HOW TO CALCULATE CT METRICS FOR YOUR STREAM TEMPERATURE DATA
USING EXCEL 2013

Thermal Class	Water Temperature (Degrees C)		
	June-August Mean	July Mean	Maximum Daily Mean
Cold	<18.29	<18.45	<22.40
Cool/Transition	18.29-21.70	18.45-22.30	22.40-26.30
Warm	>21.70	>22.30	>26.30

PART 1: Organize Your Data for Analysis

Before conducting analysis in Excel 2013, you will need to organize your stream temperature data so that you have at least four columns containing all of your data:

- Unique Station ID (e.g. DEEP AWQ Site Number)
- Date (MM/DD/YY)
- Time (Military)
- Stream temperature value (Data should be in degrees Celsius – do not include any text such as degree symbols, 'C' etc.)

If you had multiple loggers at a given station at the same time, you will need a "Logger ID" field. Each row of data should be assigned to the logger used to collect it.

If you are analyzing multiple summers' worth of data for the same station, you will need to add a "Year" column. Fill the column with the year that corresponds with the date the data was collected – e.g. if the data point was collected on 06/24/14 then the year would be "2014".

Below is an example of an Excel worksheet containing stream temperature data organized as discussed:

	A	B	C	D	E	F	G	H	I
1	StationID	year	Logger ID	date	time	value			
2	18827	2014	10015957	5/10/2014	0:00	12.001			
3	18827	2014	10015958	5/10/2014	1:00	12.05			
4	18827	2014	10015959	5/10/2014	2:00	12.147			
5	18827	2014	10015960	5/10/2014	3:00	12.268			
6	18827	2014	10015961	5/10/2014	4:00	12.364			
7	18827	2014	10015962	5/10/2014	5:00	12.485			
8	18827	2014	10015963	5/10/2014	6:00	12.582			
9	18827	2014	10015964	5/10/2014	7:00	12.678			
10	18827	2014	10015965	5/10/2014	8:00	12.775			
11	18827	2014	10015966	5/10/2014	9:00	12.944			
12	18827	2014	10015967	5/10/2014	10:00	13.281			
13	18827	2014	10015968	5/10/2014	11:00	13.978			
14	18827	2014	10015969	5/10/2014	12:00	15.294			
15	18827	2014	10015970	5/10/2014	13:00	17.368			
16	18827	2014	10015971	5/10/2014	14:00	19.294			
17	18827	2014	10015972	5/10/2014	15:00	20.079			

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READY

If you are analyzing data from multiple sites and/or loggers, 'stack' the data on top of each other in the same worksheet. (NOTE: Excel has a limit of ~60,000 rows of data per worksheet, so if you have many sites/loggers you may need to divide your data across two or more worksheets. If you do this, make sure all of the data for a given site/logger are on the same sheet – don't split datasets across two sheets.)

