GIS: Metadata for Map Projection Decisions

Summary

The first tutorial/project focuses on differences between equal area and conformal projections. The 2nd tutorial/project focuses on the choice of center for a conformal projection. That choice is important metadata and enlightens students about UTM zones.

Materials

ArcView 3.x software
data files in cg_projection.zip attached

Background for Teachers

All of these files should be put into a folder called cg_projection, and the cg_projection folder should be placed under c:. Shapefiles made especially for two tutorial projects are included for this cg_projection folder. The projects also use "normal" shape files available in c:\esri\esridata\world. There are two project files (projection1.apr and projection2.apr), and there is a corresponding tutorial document (.rtf) for each project (MapProjection-1st and MapProjection-2nd).
The main goal of the first tutorial is to show how equal area and conformal projections differ. The main goals of the second tutorial are to draw attention to the importance of choice of "center" for a projection and to understand the logic of having many UTM zones. Thus, students may appreciate metadata about centering decisions for projections.

Instructional Procedures

Map Projections - part 1 of 2
Note: You need the normal c:\esri\esridata\world folder. Other themes and the project (.apr) file are included in the folder cg_projection which should be under c:.
Learning Goals:

- Understand that specific projections are designed for different purposes
- Differentiate characteristics of purposefully designed projections
  - Conformal (using Mercator as an example)
  - Equal Area (using Peters, Mollweide, and Sinusoidal as examples)
- See how "distortion indices" change when projection choice changes

Start -- Programs -- ArcView 3.x etc. to launch ArcView
From the pull-down menu select File - Open Project and select this path: c:\ cg_projection and then select projection1.apr
Focus on View 1 -- Mercator projection. (View 1 should be the active view.)
The Mercator conformal projection is most emphatically NOT an equal area projection. It was never intended to be. It is conformal. There are several other conformal projections; remember for example that some U.S.G.S. topographic sheets use the Lambert Conformal Conic Projection or the Universal Transverse Mercator Conformal projection.

- Take a look at the two green areas, Greenland and Mexico, on the Mercator Projection
- Check what their sizes are on the globe (not projected). We set up the green theme to include the following:
  - Greenland has an actual area of 2,142,661 square km.
  - Mexico-Belize-Guatemala have an actual area of 2,094,614 square km.
- Notice what the Mercator projection does to these "green" regions that actually are similar in area.
- Take a look at the colored portions of Europe and Africa. We chose them because on the globe

(not projected) they are roughly equal in size.

- Blue

  ---------- European area = 5,747,117 sq. km.

- Orange

  ---------- African area = 5,883,974 sq. km

Again, notice what the Mercator projection has done to these two regions. AARGH!!!!!
We put several pink symbols in the oceans because we want you to think about *"distortion indices."* Notice the shape of all the pink symbols in this conformal projection.
What shape do you see? _____
One significant element in the definition of conformal projections is that the scale of miles (around any particular local point) is the same length in all directions (e.g., forming a circle).
An extension for more challenging investigation. This View shows light blue latitude & longitude lines that are spaced every 30 degrees. Be sure that you can find the equator, the 30-degree, and the 60-degree latitude lines. Notice what Mercator deliberately did to the spacing of latitude lines.

Summarize how Mercator decided to handle the spacing of latitude lines.

Soon you can see how Peters decided to handle the spacing of latitude lines.

Next, focus on View 2 -- that starts you out with a Peters (Gall) Projection. It's important that View 2 is now the active view. (Click on its top bar.)
Prof. Peters is the self-appointed nemesis of Mercator. Clearly, the Peters equal area projection gives a different impression than Mercator's conformal projection!

Notice how Peters handles the green areas. Do the 2 green areas appear similar in area? ___

Notice how Peters handles Europe vs. Africa. Do the blue and orange areas appear similar in area? ___

Notice how Peters has chosen to draw his latitude lines. (i.e., his spacing of the 0-, 30-, and 60-degree latitudes).

Finally, look at the pink shapes. (This helps us understand more about *Tissot's index of distortion* discussed in cartography and GIS textbooks.)

Notice how these shapes differ from the pink shapes of the Mercator projection!

Get more info about the Peters projection. Click on View, then Properties, and then on Projection and record info

Central Meridian _____

Standard Parallel _____ Where is Peter's most accurate?????

Standard parallel refers to the latitude on a globe where this projectionis tangent or secant and therefore is most accurate.
While we are still at this "Projection Properties" screen, we'll try out a few other projections.
Stay with Category: Projections of the World for now, so you can look at different world projections.
Type:-- press arrow to see list of other types.
Select Mollweide and press OK and OK.
Wait patiently!
Is Mollweide an equal area projection? _____
View -- Properties -- Projection
Category: Projections of the World
Type: press arrow to see list.
Select Sinusoidal and press OK and OK.

Wait patiently.
Is this an equal area projection? _____
Summary question: Is the Peters Projection the only easily available equal area projection? Be ready to explain.
Extension: Try other world projections (e.g., Robinson, Miller, Plate Caree) and decide whether they are conformal, equal area, or neither. Remember that:

conformal shows our "pink shapes" as circles but does not represent relative area properly, and equal area maintains proper relationships among areas of countries or regions.

