Data Analysis

Matlab Tutorial

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Agenda

Zwally et al., 2002, Science

- Motivation
- Background
- Analysis Methods
  - Statistics
  - Interpolation/Extrapolation
  - Gridded Data
  - Selection
  - Visualization
- Examples

Motivation

Importance of polar regions

- Ice Sheets and Glaciers
  - Melting contributes to sea level rise
- Importance of understanding mass balance
  - Greenland loses 100 Gigatons annually (100 km^3)
  - 360 Gigatons=1mm global sea level
  - Snowfall accumulation is between 10cm-2m per year
- Importance of including polar regions in climate models

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Definitions

- Data: measurements or observations of a variable
- Analysis: act of transforming data with the aim of extracting useful information and facilitating calculations

Background

- Data Analysis help the knowledge process come full-circle:
    1. Science defines questions and hypotheses
    2. Technology is developed based on this science
    3. Measurements/observations are taken
    4. Data analysis performed on measurements/observations
    5. Conclusions drawn, added to science
    6. New science used to drive new questions and hypotheses

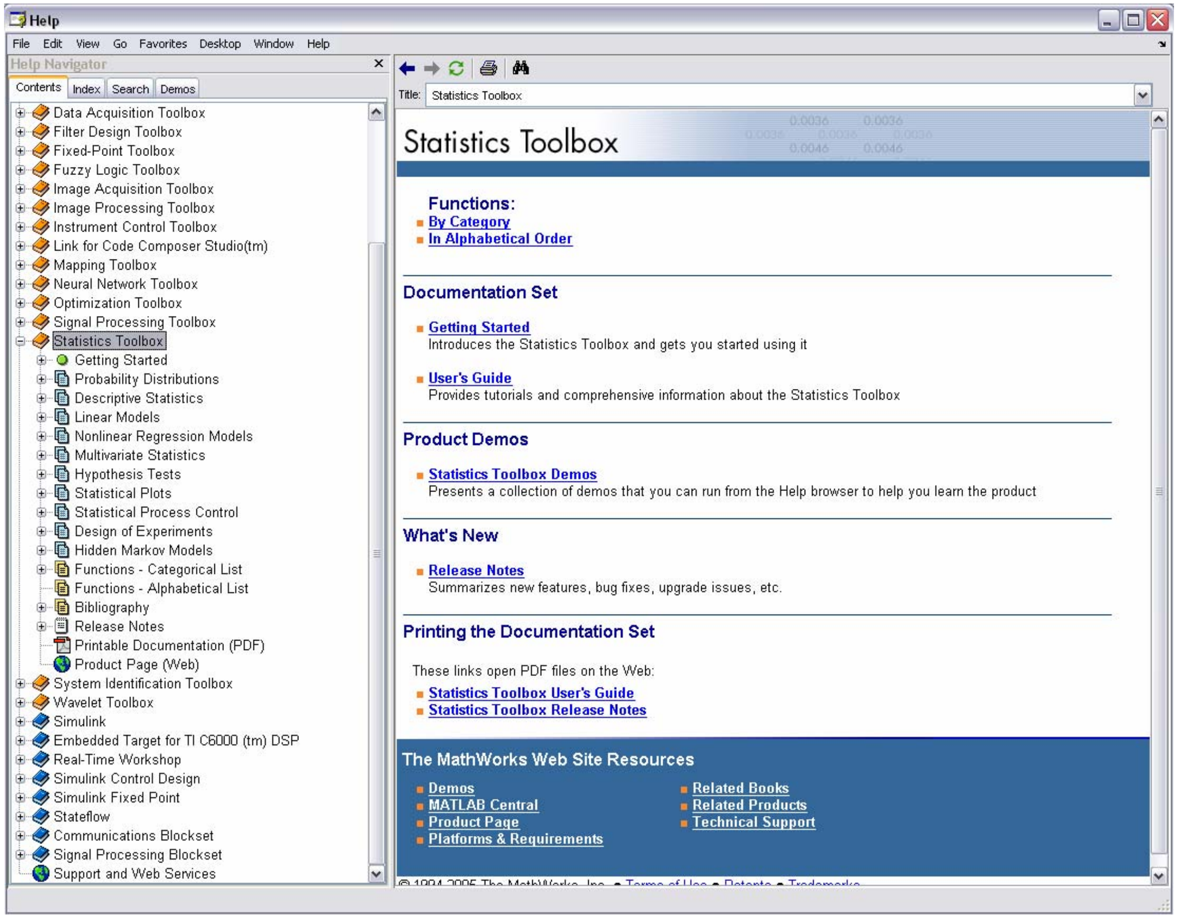
Analysis Methods

- Statistics and curve fitting (regression)
- Interpolation/Extrapolation (modeling)
- Gridded Data (modeling)
- Selecting/Discarding subsets of data based on criteria
- Visualization (explorative analysis)

Statistics

- Myriad of statistical functions built into Matlab
  - Probability distributions
  - Descriptive statistics
  - Linear/Non-Linear regression
  - Plotting

