ADDA
Lab

Map Projections and Coordinate Systems in QGIS

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Overview, Objective, and Skills

In this lab, you will familiarize yourself with map projections in QGIS. You will appreciate the importance of assigning map projections when working with GIS data.

Objective: Assess projection systems and re-project GIS Data

Data: In this lab, you will use the Blantyre district boundary and the Blantyre district schools vector datasets.

Data Download: Go to Moodle page for Day 4 and download the contents to your Lab folder for Day 4. There should be 15 files, representing three GIS data layers.

Map projections and Coordinate reference systems

A map projection is a mathematical transformation used to transform the three-dimensional surface of the earth on a flat surface. It uses mathematical formula to relate spherical coordinates on the globe to flat, planar coordinates. A coordinate reference system defines how the two-dimensional projected map in a GIS is related to real places on the earth.

When working with GIS data, either preparing a map or doing analysis, it is important to assign a coordinate reference system (CRS) to the data. Every place on the earth can be specified by a set of three numbers called coordinates with the help of the coordinate reference system. The CRS is divided into geographic coordinate system and projected coordinate reference system (also called Cartesian or rectangular coordinate reference system).

Geographic Coordinate System:

A geographic coordinate system uses three-dimensional surface to define locations on the earth. It includes an angular unit of measure, a prime meridian and a datum. In Geographic coordinate system, a point is referenced by its longitude and latitude values. Longitude and latitude are angles measured from the earth's center to a point on the earth's surface. The latitude and longitude values are measured in degrees, minutes and seconds or in grads. Lines of latitude run parallel to the equator and divide the earth into 180 equally spaced sections from North or South or vice versa. The equator is the reference line for latitude and each hemisphere is divided into ninety sections each representing one degree of latitude. In the northern hemisphere, degrees of latitude are measured from zero at the equator to ninety at the north pole. Degrees of latitude are measured from s=zero at the equator to ninety at the south pole in the southern hemisphere. Note that degrees of latitude in the southern hemisphere are assigned negative values (0˚ to -90˚).

Lines of longitude run perpendicular to the equator converging at the poles. The reference line of the longitudes being the prime meridian which runs from the North pole to the South Pole through the Greenwich, England. Lines of longitude are measured from zero to 180 degrees East or West of the prime meridian with values West of the prime meridian being assigned negative values. WGS 84 is the most popular geographic coordinate reference system.

Projected Coordinate system:

A projected coordinate reference system is defined on a flat, two-dimensional surface. This coordinate reference system is always based on a geographic coordinate system that is based on a sphere or spheroid. In a projected coordinate system, locations are identified by x,y coordinates on a grid, with the origin at the center of the grid. Two values reference each point to the central location. The two values are called x- coordinate and y-coordinated where at the origin, both x and y coordinates have the value zero. The horizontal axis is normally labelled X and the vertical axis is labelled Y. In the southern hemisphere, a projected coordinate reference system has its origin on the equator at a specific Longitude. The values of Y increase south wards and the values of X increase to the West. In the northern hemisphere, Y values increase northwards and the values of X increase to the East. One of the common projected coordinated reference system is the Universal Transverse Mercator (UTM).

In QGIS you can view the CRS of the QGIS project and layer, save the QGIS project and layer CRS into another CRS. QGIS also offers the capability of creating new CRS or modifying an existing CRS.

