GIS: Latitude, Longitude, Projections and Great Circles

Summary

This lesson was created to introduce latitude, longitude, map projections and great circles to a large group of students. The lesson was created for a classroom where the teacher has access to a computer upon which the exercise can be completed. Students view the teacher's work on a television and complete an associated worksheet demonstrating basic concepts.

Materials

ArcView GIS for PC
Television to allow students visual access to the teacher's project
Teacher Instruction Sheet from prjtns.pdf
Student Activity Sheet from prjtns.pdf (one per student)

- "Prjtns.pdf" document
- "projections.apr"

ArcView project
contents of "projections/data" directory from zip file attached.

Background for Teachers

Background

This lesson was created to introduce latitude, longitude, map projections and great circles to a large group of students. The lesson was created for a classroom where the teacher has access to a computer upon which the exercise can be completed. Students view the teacher's work on a television and complete an associated worksheet demonstrating basic concepts.

Documents Included in Lesson

Teacher Instructions:

This is a lesson plan for the teacher that shows what to do in ArcView step by step. This lesson was created for use by a teacher that has very little experience with GIS and ArcView. It would be a great advantage if the teacher was familiar with turning a theme on and off and zooming in a view.

Student Worksheet:

This is a worksheet that the students fill out as they follow along with the teacher.

Required Utilities:

This lesson uses a customized ArcView project. The computer running the application should have a resolution of 1024x768 or larger.

Instructional Procedures

Introduction

Positions of objects on the Earth are measured in degrees of latitude and longitude. Latitude is zero at the Equator, runs to positive 90 degrees at the north pole and runs to negative 90 degrees at the south pole. Longitude is zero at the Prime Meridian, runs to positive 180 degrees to the east and runs 180 degrees to the west to meet at the International Date Line. Longitudes to the west of the Prime Meridian have negative values. If you know the latitude and longitude of a city, you can find it in the world.

Lab Open the View titled '1 - Learning Latitude and Longitude'

How To: Double click on the view title in the project window

Questions for Students:

What continents does the Prime Meridian cut through?

What continents does the Equator cut through?

What is the degree value of the Tropic of Cancer? (-25 degrees or 25 degrees South)
If you look at the top right-hand corner of your screen, you will notice that the latitude and longitude of the cursor is listed.
Place your cursor on the Prime Meridian, move the cursor to the right, what happens to the longitude? (It gets larger)
Now, place your cursor on the Prime Meridian and move it to the left, what happens to the longitude? (It gets larger in the negative direction)
Repeat the process with the Equator, looking at the latitude values.
The students have the following short list of world capitals in front of them:
Beijing, China
Brasilia, Brazil
Cairo, Egypt
Canberra, Australia
Kuala Lumpur, Malaysia
Lagos, Nigeria
Madrid, Spain
Paris, France
Tokyo, Japan
Washington D.C., United States
Ask your students to guess which capital goes with the following latitude and longitudes.
35.31° S, 149.04°E - Canberra, Australia
38.90° N, 76.96°W - Washington D.C., United States
30.08° N, 31.26°E - Cairo, Egypt
Close the '1 - Learning Latitude and Longitude' View
How To: Click the X in the top, right-hand corner of the view.
Map Projections
Introduction
The Earth is a 3-dimensional object. Therefore, the most accurate way to present the Earth is a 3-dimensional globe. Unfortunately, there are a few problems with using the globe to represent the Earth. First is scale, even the largest globe has a small scale and therefore shows very little detail. Not to mention, a globe is takes up quite a bit of room to store and carry. If you were going to take a vacation from Arizona to Washington D.C., a globe would not be a very useful for navigation and it would be hard to find a place in the car to keep it. For reasons such as this, we choose to represent the Earth as a 2-dimensional object, or flat map. When you take a 3-dimensional object and transform it to a 2-dimensional object, there are going to be some changes in the way that it is represented. For example, imagine you have an orange. If you took the skin off the orange and tried to place it flat on your desk, the skin would warp. It would bubble out in some places and rip apart in others. A 3-dimensional object does not fit into a 2-dimensional plane. The same problem occurs when trying to represent the Earth as a flat map. Whenever the Earth is projected onto a flat surface, or map, there is going to be some distortion, or misrepresentation, of the Earth's surface. All map projections produce distortion of one or more of the following properties: shape, areas, distance and direction. The key to using map projections is to determine which property is the most important to you, and choose the projection that distorts that property the least.
Lab
Open the View titled '2-Learning Projections'
How To: Double click on the view title in the project window.
Change the projection to Mercator
How To: Change the projection by clicking on the button labeled P. Clicking the P button will cause the 'View Properties' box to pop up. In the 'View Properties' box, click the button labeled Projection

