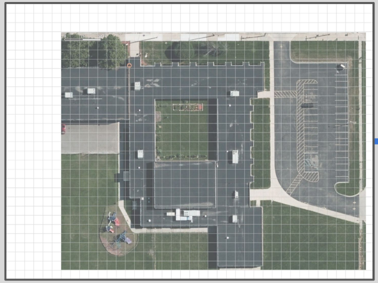
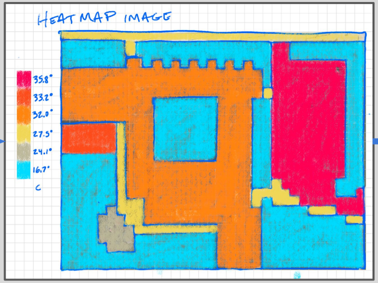
Manual Image Classification - Create a Surface Temperature Map

In this learning activity, the students will use a handheld Infrared Thermometer (IRT) to measure skin temperatures of different surface materials and then use the manual image classification technique to create a classified image and assign temperature values to each identified class of surface material. The result will be a map of surface temperatures.

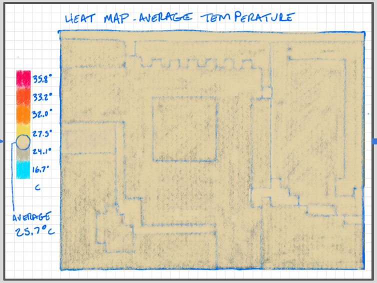
Following this they will create an average temperature for the entire scene, and then a 30 meter x 30 meter resolution image, similar to what we would see in a Landsat thermal image of the same area.



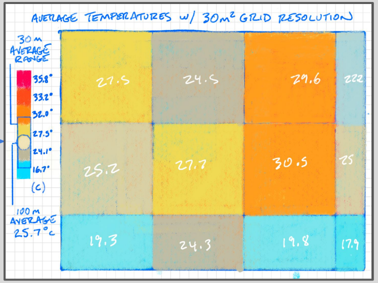
Gridded image (~3m^2 per pixel)



Heat map (~3m^2 per pixel)



Heat map (~100 m^2 per pixel)



Heat map (~30 m^2 per pixel)

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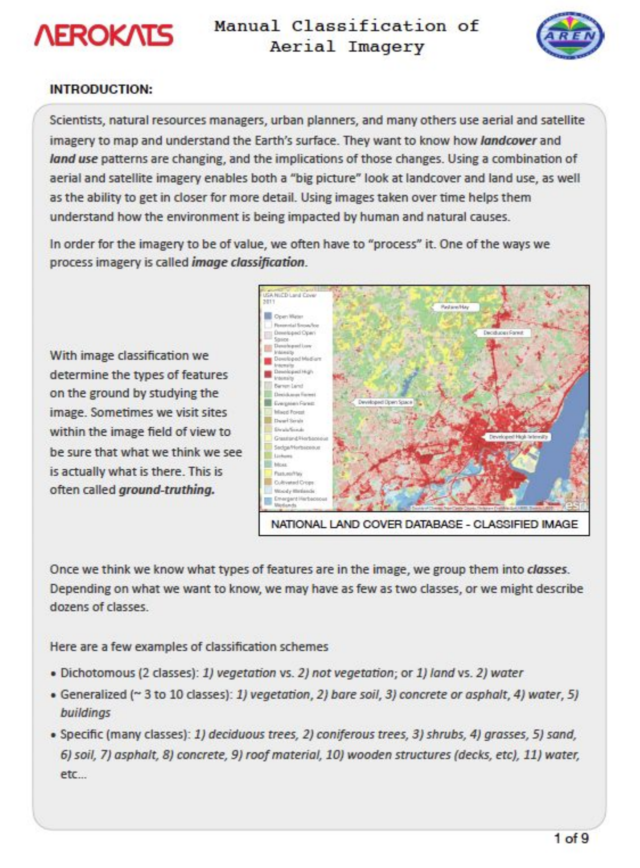
Additional background on image classification and resources can be found in the Manual Image Classification Learning Activity:
https://tinyurl.com/kda8v25w

Overview of Manual Image Classification (Video)
https://tinyurl.com/yvdyf9c4

If you do not have graph paper that you can print on, an tool for creating a gridded image to print with instructions can be found here:
https://tinyurl.com/zkyhzeaz



AEROKATS Manual Classification of Aerial Imagery

INTRODUCTION:

Scientists, natural resources managers, urban planners, and many others use aerial and satellite imagery to map and understand the Earth's surface. They want to know how ***landcover*** and ***land use*** patterns are changing, and the implications of those changes. Using a combination of aerial and satellite imagery enables both a "big picture" look at landcover and land use, as well as the ability to get in closer for more detail. Using images taken over time helps them understand how the environment is being impacted by human and natural causes.

In order for the imagery to be of value, we often have to "process" it. One of the ways we process imagery is called ***image classification***.

With image classification we determine the types of features on the ground by studying the image. Sometimes we visit sites within the image field of view to be sure that what we think we see is actually what is there. This is often called ***ground-truthing.***

NATIONAL LAND COVER DATABASE - CLASSIFIED IMAGE

Once we think we know what types of features are in the image, we group them into ***classes***. Depending on what we want to know, we may have as few as two classes, or we might describe dozens of classes.

