# GEOS 5V08-001: Geospatial Applications in Earth Science

Dr. T. Brikowski, Dr. C. Aiken

February 9, 2010

## 1 Introduction

The purpose of this course is to review the application of spatial data gathering, analysis and interpretation in the geosciences. This course will emphasize geospatial data management and interpretation (GIS), remote sensing applications, terrestrial surveying (LIDAR). Topics will generally be treated as case studies, emphasizing applications in structural geology, sedimentology, and environmental geology.

Student activities in this course will emphasize a number of case studies, and will use those studies to teach the students the basic skills needed for geospatial data capture and analysis in earth sciences.

## 2 Syllabus

Since this class is being offered for the first time, and is taught by a team of faculty, the schedule of topics will be approximate until mid-semester (see Table 1).

## 3 Case Studies

### 3.1 Introduction to Geospatial Mapping

Purpose: To introduce students to the concepts and procedures involved in creating a digital map. We will utilize a general tutorial for map creation using ArcGIS. The final product will be a map of point data selected by attribute superimposed on polygonal data (Fig. 1).

General concepts to be learned:

**ArcCatalog** browsing, organizing and previewing spatial data (vector and raster)

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vers. 1.2, January 12, 2010

Table 1: Course Syllabus.

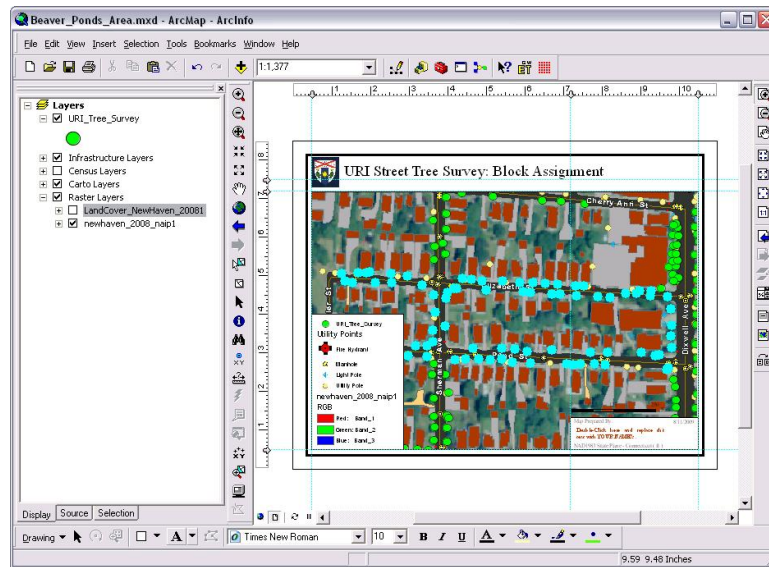| Week | Date | Topic | Exercise |
|---|---|---|---|
| 1 | Jan. 12 | Organizational Meeting, Geospatial Overview | - |
| 2 | Jan. 19 | Intro. to Geospatial Mapping | Intro. GoogleEarth, ArcGIS |
| 3 | Jan. 26 | Geospatial Analysis | Analysis with ArcGIS |
| 4 | Feb. 2 | Intro. to Geologic Analysis | Geologic analysis in ArcGIS: Sand Hills hydrology |
| 5 | Feb. 9 | Interpolation: From points to fields | ArcGIS Geostatistical Analyst Tutorial |
| 6 | Feb. 16 | | |
| 7 | Feb. 23 | | |
| 8 | Mar. 2 | | |
| 9 | Mar. 9 | | |
| - | Mar. 16 | Spring Break | |
| 10 | | | |



Figure 1: Final map in ArcGIS, Introduction to Geospatial mapping.

