# Assignment 4: London Weather Data Analysis

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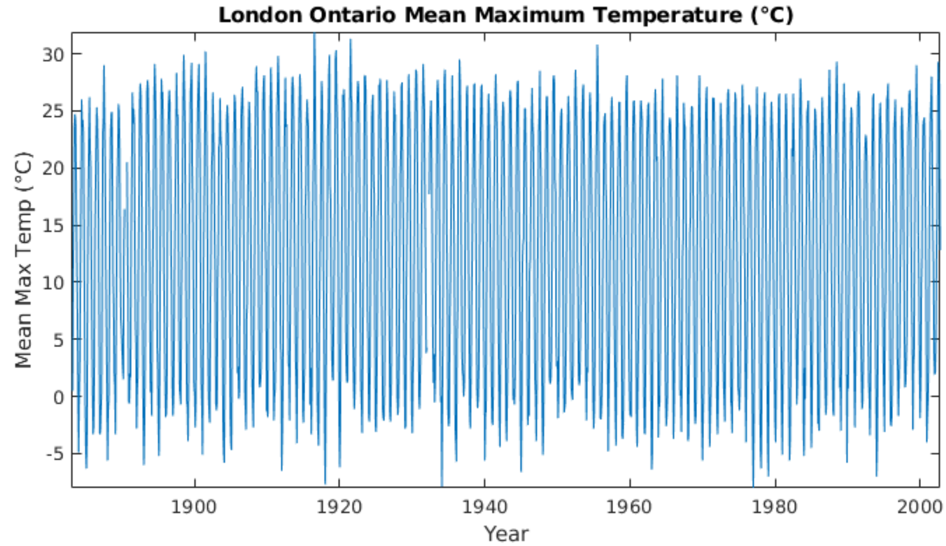
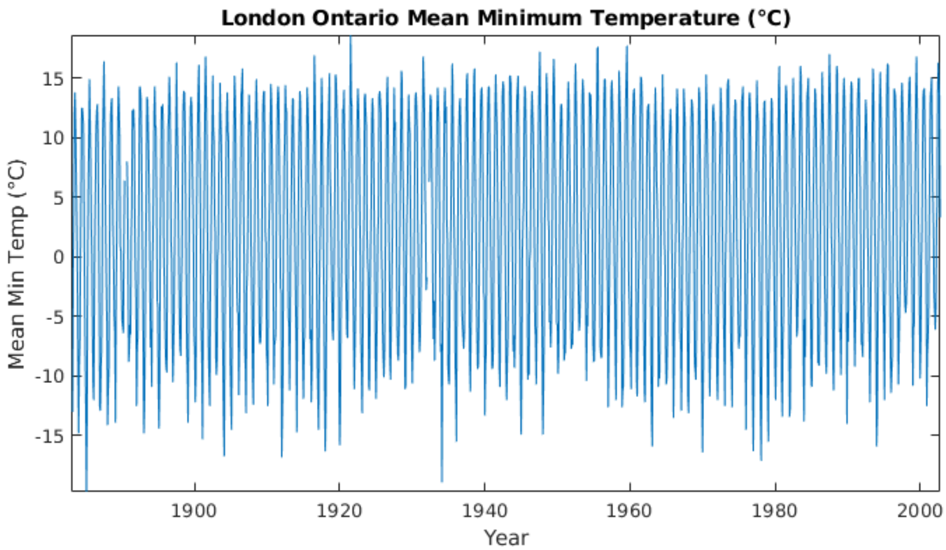
# Input Data

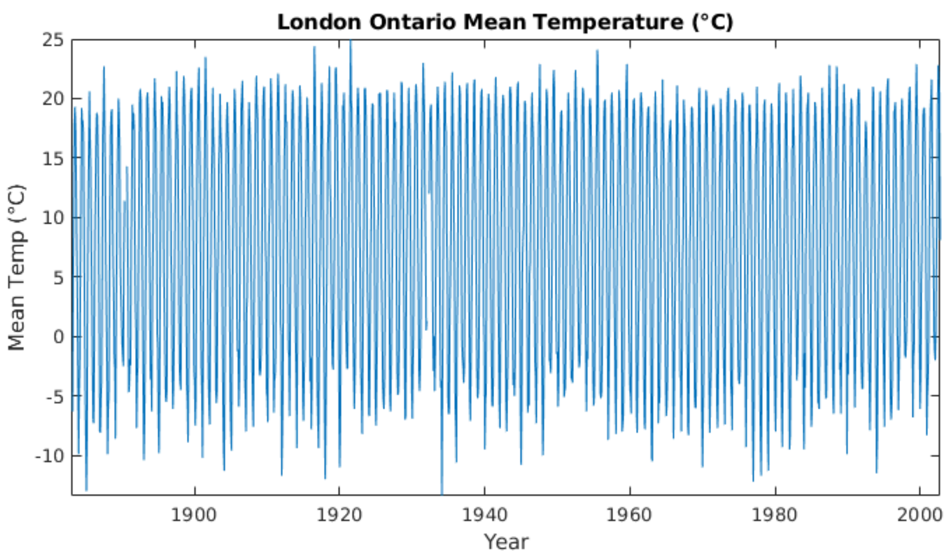
```
clear
ylabels = {'Year','Month','Mean Max Temp (°C)','Mean Min Temp
 (°C)',...
    'Mean Temp (°C)','Extr Max Temp (°C)','Extr Min Temp (°C)',...
    'Total Rain (mm)','Total Snow (cm)','Total Precip (mm)'};
titles = {'Year','Month','Mean Maximum Temperature (°C)',...
    'Mean Minimum Temperature (°C)','Mean Temperature (°C)',...
    'Extreme Maximum Temp (°C)','Extreme Minimum Temp (°C)',...
    'Total Rain (mm)','Total Snow (cm)','Total Precipitation (mm)'};

D1 = csvread('London_South_Monthly_1883-1932.csv',19,1);
D2 = csvread('London_Lambeth_A_Monthly_1930-1941.csv',19,1);
D3 = csvread('London_Intl_Airport_Monthly_1940-2006.csv',19,1);
D = [D1(3:end-8,:); D2(29:end-17,:); D3(8:end-50,:)];
```

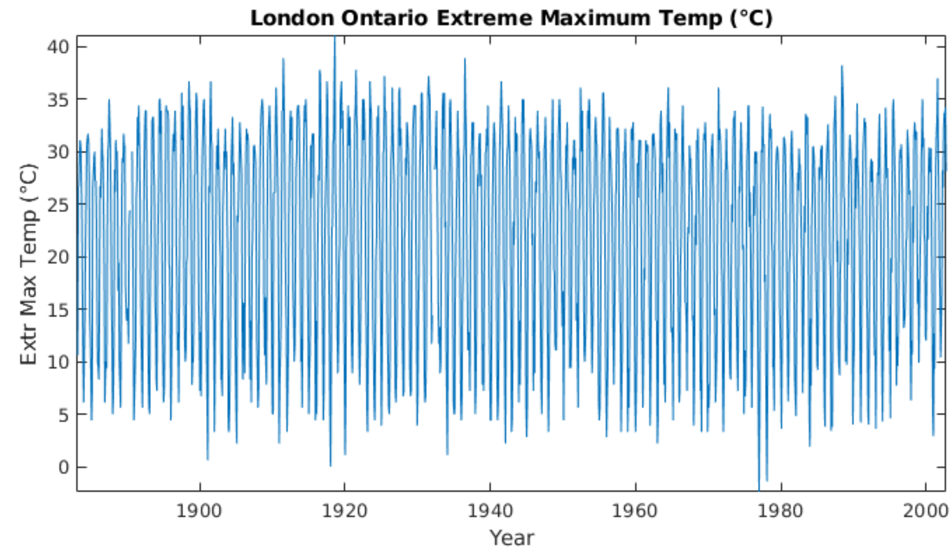
# Plot Data

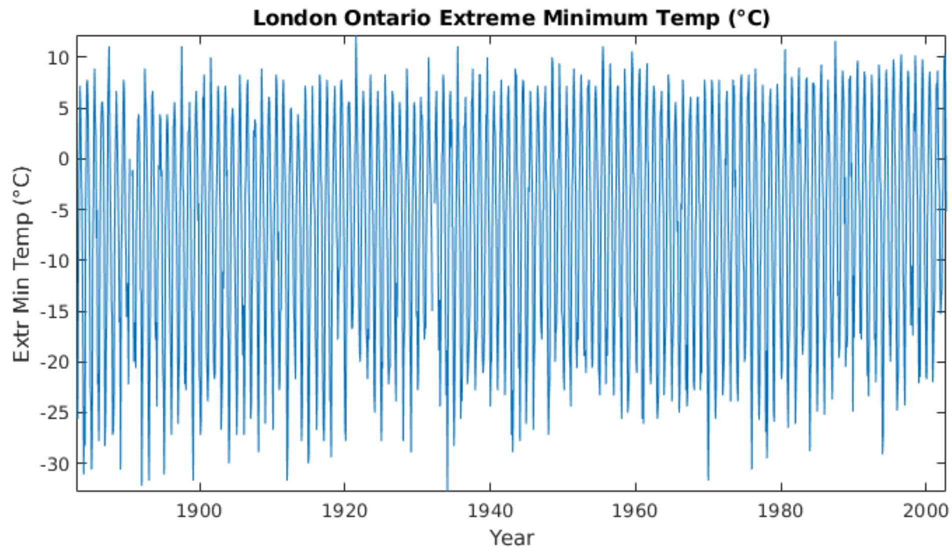
```
x = D(:,1)+(D(:,2)-1)/12;
for n=3:10
    figure
    plot(x,D(:,n))
    xlabel('Year')
    ylabel(ylabels(n))
    title(strcat('London Ontario', " ", titles(n)))
    axis tight
    set(gcf,'Position',[100 100 800 400])
    print(strcat("London ",ylabels(n),".png"),'-dpng')
end
```

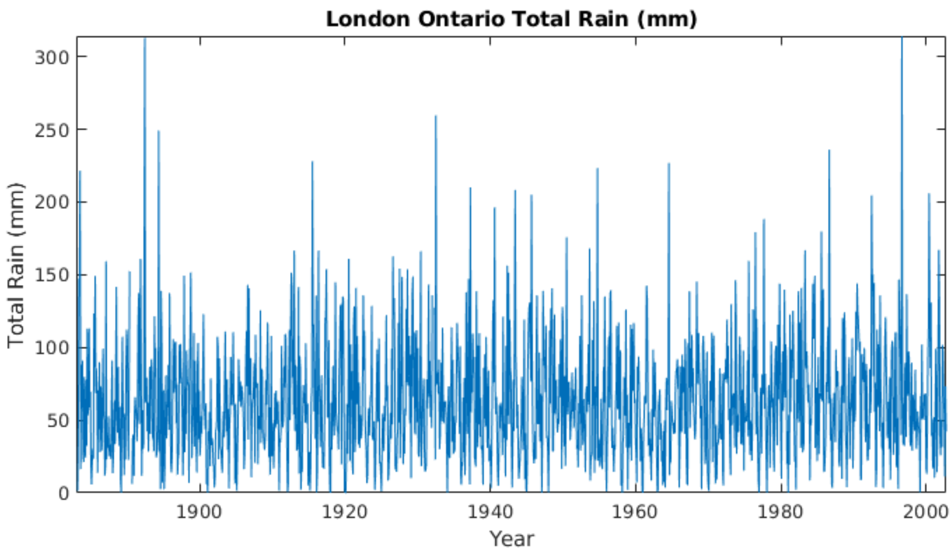

London Ontario Mean Maximum Temperature (°C)
Mean Max Temp (°C)
30
25
20
15
10
5
0
-5
1900
1920
1940
1960
1980
2000
Year

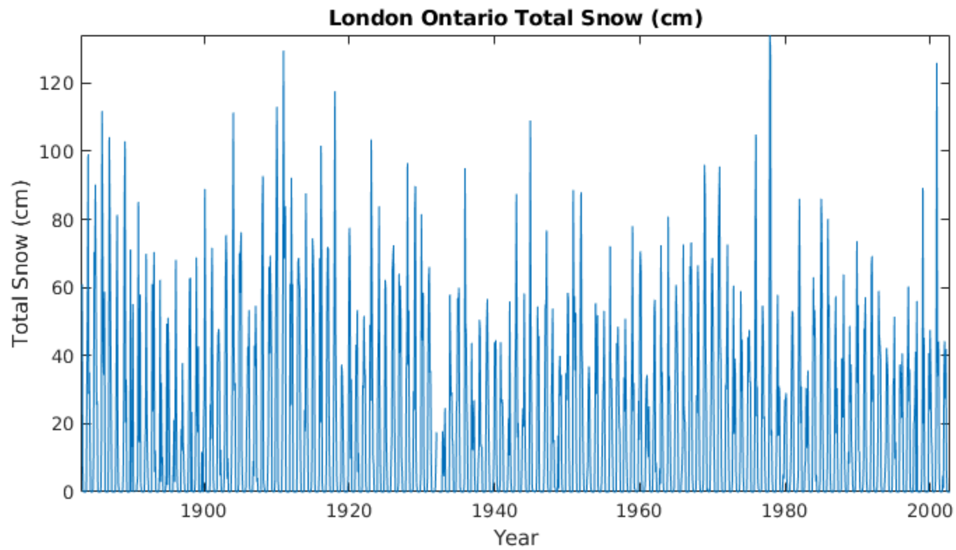

London Ontario Mean Minimum Temperature (°C)
Mean Min Temp (°C)
15
10
5
0
-5
-10
-15
1900
1920
1940
1960
1980
2000
Year

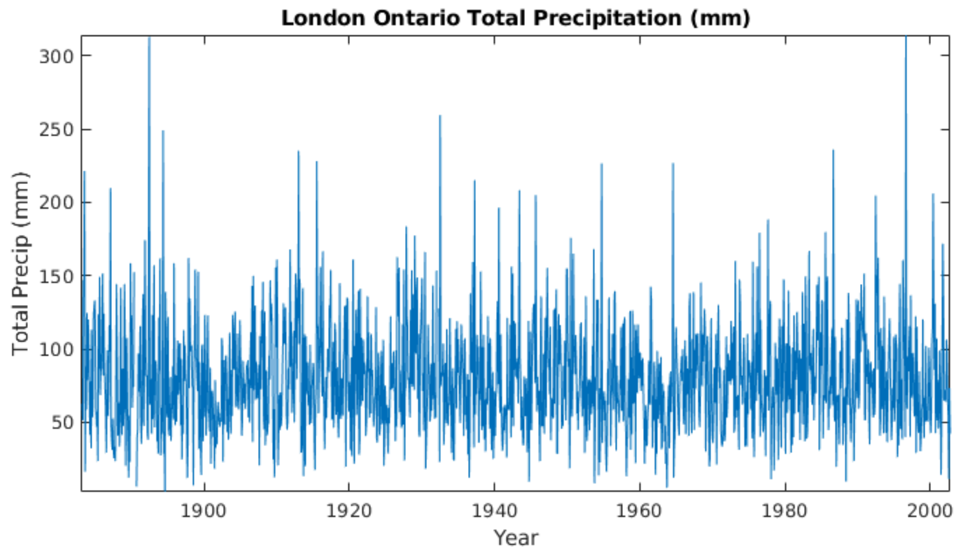

London Ontario Mean Temperature (°C)
Mean Temp (°C)
25
20
15
10
5
0
-5
-10
1900
1920
1940
1960
1980
2000
Year


