Geographic Information Systems 2023-2024

Exercise 6 - Coordinate Reference System - ArcGIS

Introduction

> **GOALS OF THE EXERCISE**
>
> - Learn how to identify and define the CRS of a map.
> - Understand how ArcGIS Pro manages different CRS in the same map
> - Project one gds from one CRS to another CRS
> - Define a new CRS for a gds and solve projection issues

Source data

Download from Fenix the file Ex06_CRS.zip, which contains the following datasets:

- `CntrCaptETRS89.shp` - point dataset with World Country Capital cities
- `etrs89lcc.shp` - polygon dataset with World countries boundaries
- `GlobalAdmCountriesWGS84.shp` - polygon dataset with World countries boundaries

1. Identify and define the CRS of a map.

1. Create a new ArcGIS Pro project

   1.1 . Add the folder with the extracted files to the newly created project with a folder connection. This can be done on the Catalog pane, or with tool “Add Folder” in the Insert tab.

2. Identify the current CRS of your map

   2.1. On the Contents pane, right-click on Map and select Properties. The entry “Coordinate Systems” shows your current CRS. Take note of the CRS, which is default for newly created maps.

   2.2. Still on Map properties, verify that you can create a list of favorite CRS.

   2.3. Add a new map to your project. Verify that the default CRS is WGS 1984 (EPSG: 3857)

3. Add the `CntrCaptETRS89` gds to map

   3.1. On the Catalog pane, use the context menu of the gds to add it.

   3.2. What is the CRS of the added gds?

   - use the context menu of the layer to see its metainformation

   3.3. Check again the map’s CRS. Did it change? Take note of its name.

4. **Remark**: the map’s CRS always changes to the first added gds CRS!

5. Add the `GlobalAdmCountriesWGS84` gds to the map

5.1. Take note of the CRS of this layer

5.2. Check the CRS of the map. Did it change?

5.3. **Remark**: ArcGIS Pro executed an "On the Fly" transformation ("on the fly" coordinate transformations – OFT) to the project CRS; therefore, presently, visualization is done using EPSG 4258. However, the layers' CRS didn't change

6. Save your project.

2. Understand how ArcGIS Pro manages different CRS in the same map

1. Change the map's CRS

   1.1. Use the context menu of the map to change the map's CRS to WGS84 (EPSG: 4326)

   1.2. **Remark**: The ETRS89 and WGS84 are both geographic CRS (both use not projected coordinate systems – lat/long in degrees).

   1.3. Would it be appropriate to change this map's CRS to a projected CRS?

2. Save your project.

3. Project one gds from one CRS to another CRS

1. Perform a gds coordinates transformation

   1.1. Export the layer `CntrCaptETRS89` as a new gds named `CntrCaptWGS84` (in a new geopackage dataOut file format under a DataOut folder) referenced to the WGS84 CRS (EPSG: 4326)

   - Use the Tab Environments in the export panel to select the CRS

   1.2. **Remark**: WGS84 and ETRS89 presently are datums coincident to within 1 meter.

2. Repeat the operation to create a new layer `CntrCaptWGS84_v2` (in the same geopackage location), but using the tool Project (Data Management Tools)

3. It is not important to save the project now. Why?

4. Define a new CRS for a gds and solve projection issues

1. Add labels to the `CntrCaptWGS84` layer to visualize the NAME_ASCI attribute values (use the green color).

2. Add labels to the `GlobalAdmCountriesWGS84` layer to visualize the FIRST_NAME attribute values (use the black color).

3. Zoom in to your country region. Is the capital wrongly located?

4. Add the `etrs89lcc` gds to the project.

5. Zoom to the `etrs89lcc` layer.

   5.1. Hint: use the layer context menu.

6. Is the result satisfactory? Why? What is the problem?
7. Save the project
8. By default ArcGIS assigns the default project CRS to gds without CRS

   8.1. Check the current CRS of the layer `etrs89lcc`
9. Actually the etrs89lcc gds coordinates are referenced to the ETRS89 + Lambert Conic Conformal projection CRS – ETRS89 / LCC Europe (EPSG: 3034)
10. To fix this problem, define the projection of the layer `etrs89lcc`

