All the Right Data in All the Right Places:

Basics of Coordinate Systems and Projections in ArcGIS

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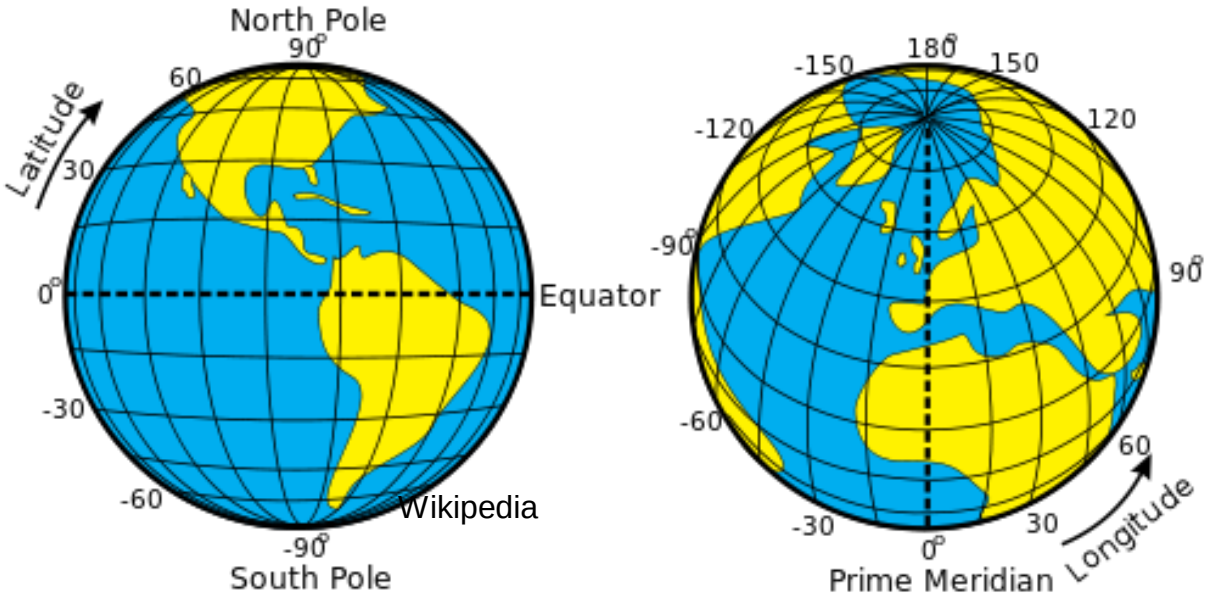
Overview

- Tutorial on Coordinate Systems and Projections in ArcGIS
  - Introductory
  - Assumes basic ArcGIS knowledge
- What Coordinate Systems and Projections are
- Why they are important
- How to work with them in ArcGIS
- Some pitfalls to avoid
- Work through an example: a San Marcos, TX area floodplain map

Modeling the earth for mapping

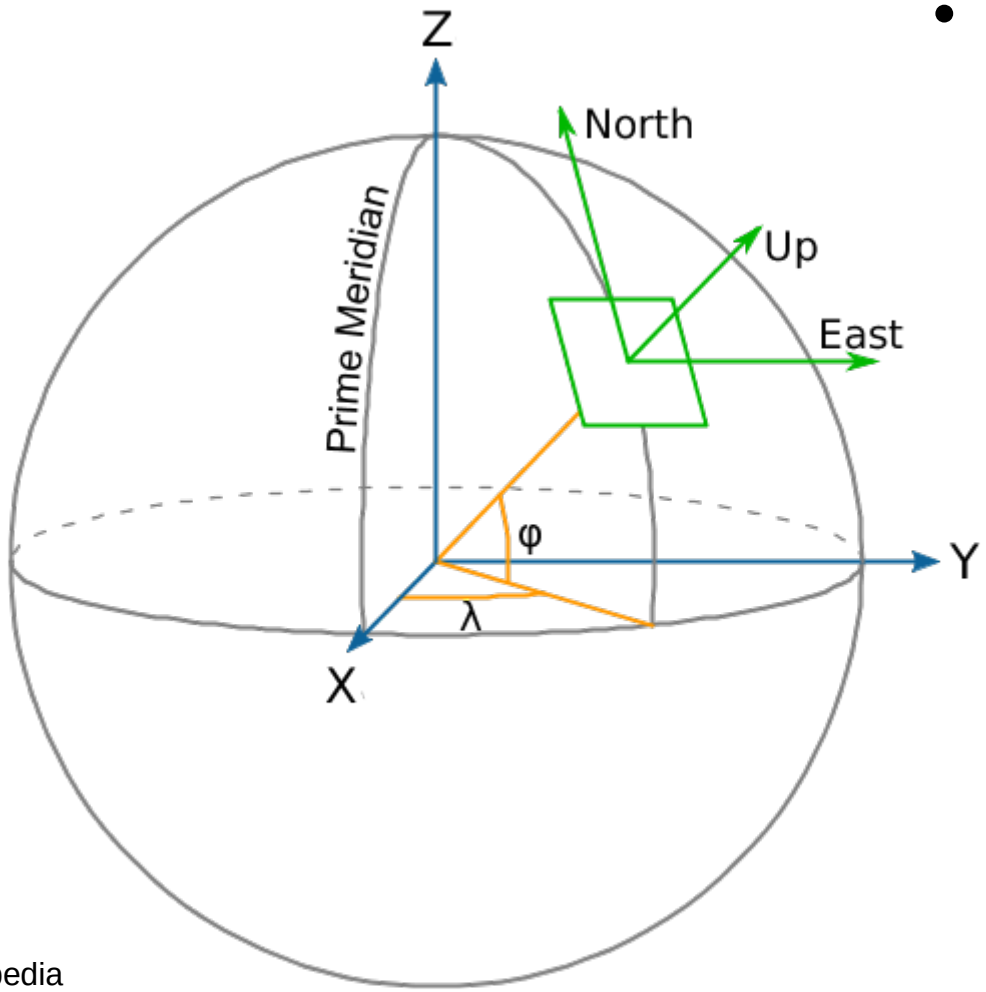
- Shape of the earth:
  - Flattened sphere
- For accurate maps:
  - Need model of the earth's surface – ellipsoid
- Add control points to the ellipsoid—datum
  - Common datums: NAD 83 and WGS 84

Coordinate systems for mapping



- Systematically locate things on the earth—need coordinate systems
- More or less like a grid, depending on the type of coordinate system
- Coordinates consist of numbers and/or letters
- Example of coordinates: degrees of latitude and longitude
  - Parallels of latitude – east and west, never cross
  - Meridians of longitude-north and south, converge at poles

Geographic coordinate systems



Wikipedia

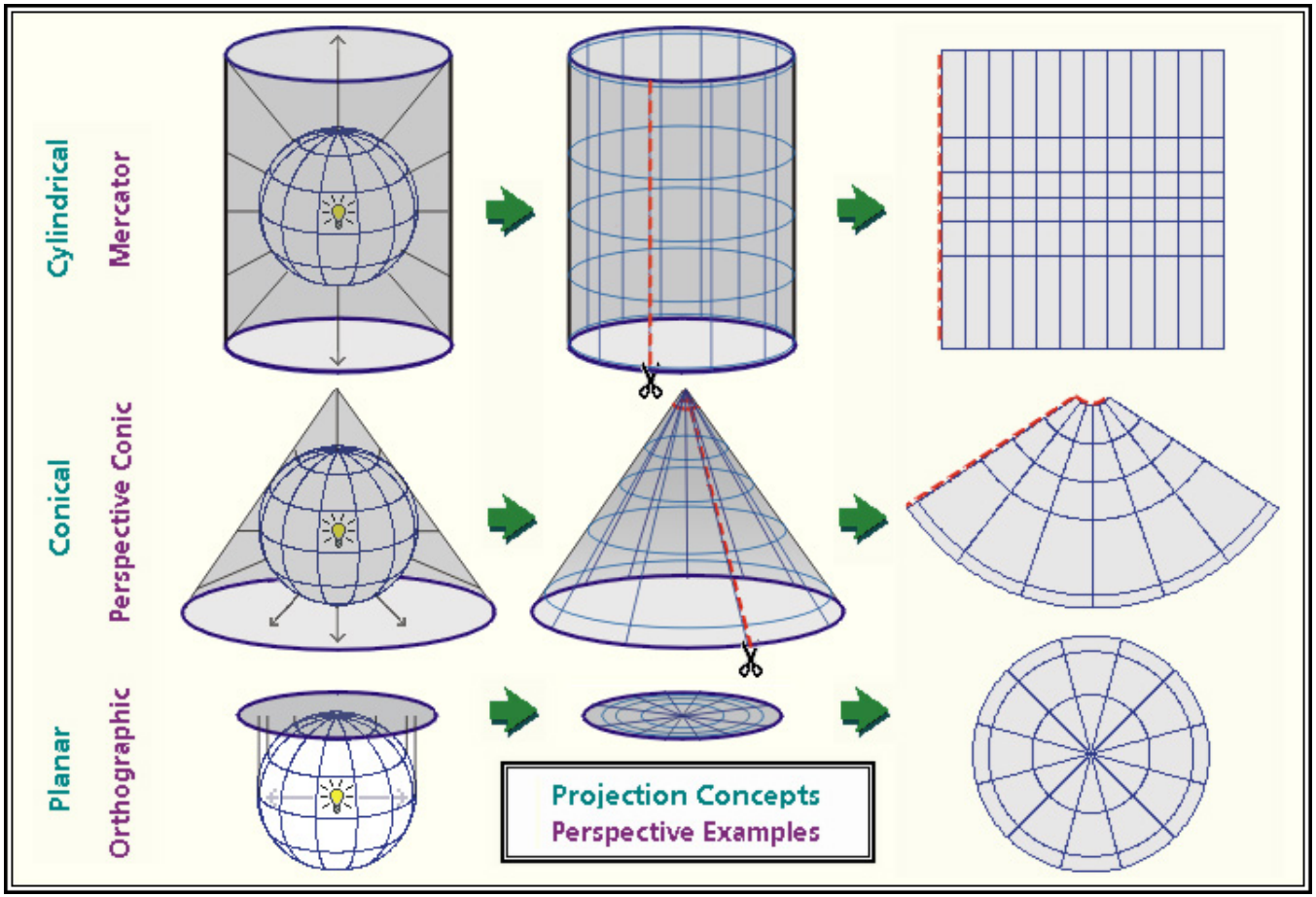
- How it locates places. Measures the angles:
  - East or west of a prime meridian (longitude=λ)
  - North or south of the equator (latitude=φ)

Components of a geographic coordinate system

- A geographic coordinate system (GCS) consists of a:
  - Datum
  - Angular unit of measure (typically Decimal Degrees)
  - Prime Meridian location (often the Royal Observatory in Greenwich, England)
- Examples: NAD 83, WGS 84
- A GCS is the minimum to reliably create/work with data in ArcGIS