Statistics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By Category
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Documentation Set
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Provides tutorials and comprehensive information about the Statistics Toolbox
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What's New
Release Notes
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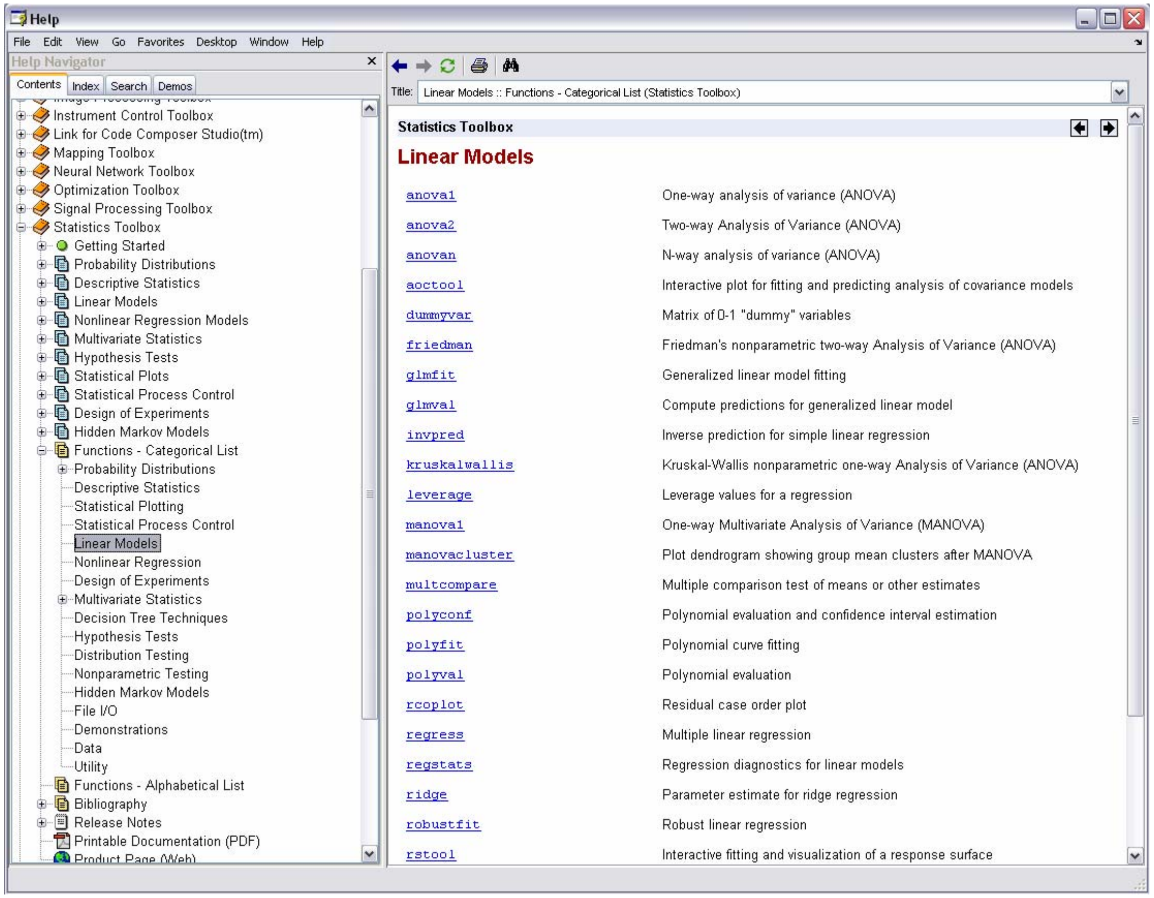
Statistics

- Commonly used functions:
  - mean, geomean, range
  - unifit, normfit, lognfit, poissfit, expfit
  - dfittool, disttool, polytool
  - boxplot, gscatter, normplot, pareto

Statistics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Title: Linear Models :: Functions - Categorical List (Statistics Toolbox)
Statistics Toolbox
Linear Models
anova1 One-way analysis of variance (ANOVA)
anova2 Two-way Analysis of Variance (ANOVA)
anovan N-way analysis of variance (ANOVA)
aoctool Interactive plot for fitting and predicting analysis of covariance models
dummyvar Matrix of 0-1 "dummy" variables
friedman Friedman's nonparametric two-way Analysis of Variance (ANOVA)
glmfit Generalized linear model fitting
glmval Compute predictions for generalized linear model
invpred Inverse prediction for simple linear regression
kruskalwallis Kruskal-Wallis nonparametric one-way Analysis of Variance (ANOVA)
leverage Leverage values for a regression
manova1 One-way Multivariate Analysis of Variance (MANOVA)
manovacluster Plot dendrogram showing group mean clusters after MANOVA
multcompare Multiple comparison test of means or other estimates
polyconf Polynomial evaluation and confidence interval estimation
polyfit Polynomial curve fitting
polyval Polynomial evaluation
rcoplot Residual case order plot
regress Multiple linear regression
regstats Regression diagnostics for linear models
ridge Parameter estimate for ridge regression
robustfit Robust linear regression
rstool Interactive fitting and visualization of a response surface

Curve Fitting

- Form of regression
- Linear regression is the simplest
- Built-in Matlab functions
  - polyfit
  - polyval

polyfit

p = polyfit(x,y,n)

[p,S] = polyfit(x,y,n)

[p,S,mu] = polyfit(x,y,n)

x and **y** define points of measured data

n defines order of desired regression polynomial

p array defining polynomial coefficients

S structure defining error function parameters

mu two-element vector specifying first two moments

polyfit

```
% FOR TESTING - Reduce to first 10000 rows
iout = iout(1:10000,:);

fprintf('Fitting data to straight line\n');
% East-North data set
[north, east, height] = eastNorth(old_lat(1), old_lon(1), old_elev(1), old_lat, old_lon, old_elev);
% find slope of polyfit line
p = polyfit(east,north,1);
path_slope = p(1,1);

% fit data to new coordinate
ortho_norm_vector = ([1 path_slope]/(1+(path_slope.^2)));
x_distance = ([east(1) north(1)] * ortho_norm_vector.');
for ENindex = 2:length(east)
    x_dist_TEMP = ([east(ENindex) north(ENindex)] * ortho_norm_vector.');
    x_distance = [x_distance, x_dist_TEMP];
end
```