London Ontario Extreme Maximum Temp (°C)
Extr Max Temp (°C)
40
35
30
25
20
15
10
5
0
1900
1920
1940
1960
1980
2000
Year


London Ontario Extreme Minimum Temp (°C)
Extr Min Temp (°C)
10
5
0
-5
-10
-15
-20
-25
-30
1900
1920
1940
1960
1980
2000
Year


London Ontario Total Rain (mm)
Total Rain (mm)
300
250
200
150
100
50
0
1900
1920
1940
1960
1980
2000
Year




# Clear Figure Data

```
close all
```

# Analyze Data

```
% Compute the number of days per month over a four year period
% Page 1: Spring
days(:,:,1)=[31*ones(4,1) 30*ones(4,1) 31*ones(4,1)];
% Page 2: Summer
days(:,:,2)=[30*ones(4,1) 31*ones(4,1) 31*ones(4,1)];
% Page 3: Fall
days(:,:,3)=[30*ones(4,1) 31*ones(4,1) 30*ones(4,1)];
% Page 4: Winter
days(:,:,4)=[31*ones(4,1) 31*ones(4,1) 28*ones(4,1)];
```

```
days(2,3,4)=29;
season = {'Spring','Summer','Fall','Winter'};
% Starting row for each season
row = [1 4 7 10];
for j=1:4
    % Compute the number of years for the current season (given by j)
    n_years = floor(size(D,1)/12);
    if (rem(size(D,1),12) >= row(j)+2)
        n_years = n_years+1;
    end
    fprintf(strcat('\n',season(j)," ",'Season Data Analysis:\n'));
    for n=3:10
        % compute first element of the years and data vectors
        years = D(1,1);
        if 3<=n && n<=5
            data = (D(row(j),n)*days(1,1,j) +
 D(row(j)+1,n)*days(1,2,j) +...
                D(row(j)+2,n)*days(1,3,j))/(sum(days(1,1:3,j)));
        elseif n==6
            data = max(D(row(j):row(j)+2,n));
        elseif n==7
            data = min(D(row(j):row(j)+2,n));
        elseif 8<=n && n<=10
            data = sum(D(row(j):row(j)+2,n));
        end
        % loop to compute the rest of years and data vectors
        for i=2:n_years-1
            % compute the row numbers of the first and last month of
            % the current season
            first_element = row(j)+i*12;
            last_element = row(j)+2+i*12;
            % collect the data values for the current season and the
            % current data field (given by n)
            yrdata = D(first_element:last_element,n);
            % check to see if there are any NaN values in the data
            % to determine whether a valid seasonal value can be
 computed
            if (~any(isnan(yrdata)))
                % add the current year to years vector
                years(end+1,1) = D(first_element,1);
                % add the the seasonal data value to the data vector
                % check for mean calculation
                if 3<=n && n<=5
                    k = mod(i,4)+1;
                    % compute a weighted average of the monthly data
                    % given the lengths of the months in the given
 season
                    data(end+1,1) = (yrdata(1)*days(k,1) +...
                        yrdata(2)*days(k,2,j) +
 yrdata(3)*days(k,3,j))/...
                        (sum(days(k,1:3,j)));
                % check for max calculation
                elseif n==6
                    data(end+1,1) = max(yrdata);
```

```
                % check for min calculation
                elseif n==7
                    data(end+1,1) = min(yrdata);
                % check for total calculation
                elseif 8<=n && n<=10
                    data(end+1,1) = sum(yrdata);
                end
            end
        end
        %years = years(70:end);
        %data = data(70:end);
        % compute the linear regression of the seasonal data for the
        % current data field
        [b, bint] = regress(data,[ones(size(years)) years],0.3173);
        % check whether the slope is exactly zero (indicating void
data)
        if (b(2) ~= 0)
            figure
            plot(years,data)
            axis tight
            hold on
            xlabel('Year')
            ylabel(ylabels(n))
            % label the plot with the current season and data field
            title(strcat('London Ontario', " ", season(j)," ",
titles(n)))
            plot(years,b(2)*years+b(1),'LineWidth',2)
            hold off
            % label the output file with the current season and data
field
            print(strcat("London ",season(j)," Trend
",ylabels(n),".png"),'-dpng')
            % check whether the slope is positive or negative and
            % display an appropriate message
            if (b(2)>0)
                disp(strcat('Potential increasing trend for',"
",titles(n),':'))
            elseif (b(2)<0)
                disp(strcat('Potential decreasing trend for',"
",titles(n),':'))
            end
            % check that the confidence interval does not contain zero
            if (sign(bint(2,1)) == sign(bint(2,2)))
                disp('  Significant trend at 68% confidence!')
                % compute standard deviation
                sigma = abs(b(2) - bint(2,1));
                fprintf('  Trend is %f +/- %f ',b(2)*100,sigma*100);
                % check for units of °C
                if 3<=n && n<=7
                    fprintf('°C/century\n');
                % check for units of mm
                elseif n==8 || n==10
                    fprintf('mm/century\n');
                % check for units of cm
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                elseif n==9
                    fprintf('cm/century\n');
                end
                % check whether 2*sigma interval contains zero
                if (sign(bint(2,1)-sigma) == sign(bint(2,2)+sigma))
                    disp('  Significant trend at 95% confidence too!')
                end
            else
                disp('  Trend is not statistically significant')
            end
        end
    end
end
```
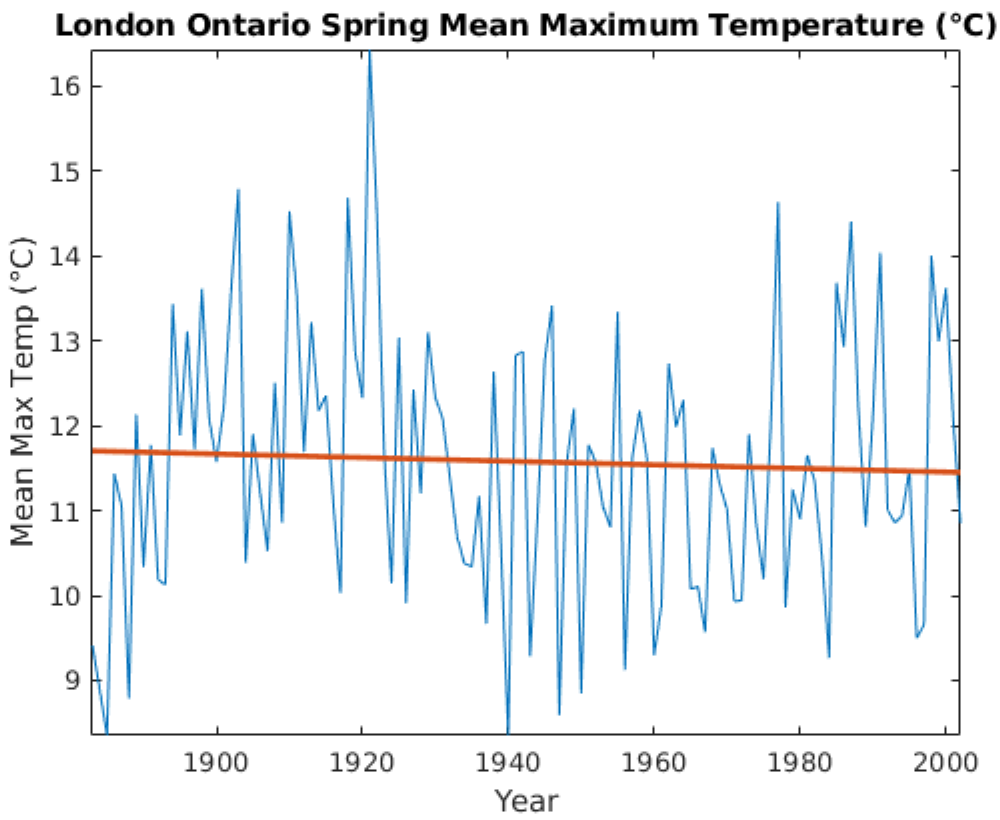
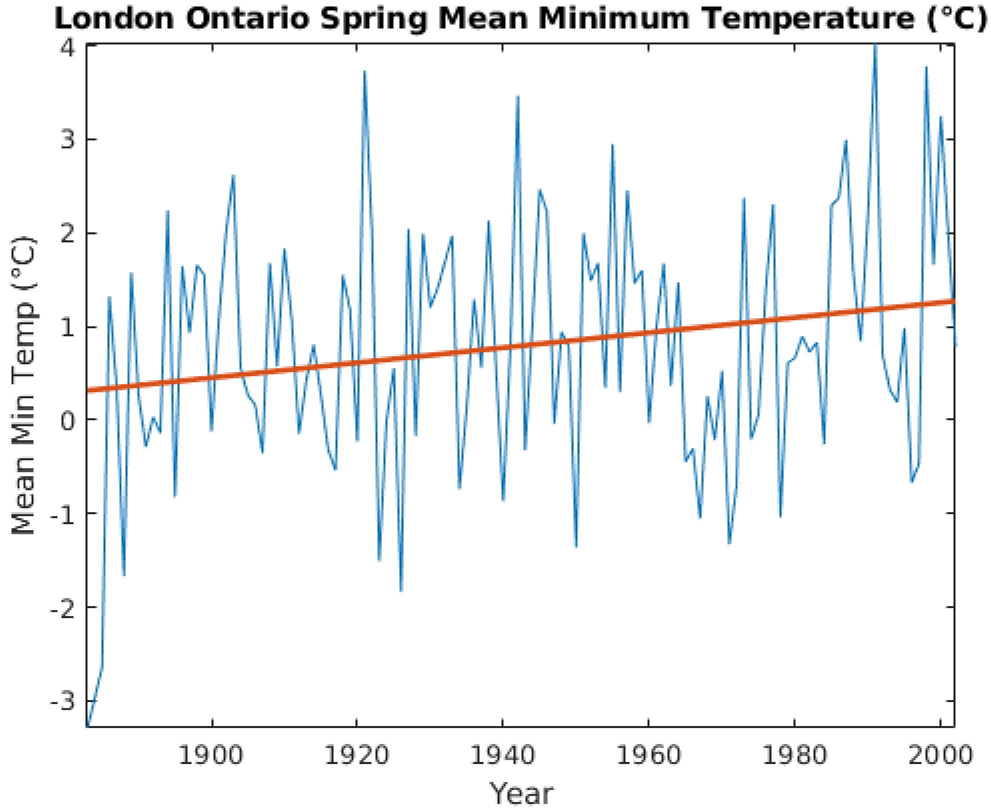
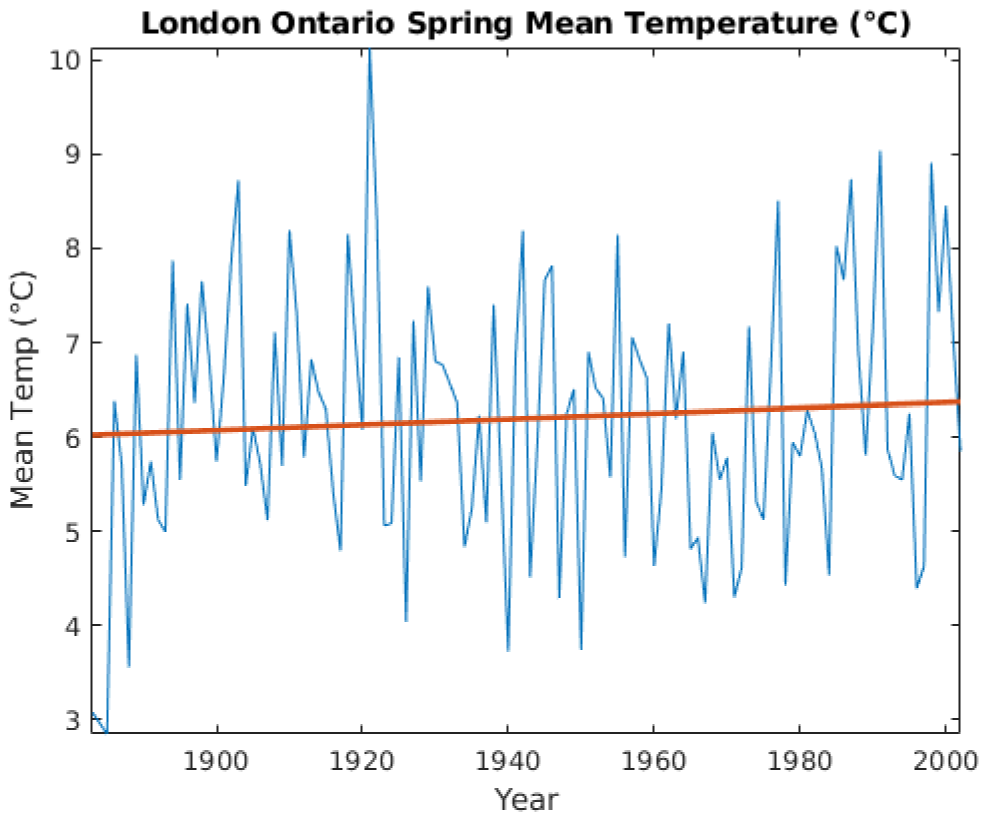

```
Spring Season Data Analysis:
Potential decreasing trend for Mean Maximum Temperature (°C):
  Trend is not statistically significant
Potential increasing trend for Mean Minimum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is 0.803753 +/- 0.343622 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Mean Temperature (°C):
  Trend is not statistically significant
Potential decreasing trend for Extreme Maximum Temp (°C):
  Significant trend at 68% confidence!
  Trend is -0.817595 +/- 0.633913 °C/century
Potential increasing trend for Extreme Minimum Temp (°C):
  Significant trend at 68% confidence!
  Trend is 2.663158 +/- 1.178542 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Total Rain (mm):
  Significant trend at 68% confidence!
  Trend is 19.633927 +/- 15.942996 mm/century
Potential decreasing trend for Total Snow (cm):
  Trend is not statistically significant
Potential increasing trend for Total Precipitation (mm):
  Trend is not statistically significant

Summer Season Data Analysis:
Potential decreasing trend for Mean Maximum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is -0.918128 +/- 0.338363 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Mean Minimum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is 0.830113 +/- 0.249303 °C/century
  Significant trend at 95% confidence too!
Potential decreasing trend for Mean Temperature (°C):
  Trend is not statistically significant
Potential decreasing trend for Extreme Maximum Temp (°C):
  Significant trend at 68% confidence!
  Trend is -1.564792 +/- 0.581093 °C/century
  Significant trend at 95% confidence too!
```