Below is a screen shot of 'stacked' data for stream monitoring sites #18766 and #18827 during 2014. The highlighted rows are where the dataset for site #18766 ends (last day of summer) and that for #18827 begins (first day of summer).
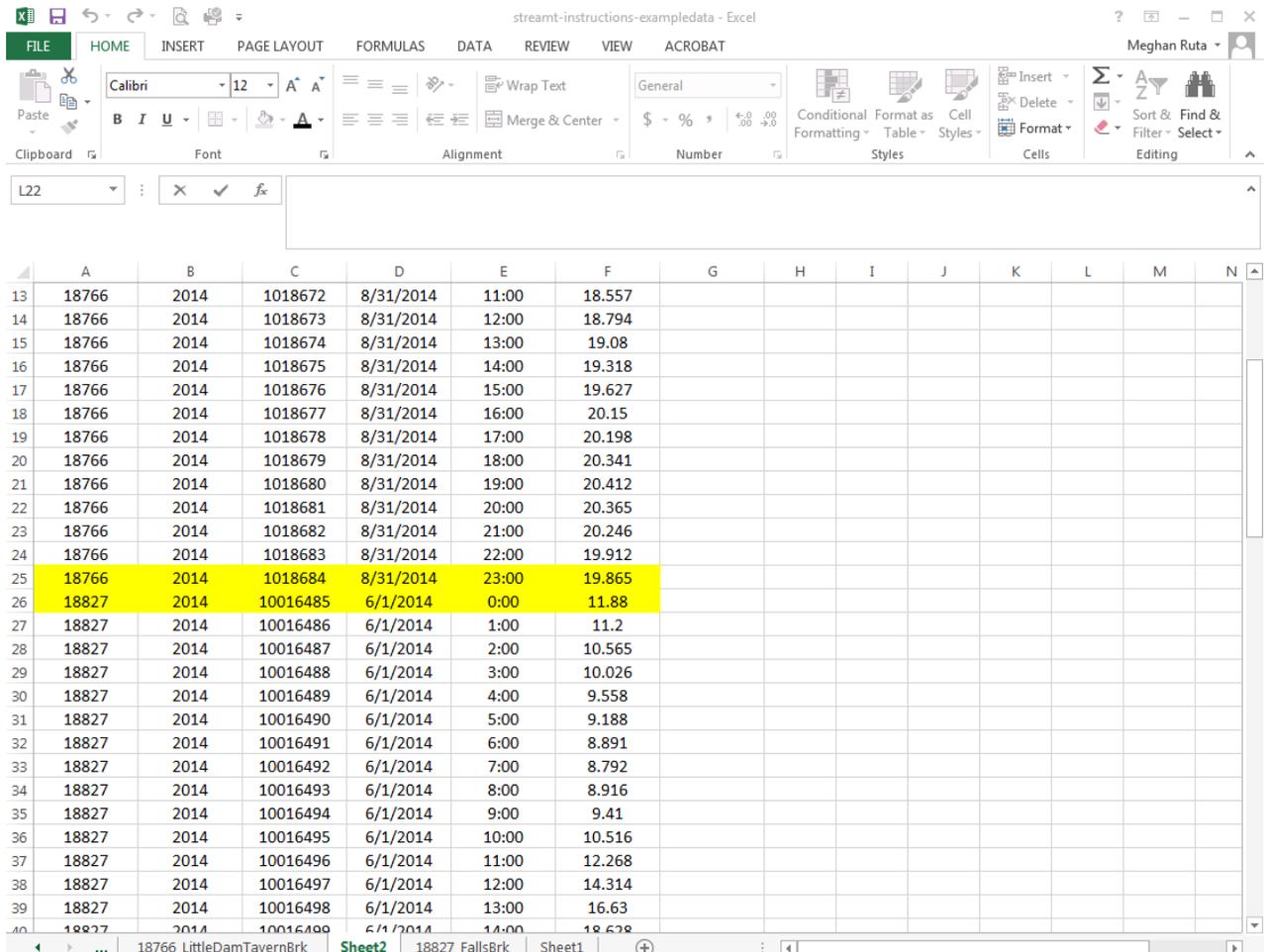
Right-click on the worksheet tab along the bottom of your screen and name this sheet "All Data". You now have a worksheet containing all of the available data for all of your sites and loggers.

Create a Summer-Only (June-Aug) Data Worksheet

Make a copy of your "All Data" worksheet. To do so, right-click on the "All Data" tab and select "Move or Copy." Check the "Create a copy" box at the bottom and click "OK". Right-click on the new worksheet tab, and click "Rename." Name this second worksheet "Jun-AugData".

Next delete all 'non-summer' data – data that was collected before June 1st and data collected after August 31st. An easy way to delete pre-June and post-August data, is once you have all of your data stacked in a common worksheet, sort your data by date. (Highlight the columns containing your data by right-clicking on the "A" column label, and then moving your mouse to the right to highlight the remaining columns. Then click "Sort and Filter"→ "Custom Sort" → Sort by: "date".)

