Lab 04: Mapping Rainfall in 3D
Due: *29 October 2010*

Objectives:

- Retrieve a set of state boundaries from the National Atlas website.
- Use the query builder to reduce the state data set to only show California.
- Make a new Theme of points (hypothetical rain gauge stations located on a lat-long grid in California) both manually and automatically.
- Join an external spreadsheet with rainfall amount to the attribute table of the rain gauges
- Label the points with the rainfall amounts
- Create a 3D model and contour map of the rainfall with ESRI's 3D Analyst Extension.

Purpose:
This exercise will introduce you to joining tables in a database, creating interpolated surfaces from point data and 3-D visualization in ArcGIS.

Step 1: Log on to the computers and set up your folder
Log-on:

a) At the login window enter your student user name and password.
b) Create your own working directory:
    1. Open (dbl-click) **My Computer**
    2. Open (dbl-click) your USB flash drive under **Devices with Removable Storage**
    3. Open the folder "***YourLastName*_GEO157**", e.g. Cochran_GEO157
    4. Create a new folder "**Lab04**"

PART I:

Step 2: Copy GIS data to your folder
This exercise will begin with a theme (aka shapefile) of U.S. states that you will reduce to just CA by means of "querying". To prevent corruption or disruption of these data files, you **MUST** first copy these files to your own ***Lab04*** folder.

Note: *you **MUST** copy **ALL** components of GIS themes, not just the *.shp component. ALL components of a theme are required for the theme to be visible and editable.*

a) Go to http://nationalatlas.gov/mld/statesp.html
b) On the right-hand side of the screen find "**Raw Data Download**" and left-click on **"State Boundaries", go to next page.**
c) Find **"shapefile: statesp020.tar.gz" i**n the row of "**State Boundaries**", right-click on it; select **Save Target As** (or **Save Link As** for Mozilla)**.**
d) Save the zipped, tarred file in your ***Lab04*** folder.
e) Unzip and untar the file. If the machines in the computer lab do not have the

software to untar, the untarred folder can be found with the Lab04 assignment on the iLearn website.

Note: *Notice that the directory contains a shape file and several other ArcGIS format files.*

f) Move all of the files into the top tier of your ***Lab04*** folder and clean up your directory by removing the original download file and the statesp020 folder.

Note: *What is the original projection of the data? The projection information can be found on the national atlas website.*

Step 3: Start ArcMap and set Layer properties

a) Open Arcmap and select "a new empty map".
b) Save the project as *Your_Last_Name_Lab04* in your new ***Lab04*** directory.
c) Set the coordinate system of the Data Frame (or **Layers** in the Table of Contents (ToC)) to NAD 1983 **(Predefined** > **Geographic Coordinate Systems** > **North America > North American Datum 1983).**
d) Press **Apply**, **OK**. The ArcMap Data View re-appears. Save your empty map.

Step 4: Bring the states theme into ArcMap and define projection

Move your mouse around in the map window. X,Y coordinate values (possibly expressed in unknown units) in the lower RH portion of the ArcMap window change as you move the mouse N,S,E,W in the window. We will specify decimal degrees (DD) for these coordinates after we add the *states* theme.

a) Press the **Add Data** button in ArcMap. Select *statesp020.shp* in your ***Lab 04*** folder.

Note: *States.shp should appear in the ArcMap window after a warning about the projection being unknown. We need to tell ArcMap that the projection is North America 1983.*

b) Open **ArcToolbox** (Window > ArcToolbox).
c) Open **Data Management Tools** under ArcToolbox.
d) Open **Projections and Transformations.**
e) Double-click on **Define Projection.**
f) The *statesp020.shp* is the Input Dataset.
g) Change the coordinate system to **North American Datum 1983**.
h) Save your project.

Step 5: Isolate California as a new layer

Notice that all the US states are shown. We don't need all the states; we only want the outline of California as our map area. Notice that each state border is composed of more that one entry in the attribute table. You will use the *states* attribute table and a query to isolate California.

a) Rt-click *statesp020* in the ToC; select **Open Attribute Table.** The *states* attribute table appears.
b) From the *statesp020* attribute table, press **Options** > **Select By Attributes.**

Note: *Now you will create a query to separate California from the rest of the states.*

c) In the "Method": window, select "**Create a new selection**"
d) In the "SELECT * FROM statesp020 WHERE" space, build your query **with your mouse** as follows: "State" = 'California'.
e) Click **Apply**.

Note: *In the map window, the California entries are highlighted in bright aquamarine blue in the attribute table and outlined in blue on your map view. If you can't see CA, select the* ***+*** *magnifying glass from your tool bar and magnify your map view until you can see it.*

f) To show the selected records, click on **Show:** *Selected*.
g) Rt-click on *statesp020* in the ToC; select **Data > Export Data**
h) Export the "Selected features" using the coordinate system of "this layer's source data".
i) Edit the output shape file to *California.shp* and make sure it will be saved in your ***Lab04*** directory.
j) Click **Yes** when asked if you want to add the selected data as a map layer. If you are not automatically asked, you will need to manually add *California.shp.*

Note: *A new theme, entitled "California" appears in the ToC and also in the Data View. Turn off statesp020 (uncheck the small box in the ToC); the statesp020 theme becomes invisible. California (which shows only the border of CA) is now the only visible theme in the Data View.*

