Product 1

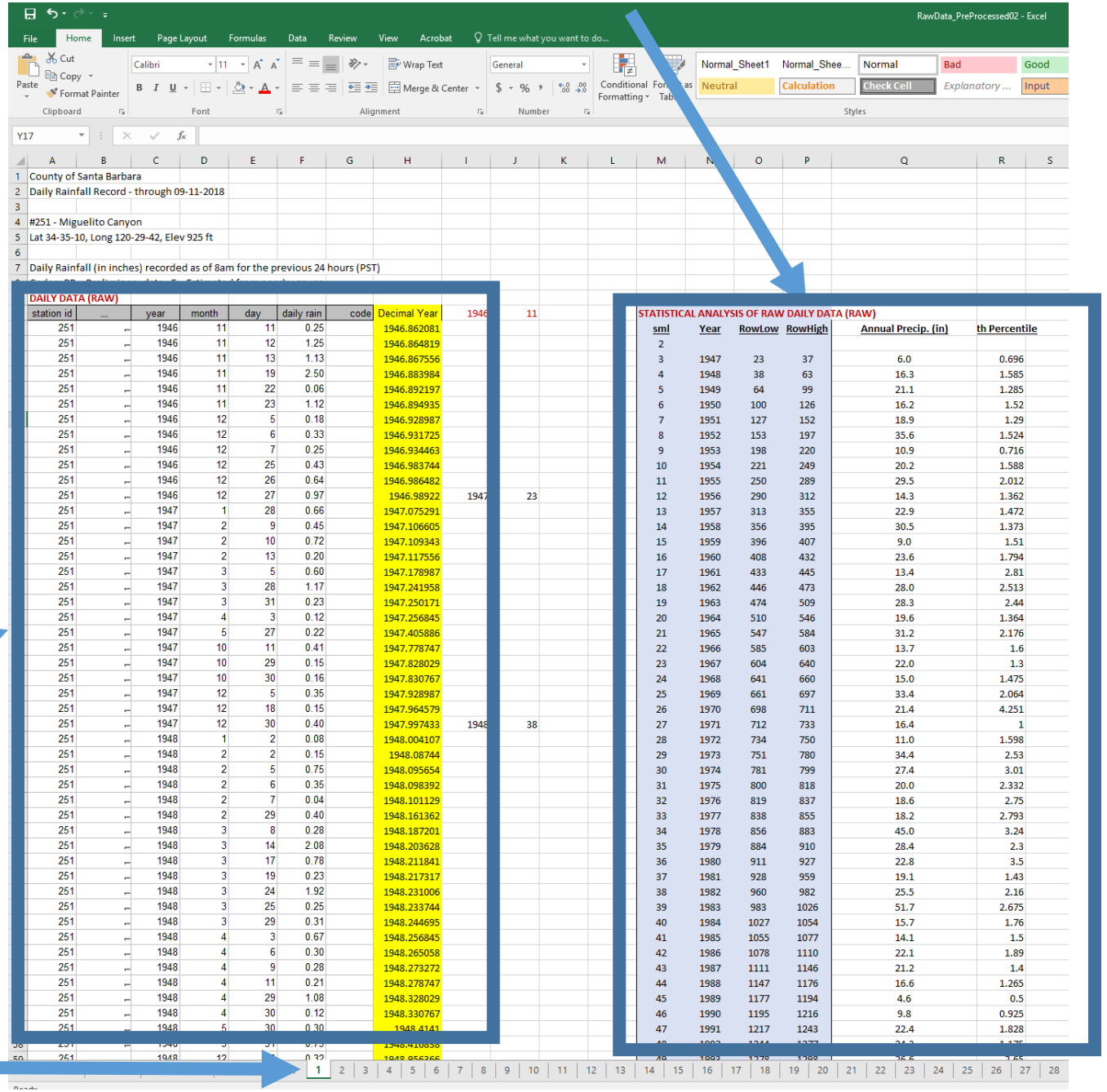
Product 1 [5 marks, total]: Analyze the precipitation dataset and create a map of long-term mean annual precipitation. Ensure a legend is included on your map, and that you specify the units of measurement [3 marks for correct results; 2 marks for map presentation quality].

Each tab contains daily (left columns) and annual (right columns) precipitation data

Annual rainfall data for one station

Daily rainfall data for one station

Each tab number is one station



County of Santa Barbara
Daily Rainfall Record - through 09-11-2018

#251 - Miguelito Canyon
Lat 34-35-10, Long 120-29-42, Elev 925 ft

Daily Rainfall (in inches) recorded as of 8am for the previous 24 hours (PST)

DAILY DATA (RAW)

