Geospatial Learning Pathways Presentation

Map Projections

by

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recorded: April 2, 2009

This is a Bureau of Land Management Geospatial Learning Pathways Presentation. Map Projections is presented by the Montana State Office. You will learn how to set projection parameters and geographic information system and global positioning system environments. Your presenter is Randy Schardt of BLM's Montana State Office.

Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface. And so when a map projection or when we use map projection, will always have distortion of the shape, the area, the distance, and direction. So, no direction can preserve all these properties. Some map projections minimize the distortion to one property at the expense of another while map projections strive to balance the overall distortion.

Coordinate systems are a part of map projection. And so what a coordinate system is, it's a reference system that is used to represent the locations of geographic features, imagery, and observations within a common geographic framework. And it basically, the coordinate system is the definition of the map projection.

There are two types of coordinate systems. The first is the geographic coordinate system and the projected coordinate system. Let's first talk about the geographic coordinate system. The geographic coordinate system is a reference system using latitude and longitude to define the location of points on the surface of a sphere or spheroid. And it can be recorded in several different formats. It can be in decimal degrees, degrees, minutes, seconds, or degrees decimal minutes. In a geographic coordinate system, the earth is not a sphere. The poles are flattened and there's bulges at the equator. So, basically, the earth becomes a spheroid or an ellipsoid.

In a geographic coordinate system, the universal coordinate system is the lat/long and this equates with the longitude values seen with the X axis and the latitude values are with the Y axis. Geographic coordinate system, or the lat/long, is good for locating positions on the surface of the globe, but it is not an efficient means for measuring distance and areas because the latitude and longitude are not uniform units of measure. So if you have data in lat/long, you'll not be able to calculate acres; you'll not be able to calculate miles, or anything like that. So you're going have to reproject that data.

In a geographic coordinate system, the datum will define the position of the spheroid relative to the center of the earth. And this is the origin and orientation of latitude and longitude lines are determined by the datum. And there are hundreds of datums customized for different parts of the world. So what common datums do we use in the US? The first one is the North American Datum of 1927 or NAD 27. This uses the Clarke 1866 spheroid. The reference point is located in Mead Branch, Kansas and it's based on ground survey that was conducted in the 1800's.

Next datum is the North American Datum 1983 or NAD 83. This uses the GRS 80 spheroid and this is based on ground surveys and satellite information.

And lastly, we have WGS 1984. This is the most recently developed datum framework or measurements worldwide. It is earth-centered. It has earth-centered perspective and this is the datum that is used by all GPS satellites at this time. WGS 1984 is nearly identical to NAD 83; therefore, NAD 83 is compatible with date collected in GPS using WGS 84. So, both those are comparable, there pretty close to one another. We are trying to get away from MAD 27. We discourage anybody from using NAD 27, that is old technology. So, if you want the most accurate datum, use NAD 83 or WGS 1984.

Now, let's talk about the projected coordinate systems. Projected coordinate system is the systematic transformation of locations on the earth, which are latitude and longitude, to planer coordinates. Projected coordinate system always will use a geographer coordinate system, which references the datum NAD 27 or NAD 83.

There are a total of 66 supported map projections. The Montana / Dakotas BLM mandates using the Albers Conic equal area 1983 projected coordinate system.

So one of the reasons that we want to use a projected coordinate system over a geographic system. With a projected coordinate system we have the ability to make accurate measurement and to be sure that the spatial analysis options calculate the distance correctly. Projected coordinate system preserves one or more of the following properties: the area, the shape, the distance, and the direction. And with projected coordinate system, we have a better overall appearance of the map. We don't have the flattening of the data as we do in the geographic coordinate system.

So why do we use the Albers projection for the Montana / Dakotas? The Albers projection uses two standard parallels compared with the distortion that a projection with one standard will give you. So although neither the shape nor the linear scale will be truly correct with the Albers. The distortion between the properties is minimized in the region between standard parallel. So, for the Albers projection for Montana, we have two standard parallels. Any data within those two standard parallels - the distortion is going to be minimized. And this projection is best suited for land maps extending in the east to west orientation rather than those lying north and south. So, because we cover three states, basically we're looking east-west. We use that instead of, maybe, a state like California who has a north-south orientation.

One final about Albers that it does not use zones. So we don't have to worry about multiple zones covering the three states.

So here's, kind of, an example of the different coordinate systems. Up in the upper left, we have the Albers, the Montana BLM custom Albers coordinate system. Over on the right, this is the Montana state plane, 5th zone 25 coordinate system. Well, you notice that for Montana, North and South Dakota, we don't have just one zone. There are three different state planes zones. So, we would have to decide which zone would look the best.

The lower left is the latitude/longitude and notice how it flattens out the data. Then, the lower right, we have the UTM coordinate system and the four zones that would make up for the Montana Dakotas. So, with these examples, the Albers would be the right choice because we don't have to deal with different zones and the data comes out looking more realistic.

So, let's talk a little about defined coordinate systems. Datasets have a defined coordinate system and can automatically integrate with different coordinate systems by projecting on the fly in ArcMap. What that means is, if we have a projection of Albers and we bring shapefile that has a projection of UTM, ArcMap will automatically reproject on the fly and place the UTM data in the right spot using Albers projection.