Step 6: Make the California theme a permanent theme

a) Rt-click on *California* in the ToC **> Save as Layer File**.
b) Save the new layer as *California.lyr* in your ***Lab04*** folder.
c) Now we want to change the symbology of *California* from a solid polygon to an outline. Select **"Hollow"** from the list of symbols.
d) Remove the *statesp020* theme by rt-clicking it in the ToC; select **Remove**. This operation removes *states020* from the ArcMap window, but it still remains in your ***Lab04*** folder.
e) Select **File** > **Save**

Step 7: Change the View Units from Degrees-Minutes-Seconds to Decimal Degrees

An analogy for degrees-minutes-seconds (DMS) and decimal degree (DD) coordinate systems can be drawn from a clock. You can write 6:30 as 6:30:00 (i.e., 6 hours, 30 minutes, zero seconds). Another way to express 6:30:00 could be 6.50 (in decimal hours). One system uses hours-minutes-seconds, while the other uses decimal fractions of hours, but the actual time remains the same. Likewise, either a DMS or a DD coordinate system can be used to locate the same point in space. For Lab04, the DD system will be easier to work with as you manually plot new points, so you will set the display units to DD. If your project units are already set to DD, you can skip these steps.

a) Rt-click on **Layers** in the Table of Contents (ToC) > **Properties** > **General** tab. In the Data Frame Properties that opens, notice that the Units > "Map" window contains a grayed-out **Decimal Degrees**, reflecting the predefined map units that are embedded in this theme.
b) In the "Display" window under "Units:" select Decimal **Degrees**
c) Press **Apply**, **OK**.

Discussion - *Move the mouse over California. Note that the coordinates are now in decimal degrees. Why is it that the X coordinate is negative? The answer lies in what you (hopefully) learned in middle school geometry class: all the numbers above and to the right of (0,0) in a Cartesian coordinate system are positive, whereas all the numbers to the left and below (0,0) are negative. Degree designation in GIS makes sense when you define the intersection of the Equator and the Prime Meridian as (0,0). The Prime Meridian (PM) runs through Greenwich, England. California is west of the PM, to the left of it in map view. Therefore, any units of measurement along the X-axis (longitude) in CA are negative.*

Step 8: Create a new attribute table and point theme for rainfall gauging stations

You will now perform onscreen, manual digitizing of 10 points to create a new theme that represents the locations of 10 rainfall measurement gauges in California. You will learn how to do this in a faster, more automated manner later in the exercise.
Recall from Lab01 that you must use **ArcCatalog** to create (and name) an empty shell of a shapefile before you start filling it with points.

a) Open **ArcCatalog** (**Start > All Programs > ArcGIS > ArcCatalog**).
b) Create a "link" to your ***Lab 04*** folder in the left window. Your current GIS shapefiles in your folder appear in the RH window.
c) At the top bar of ArcCatalog, select **File > New > Shapefile**. A Create New Shapefile window appears, with a default shapefile name (*New_shapefile*) in the Name window.
d) Type *rain_locs_manual* in the Name: window. Select "Point" as the Feature Type.
e) Define the coordinate system as North American Datum 1983
f) Click **OK**; *rain_locs_manual.shp* appears in the RH window.

Discussion: *Make sure you have both the ArcCatalog and ArcMap windows open, small enough so they are both visible on the screen. Make sure that the "Display" tab (NOT "Source" tab) at the bottom of the ToC is active.*

a) Copy and paste (or drag) the *rain_locs_manual.shp* icon from ArcCatalog into the ToC of ArcMap. Click **OK** if a "one or more layers are missing spatial reference information" window appears. Drag the *rain_locs_manual.shp* from the bottom of the ToC to the top.

Note: *It is good practice to have your vector data at the top of the ToC followed by raster data. In this manner, your vector data should be ordered as point, line, polygon from top to bottom, respectively.*

b) Once you have copied the *rain_locs_manual.shp* over to ArcMap, close ArcCatalog.
c) Select *rain_locs_manual.shp* (it will turn dark blue in the ToC). You are now ready to edit the new feature you've created.
d) Turn on your Editor tool (Go up to **View > Toolbars,** and make sure the Editor toolbar is checked).
e) Select the black arrow next to Editor and select **Start Editing f**rom the drop-down menu. A **Start Editing** window may appear that asks which folder or database you want to edit.
f) Select the file that you want to edit, in this case *rain_locs_manual*; click **OK**.

Note: *Before going any further, MAKE SURE that: a)* ***Create New Feature*** *is in the "Task" window and b) rain_locs_manual.shp is in the "Target window".*

Step 9: Perform onscreen digitizing of 10 rain gauge locations

You will manually perform "onscreen digitizing" (OSD) of the following 10 rain gauge stations by using a point to locate each station. Each time you digitize a point, you will also type in the ID number for that point in the ID column of the attribute table.