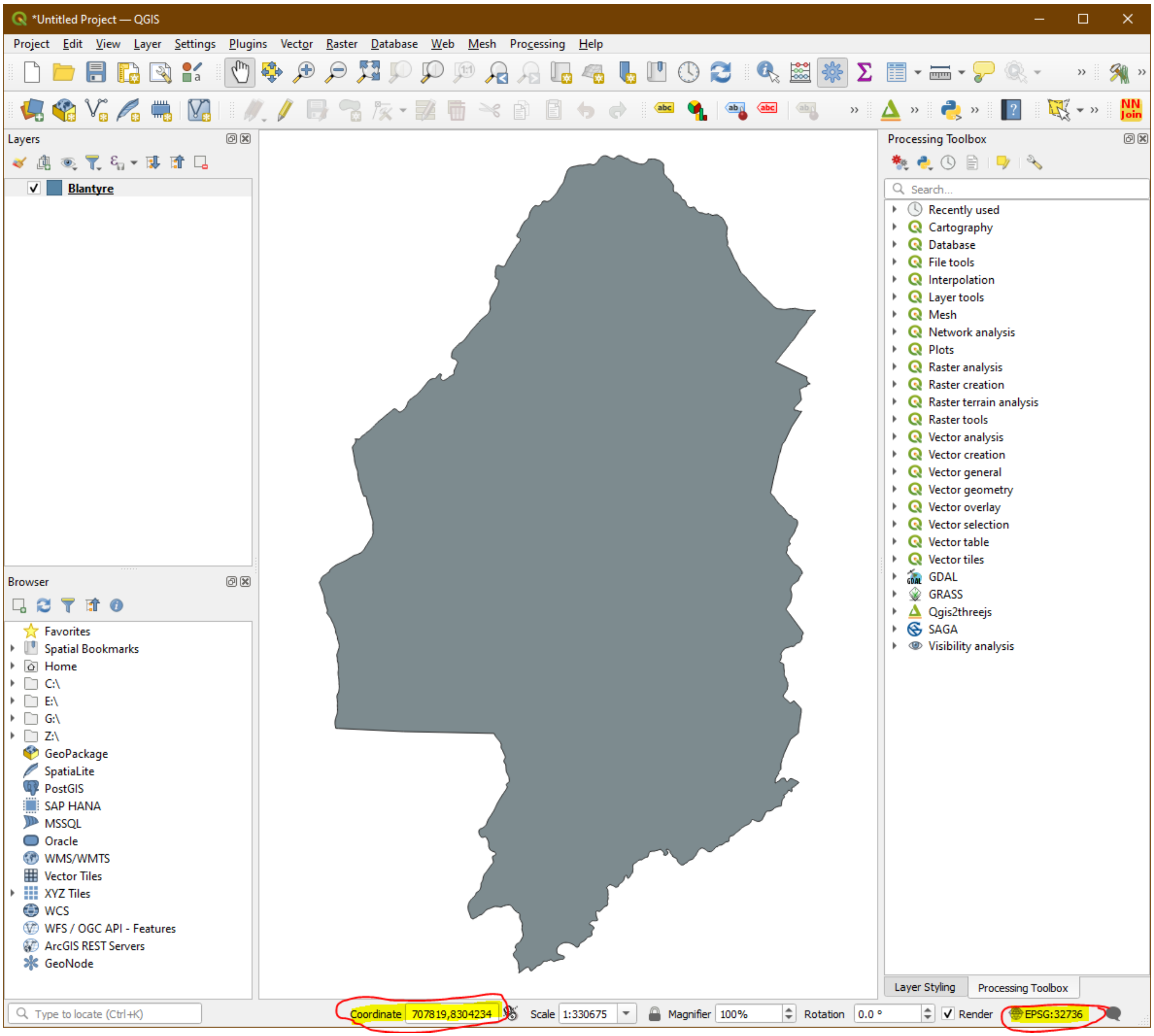
Before you start the Lab, save the data in ADDA_GIS_Labs , Lab Activity, DAY 4 folder.

Section one: Viewing the Project and layer CRS

Start QGIS searching on the windows search space: Type **QGIS** and Click on **QGIS Desktop 3.20.X**.

