INTRODUCTION TO QGIS

PRACTICAL EXERCISE 1B

This exercise builds on Practical 1A. Its purpose is to demonstrate some of the very basic handling procedures for work sessions involving three main types of data you will be using in QGIS (i.e. vectors, rasters and ASCII-based data). The tasks that follow are designed to introduce the following:

1) Working with data files (vectors and rasters) from different sources and in different coordinate systems and projections

2) Exploring simple data selection and extraction methods

3) Working with data in ASCII format

4) Changing the properties of raster and vector data for better visualization and analysis

Instructors

- **Mr. Grahame Niles** - Remote Sensing/GIS Specialist, CIMH, Barbados
- **Ms. Elena Flórez** - Junior scientist, Agencia Estatal de Meteorología, Spain
- **Mr. Courtney Forde** - Intern, CIMH, Barbados
- **Ms. Soumaya Ben Rached** - Ingénieur des travaux, Institut National de la Météorologie, Tunisia

1 INTRODUCING RASTERS

1.1 Looking at Raster Properties

In this section you will be introduced to examples of raster datasets. The main raster files you will be working with are located in your workspace folder and listed below:

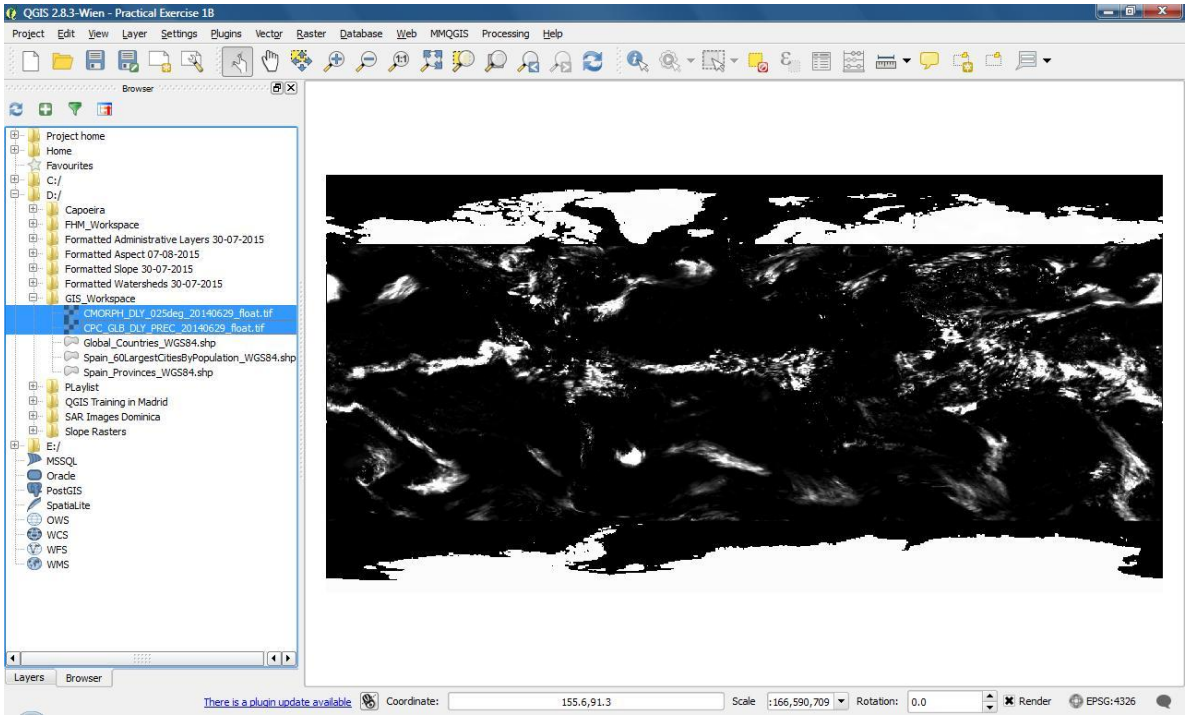
1. **"CMORPH_DLY_025deg_20140629_float.tif"** – Provides daily global rainfall estimates (in mm) at a spatial resolution of 0.25 x 0.25 degrees.

2. **"CPC_GLB_DLY_PREC_20140629_float.tif"** – Provides daily global rainfall estimates (in mm) at a spatial resolution of 0.5 x 0.5 degrees.

Note: During this exercise we will refer to the former layer as "Layer 1" and the latter as "Layer 2".

The source of these data is the Climate Prediction Center (http://www.cpc.ncep.noaa.gov/). These files provide estimations of rainfall on a global scale; at the same temporal resolution but at different spatial resolutions. Data reflected in each layer is associated with a 24-hour period covering the date, June 29th, 2014.

Start a new instance of QGIS, save it as **"Practical Exercise 1B"**; import these layers through the **Browser Panel** and let's get started.



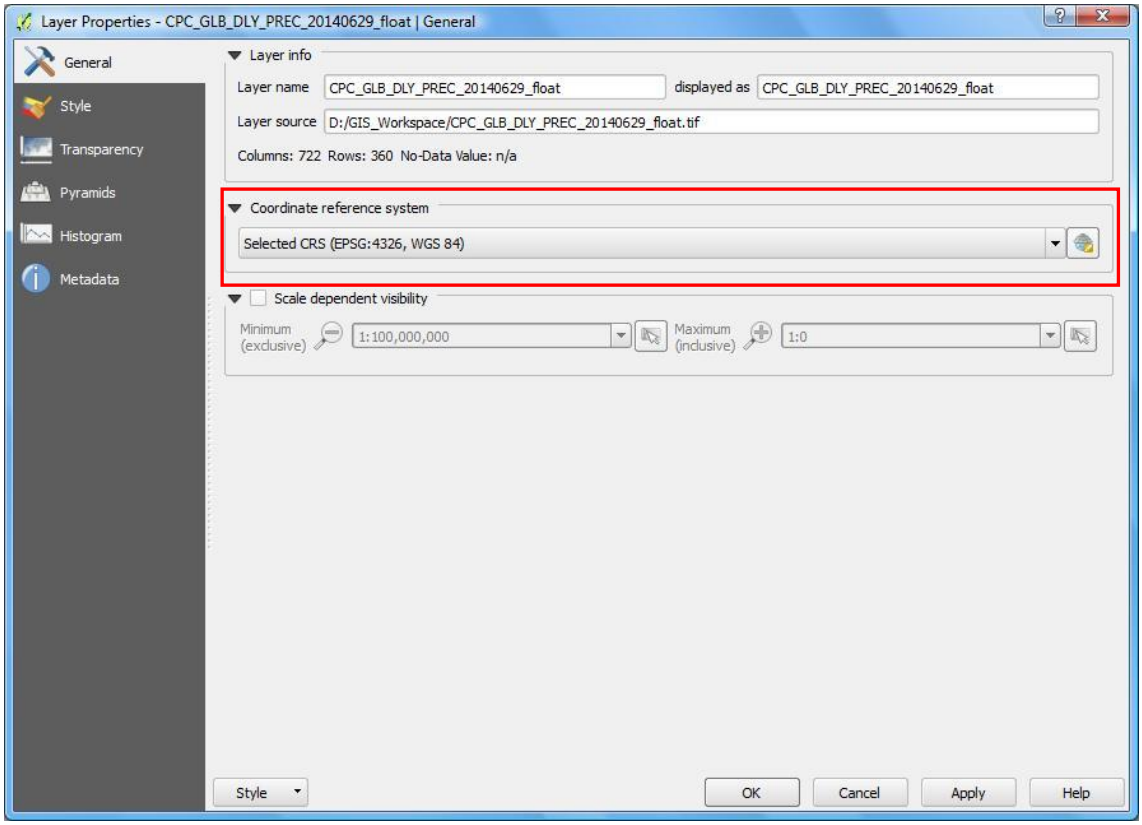
Note: With the precipitation raster files loaded, your Map Canvas and Layers Panel should resemble the previous image. In the last exercise you explored examples of Vector Data. Now we will begin by exploring Rasters.

1. Disable Layer 1 (**"CMORPH_DLY_025deg_20140629_float.tif"**) so that only Layer 2 **("CPC_GLB_DLY_PREC_20140629_float.tif")** is visible in the **Map Canvas**.

2. Right-click Layer 2; open the **{Properties}** menu and activate the **{General}** tab.

   Tip: You can open the layer {Properties} menu from the Layers Panel by double-clicking on a layer symbol or layer name.

3. Observe the **Coordinate Reference System** associated with the layer.

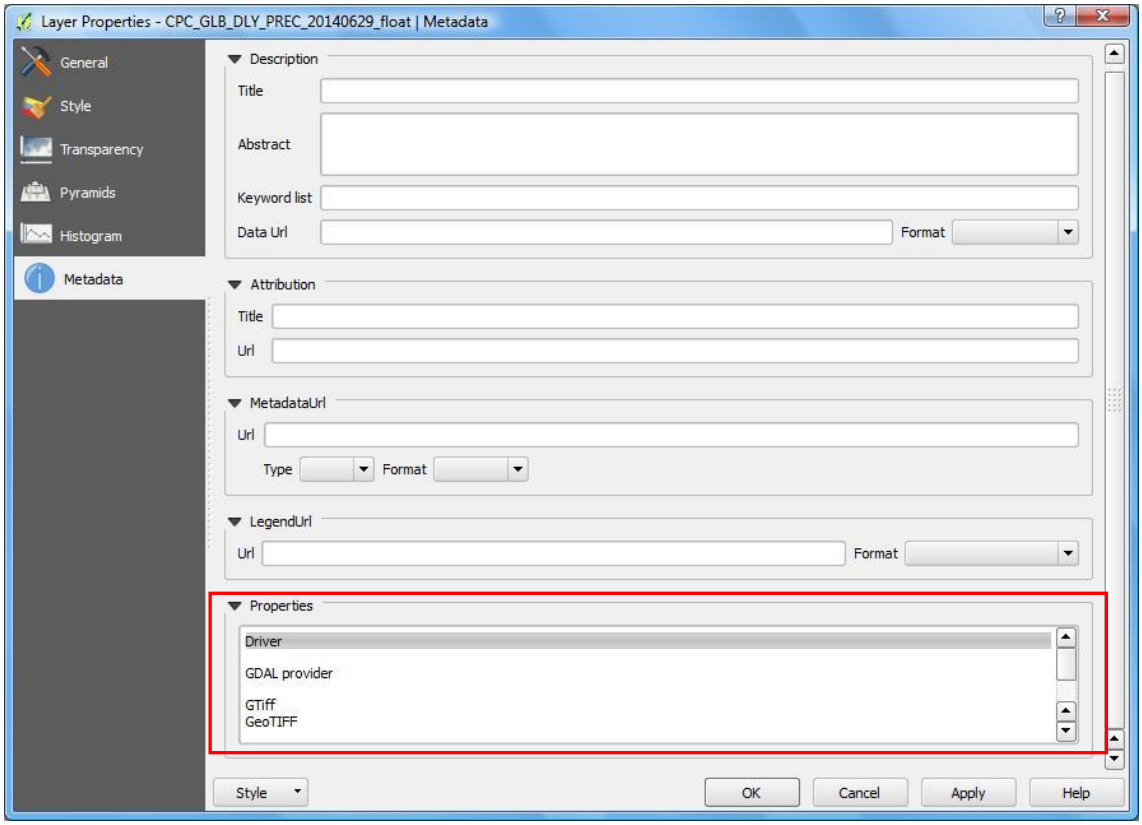


Note: Spatial data in GIS platforms are associated with two main types of Coordinate Systems. These are known as Geographic Coordinate Systems and Projected Coordinate Systems. The former applies a method for describing the position of a geographic location on the earth's surface using what are known as datums. A datum is a system that enables accurate location of objects (via

latitudes, longitudes and altitudes) modelled on a three-dimensional surface that is representative of the earth. With Geographic Coordinate Systems, angular measurements (in degrees) are used to identify a point on the earth's surface relative to the earth's centre. However, a "Projected Coordinate System" is defined on a flat, two-dimensional surface. Unlike a Geographic Coordinate System, a Projected Coordinate System has constant lengths, angles, and areas across the two dimensions. It is important to note that Projected Coordinate Systems are always derived from Geographic Coordinate Systems which use a spheroid for their earth model. Examples of the numerous Geographic Coordinate Systems and Projected Coordinate Systems are available for use within QGIS.

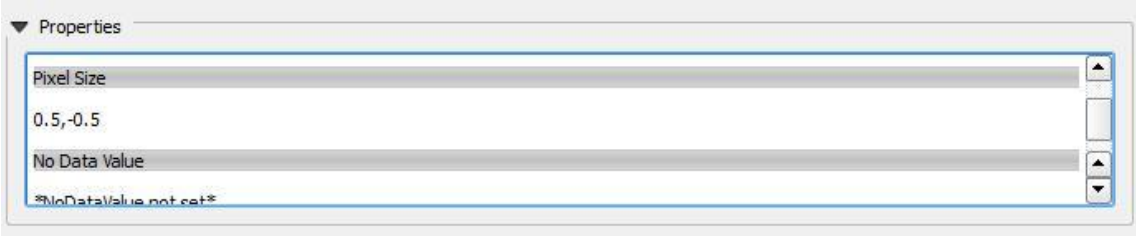
The Coordinate Reference System associated with Layer 2 is "EPSG:4326, WGS 84" - (See previous image). This is a popular Geographic Coordinate System used for mapping and analysis at both local and global scales. It is commonly associated with GPS, 3D global models, web-based geospatial tools and many other types of applications.

4. Now activate the **{Metadata}** tab under the **Layer Properties** menu and refer to the **{Properties}** section as shown in the following image.



Note: The {Properties} section provides basic information about the Raster. You can scroll through the list of properties to gain useful information. For the purposes of this exercise we will focus on just five of these properties.

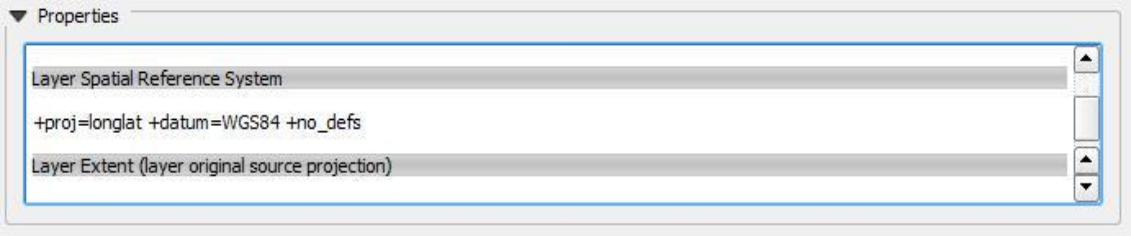
5. Scroll through the properties listings to the **"Pixel Size"** heading and view the information listed.



Note: This section contains very important information about your Raster. The pixel size of a raster (given in two dimensions) tells us the width and height of a single cell within the raster. In turn, the dimensions or size of a cell tells us about the spatial resolution of the raster layer. From the information provided, you can see that the raster has a spatial resolution of 0.5 degrees. We know the resolution units are in degrees, since the layer uses a Geographic Coordinate System.

It is often important to know the spatial resolution of the raster you are using. Smaller cell sizes indicate higher resolutions and larger cells sizes indicate lower resolutions. This information can help you to make decisions about how the raster is applied in mapping or analyses. For example, if you are comparing two or more rasters, you may need to first ensure that they are all of the same resolution so that the validity of your comparison is not compromised. Alternatively, knowing the resolution of a raster can help you to determine its suitability for certain applications. For example, with in-depth analyses that require high levels of precision, it would be better to use a raster with a higher resolution, due to the accuracy benefits provided by small cell sizes. However, for quick preliminary analyses where high precision is not a requirement, a lower resolution may be more appropriate.

6. Next, scroll to the **"Layer Spatial Reference System"** heading and view the details listed.



Note: The information contained here is very useful because it tells you about the projection used to render the raster and also the datum which the coordinate system uses. Two data layers that portray the same geographic area may not necessarily line up if they use different projections. However, one may be more easily transformed to align with the other if they both use the same datum.

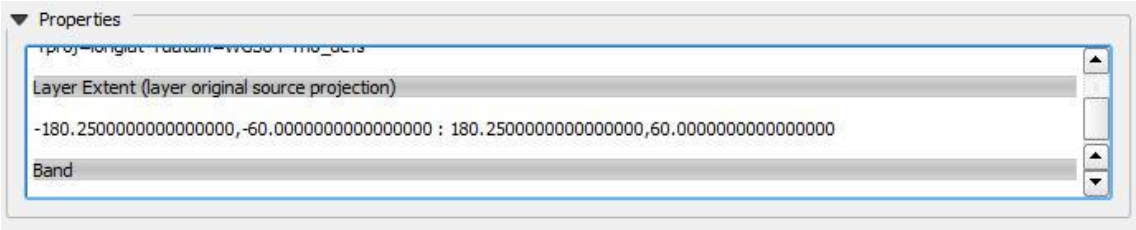
7. Switch off **Layer 2** and enable **Layer 1**.

8. Repeat steps 2 to 6 with Layer 1 and compare the information.

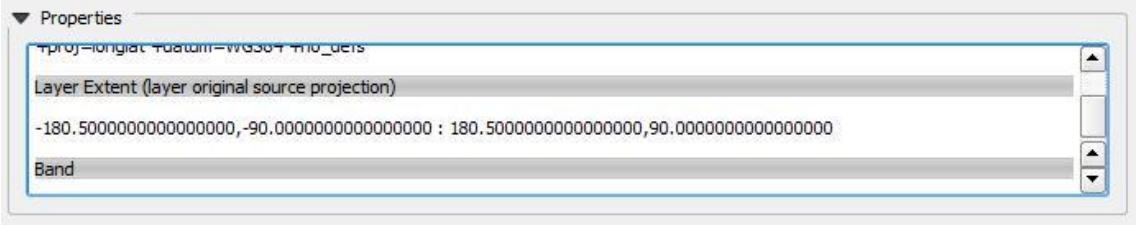
   Note: You should notice that Layer 1 and Layer 2, each use the same Geographic Coordinate System and hence, the same datum. However, they are of different spatial resolutions. Layer 1 has a spatial resolution of 0.25 degrees which is higher than the resolution of Layer 2 (0.5 degrees).

9. Next, view the **"Layer Extent (Layer original Source Projection)"** heading under the {**Metadata} → {Properties}** section for each layer and compare the information.

   Layer 1



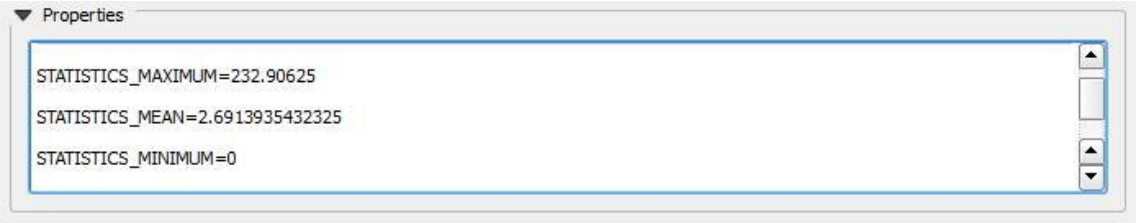
   Layer 2



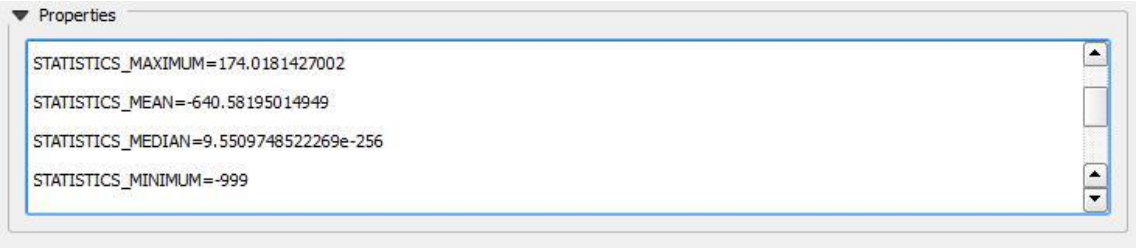
   Note: From looking at the layers in the Map Canvas, we can see that they both cover a global scale with some degree of overlap. However, Layer 2 appears to have a larger Geographic extent than Layer 1. This is confirmed by the information under the Layer Extent heading as seen above. Layer 1 covers a rectangular area that is enclosed by Latitudes, -180.25 degrees and 180.25 degrees and Longitudes -60 degrees and 60 degrees. However Layer 2 covers a wider rectangular area stretching from -180.5 to 180.5 degrees for Latitudes and from -90 to 90 degrees for Longitudes.

10. Next, locate the **"Band 1"** heading under the **{Metadata} → {Properties}** section for each layer and compare the statistical information present. Two important fields to take note of are the **"Statistics_Maximum"** and **"Statistics_Minimum"** fields. The former will tell you the maximum pixel value within the layer and the latter indicates the minimum pixel value.

Layer 1



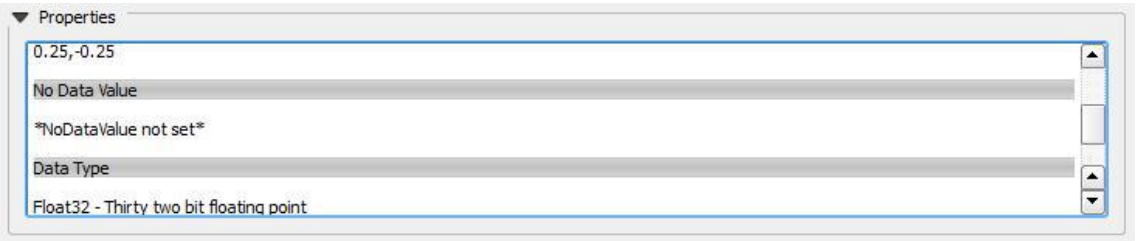
Layer 2



Note: A band may be considered to be a matrix of a specific type of data about a geographic area with a specified extent. Many rasters consist of a single band, which means only one type of data can be obtained for cell areas within a specified region. However, some rasters may contain two or more coincident bands which each provide a different type of information for the same cell locations.

Each of the layers currently loaded in QGIS are single band rasters. The "Band 1" heading shows the statistics across all the cells in the raster. From these statistics we see that the cell values in Layer 1 range from 0 to 232.9062. However in Layer 2, the minimum cell value is -999 and the maximum is 174.0181427002. While it is customary to assume that a value such as -999 or -9999 represents a code for absence of data (.i.e. a No DATA value). It is still advisable to consult the metadata for verification under the "No Data Value" section. Please note that "No DATA" values have not been officially set for either layer (see images below).

Layer 1



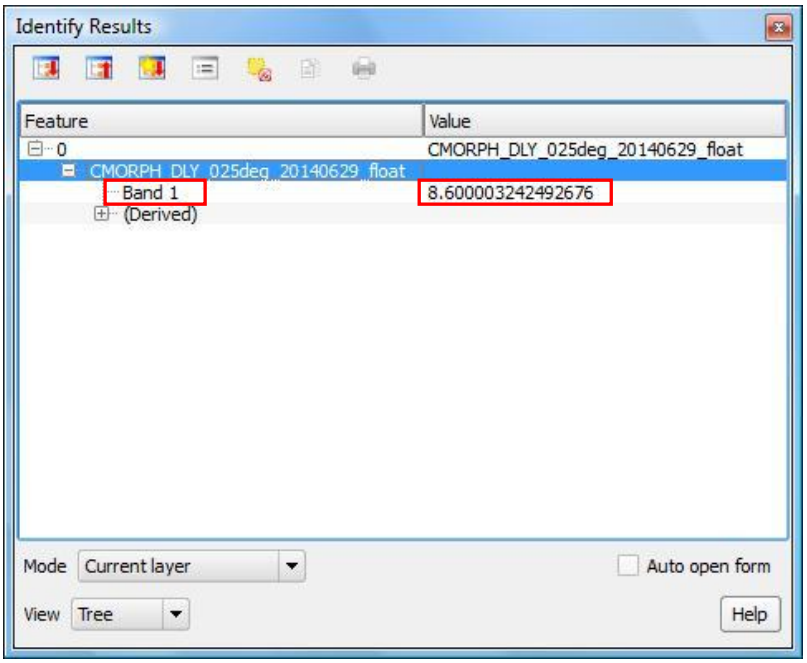
Layer 2

1.2 Looking at Raster Cells

In exercise 1A, you used the **Identify Tool** to obtain information about Vectors. Now you will do the same with the raster layers in your **Map Canvas**.

1. Disable Layer 2 in your map.

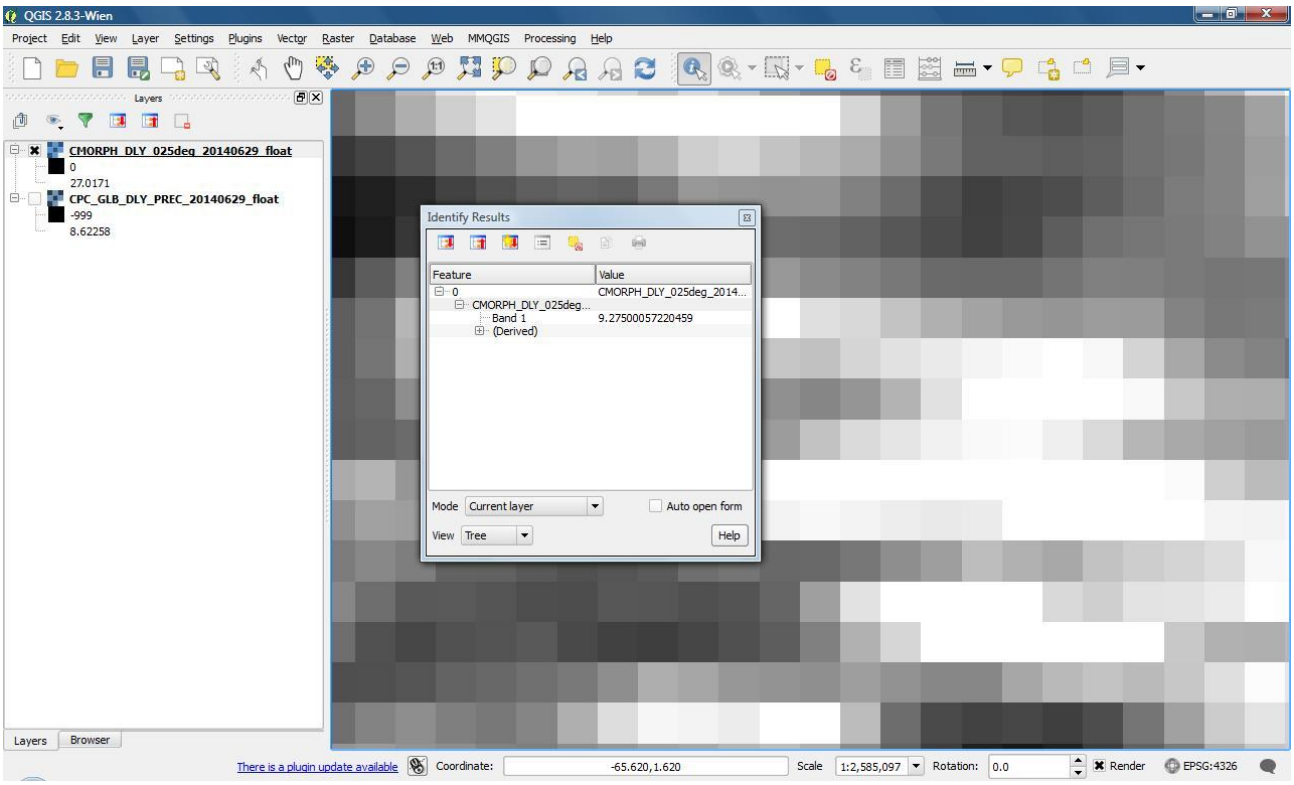
2. Highlight Layer 1 in your **Layers Panel**; activate the **Identify Tool** and click on a random area within the raster.



Note: The Identify results table will appear. Under the Feature Column, there should be an entry named "Band 1" and a corresponding value under the Value column. In the example (shown left), the value for the cell clicked on in Band 1 is 8.60000322492676.

You may also notice that the option to view feature results through a form is unavailable. This function is typically only available with vectors, for displaying multiple attributes that can be arranged in columns.

Tip: Try zooming in on the raster until its cellular structure is more apparent and then click on a cell of your choice. The following image gives an example.



Note: as you click around in random spots on the raster, you may come to notice that the black areas in the raster have a cell value of zero and that values greater than 0 exist for cells ranging from very dark grey (almost black) to white.

Tip: Once zoomed in, you can use the pan tool to move the raster around and look at different cells. Also remember to return the raster to its full extent of view by using the Zoom Full tool. Alternatively, you can return to the full extent of view by right-clicking the raster in the Layers Panel and choosing {Zoom to Layer} from the menu.

3. Disable **Layer 1**; enable **Layer 2** and explore its cell values with the **Identify Tool** as outlined in the previous step.

2 DIFFERENCES IN PROJECTIONS

Now that you've had some practice importing and looking at some of the properties of rasters. We shall explore an example of dealing with layers that use different projections.

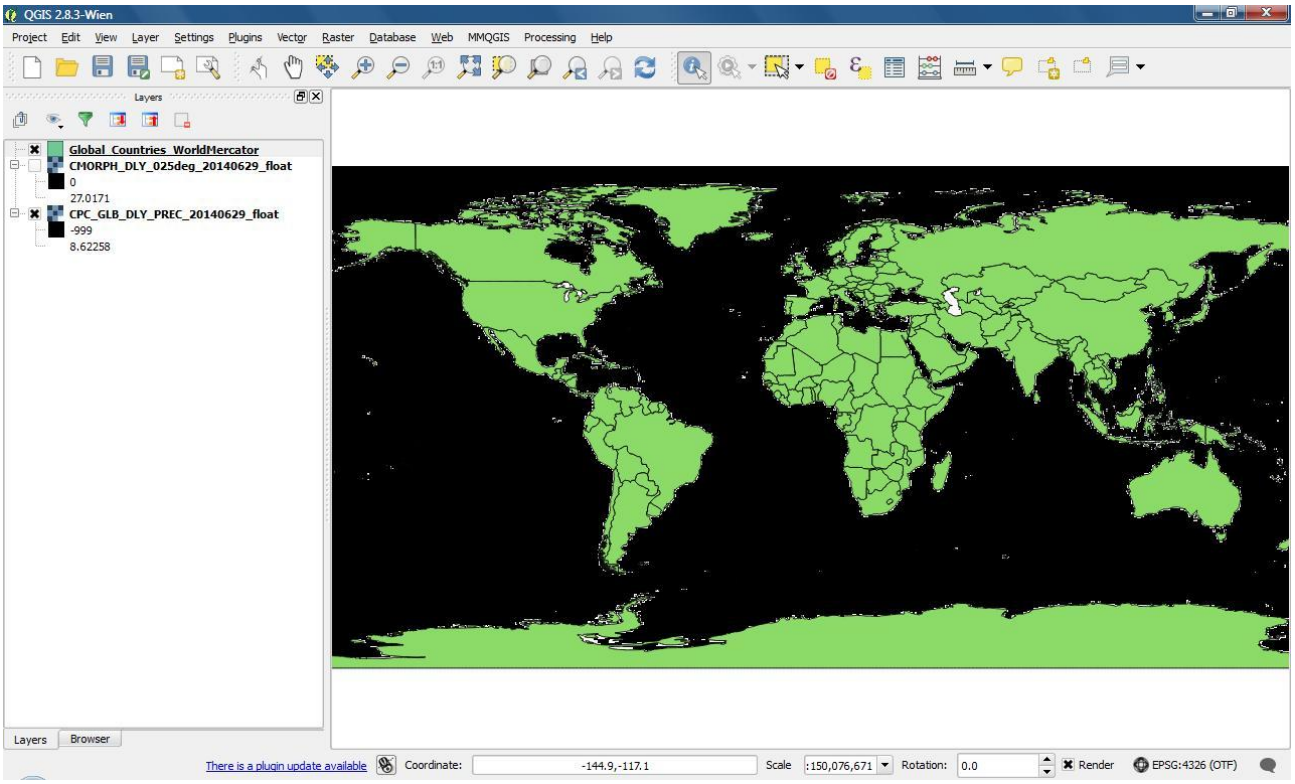
There are times when you will work with multiple datasets created by different entities that each use different data management and development standards. One common type of issue encountered in such scenarios is the variations seen in coordinate and projection systems applied to datasets that describe the same geographic area. This will often mean that datasets (with such differences), which should be rendered within the same geographical extent, can possibly be drawn in totally different regions of space on a two-dimensional plane. However, most GIS platforms have the ability to apply what are known as mathematical transformations to change the way data are projected onto a two-dimensional plane. These transformations allow layers with these differences (in coordinate systems and projections) to be drawn together in the same geographic space.

In QGIS there is an option within the **{Project Properties}** sub-menu of the main **[Project]** menu known as **"Enable 'on the fly' CRS Transformation"**. Once this option is selected, QGIS is then prompted to transform all incoming layers with different projection systems to match system that the Project is using to render other layers already in the **Map Canvas**. This is particularly effective when the incoming layer uses the same datum as the layer or layers already in the map. This section explores how this function works and also exposes the importance of working with layers that are in the same coordinate and projection system.

2.1 Layer Transformation in QGIS

1. Return the **Map Canvas** to the full extent of view and ensure that only Layer 2 is enabled in the **Layers Panel** and the **Map Canvas**.

2. Use the **Browser Panel** to locate and add the vector layer named, **"Global_Countries_WorldMercator.shp"**.

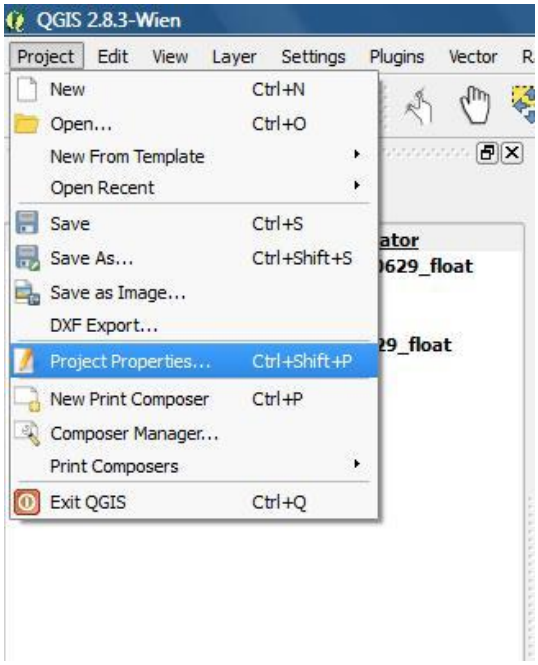


Note: You've just added the vector layer to the Map Canvas which illustrates countries on a Global Scale. Notice how it appears to line up with the enabled raster in your Map Canvas. Recall that the Coordinate System used by the raster layer is WGS 84, which is a Geographic Coordinate System. However, Geographic Coordinate Systems still need to be projected onto a 2D plane for visualisation on your screen. When drawing layers encoded with WGS 84, QGIS uses a system known as plate carée to map the angular units to linear 2-dimensional units of longitude and latitude for display in the Map Canvas.

