Tree Rings and Precipitation Data Lab

Introducing: Paleoclimatology

What is Paleoclimatology?

- Clues: What does the Prefix Paleo mean in geologic time?

- It means "old" or ancient
- Another similar word that you might be familiar with that has the same prefix – is Paleontology.
- The suffix – "ology" any branch of science or knowledge.

Paleoclimatology:

Is the study of past climates. Climate 'proxies' allow scientists to go back in time and reconstruct the climate conditions over long periods of time - hundreds, thousands even millions of years ago.

What are Climate 'Proxies'?

Are sources of information from natural archives such:

- Tree rings
- Ice cores from glaciers
- Corals, lake and ocean sediments
- Fossilized Tree Pollen
- Historical records or diaries prier to the mid 19th Century

Ice Cores

Trapped in the ice cores of are gas bubbles, dust and dissolved chemicals that offer clues about previous atmospheric conditions.

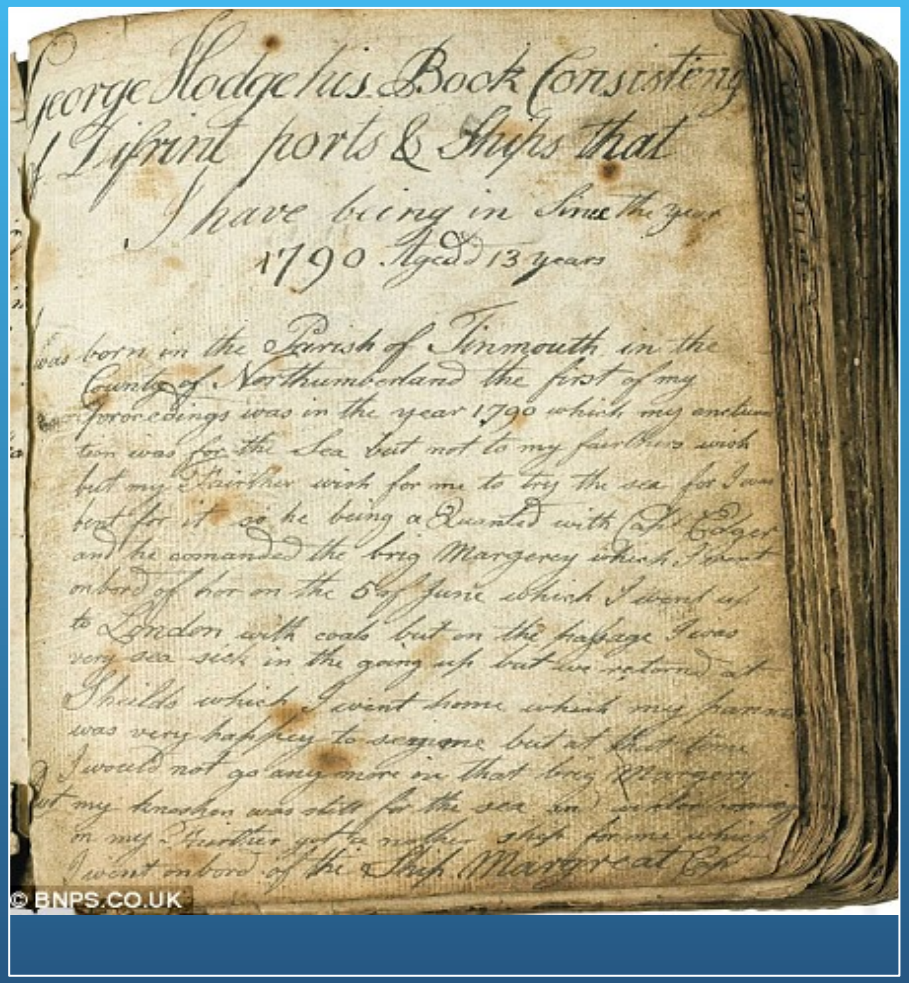
Fossils

Fossils can provide evidence of how Earth's climate was like millions of years ago.

Pollen

Scientists can use pollen found in sediment from oceans and lakes. Ancient pollen offers clues about what was the climate like for the time period for the time period the plant was alive.

Historical Records



This is a diary of an 18th century sailor (1790). Navel logbooks tend to have very accurate descriptions and measurements of weather and astronomical observations.

Tree Rings

Hundred year old tree rings can help scientists estimate past precipitation levels of a particular geographical area. They can tell us if there were drought conditions or abundant rain fall.

Tree Rings - Dendrochrology

The field of dendrochronology is the scientific method used to date a trees growth rings. This information can tell us when were the trees formed as well as their growth conditions in relation to climate – moisture (rain), cloudiness, sunshine, and forest fires.

Each ring represents a year of growth. The distance or separation between the rings can tell us if the tree had enough rain and nutrients or experienced drought conditions.

Tree Ring Lab
Climate Data Sources

In order to understand how Tree Rings can serve as a climate proxy to reveal what type of climate was prevalent when the Tree was growing two sets of data will be used. This will help corroborate the inferences that can be made by studying tree rings. Data will consist of:

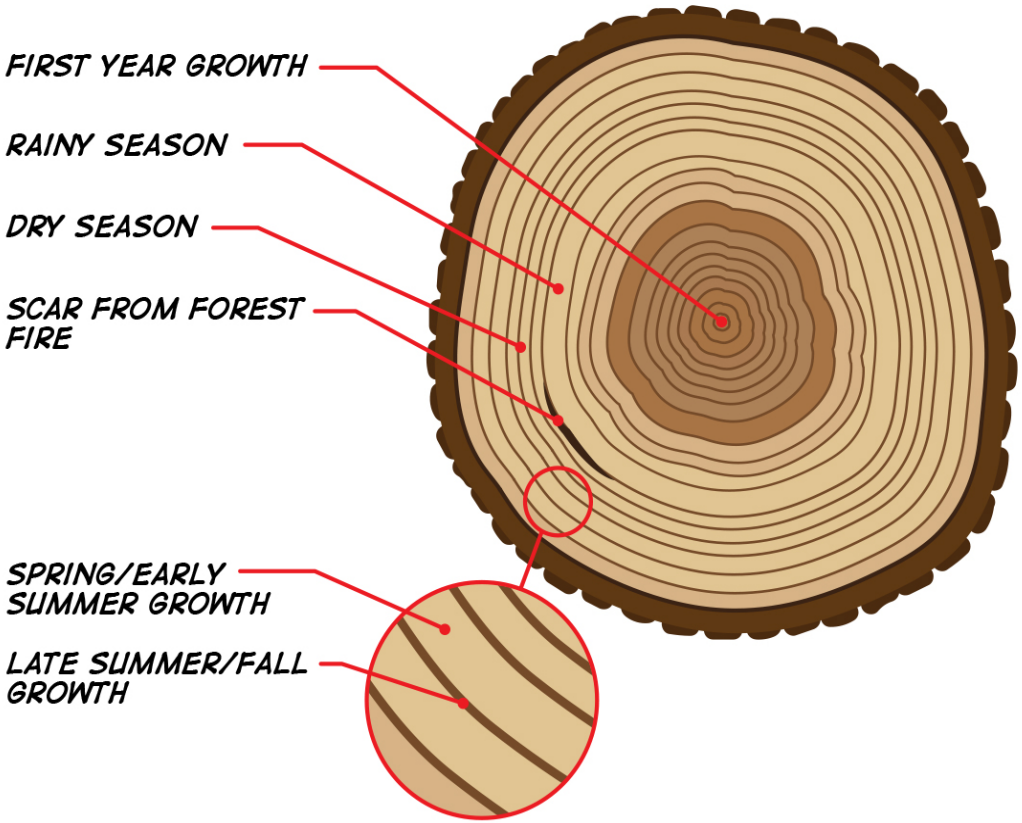
- Paper copies of simulation tree rings and;
- Numerical precipitation data from NASA satellite data archives.

These two sets will be compared to each other.

Comparing Tree Ring and Precipitation Data Lab

- Use tree ring data and compare it to precipitation from NASA satellites data of the region in which the tree grew to learn about local decadal precipitation and variability.
- This lab is called EPA-Tree Rings Precipitation Data Analysis. URL: https://www3.epa.gov/climatechange//kids/documents/tree-rings.pdf
- For this lab you will need a printout Tree Ring Analysis Worksheet, a computer with internet access and excel. You may need ruler and magnifying lens (to aid with counting of tree rings).
- Printout of one of four tree rings labeled: Use the Tree Rings at the end of the activity PDF.
  - Jackson, MS
  - Columbia, MO
  - Boston, MA
  - Seattle, WA

Reading Tree Rings



You don't have to cut a tree to measure the tree rings. A sample of the core can be obtained without damaging the tree.

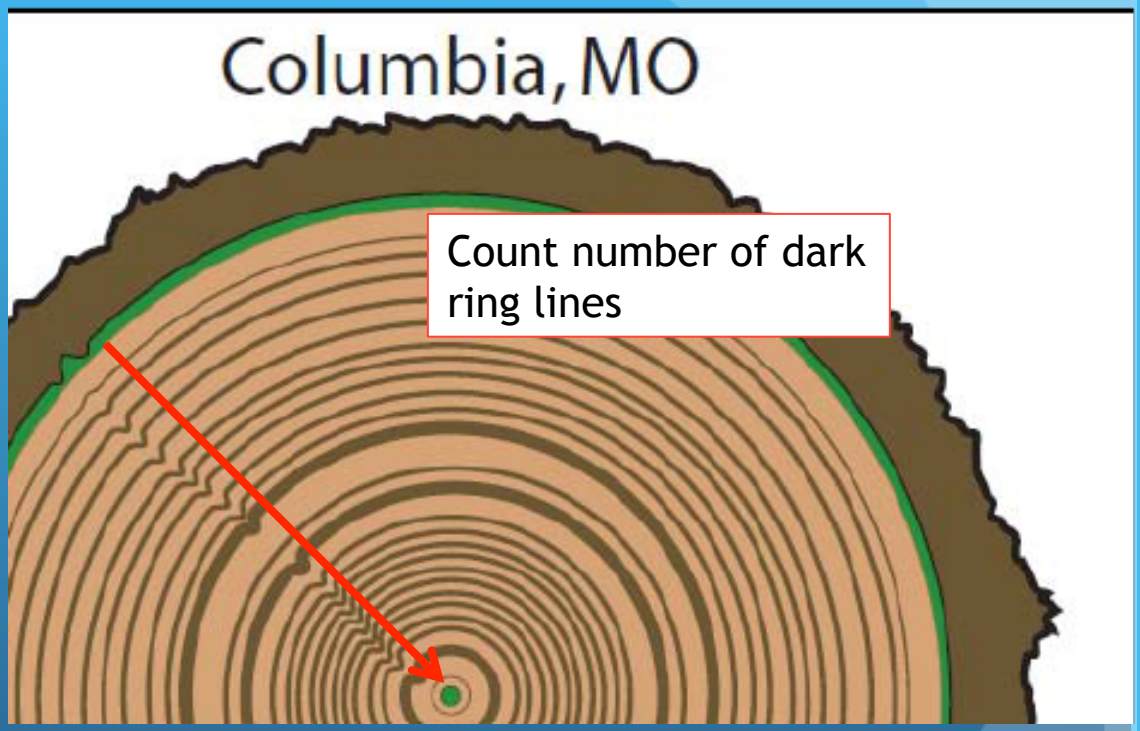
This sample maybe from a logged tree or dead tree.

How To Measure Tree Rings

1. The first circle is the first year of growth.
2. The space between the dark rings is the time when the tree grew the most in a particular year.
3. If the space is wide between the brown rings then the tree had plenty of water. If not it was a stressful year.

How to Measure Tree Rings

1. Count the rings beginning from the outside towards the center.
2. Choose one of the four samples of tree rings.
3. Begin counting only the dark rings beginning from the center of the tree working toward the edge. (The outer very dark thick band is the bark – do not count the bark as a ring).



Sample **Tree Ring Activity Printout**

Calculate the Age of the Tree

1. To calculate the age of the tree you will need two figures:
   - The **number or rings you counted** which represent the number of years the tree grew.
   - The **date the tree was harvested** (this date will appear on the bottom left of your tree ring sheet. It will show the month and year.
2. Now you have to calculate the age of the tree. What do you think you need to do?
3. Record your on the The Tree Ring Analysis Work Sheet.

Tree Ring Age Calculation Chart

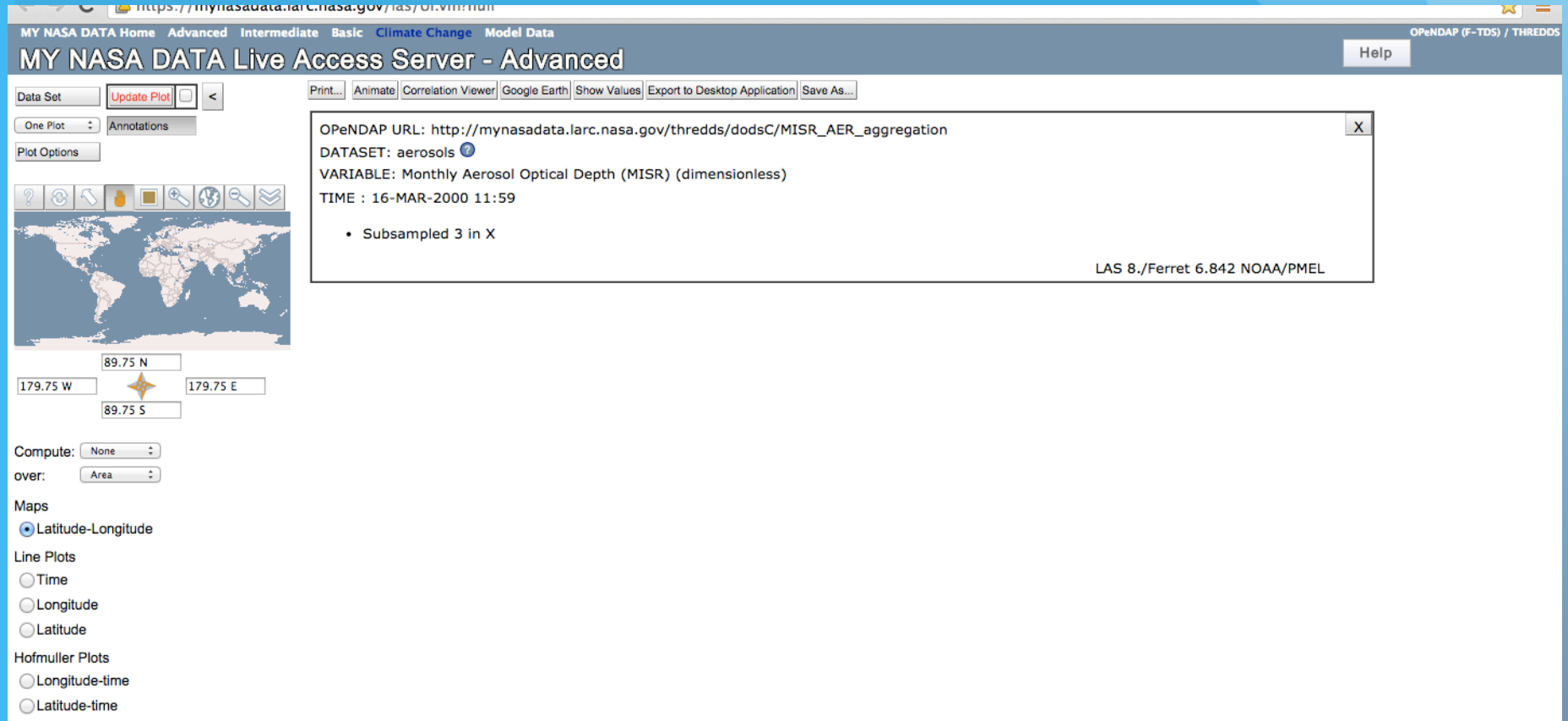
TR Location	Coordinates	Yr. Harvested/ Yr. Planted	Number of Rings	Average Precipitation
Boston, MA	42°N, 71°W	Oct. 2000 1981	19	3.76mm/day
Columbia, MO	39°N, 92°W	Dec. 2005 1980	25	3.0mm/day
Jackson, MS	32°N, 90°W	Feb. 2006 1982	24	3.73mm/day
Seattle, WA	47°N, 122°W	Sept/2003 1980	23	3.5mm/day

Select Ring With Bellow Average Precipitation

1. Based on the tree rings width, select the ring for the year of least precipitation. This would be the narrowest ring.
2. Calculate the year corresponding to that ring and enter it on the Tree Analysis Worksheet.
3. Once you have calculated:
   - Age
   - Year it was Planted
   - Bellow Average Precipitation year

   Consult with others with the same tree ring location to check your calculations.

Click on URL:
https://mynasadata.larc.nasa.gov/las/getUI.do
or enter the URL or cut and past. The browser should open to a page that looks like the page bellow.



How to Obtain Precipitation Data?

1. On the upper left hand corner click on the **DATA SET** button.
2. Then Select **"ATMOSPHERE",**
3. Under" Atmosphere" Select **"PRECIPITATION"**
4. Under Precipitation Select **"Monthly Precipitation (GPCP)**
5. Scroll down find "LINE PLOTS" under small map on left hand side of main screen and click on **TIME.**
6. Go To **Start Date/Time** – It's on the left bellow the cardinal coordinates. Click on the year and select the **year your tree was born**, **select January** for the month. Make sure you have the right year. **End DATE** – The year when the tree was Harvested, and the month should be **December**, regardless of the month it was harvested.