**ArcGIS** one of the most popular (and expensive) software tools for geospatial mapping and analysis

**Map Documents** opening, manipulating and saving Map Documents ("*.mxd")

**Shapefiles** ESRI's proprietary format for vector geospatial data (e.g. see Wikipedia; geometry: *.shp, attributes: *.dbf, geographic projection: *.prj). Can't handle very large datasets (e.g. LIDAR)

**Attributes** browsing and selection of data by attributes or location

**Map Appearance** setting feature symbology, adding map decoration (e.g. scale, legend, ...)

**Map Export** saving the final product for inclusion in other documents (e.g. PDF export from Layout View)

**ArcToolbox** batch processing of data/shapefiles

## 3.2 Introduction to Geospatial Analysis

Purpose: To introduce students to the concepts and procedures involved in geospatial analysis using ArcGIS. We will utilize a general tutorial for geospatial analysis using ArcGIS. The final result will be a map summarizing water contaminant releases by major watershed in Connecticut (Fig. 2).

General concepts to be learned:

**Appending Data** how to add data to a map, and how to rearrange depth of data (order it is drawn)

**Field Calculation** adding standard geometric fields to a shapefile/attribute table (e.g. compute polygonal area in *.dbf). Calculatiing new fields/attributes as simple combinations of other fields. Calculating only for a subset of records.

**Polygon Intersection** breaking polygonal areas into sub-units depending on their union with other polygonal coverages

**Linking Data** joining additional datasets indexed by a mutual attribute

**Adding Tabular Data** adding data from a tabular format (e.g. *.dbf or *.xls), identifying its spatial fields (X and Y), and plotting it on the map

**Spatial Selection of Data** using "spatial join" to operate on a subset of data by location

**Background Data** adding network-stored data, e.g. shaded relief base map
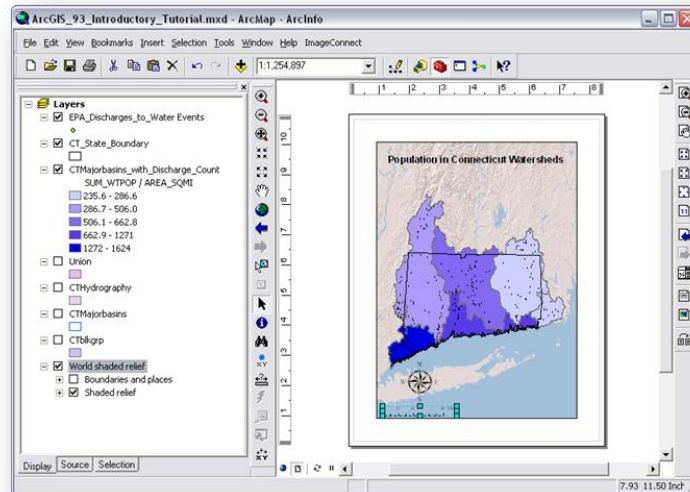
Figure 2: Final map in ArcGIS, Introduction to Geospatial mapping.



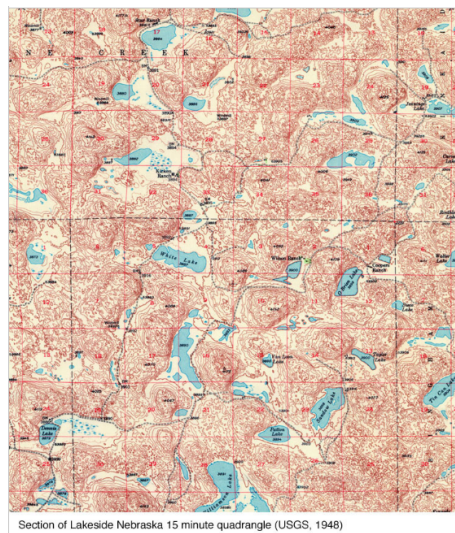Section of Lakeside Nebraska 15 minute quadrangle (USGS, 1948)

Figure 3: Portion of Lakeside, NE 15-minute quadrangle, showing part of the Sand Hills and lakes.

## 3.3 Groundwater Movement in the Sand Hills

Purpose: to use GIS tools (*ArcGIS*) to perform basic spatial analysis and correlation in an unusual hydrologic setting, the Sand Hills of central Nebraska (Fig. 3).

