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Homework 8

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GEOS597 Homework #8: GPS, streamflow data and statistics

Due: 11/14/2016

```
clear all;
close all;
clc;
```

Part 1: Automated GPS Data Processing

1.4 Compare the best-fit polynomial

Overall, the estimated values of average motion remain consistent and the vast majority are within 0.1 cm/yr of the compared values for all directions. In light of these small discrepancies, polyfit is theoretically more accurate becuse it is estimating all values rather than just the beginning and end points. In more variable data, we suspect this difference would be more pronounced. The largest discrepancies were in the vertical motion estimates, which were also the lowest in magnitude. These lower values may be approaching the low end of sensor range. Similarly, perhaps vertical motion is systematically more difficult to detect than horizontal motion.

```
[V,map] = imread('VelocityTable_HW8.PNG', 'png');
imshow(V,map);
```

Station Name	N velocity [cm/yr]	N velocity using polyfit	E velocity	E velocity using poly fit	Vertical velocity	Vertical velocity using polyfit
ana1	2.241	2.215	-4.078	-4.084	0.121	0.001
bbdm	2.045	2.035	-4.08	-4.101	0.021	0.066
cirx	2	1.972	-3.99	-3.971	-0.03	-0.027
cmp9	1.381	1.343	-3.675	-3.644	0.073	-0.028
dam2	1.365	1.337	-3.605	-3.649	0.016	0.056
kbrc	1.253	1.268	-3.851	-3.877	0.05	-0.04
p729	1.918	1.927	-4.153	-4.108	-0.402	-0.329

1.6: Process all of the data

```
allGPS_HW8
```

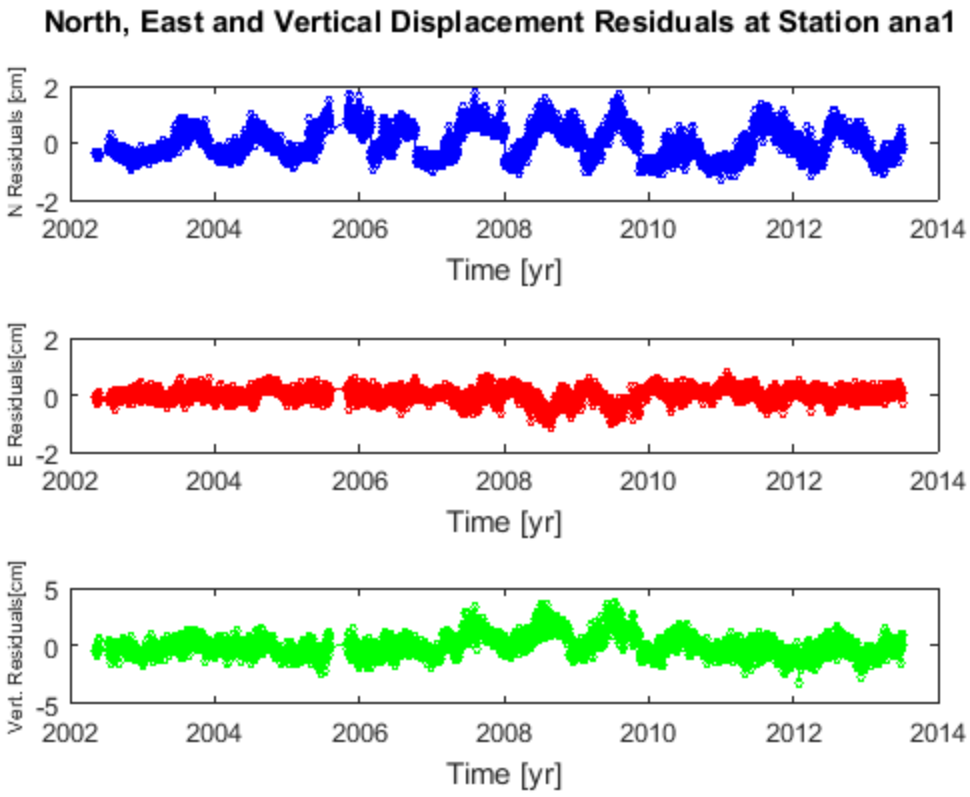
```
.                               cavecreek.txt
..                              cirxCleanUnf.neu
GEOS597_HW8_DudunakeShuler.asv  cmp9CleanUnf.neu
GEOS597_HW8_DudunakeShuler.m    dam2CleanUnf.neu
VelocityTable.xlsx              detrendGPS.m
VelocityTable_HW8.PNG           detrendGPS.pdf
allGPS_HW8.m                    kbrcCleanUnf.neu
ana1CleanUnf.neu                p729CleanUnf.neu
bbdmCleanUnf.neu

Site Name: ana1
Time span: 11.15 [yrs]
Number of days with data: 3862
Total north displacement:     25.00 [cm]
Total east displacement:      -45.48 [cm]
Total vertical displacement:  1.35 [cm]
Avg north velocity:     2.241 [cm/yr]
Avg east velocity:      -4.078 [cm/yr]
Avg vertical velocity:  0.121 [cm/yr]
Avg north velocity using best-fit polynomial:     2.215 [cm/yr]
Avg east velocity using best-fit polynomial:      -4.084 [cm/yr]
Avg vertical velocity best-fit polynomial:        0.001 [cm/yr]

Site Name: bbdm
Time span: 12.79 [yrs]
Number of days with data: 4543
Total north displacement:     26.15 [cm]
Total east displacement:      -52.17 [cm]
Total vertical displacement:  0.27 [cm]
Avg north velocity:     2.045 [cm/yr]
Avg east velocity:      -4.080 [cm/yr]
Avg vertical velocity:  0.021 [cm/yr]
Avg north velocity using best-fit polynomial:     2.035 [cm/yr]
Avg east velocity using best-fit polynomial:      -4.101 [cm/yr]
Avg vertical velocity best-fit polynomial:        0.066 [cm/yr]

Site Name: cirx
Time span: 12.71 [yrs]
Number of days with data: 4445
Total north displacement:     25.44 [cm]
Total east displacement:      -50.71 [cm]
Total vertical displacement:  -0.40 [cm]
Avg north velocity:     2.001 [cm/yr]
Avg east velocity:      -3.989 [cm/yr]
Avg vertical velocity:  -0.031 [cm/yr]
Avg north velocity using best-fit polynomial:     1.972 [cm/yr]
Avg east velocity using best-fit polynomial:      -3.971 [cm/yr]
Avg vertical velocity best-fit polynomial:        -0.027 [cm/yr]
```

