The Recipes for Earth Sciences Go Trilingual: MATLAB, Python and Julia

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EGU General Assembly 2022

MATLAB vs. PYTHON from a MATLAbers Perspective

M.H. Trauth, 14. März 2022 10:47 Uhr

	MATLAB	PYTHON
Origins	The first version of MATLAB was an interactive matrix calculator, written in Fortran by Cleve Molar in the late 1970s. Together with Jack Little and Steve Bangert, he decided to make it a commercial product, founded MathWorks and released the first reversion of MATLAB written in C in 1984 (Source).	PYTHON was written by Guido van Rossum in the late 1980s and released as PYTHON 0.9.0 in 1991, PYTHON 2.0 in 2000 and PYTHON 3.0, not completely backward compatible, released in 2008. PYTHON 2 was discontinued in 2020 (Source).
Developer	MATLAB is the product of MathWorks Inc., which is a company with 5,000+ employees and a 1.05 billion USD revenue (2019). (Source). MATLAB, with 5 million+ users, is one of several products of the company, which also includes SIMULINK for simulation and model-based design of multidomain and embedded engineering systems (Source).	PYTHON is promoted, protected and advanced by the PYTHON Software Foundation (PSF), a nonprofit organization with a 4.503 million USD revenue (2019) (Source). There are different levels of membership, started from basic members supporting the PSF without a financial contribution, to supportive members, managing members, contributing members and fellows.
Business Model	MathWorks offers different license models for standard, education, home and student use of the software. The license includes the software, documentation and support with a 24-hour response time (Source).	PYTHON is free and comes with an online documentation, but without support (Source). However, there are numerous companies providing commercial services, consulting, trainings and tools with/ for PYTHON (Source).
Features	MATLAB is both a programming language and a desktop programming environment, which includes an editor, a debugger, workspace browser, sophisticated graphics and a compiler for stand-alone applications. It can be run in a text terminal with an external editor, in the graphical user interface called MATLAB Desktop, as well as in a browser using MATLAB Online in a cloud environment. A mobile client called MATLAB Mobile exists to run it remotely on mobile devices such as smartphones and tablet computers.	PYTHON is used in a text terminal. However, Spyder, as an example, provides a development environment similar to MATLAB Desktop with an Editor, workspace browser, console (equivalent to the Command Window of MATLAB) and graphics. It can be installed together with PYTHON, or, which is recommended, as part of the Anaconda Distribution, which helps installing and managing the most important packages (see Setup) for PYTHON. Jupyter Notebook is a web-based interactive computing environment.
Setup	MATLAB is modular, with >90 toolboxes from MathWorks (Source) and a large number of user-provided toolboxes, partly commercial, others available for free available from the MathWorks File Exchange (Source). The File Exchange currently lists 42,967 user contributed scripts, functions and toolboxes as of March 2022, including 296 files contributed by MathWorks.	PYTHON is modular, with a large number of packages provided by independently operating teams, available for download from individual webpages. A list of PYTHON packages is available online on the Python Package Index. This index currently lists ~5.7M user contributed files from ~578k users as of March 2022.