When you are done with this tutorial, File - Exit and NO, don't save changes.

Map Projections -- part 2 of 2 - the importance of "centering"
Note: You need the normal c:\esri\esridata\world folder. Other themes and the project (.apr) file are included in the folder cg_projection which should be under c:.
Earlier. we learned that projections have different purposes:

- Equal area *(maintains proper area relationships among countries and regions)*
- Conformal *(the scale is the same in all directions around a local point; the index of distortion is circular)*

Other special purpose projections *(neither equal area nor conformal)*

Now, our learning goal focuses on the deliberate choice of the center for each projection. As we go through the tutorial, notice the characteristics of regions that are *near vs. far away from* the center lines or center points of projections. A summary question at the end focuses on "UTM zones" and who "centering" a projection relates to them.
Start -- Programs -- ArcView 3.x etc. to launch ArcView.
From the pull-down menu select File - Open Project and select this path: c:\ cg_projection and then select projection2.apr
This tutorial focuses on centering decisions.
In addition, it also looks at centering decisions for different types of projections: Lambert *Equal Area* Azimuthal and Transverse Mercator *Conformal*.
Views 3 & 4 start out as the same type of projection (Lambert Equal Area Azimuthal).
Centering: Notice that we chose a *different central meridian* for each view. (It's helpful to have a globe on which we can find the 0, 30 West, and 60 West longitude lines if students want to review longitude.) The blue lines of longitude are spaced every 30 degrees.

What is the central meridian for View 3? (centered on a meridian through Greenland)
What is the central meridian for View 4? (centered on a meridian through England and West Africa)

Distortion: Notice the 5 pink shapes. Each shape shows 500 miles around a central point and is a crude version of an "index of distortion" similar to Tissot's index.
All of the shapes are along the 45 degree North latitude (at 60W, 30W, 0, 30E, and 60E longitude).
Compare the sizes (areas) of the 5 pink shapes in each of these equal area projections.

Are the shapes basically the same in some way?
Are the shapes clearly different in some way?

Look in View 3. Which shape is most close to being circular? (Note it's longitude.)
Look in View 4. Which shape is most close to being circular? (Note it's longitude.)
Where is the most circular shape located (in each equal area projection)?
Try to make a generalization from what you just looked at!

We have two equal area projections that are centered differently.
Where is each equal area projection most "conformal" (i.e., a circular pink shape)?

Continue to look at both View 3 and View 4.
What difference does that *centering* decision make in these equal area projections?

Do relative areas of continents vary, depending on center line?

What does change because of the centering decision? HINT: Consider appearance of Africa and South America, for example.

Next, focus only on View 3, so you can experiment with another type of projection and *centering* decisions for it.
Soon, you will choose the Transverse Mercator *Conformal* Projection which is an important conformal projection (with different characteristics from the Mercator projection, but conformal like it).
View 3 must be the active view.
Click on View -- Properties - Projection
From Projection: _____ click on arrow to get drop down list and choose Transverse Mercator near the bottom of the list.
Spheroid: Clarke 1866 is ok.
Central Meridian: type in 0 for the Prime Meridian.
Take the default values for everything else.
Click on OK and OK.
For this central meridian of 0 degrees longitude, describe the following:

Where are Europe and Central Africa in relation to the central meridian?

Describe what has happened to South America which is quite far from the central meridan.

Finally, compare this Transverse Mercator *Conformal* projection currently in View 3 to the Lambert *Equal Area* projection in View 4. Both are centered on the Prime Meridian.
Describe major differences between the Transverse Mercator *Conformal* and the Lambert *Equal Area* projection. (Compare sizes of continents. Compare shapes and sizes of the pink shapes.)
Now make View 4, the lower view, active. Soon, we will compare two Transverse Mercator projections.
Click on View -- Properties - Projection
From Projection use drop down list and choose Transverse Mercator again
Spheroid: Clarke 1866 is ok.
Central Meridian: type in --30 for 30 West longitude.
Take the default values for everything else.
Click on OK and OK.
Wait patiently for many computations.
For a central meridian of 30 degrees west longitude, notice the following:

What has happened to Europe? Compare with View 3 where Transverse Mercator is centered at 0.

What has happened to South America? Compare with View 3 where Transverse Mercator is centered at 0.

What generalization can you make regarding *centering* decisions and distortion in this projection? Consider size (area) distortion as well as gross shape distortion.

Compare what has happened to the pink shapes on the 2 Transverse Mercator conformal projections.

In general, what shape do the "pink shapes" always take on these conformal projections? _____

In general, where are the pink shapes larger or more distorted in size in these conformal projections? _____

EXTRA: If you want to see even more "distortion" , try centering the Transverse Mercator on -60

or 60 degrees West longitude.
The next question makes more sense if you have read about "UTM coordinates."
SUMMARY: Why does the UTM system choose to use 60 differently centered Transverse Mercator projections? (What does each of the 60 zones do with the areas that are far away from the central meridian of the zone?) _____
When you are done with this tutorial, File - Exit and NO, don't save changes.

Additional handout entitled "Transverse Mercator" is attached.

Bibliography

Authors

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