- Find linear regression (n=1)
- Fit data points to that regression
- Decompose fitted points into east and north components
- Example: used in FK migration process so that DFT can be performed

polyval

Y = polyval(p,X)

[Y, DELTA] = polyval(p,X,S)

p array of polynomial coefficients defined by polyfit

X values for which Y values are defined

Y desired values of **p** function as desired by **X**

DELTA error estimates → **Y ± DELTA**

Interpolation

- Interpolation and Extrapolation are both handled via the **interp** functions
  - interp1 (one dimension)
  - interp2 (two dimension)
  - interp3 (three dimension)
  - interpn (n dimension)
  - interpft (one dimension interpolation using the FFT method)

interp1

yi = interp1(x,Y,xi)

yi = interp1(x,Y,xi,method)

yi = interp1(x,Y,xi,method,'extrap')

yi newly interpolated y values based on xi positions

x original data x vector

Y original data y vector

xi new x position vector, used to define interpolation points

method defines the interpolation method (i.e. 'linear', 'spline', 'cubic')

interp1

```
if (ispc)
  acid = load('P:\prism\radar\radar_simulator\profiles\gisp2_dep_20030914.txt');
else
  acid = load('/projects/prism/radar/radar_simulator/profiles/gisp2_dep_20030914.txt');
end
eV = 0.22;
acid_interp = 1e-6 * interp1(acid(:,1),acid(:,3),depthInt,'linear','extrap').';
condInterp = 1e-6 * interp1(acid(:,1),acid(:,2),depthInt,'linear','extrap').';
if (plotFlag)
  plot(depthInt,1e6*acid_interp,'k-');
  old = axis; axis([0 3047.9 old(3:4)]);
  xlabel('Depth (meters)');
  ylabel('Acidity (micromolarity)');
  fprintf('Mean acidity = %f micromolarity\n', mean(acid_interp)/1e-6);
  pause;
  plot(depthInt,1e6*condInterp,'k-');
  old = axis; axis([0 3047.9 old(3:4)]);
  xlabel('Depth (meters)');
  ylabel('Conductivity (uS/m)');
  fprintf('Mean conductivity = %f uS/m\n', mean(condInterp)/1e-6);
  pause;
end
```

- Interpolate ice acid content data to the predefined depth array
- Linear interpolation, with extrapolation of the acid content data for the extra points at the bottom of the ice sheet

Gridded Data

- Measured data is often random in both space and time
- In order for this data to be useful for selection/visualization/modeling, it must be fit to a grid that is evenly divided in both space and time
- Requires methods of interpolation (and sometimes extrapolation)
- Matlab provides functions for this:
  - meshgrid
  - griddata

meshgrid

[X,Y] = meshgrid(x,y)

[X,Y,Z] = meshgrid(x,y,z)

- Used to define a 2D or 3D grid **[X,Y]** based on **x** and **y**
- **x** and **y** must be monotonically increasing vectors
- meshgrid is required in order to define interpolation (and extrapolation) points for griddata

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griddata

Zi = griddata(x,y,z,Xi,Yi,*method*,*options*)

Zi is the interpolated (extrapolated) **z** values by remapping them from the original **x,y** system to the defined **Xi,Yi** system created with meshgrid

method defines the interpolation method

- 'linear'
- 'cubic'
- 'nearest'

options typically not used

Gridded Data

```
% create_grid_data
% Cameron Lewis
% This program will create gridded data out of complete_bedrock
% Requires: complete_bedrock, complete_lat, complete_lon, and complete_elev

path(path,genpath('/ps3/matlab/support/geometry'));

file = load('/ps3/insar/results/complete_bedrock');

[north, east, height] = eastNorth(1.26672971, -0.671246297, 3252.3602, file.complete_lat, ...
        file.complete_lon, file.complete_elev);
north_min = min(north);
north_max = max(north);
east_min = min(east);
east_max = max(east);
[X,Y] = meshgrid(east_min:100:east_max, north_min:100:north_max);
Z = griddata(east, north, file.complete_bedrock, X, Y);
~
~
                                                                        1,1           All
```

- Create gridded data of bedrock depth by remapping from track lines to grid
- Use **imagesc**, **mesh**, **surf**, etc to plot the results

