

Overview

In this exercise, we will take a dataset collected with an AREN TerraROVER and UHIP and import it into QGIS. QGIS is a powerful Geographic Information System (GIS) application that allows you to process and analyze spatial datasets on their own, and in relation to other spatial datasets through the use of layers.

The UHIP has an onboard GPS receiver, which provides spatial coordinates (Latitude and Longitude) for each point in the dataset. This will enable QGIS to plot the data on a map. Once our data is plotted, we will symbolize it in a way that represents the range of values in the data. We will then overlay it on aerial imagery so that we can explore the relationship between the data and the surface features where it was collected.

If necessary, please download and install the latest “stable” QGIS software from this link:
<https://www.qgis.org/en/site/forusers/download.html>.

Part One: Prepare your data.

The data from the UHIP is a text-based .CSV file. In order to use it with a Geographic Information System like QGIS, you must make a small change to the file.

Open your file using a spreadsheet program such as Microsoft Excel, Google Sheets, Apple Numbers, or Libre Office Calc. Once the file is open, save it as a Comma Separated Values (CSV) file with a new name. (Ignore any workbook warnings when saving this file type in Excel.)

You will use this new file with QGIS.

Part Two: Launch QGIS, start a new project, set the CRS, and load a basemap.

1. Launch the QGIS Application
2. When it loads, open the **Project menu** and select *New*.

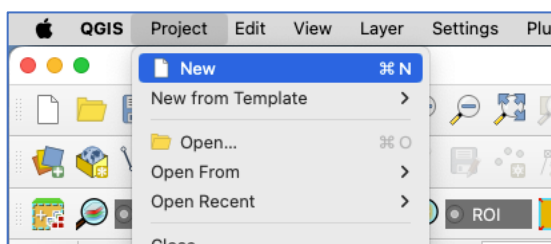


Figure 1 – Start a new Project

A new blank Project window appears (Figure 2).

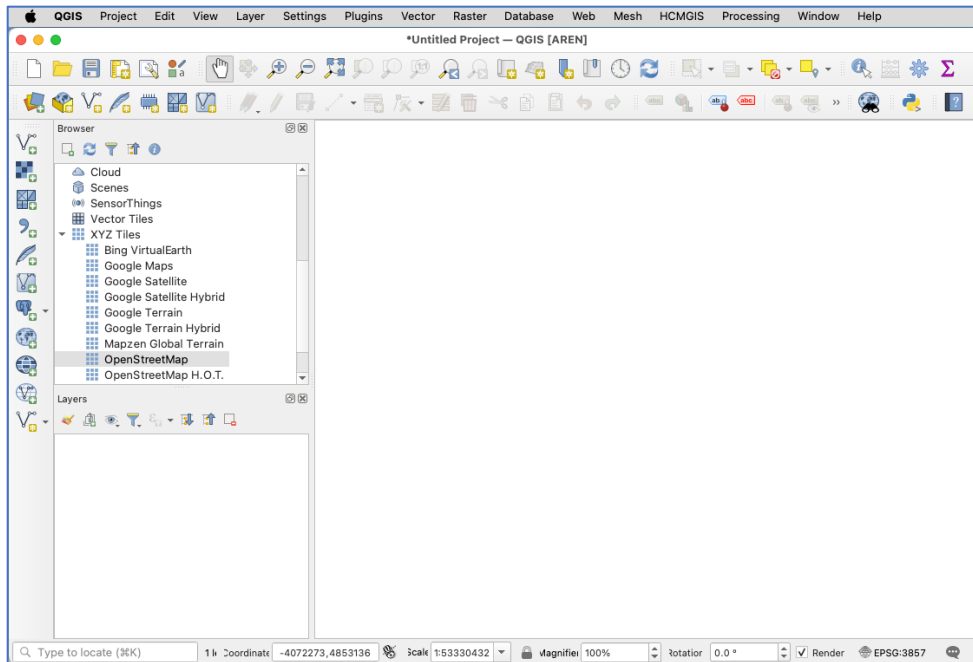


Figure 2 – New Project Window

Cartographers use coordinate systems in order to map data to the surface of the Earth. Geographic coordinate systems are used to plot x, y coordinates on the surface of the Earth. Projected coordinates determine how those locations will be projected onto a flat surface (map).

Because the Earth is roughly a spheroid (or more accurately, a geoid that is not evenly smooth), there are many different coordinate systems in use to accurately map data on local or global scales. We want to make sure that the coordinate systems we use work with our data. Before we add layers, we will set the map environment up so that the coordinate systems we use plot our data correctly.

3. Click the Settings tab in the top menu, and select Options

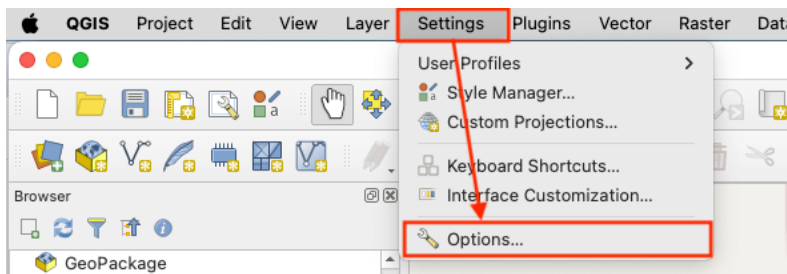


Figure 3 – Open the Options window

The options window will open.

4. Click the down arrow next to **CRS and Transforms** in the left panel, and select **CRS Handling**
5. In the CRS Handling Window, set the options as they appear in Figure 4.
 - a. Under **CRS for Projects**, check the **Use CRS from the first layer added** option
 - b. Under **CRS for Layers**, the **Default CRS for Layers** should be *EPSG:4326 – WGS 84*, and **Use default layer CRS** should be checked
 - c. Click OK

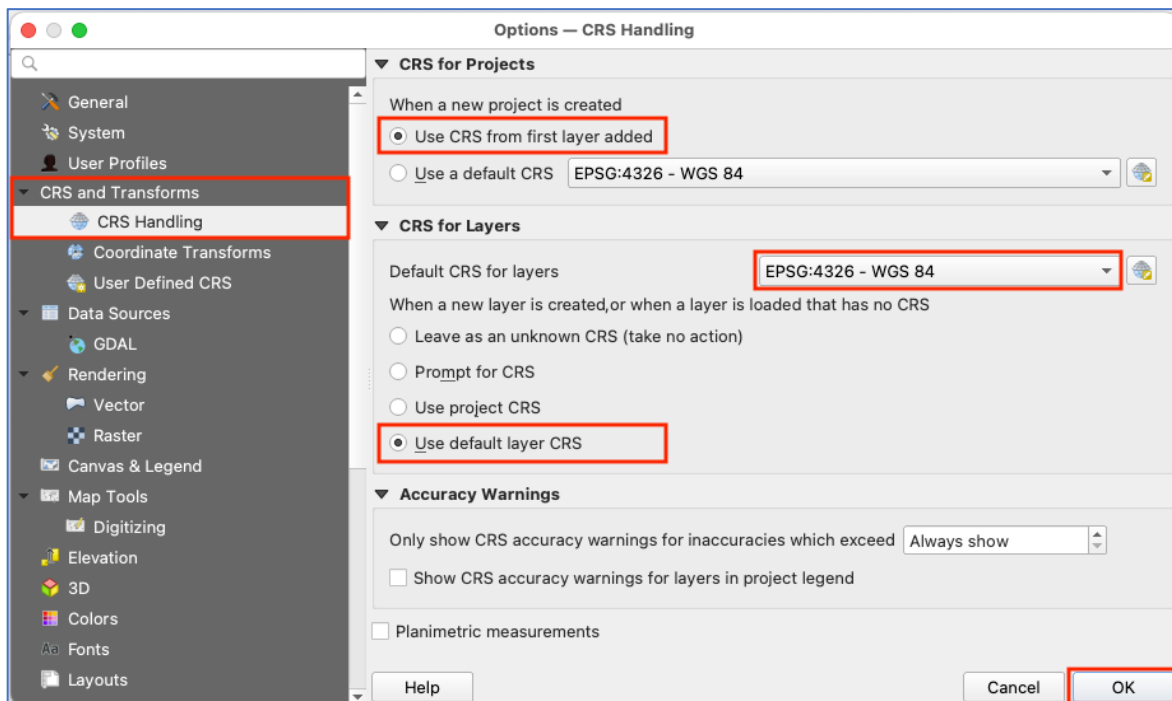


Figure 4 – Setting the Coordinate Reference System (CRS) defaults

Your coordinate reference systems should be set correctly.

6. Add a basemap.
 - a. In the browser window, click the *down arrow* next to **XYZ Tiles**. You should see a list of XYZ basemap tiles.
 - b. Drag the *Open Street Map* tile from the **Browser** window into the **Layers** window to load it in the project window. The map will update, and OpenStreetMap will appear in the Layers window.