Here are a few examples of classification schemes

- Dichotomous (2 classes): *1) vegetation vs. 2) not vegetation*; or *1) land vs. 2) water*
- Generalized (~ 3 to 10 classes): *1) vegetation, 2) bare soil, 3) concrete or asphalt, 4) water, 5) buildings*
- Specific (many classes): *1) deciduous trees, 2) coniferous trees, 3) shrubs, 4) grasses, 5) sand, 6) soil, 7) asphalt, 8) concrete, 9) roof material, 10) wooden structures (decks, etc), 11) water, etc...*

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PROCEDURE

1. Obtain an aerial image of the area you wish to study

   (Possible sources include an image from an Aeropod, Google Maps or similar)

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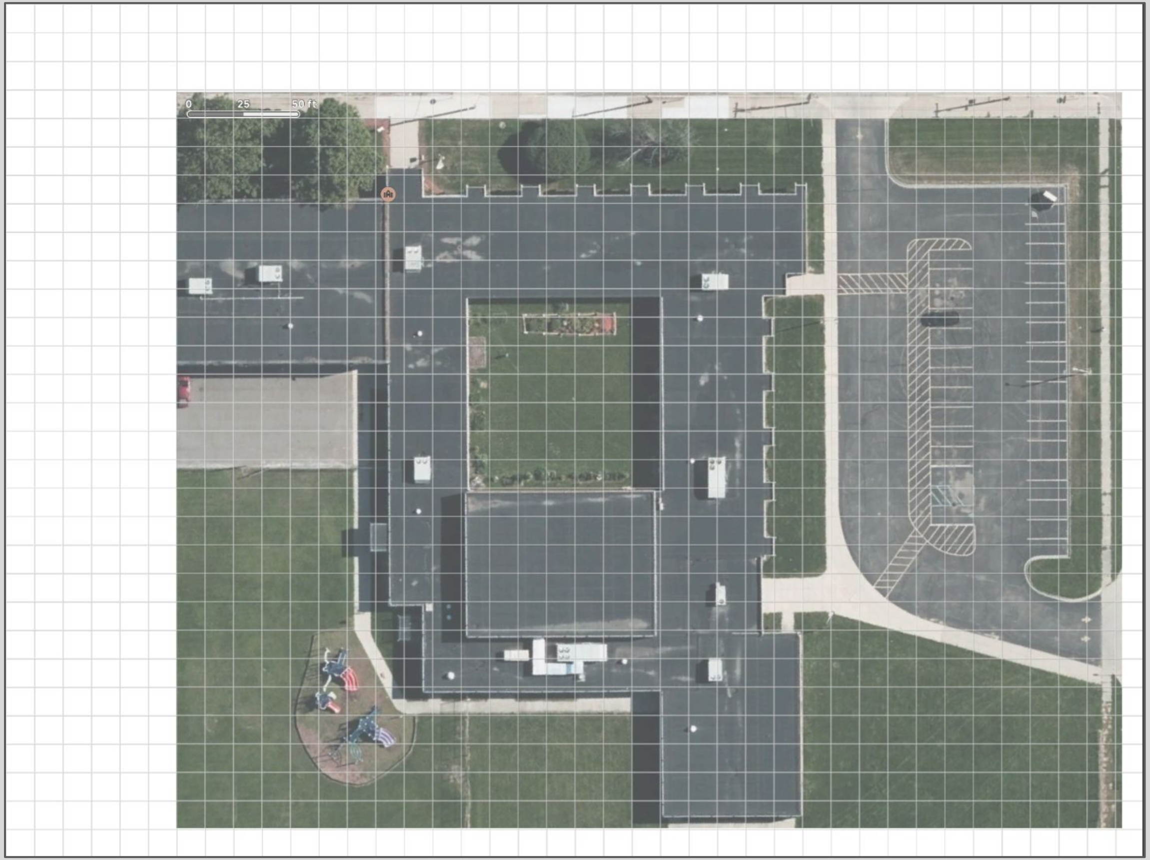
2. Print the image of your study area on graph paper, or use the gridded image tool template linked here:

https://tinyurl.com/zkyhzeaz



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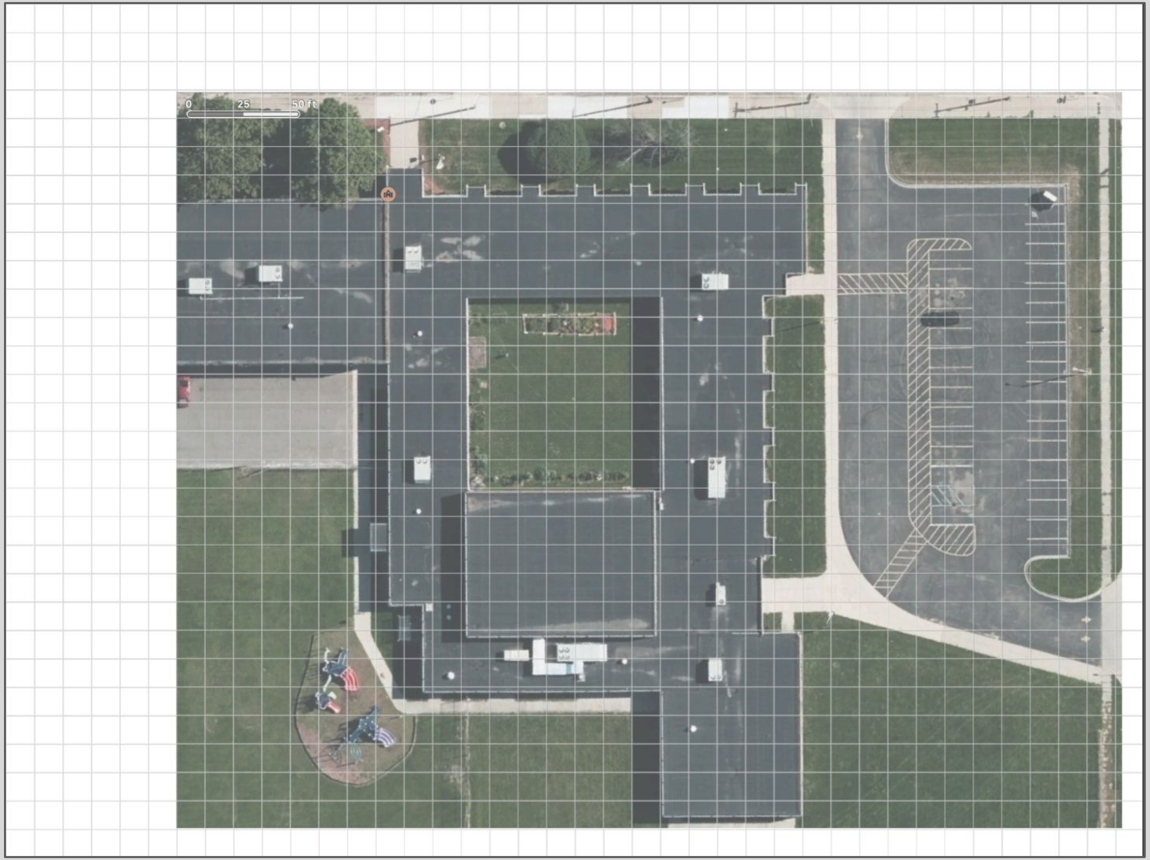
3. Determine Your Land Cover Classes

   Identify the major surface types (classes) in the image.