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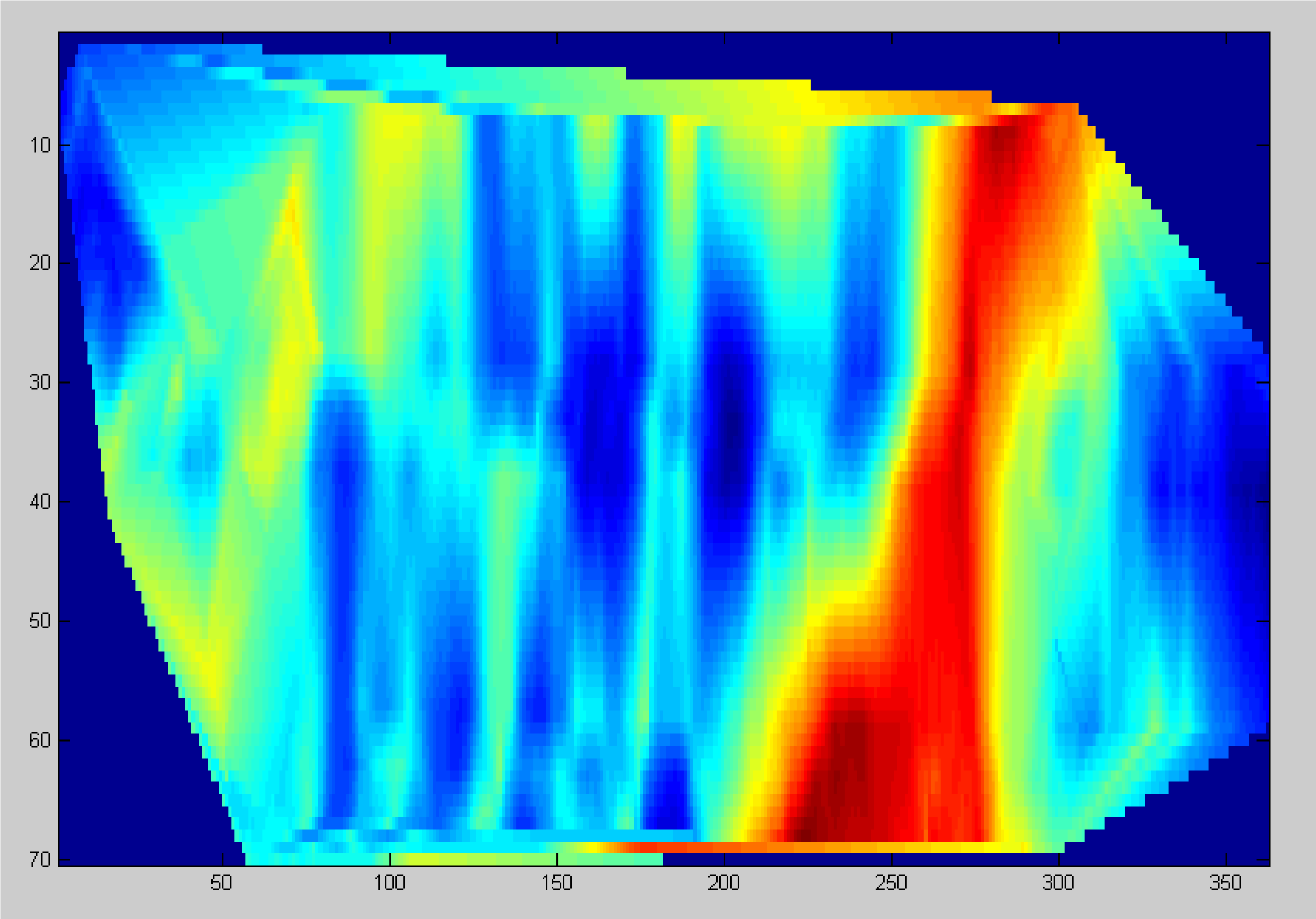
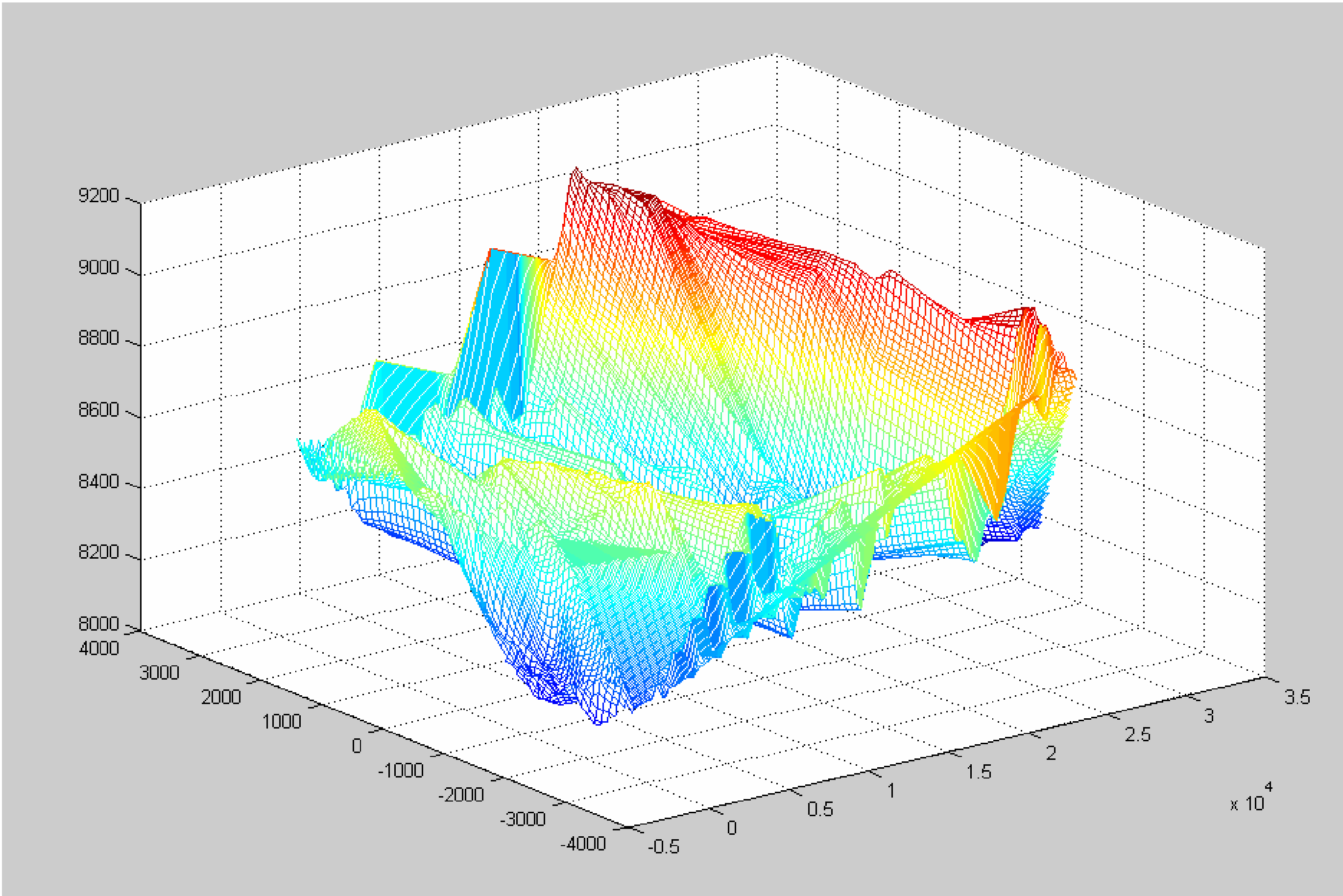
imagesc