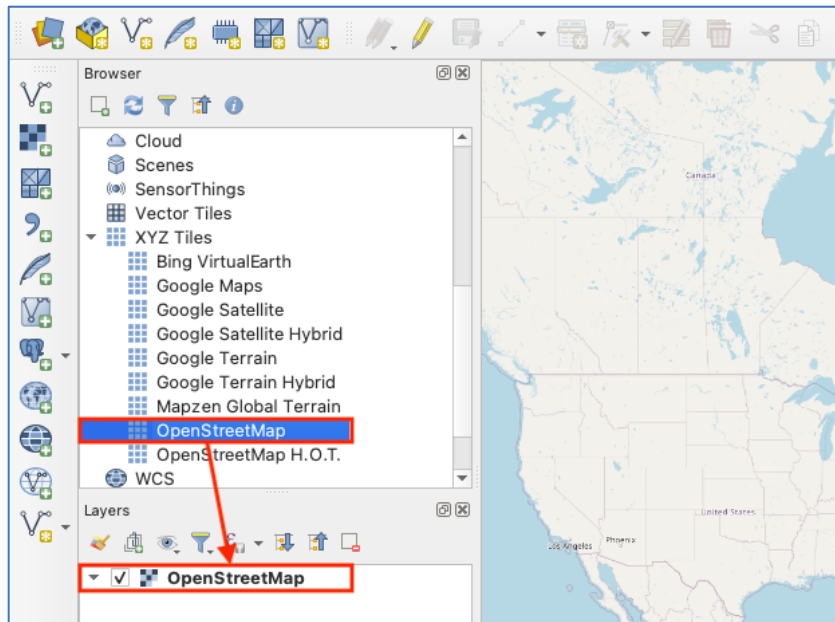


Figure 5 – Load a Basemap

The OpenStreetMap basemap now appears in the project window.

Part Three: Add your CSV file to the map as a layer.

One of the most powerful features in a GIS is the ability to add layers to a map. Layers can include many different types of spatial data, and analysis tools can be used to find relationships between data in different layers and even create new data layers from existing ones.

The two primary types of data layers used in a GIS are **Vector** and **Raster**.

A vector layer is composed of points, lines, or polygons. These are mathematical constructions that contain spatial information. Examples of vector datasets include address locations represented as points, roads or rivers represented by lines, and building footprints or property boundaries represented by polygons. The location and shape data for vector datasets are contained in their attribute tables. There can be many other attributes associated with the vector features stored in the attribute table as well. (This is the data in your CSV file.)

Raster datasets represent continuous features like terrain or aerial imagery. Rasters are arrays of data, often in pixel format, where individual pixels contain values that can be analyzed and manipulated.

In this example, we are going to add our UHIP CSV data to the map. The UHIP data contains longitude and latitude information for each point, which was obtained by the GPS receiver on the UHIP instrument.

Start by finding the approximate location where your data was collected. If you know the location name or address, you can type it into the search box in the lower left of the project window.

- Find the **Type to locate** search field in the bottom left corner of your project window. Click on the Search icon to be sure the **Nominatim Geocoder** is selected. The geocoder is a tool that searches the map for address locations. (Figures 6 and 7)

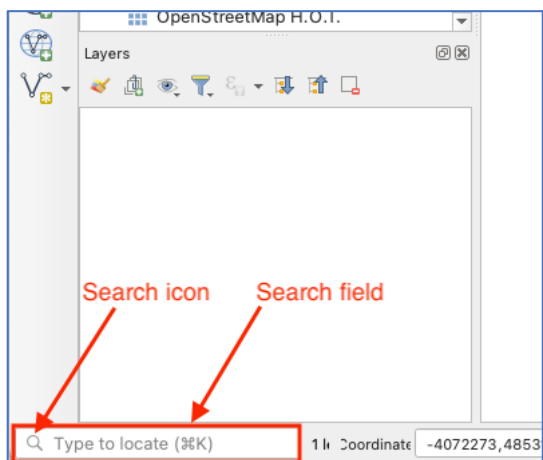


Figure 6 – Search field and icon

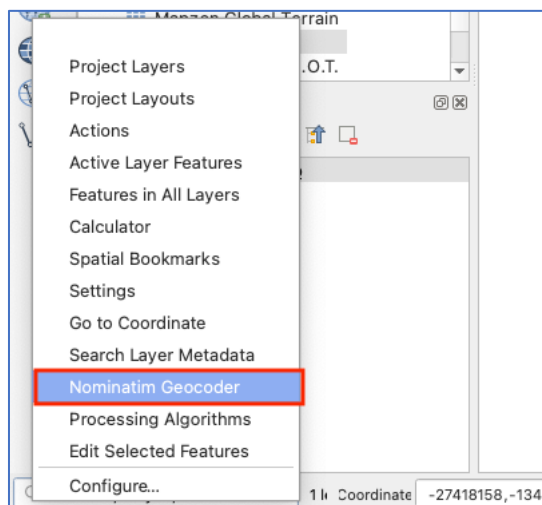


Figure 7 – Select the Geocoder

- After you select the geocoder, type the address into the field and select it from the list of candidates that appears.

The map should jump to the address location. You will probably need to adjust the location somewhat. To center the map over your target area, use your scroll wheel to zoom in and out, and hold down on your left mouse button and drag to pan or move around the map.

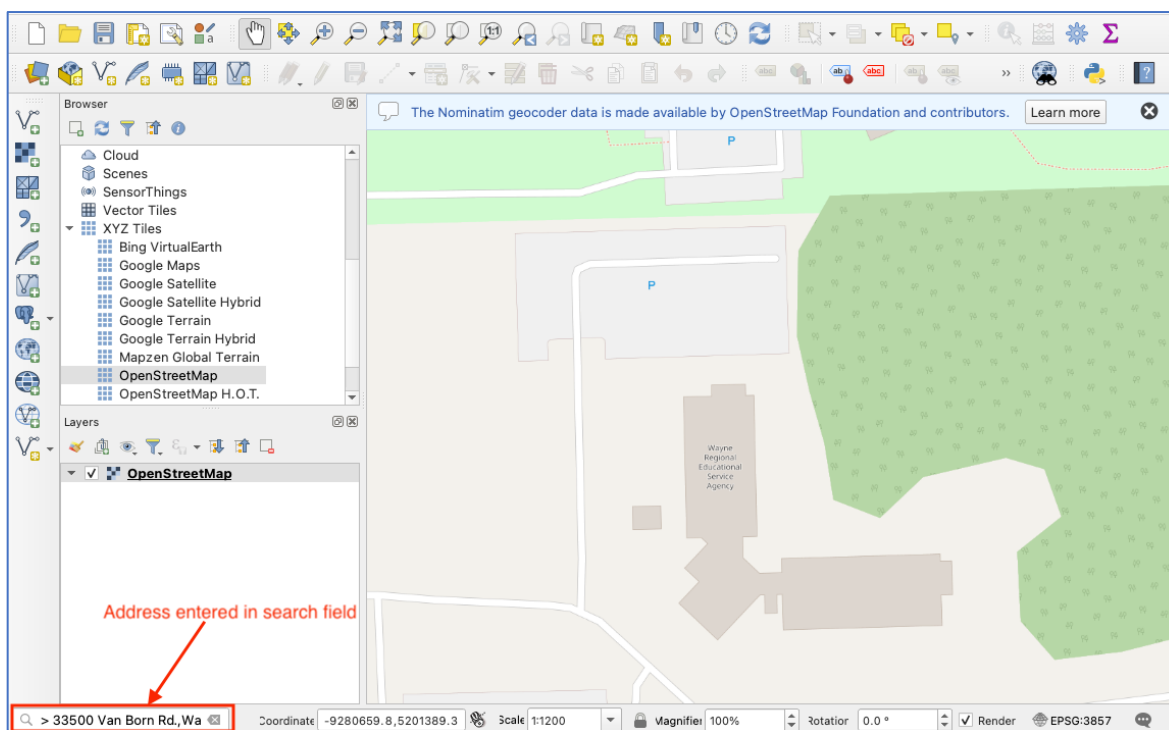


Figure 8 – Enter address and map jumps to location

Now we will proceed to add our UHIP data. UHIP data is in CSV (Comma Separated Values) format. This is a type of delimited text file, in which the attributes are separated by a delimiter (in this case, a comma). We will import the file as a Delimited Text Layer. The software will use the Longitude and Latitude attributes in the file to create a point feature vector layer in the map.

9. Select **Layer > Add Layer > Delimited Text Layer** from the top menu. (Figure 9)

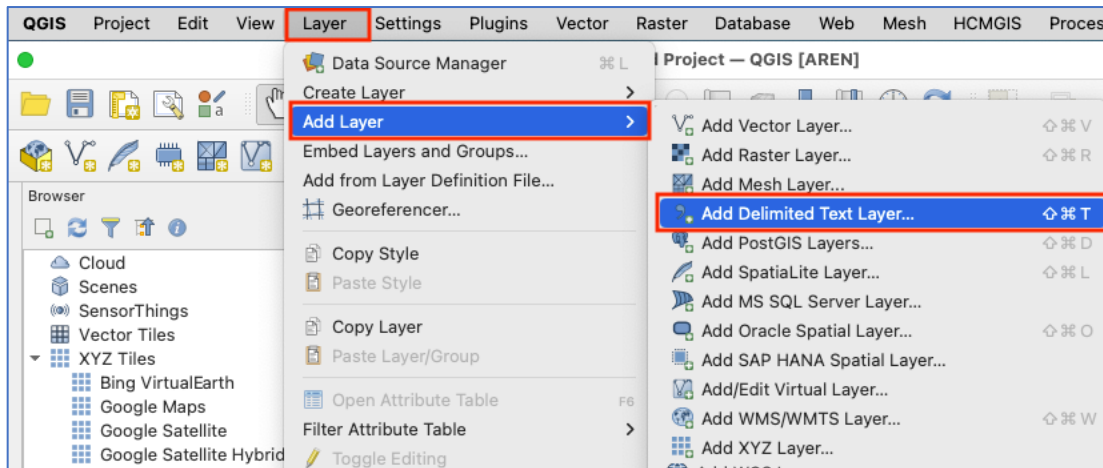


Figure 9 – Add Delimited Text Layer

The Data Source Manager window opens

10. Confirm that Delimited Text is selected in the left panel, then click on the ellipsis (•••) button in the upper right to navigate to your UHIP data file (Figure 10)