1	-117.00	33.00
2	-116.00	33.00
3	-115.00	33.00
4	-117.50	34.00
5	-114.50	34.00
6	-120.00	35.00
7	-119.00	35.00
8	-118.00	35.00
9	-117.00	35.00
10	-116.00	35.00

a) Set the map scale to 1:750,000 (you can simply type this into the scale bar). Use the mouse to find the location of the first point by following the lat-long coordinates in the lower RH portion of the screen.

b) You will need to view the area of the map that contains the above points. You may need to Zoom to Layer to view the entire state of California (Rt-click California > Zoom to Layer) Select the hand on the toolbar and drag the map to a new location if necessary.
c) Open the *rain_locs_manual.shp* attribute table. Note that the attribute table has FID, Shape, and ID fields.
d) Click on the pencil tool in the Editor toolbar to “create a new feature”. You will now be able to use the pencil to draw a point that will be saved as a feature on the map and in the *rain_locs_manual.shp* attribute table.
e) Move the mouse to your first point (-117.00, 33.00) and left-click. A bright, aqua-blue point should appear on the map, and a new line in bright blue should appear in the attribute table.
f) In the attribute table, select the ID entry (0) and type 1. Press **Enter** on your keyboard to save the ID entry.
g) Move to the next point (-116.00, 33.00), digitize the point and enter the ID value (2) in the attribute table.
h) Continue digitizing and entering ID values for the remaining 8 points. If you make a mistake in digitizing a point, you can delete the point by right-clicking the row in the attribute table and select "Delete Selected".
i) Select **Editor > Save Edits** periodically during the digitizing process. When you have finished all 10 points, select **Editor > Save Edits** and finally **Editor > Stop Editing**.
j) **File > Save** to save your project.

Step 10: Create 30 rain gauge station points in MS Excel

ArcMap can recognize columns of X,Y data in tables and automatically plot points, which can be a much faster way to create a large number of points than manual digitizing. You will create a table of 30 rain gauge data points in MS Excel and save it as an .xls (Excel) file. You will then save it as a .dbf (dBase) or .csv (comma delimited) file.

a) Open a new MS Excel workbook or worksheet. A blank spreadsheet appears.
b) Type these 3 column headers in the first row: ID Lon_degrees Lat_Degrees
c) Type in values from 1 to 33 in the ID column (*Hint: Excel shortcut! After entering "1" in the first cell, drag down to the next cell. Click the small box that appears below the bottom right corner of the cell and select "Fill Series". This should fill a "2" into the cell below "1". Use the same method and drag down 33 cells*).
d) Select the B and C column headers (columns selected in blue); select **Format** > **Cells.**
e) The **Format Cells** window appears; select **Number** under “Category:” and **2** in “Decimal places”
f) Press **OK**

Note: *There should be no empty columns or rows in this spreadsheet! If names are too* *long for an initial column width, simply make the column wider (use Help if necessary). It is* ***CRITICAL*** *to format the latitude and longitude columns for 2 decimal places. Otherwise, Excel will automatically round the lat-long values to whole numbers, which will cause a number of points to "overplot" on top of each other.*

g) Enter the following latitude and longitude data into the spreadsheet:

ID	Lon_degrees	Lat_degrees
1	-124.00	40.00
2	-124.00	41.00
3	-123.50	42.00
4	-123.00	39.00
5	-123.00	41.00
6	-122.50	38.00
7	-122.00	37.00
8	-122.00	39.00
9	-122.00	41.00
10	-121.00	37.00
11	-121.00	39.00
12	-121.00	41.00
13	-120.50	36.00
14	-120.50	40.00
15	-120.50	42.00
16	-120.00	35.00
17	-120.00	37.00
18	-120.00	39.00
19	-120.00	41.00
20	-119.50	38.00
21	-119.00	35.00
22	-119.00	37.00
23	-118.00	35.00
24	-118.00	37.00
25	-117.50	34.00
26	-117.00	33.00
27	-117.00	35.00
28	-116.50	36.00
29	-116.00	33.00
30	-116.00	35.00
31	-115.00	33.00
32	-115.00	35.00
33	-114.50	34.00

k) When you've finished entering the data, highlight all the columns and rows that contain data and then select **File>Save As.** Navigate to your ***Lab04*** folder and save as *rain_locs_auto*.xls (Excel) file. Lastly, re-save the file as a *.dbf* (dBase) (or *.csv* (comma delimited) file if *.dbf* is not available).

***Note: Make sure** you save this Excel spreadsheet **inside** your **Lab04** folder! **Use underscores (_)** between file name words to avoid error messages later.*

Step 11: Add X-Y (lon-lat) data and automatically create a new point theme
In ArcMap, longitude and latitude are interpreted as "X" and "Y" values in a coordinate system. ArcMap can read the longitude-latitude values from *rain_locs_auto.dbf* and automatically plot those values on a map much faster than you can plot manually.

a) From the ArcMap upper menu bar, select **Tools > Add XY data**:
b) In the **Add XY Data** window that opens, browse to your ***Lab04*** folder and select *rain_locs_auto.dbf*. The **Add XY Data** window returns.
c) ***rain_locs_auto*** is in the "Choose a table…" window, **LON_DEGREE** is the X field, and **LAT_DEGREE** is the Y field.
d) Edit the Coordinate system to be North American Datum 1983
e) Click **OK.** A layer of 33 points appears, named ***rain_locs_autoEvents***.