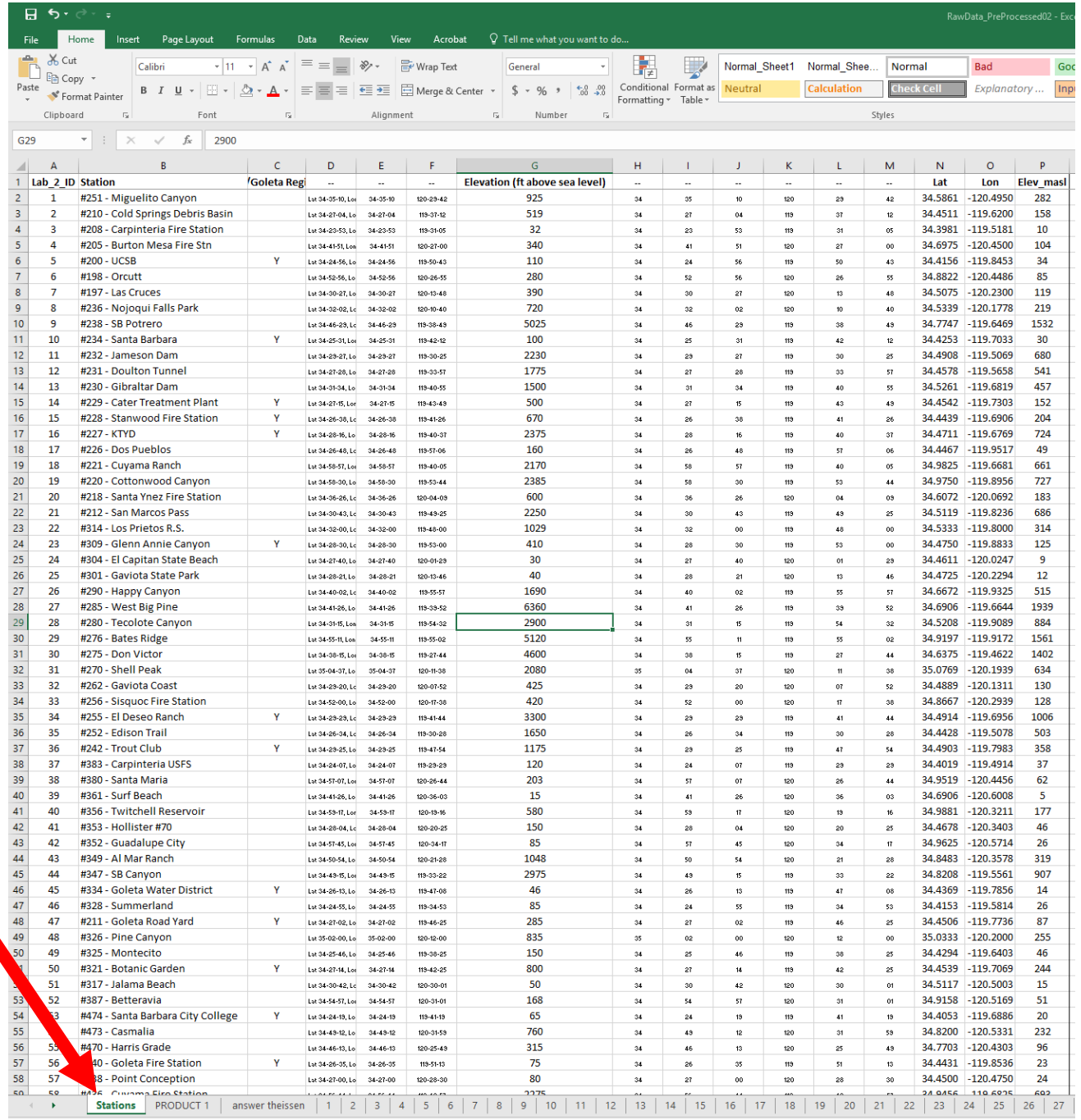
station id	....	year	month	day	daily rain	code	Decimal Year		
251	...	1946	11	11	0.25		1946.862081	1946	11
251	...	1946	11	12	1.25		1946.864819		
251	...	1946	11	13	1.13		1946.867556		
251	...	1946	11	19	2.50		1946.883984		
251	...	1946	11	22	0.06		1946.892197		
251	...	1946	11	23	1.12		1946.894935		
251	...	1946	12	5	0.18		1946.928987		
251	...	1946	12	6	0.33		1946.931725		
251	...	1946	12	7	0.25		1946.934463		
251	...	1946	12	25	0.43		1946.983744		
251	...	1946	12	26	0.64		1946.986482		
251	...	1946	12	27	0.97		1946.98922	1947	23
251	...	1947	1	28	0.66		1947.075291		
251	...	1947	2	9	0.45		1947.106605		
251	...	1947	2	10	0.72		1947.109343		
251	...	1947	2	13	0.20		1947.117556		
251	...	1947	3	5	0.60		1947.178987		
251	...	1947	3	28	1.17		1947.241958		
251	...	1947	3	31	0.23		1947.250171		
251	...	1947	4	3	0.12		1947.256845		
251	...	1947	5	27	0.22		1947.405886		
251	...	1947	10	11	0.41		1947.778747		
251	...	1947	10	29	0.15		1947.828029		
251	...	1947	10	30	0.16		1947.830767		
251	...	1947	12	5	0.35		1947.928987		
251	...	1947	12	18	0.15		1947.964579		
251	...	1947	12	30	0.40		1947.997433	1948	38
251	...	1948	1	2	0.08		1948.004107		
251	...	1948	2	2	0.15		1948.08744		
251	...	1948	2	5	0.75		1948.095654		
251	...	1948	2	6	0.35		1948.098392		
251	...	1948	2	7	0.04		1948.101129		
251	...	1948	2	29	0.40		1948.161362		
251	...	1948	3	8	0.28		1948.187201		
251	...	1948	3	14	2.08		1948.203628		
251	...	1948	3	17	0.78		1948.211841		
251	...	1948	3	19	0.23		1948.217317		
251	...	1948	3	24	1.92		1948.231006		
251	...	1948	3	25	0.25		1948.233744		
251	...	1948	3	29	0.31		1948.244695		
251	...	1948	4	3	0.67		1948.256845		
251	...	1948	4	6	0.30		1948.265058		
251	...	1948	4	9	0.28		1948.273272		
251	...	1948	4	11	0.21		1948.278747		
251	...	1948	4	29	1.08		1948.328029		
251	...	1948	4	30	0.12		1948.330767		
251	...	1948	5	30	0.30		1948.4141		

STATISTICAL ANALYSIS OF RAW DAILY DATA (RAW)

sml	Year	RowLow	RowHigh	Annual Precip. (in)	th Percentile
2					
3	1947	23	37	6.0	0.696
4	1948	38	63	16.3	1.585
5	1949	64	99	21.1	1.285
6	1950	100	126	16.2	1.52
7	1951	127	152	18.9	1.29
8	1952	153	197	35.6	1.524
9	1953	198	220	10.9	0.716
10	1954	221	249	20.2	1.588
11	1955	250	289	29.5	2.012
12	1956	290	312	14.3	1.362
13	1957	313	355	22.9	1.472
14	1958	356	395	30.5	1.373
15	1959	396	407	9.0	1.51
16	1960	408	432	23.6	1.794
17	1961	433	445	13.4	2.81
18	1962	446	473	28.0	2.513
19	1963	474	509	28.3	2.44
20	1964	510	546	19.6	1.364
21	1965	547	584	31.2	2.176
22	1966	585	603	13.7	1.6
23	1967	604	640	22.0	1.3
24	1968	641	660	15.0	1.475
25	1969	661	697	33.4	2.064
26	1970	698	711	21.4	4.251
27	1971	712	733	16.4	1
28	1972	734	750	11.0	1.598
29	1973	751	780	34.4	2.53
30	1974	781	799	27.4	3.01
31	1975	800	818	20.0	2.332
32	1976	819	837	18.6	2.75
33	1977	838	855	18.2	2.793
34	1978	856	883	45.0	3.24
35	1979	884	910	28.4	2.3
36	1980	911	927	22.8	3.5
37	1981	928	959	19.1	1.43
38	1982	960	982	25.5	2.16
39	1983	983	1026	51.7	2.675
40	1984	1027	1054	15.7	1.76
41	1985	1055	1077	14.1	1.5
42	1986	1078	1110	22.1	1.89
43	1987	1111	1146	21.2	1.4
44	1988	1147	1176	16.6	1.265
45	1989	1177	1194	4.6	0.5
46	1990	1195	1216	9.8	0.925
47	1991	1217	1243	22.4	1.828

