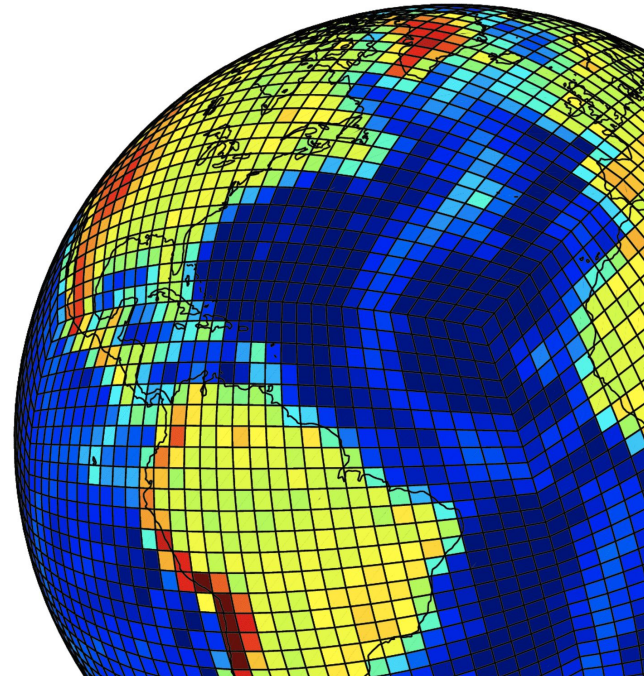


# Data Analysis, using MATLAB


Frederik J Simons  
Princeton University



MATLAB is a *program*—many ways to use

MATLAB is a *language*—many ways to learn

MATLAB is a *community*—many ways to join



## Princeton Research Computing

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- Learn ▾**
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- CSE Graduate Certificate
- Workshops & Live Training
- Tutorials
- User Groups
  - Matlab**
  - Python
  - TensorFlow and PyTorch
- Academic Seminars
- Glossary

### MATLAB Users Group

The MATLAB Users Group provides opportunities for campus MATLAB users to learn more about using MATLAB, help each other, and learn more about research and teaching being done at Princeton using MATLAB. To be added to the group's mailing list or to volunteer to help with planning and putting on future events, send e-mail to [rcinfo@princeton.edu](mailto:rcinfo@princeton.edu) ✉

#### Past events

**Thursday, March 8, 4:30 pm - 6:00 pm**  
**120 Lewis Science Library, Washington Road & Ivy Lane**

From medical diagnosis, speech and handwriting recognition to automated trading and movie recommendations, machine learning techniques are being used to make critical business and life decisions every moment of the day. In this session, we explore the fundamentals of machine learning using MATLAB. Working with a range of classification models, we will perform model assessment and comparisons.

Dr. Elvira Osuna-Highley is a Senior Customer Success Engineer at MathWorks, where she supports faculty in their teaching and research with MATLAB. Prior to joining MathWorks, she was a Lecturer in the Computational Biology department at Carnegie Mellon University. Dr. Osuna-Highley holds a doctorate in Biomedical Engineering from Carnegie Mellon University.

# Online

The screenshot shows the MATLAB Online Help Center interface. At the top, there is a blue header with the MATLAB logo on the left, a search bar labeled "Search Help Center" in the middle, and a user profile icon and a grid icon on the right. Below the header, the page is divided into a left sidebar and a main content area. The sidebar contains two sections: "Get Help" with links for Help Center, Answers, File Exchange, and Videos; and "Learn" with links for Online Training, Cody, and Blogs. The main content area features a "View all files" link in the top right. The primary focus is the "Online Training" section, which displays six course cards in a 2x3 grid. Each card includes a representative image, the course title, the access status, and a "Start" button. The courses are: MATLAB Onramp (Unlimited Access), Simulink Onramp (Unlimited Access), MATLAB Fundamentals (Access Expires 3/1/2023), Machine Learning Onramp (Unlimited Access), Deep Learning Onramp (Unlimited Access), and Circuit Simulation Onramp (Unlimited Access). At the bottom of the training section, there are "View more" and "View all courses" links. The footer contains a row of links: Patents | Trademarks | Privacy Policy | Preventing Piracy | Application Status, and a copyright notice: © 1994-2021 The MathWorks, Inc.