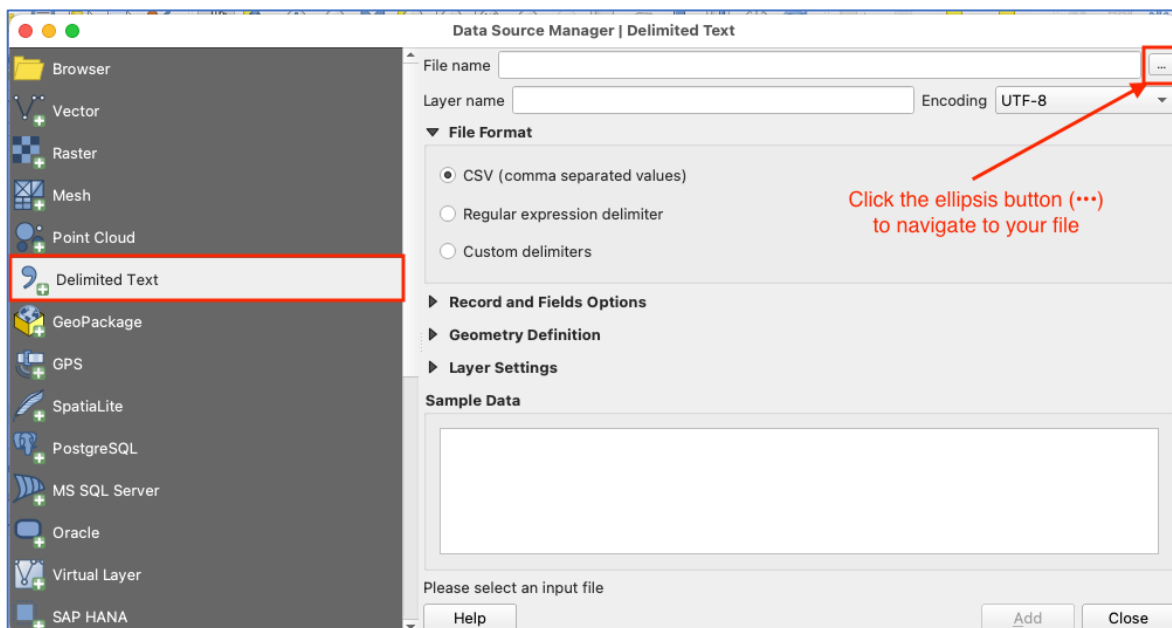


Figure 10 – Data Source Manager / Delimited Text

11. In the pop-up window, navigate to your saved UHIP CSV file. Select the file and click Open (Figure 11).

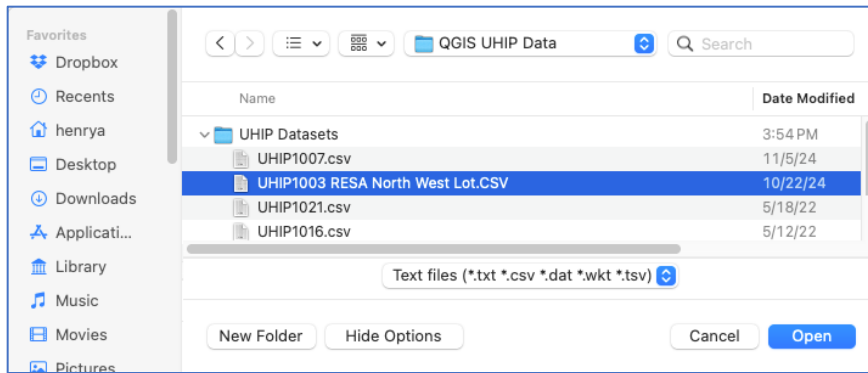


Figure 11 – File Navigation window

The Data Source Manager | Delimited Text window will update.

12. Examine the window and ensure the following parameters are set (as seen in Figure 12).

- The path and imported file name are listed under **File Name**
- The **File Format** is CSV (Comma Separated Values)
- Click the arrow next to **Geometry Definition** (if it is not open).
- The **Point Coordinates** should be checked
- The **X field** should be **Longitude**
- The **Y field** should be **Latitude**
- The **Geometry CRS** should be **EPSG:4326 - WGS 84**
- You should see a sample of your data in the **Sample Data** window.

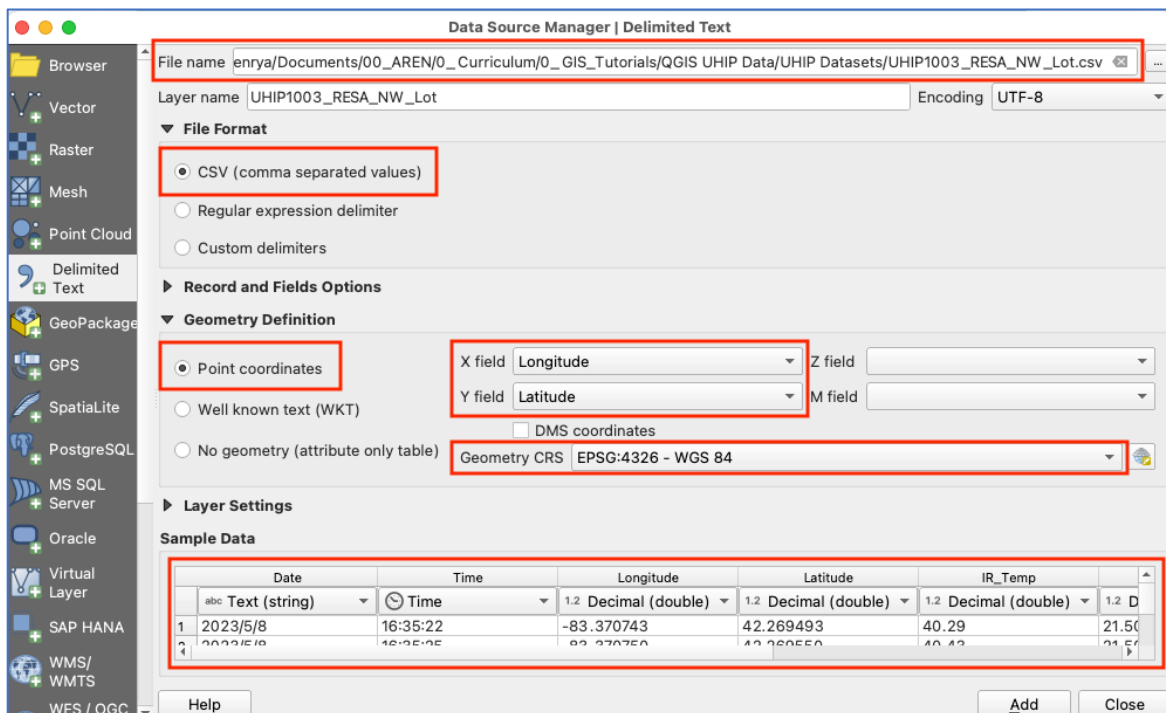


Figure 12 – Data Source Manager | Delimited Text settings

13. When the settings look correct, click **Add**

14. Close the Data Source Manager window

A new data layer will appear in the Layers window, and the data points will appear in the map window.

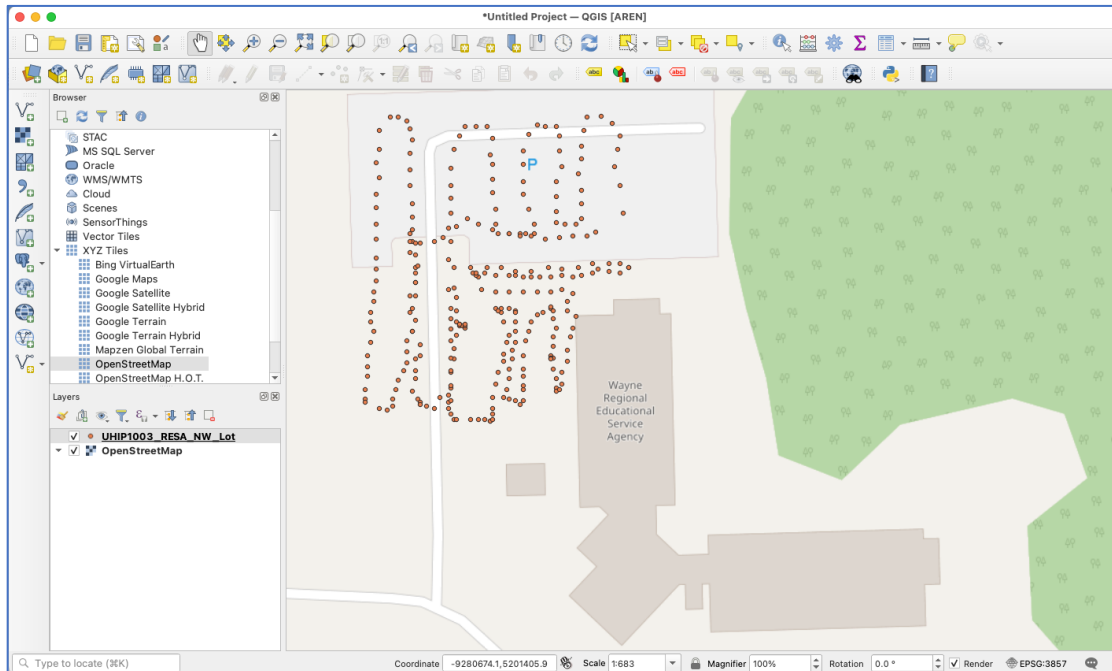


Figure 13 – UHIP data added to the map

15. Right-click on the layer name in the **Layers panel** and select **Zoom to Layer(s)**.

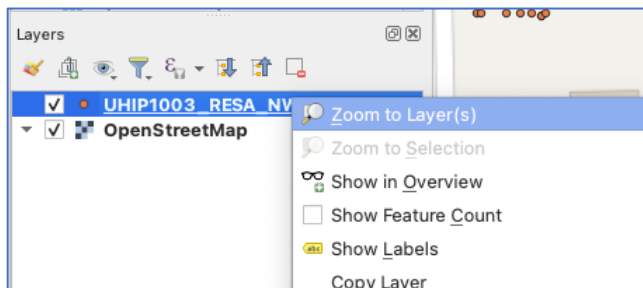


Figure 14 – Zoom to your UHIP layer

Your data layer is now centered in the window. Let's take a closer look at the data.

