Exercise

Working with Map Projections

Section 2 Exercise 1

January 27, 2021

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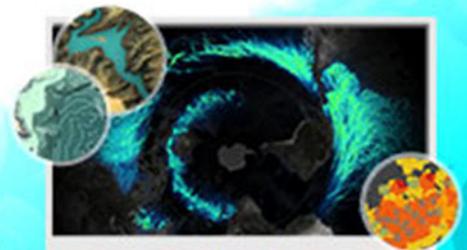
Working with Map Projections

Instructions

Use this guide and ArcGIS Pro to reproduce the results of the exercise on your own.

Note: The version of ArcGIS Pro that you are using for this course may produce slightly different results from the screen shots that you see in the course materials.

Time to complete

Approximately 15-25 minutes

Software requirements

ArcGIS Pro 2.7
ArcGIS Pro Standard license (or higher)

Note: The MOOC provides a separate ArcGIS account (user name and password) that you will need to use to license ArcGIS Pro and access other software applications used throughout the MOOC exercises. This account (user name ending with _cart) provides the appropriate ArcGIS Online role, ArcGIS Pro license, ArcGIS Pro extensions, and credits. We strongly recommend that you use the provided course ArcGIS account to ensure that you have the appropriate licensing to complete the exercises. Exercises may require credits. Using the provided course ArcGIS account ensures that you do not consume your organization's credits. Esri is not responsible for any credits consumed if you use a different account. Moreover, Esri will not provide technical support to students who use a different account.

Introduction

Every map has been *projected* onto a flat surface. Even globes, which of course are not flat, are made up of flat strips of maps that have been projected.

Because the earth happens to be *roundish* (the earth's shape is not perfectly spherical; it bulges a bit at the equator because of its spin and also has some bumps and dents), those comfortable with the math of geometry have come up with all sorts of ways of representing our three-dimensional home on a flat surface. As such, each projected map has to warp the representation of the earth in some way to flatten it out.

Distortion and purpose

Each map projection (https://bit.ly/3euMRul) has to, by its nature, distort some property of the earth—specifically, area, shape, direction or bearing, and distance. Some map projections, depending on their intended purpose, strive to preserve one or two of these geographic properties as much as possible while sacrificing the others to distortion. Some map projections spread out the distortion to all these properties for aesthetic purposes.

A cartographer's goal is to choose a projection that best honors the phenomenon that he or she wants to represent. If comparing the sizes of areas is important, an equal-area projection should be chosen. If a consistent presentation of distance is important, one might choose an equidistant projection.

Overall, a cartographer should thoughtfully select a map's projection—not just accept the default. So, actively consider the purpose of a map and choose a projection that supports it. There is no shortage of options!

What will you learn?

This exercise uses ArcGIS Pro to explore the appearance, and relative merits, of some map projections. You will walk through some popular projections and compare how they affect not just familiar geographic shapes but also helpful imaginary islands of equal size and shape. Additionally, you will see how projections can have a strong aesthetic effect on a map and what it communicates.

Step 1: Download the exercise data file

In this step, you will download the exercise data file.

a Open a new web browser tab or window.

b Go to https://bit.ly/2VphIkq and click Download to download the exercise data file.

Note: The complete URL to the exercise data file is https://www.arcgis.com/home/item.html?id=8a629f745f5b4540b482e7bdaad310ce. The file is 6 MB.

**c** Save the file in a location that you will remember.

Step 2: Open an ArcGIS Pro project

a Start ArcGIS Pro and, if necessary, sign in using your provided course ArcGIS credentials (user name ending with _cart).

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b From the main ArcGIS Pro start page, near the bottom left, click Open Another Project.

c In the Open Project dialog box, browse to the location where you saved the exercise data file and open the Projections.ppkx project package.

