GIS in Water Resources

Fall 2015

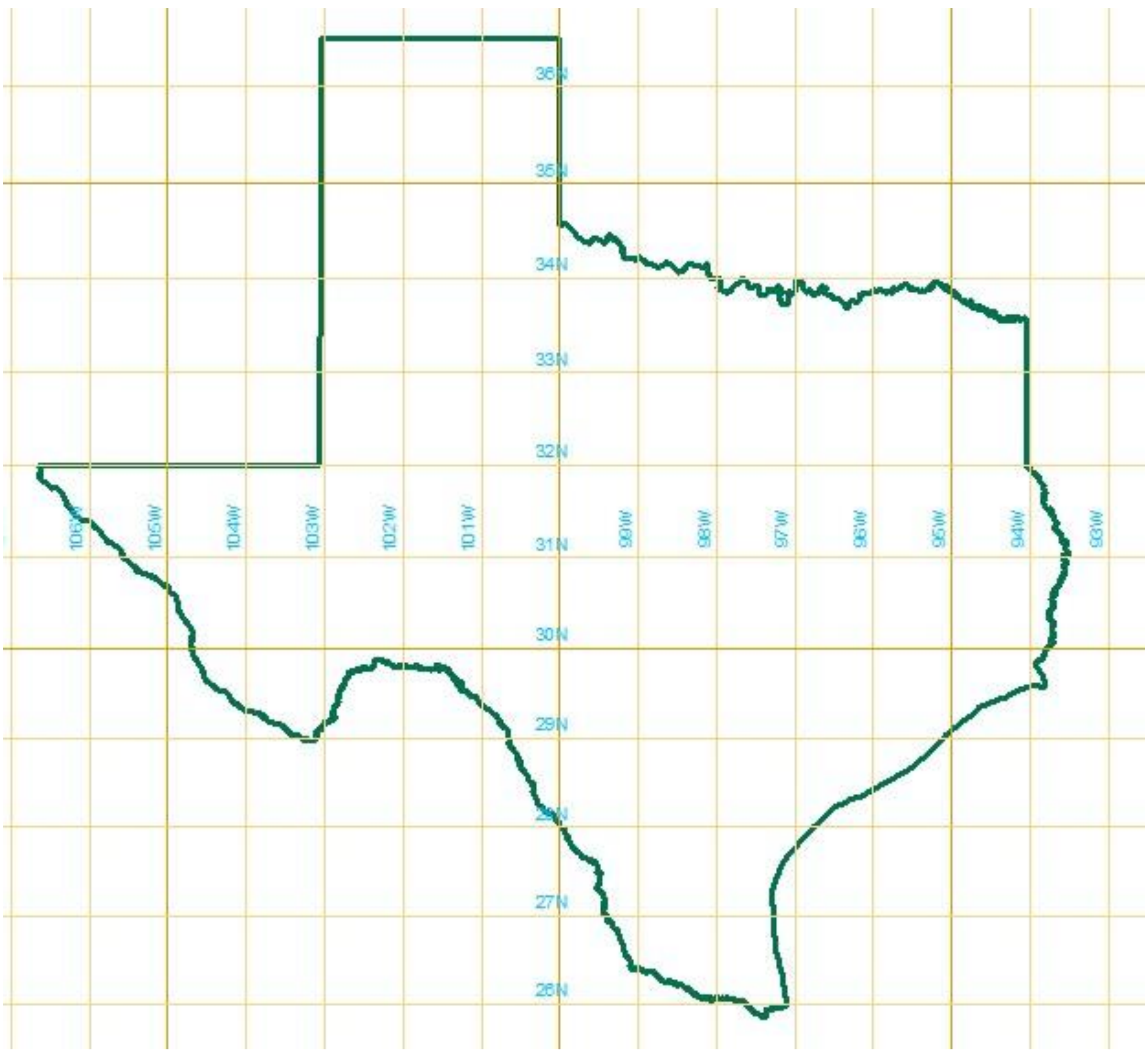
Homework #1

Goal

The goal of this homework is to reinforce the lecture material on Geodesy, Map Projections and Coordinate Systems by having you identify attributes and perform hand calculations related to coordinate systems and distances between points on a spherical earth.

