CEEN 114 Geomatics

Lab 7 Projection and Coordinate Systems

Introduction and Instruction

The earth is a complex shape to model. The study of the shape of the earth is called Geodesy. Engineers frequently only need to map or model relatively small spaces. To create a 3D model of the earth in order to represent a small area would be unproductive. To do so on a computer takes considerably more computing power than. As in many settings, engineers solve this problem by first making some helpful assumptions and approximations. These approximations are "projections" that can accurately show the real dimensions and shape of the earth at a point. Not all projections are equally suited for a specific purpose and are not necessarily interchangeable.

During this lab you will be required to change the projection and coordinate system used by ArcMap. You will use data in groups called Data Frames. You can create new data frames by clicking Insert -> Data Frame. To change the projection used by a data frame, right click on the name of the data frame in the table of contents, open the properties menu, and open the Coordinate System tab. You can switch between which data frame you are editing in the table of contents by right clicking on the data frame you want to view and selecting activate. The name will become bolded and you can will see what is in that data frame.

By the end of the lab you should be comfortable with the following concepts/tools:

- Inspecting and changing the projection/coordinate system of a data frame
- Projections that preserve area, distance, shape, direction
- Measure Tool
- Creating additional data frames
- Exporting maps with multiple data frames
- Where error is minimized in a projection
- Using a Tissot Indicator to observe distortion on a map
- Select by attributes, zoom to selection
- Zoom, pan, scroll, zoom to layer
- Full extent

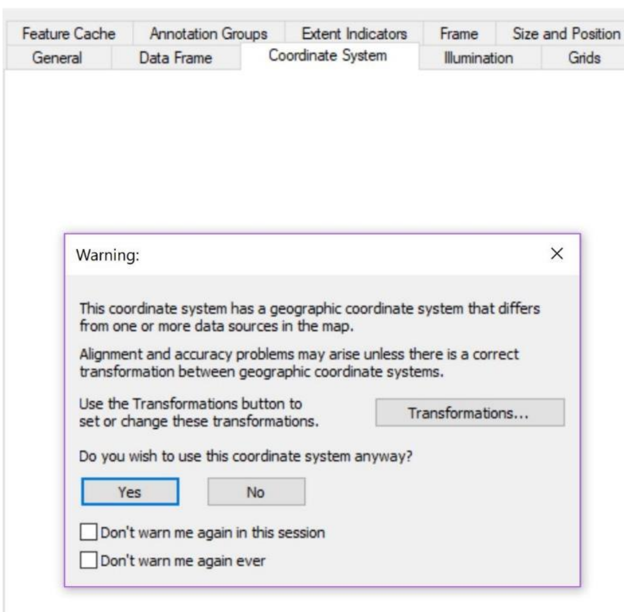
1 Inspecting Projections

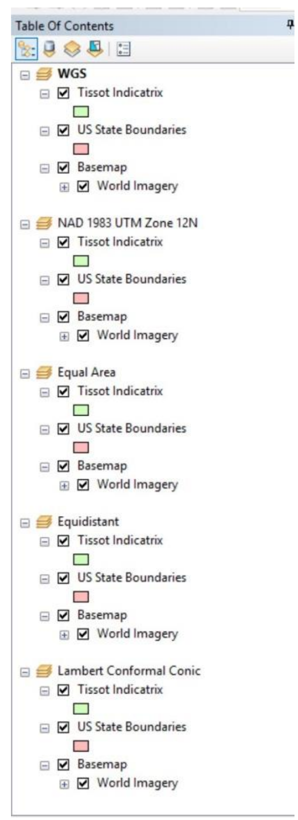
Download the data for the lab from the folder of lab data on LearningSuite. Use the geodatabase of information marked for lab 7. Keep this file on the D:/ drive if you are on a CAEDM computer. Extract the folder and make a folder connection to it in ArcMap. Add the file to a new map project. Add an imagery basemap layer. In the Table of Contents, choose sort by drawing order if it is not already like that.

