Exercise 1: Work with map projections

How can I print an exercise to PDF format?

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 graphics that you see in the course materials.

Software requirements

- ArcGIS Pro 3.5.X (latest version)
- ArcGIS Pro Standard license (or higher)

The MOOC provides a separate ArcGIS account (username and password) that you will need to use to license ArcGIS Pro and access other software applications used throughout the MOOC exercises. This account (username 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://links.esri.com/ProjectedCoordinateSystem) 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 they want 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.

Note: The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

Estimated completion time in minutes: 45 minutes

Expand all steps | Collapse all steps

- 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://links.esri.com/Sec2Projections 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 3 MB.

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

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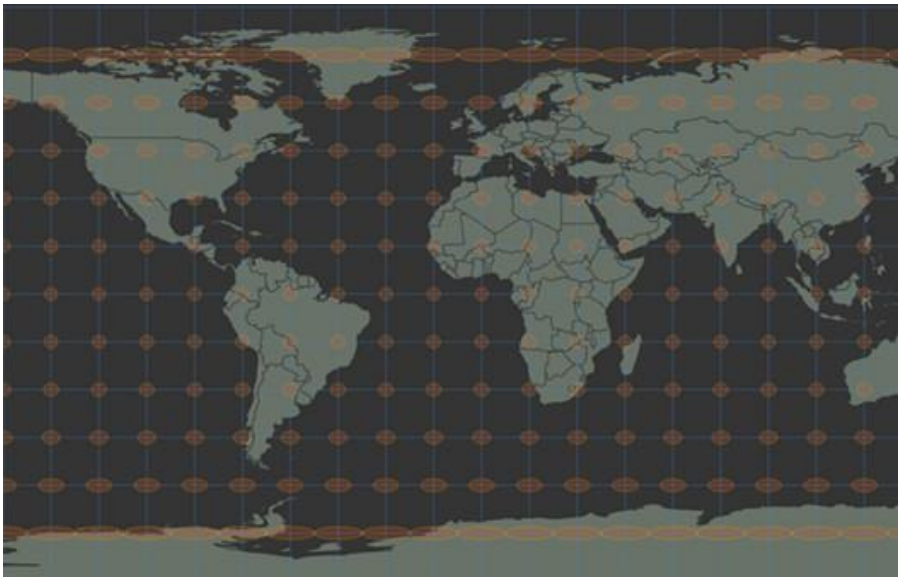
- Step 2: Open an ArcGIS Pro project

In this step, you will familiarize yourself with a map designed to help visualize projections.

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

b From the ArcGIS Pro start page, near Recent Projects, 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.



*Step 2c***: Open an ArcGIS Pro project.*

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

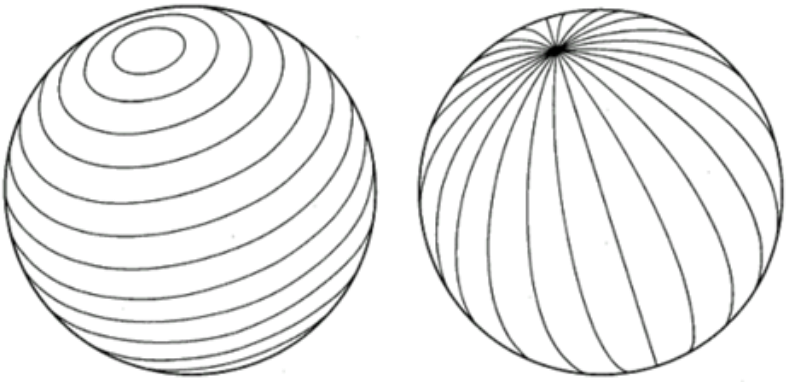
d From the Project tab, click Save Project As and type a name for your project, such as **Projections_<your first and last name>**.aprx.

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://links.esri.com/TissotsIndicatrix).

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.

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- 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 the Coordinate Systems tab.

c 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").