ArcPad does not reproject on the fly, so it requires all the data to be in the same coordinate system. So, if you have data that has not been defined, you will not be able to use that in ArcPad, because ArcPad will not know the coordinate system and where to place it.

If the data has a coordinate system definition but it does not match the BLM coordinate system, you can project that data. To do that, you go to the Project tool, or the Project Raster Tool and the Data Management Tool Box. Or, you can add the data to an ArcMap project; you can set the data view coordinate system to the BLM custom Albers projection and export the data out using the coordinate system of the data frame. So there's two different ways of doing that and we'll cover this a little bit later.

We talked about defined coordinate systems, let's talk a little bit about undefined coordinate systems. Undefined coordinate systems, data with undefined coordinate systems will work in ArcGIS. However, you will not be able to take advantage of the functionality in ArcGIS. For example, the shapefile cannot be projected on the fly. It will draw, but it won't be put in the right spot. If the data frames coordinate system is not the same as the undefined data, the data will not be displayed. Also, if the data hasn't been defined yet, the metadata will not automatically be updated and it will be incomplete.

So, if you have some data and it's not being displayed or it's not lining up with the other data, what's the problem? If your data is not displaying, most likely it's a projection problem. And if it's a projection problem, your data has huge errors and the features are likely being displayed in the wrong state or the wrong hemisphere. So it's thrown out in the middle of nowhere. What would be the cause of this? The data does not have a defined coordinate system. Or the defined coordinate system that has been assigned to it is wrong. Somebody has given it the wrong coordinate system. So, to fix this, you're going to define the coordinate system by using the defined projection tool, in the data management tool box or in ArcCatalog you can right-click on the data set, choose Properties, select the XY coordinate System Tab and then you will be able to one of three things. You can select a pre-defined coordinate system, you can import the coordinate system parameters used by another data source, or you can define a new custom coordinate system.

What happens if my data doesn't line up? Most likely that is a datum issue. If your data is able to overlay with your existing GIS data but you're off by several hundred feet, that's probably the datum issue that I've just talked about.

The difference between the NAD 27 and the NAD 83 can be as much as 500 feet difference there. So you can have 500 feet of play when you're talking the difference NAD 27 and NAD 83. And this, really, will create a problem when doing analysis. So you want all your datum to be the same for all your data. So the cause of this is the data has the wrong datum defined. To fix this, you need to define the coordinate system with the correct datum by using the defined projection tool in the Data Management Toolbox. Or, in ArcCatalog, you right-click on the data set, choose Properties, select the XY coordinate system tab, and select the coordinate system that has the correct datum.

Finding a projecting rule of thumb. If the data does not have a coordinate system defined or the defined coordinate system is incorrect, you will use the defined projection and this does not create a new data set. It just defines the projection of the existing data set. If the data has the correct coordinate system defined and you want to change to a different coordinate system, use project. This creates a totally new data set.

If you have a shapefile and you think the projection is wrong, if you do project on it, you're going to end up with a data set that's still messed up because the projection of it is wrong to begin with. So you would need to use the defined projection and then use the project on that data set.

Let's talk a little bit about the coordinate system and how they are in GPS. The GPS units collect in lat/long WGS 84, but can be set up to be displayed in another coordinate system as a UTM or state plane on the GPS unit. So, what I like to do is, to avoid confusion, I export all of my GPS data collected using a Garmin or Trimble TerrSync in lat/long WGS 1984 projection. That way you won't be confused later on. Did I export it out in UTM; did I export it out in state plane? It will always be in the projection that it was collected in.

Let's talk about coordinate systems in ArcPad. Each layer in ArcPad must have the same define projection. ArcPad will not add layers with different projections to the same map. Default projection for a new map in ArcPad is latitude/longitude WGS 84. Any data added to a newly created ArcPad project will change the default projection to the data defined projection. So, if you open up an ArcPad projection or an ArcPad project, and you add data that has BLM Albers custom projection in it, the projection for that ArcPad session will be changed to the BLM custom projection.

ArcPad supports on the fly projection and datum conversion from the GPS input datum to the projection of the current map. That doesn't meant that it reprojects on the fly the data; it'll just project on the fly the GPS collection data from the unit to whatever projection ArcPad session is set to.

The projection information for each layer is contained in the layers projection or .prj file. In addition, each map has an associated projection that can be stored in the ArcPad map or .apm file. So to view the ArcPad map projection, what you would do is you would tap the Table of Contents button, you would tap the map properties dialog and select the Projection tab and that will tell you the projection of your ArcPad project.

If you want to specify projection to an ArcPad map, you would tap the Table of Contents button. You would tap the map projection definition file, which is the top button there. And then it will let you navigate to the projection file that you would want to use and you would select that projection file and that would be assigned to your ArcPad session.

Any shapefile that's created in ArcPad will be given the projection of the current ArcPad project. So if the ArcPad project is set to the BLM custom Albers projection, you create a new shapefile, that shapefile will have that projection with it. And when you bring that back into ArcMap, that projection will be assigned to that shapefile.