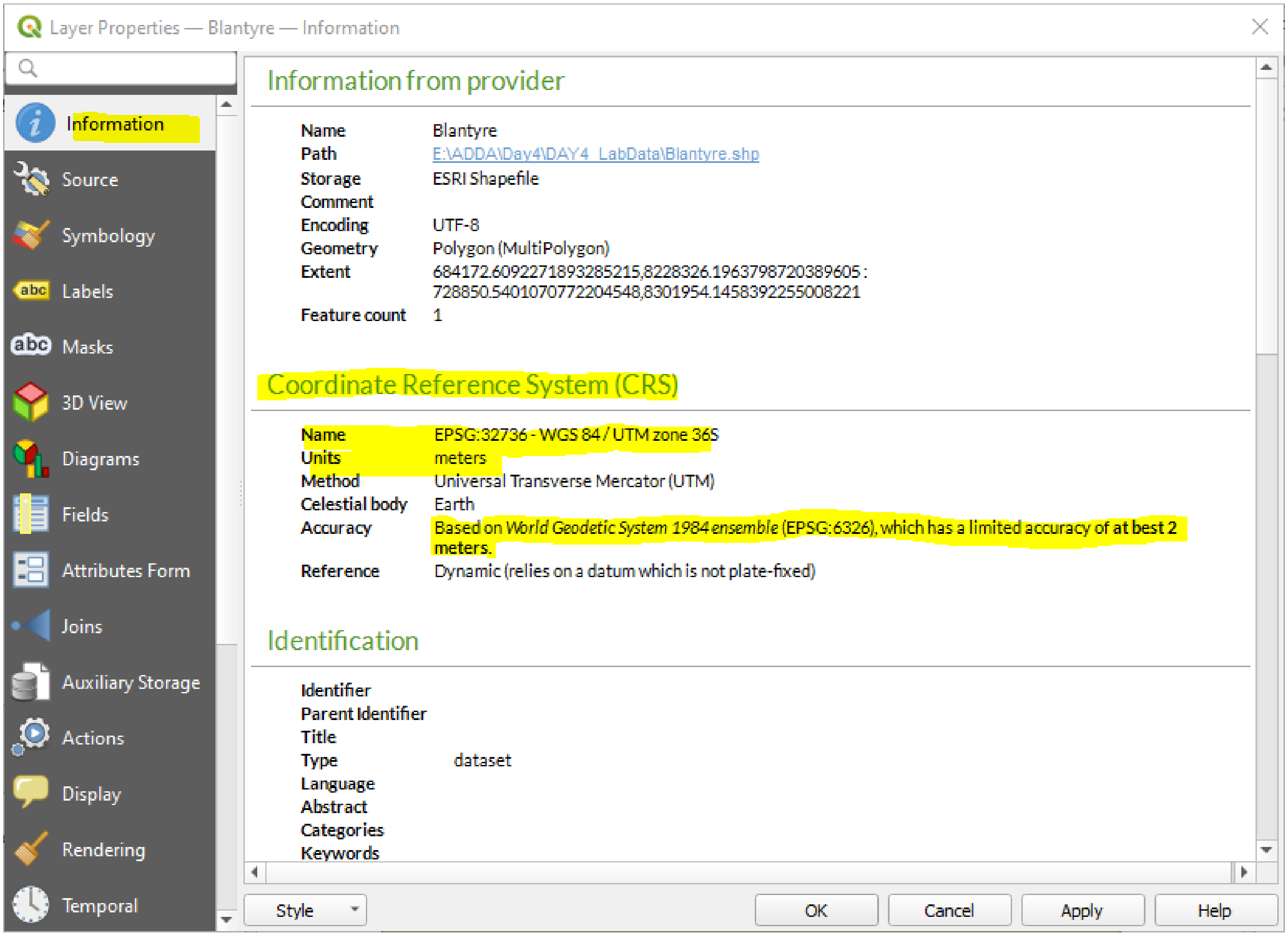
Before we start adding data and working on this lab, you need to **save** this project. Click on Project then click Save. In the dialog box, save the project as **Projection_Coordinates** in your DAY 4 working folder.

1. In QGIS, Menu bar click **Layer → Add Layer → Add Vector Layer**.
2. Under Source, You will see Vector Dataset(s) section. Click on the 3 dots (…) and navigate to the DAY 4 Folder and add the file Blantyre.shp. Your project should like something shown below:



3. At the bottom of the page, you will see **Coordinates** displayed. When you move your mouse curser over your map, you will notice that these coordinate values change. They are updated in real time as your mouse curser is moved – that means the computer has stored information regarding what type of coordinate system should be used.

