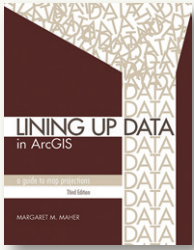


LINING UP DATA IN ARCGIS: A GUIDE TO MAP PROJECTIONS, THIRD EDITION



By Margaret M. Maher

Esri Press, 2018

254 pages, \$39.99, softcover.

ISBN: 978-1-58948-520-4

Review by: Fritz C. Kessler, The Pennsylvania State University

I previously had the privilege of reviewing the first edition of this practical “how to” book (Kessler 2012) and was pleasantly surprised to see that a third edition had been published. If you work with geospatial data in the ArcGIS environment, then you have probably encountered situations where your data didn’t align. The culprit was undoubtedly one coordinate system not being in sync with another. Coordinate systems seem to strike fear into the hearts of many GIS users—a circumstance most likely due to the daunting mathematics that underpin them. This is unfortunate, as coordinate systems are an essential component of geospatial data, and working with them does not require an understanding of their sometimes-complicated mathematics. *Lining up Data in ArcGIS* avoids coordinate system math entirely, and instead focuses on the basic premise of understanding how to troubleshoot coordinate systems when things “go bad.”

Eleven chapters are presented, with each focused on a different fundamental question that a GIS user may ask when working with a coordinate system—for example, “How can I tell what datum my data is on?” or, “How do I apply a vertical transformation?” According to Maher, these questions typify those “heard most often” among the nearly 16,000 customer queries she fielded in her 18 years working with the Esri Support Center (xiv).

Lining up Data in ArcGIS begins with a Table of Contents, Preface, and Introduction. The Preface explains that the third edition offers new content over and above the previous editions. The book is updated to reflect the release of ArcGIS Desktop 10.6, although the demonstrations are still valid as far back as version 10.1. A new chapter on vertical datums is included. Data sets used in the book are now provided for users to download and work with while reading through the chapters.

Chapter One briefly describes geographic, projected, and local coordinate systems, and how to identify them. This chapter also briefly touches on the project-on-the-fly process and common error messages. A helpful guide to identifying a coordinate system based on the numeric extents of the dataset is included. The guide suggests, for example, that a dataset based on latitude and longitude reports a maximum of two or three digits to the left of the decimal for the north-south and east-west extent, respectively. The chapter ends with a discussion of commonly used projected coordinate systems.

Chapter Two explains how to work with data defined in a geographic coordinate system (GCS). This chapter focuses on how to correct the offset between the North American Datum (NAD) of 1927 (NAD 1927 or NAD27) and NAD 1983 (or NAD83). One highlight from the instructions is an explanation of how to determine an appropriate geographic transformation option. For example, the chapter points out that there are many options for moving between the World Geodetic System of 1984 (WGS84) and NAD83—noting along the way that more than one NAD83 definition exists—and explains how one goes about making an appropriate selection. The chapter also discusses the importance of the High Accuracy Reference Network (HARN), as well as how to interpret the various errors and warnings associated with geographic transformation methods. The author makes the important point that datum transformations are two-way streets—the name given to the transformation is not an indication of its direction. A useful sidebar on the impact of GCSs and projected coordinate systems (PCS) on measurement types (planar, geodesic, loxodrome, and great elliptic) is provided.

Chapter Three provides an overview of two PCSs: the State Plane Coordinate System (SPCS) and Universal Transverse Mercator (UTM). The chapter begins with SPCS, SPCS zones, the maximum numerical values associated with the data extents, and common datums and units assigned to SPCS zones. An overview of the UTM PCS follows and focuses on the maximum numerical values associated with the data extents and common datums used with UTM zones. Helpful guidance on identifying an unknown PCS is provided. For example, when identifying a coordinate system for a United States–based

dataset, one should consider that it may be a SPCS zone, UTM zone, or one of the unique county, state-wide, or continental coordinate systems in common or official use.

Chapter Four is one of three that focuses on integrating CAD data into the ArcGIS environment. Specifically, this chapter lays out step-by-step instructions on bringing AutoCAD (.DWG or .DXF) and Bentley (.DGN) file formats into an ArcMap session. Particular attention is paid to manipulating the projection, dealing with small measurement units associated with CAD files, and an explanation of the differences between the US and International Foot. The chapter closes with commentary on saving a custom projection file to disk, defining the projection using a custom projection file, and defining the projection for CAD data.

Chapter Five builds on material from Chapter Four, and discusses nine potential issues that ArcMap users may encounter when aligning CAD data once they have been brought into the ArcMap session. Each issue is presented separately, and the procedures on how to handle these potential issues are explained in detail. Some of these issues include non-standard units (e.g., tenths of a foot), CAD data that rest below sea level, the addition of a scale factor parameter to the projection file, and the need to apply a custom projection definition to the CAD file.

Chapter Six completes the process of importing CAD data into an ArcMap session. Surveyors often use a point of beginning (POB) to “fix” their survey to a real or assumed coordinate value and elevation. The CAD file may be rotated about this POB, and this can cause problems when bringing the CAD file into ArcMap. This chapter provides a step-by-step procedure on reconciling any rotation that had been performed in the native CAD environment. These step-by-step instructions are accompanied by many screen shots illustrating how the CAD files appear at each step of being brought into alignment in the ArcMap environment.

Chapter Seven covers the importance of datum transformations, and begins by explaining what a geographic transformation is and why it is important. The components of three-parameter and seven-parameter geographic transformations are compared. Common geographic transformation methods—including NADCON, NTV2, Molodensky-Badekas, longitude rotation, null, unit change, and Geographic 2D offset—are briefly described.

