Combining Old School Methods and New School Technology in an Earth Science Field Methods Course

by Les Hasbargen, Dept. of Earth Sciences, SUNY College at Oneonta

Geosciences has experienced rapid growth of new spatial technology
There are some pitfalls…
- Technology can eliminate the need for thought (plug-and-play, push button technology)

But there are huge advantages
- Technology can empower data collection, sharing, and portrayal of information

The goal for teaching Geologic Data and Analysis, a sophomore level Earth Sciences course for majors
- Have students learn how to transform field data collected with analog equipment into coordinate data layers appropriate for today's GIS world
- Engage students in mastering the tools, concepts, and software

How to do this?

Step 1
Start with basic surveying tools: tape measures and compasses
They learn how to map features using a traverse, measuring a bearing and distance from point to point
They next learn how to apply trigonometry to compute cartesian coordinates of each point
Spreadsheets come in handy here! Steep learning curve for most students…
The students then create "maps" in Excel using the scatter plot chart function

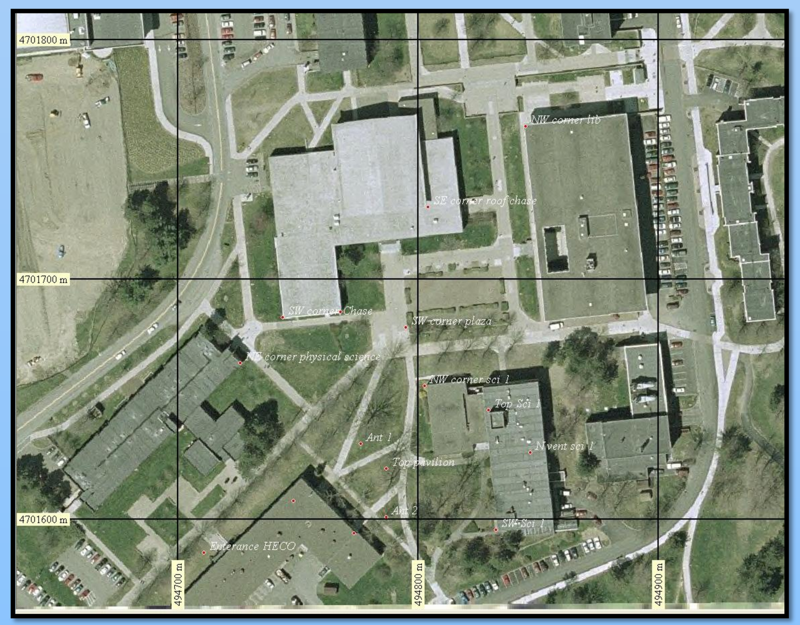
Step 2
A Field Project: Map geomorphic features (stream channel, floodplains, and terrace) using a compass and tape measure
The students discover how to add more lines (i.e., new layers) to a map ("series", in Excel)
Once students have learned the above method, it's time for higher tech

Step 3
We re-survey a location with high precision survey equipment: a total station
The next problem they must face is how to move between local reference frames; thus they learn how coordinate transformations work
They apply linear algebra to solve 4 equations in 4 unknowns involved in a 2-D coordinate transformation which involves translation, rotation, and re-scaling, and they use Excel to compute the transformation parameters

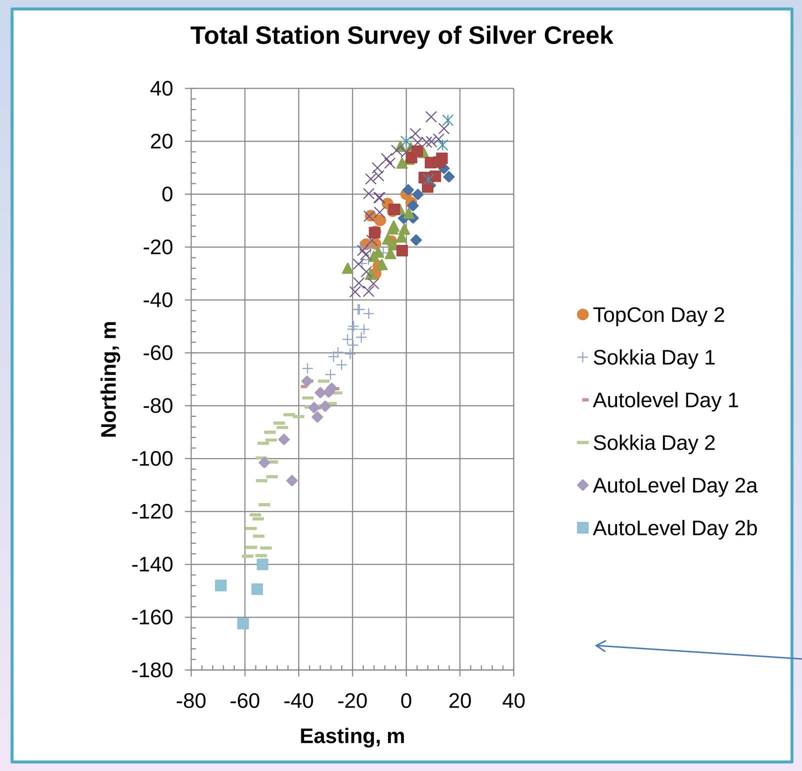
Step 4
Once they are comfortable with translations and rotations, the next step is easy: bring in GPS as a survey tool to find the global coordinates of known points
Most students are already very comfortable with handheld devices
The technology is quite advanced, permitting easy transfer of data from handheld device to a computer environment