and the 'Projection Properties' box will appear. Using your mouse, click inside the white box that says Geographic. This will cause a list of projections to appear. From that list, choose the Mercator projection. Click OK in the 'Projection Properties' box and then click OK in the 'View Properties' box. Notice that the projection has been changed to Mercator. Ask your students what changes they noticed. Which of the following have become distorted or misrepresented: size, shape, distance and direction.

Facts Concerning Mercator Projection

- Land shapes near the equator are fairly accurate, however, there is extreme distortion of land near the poles. Note that in the Mercator projection, Alaska is nearly as big as the contiguous 48 states.
- The Mercator projection shows true directions between two points along a straight line.
- Introduced in 1569 by Mercator.

Teacher Instructions

Change the projection to Robinson

How To: Change the projection by clicking on the button labeled P. Clicking the P button will cause the 'View Properties' box to pop up. In the 'View Properties' box, click the button labeled Projection and the 'Projection Properties' box will appear. Using your mouse, click inside the white box that says Mercator. This will cause a list of projections to appear. From that list, choose the Robinson projection (you may have to scroll down the list). Click OK in the 'Projection Properties' box and then click OK in the 'View Properties' box.

Notice that the projection has been changed to Robinson. Ask your students what changes they noticed. Which of the following have become distorted or misrepresented: size, shape, distance and direction.

Facts Concerning Robinson Projection

- The Robinson projection is similar to the Mercator projection, however, there is a better balance of size and shape in high latitudes (near the poles).
- Direction is true along the parallels.
- Introduced in 1963 by Robinson.

Change the projection to Sinusoidal

How To: Change the projection by clicking on the button labeled P. Clicking the P button will cause the 'View Properties' box to pop up. In the 'View Properties' box, click the button labeled Projection and the 'Projection Properties' box will appear. Using your mouse, click inside the white box that says Robinson (you may have to scroll down the list). This will cause a list of projections to appear. From that list, choose the Sinusoidal projection. Click OK in the 'Projection Properties' box and then click OK in the 'View Properties' box.

Notice that the projection has been changed to Sinusoidal. Ask your students what changes they noticed. Which of the following have become distorted or misrepresented: size, shape, distance and direction.

Facts Concerning Sinusoidal Projection

- Sinusoidal is an equal area projection. Therefore, areas on the map are proportional to the same areas on the Earth. This fact makes Sinusoidal a good projection for showing distribution patterns across the planet.
- Sinusoidal is one of the better projections for representing distance.
- Introduced in 1570 by Cossin and Hondis.

Close the '2 -- Learning Projections' View

How To: Click the X in the top, right-hand corner of the view.

Real Life Example

Let's say you are a pilot. Next week you will be flying from Washington D.C. to Paris. It is very important that you know the distance between the cities so that you have enough fuel. The next exercise will demonstrate that using the appropriate projection is important to finding specific information.

Open the View titled '3 A - Distance Comparison - MERCATOR PROJECTION'

How To: Double click on the view title in the project window. Notice the yellow markers showing Washington D.C. and Paris. Measure the distance between Washington D.C. and Paris

How To: Click on the tool that looks like a ruler with a question mark. Move your mouse so that is it on top of Washington D.C. and single click. Now, move your mouse so that it is on top of Paris and double click. Look in the lower left-hand corner of the ArcView window and notice that it will tell you length in miles. Have the students mark the distance down. (It should be about 5,600 miles) Close the '3 A - Distance Comparison - MERCATOR PROJECTION' View

How To: Click the X in the top, right-hand corner of the view.