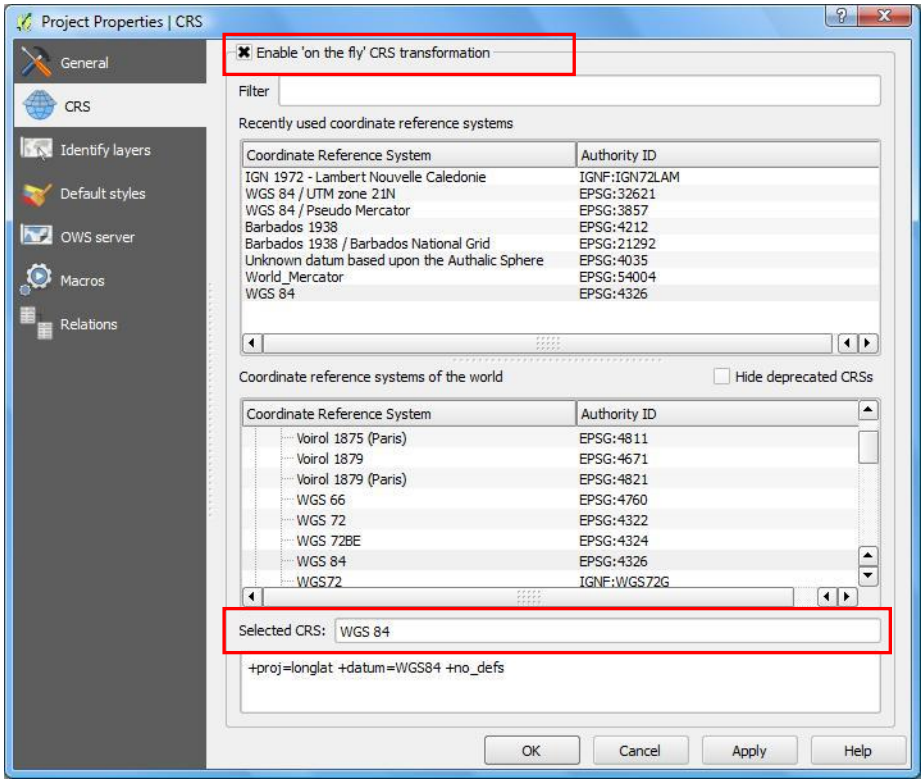
3. Open the **{Properties}** menu for the vector layer; activate the **{Metadata}** tab and browse to the **"Layer Spatial Reference System"** heading.

   Note: Here you will discover that the vector file in your Map Canvas is using a different projection system, but the same datum as your raster layers. If you return to the {Properties} menu and open the General Tab. You may also discover that it is using a Projected Coordinate System known as "EPSG: 54004, World_Mercator".

   The reason these layers line up in the Map Canvas is due to the Project Properties setting previously mentioned (i.e. "Enable 'on the fly' CRS Transformation").



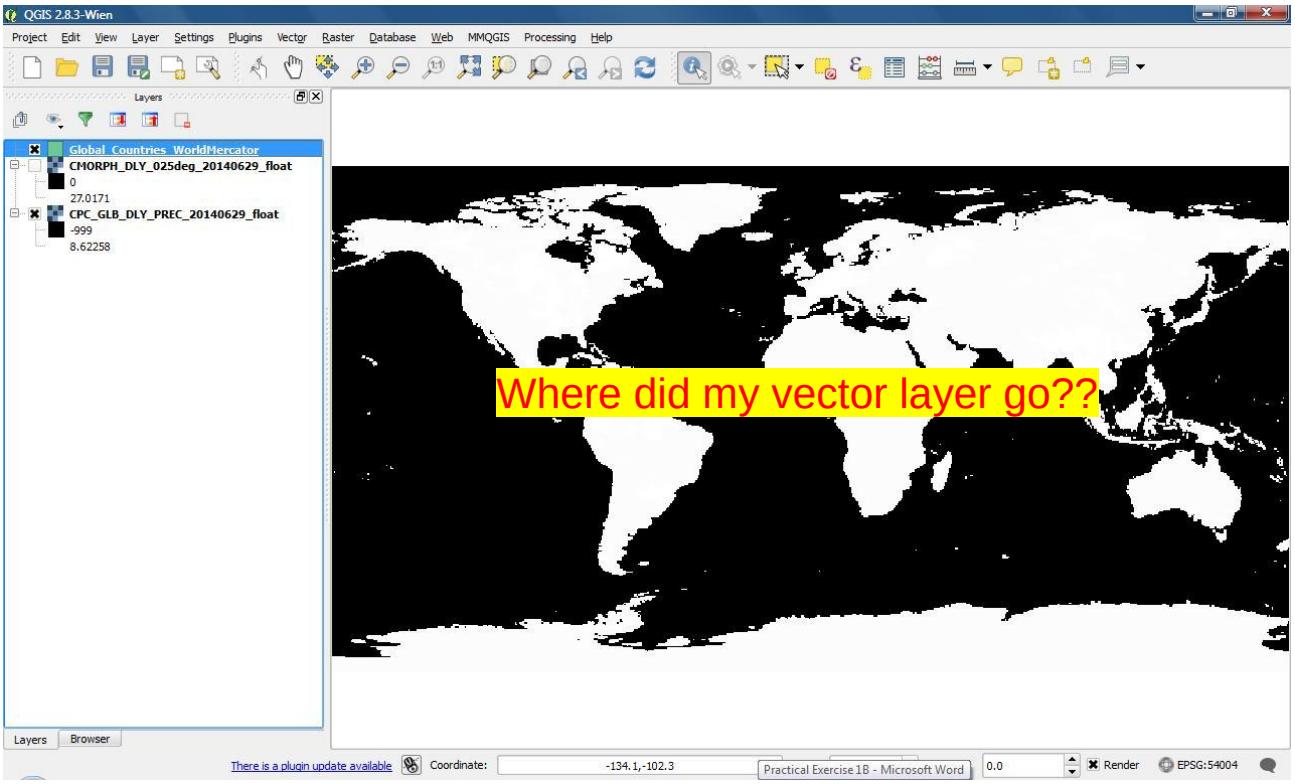
4. Select the main **[Project]** menu; select **{Project Properties}** and then activate the CRS tab as shown in the following image.



Note: The highlighted field at the bottom of the CRS menu indicates the main coordinate system deployed for the project. The project takes on the coordinate system of the first layer or layers added to the Map Canvas. Since the first two raster layers added were registered in WGS 84, then the project inherited this coordinate system from the raster layers. If layers using different types of coordinate systems and

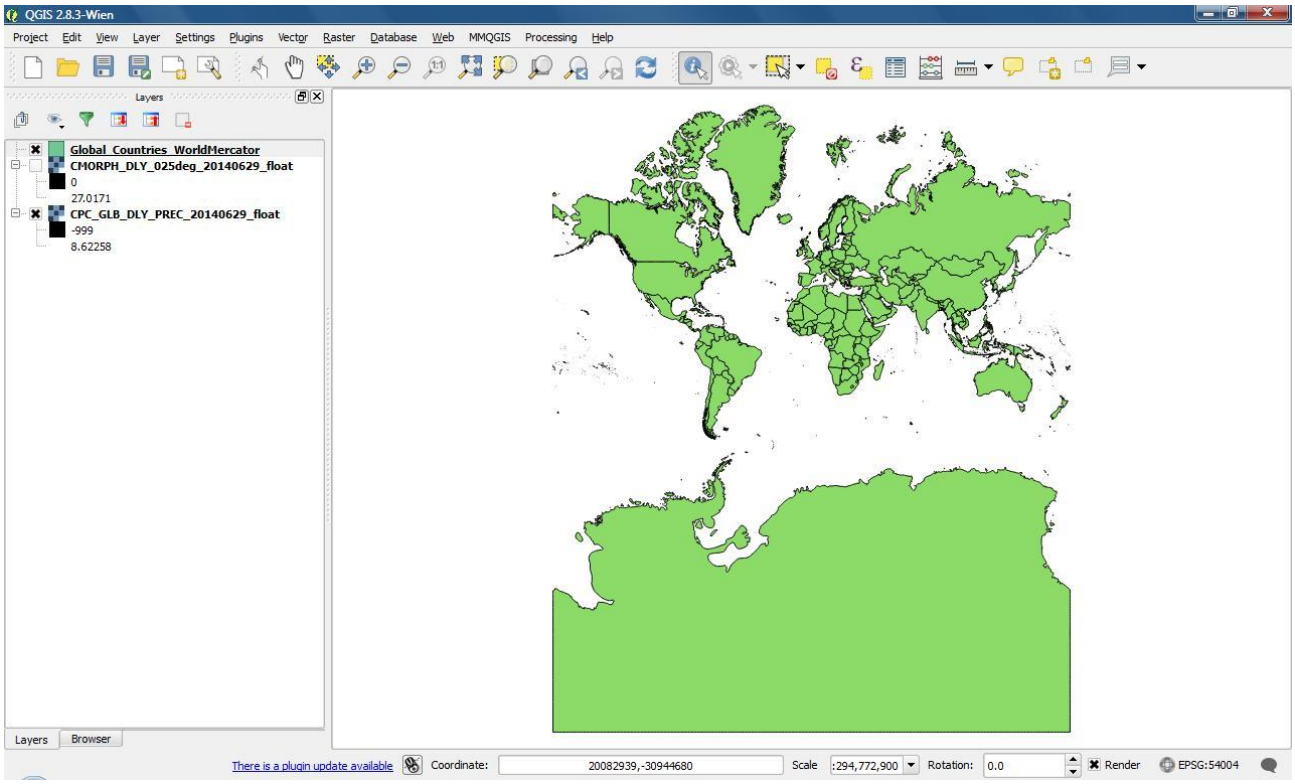
projections are added to the Map Canvas, QGIS will automatically attempt to transform the newly added layer so that it is compatible with the pre-existing layers. In this case, the vector layer was transformed to match up with the rasters. This was made possible by the setting seen at the top of the CRS menu (i.e. "Enable 'on the fly' CRS transformation" – See previous image). If you were to disable this option, the transformation would be removed and incompatible layers would no longer align.

5. Uncheck the option **("Enable on the fly CRS transformation"**) in the **CRS** menu; Click **{OK}** and see what happens.

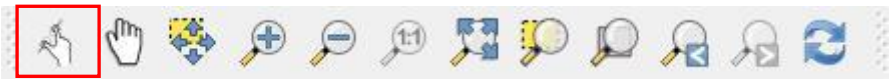


Note: Your vector layer, although enabled in the Layers Panel, is now missing. It has disappeared!! This happened because without the Transformation, the Projected System coordinates, which are based on metric values cannot be exchanged for coordinates in the same range used to display the rasters on your screen. The vector layer is still in your map, but simply now out of range of the geographic extent shown in the Map Canvas. To view the vector layer you will need to zoom to the extent where the layer is actually situated.

6. Right-click the vector layer in the **Layers Panel** and select **{Zoom to Layer}.**



Note: The Vector layer should now be visible in the Map Canvas while the rasters are not. You may also notice that the appearance of the layer is somewhat different from when previously transformed to line up with the rasters.



Tip: Activate the Touch Zoom and Pan Tool (shown above); pass your mouse over any area of the map and observe the coordinates in the Status Bar. You will notice that the coordinate values are far larger than those for the rasters. This is because the coordinates revealed are actually the projected system coordinates (in metres) which far exceed the range of coordinate values listed for the rasters. You can verify this by returning to the extent of one of the rasters and using the Touch Zoom and Pan Tool along with the Status Bar. You will notice huge differences in the coordinate numbers for the same general areas.

Note: The map coordinates above were taken from the vector layer for an area in a southern part of South America. However, the coordinates below were taken from one of the raster layers for an area in the same vicinity.

7. Zoom to the extent of the raster layer; open **{Project Properties}**, reactivate the **"Enable on the fly CRS transformations"** option and hit **OK**

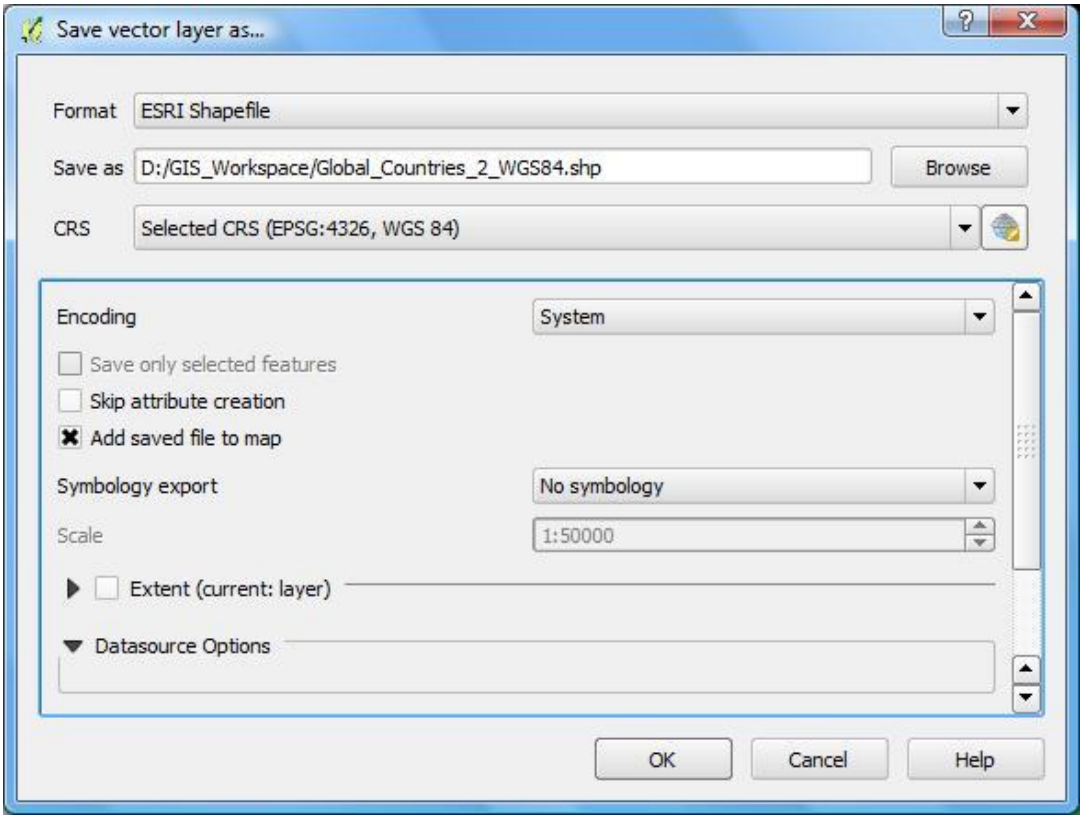
   Note: This will realign the layers. Use the Zoom Full tool to reset the Map Canvas.

2.2 Coordinate System Compatibility

Compatibility between layers in QGIS is essential for mapping and spatial analysis. Although QGIS may be capable of performing transformations that satisfy visualization objectives, there are many spatial processes which still require that layers be in the same coordinate system for processing to yield accurate results or to even function. The next steps illustrate how to change the coordinate systems that layers are registered in. The Vector Layer, which is in a Projected Coordinate System ("World Mercator") that uses the WGS 84 datum, will be converted to a new layer that is registered in the WGS 84 Geographic Coordinate System to ensure compatibility with the raster layers.

1. Right-click the vector layer in the **Layers Panel** and select **{Save As}.**

   Note: This will launch a menu with options you can configure for saving the layer. See image below.

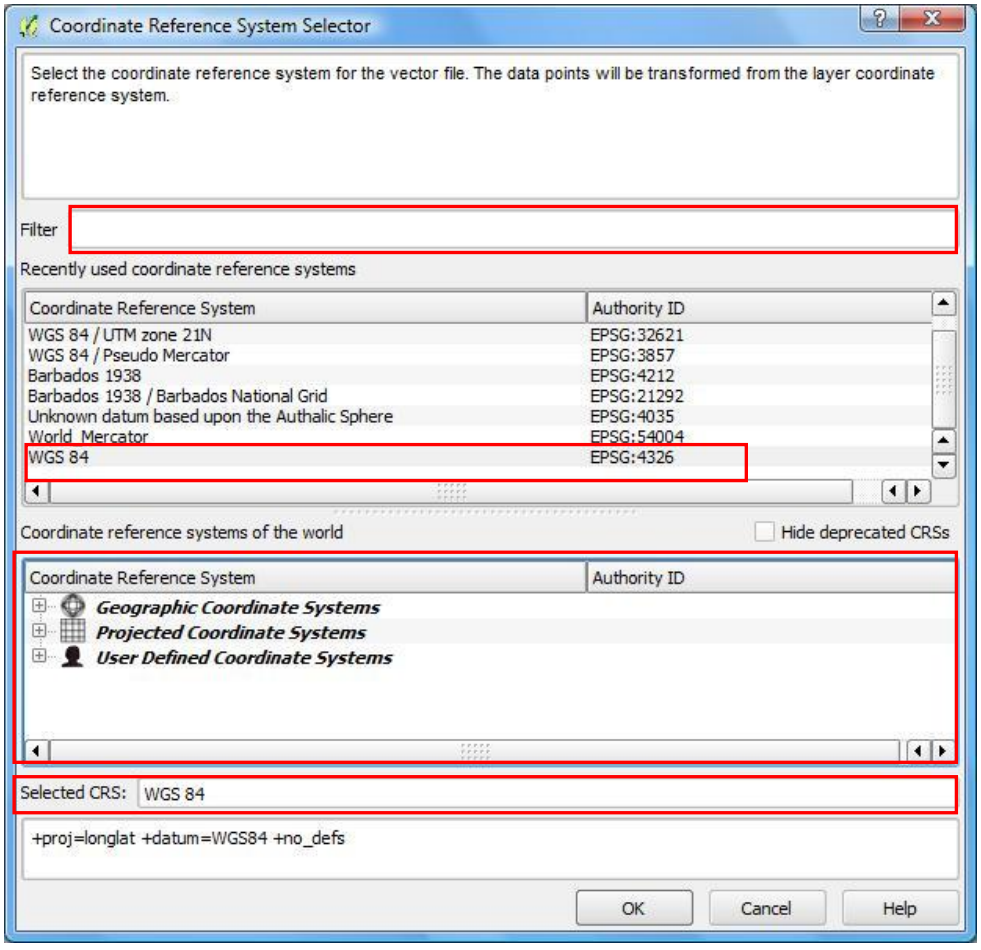


2. Set the following menu fields as instructed below and hit **{OK}**:

   - **Format:** - Select “ESRI Shapefile”

   - **Save as** – Use the **Browse** button to locate the workspace directory on your desktop as the location to save the save. There is already a file in your workspace folder named, **“Global_Countries_WGS84”**. If you enter the same file name, the vector layer in your workspace will be overwritten. Therefore, you should name this file, **“Global_Countries_2_WGS84”** and hit **{Save}**.

   - **CRS** – This field currently reflects the **World Mercator** coordinate reference system. However, the new layer you are creating must instead use the WGS 84 coordinate system. Hence, you’ll need to specify the change here. Hit the **Select CRS** button (see below) to open up the **Coordinate Reference System Selector** menu.

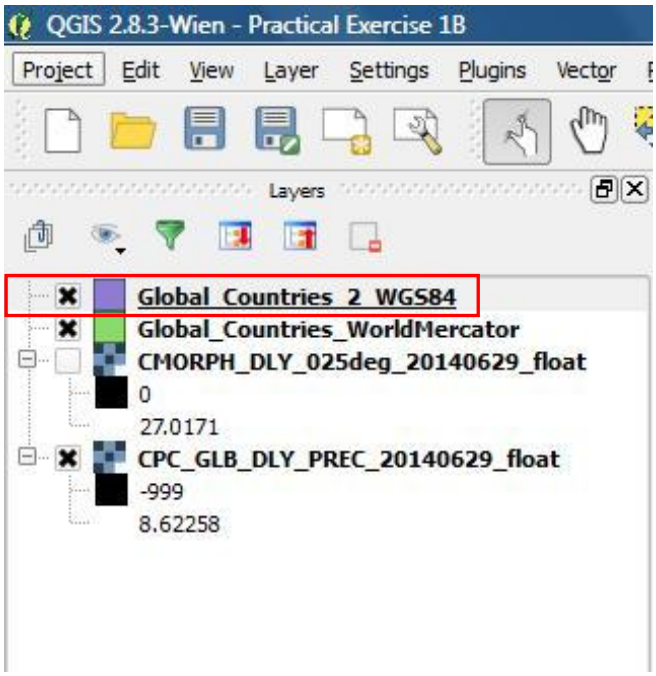


Since you've already used the WGS 84 Coordinate System in your project it should be listed under **"Recently used coordinate reference systems"**. You may scroll through the list and select it. The selection you make (WGS 84) should be reflected at the bottom of the menu under the **"Selected CRS:"** field. Refer to previous image.

Note: If for some reason your list of recently used coordinate reference systems is empty, you can find the WGS 84 coordinate system by using the Filter field or by searching manually under the Geographic Coordinate Systems list at the bottom of the menu. However, using the Filter field is perhaps the most effective way of locating the CRS of your choice. Simply type "WGS 84" into the Filter field exactly as stated and it will be located in the Geographic Coordinate Systems list.

Once the WGS 84 coordinate system has been selected, click **{OK}** to return to the previous menu.

- **Add saved file to map –** Select this option



Note: After selecting {OK}, a new version of the Countries layer named, "Global_Countries_2_WGS84" should appear in your map. You can check out its Metadata and General properties to confirm that the coordinate system (WGS 84) has been correctly assigned.

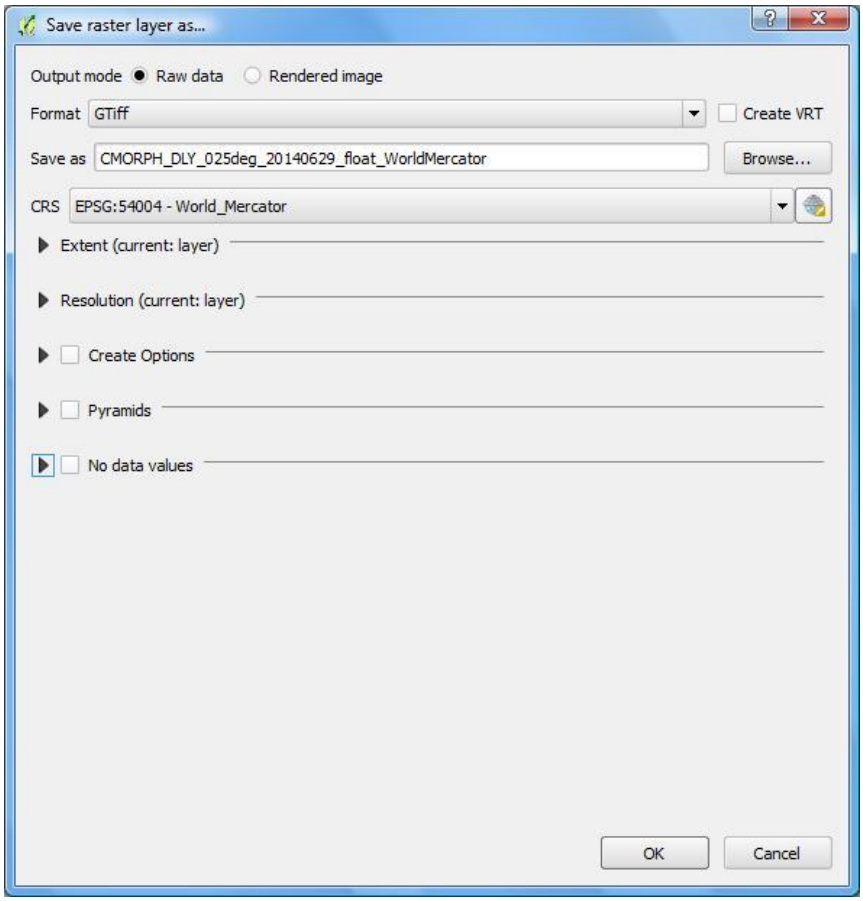
3. Remove the previous vector layer (**"Global_Countries_WorldMercator"**) from the **Layers Panel**.

Note: Now you can perform another test to see whether your task of changing the coordinate system of the Countries layer actually worked. If you open up the {Project Properties} menu; turn off the "Enable 'on the fly' CRS transformation" option and hit {OK}, the countries layer should not disappear this time. If it stays in view within the Map Canvas it would suggest that the layer didn't need to be

transformed because it was using the same coordinate system as the raster layers (i.e. WGS 84). You may run this test to confirm the results.

4. Try changing the coordinate system of the project, under **{Project Properties}** from WGS 84 to the World Mercator coordinate system and then convert the raster layers from the WGS 84 coordinate system to the World Mercator coordinate system.

   Note: When creating the new raster layers, add the suffix, "_WorldMercator" to the file names you choose. You should also be aware that the Save menu for rasters is a bit different from the one used with vectors. An example is shown below.



- ***Output Mode*** *– Choose "**Raw data**"*
- ***Format*** *– Choose **"GeoTiff"***
- ***Save as*** *– Use this field to create a new file name*
- ***CRS*** *– Use the **Select CRS** menu to choose the **World Mercator** coordinate system*

- *Select **{OK}***

Tip: Remove the WGS 84 encoded layers from the Map Canvas after you've created the new raster versions and then test that the coordinate systems have been changed correctly.

3 BASIC GEOPROCESSES

This section introduces several simple methods for selecting features within a vector dataset. A selected vector feature will be exported as a separate layer and used as a mask for "clipping" the extent of a raster. Finally, you will learn how to plot ASCII data in QGIS as points. These are all useful operations which may be applied to analysis and mapping of climate data.

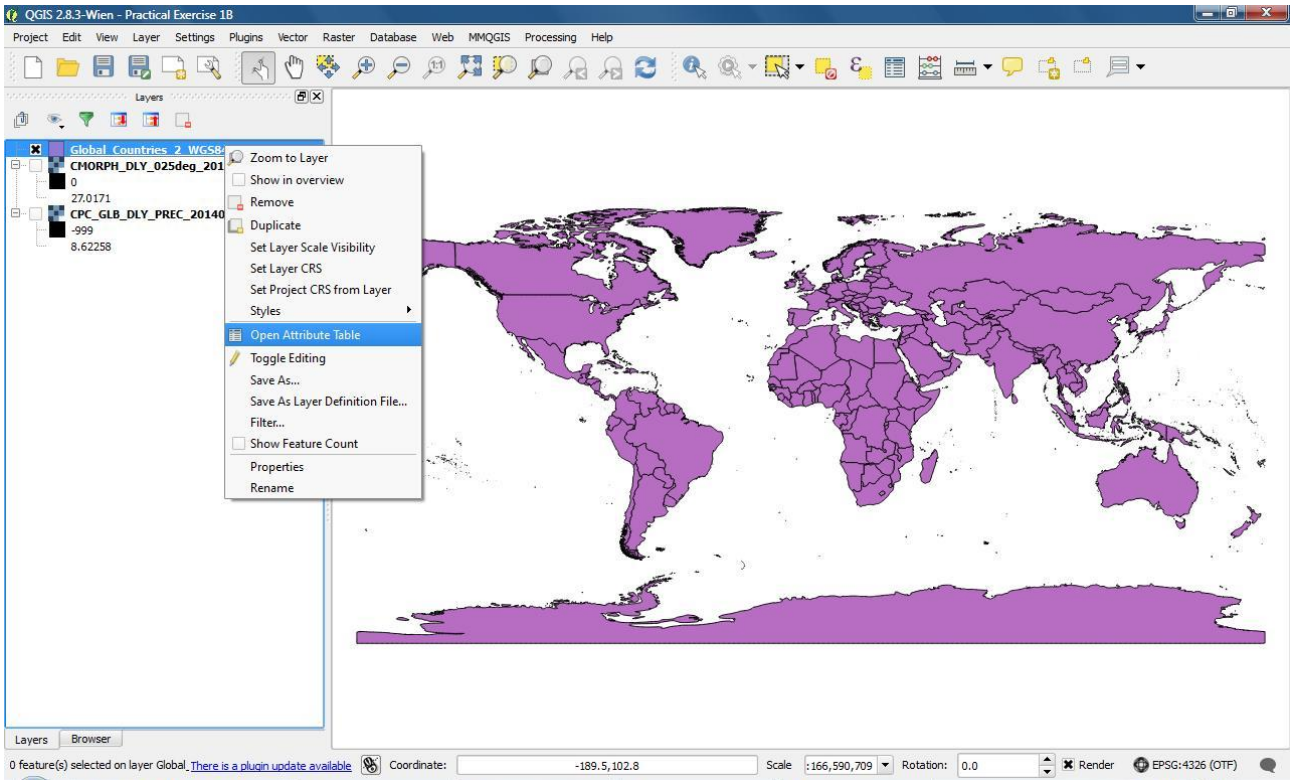
3.1 Selecting Features from the Attribute Table

1. Remove all layers presently in your **Layers Panel.**

2. Load the WGS 84 versions of the precipitation rasters and either of the vector layers (i.e. **"Global_Countries_WGS84"** or **"Global_Countries_2_WGS84"**).

3. Disable the raster layers.

4. Right-click on the vector layer in the **Layers Panel** and select **{Open Attribute Table}**.



Note: This opens up a table that shows all attributes associated with the layer. There are 4 attribute columns in the layer. These are described below.

- ***ISO3 – The values in this field are official codes for the various countries and their subdivisions as designated by the International Organization for Standardization.***
- ***COUNTRY– This field lists the official names of countries***
- ***SOVEREIGN – This field contains the official name of the sovereign nation for which a territory/country is a part of. For example, the SOVEREIGN attribute for the country Bermuda is listed as United Kingdom.***
- ***CONTINENT – This field lists the names of the continent that a country is a part of.***

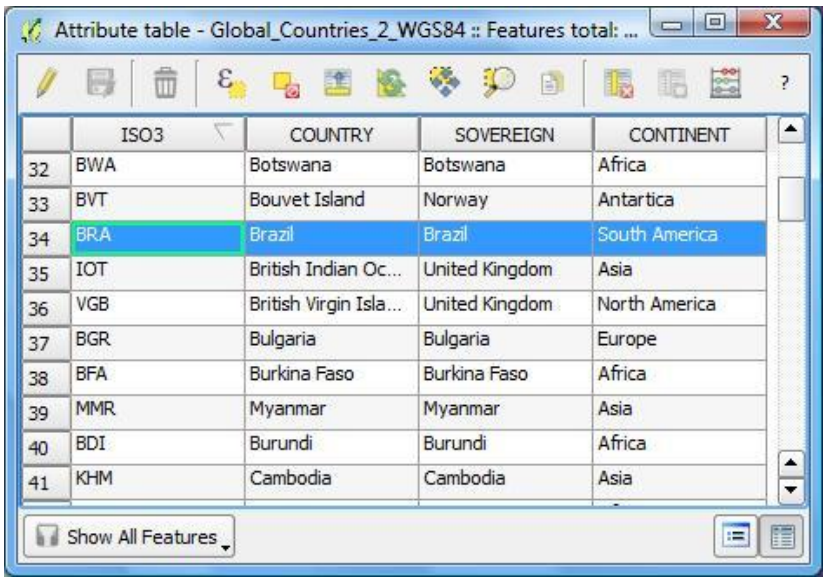
The attribute table may be used to select or highlight features of interest within a layer. Once features are selected, they may be exported as standalone features. In the next step you will demonstrate this by searching the table to make a selection for the feature in the layer that represents the country of Brazil.

5. Sort the values in your attribute table (alphabetically) using the **COUNTRY** field. Do this by clicking on the field heading.

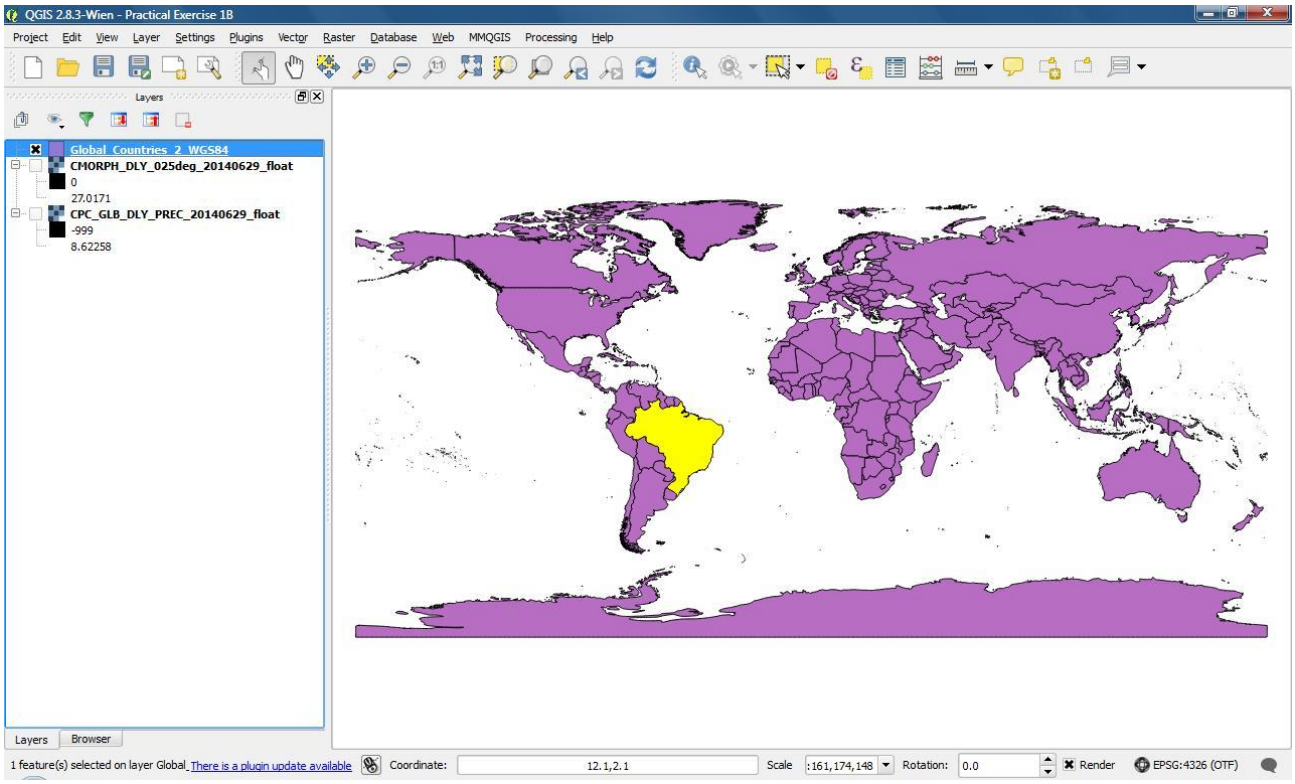
   Note: Your COUNTRY column may have already been arranged alphabetically. However, clicking on field heading will ensure that the field values are sorted so that a manual search is easier to achieve.

6. Scroll through the list of values under the **COUNTRY** column and locate **"Brazil"**.

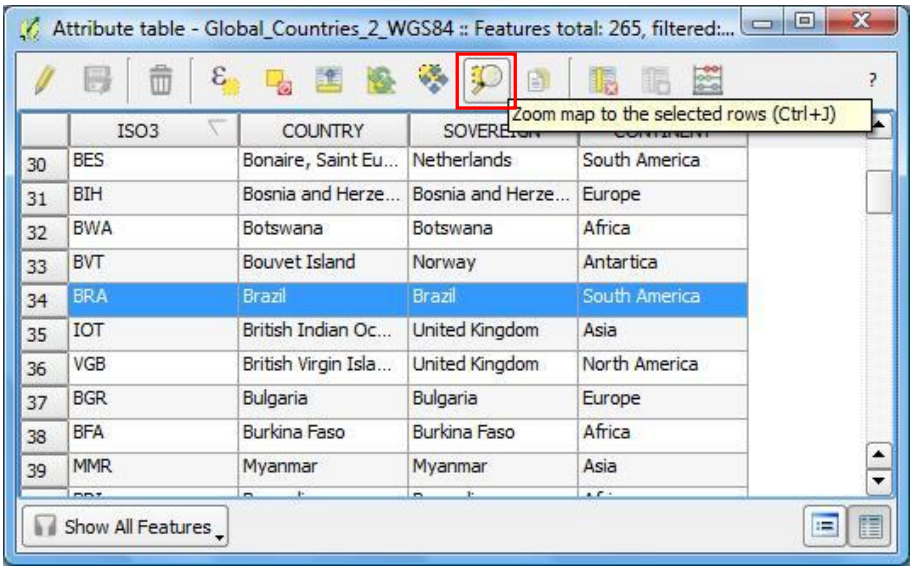
7. Make a selection of this feature by clicking on the row value (34) at the left end of the table. Refer to the image on the right.