Step 5
Combine total station and high resolution GPS field data into global reference frame
Students record the local reference frame survey data and convert them into UTM coordinates in Excel
They then create files that can be read as layers into a GIS package

Students learn the issues involved in mapping spatial data by starting with old school methods, and then adding in new school technology. The overarching goal: create a rich learning environment for students, and challenge them to develop a rich spectrum of skills along the way!



The final step in the process was to survey in points on campus with a total station, and include high resolution GPS receivers, pictured below, to locate two points in a global reference frame. Using these control points, we then transformed the total survey points into the global reference frame in Excel. We then loaded this data set into a GIS software (Global Mapper), with a georeferenced air photo as the background. The transformation worked beautifully! The survey points match locations on the air photo remarkably well.



We moved each data set via translations in Easting and Northing, until the surveyed points approximated the location of the channel of Silver Creek.

The 2-D Conformal Coordinate Transformation involves rotation around a vertical axis, translation and re-scaling.
The equations look like this:

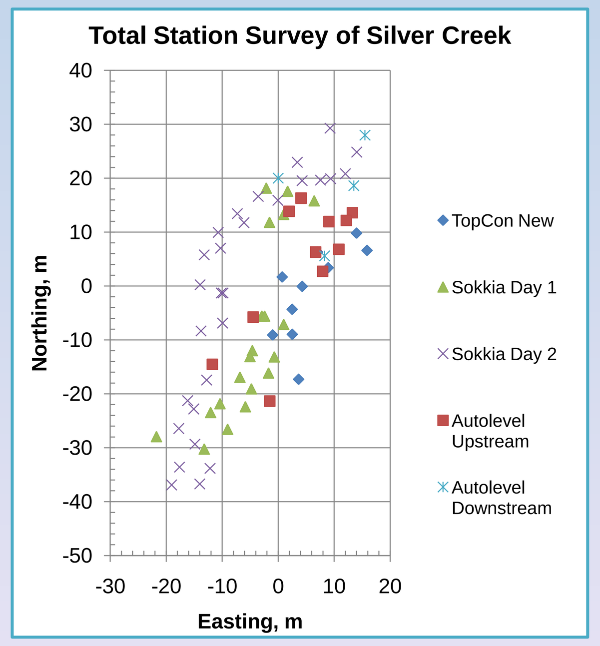
$$x' = T_x + ax + by$$
$$y' = T_y - bx + ay$$

Where x' and y' are the coordinates in the new rotated and rescaled reference frame, T_x and T_y are the translations, and a and b encompass scaling and rotation.

To determine the transform parameters (a, b, T_x, T_y), we first assume we know two point locations in both reference frames. We then have 4 equations containing the 4 unknown parameters. We rearrange the equations to solve for the unknown parameters:

$$b = \frac{(x_2' - x_1')(y_2 - y_1) - (y_2' - y_1')(x_2 - x_1)}{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$
$$a = \frac{(x_2' - x_1') + b(y_2 - y_1)}{(x_2 - x_1)}$$
$$T_x = x_1' - ax_1 - by_1$$
$$T_y = y' + bx_1 - ay_1$$