   Examples in this image:
   1) Concrete (sidewalks)
   2) Grass/vegetation
   3) Rooftop
   4) Asphalt (E parking lot)
   5) Asphalt - 2 (S parking lot)
   6) Sand (playground)



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4. In the field, use a handheld Infrared Thermometer (IRT) to make multiple (five or more) measurements of each type (class) of surface material.
5. Record the measurements on paper or in a spreadsheet table.

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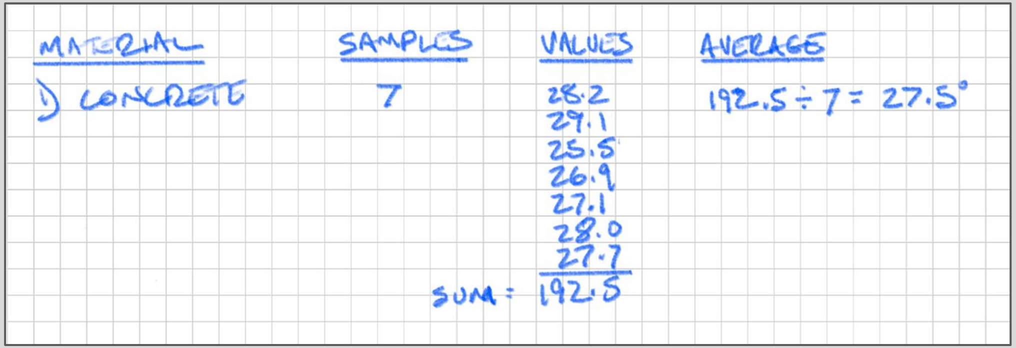
6. For each identified surface material class, add the measured values and then divide the total by the number of measurements to obtain an average value for that material.



Example of averaging sample measurements of one surface type

Average Surface Temperatures (ºC) used in this example:

1) Concrete (sidewalks) 27.5º
2) Grass/Vegetation 16.7º
3) Rooftop 32º
4) Asphalt (E parking lot) 35.8º
5) Asphalt - 2 (W lot) 33.2º
6) Sand (playground) 24.1º

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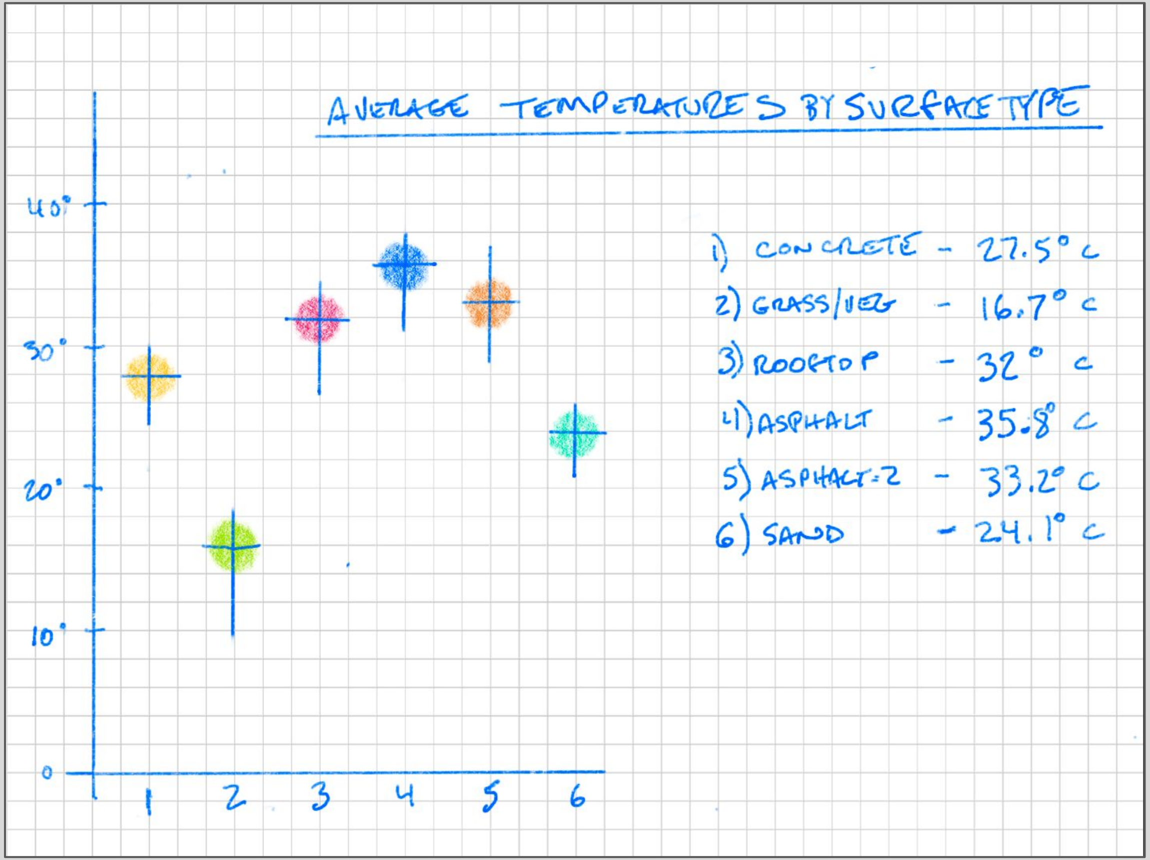
7. Make a plot on graph paper showing the distribution of temperatures by surface type.