Note: When a selection is made, there are two things that happen: 1) The selected feature is highlighted in the attribute table in blue and 2) the feature is highlighted in the Map Canvas (the default colour is usually yellow, but may also be a different colour). The selection is visible in the attribute table. However, if you close the table and return to the Map Canvas, you will notice that the country feature for Brazil has also been highlighted. Be sure to zoom to the full extent of the layer (if necessary) so you can see the selection made.



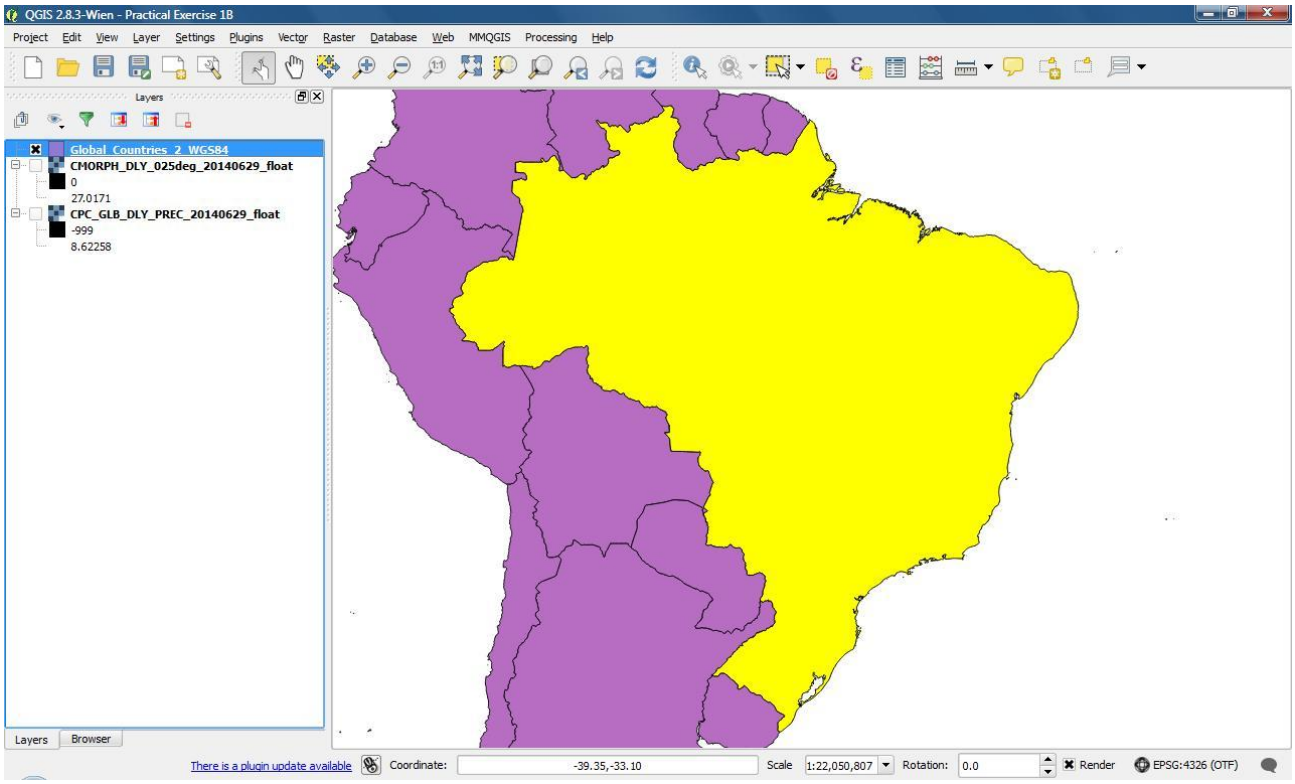
8. Reopen the attribute table and locate the tool shown below.



9. Select the tool highlighted above.

   Note: This tool will zoom the map to the extent of the features that have been selected.

10. Close the attribute table and observe the **Map Canvas**.

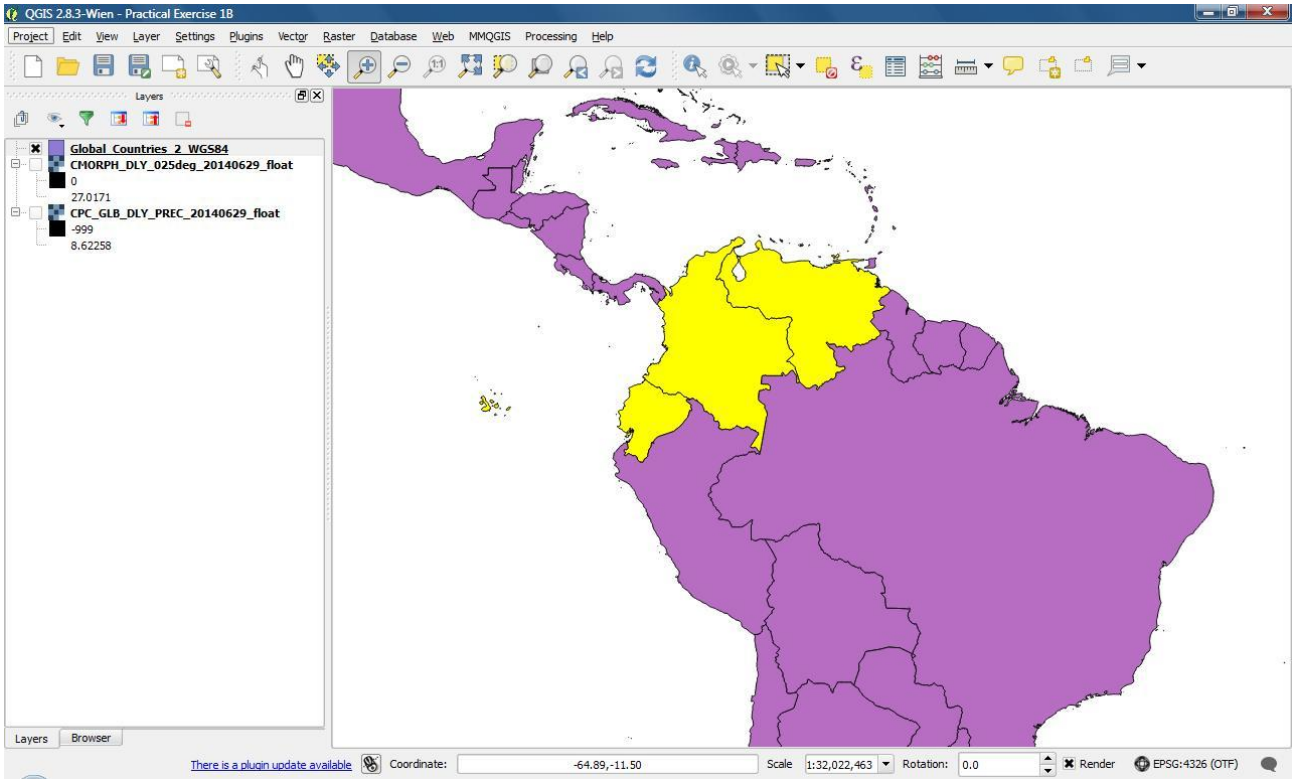


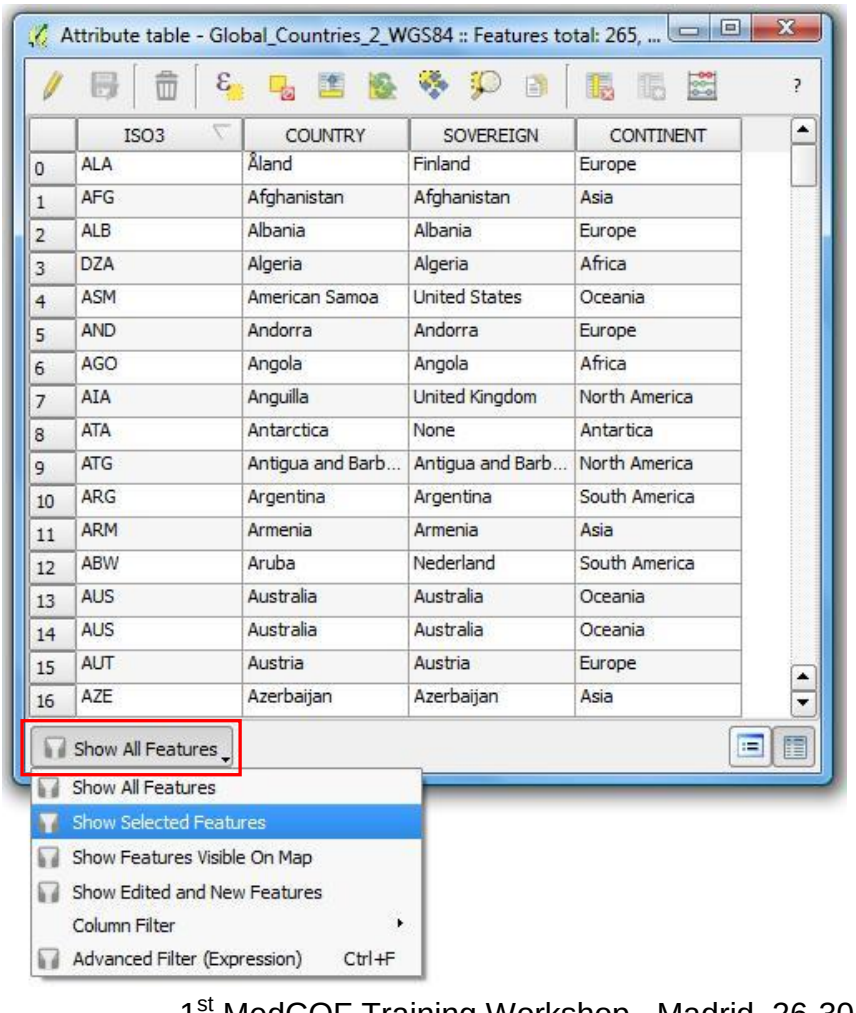
11. Return to the full extent of the **Map Canvas**.

12. Use steps 4 to 11 to locate, select and view 4 or 5 other countries of your choice.

    Note: Once you've finished exploring this selection method, close the attribute table and return the Map Canvas to the full extent of the countries layer.

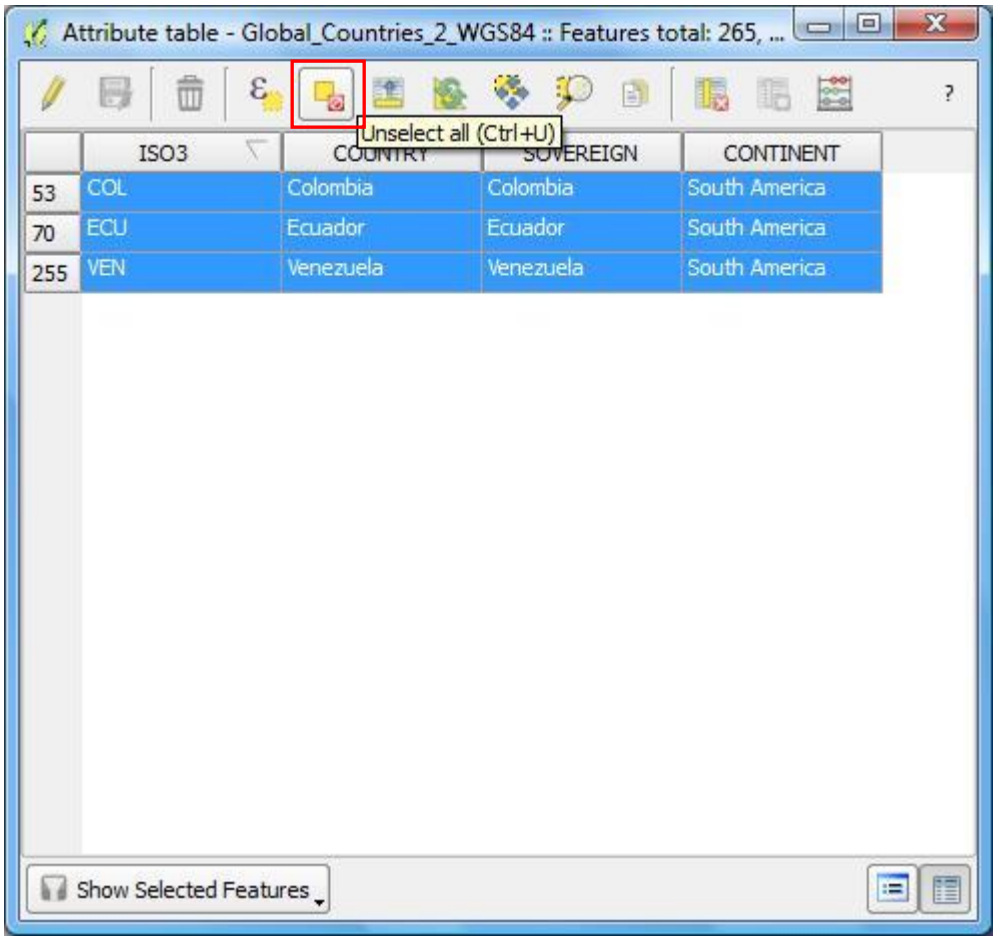
    Tip: You can make more than one selection from the table at a time by using the Ctrl key. Select one feature of your choice; press and hold the Ctrl key and then select another. You can select as many features you desire with this method. In the example below, the countries Ecuador, Colombia and Venezuela were selected via this method.





	ISO3	COUNTRY	SOVEREIGN	CONTINENT
0	ALA	Åland	Finland	Europe
1	AFG	Afghanistan	Afghanistan	Asia
2	ALB	Albania	Albania	Europe
3	DZA	Algeria	Algeria	Africa
4	ASM	American Samoa	United States	Oceania
5	AND	Andorra	Andorra	Europe
6	AGO	Angola	Angola	Africa
7	AIA	Anguilla	United Kingdom	North America
8	ATA	Antarctica	None	Antartica
9	ATG	Antigua and Barb...	Antigua and Barb...	North America
10	ARG	Argentina	Argentina	South America
11	ARM	Armenia	Armenia	Asia
12	ABW	Aruba	Nederland	South America
13	AUS	Australia	Australia	Oceania
14	AUS	Australia	Australia	Oceania
15	AUT	Austria	Austria	Europe
16	AZE	Azerbaijan	Azerbaijan	Asia

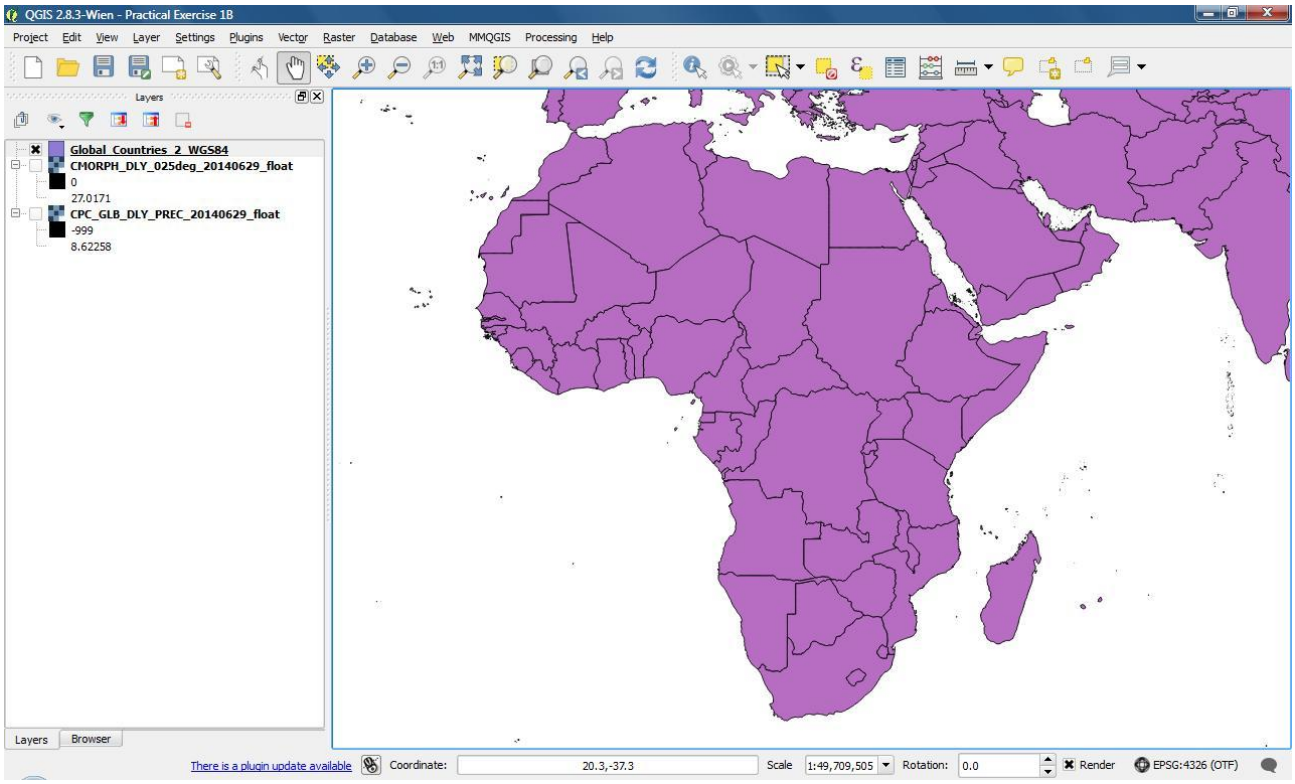
Tip: Your attribute table currently shows all features within the layer. However, you can change the display of the table so that it only shows features that have been selected. Do this by clicking the button shown (in the image on the left) and choosing {Show Selected Features} from the options.



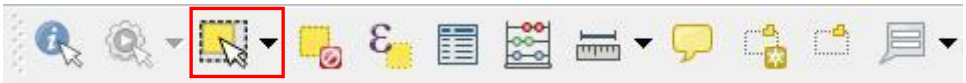
Tip: Any selections made may be removed from the attribute table with the tool highlighted below (i.e. Unselect all). Reset the table to {Show All Features} when complete.

3.2 Using the Select Tool

1. Use the **Zoom in** tool or your mouse wheel and **Pan** tool if necessary, to zoom in on an area which focuses on the African Continent.

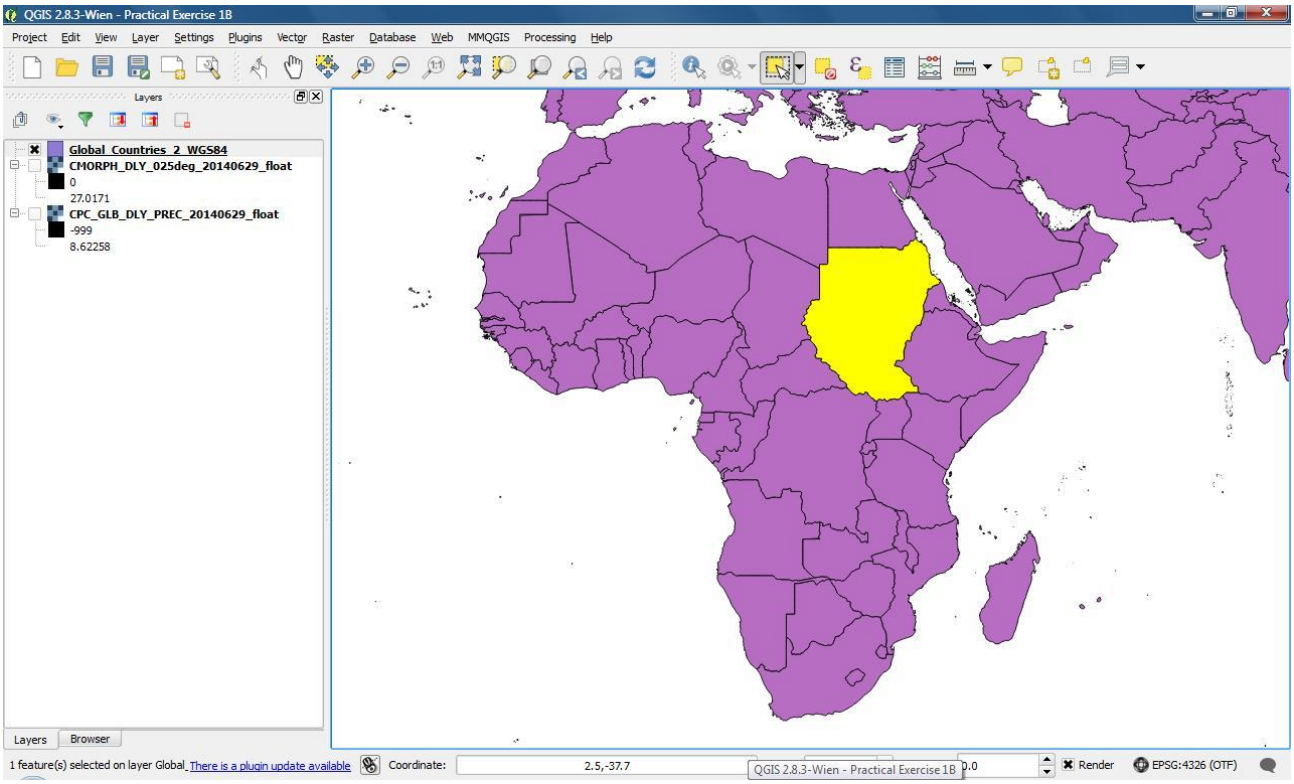


2. Locate the tool highlighted in the image below and activate it.



Note: This tool allows you to select features by clicking on them in the Map Canvas.

3. Click on the feature representing Sudan to select it as illustrated in the following image.



Note: You can remove the selection from the Map Canvas with the tool highlighted in the image below. Once you've tested this out, select Sudan again with the selection tool.

4. Open the attribute table and change the view, so that only selected records are shown.

Note: You table should now only reflect one feature (Sudan) highlighted in blue, as seen in the following image.

5. Remove the selection; reset the attribute table to display all features; close the attribute table and then return the Map Canvas to the full extent.

6. Use steps 1 to 4 to make 5 selections of your choice.

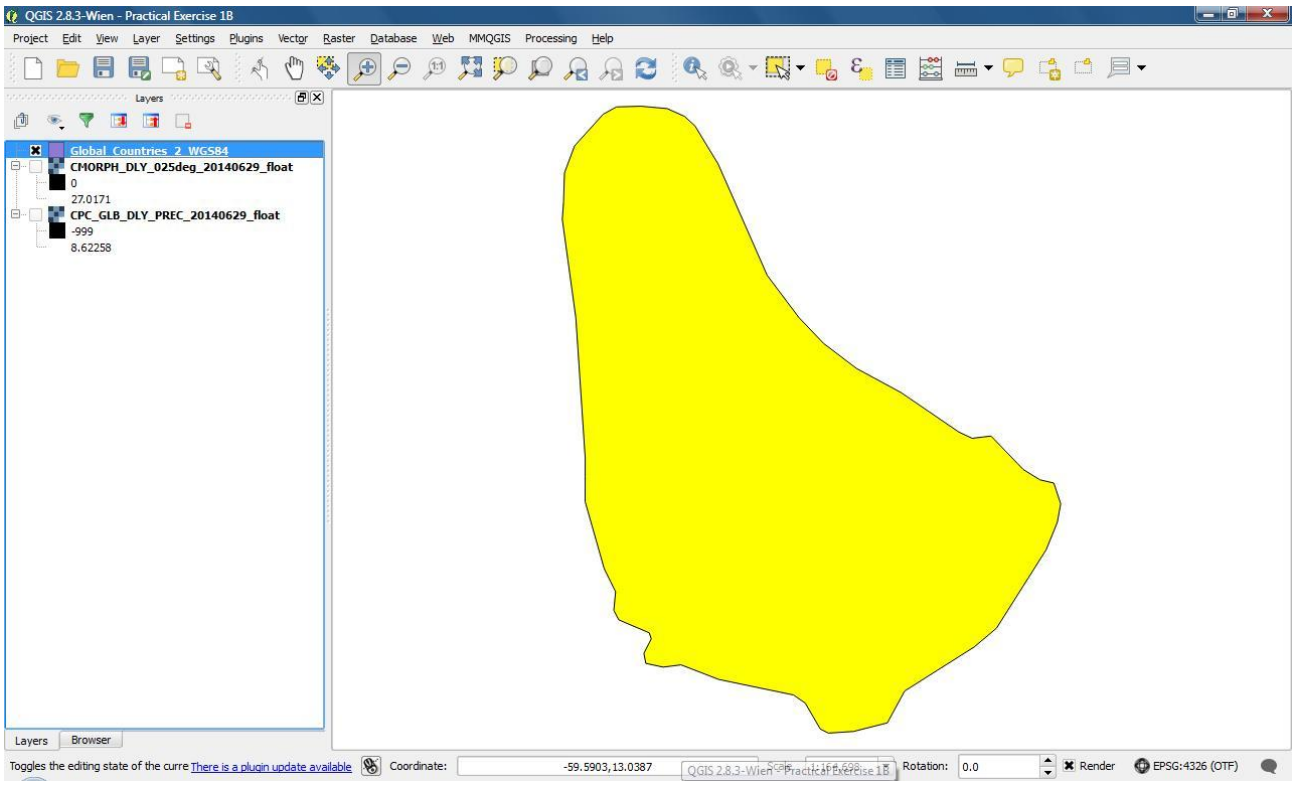
   Tip: Multiple features can be selected by pressing and holding the Ctrl key, while clicking with the selection tool.

   Note: Once you've finished exploring this selection method, remove all selections from the Map Canvas and return the Map Canvas to the full extent.

3.3 Feature Extraction with Vectors

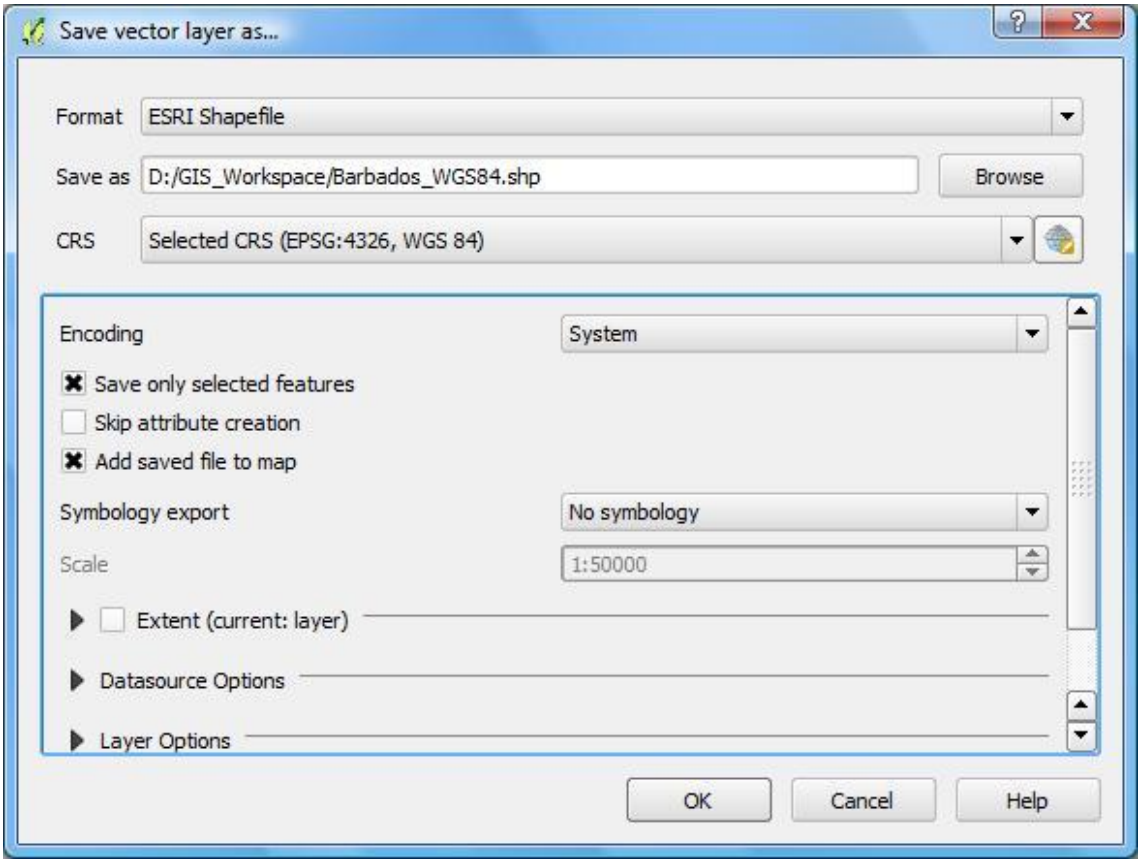
Selections made via the attribute table or the selection tool may be exported as separate layers. The following steps illustrate how this can be achieved.

1. Locate and select the country of Barbados.



2. Right-click the countries layer in the **Layers Panel** and select **{Save As}**.

3. Set the menu as shown below.



- **Format – Choose "ESRI Shapefile"**
- **Save as – The new file should be named, "Barbados_WGS84" and saved to your workspace folder**
- **CRS - Choose WGS 84 as the Coordinate Reference System**
- **Save only selected features – Select this option**
- **Add saved file to map – Select this option**

4. Select **{OK}** to export the selected features.

Note: A new layer ("Barbados_WGS84") will be added to your Map Canvas. The country of Barbados is only 166 square miles in area. Therefore if you are zoomed to the full extent of the map, the selection will be too small to see clearly. However, if you turn off the countries layer; right-click on the "Barbados_WGS84" layer in the Layers Panel and then select {Zoom to Layer}, the new layer will be clearly visible.

5. Remove the **"Barbados_WGS84"** layer from the **Map Canvas**. Switch on the countries layer and return the **Map Canvas** to the full extent of this layer.

6. Practise selecting and exporting 5 other countries of your choice. Make sure you save all exports to your workspace folder.

Note: Once you've finished experimenting with selecting and exporting countries of your choice, remove all newly extracted layers from the Layers Panel so that you are left with only the countries layer and the precipitation rasters. Ensure that you zoom to the full extent.

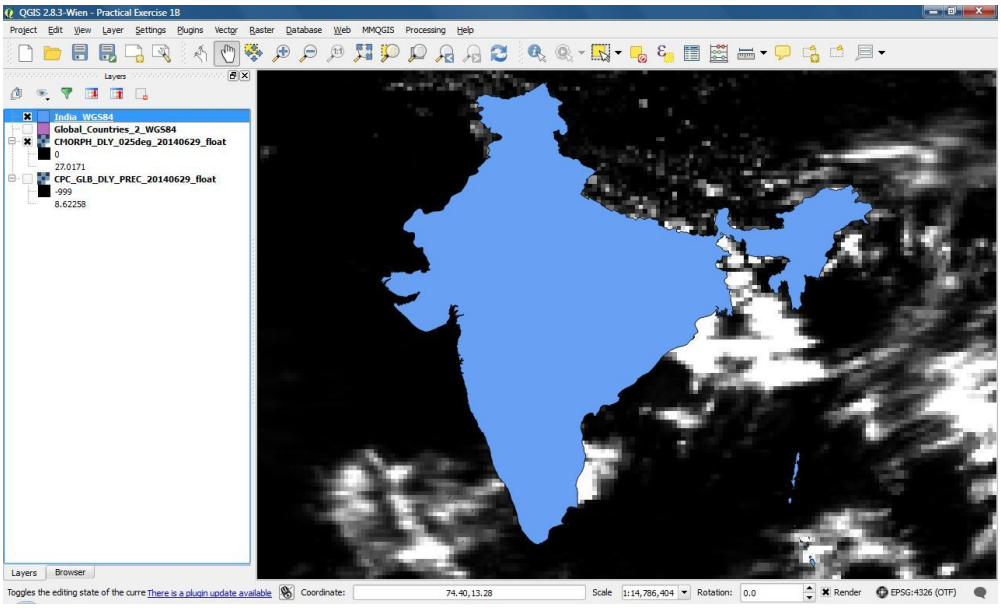
3.4 Clipping the Extent of Rasters

You've learnt two simple methods for making feature selections and also how to extract selected vector features as separate layers. You will now investigate how to use a vector layer as a mask for extracting a region within a raster layer.

1. Locate the country of India within the countries layer and export the representative feature as a separate layer.

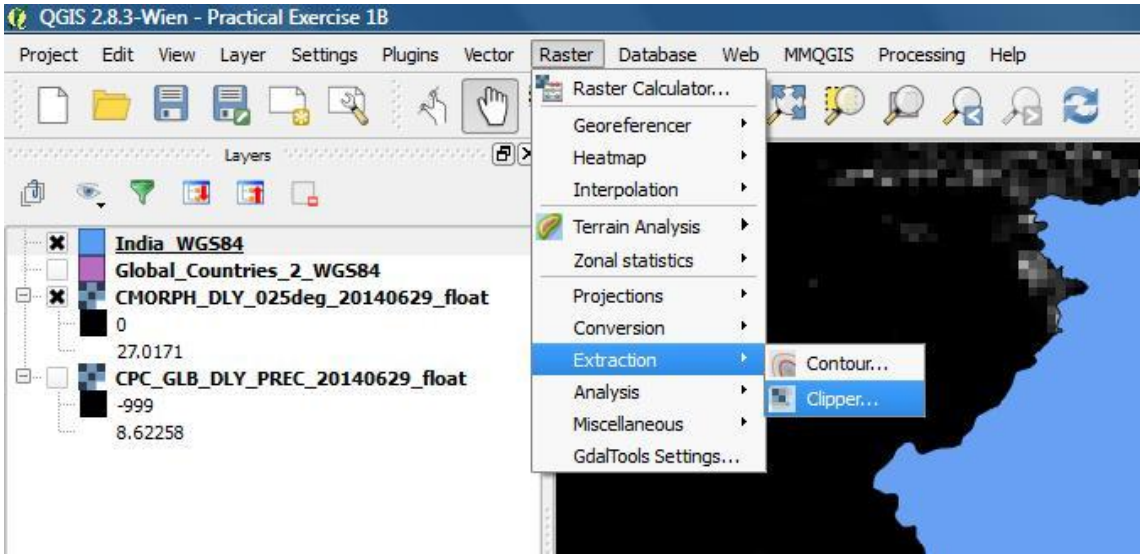
Note: Ensure that you save the selected features under the name, "India_WGS84", to your workspace. Also make sure the exported layer is added to the Map Canvas.

2. Switch off the countries layer; switch on the precipitation raster layer named, **"CMORPH_DLY_025deg_20140629_float"**; then zoom to the full extent of your layer for India.



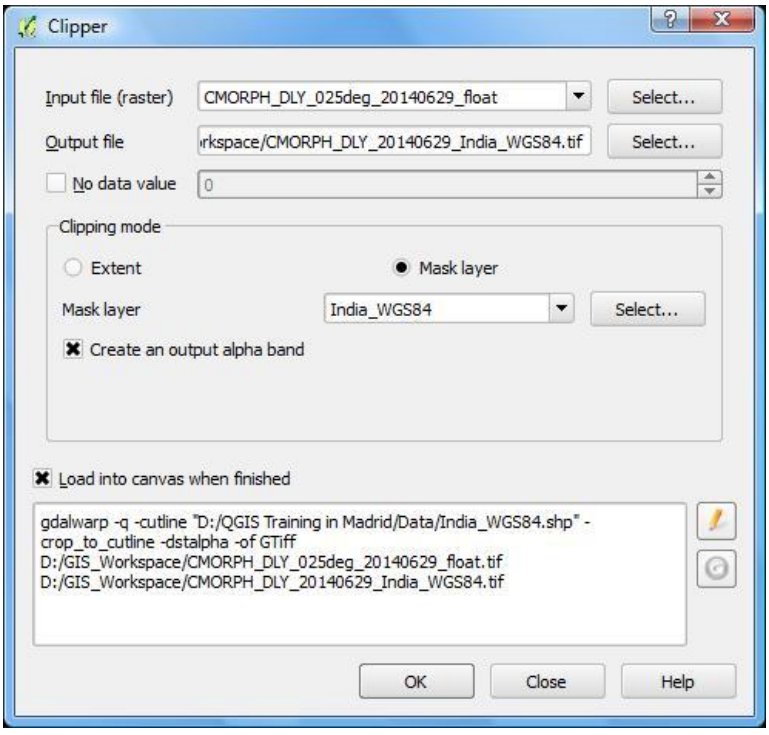
Note: Now you will execute a function that extracts an area of the raster that covers the country of India only.