***Note:** If there are **NOT** 33 points, you formatted the lat-long columns of the original Excel spreadsheet incorrectly; you must return to that step and perform it correctly. Rt-click on rain_locs_autoEvents > **Open Attribute Table**. It appears with Latitude, Longitude, FID, ID, and Shape columns. **Don't panic** if the X and Y values do not all show 2 decimal places; ArcGIS has chopped off unnecessary zeroes. If you formatted the original Excel sheet correctly to 2 decimal places, each one of the 33 points will plot as in the map above.*

Step 12: Creating external "rainfall" table for joining
One of the most powerful features of a GIS is its ability to "join" external spreadsheets and databases to internal attribute tables. This enables mapping ALL the attributes from the "joined" table, even though this table is not "in" a GIS per se. In this next step, you will create a spreadsheet of measured rainfall data taken from each of the 30 rain gauge stations that you just plotted. You will be joining this external "rainfall" spreadsheet to "rain_locs_auto"

a) Open MS Excel, and set up a spreadsheet with two columns of data - **ID** and **rain_2006**.
b) Enter the following data:

ID	**rain_2006**
1	10.00
2	6.00
3	4.00
4	21.00
5	3.00
6	15.00
7	23.00
8	13.00
9	4.00

10	3.00
11	7.00
12	22.00
13	4.00
14	35.00
15	11.00
16	12.00
17	34.00
18	5.00
19	31.00
20	38.00
21	43.00
22	19.00
23	66.00
24	26.00
25	82.00
26	13.00
27	95.00
28	47.00
29	68.00
30	18.00
31	13.00
32	80.00
33	15.00

c) When you are done entering the data, highlight the occupied cells and save this table in your ***Lab04*** folder as *rainfall_2006* first in ***.xls*** and then in ***.dbf*** (or ***.csv***) format, like you did earlier for *rain_locs_auto*. Refer to those steps if necessary.

Step 13: Join rainfall data to the rain gauge locations

In order for one table to be joined to another, the tables must share a common field (column) known as the "primary key". There are various types of joins, but the one you want to perform here is "one-to-one", because you want one 2006 rainfall amount value to be associated with one (and only one) rain gauge. The primary key will be **ID**.

a) In ArcMap, rt-click on *rain_locs_autoEvents* > **Joins and Relates** > **Join**:
b) A **Join Data** window appears:
   1) Fill in the blanks: "What do you want to join to this layer?" **Join attributes from a table**
   2) Choose the field in the layer that the join will be based on: **ID**
   3) Choose the table to join to this layer: **rainfall_2006**
   4) Choose the field in the table to base the join on: **ID**. Click **OK.**
c) In ArcMap, rt-click on *rain_locs_autoEvents* in the ToC > **Open Attribute Table**.
d) The source of the field can be determined by the prefix

(rain_locs_auto_Features and rain_2006). The unique identifying number that is the same for each row is **ID**.

Note: *To preserve your points, it is wise to convert this "events" theme to a shapefile.*

a) In the ArcGIS ToC, rt-click on *rain_locs_autoEvents* and export this layer as a shapefile named *rain_locs_with_rain*. Be sure to save to your ***Lab 04*** folder.
b) Add the new shapefile to your ToC. Note that the points should directly overlie those of *rain_locs_autoEvents*; if so, rt-click > **Remove** *rain_ _locs_autoEvents.*
c) **File** > **Save** your project.

Step 14: Labeling each rain gauge station

Prior to construction of a 3D model and contour mapping of rainfall, it is wise to label each gauging station with the 2006 rainfall recorded at that location, since this is the data that will be used to construct the model and create the contours.

a) Rt-click on *rain_locs_with_rain* in the ToC **> Properties.** Select the **Labels** tab and fill in the **Layer Properties** window with the following information.
    1) Check box next to "Label features in this layer".
    2) Method: "Label all features the same way"
    3) Label field: **rain_2006** (ArcGIS truncates *2006_rain_in* to 10 characters maximum)
b) Click **Apply;** click **OK.** The 2006 rainfall amount appears to the upper right of each rain gauge station point.
c) **File** > **Save** your project to your ***Lab04*** folder

Step 14: Create a triangulated irregular network (TIN) with 3D Analyst

Introduction: 3D visualization of "continuous surfaces" and the companion ability to represent these 3D surfaces in 2D are very useful skills because they allow you to interpret ("map") data and communicate those interpretations to a wide audience. An example of a continuous surface is the Earth's surface, which is 3D in nature. This 3D surface can be represented in 2D by creating a map of points, each with an attribute of elevation above sea level, and then drawing "isolines" ("iso" means equal) to connect equal elevation values. Hills and mountains are typically contoured as "closed highs" extending above sea level, whereas ocean basins are "closed lows" extending below sea level. In the same manner as you represent the Earth's surface in 3D or 2D, you can represent California's 2006 rainfall by creating a 3D model and creating a 2D contour map. If you need further background on continuous surfaces and contour mapping, consult your text, use Google, or ask your instructor for more information.

Triangulated Irregular Networks (TINs) are models of 3D surfaces that ArcGIS creates from vector point data. ArcGIS treats a user-defined attribute (e.g., elevation above sea level or 2006_rain_in) as a "z-value" ("elevation value") in X-Y-Z space, then it uses the simplest forms of planes (triangles) to connect these z-values together into a continuous surface. The TIN can then be displayed in 3D. It also serves as a surface that can be contoured in 2D.

a) Determine if the 3D Analyst extension pack is available by going to **Tools** > **Extensions** and marking a check next to all of the extensions (it is possible that not all extensions are available through the University license).
b) Activate 3D Analyst by clicking **View > Toolbars** and check **3D Analyst**
c) Click the dropdown arrow on 3D Analyst toolbar and select **Create/Modify TIN** > **Create TIN from features**:
d) A "Create TIN from Features" window appears:
    1) In the Layers: window, check the box next to *rain_locs_with_rain*.
    2) In the Settings for Selected Layer panel, choose the following settings:
        i. Height Source: **rain_2006**
        ii. Triangulate as: **Mass points**
        iii. Tag value field: **ID**
e) In the Output TIN window, browse to your ***Lab04*** folder and save this TIN file as *TIN_YourLastName*. Press **OK.**