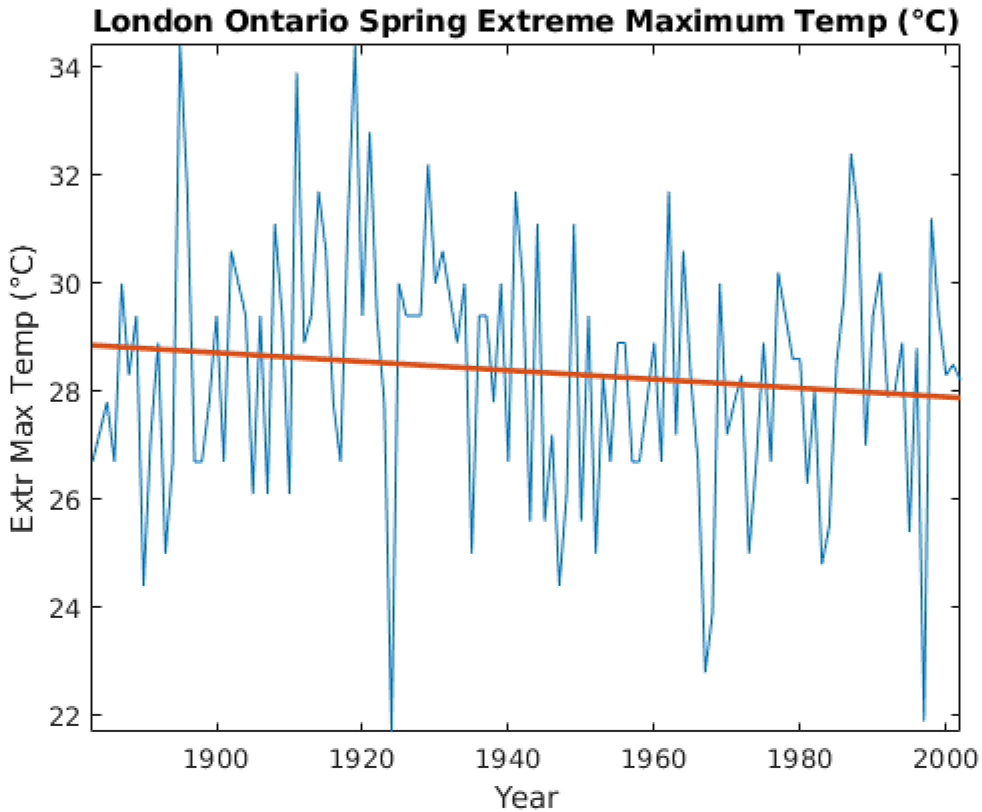
```
Potential increasing trend for Extreme Minimum Temp (°C):
  Significant trend at 68% confidence!
  Trend is 2.054747 +/- 0.492615 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Total Rain (mm):
  Trend is not statistically significant
Potential increasing trend for Total Precipitation (mm):
  Trend is not statistically significant

Fall Season Data Analysis:
Potential decreasing trend for Mean Maximum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is -0.433043 +/- 0.342183 °C/century
Potential increasing trend for Mean Minimum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is 0.645995 +/- 0.261145 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Mean Temperature (°C):
  Trend is not statistically significant
Potential decreasing trend for Extreme Maximum Temp (°C):
  Significant trend at 68% confidence!
  Trend is -1.772122 +/- 0.640873 °C/century
  Significant trend at 95% confidence too!
Potential increasing trend for Extreme Minimum Temp (°C):
  Significant trend at 68% confidence!
  Trend is 1.862558 +/- 0.966408 °C/century
Potential increasing trend for Total Rain (mm):
  Significant trend at 68% confidence!
  Trend is 47.363036 +/- 18.228835 mm/century
  Significant trend at 95% confidence too!
Potential decreasing trend for Total Snow (cm):
  Trend is not statistically significant
Potential increasing trend for Total Precipitation (mm):
  Significant trend at 68% confidence!
  Trend is 39.743363 +/- 18.553673 mm/century
  Significant trend at 95% confidence too!

Winter Season Data Analysis:
Potential decreasing trend for Mean Maximum Temperature (°C):
  Trend is not statistically significant
Potential increasing trend for Mean Minimum Temperature (°C):
  Significant trend at 68% confidence!
  Trend is 0.706408 +/- 0.531246 °C/century
Potential increasing trend for Mean Temperature (°C):
  Trend is not statistically significant
Potential increasing trend for Extreme Maximum Temp (°C):
  Significant trend at 68% confidence!
  Trend is 1.272185 +/- 0.746047 °C/century
Potential increasing trend for Extreme Minimum Temp (°C):
  Significant trend at 68% confidence!
  Trend is 3.870731 +/- 1.003624 °C/century
  Significant trend at 95% confidence too!
Potential decreasing trend for Total Rain (mm):
  Trend is not statistically significant
```

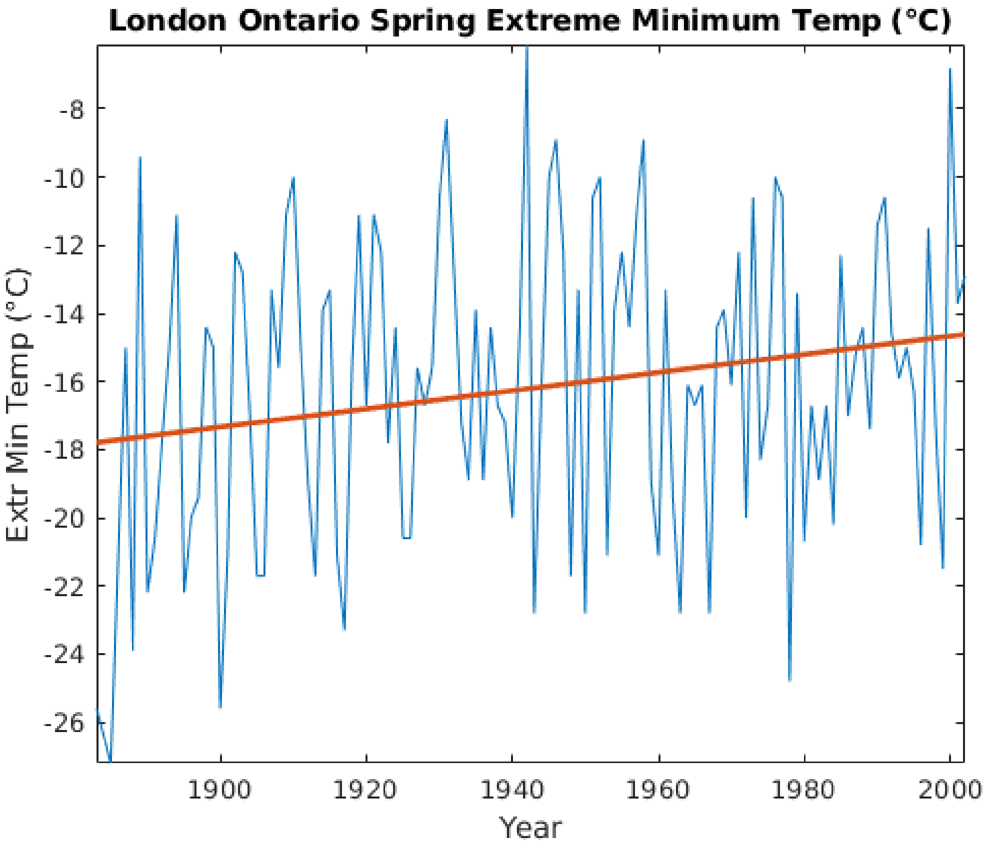
```
Potential decreasing trend for Total Snow (cm):
  Significant trend at 68% confidence!
  Trend is -24.436681 +/- 13.336432 cm/century
Potential decreasing trend for Total Precipitation (mm):
  Significant trend at 68% confidence!
  Trend is -69.035065 +/- 16.391102 mm/century
  Significant trend at 95% confidence too!
```

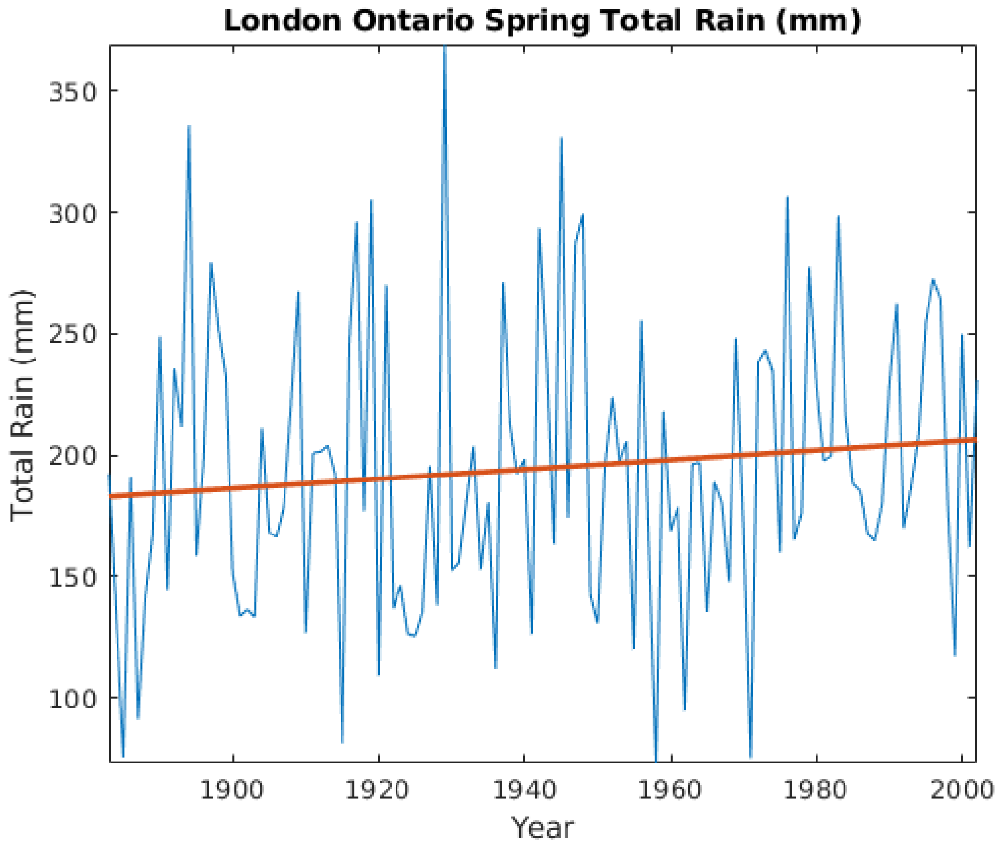


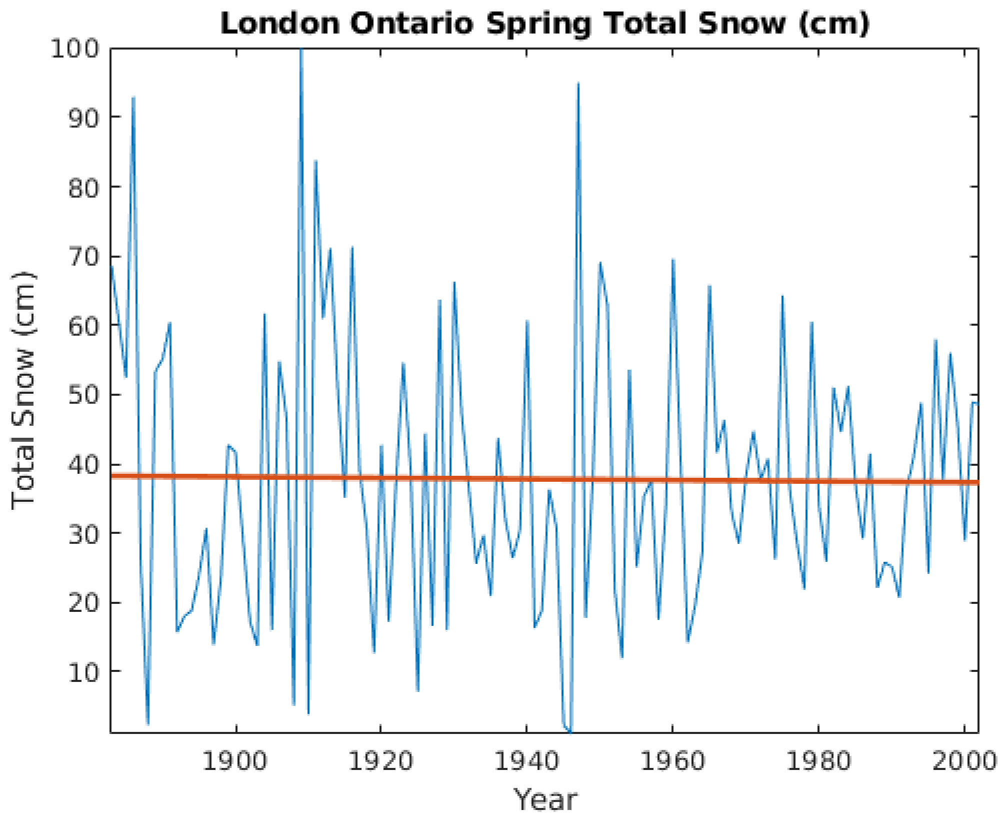

London Ontario Spring Mean Minimum Temperature (°C)
Mean Min Temp (°C)
Year
4
3
2
1
0
-1
-2
-3
1900
1920
1940
1960
1980
2000