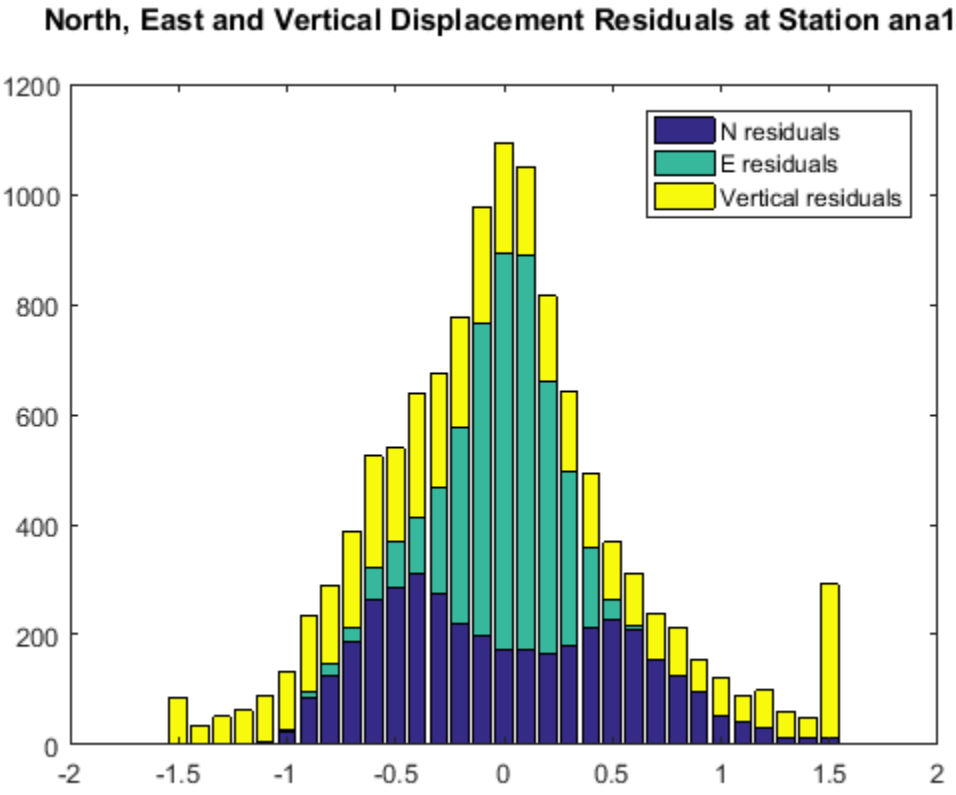
Site Name: cmp9
Time span: 18.04 [yrs]
Number of days with data: 6240
Total north displacement: 24.91 [cm]
Total east displacement: -66.29 [cm]
Total vertical displacement: 1.32 [cm]
Avg north velocity: 1.381 [cm/yr]
Avg east velocity: -3.675 [cm/yr]
Avg vertical velocity: 0.073 [cm/yr]
Avg north velocity using best-fit polynomial: 1.343 [cm/yr]
Avg east velocity using best-fit polynomial: -3.644 [cm/yr]
Avg vertical velocity best-fit polynomial: -0.028 [cm/yr]

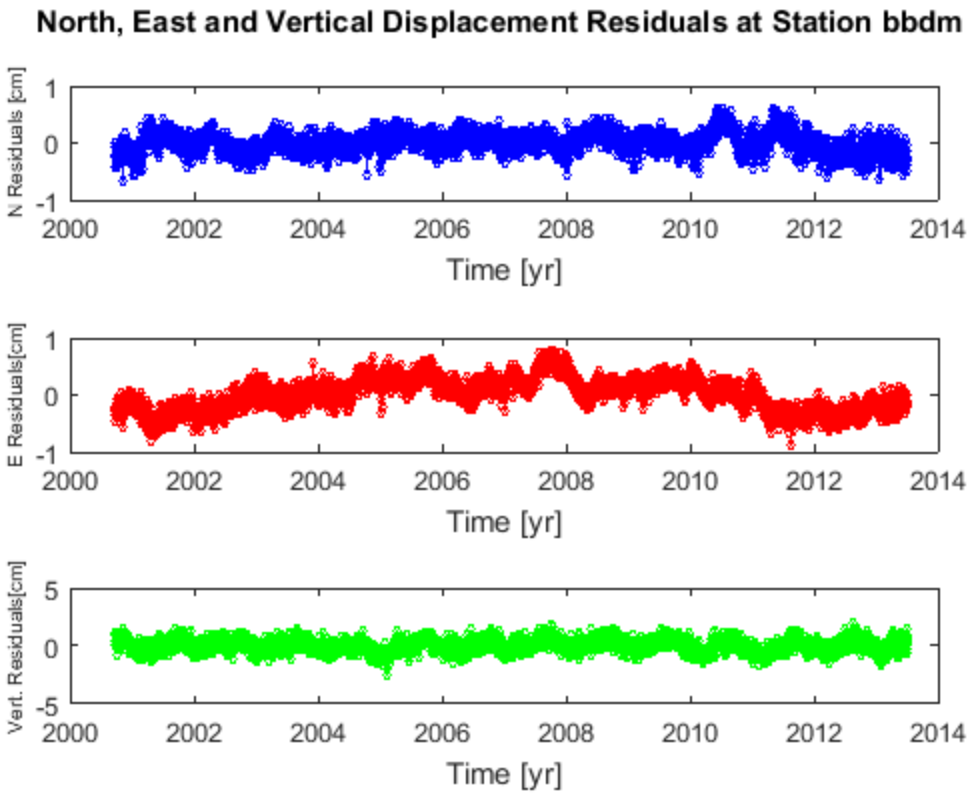
Site Name: dam2
Time span: 17.87 [yrs]
Number of days with data: 4702
Total north displacement: 24.38 [cm]
Total east displacement: -64.41 [cm]
Total vertical displacement: 0.28 [cm]
Avg north velocity: 1.365 [cm/yr]
Avg east velocity: -3.605 [cm/yr]
Avg vertical velocity: 0.016 [cm/yr]
Avg north velocity using best-fit polynomial: 1.337 [cm/yr]
Avg east velocity using best-fit polynomial: -3.649 [cm/yr]
Avg vertical velocity best-fit polynomial: 0.056 [cm/yr]

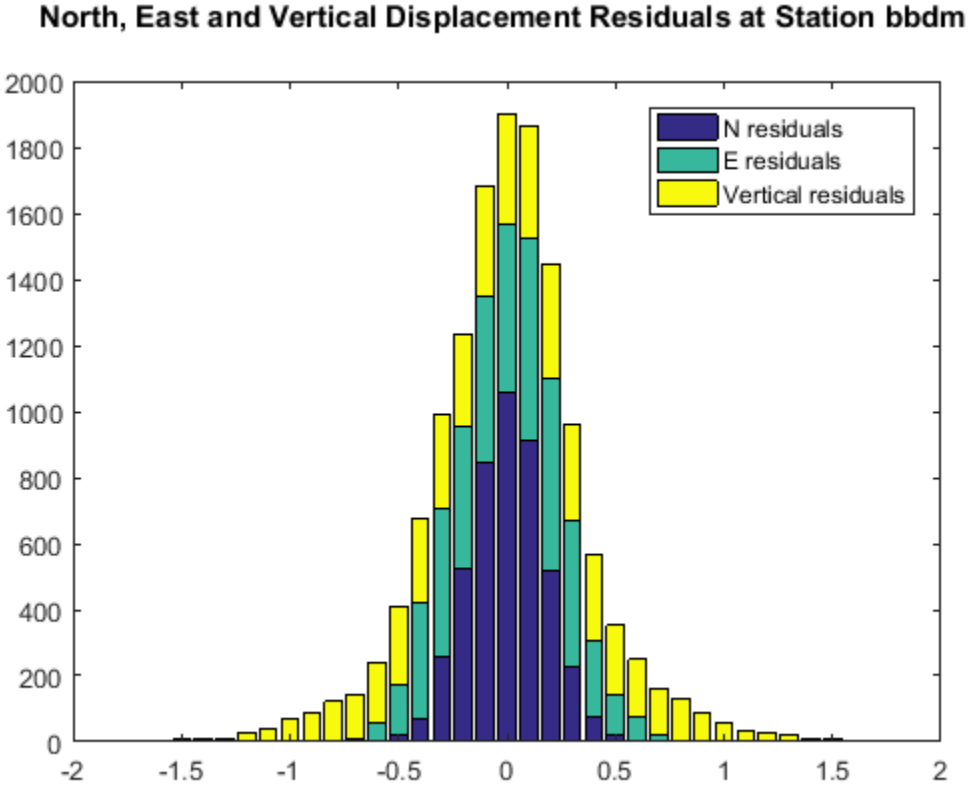
Site Name: kbrc
Time span: 12.53 [yrs]
Number of days with data: 4325
Total north displacement: 15.70 [cm]
Total east displacement: -48.26 [cm]
Total vertical displacement: 0.63 [cm]
Avg north velocity: 1.253 [cm/yr]
Avg east velocity: -3.851 [cm/yr]
Avg vertical velocity: 0.050 [cm/yr]
Avg north velocity using best-fit polynomial: 1.268 [cm/yr]
Avg east velocity using best-fit polynomial: -3.877 [cm/yr]
Avg vertical velocity best-fit polynomial: -0.040 [cm/yr]