An explanation of the process of creating and saving a custom geographic transformation concludes the chapter.

Chapter Eight looks at the way geographic transformations are applied, and focuses on what to do when a separate GCS defines each dataset. A detailed, step-by-step explanation shows how to apply a composite geographic transformation when moving between two disparate datums—NAD 1927 and NAD 1983 HARN—with a focus on the several intermediate transformations that are necessary in this process. The chapter concludes with a discussion of using the ArcToolbox Project tool to apply a geographic transformation.

Chapter Nine discusses vertical coordinate systems, and is new to this edition. It starts with an overview of vertical datums and how they differ from horizontal datums. The various components of a vertical datum—including ellipsoidal, geoid, and orthometric heights—are introduced, and then the process of applying a vertical datum transformation is discussed. This discussion includes a sample workflow where elevation data in text string format is downloaded from a National Geodetic Survey website and transformed into numeric data using the ArcToolbox Project tool. Readers are also cautioned in regard to the necessity of performing horizontal and vertical datum transformation separately. The chapter concludes with a reference to two useful online tools designed for working with United States vertical datums—VDATUM and VERTCON—created by the National Oceanic and Atmospheric Administration and the National Geodetic Survey, respectively.

Chapter Ten considers how one determines which map projection is appropriate for a given dataset. Beginning with a definition of GCSs, the author discusses the length of a degree and how GCS data are displayed in the ArcMap data frame. Attention turns next to PCSs, and the different elements of a PCS are individually described, including the properties of the various projection types—such as conformal, equal area, equidistant, and true direction—and the effects of these properties on linear units of measurement, including concepts such as “map units” and “grid north.” The discussion of how to choose an appropriate projection for a GIS project is very helpful. Creating a custom projection is covered, with attention to the different map projection parameters that a user may need to modify (e.g., standard parallels). The concepts of false easting and false northing are also presented, and a

brief overview of the Web Mercator projection rounds out the chapter.

Chapter Eleven is a collection of miscellaneous content that includes how to define a projection and its parameters, how to handle x,y data, and the shapes of buffers. The chapter begins by listing the components that are required for every GCS—name, units of measure, datum, spheroid, and prime meridian—and is followed by a list of possible components that a PCS could include. The author points out that, unlike a GCS, not every PCS has the same components. The advantages of using a PCS instead of only a GCS are detailed next, and the concept of a local coordinate system is explained. The process of adding x,y data to ArcMap, defining a coordinate system, and converting those data to a shapefile is explained and illustrated. The chapter finishes up with a detailed examination of how coordinate systems impact the shape of buffers in ArcMap.

Two appendices appear in the book. Appendix A lists eleven “Knowledge articles” from Esri’s Support Center that focus on topics related to coordinate systems. Appendix B lists an additional fourteen online resources covering a range of coordinate system topics. A short bibliography of three additional readings and an index concludes the book.

Lining up Data in ArcGIS is intended to give GIS users a practical guide to solving many coordinate system issues, and, generally speaking, it succeeds in this. Since each chapter is framed around a “typical” coordinate system question, each chapter can stand on its own, and readers can pick and choose those that best suit their needs. For coordinate system novices, the framing questions are especially helpful in directing the reader to the relevant chapter. Reading this book will not provide the reader with any of the theory behind why data don’t align, the mathematical underpinnings of coordinate systems, or research on coordinate systems, but there are other texts that provide this kind of knowledge. For example, Snyder’s *Map Projections: A Working Manual* presents a mathematical basis of coordinate systems, while Canters’s *Small-scale Map Projection Design* delves into research useful for designing new projections. In any event, if your aim is to learn about these advanced coordinate system topics, this isn’t the book for you. The graphics included in the third edition of *Lining up Data in ArcGIS* reflect the

Esri ArcMap interface design. However, as the Esri world transitions from ArcMap to ArcPro, I hope that when the fourth edition appears it will use screen shots and step-by-step instructions reflecting the newer software environment. Similarly, while data in vector format are, and will remain, prevalent, the next edition should include at least one chapter on coordinate systems and raster data.

Organizationally, it seems odd that the essential definitions of geographic and projected coordinate systems (GCSs and PCSs) and their components—concepts and terms that are used throughout the book—are to be found in the last chapter, rather than in the first. Readers could be directed to read through this chapter first to make sure they are equipped with this foundational knowledge before diving into other chapters. While this approach would reduce the amount of material repeated in multiple chapters, it would also render each chapter a little less self-contained and less able to stand alone. Done properly, however, it would be an advantage.

Finally, this book persists in propagating the incorrect idea that conformal projections preserve the shape of the data. Conformal projections in fact preserve angular relations—a property often associated with navigational map tasks such as charting rhumb lines or determining azimuths, bearings, and directions—and while this does mean that shape is preserved *locally*, this is not a *general* property and shapes of any size are still distorted.

The bottom line is that if you work with geospatial data in the ArcGIS environment and have problems with your data not aligning correctly, you should give *Lining up Data in ArcGIS* a careful read. You may just find answers to your coordinate system questions.

REFERENCES

- Canters, Frank. 2002. *Small-scale Map Projection Design*. New York: Taylor and Francis.
- Kessler, Fritz C. 2012. “Review of Lining Up Data in ArcGIS: A Guide to Map Projections.” *Cartographic Perspectives* 72: 97–99. doi: [10.14714/CP72.197](https://doi.org/10.14714/CP72.197).
- Snyder, John. 1987. *Map Projections: A Working Manual*. Washington, DC: United States Geological Survey.