   Place the temperature range on the Y-axis and the surface material classes on the X-axis. Plot the average temperatures as shown. You can denote the range within each class by extending a vertical line from the average point, as in a box plot.



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8. Using the grid, divide the image into classes you identified in the previous step.

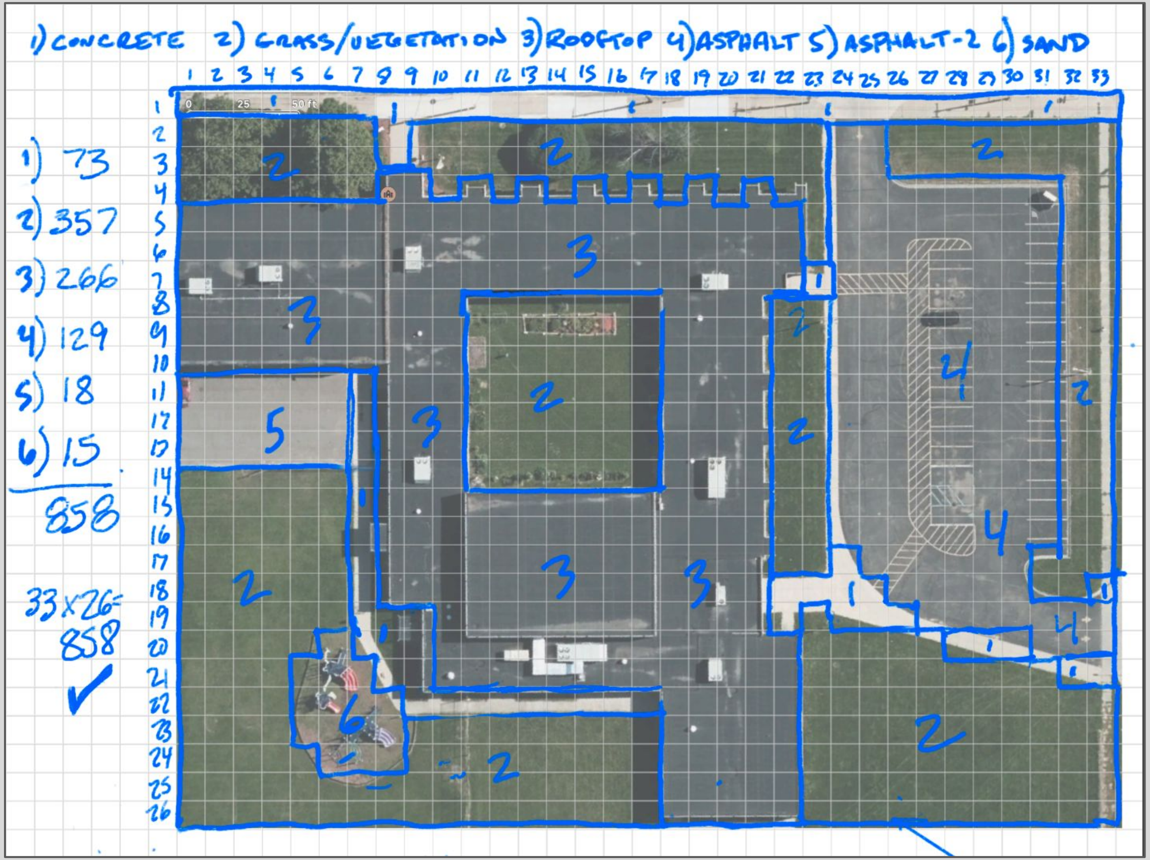
   Note:

   - Each square represents a pixel.
   - Each pixel can only contain one surface type.
   - If a pixel is divided between two surface types, assign it to the type that makes up most of of it.

9. Add up the pixels for each class and record the totals.

10. Be sure that the number of pixels adds up to the total number of pixels in the image.

    (Hint, multiply the rows by columns to get the total number of pixels in the image.)



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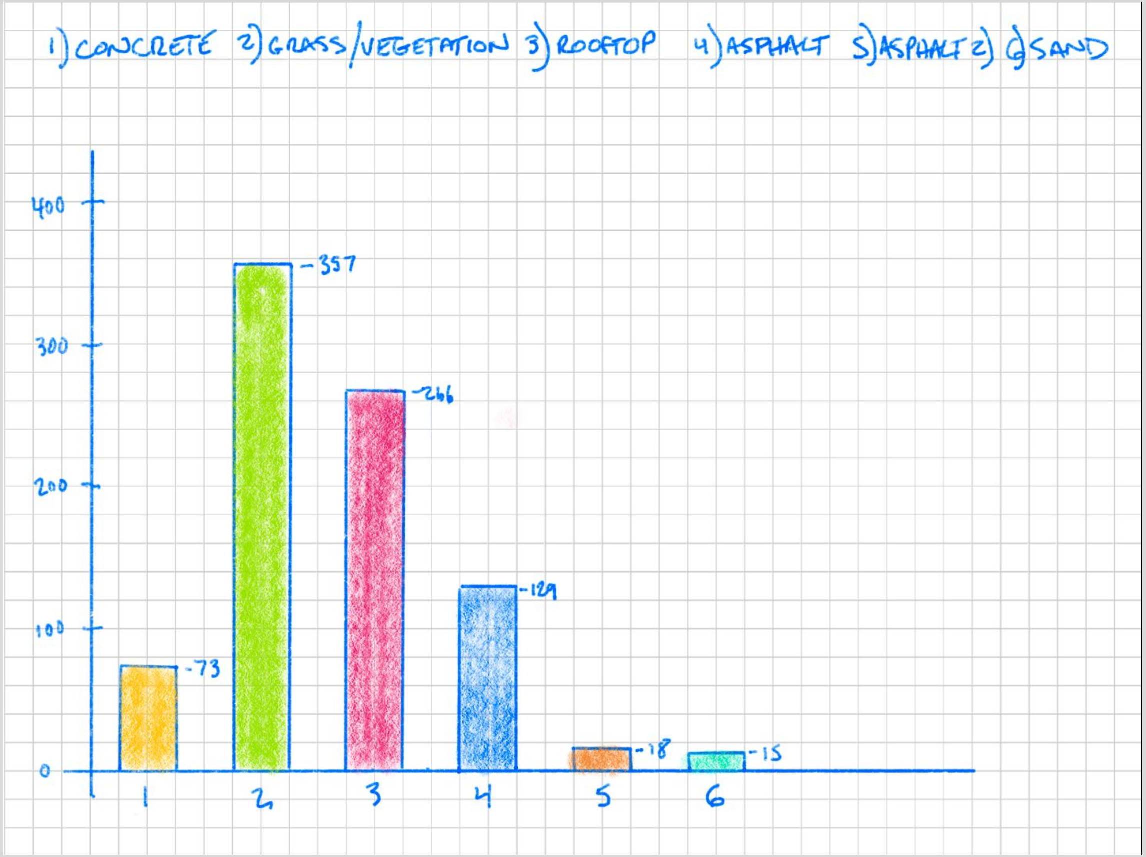
11. Create a Land Cover Bar Chart