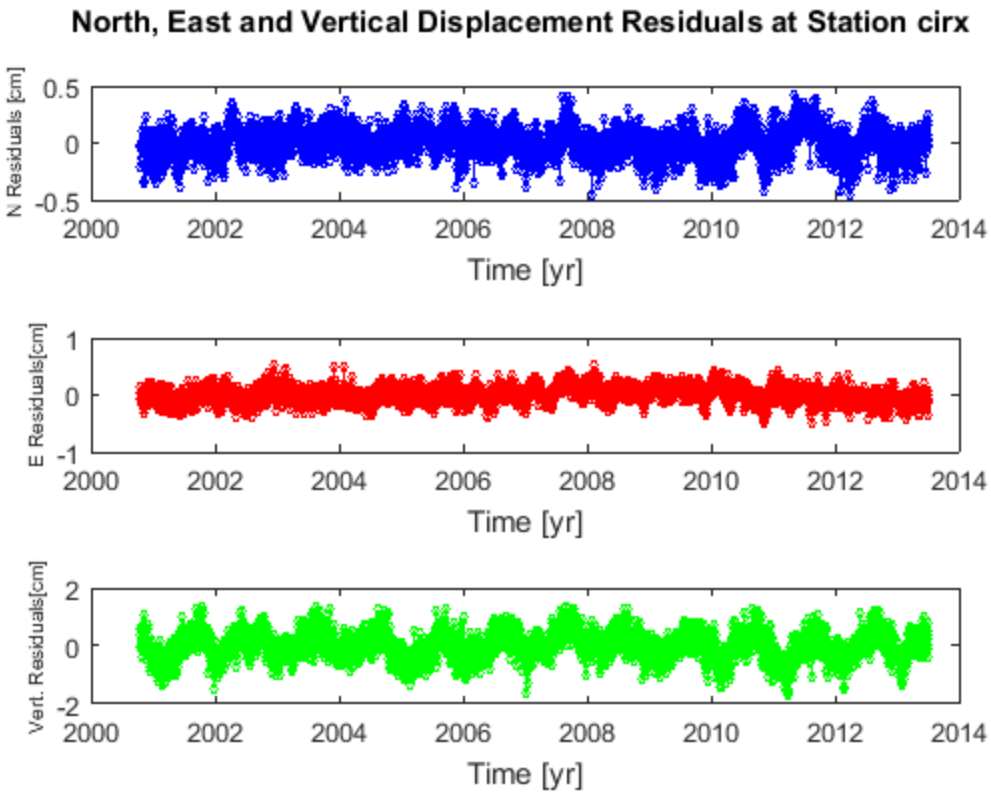
Site Name: p729
Time span: 6.46 [yrs]
Number of days with data: 2354
Total north displacement: 12.39 [cm]
Total east displacement: -26.83 [cm]
Total vertical displacement: -2.60 [cm]
Avg north velocity: 1.918 [cm/yr]
Avg east velocity: -4.153 [cm/yr]
Avg vertical velocity: -0.402 [cm/yr]
Avg north velocity using best-fit polynomial: 1.927 [cm/yr]
Avg east velocity using best-fit polynomial: -4.108 [cm/yr]
Avg vertical velocity best-fit polynomial: -0.329 [cm/yr]

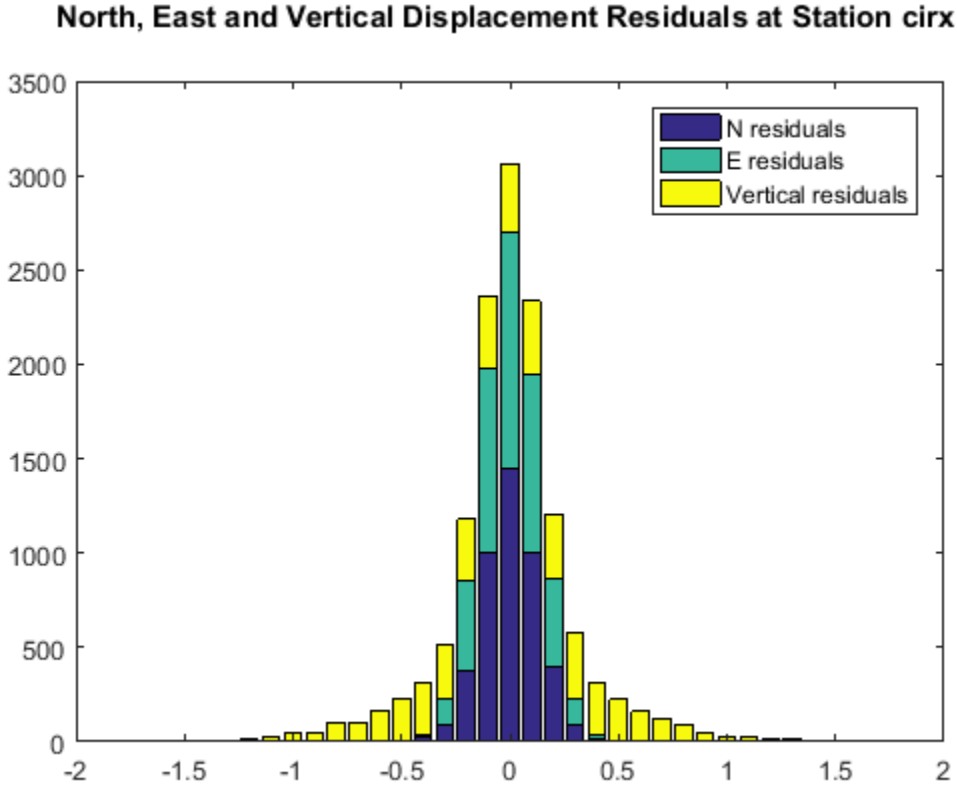

North, East and Vertical Displacement Residuals at Station ana1
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
2002
2004
2006
2008
2010
2012
2014