Let's talk a little bit about the DNR Garmin version. The DNR Garmin program has integrated a projection utility that allows users to save and load projected data without the need for an external GIS program. So, in DNR Garmin what you're going to want to do is you're going to want to set your projection and once you projection is set, that will stay set until you go back and change it. So to do that, you're going to go ahead and you're going to click on the file under DNR Garmin, and you're going to choose the set projection. You will then get the DNR Garmin Properties window. You will select the projection tab and you're going to populate the drop down as shown here. You're going to want the PSOC code to be 4326 and you're going to want your datum to be GSE WGS 1984. Once you do that, the lower drop downs will populate automatically. You will then click ok. At this point, all data that you're exporting out from DNR Garmin, will be exported out in GSE WGS 1984.

You have data in DNR Garmin and so you're going to want to take that data and you're going to want to export it out into a shapefile. To do that, you click file, save to, ArcMap, and shapefile layer. It will then export out the data collected from DNR Garmin into a shapefile. Once you have the shapefile, what you're going to need to do is you're going to need to define this data. DNR Garmin does not define the projection after it's been exported. So you're going to need to do that. So to do that, you will go into ArcToolbox, you're going to go to Data Management Tools, you're going to go to projection and transformation, and you're going to choose define projection. It will bring up your Define Projection window. What you'll do is you will put your shapefile in that input data set for feature class and the coordinate system is GSE WGS 1984, and you'll click ok. Your data will then be defined with WGS 84 projection.

The coordinate system can also be assigned to ArcCatalog. So what you do if you want to assign your projection in ArcCatalog, you would open up ArcCatalog, you would right-click on the layer or shapefile, you would select the XY coordinate system tab, and then you would either choose select, import, or create a new coordinate system. You choose select, it'll give you a list of projected coordinate systems, or geographic coordinate systems, that you'd be able to use.

After the data has been defined, you're going to want to reproject that data into the BLM custom Albers. So, to do this, you would go to ArcToolbox, you'll go to the Data Management Tools, the projections and transformations, and then you would go to the feature, and then underneath that feature you would have your project tool. And your project window comes up, you give it the name of your new shapefile. It automatically puts in the projection that's assigned to that shapefile. If there wasn't a defined projection there and you knew what it was, you could add it here. It asks you for the output shapefile and what you want your new projection to be. You would click ok. You would then have your shape file, reprojected shapefile with your custom Albers projection.

Let's talk about the Trimble GPS Pathfinder Office. In Pathfinder Office, you're going to want to export your data from TerraSync. So what you're going to want to do, is you're going to want to choose utilities and select the export option. Your export window will come up and it's going to ask you several different things. It's going to ask you the file, the data file that you're going to want to export, it's going to ask you the output folder you're going to want to put it in to. It's going to ask you the export set up; then it's going to ask what projection do you want it to be in. You're going to want to verify that you want to export this out as lat/long WGS 1984. If that was not set to WGS 1984, you have the option to change it. To do that, you would click on the property button and then you would have your export properties window open up. You would select the coordinate system tab, and then you would select change and if it was set to UTM, it would give you an option to change to lat/long WGS 1984. So you click ok, and when you export it out, your data from Pathfinder Office, it would be exported out as WGS 1984 projection.

After that has been exported out, you're going to define that projection for the newly created shapefile, WGS 1984, but because Pathfinder also does not put on the projection when you export it out, so you need to define it. Then once this defines, you're going to want to project the data to Albers in the process that we discussed previously with DNR Garmin.

So, basically, that's the end of the presentation. Are there any questions?

Voice: Hey, Randy? The ArcPad has the capabilities to reproject your shape files in case you get a mismatch?

Randy: Yes, it does.

Jack: Hey Randy, this is Jack from Arizona. I got a question on defining projections. If you have a shapefile or a feature class, whatever it is that is undefined, is there a method to find out what projection that is?

Randy: Yeah, there is. It's kind of a hit and miss.

What you need to do is to open up the properties for the shapefile and it should give you some coordinates there. It gives you lat/long coordinates, then it will be it's geographic, and then what you'll have to do is assign the geographic coordinate system. Start with NAD 27 and assign it and then compare with your data. If it matches up, then it's NAD 27. If it doesn't, then use NAD 83.

Jack: Okay, if it is projected though?

Randy: If it's projected…

Jack: Like if it's a UTM, you'll just have to be able tell if the coordinate pairs up?

Randy: If it's UTM, you will have to do the same process, but you're going to have to figure out and do it by zone. If it's zone, you know, start with whatever zones cover your state. Usually, a majority of the state will be in one zone.

Jack: Right, yeah. We use it on 12 UTM.

Randy: That's, basically, what we use here. Majority of the state as well. So you'd start with Zone 12 and, you know, you're probably sure it's going to be NAD 83, so you can use Zone 12 NAD 83 and give that a shot.

Jack: Okay.

Randy: There really isn't a scientific way of doing that. It's just trial and error.

Jack: Right, okay. I just thought there might have been some magic that I didn't know about.

Randy: No, there's not.

Any other questions?

Thanks, Randy! Okay!

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