Delete all rows at the start of your dataset that have a date of 05/31/YY or earlier and all rows at the end of your dataset with a date of 09/01/YY or later. You now have a worksheet containing all of the June through August data for all of your sites and loggers.

Create a July-Only Data Worksheet

To calculate the July-based metric, create a copy of this worksheet and delete the June and August data. To do so, right-click on the "Jun-Aug Data" tab and select "Move or Copy." Check the "Create a copy" box at the bottom and click "OK".   Right-click on the new worksheet tab, and click "Rename." Name this second worksheet "JulyData".   Sort your data by date, and delete all data before July 1 and after July 31.

You're now ready to computer your summer metrics for your data.

PART 2: Calculate Your Summer Metrics

Once all of your data for all of your sites is organized into a June-August worksheet and a July-only worksheet as described in Part 1, you are ready to calculate your summer metrics using the pivot table feature. You will calculate three metrics to evaluate your data:

- **June-August Mean**: the mean of all data collected at a site (by a single logger during a single year) between June 1 and August 31
- **July Mean**: the mean of all data collected at a site (by a single logger during a single year) during the month of July
- **Maximum Daily Mean**: For all data collected at a site (by a single logger during a single year), the largest daily mean* value for the available dataset (e.g. all dates, including non-summer dates). (Daily mean = the average of all hourly values collected during a given day.)

June-August Mean

Click on the "Jun-AugData" tab to view it if it is not already open. Highlight all of the data in the worksheet. (To highlight all data, click on the corner cell between row 1 and column A.) With the data still highlighted click "Insert" and then "Pivot Table".   Click "OK".   A new worksheet is opened with a blank pivot table, and a list of possible pivot table files along the right. Yours should look similar to this one:
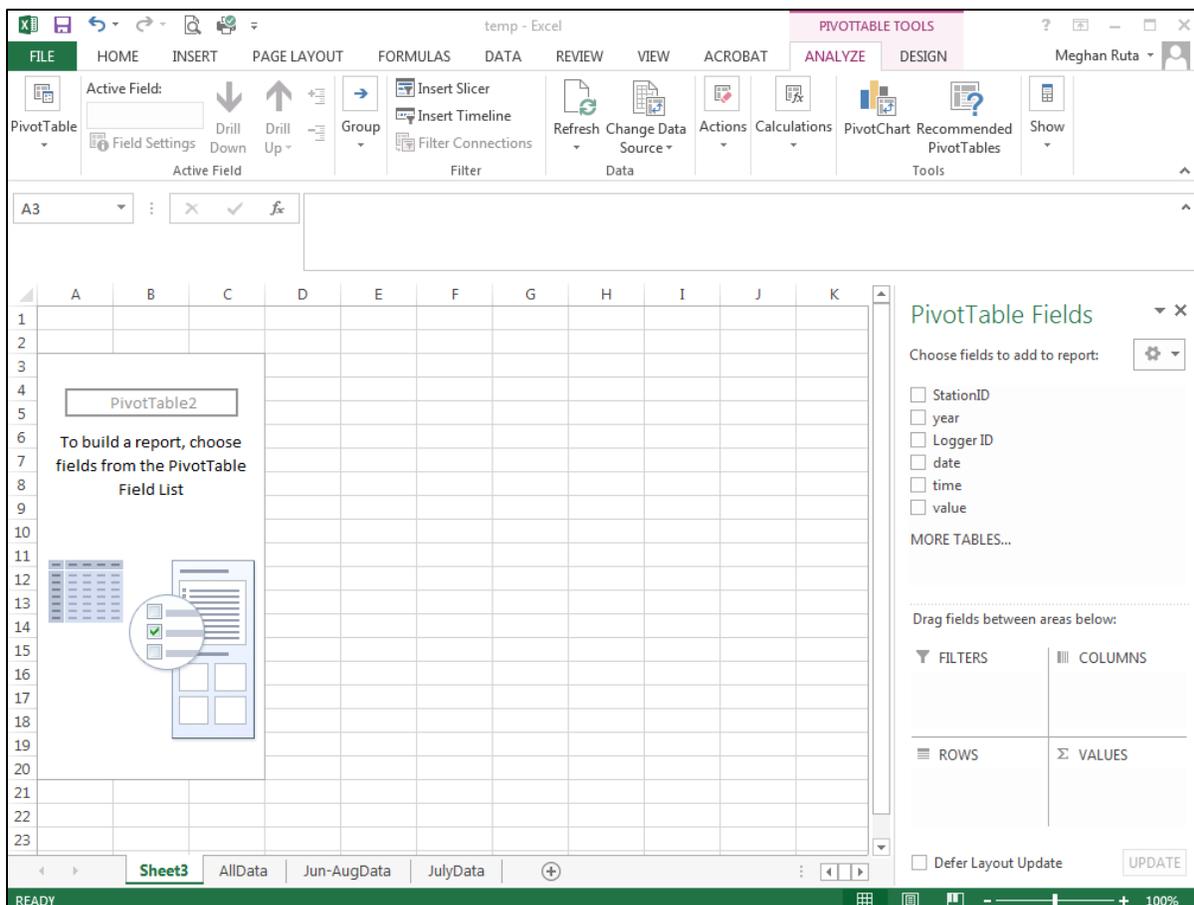
Right-click on the PivotTable tab, select "Rename" and label it "MeanSummerT".