Part Four: Explore your data.

16. Locate the **Identify Features** button in the menu bar and select it. (Figure 15)

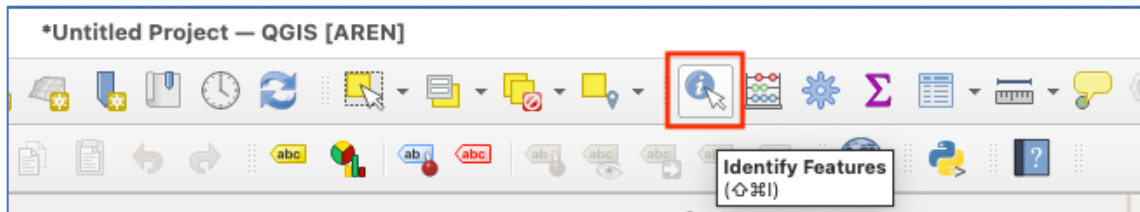


Figure 15 – Select the Identify Features tool

17. Click on a data point in the map

A panel will open on the side and display the attribute data associated with that point. (Figure 16). Examine the values in the fields. Try clicking on a few others. Closes the panel when you are finished.

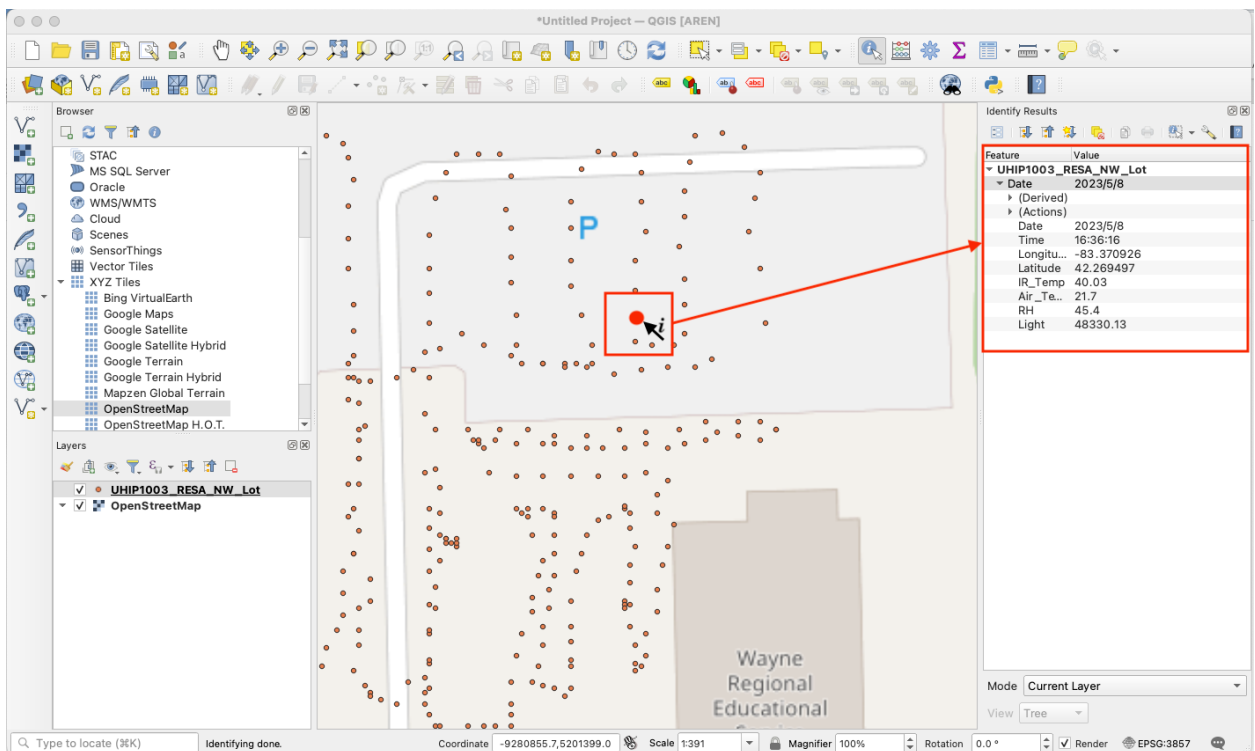


Figure 16 – Attribute data for a point

18. To see all of your attribute data in table format, click the **Open Attribute Table** button

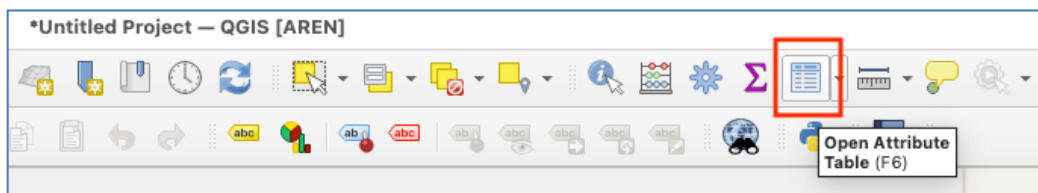


Figure 17 – Open Attribute Table button

A table will appear with all of your attributes (Figure 18). This should look familiar – much like viewing your data in a spreadsheet.

	Date	Time	Longitude	Latitude	IR_Temp	Air_Temp	RH	Light
1	2023/5/8	16:49:50	-83.370819	42.269455	42.31	20.3	48.5	60038.2
2	2023/5/8	16:49:47	-83.370842	42.269447	41.19	20.2	48.7	61461.18
3	2023/5/8	16:49:44	-83.37088	42.269447	41.25	20.1	48.7	60130.37
4	2023/5/8	16:49:41	-83.370918	42.269444	28.89	20.2	49.1	17019.95
5	2023/5/8	16:49:38	-83.370956	42.26944	23.75	20.2	49.3	12053.52
6	2023/5/8	16:49:35	-83.370995	42.269447	25.91	20.3	49.7	15634.61
7	2023/5/8	16:49:32	-83.371025	42.269447	32.45	20.4	50	59267.24
8	2023/5/8	16:49:29	-83.371056	42.269451	28.51	20.4	50.7	21365.54
9	2023/5/8	16:49:26	-83.371101	42.269459	42.45	20.3	50.7	59163.84

Figure 18 – Attribute Table

There are several tools in the attribute table header. For now, we will work with the **Filter/Select tool** to find the hottest surface temperatures in our data.

If we scroll through this attribute data, we will see that the values in the **IR_Temp** field (the surface temperature field) range from 17.47°C to 42.25°C. We would like to see where the hottest values are on the map – say everything over 40°C.

- Click on the **Select/filter features** button in the attributes table menu (Figure 18).

Figure 19 – Select/filter features button

The table changes to a form.

- Enter “40” into the **IR_Temp Field**, then click the “**Exclude Field**” button to the right of the **IR_Temp field** and select the “**Greater than (>)**” option from the dropdown. (Figure 20)

Figure 20 – Filter form with Greater than (>) selected for IR_Temp field

21. Click the **Select Features** button in the lower right of the window and choose **Select Features** from the dropdown menu.

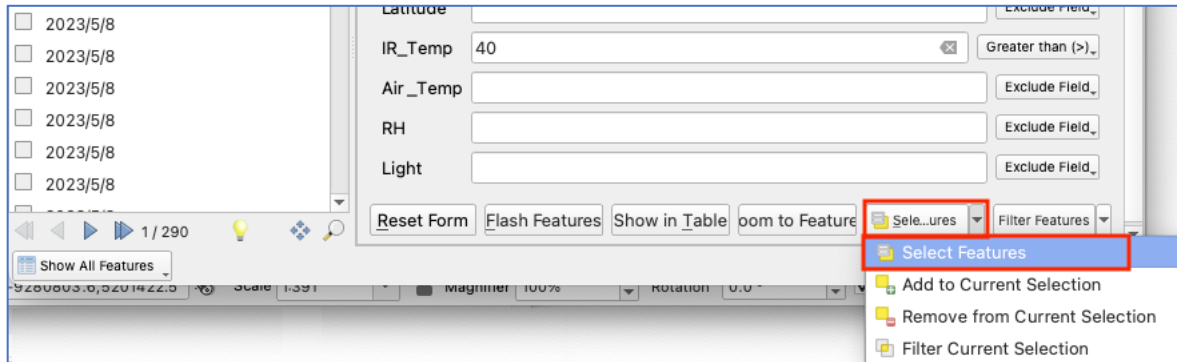


Figure 21 – Select Features button and dropdown

Your map will now highlight in yellow all the points where the measured surface temperature (IR_Temp) is over 40°C. (Figure 22) You may need to move the form window to see all of your data points.