3. Browse through the main menu options and select **[Raster] →{Extraction} → {Clipper}.**



Note: This launches the {Clipper} function which supports extraction of a raster area according to the boundaries of a specified vector.

4. Configure the raster clipper menu as shown below and click **{OK}**.



- **Input file (raster)** – Select the raster file to be clipped. In this case we want to clip the raster layer named, "**CMORPH_DLY_025deg_20140629_float.tif**"

- **Output file** – Name the output file, **"CMORPH_DLY_20140629_India_WGS84.tif"** and save it to your workspace folder.

- **No data value** - A **"no data"** value has not been set for the raster layer you are about to clip. Therefore the **"No data value"** option should not be enabled.

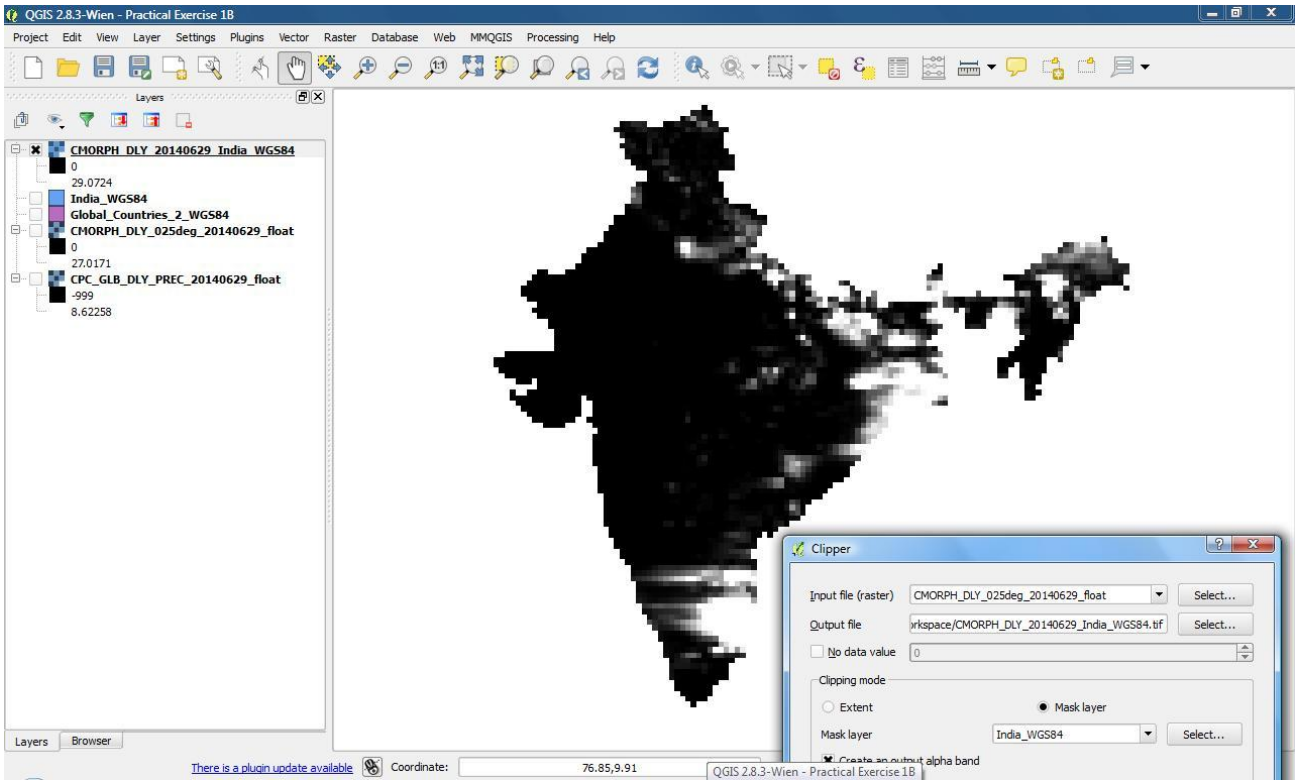
- **Mask Layer** – Enable this option under the **Clipping mode** section and select **"India_WGS84"** from the drop-list.

- **Create an output alpha band** – Enable this option. It will ensure that areas outside of the mask are not visible in the output. However, it will add another band to your raster which you will see listed if you use the Identify Tool, or view the raster's properties.

- **Load into canvas when finished** – Enable this option

5. Select **{OK}.**

Note: A new raster named, "CMORPH_DLY_20140629_India_WGS84.tif", should have been added to the Map Canvas. Disable all other layers in your Map



Canvas and zoom to the full extent of the clipped raster. You will notice that the area covered by the new raster is consistent with the vector layer for India.

6. Close the **{Clipper}** function menu.

7. Select and extract two more countries of your choosing, from the "**Global_Countries_WGS84"** vector layer and then use these extracted data layers to create new rainfall rasters as demonstrated in steps 1 to 6 above. Your new raster layers should be extracted from each of the global rasters provided:

   - **"CMORPH_DLY_025deg_20140629_float.tif"**
   - "**CPC_GLB_DLY_PREC_20140629_float**"

Note: Try zooming in to observe the differences between the clipped rasters for the regions you selected.

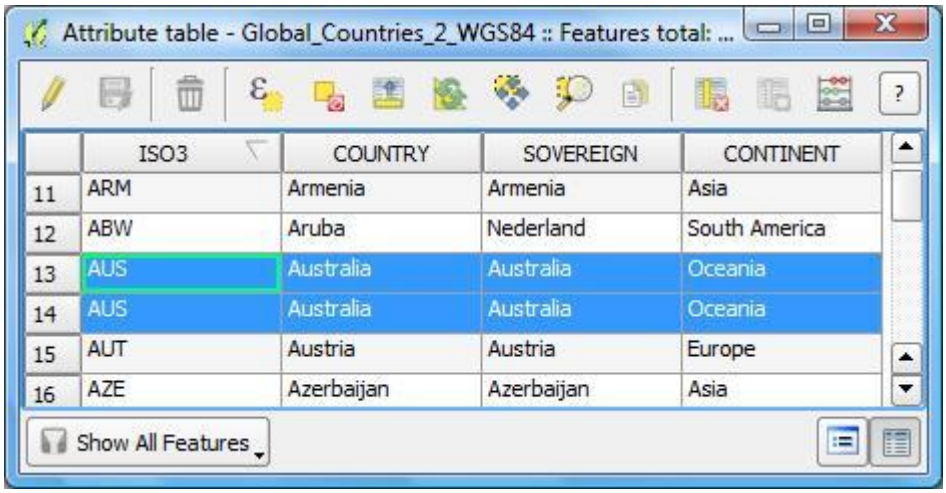
3.5 Importing ASCII Data with Spatial Details

In this final section of the chapter, you will learn how to import spatial details stored in ASCII format and display these data as plotted vector points. In this exercise, you will do the following:

- Use methods from the previous sections to extract a specified country layer from the global countries vector file
- Use the extracted country layer to clip a raster providing temperature forecast information
- Prepare text-based data on cities within the extracted country for import
- Import city data to QGIS
- Plot cities as vector points on top of the temperature raster and country vector.

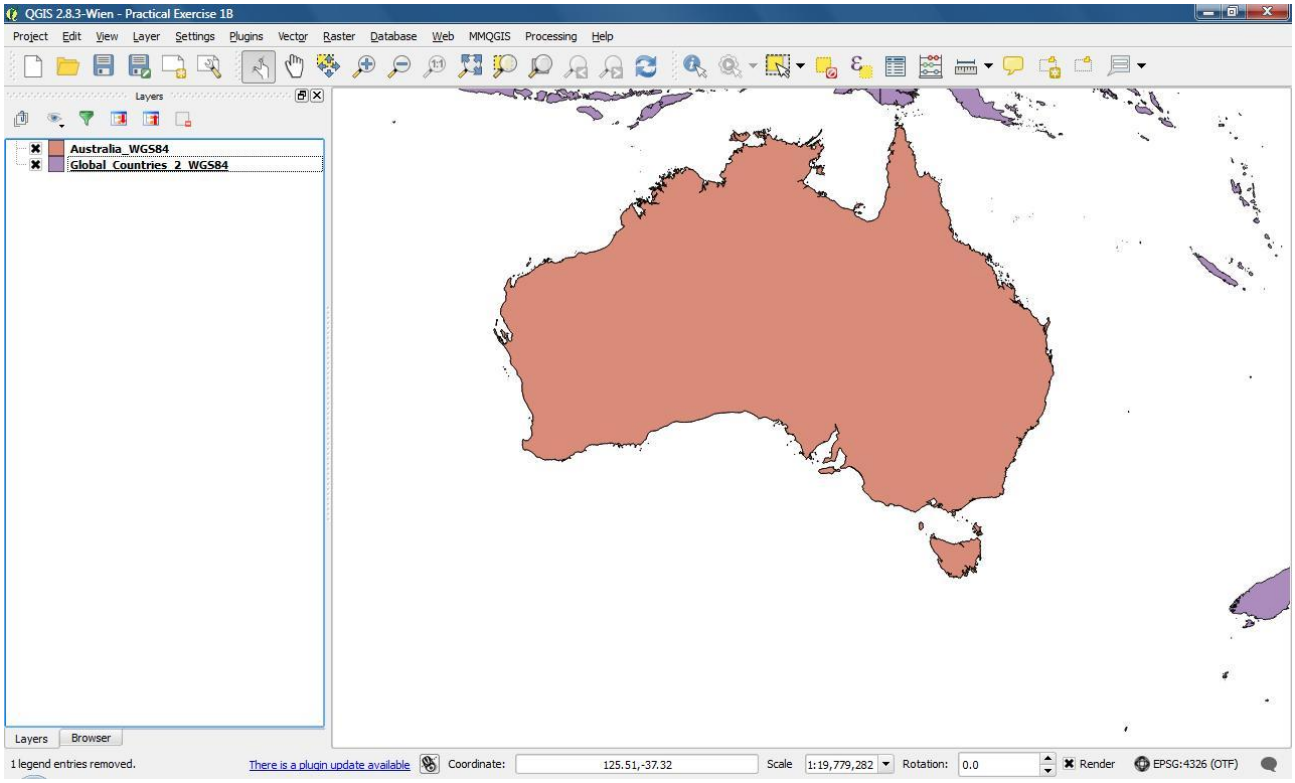
1. Remove all layers from the **Layers Panel** except for the countries.
2. Zoom to the full extent of this layer
3. Locate and extract the feature for the country of Australia.

Tip: There is more than one feature in the attribute table with the value, "Australia" under the COUNTRY field. Therefore you will need to select more than one feature in the layer.



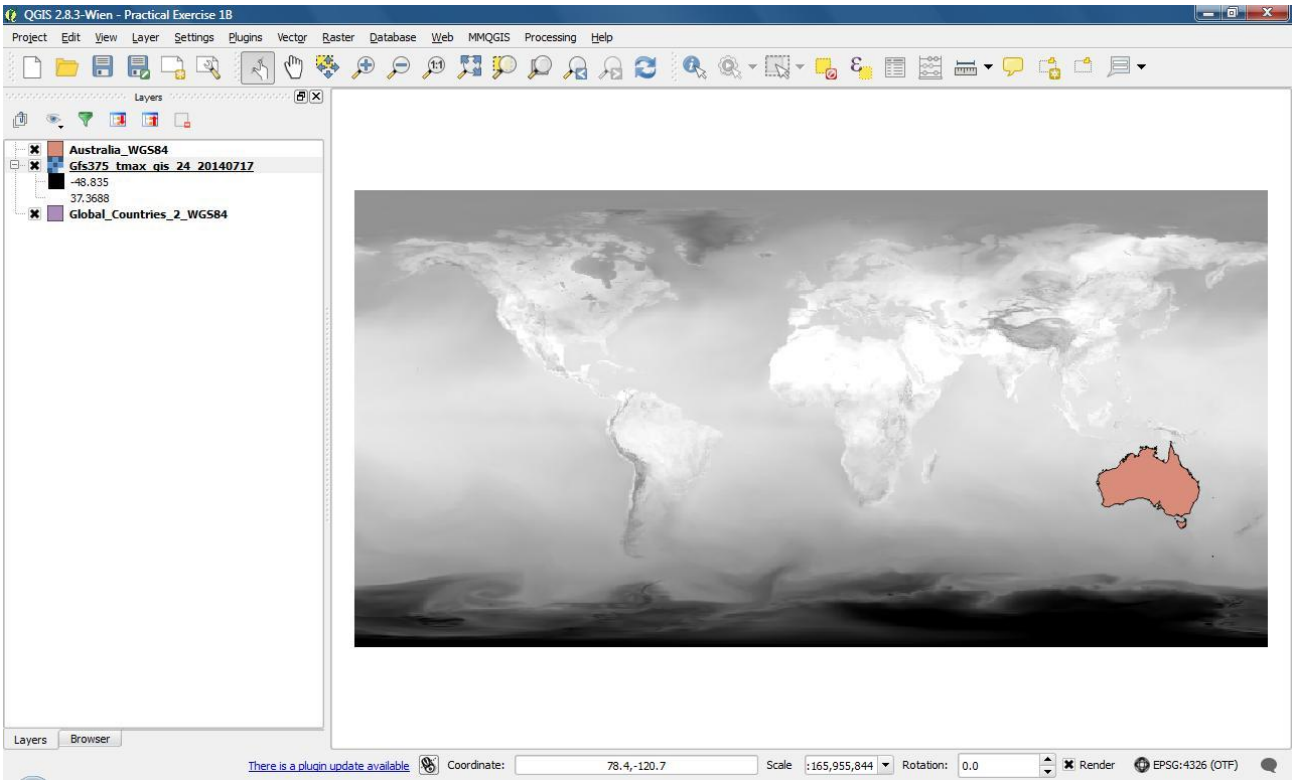
	ISO3	COUNTRY	SOVEREIGN	CONTINENT
11	ARM	Armenia	Armenia	Asia
12	ABW	Aruba	Nederland	South America
13	AUS	Australia	Australia	Oceania
14	AUS	Australia	Australia	Oceania
15	AUT	Austria	Austria	Europe
16	AZE	Azerbaijan	Azerbaijan	Asia

Note: Name the extracted feature, "Australia_WGS84.shp".



4. Use the **Browser Panel** to add the raster layer named, **"gfs375_tmax_gis_24_20140717.tif"** to the **Layers Panel.**

Note: The source of this raster layer is the Climate Prediction Center. The layer is essentially a maximum temperature output from the Global Forecast Model. It was developed for use as a 24-hour global temperature forecast, associated with the date July 17th, 2014. Zoom to the full extent of the map and proceed.



Tip: Observe the details within the General and Metadata tabs under the {Properties} menu for this raster layer. You will notice that it uses a different Coordinate Reference System from the other layers in your map (which use WGS 84). The datum it uses is unknown but based on a spherical model. However, you should note that the Coordinate Reference System used by the temperature layer is also a Geographic Coordinate System (like WGS 84) and that its spatial extent is very similar to the extent of the countries layer. This suggests that these two layers are lining up without the need for a transformation. However, it is still advisable to convert the temperatures layer to WGS 84 to ensure full compatibility.

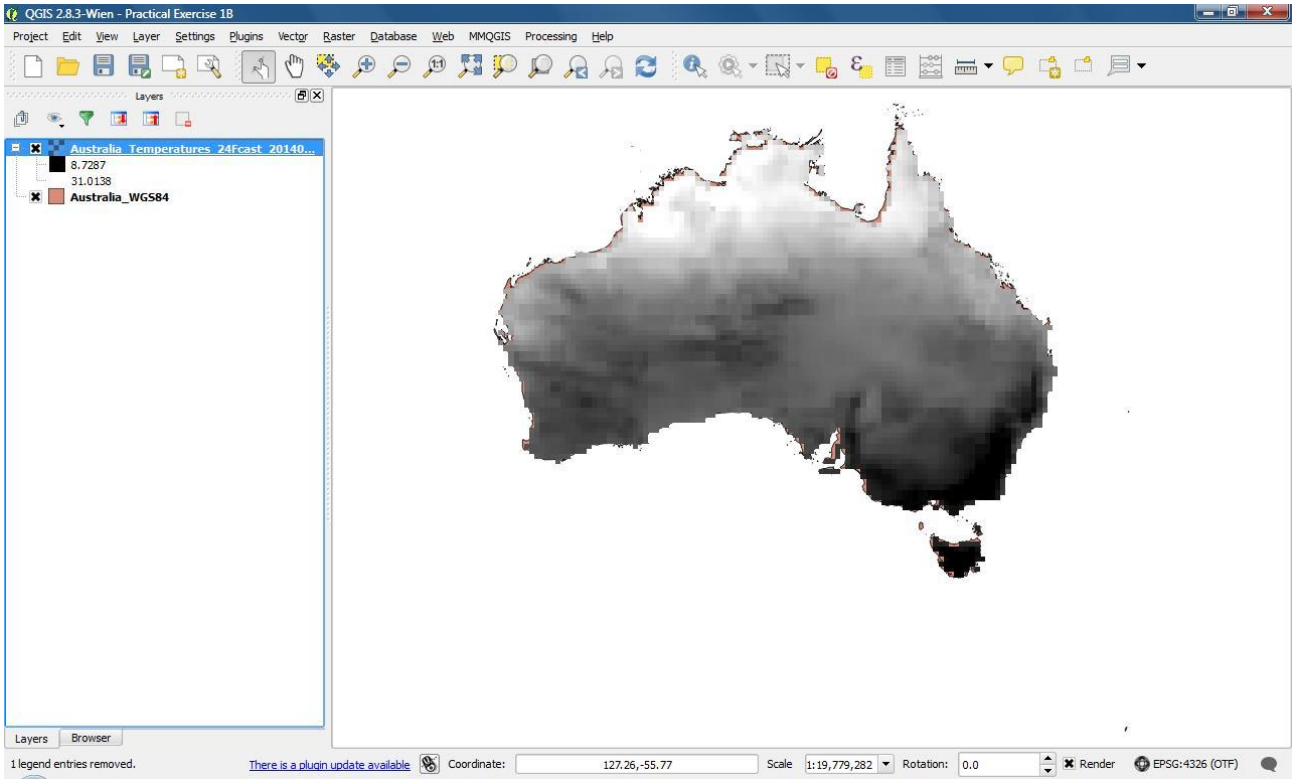
Try creating a new version of this temperature layer that is registered in the WGS 84 CRS to ensure that it is fully compatible with your other map layers. Save the converted layer to your workspace folder under the name, "Global_Temperatures_24Fcast_20140717_WGS84.tif". Add the new temperature layer to the map and remove the originally imported version.

5. Use the **{Clipper}** function under the **[Raster]** menu to extract a region of the global temperature layer that is specific to Australia.

Note: Name the newly extracted raster layer, "Australia_Temperatures_24Fcast_20140717_WGS84.tif". Save it to your

workspace folder and make sure it is imported to the map when the operation is complete.

6. Remove the global temperature and the countries layers and then zoom to the full extent of the newly extracted temperature raster for Australia.



7. Visit your desktop; open the workspace folder and launch a text file named, **"Australia_Cities.txt"**. The file may be viewed with any text editor application on your system.

Australia_Cities - Notepad

File Edit Format View Help

Rank	City	Population (2000)	Latitude (DD)	Longitude (DD)
1	Sydney	4277200	-33.870	151.210
2	Melbourne	3666000	-37.810	144.960
3	Brisbane	1598600	-27.460	153.020
4	Perth	1412900	-31.960	115.840
5	Adelaide	1089700	-34.930	138.600
6	Newcastle	502300	-32.920	151.750
7	Gold coast	457900	-28.070	153.440
8	Canberra	323100	-35.310	149.130
9	Wollongong	262500	-34.420	150.870
10	Sunshine coast	254700	-25.880	152.560
11	Hobart	201000	-42.850	147.290
12	Geelong	161500	-38.140	144.320
13	Townsville	152400	-19.260	146.780
14	Cairns	128500	-16.920	145.750
15	Launceston	99400	-41.450	147.130
16	Albury-wodonga	97300	-36.060	146.920
17	Darwin	95000	-12.430	130.850
18	Toowoomba	91800	-27.560	151.960
19	Ballarat	85300	-37.560	143.840
20	Shoalhaven	81600	-34.880	150.590
21	Bendigo	80400	-36.760	144.280
22	Burnie-devonport	78400	-41.060	145.890
23	Bathurst-orange	76600	-33.420	149.570
24	Mackay	72700	-21.140	149.180
25	Hastings	68000	-38.310	145.190
26	Rockhampton	66100	-23.370	150.510
27	Coffs harbour	62600	-30.300	153.120
28	Bundaberg	60300	-24.870	152.350
29	Wagga wagga	56400	-35.120	147.350
30	Mildura	46900	-34.190	142.160
31	Shepparton-mooroopna	45300	-36.370	145.400
32	Maroochydore-mooloolaba	45100	-26.680	153.120
33	Taree	44900	-31.900	152.470
34	Lismore	43200	-28.810	153.290
35	Gladstone	42900	-23.850	151.250
36	Mandurah	40800	-32.530	115.750
37	Hervey bay	39700	-25.290	152.840

Note: This is a text file which lists cities in Australia and ranks them by population size. The data was obtained from, http://www.tageo.com. There are a few things about the file that allow it to be imported into QGIS as data which can be plotted. These are as follows:

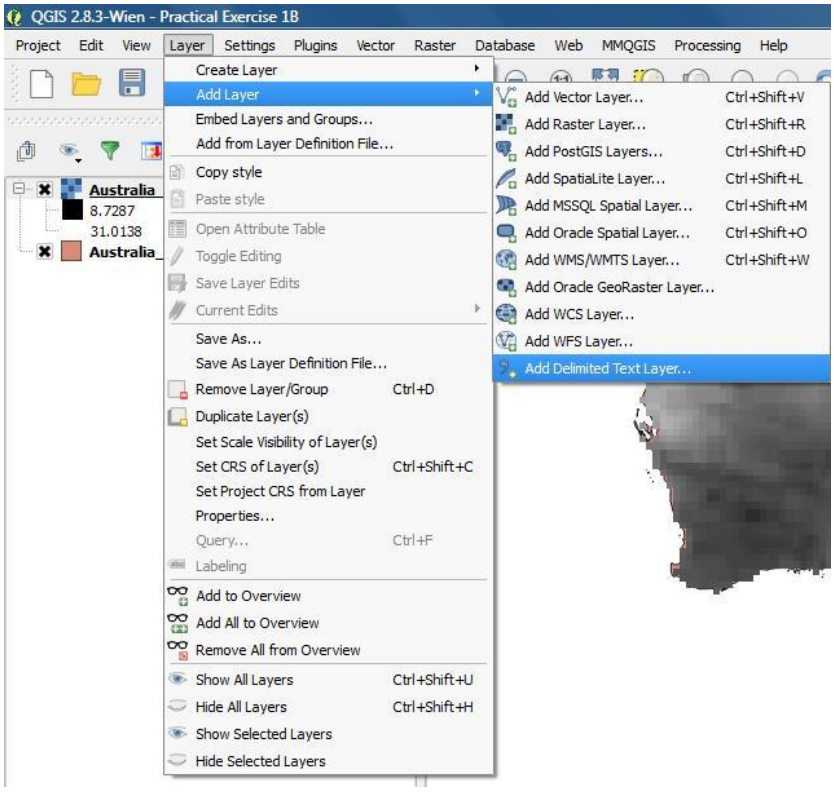
i. ***It is organized in columns with headings that can be interpreted as attribute field headings***

ii. ***The data within each row is delimited by tab spaces. These uniform gaps between values in rows can be used to correctly assign values to columns in an attribute table. Different types of delimiters such as commas, spaces, colons, semicolons and other symbols may also provide the same advantage. Without the presence of uniformly applied delimiters in text-data, import into QGIS would not be possible without some degree of pre-formatting.***

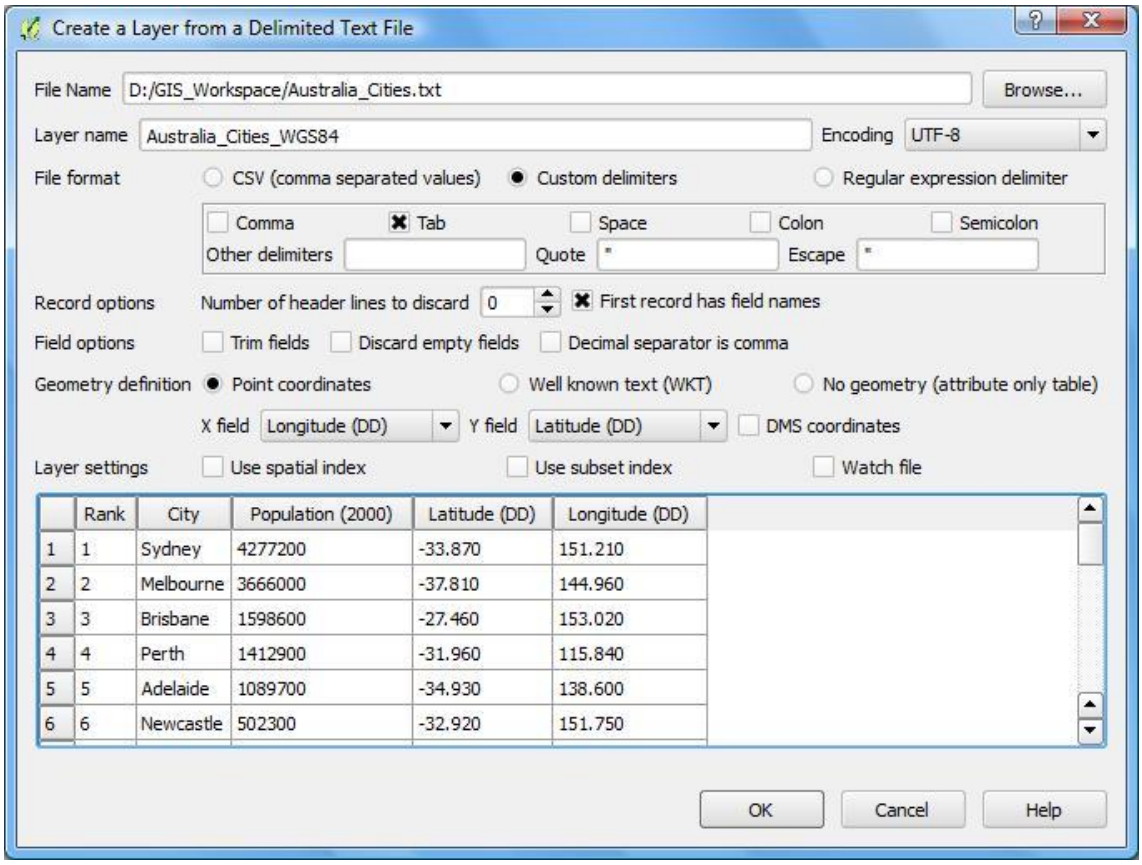
iii. ***The file contains a column of data with latitude values (in units of decimal degrees) and a corresponding column of data with longitude values (also in units of decimal degrees). These coordinate values can be used to draw/plot reference points in the Map Canvas according to a specified coordinate system.***

8. Close the Text file in your system and return to QGIS.

9. Open **[Layer]** from the main menu options and select **{Add Layer} → {Add Delimited Layer}**



Note: This launches a new menu. You will need to configure it as illustrated and explained:



i. **File Name:** Browse to your workspace folder and select the text file (**"Australia_Cities.txt"**)

ii. **Layer Name:** Enter a name for the imported layer here. The name **"Australia_Cities_WGS84"** is recommended.

iii. **File Format:** Choose the **"Custom delimiters"** option and then select the **"Tab"** option beneath.

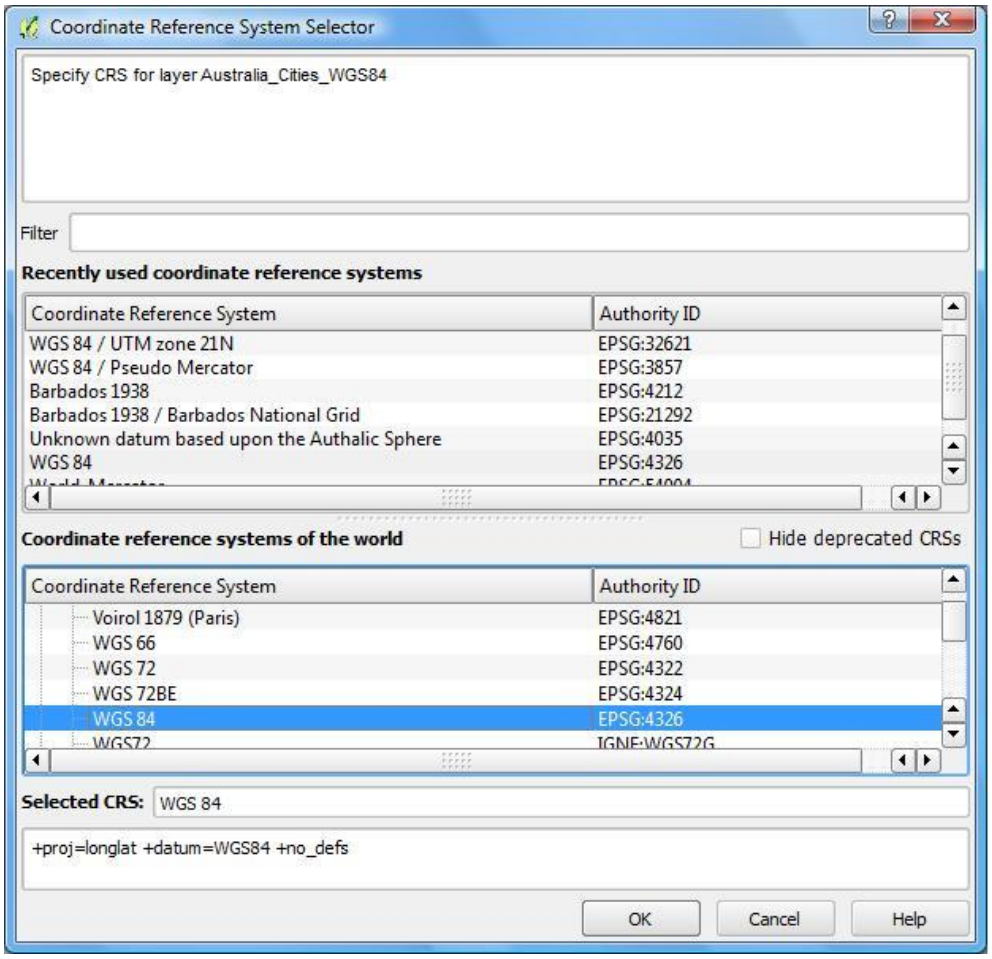
iv. **Record Options:** Select the **"First record has field names"** option.

v. **Geometry Definition:** Select the **"Point coordinates"** option

vi. **X field:** Make sure that **"Longitude (DD)"** is selected

vii. **Y Field:** Make sure that **"Latitude (DD)"** is selected

10. Hit **{OK}.**



Note: This launches the Coordinate Reference System Selector menu. You may use this menu to set a coordinate system for the points layer that will be created from this text-data import.

11. Select the **WGS 84** coordinate system and hit **{OK}**.

Note: You should now see points plotted in your Map Canvas distributed across various regions of Australia. You may view the attribute table of this layer to have a look at the data. Five data columns are listed. These are described below:

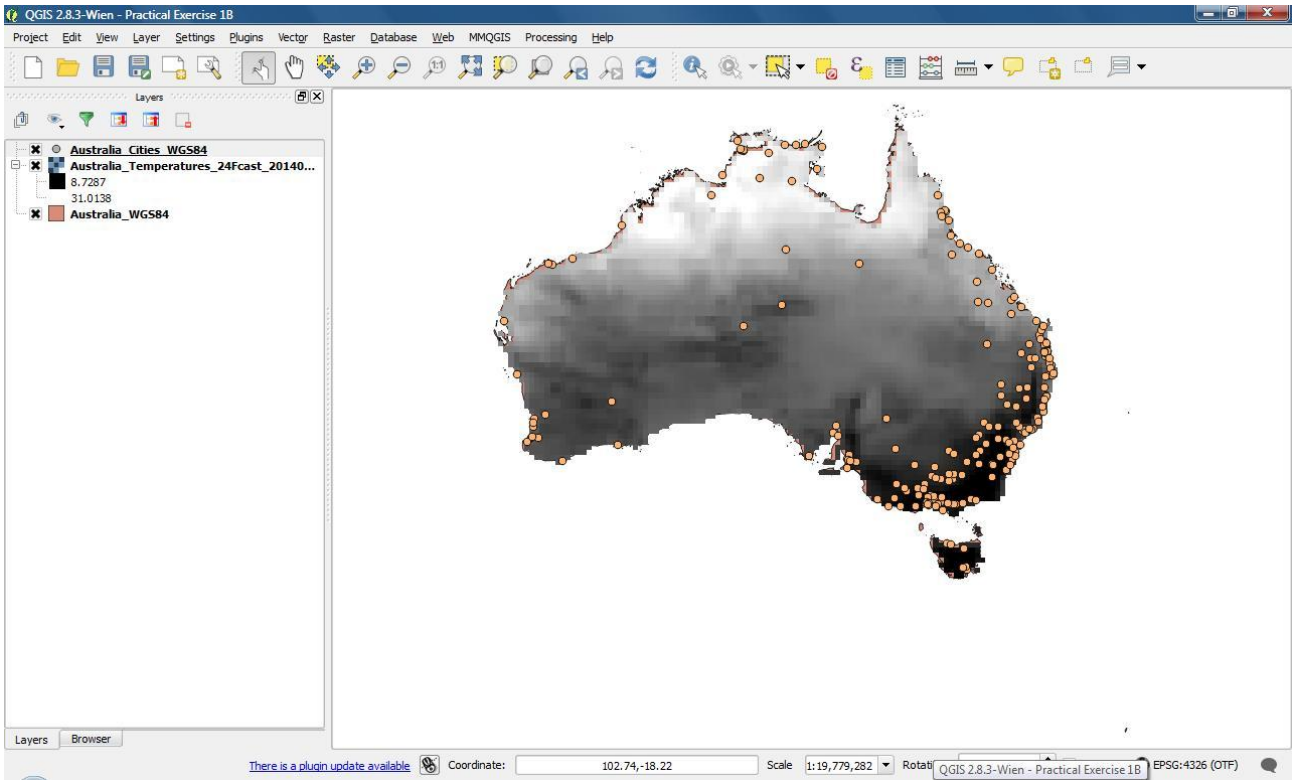
i. Rank – The rank of cities by their population size

ii. City – The official names of the cities in Australia

iii. Population (2000) – The population sizes of cities in Australia

iv. Latitude (DD) – The latitude coordinates associated with approximate locations of cities in Australia

v. Longitude (DD) – The longitude coordinates associated with approximate locations of cities in Australia



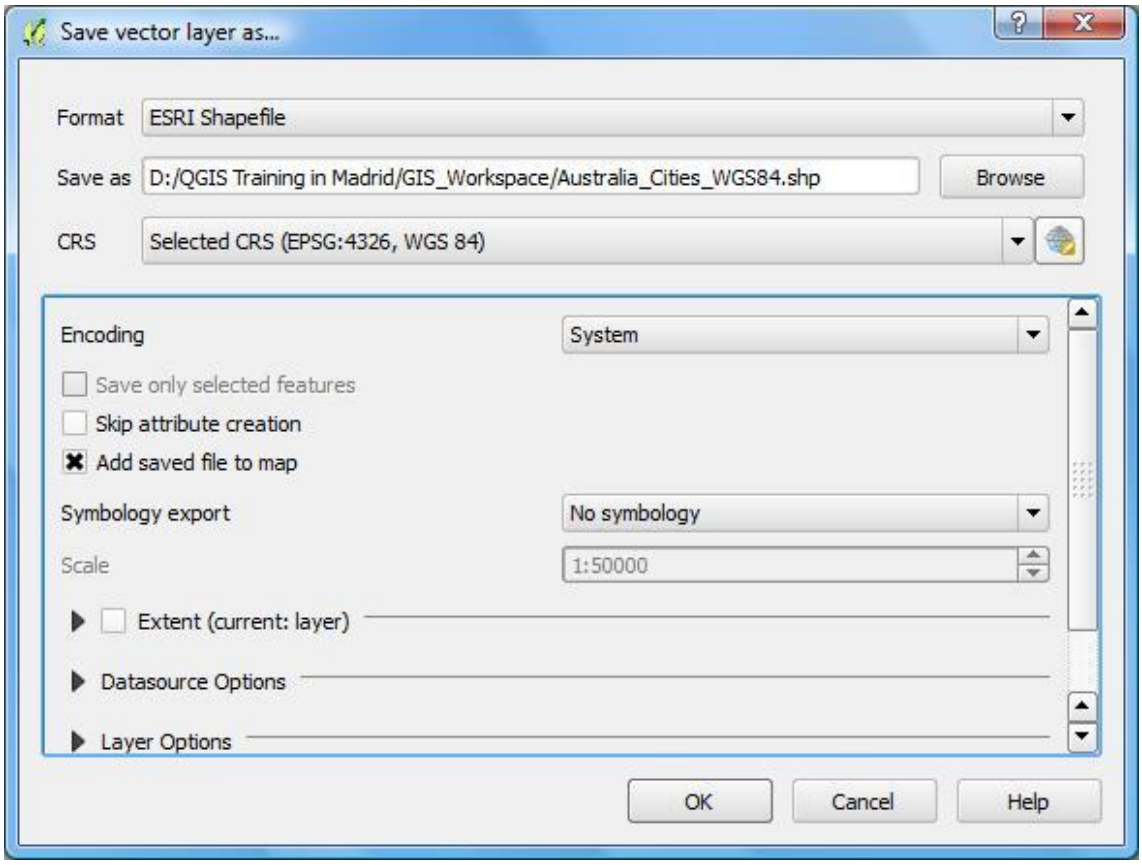
Attribute table - Australia_Cities_WGS84 :: Features total: 210, filtered: 210, selec...