MATLAB

Search Help Center

View all files


### Get Help

- Help Center
- Answers
- File Exchange
- Videos

### Learn

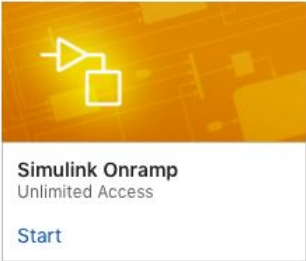
- Online Training
- Cody
- Blogs

### Online Training




**MATLAB Onramp**  
Unlimited Access

[Start](#)



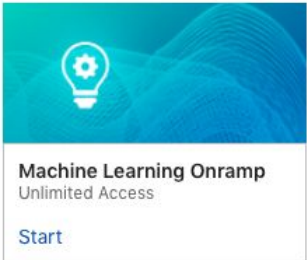
**Simulink Onramp**  
Unlimited Access

[Start](#)



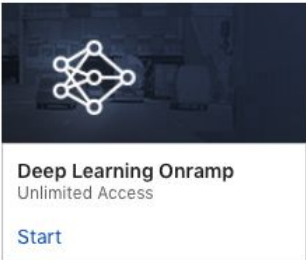
**MATLAB Fundamentals**  
Access Expires 3/1/2023

[Start](#)



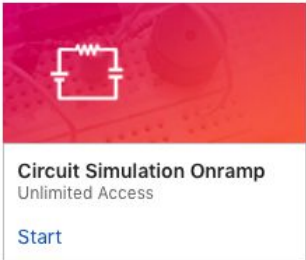
**Machine Learning Onramp**  
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**Deep Learning Onramp**  
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YouTube



# Introduction to MATLAB

Frederik J. Simons

[www.frederik.net](http://www.frederik.net)