Left-click on the 'StationID' label in the PivotTable Fields list and drag it down to the "ROWS" box at the bottom right of your screen. Repeat with the "Year" and then the "Logger ID" labels.

Next, left-click and drag the "value" label to the "VALUES" box at the bottom right of your screen. The default is the "count of value" setting. Click on drop-down arrow next to the 'Count of value' label in the "VALUES" box and select "Value Field Settings." Select "Average" and click "OK".

Left-click anywhere within your pivot table, then right-click and select "Pivot Table Options." Click on the "Display" tab and select "Classic Pivot Table layout". Click OK.

Your PivotTable will be reorganized to the classic layout, which is easier for us to work with. Lastly, click on a cell within the "Station ID" column that says "Total", then right-click and uncheck the 'Subtotal "StationID"' option. Repeat this with the Year and Logger ID columns. Your PivotTable should now look like this:

For this dataset, each station had only one corresponding year of data and one logger associated with it. If there had been a station with multiple loggers or multiple years of data you would additional rows of information beneath that Station ID.

The "Total" value shown at the right is the Average Mean Summer Temperature from June 1-August 31 for that station for the given year. Highlighting only the white cells within your PivotTable, highlight the Station ID

through Total data (e.g. cells A5 to D5 and then down to A13-D13 in the example above.) Right-click and select "Copy". Click the "+" button to the right of your worksheet tabs to add a new sheet. When the new sheet opens, click on cell A2, then right-click and select the clipboard or "Paste" icon. Add a label above each column of data (e.g. 'Station ID', 'Year', "Logger ID', and "Mean Summer Temp"). Right click on the new sheet tab and rename it to "Final Metrics". (Click Save to save your workbook before continuing!).

July Mean

Calculating the July mean is very similar to calculating the June-August mean, only you will use the JulyData worksheet.

Click on the "JulyData" tab to view it. Highlight all of the data in the worksheet, click "Insert" and then "Pivot Table".   Click "OK".   A new worksheet is opened with a blank pivot table. Rename the worksheet tab "JulyMeanT".

Left-click on the 'StationID' label in the PivotTable Fields list and drag it down to the "ROWS" box at the bottom right of your screen. Left-click and drag the "value" label to the "VALUES" box at the bottom right of your screen. Click on drop-down arrow next to the 'Count of value' label in the "VALUES" box and select "Value Field Settings." Select "Average" and click "OK".