Projected Coordinate Systems

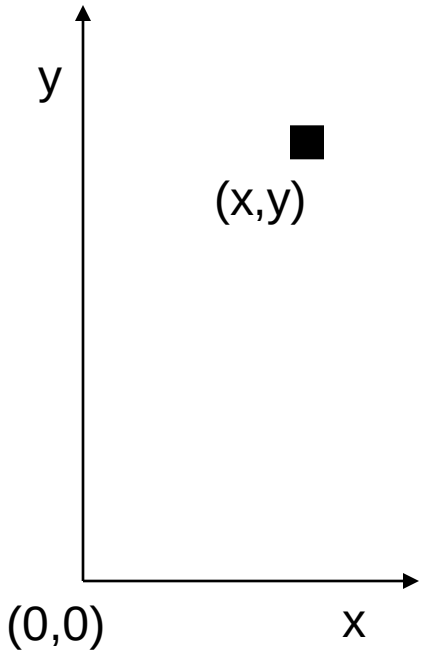
- These transform a 3D model of the earth (GCS) into a 2D surface or ‘flat map’



http://www.geog.ucsb.edu/~dylan/mtpe/geosphere/topics/map/map1.html#proj

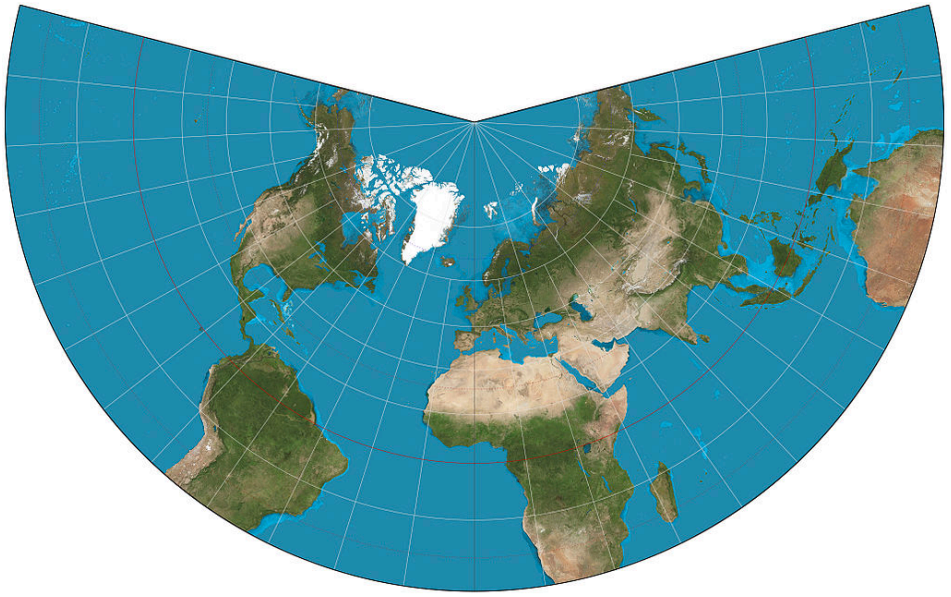
Projected Coordinate Systems

- Coordinates are located in a plane
- Origin of plane is (0,0)
- Data is located at points (x,y) from the origin



Projected Coordinate Systems

- They consist of:
  - Geographic coordinate system
  - Projection (transformation type)
  - Linear unit of measure (feet, meters, etc.)
- Examples:
  - Mercator (WGS 1984 World Mercator)
  - North America Lambert Conformal Conic (Shown)

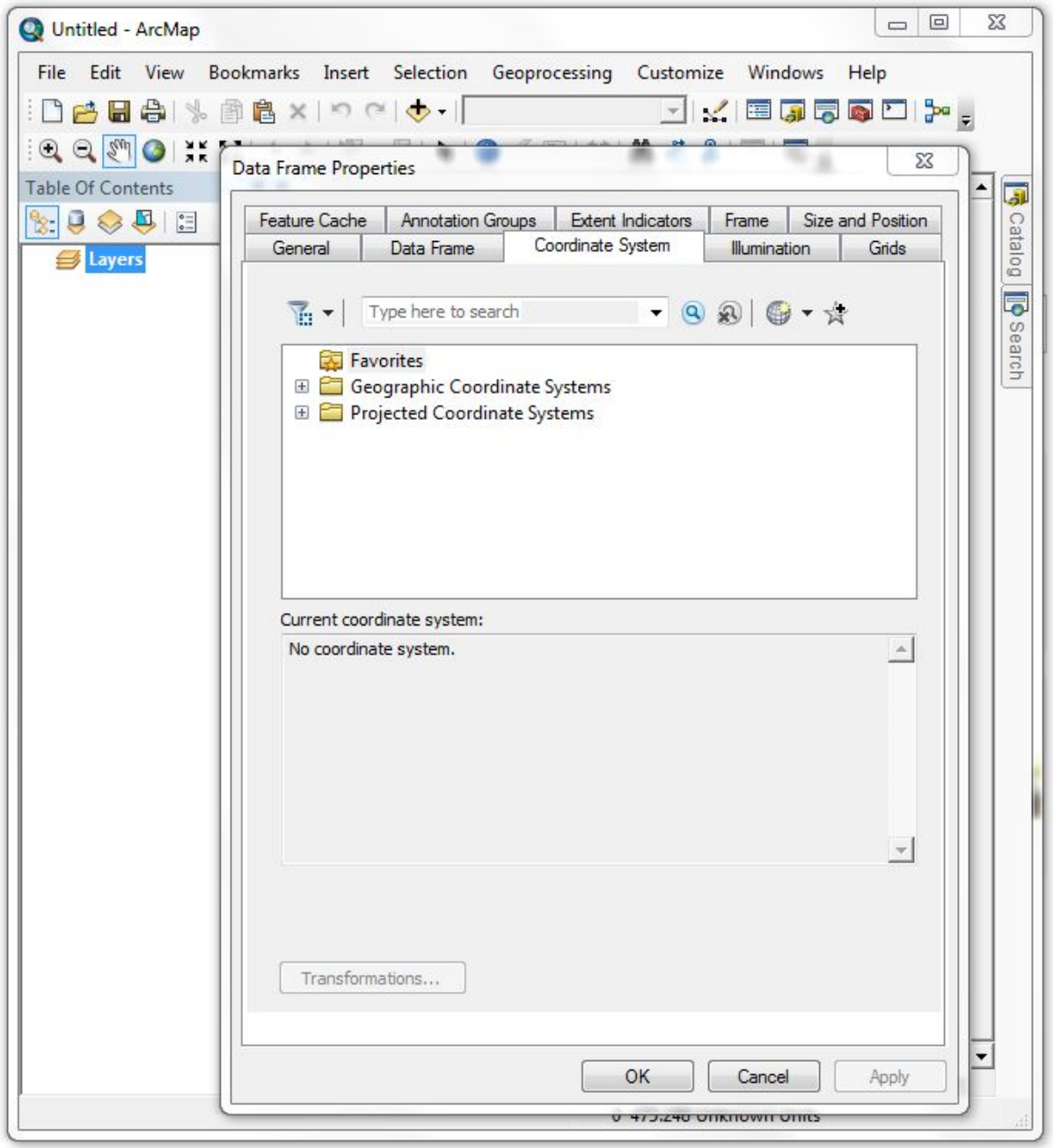


Why use a projected coordinate system?

- Higher accuracy
  - Calculations or measurements
  - Geoprocessing such as buffers
- Choose one that will correct a map distortion:
  - Area (equal or equivalent projections)
  - Shape (conformal projections)
  - Distance (equidistant projections)
  - Direction (azimuthal projections)
- Aesthetics
- Matching the projected coordinate system to other data layers in your map

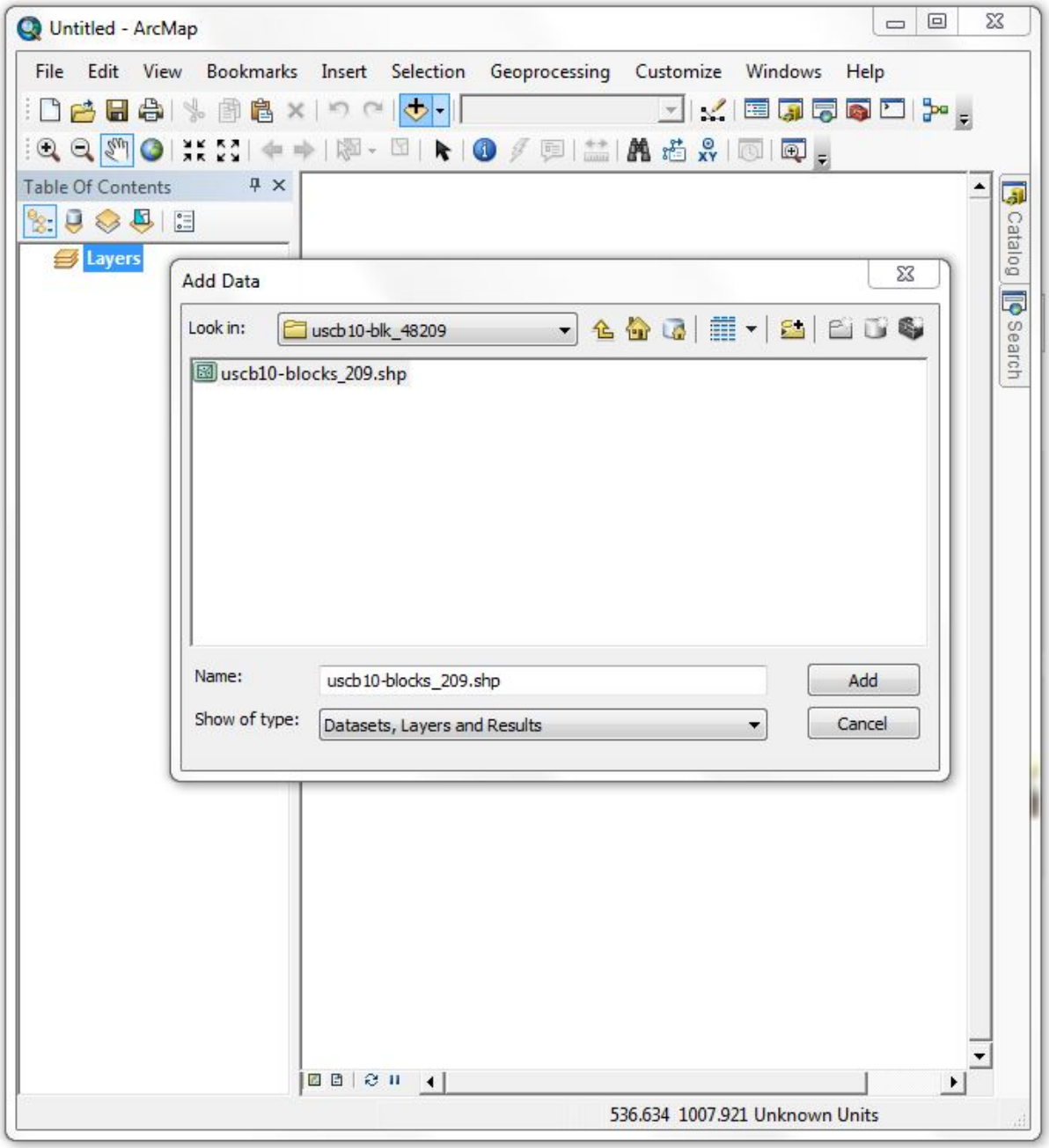
Does my data all need the same CS?

