# 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 19<sup>th</sup> Century

## Ice Cores



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

# 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

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This is a diary of an 18<sup>th</sup> 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: <u>https://www3.epa.gov/climatechange//kids/documents/tree-rings.pdf</u>
- 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.
  - <u>The date the tree was harvested</u> (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/getUl.do or enter the URL or cut and past. The browser should open to a page that looks like the page bellow.

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MY NASA DATA Home Advanced Intermedia	ite Basic Climate Change Model Data		OPeNDAP (F-TDS) / THREDD
MY NASA DATA Live A	Access Server - Advanced		Help
Data Set Update Plot <	Print Animate Correlation Viewer Google Earth Show Values Export to Desktop Application Save As		_
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○ Longitude-time			
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# 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 <u>TIME.</u>
- 6. Go To <u>Start Date/Time</u> 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**

# Specify your data's requirements and then click "Save" to download.



#### "SAVE" to Download

- 1. Go to the <u>NetCDF</u> button and select <u>ASCII</u> (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 <u>Start date/time</u> and the End date/ time correspond to your data. Year your tree was born
  - starting in Jan. The End <u>date/time</u> the year and month it was harvested
- 3. Press the <u>SAVE</u> 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

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.

01-JAN-1981 00 3.061229

#### Importing DATA to Excel

- Open Excel
- Go to Mac <u>File</u> menu and select <u>Import</u> 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 <u>Text File</u> then click <u>Import</u>



#### 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

	Text Import Wizard – Step 1 of 3								
	The Text Wizard has determined that your data is Fixed Width.								
Delimited									
	If this is correct, choose Next, or choose the Data Type that best describes your data.								
	Original data type								
	Choose the file type that best describes your data:								
	Delimited - Characters such as commas or tabs separate each field.								
	Fixed width – Fields are aligned in columns with spaces between each field.								
	Start import at row: 1 🗍 🗘 File origin: Macintosh 💠								
	Preview of file Global Land and Ocean Temperature Anomalies 1880 201								
	1 Global Land and Ocean Temperature Anomalies January-December								
	ZUnits: Degrees Celsius 3 Base Period: 1901-2000								
	4 Missing: -999.0000 5 Year, Value								
	<u>6</u> 1880, -0.13								
	Cancel < Back Next > Finish								

## Select Delimiters on Text Import Wizard

Check (select) Tab, Space and Comma.

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

Delimiters				Treat consecutive delimiters as one
🗹 Tab	🗌 Semic	olon 🗹 🗹	Comma	Text qualifier: " +
Space	Other	•	<b>n</b>	
Select Ta	ab, Spac	e,		Select Treat consecutive delimiters as one
Data previe	w			
Global Units: Base Missing: Year 1880	Land Degrees Period: -999.0000 Value -0.13	and Oc Celsius 1901-2000	ean Tempe	erature Anomalies January-December

## 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 =\$A\$1 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 I	В	С	D							
	VARIABLE	:	Average	1 A	3	С				
	DATA	SET	:		VARIABLE	:	Average		В	C
1	FILENAME	:	precip.mon.mear		DATA	SET	:	1-Jan-81	0	5.061229
	<b>ΕΙΙ ΕΡΔΤΗ</b>	•	/usr/local/fer_da		FILENAME	:	precip.mon.m	1-Feb-81	0	7 090249
			, usi/iocal/ici_uu		FILEPATH	•	/usr/local/fer	1-Mar-81	0	1 715737
	BAD	FLAG	•		BAD	FLAG		1-Api-81	0	1 67308
	SUBSET	:					•	1-lup-81	0	1 633972
	LONGITUDE:	178.8E		_	SUBSET	:		1-Jul-81	0	1 917902
	LATITUDE	:	1.3S		LONGITUDE:	178.8E		1-Jui-81	0	0.5376872
	178.8E				LATITUDE	:	1.3S	1-Sep-81	0	1 697158
1-lan-81	0	3 061229			178.8E			1-Sep-81	0	0.9510698
1 Juli 01	0	5.001225		1-Jan-81	0	3.061229		1-Nov-81	0	1 054505
1-FeD-01	0	5.547569		1-Feb-81	0	5.547589		1-NOV-01	0	5.094062
1-Mar-81	0	7.089248		1-Mar-81	0	7 089248		1-Jan-82	0	0.6225085
1-Apr-81	0	4.715737		1 Apr 01	0	1.005240		1-Jan-82	0	2 96147
1-May-81	0	1.67308		1-Apr-61	0	4./15/5/		1-Mar-82	0	2.50147
1-Jun-81	0	1.633972		1-May-81	0	1.67308		1-Δnr-82	0	2 357666
1-Jul-81	0	1 91 7902		1-Jun-81	0	1.633972		1-May-82	0	1 467611
1 Aug 81	0	0 5276972		1-Jul-81	0	1.917902		1-lun-82	0	2.418841
1-Aug-01	0	0.5570872		1-Aug-81	0	0.5376872		1-Jul-82	0	6.253074
1-Sep-81	0	1.69/158		1-Sep-81	0	1.697158		1-Aug-82	0	7.501373
1-Oct-81	0	0.9510698		1-Oct-81	0	0.9510698		1-Sep-82	0	4.010446
1 Nov 01	^	1 05 4505		1 000 01	J	5.5510550		1 000 02	Ű	1.010110