Add the State Boundary and Tissot Indicatrix layer to a map. The Tissot Indicatrix is a circle that visually represents how the projection has distorted a map. If there was zero distortion, each of the circles would appear as a perfect circle, perfectly spaced, equal in size to the others. Projections that preserve area will have circles of identical area but not necessarily shape or spacing. A projection that is equidistant keep the relative distances constant. A projection that preserves shape doesn't necessarily preserve size, spacing, etc. A "standard circle" for a projection is a Tissot Indicator that does not get distorted.

This map of the United States is the shape you're probably familiar with. It is the spheroid projection "GRS 1980." Change it to "WGS 1984". Duplicate this map in another data frame view by clicking and dragging only the shapefile from one data frame to another (in the table of contents). Switch to the Projected Coordinate System NAD 1983 UTM Zone 12N (typical for Utah).

When you switch, ArcMap will warn you saying the data doesn't match the coordinate system in the projected system you just switched to. ArcMap offers to perform the calculations to transform the coordinates from one system to another. DO NOT CHANGE THESE SETTINGS. You will not get the correct outputs if you change these transformations.





Copy the State and Tissot layer and basemap to additional data frames for each of the following projections. You should rename the data frame (data frame properties -> general -> name) with the name of the projection to stay organized and prevent mistakes.

1. Lambert Conformal Conic projected coordinate system. Projected Coordinate Systems -> Continental -> North American -> USA Contiguous Lambert Conformal Conic.
2. Equidistant Conic projected coordinate system. Projected Coordinate Systems -> Continental -> North American -> USA Contiguous Equidistant Conic.
3. Albers Equal Area Conic projected coordinate system. Projected Coordinate Systems -> Continental -> North American -> USA Contiguous Albers Equal Area Conic.

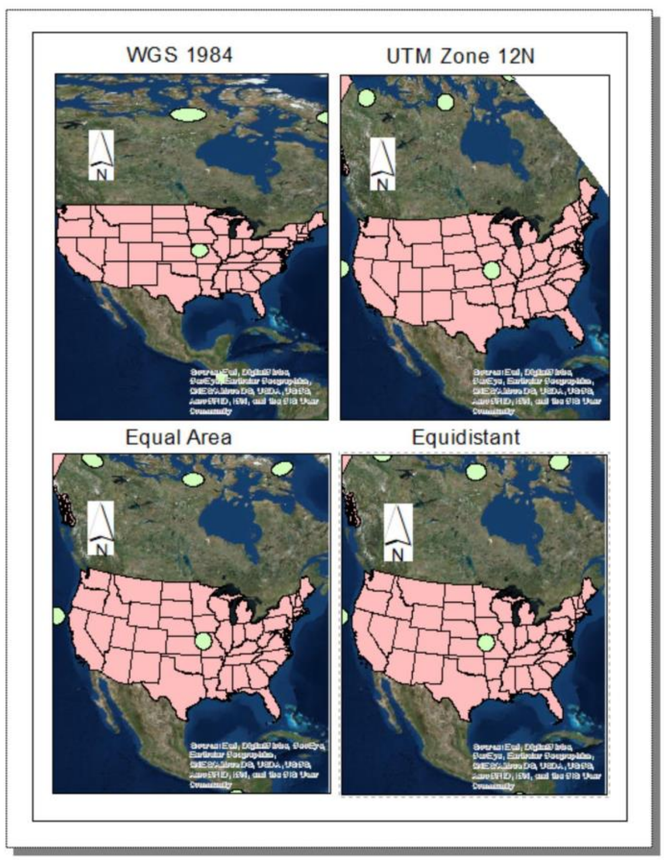
Observe the shape of the earth, the size and spacing of the circles and the size, shape and orientation of the states. ArcMap can measure the perimeter and area of a polygon feature. One of the options in the measure tool is called Measure A Feature. Click anywhere inside a polygon to get area and perimeter measurements. Record the area and perimeter of Utah in each of the projections and fill in the table in the deliverables section.