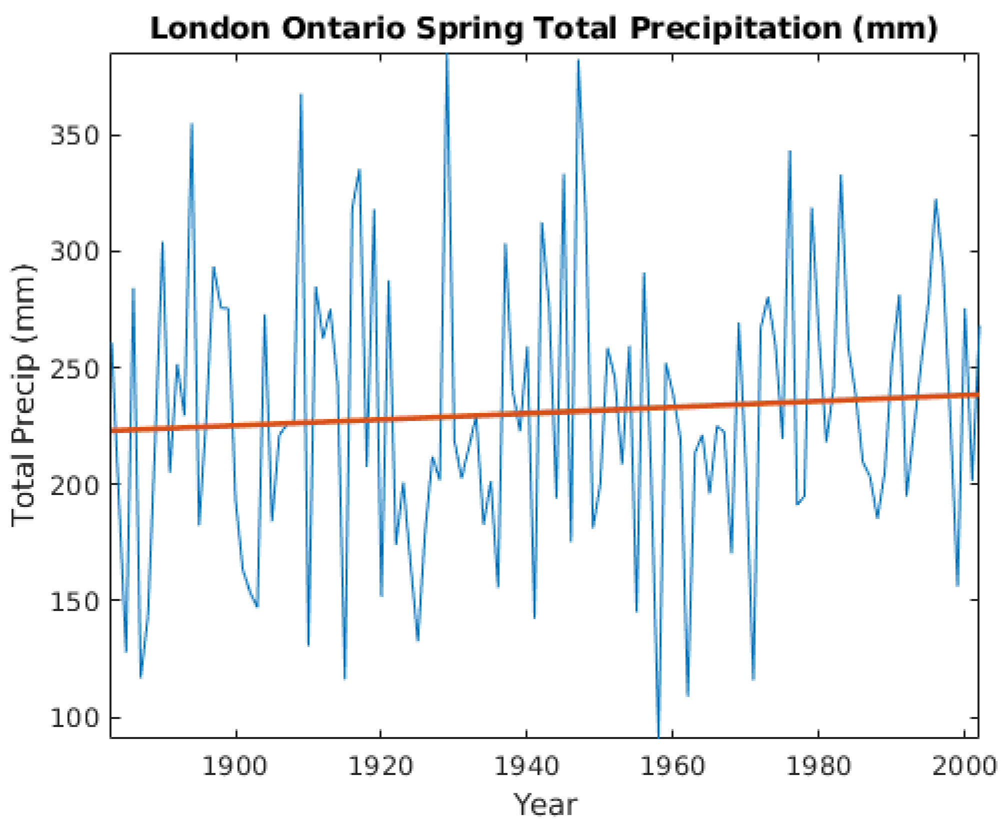

London Ontario Spring Mean Temperature (°C)
Mean Temp (°C)
Year
10
9
8
7
6
5
4
3
1900
1920
1940
1960
1980
2000

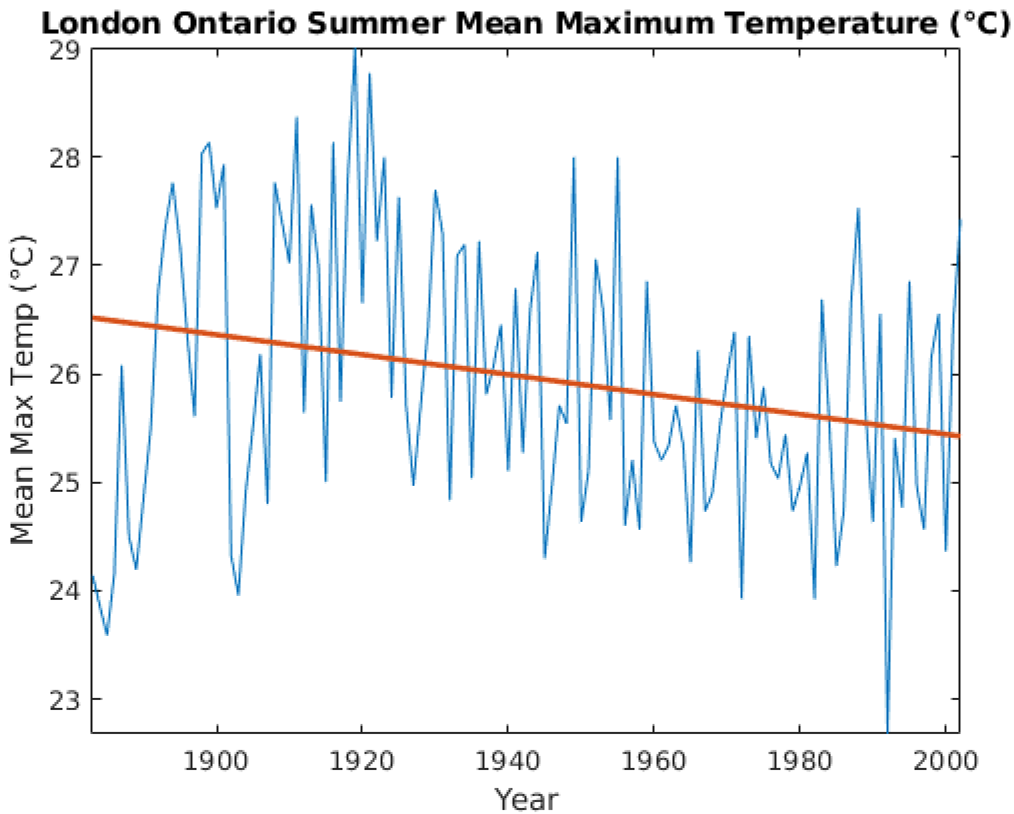

London Ontario Spring Extreme Maximum Temp (°C)
Extr Max Temp (°C)
Year
34
32
30
28
26
24
22
1900
1920
1940
1960
1980
2000

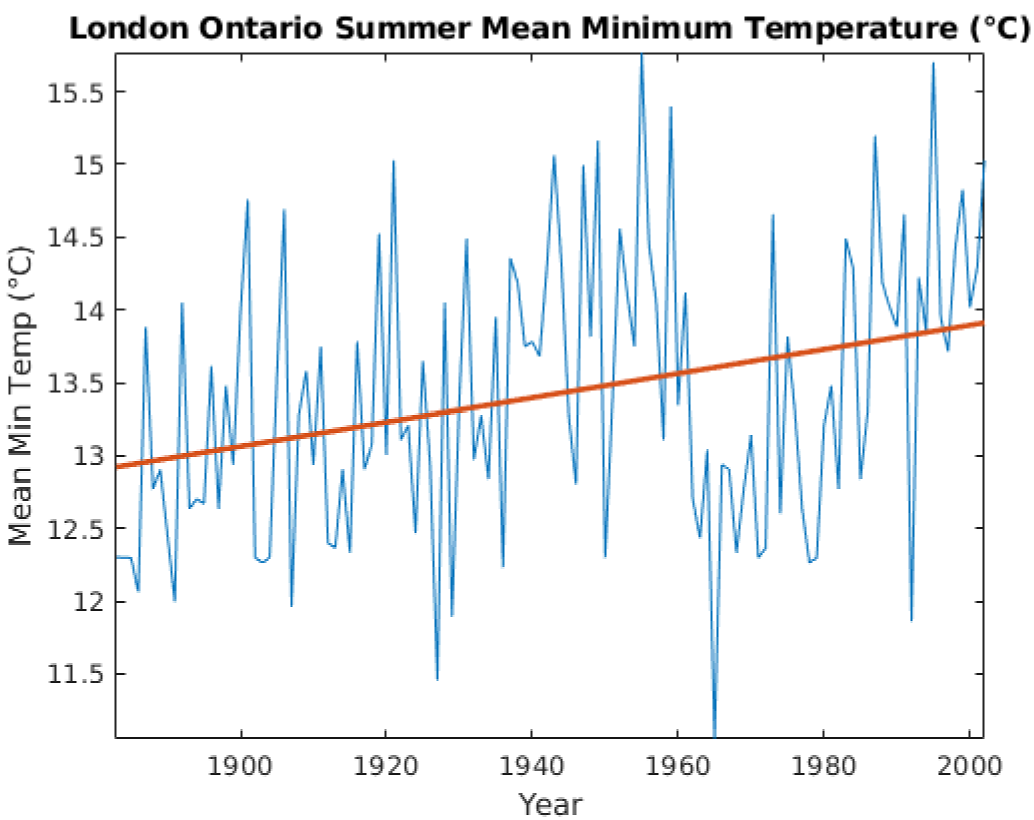

London Ontario Spring Extreme Minimum Temp (°C)
Extr Min Temp (°C)
Year
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
1900
1920
1940
1960
1980
2000

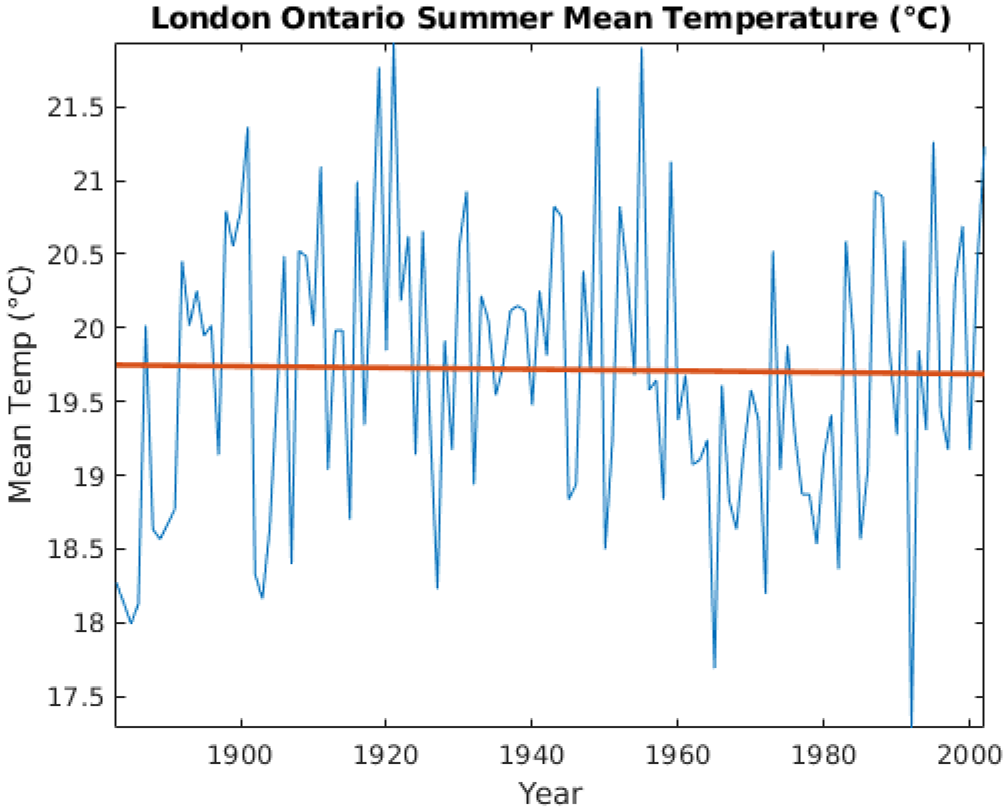

London Ontario Spring Total Rain (mm)
Total Rain (mm)
350
300
250
200
150
100
1900
1920
1940
1960
1980
2000
Year

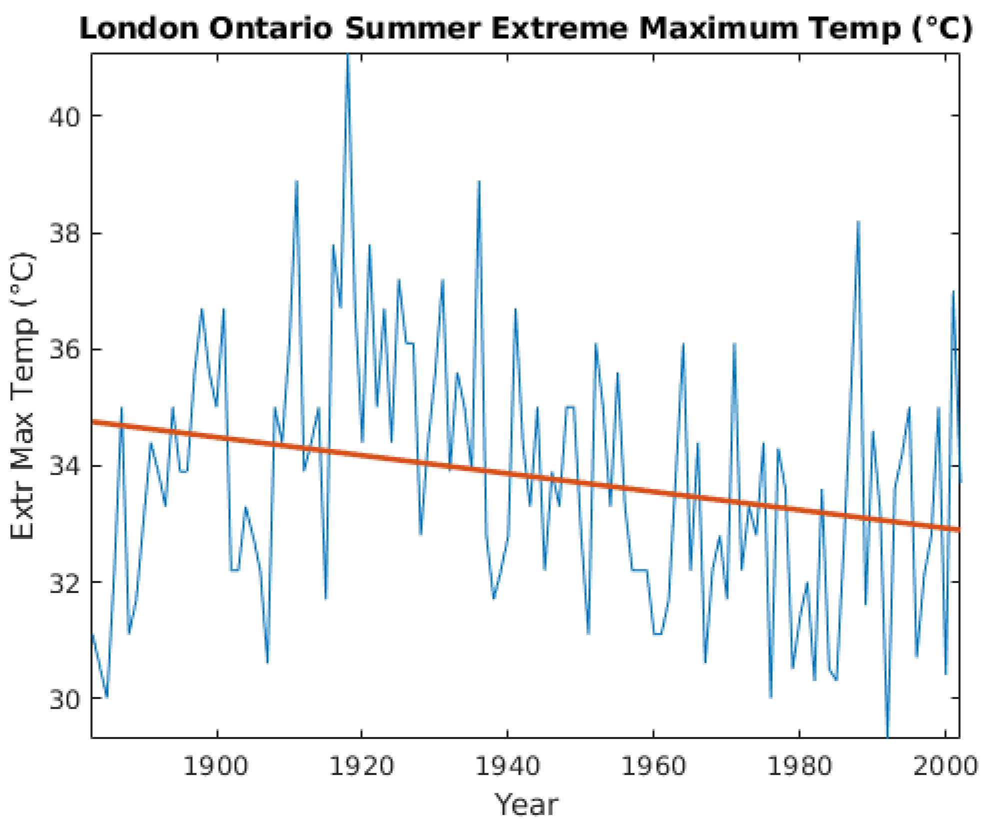

London Ontario Spring Total Snow (cm)
Total Snow (cm)
Year
100
90
80
70
60
50
40
30
20
10
1900
1920
1940
1960
1980
2000

