How to Define Map Projections

Making Sure Your GIS Data Is in the Right Place on the Map

As people share their data over the Web, it's becoming more important to define the coordinate system to ensure that a dataset displays in its proper location and aligns correctly with other data.

What Is a Coordinate System?

Coordinate systems provide a common basis for communication about a particular place or area on the earth's surface—they are reference systems used to locate features. Coordinate system information should be included with a geospatial dataset's metadata or in a separate projection file (PRJ). However, geographic information system (GIS) professionals frequently receive datasets whose coordinate system information is missing.

## Identifying the Coordinate System Type—Geographic or Projected

GIS data is created in one of two types of coordinate systems: geographic or projected. One easy way to identify whether a dataset uses a geographic or projected coordinate system is to examine the dataset's coordinates in ArcMap™ using the steps below:

1. Start ArcMap with a new, empty map.

2. Click the Add Data button and add the data with the unknown coordinate system to ArcMap.

3. Click OK if you see the Unknown Spatial Reference message.

4. Right-click the layer in the Table of Contents, click Properties, then click the Source tab on the Layer Properties dialog box.

5. Count the number of digits to the left of the decimal for Top, Bottom, Left, and Right in the Extent area of the dialog box. Ignore any digits to the right of the decimal.

6. Note the number of characters in each of these positions, including the negative sign (-) if the coordinates are negative.

7. Your coordinate system can then be determined as follows:

- In North America, if your dataset has an x-coordinate between 180 and 0, and a y-coordinate between 0 and 90, then your coordinate system is geographic.

- In North America, if your dataset has an x- or y-coordinate with 6, 7, or 8 digits to the left of the decimal point, then your coordinate system is projected (most likely to the State Plane or UTM coordinate systems).

Geographic Coordinate Systems

Geographic coordinate systems (GCS) use units of decimal degrees for coordinates. These units are often referred to as latitude/longitude. Decimal degrees (DD) are angles, and because there are 360 degrees in a circle, coordinates in DD can never be over three digits to the left of the decimal.

X-coordinates are longitude values. For data in North America, longitude values are negative numbers between 0 and -180. Y-coordinates are latitude values. For data in North America, latitude values are positive numbers between 0 and 90.
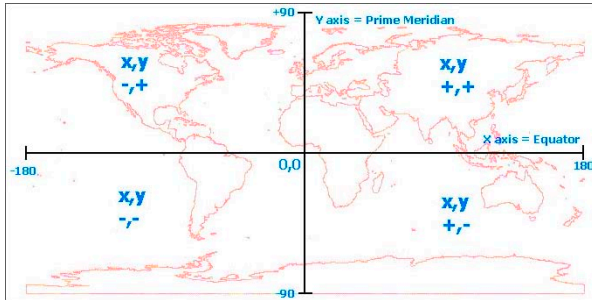
The worldwide distribution of positive and negative values for longitude (x) and latitude (y) coordinates is illustrated here.

Projected Coordinate Systems

Projected coordinate systems (PCS) commonly use units of feet or meters. In the United States, the most commonly used projected coordinate systems are state plane and universal transverse Mercator (UTM).

Data that uses a projected coordinate system usually has an extent with six to eight digits to the left of the decimal. If the data is in the United States and shows an extent in which the coordinates to the left of the decimal are six, seven, or eight digits, the data is probably projected to the state plane or UTM coordinate system. Both state plane and UTM have defined coordinate systems for specific areas.

Defining the Coordinate System

Once you have identified whether a dataset uses a geographic or projected coordinate system, the next step is to define the specific geographic or projected coordinate system that should be used for the dataset. In ArcGIS®, when a dataset is missing its coordinate system information, use the Define Projection tool—found in the ArcToolbox™ Data Management toolbox > Projections and Transformations toolset—to define the coordinate system.

With the Define Projection tool, you can interactively select from a list of the many predefined geographic and projected coordinate systems that are included with ArcGIS. Alternatively, you can easily import a coordinate system definition from another geospatial dataset that has a defined coordinate system that matches what you need.

To determine which specific geographic or projected coordinate system is appropriate for your data, read the ESRI Support Center technical articles listed below at support.esri.com.

- Article 29280, "What Geographic Coordinate System or Datum Should Be Used for My Data," links to a document that lists all geographic coordinate systems by continent and country.
- Article 24893, "How to Identify an Unknown Projected Coordinate System Using ArcMap," provides a step-by-step guide using ArcMap and a file included with your ArcGIS installation.

To learn more about coordinate systems and their importance for accurate GIS data and analysis results, explore the resources listed below:

ArcGIS Desktop Help (http://webhelp.esri.com)
Search: Map projections and coordinate systems

ESRI Training (www.esri.com/training)
Understanding Map Projections and Coordinate Systems—Web course that includes a free first module

ESRI Press (www.esri.com/esripress)
Lining Up Data in ArcGIS: A Guide to Map Projections
by Margaret M. Maher

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