003

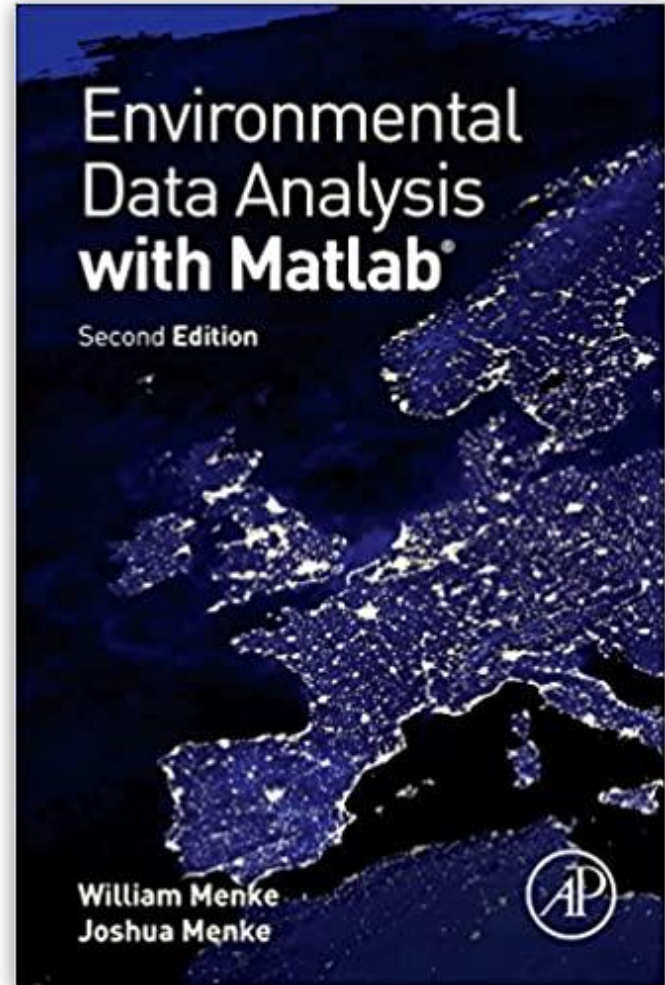
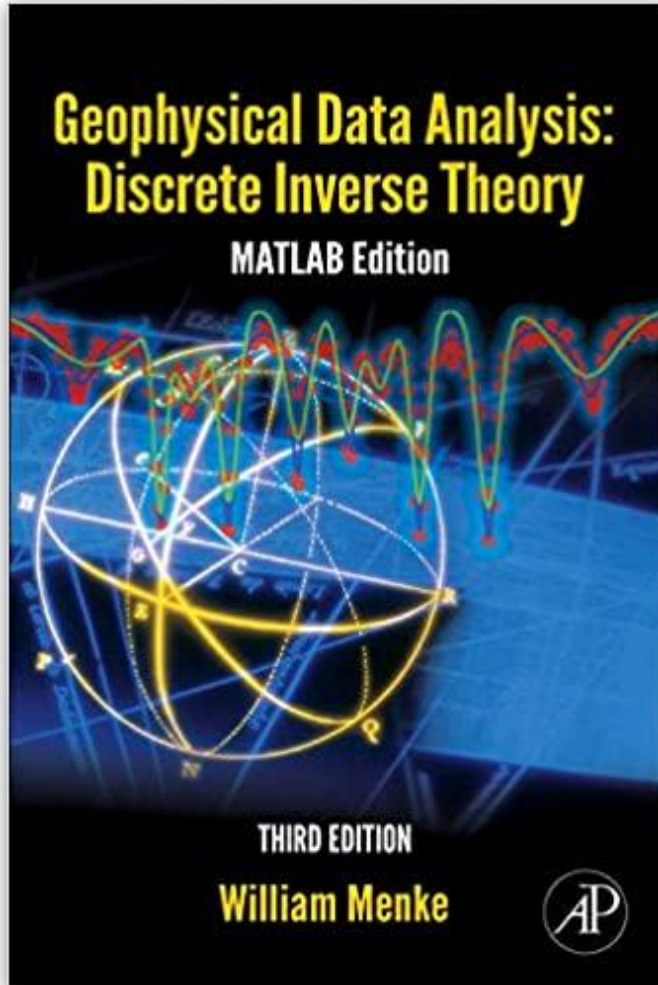
Into MATLAB | 003