Next, you will save a copy of the exercise project with a new name so that you do not overwrite the original file.

d From the Project tab, click Save As and type a name for your project, such as **Projections_<your first and last name>**.aprx.

e Save the project to the folder on your computer where you are saving your work.
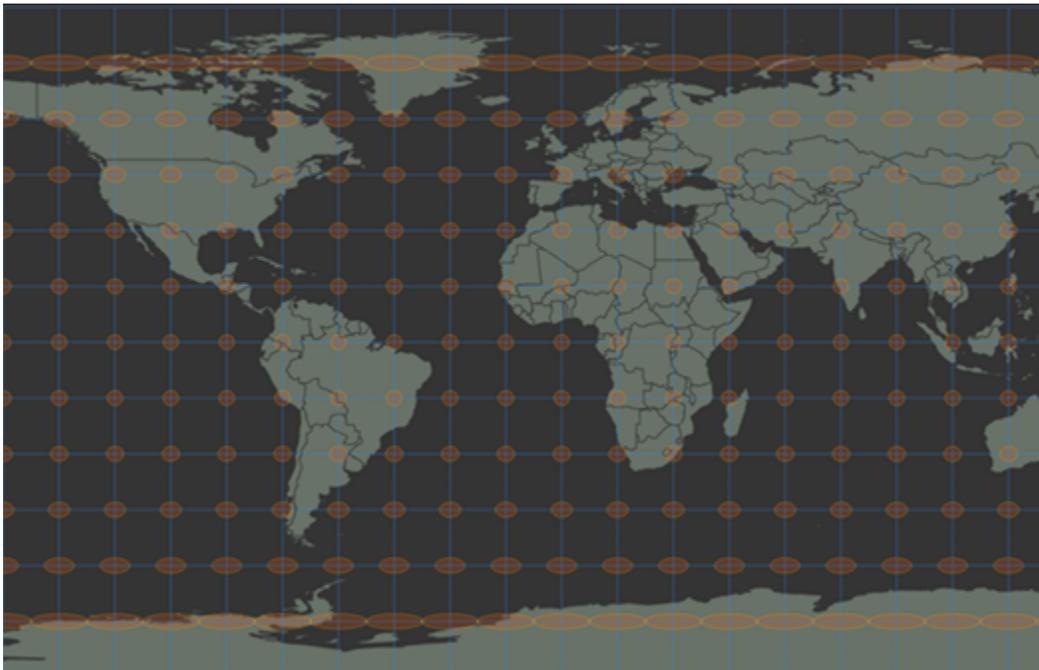
f Notice the blue grid lines crisscrossing the map at equal intervals and the tendency of the orange imaginary circular islands to appear stretched as they approach the poles.

Note: The orange imaginary circular islands are actually known as Tissot's indicatrix (https://bit.ly/2KnUl3c).