## DATA ANALYSIS - Average Annual Precipitation - Graph

Α	В	
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 <u>Date</u> and B Column <u>Precipitation mm</u> (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 <u>SUM</u>.

Security Warning Data connections have been disabled.						
SUM	🗧 😣 📀	(= fx	=SUM	SUM		
Α	В	С	D	Functions		
Date	Percipitation mm	Year		SEARCH		
1/1/81	3.061229	1981	=SUM	SECOND		
2/1/81	5.547589	1982		SERIESSUM		
3/1/81	7.089248	1983		SIGN		
4/1/81	4.715737	1984		SIN		
5/1/81	1.67308	1985		SINH		
6/1/81	1.633972	1986		SKEW		
7/1/81	1.917902	1987		SLN		
8/1/81	0.5376872	1988		SLOPE		
9/1/81	1.697158	1989		SMALL		
10/1/81	0.9510698	1990		SORT		
11/1/81	1.054505	1991		SORTPI		
12/1/81	5.094062	1992		STANDARDIZE		
1/1/82	0.6225085	1993	R	STDEV.P		
2/1/82	2.96147	1994		STDEV.S		
3/1/82	2.642316	1995		STDEVA		
4/1/82	2.357666	1996		STDEVPA		
5/1/82	1.467611	1997		CTEVY		
6/1/82	2.418841	1998	lict \	Voars in		
7/1/82	6.253074	1999	LISC			
8/1/82	7.501373	2000	Colu	mn C		
9/1/82	4.010446		Cota			

## 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.

SUM	÷	8	S	) (e.	fx	=	SUM( <mark>B</mark> 2	2:B13)		
A		В		(	С		D	E		F
Date	Percipita	ation m	m	Year						
1/1/81		3.0612	229		1981	=S	UM( <mark>B2:</mark>	313)		
2/1/81		5.5475	589		1982	S	UM(num	<b>ber1</b> , [nu	ım	be
3/1/81		7.0892	248		1983			, .	-	_
4/1/81		4.7157	737		1984					
5/1/81		1.673	808		1985					
6/1/81		1.6339	972		1986			1. 1.		
7/1/81		1.9179	902		1987		High	light		
8/1/81		0.53768	372		1988		data	for		
9/1/81		1.6971	L <b>58</b>		1989		the	1001		
10/1/81		0.95106	5 <mark>98</mark>		1990		the	1901		
11/1/81		1.0545	505		1991		year	•		
12/1/81		5.0940	)62 <mark>.</mark>		1992		·			
1/1/82		0.62250	)85		1993					
2/1/82		2.961	L <b>47</b>		1994					
3/1/82		2.6423	816		1995					
4/1/82		2.3576	666		1996					
5/1/82		1.4676	511		1997					
6/1/82		2.4188	341		1998					
7/1/82		6.2530	)74		1999					
8/1/82		7.5013	373		2000					