100 weergaven • 9 aug. 2016

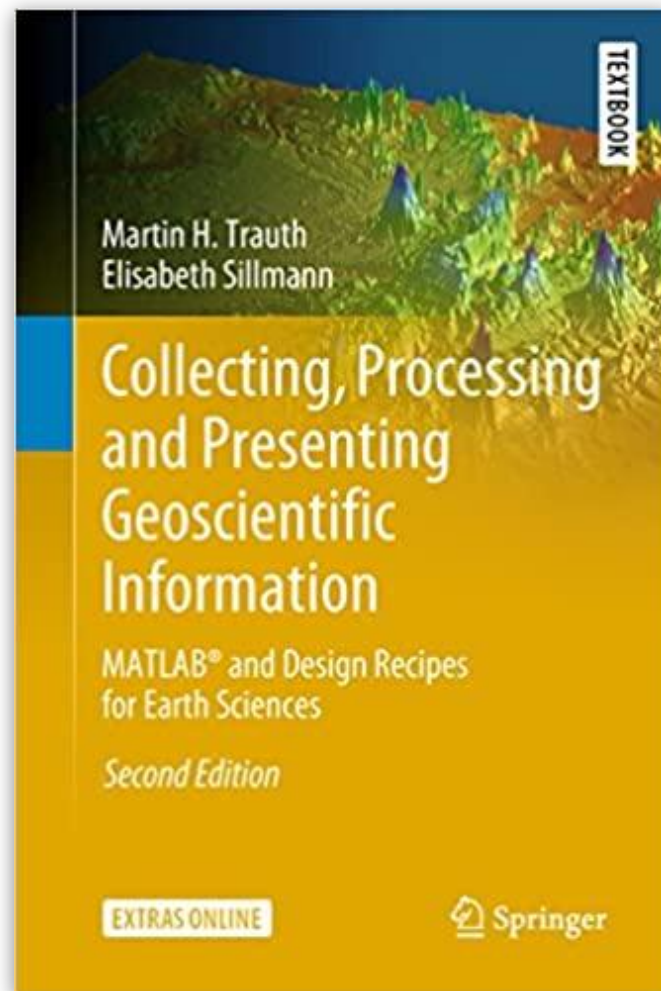
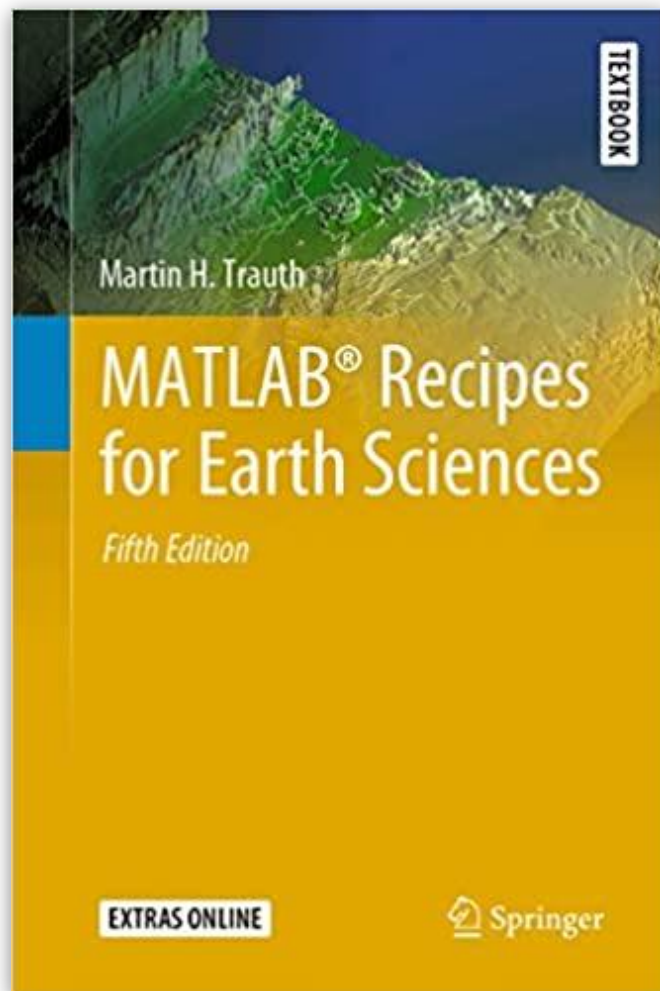
 0  0  DELEN  OPSLAAN ...



## Books



# Books



# Mobile



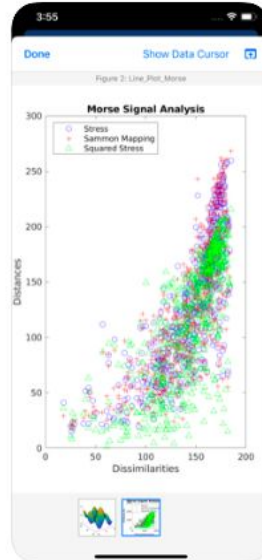
**MATLAB Mobile** (4+)

MathWorks

★★★★☆ 3.4 • 123 Ratings

Free

## Screenshots [iPhone](#) [iPad](#)



Connect to MATLAB® from your iPhone or iPad.