How to Obtain Precipitation Data

1. **Coordinates** – Obtain your coordinates from your Tree Ring Sheet. It's printed on the bottom left of tree ring sheet. Or on the Data Chart on slide 17 and 23 of this Power Point.

2. There are only have two sets of coordinates. Enter the coordinate **North on the top**; **West on the right** or left and press enter; it will automatically fill in the other coordinate points.

3. Now that you have all of your information in you need to **press the UPDATE button** that appears in red on the upper left side of the sheet. Notice that a graph will appear on the screen.

Update Plot

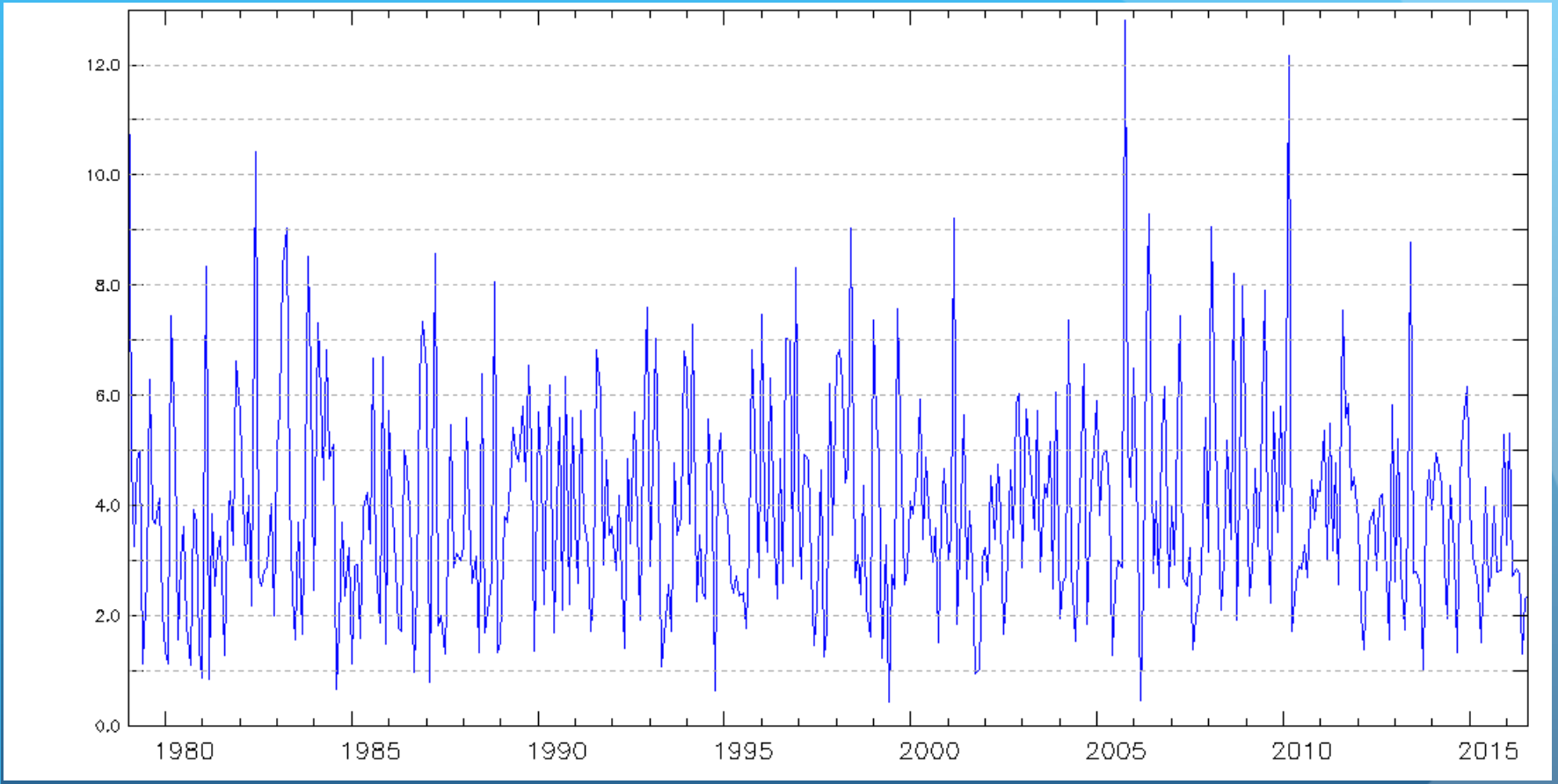
- The **Update Plot button is on the upper right hand side next to the Data Set button with turn RED – Update Plot.**

Warning Every Time You Make Changes and the button turns RED Click on IT.

Tree Ring Coordinates

TR Location	Coordinates	Year Harvested? Year Planted	Average Precipitation
Boston, MA	42°N, 71°W	Oct. 2000 - 1981	3.76mm/day
Columbia, MO	39°N, 92°W	Dec. 2005 - 1980	3.00 mm/day
Jackson, MS	32°N, 90°W	Feb. 2006 - 1982	3.73 mm/day
Seattle, WA	47°N, 122°W	Sept. 2003 - 1980	3.5 mm/day

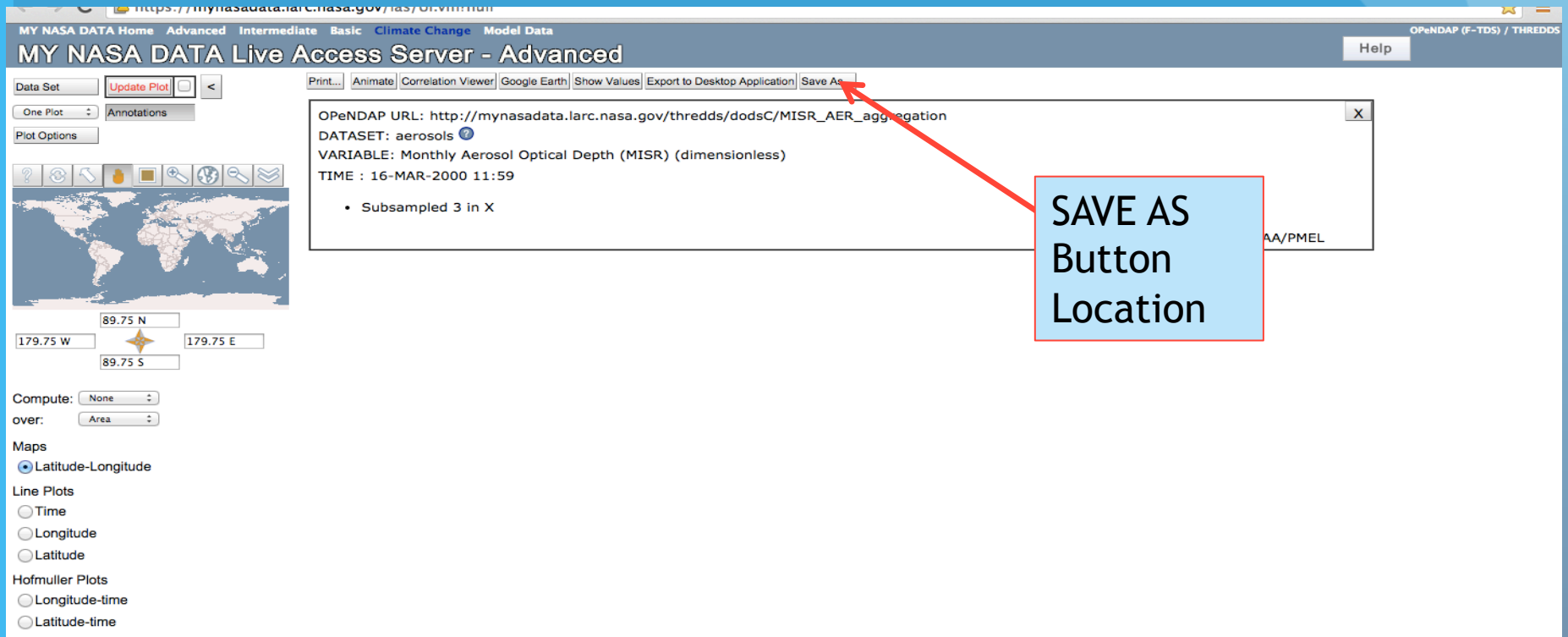
MYNASA DATE Precipitation Graph



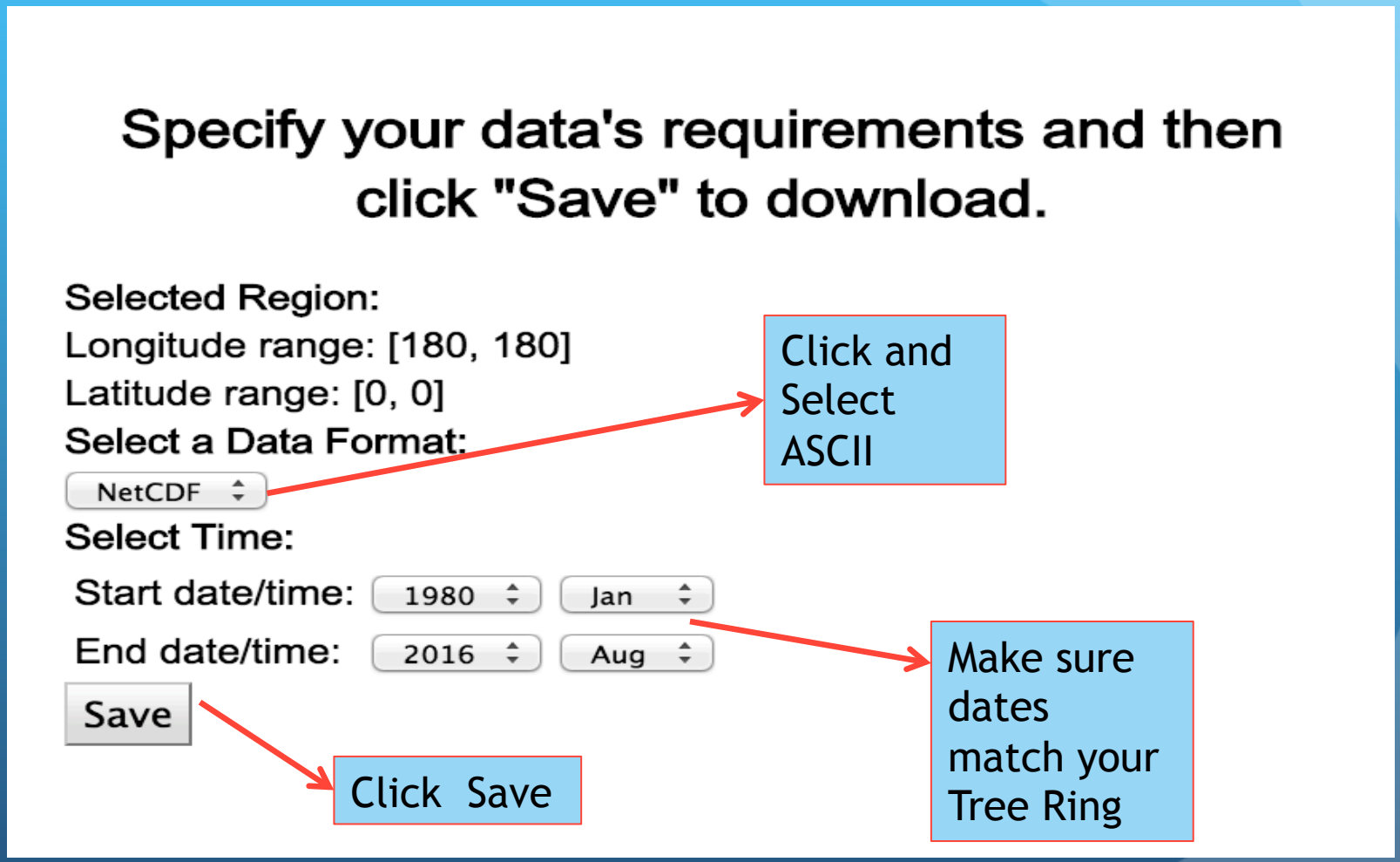
Once you update your data a similar graph might show on your screen. You can save it if you press print. It's hard to read because it has monthly data points for every year.

How to Download Numerical Data to Analyze in Excel

1. To retrieve the numerical precipitation data press the **SAVE AS** button on the upper right hand side.



Retrieving DATA



“SAVE” to Download

1. Go to the **NetCDF** button and select **ASCII** - **(**American Standard Code) It will convert the data file in a standard code so that Excel can read the data file.
2. Make sure the **Start date/time** and the End date/ time correspond to your data. Year your tree was born – starting in Jan. The End **date/time the year and month it was harvested**
3. Press the **SAVE** button and a numerical chart should appear.

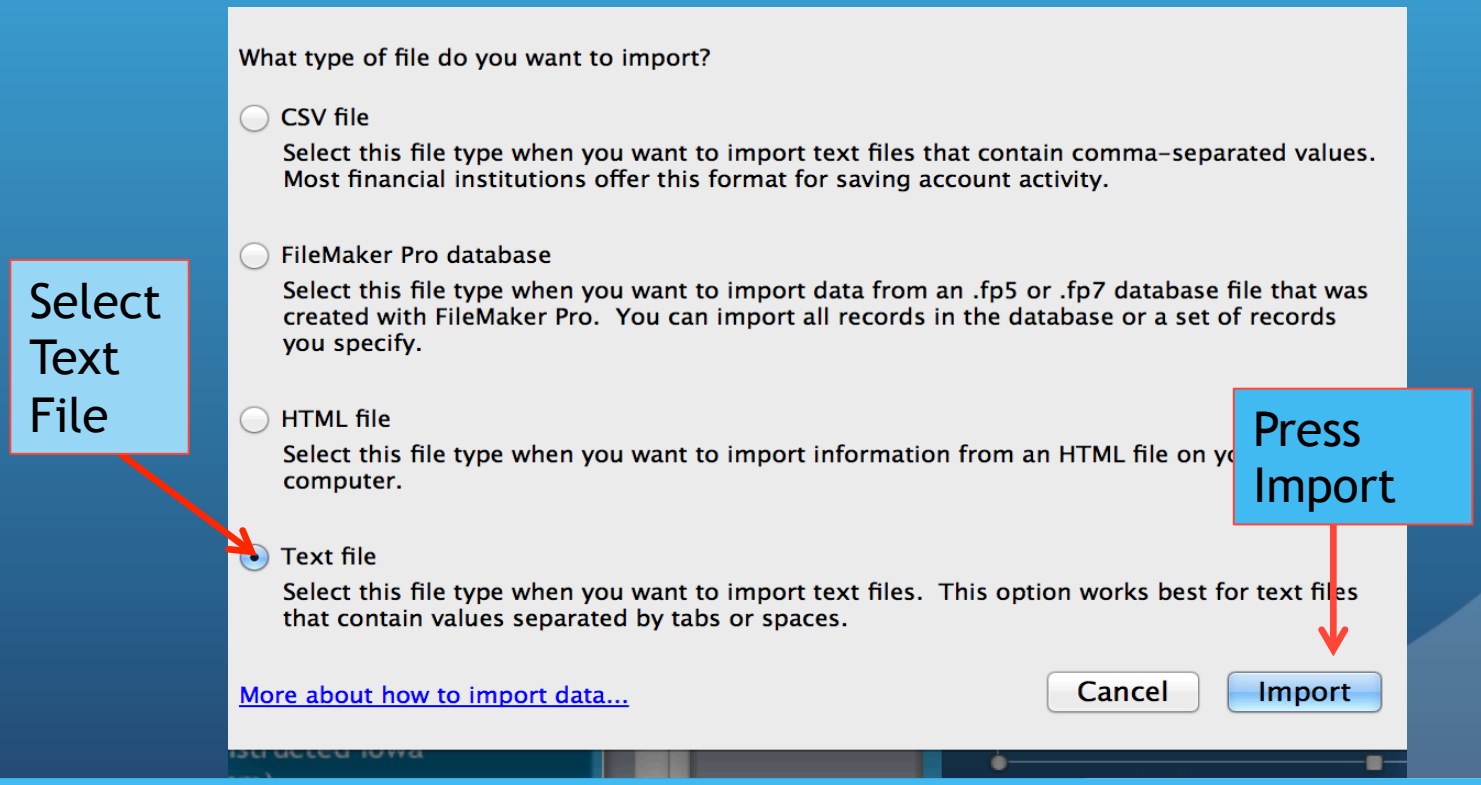
DATA CHART – Name File and Save

```
              VARIABLE : Average Monthly Rate of Precipitation (mm/day)
              DATA SET : GPCP Version 2.3 Combined Precipitation Dataset (Final)
              FILENAME : precip.mon.mean.nc
              FILEPATH : /usr/local/fer_data/data/GPCP/
              BAD FLAG : -9.96921E+36
              SUBSET   : 440 points (TIME)
              LONGITUDE: 178.8E
              LATITUDE : 1.3S
                 178.8E
01-JAN-1980 00  3.956447
01-FEB-1980 00  2.797909
01-MAR-1980 00  6.733422
01-APR-1980 00  4.065239
01-MAY-1980 00  2.56016
01-JUN-1980 00  4.021449
01-JUL-1980 00  2.259974
01-AUG-1980 00  3.926765
01-SEP-1980 00  1.8203
01-OCT-1980 00  1.587919
01-NOV-1980 00  2.455375
01-DEC-1980 00  2.497477
01-JAN-1981 00  3.061229
```

Go to **File** and **Save AS**: Enter the Name of the City and State Precipitation and your initials. Save on to your folder or drive for retrieval later.