## 3.4 Epidemiology and Climate

Purpose: Utilize GIS tools to map data onto various geometric entities (e.g. state polygons). For example to correlate apparent temperature (heat index, Steadman, 1984) with various health indices (Fig. 4).
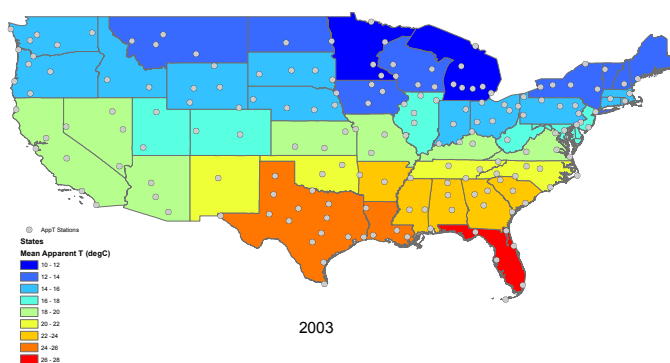


Figure 4: Apparent temperature by state, 2003

## 3.5 Erosion Monitoring Using Lidar: Wilson Creek

Purpose: to learn the basic procedures of geologic surface capture, using ground-based LIDAR (laser scanners). Students will participate in a survey of stream bank position at Wilson Creek, The Heard Museum of McKinney. Gain experience with high-density data analysis, detailed surface generation (*RyScan*), and visualization (*Polyworks, Paraview*, Fig. 5).

## 3.6 Integration of Captured and Mapped Data: Slick Hills

Purpose: to learn the procedures required to integrate paper-based field mapping (raster data), topographic scanning, lithologic correlation, and structural mapping (Fig. 6).
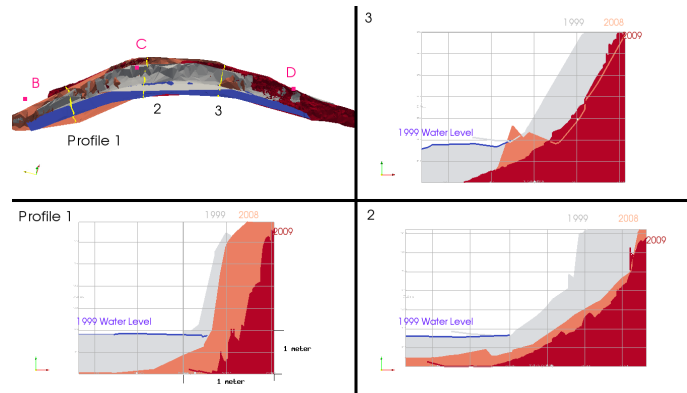
Figure 5: Wilson Creek bank comparision, 1999, 2008, 2009

## 3.7   Climate Change Impacts: Precipitation Anomaly, South Central U.S.

Purpose: gain experience in handling climate datasets in standard formats (e.g. NetCDF), using standard climate analysis tools (i.e. VCDAT). Working with an observed precipitation anomaly in the south-central U.S. (Fig. 7), explore the consequences and future significance of this event.

# References

al Farhan, M., White, L., Tuck, D., Aiken, C., 2010, Laser Rangefinders And ArcGIS Combined With Three-Dimensional Photorealistic Modeling For Mapping Outcrops In The Slick Hills, Oklahoma. Geosphere In prep.

Brikowski, T., 2009, Wet, Dry, Dim, or Bright? The Future of Water Resources in North Texas. In: *EOS Trans.*, vol. 90 of *Fall Meet. Suppl.*, Abstract H13D-1016.

Garbrecht, J. D., Schneider, J. M., 2008, Case Study of Multi-Year Precipitation Variations and the Hydrology of Fort Cobb Reservoir. J. Hydrol. Engrg. 13(2), 64–70.