The grid lines are latitude (horizontal) and longitude (vertical). On the round earth (and globes), lines of latitude are equally spaced from the equator, around the middle, to the poles—like a ladder. That equal latitudinal spacing is maintained in this map's projection. On the earth (and globes), lines of longitude all converge to a single location at the poles. However, they are all parallel to each other in this map's projection.
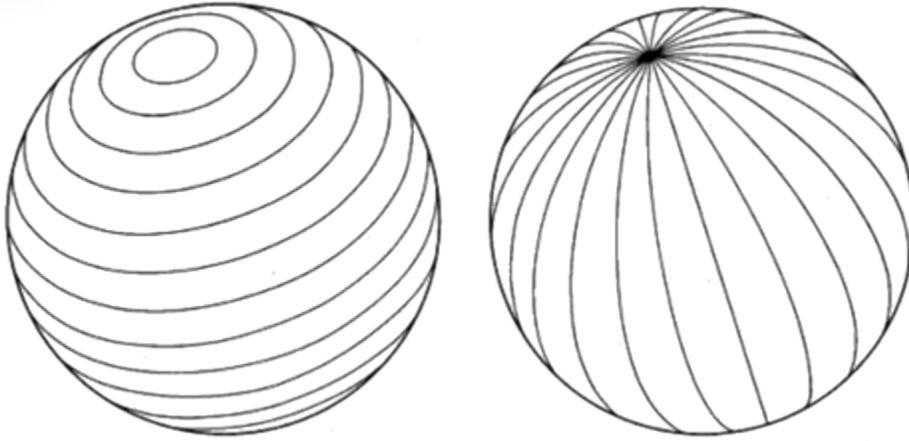
The projection that you are looking at has taken the latitude and longitude of the earth and warped them into an even grid of squares. The result on the imaginary, equally sized circular islands is a horizontal stretching as the north-most and south-most parts of the earth are stretched to accommodate a rectangular map shape. While the shapes are distorted, their orientation remains intact: "Up" on this map always corresponds to north.
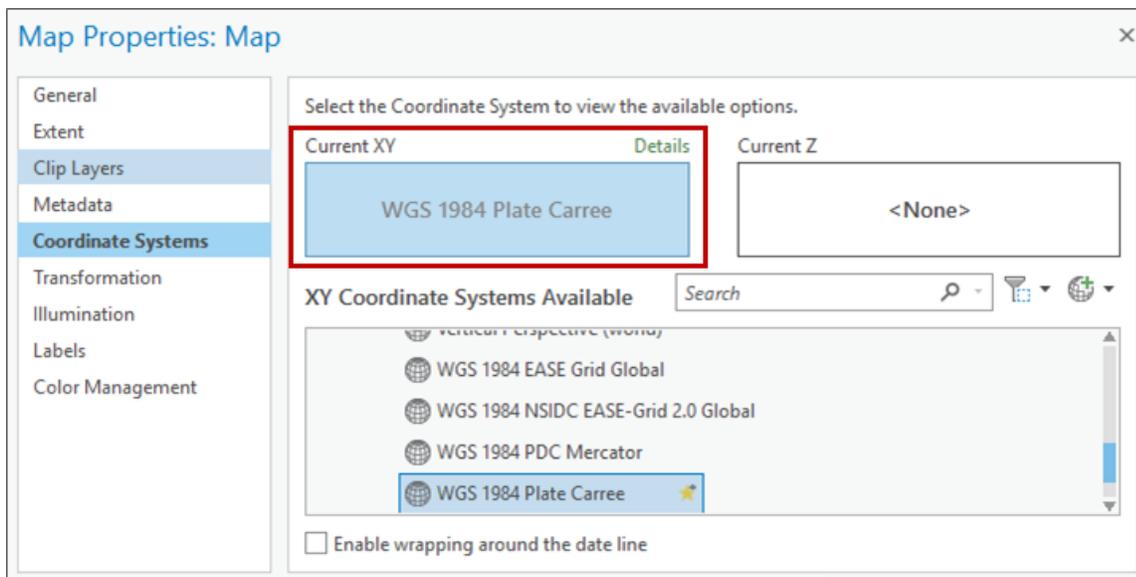
Step 3: Explore the Plate Carrée coordinate system

You will explore a common projection called Plate Carrée.

a   In the Contents pane, double-click Map to open the Map Properties dialog box.
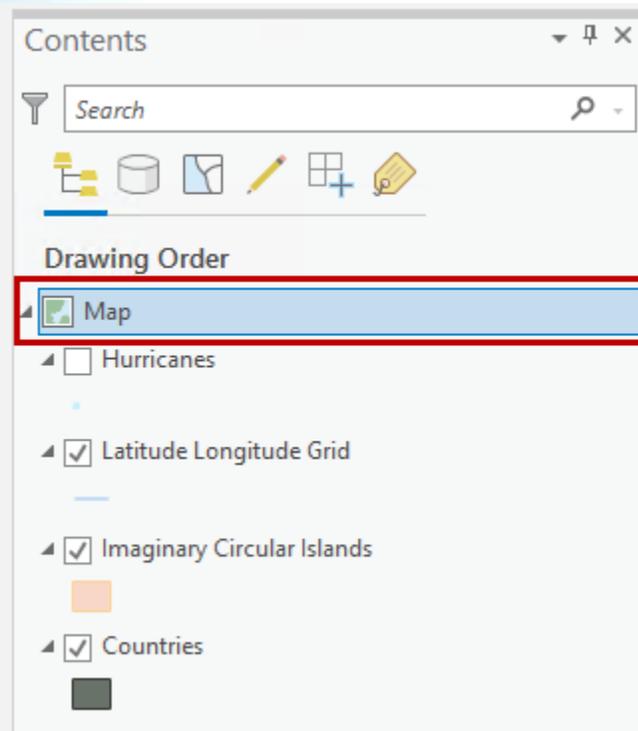
b Click Coordinate Systems and note the current coordinate system: WGS 1984 Plate Carree.