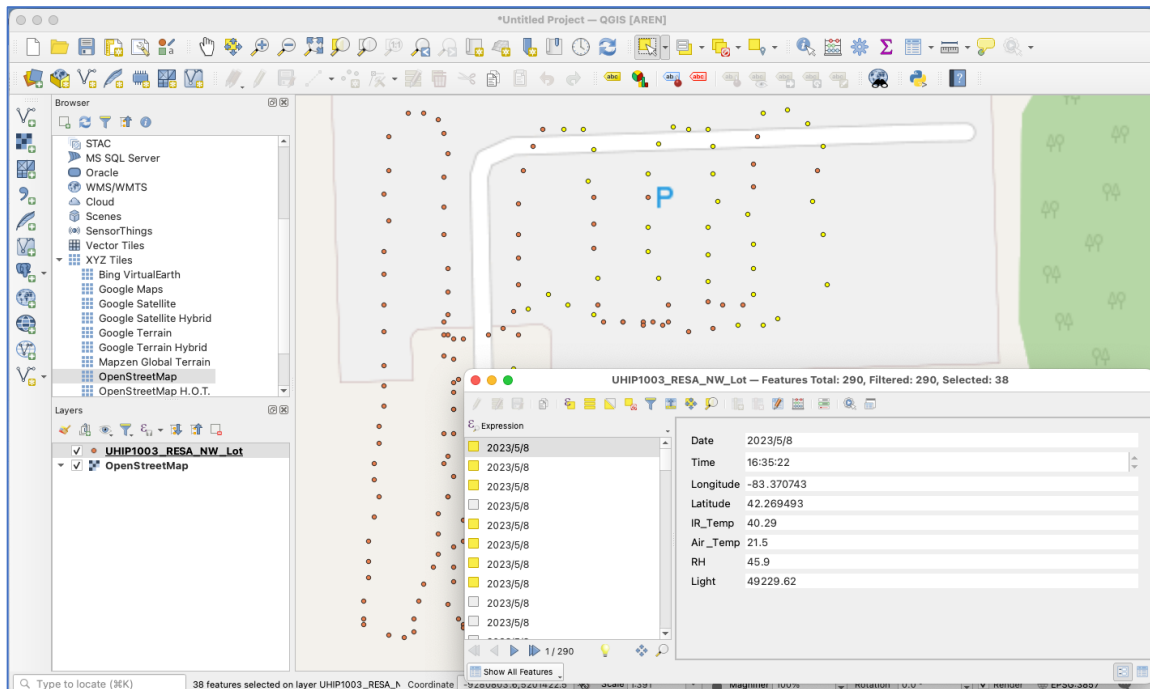


Figure 22 – Selected data points with surface temps over 40°

You can build simple or complex filters to quickly explore many aspects of your data. This is just a quick example.

22. Click the **Deselect all features** button.

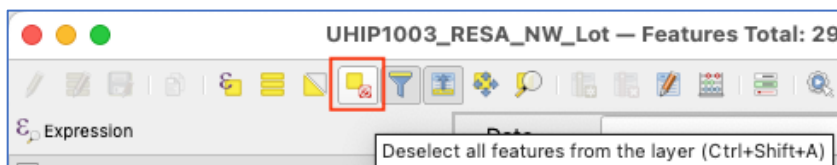


Figure 23 – Deselect data points

23. Close the attribute table/form window

Part Five: Add a satellite imagery basemap and symbolize your data to reflect an attribute.

The TerraROVER UHIP collects data from the surface features you drive over and the atmosphere directly above them. Our data is currently plotted over a street map, which does a good job of showing the location of the data, but it would be more meaningful if we could see the actual surface features over which we collected the data. Then we could begin to make inferences about the relationship between surface feature types and our measurements.

We will add a layer of satellite imagery as a basemap.

24. Click the **HCMGIS** tab in the menu bar, and select **Basemaps > Bing Virtual Earth**. You could also select Google Satellite or Esri Satellite Imagery from the dropdown if you prefer. **If the HDGMIS tab is not available, follow the steps in the Appendix (page 18) to activate it.**

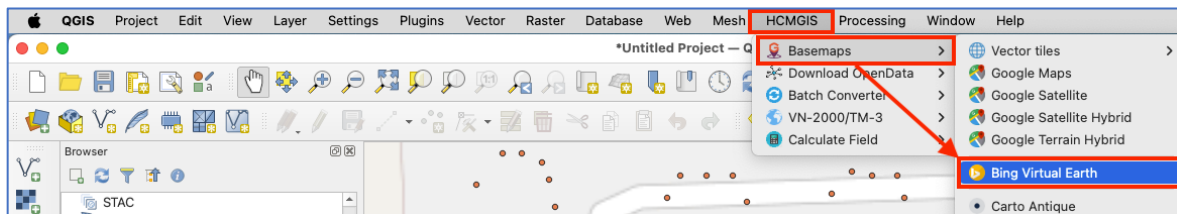


Figure 24 – Add Basemap from HCMGIS menu

Bing Virtual Earth appears in the Layers Menu and in your map window. (Figure 24)

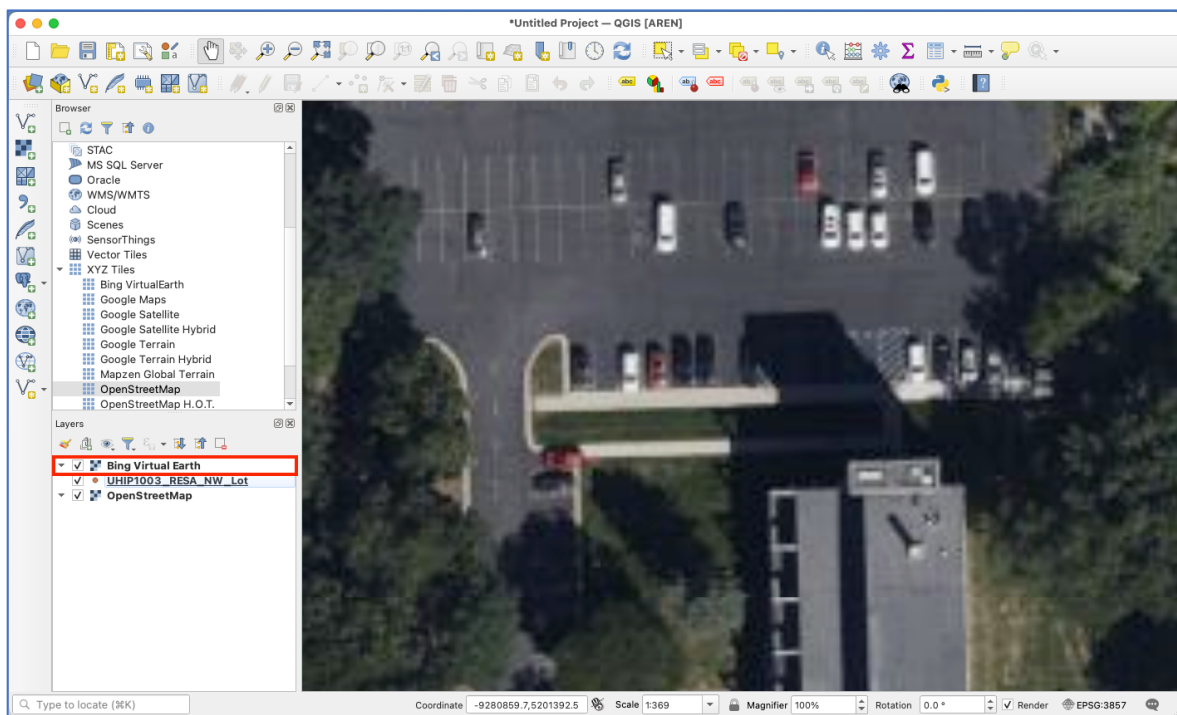


Figure 25 – Bing Virtual Earth added to Layers

When you add a new layer in QGIS, it appears at the top of the layers list by default. Unfortunately, it is covering up our UHIP data layer. We will reorder layers in the **Layer** menu to expose our data.

25. Use your mouse to grab the UHIP data layer in the Layers menu and drag it to the top of the list. Uncheck the OpenStreetMap layer as well. (Figure 26.)

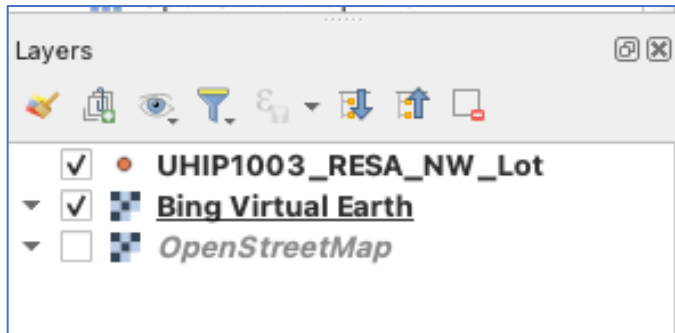


Figure 26 – Reorder layers

The UHIP data now appears above the satellite imagery.