Note: *The TIN (a polygon with different colors in a "stripe" pattern) should appear. If not, check your settings and directory path. If the settings and path look OK, but your TIN does not look right contact your instructor right away, rather than spend hours (literally) trying to troubleshoot the problem.*

Step 15: Modify the class breaks on the TIN to correspond with contour values

The TIN is a 3D model that uses colored bands to distinguish ranges of values. Note in your ToC that the TIN breaks at present don't make a lot of sense. The TIN has defaulted to an "equal interval" classification of values, which you will change momentarily.

a) Rt-click on *tin_** (where * is *YourLastName*) in the ToC > **Properties** > **Symbology**. Make sure that there is the **Elevation** option in the **Show** window and that the box next to **Elevation** is checked.
b) In the lower left part of the window, **uncheck "**show hillshade illumination effect in 2-D display".
c) Press **Apply**, **OK.** You now see the full range of TIN colors in the Data View.
d) Rt-click on *tin_** > **Properties** > **Symbology**. In the **Layer Properties** window, click the **Classify** button. A Classification window opens.
e) We now want to change the TIN breaks from the "equal interval" classification of values. In the "Method" window, select **Defined Interval**, and set the "Interval Size" to **5**.
f) Click **OK** in the lower right-hand corner of the window. The **Layer Properties** window returns. The breaks that separate the colors are now in increments of 5 inches of rainfall.
g) If you don't care for the default colors, select a "Color Ramp" that is pleasing to you. Press **OK.** The Data View returns with the TIN color-coded according to your specifications.

h) Save your project.

Step 16: Display the TIN in 3D in ArcScene
ArcScene is part of the ArcGIS package (along with ArcCatalog and ArcMap). It enables you to bring 3D files into a view, and then manipulate them in order to aid 3D visualization.

a) Select **Start > All Programs > ArcGIS > ArcScene**. An empty ArcScene window opens.
b) Select **File** > **Add Data** or press the **Add Data** button. Scroll to your *tin_** file and select it. The TIN appears, but in a very distorted manner.
c) Select **View** > **Scene Properties**:
d) The **Scene Properties** window appears: Select the **Genera**l tab.
e) Next to the “Vertical Exaggeration” window, press **Calculate from Extent**.
f) A number will appear in the “Vertical Exaggeration” window. Press **Apply**, **OK**. The TIN should look 3D in ArcScene.

NOTE: *You may have to rt-click and drag the mouse toward you to increase TIN size in the View by selecting the Navigate button, then pressing and holding the Right mouse button and pull the mouse toward you.*

g) Rt-click on the TIN in the ToC > **Properties** > **Symbology**.
h) In the **Layer Properties** window that appears, follow your previous steps
    1) Make sure there is the **Elevation** option in the **Show** window, check the box before **Elevation,** and select (highlight) it by left clicking on it once. *(Hint: If you do not have* ***Elevation*** *in your Show: window, click the Add button and select "Face elevation with graduated color ramp").*
    2) Uncheck “show hillshade illumination”
    3) Press **Classify**.
    4) In the **Classification** window, set the “Classification Method” to **Defined Interval** and set the Interval to **5** and then press **OK** in the **Classification** window
    5) Then press **Apply**, **OK** in the **Layer Properties** window. The Data View returns.
i) Select **File > Save As**, scroll to your ***Lab04*** folder and save the Scene as ***YourLastName_Lab04_3D.sxd.***

Note: *To maximize the 3D effect, select the Navigator button, then press and hold the Right mouse button and pull the mouse toward you. The image gets larger.*

Press and hold the Left mouse button and the image will start rotating about various axes, allowing you to move the image around in 3D space. Move the image to a position where you are looking at the side of the TIN, with the lines separating the 5-inch intervals approximately horizontal. This will help you see how contour lines are created.

Step 17: Create contours of CA rainfall with 3D Analyst based upon the rainfall TIN

The color breaks at every 5” of rainfall on the TIN wrap all the way around the TIN, except for the north end. You can see these breaks easily in 3D in ArcScene. In ArcMap, you can only view the TIN from a “map” view (directly from above). From above, the only places you see color changes are where the 5-inch increments intersect the outer surface of the TIN. These “isolines” are **contour lines**, drawn around the outer surface of the TIN. An isoline connects equal values of measurement on any continuous surface. In this exercise, you are going to create isolines at a contour interval (C.I) = 10”, and then overlay those contours on the 3D TIN of rainfall. This will give you a better understanding of how contour mapping allows you to represent 3 dimensions in 2D.

a) Re-open your ***YourLastName_Lab04.mxd*** project in ArcMap (not ArcScene).