1. Map Projection Parameters

The map below shows Texas and a grid of world latitude and longitude from ArcGIS Online.



Here are the parameters of the State Plane Coordinate system of Texas, Central Zone:

NAD_1983_2011_StatePlane_Texas_Central_FIPS_4203
WKID: 103155 Authority: ESRI

Projection: Lambert_Conformal_Conic
False_Easting: 700000.0
False_Northing: 3000000.0
Central_Meridian: -100.3333333333333
Standard_Parallel_1: 30.11666666666667
Standard_Parallel_2: 31.88333333333333
Latitude_Of_Origin: 29.66666666666667
Linear Unit: Meter (1.0)

Geographic Coordinate System: GCS_NAD_1983_2011
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_NAD_1983_2011
  Spheroid: GRS_1980
    Semimajor Axis: 6378137.0
    Semiminor Axis: 6356752.314140356
    Inverse Flattening: 298.257222101

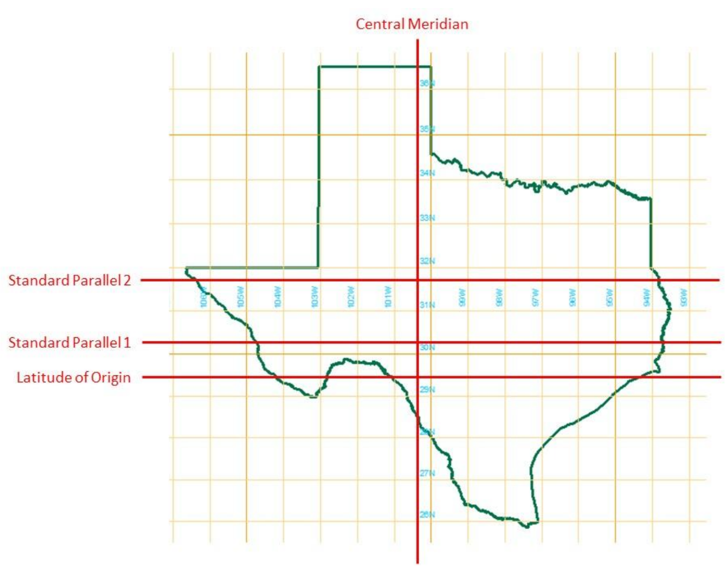
(a) What earth datum is used in this coordinate system?

North American 1983

(b) What map projection is used in this coordinate system?

Lambert Conformal Conic

(c) Sketch on the map the standard parallels, the central meridian and the latitude of origin of this projection.



(d) For this projection, what are the coordinates of the origin (ϕ_o, λ_o) (in units of degrees minutes and seconds) and the corresponding (X_o, Y_o) (in units of meters)?

$$(\phi_0, \lambda_0) = (29°40'0"N; 100°20'0"W)$$
$$(x_0, y_0) = (700{,}000; 3{,}000{,}000)$$

(e) The geographic coordinates of UT Austin are: 30° 17' 10" N 97°44' 22" W. Assuming a spherical earth with radius 6371.0 km, calculate the distances in meters that UT Austin is north of the latitude of origin and east of the central meridian.

In decimal degrees the latitude of UT Austin is 30+17/60+10/3600 = 30.28611
In decimal degrees the latitude of origin is 29+40/60 = 29.66667
UT Austin is thus 30.28611 - 29.66667 = 0.61944 deg N of the latitude of origin. This corresponds to a distance of 0.61944 * π/180 * 6371 = 68.8786 km = **68,878.6 m**

In decimal degrees the longitude of UT Austin is -(97+44/60+22/3600) = -97.73944
In decimal degrees the prime meridian is -(100+20/60) = -100.33333
UT Austin is thus -97.73944 -(-100.33333) = 2.59389 deg E of the prime meridian. This corresponds to a distance of 2.59389 * π/180 * 6371 * cos(30.28611) = 249.0622 km

(f) Based on your answers to (e) determine the approximate coordinates of UT Austin in the Texas State Plane Coordinate system.