    Use graph paper to make a bar graph showing the distribution of pixels by surface type using pixel count that you just created.

    Place the pixel count on the Y-axis and the plot each surface type along the X-axis, as shown here.



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12. Create a Land Cover Pie Chart showing the percentage of the total of each surface type.
    - 12.1. Divide the number of pixels in each class by the total number of pixels in the image to get the percent as a decimal.
    - 12.2. Multiply the percent as decimal figure by 360 to get the degree of arc for your pie chart.
    - 12.3. Multiply the percent as decimal by 100 to get the value represented as a percentage of the whole.

CLASS	PCT AS DECIMAL	DEGREE OF ARC
1) CONCRETE:	73 ÷ 858 = 0.085	360 x 0.085 = 30.6°
	PERCENT = 0.085 x 100 = 8.5 %	
2) GRASS/VEG.:	357 ÷ 858 = 0.416	360 x 0.416 = 149.8°
	PERCENT = 0.416 x 100 = 41.6%	
3) ROOFTOP:	266 ÷ 858 = 0.310	360 x 0.310 = 111.6°
	PERCENT = 0.310 x 100 = 31.0%	
4) ASPHALT:	129 ÷ 858 = 0.150	360 x 0.150 = 54.1°
	PERCENT = 0.150 x 100 = 15.0%	
5) ASPHALT-2:	18 ÷ 858 = 0.020	360 x 0.020 = 7.6°
	PERCENT = 0.021 x 100 = 2.1 %	
6) SAND:	15 ÷ 858 = 0.018	360 x 0.018 = 6.3°
	PERCENT = 0.018 x 100 = 1.8 %	

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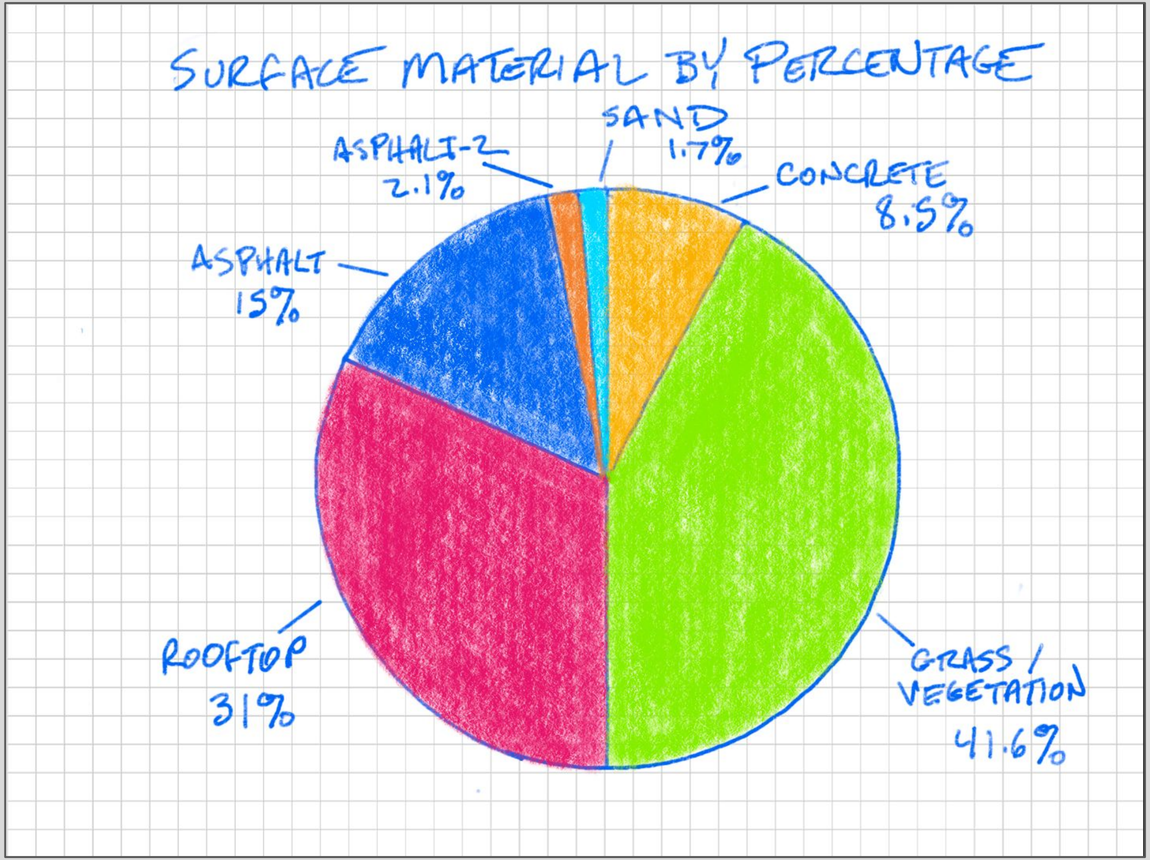
13. Use the degrees of arc results to divide a circle into corresponding pie slices.
14. Label the slices with the class name and percent of total