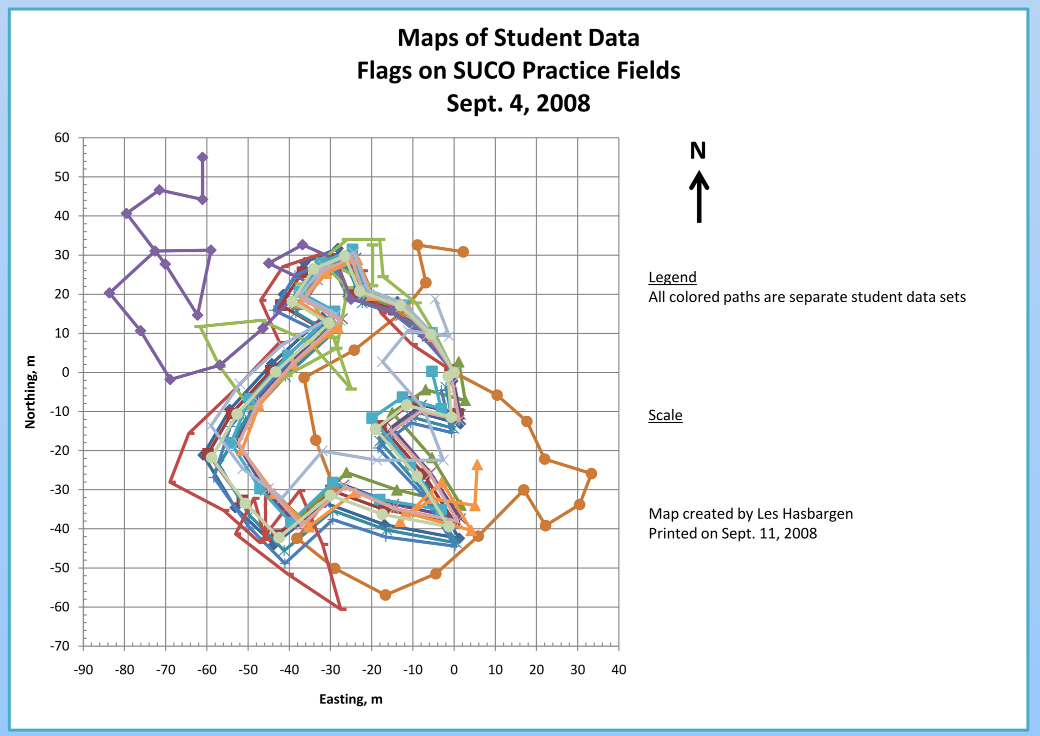
The transformations largely failed during this exercise. We did not record control points between stations adequately.



We utilized several total stations, and mapped over several days. Hence, we needed to convert all of the survey data into a common reference frame. The chart above shows all of the data sets from each station. Bringing all the data sets into a unified reference frame turned out to be a difficult task, as we failed to collect sufficient information to completely tie together all the data sets. We resorted to trial and error translations to get the data sets to line up correctly along the stream course.

Ideally, one would use 2 common points in each survey data set to bring the points into a unified reference frame.

In the figure above, students learn how to map a traverse with a hand-held compass and a calibrated stride.



Plotted in the map above are students' traverse data, transformed into coordinate data in a spreadsheet.
Key points: 1) Students can readily compare their data with others. This is not easy with analog methods. 2) Both directional and distance errors in the measurements can be assessed .