Approximate coordinates of UT Austin are thus
$$x_0 = 700{,}000 + 249{,}062.2 = 949{,}062.2\ m$$
$$y_0 = 3{,}000{,}000 + 68{,}878.6 = 3{,}068{,}878.6\ m$$

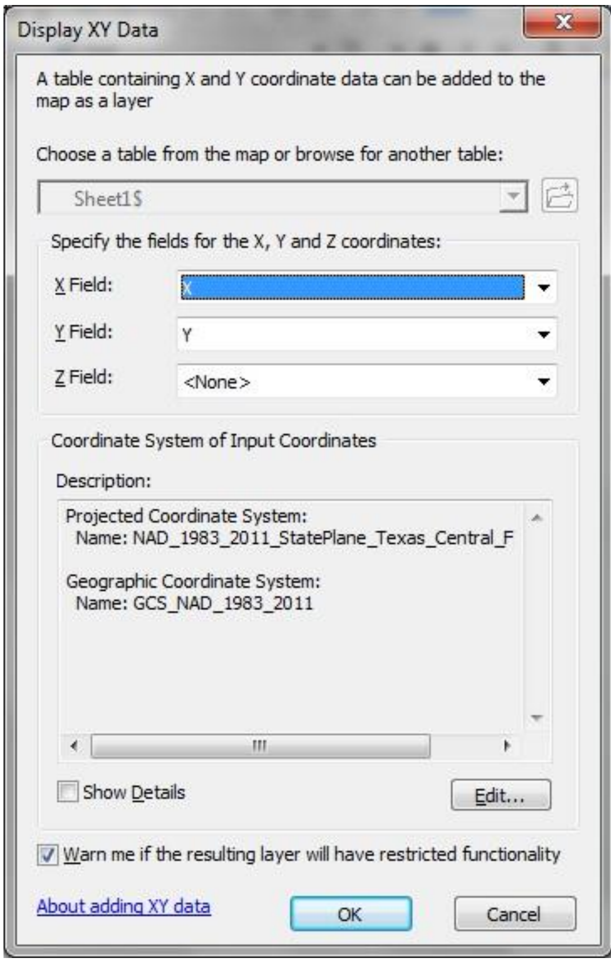
Note that your answers in (f) are approximate because of the assumption of a spherical earth rather than using the GRS_1980 spheriod and Lambert Conformal Conic projection geometry which is too involved for a hand calculation. Let's use ArcGIS to see how approximate this is.

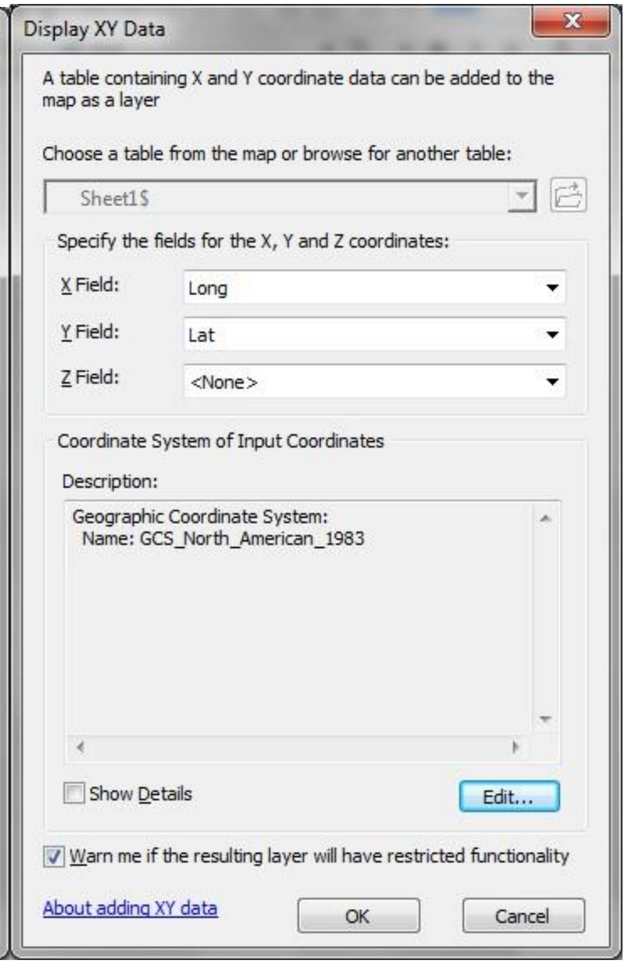
(g) Use the Display XY data function in ArcGIS to display the UT Austin location from geographic coordinates and from the approximate projected coordinates. Use a basemap to provide context. Label each point and use the distance tool to estimate the distance between these points.