mesh

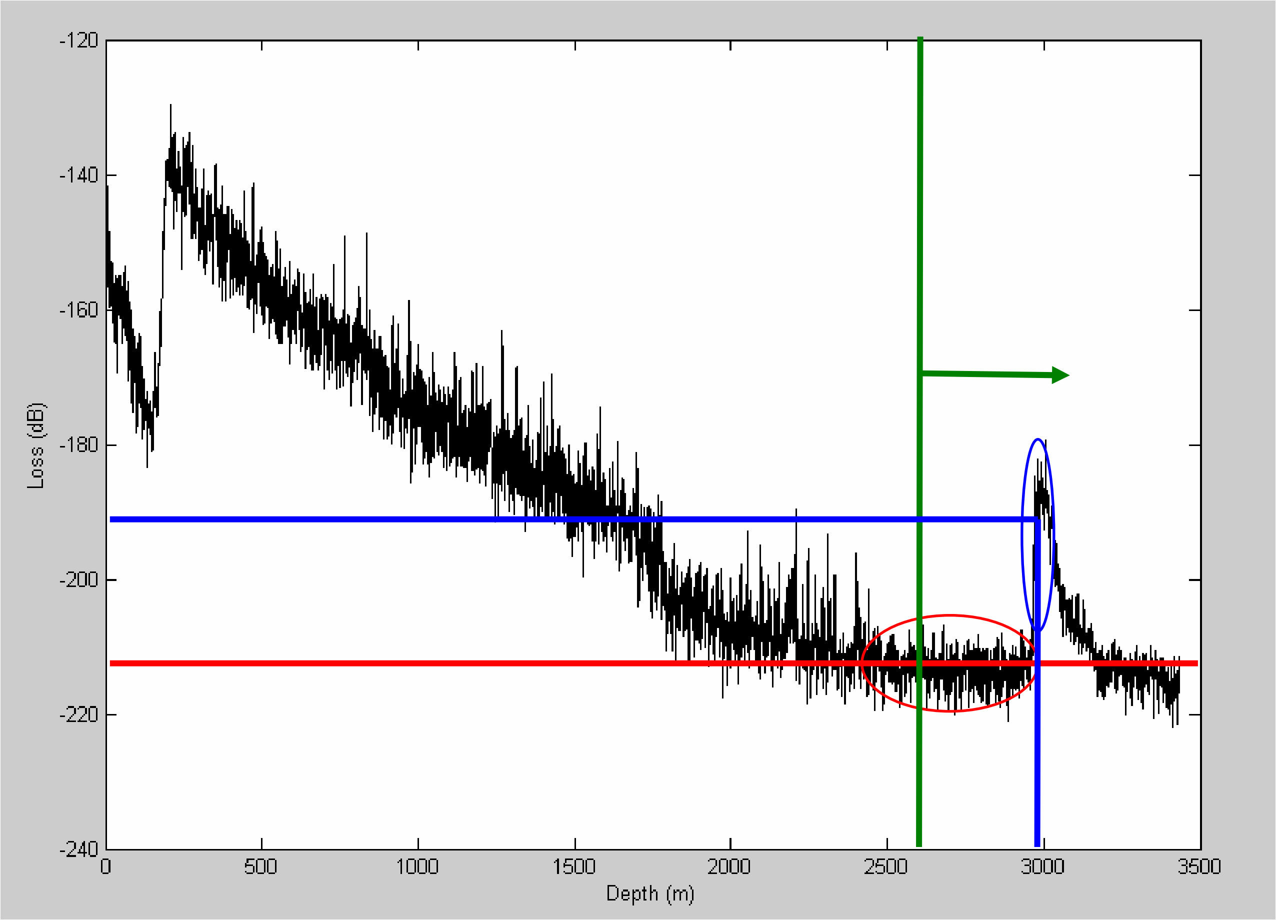


9200
9000
8800
8600
8400
8200
8000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
x 10^4

Selection

- Selection or deletion of a subset of data based on a criteria
- Example: find the bedrock depth by finding the first point, below 2600m, that is 20dB above the noise floor

AScope



-120
-140
-160
-180
-200
-220
-240
Loss (dB)
0
500
1000
1500
2000
2500
3000
3500
Depth (m)