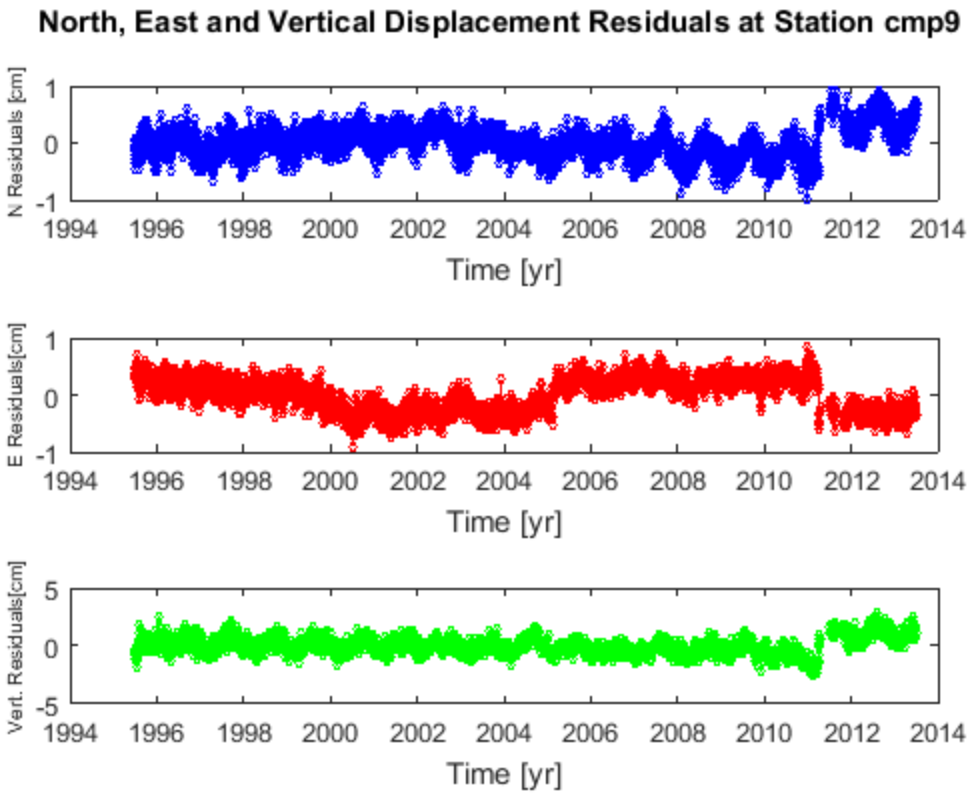

North, East and Vertical Displacement Residuals at Station ana1
N residuals
E residuals
Vertical residuals

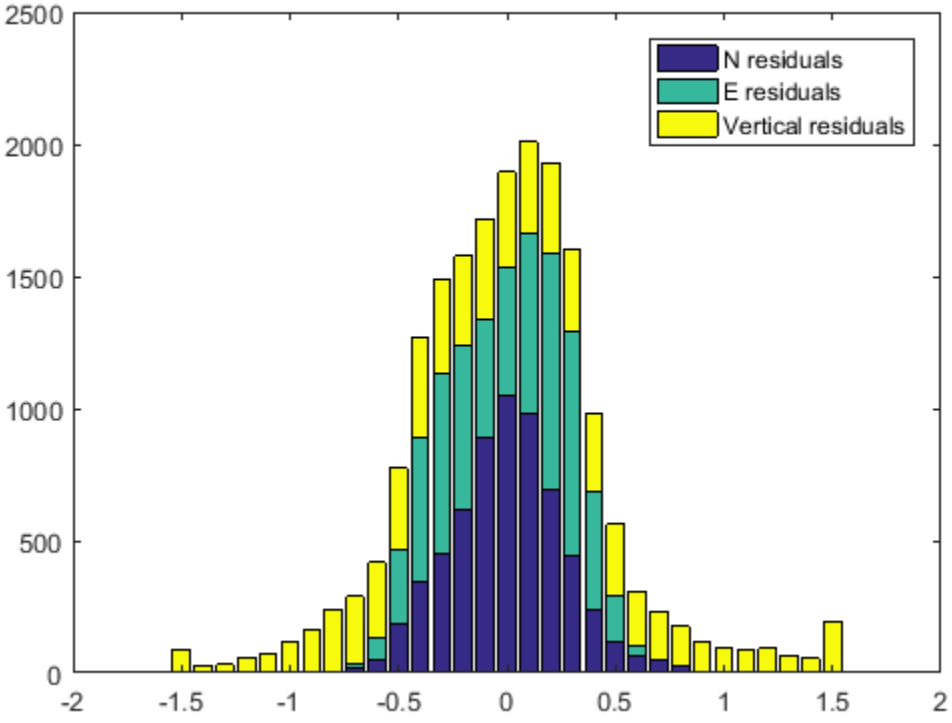

North, East and Vertical Displacement Residuals at Station bbdm
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
2000
2002
2004
2006
2008
2010
2012
2014

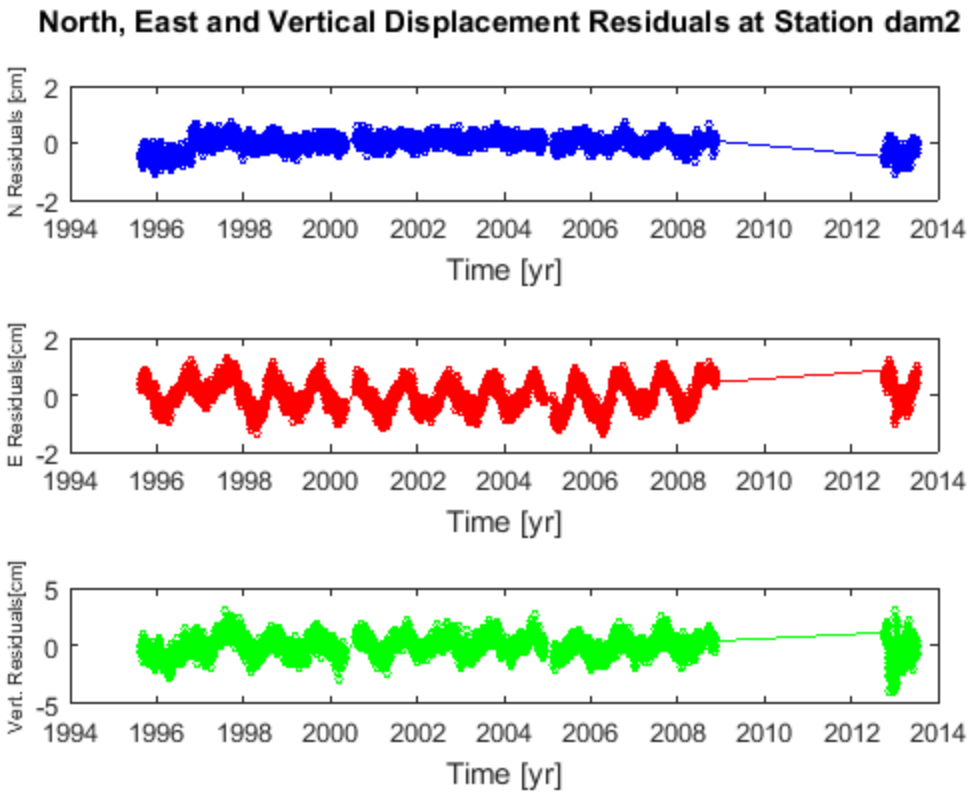

North, East and Vertical Displacement Residuals at Station bbdm
N residuals
E residuals
Vertical residuals