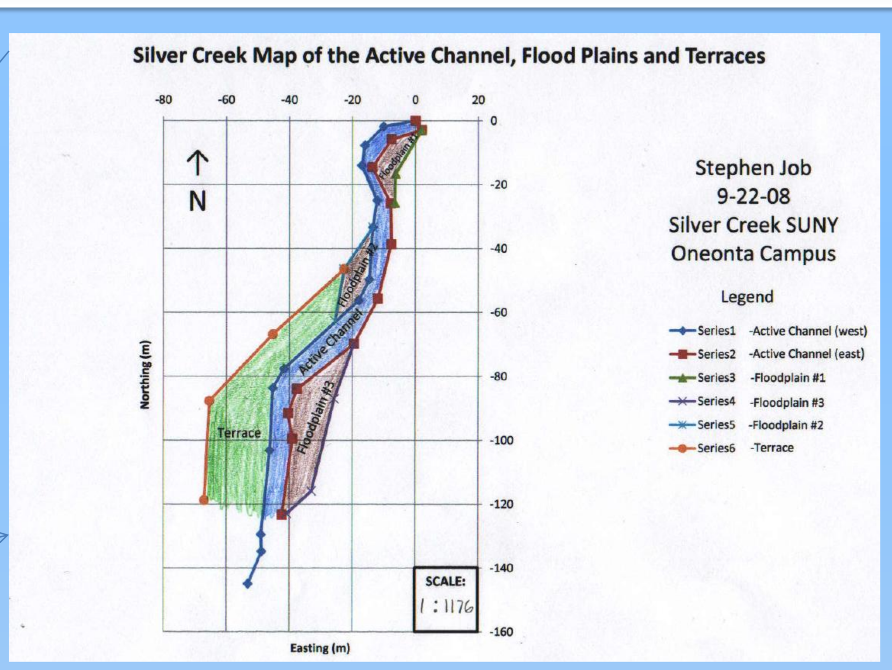
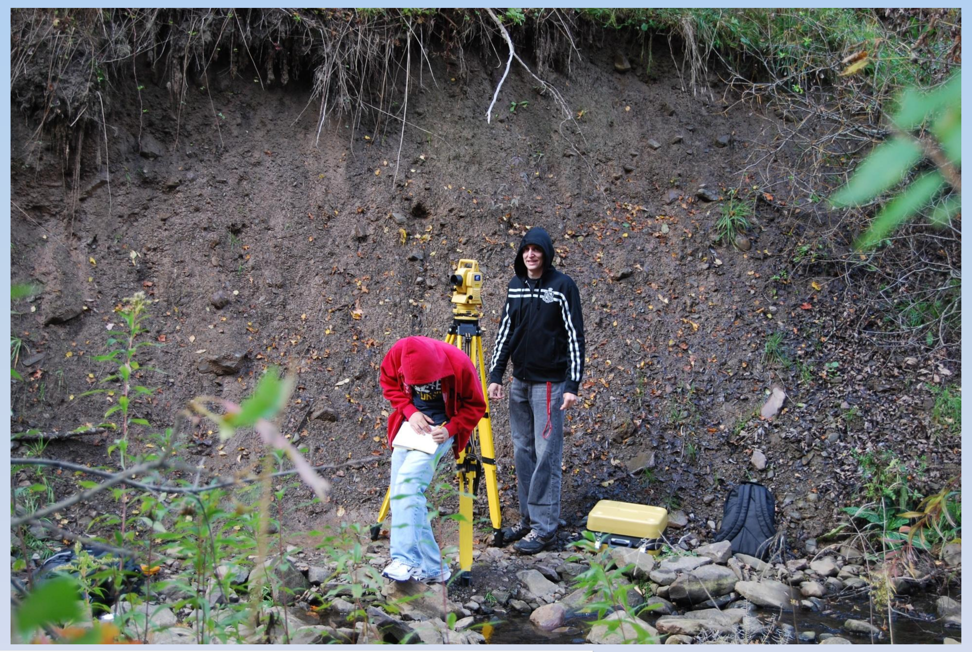


Figure above represents a spreadsheet generated map. Each data series derives from x,y coordinates computed from a traverse along the feature. Students input their distance-azimuth data into a spreadsheet, then compute coordinate data using trigonometry.

Key aspects: 1) Defining a local origin for each new path; 2) forcing the chart to preserve a uniform scale in easting and northing directions.



Students mapped stream , floodplain, and terrace locations with high precision surveying tools—total stations.

Abstract
Wireless communications, an Earth orbiting constellation of satellites (GPS), fast clocks, and small circuits have revolutionized spatial location, and hence, mapping, of features on and below Earth's surface. The technology has increasingly been integrated into all aspects of life, most often out of sight and with little awareness of the user. The benefits of working within a global referenced spatial system are immense. Geologists have long mapped Earth's rocks and features using handheld compasses and base maps, and occasionally with higher precision survey tools. Thus the new technology offers significant benefits for geoscientists, and a course that introduces well-established mapping practices and integrates those approaches with the latest positioning technology serves a vital role for Earth Sciences students at SUCO. This poster maps the trajectory of the course (GEOL 275), essentially following the progression from old school methods to new. Students gain experience with surveying equipment and creating paper maps; they apply trigonometry and algebra to field measurements in spreadsheets and create charts from their data; they learn how to use GPS, compute coordinate transformations, and how to get their data into GIS software. Along the way, students gain an appreciation for the limits of various tools in locating Earth's features by analyzing their measurements and comparing the different methods to each other.

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