Bedrock Locator

```
% Attempt 2: Threshold
% Look for first point that is 20dB above noise floor below point 7500

noise_floor = -124;
bedrock_sig = (noise_floor + 20);
start = 7500;
max_rows = size(rds_data,1);
memory_spread = 40;
bedrock_loc = zeros(1,size(rds_data,2));

for column = 1:size(rds_data,2);
    for row = start:max_rows
        value = rds_data(row, column);
        if((column == 1) && (memory_in == 0))
            if(value > bedrock_sig)
                bedrock_loc(column) = row;
                break;
            end
        elseif((column == 1) && (memory_in ~= 0))
            bottom = (memory_in - memory_spread);
            top = (memory_in + memory_spread);
            if((value > bedrock_sig) && (row > bottom) && (row < top))
                bedrock_loc(column) = row;
                break;
            end
        elseif((column > 1) && (bedrock_loc(column-1) ~= 0))
            bottom = (bedrock_loc(column-1) - memory_spread);
            top = (bedrock_loc(column-1) + memory_spread);
            if((value > bedrock_sig) && (row > bottom) && (row < top))
                bedrock_loc(column) = row;
                break;
            end
        elseif((column > 1) && (bedrock_loc(column-1) == 0))
            if(value > bedrock_sig)
                bedrock_loc(column) = row;
                break;
            end
        end
    end
    if(bedrock_loc(column) == 0)
        warning = sprintf('Warning: Lost bedrock at column %d', column);
        disp(warning);
    end
end
memory_out = bedrock_loc(column);
```

- Program acquires bedrock location in first column
- This is used as a starting point in the next column
- If bedrock is lost, program returns to acquisition step

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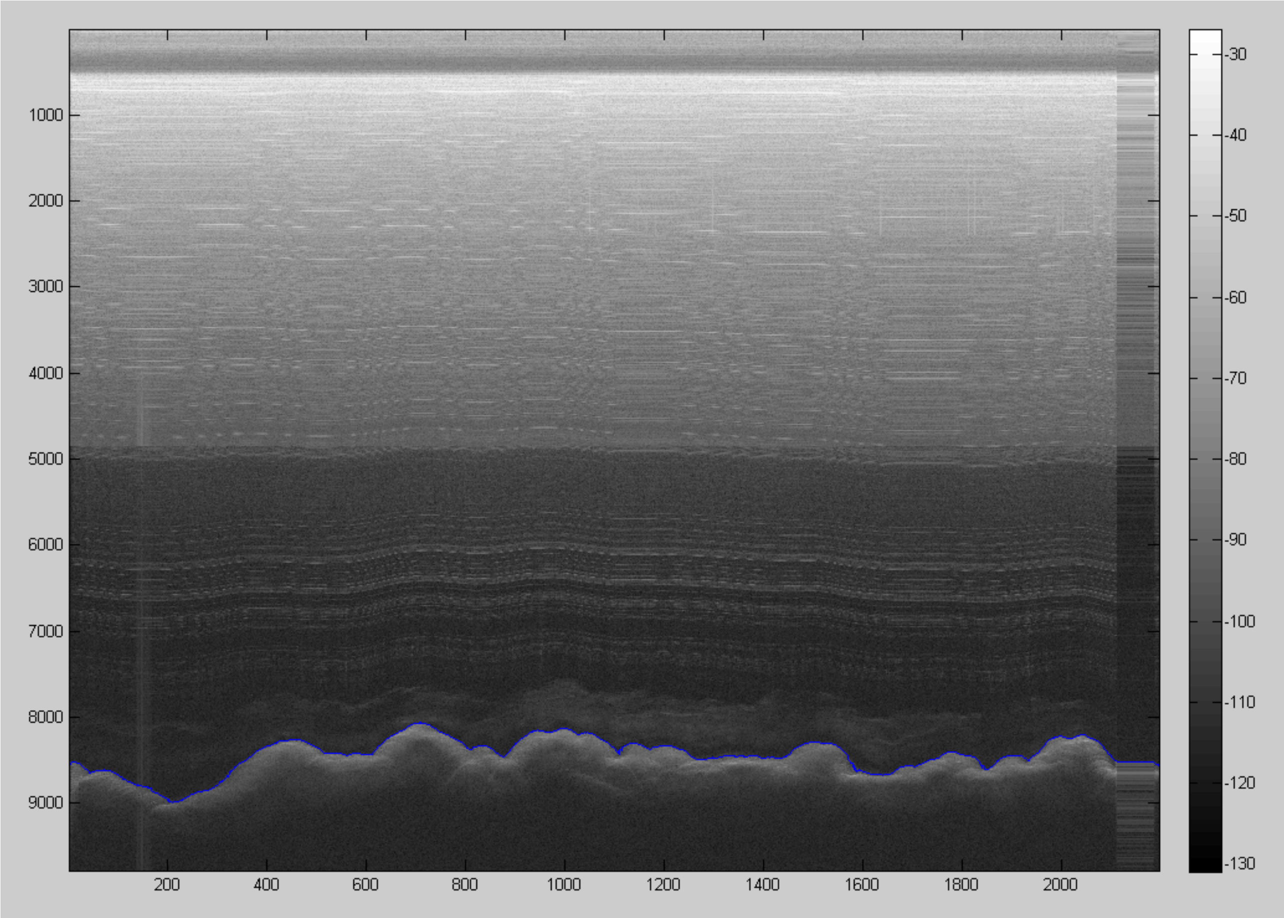
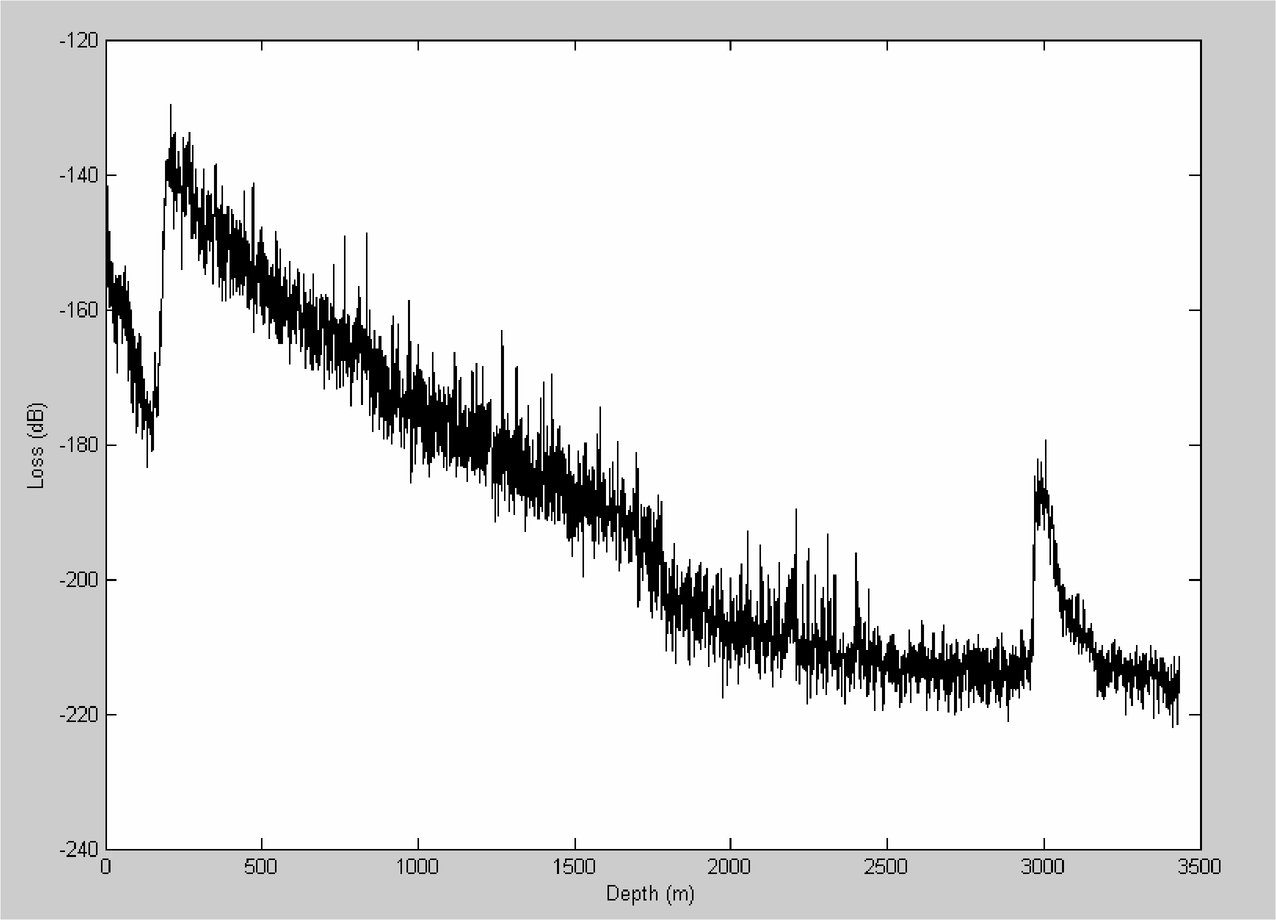
Visualization