Export your results

In each of these layers, zoom in to view the contiguous United States. The best way to do that is to use Select by Attributes to select both California and Maine then choose zoom to selection. You will need to use the OR logical operator to select both California and Maine. After selecting them both, right click on the layer, choose selection, then zoom to selection.

The conic projections should look mostly the same and the Mercator projection should have a similar shape with a different orientation. Upon further inspection, you will notice slight changes in the shape, size, and orientation of the states.

Enter Layout View. For each data frame you created, ArcMap created an additional map view to use in layout view. Create a map containing all the projections except for the lambert conformal conic. Each map should meet the criteria listed and look like the example.



- Be zoomed to the United States by using select by attributes, select California and Maine, using the zoom to selection function. (right click on the file in table of contents, choose selection then zoom to selected features)

- Clear the selection so the blue highlights are no longer visible
- Arrange the maps in a 2x2 grid
- Give each of the 4 views a title corresponding to the projection used
- A north arrow (click on the data frame you want to add a north arrow to. Make sure it is selected in the table of contents. Then add a north arrow as usual)
- A neatline surrounding all the map views
- Because you are adding so much data to this map, you do not need to add more detailed projection/coordinate system information, add a legend, include your name, etc. Save as much space as possible so that the maps are as large as possible.

2 Inspecting Coordinate Systems

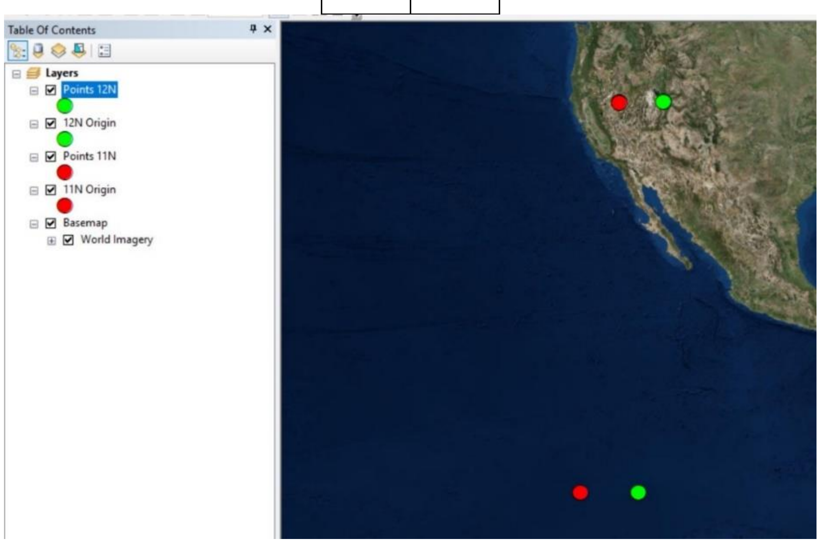
Save then close your last ArcMap project. Open a new project. Import the csv file of traverse coordinates you calculated in lab 3 and created in lab 4 (File->Add Data->Add XY Data). Makes sure the x and y columns are chosen correctly. Instead of choosing NAD 1983 UTM Zone 12N as the Projected Coordinate System for the csv file, choose Zone 11N. Where do your points show up? If done correctly, they should be about as far north as you would have expected but considerably off to the west.

Why is there error? Projections and coordinate systems always go together. Are any coordinate systems the same? Are they interchangeable?