Familiarize yourself with the columns in each of the numbered tabs

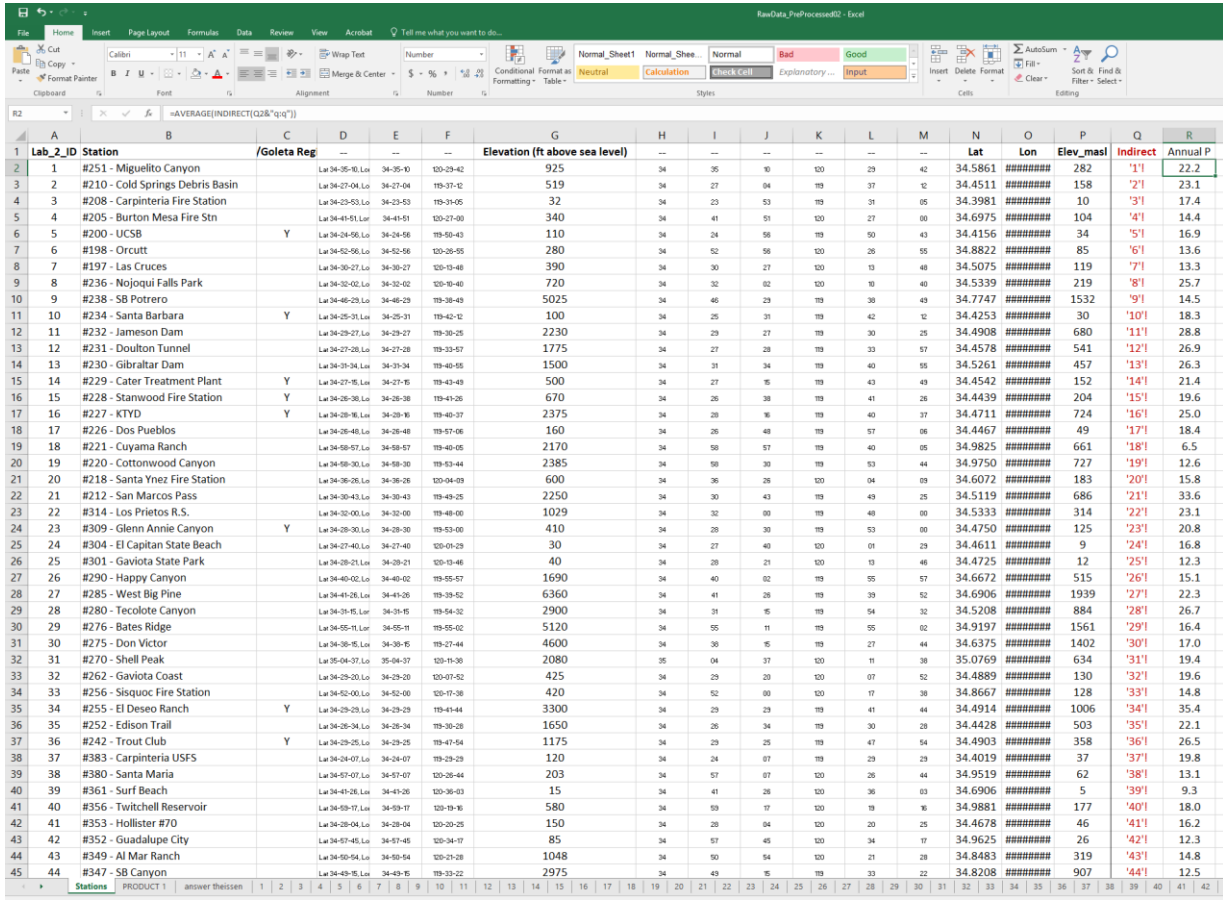
- Then, go to the tab entitled “Stations”
- Each row represents one station. The “Lab_2_ID” number corresponds to the tab (sheet) number where the daily and annual precipitation data are stored



Lab_2_ID	Station	Goleta Regi	Elevation (ft above sea level)	Lat	Lon	Elev_masl
1	#251 - Miguelito Canyon		925	34.5861	-120.4950	282
2	#210 - Cold Springs Debris Basin		519	34.4511	-119.6200	158
3	#208 - Carpinteria Fire Station		32	34.3981	-119.5181	10
4	#205 - Burton Mesa Fire Stn		340	34.6975	-120.4500	104
5	#200 - UCSB	Y	110	34.4156	-119.8453	34
6	#198 - Orcutt		280	34.8822	-120.4486	85
7	#197 - Las Cruces		390	34.5075	-120.2300	119
8	#236 - Nojoqui Falls Park		720	34.5339	-120.1778	219
9	#238 - SB Potrero		5025	34.7747	-119.6469	1532
10	#234 - Santa Barbara	Y	100	34.4253	-119.7033	30
11	#232 - Jameson Dam		2230	34.4908	-119.5069	680
12	#231 - Doulton Tunnel		1775	34.4578	-119.5658	541
13	#230 - Gibraltar Dam		1500	34.5261	-119.6819	457
14	#229 - Cater Treatment Plant	Y	500	34.4542	-119.7303	152
15	#228 - Stanwood Fire Station	Y	670	34.4439	-119.6906	204
16	#227 - KTYD	Y	2375	34.4711	-119.6769	724
17	#226 - Dos Pueblos		160	34.4467	-119.9517	49
18	#221 - Cuyama Ranch		2170	34.9825	-119.6681	661
19	#220 - Cottonwood Canyon		2385	34.9750	-119.8956	727
20	#218 - Santa Ynez Fire Station		600	34.6072	-120.0692	183
21	#212 - San Marcos Pass		2250	34.5119	-119.8236	686
22	#314 - Los Prietos R.S.		1029	34.5333	-119.8000	314
23	#309 - Glenn Annie Canyon	Y	410	34.4750	-119.8833	125
24	#304 - El Capitan State Beach		30	34.4611	-120.0247	9
25	#301 - Gaviota State Park		40	34.4725	-120.2294	12
26	#290 - Happy Canyon		1690	34.6672	-119.9325	515
27	#285 - West Big Pine		6360	34.6906	-119.6644	1939
28	#280 - Tecolote Canyon		2900	34.5208	-119.9089	884
29	#276 - Bates Ridge		5120	34.9197	-119.9172	1561
30	#275 - Don Victor		4600	34.6375	-119.4622	1402
31	#270 - Shell Peak		2080	35.0769	-120.1939	634
32	#262 - Gaviota Coast		425	34.4889	-120.1311	130
33	#256 - Sisquoc Fire Station		420	34.8667	-120.2939	128
34	#255 - El Deseo Ranch	Y	3300	34.4914	-119.6956	1006
35	#252 - Edison Trail		1650	34.4428	-119.5078	503
36	#242 - Trout Club	Y	1175	34.4903	-119.7983	358
37	#383 - Carpinteria USFS		120	34.4019	-119.4914	37
38	#380 - Santa Maria		203	34.9519	-120.4456	62
39	#361 - Surf Beach		15	34.6906	-120.6008	5
40	#356 - Twitchell Reservoir		580	34.9881	-120.3211	177
41	#353 - Hollister #70		150	34.4678	-120.3403	46
42	#352 - Guadalupe City		85	34.9625	-120.5714	26
43	#349 - Al Mar Ranch		1048	34.8483	-120.3578	319
44	#347 - SB Canyon		2975	34.8208	-119.5561	907
45	#334 - Goleta Water District	Y	46	34.4369	-119.7856	14
46	#328 - Summerland		85	34.4153	-119.5814	26
47	#211 - Goleta Road Yard	Y	285	34.4506	-119.7736	87
48	#326 - Pine Canyon		835	35.0333	-120.2000	255
49	#325 - Montecito		150	34.4294	-119.6403	46
50	#321 - Botanic Garden	Y	800	34.4539	-119.7069	244
51	#317 - Jalama Beach		50	34.5117	-120.5003	15
52	#387 - Betteravia		168	34.9158	-120.5169	51
53	#474 - Santa Barbara City College	Y	65	34.4053	-119.6886	20
54	#473 - Casmalia		760	34.8200	-120.5331	232
55	#470 - Harris Grade		315	34.7703	-120.4303	96
56	#40 - Goleta Fire Station	Y	75	34.4431	-119.8536	23
57	#8 - Point Conception		80	34.4500	-120.4750	24
58	#426 - Cuyama Fire Station		2275	34.9456	-119.6825	693