The Plate Carrée coordinate system is a common projection, where the latitude and longitude grid has been warped to form a uniform grid ("plate carrée" is French for "flat square").

Step 4: Explore the Mercator coordinate system

You will now explore another common coordinate system.

(a) In the same Map Properties dialog box, in the Search field, type **Mercator** and press Enter.

(b) Within the resulting hierarchy of available coordinate systems, in the Projected Coordinate System section, expand World and select WGS 1984 Web Mercator (Auxiliary Sphere).
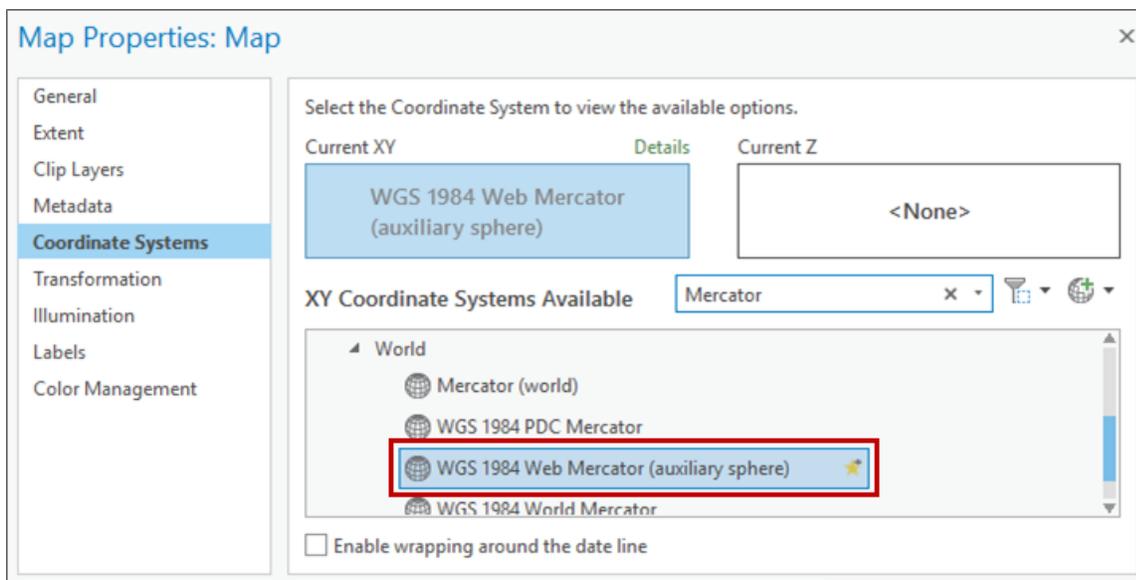
(c) Click OK to choose this projection and close the Map Properties dialog box.

The map redraws, showing the newly selected Mercator projection.

d If necessary, zoom out so that you can see the whole map.

What do you see? How has this new projection changed the appearance of the countries? You will see that the spacing of the lines of latitude is no longer consistent. How has this projection altered the appearance of the orange imaginary islands?

This projection should look familiar. The Mercator projection is used by most web mapping platforms, which makes it the most commonly seen map projection. Mercator does a good job of preserving the shape of things, but it has to massively exaggerate size to preserve shapes. To accommodate the vertical stretching of things near the poles, as you noted in the previous projection, Mercator also increasingly spreads out the lines of latitude so that mapped objects stretch horizontally just as much as they stretch vertically.

The result is an island of Greenland that appears larger than all of South America (Greenland is actually about one-fifth the size of South America). The orange circular islands hold up reasonably well as circles, but they appear to grow at an alarming rate as they approach the poles.

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*The Mercator projection massively exaggerates the size of the island of Greenland.*

Next, you will look at a projection that does its best to preserve relative size: equal-area projections.