    10.1. Open the tool **Define Projection** (Data Management Tools)

    10.2. Select the layer and define the CRS (note: check the correct CRS through its EPSG ID)
11. Refresh and check is the layer is correctly projected
12. Save the project

5. Calculate point feature coordinates in different CRS

1. Create a new gds from the `CntrCaptWGS84`, containing only the following capitals: Lisbon, Madrid, Berlin and Amsterdam; this new gds must be referenced to the ETRS89 / LAEA Europe CRS (EPSG: 3035); name this new gds `Europe4CaptETR89LAEA`

   1.1. LEAE = Lambert Azimuthal Equal Area projection.

   1.2. The LEAE projection is appropriate to represent the whole EU and units are meters.

   1.3. It is possible to convert the `GlobalAdmCountriesWGS84` gds to the EPSG 3035 but the result is not satisfactory – try it later on …
2. Use the Add Geometry Attributes on the Attribute table of the layer to calculate new attributes named “latitude” and “longitude”, and containing point-y and point-x values for the 4 capitals mentioned above referenced to the EPSG 3035

   2.1. Analyze the result, comparing to the LAT and LONG original values
3. Save the project

6. Calculate distances

1. Turn off all project layers but the `Europe4CaptETRS89LAEA` layer
2. Zoom to this layer extent
3. In order to calculate the distances between the 4 capitals, use the tool **Generate Origin Destination Links**

   3.1. As origin layer choose `Europe4CaptETRS89LAEA`.

   3.2. As destination layer select the same layer

3.3. Give the name CaptDistMatr to the output class

3.4. Do not select group fields

4. Open the attribute table of the newly created output class and take note of the distances between capitals
5. Analyze the result
6. Save the project
7. From the original, `CntrCaptETRS89`, export a new layer named `EuropeanCaptETRS89`, with only Lisbon, Madrid, Berlin and Amsterdam selected.
8. Use the tool **Generate Origin Destination Links** to calculate distances in this layer, over the ellipsoid GRS 1980 (the ETRS89 ellipsoid):

   8.1. Lisbon-Madrid: 504,327.702m

   8.2. Lisbon-Berlin: 2,309,476.737m

9. Euclidean distances (on the map), from `Europe4CaptETRS89LAEA`:

   9.1. Lisbon-Madrid: 501,691.748m

   9.2. Lisbon-Berlin: 2,300,384.469m

10. Differences:

    10.1. Lisbon-Madrid: 2,635.955m

    10.2. Lisbon-Berlin: 9,092.268m

11. Were these differences expected?
12. Save the project

7. Ad-hoc measurements using ArcGIS

1. Set the CRS project to WGS 84 (not projected)

   1.1. ...the reason being that the gds in this project are global

2. Open the Measure tool available from the Map tab

   2.1. On the layer EuropeanCaptETRS89, measure distance between capitals

   2.2. Note that:

   - planar measurements are not available
   - the distance link shows a curve shape

3. Why will the measurements be referenced to the WGS84 ellipsoid?

4. Zoom in to your country region and measure the distance between some pairs of capitals (units may be changed ...).
5. Explore the Measure tool. Click on the starting and ending points of the segment to be measured

   5.1. Double-click to end a measurement

   5.2. Do composed measurements based on several segments, for example, over a main road of the background image
6. The Measure Line / Area / Angle tool results often are imprecise ...

   6.1. It is suitable only to obtain ad-hoc measurements
7. Insert a new map (in tab Insert)
8. Copy the layer `EuropeanCaptETRS89` to this new map and zoom to the layer
9. Confirm that the map CRS is ETRS 1989 (EPSG: 4258)
10. Insert a new map, add `EuropeanCaptETRS89`, zoom to the layer extent and change the project CRS to ETRS89 / LAEA Europe (EPSG: 3035) and analyze the result.
11. Repeat with CRS ETRS89 / LCC Europe (EPSG: 3034) and analyze the result.
12. Repeat with CRS WGS 84 (EPSG: 4326) and save the project!
13. Save the project