- No, but it helps
- If you have multiple data layers in a data frame:
  - Should have same geographic coordinate system
    - If not, you will likely get a warning when you import data to your map.
    - Can do a transformation (won't go into that now)
  - Helps to have the same projected coordinate system, but not as necessary. Can increase accuracy of operations.
- If your data layers have different CSs,
  - ArcGIS will "project on the fly" the layers that differ from the data frame
  - "Project on the fly"
    - Typically works OK
    - Slows down the system some
    - Can cause accuracy issues



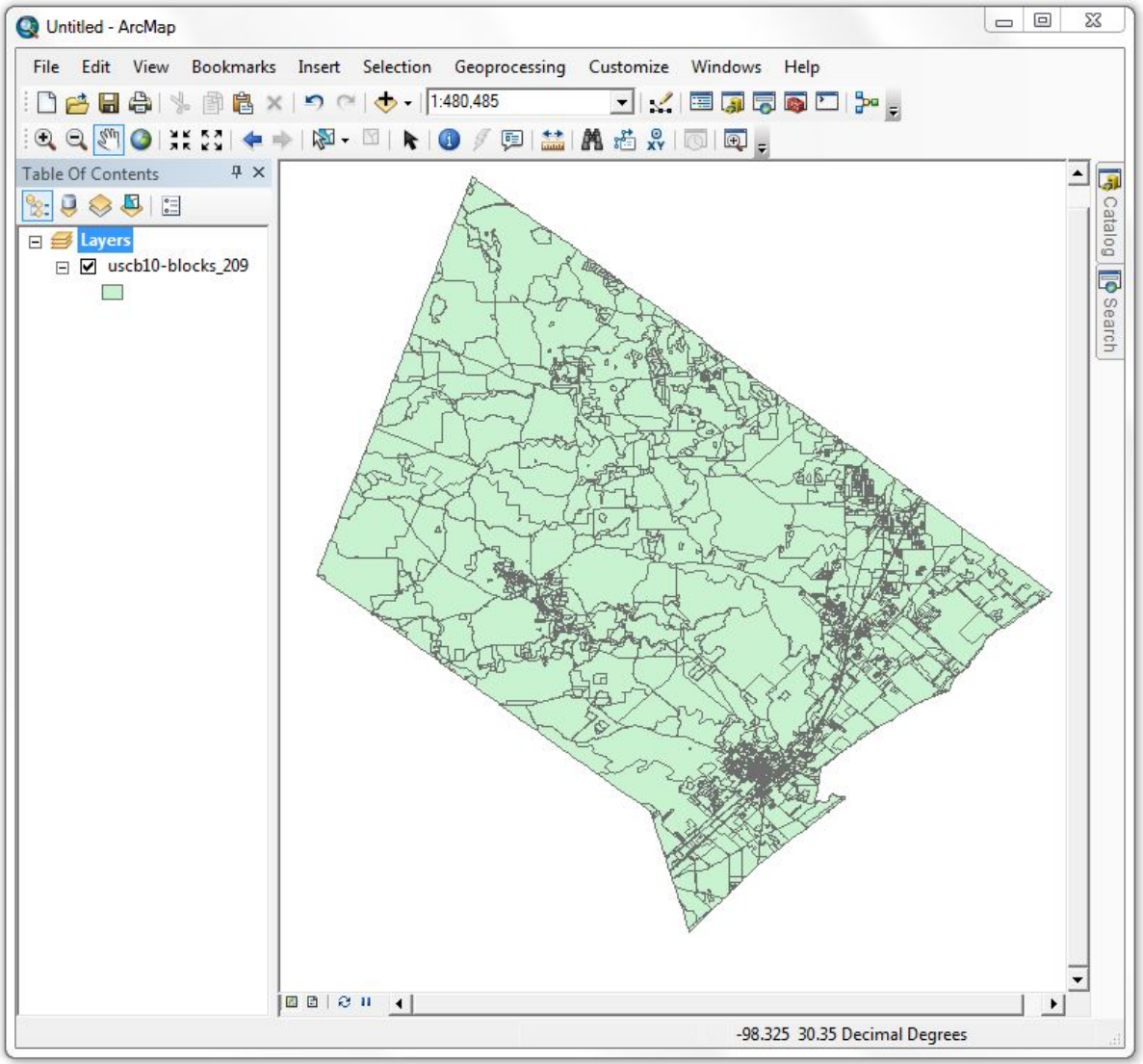
Blank map

- First start ArcMap or click new and select ‘blank map’
- Importance of data frame
- How to see the data frame’s coordinate system
- Notice blank maps start with no coordinate system