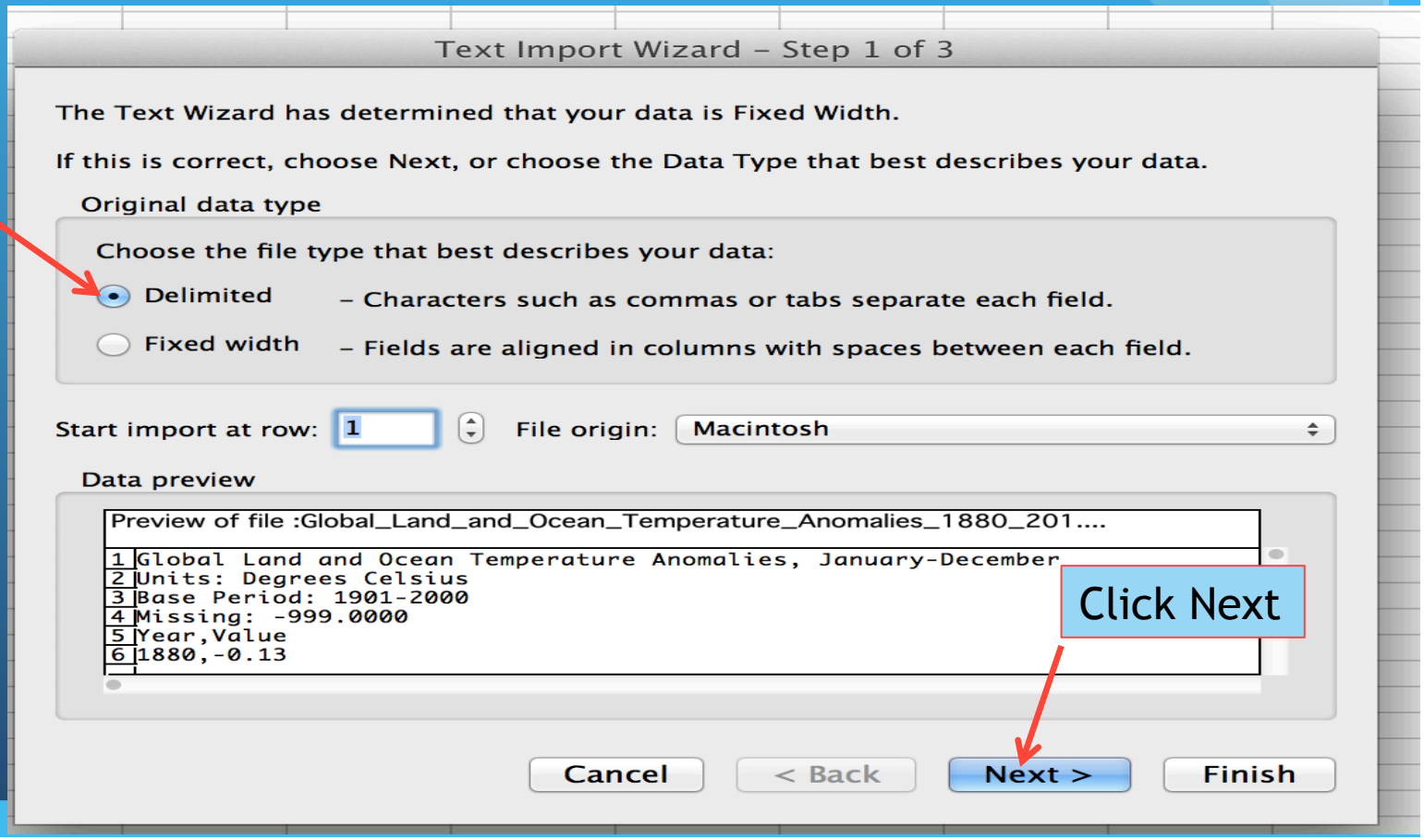
Importing DATA to Excel

- Open **Excel**
- Go to **Mac File** menu and select **Import** or for **PC** click the **Data** tab and select **Get External Data** then click **From Text**
- What type of File you want to Import? - **Select Text File** then click **Import**



Select File - Text Import Wizard

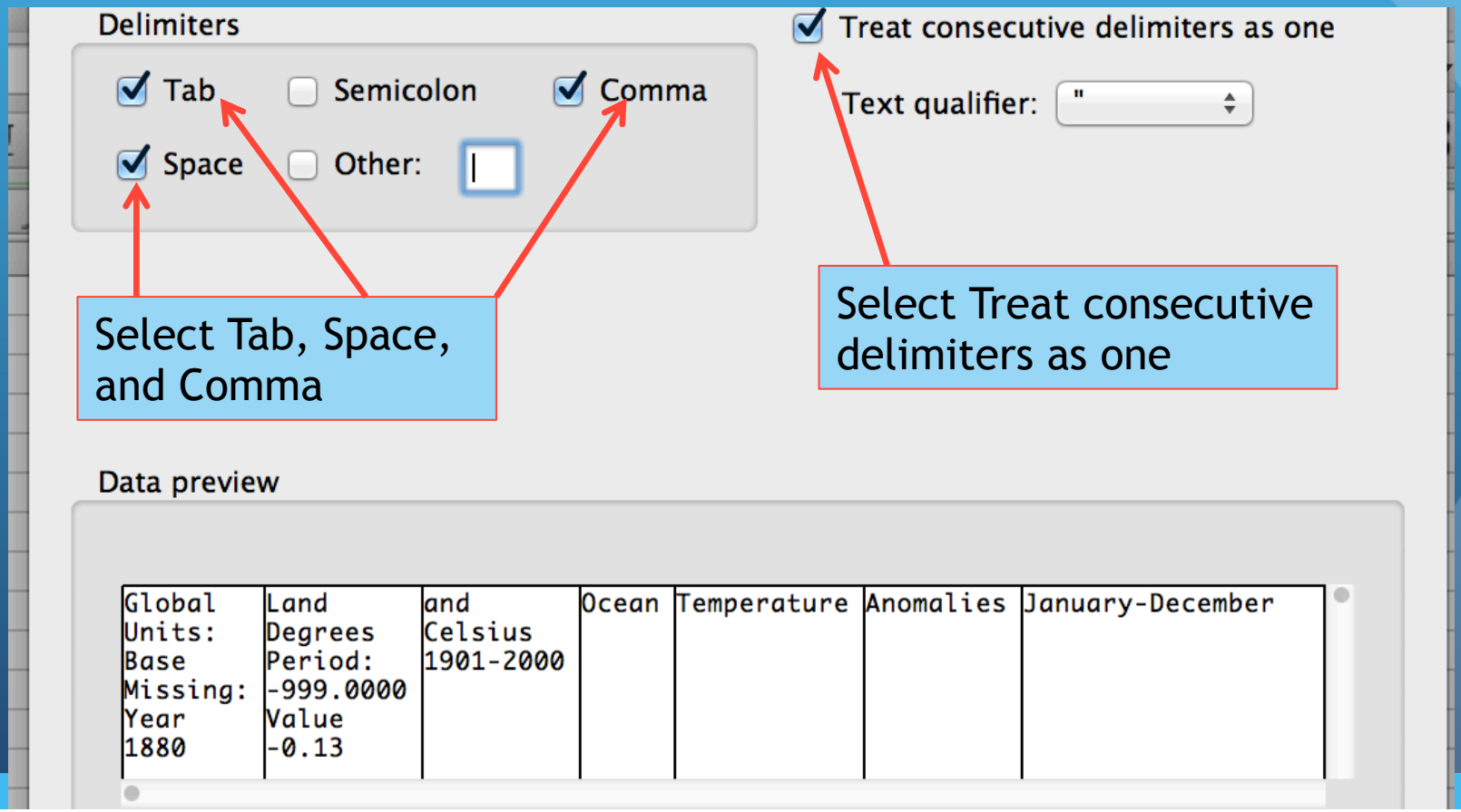
- Select the file file (name) from your drive of the data to be imported to Excel.
- Once you have selected the file name the Text Import Wizard



Select Delimiters on Text Import Wizard

Check (select) **Tab**, **Space** and **Comma**.

Make sure that **Treat consecutive delimiters** as one is checked.



Graph of Reconstructed Iowa Precipitation (cm)

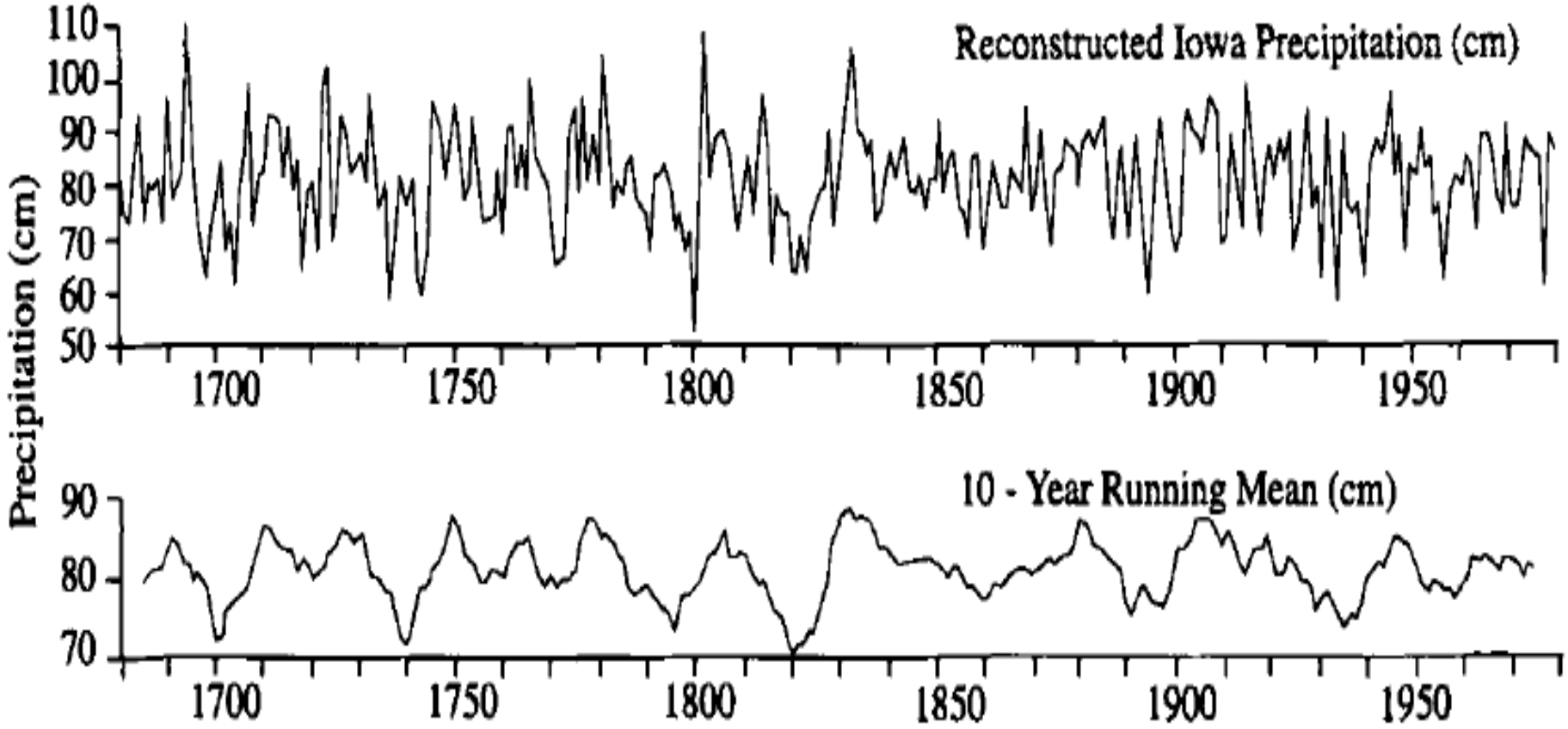
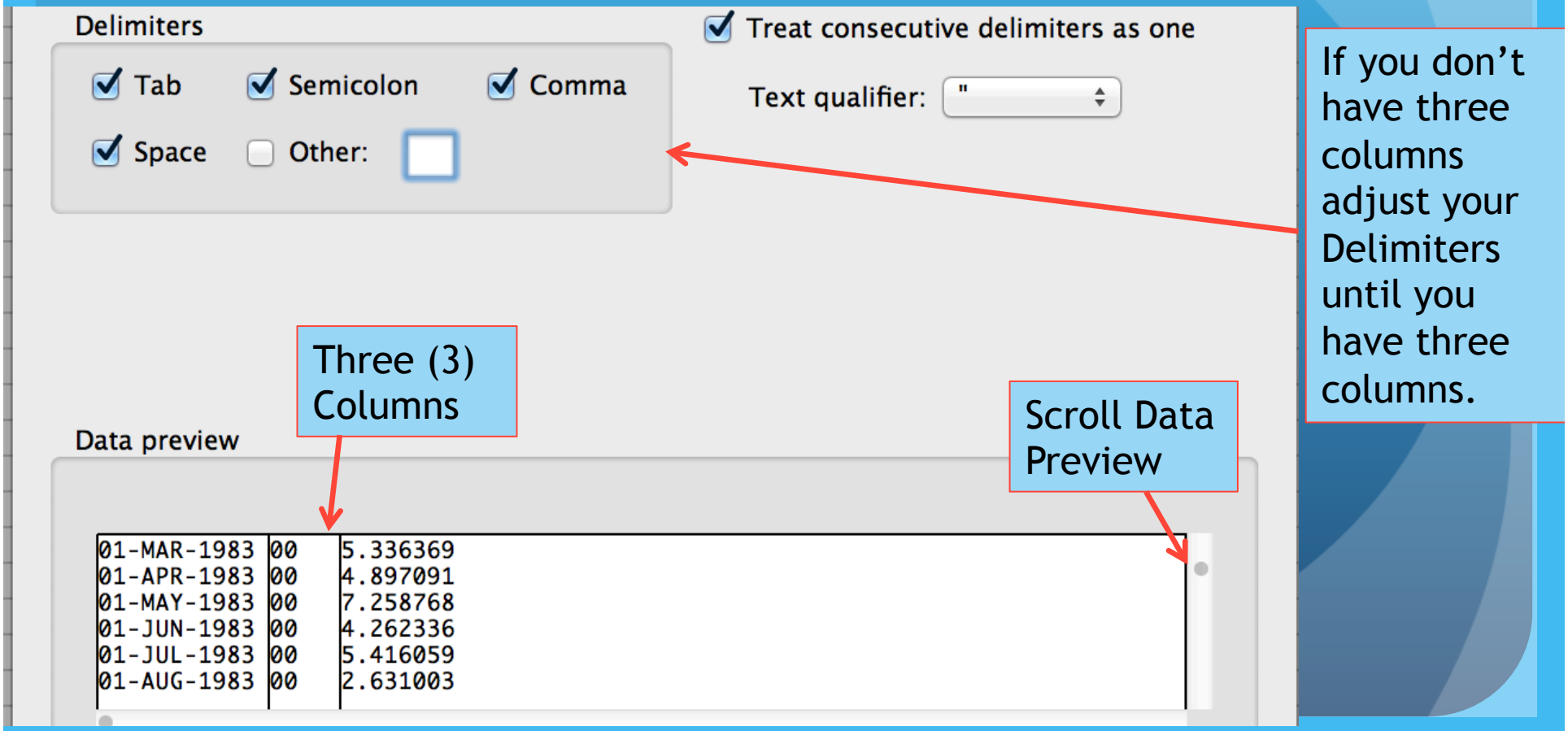


Fig. 8.3 Time history of precipitation in Iowa derived from tree-ring analysis. [From Duvick and Blasing (1981).]