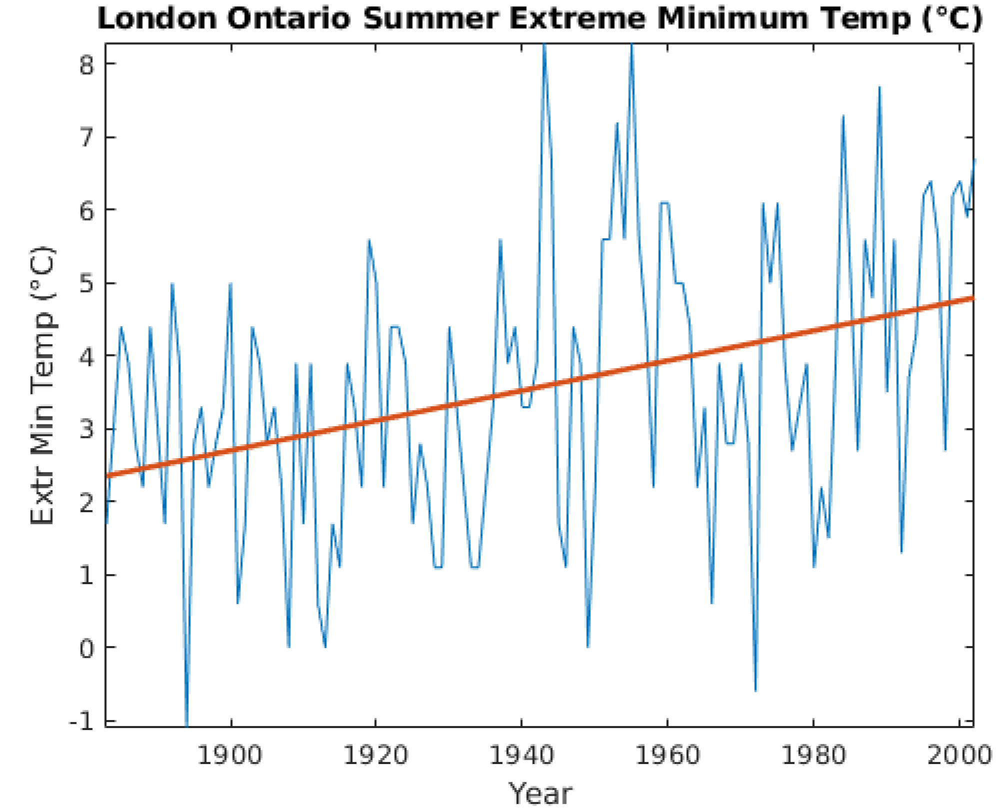

London Ontario Spring Total Precipitation (mm)
Total Precip (mm)
Year
350
300
250
200
150
100
1900
1920
1940
1960
1980
2000

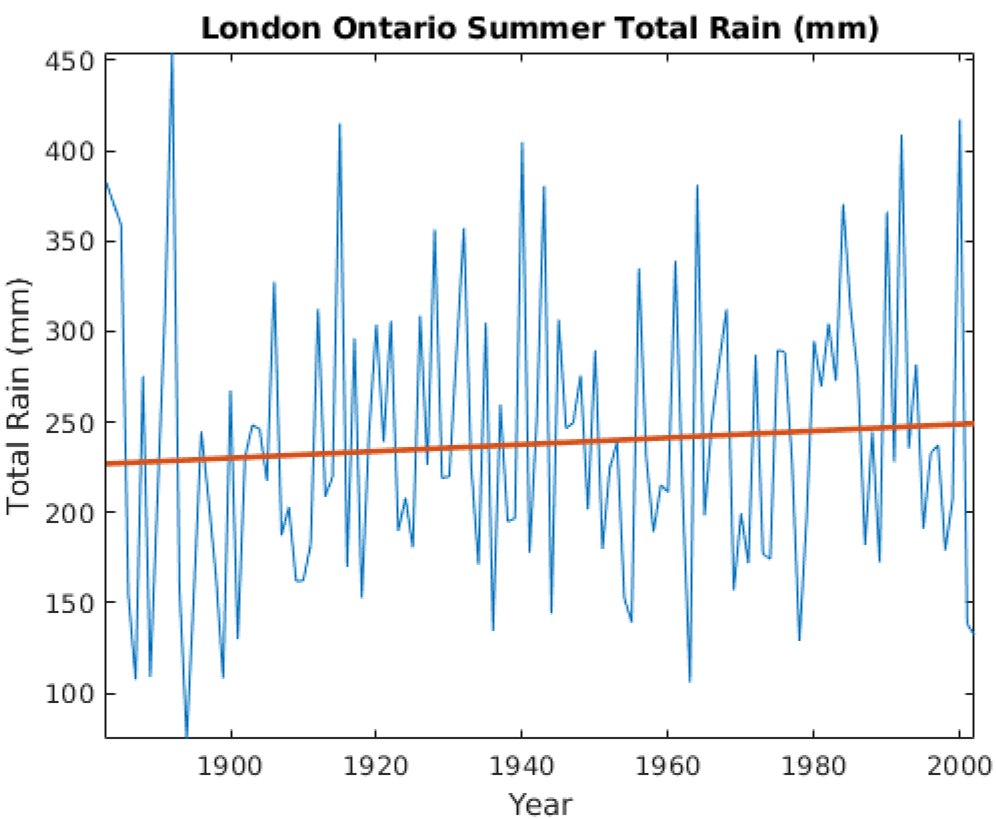

London Ontario Summer Mean Maximum Temperature (°C)
Mean Max Temp (°C)
Year
29
28
27
26
25
24
23
1900
1920
1940
1960
1980
2000

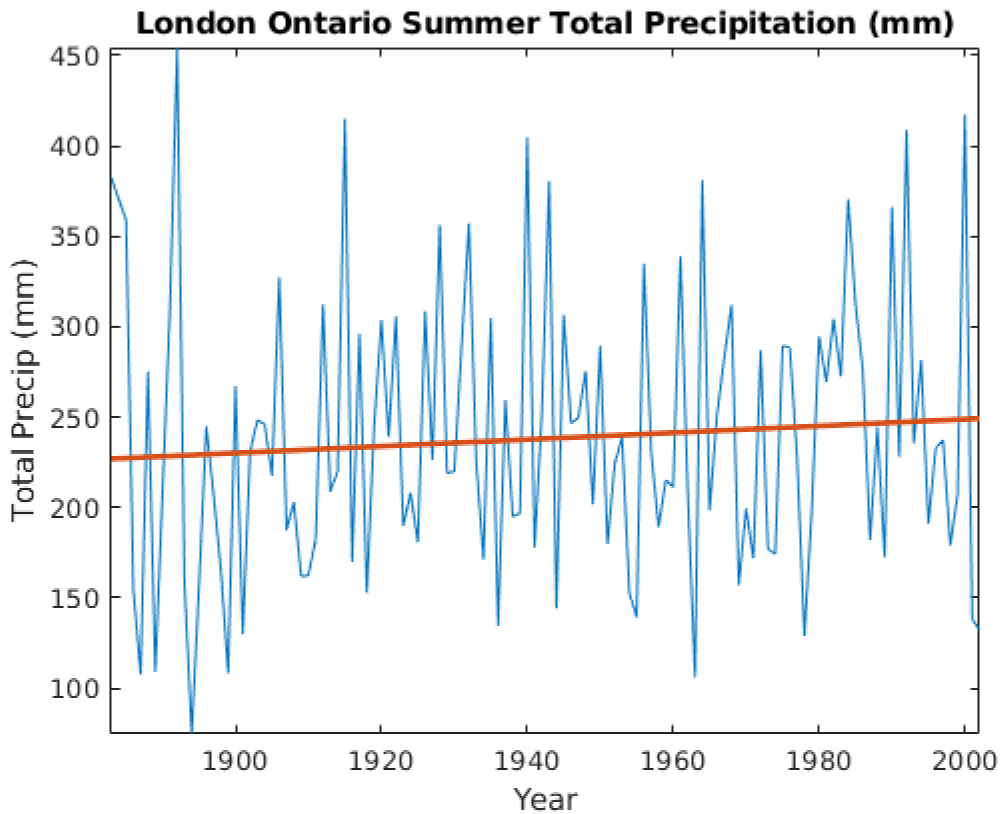

London Ontario Summer Mean Minimum Temperature (°C)
Mean Min Temp (°C)
Year
15.5
15
14.5
14
13.5
13
12.5
12
11.5
1900
1920
1940
1960
1980
2000

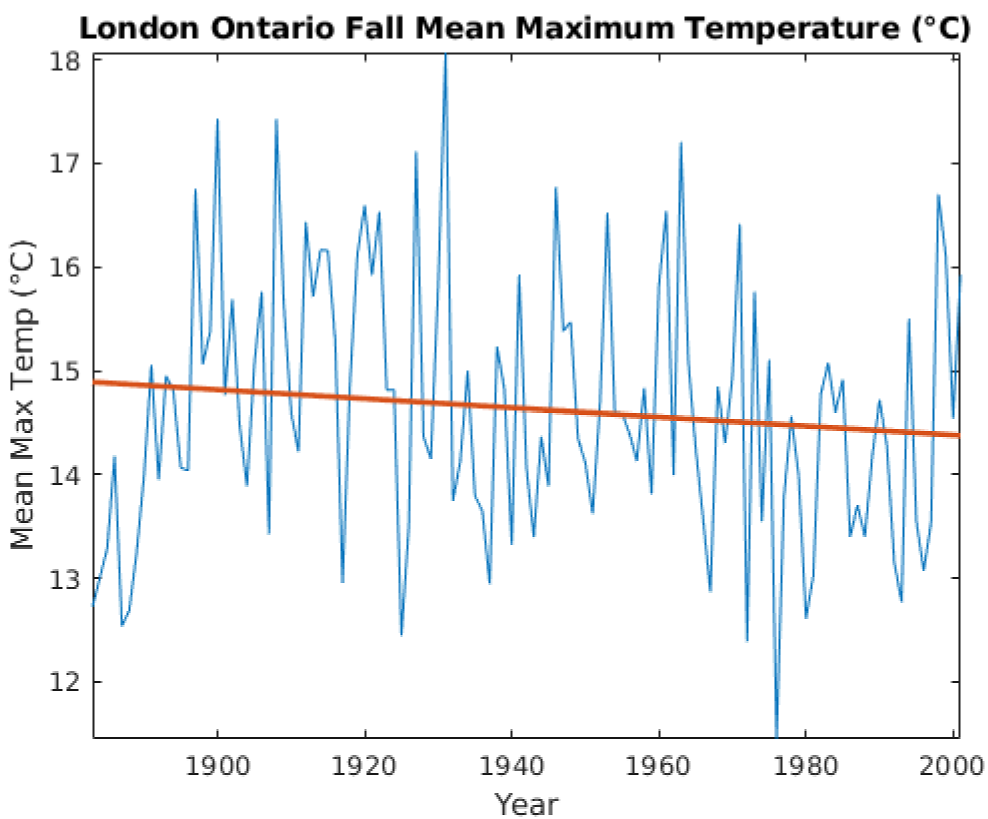

London Ontario Summer Mean Temperature (°C)
Mean Temp (°C)
21.5
21
20.5
20
19.5
19
18.5
18
17.5
1900
1920
1940
1960
1980
2000
Year

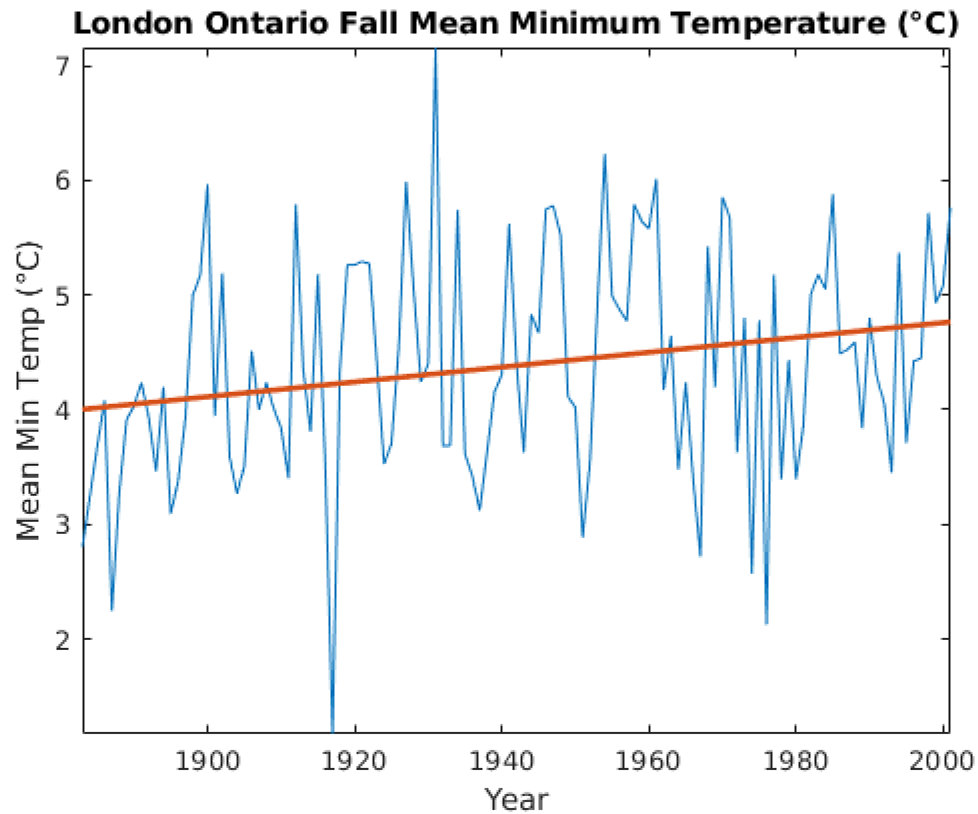

London Ontario Summer Extreme Maximum Temp (°C)
Extr Max Temp (°C)
40
38
36
34
32
30
1900
1920
1940
1960
1980
2000
Year