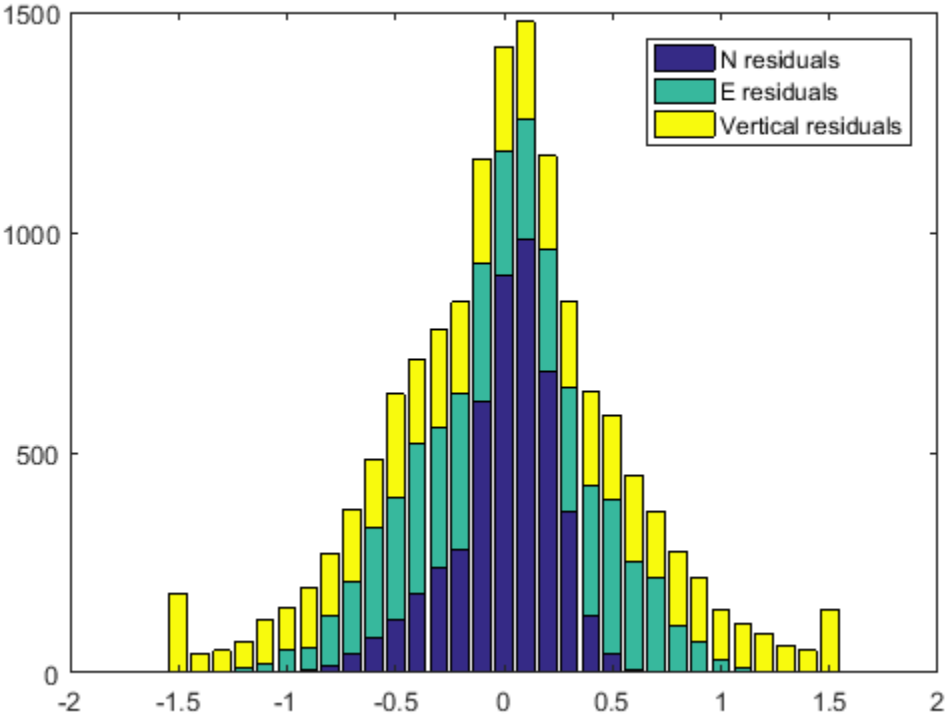

North, East and Vertical Displacement Residuals at Station cirx
N Residuals [cm]
0.5
0
-0.5
2000
2002
2004
2006
2008
2010
2012
2014
Time [yr]
E Residuals[cm]
1
0
-1
Time [yr]
Vert. Residuals[cm]
2
0
-2
Time [yr]

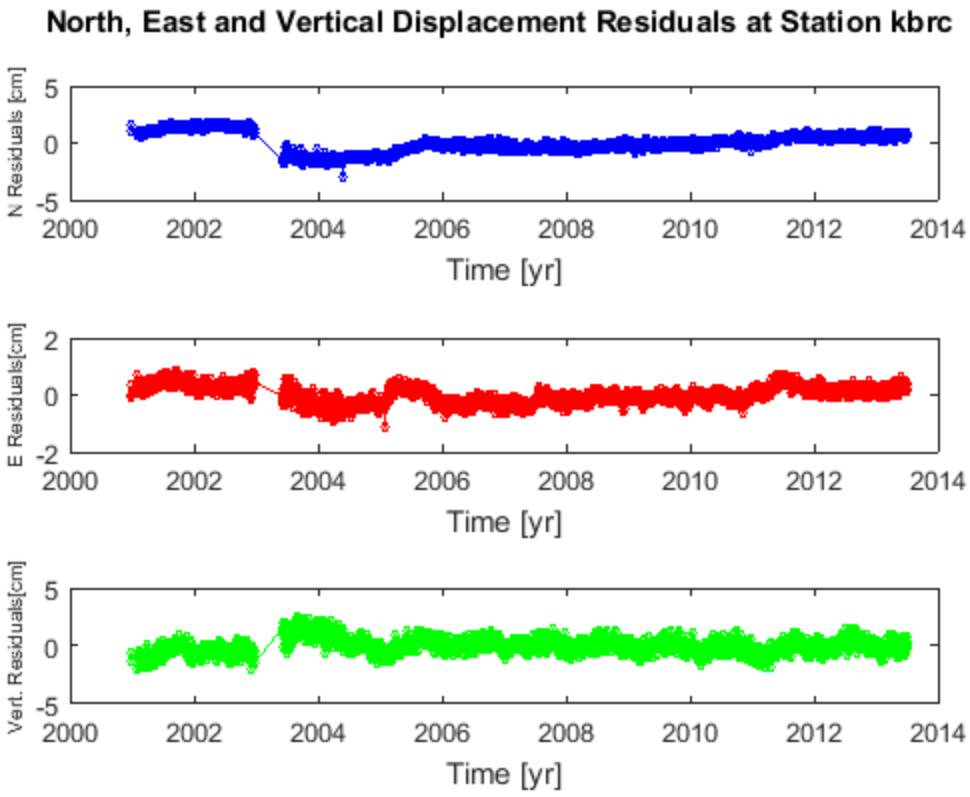

North, East and Vertical Displacement Residuals at Station cirx
N residuals
E residuals
Vertical residuals
3500
3000
2500
2000
1500
1000
500
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

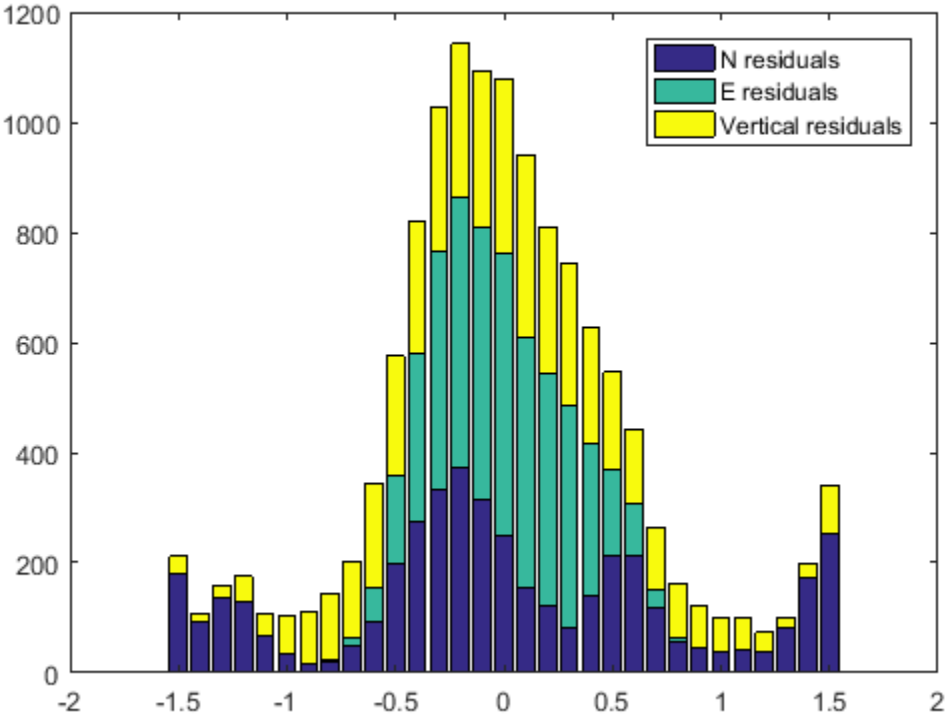

North, East and Vertical Displacement Residuals at Station cmp9
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

