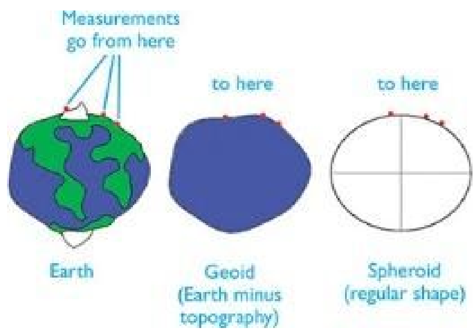
Datums

A geographic coordinate system is defined by three things: an angular unit of measure (usually degrees), a prime meridian (usually Greenwich), and a datum. The datum is the part that gives people trouble. To understand it, start with the shape of the earth.

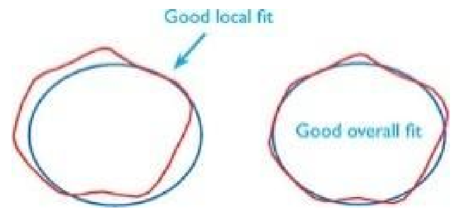
The earth isn't a perfect sphere, or even a mathematically regular spheroid. It's a lump with an uneven shape owing to different concentrations of mass (and therefore unequal gravity) over its surface. In addition, it has topographic features such as mountains and valleys.

When the spatial positions of features are determined—as was formerly done by survey, and is now mostly done by satellite—they are first determined on the earth's surface. These raw measurement values are then mathematically "leveled" to a geoid. A geoid is the (still gravitationally lumpy) shape that the earth would have if it was covered by a mean sea level surface—in other words, if it had no topography.

The shape of the geoid, however, is too complex to be a working model. So the next step is to move the measurements from the geoid to a spheroid: a model with a regular, non-lumpy shape.



That's where the datum comes in. The datum is two things: first, it's a chosen spheroid, which could be WGS 1984, GRS 1980, Clarke 1866, Bessel 1841, or a number of others. (The world is standardizing on the GRS 1980 spheroid but isn't all the way there yet.) Second, it's a mathematical orientation, or "fit," of the geoid to the spheroid. In the transfer of measurements from geoid to spheroid, some error will be introduced because the lumps must be smoothed out. How that error is distributed is the "fit." One approach is to make the fit really good for one part of the world, such as North America, and not to worry about the rest. That's a local datum. It's designed to maintain high accuracy for measurements over a limited area. The other approach is to average the error over the whole surface. That's an earth-centered datum. It's designed to maintain high accuracy for the world as a whole.



When two geographic coordinate systems are different, it's usually because the datums are different (which, in turn, is either because the spheroids are different or the fit is different). When you get a coordinate system warning in ArcGIS Pro, one possibility is to ignore it and leave the data slightly out of alignment.

Depending on your needs for accuracy, this may be an entirely sensible choice. The amount of misalignment depends on the datums involved and the part of the world being mapped, but in the mismatch that North Americans usually encounter (between the World Geodetic System of 1984 and the North American Datum of 1983), it typically doesn't exceed a few feet. At most scales, the difference isn't noticeable.

The other option is to reconcile the systems through a geographic transformation. Transformations are often done in conjunction with a coordinate system projection. Like projections, they can be permanently applied to datasets with data processing tools, or they can be done on the fly in ArcGIS Pro. Transformations require some expert knowledge. There are default methods to convert one spheroid to another, but there aren't default fits, because the right fit depends on your area of interest. The table on "geographic (datum) transformations: well-known IDs, accuracies, and areas of use," at https://desktop.arcgis.com/en/arcmap/latest/map/projections/pdf/geographic_transformations.pdf, can help you find the right fit for an area of interest.