Your PivotTable should look like this:
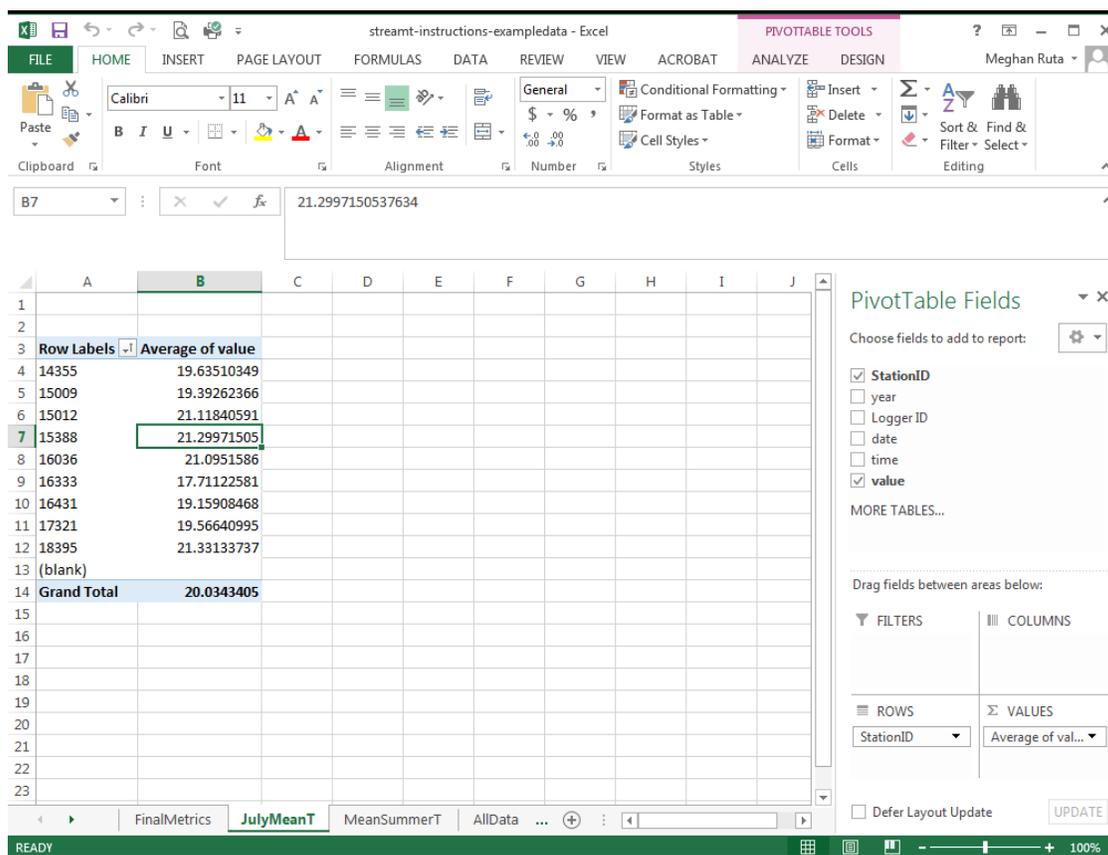
If when calculating your mean summer metrics, you observed that you had more than one year or more than one logger per station, then also add the "Year" and then the "Logger ID" labels to the ROW area. Then left-click anywhere within your pivot table, right-click and select "Pivot Table Options." Click on the "Display" tab and select "Classic Pivot Table layout". Click OK. Uncheck the 'Subtotal' option for the Station ID, Year and Logger ID.