In making the map that follows I entered geographic and projected coordinates in the following spreadsheet. The columns at the right were so I could label the point

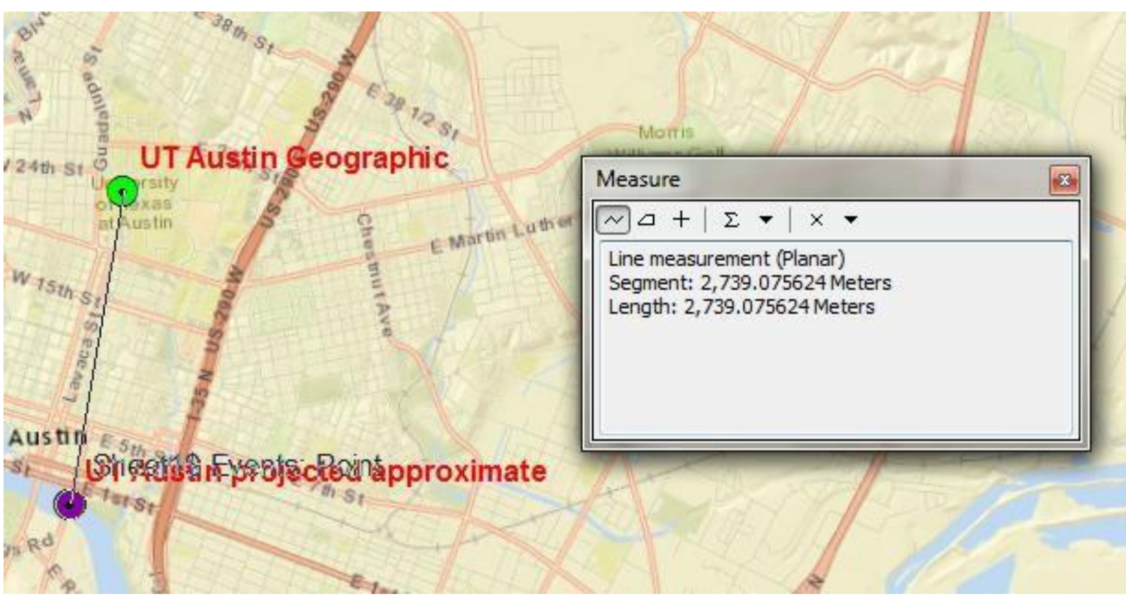
Lat	Long	X	Y	Geog	ProjApprox
30.28611	-97.7394	949062.2	3068878.6	UT Austin Geographic	UT Austin projected approximate

I then added the spreadsheet to ArcGIS and used Display XY data specifying the following coordinate system information.



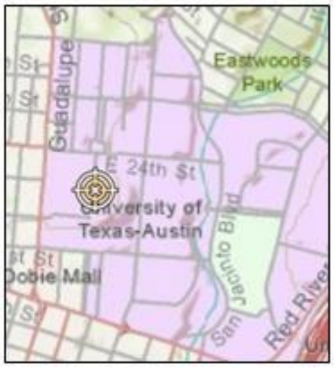


I then labeled each point based on the coordinates used to plot it. The points plot relatively close together in the Austin area. The geographic coordinates plot is right over UT Austin, while the approximate point we computed is 2.739 km away using the distance tool.



2. Locations on the Earth

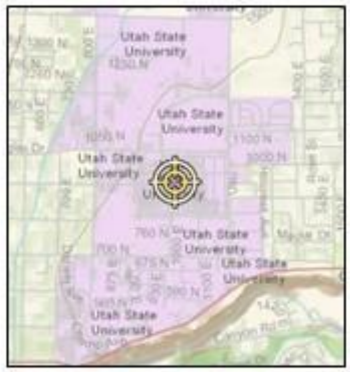
Using ArcGIS Explorer Online and zooming to Austin and Logan reveals the following designated locations for these universities. Convert these locations into decimal degrees. Find the great circle distance between Austin and Logan in km if the radius of an equivalent spherical earth is 6371.0 km. Elevations for these locations were determined using Google Earth. 1 ft = 0.3048 m. Compute the slope along the great circle distance and indicate whether, based on this slope, water would flow from Austin to Logan or Logan to Austin along this path.