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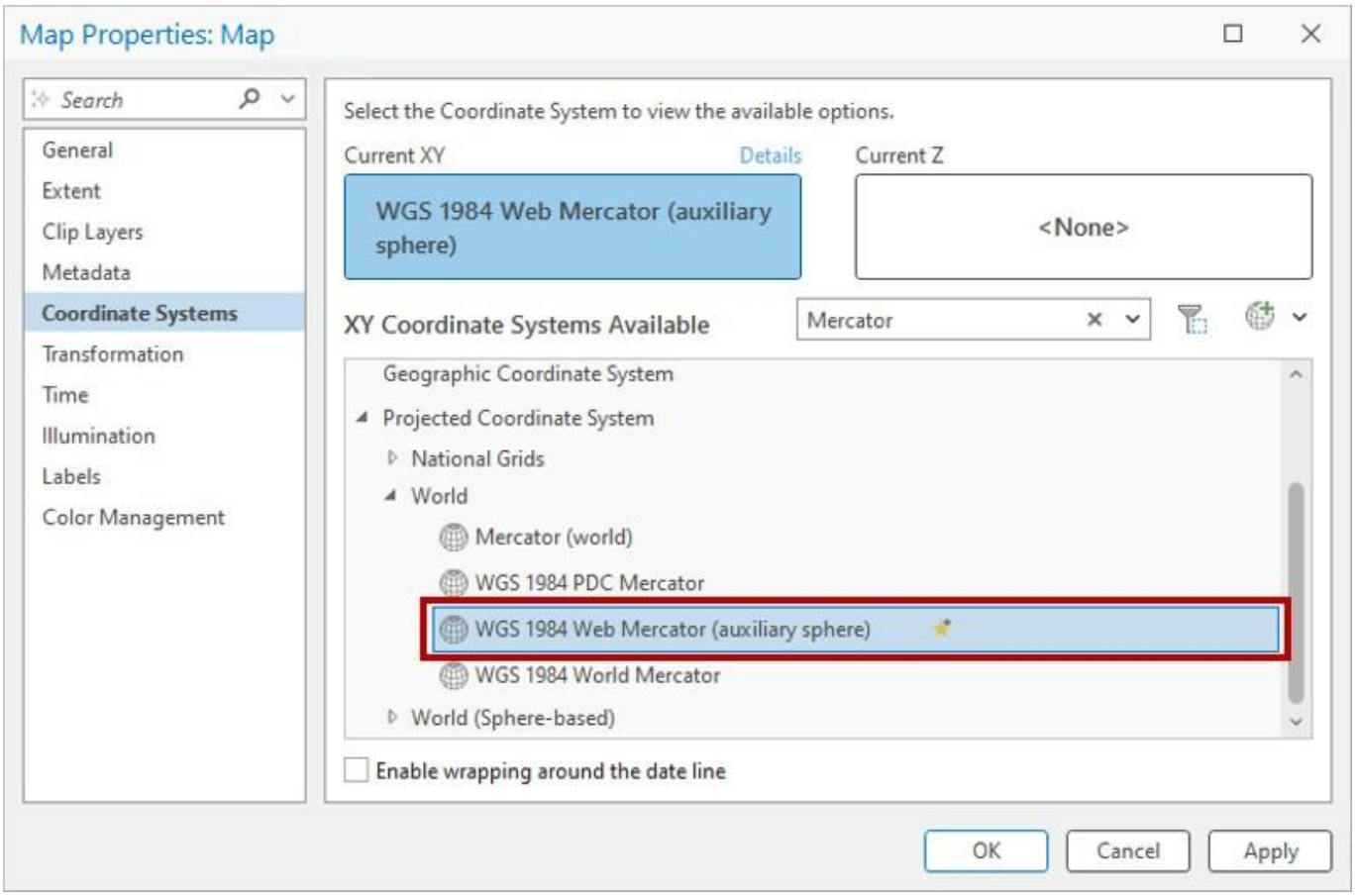
- Step 4: Explore the Mercator coordinate system

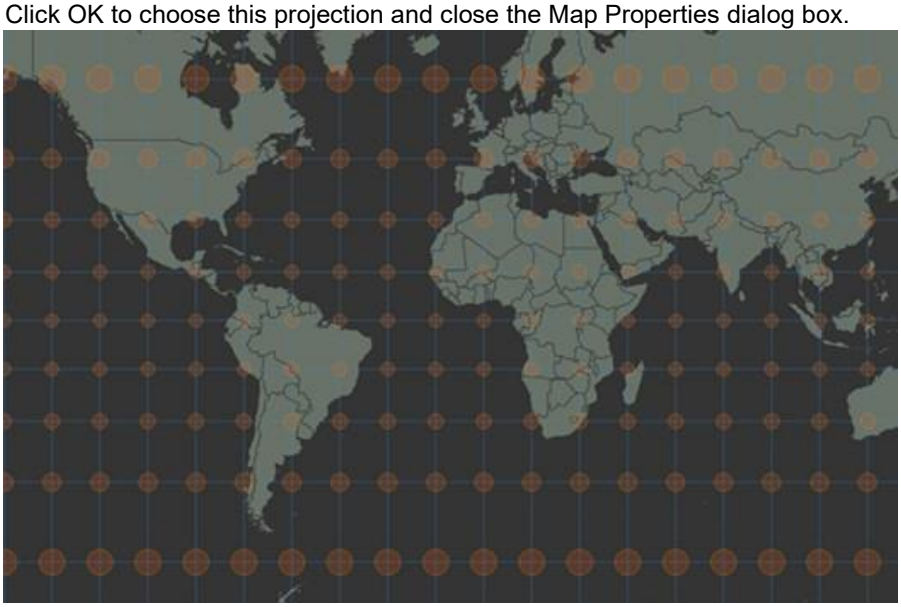
Next, you will explore another common coordinate system.