Step 5: Explore equal-area projections

An equal-area projection is a projection in which the whole of the map as well as each part has the same proportional area as the corresponding part of the earth. An equal-area projection may distort shape, angle, scale, or any combination thereof. No flat map can be both equal area and conformal (https://bit.ly/2QxlntN).

  a In the Contents pane, double-click Map to open the Map Properties dialog box and confirm that the Coordinate Systems tab is still active.

b In the Search field, type **Equal Area** and press Enter.

c Within the resulting hierarchy of available coordinate systems, expand Projected Coordinate System, and then expand Continental.

**d** Expand Europe and select Europe Albers Equal Area Conic.
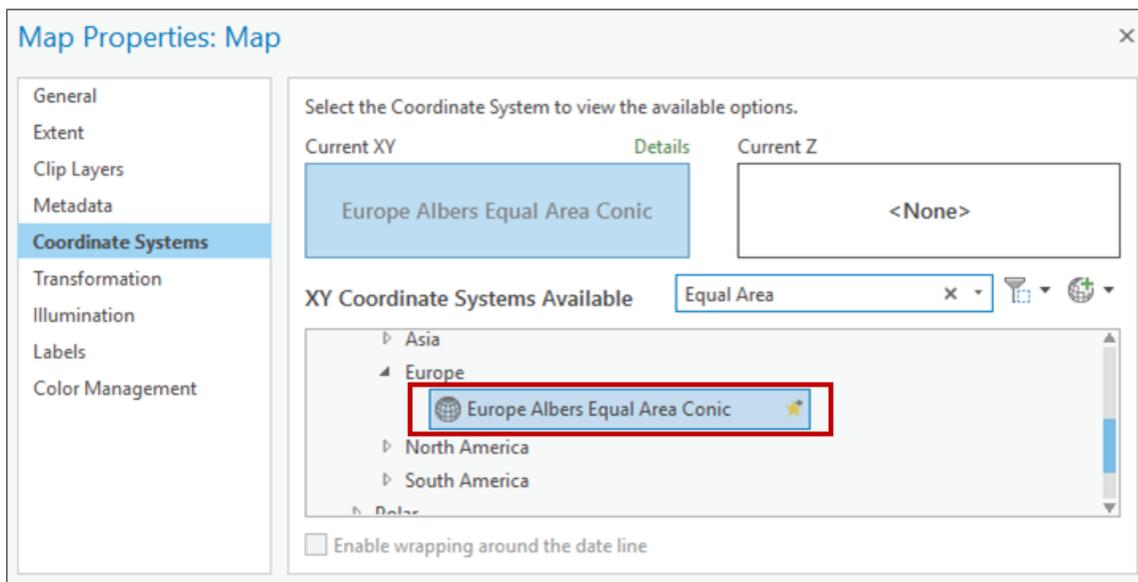
e Click OK to choose this projection and close the Map Properties dialog box.

The map redraws, showing the newly selected Europe Albers Equal Area Conic projection. The map looks much different than before. This projection, rather than preserving the relative shape of things or their orientation on a compass, maintains a consistent size of things (area). The orange circular islands, which vary wildly in shape and are oriented in a conical fashion, are all the same size.