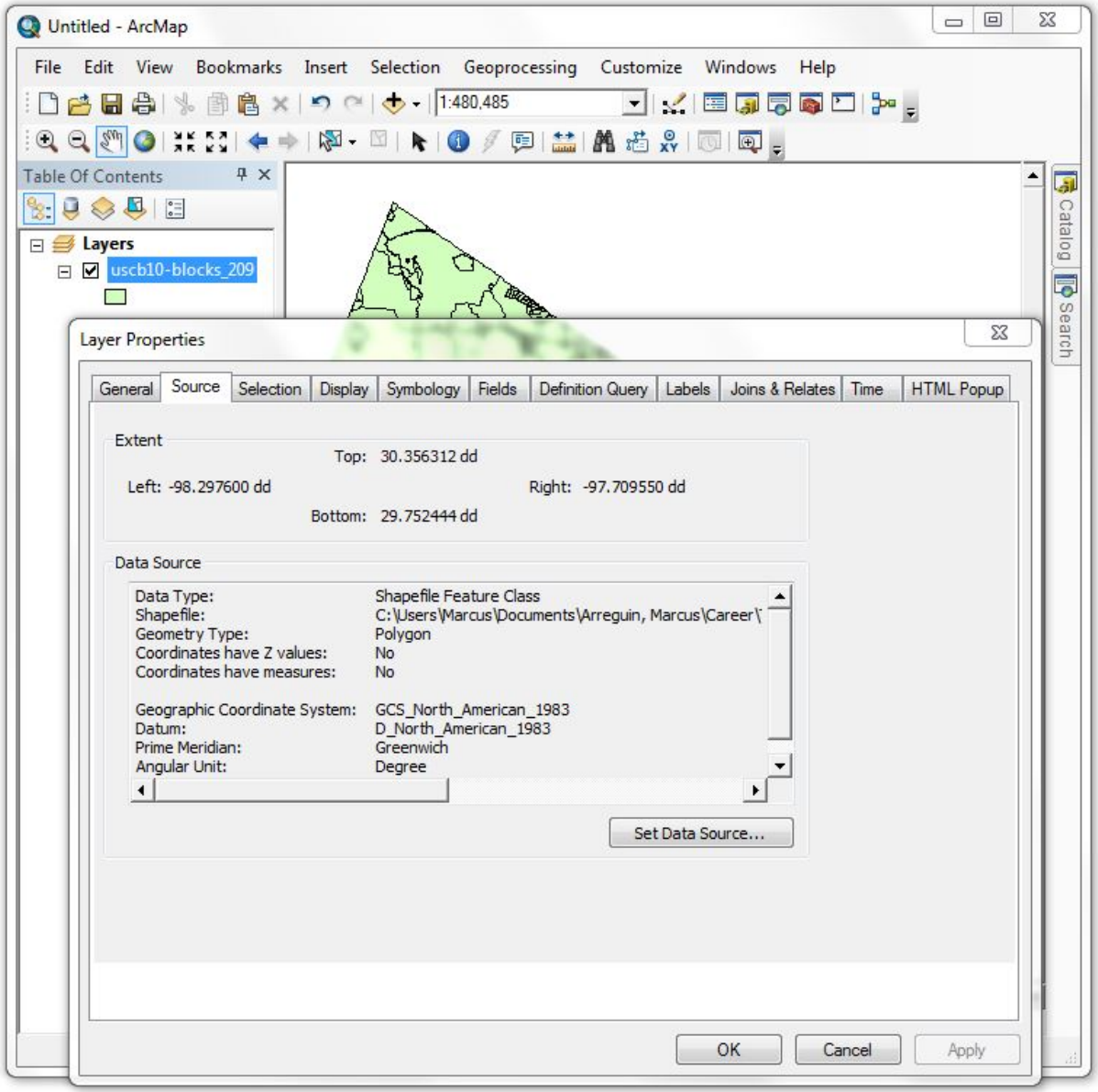
Adding data

- How to add data



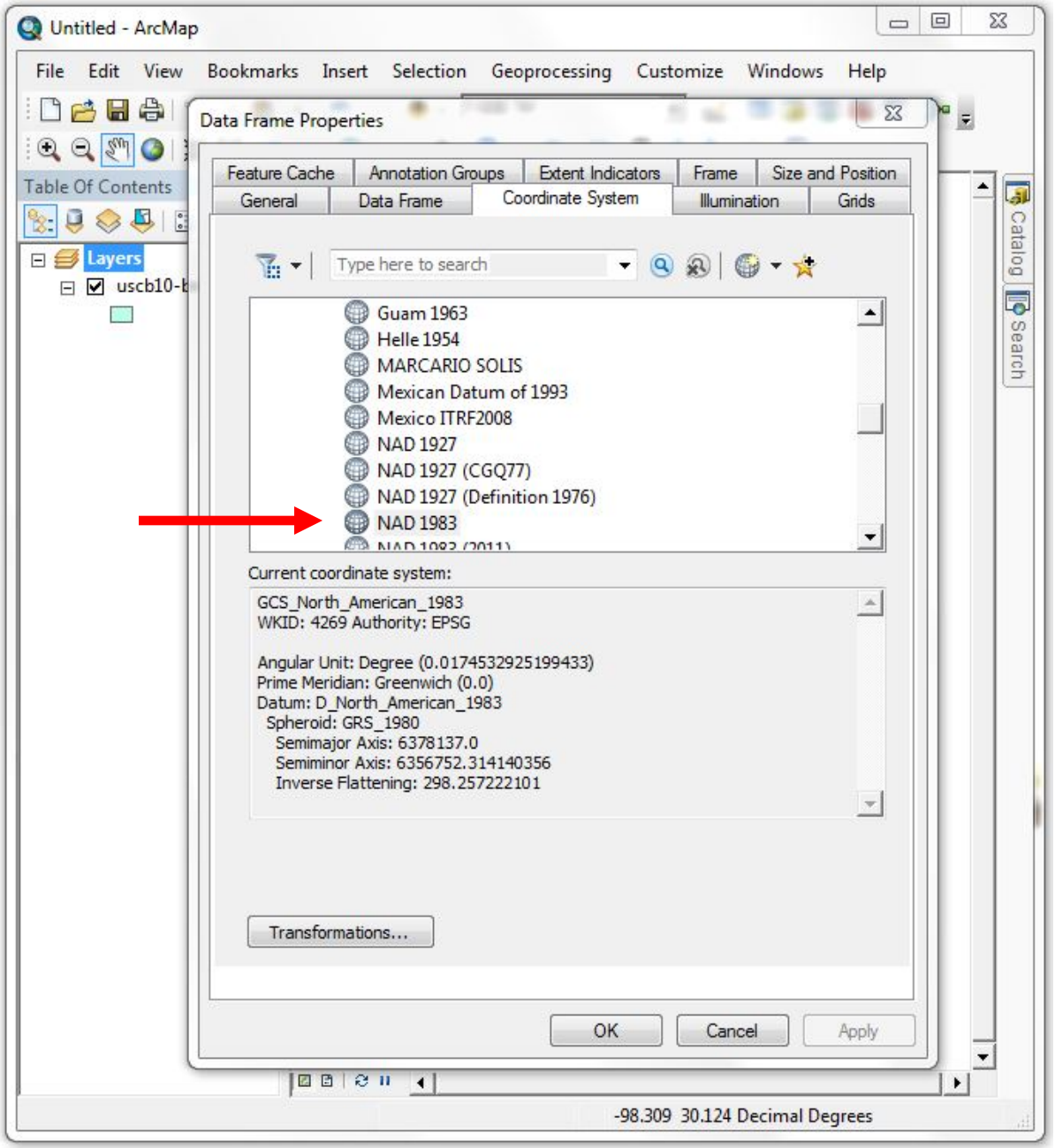
The data

- Hays County Census Blocks
- Sources: TNRIS website, US Census 2010



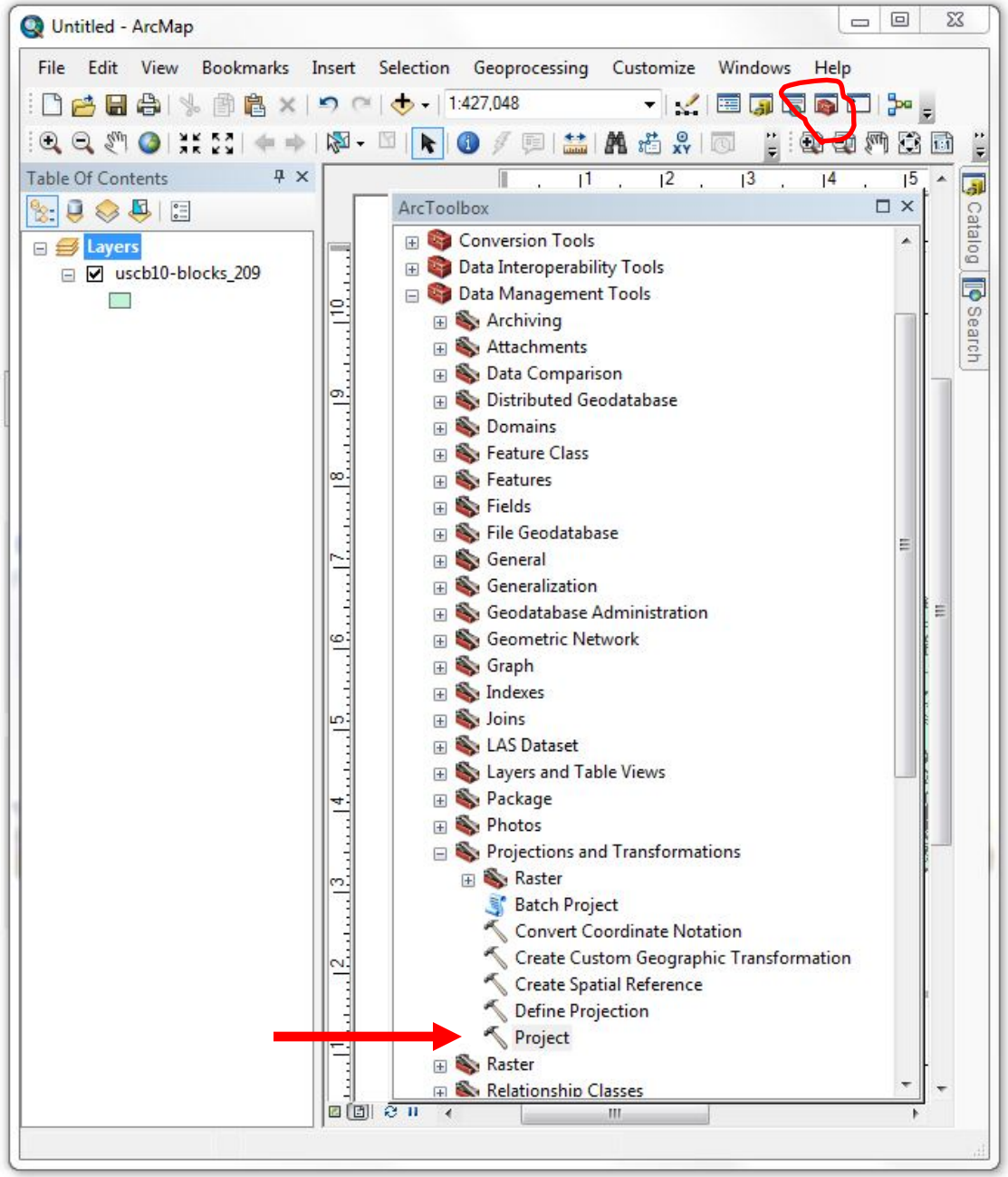
Coordinate system for the data layer

- How to see the coordinate system
- What type this one has:
  - Geographic
  - NAD 83



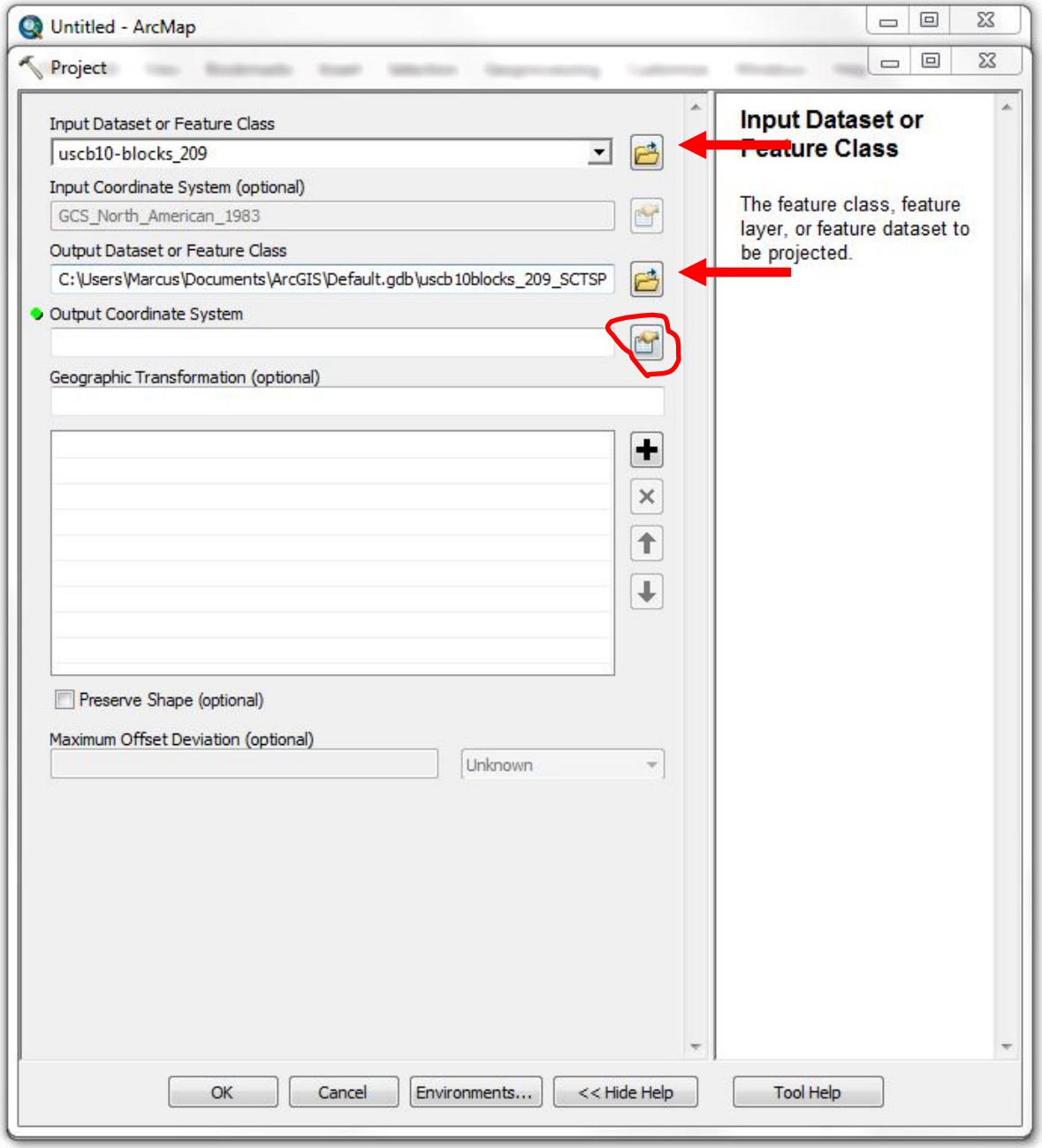
Coordinate system for the data frame

- How to see the coordinate system
- What type this one has:
  - Geographic
  - NAD 83
- Same as the data layer