## **Total Annual Precipitation**

D3	17 8 V	(= Jx						
Α	В	С	D		Calculato			
Date	Percipitation mm	Year			Calculate		С	D
1/1/81	3.061229	1981	34.97324		Annual		Year	Annual Precipitation
2/1/81	5.547589	1982			Precipitatio	n	1981	34.973239
3/1/81	7.089248	1983			for or child		1982	57.9304845
4/1/81	4.715737	1984			for each ye	ar in	1983	51.1412138
5/1/81	1.67308	1985			all cells unt	cil 🛛	1984	19.741379
6/1/81	1.633972	1986			the year 20	00	1985	22.5588494
7/1/81	1.917902	1987			the year 20	00.	1980	40.08974304
8/1/81	0.5376872	1988					1000	25 8606648
9/1/81	1,697158	1989					1980	13 46194059
10/1/81	0.9510698	1990					1990	51 4079069
11/1/81	1 054505	1991					1991	47,710694
12/1/81	5 094062	1992					1992	82.8219972
1/1/82	0 6225085	1992					1993	70.549522
2/1/82	2 961/17	100/					1994	52.588258
2/1/02	2.50147	1005					1995	18.9003324
3/1/02	2.042310	1995		Tot	leuran le		1996	11.98357226
4/1/0Z	2.337000	1990			at Annuat		1997	89.058974
5/1/82	1.40/011	1997		Pre	cipitation		1998	25.8696648
0/1/82	2.418841	1998		for	each vear.		1999	9.4791934
//1/82	6.253074	1999			cuen yeun		2000	9.45519766
8/1/82	7.501373	2000						

### **Graph Annual Precipitation**

- Highlight the data for both columns - the <u>Date</u> column and the <u>Annual</u> <u>Precipitation</u> column.
- 2. Go to Insert select Chart.
- 3. Select Line then selected Market Line.

С	D	
Year	Annual Precipitation	١
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	Γ
1990	51.4079069	Γ
1991	47.710694	Γ
1992	82.8219972	Γ
1993	70.549522	Γ
1994	52.588258	Γ
1995	18.9003324	Γ
1996	11.98357226	Γ
1997	89.058974	
1998	25.8696648	
1999	9.4791934	
2000	9.45519766	Γ

## 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 =  $\sum X$ n  $\sum Z = SUM;$  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



## 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

	Format Axis
<ul> <li>Scale</li> <li>Number</li> <li>Ticks</li> <li>Font</li> <li>Text Box</li> <li>Fill</li> <li>Line</li> <li>Shadow</li> <li>Glow &amp; Soft Edges</li> </ul>	Horizontal axis scale   Auto   Minimum: 1981.0   Major unit: 1.0   Major unit: 0.2   ✓ Minor unit: 0.2   ✓ Vertical axis crosses at:   Display units: None
	Cancel OK

- 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

	Format Axis
<ul> <li>Scale</li> <li>Number</li> <li>Ticks</li> <li>Font</li> <li>Text Box</li> <li>Fill</li> <li>Line</li> <li>Shadow</li> <li>Glow &amp; Soft Edges</li> </ul>	Vertical axis scale   Auto    Minimum:     Maximum:     Major unit:     Major unit:     Minor unit:     Minor unit:     Minor unit:     Minor unit:     Minor unit:     Minor unit:     Mais crosses at:       Display units: None   None    Show display units label on chart   Logarithmic scale   Base: 10.0    Values in reverse order   Horizontal axis crosses at maximum value
	Cancel OK

1. Click on Scale

- 2. Change Minimum value to unit to 1.
- 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	Н
	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		Н
		Μ	ean Annual Precipitation mm
			2.914436583
			4.827540375
			4.261767817
			1.645114917
			1.879904117
			3.390812137
			7.421581167
			2.1558054
			1.121828383
			4.283992242
H.	ZZ Cell		3.975891167
ΤI	ne sum		7.529272473
_	E all tha		5.879126833
0I	all the		4.382354833
ar	nnual		1.5750277
ວເ	orados		0.998631022
<u>a</u>	relages		6.6497095
			3.88019594
			0.789932783
			1.050577518
	Total		70.6135029

## 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.

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

#### 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		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.

	Data connections	have been disabled.	Edit	V
This window	Paste	<ul> <li>All using Source theme</li> <li>All except borders</li> </ul>	Un Re	ido pea
appears. Select FORMULAS	<ul> <li>Values</li> <li>Formats</li> <li>Comments</li> <li>Validation</li> </ul>	<ul> <li>Column widths</li> <li>Formulas and number formats</li> <li>Values and number formats</li> <li>Merge conditional formatting</li> </ul>	Cu Co Co	it py py
	Operation None Add Subtract	<ul><li>Multiply</li><li>Divide</li></ul>	Pa: Pa:	ste ste
	Skip blanks Paste Link	Cancel OK		