As its name suggests, this equal-area projection is intended for use around Europe. If you zoom in on the map to the area of Europe, you will notice that the shape distortion is negligible. This projection is a good compromise for users wanting to make a map of European countries, where the relative sizes of things are, ideally, consistent.
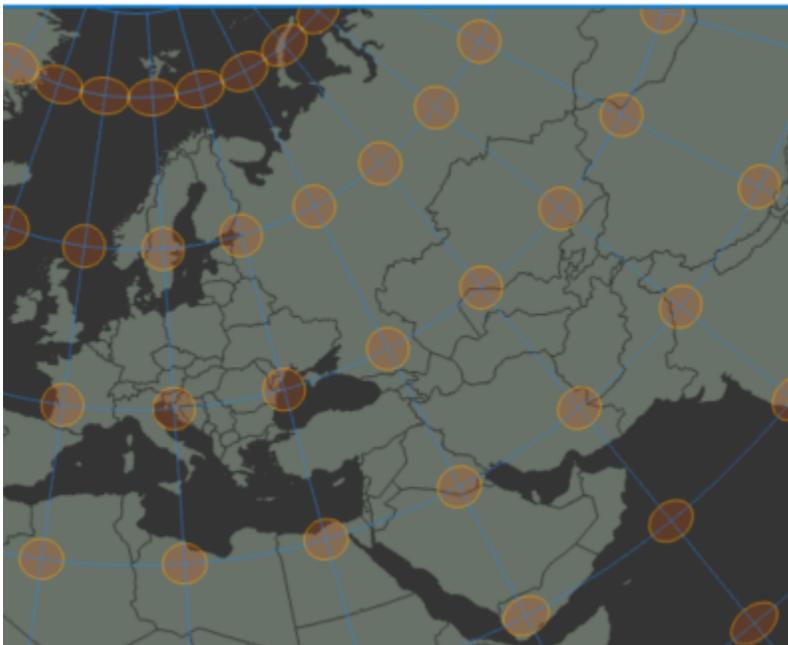
Mapmakers should always choose a projection that fits best with the phenomenon that they are mapping. Sometimes, it is a technical consideration, like ensuring the consistent appearance of same-sized objects or choosing a projection that maintains relative direction for navigation maps. Often, though, projection selection has to do with the mapmaker's aesthetic preference because it helps communicate something interesting about the mapped data.

## Step 6: Choose a projection for mapping hurricane and tropical storm data

In this step, you will choose a meaningful projection for a map showing hurricane data.

a   In the Contents pane, turn off the Imaginary Circular Islands layer.

b Zoom out to a global extent.

Hint: From the Map tab, in the Navigate group, click the Full Extent button ⊙. You can also zoom out until you see the entire globe in the map pane.

c In the Contents pane, turn on the Hurricanes layer.
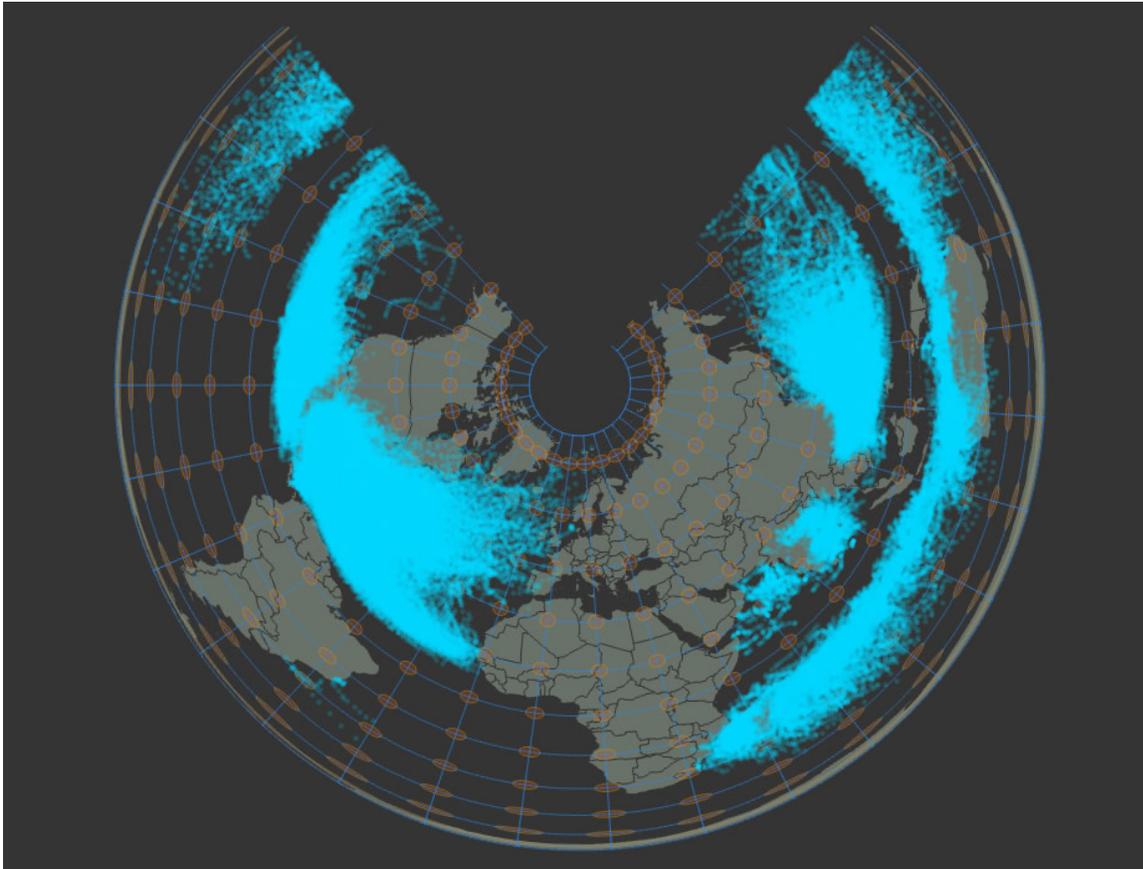
Note: Because this layer includes a large dataset, it might take several seconds to draw on your screen.