- Analysis of data through sight
- An important part of the analysis process
- Particularly used during explorative data analysis, where the analysis is driven by the data itself, as opposed to a hypothesis

Cross Sections



AScope



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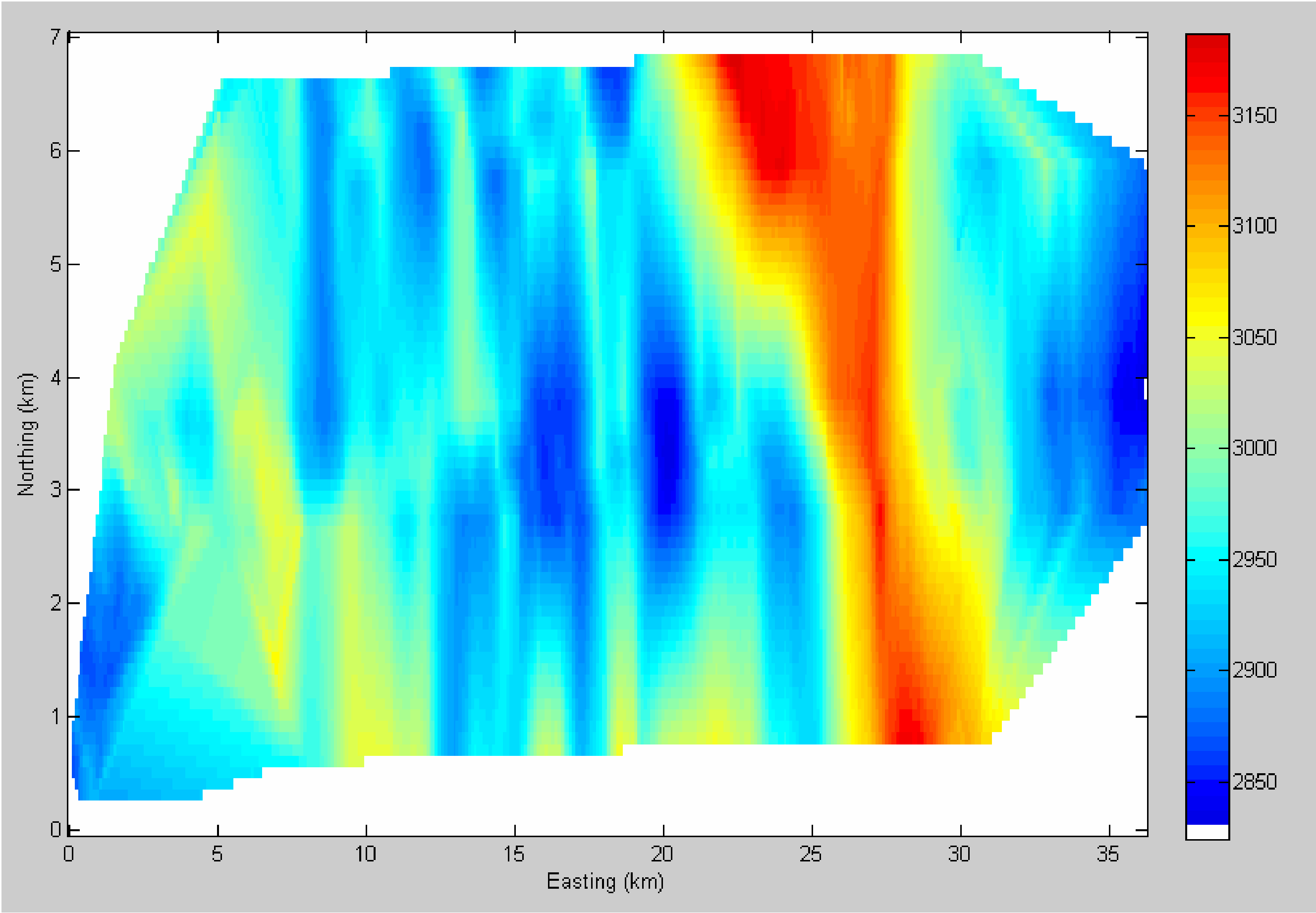
Thickness Chart