Calculate long-term mean annual rainfall for each station

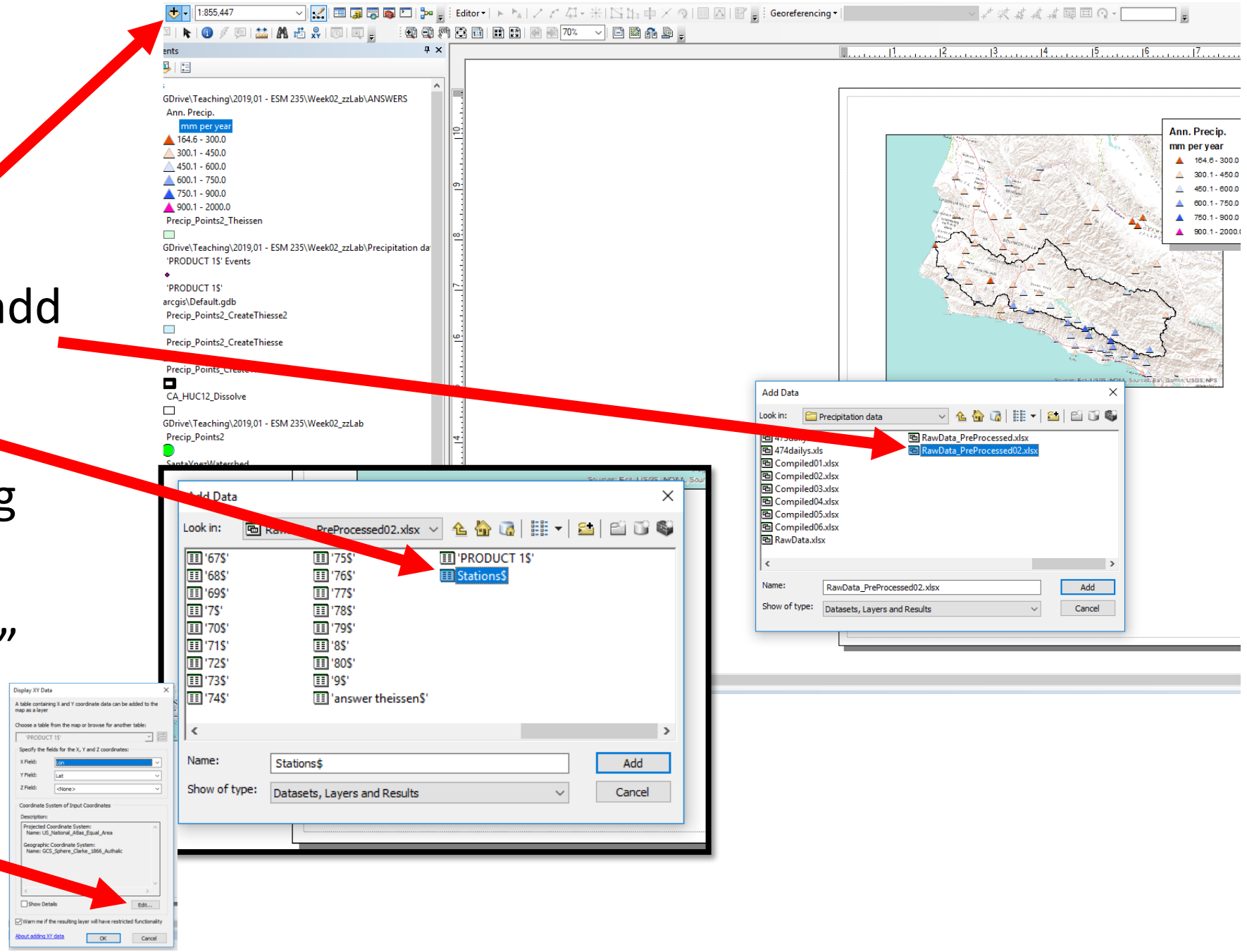
- Calculate the average value for column Q in each of the n=80 sheets (i.e., tabs)
- You could do this using the Excel formula **=Average(Q:Q)** in each tab, but this would take awhile
- Instead, try an ‘indirect’ function
- In cell Q2 in tab “Stations” enter the formula **=""&A2&"'!"** – then in cell R2 enter **=AVERAGE(INDIRECT(Q2&"q:q"))**
- You have now calculated the average value in column Q for sheet 1. You can copy cells Q2 and R2 and paste them into columns Q and R for all 80 stations to calculate long-term average precip. for all stations