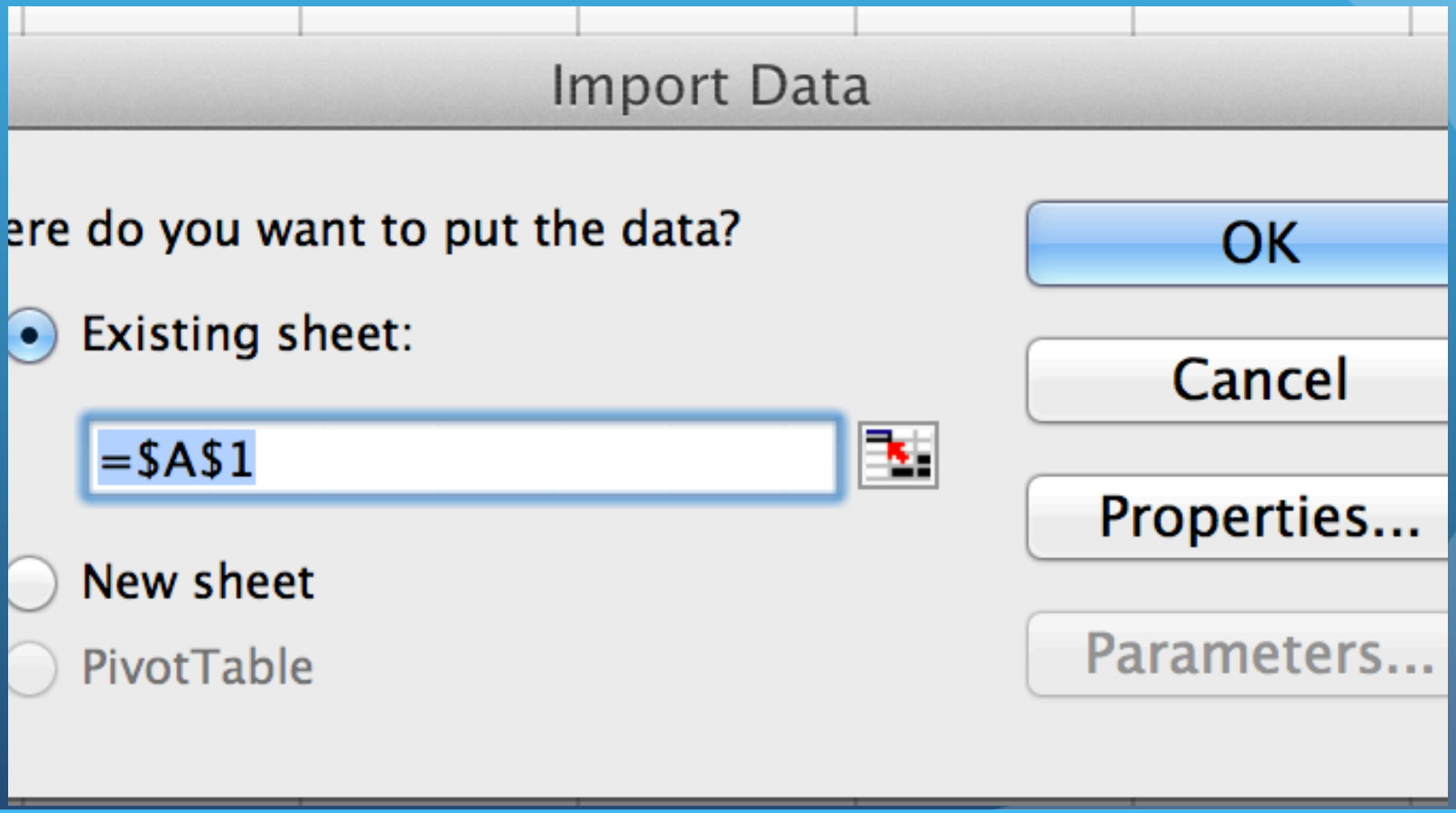
Scroll down Data Preview

Scroll down **Data Preview** make sure the columns are divided in different columns: **Date; Zero Value** (the column with zeros will be deleted in Excel); and the Precipitation Data.



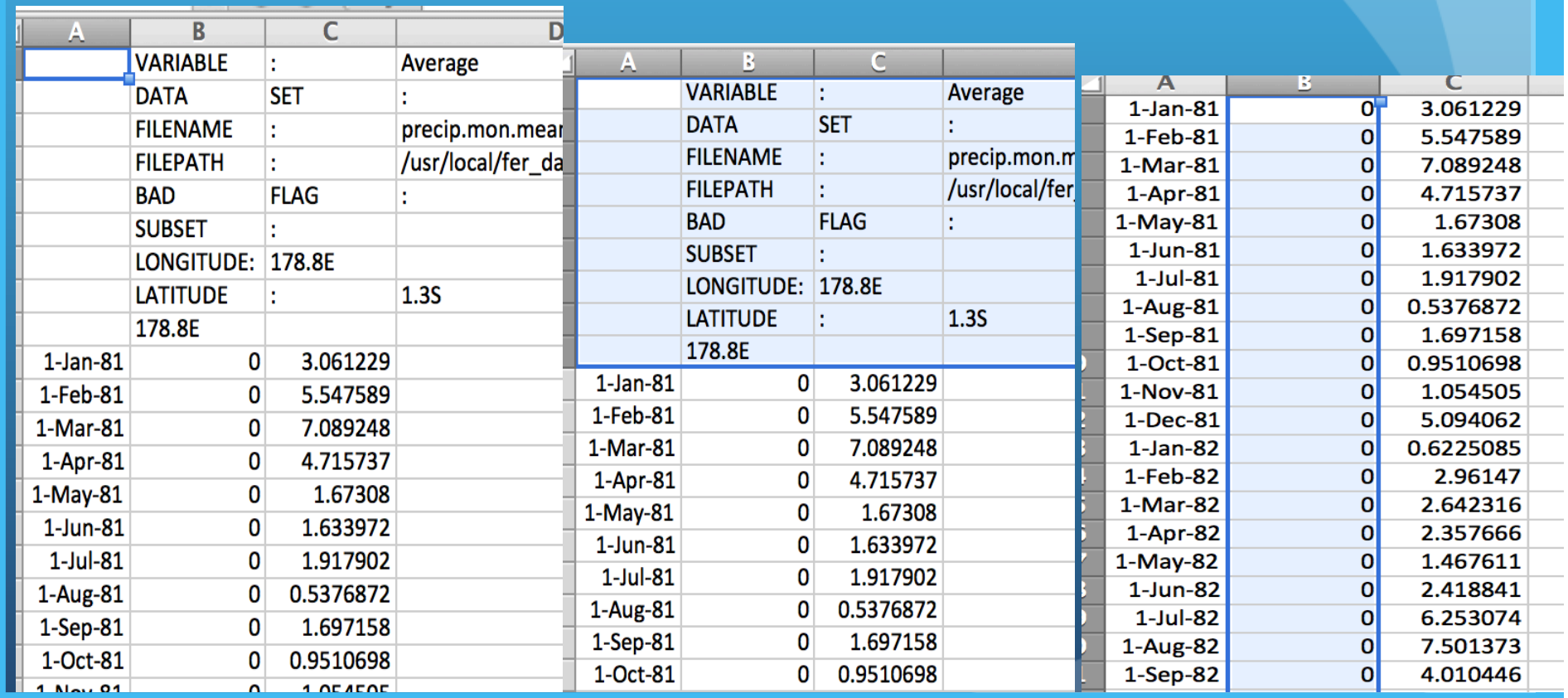
Final Step

Click OK if the **Existing Sheet** is Selected and **=A1** code is in the box bellow.
The click **OK.**



Organize Columns in Excel

1. Delete top rows as they appear in Figure 1. **Highlight the rows,** Go to Edit – **Delete** – **Shift Up** – Delete.
2. Delete Column with Zeros (0's) **- Click on the B** (column label) the entire column should be highlighted Go To **Edit** – **Select Delete Column.**



A	B	C	D
	VARIABLE	:	Average
	DATA	SET	:
	FILENAME	:	precip.mon.mean
	FILEPATH	:	/usr/local/fer_da
	BAD	FLAG	:
	SUBSET	:	
	LONGITUDE:	178.8E	
	LATITUDE	:	1.3S
	178.8E		
1-Jan-81	0	3.061229	
1-Feb-81	0	5.547589	
1-Mar-81	0	7.089248	
1-Apr-81	0	4.715737	
1-May-81	0	1.67308	
1-Jun-81	0	1.633972	
1-Jul-81	0	1.917902	
1-Aug-81	0	0.5376872	
1-Sep-81	0	1.697158	
1-Oct-81	0	0.9510698	

A	B	C	
	VARIABLE	:	Average
	DATA	SET	:
	FILENAME	:	precip.mon.m
	FILEPATH	:	/usr/local/fer
	BAD	FLAG	:
	SUBSET	:	
	LONGITUDE:	178.8E	
	LATITUDE	:	1.3S
	178.8E		
1-Jan-81	0	3.061229	
1-Feb-81	0	5.547589	
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1-Aug-81	0	0.5376872	
1-Sep-81	0	1.697158	
1-Oct-81	0	0.9510698	

A	B	C
1-Jan-81	0	3.061229
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1-Jul-81	0	1.917902
1-Aug-81	0	0.5376872
1-Sep-81	0	1.697158
1-Oct-81	0	0.9510698
1-Nov-81	0	1.054505
1-Dec-81	0	5.094062
1-Jan-82	0	0.6225085
1-Feb-82	0	2.96147
1-Mar-82	0	2.642316
1-Apr-82	0	2.357666
1-May-82	0	1.467611
1-Jun-82	0	2.418841
1-Jul-82	0	6.253074
1-Aug-82	0	7.501373
1-Sep-82	0	4.010446

DATA ANALYSIS – Average Annual Precipitation - Graph

A	B
1-Jan-81	3.061229
1-Feb-81	5.547589
1-Mar-81	7.089248
1-Apr-81	4.715737
1-May-81	1.67308
1-Jun-81	1.633972
1-Jul-81	1.917902
1-Aug-81	0.5376872
1-Sep-81	1.697158
1-Oct-81	0.9510698
1-Nov-81	1.054505
1-Dec-81	5.094062
1-Jan-82	0.6225085
1-Feb-82	2.96147
1-Mar-82	2.642316
1-Apr-82	2.357666
1-May-82	1.467611
1-Jun-82	2.418841
1-Jul-82	6.253074

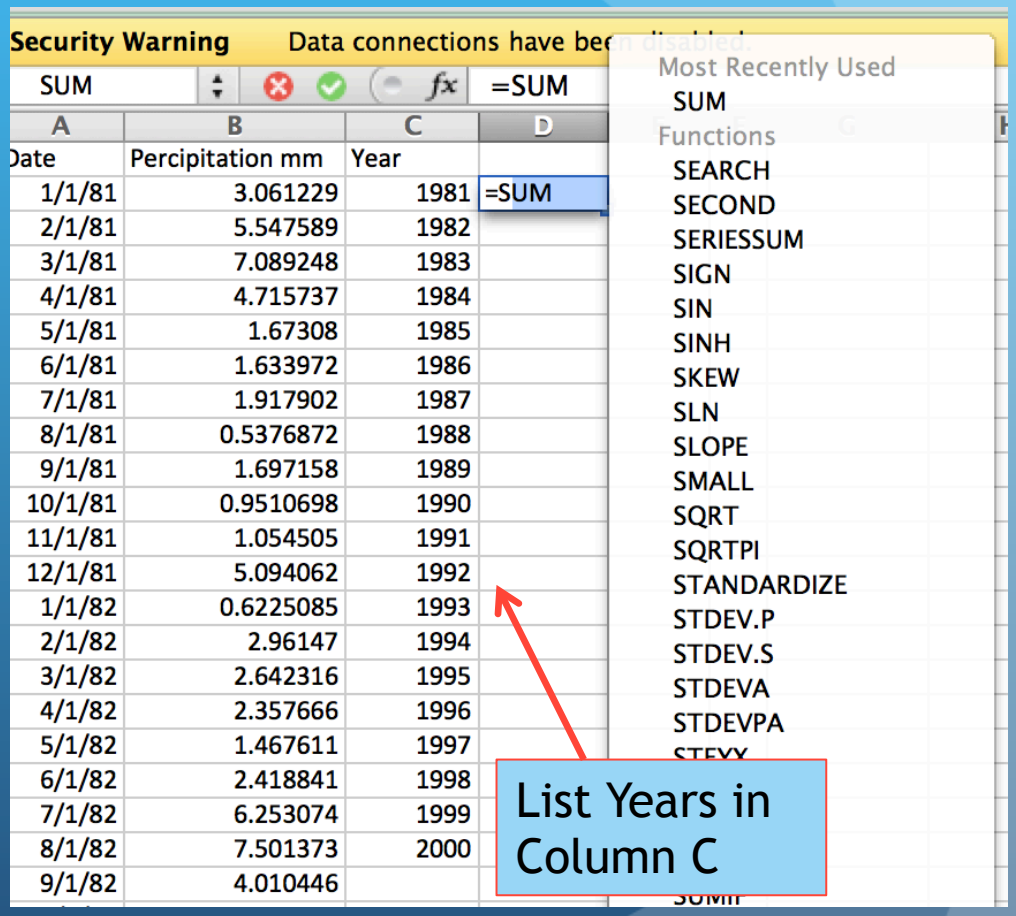
- Label A Colum **Date** and **B Column Precipitation mm** (millimeter unit). Click on cell 1 and Go to Insert and select Row.
- How can the total annual precipitation in mm be calculated?
- Average Precipitation – How can the annual average precipitation (mm) be calculated?

Create a New Date Column

- In Column C label the first cell Year.
- Enter Years beginning with the year the tree was planted. Example 1981, 1982 …. 2000
- Use Column D to add the annual precipitation per year.
- Use Formula =SUM(). Go to the first cell C2 and enter = capital S and a function menu pops up select SUM. A formula will show up in the cell.
- Go to the monthly precipitation column and high light the Jan 1981 … Dec 1981 hit enter. The total annual precipitation value should show up in the cell.

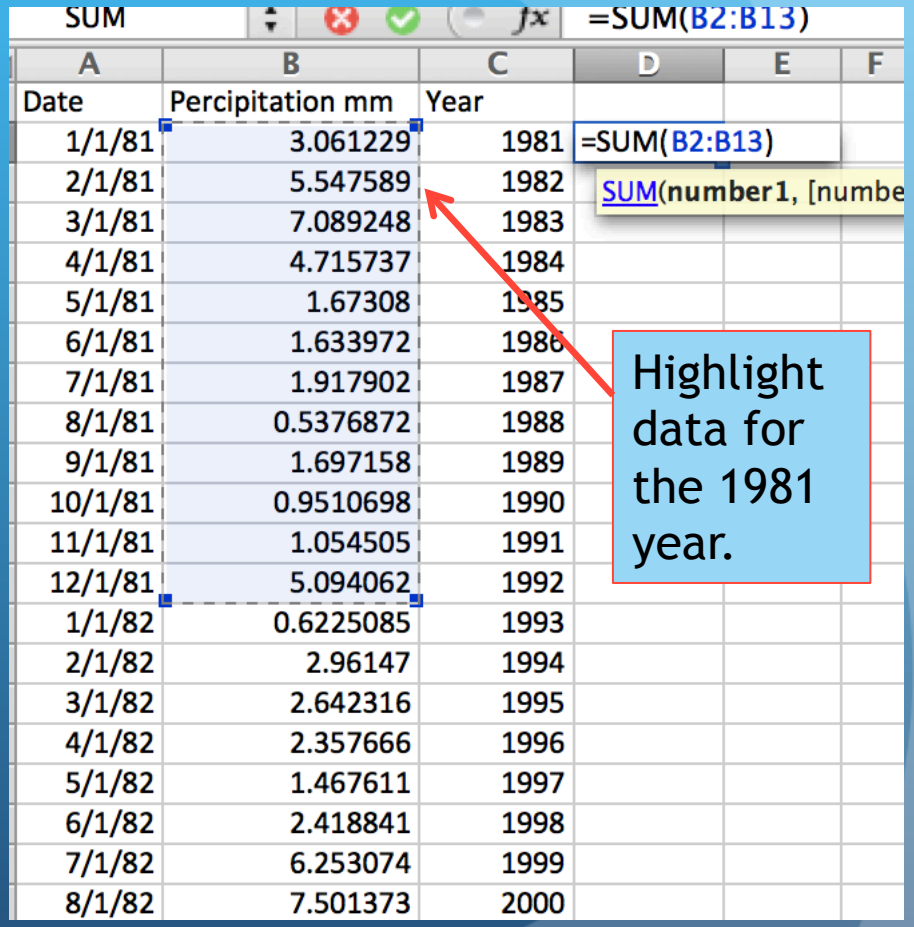
DATA ANALYSIS – Average Annual Precipitation - Graph

- In Column C, List every year.
- Calculate Annual Precipitation.
  - In cell 2 of column D enter Formula. To do so enter = sign then capital **S** (and a formula list will pop up, select **SUM**.



Calculating Total Annual Precipitation

- Once the formula appears in cell 2 of column D move cursor to column B and **highlight the monthly precipitation data for 1981** and press enter.
- The total will appear in cell 2 of column D.
- Repeat the same process for every year. Until there are values for every year in column D.



Total Annual Precipitation

D3

A	B	C	D
)ate	Percipitation mm	Year	
1/1/81	3.061229	1981	34.97324
2/1/81	5.547589	1982	
3/1/81	7.089248	1983	
4/1/81	4.715737	1984	
5/1/81	1.67308	1985	
6/1/81	1.633972	1986	
7/1/81	1.917902	1987	
8/1/81	0.5376872	1988	
9/1/81	1.697158	1989	
10/1/81	0.9510698	1990	
11/1/81	1.054505	1991	
12/1/81	5.094062	1992	
1/1/82	0.6225085	1993	
2/1/82	2.96147	1994	
3/1/82	2.642316	1995	
4/1/82	2.357666	1996	
5/1/82	1.467611	1997	
6/1/82	2.418841	1998	
7/1/82	6.253074	1999	
8/1/82	7.501373	2000	

Calculate Annual Precipitation for each year in all cells until the year 2000.

Total Annual Precipitation for each year.