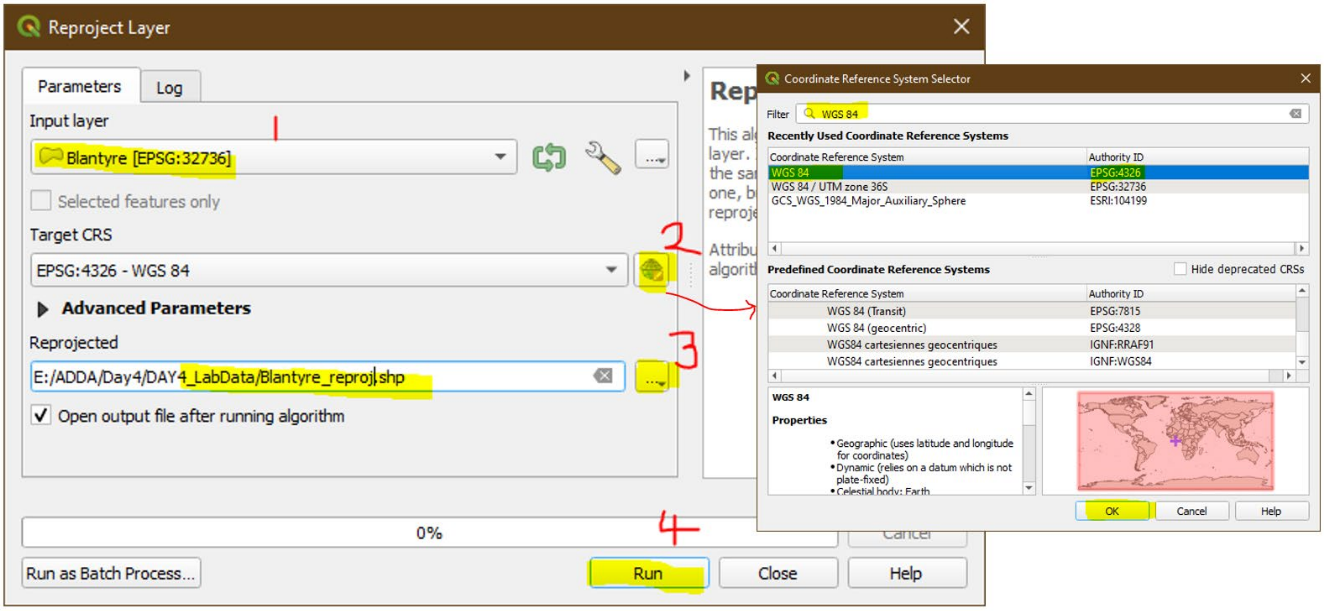
4. At the bottom-right corner, you will see EPSG:32736. This is the code for the current CRS (Projection) for the project. This is what dictates what kind of coordinates should be displayed for the map under **coordinate** box.
5. To learn more about the layer's projection, we can **Right Click** → Select **Properties**
6. Under **Properties** window, switch to **Information** tab.



In a majority of situations, the data you download or receive from other sources should have projection and coordinate system information embedded in the data as such. So when you open the file, the computer reads the embedded information and uses them to properly assign projection parameters and appropriate coordinates to display the contents of your data layer.

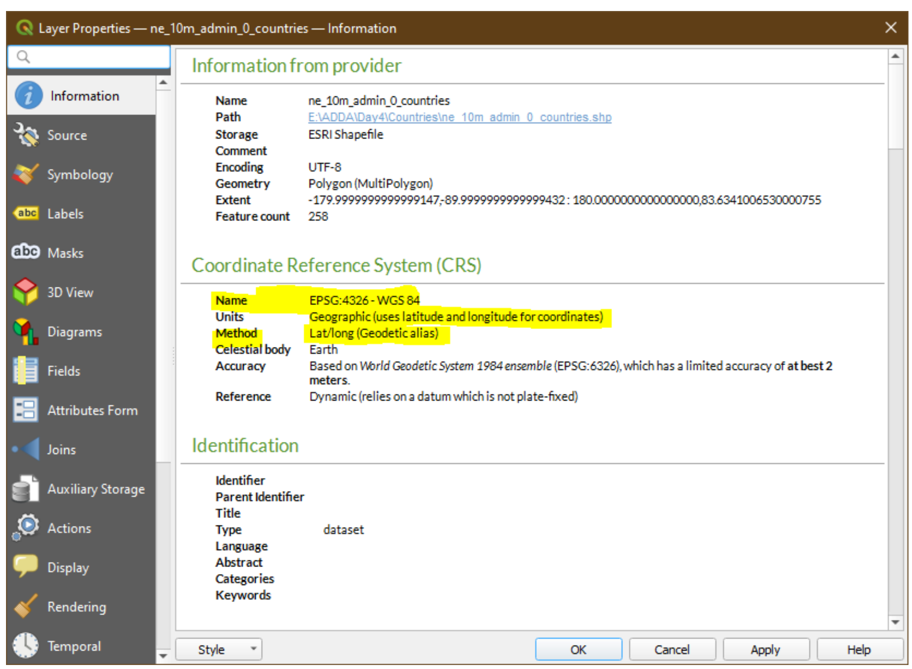
However, occasionally, you might encounter data where you were not provided with the projection details and the data does not contain the additional file that would help with visualization and analysis of the data. In such instances, you will have to reach out to the source of the data and enquire if they would be able to share with you the projection parameters. Without the projection information, data analysis is not possible.