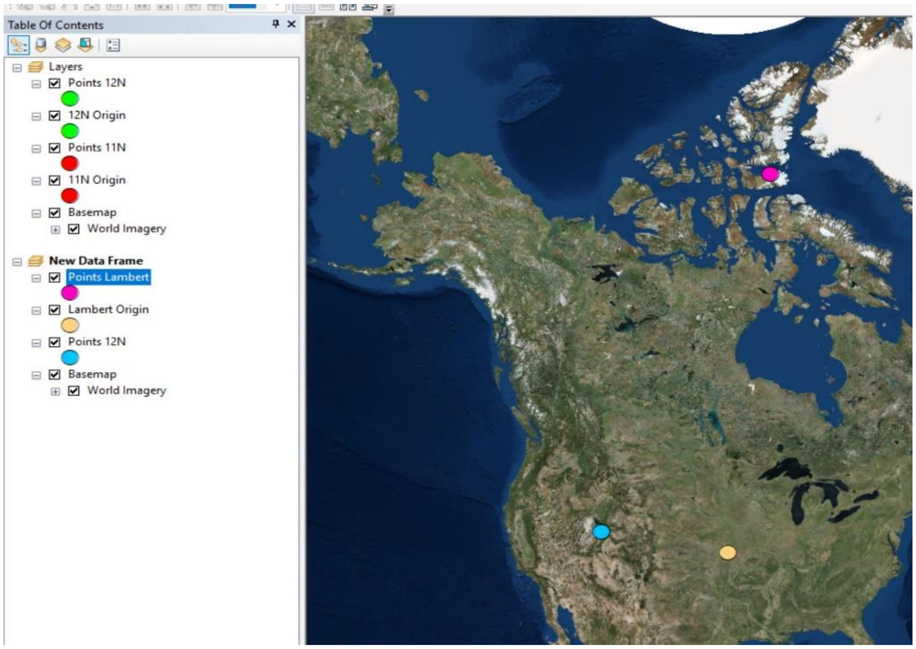
For UTM zones, the origin of the coordinate system is along the equator in the bottom left corner of the UTM zone. Create a new csv file that contains only the origin (0,0). Name it Origin Locator. Add this file to ArcMap in the 11N zone and again in the 12N zone. *<u>You should label the layers</u>* to keep them organized.

Example table format and map output

x	y
0	0



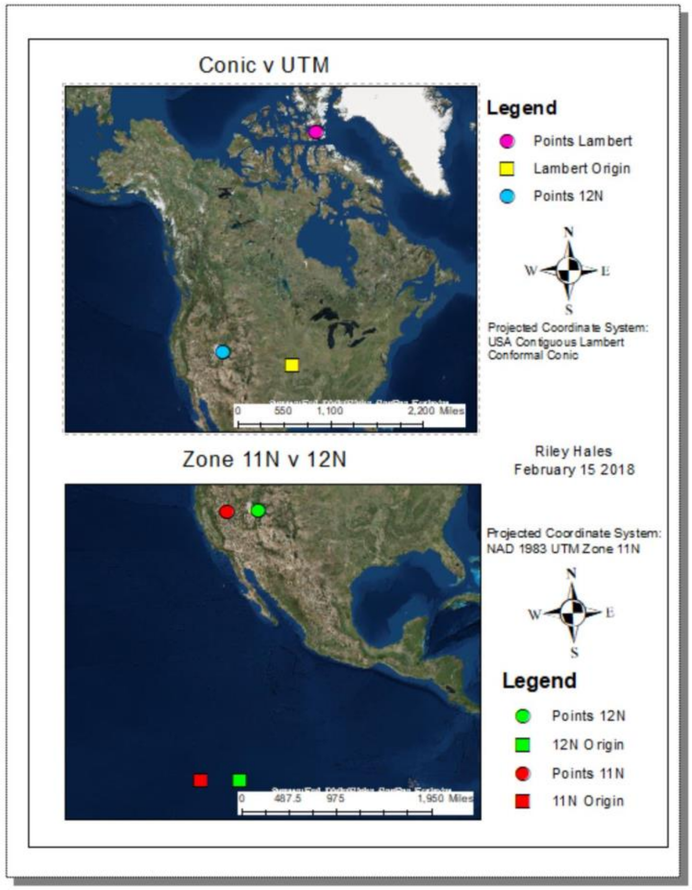
Create another data frame. Set the projection zone for this data frame to be the Lambert Conformal Conic (Projected Coordinate Systems -> Continental -> North American -> USA Contiguous Lambert Conformal Conic). Add the origin locator csv file using the Lambert Conformal Conic projected coordinate system. Add the traverse points csv file in the UTM Zone 12N and the Lambert Conformal Conic projected coordinate system. When you're finished, you should have a second map view that looks like this.