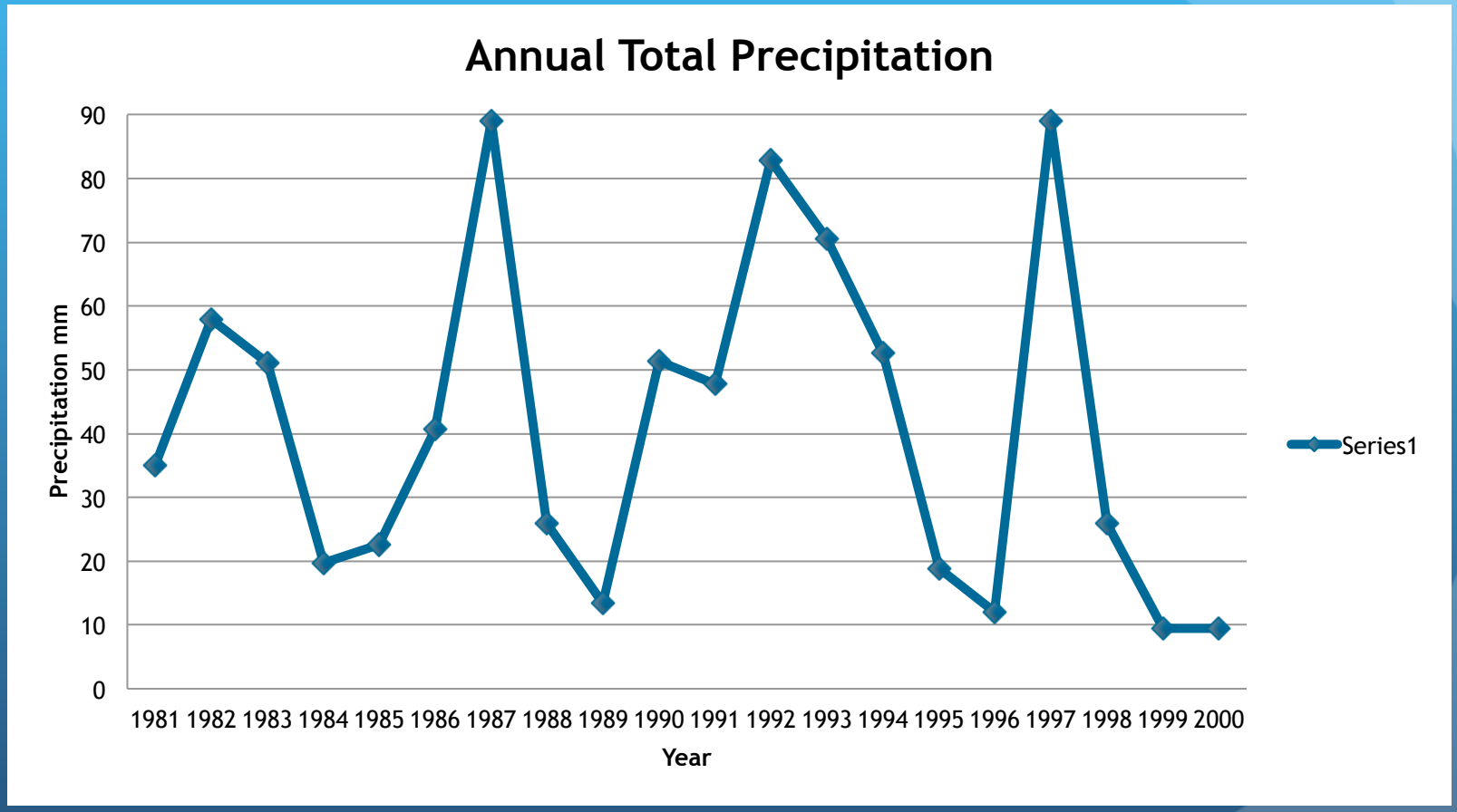
C	D
Year	Annual Precipitation
1981	34.973239
1982	57.9304845
1983	51.1412138
1984	19.741379
1985	22.5588494
1986	40.68974564
1987	89.058974
1988	25.8696648
1989	13.46194059
1990	51.4079069
1991	47.710694
1992	82.8219972
1993	70.549522
1994	52.588258
1995	18.9003324
1996	11.98357226
1997	89.058974
1998	25.8696648
1999	9.4791934
2000	9.45519766

Graph Annual Precipitation

1. Highlight the data for both columns – the **Date** column and the **Annual Precipitation** column.
2. Go to Insert select Chart.
3. **Select Line** then selected **Market Line.**

C	D
Year	Annual Precipitation
1981	34.973239
1982	57.9304845
1983	51.1412138
1984	19.741379
1985	22.5588494
1986	40.68974564
1987	89.058974
1988	25.8696648
1989	13.46194059
1990	51.4079069
1991	47.710694
1992	82.8219972
1993	70.549522
1994	52.588258
1995	18.9003324
1996	11.98357226
1997	89.058974
1998	25.8696648
1999	9.4791934
2000	9.45519766

Graphing Total Annual Precipitation (Marked Line)



Graph of Reconstructed Iowa Precipitation (cm)

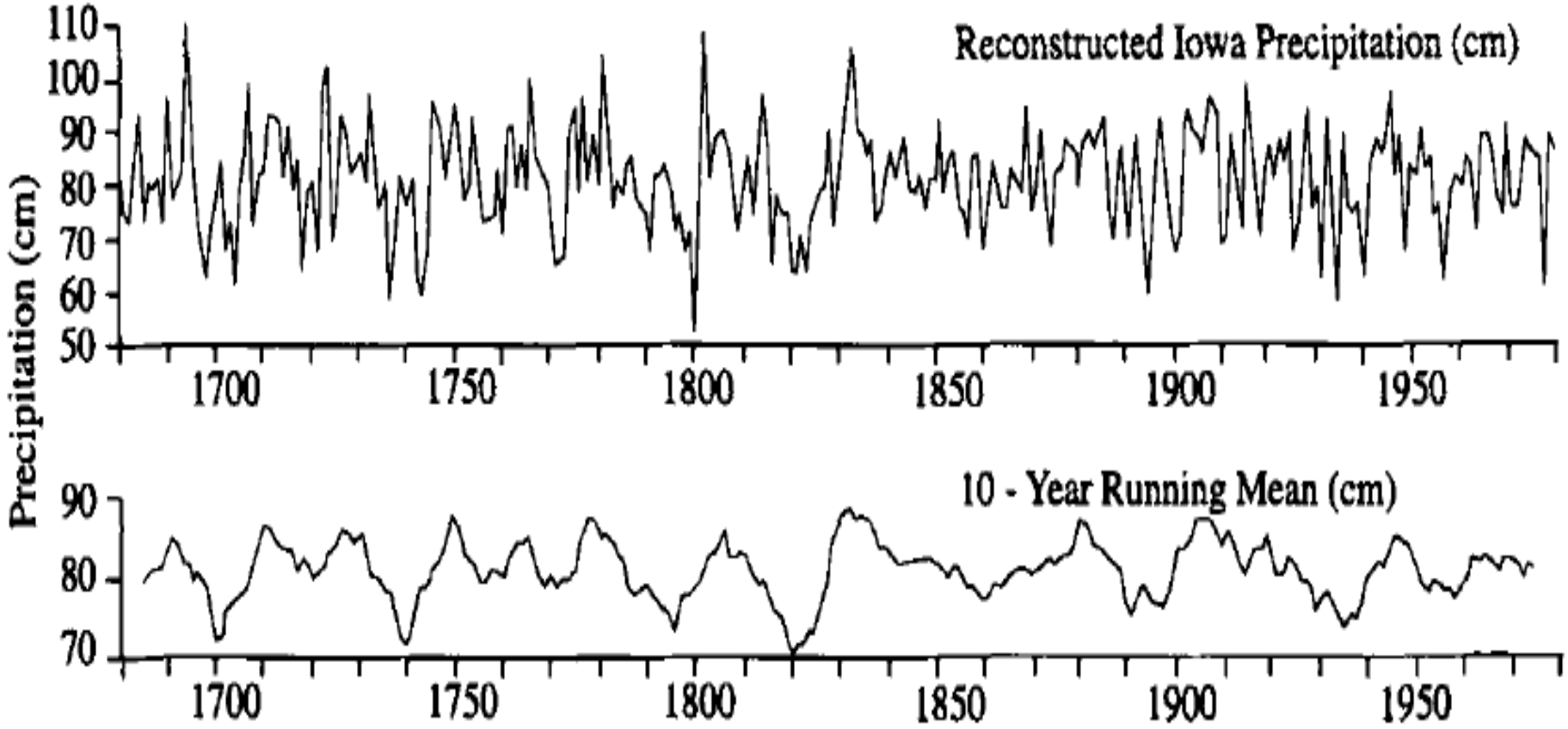
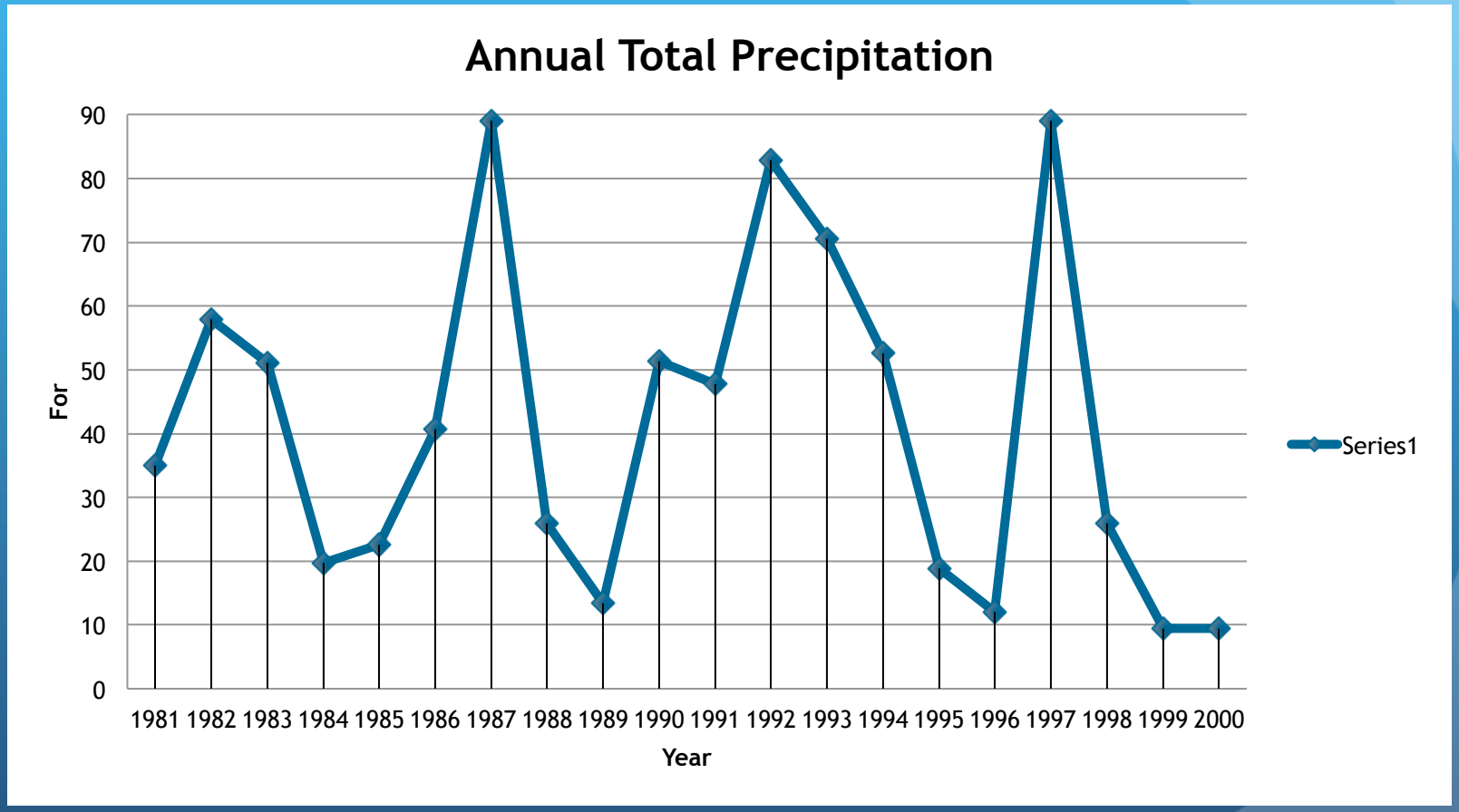


Fig. 8.3 Time history of precipitation in Iowa derived from tree-ring analysis. [From Duvick and Blasing (1981).]

Label The Graph

- Highlight the X Axis on the graph and go to Format and Select **Axis**. It can also be labeled in **Chart**, repeat for the Y Axis.
- It can also be labeled under **Chart Layouts** and from the menu select **Chart Title and Axis Title** (one a time), label the graph accordingly.
- To facilitate reading the points lines can be inserted connecting the points to the specific coordinate (Year) on the X Axis.
- To mark lines go to Chart Layout go to Analysis menu and select lines and select drop lines. (see next slide)

Line Graph with Drop Lines



Clustered Column
Total Annual Precipitation

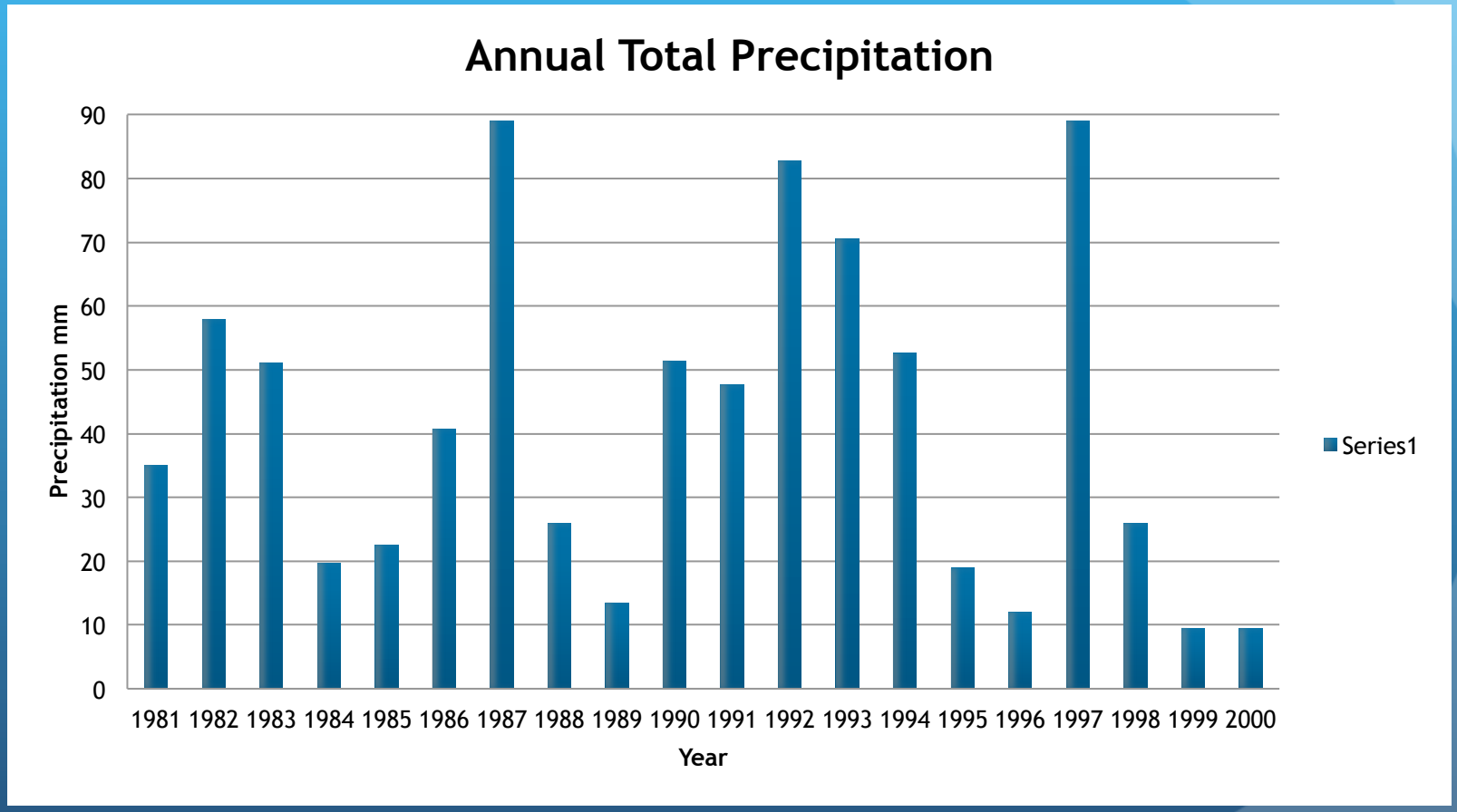


Chart the Annual Precipitation

- Once all the total annual precipitation for each year has been calculated in column C graph the total annual precipitation.
- Using :
  - Which year had the lowest precipitation and which year had the highest?
  - Compare it to the Year you selected as the year with the lowest precipitation.

Why Average and It's Advantages

- An average expresses an amount that is typical.
- The average also helps summarize a large amount of data with a single value.
- To Indicate variability around a single value. This is very important in being able to compare different sets of data.
- There are three different types of mathematical averages.
  - Mean, Median and Mode.
- The Mean will be used for the analysis
  - The Formula for Mean = $\frac{\Sigma X}{n}$

$\overline{X}$ = Symbol of Mean (a bar over the X
Σ = SUM;
X = values;
n = number of values of data set

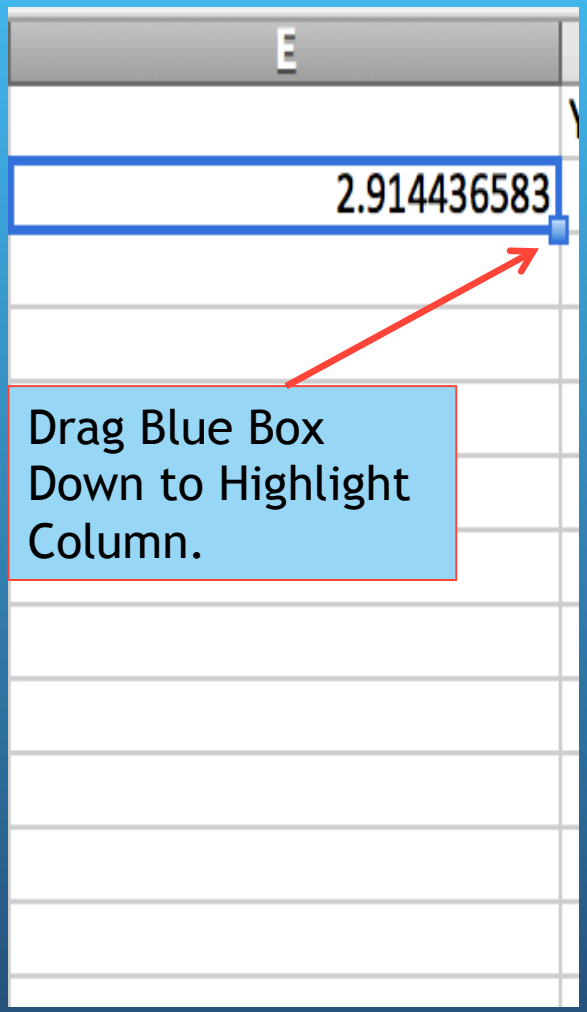
Graph Mean Annual Precipitation

- If you just want to be able to highlight the data create a another Year Column. This column will be located next, but before the Annual Mean Precipitation Column. The previous date column can also be used. To Highlighting the data requires a different method because the columns are not next to each other.
- Label a new column **Mean Annual Precipitation mm.**
- **Mean Calculation:** Since you have already added the annual precipitation by year these values can be used to calculate the average. How can it be calculated?