7. Now, let's see if we can change the layer's projection. This operation is called **Re-projection**.
8. On the **Processing Toolbox**, search for **Reproject layer** tool.
9. Under the Reproject Layer window, select **Blantyre** as the **Input Layer**



10. For target CRS, click on the Earth icon and search for WGS 84 (EPSG: 4326) and select.
11. For the output **Reprojected**, click the three dots to bring up the **Save To File**. Option.
12. Navigate to your lab folder and enter the name **Blantyre_reproj**. Then Click **Run**.
13. When the process is complete, you will notice a new output layer **Blantyre_reproject** will appear on the Layer (or table of contents Panel. As you see, both the layers still line up exactly with each other - even though they are in different CRSs. This is because QGIS supports **On-The-Fly (OTF) CRS transformation**. Which means that whenever a layer's CRS doesn't match the Project CRS, it will automatically be transformed to the Project CRS so it can be displayed correctly.
14. Now let's set the Project CRS to match the newly created **Blantyre_reproject** Layer's CRS.
15. Right click on the **Blantyre_reproject** layer, then click **Layer CRS → Set Project CRS from Layer**.
16. You will see the Project CRS is updated to EPSG:4326 (bottom right corner of QGIS)

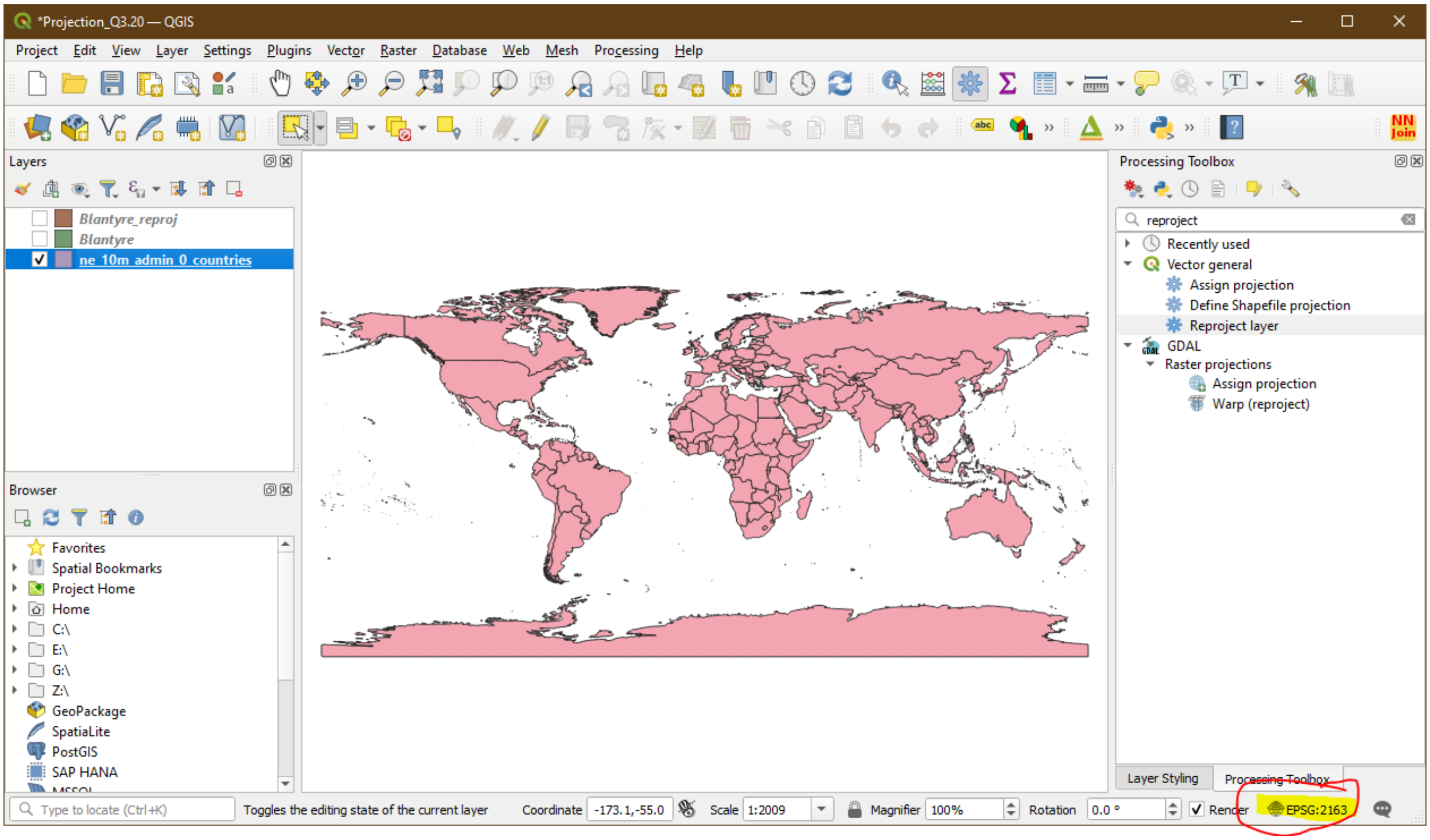
In this case, since we are looking at a very small part of the Earth, the impact of different projection is not visible obviously. So let's take a global view and find a larger area to understand the impact of the type of projection we use on how it modifies the way the map looks.