a In the same Map Properties dialog box, in the Search field, next to XY Coordinate Systems Available, 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), as shown in the following graphic.



c Click OK to choose this projection and close the Map Properties dialog box.



*Step 4c***: Explore the Mercator coordinate system.*

The map redraws, showing the newly selected Mercator projection. d

Zoom out so that you can see the whole map, if necessary.

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.

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.

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- Step 5: Explore equal-area projections

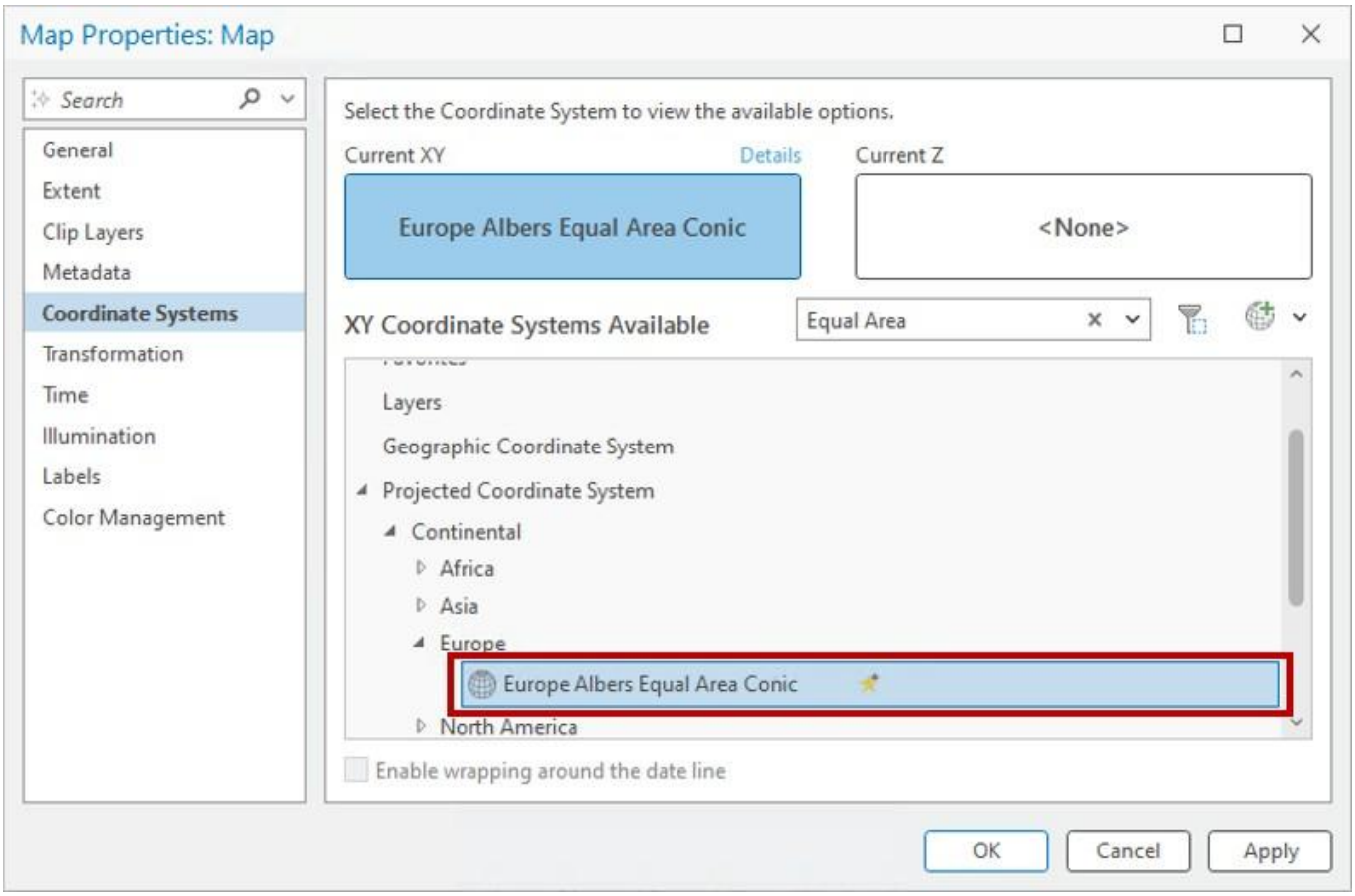
An equal-area projection is a projection in which the whole of the map as well as each part has the same proportional area as the corresponding part of the earth. An equal-area projection may distort shape, angle, scale, or any combination thereof. No flat map can be both equal area and conformal (https://links.esri.com/ConformalProjection).