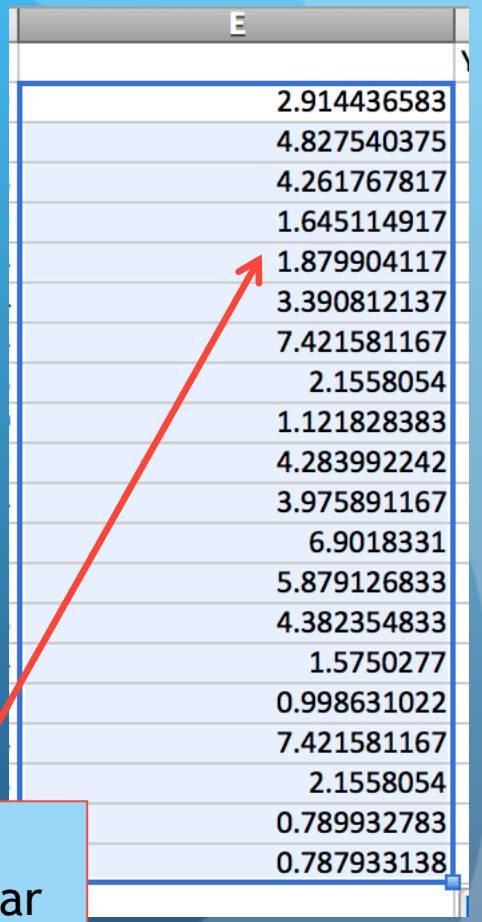
Calculating the Mean Annual Precipitation

- Click on cell 2 of the column where the mean will be calculated.
- Click on = (equal sign) right the letter S and select from the pop up menu SUM.
- Enter D2 - or the column letter and cell number the 1981 (planting year of data) annual precipitation value is located.
- =SUM(D2 enter / (backslash) sign followed by the number 12 close parenthesis.
- =SUM(D2/12) The Mean Annual Precipitation for 1981 (first year should appear)
- For a short cut of how to get the values for all years see next slide.

Short Cut Calculating the Mean for the Entire Column



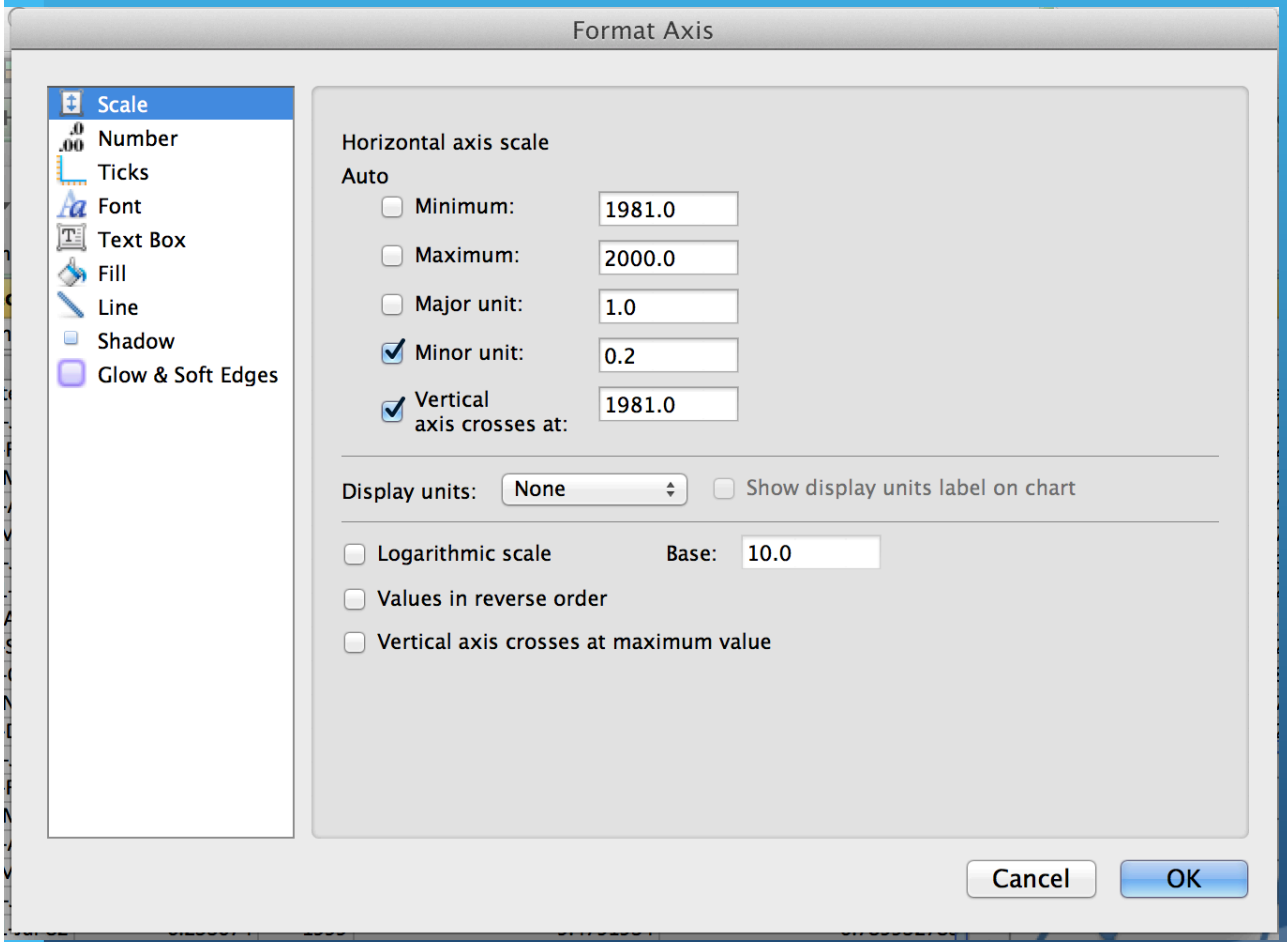
- To calculate the mean for every year there is no need to repeat the formula.
- Place the cursor on the small blue box until it becomes a cross and drag it down.



Graph the Mean Annual Precipitation

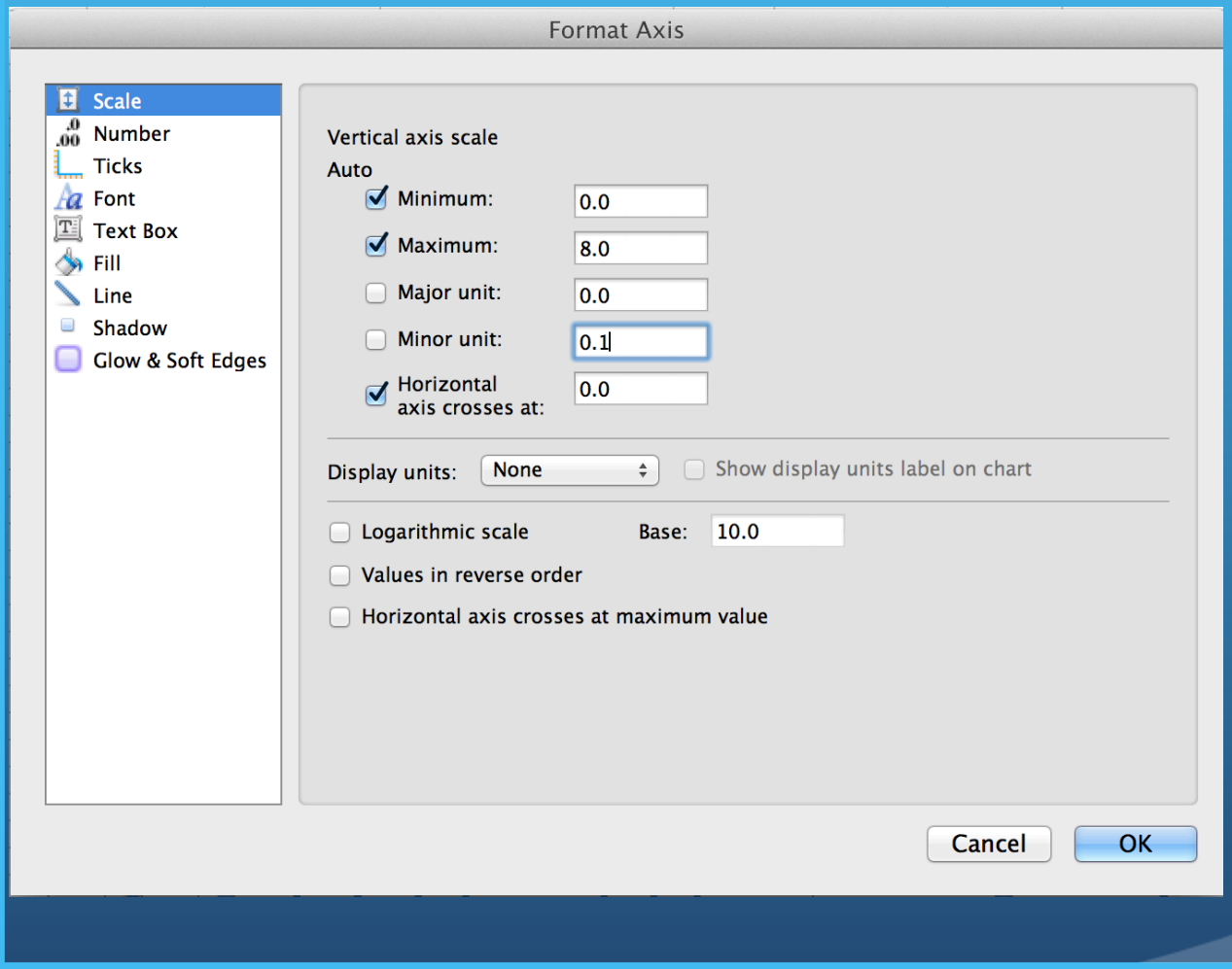
- Select Chart, go to Scatter and select Straight Marked Line.
- Graph appears. Label Graph
- Change X Axis values to show every year in the X Axis. Highlight the X Axis go to Format click on X Axis a screen will pop up where minimum and maximum can be change. See next slide.

Change X Axis Min and Max Values



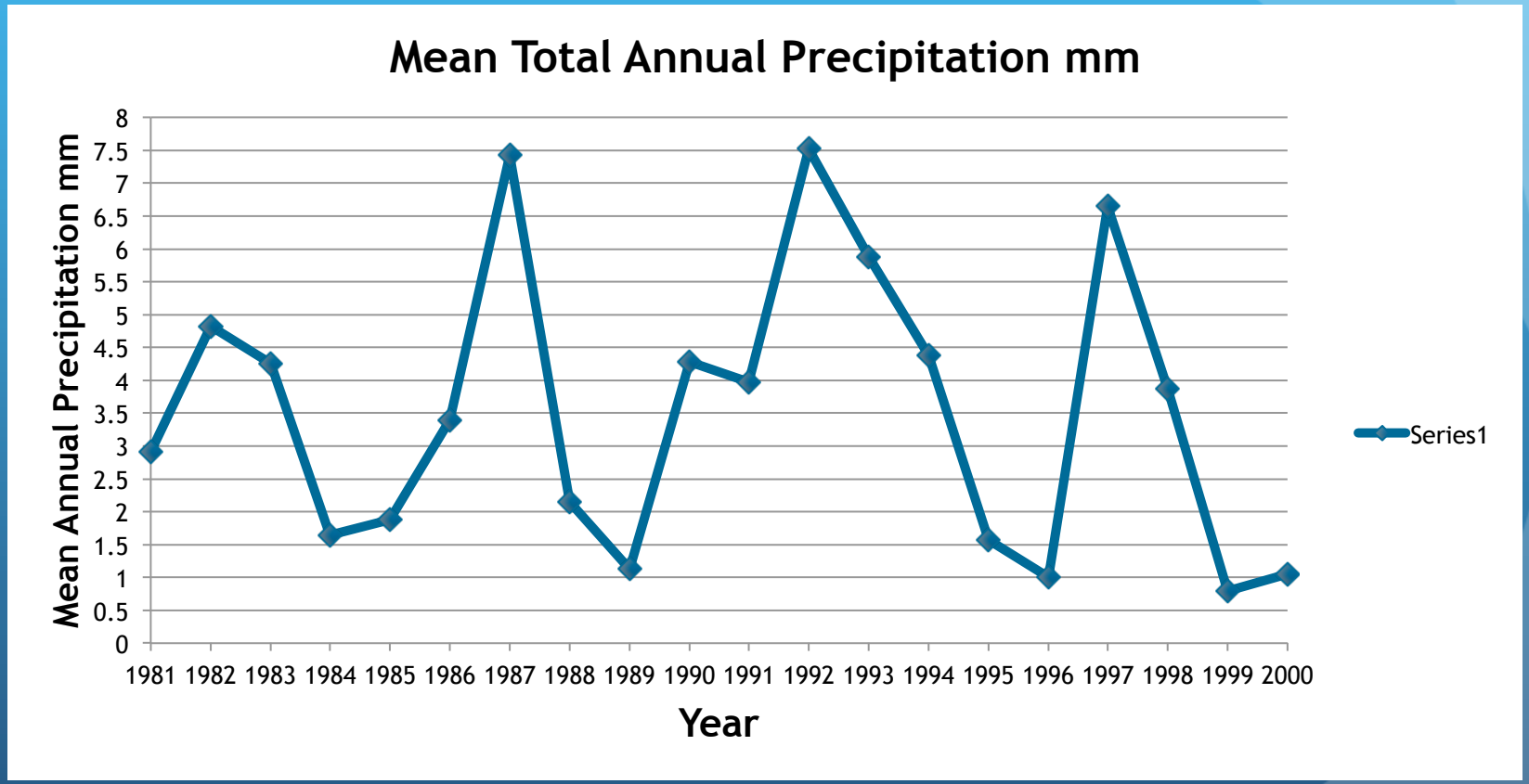
1. Click on Scale
2. Change Minimum value to **1981** (Year Tree was planted).
3. Change Maximum to **2000** (Year Tree was Harvested)
4. Change Major Unit to 1.
5. Press OK

Change Y Axis Minimum and Maximum Values



1. Click on Scale
2. Change Minimum value to unit to 1.
3. Change Maximum to 1.
4. Change Major Unit to 1.
5. Change the Minor Unit to 0.10
6. Press OK

Scattered Straight Marked Graph



Calculating Anomaly

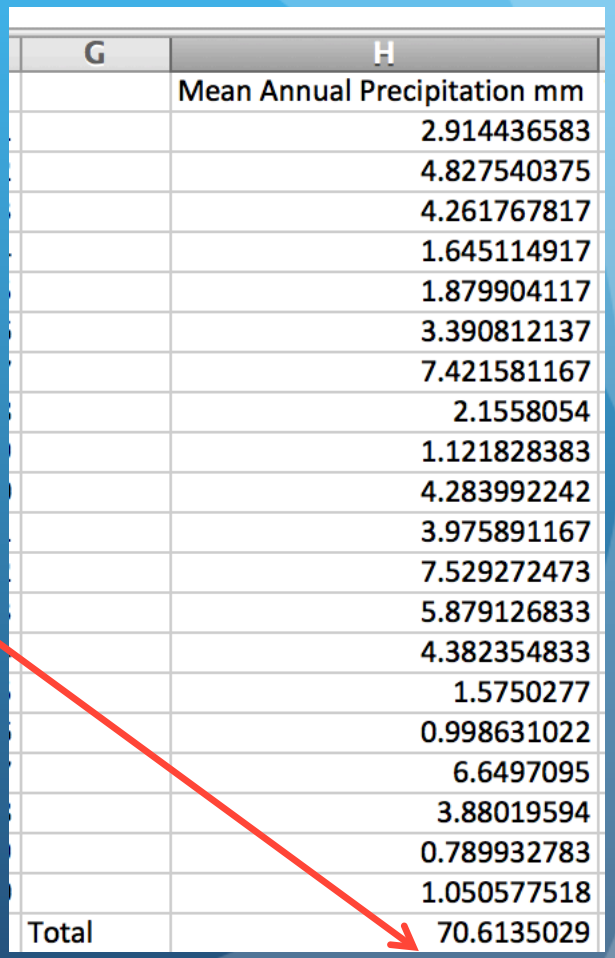
- The anomaly of data allows us to detect points of data that don't conform with the norm.
- For Example if for a few years the precipitation was bellow the historical average then these data points are considered out of the norm. This is very valuable in the analysis of climate variations and changes.