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Lab_2_ID	Station	/Goleta Reg	--	--	--	Elevation (ft above sea level)	--	--	--	--	--	--	Lat	Lon	Elev_masl	Indirect	Annual P
2	1	#251 - Miguelito Canyon		Lat 34-35-10,Lo	34-35-10	120-29-42	925	34	35	10	120	29	42	34.5861	########	282	'1'!	22.2
3	2	#210 - Cold Springs Debris Basin		Lat 34-27-04,Lo	34-27-04	119-37-12	519	34	27	04	119	37	12	34.4511	########	158	'2'!	23.1
4	3	#208 - Carpinteria Fire Station		Lat 34-23-53,Lo	34-23-53	119-31-05	32	34	23	53	119	31	05	34.3981	########	10	'3'!	17.4
5	4	#205 - Burton Mesa Fire Stn		Lat 34-41-51,Lo	34-41-51	120-27-00	340	34	41	51	120	27	00	34.6975	########	104	'4'!	14.4
6	5	#200 - UCSB	Y	Lat 34-24-56,Lo	34-24-56	119-50-43	110	34	24	56	119	50	43	34.4156	########	34	'5'!	16.9
7	6	#198 - Orcutt		Lat 34-52-56,Lo	34-52-56	120-26-55	280	34	52	56	120	26	55	34.8822	########	85	'6'!	13.6
8	7	#197 - Las Cruces		Lat 34-30-27,Lo	34-30-27	120-13-48	390	34	30	27	120	13	48	34.5075	########	119	'7'!	13.3
9	8	#236 - Nojoqui Falls Park		Lat 34-32-02,Lo	34-32-02	120-10-40	720	34	32	02	120	10	40	34.5339	########	219	'8'!	25.7
10	9	#238 - SB Potrero		Lat 34-46-29,Lo	34-46-29	119-38-49	5025	34	46	29	119	38	49	34.7747	########	1532	'9'!	14.5
11	10	#234 - Santa Barbara	Y	Lat 34-25-31,Lo	34-25-31	119-42-12	100	34	25	31	119	42	12	34.4253	########	30	'10'!	18.3
12	11	#232 - Jameson Dam		Lat 34-29-27,Lo	34-29-27	119-30-25	2230	34	29	27	119	30	25	34.4908	########	680	'11'!	28.8
13	12	#231 - Doulton Tunnel		Lat 34-27-28,Lo	34-27-28	119-33-57	1775	34	27	28	119	33	57	34.4578	########	541	'12'!	26.9
14	13	#230 - Gibraltar Dam		Lat 34-31-34,Lo	34-31-34	119-40-55	1500	34	31	34	119	40	55	34.5261	########	457	'13'!	26.3
15	14	#229 - Cater Treatment Plant	Y	Lat 34-27-15,Lo	34-27-15	119-43-43	500	34	27	15	119	43	43	34.4542	########	152	'14'!	21.4
16	15	#228 - Stanwood Fire Station	Y	Lat 34-26-38,Lo	34-26-38	119-41-26	670	34	26	38	119	41	26	34.4439	########	204	'15'!	19.6
17	16	#227 - KTYD	Y	Lat 34-28-16,Lo	34-28-16	119-40-37	2375	34	28	16	119	40	37	34.4711	########	724	'16'!	25.0
18	17	#226 - Dos Pueblos		Lat 34-26-48,Lo	34-26-48	119-57-06	160	34	26	48	119	57	06	34.4467	########	49	'17'!	18.4
19	18	#221 - Cuyama Ranch		Lat 34-58-57,Lo	34-58-57	119-40-05	2170	34	58	57	119	40	05	34.9825	########	661	'18'!	6.5
20	19	#220 - Cottonwood Canyon		Lat 34-58-30,Lo	34-58-30	119-53-44	2385	34	58	30	119	53	44	34.9750	########	727	'19'!	12.6
21	20	#218 - Santa Ynez Fire Station		Lat 34-36-26,Lo	34-36-26	120-04-09	600	34	36	26	120	04	09	34.6072	########	183	'20'!	15.8
22	21	#212 - San Marcos Pass		Lat 34-30-43,Lo	34-30-43	119-49-25	2250	34	30	43	119	49	25	34.5119	########	686	'21'!	33.6
23	22	#314 - Los Prietos R.S.		Lat 34-32-00,Lo	34-32-00	119-48-00	1029	34	32	00	119	48	00	34.5333	########	314	'22'!	23.1
24	23	#309 - Glenn Annie Canyon	Y	Lat 34-28-30,Lo	34-28-30	119-53-00	410	34	28	30	119	53	00	34.4750	########	125	'23'!	20.8
25	24	#304 - El Capitan State Beach		Lat 34-27-40,Lo	34-27-40	120-01-29	30	34	27	40	120	01	29	34.4611	########	9	'24'!	16.8
26	25	#301 - Gaviota State Park		Lat 34-28-21,Lo	34-28-21	120-13-46	40	34	28	21	120	13	46	34.4725	########	12	'25'!	12.3
27	26	#290 - Happy Canyon		Lat 34-40-02,Lo	34-40-02	119-55-57	1690	34	40	02	119	55	57	34.6672	########	515	'26'!	15.1
28	27	#285 - West Big Pine		Lat 34-41-26,Lo	34-41-26	119-39-52	6360	34	41	26	119	39	52	34.6906	########	1939	'27'!	22.3
29	28	#280 - Tecolote Canyon		Lat 34-31-15,Lo	34-31-15	119-54-32	2900	34	31	15	119	54	32	34.5208	########	884	'28'!	26.7
30	29	#276 - Bates Ridge		Lat 34-55-11,Lo	34-55-11	119-55-02	5120	34	55	11	119	55	02	34.9197	########	1561	'29'!	16.4
31	30	#275 - Don Victor		Lat 34-36-15,Lo	34-36-15	119-27-44	4600	34	36	15	119	27	44	34.6375	########	1402	'30'!	17.0
32	31	#270 - Shell Peak		Lat 35-04-37,Lo	35-04-37	120-11-38	2080	35	04	37	120	11	38	35.0769	########	634	'31'!	19.4
33	32	#262 - Gaviota Coast		Lat 34-29-20,Lo	34-29-20	120-07-52	425	34	29	20	120	07	52	34.4889	########	130	'32'!	19.6
34	33	#256 - Sisquoc Fire Station		Lat 34-52-00,Lo	34-52-00	120-17-38	420	34	52	00	120	17	38	34.8667	########	128	'33'!	14.8
35	34	#255 - El Deseo Ranch	Y	Lat 34-29-29,Lo	34-29-29	119-41-44	3300	34	29	29	119	41	44	34.4914	########	1006	'34'!	35.4
36	35	#252 - Edison Trail		Lat 34-26-34,Lo	34-26-34	119-30-28	1650	34	26	34	119	30	28	34.4428	########	503	'35'!	22.1
37	36	#242 - Trout Club	Y	Lat 34-29-25,Lo	34-29-25	119-47-54	1175	34	29	25	119	47	54	34.4903	########	358	'36'!	26.5
38	37	#383 - Carpinteria USFS		Lat 34-24-07,Lo	34-24-07	119-29-29	120	34	24	07	119	29	29	34.4019	########	37	'37'!	19.8
39	38	#380 - Santa Maria		Lat 34-57-07,Lo	34-57-07	120-26-44	203	34	57	07	120	26	44	34.9519	########	62	'38'!	13.1
40	39	#361 - Surf Beach		Lat 34-41-26,Lo	34-41-26	120-36-03	15	34	41	26	120	36	03	34.6906	########	5	'39'!	9.3
41	40	#356 - Twitchell Reservoir		Lat 34-59-17,Lo	34-59-17	120-19-16	580	34	59	17	120	19	16	34.9881	########	177	'40'!	18.0
42	41	#353 - Hollister #70		Lat 34-28-04,Lo	34-28-04	120-20-25	150	34	28	04	120	20	25	34.4678	########	46	'41'!	16.2
43	42	#352 - Guadalupe City		Lat 34-57-45,Lo	34-57-45	120-34-17	85	34	57	45	120	34	17	34.9625	########	26	'42'!	12.3
44	43	#349 - Al Mar Ranch		Lat 34-50-54,Lo	34-50-54	120-21-28	1048	34	50	54	120	21	28	34.8483	########	319	'43'!	14.8
45	44	#347 - SB Canyon		Lat 34-43-15,Lo	34-43-15	119-33-22	2975	34	43	15	119	33	22	34.8208	########	907	'44'!	12.5