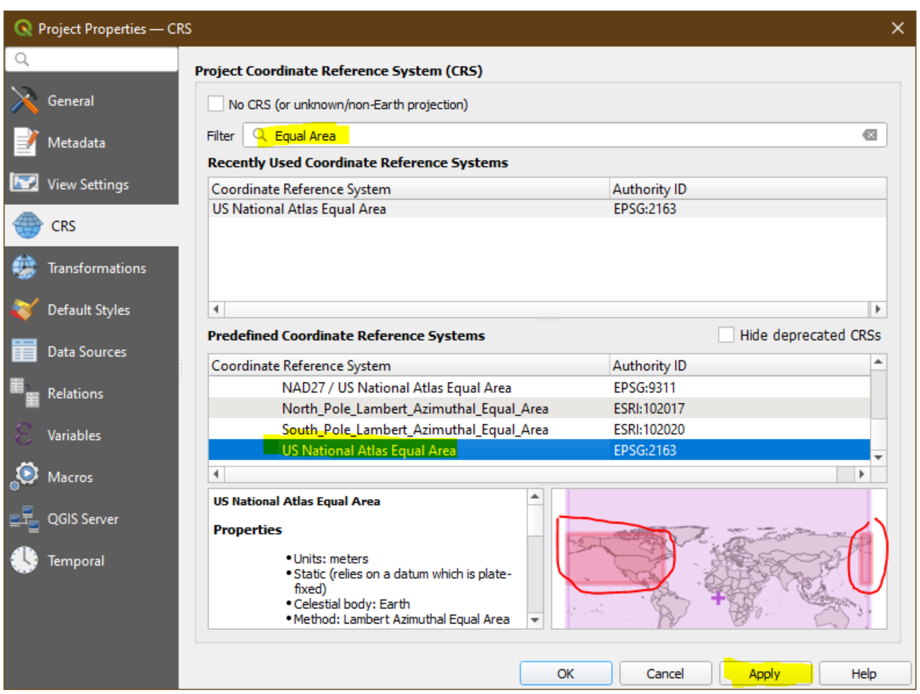
1. Using **Layer → Add Layer → Add Vector Layer** option, select **ne_10m_admin_0_countries.shp** data layer and add it to your project. This is a world map showing all the countries.
2. Right click on your newly added world map layer and select **Properties**. In the resulting window, note down the projection information associated with the layer. It should be WGS 84 (EPSG 4326). This map actually distorts the shapes and areas of different land mases. Look at Antarctica!

Now, currently the project CRS is set to be EPSG:4326. Let's change this to a different projection that would maintain correct areas of different land mases – it is called Equal Area Projection. What we want to see is, how changing the projection to Equal Area type modifies how the world map is represented!