    You can also do this using the charts and graphs functions in a spreadsheet program like MS Excel or Apple Numbers



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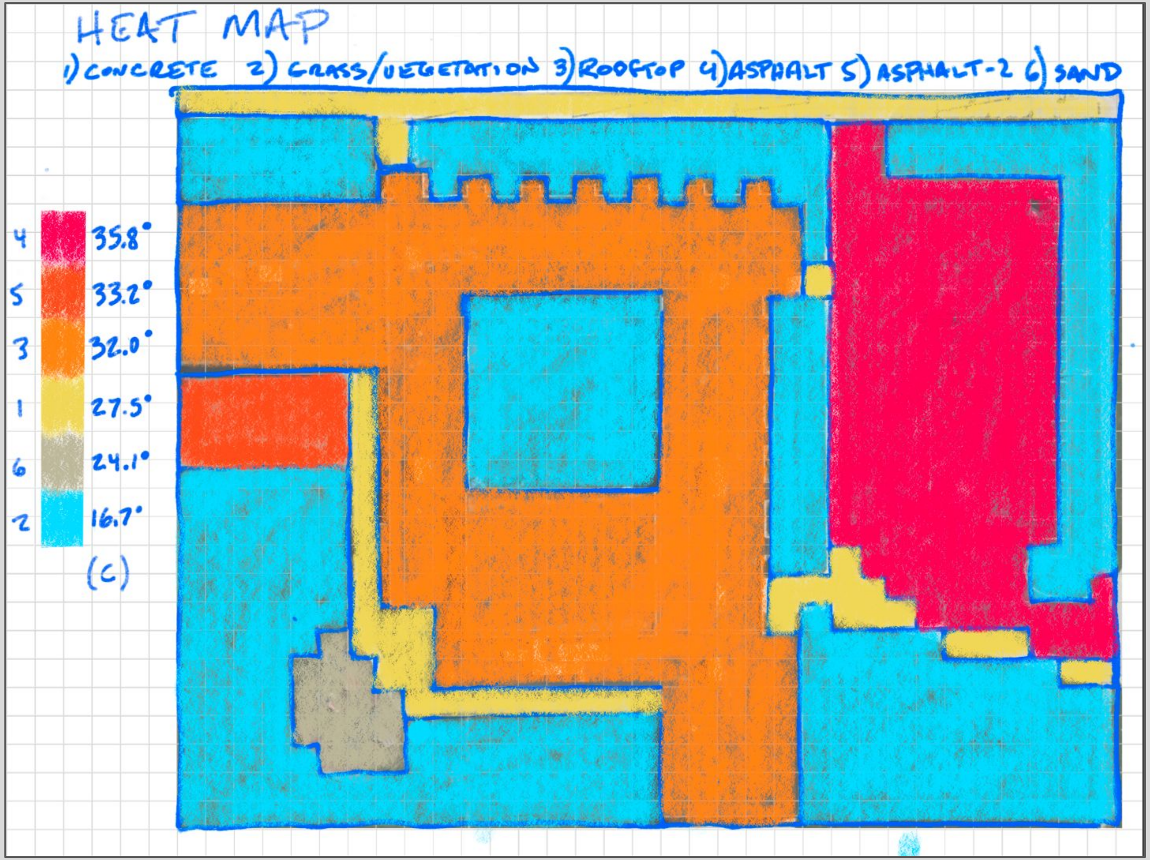
15. Color in the class areas you created in Step 8 to create a classified Surface Temperature Map using colors which represent the surface temperature averages.

    Tip: Use a color ramp from cool colors (blues and greens) to warm colors (yellows and reds) to show increasing temperature as seen here.

    Assign the colors to each surface type according to the corresponding temperature.



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16. Calculate the average surface temperature for the entire image.
    16.1. For each surface type, multiply the number of pixels by the average temperature.
    16.2. Add all of the results, and
    16.3. Divide the total by the number of pixels in the image.

CALCULATE AVERAGE SURFACE TEMPERATURE

MATERIAL	CELLS		TEMP		
1) CONCRETE	73	×	27.5°C	=	2,007.5
2) GRASS/VEG	357	×	16.7°C	=	5,961.9
3) ROOFTOP	266	×	32°C	=	8,512.0
4) ASPHALT	129	×	35.8°C	=	4,618.2
5) ASPHALT 2	18	×	33.2°C	=	597.6
6) SAND	15	×	24.1°C	=	361.5
	858				22,058.7