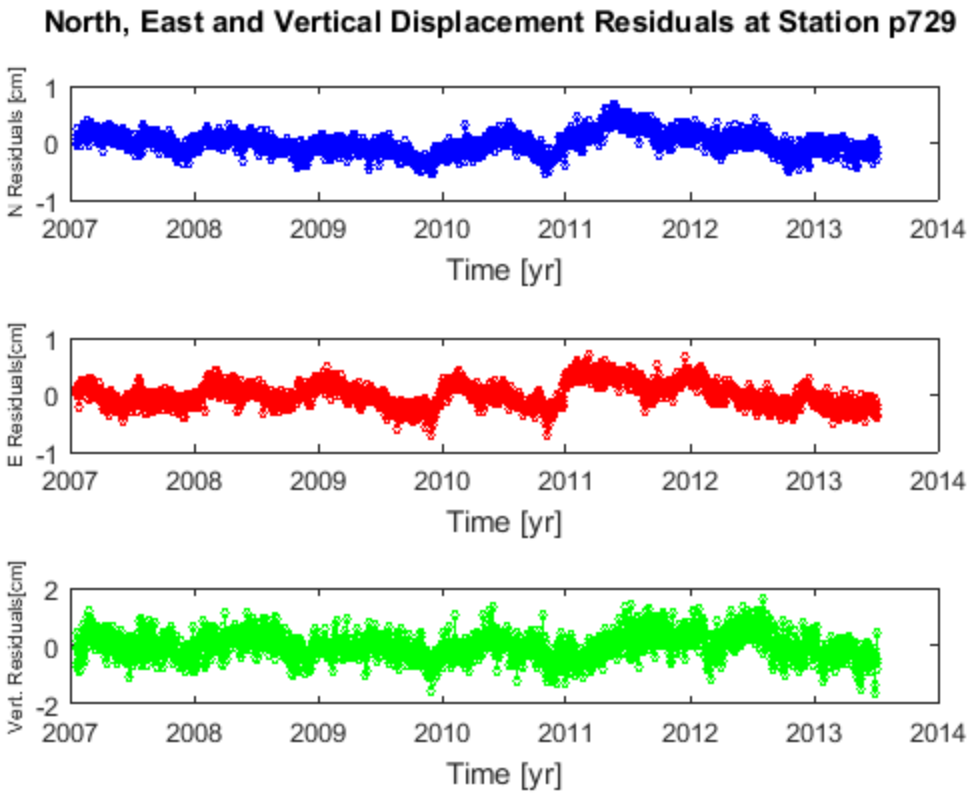

North, East and Vertical Displacement Residuals at Station cmp9
N residuals
E residuals
Vertical residuals

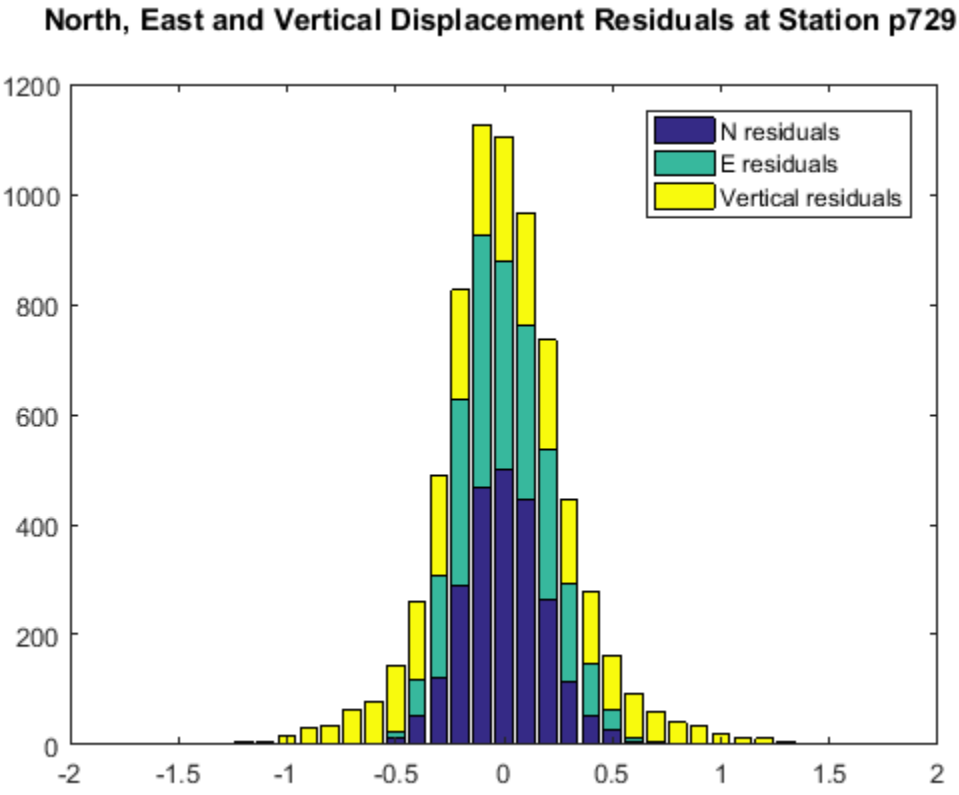

North, East and Vertical Displacement Residuals at Station dam2
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


North, East and Vertical Displacement Residuals at Station dam2
N residuals
E residuals
Vertical residuals


North, East and Vertical Displacement Residuals at Station kbrc
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
2000
2002
2004
2006
2008
2010
2012
2014


North, East and Vertical Displacement Residuals at Station kbrc
N residuals
E residuals
Vertical residuals


North, East and Vertical Displacement Residuals at Station p729
N Residuals [cm]
E Residuals[cm]
Vert. Residuals[cm]
Time [yr]
2007
2008
2009
2010
2011
2012
2013
2014


North, East and Vertical Displacement Residuals at Station p729
N residuals
E residuals
Vertical residuals

1.7: Analyze the results

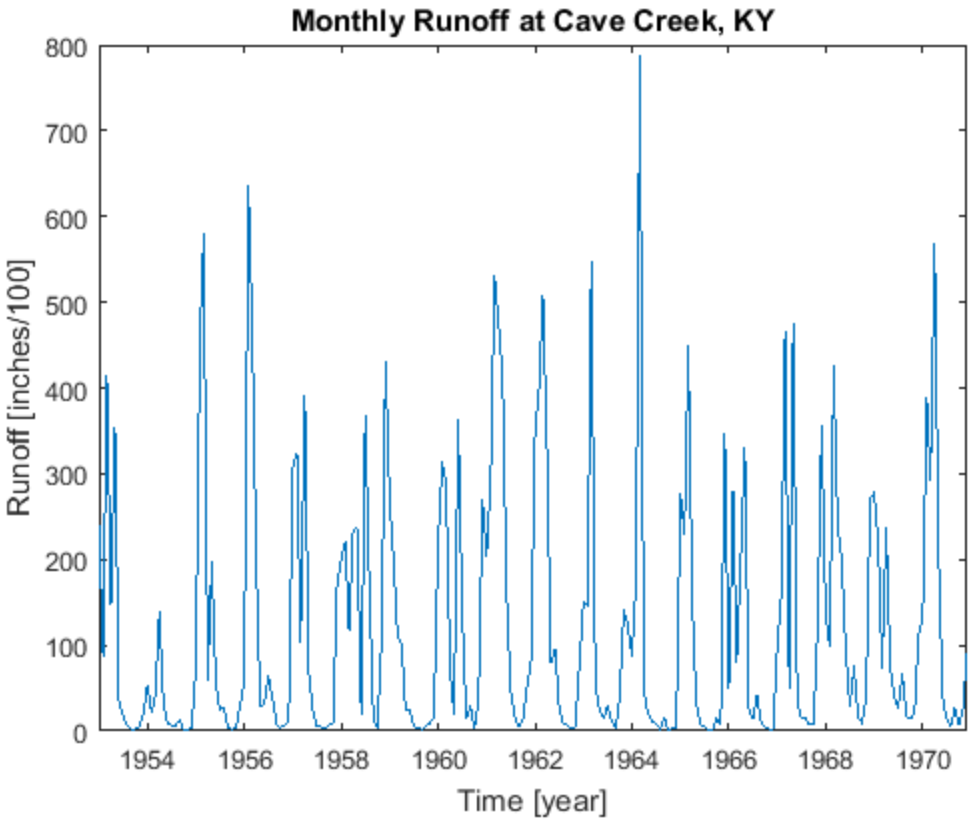
Residual time series data shows sinusoidal variations in plate motion. When plotted as histograms, these data most nearly approximate a normal distribution. The histograms make sense given the general trends observed in the plots of residual movement versus time and analysis of the velocity table data .Vertical residual values tend to have greater variability about the trend line as the histograms show a greater spread for the vertical residuals. The eastern and northern direction residuals tend to have less variability and are more clustered around zero residual motion because the polynomial fit is much better. A few stations show northern residuals that appear bimodally distributed, which may be better addressed with higher order polynomials. Generally, the first order polynomial did an adequate job of detrending the plate movement data. If the bins were smaller, the normal distributions would become smoother. Conversely, coarser bin sizes would decrease the appearance of a normal distribution of the residual data and likely make interpretation more difficult. The chosen number of bins seems appropriate in this instance.

