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Coordinate Systems

Just as all maps have a map scale, all maps have locations, too. Coordinate systems are frameworks that are used to define unique positions. For instance, in geometry we use x (horizontal) and y (vertical) coordinates to define points on a two dimensional plane. The coordinate system that is most commonly used to define locations on the three-dimensional earth is called the geographic coordinate system (GCS) , and it is based on a sphere or spheroid. A spheroid (a.k.a. ellipsoid) is simply a sphere that is slightly wider than it is tall and approximates more closely the true shape of the earth. Spheres are commonly used as models of the earth for simplicity.

The unit of measure in the GCS is degrees, and locations are defined by their respective latitude and longitude within the GCS. Latitude is measured relative to the equator at zero degrees, with maxima of either ninety degrees north at the North Pole or ninety degrees south at the South Pole. Longitude is measured relative to the prime meridian at zero degrees, with maxima of 180 degrees west or 180 degrees east. Note that latitude and longitude can be expressed in degrees-minutes-seconds (DMS) or in decimal degrees (DD). When using decimal degrees, latitudes above the equator and longitudes east of the prime meridian are positive, and latitudes below the equator and longitudes west of the prime meridian are negative (see the following table for examples)

Nominal location	Absolute location (DMS)	Absolute location (DD)
Sydney, Australia	33° 51′ South, 151° 12′ East	−33.859, 151.211
Sao Paolo, Brazil	23° 33′ South, 46° 38′ West	−23.550, −46.634

Nominal location	Absolute location (DMS)	Absolute location (DD)
Los Angeles, US	34° 3′ North, 118° 15′ West	+34.05, −118.25
Mumbai, India	18° 58′ North, 72° 49′ East	+18.975, +72.8258

Converting from DMS to DD is a relatively straightforward exercise. For example, since there are sixty minutes in one degree, we can convert 118° 15 minutes to 118.25 (118 + 15/60). Note that an online search of the term "coordinate conversion" will return several coordinate conversion tools.

When we want to map things like mountains, rivers, streets, and buildings, we need to define how the lines of latitude and longitude will be oriented and positioned on the sphere. A datum serves this purpose and specifies exactly the orientation and origins of the lines of latitude and longitude relative to the center of the earth or spheroid.

Depending on the need, situation, and location, there are several datums to choose from. For instance, local datums try to match closely the spheroid to the earth's surface in a local area and return accurate local coordinates. A common local datum used in the United States is called NAD83 (i.e., North American Datum of 1983). For locations in the United States and Canada, NAD83 returns relatively accurate positions, but positional accuracy deteriorates when outside of North America.

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The global WGS84 datum (i.e., World Geodetic System of 1984) uses the center of the earth as the origin of the GCS and is used for defining locations across the globe. Because the datum uses the center of the earth as its origin, locational measurements tend to be more consistent regardless where they are obtained on the earth, though they may be less accurate than those returned by a local datum. Note that switching between datums will alter the coordinates (i.e., latitude and longitude) for all locations of interest