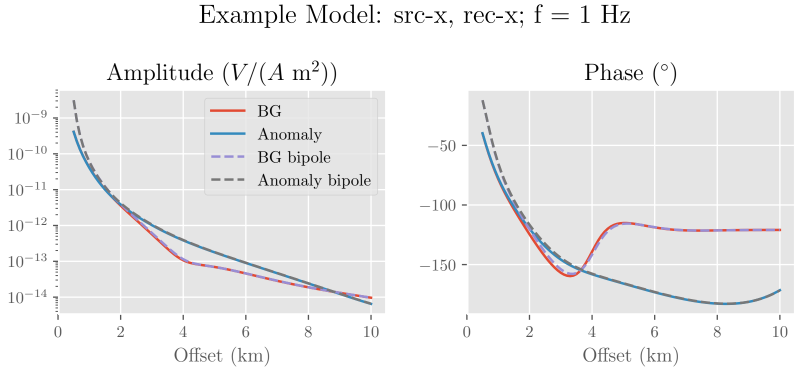
github.com/empymod/example-notebooks/2a_Time_Step-and-Impulse.ipynb

Method	# freq	min freq Hz	max freq Hz	time ms
FFTLog	60	1.8e-4	1.4e2	7
Sine-filter	116	5.3e-6	5.7e4	13
FFT	61	5.0e-4	5.2e2	640
QWE	173	3.4e-4	1.6e5	2113

Educational III: Point dipole vs finite dipoles

github.com/empymod/example-notebooks/1b_Frequency_Dipole-vs-Bipole.ipynb

Canonical model, point source versus 800 m dipole source.



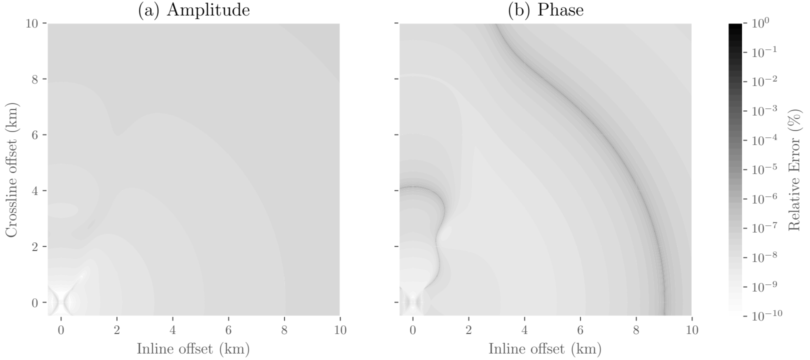
Educational IV: Diffusive approx. vs full wavefield

github.com/empymod/example-notebooks/3a_Full-Diffusive_comparison.ipynb

$$\text{Frequency} = 0.5\,\text{Hz}; \qquad \varepsilon_{r;H} = \varepsilon_{r;V} = 1; \qquad \mu_{r;H} = \mu_{r;V} = 1$$

Analytical fullspace solution

Difference between full wavefield and diffusive approximation.



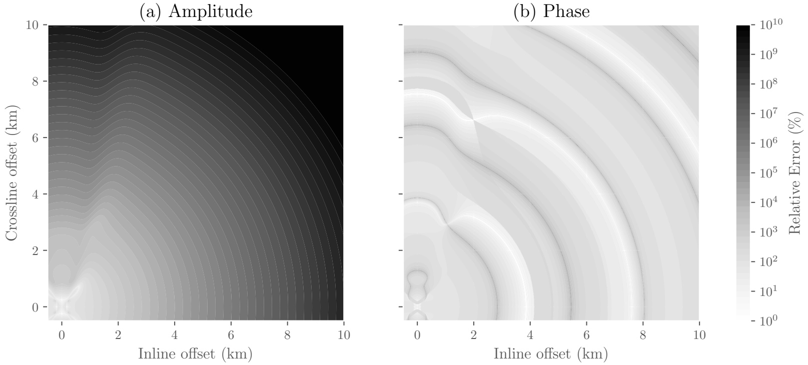
Educational IV: Diffusive approx. vs full wavefield

github.com/empymod/example-notebooks/3a_Full-Diffusive_comparison.ipynb

$$\text{Frequency} = 0.5\,\text{Hz}; \qquad \varepsilon_{r;H} = \varepsilon_{r;V} = 1; \qquad \mu_{r;H} = \mu_{r;V} = 10$$

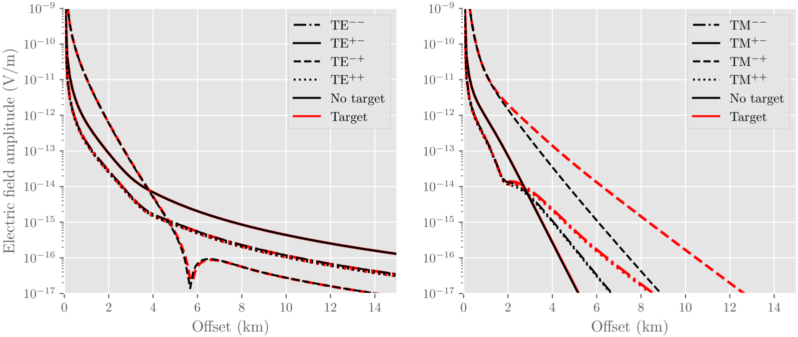
Analytical fullspace solution

Difference between full wavefield and diffusive approximation.