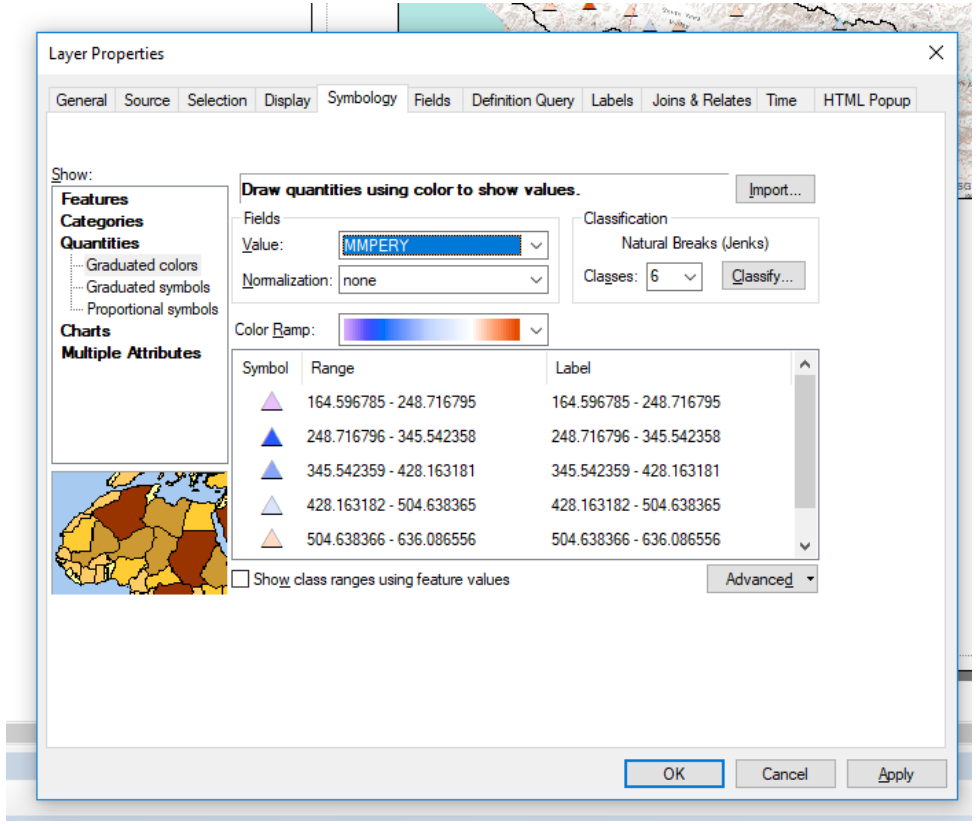
Map the data

- Save your excel file open ArcMap
- Click “add data” and add your excel workbook
- Add stations sheet
- Right click on resulting table in your ArcMap table of contents, click “Display X,Y data”
- Select WGS_1984 Geographic projection (select edit)



Create a map of annual precipitation rate

- Once points appear, right click in table of contents and export these points as shapefile.
- Add this file to map, and then rightclick on the new point data file. Open properties and go to the “Symbology Tab”
- You can rightclick on “Label” and reduce the number of digits that show in the map legend
- To add legend: Click on “Insert” dropdown at top of arcmap window and add legend



Product 2

Product 2 [1 mark, total]: Create a plot long-term mean annual precipitation rates (one point for each station) against elevation. Plot only the n=13 points with “Y” listed under the heading “SB/Goleta Region”. Ensure your plot axes are appropriately labelled, and that units of measurement are presented [1 mark].

Plot precipitation and station elevation

- Only plot stations in the Santa Barbara / Goleta area

- Create a chart plotting elevation (in ft or in m above sea level) vs long-term average annual precipitation

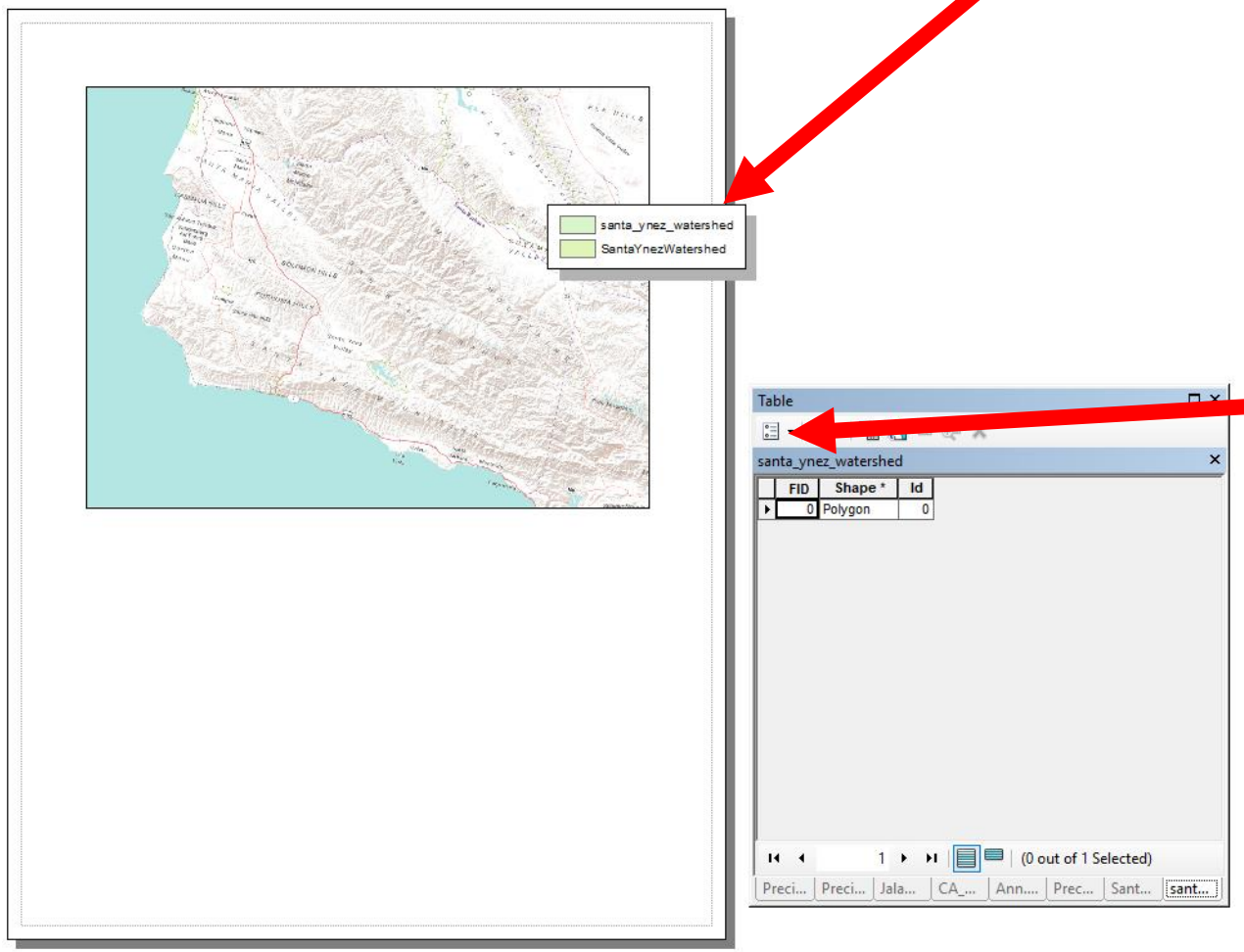
Product 3

Write a short ~300 word ‘Results’ paragraph. In this, detail (i) the range of mean annual precipitation rates measured among the n=80 stations [1 mark], (ii) the median annual precipitation rate among the n=80 stations [1 mark], (iii) spatial variations in mean annual precipitation among the study sites [1 mark], and (iv) any correlation between station elevation and annual precipitation among points with “Y” listed under the heading “SB/Goleta Region” [1 mark].

Product 4

Product 4 [1 mark, total] Calculate the total area of the delineated catchment [1 mark]. Report the units of your estimate.