22,058.7 ÷ 858 = 25.7

AVERAGE SURFACE TEMPERATURE OVER FULL IMAGE = 25.7°C

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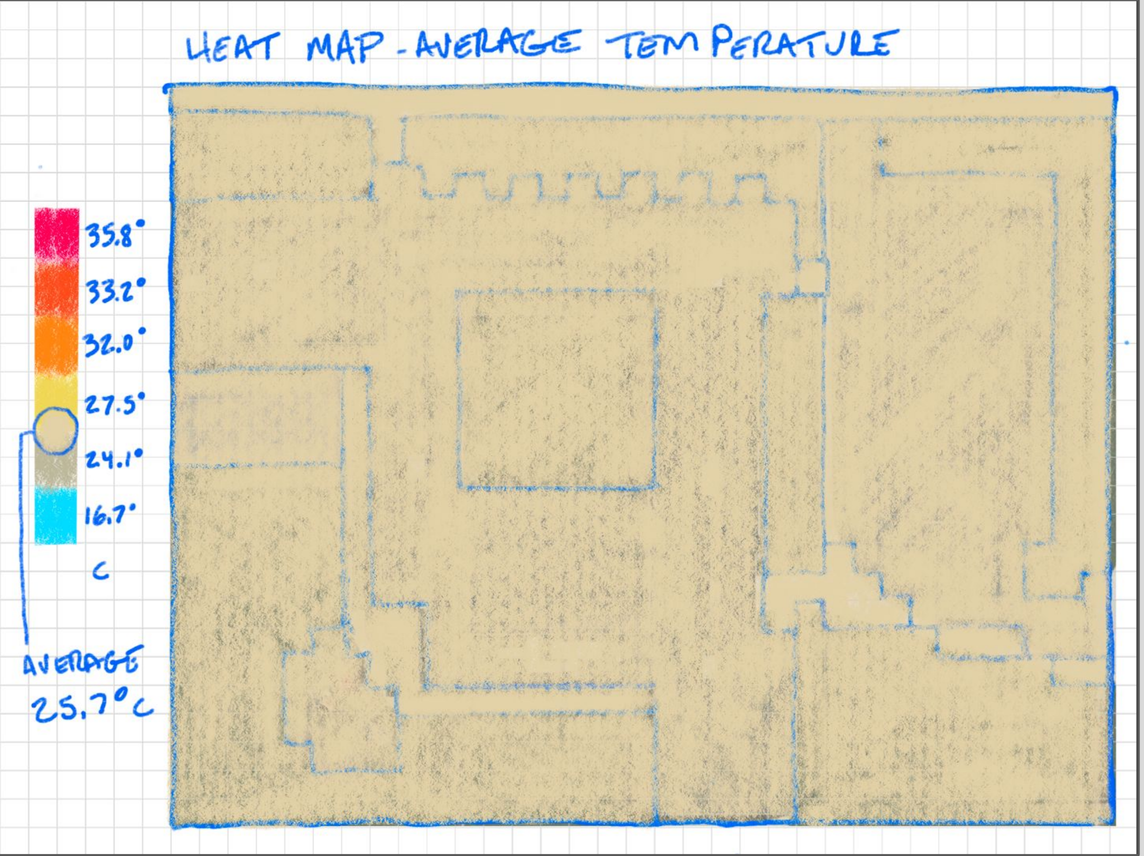
Average Temperature image

Each gridded cell (pixel) in this image is ~ 3m^2 on the ground. (This was calculated using the measurement tool in Google Earth, where the image came from).

The total area in our image is about 78m x 99m.

The native resolution of a single pixel in a Landsat thermal band is 100m x 100m. So our entire study area could fall within a single pixel!

Landsat thermal imagery is now available in 30m resolution. To approximate what our image would look like at this scale, we will create a grid of 30m x 30m cells.



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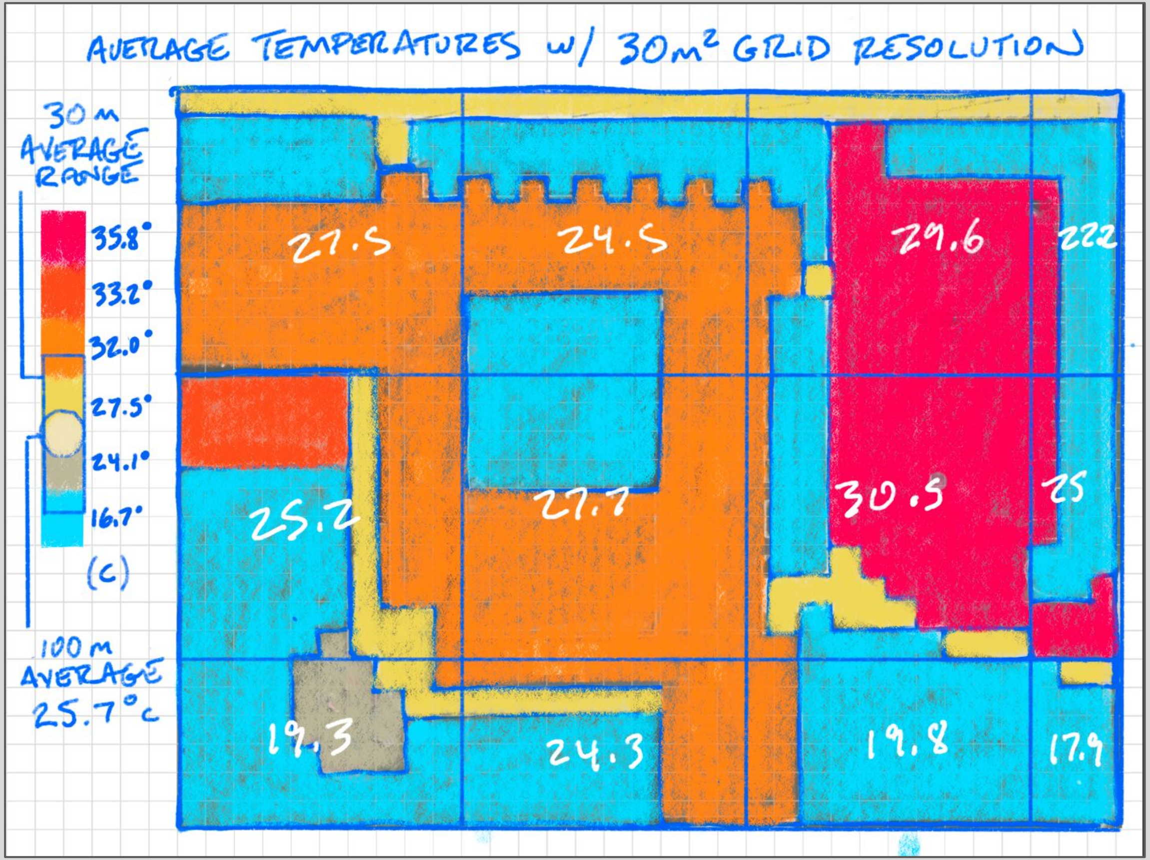
17. Create a 30m x 30m Resolution Image
    17.1. Divide the image into 10x10 cell blocks (~30m^2). (Recall that each gridded cell (pixel) in this image is ~ 3m^2.)
    17.2. Count the pixels of each class within the new cells, add the temperatures for each pixel and divide by the number of pixels (100) within each new cell.