The blue areas on the map are actually small blue dots that represent the position and time of each known hurricane and tropical storm that has occurred over the past 100 years.

d In the Contents pane, double-click Map to open the Map Properties dialog box.

e Choose a projection and click OK to see how it visually displays the distribution and overall patterns of these historical hurricanes.

Each projection is a unique way of presenting our world as a flat surface and provides different insights about the phenomenon being mapped.

Hurricanes, when viewed in large numbers, form their own circuitous patterns. They are also physically incapable of crossing the equator. While exploring the projections available to you, did you find a projection that reinforced that phenomenon or presented it in an especially beautiful way?

Step 7: Use a definition query to filter inconsistent data

There is a rather abrupt change in the number of storm features along longitude 180 (roughly the International Dateline). To make the discrepancy more visible, you will change the projected coordinate system one more time.

a   Open the Map Properties dialog box, Coordinate Systems, and search for Equal Area.

b   Expand the Projected and Continental nodes, and then expand North America.

c   Choose North America Albers Equal Area Conic.

The abrupt change is now more visible on the map. There is no magical wall along that line of longitude that influences weather differently on either side of it. The effect is caused by slight differences in the way that various contributors to this layer manage data. Handling inconsistent data is a fact of life for map makers and a large part of a cartographer's job.

In this step, you will use a definition query to filter out some of this "noise."

d   In the Contents pane, right-click the Hurricanes layer and choose Properties.

e   On the left side of the Layer Properties dialog box, click Definition Query.

A definition query lets you show and hide various features of a layer without having to actually delete them. You will use the wmo_wind attribute, which is the measure of wind speed, as a filter for the layer.

f   Click New Definition Query.

g   Use the query builder to build the following expression: `Where wmo_wind is greater than 0`.
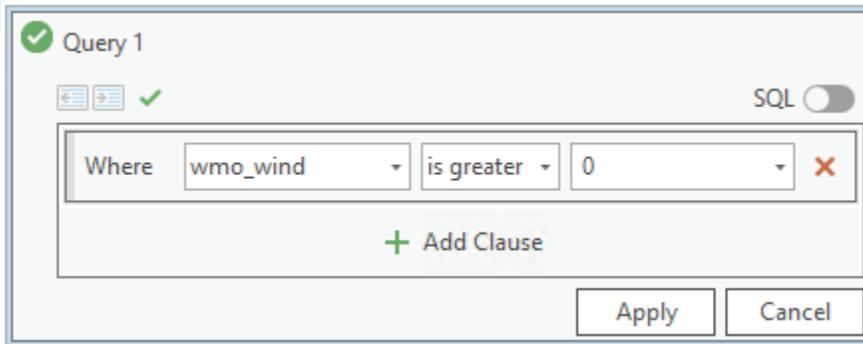
h Click Apply, then click OK to apply the definition query to your layer.

Hurricane points that actually have a viable wind speed value are all that remain on your map, filtering out points with negative or no wind speed.

i Save your project and exit ArcGIS Pro.

Conclusion

In this exercise, you were introduced to the concept, and inevitability, of map projections. You learned about some of the map properties that a projection distorts and what their visual effect is on mapped data. You explored the Coordinate Systems category of the Map Properties dialog box and familiarized yourself with browsing and selecting map projections. You considered the appropriate technical reasons to choose a projection, as well as the aesthetic implications on the resulting map's message.