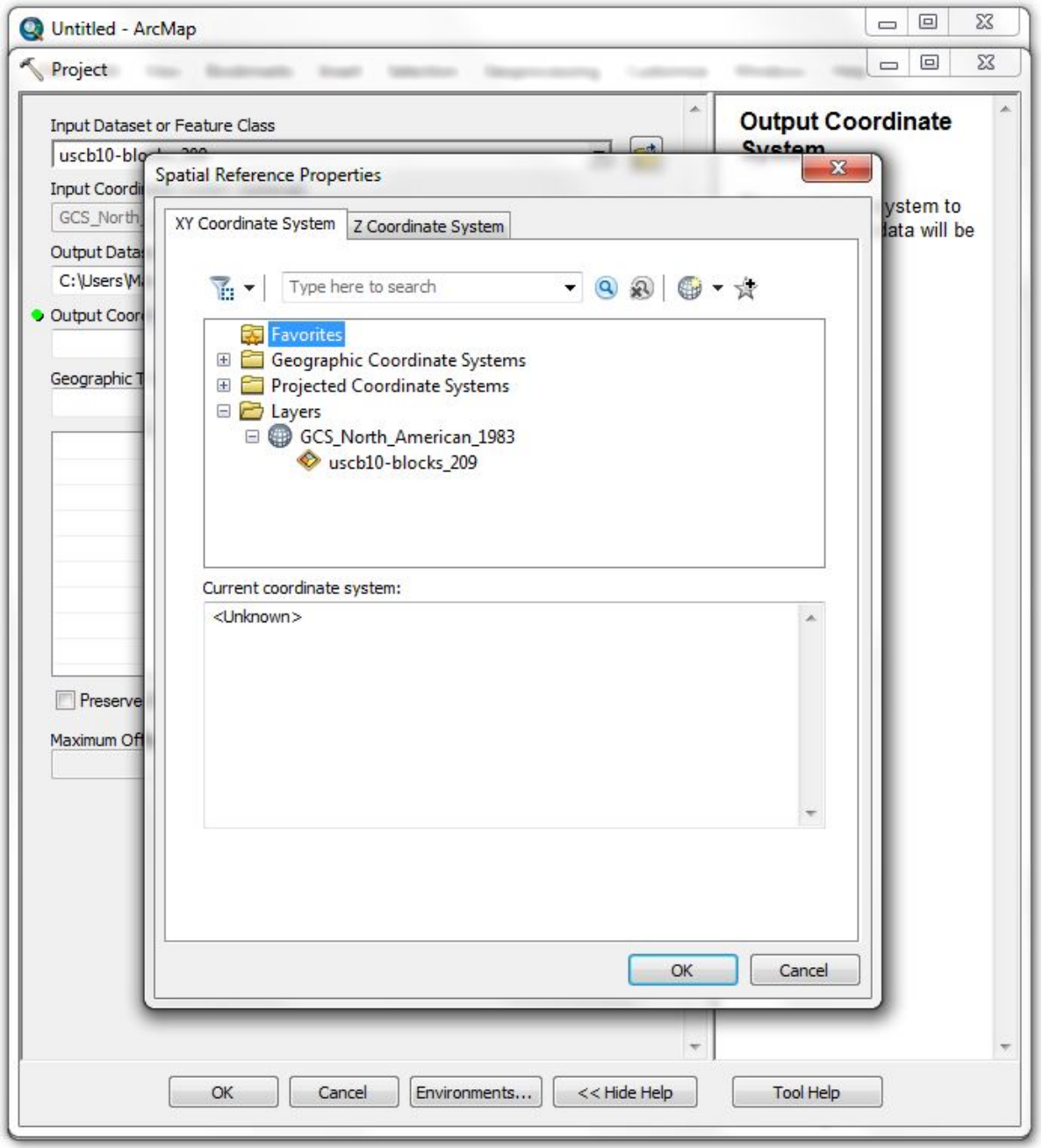
Change the layer's coordinate system

- The Project tool
  - ArcToolbox -> Data Management Tools -> Projections and Transformations -> Project
  - Creates new data file/preserves original
  - Won't change data frame CS



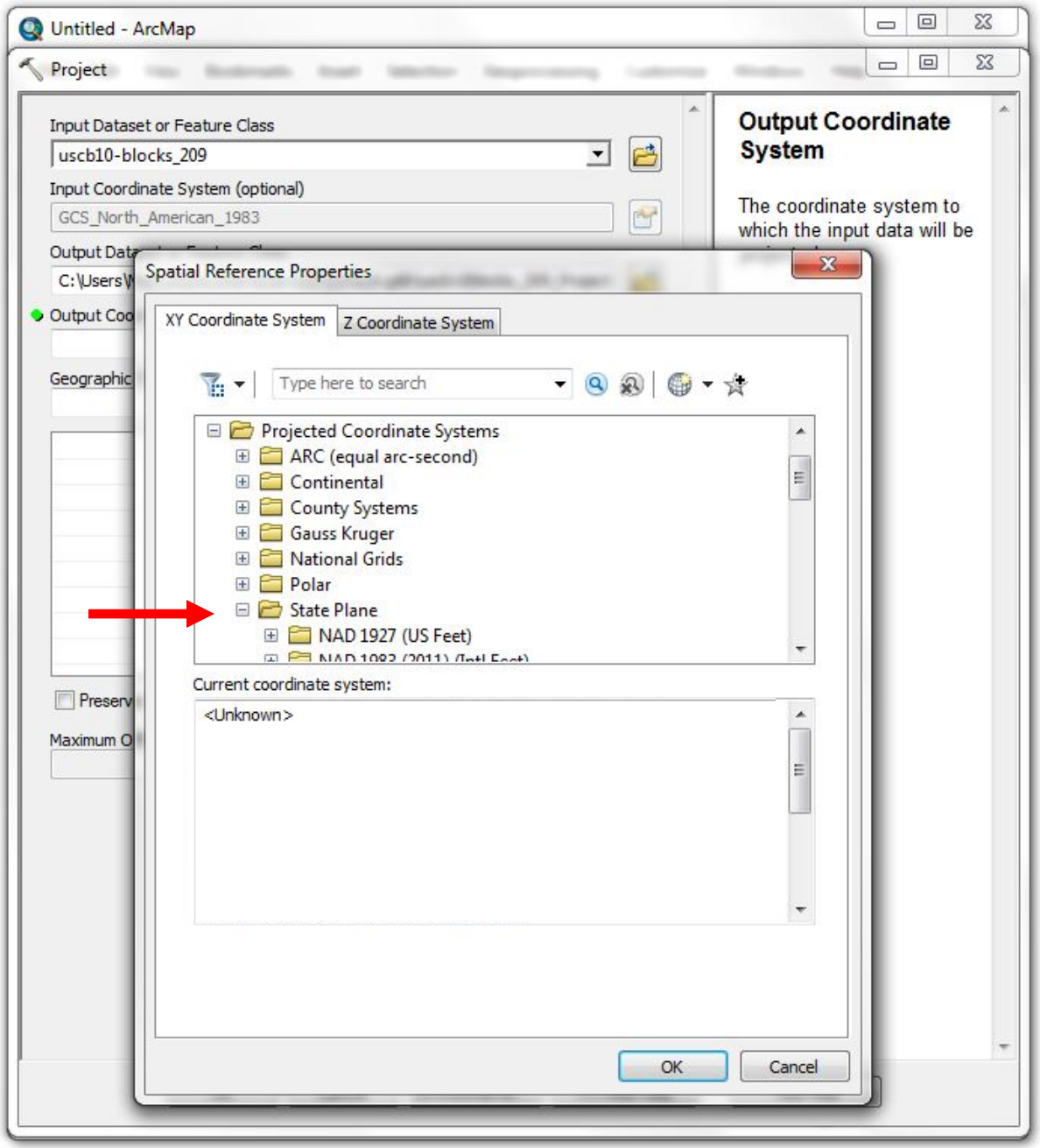
Using the Project Tool

- Choose file to project
- Check the name & location of the output
- Click on the output CS button