Open the View titled '3 B - Distance Comparison - SINUSOIDAL PROJECTION'

How To: Double click on the view title in the project window. Notice the yellow markers showing Washington D.C. and Paris.

Measure the distance between Washington D.C. and Paris

How To: Click on the tool that looks like a ruler with a question mark. Move your mouse so that is it on top of Washington D.C. and single click. Now, move your mouse so that it is on top of Paris and double click. Look in the lower left-hand corner of the ArcView window and notice that it will tell you length in miles. Have the students mark the distance down. (It should be about 4,300 miles) Close the 3 B - Distance Comparison - SINUSOIDAL PROJECTION' View

How To: Click the X in the top, right-hand corner of the view.

Observations

Which projection computed a longer distance between cites? What is the difference between the two distances? (1,300 miles is quite a big difference.) We learned in the projection exercise that Sinusoidal is a pretty good projection for determining distance. The distance between the two cities as determined by using the Sinusoidal projection is more accurate. This information would be very important to us if we needed actual distance.

FYI, the true distance from Washington D.C. to Paris as the crow files is approximately 3,839 miles.

Great Circles

Introduction

In school we often learn that the shortest distance between two points is a straight line, but this is not so when computing extreme distances on a map. The shortest path between two points on the Earth is a straight line, but remember a map distorts shapes of the Earth. Therefore, a straight line on the Earth will not be a straight line on a map, it will be a curved line. We refer to these curved paths as great circles. A great circle is the shortest distance between any two points on the Earth. We will demonstrate the great circle in the following exercise.

Lab

Open the View titled '4 - Great Circle Exercise'

How To: Double click on the view title in the project window. Notice the yellow markers showing Washington D.C. and Paris. Draw a straight line between Washington D.C. and Paris

How To: Click on the tool that looks like a line. Move your mouse so that is it on top of Washington D.C. and press down and hold. Now, drag your mouse so that it is on top of Paris and let up. The 'Pen Palette' box will pop up. Change the 'Size' from 0.1 to 2 (using the arrow to see different values). Click on the button in the box that looks like a paintbrush. Click on the color red. Click on the X in the upper right corner of the palette to get the box to disappear. Click on the button labeled U to get rid of the boxes around the line. Change the projection to The World from Space

How To: Change the projection by clicking on the button labeled P. Clicking the P button will cause the 'View Properties' box to pop up. In the 'View Properties' box, click the button labeled Projection and the 'Projection Properties' box will appear. Using your mouse, click inside the white box that says

The World from Geographic. This will cause a list of projections to appear. From that list, choose The World from Spaceprojection (you may have to scroll down the list). Click OK in the 'Projection Properties' box and then click OK in the 'View Properties' box. Notice that the line we draw was straight on a 2-dimensional map, but looks curved on a 3-dimensional representation. Now, let's look at a straight line on a 3-dimensional representation Draw a straight line between Washington D.C. and Paris

How To: Click on the tool that looks like a line. Move your mouse so that is it on top of Washington D.C. and press down and hold. Now, drag your mouse so that it is on top of Paris and let up. The 'Pen Palette' box will pop up. Change the 'Size' from 0.1 to 2 (using the arrow to see different values). Click on the button in the box that looks like a paintbrush. Click on the color blue. Click on the X in the upper right corner of the palette to get the box to disappear. Click on the button labeled U to get rid of the boxes around the line. Change the projection back to Geographic

How To: Change the projection by clicking on the button labeled P. Clicking the P button will cause the 'View Properties' box to pop up. In the 'View Properties' box, click the button labeled Projection and the 'Projection Properties' box will appear. Using your mouse, click inside the white box that says The World from Space. This will cause a list of projections to appear. From that list, choose the Geographic projection. Click OK in the 'Projection Properties' box and then click OK in the 'View Properties' box.