Part 2: Water-year data loading & visualization

2.1: Load the data, sort and plot

This data needs to be sorted chronologically because the raw format is organized by water year from Oct 1 - Sept 31 (Table 1 in the HW doc), rather than from January to December.

```
load('cavecreek.txt');
tEnd = datetime(1953, 9, 1) + calmonths(1:3);
tBeg = datetime(1953, 0, 1) + calmonths(1:9);
tfirst = [tEnd tBeg];
tfinal(1,:) = tfirst;

for i=1:17;
    tfinal(i+1,:) = tfirst + calyears(i);
end

tfinal2 = tfinal';
tArray = (reshape(tfinal2,1,216))';

[tArraysorted, SortIndex] = sort(tArray);
cavecreeksorted = cavecreek(SortIndex);

h = figure;
plot(tArraysorted, cavecreeksorted);
xlabel('Time [year]')
ylabel('Runoff [inches/100]')
title('Monthly Runoff at Cave Creek, KY')
```

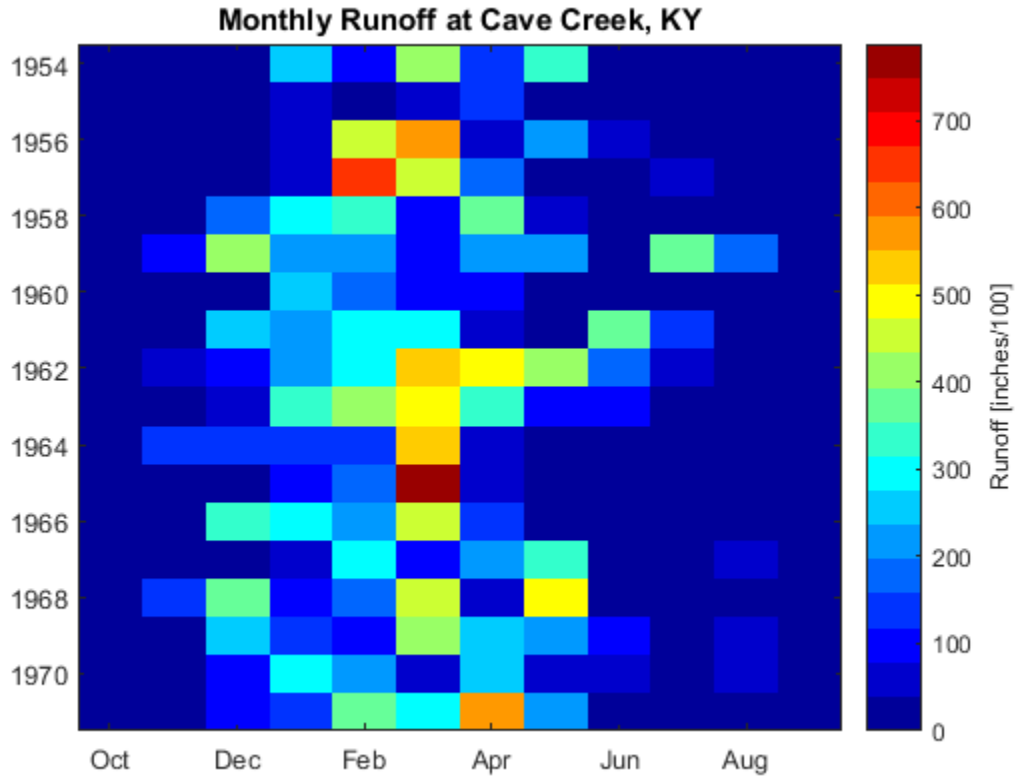


2.2: Reshape vector into a matrix and plot

```
B = reshape(cavecreek,[12,18]);
runoffArray = B';

h = figure;
imagesc(runoffArray);
xticks([1:2:12])
xticklabels({'Oct','Dec','Feb','Apr','Jun','Aug'})
yticks([1:2:18])
yticklabels({'1954','1956','1958','1960','1962','1964','1966','1968','1970'})
c = colorbar;
colormap(jet(20))
c.Label.String = 'Runoff [inches/100]'
title('Monthly Runoff at Cave Creek, KY')
```

```
c =

  ColorBar (Runoff [inches/100]) with properties:

    Location: 'eastoutside'
      Limits: [0 788]
    FontSize: 9
    Position: [0.8202 0.1095 0.0476 0.8167]
       Units: 'normalized'
```

```
Use GET to show all properties
```



2.3: Median and Mean

Mean and median runoff values do not match because the mean is influenced by outliers in the data moreso than is median. Particularly high or low runoff years can skew the mean, while only marginally affecting median. In this dataset, the mean for all months is greater than or roughly equal to the median, except in March, where the opposite was true.

```
for i = 1:12;
medianArray (1,i) = median(runoffArray(:,i))
meanArray (1,i) = mean(runoffArray(:,i))
end

monthArray = [1:1:12];

h = figure;
plot(monthArray, medianArray,'o','MarkerSize',10);
hold on;
plot(monthArray, meanArray,'x','MarkerSize',10);
title('Mean and Median Runoff at Cave Creek, KY')
legend('Median','Mean')
xticks([1:12])
xticklabels({'Oct','Nov','Dec','Jan','Feb','March','Apr','May','Jun','July','Aug',
```