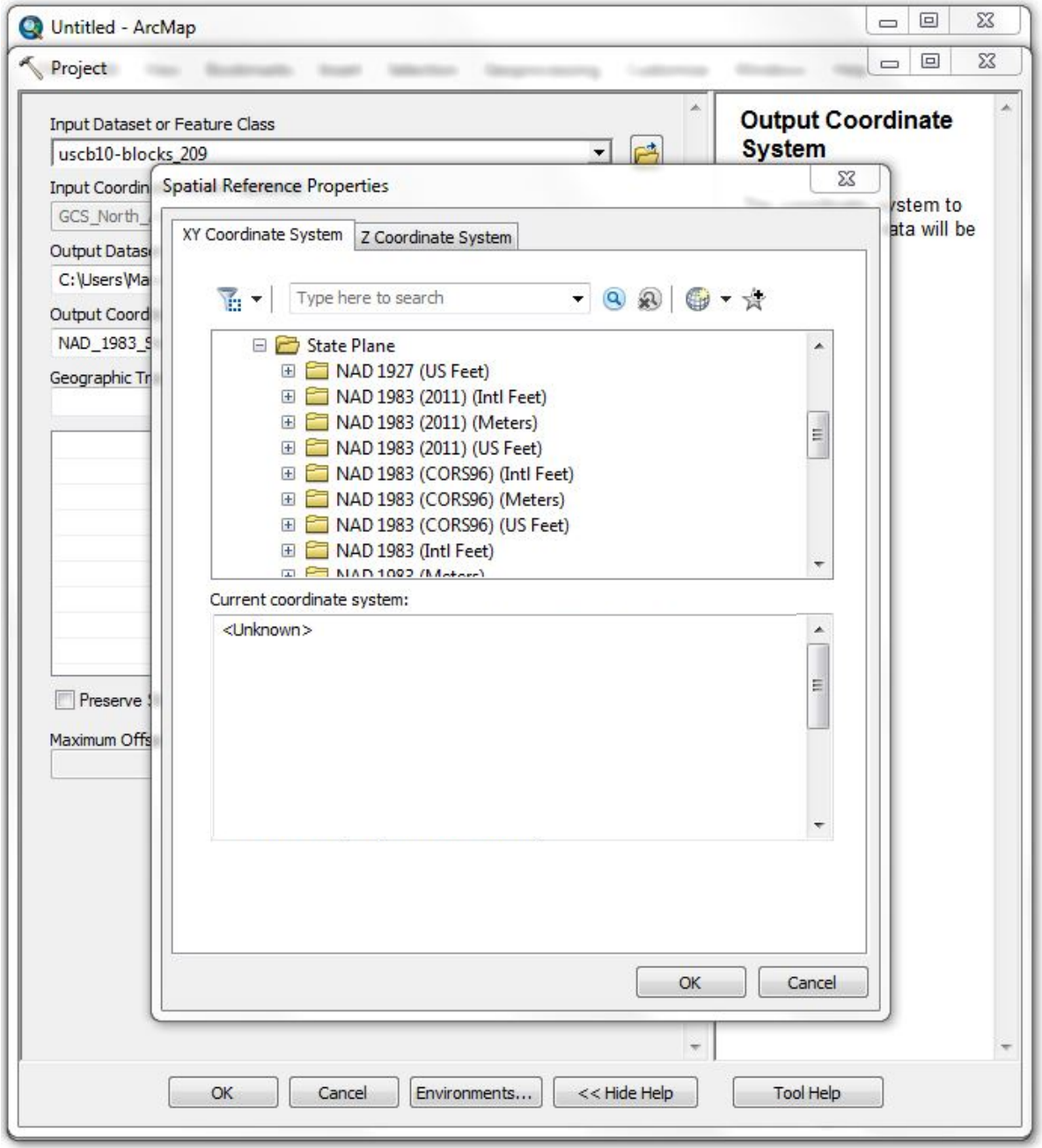
Coordinate system

- Choices:
  - Geographic
  - Projected
  - Data frame layers



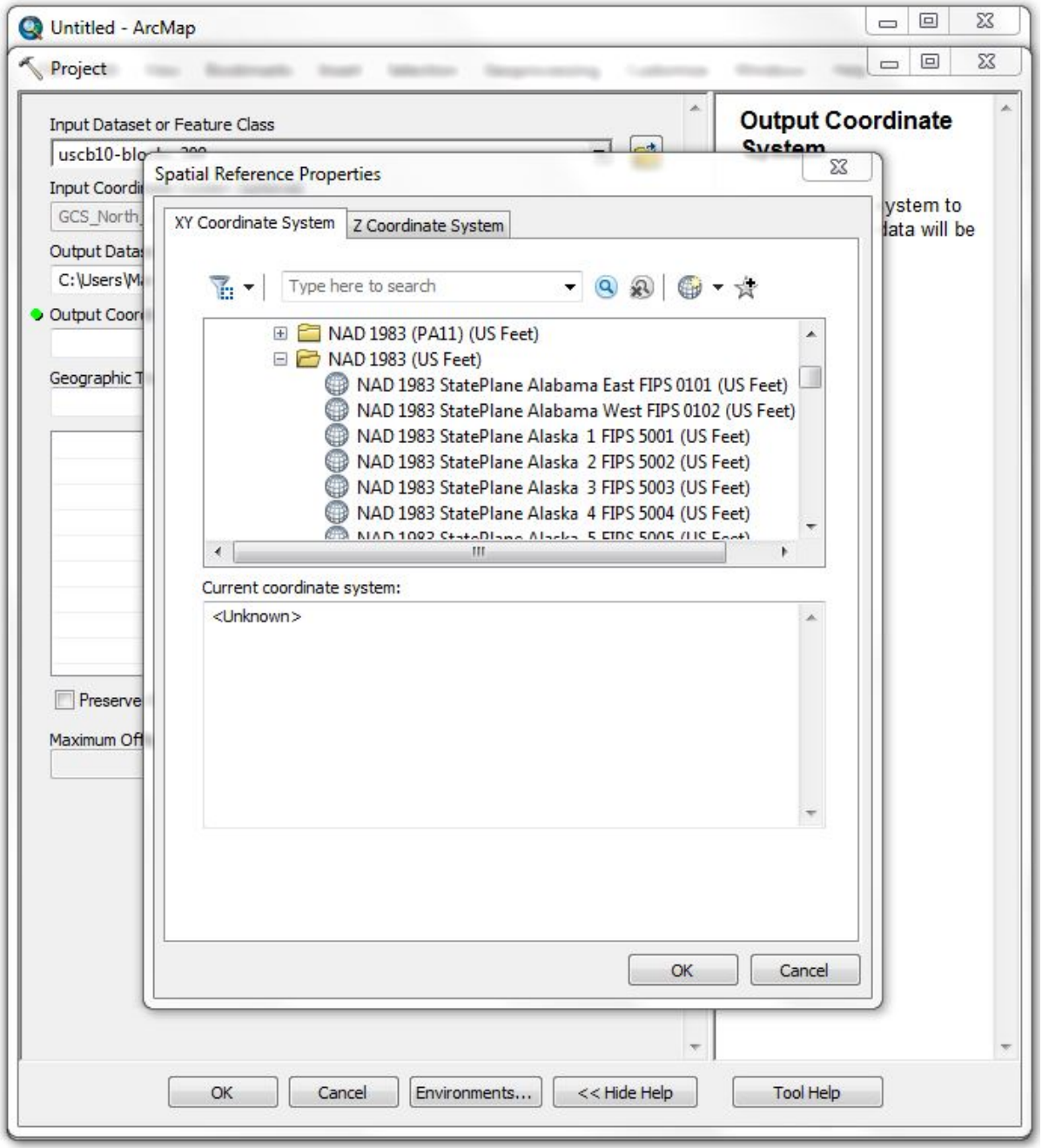
Coordinate system

- Projected Coordinate Systems -> State Plane
- Why State Plane
  - Small area, local projection -> most accurate
  - Has the same GCS as the layer, NAD 83



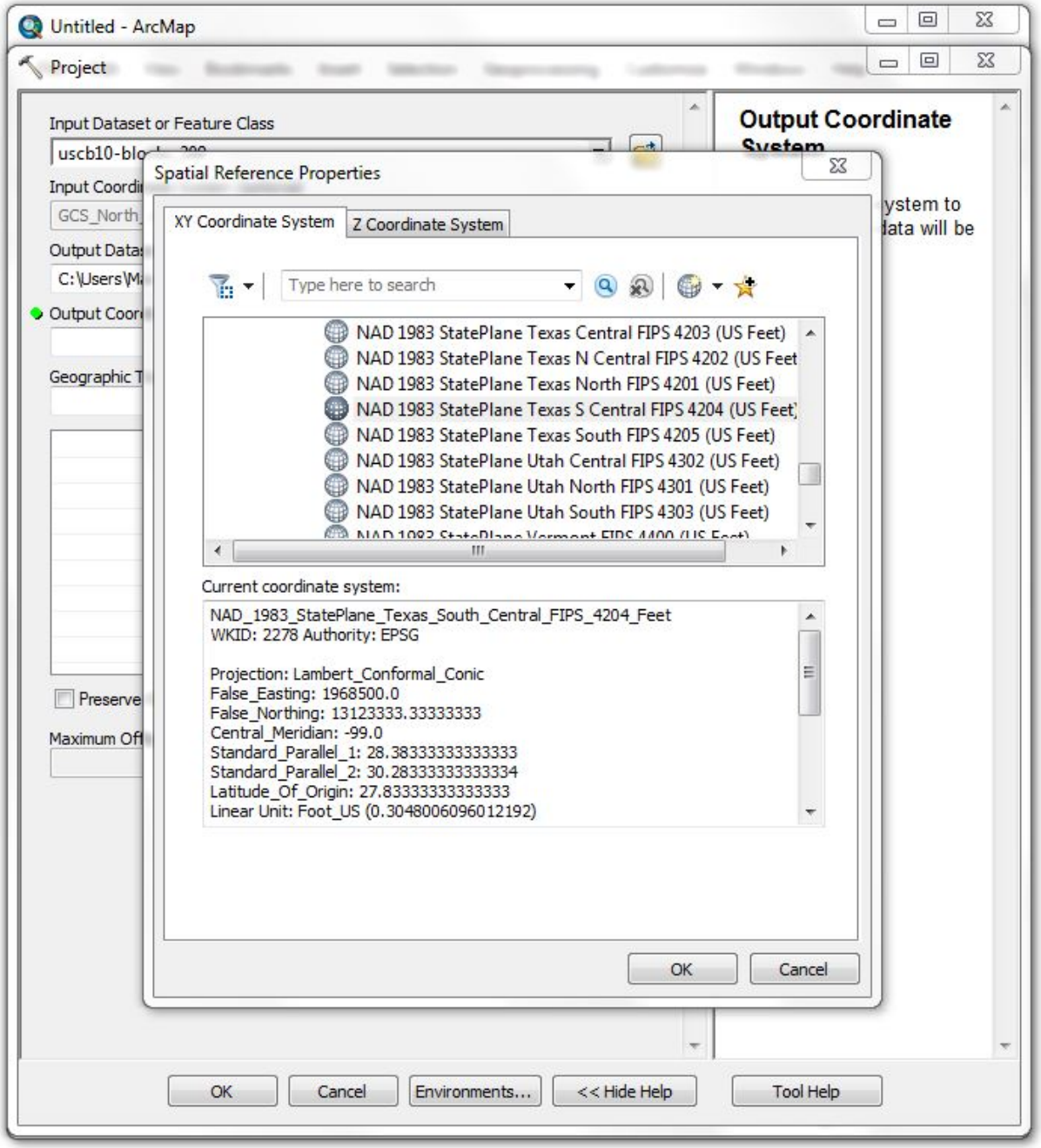
Choose GCS Variant

- State Plane PCSs:
  - GCS
  - Unit of measure
- Only one matches our GCS: NAD 83 (US Feet)