Export your results

Go to layout view and create a map showing both data frames. Your map should meet the following criteria and look like the example

- Zoom as much as you can so that your map is shows both the origin and the location of the points.
- Using the symbology skills you gained in the previous lab, change the symbol color and/or shape to correlate based on projection.
- Include all the cartographic elements you have learned about in this class.
    - Neatline- a thin line that surrounds all of the elements of your map. Not filled in.
    - North Arrow- Any style is acceptable if it is professional and readable
    - Scale Bar- Be sure to use distance units appropriate for the zoom level of the map
    - Title- The title should convey the purpose of the map and/or describe the contents
    - Projection information- Varies depending on the map
    - Coordinate System Information- Every projection has a corresponding coordinate system
    - Author- Include the name of all group members when applicable
    - Legend- Should always be exhaustive (show all symbols used)
    - Basemap- background imagery and/or labels to supplement the GIS data
    - Date- When the map was created
- NOTE: You will need two of all the cartographic elements except your name/date and neatline



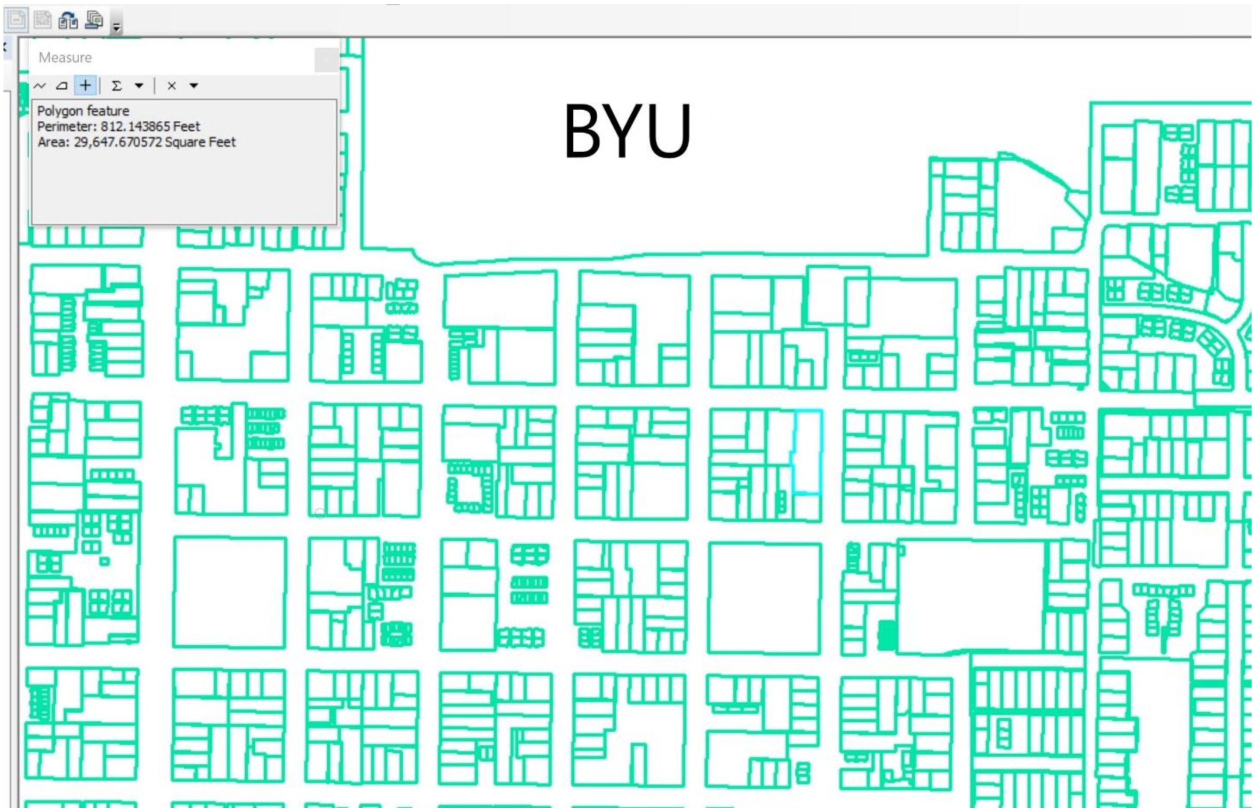
3 Local Level Change

Start a new map project. Add a base map and the ‘UTCadastre’ file from the geodatabase you downloaded for this lab. This data was created using the NAD 1983 UTM Zone 12N projected coordinate system. Notice the size, shape and orientation of the lake and the pattern of the roads.

Create another data frame, add the ‘UTCadastre’ file and a basemap. Set the projection for this frame to the Lambert Conformal Conic projected coordinate system. Zoom to somewhere in Provo that you know, eg your apartment complex, a favorite restaurant. Between these two zones, the polygons should appear mostly the same. While they look similar, there are still differences between them.

Using the measure tool as previously described in Exercise 1, record the area and perimeter of these polygons. The differences are small so you will need to record all the digits reported by ArcMap to accurately estimate the differences between them.

<u>Tips to make navigating around Provo as easy as possible:</u> use an imagery basemap layer, change the polygons in the Cadastre data set to be outlined by a thin line and not filled in, use a dataset you already have for BYU (the traverse points, the buildings and roads file your created in the symbology lab, etc) and zoom to the layer then remove it from your project.