Calculate the Total Mean Annual Precipitation

How can the mean of the 20 years of precipitation data be calculated?

Calculating the Mean for 20 Years of Precipitation DATA

- Add all the Mean Annual Precipitation Data.
- Formula =SUM(H2:H21). The highlighting technique can be used. Type = S pick SUM from pop up screen and highlight all the values.
- Now you have the total of all of the 20 Annual Averages.
- Go to the column next to column H, Column i) and enter the formula to calculate the mean of the 20 Mean Annual Averages in cell i2.



G	H
	Mean Annual Precipitation mm
	2.914436583
	4.827540375
	4.261767817
	1.645114917
	1.879904117
	3.390812137
	7.421581167
	2.1558054
	1.121828383
	4.283992242
	3.975891167
	7.529272473
	5.879126833
	4.382354833
	1.5750277
	0.998631022
	6.6497095
	3.88019594
	0.789932783
	1.050577518
Total	70.6135029

Calculating the Mean for 20 Years of Precipitation DATA

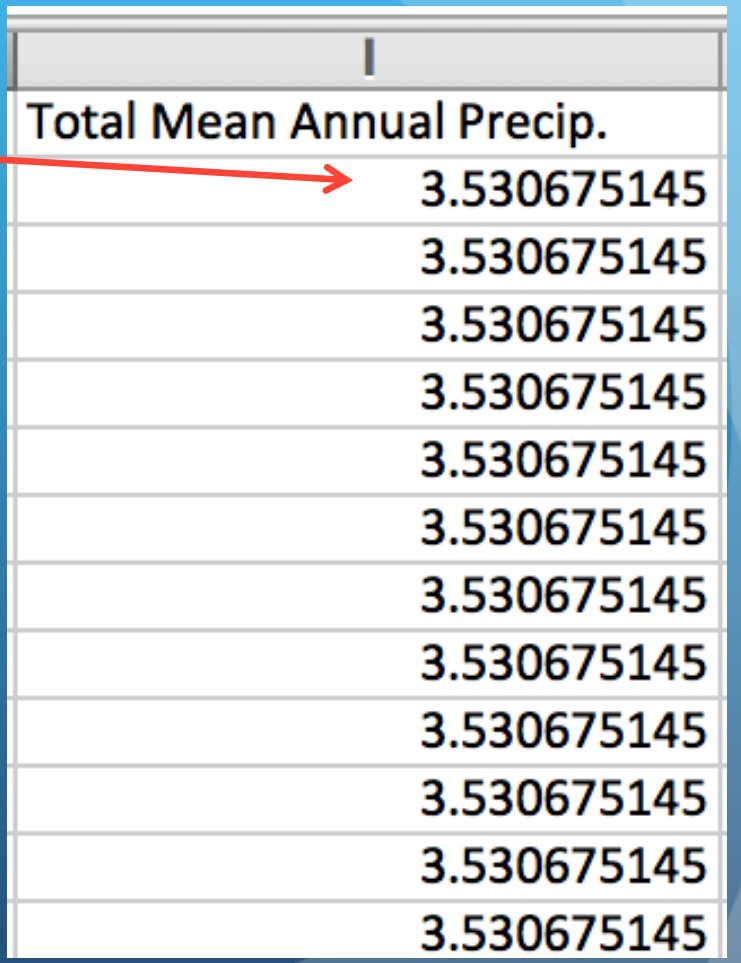
- Enter the formula in the new column in this case column i (keep in mind that the cell values may differ depending on the location of the data.
- Formula =SUM(H22/20)
- Cell H22 contain the Sum of the total averages.
- 20 is the amount of years.

G	H
	Mean Annual Precipitation mm
	2.914436583
	4.827540375
	4.261767817
	1.645114917
	1.879904117
	3.390812137
	7.421581167
	2.1558054
	1.121828383
	4.283992242
	3.975891167
	7.529272473
	5.879126833
	4.382354833
	1.5750277
	0.998631022
	6.6497095
	3.88019594
	0.789932783
	1.050577518
Total	70.6135029

H22 Cell The sum of all the annual averages

Calculating the Mean for 20 Years of Precipitation DATA

1. The =SUM(H22/20) gives you this value.
2. In order to calculate the anomaly 3.530675145 needs to be subtracted from each Annual Average.
3. To facilitate the process the Total Mean Annual Precipitation is copied 20 times.
4. To copy the number 20 times, Go To Edit press copy and then SPECIAL PASTE highlight all the cells that need to be copied.



I
Total Mean Annual Precip.
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145
3.530675145

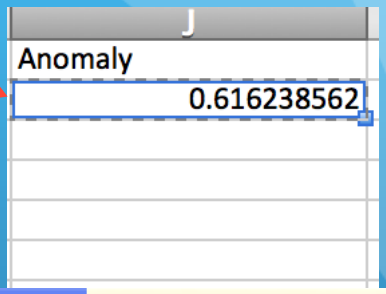
Calculate the Anomaly Per Year

- To calculate the anomaly the 3.530675145 (The Mean for the Total Annual Precipitation Averages) is subtracted from every annual average.

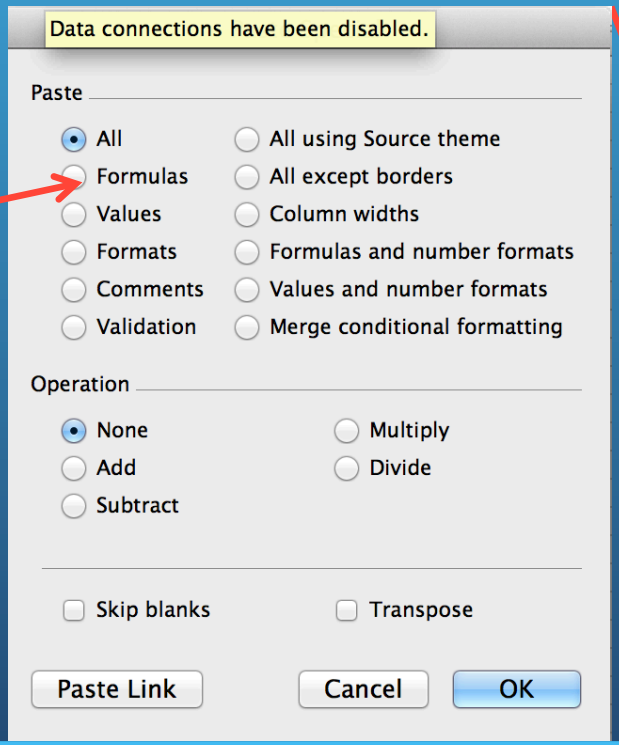
H	I	J
Mean Annual Precipitation mm	Total Mean Annual Precip.	Anomaly
2.914436583	3.530675145	0.616238562
4.827540375	3.530675145	-1.29686523
4.261767817	3.530675145	-0.731092671
1.645114917	3.530675145	1.885560229
1.879904117	3.530675145	1.650771029
3.390812137	3.530675145	0.139863009
7.421581167	3.530675145	-3.890906021
2.1558054	3.530675145	1.374869745
1.121828383	3.530675145	2.408846763
4.283992242	3.530675145	-0.753317096
3.975891167	3.530675145	-0.445216021
7.529272473	3.530675145	-3.998597327

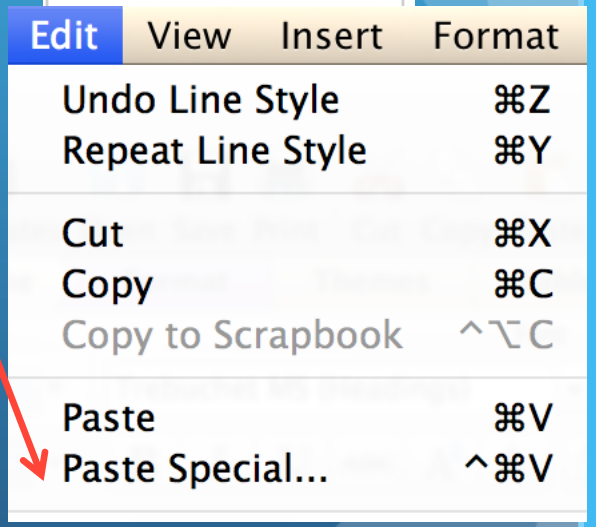
Copy and Special Paste to Calculate Anomalies

1. Place cursor on cell **i2** go to Edit and click Copy.
2. Go to Edit and click on Special Paste.



This window appears. Select **FORMULAS**



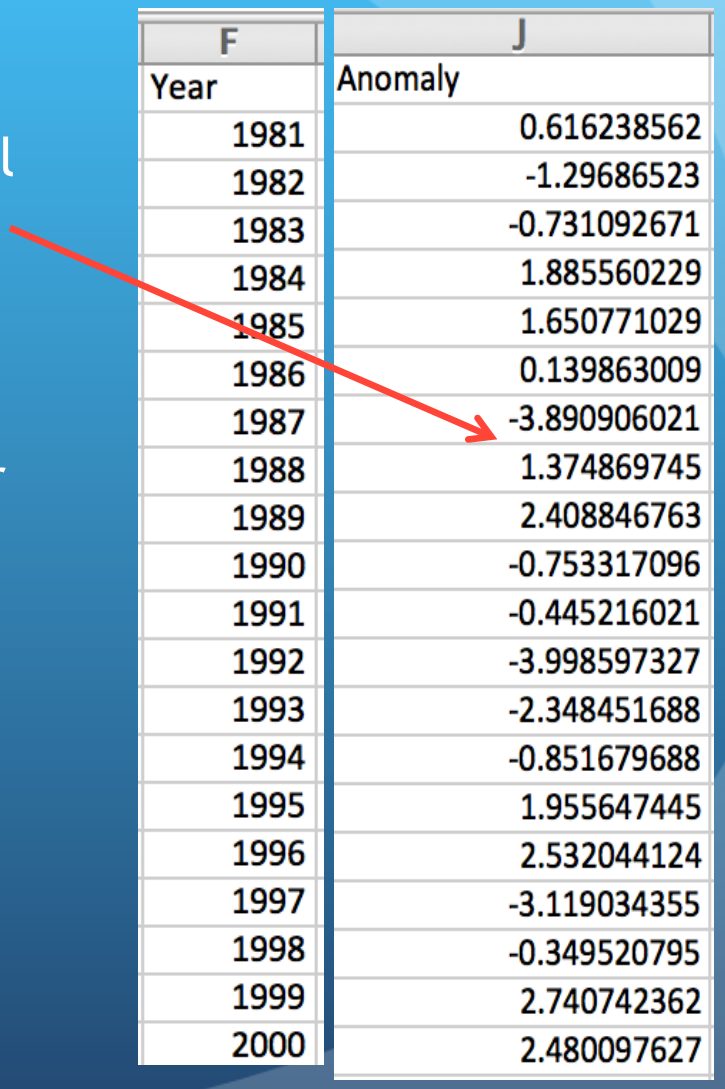


Calculate Anomalies Per Year and Graphing

Highlight all the 19 cells bellow cell 2 and press enter. All the anomaly values should appear.

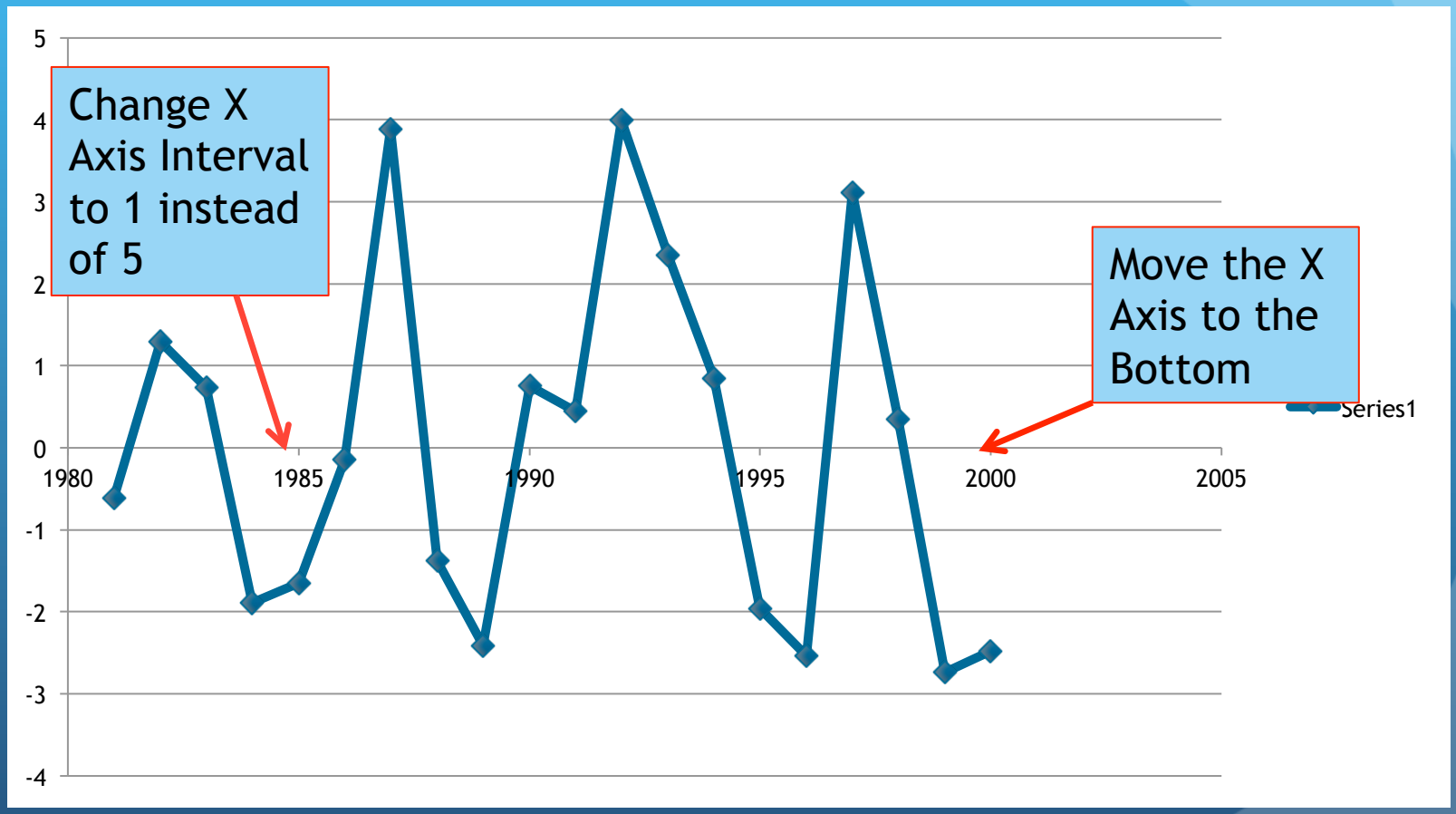
To Graph - highlight column YEAR first. Then press command (Mac) or Ctrl (PC) and while pressing the command or Crtl button down highlight the Anomaly Column.