Note: *There may be a red exclamation point (**!**) to the left of the TIN in the ToC; this indicates that you need to re-set the directory path to the source of your TIN. You can reset the source by double clicking the **!** and navigating to the tin_* file. Alternatively, you can rt-click on the tin_* (* = YourLastName) in the ToC > **Properties** > **Source** Tab. Click **Set Data Source** and navigate to your tin_* file.*

b) Click on the drop-down arrow on the 3D Analyst menu > **Surface Analysis** > **Contour**.
c) A **Contour** window appears (below left), select the following parameters:
   1) Input surface : **tin_*** (* = *YourLastName*)
   2) Contour Interval: **10** (1 line for every 10” of rain)
   3) Base Contour: **0** (this will be the first, lowest contour line)
   4) Z factor: **1** (a measure of vertical exaggeration)
   5) Output features: Use the folder button to set the directory path to your ***Lab04*** folder, and save the contour map as *rainfall_contours*.
   6) Press **OK** on the bottom of the **Contour** window

Note: *The rainfall_contours shapefile should appear in your map window and in your ToC. The default black lines should overlay the TIN at 10, 20, 30, 40, and 50”, at the breaks in color that correspond to each of those values.*

d) Rt-click on *rainfall_contours* > **Properties** > **Labels** tab; **Layer Properties** appears.
   1) Checkmark “Label Features in this layer”.
   2) In the “Label field:” window, select **Contour**
   3) Click **Apply**, **OK**. The ArcMap Data View will return with 10, 20, 30, 40, and 50-in rainfall contours labeled.
   4) Change the label properties and contour line symbology to fit your preferences.
e) Select **File** > **Save**

Step 18: Open ArcScene, add rainfall contours to the 3D view
You will use ArcScene to look at the relationship between a TIN and the Contour map created from it.

a) Re-open your ***YourLastName_Lab04_3D.sdx*** file.
b) Select **File** > **Add Data**, scroll to your ***Lab04*** folder, and select *rainfall_contours.shp*.

Note: *The contours are displayed in a flat plane, underlying the TIN. If you can't see the contours, use the Navigate tool to view the "underside" of the TIN. To make the contours visible on the 3-D surface, the operator has to instruct ArcMap to "drape" line features over the TIN.*

c) Rt-click on *rainfall_contours* > **Properties** > **Base Heights** tab:
    1) Under "Height:" select **Obtain heights for layer from surface**. The window should read *PathToYourFiles*/**tin_*** (* = your name).
    2) Leave the Z-init conversion at 1.
    3) Do not add an offset.
    4) Click **Apply, OK**. The contours "rise" into position at the breaks between colors.
d) Instead of text labeling, this time we will color the contour lines to show contour value. In the *rainfall_contours* **Layer Properties** window, select the Symbology tab.
e) In the **Show:** window, click **Categories** and select **Unique Values**.
f) In **Value Field**, select *Contour* from the dropdown menu.
g) Click the **Add All Values** button. Note that now the contour values appear with a colored line symbol. Change the **Color Ramp** to fit your preferences.
h) Select **File > Save**.

Step 19: Visually evaluate the rainfall TIN and contours in 3D and 2D
Spend some time moving the *TIN_** and *rainfall_contours* around in ArcScene. Rotate the image to the cross-sectional view portrayed in the exercise instructions above, and make sure you see how the contours wrap around the outside of the TIN, connecting equal values together (all the 10s, 20s, 30s, 40s, and 50s). Take the image to "map view" (as though you are directly overhead) and note its similarity to ArcMap - now it is a 2D view. Can you see how contours can represent 3D images in 2D? Contouring is perhaps the most powerful quantitative mapping tool in existence. Even nonspatial thinkers, managers, and your bosses can see "highs", be they for elevation, contamination, or number of crimes per day. If you learn how to use this tool, your analytical capabilities will improve immensely, along with your abilities to share your analyses with others.

Step 20: Export ArcScene views
ArcScene does not have a layout mode, so you will export a view from ArcScene.

a) Use the navigate tool to move your TIN so that it is in "map view" (as if you were staring directly down onto the surface).
b) Export the map in 2-D by going to **File > Export Scene > 2D ….** Save as ***YourLastName_Lab04_2D*** in both PDF and JPG formats.

Part II - Spatial Interpolation of Rainfall Data

Discussion: Many GIS models for environmental management and planning require rainfall as an input. However, most rainfall data is collected using rain gauges, which is point data in nature. For hydrologic modeling purposes however, spatially continuous data is required. To obtain spatially continuous data from a discrete number of data points, spatial interpolation methods must be used. The accuracy of a spatially continuous representation of rainfall is dependent on the number and location of rain gauges and the spatial interpolation method used.

In this section we will examine four different spatial interpolation techniques for interpreting our California rainfall dataset. Within the ArcToolbox Spatial Analyst toolset, we will use the following interpolation methods: inverse distance weighting (variable), and kriging (Ordinary: exponential), natural neighbor, and TIN (triangulated irregular network). Throughout this exercise, realize that we are working with models of rainfall data and that it is difficult to model the real-world variability of rainfall patterns. With this in mind, we want to evaluate the effects of different types of interpolation applied to the rainfall data.