# Grader Cody

## MATLAB Grader

Frederik Simons

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Wintersession 2022

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Week 1

**Create a sequence of numbers**

Find a specific entry in a vector

Make a formatted string

[ADD PROBLEM](#)

Week 2

Week 3

Week 4

Week 5

Week 6

[ADD ASSIGNMENT](#)

[Manage People](#)

Wintersession 2022 > Week 1 >

### Create a sequence of numbers

[Edit](#) [Actions](#)

#### Problem Summary

**Generate a sequence of numbers *between 2 and 22 (inclusive), spaced 2 apart*. You can use a colon operator, or you can use a pre-programmed function such as `linspace`. The variable that you create must be called `y`.**


You may or may not close with a semicolon, to suppress output to your screen. There are, literally, an infinite number of ways in which you can accomplish what's asked. You may choose to use brackets or not in this example. In the template, I have suggested square brackets within which you can type your solution.

Your *script*, the answer to this question, need only be that one line long! And you need only type within the brackets.

[Learner Preview](#)


#### Learner Analytics: How Learners Are Doing on the Problem

##### Class Overview



- Percent solved / not solved
- Average number of submissions
- Which tests are hardest

##### Learner Solutions



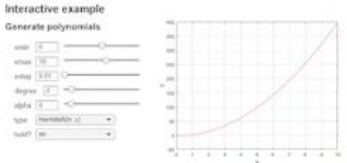
- Search solutions
- [Map](#) and [List](#) views of solutions

# Live

## Live Script Gallery

Open and run these example live scripts from the MATLAB Community.

Create your own live scripts using the [Live Editor](#). Combine code, output, and formatted text in a single executable document.




**Interactive example**  
Generate polynomials

order: 4  
axes: 100  
step: 1000  
degree: 2  
alpha: 1  
type: HermiteHn, x1  
hold: on

**OrthogonalPolynomials**  
by [Vilem Karsky](#)

[Run this example](#)  
[View on File Exchange](#)



**Remove Trends**  
Remove 2th degree polynomial from mabyEKG

Select data  
Input data: mabyEKG  
Y-axis: default


Specify trend parameters  
Degree: Custom  
Breakpoints: None

Visualize results  
 Original data  Trend data  Trend

```
xLabel('millsseconds')  
yLabel('millsvolts')
```

**Calculate Heart Rate from Electrocardiogram Data**  
by [Heather Gorr](#)

[Run this example](#)  
[View on File Exchange](#)



**2016 Summer Olympic Medals**

**GDP and Olympic Success**  
by [David Garrison](#)


[Run this example](#)  
[View on File Exchange](#)

# Loren

## Blogs

Blogs

MATLAB Central | All MathWorks Blogs | Subscribe



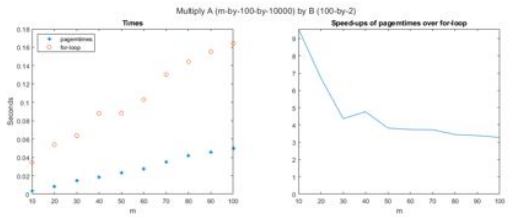
### Loren on the Art of MATLAB

Turn ideas into MATLAB

<< 1 2 ... 52 >>

## Paged Matrix Functions 6

Posted by [Loren Shure](#), January 14, 2021



Multiply A (m-by-100-by-10000) by B (100-by-2)

Left Plot: Times (seconds) vs m. Legend: pagetimes (blue dots), for-loop (orange circles).


Right Plot: Speed-ups of pagetimes over for-loop vs m.

Today's guest blogger is Mary Fenelon, who is the product marketing manager for Optimization and Math here at MathWorks. In today's post she describes how using the new paged matrix functions can... [read more >>](#)

Send Tweet in Share Share 2

## How to Chart My Year (Redux)

Posted by [Loren Shure](#), December 22, 2020




### Community Treasure Hunt


Find the treasures in MATLAB Central and discover how the community can help you!