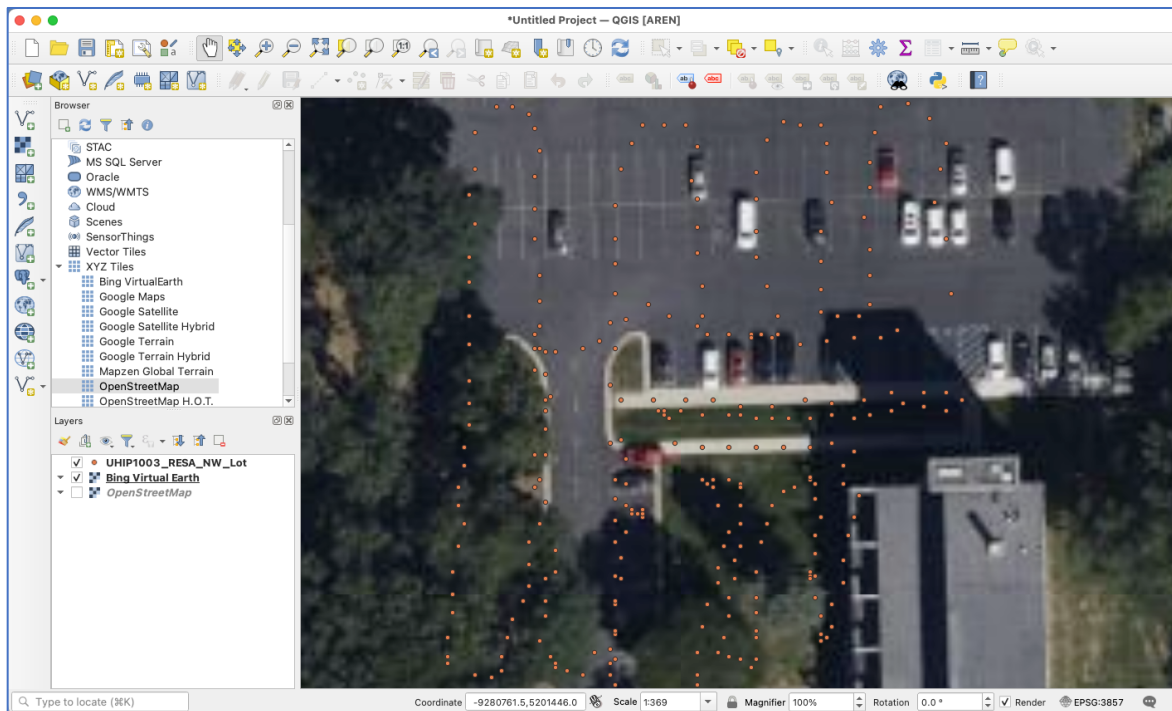


Figure 27 – UHIP data on top of satellite imagery

We can now see our data points overlain on imagery of the surface feature. Next, we will symbolize our data so that the data point colors represent an attribute of the data. We will use a color ramp to symbolize the **IR_Temp** (surface temperature) attribute.

26. Right-click on the layer name and select **Properties** from the dropdown

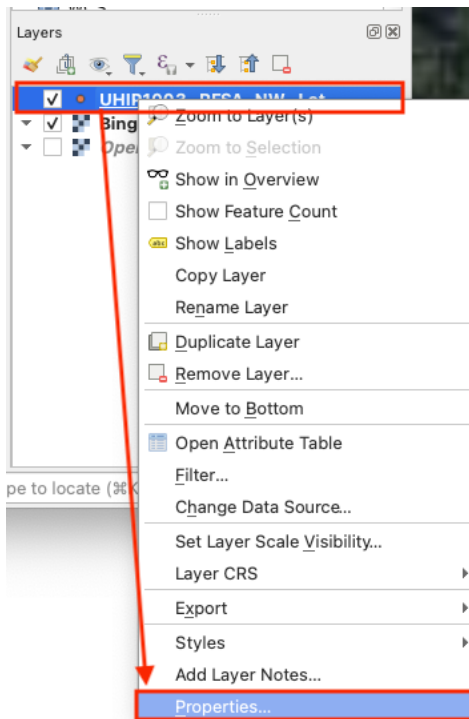


Figure 28 – Open Layer Properties

27. Click on **Symbology** on the left panel of the **Layer Properties** dialogue window.

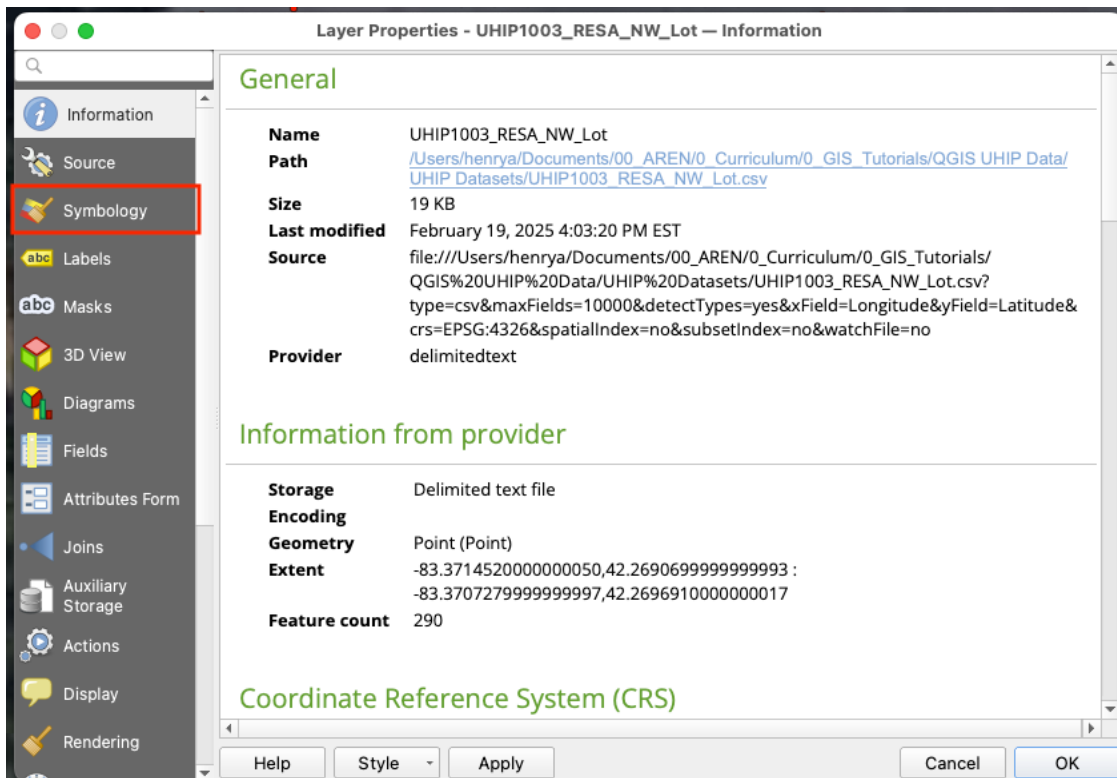


Figure 29 – Open Layer Properties – click on Symbology

The **Symbology** panel opens. (Figure 30)

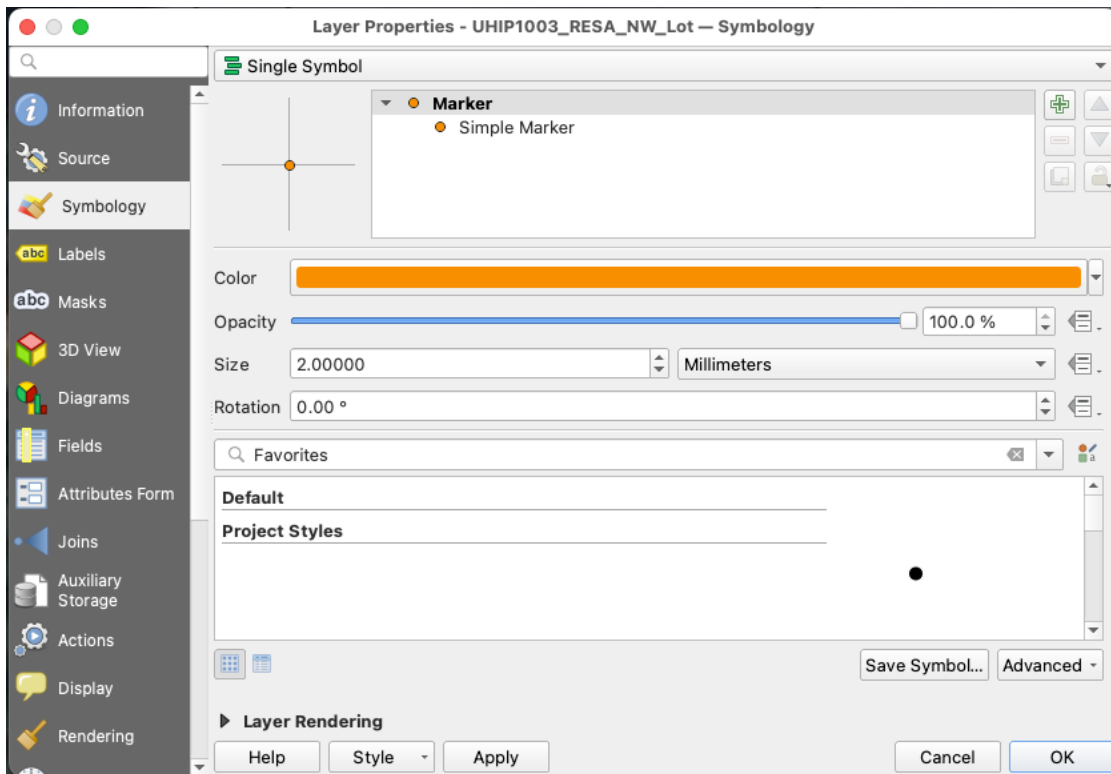


Figure 30 – Symbology Panel

Currently, all of the data is represented with a single symbol. We want the symbols to represent the range of our surface temperature data, so we will change this to graduated symbols and use a color ramp that bins the data into 5 equal interval classes from low to high.

28. Make the following adjustment to the settings (refer to Figure 31 on the next page):
 - a. Click on the "**Single Symbol**" dropdown and select "**Graduated**" from the list.
 - b. Select a variable from the **Value** field (**IR_Temp** in our example).
 - c. Make sure **Method** is set to "**Color**"
 - d. Leave **Symbol**, **Legend format**, and **Color ramp** in their defaults for now.
 - e. Click on "**Mode**"
 - f. Select "**Equal Interval**". This creates categories, or classes, with equal intervals, which is useful for temperature data.
 - g. Set **Classes** to **5**.

QGIS selects the high and low values and divides the range into 5 equal intervals. The UHIP data in this example has a range from about 17.5°C to 42.5°C for the IR_Temp field. This is a 25°C range. If we use 5 classes, each class will span 5°. We could use 10 classes, and each would span 2.5° for a higher degree of precision. We will use 5 for now.