Step 21: Spatial Interpolation of Rainfall Data: Kriging

a) Open Arcmap and select "a new empty map".
b) Save the project as *Your_Last_Name_Lab04_Spat_Interp* in your ***Lab04*** directory.
c) Set the coordinate system of the Data Frame (or **Layers** in the Table of Contents (ToC)) to NAD 1983 **(Predefined** > **Geographic Coordinate Systems** > **North America > North American Datum 1983).**
d) Press **Apply**.
e) Click the "General" tab. Rename the Name: of the Data Frame from "Layers" to "Kriging". Click **Apply**.
f) Click the "Data Frame" tab and set the **Extent:** to a **Fixed Scale** of 1:12,500,000. Click **Apply**, and **OK**.
g) Add the following data from your ***Lab04*** folder to your **Kriging** Data Frame: *rain_locs_with_rain* and *rainfall_contours* and *California*. Order the layers in this manner in the ToC.
h) In **ArcToolbox**, go to **Spatial Analyst Tools** > **Interpolation** > **Kriging**.
i) With the Kriging window open, select the following arguments:
    1) Input point features: *rain_locs_with_rain*
    2) Z-value field: *Rain_2006*
    3) Output Raster: navigate to your ***Lab04*** folder and call the new shapefile "*Kriging_rain*"

4) For **Kriging Method:** choose ***Ordinary*** then select "***Exponential***" from the dropdown menu.
5) Use the default values for the other fields.
6) Click **OK**.

j) After the kriging calculation is complete, *kriging_rain* should be added to your ToC under *California*. If not, manually add the file and drag it to the bottom of the ToC.
k) Open the Layer Properties window for *kriging_rain* and select the **Symbology** tab.
l) In the **Show:** window, select "**Classified**" and in the "**Classification**" section, click "**Classify**"
m) In the "**Classification**" section, choose **Method: *Defined Interval*** and **Interval Size: *10***. Click **OK**.
n) Change the **Color Ramp** to the color scheme of your preference. When finished, click **Apply.**
o) In the **Symbology** tab, Click the "**Label**" header in the window with your symbols. A window appears, select "**Format Labels ...**". The **Number Format** window appears.
p) In the **Rounding** portion of the window, change the number of decimal places to "1". Click **OK**, then **Apply** and **OK** to close the Layer Properties window.
q) Save your project.

Step 22: Spatial Interpolation of Rainfall Data: Inverse Distance Weighting (IDW)

a) Add a new Data Frame to your project by **Insert > Data Frame** from the top menu.
b) Set the coordinate system of the Data Frame to NAD 1983**.** Press **Apply**.
c) Click the "**General**" tab. Rename the **Name:** of the Data Frame to "*IDW*". Click **Apply**.
d) Click the "Data Frame" tab and set the **Extent:** to a **Fixed Scale** of 1:12,500,000. Click **Apply**, and **OK**.
e) Add the following data from your ***Lab04*** folder to your *IDW* Data Frame: *rain_locs_with_rain* and *rainfall_contours* and *California*. Order the layers in this manner in the ToC.
f) In **ArcToolbox**, go to **Spatial Analyst Tools > Interpolation > IDW**.
g) With the **IDW** window open, select the following arguments:
    1) Input point features: *rain_locs_with_rain*
    2) Z-value field: *Rain_2006*
    3) Output Raster: navigate to your ***Lab04*** folder and call the new shapefile "*IDW_rain*"
    4) Use the default values for the other fields.
    5) Click **OK**.

h) After the IDW calculation is complete, *IDW_rain* should be added to your ToC under *California*. If not, manually add the file and drag it to the bottom layer of the Data Frame.

i) Open the **Layer Properties** window for *IDW_rain* and select the **Symbology** tab.
j) In the **Show:** window, select "**Classified**" and in the "**Classification**" section, click "**Classify**"
k) In the "**Classification**" section, choose **Method:** ***Defined Interval*** and **Interval Size:** ***10***. Click **OK**.
l) Change the **Color Ramp** to the <u>same</u> color scheme that you used for *kriging_rain*. When finished, click **Apply**.
m) Still within the **Symbology** tab, Click the "**Label**" header in the window with your symbols. A window appears, select "**Format Labels ...**". The **Number Format** window appears.
n) In the **Rounding** portion of the window, change the number of decimal places to "1". Click **OK**, then **Apply** and **OK** to close the Layer Properties window.
o) Save your project.

Step 23: Spatial Interpolation of Rainfall Data: Natural Neighbor

a) Add a new Data Frame to your project by **Insert > Data Frame** from the top menu.
b) Set the coordinate system of the Data Frame to NAD 1983**.** Press **Apply**.
c) Click the "**General**" tab. Rename the **Name:** of the Data Frame to "***NatNghbr***". Click **Apply**.
d) Click the "Data Frame" tab and set the **Extent:** to a **Fixed Scale** of 1:12,500,000. Click **Apply**, and **OK**.
e) Add the following data from your ***Lab04*** folder to your ***NatNghbr*** Data Frame: *rain_locs_with_rain* and *rainfall_contours* and *California*. Order the layers in this manner in the ToC.
f) In **ArcToolbox**, go to **Spatial Analyst Tools > Interpolation > Natural Neighbor**.
g) With the **Natural Neighbor** window open, select the following arguments:
    1) Input point features: *rain_locs_with_rain*
    2) Z-value field: *Rain_2006*
    3) Output Raster: navigate to your ***Lab04*** folder and call the new shapefile "*natnghbr_rain*"
    4) Use the default values for the other fields
    5) Click **OK.**

h) After the natural neighbor calculation is complete, *natnghbr_rain* should be added to your ToC under *California*. If not, manually add the file and drag it to the bottom of the Data Frame.
i) Open the Layer Properties window for *natnghbr_rain* and select the **Symbology** tab.
j) In the **Show:** window, select "**Classified**" and in the "**Classification**" section, click "**Classify**"
k) In the "**Classification**" section, choose **Method:** ***Defined Interval*** and **Interval Size:** ***10***. Click **OK**.
l) Change the **Color Ramp** to the same color scheme that you used for *kriging_rain*

and *IDW_rain*. When finished, click **Apply**.
m) Still within the **Symbology** tab, Click the "**Label**" header in the window with your symbols. A window appears, select "**Format Labels ...**". The **Number Format** window appears.
n) In the **Rounding** portion of the window, change the number of decimal places to "1". Click **OK**, then **Apply** and **OK** to close the Layer Properties window.
o) Save your project.