	Rank	City	Population (2000)	Latitude (DD)	Longitude (DD)
0	1	Sydney	4277200	-33.87	151.21
1	2	Melbourne	3666000	-37.81	144.96
2	3	Brisbane	1598600	-27.46	153.02
3	4	Perth	1412900	-31.96	115.84
4	5	Adelaide	1089700	-34.93	138.6
5	6	Newcastle	502300	-32.92	151.75
6	7	Gold coast	457900	-28.07	153.44
7	8	Canberra	323100	-35.31	149.13
8	9	Wollongong	262500	-34.42	150.87
9	10	Sunshine coast	254700	-25.88	152.56
10	11	Hobart	201000	-42.85	147.29
11	12	Geelong	161500	-38.14	144.32
12	13	Townsville	152400	-19.26	146.78
13	14	Cairns	128500	-16.92	145.75
14	15	Launceston	99400	-41.45	147.13
15	16	Albury-wodonga	97300	-36.06	146.92

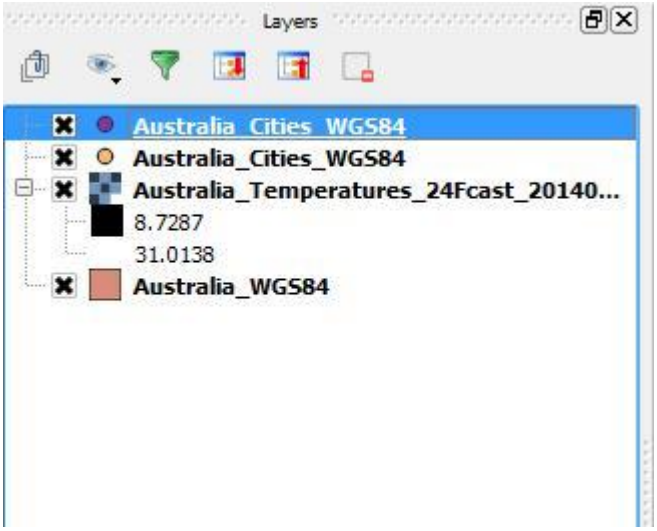
Show All Features

Although the file you've imported has been displayed as vector points in the Map Canvas, you should note that they are still stored as text data. Therefore, it is perhaps best to convert the imported layer to an official shapefile format.

12. Right-click the imported text layer (**in the Layers Panel**) and select **{Save As}** to launch the save (**Save vector layer as...**) menu.



Note: Make sure that the option selected for the Format field is "ESRI Shapefile". You should also save the output to your workspace folder under the name, "Australia_Cities_WGS84.shp". Set the CRS as WGS 84; select "Add saved file to map" and then hit {OK}. After completing this step you will have two layers in your map with the same name (i.e. "Australia_Cities_WGS84.shp"- see image on the right). However, one is an actual vector shapefile and the other is a tab-delimited

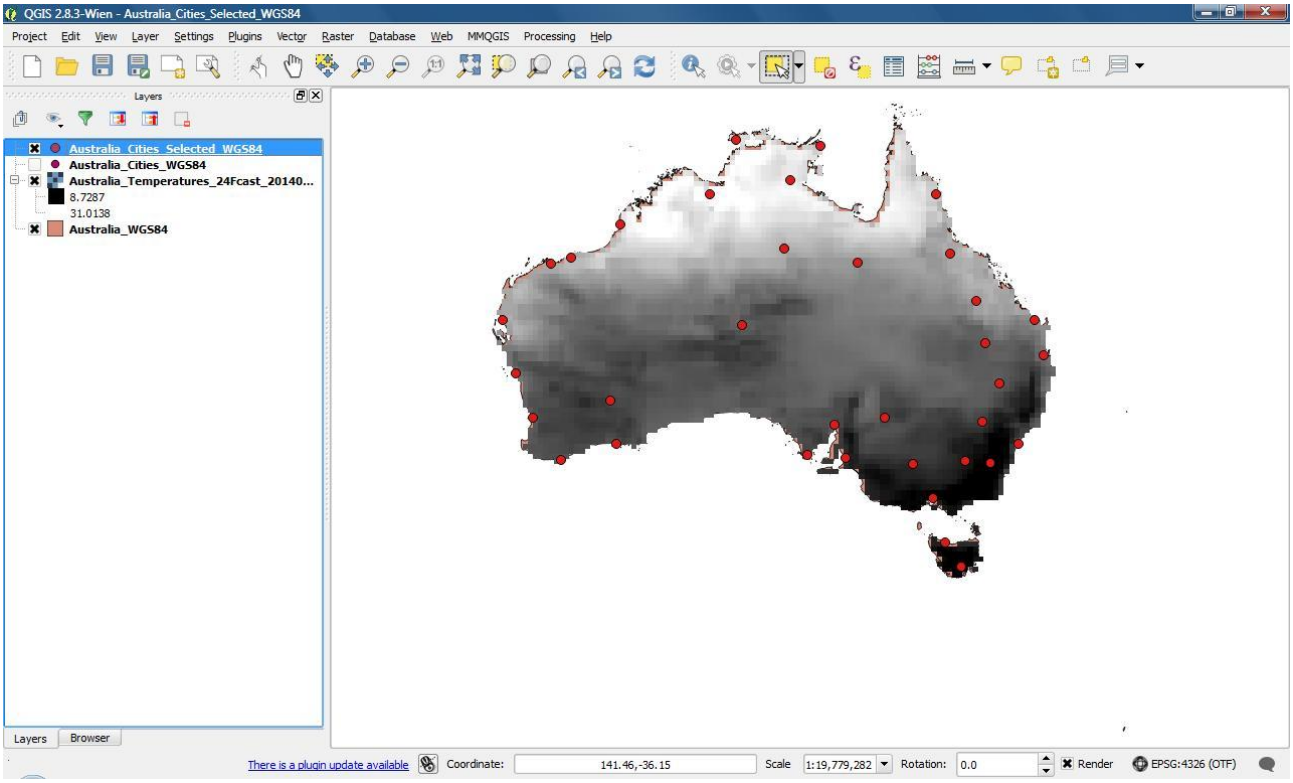


text file displayed as a point vector. Remove the delimited text-file layer from the map.

Tip: If you are unsure which layer is the actual shapefile, you can use the Metadata tab under the {Properties} menu of the layers to help you figure it out.

13. In this final step, your task will be to select and extract 35 cities from the total list of cities in the layer (**"Australia_Cities_WGS84"**).

Note: Notice how many of the points in the newly generated cities layer appear tightly clustered when viewed at the full extent of the map. This is especially evident on the eastern coast of the country. In the following illustration, 35 cities were selected and extracted from the original cities list. Notice how the selected cities are distributed across the north, south, east, west and central parts of the country and that they are not tightly clustered. Five of these selected cities have populations greater than 1 million and one of them is the capital city.



Use your knowledge of feature selection to create a new layer of 35 selected cities that is similar to the illustration above. Ensure that your final selection includes the five cities with populations over 1 million and also the capital city of **Canberra**. Export the selected cities to your workspace folder under the name **"Australia_Cities_Selected_WGS84"**.

Note: Remove the original cities layer (“Australia_Cities_WGS84”) from the map. Save your QGIS project and proceed to the next chapter. You will be using the layers presently in your map to conduct a lesson on styling for effective visualization of data.

4 STYLING DATA FOR VISUALIZATION

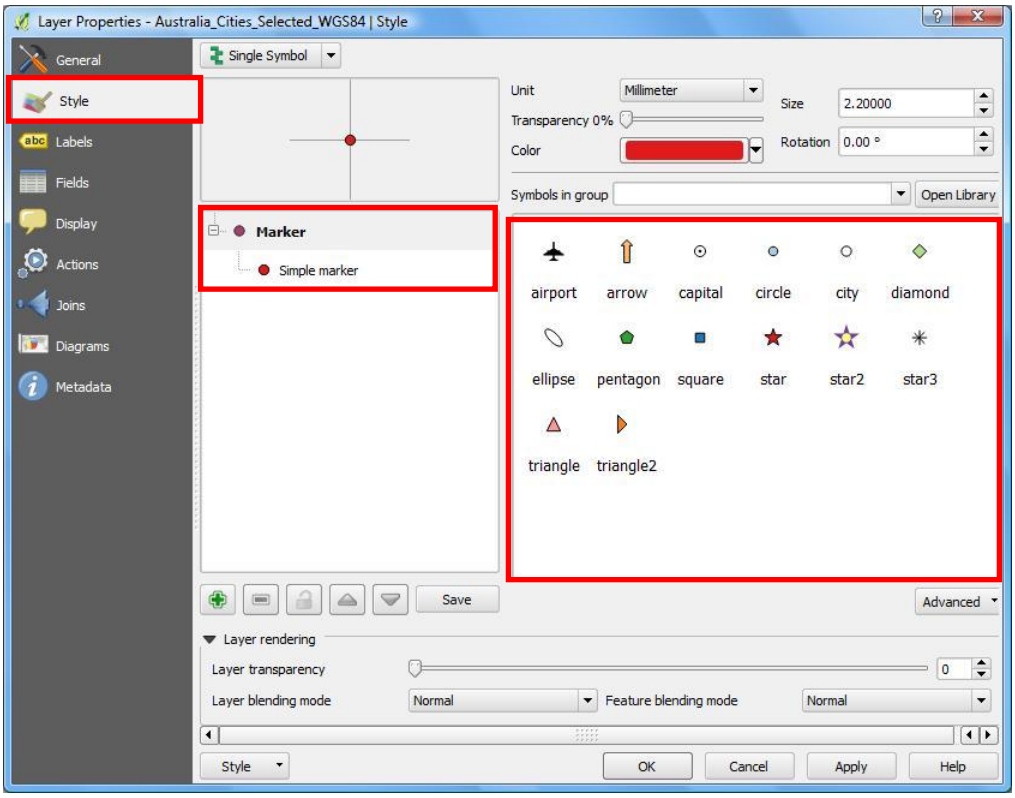
So far you've used a few basic handling procedures for vector and raster data in QGIS. However, the data has not been styled appropriately for effective visualization and analysis. This is especially the case for the raster data you have experimented with so far. In this final chapter, you will learn ways of styling data so that it can be better interpreted by viewers. You will continue working with the data for Australia from the previous section

4.1 Styling the Points Layer

Note: If your cities layer ("Australia_Cities_Selected_WGS84") is beneath other layers in the Layers Panel list then bring it to the top position, so that the changes you are about to make to it can be clearly visualized.

1. Open the **{Properties}** menu for the cities layer.

2. Select the **Style** tab from the left-panel.



Note: Options for styling your points should now be visible.

3. Locate the section of the menu with the caption, **"Marker" –** see the previous image.

   Note: Under this part of the menu you will see an entry named, "Simple marker". This tells you the category of symbol/marker currently being used to represent the points in the layer. The adjacent pane contains a list of marker options that may be used in place of the default style currently applied to your points.

4. Choose any one of the marker options from this pane *(see previous image)* and then select **{Apply}** to change the type of symbol used to represent points.

   Note: The point symbols on your Map Canvas should have changed to the option you applied. If your menu is blocking the Map Canvas, you will need to temporarily shift it out of the way to observe the change. Try changing the type of point symbol a few more times before proceeding.

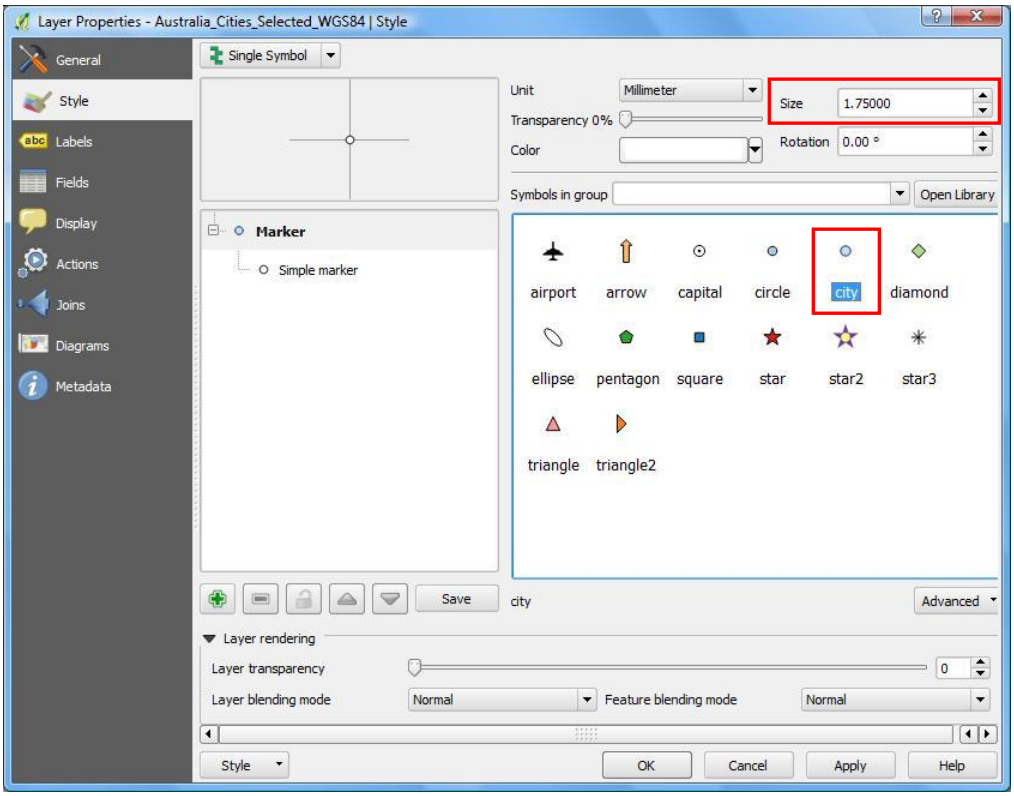
5. Select the **"city"** marker from the pane and **apply** it *(**see next illustration**)*.

   Note: Now that you have chosen the "city" marker to represent your point objects, you can adjust their final colour, size and even degree of transparency.

6. Locate the **"Size"** field in the section above *(**see next illustration**)*.

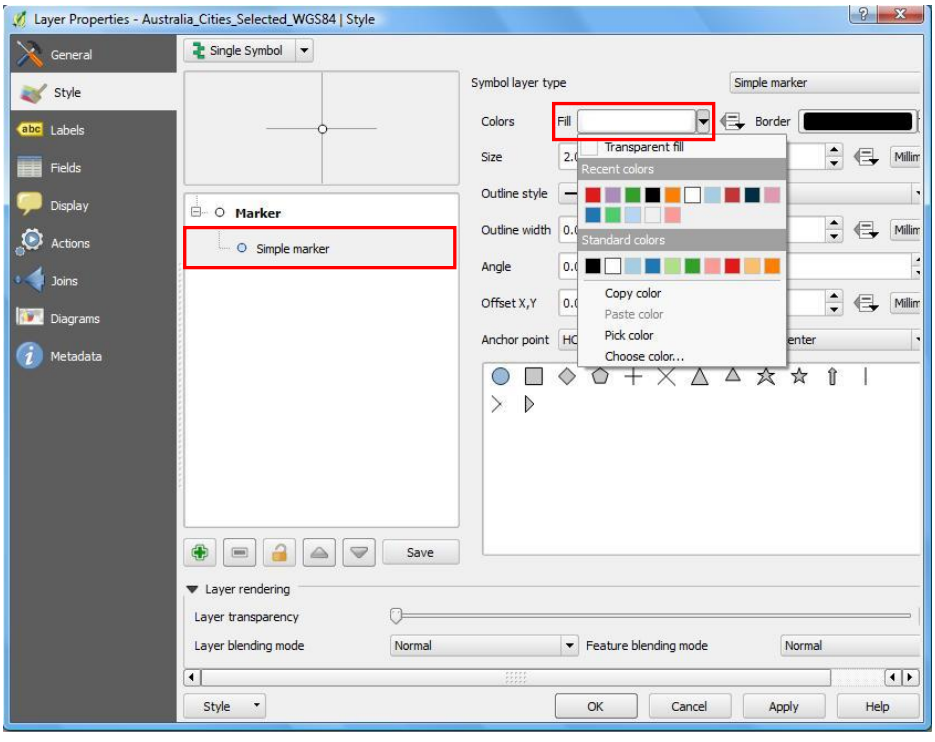
   Note: The default size of the "city" marker option should be 2.2 and the units should be millimetres.

7. Change the size entered in the field from 2.2 to 1.75 and select **{Apply}** to see the change.



Note: You may experiment with different sizes to see how they look, but be sure to apply a final size of 2.2. Next you will try changing the colour of the "city" markers.

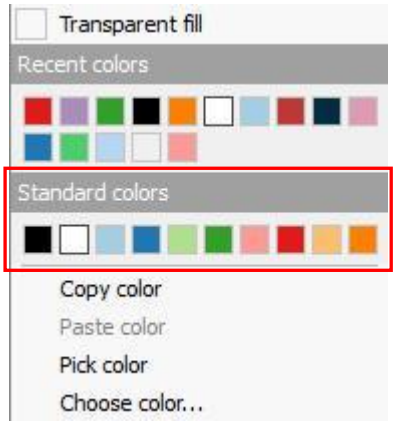
8. Select **"Simple marker"**; locate the **"Fill"** menu option and click on the drop-button next to the field.



Note: There are different ways to set colours for symbols in QGIS 2.8. Some of these are discussed below:

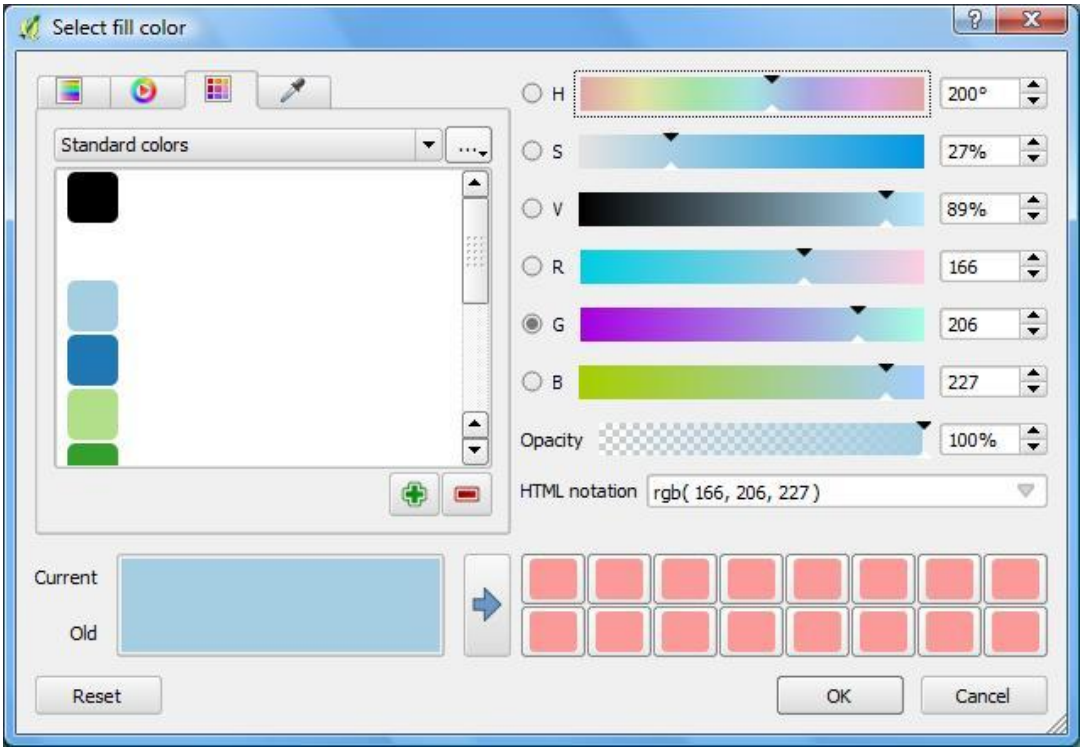
i. Choosing from the "Standard Colors" list.

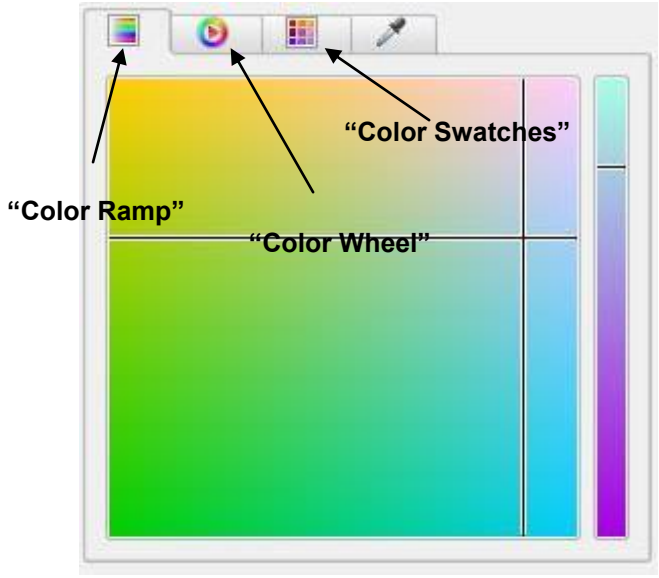
Note: Simply click on one of the colours shown in this row.



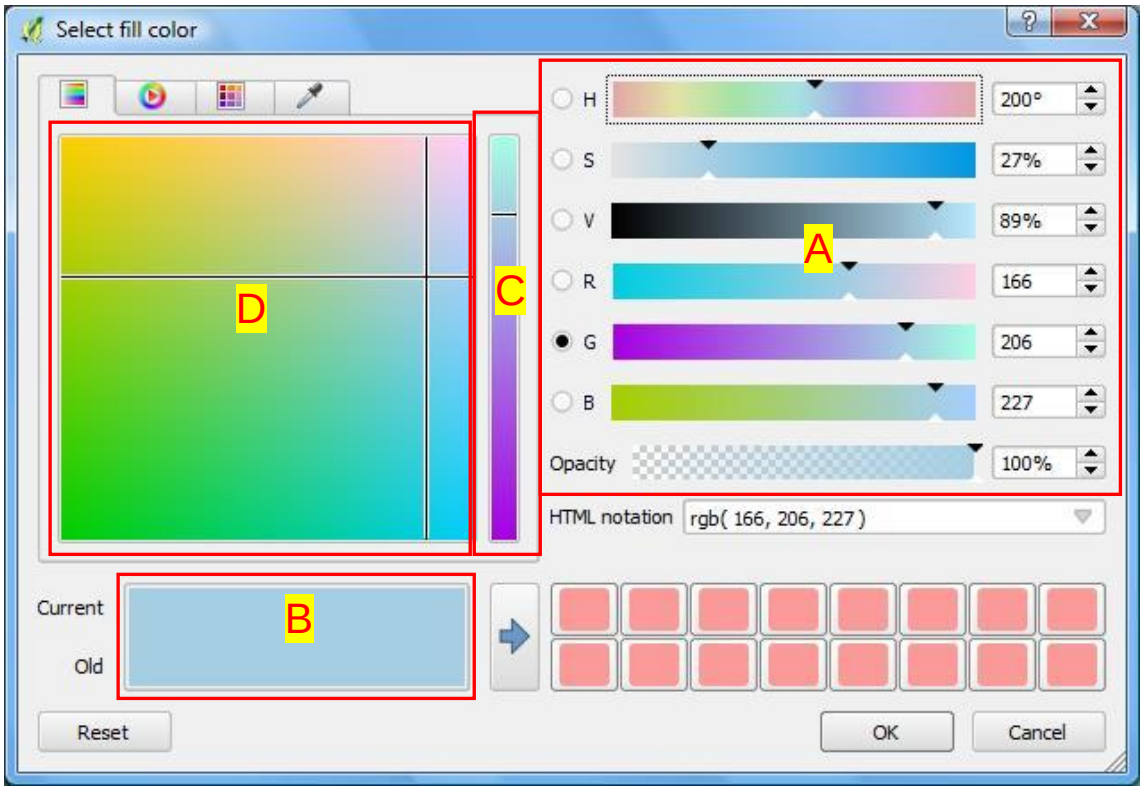
ii. Using the "Color Ramp" or "Color Wheel"

Note: To access the "Color Ramp" or "Color Wheel", you must first click on the "Fill" menu option to open up the "Select fill color" menu. See illustration below.





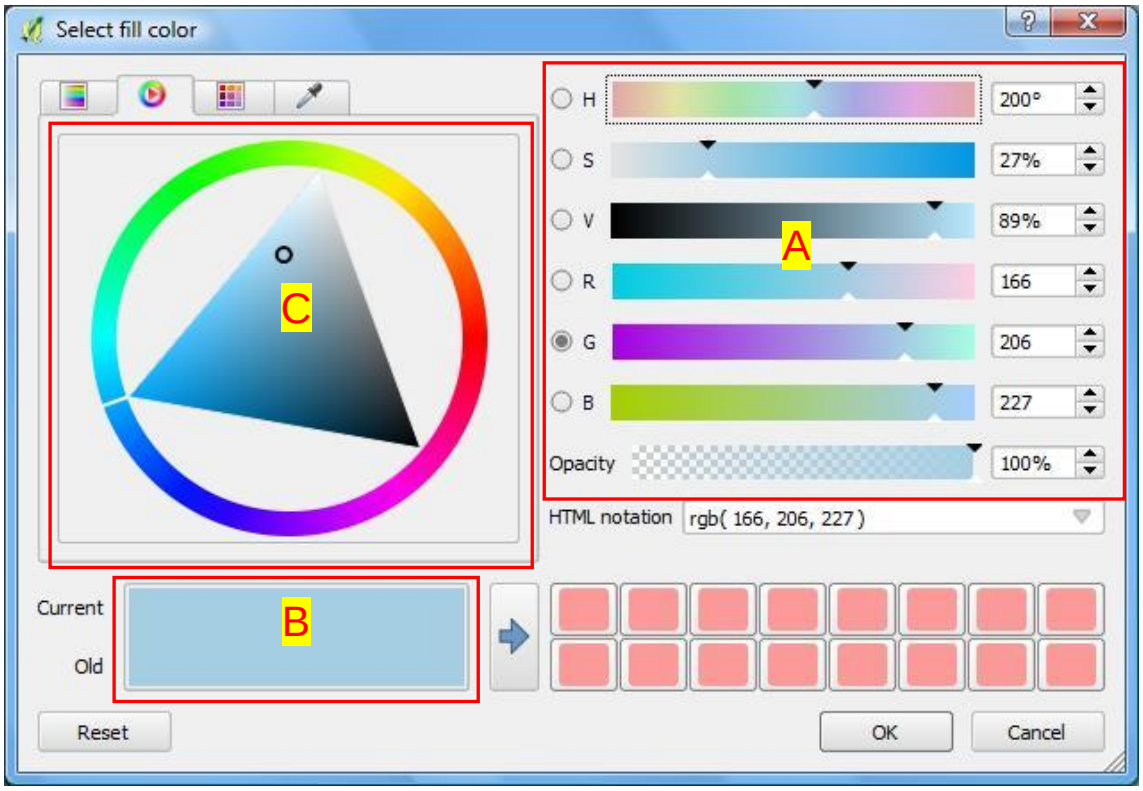
- To use the **"Color Ramp"** you must first activate it via the tab (as shown on the left).



In the menu, you will see controls on the right (section A above) for the HSV (Hue, Saturation and Value) and RGB (Red, Green and Blue) colour scales. These dials will be automatically set for the colour that is currently applied to your symbol. However, you can shift them around or enter numbers into the various scale fields to change the colour seen at (section B above). This will create a ramp (section C above) based on the combinations you chose. You can slide the dial up and down the

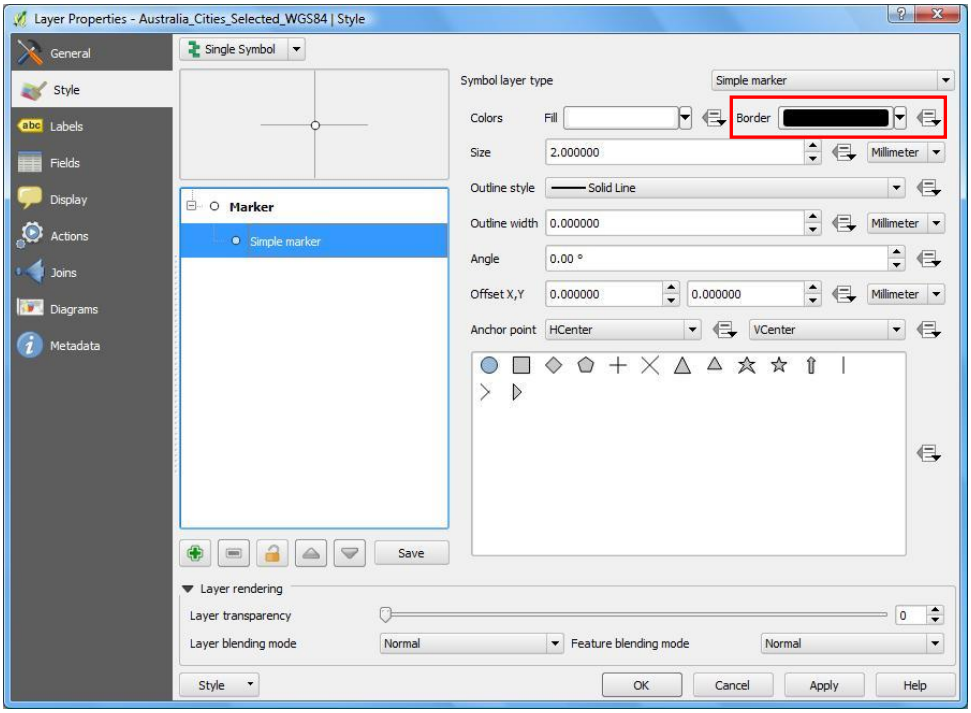
ramp to settle on a colour or intensity of your choice. Alternatively, the ramp can be set using the colour pane to its left (section D above). Simply click on a different area within this pane to change the colour range of the ramp. Once you've decided on a colour, hit **{OK}** to choose it.

- To use the "**Color Wheel"** you must first activate it via the tab previously illustrated



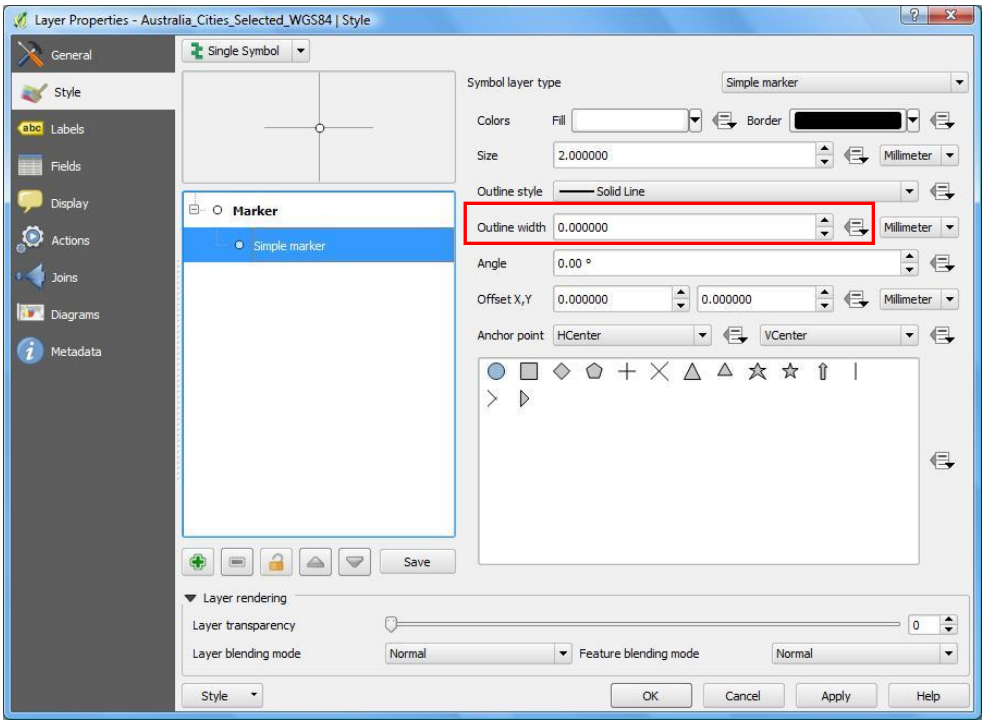
In the menu, you will again see the HSV and RGB controls on the right (section A above) which you can shift around. Doing this will change the colour selected (see section B) and will also change the position of the colour wheel (see Section C). Alternatively, you may rotate the colour wheel to the colour range of your choice and then select the level of colour intensity within the range by clicking on a desired area inside the triangle. Once you've decided on a colour, hit **{OK}** to choose it.

9. Locate the **"Border"** option (**see image below**) and use any of the methods described in the previous step to choose a different colour for your border.