Note - if there are not enough cells for the entire image to be evenly divided into 10x10 cell blocks, you can average the available cells as shown here in the bottom row and the right column.



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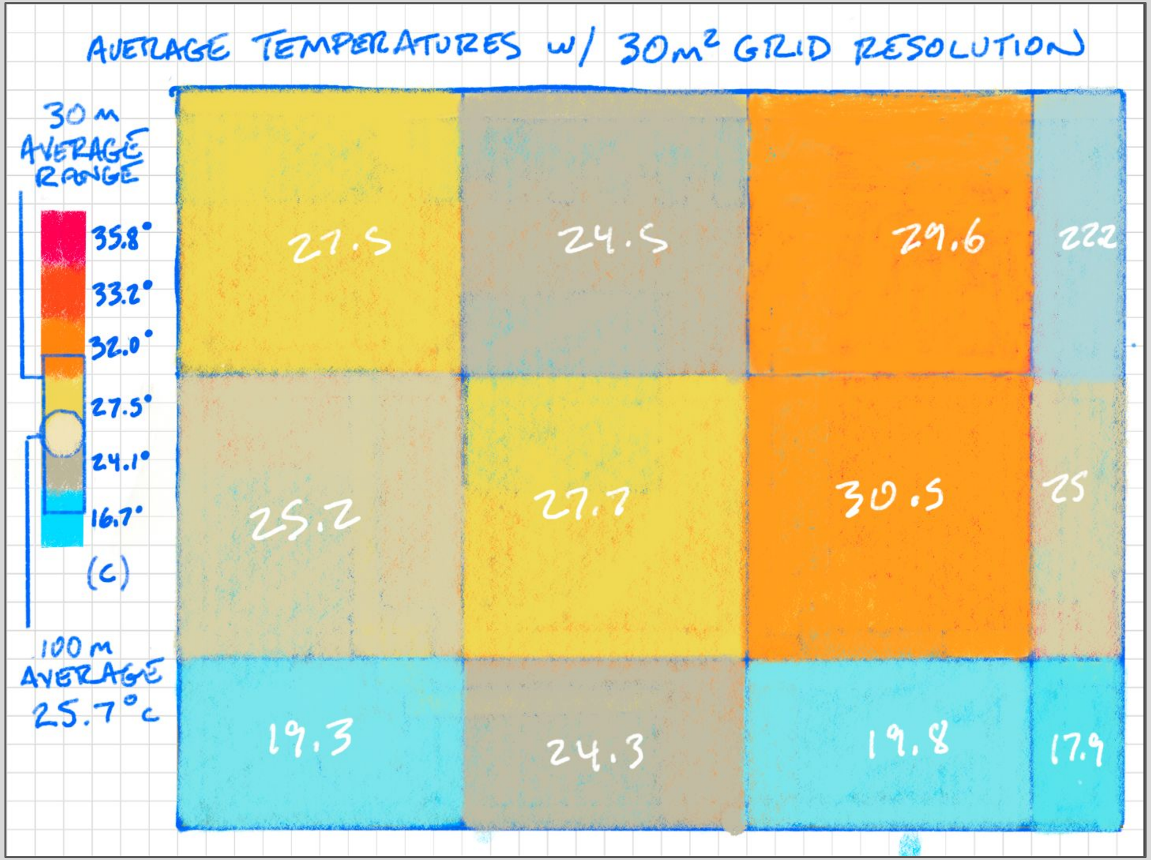
18. On a new sheet of graph paper, draw the grid you just created and color it using the newly derived values for each cell.
19. Use the same color ramp as before.

Because the values are averaged in each cell, the range of temperatures appears more narrow than in the original surface temperature map.

This is our study area at the resolution of a satellite image with 30m^2 pixels.

How does this compare to the previous images with 3m^2 and 100m^2 pixels?

Why is it important to gather this information at different scales?



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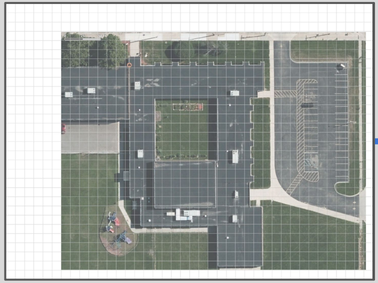
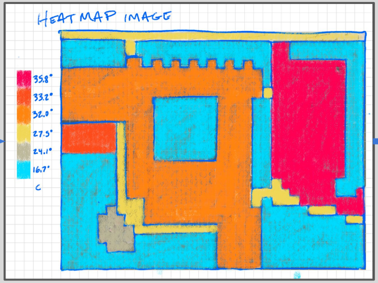
Questions…

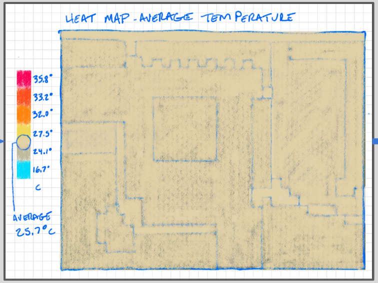
- What could be done to change the overall temperature of your study area to help mitigate the urban heat island effect?
- What changes might make it worse?
- How could you demonstrate that with a model?
- What effect might clouds play in surface temperatures? (Try collecting data on both sunny and cloudy days)



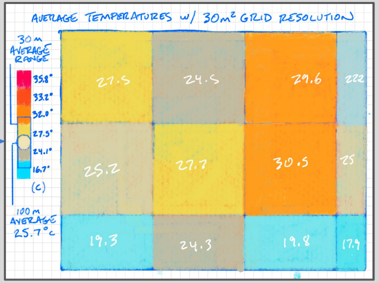
Gridded image (~3m^2 per pixel)



Heat map (~3m^2 per pixel)



Heat map (~100 m^2 per pixel)



Heat map (~30 m^2 per pixel)