[» Start Hunting!](#)


Loren's 2020 mostly NON Travels




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**Frederik J. Simons**  
10 total contributions since 2017  
I am a geologically inspired, geophysically educated, computationally motivated and mathematically minded geoscientist  
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**Your Badges**

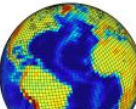
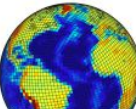
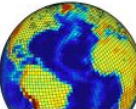


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<b>FILE EXCHANGE</b> 12,894 RANK of 16,237 ACTIVITY(12 MONTHS)	<b>MATLAB ANSWERS</b> 29,085 RANK of 224,804 ACTIVITY(12 MONTHS)	<b>CODY</b> N/A ACTIVITY(12 MONTHS)	<b>THINGSPEAK</b> N/A ACTIVITY(12 MONTHS)
--	--	---	---

**Contributions in**  **View by**

- Submitted [slepian\\_delta](#)  
Spatiospectral localization of data from the GRACE mission using Slepian functions  
3 months ago | 3 downloads | ★★★★★ 
- Submitted [slepian\\_zero](#)  
MATLAB functions with a more or less strictly educational value in geophysics  
3 months ago | 2 downloads | ★★★★★ 
- Submitted [slepian\\_oscar](#)  
Seismic and GPS processing bits and pieces  
3 months ago | 1 download | ★★★★★ 

# GitHub



**Frederik J Simons**  
fjsimons

I am a geologically inspired, geophysically educated, computationally motivated and mathematically minded geoscientist, passionate about reproducible research.

[Edit profile](#)

🔍 98 followers · 26 following · ☆ 0

📍 @PrincetonUniversity

📍 Princeton, NJ, 08544

🌐 <http://www.frederik.net>

## Highlights

[Overview](#) [Repositories](#) 5 [Projects](#) [Packages](#)



## Pinned

 [csdms-contrib/slepian\\_alpha](#) ⋮

Scalar spherical-harmonic analysis and Slepian functions

● MATLAB ☆ 14 🍷 25

 [csdms-contrib/slepian\\_juliet](#) ⋮


Maximum-likelihood analysis of univariate isotropic Matérn random fields

● MATLAB ☆ 2 🍷 3

 [earthscopeoceans](#) ⋮

Website for [www.earthscopeoceans.org](http://www.earthscopeoceans.org)