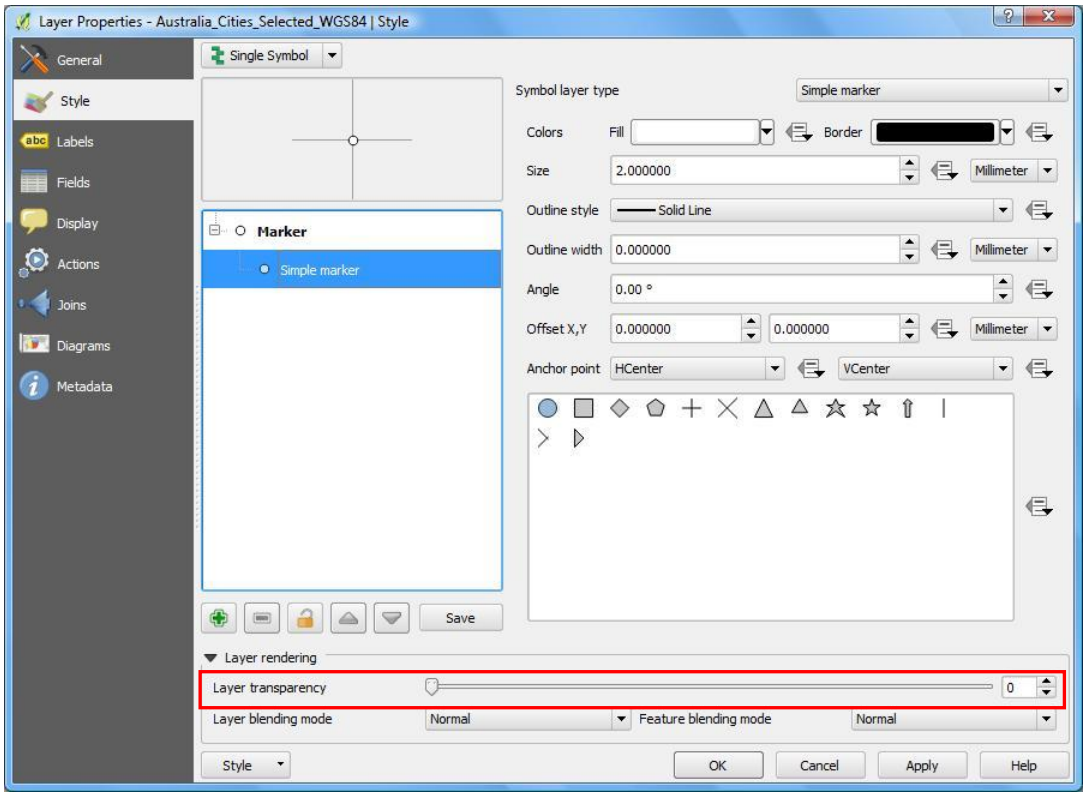
Note: You can change the colour of the borders for your symbols in QGIS. However, in most cases it is better to have a black or very dark border on your symbols to create a very sharp contrast. Experiment with different border colours at your leisure.

10. Change the width of the symbol border by adjusting the value in the **"Outline Width"** field (**see image below**).



Note: Try changing this value from 0 to 0.4.

Your point markers should now all be rendered in the "city" style with a size of 2.2 millimetres, a fill colour and border colour of your choosing and a border outline width of 0.4 millimetres. Feel free to experiment with different symbols, sizes, colours and border settings. By default, the transparency of data layers is set to zero. However, if you want to experiment with this setting, you may do so by shifting the transparency bar to the right and left to increase and decrease transparency (**see image below**).



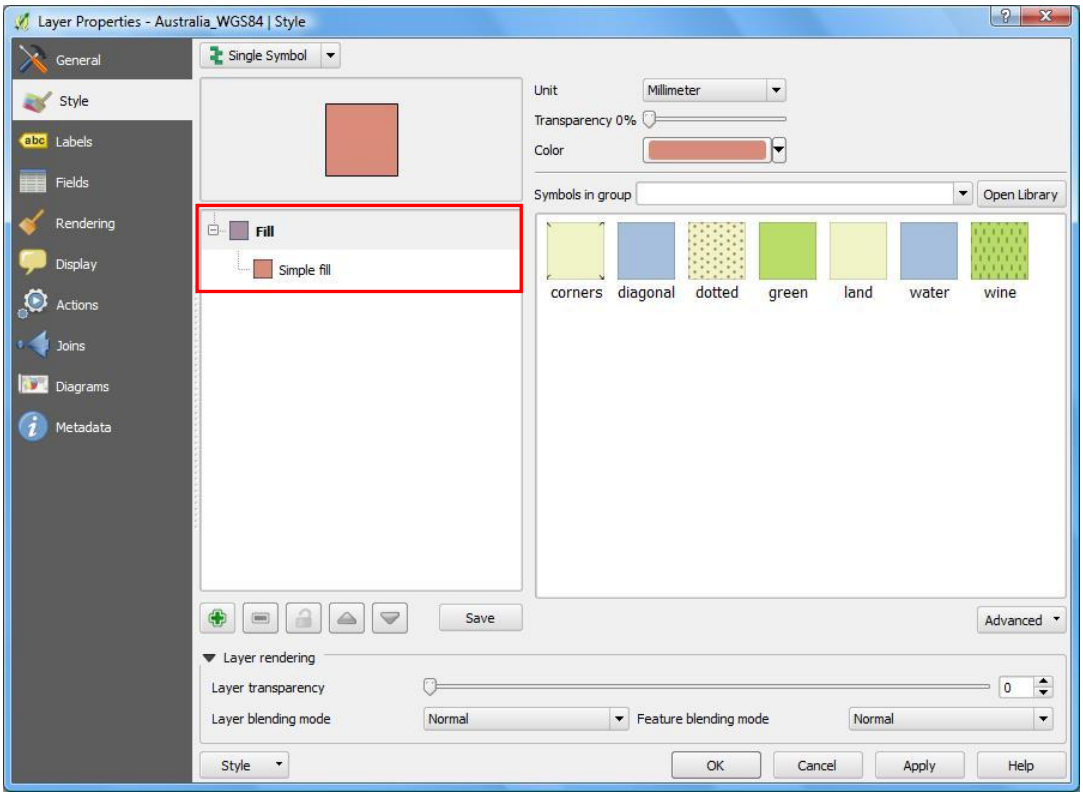
The styling exercise for the cities layer is now complete. You may now proceed with styling the country (polygon) layer. Close the **Layer Properties** menu before continuing.

4.2 Styling the Polygon Layer

Note: Before proceeding, shift the polygon ("Australia_WGS84") layer's position in the Layers Panel so that it is above the raster layer ("Australia_Temperatures_24Fcast_20140717_WGS84") and beneath the points layer ("Australia_Cities_WGS84"). Now turn the temperatures (raster) layer off.

1. Open the **{Properties}** menu for the polygon layer (***"Australia_WGS84"***).

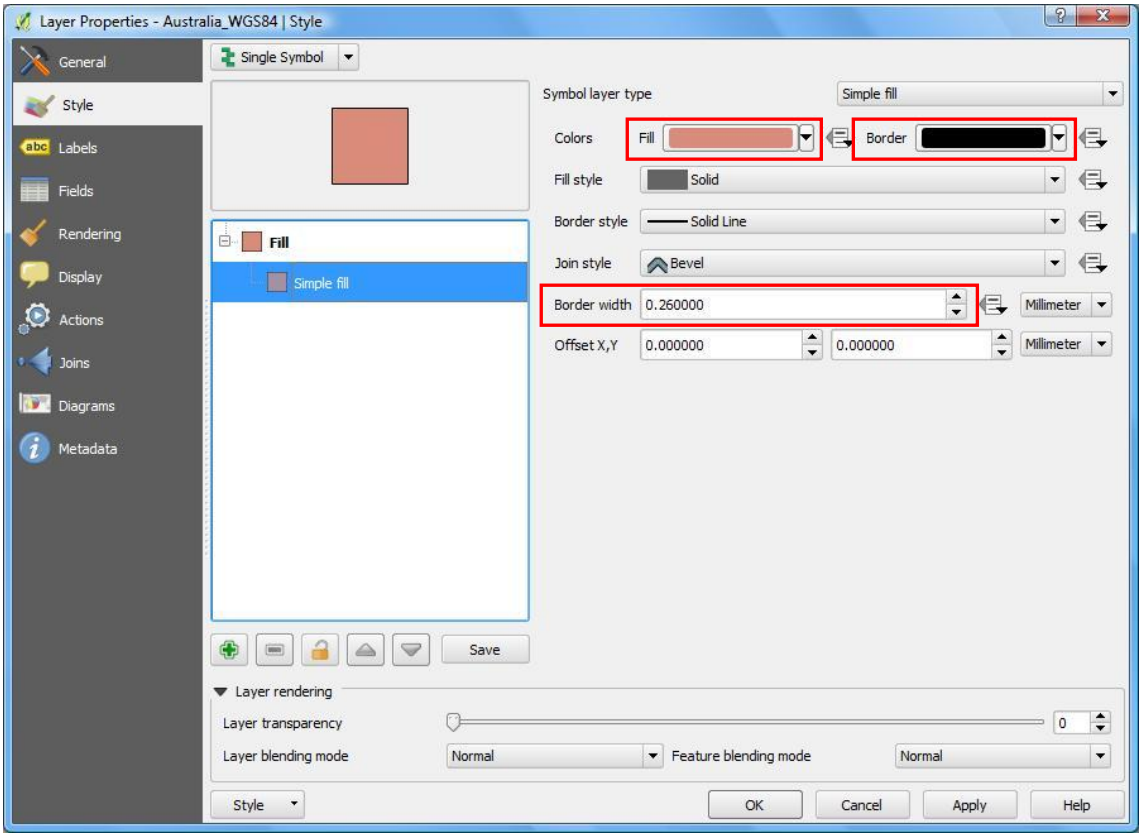
2. Locate the **“Fill” and “Simple Fill”** menu section (***see next illustration)***.



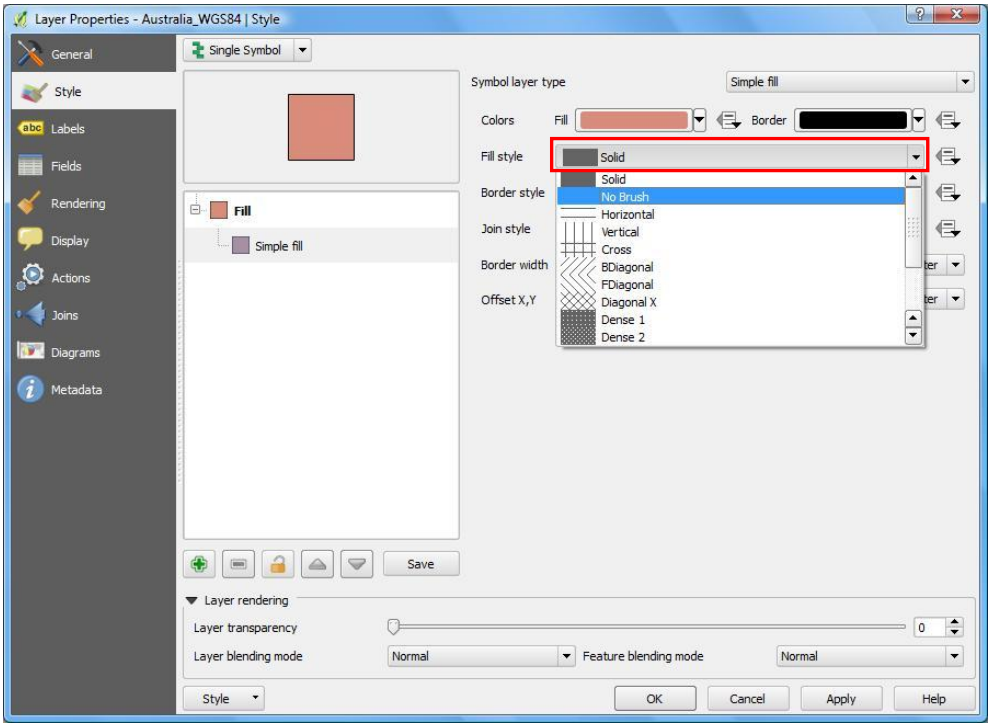
3. Highlight the **“Simple Fill”** entry.

   Note: This reveals a new section with options to change the “Fill Style”, “Border Style” and other properties.

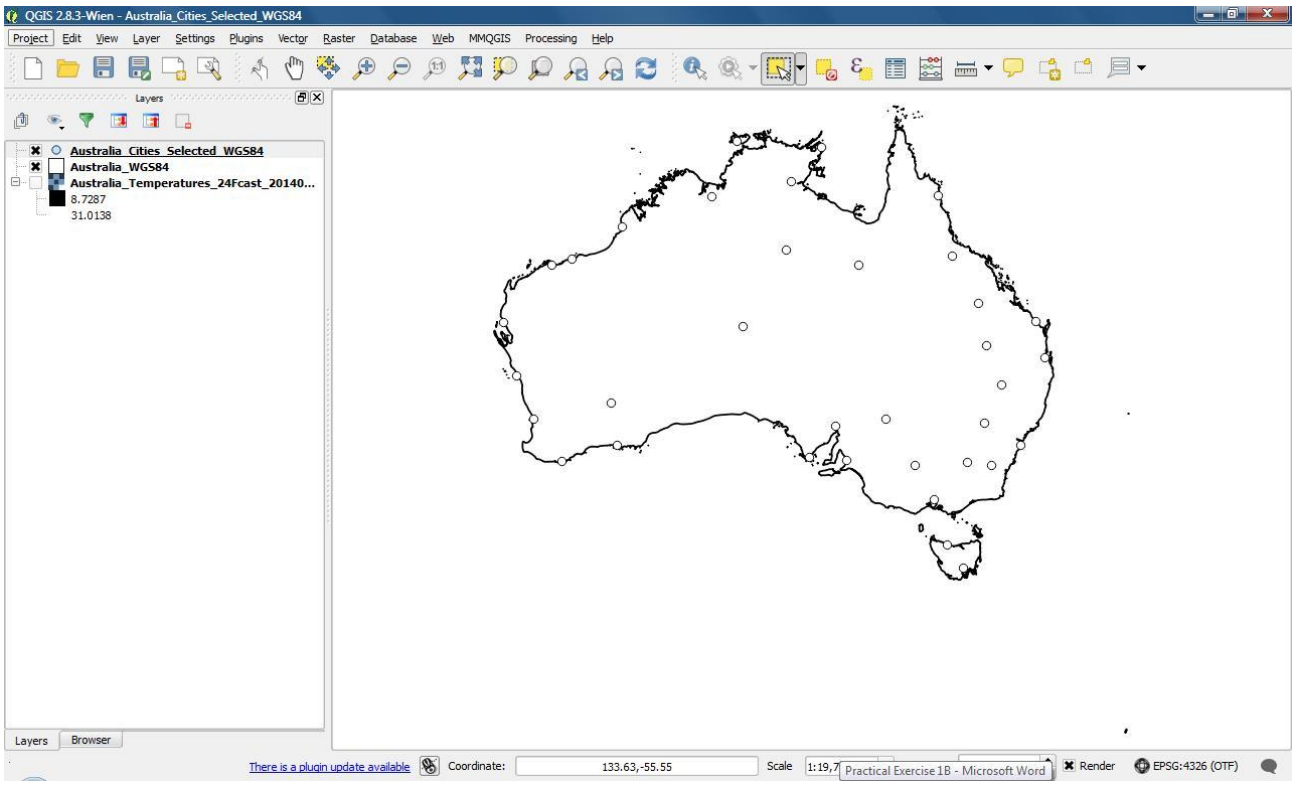
4. Experiment by changing the **Fill** colour and **Border** properties for the polygon by using the **“Fill”, “Border”** and **“Border Width”** menu options as described in the previous section (***see next image***). Remember to hit **{Apply}** after you’ve made a change to see how it looks in the **Map Canvas**.



Note: Once you've finished experimenting with colours, select "Fill Style" (see image below) and choose the "No Brush" option. Then change the "Border" colour to black if you've previously set it to a different colour. Select {OK} to complete the change.



When you view the Map Canvas, you will notice that the polygon layer is now colourless with a black border. If you try turning back on the raster layer in the Layers Panel then it should be visible although it is positioned underneath the polygon.



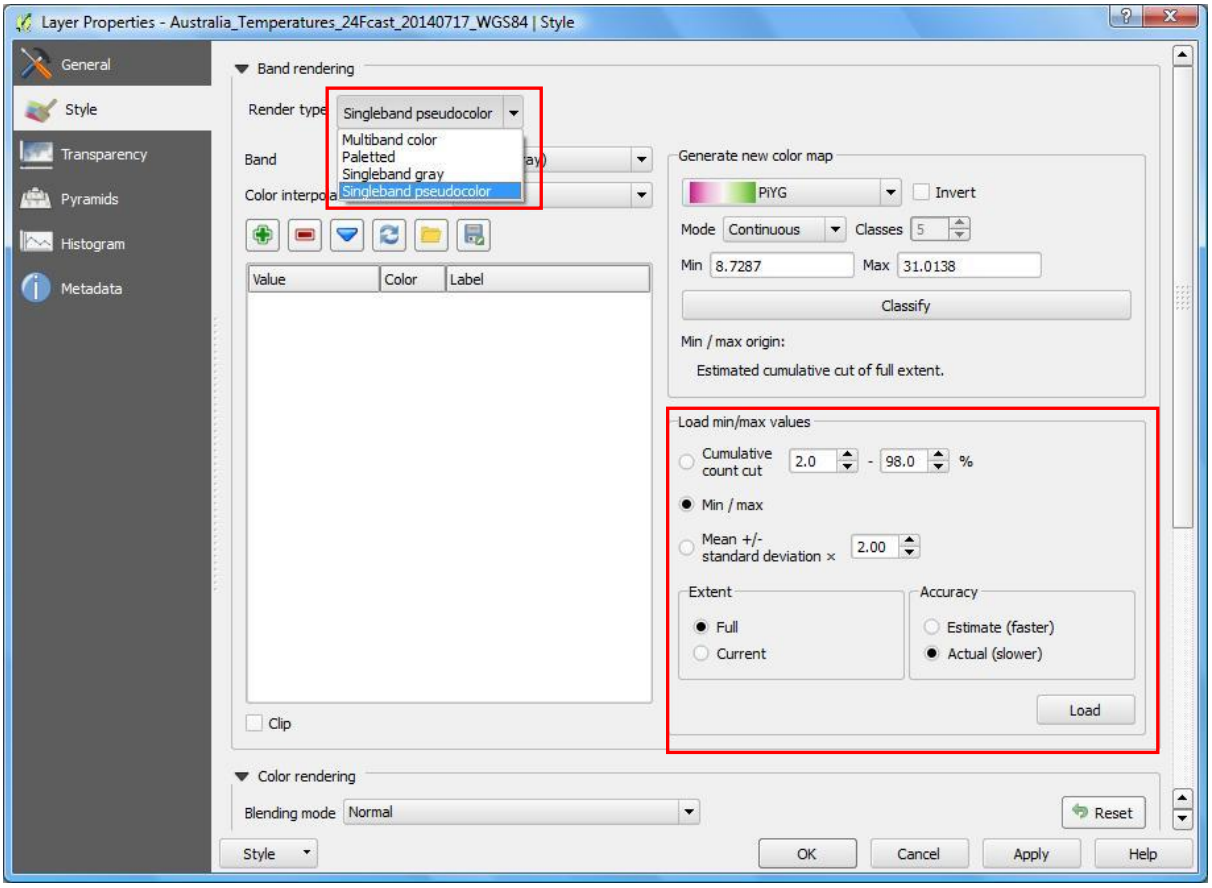
This completes the styling exercise for the polygon layer. Remember to close the **Layer Properties** menu before proceeding. Next you will experiment with options for styling a raster. Ensure the raster layer is enabled before proceeding.

4.3 Styling the Raster

1. Open the **{Properties}** from the menu for the raster layer.

   Note: the default styling for your raster uses a "stretched" method, where only a sample of the full range of values in the layer is depicted. This sample is rendered using a black-to-white theme where the range starts with black (the minimum value) and progresses to white (the maximum value). You are about to change this styling method to reflect the entire range of values in the raster using a "classified" method. The range of raster values will be divided into ten classes.

2. Locate the **"Render type"** field under the section with the caption, **"Band rendering"** (***see next image***) and select **"Singleband psuedocolor"** from the drop-list.



3. Locate the section of the map labelled, **"Load min/max values"**; select the **"Min/max"** ***(see previous image)***.

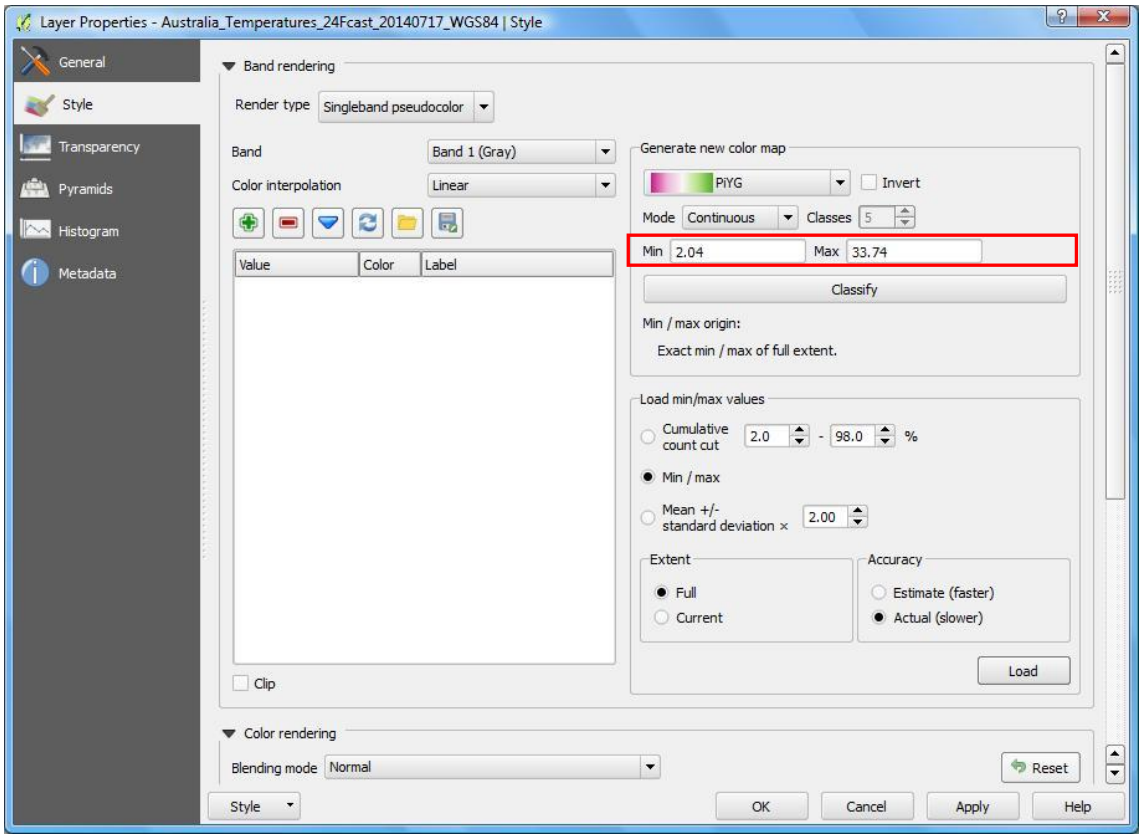
   Note: This step identifies the minimum and maximum temperature values from the grid. These values will be used in the following steps to classify the cells of the raster layer into ten groups beginning with the lowest temperature value and ending with the highest.

4. Under **"Extent"**, select the **"Full"** option (***see previous image***).

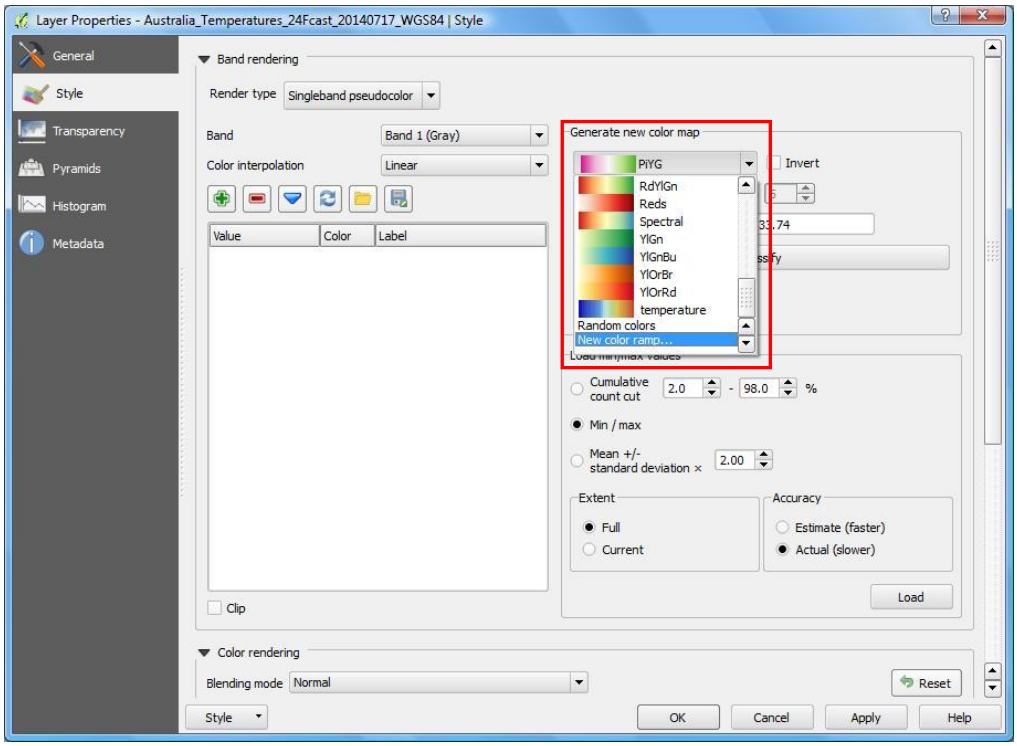
5. Under **"Accuracy"**, select **"Actual (Slower)"** (***see previous image***).

6. Hit **{Load}**.

   Note: You should now notice that the Min and Max values have changed from their previous range to reflect the full range within the layer (see next image).

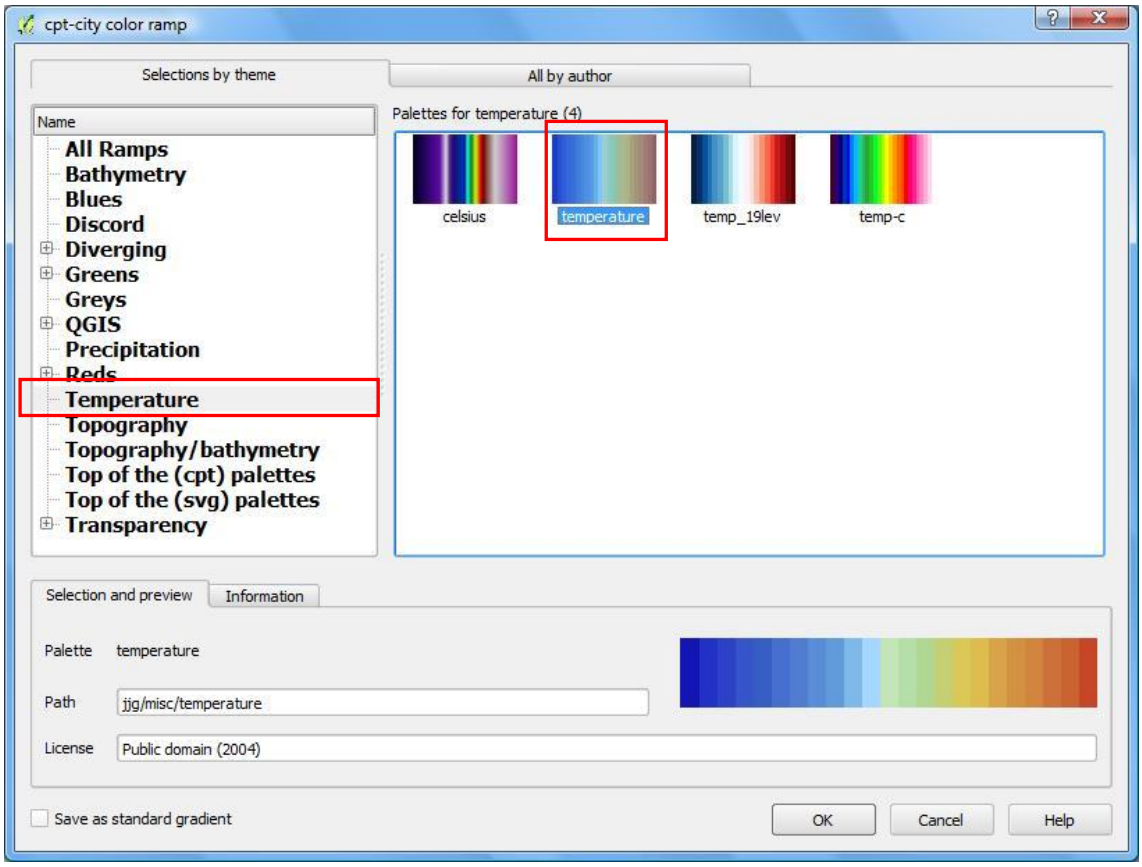


7. Scroll up to the section of the menu labelled, **"Generate new color map"** *(**see next image**) and hit the drop-list*.

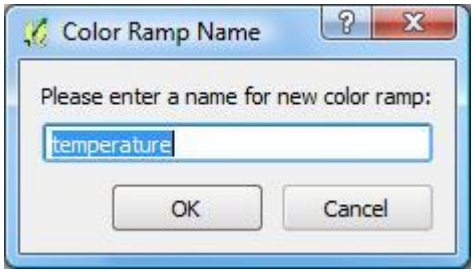


Note: This presents a series of colour templates which can be applied to a classified raster. You can either pick from the drop- list or scroll to the bottom and select {New color ramp}. Selecting the {New color ramp} option will launch a sub-menu as shown below:

From this menu you can select from four 4 different group templates. For this exercise, it is recommended that you choose the "cpt-city" option. This will in turn launch a new menu as shown below:



This menu provides a series of colour schemes arranged by theme. Under the "Selections by theme" tab, there is a listing for temperatures. Select the Temperature option to view the list of templates; choose a template and then hit {OK} (Refer to the image above).

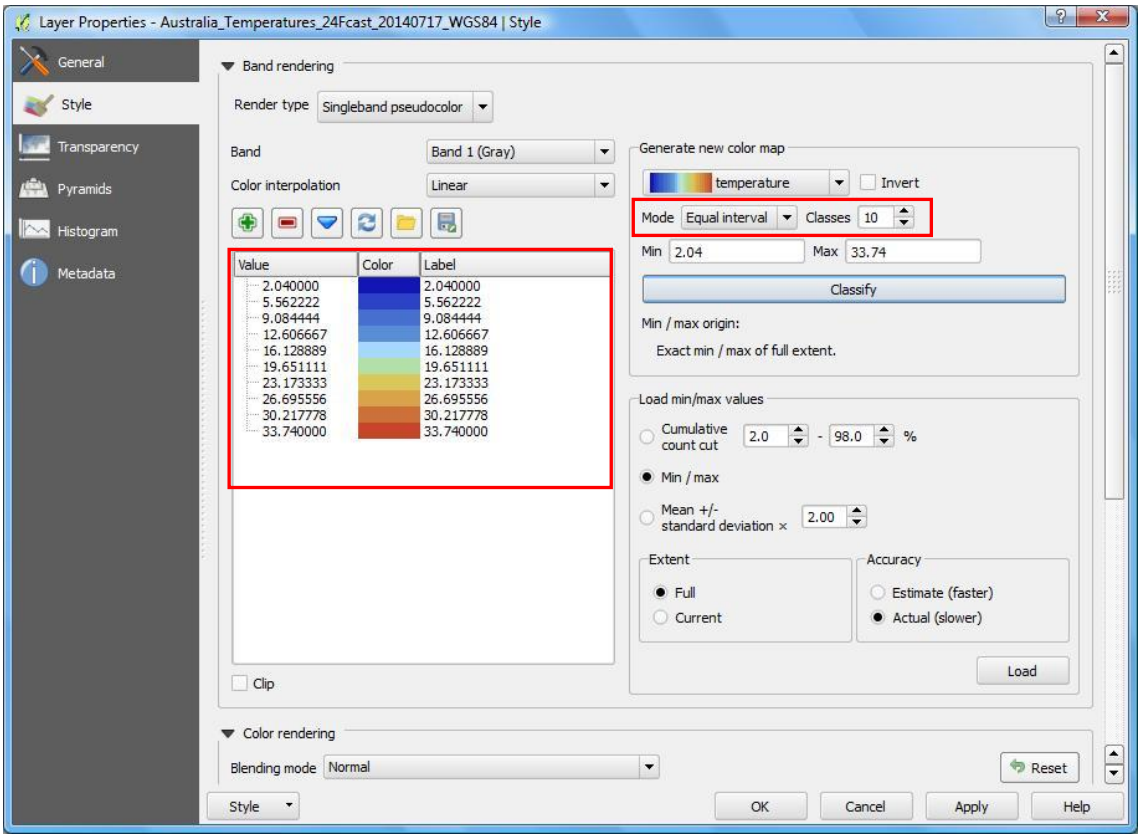


Hit {OK} on the previous menu.

8. Locate the **"Mode"** field and select **"Equal Interval"** *(**illustrated in next image**)*.

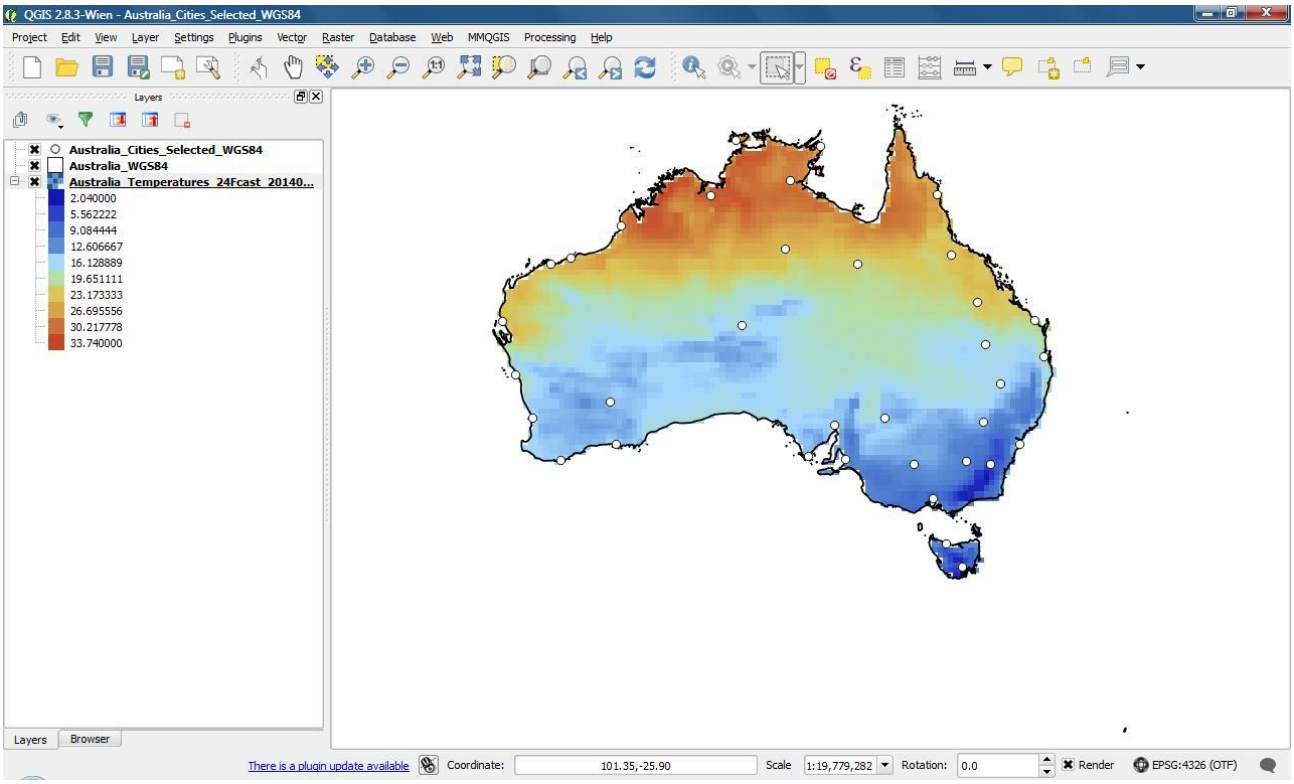
9. Locate the adjacent field **(Classes)** and change the number of classes from 5 to 10.