Stretch goal

If you would like to create a custom projected coordinate system, you can complete the following high-level tasks:

1. Open the Map Properties box.
2. Next to the Search Field, click Add Coordinate System, then click New Suggested Projected Coordinate System.
3. Use the Create A New Suggested Projected Coordinate tool (https://bit.ly/3ilBRSs) to create a custom Projected Coordinate System.

    • Experiment with different settings to get the effect that you desire.
    • Watch this video (https://bit.ly/3sq1HJA) to learn how to tweak projection parameters.

Reminder that stretch goals are community supported and a great opportunity to work together to learn together.
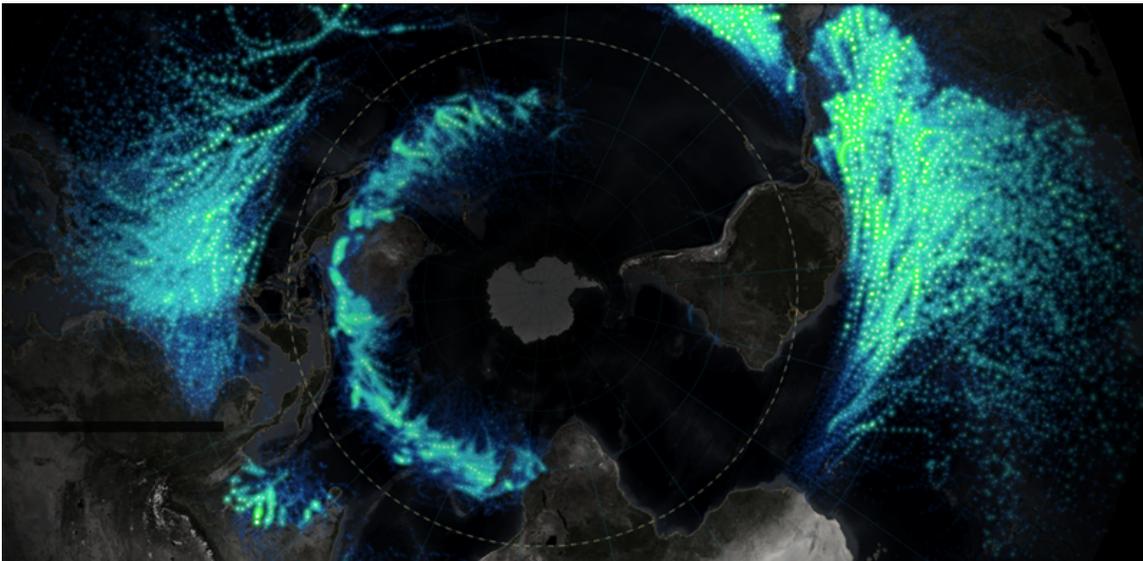
Use the Lesson Forum to post your questions and observations. Be sure to include the **#stretch** hashtag in the posting title.

If you did some experimenting on your own beyond the steps of an exercise, we would love to hear about and see what you did! If you completed a map based on the exercise steps, that is awesome! However, there is no need to share it in the Forum.

Stretch goal

If you would like to continue working with map projections, you can complete the following high-level tasks:

1. Try replicating this hurricane map (https://bit.ly/2wKYevz) using the data from this exercise.

2. Add a vignette effect (a faded edge) to the map, using this short how-to video (https://bit.ly/3nKXIU8) as a guide.
3. Create the glowing dots by symbolizing points with pictures, as demonstrated in this video (https://bit.ly/3oGnlXE).

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Learn More

- Get some background information on coordinate systems, projections, and transformations in ArcGIS Pro: https://bit.ly/2qih20s
- Read some community responses regarding an inquiry about projections and coordinate systems: https://bit.ly/2qiimQY
- Learn from the Wikipedia community about map projections: https://bit.ly/1hLLoB1
- Discover the new Equal Earth projection: https://bit.ly/2TIJNPx and the new Spilhaus World Ocean Map in a Square: https://bit.ly/2LRNXX2