● HTML 🍷 1

 [csdms-](#) ⋮

Cubed-spher


● MATLAB

**You discovered dark mode!**  
Go to [Settings](#) to choose your theme preferences.  
[Got it!](#)

 [csdms-contrib/slepian\\_oscar](#) ⋮

Seismic and GPS processing bits and pieces

● MATLAB ☆ 3 🍷 8

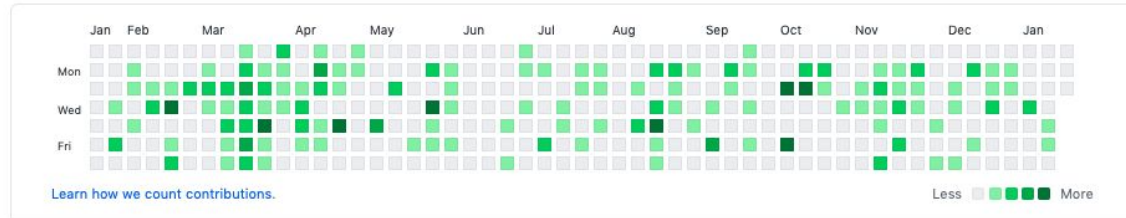
 [csdms-contrib/slepian\\_zero](#) ⋮

MATLAB functions with a more or less strictly educational value in geophysics

● MATLAB 🍷 2

## 622 contributions in the last year

[Contribution settings](#) ▾





# Emacs XEmacs

```
fjsimons@lemaitre — tcsh
x fjsimons@lemaitre — emacs -nw drop2...  fjsimons@lemaitre — -tcsh  fjsimons@dynamic-oit-vapornet100-1...  fjsimons@stadius — -tcsh  ... +

    % Start the actual data structure... some versions have empties
    d.(char(v1{1}))=char(v2{1});
end

% Pick out the data variable names
vnames=h{4}; vnames(abs(vnames)==32)='';
% You'll now know there are FOUR to SIX variables of interest (any empties?)
[~,v1,v2,v3,v4,v5,v6]=stread(vnames,'%q%q%q%q%q%q','delimiter','');

% Pick out the unit name strings
index=5;
vnames=h{index}; vnames(abs(vnames)==32)='';
% You'll now know there are FOUR to SIX units of interest (two empties?)
[~,u1,u2,u3,u4,u5,u6]=stread(vnames,'%q%q%q%q%q%q','delimiter','');

% For the next loop, it's a DROP 2 or a DROP 3
maxi=5+~isempty(u5)*2;

% Give the variables their proper place
for index=2:maxi
    % Don't redo the time, you've got it already
    b=char(a{index});
    % Comma goes to decimal point
    b(abs(b)==44)='.';
    % Final assignment to human-intelligible variables
    c{index}=str2num(b);
    % Hark back to the old spitout subfunction
    eval(sprintf('d.(char(v%i))=c{%i};',index-1,index))
end
-----F1 drop2mat.m 31% L79 (Matlab Fill)-----
Find file: ~/PROGRAMS/MFILES/git/slepian_zero/
```

# Anatomy

```
fjsimons@lemaitre — tcsh
fjsimons@lemaitre — emacs -n...  fjsimons@lemaitre — ssh -Y -Y...  fjsimons@dynamic-cit-vapor...  fjsimons@stadius — -tcsh ... +
function varargout=anatomy(fname, snumber)
% [t,d]=ANATOMY(fname,snumber)
%
% Anatomy of a proper and flexible function
%
% INPUT:
%
% fname      A complete file name string
% snumber    Some numbers(s) [default: 21]
%
% OUTPUT:
%
% t          The timestamp as a DATETIME array
% d          The data as a STRUCTURE array
%
% SEE ALSO: MARK2MAT
%
% EXAMPLE: drop2mat('demo1')
%
% TESTED ON: MATLAB Version: 9.8.0.1451342 (R2020a) Update 5
%
% Last modified by fjsimons-at-alum.mit.edu, 01/19/2021

if isempty(strfind(fname,'demo'))
    % Do something interesting

elseif strcmp(fname,'demo1')
    % Call your own example... check out DEFVAL
    [t,d]=anatomy('somefile',pi);
end

% Optional output
varns={t,d};
varargout=varns(1:nargout);

--uu:---F1  anatomy.m      All L28      (Matlab Fill)-----
Wrote /Users/fjsimons/PROGRAMS/MFILES/anatomy.m
```

# Git

```
fjsimons@lemaitre — tcsh
fjsimons@lemaitre — -tcsh  fjsimons@lemaitre — -tcsh  fjsimons@dynamic-oit-vapornet100-1...  fjsimons@stadius — -tcsh  ... +
stadius:slepian_alpha% git log -4
commit 414aee7299c75f5bb9381d510beef95a225126b5 (HEAD -> master, origin/master, origin/HEAD)
Author: Frederik J Simons <fjsimons@gmail.com>
Date: Tue Oct 13 11:05:10 2020 -0400

    Update README.md

commit ca2ba044b403d73d6a815c2356034ba83051fde6 (tag: 1.0.5)
Author: Frederik J. Simons <fjsimons@gmail.com>
Date: Thu Aug 20 13:26:46 2020 -0400

    Backus-Robin asymptotic approximation of Legendre polynomials

commit 277127ad36da24f7e2a79648b6e32b7af78849d3
Author: Frederik J. Simons <fjsimons@gmail.com>
Date: Mon Aug 17 14:10:11 2020 -0400

    Moves a graphics handle to the bottom of the stack

commit c27b89e98095d07827754bba3aa17048d40d4177
Author: Frederik J. Simons <fjsimons@gmail.com>
Date: Mon Aug 17 14:10:00 2020 -0400

    Moves a graphics handle to the top of the stack
stadius:slepian_alpha% git status
On branch master
Your branch is up to date with 'origin/master'.

nothing to commit, working tree clean
stadius:slepian_alpha% █
```