The "Average of value" value shown at the right is the Mean July Temperature for your stations. Highlighting only the white cells within your PivotTable, highlight the Station ID and Mean July temperature data. Copy and paste it into your table on the "Final Metrics" worksheet. Make sure the station IDs are in the same order as the existing Final Metrics table; if so, delete the Station data, and add a "July Mean Temp" column label above the July Mean data. Your Final Metrics table should now look similar to this one:

	A	B	C	D	E	F	G
1	StationID	year	Logger ID	Mean Summer Temp	July Mean Temp		
2	14355	2014	10506941	18.26870063	19.63510349		
3	15009	2014	10354191	18.65428125	19.39262366		
4	15012	2014	10354196	19.87925679	21.11840591		
5	15388	2014	9994026	19.98309692	21.29971505		
6	16036	2014	10506942	19.8408673	21.0951586		
7	16333	2014	9994029	16.73114266	17.71122581		
8	16431	2014	10354192	17.9138673	19.15908468		
9	17321	2014	10354194	18.2839615	19.56640995		
10	18395	2014	10354195	20.00697328	21.33133737		
11							
12							
13							

(Click Save to save your workbook before continuing!).

Maximum Daily Mean (All Available Dates)

Click on the "All Data" tab to view it. Highlight the data and create a new pivot table. Rename the pivot table worksheet tab "Max Daily Mean T".

Left-click on the 'StationID' label in the PivotTable Fields list and drag it down to the "ROWS" box at the bottom right of your screen. Repeat with the "Date" label.

Next, left-click and drag the "value" label to the "VALUES" box at the bottom right of your screen. Change the "Value Field Settings" to "Average" and click "OK".

Add a second 'value' label to the 'VALUES' box and change the 'Value Field Settings' to "Average" and rename the Custom Name to "Rank". Then click on the "Show Values As" tab and click "Rank Largest to Smallest" from the drop down list. Select "Date" as the base field. Click OK.

Left-click anywhere within your pivot table, then right-click and select "Pivot Table Options." Click on the "Display" tab and select "Classic Pivot Table layout". Click OK. Uncheck the 'Subtotal' option for any columns that are sub-totaled to simplify your table.

Your pivot table should look similar to this one:

For every station there will be a row for each date for which there is data available. Next to the date will be the average temperature for that day, and then a ranking of how 'hot' it was relative to all other average daily temperatures at that site that summer. The row ranked "1" is the hottest day for that station – and the corresponding temperature is the maximum daily mean temperature for that station for that summer.

Highlight all of the white cells in your pivot table (above the row with "blank" in it), right-click and select "Copy". Create a new worksheet in your workbook, click on cell A1, and right-click to paste the pivot table data into the new worksheet.

Click on the first cell that has a station ID (should be cell A1). With the cell highlighted there is a small square in the bottom-right corner of the cell's highlighted border. Hover your cursor over this square until the cursor changes from a thick white cross-hair to a thinner black cross-hair and then click on the square. This should have resulted in the value from cell A1 being copied into all blank cells beneath it until it reach a non-blank cell (e.g. the next Station ID.) Repeat this process to assign each date/temperature/rank row a corresponding station ID.

	A	B	C	D	E
79	**14355**	8/18/2014	17.0845	73	
80	**14355**	8/19/2014	16.92145833	78	
81	**14355**	8/20/2014	17.41070833	65	
82	**14355**	8/21/2014	17.56366667	60	
83	**14355**	8/22/2014	17.4815	63	
84	**14355**	8/23/2014	17.34954167	67	
85	**14355**	8/24/2014	17.053625	75	
86	**14355**	8/25/2014	17.13679167	70	
87	**14355**	8/26/2014	17.841	50	
88	**14355**	8/27/2014	18.42383333	40	
89	**14355**	8/28/2014	19.35733333	24	
90	**14355**	8/29/2014	17.41279167	64	
91	**14355**	8/30/2014	16.35345833	81	
92	**14355**	8/31/2014	17.606125	59	
93	**15009**	6/1/2014	16.15445833	90	
94		6/2/2014	16.898375	86	
95		6/3/2014	18.53808333	54	
96		6/4/2014	18.97608333	33	

Previously blank cells that have been filled in with previous Station ID number

Square at bottom right of highlighted cell. Click on when cursor turns to black cross-hair to copy value to blank cells beneath

Once all of your date/temperature/rank rows have been assigned a Station ID, highlight columns A through D and click "Sort & Filter" (on the Home menu), then click "Custom Sort." If checked off, uncheck the 'My data has headers' box at the top right of the dialogue box, then select sort by "column D". (Column D should contain your rank values, if not select the column that does.) Order from smallest to largest.