Cont'd

M.H. Trauth, 29. Oktober 2021 08:35 Uhr

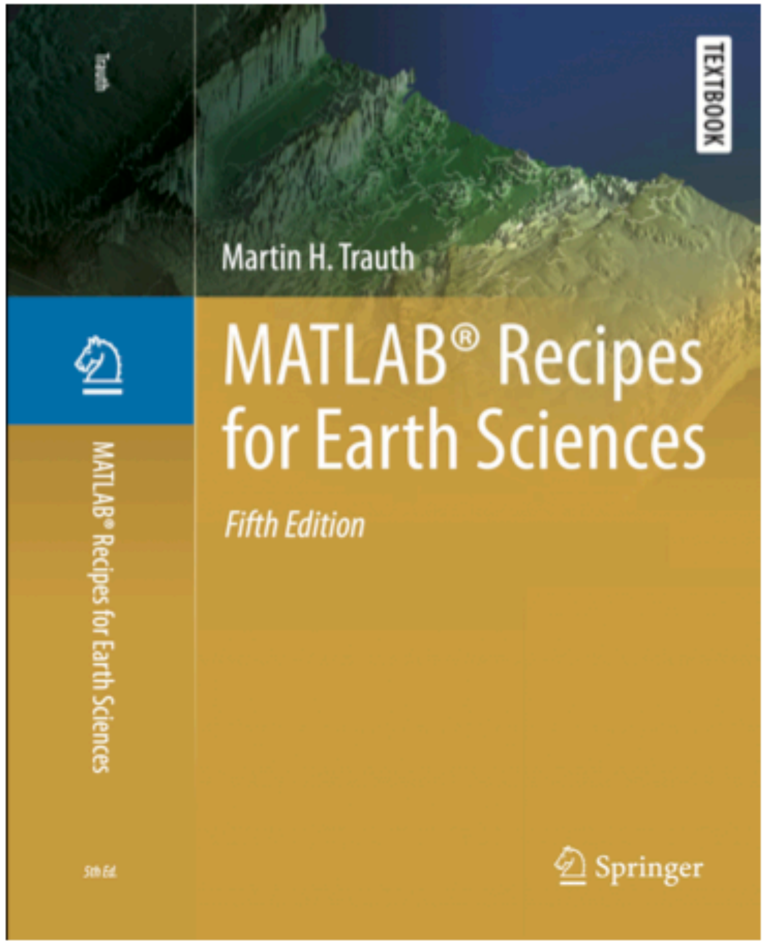
This is a comparison of codes in MATLAB, PYTHON and Julia. In the file in Microsoft Word format, the contents can be marked column by column, copied and pasted into a text editor.

MATLAB	PYTHON	JULIA

	import numpy as np
	import matplotlib.pyplot as plt
		import Pkg
		Pkg.add("Plots")
		using Plots

x = 0 : pi/10 : 2*pi;	x = np.linspace(0, 2*np.pi, 21)	x = 0 : pi/10 : 2*pi;
y1 = sin(x);	y1 = np.sin(x)	y1 = sin.(x);

plot(x,y1)
title('My first plot')
xlabel('x-axis')
ylabel('y-axis')
	plt.plot(x,y1)
	plt.title('My first plot')
	plt.xlabel('x-axis')
	plt.ylabel('y-axis')
		plot(x, y1,
		   title="My first plot",
		   xaxis=("x-axis"),
		   yaxis=("y-axis"))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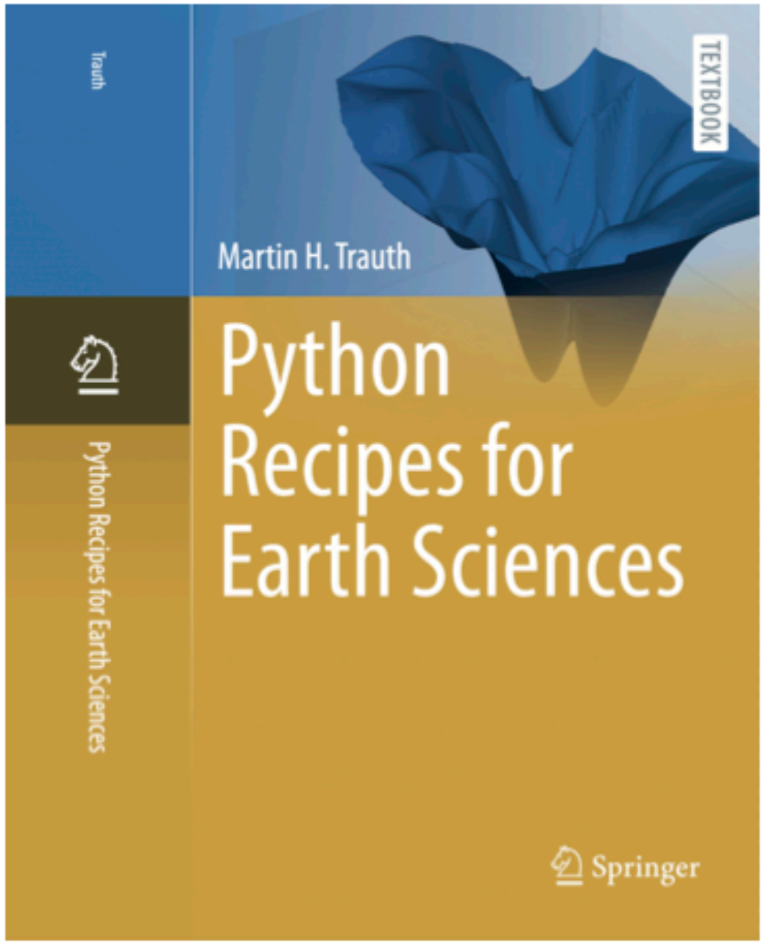
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Python Recipes for Earth Sciences
Springer