Watershed Area



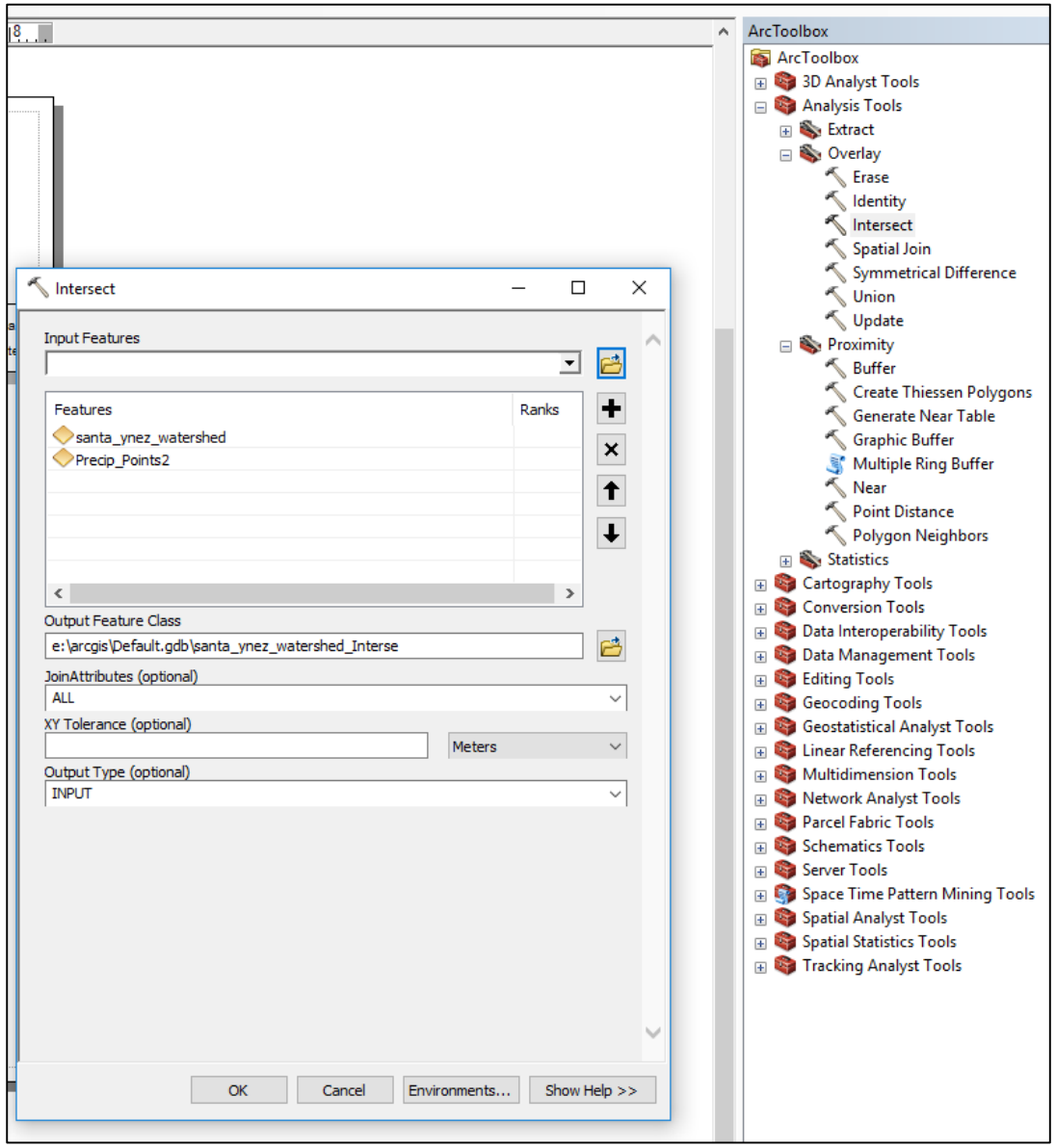
- Add the Santa Ynez watershed file to ArcMap using “Add Data”
- Right click on layers at the top of the table of contents, click on properties, to go the ‘coordinate system’ tab, change the projection to “US National Atlas Equal Area”
- Right click on the Santa Ynez Watershed shapefile and open the attribute table.
- Click on the dropdown menu in the top left of the attribute table and “add Field” type “Double”. Right click on this new column (on the heading) and select calculate geometry. Calculate the area.

Product 5

Product 5 [4 marks, total] Create a map of the Santa Ynez watershed overlaid by Theissen polygons constructed from the n=80 precipitation stations [1 mark]. Create a table detailing the fraction of the Santa Ynez watershed that intersects each precipitation monitoring station's Theissen polygon [2 marks]. At the base of the table, calculate your estimate of mean annual precipitation in the Santa Ynez watershed (Eqn. 1) [2 marks].

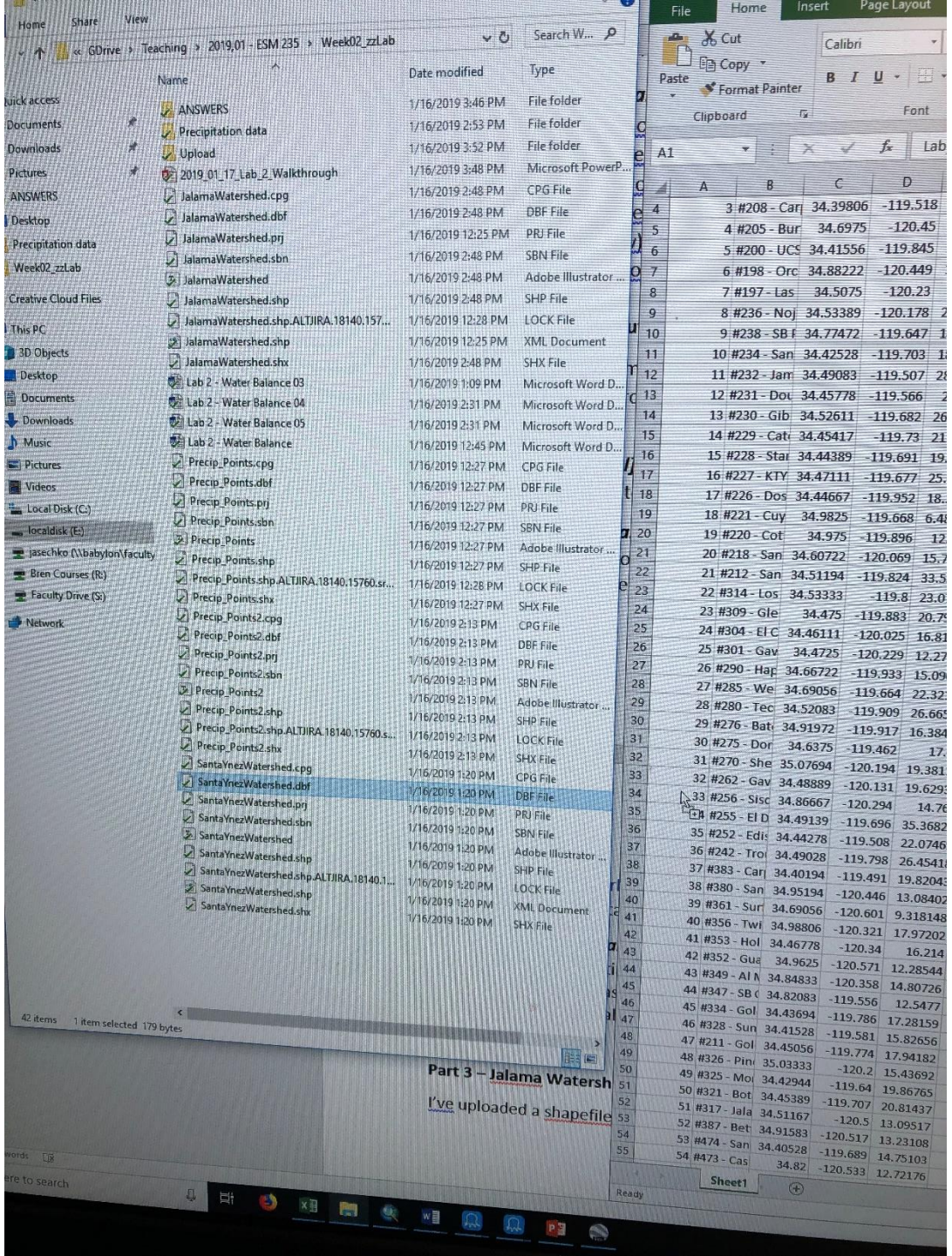
Theissen

- Add your precipitation station point data to the map
- Create Theissen Polygons on the basis of these point data (select windows dropdown from top of arcmap, click search, enter word “Theissen” into search box)
- ‘Intersect’ the resulting Theissen polygons with the Santa Ynez Watershed shapefile (open arctoolbox → “Analysis Tools” → Overlay” → Intersect