Go to Charts and select Scattered, Straight Marked Scattered

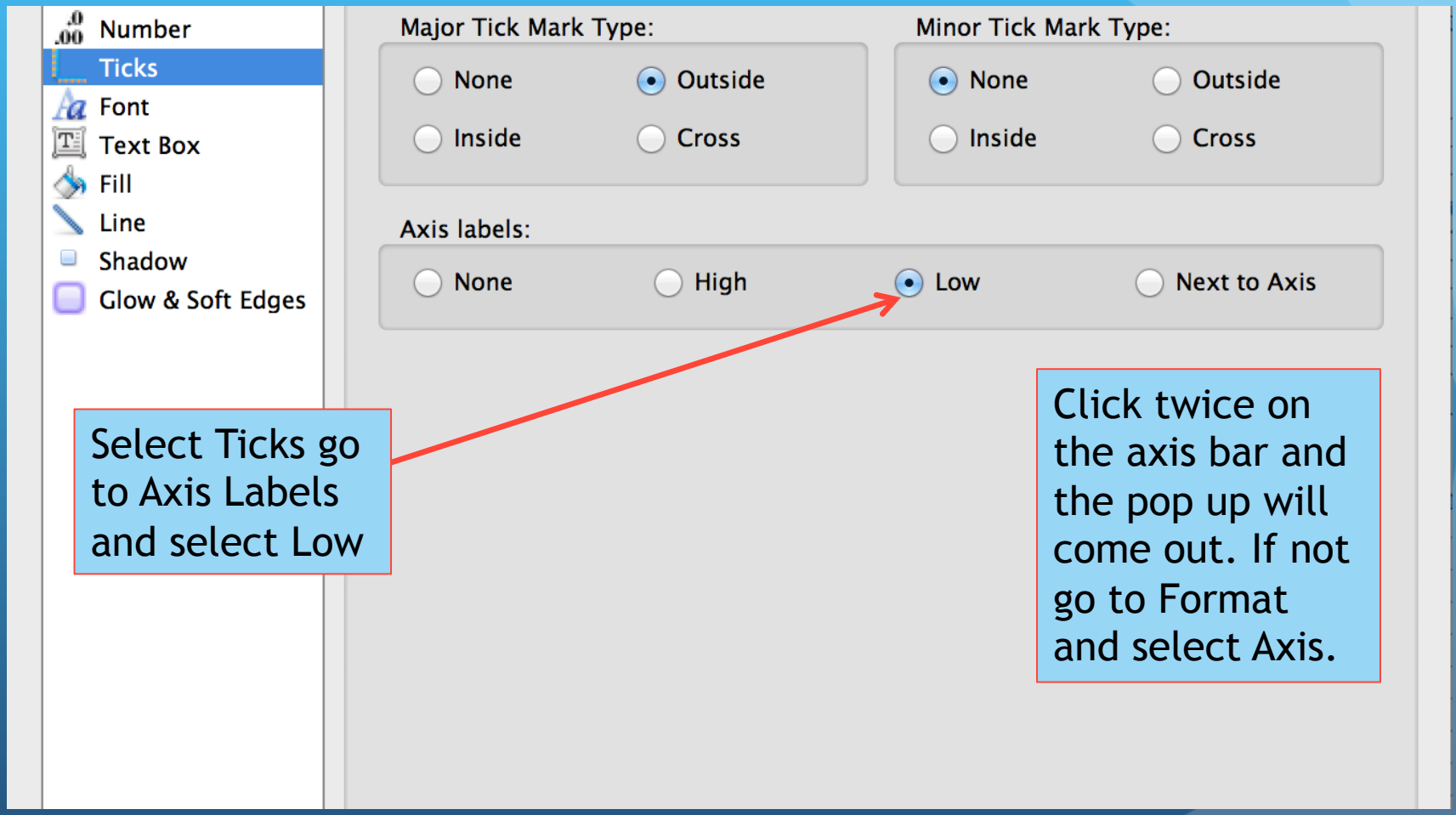


F	J
Year	Anomaly
1981	0.616238562
1982	-1.29686523
1983	-0.731092671
1984	1.885560229
1985	1.650771029
1986	0.139863009
1987	-3.890906021
1988	1.374869745
1989	2.408846763
1990	-0.753317096
1991	-0.445216021
1992	-3.998597327
1993	-2.348451688
1994	-0.851679688
1995	1.955647445
1996	2.532044124
1997	-3.119034355
1998	-0.349520795
1999	2.740742362
2000	2.480097627

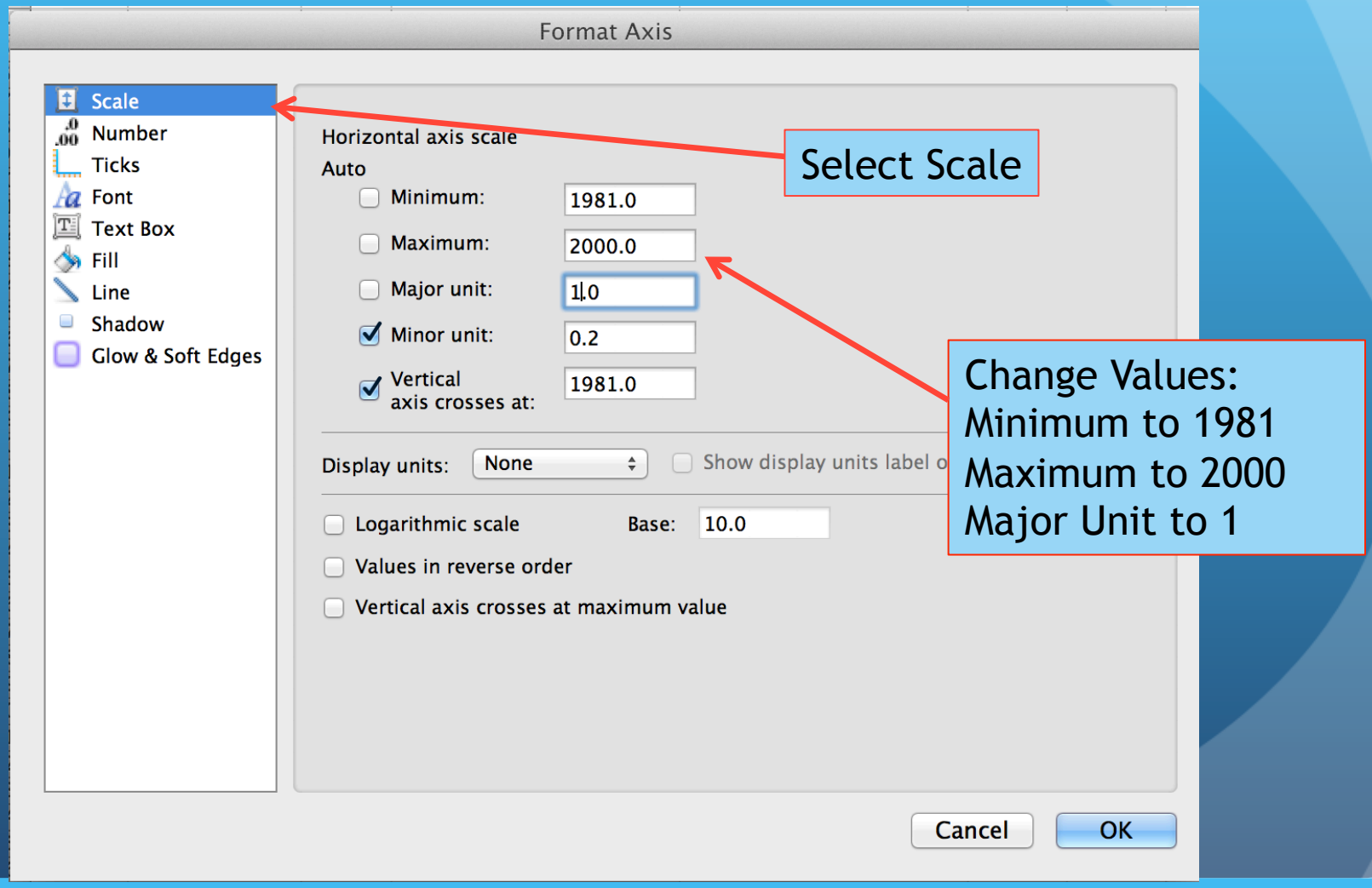
Changing Graphs Parameters



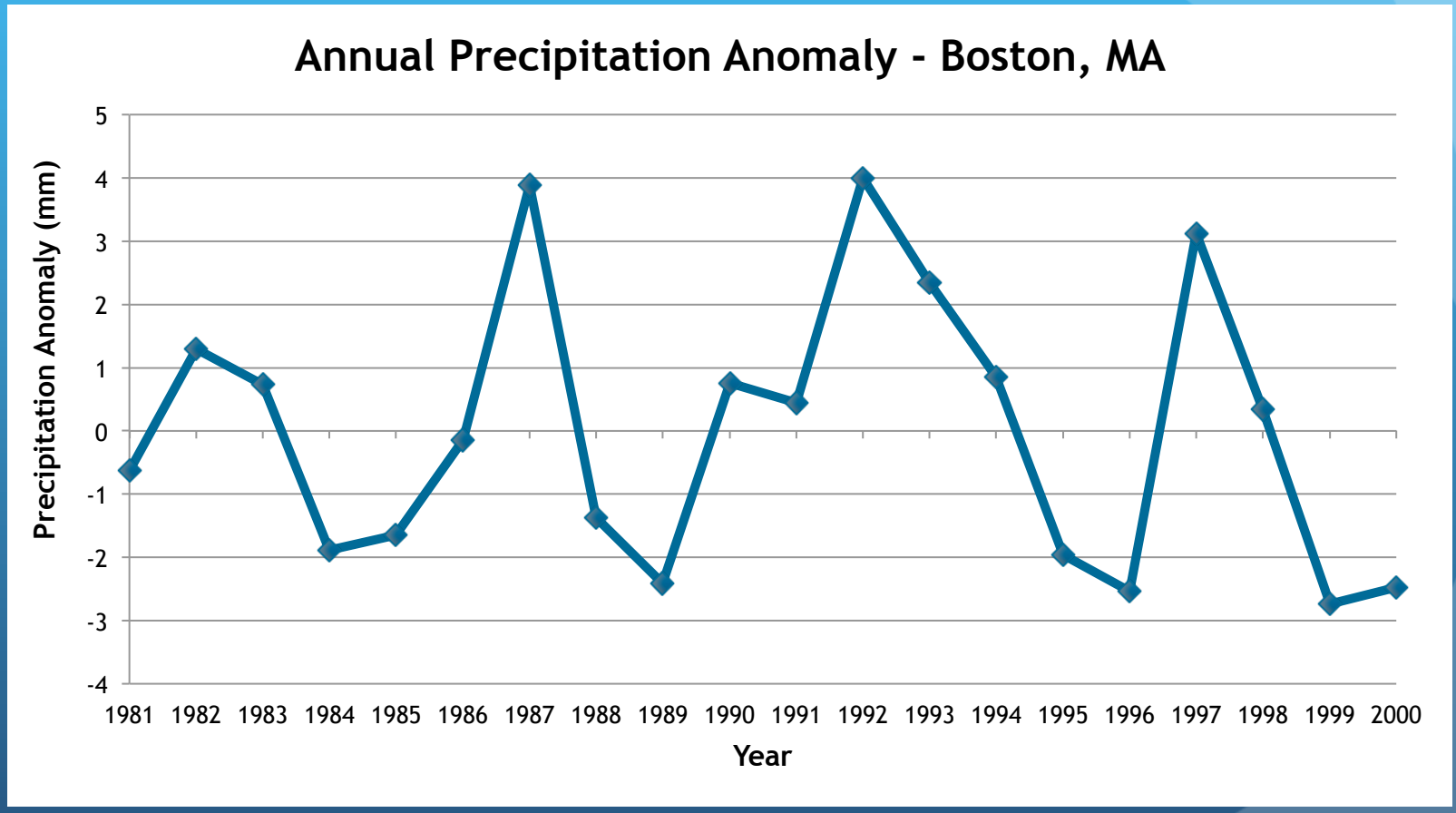
How to Lower the X Axis



Change Graph Parameters



Decadal Precipitation Anomaly Graph



Calculating Standard Deviation

To calculate the standard deviation there are several figures that will be needed:

1. Obtain the mean of the annual data for each year of your data set.

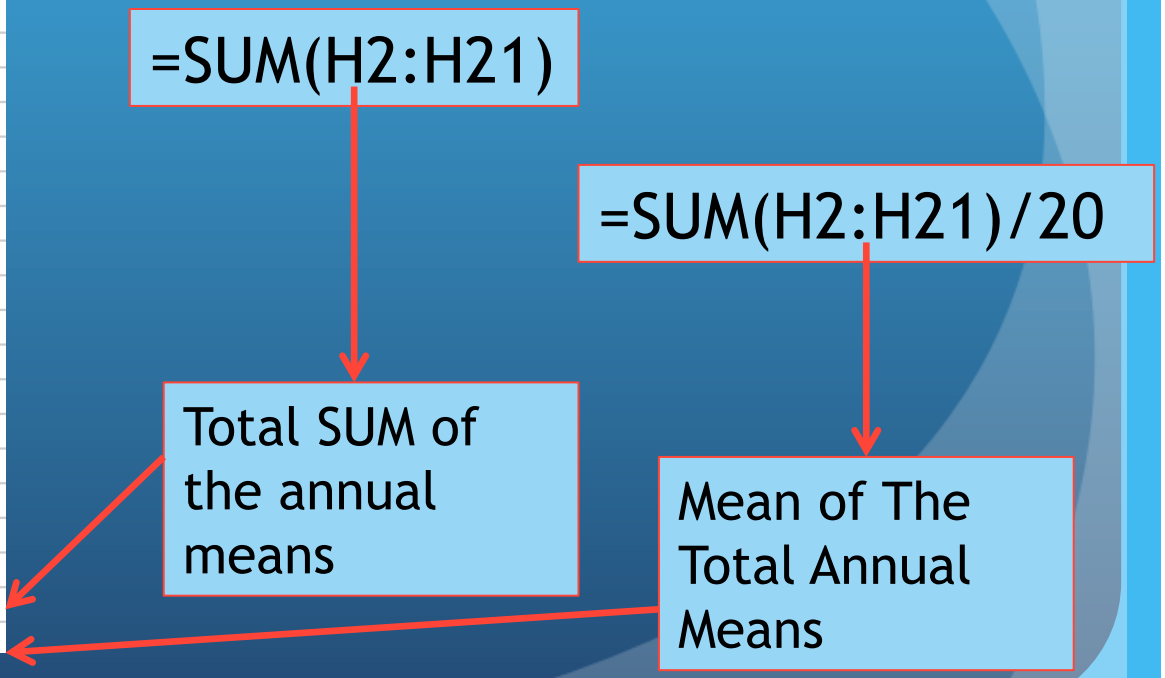
C	D	E
Year	Annual Precipitation	Mean Annual Precipitation mm
1981	34.973239	2.914436583
1982	57.9304845	4.827540375
1983	51.1412138	4.261767817
1984	19.741379	1.645114917
1985	22.5588494	1.879904117
1986	40.68974564	3.390812137
1987	89.058974	7.421581167
1988	25.8696648	2.1558054
1989	13.46194059	1.121828383
1990	51.4079069	4.283992242
1991	47.710694	3.975891167
1992	82.8219972	6.9018331
1993	70.549522	5.879126833
1994	52.588258	4.382354833
1995	18.9003324	1.5750277
1996	11.98357226	0.998631022
1997	89.058974	7.421581167
1998	25.8696648	2.1558054
1999	9.4791934	0.789932783
2000	9.45519766	0.787933138

The mean for each year of data

Calculating Standard Deviation

- Once the Mean for every year of data has been obtain the next step is to find the mean for the total of years of data.

F	G	H
Year		Mean Annual Precipitation mm
1981		2.914436583
1982		4.827540375
1983		4.261767817
1984		1.645114917
1985		1.879904117
1986		3.390812137
1987		7.421581167
1988		2.1558054
1989		1.121828383
1990		4.283992242
1991		3.975891167
1992		7.529272473
1993		5.879126833
1994		4.382354833
1995		1.5750277
1996		0.998631022
1997		6.6497095
1998		3.88019594
1999		0.789932783
2000		1.050577518
Total	Total	70.6135029
	Mean	3.530675145



Calculating Standard Deviation

- Subtract the Annual Total Mean from the mean for each year to find the variation from the mean.

I	J
Total Mean Annual Precip.	Anomaly
3.530675145	-0.616238562
3.530675145	1.29686523
3.530675145	0.731092671
3.530675145	-1.885560229
3.530675145	-1.650771029
3.530675145	-0.139863009
3.530675145	3.890906021
3.530675145	-1.374869745
3.530675145	-2.408846763
3.530675145	0.753317096
3.530675145	0.445216021
3.530675145	3.998597327
3.530675145	2.348451688
3.530675145	0.851679688
3.530675145	-1.955647445
3.530675145	-2.532044124
3.530675145	3.119034355
3.530675145	0.349520795
3.530675145	-2.740742362
3.530675145	-2.480097627

This figure tells us how much above or bellow the mean the Annual Precipitation mean is. This is called anomaly.

Calculating Standard Deviation

A	B	C
Year	Anomaly/Variation	Square of Variation
1981	-0.616238562	0.379749965
1982	1.29686523	1.681859424
1983	0.731092671	0.534496494
1984	-1.885560229	3.555337376
1985	-1.650771029	2.725044989
1986	-0.139863009	0.019561661
1987	3.890906021	15.13914967
1988	-1.374869745	1.890266816
1989	-2.408846763	5.802542726
1990	0.753317096	0.567486648
1991	0.445216021	0.198217306
1992	3.998597327	15.98878059
1993	2.348451688	5.515225331
1994	0.851679688	0.725358291
1995	-1.955647445	3.82455693
1996	-2.532044124	6.411247444
1997	3.119034355	9.728375306
1998	0.349520795	0.122164786
1999	-2.740742362	7.511668694
2000	-2.480097627	6.150884242
TOTAL		88.47197468

Next step: Square each anomaly value. Now all the numbers are positive.

=POWER(C2,2)

C2 = Cell of Number
2 = Power to raise the number

Add the Total of all the squared values

Standard Deviation

Next Step: Find the the mean of the square number.

=SUM(C23)/20-1

C	D
Square of Variation	
0.379749965	
1.681859424	
0.534496494	
3.555337376	
2.725044989	
0.019561661	
15.13914967	
1.890266816	
5.802542726	
0.567486648	
0.198217306	
15.98878059	
5.515225331	
0.725358291	
3.82455693	
6.411247444	
9.728375306	
0.122164786	
7.511668694	
6.150884242	
88.47197468	3.423598734

Divide the number by n - 1 as the denominator. Where n = is the number of years.

88.4719468 ÷ (n – 1) = 3.423598734

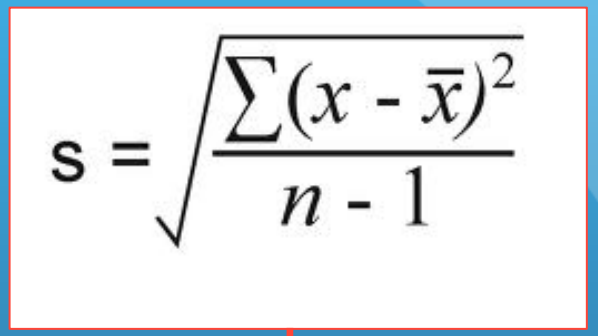
$$\frac{\Sigma(x - \bar{x})^2}{n - 1}$$

=SUM(C23)/20-1

Standard Deviation

Final Step: Take the Square Root of the mean of the variance.

x = Symbol of Mean (a bar over the X
Σ = SUM;
X = values;
n = number of values of data set



=SQRT(D23)