University of Texas at Austin

30°17'10"N, 97°44'22"W

Elevation 693 ft



Utah State University

41°44'54"N, 111°48'30"W

Elevation 4789 ft

Austin $\phi = 30°17'10"N = 30 + 17/60 + 10/3600 = 30.2861°$
$\lambda = 97°44'22"W = 97 + 44/60 + 22/3600 = -97.7394°$
$Lat, Long = (30.2861°, -97.7394°)$

Logan $\phi = 41°44'54"N = 41 + 44/60 + 54/3600 = 41.7483°$
$\lambda = 111°48'30"W = 111 + 48/60 + 30/3600 = -111.8083°$
$Lat, Long = (41.7483°, -111.8083°)$

<u>Distance Logan to Austin</u>

Logan $\phi_A = 41.7483°(\pi/180°) = 0.728646$
$\lambda_A = -111.8083°(\pi/180°) = -1.951424$

Austin $\phi_B = 30.2861°(\pi/180°) = 0.528592$
$\lambda_B = -97.7394°(\pi/180°) = -1.705875$

$R = 6371 km$

$$Dist = R\cos^{-1}[\sin\phi_A \sin\phi_B + \cos\phi_A \cos\phi_B \cos(\lambda_A - \lambda_B)]$$
$$Dist = 1{,}791 km$$

<u>Slope Logan to Austin</u>

$$S = \frac{4{,}789 - 693}{1{,}791}\left(\frac{0.3048}{1{,}000}\right) = 0.0007$$

The water would flow from Logan to Austin

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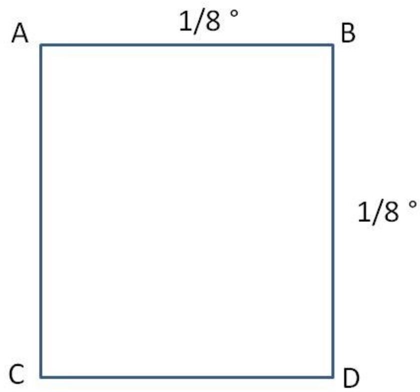
3. Sizes of DEM Cells

The National Land Data Assimilation System is a dataset produced by NASA to describe the time variation of the land surface hydrology of the United States. Data from this system are produced using 1/8 ° cells. When applied, they are projected to a coordinate system in which the (X,Y) coordinates are in meters. A spherical earth that has the same volume and surface area as a reference ellipsoid has a radius of 6371.0 km. Calculate the corresponding distances AB and AC in kilometers, and the area ABCD in square kilometers, for this cell on a spherical earth at Austin and Logan.



a) Austin

$\phi = 30.2861° = 0.528592$ radians

$$\overline{AB} = R_e \Delta\lambda \cos\phi$$
$$\overline{AB} = (6{,}371\ km)(2.1817 \times 10^{-3}) \cos(0.528592)$$
$$\overline{AB} = 12.00 km$$

$$\overline{AC} = R_e \Delta\phi$$
$$\overline{AC} = (6{,}371\ km)(2.1817 \times 10^{-3})$$
$$\overline{AC} = 13.90 km$$

$$\overline{ABCD} = 12.00 \times 13.90 = 166.8 km^2$$

a) Logan

$\phi = 41.7483° = 0.72864$ radians

$$\overline{AB} = R_e \Delta\lambda \cos\phi$$
$$\overline{AB} = (6{,}371\ km)(2.1817 \times 10^{-3}) \cos(0.728646)$$
$$\overline{AB} = 10.37 km$$

$$\overline{AC} = R_e \Delta\phi$$
$$\overline{AC} = (6{,}371.\ km)(2.1817 \times 10^{-3})$$
$$\overline{AC} = 13.90 km$$

$$\overline{ABCD} = 10.37 \times 13.90 = 144.1 km^2$$