10. Hit the **"Classify"** button.



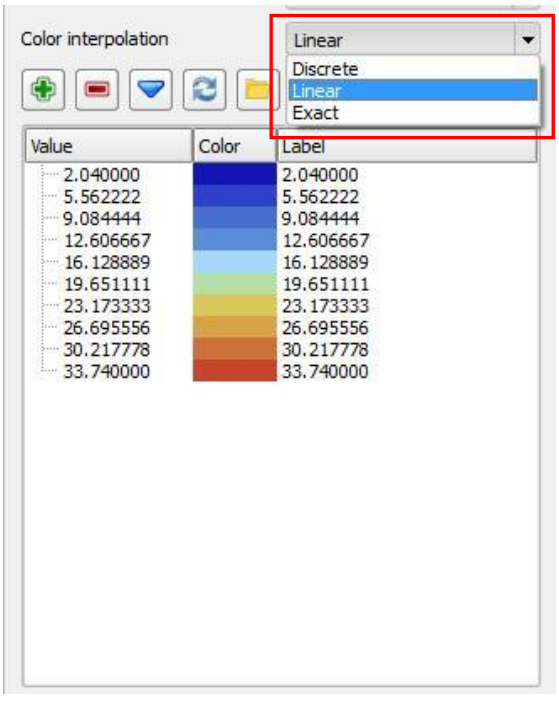
Note: You will notice a change in the menu. The temperature classes can now be seen in the menu as illustrated below. The upper limit of each temperature class is now marked by a value and a corresponding class colour.

11. Hit **{Apply}** and view the **Map Canvas** to observe the change in your raster layer.

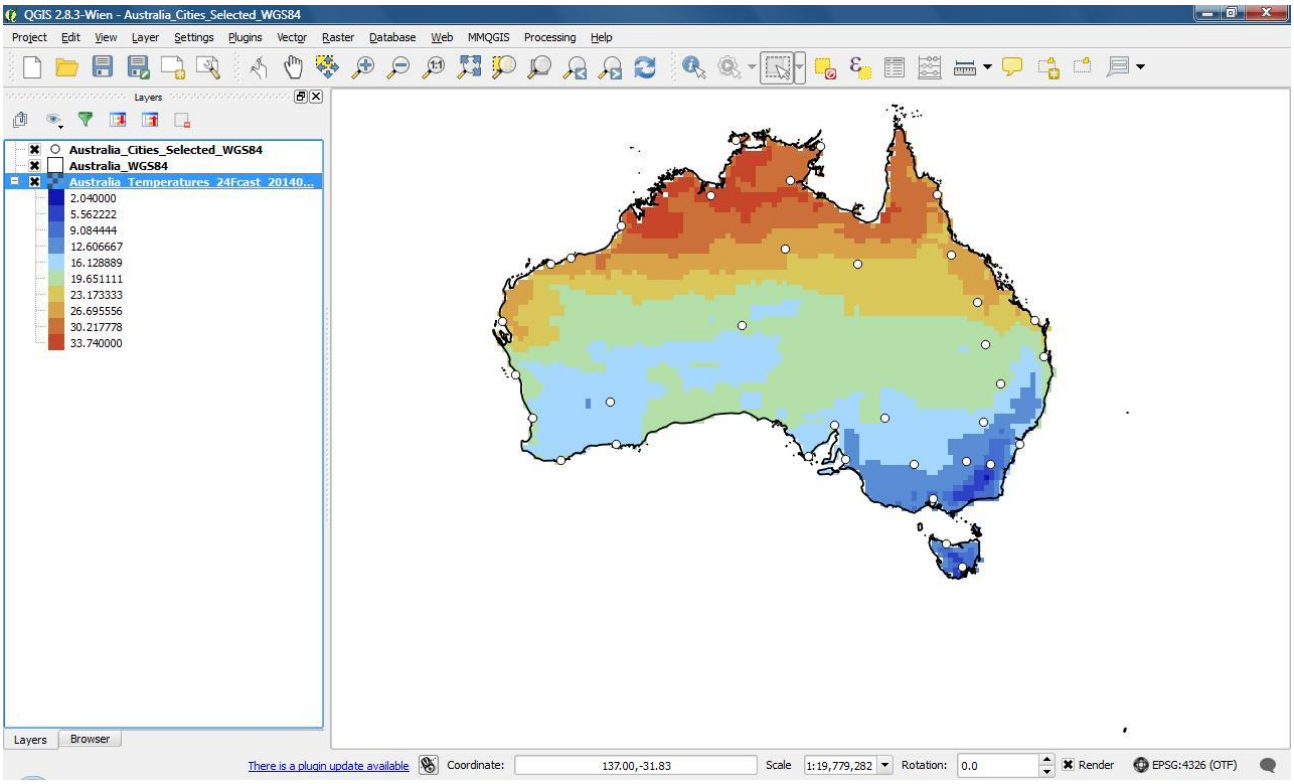


Note: Collapse the raster layer entry in the Layers Panel to see the symbol Legend. With the raster in this styling format, it is much easier to appreciate the spatial differences in temperatures across the country. However, there are a few more styling changes that you can make to further improve the appearance of your raster and the information it is trying to convey.

12. Return to the **Style** menu; locate the **"Color interpolation"** option and open the drop-list as seen in the following image.

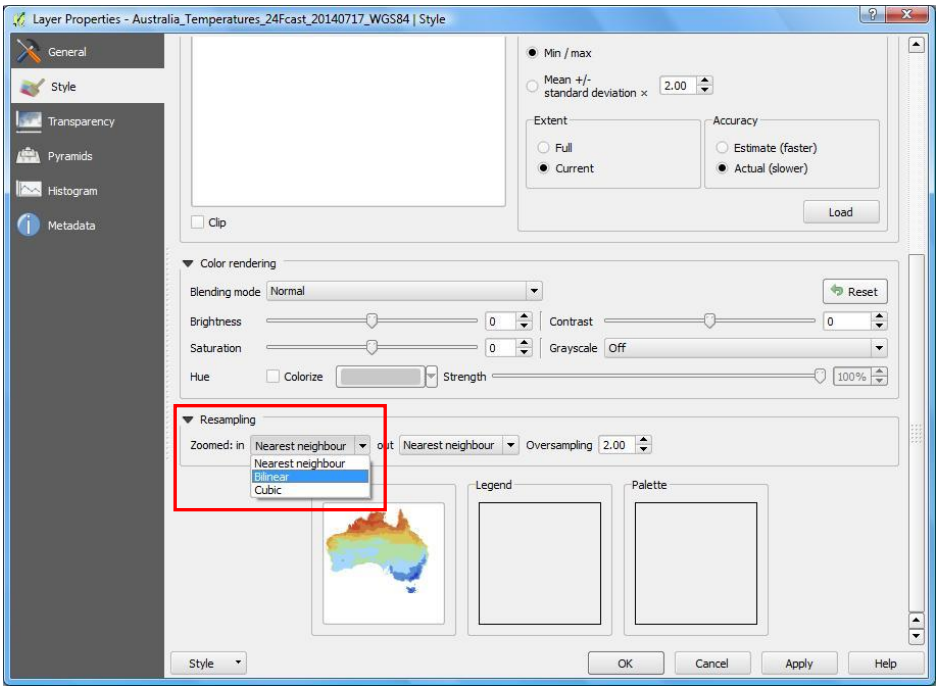


Note: At present, your raster is rendered using a linear colour interpolation method. This method displays classes in a linear or continuous fashion by averaging the boundaries of neighbouring cells so that they appear to flow into each other. Change the setting to "Discrete"; hit {Apply} and see the difference in the Map Canvas.



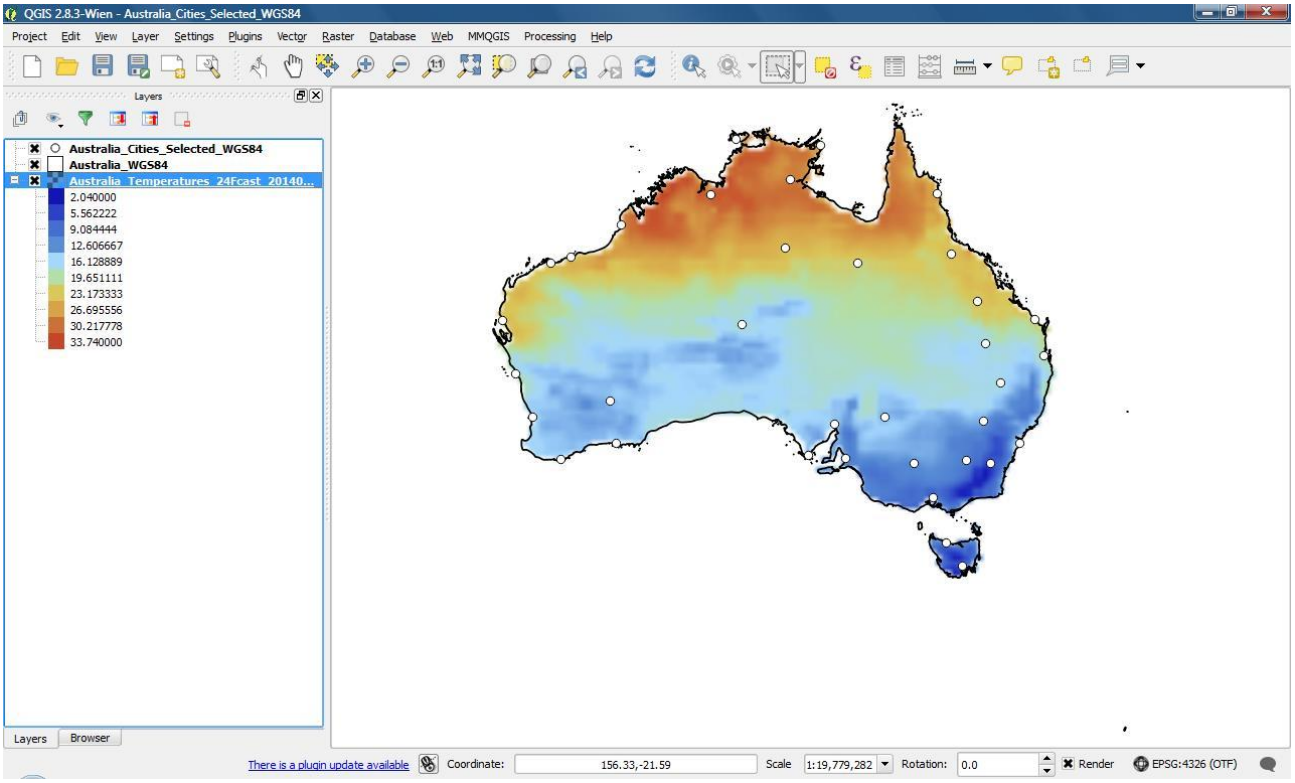
With a discrete colour interpolation method, the boundaries between the colour classes are more obvious. However, the appearance is far coarser. There are many examples which may be found that demonstrate the use of both these methods for conveying raster data. However, for this exercise, you are advised to apply the linear method for your colour interpolation

13. Scroll down to the **Resampling** menu section and open the drop-list as shown below:

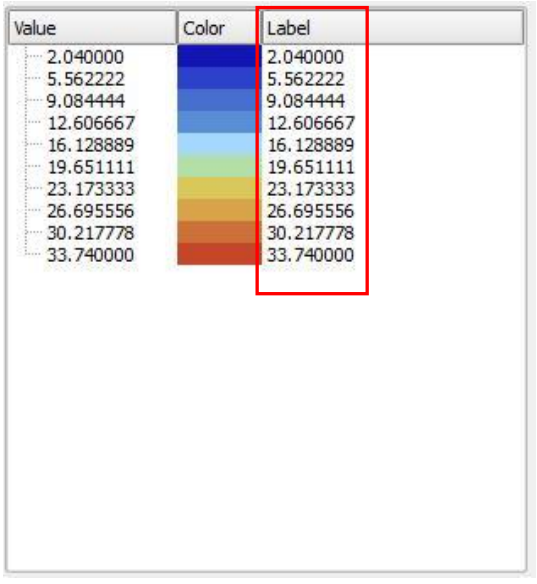


Note: At present your raster is being rendered using a "Nearest Neighbour" resampling method. This method renders a resampled grid that illustrates actual cell values. Hence it is ideal for representing data that is discrete in nature.

Change the resample method to "Bilinear"; hit {Apply} and see what happens to the raster.



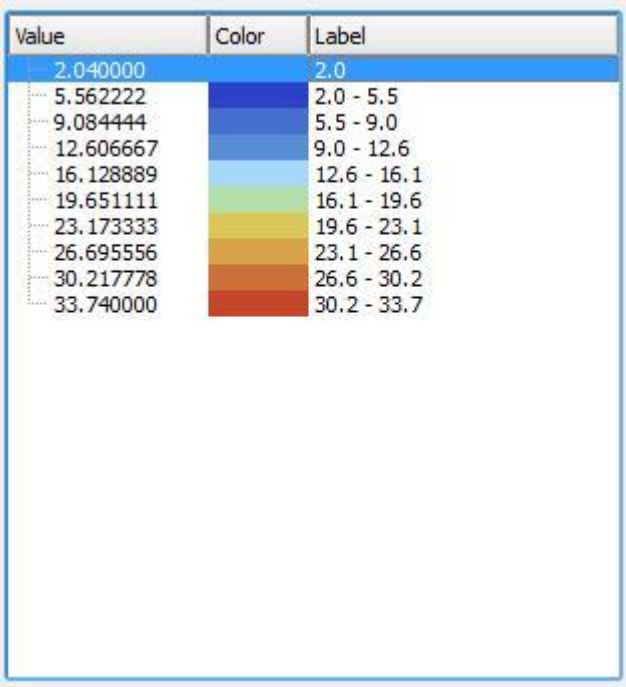
The Bilinear Resampling method renders a resampled grid with cells that contain averages calculated from neighbouring cells. This essentially creates a much smoother appearance with a compromise of precision. You should note that this new setting will render the data using a Bilinear resampling method when the map is zoomed in.



The final change you will make to your raster is associated with labelling. The label column as illustrated in the image on the left, lists the class values that will be displayed in your raster Legend. These values may be edited so that they describe the data in a more viewer-friendly fashion. Each class group is associated with a number that represents the upper limit of a temperature class (in degrees celsius) and the range starts from 2.04. Therefore, the second colour class contains temperature values 2.04 to

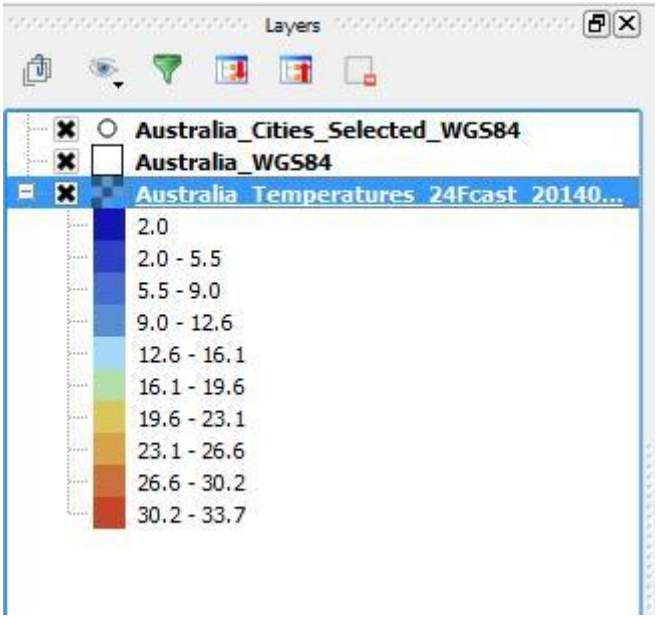
5.5622 and the third class contains values between 5.5622 and 9.0844 etc. However, it would perhaps be better to present this information without the high precision in decimal values and instead as rounded ranges.

14. Double-click the fields in the **Label** column to access the class labels and make changes to the entries until they all match the image below.



15. Hit **{OK}**

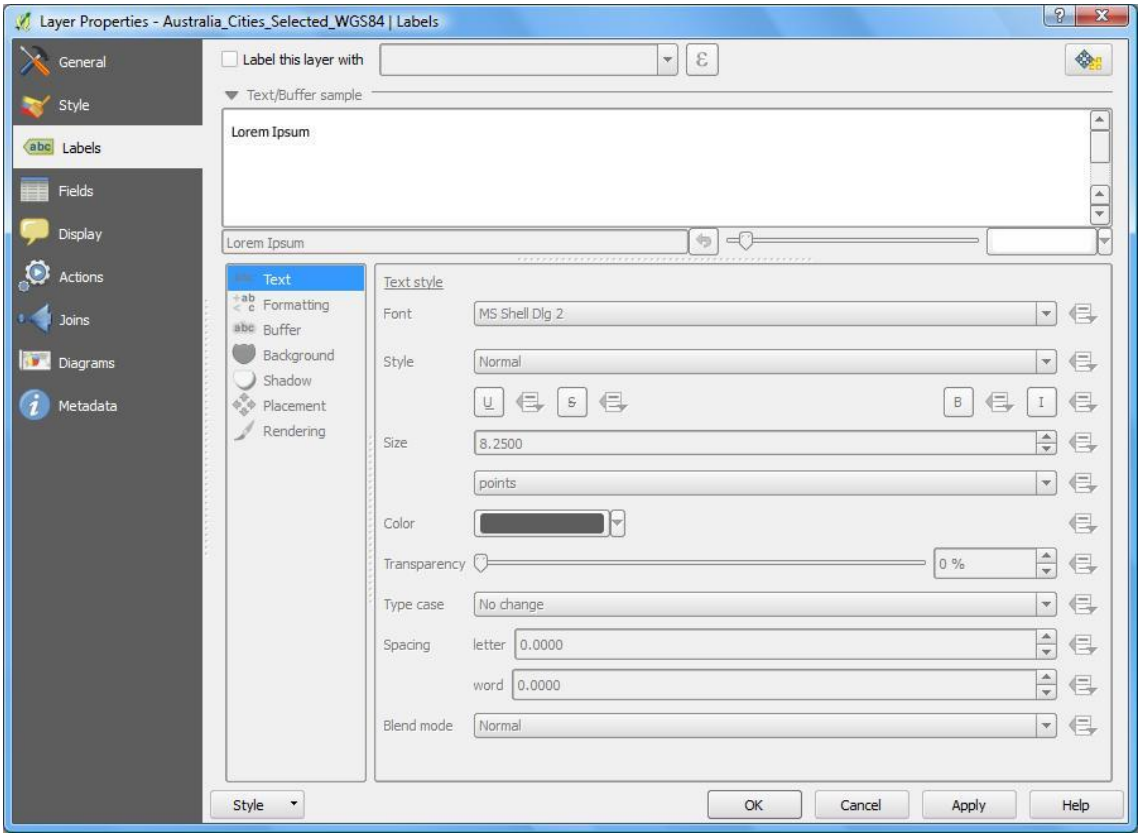
Note: The changes you've just made to the raster legend labels should now be visible in the Layers Panel as shown above.



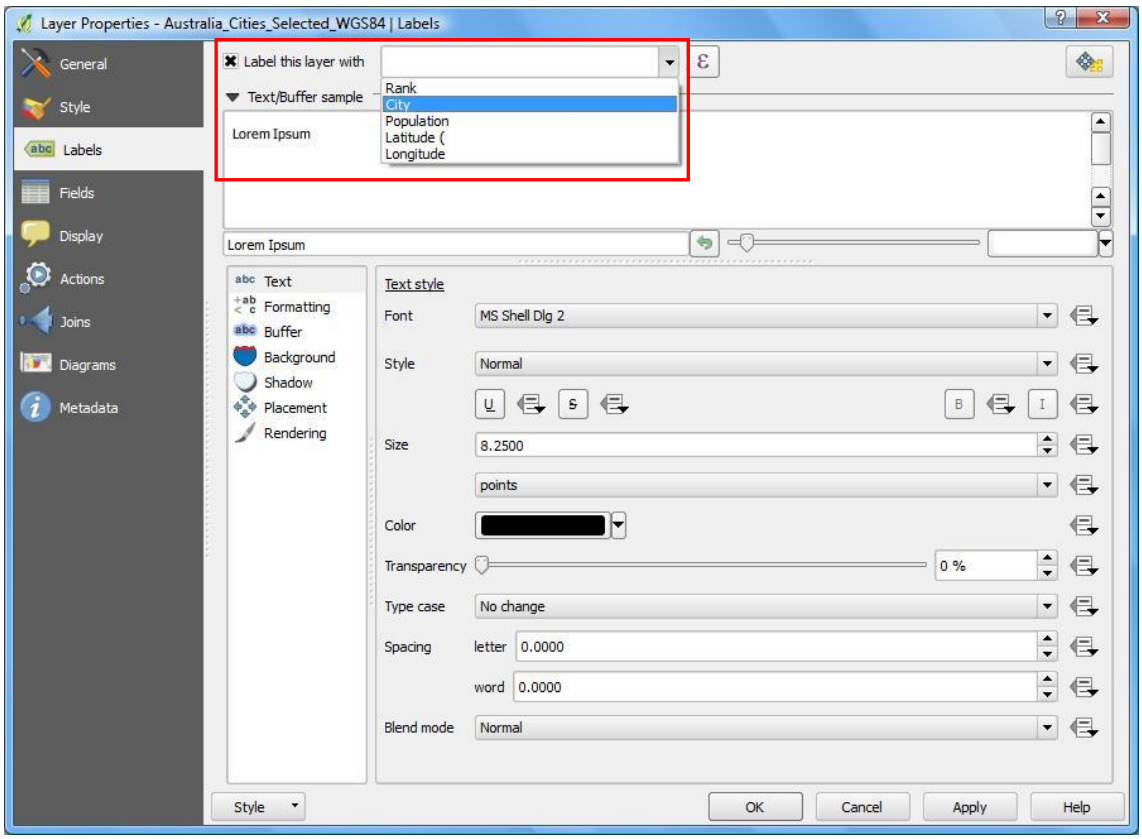
4.4 Adding Labels

There are perhaps a few more things you can do to improve the conveyance of the information. Would it help to communicate the story a bit better if the cities were labelled? What if you could also, change the symbol sizes and styles for some of the cities? - Perhaps the larger cities with populations over 1 million. Maybe you would want the country's capital (**Canberra**) to be symbolized differently. Theses final modifications can be achieved and are explored below.

1. Open the **{Properties}** menu for the cities layer and activate the **Labels** tab.



2. Enable the option shown in the next image (captioned, **"Label this layer with"**) and hit the drop-list to reveal the layer attribute field names.



Note: Attribute values may be used to label features. By choosing "City" from this list, QGIS will be instructed to use the values (i.e. city names) in the "City" column of the layer attributes to label the points. Click {Apply} to see results.

Next you'll determine the characteristics of the font used to label the cities.

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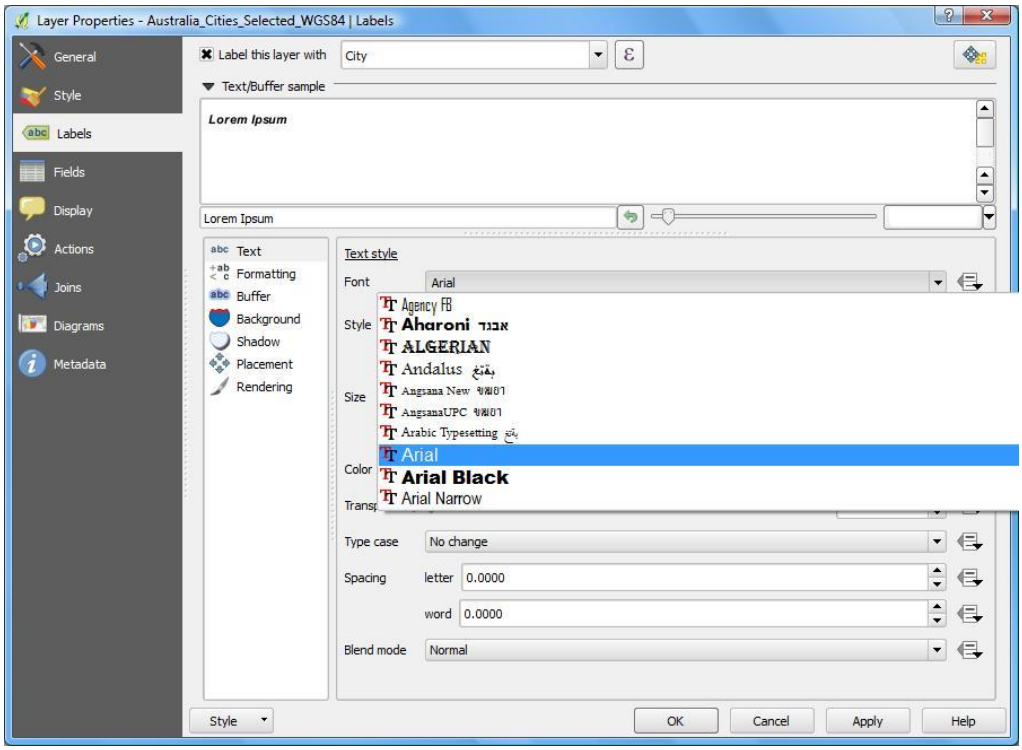
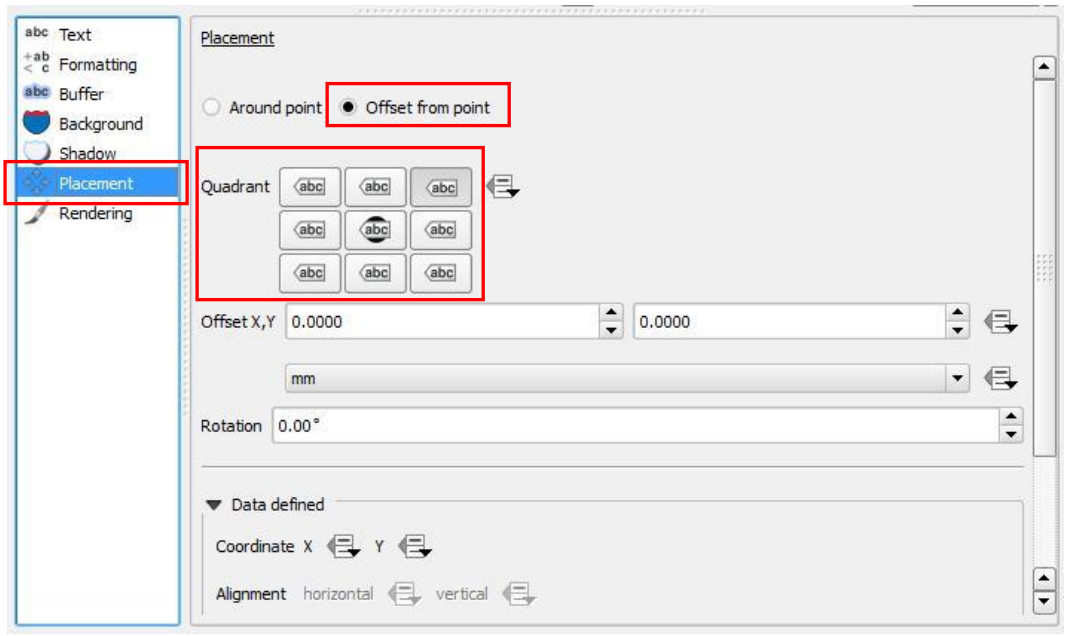
3. Activate the **"Text"** option from the left pane **(*see next image*)**; select the "**Font"** drop-list on the right and then choose **Arial** as the font type.



4. Set the “Style” field to **Bold Italic** and then set the **“Size”** field to 7.

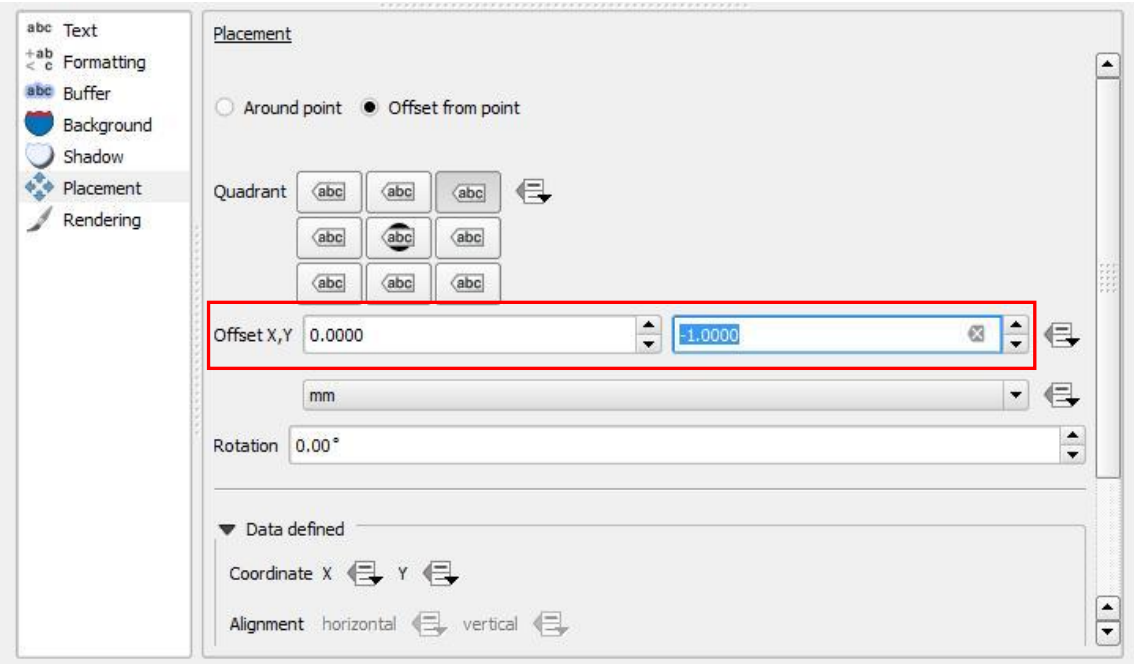
Note: Click {Apply} to see the effects of changing the font.

5. Activate the **“Placement”** option from the left pane and choose **“Offset from centroid”**; locate the portion of the menu with the caption, **“Quadrant”,** and then select the upper-right option as indicated in the following image. All other default settings should remain.



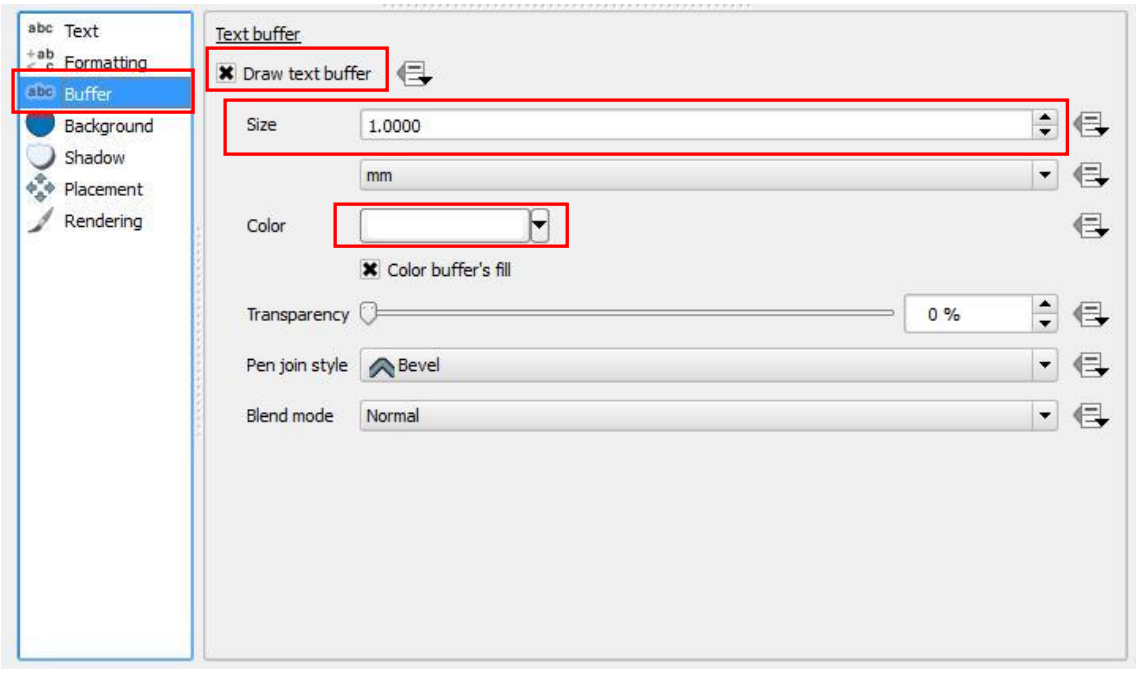
Note: This step determines the positioning of your labels. In this case, labels will be offset from the centre of the points and positioned to the upper-right. These positions can be further offset by changing the X and Y offset values in the fields below.

Set the Y field to a value of -1 as shown below and hit {Apply} to see the shift in position of the font.

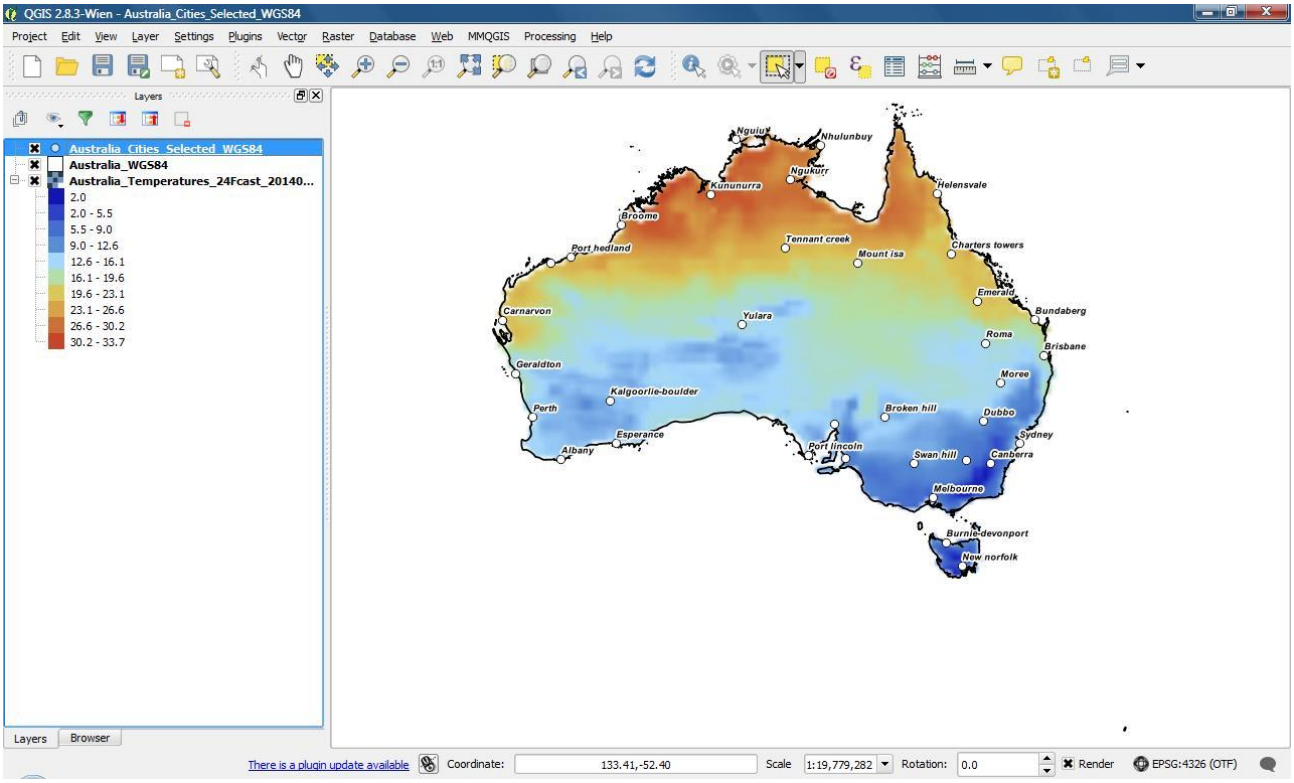


The next step is to place a buffer or "halo" around the text to make it stand out more.