Theissen

- Open attribute table of the resulting ‘intersected’ theissen polygons. Calculate the area of each Theissen polygon.
- Close ArcMap, open explorer (windows explorer i.e., rightclick on start icon and open explorer)
- Navigate to folder with the shapefile representing the intersected theissen polygons. Find the ‘.dbf’ part of the file. Drag this file atop an open excel window and release (file→open will not work)



Theissen

- Reopen your Excel file containing the station data (i.e., from part 1).
- In Cell S1 in tab “Stations” add the title “Theissen polygon area in Santa Ynez Watershed”
- In cell S2 in tab “Stations” create a vertical lookup to obtain area data from the .dbf file:
  =vlookup(A2,[SantaYnezTheissenPolgyons.dbf]Sheet1!$A:$E,5,false)
- In Cell T2, multiple the Theissen area by the annual precipitation for the station
- Copy and paste cells S2 and T2 down to row 81 (i.e., calculate for all eighty stations)

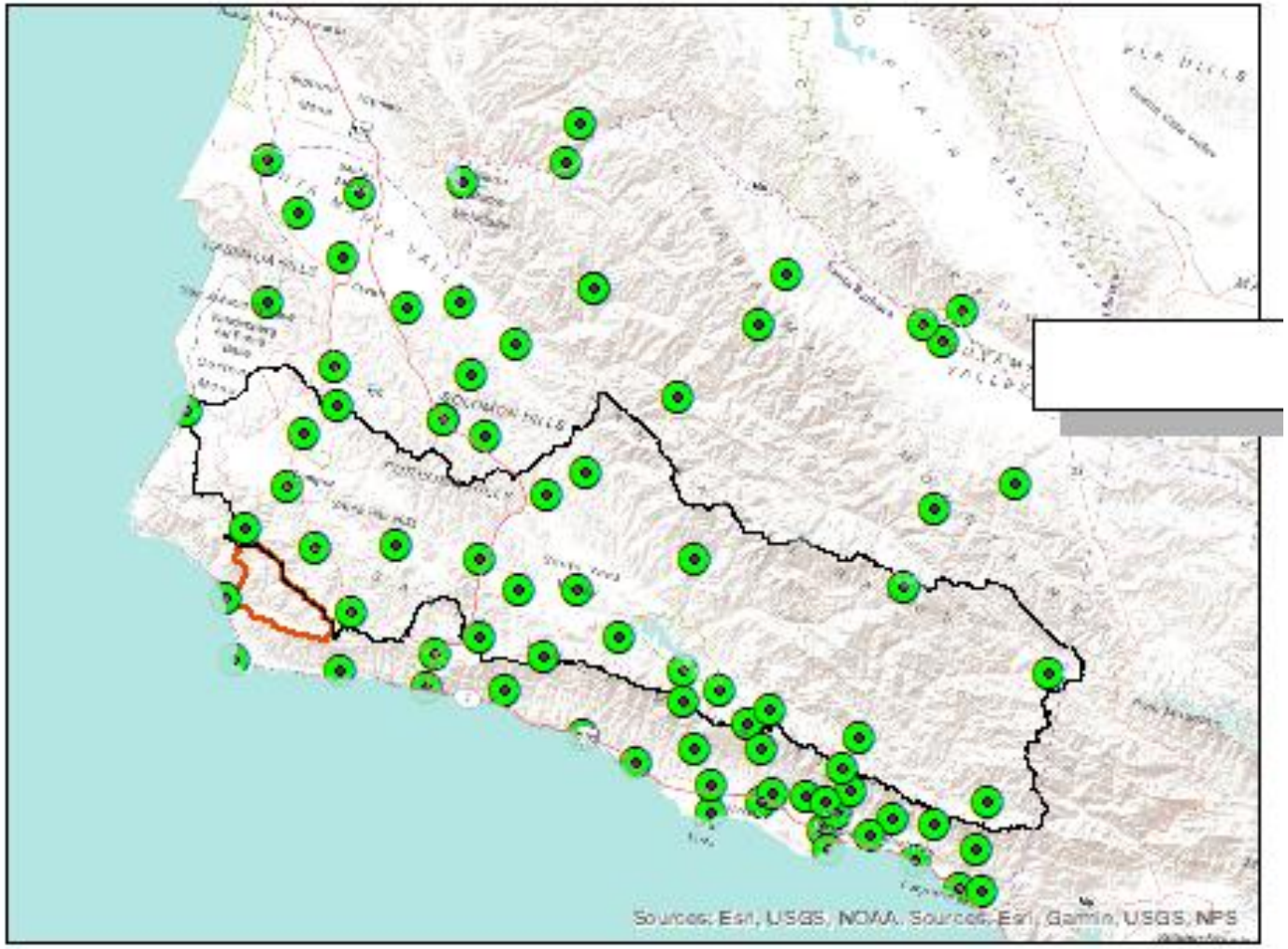
Theissen

- Delete any values in columns S and T that return a value of “#N/A” (alternately you could’ve written **=if(isna(vlookup(A2,[SantaYnezTheissenPolgyons.dbf]Sheet1!$A:$E,5,false)),””, vlookup(A2,[SantaYnezTheissenPolgyons.dbf]Sheet1!$A:$E,5,false))** in column S
- Sum (=SUM(…) columns S and T. Divide the sum of column T by the sum of column S (see Eqn. 1 in Lab write up)

Product 6

Product 6 [3 marks, total] Write a short ~300 word paragraph describing (i) how mean annual precipitation varies spatially within the watershed [2 marks], (ii) a limitation of the mean annual precipitation analysis based on Theissen-polygons [1 mark], (iii) the runoff ratio for the watershed (mean annual flow at outlet is 1.7 m^3/s (USGS site ID: 11134000) [1 mark].

Part 3



Part 3 – Jalama Watershed [7 marks]

I've uploaded a shapefile for Jalama watershed. Use spatial data and develop an estimate of annual precipitation inputs for the watershed. You may use the Theissen polygon approach, or develop another approach. Justify your answer with written text describing your methodology and results [3 marks]. Present at least two figures (maps, plots) [4 marks: one mark for presenting each of the two figures, another mark for each figure based on the quality of presentation in the figure].