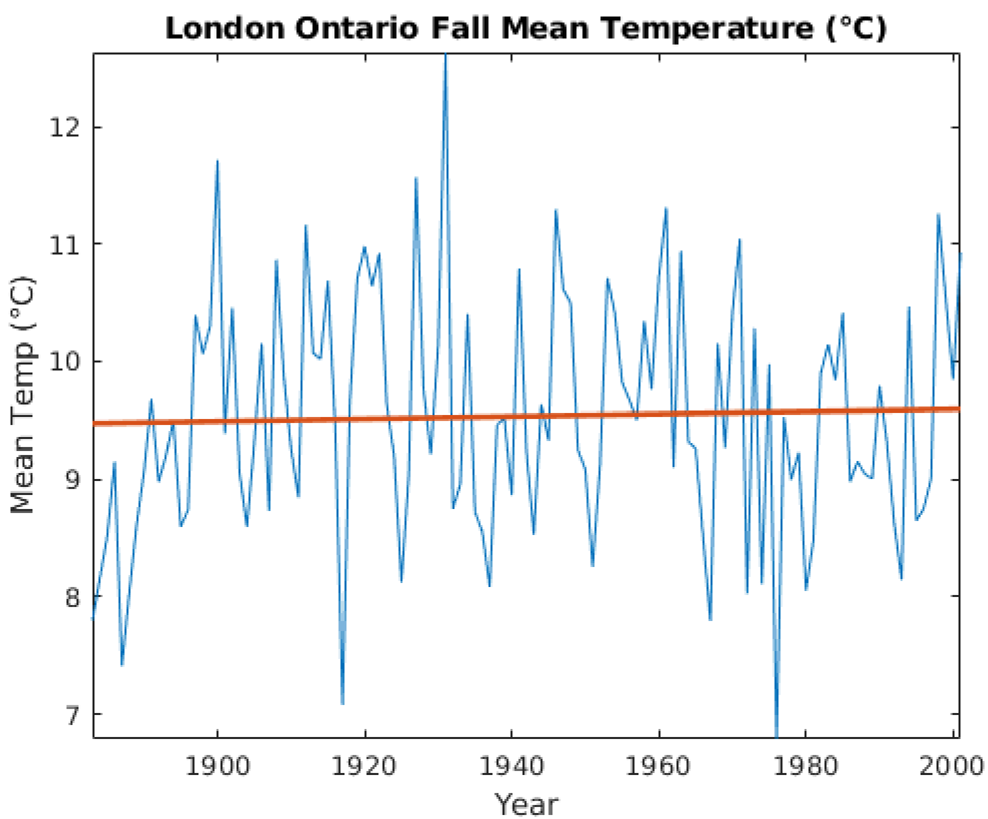

London Ontario Summer Extreme Minimum Temp (°C)
Extr Min Temp (°C)
Year
-1
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000

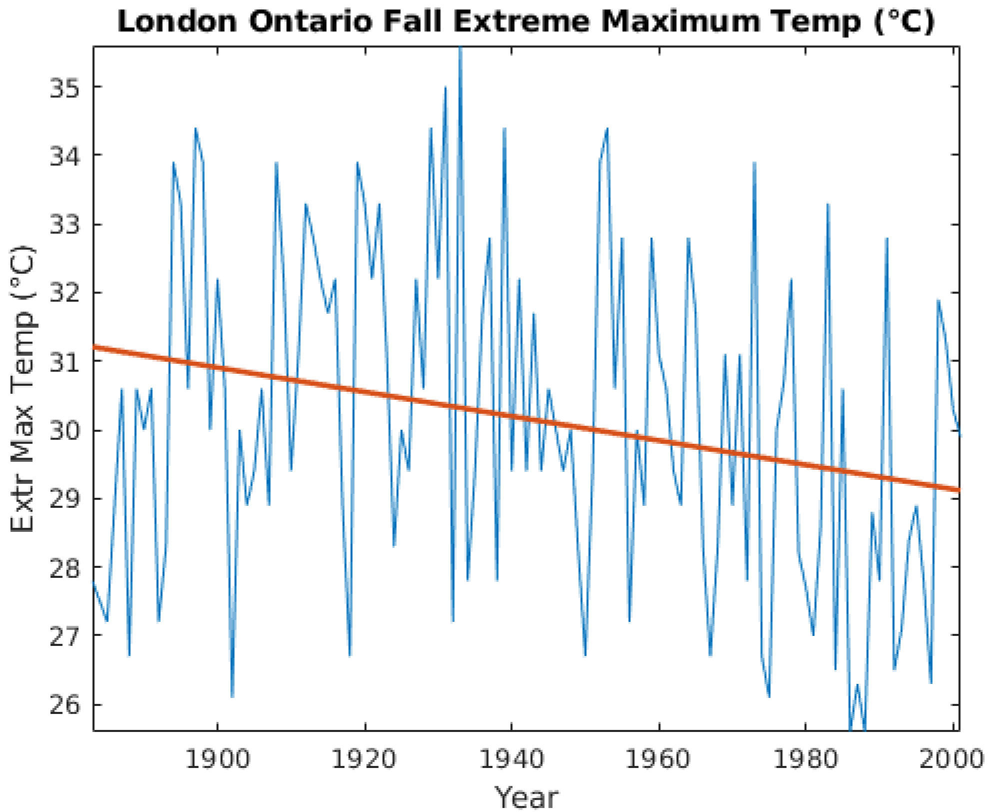

London Ontario Summer Total Rain (mm)
Total Rain (mm)
Year
100
150
200
250
300
350
400
450
1900
1920
1940
1960
1980
2000

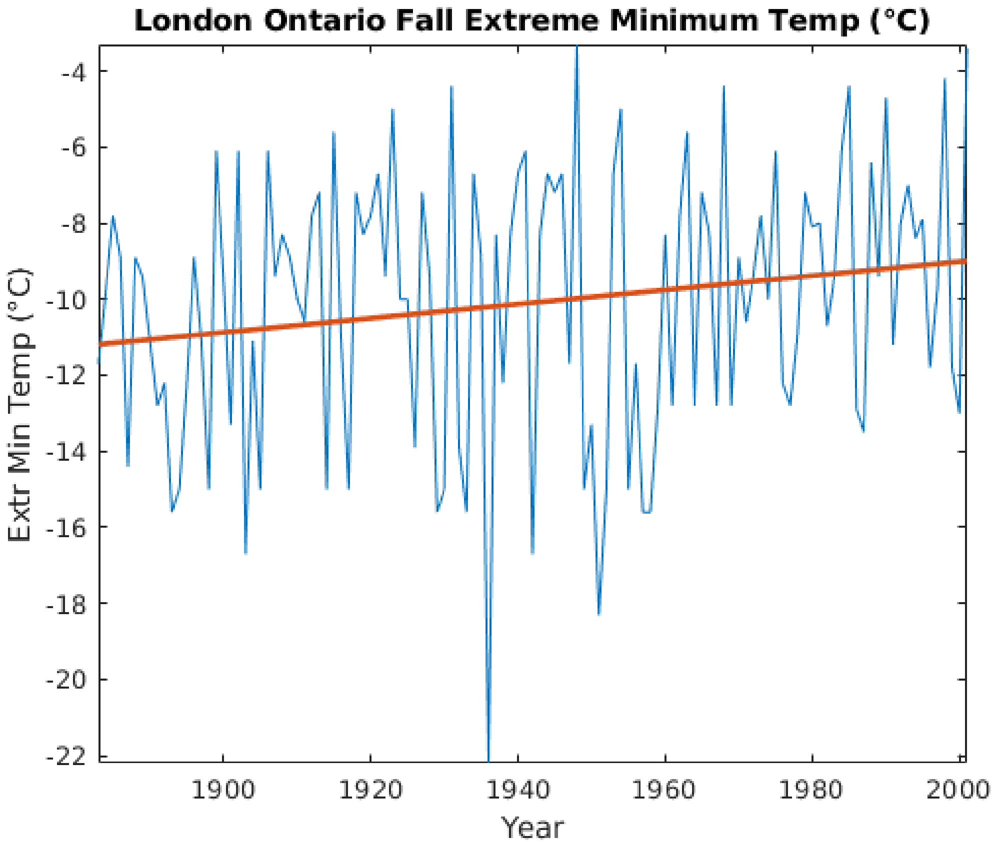

London Ontario Summer Total Precipitation (mm)
Total Precip (mm)
450
400
350
300
250
200
150
100
1900
1920
1940
1960
1980
2000
Year

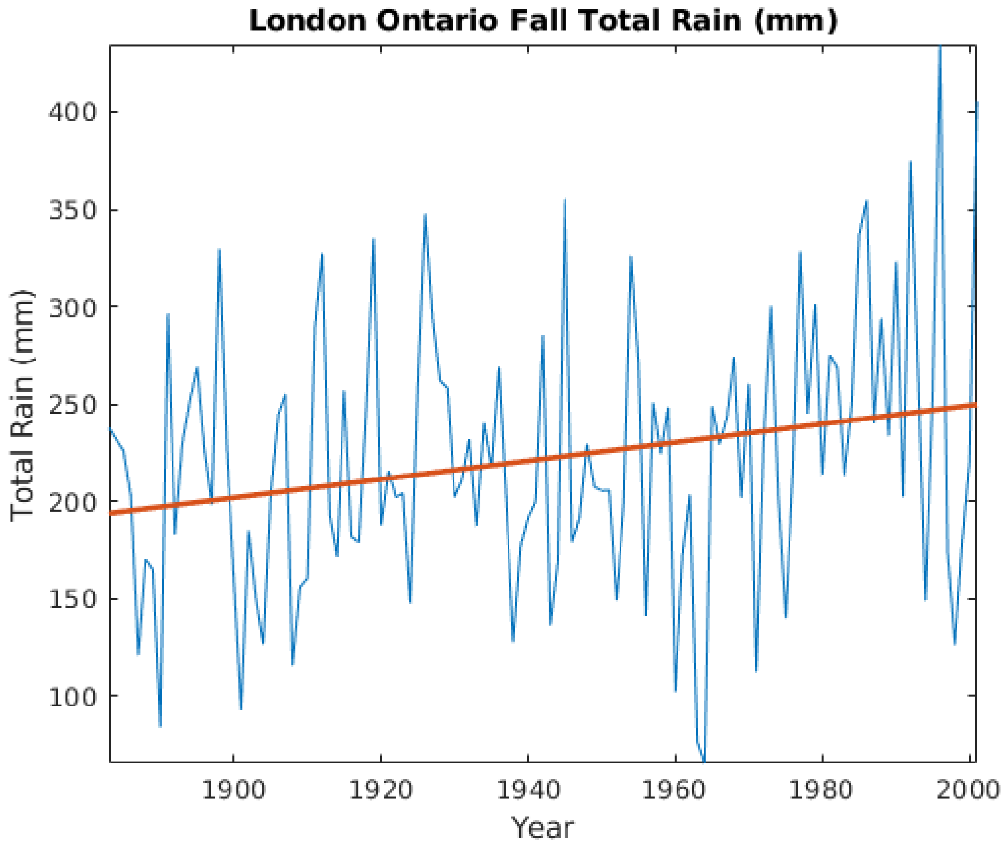

London Ontario Fall Mean Maximum Temperature (°C)
Mean Max Temp (°C)
18
17
16
15
14
13
12
1900
1920
1940
1960
1980
2000
Year

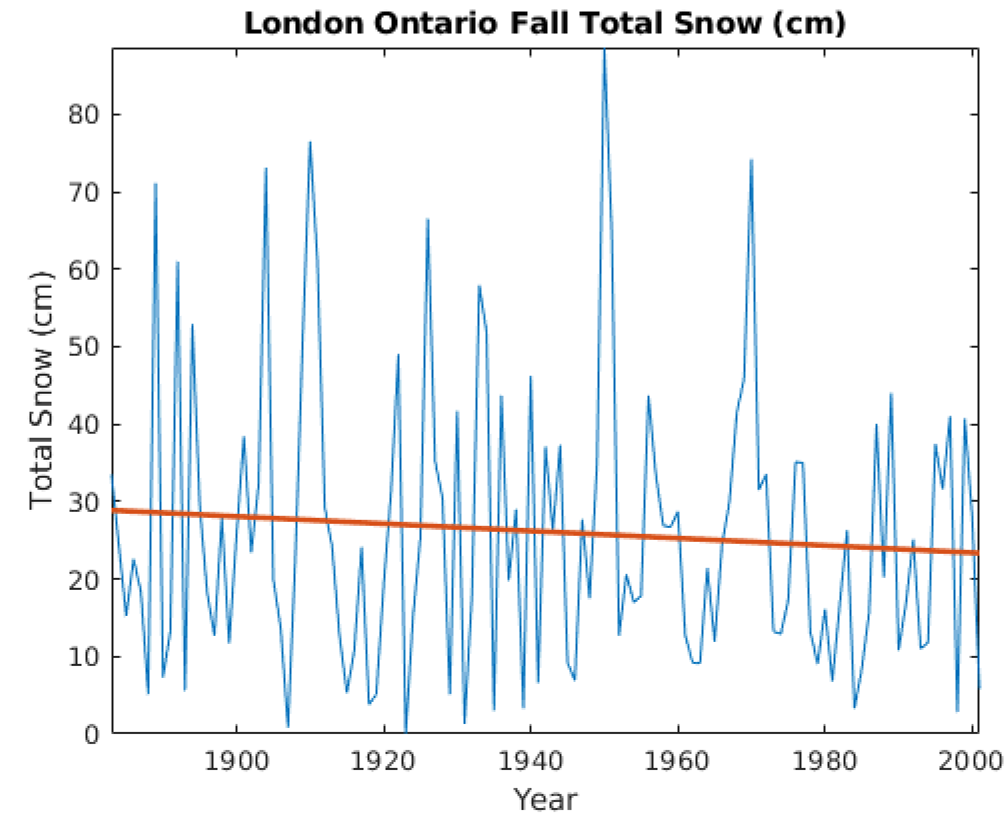

London Ontario Fall Mean Minimum Temperature (°C)
Mean Min Temp (°C)
Year
1900
1920
1940
1960
1980
2000
2
3
4
5
6
7

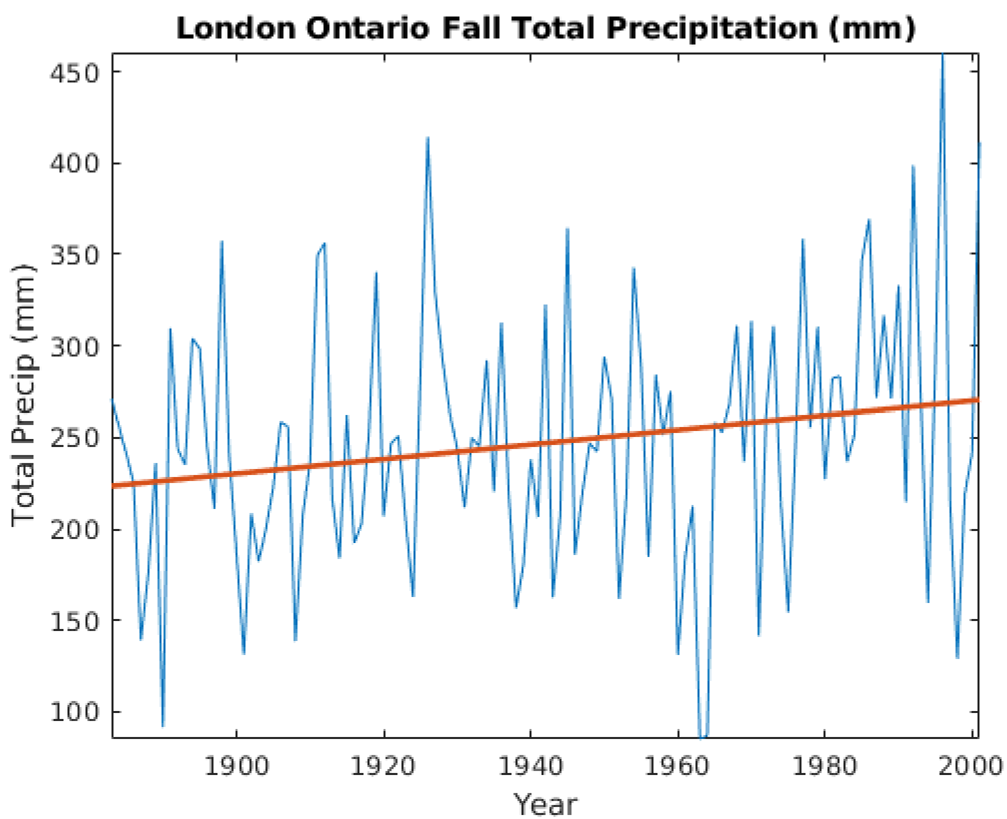

London Ontario Fall Mean Temperature (°C)
Mean Temp (°C)
Year
1900
1920
1940
1960
1980
2000
7
8
9
10
11
12