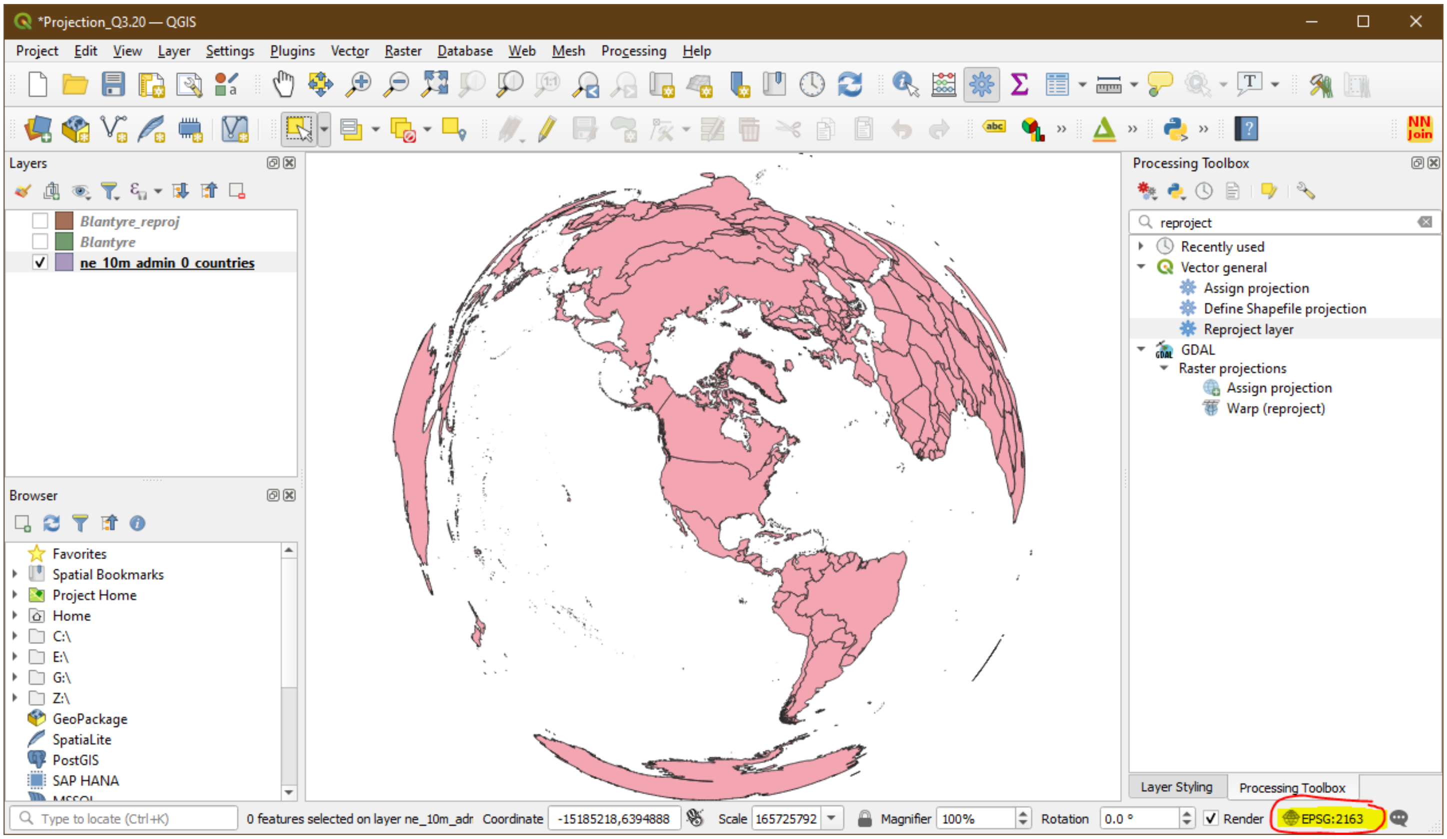
3. Click on the CRS box at the bottom right corner.



4. In the resulting **Project Properties – CRS** window, search for Equal Area projection and select **US National Atlas Equal Area (EPSG: 2163)** as the projection of choice. Then click **Apply**.



5. Instantly, the view of the world has transformed to be very different from what was previously visible. Remember, this is still a 2D map representation – even though it gives the appearance of a 3D globe. If it were a 3D globe, you would not be able to see all the countries at once!



You are encouraged to experiment with selection different CRS for the world data layer and see how it changes the shape of the countries and continents!

Hopefully, this hands-on example provides you a reasonable idea as to the importance of projections and coordinate systems. As we further explore this topic in the future, you will develop even deeper understanding of the importance of choosing the right projection/coordinate system for your project.

Remember: Any time you are engaged in a project where you are bringing a variety of data from various sources, you must make sure all data are reprojected to be in the same projection system. If different data layers have different projection system, many of the GIS analysis will fail to execute.

You don't have anything to submit for this lab.