Step 24: Spatial Interpolation of Rainfall Data: TIN

a) Add a new Data Frame to your project by **Insert > Data Frame** from the top menu.
b) Set the coordinate system of the Data Frame to NAD 1983**.** Press **Apply**.
c) Click the "**General**" tab. Rename the **Name:** of the Data Frame to "***TIN***". Click **Apply**.
d) Click the "Data Frame" tab and set the **Extent:** to a **Fixed Scale** of 1:12,500,000. Click **Apply**, and **OK**.
e) Add the following data from your ***Lab04*** folder to your ***TIN*** Data Frame: *rain_locs_with_rain*, *rainfall_contours*, *California,* and *tin_yourlastname*. Order the layers in this manner in the ToC.
f) Open the Properties window of *tin_yourlastname* and click "Symbology". Make sure that "Show hillshade illumination effect in 2D display" is NOT selected.
g) In the "**Classification**" section, choose **Classify** and **Method: *Defined Interval*** and **Interval Size: *10***. Click **OK**.
h) Change the **Color Ramp** to the same color scheme that you used for *kriging_rain*, *IDW_rain, and natnghbr_rain*. When finished, click **Apply**, then **OK**.
i) Still in the **Symbology** tab, Click the "**Label**" header in the window with your symbols. A window appears, select "**Format Labels ...**". The **Number Format** window appears.
j) In the **Rounding** portion of the window, change the number of decimal places to "1". Click **OK**, then **Apply** and **OK** to close the Layer Properties window.
k) Save your project.

Step 25: Make a layout in ArcMap with a title legend, north arrow, scale bar.
Discussion: In order for your map to be a complete, presentation-ready document (known as Layout), your map needs additional information, including a title, legend, scale bar, and your attribute table. You should spend time on your layout and create a professional-looking map.

a) Open your Layout View.
b) You will notice that you have 4 data frame windows containing the 4 maps of different interpolation methods. Place them in an organized manner on the page layout.
    1) To help you with your layout organization, you can turn on

either/or grids and guidelines by going to **View > Guides**, **Grids**.
2) Notice that one of the three Data Frames has a dashed line surrounding it in the Layout and is BOLD in the ToC. These characteristics show you the "Active" Data Frame, or the one that you are currently editing.
3) To activate one of the other data frames for editing, right-click the data frame in the ToC and choose "Activate" (or you can simply click on the data frame in the Layout View)

c) Select **Insert** > **Title**. Use an overall title that describes the 4 maps.
d) Insert textboxes into the individual Data Frame windows that state the name of the interpolation method used to create that map.
e) Select **Insert** > **Legend**. Insert legends into the individual data frames. Note that to do this you will need to activate each frame individually.
f) Select **Insert > North Arrow.** Insert a single north arrow for your overall layout.
g) Select **Insert** > **Scale Bar**. Select a scale bar and change the units to kilometers. Since we have set the four maps to the same fixed scale, it is sufficient to use one scale bar for your layout.
h) Select **Insert** > **Text**. Drag the box that appears to the bottom right corner of your layout. Double click the word "Text" and type your name, the lab number, and the date that you created the map.
i) Select **Insert** > **Text.** Label the textbox as "Metadata" and enter metadata information for the electronic data used in the lab. Remember to answer questions such as who, when, where and coordinate system projection for data that you did not create yourself.
j) Click **File > Save** to save your project.

Step 26: Export the ArcMap Layout to .jpeg and .pdf formats

Discussion: It is an important step to be able to communicate your GIS data to others who do not have ArcGIS software; thus we will create our final maps in both .jpeg and .pdf formats.

a) Export your map as both a .jpeg and a .pdf file.
b) Select **File** > **Save** to save your ArcMap project before you close.

Step 27: Prepare a report explaining how you prepared this exercise.
Use the following layout :

Use the outlined format below in your report. Be sure to include lab number and title, date report is due, and your name. Please number the pages of your report.

a) Post the ArcScene image
b) Briefly summarize the procedure you used to perform Part I of this exercise. Be sure to explain how you used table joins, 3D surfacing and viewing, and contouring.
c) Post the .jpeg copy of your final map from ArcMap.

d) Describe the four types of spatial interpolation that you used in Part II.
    1) Describe their similarities and differences.
e) Based on your analysis, which spatial interpolation most accurately fits the rainfall data set? Explain your reasoning.
    1) Are there any additional datasets that could be included that would improve the interpolation?

Feel free to also indicate what you liked and didn't like about the exercise, as well as areas for improvement or expansion. Your feedback always improves GIS exercises for future classes.

Turn in a print-out of your report to your TA by the due date. Reports are to be handed in at the beginning of the lab on the due date. An electronic copy of your lab folder from your external storage will also be turned in to TA at this time.

Electronic reports will **not** be accepted for grading. Lab reports turned in after the beginning of lab will be considered late. Late lab reports will incur a point deduction. See course syllabus for more information.