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, as shown in the following graphic.



e Click OK to choose this projection and close the Map Properties dialog box.

*Step 5e***: Explore equal-area projections.*

The map redraws, showing the newly selected Europe Albers Equal Area Conic projection. The map looks much different from 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.

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- **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.

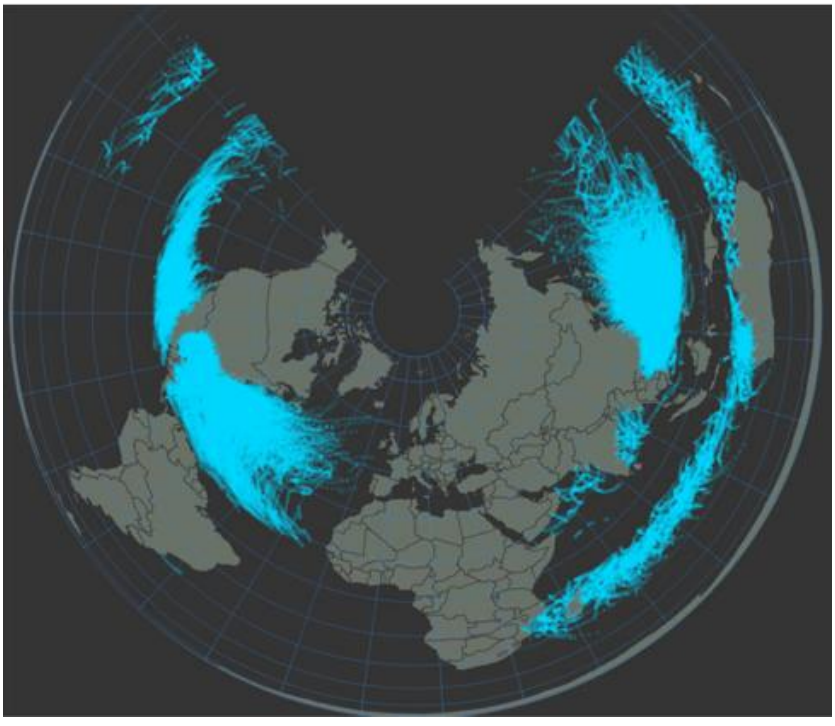
a In the Contents pane, turn off the Imaginary Circular Islands layer.

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.



*Step 6c***: Choose a projection for mapping hurricane and tropical storm data.*

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 path and time of each known hurricane since 1851.

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.

f If you found a projection that presented the phenomenon of historical hurricanes in an interesting or thoughtprovoking way, consider sharing a graphic of it in the Forum and describe what about this projection makes it an effective choice for your map.

Sharing is optional but encouraged.

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?

g Save your project.

h If you are continuing to the stretch goals, leave ArcGIS Pro open; otherwise, exit ArcGIS Pro.

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- Step 7: 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.

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- Step 8: Stretch goal (optional): Create a custom projected coordinate system

If you would like to create a custom projected coordinate system, you can complete the following stretch goal. a

Open the Map Properties dialog box.

b Next to the search field, click the Add Coordinate System button  , and then choose New Suggested Projected Coordinate System.

c Watch this how-to video (https://links.esri.com/ProjectionPicker), and then use the Create A New Suggested Projected Coordinate tool to create a custom projected coordinate system.

- Experiment with different settings to get the effect that you desire.
- Watch this video (https://links.esri.com/ProjectionParameters) 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! On the other hand, if you completed a map based on the exercise steps, that is awesome! However, there is no need to share it in the Forum.