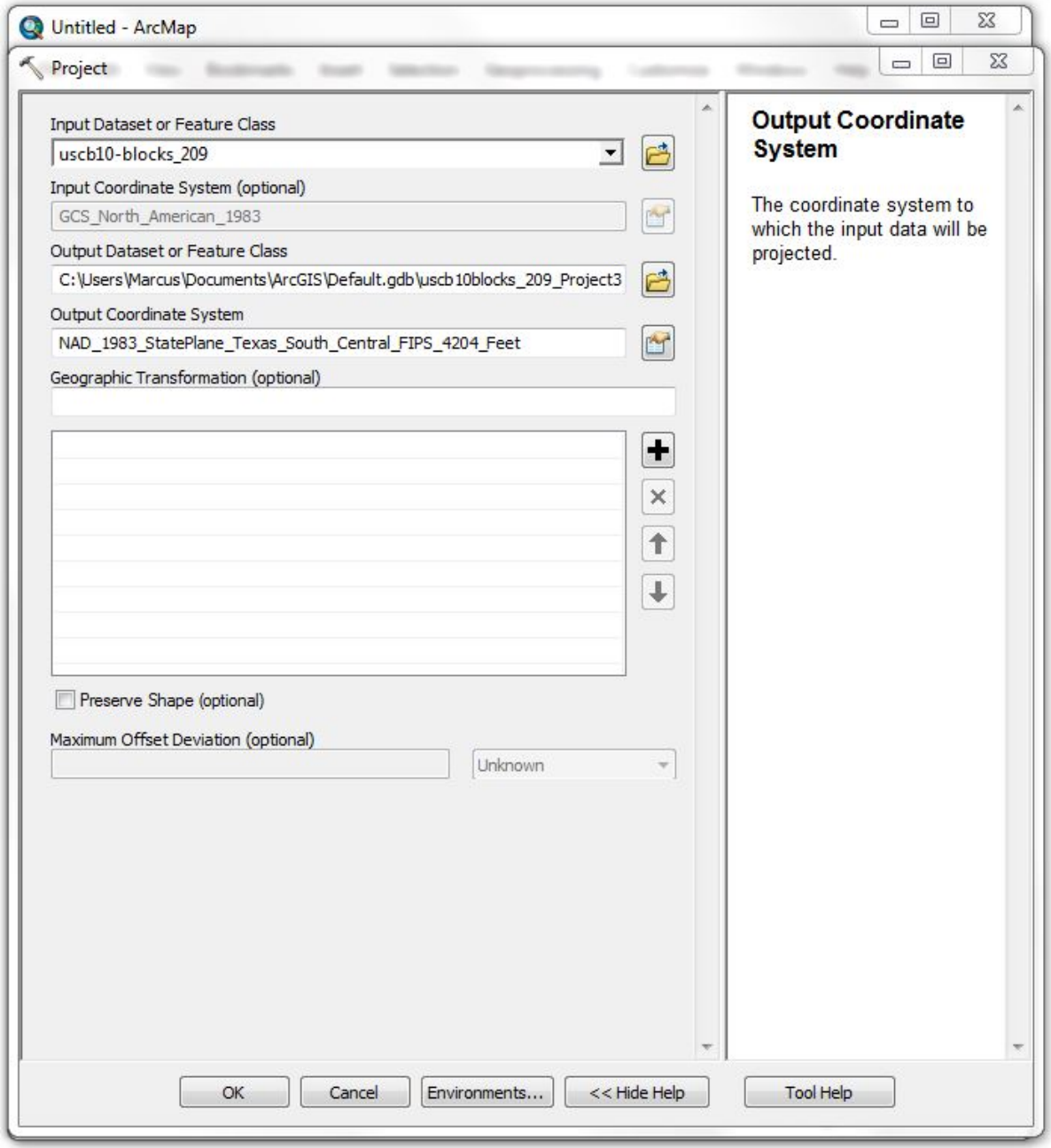
Choose GCS variant

- Open the NAD 83 (feet) folder
- Scroll down



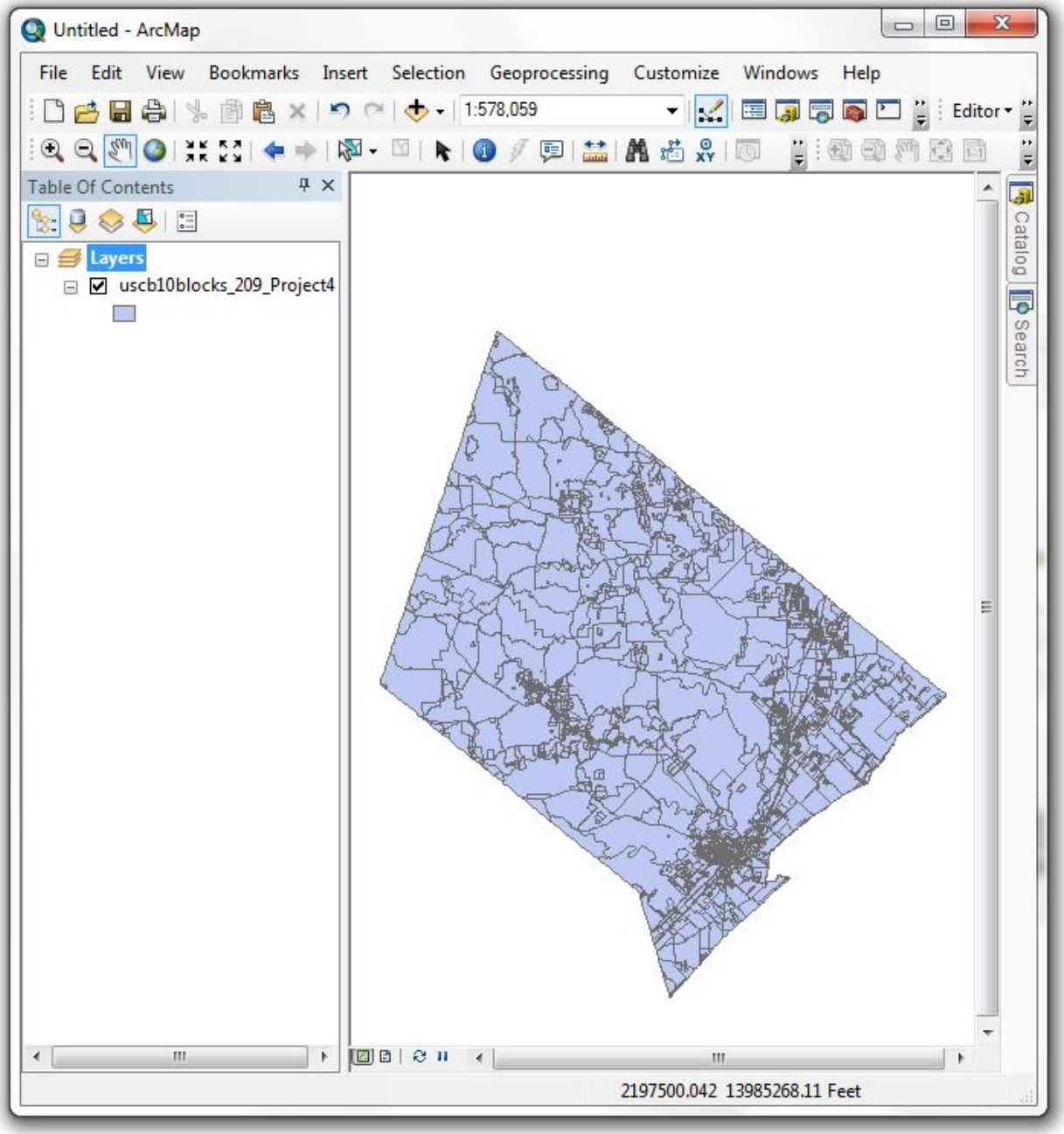
Choose State Plane Zone

- Select Texas South Central
- Hit OK



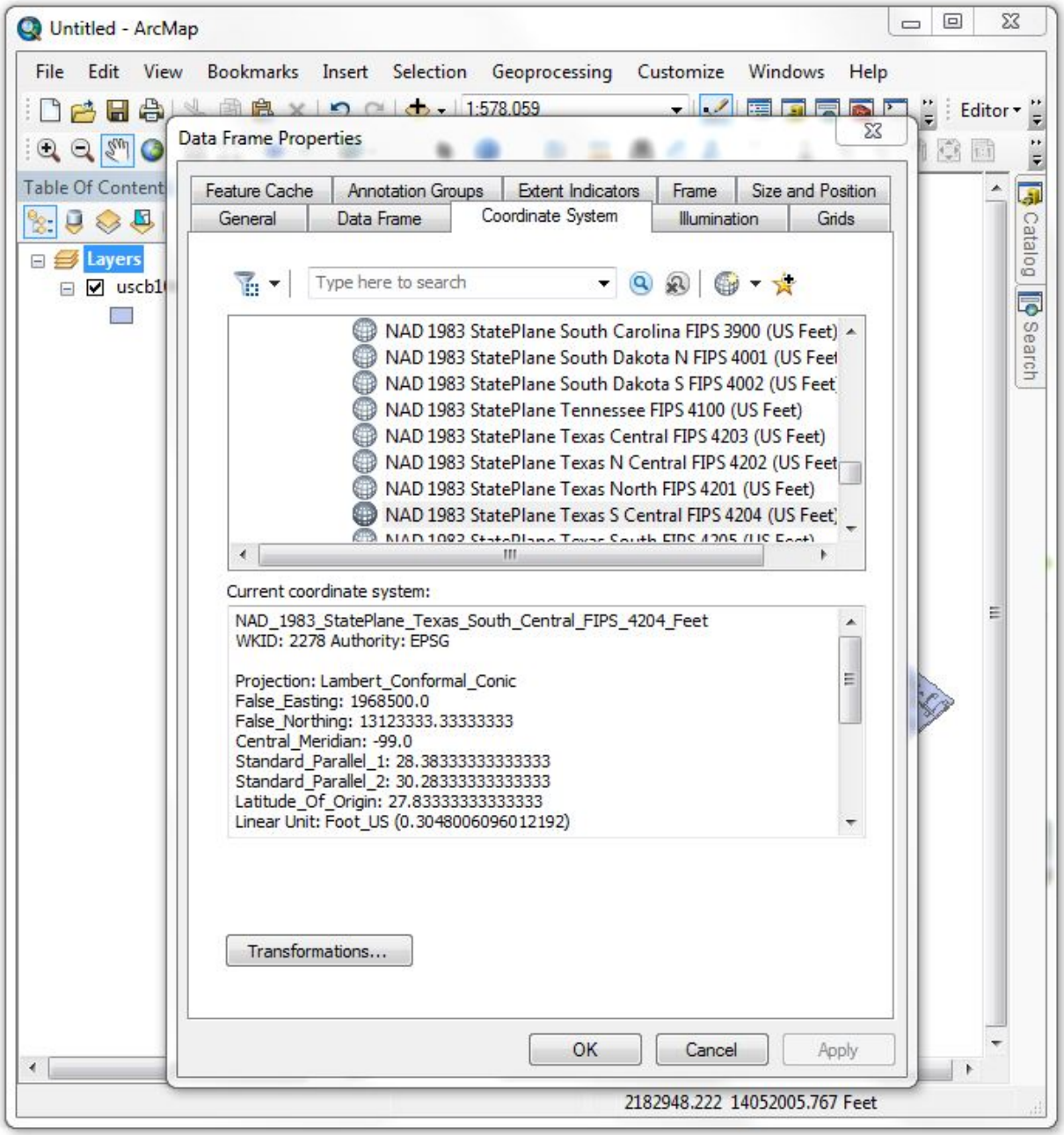
Ready to finish

- No Geographic Transformation needed
- Click OK

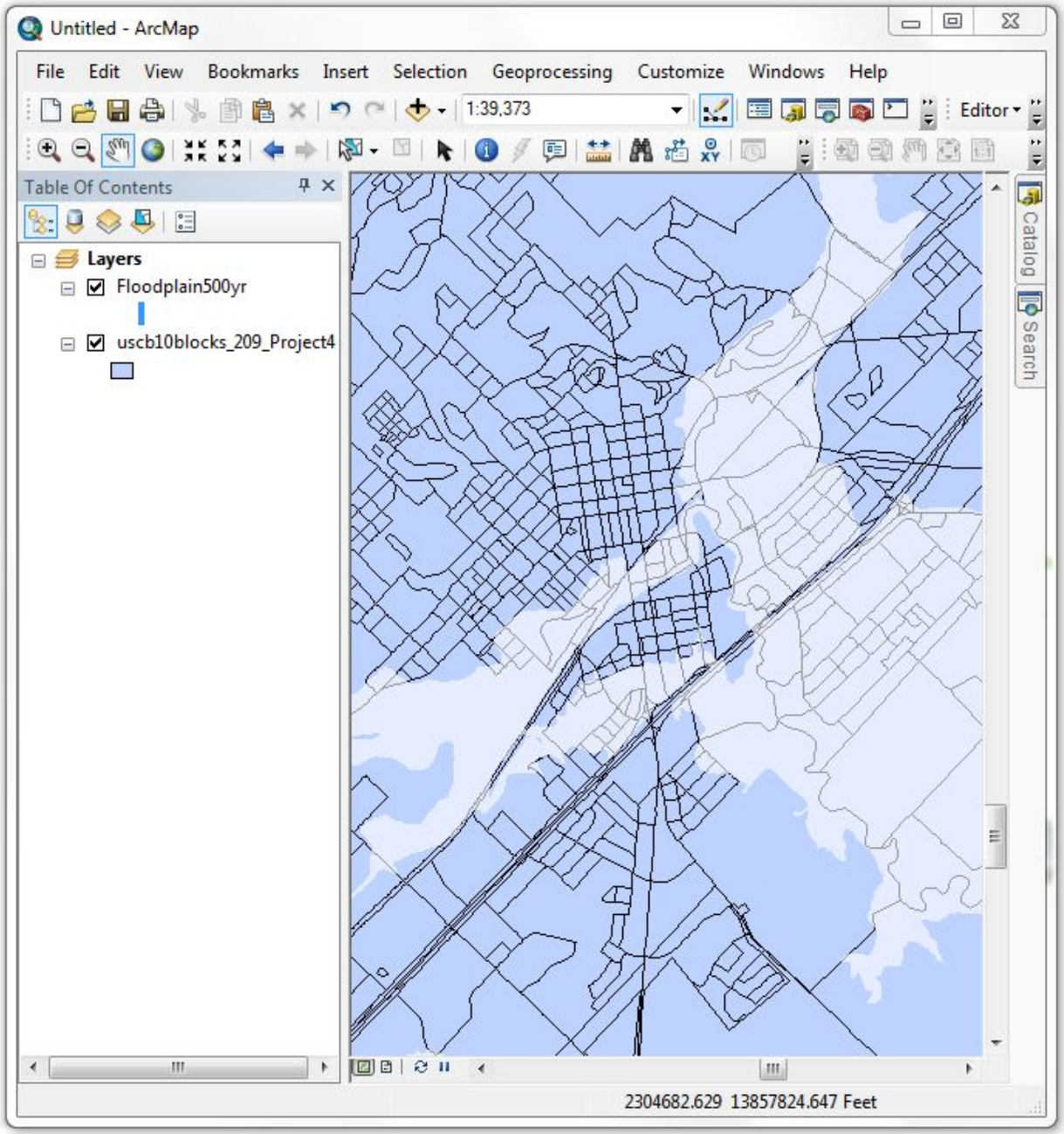


Start over with blank map

- Add the newly projected data
- Result shown: looks a bit different

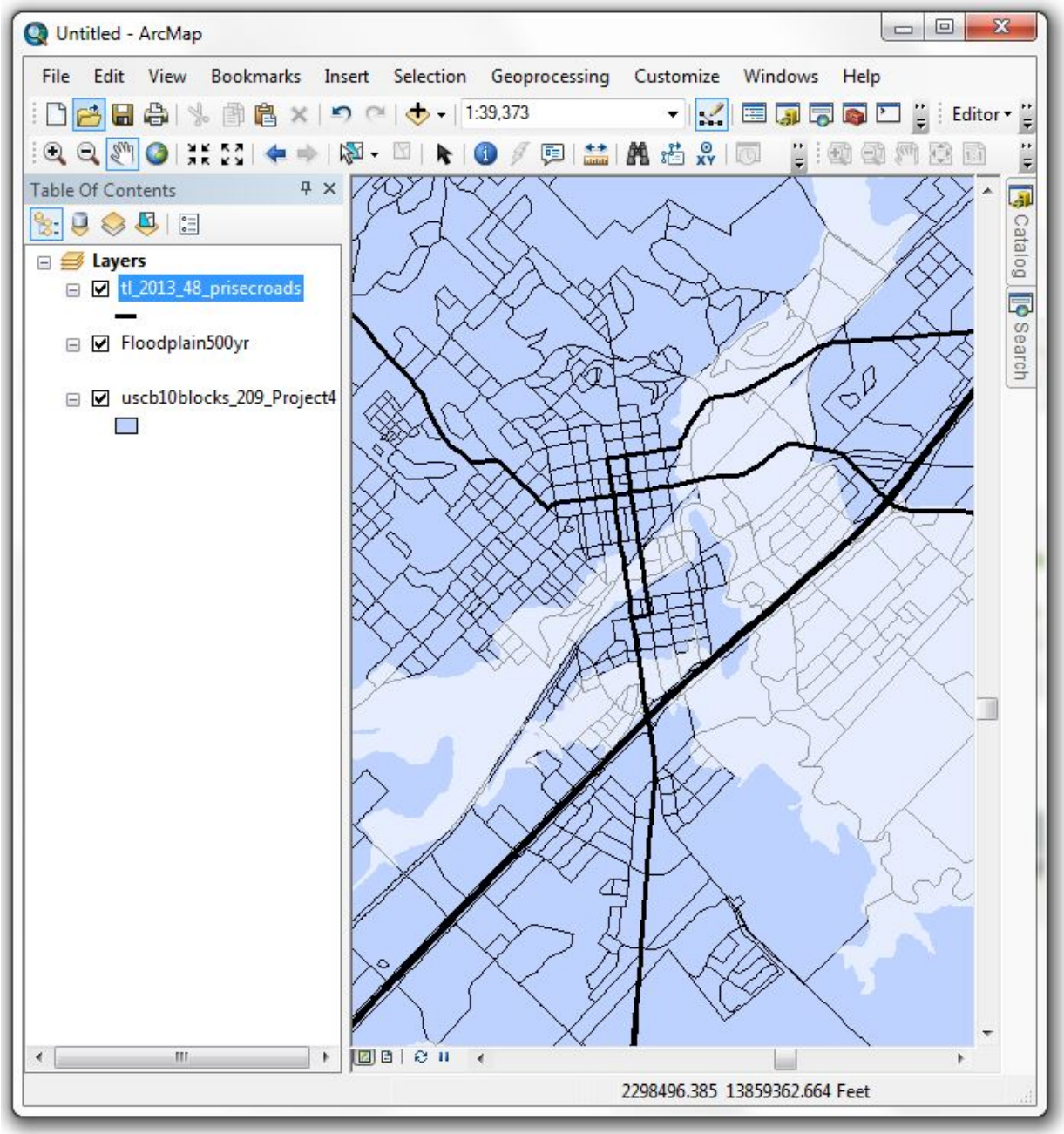


Data frame now has Projected coordinate system



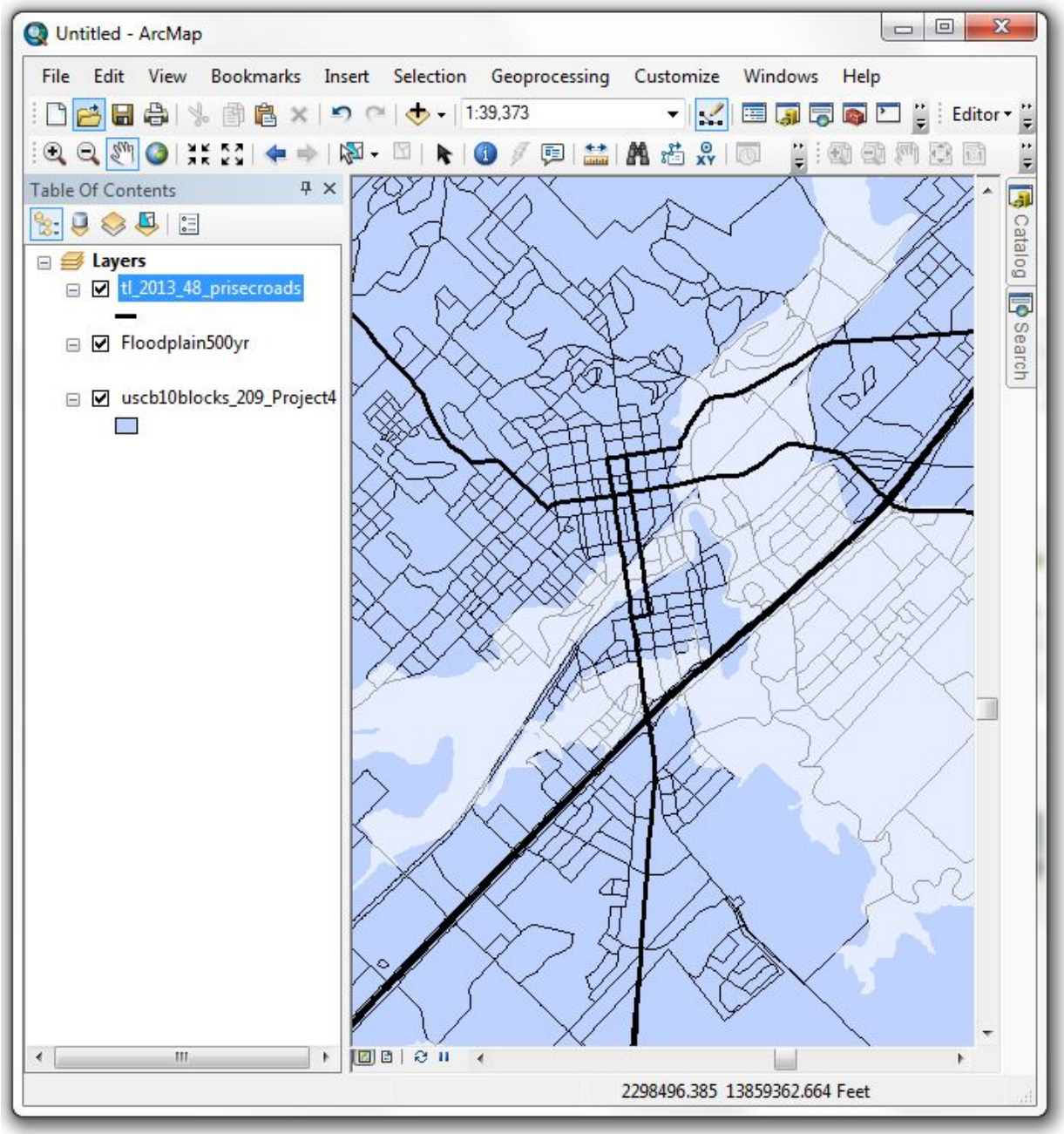
Add floodplain data

- Add 500 year floodplain layer
- From City of San Marcos website: 2005 Floodplain dataset
- Zoomed in on central San Marcos



Add Texas roads

- Add Texas main road layer
- From Census Bureau 2013 Tiger Line Files
- Coordinate system:
  - NAD 83
  - Projects on the fly to the state plane PCS



Results

- Can see that many Census blocks are entirely in the 500 year flood area
- Could do analysis to see how many households were in the floodplain
- Can compare this or the 100 year floodplain map to actual flood maps when they come out

Summary

- You need at least a GCS to create/use GIS data
- Data in a data frame should have the same geographic coordinate system
- Projected coordinate systems help with map aesthetics and accuracy.
- “Project on the Fly” will attempt to line up data layers with different coordinate systems
- Use the Project Tool in ArcGIS to create or change the coordinate system in a data layer