5.4 Examples of Auto-Spectral and Cross-Spectral Analysis

The code for the power spectral density can be rewritten to make it independent of the sampling frequency,

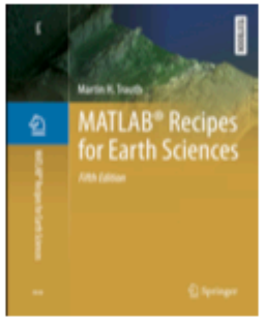
```
Fs = 1;

t = 1/Fs :1/Fs : 1000/Fs; t = t';
x = 2*sin(2*pi*t/50) + sin(2*pi*t/15) + 0.5*sin(2*pi*t/5);

nfft = 2^nextpow2(length(t));
Xxx = fft(x,nfft);

Pxx2 = abs(Xxx).^2 /Fs /length(x);
Pxx = [Pxx2(1); 2*Pxx2(2:512)];
f = 0 : Fs/(nfft-1) : Fs/2;

plot(f,Pxx), grid
axis([0 0.5 0 max(Pxx)])
```

where the function `nextpow2` computes the next power of two closest to the length of the time series `x(t)`. This code allows the sampling frequency to be modified and the differences in the results to be explored. We can now compare the results with those obtained using the function `periodogram(x,window,nfft,fs)`.

```
[Pxx,f] = periodogram(x,[],1024,1);
```

This function allows the windowing of the signals with various window shapes to overcome spectral leakage. However, we use the default rectangular window by choosing an empty vector `[]` for `window` to compare the results with the above experiment. The power spectrum `Pxx` is computed using an FFT of length `nfft=1024`, which is the next power of two closest to the length of the series `x` and which is padded with zeros to make up the number of data points to the value of `nfft`. A sampling frequency `fs` of one is used within the function in order to obtain the correct frequency scaling for the *f*-axis. We display the results by typing

```
plot(f,Pxx), grid
xlabel('Frequency')
ylabel('Power')
title('Auto-Spectrum')
```



5.4 Examples of Auto-Spectral and Cross-Spectral Analysis

The code for the power spectral density can be rewritten to make it independent of the sampling frequency,

```
Fs = 1

t = np.arange(1/Fs,1000/Fs+1/Fs,1/Fs)
t = np.transpose(t)
x = 2*np.sin(2*np.pi*t/50) + \
    np.sin(2*np.pi*t/15) + \
    0.5*np.sin(2*np.pi*t/5)

nfft = 2**np.ceil(np.log2(t.size))
Xxx = np.fft.rfft(x,int(nfft))

Pxx2 = np.abs(Xxx)**2/Fs/len(x)
Pxx = np.hstack((Pxx2[0],2*Pxx2[1:512]))
f = np.arange(0,Fs/2,Fs/(nfft-1))

plt.figure()
plt.plot(f,Pxx)
plt.grid
plt.axis(np.array([0,0.5,0,np.amax(Pxx)]))
plt.show()
```

where `nfft=2**np.ceil(np.log2(t.size))` computes the next power of two closest to the length of the time series `x(t)`. This code allows the sampling frequency to be modified and the differences in the results to be explored. We can now compare the results with those obtained using `periodogram()`:

```
f,Pxx = signal.periodogram(x,fs=1,nfft=1024)
```

This function allows the windowing of the signals with various window shapes to overcome spectral leakage. However, we use the default rectangular window to compare the results with the experiment outlined above. The power spectrum `Pxx` is computed using an FFT of length `nfft=1024`, which is the next power of two closest to the length of the series `x` and which is padded with zeros to make up the number of data points equal to the value of `nfft`. A sampling frequency `fs` of one is used within the function in order to obtain the correct frequency scaling for the *f*-axis. We display the results by typing

```
plt.figure()
plt.plot(f,Pxx)
plt.grid
plt.xlabel('Frequency')
plt.ylabel('Power')
plt.show()
```

The Recipes for Earth Sciences Go Trilingual

- ☐ students get away from a particular software or programming language, and focus instead on the method they want to implement.
- ☐ solutions often use mixtures of programming languages, exploiting the advantages of each.
- ☐ makes the students fit for a job in academia or industry, where other software tools are used than the ones we use in class.