Click "Add level" and then add "Column A" (or the column that contains your station ID values) to the 'Then by' field; select Smallest to largest, and click OK.

Scroll to the top of your datasheet. You should see for each station, a date/temperature combination that was ranked "1", indicating it was the highest daily mean temperature for that site for the given dataset. The rank 1 values should be further organized by Station ID from smallest ID number to largest.

Warmest daily mean temperatures for the stations evaluated.
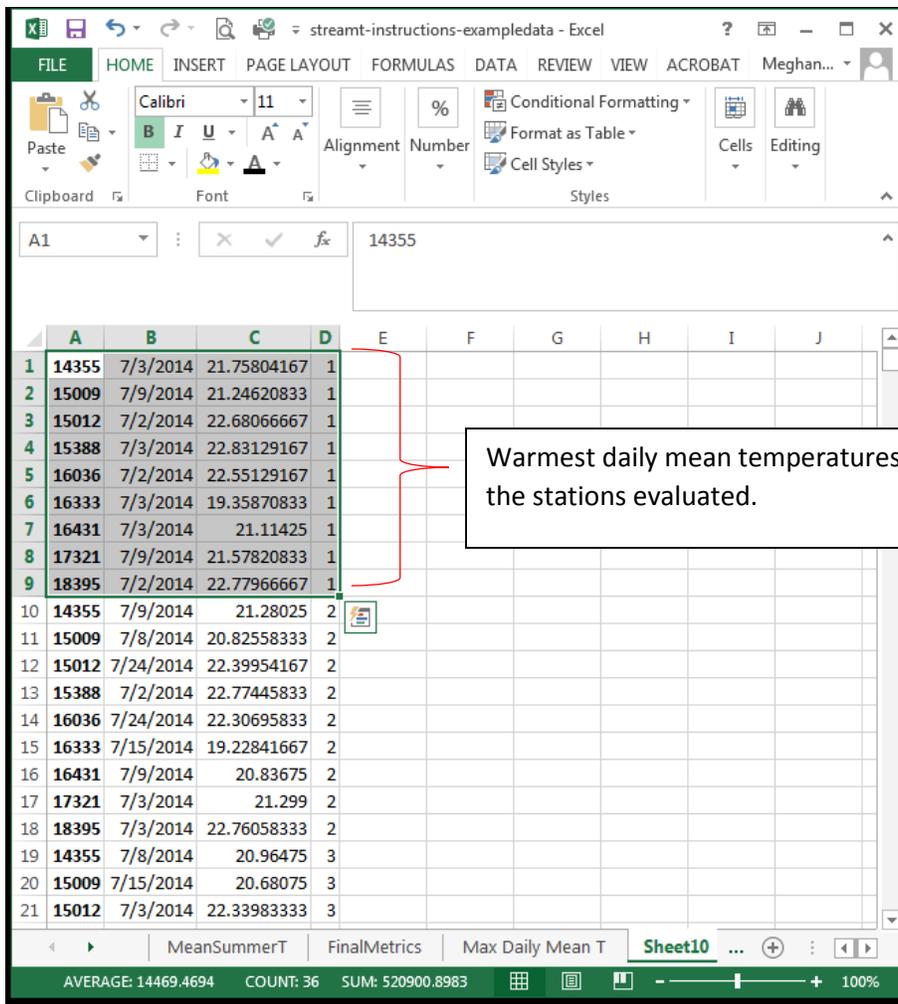
Highlight the data with a rank of 1 and copy and paste it onto your Final Metrics worksheet. Make sure the stations are in the same order as the other data in your Final Metrics table, and if so delete the rank, date, and station ID columns from the data you just pasted. Add a 'Max Daily Mean' column label above the new data. Your Final Metric Table should now look similar to this:

