Geology 472: GIS Exercise

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See also: Geology 472/572 Syllabus | Project 2 | Report Template

Estimating Areal Rainfall in the Lake Whatcom Watershed

The objective of this GIS exercise is to estimate the yearly, areal-average precipitation in the Lake Whatcom watershed using methods in ArcGIS. The techniques will require a shapefile that you will create that contains the locations of the rain gauges in the watershed and the respective magnitudes of precipitation at these locations, the watershed grid (*lwgrid*) and the watershed DEM (*lwwdem*) that you created in GIS_ex1.

Key words: Projection, shapefile, coordinate system, geographic transformation, raster calculator

Data: Data are located in *J:\saldata\Geol472\GIS_ex2*

1. Create a folder in *Geol472*on the U drive called *GIS_ex2 (U:\Geol472\GIS_ex2*)

2. Copy the *lwdem* and *lwgrid* raster files and *lwmask.shp* from GIS_ex1 to GIS_ex2 using ArcCatalog

Create a shapefile by adding an Excel file into ArcGIS

The *lwrain2006.xls* Excel file contains x,y positions for the locations of the rain gauges in the Lake Whatcom watershed. The points are in lat-long coordinates (decimal degrees) in NAD83. In a step below you will convert NAD83 to NAD27 and decimal degree to UTM.

1. Import the Excel data into ArcMap and create a shapefile

a. Using My Computer, open up the Excel file and examine the names, locations, magnitudes of the rain gauges. Close the Excel file.
b. Open Arc Catalog and use the file manager to locate the workspace having the Excel file. Double click on *lwrain2006.xls*. You should see 3 files (sheet1, sheet2, sheet3)
c. Click on *sheet1* in Arc Catalog and drag it into ArcMap
d. Right Click on the *Sheet1$* → Display X,Y → Edit → Import

import a degree decimal shape file called *rainstations_nad83dd.shp*

→OK

→OK

e. Right Click on *Sheet1$Events* → Data → Export Data (feature) give it a name (*precip2006*)

2. Change the coordinate system and perform geographic transformation

Use the following commands in the Arctoolbox to change the coordinates of the points in the shapefile (*precip2006.shp*). Follow the steps in the window below and name the new shapefile *precip2006_utm.shp*.

Arctoolbox → Data Management Tools → Projections and Transformations → Feature → Project

For the Output Coordinate System, choose Import, *lwgrid*

For the Geographic Transformation choose *NAD_1927_To_NAD_1983_NADCON*

→OK

Areal Rainfall Estimate: Thiessen Polygons

Read about Thiessen polygons in the textbook. The Thiessen Polygon tool in ArcGIS will use the x,y positions (UTM reference frame) in the precip2006_utm.shp and step through the procedures outline in the text to create polygons (areas) that weight each gauge.

1. Apply the Thiessen Polygon tool

a. Open ArcMap and add the raingauge shapefile (*precip2006_utm.shp*)
b. Add *lwmask*
c. Arctoolbox → Analyst Tools → Proximity → Create Thiessen Polygons
d. In the "Environments" icon, General Settings, set the "Extent" to the *lwmask*

→OK

Input Features: *precip2006_utm.shp*

Output feature: *thiessen*

Output fields: All

→OK

e. Click on the information icon in the tool bar and then click on each point (gauge) to determine the magnitude of the precipitation (meters) at each gauge.

2. Clip the Thiessen polygons to the Watershed

ArcToolbox → Analyst Tools → Extract → Clip

Input feature class: *thiessen*

Clipped Features: *lwmask*

Output feature class: *lwthiessen*

→OK

3. Determine the area of the polygons in the watershed

ArcToolbox → Spatial Statistics Tools → Utilities → Calculate Areas

Input feature class: *lwthiessen*

Output feature class: *lwthiessenareas*

→OK

Right click on *lwthiessenareas* and look in the attribute table for the areas. Or, use the Identify button and click on each polygon to determine the area. The areas in each case will be in square meters. Use these values to determine the areal average using the Thiessen polygon method.

Areal Rainfall Estimate: Interpolate to Raster

In this method you will take advantage of the pixel (grid cell) nature of the Lake Whatcom watershed grid (*lwgrid*). The grid is composed of about 163,000 30 x 30 meter grid cells. Each one of these cells is linear distance from each of the rain gauges in the watershed. The inverse distance weighted technique determines the rainfall at a respective grid cell by weighting the rainfall at the other gauges using their distances to the respective pixel.

1. Apply the Interpolate to Raster Tool

a. Open ArcMap and add *precip2006_utm.shp* and the *lwgrid* raster

b. First set the analysis environment using the following steps

Spatial Analyst toolbar → Options

General tab, Working directory: *U:\Geol472\GIS_ex2*

Extent tab, Analysis extent: Same as layer *lwgrid*

Cell size tab, Analysis cell size: Same as layer *lwgrid*

→OK

c. apply the interpolate by raster tool

Spatial Analyst toolbar → Interpolate by Raster → Inverse Distance Weighted

Input Points: *precip2006_utm.shp*

Z value field: 2006_Rainf

Power: 2

Search Radius: variable

Number of points: 4

Maximum Distance: Blank

Output Cell Size: 30

Output raster: idw2006

OK

2. Clip the IWD raster

a. After the IWD weighting is complete, clip it to the watershed

Arctoolbox Spatial Analyst Tools Extract Extraction Extract by Mask

Input raster: idw2006

Input raster or feature mask: lwgrid

Output raster: lwidw2006

OK

b. Remove idw2006 from ArcMap

3. Determine the areal rainfall

Right click on lwidw2006 properties sources. Scroll down to Statistics and find the Mean value of precipitation. This is the areal average. How does it compare to the Thiessen polygon value?

Areal Rainfall Estimate: Interpolate to Raster and Raster Calculator

Note the all 4 rain gauges are at or close to lake level (~93.6 m). It is known however, that rainfall increases with elevation due to the orographic effect. To simulate the orographic effect, you will use a lapse rate equation that linearly increases rainfall with elevation. You will take advantage of a powerful tool in ArcGIS called the raster calculator. The lwidw2006 grid you created in the previous steps contains about 163,000 30 x 30 meter grid cells. Each one of these cells has a precipitation value, but all those values are at 93.6 meters. You will add the Lake Whatcom watershed DEM (lwdem) to ArcMap and use an algorithm in the raster calculator that will compare the elevation of a pixel on the DEM to its counter part on the lwidw2006 grid. The elevation difference will be used in the lapse-rate equation below to increase (or decrease) the precipitation on the respective pixel of the lwidw2006 grid.

1. Applying the raster calculator

a. Add the ldem grid to ArcMap along with the lwidw2006 grid and apply the raster calculator.

Spatial Analyst toolbar Raster Calculator …

Type the expression below (make sure there is a space on both sides of the +, -, * signs.

2. Determine the areal rainfall

Right click on lwlapse properties sources. Scroll down to Statistics and find the Mean value of precipitation. This is the areal average. How does it compare to the areal estimates above? Also examine the Minimum and Maximum rainfalls. Where do you think these occur? Click on the Identify button in the standard ArcMap toolbar and use the mouse to click on different locations in the lwlaspe raster.

3. Volume calculation. Use the area of the watershed that you determined in GIS_ex1 and calculate the volume of rainfall (cubic meters) that each areal average technique produces.