- h. Leave **Link class boundaries** checked
- i. Click the **Classify** button
- j. Click **Apply** to preview the changes
- k. When satisfied, click **OK**

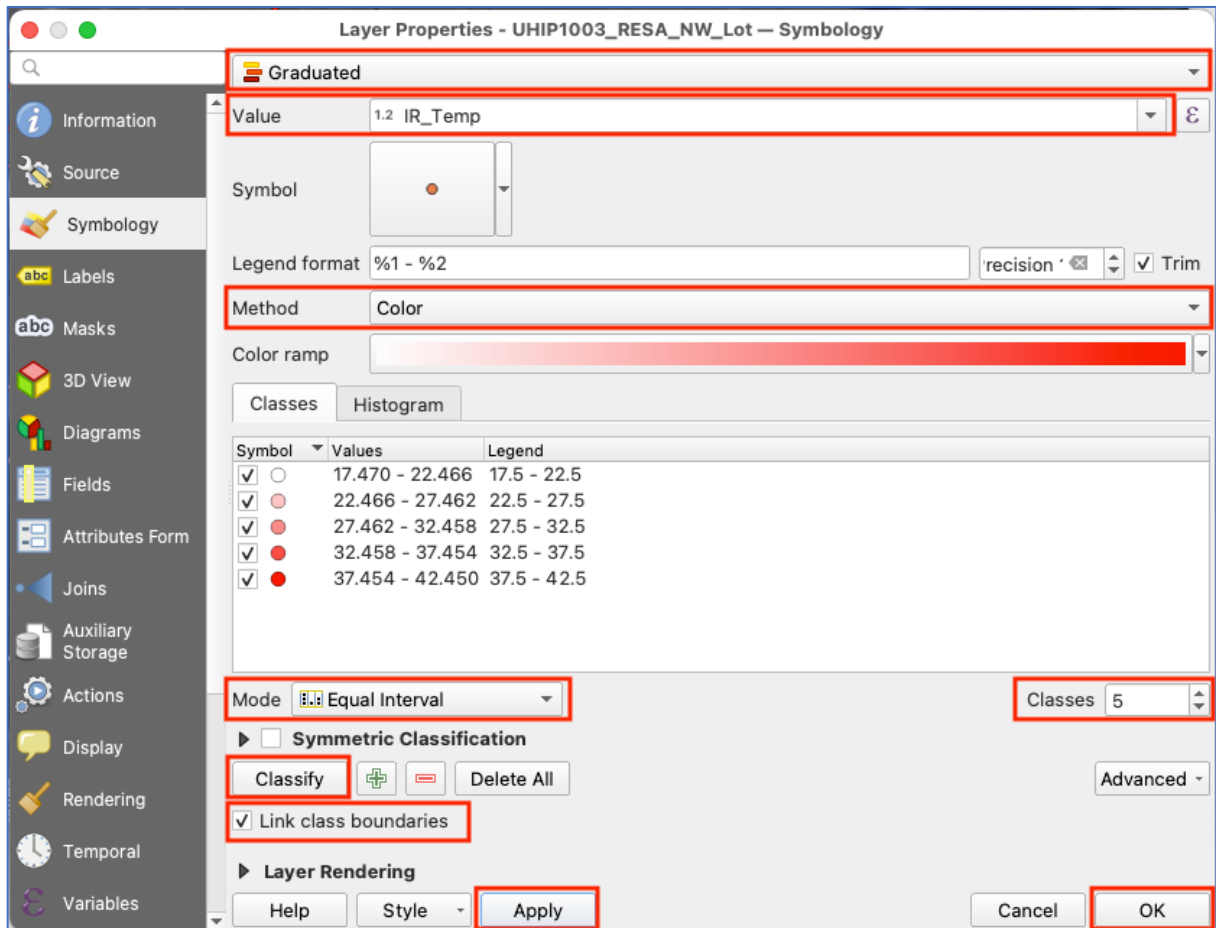


Figure 31 – Symbology Panel settings

The UHIP Data now appears with symbology that represents temperature. (Figure 32). Can you detect any patterns in how the surface temperature is distributed over land cover? Are there any surprises?

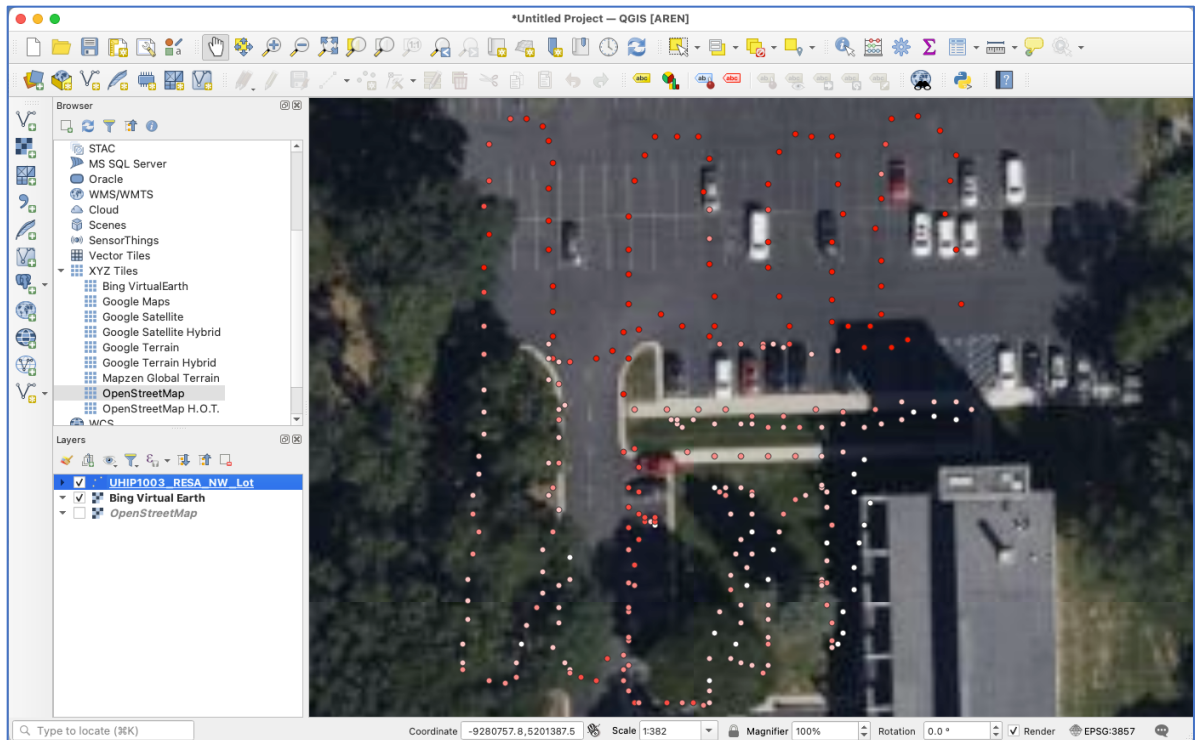


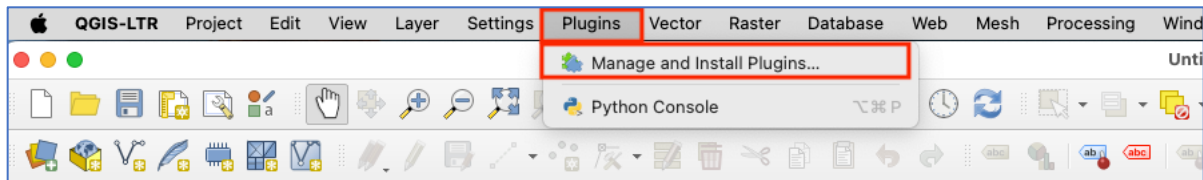
Figure 33 – Symbolized UHIP data

You can go back into the symbology panel and try different settings to see how they affect your data display. There are many possibilities. Try looking at the Air Temp field instead of IR Temp. How is it similar or different? What might explain these patterns?

Appendix: Adding Basemaps by Enabling the HCMGIS Plugin

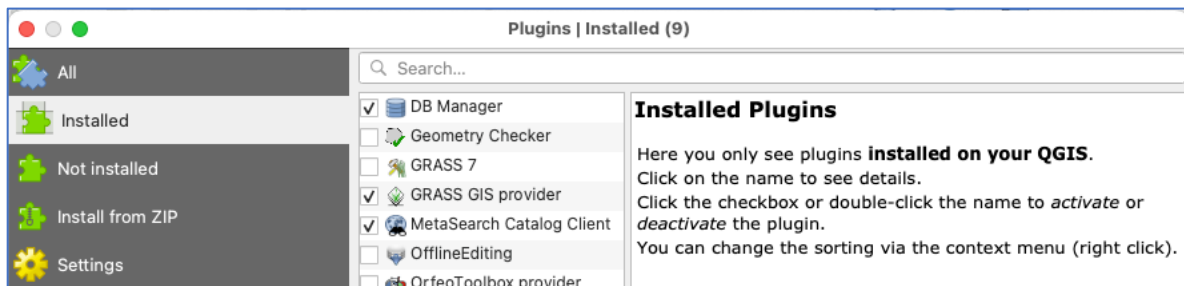
You can expand the capabilities of QGIS through the use of **Plugins**. These are add-on tools that have been developed to allow QGIS to do tasks that aren't included in the base installation. We are going to enable and use the HCMGIS plugin to add basemaps to our map.