Notice that the line we draw was straight on a 3-dimensional map, but looks curved on a 2-dimensional map. This demonstrates the concept of great circles. On a curved surface, the shortest distance between two points is a straight line, however, when that line is drawn on a flat surface, the line looks curved.

Close the '4 - Great Circle Exercise' View

How To: Click in the X in the top, right hand corner of the view.

Student Activity Page

Latitude and Longitude

Introduction

Positions of objects on the Earth are measured in degrees of latitude and longitude. Latitude is zero at the Equator, runs to positive 90 degrees at the north pole and runs to negative 90 degrees at the south pole. Longitude is zero at the Prime Meridian, runs to positive 180 degrees to the east and runs 180 degrees to the west to meet at the International Date Line. Longitudes to the west of the Prime Meridian have negative values. If you know the latitude and longitude of a city, you can find it in the world.

Lab

Your teacher is going to show you a view of the world with latitude and longitude information on it. Using the view, answer the following questions.

What continents does the Prime Meridian cut through?

What continents does the Equator cut through?

What is the degree value of the Tropic of Cancer?

If you look at the top right-hand corner of the screen, you will notice that the latitude and longitude of the cursor is listed.

When the cursor moves to the right of the Prime Meridian what happens to the longitude?

When the cursor moves to the left of the Prime Meridian what happens to the longitude?

What happens to the latitude as the cursor moves above and below the Equator?

Using the list of world capitals given below, guess which capitals have the following latitude and longitude coordinates:

35.31° S, 149.04°E

38.90° N, 76.96°W

30.08° N, 31.26°E

List of capitals

- Beijing, China
- Brasilia, Brazil
- Cairo, Egypt
- Canberra, Australia
- Kuala Lumpur, Malaysia
- Lagos, Nigeria
- Madrid, Spain
- Paris, France
- Tokyo, Japan
- Washington D.C., United States

Map Projections

Introduction

The Earth is a 3-dimensional object. Therefore, the most accurate way to present the Earth is a 3-dimensional globe. Unfortunately, there are a few problems with using the globe to represent the Earth. First is scale, even the largest globe has a small scale and therefore shows very little detail. Not to mention, a globe is takes up quite a bit of room to store and carry. If you were going to take a vacation from Arizona to Washington D.C., a globe would not be a very useful for navigation and it would be hard to find a place in the car to keep it. For reasons such as this, we choose to represent the Earth as a 2-dimensional object, or flat map. When you take a 3-dimensional object and transform it to a 2-dimensional object, there are going to be some changes in the way that it is represented. For example, imagine you have an orange. If you took the skin off the orange and tried to place it flat on your desk, the skin would warp. It would bubble out in some places and rip apart in others. A 3-dimensional object does not fit into a 2-dimensional plane. The same problem occurs when trying to represent the Earth as a flat map. Whenever the Earth is projected onto a flat surface, or map, there is going to be some distortion, or misrepresentation, of the Earth's surface. All map projections produce distortion of one or more of the following properties: shape, areas, distance and direction. The key to using map projections is to determine which property is the most important to you, and choose the projection that distorts that property the least.

Lab

Notice the shape and placement of the countries in the map that your teacher has open on screen. The teacher will change the projection to Mercator, what changes do you notice? The teacher will now change the projection to Robinson, what features of the continents have changed? Finally, the projection will be changed to Sinusoidal, which do you think has been least distorted; shape of features, size of features, distance between features or direction between features?

Real Life Example

Let's say you are a pilot. Next week you will be flying from Washington D.C. to Paris. It is very important that you know the distance between the cities so that you have enough fuel. The next exercise will demonstrate that using the appropriate projection is important to finding specific information. Your teacher has opened a view that shows the United States and Europe using a Mercator projection. Notice the yellow markers showing Washington D.C. and Paris. Using the measure tool, the teacher is going to measure the distance between Washington D.C. and Paris Mark the distance down.

Your teacher has now opened a view that shows the same part of the world, but the projection is now Sinusoidal. Again, notice the yellow markers showing Washington D.C. and Paris. Using the measure tool, the teacher is going to measure the distance between Washington D.C. and Paris.

Bibliography

Authors

Utah LessonPlans