# What is data analysis?

**Visualization**, in multiple *dimensions*

**Summaries**, using few *statistics*

**Reduction**, to fewer *dimensions*

**Inference**, using *hypothesis tests*

**Simulation**, for ground *truthing*

**Prediction**, and *retrodiction*

**Interpolation**, and *extrapolation*

**Regression** and *inversion*

# Options:

The extreme MATLAB **basics**

MATLAB and **compiled** languages

MATLAB and **parallel** computing

MATLAB and **GPU** computing

My favorite MATLAB **tricks**

My favorite MATLAB **tips**

My favorite MATLAB **plots**



# Getting to it:

## **Hypothesis Testing**

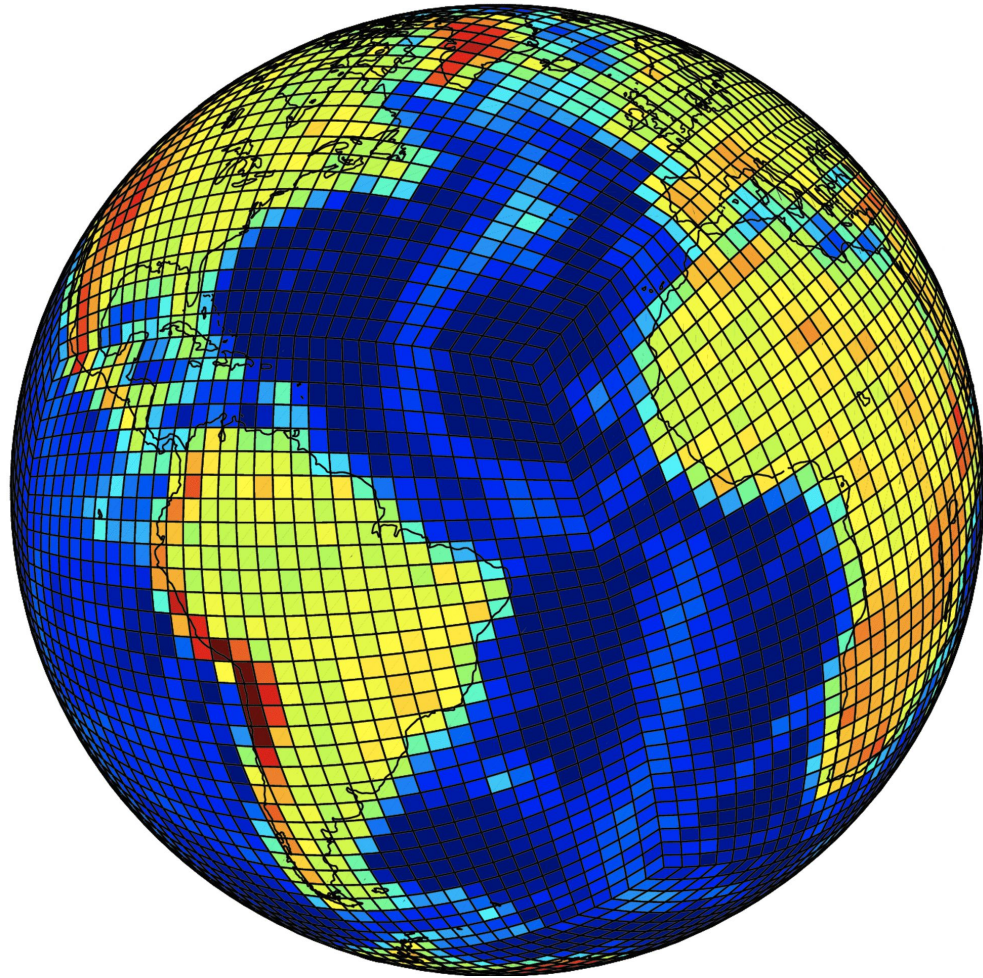
- Distribution
- Correlation

## **Regression**

- Ordinary
- Constrained

## **Fourier Spectral Analysis**

- Six ways



# Making your figures work for you, using MATLAB

Frederik J Simons  
Princeton University