Steadman, R. G., 1984, A universal scale of apparent temperature. J. Climate Appl. Meteor. 23, 1674–1282.
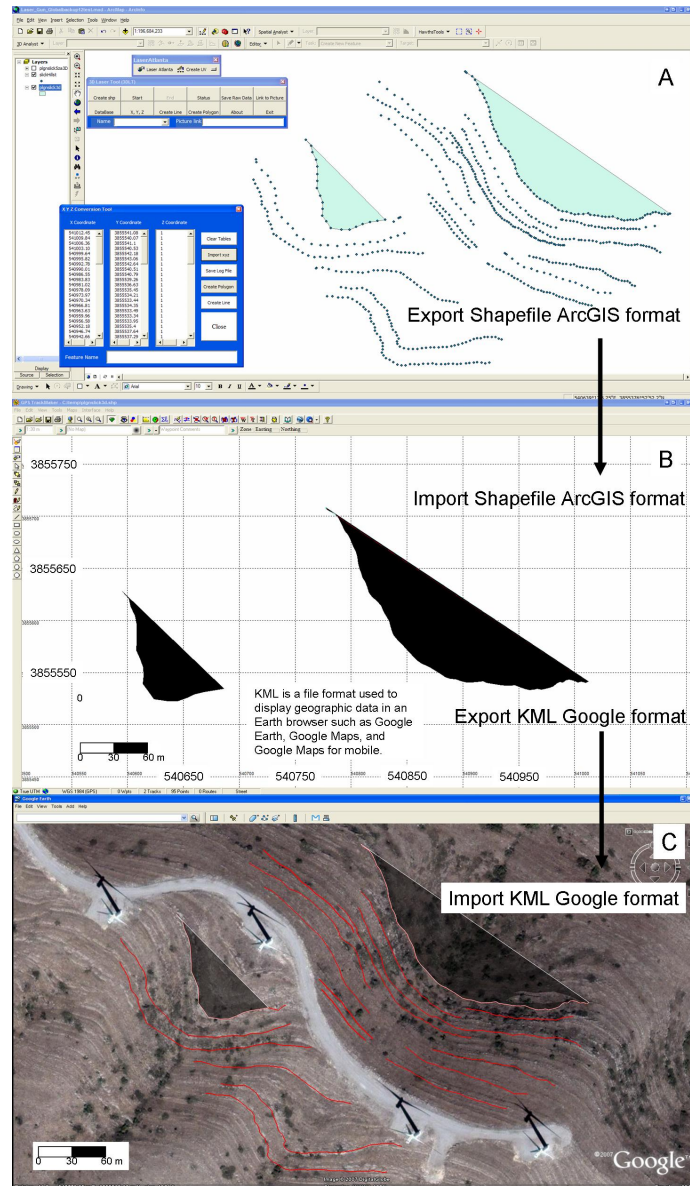
Figure 6: Fitting surfaces created by 3DLT (three-dimensional laser tool) mapped features on top of a ridge in the southeast Slick Hills, OK. (A) Laser mapping in 3DLT/ArcGIS with surface fit of two contacts. (B, C) Shapefiles imported into TrackMaker software in UTM zone 14S coordinates to allow data to be imported into Google Earth. Also note 3DLT mapping of stratigraphy around area (red). Black surfaces are surface fitting of points from the 3DLT mapping. Note energy windmills on top of ridge. From (al Farhan *et al.*, 2010).
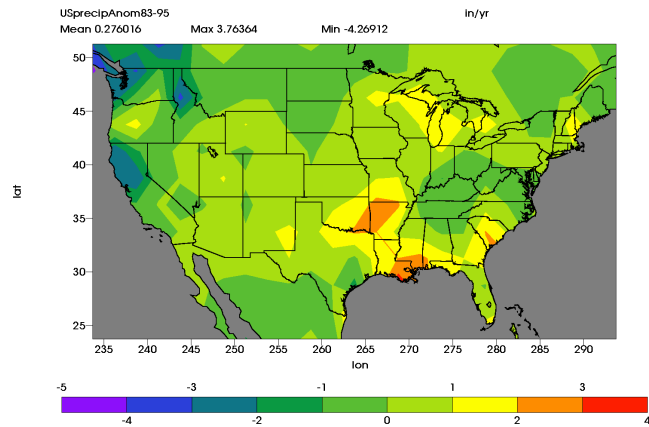
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Figure 7: U.S. mean annual precipitation departure, 1983-1995