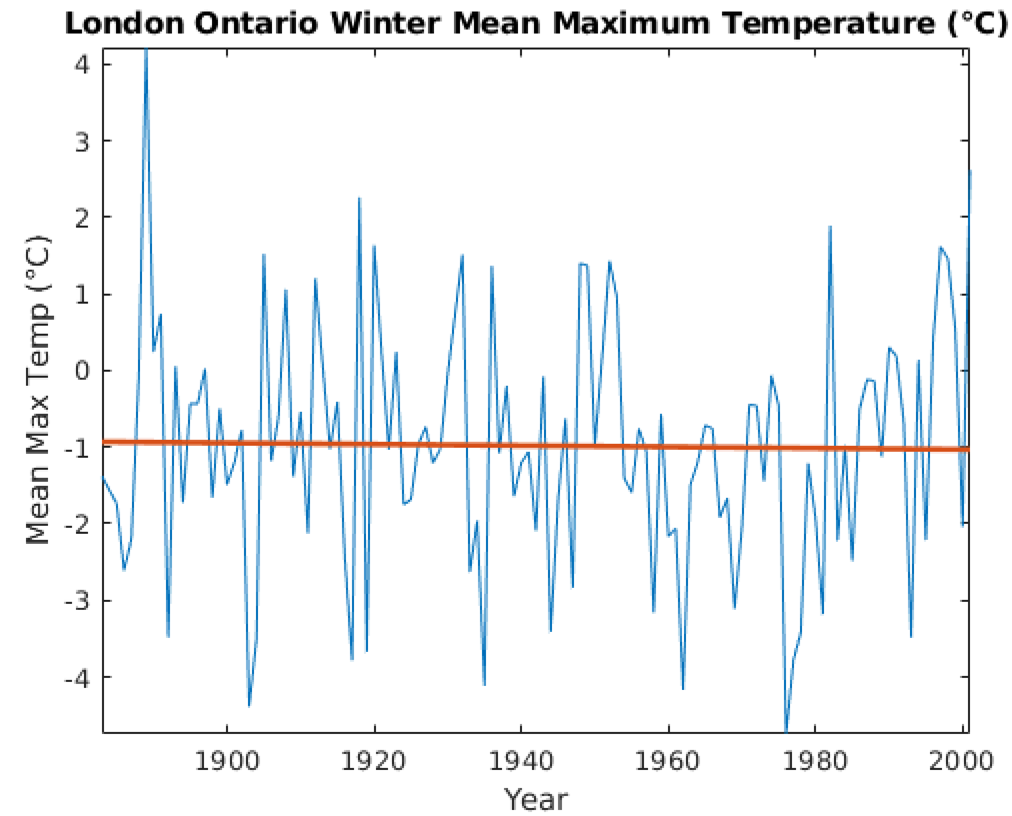

London Ontario Fall Extreme Maximum Temp (°C)
Extr Max Temp (°C)
Year
35
34
33
32
31
30
29
28
27
26
1900
1920
1940
1960
1980
2000

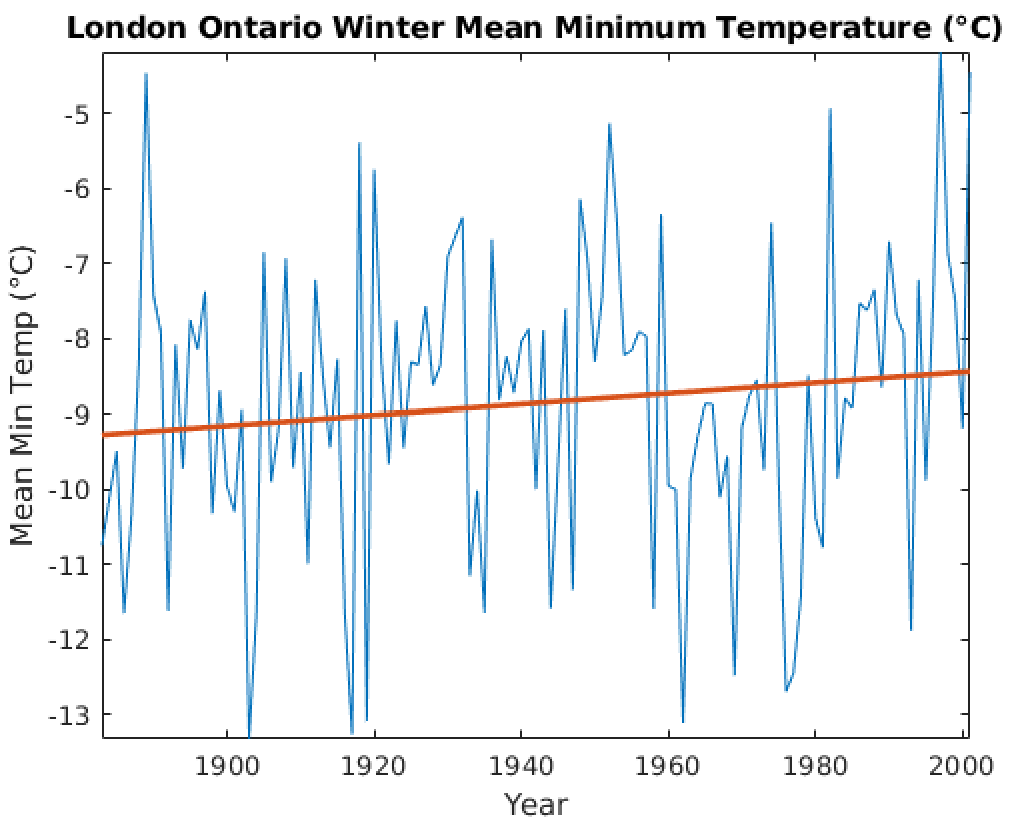

London Ontario Fall Extreme Minimum Temp (°C)
Extr Min Temp (°C)
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
1900
1920
1940
1960
1980
2000
Year

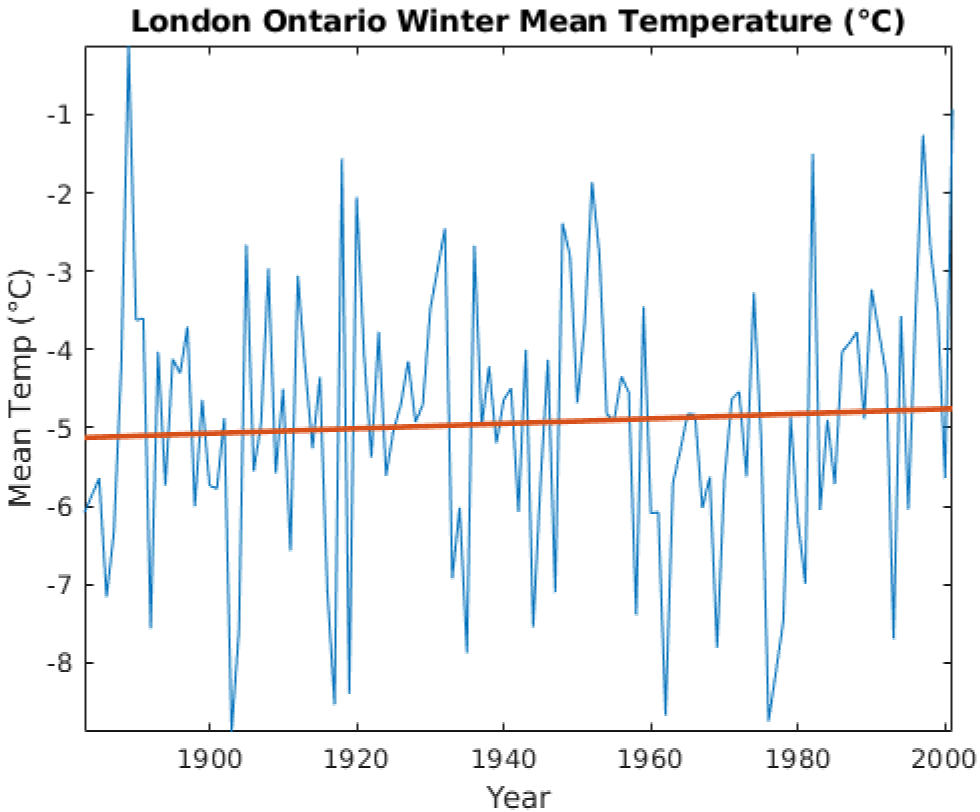

London Ontario Fall Total Rain (mm)
Total Rain (mm)
400
350
300
250
200
150
100
1900
1920
1940
1960
1980
2000
Year

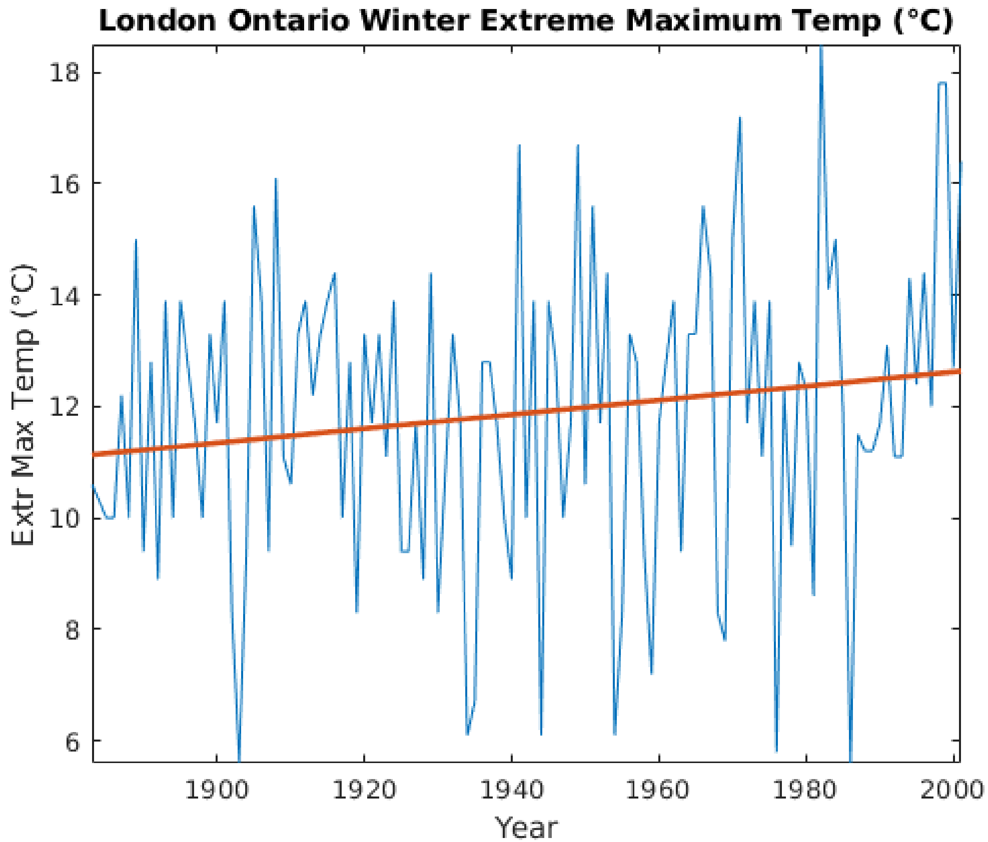

London Ontario Fall Total Snow (cm)
Total Snow (cm)
Year
0
10
20
30
40
50
60
70
80
1900
1920
1940
1960
1980
2000

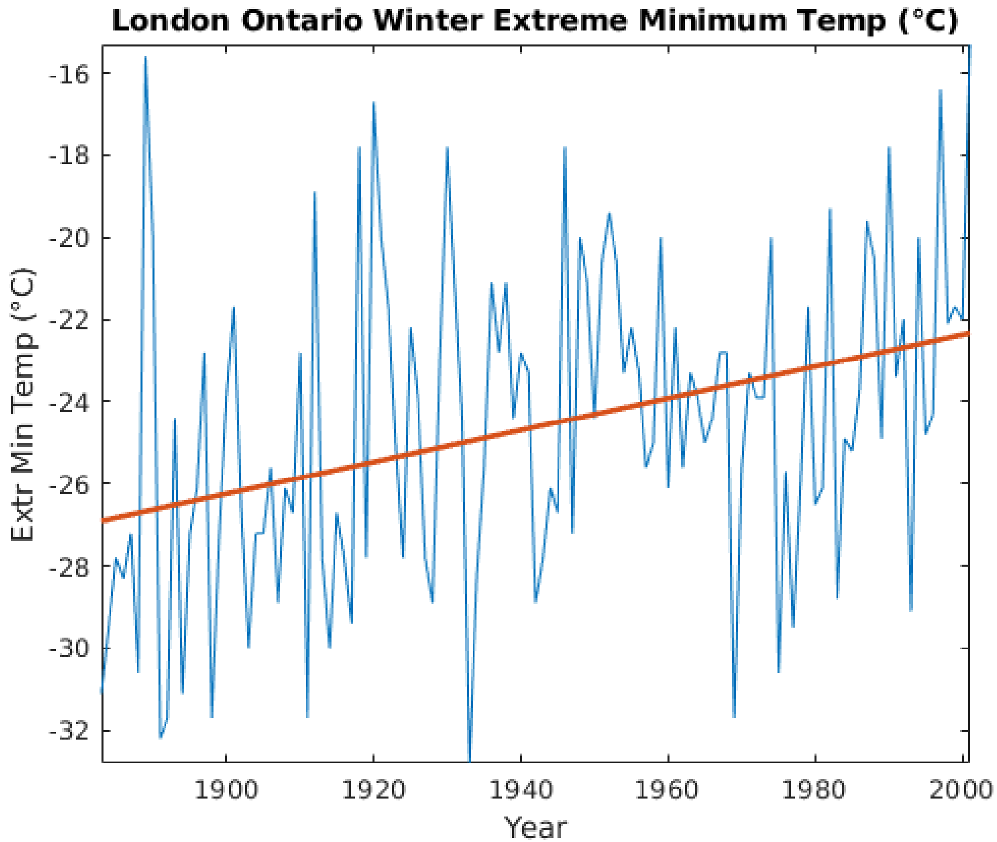

London Ontario Fall Total Precipitation (mm)
Total Precip (mm)
Year
100
150
200
250
300
350
400
450
1900
1920
1940
1960
1980
2000