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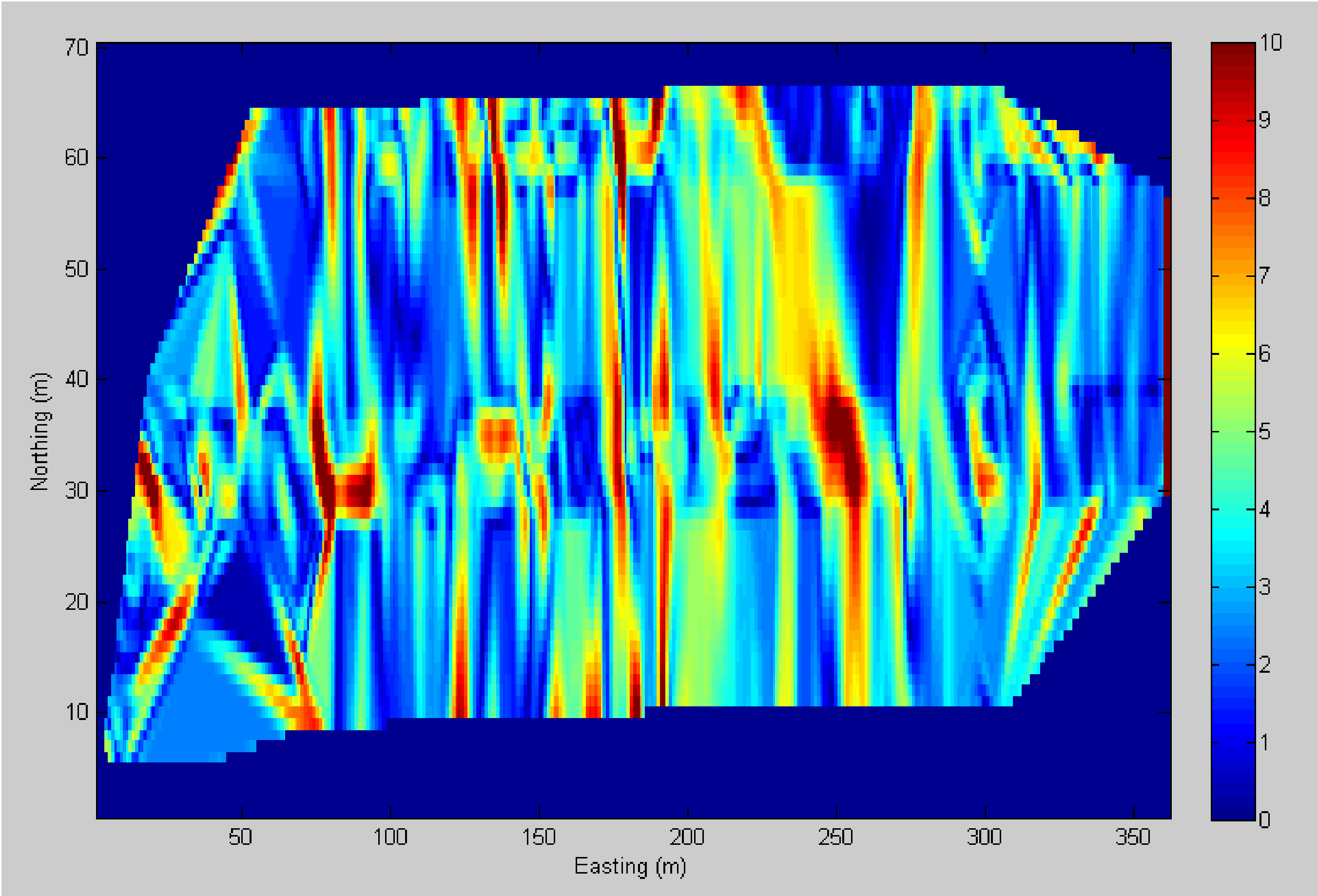
Slope Chart



Northing (m)
Easting (m)
70
60
50
40
30
20
10
50
100
150
200
250
300
350
10
9
8
7
6
5
4
3
2
1
0

Questions?

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