- 1) Click **Plugins** in your menu bar and select "**Manage and Install Plugins...**" from the dropdown menu



Appx. B: Fig. 1 – Select the Manage and Install Plugins window

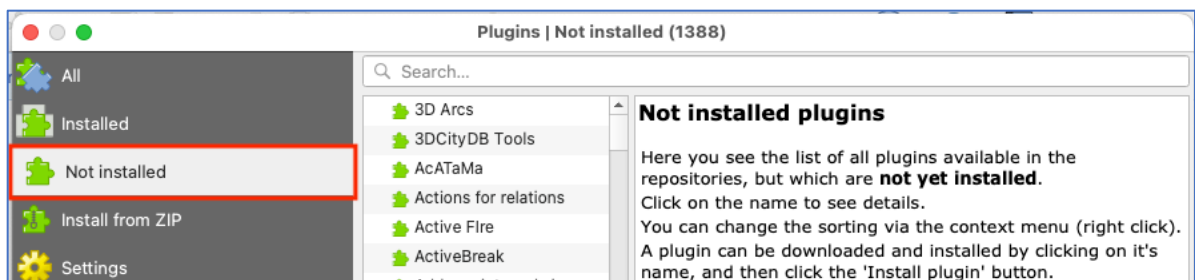
- 2) In the pop-up window, click on the **Installed** tab.



Appx. B: Fig. 2 – Installed Plugins list

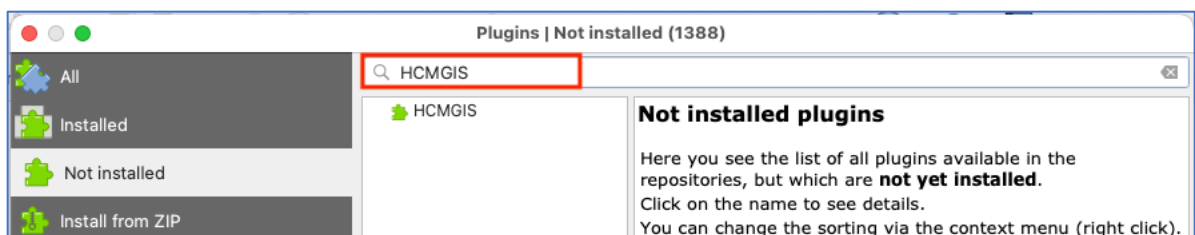
If you see the **HCMGIS** plugin listed, make sure its box is checked, close the window and skip ahead to Step 7.

- 3) If you do not see HCMGIS listed, click on the **Not Installed** tab.



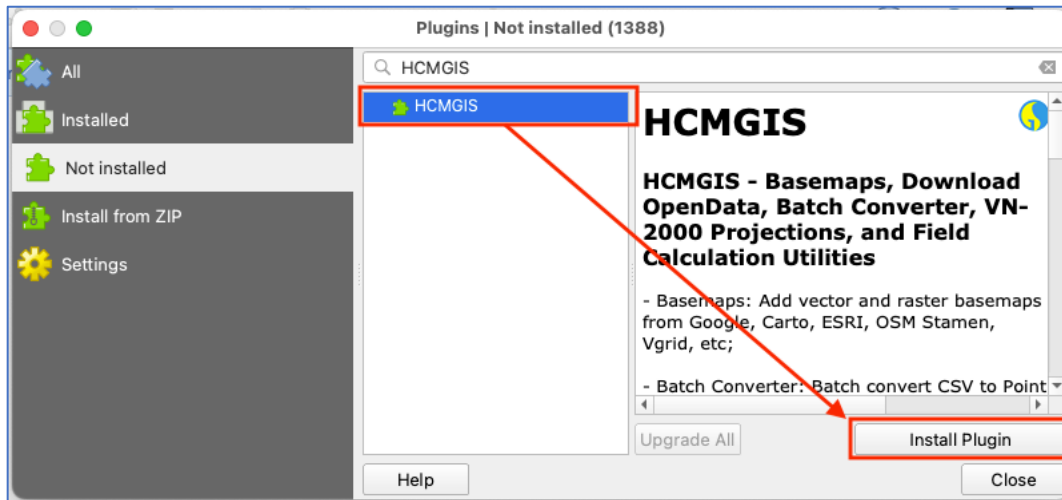
Appx. B: Fig. 3 – Not Installed Plugins list

- 4) You will see a long list of plugins. To make finding ours easy, type **HCMGIS** into the search bar at the top of the window.



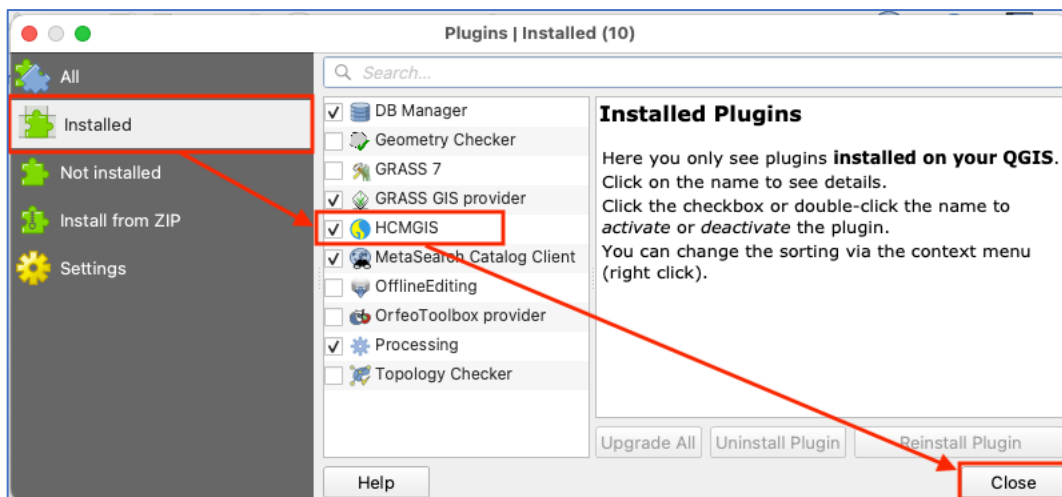
Appx. B: Fig. 4 – Search for HCMGIS plugin

- 5) Now only the HCMGIS plugin appears. Select it, then click **Install Plugin**



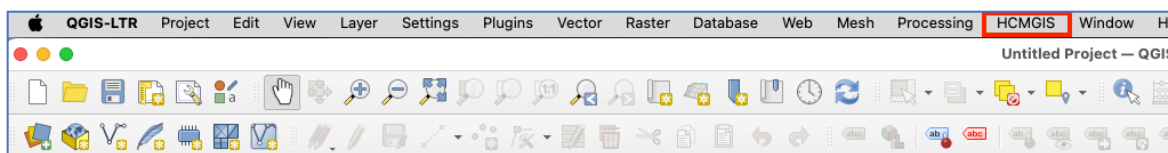
Appx. B: Fig. 5 – Install the HCMGIS plugin

- 6) Click on the **Installed** plugins tab again, and you will see the **HCMGIS** plugin listed. Make sure it is checked, then click **Close**



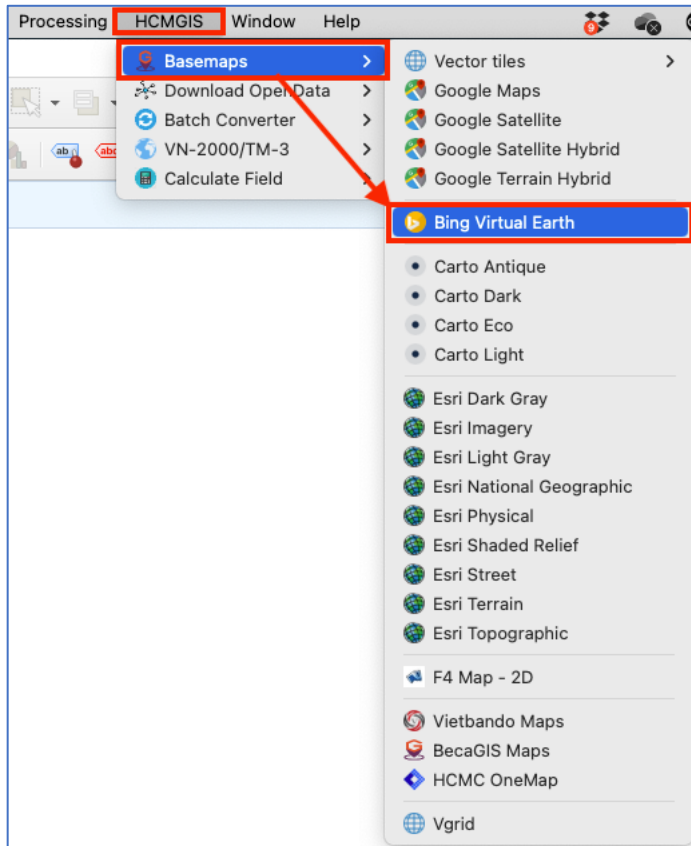
Appx. B: Fig. 6 – Confirm HCMGIS plugin is active then close window

- 7) The HCMGIS plugin now appears in your menu bar.



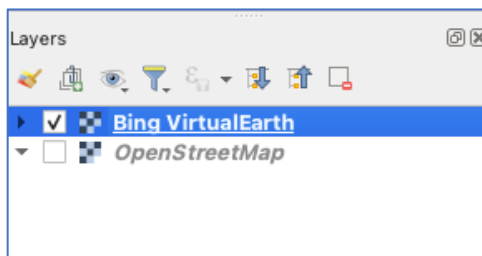
Appx. B: Fig. 7 – Locate HCMGIS plugin in menu bar

- 8) Click on HCMGIS. In the dropdown, select Basemaps, then choose one from the list. For this exercise, choose either Google Satellite or Bing Virtual Earth.



Appx. B: Fig. 8 – Select a basemap from the plugin

The newly added basemap will appear in your Layers menu and be displayed in the map window.



Appx. B: Fig. 9 – New Basemap appears in the Layers menu

Hint – you can add more than one to your map and toggle between them. You may find that at different scales, you prefer one over the other.

Now that it is installed, the HCMGIS plugin is available from the menu bar anytime you run QGIS. Just click on it and select the basemap you wish to use.