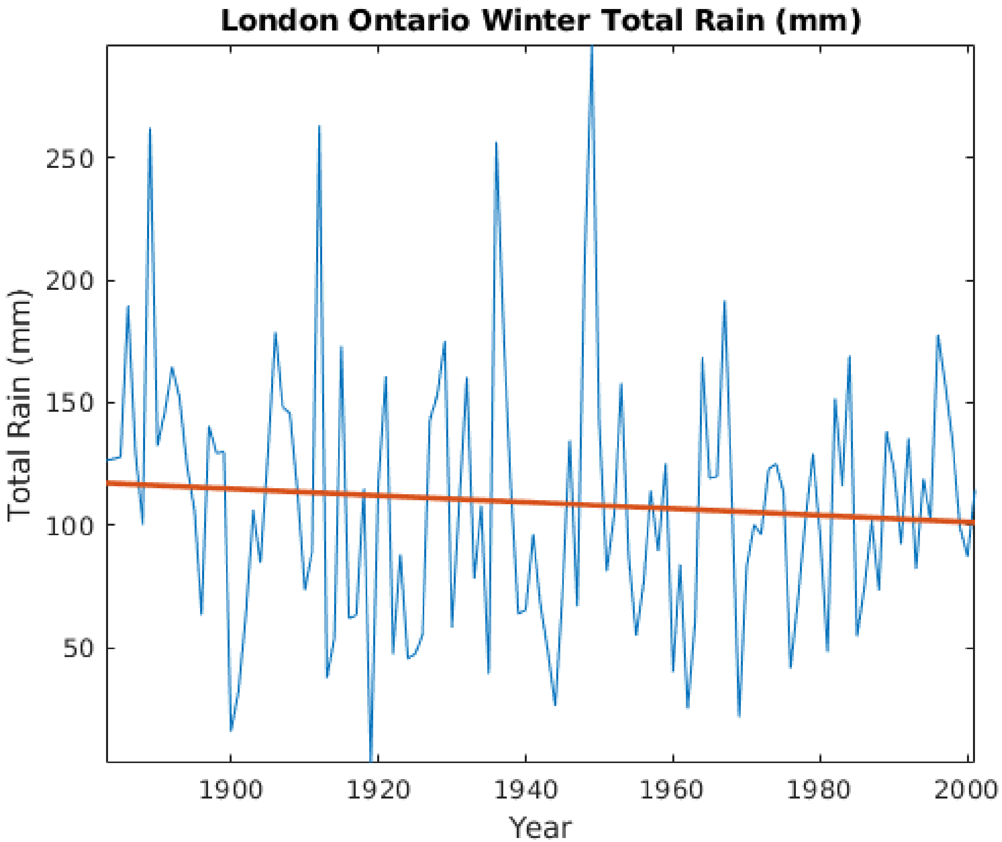

London Ontario Winter Mean Maximum Temperature (°C)
Mean Max Temp (°C)
Year
4
3
2
1
0
-1
-2
-3
-4
1900
1920
1940
1960
1980
2000

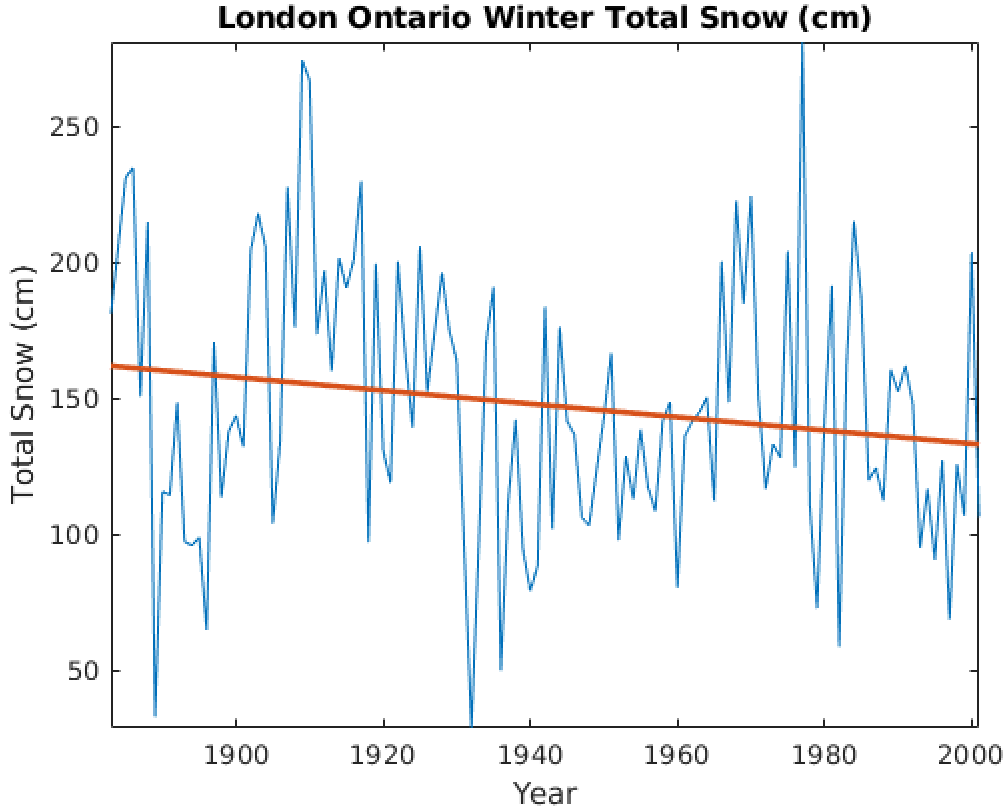

London Ontario Winter Mean Minimum Temperature (°C)
Mean Min Temp (°C)
Year
-5
-6
-7
-8
-9
-10
-11
-12
-13
1900
1920
1940
1960
1980
2000

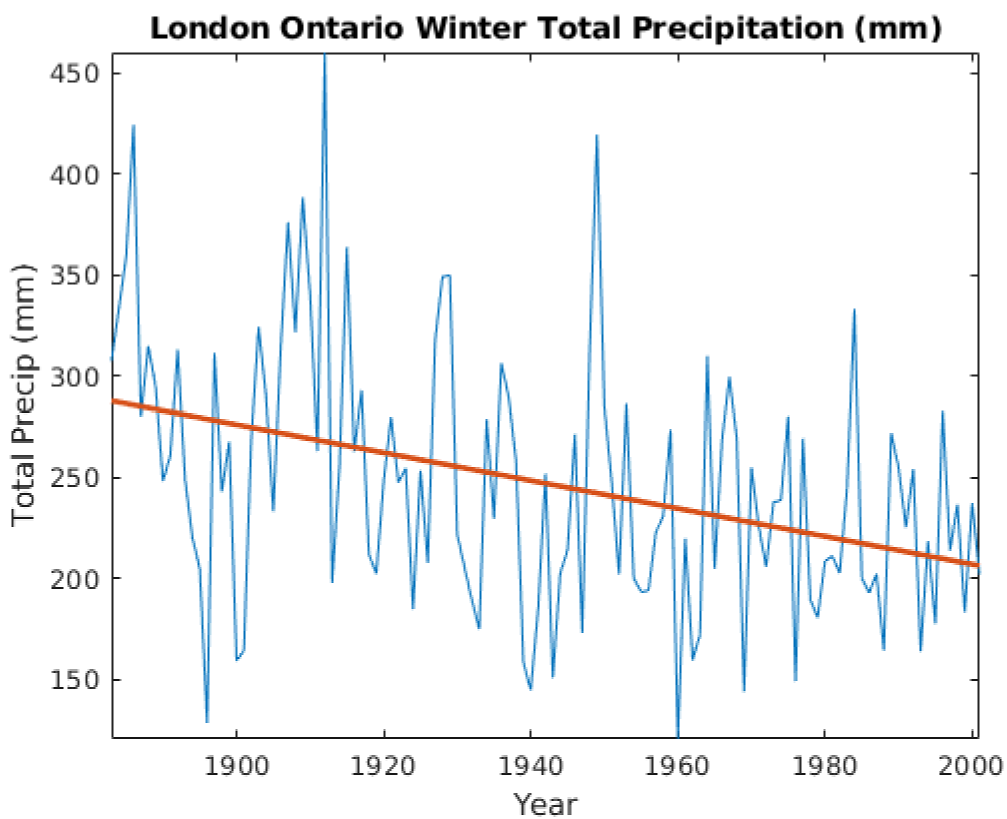

London Ontario Winter Mean Temperature (°C)
Mean Temp (°C)
-1
-2
-3
-4
-5
-6
-7
-8
1900
1920
1940
1960
1980
2000
Year


London Ontario Winter Extreme Maximum Temp (°C)
Extr Max Temp (°C)
Year
6
8
10
12
14
16
18
1900
1920
1940
1960
1980
2000


London Ontario Winter Extreme Minimum Temp (°C)
Extr Min Temp (°C)
-16
-18
-20
-22
-24
-26
-28
-30
-32
1900
1920
1940
1960
1980
2000
Year


London Ontario Winter Total Rain (mm)
Total Rain (mm)
250
200
150
100
50
1900
1920
1940
1960
1980
2000
Year


London Ontario Winter Total Snow (cm)
Total Snow (cm)
250
200
150
100
50
1900
1920
1940
1960
1980
2000
Year


London Ontario Winter Total Precipitation (mm)
Total Precip (mm)
450
400
350
300
250
200
150
1900
1920
1940
1960
1980
2000
Year

# Discussion of Results

Spring Season:

Quantities showing a decreasing trend: Mean Max T, Extr Max T, Total Snow.

Quantities showing an increasing trend: Mean Min T, Mean T, Extr Min T, Total Rain, Total Precip.

Statistically significant tends at 68% confidence: Mean Min T, Extr Max, Extr Min T and Total Rain

Taken together, we see the maximum temperature decreasing, the minimum temperature increasing, with a very small increase in overall temperature, together with a decrease in snow and an increase in rain. Yes, these trends are consistent. Together they suggest a minimal warming over spring while the temperature variation is becoming less extreme (max decrease, min increase). Only the min increase has a reasonably strong statistical significance.

Summer Season:

Quantities showing a decreasing trend: Mean Max T, Mean T, Extr Max T.

Quantities showing an increasing trend: Mean Min T, Extr Min T, Total Rain, Total Precip

Statistically significant trends at 68% confidence: Mean Max T, Mean Min T, Extr Max T, Extr Min T.

Taken together, we see the maximum temperature decreasing, the minimum temperature increasing, with a very small decrease in overall temperature, together with an increase in rain. Yes, these trends are consistent. Together they suggest a minimal cooling over summer while the temperature variation is becoming less extreme (max decrease, min increase). In this case the max decrease and min increase for both mean and extreme values is reasonably statistically significant, with the minimum increases significant also at 99%, lending greater credence to the hypothesis that weather in London is becoming less extreme.

Fall Season:

Quantities showing a decreasing trend: Mean Max T, Extr Max T, Total Snow

Quantities showing an increasing trend: Mean Min T, Mean T, Extr Min T, Total Rain, Total Precip

Statistically significant trends at 68% confidence: Mean Max T, Mean Min T, Extr Max T, Extr Max, Extr Min T, Total Rain, Total Snow, Total Precip

Taken together we see the maximum temperature decreasing, the minimum temperature increase, with a very small increase in overall temperature, together with a decrease in snow and an increase in rain and total precipitation. with all of these trends being roughly statistically significant. Once again, these are consistent. Taken together they suggest a minimal warming over the fall season with the overall temperature variation becoming less extreme. There is evidence of an increase in rain in the fall, with the rain contributing to an increase in precipitation.

Winter Season:

Quantities showing a decreasing trend: Mean Max T, Total Rain, Total Snow, Total Precip.

Quantities showing an increasing trend: Mean Min T, Mean T, Extr Max T, Extr Min T.

Statistically significant trends at 68% confidence: Mean Min T, Extr Max T, Extr Min T, Total Snow, Total Precip.

Taken together we see the maximum temperature decreasing, the minimum and overal temperature increasing, with a slight increase in extreme high temperatures, together with a decrease of rain and snow. These trends are certainly consistent too. Taken together they suggest a minimal warming over the winter season, with the overall temperature variation becoming less extreme, together with an overall decrease in both kinds of preciptiation.

95% Confidence Trends:

The trends that are significant at 95% confidence are the following: Spring: Mean Min T, Extr Min T Summer: Mean Max T, Mean Min T, Extr Max T, Extr Min T Fall: Mean Min T, Extr Max T, Total Rain, Total Precip Winter: Extr Min, Total Precip

Everyone should find: (1) extreme min temperature in the Spring, Summer and Winter; (2) extreme max temperature in the Summer and Fall.

Only some will find (depending on what variables you computed): (3) mean min temperature in Spring, Summer and Fall; (4) mean max temperature in Summer; (5) total rain in Fall; (6) total precipitation in Winter.

Some other quantities are close to being 95% significant, but it is not necessary to identify these.

The extreme min increases and max decreases, which everyone should find, are of certainly consistent, indicating less extreme temperature variations. This hypothesis is corroborated by the mean min increases and mean max increases among the Spring, Summer and Fall seasons. Thus, there is decent evidence that (over the 1883-2001) period, the weather in London became less extreme.

The increase in rain and precipitation are also consistent, suggesting that the Fall and Winter seasons are becoming wetter. Any judgement of the reason for this is not supported by the data.

Overall Conclusion:

Overall the results support the conclusion that the weather in London has become less extreme over the last 100 years, though a more careful analysis would be needed to establish this, including looking for corroborating evidence from other weather stations and seeing how strong the effect is when yearly averages are computed.

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*Published with MATLAB® R2018a*