Measure
Polygon feature
Perimeter: 812.143865 Feet
Area: 29,647.670572 Square Feet
BYU

Deliverables

1. Create a table like the following and fill in the cells with your measurements from the measurement tool. Use the dimensions specified in the table. Convert or make new measurements if necessary. Report answers to 2 decimal places.

Utah Measurements	NAD 1983 UTM Zone 12N	Lambert Conformal Conic	USA Contiguous Equidistant Conic	USA Contiguous Albers Equal Area Conic
Area (km^2)				
Perimeter (km)				

2. Create a table like the following for your measurements made for land parcels in Utah.

Area of parcels in Utah County	Your Apartment	A Restaurant	Provo Temple
NAD 1983 UTM Zone 12N			
Lambert Conformal Conic			

3. Suppose the actual area of Utah is 219,887 km^2 and the actual perimeter is 1995 km. Write a short paragraph commenting on which projection is best for preserving shape, area, and size. Describe the outcome of your observations in exercise 3. In your opinion, which projection is best overall?
4. Include the two maps you created as outputs from manipulating the spatial data. DO NOT screenshot these maps. They should be the 8.5x11 size pdf output generated by ArcMap.
    a. The first map only needs the 4 map views, a neatline, titles for each frame and a north arrow for each frame.
    b. The second map needs all the cartographic elements as outlined in the lab instructions.

All these items (tables, paragraph, two maps) should be submitted as a single pdf file. Combine them using the adobe software or searching for a website that will do it for you. DO NOT include any portion of this lab document including the deliverables section and the rubric. DO NOT attempt to submit your lab in any other format.

Rubric

10 points: Tables of data and paragraph of conclusions

- .5 pt/value in the tables
- 3pts: paragraph makes the requested conclusions
- If you used the correct projections and made the right measurements, there will not be a difference between what you measured and the value on the key. Follow directions carefully and make sure you answer all the questions.

10 points: Map 1

- 2 pts/data frame: data frame visible and properly zoomed/showing data
- Points will be deducted if cartographic elements are missing

10 points: Map 2

- About 1 point/cartographic element