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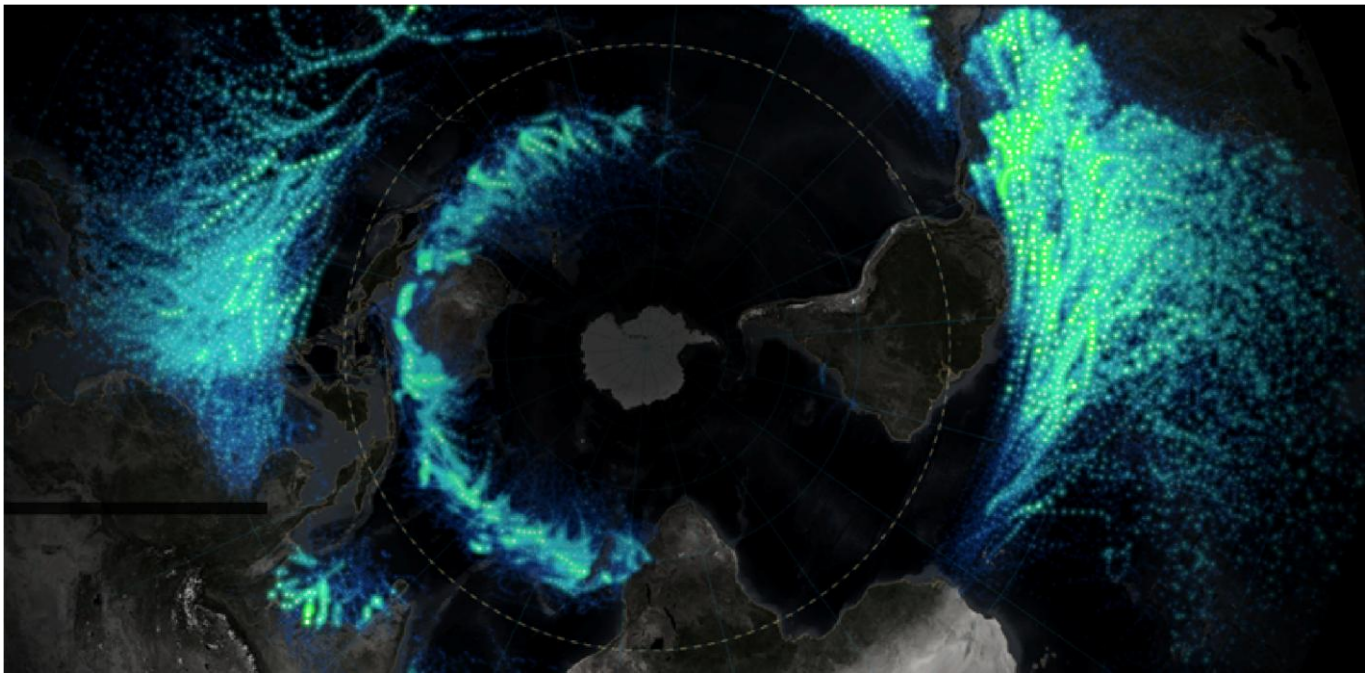
- Step 9: Stretch goal (optional): Create a hurricane map using a different projection

If you would like to continue working with map projections, you can complete the following stretch goal.

a Replicate this hurricane map (https://links.esri.com/HowToHurricaneMap) using the data from this exercise.



b Add a vignette effect (a faded edge) to the map.

- Use this short how-to video (https://links.esri.com/CreateVignette) as a guide.

c Create the glowing dots by symbolizing points with pictures.

- Use the technique demonstrated in this video (https://links.esri.com/PicturesAsPoints).

Use the Lesson Forum to post your questions and observations. Be sure to include the **#stretch** hashtag in the posting title.

d After you are finished, save your project and exit ArcGIS Pro.

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- Step 10: Learn more

a Here are some links to resources relevant to this exercise and related topics that you might find interesting:

- Get background information on coordinate systems, projections, and transformations in ArcGIS Pro:

  ArcGIS Pro Help: Coordinate systems, projections, and transformations (https://links.esri.com/CoordinateSystems)

- Read community responses regarding an inquiry about projections and coordinate systems (https://links.esri.com/PCSvsGCS)

- Learn from the Wikipedia community about map projections (https://links.esri.com/WikiMapProjections)

- Discover the Equal Earth projection (https://links.esri.com/EqualEarth) and the Spilhaus World Ocean Map in a Square (https://links.esri.com/Spilhaus)

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