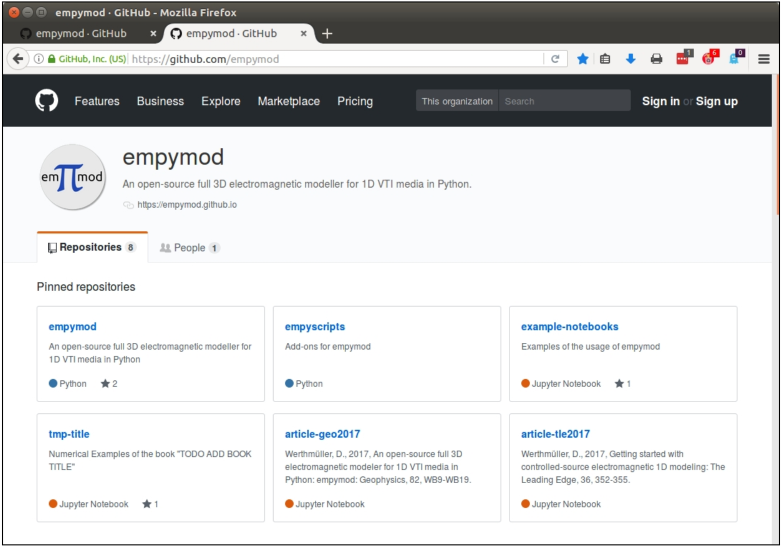
Educational V: TE/TM-split

github.com/empymod/example-notebooks/1c_TMTE-split.ipynb



Notebooks

Lots of examples (github.com/empymod)



Installation

conda, pip, anaconda

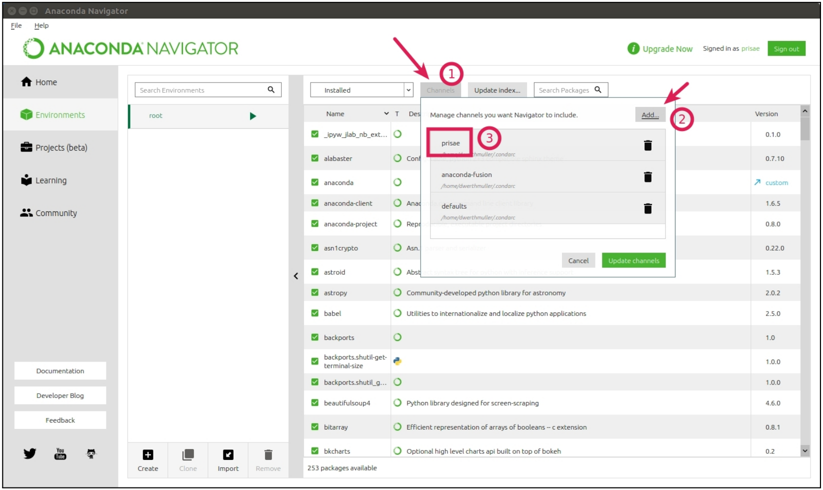
- **Website:** empymod.github.io
- **Requirements:** Python3, NumPy, SciPy
- **Installation**
  - **pip:** `pip install empymod`
  - **Anaconda:** anaconda.com

    conda: `conda install -c prisae empymod`

    Anaconda-Navigator
  - **GitHub**

Installation

conda, pip, anaconda



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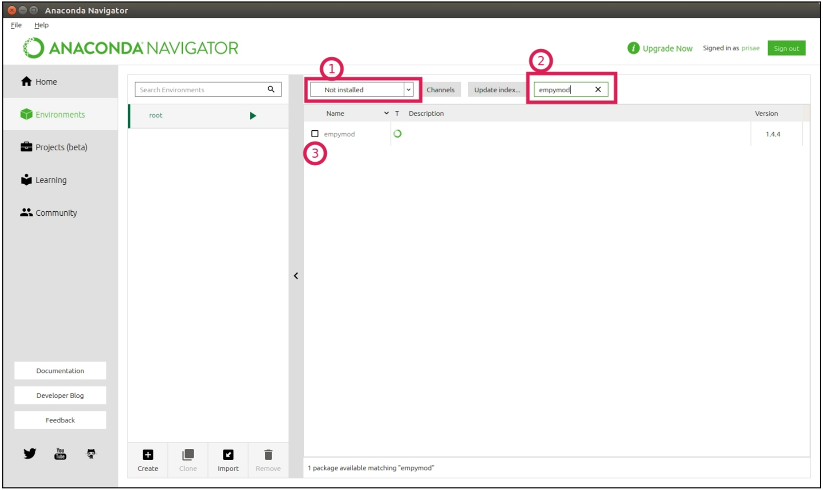

Free and Open Source codes

en.wikipedia.org/wiki/Comparison_of_free_geophysics_software

- **SimPEG** simpeg.xyz
- **fatiando a terra** fatiando.org
- **PETGEM** petgem.bsc.es
- **pyGIMLi** pygimli.org
- **PyGMI** patrick-cole.github.io/pygmi
- **P223Suite** p223suite.sourceforge.net
- **DIPOLE1D, 2DMT** marineemlab.ucsd.edu
- **MARE2DEM** mare2dem.ucsd.edu
- **ga-aem** github.com/GeoscienceAustralia/ga-aem

Referencias

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