6. Activate the **"Buffer"** option from the left pane; enable the **"Draw text buffer"** option; set the "**Size"** field to 1 and then set the "**Color"** field to white. These settings are illustrated below.



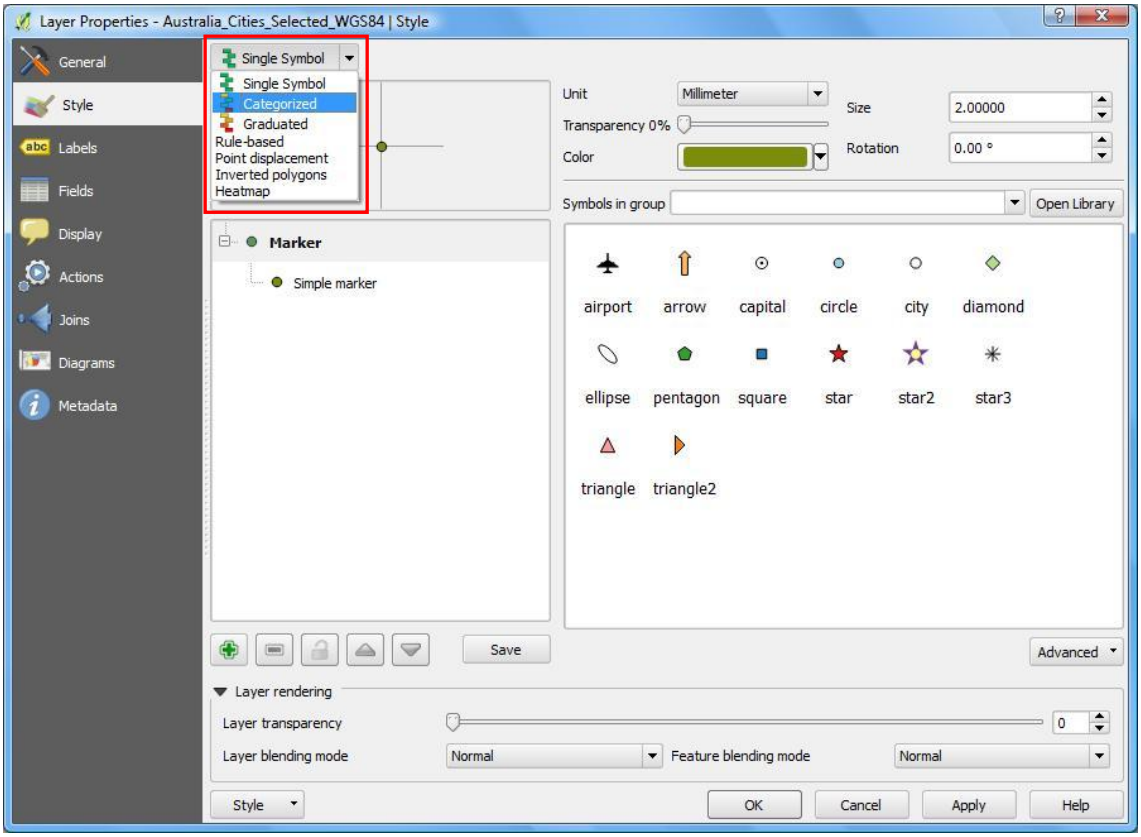
7. Click **{OK}** to complete the process and view the labelling results.



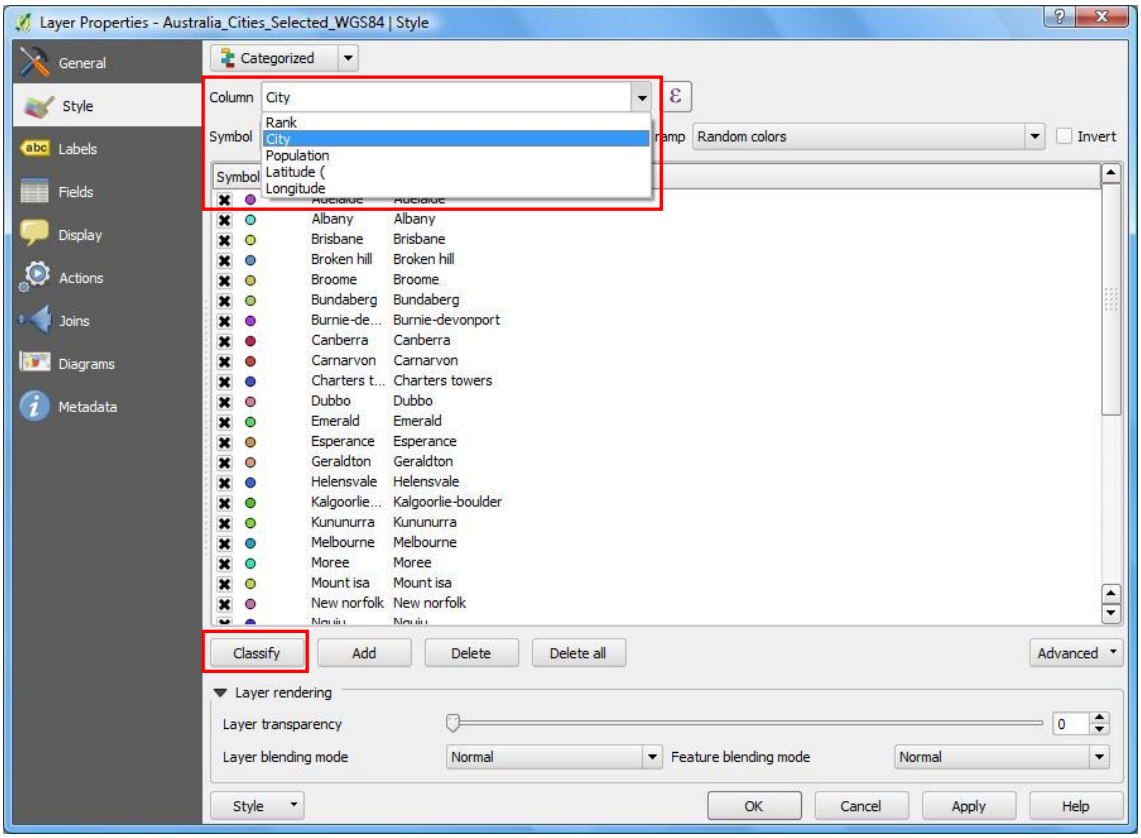
Now we'll introduce some variation to the city symbols.

8. Open the **{Properties}** menu for the cities layer and activate the **Style** tab.

9. Locate the menu drop-list highlighted in the following image and change the option from **"Single Symbol"** to **"Categorized".**

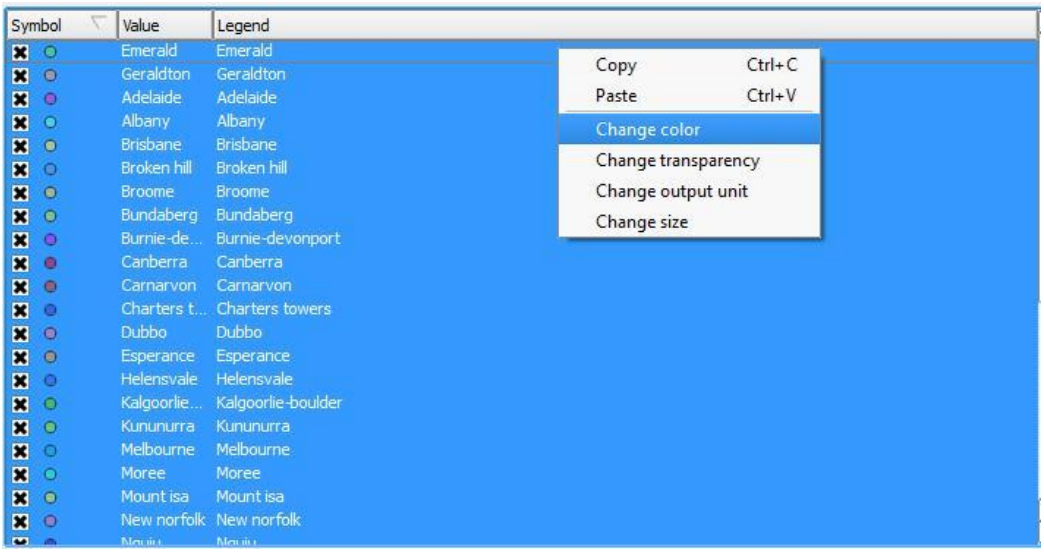


10. Select **"City"** form the drop-list next to the **"Column"** field; then hit the **Classify** button as shown next.

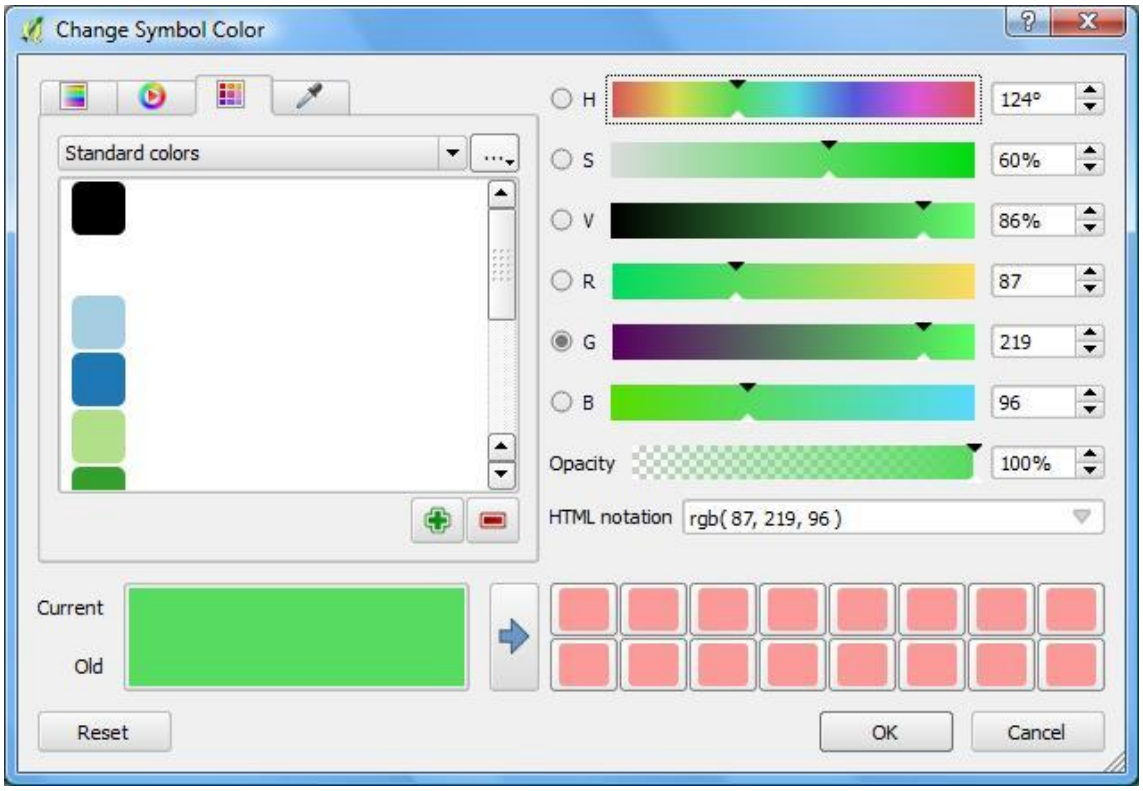


Note: A list of city items will be generated and styled according to the default colour ramp. However, given our aim, which is to change the symbol styles of only the 5 cities with populations over 1 million and also the capital city, perhaps you should first change all the symbol style colours back to white.

11. Highlight/Select all points in the list as shown below; right-click on any selected row and select **{Change color}**. You can make the selections by holding the Ctrl key and clicking to select multiple rows.



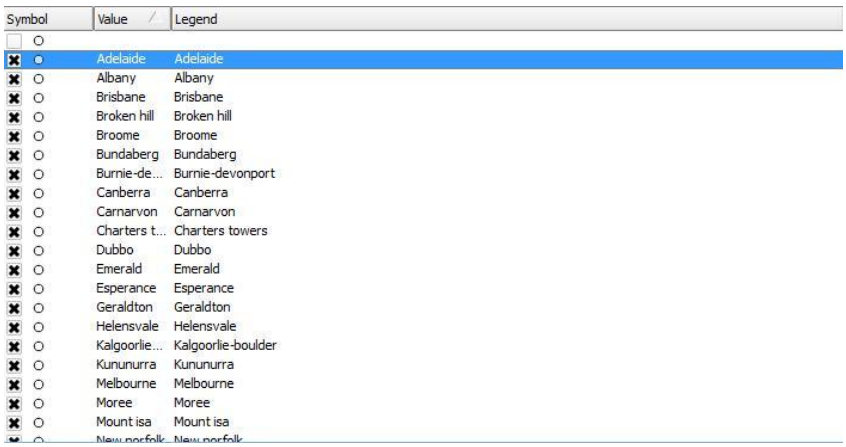
Use the following menu to set the colour back to white.



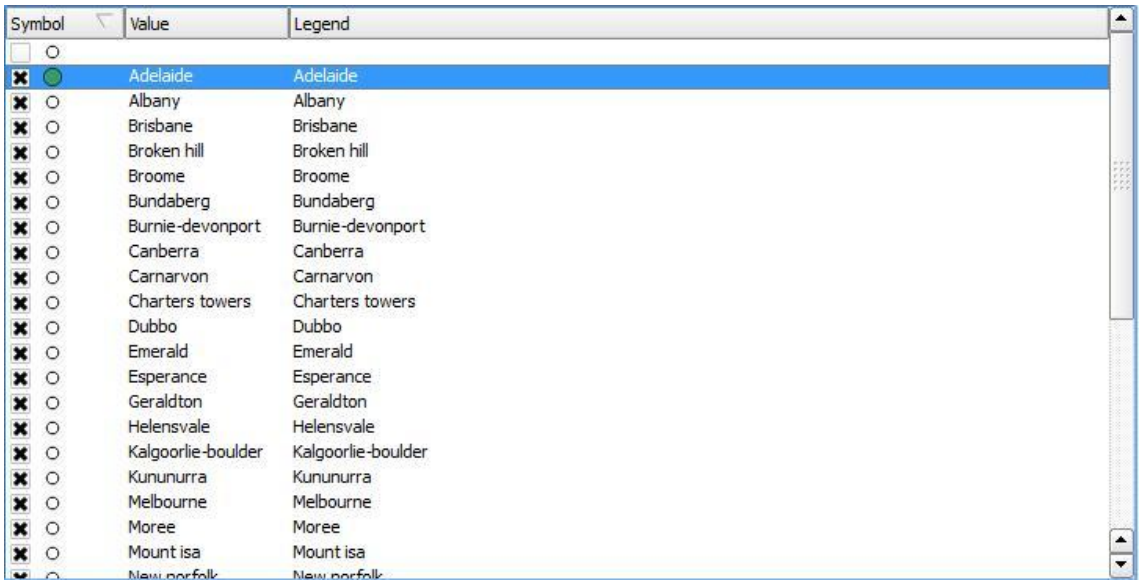
Note: Now you will locate the 5 cities with populations over 1 million and increase their symbol sizes.

Tip: Hit {OK} and then open the attribute table for the cities layer. Sort the table on the "Rank" field to list the cities in the order of their size. The first five cities in the list are the ones you will need to change the symbol sizes for. These are Sydney, Melbourne, Brisbane, Perth and Adelaide.

12. Return to the **Style** properties menu and locate Adelaide. This city should be the first in the list (***see image below***). You can sort the list by clicking on the **"Value"** column heading.



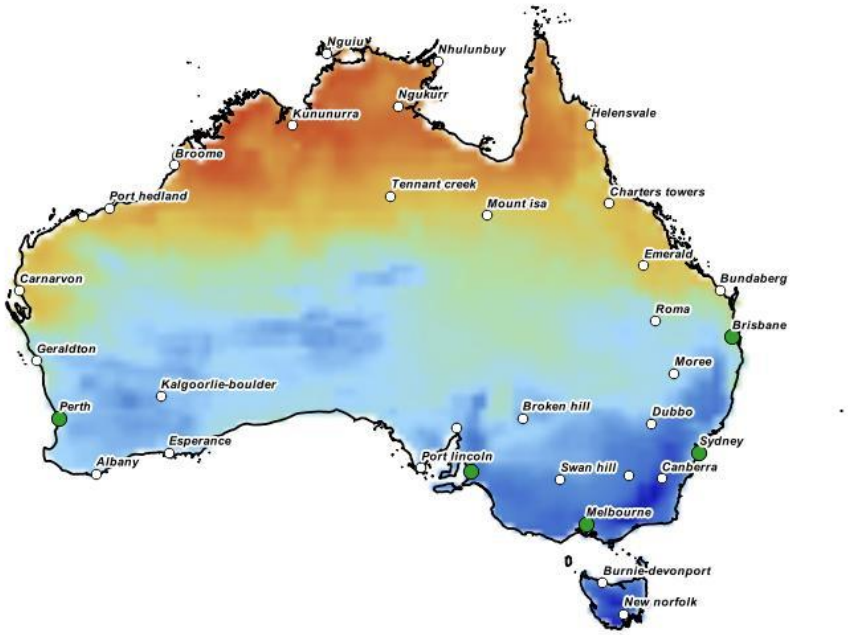
13. Double-click the symbol for Adelaide and change the size from 2.2 to 3.0 and the colour to green.



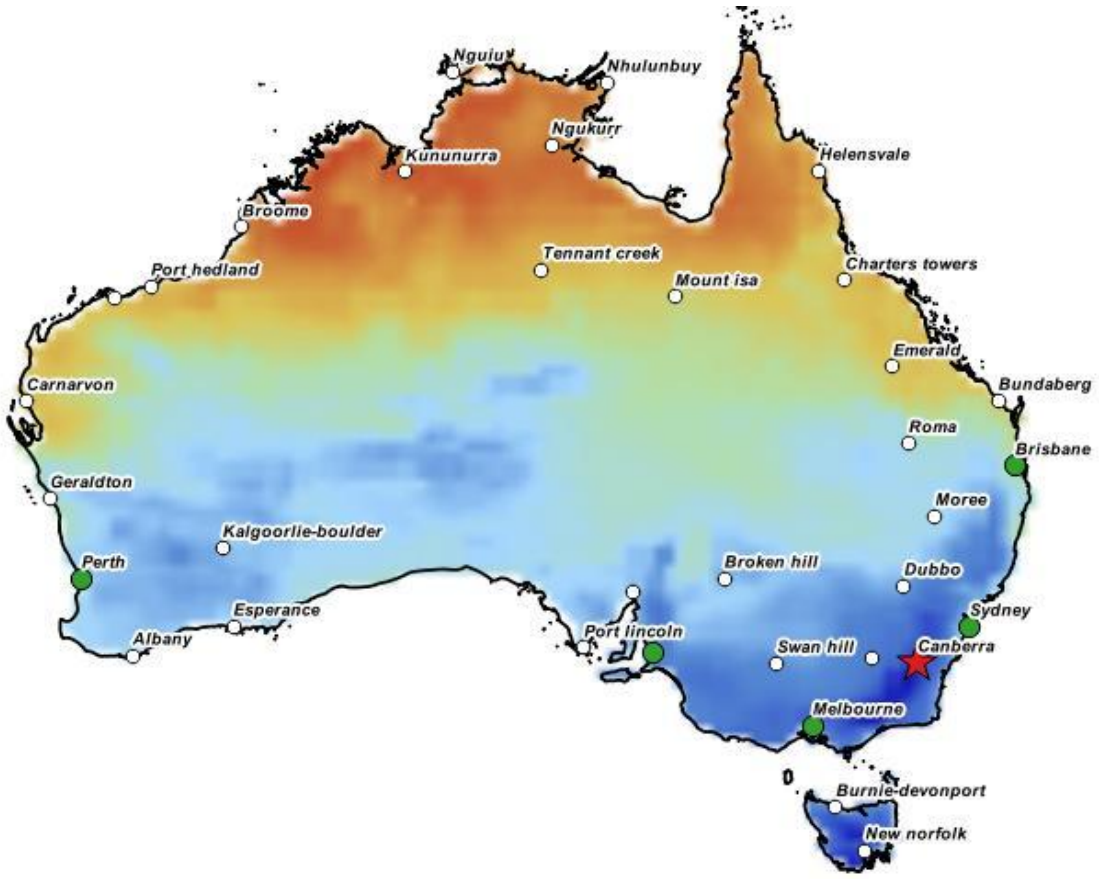
Symbol	Value	Legend
	Adelaide	Adelaide
	Albany	Albany
	Brisbane	Brisbane
	Broken hill	Broken hill
	Broome	Broome
	Bundaberg	Bundaberg
	Burnie-devonport	Burnie-devonport
	Canberra	Canberra
	Carnarvon	Carnarvon
	Charters towers	Charters towers
	Dubbo	Dubbo
	Emerald	Emerald
	Esperance	Esperance
	Geraldton	Geraldton
	Helensvale	Helensvale
	Kalgoorlie-boulder	Kalgoorlie-boulder
	Kununurra	Kununurra
	Melbourne	Melbourne
	Moree	Moree
	Mount isa	Mount isa
	New norfolk	New norfolk

Note: Click {Apply} to see the change in the Map Canvas. You will notice that the symbol for the city of Adelaide (which is east of Port Lincoln) is now larger than all other symbols on the map. The label for Adelaide in the example shown below is not visible because it clashes with another label. You may have experienced a similar outcome with your map based on the cities you selected and their proximity. However, a solution to this issue will be illustrated soon.

14. Return to the **Style** properties menu and repeat steps 12 and 13 for the cities **Sydney, Melbourne, Brisbane and Perth**.

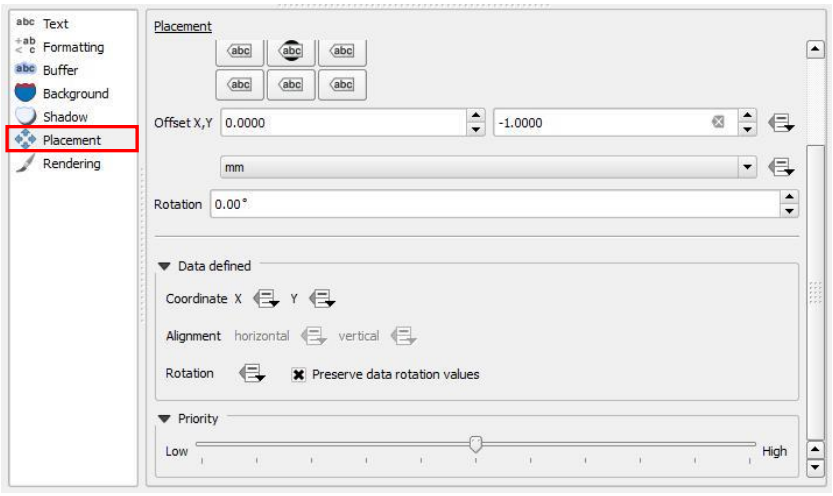


15. Change the symbol style used for the capital, **Canberra**, so that it stands apart from all others.

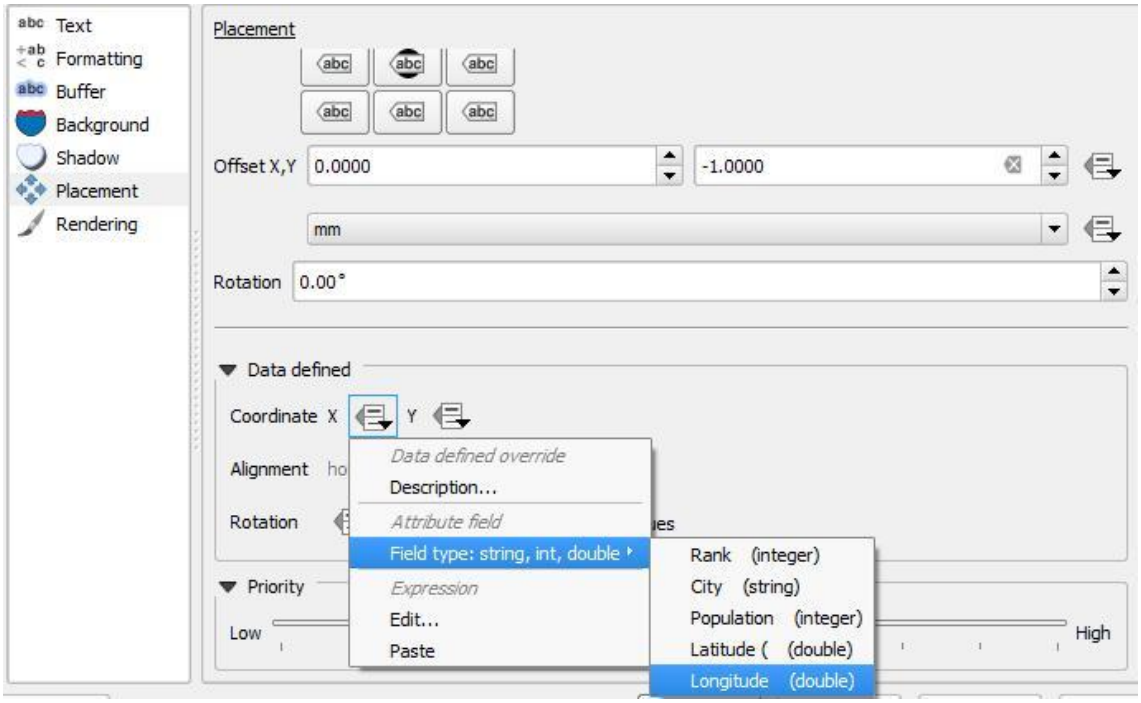


Your final step will be to manually adjust some of the labels so that there are no clashes and all of the labels can be seen.

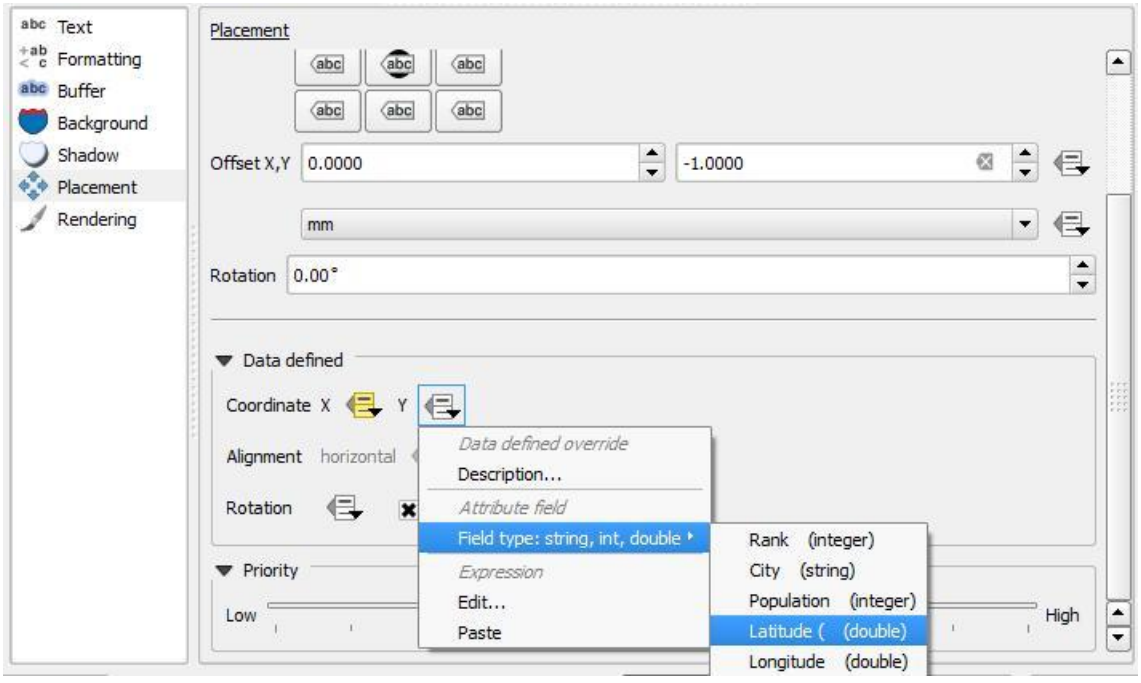
16. Activate the **Labels** tab in the **{Properties}** menu and then open the **Placement** menu as seen below.



17. Locate the **"Data defined"** section; activate the **Coordinate X** option; select **{Field type: string, int, double}** and then select **{Longitude (double)}** as shown below.



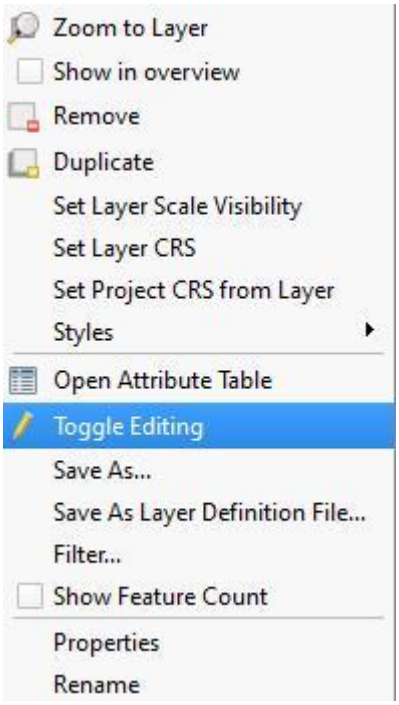
18. Repeat the step above for the **Y** coordinate, but select **{Latitude (double)}** as shown below.



19. Select **{OK}** and return to the **Map Canvas**.

Note: With this change made, you are now free to move labels around manually to ensure that they are all visible. However, you will need to use the Label toolbar to do this.

20. Open the **[View]** menu; select **{Toolbars}** and then activate the **Label** toolbar.



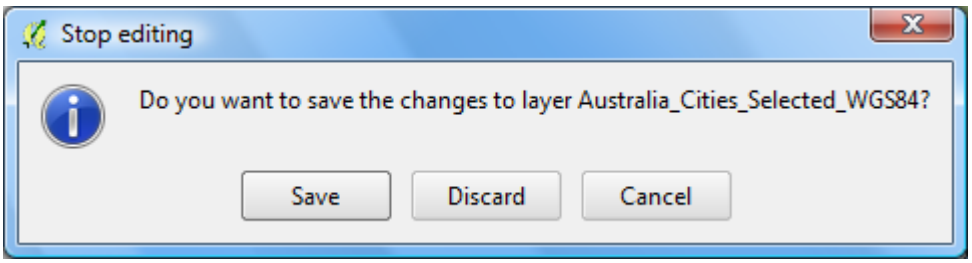
21. Right-click the cities layer and select **{Toggle Editing}**.

Note: This step enables more functions on the Label toolbar. The tool you will need to shift the labels around is the {Move Label} tool as shown below.

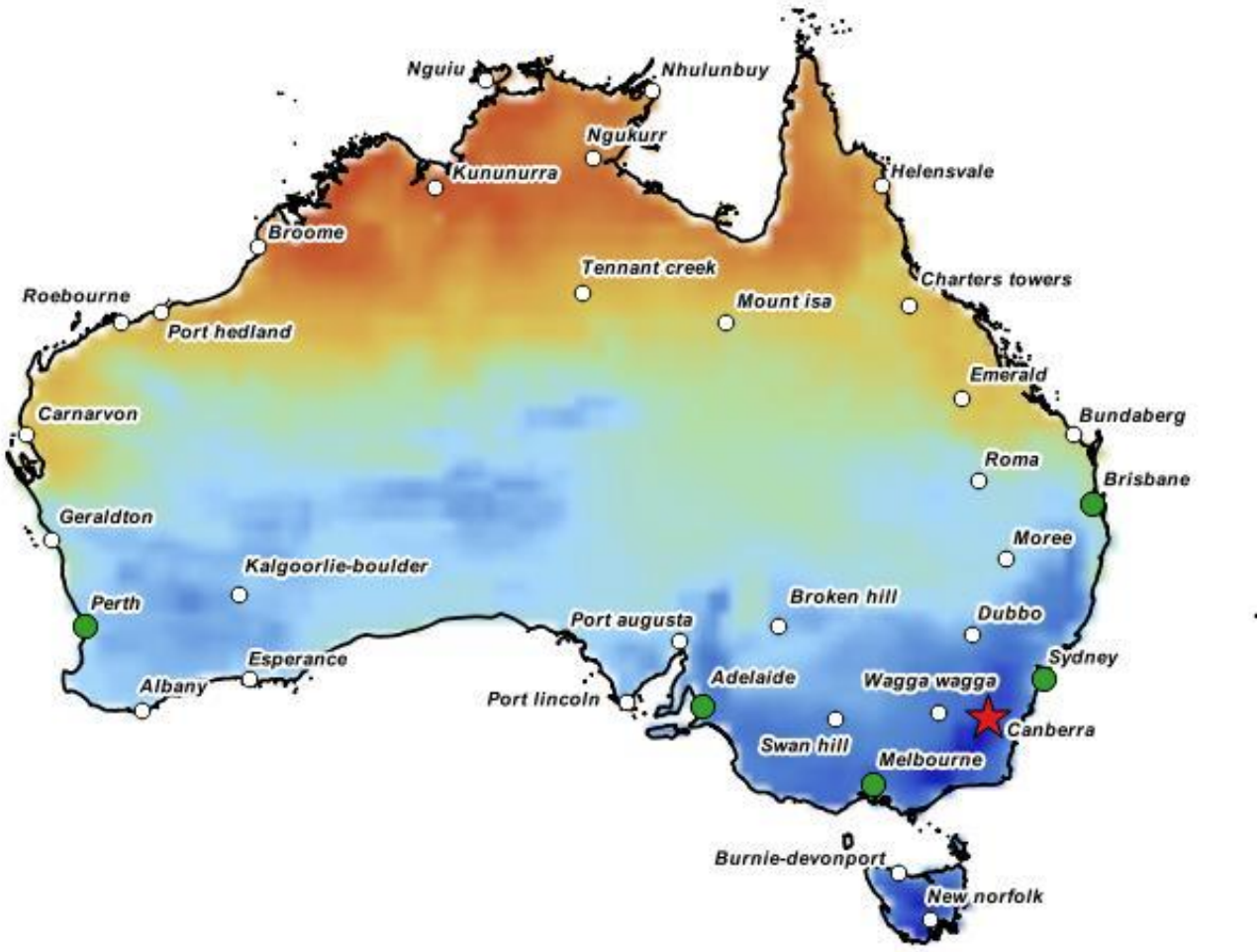
22. Activate the **Move Label** tool; click on any label of your choice and drag it to its new position.

23. Shift around the labels on your map until you are satisfied with the new positions.

Note: Make sure they do not clash and that all labels are visible in the end. When you are finished, return to the Layers Panel; right-click the cities layer and deactivate {Toggle Editing}. When the following menu appears, click {Save} to keep the changes made for the Label positions.



Also remember to save your project.



This completes Practical 1B. Feel free to experiment with the styled layers at your leisure using what you've learnt. In the next practical, you will learn how to compose and publish a map using the data from this exercise.