	A	B	C	D	E	F	G
1	StationID	year	Logger ID	Mean Summer Temp	July Mean Temp	Max Summer Daily Mean	
2	14355	2014	10506941	18.26870063	19.63510349	21.75804167	
3	15009	2014	10354191	18.65428125	19.39262366	21.24620833	
4	15012	2014	10354196	19.87925679	21.11840591	22.68066667	
5	15388	2014	9994026	19.98309692	21.29971505	22.83129167	
6	16036	2014	10506942	19.8408673	21.0951586	22.55129167	
7	16333	2014	9994029	16.73114266	17.71122581	19.35870833	
8	16431	2014	10354192	17.9138673	19.15908468	21.11425	
9	17321	2014	10354194	18.2839615	19.56640995	21.57820833	
10	18395	2014	10354195	20.00697328	21.33133737	22.77966667	
11							
12							
13							
14							

Your metric calculations are now complete!

NOTE: This process assumes you had at most only one year's worth of data and only one logger per site. If you are analyzing multiple years/summers per site or have multiple loggers per site, you'll need to modify the steps above to include a year and/or logger field. If you are new to Pivot Tables, we suggest creating one JulyData tab for each year of data to keep your tables simple. For sites with multiple loggers worth of data, a simply solution may be to provide a temporary station ID that is modified to include a portion of the logger number. So for station 15009 if there were two loggers number 98795384 and 46829541 you could create dummy station IDs in your original data of 15009-987 and 15009-468 to help differentiate the data from the two loggers. There are many ways to address the issue, just be aware of the potential to accidental combine data for multiple years or multiple loggers for a given station if you do not include these fields in your pivot table analysis.

PART 3: Evaluate Your Results

The last step is to evaluate your results in the context of the published (Beauchene et al. 2014) Connecticut stream thermal classifications:

Thermal Class	Water Temperature (Degrees C)		
	June-August Mean	July Mean	Maximum Daily Mean
Cold	<18.29	<18.45	<22.40
Cool/Transition	18.29-21.70	18.45-22.30	22.40-26.30
Warm	>21.70	>22.30	>26.30

A helpful visual tool for displaying and summarizing this data for others is to sort your final metric table by the 'Mean Summer Temp' field first. Highlight all cells in the Mean Summer Temp column that are less than 18.29 green, all that are greater than 21.70 red, and all in between yellow (or the colors of your choosing).

Resort your data based on the July mean, again color coding cold, cool, and warm according to the cutoffs noted in the table above. Sort again by the Max Summer Daily mean column and color-code these cells as well.

For the example dataset the results are as follows (reorganized one last time by Station ID):

	A	B	C	D	E	F
1	StationID	Year	Logger ID	Mean Summer Temp	July Mean Temp	Max Daily Mean
2	14355	2014	10506941	18.27	19.64	21.76
3	15009	2014	10354191	18.65	19.39	21.25
4	15012	2014	10354196	19.88	21.12	22.68
5	15388	2014	9994026	19.98	21.30	22.83
6	16036	2014	10506942	19.84	21.10	22.55
7	16333	2014	9994029	16.73	17.71	19.36
8	16431	2014	10354192	17.91	19.16	21.11
9	17321	2014	10354194	18.28	19.57	21.58
10	18395	2014	10354195	20.01	21.33	22.78
11						

In the example dataset, none of the calculated metrics fell within the 'warm' thermal classification. Most of the stations scored partially or mostly within the 'Cool' thermal classification, the most common class for

Connecticut streams. Only Station 16333 scored 'Cold' in all three metrics, indicating that this may be a cold water stream.

To confidently classify a stream into one of the thermal classes, ideally several years of summer data will be collected and evaluated. Stations 14355, 16431, and 17321 in the example above may be cold streams for example, however extreme low flows during the summer of 2014 may have resulted in higher than average stream temperatures for these reaches during the data period evaluated. Follow-up monitoring in future years could help clarify whether these streams are best classified as 'cool' or 'cold' water streams.

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