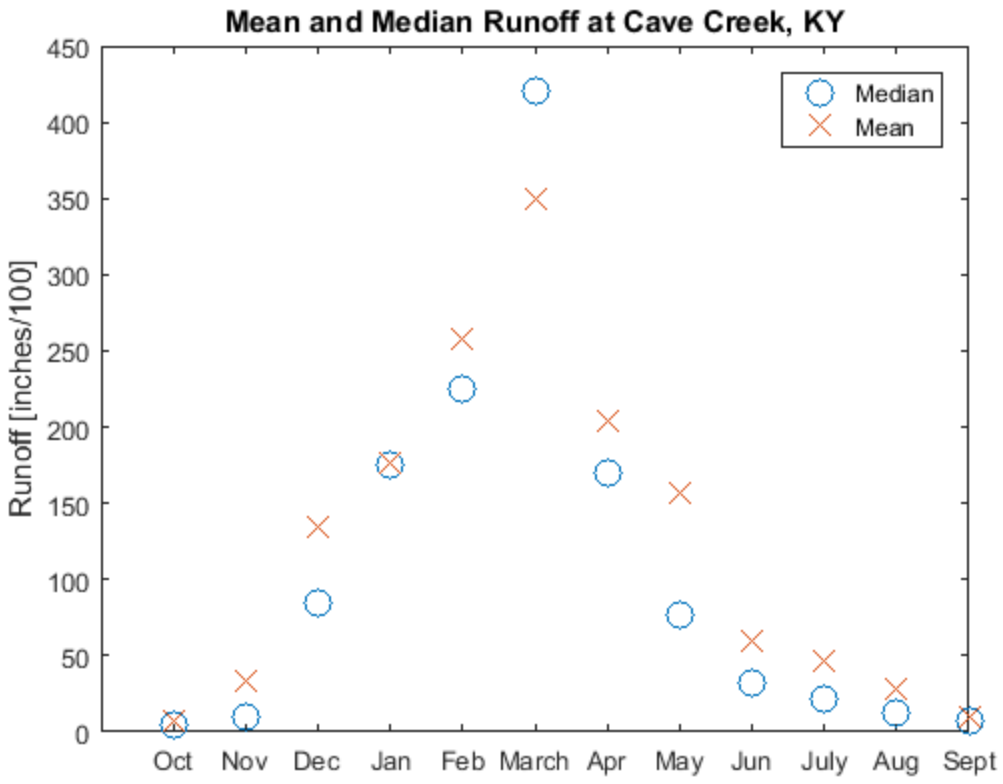
```
ylabel('Runoff [inches/100]')
```

```
medianArray =

     5

meanArray =

    7.6111

medianArray =

    5.0000    9.5000

meanArray =

    7.6111   33.0000

medianArray =

    5.0000    9.5000   85.0000

meanArray =

    7.6111   33.0000  134.3333

medianArray =

    5.0000    9.5000   85.0000  175.0000

meanArray =

    7.6111   33.0000  134.3333  176.3333

medianArray =

    5.0000    9.5000   85.0000  175.0000  225.5000

meanArray =

    7.6111   33.0000  134.3333  176.3333  258.4444

medianArray =
```

```
    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000

meanArray =

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222

medianArray =

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

meanArray =

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

medianArray =

  Columns 1 through 7

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

  Column 8

   76.5000

meanArray =

  Columns 1 through 7

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

  Column 8

  156.5556

medianArray =

  Columns 1 through 7

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

  Columns 8 through 9

   76.5000   31.5000

meanArray =
```

```
  Columns 1 through 7

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

  Columns 8 through 9

  156.5556   59.5556

medianArray =

  Columns 1 through 7

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

  Columns 8 through 10

   76.5000   31.5000   21.0000

meanArray =

  Columns 1 through 7

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

  Columns 8 through 10

  156.5556   59.5556   47.1667

medianArray =

  Columns 1 through 7

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

  Columns 8 through 11

   76.5000   31.5000   21.0000   12.5000

meanArray =

  Columns 1 through 7

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

  Columns 8 through 11

  156.5556   59.5556   47.1667   28.6111

medianArray =
```

```
  Columns 1 through 7

    5.0000    9.5000   85.0000  175.0000  225.5000  420.5000  169.5000

  Columns 8 through 12

   76.5000   31.5000   21.0000   12.5000    7.5000

meanArray =

  Columns 1 through 7

    7.6111   33.0000  134.3333  176.3333  258.4444  349.2222  204.3333

  Columns 8 through 12

  156.5556   59.5556   47.1667   28.6111   10.1111
```



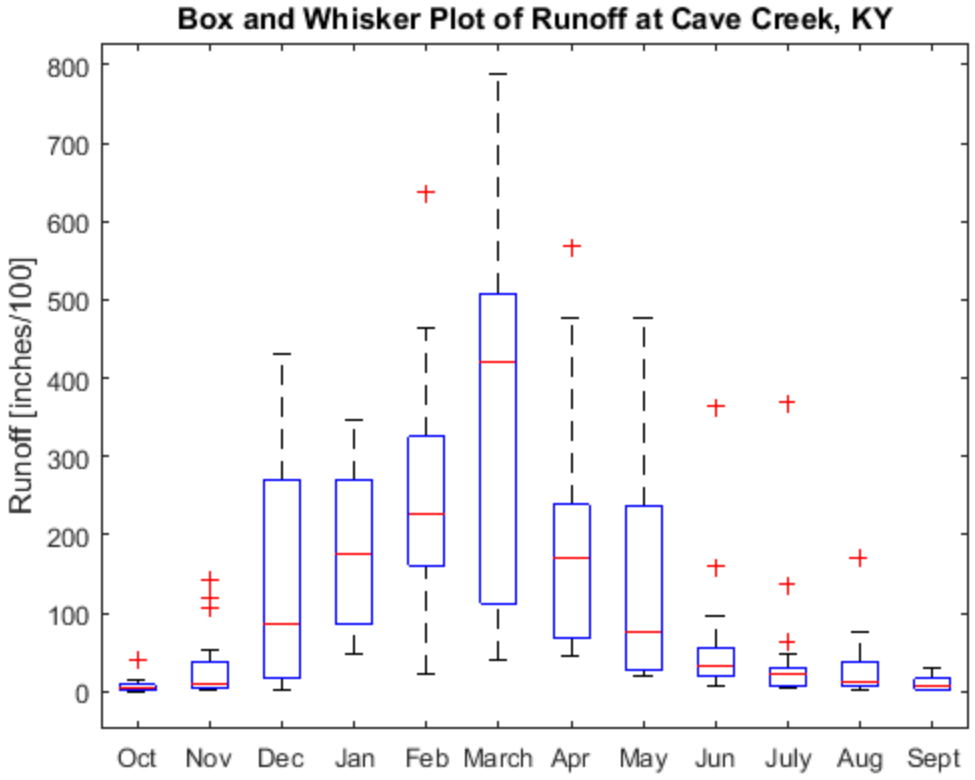
2.4: Box and whisker plot of each month

Box and whisker plots display this data with more statisical information. The central 50% of the data is bounded by the boxes. The median is represented by the red line in each box. The 75-100% quartile and the

0-25% quartiles are representd by the 'whiskers' on the two ends of each box. The small crosses represent outlie values not included in the box and whisker construction.

Our plot shows March to be by far the wettest month of the year at Cave Creek, though it has also the widest spread in values. The median values for each month appear to be normally distributed. The range of values in the drier months (June-November) is markedly lower than the months with greater runoff (December-May). There are more outlier values in the drier months as well.

```
h = figure;
boxplot(runoffArray);
xticks([1:12])
xticklabels({'Oct','Nov','Dec','Jan','Feb','March','Apr','May','Jun','July','Aug',
title('Box and Whisker Plot of Runoff at Cave Creek, KY')
xticks([1:12])
xticklabels({'Oct','Nov','Dec','Jan','Feb','March','Apr','May','Jun','July','Aug',
ylabel('Runoff [inches/100]')
```



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