E	dit	View	Insert	Format
	Uno Rep	lo Line eat Lin	Style e Style	業Z 業Y
	Cut			жх
	Cop	ру		ЖC
	Cop	by to Sc	rapbook	~\C
	Pas	te		жv
Y	Pas	te Spec	ial	^ <b>%</b> V

0.616238562

Anomaly

# 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

.00 Number	Major Tick Mark Type:		Minor Tick Ma	Minor Tick Mark Type:			
Ticks A Font Text Box Fill	<ul><li>None</li><li>Inside</li></ul>	<ul><li>Outside</li><li>Cross</li></ul>	<ul><li>None</li><li>Inside</li></ul>	<ul><li>Outside</li><li>Cross</li></ul>			
🔪 Line	Axis labels:						
Shadow Glow & Soft Edges	O None	🔵 High	• Low	Next to Axis			
Select Ticks g to Axis Labels and select Lo	30 5 W		t t g a	Click twice on he axis bar and he pop up will come out. If not to Format and select Axis.			

## **Change Graph Parameters**

	Format Axis		
<ul> <li>Scale</li> <li>Number</li> <li>Ticks</li> <li>Font</li> <li>Text Box</li> <li>Fill</li> <li>Line</li> <li>Shadow</li> <li>Glow &amp; Soft Edges</li> </ul>	Horizontal axis scale   Auto   Minimum:   1981.0   Major unit:   10   Minor unit:   0.2   Vertical   axis crosses at:   Display units:   None   Show display units label o   Logarithmic scale	cale Change Value Minimum to Maximum to Maximum to Major Unit to	es: 1981 2000 5 1
	<ul> <li>Values in reverse order</li> <li>Vertical axis crosses at maximum value</li> </ul>	Cancel OK	

## Decadal Precipitation Anomaly Graph



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.

The mean for

each year of

data

С	D	<u> </u>	
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	1.879904	
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	

 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	Н								
Year		Mean Annual Precipitation mm								
1981		2.914436583								
1982		4.827540375								
1983		4.261767817								
1984		1.645114917	[				]			
1985		1.879904117			<b>(H</b>	2·H21)				
1986		3.390812137		-50M	<b>'</b> '	<b>Z</b> •••• <b>Z</b> ••				
1987		7.421581167								
1988		2.1558054								
1989		1.121828383					с –			$\mathbf{a}$
1990		4.283992242					= 5	UM(HZ	:HZI)//	ZU
1991		3.975891167					L	<u> </u>	,	_
1992		7.529272473								
1993		5.879126833								
1994		4.382354833								
1995		1.5750277		<b>T</b> ( )	CI	1AA . C				
1996		0.998631022		Iotal	SU	JM OT				
1997		6.6497095				امير			·	
1998		3.88019594		the a	nn	ual		Mean o	f The	
1999		0.789932783		moor						
2000		1.050577518		mear	12			lotal Ar	าทนลไ	
Total	Total	70.6135029								
	Mean	3.530675145	<u></u>					means		

• 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.

1 <b>A</b>	В	С
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



squared values

### **Standard Deviation**

		Next Step:	: F1n	d the the mean	
=SUM(C23)/20-	·1				
С	D	i of the squ	are r	number.	
Square of Variation					
0.379749965					
1.681859424					
0.534496494				$\sum (\mathbf{y} - \mathbf{y})^2$	
3.555337376	Di	vide the number			
2.725044989	h	up 1 ac tha			
0.019561661	Dy	n - i as the		n - 1	
15.13914967	de	nominator.			
1.890266816					
5.802542726	W	here n = is the			
0.567486648	nı	imber of vears			
0.198217306		inder of years.		$-SUM(C23)/20_1$	
15.98878059				$-301 (CZ3) / Z0^{-1}$	
5.515225331					
0.725358291		. 🔸			
3.82455693					
6.411247444		88.4/19468 ÷ (n - 1)	=		
9.728375306		3.423598734			
0.122164786					
7.511668694					
6.150884242					
88.47197468	3.423598734				
## **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

$$s = \sqrt{\frac{\sum (x - \overline{x})^2}{n - 1}}$$

